



## CRUISE REPORT<sup>1</sup>

**VESSEL:** *Hi'ialakai*, Cruise HI-06-10

**CRUISE PERIOD:** July 27-August 20, 2006

**AREA OF OPERATION:** Main Hawaiian Islands (Oahu, Kauai, Niihau, Kaula Rock, Lehua Rock, Molokai, Maui, Lanai, and Hawaii) (Fig. 1)

**TYPE OF OPERATION:** Personnel from the Coral Reef Ecosystem Division, Pacific Islands Fisheries Science Center (PIFSC), National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA) and the Division of Aquatic Resources of the Hawaii Department of Land and Natural Resources conducted coral reef ecosystem assessment, monitoring, and mapping operations in waters of the main Hawaiian Islands, including the islands of Oahu, Kauai, Niihau, Kaula Rock, Lehua Rock, Molokai, Maui, Lanai, and Hawaii.

### ITINERARY

27 July Start of cruise. Embarked Paul Murakawa (fish), Jason Leonard (fish), Jill Zamzow (fish), Dave Gulko (coral), Bernardo Vargas Angel (coral disease), Holly Bolick (invertebrates), Aline Tribollet (algae), John Mitchell (algae), Brian Zgliczynski (towed-diver survey/fish), Ben Richards (towed-diver survey/fish), Rusty Brainard (towed-diver survey/habitat), Jake Asher (towed-diver survey/habitat), Kyle Hogrefe (oceanography), Ron Hoeke (oceanography), Sean Guerin (oceanography), Kevin Lino (oceanography), Russell Moffitt (data manager), and Jim Bostick (dive-master/chamber operator). Departed Honolulu at 0830, en route for Makapuu Point and Manana (Rabbit) Island off windward Oahu. An introductory meeting was held for all scientific personnel and new crewmembers at 0900. A dive safety meeting was held for all divers at 0930. Following arrival off Makapuu Point, commenced coral reef ecosystems surveys consisting of one Rapid Ecological Assessment (REA) dive off Kaohikaipu Island (OAH-13), three towed-diver habitat/fish/macro-invertebrate surveys, five shallow water conductivity-temperature-depth

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<sup>1</sup> PIFSC Cruise CR-08-013  
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- (CTD) casts, and one oceanography team reconnaissance dive. Medical Officer Chris Walsh was embarked via small boat from the Makai Pier at 1430. Following small boat operations, the ship departed for Kauai at 1800. At 1900, the scientific party conducted a planning meeting to discuss operations for the next day.
- 28 July Arrived at Kauai Island at 0730 to commence field operations. The REA team (less two members) partially occupied two established sites on the northeast and north sides of the island (KAU-1, KAU-2) and established one new site off northwest Kauai (KAU-13). The team worked short-handed due to inability to launch the ship's Zodiac Inflatable boat, HI-5, because of moderate sea conditions. The towed-diver survey team completed five dives east to west from near Papaa Bay to Hanalei Bay. Found a Fish Aggregating Device (FAD) grounded on the reef at position N22 14.5208 W159 25.1988. The oceanography team deployed an ocean data platform (ODP) anchor in Hanalei Bay and conducted 13 shallow water CTD casts and performed 5 water quality profiles during which water samples were taken to be later analyzed for chlorophyll and nutrient contents. At 1800, departed for west Molokai Island.
- 29 July Arrived off west end of Molokai Island at 1200 to commence reef assessment surveys. The REA team conducted one REA survey at site MOL-5 and aborted a second REA survey due to strong current conditions. The towed-diver survey team conducted three dives along the west end from Ilio Point south to and around Laau Point. The oceanography team recovered and replaced two STRs, conducted six 30-m CTD casts. During the night the ship conducted three 500-m CTD/water quality casts during which 15 water samples were taken to be later analyzed for chlorophyll (15 samples) and nutrient (15 samples) content.
- 30 July Arrived off northwest coast of Maui Island at 0730 to commence reef assessment surveys. The REA team conducted three new REA surveys off Mokeehia Islet (MAI-10), Kahakuloa Point (MAI-11), and Kanounou Point (MAI-12). The towed-diver survey team conducted six dives along the windward facing northwest coast from Nehe Point to northwest to Kanounou Point. The oceanography team deployed one subsurface temperature recorder (STR), conducted nineteen 30-m CTD casts, and performed eight water quality profiles during which water samples were taken to be later analyzed for chlorophyll and nutrient contents. During the night the ship conducted two 500-m CTD/water quality casts during which 10 water samples were taken to be later analyzed for chlorophyll and nutrient content.
- 31 July Arrived off northeast coast (Alenuihaha Channel) of Maui Island at 0730 to commence reef assessment surveys. The REA team conducted three new REA surveys off Alan Islet (MAI-13), Mamalu Bay (MAI-14), and Kaapahu Bay (MAI-15). The towed-diver survey team conducted six dives

along the southeast coast from Alan Islet southwest to Mamalu Bay. The oceanography team conducted twenty-seven 30-m CTD casts, and performed nine water quality profiles during which water samples were taken to be later analyzed for chlorophyll and nutrient contents. During the night the ship conducted two 500-m CTD/water quality casts during which 10 water samples were taken to be later analyzed for chlorophyll and nutrient content. Ship-based multibeam mapping operations were also conducted.

01 August

Continued reef assessment surveys off southeast Maui in the Alenuihaha Channel. The REA team conducted one repeat REA site at Nuu Landing (MAI-3) and two new REA surveys off Nakaohu Point (MAI-16) and in Kanaloa Bay (MAI-17). The towed-diver survey team conducted six dives along the southeast coast from Mamalu Bay southwest to Kamanamana Point. Another Fish Aggregation Device (FAD) buoy number NL was found grounded on the reef as position N20 35.6751 W156 16.2306. The oceanography team deployed an EAR and an STR in La Perouse Bay, conducted twenty-one 30-m CTD casts, and performed three water quality profiles during which water samples were taken to be later analyzed for chlorophyll and nutrient contents. Command of ship assumed by CDR Carl Groeneveld as CDR Kuester, CDR Swallow, and Medical Officer Walsh disembarked via small boat to Maalaea Harbor. Embarked Medical Officer William Foust. During the night the ship conducted two 500-m CTD/water quality casts during which five water samples were taken to be later analyzed for chlorophyll and nutrient content. Ship-based multibeam mapping operations were also conducted.

02 August

Conducted reef assessment surveys off northeast and north Kohala coast of Hawaii Island. The REA team conducted three new REA surveys off Kohala Mountains on the windward coast (HAW-20, HAW-21, and HAW-32) The towed-diver survey team conducted five dives along the southeast coast from unnamed windward islets northwest to Upolu Point. The oceanography team recovered and replaced one STR, conducted twenty-seven 30-m CTD casts, and performed six water quality profiles during which water samples were taken to be later analyzed for chlorophyll and nutrient contents. During the night the ship conducted one 500-m CTD/water quality casts during which five water samples were taken to be later analyzed for chlorophyll and nutrient content. Ship-based multibeam mapping operations were also conducted.

03 August

Conducted reef assessment surveys off southwest coast of Hawaii Island north from Ka Lae to Kauna Point. The REA team conducted three new REA surveys (HAW-22, HAW-23, and HAW-24). The towed-diver survey team conducted six dives along this same coast from Kailikii Shoal to near Kauna Point. The oceanography team recovered and replaced one STR, conducted sixteen 30-m CTD casts, and performed one water quality profile during which water samples were taken to be later analyzed for

chlorophyll and nutrient contents. Ship-based multibeam mapping operations were also conducted.

04 August

Conducted reef assessment surveys off northeast coast of Lanai Island north from Shipwreck Beach to near Manele Bay. The REA team conducted one new REA survey off Shipwreck Beach (LAN-8) and two established sites (LAN-4 and LAN-5). The towed-diver survey team conducted six dives along this same coast from Shipwreck Beach to Kamaiki Point. The oceanography team recovered and replaced one STR, conducted twenty-three 30-m CTD casts, and performed seven water quality profiles during which water samples were taken to be later analyzed for chlorophyll and nutrient contents. During the night the ship conducted two 500-m CTD/water quality casts during which 10 water samples were taken to be later analyzed for chlorophyll and nutrient content. Ship-based multibeam mapping operations were also conducted.

05 August

Conducted reef assessment surveys off south coast of Lanai from Kaa on the east coast to Nahahoa on the west coast. The REA team conducted one new REA survey off Kaa (LAN-7) and two established sites (LAN-3 and LAN-6). The towed-diver survey team conducted five dives from Manele Bay to north of Nahahoa on the west coast. The oceanography team recovered and replaced one STR, conducted fourteen 30-m CTD casts, and performed one water quality profile during which water samples were taken to be later analyzed for chlorophyll and nutrient contents. During the night the ship conducted one 500-m CTD/water quality cast during which five water samples were taken to be later analyzed for chlorophyll and nutrient content.

06 August

Conducted reef assessment surveys off north coast of Maui from Pauwela Point to Kahului after initial launch plans further east were aborted due to adverse wind and sea conditions. At 1100, the towed-diver and oceanography teams were deployed in Kahului Bay prior to increasing seas aborting the launch of the REA team. The towed-diver survey team conducted two dives from Pauwela Point to Paia and one dive off submerged reefs in Kahului Bay. The oceanography team conducted fourteen 30-m CTD casts, and performed three water quality profiles during which water samples were taken to be later analyzed for chlorophyll and nutrient contents. During the night the ship conducted one 500-m CTD/water quality casts during which five water samples were taken to be later analyzed for chlorophyll and nutrient content. Ship-based multibeam mapping operations were also conducted.

7 August

Arrived at Pier 34 Honolulu Harbor at 0830 to conclude Leg I. Disembarked Vargas Angel, Bolick, Moffitt, Hogrefe, Gulko, Zamzow, Lino, Mitchell, Leonard, Murakawa, and O'Connor. Replenished nine 55-gallon drums of gasoline. Embarked Kenyon, Wheeler, Okano, Godwin, Sta-



moulis, Cotton, Montgomery, Coccagna, Charette, Collier, and Lyons. Departed Honolulu at 1215 to commence Leg II. Conducted orientation and dive safety meetings en route to REA dive site off Ewa Beach. Launched HI-2 small boat with REA team (Kenyon, Wheeler, Tribollet, Okano, Godwin, Stamoulis, Cotton, and Montgomery) to conduct fish and benthic REA survey. Conducted dive safety drill simulating dive accident. During drill, simulated use of oxygen in small boat resulted in accidental facial injury to Kenyon. Review by ship's medical officer found no noteworthy injury. Transited to Kauai during the night conducting one CTD off west Oahu which experienced winch electronic problems. Ship-based multibeam mapping operations were also conducted.

8 August

Arrived off east Kauai at 0730. Conducted reef assessment surveys off east and southeast coasts of Kauai from Anahola Bay to Poipu. Due to heavy rains the previous day, underwater visibility was severely restricted at each of the planned REA sites resulting in no surveys being conducted. The towed-diver survey team conducted five towed-diver surveys from Kapaa to Poipu. One planned towed-diver survey was aborted because of poor visibility. The oceanography team replaced two STRs at Anahola Bay and SE Kauai and conducted twenty-five 30-m CTD casts, and performed four water quality profiles during which water samples were taken to be later analyzed for chlorophyll and nutrient contents. During the night the ship conducted two 500-m CTD/water quality casts during which 10 water samples were taken to be later analyzed for chlorophyll and nutrient content.

9 August

Arrived off north Niihau at 0730. Conducted reef assessment surveys off east coast of Niihau from Lehua Channel in the north to Kaumuhonu Bay in the south. The REA team conducted three REA surveys at established sites (NII-1, NII-3, and NII-7). The towed-diver survey team conducted six towed-diver surveys from Lehua Channel to Kaumuhonu Bay. The oceanography team replaced an STR off NE Niihau and conducted twenty-four 30-m CTD casts, and performed two water quality profiles during which water samples were taken to be later analyzed for chlorophyll and nutrient contents. During the night the ship conducted three 500-m CTD/water quality casts during which 10 water samples were taken to be later analyzed for chlorophyll and nutrient content. Transited to Kaula Rock.

10 August

Arrived off Kaula Rock at 0730. Conducted reef assessment surveys around Kaula Rock and at Five Fathom Pinnacle. The REA team conducted two new REA surveys on the west side of Kaula Rock (KAL-1 and KAL-2) and a qualitative assessment survey at Five Fathom Pinnacle. The towed-diver survey team conducted three towed-diver surveys completely around Kaula Rock and two free-swim photographic surveys at Five Fathom Pinnacle. The oceanography team deployed an STR on Five

Fathom Pinnacle and conducted nine 30-m CTD casts; performed one water quality profile during which water samples were taken to be later analyzed for chlorophyll and nutrient contents. During the night the ship conducted three 300-m CTD casts. Ship-based multibeam mapping operations were also conducted.

- 11 August Arrived off southwest Niihau at 0730. Conducted reef assessment surveys of west side of Niihau from Kaumuhono Bay in the south to Keawanui Bay to the north. The REA team conducted REA surveys at two new sites (NII-8 and NII-9) and one established site (NII-5). The towed-diver survey team conducted six towed-diver surveys from Kaumuhono Bay to Keawanui Bay. The oceanography team conducted twenty-eight 30-m CTD casts, and performed two water quality profiles during which water samples were taken to be later analyzed for chlorophyll and nutrient contents. During the night the ship conducted one 300-m and CTD cast. Transited to Lehua Rock.
- 12 August Arrived off Lehua Rock at 0730. Conducted reef assessment surveys around Lehua Rock and northern Niihau. The REA team conducted three REAs at established sites inside the crater at Lehua Rock (LEH-2), along the southeast side of Lehua Rock (LEH-1), and along the west side of Lehua Rock (LEH-3). The towed-diver survey team conducted three towed-diver surveys completely around Lehua Rock, one towed-diver survey across the channel from Lehua Rock to north Niihau, one towed-diver survey along northwest Niihau, and one towed-diver survey to locate a lost STR. The oceanography team performed three dive surveys to locate a suitable ecological acoustic recorder (EAR) deployment site and deployed an EAR and an STR on the south side of Lehua. An STR was recovered with the assistance of the towed divers. During the night the ship conducted one 500-m CTD/water quality cast during which five water samples were taken to be later analyzed for chlorophyll and nutrient content. Transited to Kaula Rock. Transited to Mana Reef off west Kauai.
- 13 August Arrived off west Kauai at 0730. Conducted reef assessment surveys of Mana Reef off southwest Kauai. The REA team conducted one drift survey and one new REA survey at Mana Reef (KAU-15). The towed-diver survey team conducted five towed-diver surveys along the extent of Mana Reef from northeast to southwest. The oceanography team recovered and redeployed a wave and tide recorder (WTR) on Mana Reef and conducted fourteen 30-m CTD casts. Transited to north Molokai.
- 14 August Arrived in lee of Kalaupapa Peninsula, Molokai at 1100. Conducted reef assessment surveys along northeast coast of Molokai from Keanapuka Bay westward to Kahi Point on the Kalaupapa Peninsula. The REA team conducted two new REA surveys on the north side of Molokai, one on the west side of Mokapu Islet (MOL-6) and the second on a ridge between Pe-

lekunu Bay and Mokohola Islet (MOL-7). The towed-diver survey team conducted four towed-diver surveys from Wailau Valley to Kahi Point. The oceanography team conducted twenty 30-m CTD casts, and performed three water quality profiles during which water samples were taken to be later analyzed for chlorophyll and nutrient contents. Transited to northeast Hawaii.

15 August

Arrived off Laupahoehoe, Hawaii at 0730, but wind and sea conditions were too rough to launch boats. Transited to Hilo Bay, arriving at 1100 to launch boats. Conducted reef assessment surveys around Kaula Rock and at Five Fathom Pinnacle. The REA team conducted two new REA surveys on the west side of Kaula Rock (KAL01 and KAL02) and a qualitative assessment survey at Five Fathom Pinnacle. The towed-diver survey team conducted three towed-diver surveys completely around Kaula Rock and two reconnaissance surveys at Five Fathom Pinnacle. The oceanography team deployed an STR on Five Fathom Pinnacle and conducted twenty-three 30-m CTD casts, and performed four water quality profiles during which water samples were taken to be later analyzed for chlorophyll and nutrient contents. During the night, the ship conducted one 500-m CTD/water quality casts during which five water samples were taken to be later analyzed for chlorophyll and nutrient content. Transited to southwest Niihau.

16 August

Arrived off the southeast coast of Hawaii at 0730. Conducted reef assessment surveys off the southeast coast of Hawaii from Kamehame Beach and Punalu'u to Ka'alu'alu Bay. The REA team conducted REA surveys at three established sites (HAW-15, HAW-16, and HAW-12). The towed-diver survey team conducted six towed-diver surveys from the vicinity of the Punaluu Harbor towards Kaalualu Bay. The oceanography team replaced an STR off Punalu'u Black Sand Beach and conducted twenty-six 30-m CTD casts, and performed two water quality profiles during which water samples were taken to be later analyzed for chlorophyll and nutrient contents. Transited to Hawaii.

17 August

Arrived off the southeast coast of Hawaii at 0730. Conducted reef assessment surveys in the vicinity of Opihikao, Kupapa'u Point, and Kalae'apuki Point. The REA team conducted REA surveys at three established sites (HAW-8, HAW-27, HAW-28). The towed-diver survey team conducted six towed-diver surveys in the southeast from Hakuma Point/Kalapana to Kaena Point. The oceanography team conducted twenty-two 30-m CTD casts, and performed two water quality profiles during which water samples were taken to be later analyzed for chlorophyll and nutrient contents. Transited to northeast Hawaii (Hamakua Coast).

- 18 August Arrived off the northeast coast of Hawaii at 0730. Conducted reef assessment surveys along the Hamakua coast in the vicinity of Laupahoehoe Point, Kuka'iaua, and just south of Honoka'a. The REA team conducted REA surveys at three established sites (HAW-29, HAW-30, HAW-31). The towed-diver survey team conducted six towed-diver surveys from Laupahoehoe Point to Waipio Bay. The oceanography team conducted twenty-eight 30-m CTD casts and performed two water quality profiles during which water samples were taken to be later analyzed for chlorophyll and nutrient contents. During the night the ship conducted one 500-m CTD/water quality casts during which five water samples were taken to be later analyzed for chlorophyll and nutrient content. Transited to northeast Maui.
- 19 August Arrived off the northeast coast of Maui at 0730. No reef assessment surveys were conducted. The towed-diver survey team conducted five towed-diver surveys from Opikoula Point to the area immediately east of Pauwela Point. The oceanography team deployed an STR just west of Keanae peninsula, at REA Site MAI02, conducted twenty-six 30-m CTD casts, and performed two water quality profiles during which water samples were taken to be later analyzed for chlorophyll and nutrient contents. Transited to Honolulu. Ship-based multibeam mapping operations were also conducted.
- 20 August Arrived at Honolulu, Hawaii to conclude HI-06-10. Disembarked Tribollet, Zgliczynski, Richards, Brainard, Asher, Hoeke, Guerin, Bostick, Kenyon, Wheeler, Okano, Godwin, Stamoulis, Cotton, Montgomery, Coccagna, Charette, Collier, and Lyons.

Table 1.--Cruise statistics for HI-06-10 (2006).

	Hawaii Island	Lanai	Maui	Molokai	Oahu	Kauai	Ni'ihau	Lehua Rock	Kaula Rock	Total
Towed-Diver habitat/fish suveys	27	11	33	7	3	15	13	5	3	117
Combined tow lengths (km)	74	29	62	18	6	35	32	9	4	269
Fish rapid ecological assessments	17	6	12	3	2	5	6	3	2	56
Benthic rapid ecological assessments	17	6	12	3	2	5	6	3	2	56
Wave and tide recorders (WTR) recovered						1				1
Wave and tide recorders (WTR) deployed						1				1
Ocean data platforms (ODP)						1				1
Ecological acoustic recorders (EAR) recovered			2					1		3
STRs recovered	3	2		2		2	1	1		11
STRs deployed	3	2	2	2		1	1	1	1	13
Shallow water quality profiles	18	8	25	3		9	4	*	1	68
Deep water quality profiles	2	2	3	2	1	2	2	*	1	15
Deepwater CTDs (from HI'IALAKAI)	3	2	3	2	1	2	2	*	1	16
Shallow water CTDs	143	37	15	26	6	55	47	5	9	343
Multibeam mapping			√						√	
SCUBA dives	176	78	145	41	27	83	72	36	26	684

\* numbers reported included in Ni'ihau column

## MISSIONS:

- A. Conduct ecosystem monitoring of the species composition, abundance, percent cover, size distribution, and general health of the fish, corals, other invertebrates, and algae of the shallow water (< 35 m) coral reef ecosystems of the main Hawaiian Islands (MHI).
- B. Deploy an array of Subsurface ODPs, subsurface WTRs, STRs, and EARs to allow remote long-term monitoring of oceanographic and environmental conditions affecting coral reef ecosystems of the main Hawaiian Islands.
- C. Collect water samples for analysis of nutrient and chlorophyll levels.
- D. Conduct shipboard CTD casts to a depth of 500 m, shallow water CTD casts from small boats to a depth of ~30 m, and shipboard acoustic Doppler current profiler (ADCP) surveys around reef ecosystems to examine physical and biological linkages supporting and maintaining these island and atoll ecosystems.
- E. Determine the existence of threats to the health of these coral reef resources from anthropogenic sources, including marine debris.
- F. Collect ADCP data during all transits. The ADCP unit shall be configured to collect narrow-band data in 16 meter bins (deepwater mode).

## RESULTS:

- A. Ecosystem monitoring of the species composition, abundance, percent cover, size distribution, and general health of the fish, corals, other invertebrates, and algae of the shallow water (<35 m) coral reef ecosystems of the MHI was completed at 56 sites.
- B. A total of 117 towed-diver surveys were conducted covering 271 km of seafloor.
- C. One subsurface WTR, 13 STRs and 3 EARs were deployed to allow remote long-term monitoring of oceanographic and environmental conditions affecting coral reef ecosystems of the MHI. One subsurface ODP, 1 subsurface WTR, and 11 STRs were recovered.
- D. Sixty-eight shallow water and 15 deepwater stations were visited to collect water samples for analysis of nutrient and chlorophyll levels.
- E. Sixteen shipboard CTD casts to a depth of 500 m and 343 shallow water CTD casts from small boats to a depth of ~30 m were completed.
- F. The existence of threats to the health of these coral reef resources from anthropogenic sources, including marine debris were noted.
- G. ADCP data was collected during all transits.

## SCIENTIFIC PERSONNEL:

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Andrew Collier, Oceanographer, Cornell University

#### **DATA COLLECTED:**

- Quantitative surveys of reef fishes (larger than 25 cm TL) to species level from REA team Stationary Point Counts
- Quantitative surveys of all reef fishes to species level from REA team Belt Transects
- Reef fish species presence records from REA team roving diver surveys
- Quantitative data surveys for coral size class distribution, abundance, and diversity.
- Quantitative data surveys for benthic cover, including live coral, dead coral, pavement, sand, macroalgae, crustose coralline algae, and other sessile invertebrates
- Quantitative data surveys for coral disease prevalence
- Digital images of diseased corals
- Field notes on signs of coral bleaching and/disease
- Semi-quantitative surveys for distribution and abundance of selected macroinvertebrates
- Digital images from algal photoquadrats
- Algal voucher specimens
- Algal field notes of species diversity and relative abundance
- Digital images of the benthic habitat from towboard surveys
- Macroinvertebrate counts from towboard surveys
- Quantitative surveys of reef fishes (larger than 50 cm TL) to species level from towboards
- Habitat lineation from towboard surveys
- Benthic composition estimations from towboard surveys
- Multibeam bathymetry and acoustic backscatter imagery at limited sites
- Acoustic Doppler current profiler (ADCP) transects
- Shipboard (Offshore) Conductivity, temperature and depth (CTD) profiles to 500 m
- Shipboard (Offshore) Water Samples to 500 m: Chlorophyll and Nutrient - 5 depths per cast
- Shallow (Inshore) Conductivity, Temperature, Depth (CTD) casts: 30 m
- Shallow (Inshore) Water Samples (30 m): Chlorophyll and Nutrient - 4 depths per cast
- Sea surface and subsurface temperature at variable depths
- Sea surface and subsurface salinity at variable depths
- Spectral wave energy and tidal elevation timeseries
- Directional ocean currents
- Wind speed/direction and turbidity

Submitted by: (/s/Russell E. Brainard)  
\_\_\_\_\_  
Russell E. Brainard, Ph.D.  
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Approved by: (/s/Kacky Andrews)  
\_\_\_\_\_  
Kacky Andrews  
Program Manager.  
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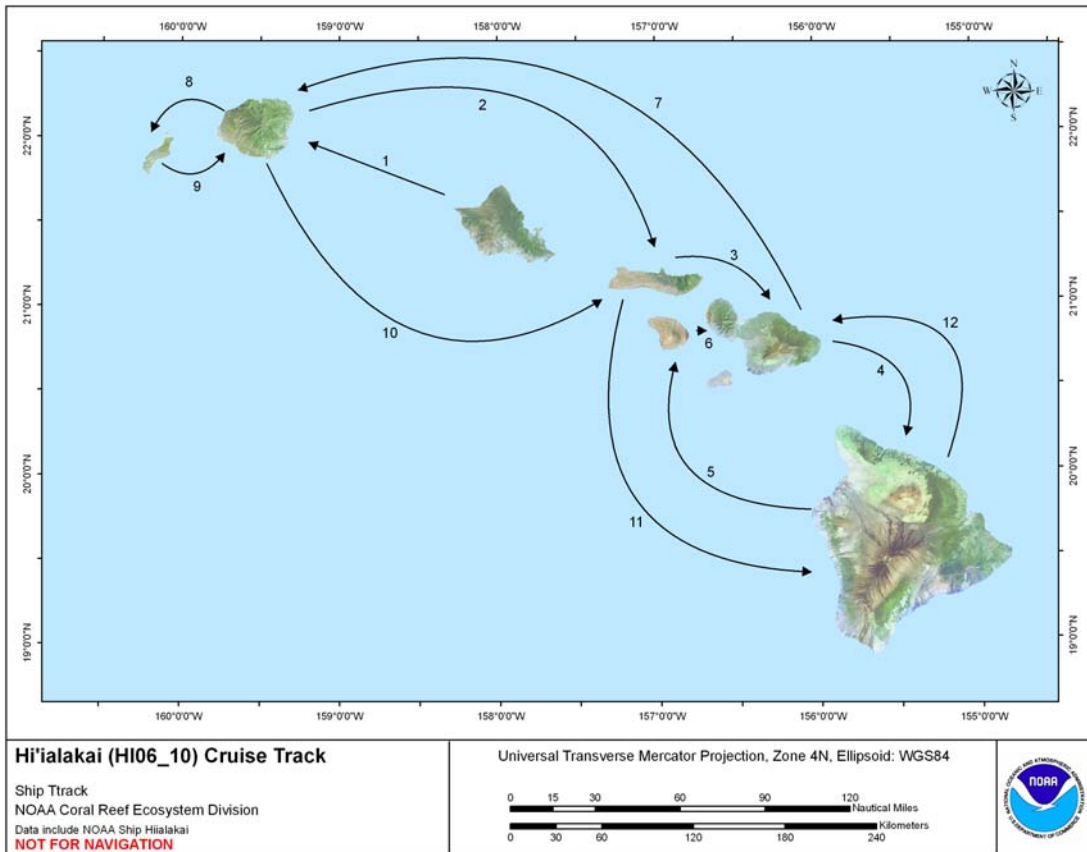


Figure 1.--Track of the NOAA Ship *Hi'ialakai* Cruise HI-06-10, July 27 to August 20, 2006.

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## Appendix A: Methods

### A.1. Oceanography & Water Quality Methods

*(Ron Hoeke, Stephane Charette, Kyle Hogrefe, Kevin Lino, Edmund Coccagna, Sean Guerin, Andrew Collier)*

Since 2001, the Coral Reef Ecosystem Division (CRED) has been conducting multidisciplinary research in the Hawaiian Archipelago, primarily in the Northwestern Hawaiian Islands. In 2005, CRED initiated research cruises to the main Hawaiian Islands (MHI), extending CRED's established methods of recovery/redeployment of instrument platforms and oceanographic/water quality surveys to the islands. These methods monitor and assess important physical, chemical, and biological variables in coral reef ecosystems. During cruise HI-06-10, the oceanography team utilized these methods to monitor long-term trends and assess oceanographic conditions.

Since logistics constrain site visits to short periods every 1-2 years, long-term oceanographic monitoring is accomplished by deployment and retrieval of a variety of internally recording instrument platforms. In the MHI, these instruments include:

- Wave and Tide Recorders (WTR): Moored instruments which measure spectral wave energy, precision tidal elevation, and subsurface water temperature.
- Ocean Data Platforms (ODP): Moored instruments which measure subsurface temperature, salinity, directional spectral wave energy, precision tidal elevation, and current profiles.
- Subsurface Temperature Recorders (STR): Moored instruments which measure high resolution subsurface temperatures.
- Ecological Acoustic Recorders (EAR): Passive acoustic moored instruments which record the ambient sound field. This data is used both to monitor biotic sounds and boat traffic.

While at each site, detailed oceanographic and water quality surveys are accomplished with the following:

- Shallow (inshore) water sampling: Conductivity, temperature and depth (CTD) casts, including turbidity measurements, were performed to a maximum depth of 30 meters from a 6-m launch using an SBE 19+ at regularly spaced intervals around each island/atoll. Water quality profiles were conducted as a subset of the CTD casts using a hand deployed Niskin bottle string at depths of 30 m, 20 m, 10 m and 1 m as allowed by the depth at each cast site. Water samples were collected for nutrient and chlorophyll concentration at each depth.
- Shipboard (offshore) water sampling: Permanent conductivity, temperature and depth (CTD) cast stations were established. Casts were performed to a depth of 500 meters and included fluorometric (chlorophyll concentration) and dissolved oxygen measurements, from the *Hi'ialakai* using an SBE911. These casts were performed along ADCP (below)

transects or independently. Water samples were collected from the majority of casts at 150 m, 125 m, 100 m, 80 m, 30 m and 3 m using Niskin bottles. Water samples were collected for nutrient and chlorophyll concentration at each depth.

- Acoustic Doppler Current Profiler (ADCP) data provide information on oceanographic current structure from the surface to 600 m. ADCP transects were conducted in conjunction with deepwater CTDs around each of the islands as well as during transits and most other vessel activity.
- Continuous recording of surface and subsurface water temperatures as a function of depth were recorded during all towed-diver operations, providing a broad and diverse spatial and thermal sampling method.

Table A.1.1 summarizes CRED instrument platforms deployments/recoveries and oceanographic and water quality surveys for cruise HI-06-10.

Table A.1.1 Summary of instrument deployment/recoveries and oceanographic/water quality surveys on the main Hawaiian Islands reef assessment and monitoring program (RAMP) cruise HI-06-10, July–August 2006.

	Hawaii	Lanai	Maui	Molokai	Oahu	Kauai	Niihau	Lehua Rock	Kaula Rock
ODPs deployed						1			
EARs deployed			2					1	
STRs recovered	3	2		2		2	1	1	
STRs deployed	3	2	2	2		1	1	1	1
WTRs recovered						1			
WTRs deployed						1			
Shallow CTDs	143	37	15	26	6	55	47	5	9
Shallow water quality profiles.	18	8	25	3		9	4	*	1
Shipboard CTDs	3	2	3	2	1	2	2	*	1
Shipboard water quality depths.)	2	2	3	2	1	2	2	*	1
Nutrient Samples – total	8	34	95	19	5	34	25	*	9
Cholorophyll Samples – total	8	34	95	19	5	34	25	*	9

*\* numbers reported included in Niihau Column*

All deepwater CTDs, ADCP, water samples, and some internally recording instrument platform data require extensive post processing and interpretation; this data is not included in the following observation sections. Selected timeseries from recovered long-term monitoring instruments and a subset of shallow water CTD data is presented below.

## A.2. Rapid Ecological Assessment Methods

(Fish: Paul Murakawa, Jill Zamzow, Jason Leonard, Tony Montgomery, Steve Cotton Coral team: Jean Kenyon PhD, Bernardo Vargas Angel, PhD, Dave Gulko, Benjamin Wheeler MSc; Invertebrates: Holly Bolick, Scott Godwin; Algae: Aline Tribollet, PhD, John Mitchell, and Ryan Okano)

The survey methodology used during HI-06-10 is the same as previously used during REA surveys conducted in 2005, when long-term monitoring sites were selected and surveyed by the full REA team (fish, corals, algae, and other invertebrates). At each REA site, three 25-m transect lines were laid out by the fish team, separated from each other by approximately 2–3 m. At most sites, transects were laid out at between 3–15 m depth. Global positioning system (GPS) coordinates for the sites visited during the HI-06-10 RAMP cruise are presented below (Table A.3). REA methods for each specific discipline are as follows.

Table A.2.1 Sites surveyed by the REA team in the main Hawaiian Islands RAMP cruise HI-06-10, July-August 2006; 56 sites + 1 drift dive (Table prepared by Jean Kenyon).

Site #	Date survey	Latitude North		Longitude West		General location	Notes
		de-grees	minutes	degrees	minutes		
<b>Hawaii</b>							
HAW-20	8/2/06	20	11.452	-155	42.247	Offshore islet S of Polulu Valley	
HAW-21	8/2/06	20	14.829	-155	46.595	Keawa'eli Bay	
HAW-32	8/2/06	20	16.022	-155	50.878		
HAW-22	8/3/06	18	58.134	-155	43.799	Kalipoa	
HAW-23	8/3/06	19	0.354	-155	47.802	Hosaka Pt./Pohue Bay	
HAW-24	8/3/06	19	2.295	-155	52.954	Kauna Pt.	
HAW-25	8/15/06	19	42.464	-154	59.055	Papua'a Bay, S of Hilo Bay	
HAW-26	8/15/06	19	44.491	-155	1.826	Keokeha Pt., Hilo Bay	
HAW-15	8/16/06	19	8.593	-155	27.912	Kamehame Beach	
HAW-16	8/16/06	19	8.031	-155	30.060	Punalu'u	
HAW-12	8/16/06	18	57.930	-155	37.057	Ka'alu'alu Bay	
HAW-8	8/17/06	19	25.438	-154	52.836	Opihikao	
HAW-27	8/17/06	19	19.956	-155	0.591	near Kupapa'u Pt.	
HAW-28	8/17/06	19	17.974	-155	5.037	near Kalae'apuki Pt.	
HAW-29	8/18/06	19	59.942	-155	14.964	Hamakua coast: Laupahoe-hoe Point	
HAW-30	8/18/06	20	3.493	-155	21.964	Hamakua coast: Kuka'iau	
HAW-31	8/18/06	20	5.706	-155	26.777	S of Honoka'a	
<b>Kauai</b>							
KAU-2	7/28/06	22	9.938	-159	17.574	Anahola	
KAU-3	7/28/06	22	13.838	-159	24.326	Kilauea Pt.	
KAU-13	7/28/06	22	13.588	-159	33.877	Tunnels area	
KAU-14	8/13/06	22	9.669	-159	43.746	N end Mana Reef	
Begin drift	8/13/06	22	8.700	-159	44.950	S to N, 0.33 mile drift dive	fish only, 1 transect
End drift	8/13/06	22	8.952	-159	44.825		
KAU-15	8/13/06	22	8.263	-159	45.680	mid-section Mana Reef	

Site #	Date survey	Latitude North		Longitude West		General location	Notes
		de-grees	minutes	degrees	minutes		
<b>Kaula</b>							
KAL-1	8/10/06	21	39.310	-160	32.619		
KAL-2	8/10/06	21	39.166	-160	32.713		
<b>Lanai</b>							
LAN-8	8/4/06	20	55.429	-156	54.595	Po'aiwa	
LAN-4	8/4/06	20	46.799	-156	49.219	Huawai Bay	
LAN-5	8/4/06	20	44.469	-156	52.545	Kapo'iili'i Bay	
LAN-7	8/5/06	20	52.234	-156	50.088	Kainehe Beach	
LAN-6	8/5/06	20	44.022	-156	55.279	Kaumalapau	
LAN-3	8/5/06	20	46.506	-156	59.379	Kaumalapau	
<b>Lehua</b>							
LEH-2	8/12/06	22	1.294	-160	5.633	inside caldera	
LEH-1	8/12/06	22	0.987	-160	5.486	SE side	
LEH-3	8/12/06	22	1.278	-160	6.096	West side	
<b>Maui</b>							
MAI-10	7/30/06	20	59.212	-156	31.613	Hakuhee Pt.	
MAI-11	7/30/06	21	0.131	-156	32.904	Kahakuloa	
MAI-12	7/30/06	21	1.820	-156	35.340	Nakalele Pt.	
MAI-13	7/31/06	20	44.743	-155	58.724	Kauiki Head	
MAI-15	7/31/06	20	37.200	-156	8.500	Kailio Pt.	
MAI-14	7/31/06	20	39.583	-156	2.466	Puhilele Pt.	
MAI-3	8/1/06	20	37.410	-156	10.692	Nu'u	
MAI-16	8/1/06	20	35.555	-156	16.781	Alena	
MAI-17	8/1/06	20	34.804	-156	20.578	Auwahi	
MAI-18	8/19/06	20	48.445	-156	2.128	Kalahu Pt.	
MAI-19	8/19/06	20	54.845	-156	12.864	near Waipio Bay	
MAI-20	8/19/06	20	56.878	-156	16.904	Opana Pt.	
<b>Molokai</b>							
MOL-5	7/29/06	21	11.164	-157	15.207	Kepuhi Bay; off Sheraton Beach	
MOL-6	8/14/06	21	11.046	-156	55.472	Mokapu Islet, E of Kalaupapa Ridge between Pelekunu Bay and Mokohola Islet	
MOL-7	8/14/06	21	10.194	-156	52.707		
<b>Niihau</b>							
NII-7	8/9/06	22	0.408	-160	4.738	N side, W of Kikepa Pt.	
NII-1	8/9/06	21	57.118	-160	3.744	NE side, S of Kaunuopou Pt.	
NII-3	8/9/06	21	49.001	-160	11.151	SE side, N of Kawaihoa	
NII-8	8/11/06	21	47.204	-160	13.410	S side, Leahi	
NII-5	8/11/06	21	54.415	-160	12.656	W side, Puuwai	
NII-9	8/11/06	21	56.746	-160	9.798	W side, Kaununui	
<b>Oahu</b>							
OAH-12	7/27/06	21	19.151	-157	39.246	Flat Island	
OAH-13	8/7/06	21	17.184	-158	2.429	Ewa	

### **A.2.1. Algae**

Macroalgae were identified to genus in the field and ranked. An abundance of algal genera was collected from 12 quadrats (0.18 m<sup>2</sup>) at each site (1 being the most abundant, 2 being the next most abundant, etc., with 10 being the maximum number of genera found in a single quadrat). Six quadrats were located at random points along the first two transects (3 per transect), and six quadrats were located at points 3 m perpendicular from each random point, in the direction of shallower water. Additionally, samples of macroalgae present within each quadrat were collected as voucher specimens (Preskitt et al., 2004). A random swim at the end of each dive augmented macroalgal collections attained from quadrats and allowed cryptic species that predominantly occurred in shaded areas to be qualitatively recorded. Because of difficulties with identification in the field, algae that fell within the functional groups of turf, cyanophytes, branching coralline algae, and crustose coralline algae were lumped into their respective categories. All ranked data were collected by the same individual to minimize the effects of observer bias.

### **A.2.2. Coral Population Parameters**

At each site, the first two transect lines, laid by the fish team, served as the focal point for coral quantitative studies. Each coral whose center fell within one half meter of either side of the transect line was assigned to a genus and one of seven size classes: 1–5 cm, 6–10 cm, 11–20 cm, 21–40 cm, 41–80 cm, 81–160 cm, and >160 cm based upon a visual estimate of the identification and long diameter of each coral. For all but a few sites, corals were completely censused along both lines, but in some cases, time was not sufficient to complete the census. In these latter cases, the length of the lines actually censused was recorded and used to establish corrections to allow for comparisons with coral census data from other sites. The above data were used to compile generic richness, frequency of corals (no. per m<sup>2</sup>), mean diameter (cm) and plot the size distribution of corals at each site. Using the formula for an ellipse, the coral census data were also used to compute coral cover data in terms of coverage of coral per transect. However, these are not directly comparable to the percent coral cover estimated by the line intercept method because of several factors. In any case it is beyond the time needed and scope of this report to calculate and present the coral cover estimates generated from the population data.

### **A.2.3. Percent Benthic Cover**

Only the first two, 25-m transect lines, previously laid out by the fish team were surveyed for percent cover of benthic elements. Transect lines were previously labeled at 50-cm intervals. As the scientist swam along the transect lines, he inspected the benthic elements falling directly underneath each 50-cm mark on the transect line. Each such element was tallied and recorded under the following scheme: live coral, dead coral, carbonate pavement, coral rubble, sand, rock, macroalgae, turf algae, macroinvertebrate, and other. Live benthic elements including coral, algae, and invertebrates were identified to the lowest taxonomic level possible. This data is used to provide the basis for quantitative estimates of live coral cover, as well as percent cover of the diverse benthic and substrate components.

#### **A.2.4. Coral Health and Disease Assessment**

At each site, using the first two transect lines laid by the fish team, an area of 3–4 m (depending on bottom time) on each side of the transect lines (approx. 300–400 m<sup>2</sup>) was surveyed to document incidence of coral bleaching and/or disease. Within this survey area, each diseased/afflicted coral colony was identified to the lowest taxonomic level possible, and the following information was recorded: (1) colony size; (2) type of affliction [bleaching, skeletal growth anomaly, white syndrome, tissue loss—other than white syndrome, trematodiasis, necrosis, other, and compromised health conditions; including pigmentation responses, algal overgrowth, predation, partial mortality, as well as unidentified syndromes. Field characterization of diseases to coral, are focused on providing a general description of the lesion instead of trying to establish a subjective interpretation of causality. We support schemes under development to apply a structured approach to the description of gross lesions and the naming of Indo-Pacific coral diseases (Work and Aeby; pers. comm.), with one pragmatic consideration; we do not include the host species or genus into each disease name, since, as shown for Caribbean corals one disease type may affect individuals across several scleractinian taxa]; (3) area affected (percent live/dead); (4) severity of the affliction (mild, moderate, marked, severe, acute); and (5) photographic records and tissue samples were procured as needed. At a later date, based on field quantifications disease incidence, coral cover, and coral colony densities, the prevalence levels of the syndromes encountered at each island will be estimated.

#### **A.2.5. Macroinvertebrates**

Quantitative counts for specific target marine invertebrates were conducted along two 10-by 25-m belt transects (first two transects laid out by the fish team). Additionally, ten 0.25 m<sup>2</sup> quadrats were surveyed (every other meter) along each transect line to determine the average percent cover of certain sessile target species or for subsampling large populations of semi-mobile species (e.g., boring urchins). Based on data from previous rapid ecological assessments, a group of target species were selected for quantitative counts because they have been shown to be common components of the reef habitats of the main Hawaiian Islands. These species generally visible (i.e., non-cryptic) and easily enumerated during the course of a single 50 to 60-minute scuba survey.

These target species are:

PORIFERA sponges

CNIDARIA

- Zoanthids – rubber corals
- Hydroidea – hydroids
- Octocorallia – wire and soft corals

ECHINODERMS

- Echinoids – sea urchins
- Holothuroids – sea cucumbers
- Asterooids – sea star
- Crinoids – feather star



## MOLLUSCA

- Bivalves – arc shells, spondylid oysters, and pearl oysters
- Nudibranchs – sea slugs
- Gastropods – snails
- Cephalopods - octopus

## CRUSTACEA

- Hermit crabs, lobsters and large crabs

The marine invertebrate species recorded and identified during the course of the field operations for HI-06-10 represent the non-cryptic fauna of the reef habitat and should not be considered the only species present at each site. There is an abundance of other organisms, both cryptic and non-cryptic, that dwell in these habitats that were included in the rapid assessment scheme. Additionally, aside from the target list, a species inventory was compiled to include all the fauna observed at each survey site. Selected sponge and hermit crab samples were collected and preserved in 70% ethanol. These will be identified and added to the species inventory list at a later time.

### **A.2.6. Fish**

The REA Fish Team conducted three types of surveys at REA sites: Belt Transects (BLT), Stationary Point Counts (SPC), and roving diver Rapid Ecological Assessments (REA). BLTs were performed along three consecutive 25-m lines set along a single depth contour. As each line was set, two observers swam about 5 m apart along either side of the line, identifying to the lowest possible taxon, counting, and recording size classes for all fishes >20 cm total length (TL) within an area 4 m wide and 4 m high. At the end of each 25-m line, the divers turned around and returned along their respective sides of the line identifying, counting, and recording size classes of all fishes <20 cm TL within 2 m of their side of the line and 4 m off the bottom. The third fish team diver simultaneously conducted four SPCs at each REA site, generally ~15 m from the transect line. SPCs consist of the diver identifying, counting, and recording the size classes for all fishes  $\geq 25$  cm total length observed in a cylindrical volume 10 m in radius during a 5-minute period. Following and opportunistically during the BLT and SPC surveys, all three fish team divers recorded the presence of all fish species seen outside the transect area and outside the SPC counts. The fish REA team's species presence records are combined with fish species observed by other divers (benthic team, tow team, or mooring team) to develop an island-wide record of all fishes observed. No collection efforts were made by the fish REA team during HI-06-10.

### **A.3. Towed-diver Survey Methods**

Towed-diver surveys were conducted in shallow water habitats using a pair of diver-observers on towboards equipped with a downward-looking high resolution digital still camera with dual strobes (benthic towboard) and a forward-looking digital video camera (fish towboard) to quantify habitat composition and complexity and abundance and distribution of ecologically and economically important fish and macroinvertebrate taxa. The downward-looking camera was maintained ~1 m of the bottom and was programmed to photograph the benthic substrate every 15 seconds. The diver-observer on the benthic towboard observed and recorded habitat composition

and characteristics (substrate percentages) and tallied conspicuous macroinvertebrates (crown-of-thorns, urchins, sea cucumbers, giant clams) over 5-minute ensembles. The fish towboard, outfitted with a forward-looking digital video camera, recorded fish distribution and habitat complexity. The diver-observer on the fish towboard recorded fish greater than 50 cm total length within limits of visibility for 1 minute followed by all fish within a 10-m swath for 4 minutes. These 5-minute segments corresponded with the same 5-minute ensembles used by the benthic observer. Both towboards were instrumented with precision temperature and depth recorders (Seabird SBE39). Each towboard was equipped with an SBE 39 which recorded temperature and depth every 5 seconds along each transect. A Garmin GPS76Map GPS was used to record position at 5-second intervals along each tow track to geo-reference the collected data. The data were downloaded and presented in Arc View GIS and overlaid on high resolution LANDSAT imagery.

## Appendix B: Kaula Rock

### B.1. Oceanography & Water Quality

Although Shallow CTDs (and water samples) were collected around Kaula Rock and Five Fathom Pinnacle, they are not plotted here. All CTD data indicated well mixed oceanic waters.

### B.2. Rapid Ecological Assessment (REA) Site Descriptions

#### KAL-1

August 10, 2006

Depth range: 8.8–13.3 m. Steep (~ 45°) slope; heavily bioeroded rock. The substrate was dominated by turf. The turf community at this site was deceptively diverse. The turf community was composed of *Dictyota friabilis*, *Amansia glomerata*, immature *Sargassum sp.*, *Padina melemele*, *Jania sp.*, and members from the order Gelidiales. Due to a new person handling the photoquad, we have workable data from only the second transect. Percent live coral cover was approximately 17% with abundant small colonies *Pocillopora meandrina* (11%), *Porites lobata* (5%); and occasional large *Leptastrea bewickensis*; numerous *Pocillopora* recruits. Other scleractinians present: *Pocillopora damicornis* and *P. lobata*. Additionally, three cases of pallor/possible-bleaching, two cases of pigmentation response were detected on *P. meandrina*. Also, numerous *Echinometra* and *Echinostrephus* boring urchins were found throughout the habitat, as well as *Heterocentrotus mammilatus* and juvenile *Echinothrix calamaris*. The sponge *Clathria* was abundant all along the ledge, and the yellow sponge *Luffariella* was also present but rare. *Acanthaster planci* was seen occasionally, but signs of its predation were very apparent. The sea star *Mithrodia fisheri* was rare at the site. Fifty-four species of fishes and 1,523 individuals were counted. Eighty of the large-bodied fishes counted were surgeonfishes (Acanthuridae). Smaller fishes were dominated by the blackfin chromis (*Chromis vanderbilti*). A large number of brighteye damselfish (*Plectroglyphidodon imparipennis*; 251 individuals) were counted. Saddle wrasses (*Thalassoma duperrey*) were common, and an unusual number of Gosline's scale eating blennies (*Plagiotremus goslinei*) were counted. A school of 100 mackerel scad (*Decapterus macarellus*) were counted on a belt transect. Twelve bandit angelfish (*Desmoholacanthus arcuatus*) were observed at the bottom of the drop-off.

#### KAL-2

August 10, 2006

On the lee side of the island inside Kaula Islet. Depth range: 13.3–15.8 m. Ledge of otherwise steep (~ 45°) slope; heavily bioeroded rock. The substrate was dominated by turf. The turf community at this site was deceptively diverse. The turf community had a green tinge due to the presence of *Microdictyon setchellianum*. Other species in this turf community included *Dictyota friabilis*, *Amansia glomerata*, immature *Sargassum sp.*, *Padina melemele*, *Styopodium flabelliforme*, *Jania sp.*, and members from the order Gelidiales. Percent live coral cover was approximately 30%, with abundant small colonies *P. meandrina* (13%), *Porites* spp. (18%), and occasional large *L. bewickensis*; numerous *Pocillopora* recruits; *P. lobata* highly fissured. Also, one case of bleaching on *P. meandrina*, two cases of trematodiasis on *Porites*, and one case of pigmentation response on *Porites* were detected. Additionally, numerous *Echinometra* and *Echi-*

*noastrephus* boring urchins were found throughout the site. Small *Echinothrix calamaris* urchins were common, and *Heterocentrotus mammilatus* was rare. The large brachyuran crab *Dromia dormia* was noted at the site. Sixty-four species of fishes and 674 individuals were counted. Surgeonfishes (Acanthuridae) dominated the large bodied fishes while triggerfishes (Balistidae) and bluelined snappers (*Lutjanus kasmira*) were common. The brighteye damselfish and blackfin chromis dominated the smaller fishes (226 and 210 individuals, respectively) while the arc-eye hawkfish (*Paracirrhites arcatus*) and scale-eating blenny were common.

### **B.3. Benthic Environment**

#### **B.3.1. Algae**

Only two sites were surveyed around Kaula Islet. A complete quantitative survey was only possible at KAL02. At KAL01, only the second transect has been studied quantitatively because of a new person handling the photoquad. Algal communities at both surveyed sites were dominated by turf algae (Table B.3.1.1). Algal diversity at Kaula was very limited. Only 12 genera and 3 functional groups were found within the photoquadrats; 15 genera when random swim data are included. Turf algae were prevalent in algal communities, as well as crustose corallines and blue green algae. In general, all genera and functional groups were found at both locations around Kaula except two genera. The red alga *Amansia* was one of the major components in algal communities at KAL-01 and was not found at KAL-02. In comparison, the brown alga *Styopodium* was abundant and commonly seen at KAL-02 while it was not found at KAL-01 within the photoquadrats.

Table B.3.1.1. Average occurrence (%) and average rank for each genera, species, or functional group found within the photoquadrats at Kaula Rock.

	<b>% Occurrence</b>	<b>Rank</b>
<b>Green algae</b>		
<i>Cladophoropsis</i>	8.3	6.0
<i>Dictyosphaeria versluysii</i>	16.7	6.5
<i>Microdictyon setchellianum</i>	75.0	4.3
<i>Rhipidosiphon javensis</i>	8.3	6.0
<b>Red algae</b>		
<i>gelid</i>	79.2	4.3
<i>Jania sp.</i>	66.7	4.4
<i>Laurencia sp.</i>	8.3	6.0
<b>Brown algae</b>		
<i>Dictyota ceylanica</i>	16.7	6.0
<i>Dictyota friabilis</i>	50.0	3.9
<i>Lobophora varigata</i>	25.0	5.7
<i>Padina sp.</i>	16.7	6.0
<i>Padina melemele</i>	20.8	5.5
<i>Sargassum sp.</i>	45.8	3.0
<i>Styopodium flabelliforme</i>	41.7	6.4
<b>Others</b>		
Blue-green	70.8	4.4
turf	100.0	1.0
CCA	41.7	6.6

### **B.3.2. Benthic Towed-diver Survey—Algae**

Macroalgae and coralline algal cover of Kaula Rock ranged between 0 and 20% and 0 and 30%, respectively over bottom habitat with medium–high structural complexity. No additional observations were recorded.

### **B.3.3. Corals**

#### **B.3.3.1 Coral Population Parameters**

Table B.3.2.1.1 and Figure B.3.2.1.1 summarize the characteristics of coral populations within belt transects at the two Kaula sites surveyed for basic coral population parameters in 2006. Both were new sites, as Kaula was not visited in 2006. A total of 3,229 corals belonging to six anthozoan taxa were censused within an area of 100 m<sup>2</sup>. The most numerically abundant taxa were *P. lobata* and *P. meandrina*. Few corals from other taxa were observed. However, *L. bewickensis* was more abundant at Kaula than at any other location surveyed by the author in 2005 or 2006, frequently forming colonies >20 cm maximum diameter.

Overall size distribution indicates 93.1% of colonies have a maximum diameter < 10 cm, and only 0.2% measure >40 cm maximum diameter. Of all the islands within the main Hawaiian Islands (MHI) surveyed in 2005 or 2006, coral communities at Kaula are characterized by the smallest colony sizes.

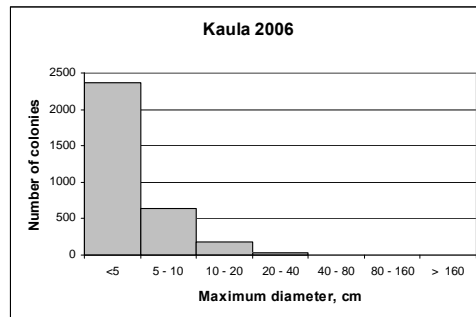


Figure B.3.2.1.1 Size class distribution of 3,229 anthozoan colonies censused within belt transects at Kaula during 2006 REA surveys.

Table B.3.2.1.2. Number of anthozoans counted within belt transects during MHI REA 2006 surveys at Kaula. Taxa contributing more than 10% of total colony abundance are in bold.		
Taxon	# of colonies	Percent of total
<i>Montipora capitata</i>	2	0.1
<i>Montipora flabellata</i>	0	0.0
<i>Montipora incrassata</i>	0	0.0
<i>Montipora patula</i>	0	0.0
<i>Montipora verrilli</i>	0	0.0
<i>Pavona duerdeni</i>	0	0.0
<i>Pavona varians</i>	0	0.0
<i>Cyphastrea ocellina</i>	0	0.0
<i>Leptastrea bewickensis</i>	45	1.4
<i>Leptastrea purpurea</i>	0	0.0
<i>Fungia scutaria</i>	0	0.0
<i>Cycloseris vauhani</i>	0	0.0
<i>Leptoseris incrustans</i>	0	0.0
<i>Pocillopora damicornis</i>	0	0.0
<i>Pocillopora eydouxi</i>	5	0.2
<i>Pocillopora ligulata</i>	1	0.0
<i>Pocillopora meandrina</i>	1193	<b>36.9</b>
<i>Porites brighami</i>	0	0.0
<i>Porites compressa</i>	0	0.0
<i>Porites evermanni</i>	0	0.0
<i>Porites lobata</i>	1983	<b>61.4</b>
<i>Porites monticulosa</i>	0	0.0
<i>Psammacora nierstraszi</i>	0	0.0
<i>Psammacora stellata</i>	0	0.0
<i>Palythoa</i> sp.	0	0.0
<i>Zoanthus pacifica</i>	0	0.0
<i>Sinularia</i> sp.	0	0.0
<i>Tubastraea coccinea</i>	0	0.0
<i>Cirripathes anguina</i>	0	0.0
<i>Antipathes</i> sp.	0	0.0
Total # colonies	3229	100
Area surveyed, m2	100	

### B.3.3.2 Percent Benthic Cover

Percent benthic cover surveys at Kaula were conducted in congruency with the coral population REA surveys at two different sites. The point-count methodology quantified a total of 204 points along 100 m of coral reef communities, mainly ocean fringing reefs, yielding a mean percent live coral cover for all sites combined of 23.5%. The most numerically abundant scleractinian taxa were *P. meandrina* and *P. lobata*, each representing 50% of the total percent live coral cover. Table B.3.2.2.1 provides an itemized summary of percent cover of the different benthic elements enumerated along the line transects at Kaula.

Table B.3.2.2.1 Percent cover of the benthic elements at Kaula Rock using the point-intercept method during the 2006 REA activities.

Item	% cover
<i>Pocillopora meandrina</i>	11.7
<i>Porites lobata</i>	11.8
Pavement/cyanobacteria	2.5
Pavement/turf	61.3
Rubble/cca	0.0
Rubble/turf	0.0
Other	12.7
<b>Percent live coral cover</b>	<b>23.5</b>

### B.3.3.3 Coral Disease

At Kaula Rock, the coral disease REA surveyed a total area of approximately 570 m<sup>2</sup> at two different sites, during the reef assessment and monitoring program (RAMP) cruise of 2006. Figure B.3.2.2.1 illustrates the cumulative number of cases of disease and compromised health conditions enumerated for all sites combined. At a future date, these data will be related to coral colony density (estimated by Dr. Kenyon) and percent live coral cover (above) in order to numerically estimate disease prevalence. These results will be contrasted with data collected for other islands in the Hawaiian Archipelago.

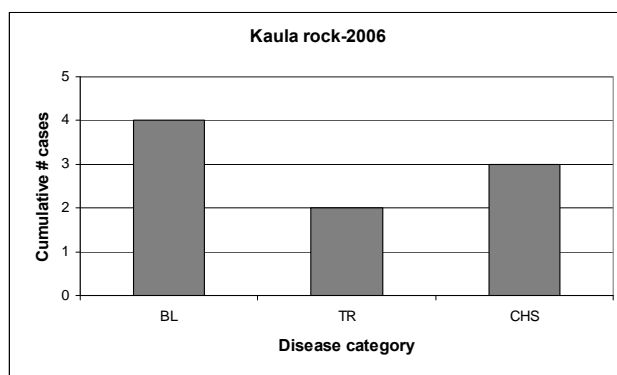


Figure B.3.2.3.1. Cumulative number of cases of disease at Kaula Rock during 2006 REA surveys. Total area surveyed: 570 m<sup>2</sup>. BL: bleaching, TR: trematodiasis, and CHS: compromised health state involving *Porites* pigmentation responses.

### B.3.3.4 Benthic Towed-diver Survey—Corals

Hard coral cover averaged approximately 9% of total benthic cover, and ranged between 0 and 30% with the highest amount of hard coral benthic cover located along the southern tip and southwest side of the rock (range 5–30%; average 14.5%) in medium–high bottom complexity. Soft coral cover consisted of wire coral and *sinularia* species, with an overall average of ap-

proximately 2% benthic cover. An isolated area of 20% soft coral cover was noted in the north-eastern corner of Kaula Rock in approximately 20 meters depth (including wire coral and an isolated black coral colony).

It is interesting to note that large numbers of bomb casings and mortar rounds were also noted in all areas surveyed except for the northwest side of Kaula Rock.

### **B.3.4. Macroinvertebrates**

This rock had only two sites, both of which were on the western side of the island. Echinoderms were the most common fauna with high abundance of boring urchins present at both. There were few crustaceans or mollusks at either site, but octopi and large brachyurans were present although rare.

Table B.3.3.1. Relative abundance data for echinoderms enumerated during REA surveys for Kaula Rock.		
Island	Kaula	Kaula
Date	8/10/06	8/10/06
Site	KAL-1	KAL-2
Depth(feet)	45	48
Habitat	Pavement	Pavement
	Avg/m2	Avg/m2
<b>Echinoids</b>		
Echinostrephus	0.64	1.56
Echinometra sp.	3.52	5.2
Echinothrix sp.	0.026	
Heterocentrotus	0.032	
Tripneustes		
Diadema		
Pseudobolentia		
Other Echinoid		
<b>Holothuroids</b>		
Holothuria atra		
Holothuria whitmaei		
Actinopyga obesa		
Actinopyga mauritiana		
Other Holothuroid	0.002	
<b>Asteroidea</b>		
Linckia multifora		
Linckia guildingi		
Acanthaster planci	0.006	0.006
Mithrodia fisheri	0.004	0.004
Other Asteroideid		
Culcita	0.002	



### **B.3.5. Benthic Towed-diver Survey—Macroinvertebrates**

Two crown-of-thorns starfish were reported during the combined surveys of Kaula Rock, along with a singular report of a sea cucumber. Sea urchin numbers were low along the windward/eastern side (12), with numbers greater along the southwestern and northwestern sections of Kaula Rock (average 151 and 161/5-minute time segment for each respective towed-diver survey).

Finally, an unidentified species of red sponge was noted in 7/10 time segments during the survey along the southwestern side of Kaula Rock.

### **B.4. Fish**

A total of 75 species and 2,197 fishes were recorded (in both Belt and SPC surveys). Damsel-fishes were most abundant accounting for 71% of the individuals, followed by surgeonfish (8%), mackerel scad (5%, a school of 100 fish), and hawkfish (Cirrhitidae; 4.5%). The most abundant species were blackfin chromis (49%) and the brighteye damselfish (22%).

#### Fish $\geq$ 25 cm TL:

Belt Transects: Of the 25 fishes measuring  $\geq$ 25 cm counted on the belt transects, 22 were surgeonfishes and 2 were parrotfishes (Scaridae).

SPCs: One hundred ninety-three fishes representing 28 species were recorded on the SPCs. Surgeonfishes were the most abundant, accounting for 62% of the individuals, followed by triggerfishes (9%), goatfishes (Mullidae; 6%) and bluelined snappers (*Lutjanus kasmira*; 5%).

#### Towed-diver Surveys (fish $>$ 50 cm TL):

At Kaula Rock the towed-diver team completed three dives over the course of 1 day covering 4.24 km of sea floor, completely circumnavigating the island (Fig. B.4.1). Surveys averaged 1.30 km in length and ranged from 1.29 km to 1.65 km. Median mean depth was  $-20.59$  m.

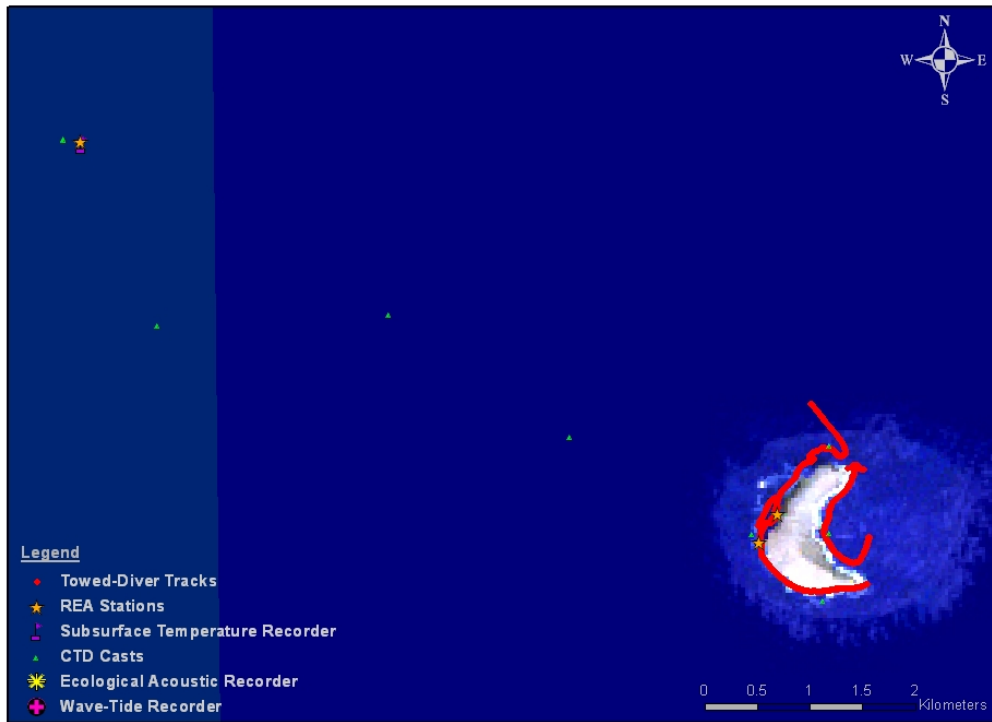


Figure B.4.1 HI-06-10 sampling stations at Kaula Rock and Five-Fathom Pinnacle.

At Kaula Rock, only three species were observed (Figs. B.4.2-B.4.3): the trumpetfish (*Aulostomus chinensis*), redlip parrotfish (*Scarus rubroviolaceus*), and sleek unicornfish (*Naso hexacanthus*). Both numeric density and biomass for these species were similar at this location.

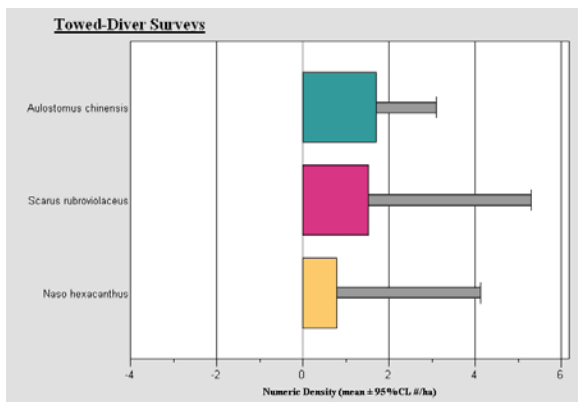


Figure B.4.2 Numeric Density (#/ha) of species at Kaula Rock.

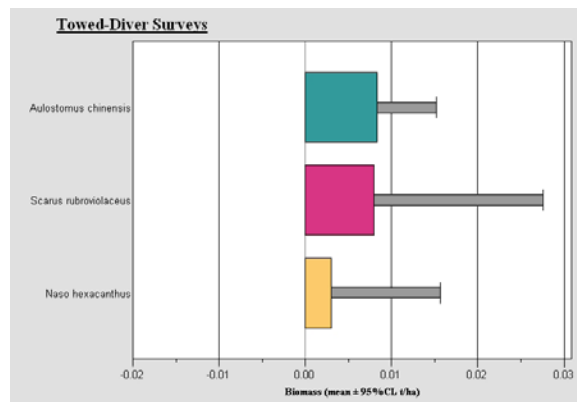


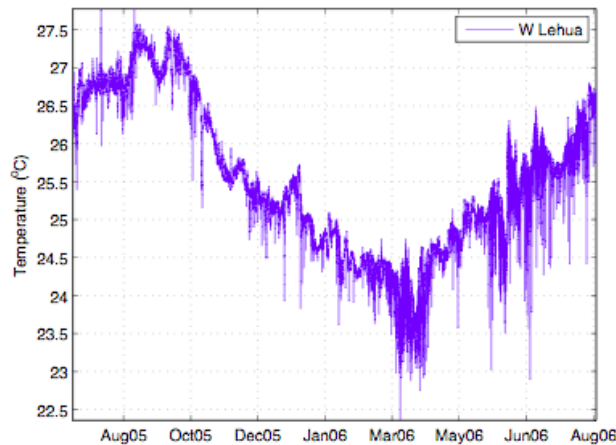
Figure B.4.3 Biomass Density (t/ha) of species at Kaula Rock

## Appendix C: Lehua Rock

### C.1. Oceanography & Water Quality

Figure C.1.1 plots subsurface temperature recorder (STR) data recovered from the W side of Lehua Rock; this data must be interpreted with caution! The instrument was originally deployed at a 5.8 m depth, but was recovered at 27.1 m deep. It is unknown when it rolled down the slope. This may affect the overall trend, but there are obvious strong, frequent pulses of cooler water. It is hypothesized that this is due to upwelling driven by internal tides.

Figure C.1.1



Please refer to Figure D.2, in the Niihau section for interpolated Shallow conductivity-temperature-depth (CTD) cast data – 10 m depths around Lehua.

### C.2. Rapid Ecological Assessment (REA) Site Descriptions

#### LEH-1

August 12, 2006

South of crater. Topography consisted of a medium relief reef structure of a mix of pavement and boulders. Depth range: 8.2–8.8 m. Algal diversity was moderate. The major algae encountered within photoquadrats were turf algae, *D. friabilis*, *Amansia*, *Tolypocladia* and *Lobophora*. Crustose coralline algae and blue-green algae were also common and abundant. *Padina* and *Microdictyon setchellianum* were also found within the photoquadrats. Percent live coral cover was approximately 23% with *Pocillopora meandrina* (86%) and *Porites lobata* (14%) representing the two major community components. Other coral species present in the general vicinity included: *Montipora capitata*, *Montipora patula*, *Leptastrea purpurea*, *Fungia scutaria*, *Pocillopora eydouxi*, *Pocillopora ligulata*, and *Palythoa* spp. Also, three cases of pigmentation response were detected on *P. lobata*. Kenyon did not dive because of sinus problems; no coral population data. There was an abundance of echinoids and two hermit crabs, *Calcinus laurentae* and *Calcinus elegans*, were common. An unknown yellow boring sponge was common in most dead coral heads and rock outcrops. The most common species of macroinvertebrates were bor-

ing urchins, while sea stars were rare. Ninety-one species of fishes and 1,194 individuals were counted. Surgeonfish (Acanthuridae) dominated the larger fishes while sea chubs (Kyphosidae) and triggerfishes (Balistidae) were common. Among smaller fishes, the blackfin chromis (*Chromis vanderbilti*) was numerically dominant while the brown surgeonfish (*Acanthurus nigrofuscus*), arc-eye hawkfish (*Paracirrhites arcatus*), saddle wrasse (*Thalassoma duperrey*), big-scale soldierfish (*Myripristis berndti*), goldring surgeonfish (*Ctenochaetus strigosus*) and various small wrasses were common.

### LEH-2

August 12, 2006

Inside Lehua caldera; substrate consisted of a mix of large boulders, pavement, and rubble along a high relief slope. Site contained several large lava tubes. Depth range: 9.4–15.2 m. Algal diversity was moderate. Algal communities were dominated by turf algae, blue-green algae, *Dictyota friabilis*, *Tolypiocladia*, and *Jania*. Crustose corallines were also often seen within the photoquadrats as well as *Amansia*. Kenyon did not dive because of sinus problems; no coral population data. Percent live coral cover was approximately 18%. Major coral species at this location were *P. lobata* (72%) and *Pocillopora meandrina* (28%). Other coral species included: *Montipora capitata*, *Pavona varians*, *Leptastrea purpurea*, *Pocillopora ligulata*, and *Palythoa* spp. Also, two cases of tissue loss, two cases of trematodiasis, and three cases of pigmentation response were detected on *Porites*. The wall had large boulders at its base and the wall itself was covered with old and active depressions of boring urchins. These depressions provided habitat for crustaceans and sponges. A steep slope existed behind this wall and it harbored boring urchins and zoanthids. The cushion sea star *Culcita novaeguinea* was occasional in this habitat. Sixty-two species of fish and 1,279 individuals were counted. The large-bodied fish were 50% surgeonfish. Three species of large goatfish (Mullidae) were common, the manybar goatfish (*Parupeneus multifasciatus*), doublebar goatfish (*Parupeneus insularis*), and the blue goatfish (*Parupeneus cyclostomus*). The Hawaiian hogfish (*Bodianus bilunulatus*) was also common. The blackfin chromis numerically dominated the smaller species. A large number of brighteye damselfish (*Plectroglyphidodon imparpennis*) were counted on the belt transects. Scale-eating blennies (*Plagiotremus goslinei*) and saddle wrasse were common. A large spotted knifejaw (*Opelgnathus punctatus*) was observed.

### LEH-3

August 12, 2006

West of Lehua crater. Reef topography consisted of a seaward pavement slope. Substrate showed signs of bioerosion by rock-boring urchins. Depth range: 7.6–13.6 m. Algal diversity was low. Algal communities were dominated by turf algae, blue-green algae, *Lobophora* and *Dictyota* (different species). *Jania* was also a major component of algal communities. Kenyon did not dive because of sinus problems; no coral population data. Percent live coral cover was approximately 9%. *P. lobata* (~77%) and *P. meandrina* (~13%) accounted for the major species at this site. Other coral species present in the general vicinity included: *Pavona varians*, *Leptastrea purpurea*, *Fungia scutaria*, *Pocillopora damicornis*, *Pocillopora ligulata*, and *Cirrihipathes* spp. No disease detected in the survey area. This site exhibited quite an abundance of boring

urchins. The banded coral shrimp *Stenopus hispidus* was common throughout and the wire coral *Cirripathes anguina* and the sea star *Thromidia catalai* were rare. No report on fish surveys.

### C.3. Benthic Environment

#### C.3.1. Algae

Lehua is a crater located near Niihau. We surveyed different reefs around the crater, one inside and two outside. Reef LEH-2 and LEH-1 were composed by boulders while the third reef (LEH-3) was a wall with a gentle slope. Algal communities of those reefs were dominated by turf algae and blue-green algae (Table C.3.1.1). Algal diversity at the Lehua crater was minimal. Only 13 genera and 4 functional groups were found within the photoquadrats; 20 genera were found in total when random swim data were included. The dominant algae in algal communities at the visited reefs were turf algae and blue-green algae. The reef LEH03 showed the highest abundance of blue-green algae; they were forming large red mats. The same algal genera and functional groups were found at the the sites except *Tolypocladia* which was not observed within the photoquadrats at LEH03.

Table C.3.1.1. Average occurrence (%) and average rank for each genera, species or functional group found within the photoquadrats at Lehua crater.

	% Occurrence	Rank
<b>Green algae</b>		
<i>Microdictyon setchellianum</i>	19.4	5.9
<i>Neomeris annulata</i>	33.3	6.9
<b>Red algae</b>		
<i>Amansia glomerata</i>	41.7	5.6
<i>Gelid</i>	36.1	6.3
<i>Jania sp.</i>	61.1	5.6
<i>Tolypocladia glomerulata</i>	75.0	3.8
<b>Brown algae</b>		
<i>Dictyopteris palagiogramma</i>	8.3	6.0
<i>Dictyota sp.</i>	62.5	5.4
<i>Dictyota ceylanica</i>	41.7	5.2
<i>Dictyota friabilis</i>	61.1	3.6
<i>Lobophora varigata</i>	58.3	5.1
<i>Padina sp.</i>	37.5	7.8
<i>Sargassum sp.</i>	16.7	3.5
<i>Stypopodium flabelliforme</i>	8.3	7.0
<i>Turbinaria ornate</i>	8.3	7.0
<b>Others</b>		
Blue-green	88.9	3.7
Turf	100.0	1.0
CCA	77.8	4.2
Sand	16.7	2.0

### **C.3.2. Benthic Towed-diver Survey—Algae**

Macroalgae appeared to peak around the windward/eastern area (avg. 16%), with a range between 5 and 30% overall bottom cover. Coralline algae also appeared to peak in the same area (avg. 17%), with a range between 10 and 30% overall bottom cover.

### **C.3.3. Corals**

#### **C.3.3.1 Coral Population Parameters**

The three sites surveyed by other members of the REA team in 2006 were not surveyed for coral population parameters by Kenyon because of sinus problems. This is the same suite of sites surveyed in 2005, at which time coral population parameter surveys were conducted.

#### **C.3.3.2 Percent Benthic Cover**

Percent benthic cover surveys at Lehua were conducted in congruency with the invertebrate and algae REA surveys at two different sites. The point-count methodology quantified a total of 306 points along 150 m of coral reef communities, mainly ocean fringing reefs, indicating that the mean percent live coral cover for all sites combined was fairly low (16.3%), with *P. meandrina* and *P. lobata* each representing 50% of the total percent live coral cover. Table F.3.2.2.1 provides an itemized summary of percent cover of the different benthic elements enumerated along the line transects at Lehua.

Table C.3.2.2.1 Percent cover of the benthic elements at Lehua using the point-intercept method during the 2006 REA activities.

<b>Item</b>	<b>% Cover</b>
<i>Pocillopora meandrina</i>	7.8
<i>Porites lobata</i>	7.8
<i>Porites compressa</i>	0.0
<i>Porites sp</i>	0.0
<i>Montipora capitata</i>	0.7
<i>Montipora patula</i>	0.0
<i>Montipora flabelallata</i>	0.0
<i>Montipora sp</i>	0.0
<i>Pavona</i>	0.0
<i>Leptastrea</i>	0.0
<i>Fungia</i>	0.0
Macro-algae	0.0
<i>Halimeda</i>	0.0
<i>Palythoa</i>	0.0
Pavement/cca	1.3
Pavement/cyano	2.3
Pavement/turf	67.3
Rubble/cca	0.0
Rubble/turf	7.2

Item	% Cover
Dead/cca	1.0
Dead/turf	2.0
Sand	0.0
Other	2.6
<b>% live coral cover</b>	<b>16.3</b>

### C.3.3.3 Coral Disease

At Lehua, the coral disease REA surveyed a total area of approximately 900 m<sup>2</sup> at three different sites, during the reef assessment and monitoring program (RAMP) cruise of 2006. Figure C.3.2.2.1 illustrates the cumulative number of cases of disease and compromised health conditions enumerated for all sites combined. At a future date, these data will be related to coral colony density (estimated by Dr. Kenyon) and percent live coral cover (above) in order to numerically estimate disease prevalence. These results will be contrasted with data collected for other islands in the Hawaiian Archipelago.

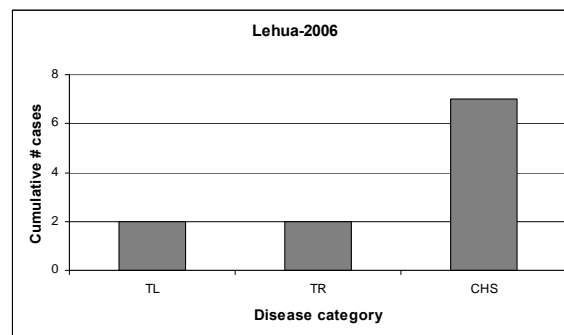


Figure C.3.2.3.1. Cumulative number of cases of disease at Lehua Rock during 2006 REA surveys. Total area surveyed: 900 m<sup>2</sup>. TL: tissue loss, TR: trematodiasis, CHS: compromised health state, including *Porites* pigmentation responses, as well as algal overgrowth.

### C.3.3.4 Benthic Towed-diver Survey—Corals

Overall hard coral cover at Lehua Rock was relatively low and uniform, averaging 6% bottom cover over medium to highly complex habitat. Soft coral cover was uncommon, with only a few time segments recording the presence of soft coral at 1%. A singular exception was noted in the northwestern corner of Lehua Rock, where one 5-minute segment recorded 40% dense *sinularia* soft coral cover.

### C.3.4. Macroinvertebrates

The three sites at Lehua were on the bottom part of the rock. On the west side, there was a higher diversity of urchins, although boring urchins were the most dominant fauna throughout the island. Echinoderms were the most diverse taxa, with sponge cover being low, and zoanthids

being rare. There were also few crustaceans recorded at any site, which may have to do with the coral cover and substrate complexity.

Table C.3.3.1. Relative abundance data for echinoderms enumerated during REA surveys for the island of Lehua.			
Island	Lehua	Lehua	Lehua
Date	8/12/06	8/12/06	8/12/06
Site	LEH-2	LEH-1	LEH-3
Depth(feet)	50	35	51
Habitat	Pavement	Boulder/sand	Pavement
	Avg/m2	Avg/m2	Avg/m2
<b>Echinoids</b>			
Echinostrephus	0.88	0.28	0.84
Echinometra sp.	3.04		1.76
Echinothrix sp.		0.012	0.006
Heterocentrotus	0.002		0.004
Tripneustes			0.002
Diadema			
Pseudobolentia			
Other Echinoid			
<b>Holothuroids</b>			
Holothuria atra	0.006		0.004
Holothuria whitmaei	0.008	0.006	
Actinopyga obesa		0.012	
Actinopyga mauritiana			
Other Holothuroid			
<b>Asteroidea</b>			
Linckia multifora	0.018	0.016	
Linckia guildingi			
Acanthaster planci	0.006	0.002	0.006
Mithrodia fisheri			
Other Asteroid			
Culcita	0.006		

### **C.3.5. Benthic Towed-diver Survey–Macroinvertebrates**

Crown-of-thorns starfish averaged 4 starfish/50-minute towed-diver survey, with 19 starfish recorded during the towed-diver survey of the north facing “interior” crater wall.

Sea urchins averaged 115/5-minute time segment for all combined towed-diver surveys, with the highest concentrations located along the leeward (eastern) edge of Lehua Rock (average 164/5-minute time segment). Sea cucumber numbers remained low, with no greater than 13 recorded during any towed-diver survey. The crater was also characterized by increased “bioerosion” (channels worn into the coral pavement) and localized increases of an unidentified red sponge.



## C.4. Fish

A total of 113 species of 4,050 fishes were recorded (in both Belt and SPC surveys). The sites were numerically dominated by damselfishes (72%) followed by surgeonfishes (8%) and wrasses (6%). The most abundant species was the blackfin chromis (62%), followed by the brighteye damselfish (10%).

### Fish $\geq 25$ cm TL:

Belt Transects: Eighty-nine fishes representing 21 species measuring  $\geq 25$  cm were counted on belt transects. Twenty-nine percent of the individuals were sea chubs, 21% surgeonfishes and 17% were bigscale soldierfish (*Myripristis berndti*).

SPCs: Three hundred thirty-one fishes represented by 33 species were recorded on the SPCs. Fifty-three percent were surgeonfishes, 11% were snappers (Lutjanidae), and 8% were goatfish.

### Towed-diver Surveys (fish $> 50$ cm TL):

At Lehua Rock the towed-diver team completed five dives over the course of 1 day covering 9.42 km of sea floor, completely circumnavigating the island. Surveys averaged 2.32 km in length and ranged from 2.25 km to 2.52 km. Median mean depth was  $-14.36$  m.

At Lehua Rock 15 species were observed (Figs. C.4.1 – C.4.2). Numeric Density was dominated by the redlip parrotfish (*Scarus rubroviolaceus*) followed by the cornetfish (*Fistularia commersoni*) and spotted eagle ray (*Aetobatus narinari*). Biomass was dominated by the spotted eagle ray followed by the redlip parrotfish and the whitetip reef shark (*Triaenodon obesus*).

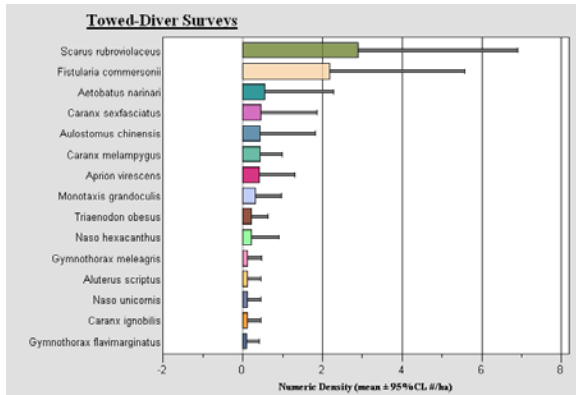


Figure C.4.1 Numeric Density (#/ha) of species at Lehua Rock.

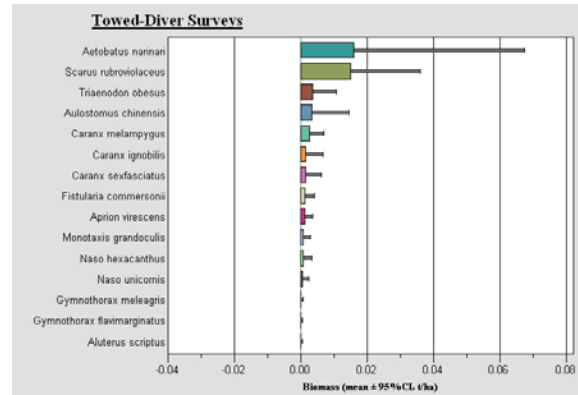


Figure C.4.2 Biomass Density (t/ha) of species at Lehua Rock.

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## Appendix D: Ni'ihau

### D.1. Oceanography & Water Quality

Figure D.1.1 plots subsurface temperature recorder (STR) data recovered from the NE side of Ni'ihau, near REA site NII01, in 12.2 m water depth.

Figure D.2 shows interpolated shallow conductivity-temperature-depth (CTD) cast data, 10 m depths around Ni'ihau and Lehua. Although then cooler, higher density waters on the west side of Ni'ihau relative to the east seem to indicate upwelling or some other process; it is more likely due to a gradual change in water type: CTD casts on each side were collected approximately a week apart. The cause of the anomalous CTD data at the NW tip of Lehua cannot be speculated on at this point.

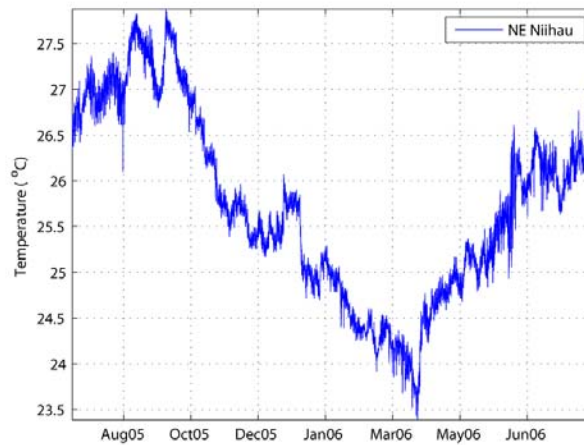


Figure D.1.1

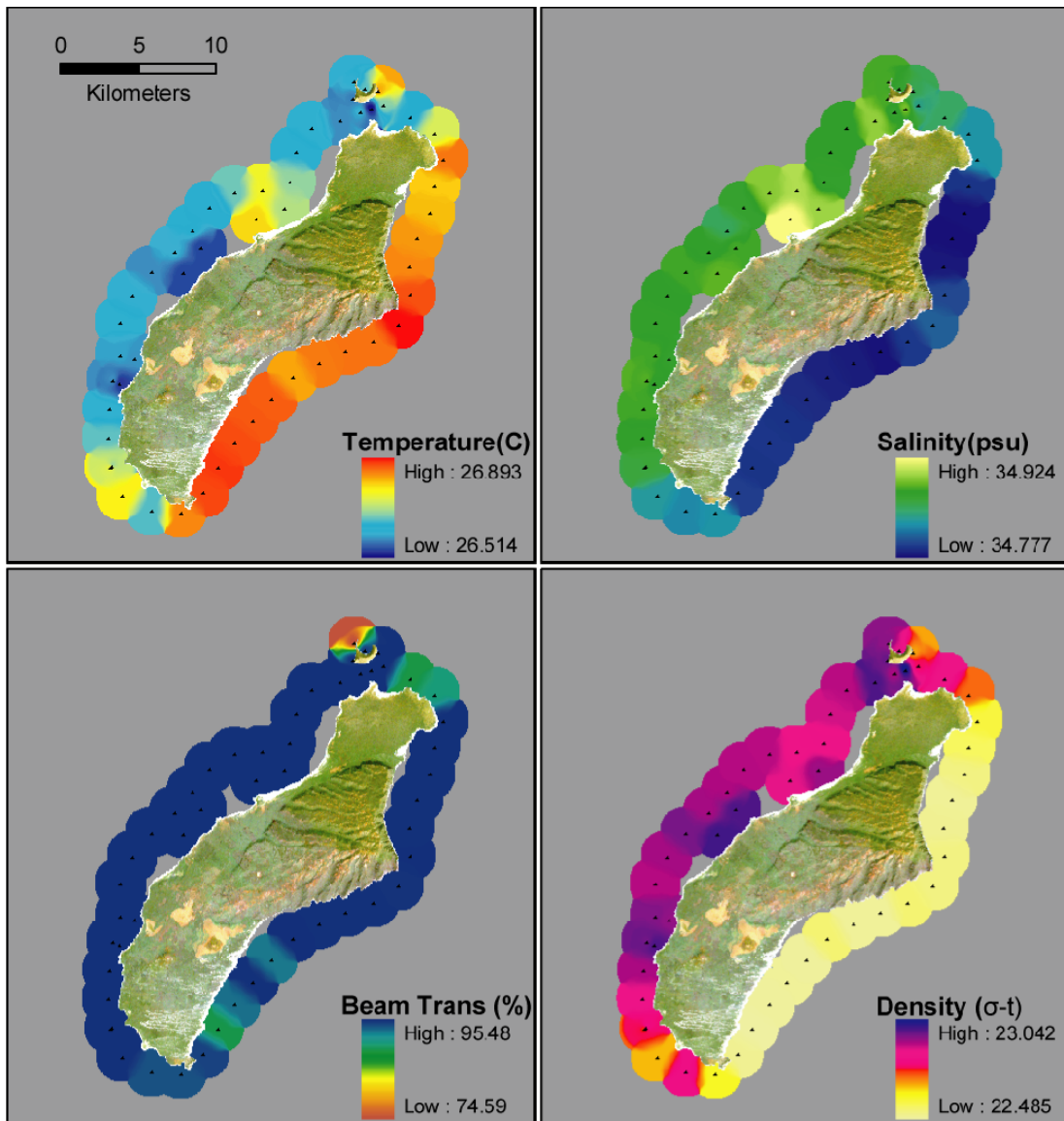


Figure D.1.2

## D.2. Rapid Ecological Assessment (REA) Site Descriptions

NII-7

August 9, 2006

N ocean fringing reef. Depth range: 11.2–13.0 m. Shelving carbonate benches; abundant live and dead (turf-epiphitized) *Pocillopora meandrina*; substrate heavily eroded by urchins. Algal communities were dominated by turf algae, *Sargassum* and *Lobophora*. Additionally, *Dictyota cey-*

*lanica* and *D. friabilis* were found in abundance within photoquadrats. Blue-green algae also dominated the substrates. Percent live coral cover was approximately 10.8% with *P. meandrina* (100%) dominating the species diversity. Other species included: *Montipora capitata*, *Porites lobata*, and *Pocillopora eydouxi*. Coral health and disease assessment: Six cases of pal-  
lor/potential bleaching were detected in *P. meandrina* and two cases of tissue loss on *P. eydouxi* (most likely predation). Also, this site exhibited a great abundance of gastropods under loose rock. The anemone *Triactis* was recorded underneath rocks but was rare. The hermit crab *Calcinus laurentae* was common, while *Ciliopagurus strigatus* was rare. Additionally, 47 species of fishes and 1,527 individuals were recorded. As at stations 1 and 3, species presence data is missing, therefore the number of species represents only those recorded on transects and SPCs. A large school of bluespined unicornfish (*Naso unicornis*; 80 individuals) was recorded on the SPC. The orangespine unicornfish (*Naso lituratus*) and orangeband surgeonfish (*Acanthurus olivaceus*) were common. A very large number of blackfin chromis (*Chromis vanderbilti*; 1,024 individuals) was counted. Among smaller fishes, the saddle wrasse (*Thalassoma duperrey*), arc-eye hawkfish (*Paracirrhites arcatus*), blue-eye damselfish (*Plectroglyphidodon johnstonianus*), blue-lined surgeonfish (*Acanthurus nigroris*), brown surgeonfish (*A. nigrofuscus*), and manybar goatfish (*Parupeneus multifasciatus*) were common.

#### NII-1

August 9, 2006

NE ocean fringing reef. Depth range: 8.2–12.1 m. Small boulders with abundant live and dead, epiphytized *P. meandrina*; sandy carbonate benthos. Algal diversity was low. Algal communities were dominated by turf algae, blue-green algae, *Dictyota* and *Lobophora*. Percent live coral cover was approximately 14% with *P.* (57%) and *P. lobata* (43%) dominating the species diversity. *Montipora capitata* was also seen in the survey area. Coral health and disease assessment: one case of pigmentation response on *Porites*, and nine cases of compromised health due to predation on *P. meandrina*. A high abundance of *Acanthaster* was present at this site observed feeding on corals. Also, this site was dominated by the urchin *Echinothrix calamaris* and the sea star *Linckia multifora*, and there was a common occurrence of the corallivorous sea star *Acanthaster planci*. There was also a rare occurrence of the octocoral *Sinularia densa*. Thirty-eight species and 1,059 individuals were counted. (Note: species presence data was missing for this site.) Species count was based on transect and SPC observations only. The total number of species present was definitely higher than 38. The larger species were dominated by large-bodied surgeonfishes (Acanthuridae), mostly the orangeband surgeonfish, and the white goatfish (*Mulloidichthys flavolineatus*). The orangespine unicornfish and bluelined snapper (*Lutjanus kasmira*) were common. The blackfin chromis dominated the smaller fishes and accounted for 66% of all species observed. Saddle wrasse, brown surgeonfish, blue-eyed damselfish, arc-eye hawkfish, blue-lined surgeonfish (*Acanthurus nigroris*), and Gosline's fangblenny (*Plagiotremus goslinei*) were common.

#### NII-3

August 9, 2006

SE ocean fringing reef. Depth range: 13.9–15.2 m. Flat terrain; consolidated sand, rubble, silt-covered carbonate pavement. Algal communities were dominated by *Hypnea*, *Cladophoropsis*,

branched coralline algae, *Bornetella*, *Neomeris* and *Dictyosphaeria*. *Halimeda discoidea* was also common within the photoquadrats, as well as *Laurencia*. Good diversity macroalgae; lots of genera were found during the random swim such as an unidentified *Caulerpa* and *Codium*. Percent live cover at this location was approximately 2%. The species diversity was dominated by *P. meandrina* (100%). Other species present at this site were *M. capitata* and *P. lobata*. No coral disease was detected at this location. There were few small dead and live coral heads that provided small islands of life for sessile invertebrate fauna, such as tunicates. Two sponge species were common throughout the site. One species appears to be an axinellid species that looked like *Reniochalina* and the other is an unknown purple species that grow closely to the substrate. Only 27 fishes were counted, representing 8 species. As for station 1, species present data is missing for this site. One green jobfish (*Aprion virescens*) was counted on the SPCs. The predominant species recorded on the transects were the elegant coris (*Coris venusta*) and bridled triggerfish (*Sufflamen fraenatus*).

#### NII-8

August 11, 2006

S ocean fringing reef. Depth range: 12.1–14.5 m. Sand and silt with turf-algal-covered boulders. The algal community was mostly composed of turf. Algal species that were frequently encountered in our quadrats included *Dictyota sp.*, immature *Sargassum sp.*, *Jaina sp.*, and members from the order Gelidiales. Small, sparse, encrusting corals and *P. meandrina*; percent live coral cover was approximately 1%. Other coral species included: *M. capitata*, *Leptastrea bewickensis*, and *P. lobata*. Coral health and disease assessment: two cases of compromised health conditions on *P. ligulata* and *P. meandrina*; one due to predation, the second one due to infestation by tube-worms. This site also exhibited low abundance of visible invertebrate species, but cryptic species were present in the boulder habitat. There was a rare occurrence of the urchins *Echinothrix calamaris* and *Echinometra mathaei*, and the sea cucumber *Actinopyga obesa*. Cryptic organisms noted were the sea cucumber *Holothuria arenicola* and the brittle stars *Ophiocoma erinaceus* and *Ophiocoma dentata*. A single octopus and the lobster *Panulirus marginatus* were noted at the site. Eighty species of fishes and 661 individuals were counted, 50% of which were the blackfin chromis. Surgeonfishes (Acanthuridae) dominated the larger species, while the bigeye emperor (*Monotaxis grandoculis*), Hawaiian hogfish, and redlip parrotfish were common. Three yellowspotted jacks (*Carangoides orthogrammus*) were counted. The blackfin chromis was numerically dominant among smaller fishes. The milletseed butterflyfish was abundant, and the brown surgeonfish, saddle wrasse, manybar goatfish, and arc-eye hawkfish were also common

#### NII-5

August 11, 2006

W ocean fringing reef. Depth range: 10.6–13.3 m. Moderate relief carbonate with sand, rubble, and boulders. This site had an extensive *Dictyopteris plagiogramma* (lipoa) bed. This year the beds have senesced. Under the first transect, the majority of the stipes has persisted, while the upper thalli are gone. The lipoa population under the second transect still appeared somewhat healthy. Other algal species were turfey. Percent live coral cover accounted for nearly 2% with *P. meandrina* representing the major coral species. Other coral species at this site included: *M. capitata*, *L. bewickensis*, *Fungia scutaria*, *Pocillopora damicornis*, and *P. lobata*. No coral dis-

eases detected at this site. Additionally, the overall abundance of macroinvertebrates was low at this site. There was a rare occurrence of the holothuroid *Holothuria whitmaei* and an unidentified white sponge, which was growing on the undersides of boulders. The urchins *Echinometra mathaei* and *Echinostrephus aciculatus* were rare, as was the sea star *Leiaster leachi*. The only common invertebrate species was the bivalve *Spondylus*. Also, 85 species of fishes and 434 individuals were recorded. The bluelined snapper was numerically dominant among the larger fishes. Surgeonfish, the Hawaiian bigeye and red-lip parrotfish were common. Four green jobfish were counted on the transects. The blackfin chromis was numerically dominant among smaller fish. Saddle wrasses, brown surgeonfishes and gold-ring surgeonfishes (*Ctenochaetus strigosus*) were common.

NII-9

August 11, 2006

WNW ocean fringing reef. Depth range: 13–15.2 m. Heavily bioeroded rocky ledge with numerous fissures and clefts; moderately high topographic relief; low visibility. The substrate was dominated by turf. *Dictyota spp.* was the most abundant algal species in the turf community. Other members included *Amansia glomerata*, *Jaina sp.*, and members from the order Gelidiales. Percent live coral cover was approximately 3% with *P. lobata* accounting for 66% of species diversity and other *Porites* species for 34%. Other species present in the area included: *M. capitata*, *P. meandrina*, and *Tubastraea coccinea*. Coral health and disease assessment: one case of pallor/potential bleaching was detected on *P. meandrina*. Additionally, the most common invertebrate species present were unknown gray and yellow sponge species and the bryozoan *Reteporellina denticulata*. Sixty-two species of fishes and 374 individuals were counted. Surgeonfishes were dominant among the large species. A large school of bluelined snapper was observed and a relatively large number were recorded on the transects and SPCs. The red-lip parrotfish was common. Among the smaller fishes, the blackfin chromis was dominant, while the brown surgeonfish, saddle wrasse, and manybar goatfish were common.

### **D.3. Benthic Environment**

#### **D.3.1. Algae**

Six sites were visited all around Ni'ihau by the algal team. Those sites showed various habitats, from flat and sandy reefs to boulder reefs. Therefore, algal diversity varied among sites. However, turf algae and crustose corallines dominated algal communities in general, except at the flat, sandy reef (Table D.3.1.1). A total of 28 genera and 5 functional groups were found within the photoquadrats at Ni'ihau; 33 genera were found in total if random swim data are included. Algal diversity varied among sites and was particularly high on a southern flat, sandy reef. The algal community of this particular reef was dominated by sand, *Hypnea sp.*, *Bornetella sphaerica*, *Cladophoropsis*, *Halimeda discoidea*, and *Laurencia sp.* Interestingly, reefs around Ni'ihau showed a high diversity of brown algae. *Dictyota sp.*, *Lobophora*, *Dictyopteris*, and *Sargassum* were very common at a few sites. A lot of green algae were also abundant. Blue-green algae were one of the major components in the algal communities except at the flat, sandy reef. This reef definitely showed a different habitat and different algal communities than at the other reefs around Ni'ihau.

Table D.3.1.1. Average occurrence (%) and average rank for each genera, species, or functional group found within photoquadrats at Ni'ihau.

	% Occurrence	Rank
<b>Green algae</b>		
<i>Bornetella sphaerica</i>	50.0	7.2
<i>Caulerpa webbiana</i>	12.5	5.3
<i>Cladophoropsis</i>	39.2	3.7
<i>Codium sp.</i>	10.0	5.0
<i>Dictyosphaeria cavernosa</i>	20.0	7.0
<i>Dictyosphaeria versluysii</i>	30.0	9.0
<i>Halimeda sp.</i>	13.9	4.8
<i>Halimeda discoidea</i>	90.0	4.2
<i>Microdictyon setchellianum</i>	12.5	4.5
<i>Neomeris annulata</i>	25.8	5.9
<i>Siphonocladus tropicus</i>	10.0	5.0
<b>Red algae</b>		
<i>Actinotrichia fragilis</i>	8.3	6.0
<i>Amansia glomerata</i>	42.5	4.1
<i>Dasya sp.</i>	30.0	8.0
<i>Gelid</i>	30.0	4.1
<i>Gibsmithia hawaiiensis</i>	8.3	8.0
<i>Halichrysis coalescens</i>	16.7	7.0
<i>Haliptilon subulatum</i>	30.0	3.7
<i>Heterosiphonia</i>	8.3	4.0
<i>Hypnea sp.</i>	80.0	2.3
<i>Jania sp.</i>	23.7	3.7
<i>Laurencia sp.</i>	40.0	7.3
<i>Tolypocladia glomerulata</i>	11.1	4.2
<b>Brown algae</b>		
<i>Dictyopteris palagiogramma</i>	17.2	4.9
<i>Dictyota sp.</i>	25.0	4.1
<i>Dictyota ceylanica</i>	38.3	5.0
<i>Dictyota friabilis</i>	37.5	3.5
<i>Lobophora varigata</i>	51.1	5.2
<i>Padina sp.</i>	16.7	5.0
<i>Padina melemele</i>	20.8	6.1
<i>Sargassum sp.</i>	52.8	4.3
<i>Styopodium flabelliforme</i>	14.6	6.3
<i>Turbinaria ornata</i>	16.7	5.0
<b>Others</b>		
Blue-green	75.0	3.7
Turf	82.5	1.2



### **D.3.2. Benthic Towed-diver Survey—Algae**

Macroalgae and coralline algal cover of Ni’ihau over bottom habitat averaged 20% (range 0-62.5%) and 8 % (range 0-50%), respectively within a variety of low–very high complexity habitats.

*Halimeda* patches and beds were seen in a variety of locations, including the eastern (windward) coast immediately south of Pueo Point, the western coast north of Kamalino, the west side of Kuakamoku Rock, and further along the northwestern coastline.

Coralline algae was highest at a survey completed along the southeastern coast, with an average overall bottom cover of 33%. Rhodoliths were also prominent during surveys off of the southeastern coast.

### **D.3.3. Corals**

#### **D.3.3.1 Coral Population Parameters**

Table D.3.2.1.1. and Figure D.3.2.1.2. summarize the characteristics of coral populations within belt transects at the six Ni’ihau sites surveyed for basic coral population parameters in 2006. Of these six sites, three had been assessed in 2005, and three were new sites. A total of 786 corals belonging to 12 anthozoan taxa were censused within an area of 300 m<sup>2</sup>. The most numerically abundant taxa were *P. meandrina*, *P. lobata*, and *M. capitata*.

Overall size distribution indicates 70.1% of colonies have a maximum diameter < 10 cm, and only 0.1% measure >40 cm maximum diameter. Small colonies therefore dominate coral communities surveyed at Ni’ihau, even more so than at other island locations in the main Hawaiian Islands (MHI).

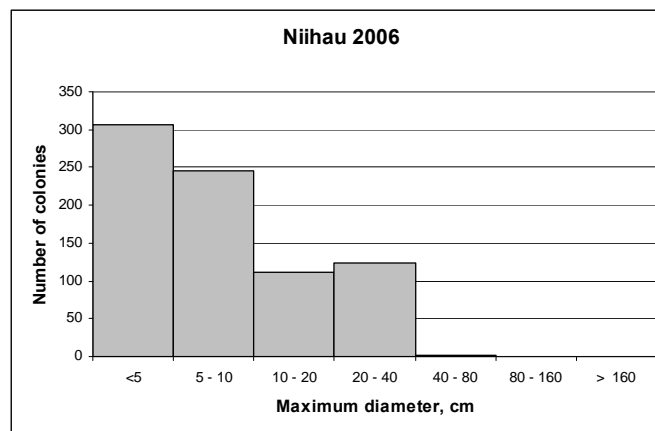


Figure D.3.2.1.1. Size class distribution of 786 anthozoan colonies censused within belt transects at Ni’ihau during 2006 REA surveys.

Table D.3.2.1.2. Number of anthozoans counted within belt transects during MHI REA 2006 surveys at Ni'ihau. Taxa contributing more than 10% of total colony abundance are in bold.		
Taxon	# of colonies	% of total
<i>Montipora capitata</i>	85	<b>10.8</b>
<i>Montipora flabellata</i>	0	0.0
<i>Montipora incrassata</i>	0	0.0
<i>Montipora patula</i>	38	4.8
<i>Montipora verrilli</i>	0	0.0
<i>Pavona duerdeni</i>	0	0.0
<i>Pavona varians</i>	2	0.3
<i>Cyphastrea ocellina</i>	0	0.0
<i>Leptastrea bewickensis</i>	0	0.0
<i>Leptastrea purpurea</i>	0	0.0
<i>Fungia scutaria</i>	0	0.0
<i>Cycloseris vaughani</i>	0	0.0
<i>Leptoseris incrustans</i>	0	0.0
<i>Pocillopora damicornis</i>	1	0.1
<i>Pocillopora eydouxi</i>	9	1.1
<i>Pocillopora ligulata</i>	3	0.4
<i>Pocillopora meandrina</i>	341	<b>43.4</b>
<i>Porites brighami</i>	5	0.6
<i>Porites compressa</i>	0	0.0
<i>Porites evermanni</i>	13	1.7
<i>Porites lobata</i>	273	<b>34.7</b>
<i>Porites monticulosa</i>	0	0.0
<i>Psammacora nierstraszi</i>	0	0.0
<i>Psammacora stellata</i>	10	1.3
<i>Palythoa sp.</i>	6	0.8
<i>Zoanthus pacifica</i>	0	0.0
<i>Sinularia sp.</i>	0	0.0
<i>Tubastraea coccinea</i>	0	0.0
<i>Cirripathes anguina</i>	0	0.0
<i>Antipathes sp.</i>	0	0.0
Total # colonies	786	100
Area surveyed, m <sup>2</sup>	300	

### D.3.3.2 Percent Benthic Cover

Percent benthic cover surveys for the island of Ni'ihau were conducted in congruency with the coral population REA surveys, at six different sites. The point-count methodology quantified a total of 612 points along 300 m of ocean fringing, forereef communities. These surveys indicated that the mean percent live coral cover for all sites combined at Ni'ihau was fairly low; 5.4%, with *P. meandrina* and *P. lobata* accounting for over 96% of the live coral cover. Turf algae also were an important component representing 57% of the live benthos. Table D. 3.2.2.1 below pro-

vides an itemized summary of percent cover of the different benthic elements enumerated along the line transects at Ni’ihau.

Table D.3.2.2.1 Percent cover of the benthic elements at Ni’ihau using the point-intercept method during the 2006 REA activities.	
Item	% cover
<i>Pocillopora meandrina</i>	3.9
<i>Porites lobata</i>	1.3
<i>Porites compressa</i>	0.0
<i>Porites</i> sp	0.2
<i>Montipora capitata</i>	0.0
<i>Montipora patula</i>	0.0
<i>Montipora flabelallata</i>	0.0
<i>Montipora</i> sp	0.0
<i>Pavona</i>	0.0
<i>Leptastrea</i>	0.0
<i>Fungia</i>	0.0
Macro-algae	0.0
<i>Halimeda</i>	0.7
<i>Palythoa</i>	0.0
Pavement/cca	0.5
Pavement/cyano	1.0
Pavement/turf	46.7
Rubble/cca	0.0
Rubble/turf	24.0
Dead/cca	2.0
Dead/turf	6.2
Sand	13.4
Other	1.0
Percent live coral cover	5.4

### D.3.3.3 Coral Disease

At Ni’ihau, the coral disease REA surveyed a total area of approximately 1470 m<sup>2</sup> at six different sites, during the reef assessment and monitoring program (RAMP) cruise of 2006. Figure I.3.2.2.1 below illustrates the cumulative number of cases of disease and compromised health states enumerated for all sites combined. The compromised health state category in the graph below includes 10 cases of *Acanthaster* predation on *Pocillopora*, one case of *Porites* pigmentation response, and one case of tube worm infestation (potential parasitism) on *P. meandrina*. At a future date, the data on the graph below will be related to coral colony density (estimated by Dr. Kenyon) and percent live coral cover (above) in order to provide a numerical estimate for disease prevalence and perform within and among island comparisons.

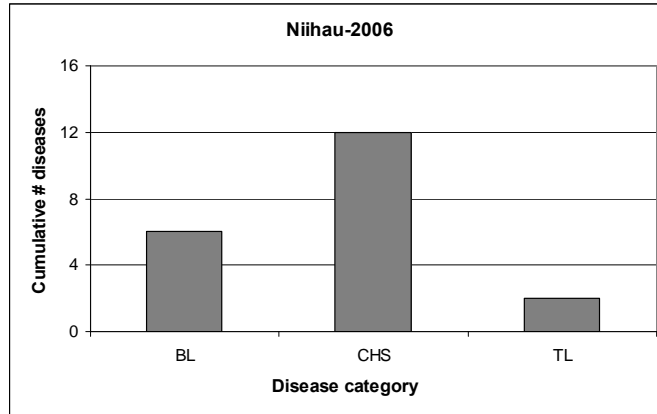


Figure D.3.2.3.1. Cumulative number of cases of disease at Ni'ihau Rock during 2006 REA surveys. Total area surveyed: 1470 m<sup>2</sup>. BL: bleaching, TL: tissue loss, and CHS compromised health state, including: predation, tube-worm infestation, and pigmentation responses.

#### **D.3.3.4 Benthic Towed-diver Survey—Corals**

The overall hard coral cover for Ni'ihau was low, averaging just over 3% total benthic cover which varied from low-relief sand flats to highly complex reef habitat. When examining coral cover in individual towed-diver surveys, it was noted that the northeastern towed-diver survey recorded the highest single survey average (8.5%) of total hard coral cover over medium to highly complex reef habitat.

Soft coral cover was very low around Ni'ihau, with the highest single survey average (~1.4%) located in the northeastern corner of the island. The bottom habitat was very complex in some areas of this survey, with drastic changes in bottom depth. Black coral was recorded in four out of ten 5-minute time segments, often seen growing on the vertical faces of reef drop-offs. Finally, *Sinularia densa* and species of wire coral were also noted for the same survey.

#### **D.3.4. Macroinvertebrates**

The fauna at Ni'ihau also had a unique assemblage, with sponges being the most common invertebrate on the SE side, and *Echinometra* urchin being most common and abundant at site 7. There was also a high abundance of small gastropods, *Spondylus* oysters, and other large bivalves with patches of zoanthids, but little to no sponge. Also of note is the crustacean fauna; no coral-dwelling trapezid crabs, no lobsters, and few hermits were recorded.

Table D.3.3.1. Relative abundance data for echinoderms enumerated during REA surveys for the island of Ni'ihau.						
Island	Niihau	Niihau	Niihau	Niihau	Niihau	Niihau
Date	8/9/2006	8/9/2006	8/9/2006	8/11/2006	8/11/2006	8/11/2006
Site	NII-1	NII-3	NII-7	NII-8	NII-5	NII-9
Depth(feet)	38	48	42	42	40	51
Habitat	Boulder/Sand	Boulder/Sand	Boulder/Sand	Boulder	Boulder	Boulder
	Avg/m2	Avg/m2	Avg/m2	Avg/m2	Avg/m2	Avg/m2
<b>Echinoids</b>						
Echinostrephus	0.2		0.4		0.24	0.28
Echinometra sp.	0.24		1.32	0.04	0.08	
Echinothrix sp.	0.128	0.002	0.026	0.002	0.004	
Heterocentrotus			0.01			
Tripneustes	0.018		0.02			
Diadema						
Pseudobolentia						
Other Echinoid						
<b>Holothuroids</b>						
Holothuria atra	0.004					
Holothuria whitmaei	0.002		0.006		0.002	
Actinopyga obesa				0.002		
Actinopyga mauritiana						
Other Holothur-oid						
<b>Asteroidea</b>						
Linckia multi- fora	0.03					
Linckia guildingi						
Acanthaster planci	0.014					
Mithrodia fisheri				0.002		
Other Asteroid					0.002	
Culcita			0.002			

### **D.3.5. Benthic Towed-diver Survey—Macroinvertebrates**

Crown-of-thorns starfish were uncommon during Ni'ihau surveys, with a maximum of seven recorded during the towed-diver survey of the northeastern corner of Ni'ihau.

Additional macroinvertebrates observed during towed-diver surveys included a number of helmet shells (*Cassia cornuta*) recorded in the northeast near Ki'i in 100% sand flats. *C. cornuta* was also observed in 75-100% sand in the southwest near Le'ahi Point. Finally, pearl oysters (*Pinctada margaritifera*) were also noted in two separate locations along the southern and western coasts.

#### D.4. Fish

Six sites were surveyed at Ni'ihau. A total of 117 species and 4,082 fishes were recorded (in both Belt and SPC surveys). Sixty percent of the fish counted were damselfishes, 14% surgeonfishes, and 8% wrasses. The blackfin chromis accounted for 58% of the fish followed by saddle wrasse (4%), and bluestripe snapper (3%).

##### Fish $\geq 25$ cm TL:

Belt Transects: One hundred fifty-nine fishes representing 18 species measuring  $\geq 25$  cm were counted on the belt transects. Forty-eight percent were surgeonfishes, 25% bluestripe snappers, and 9% Hawaiian hogfish (*Bodianus bilunulatus*).

SPCs: Five hundred twenty-one fishes representing 40 species were counted on the SPCs. Forty-eight percent were surgeonfishes, 14% bluestripe snappers, 8% parrotfishes, and 8% goatfishes.

##### Towed-diver Surveys (fish $> 50$ cm TL):

At Ni'ihau the towed-diver team completed 13 dives over the course of 3 days covering 31.70 km of sea floor, completely circumnavigating the island (Fig. D.4.1). Surveys averaged 2.54 km in length and ranged from 1.54 km to 3.23 km. Median mean depth was  $-16.96$  m.

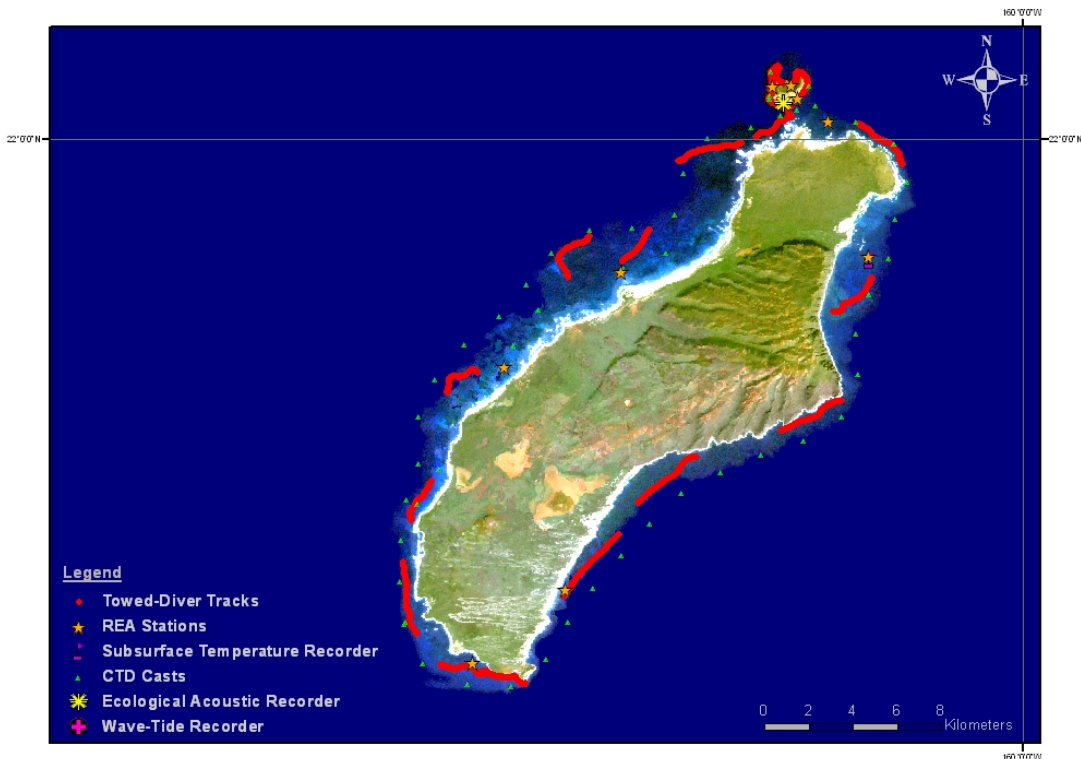


Figure D.4.1 HI-06-10 sampling stations at Ni'ihau Island.

At Ni’ihau 15 species were observed (Figs. D.4.2 – D.4.3). Numeric density was dominated by the redlip parrotfish followed by the green jobfish and spectacled parrotfish (*Chlorurus perspicillatus*). Biomass was dominated by the redlip parrotfish followed by the gray reef shark (*Carcharhinus amblyrhynchos*) and white tip reef shark (*Triaenodon obesus*).

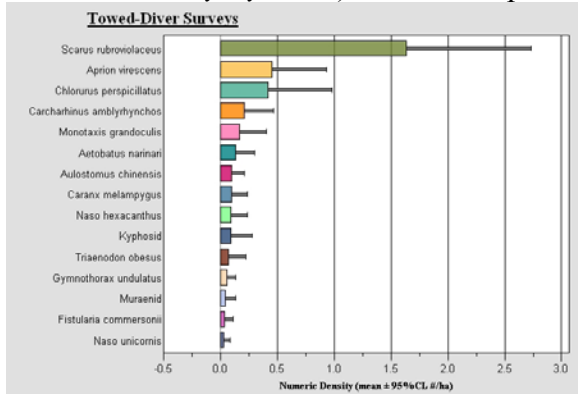


Figure D.4.2 Numeric Density (#/ha) of species at Ni’ihau.

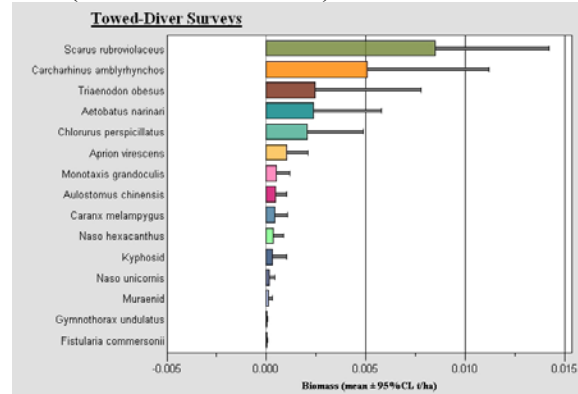


Figure D.4.3 Biomass Density (t/ha) of species at Ni’ihau.

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**Appendix E: Kauai**

**E.1. Oceanography & Water Quality**

Figure E.1.1 plots subsurface temperature recorder (STR) and wave and tide recorder (WTR) temperature data recovered from three sites on the island of Kauai: STR data from near REA Site KAI02 in Anahola Bay on the NE side of the island, STR data from near REA Site KAI05 near Makahuena Point on the south side of the island, and WTR data from Mana Reef on the west side of the island. These instruments were deployed at 14.9, 6.7, and 25.3 m water depths, respectively.

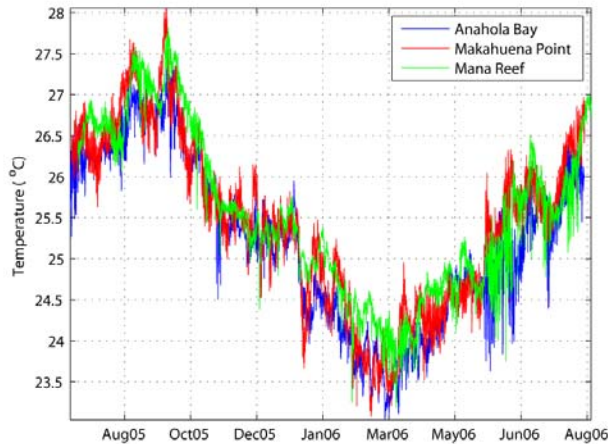


Figure E.1.1

Figure E.1.2 plots in situ significant wave height from the Mana Reef WTR. Many significant swells occurred during the 2005/2006 winter, notably one in early February, when measured significant wave height hit 6 meters.

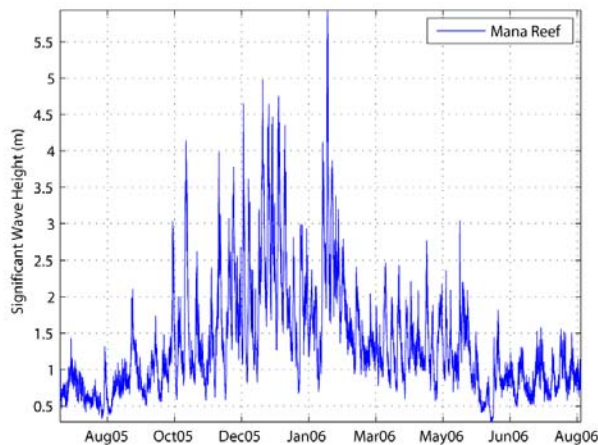
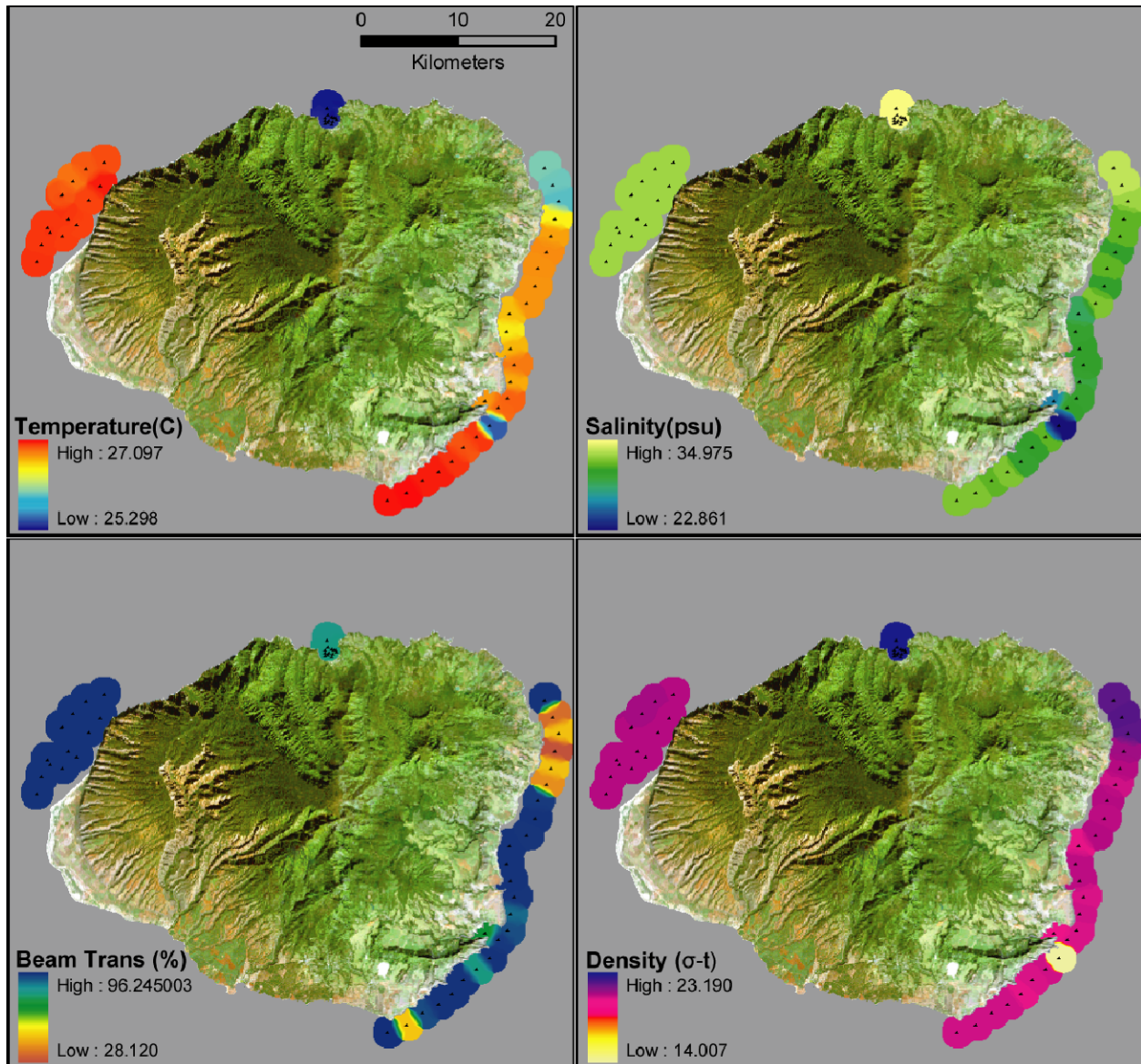


Figure E.1.2

Figure E.1.3 shows interpolated shallow conductivity-temperature-depth (CTD) cast data – 10 m depths around Kauai. Several areas of relatively high turbidity (beam transmission < 40%) are evident along the east side of the island; some or all of these areas may be associated with land-based runoff. Freshwater inputs near Nawiliwili Harbor are evident. Shallow CTD data at Mana Reef exhibited oceanic characteristics: warm and well mixed.



**Figure E.1.3**

## **E.2. Rapid Ecological Assessment (REA) Site Descriptions**

### KAU-2

July 28, 2006

E-NE, Ocean fringing reef. Depth range 12–13.6 m. The algal diversity was high; only a random swim was done at this site due to the swell. Turf algae overgrowing the carbonate pavement comprised 80% of the benthic cover. Live coral cover was relatively low (9.8%), and the community was dominated by a mix of *Porites lobata* and *Pocillopora meandrina*. Montiporid corals were present, but in low abundance (0.9% cover). Coral health and disease assessment: one case of mild bleaching and one case of trematodiasis were observed in *P. meandrina* and *P. lobata*, respectively. Additionally, two cases discoloration (dark spots) were observed on *Porites*; it is unclear if this condition poses any health threat to the corals. The substrate was comprised of turf algae and sediment, with very little encrusting species including sponges, but there were a few patches of soft corals (*Sinularia*) near the anchor line and small patches of zoanthids (*Palythoa caesia*) around the first transect. There were two species of urchin (*Echinostrephus* and *Echinothrix*) and a few species of mollusks (gastropod, bivalve, and nudibranch). The other mobile species were small and associated with corals (trapezid crabs and hermits). Numerically, the fish species that dominated the fish fauna was the blackfin chromis (*Chromis vanderbilti*). Among larger-bodied fishes, the orangeband surgeonfish (*Acanthurus olivaceus*) and the bridled triggerfish (*Sufflamen fraenatus*) were most abundant.

### KAU-3

July 28, 2006

E-NE, ocean fringing flat carbonate pavement platform. Average depth 9 m. Algal diversity was moderate, dominated by turf algae, *Microdictyon umbilicatum* and *Melamansia*. *Martensia*, *Neomeris*, *Jania*, and *Lobophora* were also observed within the photoquadrats. Percent live coral cover was close to 5%. Coral fauna was dominated by *Montipora* spp., *Pocillopora*, and *Porites*. Coral health and disease assessment: one case of *Porites* trematodiasis, and four cases of discoloration on *Porites* and *Pavona varians*; it is unknown if this condition poses any health threat to the corals. The most dominant mobile invert fauna included the boring urchin (*Echinostrephus*), two species of cone snail, trapezid crabs, and hermits. The sessile fauna were made up of three species of sponge, one species of bivalve, and quite a few Christmas tree polychaetes (*Spirobranchus*). There were also a few small areas (off the transect lines) with indents that supported a larger diversity of inverts including two species of sea star (*Acanthaster* and *Mithrodia*) and a pearl oyster. Numerically, the fish species that dominated the fish fauna was the blackfin chromis (*Chromis vanderbilti*). Among larger-bodied fishes, the orangeband surgeonfish (*Acanthurus olivaceus*) and the bridled triggerfish (*Sufflamen fraenatus*) were most abundant. The saddle wrasse (*Thalassoma duperrey*) was the most numerous species on the belt transect (BLT) surveys. Among the larger fish, the redlip parrotfish (*Scarus rubroviolaceus*) and the bluestripe snapper (*Lutjanus kasmira*) were most numerous on the stationary point count (SPC).

KAU-13  
July 28, 2006

N, ocean fringing reef. 3-D carbonate topography on sandy bottom. Depth range: 8–9 m, visibility ~60 feet. Algal diversity was moderate. Algal communities were dominated by turf algae and *Melamansia*. Crustose corallines, *Peyssonnelia* and *Dictyota* were also seen in abundance within the photoquadrats. Algal turf growing on the carbonate pavement comprised 64% of the benthic cover. Percent live coral cover was 15.7%, and coral diversity was dominated by *Porites* spp. and *Montipora capitata*, *M. patula*. Other corals observed in the survey area included: *P. meandrina*, *Pavona varians*, and *Pocillopora ligulata*. Coral health and disease assessment: six cases of growth anomalies were detected on colonies of *Porites* and *Montipora*, three cases of *Porites* trematodiasis and 2 cases of white syndrome on *Montipora*. In addition, three cases of compromised health conditions were observed (predation) on *Montipora*, *Porites*, and *Pocillopora*. Finally one case of discoloration was observed on a colony of *Porites*; it is unknown if this condition poses any health threat to the corals. Invertebrate surveys indicated that the most common and abundant were the zoanthids *Palythoa* and *Protospalythoa*, and there were at least five different species of sponge under the coral ledges. Also, the most abundant mobile inverts were cone snails and other gastropods, along with a few small species of shrimp including banded coral shrimp, small rubble shrimp, and alpheid. The fish species that dominated the fish fauna on the BLT survey were the saddle wrasse (*Thalassoma duperrey*), the brown surgeonfish (*Acanthurus nigrofuscus*), and the blackfin chromis (*Chromis vanderbilti*). For the larger fish, the black durgon (*Melichthys niger*) and the orangeband surgeonfish (*Acanthurus olivaceus*) were most abundant on the SPC. A white tip reef shark (*Triaenodon obesus*) was observed on an SPC survey.

KAU-14  
August 13, 2006

Mana Reef, off W coast. Only one transect surveyed by fish team, then dive aborted because of strong current. No benthic rapid ecological assessment (REA) conducted. No SPC was performed. Only 17 species and 100 individuals were counted. Large herbivores were observed in feeding schools.

Drift dive  
August 13, 2006

Mana Reef, off W coast. Top of reef ("crest" or "flat"). Depth range: 14.2–16.7 m; moderately high topographical relief shoreward of reef crest/flat. The following algae were observed during this dive: turf algae, crustose corallines, *Lobophora*, *Laurencia*, *Actinotrichia*, *Microdictyon setchellianum*, *Neomeris*, *Bryopsis pennata*, *Predea*, *Platoma*, *Halimeda discoidea*, *Portiera*, *Padina*, *Gibsmithia* (two different species), *Caulerpa webbiana*, *Amansia*, *Martensia*, *Rhizidosiphon*, *Dictyota ceylanica*, *Tolypocladia*, and *Acanthophora pacifica*. Overall estimate 20% live coral cover along crest/flat, lower along inner, higher relief substrate. Flat reef top dominated by *P. meandrina*, *P. lobata*, and *M. patula*. *Montipora incrassata* common, much more abundant than Kenyon has seen elsewhere in Hawaii. Also common were small clumps *Porites annae*. Along high-relief inside of crest/flat, *Pavona duerdeni* common, plus encrusting *M. patula*, *P. meandrina*. Large (>1 meter) *P. lobata* occasional. Max. depth 70 feet. Occasional

*Acanthaster*. Coral disease and health and disease assessment: as observed during drift detected possible bleaching/pallor of *Montipora* spp. and predation by *Acanthaster*. The crest had *Acanthaster planci* as its main macroinvertebrate, and the sides of the reef platform were populated mostly by *Echinometra* and *Echinostrephus* urchins and the sea star *Linckia multifora*. Many fish were observed in deeper water while relatively few were seen on the reef flat. Sixty-two species were observed during the dive.

KAU-15

August 13, 2006

Mana Reef, off W coast. Depth range: 12.4–18.5 m. Carbonate substrate with thin cover sand, abundant macro- and turf algae. Algal cover and algal diversity were relatively high. Algal communities were dominated by *Laurencia* sp, *Microdictyon setchellianum*, and *Amansia*. Additionally, *Halimeda discoida*, *Padina*, *Dictyota*, and *Gelid* were also found in abundance within the photoquadrats. Turf algae and crustose corallines were also observed but were not prevalent in general. Percent live coral cover was approximately 37; relatively high diversity with *Montipora capitata* (28%) and *Pocillopora meandrina* (6%) dominating the area. Other species detected in this area included: *Montipora flabellata*, *Montipora patula*, *Leptastrea bewickensis*, *Pocillopora eydouxi*, *Porites lutea*, *Porites lutea*, *Porites lobata*, *Porites rus*, and *Porites annae*. Two colonies of *Acropora cytherea* were observed within 500 m<sup>2</sup> (rare, special sightings). Coral health and disease assessment: Pallor in *Montipora capitata* was detected (possible photoadaptation). Additionally, the most commonly seen macroinvertebrate was the boring sponge *Spirastrella*. *Echinothrix calamaris* was noted but was rare. Forty-seven species and 470 individuals were counted. No SPC was performed. The largest fish counted were triggerfish while one gray snapper (*Aprion virescens*) and one yellowspotted jack (*Carangoides orthogrammus*) were observed in the area.

### **E.3. Benthic Environment**

#### **E.3.1. Algae**

The highest algal diversity was found at the sites experiencing important current and swell. The other sites showed a moderate diversity. At all sites, turf algae and crustose coralline algae dominated algal communities. But *Microdictyon* sp. and *Melamansia/Amansia* were also very abundant and common within the photoquadrats (Table E.3.1.1.). A total of 22 genera and 4 functional groups were found within the photoquadrats at Kauai; and 28 genera, if random swim data are included. Algal diversity appears higher at locations where surge and swell were important. One of those locations includes the Mana barrier reef. Algal diversity was impressive at this location. Algal communities were, at this site, dominated by *Laurencia* sp, *Amansia* and *Microdictyon setchellianum*. The genus *Microdictyon* was abundant and commonly seen at different studied reefs around Kauai. The common points among sites were turf algae and crustose coralline algae prevailing in algal communities. *Halimeda* sp, *Jania*, and *Dictyota* were also one of the major algal components in communities around Kauai.

Table E.3.1.1. Average occurrence (%) and average rank for each genera, species, or functional group found within the photoquadrats at Kauai.

	% Occurrence	Rank
<b>Green algae</b>		
<i>Caulerpa webbiana</i>	16.7	10.0
<i>Cladophoropsis</i>	8.3	5.0
<i>Dictyosphaeria cavernosa</i>	8.3	10.0
<i>Dictyosphaeria versluisii</i>	16.7	7.0
<i>Halimeda</i> sp.	58.3	4.9
<i>Halimeda discoidea</i>	91.7	3.6
<i>Microdictyon setchellianum</i>	91.7	2.3
<i>Neomeris annulata</i>	25.0	6.7
<b>Red algae</b>		
<i>Amansia glomerata</i>	72.2	3.6
<i>Dasya iridescens</i>	8.3	6.0
<i>Dasya</i> sp.	8.3	8.0
<i>Galaxaura</i> sp.	12.5	5.3
<i>gelid</i>	33.3	6.1
<i>Gibsmithia hawaiiensis</i>	16.7	7.5
<i>Haloplegma duperreyi</i>	12.5	6.0
<i>Hypnea</i> sp.	16.7	6.0
<i>Jania</i> sp.	58.3	5.4
<i>Laurencia</i> sp.	58.3	4.7
<i>Laurencia parvipapillata</i>	8.3	6.0
<i>Liagora</i> sp.	16.7	8.0
<i>Martensia</i> sp.	66.7	4.6
<i>Martensia flabelliformis</i>	33.3	7.0
<i>Peyssonnelia</i> sp.	37.5	5.0
<i>Tolypocladia glomerulata</i>	8.3	8.0
<b>Brown algae</b>		
<i>Dictyota</i> sp.	50.0	5.8
<i>Dictyota friabilis</i>	25.0	6.0
<i>Lobophora varigata</i>	13.9	7.0
<i>Padina</i> sp.	37.5	6.9
<b>Others</b>		
Blue-green	36.1	6.1
turf	97.2	1.5
CCA	61.1	4.2
sand	25.0	8.3

### E.3.2. Benthic Towed-diver Survey—Algae

Macroalgae and coralline algal cover of Kauai over bottom habitat averaged 26% (range 0–75%) and 3 % (range 0–30%), respectively within a variety of low–high complexity habitats. Macroalgae was highest during a towed-diver survey between Papaa Bay and Moloaa Bay in the north-east (average 59%). *Halimeda* patches, beds, and meadows were noted in a number of locations around the island. Coralline algae was highest during the towed-diver survey completed in the

southeastern corner of Kauai between Paoo Point, past Kamala Point and the forereef areas directly across from the Paa Cones (average 10%).

### **E.3.3. Corals**

#### **E.3.3.1 Coral Population Parameters**

Table E.3.2.1.1 and Figure E.3.2.1.2 summarize the characteristics of coral populations within belt transects at the four Kauai sites surveyed for basic coral population parameters in 2006 (an additional site, KAU-14, was not surveyed by the benthic team due to strong current). Of these four sites, two had been assessed in 2005, and two were new sites. A total of 2,017 corals belonging to 23 anthozoan taxa were censused within an area of 194 m<sup>2</sup>. The most numerically abundant taxa were *M. patula*, *M. capitata*, and *P. lobata*. At some sites, *P. meandrina* or *M. flabellata* contributed substantially to the coral fauna. Of special note was the rare sighting and documentation of two colonies of *Acropora cytherea* at KAU-15 on Mana Reef off the west coast of Kauai, as the existence of this species off Kauai is poorly documented.

Overall size distribution indicates 49.6% of colonies have a maximum diameter < 10 cm, and only 8.5% measure >40 cm maximum diameter. Small colonies therefore dominate coral communities surveyed at Kauai.

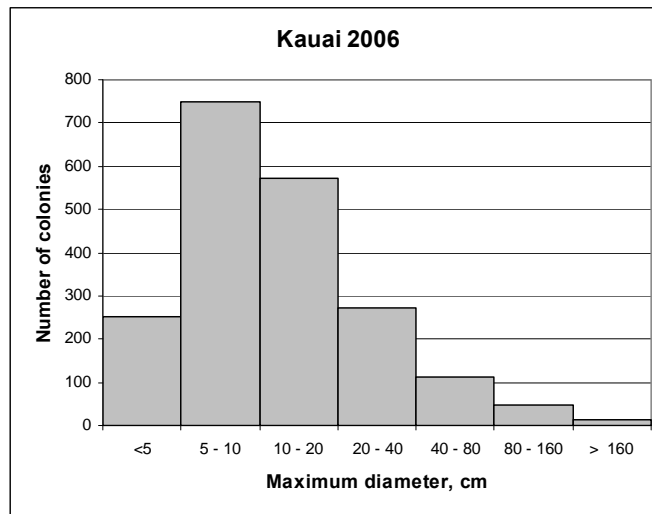


Figure E.3.2.1.1. Size class distribution of 2017 anthozoan colonies censused within belt transects at Kauai during 2006 REA surveys.

Table E.3.2.1.2. Number of anthozoans counted within belt transects during MHI REA 2006 surveys at Kauai. Taxa contributing more than 10% of total colony abundance are in bold.

Taxon	# of colonies	Percent of total
<i>Acropora cytherea</i>	1	0.0
<i>Montipora capitata</i>	471	<b>23.4</b>
<i>Montipora flabellata</i>	109	5.4
<i>Montipora incrassata</i>	6	0.3
<i>Montipora patula</i>	572	<b>28.4</b>
<i>Montipora verrilli</i>	0	0.0
<i>Pavona duerdeni</i>	3	0.1
<i>Pavona varians</i>	37	1.8
<i>Cyphastrea ocellina</i>	7	0.3
<i>Leptastrea bewickensis</i>	0	0.0
<i>Leptastrea pruinosa</i>	1	0.0
<i>Leptastrea purpurea</i>	2	0.1
<i>Fungia scutaria</i>	1	0.0
<i>Cycloseris vaughani</i>	4	0.2
<i>Leptoseris incrustans</i>	0	0.0
<i>Pocillopora damicornis</i>	0	0.0
<i>Pocillopora eydouxi</i>	33	1.6
<i>Pocillopora ligulata</i>	5	0.2
<i>Pocillopora meandrina</i>	131	6.5
<i>Porites cf. annae</i>	52	2.6
<i>Porites brighami</i>	2	0.1
<i>Porites compressa</i>	90	4.5
<i>Porites evermanni</i>	16	0.8
<i>Porites lobata</i>	275	<b>13.6</b>
<i>Porites monticulosa</i>	0	0.0
<i>Psammacora nierstraszi</i>	0	0.0
<i>Psammacora stellata</i>	3	0.1
<i>Palythoa sp.</i>	148	7.3
<i>Zoanthus pacifica</i>	48	2.4
<i>Sinularia sp.</i>	0	0.0
<i>Tubastraea coccinea</i>	0	0.0
<i>Cirripathes anguina</i>	0	0.0
<i>Antipathes sp.</i>	0	0.0
Total # colonies	2017	100
Area surveyed, m2	194	



### E.3.3.2 Percent Benthic Cover

Percent benthic cover surveys at the island of Kauai were conducted in congruency with the coral population REA surveys, at four different sites (an additional site, KAU-14, was not surveyed by the benthic team due to strong current). The line intercept methodology quantified a total of 408 points along 200 m of coral reef communities, mainly ocean fringing reefs. The point-count surveys at the island of Kauai indicated that the mean percent live coral cover for all sites combined was moderately low; 17.2%; the most numerically abundant scleractinian taxa were *M. capitata*, *M. patula*, and *P. meandrina* representing 41.3%, 22.7%, and 19.9 %, of the total percent live coral cover, respectively. Table E.3.2.2.1 provides an itemized summary of percent cover of the different benthic elements enumerated along the line transects at Kauai.

Table E.3.2.2.1 Percent cover of the benthic elements at Kauai using the point-intercept method during the 2006 REA activities.	
Item	% cover
<i>Pocillopora meandrina</i>	3.4
<i>Porites lobata</i>	2.2
<i>Montipora capitata</i>	7.1
<i>Montipora patula</i>	3.9
<i>Montipora sp</i>	0.5
Macroalgae	4.2
<i>Halimeda</i>	3.9
<i>Palythoa</i>	1.5
Pavement/cca	1.7
Pavement/turf	62.3
Rubble/cca	0.2
Rubble/turf	0.5
Dead/cca	1.0
Dead/turf	3.2
Sand	4.4
Other	0.2
Percent live coral cover	17.2

### E.3.3.3 Coral Disease

At Kauai, the coral disease REA surveyed a total area of approximately 1200 m<sup>2</sup> at four different sites, during the reef assessment and monitoring program (RAMP) cruise of 2006. Figure E.3.2.2.1, illustrates the cumulative number of cases of disease and compromised health conditions enumerated for all sites combined. At a future date, these data will be related to coral colony density (estimated by Dr. Kenyon) and percent live coral cover (above) in order to numerically estimate disease prevalence. These results will be contrasted with data collected for other islands in the Hawaiian Archipelago.

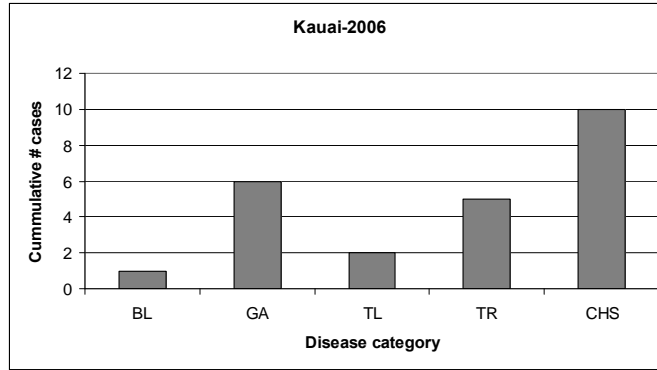


Figure E.3.2.3.1 Cumulative number of cases of disease at Kauai Island during 2006 REA surveys. Total area surveyed: 1200 m<sup>2</sup>. BL: bleaching, GA: growth anomaly, TL: tissue loss, TR: trematodiasis, and CHS: compromised health state, involving predation patchy over-pigmentation in *Porites lobata* and *Pavona varians*.

#### **E.3.3.4 Benthic Towed-diver Survey—Corals**

The overall hard coral cover for Kauai was low, averaging over 11% total benthic cover which varied from low-relief sand flats to highly complex reef habitats. When examining coral cover in individual towed-diver surveys, it was noted that the towed-diver survey in the north between Hinono Point and Kaweonui Point recorded the highest single survey average (18%) of total hard coral cover over medium to highly complex reef habitat.

Coral stress averaged 2% island-wide, with the highest levels of stress located during a survey in the northeast between Lepeuli and Kilauea Bay (5% live coral; 7% coral stress). A second survey along the leeward side in the area known as Mana Reef, south of Makana Point, also registered higher coral stress (12% live coral; 7% coral stress).

Soft coral was uncommon on Kauai, never exceeding 1% in a single 5-minute time segment.

#### **E.3.4. Macroinvertebrates**

There were five total sites at Kauai which were on the north end (three sites), the west side (one site), and south side (one site). The north site of Mana Reef supported a more abundant diverse macroinvertebrate fauna than the south with echinoderms and sponges being the most common at both sites. The northern sites had an even more diverse and rich assemblage which included more soft corals and zoanthids and more species of echinoderms. There were also more species of sponges and mollusks in the north.

Table E.3.3.1. Relative abundance data for echinoderms enumerated during REA surveys for the island of Kauai.				
Island	Kauai	Kauai	Kauai	Kauai
Date	08/13/06	07/28/06	07/28/06	07/28/06
Site	KAU-15	KAU-2	KAU-3	KAU-13
Depth(feet)	55			
Habitat		coast	coast	coast
	Avg/m2	Avg/m2	Avg/m2	Avg/m2
<b>Echinoids</b>				
Echinostrephus	0.2	0.04	0.02	0.001
Echinometra sp.	0.08			
Echinothrix sp.	0.004	0.01		
Heterocentrotus				
Tripneustes				
Diadema				
Pseudobolentia				
Other Echinoid				
<b>Holothuroids</b>				
Holothuria atra				
Holothuria whitmaei	0.002			
Actinopyga obesa				
Actinopyga mauritiana				
Other Holothuroid				
<b>Asteroidea</b>				
Linckia multifora				
Linckia guildingi				
Acanthaster planci	0.002			
Mithrodia fisheri				
Other Asteroid				
Culcita				

### **E.3.5. Benthic Towed-diver Survey—Macroinvertebrates**

Several areas recorded localized increases in crown-of-thorns starfish populations. A towed-diver survey conducted between Makaha Point and Polihale recorded 63 crown-of-thorns starfish between 17 and 21 meters depth. A second survey completed in the vicinity of Keawanui and Makana Point recorded 45 crown-of-thorns starfish (37 recorded during the first 5-minute time segment) between 17 and 21 meters depth. Finally, a towed-diver survey conducted around Makuaiki Point and Keawanui recorded 41 crown-of-thorns starfish, with 37 noted during the second 5-minute time segment between 16 and 22 meters depth.

These three towed-diver surveys were conducted in the area known as Mana Reef, located off the leeward side of Kauai between 0.75 and 2.25 nautical miles from shore. An important observation was mentioned outside of the towed-diver transect conducted around Keawanui and Makaha

Point, where divers observed “hundreds” of crown-of-thorns starfish prior to beginning the towed-diver survey (location: N22 09.1298; W159 44.790).

#### **E.4. Fish**

Five sites were surveyed on Kauai. A total of 97 species and 2,038 fishes were recorded (in both Belt and SPC surveys). Damselfishes (Pomacentridae) were most abundant, accounting for 60% of the individuals, followed by wrasses (Labridae; 13%), surgeonfishes (Acanthuridae; 8%), and blennies (Blennidae; 3.5%). Blackfin chromis (*Chromis vanderbilti*) were the most commonly observed fish species, accounting for 55% of all fishes tallied during the survey period. The saddle wrasse (*Thalassoma duperrey*), arceye hawkfish (*Paracirrhites arcatus*), oval chromis (*Chromis ovalis*), Gosline’s scale-eating fangblenny (*Plagiotremus goslinei*), and orangeband surgeonfish (*Acanthurus olivaceus*) accounted for 22% of the individual fish species observed.

##### Fish $\geq 25$ cm TL:

Belt Transects: Fifty-eight fishes representing 17 species and measuring  $\geq 25$  cm were counted along the belt transects at five sites. Fifty-two percent of the fishes recorded were surgeonfishes and 28% were triggerfishes, mostly the bridled triggerfish (*Sufflamen fraenatus*).

SPCs: Eighty-seven fishes representing 22 species were counted on SPCs at three sites. Surgeonfishes were most abundant, accounting for 57% of the individuals followed by the bluestripe snapper (*Lutjanus kasmira*; 10%), and Hawaiian hogfish (*Bodianus bilunulatus*; 7%).

##### Towed-diver Surveys (fish $> 50$ cm TL):

At Kauai, the towed-diver team completed 15 dives over the course of 3 days covering 35.45 km of sea floor (Fig. E.4.1). Surveys nearly circumnavigated the island with the exception of the southern coast, the Na Pali coast and a short section of the eastern coast which was affected by a significant rain event that reduced visibility to the point where surveys could not be conducted. Surveys averaged 2.43 km in length and ranged from 1.40 km to 3.07 km. Median mean depth was -14.46 m.

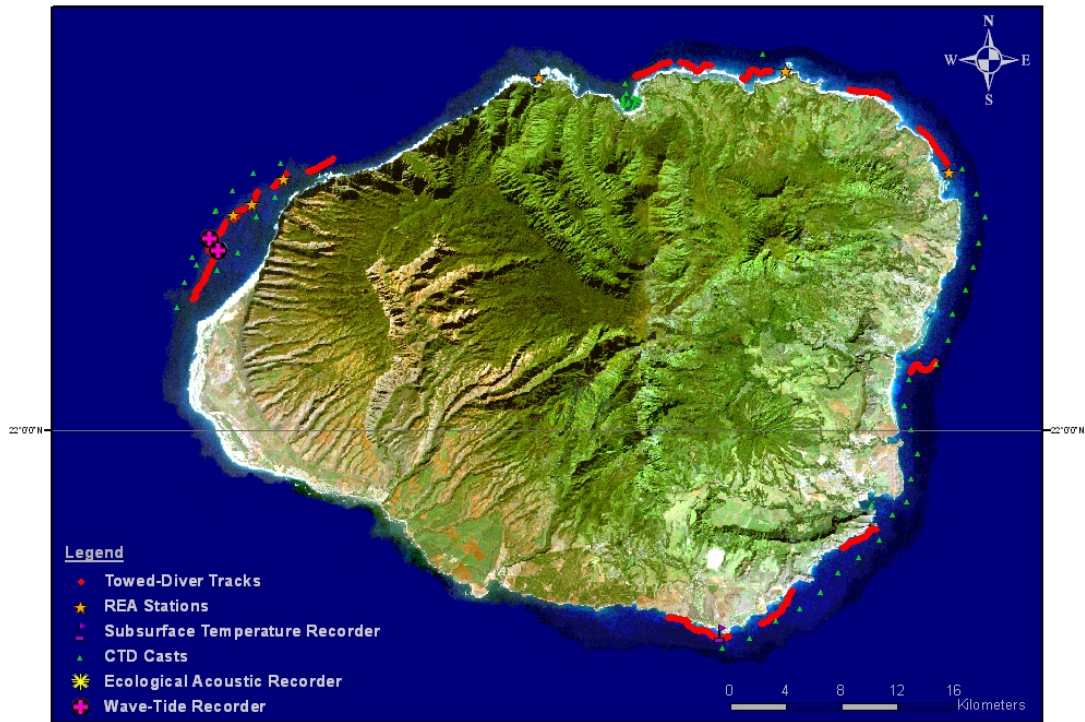


Figure E.4.1 HI-06-10 sampling stations at Kauai Island. Efforts were limited along the southern coast due to its great accessibility and limited visibility.

At Kauai, 20 species were observed (Figs. E.4.2 - E.4.3). The redlip parrotfish (*Scarus rubroviolaceus*) dominated both observed numeric density and observed biomass. The bluespine unicornfish (*Naso unicornis*) and sleek unicornfish (*Naso hexacanthus*) followed in numeric density while grey reef sharks (*Carcharhinus amblyrhynchos*) and bluespine unicornfish followed in biomass.

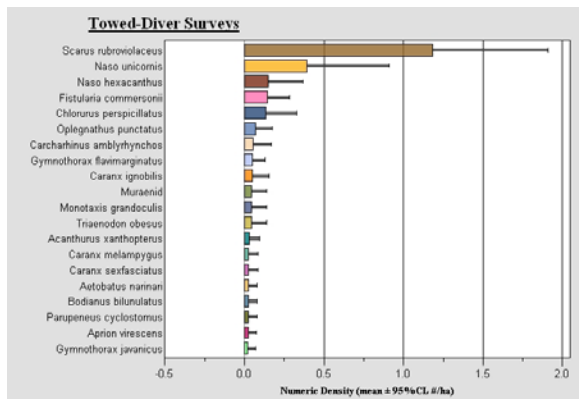


Figure E.4.2 Numeric Density (#/ha) of species at Kauai.

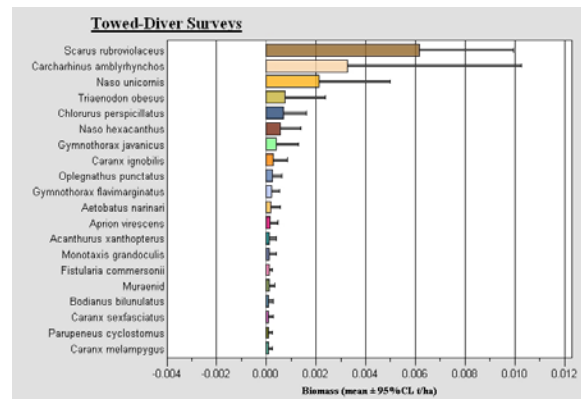


Figure E.4.3 Biomass Density (t/ha) of species at Kauai.

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## Appendix F: Oahu

### F.1. Oceanography & Water Quality

Six conductivity-temperature-depth (CTDs) were collected near Makapu'u, east Oahu. These are not plotted here as they were all similar and well mixed.

### F.2. Rapid Ecological Assessment (REA) Site Descriptions

#### OAH-12

July 27, 2006

E-SE, South of Rabbit Island (Flat Island). Ocean fringing reef. Depth range: 13.6–15 m. Turf and blue-green algae occurred intermingled with branching and massive coral heads. Crustose coralline red algae were not very abundant in comparison to *Dictyota*. *Padina*, *Caulerpa* (nummularia?), *Neomeris*, *Amansia*, *Lobophora*, and *Asparagopsis* were observed but were not very abundant. Percent live coral cover was 12%. Coral community dominated by *Porites lobata/evermanni*, *Pocillopora meandrina*, and *Montipora* spp. Pavement/turf comprised nearly 52% of benthic cover. Coral health and disease assessment: surveys detected three cases of *Porites* trematodiasis, three cases of tissue loss (two on *Porites*, and one on *Montipora*), and one case of growth anomaly on *Porites*. Additionally, eight cases of compromised health condition were observed: three cases of predation on *Pocillopora*, three cases of pigmentation response on *Porites*, one case of algal colonization on *Pocillopora*, and one case of unusual bleaching patterns in *Montipora*. At this site, the most abundant mobile invertebrates were *Echinometra* and *Echinothrix* sea urchins. Other echinoderms were present but not common, including two species of sea cucumbers and three other species of sea urchins (*Heterocentrotus*, *Eucidaris* and *Tripneustes*). The other cryptic fauna consisted of nudibranchs, flatworms, small xanthid crabs, and a sessile bryozoan (*Reteporellina*) found under and around rubble and dead coral. Numerically, the two fish species that dominated at this site were the blackfin chromis (*Chromis vanderbilti*) and saddle wrasse (*Thalassoma duperrey*). Among larger-bodied fishes, the black durgon (*Melichthys niger*) and introduced bluestripe snapper (*Lutjanus kasmira*) were most abundant.

#### OAH-13

August 7, 2006

S, off Ewa Plain. Ocean fringing reef. Depth range: 16.5 m. Flat, sand-covered pavement with rubble. Algal cover was moderate. Turf algae were prevalent with *Dictyota* and *Gelid*. Crustose coralline algae were also very abundant within the photoquadrats. Occasional patches *Pocillopora/P. lobata/evermanni*, many pocilloporids overgrown with turf and macroalgae. No point-count or disease survey conducted. No invertebrate survey conducted either. This site was depauperate in both species richness and numbers of fishes. Only 4 species and 19 individuals, mostly surgeonfishes (Acanthuridae), were recorded on the SPCs. On the belt transects, 19 species and 98 individuals were counted. Fifty of the individuals were blackfin chromis. Thirty-three species in total were recorded by all methods.

### F.3. Benthic Environment

#### F.3.1. Algae

Only two sites were visited during this survey. One was located next to Rabbit Island on the east side of Oahu. The other one was situated in front of Barber's Point on the southwest shore of Oahu. Algal diversity was very low with turf algae prevailing in algal communities (Table F.3.1.1). Algal diversity was low at the two sites visited around Oahu although they were distinct from each other. The reef in front of Barber's Point was a flat pavement without any roughness, while the reef near Rabbit Island was characterized by lava outcroppings. A total of 15 genera and 4 functional groups were found within the photoquadrats (16 genera if data from the random swim are included). Turf algae were prevalent in algal communities with *Dictyota* sp. and *Gelid*. Blue-green algae were also very common and abundant in the photoquadrats. Crustose coralline algae were found in half of the photoquadrats.

Table F.3.1.1. Average occurrence (%) and average rank for each genera, species, or functional group found within the photoquadrats at Oahu.

	% Occurrence	Rank
<b>Green algae</b>		
<i>Caulerpa</i> sp	10.0	4.0
<i>Dictyosphaeria cavernosa</i>	10.0	7.0
<i>Halimeda</i> sp.	20.0	5.5
<i>Microdictyon setchellianum</i>	30.0	5.3
<i>Neomeris annulata</i>	34.2	6.1
<b>Red algae</b>		
<i>Amansia glomerata</i>	14.2	5.5
<i>Asparagopsis taxiformis</i>	8.3	6.0
<i>gelid</i>	66.7	3.5
<i>Hypnea</i> sp.	10.0	6.0
<i>Jania</i> sp.	20.0	5.5
<i>Martensia</i> sp.	10.0	5.0
<i>Sciniaia hormoides</i>	10.0	6.0
<i>Dictyota</i> sp.	85.8	3.3
<i>Lobophora varigata</i>	19.2	3.8
<i>Padina</i> sp.	28.3	4.0
<b>Others</b>		
Blue-green	86.7	3.2
Turf	95.8	1.0
CCA	55.8	2.9
Sand	16.7	1.5



### F.3.2. Benthic Towed-diver Survey—Algae

Macroalgae was observed throughout the windward side of Oahu, dominating the substrate on the eastern facing forereefs of Manana (Rabbit) Island and reaching 75% cover in some places. Coralline algal cover remained relatively low around the windward towed-diver tracks, never exceeding 10% coverage for any one time segment.

Finally, *Halimeda* was noted for time segments 4-9 in approximately 12-15 meters depth on the third towed-diver survey, along the stretch of forereef northwest of Manana Island and parallel to Waimanalo Beach.

### F.3.3. Corals

#### F.3.3.1 Coral Population Parameters

Table F.3.2.1.1. and Figure J.3.2.1.2. summarize the characteristics of coral populations within belt transects at the two Hawaii sites surveyed for basic coral population parameters in 2006. Neither site had been assessed during the 2005 surveys. A total of 1,091 corals belonging to 15 anthozoan taxa were censused within an area of 100 m<sup>2</sup>. The most numerically abundant taxa were *Porites lobata*, *Pocillopora meandrina*, and *Montipora patula*.

Overall size distribution indicates 61.7% of colonies have a maximum diameter < 10 cm and only 2.8% measure >40 cm maximum diameter. Small colonies therefore dominate the coral communities surveyed at Oahu in 2006.

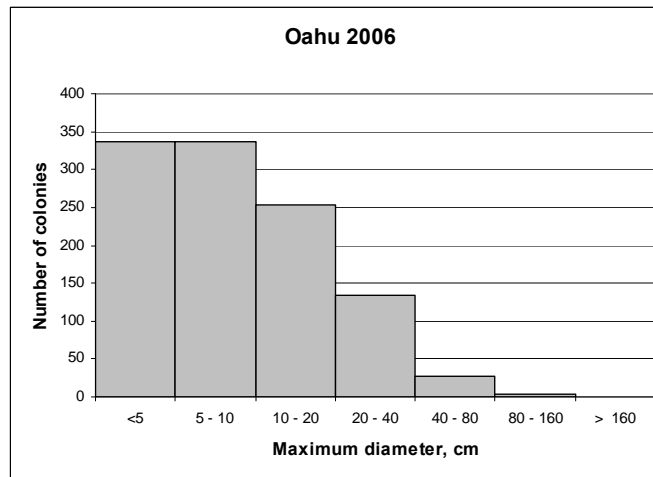


Figure F.3.2.1.1. Size class distribution of 1,091 anthozoan colonies censused within belt transects at Oahu during 2006 REA surveys.

Table F.3.2.1.2. Number of anthozoans counted within belt transects during MHI REA 2006 surveys at Oahu. Taxa contributing more than 10% of total colony abundance are in bold.

Taxon	# of colonies	% of total
<i>Montipora capitata</i>	57	5.2
<i>Montipora flabellata</i>	3	0.3
<i>Montipora incrassata</i>	0	0.0
<i>Montipora patula</i>	160	<b>14.7</b>
<i>Montipora verrilli</i>	0	0.0
<i>Pavona duerdeni</i>	4	0.4
<i>Pavona varians</i>	4	0.4
<i>Cyphastrea ocellina</i>	3	0.3
<i>Leptastrea bewickensis</i>	0	0.0
<i>Leptastrea purpurea</i>	3	0.3
<i>Fungia scutaria</i>	0	0.0
<i>Cycloseris vaughani</i>	0	0.0
<i>Leptoseris incrustans</i>	0	0.0
<i>Pocillopora damicornis</i>	1	0.1
<i>Pocillopora eydouxi</i>	37	3.4
<i>Pocillopora ligulata</i>	0	0.0
<i>Pocillopora meandrina</i>	288	<b>26.4</b>
<i>Porites brighami</i>	5	0.5
<i>Porites compressa</i>	3	0.3
<i>Porites evermanni</i>	15	1.4
<i>Porites lobata</i>	500	<b>45.8</b>
<i>Porites monticulosa</i>	0	0.0
<i>Psammacora nierstraszi</i>	0	0.0
<i>Psammacora stellata</i>	0	0.0
<i>Palythoa sp.</i>	8	0.7
<i>Zoanthus pacifica</i>	0	0.0
<i>Sinularia sp.</i>	0	0.0
<i>Tubastraea coccinea</i>	0	0.0
<i>Cirripathes anguina</i>	0	0.0
<i>Antipathes sp.</i>		0.0
Total # colonies	1091	100
Area surveyed, m <sup>2</sup>	100	

### F.3.3.2 Percent Benthic Cover

Percent benthic cover surveys for the island of Oahu were conducted in congruency with the coral population REA surveys at site OAH-12 (new site); no benthic cover survey was conducted at OAH-13 (also new site). The point-count methodology quantified a total of 102 points along 50 m of ocean fringing, forereef communities. This one survey indicated that the mean percent live coral cover for that site was fairly low: 12.7%, with *Porites* sp. accounting for over 100% of the living corals enumerated along the transect lines. Turf algae also were an important benthic component, accounting for over 84% of the live bottom cover. Table F.3.2.2.1 below provides an

itemized summary of percent cover of the different benthic elements enumerated along the line transects at site OAU-12.

Table F.3.2.2.1 Percent cover of the benthic elements at Oahu using the point-intercept method during the 2006 REA activities.	
Item	% cover
<i>Pocillopora meandrina</i>	0.0
<i>Porites lobata</i>	0.0
<i>Porites compressa</i>	0.0
<i>Porites</i> sp	12.7
<i>Montipora capitata</i>	0.0
<i>Montipora patula</i>	0.0
<i>Montipora flabelallata</i>	0.0
<i>Pavona</i>	0.0
<i>Leptastrea</i>	0.0
<i>Fungia</i>	0.0
Macro-algae	1.0
<i>Halimeda</i>	0.0
<i>Palythoa</i>	0.0
Pavement/cca	0.0
Pavement/cyano	0.0
Pavement/turf	52.0
Rubble/cca	0.0
Rubble/turf	18.6
Dead/cca	0.0
Dead/turf	13.7
Sand	1.0
Other	0.0
Percent live coral cover	12.7

### F.3.3.3 Coral Disease

At Oahu, the coral disease REA surveyed a total area of approximately 350 m<sup>2</sup> at one site (OAH-12) during the reef assessment and monitoring program cruise of 2006. Figure F.3.2.2.1 below illustrates the cumulative number of cases of disease and compromised health states enumerated for site OAH-12. Seven cases of disease (tissue loss, trematodiasis, and growth anomalies) were detected, as well as eight cases of compromised health conditions. Within this category, in the graph below, three cases of *Porites* pigmentation response, three cases of predation, one of discoloration (other than bleaching), and finally, one case of partial mortality and algal overgrowth were counted. At a later date, the data on the graph below will be related to coral colony density (estimated by Dr. Kenyon) and percent live coral cover (above) in order to provide a numerical estimate for disease prevalence and perform within and among island comparisons.

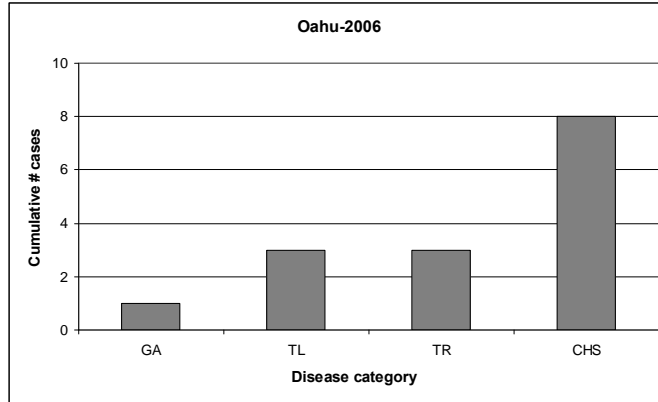


Figure F.3.2.3.1. Cumulative number of cases of disease at Oahu Island during 2006 REA surveys. Total area surveyed: 350 m<sup>2</sup>. GA: growth anomaly; TL: tissue loss; TR: trematodiasis; CHS: compromised health state, including pigmentation responses, predation, and other.

### F.3.3.4 Benthic Towed-diver Survey—Corals

Total hard coral cover was low-moderate along the windward towed-diver surveys. The highest coral cover was recorded between 40 and 50% for the last two time segments of the third towed-diver survey off of Waimanalo Beach in approximately 20 meters of water.

### F.3.4. Macroinvertebrates

There was only one site surveyed at Oahu located on the east shore adjacent to an offshore islet (Flat Island); this environment harbored a healthy and diverse community of coral and macroinvertebrates. Site OAH-13 off Barber’s Point was not surveyed for macroinvertebrates.

Table F.3.3.1. Relative abundance data for echinoderms enumerated during REA surveys for the island of Oahu.	
<b>Island</b>	Oahu
<b>Date</b>	7/27/06
<b>Site</b>	OAH-12
<b>Depth(feet)</b>	
<b>Habitat</b>	islet
Avg/m2	
<b>Echinoids</b>	
Echinostrephus	
Echinometra sp.	0.29
Echinothrix sp.	0.1
Heterocentrotus	0.004
Tripneustes	0.004
Diadema	
Pseudobolentia	
Other Echinoid	0.01

<b>Holothuroids</b>	
Holothuria atra	
Holothuria whitmaei	0.002
Actinopyga obesa	
Actinopyga mauritiana	
Other Holothuroid	0.02
<b>Asteroidea</b>	
Linckia multifora	
Linckia guildingi	
Acanthaster planci	0.002
Mithrodia fisheri	0.002
Other Asteroid	
Culcita	

### **F.3.5. Benthic Towed-diver Survey – Macroinvertebrates**

Overall macroinvertebrate counts remained mixed along the windward coast of Oahu. Sea urchins were the most abundant, with 7/20 time segments (completed during the first two towed-diver surveys) recording an average of 175 urchins. Higher counts (two-time segments numbering 350 urchins recorded during two-time segments; 750 urchins recorded during one-time segment) were also noted at three locations along the first two tows, with the greatest overall concentration occurring along the eastern forereef of Manana (Rabbit) Island. It is interesting to note that the maximum number of urchins recorded during the third survey never exceeded 11, which indicated a significant drop in overall counts as surveys headed north along the windward coast.

Crown-of-thorns starfish were uncommon along the windward coast of Oahu, with no more than two individuals recorded during any time segment and a total of seven recorded for all three towed-diver surveys. Similarly, sea cucumber numbers remained low, with no more than two individuals recorded during any time segment and a total of nine recorded for all three towed-diver surveys.

### **F.4. Fish**

Two sites were surveyed on Oahu. A total of 82 species were recorded (in both Belt and stationary point count (SPC) surveys). Of the 882 fishes counted, 50% were blackfin chromis, (*Chromis vanderbilti*). The saddle wrasse (*Thalassoma dupperey*), manybar goatfish (*Parupeneus multifasciatus*), orangeband surgeonfish (*Acanthurus olivaceus*), belted wrasse (*Stethojulis balteata*), and arceye hawkfish (*Paracirrhites arcatus*) comprised 18% of the remaining fishes.

#### Fish >25 cm TL:

Belt Transects: Eight fishes measuring  $\geq 25$  cm were counted on the belt transects. Ten species, mostly surgeonfishes, were recorded.

SPCs: Ninety-two fishes representing 20 species were counted on the SPCs. Approximately 70% of these fish were surgeonfishes, snappers (Lutjanidae), and triggerfishes (Balistidae).

Towed-diver Surveys (fish >50 cm TL):

At Oahu, the towed-diver team completed three dives over the course of 1 day covering 6.38 km of sea floor (Fig. F.4.1). Because it was the first day of operations and as Oahu is heavily monitored by other groups, our surveys were limited to the eastern tip of the island near Makapu'u Point. Surveys averaged 2.04 km in length and ranged from 1.97 km to 2.38 km. Median mean depth was -13.58 m.

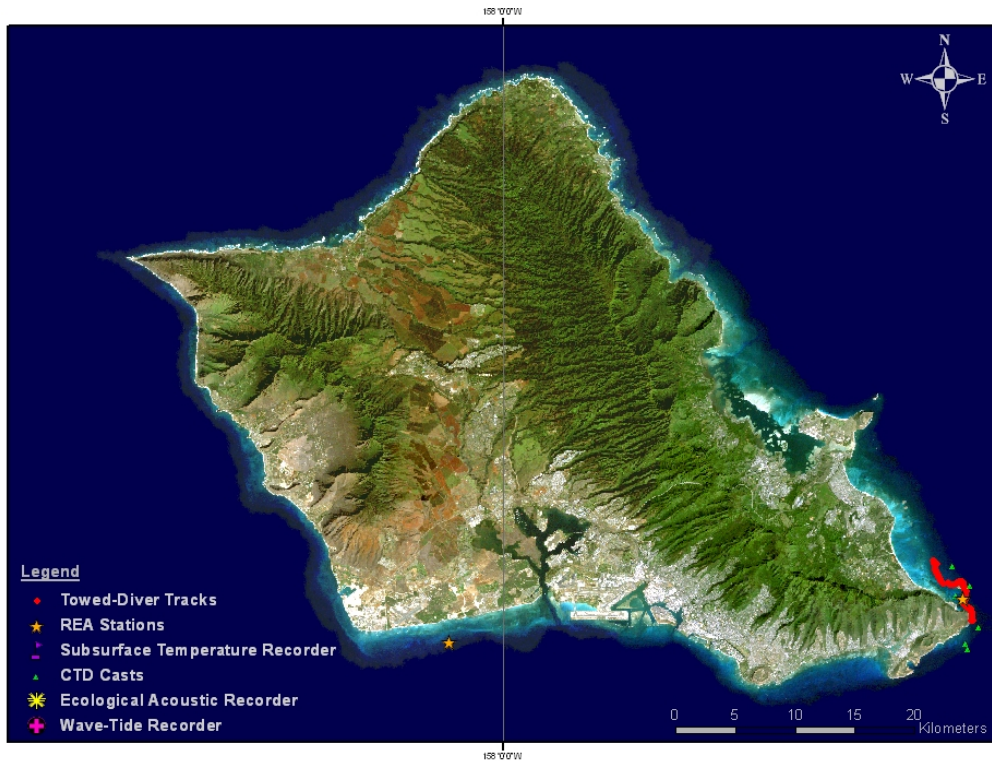


Figure F.4.1 HI-06-10 sampling stations at Oahu Island. Efforts were greatly limited at Oahu due to its high accessibility. The sampling station at the eastern end of the island was used as a “shake-down” effort on the first day of the mission.

At Oahu, nine species were observed (Figs. F.4.2 - F.4.3). Given the small sample size, the data for Oahu are not significant. Numeric density was slightly higher for undifferentiated moray eels (*Gymnothorax* sp.) followed by undifferentiated surgeonfishes (*Acanthurus* sp.) and cornetfish (*Fistularia commersonii*). Biomass was highest for manta rays (*Manta birostris*) followed by undifferentiated moray eels and the orangespine unicornfish (*Naso lituratus*).

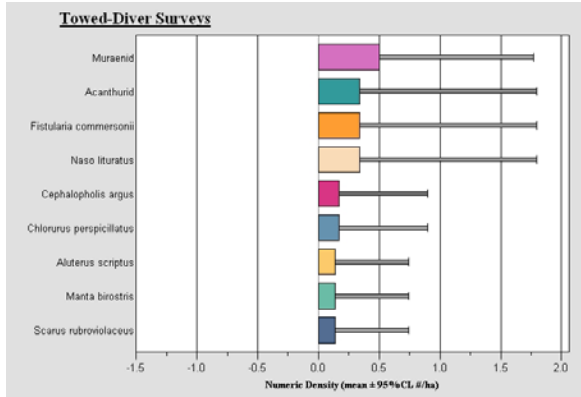


Figure F.4.3 Numeric Density (#/ha) of species at Oahu.

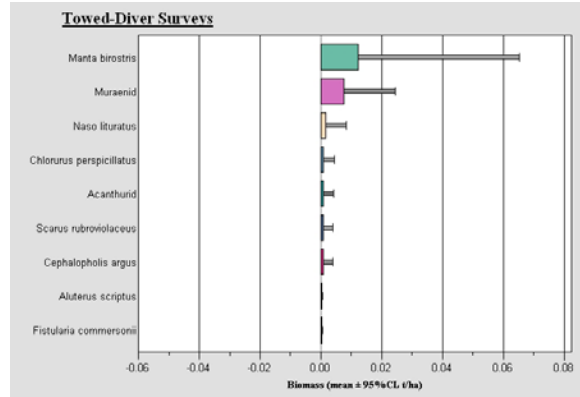


Figure F.4.3 Biomass Density (t/ha) of species at Oahu.

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## Appendix G: Molokai

### G.1. Oceanography & Water Quality

Figure G.1 plots subsurface temperature recorder (STR) data recovered from two sites: NW side of Molokai at REA site 1 and at the west end of the south side of the island at REA site 3 in 10.4 m and 19.5 m of water depths, respectively.

Figure G.1.1

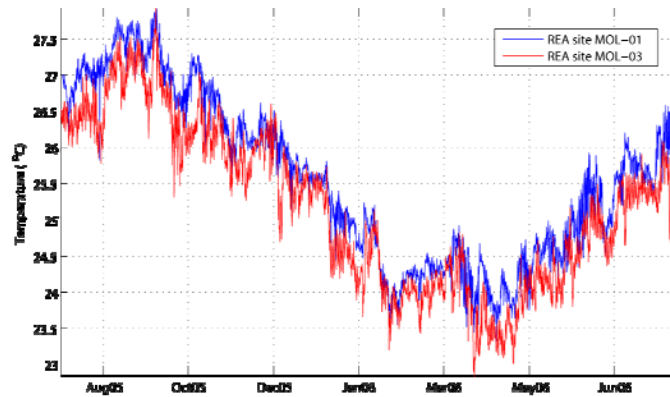


Figure G.1.2 shows interpolated shallow conductivity-temperature-depth (CTD) cast data – 10 m depths around Molokai. CTD measurements here were essentially very similar; with best mixed, lowest turbidity water east of Kalaupapa.

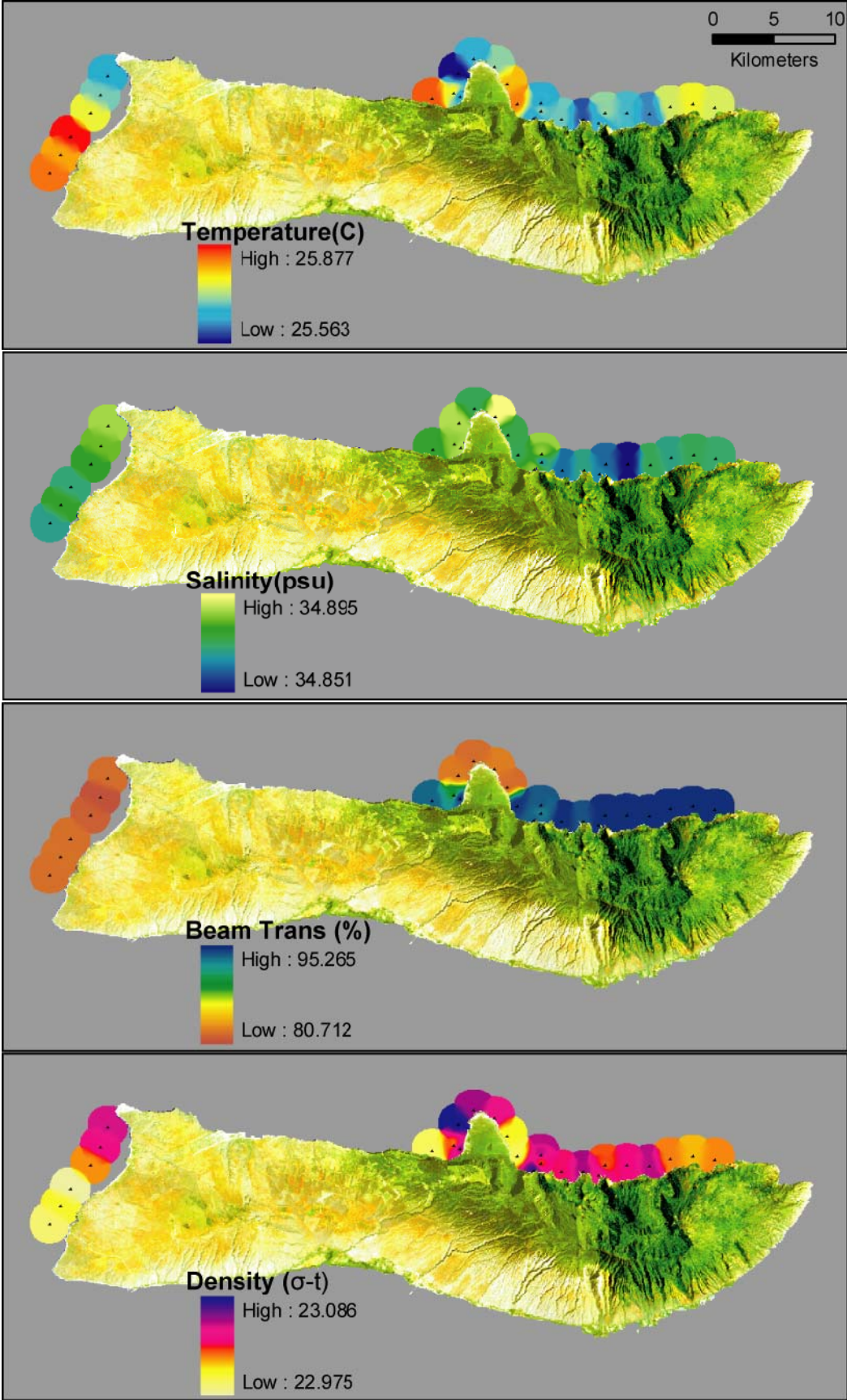


Figure G.1.2

## **G.2. Rapid Ecological Assessment (REA) Site Descriptions**

### MOL-5

July 29, 2006

E-NE, ocean fringing reef. Flat carbonate platform. Depth range: 9.3–11 m; visibility ~10 m. Algal cover was moderate with usually small macroalgae. The dominant algae were turf algae, *Microdictyon*, *Martensia*, *Padina*, *Dictyota*, and *Dictyosphaeria*. Crustose coralline algae, *Neomeris*, *Lobophora*, *Laurencia*, and *Dictyopteris* were also seen within the photoquadrats. During the random swim, lots of *Trichogloea* were recorded as well as *Hypnea* and branching corallines. *Botryocladia* was observed. The benthic substrate was mostly carbonate pavement covered by algal turf (~80%). Coral cover was low (5.8%) with the dominant corals being *Porites* spp. and *Pocillopora* spp. (*P. meandrina*, *P. ligulata*, and *P. damicornis*). Other corals observed in the survey area included: *Pavona varians* and *Cycloseris*. Also, within the area surveyed (~375 m<sup>2</sup>), five cases of trematodiasis on *Porites* and one case of growth anomaly on *Porites* were observed. Additionally, one case of discoloration on *Porites* was detected. It is unclear if this condition poses any health threat to the coral. Also, this site exhibited a fairly diverse assemblage of invertebrates which included the mobile xanthid and other small crabs, hermits, brittle stars, callianassid shrimp, cone snails and other gastropods, and two species of urchins (*Tripneustes* and *Echinometra* the most dominant fauna at the site). The sessile fauna (found mainly on the underside of the loose rocks) was made up of encrusting sponges, bryozoans, didemnum tunicates, and Christmas tree worms (*Spirobranchus*). The saddle wrasse (*Thalassoma duperrey*) was the most abundant of the smaller fish species, while the triggerfishes (Balistidae) represented the larger fishes in the area.

### MOL-6

August 14, 2006

Mokapu Islet, east of Kalaupapa peninsula. Depth range: 13–16.4 m. Steep slope (~50°) of basalt wall. Algal communities were dominated by turf algae, crustose algae, and *Dictyota friabilis*. *Jania*, *Lobophora* and *Topolytiocladia* were also abundant in the photoquadrats. Substrate consisted of turf-covered pavement (38%), pavement with encrusting coralline algae (22%). Coralline algae encrusting dead coral heads comprised 10% of substrate. Percent live coral cover on wall was 25%; moderate coral diversity dominated by *Porites* spp. and *Pocillopora* spp. (*P. meandrina*, *P. ligulata*). Other corals observed in the transect area included: *Pavona varians*, *Montipora capitata*, and *Palythoa* spp.; *Pocillopora molokensis* common as well as zoanthids *Protopalythoa* and *Zoanthus*. One single colony *Leptoseris scabra* observed. Additionally, three cases of growth anomalies on *Porites*, three cases of pigmentation response on *Porites*, and one case of potential infestation by tube-worms were detected. Also, at this site, the mobile macroinvertebrate fauna was made up of the urchins *Echinothrix calamaris*, the sea cucumber *Holothuria atta*, and the sea stars *Mithrodia fisheri* and *Culcita novaeguinea*. The red sponge *Clathria* was abundant throughout, as were the zoanthids *Protopalythoa*, *Zoanthus*, and *Palythoa*. The nudibranchs *Chromodoris vibrata*, *Halgerda terramuentis*, and *Hexabranhus sanguineus* were all noted within the study site. The octocoral *Sarcothelia edmondsoni* was abundant but *Carijoa rissei* was rare. The dominant small fish species was the blackfin chromis (*Chromis vanderbilti*) followed closely by the saddle wrasse. The milletseed butterflyfish (*Chaetodon miliaris*) and arceye hawkfish (*Paracirrhites arcatus*) were common. Numerous bandit angelfish (*Desmohola-*

*canthus arcuatus*) were observed around 70 feet. At 20 feet depth, many surge species were observed; at 50 feet, bluehead (*Chaetodon Kleinii*) and milletseed butterflyfish and Potter's angelfish (*Centropyge potteri*) were common. Below about 70 feet, red-lip parrotfish (*Scarus rubroviolaceus*) and large-bodied surgeonfishes, mainly bluespined unicornfish (*Naso unicornis*), sleek unicornfish (*Naso hexacanthus*), and paletail unicornfish (*Naso brevirostris*) were common.

## MOL-7

August 14, 2006

Small, shallow offshore ridge between Pelekunu Bay and Mokohola Islet, N side. Depth range: 11–16 m; large, jumbled, rocky slabs. Algal cover was high while algal diversity was pretty low. Algal communities were dominated by turf algae, crustose corallines, *Lobophora* and blue-green algae. *Dictyota*, *Amansia*, and *Jania* were also commonly seen in photoquadrats. Benthic cover: Boulder/rubble substrate with turf algae (53%); live coral cover 31%. Moderate coral diversity dominated by *Porites* spp. and *Pocillopora meandrina*. Other corals observed in the survey area included: *Pavona varians*, *Montipora capitata*, *Pocillopora ligulata*, *Palythoa*, *Leptastrea* spp. and *P. molokensis*; *Zoanthids* also abundant. Additionally, one case of growth anomaly on *Porites*, three cases of pigmentation responses on *Porites*, one case of partial mortality on *Porites*, one case of heavy predation on *Pocillopora*, and one case of potential tissue thinning on *Porites* were detected. Several *Pocillopora* spp. colonies in the general transect area showed signs of heavy predation. Abundant invertebrate macrofauna was present; *Octopus cyanea* and the gastropods *Cypraea tigrina* and *Cypraea maculifera* were common. The nudibranchs *Phyllidia varicose* and *Hexabranhus sanguineus* were common. The sessile fauna was primarily made up of the sponge *Clathria*, the zoanthid *Palythoa caesia*, and the tunicate *Aplidium*. The urchin *Echinothrix calamaris* was abundant and the sea cucumber *Holothuria whitmaei* was rare. There was a single sighting of the large xanthid brachyuran *Carpilius convexus* and the lobster *Panulirus marginatus*. The bluelined snapper (*Lutjanus kasmira*) was most numerous among the larger fishes. The eyestripe surgeonfish (*Acanthurus dussumieri*), bigscale soldierfish (*Myripristis berndti*), Hawaiian bigeye (*Priacanthus meeki*) and redlip parrotfish were common. The smaller fishes were numerically dominated by the blackfin chromis (39% of all fish counted). The oval chromis, saddle wrasse and arceye hawkfish were common.

### **G.3. Benthic Environment**

#### **G.3.1. Algae**

Three sites were surveyed north of Molokai. One site had low visibility because of high sediment resuspension (MOL-5) and the habitat was flat (no roughness at all). The two other sites were a pinnacle and a vertical wall; so very different habitats. Algal diversity was moderate in general, and the prevailing algae in benthic communities were turf algae, crustose coralline algae, *Jania*, *Lobophora*, and *Dictyota* (Table G.3.1.1). A total of 22 algal genera and 3 functional groups were found within the photoquadrats (27 genera if random swim data are included). The algal cover and algal diversity varied from east to west on the northern side of Molokai. The flat reef located northwest of Molokai showed a higher diversity than the other northern reefs while a high sedimentation rate occurred. *Microdictyon setchellianum*, *Halimeda discoidea*, and *Martensia* sp. were commonly seen within the photoquadrats only at the northwestern reef. In contrast,

*Jania*, *Gelid*, *Amansia glomerata*, and *Dictyota friabilis* were commonly seen only at the two other reefs. Those differences are probably due to the different nature of the reefs surveyed (vertical wall of an islet, flat bioeroded reef and pinnacle). However, turf algae, crustose coralline algae, and blue-green algae were prevailing in algal communities at the three sites.

Table G.3.1.1 Average occurrence (%) and average rank for each genera, species, or functional group found within the photoquadrats at Molokai.

	% Occurrence	Rank
<b>Green algae</b>		
<i>Acetabularia sp.</i>	8.3	7.0
<i>Dictyosphaeria cavernosa</i>	33.3	2.8
<i>Dictyosphaeria versluysii</i>	33.3	4.3
<i>Halimeda discoidea</i>	91.7	4.6
<i>Microdictyon setchellianum</i>	33.3	4.7
<i>Neomeris annulata</i>	8.3	10.0
<i>Rhipidosiphon javensis</i>	8.3	8.5
<b>Red algae</b>		
<i>Acanthophora pacifica</i>	16.7	5.0
<i>Amansia glomerata</i>	22.2	5.3
<i>Botryocladia skottsbergii</i>	8.3	6.0
<i>Chondria</i>	8.3	4.0
<i>Dasya sp.</i>	8.3	7.0
<i>Gelid</i>	41.7	6.0
<i>Jania sp.</i>	87.5	5.0
<i>Laurencia sp.</i>	8.3	9.0
<i>Liagora sp.</i>	8.3	5.0
<i>Martensia sp.</i>	66.7	5.1
<i>Tolypocladia glomerulata</i>	16.7	5.2
<b>Brown algae</b>		
<i>Dictyopteris palagiogramma</i>	33.3	7.3
<i>Dictyota sp.</i>	38.9	4.8
<i>Dictyota ceylanica</i>	8.3	6.0
<i>Dictyota friabilis</i>	70.8	2.6
<i>Lobophora varigata</i>	55.6	4.4
<i>Padina sp.</i>	16.7	6.0
<i>Padina melemele</i>	8.3	7.0
<i>Sargassum sp.</i>	8.3	5.0
<b>Others</b>		
Blue-green	44.4	6.0
Turf	100.0	1.3
CCA	94.4	2.6

### **G.3.2. Benthic Towed-diver Survey—Algae**

It is important to note that the towed-diver surveys completed along the northern coastline of Molokai recorded large swaths of low-relief flats, with little visible biological growth. The towed-diver survey near Waiehu Point/Wailau had 7/10 5-minute segments at 100% sand cover, while a survey completed between Umilehi Point and Pahau Point resulted in 5/10 segments of total sand cover.

Towed-diver surveys along the leeward/western coast of Molokai noted higher macroalgae cover (up to 75% benthic cover in some areas) in varied low to medium-high complexity habitat, including areas of sparse *Halimeda* patches. Coralline algae was recorded at a range of 0–10% per 5-minute time segments overall benthic cover on the leeward side.

Small *Halimeda* patches were also noted in the area west of Okala Island, near Waikolu between 16 and 20 meters depth.

### **G.3.3. Corals**

#### **G.3.3.1 Coral Population Parameters**

Table G.3.2.1.1. and Figure G.3.2.1.2. summarize the characteristics of coral populations within belt transects at the three Molokai sites surveyed for basic coral population parameters in 2006. Of these three sites, none had been assessed in 2005; all were new sites. A total of 1,040 corals belonging to 20 anthozoan taxa were censused within an area of 150 m<sup>2</sup>. The most numerically abundant taxa were *Porites lobata* and *Pocillopora meandrina*. Zoanths belonging to three genera (*Palythoa*, *Protospalythoa*, and *Zoanthus*) were particularly abundant at MOL-6 (Mokapu Islet) east of the Kalaupapa Peninsula. A single colony of *Leptoseris scabra*, not previously seen by the author during hundreds of dives in the Hawaiian Archipelago, was also seen at this location outside the belt transects.

Overall size distribution indicates 62.6% of colonies have a maximum diameter <10 cm, and only 1.3% measure >40 cm maximum diameter. Small colonies therefore dominate coral communities surveyed at Molokai.

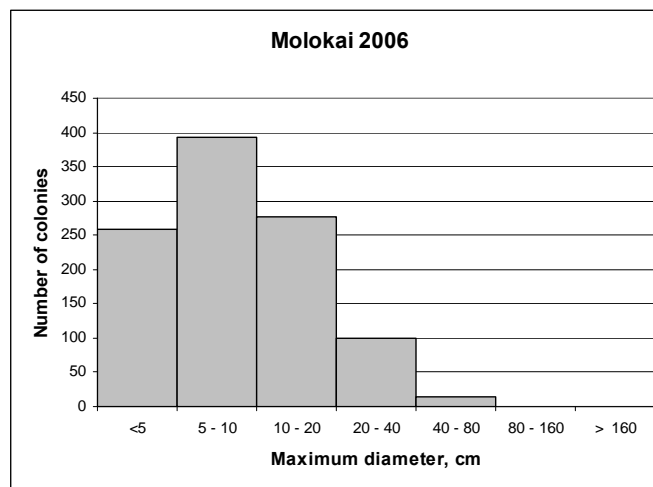


Figure G.3.2.1.1 Molokai-Corals. Size class distribution of 1,040 anthozoan colonies censused within belt transects at Molokai during 2006 REA surveys.

Table G.3.2.1.2. Number of anthozoans counted within belt transects during MHI REA 2006 surveys at Molokai. Taxa contributing more than 10% of total colony abundance are in bold.

Taxon	# of colonies	Percent of total
<i>Montipora capitata</i>	17	1.6
<i>Montipora flabellata</i>	0	0.0
<i>Montipora incrassata</i>	0	0.0
<i>Montipora patula</i>	23	2.2
<i>Montipora verrilli</i>	0	0.0
<i>Pavona duerdeni</i>	19	1.8
<i>Pavona maldivensis</i>	1	0.1
<i>Pavona varians</i>	9	0.9
<i>Cyphastrea ocellina</i>	0	0.0
<i>Leptastrea bewickensis</i>	0	0.0
<i>Leptastrea purpurea</i>	2	0.2
<i>Fungia scutaria</i>	0	0.0
<i>Cycloseris vaughani</i>	2	0.2
<i>Leptoseris incrustans</i>	0	0.0
<i>Pocillopora damicornis</i>	12	1.2
<i>Pocillopora eydouxi</i>	15	1.4
<i>Pocillopora ligulata</i>	10	1.0
<i>Pocillopora meandrina</i>	362	<b>34.8</b>
<i>Pocillopora molokensis</i>	20	1.9
<i>Porites brighami</i>	2	0.2
<i>Porites compressa</i>	70	6.7
<i>Porites evermanni</i>	1	0.1
<i>Porites lobata</i>	390	<b>37.5</b>
<i>Porites monticulosa</i>	0	0.0
<i>Psammacora nierstraszi</i>	0	0.0
<i>Psammacora stellata</i>	25	2.4
<i>Palythoa sp.</i>	56	5.4
<i>Protopalythoa sp.</i>	2	0.2
<i>Zoanthus pacifica</i>	2	0.2
<i>Sinularia sp.</i>	0	0.0
<i>Tubastraea coccinea</i>	0	0.0
<i>Cirrhopathes anguina</i>	0	0.0
<i>Antipathes sp.</i>	0	0.0
Total # colonies	1040	100.0
Area surveyed, m2	150	

### G.3.3.2 Percent Benthic Cover

Percent benthic cover surveys for the island of Molokai were conducted in congruency with the coral population REA surveys at three different sites; one on the north-northeast shore and two along the north, northwest shore, east of Kalaupapa peninsula. The point-count methodology quantified a total of 306 points along 150 m of ocean fringing, forereef communities, indicating

that the mean percent live coral cover for all sites combined was moderate: 20.9%. The most numerically abundant scleractinian taxa in order of importance were: *P. meandrina* (62.5%), *P. lobata* (34.4.6%), followed by *M. capitata* and *Pavona* sp. (1.5% each). Turf algae also were an important component accounting for 57% of the living benthos. Table G. 3.2.2.1 below provides an itemized summary of percent cover of the different benthic elements enumerated along the line transects at Molokai.

Table G.3.2.2.1 Percent cover of the benthic elements at Molokai using the point-intercept method during the 2006 REA activities.

<b>Item</b>	<b>% Cover</b>
<i>Pocillopora meandrina</i>	13.1
<i>Porites lobata</i>	7.2
<i>Porites compressa</i>	0.0
<i>Porites</i> sp	0.0
<i>Montipora capitata</i>	0.3
<i>Montipora patula</i>	0.0
<i>Montipora flabelallata</i>	0.0
<i>Pavona</i>	0.3
<i>Leptastrea</i>	0.0
<i>Fungia</i>	0.0
Macro-algae	0.0
<i>Halimeda</i>	0.0
<i>Palythoa</i>	1.0
Pavement/cca	8.2
Pavement/cyano	0.0
Pavement/turf	39.2
Rubble/cca	2.0
Rubble/turf	17.6
Dead/cca	5.6
Dead/turf	1.0
CCA	0.7
Sand	3.3
Other	0.7
<b>Percent live coral cover</b>	<b>20.9</b>

### **G.3.3.3 Coral Disease**

At Molokai, the coral disease REA surveyed a total area of approximately 975 m<sup>2</sup> at three different sites, during the reef assessment and monitoring program cruise of 2006. Figure G.3.2.3.1 below illustrates the cumulative number of cases of disease and compromised health states enumerated for all sites combined. The compromised health state category includes seven cases of *Porites* pigmentation responses associated with algal overgrowth, four cases of predation of *P. ligulata*, and three cases involving: tissue thinning, over-pigmentation, and potential parasites on *P. meandrina*.



At a future date, these data will be related to coral colony density (estimated by Dr. Kenyon) and percent live coral cover (above) in order to provide a numerical estimate for disease prevalence and perform within and among island comparisons.

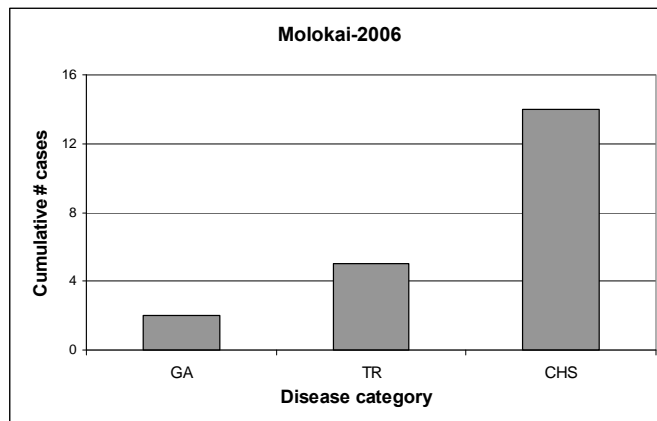


Figure G.3.2.3.1. Cumulative number of cases of disease at Molokai Island during 2006 REA surveys. Total area surveyed: 975 m<sup>2</sup>. GA: growth anomaly; TR: trematodiasis; CHS: compromised health state, including: pigmentation responses, predation, parasitism, over-pigmentation, and apparent tissue thinning.

#### **G.3.3.4 Benthic Towed-diver Survey—Corals**

Northern Molokai was characterized by relatively low hard coral cover, with many surveys including large tracts of 100% sandy bottom (northern coastline).

Molokai recorded an overall average of 9% hard coral cover for all combined towed-diver surveys. The highest hard coral cover recorded for Molokai was found during the towed-diver survey completed near the Molokai Lighthouse, with an average of 32% observed hard coral cover. The three towed-diver surveys along the leeward coast recorded a range of 1–30% coral cover, with an overall average of 7.5%. Stressed coral was also noted on the leeward coast, averaging almost 3% (of all hard coral) over the three surveys. Stressed coral appeared to peak in the hard coral between the survey conducted at Na Puu Kulua and Kaunalu, with two time segments recording 10% stress levels of all hard coral in approximately 15 meters depth.

Soft coral cover was low, never exceeding 5% overall bottom cover in the north and never exceeded 1% along leeward surveys. *Sinularia* was the genus most commonly sighted, especially during the survey between Kukaiwaa Point to Waikolu and the survey between Umilehi Point and Pahu Point. Finally, a single record for black tree coral was noted between 18 and 25 meters during the latter survey in an area of high complexity along the face of a vertical pinnacle.

#### **G.3.4. Macroinvertebrates**

This island had three sites on different sides of the island. The north site was a protected bay with a diverse community of molluscs and soft bodied animals such as zoanthids, soft coral, and

nudibranchs. The west site was a steep wall area which created good habitat for a diverse community, mainly echinoderms and zoanthids and sponges. The east site was exposed to anthropogenic input and as a result, had a less diverse invertebrate community structure without the cnidarian fauna seen at the other sites.

Table G.3.3.1-Relative abundance data for echinoderms enumerated during REA surveys for the island of Molokai.			
Island	Molokai	Molokai	Molokai
Date	8/14/2006	8/14/2006	7/29/2006
Site	MOL-6	MOL-7	MOL-5
Depth(feet)	45	50	
Habitat	Islet Wall	Pinnacle	
	Avg/m2	Avg/m2	Avg/m2
<b>Echinoids</b>			
Echinostrephus			
Echinometra sp.			
Echinothrix sp.	0.009	0.036	
Heterocentrotus			
Tripneustes			0.02
Diadema			
Pseudobolentia			
Other Echinoid			
<b>Holothuroids</b>			
Holothuria atra	0.002		0.004
Holothuria whitmaei			
Actinopyga obesa			
Actinopyga mauritiana			
Other Holothuroid			
<b>Asteroidea</b>			
Linckia multifora			
Linckia guildingi			
Acanthaster planci			
Mithrodia fisheri	0.002		
Other Asteroid	0.002		
Culcita			

### **G.3.5. Benthic Towed-diver Survey—Macroinvertebrates**

Crown-of-thorns starfish were rarely reported during towed-diver surveys of Molokai, with only three noted during all combined surveys. Sea cucumbers were also uncommon, never exceeding seven individuals during any 50-minute survey. Finally, sea urchins were highest in the north-western survey around Ilio Point (average 45.6 urchins/5-minute time segment), with all other towed-diver surveys recording significantly fewer numbers.

#### **G.4. Fish**

Three sites were surveyed on Molokai. A total of 99 species and 1,153 fishes were recorded (in both Belt and stationary point count (SPC) surveys). Forty-five percent of the fishes counted were damselfishes, 19% wrasses, 8% hawkfishes, and 7% surgeonfishes. The blackfin chromis was numerically dominant (33%), followed by saddle wrasse (13%), arceye hawkfish (7%), oval chromis (6%) and bluestripe snapper (5%).

##### Fish $\geq 25$ cm TL:

Belt Transects: Seventy-three fishes representing 13 species measuring  $\geq 25$  cm were counted on the belt transects. Thirty-six percent were bluestripe snapper, 16% surgeonfishes, 16% Hawaiian bigeye, and 14% bigscale soldierfish.

SPCs: Eighty-nine fishes representing 18 species were recorded on the SPCs. Thirty-nine percent were surgeonfishes, 19% triggerfishes, and 12% bluestripe snapper.

##### Towed-diver Surveys (fish $> 50$ cm TL):

At Molokai, the towed-diver team completed seven dives over the course of 2 days covering 18.41 km of sea floor (Fig. G.4.1). Surveys were concentrated on the west coast and the eastern portion of the northern coast. Surveys averaged 2.68 km in length and ranged from 2.10 km to 3.19 km. Median mean depth was  $-15.71$  m.

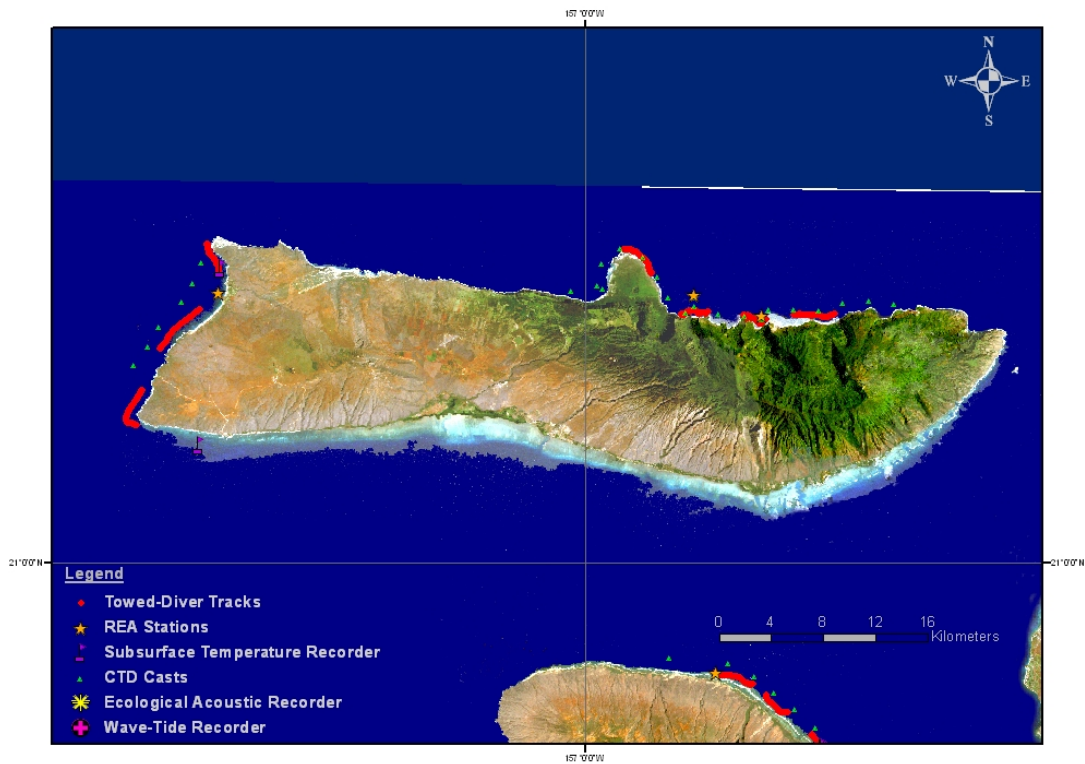


Figure G.4.1 HI-06-10 sampling stations at Molokai Island. Efforts were limited along the southern coast which is more easily accessible. Efforts along much of the northern coast were hampered by high winds and seas.

At Molokai, eight species were observed (Figs. G.4.2 – G.4.3). Numeric density was dominated by the redlip parrotfish followed by the sleek unicornfish and the green jobfish (*Aprion virescens*). Biomass was dominated by the redlip parrotfish followed by the sleek unicornfish and the spectacled parrotfish (*Chlorurus perspicillatus*).

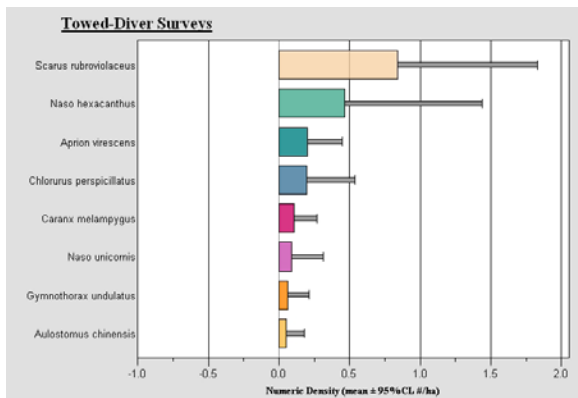


Figure G.4.2 Numeric Density (#/ha) of species at Molokai.

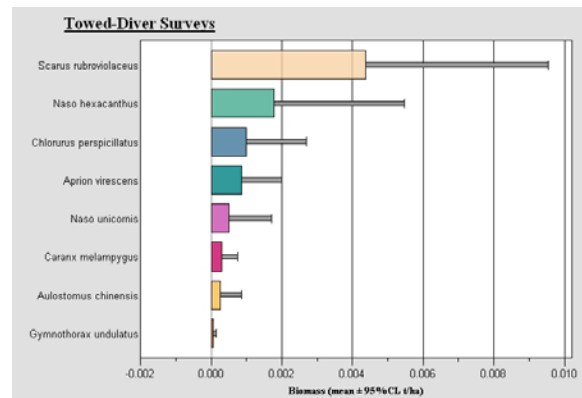


Figure G.4.3 Biomass Density (t/ha) of species at Molokai.

## Appendix H: Maui

### H.1. Oceanography & Water Quality

No moored instruments were recovered in Maui.

Figure H.1 shows interpolated shallow conductivity-temperature-depth (CTD) cast data—10-m depths around Maui. CTD data north coast of the island east of Kahului exhibited clear water with relatively higher salinity, e.g., typical of oceanic water. An area of anomalous high turbidity water was encountered just to the west of Hana Airport; other areas show influence of coastal processes, particularly Kahului Harbor area.

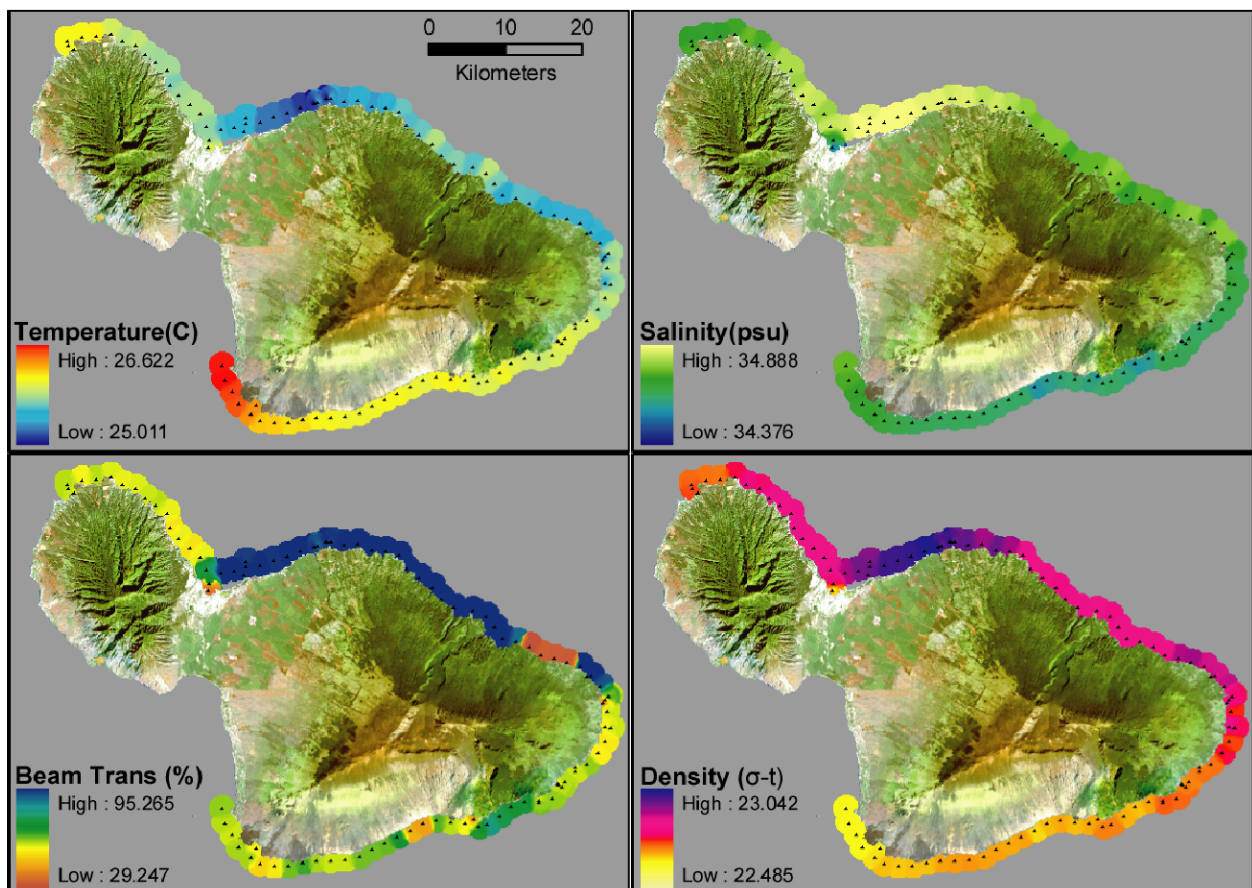


Figure H.1.1

### H.2. Rapid Ecological Assessment (REA) Site Descriptions

MAI-10

July 30, 2006

N-NW. Basalt boulders. Depth range: 13.6–18 m; visibility ~15 m. Algal cover was high. Algal communities were dominated by turf algae, crustose corallines, *Lobophora*, *Dictyota*, and *Jania*. *Neomeris*, *Padina*, and *Microdictyon* were also encountered in the photoquadrats. Turf algae on

the rocky boulders comprised 73% of the benthic cover. Percent live coral cover was 16.7%, and the coral community was dominated by *Porites* spp., with occasional *Pocillopora meandrina*. Also, within the total area surveyed (300 m<sup>2</sup>), five cases of growth anomalies on *Porites*, two cases of trematodiasis on *Porites*, and three cases of compromised health conditions (predation?) on *Porites* were detected. Additionally, the smaller boulders were loose and formed agglomerations of holes and hiding places, which accommodated a diverse group of invertebrates (both sessile and mobile) including didemnum tunicates, bryozoans, sea stars (*Linckia multifora* and *Acanthaster*), *Eucidaris* urchins, sea cucumbers, molluscs (gastropods, bivalves, and nudibranchs) and other polychaetes. The most common invertebrates were the bryozoan *Reteporillina* (found mainly under ledges) and the zoanthid *Palythoa caesia*. This site had very good diversity of fishes. The oval chromis (*Chromis ovalis*), blackfin chromis (*Chromis vanderbilti*), and the goldring surgeonfish (*Ctenochaetus strigosus*) were most numerous on the belt transect (BLT). The yellowstripe goatfish (*Mulloidichthys flavolineatus*), the orangespine unicornfish (*Naso lituratus*), and the bigeye emperor (*Monotaxis grandoculis*) were the larger bodied fishes at this station.

#### MAI-11

July 30, 2006

N-NW. Basalt boulders. Depth range: 4.5–6.0 m; visibility ~20 m. Algal cover was high and algal communities were dominated by turf algae, crustose corallines, blue-green algae, *Dictyota*, and *Jania*. *Lobophora variegata* was also very abundant. Turf algae on the rocky boulders comprised 60%. Percent coral cover was comparable to site MAI-10 (16.7%), as was the relative coral species richness. Also, within the area surveyed (300 m<sup>2</sup>), 18 cases of *Porites* trematodiasis, 8 cases of tissue loss on *Porites*, 1 case of mild, patchy and multifocal bleaching on *Porites*, and 1 case of growth anomaly on *Porites* were detected. Also, five cases of compromised health conditions on *Porites* were observed, consisting of pigmentation responses associated to algal overgrowth. The non-coral invertebrate fauna at this site was very similar to the previous site (which was just W of site 10) in abundance and diversity. However, this site had a higher diversity of sponges and also had some patches of soft coral (*Sinularia*). There was also a large palinurid lobster. Additionally, the blackfin chromis (*Chromis vanderbilti*), the goldring surgeonfish (*Ctenochaetus strigosus*), the brown surgeonfish (*Acanthurus nigrofuscus*), and the bigscale soldierfish (*Myripristis berndti*) were the most numerous on the BLT. The paletail unicornfish (*Naso brevirostris*) and the bullethead parrotfish (*Chlorurus sordidus*) were most numerous on the SPC.

#### MAI-12

July 30, 2006

N-NW, ocean fringing reef. Corals growing on basalt boulders. Depth range: 13–15.5 m; visibility ~20 m. Algal communities were dominated by turf algae, crustose corallines, blue-green algae, *Dictyota*, and *Jania*. *Lobophora variegata* was also abundant. Turf algae on the rocky boulders comprised nearly 60% of the bottom cover, and percent live coral cover was 18.6%. Although the coral community seemed to be dominated by *Porites* spp., the line intercept method indicated that following relative coral percent cover composition: *Montipora* spp 47.3 %, *Pocillopora* 26.3%, *Porites* 20.9%, and *Pavona*, 4.8%. Other corals present in the general vicinity in-

cluded *Montipora capitata*, *M. patula*, *Pocillopora eydouxi*, *P. meandrina*, *Fungia scutaria*, *Lepastrea traversa*, and *Pavona varians*. Also, within the area surveyed (300 m<sup>2</sup>): one case of mild, patchy bleaching on *Porites*, three cases of growth anomalies on *Porites*, six cases of *Porites* trematodiasis, and two cases of compromised health on *Porites* consisting of pigmentation responses, associated with algal overgrowth were observed. Additionally, there were similarities to the previous two sites in the types of invertebrates and the diversity of both encrusting and semi-mobile species, the exceptions being a spaghetti worm (*Lomia medusa*) and medium sized octopus at the end of the second transect. The blackfin chromis (*Chromis vanderbilti*), goldring surgeonfish (*Ctenochaetus strigosus*), brown surgeonfish (*Acanthurus nigrofuscus*), oval chromis (*Chromis ovalis*), and the saddle wrasse (*Thalassoma duperrey*) were the most numerous on the BLT. The orangespine unicornfish (*Naso lituratus*), bigeye emperor (*Monotaxis grandoculis*), and the smalltooth jobfish (*Aphareus furca*) were the larger bodied fish at this station.

#### MAI-13

July 31, 2006

E-SE. Basalt ridges and boulders heavily epiphytized with algal turf. Gullies between ridges with sand and rubble. Depth range: 9.6–10.6 m; visibility ~20 m. Algal cover was high, basically due to turf algae. However, *Jania*, *Dictyota*, *Dasya*, and crustose coralline algae were also abundant. Coral cover was rather low: 11.7%. Coral community dominated by *P. lobata* and *P. meandrina*; also, numerous recruits *Pocillopora* and *Porites*. Also, one case of bleaching on *Porites*, two cases of *Porites* trematodiasis, and one case of compromised health on *Porites* consisting of pigmentation response associated with algal overgrowth were detected. At this site, the rocky boulders were also covered by large accumulations of at least five different species of sponge. The most common invert fauna were the sponges (relatively high abundance under ledges and on vertical slopes of the islet), three species of urchin, small crustaceans (hermits, burrowing shrimp and coral shrimp), and a few patches of the common zoanthid (*Palythoa*). Also of mention were the molluscs (both gastropods- cones and bivalves- pen shells). The blackfin chromis (*Chromis vanderbilti*) and the saddle wrasse (*Thalassoma duperrey*) were the most numerous on the BLT. The orangeband surgeonfish (*Acanthurus olivaceus*) was the larger bodied fish at this station.

#### MAI-14

July 31, 2006

E-SE. Basalt ridges heavily colonized with algal turf; gullies between ridges with amalgam of carbonate/siliciclastic sand and rubble. Depth range: 12–14 m; visibility ~10 m. Algal cover was high but covered by a thick layer of thin particles (black sand). Algal communities were dominated by turf algae, *Lobophora*, *Peyssonnelia*, *Galaxaura*, *Dasya*, and *Jania*. *Halimeda* and blue-green algae were also recorded within the photoquadrats. Turf algae on the rocky boulders comprised over 70 % of benthic cover, and percent live coral cover amounted to only 5.8%. Dominant corals: *P. meandrina* and *P. lobata*. Also, one case of bleaching on *Porites* was detected. The invertebrate macrofauna at this site consisted of similar species of sponges, tunicates, and other inverts to the previous site; the diversity and abundance was not as great as the previous site because of the lack of loose rocks which provide habitat and hiding places used by most of the fauna. The blackfin chromis (*Chromis vanderbilti*), manybar goatfish (*Parupeneus multifasciatus*), yellow tang (*Zebrasoma flavescens*), and the arceye hawkfish (*Paracirrhites arcatus*)

were the most numerous on the BLT. The orangeband surgeonfish (*Acanthurus olivaceus*) and the sleek unicornfish (*Naso hexacanthus*) were the larger bodied fishes at this station.

#### MAI-15

July 31, 2006

E-SE. Similar topography to sites MAI-13 and -14; basalt ridges and boulders heavily covered by algal turf; gullies between ridges covered by rubble. Depth range: 9.0–10.6 m; visibility: 20 m. Algal cover was high and dominated by turf algae and *Amansia*. *Jania*, *Dasya*, *Dictyota*, and *Turbinaria* were also abundant. Crustose corallines, *Microdictyon*, *Padina*, *Galaxaura*, and *Neomeris* were found within the photoquadrats. Algal communities were covered by a layer of thin particles (black sand). Turf algae on the rocky boulders comprised 79%, and live coral cover amounted to 15.6% of the benthos. Dominant corals along the transect lines in order of importance: *P. lobata*, *P. meandrina*, *M. capitata*, and *M. patula*. Other corals present in the general vicinity included: *Pocillopora eydouxi*, *P. ligulata*, *Porites lutea*, and *Montipora flabelatta*. Numerous recruits of *Pocillopora* and *Porites* also present. Additionally, within the area surveyed (300 m<sup>2</sup>): two cases of bleaching on *Porites*, and two cases *Porites* trematodiasis, and five cases of compromised health on *Porites*, consisting of pigmentation response associated with algal overgrowth (three cases) and algal overgrowth (two cases), were detected. This was one of the most diverse and abundant sites for invertebrates throughout the islands in that all the major invertebrate taxa were well represented in diversity and abundance. The more dominant fauna were sponges, five species of urchin, three species of cucumber, small crustaceans (xanthids, trapezids, hermits, alpheids, and coral shrimp), didemnum tunicates, and sea whips. Also noted were gastropods, bivalves, nudibranchs (*Glossodoris*), hydroids, zoanthids, polychaetes (Amphinomidae) and bryozoans. The blackfin chromis (*Chromis vanderbilti*), arceye hawkfish (*Paracirrhites arcatus*), and the bigscale soldierfish (*Myripristis berndti*) were the most numerous on the BLT. The orangeband surgeonfish (*Acanthurus olivaceus*), orangespine unicornfish (*Naso lituratus*), and the eyestripe surgeonfish (*Acanthurus dussumieri*) were the larger bodied fish at this station.

#### MAI-3

August 1, 2006

South shore. Algal communities were dominated by turf algae. Crustose corallines, *Lobophora*, *Amansia*, and *Jania* were also abundant within the photoquadrats. Algal diversity was low. Turf algae on the rocky boulders comprised over 77 % of benthic cover. Moderate coral cover (20.5%) dominated by the finger and lobe corals *Porites compressa* and *P. lobata*. High coral species diversity; 15 species enumerated. Also, within the area surveyed (300 m<sup>2</sup>), three cases of *Porites* trematodiasis were detected. At this site, the silt flats provided good habitat for many large green wire corals. The other highly abundant invertebrates (living in the live and dead coral) were *Tripneustes* urchins and *Linckia* sea stars. The less abundant fauna at this site were sponges (*Stylinos*), small patches of *Palythoa* zoanthid, boring urchins (*Echinometra* and *Echinostrephus*), and the trapezid and hermit crabs. The goldring surgeonfish (*Ctenochaetus strigosus*), brown surgeonfish (*Acanthurus nigrofuscus*), yellow tang (*Zebrasoma flavescens*), and the multiband butterflyfish (*Chaetodon multicinctus*) were the most numerous on the BLT. The pinktail durgon (*Melichthys vidua*) was the larger bodied fish at this station.



MAI-16

August 1, 2006

South shore. Depth range: 12–13.6 m; visibility ~20 m. Algal cover was moderate. Algal communities were dominated by turf algae, crustose corallines, *Lobophora* and blue-green algae. Also, moderate percent live coral cover; 28.5%, dominated the by finger and lobe corals *Porites compressa* and *P. lobata*. Additionally, within the area surveyed (300 m<sup>2</sup>), 11 cases of *Porites* growth anomalies, 5 cases of compromised health due to crown-of-thorns starfish (COTS) predation, and an unidentified syndrome (involving tissue loss and discoloration) were detected. In contrast to site MAI-3, at this site sand was coarse, allowing for excellent visibility but a lack of wire coral. The most common and highly abundant invertebrates were five types of urchins of the genera *Echinometra*, *Echinothrix*, *Heterocentrotus*, *Tripneustes*, and *Eucidaris*. Also abundant were two species of sea stars (*Linckia* and *Acanthaster*), but less common were zoanthids and hermit crabs. The goldring surgeonfish (*Ctenochaetus strigosus*), yellow tang (*Zebrasoma flavescens*), blackfin chromis (*Chromis vanderbilti*), agile chromis (*Chromis agilis*), and the chocolatedip chromis (*Chromis hanui*) were the most numerous on the BLT. The black durgon (*Melichthys niger*) was the larger bodied fish at this station.

MAI-17

August 1, 2006

South shore. Depth range 12–14 m; visibility: ~20 m. Algal communities were dominated by turf algae, crustose corallines, *Lobophora*, and blue-green algae. *Microdictyon* was recorded within the photoquadrats. Moderately high percent live coral cover (40%), mainly composed of finger and lobe *Porites*. Within the total area surveyed (300 m<sup>2</sup>), 10 cases of *Porites* growth anomalies were detected. Additionally, two cases of *Porites* tissue loss were observed, one involving growth anomalies, and the other one algal overgrowth. Finally, seven cases of pigmentation responses were also detected. As for macroinvertebrates, the boring urchin *Echinometra mathaei* was dominant; however, three other species of urchins were present and abundant as well. The other less dominant (non-mobile) fauna were sponges, zoanthid (*Palythoa caesia*), hydroids, *Spirobranchus* polychaetes, arc shells, and two non-toothed pearl oysters. The goldring surgeonfish (*Ctenochaetus strigosus*) and the blackfin chromis (*Chromis vanderbilti*) were the most numerous on the BLT. The pinktail durgon (*Melichthys vidua*) and the bigeye emperor (*Monotaxis grandoculis*) were the larger bodied fish at this station. Algal cover was moderate.

MAI-18

August 19, 2006

NE ocean fringing reef near Haleophiihilani. Depth range: 12–14.5 m. Boulders and black sand with heavy cover turf and macroalgae; moderately high topographic relief. Algal communities were, however, dominated by turf algae, crustose coralline algae, *Sargassum*, *Amansia*, *Jania*, and different species of *Padina* and *Dictyota*. Different species of *Codium* and *Galaxaura* were observed within the photoquadrats. *Caulerpa taxifolia* was commonly seen along transects. Coral cover was close to 14% with *P. lobata* (49.6%) and *P. meandrina* (~36%) dominating the species in this moderate-diversity site. Other coral scleractinians included: *M. capitata*, *Pocillopora ligulata*, *Pocillopora damicornis*, and *Pavona varians*. Also, one case growth anomaly on *Porites*,

and one case of pigmentation response in *Porites* (possible trematodiasis) were detected. Predation scars were also noted for *Pocillopora* species. Macroinvertebrate fauna at this site was dominated by sessile cryptic species. Sponges and zoanthids were the most common sessile organisms. The sea star *Acanthaster planci* was rare and lobster was present. Sponge fauna was made up of *Spongia oceania*, *Clathria*, and an unknown species of brown, pink, and green sponges. The nudibranchs *Phyllidiella pustulosa* and *Phyllidia varicose* were seen commonly while another nudibranch *Dendrodoris tuberculosa* was rare. A high species count (85) was obtained; however, most of these fishes were recorded as present only and observed among boulders off the transect lines. Only 460 individuals were counted on the belt transects and SPCs. The majority of the larger fishes were surgeonfishes, primarily the orangespine unicornfish (*Naso lituratus*). The bluelined snapper (*Lutjanus kasmira*), the Hawaiian hogfish, and redlip parrotfish were also common. The blackfin chromis numerically dominated the smaller species. The arceye hawkfish, saddle wrasse and brown tang (*Acanthurus nigrofuscus*) were common. A male and female cigar wrasse (*Chelio inermis*) were observed among the boulders as were a large number of pearl wrasse (*Anampses cuvier*).

#### MAI-19

August 19, 2006

N ocean fringing reef, Depth range: 9.7–17.8 m. Large boulders, moderately high topographical relief. Algal cover was important while algal diversity was moderate. The most commonly seen algae within the photoquadrats were turf algae, *Sargassum*, crustose coralline algae and different species of *Dictyota*. *Jania*, *Padina* (different species), and *Peyssonelia* were also abundant. Additionally, blue-green algae were particularly common within the photoquadrats. Coral cover was approximately 23%. Coral species diversity was medium with *P. lobata* (56%; highly fissioned) and *P. meandrina* (44%; numerous recruits) representing the two species present along the transect lines. Other coral species present in the transect vicinity included: *M. capitata*, *P. ligulata*, *Pocillopora damicornis*, *Pavona varians*, *Leptastrea bewickensis*, *Sinularia* spp., and *Palythoa* spp. Coral health and disease assessment: five cases of growth anomalies and one case of pigmentation response detected on *Porites* were detected. Predation was also noted on some *Pocillopora* species. Analogous to site MAI-18, the macroinvertebrate fauna at MAI-19 was dominated by sessile cryptic species. Sponges and zoanthids were the most common sessile organisms. *Acanthaster planci* was rare. Sponge fauna was made up of *Spongia oceania*, *Clathria*, and an unknown species of brown, pink, and green sponges. The nudibranchs *Phyllidiella pustulosa* and *Phyllidia varicose* were seen commonly while another nudibranch *Dendrodoris tuberculosa* was rare. A high fish species count (82) and low individual count (449) were obtained at MAI-19. Many species were recorded off transect and among the boulders. The larger fish counted were mostly surgeonfish, the orangespine unicorn fish being most common. The Hawaiian hogfish, manybar goatfish and redlip parrotfish were common. Three bluefin trevally (*Caranx melampygus*) were counted on the transect lines. One large giant trevally (*Caranx ignobilis*) was observed among the boulders. Among smaller fishes were blackfin chromis, gold-ring surgeonfish, and saddle wrasses. The arceye hawkfish, brown surgeonfish, whitebar surgeonfish (*Acanthurus leucopareius*), and oval chromis (*Chromis ovalis*) were common on the belt transects. Two bandit angelfish (*Desmoholacanthus arcuatus*) were counted on the transects, and several more were present in the area. An unusually large number of rare longnose butterflyfish (*Forcipiger longirostris*) were also present.

MAI-20

August 19, 2006

N, ocean fringing reef. Depth range: 13.3–16.3 m. Large boulders. Algal communities were dominated by turf algae, crustose coralline algae, and various species of *Dictyota*, *Jania*, *Padina* and *Lobophora*. Blue-green algae were also abundant. *P. meandrina* was abundant; encrusting and nodular *P. lobata* was common. Numerous dead *Pocillopora* with coralline algal cover. No percent cover or coral disease survey conducted (Jay Wheeler did not dive due to another diver's tank loaded on launch by mistake). The macroinvertebrate fauna at MAI-20 was also dominated by sessile cryptic species. Sponges and zoanthids were the most common sessile organisms. *Acanthaster planci* was rare and lobsters were present. Sponge fauna was made up of *Spongia oceania*, *Clathria*, and an unknown species of brown, pink, and green sponges. The nudibranchs *Phyllidiella pustulosa* and *Phyllidia varicose* were seen commonly while another nudibranch *Dendrodoris tuberculosa* was rare. Seventy-three species of fishes and 436 individuals were recorded at this site. Two schools of larger fishes were counted. A school of 84 Hawaiian bigeye, (*Priacanthus meeki*) was counted on the SPC, and a school of 43 yellowfin goatfish was counted on a belt transect. The bigeye emperor (*Monotaxis grandoculis*) and the orangespine unicornfish were common among the larger fishes. Among smaller fishes, the goldring surgeonfish was dominant. Most of these individuals were near the maximum recorded size for the species. The brown surgeonfish and saddle wrasse were also common. The blackfin chromis was present but in much reduced numbers.

### **H.3. Benthic Environment**

#### **H.3.1. Algae**

The algae team surveyed 12 sites around Maui. They were located northwest, north, southeast and south of the island. A few were embayment offering some protection from trade winds while others were exposed to strong winds and showed important swell. A few sites from the south and southeast region of Maui showed a poor visibility because of a high level of particles in suspension. Algal cover and algal diversity were relatively high. The dominant algae in Maui reefs were: turf algae, crustose coralline algae, *Sargassum*, *Padina melemele*, *Lobophora variegata*, *Dictyota ceylanica*, and *Jania* (Table H.3.1.1.). Blue-green algae were also commonly seen along both transects at different sites. The algal cover and algal diversity seem relatively homogenous around Maui. A total of 41 genera and 4 functional groups were found within the photoquadrats (47 genera if random swim data are included). Algal diversity at MAI-3 was lower than at the other locations due to a high sedimentation. The dominant algae in Maui reefs (% occurrence 50%) were: turf algae, crustose coralline algae, *Sargassum*, *Padina melemele*, *Lobophora variegata*, *Dictyota ceylanica*, and *Jania*. Blue-green algae were also commonly seen along both transects at different sites. Other algae were also commonly seen within the photoquadrats (30–50% of occurrence) such as: *Halimeda opuntia*, *Amansia glomerata*, *Dasya irridescens*, *Peyssonelia*, *Tolypocladia glomerulata*, *Dictyota friabilis*, *Padina sp.*, and *Styopodium*.

Table H.3.1.1 Average occurrence (%) and average rank for each genera, species, or functional group found within the photoquadrats at Maui.

	% Occurrence	Rank
<b>Green algae</b>		
<i>Caulerpa sp.</i>	8.3	9.0
<i>Cladophoropsis</i>	12.5	9.8
<i>Codium arabicum</i>	8.3	8.5
<i>Codium edule</i>	16.7	4.5
<i>Chlorodesmis caespitosa</i>	8.3	12.0
<i>Dictyosphaeria cavernosa</i>	16.7	8.0
<i>Dictyosphaeria versluysii</i>	16.7	6.2
<i>Halimeda discoidea</i>	8.3	3.0
<i>Halimeda opuntia</i>	33.3	6.1
<i>Microdictyon setchellianum</i>	27.1	6.2
<i>Microdictyon umbilicatum</i>	25.0	7.0
<i>Neomeris annulata</i>	21.3	7.4
<i>Phyllocladon</i>	8.3	9.0
<i>Rhipidosiphon javensis</i>	8.3	6.0
<i>Ventricaria ventricosa</i>	8.3	8.5
<b>Red algae</b>		
<i>Acanthophora pacifica</i>	8.3	4.0
<i>Actinotrichia fragilis</i>	16.7	8.5
<i>Amansia glomerata</i>	31.3	5.1
<i>Asparagopsis taxiformis</i>	18.8	4.4
<i>Botryocladia skottsbergii</i>	16.7	7.8
<i>Champia viellardii</i>	8.3	10.0
<i>Chondria</i>	8.3	6.0
<i>Dasya iridescens</i>	41.7	8.0
<i>Dasya sp.</i>	26.0	6.1
<i>Galaxaura marginata</i>	11.1	7.8
<i>Galaxaura obtusata</i>	25.0	6.2
<i>Galaxaura rugosa</i>	58.3	5.1
<i>Gelid</i>	21.7	4.5
<i>Gibsmithia hawaiiensis</i>	8.3	10.0
<i>Haloplegma duperreyi</i>	8.3	5.0
<i>Hypnea sp.</i>	8.3	11.0
<i>Jania sp.</i>	59.8	4.6
<i>Laurencia sp.</i>	16.7	7.5
<i>Liagora sp.</i>	8.3	6.0
<i>Martensia sp.</i>	25.0	6.0
<i>Peyssonnelia sp.</i>	38.9	4.3
<i>Portieria hornemannii</i>	19.4	5.9
<i>Pterocladia capillacea</i>	8.3	7.0
<i>Tolypocladia glomerulata</i>	29.2	7.1
<i>Trichogloea sp.</i>	8.3	2.0
<i>Tricleocarpa fragilis</i>	16.7	8.5
<b>Brown algae</b>		
<i>Dictyopteris palagiogramma</i>	25.0	5.2
<i>Dictyota sp.</i>	46.7	5.3
<i>Dictyota ceylanica</i>	50.0	4.1
<i>Dictyota friabilis</i>	36.1	4.9

	% Occurrence	Rank
<i>Lobophora varigata</i>	57.6	3.9
<i>Padina sp.</i>	33.3	6.4
<i>Padina melemele</i>	52.8	6.9
<i>Sargassum sp.</i>	69.4	4.9
<i>Styopodium flabelliforme</i>	33.3	8.5
<i>Turbinaria ornata</i>	19.4	5.8
<b>Others</b>		
Blue-green	46.5	5.0
Turf	95.8	1.3
CCA	78.5	2.8
orange crust	12.5	2.5

### **H.3.2. Benthic Towed-diver Survey—Algae**

Macroalgae and coralline algal cover averaged 20% (range 0–75%) and 7% (range 0–50%) respectively over bottom habitat within a variety of low–very high complexity habitats. Macroalgae cover was highest during the towed-diver survey conducted east of Pauwela (average 56% benthic cover), while coralline algae cover was highest (average ~26%) around Honokala Point and Honopou.

*Halimeda* meadows were noted during the towed-diver surveys conducted between Alena and Auwahi, along with Kanaio and Hanamanioa in low to medium complexity habitat. The presence of sparse *Halimeda* and/or consistent *Halimeda* patches was noted in several other surveys, including those conducted between Alau Island to Hamaloa Moka'e, Kakio to just past Popokanaloa Point, Muolea Point to Wailua, Papiha Point, Hoalua Bay/Huelo Point, Kapukaulua Point near Pauwela (including the area near the lighthouse), Waihee Point, and Poelua Bay/Nakalene Point.

Finally, a possible area of invasive *Cladophora sericea* was potentially identified near the point just east of Maliko. The average depth in the area was approximately 12 meters, in medium-high complexity habitat of mostly hard coral and sand.

### **H.3.3. Corals**

#### **H.3.3.1 Coral Population Parameters**

Table H.3.2.1.1. and Figure H.3.2.1.2. summarize the characteristics of coral populations within belt transects at the 12 Maui sites surveyed for basic coral population parameters in 2006. Of these 12 sites, only 1 had been assessed in 2005, and 11 were new sites. A total of 7,617 corals belonging to 18 anthozoan taxa were censused within an area of 600 m<sup>2</sup>. The most numerically abundant taxa were *P. lobata*, *Porites compressa*, *M. capitata*, and *P. meandrina*. At some sites, *Montipora patula* contributed substantially to the coral fauna.

Overall size distribution indicates 55.6% of colonies have a maximum diameter <10 cm, and only 7.9% measure >40 cm maximum diameter. Small colonies therefore dominate coral communities surveyed at Maui.

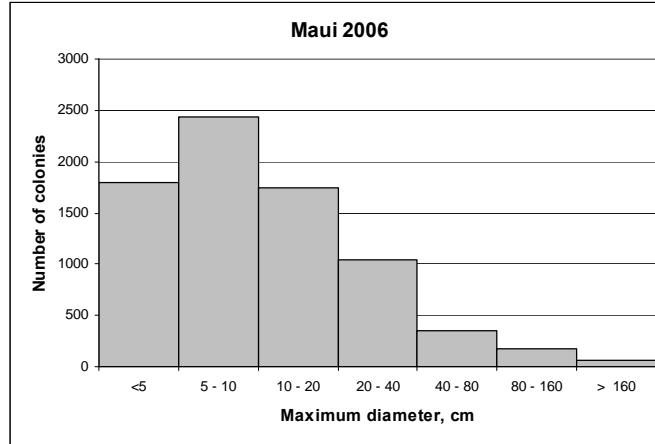


Figure H.3.2.1.1. Size class distribution of 7,617 anthozoan colonies censused within belt transects at Maui during 2006 REA surveys.

Table H.3.2.1.2 Number of anthozoans counted within belt transects during MHI REA 2006 surveys at Maui. Taxa contributing more than 10% of total colony abundance are in bold.

Taxon	# of colonies	Percent of total
<i>Montipora capitata</i>	924	<b>12.1</b>
<i>Montipora flabellate</i>	25	0.3
<i>Montipora incrassate</i>	0	0.0
<i>Montipora patula</i>	702	9.2
<i>Montipora verrilli</i>	0	0.0
<i>Pavona duerdeni</i>	0	0.0
<i>Pavona varians</i>	87	1.1
<i>Cyphastrea ocellina</i>	11	0.1
<i>Leptastrea bewickensis</i>	0	0.0
<i>Leptastrea purpurea</i>	26	0.3
<i>Fungia scutaria</i>	5	0.1
<i>Cycloseris vaughani</i>	0	0.0
<i>Leptoseris incrustans</i>	0	0.0
<i>Pocillopora damicornis</i>	0	0.0
<i>Pocillopora eydouxi</i>	79	1.0
<i>Pocillopora ligulata</i>	6	0.1
<i>Pocillopora meandrina</i>	826	<b>10.8</b>
<i>Porites brighami</i>	7	0.1
<i>Porites compressa</i>	1212	<b>15.9</b>
<i>Porites evermanni</i>	32	0.4
<i>Porites lobata</i>	3424	<b>45.0</b>
<i>Porites monticulosa</i>	0	0.0
<i>Psammacora nierstraszi</i>	0	0.0
<i>Psammacora stellata</i>	2	0.0
<i>Palythoa</i> sp.	246	3.2
<i>Zoanthus pacifica</i>	1	0.0
<i>Sinularia</i> sp.	2	0.0

Taxon	# of colonies	Percent of total
<i>Tubastraea coccinea</i>	0	0.0
<i>Cirrhopathes anguina</i>	0	0.0
<i>Antipathes</i> sp.	0	0.0
Total # colonies	7617	100
Area surveyed, m2	600	

### H.3.3.2 Percent Benthic Cover

Percent benthic cover surveys at the island of Maui were conducted in congruency with the coral population REA survey at 11 different sites. Site MAI-20 was unattainable because the wrong diver's tank was loaded on launch by mistake. The line intercept methodology quantified a total of 1,122 points along 550 m of ocean fringing coral reef communities. Surveys indicated that the mean percent live coral cover for all sites combined was relatively low: 19.2%. The most numerically abundant scleractinian taxa in order of importance were: *P. lobata* (56.6%), *P. meandrina* (16.2%), *M. capitata* (15.3%), and *M. patula* (6%). Site MAI-17 exhibited the highest percent of live coral cover (42%) recorded for the island. Table H. 3.2.2.1 provides an itemized summary of percent cover of the different benthic elements enumerated along the line transects at Maui.

Table H.3.2.2.1 Percent cover of the benthic elements at Maui using the point-intercept method during the 2006 REA activities.

Item	% Cover
<i>Pocillopora meandrina</i>	3.1
<i>Porites lobata</i>	10.9
<i>Porites compressa</i>	2.9
<i>Porites</i> sp.	0.0
<i>Montipora capitata</i>	0.8
<i>Montipora patula</i>	1.2
<i>Montipora flabelallata</i>	0.2
<i>Pavona</i>	0.1
<i>Leptastrea</i>	0.0
<i>Cyphastrea</i>	0.0
<i>Fungia</i>	0.0
Macroalgae	0.4
<i>Halimeda</i>	0.0
<i>Palythoa</i>	0.1
Pavement/cca	0.4
Pavement/cyano	0.1
Pavement/turf	12.3
Rubble/cca	0.4
Rubble/turf	7.7
Rock/turff	23.4
Dead/cca	2.5
Dead/cyano	0.2
Dead/turf	25.0

Item	% Cover
CCA	0.7
Sand	7.6
Other	0.3
<b>Percent live coral cover</b>	<b>19.2</b>

### H.3.3.3 Coral Disease

At Maui, the coral disease REA surveyed a total area of approximately 3050 m<sup>2</sup> at 11 different sites, during the reef assessment and monitoring program cruise of 2006. Site MAI-20 was unattainable because the wrong diver's tank was loaded on launch by mistake. Figure H.3.2.2.1 below illustrates the cumulative number of cases of disease and compromised health conditions enumerated for all sites combined, indicating that growth anomalies and trematodiasis were the two most numerically abundant afflictions to corals. At a future date, the data below will be related to coral colony density (estimated by Dr. Kenyon) and percent live coral cover (above) in order to provide a numerical estimate for disease prevalence. These results will be contrasted within and among islands.

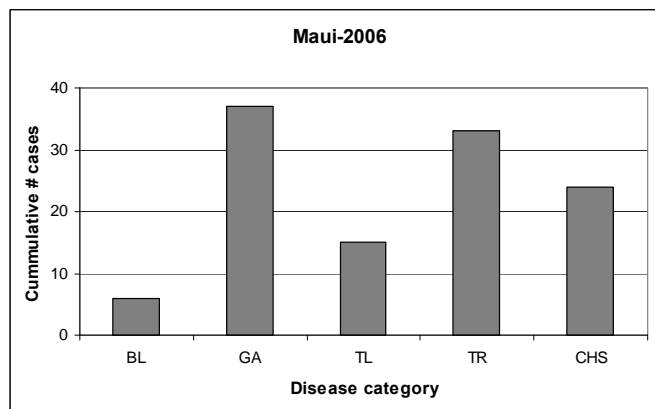


Figure H.3.2.3.1. Cumulative number of cases of disease at Maui Island during 2006 REA surveys. Total area surveyed: 3,050 m<sup>2</sup>. BL: bleaching; GA: growth anomaly; TL: tissue loss; TR: trematodiasis; and CHS: compromised health state, involving several cases of *Porites* pigmentation responses and *Porites* filamentous algal overgrowth.

### H.3.3.4 Benthic Towed-diver Survey—Corals

The average overall hard coral cover for all combined towed-diver surveys was surprisingly high (31%), with the highest towed-diver survey average recorded at over 71% (range 50–100% cover), with the survey location southeast of Waihee Point with medium-high to highly complex habitat in around 15 meters depth. Stressed coral ranged between 1 and 10% of all total hard coral for this survey as well (Waihee Point), which included possible *Montipora* tumors, along with discoloration and possible tumors on *P. lobata*.



Soft coral cover included *Sinularia* and a variety of zoanthid species, *Palythoa* colonies, wire coral, and black coral. A single *Carijoa* recorded was noted for the area near the southeastern end of Hoalua Bay; however, no additional information was recorded.

### H.3.4. Macroinvertebrates

The macroinvertebrate fauna on Maui was similar around the island in terms of most common taxa (echinoderms; see Table below) and the amount of different species (all but two sites had zoanthids and sponges). The sites close together tended to have the most similar fauna (especially the three sites in the NW part of the island). Echinoderms were the most abundant at all sites, but other soft bodied zoanthids and soft corals were seen throughout. Lobsters, octopi, and pearl oysters were seen sporadically at different sites.

Table H.3.3.1 Relative abundance data for echinoderms enumerated during REA surveys for the island of Maui.

Island	Maui	Maui	Maui	Maui	Maui	Maui	Maui	Maui	Maui	Maui	Maui
Date	8/19/06	8/19/06	7/30/06	7/30/06	7/30/06	7/31/06	7/31/06	7/31/06	8/1/06	8/1/06	8/1/06
Site	MAI-19	MAI-20	MAI-10	MAI-11	MAI-12	MAI-13	MAI-15	MAI-14	MAI-3	MAI-16	MAI-17
Depth(feet)	50	45									
Habitat	Boulder	Boulder	islet	cove	cove	islet	coast	coast	coast	coast	cove
	Avg/m2	Avg/m2	Avg/m2	Avg/m2	Avg/m2	Avg/m2	Avg/m2	Avg/m2	Avg/m2	Avg/m2	Avg/m2
<b>Echinoids</b>											
Echinostrephus		0.04		0.02	0.01		0.01	0.01			0.008
Echinometra sp.			0.01	0.01	0.01	0.01	0.01		0.002	0.28	0.97
Echinothrix sp.	0.002						0.002		0.002	0.01	0.004
Heterocentrotus					0.002					0.11	0.05
Tripneustes							0.001		0.02	0.13	0.08
Diadema							0.012	0.006			
Pseudobolentia											
Other Echinoid			0.05	0.004	0.003	0.01	0.006	0.01	0.002	0.05	0.05
<b>Holothuroids</b>											
Holothuria atra	0.004			0.002							
Holothuria whitmaei								0.002			
Actinopyga obesa				0.002							
Actinopyga mauritiana											
Other Holothuroid							0.04				
<b>Asteroidea</b>											
Linckia multifora			0.002		0.002				0.03	0.04	
Linckia guildingi											
Acanthaster planci	0.004	0.006	0.002		0.004					0.002	
Mithrodia fisheri											
Other Asteroideid				0.002							
Calcita											

### **H.3.5. Benthic Towed-diver Survey—Macroinvertebrates**

Crown-of-thorns starfish numbers remained low around Maui, never exceeding 17 starfish during any towed-diver survey. The survey around Kuau/Paia recorded 16 crown-of-thorns starfish during one 5-minute time segment, with one additional starfish recorded during the remaining survey. Sea urchin numbers were highest during a towed-diver survey completed west of Kanaloa Point, averaging 175 urchins per 5-minute time segment. Finally, sea cucumber numbers remained low, never exceeding four during any 5-minute time segment.

### **H.4. Fish**

Twelve sites were surveyed at Maui. One hundred fifty species and 6,350 fishes were recorded (in both Belt and SPC surveys). Thirty-nine percent of the fishes counted were damselfishes (Pomacentridae), 25% surgeonfishes (Acanthuridae), and 7% wrasses (Labridae).

The blackfin chromis (*Chromis vanderbilti*) again was numerically dominant (28%), followed by the goldring surgeonfish (*Ctenochaetus strigosus*), (9%), oval chromis (*Chromis ovalis*), saddle wrasse (*Thalassoma duperrey*), black triggerfish (*Melichthys niger*), arceye hawkfish (*Paracihites arcatus*) and brown surgeonfish (*Acanthurus nigrofuscus*; 4% each) and yellow tang (*Zebrasoma flavescens*; 3%).

#### Fish $\geq 25$ cm TL:

Belt Transects: Four hundred fifteen fishes representing 46 species measuring  $\geq 25$  cm were counted on belt transects. Thirty-nine percent were surgeonfishes, 16% goatfishes (Mullidae), 10% parrotfishes (Scaridae), 10% triggerfishes (Balistidae), and 6% snappers (Lutjanidae).

SPCs: Nine hundred sixty-nine fishes representing 51 species were recorded on the SPCs. Twenty-nine percent were surgeonfishes, 25% triggerfishes, 9% were Hawaiian bigeye (*Priacanthus meekii*), parrotfishes (7%), bigeye emperor (*Monotaxis grandoculis*) (6%), and goatfishes (5%).

#### Towed-diver Surveys (fish $> 50$ cm TL):

At Maui, the towed-diver team completed 33 dives over the course of 6 days covering 62.09 km of sea floor (Fig. H.4.1). Surveys were concentrated along the northern and southeastern coast bordering the Alinuihaha Channel to the exclusion of the south and west coasts which are heavily surveyed through State of Hawaii CRAMP and other monitoring efforts. Surveys averaged 2.28 km in length and ranged from 1.57 km to 3.01 km. Median mean depth was -15.28 m.

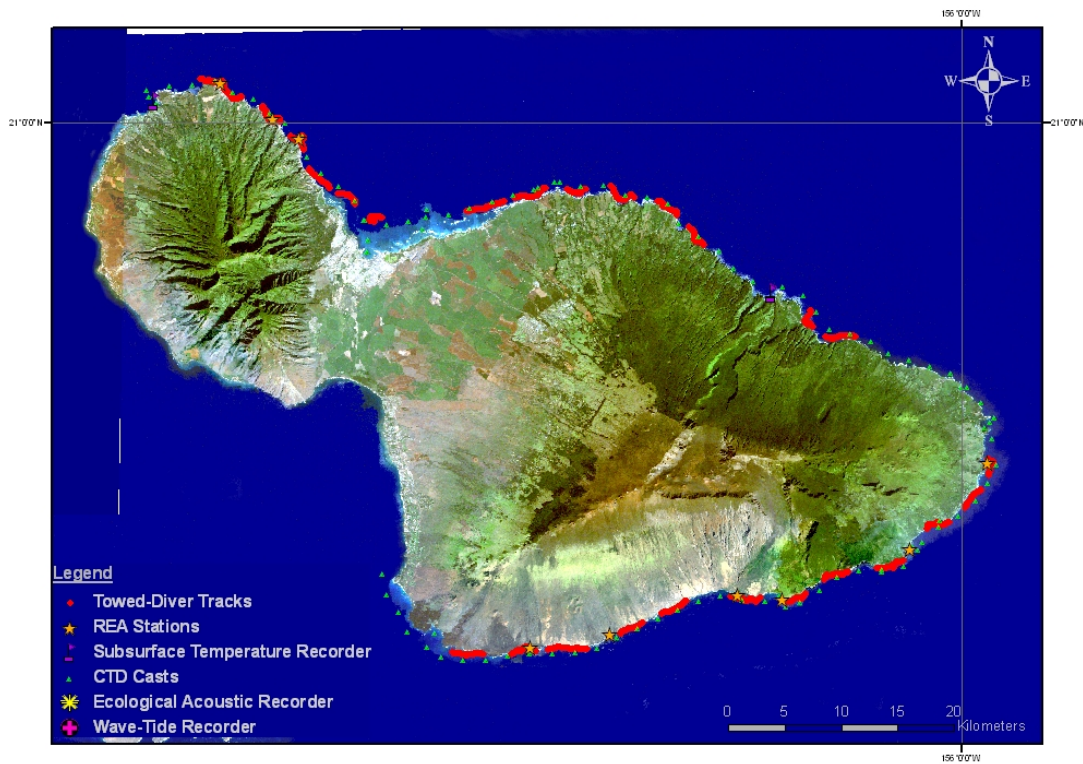


Figure H.4.1 HI-06-10 sampling stations at Maui Island. Effort was limited along the southern and western coasts as these areas are more easily accessible.

At Maui, 22 species were observed (Figs. H.4.2 – H.4.3). Numeric density was dominated by the redlip parrotfish (*Scarus rubroviolaceus*) followed by the spectacled parrotfish (*Chlorurus perspicillatus*) and the trumpetfish (*Aulostomus chinensis*). Biomass was dominated by the redlip parrotfish followed by the manta ray (*Manta birostris*) and the spectacled parrotfish.

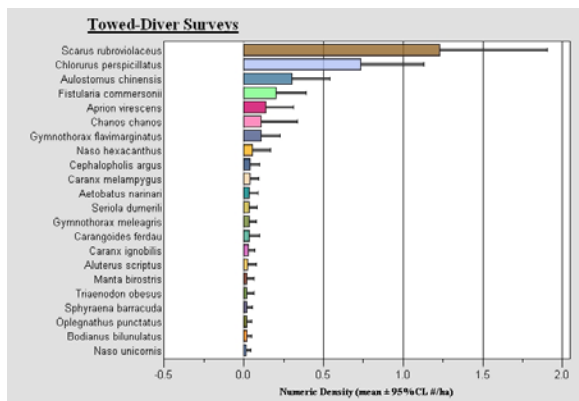


Figure H.4.2 Numeric Density (#/ha) of species at Maui.

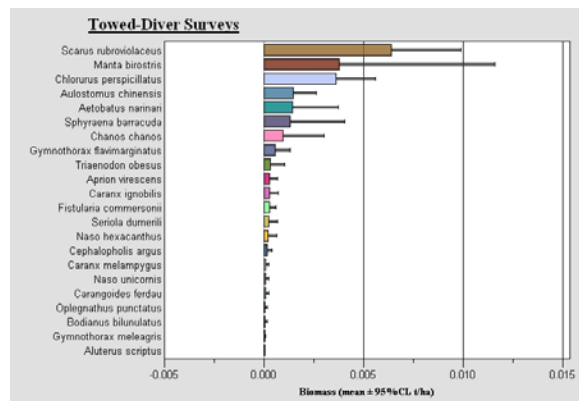


Figure H.4.3 Biomass Density (t/ha) of species at Maui.

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## Appendix I: Lanai

### I.1. Oceanography & Water Quality

Figure I.1.1. plots subsurface temperature recorder (STR) data recovered from the SW tip of Lanai in 8.2 m water depth.

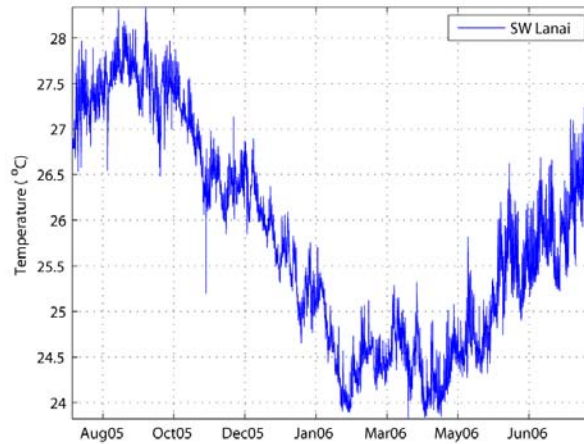


Figure I.1.1.

Figure I.1.2 shows interpolated shallow conductivity-temperature-depth (CTD) cast data – 10-m depths around Lanai.

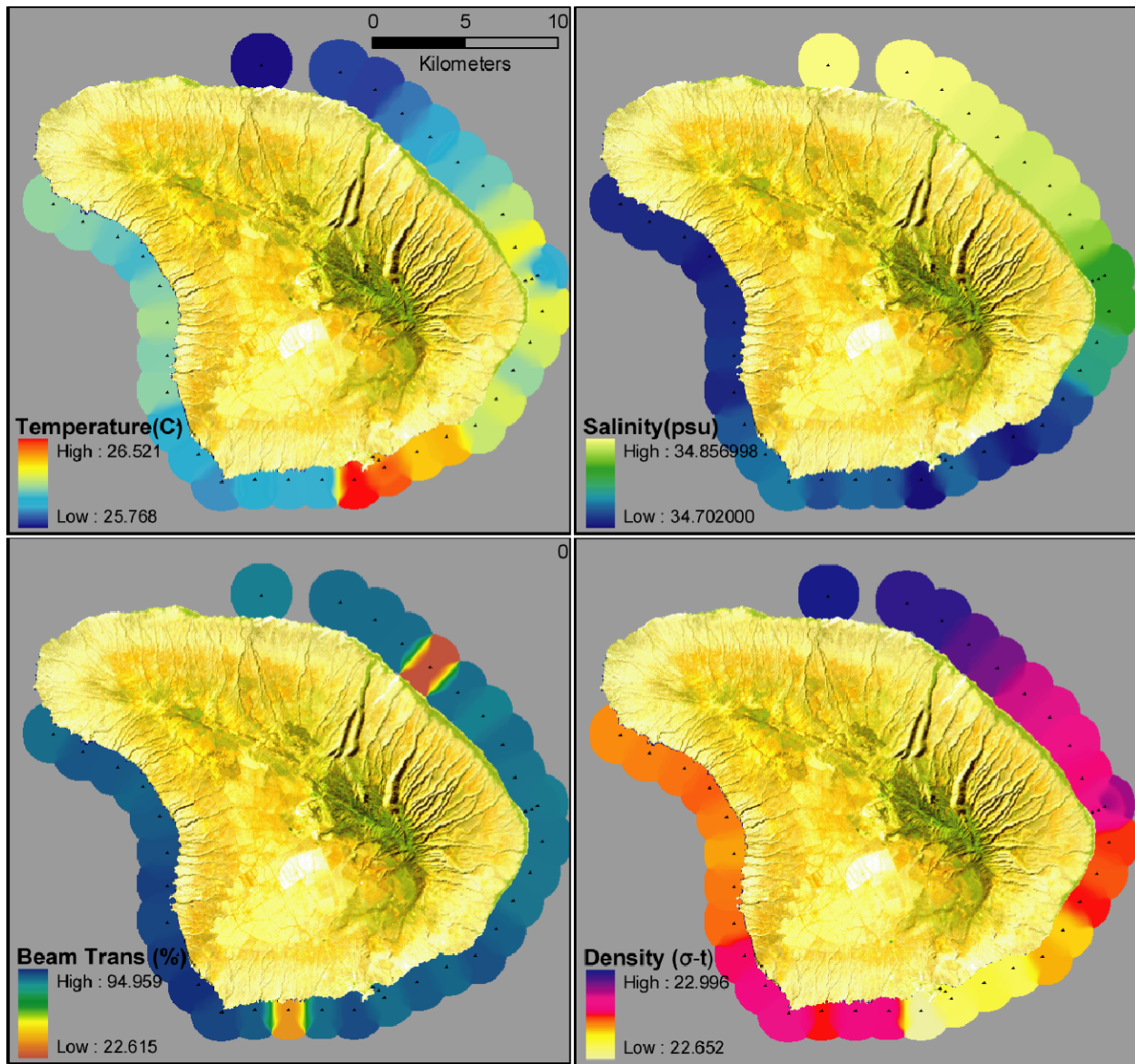


Figure I.1.2

## I.2. Rapid Ecological Assessment (REA) Site Descriptions

LAN-8

August 4, 2006

E-NE, off shipwreck. Depth range: 10.9–13.9 m; visibility ~4.5 m. Algal diversity was moderate with coverage being high. The algal community was dominated by *Amansia* and *Haloplegma*. Turf and macroalgae comprised over 81% of benthic cover, and percent live coral accounted for 5.8%. Sparse coral colonies, mainly *Porites* and *Pocillopora*. Also located at this site were two cases of *Porites* bleaching, one case of *Porites* growth anomaly, one case of *Porites* pigmentation response, and one case of *Porites* compromised health state due to algal overgrowth. This

was not a good habitat for large invertebrate macrofauna, and as such there were few specimens except for some sponges and didemnum tunicates under loose rubble and a few *Spirobranchus* polychaetes and hydroids among the algae and bits of coral. The saddle wrasse (*Thalassoma duperrey*) was the most numerous fish on the belt transect (BLT). The orangeband surgeonfish (*Acanthurus olivaceus*) and the bluespine unicornfish (*Naso unicornis*) were the larger bodied fish at this station.

#### LAN-4

August 4, 2006

E-SE, ocean fringing old *Porites* reef. Increased turbidity due to coastal runoff (old pineapple fields). Depth range: 12.1–17.3 m, visibility: ~12 m. Algal cover was moderate, and communities were dominated by turf algae, *Tolypocladia*, *Halimeda opuntia*, *Jania*, and *Heterosiphonia*. *Rhispidosiphon* was also abundant within the photoquadrats. Percent live coral cover was 44.1%; other species present included: *Montipora capitata*, *Porites compressa*, *Montipora fabellata*, and *Pavona varians*. Also at this site, three cases of *Porites* growth anomalies, and three cases of *Porites* pigmentation response (possible trematodiasis? and algal overgrowth?) were observed. Abundance and diversity of invertebrate fauna were low at this site, the most dominant fauna being sea urchins and hydroids. There were also a few (less common) encrusting species such as bryozoans, tunicates, and zoanthids. Additionally, the agile chromis (*Chromis agilis*), yellow tang (*Zebrasoma flavescens*), and the sleek unicornfish (*Naso hexacanthus*) were the most numerous on the BLT. The sleek unicornfish (*Naso hexacanthus*) and the introduced peacock grouper (*Cephalopholis argus*) were the larger bodied fish at this station.

#### LAN-5

August 4, 2006

S, ocean fringing old *Porites lobata/evermanni* reef. Depth range: 12.1–17.3 m. Increased turbidity due to coastal runoff (pineapple fields). Algal communities were dominated by turf algae, *Tolypocladia*, *Halimeda opuntia*, *Jania*, and *Heterosiphonia*. *Rhispidosiphon* was also abundant within the photoquadrats. Percent live coral cover was moderately high (52%). Other scleractinians present included: *P. compressa*, *M. fabellata*, *M. capitata*, and *Pavona*. Also, seven cases of *Porites* growth anomalies, eight cases of *Porites* pigmentation response (trematodiasis? and algal overgrowth?), and two cases of *Porites* compromised health conditions due to algal overgrowth were observed. Additionally, the dominant invertebrates (in addition to a few encrusting species) found at this site were a slipper lobster, a cushion star, and a small blue octocoral. Other mobile fauna included only two species of urchins, brittle stars, and hermits. The other sessile fauna included zoanthids, hydroids, sponges, arc shells, and green wire coral. The high coral cover provided good structure for trapezid crabs and alpheidids as well. The goldring surgeonfish (*Ctenochaetus strigosus*), brown surgeonfish (*Acanthurus nigrofuscus*), and the agile chromis (*Chromis agilis*) were most numerous on the BLT survey. Of the larger bodied fish, the bullethead parrotfish (*Chlorurus sordidus*) and the introduced blacktail snapper (*Lutjanus fulvus*) were most numerous. The hybrid *Acanthurus achilles/nigricans* was observed on the BLT at this station.

LAN-7

August 5, 2006

E, ocean fringing reef. Mainly built by *P. compressa*, now heavily colonized by *M. capitata*. Depth range: 12.1–15.2 m. Algal cover was moderate and dominated by turf algae, crustose corallines, and an unidentified red alga (probably a *Gracilaria*). Percent live coral cover was 45%. Other species present included: *P. compressa*, *M. patula*, *M. fabellata*, and *P. varians*; no coral diseases observed. Additionally, the only mobile inverts were a few sea stars, urchins, hermits, and trapezid crabs in the Pocilloporid coral heads. BLT surveys recorded mostly the saddle wrasse (*Thalassoma duperrey*) and the goldring surgeonfish (*Ctenochaetus strigosus*), while the bigger fish were the paletail unicornfish (*Naso brevirostris*) and the peacock grouper (*Cephalopholis argus*), an introduced species to Hawaii.

LAN-6

August 5, 2006

S, ocean fringing reef. Depth range: 12.1–17.3 m. Algal cover was high and algal communities were dominated by turf algae and crustose corallines. However, lots of other algae were also found within the photoquadrats, such as *Heterosiphonia*, *Jania*, *Haloplegma*, *Rhizidosiphon*, *Dictyota*, and *Cladophora*. Algal diversity was relatively high at this site. Additionally, *Halimeda opuntia*, *Dasya*, *Neomeris*, and *Gelid* were observed within the photoquadrats. Percent live coral cover was close to 30%; community composed of a *P. compressa* and *P. lobata* amalgam. Other scleractinians present included: *M. fabellata*, *M. capitata*, *M. patula* and *P. meandrina* and *P. eydouxi*. Additionally, three cases of *Porites* growth anomalies and five cases of *Porites* pigmentation response (possibly trematodiasis? and algal overgrowth) were observed. There was good visibility because of the coarseness of the sand and there were loose rocks and rubble, which created good habitats for encrusting species like hydroids, sponges, zoanths, and boring polychaetes. There were also a few urchins, sea stars, cucumbers, hermits, and trapezid guard crabs, but the overall abundance and diversity was not high. Good diversity of fish at station 6. BLT transect was dominated by the damselfishes, blackfin chromis (*Chromis vanderbilti*) and the agile chromis (*Chromis agilis*). Among the larger bodied fish the black durgon (*Melyichthys niger*) and the orangeband surgeon (*Acanthurus olivaceus*) were the most numerous.

LAN-3

August 5, 2006

E-SE. Depth range: 9.1–12.1 m; low turbidity. Algal cover was high and algal communities were dominated by turf algae and crustose corallines. However, other algae were also found within the photoquadrats, such as *Amansia*, *Dictyota*, and *Actinotrichia*. Algal diversity was moderate at this site. Additionally, *Gelid*, *Lobophora*, and different species of *Caulerpa* were observed within the photoquadrats. Benthic landscape was dominated by rocky boulders and ridges intermingled with sand gullies; boulders and ridges dotted with colonies of *P. lobata*, *P. compressa*, *M. fabellata*, *M. capitata*, *P. meandrina*, and *P. varians*; percent live coral cover was 13%. One case of *Porites* growth anomaly and two cases of *Porites* pigmentation response (potentially trematodiasis and/or algal overgrowth) were recorded. This site had a high diversity and abundance



of inverts including the same encrusting and boring species as the previous sites of the island (zoanthids, sponges, hydroids, bryozoans, wire coral, and anemones) and a higher abundance of mobile species of echinoderms (six species) and nudibranchs (two species). Along with the high diversity of gastropods at this site, there was a large amount of a certain cerithid gastropod and a large number of hermits inhabiting their dead shells. BLT surveys were dominated by the blackfin chromis (*Chromis vanderbilti*), while the larger fish recorded were the black durgon (*Melyichthys niger*) and the orangeband surgeon (*Acanthurus olivaceus*). The Pennantfish (*Hemiochus diphreutes*) was also observed at this station.

### I.3. Benthic Environment

#### I.3.1. Algae

Six sites around Lanai were visited including one qualitative survey and five quantitative surveys. Where the surge and the swell were important, visibility was reduced. At those locations, algal cover and algal diversity were limited. The prevailing algae within the photoquadrats were turf algae and crustose corallines (Table I.3.1.1.). Other algae were found commonly within the photoquadrats but genera varied among sites. A total of 22 genera and 4 functional groups were found around Lanai during this survey (29 genera if random swim data are included). Algal diversity varied among sites but turf algae and crustose coralline algae dominated algal communities at each site. Algae such as *Heterosiphonia* were, however, found abundant only at three of the six sites. Similar trends were observed for *Amansia*, *Haloplegma*, *Tolypiocladia*, and *Halimeda opuntia*. Algal diversity seems higher at the southern reefs than at the other reefs, especially those showing high water motion.

Table I.3.1.1 Average occurrence (%) and average ran for each genera, species, or functional group found within the photoquadrats at Lanai.

	% Occurrence	Rank
<b>Green algae</b>		
<i>Caulerpa sp</i>	8.3	6.0
<i>Caulerpa webbiana</i>	8.3	5.5
<i>Cladophora</i>	20.8	5.1
<i>Dictyosphaeria cavernosa</i>	8.3	5.3
<i>Dictyosphaeria versluysii</i>	8.3	6.0
<i>Halimeda opuntia</i>	50.0	4.8
<i>Neomeris annulata</i>	29.2	6.2
<i>Rhipidosiphon javensis</i>	29.2	5.8
<i>Ventricaria ventricosa</i>	8.3	7.0
<b>Red algae</b>		
<i>Actinotrichia fragilis</i>	8.3	7.0
<i>Amansia glomerata</i>	50.0	4.3
<i>Asparagopsis taxiformis</i>	12.5	5.0
<i>Dasya sp.</i>	22.9	6.3
<i>gelid</i>	41.7	4.2
<i>Haloplegma duperreyi</i>	8.3	5.0
<i>Heterosiphonia</i>	35.4	4.5
<i>Jania sp.</i>	41.7	4.5
<i>Laurencia parvipapillata</i>	8.3	10.0
<i>Peyssonnelia sp.</i>	12.5	4.0

	<b>% Occurrence</b>	<b>Rank</b>
<i>Portieria hornemannii</i>	27.8	4.6
<i>Tolyptocladia glomerulata</i>	16.7	4.8
<b>Brown algae</b>		
<i>Dictyota sp.</i>	25.0	6.1
<i>Lobophora varigata</i>	36.7	4.1
<i>Padina sp.</i>	8.3	4.0
<b>Others</b>		
Blue-green	33.3	5.7
turf	100.0	1.1
CCA	71.7	2.7
sand	31.7	2.1

### **I.3.2. Benthic Towed-diver Survey—Algae**

Overall macroalgae bottom cover for Lanai averaged approximately 4% for all combined towed-diver surveys. *Halimeda* beds, meadows, and patches were recorded during 6/11 towed-diver surveys, including the area near Kikoa Point, Kaimaiki Point, Anapuka, and north of Kaumalapau. In the area northeast of Naha (windward coast), extensive *Halimeda* meadows were often found in the middle of sand flats (constituting 75% of the bottom cover for several time segments), along with the area near Kahokunu (coverage up to 62.5%). Coralline algae cover recorded an overall average of 2%, with the highest percentage cover (20%) located northwest of Palaoa Point.

An algae belonging to the *Asparagopsis* genera was recorded in several locations during the towed-diver survey north of Kikoa Point that appeared to be growing over small patches of stressed coral in the area (see below). Finally, this particular survey was also characterized by heavy brown, thick sediment in several places that was not noted during any other towed-diver survey around Lanai.

### **I.3.3. Corals**

#### **I.3.3.1 Coral Population Parameters**

Table I.3.2.1.1. and Figure I.3.2.1.2 summarize the characteristics of coral populations within belt transects at the six Lanai sites surveyed for basic coral population parameters in 2006. Of these six sites, four had been assessed in 2005, and two were new sites. A total of 5,199 corals belonging to 17 anthozoan taxa were censused within an area of 295 m<sup>2</sup>. The most numerically abundant taxa were *P. lobata*, *P. compressa*, *M. patula*, and *M. capitata*.

Overall size distribution indicates 30.3% of colonies have a maximum diameter <10 cm, and 17.6% measure >40 cm maximum diameter. Compared to some other locations within the main Hawaiian Islands (MHI) surveyed in 2006 (e.g., Hawaii, Maui), coral communities at Lanai are characterized by larger colony sizes.

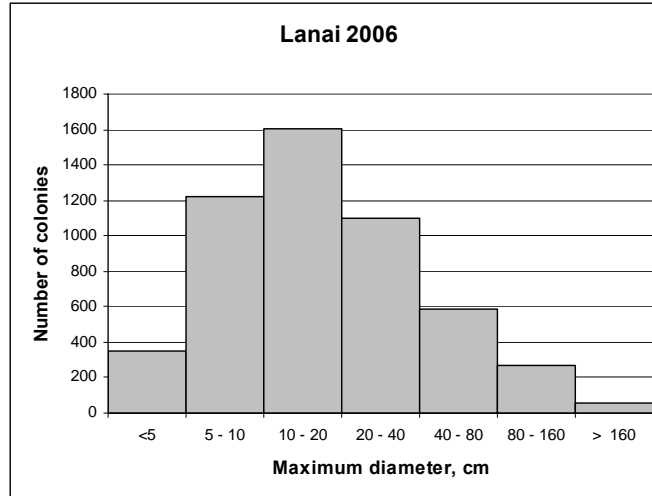


Figure I.3.2.1.1. Size class distribution of 5,199 anthozoan colonies censused within belt transects at Lanai during 2006 REA surveys.

Table I.3.2.1.2 Number of anthozoans counted within belt transects during MHI REA 2006 surveys at Lanai. Taxa contributing more than 10% of total colony abundance are in bold.

Taxon	# of colonies	% of total
<i>Montipora capitata</i>	1001	<b>19.3</b>
<i>Montipora flabellata</i>	43	0.8
<i>Montipora incrassata</i>	0	0.0
<i>Montipora patula</i>	821	<b>15.8</b>
<i>Montipora verrilli</i>	0	0.0
<i>Pavona duerdeni</i>	1	0.0
<i>Pavona varians</i>	56	1.1
<i>Cyphastrea ocellina</i>	1	0.0
<i>Leptastrea bewickensis</i>	0	0.0
<i>Leptastrea purpurea</i>	3	0.1
<i>Fungia scutaria</i>	3	0.1
<i>Cycloseris vaughani</i>	0	0.0
<i>Leptoseris incrustans</i>	0	0.0
<i>Pocillopora damicornis</i>	0	0.0
<i>Pocillopora eydouxi</i>	62	1.2
<i>Pocillopora ligulata</i>	1	0.0
<i>Pocillopora meandrina</i>	120	2.3
<i>Porites brighami</i>	17	0.3
<i>Porites compressa</i>	1091	<b>21.0</b>
<i>Porites evermanni</i>	232	4.5
<i>Porites lobata</i>	1724	<b>33.2</b>
<i>Porites monticulosa</i>	0	0.0
<i>Psammacora nierstraszi</i>	0	0.0
<i>Psammacora stellata</i>	8	0.2
<i>Palythoa sp.</i>	15	0.3
<i>Zoanthus pacifica</i>	0	0.0
<i>Sinularia sp.</i>	0	0.0

<b>Taxon</b>	<b># of colonies</b>	<b>% of total</b>
<i>Tubastraea coccinea</i>	0	0.0
<i>Cirripathes anguina</i>	0	0.0
<i>Antipathes sp.</i>	0	0.0
Total # colonies	5199	100.0
Area surveyed, m <sup>2</sup>	295	

### **I.3.3.2 Percent Benthic Cover**

Percent benthic cover surveys at the island of Lanai were conducted in congruency with the coral population REA surveys at six different sites. The point-count methodology quantified a total of 612 points along 300 m of coral reef communities. These surveys indicated that the mean percent of live coral cover for all sites combined at Lanai was moderate: 31.7%; the most numerically abundant scleractinian taxa were *P. lobata*, *M. capitata*, and *P. compressa*, representing 41.2%, 23.1%, and 22.7%, of the total percent live coral cover, respectively. Table I.3.2.2.1 provides an itemized summary of percent cover of the different benthic elements enumerated along the line transects at Lanai.

Table I.3.2.2.1 Percent cover of the benthic elements at Lanai using the point-count method during the 2006 REA activities.	
<b>Item</b>	<b>% cover</b>
<i>Pocillopora meandrina</i>	1.3
<i>Pocillopora eydouxi</i>	0.2
<i>Porites lobata</i>	13.1
<i>Porites compressa</i>	7.2
<i>Porites sp.</i>	0.8
<i>Montipora capitata</i>	7.4
<i>Montipora patula</i>	1.3
<i>Montipora flabelallata</i>	0.5
Macroalgae	10.5
<i>Halimeda</i>	0.2
Pavement/turf	3.1
Rubble/turf	4.2
Dead/cca	4.6
Rock turf	11.1
Dead/Lobo	0.3
Dead/turf	26.1
Sand	7.7
Other	0.3
% Live coral cover	31.7

### **I.3.3.3 Coral Disease**

At Lanai, the coral disease REA surveyed a total area of approximately 1,200 m<sup>2</sup> at six different sites during the reef assessment and monitoring program (RAMP) cruise of 2006. Figure I.3.2.3.1 illustrates the cumulative number of cases of disease and compromised health conditions enumerated for all sites combined. At a future date, these data will be related to coral colony density (estimated by Dr. Kenyon) and percent live coral cover (above) in order to numerically estimate disease prevalence. These results will be contrasted with data collected for other islands in the Hawaiian Archipelago.

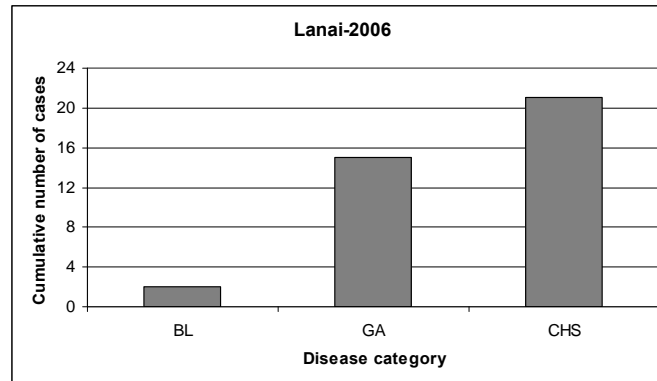


Figure I.3.2.3.1 Hawaii Coral diseases. Cumulative number of cases of disease at Lanai Island during 2006 REA surveys. Total area surveyed: 1,800 m<sup>2</sup>. BL: bleaching; GA: growth anomaly, and CHS: compromised health state, involving *Porites* pigmentation responses, and filamentous algal overgrowth.

### **I.3.3.4 Benthic Towed-diver Survey—Corals**

The overall coral cover on Lanai was some of the highest recorded in the main Hawaiian Island Archipelago, with many areas dominated by *Montipora* species. The average overall hard coral benthic cover for all combined surveys was approximately 31%. Three surveys conducted along the northeastern section of the windward side recorded the highest coral cover (average 89%, 69%, and 52%, respectively per survey) between Shipwreck Beach and Keomuku, with the area between the WWII Liberty ship and Kahokuni recording six 5-minute time segments of 100% coral cover.

In an area north of Kikoa Point, there were small patches of pale *Montipora* that appeared stressed in comparison with colonies from previous surveys (two time segments recorded 5–10% of all hard coral appeared stressed). Of note was the thick sediment described in the previous section not seen anywhere else along the Lanai coastline, along with a significant decrease in visibility. Finally, the northernmost towed-diver survey, which paralleled the location of the WWII Liberty ship in 10–12 meters depth, recorded 20–30% coral stress during the first 10 minutes of the survey.

Soft corals were uncommon, with only four 5-minute time segments recording 1% benthic coverage from all combined towed-diver surveys. Soft corals mostly consisted of wire coral, although a single black coral tree was sighted in approximately 25-meters depth on a west-facing wall near Paakai Point.

#### **I.3.4. Macroinvertebrates**

Lanai had a unique assemblage of invertebrates. Noteworthy differences for this island in comparison to the other MHI include the absence of any common mollusc fauna, and the low abundance of boring urchins. The most common echinoderm on the island was the collector urchin. The total abundance and diversity of total echinoderm fauna was also lowest of all of the MHI. Beyond echinoderms, there were areas that housed a higher amount of mobile species (such as crustaceans at station 15) and others that contained high amounts of cryptic species and coral commensals (like station 3).

Table I.3.3.1 Relative abundance data for echinoderms enumerated during REA surveys for the island of Lanai.						
Island	Lanai	Lanai	Lanai	Lanai	Lanai	Lanai
Date	8/4/06	8/4/06	8/4/06	8/5/06	8/5/06	8/5/06
Site	LAN-8	LAN-4	LAN-5	LAN-7	LAN-6	LAN-3
Depth(feet)						
Habitat	coast	coast	coast	coast	coast	Coast
	Avg/m2	Avg/m2	Avg/m2	Avg/m2	Avg/m2	Avg/m2
<b>Echinoids</b>						
Echinostrephus						0.006
Echinometra sp.						0.006
Echinothrix sp.					0.006	0.02
Heterocentrotus						
Tripneustes		0.07	0.012	0.002	0.004	0.01
Diadema						
Pseudobolentia						
Other Echinoid		0.03			0.02	
<b>Holothuroids</b>						
Holothuria atra		0.004				
Holothuria whitmaei					0.002	
Actinopyga obesa						
Actinopyga mauritiana						
Other Holothuroid						0.02
<b>Astroidea</b>						
Linckia multifora		0.02		0.01	0.01	0.02
Linckia guildingi						
Acanthaster planci		0.002				
Mithrodia fisheri						
Other Asteroid			0.002			
Culcita						

### **I.3.5. Benthic Towed-diver Survey—Macroinvertebrates**

Crown-of-thorns starfish were uncommon along Lanai, with no more than 3 recorded during 10 of the 50-minute towed-diver surveys. The eleventh towed-diver survey, which was conducted between Mamaki and Pali Kaholo along the southwestern corner of Lanai, showed a localized increase of 26 crown-of-thorns starfish recorded during the survey.

Sea cucumbers were also uncommon, with only 20 individuals recorded during the combined towed-diver surveys around Lanai.

Sea urchins were highest near Kaimaiki Point, with 175 recorded in each of the first four 5-minute time segments. Numbers dropped off significantly during the remaining six time segments, never exceeding five urchins. This may have corresponded with a change in the benthic habitat (medium-low to low complexity *Halimeda* beds in mostly sand flats during the first 20 minutes, increasing to medium-low to medium-high complexity reef).

### **I.4. Fish**

Six sites were surveyed at Lanai. A total of 94 species and 2,020 fishes were recorded (in both Belt and stationary point count (SPC) surveys). Damselfishes (Pomacentridae) were the most abundant (43%), followed by surgeonfish (Acanthuridae, 18%), wrasses (Labridae, 14%), and triggerfish (Balistidae, 5%). The blackfin chromis (*Chromis vanderbilti*) accounted for 26% of the total fish counted, and the agile chromis (*Chromis agilis*) accounted for 13%.

#### Fish $\geq 25$ cm TL:

Belt Transects: One hundred eight fishes representing 23 species and measuring  $\geq 25$  cm were counted on belt transects. Thirty-two percent of the individuals were surgeonfishes, 31% were triggerfishes, 10% were large wrasses (Hawaiian hogfish (*Bodianus bilunulatus*) and ringtail wrasse (*Oxycheilinus unifasciatus*)), 10% were parrotfishes, and 8% were the introduced peacock grouper (*Cephalopholis argus*).

SPCs: One hundred sixty-seven fishes representing 21 species were counted on the SPCs. Thirty-seven percent of the individuals were triggerfishes, 31% were surgeonfishes, 8% were the peacock groupers, 7% were wrasses, and 6% were parrotfish.

#### Towed-diver Surveys (fish $> 50$ cm TL):

At Lanai, the towed-diver team completed 11 dives over the course of 2 days covering 29.10 km of sea floor (Fig. I.4.1). Surveys were completed around the majority of the island with the exception of the northern coast. Surveys averaged 2.60 km in length and ranged from 2.11 km to 3.22 km. Median mean depth was -14.88 m.

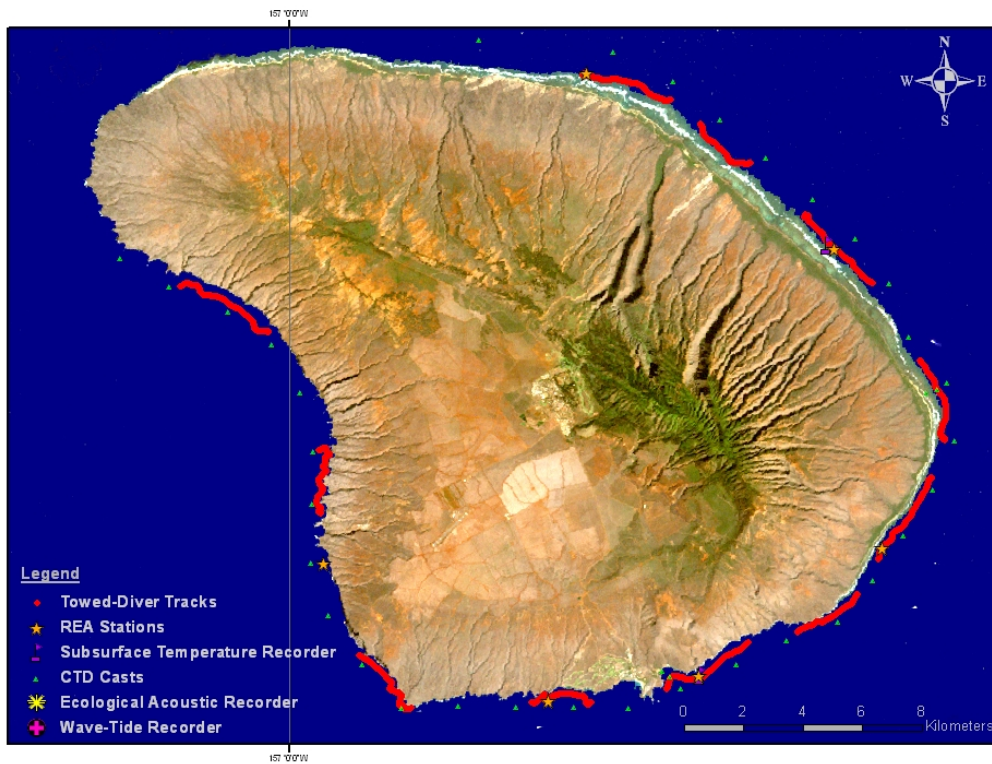


Figure I.4.1 HI-06-10 sampling stations at Lanai Island.

At Lanai 13 species were observed (Figs. I.4.2 – I.4.3). Numeric density was dominated by the redlip parrotfish (*Scarus rubroviolaceus*) followed by the spotted eagle ray (*Aetobatus narinari*) and the peacock grouper (*Cephalopholis argus*). Biomass was dominated by the spotted eagle ray followed by the redlip parrotfish and the giant moray eel (*Gymnothorax javanicus*).

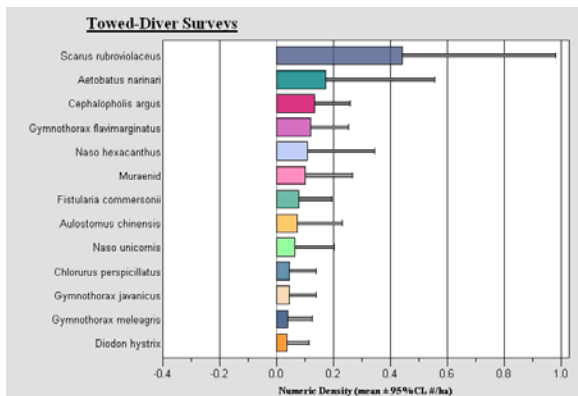


Figure I.4.2 Numeric Density (#/ha) of species at Lanai.

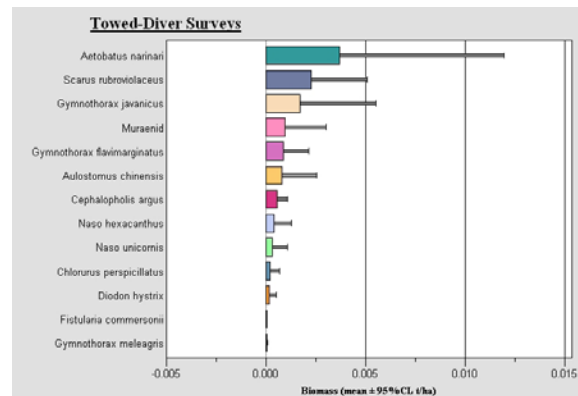


Figure I.4.3 Biomass Density (t/ha) of species at Lanai.



## Appendix J: Hawaii

### J.1. Oceanography & Water Quality

Figure J.1.1 plots subsurface temperature recorder STR data recovered from two sites on the Island of Hawaii: Punaluu Harbor on the southern Puna Coast near REA site HAW16 and near Mahukona on the northern Kohala Coast in 12.8 m and 9.8 m water depths, respectively. Temperatures are generally warmer with much greater diel variation at Mahukona than at Punaluu; this is partially a factor of depth, but also of greater insolation a probably lower wind/wave water mixing at Mahukona. There also a few notable short periods of cooler water at Mahukona; this may have to do with eddy-induced or internal tidal upwelling in the Alenuihaha Channel.

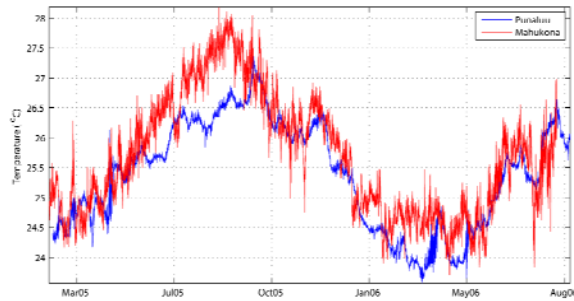


Figure J.1.1

Figure J.1.2 shows interpolated shallow conductivity-temperature-depth (CTD) cast data—10-m depths around Hawaii. This data shows relatively cooler water along the Hamakua Coast, probably the effect of cloudcover and lower insolation relative to other areas of the island. Turbidity plumes associated with stream runoff are also apparent.

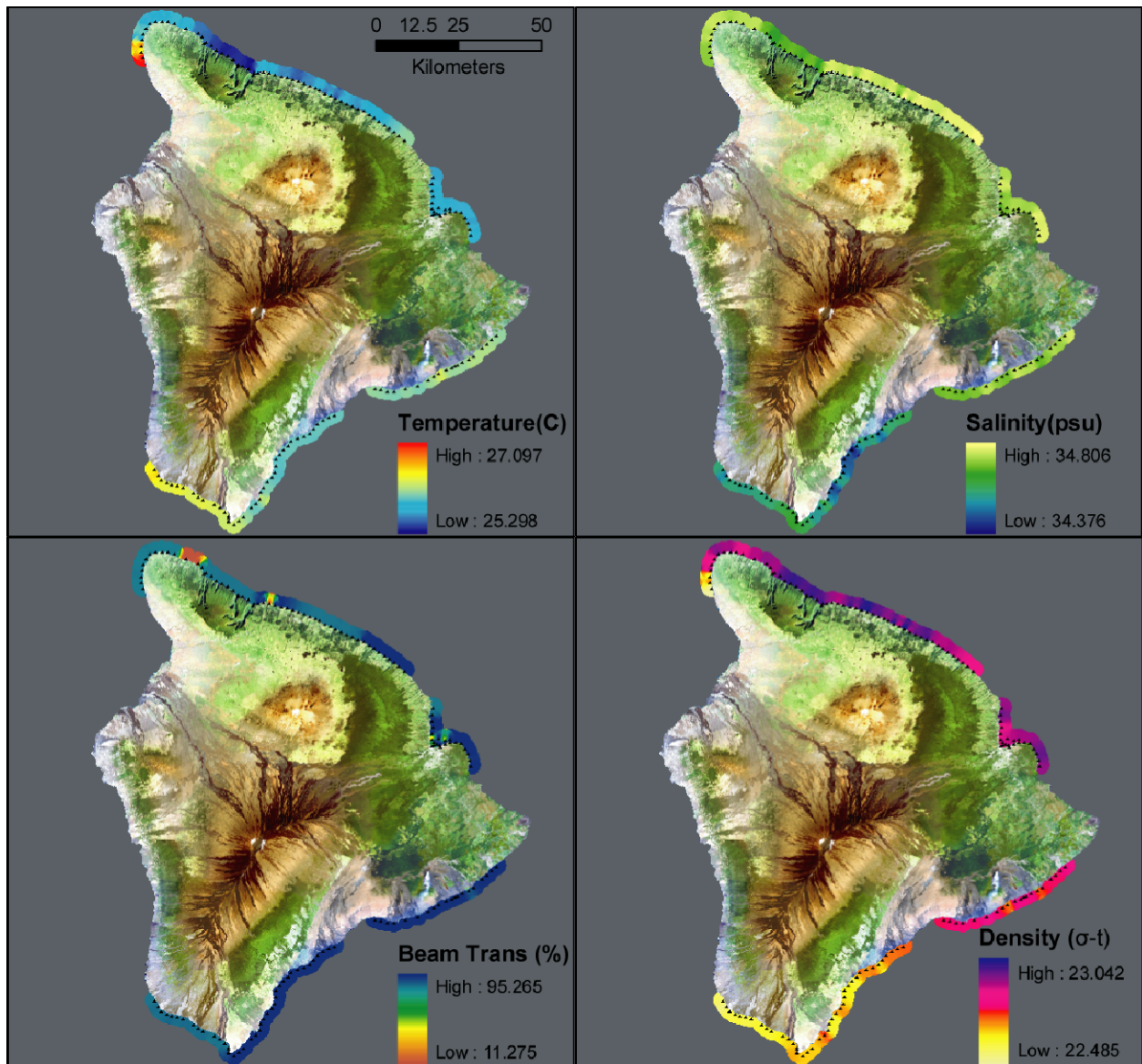


Figure J.1.2

## J.2. Rapid Ecological Assessment (REA) Site Descriptions

HAW-20

August 2, 2006

N-NE, rocky islets east of Upole Point. Basalt boulders. Depth range: 8.8–12 m; visibility ~20 m. Algal communities were dominated by crustose corallines and turf algae. *Amansia*, *Gelid*, and *Haloplegma* were also seen in abundance within the photoquadrats. Turf algae on the rocky boulders comprised over 93% of benthic cover. Corals grew directly on basalt boulders; percent cover was low (3.9%). Also, relative low coral diversity, community dominated by *Porites lobata*. However, abundant coral recruits, particularly pocilloporids. Coral health and disease assessment: only one case of *Porites* trematodiasis was observed. Additionally, this site (of me-

dium rugosity) was characterized by good invert diversity including three octopi found in holes among the large boulders. Apart from the high diversity of sponges, the other non-mobile fauna included vermetids, *Spirobranchus* polychaetes, *Palythoa* zoanthids, bryozoans, and a wide range of didemnum tunicates. The other mobile fauna included gastropods (*Conus*), three types of nudibranchs, two species of sea cucumbers, small crabs (spider crabs and hermits), and shrimp (*Stenopus*). The blackfin chromis (*Chromis vanderbilti*), bigscale soldierfish (*Myripristis berndti*), saddle wrasse (*Thalassoma duperrey*), and the introduced bluestripe snapper (*Lutjanus kasmira*) were the most numerous on the belt transect (BLT). The eyestripe surgeonfish (*Acanthurus dussumieri*), ringtail surgeonfish (*Acanthurus blochii*), and the introduced bluestripe snapper (*Lutjanus kasmira*) were the larger bodied fish at this station.

#### HAW-21

August 2, 2006

N-NE, east of Upole Point. Basalt boulders. Depth range: 16.1–18 m; visibility: ~20 m. Algal cover was high. Algal communities were composed mostly by turf algae, *Gelid*, *Amansia*, *Jania*, and *Lobophora*. Crustose corallines and *Laurencia* were also abundant within the photoquadrats. Turf algae on the rocky boulders comprised 78%, and percent live coral cover was 9.8 %, dominated by *Porites* spp. Other species present included: *Porites compressa*, *Montipora fabellata*, *M. capitata*, and *M. patula*. Abundant coral recruits, particularly pocilloporids. Some rare species included: *Leptoseris brewickensis*, *Leptoseris incrustans*, *Coscinaraea wellsi*, and *Leptastrea purpurea*. Coral health and disease assessment: one case of compromised health (predation) on *Porites* was observed. Macroinvertebrate surveys yielded echinoderms (urchins, sea stars, and cucumbers) as the most dominant fauna (of a very diverse accumulation of invertebrates). Encrusting invertebrates were also common including bryozoans, didemnum tunicates, and at least three species of sponge. Crustaceans were also diverse at this site including one Palinurid lobster, a pom pom crab, and many trapezid crabs (in coral heads) and hermits. The other rare to common fauna included brittle stars, nudibranchs, and Christmas tree worms (*Spirobranchus giganteus*). The blackfin chromis (*Chromis vanderbilti*), arceye hawkfish (*Paracirrhites arcatus*), and the whitebar surgeonfish (*Acanthurus leucopareius*) were the most numerous on the BLT. The sleek unicornfish (*Naso hexacanthus*) and the orangespine unicornfish (*Naso lituratus*) were the larger bodied fish at this station. A large hammerhead shark (*Sphyrna lewini*) was observed by a member of the benthic REA team.

#### HAW-32

August 2, 2006

N-NW, ocean fringing. West of Upole Point. Depth range: 11.8–12.7 m, visibility: 20 m. Old *Porites* reef in moderate stage of bioerosion. Numerous echinoid grazers were observed, including *Tripneustes* and *Echinometra*. Algal diversity was low, and algal communities were dominated principally by turf algae, crustose corallines, *Lobophora*, and blue-green algae. *Jania* and *Neomeris* were also seen within the photoquadrats. *Gibsmithia* was relatively abundant and found during the random swim. Turf algae and crustose coralline red algae (CCA) on the dead coral carbonate substrate comprised nearly 68% of the bottom cover; live coral cover amounted to 13.7%, and sand pockets represented 15% of the benthos. Main reef builders: *Porites lobata* and *P. compressa*. Coral health and disease assessment: two cases of *Porites* growth anomalies

were observed. Also, high abundance of boring sea urchins in this area. Five species of urchin total, with *Echinometra* being the most dominant. Also characteristic of this site were sand patches and loose rocks, which created good habitats for encrusting species (zoanthids, tube-dwelling polychaetes, and sponges), as well as nonmobile bivalves (*Spondylus* and *Isogonomon*) and mobile gastropods (*Cypraea* and *Drupa*), one banded coral shrimp, and hermits. The goldring surgeonfish (*Ctenochaetus strigosus*), agile chromis (*Chromis agilis*), brown surgeonfish (*Acanthurus nigrofuscus*), and the blackfin chromis (*Chromis vanderbilti*) were the most numerous on the BLT. The black durgon (*Melichthys niger*), bigeye emperor (*Monotaxis grandoculis*), and the orangeband surgeonfish (*Acanthurus olivaceus*) were the larger bodied fish at this station.

#### HAW-22

August 3, 2006

S-SW, west of South Point, off the Pu'u Hou flow. Depth range: 14.8–18 m, visibility: 20 m. Algal diversity was low. Algal communities were dominated by turf algae. *Lobophora*, crustose corallines and blue-green algae were also abundant within the photoquadrats. *Predea* was seen in some photoquadrats. Turf algae and CCA on the dead coral carbonate substrate comprised over 68% of the bottom cover, and coral cover amounted for 28.4%. Main reef builder: *P. lobata*. Coral health and disease assessment: Six cases of *Porites* pigmentation response with varying degrees of algal overgrowth were observed. Three of these colonies could also present trematodiasis. Additionally, the most dominant invertebrates at this site were urchins, bryozoans, and small patches of encrusting zoanthids and sponges (mostly on the underside of rocks). The other less common fauna included hydroids, a few small wire corals, nudibranchs, coral shrimp, hermits, and a few large gastropods. The goldring surgeonfish (*Ctenochaetus strigosus*), agile chromis (*Chromis agilis*), brown surgeonfish (*Acanthurus nigrofuscus*), disappearing wrasse (*Pseudocheilinus evanidus*), and the blackfin chromis (*Chromis vanderbilti*) were the most numerous on the BLT. The black durgon (*Melichthys niger*) was the larger bodied fish at this station. The black surgeonfish (*Ctenochaetus hawaiiensis*) was recorded at this station.

#### HAW-23

August 3, 2006

S-SW, ocean fringing. West of South Point, off the Pu'u Ki flow. Depth range: 14.5–18 m, visibility 20 m. Algal diversity was moderate. Algal communities were dominated by turf algae. *Lobophora*, crustose corallines, and blue-green algae were also abundant within the photoquadrats. *Padina*, *Dictyota*, and *Jania* were also abundant within the photoquadrats. *Predea*, *Turbinaria*, *Laurencia*, and *Gibsmithia* were seen during the random swim. Turf algae on the coral pavement and rubble substrate comprised nearly 70% of the bottom cover. Turf algae on dead coral surfaces comprised 14% cover. Also, sand pockets comprised nearly 12% of benthic cover. Coral cover amounted for 11.7%, and the main reef builder was *P. lobata*. Coral health and disease assessment: one case of *Porites* bleaching, one case of *Porites* growth anomaly, one case of *Porites* pigmentation response, and two cases of compromised health states in *Porites* due to algal and cyanobacterial overgrowth. There was a high diversity of invert fauna with the most dominant being echinoderms, including three species of sea star (*Acanthaster planci*, *Linckia guildini*, and *Culcita novaeguineae*), two species of cucumbers (including the chocolate chip species), and five

urchin species. Also present were zoanthids, wire coral, and arc shells. Additionally, the blackfin chromis (*Chromis vanderbilti*), agile chromis (*Chromis agilis*), and the chocolatedip chromis (*Chromis hanui*) were the most numerous on the BLT. No stationary point count (SPC) at this station due to equipment failure.

#### HAW-24

August 3, 2006

S-SW, ocean fringing. Close to Kauna Point. Average depth: 16.4 m; visibility 20 m. Algal diversity was moderate. Algal communities were dominated by turf algae. *Lobophora*, crustose corallines, and blue-green algae were also abundant within the photoquadrats. *Dictyota*, *Jania*, and at least three different species of *Caulerpa* were found within the photoquadrats. Only one transect was surveyed for coral community composition and coral disease (issues with dive buddy). Old *Porites* reef with moderately high percent live coral cover (57%). High coral diversity; 17 species enumerated. Coral species abundance in descending order of contribution to percent live coral cover included: *P. lobata* (27%) *P. meandrina* (17%), *M. flabellata* (~4%), *P. eydouxi* (~4%), *M. capitata* (~2%), and *P. compressa* (~2%). Reef in moderate stage of bioerosion. Numerous echinoid grazers, including: *Tripneustes*, *Echinometra*, *Echinothrix*, *Eucidaris*, and *Echinostrephus*. Coral health and disease assessment: one case of *Porites* pigmentation response was observed, as well as two cases of compromised health states in *Porites* due to algal overgrowth. Also at this site, the most common inverts recorded at this site were small hermits, small hydroids, and sponges. The high coral cover yielded a high number of alpheid and trapezid guard crabs found in the *Pocillopora* coral heads. Also present, but less common were wire coral, bryozoans, nudibranchs, gastropods, and small xanthid crabs. Urchins were present at this site, but were in a much lower number than the previous sites of the day. The blackfin chromis (*Chromis vanderbilti*), goldring surgeonfish (*Ctenochaetus strigosus*), arceye hawkfish (*Paracirrhites arcatus*), and the Thompson's butterflyfish (*Hemitaurichthys thompsoni*) were the most numerous on the BLT. The sleek unicornfish (*Naso hexacanthus*) and the introduced peacock grouper (*Cephalopholis argus*) were the larger bodied fish at this station. The gilded triggerfish (*Xanthichtys auromarginatus*) was present at this station.

#### HAW-25

August 15, 2006

Ocean fringing reef S of Hilo Bay; Kings Landing. Depth range: 13.3–16 m. Dark basalt rock/sand; moderately high topographical relief. Algal cover and diversity were high. Algal communities were, however, dominated by turf algae, crustose corallines, *Dictyota friabilis*, *Lobophora*, and *Jania*. *P. meandrina* dominant; abundant *Palythoa* and coralline algae. Percent live coral cover was 50%. High diversity coral diversity (personal observations detected at least 13 species; probably more; multiple *Porites* species, see Kenyon data). Major coral species in terms of abundance were *P. lobata* (25%), *P. meandrina* (17%), and *M. capitata* (6%). Other coral species observed within transect area included: *M. patula*, *P. varians*, *Leptastrea* spp., *P. eydouxi*, *P. ligulata*, *P. compressa*, *P. lutea*, *P. rus*, and *Palythoa* spp. Coral health and disease assessment: observations detected six cases of pigmentation response on *Porites*, one case of growth anomaly on *Porites*, and one case trematodiasis, also on *Porites*. There were also signs of heavy predation on *Pocillopora* and *Porites* in the area. Also, the zoanthid *Palythoa caesia* was

common throughout the site. The urchin *Echinothrix calamaris* and the holothuroid *Actinopyga obesa* were rare. A single spiny lobster *Panulirus marginatus* was recorded at the site. Additionally, 67 species of fishes and 1,015 individuals were counted. Seventy-five percent of the large bodied fishes were surgeonfish, mostly the orangeband surgeonfish. Smaller fish were dominated by the blackfin chromis followed by the arceye hawkfish, scale eating blennies, and various small wrasse.

#### HAW-26

August 15, 2006

Ocean fringing reef, Hilo Bay. Moderate topographical relief; mixed boulder/pavement habitat. Depth range: 9–11 m. Ryan Okano says area is affected by freshwater seeps from the seabed. Algal diversity within the photoquadrats was pretty low while it was high during the random swim. Algal communities were dominated by turf algae, crustose corallines, *Peyssonellia*, and *Dictyota friabilis* within the photoquadrats. *Dasya irridescens* was also commonly seen in the photoquadrats as well as *Amansi*. Percent live coral cover was approximately 62%. Major coral species present at this site were *M. flabellata* (15%) and *P. lobata* (22%). Coral diversity was medium to high with at least 11 species detected. Other coral species observed within the survey area were *M. capitata*, *M. patula*, *P. varians*, *Leptastrea* spp., *Fungia scutaria*, *P. compressa*, *P. lutea*, *P. rus*, and *Palythoa* spp. Coral health and disease assessment: observations detected one case of growth anomaly, one case of tissue loss on *Porites*, five cases of trematodiasis on *Porites*, and two cases of pigmentation responses on *Porites* (different than that triggered by trematodiasis). Also, the urchin *Echinothrix calamaris* and the holothuroid *Actinopyga obesa* were the only common macroinvertebrates observed at this site. Sixty-six species of fishes and 475 individuals were recorded. The predominant large bodied fish were surgeonfish, followed by triggerfish and the Hawaiian hogfish. Again, the smaller fish were dominated by the blackfin chromis. The remaining small species were mostly arceye hawkfish, lavender tang, and saddle wrasse.

#### HAW-15

August 16, 2006

SE ocean fringing reef. Depth range: 12–15.5 m. Boulder habitat offshore from Kamehame Hill with coarse basaltic sediment. Dark basalt rock/sand; moderately high topographical relief. Algal cover was moderate. Algal communities were dominated by crustose coralline algae, turf algae, *Lobophora*, and *Peyssonellia*. *Jania* and *Dictyota friabilis* were also pretty common within the photoquadrats. Diversity was higher during the random swim. Percent live coral cover was approximately 37%. Coral species diversity was medium with 10 species detected. Major coral species detected at this site were *P. meandrina* (17%) and *P. lobata* (15%). Other species observed include: *M. capitata*, *M. patula*, *M. flabellata*, *P. varians*, *P. ligulata*, and *P. compressa*. Also abundant were *Palythoa* and coralline algae. One case of bleaching on *P. meandrina*, and three cases of pigmentation responses on *Porites* (grossly, different than trematodiasis) were observed. Also, the sea star *Linckia multifora* was commonly seen, as was the boring urchin *Echinometra mathaei*. The zoanthid *Palythoa caesia* has patchy coverage at depths from 60 to

30 feet. Above this depth there was far more uniform coverage of this zoanthid. Two individuals of the brachyuran crab *Charybdis* and a single octopus were recorded at the site. Ninety-one species of fishes and 1,374 species were recorded. Among the medium to large sized fishes ( $\geq 25$  cm) surgeonfish accounted for 50% of the individuals. The bluelined snapper was the dominant species accounting for 31% of the large bodied individuals. Of the smaller fishes, the blackfin chromis was dominant while the goldring surgeon, arceye hawkfish, yellow and lavender tangs were common. An unusual number of fourline wrasse (*Pseudocheilinus tetrataenia*) were counted (57 individuals).

#### HAW-16

August 16, 2006

SE ocean fringing reef, near Punalu'u. Basalt boulders and rubble topography with patches of sand and pavement. Depth range: 9–11 m. Algal communities were dominated by turf algae, *Gelid*, *Peyssonelia*, and *Acanthophora pacifica*. Crustose corallines were also common within the photoquadrats. A lot of different algal genera were found during the random swim. Coral diversity was moderate, with nine species detected; abundant encrusting *M. patula*, *M. capitata*; several large ( $>1$  m) *P. lobata* in area. Major coral species detected at this site were *P. lobata* (17%) and *M. capitata* (17%). Other species included *M. flabellata*, *P. varians*, *P. ligulata*, *P. meandrina*, *P. compressa*, *P. lutea*, and *Palythoa* spp. Coral health and disease assessment: surveys detected 1 case of trematodiasis and 17 cases of pigmentation response (grossly different than trematodiasis), all on *Porites*. Additionally, the zoanthid *Palythoa caesia* was patchily distributed and was mostly on boulders. There were abundant gastropods (*Conus miles*, *Conus flavidus*, and *Latirus nodatus*) and sea stars (*Linckia guildingi*). There was a rare occurrence of the boring urchins *Echinostrephus aciculatus* and *Echinometra mathaei*, as well as the sea star *Asteropsis carinifera*. The spiny lobster *Panulirus marginatus* and slipper lobster *Parribacus antarcticus* were rare. Fifty-six species of fish and 519 individuals were counted. Eighty-two of the 91 large bodied individuals were surgeonfish while among smaller fish, the blackfin chromis was numerically dominant (67%). Lavender tang, saddle wrasse, arceye hawkfish, brighteye damselfish, and the ornate wrasse (*Halichoeres ornatissimus*) were most common among the remaining individuals.

#### HAW-12

August 16, 2006

SE, E of South Point, ocean fringing reef. Depth range: 12.4–15.5 m. Heterogeneous habitat; coral beds mixed with large patches of sand, rubble, and a large net snagged on the reef damaging corals. Algal cover was high, but algal diversity was less important at this site than at the others. Algal communities were dominated by crustose coralline and turf algae. *Peyssonelia* was also dominant. Coral cover patch composed of large field of *Porites compressa* mixed with sand habitat. Percent live coral cover was approximately 41%. Coral diversity was high with 14 species detected. Major coral species detected at this site were *P. lobata* (9%) and *P. compressa* (20%). Other species detected include *M. capitata*, *M. flabellata*, *M. patula*, *Pavona duerdeni*, *P. varians*, *Fungia scutaria*, *P. ligulata*, *P. meandrina*, *P. lutea*, *Porites lichen*, *Palythoa* spp., and *Zoanthus* spp. Coral health and disease assessment: surveys detected one case of growth anomaly on *Porites* and three cases of pigmentation response—two on *Porites* and one on *M.*

*capitata*. Compromised health states due to predation were also noted on colonies of *Porites* and *Pocillopora*. Additionally, there were abundant macroinvertebrates throughout the site composed mostly of the echinoid echinoderms *Heterocentrotus mammilatus*, *Tripneustes gratilla*, and *Echinothrix calamaris*. The holothuroids *Actinopyga obesa*, *Holothuria whitmaei*, and *Holothuria leucospilota* were also common. Also, fifty-five species of fish and 536 individuals were counted. Medium bodied surgeonfish, the redlip parrotfish (*Scarus rubroviolaceus*), and the bluelined snapper accounted for most of the larger species. As expected in a finger coral habitat, large numbers of goldring surgeonfish and yellow tang were present as well as some yellow tang recruits. The blackfin chromis, lavender tang, and arceye hawkfish were also common on the belt transects.

#### HAW-8

August 17, 2006

SE, ocean fringing reef. Depth range: 7.8–10.3 m. Basalt boulders, black sand, large rubble. Algal cover was high. Algal diversity was moderate. Algal communities were dominated by turf algae, *Sargassum*, crustose corallines, *Peyssonelia*, and *Dictyota friabilis*. *Amansia*, *Dictyota ceylanica*, and *Jania* were also seen commonly within the photoquadrats. Percent live coral cover was approximately 29%; dominant *P. meandrina*, abundant *P. lobata*, encrusting montiporids and *P. lobata*. Coral health and disease assessment: one case of bleaching on *Porites*, seven cases of trematodiasis, accompanied by pigmentation responses, and one case of pigmentation response with algal overgrowth. Also at this site, the urchins *Echinometra mathaei*, *Echinothrix calamaris*, and *Tripneustes gratilla* were common, while the holothuroids *Holothuria whitmaei* and *Actinopyga obesa* and the asteroid *Acanthaster planci* were rare. There was an unknown blue didemnid tunicate throughout the site and a rare occurrence of the bryozoan *Triphyllozoon*. Additionally, fish species diversity was high; 96 species and 1,911 individuals were counted. Among large bodied fishes, surgeonfish were dominant. On the belt transects, the blackfin chromis was dominant. Nineteen fourspot butterflyfish (*Chaetodon quadrimaculatus*) were counted, more than any other sites on both legs of the cruise. Only seven parrotfish were recorded. The rare bandit angelfish (*Apolemichthys arcuatus*) was present. One whitetip reef shark (*Triaenodon obesus*) was observed entering a cave.

#### HAW-27

August 17, 2006

SE ocean fringing reef near Kalapana, off the lava field; very thinly colonized substrate, Depth range: 11.8–14 m (working area). Mixed habitat of large boulders and black sand on a steep, seaward slope. No algal survey. Black lava boulders, rubble, and sand with very patchy abundance of *P. meandrina* and *P. lobata* recruits. Percent live coral cover was less than 1%. Coral species detected at this site included *M. capitata* and *P. ligulata*. Interesting to know these were truly *P. lobata* recruits, not the product of fissioning. Young substrate; how Hawaiian coral reefs begin. Encrusting tunicates, hydroids, barnacles, tuft-eating crabs, eels. No corals on one transect! Yet fish divers report high abundance and diversity. No algal divers due to equipment problems. No disease detected at this location. The urchin *Echinothrix calamaris* was the only numerous non-cryptic invertebrate at the site. The fauna at the site was mostly sessile fauna such as barnacles, tunicates, and bryozoans on the underside and lower regions of the boulders. The



anemone hermit crab *Dardanus gemmatus* was unusually abundant at the site. Additionally, a total of 94 species of fish and 928 individuals were counted. Among the large bodied fishes, the sleek unicornfish (*Naso hexacanthus*) was numerically dominant. Three species of snapper, the bluelined snapper, blacktail snapper (*Lutjanus fulvus*), and the gray snapper (*Aphareus furca*) were common. Two leatherbacks (*Scomberoides lysan*) were counted. The blackfin chromis was dominant among small fishes. An unusual number of small wrasse, the ornate wrasse, and the elegant coris (*Coris venusta*) were counted. A large conger eel was present on a transect line.

#### HAW-28

August 17, 2006

SE, near lava plume. Depth range: 9.4–13 m. Large basalt boulders, black sand. Low visibility, moderate surge. Divers heard lava balls underwater from nearby lava plumes. Thick cover algal turf. Algal cover was important but algal diversity was very limited. Algal communities were dominated by *Gelid*, turf algae, crustose corallines, *Dictyota friabilis*, and *Amansia*. *Peyssonelia* and *Jania* were seen commonly within the photoquadrats but were not dominant. Percent live coral cover was 13%; encrusting *P. lobata* and *P. meandrina* common. Numerous larger, dead pocilloporids covered with coralline algae. More advanced successional development than previous site (more time for colonization and development, reflected in more colonies, larger size, greater diversity, dead pocilloporids overgrown with coralline algae). Coral health and disease assessment: two cases of bleaching on *Porites* and two cases of pigmentation responses on *Porites*. Predation detected on *Pocillopora* species. Sponge fauna was a common component throughout the site and was predominantly the genus *Clathria*. Three unknown species of sponge were also common. The holothuroid *Actinopyga mauritiana* was recorded but was rare, as were *Octopus cyanea* and the lobster *Panulirus marginatus*. Additionally, low fish species diversity (41 species and 438 individuals) and high biomass were also noteworthy at this site. Many large surgeonfish including the yellowfin surgeonfish (*Acanthurus Xanthopterus*) were present as well as bluelined and blacktail snappers and several bluefin trevally (*Caranx melampygus*). A large school of leatherbacks, about 50 individuals, passed through the site. The blackfin chromis was numerically dominant but in substantially less numbers than most other sites (70 individuals). Saddle wrasse, ornate wrasse, and arceye hawkfish were relatively common.

#### HAW-29

August 18, 2006

Ocean fringing reef, Hamakua Coast. Depth range: 9.3–15 m. Large basalt boulders, black sand. Moderately high topographical relief. Moderate surge. Algal diversity was moderate while algal cover was pretty important. Algal communities were dominated by turf algae, crustose corallines, *Amansia*, *Gelid*, *Jania*, and *Peyssonelia*. *Dictyota ceylanica* and *D. friabilis* were also commonly found within the photoquadrats. Percent live coral cover was approximately 23%; abundant *P. meandrina*, encrusting *M. patula*, *M. capitata*, *M. flabellata*, *P. lobata*. The dominant coral species at this site were *P. lobata* (10%) and *M. capitata*. Coral health and disease assessment: one case of growth anomaly, one case of tissue loss, and one case of pigmentation response; all detected on *Porites*. Some predation observed on *Pocillopora* and *Porites* species. Additionally, the dominant invertebrate species was an unknown green sponge species. Also, 80 species of fish and 1,072 individuals were counted at this site. Schools of large-bodied surgeon-

fish and sea chubs were common. The redlip parrotfish and bluelined snapper were also common. Among smaller fish, the blackfin chromis was again numerically dominant. The arceye hawkfish, saddle wrasse, and Pacific Gregory were common.

#### HAW-30

August 18, 2006

Ocean fringing reef, Hamakua Coast. Depth range: 11.2–16.6 m. Large basalt boulders and smaller rubble; very high topographical relief. Algal diversity was moderate to high. Algal communities were dominated by turf algae, crustose corallines, *Dictyota friabilis*, and *Jania*. At this location, *Caulerpa taxifolia* was relatively seen commonly along the transects and within the photoquadrats. Blue-green algae were prevalent in some photoquadrats. Percent live coral cover was approximately 56%. Dominant coral species at this site were *P. meandrina* (18%), *M. capitata* (17%), and *P. lobata* (16%). Numerous colonies; a coral censusing challenge! Other coral species present included: *M. flabellata*, *M. patula*, *Pavona varians*, *Fungia scutaria*, *Pocillopora eydouxi*, *Pocillopora ligulata*, *Porites lutea*, *Palythoa* spp., and *Zoanthus* spp. Coral health and disease assessment: one growth anomaly detected on *Porites*, and three cases of pigmentation response on *Porites*. Light predation detected on *Pocillopora* species. Additionally, the dominant invertebrate species was an unknown green sponge species. Seventy-two species of fish and 1,502 individuals were counted. Many large fish, mostly schools of surgeonfish, were observed. The eyestripe surgeonfish and ringtail surgeonfish (*Acanthurus blochii*), the redlip parrotfish, and the Hawaiian hogfish were dominant among the larger fishes. The spectacled parrotfish (*Chlorurus perspicillatus*) was present. The smaller fish were dominated by the blackfin chromis followed by the saddle wrasse, lavender tang, and whitebar surgeonfish (*Acanthurus leucopareus*).

#### HAW-31

August 18, 2006

Ocean fringing reef, Hamakua Coast. Depth range: 14.5–17 m. Kenyon did not dive due to low tank fill; divers indicated benthos similar to previous sites but lesser coral cover. Reef substrate was a mix of large boulders and smaller rubble. Algal cover was important but algal diversity was low. Algal communities were dominated by turf algae, crustose coralline algae, *Gelid*, and different species of *Dictyota*. *Peyssonelia* and blue-green algae were also commonly observed within the photoquadrats. Percent live coral cover was approximately 20%. The dominant coral species at this site were *P. lobata* (10%) and *M. capitata* (8%). Coral health and disease assessment: 1 case of growth anomaly on *M. capitata* and 13 cases of pigmentation responses on *Porites*, 3 of which may involve trematodiasis; 8 of the 12 cases of pigmentation response involved prolific algal overgrowth. Also, light predation detected on *Pocillopora* species. *Acanthaster* also observed at this site. Additionally, the dominant invertebrate species was an unknown green sponge species. This site was similar to HAW-29 and -30, with the exception that *Acanthaster planci* was recorded at site HAW-31 only, where it was common. Also, 65 species of fish and 546 individuals were counted. The larger fish were mostly surgeonfish (23% of all fish counted). Sea chubs, bluelined and blacktail snappers, and redlip parrotfish were common. Blackfin chromis were numerically dominant among smaller fishes. The arceye hawkfish, saddle wrasse, and lavender tang were common.

### J.3. Benthic Environment

#### J.3.1. Algae

A total of 16 sites were visited by the algae team around Hawaii (Big Island) between July and August 2006. Those sites were located north, east, and south of the island. Algal diversity and algal cover varied among sites. The most common algae observed within the photoquadrats were turf algae, crustose corallines, *Peyssonelia* and *Sargassum*. Algal diversity was relatively high around the island of Hawaii and especially, in the southeastern region. A total of 38 genera and 5 functional groups comprising crustose coralline algae, turf algae, blue-green algae, orange crusts and sand were found within the photoquadrats (Table J.3.1.1.). If data from the random swim are included, then a total of 52 genera were observed during the survey. The most common algae observed and ranked within the photoquadrats were: turf algae, crustose coralline algae, *Sargassum* and *Peyssonelia* with an average percentage occurrence in photoquadrats higher than 50%. The percent occurrence of blue-green algae was also >50%. Other algae were also commonly seen (30–50% of occurrence) along both transects. Those algae are: *Caulerpa taxifolia*, *Acanthophora pacifica*, *Amansia glomerata*, *Dasya irridescens*, *Gelid*, *Jania sp.*, *Dictyota sp.*, *Dictyota ceylanica*, *Dictyota friabilis*, *Lobophora*, and *Padina melemele*.

Table J.3.1.1 Average occurrence (%) and average rank for each genera, species, or functional group found within the photoquadrats in Hawaii.

	% Occurrence	Rank
<b>Green Algae</b>		
<i>Caulerpa nummularia</i>	8.3	6.0
<i>Caulerpa sp.</i>	8.3	5.7
<i>Caulerpa macrophysa</i>	8.3	4.0
<i>Caulerpa serrulata</i>	8.3	6.0
<i>Caulerpa taxifolia</i>	33.3	5.0
<i>Caulerpa webbiana</i>	15.6	7.6
<i>Cladophoropsis</i>	12.5	8.3
<i>Chlorodesmis caespitosa</i>	8.3	4.5
<i>Halimeda opuntia</i>	17.9	5.6
<i>Microdictyon setchellianum</i>	8.3	5.0
<i>Microdictyon umbilicatum</i>	8.3	8.0
<i>Neomeris annulata</i>	22.0	7.3
<i>Phyllocladon</i>	8.3	7.7
<i>Rhipidosiphon javensis</i>	8.3	4.0
<i>Ventricaria ventricosa</i>	12.5	5.0
<b>Red algae</b>		
<i>Acanthophora pacifica</i>	33.3	5.9
<i>Actinotrichia fragilis</i>	20.8	5.1
<i>Amansia glomerata</i>	41.0	4.2
<i>Asparagopsis taxiformis</i>	16.7	6.5
<i>Botryocladia skottsbergii</i>	8.3	8.0
<i>Dasya iridescens</i>	33.3	6.2
<i>Dasya sp.</i>	13.9	5.8
<i>Galaxaura marginata</i>	8.3	4.0
<i>Galaxaura obtusata</i>	8.3	5.0
<i>Gelid</i>	36.4	3.8

	% Occurrence	Rank
<i>Gibsmithia hawaiiensis</i>	8.3	5.0
<i>Gracilaria</i>	8.0	8.0
<i>Haliptilon subulatum</i>	8.3	6.0
<i>Haloplegma duperreyi</i>	16.7	5.6
<i>Heterosiphonia</i>	8.3	6.0
<i>Hypnea sp.</i>	8.3	3.0
<i>Jania sp.</i>	41.7	5.1
<i>Laurencia sp.</i>	13.9	4.2
<i>Martensia sp.</i>	11.1	5.7
<i>Martensia flabelliformis</i>	16.7	7.5
<i>Neomartansia</i>	8.3	3.0
<i>Peyssonnelia sp.</i>	51.7	4.0
<i>Platoma ardreanum</i>	8.3	6.5
<i>Portieria hornemannii</i>	15.6	6.0
<i>Predaea weldii</i>	16.7	4.0
<i>Tolypiocladia glomerulata</i>	11.1	6.3
<b>Brown algae</b>		
<i>Dictyopteris palagiogramma</i>	19.4	5.1
<i>Dictyota sp.</i>	35.2	5.1
<i>Dictyota ceylanica</i>	29.8	5.0
<i>Dictyota friabilis</i>	49.2	4.7
<i>Lobophora varigata</i>	38.7	4.4
<i>Padina sp.</i>	21.7	6.8
<i>Padina melemele</i>	30.6	6.5
<i>Sargassum sp.</i>	62.5	4.8
<i>Turbinaria ornate</i>	8.3	7.0
<b>Functional groups</b>		
Blue-green	54.8	4.3
Turf	92.7	1.4
CCA	77.6	2.5
orange crust	10.4	3.9
Sand	24.4	2.4

### J.3.2. Benthic Towed-diver Survey—Algae

Macroalgae and coralline algae cover for the Big Island both recorded an overall average of 18%, with macroalgal cover ranging from 0–75% and coralline algae cover ranging from 0–62.5%. The towed-diver survey conducted near Kauhola Point recorded the highest macroalgal cover (average 43%; range 20–75%), while the survey completed west of Leleiwi Point recorded the highest coralline algae cover (average 49%; range 40–62.5%).

*Halimeda* patches were noted during during the towed-diver survey conducted in the vicinity of Akoakoa Point (near a dropoff) and additional surveys completed near Kukulhaele Ldg. Finally, *Dictyopteris* algal meadows were noted during towed-diver surveys completed near Kauhola Point and Upolu Point.

### J.3.3. Corals

#### J.3.3.1 Coral Population Parameters

Table J.3.2.1.1 summarize the characteristics of coral populations within belt transects at the 16 Hawaii sites surveyed for basic coral population parameters in 2006 (an additional site, HAW-31, was not censused because of problems with dive gear). Of these 16 sites, only 4 had been assessed in 2005, and 12 were new sites. A total of 7,881 corals belonging to 19 anthozoan taxa were censused within an area of 775 m<sup>2</sup>. The most numerically abundant taxa were *P. meandrina*, *P. lobata*, and *M. capitata*. At some sites, *P. compressa* or *M. patula* contributed substantially to the coral fauna.

Overall size distribution indicates 50.0% of colonies have a maximum diameter <10 cm, and only 4.1% measure >40 cm maximum diameter. Small colonies therefore dominate coral communities surveyed in Hawaii.

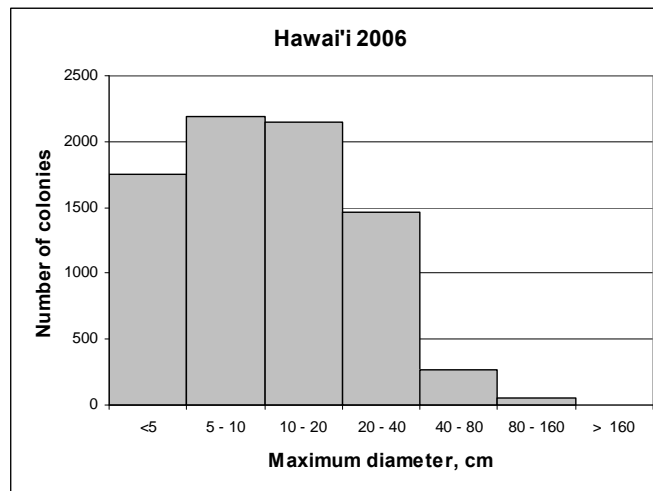


Figure J.3.2.1.1. Hawaii-Corals. Size class distribution of 7,881 anthozoan colonies censused within the belt transects in Hawaii during 2006 REA surveys.

Table J.3.2.1.2 Number of anthozoans counted within the belt transects during MHI REA 2006 surveys in Hawaii. Taxa contributing more than 10% of total colony abundance are in bold.

Taxon	# of colonies	% of total
<i>Montipora capitata</i>	1002	<b>12.7</b>
<i>Montipora flabellata</i>	112	1.4
<i>Montipora incrassata</i>	6	0.1
<i>Montipora patula</i>	474	6.0
<i>Montipora verrilli</i>	0	0.0
<i>Pavona duerdeni</i>	34	0.4
<i>Pavona varians</i>	52	0.7
<i>Cyphastrea ocellina</i>	0	0.0
<i>Leptastrea bewickensis</i>	0	0.0
<i>Leptastrea purpurea</i>	21	0.3
<i>Fungia scutaria</i>	2	0.0
<i>Cycloseris vaughani</i>	1	0.0
<i>Leptoseris incrustans</i>	1	0.0
<i>Pocillopora damicornis</i>	0	0.0
<i>Pocillopora eydouxi</i>	58	0.7
<i>Pocillopora ligulata</i>	13	0.2
<i>Pocillopora meandrina</i>	1949	<b>24.7</b>
<i>Porites brighami</i>	14	0.2
<i>Porites compressa</i>	650	8.2
<i>Porites evermanni</i>	105	1.3
<i>Porites lobata</i>	3066	<b>38.9</b>
<i>Porites monticulosa</i>	0	0.0
<i>Psammacora nierstraszi</i>	0	0.0
<i>Psammacora stellata</i>	6	0.1
<i>Palythoa</i> sp.	315	4.0
<i>Zoanthus pacifica</i>	0	0.0
<i>Sinularia</i> sp.	0	0.0
<i>Tubastraea coccinea</i>	0	0.0
<i>Cirripathes anguina</i>	0	0.0
<i>Antipathes</i> sp.	0	0.0
Total # colonies	7881	100.0
Area surveyed, m <sup>2</sup>	775	

### J.3.3.2 Percent Benthic Cover

The line intercept methodology quantified a total of 1,683 points along 825 m of coral reef communities, mainly ocean fringing forereef environments. Table J.3.2.2.1 provides an itemized summary of percent cover of the different benthic elements enumerated along the line transects at the Island of Hawaii. The most numerically abundant taxa were *P. lobata*, *P. meandrina*, and *M. capitata*, representing 43.5, 22.2, and 15.7%, of the total percent live coral cover, respectively.

Table J.3.2.2.1 Percent cover of the benthic elements at Hawaii using the point-count method during the 2006 REA activities.

Item	% cover
<i>Pocillopora meandrina</i>	6.5
<i>Pocillopora ligulata</i>	0.1
<i>Pocillopora eydouxi</i>	0.3
<i>Pocillopora molokensis</i>	0.2
<i>Porites lobata</i>	12.7
<i>Porites evermanni</i>	0.2
<i>Porites compressa</i>	1.7
<i>Porites</i> sp.	0.1
<i>Montipora capitata</i>	4.6
<i>Montipora patula</i>	0.6
<i>Montipora flabelallata</i>	1.7
<i>Pavona varians</i>	0.3
<i>Pavona</i> sp	0.0
<i>Leptoseris incrustans</i>	0.1
<i>Leptastrea</i> sp.	0.0
<i>Fungia</i> sp.	0.1
Macro-algae	0.4
<i>Halimeda</i>	0.0
<i>Palythoa</i>	0.7
Pavement/cca	1.2
Pavement/turf	11.2
Pavement/cyano	0.3
Rubble/cca	2.3
Rubble/turf	23.0
Rubble/cyano	0.1
Dead/cca	5.3
Dead/cyano	0.1
Rock/turf	10.4
Dead/ <i>Lobophora</i>	0.7
Dead/turf	8.4
Sand	6.5
Other	0.2
% Live coral cover	29.3

### J.3.3.3 Coral Disease

Figure J.3.2.3.1 illustrates the cumulative number of cases of disease and compromised health states enumerated for all sites combined for the island of Hawaii. At a future date, these data will be related to coral colony density and coral cover (estimated by Dr. Kenyon) in order to numerically estimate disease prevalence. These results will be contrasted with data collected for other islands.

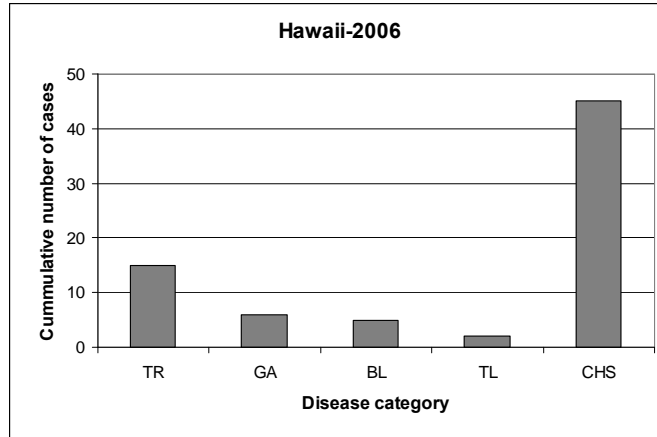


Figure J.3.2.3.1 Cumulative number of cases disease at Hawaii Island during 2006 REA surveys. TR: trematodiasis, GA: growth anomaly; BL: bleaching, TL: tissue loss; and CHS: compromised health state, mainly due to pigmentation responses.

#### J.3.3.4 Benthic Towed-diver Surveys—Corals

Overall hard coral cover averaged 22% for the combined towed-diver surveys around the Big Island. The highest coral cover was recorded for a towed-diver survey completed around Palima Point (average 46%; range 10–62.5%). Overall stressed coral was low, with the highest levels of stress recorded for the towed-diver survey completed near Eleiwi Point (average 3%; range 1–5%).

Additional observations included the following:

- Large *P. lobata* colonies (est. 5-meters diameter) noted for three 5-minute time segments during the towed-diver survey completed near Maniania/Kipaepae/Kapuna Bay
- Large *P. lobata* and *Pavona duerdini* (between 4 and 5 meters diameter) colonies noted during the towed-diver survey completed between Kahilipali Point and Kamilo Point.

Soft coral cover was relatively low during all towed-diver surveys. An exception was noted for the survey completed near Palima Point (average 5% soft coral cover; range 1–10%), where *Palythoa caesia* made up the majority of soft coral bottom cover. Additional observations included the following:

- Wire coral species were recorded for 7/10 5-minute time segments during a survey completed to the southeast of Puu Ki;
- Wire coral species were recorded for 8/10 5-minute time segments during a survey completed around Na Puu a Pele (west of Humuhumu Point);
- A small patch of *Carijoa* was noted along a cliff face during the fourth 5-minute time segment during a survey completed near Kamokuna, with an additional sighting in the first 5-minute time segment noted in a survey completed near Ka Lae Apuki.



#### **J.3.4. Macroinvertebrates**

The island of Hawaii was extensively studied and had a wide variety of habitats, macroinvertebrate assemblages, and dominant taxa. Echinoderms, especially urchins, (found in decent numbers at 16 of 17 sites) were the most common invert, with sea stars and cucumbers also being common at most sites. The only region with low diversity but high abundance of a few taxa (urchins and zoanthids) was north of Laupahoepahoe. Octopi were found at 7 of 17 sites, lobster found at 3 sites, and pearl oysters found at 2 sites. Also of mention were two sites (8 and 15) where the relative abundance of zoanthids was unusually high in comparison to the average cover over all the islands.

Table J.3.3.1 Relative abundance data for echinoderms enumerated during REA surveys for the island of Hawaii.

Island	Hawaii	Hawaii	Hawaii	Hawaii	Hawaii	Hawaii	Hawaii	Hawaii	Hawaii	Hawaii	Hawaii	Hawaii	Hawaii	Hawaii	Hawaii	Hawaii	Hawaii
Date	8/14/06	8/14/06	8/15/06	8/15/06	8/15/06	8/17/06	8/17/06	8/17/06	8/17/06	8/18/06	8/18/06	8/2/06	8/2/06	8/2/06	8/3/06	8/3/06	8/3/06
Site	HAW-25	HAW-26	HAW-15	HAW-16	HAW-12	HAW-08	HAW-27	HAW-28	HAW-29	HAW-30	HAW-31	HAW-20	HAW-21	HAW-4	HAW-22	HAW-23	HAW-24
Depth(feet)	45	35	47	35	35	50	52	50	48	50	55						
Habitat	Boulder	Reef	Boulder	Basalt/San	Reef	Boulder	Boulder	Boulder	Boulder	Boulder	Boulder	islet	cove	coast	coast	coast	cove
	Avg/m2	Avg/m2	Avg/m2	Avg/m2	Avg/m2	Avg/m2	Avg/m2	Avg/m2	Avg/m2	Avg/m2	Avg/m2	Avg/m2	Avg/m2	Avg/m2	Avg/m2	Avg/m2	Avg/m2
<b>Echinoids</b>																	
Echinostrephus		0.16		0.04						0.04	0.08	0.008	0.02	0.01		0.01	0.03
Echinometra sp.	0.2	0.32	0.2	0.44	0.16	1.32			0.04		0.12		0.002	0.78	0.15	0.22	0.04
Echinothrix sp.	0.018	0.026	0.02	0.004	0.032	0.074	0.016						0.006	0.038	0.01	0.022	0.02
Heterocentrotus				0.002	0.034									0.02	0.01		
Tripneustes			0.006	0.006	0.08	0.02								0.09	0.02	0.07	
Diadema																	
Pseudobolentia																	
Other Echinoid												0.002		0.008	0.02	0.002	
<b>Holothuroids</b>																	
Holothuria atra			0.004													0.004	
Holothuria whitmaei					0.006	0.004								0.001			
Actinopyga obesa	0.014	0.002	0.004		0.024	0.004											
Actinopyga mauritiana																	
Other Holothuroid							0.004		0.002		0.006	0.002					
<b>Asteroidea</b>																	
Linckia multifora			0.05					0.002					0.002				
Linckia guildingi				0.016												0.004	
Acanthaster planci						0.002				0.004	0.01					0.002	
Mithrodia fisheri																	
Other Asteroid			0.004		0.002											0.002	

### **J.3.5. Benthic Towed-diver Survey—Macroinvertebrates**

Crown-of-thorns starfish were uncommon around the Big Island, never exceeding four starfish during any 5-minute time segment. The highest overall total of crown-of-thorns starfish (20) was recorded during the 50-minute towed-diver survey off the northern coastline near Kapulena. Sea urchins were also uncommon, with the highest average number of sea urchins per 5-minute time segment (62) recorded during the towed-diver survey completed east of Puu Ki. Finally, sea cucumbers were uncommon around the Big Island, with four sea cucumbers representing the highest numbers recorded during any single 5-minute time segment.

### **J.4. Fish**

Seventeen sites were surveyed on the Big Island. A total of 166 species and 16,275 individuals were recorded (in both Belt and stationary point count (SPC) surveys). Damselfishes (Pomacentridae) were most abundant, accounting for 61% of the total fishes recorded, followed by surgeonfishes (Acanthuridae, 15%), wrasses (Labridae, 8%) and butterflyfishes (Chaetodontidae, 2.5%). Fifty-four percent of all fishes observed were blackfin chromis (*Chromis vanderbilti*). The arceye hawkfish (*Paracirrhites arcatus*), goldring surgeonfish (*Ctenochaetus strigosus*), agile chromis (*Chromis agilis*), lavender tang (*Acanthurus nigrofuscus*), saddle wrasse (*Thalassoma dupperey*), orangeband surgeonfish (*Acanthurus olivaceus*), bluestripe snapper (*Lutjanus kasmira*), and eyestripe surgeonfish (*Acanthurus dussumieri*) comprised 21% of the total fishes counted.

#### Fish $\geq 25$ cm TL:

Belt Transects: Six hundred fifty-five fishes representing 50 species and measuring  $\geq 25$  cm were counted on the belt transects. The most abundant species, accounting for 63% of the individuals, were the bluestripe snapper (*Lutjanus kasmira*), orangespine unicornfish (*Naso lituratus*), eyestripe surgeonfish, orangeband surgeonfish, gray snapper (*Aphareus furca*), sea chubs (*Kyphosus sp.*), redlip parrotfish (*Scarus rubroviolaceus*), peacock grouper (*Cephalopholis argus*), bigeye emperor (*Monotaxis grandoculis*), and blacktail snapper (*Lutjanus fulvus*).

SPCs: One thousand five hundred seventy-five fishes representing 50 species were counted on SPCs at 16 sites. Medium and large bodied surgeonfish were most abundant (51% of individuals counted). Bluestripe and blacktail snappers, redlip and bullethead parrotfishes (*Chlorurus sordidus*), sea chubs, and the bigeye emperor (*Monotaxis grandoculis*) comprised 23% of the fish counted.

#### Towed-diver Surveys (fish $> 50$ cm TL):

At the Big Island the towed-diver team completed 27 dives over the course of 5 days covering 74.14 km of sea floor (Fig. J.4.1). Surveys were concentrated along the northeastern and southeastern coast to the exclusion of the west coast which is heavily surveyed through State of Hawaii CRAMP and other monitoring efforts. Surveys averaged 2.36 km in length and ranged from 0.98 km to 3.07 km. Median mean depth was  $-15.35$  m.

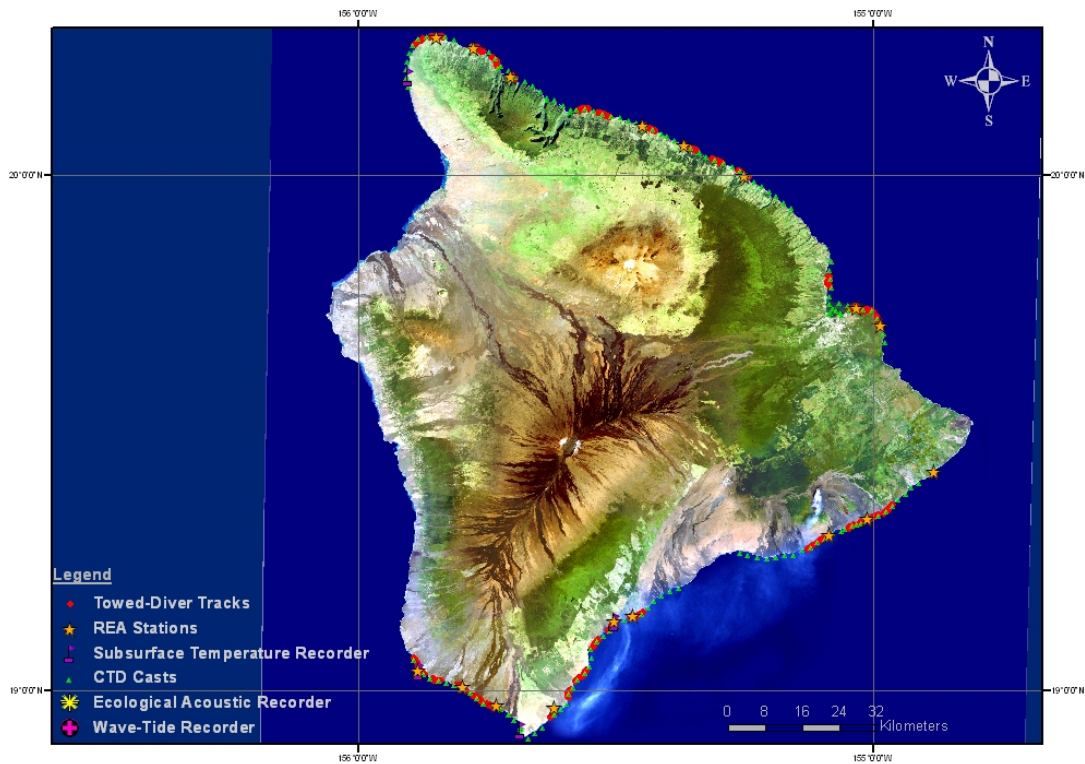


Figure J.4.1 HI-06-10 sampling stations at the Big Island. Efforts were limited along the Kona (western) Coast as this area is extensively sampled by state and local agencies.

At the Big Island, 29 species were observed (Figs. J.4.2–J.4.3). The redlip parrotfish (*Scarus rubroviolaceus*) dominated both observed numeric density and observed biomass. The Hawaiian garden eel (*Gorgasia hawaiiensis*) and the sleek unicornfish (*Naso hexacanthus*) followed in numeric density while hammerhead sharks (*Sphyna lewini*) and much lower spectacled parrotfish (*Chlorurus perspicillatus*) followed in biomass.

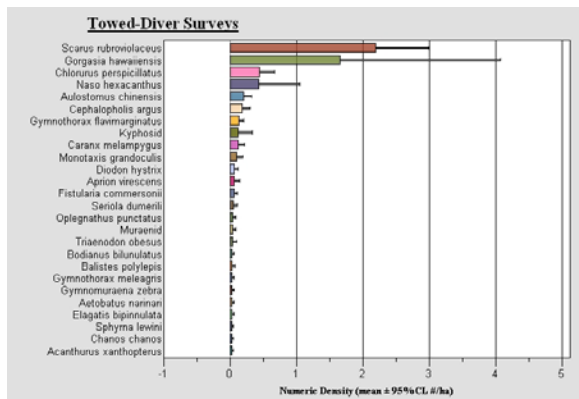


Figure J.4.2 Numeric Density (#/ha) of species at the Big Island.

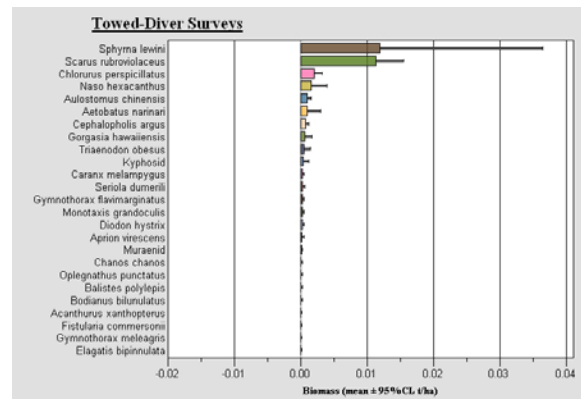


Figure J.4.3 Biomass Density (t/ha) of species at the Big Island.

## Appendix K: Other

### General Discussion

The 2006 MHI RAMP surveys show that the algal diversity is higher around Hawaii and Maui than elsewhere across the main Hawaiian Islands (MHI). However, this might be an artifact of the varying levels of monitoring effort around the different islands. Thus, it is possible that the small number of sites surveyed around the other islands, especially at Oahu, is responsible for the lower algal diversity found around other islands. It appears that at the islands where between 3 and 6 sites were surveyed, the algal diversity was moderate with between 20 and 33 genera and 4-5 functional groups recorded. When only 2 sites were surveyed, the algal diversity dropped to 15-16 genera and 3-4 functional groups. In contrast, when more than 10 reefs were surveyed, such as around Hawaii and Maui, the algal diversity increased to 47 to 52 genera and 5 functional groups. In general, algal diversity varied among sites within an island because of the diversity of habitats around some islands, especially the larger ones such as Hawaii. Additionally, algal diversity appeared higher on reefs with low bathymetric slope and high sedimentation rates. Turf algae and crustose coralline algae were among the most common algae found and ranked within the photoquadrats at each site. Other algal functional groups were also found in moderate abundance within the photoquadrats, but varied among sites and islands.

The fish REA team for the second leg of the MHI RAMP cruise (August 7 through August 20, 2006) consisted of members Tony Montgomery, Kosta Stamoulis, and Steve Cotton. Quantitative data were collected from 30 sites on the islands of Oahu (1), Kauai (2), Niihau (6), Molokai (2), Maui (3), Hawaii (11), Lehua Rock (3), and Kaula Rock (2). Belt transect, stationary point count (SPC), and species presence data (REA) were collected at all sites except Kauai. SPC data were not collected around Kauai due to one diver's absence. Because of strong currents, only species presence data were collected during a drift dive at Mana Reef. An attempt was made to survey Five Fathom Pinnacle, but strong current conditions prohibited data collection.

During the course of the 2006 MHI RAMP cruise aboard the NOAA Ship *Hi'ialakai* (HI-06-10), the towed-diver team of Rusty Brainard, Brian Zgliczynski, Benjamin Richards, and Jake Asher completed 117 survey dives totalling 270.93 km (Fig. K.1). The priority for this mission was to survey the windward coasts of the main eight Hawaiian Islands which are less accessible to other monitoring efforts. As such, sampling was limited around the easily accessible island of Oahu and along the Kona Coast of Hawaii Island, which is extensively surveyed by state and local agencies. The median mean depth for these towed diver surveys was -15.47 m. The average survey length was 2.35 km with shortest survey being 0.98 km and the longest being 3.23 km.

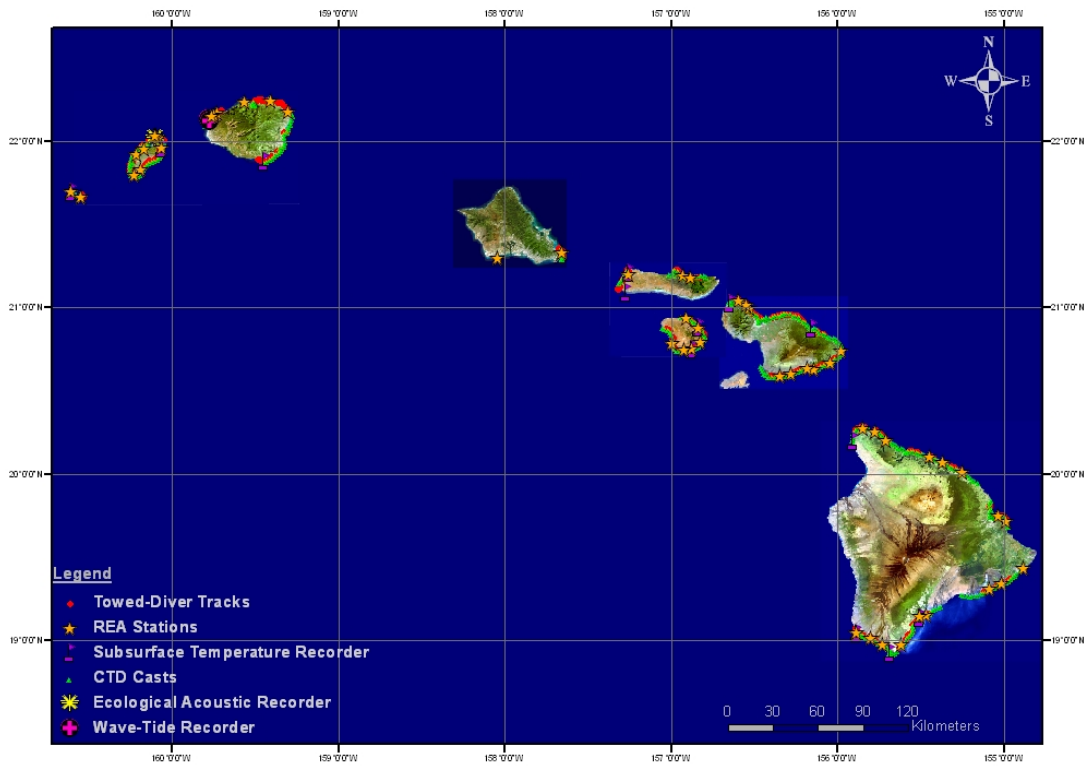


Figure K.1 Scope and stations sampled during HI-06-10. Survey effort was concentrated along the windward and least accessible areas of the islands. Surveys were limited around Oahu and along the Kona Coast of Hawaii Island.

Pooling all species, Lehua Rock showed the highest observed numeric density followed by Hawaii Island, Kaula Rock, Niihau, Maui, Kauai, Oahu, Molokai, and Lanai (Fig. K.2). In terms of biomass, Lehua Rock again showed the highest observed values followed by Hawaii, Oahu, Niihau, Maui, Kaula Rock, Kauai, Lanai, and Molokai (Fig. K.3).

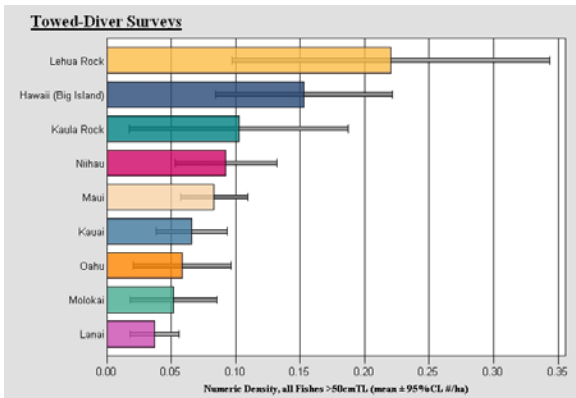


Figure K.2. Numeric Density (#/ha) of all species pooled by island.

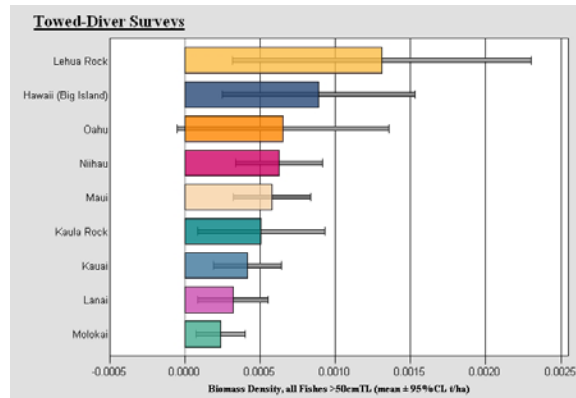


Figure K.3 Biomass Density (t/ha) of all species pooled by island.

Across the main Hawaiian Islands, the redlippped parrotfish (*Scarus rubroviolaceus*) dominated both observed numeric density and biomass (Figs. K.4–K.5). In numeric density, *Scarus rubroviolaceus* was followed by the Hawaiian garden eel (*Gorgasia hawaiiensis*), the spectacled parrotfish (*Chlorurus perspicillatus*), (*Naso hexacanthus*), (*Aulostomus chinensis*), (*Fistularia commersonii*), (*Aprion virescens*), (*Caranx melampygus*), (*Gymnothorax flavimarginalis*), and (*Naso unicornis*). In biomass, *Scarus rubroviolaceus* was followed by (*Sphyna lewini*), (*Aetobatus narinari*), (*Chlorurus perspicillatus*), (*Manta birostris*), (*Aulostomus chinensis*), (*Caracharinus amblyrhynchos*), (*Naso hexacanthus*), (*Triaenodon obesus*), and (*Naso unicornis*).

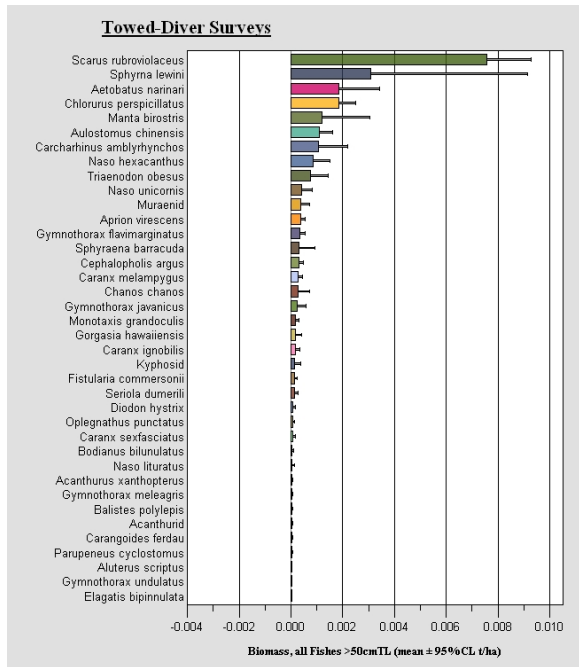


Figure K.4 Numeric Density (#/ha) of all species pooled.

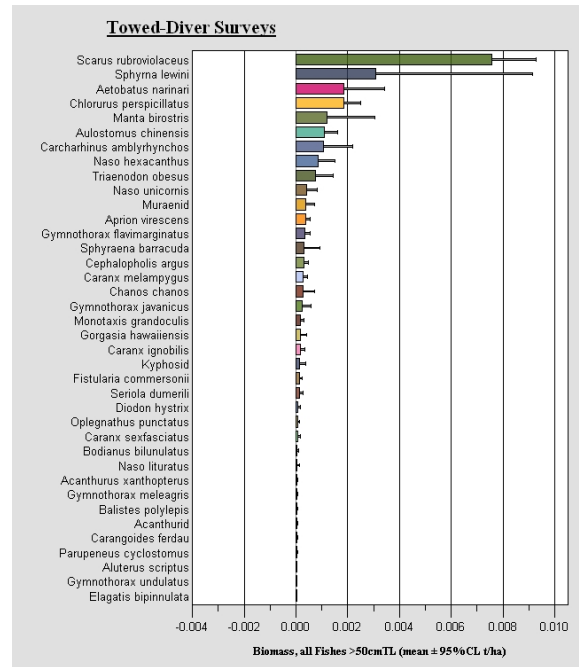


Figure K.5 Biomass Density (t/ha) of all species pooled.

Across the main Hawaiian Islands, the island-wide average number of reef fish species per survey was highest around Lehua Rock and Niihau (~75 species/survey) and lowest around Lanai, and Kauai (~45 species/survey) dominated both observed numeric density and biomass (Fig. K.6). Island-wide numerical densities were highest around Lehua Rock and Kaula Rock (~1300 #/ha and ~1100 #/ha, respectively) and lowest around Molokai and Lanai (~300 #/ha) (Fig. K.7). A total of 39,169 fish were recorded at all islands. Of these 48% were blackfin chromis. Island-wide numerical densities excluding estimates of blackfin chromis (Fig. K.8) demonstrate a significant recruitment event during the period of observation. Seventeen percent of the total fish counted were  $\geq 25$  cm. Island-wide average numerical densities of reef fish  $\geq 25$  cm per REA survey were generally high around Hawaii, Lehua, Maui, Niihau, and Kaula (~105-135 #/ha) and low around Oahu, Molokai, Kauai, and Lanai (~40-50 #/ha) (Fig. K.9). A large majority of the reef fish  $\geq 25$  cm in the main Hawaiian Islands were Acanthurids (Fig. K.10). A total of 110 fish over 50 cm were counted. Of a total of 183 Carangids recorded around the main Hawaiian Islands, 109 of which were mackerel scad and 61 of which were bluefin trevally. Two eagle rays and one shark were counted.

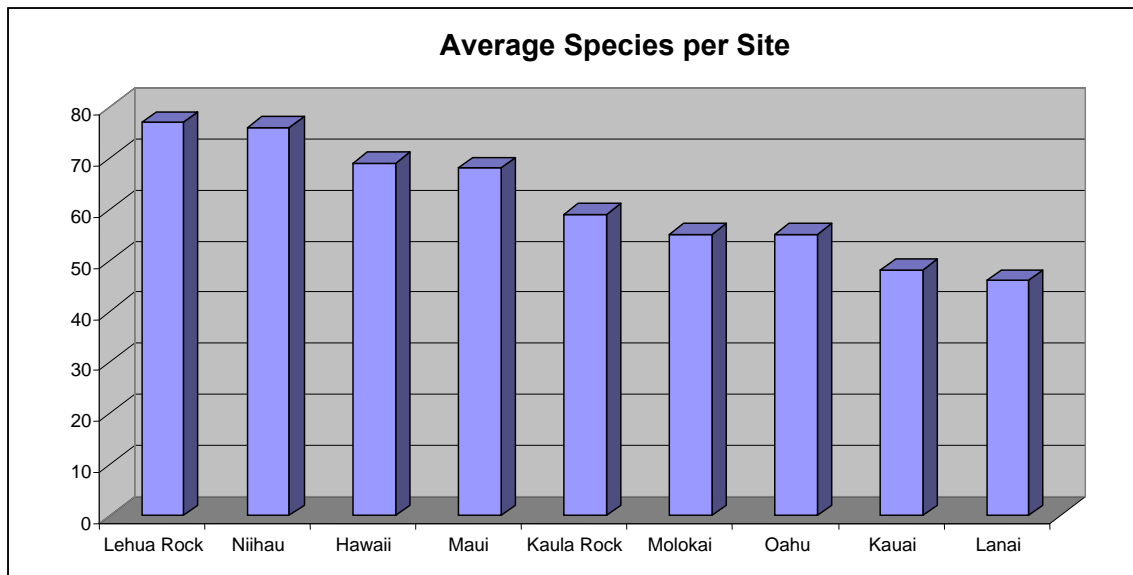


Figure K.6 Average number of reef fish species per REA survey during MHI RAMP 2006.

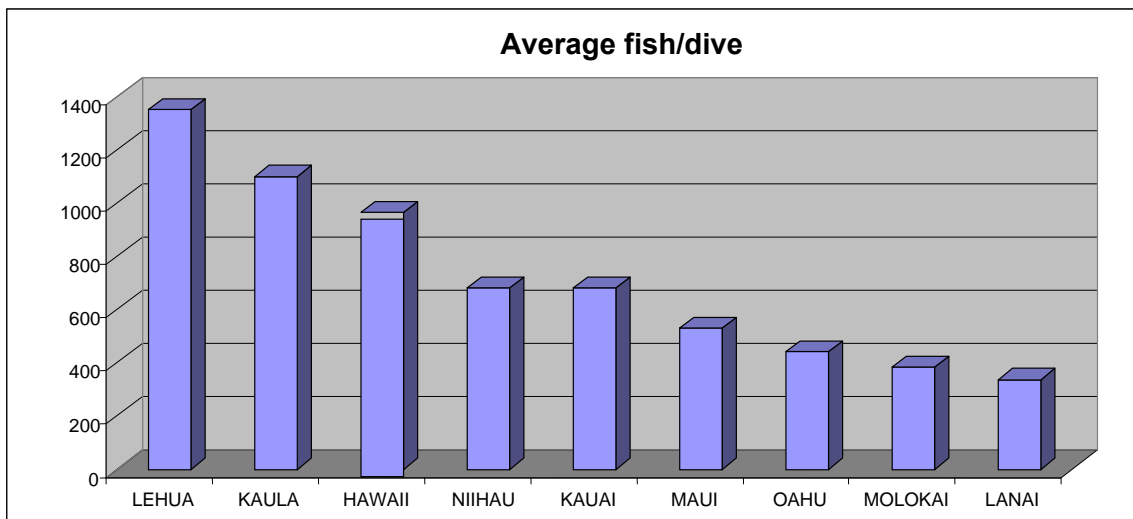


Figure K.7 Average numerical density of reef fish per REA survey during MHI RAMP 2006.



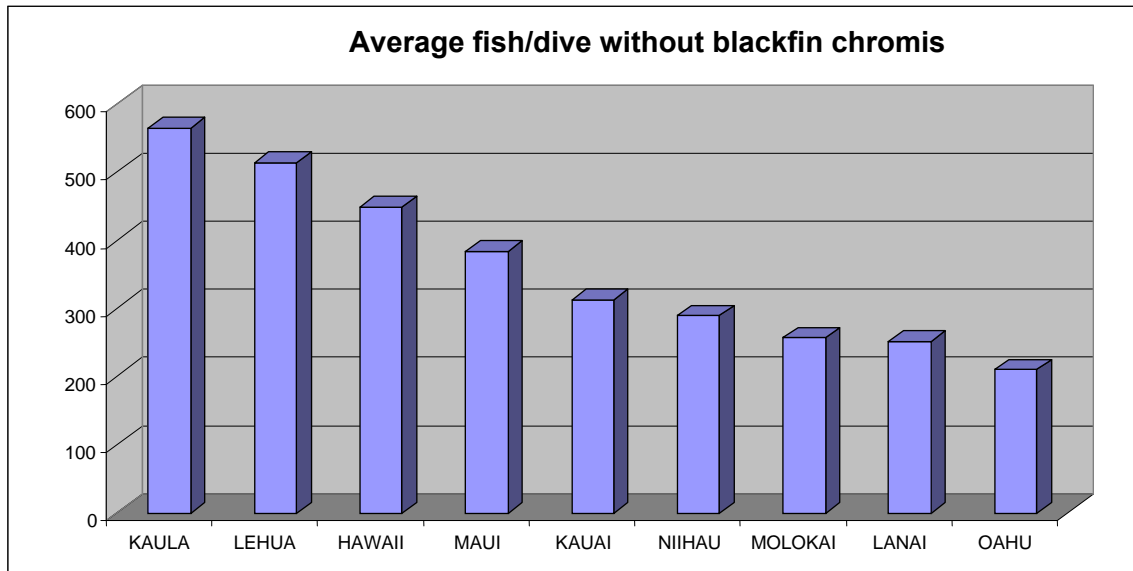


Figure K.8 Average numerical density of reef fish per REA survey during MHI RAMP 2006, excluding blackfin chromis.

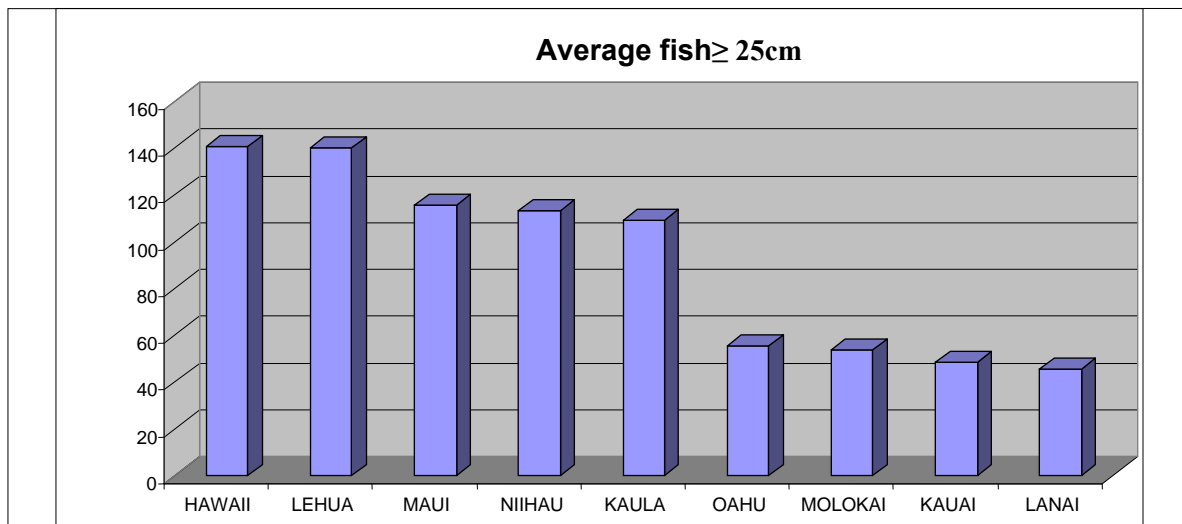


Figure K.9 Average numerical density of reef fish  $\geq 25$  cm per REA survey during MHI RAMP 2006.

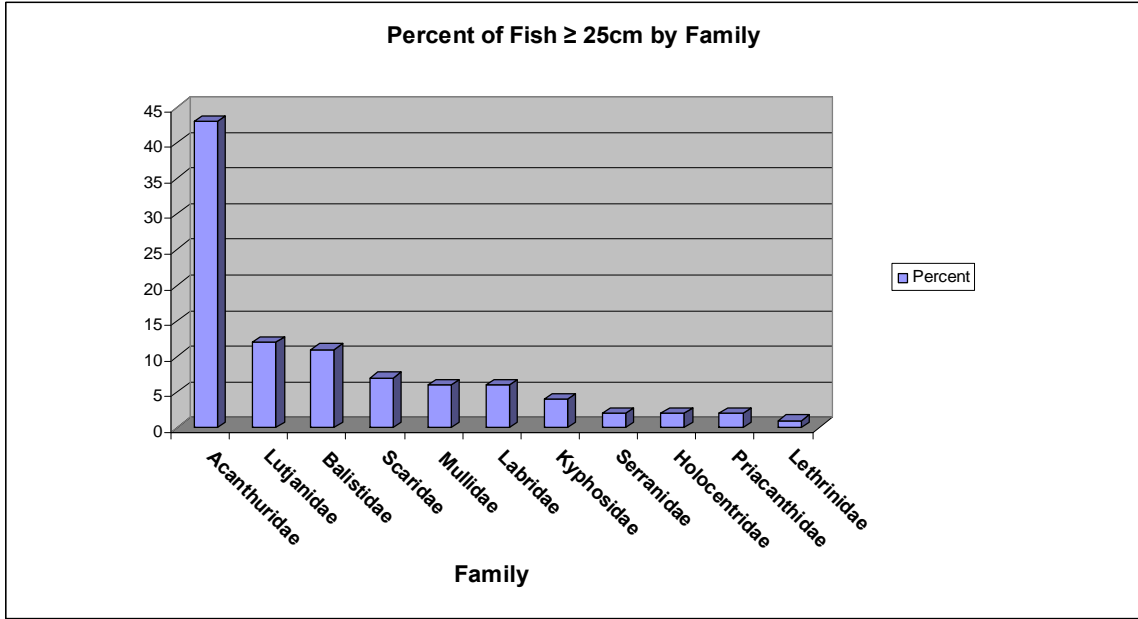


Figure K.10 Average percentage of reef fish  $\geq$ 25 cm by family during MHI RAMP 2006.