U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE

Pacific Island Fisheries Science Center
2570 Dole St. • Honolulu, Hawaii 96822-2396
(808) 983-5300 • Fax: (808) 983-2902

CRUISE REPORT[1]

VESSEL: *Oscar Elton Sette*, Cruise OES-06-11 (OES-47)

CRUISE PERIOD: 8–28 October 2006 (on site at French Frigate Shoals 10–26 October 2006)

AREA OF OPERATION: French Frigate Shoals, Northwestern Hawaiian Islands Marine National Monument

TYPE OF OPERATION: Personnel from the Coral Reef Ecosystem Division (CRED), Pacific Islands Fisheries Science Center (PIFSC), National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA), Northwestern Hawaiian Islands Marine National Monument, National Ocean Service, NOAA, Panama City Laboratory, Southeast Fisheries Science Center, NMFS, NOAA, the U.S. Fish and Wildlife Service (USFWS), the National Park Service, the University of Hawaii Hawaii Institute of Marine Biology, Joint Institute for Marine and Atmospheric Research, and Botany Department, the University of Florida, Florida Museum of Natural History, the Natural History Museum of Los Angeles County, the University of Puerto Rico, and the Institute de Ciencias do Mar in Brazil conducted a Census of Coral Reef Ecosystems (CReefs) biodiversity census at French Frigate Shoals in the Northwestern Hawaiian Islands Marine National Monument as part of the international Census of Marine Life (CoML). All activities described in this report were covered by the following permits: NWHIMNM-2006-015, with amendments A1 to A5, and DLNR.NWHI06R021 with associated amendments.

[1] PIFSC Cruise Report CR-07-007
Issued 15 March 2007

ITINERARY:

8 October	Start of cruise. Embarked Russell Brainard (Chief Scientist), Brian Zgliczynski (Divemaster), Amy Hall (dive support), Elizabeth Keenan (dive support), Jim Maragos (corals, photographer), Gustav Paulay (invertebrates), Scott Godwin (invertebrates), Jody Martin (invertebrates), Leslie Harris (invertebrates), Corydon Pittman (invertebrates), John Starmer (invertebrates), Tito Lotufo (invertebrates), Sea McKeon (invertebrates), Rebecca Most (algae), Kris Coontz (algae), Emmanuel Irizarry Soto (microbes), Russell Moffitt (data manager), Andy Collins (outreach and education), Susan Middleton (outreach and education. photographer), and Steve Matthews (chamber operator). All personnel signed Northwestern Hawaiian Islands Marine National Monument (NWHIMNM) permit number NWHIMNM-2006-015 at 1700 after successful testing of Vessel Monitoring System (VMS). Departed Honolulu at 1800, en route to French Frigate Shoals (FFS), NWHIMNM. A shipboard orientation meeting was held for all scientific personnel and new crew members at 1900. A scientific meeting was convened at 2000 to discuss operations and plans for 2-day transit to FFS, including a thorough review of the NWHIMNM and State scientific permits.
9 October	Continued transit to FFS. During permit reviews, the scientific party identified numerous concerns that would prevent most planned sampling at FFS. Conducted abandon ship and dive accident management safety stand-down drills including medical evacuation to the recompression chamber and oxygen administration. At 1600, Chief Scientist attempted to contact and left voice messages for the PIFSC Director and NWHIMNM Administrator by satellite phone about permit concerns. Conducted standard 500-m conductivity-temperature-depth (CTD) at permanent Nihoa Island CTD site. At 1800 and 1820, Chief Scientist received calls from PIFSC Director and NWHIMNM staff to discuss permit concerns. At 1900, the scientific party conducted a planning meeting to discuss operations, data management, permit restrictions, and alternative plans for conducting operations in the main Hawaiian Islands.
10 October	Scientific party continued preparing gear during the day while transiting toward FFS. Conducted standard 500-m CTD at permanent Necker Island CTD site. Conducted scientific planning meeting at 1830 to discuss permit status and upcoming operations for night and following day. Arrived at southeast corner of FFS at 1900. At 1945 received e-mail version of Monument Permit Amendment NWHIMNM-2006-015-A1 allowing operations to proceed as planned and generally consistent with State of Hawaii Permit DLNR.NWHI106R021. At 2045, initiated deployment of three strings of eight baited traps in depths ranging from 250 m to 100 m

at Deep Slope site 1 (DRS 1). Conducted standard 500 m CTD at permanent FFS CTD site.

11 October — Conducted morning dive and small boat safety meeting at 0730. At 0752, launched three small boats (PIFSC 19-ft SAFEboat, CRED 19-ft SAFEboat, and ship's 15-ft SAFEboat) to commence diver- based biodiversity surveys at Lagoon Patch Reef site 2 (LPR 2) consisting of hand collection, algae collection, microbial collections (sediment and water), vacuuming, sand collection, sand sifting, rubble brushing, and rubble extraction. At 0928, commenced hauling baited traps from DRS 1 site. Conducted snorkel surveys of intertidal shore around La Perouse Pinnacle site. Completed retrieval of baited trap strings from site DRS 1 at 1622. Deployed five individual shallow water baited traps at Lagoon Sand site 1 (LS 1) just east of East Island in 4-7 m of water. Deployed light trap plankton collector at the last baited trap site. At 1856, commenced deployment of three strings of eight baited traps in depths ranging from 250 m to 100 m at Deep Reef Slope site 2 (DRS 2). Received e-mail copy of Monument Permit Amendent NWHIMNM-2006-015-A2. Conducted nightly scientific review and planning meeting at 2000.

12 October — Conducted morning dive and small boat safety meeting at 0730. At 0742, launched three small boats (PIFSC 19-ft SAFEboat, CRED 19ft SAFEboat, and ship's 15-ft SAFEboat) to commence diver- based biodiversity surveys at Fore Reef 1 site at a depth of 25 m (FR25_1) consisting of hand collection, algae collection, microbial collections (sediment and water), vacuuming, sand collection, rubble brushing, and rubble extraction. At 0955, commenced hauling baited traps from DRS 2 site. Conducted diver-based biodiversity surveys at Fore Reef 1 site (shifted east because of large northwest swell) at a depth of 10 m (FR10 1) consisting of hand collection, algae collection, microbial collections (sediment and water), vacuuming, sand collection, sand sifting, rubble brushing, and rubble extraction. Retrieved five individual shallow water baited traps and light trap collector at LS_1 and redeployed five baited traps at Lagoon Sand site 2 (LS 2). At 1841, commenced deployment of three strings of eight baited traps in depths ranging from 250 m to 100 m at Deep Slope site 3 (DRS 3) along the southeast slope of FFS. Conducted nightly scientific review and planning meeting at 2000.

13 October — Conducted morning dive and small boat safety meeting at 0730. At 0745, launched three small boats (PIFSC 19-ft SAFEboat, CRED 19-ft SAFEboat, and ship's 15-ft SAFEboat) to commence diver- based biodiversity surveys at Fore Reef 2 site (shifted south because of lack of suitable habitat) at a depth of 5-10 m (FR5 2) consisting of hand collection, algae collection, microbial collections (sediment and water), vacuuming, sand collection, rubble brushing, and rubble extraction. At

	0834, commenced hauling baited traps from southeast deep reef slope site DRS 3. Conducted diver based biodiversity surveys at Fore Reef 2 site at a depth of 25 m (FR25 2) consisting of hand collection, algae collection, microbial collections (sediment and water), vacuuming, sand collection, sand sifting, rubble brushing, and rubble extraction. Retrieved five individual shallow water baited traps at LS 2 and redeployed five baited traps at a Lagoon Patch Reef site 4 (recorded as BR 10) near southern patch reefs. Conducted two Ekman bottom grabs along southeast reef slope at 1340. At 1826, commenced deployment of three strings of eight baited traps in depths ranging from 250 m to 100 m at Deep Slope site 4 (DRS 4) along the southwest slope of FFS. Conducted nightly scientific review and planning meeting at 1930.
14 October	Conducted morning dive and small boat safety meeting at 0730. At 0747, launched three small boats (PIFSC 19-ft SAFEboat, CRED 19-ft SAFEboat, and ship's 15-ft SAFEboat) to commence diver- based biodiversity surveys at Fore Reef 3 site (shifted to Rapture Reef site) at a depth of 25 m (FR25 3) consisting of hand collection, algae collection, microbial collections (sediment and water), vacuuming, sand collection, sand sifting, rubble brushing, and rubble extraction. At 0853, commenced hauling baited traps from southeast deep reef slope site DRS 4. Conducted diver-based biodiversity surveys at Fore Reef 3 site at a depth of 10 m (FR10 3) consisting of hand collection, algae collection, microbial collections (sediment and water), vacuuming, sand collection, sand sifting, rubble brushing, and rubble extraction. Retrieved five individual shallow water baited traps at (BR 10) and redeployed five baited traps at a Lagoon Sand site (recorded as BR 20) near southern patch reefs. At 1515, initiated two sand dredge tow tests along western bank top and slope with minimal sample returned. During the second dredge, the dredge was damaged. At 1811, commenced deployment of three strings of eight baited traps in depths ranging from 300 m to 150 m at Deep Slope site 5 (DRS 5) along the southwest slope of FFS. Conducted nightly scientific review and planning meeting at 2000.
15 October	Conducted morning dive and small boat safety meeting at 0730. At 0756, launched three small boats (PIFSC 19-ft SAFEboat, CRED 19-ft SAFEboat, and ship's 15-ft SAFEboat) to commence diver based biodiversity surveys at Lagoon Patch Reef 3 site at a depth of 20 m (LPR 3) consisting of hand collection, algae collection, microbial collections (sediment and water), vacuuming, sand collection, sand sifting, rubble brushing, and rubble extraction. At 0859, commenced hauling baited epifauna traps from southwest deep reef slope site DRS 5. All epifauna traps successfully hauled aboard by 1009. Completed dive surveys at LPR 3 at 1230. Retrieved five baited traps and one light trap at Br 20. Conducted six Ekman bottom grabs (2 sets) in sand habitats along the west

bank top and slope over the period 1214–1236. At 1553, commenced deployment of three strings of eight baited traps in depths ranging from 275 m to 75 m at Deep Slope site 6 (DRS 6) along the northwest slope of FFS. Conducted three unsuccessful Ekman grabs in sand habitats of west bank top over the period 1840–1908. Conducted nightly scientific review and planning meeting at 1930.

16 October — Conducted morning dive and small boat safety meeting at 0730. At 0743, launched three small boats (PIFSC 19-ft SAFEboat, CRED 19-ft SAFEboat, and ship's 15-ft SAFEboat) to commence diver- based biodiversity surveys at Reef Crest site 2 (RC 2) and Back Reef site 2 (BR 2) at depths ranging from 0.5 m to 8 m (FR25 3) consisting of hand collection, algae collection, microbial collections (sediment and water), sand collection, sand sifting, rubble brushing, and rubble extraction. At 0849, commenced hauling baited epifauna traps from northwest deep reef slope site DRS 6. All epifauna traps successfully hauled aboard by 0957. Completed dive surveys at RC 2 and BR 2 at 1430. Attempted nine Ekman bottom grabs in sand habitats along the west slope over the period 1212–1300 with minimal success. At 1544, conducted sand dredge with modified dredge. At 1733, commenced deployment of three strings of eight baited traps in depths ranging from 275 m to 75 m at Deep Slope site 7 (DRS 7) along the north slope of FFS. Conducted nightly scientific review and planning meeting at 2000.

17 October — Conducted morning dive and small boat safety meeting at 0730. At 0742, launched three small boats (PIFSC 19-ft SAFEboat, CRED 19-ft SAFEboat, and ship's 15-ft SAFEboat) to commence diver- based biodiversity surveys at Arc Shell Reef site 2 (ASR 2) at a depth of 10 m consisting of hand collection, algae collection, microbial collections (sediment and water), vacuuming, sand collection, sand sifting, rubble brushing, and rubble extraction. At 0852, commenced hauling baited epifauna traps from northwest deep reef slope site DRS 7. All epifauna traps successfully hauled aboard by 1030. Completed dive surveys at ASR 2 at 1330. Conducted three Ekman grabs between 1233 and 1238. Conducted two successful dredge surveys at site Deep Bank Top site 3 (DBT 3) with revamped dredge. At 1826, commenced deployment of three strings of eight baited traps in depths ranging from 275 m to 100 m at Deep Slope site 8 (DRS 8) along the northeast slope of FFS. Received NWHIMNM Permit Amendment #NWHIMNM-2006-015-A4 and NWHIMNM-2006-015-A5 and State of Hawaii 2nd Amendment of NWHI State Marine Refuge Permit DLNR.NWHI06R021. Conducted nightly scientific review and planning meeting at 1930.

18 October — At 0730, commenced hauling baited epifauna traps from northwest deep reef slope site DRS 8. All epifauna traps successfully hauled aboard by

0915. Conducted morning dive and small boat safety meeting at 1000. At 1010, launched three small boats (PIFSC 19-ft SAFEboat, CRED 19-ft SAFEboat, and ship's 15-ft SAFEboat) to commence diver-based biodiversity surveys at Back Reef site 1 (BR 1) and Back Reef site 2 (BR 2) consisting of hand collection, algae collection, microbial collections (sediment and water), sand collection, sand sifting, rubble brushing, and rubble extraction. Launched ship's inflatable boat at 1230 to provide snorkeling opportunity for some members of the ship's crew. At 1828, commenced deployment of three strings of eight baited traps in depths ranging from 275 m to 100 m at Deep Slope site 9 (DRS 9) along the northeast slope of FFS. Conducted nightly scientific review and planning meeting at 2030.

19 October

At 0730, commenced hauling baited epifauna traps from northwest deep reef slope site DRS 9. All epifauna traps successfully hauled aboard by 0920. Conducted morning dive and small boat safety meeting at 1045. At 1055, launched three small boats (PIFSC 19-ft SAFEboat, CRED 19-ft SAFEboat, and ship's 15-ft SAFEboat) to commence diver-based biodiversity surveys at Fore Reef site 4 at a depth of 10 m (FR10 4) and Fore Reef site 2 at a depth of 10 m (FR10 2) consisting of hand collection, algae collection, microbial collections (sediment and water), vacuuming (FR10 4), sand collection, sand sifting, rubble brushing, and rubble extraction. At 1700, completed deployment of three Autonomous Reef Monitoring Structures (ARMS) at a depth of 14 m at ARMS site REA 25. At 1752, commenced deployment of three strings of eight baited traps in depths ranging from 275 m to 100 m at Deep Slope site 10 (DRS 10) along the southeast slope of FFS. Conducted nightly scientific review and planning meeting at 2000. Conducted three plankton tows over the southwest bank top between 2110 and 2211.

20 October

At 0723, commenced hauling baited epifauna traps from northwest deep reef slope site DRS 10. After several hang-ups, all epifauna traps successfully hauled aboard by 1130. Conducted morning dive and small boat safety meeting at 1215. At 1236, launched three small boats (PIFSC 19-ft SAFEboat, CRED 19-ft SAFEboat, and ship's 15-ft SAFEboat) to commence diver-based biodiversity surveys at Lagoon Patch Reef 4 site at a depth of 25 m (LPR 4) consisting of hand collection, algae collection, microbial collections (sediment and water), vacuuming, sand collection, sand sifting, rubble brushing, and rubble extraction. Conducted a bottom dredge at Bank Top Site 2 (DBT 2) in 21 meters of water. At 1833, commenced deployment of three strings of eight baited traps in depths ranging from 275 m to 75 m at Deep Slope site 11 (DRS 11) along the west slope of FFS. Conducted nightly scientific review and planning meeting at 1930. Conducted three plankton tows over the west bank top near La Perouse Pinnacle during the period from 2019 until 2121.

21 October

Conducted morning dive and small boat safety meeting at 0730. At 0747, launched three small boats (PIFSC 19-ft SAFEboat, CRED 19-ft SAFEboat, and ship's 15-ft SAFEboat) to commence diver- based biodiversity surveys at La Perouse Pinnacle (LP) consisting of hand collection, algae collection, microbial collections (sediment and water), vacuuming, sand collection, sand sifting, rubble brushing, and rubble extraction. At 0854, commenced hauling baited epifauna traps from west deep reef slope site DRS 11. All traps, except one, were successfully retrieved by 1115. The single lost trap accidentially came off the line as it was coming over onto the deck of the ship and fell overboard with no lines attached. Small boat operations were completed after the 2nd dive survey at LP at 1230 and all boats initiated returning to the ship. At 1805, commenced deployment of two strings of eight baited traps in depths ranging from 175 m to 75 m at Deep Slope site 12 (DRS 12) along the northwest slope of FFS (deep string was not set because of adverse sea conditions). Cancelled plankton tows because of high wind and sea conditions. Conducted nightly scientific review and planning meeting at 2030.

22 October

Conducted morning dive and small boat safety meeting at 0800. After a short weather delay, initiated launching of three small boats (PIFSC 19-ft SAFEboat, CRED 19-ft SAFEboat, and ship's 15-ft SAFEboat) at 0826 to commence diver-based biodiversity surveys of a small portion of the intertidal shore on the north side of Tern Island (IS 2) and Back Reef site 3 (BR_3) consisting of hand collection, algae collection, microbial collections (sediment and water), sand collection, sand sifting, rubble brushing, and rubble extraction. At 0928, commenced hauling baited epifauna traps from northwest deep reef slope site DRS 12. All traps were successfully retrieved by 1040. At 1300, completed deployment of three ARMS at a depth of 1 m at ARMS site REA R30. Transferred two 55-gal drums of gasoline from Tern Island to ship. During the period between 1323 and 1738 conducted three bottom grabs and one sand dredge in sand habitats of northern bank top. At 1820, initiated deployment of three strings of eight baited traps in depths ranging from 275 m to 75 m at Deep Slope site 13 (DRS 13) along the western slope of FFS. Conducted nightly scientific review and planning meeting at 2015. Conducted three plankton tows north of La Perouse Pinnacle during the period between 2009 and 2110.

23 October

Conducted morning dive and small boat safety meeting at 0800. After a short delay for a passing squall, launched three small boats (PIFSC 19-ft SAFEboat, CRED 19-ft SAFEboat, and ship's 15-ft SAFEboat) at 0904 to commence diver-based biodiversity surveys at La Perouse Pinnacle 3 site (LP) consisting of hand collection, algae collection, and rubble brushing. At 1005, commenced hauling baited epifauna traps from west deep reef

	slope site DRS 13. All traps were successfully retrieved by 1130. Completed two dive surveys at 1330 and retrieved small boats because of prolonged heavy showers, lightning, thunder, and gusty winds. Conducted three bottom grabs and one sand dredge over shallow bank top during the period between 1554 and 1631. At 1815, commenced deployment of three strings of eight baited traps in depths ranging from 275 m to 75 m at Deep Slope site 14 (DRS 14) along the west slope of FFS. Conducted nightly scientific review and planning meeting at 2015.
24 October	Conducted morning dive and small boat safety meeting at 0800. At 0819, launched three small boats (PIFSC 19-ft SAFEboat, CRED 19-ft SAFEboat, and ship's 15-ft SAFEboat) to commence diver- based biodiversity surveys at Halimeda Site 1 (HAL_1) in the central lagoon consisting of hand collection, algae collection, microbial collections (sediment and water), vacuuming, sand collection, sand sifting, rubble brushing, and rubble extraction. At 0934, commenced hauling baited epifauna traps from west deep reef slope site DRS 14. Traps retrieval completed at 1245 after accidentally losing three traps when line was cut by ship's propeller. At 1715, completed deployment of three ARMS at Lagoon Patch Reef REA site 33. At 1905, commenced deployment of 2 strings of 10 baited traps in depths ranging from 275 m to 75 m at Deep Slope site 15 (DRS 15) on northeast slope of FFS. Conducted nightly scientific review and planning meeting at 1930. Conducted three plankton tows in lagoon waters south of Tern Island during the period between 2155 and 2255.
25 October	At 0730, commenced hauling baited epifauna traps from northeast deep reef slope site DRS 15. All traps successfully retrieved at 0920. Conducted morning dive and small boat safety meeting at 1055. At 1106, launched three small boats (PIFSC 19-ft SAFEboat, CRED 19-ft SAFEboat, and ship's 15-ft SAFEboat) to commence diver-based biodiversity surveys at Lagoon Patch Reef 5 site at a depth of 25 m (LPR 5) and La Perouse Pinnacle (LP) consisting of hand collection, algae collection, microbial collections (sediment and water), sand collection, sand sifting, rubble brushing, and rubble extraction. Attempted to deploy three ARMS near rapid ecological assessment (REA) site H6 along the northern forereef, but could not get stainless steel stakes to penetrate carbonate substrate sufficiently to hold in place. Deployed three ARMS at REA site 12 on the southwest forereef in water depths ranging from 12 m to 14 m. At 1842, commenced deployment of 2 strings of 10 baited traps in depths ranging from 275 m to 75 m at Deep Slope site 16 (DRS 16) on southwest slope of FFS. Conducted one sand dredge in northern sand habitat of western lagoon from 2042 until 2153. Conducted nightly scientific review and planning meeting at 2000.

26 October	Conducted morning dive and small boat safety meeting at 0800. At 0813, launched three small boats (PIFSC 19-ft SAFEboat, CRED 19-ft SAFEboat, and ship's 15-ft SAFEboat) to commence diver- based biodiversity surveys at Fore Reef 1 site at a depth of 25 m (FR25 1) consisting of hand collection, algae collection, vacuuming, rubble brushing, and rubble extraction. Conducted diver-based biodiversity surveys at Back Reef 3 site near Shark Island in water depths of 18–20 m (BR 3) consisting of hand collection, algae collection, rubble brushing, and rubble extraction. Conducted diver-based biodiversity surveys at Reef Crest site 3 near Shark Island in depths of 0.5 to 2 m (RC 3) consisting of hand collection, rubble brushing, and rubble extraction. Conducted diver-based biodiversity surveys at Back Reef site 2 at water depths of 2–5 m (BR 2) consisting of yabbie pump suction. At 1000, commenced hauling baited epifauna traps from DRS 16. All traps successfully retrieved at 1116. Operations completed at FFS; departed FFS en route to Honolulu at 1650. Conducted nightly scientific review and planning meeting at 2030 to discuss cruise press conference, cruise report, and follow-up publications.
27 October	In transit. Conducted scientific meeting to discuss press conference, cruise report, and follow-up publications at 1300.
28 Ocotber	In transit. Conducted scientific meeting to discuss press conference, cruise report, and follow-up publications at 0900. Arrived Honolulu at 2000. End of cruise. Disembarked Brainard, Zgliczynski, Hall, Keenan, Moffitt and Maragos. Paulay, Harris, McKeon Godwin, Most, Collins, Middleton, and Matthews. Martin, Starmer, Pittman, Lotufo, Izarrry Soto housed aboard ship for 1 additional night, disembarking on October 29.

French Frigate Shoals Activity Sites and Collection Methodologies

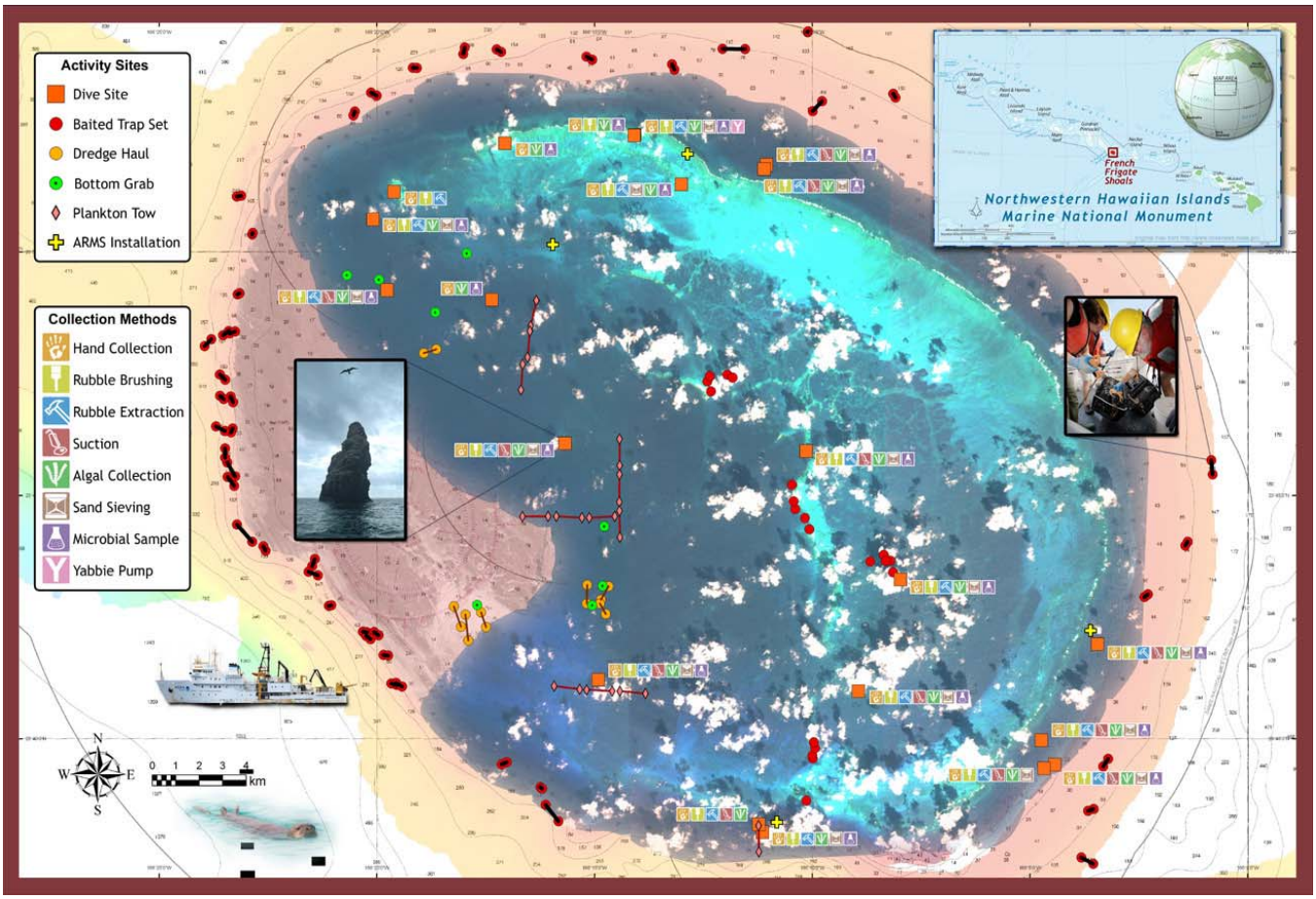


Figure 1.--This IKONOS image of French Frigate Shoals, in the Northwestern Hawaiian Islands Marine National Monument, is placed over multibeam data to give a general idea regarding the types of locations surveyed (i.e., forereef, backreef, lagoonal patch reef, sand areas, deeper areas, etc.). The symbols show the types of activities and collection methodologies employed and the locations they were used.

Table 1: Numbers of sampling operations per method for each habitat type used during cruise at French Frigate Shoals.

Methods/Habitat types	**Fore Reef**	**Reef Crest**	**Back Reef**	**Inter-Tidal**	**Lagoon Sand**	**Lagoon Patch Reef**	**La Perouse**	**Acropora Area**	**Halimeda Field**	**Arc Shell Reef**	**Deep Bank Top**	**Deep Reef Slope**	**Pelagic**
Hand collection	9	2	6	1	0	5	4	1	2	1			
Algae collection	8	0	4	1	0	4	3	1	1	1			
Rubble brushing	9	2	4	0	0	2	2	1	1	1			
Rubble extraction	8	1	3	0	0	2	1	1	1	1			
Vacuum (Suction)	7	0	0	0	0	4	1	1	0	1			
Sand sampling	8	0	3	0	0	2	1	1	2	1			
Yabbie pumps	0	0	1	0	0	0	0	0	0	0			
Microbial collection (sediment)	7	1	5	1	0	3	1	1	1	1			
Microbial collection (water)	7	1	5	1	0	3	1	1	1	1			
ARMS deployments	2	0	1	0	0	1	0	0	0	0			
Baited traps (deepwater)												45 sets of 8	
Baited traps (shallow individual)			2 sets of 5		2 sets of 5								
Light traps			2		2								
Ekman grabs											8		
Epifauna dredge tows											7		
Plankton tows	1										12		
CTD casts													3
Cholorophyll samples – total													3 sets of 5 bottles
ADCP													1 continuous

MISSIONS AND RESULTS:

A. To investigate and document the biodiversity of reef-associated non-coral invertebrates, macroalgae, turf, and coralline algae, and microbial communities at FFS using an array of invertebrate, algal, and microbial collection techniques. These methods were conducted by means of self-contained underwater breathing apparatus (SCUBA) and snorkel, as well as shipboard operations over a range of habitats throughout the atoll.

1. Algae Preliminary Report (Rebecca Most and Kris Coontz)

During the FFS cruise, a total of 366 algal specimens were catalogued and preserved for post-cruise molecular and taxonomic analysis. Thirty-one algal sampling events were conducted by SCUBA divers and snorkelers. Processed samples were sorted into 160 unique morphospecies by appearance, excluding crustose coralline samples, which often had multiple species catalogued under 1 specimen number. This number is a rough estimate and should be treated as such. Experts in Hawaiian algal flora will subject samples to sequencing and detailed taxonomic analysis before a species list can be finalized. It should be noted that 179 described taxa have been reported from all previous trips to FFS (Vroom, 2006). While this number is similar to the current estimate, many species listed by Dr. Peter Vroom of CRED in his comprehensive list of previously collected species were not found on this trip. Because of the high number of unknown species among the 160 estimated unique taxa from this expedition, it would be premature to try to establish which species are new records for FFS.

Table 2 shows the breakdown of the total specimens collected on this expedition into taxonomic divisions. Two hundred nineteen specimens were from the division Rhodophyta (59.83% of total collected), 109 were from the division Chlorophyta (29.78% of total collected), 25 were from the division Phaeophyta (6.83% of total collected), 11 were unknowns (3.01% of total collected), and 2 were cyanobacteria (0.54% of total collected). Cyanobacteria was not a focus of these collections, therefore while cyanobacteria was commonly seen in the field, it was not purposefully collected for this study.

A crustose coralline genus (*Titanoderma* sp.) was collected during this expedition, which was not included as a known genus in Dr. Vroom's list from 2006. Several crustose coralline species found are believed to have reproductive features, which will aid in the taxonomic identification process and increase our understanding of the life cycle of these poorly described taxa. Additionally, many macroalgal species were found with reproductive structures, and some of these may help complete previously unknown life cycles. An interesting macroalgal specimen collected from the lobster trapping method was *Dasya atropurpurea* (Rhodophyta), which is a new species described by Dr. Peter Vroom from Pearl and Hermes Atoll and is potentially a new record for FFS. This specimen is also believed to be reproductive.

All specimens will be transported by NOAA personnel to Dr. Alison Sherwood's lab at UH Manoa for post-processing. Dr. Sherwood will be utilizing the specimens for DNA analysis when appropriate. Specimens will also be shared with Dr. Peter Vroom's lab at the PIFSC CRED for aid with taxonomic investigations. The collections from this trip will provide valuable information about the biodiversity of FFS. In addition to broadening current knowledge about the life cycle and taxonomy of many species, information gathered from collections will contribute to a greater understanding of phylogenetic, distribution, and dispersal factors for the species collected.

Table 2: Total number of algal specimens collected during the Census of Marine Life Cruise, October 2006. *N* = 366 algal specimens.

Division	Total # collected	% of total
Rhodophyta	219	59.83%
Chlorophyta	109	29.78%
Phaeophyta	25	6.83%
Unknown	11	3.01%
Cyanobacteria	2	0.54%

Table 3: Unique Algal Species.

New Records for FFS		**Interesting specimens**	
REDS	specimen #		specimen #
Laurencia parvipapillata	*38, 107, 139, 190*	*Melanamansia sp.1*	*366, 314*
Titanoderma tessellatum		*Kallymenia sp. 1*	*1, 15, 160, 170 (repr.?), 296, 315, 300*
Dasya astropurpurea	*217, 298*	*Kallymenia sp. 2*	*171, 227, 131, 212, 239*
		Kallymenia sp. 3	*172, 286*
		Halichrisis sp.1	*116, 129, 242, 301, 263*
		Hallymenia sp.1?	*55, 103, 122, 321, 263*
		Hallymenia sp.2?	*254*
		20	*302*
		23	*229*
GREENS			
Caulerpa macrophysa	*123, 317, 251*	Green sp.6	*325*
Bornetella sphaerica	*71, 93*	*Caulerpa sp.1*	*35, 274*
Acetabularia parvula	*85*	*Caulerpa sp.2*	*313*
Enteromorpha sp.	*308*	*Caulerpa sp.3*	*364*

2. Microbial Sampling Preliminary Report (Emmanuel Irrizarry Soto)

For the purposes of microbial analysis, 29 water and 19 sediment samples were collected from FFS. The water samples consisted of a total of 29 liters (2 to 3 liters sampled at each habitat type) and sediment, 21.25 ml.

The water column and sediment were sampled using the approved microbial protocols (see Appendix A 1.7), and both water and sediment samples were conducted at the same habitat stations. No sampling took place in coral colonies or live rock following permit guidelines. All samples were processed through a Sterivex Filtration system using basic sterilizion techniques. Water samples were relaxed in Lysis buffer and frozen at -20 C. All sediment samples were relaxed with RNA later in 15-ml test tubes and frozen at -20 C. The coarse sediments sampled were classified as sediments composed mostly of coarse sand grains, small bedrocks, mollusks shells, and *Halimeda*. In contrast, fine sediments were characterized by fine sand grains and fine grains of bedrock.

Although all samples are considered significant because the communities and diversity of microbial species are widely unknown in these habitats in FFS, special attention should be paid to the samples taken around La Perouse Pinnacle and Tern Island. These particular habitats have abundant colonies of sea birds, and Tern Island serves as a nesting ground for monk seals and turtles. It could be possible that these two habitats demonstrate a marked difference in microbial communities and their diversity.

Table 4: Microbial Sediment Samples.

Date	Site	Sample	Bottle	Depth	Sample type	Volume (ml)	Notes
10/11/2006	LPR_2	MICRO_101	SA	10	HAND	1.25	coarse sediment
10/12/2006	FR10_1	MICRO_101	SA	10	HAND	1.25	coarse sediment
10/12/2006	FR25_1	MICRO_101	SA	25	HAND	1.25	fine sediment
10/14/2006	FR25_3	MICRO_101	SA	25	HAND	1.25	fine sediment
10/14/2006	FR25_3	MICRO_101	SB	25	HAND	1.25	fine sediment
10/15/2006	LPR_3	MICRO_101	SA	25	HAND	1.25	fine sediment
10/15/2006	LPR_3	MICRO_101	SB	25	HAND	1.25	fine sediment
10/15/2006	LPR_3	MICRO_101	SC	25	HAND	1.25	fine sediment
10/16/2006	BR_2	MICRO_101	SA		HAND	1.25	fine sediment
10/16/2006	BR_2	MICRO_101	SB		HAND	1.25	fine sediment
10/16/2006	BR_2	MICRO_101	SC		HAND	1.25	fine sediment
10/16/2006	DBT_12	EKMAN_1	SA	23	Bottom Grab	1.25	
10/17/2006	ARC_2	MICRO_101	SA		HAND	1.25	fine sediment
10/17/2006	ARC_2	MICRO_101	SB		HAND	1.25	fine sediment
10/17/2006	ARC_2	MICRO_101	SC		HAND	1.25	fine sediment
10/18/2006	BR_1	MICRO_101	SA		HAND	1.25	fine sediment

Date	Site	Sample	Bottle	Depth	Sample type	Volume (ml)	Notes
10/18/2006	BR_1	MICRO_101	SB		HAND	1.25	fine sediment
10/18/2006	BR_1	MICRO_101	SC		HAND	1.25	fine sediment
10/20/2006	LPR_4	MICRO_101	SA		HAND	1.25	coarse sediment
10/21/2006	LP	MICRO_101	SA		HAND	1.25	coarse sediemnt
10/22/2006	IS_1	MICRO_101	SA		HAND	1.25	fine sediment
10/22/2006	BR_3	MICRO_101	SA		HAND	1.25	coarse sediment
10/24/2006	HAL_1	MICRO_101	SA		HAND	1.25	
10/25/2006	LPR_5	MICRO_101	SA		HAND	1.25	fine sediment
10/26/2006	BR_3	MICRO_102	SA		HAND	1.25	coarse sediment
10/26/2006	FR25_1	MICRO_102	SA	23	HAND	1.25	fine sediment

Table 5: Microbial Water Samples.

Date	Site	Sample	Label	Depth (m)	Sample type	Volume (L)	notes
10/11/2006	LPR_2	MICRO_101	A	5	HAND	1	TURBID
10/11/2006	LPR_2	MICRO_101	B	5	HAND	1	TURBID
10/11/2006	LPR_2	MICRO_101	C	5	HAND	1	TURBID
10/11/2006	LPR_2	MICRO_101	D	10	HAND	1	TURBID
10/11/2006	LPR_2	MICRO_101	E	10	HAND	1	TURBID
10/11/2006	LPR_2	MICRO_101	F	10	HAND	1	TURBID
10/12/2006	FR10_1	MICRO_101	A	5	HAND	1	CLEAR
10/12/2006	FR10_1	MICRO_101	B	10	HAND	1	CLEAR
10/12/2006	FR25_1	MICRO_101	A	5	HAND	1	CLEAR
10/12/2006	FR25_1	MICRO_101	B	10	HAND	1	CLEAR
10/12/2006	FR25_1	MICRO_101	C	25	HAND	1	CLEAR
10/13/2006	FR5_2	MICRO_101	A	5	HAND	1	CLEAR
10/13/2006	FR25_2	MICRO_101	A	25	HAND	1	CLEAR
10/14/2005	FR25_3	MICRO_101	A	5	HAND	1	TURBID
10/14/2005	FR25_3	MICRO_101	B	10	HAND	1	CLEAR
10/14/2005	FR25_3	MICRO_101	C	25	HAND	1	CLEAR
10/15/2006	LPR_3	MICRO_101	A		HAND	1	TURBID
10/16/2006	BR_2	MICRO_101	A	0	HAND	1	TURBID
10/17/2006	ARC_2	MICRO_101	A		HAND	1	TURBID
10/18/2006	BR_2	MICRO_102	A	0	HAND	1	CLEAR
10/18/2006	RC_2	MICRO_101	A	0	HAND	1	CLEAR
10/19/2006	FR10_4	MICRO_101	A		HAND	1	CLEAR
10/19/2006	FR10_4	MICRO_101	B		HAND	1	CLEAR
10/20/2006	LPR_4	MICRO_101	A		HAND	1	TURBID
10/21/2006	LP	MICRO_101	A	5	HAND	1	CLEAR
10/21/2006	LP	MICRO_101	B	10	HAND	1	CLEAR
10/21/2006	LP	MICRO_101	C	25	HAND	1	CLEAR

Date	Site	Sample	Label	Depth (m)	Sample type	Volume (L)	notes
10/22/2006	IS_1	MICRO_101	A	0	HAND	1	TURBID
10/22/2006	BR_3	MICRO_101	A	0	HAND	1	CLEAR
10/24/2006	HAL_1	MICRO_101	A	5	HAND	1	
10/24/2006	HAL_1	MICRO_101	B	10	HAND	1	
10/25/2006	LPR_5	MICRO_101	A	15	HAND	1	CLEAR
10/25/2006	LPR_5	MICRO_101	B	10	HAND	1	CLEAR
10/25/2006	LPR_5	MICRO_101	C	0	HAND	1	CLEAR
10/26/2006	BR_3	MICRO_102	A	0	HAND	1	CLEAR
10/26/2006	FR25_1	MICRO_102	A	0	HAND	1	CLEAR
10/26/2006	FR25_1	MICRO_102	B	5	HAND	1	CLEAR
10/26/2006	FR25_1	MICRO_102	C	10	HAND	1	CLEAR
10/26/2006	FR25_1	MICRO_102	D	20	HAND	1	CLEAR

3. Invertebrate Sampling Preliminary Report

a. General Invertebrates Preliminary Report (Dr. Gustav Paulay)

Animal biodiversity is dominated by "invertebrates" the thirty plus phyla and millions of species that constitute >99% of animal diversity on Earth. "Focusing" on invertebrate diversity is little different than working on animal diversity, as the subphylum Vertebrata contributes relatively little to sheer species numbers. With likely more than a million species of invertebrates inhabiting coral reefs and tens of thousands living at FFS, it is not surprising that CReefs found numerous new species, state records, and regional records. The main limitations for documenting diversity were logistic: how much could an expedition this size cover and process in the time alloted, with the methods and facilities available. CReefs documented >1000 species. For comparison this corresponds to around 20% of the Hawaiian marine invertebrate fauna documented over the past 200 years. That such proportionately high diversity was documented during 16 survey days at a single, small atoll within the archipelago, reflects both on the success of the project and the relatively poorly known nature of tropical marine invertebrates. This is especially brought out when one considers taxa, like ascidians (sea squirts), that have been especially understudied in Hawaii. Thus, one scientist (Dr. Tito Lotufo) specializing on ascidians on this cruise documented >50 species, including several new records and species, even though he was not able to dive. In comparison, only 67 species have been previously recorded from the whole archipelago, and several of these are non-indigenous species restricted to harbors in the main Hawaiian Islands. In contrast in well studied groups the level of novelty was less. Thus a several decade effort by a group of sea slug afficionados has resulted in the documentation of >490 species of opisthobranchs from the Hawaiian Islands. In comparison 63 species were found by CReefs, although included in these

are a new species of 4-inch nudibranch and a new species of a 2-pound side-gilled slug.

Until the collections are analyzed, the extent of new discovery cannot be enumerated; however preliminary estimates suggest that perhaps 30–50 species new to science and at least 100 new to the area were encountered. Probable new species were found among sponges, corals, anemones, flatworms, segmented worms, hermit crabs, crabs, sea slugs, bivalves, gastropods, octopus, sea cucumbers, sea stars, and sea squirts, to name some of the most conspicuous. Some anecdotal figures serve to show the extent of novelty. Perhaps a third of the species encountered were found at only one station or were represented by but a single specimen, indicating that much remains to be discovered. For example six specimens of octopus were collected; these represent six different species, three of which may be new to science. In comparison, 15 species of octopus were previously known from the Hawaiian Islands. At least 25 species of sea cucumbers documented are three new species and two new records for the Hawaiian fauna; previously ca. 30 species of shallow water holothurians have been documented from Hawaiian waters. It is important to note that the proportion of "new" taxa is low in most biodiversity surveys, even when undescribed diversity greatly exceeds described diversity. The reason is that the most common, conspicuous, and easily encountered animals are documented most easily and thus dominate limited efforts, and these same typically represent the species previously documented as well. Thus the extent of undiscovered diversity at FFS is substantially greater than these proportional figures suggest.

Also noteworthy were the relatively high diversity of some and strikingly low diversity or absence of other taxa, in comparison with other tropical Pacific reef systems. Thus, for example, sponges, bryozoans, eulimid gastropods, hermit crabs, echinoderms, and ascidians were relatively diverse for a central Pacific atoll; in contrast the virtual or complete absence of corallimorph anemones, galatheid squat lobsters, porcellanid crabs, pea crabs, and coral barnacles was striking. The absence of some conspicuous species that are widespread in the central Pacific or even in the main Hawaiian Islands, like christmas-tree worms (*Spirobranchus*), giant vermetids (*Dendropoma maxima*), *Protopalythoa* anemones, etc., was also striking.

Notable differences in the habits of several species encountered may be related to the absence or rarity of certain predators at this remote location; these differences were especially striking among echinoderms. Thus two of three species of *Leiaster* encountered were day-active, an unusual behavior for this genus that is otherwise nocturnal, taking shelter within the reef during the day at other reefs in Oceania. The same is true for one of the new species *Stichopus* sea cucumbers encountered, as species of that genus are also usually nocturnal. The propensity with which the sea cucumbers *Holothuria pervicax*

and *H. fuscorubra/leucospilota* discharged their defensive, sticky, cuvierian tubules at FFS was much less than at other central Pacific locations. A new species of *Holothuria (Stauropora)* was diurnal and did not discharge tubes upon handling, even though other species of *Stauropora* are nocturnal and among the most prone to discharging cuvierian tubules. These differences may be the result of ecological release resulting from the absence of certain predators. For example, predators such as lutjanine snappers, groupers, napoleon fish, some other wrasses, and triggerfish are rare or absent from the Hawaiian Islands in general and FFS in particular, clearly creating a very different ecological seascape. The abundance and ubiquity of ulua is likely also a result of ecological release.

The unusual geomorphology and setting of FFS exerts a strong influence on community structure and diversity. Lagoonal sites varied substantially, ranging from strikingly barren patch reefs to others with rich and diverse suspension feeding communities to *Halimeda* meadows with their own specialized biota. Forereefs on the exposed northern rim of the atoll appeared scoured, held little rubble and sand, and had a relatively depauparate biota, presumably as a result of exposure to huge winter storm surge. In contrast, the algal-dominated forereefs off the southeast corner of the atoll held a diverse and unusual biota. Numerous species were encountered only around La Perouse Pinnacle, many likely requiring volcanic rocks for habitat. Overall, we were as struck by the apparent large influence of physical forces in structuring the biota as by the release from biological forces mentioned above.

Deep trapping brought in a striking community associated with hermit crabs. At least eight species of large-bodied hermit crabs were involved, with a variety of symbionts. These included five species of hermit crab-associated sea anemones, one species of oyster, serpulid polychaetes, the living fossil barnacle *Chionelasmus darwini*, and the parasitic gooseneck barnacle *Koleolepas tinkeri*, which feeds on hermit-associated anemone tentacles. Late in the cruise, we noticed polyclad flatworms living inside the shells and found two species in the two species of hermit crabs investigated.

Other noteworthy results include the large number of species photodocumented and/or subsampled for DNA barcoding. Most of the macrofauna that was sorted to species on board was photodocumented; these will provide excellent coverage for Hawaiian invertebrates. Many species photodocumented have never been photographed fresh or alive before, thus the resulting photos represent the first documentation of their living color and appearance and will be of general interest. Over 1100 genetic subsamples taken will facilitate DNA-based identification of Hawaiian and tropical Pacific invertebrates in the future.

b. Decapod Crustaceans Preliminary Report (Dr. Joel Martin and Scott Godwin)

Decapod crustaceans are a well known and highly diverse component of reef faunas worldwide. During the 2006 French Frigate Shoals (FFS) survey, decapods were encountered at every habitat sampled and were collected using every method employed (see Appendix A), with the exception of the light trap and the microbial sampling methods. Although more detailed taxonomic breakdowns of these collections, including reports of new records and new species, will appear in subsequent reports and in the scientific literature over the coming months and years, there are broad comparisons we can make with previous documented records from FFS (DeFelice, Minton, and Godwin, August, 2002, report of the Hawaii Biological Survey, Bishop Museum, for French Frigate Shoals, hereafter referred to as FFS-2002) and including other collections of invertebrates made primarily by hand collecting during the years 2000–2005; Scott Godwin, unpublished data).

Table 6 summarizes the increase in knowledge of decapod crustacean diversity between the two reports. This table is initially extremely conservative in that a large number of species seen and collected could not yet, with certainty, be placed in a given genus or family. For these records, and until further processing determines otherwise, we have erred on the side of assuming that these are known species not recognized by us, as opposed to assuming that they are unknown species. Family names in bold are new records of that family for FFS.

FFS 2006 Expedition				FFS-2002 Report		
Families	Est. # Genera	Est. # species		Families	Genera	Species
PENAEOIDEA				PENAEOIDEA		
Penaeidae	2	2		Penaeidae	1	1
STENOPODIDEA				STENOPODIDEA		
Stenopodidae	1	1		Stenopodidae	1	1
CARIDEA				CARIDEA		
Stylodactylidae	0	0		Stylodactylidae	1	1
Nematocarcinidae	1	1		Nematocarcinidae	1	1
Rhynchocinetidae	1	1		Rhynchocinetidae	1	1
Gnathophyllidae	3	5		Gnathophyllidae	2	3
Palaemonidae	4	5		Palaemonidae	6	10
Alpheidae	5	12		Alpheidae	3	7
Hippolytidae	4	7		Hippolytidae	4	5
Pandalidae	0	0		Pandalidae	2	2
Pontoniidae	3	3				
Eugonatonotidae	1	1				
BRACHYURA				BRACHYURA		

Families	Est. # Genera	Est. # species		Families	Genera	Species
Raninidae	1	1		Raninidae	1	1
Cryptochiridae	*			Cryptochiridae	1	1
Grapsidae	6	7		Grapsidae	4	6
Ocypodidae	1	1		Ocypodidae	1	2
Portunidae	5	7		Portunidae	2	4
Carpiliidae	1	2		Carpiliidae	1	1
Pilumnidae	2	2		Pilumnidae	1	2
Trapeziidae	*			Trapeziidae	1	3
Tetraliidae	*			Tetraliidae	4	4
Xanthidae	12	20		Xanthidae	15	28
Dromiidae	2	2		Dromiidae	1	1
Dynomenidae	2	2		Dynomenidae	1	1
Majidae	6	9		Majidae	5	6
Parthenopidae	4	5		Parthenopidae	1	1
Aethridae	0	0		Aethridae	1	1
Calappidae	1	3		Calappidae	1	2
Inachidae	2	4				
Palicidae	1	2				
Homolidae	4	5				
Leucosiidae	4	6				
Goneplacidae	2	2				
Geryonidae	1	1				
ANOMURA				ANOMURA		
Diogenidae	6	16		Diogenidae	3	10
Paguridae	2	2		Paguridae	1	1
Galatheidae	3	3		Galatheidae	1	1
Porcellanidae	2	2		Porcellanidae	1	1
Hippidae	1	1		Hippidae	1	1
THALASSINIDEA				THALASSINIDEA		
Axiidae	2	2		Axiidae	1	1
Callianassidae	1	1				
PALINURIDEA				PALINURIDEA		
Palinuridae	1	2*		Palinuridae	1	2
Scyllaridae	2	3*		Scyllaridae	1	1

*Species in several families were seen but not collected. Cryptochirids, trapezoids, and tetraliids live on live coral, which we were not permitted to disturb in the 2006 survey. Species in these families were observed (galls were seen on some corals, for example) but were not collected and thus cannot be placed with certainty in a known genus or family.

Similarly, commercially harvested species of some lobsters and crabs were seen but not collected, or were collected inadvertently (in traps) and immediately released, as this would have violated the conditions of our permit. Such species included both species of spiny lobsters (*P. penicillatus* and *P. marginatus*) and the two large species of slipper lobsters (*Scyllarides haani* and *S. squamosa*). The latter species are well known from previous (but unpublished) records of trapping in the Northwestern Hawaiian Islands.

Caveat 1: Some of the apparent increase in the number of reported families is because certain groups of decapods are now recognized as separate families, whereas they were treated as members of a single family in the FFS-2002 report. In other words, some of the increase is an artifact of nomenclatural taxonomic changes. Other additional families, such as the *Homolidae* and *Geryonidae*, are the result of deeper water sampling, which was not conducted for the earlier FFS-2002 study.

Caveat 2: Numbers may be misleading; the number 1 indicates one species found in that family, but it may or may not be the same species collected earlier. For example, the single species in the family *Hippidae* reported in the FFS-2002 survey was *Hippa pacifica;* the species collected in the 2006 survey is different and may be an albuneid. In the table, these appear simply as the number 1 in both surveys. Thus, with further analysis, overall diversity of decapods will be slightly higher than the estimated totals presented here.

The most productive techniques in terms of decapod numbers and diversity were the rubble extraction protocols, especially with regard to the numbers of specimens. This is followed by baited traps, more for diversity than for numbers.

During this survey, as in previous years, the dominant group of decapods in shallow waters was the crab family Xanthidae. Xanthid crabs were the most numerous components of forereef, backreef, reef crest, and patch reef hand collections, although the number of small majoid crabs also was high in these areas and may, after more detailed analysis, prove to be as high as that of the xanthids. Xanthids were also present in the deep water (baited trap) collections, although less diverse (1 species) and less numerous.

In summary, from this 2006 sampling effort, at least 7 families of decapods, and an estimated 20 genera and 33 species, are reported from FFS for the first time; estimates are based primarily on photographic documentation (see accompanying database and associated photographs of J. Martin, L. Harris, and G. Paulay) and will need laboratory verification. Some families previously reported from FFS could not be collected or verified because of permit restrictions. Additional family records may result from ongoing taxonomic work on these collections. Most of the new records of decapods are from the deep water sampling (baited traps), but small cryptic decapods, especially in the family Xanthidae, were diverse and numerous in coral rubble.

c. Ascidiacea Preliminary Report (Dr. Tito Lotufo)

A total of 198 lots/specimens of ascidians were collected over the 16-day sampling effort throughout the habitats surveyed at FFS. The actual number of

species collected is still unknown, as the identification process requires extensive laboratory work. Because the region has never been subjected to a thorough survey of ascidian fauna, almost all the material collected consists of new records or even new species. A total of 58 discrete morphospecies were recorded, but a larger number of actual species may be revealed after laboratory work is completed on the different specimens. The most abundant taxon observed was the family Didemnidae, consisting of small encrusting colonial ascidians that live generally under rocks or on negative surfaces and because of that are usually undetected in routine monitoring or surveys. Other very important taxa were the subfamily Botryllinae and other Styelidae, both solitary and colonial forms.

It is worth noting that the total number of recorded species for the main Hawaiian Islands is 67, including many widespread cosmopolitan species that are commonly found in harbors and marinas. In a mere 16 days at FFS, a similar number of species was obtained, including a considerable number of new records to the Hawaiian Archipelago as a whole.

Although the complete determination of the species will be conducted in the laboratory, some of the specimens were identified to the generic level, revealing new records for the Hawaiian Archipelago and, in at least one case, a possible new species. An unusual *Corella* sp. was collected at Fore Reef Site 3, with a set of features that in no way resembles any known species of the genus. In the Arc Shell Reef, a *Eudistoma* sp. dominates the top of the reef, and is not a species known to the main Hawaiian Islands. Other rare forms of didemnids were also found exclusively on peculiar habitats, such as inside a cave in the La Perouse Pinnacle or growing over *Halimeda* blades. There were eight different species of ascidians growing in *Halimeda* blades, and possibly a Molgulidae was found, making it the first record of the family in the NWHI. Divers also returned from a backreef and reef crest site on the last day of operations yielding a *Eusynstyela* sp.--a new record for the cruise.

The most efficient method for gathering ascidians was by hand collection during SCUBA diving. Another technique that yielded a considerable number of specimens was rubble extraction. Further specimens were also found through other methods, notably the baited traps and rubble brushing.

In summary, a significant number of ascidean species were collected from FFS, adding to the success of the cruise. The final results will certainly improve overall knowledge in terms of historical biogeography and the evolution of the Pacific marine fauna.

d. Opisthobranch Mollusks Preliminary Report (Cory Pittman)

The *Opisthobranchs* are a subclass of gastropod mollusks that include many small and cryptic species. The Hawaiian fauna is relatively well studied with approximately 500 species reported in published and unpublished works by the author, Pauline Fiene, Scott Johnson, Terry Gosliner, John Hoover, Keoki Stender and others. Uncertainty in the number of species is attributed to the taxonomically ambiguous material that requires further work. About 140 of these species are known from the Northwestern Hawaiian Islands, primarily from Midway Atoll. However, little work had been done at FFS prior to 2006 with the previous NWHI Coral Reef Assessment and Monitoring Program (NOW-RAMP) expeditions yielding only 18 species as reported in Bishop Museum lists (mostly from 2000). In addition, two others had been collected previously (personal communication): a *Discodorid* found and photographed by Keoki Stender and a *Chromodorid* found by Stan Jazwinski and photographed by Scott Johnson.

During the FFS 2006 expedition, 62 species were collected. Of these, at least 48 are more than likely new records for FFS and and at least 27 are more than likely new records for the Northwestern Hawaiian Islands. Four are probably new records for Hawaii and three of those may be undescribed. Since five of the previously reported species were not found during the 2006 cruise, the known FFS fauna was increased to 67 species. Eighteen families and 29 genera may be newly recorded for FFS although these numbers may change with taxonomic revisions. The recorded fauna for the Northwestern Hawaiian Islands was increased to about 167 species. Additional shell-bearing species will probably be added to this list when the 2006 sand samples are sorted. Also, a number of planktonic species in the *Thecosomata* and *Gymnosomata* may have been collected in the plankton tows. Future access to currently unavailable, unpublished data may alter the number of new records in the final report.

Opisthobranchs were collected by all sampling methods with the exception of the light traps and the microbial sampling. Rubble brushing, rubble extraction, and hand collecting were the most productive methods. However, sand sampling may prove important for shell bearing species when the material is sorted.and, perhaps, the most noteworthy species (a *Pleurobranchaea* sp. representing a new genus for Hawaii) was taken with the baited traps.

Table 7. Summary of opisthobranchs. Families newly recorded from FFS are in bold.

FFS 2006 Expedition				**FFS pre-2002 List**		
Families	Genera	Species		Families	Genera	Species
CEPHALASPIDEA				CEPHALASPIDEA		
Bullidae	1	1		Bullidae		
Haminoeidae	2	4		Haminoeidae	3	4
Runcinidae	1	1		Runcinidae		
Aglajidae	2	2		Aglajidae		
Philinidae	1	1		Philinidae		
ANASPIDEA				ANASPIDEA		
Aplysiidae	4	6		Aplysiidae	2	4
SACOGLOSSA				SACOGLOSSA		
Juliidae	2	3		Juliidae	1	1
Placobranchidae	3	7		Placobranchidae	2	2
Limapontiidae	1	1		Limapontiidae		
Caliphyllidae	1	1		Caliphyllidae		
TYLODINOIDEA				TYLODINOIDEA		
Tylodinidae	1	1		Tylodinidae		
PLEUROBRANCHOMORPHA				PLEUROBRANCHOMORPHA		
Pleurobranchidae	3	4		Pleurobranchidae	2	2
NUDIBRANCHIA				NUDIBRANCHIA		
DORIDACEA				DORIDACEA		
Aegiretidae	1	1		Aegiretidae		
Polyceridae	1	1		Polyceridae		
Gymnodorididae	1	2		Gymnodorididae		
Doridiidae	1	1		Doridiidae		
Discodorididae	4	4		Discodorididae	2	2
Chromodorididae	6	8		Chromodorididae	3	3
Dendrodorididae	1	3		Dendrodorididae		
Phyllidiidae	2	3		Phyllidiidae	1	1
DENDRONOTACEA				DENDRONOTACEA		
Dotoidae	1	1		Dotoidae		
Tethyidae	1	1		Tethyidae		
AOLIDACEA				AOLIDACEA		
Eubranchidae	1	1		Eubranchidae		

Families	Genera	Species		Families	Genera	Species
Aeolidiidae	1	1		Aeolidiidae		
Facelinidae	1	1		Facelinidae	1	1
Tergipedidae	1	1		Tergipedidae		
Fionidae	1	1		Fionidae		

e. Polychaetous Annelids Preliminary Report (Leslie Harris)

Polychaetes are important components in reef systems because of their role as food for other organisms and as principal agents of bioerosion. They are often the dominant invertebrates in terms of both biomass and numbers of species and individuals, representing a significant amount of bioactivity. They occur in all habitats but can be difficult to sample unless the right methods are used. Unfortunately, little is known about coral reef polychaetes compared to other invertebrate groups such as crustaceans, molluscs, and echinoderms. The majority are small (under 1 cm in length), cryptic in appearance, hidden in burrows or among sessile epifauna or algae or under soft sediments. Once preserved and in a lab, identification of tropical polychaetes is difficult owning to a lack of taxonomic literature. It is quite likely that the number of unidentified polychaetes is higher than that of identified polychaetes on coral reefs.

Some of the sampling methods used on this cruise were best suited for the collection of large invertebrates. Hand collecting and dredging produced only a few large worms. No worms were found in the baited traps except those living in the sponges carried by homolid crabs or on the shells worn by hermit crabs. Other methods, such as the rubble extraction or rubble brushing, failed to produce many polychaetes because the type of rubble available—mostly Porites sp.—was unsuitable or because polychaetes cling more tightly to substrates when disturbed. As a result the number of polychaetes brought back to the ship's lab and preserved was relatively small for the amount of collection effort and in comparison to how many were probably in the sample areas.

In the lab, the worms were easily identified and sorted into morpho-species, i.e., grouped together by obvious physical characters such as pigment patterns. These will need to be identifed further. Approximately 1052 individuals spread among 115 morphospecies in 28 families were found. Members of the polychaete families *Eunicidae*, *Syllidae*, and *Nereididae* were dominant as is typical of most coral reefs. Eunicids are bioeroders and contribute greatly to the breakdown of dead coral into small particles. Large sabellids and serpulids (collectively known as feather dusters and Christmas tree worms) were surprisingly absent from the area.

The worms will be identified to species once they arrive at the Natural History Museum of Los Angeles County polychaete lab. Some of the polychaetes from the 2002 survey are already on loan to NHMLAC as are worms from other NWHI locations (courtesy of the Bernice P.

Bishop Museum) so they can be identified at the same time, ensuring taxonomic stability.

In the previous FFS survey (DeFelice, Minton, and Godwin, 2002) polychaetes were largely ignored because of the lack of a specialist to identify them. Worms from just one station were identified and the majority of names were provisional. As the authors stated, "There will undoubtedly be a number of new records for the Hawaiian Islands and many undescribed species found from the samples taken, as there are over 100 undescribed species already known from throughout the Hawaiian Islands (J. Brock, pers. comm.)." No doubt the same will be true for the specimens collected during this survey.

4. Range Extensions and Possible New Species of Corals and Anemones
(Dr. James Maragos)

This expedition to FFS and the NOWRAMP surveys in September 2006 have yielded records and photos of many new range extensions and possible new species of corals not previously reported at FFS, the NWHI, or anywhere else in the Hawaiian Archipelago.

The first surveys of corals in the NWHI were accomplished by Thomas Vaughan (1907), primarily relying on dredge hauls to collect and examine a few dead coral skeletons near Laysan Island. Thomas Dana (1971) later collected corals through snorkeling, and with the assistance of John Wells, reported about 22 species from Kure Atoll. The first modern scuba-assisted surveys in the NWHI by Richard Grigg and Stephen Dollar (1980) yielded 29 species based on 2 to 8 dives at each of the 10 NWHI. The results of a second wave of rapid ecological assessment surveys in the NWHI totaling over 450 dives by several coral specialists between 2000 and 2002 yielded 56 species of stony corals, nearly double the previous totals (Maragos et al., 2004). At least 5 to 8 of these species were considered new to science but have not been subsequently described. Coral specialist Greta Aeby and the author recorded a few additional records in 2004 and 2003, respectively.

However, the 2006 NOWRAMP survey and the subsequent Census of Marine Life expedition at FFS were the first primarily focused on **looking** for new species and in the case of NOWRAMP, inventorying all coral species. The REA team (Jean Kenyon, Bernardo Vargas) respectively reported new records of *Leptoseris incrustans*, and a possible new species of *Montipora,* at Pearl and Hermes Atoll. Kenyon also added new records of *Acropora valida* at Laysan and *Pavona maldivensis* at Maro. An exploratory team that included coral specialist Jim Maragos, Yannis Papastamatiu, and Carl Meyer made several deep water dives to 30 m off Lisianski Island/Neva Shoal, Midway Atoll, and Pearl and Hermes Atoll and documented several new records of deepwater mushroom coral species: *Diaseris distorta, Cycloseris vaughani,* a possible new fungiid species or *Cycloseris tenuis,* and the soft coral *Sinularia*. However, among these, the most

exciting discoveries during NOWRAMP 2006 resulted from the initial sightings by towboard scientists Jake Asher and Brian Zgliczynski of table coral *Acropora* off the southwest spur-and-groove habitat at Pearl and Hermes Atoll and off the shallow southeast forereef at Neva Shoals that extended the range of these corals 450 nmi towards the northwestern end of the island chain. These sightings were verified by Jim Maragos of the exploratory team and REA teams which confirmed the presence of *Acropora cytherea* and *A. cerealis-valida* at Pearl and Hermes, and *Acropora valida* at Neva that led to other discoveries at Neva, a second *Acropora* and three *Montipora* species, all likely new to science.

Later, during the Census of Marine Life (CoML) cruise, additional sightings of rare species were reported for *Diaseris distorta,* the new *Cycloseris* cf. *tenuis*, several unknown *Leptoseris, Porites, Leptastrea, Pocillopora, Montipora,* and a second sighting of the new *Acropora* species and possibly two additional species of *Acropora*. By the end of the 3-week expedition, an additional 15–20 species of corals were reported as being new records or new species, and a grand total of 22 possible new species have now been collectively reported during surveys from 2000 to 2006. As a result of permit restrictions (strict guidelines not to touch corals) however, the collection of corals was prohibited during the two 2006 efforts. Thus it is not possible to determine which of the candidate new species are confirmed as new species until collection, examination of corals, and comparison to type specimens of coral species held at museums and other institutions are allowed.

By far the most spectacular coral discovery was by invertebrate specialist John Starmer and Jim Maragos at FFS on October 19, 2006. The coral is completely new to science and has not yet been assigned to either a genus or family. The presence of this coral, as well as the *Acropora* and remaining stony coral discoveries, is strong evidence of a long history of speciation and evolution occurring in the NWHI and its predecessors (Emperor Seamounts) over many millions of years. This coral (photographed by Jim Maragos) is among the photos of the new records and species of corals reported during the CoML effort and available to the NWHI Marine National Monument (NWHI-MNM) co-trustees. Additional towboard and stationary dive surveys will be required to assemble a more complete list of the corals and to determine their origins, nearest neighbors, and extent of their ranges. Additional dives to 30 m or more should also help fill the void of deeper water species records and yield a more informed assessment of the biodiversity of corals and anemones across the NWHI.

Table 1 gives the current listing of all coral and anemone species reported at 11 islands, banks, atolls and reefs in NWHI. As was the case during earlier compilations, the larger, most studied atolls with diverse habitat and shelter from large northwest swells support greater number of species. The choice of FFS as the target for the first CoML expedition was an excellent one from the standpoint of yielding new species of corals, other invertebrates, and benthic algae and extending the range of many other species. Fifteen to 20 more species of

cnidarians have already been reported from the atoll, further cementing the atoll's status as the most diverse for corals in Hawaii. FFS is the closest of the Hawaiian chain to Johnston Atoll located 450 nmi to the southwest, and Johnston may be serving as a "stepping stone" for the dispersal of species to Hawaii from the Line Islands and other neighboring archipelagos south of Hawaii (Maragos and Jokiel, 1986; Maragos et al., 2004; Brian Bowen, pers. comm. Jan. 2007). This connection would help explain why FFS has so many *Acropora* species which flourish at Johnston and why it has higher numbers of coral species compared to any of the other Hawaiian Islands.

Table 1. Distribution of stony corals reported in the NWHI during 1907-2006.Compiled by Maragos from Dana 1846, Vaughan (1907), Dana (1971), Maragos et al. (2004), and the unpublished records of G. Aeby, J. Asher, J. Kenyon, J. Maragos, B. Vargas, and B. Zgliczynski. Asterisk (*) = undescribed or undetermined species. **Bold = species mostly at depths of > 30 m.** Red are new records or species (*) reported during the CoML cruise October 2006. The names and species numbers listed below correspond to those of the labels for the accompanying digital photos.

Island	NIH	NEC	FFS	GAR	MAR	LAY	LIS	P&H	MID	KUR	RAI	# of isl.
Stony corals												
Acropora cerealis			1	1	1							**3**
A. cytherea		1	1	1	1	1		1				**6**
A. gemmifera			1	1								**2**
A. humilis			1	1	1							**3**
A. nasuta			1		1	1						**3**
A. paniculata			1									**1**
A. sp.1 (prostrate)			1*				1					**2**
A. sp.28 cf. *retusa*			1*									**1**
A. valida			1		1	1	1	1				**5**
A. sp.29 (table)			1*									**1**
A. sp.30 cf. *palmerae*			1*									**1**
A. sp. 20 (neoplasia/tumor?)			1*									**1**
A. sp.26 cf. *loripes*			1*									**1**
Montipora capitata	1	1	1	1	1	1	1	1	1	1	1	**11**
Unidentified coral, (Starmer) sp18			1*									**1**
M. flabellate		1	1	1	1	1	1	1	1	1		**9**
M. patula	1	1	1	1	1	1	1	1	1	1		**10**
**M.* sp.4 cf. *incrassata*		1	1*		1					1		**4**
M. dilatata						1	1					**2**
**M.* sp.6 cf. *dilatata*					1							**1**
**M.* sp.7 (foliaceous)			1*				1	1	1			**4**
**M.* sp.2 (ridges)								1		1		**2**
**M.* sp.5 (branching)							1					**1**
**M.* sp.14 (nodular) Vargas								1				**1**
M. tuberculosa			1		1	1	1	1	1	1		**7**
M. sp.24 (irregular)			1*									**1**
**M.* sp.3 cf. *turgescens*					1	1	1	1	1	1		**6**
M. verrilli			1		1	1	1	1	1	1		**7**

Island	NIH	NEC	FFS	GAR	MAR	LAY	LIS	P&H	MID	KUR	RAI	# of
Gardineroseris planulata									1			**1**
Leptoseris hawaiiensis			1			1						**2**
L. incrustans			1					1	1	1		**4**
L. sp.22 cf. incrustans			1*									**1**
L. mycetoseroides			1									**1**
***L.* cf. *papyracea* sp19**			1*									**1**
***L.* cf. *scabra* sp17**			1*				1					**2**
Pavona clavus								1	1	1		**3**
P. duerdeni	1	1	1	1	1	1	1	1	1	1		**10**
P.maldivensis			1		1		1	1	1	1		**6**
P. varians	1	1	1	1	1	1	1	1	1	1		**10**
**Balanophyllia* sp. (pink)			1		1					1		**3**
Cladopsammia eguchii			1	1	1	1		1	1	1		**7**
Tubastraea coccinea	1		1	1	1	1		1	1	1	1	**9**
Cyphastrea ocellina	1	1	1	1	1	1	1	1	1	1		**10**
Leptastrea agassizi			1		1				1			**3**
L. bewickensis			1				1	1				**3**
L. purpurea	1	1	1	1	1	1	1	1	1	1		**10**
L. pruinosa		1	1	1	1							**4**
**L.* sp.8 cf. *F. hawaiiensis*		1	1		1		1			1		**5**
***Cycloseris* cf. *tenuis* or sp.9 (equal septae)**			1*				1	1				**3**
C. vaughani			1	1			1	1	1			**4**
Diaseris distorta			1				1					**2**
Fungia scutaria	1		1	1	1	1	1	1	1	1		**9**
F. granulose					1	1		1				**3**
Pocillopora damicornis			1		1	1	1	1	1	1	1	**8**
P. eydouxi	1	1	1	1	1	1	1	1	1			**9**
P.* sp.10 cf. *laysanensis			1			1				1	1	**4**
P. ligulata	1	1	1	1	1	1	1	1	1	1	1	**11**
P. meandrina	1	1	1	1	1	1	1	1	1	1		**10**
P. molokensis	1		1	1	1	1	1	1		1	1	**9**
P. sp.32 cf. *verrucosa*			1				1	1				**3**
P. sp.33 cf. *zelli*			1									**1**
**P.* sp.11 cf. *capitata*			1		1	1	1	1	1	1	1	**8**
**Porites* sp.12 cf. *annae*							1	1		1		**3**
P. sp. 15 (paliform lobes)			1*									**1**
Porites brighami	1	1	1	1	1	1	1	1		1		**9**
P. compressa	1	1	1	1	1	1	1	1	1	1	1	**11**
P. sp.23 (arthritic fingers)			1*									**1**
P. duerdeni		1	1	1	1			1		1		**6**
P. evermanni	1	1	1	1	1	1	1	1	1	1		**10**
P. hawaiiensis		1	1	1	1	1	1	1	1	1		**9**
P. lobata	1	1	1	1	1	1	1	1	1	1		**10**
P. sp.21 cf. *lobata*			1*									**1**
**P.* sp.16 cf. *lutea*			1									**1**
P. rus					1							**1**
P. sp.27 (columns)			1*									**1**

Island	NIH	NEC	FFS	GAR	MAR	LAY	LIS	P&H	MID	KUR	RAI	# of
**P.* sp.13 cf. *solida*			1*	1		1		1	1	1		**6**
Psammocora explanulata				1								**1**
P. nierstraszi		1	1	1	1	1	1	1	1			**8**
P. stellata	1		1	1	1	1	1	1	1	1	1	**10**
P. verrilli								1	1	1		**3**

total NWHI species of stony corals: 80

total for all cnidarians: 89

New records for FFS (CoML): 22

Possible new species: approximately 17, pending collections, analyses and descriptions

5. DNA Subsample Preliminary Report (Russell Moffitt)

DNA subsamples from the cruise total 1279. Of these samples, 117 are algal and 1162 are invertebrates. We have 3196 total labeled containers/specimens (360 algae, 2836 inverts). So 40% of all samples have a DNA subsample. We have somewhere between 1611 and 2151 unique morphospecies. Most repeat taxa were not DNA subsampled multiple times, so we potentially have DNA subsamples for 59–79% of all unique morphospecies. This is not exact and the actual value could be a little bit lower. Anything preserved in ethanol can still be subsampled for DNA work later.

B. To install Autonomous Reef Monitoring Structures (ARMS) at three habitats—the forereef, the backreef, and a lagoonal patch reef for collection of sessile and mobile epifauna.

1. A total of 12 ARMS were deployed at four sites with three replicates at each site on the following habitat types: 2 on the forereef, 1 on a backreef, and 1 on a lagoon patch reef. Each of the ARMS were deployed with ~50 lbs of PVC-encapsulated lead weights attached to the carbonate pavement using four stainless steel 50 cm threaded 5/16 inch rods pounded into place using a sledgehammer. The two forereef ARMS sites were located at long-term REA monitoring sites 25 and H6 on the southeastern and north forereef at depths of 14 m and 13 m. The lagoonal patch reef ARMS site was located at the long-term REA monitoring site 33 in 7 m of water. The backreef ARMS site was located at the long-term REA monitoring site R30 in 1 m of water. These ARMS will be deployed for 1 year to systematically assess biodiversity recruitment over time. The replicates will provide a measure of the variance in biodiversity at each site.

2. This is the first deployment for this prototype of ARMS and it is being evaluated for incorporation into the long-term CReefs biodiversity methodology as well as into the CRED Pacific Reef Assessment and Monitoring Program (Pacific RAMP) to use as an additional index of invertebrate biodiversity.

C. To deploy baited traps, minnow traps, and light traps for specimen collection at a depth of 100–300 meters for collection of mobile epifauna and plankton.

1. In addition to implementing the diver collection techniques at shallower depths, the team deployed deep baited/minnow traps for specimen collection at depths ranging from 100 to 300 meters. Overall, a total of 45 strings of 8 traps were deployed in the afternoon/evening at varying depths and collected the next morning. The replicates from all methods will provide a measure of the variance in biodiversity at each site. Sample processing was conducted on a daily basis in the shipboard laboratories and the samples have been documented, labeled, and packaged to be shipped for further processing by the specialists involved in this effort.

2. Divers also deployed a total of 20 shallow (<9.5 m) baited traps at various locations in the shallow sandy areas of the inner lagoon at FFS.

3. Light traps were deployed overnight and attached to one of the single shallow baited traps. Overall, nine light trap deployments were performed.

D. To collect epifauna and infaunal organisms using a dredge and an Ekman grab on the soft bottom substrate of the atoll at a depth of approximately <100 meters.

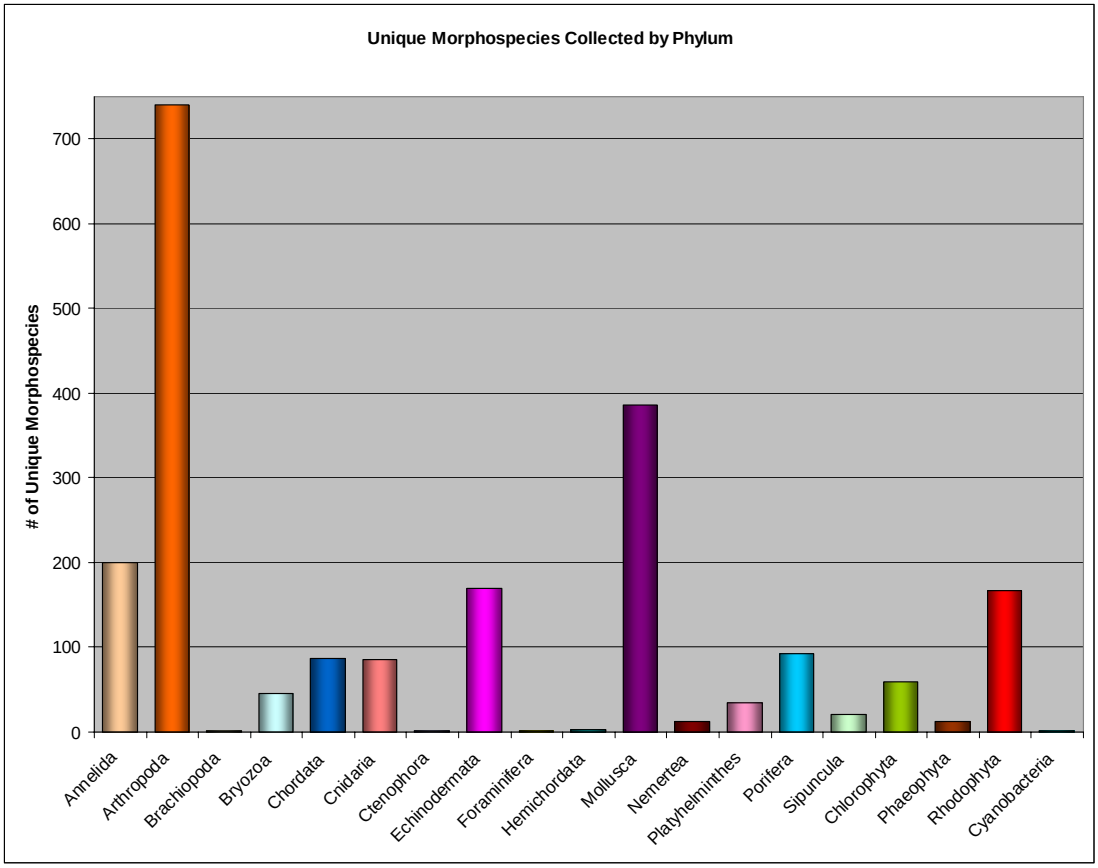
1. Specimens were collected at depths of less than 100 meters using a dredge (outside of the State Marine Refuge) and an Ekman grab on the soft bottom substrate of the atoll. A total of eight bottom grabs and seven dredge hauls were conducted over the course of the cruise.

E. Fill data gaps by investigating understudied species and determining existence of undiscovered species.

1. The sampling effort focused on understudied species including invertebrates, algae, and microbes. This approach was taken in order to fill gaps in current coral reef ecosystem data for FFS. Prior to this effort, studies were focused primarily on corals and fish with limited sampling of macroinvertebrates and algae. The scientists used information generated from previous efforts to avoid taking already known species. Preliminary analyses indicate that approximately 1611–2151 unique morphospecies were documented during this effort. It also appears from intial identifications that more than 100 new species and records will be recorded from this effort.

Tables 8 and 9 in sections E and F show unique morphospecies collected by phylum, habitat, and method. *Note: Total specimens from each habitat may depend in part on the number of times the sites, habitats, and methods were used.*

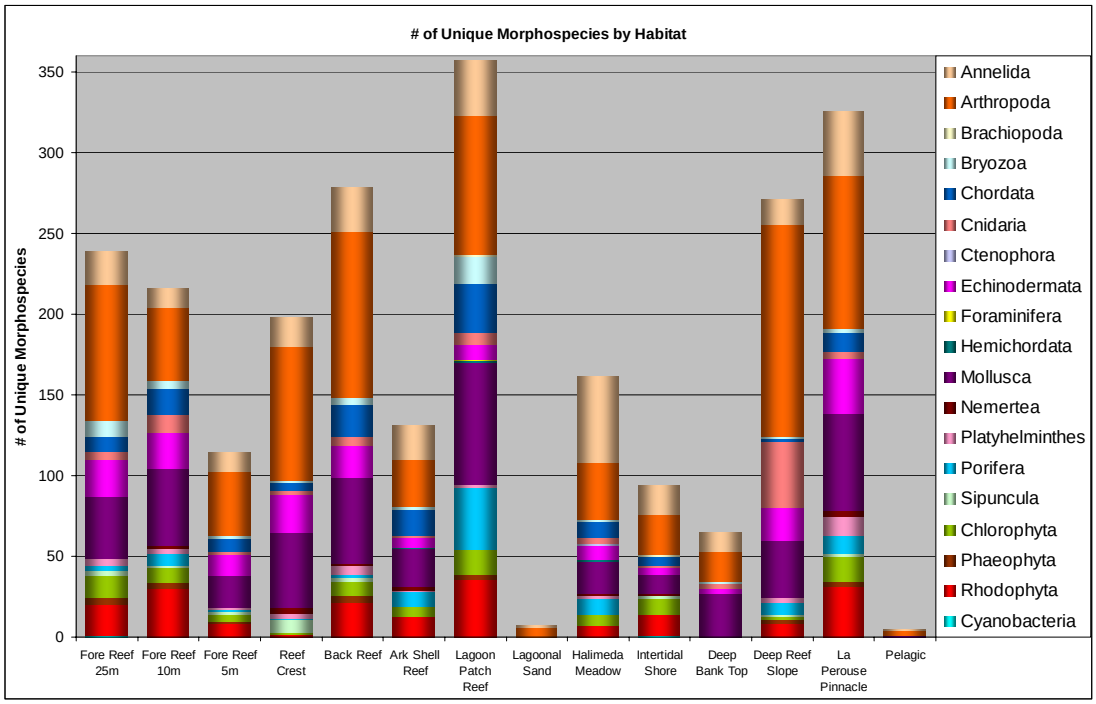
Table 8. Number of unique morphospecies collected by Phylum.



2. In order to get a broad representation of the biodiversity of these organisms at FFS, the scientific team targeted 12 distinct habitats:

- Forereef (5, 10, 25 m)
- Reef crest (0-1 m)
- Back reef (1 m)
- Intertidal shores (0-1 m)
- Lagoon sand (5-10 m)
- Lagoon patch reef (5-10 m)
- Deep bank tops (30-100 m)
- Deep reef slopes (50-200 m)
- La Perouse
- Arc shell reefs
- Acropora areas
- Halimeda fields

Table 9. Number of unique morphospecies collected by habitat type.



3. Because the scientists visited a range of habitats, areas that had not previously been visited during Reef Assessment and Monitoring Program cruises also yielded new records/species of coral. There were several coral species likely new to science observed on this trip, and although *Acropora* is pretty common at FFS where it seems to show at least four growth forms, it appears that a new species of *Acropora* was also found. The collection of corals was not permitted, therefore, the formal description and naming of the new species will need to await the collection of type specimens of the species.

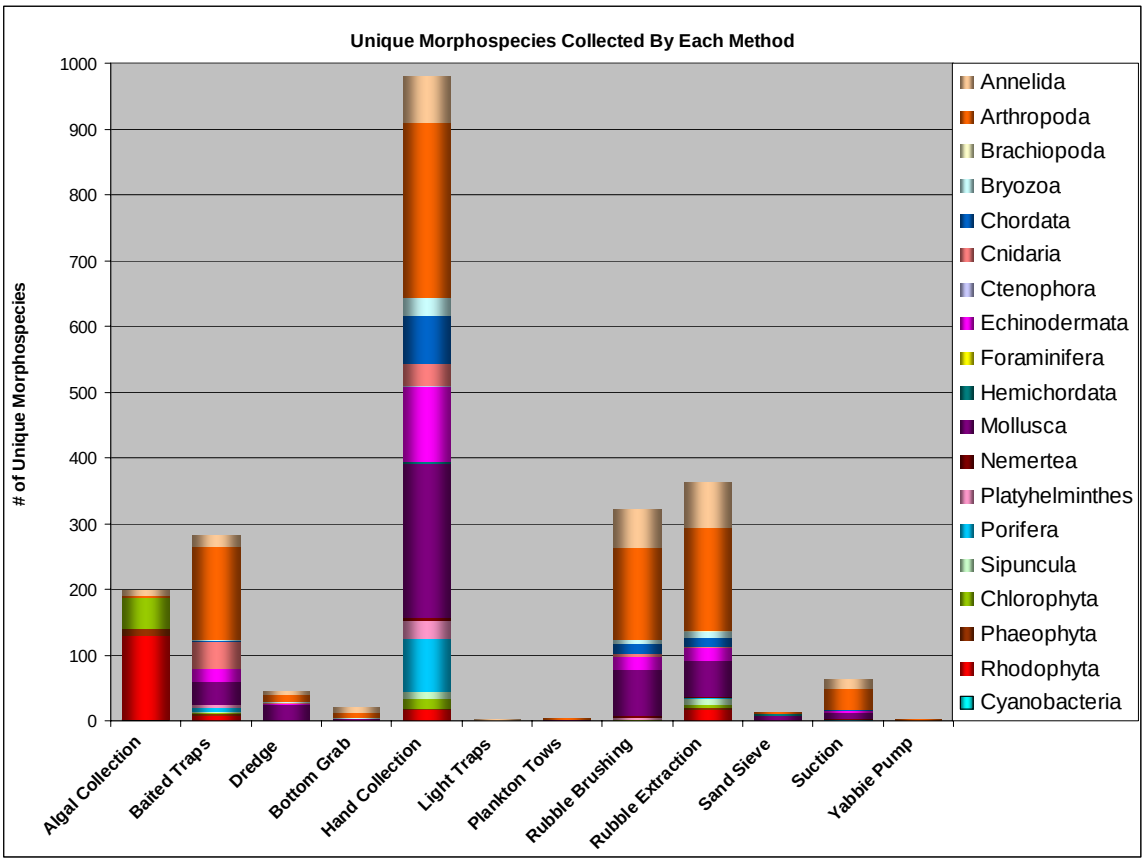
F. Test and enhance taxonomic protocols for the development of a more unified global approach.

1. The investigation and documentation of reef-associated non-coral invertebrates, macroalgae, turf and coralline algae, and microbial communities at FFS were completed using an array of field collection techniques. These techniques, conducted by SCUBA and snorkeling as well as shipboard operations, were carried out over a range of habitats throughout the atoll. The marine scientists were extremely careful in following approved protocols that would minimize disturbance to the environment. The following 14 approved methodologies (13 in the State Marine Refuge) were used during this effort (see Appendix A):

- Hand collecting
- Rubble extraction
- Rubble brushing
- Sand sampling

- Yabbie pumps
- Microbial collections
- Algal collections
- Suction/Vacuum
- Baited Traps
- Light traps
- Ekman Grab
- Autonomous Reef Monitoring Structures (ARMS)
- Plankton Nets
- Scoop/Dredge (not used in State waters)

Table 10. Number of unique morphospecies collected by method.



G. Provide data to managers, Pacific Regional and global databases.

1. Data from the cruise will be posted to numerous databases including Moorea Biocode, NBII Pacific Basin Information Node (PBIN), and the international Ocean Biogeographic Information System (OBIS) and will be accessible to the public and resource managers.

2. A summary cruise report has been submitted to the NWHIMNM co-trustee agencies, followed by this report with further, more detailed information.

3. A poster summarizing the cruise will be distributed to the management agencies.

4. As the samples are processed, joint agency publications will also be made available to the management agencies.

H. Conduct outreach and education relative to the collection efforts. **(**Megan Moews)

1. Outreach and Education Activities

The expedition included a strong outreach contingent consisting of a dedicated nature photographer (Susan Middleton) and the NWHIMNM outreach coordinator (Andy Collins) onboard the ship who communicated daily with USFWS, NOAA PIFSC, web staff and teachers in the main Hawaiian Islands to provide information for multiple websites (www.creefs.org and www.hawaiianatolls.org) following the course of the cruise, answer student/teacher questions, and provide other media information. CReefs worked with agencies internationally to create its dynamic website (www.creefs.org) and linked Plone site (http://adc.aims.gov.au/nwhicreefs) that allowed, in conjunction with the www.hawaiianatolls.org site, management agencies, schools, and other interested viewers to follow the NWHI expedition. Timed to air with the cruise departure's press release, the sites have maintained high visibility since. Overall, the effort generated significant positive national and international media coverage. National Geographic News, Discovery Canada, leading news channels, magazines from Japan, Germany, and France, and over 100 websites picked up the news from this effort and have been reaching out to the global community since. A cruise poster has been developed for distribution and to be posted on the CReefs site, available for downloading.

2. Outreach Photography (Susan Middleton)

Middleton concentrated on photographing live specimens (collected by the scientists) in the shipboard studio that she set up, which essentially consisted of small aquariums and flat plexiglas and glass trays for shooting straight down. A variety of lighting techniques were employed, most using two flash units with one of them handheld most of the time for precise placement. Middleton made portraits of each subject, visually isolating it against a neutral backdrop, either white or black. Her objective was to capture the detail, structural complexity, and living essence of each animal and plant, to create images that would convey the beauty of these creatures and evoke an emotional response in the viewer. They are conceived to communicate to the public and raise awareness. In these ways her photography differed from the scientific photographic documentation performed by the scientists, who were aiming to record maximum scientific information about their subjects. Middleton went into

the field on two occasions, each day as a snorkeler. However, on each of these days the visibility was poor and not great for photography. The first day was October 18, when the scientists were collecting in coral rubble fields. The second day was October 22, around La Perouse Pinnacle, during which, conditions were very rough and surgy.

Beginning October 11 and working through October 27, Middleton photographed approximately 100GB of image information and over 6000 pictures of approximately 80 species; sometimes she photographed more than one specimen of a species and often worked for several hours with one specimen. The important and relevant number when Middleton assesses her work is not how many shots were taken but rather how many successful images resulted from the work. That number is determined in the editing and processing phase. Middleton is aiming for fifty. Shots were taken in raw format which records maximum information but also requires processing in the post production phase. Because of the photographic approach of visually isolating each subject and maintaining maximum visual acuity, the processing required is extensive and time consuming. The CoML cruise was the first photographic project Middleton has undertaken with exclusively digital capture, and it was found that the workflow was generally faster when capturing the images, while considerably slower in the editing and processing phase.

SCIENTIFIC PERSONNEL:

Russell E. Brainard, Ph.D., Chief Scientist, Coral Reef Ecosystem Division (CRED), Pacific Islands Fisheries Science Center (PIFSC), National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA)
Brian Zgliczynski, Divemaster, Collection Support, CRED, PIFSC, NMFS, NOAA
Amy Hall, Collection Support, University of Hawaii (UH)-Joint Institute for Marine and Atmospheric Research (JIMAR), PIFSC-CRED
Elizabeth Keenan, Collection Support, UH-JIMAR, PIFSC-CRED
Russell Moffitt, Data Manager, UH-JIMAR, PIFSC-CRED
James Maragos, Ph.D., Coral Reef Biologist, Scientific and Collection Support, Pacific Remote Islands National Wildlife Refuge Complex, U.S. Fish and Wildlife Service
Scott Godwin, Invertebrates–general, UH-Hawaii Institute of Marine Biology
Gustav Paulay, Ph.D., Invertebrates–general, University of Florida (UF), Florida Museum of Natural History (FMNH)
Sea McKeon, Invertebrates–general, UF-FMNH
John Starmer, Invertebrates–general, UF-FMNH and Commonwealth of the Northern Mariana Islands Office of Coastal Resource Management.
Joel Martin, Ph.D., Invertebrates–Decapods, Natural History Museum of Los Angeles County (NHMLAC)
Leslie Harris, Invertebrates–Polychaetes, NHMLAC
Tito Lotufo, Ph.D., Invertebrates–ascidians, Laboratorio de Ciencias do Mar, Universidade Federal do Ceara, Brazil

Cory Pittman, Invertebrates–molluscs, NOAA Federal Volunteer
Rebecca Most, Algae, Kaloko Honokohau National Historical Park, National Park Service,
Kris Coontz, Algae, UH Botany Department
Emmanuel Irizarry Soto, Microbes, University of Puerto Rico, associated with the International Census of Marine Microbes (ICOMM) project
Andy Collins, Education Coordinator, Northwestern Hawaiian Islands Marine National Monument, NOAA
Susan Middleton, Photographer/Outreach, NOAA Federal Volunteer
Steve Matthews, Chamber Operator, Panama City Laboratory, NMFS, NOAA

DATA COLLECTED:

- Algal specimen samples including macro, turf and coralline algae
- Microbial samples including water and sediment samples
- Invertebrate specimen samples including decapods, ascidians, opisthobranchs, and polychaetous annelids
- Algal and invertebrate voucher specimens for DNA analysis
- 40,000 digital images including specimens sampled, protocols, and site footprint photographs
- Daily Operations log
- Documentation of specimens in Excel spreadsheet
- Outreach and education information relative to the collection efforts.

All specimens were assigned tracking numbers and matched with photographs and other relevant information (such as substrate, functional group, genera and species if known, and collector) in the following Excel spreadsheets.

(/s/Russell E. Brainard)

Submitted by: _____
Russell E. Brainard
Chief Scientist

(/s/Samuel Pooley)

Approved by: _____
Samuel Pooley
Science Director
Pacific Islands Fisheries Science Center

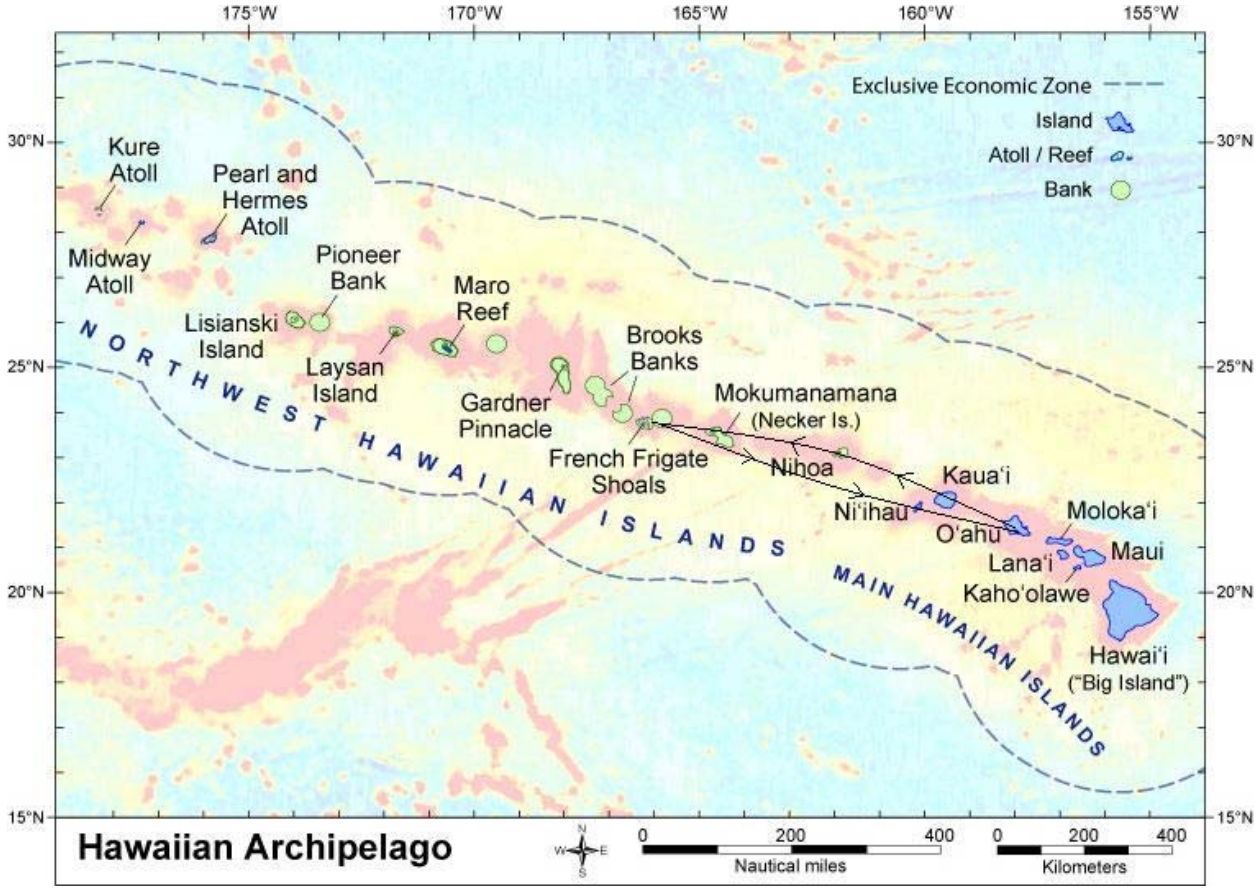


Figure 2.--Track of the NOAA ship *Oscar Elton Sette* OES-06-11, October 8–29, 2006.

Appendix A: Methods

A. With the expertise and input of the scientists/taxonomic experts involved and the cotrustee management agencies, protocols for 14 different sampling techniques were developed to investigate with minimal impact, a range of unkown and understudied coral reef species over an array of habitats. For the purposes of this report, we have divided these methods into four separate categories: (A.1) Dive Collection Methods, (A.2) Shallow Water Collection Methods, (A.3) Deep Water Collection Methods, (A.4) Plankton Nets, and (A.5) Autonomous Reef Monitoring Structures.

A.1. Dive Collection Methods

(Russell Brainard, Brian Zgliczynski, Amy Hall, Elizabeth Keenan, Scott Godwin, Gustav Paulay, Sea McKeon, John Starmer, Joel Martin, Tito Lotufo, Cory Pittman, Rebecca Most, Kris Coontz, Emmanuel Irizarry Soto, and James Maragos)

A. 1.1 Hand collecting

Hand collecting is the sampling of animals by hand. Animals are placed in bags, jars, or buckets with ample seawater, and taken to the shipboard laboratory for study. Many species are simply taken from the reef surface; others are taken from under rubble. For the latter, loose pieces of coral rubble are gently lifted, targeted specimens secured, and the rubble replaced in the same position as it was found to cause minimal disturbance to other organisms.

A 1.2 Rubble extraction

Rubble (live rock) extraction is defined as gathering pieces of loose rubble (in the 20–40 cm range, greatest dimension). Pieces of rubble gathered underwater from a small area (3–5 m^2) are placed in a 5-gallon bucket to prevent the escape of small organisms. On the surface, pieces of rubble are maintained in running seawater, surfaces are examined for sessile invertebrates, they are then cracked to remove boring fauna, and ultimately held under mildly anoxic conditions to expel resident invertebrates. After each step of the treatment, the rubble may be washed and the seawater is decanted and sieved in order to collect the additional animals.

A 1.3 Rubble brushing

Brushing coral rubble is an effective method for collecting small invertebrates that are either difficult to see because they are cryptic or small or are more efficiently collected by brushing because they are numerous. Coral rubble is held over a basket lined with a fine screen and gently brushed with a soft brush, so that animals fall/swim off the rubble into the basket. After brushing, the rubble is replaced on the bottom in the same position that it was found. Rubble brushing is one of the most productive methods for collecting invertebrates in the 1-10 mm size range. In sites without loose rubble, a surface area of no more than 50 square meters may be lightly brushed and the small animals that are dislodged are collected by sweeping with a 15–cm diameter, 1/4 mm mesh net. In some cases, brushing rubble over a fine mesh net can be substituted for, or done in addition to, the basket method.

A 1.4 Sand sampling (death assemblages)

Sand sampling (death assemblages) is targeting dead components of the sand fauna by gathering and washing sand in fresh water and air drying. The fauna studied using this methiod is dominated principally by mollusks, although forams, ostracods, and other taxa could also be studied if future interest and expertise permit. Up to 2 liters of sand per site maximum is collected in a plastic bag, washed with freshwater and air-dried. Shells will be picked post cruise by first sieving the sample into size fractions to facilitate sorting, then picking proportionately across size fractions, until 500 mollusk shells have been picked. These quantitative samples permit rigorous comparisons of mollusk biodiversity among habitats and sites (see Peshut, 2000), and can be the most productive technique for documenting the diversity of primarily infaunal taxa, such as bivalve mollusks (Paulay, 2003). The remainder of the samples collected to study death assemblages will be examined to compile a qualitative list of the relevant taxa. From certain habitats the sand from the field screening that remains after removal of live animals was retained for these purposes as well.

A 1.5 Sand sampling (live assemblages)

Sand sampling of live assemblages is defined as the collection of live components of the sand fauna by sieving sand underwater over a 1 mm mesh screen, with the retained fraction taken on board for sorting. Live components are collected by sieving less than 15 gallons of reef sand per site over a mesh screen underwater, with only the retained fraction taken on board for sorting.

A 1.6 Yabbie pumps

The yabbie pump, used in burrows, is a simple stainless steel suction device that is hand operated and used to extract burrowing organisms along with their commensals. It consists of an external steel cylinder approximately 1 meter in length, within which is a long steel rod with a plunger on the downstream end that seals against the sides of the cylinder with a rubber gasket. When the opening of the cylinder is placed against the opening of burrow, the operator pulls the handle of the plunger rapidly upward, creating a suction that removes the contents of the burrow. The contents (including mud and sand) are then pushed back out by the plunger into a sieve for examination (Hailstone, 1962; Manning, 1975; Manning and Felder, 1986).

A 1.7 Microbial collections

Lipid analyses of sediment
In the field, sediment samples are taken by scooping sediment into a whirl pack. Once on board, the sediment samples are placed into a 15-ml sterile centrifuge tube that contains 5 ml of RNAlater (Ambion), and then stored at –20 ˚C. Samples can then be later analysed in the lab by taking the sand from the pack with a 1.25 ml sterilized spoon and should be 1–10 grams in size depending on organic matter contents.

Sampling water for DNA/RNA extraction using a Sterivex filter
One to three liters of water are taken from each site at various depths and filtered on board using the Sterivex filtration method. Sterivex filters are 0.22 micron capsules (Millipore) that are

routinely used by ICoMM scientists concentrating water samples for further DNA or RNA sample extraction. The traditional application involves filtering a recorded volume of water through the filter using a sterile syringe (140 or 60 cc). The sterivex then is relaxed with Puregene Lysis Buffer and kept frozen at –20 ˚C, until further processing.

A 1.8 Algal collections

The algal team uses hand collection methods to sample representatives of algal species for each site, which are then brought back to the ship for identification and preservation. A bag of no more than 1 gallon of specimens is collected by hand and forceps at each site. Representatives of turf, coralline, and macroalgal groups are sampled. Crustose coralline algae is collected using a small chisel to remove pieces of algae no larger than 1in by 1 in. Depths of 0 to 30 m at the target habitats are sampled. No more that five specimens per species per habitat type are collected. On board, samples are sorted and cleaned. Macroalgal and turf samples are pressed onto herbarium paper, and coralline specimens are dried. Specimens with reproductive structures or samples thought to be new records are put in 4% formalin-seawater solution. Additionally, portions of specimens are cleaned of epiphytes and put in whirl-pac bags with silica crystals for future DNA analysis. Algal specimens that are incidentally collected by other methods are delivered to the algal team for processing in the same manner as described above. Samples will initially be processed by Dr. Alison Sherwood's lab at the University of Hawaii for molecular barcoding analysis to determine genetic diversity of the Hawaiian algal flora. Dr. Peter Vroom of NOAA will help with taxonomic identification of samples. Detailed microscopic analysis and the placement of holotype specimens in internationally accepted herbaria are a necessary part of this process. Once processed, these samples will be moved to Bishop Museum for long-term storage and to assure future access to researchers.

A 1.9 Suction/Vacuum

Suction sampling is a small-scale, objective procedure to collect baseline information, particularly on biodiversity in a given area. A vacuum-type device is used to suction samples in an area to obtain ‘whole community’ and potential key species information. This type of sampling involves lifting small organisms from exposed hard bottoms through suction generated by compressed air into a 2–4-inch diameter pipe. The gentle current created lifts small, mobile organisms into the pipe, capturing them in a mesh bag tied to the end of the pipe. Suction sampling is the most effective method for surveying small or cryptic mobile invertebrates from exposed hard bottoms.

A 2. Shallow Water Collection

A 2.1 Baited traps

The baited traps that are set individually are standard, commercial-style Fathoms Plus polyethylene plastic traps. A minnow trap is placed in each trap for the purpose of capturing organisms smaller than the mesh of the trap, such as crabs, shrimp, and snails. The traps are baited (following official standards for frozen bait), and the openings narrowed (to avoid collection of larger known organisms), and then they are hand placed by divers, and soaked

overnight. To prevent nontarget organisms such as the lobsters *Panulirus marginatus* and *Panulirus penicillatus* from entering the traps, tie wraps are attached across the openings of the traps, making the openings smaller. Should nontarget organisms such as the Triton's Trumpet *Charonia tritonis* or Horned Helmet Shell *Cassis cornuta* be found in the traps, they are culled from the traps immediately after retrieval and released. Each trap is attatched to a line with an inflatable buoy attached. The traps are hand-placed in sandy areas located by means of bathymetric, backscatter, and video data. Five traps per night are set within the site area, time permitting. Traps are then removed the following day and specimens processed. Prior to field deployment, the traps are soaked, cleaned, and disinfected.

A 2.2 Light traps

Light traps are composed of a black PVC body with four openings lined by plastic funnels. The light traps are designed to trap larvae and zooplankton. Plankton enter by the wide end of the funnel and become trapped within the PVC body. Lighting is achieved by inserting disposable cyalume "light sticks." The traps are designed so that there are three separate compartments each with a different color light stick to determine if varying colors attract different organisms. "Light traps" of various designs have been used for years to collect invertebrates, especially their larvae and other zooplankton at night. Target taxa include various planktonic crustaceans such as mysids, cumaceans, isopods, as well as marine worms (should small fish get caught, there will be little chance of mortality and they will be released). Many planktonic organisms navigate by and are attracted to light, and this method takes advantage of that fact. The traps themselves are not placed on the bottom; it is best that they hang in the water column just below the surface. The light traps are designed to be deployed on the float of one of the individual baited traps and soaked overnight.

A 3. Deep Water Collection Methods

(Russell Moffitt, Rusty Brainard, Jody Martin, Scott Godwin, and Gustav Paulay)

A. 3.1 Deep-baited traps

Three strings with eight lobster-type traps (standard commercial-style Fathoms Plus polyethylene plastic traps) are baited (following official standards for frozen bait) and soaked overnight at a depth of 30–300 meters. Each trap on the string is separated by groundline, and the first trap in each string is connected to a floatline with an inflatable buoy and a hard buoy attached. All traps have encapsulated lead inside to weight them down. A minnow trap is placed in each trap for the purpose of capturing organisms smaller than the mesh of the trap, such as crabs, shrimp, and snails. The traps are placed in sandy areas located by means of bathymetric, backscatter, and video data. To prevent nontarget organisms such as the lobsters *Panulirus marginatus* and *Panulirus penicillatus* from entering the traps, tie wraps are attached across the openings of the traps, making the openings smaller. Should non target organisms such as the Triton's Trumpet *Charonia tritonis* or Horned Helmet Shell *Cassis cornuta* be found in the traps, they will be culled from the traps immediately after retrieval and released. Prior to field deployment, the traps are soaked, cleaned, and disinfected.

A 3.2 Ekman Grab

The Ekman Grab is a grab with two hinged upper lids lowered from a boat to sample soft-bottomed substrate. The grab's two hinged upper lids swing open to let water pass through and close upon retrieval on the substrate, thus preventing substrate washout. It is particularly ideal for slow moving or sedentary species. The grab used is 12 inches long, 8 inches wide and cylindrically shaped. It is used at depths of approximately 24 to 40 meters. The grab is used in sandy areas located by means of bathymetric, backscatter, and video data. It will retrieve a sample of a given surface area of benthic substrate and the organisms on and within that substrate. The advantage of a grab is that it can be deployed and retrieved quickly, bringing up a small amount of sediment and getting a perfect sample with very little bottom disturbance. From this, sand sampling can be done, providing samples with distinct fauna from deeper depths. This method of sampling is an extension of the previously described sand sampling and will be used to reach sand habitats that are beyond SCUBA depths.

A 3.3 Scoop/Dredge

The dredge is a scoop designed to sample a very shallow layer of the surficial sediment. Within the framework of the dredge is a modified plankton net used to capture the samples. The dredge is designed to pick up sand, rubble and animals, targeting macrofauna, infaunal and epifaunal organisms in deeper, flat sand areas. It is used in sandy areas located by means of bathymetric, backscatter, and video data. The tows are approximately 24 to 40 meters in depth. The dredge is towed up to 500–1000 m^2, 1–2 times per day, time permitting. The dredge is supported by the ship using 180–200 fathoms cable attached to a winch or pot hauler.

A 4. Plankton Nets
(Russell Moffitt, Scott Godwin, Elizabeth Keenan, and Leslie Harris)

Plankton nets are used to sample plankton communities. Plankton nets sample the water as subsurface tows with a 1 meter diameter, 100µ net towed for 500–1000 m per replicate. The tows are conducted off of both the small boats and the ship. Collected plankton samples are divided in half, half fixed in formalin for morphological study and half fixed in 95% ethanol. Plankton includes taxa that spend their entire life in the water column (holoplankton), as well as the larval stages of benthic species (meroplankton). DNA barcoding techniques provide a novel method for matching planktonic larval and benthic adult stages. Barcoding plankton samples will also allow us to estimate what percentage of the benthic fauna were successfully sampled by providing an independent estimate of that fauna in their larval stages: thus the proportion of meroplankter sequences encountered that are not represented in the benthos is an indication of how incomplete benthic sampling has been.

A 5. Autonomous Reef Monitoring Structures (ARMS) Deployment

ARMS are small, long-term collecting devices designed to mimic, to some degree, the structural complexity of a coral reef, thus attracting colonizing invertebrates over the period during which the ARMS are left in the field (Zimmerman and Martin, 2004). Each of the ARMS measures 14 in by 18 in by 8 in. Layers (9 in by 9 in) include flat sandwich layers with holes of varying sizes

ranging from 3/4 in to 3/32 in in diameter. The deployment sites are associated with CRED's already established REA sites from the Reef Assessment and Monitoring Program. To compare the biota of different habitats, two sites were located on the forereef, one site on the backreef, and one on a lagoon patch reef. The ARMS are placed on pavement or sand, in proximity to coral reef structures, specifically to avoid coral damage. The ARMS are deployed by CRED working divers using stainless steel stakes and weights to insure that they remain in place for the duration of 1–2 years. A Global Positioning System (GPS) point is taken for each of the ARMS after deployment for accurate relocation. The Coral Reef Ecosystem Division of the Pacific Islands Fisheries Science Center will be responsible for maintaining and removing the installations during a follow-up cruise.