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CRUISE REPORT¹

VESSEL: NOAA Ship *Hi'ialakai*, Cruise HA-11-01, Legs II and III

CRUISE PERIOD: 7 April–9 May 2011

AREA OF OPERATION: Guam and the Commonwealth of the Northern Mariana Islands (CNMI)

TYPE OF OPERATION: Personnel from the Coral Reef Ecosystem Division (CRED) of the NOAA Pacific Islands Fisheries Science Center (PIFSC), NOAA Pacific Islands Regional Office, San Diego State University, University of Guam, Scripps Institution of Oceanography (SIO) of the University of California San Diego, Guam Bureau of Statistics and Plans' Coastal Management Program, and Commonwealth of the Northern Mariana Islands (CNMI) Division of Environmental Quality (DEQ) conducted interdisciplinary Pacific Reef and Assessment Monitoring Program (Pacific RAMP) surveys in waters surrounding Guam and the CNMI. A summary of Pacific RAMP planned operations and required permitting applications were sent to the following institutions: United States Army Corps of Engineers, U.S. Fish and Wildlife Service, Guam Department of Agriculture's Division of Aquatic and Wildlife Resources, CNMI Coastal Resources Management Office, and CNMI Division of Fish and Wildlife.

ITINERARY:

3–6 April In port at Saipan Harbor following cruise HA-11-01, Leg I (Wake leg). Activities included calibration dives for Rapid Ecological Assessment (REA) benthic and fish teams, cruise welcome and ship walkthroughs, neurological exams, and drills for all new incoming scientific staff.

7 April Start of cruise HA-11-01, Leg II. Embarked all Leg II scientific staff, departed Saipan Harbor, and began standard Pacific RAMP operations around Saipan at 0745. The typical suite of REA benthic surveys—which includes belt-transect, line-point-intercept (LPI), and roving-diver surveys and transect photographs—

¹ PIFSC Cruise Report CR-11-008
Issued 18 November 2011



was completed at REA sites SAI-06 and SAI-07, along with additional small-boat safety and scenario drills to familiarize incoming staff with the new HI-1A small-boat platform. The REA benthic team also recovered and deployed a series of autonomous reef monitoring structures (ARMS) at REA site SAI-06. The REA fish team completed surveys at seven sites (SAI-98, 174, 183, 94, 199, 271, and 198), while the oceanography team recovered and replaced two subsurface temperature recorders (STRs) and deployed a sea-surface temperature (SST) buoy, completed nearshore CTD casts and water sampling (which included microbial water samples) at SAI-06, and deployed calcification acidification units (CAUs) at SAI-06. Four towed-diver surveys were conducted. Deepwater conductivity, temperature, and depth (CTD) casts, along a western transect, were limited to two deployments, primarily because of equipment concerns. Acoustic Doppler current profiler (ADCP) data were collected during this short transect.

- 8 April Continued field operations at Saipan. The REA benthic team completed surveys at SAI-05, SAI-03, and SAI-10. SAI-02 was unsuitable for diving because of weather conditions. A new REA benthic site, SAI-10 was established in Laolao Bay per recommendations from Ryan Okano of the CNMI DEQ. A series of ARMS was recovered and deployed at SAI-05. The REA fish team completed surveys at nine sites (SAI-72, 86, 87, 116, 172, 240, 261, 274, and 294), while the oceanography team completed nearshore CTD casts and water sampling (which included microbial water samples) and deployed CAUs at SAI-03 and SAI-05, recovered one ecological acoustic recorder (EAR) at mooring site SAI-004, and recovered and replaced one STR each at SAI-004 and SAI-007. Four towed-diver surveys were conducted, along with a benthic towed-diver calibration survey. The deepwater CTD casts planned for April 8 along an eastern transect were canceled because of increasing swell conditions.
- 9 April Operations off northwestern Saipan were canceled because of high-surf conditions. Transited to Tinian. Began field operations at Tinian at 0930. The REA benthic team completed surveys at TIN-03, TIN-02, and TIN-05. The REA fish team completed surveys at seven sites (TIN-146, 137, 63, 149, 159, 110, and 81), while the oceanography team completed nearshore CTD casts and water sampling, collected water and other samples for microbial analyses at TIN-03, and deployed CAUs at TIN-03 and TIN-02. Four towed-diver surveys were conducted. Began transit to Sarigan.
- 10 April Arrived at Sarigan and began field operations. The REA benthic team completed surveys at SAR-01, SAR-02, and SAR-03. The REA fish team completed surveys at nine sites (SAR-105, 95, 90, 69, 60, 73, 104, 109, and 87), while the oceanography team collected a nearshore nutrient water sample and other water samples for microbial analyses at SAR-03, and

recovered and deployed STRs at mooring sites SAR-002 and SAR-003. Four towed-diver surveys were conducted; additional surveys were canceled because of continued large-surf activity out of the northeast. A short series of deepwater CTD casts were conducted and ADCP data were collected along a western transect prior to beginning transit to Pagan.

- 11 April Arrived at Pagan and began field operations. The REA benthic team completed surveys at PAG-09, PAG-11, and PAG-06, and collected algal voucher specimens at PAG-09 and PAG-11. A series of ARMS was recovered (two units; one lost) and deployed (three units) at SAI-05. The REA fish team completed surveys at eight sites (PAG-132, 87, 216, 151, 229, 85, 155, and 220), while the oceanography team completed nearshore CTD casts and water sampling (which included microbial water samples at PAG-05) and deployed CAUs at PAG-09 and PAG-05. Recovered one EAR at mooring site PAG-006, recovered and deployed one SST buoy at PAG-001, and recovered and replaced three STRs at PAG-004, PAG-005, and PAG-006. Six towed-diver surveys were conducted. Along a western transect, 10 deepwater CTD casts were completed and ADCP data were collected.
- 12 April Continued field operations at Pagan. The REA benthic team completed surveys at PAG-12 and PAG-06. No REA benthic surveys were completed at PAG-03 because of surge conditions. A series of ARMS was recovered and deployed at PAG-05 and a series was recovered from PAG-06. The REA fish team completed surveys at nine sites (PAG-127, 91, 167, 215, 95, 98, 186, 243, and 208), while the oceanography team completed nearshore CTD casts and water sampling and at PAG-03, collected water and other samples for microbial analyses, deployed CAUs at PAG-03, and extracted a coral core (*Porites* sp.) at PAG-11. Additional activities included collection of one core sample from a coral of the genus *Porites* at PAG-11 and recovery of an EAR anchor at mooring site PAG-006. Four towed-diver surveys were conducted, along with a benthic towed-diver calibration survey. Conditions along the north side prevented the completion of a sixth towed-diver survey. Along an eastern transect, nine deepwater CTD casts were completed and ADCP data were collected.
- 13 April Continued field operations at Pagan. The REA benthic team completed surveys at PAG-01 and PAG-13 and collected algal voucher specimens at PAG-13. No REA benthic operations were completed at PAG-08 because of unfavorable sea-surface conditions and patchy radio communications. A series of ARMS was deployed at PAG-01. The REA fish team completed surveys at 12 sites (PAG-122, 214, 217, 192, 71, 158, 78, 97, 211, 200, 162, and 204), while the oceanography team completed nearshore CTD casts and water sampling (which included microbial water samples at PAG-01) and deployed CAUs at PAG-01 and PAG-13. Four

towed-diver surveys and two plankton tows were completed. Began transit to Asuncion.

- 14 April Arrived at Asuncion and began field operations. The REA benthic team completed macroinvertebrate surveys as well as the typical suite of surveys at ASC-03, ASC-06, and ASC-02. The REA fish team completed surveys at 11 sites (ASC-79, 73, 98, 114, 72, 93, 84, 116, 129, 121, and 112), while the oceanography team completed nearshore CTD casts and water sampling (which included microbial water samples at ASC-03) and deployed CAUs at ASC-03, ASC-06, and ASC-02. One STR was recovered and replaced at each of three mooring sites: ASC-001, ASC-002, and ASC-003. Five towed-diver surveys were conducted. Along a western transect, 10 deepwater CTD casts were completed and ADCP data were collected.
- 15 April Continued field operations at Asuncion. The REA benthic team completed surveys at ASC-04, ASC-01, and ASC-05, collected microbial water samples at ASC-05, and deployed CAUs at ASC-04. The REA fish team completed surveys at nine sites (ASC-68, 110, 127, 87, 89, 71, 69, 91, and 90), while the oceanography team was inactive because of a required rest day from diving. One towed-diver survey was conducted, along with one fish and one benthic towed-diver calibration survey and two plankton tows. Along an eastern transect, six deepwater CTD casts were completed and ADCP data were collected. Began transit to Supply Reef.
- 16 April Arrived at Supply Reef and began field operations. The REA benthic and fish and towed-diver teams were inactive because of a required rest day from diving. The oceanography team recovered and replaced an STR and recovered an anchor. Began transit to Farallon de Pajaros.
- 17 April Arrived at Farallon de Pajaros and began field operations. The REA benthic team completed macroinvertebrate surveys as well as the typical suite of surveys at FDP-02, FDP-01, and FDP-04. The REA fish team completed surveys at 12 sites (FDP-69, 105, 78, 75, 73, 70, 101, 113, 102, 77, 80, and 104), while the oceanography team recovered and replaced three STRs at mooring sites near REA site FDP-01 and three STRs at mooring sites near FDP-02. Water samples were collected for microbial analyses at FDP-01. Four towed-diver surveys and two plankton tows were completed. Along a western transect, five deepwater CTD casts were completed and ADCP data were collected. Began transit to Maug.
- 18 April Arrived at Maug and began field operations. The REA benthic team completed surveys at MAU-04, MAU-12, and MAU-06. The scheduled recovery of ARMS at MAU-04 was unsuccessful, as the units were buried. A series of new ARMS was deployed at a more sheltered location at MAU-04. The REA fish team completed surveys at 11 sites (MAU-74,

154, 124, 178, 82, 71, 138, 179, 131, 174, and 127), while the oceanography team completed nearshore CTD casts and water sampling (which included microbial water samples at MAU-06), deployed CAUs at MAU-04, completed one remote access sampler (RAS) deployment and recovered and deployed one STR near REA site MAU-02, and recovered and deployed one SST buoy and one STR off the northern tip of East Island. At a cluster of mooring sites off the southwestern coast of West Island, three STRs were recovered and replaced. The towed-diver team completed six surveys and served as standby divers for the oceanography team during the RAS deployment at MAU-02.

- 19 April Continued field operations at Maug. The REA benthic team completed surveys at MAU-01, MAU-11, and MAU-10 and collected algal voucher specimens at MAU-10. Two ARMS were recovered at MAU-11; the third ARMS was buried and not successfully recovered. Three ARMS were deployed at that same site. The REA fish team completed surveys at 11 sites (MAU-77, 163, 136, 184, 72, 162, 78, 135, 115, 106, and 137), while the oceanography team completed nearshore CTD casts and water sampling and deployed CAUs at MAU-11 and MAU-12, collected water and other samples for microbial analyses at MAU-10, and recovered one STR and one EAR and anchor and deployed one STR at mooring site MAU-008. Also, one STR, EAR, and anchor were recovered at mooring site MAU-009. The towed-diver team conducted three surveys, along with one benthic towed-diver calibration survey and served as standby divers for the oceanography team during EAR and anchor recoveries. Along an eastern transect, 10 deepwater CTD casts were completed and ADCP data were collected.
- 20 April Continued field operations at Maug. The REA benthic team completed surveys at MAU-09, MAU-05, and MAU-02. A series of ARMS was recovered and deployed at MAU-09, where water samples for microbial analyses were collected. The REA fish team completed surveys at eight sites (MAU-84, 126, 182, 85, 102, 117, 121, and 128), while the oceanography team completed nearshore CTD casts and water sampling, deployed CAUs at MAU-02, recovered the RAS originally deployed at the same site on April 18, and extracted coral cores (*Porites* spp.) at MAU-02 and MAU-03. The towed-diver team conducted one benthic towed-diver calibration survey, collected water samples at MAU-09, and deployed CAUs at MAU-09 and MAU-05, searched for the missing ARMS at MAU-04, served as standby divers for the oceanography team during the RAS recovery, and completed two plankton tows. Along a western transect, 10 deepwater CTD casts were completed and ADCP data were collected. Began transit to Agrihan.
- 21 April Arrived at Agrihan and began field operations. The REA benthic team completed surveys at AGR-04, AGR-07, and AGR-01. The REA fish team

completed surveys at 10 sites (AGR-97, 90, 79, 180, 149, 141, 61, 87, and 127), while the oceanography team completed nearshore CTD casts and water sampling (which included microbial water samples at AGR-07) and deployed CAUs at AGR-01, AGR-04, and AGR-07 and recovered and replaced one STR at each of two mooring sites, AGR-002 and AGR-003. Six towed-diver surveys were conducted. Along an eastern transect, 10 deepwater CTD casts were completed and ADCP data were collected.

- 22 April Continued field operations at Agrihan. The REA benthic team completed surveys at AGR-02, AGR-05, and AGR-06. The REA fish team completed surveys at 10 sites (AGR-84, 86, 113, 131, 134, 137, 138, 148, 164, and 181), while the oceanography team completed nearshore CTD casts and water sampling (which included microbial water samples at AGR-06) and deployed CAUs at AGR-02 and AGR-06. Four towed-diver surveys and two plankton tows were conducted. Began transit to Alamagan. Ship detoured to Pagan because of concerns over volcanic activity and possible light signals directed at the ship from island residents.
- 23 April Arrived at Pagan, launched small boat (HI-1A) to investigate signals from previous evening. No issues encountered; departed Pagan en route to Alamagan. Arrived Alamagan at ~ 1200 and began field operations. The REA benthic team completed surveys at ALA-02 and ALA-03. The REA fish team completed surveys at five sites (ALA-69, 70, 91, 68, and 83), while the oceanography team collected a nearshore nutrient water sample and other water samples for microbial analyses at ALA-01 and recovered and replaced one STR at mooring site ALA-001 and one STR at ALA-003. Three towed-diver surveys were conducted. Along a western transect, 7 deepwater CTD casts were completed and ADCP data were collected. Began transit to Guguan.
- 24 April Arrived at Guguan and began field operations. The REA benthic team completed macroinvertebrate surveys as well as the typical suite of surveys at GUG-01, GUG-02, and GUG-03 and collected algal voucher specimens at GUG-01. The REA fish team completed surveys at 10 sites (GUG-69, 96, 110, 109, 92, 60, 88, 87, and 106), while the oceanography team recovered and replaced one STR at mooring site GUG-001 and collected a nearshore nutrient water sample and other water samples for microbial analyses at REA site GUG-02. Five towed-diver surveys were conducted. Along a western transect, eight deepwater CTD casts were completed and ADCP data were collected. Began transit to Zealandia.
- 25 April Arrived at Zealandia and began field operations. The oceanography team completed one anchor lift and recovered and deployed one STR. Began transit to Anatahan. Additional and scheduled operations at Anatahan were halted to conduct review of dive safety fundamentals and communications protocols. Began transit to Saipan.

- 26 April Arrived at Saipan and began field operations. The REA benthic team completed surveys at SAI-01 and SAI-02 and installed CAUs at SAI-01. The fish team completed surveys at five sites (SAI-117, 127, 291, 78, and 187). Three towed-diver surveys were conducted. Field operations were completed at approximately 1330, with the ship pulling into Saipan Harbor at 1600. End of cruise HA-11-01, Leg II.
- 27–29 April In port at Saipan Harbor. Disembarked Jeff Anderson, Paula Ayotte, Chris Sullivan, Ryan Okano, and Steve McKagan. Embarked Valerie Brown, David Burdick, Roxanna Miller, Karen Geisler, and Mark Manuel. Conducted education and outreach events on the *Hi`ialakai* and REA benthic calibration dives.
- 30 April Start of cruise HA-11-01, Leg III. Embarked all Leg III scientific staff, departed Saipan Harbor, and began standard Pacific RAMP operations around Saipan at 0745. The REA benthic team completed surveys at SAI-08 and SAI-04. Two ARMS were recovered and three ARMS were deployed at SAI-08. The REA fish team completed surveys at nine sites (SAI-100, 124, 142, 221, 298, 400, 403, 411, and 417), while the oceanography team completed nearshore CTD casts and water sampling (which included microbial water samples at SAI-08), deployed CAUs at SAI-08, and swapped out the SST buoy originally deployed on April 7. Two plankton tows and five towed-diver surveys were conducted; one of these surveys was cut short. Additional towed-diver surveys north of Banzai Cliffs were canceled because of heavy seas. The high-frequency acoustic recording package (HARP), which was originally recovered off the northwestern coast of Saipan by staff aboard the *Hi`ialakai* before the ship pulled into Saipan Harbor at the end of cruise HA-11-01, Leg I, was redeployed at approximately the same location. Began transit to Rota.
- 1 May Arrived at Rota and began field operations. The REA benthic team completed surveys at ROT-07, ROT-03, and ROT-02 and collected algal voucher specimens at ROT-02. The REA fish team completed surveys at 12 sites (ROT-107, 111, 114, 121, 134, 159, 172, 62, 66, 72, 76, and 88), while the oceanography team completed nearshore CTD casts and water sampling, collected microbial water and other samples at ROT-02, deployed CAUs at ROT-03 and ROT-02, recovered and replaced an SST buoy at mooring site ROT-002, recovered and replaced STRs at mooring sites ROT-060 and ROT-007, and recovered an EAR at ROT-007. Six towed-diver surveys were conducted. Along a western transect, five deepwater CTD casts were completed and ADCP data were collected.
- 2 May Continued field operations at Rota. The REA benthic team completed surveys at ROT-06 and ROT-05 and collected algal voucher specimens at ROT-05. A series of ARMS was recovered at ROT-06. REA benthic

operations planned for ROT-01 were terminated because of surge conditions. An assessment of ROT-04 deemed the site unworthy of additional belt-transect or LPI work (since only pavement substrate and macroalgae of the genera *Halimeda* or *Microdictyon* were observed). The REA fish team completed surveys at 12 sites (ROT-120, 145, 156, 176, 200, 201, 61, 65, 68, 69, 78, and 82), while the oceanography team completed nearshore CTD casts and water sampling, collected microbial water and other samples at ROT-05, and deployed CAUs at ROT-06 and ROT-05, and recovered and replaced STRs at mooring sites ROT-004 and ROT-005. Five towed-diver surveys and two plankton tows were conducted. Along an eastern transect, four deepwater CTD casts were completed and ADCP data were collected. Began transit to Tinian.

- 3 May Arrived at Tinian and began field operations. The REA benthic team completed surveys at TIN-06, TIN-01, and TIN-04 and collected algal voucher specimens at TIN-06. The REA fish team completed surveys at 12 sites (TIN-116, 119, 126, 129, 153, 177, 179, 61, 65, 78, 92, and 96), while the oceanography team completed nearshore CTD casts and water sampling (which included microbial water samples at TIN-04), and deployed CAUs at TIN-06, TIN-01, and TIN-04, recovered STRs at mooring sites TIN-001 and TIN-002 and deployed STRs at TIN-002 and TIN-003. Six towed-diver surveys were conducted. Along an eastern transect, six deepwater CTD casts were completed and ADCP data were collected. Began transit to Aguijan.
- 4 May Arrived at Aguijan and began field operations. The REA benthic team completed macroinvertebrate surveys as well as the typical suite of surveys at AGU-02 and AGU-03 and collected algal voucher specimens at AGU-02. Planned field operations at AGU-01 were terminated because of surge and rough sea conditions. The REA fish team completed surveys at 13 sites (AGU-100, 103, 105, 114, 118, 64, 66, 75, 78, 79, 86, 95, and 96), while the oceanography team collected a nearshore water sample and other samples for microbial analyses at AGU-02 and recovered and replaced an STR at mooring site AGU-002. Four towed-diver surveys, one benthic towed-diver calibration survey, and two plankton tows were conducted. Along a southern transect, six deepwater CTD casts were completed. Began transit to Guam.
- 5 May Arrived at Guam and began field operations. The REA benthic team completed surveys and collected algal voucher specimens at GUA-08, GUA-11, and GUA-06. A series of ARMS was recovered and deployed at GUA-08. The REA fish team completed surveys at 13 sites (GUA-83, 140, 189, 214, 245, 348, 361, 436, 468, 488, 510, 595, and 617), while the oceanography team completed nearshore CTD casts and water sampling (which included microbial water samples at GUA-06) and deployed CAUs at GUA-08 and GUA-13. Five towed-diver surveys were conducted. A

sixth towed-diver survey was terminated because of a leaky scuba tank and neck seal. Along an eastern transect, six deepwater CTD casts were completed and ADCP data were collected.

- 6 May Continued field operations at Guam. The REA benthic team completed surveys at GUA-05, GUA-9, and GUA-07 and collected algal voucher specimens at GUA-07 and GUA-09. A series of ARMS was recovered and deployed at GUA-05. The REA fish team completed surveys at 10 sites (GUA-107, 129, 153, 199, 241, 253, 269, 368, 607), while the oceanography team completed nearshore CTD casts and water sampling (which included microbial water samples at GUA-09), deployed CAUs and extracted coral cores (*Porites* spp.) at GUA-05, recovered and replaced an STR and recovered an EAR at mooring site GUA-006, and recovered and replaced an STR at GUA-004. Five towed-diver surveys were conducted. Along a northern transect, seven deepwater CTD casts were completed and ADCP data were collected.
- 7 May Continued field operations at Guam. The REA benthic team completed surveys at GUA-02, GUA-03, and GUA-13 and collected algal voucher specimens at GUA-02 and GUA-13. A series of ARMS was recovered and deployed at GUA-02. The REA fish team completed surveys at 12 sites (GUA-126, 136, 228, 333, 343, 454, 470, 527, 552, 579, 600, and 644), while the oceanography team completed nearshore CTD casts and water sampling (which included microbial water samples at GUA-03), deployed CAUs and extracted coral cores (*Porites* spp.) at GUA-02, and recovered and replaced an STR at mooring site GUA-005. Five towed-diver surveys and two plankton tows were conducted. Along a western transect, six deepwater CTD casts were completed and ADCP data were collected.
- 8 May Continued field operations at Guam. The REA benthic team completed surveys at GUA-12, GUA-10, and GUA-04 and collected algal voucher specimens at GUA-10 and GUA-12. A series of ARMS was recovered and deployed at GUA-12. The REA fish team completed surveys at 11 sites (GUA-117, 160, 165, 326, 367, 390, 391, 467, 497, 598, and 634), while the oceanography team completed nearshore CTD casts and water sampling, collected water and other samples for microbial analyses at GUA-04, deployed CAUs at GUA-12, and recovered and replaced an SST buoy, STR, and anchor at the same location on the northwestern coast (mooring sites GUA-003 and GUA-002). Six towed-diver surveys were conducted. Along a southern transect, two deepwater CTD casts were completed and ADCP data were collected.
- 9 May Continued field operations at Guam. The REA benthic team completed surveys and collected microbial water samples at GUA-01. The REA fish team completed surveys at 11 sites (GUA-150, 167, 170, 478, 577, 582, and 601), while the oceanography team did not conduct any operations.

Two towed-diver surveys were conducted. Field operations were completed at ~ 1330, with the ship pulling into Apra Harbor at 1600.

10–12 May In port at Apra Harbor. Disembarked all scientists. Conducted education and outreach events on the *Hi`ialakai*. End of cruise HA-11-01, Leg III.

MISSIONS:

- A. Conducted ecosystem monitoring of the species composition, abundance, percentage of cover, size distribution, and general health of the fishes, corals, target macroinvertebrates, and algae of the shallow-water (≤ 30 m) coral reef ecosystems of Guam and the CNMI.
- B. Deployed and retrieved a suite of instruments and installations—including SST buoys, STRs, RAS, CTD sensor, ADP, ARMS, CAUs, and EARs—to allow for remote, long-term monitoring of oceanographic, environmental, and ecological conditions of the coral reef ecosystems of Guam and the CNMI.
- C. Conducted shallow-water CTD casts and collected water samples for Chl-*a*, nutrient, dissolved inorganic carbon (DIC), total alkalinity (TA), salinity, and microbial community analyses to depths ≤ 30 m to examine physical and biological linkages supporting and maintaining these island ecosystems.
- D. Conducted shipboard oceanographic and meteorological observations to examine physical and biological linkages supporting and maintaining these island ecosystems, using CTD casts deployed to a depth of 500 m with concurrent water samples taken at select locations and depths, collecting continuous ADCP, SST, salinity, and partial pressure of carbon dioxide ($p\text{CO}_2$) data around reef ecosystems and fundamental meteorological data, such as air temperature, wind speed and direction, barometric pressure, and relative humidity.
- E. Collected a small number of shallow-water coral cores to examine calcification (growth) rates in recent decades and assess potential early impacts of ocean acidification.
- F. Determined the existence of threats to the health of these coral reef resources from anthropogenic sources, including marine debris.
- G. Deployed a refurbished HARP at Saipan. Part of the cetacean research program headed by Erin Oleson, PhD, of the PIFSC Protected Species Division, the HARP passively records ambient underwater sounds produced by biological, environmental, and man-made sources.

RESULTS:

This section provides tallies of research activities (Table 1), a list of data collected during cruise HA-11-01, Legs II and III, and a summary of important highlights. For more information pertaining to the data collected, methodology employed, and preliminary findings at the islands visited, see Appendices A–Q.

Table 1.--Statistics for the Pacific RAMP 2011 cruise to Guam and the CNMI (cruise HA-11-01, Legs II and III). In the CNMI, activities occurred at the following islands and banks: Farallon de Pajaros (FDP), Supply Reef (SUP), Maug (MAU), Asuncion (ASC), Agrihan (AGR), Pagan (PAG), Alamagan (ALA), Guguan (GUG), Zealandia Bank (ZEA), Sarigan (SAR), Saipan (SAI), Tinian (TIN), Aguijan (AGU), and Rota (ROT). The numbers for REA sites include sites where REA benthic or fish surveys were conducted. The numbers in the first row for towed-diver surveys include calibration surveys, but the numbers in the separate rows for benthic and fish surveys do not. The totals for scuba dives include all dives carried out for all activities at each island.

Research Activity	FDP	SUP	MAU	ASC	AGR	PAG	ALA	GUG	ZEA	SAR	SAI	TIN	AGU	ROT	GUA	Total
Scuba Dives	61	9	176	116	107	156	32	55	16	58	180	100	54	128	238	1486
Biological Surveys																
Towed-diver Surveys: Benthic and Fish	4	0	11	8	10	15	3	5	0	4	17	10	5	11	23	126
Towed-diver Surveys: Benthic	4	0	11	7	10	15	3	5	0	4	17	10	5	11	23	125
Towed-diver Surveys: Fish	4	0	9	7	10	14	3	5	0	4	16	10	4	11	23	120
Combined Length (km) of Towed-diver Surveys	8.4	0	24.1	16.8	22	31.6	7.3	10.6	0	8	35.6	22.6	11.1	23.9	57	279
REA Sites: Benthic	3	0	9	6	6	7	2	3	0	3	9	6	2	5	13	74
REA Sites: Fish	12	0	30	20	20	29	5	10	0	9	30	19	13	24	52	273
Biological Sample Collections																
Algal Voucher Specimens	0	0	4	0	0	15	0	2	0	0	0	4	2	9	23	59
Coral Core Samples	0	0	4	0	0	1	0	0	0	0	0	0	0	0	5	10
Microbial Water Samples	7	0	15	8	11	15	4	7	0	7	15	8	4	11	20	132
Microbial Benthic Samples	0	0	6	0	0	10	0	0	0	0	0	10	6	14	6	52
Plankton Tows	2	0	2	2	2	2	0	0	0	0	2	0	2	2	2	18
Biological Monitoring Installations																
ARMS Retrieved	0	0	5	0	0	8	0	0	0	0	8	0	0	3	12	36
ARMS Deployed	0	0	9	0	0	9	0	0	0	0	9	0	0	0	12	39
CAUs Deployed	0	0	30	20	25	25	0	0	0	0	25	25	0	20	25	185
EARs Retrieved	0	0	2	0	0	1	0	0	0	0	2	0	0	1	1	7

Research Activity	FDP	SUP	MAU	ASC	AGR	PAG	ALA	GUG	ZEA	SAR	SAI	TIN	AGU	ROT	GUA	Total
HARP Deployed	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
Oceanographic Moored Instruments																
SST Buoys Retrieved	0	0	1	0	0	1	0	0	0	0	1	0	0	1	1	5
SST Buoys Deployed	0	0	1	0	0	1	0	0	0	0	2	0	0	1	1	6
STRs Retrieved	6	1	7	3	2	5	2	1	1	2	5	2	1	4	4	46
STRs Deployed	6	1	6	3	2	5	2	1	1	2	5	2	1	4	4	45
ADP Deployed and Retrieved	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
CTD Sensor Deployed and Retrieved	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Hydrographic Surveys																
Shallow-water CTD Casts	0	0	6	3	5	5	0	0	0	0	5	5	0	5	5	39
Deepwater CTD Casts	5	0	20	16	10	19	7	8	0	4	2	6	6	9	21	133
Total length (km) of ADCP Transects	25	0	100	80	50	200	50	45	0	20	15	23	0	35	85	728
Water-quality Sampling																
Shallow-water Nutrient Water Samples Collected	1	0	15	7	12	10	1	1	0	1	10	10	1	8	14	91
Shallow-water Chl- <i>a</i> Water Samples Collected	0	0	12	6	10	10	0	0	0	0	10	10	0	8	10	76
Shallow-water Salinity Water Samples Collected	0	0	12	6	10	10	0	0	0	0	10	10	0	8	10	76
Shallow-water DIC Water Samples Collected	0	0	49	6	10	10	0	0	0	0	10	10	0	8	10	113
Deepwater Nutrient Water Samples Collected	0	0	10	5	5	10	0	5	0	5	5	5	5	5	5	65
Deepwater Chl- <i>a</i> Water Samples Collected	0	0	10	5	5	10	0	5	0	5	5	5	5	5	5	65
RAS Deployed and Retrieved	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1

The coral reef ecosystems of Guam and the CNMI are surveyed biennially through CRED's Pacific RAMP. The cruise HA-11-01, Legs II and III, marked this program's fifth expedition to the Mariana Archipelago. The majority of benthic surveys recorded reef conditions similar to the conditions found during surveys in previous years. Belt-transect surveys did not indicate any major increases in coral disease prevalence at the REA benthic sites visited. In addition, the following qualitative observations were noted:

Guam

- At the northeastern point of Guam, towed divers recorded up to 50% coral cover, with divers qualitatively observing coral diversity among the highest seen during towed-diver surveys conducted around Guam during this cruise.
- In other areas along the northeastern coast, towed divers recorded high levels (20.1%–30%) of stressed-coral cover compared to other areas surveyed at Guam during this cruise, a finding that appeared to correspond with a localized area where crown-of-thorns seastar (COTS) densities were higher than in other survey areas. The REA fish team also noted high numbers of COTS during one survey at a site off the northeast coast.
- Napoleon wrasse (*Chelinus undulatus*), also called humphead wrasse, were observed by towed divers and on or off transect by the REA fish team. Blacktip reef shark (*Carcharhinus melanopterus*) were observed off transect by the REA fish team.
- Bridled cardinalfish (*Apogon fraenatus*), which had not been seen before by the REA fish team at Guam, were noted.

Rota

- Napoleon wrasse were observed by towed divers and off transect by the REA fish team.
- Blacktip reef shark and grey reef shark (*Carcharhinus amblyrhynchos*) were observed off transect by the REA fish team.

Aguijan

- Napoleon wrasse were observed by towed divers and off transect by the REA fish team.
- Blacktip reef shark were observed off transect by the REA fish team.

Tinian

- Napoleon wrasse were recorded by towed divers.

Saipan

- The HARP recovered during cruise HA-11-01, Leg I, was successfully refurbished in Saipan by Tim Christianson of the SIO. The unit was reloaded and

successfully redeployed northeast of Saipan at a depth of 697 m at 15.3171° N, 145.4577° W .

- Napoleon wrasse were recorded by the towed divers.
- Blacktip reef shark were observed off transect by the REA fish team.

Sarigan

- The majority of benthic surveys found reef conditions similar to the conditions observed during surveys in previous years. Belt-transect surveys did not indicate any major increases in coral disease prevalence at the REA benthic sites visited.
- Napoleon wrasses were recorded by towed divers.

Guguan

- The majority of benthic surveys found reef conditions similar to the conditions observed during surveys in previous years. Belt-transect surveys did not indicate any major increases in coral disease prevalence at the REA benthic sites visited.
- Whitetip reef shark (*Triaenodon obesus*) were recorded on transect by the REA fish team.
- Towed divers recorded the third-highest number of sharks seen on transect (12, all species pooled) in the Mariana Archipelago during this cruise. Napoleon wrasse also were recorded by towed divers.

Alamagan

- Grey reef shark and whitetip reef shark were recorded on transect by the REA fish team (Fig. 1).



Figure 1.--Large numbers of grey reef shark (*Carcharhinus amblyrhynchos*) were observed at Alamagan by the REA fish team. NOAA photo by Steve McKagan

Pagan

- Increased volcanic activity (incandescence from the North Pagan crater) was reported to the U.S. Geological Survey while in night transit from Agrihan to Alamagan. As a result, the U.S. Geological Survey adjusted their threat-level ranking. No similar activity or observations were recorded during daytime or

nighttime field survey activities during Mariana Archipelago RAMP (MARAMP) 2011 or any previous MARAMP cruise led by CRED.

- Helfrichs' dartfish (*Nemateleotris helfrichi*), not seen before by the REA fish team at Pagan, were noted.
- Blacktip reef shark and grey reef shark were observed off transect by the REA fish team, while whitetip reef shark were recorded on transect.
- Towed divers recorded the second-highest number of sharks seen on transect (13, all species pooled) in the Mariana Archipelago during this cruise. Napoleon wrasse also were recorded by towed divers.

Agrihan

- A new, uncharted vent site was discovered by towed divers along a sand flat at Agrihan (Fig. 2). Physical characteristics included localized areas of high subsurface temperatures, compared to other areas surveyed at Agrihan, yellow color-shift in sand, and gas bubbling.
- A black-banded snapper (*Lutjanus semicinctus*), which had not been seen before by the REA fish team at Agrihan, was noted.
- Grey reef shark and whitetip reef shark were recorded on transect by the REA fish team.
- Towed divers recorded the highest number of sharks seen on transect (19, all species pooled) in the Mariana Archipelago during this cruise.

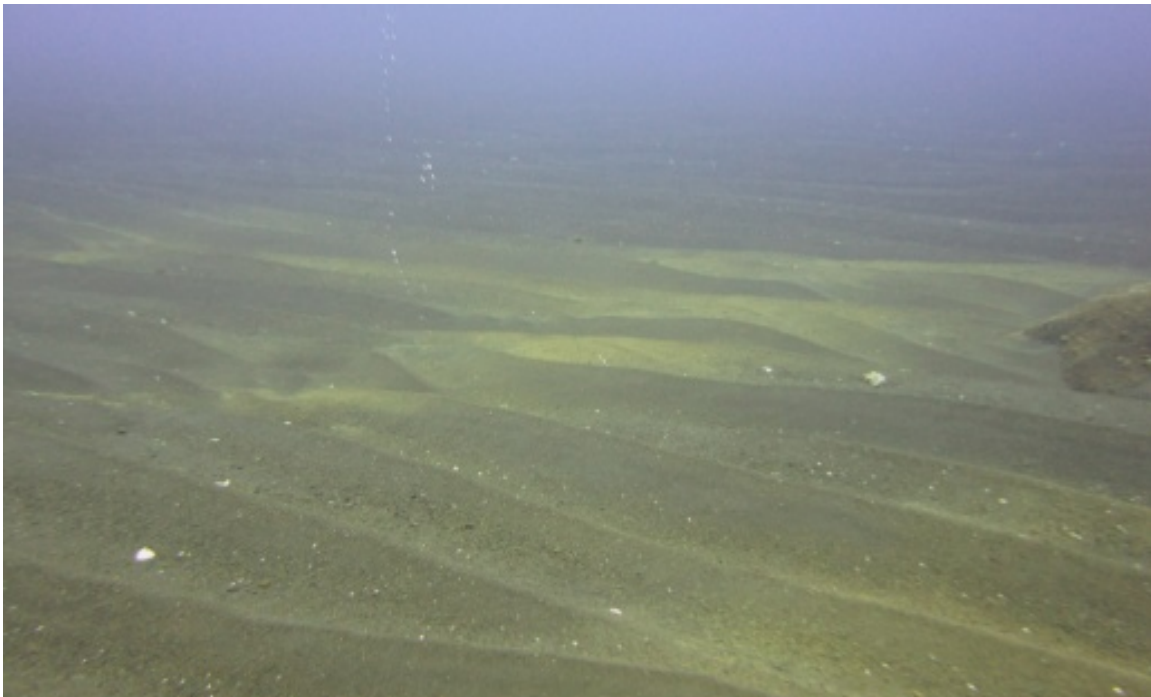


Figure 2.--Towed divers found a new vent site at Agrihan. NOAA photo by Kevin Lino

Asuncion

- Grey reef shark were recorded on and off transect by the REA fish team.

Maug

- Towed divers qualitatively noted increases in slide activity since the last Mariana Archipelago RAMP (MARAMP) cruise in 2009, especially around the interior caldera.
- Maug, among all of the islands surveyed in the Mariana Archipelago, had the highest overall mean coral cover of 39% (SE 1.4%) recorded during towed-diver surveys.
- The condition of the extensive *Porites rus* colonies immediately south of the vent along the East Island caldera shoreline appeared similar to observations made during previous MARAMP cruises (Fig. 3).
- Snubnose grouper (*Epinephelus macrospilos*), which had not been seen before by the REA fish team at Maug, were noted.
- Whitetip reef shark were recorded on transect by the REA fish team.

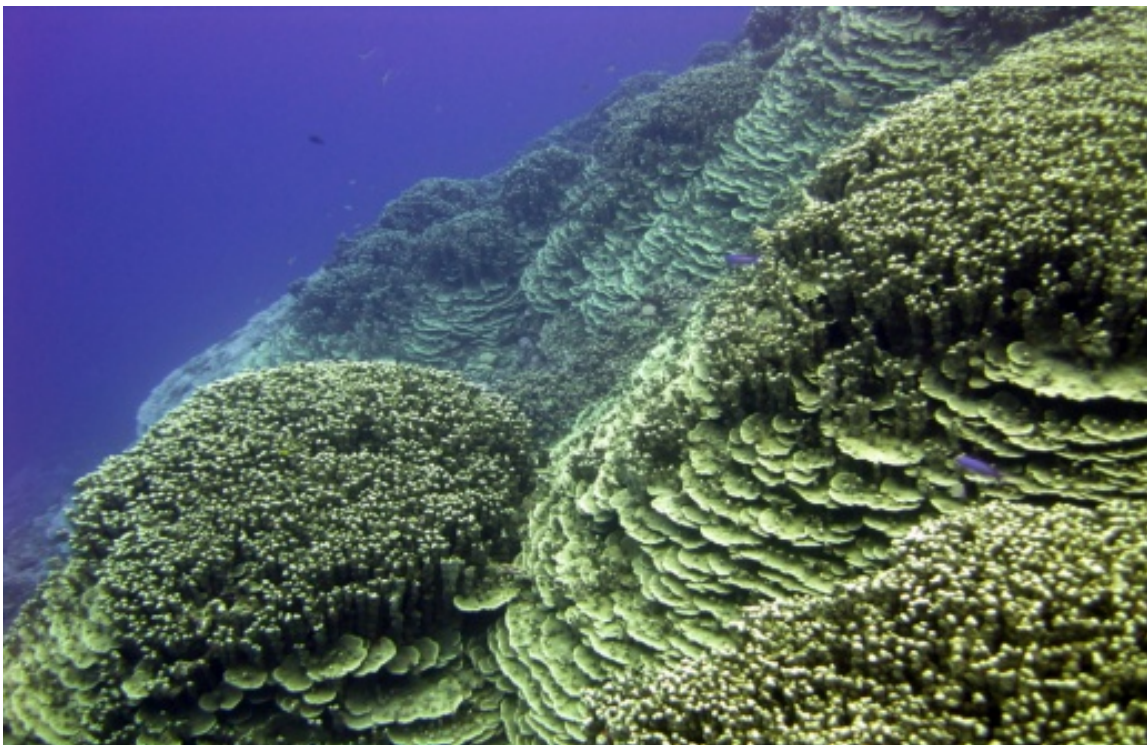


Figure 3.--*Porites rus* colonies located inside of the Maug caldera. NOAA photo by Erin Looney

Farallon de Pajaros

- Following historic patterns, the lowest overall mean coral cover observed at any island surveyed in the CNMI was recorded at Farallon de Pajaros at 12% (SE 1.7%).
- Grey reef sharks were recorded on transect by the REA fish team.
- Towed divers recorded the fourth-highest number of sharks seen on transect (11, all species pooled) in the Mariana Archipelago during this cruise.

The following data and samples were collected during this expedition:

REA Benthic Surveys:

- Digital still photographs of overall site character and typical benthos
- Digital still photographs of the benthos along transect lines
- Quantitative assessments of benthic composition from line-point-intercept surveys
- Algal voucher specimens necessary for algal species identification
- Field notes of algal species diversity and relative abundance
- Number, species or genus, size, and health condition of all coral colonies observed within belt transects of known area
- Field notes on signs of coral bleaching or disease
- Quantitative assessments of target macroinvertebrate taxa
- Collection of coral cores of massive reef building corals for the assessment of calcification rates

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

Towed-diver Surveys:

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

Shipboard Oceanography:

- Deepwater CTD profiles to a depth of 500 m
- Nutrient and Chl-*a* concentrations from water samples collected at variable depths
- Dissolved oxygen, turbidity, and fluorescence measurements recorded by CTD sensor
- Transects of profiles of ocean current velocity and direction collected using a shipboard ADCP unit
- Solar radiation, air temperature, barometric pressure, and wind speed and direction
- Select surface measurements of partial pressure of carbon dioxide (pCO₂)
- Surface temperature and salinity measurements

Nearshore Oceanography from Small Boats:

- Shallow-water (nearshore) CTD profiles to depths ≤ 30 m at all REA sites where CAUs were installed, with dissolved oxygen measurements
- Concentrations of nutrients, Chl-*a*, salinity, DIC, and TA from water samples collected in concert with shallow-water (≤ 30 m) CTD casts
- Temporary high-resolution carbonate chemistry from the RAS deployment
- Phyto- and zooplankton collected during surface plankton tows

Biological Monitoring Installations:

- Environmental acoustics of reefs, marine mammals, and boat traffic from EARs
- Assessment of taxonomic diversity of coral reef species by collection of invertebrate specimens from retrieved ARMS
- Installation of calcification acidification units (CAUs) to allow for future assessment of calcification rates once they are retrieved in about two years

Oceanographic Moored Instruments:

- Sea-surface and subsurface temperature at variable depths
- Subsurface salinity at variable depths
- ADP current profiles and wave spectra

SCIENTIFIC PERSONNEL:

Leg II

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James Bostick, Chamber Operator, NOAA Dive Center

Edmund Coccagna, Benthic Team—Towed Diver, UH-JIMAR, PIFSC-CRED

Annette DesRochers, Data Manager, UH-JIMAR, PIFSC-CRED

Emily Donham, Fish Team, UH-JIMAR, PIFSC-CRED

Marie Ferguson, Fish Team, UH-JIMAR, PIFSC-CRED

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Leg III

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James Bostick, Chamber Operator, NOAA Dive Center

Valerie Brown, Fish Team, PIRO

David Burdick, Benthic Team—Coral Populations and Disease, Coastal Management
Program, Guam Bureau of Statistics and Plans

Edmund Coccagna, Benthic Team—Towed Diver, UH-JIMAR, PIFSC-CRED

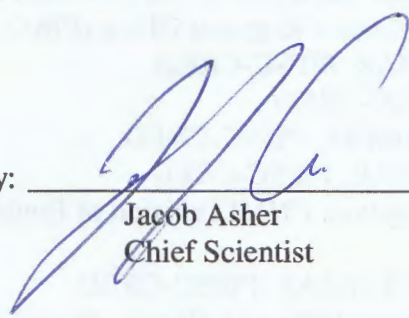
Annette DesRochers, Data Manager, UH-JIMAR, PIFSC-CRED

Emily Donham, Fish Team, UH-JIMAR, PIFSC-CRED

Marie Ferguson, Fish Team, UH-JIMAR, PIFSC-CRED

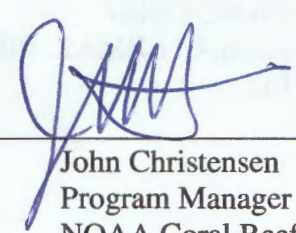
Karen Geisler, Benthic and Oceanography Teams—Microbial/Ocean Acidification, SDSU
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Jill Zamzow, Fish Team, UH-JIMAR, PIFSC-CRED

Submitted by: _____



Jacob Asher
Chief Scientist

Approved by: _____



John Christensen
Program Manager
NOAA Coral Reef Conservation Program

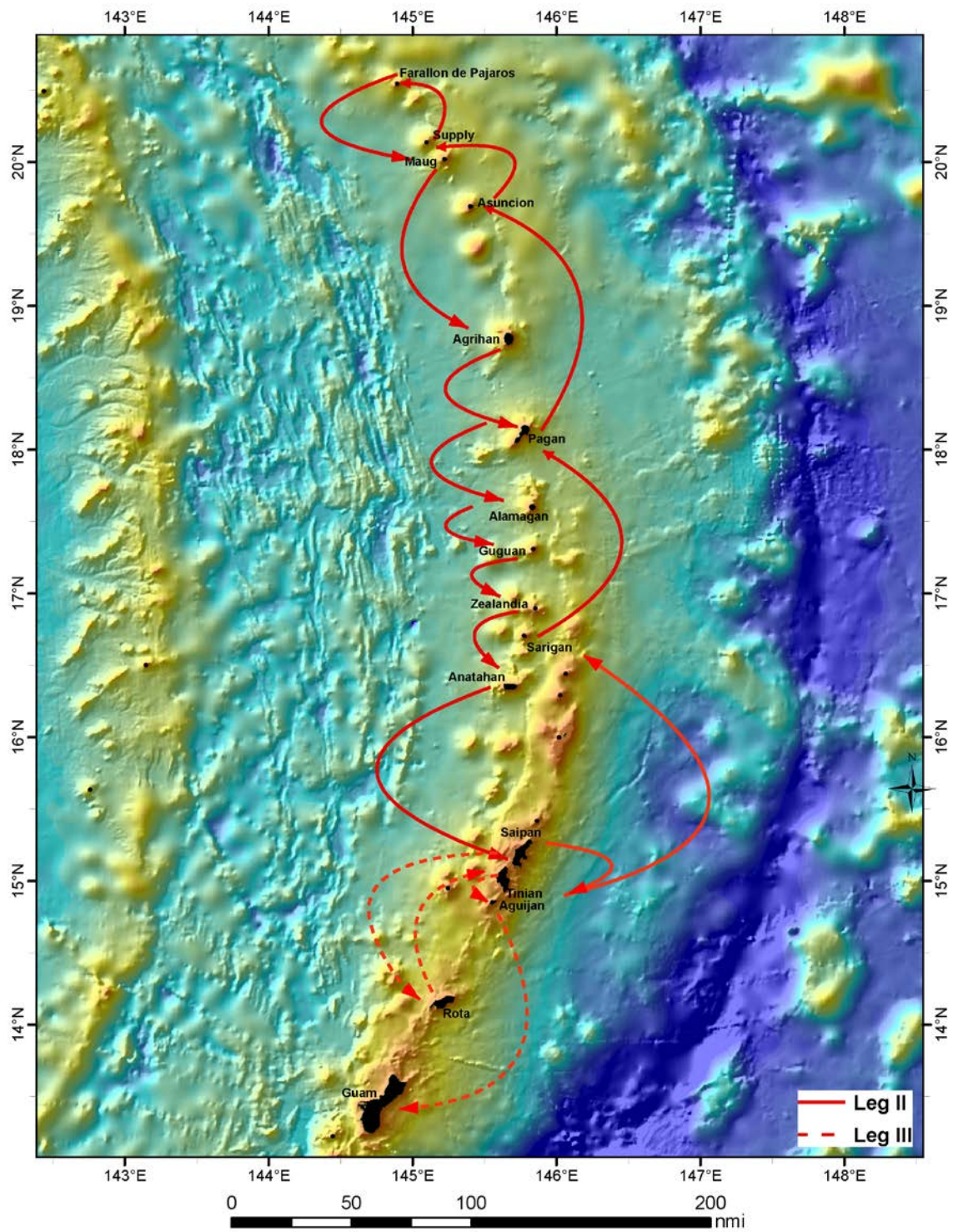


Figure 4.--Track of the NOAA Ship *Hi'ialakai* for the cruise HA-11-01, Legs II and III, April 7–May 9, 2011. Imagery SIO, NOAA, U.S. Navy, NGA, GEBCO (Becker, 2009; Smith and Sandwell, 1997) © 2008 The Regents of the University of California.

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APPENDIX A: METHODS

This appendix describes the methods and procedures used by the Coral Reef Ecosystem Division (CRED) of the NOAA Pacific Islands Fisheries Science Center during its Mariana Archipelago Reef Assessment and Monitoring Program (MARAMP) cruise HA-11-01, Legs II and III, on the NOAA Ship *Hi'ialakai* during the period of April 7–May 9, 2011. The first coral reef assessments led by CRED in the Mariana Archipelago were conducted in 2003.

A.1. Oceanography and Water Quality

(Frank Mancini, Daniel Merritt, Russell Reardon, and Oliver Vetter)

To assess and monitor the oceanographic and water-quality parameters influencing the coral reef ecosystems at Guam and the Commonwealth of the Northern Mariana Islands, the oceanography team performed the following activities: (1) conducted deepwater oceanographic surveys characterizing prevailing water properties and ocean currents around these islands, (2) completed nearshore oceanographic and water-quality surveys, and (3) deployed and retrieved an array of subsurface moored instruments designed to provide continuous, high-resolution time-series observations. Shipboard meteorological observations, including wind speed and direction, relative humidity, air temperature, and barometric pressure, were recorded. In addition, the oceanography team retrieved and deployed ecological acoustic recorders (EARs) and high-frequency acoustic recording packages (HARPs), both of which passively record ambient underwater sounds produced by biological, environmental, and man-made sources, and participated in installations of calcification acidification units (CAUs) for the assessment of calcification rates of crustose coralline red algae and hard corals (see Section A.2.3: “Installations for Monitoring Marine Life,” for information about EAR and CAU techniques).

A.1.1. Moored Instruments for Time-series Observations

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

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

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

Remote Access Sampler (RAS): the McLane Remote Access Sampler (McLane Research Laboratories Inc., East Falmouth, Mass.) is an autonomous water sampling instrument that can collect up to 48 water samples, each 500 mL, over a programmer-dictated time series. This instrument has the capability for high-frequency, hourly sampling. CRED uses this RAS in depths up to 30 m, but this sampler has a maximum sampling depth of 5500 m. The RAS was deployed and retrieved with an ADP and conductivity, temperature, and depth (CTD) sensor attached.

Acoustic Doppler Profiler (ADP): provides directional current profiles and wave spectra using a 3-beam-configured 1-MHz Aquadopp Profiler (Nortek, Rud, Norway, accuracy of 0.005 m s^{-1} in current and 0.1% in pressure). Sample intervals for current and wave data vary depending on duration of deployment. This type of subsurface instrument is deployed at depths of 5–20 m. The ADP was deployed and retrieved with the RAS.

CTD Sensor: provides high-resolution conductivity, pressure, and temperature data (SBE 19*plus* Seacat Profiler, accuracy of 0.005 S m^{-1} in conductivity, 0.0002°C in temperature, and 0.1% in pressure). Conductivity data is used to calculate salinity, and pressure is used to calculate depth. This CTD sensor was deployed and retrieved with the RAS.

A.1.2. Hydrographic Surveys

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

Shallow-water (Nearshore) Conductivity, Temperature, and Depth Casts: a CTD profiler deployed from a small boat provided data on temperature, conductivity, which is related to salinity, and pressure, which is related to depth (SBE 19*plus* Seacat Profiler). A transmissometer (C-Star, WET Labs, Philomath, Ore.) provided profiles of beam transmittance, which is related to turbidity. A dissolved oxygen sensor (SBE 43, accuracy of 2% of saturation) also was attached and measurements were made in concert with CTD measurements. A CTD cast was performed at each of the Rapid Ecological Assessment (REA) sites where CAUs were deployed. Data were collected by hand lowering this profiler off a small boat at descent rates of $\sim 0.5\text{--}0.75 \text{ m s}^{-1}$ at depths $\leq 30 \text{ m}$.

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

Shipboard Acoustic Doppler Current Profiler (ADCP): a ship-based sensor provided transects of directional ocean current data (75-kHz Ocean Surveyor, Teledyne RD

Instruments Inc., Poway, Calif.). The system was configured with an 8-m pulse length, 16-m depth bins starting at 25 m and extending typically to 600 m (range depended on density and abundance of scatterers), and 15 min averaged ensembles.

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

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

(Jeff Anderson, Jacob Asher, David Burdick, Edmund Coccagna, Karen Geisler, Kerry Grimshaw, Erin Looney, Roxanna Miller, Ryan Okano, Russell Reardon, , Chris Sullivan, Molly Timmers, and Rodney Withall)

CRED collected integrated information on the species composition (diversity), condition, abundance, and distribution of communities of corals, algae, and target macroinvertebrates and on benthic habitat complexity and substrates using two primary methodologies: Rapid Ecological Assessment (REA) surveys and towed-diver surveys. Performed at selected hard-bottom locations, REA benthic surveys include multiple methodologies that use two 25-m transect lines deployed at each REA site. Towed-diver surveys, which follow a depth contour of ~ 15 m and encompass various substrates, cover an area that is much broader than the area surveyed using fine-scale REA techniques. In addition, three types of monitoring installations, autonomous reef monitoring structure (ARMS), CAU, and EAR, serve as mechanisms to quantify marine invertebrates that are not easily identifiable during REA surveys, help to determine accretion rates of crustose coralline red algae and hard corals, or monitor the sounds of marine life and vessel traffic. Note that the sites where REA benthic surveys were conducted typically are different locations from the REA sites selected for fish surveys. REA sites for benthic surveys are selected for long-term monitoring of specific benthic communities over time, whereas REA sites for fish surveys are selected using a stratified random sampling design to provide representative coverage of three depth strata.

A.2.1. Benthic Composition

Using a line-point-intercept (LPI) method at REA sites, hard corals, octocorals, macroalgae, crustose coralline red algae, turf algae, cyanobacteria, and macroinvertebrates were identified to the highest possible taxonomic resolution and recorded, along with sand cover, at 20-cm intervals along two 25-m transect lines set in a single file row (separated by 5 m). These surveys generate 125 points per transect (250 points per site) that can be used to generate percentage of cover of benthic organisms and sand at each REA site. Additionally, in concert with LPI surveys, still photographs were taken to record the benthos at intervals of 2 m along the same 2 transect lines with a high-resolution digital camera mounted on a pole. This work generates 30 photographs per site that are later analyzed by staff at CRED, using the computer program Coral Point Count

with Excel extensions (CPCe), to determine the benthic composition at higher taxonomic levels for each REA site (similar photographs of the benthos taken at REA sites surveyed by the fish team will also be analyzed).

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

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

In addition to site-specific REA surveys, broad-scale towed-diver surveys were used to determine the benthic composition of shallow-water habitats around each island and to quantify the abundance of target macroinvertebrates, including crown-of-thorns seastars (COTS), sea urchins, sea cucumbers, and giant clams. A pair of divers, by means similar to a manta-tow technique, were towed 60 m behind a small boat, a 6-m survey launch from SAFE Boats International (Port Orchard, Wash.), with one diver quantifying the benthos and the other quantifying fish populations. Each towed-diver survey lasted 50 min, broken into ten 5-min segments, and covered ~ 2 km. To georeference the survey launch's track, latitude and longitude coordinates were recorded at 5-s intervals using a Garmin GPSMap 76 global positioning system (GPS) unit on the boat. A custom algorithm was used to calculate the track of the divers based on speed and course of the boat and depth of the diver. Each towed-diver platform, or towboard, was equipped with an SBE 39 temperature and depth sensor programmed to record at 5-s intervals. At the end of each day, data were downloaded, processed, and presented in ArcGIS and can be displayed in conjunction with IKONOS satellite imagery, NOAA chart data, or other spatial data layers.

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

A.2.2. Community Structure and Disease

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

For each coral colony identified during belt-transect surveys, the extent of mortality, both recent and old, was estimated and signs of disease or compromised health were recorded, including type of lesion (bleaching, skeletal growth anomaly, white syndrome, tissue loss other than white syndrome, trematodiasis, necrosis, pigmentation responses, algal overgrowth, or other), extent (percentage of colony affected), and severity (mild, moderate, marked, severe, or acute). Levels of predation of corals also were recorded. In tandem with these coral disease surveys at each REA site, the belt-transect method also was used to quantify coralline-algal disease and syndromes, including coralline lethal orange disease, coralline white band syndrome, and coralline cyanobacterial disease.

REA surveys of target macroinvertebrates along two belt transects (each 2 × 25 m) were conducted on an opportunistic basis at REA sites where no ARMS installations or recoveries occurred. Target macroinvertebrates from the following groups were enumerated:

CNIDARIA

Actinaria—anemones

ECHINODERMATA

Echinoids—sea urchins

Holothuroids—sea cucumbers

Ophiuroids—brittle stars (generally cryptic but are visible in some cases)

Crinoids

MOLLUSCA

Bivalves—ark shells, spondylid oysters, pearl oysters, tridacnid clams

Nudibranch—sea slugs

Gastropods—snails

Cephalopod—octopi

CRUSTACEA

Hermit crabs, brachyuran crabs, shrimps, and lobsters

A.2.3. Moored Installations for Monitoring Benthic Communities

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

Autonomous Reef Monitoring Structures (ARMS): recovered and deployed at several sites at each island, ARMS provide a mechanism to quantify marine invertebrates that were not easily identifiable or accountable on the transect lines used for REA surveys. ARMS were previously installed on the benthos by pounding stainless steel rods by hand into bare substrate during the MARAMP 2009 cruise. They remained on the benthos for two years, enabling the recruitment and colonization of lesser known, cryptic marine invertebrates. Each ARMS was composed of 10 grey, Type 1 PVC plates (23 × 23 cm) stacked in an alternating series of open and obstructed layers attached to a base plate (35 × 45 cm) that was affixed to a reef.

ARMS previously deployed during the MARAMP 2009 cruise were retrieved. First, on the seafloor, the ARMS were covered in a mesh-lined lid to trap the contents, and then they were removed and transported to the ship. There, each unit was systematically disassembled and photo-documented, and all organisms contained in these structures were preserved in ethanol for later genetic and other molecular analyses. At a subsample of these sites, new ARMS units were deployed onto existing stainless steel rods, with the goal of recovering them during the next MARAMP cruise scheduled for 2013.

Calcification Acidification Unit (CAU): deployed at multiple sites at each island, CAUs provide mechanisms to quantify accretion rates by crustose coralline red algae and scleractinian (hard) corals. Each CAU consists of two grey PVC plates (10 × 10 cm) separated by a 1-cm spacer. CAUs were installed on the benthos by pounding stainless steel rods by hand into bare substrate and then bolting plate assemblies to those rods. It has been demonstrated that PVC encourages growth of crustose coralline red algae and recruitment of corals, and the net weight gain of calcium carbonate (CaCO₃) on the surfaces of the CAUs can be an indicator of net calcification. The CAUs installed during this cruise will remain on the benthos for about two years, enabling the recruitment and colonization of crustose coralline red algae and hard corals, upon which time they will be collected and analyzed. The data obtained from CAUs will enable a comparison of net calcification rates among islands and atolls and between archipelagos and form a baseline of accretion rates throughout the U.S. Pacific, allowing for future comparisons to determine possible consequences of increased ocean acidity and lowered aragonite saturation states.

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

deployed at depths of 5–25 m. Note: information about retrievals and deployments of EARs are provided along with information about STR installations in the island appendices, since those instruments are sometimes moored to the same anchor and EARs are typically installed by members of the oceanography team.

A.2.4. Coral Core Collections

The coring of massive coral colonies is aimed at studying coral growth and accretion rates to provide calcification and extension rate chronologies to hindcast the carbonate chemistry climate of coral reefs from hundreds of years past. To quantify the size and density of annual growth bands in coral skeletons, core samples were collected and preserved for analysis by nondestructive computerized axial tomography (CAT)-scan and image-analysis techniques to visualize growth bands that cannot otherwise be observed.

Dependant on ocean conditions, a maximum of two REA sites at each island was selected for coring. Collection of coral core samples targeted colonies of *Porites* spp., since their massive growth forms give them the greatest potential to provide long growth histories. At each REA site, a minimum of two and a maximum of five sample cores (with the exception of a single core taken at Pagan) were collected in close proximity (3–5 m) to each other, using a small, handheld pneumatic drill operated from a scuba tank. The coring bit used was 35 cm long with an outer diameter of 3.8 cm and an inner diameter of 2.5 cm. Each core was collected from a single colony of sufficient size and health such that extracting a core 2.5 cm in diameter and 10–35 cm in length was judged not to be destructive or detrimental to the longevity of a colony. Through analyses of data from past CRED monitoring efforts, the abundance of coral colonies meeting coring criteria was established for each island, and cores were collected from areas where impact to coral populations was determined to be minimal. Upon completion of a coring, a cement plug was affixed to seal the hole, preventing invasion of bioeroding organisms. A cement plug provides a suitable surface over which surrounding coral tissue can grow. Coral core samples will be shipped to Woods Hole Oceanographic Institution in Woods Hole, Mass., for analyses using CAT-scan technology.

A.2.5. Microbial Communities and Water Chemistry

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

It is well known that bacteriophages (bacterial viruses) are the most abundant form of life in the ocean, ranging from 1×10^6 virus-like particles (VLPs) per milliliter of seawater in the open ocean to 1×10^8 VLPs per milliliter in more productive coastal waters. The number of microbial cells in seawater is typically 1×10^6 cells per milliliter. Microbial and viral loading and the dominance of heterotrophic bacteria in reef water are linked to

coral disease. The most direct method for assessing and monitoring changes in abundance of these microbiological components is by fluorescent microscopy using nucleic acid staining.

A direct parallel exists between microbial and viral loading, increasing human disturbance, and reef health. Microbial communities in more degraded coral reef systems support a high abundance of potential pathogens and heterotrophic microbes (a heterotrophic organism obtains food only from organic material, such as carbon and nitrogen, and is unable to use inorganic matter to form proteins and carbohydrates). In contrast, near-pristine reefs support microbial communities that are balanced between heterotrophs and autotrophs and contain very few potential pathogens (an autotrophic organism can synthesize food from inorganic material).

Spatial assessment of microbial and viral components with respect to levels of dissolved organic carbon (DOC), nutrients (NO_2^- ; NO_3^- ; PO_4^{3-} ; and ammonium, NH_4), and particulate organic carbon (POC) within coral reef ecosystems may identify important predictors of coral reef ecosystem degradation. For example, in addition to microbial abundance, bacterial growth efficiency (BGE) may also play a role in reef system health. BGE is greatly affected by DOC:Nitrogen ($\text{NO}_x + \text{NH}_4$) ratios in the water column. Water column stoichiometry—carbon to nitrogen to phosphorous (C:N:P) ratios—directly affects microbial growth rates.

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

Collection of Microbial Water Samples: At select REA sites, four 2-L samples of water were collected daily from < 1 m above the benthos using diver-deployable Niskin bottles. These water samples were returned to the ship, where they were processed for analyses of DOC, POC, particulate organic matter (POM), nutrients, microbial (bacteria and archaea) and viral abundance (fluorescent microscopy), fluorescence-activated cell sorting (FACS, heterotrophs vs. autotrophs), microbial and viral community composition (coarse analysis: 16s rRNA). Also, when possible, at one REA site at each island, ~ 60 L of water were collected from reef crevices and surfaces for metagenomic analysis of the microbial and viral community associated with reef benthos.

The following data items were collected daily at each REA site:

- DOC: 4 replicates
- POM: 4 replicates
- Nutrients: 2 replicates
- Microbial (bacteria and archaea) and viral abundance : 4 replicates (0.02- μm filters, stained using SYBR Gold, Molecular Probes Inc., Eugene, Ore.)
- Microbial (bacteria and archaea) size structure : 4 replicates (0.2- μm filters, stained using 4',6-Diamidino-2-phenylindole (DAPI))
- Microbial community composition (FACS, heterotrophs/autotrophs) : 5 replicates
- Microbial community composition (16s rRNA): 2 replicates (.22- μm filters)

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

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

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

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

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

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

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

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

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

At one REA site at most islands, ~ 60 L of water was collected by filling three 20-L collapsible carboys with water from reef crevices or benthos using a manual bilge pump. Upon return to the ship, this sample was pre-filtered through 100-µm mesh and concentrated using tangential flow filtration (TFF). TFF concentrates the bacteria and viruses in the water, bringing the initial ~ 80 L of water to a final volume of ~ 500 mL. This concentrate was then filtered through 0.45-µm filters to capture microbes (bacteria and archaea). These filters were then frozen. The DNA of the entire community will be extracted and sequenced at SDSU, and the diversity and function of the microbial communities associated with the reef benthos will be analyzed. The filtrate from this sample contains concentrated viruses. Chloroform was added to this filtrate to kill any small microbes that made it through the 0.45-µm filter, and this sample was stored at 4°C. Once shipped to SDSU, viruses will be isolated from the viral concentrate, and community DNA will be extracted and sequenced. This extracted and sequenced DNA will then be analyzed for viral community diversity and function.

Collection of Benthos-associated Microbial DNA: This section describes samples, or benthic grabs, collected if time permitted. The following data items were collected at REA sites when time permitted:

- Coral rubble and sediment: several replicate bags
- Algae: several replicate bags

In addition to monitoring changes in microbial communities associated with the water column, this work is investigating whether or not community shifts in the microbes associated with the benthos are a useful indicator of reef health. When time permitted, several “fist-fulls” of coral rubble and sediment and several pieces of the most dominant type of alga were collected in Ziploc bags. These samples were frozen at – 20°C and will stay on the ship until it returns to Honolulu. The bacterial 16s rRNA genes associated

with these samples will be sequenced to characterize the microbial communities associated with the benthos (rubble and algae).

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

A.3. Surveys of Reef Fishes

(Paula Ayotte, Valerie Brown, Emily Donham, Marie Ferguson, Kevin Lino, Mark Manuel, Kaylyn McCoy, Steve McKagan, Noah Pomeroy, and Jill Zamzow)

Six divers conducted REA fish surveys using the stationary-point-count (SPC) method at preselected REA sites. Three separate teams performed these surveys. Each team consisted of two divers and conducted either one or two SPC surveys per site. All REA fish 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. 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 two 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 one diver at each, served as the center of a visually estimated cylindrical survey area with a radius of 7.5 m. During the first 5 min, divers only recorded the presence of species within their respective cylinders. Afterwards, divers went down their respective species lists, which were created from their work during the initial 5 min of a survey, sizing and counting all individuals within their cylinder, one species at a time. Cryptic species missed during the initial 5 min of a survey could still be counted, sized, and added to the original species list. Fish species observed at a REA site but not recorded during the SPCs were recorded for presence data.

After a survey was completed, divers recorded benthic habitat information within their respective cylindrical survey areas. Divers visually estimated habitat complexity, habitat type, and percentage of cover for hard corals, macroalgae, crustose coralline red algae, turf algae, and sand. Every 2 m along the transect line, still photographs were taken of the benthos at a distance of 1 m from the right side of the line. If only one replicate survey was completed at a REA site (because of insufficient air pressure or bottom time), benthic photographs were taken at each meter mark. Like the photographs taken along transect lines during surveys at REA benthic sites, these images will be analyzed later.

If bottom time and air permitted, the 30-m transect line was moved to another location 5–10 m away at the same depth stratum, and this procedure was repeated.

In addition to site-specific REA surveys, broad-scale towed-diver surveys were used to characterize the fish communities of shallow-water habitats around each island. A pair of divers, by means similar to a manta-tow technique, was towed 60 m behind a small boat, with one diver quantifying fish populations and the other quantifying the benthos (for more details about towed-divers surveys, see Section A.2.1: “Benthic Composition”).

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.

APPENDIX B: GUAM

The island of Guam is located at 13.45° N, 144.77° W in the North Pacific and is the largest and most populated island in the Mariana Archipelago. For information about the methods used to perform the activities discussed in this appendix, please see Appendix A: “Methods.”

B.1. Oceanography and Water Quality

Oceanographic operations during the cruise HA-11-01, Leg III, at Guam entailed numerous retrievals and deployments of oceanographic moored instruments; installation of calcification acidification units (CAUs), nearshore water sampling and conductivity, temperature, and depth (CTD) casts, and coral coring at select Rapid Ecological Assessment (REA) sites; and shipboard water sampling and CTD casts offshore to a depth of 500 m and acoustic Doppler current profiler (ADCP) transect lines.

Four subsurface temperature recorders (STRs) were retrieved, and four STRs were deployed (Fig. B.1.1 and Table B.1.1). One of these STRs was deployed on the sea-surface temperature (SST) mooring anchor, and another was deployed on the ecological acoustic recorder (EAR) anchor. One SST buoy was recovered and replaced. One EAR unit was removed and the anchor left in place for possible future deployments. For information regarding the CAU deployments and coral core collections at Guam, please see Section B.2: “Benthic Environment.”

At nearshore locations around Guam, five shallow-water (≤ 30 m) CTD casts were performed (Fig. B.1.1), including one cast at each of the five select REA sites where CAUs were installed. In concert with each CTD cast, two water samples were taken to measure the following parameters: dissolved inorganic carbon (DIC), total alkalinity (TA), salinity, nutrient, and chlorophyll-*a* (Chl-*a*) concentrations. Accounting for additional nutrient samples taken alone for microbial analyses, 10 DIC and TA, 10 salinity, 14 nutrient, and 10 Chl-*a* water samples were collected. At each of the five select REA sites, one water sample was taken from the surface and one near the reef. At four additional locations, a single nutrient water sample was taken from the reef.

From the NOAA Ship *Hi`ialakai*, ~ 85 km of ADCP transect lines were run in the cardinal directions around this island during night operations. On the reciprocal course, shipboard CTD casts were conducted to a depth of 500 m per transect line every 5 km for a total of 21 deepwater CTD casts. Water samples were collected concurrently with one select shipboard CTD cast at five depths between the surface and 200 m, depending on the depth of mixed layer as determined by the CTD downcast (Fig. B.1.2). Near Guam, then, five nutrient and five Chl-*a* shipboard water samples were collected.

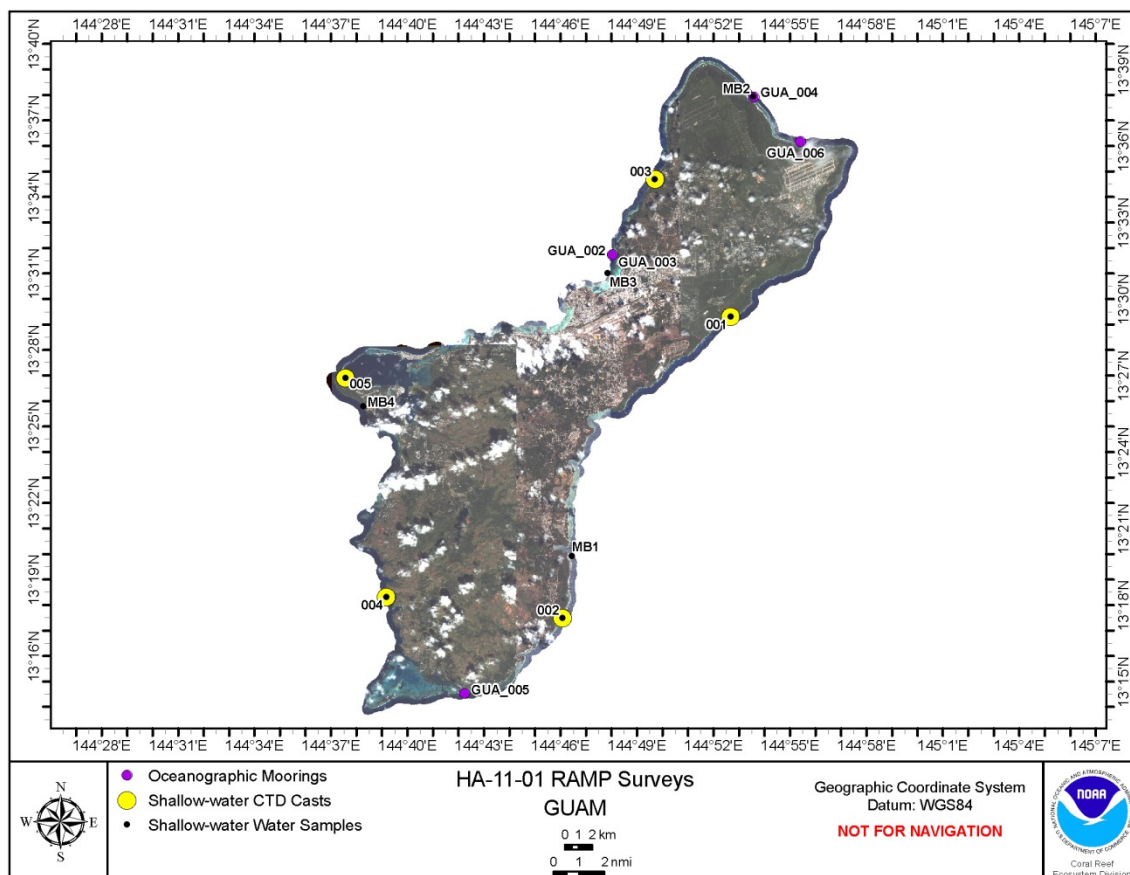


Figure B.1.1.--Mooring sites where oceanographic instruments were retrieved or deployed and locations of nearshore CTD casts and water sampling performed at Guam during cruise HA-11-01, Leg III (IKONOS Carterra Geo Data, 2003). MB1–4 labels indicate locations where additional nutrient water samples were collected for microbial analyses.

Table B.1.1.--Geographic coordinates and sensor depths of the moored oceanographic instruments, EAR, and anchors that were retrieved or deployed at Guam during cruise HA-11-01, Leg III.

Mooring Site	Date	Instrument Type	Latitude	Longitude	Depth (m)	Retrieved	Deployed
GUA-004	6-May	STR	13.63241	144.89296	8.5	1	1
GUA-006	6-May	EAR	13.60312	144.92357	12.8	1	0
GUA-006	6-May	STR	13.60312	144.92357	12.8	1	1
GUA-005	7-May	STR	13.24218	144.70390	4.9	1	1
GUA-002	8-May	STR	13.52902	144.80047	12.2	1	1
GUA-002	8-May	Anchor	13.52902	144.80047	12.2	1	1
GUA-003	8-May	SST	13.52902	144.80047	0.3	1	1

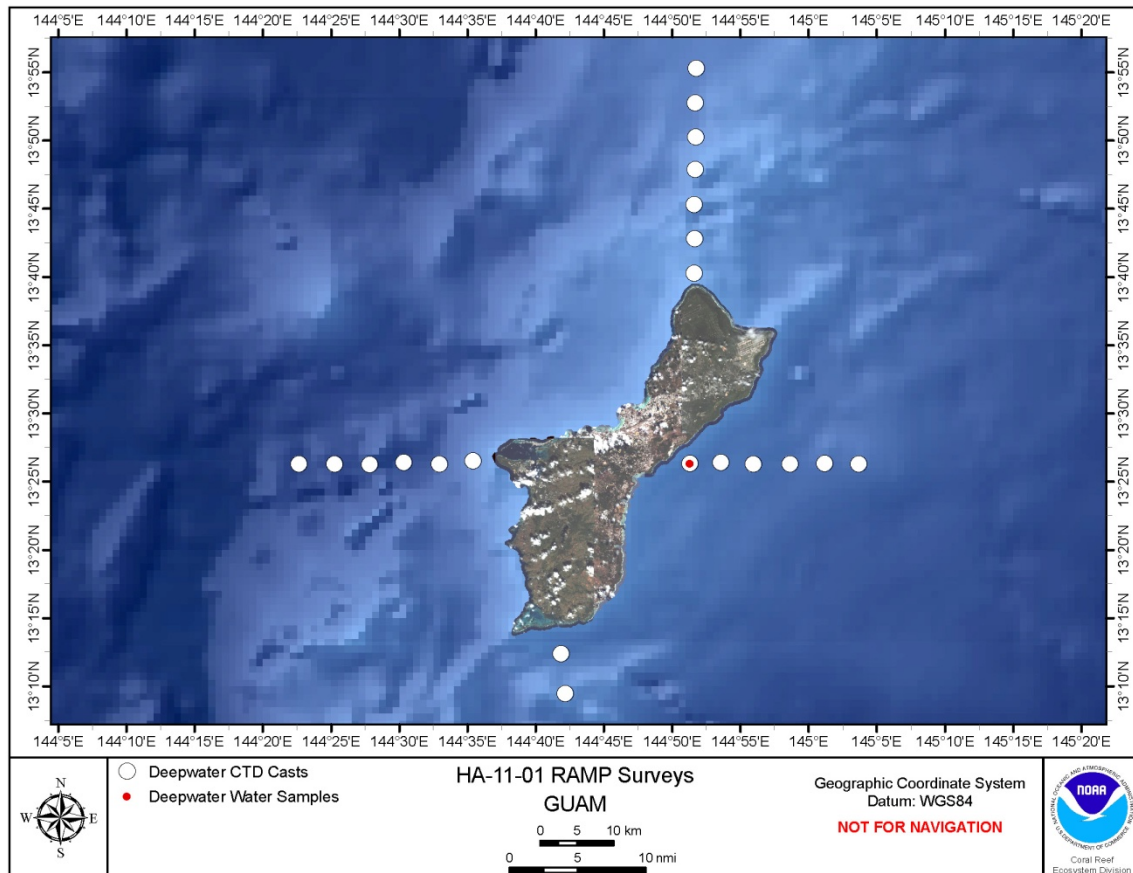


Figure B.1.2.--Locations of deepwater CTD casts and water sampling performed at Guam during cruise HA-11-01, Leg III. Island satellite image IKONOS Carterra Geo Data, 2003, and background imagery SIO, NOAA, U.S. Navy, NGA, GEBCO (Becker, 2009; Smith and Sandwell, 1997) © 2008 The Regents of the University of California.

B.2. Benthic Environment

Belt-transect, line-point-intercept (LPI), and roving-diver algal surveys were conducted and photographs were taken along transect lines at 13 REA sites around Guam to assess benthic composition, coral and algal community structure, and coral and algal disease (Fig. B.2.1 and Table B.2.1).

Various samples were collected at 13 REA sites (Table B.2.2): 23 algal voucher specimens at nine REA sites for taxonomic identification, five coral cores (10–15 cm in length) from *Porites* coral heads at two REA sites for calcification research, and 20 water samples for microbial analyses at five REA sites with four water samples of 2 L each. Additional microbial work included benthic grabs of coral rubble and unidentified macroalgae at one REA site and plankton tows conducted at one nearshore and one offshore location. For more information about collections made at REA sites, see Table Q.1.1 in Appendix Q: “Biological Collections.”

Twelve autonomous reef monitoring structures (ARMS) were recovered and deployed: three ARMS each at REA sites GUA-02, GUA-05, GUA-08, and GUA-12 (Table B.2.2). At each of five select REA sites, an array of five CAUs was deployed for a total of 25 CAUs installed at Guam (Table B.2.2). For information about the EAR recovery at Guam, see Section B.2: “Oceanography and Water Quality.”

In total, the benthic team conducted 56 individual dives at REA sites around Guam.

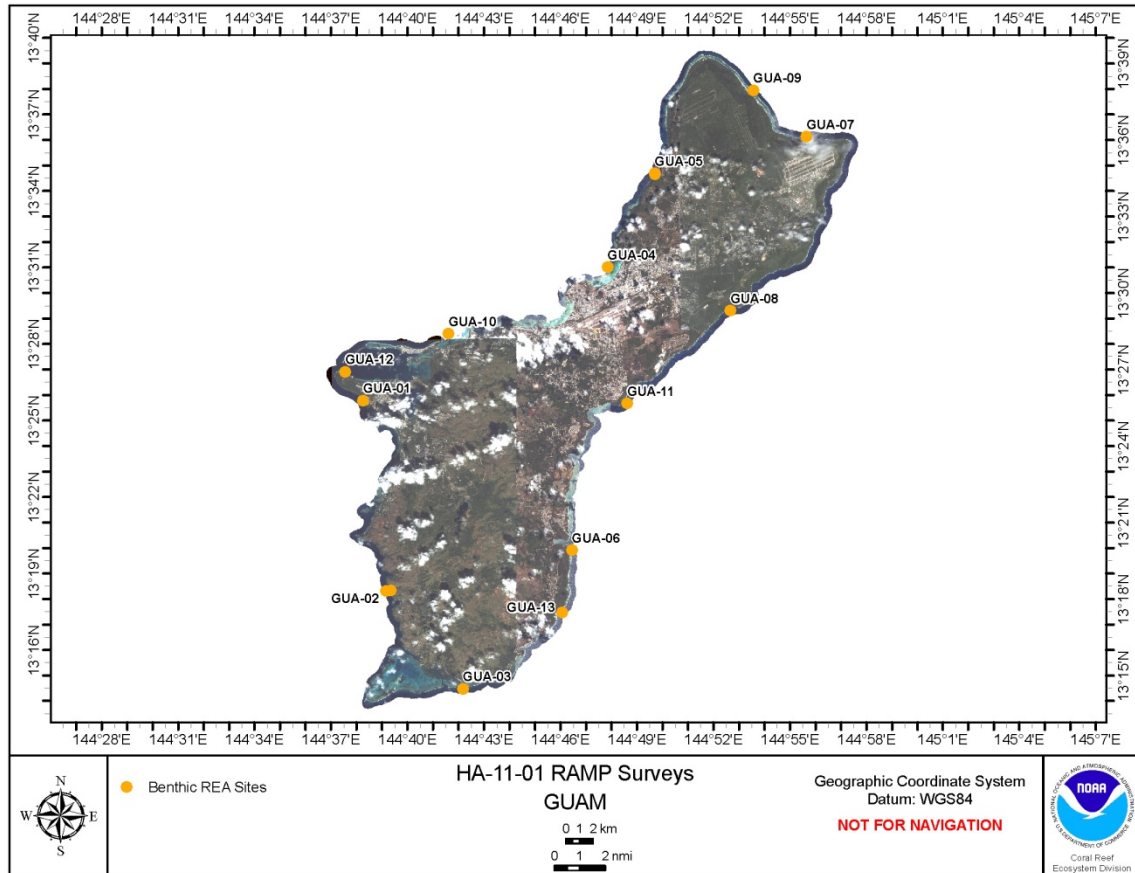


Figure B.2.1.--Locations of REA benthic sites surveyed at Guam during cruise HA-11-01, Leg III (IKONOS Carterra Geo Data, 2003).

Table B.2.1.--Summary of REA benthic surveys performed at Guam during cruise HA-11-01, Leg III. Indication that an LPI survey was completed also means that photographs were taken along transect lines.

REA Site	Date	Latitude	Longitude	REA Surveys			
				LPI	Roving Diver	Corals	Inverts
GUA-06	5-May	13.33223	144.77422	×	×	×	–
GUA-08	5-May	13.48871	144.87796	×	×	×	–
GUA-11	5-May	13.42809	144.81037	×	×	×	–
GUA-13	5-May	13.29157	144.76772	–	–	–	–
GUA-05	6-May	13.57817	144.82834	–	–	–	–
GUA-05	6-May	13.57798	144.82838	–	–	–	–
GUA-05	6-May	13.57847	144.82831	×	×	×	–
GUA-07	6-May	13.60240	144.92737	×	×	×	–
GUA-09	6-May	13.63271	144.89265	×	×	×	–
GUA-02	7-May	13.30601	144.65565	–	–	–	–
GUA-02	7-May	13.30595	144.65550	–	–	–	–
GUA-02	7-May	13.30596	144.65570	–	–	–	–
GUA-02	7-May	13.30553	144.65257	×	×	×	–
GUA-03	7-May	13.24143	144.70287	×	×	×	–
GUA-13	7-May	13.29157	144.76777	×	×	×	–
GUA-04	8-May	13.51713	144.79752	×	×	×	–
GUA-10	8-May	13.47359	144.69352	×	×	×	–
GUA-12	8-May	13.44878	144.62596	×	×	×	–
GUA-01	9-May	13.43002	144.63746	×	×	×	–

Table B.2.2.--Summary of CAU installations and ARMS retrievals (Ret.) and deployments (Dep.) performed as well as algal specimens, microbial water samples, and coral cores collected at Guam during cruise HA-11-01, Leg III.

REA Site	Date	Latitude	Longitude	Installations and Collections					
				CAUs	ARMS Ret	ARMS Dep	Algae	Microbial Samples	Coral Cores
GUA-06	5-May	13.33223	144.77422	0	0	0	4	4	0
GUA-08	5-May	13.48871	144.87796	5	3	3	3	0	0
GUA-11	5-May	13.42809	144.81037	0	0	0	4	0	0
GUA-13	5-May	13.29157	144.76772	5	0	0	0	0	0
GUA-05	6-May	13.57817	144.82834	0	0	0	0	0	1
GUA-05	6-May	13.57798	144.82838	0	0	0	0	0	1
GUA-05	6-May	13.57847	144.82831	5	3	3	0	0	0
GUA-07	6-May	13.60240	144.92737	0	0	0	1	0	0
GUA-09	6-May	13.63271	144.89265	0	0	0	2	4	0
GUA-02	7-May	13.30601	144.65565	0	0	0	0	0	1
GUA-02	7-May	13.30595	144.65550	0	0	0	0	0	1
GUA-02	7-May	13.30596	144.65570	0	0	0	0	0	1
GUA-02	7-May	13.30553	144.65257	5	3	3	3	0	0
GUA-03	7-May	13.24143	144.70287	0	0	0	0	4	0
GUA-13	7-May	13.29157	144.76777	0	0	0	1	0	0
GUA-04	8-May	13.51713	144.79752	0	0	0	0	10	0
GUA-10	8-May	13.47359	144.69352	0	0	0	1	0	0
GUA-12	8-May	13.44878	144.62596	5	3	3	4	0	0
GUA-01	9-May	13.43002	144.63746	0	0	0	0	4	0

During cruise HA-11-01, Leg III, CRED completed 23 towed-diver surveys at Guam, covering a total length of 57.0 km (an area of 57.0 ha) on the ocean floor (Fig. B.2.2). The mean survey length was 2.5 km with a range of 2.1–3.0 km. The mean survey depth was 15.3 m with a range of 13.8–17.1 m. The mean temperature from data recorded during these surveys was 29.2°C with a range of 29.0°C–29.4°C.

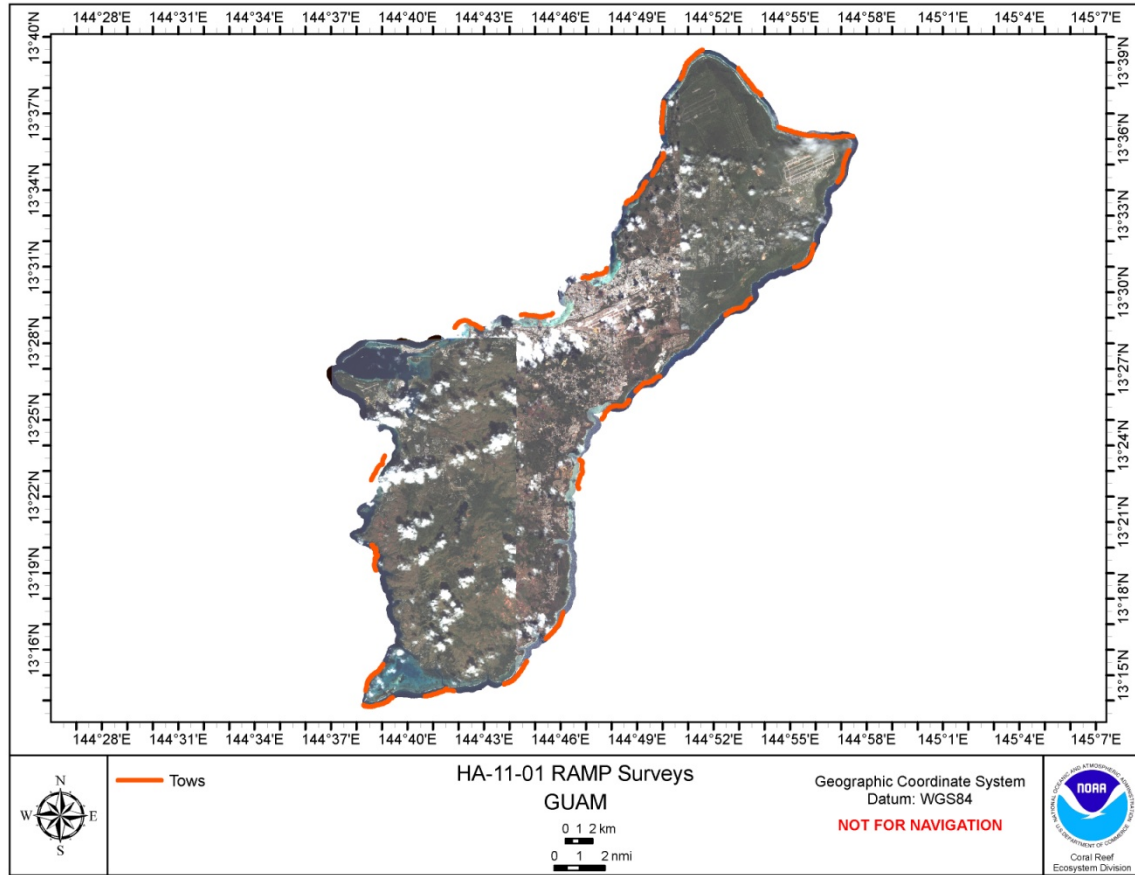


Figure B.2.2.--Track locations of towed-diver surveys conducted at Guam during cruise HA-11-01, Leg III (IKONOS Carterra Geo Data, 2003).

B.3. Reef Fish Community

REA fish survey sites were chosen using a stratified random design. Stationary-point-count surveys were conducted at 52 REA sites at Guam in the deep, moderate, and shallow forereef strata (Fig. B.3.1 and Table B.3.1). No fishes were collected during these surveys.

In addition, CRED completed 23 towed-diver surveys at Guam, as described previously in Section B.2 of this appendix.

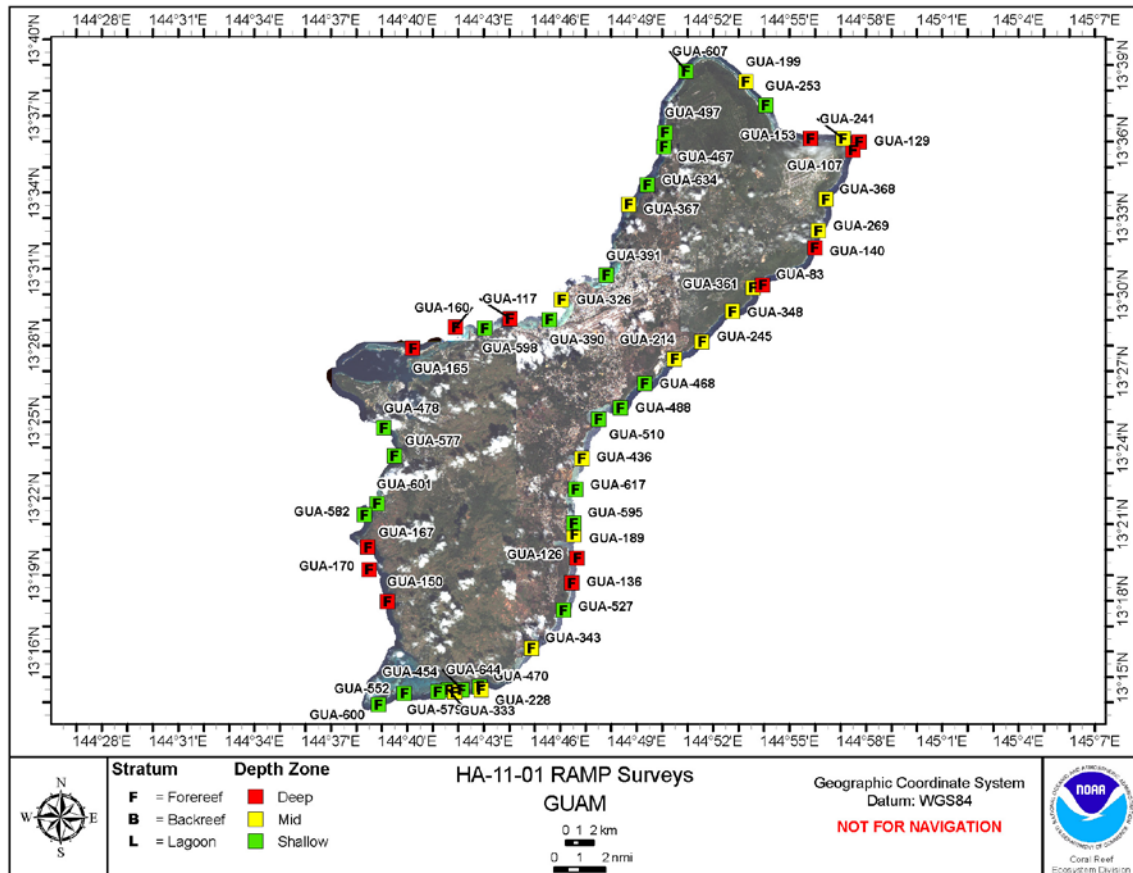


Figure B.3.1.--Locations of REA fish sites surveyed at Guam during cruise HA-11-01, Leg III (IKONOS Carterra Geo Data, 2003). All of these REA sites were selected using a stratified random design.

Table B.3.1.--Summary of sites where REA fish surveys were conducted at Guam during cruise HA-11-01, Leg III.

REA Site	Date	Depth Zone	Stratum	Depth (m)	Latitude	Longitude
GUA-83	5-May	Deep	Forereef	20	13.50642	144.89907
GUA-140	5-May	Deep	Forereef	28.6	13.53079	144.93318
GUA-189	5-May	Moderate	Forereef	17	13.34326	144.77571
GUA-214	5-May	Moderate	Forereef	7	13.45802	144.84157
GUA-245	5-May	Moderate	Forereef	15.8	13.46951	144.85933
GUA-348	5-May	Moderate	Forereef	15	13.48908	144.87947
GUA-361	5-May	Moderate	Forereef	9	13.50471	144.89280
GUA-436	5-May	Moderate	Forereef	16	13.39292	144.78071
GUA-468	5-May	Shallow	Forereef	6	13.44205	144.82196
GUA-488	5-May	Shallow	Forereef	5	13.42613	144.80616
GUA-510	5-May	Shallow	Forereef	3.3	13.41881	144.79168
GUA-595	5-May	Shallow	Forereef	6	13.35061	144.77564
GUA-617	5-May	Shallow	Forereef	5	13.37275	144.77677
GUA-107	6-May	Deep	Forereef	21	13.59466	144.95821
GUA-129	6-May	Deep	Forereef	28	13.59998	144.96243
GUA-153	6-May	Deep	Forereef	22	13.60228	144.93051
GUA-199	6-May	Moderate	Forereef	13	13.63937	144.88805
GUA-241	6-May	Moderate	Forereef	12	13.60212	144.95167
GUA-253	6-May	Shallow	Forereef	5	13.62393	144.90087

REA Site	Date	Depth Zone	Stratum	Depth (m)	Latitude	Longitude
GUA-269	6-May	Moderate	Forereef	10	13.54195	144.93572
GUA-368	6-May	Moderate	Forereef	13.6	13.56237	144.94050
GUA-607	6-May	Shallow	Forereef	6	13.64638	144.84898
GUA-126	7-May	Deep	Forereef	22	13.32785	144.77784
GUA-136	7-May	Deep	Forereef	21	13.31161	144.77418
GUA-228	7-May	Moderate	Forereef	15.5	13.24186	144.71503
GUA-333	7-May	Moderate	Forereef	9.7	13.24042	144.69730
GUA-343	7-May	Moderate	Forereef	12.5	13.26885	144.74791
GUA-454	7-May	Shallow	Forereef	5	13.24061	144.68645
GUA-470	7-May	Shallow	Forereef	5	13.24405	144.71401
GUA-527	7-May	Shallow	Forereef	6	13.29369	144.76868
GUA-552	7-May	Shallow	Forereef	3	13.23943	144.66463
GUA-579	7-May	Shallow	Forereef	4	13.24169	144.69353
GUA-600	7-May	Shallow	Forereef	5.4	13.23221	144.64775
GUA-644	7-May	Shallow	Forereef	3.3	13.24182	144.70217
GUA-117	8-May	Deep	Forereef	24	13.48459	144.73369
GUA-160	8-May	Deep	Forereef	23.3	13.47889	144.69822
GUA-165	8-May	Deep	Forereef	22	13.46504	144.67025
GUA-326	8-May	Moderate	Forereef	10.6	13.49681	144.76743
GUA-367	8-May	Moderate	Forereef	10	13.55925	144.81174
GUA-390	8-May	Shallow	Forereef	4	13.48378	144.75955
GUA-391	8-May	Shallow	Forereef	4	13.51286	144.79679
GUA-467	8-May	Shallow	Forereef	2.4	13.59704	144.83441
GUA-497	8-May	Shallow	Forereef	3.6	13.60616	144.83509
GUA-598	8-May	Shallow	Forereef	4.8	13.47809	144.71718
GUA-634	8-May	Shallow	Forereef	4.2	13.57186	144.82348
GUA-150	9-May	Deep	Forereef	22	13.29942	144.65364
GUA-167	9-May	Deep	Forereef	24	13.33483	144.64086
GUA-170	9-May	Deep	Forereef	23.3	13.32036	144.64164
GUA-478	9-May	Shallow	Forereef	4	13.41300	144.65122
GUA-577	9-May	Shallow	Forereef	3	13.39470	144.65818
GUA-582	9-May	Shallow	Forereef	5.5	13.35625	144.63842
GUA-601	9-May	Shallow	Forereef	2.1	13.36352	144.64663

APPENDIX C: ROTA

The island of Rota is located at 14.14° N, 145.21° W in the North Pacific and is one of the larger and more populated islands of the Mariana Archipelago. For information about the methods used to perform the activities discussed in this appendix, please see Appendix A: “Methods.”

C.1. Oceanography and Water Quality

Oceanographic operations during the cruise HA-11-01, Leg III, at Rota entailed numerous retrievals and deployments of oceanographic moored instruments; installation of calcification acidification units (CAUs) and nearshore water sampling and conductivity, temperature, and depth (CTD) casts at select Rapid Ecological Assessment (REA) sites; and shipboard water sampling and CTD casts offshore to a depth of 500 m and acoustic Doppler current profiler (ADCP) transect lines.

Four subsurface temperature recorders (STRs) were retrieved, and four STRs were deployed (Fig. C.1.1 and Table C.1.1). One of these STRs was deployed on the mooring anchor of the sea-surface temperature buoy, and another was deployed on the ecological acoustic recorder (EAR) anchor. One SST buoy was recovered and replaced. One EAR unit was removed and the anchor left in place for possible future deployments. For information regarding the CAU deployments at Rota, please see Section C.2: “Benthic Environment.”

At nearshore locations around Rota, five shallow-water (≤ 30 m) CTD casts were performed (Fig. C.1.1), including one cast at each of the five select REA sites where CAUs were installed. In concert with four of these five CTD casts, two water samples were taken to measure the following parameters: dissolved inorganic carbon (DIC), total alkalinity (TA), salinity, nutrient, and chlorophyll-*a* (Chl-*a*) concentrations. A total of eight DIC and TA, eight salinity, eight nutrient, and eight Chl-*a* water samples were collected, one from the surface and one near the reef at each REA site.

From the NOAA Ship *Hi`ialakai*, an ADCP transect line ~ 20 km long was run to the west and an ADCP transect line ~ 15 km long was run to the east away from this island during night operations. On the reciprocal course, shipboard CTD casts were conducted to a depth of 500 m per transect line every 5 km for a total of nine deepwater CTD casts. Water samples were collected concurrently with one select shipboard CTD cast at five depths between the surface and 200 m, depending on the depth of mixed layer as determined by the CTD downcast (Fig. C.1.2). Near Rota, then, five nutrient and five Chl-*a* shipboard water samples were collected.

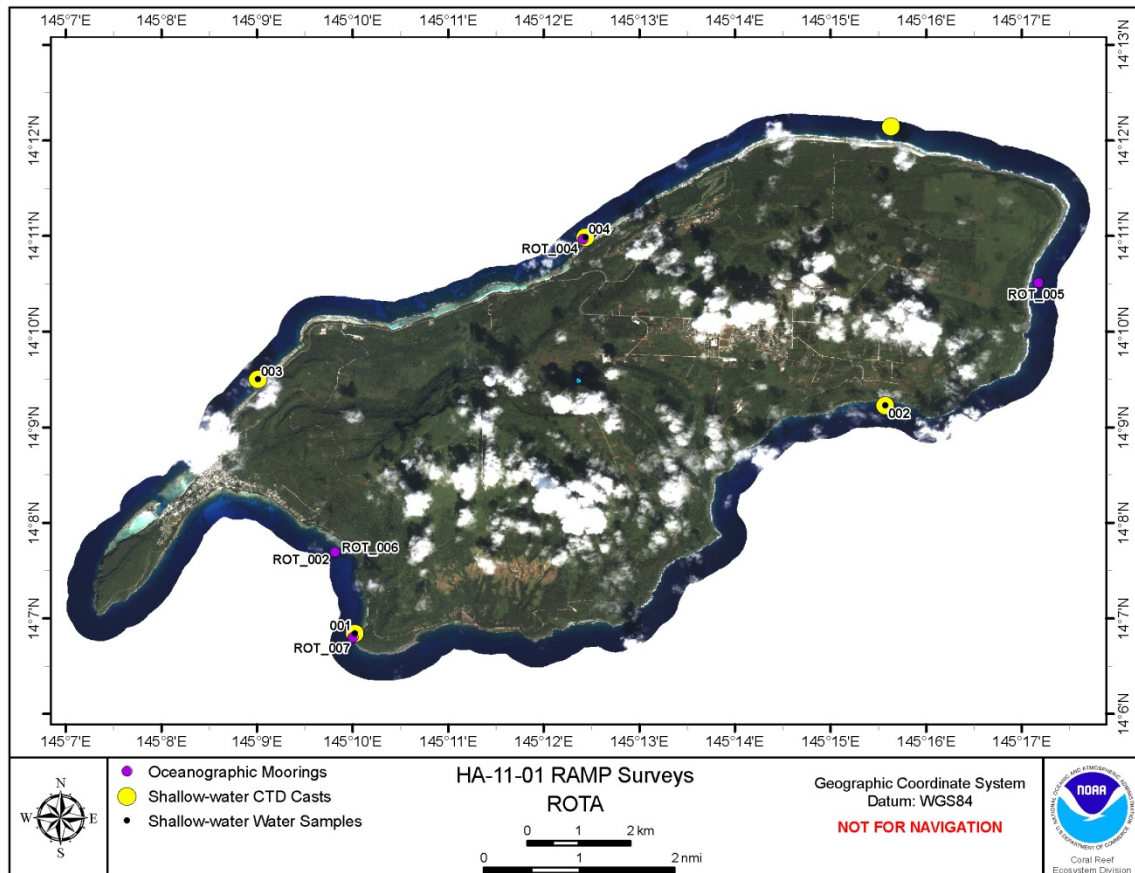


Figure C.1.1.--Mooring sites where oceanographic instruments were retrieved or deployed and locations of nearshore CTD casts and water sampling performed at Rota during cruise HA-11-01, Leg III (IKONOS Carterra Geo Data, 2000).

Table C.1.1.--Geographic coordinates and sensor depths of the moored oceanographic instruments, EAR, and anchors that were retrieved or deployed at Rota during cruise HA-11-01, Leg III.

Mooring Site	Date	Instrument Type	Latitude	Longitude	Depth (m)	Retrieved	Deployed
ROT-002	1-May	SST	14.12827	145.16363	0.3	1	1
ROT-006	1-May	STR	14.12827	145.16363	11.9	1	1
ROT-006	1-May	Anchor	14.12827	145.16363	11.9	1	1
ROT-007	1-May	STR	14.11340	145.16667	13.7	1	1
ROT-007	1-May	EAR	14.11340	145.16667	13.7	1	0
ROT-004	2-May	STR	14.18285	145.20681	10.4	1	1
ROT-005	2-May	STR	14.17520	145.28627	16.2	1	1

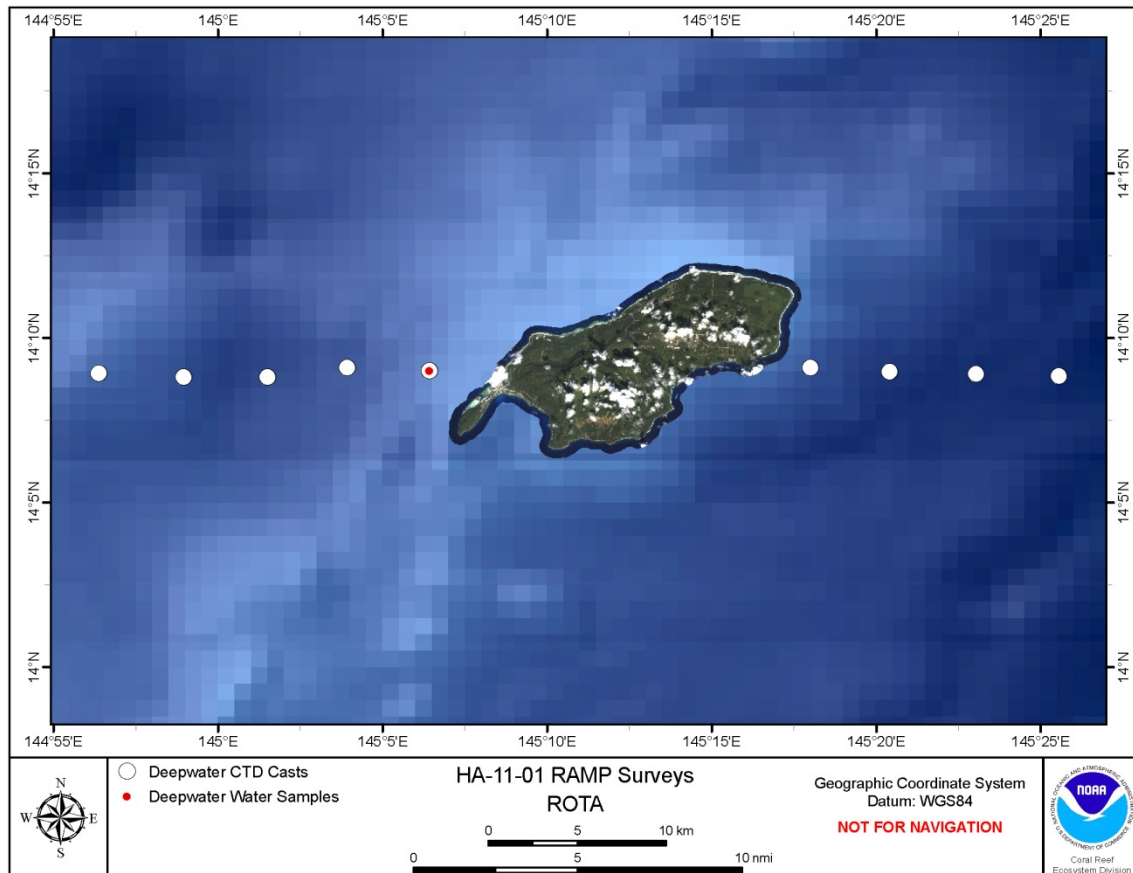


Figure C.1.2.--Locations of deepwater CTD casts and water sampling performed at Rota during cruise HA-11-01, Leg III. Island satellite image IKONOS Carterra Geo Data, 2000, and background imagery SIO, NOAA, U.S. Navy, NGA, GEBCO (Becker, 2009; Smith and Sandwell, 1997) © 2008 The Regents of the University of California.

C.2. Benthic Environment

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

Various samples were collected at two REA sites (Table C.2.2): nine algal voucher specimens at REA sites ROT-02 and ROT-05 for taxonomic identification and 11 water samples for microbial analyses, with four water samples of 2 L each at each of the same two sites and three water samples of 20 L each at ROT-05. Additional microbial work included benthic grabs of coral rubble and unidentified macroalgae at the two sites and plankton tows conducted at one nearshore and one offshore location. For more information about collections made at REA sites, see Table Q.1.1 in Appendix Q: “Biological Collections.”

Three autonomous reef monitoring structures (ARMS) were recovered from ROT-06 (Table C.2.2). No ARMS were deployed. At each of four select REA sites, an array of five CAUs was deployed for a total of 20 CAUs installed at Rota (Table C.2.2). For information about the EAR recovery at Rota, see Section C.2: “Oceanography and Water Quality.”

In total, the benthic team conducted 32 individual dives at REA sites around Rota.

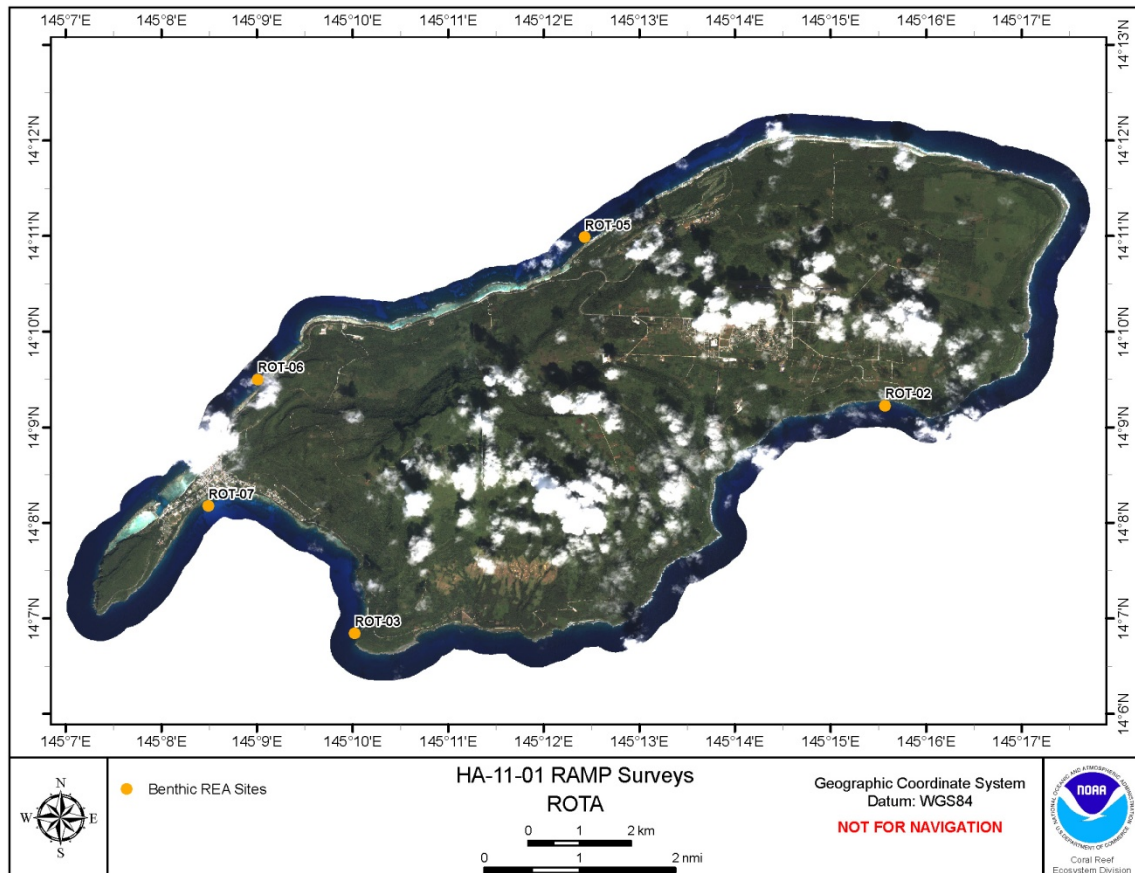


Figure C.2.1.--Locations of REA benthic sites surveyed at Rota during cruise HA-11-01, Leg III (IKONOS Carterra Geo Data, 2000).

Table C.2.1.--Summary of REA benthic surveys performed at Rota during cruise HA-11-01, Leg III. Indication that an LPI survey was completed also means that photographs were taken along transect lines.

REA Site	Date	Latitude	Longitude	REA Surveys			
				LPI	Roving Diver	Corals	Inverts
ROT-02	1-May	14.15382	145.25949	×	×	×	–
ROT-03	1-May	14.11411	145.16705	×	×	×	–
ROT-07	1-May	14.13634	145.14154	×	×	×	–
ROT-05	2-May	14.18319	145.20720	×	×	×	–
ROT-06	2-May	14.15839	145.15013	×	×	×	–

Table C.2.2.--Summary of CAU installations and ARMS retrievals (Ret.) and deployments (Dep.) performed as well as algal specimens and microbial water samples collected at Rota during cruise HA-11-01, Leg III.

REA Site	Date	Latitude	Longitude	Installations and Collections					
				CAUs	ARMS Ret	ARMS Dep	Algae	Microbial Samples	Coral Cores
ROT-02	1-May	14.15382	145.25949	5	0	0	2	10	0
ROT-03	1-May	14.11411	145.16705	5	0	0	0	0	0
ROT-07	1-May	14.13634	145.14154	0	0	0	0	0	0
ROT-05	2-May	14.18319	145.20720	5	0	0	7	15	0
ROT-06	2-May	14.15839	145.15013	5	3	0	0	0	0

During cruise HA-11-01, CRED completed 11 towed-diver surveys at Rota, covering a total length of 23.9 km (an area of 23.9 ha) on the ocean floor (Fig. C.2.2). The mean survey length was 2.2 km with a range of 1.8–2.6 km. The mean survey depth was 15.5 m with a range of 14.4–16.9 m. The mean temperature from data recorded during these surveys was 28.9°C with a range of 28.7°C–29.1°C.

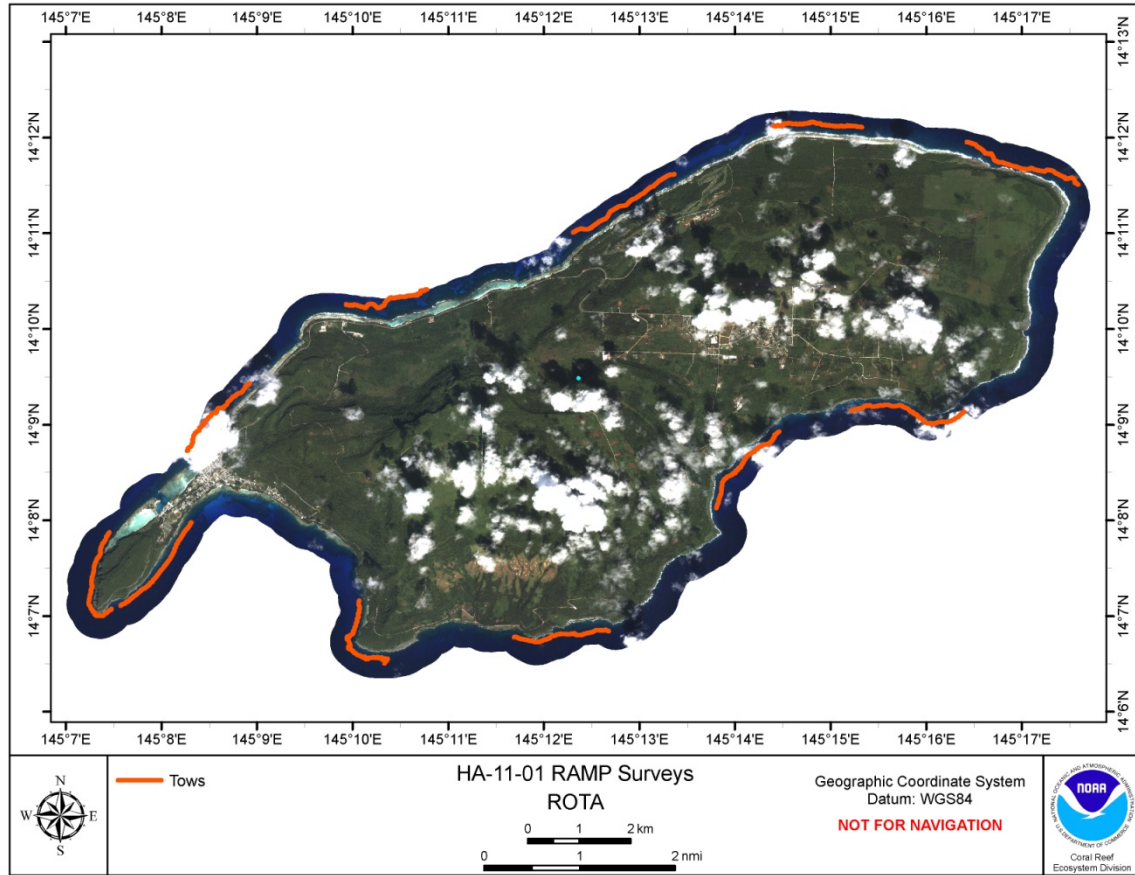


Figure C.2.2.--Track locations of towed-diver surveys conducted at Rota during cruise HA-11-01, Leg III (IKONOS Carterra Geo Data, 2003).

C.3. Reef Fish Community

REA fish survey sites were chosen using a stratified random design. Stationary-point-count surveys were conducted at 24 REA sites at Rota in the deep, moderate, and shallow forereef strata (Fig. C.3.1 and Table C.3.1). No fishes were collected during these surveys.

In addition, CRED completed 11 towed-diver surveys at Rota, as described previously in Section C.2 of this appendix.

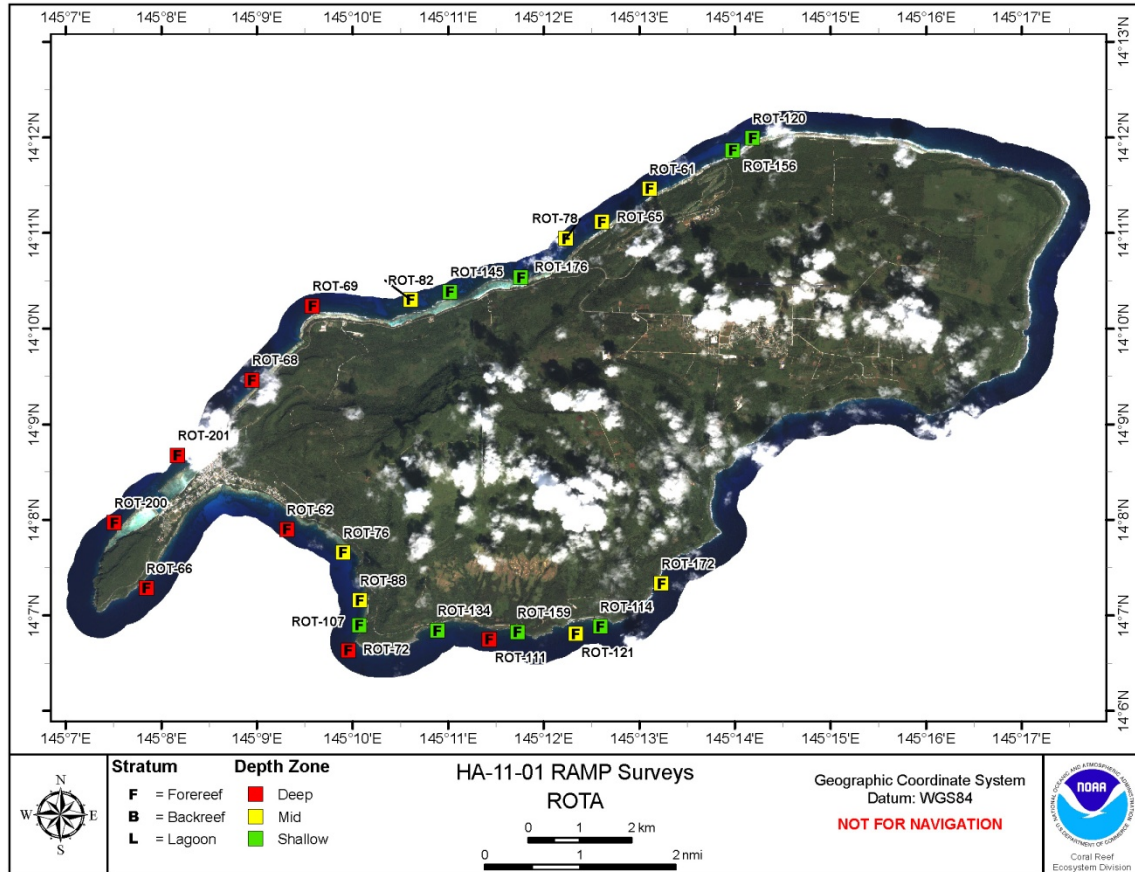


Figure C.3.1.--Locations of REA fish sites surveyed at Rota during cruise HA-11-01, Leg III (IKONOS Carterra Geo Data, 2000). All of these REA sites were selected using a stratified random design.

Table C.3.1.--Summary of sites where REA fish surveys were conducted at Rota during cruise HA-11-01, Leg III.

REA Site	Date	Depth Zone	Stratum	Depth (m)	Latitude	Longitude
ROT-62	1-May	Deep	Forereef	20	14.13171	145.15522
ROT-66	1-May	Deep	Forereef	24	14.12145	145.13074
ROT-72	1-May	Deep	Forereef	24	14.11065	145.16591
ROT-76	1-May	Moderate	Forereef	15	14.12767	145.16504
ROT-88	1-May	Moderate	Forereef	12.4	14.11934	145.16794
ROT-107	1-May	Shallow	Forereef	5	14.11504	145.16784
ROT-111	1-May	Deep	Forereef	21	14.11255	145.19047
ROT-114	1-May	Shallow	Forereef	6	14.11476	145.20986
ROT-121	1-May	Moderate	Forereef	12.5	14.11351	145.20558
ROT-134	1-May	Shallow	Forereef	6	14.11408	145.18144
ROT-159	1-May	Shallow	Forereef	5	14.11381	145.19539
ROT-172	1-May	Moderate	Forereef	14	14.12227	145.22049
ROT-61	2-May	Moderate	Forereef	15.1	14.19111	145.21846
ROT-65	2-May	Moderate	Forereef	13	14.18534	145.21013
ROT-68	2-May	Deep	Forereef	23	14.15775	145.14909
ROT-69	2-May	Deep	Forereef	24	14.17067	145.15965
ROT-78	2-May	Moderate	Forereef	14	14.18242	145.20390
ROT-82	2-May	Moderate	Forereef	14	14.17173	145.17677
ROT-120	2-May	Shallow	Forereef	6	14.19993	145.23641
ROT-145	2-May	Shallow	Forereef	4	14.17315	145.18368
ROT-156	2-May	Shallow	Forereef	5	14.19781	145.23294
ROT-176	2-May	Shallow	Forereef	16	14.17566	145.19601
ROT-200	2-May	Deep	Forereef	25.1	14.13287	145.12511
ROT-201	2-May	Deep	Forereef	25	14.14465	145.13613

APPENDIX D: AGUIJAN

The island of Aguijan is located at 14.84° N, 145.55° W in the North Pacific in the Mariana Archipelago. For information about the methods used to perform the activities discussed in this appendix, please see Appendix A: “Methods.”

D.1. Oceanography and Water Quality

Oceanographic operations during the cruise HA-11-01, Leg III, at Aguijan entailed the retrieval and replacement of one subsurface temperature recorder (STR), shipboard water sampling and conductivity, temperature, and depth (CTD) casts offshore to a depth of 500 m, and an acoustic Doppler current profiler (ADCP) transect line (Figs. D.1.1 and D.1.2 and Table D.1.1). A single nutrient water sample was collected at a nearshore location near Rapid Ecological Assessment (REA) site AGU-02 for microbiological analysis.

From the NOAA Ship *Hi`ialakai*, six shipboard CTD casts were conducted to a depth of 500 m every 5 km to the south of this island. Water samples were collected concurrently with one select shipboard CTD cast at five depths between the surface and 200 m, depending on the depth of mixed layer as determined by the CTD downcast (Fig. D.1.2). Near Aguijan, then, five nutrient and five Chl-*a* shipboard water samples were collected.

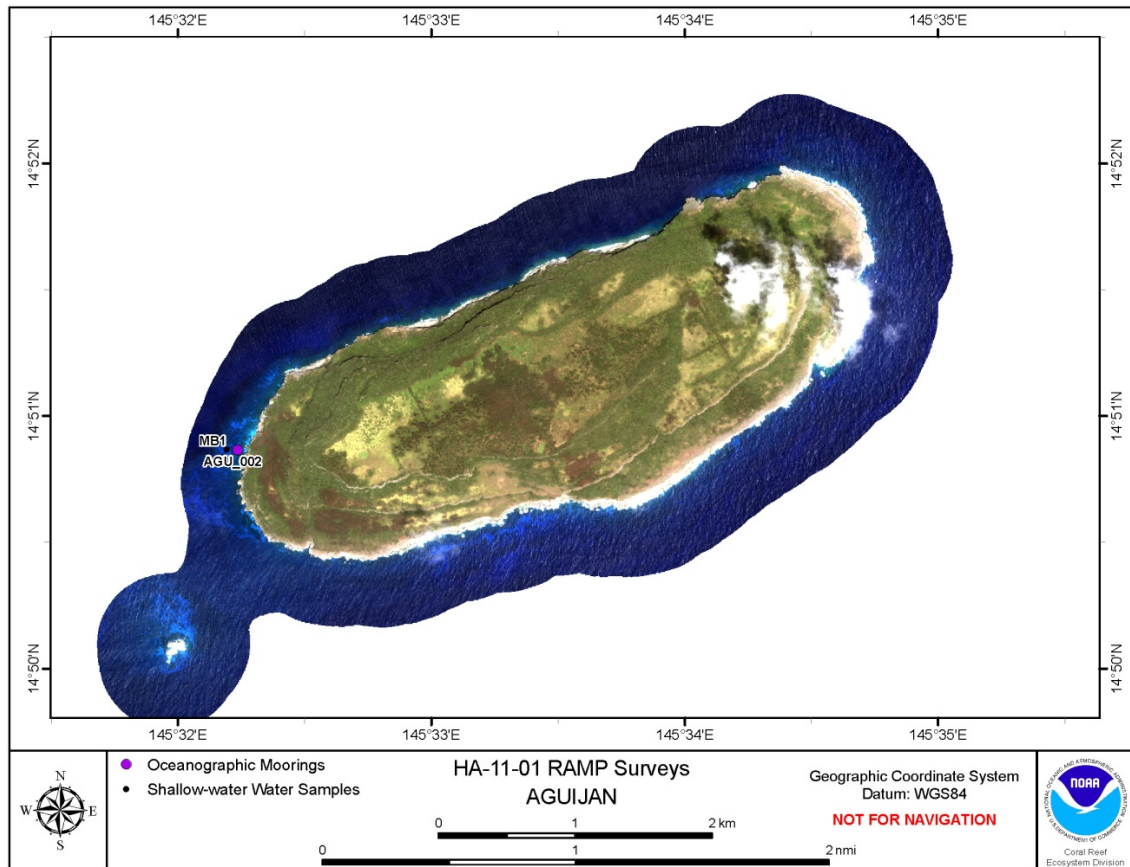


Figure D.1.1.--Mooring site at Aguijan where an STR was retrieved or deployed and location (MB1) of the nearshore water sampling performed during cruise HA-11-01, Leg III (IKONOS Carterra Geo Data, 2003).

Table D.1.1.--Geographic coordinates and sensor depth of the STRs that were retrieved or deployed at Aguijan during cruise HA-11-01, Leg III.

Mooring Site	Date	Instrument Type	Latitude	Longitude	Depth (m)	Retrieved	Deployed
AGU-002	4-May	STR	14.84778	145.53724	8.2	1	1

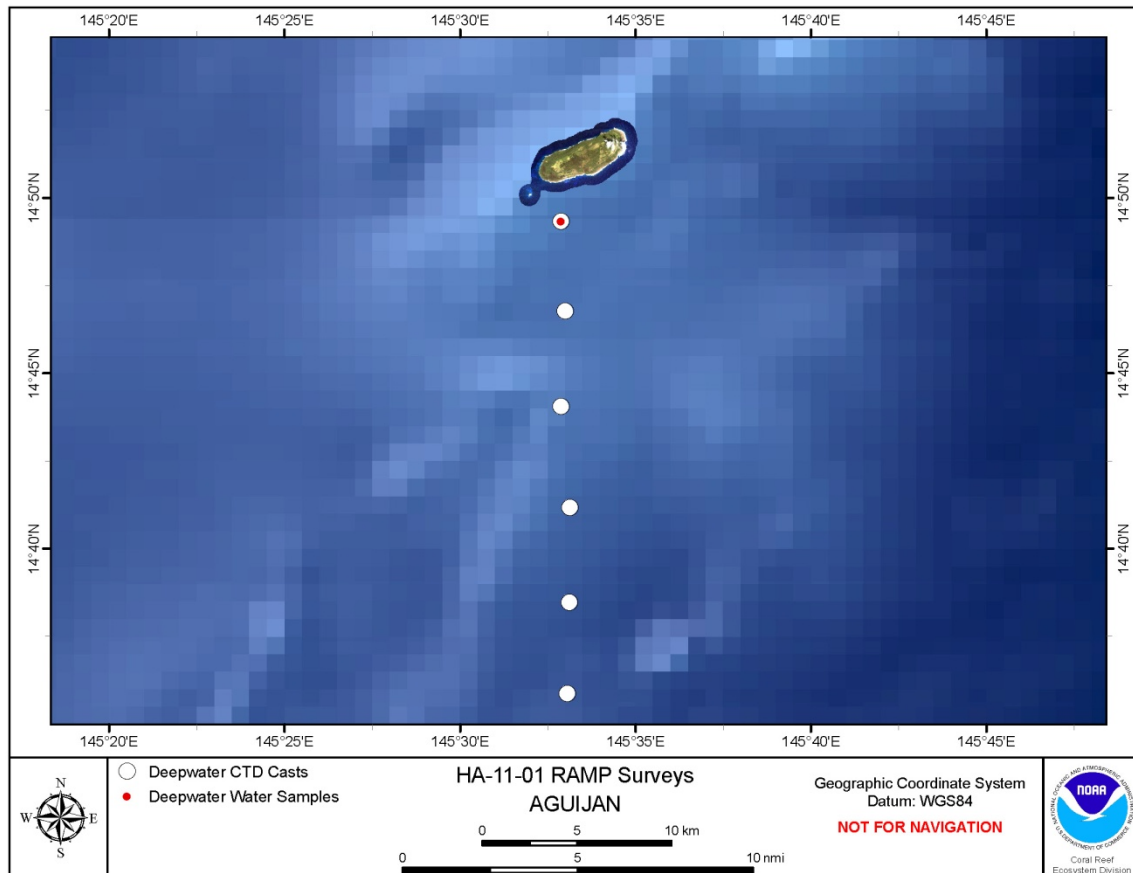


Figure D.1.2.--Locations of deepwater CTD casts and water sampling performed at Aguijan during cruise HA-11-01, Leg III. Island satellite image IKONOS Carterra Geo Data, 2003, and background imagery SIO, NOAA, U.S. Navy, NGA, GEBCO (Becker, 2009; Smith and Sandwell, 1997) © 2008 The Regents of the University of California.

D.2. Benthic Environment

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

Samples collected at AGU-02 (Table D.2.2) included two algal voucher specimens for taxonomic identification and four water samples of 2 L each for microbial analyses. Additional microbial work included benthic grabs of coral rubble and unidentified macroalgae at AGU-02 and plankton tows conducted at one nearshore and one offshore location. For more information about collections made at REA sites, see Table Q.1.1 in Appendix Q: “Biological Collections.”

In total, the benthic team conducted 13 individual dives at REA sites at Aguijan.

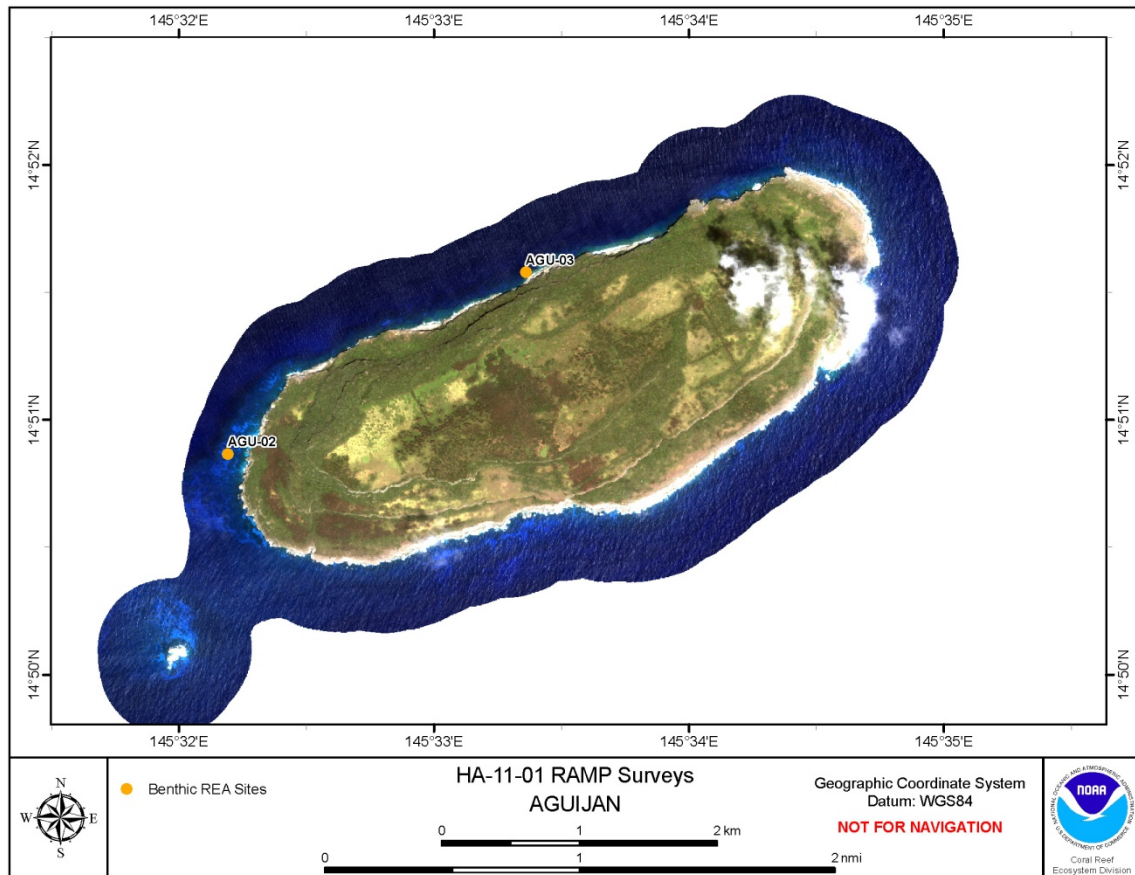


Figure D.2.1.--Locations of REA benthic sites surveyed at Aguijan during cruise HA-11-01, Leg III (IKONOS Carterra Geo Data, 2003).

Table D.2.1.--Summary of REA benthic surveys performed at Aguijan during cruise HA-11-01, Leg III. Indication that an LPI survey was completed also means that photographs were taken along transect lines.

REA Site	Date	Latitude	Longitude	REA Surveys			
				LPI	Roving Diver	Corals	Inverts
AGU-02	4-May	14.84779	145.53651	×	×	×	×
AGU-03	4-May	14.85967	145.55600	×	×	×	×

Table D.2.2.--Summary of installation and collection activities at REA sites at Aguijan during cruise HA-11-01, Leg III, including collection of algal specimens and microbial water samples. No calcification acidification units (CAUs) or autonomous reef monitoring structures (ARMS) were installed and retrieved.

REA Site	Date	Latitude	Longitude	Installations and Collections					
				CAUs	ARMS Ret	ARMS Dep	Algae	Microbial Samples	Coral Cores
AGU-02	4-May	14.84779	145.53651	0	0	0	2	10	0
AGU-03	4-May	14.85967	145.55600	0	0	0	0	0	0

During cruise HA-11-01, Leg III, CRED completed five towed-diver surveys at Aguijan, including one benthic calibration survey, covering a total length of 11.1 km (an area of 11.1 ha) on the ocean floor (Fig. D.2.2). The mean survey length was 2.2 km with a range of 1.6–2.8 km. The mean survey depth was 15.8 m with a range of 13.7–17.3 m. The mean temperature from data recorded during these surveys was 29.1°C with a range of 29.0°C–29.2°C.

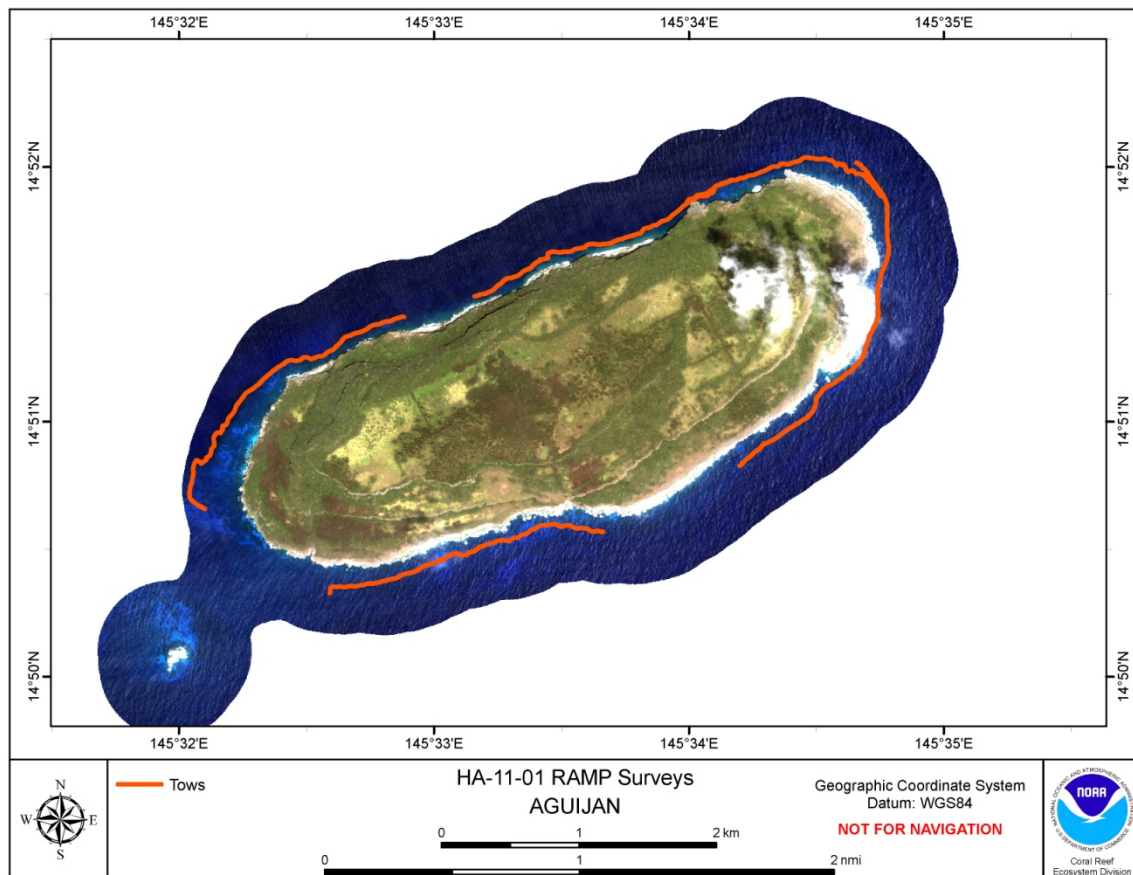


Figure D.2.2.--Track locations of towed-diver surveys conducted at Aguijan during cruise HA-11-01, Leg III (IKONOS Carterra Geo Data, 2003).

D.3. Reef Fish Community

REA fish survey sites were chosen using a stratified random design. Stationary-point-count surveys were conducted at 13 REA sites at Aguijan in the deep, moderate, and shallow forereef strata (Fig. D.3.1 and Table D.3.1). No fishes were collected during these surveys.

In addition, CRED completed four towed-diver fish surveys at Aguijan, as described previously in Section D.2 of this appendix.

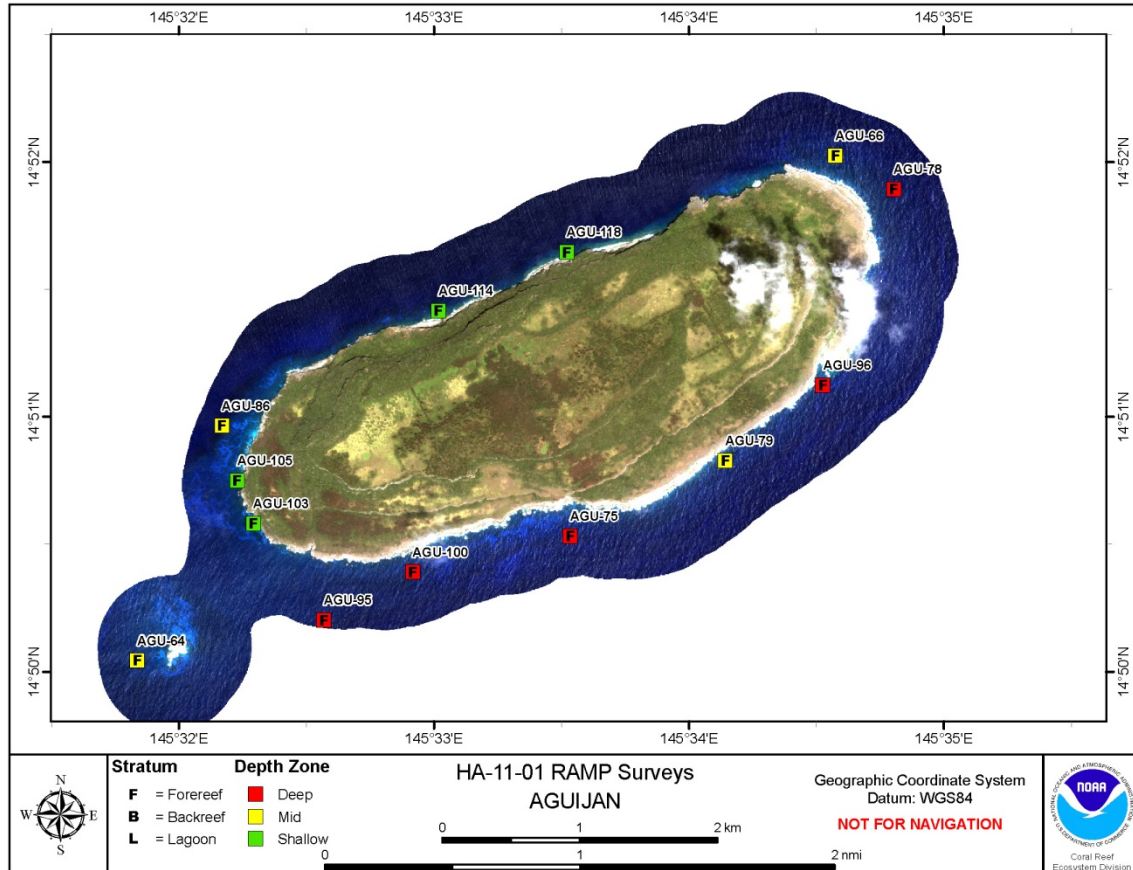


Figure D.3.1.--Locations of REA fish sites surveyed at Aguijan during cruise HA-11-01, Leg III (IKONOS Carterra Geo Data, 2003). All of these REA sites were selected using a stratified random design.

Table D.3.1.--Summary of sites where REA fish surveys were conducted at Aguijan during cruise HA-11-01, Leg III.

REA Site	Date	Depth Zone	Stratum	Depth (m)	Latitude	Longitude
AGU-64	4-May	Moderate	Forereef	14	14.83408	145.53060
AGU-66	4-May	Moderate	Forereef	13	14.86709	145.57624
AGU-75	4-May	Deep	Forereef	22.7	14.84223	145.55891
AGU-78	4-May	Deep	Forereef	20	14.86492	145.58005
AGU-79	4-May	Moderate	Forereef	13	14.84716	145.56905
AGU-86	4-May	Moderate	Forereef	11	14.84943	145.53613
AGU-95	4-May	Deep	Forereef	24	14.83673	145.54281
AGU-96	4-May	Deep	Forereef	22	14.85210	145.57543
AGU-100	4-May	Deep	Forereef	20	14.83986	145.54861
AGU-103	4-May	Shallow	Forereef	4	14.84304	145.53818
AGU-105	4-May	Shallow	Forereef	5	14.84585	145.53713
AGU-114	4-May	Shallow	Forereef	5	14.85696	145.55028
AGU-118	4-May	Shallow	Forereef	4	14.86078	145.55867

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APPENDIX E: TINIAN

The island of Tinian is located at 15.00° N, 145.64° W in the North Pacific and is one of the larger and more populated islands of the Mariana Archipelago. For information about the methods used to perform the activities discussed in this appendix, please see Appendix A: “Methods.”

E.1. Oceanography and Water Quality

Oceanographic operations during the cruise HA-11-01, Legs II and III, at Tinian entailed retrievals and deployments of subsurface temperature recorders (STRs); installation of calcification acidification units (CAUs) and nearshore water sampling and conductivity, temperature, and depth (CTD) casts at select Rapid Ecological Assessment (REA) sites; shipboard water sampling and CTD casts offshore to a depth of 500 m; and an acoustic Doppler current profiler (ADCP) transect line.

Two STRs were retrieved, and two STRs were deployed (Fig. E.1.1 and Table E.1.1). One STR mooring site was moved slightly offshore because consistent large swell events at the previous location have made deployments and recoveries there unsafe, and the new location is closer to a REA site where a CAU was installed. For information about CAU deployments completed at Tinian, see Section E.2: “Benthic Environment.”

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

From the NOAA Ship *Hi`ialakai*, an ADCP transect line ~ 23 km long was run to the west away from this island during night operations. On the reciprocal course, shipboard CTD casts were conducted to a depth of 500 m every 5 km for a total of six deepwater CTD casts. Water samples were collected concurrently with one select shipboard CTD cast at five depths between the surface and 200 m, depending on the depth of mixed layer as determined by the CTD downcast (Fig. E.1.2). Near Tinian, five nutrient and five Chl-*a* shipboard water samples were collected.

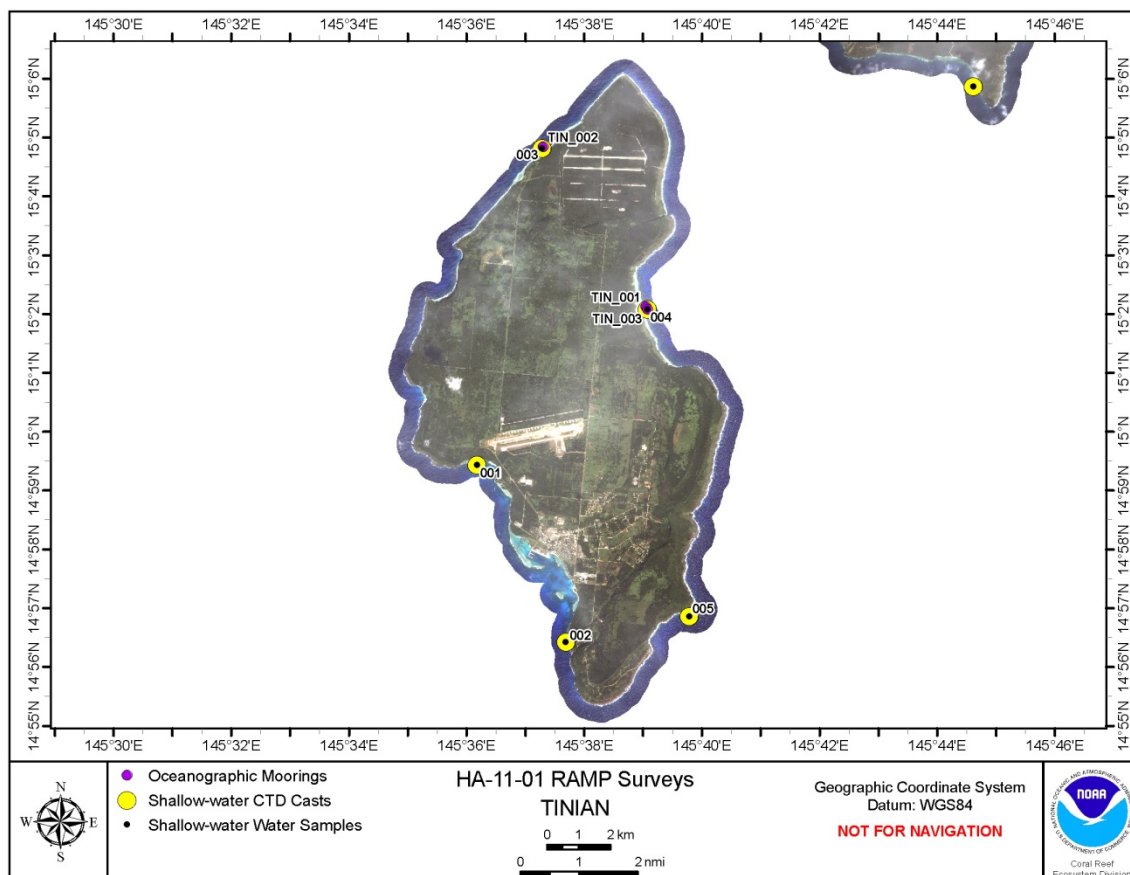


Figure E.1.1.--Mooring sites where STRs were retrieved or deployed and locations of nearshore CTD casts and water sampling performed at Tinian during cruise HA-11-01, Legs II and III (IKONOS Carterra Geo Data, 2003).

Table E.1.1.--Geographic coordinates and sensor depths of the STRs that were retrieved or deployed at Tinian during cruise HA-11-01, Legs II and III.

Mooring Site	Date	Instrument Type	Latitude	Longitude	Depth (m)	Retrieved	Deployed
TIN-001	3-May	STR	15.03550	145.65076	7	1	—
TIN-002	3-May	STR	15.08076	145.62164	13.4	1	1
TIN-003	3-May	STR	15.03475	145.65113	11.3	—	1

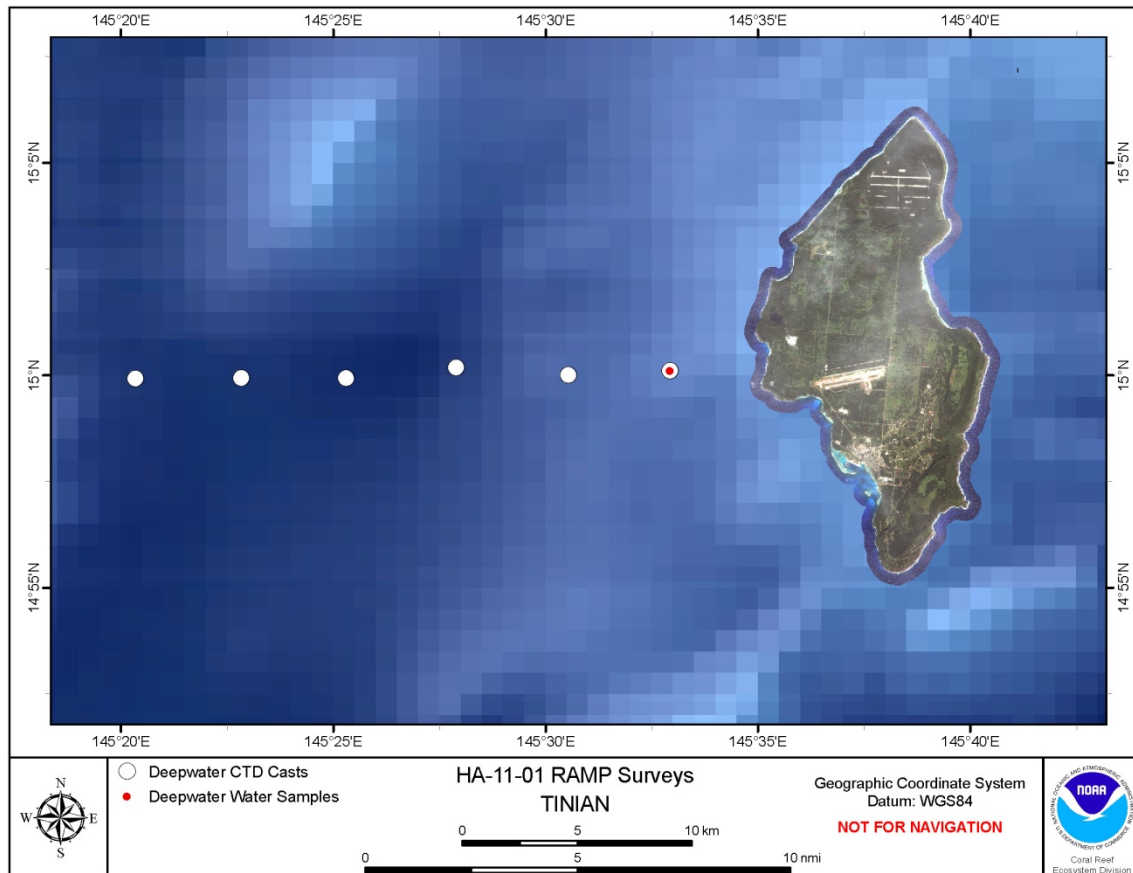


Figure E1.2.--Locations of deepwater CTD casts and water sampling performed at Tinian during cruise HA-11-01, Legs II and III. Island satellite image IKONOS Carterra Geo Data, 2003, and background imagery SIO, NOAA, U.S. Navy, NGA, GEBCO (Becker, 2009; Smith and Sandwell, 1997) © 2008 The Regents of the University of California.

E.2. Benthic Environment

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

Various samples were collected at three REA sites (Table E.2.2): four algal voucher specimens at REA site TIN-06 for taxonomic identification and eight water samples for microbial analyses at two sites with four water samples of 2 L each at each site. Additional microbial work included benthic grabs of coral rubble and unidentified macroalgae at TIN-03. For more information about collections made at REA sites, see Table Q.1.1 in Appendix Q: “Biological Collections.”

At each of five select REA sites, an array of five CAUs was deployed for a total of 25 CAUs installed at Tinian (Table E.2.2).

In total, the benthic team conducted 28 individual dives at REA sites around Tinian.

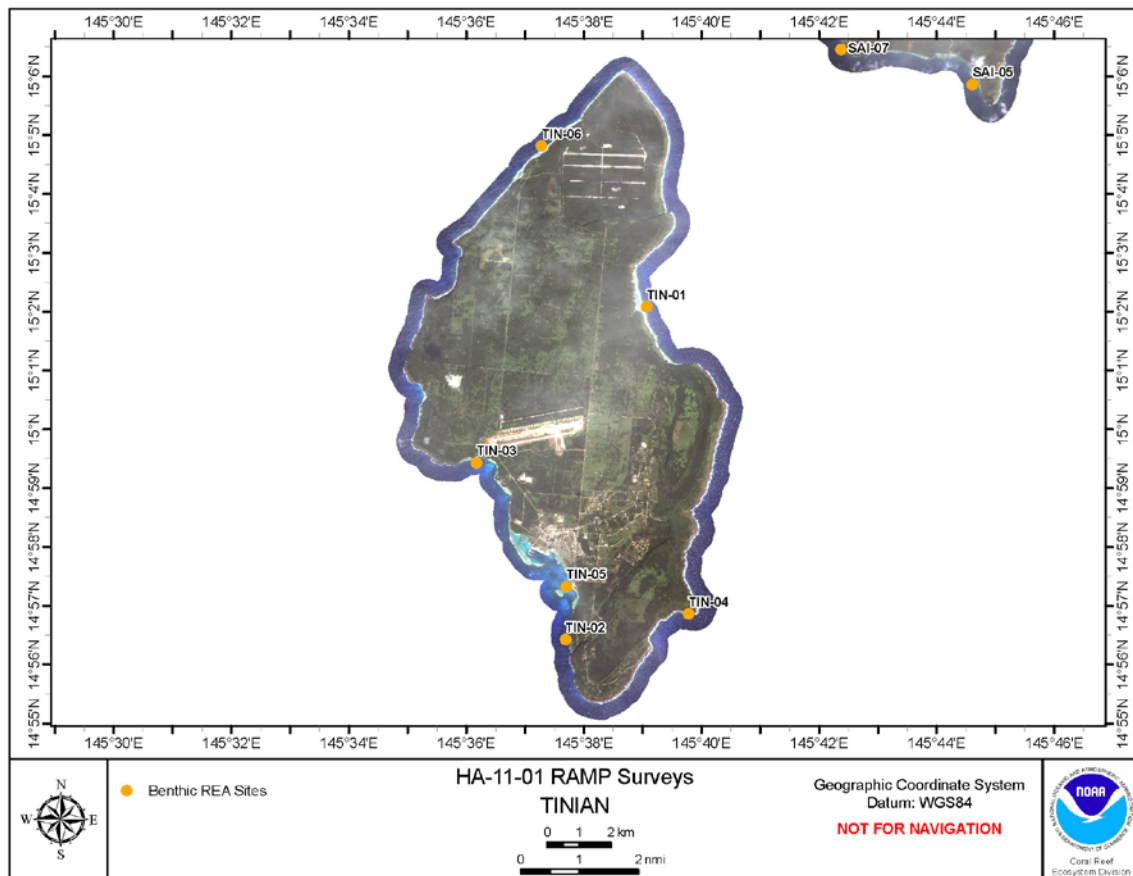


Figure E.2.1.--Locations of REA benthic sites surveyed at Tinian during cruise HA-11-01, Legs II and III (IKONOS Carterra Geo Data, 2003).

Table E.2.1.--Summary of REA benthic surveys performed at Tinian during cruise HA-11-01, Legs II and III. Indication that an LPI survey was completed also means that photographs were taken along transect lines.

REA Site	Date	Latitude	Longitude	REA Surveys			
				LPI	Roving Diver	Corals	Inverts
TIN-02	9-Apr	14.94053	145.62804	×	×	×	—
TIN-03	9-Apr	14.99064	145.60289	×	×	×	—
TIN-05	9-Apr	14.95553	145.62840	×	×	×	—
TIN-01	3-May	15.03475	145.65112	×	×	×	—
TIN-04	3-May	14.94772	145.66302	×	×	×	—
TIN-06	3-May	15.08037	145.62135	×	×	×	—

Table E.2.2.--Summary of CAU installations and algal specimens and microbial water samples collected at Tinian during cruise HA-11-01, Legs II and III.

REA Site	Date	Latitude	Longitude	Installations and Collections					
				CAUs	ARMS Ret	ARMS Det	Algae	Microbial Samples	Coral Cores
TIN-02	9-Apr	14.94053	145.62804	5	0	0	0	0	0
TIN-03	9-Apr	14.99064	145.60289	5	0	0	0	14	0
TIN-05	9-Apr	14.95553	145.62840	0	0	0	0	0	0
TIN-01	3-May	15.03475	145.65112	5	0	0	0	0	0
TIN-04	3-May	14.94772	145.66302	5	0	0	0	4	0
TIN-06	3-May	15.08037	145.62135	5	0	0	4	0	0

During cruise HA-11-01, Legs II and III, CRED completed 10 towed-diver surveys at Tinian, covering a total length of 22.6 km (an area of 22.6 ha) on the ocean floor (Fig. E.2.2). The mean survey length was 2.2 km with a range of 1.8–2.6 km. The mean survey depth was 16.3 m with a range of 15.4–19.5 m. The mean temperature from data recorded during these surveys was 29.0°C with a range of 28.9°C–29.2°C.

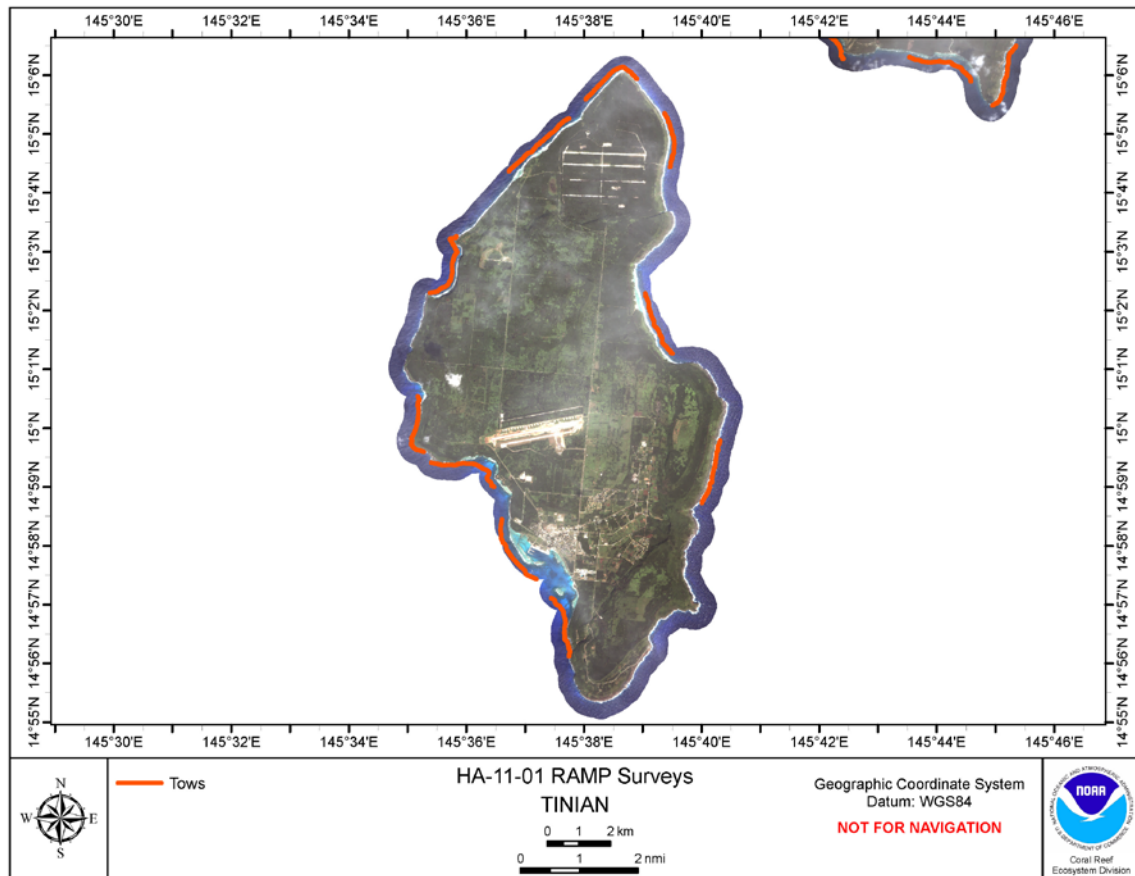


Figure E.2.2.--Track locations of towed-diver surveys conducted at Tinian during cruise HA-11-01, Legs II and III (IKONOS Carterra Geo Data, 2003).

E.3. Reef Fish Community

REA fish survey sites were chosen using a stratified random design. Stationary-point-count surveys were conducted at 19 REA sites at Tinian in the deep, moderate, and shallow foreereef strata (Fig. E.3.1 and Table E.3.1). No fishes were collected during these surveys.

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

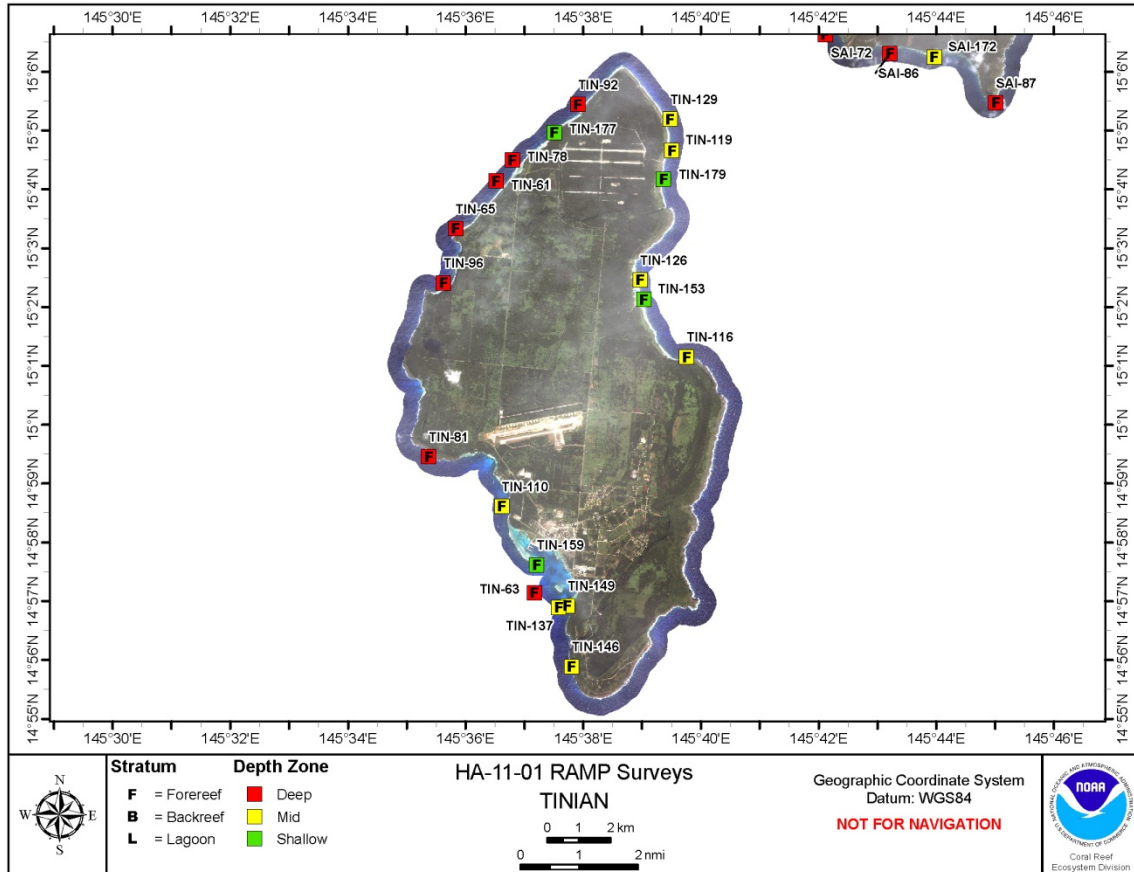


Figure E.3.1.--Locations of REA fish sites surveyed at Tinian during cruise HA-11-01, Legs II and III (IKONOS Carterra Geo Data, 2003). All of these REA sites were selected using a stratified random design.

Table E.3.1.--Summary of sites where REA fish surveys were conducted at Tinian during cruise HA-11-01, Legs II and III.

REA Site	Date	Depth Zone	Stratum	Depth (m)	Latitude	Longitude
TIN-63	9-Apr	Deep	Forereef	27	14.95246	145.61942
TIN-81	9-Apr	Deep	Forereef	24	14.99100	145.58960
TIN-110	9-Apr	Moderate	Forereef	18	14.97693	145.61026
TIN-137	9-Apr	Moderate	Forereef	19	14.94837	145.62640
TIN-146	9-Apr	Moderate	Forereef	12	14.93154	145.63004
TIN-149	9-Apr	Moderate	Forereef	9	14.94875	145.62889
TIN-159	9-Apr	Shallow	Forereef	6	14.96034	145.62017
TIN-61	3-May	Deep	Forereef	27	15.06910	145.60868
TIN-65	3-May	Deep	Forereef	21	15.05561	145.59720
TIN-78	3-May	Deep	Forereef	20	15.07505	145.61319
TIN-92	3-May	Deep	Forereef	22	15.09076	145.63184
TIN-96	3-May	Deep	Forereef	25	15.04023	145.59373
TIN-116	3-May	Moderate	Forereef	15	15.01925	145.66261
TIN-119	3-May	Moderate	Forereef	13	15.07773	145.65842
TIN-126	3-May	Moderate	Forereef	12	15.04110	145.64947
TIN-129	3-May	Moderate	Forereef	20	15.08659	145.65793
TIN-153	3-May	Shallow	Forereef	6	15.03552	145.65054
TIN-177	3-May	Shallow	Forereef	5	15.08291	145.62507
TIN-179	3-May	Shallow	Forereef	12	15.06957	145.65610

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APPENDIX F: SAIPAN

The island of Saipan is located at 15.20° N, 145.75° W in the North Pacific and is the largest and most populated island of the Commonwealth of the Northern Mariana Islands. For information about the methods used to perform the activities discussed in this appendix, please see Appendix A: “Methods.”

F.1. Oceanography and Water Quality

Oceanographic operations during the cruise HA-11-01, Legs II and III, at Saipan entailed numerous retrievals and deployments of oceanographic moored instruments; installation of calcification acidification units (CAUs) and nearshore water sampling and conductivity, temperature, and depth (CTD) casts at select Rapid Ecological Assessment (REA) sites; shipboard water sampling and CTD casts offshore to a depth of 500 m; and an acoustic Doppler current profiler (ADCP) transect line.

Five subsurface temperature recorders (STRs) were retrieved, and five STRs were deployed (Fig. F.1.1 and Table F.1.1). One of these STRs was deployed on the anchor of the sea-surface temperature (SST) buoy. At SAI-008, one SST buoy was deployed on April 7 but experienced technical difficulties; so, that buoy was recovered and a different STR was deployed on April 30 (Table F.1.1). Two EAR units were removed and their anchors left in place for possible future deployments. Also, a high-frequency acoustic recording package (HARP) was deployed at a depth of 697 m at 15.3171° N, 145.4577° W for the PIFSC Protected Species Division. For information regarding the CAU deployments at Saipan, please see Section F.2: “Benthic Environment.”

At nearshore locations around Saipan, five shallow-water (≤ 30 m) CTD casts were performed (Fig. F.1.1), including one cast at each of the five select REA sites where CAUs were installed. In concert with each CTD cast, two water samples were taken to measure the following parameters: dissolved inorganic carbon (DIC), total alkalinity (TA), salinity, nutrient, and chlorophyll-*a* (Chl-*a*) concentrations. A total of 10 DIC and TA, 10 salinity, 10 nutrient, and 10 Chl-*a* water samples were collected, one from the surface and one near the reef at each REA site.

From the NOAA Ship *Hi`ialakai*, an ADCP transect line of ~ 15 km was run west away from this island during night operations. On the reciprocal course, shipboard CTD casts were conducted to a depth of 500 m every 5 km for a total of two deepwater CTD casts. Water samples were collected concurrently with one shipboard CTD cast at five depths between the surface and 200 m, depending on the depth of mixed layer as determined by the CTD downcast (Fig. F.1.2). Near Saipan, five nutrient and five Chl-*a* shipboard water samples were collected.

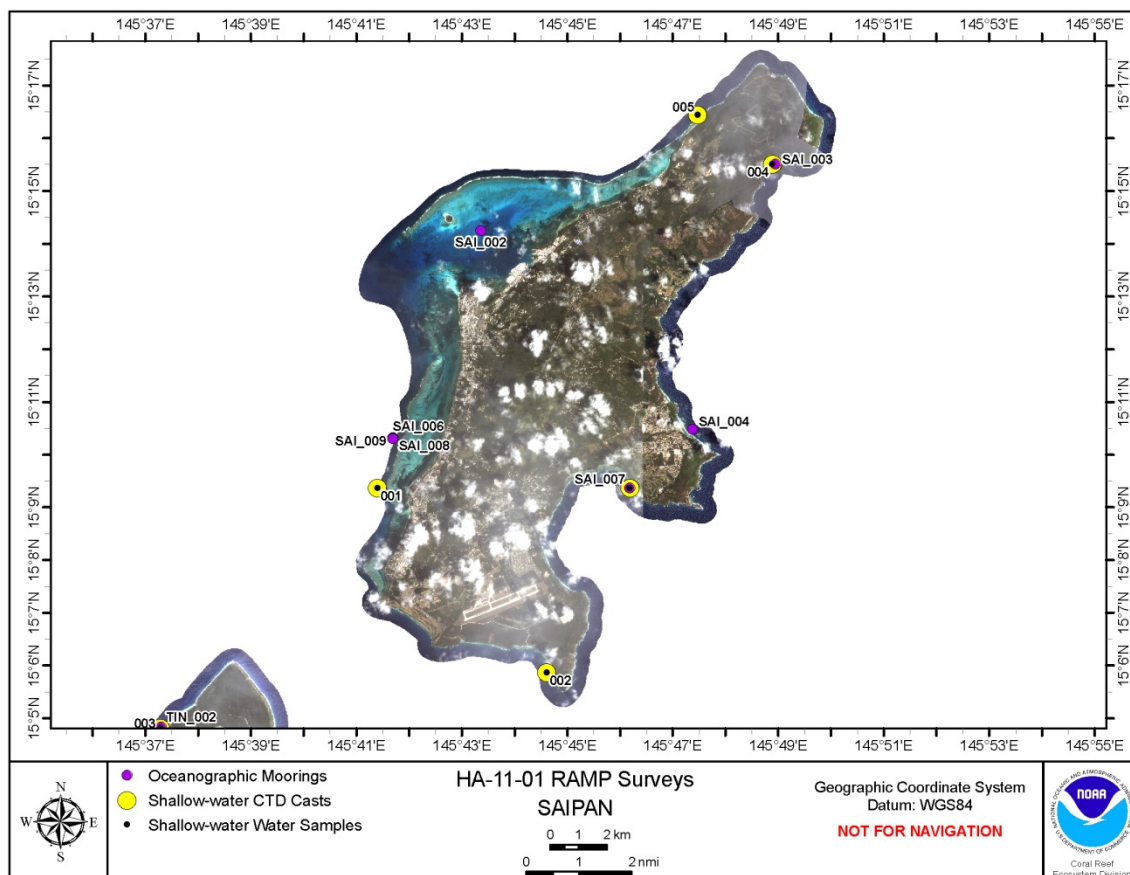


Figure F.1.1.--Mooring sites where oceanographic instruments were retrieved or deployed and locations of nearshore CTD casts and water sampling performed at Saipan during cruise HA-11-01, Legs II and III (IKONOS Carterra Geo Data, 2003).

Table F.1.1.--Geographic coordinates and sensor depths of the moored oceanographic instruments, EARs, and anchors that were retrieved or deployed at Saipan during cruise HA-11-01, Legs II and III.

Mooring Site	Date	Instrument Type	Latitude	Longitude	Depth (m)	Retrieved	Deployed
SAI-002	7-Apr	STR	15.23748	145.72252	5.5	1	1
SAI-006	7-Apr	STR	15.17213	145.69481	17.7	1	—
SAI-006	7-Apr	Anchor	15.17213	145.69481	17.7	1	—
SAI-008	7-Apr	SST	15.17184	145.69470	0.3	—	1
SAI-009	7-Apr	STR	15.17184	145.69470	18	—	1
SAI-009	7-Apr	Anchor	15.17184	145.69470	18	—	1
SAI-004	8-Apr	EAR	15.17485	145.78948	19.5	1	—
SAI-004	8-Apr	STR	15.17485	145.78948	19.5	1	1
SAI-007	8-Apr	STR	15.15614	145.76972	14.6	1	1
SAI-003	26-Apr	EAR	15.25862	145.81575	16.5	1	—
SAI-003	26-Apr	STR	15.25862	145.81575	16.5	1	1
SAI-008	30-Apr	SST	15.17189	145.69474	0.3	1	1

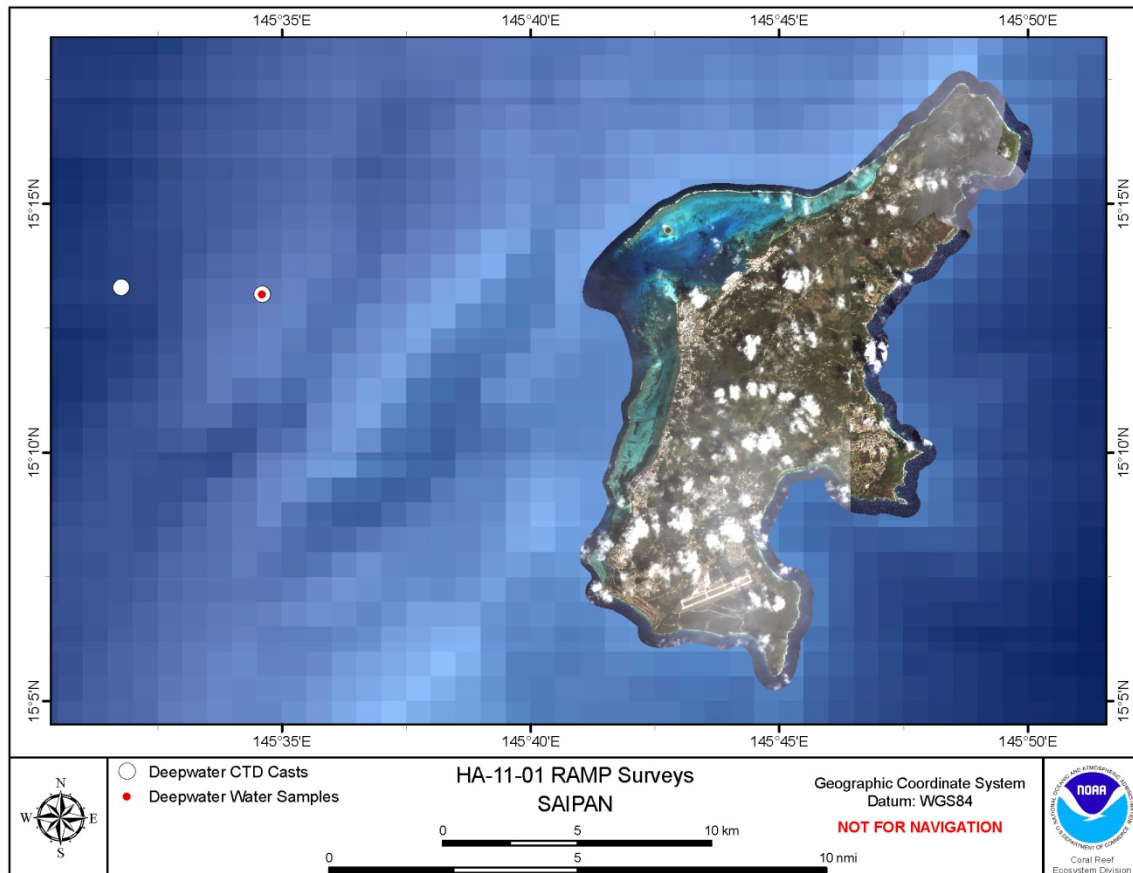


Figure F.1.2.--Locations of deepwater CTD casts and water sampling performed Saipan during cruise HA-11-01, Legs II and III. Island satellite image IKONOS Carterra Geo Data, 2003, and background imagery SIO, NOAA, U.S. Navy, NGA, GEBCO (Becker, 2009; Smith and Sandwell, 1997) © 2008 The Regents of the University of California.

F.2. Benthic Environment

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

Various samples were collected at three REA sites (Table F.2.2): 15 water samples for microbial analyses with four water samples of 2 L each at each site and three water samples of 20 L each at REA site SAI-08. Also, plankton tows were conducted at one nearshore and one offshore location. For more information about collections made at REA sites, see Table Q.1.1 in Appendix Q: “Biological Collections.”

Eight autonomous reef monitoring structures (ARMS) were recovered: two ARMS from SAI-08 and three ARMS each from SAI-05 and SAI-06 (Table F.2.2). Nine ARMS were deployed with three ARMS each at SAI-05, SAI-06, and SAI-08. At each of five select

REA sites, an array of five CAUs was deployed for a total of 25 CAUs installed at Saipan (Table F.2.2). For information about the EAR recoveries at Saipan, see Section F.2: “Oceanography and Water Quality.”

In total, the benthic team conducted 49 individual dives at REA sites around Saipan.

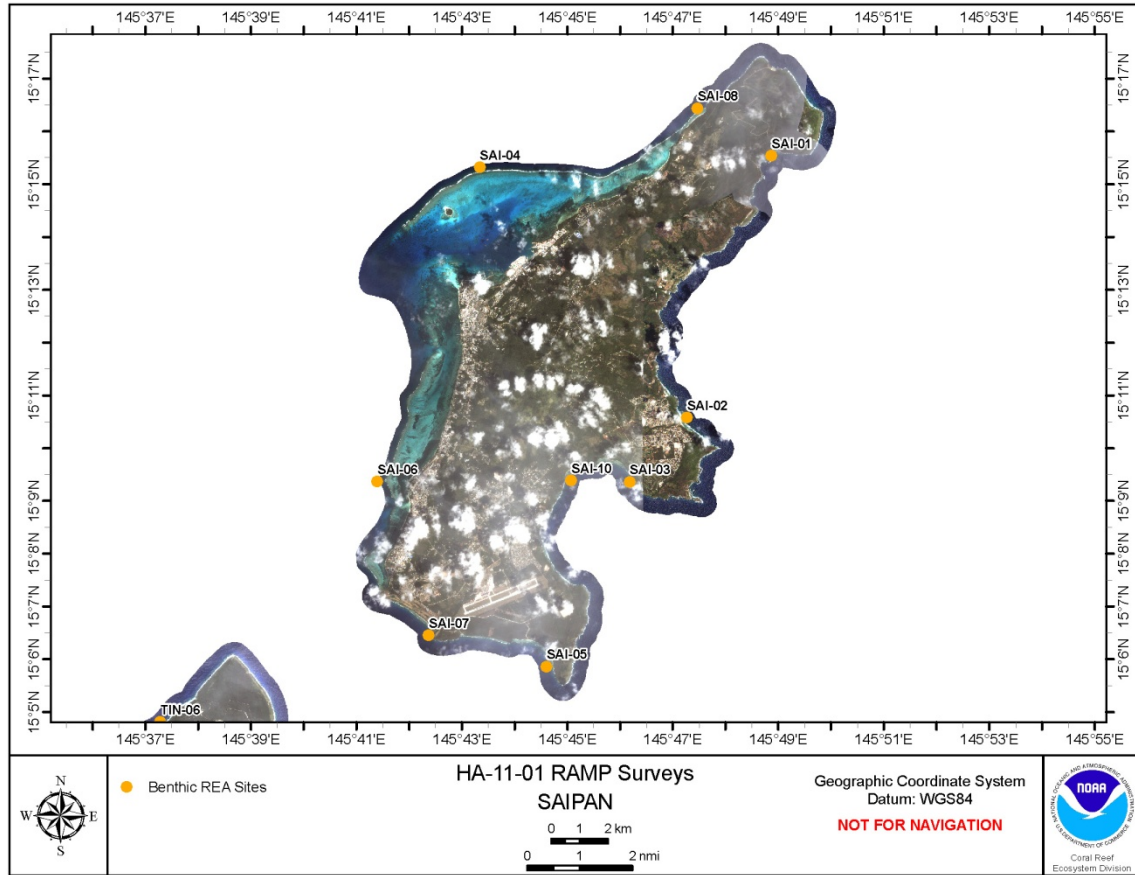


Figure F.2.1.--Locations of REA benthic sites surveyed at Saipan during cruise HA-11-01, Legs II and III (IKONOS Carterra Geo Data, 2003).

Table F.2.1.--Summary of REA benthic surveys performed at Saipan during cruise HA-11-01, Legs II and III. Indication that an LPI survey was completed also means that photographs were taken along transect lines.

REA Site	Date	Latitude	Longitude	REA Surveys			
				LPI	Roving Diver	Corals	Inverts
SAI-06	7-Apr	15.15629	145.68994	×	×	×	–
SAI-07	7-Apr	15.10771	145.70618	×	×	×	–
SAI-03	8-Apr	15.15610	145.76971	×	×	×	–
SAI-05	8-Apr	15.09784	145.74345	×	×	×	–
SAI-10	8-Apr	15.15660	145.75123	×	×	×	–
SAI-01	26-Apr	15.25903	145.81447	×	×	×	–
SAI-02	26-Apr	15.17646	145.78779	×	×	×	–
SAI-04	30-Apr	15.25542	145.72233	×	×	×	–
SAI-08	30-Apr	15.27406	145.79106	×	×	×	–

Table F.2.2.--Summary of CAU installations and ARMS retrievals (Ret.) and deployments (Dep.) performed as well as microbial water samples collected at Saipan during cruise HA-11-01, Legs II and III.

REA Site	Date	Latitude	Longitude	Installations and Collections					
				CAUs	ARMS Ret	ARMS Dep	Algae	Microbial Samples	Coral Cores
SAI-06	7-Apr	15.15629	145.68994	5	3	3	0	4	0
SAI-07	7-Apr	15.10771	145.70618	0	0	0	0	0	0
SAI-03	8-Apr	15.15610	145.76971	5	0	0	0	0	0
SAI-05	8-Apr	15.09784	145.74345	5	3	3	0	4	0
SAI-10	8-Apr	15.15660	145.75123	0	0	0	0	0	0
SAI-01	26-Apr	15.25903	145.81447	5	0	0	0	0	0
SAI-02	26-Apr	15.17646	145.78779	0	0	0	0	0	0
SAI-04	30-Apr	15.25542	145.72233	0	0	0	0	0	0
SAI-08	30-Apr	15.27406	145.79106	5	2	3	0	7	0

During cruise HA-11-01, Legs II and III, CRED completed 17 towed-diver surveys at Saipan, including one benthic calibration survey, covering a total length of 35.6 km (an area of 35.6 ha) on the ocean floor (Fig. F.2.2). One of these surveys was cut short and included less than the typical 10 survey segments. The mean survey length was 2.1 km with a range of 1.0–2.7 km. The mean survey depth was 14.8 m with a range of 12.2–17.8 m. The mean temperature from data recorded during these surveys was 28.3°C with a range of 27.9°C–28.7°C.

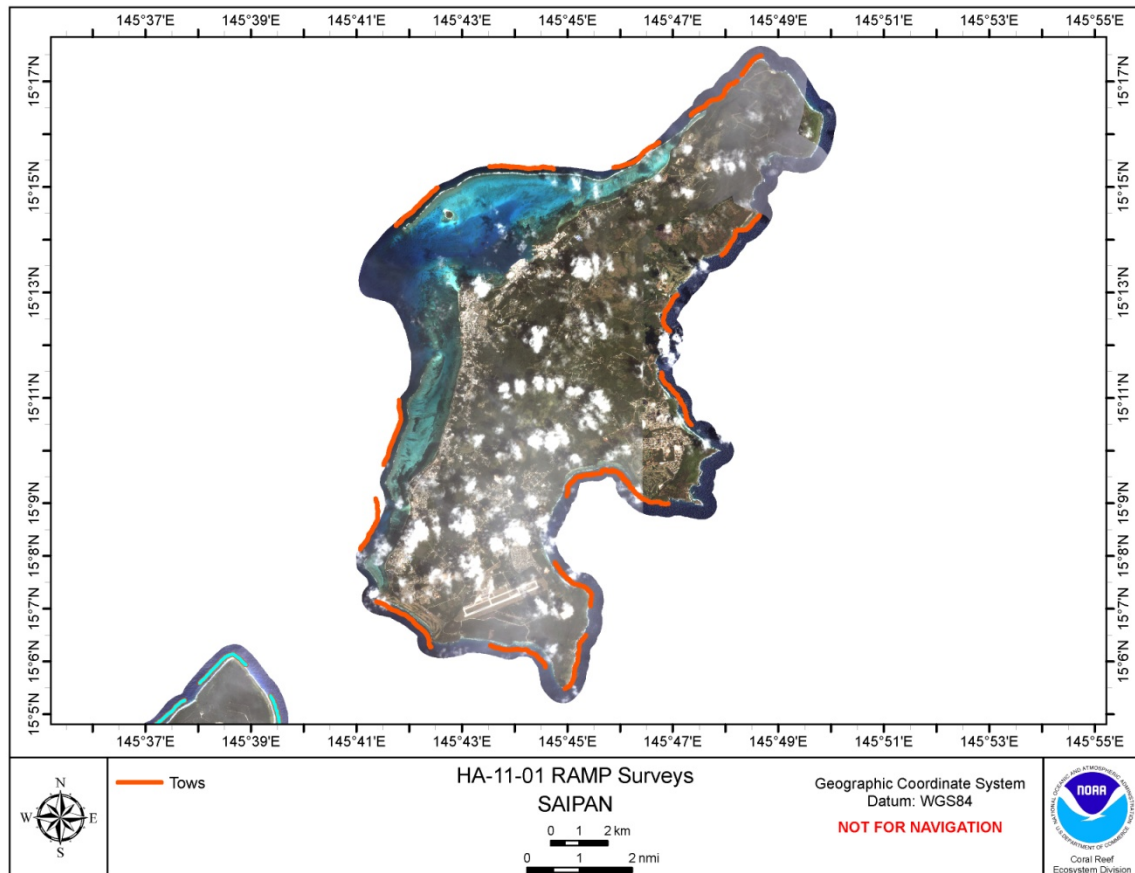


Figure F.2.2.--Track locations of towed-diver surveys conducted at Saipan during cruise HA-11-01, Legs II and III (IKONOS Carterra Geo Data, 2003).

F.3. 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 Saipan in the deep, moderate, and shallow foreereef strata (Fig. F.3.1 and Table F.3.1). No fishes were collected during these surveys.

In addition, CRED completed 16 towed-diver fish surveys at Saipan, as described previously in Section F.2 of this appendix. One of these surveys was cut short and included less than the typical 10 survey segments.

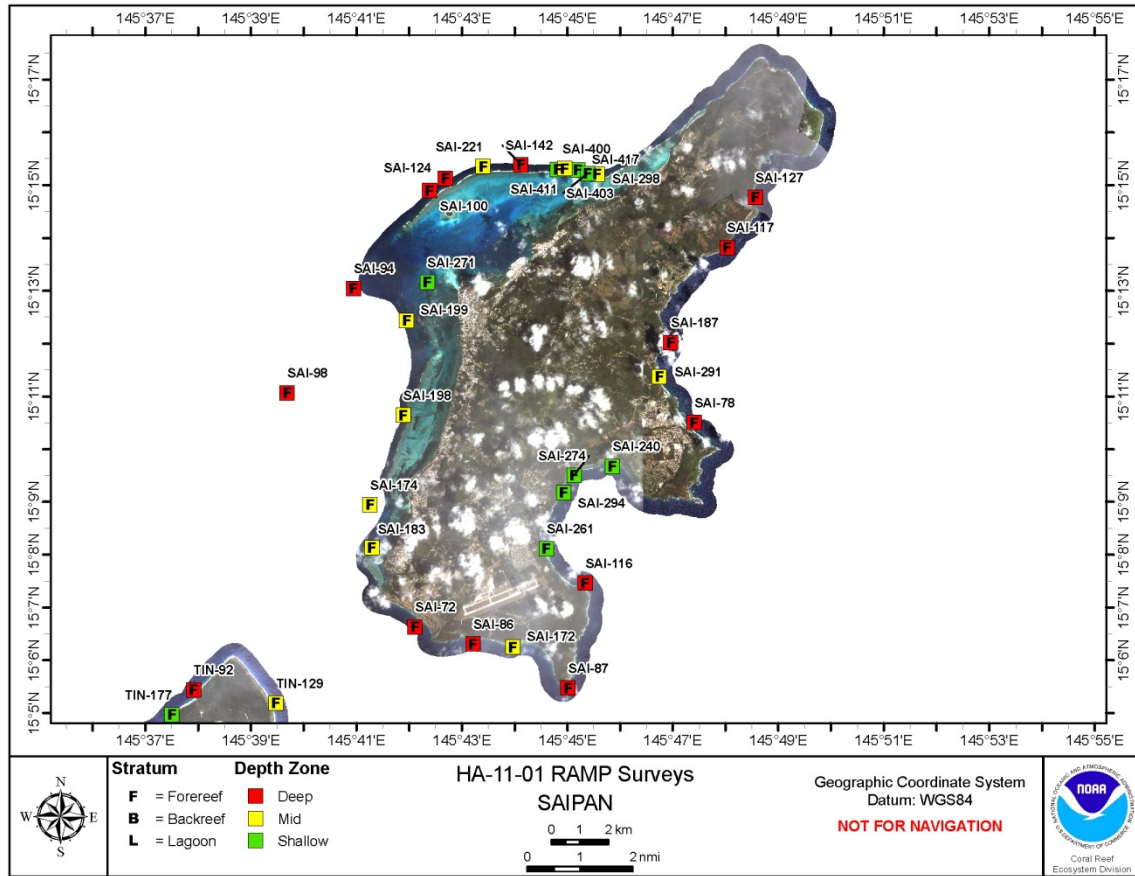


Figure F.3.1.--Locations of REA fish sites surveyed at Saipan during cruise HA-11-01, Legs II and III (IKONOS Carterra Geo Data, 2003). All of these REA sites were selected using a stratified random design.

Table F.3.1.--Summary of sites where REA fish surveys were conducted at Saipan during cruise HA-11-01, Legs II and III.

REA Site	Date	Depth Zone	Stratum	Depth (m)	Latitude	Longitude
SAI-94	7-Apr	Deep	Forereef	28	15.21748	145.68245
SAI-98	7-Apr	Deep	Forereef	21	15.18449	145.66151
SAI-174	7-Apr	Moderate	Forereef	18	15.14921	145.68766
SAI-183	7-Apr	Moderate	Forereef	9	15.13558	145.68825
SAI-198	7-Apr	Moderate	Forereef	8	15.17748	145.69817
SAI-199	7-Apr	Moderate	Forereef	13	15.20737	145.69923
SAI-271	7-Apr	Shallow	Forereef	5	15.21942	145.70572
SAI-72	8-Apr	Deep	Forereef	23	15.11063	145.70190
SAI-86	8-Apr	Deep	Forereef	22	15.10523	145.72023
SAI-87	8-Apr	Deep	Forereef	25.7	15.09128	145.75022
SAI-116	8-Apr	Deep	Forereef	23.7	15.12443	145.75567
SAI-172	8-Apr	Moderate	Forereef	13	15.10422	145.73283
SAI-240	8-Apr	Shallow	Forereef	5	15.16129	145.76430
SAI-261	8-Apr	Shallow	Forereef	5.5	15.13534	145.74341
SAI-274	8-Apr	Shallow	Forereef	5	15.15849	145.75218
SAI-294	8-Apr	Shallow	Forereef	4	15.15304	145.74883
SAI-78	26-Apr	Deep	Forereef	24	15.17512	145.79009
SAI-117	26-Apr	Deep	Forereef	26	15.23038	145.80050
SAI-127	26-Apr	Deep	Forereef	21	15.24626	145.80945
SAI-187	26-Apr	Deep	Forereef	24	15.20038	145.78270
SAI-291	26-Apr	Moderate	Forereef	6	15.18960	145.77904
SAI-100	30-Apr	Deep	Forereef	20	15.24833	145.70637
SAI-124	30-Apr	Deep	Forereef	22	15.25223	145.71148
SAI-142	30-Apr	Deep	Forereef	27	15.25652	145.73532
SAI-221	30-Apr	Moderate	Forereef	12.5	15.25597	145.72341
SAI-298	30-Apr	Moderate	Forereef	12	15.25354	145.75943
SAI-400	30-Apr	Moderate	Forereef	11.6	15.25532	145.74910
SAI-403	30-Apr	Shallow	Forereef	5	15.25380	145.75643
SAI-411	30-Apr	Shallow	Forereef	6	15.25506	145.74691
SAI-417	30-Apr	Shallow	Forereef	6	15.25483	145.75334

APPENDIX G: SARIGAN

The island of Sarigan is located at 16.70° N, 145.78° W in the North Pacific in the Mariana Archipelago. For information about the methods used to perform the activities discussed in this appendix, please see Appendix A: “Methods.”

G.1. Oceanography and Water Quality

Oceanographic operations during the cruise HA-11-01, Leg II, at Sarigan entailed retrieval and replacement of two subsurface temperature recorders (STRs), shipboard water sampling and conductivity, temperature, and depth (CTD) casts offshore to a depth of 500 m, and an acoustic Doppler current profiler (ADCP) transect line (Fig. G.1.1 and Table G.1.1). A single nutrient water sample was collected at a nearshore location near Rapid Ecological Assessment (REA) site SAR-03 for microbiological analysis.

From the NOAA Ship *Hi'ialakai*, an ADCP transect line ~ 20 km long was run west away from this island during night operations. On the reciprocal course, shipboard CTD casts were conducted to a depth of 500 m every 5 km for a total of four deepwater CTD casts (Fig. G.1.2).

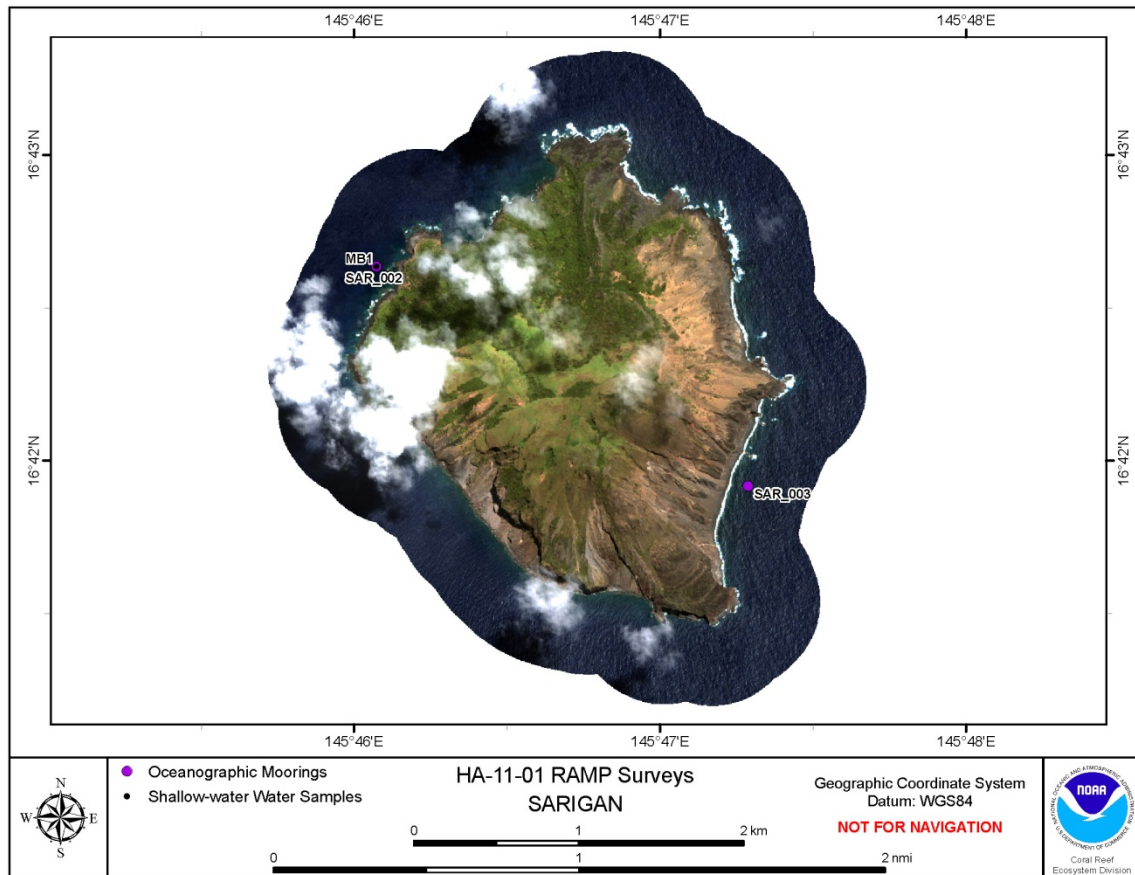


Figure G.1.1.--Mooring sites where oceanographic instruments were retrieved or deployed and the location (MB1) of nearshore water sampling performed at Sarigan during cruise HA-11-01, Leg II (IKONOS Carterra Geo Data, 2002).

Table G.1.1.--Geographic coordinates and sensor depths of STRs that were retrieved or deployed at Sarigan during cruise HA-11-01, Leg II.

Mooring Site	Date	Instrument Type	Latitude	Longitude	Depth (m)	Retrieved	Deployed
SAR-002	10-Apr	STR	16.71059	145.76787	5.8	1	1
SAR-003	10-Apr	STR	16.69862	145.78812	11.3	1	1

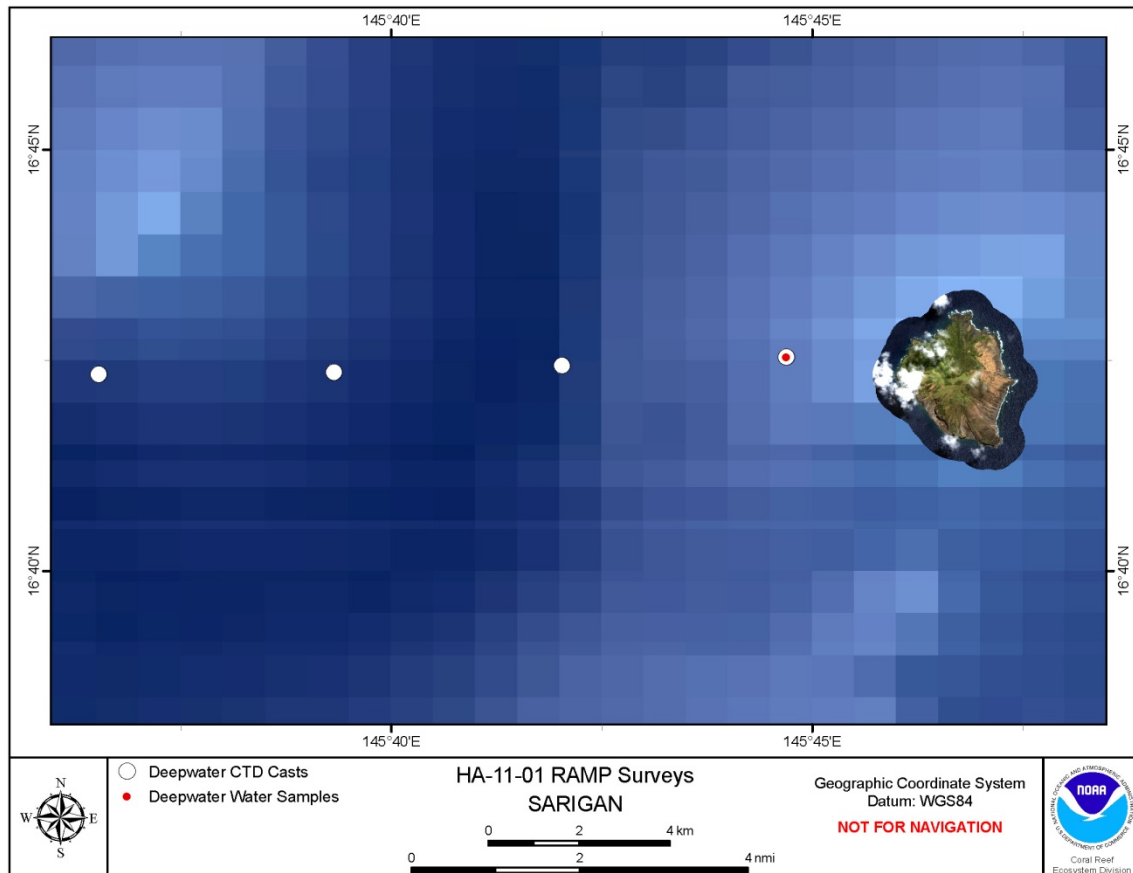


Figure G.1.2.--Locations of deepwater CTD casts and water sampling performed at Sarigan during cruise HA-11-01, Leg II. Island satellite image IKONOS Carterra Geo Data, 2002, and background imagery SIO, NOAA, U.S. Navy, NGA, GEBCO (Becker, 2009; Smith and Sandwell, 1997) © 2008 The Regents of the University of California.

G.2. Benthic Environment

Belt-transect and line-point-intercept (LPI) surveys were conducted and photographs were taken along transect lines at three REA sites at Sarigan to assess benthic composition, coral and algal community structure, and coral and algal disease (Fig. G.2.1 and Table G.2.1).

Seven water samples were collected at SAR-03 for microbial analyses, with four water samples of 2 L each and three water samples of 20 L each (Table G.2.2). For more information about collections made at REA sites, see Table Q.1.1 in Appendix Q: “Biological Collections.”

In total, the benthic team conducted 18 individual dives at REA sites at Sarigan.

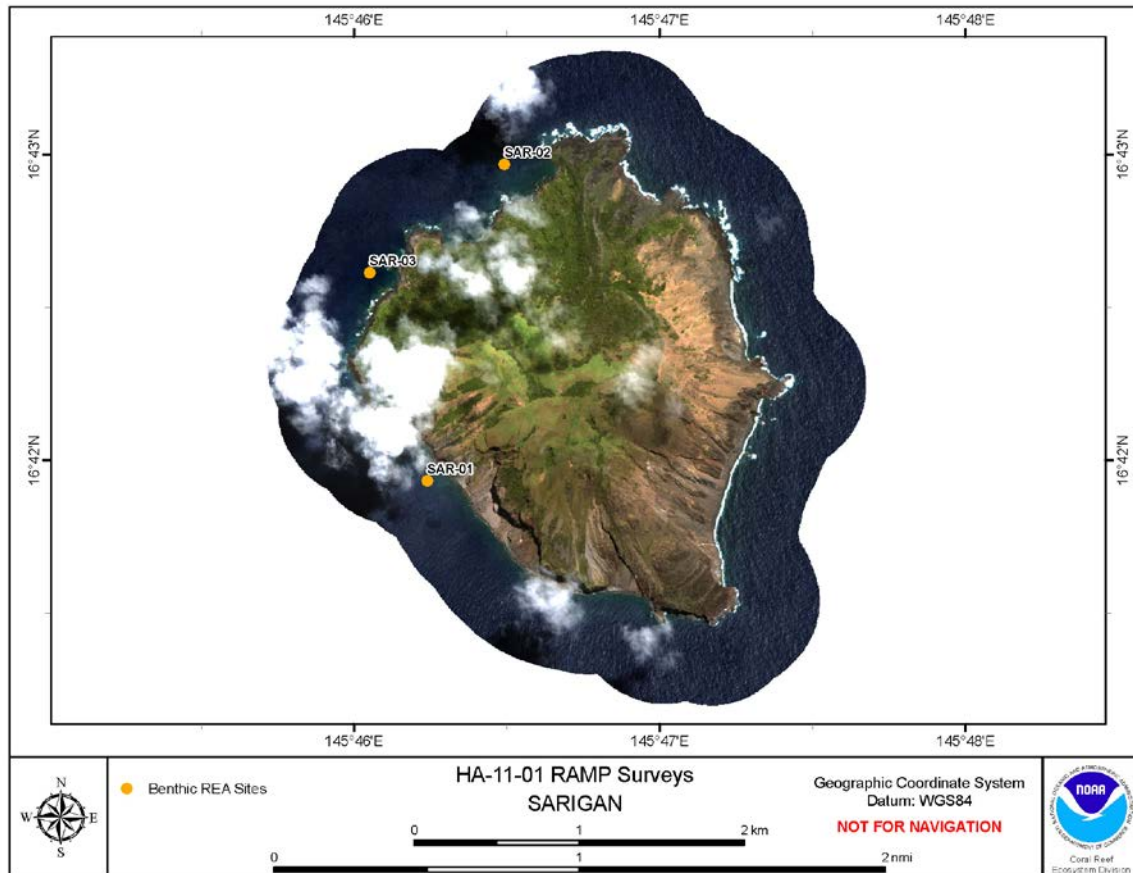


Figure G.2.1.--Locations of REA benthic sites surveyed at Sarigan during cruise HA-11-01, Leg II (IKONOS Carterra Geo Data, 2002).

Table G.2.1.--Summary of REA benthic surveys performed at Sarigan during cruise HA-11-01, Leg II. Indication that an LPI survey was completed also means that photographs were taken along transect lines.

REA Site	Date	Latitude	Longitude	REA Surveys			
				LPI	Roving Diver	Corals	Inverts
SAR-01	10-Apr	16.69888	145.77065	×	×	×	—
SAR-02	10-Apr	16.71614	145.77486	×	×	×	—
SAR-03	10-Apr	16.71023	145.76752	×	×	×	—

Table G.2.2.--Summary of installation and collection activities at REA sites at Sarigan during cruise HA-11-01, Leg II, including collection of microbial water samples.

REA Site	Date	Latitude	Longitude	Installations and Collections					
				CAUs	ARMS Ret	ARMS Dep	Algae	Microbial Samples	Coral Cores
SAR-01	10-Apr	16.69888	145.77065	0	0	0	0	0	0
SAR-02	10-Apr	16.71614	145.77486	0	0	0	0	0	0
SAR-03	10-Apr	16.71023	145.76752	0	0	0	0	7	0

During cruise HA-11-01, Leg II, CRED completed four towed-diver surveys at Sarigan, covering a total length of 8.0 km (an area of 8.0 ha) on the ocean floor (Fig. G.2.2). The mean survey length was 2.0 km with a range of 1.2–2.4 km. The mean survey depth was 15.7 m with a range of 14.5–17.5 m. The mean temperature from data recorded during these surveys was 27.5°C with a range of 27.4°C–27.6°C.

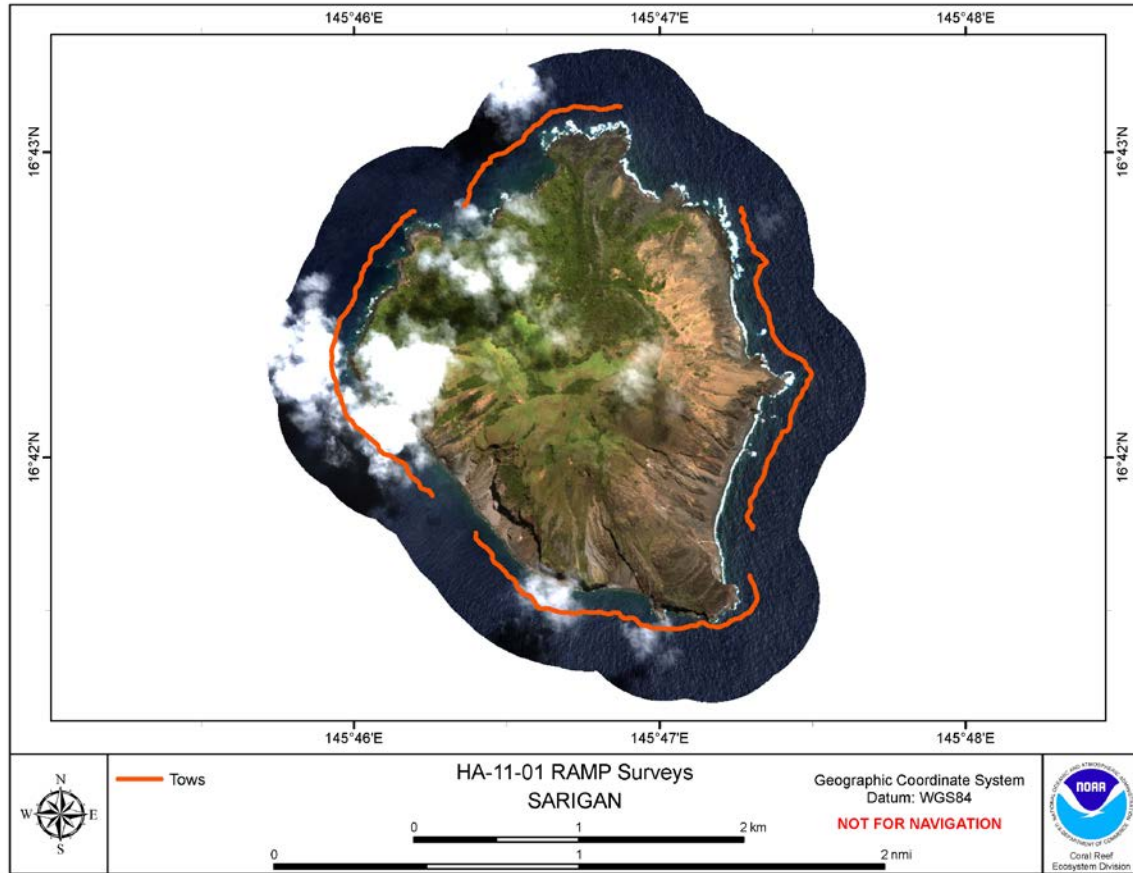


Figure G.2.2.--Track locations of towed-diver surveys conducted at Sarigan during cruise HA-11-01, Leg II (IKONOS Carterra Geo Data, 2002).

G.3. Reef Fish Community

REA fish survey sites were chosen using a stratified random design. Stationary-point-count surveys were conducted at nine REA sites at Sarigan in the deep, moderate, and shallow forereef strata (Fig. G.3.1 and Table G.3.1). No fishes were collected during these surveys.

In addition, CRED completed four towed-diver surveys at Sarigan, as described previously in Section G.2 of this appendix.

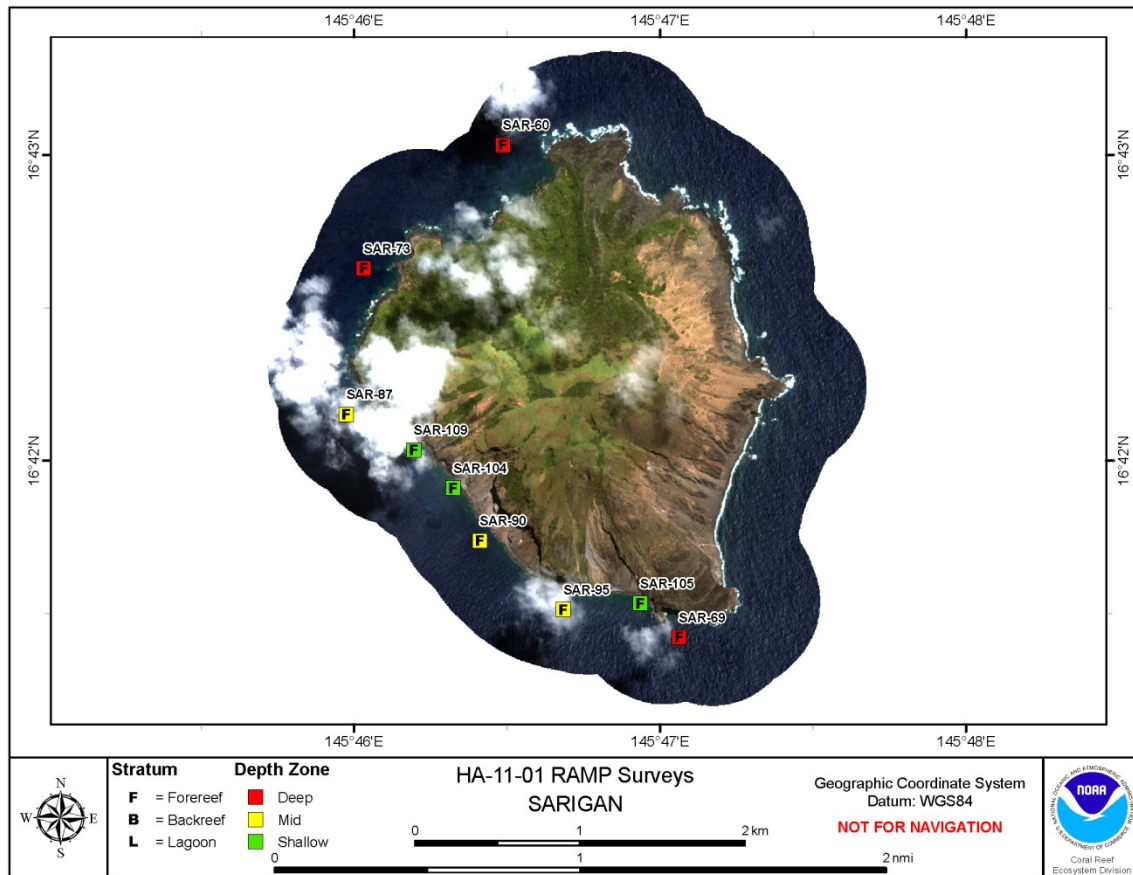


Figure G.3.1.--Locations of REA fish sites surveyed at Sarigan during cruise HA-11-01, Leg II (IKONOS Carterra Geo Data, 2002). All of these REA sites were selected using a stratified random design.

Table G.3.1.--Summary of sites where REA fish surveys were conducted at Sarigan during cruise HA-11-01, Leg II.

REA Site	Date	Depth Zone	Stratum	Depth (m)	Latitude	Longitude
SAR-60	10-Apr	Deep	Forereef	26	16.71723	145.77476
SAR-69	10-Apr	Deep	Forereef	23	16.69039	145.78436
SAR-73	10-Apr	Deep	Forereef	21	16.71050	145.76719
SAR-87	10-Apr	Moderate	Forereef	15	16.70254	145.76624
SAR-90	10-Apr	Moderate	Forereef	15	16.69566	145.77352
SAR-95	10-Apr	Moderate	Forereef	12	16.69190	145.77806
SAR-104	10-Apr	Shallow	Forereef	4	16.69852	145.77207
SAR-105	10-Apr	Shallow	Forereef	5	16.69224	145.78224
SAR-109	10-Apr	Shallow	Forereef	6	16.70060	145.76990

APPENDIX H: ZEALANDIA BANK

Zealandia Bank, located at 16.90° N, 145.85° W in the North Pacific, is a submerged bank with no emergent land in the Mariana Archipelago. Oceanographic operations during the cruise HA-11-01, Leg II, at Zealandia Bank (Table H.1.1) entailed the removal of a mooring anchor and retrieval and deployment of one subsurface temperature recorder (STR). No Rapid Ecological Assessment or towed-diver surveys were conducted. For information about the methods used to perform the activities discussed in this appendix, please see Appendix A: “Methods.”

Table H.1.1.--Geographic coordinates and depths of the STRs and anchor that were deployed at Zealandia Bank during cruise HA-11-01, Leg II.

Mooring Site	Date	Instrument Type	Latitude	Longitude	Depth (m)	Retrieved	Deployed
ZEA-001	25-Apr	STR	16.89749	145.85339	23.95	1	1
ZEA-001	25-Apr	Anchor	16.89748	145.85340	24.7	1	–

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APPENDIX I: GUGUAN

The island of Guguan is located at 17.31° N, 145.84° W in the North Pacific in the Mariana Archipelago. For information about the methods used to perform the activities discussed in this appendix, please see Appendix A: “Methods.”

I.1. Oceanography and Water Quality

Oceanographic operations during the cruise HA-11-01, Leg II, at Guguan entailed the retrieval and replacement of one subsurface temperature recorder (STR), shipboard water sampling and conductivity, temperature, and depth (CTD) casts offshore to a depth of 500 m, and an acoustic Doppler current profiler (ADCP) transect line (Fig. I.1.1 and Table I.1.1). A single nutrient water sample was collected at a nearshore location near Rapid Ecological Assessment (REA) site GUG-02 for microbiological analysis.

From the NOAA Ship *Hi'ialakai*, an ADCP transect line ~ 45 km was run west away from this island during night operations. On the reciprocal course, shipboard CTD casts were conducted to a depth of 500 m every 5 km for a total of eight deepwater CTD casts. Water samples were collected concurrently with one select shipboard CTD cast at five depths between the surface and 200 m, depending on the depth of mixed layer as determined by the CTD downcast (Fig. I.1.2). Near Guguan, five nutrient and five Chl-*a* shipboard water samples were collected.

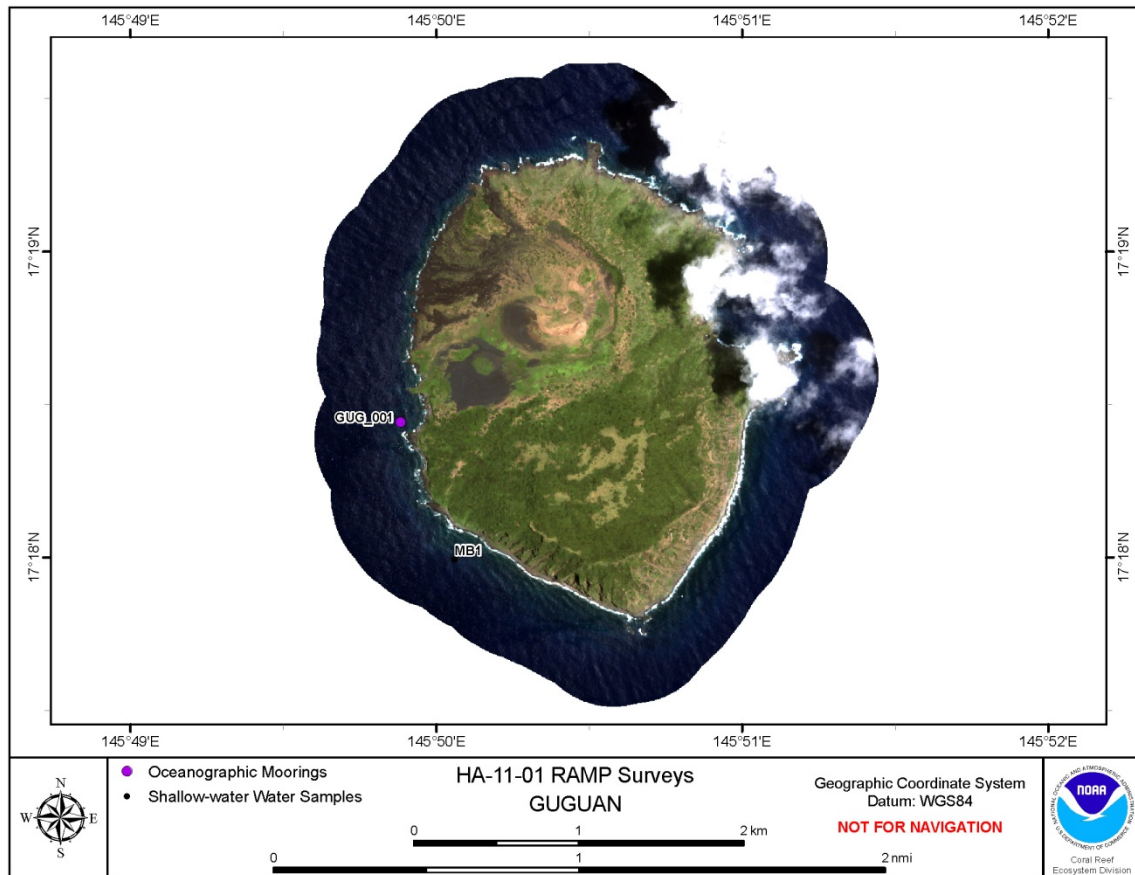


Figure I.1.1.--Mooring site where an STR was retrieved or deployed and location (MB1) of the nearshore water sampling performed at Guguan during cruise HA-11-01, Leg II (IKONOS Carterra Geo Data, 2002).

Table I.1.1.--Geographic coordinates and sensor depth of the STRs that were retrieved or deployed at Guguan during cruise HA-11-01, Leg II.

Mooring Site	Date	Instrument Type	Latitude	Longitude	Depth (m)	Retrieved	Deployed
GUG-001	24-Apr	STR	17.30738	145.83138	6.4	1	1

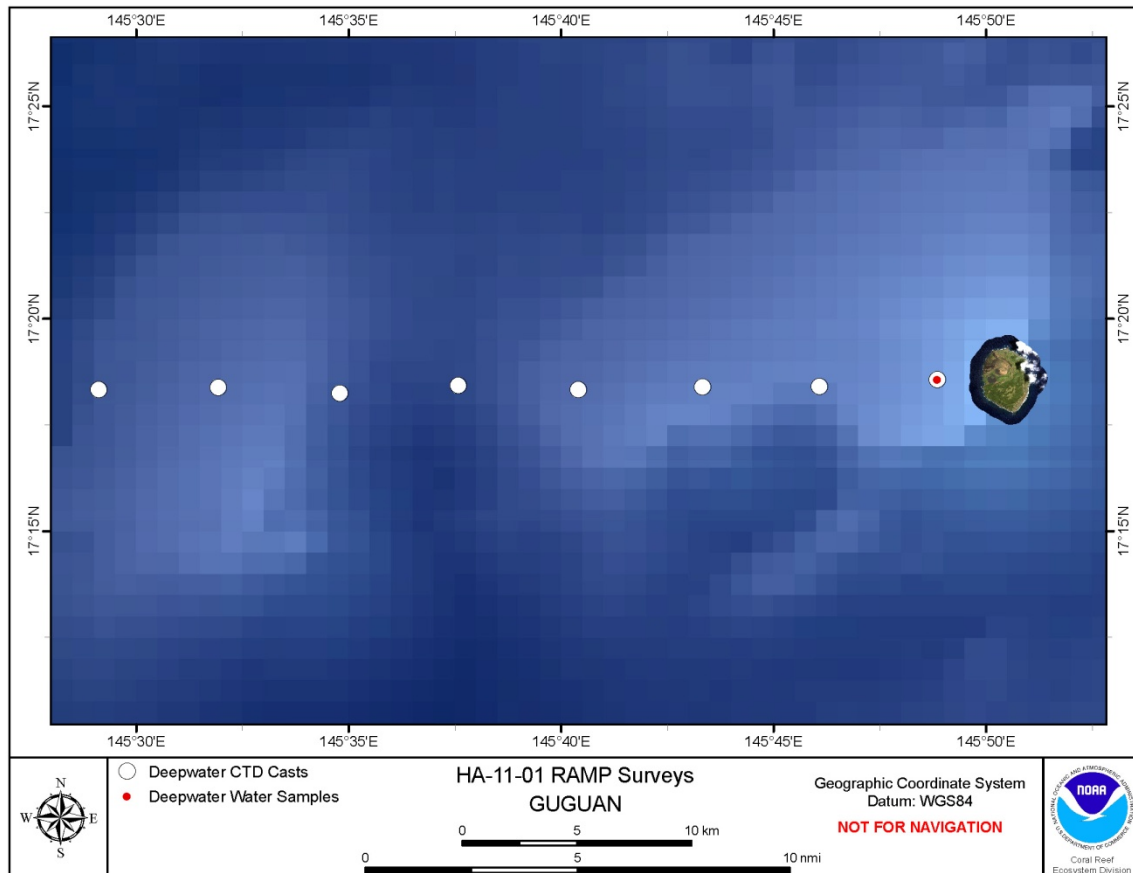


Figure I.1.2.--Locations of deepwater CTD casts and water sampling performed at Guguan during cruise HA-11-01, Leg II. Island satellite image IKONOS Carterra Geo Data, 2002, and background imagery SIO, NOAA, U.S. Navy, NGA, GEBCO (Becker, 2009; Smith and Sandwell, 1997) © 2008 The Regents of the University of California.

I.2. Benthic Environment

Belt-transect, line-point-intercept (LPI), and roving-diver algal surveys were conducted and photographs were taken along transect lines at three REA sites at Guguan to assess benthic composition, coral and algal community structure, coral and algal disease, and target macroinvertebrates (Fig. I.2.1 and Table I.2.1).

Various samples were collected at two REA sites (Table I.2.1): two algal voucher specimens at GUG-01 for taxonomic identification and seven water samples for microbial analyses at GUG-02 with four water samples of 2 L each and three water samples of 20 L each. For more information about collections made at REA sites, see Table Q.1.1 in Appendix Q: “Biological Collections.”

In total, the benthic team conducted 20 individual dives at REA sites at Guguan.

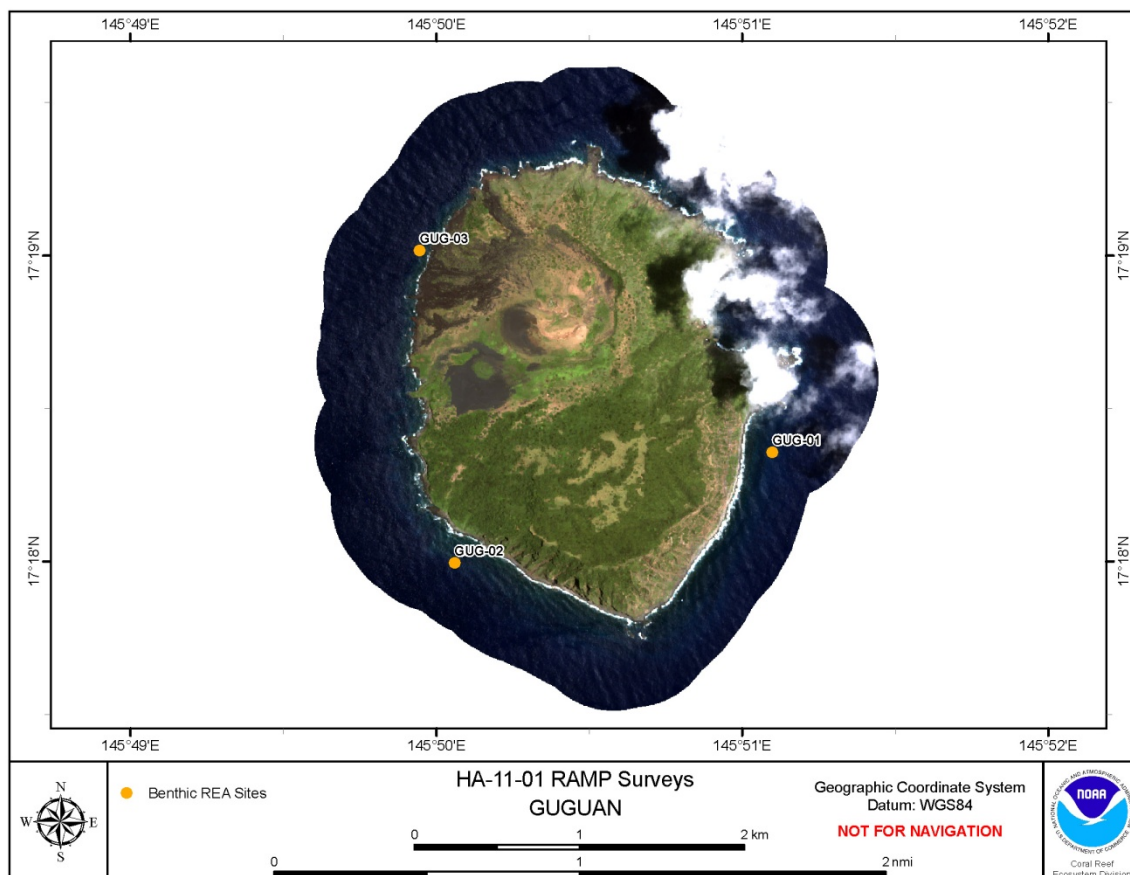


Figure I.2.1.--Locations of REA benthic sites surveyed at Guguan during cruise HA-11-01, Leg II (IKONOS Carterra Geo Data, 2002).

Table I.2.1.--Summary of REA benthic surveys performed at Guguan during cruise HA-11-01, Leg II. Indication that an LPI survey was completed also means that photographs were taken along transect lines.

REA Site	Date	Latitude	Longitude	REA Surveys			
				LPI	Roving Diver	Corals	Inverts
GUG-01	24-Apr	17.30597	145.85164	×	×	×	×
GUG-02	24-Apr	17.29993	145.83433	×	×	×	×
GUG-03	24-Apr	17.31696	145.83243	×	×	×	×

Table I.2.2.--Summary of installation and collection activities at REA sites at Guguan during cruise HA-11-01, Leg II, including collection of algal specimens and microbial water samples.

REA Site	Date	Latitude	Longitude	Installations and Collections					
				CAUs	ARMS Ret	ARMS Dep	Algae	Microbial Samples	Coral Cores
GUG-01	24-Apr	17.30597	145.85164	0	0	0	2	0	0
GUG-02	24-Apr	17.29993	145.83433	0	0	0	0	7	0
GUG-03	24-Apr	17.31696	145.83243	0	0	0	0	0	0

During cruise HA-11-01, Leg II, CRED completed five towed-diver surveys at Guguan, covering a total length of 10.6 km (an area of 10.6 ha) on the ocean floor (Fig. I.2.2). The mean survey length was 2.1 km with a range of 1.5–2.7 km. The mean survey depth was 14.8 m with a range of 13.7–15.7 m. The mean temperature from data recorded during these surveys was 27.8°C with a range of 27.8°C–27.9°C.

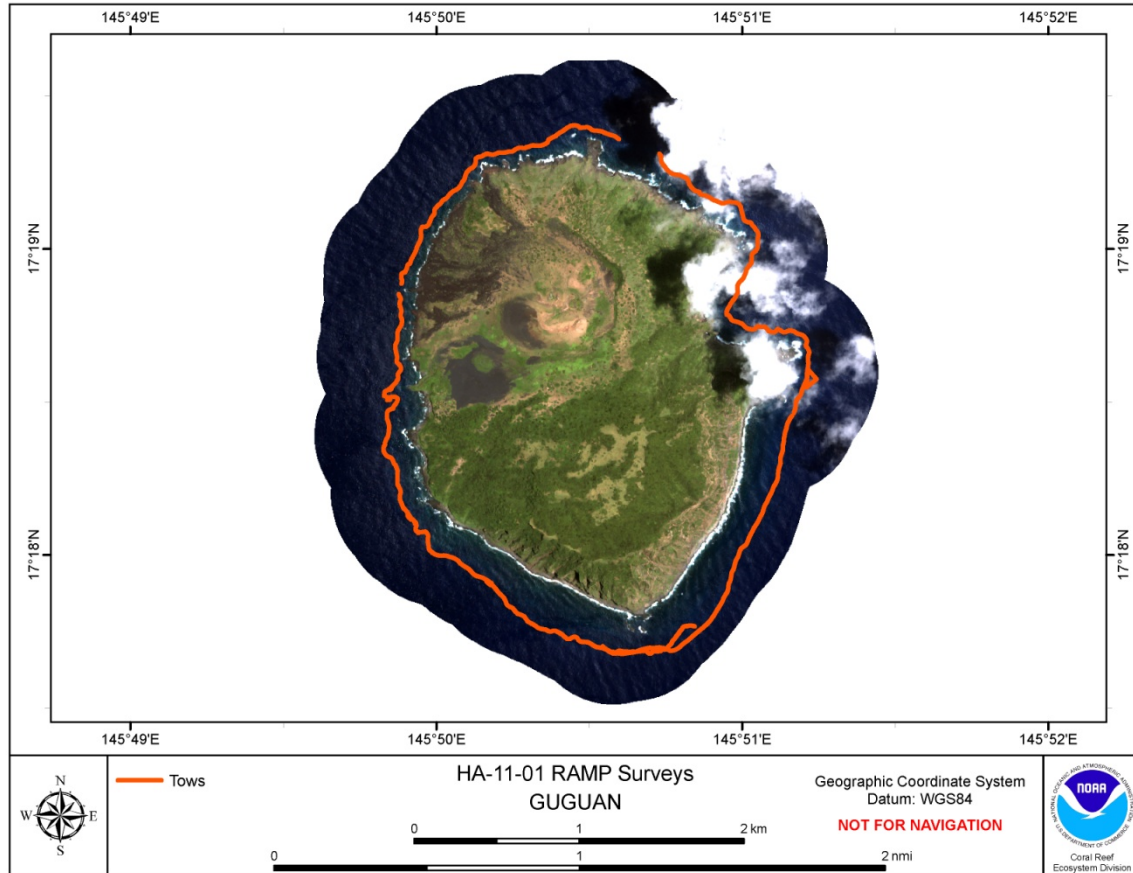


Figure I.2.2.--Track locations of towed-diver surveys conducted at Guguan during cruise HA-11-01, Leg II (IKONOS Carterra Geo Data, 2002).

I.3. Reef Fish Community

REA fish survey sites were chosen using a stratified random design. Stationary-point-count surveys were conducted at 10 REA sites at Guguan in the deep, moderate, and shallow forereef strata (Fig. I.3.1 and Table I.3.1). No fishes were collected during these surveys.

In addition, CRED completed five towed-diver surveys at Guguan, as described previously in Section I.2 of this appendix.

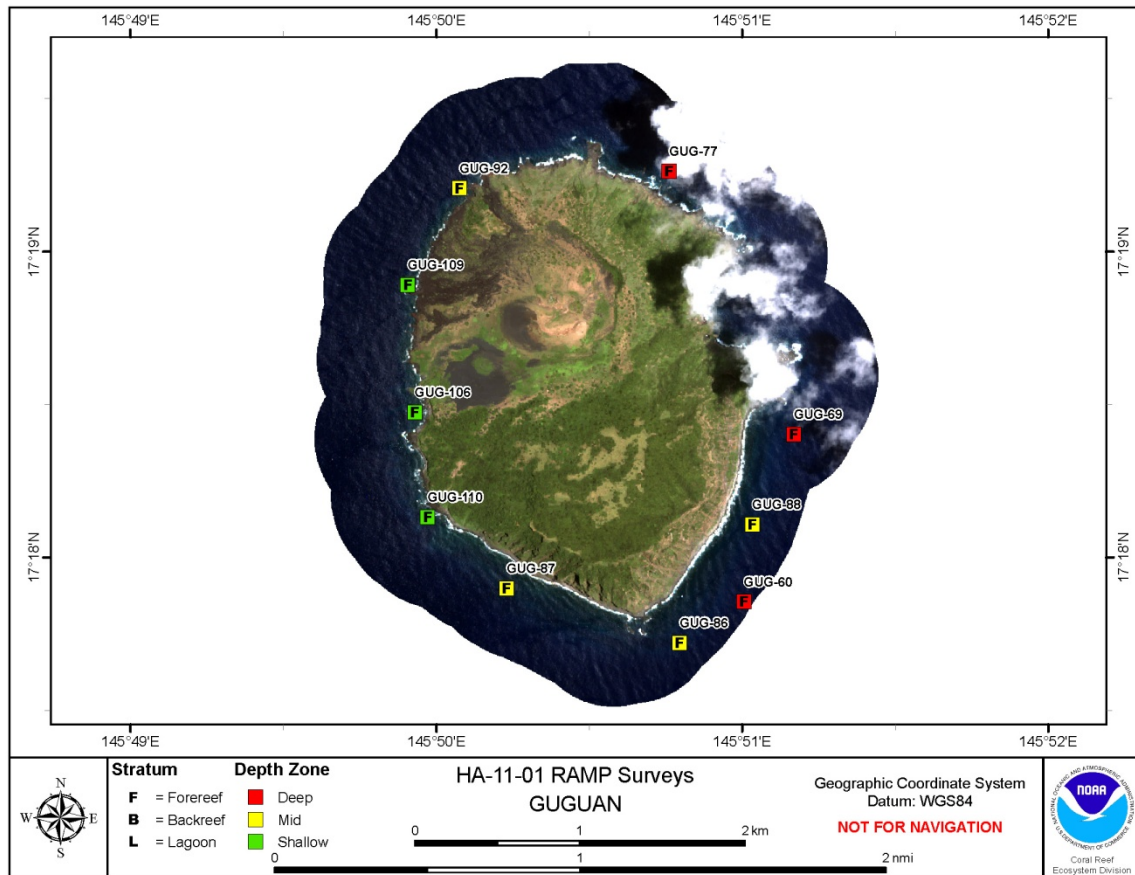


Figure I.3.1.--Locations of REA fish sites surveyed at Guguan during cruise HA-11-01, Leg II (IKONOS Carterra Geo Data, 2002). All of these REA sites were selected using a stratified random design.

Table I.3.1.--Summary of sites where REA fish surveys were conducted at Guguan during cruise HA-11-01, Leg II.

REA Site	Date	Depth Zone	Stratum	Depth (m)	Latitude	Longitude
GUG-60	24-Apr	Deep	Forereef	23	17.29761	145.85010
GUG-69	24-Apr	Deep	Forereef	21	17.30673	145.85281
GUG-77	24-Apr	Deep	Forereef	23	17.32107	145.84603
GUG-86	24-Apr	Moderate	Forereef	16	17.29538	145.84658
GUG-87	24-Apr	Moderate	Forereef	11	17.29834	145.83717
GUG-88	24-Apr	Moderate	Forereef	14	17.30182	145.85055
GUG-92	24-Apr	Moderate	Forereef	15	17.32013	145.83459
GUG-106	24-Apr	Shallow	Forereef	5	17.30794	145.83216
GUG-109	24-Apr	Shallow	Forereef	6	17.31487	145.83177
GUG-110	24-Apr	Shallow	Forereef	5	17.30223	145.83287

APPENDIX J: ALAMAGAN

The island of Alamagan is located at 17.60° N, 145.83° W in the North Pacific in the Mariana Archipelago. For information about the methods used to perform the activities discussed in this appendix, please see Appendix A: “Methods.”

J.1. Oceanography and Water Quality

Oceanographic operations during the cruise HA-11-01, Leg II, at Alamagan entailed retrieval and replacement of two subsurface temperature recorders (STRs), shipboard conductivity, temperature, and depth (CTD) casts offshore to a depth of 500 m, and an acoustic Doppler current profiler (ADCP) transect line (Fig. J.1.1 and Table J.1.1). A single nutrient water sample was collected at a nearshore location near Rapid Ecological Assessment (REA) site ALA-03 for microbiological analysis.

From the NOAA Ship *Hi'ialakai*, an ADCP transect line ~ 50 km long was run west away from this island during night operations. On the reciprocal course, shipboard CTD casts were conducted to a depth of 500 m every 5 km for a total of seven deepwater CTD casts (Fig. J.1.2.). Shipboard water samples were not collected at Alamagan.

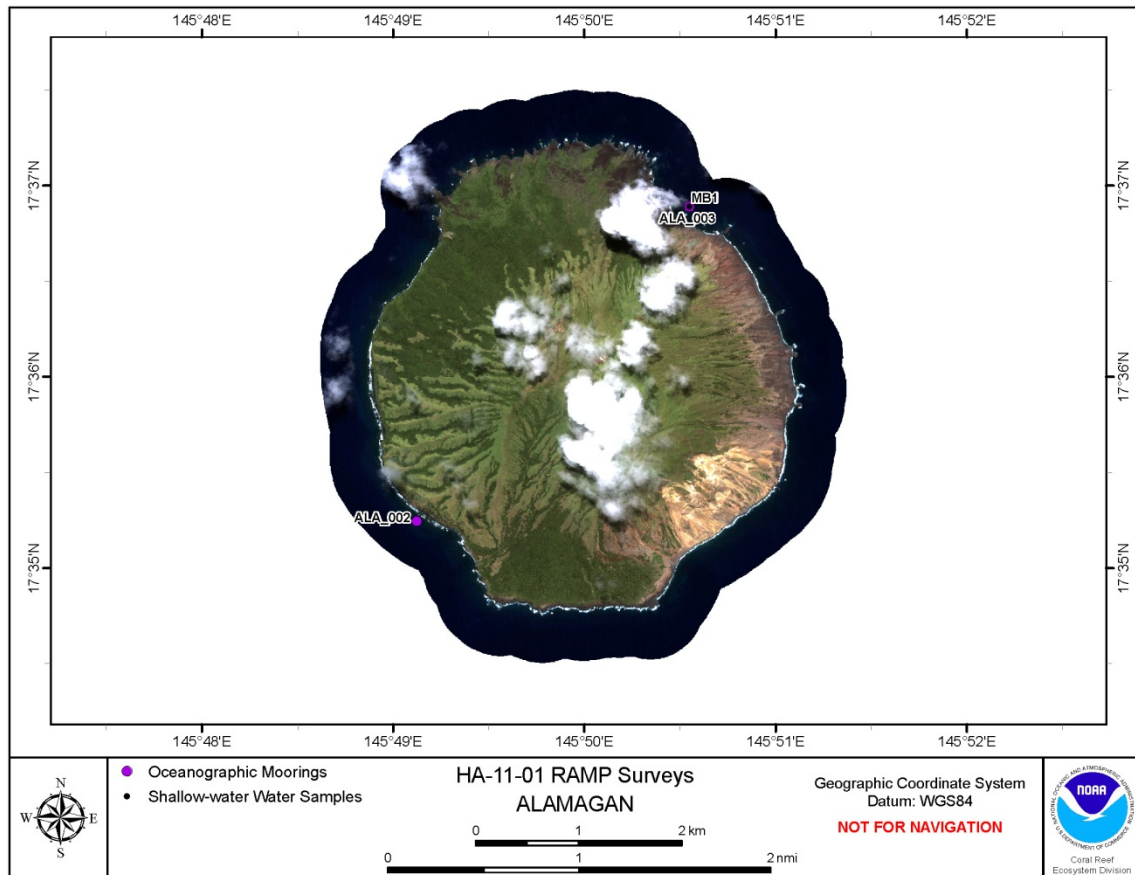


Figure J.1.1.--Mooring sites where STRs were retrieved or deployed and location (MB1) of the nearshore water sampling performed at Alamagan during cruise HA-11-01, Leg II (IKONOS Carterra Geo Data, 2002).

Table J.1.1.--Geographic coordinates and sensor depths of the STRs that were retrieved or deployed at Alamagan Island during cruise HA-11-01, Leg II.

Mooring Site	Date	Instrument Type	Latitude	Longitude	Depth (m)	Retrieved	Deployed
ALA-002	23-Apr	STR	17.58745	145.81873	6.7	1	1
ALA-003	23-Apr	STR	17.61485	145.84250	15.8	1	1

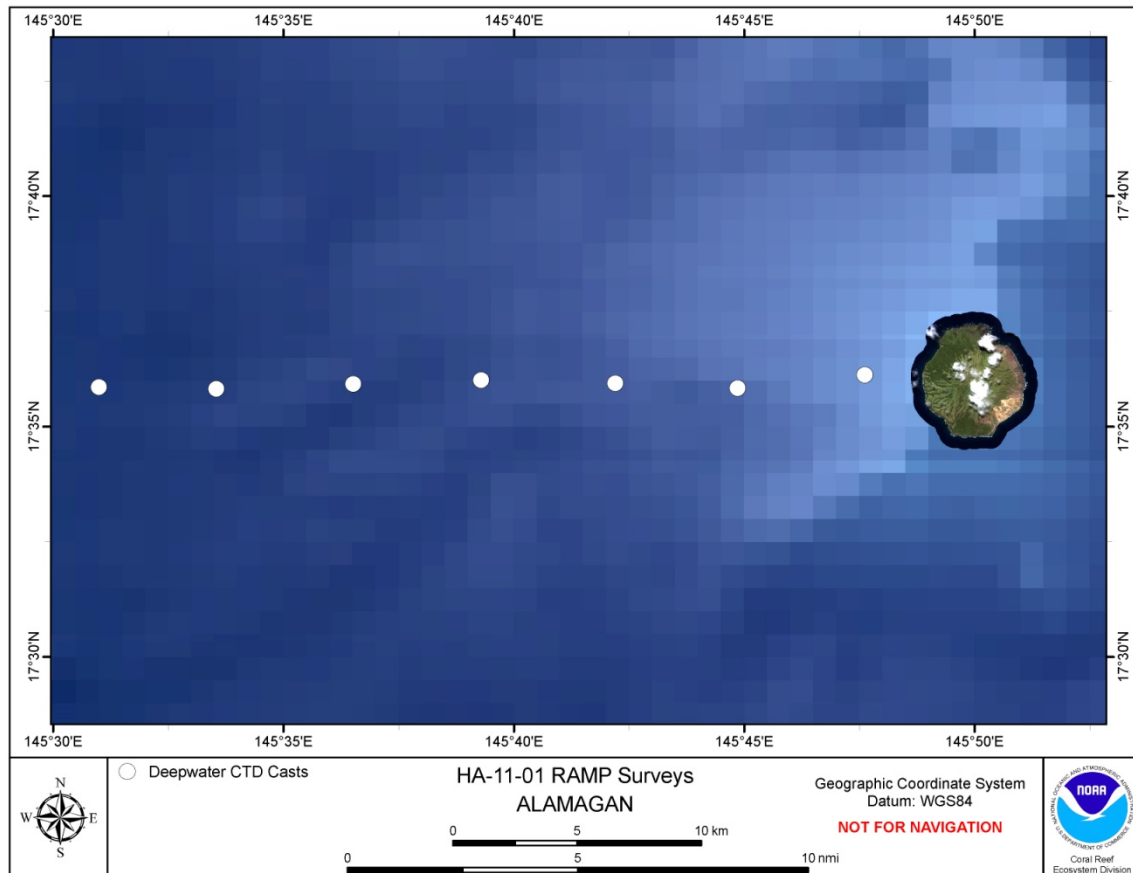


Figure J.1.2.--Locations of deepwater CTD casts performed at Alamagan during cruise HA-11-01, Leg II. Island satellite image IKONOS Carterra Geo Data, 2002, and background imagery SIO, NOAA, U.S. Navy, NGA, GEBCO (Becker, 2009; Smith and Sandwell, 1997) © 2008 The Regents of the University of California.

J.2. Benthic Environment

Belt-transect, line-point-intercept (LPI), and roving-diver algal surveys were conducted and photographs were taken along transect lines at two REA sites at Alamagan, ALA-02 and ALA-03, to assess benthic composition, coral and algal community structure, and coral and algal disease (Fig. J.2.1 and Table J.2.1). No benthic surveys were completed at ALA-01 because of heavy sea conditions.

Four water samples of 2 L each were collected at ALA-01 for microbial analyses (Table J.2.2). For more information about collections made at REA sites, see Table Q.1.1 in Appendix Q: “Biological Collections.”

In total, the benthic team conducted 12 individual dives at REA sites at Alamagan.

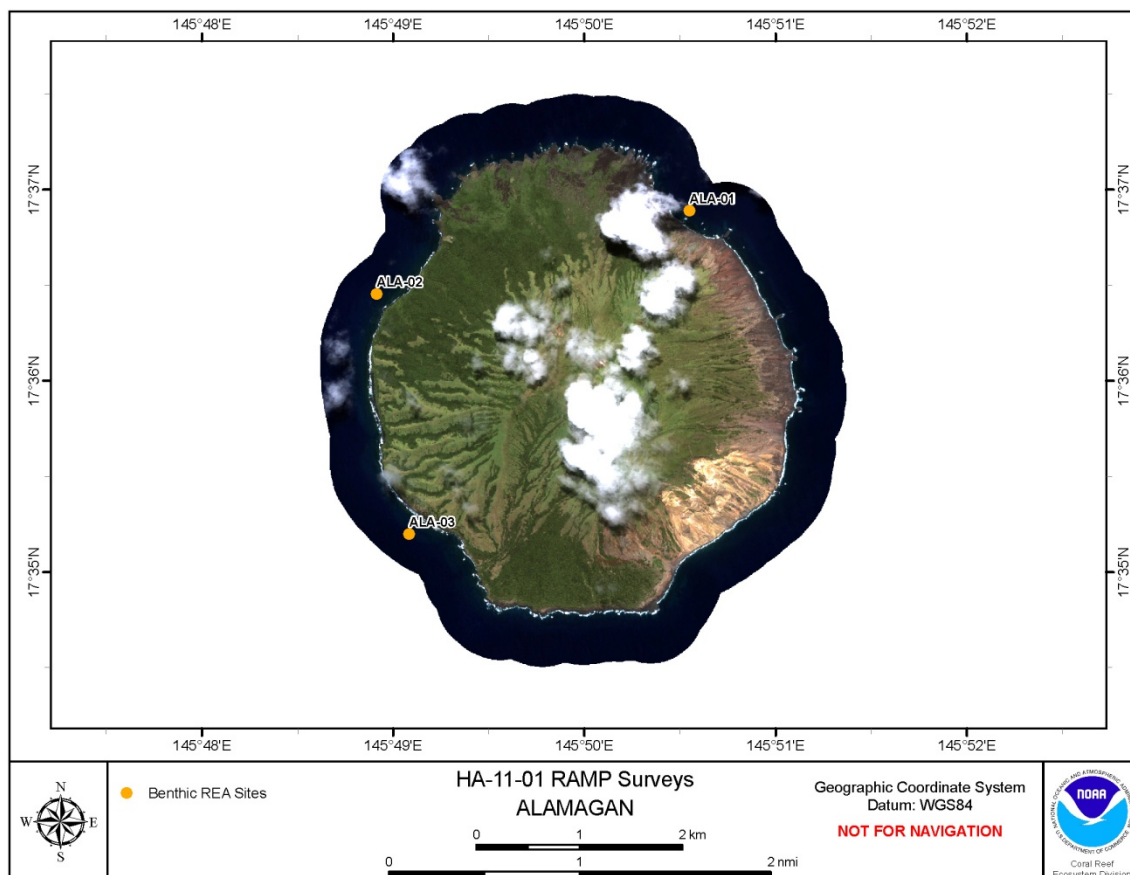


Figure J.2.1.--Locations of REA benthic sites surveyed at Alamagan during cruise HA-11-01, Leg II (IKONOS Carterra Geo Data, 2002).

Table J2.1.--Summary of REA benthic surveys performed at Alamagan during cruise HA-11-01, Leg II. Indication that an LPI survey was completed also means that photographs were taken along transect lines.

REA Site	Date	Latitude	Longitude	REA Surveys			
				LPI	Roving Diver	Corals	Inverts
ALA-01	23-Apr	17.61485	145.84250	–	–	–	–
ALA-02	23-Apr	17.60759	145.81523	×	×	×	–
ALA-03	23-Apr	17.58667	145.81806	×	×	×	–

Table J.2.2.--Summary of installation and collection activities at REA sites at Alamagan during cruise HA-11-01, Leg II, including collection of microbial water samples.

REA Site	Date	Latitude	Longitude	Installations and Collections					
				CAUs	ARMS Ret	ARMS Det	Algae	Microbial Samples	Coral Cores
ALA-01	23-Apr	17.61485	145.84250	0	0	0	0	4	0
ALA-02	23-Apr	17.60759	145.81523	0	0	0	0	0	0
ALA-03	23-Apr	17.58667	145.81806	0	0	0	0	0	0

During cruise HA-11-01, Leg II, CRED completed three towed-diver surveys at Alamagan, covering a total length of 7.3 km (an area of 7.3 ha) on the ocean floor (Fig. J.2.2). The mean survey length was 2.4 km with a range of 2.2-2.6 km. The mean survey depth was 14.7 m with a range of 12.5-16.9 m. The mean temperature from data recorded during these surveys was 27.8°C with a range of 27.8°C–27.9°C.

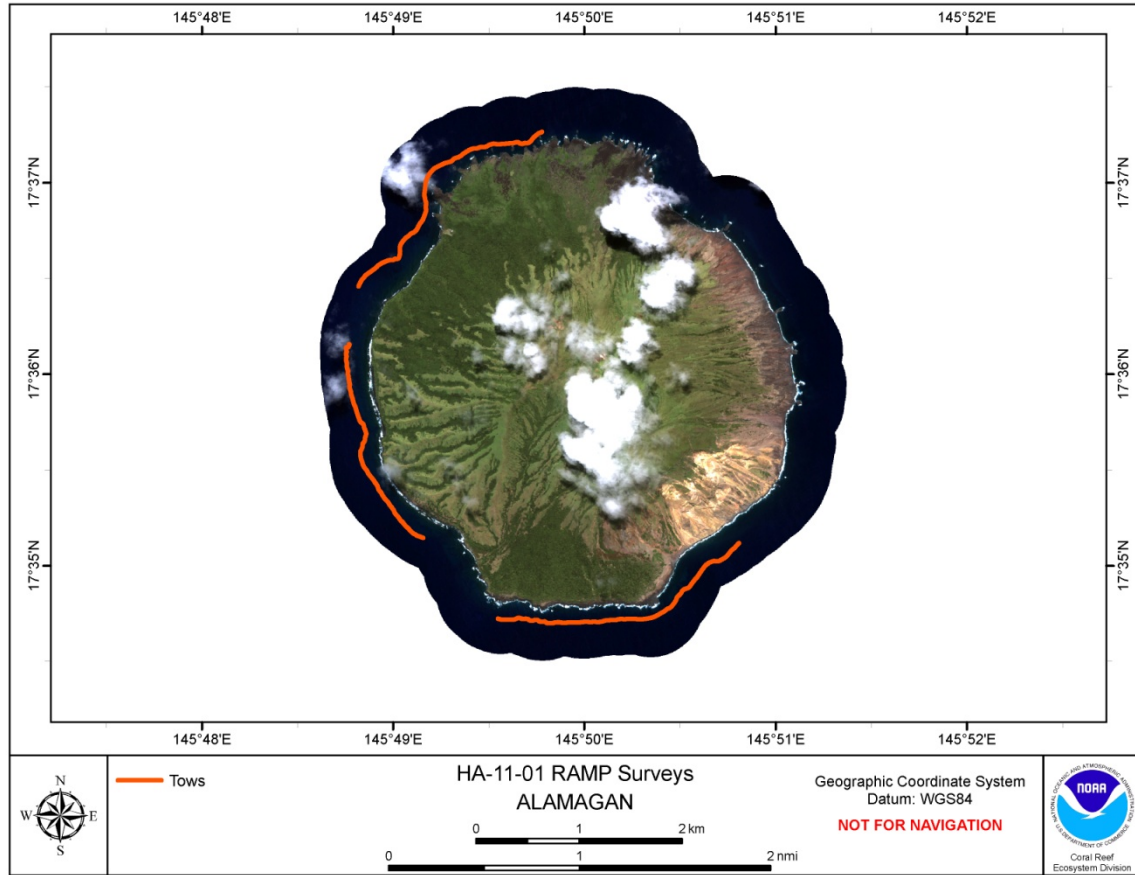


Figure J.2.2.--Track locations of towed-diver surveys conducted at Alamagan during cruise HA-11-01, Leg II (IKONOS Carterra Geo Data, 2002).

J.3. Reef Fish Community

REA fish survey sites were chosen using a stratified random design. Stationary-point-count surveys were conducted at five REA sites at Alamagan in the deep and moderate forereef strata (Fig. J.3.1 and Table J.3.1). No fishes were collected during these surveys.

In addition, CRED completed three towed-diver surveys at Alamagan, as described previously in Section J.2 of this appendix.

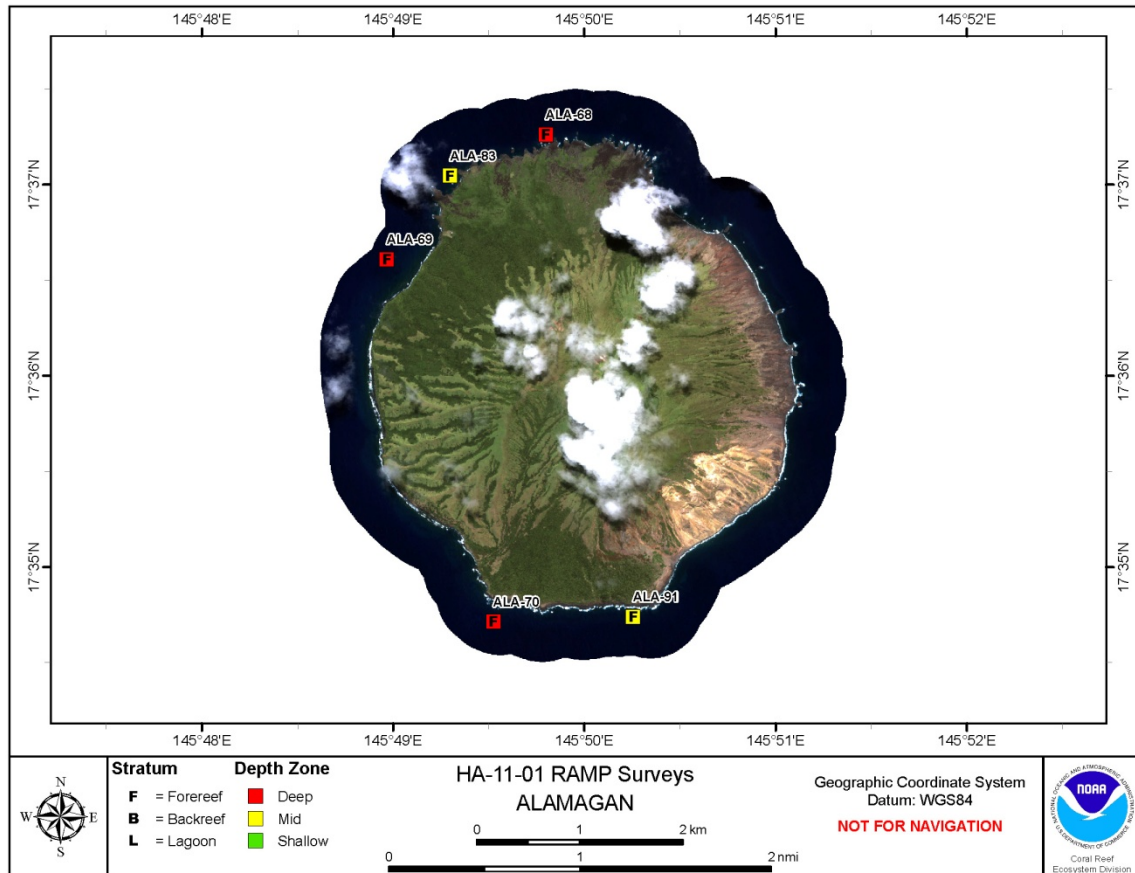


Figure J.3.1.--Locations of REA fish sites surveyed at Alamagan during cruise HA-11-01, Leg II (IKONOS Carterra Geo Data, 2002). All of these REA sites were selected using a stratified random design.

Table J.3.1.--Summary of sites where REA fish surveys were conducted at Alamagan during cruise HA-11-01, Leg II.

REA Site	Date	Depth Zone	Stratum	Depth (m)	Latitude	Longitude
ALA-68	23-Apr	Deep	Forereef	25	17.62106	145.82996
ALA-69	23-Apr	Deep	Forereef	22	17.61018	145.81610
ALA-70	23-Apr	Deep	Forereef	19	17.57861	145.82540
ALA-83	23-Apr	Moderate	Forereef	11	17.61747	145.82160
ALA-91	23-Apr	Moderate	Forereef	11	17.57902	145.83757

APPENDIX K: PAGAN

The island of Pagan is located at 18.13° N, 145.78° W in the North Pacific in the Mariana Archipelago. For information about the methods used to perform the activities discussed in this appendix, please see Appendix A: “Methods.”

K.1. Oceanography and Water Quality

Oceanographic operations during the cruise HA-11-01, Leg II, at Pagan entailed numerous retrievals and deployments of oceanographic moored instruments; installation of calcification acidification units (CAUs), coral coring, and nearshore water sampling and conductivity, temperature, and depth (CTD) casts at select Rapid Ecological Assessment (REA) sites; and shipboard water sampling and CTD casts offshore to a depth of 500 m and acoustic Doppler current profiler (ADCP) transect lines.

Five subsurface temperature recorders (STRs) were retrieved, and five STRs were deployed (Fig. K.1.1 and Table K.1.1). One SST buoy and its mooring anchor were recovered and replaced. One EAR unit and its mooring anchor were removed (Table K.1.1). For information regarding the CAU deployments and coral core collection at Pagan, please see Section K.2: “Benthic Environment.”

At nearshore locations around Pagan, five shallow-water (≤ 30 m) CTD casts were performed (Fig. K.1.1), including one cast at each of the five select REA sites where CAUs were installed. In concert with each CTD cast, two water samples were taken to measure the following parameters: dissolved inorganic carbon (DIC), total alkalinity (TA), salinity, nutrient, and chlorophyll-*a* (Chl-*a*) concentrations. A total of 10 DIC and TA, 10 salinity, 10 nutrient, and 10 Chl-*a* water samples were collected, one from the surface and one near the reef at each REA site.

From the NOAA Ship *Hi`ialakai*, ~ 200 km of ADCP transect lines were run east and west away from this island during night operations. On the reciprocal course, shipboard CTD casts were conducted to a depth of 500 m per transect line every 5 km for a total of 19 deepwater CTD casts. Water samples were collected concurrently with two select shipboard CTD casts at five depths between the surface and 200 m, depending on the depth of mixed layer as determined by the CTD downcast (Fig. K.1.2). Near Pagan, 10 nutrient and 10 Chl-*a* shipboard water samples were collected.

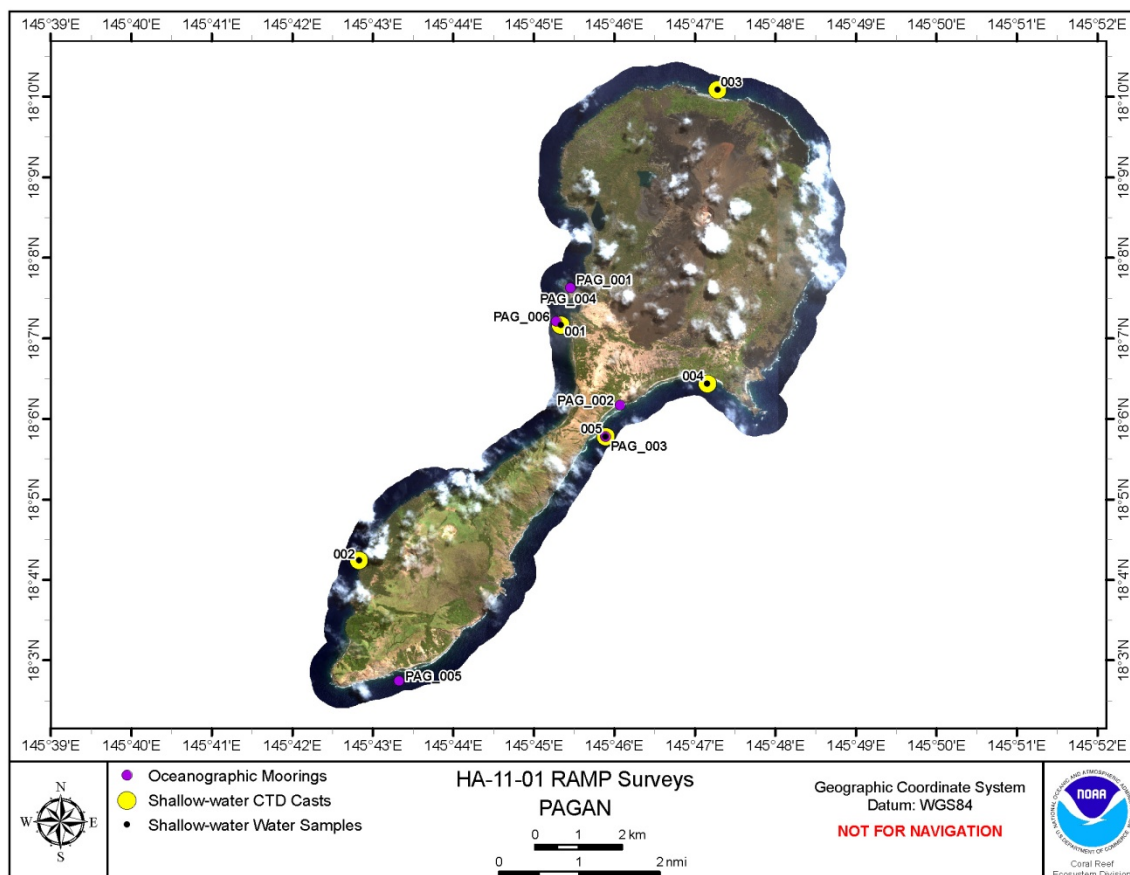


Figure K.1.1.--Mooring sites where oceanographic instruments were retrieved or deployed and locations of nearshore CTD casts and water sampling performed at Pagan during cruise HA-11-01, Leg II (IKONOS Carterra Geo Data, 2002).

Table K.1.1.--Geographic coordinates and sensor depths of the moored oceanographic instruments, EAR, and anchors that were retrieved or deployed at Pagan during cruise HA-11-01, Leg II.

Mooring Site	Date	Instrument Type	Latitude	Longitude	Depth (m)	Retrieved	Deployed
PAG-001	11-Apr	SST	18.12726	145.75751	0.3	1	1
PAG-004	11-Apr	STR	18.12726	145.75751	6.1	1	1
PAG-004	11-Apr	Anchor	18.12726	145.75751	6.1	1	1
PAG-005	11-Apr	STR	18.04578	145.72202	18.9	1	1
PAG-006	11-Apr	STR	18.12018	145.75462	17.1	1	1
PAG-006	11-Apr	EAR	18.12018	145.75464	17.1	1	—
PAG-006	11-Apr	Anchor	18.12018	145.75464	17.1	1	—
PAG-002	13-Apr	STR	18.10295	145.76787	0.6	1	1
PAG-003	13-Apr	STR	18.09635	145.76486	14.3	1	1

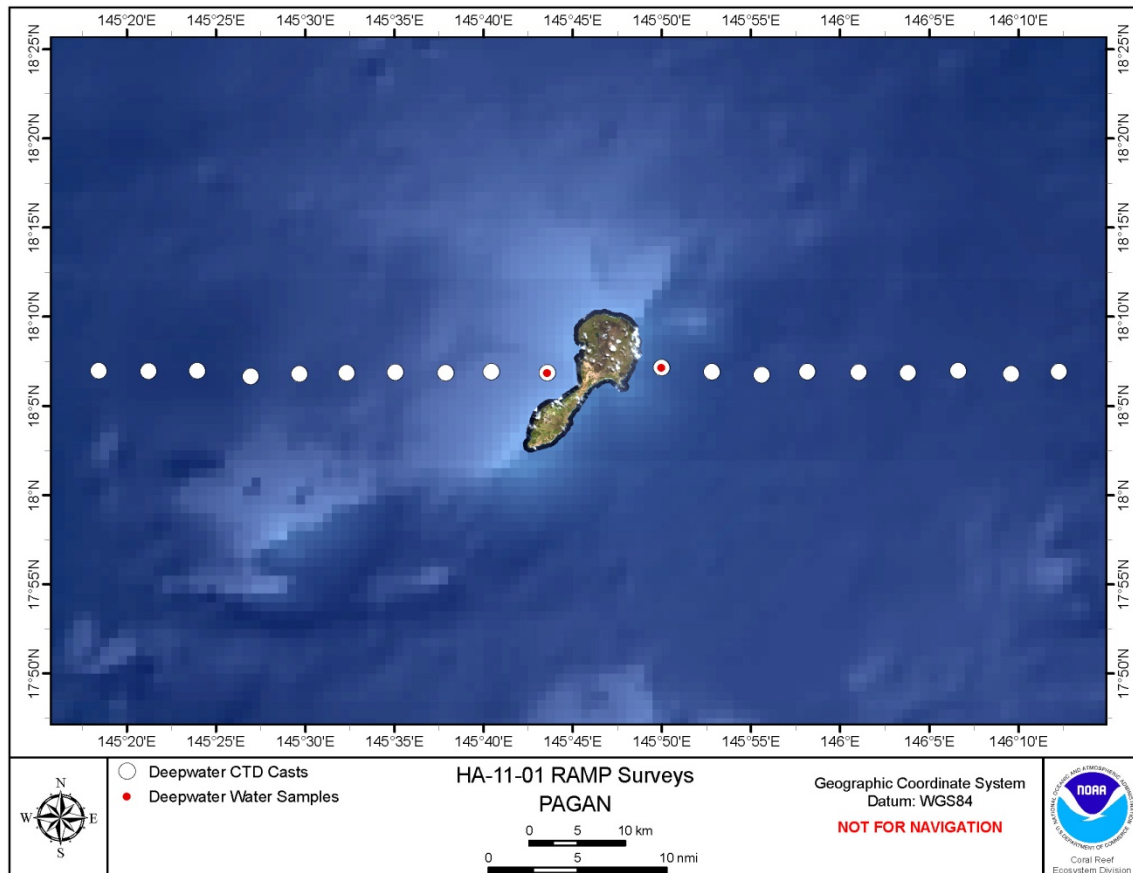


Figure K.1.2.--Locations of deepwater CTD casts and water sampling performed at Pagan during cruise HA-11-01, Leg II. Island satellite image IKONOS Carterra Geo Data, 2002, and background imagery SIO, NOAA, U.S. Navy, NGA, GEBCO (Becker, 2009; Smith and Sandwell, 1997) © 2008 The Regents of the University of California.

K.2. Benthic Environment

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

Various samples were collected at 10 REA sites (Table K.2.2): 15 algal voucher specimens at four REA sites for taxonomic identification, one coral core (< 20 cm in length) from a *Porites* coral head at one REA site for calcification research, and 15 water samples for microbial analyses at three REA sites with four water samples of 2 L each at each site and three water samples of 20 L each at REA site PAG-01. Additional microbial work included benthic grabs of coral rubble and unidentified macroalgae at PAG-03 and plankton tows conducted at one nearshore and one offshore location. The oceanography team collected the coral core opportunistically, hence the lack of repeat cores, after the benthic team reported seeing a mounding, massive coral (*Porites lobata*) > 8 m in height

and > 1 m in diameter. For more information about collections made at REA sites, see Table Q.1.1 in Appendix Q: “Biological Collections.”

Eight autonomous reef monitoring structures (ARMS) were recovered: two ARMS from PAG-09 and three ARMS each from PAG-05 and PAG-06 (Table K.2.1). Nine ARMS were deployed with three ARMS each at PAG-01, PAG-05, and PAG-09. At each of five select REA sites, an array of five CAUs was deployed for a total of 25 CAUs installed at Pagan (Table K.2.1). For information about the EAR recovery and coral coring at Pagan, see Section K.2: “Oceanography and Water Quality.”

In total, the benthic team conducted 43 individual dives at REA sites around Pagan.

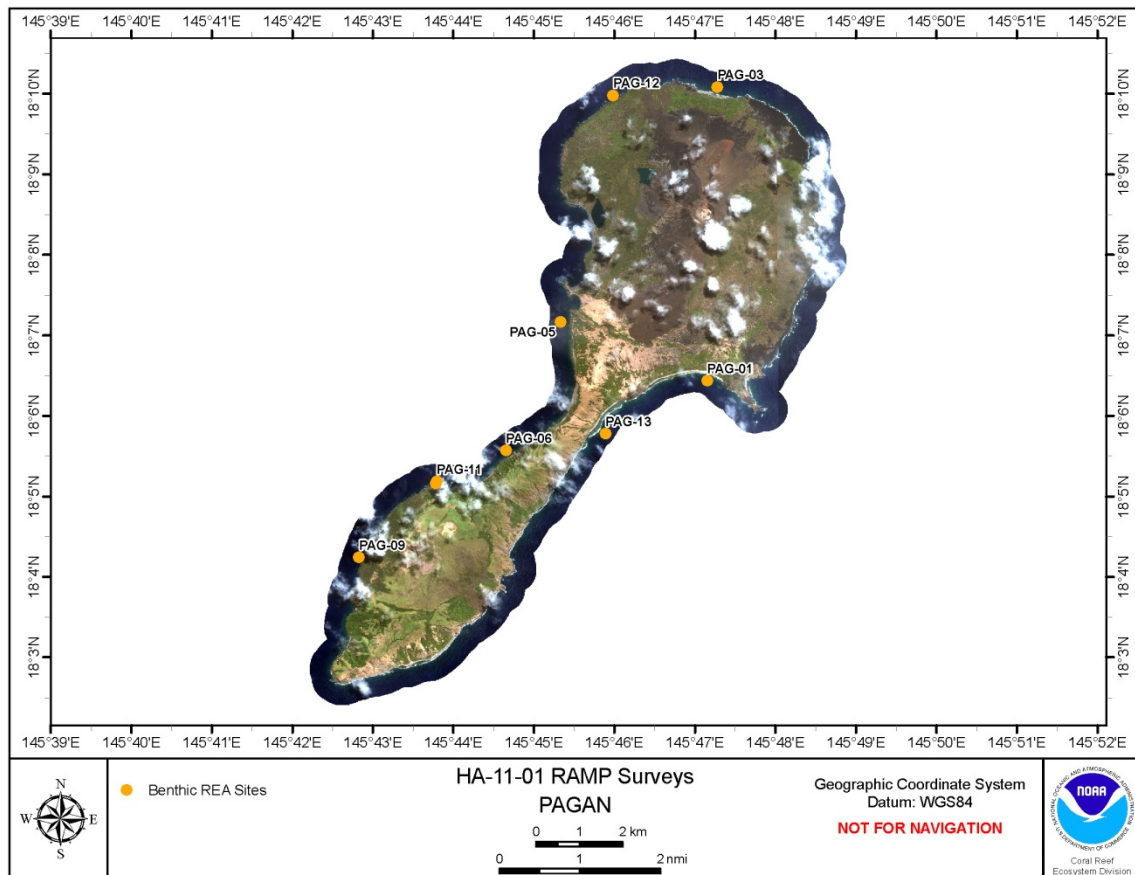


Figure K.2.1.--Locations of REA benthic sites surveyed at Pagan during cruise HA-11-01, Leg II (IKONOS Carterra Geo Data, 2002).

Table K.2.1.--Summary of REA benthic surveys performed at Pagan during cruise HA-11-01, Leg II. Indication that an LPI survey was completed also means that photographs were taken along transect lines.

REA Site	Date	Latitude	Longitude	REA Surveys			
				LPI	Roving Diver	Corals	Inverts
PAG-05	11-Apr	18.11946	145.75554	–	–	–	–
PAG-06	11-Apr	18.09294	145.74424	×	×	×	–
PAG-09	11-Apr	18.07077	145.71379	×	×	×	–
PAG-11	11-Apr	18.08651	145.72986	×	×	×	–
PAG-03	12-Apr	18.16820	145.78799	–	–	–	–
PAG-05	12-Apr	18.11948	145.75556	×	×	×	–
PAG-06	12-Apr	18.09292	145.74422	–	–	–	–
PAG-11	12-Apr	18.08607	145.72969	–	–	–	–
PAG-12	12-Apr	18.16641	145.76644	×	×	×	–
PAG-01	13-Apr	18.10734	145.78587	×	×	×	–
PAG-13	13-Apr	18.09640	145.76480	×	×	×	–

Table K.2.2.--Summary of CAU installations and ARMS retrievals (Ret.) and deployments (Dep.) performed as well as algal specimens, microbial water samples, and the coral core collected at Pagan during cruise HA-11-01, Leg II.

REA Site	Date	Latitude	Longitude	Installations and Collections					
				CAUs	ARMS Ret	ARMS Dep	Algae	Microbial Samples	Coral Core
PAG-05	11-Apr	18.11946	145.75554	5	0	0	0	4	0
PAG-06	11-Apr	18.09294	145.74424	0	0	0	0	0	0
PAG-09	11-Apr	18.07077	145.71379	5	2	3	4	0	0
PAG-11	11-Apr	18.08651	145.72986	0	0	0	3	0	0
PAG-03	12-Apr	18.16820	145.78799	5	0	0	0	14	0
PAG-05	12-Apr	18.11948	145.75556	0	3	3	0	4	0
PAG-06	12-Apr	18.09292	145.74422	0	3	0	1	0	0
PAG-11	12-Apr	18.08607	145.72969	0	0	0	3	0	1
PAG-12	12-Apr	18.16641	145.76644	0	0	0	0	0	0
PAG-01	13-Apr	18.10734	145.78587	5	0	3	0	7	0
PAG-13	13-Apr	18.09640	145.76480	5	0	0	4	0	0

During cruise HA-11-01, Leg II, CRED completed 15 towed-diver surveys at Pagan, including one benthic calibration survey, covering a total length of 31.6 km (an area of 31.6 ha) on the ocean floor (Fig. K.2.2). The mean survey length was 2.1 km with a range of 1.5–2.6 km. The mean survey depth was 14.5 m with a range of 13.0–17.2 m. The mean temperature from data recorded during these surveys was 27.0°C with a range of 26.3°C–27.3°C.

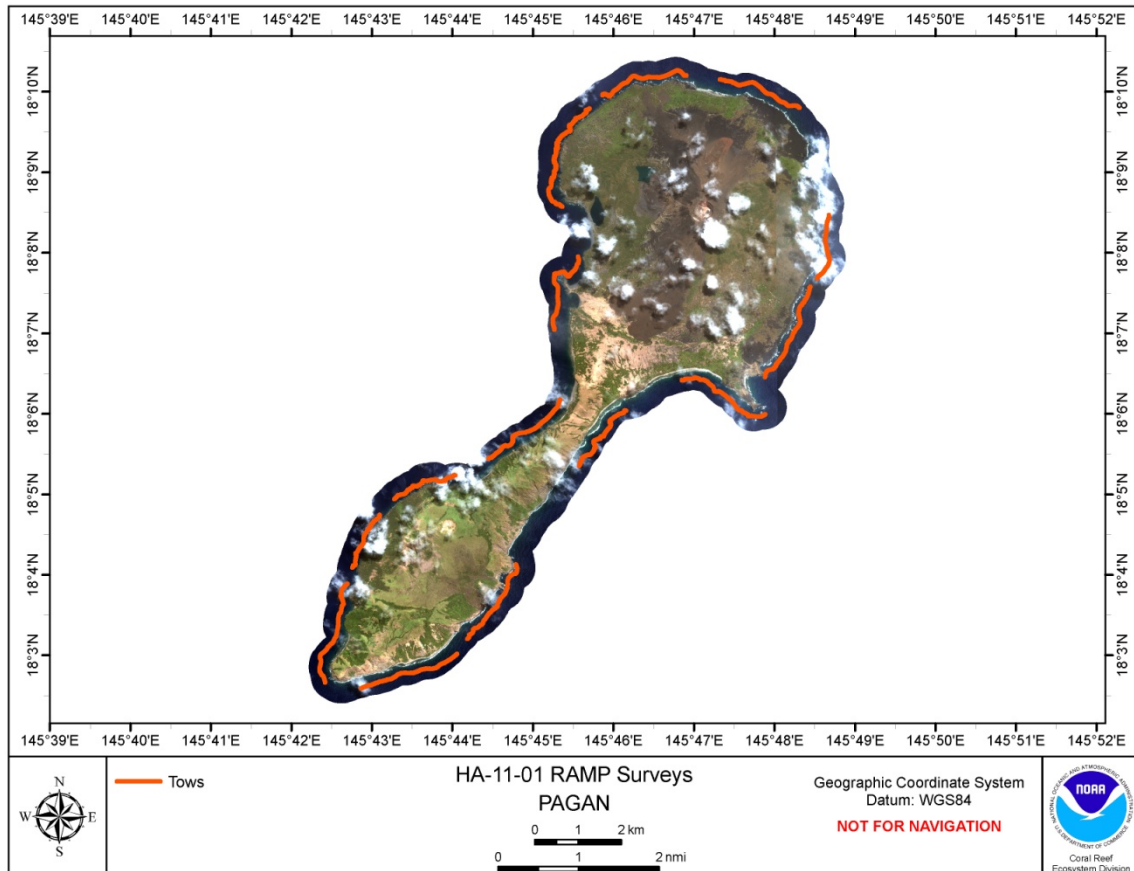


Figure K.2.2.--Track locations of towed-diver surveys conducted at Pagan during cruise HA-11-01, Leg II (IKONOS Carterra Geo Data, 2002).

K.3. 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 Pagan in the deep, moderate, and shallow foreereef strata (Fig. K.3.1 and Table K.3.1). No fishes were collected during these surveys.

In addition, CRED completed 14 towed-diver fish surveys at Pagan, as described previously in Section K.2 of this appendix.

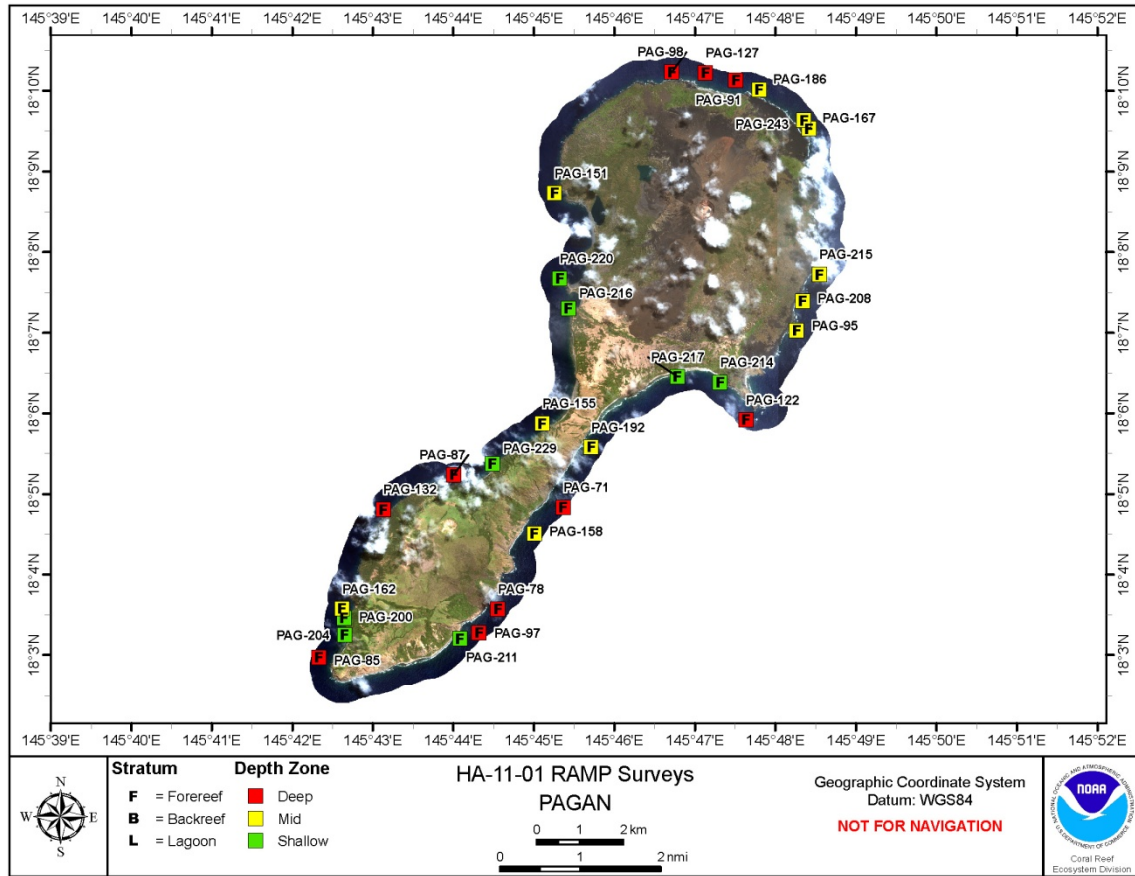


Figure K.3.1.--Locations of REA fish sites surveyed at Pagan during cruise HA-11-01, Leg II (IKONOS Carterra Geo Data, 2002). All of these REA sites were selected using a stratified random design.

Table K.3.1.--Summary of sites where REA fish surveys were conducted at Pagan during cruise HA-11-01, Leg II.

REA Site	Date	Depth Zone	Stratum	Depth (m)	Latitude	Longitude
PAG-85	11-Apr	Deep	Forereef	20	18.04957	145.70552
PAG-87	11-Apr	Deep	Forereef	24	18.08740	145.73344
PAG-132	11-Apr	Deep	Forereef	23	18.08016	145.71880
PAG-151	11-Apr	Moderate	Forereef	13	18.14561	145.75426
PAG-155	11-Apr	Moderate	Forereef	14	18.09795	145.75177
PAG-216	11-Apr	Shallow	Forereef	4	18.12174	145.75715
PAG-220	11-Apr	Shallow	Forereef	6	18.12796	145.75532
PAG-229	11-Apr	Shallow	Forereef	5	18.08963	145.74141
PAG-91	12-Apr	Deep	Forereef	19	18.16898	145.79182
PAG-95	12-Apr	Moderate	Forereef	21.6	18.11718	145.80442
PAG-98	12-Apr	Deep	Forereef	23	18.17066	145.77859
PAG-127	12-Apr	Deep	Forereef	20	18.17046	145.78551
PAG-167	12-Apr	Moderate	Forereef	14	18.15893	145.80691
PAG-186	12-Apr	Moderate	Forereef	13	18.16704	145.79666
PAG-208	12-Apr	Moderate	Forereef	13	18.12329	145.80563
PAG-215	12-Apr	Moderate	Forereef	14	18.12878	145.80913
PAG-243	12-Apr	Moderate	Forereef	13	18.16064	145.80593
PAG-71	13-Apr	Deep	Forereef	22	18.08061	145.75609
PAG-78	13-Apr	Deep	Forereef	23	18.05957	145.74254
PAG-97	13-Apr	Deep	Forereef	29	18.05470	145.73866
PAG-122	13-Apr	Deep	Forereef	22	18.09869	145.79389
PAG-158	13-Apr	Moderate	Forereef	21	18.07522	145.75010
PAG-162	13-Apr	Moderate	Forereef	16	18.05967	145.71029
PAG-192	13-Apr	Moderate	Forereef	18	18.09306	145.76184
PAG-200	13-Apr	Shallow	Forereef	5	18.05772	145.71069
PAG-204	13-Apr	Shallow	Forereef	3	18.05420	145.71080
PAG-211	13-Apr	Shallow	Forereef	6	18.05347	145.73469
PAG-214	13-Apr	Shallow	Forereef	6	18.10650	145.78858
PAG-217	13-Apr	Shallow	Forereef	5	18.10764	145.77974

APPENDIX L: AGRIHAN

The island of Agrihan is located at 18.77° N, 145.66° W in the North Pacific in the Mariana Archipelago. For information about the methods used to perform the activities discussed in this appendix, please see Appendix A: “Methods.”

L.1. Oceanography and Water Quality

Oceanographic operations during the cruise HA-11-01, Leg II, at Agrihan entailed retrieval and replacement of two subsurface temperature recorders (STRs); installation of calcification acidification units (CAUs) and nearshore water sampling and conductivity, temperature, and depth (CTD) casts at select Rapid Ecological Assessment (REA) sites; shipboard water sampling and CTD casts offshore to a depth of 500 m; and an acoustic Doppler current profiler (ADCP) transect line (Fig. L.1.1 and Table L.1.1).

At nearshore locations around Agrihan, five shallow-water (≤ 30 m) CTD casts were performed (Fig. L.1.1), including one cast at each of the five select REA sites where CAUs were installed. In concert with each CTD cast, two water samples were taken to measure the following parameters: dissolved inorganic carbon (DIC), total alkalinity (TA), salinity, nutrient, and chlorophyll-*a* (Chl-*a*) concentrations. Accounting for losses and additional nutrient samples taken alone for microbial analyses, 10 DIC and TA, 10 salinity, 12 nutrient, and 10 Chl-*a* water samples were collected, including one from the surface and one near the reef at each REA site. For information regarding the CAU deployments at Agrihan, please see Section L.2: “Benthic Environment.”

From the NOAA Ship *Hi'ialakai*, an ADCP transect line ~ 50 km long was run east away from this island during night operations. On the reciprocal course, shipboard CTD casts were conducted to a depth of 500 m every 5 km for a total of 10 deepwater CTD casts. Water samples were collected concurrently with one select shipboard CTD cast at five depths between the surface and 200 m, depending on the depth of mixed layer as determined by the CTD downcast (Fig. L.1.2). Near Agrihan, five nutrient and five Chl-*a* shipboard water samples were collected.

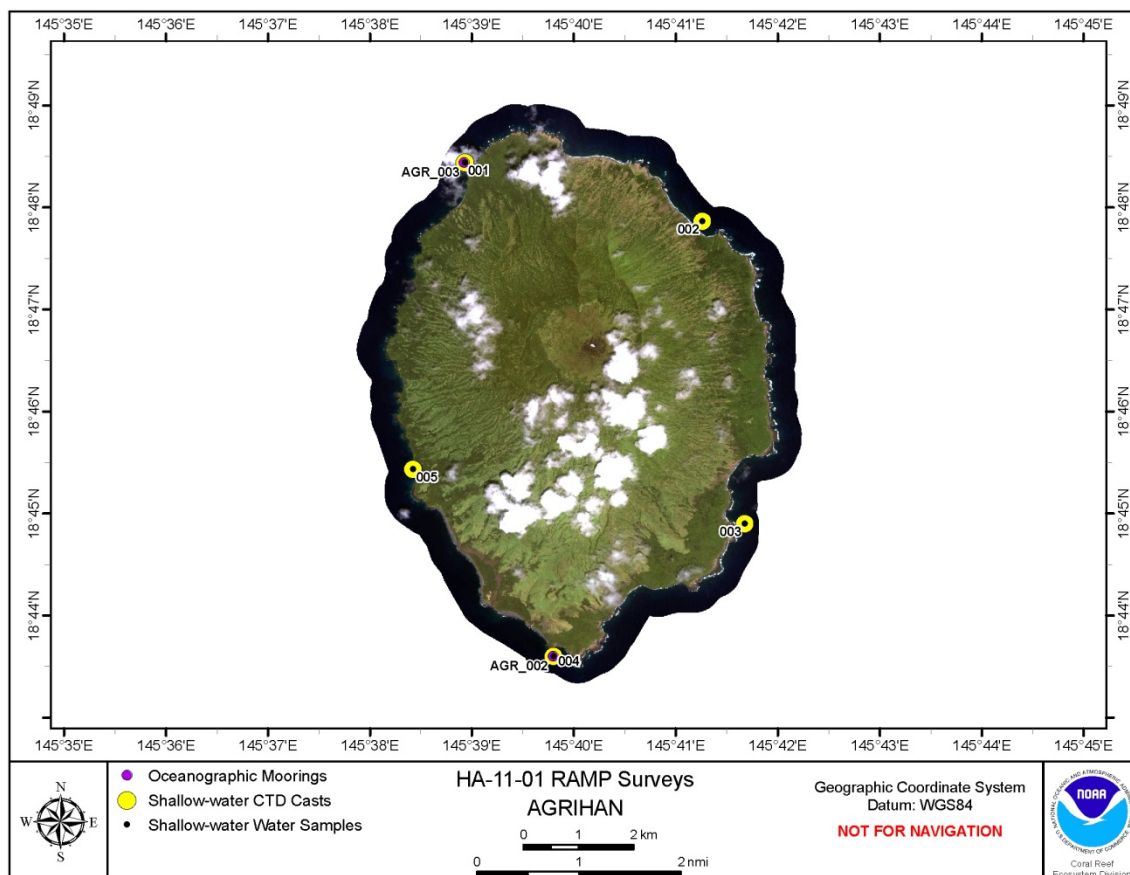


Figure L.1.1.--Mooring sites where STRs were retrieved or deployed and locations of nearshore CTD casts and water sampling performed at Agrihan during cruise HA-11-01, Leg II (IKONOS Carterra Geo Data, 2002). Additional nutrient water samples were collected for microbial analyses at CTD casts 002 and 005.

Table L.1.1.--Geographic coordinates and sensor depths of the STRs that were retrieved or deployed at Agrihan during cruise HA-11-01, Leg II.

Mooring Site	Date	Instrument Type	Latitude	Longitude	Depth (m)	Retrieved	Deployed
AGR-002	21-Apr	STR	18.72670	145.66321	8.8	1	1
AGR-003	21-Apr	STR	18.80743	145.64872	14.3	1	1

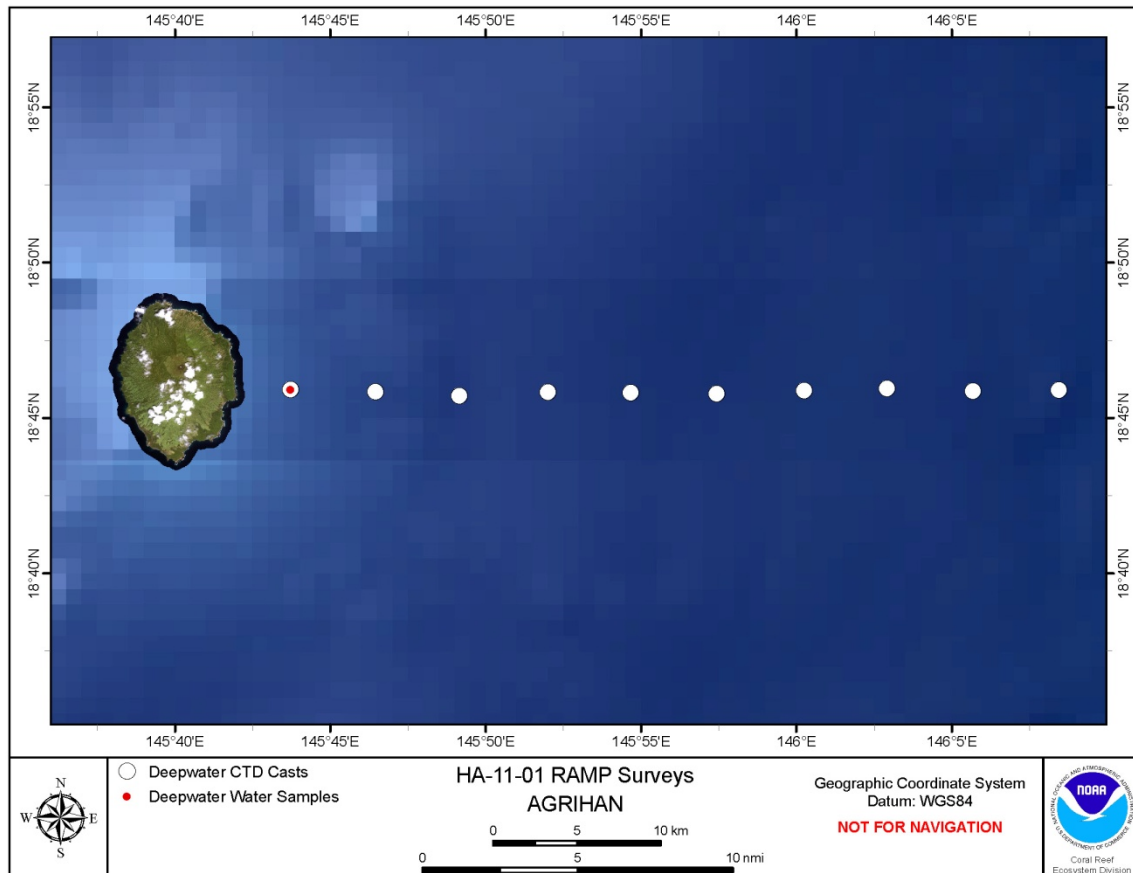


Figure L.1.2.--Locations of deepwater CTD casts and water sampling performed at Agrihan during cruise HA-11-01, Leg II. Island satellite image (IKONOS Carterra Geo Data, 2002, and background imagery SIO, NOAA, U.S. Navy, NGA, GEBCO (Becker, 2009; Smith and Sandwell, 1997) © 2008 The Regents of the University of California.

L.2. Benthic Environment

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

Samples were collected at two REA sites, AGR-07 and AGR-06 (Table L.2.2): 11 water samples for microbial analyses, with four water samples of 2 L each at each site and three water samples of 20 L each at AGR-07. Additional microbial work included plankton tows conducted at one nearshore and one offshore location. For more information about collections made at REA sites, see Table Q.1.1 in Appendix Q: “Biological Collections.”

At each of five select REA sites, an array of five CAUs was deployed for a total of 25 CAUs installed at Agrihan (Table L.2.1).

In total, the benthic team conducted 30 individual dives at REA sites around Agrihan.

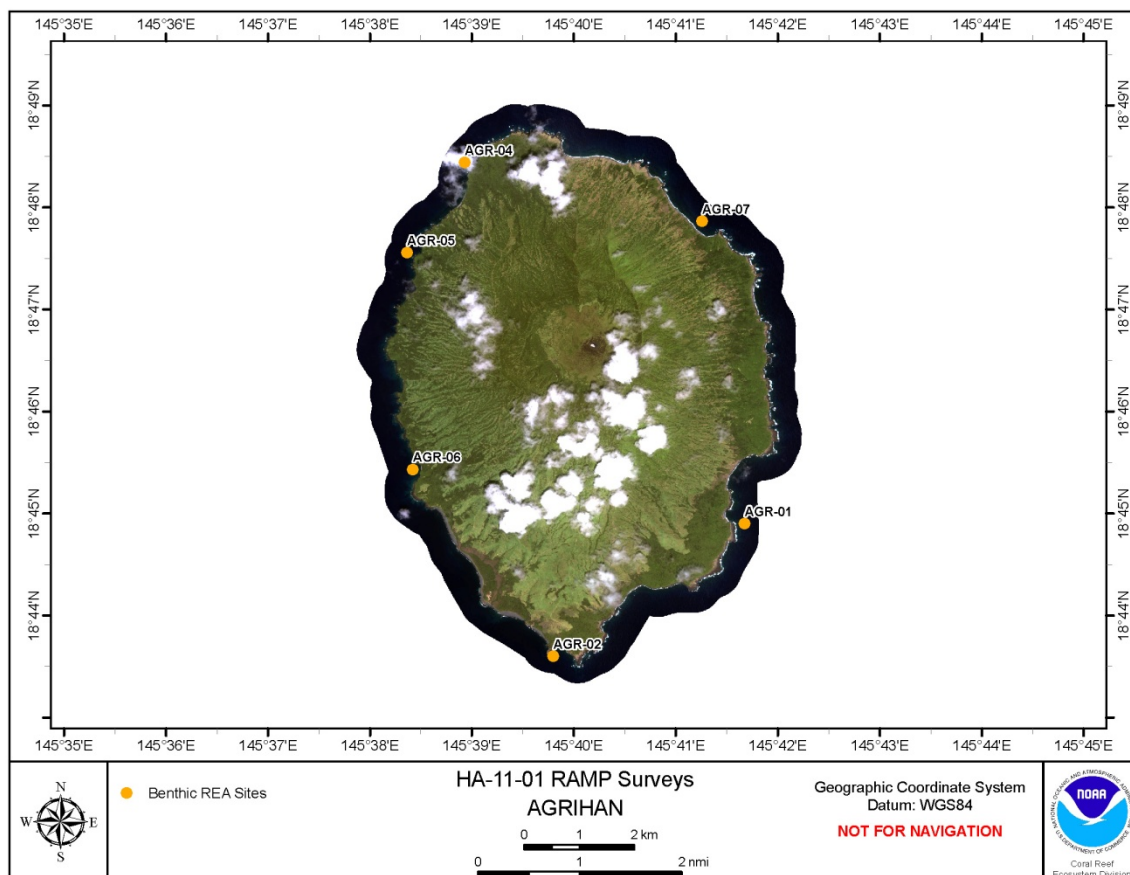


Figure L.2.1.--Locations of REA benthic sites surveyed at Agrihan during cruise HA-11-01, Leg II (IKONOS Carterra Geo Data, 2002).

Table L.2.1.--Summary of REA benthic surveys performed at Agrihan during cruise HA-11-01, Leg II. Indication that an LPI survey was completed also means that photographs were taken along transect lines.

REA Site	Date	Latitude	Longitude	REA Surveys			
				LPI	Roving Diver	Corals	Inverts
AGR-01	21-Apr	18.74842	145.69460	×	×	×	—
AGR-04	21-Apr	18.80742	145.64885	×	×	×	—
AGR-07	21-Apr	18.79780	145.68767	×	×	×	—
AGR-02	22-Apr	18.72669	145.66336	×	×	×	—
AGR-05	22-Apr	18.79268	145.63938	×	×	×	—
AGR-06	22-Apr	18.75728	145.64038	×	×	×	—

Table L.2.2.--Summary of CAU installations and microbial water samples collected at Agrihan during cruise HA-11-01, Leg II.

REA Site	Date	Latitude	Longitude	Installations and Collections					
				CAUs	ARMS Ret	ARMS Det	Algae	Microbial Samples	Coral Cores
AGR-01	21-Apr	18.74842	145.69460	5	0	0	0	0	0
AGR-04	21-Apr	18.80742	145.64885	5	0	0	0	0	0
AGR-07	21-Apr	18.79780	145.68767	5	0	0	0	7	0
AGR-02	22-Apr	18.72669	145.66336	5	0	0	0	0	0
AGR-05	22-Apr	18.79268	145.63938	0	0	0	0	0	0
AGR-06	22-Apr	18.75728	145.64038	5	0	0	0	4	0

During cruise HA-11-01, Leg II, CRED completed 10 towed-diver surveys at Agrihan, covering a total length of 22 km (an area of 22 ha) on the ocean floor (Fig. L.2.2). The mean survey length was 2.2 km with a range of 1.8-2.5 km. The mean survey depth was 15.2 m with a range of 13.5-16.5 m. The mean temperature from data recorded during these surveys was 27.5°C with a range of 27.3°C–27.6°C.

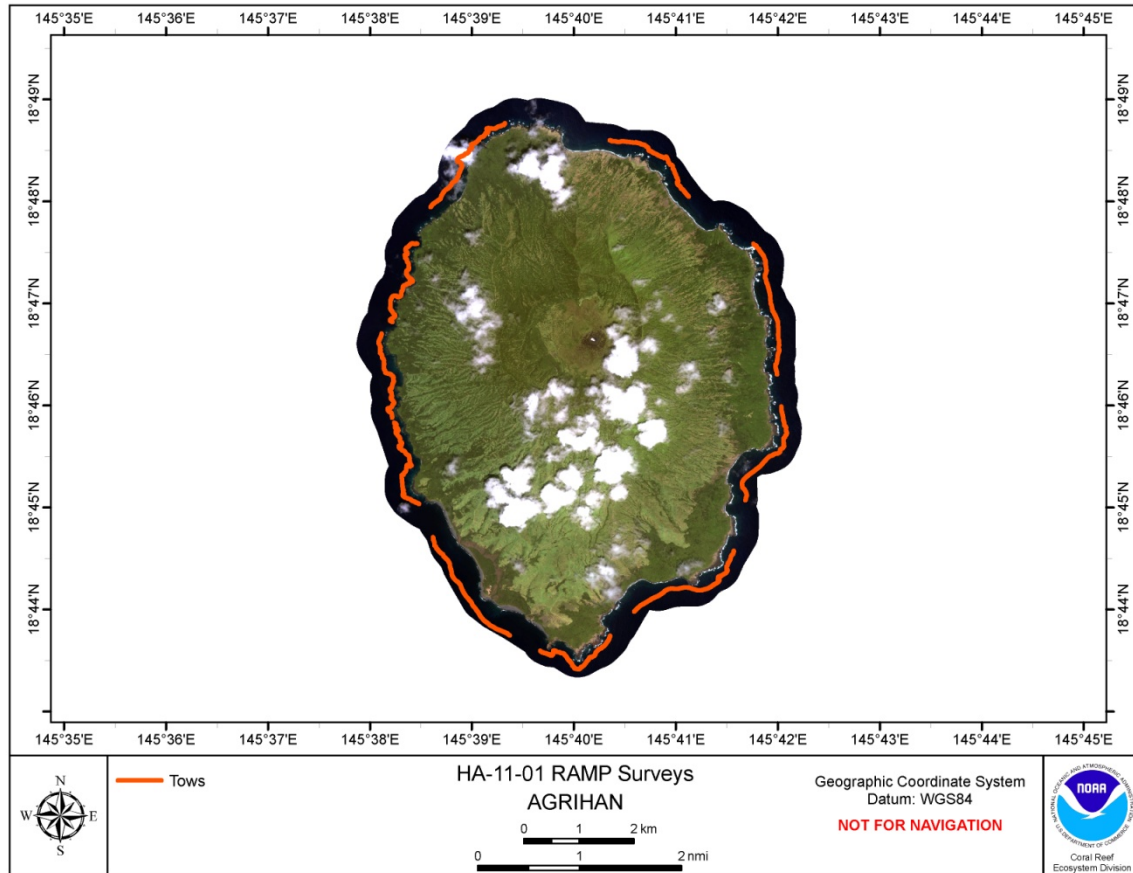


Figure L.2.2.--Track locations of towed-diver surveys conducted at Agrihan during cruise HA-11-01, Leg II (IKONOS Carterra Geo Data, 2002).

L.3. Reef Fish Community

REA fish survey sites were chosen using a stratified random design. Stationary-point-count surveys were conducted at 20 REA sites at Agrihan in the deep, moderate, and shallow foreereef strata (Fig. L.3.1 and Table L.3.1). No fishes were collected during these surveys.

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

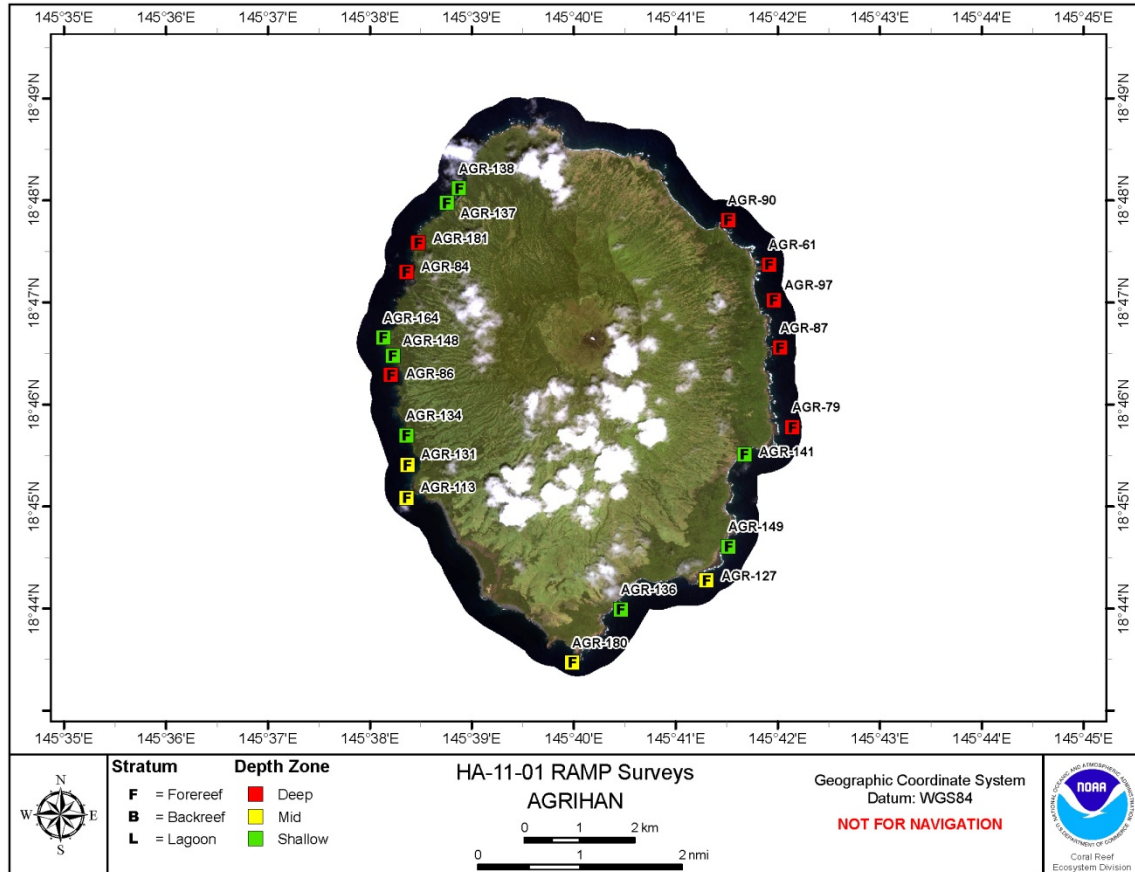


Figure L.3.1.--Locations of REA fish sites surveyed at Agrihan during cruise HA-11-01, Leg II (IKONOS Carterra Geo Data, 2002). All of these REA sites were selected using a stratified random design.

Table L.3.1.--Summary of sites where REA fish surveys were conducted at Agrihan during cruise HA-11-01

REA Site	Date	Depth Zone	Stratum	Depth (m)	Latitude	Longitude
AGR-61	21-Apr	Deep	Forereef	25	18.78958	145.69855
AGR-79	21-Apr	Deep	Forereef	23	18.76299	145.70238
AGR-87	21-Apr	Deep	Forereef	23	18.77599	145.70041
AGR-90	21-Apr	Deep	Forereef	20	18.79686	145.69186
AGR-97	21-Apr	Deep	Forereef	24	18.78374	145.69940
AGR-127	21-Apr	Moderate	Forereef	12	18.73795	145.68835
AGR-136	21-Apr	Shallow	Forereef	5	18.73324	145.67437
AGR-141	21-Apr	Shallow	Forereef	4	18.75858	145.69457
AGR-149	21-Apr	Shallow	Forereef	6	18.74352	145.69192
AGR-180	21-Apr	Moderate	Forereef	15	18.72453	145.66641
AGR-84	22-Apr	Deep	Forereef	25	18.78840	145.63927
AGR-86	22-Apr	Deep	Forereef	20	18.77152	145.63678
AGR-113	22-Apr	Moderate	Forereef	18	18.75145	145.63936
AGR-131	22-Apr	Moderate	Forereef	18	18.75679	145.63948
AGR-134	22-Apr	Shallow	Forereef	5.5	18.76169	145.63928
AGR-137	22-Apr	Shallow	Forereef	5	18.79965	145.64589
AGR-138	22-Apr	Shallow	Forereef	4	18.80204	145.64791
AGR-148	22-Apr	Shallow	Forereef	6	18.77466	145.63706
AGR-164	22-Apr	Shallow	Forereef	4	18.77764	145.63555
AGR-181	22-Apr	Deep	Forereef	24	18.79312	145.64122

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APPENDIX M: ASUNCION

The island of Asuncion is located at 19.69° N, 145.41° W in the North Pacific and is one of the islands, along with Maug and Farallon de Pajaros, that are part of the Marianas Trench Marine National Monument in the Mariana Archipelago. For information about the methods used to perform the activities discussed in this appendix, please see Appendix A: “Methods.”

M.1. Oceanography and Water Quality

Oceanographic operations during the cruise HA-11-01, Leg II, at Asuncion entailed the retrieval and replacement of three subsurface temperature recorders (STRs); installation of calcification acidification units (CAUs) and nearshore water sampling and conductivity, temperature, and depth (CTD) casts at select Rapid Ecological Assessment (REA) sites; and shipboard water sampling and CTD casts offshore to a depth of 500 m and acoustic Doppler current profiler (ADCP) transect lines (Fig. M.1.1 and Table M.1.1).

At nearshore locations at Asuncion, three shallow-water (≤ 30 m) CTD casts were performed (Fig. M.1.1), including one cast at each of the three select REA sites where CAUs were installed. In concert with each CTD cast, two water samples were taken to measure the following parameters: dissolved inorganic carbon (DIC), total alkalinity (TA), salinity, nutrient, and chlorophyll-*a* (Chl-*a*) concentrations. Accounting for an additional nutrient sample taken alone for microbial analyses, six DIC and TA, six salinity, seven nutrient, and six Chl-*a* water samples were collected, including one from the surface and one near the reef at each REA site. The additional microbial nutrient sample in this case did not overlap with the locations of oceanographic sampling (Fig. M.1.1). For information regarding the CAU deployments at Asuncion, please see Section M.2: “Benthic Environment.”

From the NOAA Ship *Hi`ialakai*, ~ 80 km of ADCP transect lines were run east and west away from this island during night operations. On the reciprocal course, shipboard CTD casts were conducted to a depth of 500 m per transect line every 5 km for a total of 16 deepwater CTD casts. Water samples were collected concurrently with one select shipboard CTD cast at five depths between the surface and 200 m, depending on the depth of mixed layer as determined by the CTD downcast (Fig. M.1.2). Near Asuncion, five nutrient and five Chl-*a* shipboard water samples were collected.

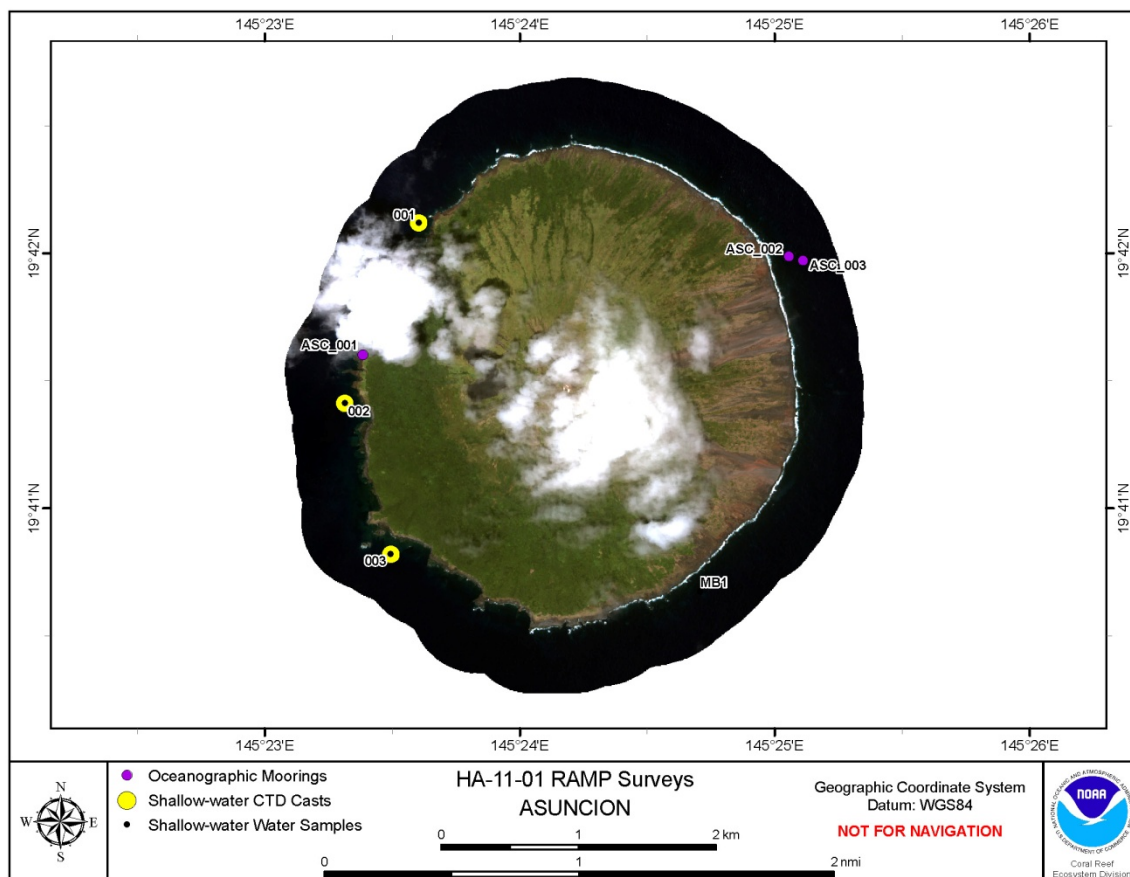


Figure M.1.1.--Mooring sites where STRs were retrieved or deployed and locations of nearshore CTD casts and water sampling performed at Asuncion during cruise HA-11-01, Leg II (IKONOS Carterra Geo Data, 2002). MB1 indicates the location where the additional nutrient water sample was collected for microbial analyses.

Table M.1.1.--Geographic coordinates and sensor depths of the STRs that were retrieved or deployed at Asuncion during cruise HA-11-01, Leg II.

Mooring Site	Date	Instrument Type	Latitude	Longitude	Depth (m)	Retrieved	Deployed
ASC-001	14-Apr	STR	19.69340	145.38974	3.4	1	1
ASC-002	14-Apr	STR	19.69982	145.41759	11.6	1	1
ASC-003	14-Apr	STR	19.69956	145.41851	29.6	1	1

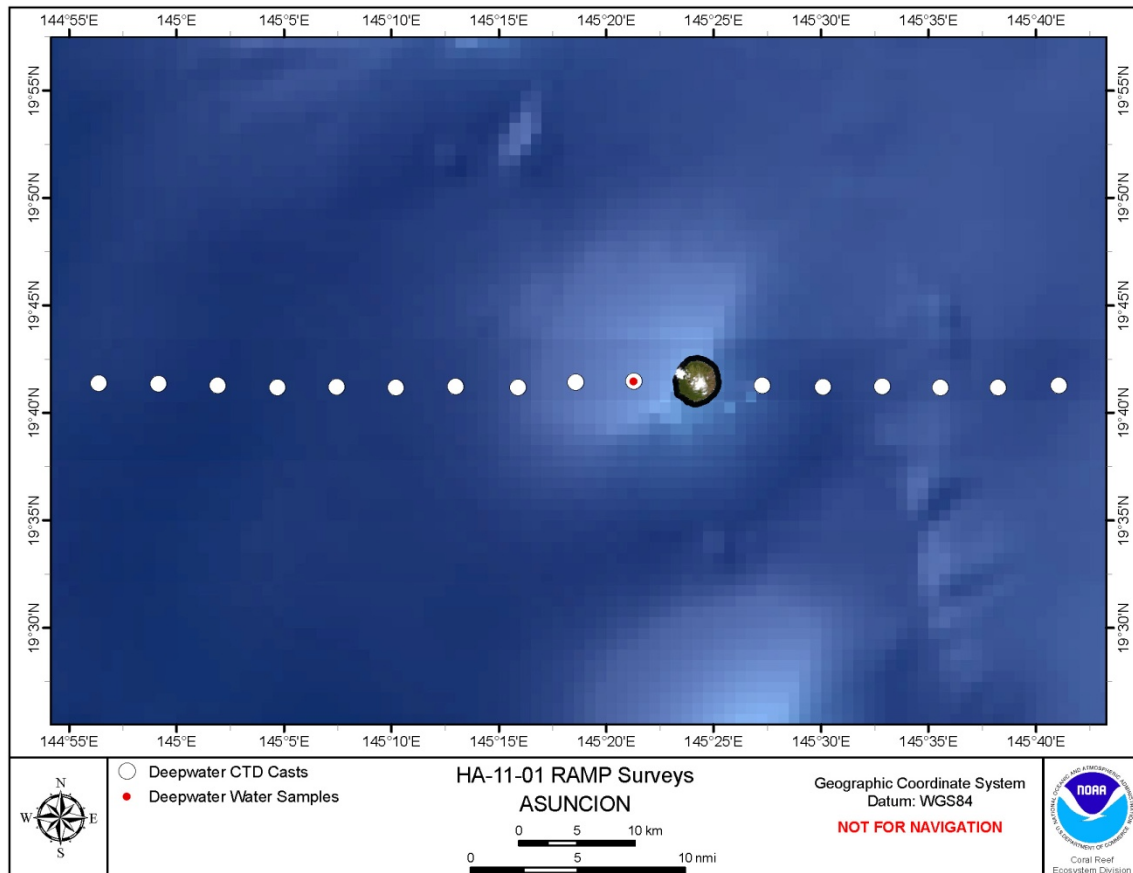


Figure M.1.2.--Locations of deepwater CTD casts and water sampling performed at Asuncion during cruise HA-11-01, Leg II. Island satellite image IKONOS Carterra Geo Data, 2002, and background imagery SIO, NOAA, U.S. Navy, NGA, GEBCO (Becker, 2009; Smith and Sandwell, 1997) © 2008 The Regents of the University of California.

M.2. Benthic Environment

Belt-transect, line-point-intercept (LPI), and roving-diver algal surveys were conducted and photographs were taken along transect lines at six REA sites around Asuncion to assess benthic composition, coral and algal community structure, and coral and algal disease (Fig. M.2.1 and Table M.2.1). At a subset of three REA sites, belt transects were surveyed for target macroinvertebrates.

Eight water samples were collected at REA sites ASC-03 and ASC-05 for microbial analyses, with four water samples of 2 L each at each site (Table M.2.2). Additional microbial work included plankton tows conducted at one nearshore and one offshore location. For more information about collections made at REA sites, see Table Q.1.1 in Appendix Q: “Biological Collections.”

At each of four select REA sites, an array of five CAUs was deployed for a total of 20 CAUs installed at Asuncion (Table M.2.1).

In total, the benthic team conducted 40 individual dives at REA sites around Asuncion.

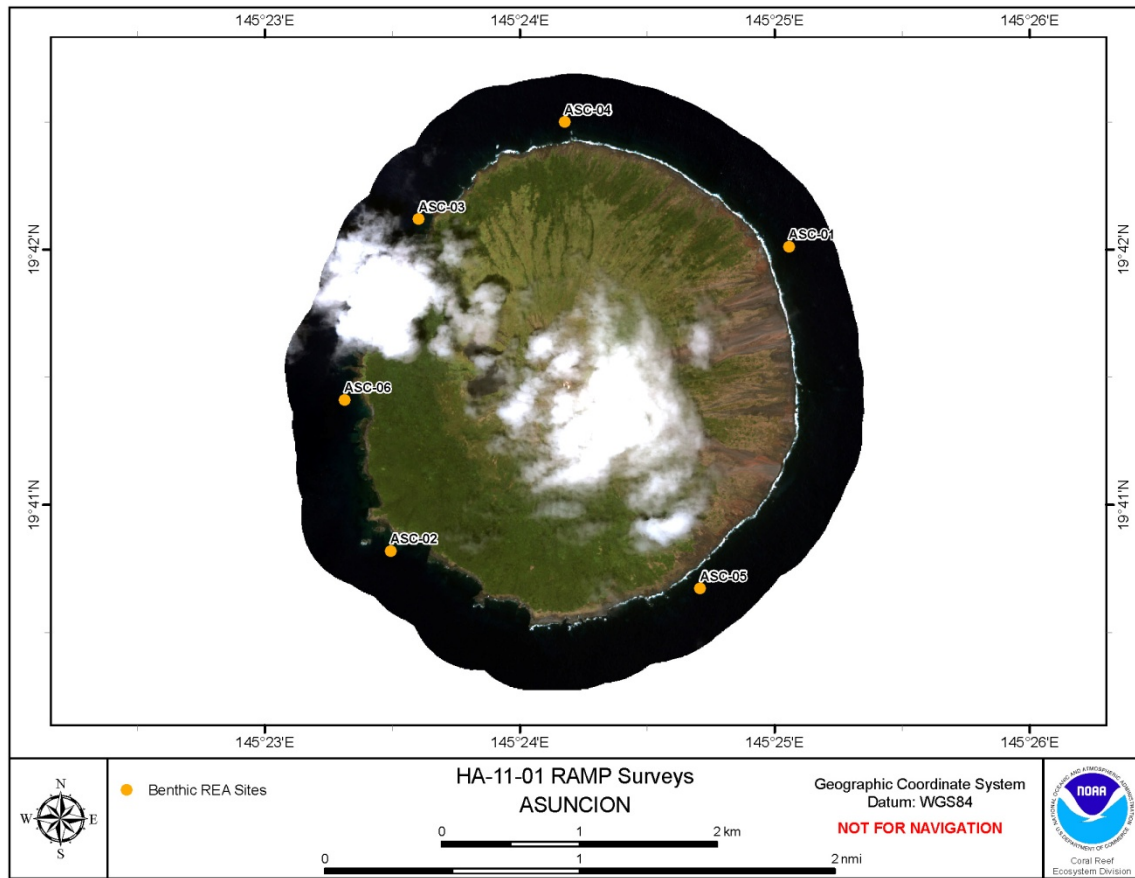


Figure M.2.1.--Locations of REA benthic sites surveyed at Asuncion during cruise HA-11-01, Leg II (IKONOS Carterra Geo Data, 2002).

Table M.2.1.--Summary of REA benthic surveys performed at Asuncion during cruise HA-11-01, Leg II. Indication that an LPI survey was completed also means that photographs were taken along transect lines.

REA Site	Date	Latitude	Longitude	REA Surveys			
				LPI	Roving Diver	Corals	Inverts
ASC-02	14-Apr	19.68035	145.39156	×	×	×	×
ASC-03	14-Apr	19.70203	145.39339	×	×	×	×
ASC-06	14-Apr	19.69021	145.38855	×	×	×	×
ASC-01	15-Apr	19.70022	145.41760	×	×	×	—
ASC-04	15-Apr	19.70836	145.40292	×	×	×	—
ASC-05	15-Apr	19.67790	145.41179	×	×	×	—

Table M.2.2.--Summary of CAU installations and microbial water samples collected at Asuncion during cruise HA-11-01, Leg II.

REA Site	Date	Latitude	Longitude	Installations and Collections					
				CAUs	ARMS Ret	ARMS Dep	Algae	Microbial Samples	Coral Cores
ASC-02	14-Apr	19.68035	145.39156	5	0	0	0	0	0
ASC-03	14-Apr	19.70203	145.39339	5	0	0	0	4	0
ASC-06	14-Apr	19.69021	145.38855	5	0	0	0	0	0
ASC-01	15-Apr	19.70022	145.41760	0	0	0	0	0	0
ASC-04	15-Apr	19.70836	145.40292	5	0	0	0	0	0
ASC-05	15-Apr	19.67790	145.41179	0	0	0	0	4	0

During cruise HA-11-01, Leg II, CRED completed eight towed-diver surveys at Asuncion, including one benthic calibration survey and one fish calibration survey, covering a total length of 16.8 km (an area of 16.8 ha) on the ocean floor (Fig. M.2.2). The mean survey length was 2.1 km with a range of 1.7–2.6 km. The mean survey depth was 14.2 m with a range of 12.6–16.1 m. The mean temperature from data recorded during these surveys was 26.1°C with a range of 25.9°C–26.4°C.

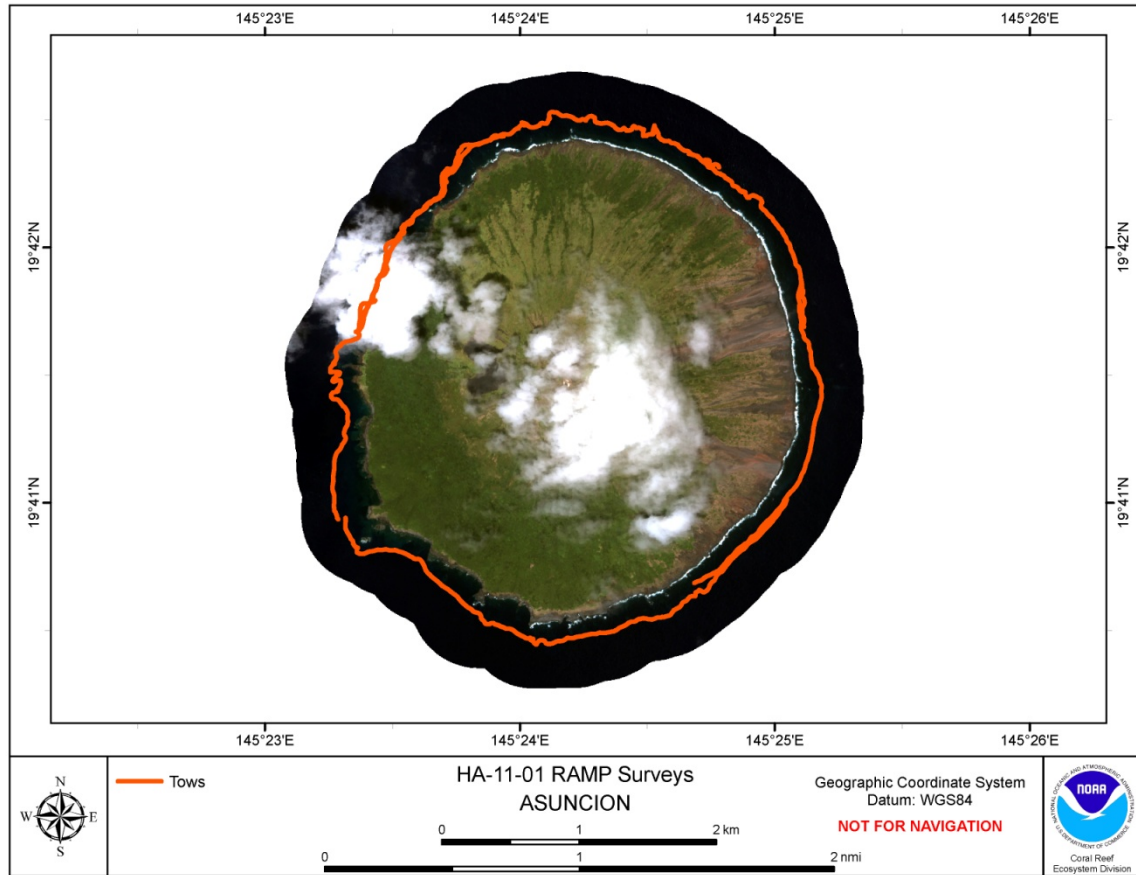


Figure M.2.2.--Track locations of towed-diver surveys conducted at Asuncion during cruise HA-11-01, Leg II (IKONOS Carterra Geo Data, 2002).

M.3. Reef Fish Community

REA fish survey sites were chosen using a stratified random design. Stationary-point-count surveys were conducted at 20 REA sites at Asuncion in the deep, moderate, and shallow foreereef strata (Fig. M.3.1 and Table M.3.1). No fishes were collected during these surveys.

In addition, CRED completed eight towed-diver surveys at Asuncion, including one fish calibration survey and one benthic calibration survey, as described previously in Section M.2 of this appendix.

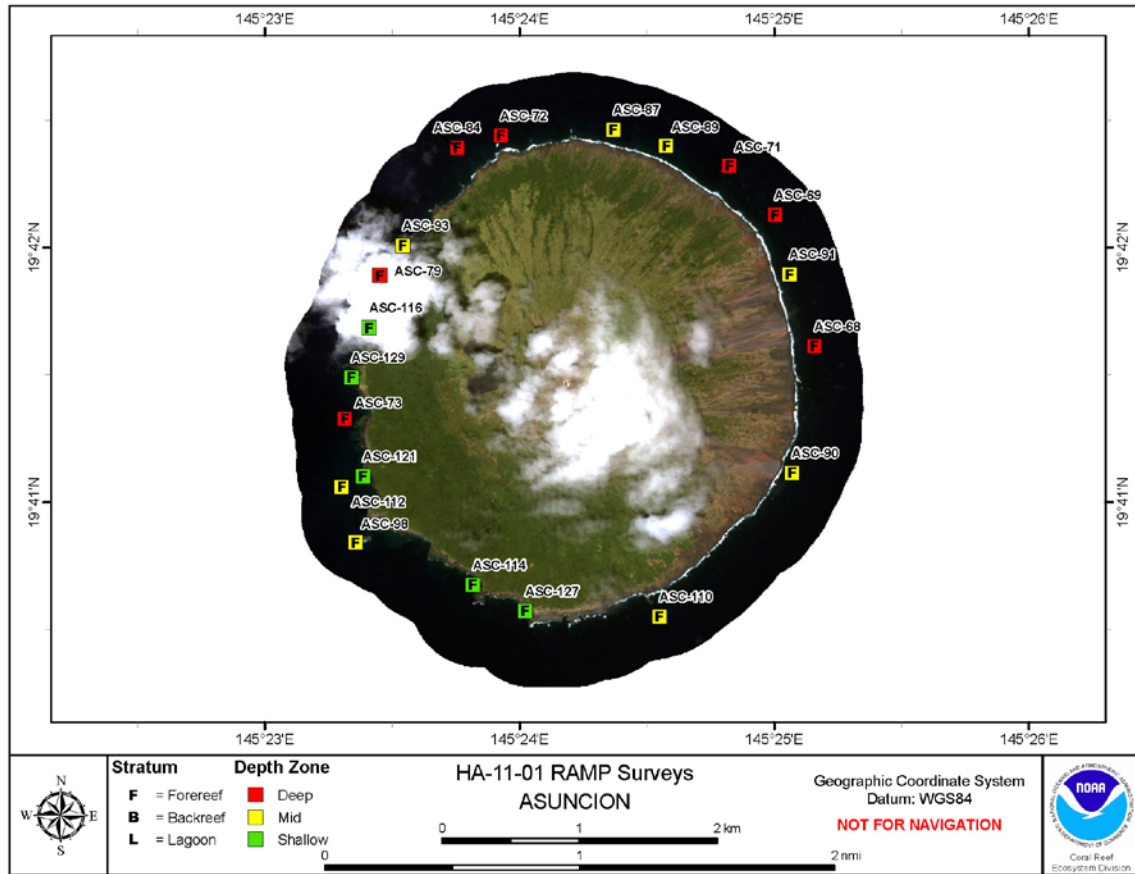


Figure L.3.1.--Locations of REA fish sites surveyed at Asuncion during cruise HA-11-01, Leg II (IKONOS Carterra Geo Data, 2002). All of these REA sites were selected using a stratified random design.

Table L.3.1.--Summary of sites where REA fish surveys were conducted at Asuncion during cruise HA-11-01, Leg II.

REA Site	Date	Depth Zone	Stratum	Depth (m)	Latitude	Longitude
ASC-112	14-Apr	Moderate	Forereef	12	19.68438	145.38836
ASC-114	14-Apr	Shallow	Forereef	5	19.67794	145.39694
ASC-116	14-Apr	Shallow	Forereef	8	19.69477	145.39017
ASC-121	14-Apr	Shallow	Forereef	4	19.68504	145.38975
ASC-129	14-Apr	Shallow	Forereef	5	19.69152	145.38901
ASC-72	14-Apr	Deep	Forereef	27	19.70734	145.39875
ASC-73	14-Apr	Deep	Forereef	22	19.68882	145.38857
ASC-79	14-Apr	Deep	Forereef	26.5	19.69818	145.39086
ASC-84	14-Apr	Deep	Forereef	24	19.70656	145.39591
ASC-93	14-Apr	Moderate	Forereef	11	19.70016	145.39236
ASC-98	14-Apr	Moderate	Forereef	14	19.68072	145.38927
ASC-110	15-Apr	Moderate	Forereef	15	19.67586	145.40914
ASC-127	15-Apr	Shallow	Forereef	6	19.67623	145.40037
ASC-68	15-Apr	Deep	Forereef	21	19.69357	145.41928
ASC-69	15-Apr	Deep	Forereef	24	19.70216	145.41672
ASC-71	15-Apr	Deep	Forereef	21	19.70539	145.41373
ASC-87	15-Apr	Moderate	Forereef	12	19.70773	145.40613
ASC-89	15-Apr	Moderate	Forereef	11	19.70669	145.40961
ASC-90	15-Apr	Moderate	Forereef	9	19.68529	145.41782
ASC-91	15-Apr	Moderate	Forereef	9	19.69827	145.41767

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APPENDIX N: MAUG

The islands of Maug, located at 20.021° N, 145.22° W in the North Pacific, are part of the Marianas Trench Marine National Monument in the Mariana Archipelago, along with Asuncion and Farallon de Pajaros. For information about the methods used to perform the activities discussed in this appendix, please see Appendix A: “Methods.”

N.1. Oceanography and Water Quality

Oceanographic operations during the cruise HA-11-01, Leg II, at Maug entailed numerous retrievals and deployments of oceanographic moored instruments; installation of calcification acidification units (CAUs), coral coring, and nearshore water sampling and conductivity, temperature, and depth (CTD) casts at select Rapid Ecological Assessment (REA) sites; and shipboard water sampling and CTD casts offshore to a depth of 500 m and acoustic Doppler current profiler (ADCP) transect lines.

Seven subsurface temperature recorders (STRs) were retrieved, and six STRs were deployed (Fig. N.1.1). One of these STRs was deployed on the mooring of the sea-surface temperature (SST) buoy. One SST buoy was recovered and replaced. Two EAR units and their mooring anchors were removed (Table N.1.1). For information regarding the CAU deployments and coral core collections at Maug, please see Section N.2: “Benthic Environment.”

At nearshore locations around Maug, six shallow-water (≤ 30 m) CTD casts were performed (Fig. N.1.1), including one cast at each of the five select REA sites where CAUs were installed and one additional cast at the hydrothermal vent site, which was added as a special site of interest. In concert with each CTD cast, two water samples were taken to measure the following parameters: dissolved inorganic carbon (DIC), total alkalinity (TA), salinity, nutrient, and chlorophyll-*a* (Chl-*a*) concentrations. Accounting for losses and additional nutrient samples taken alone for microbial analysis, 12 DIC and TA, 12 salinity, 15 nutrient, and 12 Chl-*a* water samples were collected, one from the surface and one near the reef at each REA site. In addition to the standard discrete water sampling, a remote auto sampler (RAS; McLane Research Laboratories Inc., East Falmouth, Mass.) was deployed at one REA site, MAU-02, collecting 37 water samples over a 48-h period for DIC and TA measurements (Fig. N.1.1). A CTD sensor (Sea-Bird Electronics Inc., Bellevue, Wash., SBE 19*plus* Seacat Profiler) collected salinity and temperature measurements every 15 min and an acoustic Doppler profiler (ADP; Aquadopp Profiler, Nortek, Rud, Norway) collected full depth current profiles. These instruments were attached to the RAS frame and collected data during the same 48-h period that the RAS was sampling.

From the NOAA Ship *Hi`ialakai*, ~ 100 km of ADCP transect lines were run east and west away from this island during night operations. On the reciprocal course, shipboard CTD casts were conducted to a depth of 500 m per transect line every 5 km for a total of 20 deepwater CTD casts. Water samples were collected concurrently with two select

shipboard CTD casts at five depths between the surface and 200 m, depending on the depth of mixed layer as determined by the CTD downcast (Fig. N.1.2). Near Maug, 10 nutrient and 10 Chl-*a* shipboard water samples were collected.

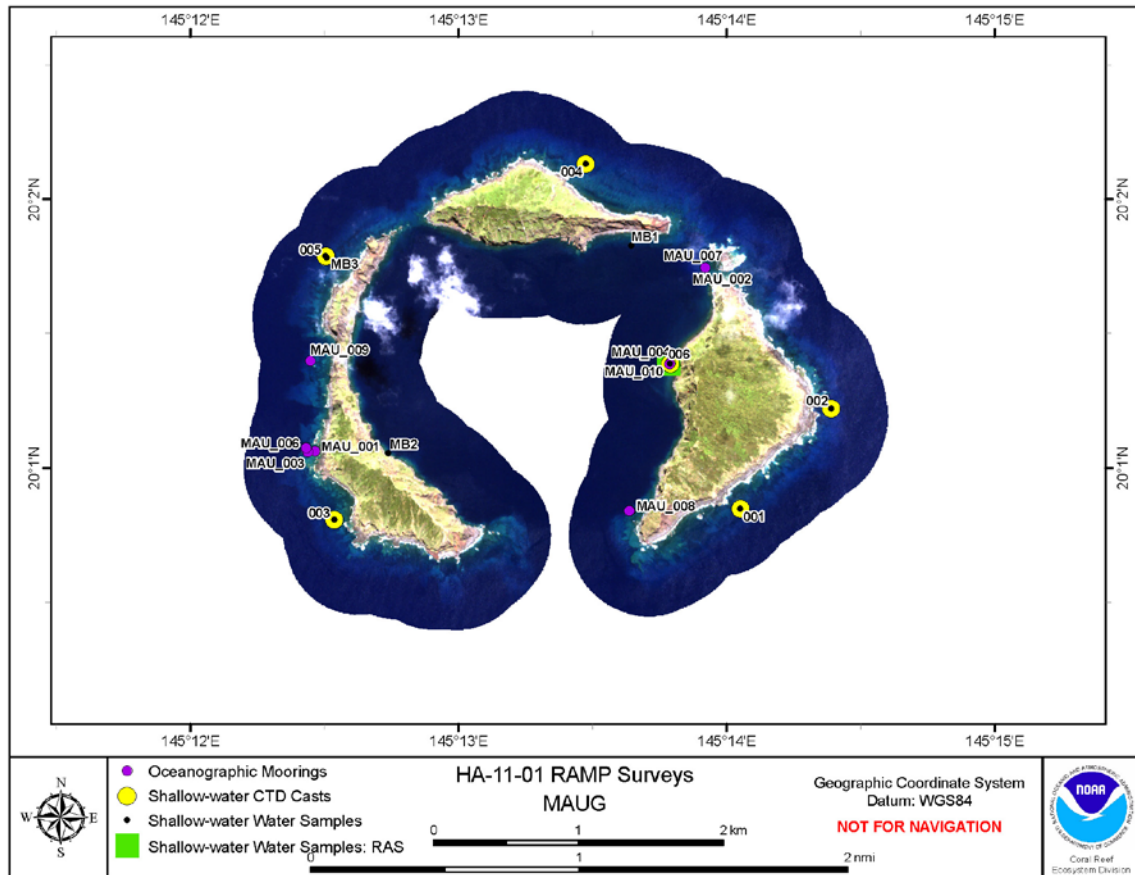


Figure N.1.1.--Mooring sites where oceanographic instruments were retrieved or deployed and locations of nearshore CTD casts and water sampling performed at Maug during cruise HA-11-01, Leg II (KONOS Carterra Geo Data, 2002). MB1–3 labels indicate locations where additional nutrient water samples were collected for microbial analyses.

Table N.1.1.--Geographic coordinates and sensor depths of the moored oceanographic instruments, RAS, EAR, and anchors that were retrieved or deployed at Maug during cruise HA-11-01, Leg II.

Mooring Site	Date	Instrument Type	Latitude	Longitude	Depth (m)	Retrieved	Deployed
MAU-001	18-Apr	STR	20.01770	145.20773	1.9	1	1
MAU-003	18-Apr	STR	20.01764	145.20727	9.8	1	1
MAU-006	18-Apr	STR	20.01791	145.20719	30.8	1	1
MAU-004	18-Apr	STR	20.02318	145.22981	9.1	1	1
MAU-002	18-Apr	SST	20.02909	145.23198	0.3	1	1
MAU-007	18-Apr	STR	20.02909	145.23198	11.6	1	1
MAU-007	18-Apr	Anchor	20.02909	145.23198	11.6	1	1
MAU-010	18-Apr	RAS	20.02311	145.22974	14	–	1
MAU-010	18-Apr	ADP	20.02311	145.22974	13.4	–	1
MAU-010	18-Apr	CTD	20.02311	145.22974	14	–	1
MAU-008	19-Apr	EAR	20.01401	145.22727	13.4	1	–
MAU-008	19-Apr	Anchor	20.01401	145.22727	13.4	1	–
MAU-008	19-Apr	STR	20.01402	145.22728	13.4	1	1
MAU-009	19-Apr	EAR	20.02330	145.20746	16.2	1	–
MAU-009	19-Apr	Anchor	20.02330	145.20746	16.2	1	–
MAU-009	19-Apr	STR	20.02330	145.20746	16.2	1	–
MAU-010	20-Apr	RAS	20.02310	145.22977	13.4	1	–
MAU-010	20-Apr	ADP	20.02310	145.22977	13.1	1	–
MAU-010	20-Apr	CTD	20.02310	145.22977	13.1	1	–

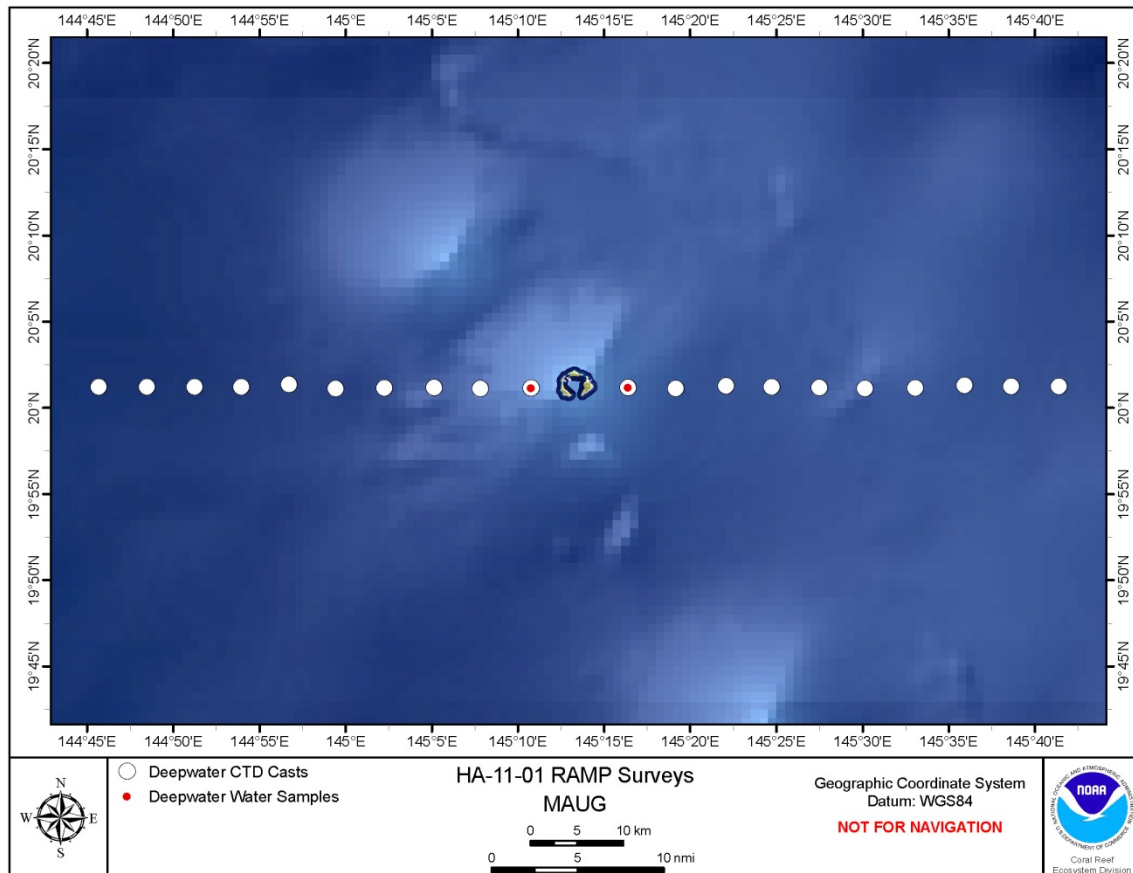


Figure N.1.2.--Locations of deepwater CTD casts and water sampling performed at Maug during cruise HA-11-01, Leg II. Island satellite image IKONOS Carterra Geo Data, 2002, and background imagery SIO, NOAA, U.S. Navy, NGA, GEBCO (Becker, 2009; Smith and Sandwell, 1997) © 2008 The Regents of the University of California.

N.2. Benthic Environment

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

Various samples were collected at five REA sites (Table N.2.2): four algal voucher specimens at MAU-10 for taxonomic identification, four coral cores (10–15 cm in length) from *Porites* coral heads at two REA sites for calcification research, and 15 water samples for microbial analyses at three REA sites with four water samples of 2 L each at each site and three water samples of 20 L each at MAU-09. Additional microbial work included benthic grabs of coral rubble and unidentified macroalgae at MAU-10 and plankton tows conducted at one nearshore and one offshore location. For more information about collections made at REA sites, see Table Q.1.1 in Appendix Q: “Biological Collections.”

Five autonomous reef monitoring structures (ARMS) were recovered: two ARMS from MAU-11 and three ARMS from MAU-09 (Table N.2.1). Nine ARMS were deployed with three ARMS each at MAU-04, MAU-09, and MAU-11. At each of five select REA sites, an array of five CAUs was deployed for a total of 25 CAUs installed at Maug (Table N.2.1). For information about the EAR recoveries at Maug, see Section F.2: “Oceanography and Water Quality.”

In total, the benthic team conducted 49 individual dives at REA sites around Maug.

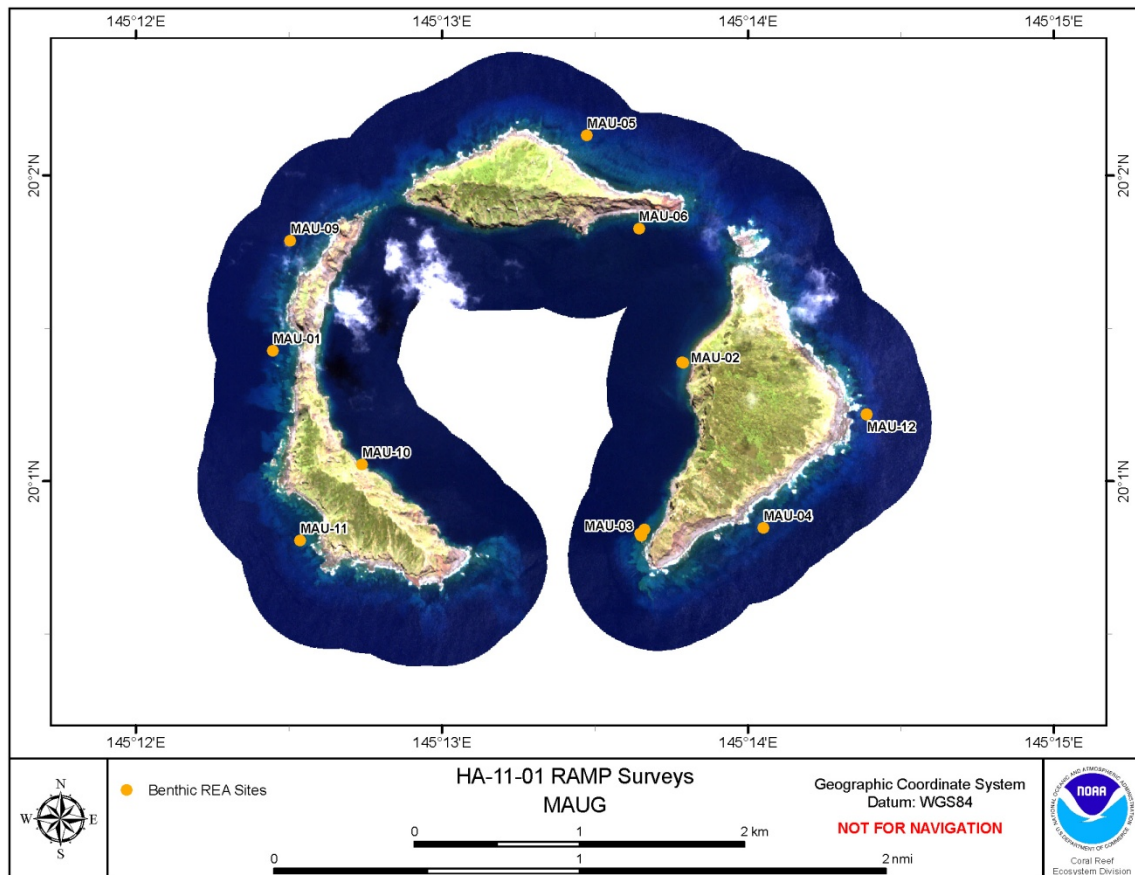


Figure N.2.1.--Locations of REA benthic sites surveyed at Maug during cruise HA-11-01, Leg II (IKONOS Carterra Geo Data, 2002).

Table N.2.1.--Summary of REA benthic surveys performed at Maug during cruise HA-11-01, Leg II. Indication that an LPI survey was completed also means that photographs were taken along transect lines.

REA Site	Date	Latitude	Longitude	REA Surveys			
				LPI	Roving Diver	Corals	Inverts
MAU-04	18-Apr	20.01414	145.23418	×	×	×	–
MAU-06	18-Apr	20.03046	145.22740	×	×	×	–
MAU-12	18-Apr	20.02032	145.23981	×	×	×	–
MAU-01	19-Apr	20.02380	145.20746	×	×	×	–
MAU-10	19-Apr	20.01759	145.21230	×	×	×	–
MAU-11	19-Apr	20.01346	145.20894	×	×	×	–
MAU-12	19-Apr	20.02034	145.23982	–	–	–	–
MAU-02	20-Apr	20.02317	145.22974	–	–	–	–
MAU-02	20-Apr	20.02316	145.22981	×	×	×	–
MAU-03	20-Apr	20.01384	145.22746	–	–	–	–
MAU-03	20-Apr	20.01372	145.22751	–	–	–	–
MAU-03	20-Apr	20.01405	145.22769	–	–	–	–
MAU-05	20-Apr	20.03552	145.22456	×	×	×	–
MAU-09	20-Apr	20.02980	145.20840	×	×	×	–

Table N.2.2.--Summary of CAU installations and ARMS retrievals (Ret.) and deployments (Dep.) performed as well as algal specimens, microbial water samples, and coral cores collected at Maug during cruise HA-11-01, Leg II.

REA Site	Date	Latitude	Longitude	Installations and Collections					
				CAUs	ARMS Ret	ARMS Dep	Algae	Microbial Samples	Coral Cores
MAU-04	18-Apr	20.01414	145.23418	5	0	3	0	0	0
MAU-06	18-Apr	20.03046	145.22740	0	0	0	0	4	0
MAU-12	18-Apr	20.02032	145.23981	0	0	0	0	0	0
MAU-01	19-Apr	20.02380	145.20746	0	0	0	0	0	0
MAU-10	19-Apr	20.01759	145.21230	0	0	0	4	10	0
MAU-11	19-Apr	20.01346	145.20894	5	2	3	0	0	0
MAU-12	19-Apr	20.02034	145.23982	5	0	0	0	0	0
MAU-02	20-Apr	20.02317	145.22974	0	0	0	0	0	1
MAU-02	20-Apr	20.02316	145.22981	5	0	0	0	0	0
MAU-03	20-Apr	20.01384	145.22746	0	0	0	0	0	1
MAU-03	20-Apr	20.01372	145.22751	0	0	0	0	0	1
MAU-03	20-Apr	20.01405	145.22769	0	0	0	0	0	1
MAU-05	20-Apr	20.03552	145.22456	5	0	0	0	0	0
MAU-09	20-Apr	20.02980	145.20840	5	3	3	0	7	0

During cruise HA-11-01, Leg II, CRED completed 11 towed-diver surveys at Maug, including two benthic calibration surveys, covering a total length of 24.1 km (an area of 24.1 ha) on the ocean floor (Fig. N.2.2). The mean survey length was 2.1 km with a range of 1.6–2.5 km. The mean survey depth was 14.7 m with a range of 12.8–15.8 m. The mean temperature from data recorded during these surveys was 26.7°C with a range of 26.2°C–27.1°C.

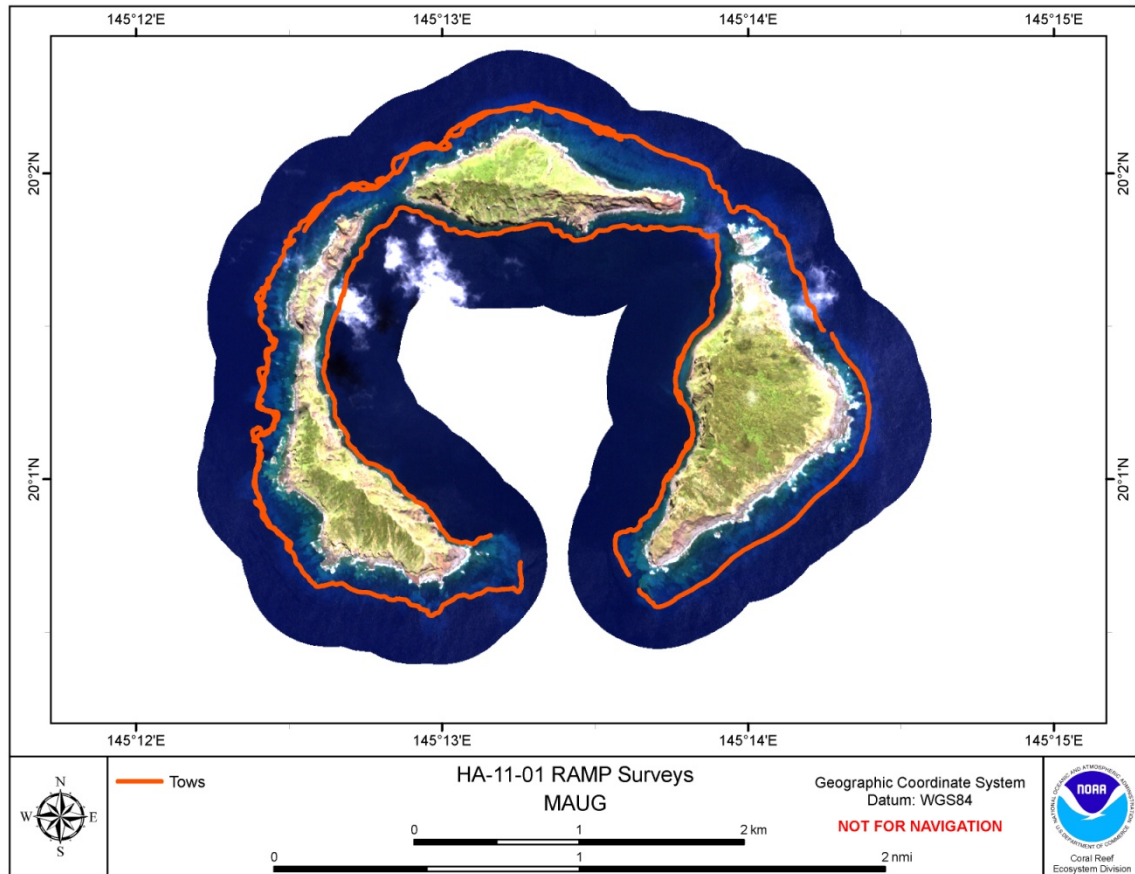


Figure N.2.2.--Track locations of towed-diver surveys conducted at Maug during cruise HA-11-01, Leg II (IKONOS Carterra Geo Data, 2002).

N.3. 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 Maug in the deep, moderate, and shallow forereef strata (Fig. N.3.1 and Table N.3.1). No fishes were collected during these surveys.

In addition, CRED completed 9 towed-diver fish surveys at Maug, as described previously in Section N.2 of this appendix.

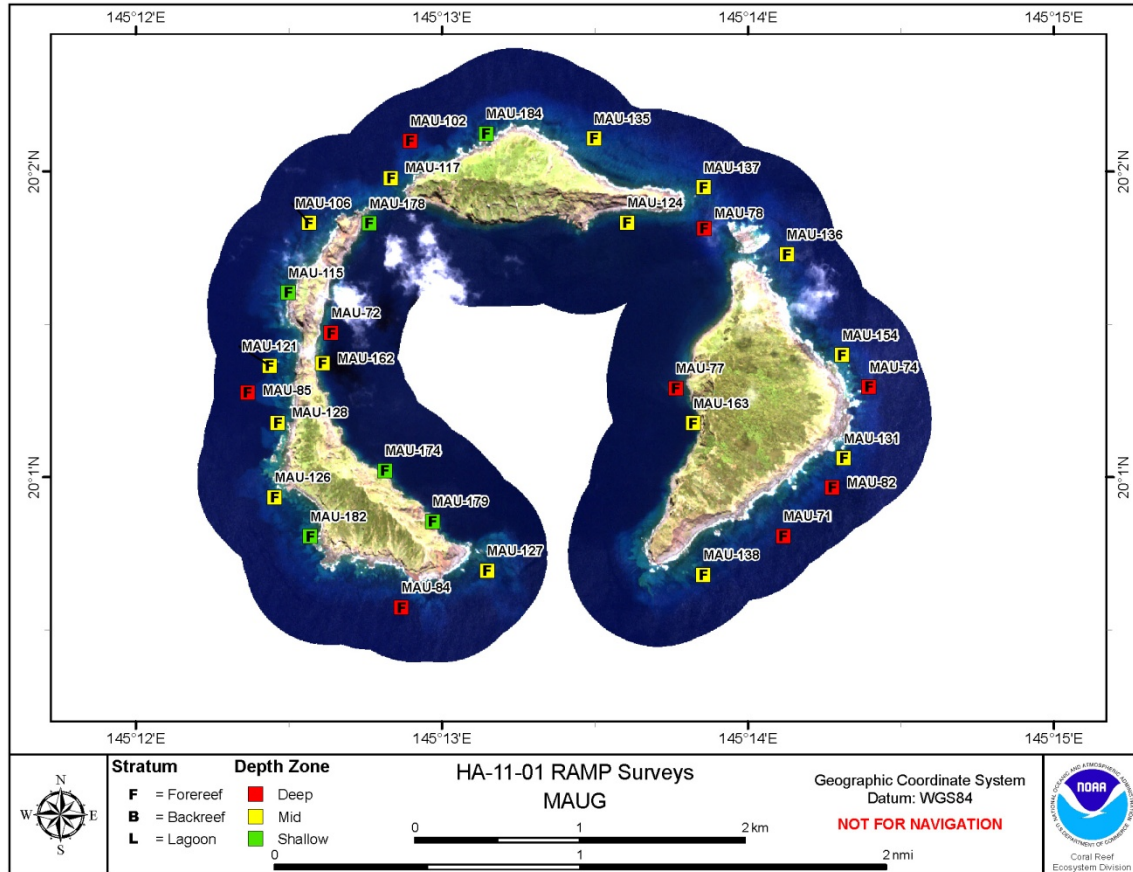


Figure N.3.1.--Locations of REA fish sites surveyed at Maug during cruise HA-11-01, Leg II (IKONOS Carterra Geo Data, 2002). All of these REA sites were selected using a stratified random design.

Table N.3.1.--Summary of sites where REA fish surveys were conducted at Maug during cruise HA-11-01, Leg II.

REA Site	Date	Depth Zone	Stratum	Depth (m)	Latitude	Longitude
MAU-71	18-Apr	Deep	Forereef	26	20.01347	145.23526
MAU-74	18-Apr	Deep	Forereef	21	20.02161	145.23994
MAU-82	18-Apr	Deep	Forereef	23	20.01613	145.23792
MAU-124	18-Apr	Moderate	Forereef	14	20.03056	145.22675
MAU-127	18-Apr	Moderate	Forereef	14	20.01160	145.21912
MAU-131	18-Apr	Moderate	Forereef	15	20.01772	145.23855
MAU-138	18-Apr	Moderate	Forereef	12	20.01137	145.23091
MAU-154	18-Apr	Moderate	Forereef	18	20.02334	145.23847
MAU-174	18-Apr	Shallow	Forereef	4.5	20.01705	145.21356
MAU-178	18-Apr	Shallow	Forereef	6	20.03052	145.21271
MAU-179	18-Apr	Shallow	Forereef	3	20.01429	145.21614
MAU-72	19-Apr	Deep	Forereef	29	20.02455	145.21063
MAU-77	19-Apr	Deep	Forereef	22.5	20.02154	145.22939
MAU-78	19-Apr	Deep	Forereef	21	20.03023	145.23095
MAU-106	19-Apr	Moderate	Forereef	14	20.03054	145.20940
MAU-115	19-Apr	Shallow	Forereef	5	20.02675	145.20829
MAU-135	19-Apr	Moderate	Forereef	10	20.03514	145.22494
MAU-136	19-Apr	Moderate	Forereef	13	20.02883	145.23545
MAU-137	19-Apr	Moderate	Forereef	15	20.03248	145.23092
MAU-162	19-Apr	Moderate	Forereef	14	20.02290	145.21015
MAU-163	19-Apr	Moderate	Forereef	16	20.01963	145.23036
MAU-184	19-Apr	Shallow	Forereef	6	20.03540	145.21906
MAU-84	20-Apr	Deep	Forereef	25	20.00958	145.21446
MAU-85	20-Apr	Deep	Forereef	22	20.02131	145.20609
MAU-102	20-Apr	Deep	Forereef	23	20.03501	145.21493
MAU-117	20-Apr	Moderate	Forereef	12	20.03298	145.21388
MAU-121	20-Apr	Moderate	Forereef	14	20.02275	145.20728
MAU-126	20-Apr	Moderate	Forereef	11.5	20.01560	145.20755
MAU-128	20-Apr	Moderate	Forereef	11	20.01964	145.20772
MAU-182	20-Apr	Shallow	Forereef	3	20.01346	145.20949

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APPENDIX O: SUPPLY REEF

Supply Reef, located at 20.14° N, 145.10° W in the North Pacific, is a submerged bank with no emergent land in the Mariana Archipelago. Oceanographic operations during the cruise HA-11-01, Leg II, at Supply Reef (Fig. O.1.1 and Table O.1.1) entailed the removal of a mooring anchor and retrieval and deployment of one subsurface temperature recorder (STR). No Rapid Ecological Assessment (REA) or towed-diver surveys were conducted at Supply Reef. For information about the methods used to perform the activities discussed in this appendix, please see Appendix A: “Methods.”

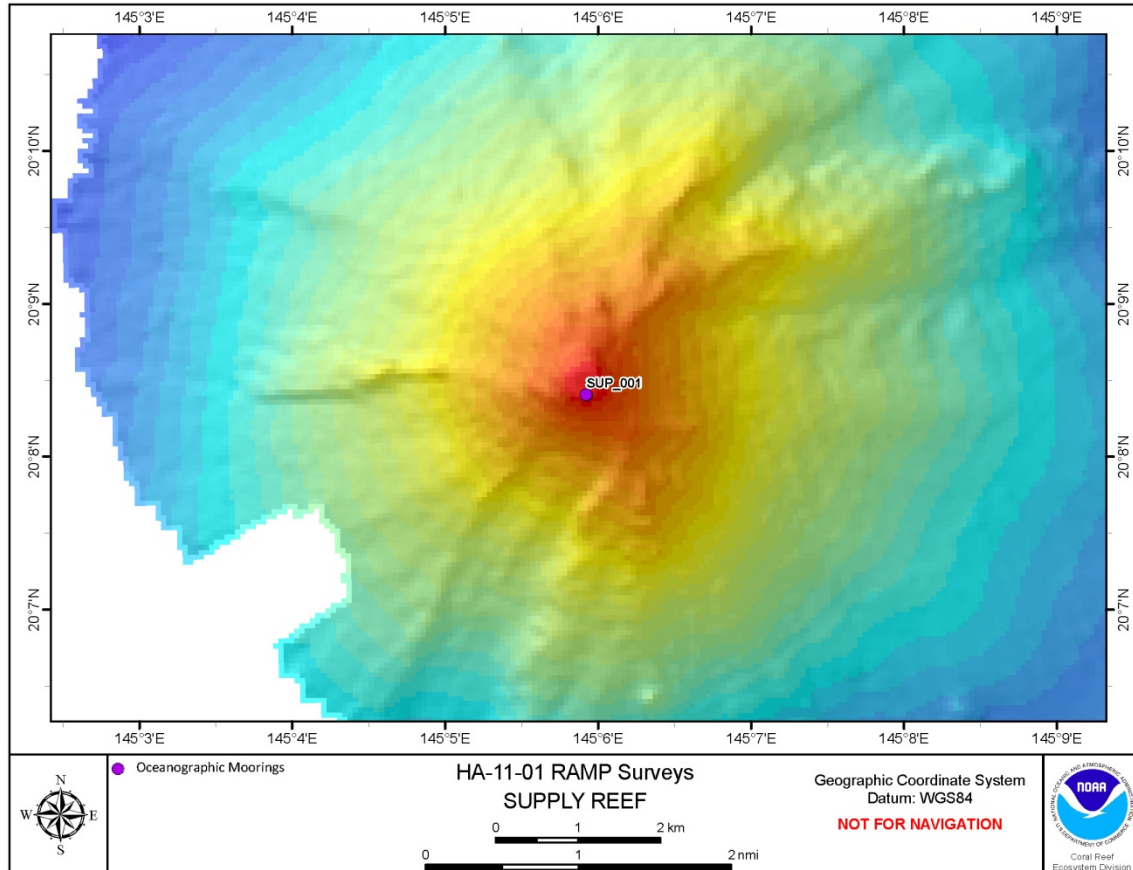


Figure O.1.1.--Mooring site at Supply Reef where an STR was retrieved or deployed during cruise HA-11-01, Leg II, shown over multibeam bathymetry (grid cell size: 60 m).

Table O.1.1.--Geographic coordinates and depths of the STRs and anchor that were retrieved or deployed at Supply Reef during cruise HA-11-01, Leg II.

Mooring Site	Date	Instrument Type	Latitude	Longitude	Depth (m)	Retrieved	Deployed
SUP-001	16-Apr	STR	20.14009	145.09865	26.65	1	1
SUP-001	16-Apr	Anchor	20.14013	145.09862	26.2	1	—

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APPENDIX P: FARALLON DE PAJAROS

The island of Farallon de Pajaros is located at 20.54° N, 144.89° W in the North Pacific and is one of the islands, along with Asuncion and Maug, that are part of the Marianas Trench Marine National Monument in the Mariana Archipelago. For information about the methods used to perform the activities discussed in this appendix, please see Appendix A: “Methods.”

P.1. Oceanography and Water Quality

Oceanographic operations during the cruise HA-11-01, Leg II, at Farallon de Pajaros entailed the retrieval and replacement of six subsurface temperature recorders (STRs), shipboard conductivity, temperature, and depth (CTD) casts offshore to a depth of 500 m, and an acoustic Doppler current profiler (ADCP) transect line (Fig. P.1.1 and Table P.1.1). A single nutrient water sample was collected at a nearshore location near Rapid Ecological Assessment (REA) site FDP-01 for microbiological analysis.

From the NOAA Ship *Hi`ialakai*, an ADCP transect line ~ 25 km long was run west away from this island during night operations. On the reciprocal course, shipboard CTD casts were conducted to a depth of 500 m every 5 km for a total of 5 deepwater CTD casts (Fig. P.1.2.). Shipboard water samples were not collected at Farallon de Pajaros.

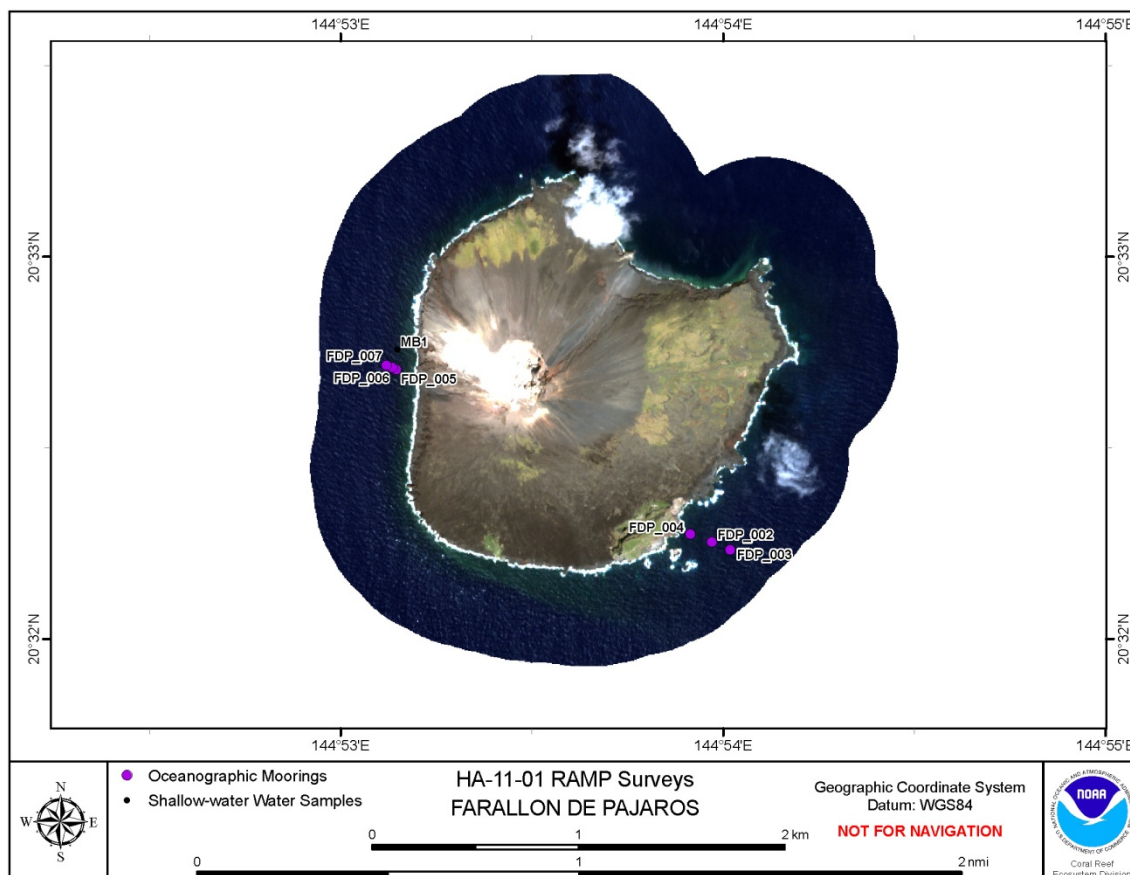


Figure P.1.1.--Mooring sites where STRs were retrieved or deployed and location (MB1) of the nearshore water sampling performed at Farallon de Pajaros during cruise HA-11-01, Leg II (IKONOS Carterra Geo Data, 2002).

Table P.1.1.--Geographic coordinates and sensor depths of the STRs that were retrieved or deployed at Farallon de Pajaros during cruise HA-11-01, Leg II.

Mooring Site	Date	Instrument Type	Latitude	Longitude	Depth (m)	Retrieved	Deployed
FDP-002	17-Apr	STR	20.53758	144.89950	17.1	1	1
FDP-003	17-Apr	STR	20.53724	144.90030	32.3	1	1
FDP-004	17-Apr	STR	20.53791	144.89858	10.7	1	1
FDP-005	17-Apr	STR	20.54509	144.88575	12.2	1	1
FDP-006	17-Apr	STR	20.54520	144.88556	18.6	1	1
FDP-007	17-Apr	STR	20.54528	144.88533	31.7	1	1

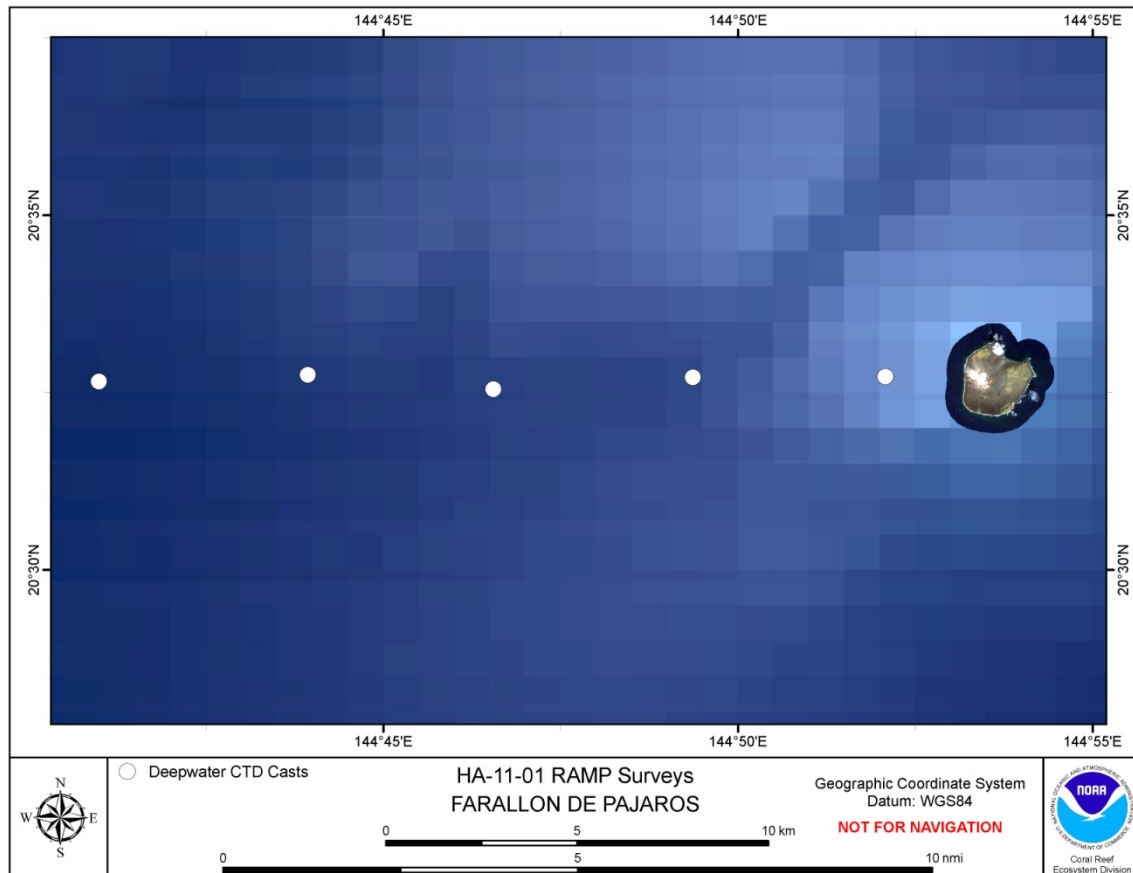


Figure P.1.2.--Locations of deepwater CTD casts performed at Farallon de Pajaros during cruise HA-11-01, Leg II. Island satellite image IKONOS Carterra Geo Data, 2002, and background imagery SIO, NOAA, U.S. Navy, NGA, GEBCO (Becker, 2009; Smith and Sandwell, 1997) © 2008 The Regents of the University of California.

P.2. Benthic Environment

Belt-transect, line-point-intercept (LPI), and roving-diver algal surveys were conducted and photographs were taken along transect lines at three REA sites at Farallon de Pajaros to assess benthic composition, coral and algal community structure, coral and algal disease, and target macroinvertebrates (Fig. P.2.1 and Table P.2.1).

Seven water samples were collected at FDP-01 for microbial analyses, with four water samples of 2 L each and three water samples of 20 L each (Table P.2.2). Additional microbial work included plankton tows conducted at one nearshore and one offshore location. For more information about collections made at REA sites, see Table Q.1.1 in Appendix Q: “Biological Collections.”

In total, the benthic team conducted 19 individual dives at REA sites at Farallon de Pajaros.

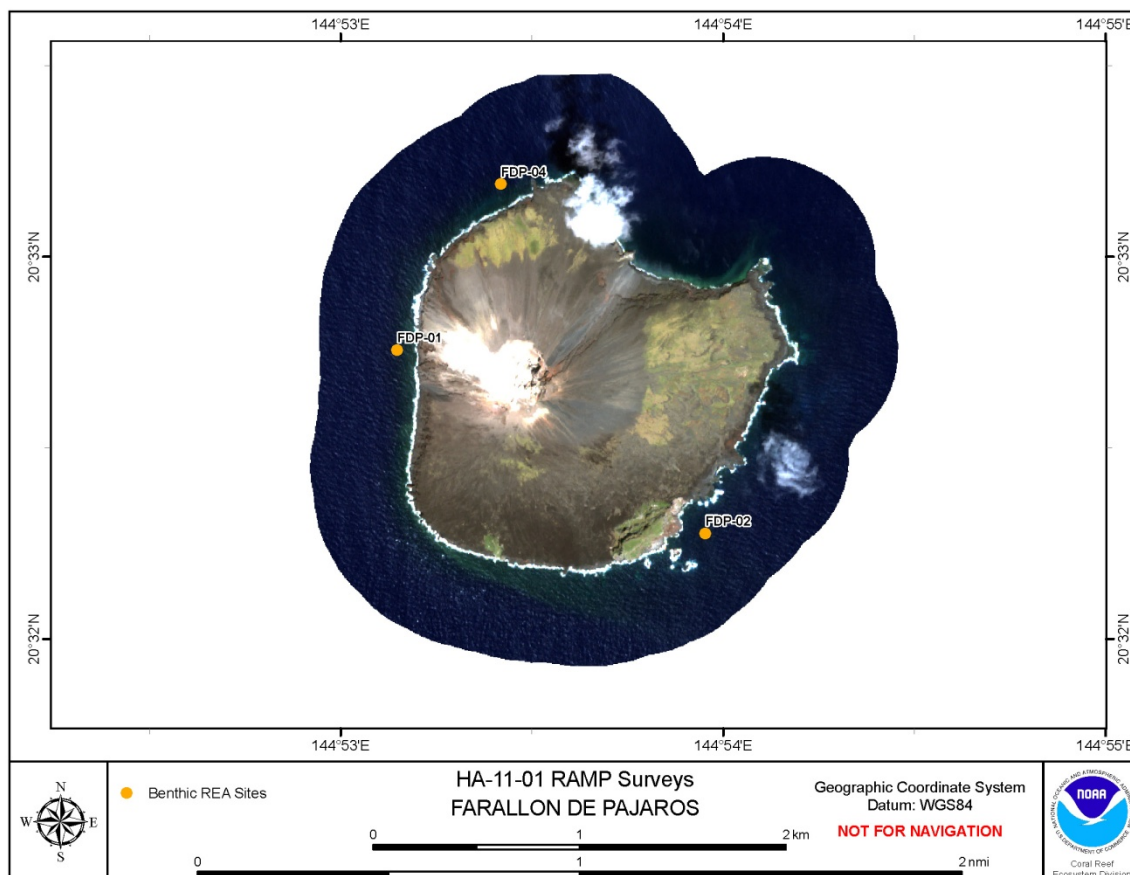


Figure P.2.1.--Locations of REA benthic sites surveyed at Farallon de Pajaros during cruise HA-11-01, Leg II (IKONOS Carterra Geo Data, 2002).

Table P.2.1.--Summary of REA benthic surveys performed at Farallon de Pajaros during cruise HA-11-01, Leg II. Indication that an LPI survey was completed also means that photographs were taken along transect lines.

REA Site	Date	Latitude	Longitude	REA Surveys			
				LPI	Roving Diver	Corals	Inverts
FDP-01	17-Apr	20.54595	144.88580	×	×	×	×
FDP-02	17-Apr	20.53796	144.89923	×	×	×	×
FDP-04	17-Apr	20.55318	144.89032	×	×	×	×

Table P.2.2.--Summary of installation and collection activities at REA sites at Farallon de Pajaros during cruise HA-11-01, Leg II, including collection of microbial water samples.

REA Site	Date	Latitude	Longitude	Installations and Collections					
				CAUs	ARMS Ret	ARMS Det	Algae	Microbial Samples	Coral Cores
FDP-01	17-Apr	20.54595	144.88580	0	0	0	0	7	0
FDP-02	17-Apr	20.53796	144.89923	0	0	0	0	0	0
FDP-04	17-Apr	20.55318	144.89032	0	0	0	0	0	0

During cruise HA-11-01, Leg II, CRED completed four towed-diver surveys at Farallon de Pajaros Island, covering a total length of 8.4 km (an area of 8.4 ha) on the ocean floor (Fig. P.2.2). The mean survey length was 2.1 km with a range of 1.7–2.3 km. The mean survey depth was 13.7 m with a range of 12.9–14.9 m. The mean temperature from data recorded during these surveys was 26.2°C with a range of 26.0°C–26.4°C.

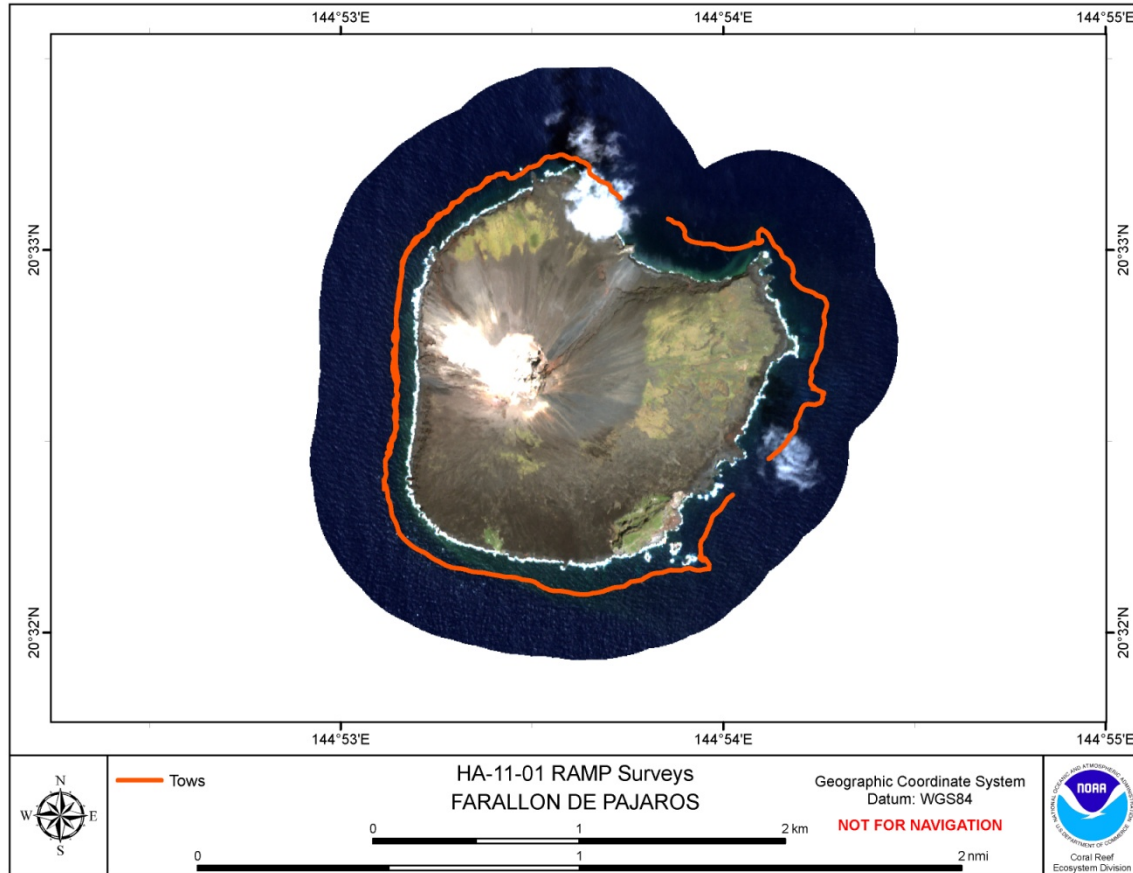


Figure P.2.2.--Track locations of towed-diver surveys conducted at Farallon de Pajaros during cruise HA-11-01, Leg II (IKONOS Carterra Geo Data, 2002).

P.3. 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 Farallon de Pajaros in the deep, moderate, and shallow forereef strata (Fig. P.3.1 and Table P.3.1). No fishes were collected during these surveys.

In addition, CRED completed four towed-diver surveys at Farallon de Pajaros, as described previously in Section P.2 of this appendix.

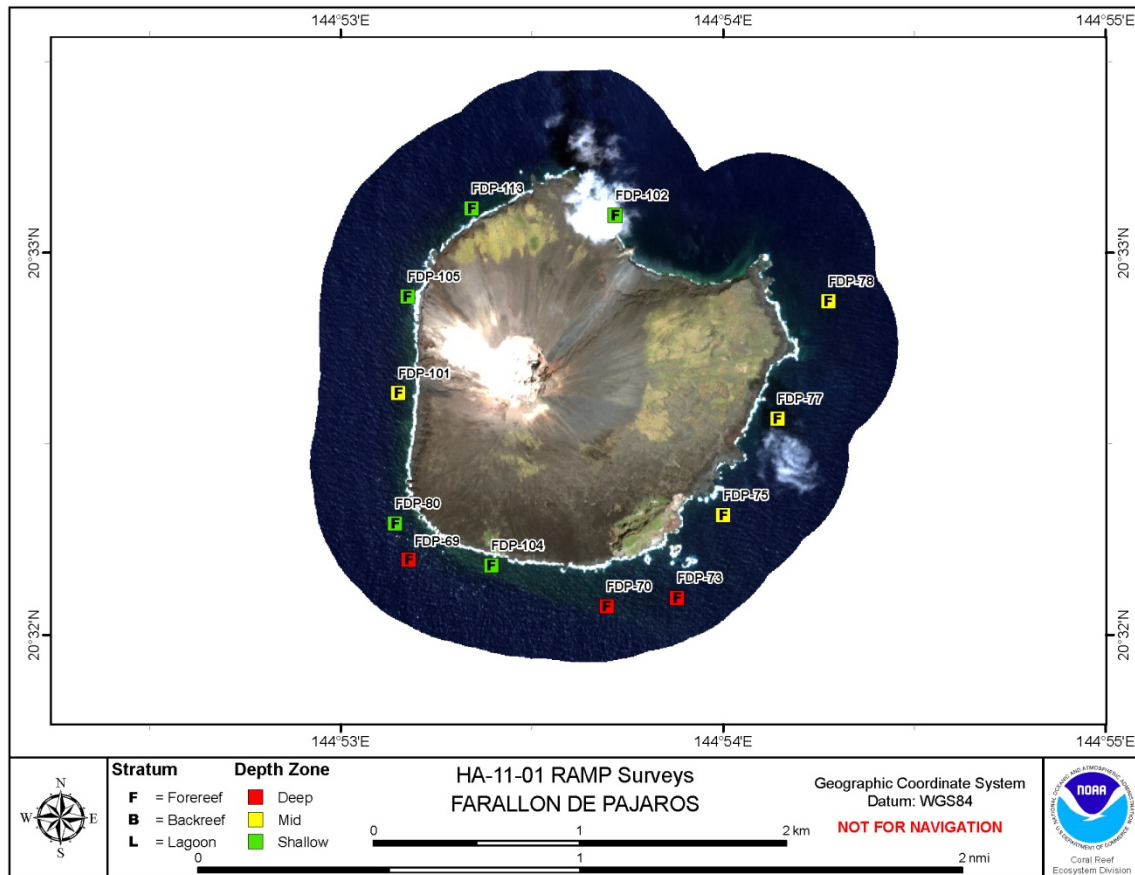


Figure P.3.1.--Locations of REA fish sites surveyed at Farallon de Pajaros during cruise HA-11-01, Leg II (IKONOS Carterra Geo Data, 2002). All of these REA sites were selected using a stratified random design.

Table P.3.1.--Summary of sites where REA fish surveys were conducted at Farallon de Pajaros during cruise HA-11-01, Leg II.

REA Site	Date	Depth Zone	Stratum	Depth (m)	Latitude	Longitude
FDP-69	17-Apr	Deep	Forereef	24	20.53663	144.88630
FDP-70	17-Apr	Deep	Forereef	23	20.53461	144.89492
FDP-73	17-Apr	Deep	Forereef	29	20.53498	144.89799
FDP-75	17-Apr	Moderate	Forereef	15	20.53857	144.90000
FDP-77	17-Apr	Moderate	Forereef	10	20.54279	144.90237
FDP-78	17-Apr	Moderate	Forereef	17	20.54790	144.90459
FDP-80	17-Apr	Shallow	Forereef	17	20.53822	144.88570
FDP-101	17-Apr	Moderate	Forereef	16	20.54390	144.88584
FDP-102	17-Apr	Shallow	Forereef	6	20.55165	144.89530
FDP-104	17-Apr	Shallow	Forereef	5	20.53638	144.88989
FDP-105	17-Apr	Shallow	Forereef	6	20.54810	144.88624
FDP-113	17-Apr	Shallow	Forereef	4	20.55194	144.88904

APPENDIX Q: SAMPLE COLLECTIONS

Samples of algae, corals, water, and sediment were collected at the islands of the Mariana Archipelago and their surrounding waters for multiple research purposes during the cruise HA-11-01, Legs II and III. These collections are listed here in Table Q.1.1.

Table Q.1.1—Samples collected in the Mariana Archipelago for taxonomic identification, ocean acidification research, or microbial analyses during cruise HA-11-01, Legs II and III.

REA Site	Date	Latitude	Longitude	Specimen Collected	Number of Samples	Depth (m)
Taxonomic Identification: Algal Voucher Specimens						
PAG-09	11-Apr	18.07077	145.71379	Red algae	3	–
PAG-09	11-Apr	18.07077	145.71379	<i>Valonia</i> sp.	1	–
PAG-11	11-Apr	18.08651	145.72986	Red algae	3	–
PAG-06	12-Apr	18.09292	145.74422	Red alga	1	–
PAG-11	12-Apr	18.08607	145.72969	Red algae	3	–
PAG-13	13-Apr	18.09640	145.76480	Red algae	4	–
MAU-10	19-Apr	20.01759	145.21230	Red algae	4	12.2
GUG-01	24-Apr	17.30597	145.85164	Unknown alga	1	–
GUG-01	24-Apr	17.30597	145.85164	Red alga	1	–
ROT-02	1-May	14.15382	145.25949	Red algae	2	–
ROT-05	2-May	14.18319	145.20720	<i>Caulerpa</i> sp.	1	–
ROT-05	2-May	14.18319	145.20720	Red alga	1	–
ROT-05	2-May	14.18319	145.20720	<i>Udotea</i> spp.	3	–
ROT-05	2-May	14.18319	145.20720	<i>Halimeda</i> spp.	2	–
TIN-06	3-May	15.08037	145.62135	<i>Halimeda</i> sp.	1	–
TIN-06	3-May	15.08037	145.62135	Red algae	3	–
AGU-02	4-May	14.84779	145.53651	Red algae	2	–
GUA-06	5-May	13.33223	144.77422	Red algae	4	–
GUA-08	5-May	13.48871	144.87796	Red algae	2	–
GUA-08	5-May	13.48871	144.87796	<i>Caulerpa</i> sp.	1	–
GUA-11	5-May	13.42809	144.81037	Red algae	4	–
GUA-07	6-May	13.60240	144.92737	<i>Halimeda</i> sp.	1	–
GUA-09	6-May	13.63271	144.89265	Red algae	2	–
GUA-02	7-May	13.30553	144.65257	Red algae	2	21.3
GUA-02	7-May	13.30553	144.65257	<i>Avrainvillea</i> sp.	1	21.3
GUA-13	7-May	13.29157	144.76777	<i>Halimeda</i> sp.	1	–
GUA-10	8-May	13.47359	144.69352	Red alga	1	–
GUA-12	8-May	13.44878	144.62596	Red algae	4	–

REA Site	Date	Latitude	Longitude	Specimen Collected	Number of Samples	Depth (m)
Ocean Acidification: Coral Core Collections						
PAG-11	12-Apr	18.08607	145.72969	<i>Porites</i> sp.	1	9.4
MAU-02	20-Apr	20.02317	145.22974	<i>Porites</i> sp.	1	13.4
MAU-03	20-Apr	20.01372	145.22751	<i>Porites</i> sp.	1	6.1
MAU-03	20-Apr	20.01384	145.22746	<i>Porites</i> sp.	1	4.9
MAU-03	20-Apr	20.01405	145.22769	<i>Porites</i> sp.	1	4.6
GUA-05	6-May	13.57817	144.82834	<i>Porites</i> sp.	1	8.8
GUA-05	6-May	13.57798	144.82838	<i>Porites</i> sp.	1	8.2
GUA-02	7-May	13.30596	144.65570	<i>Porites</i> sp.	1	4.9
GUA-02	7-May	13.30601	144.65565	<i>Porites</i> sp.	1	3.4
GUA-02	7-May	13.30595	144.65550	<i>Porites</i> sp.	1	5.2
Microbial Analyses: Water Samples, Corals, Algae, and Rubble						
SAI-06	7-Apr	15.15629	145.68994	2 L	4	10.1
SAI-05	8-Apr	15.09784	145.74345	2 L	4	14.9
TIN-03	9-Apr	14.99064	145.60289	2 L	4	9.1
TIN-03	9-Apr	14.99064	145.60289	Coral fragment	1	10.4
TIN-03	9-Apr	14.99064	145.60289	Algal fragments	6	10.4
TIN-03	9-Apr	14.99064	145.60289	Sediment, soil, or rubble	3	10.4
SAR-03	10-Apr	16.71023	145.76752	2 L	4	11.6
SAR-03	10-Apr	16.71023	145.76752	20 L	3	11.6
PAG-05	11-Apr	18.11946	145.75554	2 L	4	11.3
PAG-03	12-Apr	18.16820	145.78799	2 L	4	10.1
PAG-03	12-Apr	18.16820	145.78799	Coral fragment	1	11.3
PAG-03	12-Apr	18.16820	145.78799	Algal fragments	6	11.3
PAG-03	12-Apr	18.16820	145.78799	Sediment, soil, or rubble	3	11.3
PAG-01	13-Apr	18.10734	145.78587	2 L	4	9.4
PAG-01	13-Apr	18.10734	145.78587	20 L	3	9.4
ASC-03	14-Apr	19.70203	145.39339	2 L	4	13.7
ASC-05	15-Apr	19.67790	145.41179	2 L	4	13.7
FDP-01	17-Apr	20.54595	144.88580	2 L	4	9.8
FDP-01	17-Apr	20.54595	144.88580	20 L	3	9.8
MAU-06	18-Apr	20.03046	145.22740	2 L	4	9.1
MAU-10	19-Apr	20.01759	145.21230	2 L	4	11
MAU-10	19-Apr	20.01759	145.21230	Coral fragment	1	12.2
MAU-10	19-Apr	20.01759	145.21230	Algal fragments	2	12.2

REA Site	Date	Latitude	Longitude	Specimen Collected	Number of Samples	Depth (m)
MAU-10	19-Apr	20.01759	145.21230	Sediment, soil, or rubble	3	12.2
MAU-09	20-Apr	20.02980	145.20840	2 L	4	11.6
MAU-09	20-Apr	20.02980	145.20840	20 L	3	11.6
AGR-07	21-Apr	18.79780	145.68767	2 L	4	13.4
AGR-07	21-Apr	18.79780	145.68767	20 L	3	13.4
AGR-06	22-Apr	18.75728	145.64038	2 L	4	12.2
ALA-01	23-Apr	17.61485	145.84250	2 L	4	12.2
GUG-02	24-Apr	17.29993	145.83433	2 L	4	13.1
GUG-02	24-Apr	17.29993	145.83433	20 L	3	13.1
SAI-08	30-Apr	15.27406	145.79106	2 L	4	10.7
SAI-08	30-Apr	15.27406	145.79106	20 L	3	10.7
ROT-02	1-May	14.15382	145.25949	2 L	4	9.8
ROT-02	1-May	14.15382	145.25949	Algal fragments	3	10.7
ROT-02	1-May	14.15382	145.25949	Sediment, soil, or rubble	3	10.7
ROT-05	2-May	14.18319	145.20720	2 L	4	11
ROT-05	2-May	14.18319	145.20720	20 L	3	11
ROT-05	2-May	14.18319	145.20720	Algal fragments	6	12.5
ROT-05	2-May	14.18319	145.20720	Sediment, soil, or rubble	2	12.5
TIN-04	3-May	14.94772	145.66302	2 L	4	9.8
AGU-02	4-May	14.84779	145.53651	2 L	4	12.8
AGU-02	4-May	14.84779	145.53651	Algal fragments	3	13.7
AGU-02	4-May	14.84779	145.53651	Sediment, soil, or rubble	3	13.7
GUA-06	5-May	13.33223	144.77422	2 L	4	10.7
GUA-09	6-May	13.63271	144.89265	2 L	4	10.7
GUA-03	7-May	13.24143	144.70287	2 L	4	9.1
GUA-04	8-May	13.51713	144.79752	2 L	4	10.7
GUA-04	8-May	13.51713	144.79752	Coral fragment	1	11.3
GUA-04	8-May	13.51713	144.79752	Algal fragments	2	11.3
GUA-04	8-May	13.51713	144.79752	Sediment, soil, or rubble	3	11.3
GUA-01	9-May	13.43002	144.63746	2 L	4	10.1