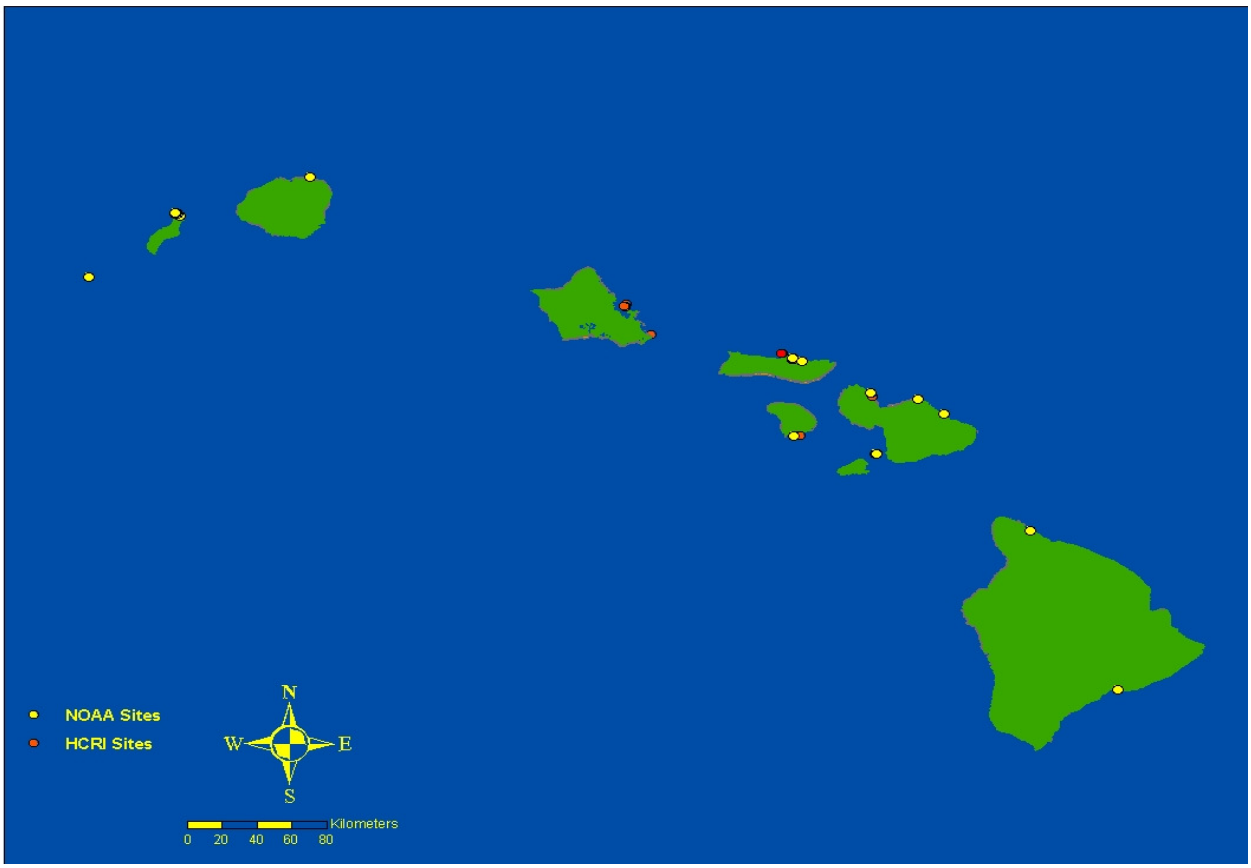

MARINE BIOTA INFORMATION BASE FOR OFFSHORE ISLETS IN THE MAIN HAWAIIAN ISLANDS

January 2010

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Final Report prepared for the Hawai`i Offshore Islet Restoration Committee

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EXECUTIVE SUMMARY

Information available from marine environmental surveys conducted for the National Oceanic and Atmospheric Administration (NOAA) and the Hawai'i Coral Reef Initiative/ National Fish and Wildlife Federation (HCR/NFWF) in 2005, 2006 and 2007 in the vicinity of offshore islets in the Main Hawaiian Islands was analyzed to develop a baseline of information for the composition of marine communities near the islets. A small amount of data from a previous study for the National Park Service in 2004 in the vicinity of islets at the Kalaupapa National Historic Park was also analyzed. Data consisted of results from surveys of marine algae, macro-invertebrates, size class distributions of reef coral populations, and reef fish transects. Although surveys were conducted with similar objectives, with the exception of fish transects, somewhat different survey methods were used for the NOAA compared to the HCRI/NFWF studies, making comparisons between available results for the two studies somewhat problematical for the algae, macro-invertebrate, and coral size class analyses. The NOAA surveys used a field-base approach which limited the completeness of sampling and generally resulted in fewer species reported per site than for the HCRI/NFWF surveys. The NOAA results also preclude quantitative estimates of coral and algal coverage. The NOAA surveys also utilized more observers in the field to acquire the data obtained. The HCRI/NFWF approach utilized field observations and collections that were analyzed in the laboratory to the lowest practicable taxa, and employed a photographic technique that produced quantitative estimates of algae and coral coverage as well as coral size class profiles after computer image analysis using the Coral Point Count with Excel extension (CPCe).

Recognizing the limitations of comparing the two major data sets and that sampling techniques exert a major biase to the results obtained, the following general conclusions can be made. With the possible exception of one site near Lehua and one near Ni'ihau the 31 sites surveyed for coral showed normal patterns of size distributions with high recruitment and survival into the larger size classes. Coral cover values, available only for the HCRI/NFWF surveys, show a wide range of values from 1.8% at a site on the north shore of Maui where wave turbulence is normally very high to 32.4% along the outer wall of Molokini Crater. Both the NOAA and the HCRI/NFWF studies showed high diversity of macroalgae, but there was no indication of algae blooms by either series of surveys. HCRI/NFWF surveys found a larger variety of macroinvertebrates, than the NOAA surveys, which consisted of counts of large, field-identifiable tax along fixed transects and some laboratory identifications. The HCRI/NFWF identified 19 introduced or cryptogenic invertebrates, mostly hydroids, with a maximum of eight found at each of the two Lāna'i sites. . The most problematical introduced invertebrate found was the invasive octocoral *Carijoa* aff. *riisei*, which occurred at one NOAA site and seven of the ten HCRI/NFWF sites and was very abundant at Ōkala in the Kalaupapa National Historic Park and at a pinnacle near Po'o Po'o at Lāna'i. No introduced alga were found on either study, but the introduced fishes *ta'au* (*Lutjanus fulvus*), *ta'ape* (*L. kasmira*) and *roi* (*Cephalopholis argus*) were found at most sites throughout the islands on both the NOAA and the HCRI/NFWF surveys.

The most comparable results between the NOAA and the HCRI/NFWF studies were for the reef fish surveys, which were conducted using the same sampling method. Similar ranges in species number and

biomass per site were found for the two studies, and biomass among each study sites varied by up to two orders of magnitude from 1.5 to 117 g/m^2, with the highest values occurring at Lehua Rock for the NOAA data and outside of Kapapa Islands, O‘ahu for the HCRI/NFWF data. The majority of these sites had mean biomasses that were higher than means that have been determined throughout the Main Hawaiian Islands for total fish biomass, primary, and secondary consumer trophic levels using the same sampling method. This suggests that the fish populations at these sites are relatively intact and have not been decreased substantially by recreational or commercial fishing. This may be largely explained by the relative remoteness of many of the sites, but other undetermined factors are surely important. For example the second highest biomass value was determined for the Kapapa site just outside Kāne‘ohe Bay and the closest site to a major population area.

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I. INTRODUCTION

Many coastal reef areas in the main Hawaiian Islands (MHI) are subject to various levels of disturbance from coastal pollution, overfishing, over-lapping and often conflicting uses by various user groups, and have been impacted by alien species-associated phase shifts that have occurred around populated areas. By contrast, and primarily by virtue of their remoteness, islands in the northwest Hawaiian chain (NWHI) from Nihoa to Kure Atoll have been relatively undisturbed, and their marine biota and ecosystems remain relatively intact due to low fishing pressure, remoteness from pollution sources and limited access to other human-related disturbances. This has resulted in contrasting conditions in the trophic structure, biomasses and dominant organism characteristics of the two major regions of the Hawaiian Islands. For example, Friedlander and DeMartini (2002) determined that mean fish standing stock in the Northwestern NWHI to be more than 260% greater than in the MHI, with 54% of the total fish biomass in the NWHI consisting of apex predators compared to less than 3% of the fish biomass in the MHI. Dominant species by weight in the NWHI were either rare or absent in the MHI and the target species that were present, regardless of trophic level, were nearly always larger in the NWHI. Further, introduced marine species are far less common in the NWHI, with only 11 species having been reported as of 2002 and most these at Midway (Friedlander et al. 2005), which was a populated island with an actively used harbor for over 50 years. By contrast, 339 introduced or cryptogenic (i.e. of uncertain origin) marine or brackish water species were estimated to occur in the MHI at that time (Friedlander et al. 2005), currently estimated to be ca. 490 (Carlton and Eldredge 2009.). Both examples of contrasting conditions between the two regions are evidence of differences in levels of exploitation and frequency of human access to coral reefs in the MHI compared to the NWHI.

Offshore Islets in the MHI may represent an intermediate state between the NWHI and the more frequently visited and exploited MHI. Because islet reefs are often more remote than other MHI locations, there is a possibility that reefs in the vicinity of these offshore islets have been more isolated from anthropogenic disturbances and impacts than occur on reefs adjacent to the main islands. Reefs and sub-habitats in the vicinity of offshore islets may function as relatively intact ecosystem complexes that have received limited impact from terrestrial sources. As such, offshore islet reefs may represent some of the last fully intact coral reef areas in the MHI, with the greatest potential for functional and intact coral reef ecosystem marine reserves.

Hawaii's offshore islets may also be the last refuge for rare coastal species. Because offshore islets are often isolated and difficult to access, they may be assumed to have a good chance of remaining relatively safe from invasion by alien species and the other disturbances occurring on reefs adjacent to the larger Hawaiian Islands. Offshore islets can provide models that can be used in refining restoration techniques for rehabilitation of impacted reefs in more disturbed areas.

Despite the potential importance of offshore islet reefs for understanding and managing coral reef ecosystems in Hawai‘i, there has been relatively little information available about the species composition, biomass or reef structure for these reef areas, and the existing data has been kept mainly with the agencies that were responsible for obtaining the data. A primary source of information for the present study was the National Oceanic and Atmospheric Administration (NOAA), which has conducted

coordinated marine baseline surveys throughout the both the MHI and the NWHI. Data for surveys conducted under NOAA support near offshore islets were provided by Michael Parke, NOAA Pacific Islands Fisheries Science Center. The other major source is information is from a series of surveys that were conducted by Bishop Museum and DAR researchers in 2007 at islets off Oʻahu, Molokaʻi, Lānaʻi and Maui with financial support from the Hawaiʻi Coral Reef Initiative (HCRI) and the National Fish and Wildlife Foundation (NFWF) (Coles et al. 2008) and available at http://hbs.bishopmuseum.org/publications/pdf/tr39.pdf).

The data available for this study covers islets throughout the MHI chain, from Kaula Rock to the island of Hawaiʻi. For the major Hawaiian islands, one site was surveyed in subsequent years off Kīlauea Point, Kauaʻi, two sites off windward Oʻahu, four sites, one in subsequent years off the Kalaupapa area of North Molokaʻi, two sites, one of them in subsequent years off South Lānaʻi, four sites, one of them in subsequent years, off northeast Maui, and two sites off Hawaiʻi, one off the north shore and one off the south shore near Halapē. Other sites included were two at Kaula Rock, one of Niʻihau, three done twice in subsequent years in the vicinity of Lehua, and four off Molokini.

In order to address the need for a coordinated, statewide program for offshore islet conservation, the Offshore Islet Restoration Committee (OIRC) was formed in September 2002. The OIRC is a multi-agency group dedicated to conducting biological surveys and restoration on selected offshore islets in Hawaii. Much of the focus of the OIRC has been on assessing, maintaining or restoring the terrestrial system and bird fauna of these offshore islets, but a need has been recognized to organize the available data that has accumulated from surveys designed to determine the composition, abundance and biomasses of the marine organisms that comprise the marine communities of coral reefs in the vicinity of offshore islets in the MHI. Therefore, the present project was conceived and completed for the OIRC to collate and analyze coral reef ecosystem information for offshore islets in the main Hawaiian chain where such information is available, and to evaluate the status of these areas for management purposes.

The 19 islets which have been surveyed marine for marine organisms are approximately one third of the 61 total in the MHI of interest to the OIRC, 56 for which terrestrial surveys have been completed and information is available at http://www2.bishopmuseum.org/HBS/islets. For the 54 islets near the main islands, one is on the north coast of Kauaʻi, 16 off Oʻahu with 15 of these on the windward side, nine off the north shore and two off the east end of Molokaʻi, 16 off the northeast shores of Maui, five off the west shore and two off the south shore of Lānaʻi, two off the south shore of Kahoʻolawe, and 3 off the north shore and one off the south shore of Hawaiʻi. The islands with the greatest gaps of information are the islets for Oʻahu, which has only two islets with data available for this study, Maui, which has four islets, with one surveyed twice, and Kahoʻolawe, which has no islet marine surveys. The lack of data for Oʻahu islets is particularly unfortunate, given the potential importance of maintaining refuges near the most populous island in the MHI, and information is particularly needed fro the strategic islets of Moku Manu, Mokolea, and Manana off Kane'ohe, Kailua and Waimanalo. These islets have been surveyed by staff of the Hawaiʻi State Division of Aquatic Resources (DAR), but these data were not available for the present analysis. Data for an additional six sites off Maui were provided by NOAA, but these were not close enough to islets to be considered relevant for this study.

II. METHODS

Data Sources

This information is derived from results of surveys conducted in the MHI to establish baseline conditions of the characteristics of the principal biota on coral reefs areas near offshore islets throughout the state. The data sources are: 1) National Oceanic and Atmospheric Administration (NOAA) which provided a subset selected from a larger number surveys conducted in 2005-2006. 2) A study focused on specific islets in 2007 near O‘ahu, Moloka‘i Lāna‘i and Maui (Coles et al. 2008) for the Hawai‘i Coral Reef Initiative (HCRI) and the National Fish and Wildlife Federation (NFWF). Also, limited information has been made available from the U. S. National Park Service for sites off the Kaluapapa National Historic Park. The locations for all the study sites are shown on Figure 1 and in greater detail for each islet area in Figures 2-6.

Site Selection

NOAA Sites

The characteristics of the 24 NOAA sites surveyed in the vicinity of offshore islets are summarized in Table 1. These include two sites at Kaula Rock (KAL 1 & 2)and one site at Ni‘ihau (NII-7) surveyed once in 2006, three sites at Lehua (LEH 1, 2 & 3)and one site off Kaua‘i (KAU-3) surveyed in 2005 and 2006. Two sites were surveyed at Moloka‘i (MOL 6 & 7) in 2006 and one site at Lāna‘i (LAN-6) in 2005 and 2006. Three sites were surveyed off Maui, one of them (MAI-2) in 2005 and two MAI 10 & 20) in 2006, and two sites at Molokini (MOK1 & 2) in 2005 and one (MOK-3) in 2006. One site was surveyed off Hawai‘i in 2005 (HAW-11) and one (HAW-20) in 2006. Fish transects were conducted on all surveys, but coral surveys were not made at the three Lehua sites in 2006 nor at one of the Maui MAI-10) sites in 2006. All coral surveys were conducted by J. Kenyon of NOAA except for Lāna‘i Site 6 in 2006, Maui Sites 2 and 10 and the Hawai‘i sites, which were surveyed by D. Gulko of DAR. Data are available for algal surveys at all sites except for the three Lehua sites in 2005, the Lāna‘i site in 2006, the Kaua‘i site in 2006, the Maui 2 site in 2005 and the three Molokini sites. The algae data for the Kaula-1 site was incomplete, so this site has been omitted for this analysis. Information on limited number of non-coral invertebrates, mostly large and easily recognizable echinoderms, is available for 12 of the 23 NOAA surveys.

HCRI/NFWF Sites

The islets surveyed for the HCRI/NFWF study in 2007 were selected in consultation with OIRC to supplement the previously available NOAA and DAR surveys. The 10 islet areas (Table 2) surveyed were Kāohikaipu and Kāpapa off the windward coast of O‘ahu, Mōkapu, ‘Ōkala and Nāmoku Islets off Kalaupapa on the windward coast of Moloka‘i, Pu’u Pehe and Po‘o Po‘o on the south coast of Lāna’i, Kaemi and Hulu off the northwest coast of Maui, and the outer rim of Molokini Island. Corals for all of the sites were surveyed by S. L. Coles of Bishop Museum, algae by L. Guiseffi, macroinvertebrates by M. Hutchinson and S. L. Coles, and fish by various DAR Staff and E. Brown of the NPS Kalaupapa National Historic park for the Moloka‘i sites. Details of site characteristics and environmental conditions at the time of these surveys are in Coles et al. (2008).

NPS Sites

In addition to these more extensive data, suveys using some of the same methods as above were conducted at Mōkapu and ʻŌkala Islet and off Kukaiwaʻa Point within the boundary of the Kalaupapa National Historic Park in September 2004 (Table 3). These surveys did not measure size classes of corals but instead made percent cover estimates for algae, corals and other invertebrates and made fish counts made by A. Friedlander with a somewhat different method than the NOAA and HCRI/NFWF studies.

Field Techniques

NOAA Surveys

- Algae

Algae surveys were conducted along two 25-m long transects at each site. Two trained observers moved along a transect together, with one observer placing a 0.18 m² photo quadrat frame and operating a high-resolution digital camera mounted on the frame. Photographs were taken at predetermined random points along the quadrat. After a photograph was taken by the first diver, the second diver identified algae within the photoquadrat, and recorded the relative abundance of the 5 most abundant algae on a scale of 1 – 5 (with 1 being most abundant). Once data are recorded, the photoquadrat was moved to the next random point and the procedure repeated for six quadrats per transect on two transects for a total of 12 quadrats per site. To prevent redundancy, only samples of new algal species found in subsequent quadrats were collected. In the laboratory the photographs taken with the photoquadrat methods were downloaded to a computer, renamed with a unique location code, then cropped and color corrected in Adobe Photoshop. Each photo was analyzed for percent cover using the software PhotoGrid (C. Bird, Dept. of Botany, University of Hawaii), a software program capable of random and stratified random point analysis on digital photography. Once all photos were analyzed, data were imported into Microsoft Excel for further statistical application. Data are reported in Appendix B as the rank of individual species within a given quadrat compared to the number of species that occurred within that quadrat

- Coral

A coral biologist used a reference bar to estimate the maximum diameter of each coral within 0.5 m² of each side of two 25-m transect lines at each site. These maximum diameters were recorded by species on underwater paper by the following size classes: 5 cm; 5–10 cm; 10-20 cm; 20-40cm; 40-80 cm; 80-160 cm; or 160 cm). The coral biologist then swam back along as many of the transect lines as bottom time permitted and listed coral species occurring within 1m of each side of the transect lines. A random swim was then conducted in the vicinity of the transect lines within an area of about 5,000 m^2 in which all coral species are listed and assigned a DACOR abundance code based on visual estimation (dominant, abundant, common, occasional, and rare). If bottom time permitted, corals showing signs of disease, bleaching, or abnormal growth were tallied, described, and photographed

Table 1.NOAA survey sites near islets in the MHI.

Island	Site #	Algae	Coral	Inverts	Fish	Location	Islet Dist. (m)	Date	LAT DecDeg	LONG DecDeg	Depth (ft)
Kaula	KAL-1	No	X	No	X	Kaula Rock	35	8/10/2006	21.6552	-160.5437	29-37
	KAL-2	X	X	No	X	Kaula Rock	35	8/10/2006	21.6528	-160.5452	44-46
Niʻihau	NII-7	X	X	X	X	N side, W of Kikepa Pt.	258	8/9/2006	22.0070	-160.0790	37-40
Lehua	LEH-1	No	X	X	X	Lehua, SE side	49	7/18/2005	22.0165	-160.0913	50
	LEH-2	No	X	X	X	Lehua, inside caldera	76	7/18/2005	22.0217	-160.0941	58
	LEH-3	No	X	X	X	Lehua, West side	41	7/18/2005	22.0212	-160.1016	48
	LEH1	X	No	No	X	Lehua, SE side	49	8/12/2006	22.0165	-160.0914	na
	LEH2	X	No	No	X	Lehua, inside caldera	76	8/12/2006	22.0216	-160.0939	na
	LEH3	X	No	No	X	Lehua, West side	41	8/12/2006	22.0213	-160.1016	na
Kauaʻi	KAU-3	No	X	No	X	Kilauea Pt.-Moku ʻAeʻae Islet	326	7/15/2005	22.2306	-159.4053	35
	KAU-3	X	X	X	X	Kilauea Pt.-Moku ʻAeʻae Islet	326	7/28/2006	22.2306	-159.4054	29-30
Molokaʻi	MOL-6	X	X	X	X	Mōkapu Islet	1	8/14/2006	21.1841	-156.9245	40-46
	MOL-7	X	X	X	X	Mokomanu Islet	327	8/14/2006	21.1699	-156.8785	41-46
Lanaʻi	LAN-6	No	X	X	X	Poʻo Poʻo Islet	77	8/3/2005	20.7337	-156.9217	48
	LAN-6	No	X	No	X	Poʻo Poʻo Islet	77	8/5/2006	20.7336	-156.9215	40-57
Maui	MAI-2		X	X	X	Moku Holua Islet	139	2/24/2005	20.8648	-156.1512	na
	MAI-10	X	No	X	X	Hakuheʻe Pt. - Kaemi Islet	50	7/30/2006	20.9869	-156.5269	45-59
	MAI-20	X	X	X	X	Papanui o Kāne Islet	388	8/19/06	20.9480	-156.2817	44-50
Molokini	MOK-1	No	X	No	X	Molokini Outer Rim	1	8/6/2005	20.6303	-156.4966	48
	MOK-2	No	X	No	X	Molokini Northwest	74	8/6/2005	20.6336	-156.4988	50
	MOK-3	No	X	No	X	Molokini Crater	117	8/6/2005	20.6322	-156.4969	45
Hawaiʻi	HAW-11	X	X	X	X	Halapē (Keaoi Islet)	98	3/1/2005	19.2673	-155.2554	na
	HAW-20	X	X	X	X	Paokolani Islet	94	8/2/2006	20.1915	-155.7041	29-40

Table 2.HCRI/NFWF survey sites.

Island	Site #	Algae	Coral	Inverts	Fish	Location	Islet Dist. (m)	Date	LAT DecDeg	LONG DecDeg	Depth (m)
Oahu	KOAI	X	X	X	X	Kāohikaipu Islet	148	8/7/2007	21.32057	-157.6543	8-12
	KAPAP	X	X	X	X	Kāpapa Islet	643	8/30/2007	21.4801	-157.7924	8-9
Molokaʻi	MOKAP	X	X	X	X	Mōkapu Islet	10	9/182007	21.1827	-156.9246	13-22
	OKAL	X	X	X	X	ʻŌkala Islet	20	9/19/2007	21.1744	-156.9300	14-19
	NAMOK	X	X	X	X	Nāmoku	26	9/20/2007	21.2070	-156.9842	11-22
Lanaʻi	PUUPE	X	X	X	X	Puʻu Pehe Islet	45	4/2/2007	20.7337	-156.890	8-11
	POOPO	X	X	X	X	Poʻo Poʻo Islet	20	4/3/2007	20.7352	-156.9223	17-18
Maui	KAEM	X	X	X	X	Kaemi Islet	48	5/29/2007	20.9573	-156.5169	6-12
	HULU	X	X	X	X	Hulu Islet	33	5/30/2007	20.9803	-156.5256	6-15
	MOLOK	X	No		X	Molokini Rim	10	5/31/2007	20.6313	-156.4933	4-28

Table 3.NPS survey sites.

Island	Site #	Algae	Coral	Inverts	Fish	Location	Islet Dist. (m)	Date	LAT DecDeg	LONG DecDeg	Depth (m)
Molokaʻi	MOKAP	X	X	X	X	Mōkapu Islet	10	9/21/2004	21.1836	-156.9244	17
	OKAL	X	X	X	X	ʻŌkala Islet	20	9/21/2004	21.1745	-156.9297	11
	KUKAIWʻA	X	X	X	X	Kukaiwaʻa	26	9/21/2004	21.1713	-156.9169	11

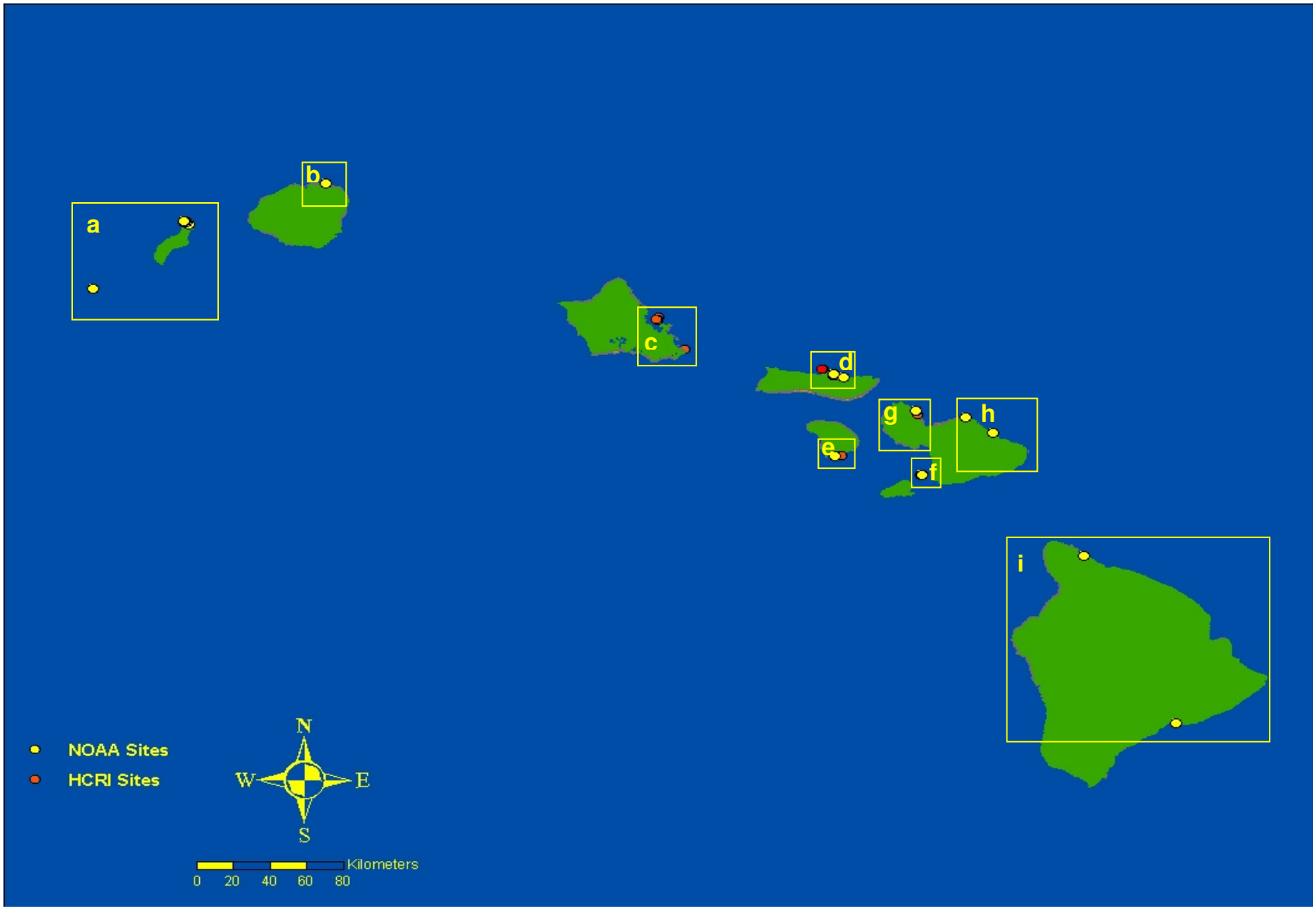

Figure 1. Locations of offshore islets sampling sites.

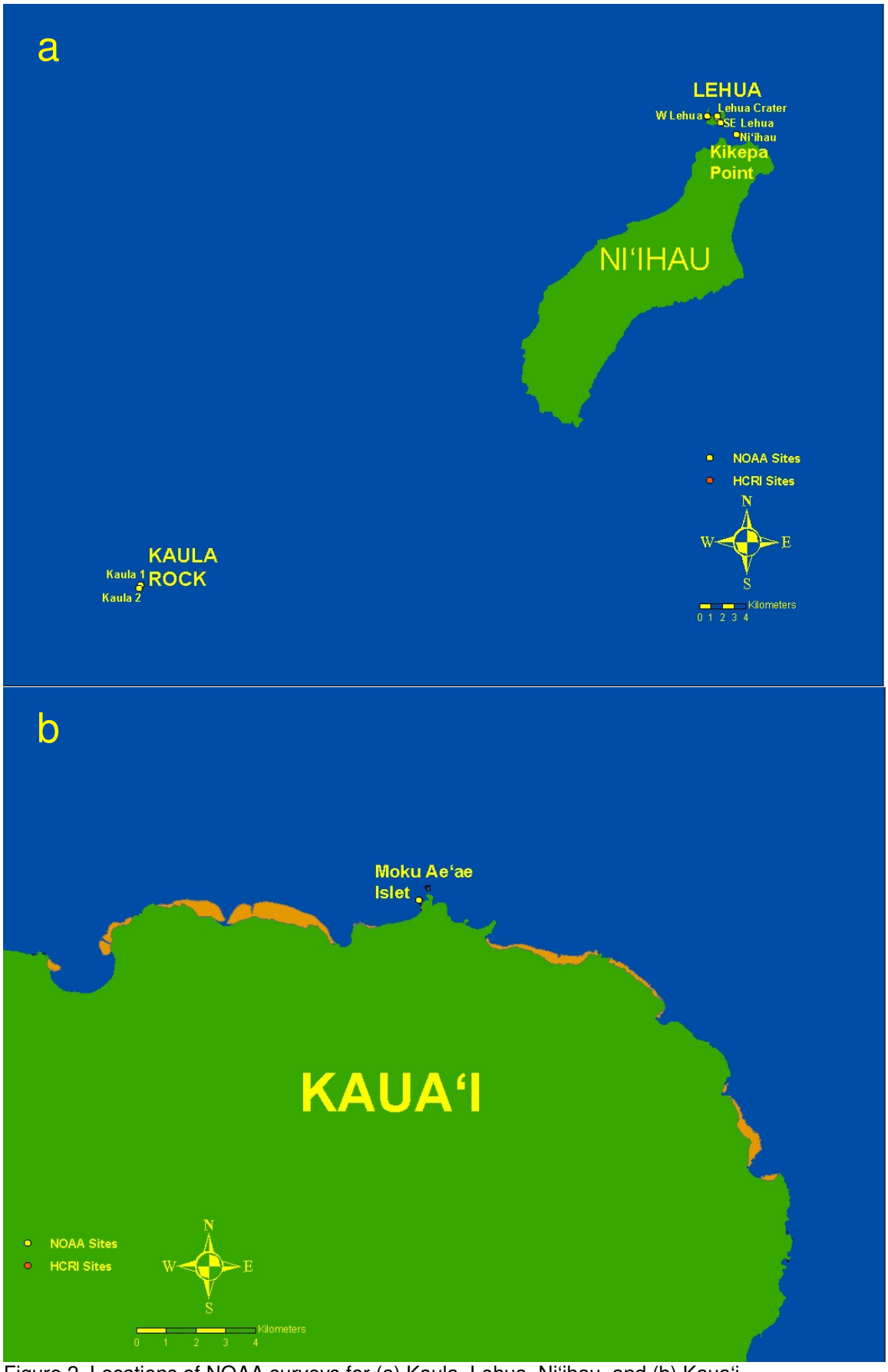

Figure 2. Locations of NOAA surveys for (a) Kaula, Lehua, Ni'ihau, and (b) Kaua'i.

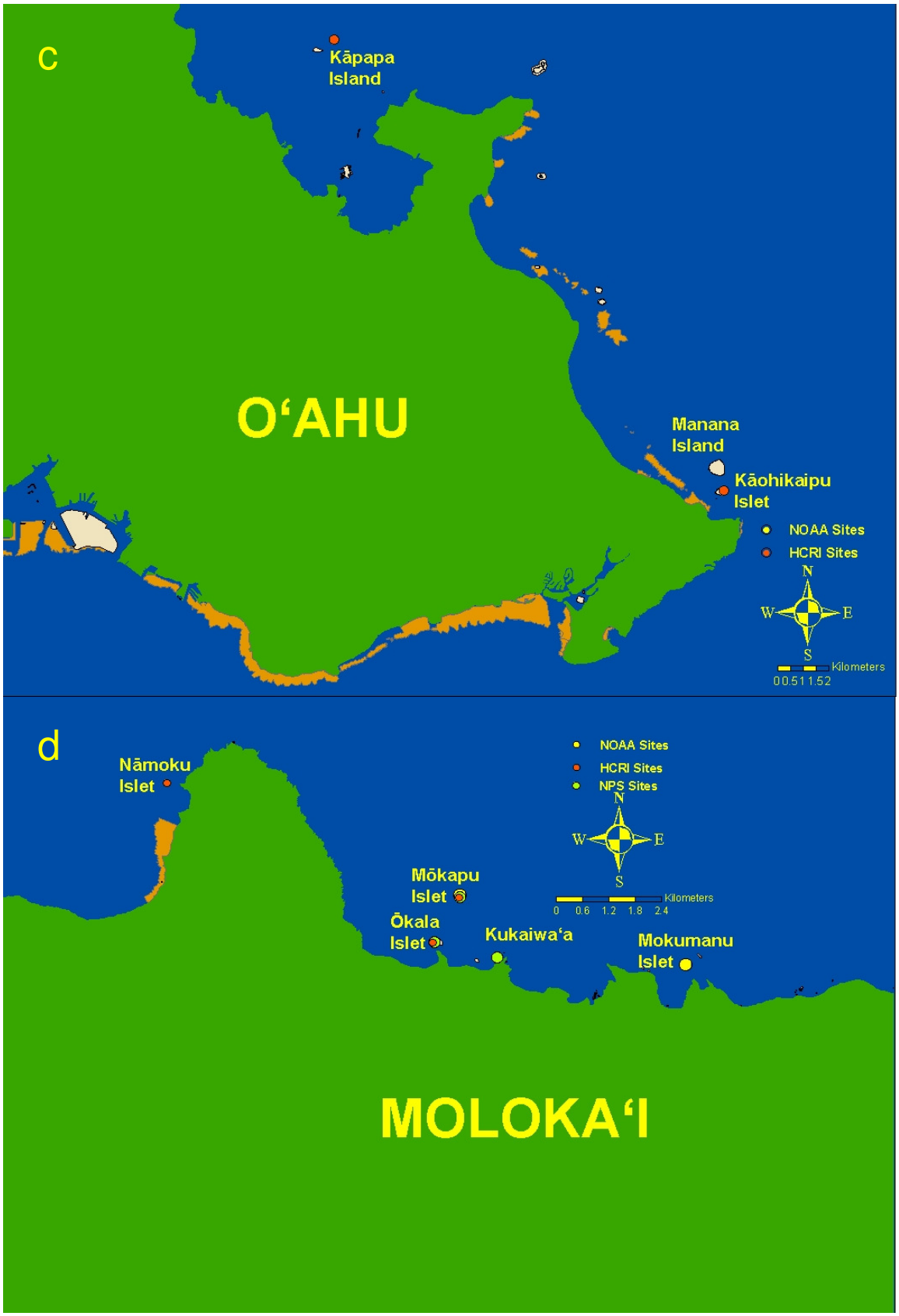

Figure 3. O‘ahu and Moloka‘i NOAA and HCRI/NFWF surveys (c and d); plus NPS surveys for Moloka‘i (d). Moloka‘i Site locations coincide for NOAA, HCRI and NPS surveys at Mōkapu Islet and for HCRI and NPS surveys at Ōkala.

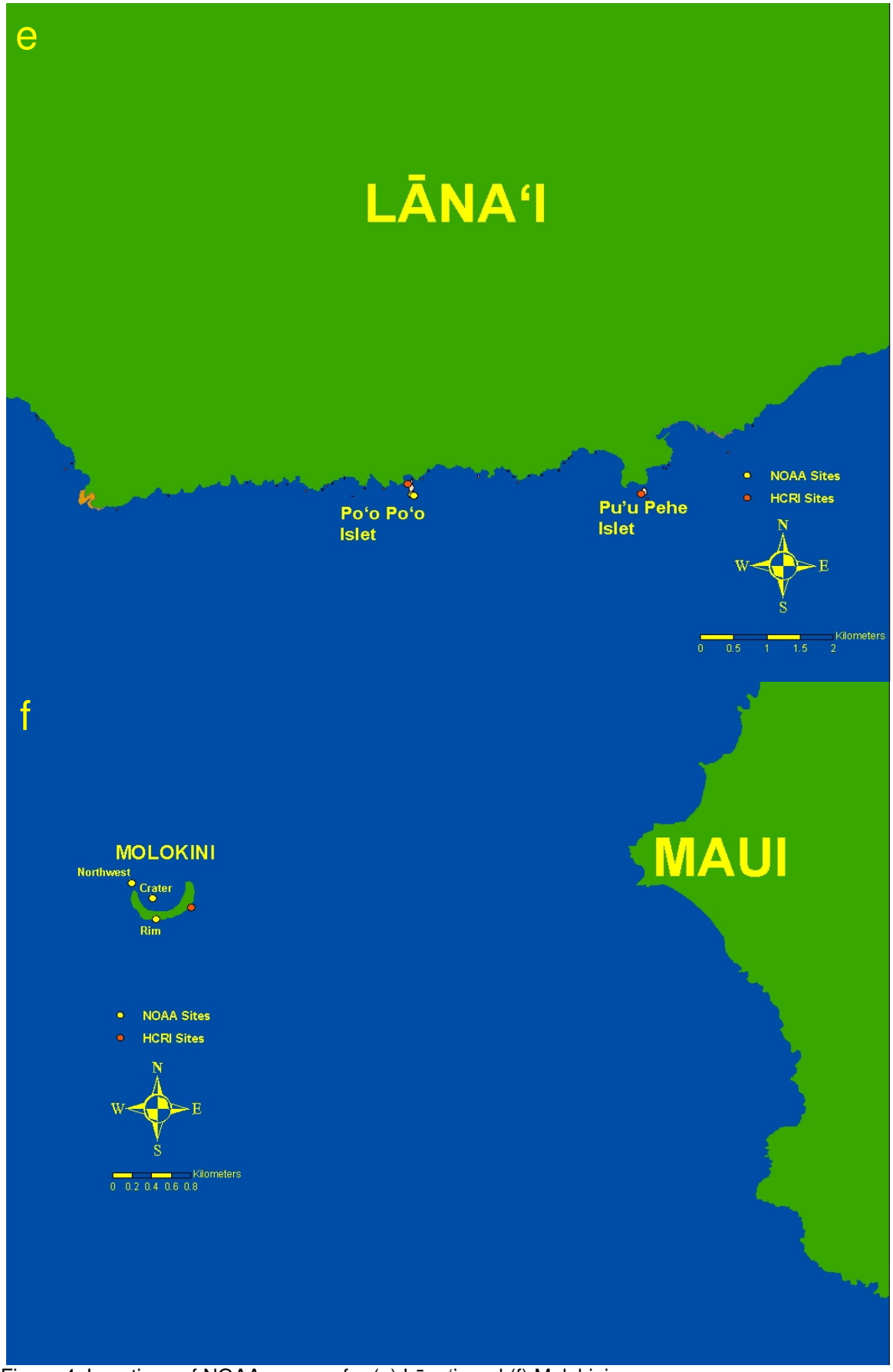

Figure 4. Locations of NOAA surveys for (e) Lāna‘i and (f) Molokini.

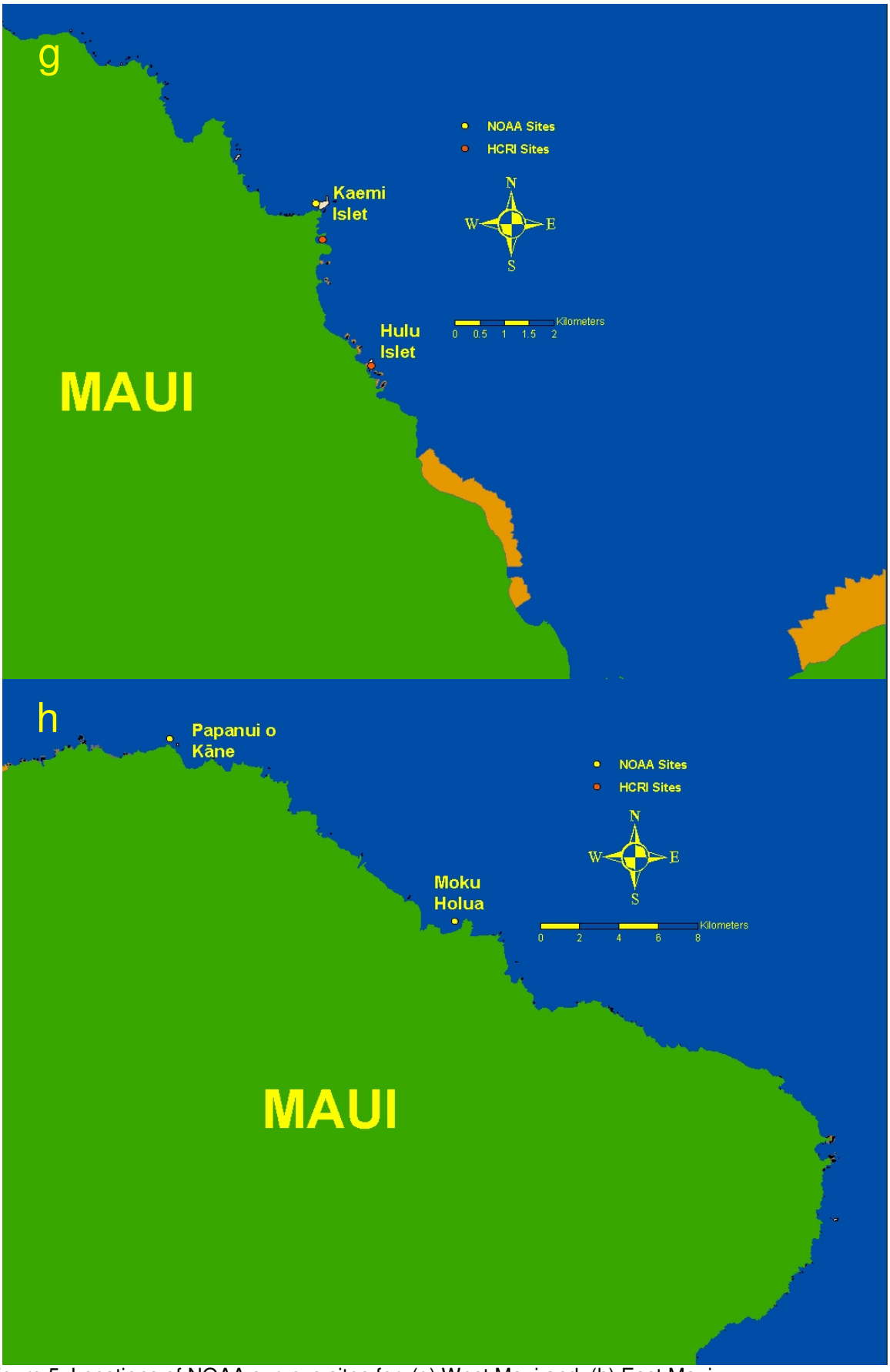

Figure 5. Locations of NOAA surveys sites for (g) West Maui and (h) East Maui.

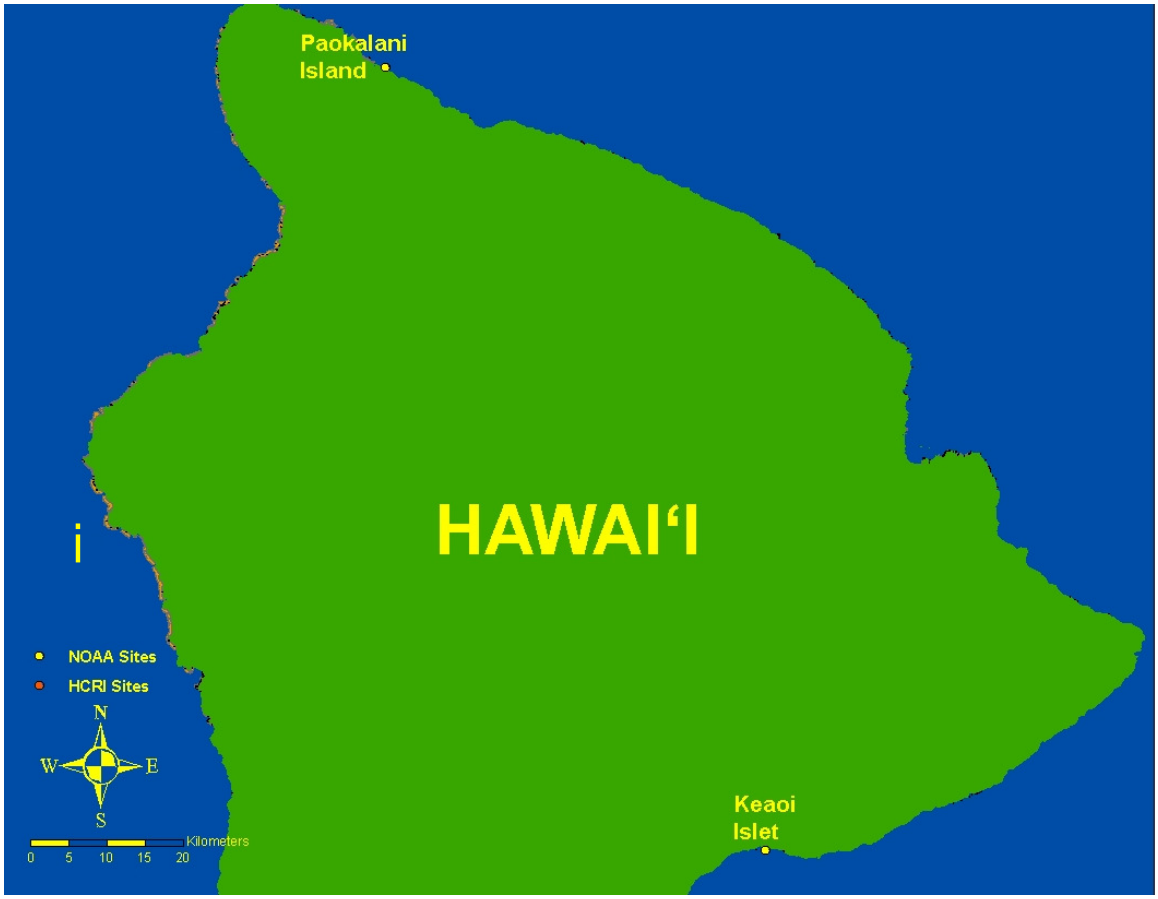

Figure 6. Locations of NOAA surveys sites for (i) Hawai'i.

- Non-coral Invertebrates

Quantitative counts of macroinvertebrates were made 1m to either side of the first two (of three) 25-m transect lines. For any species that could not be identified in the field, a representative specimen was collected for later identification. After the completion of the two transects, a roving swim was conducted in the general area to collect qualitative data for rare and cryptic organisms and to survey any additional habitats present at the site; e.g. sand, sea grass, pavement, etc. This is accomplished by swimming a zig-zag pattern that extends roughly 5 m on either side of the two transects. Additional collections were taken of organisms unable to be identified *in situ*.

- Fish

A pair of scuba diver-observers deployed and conducted parallel swims along three 25 m long transect lines at each site, recording size-class specific counts of all fishes encountered, to species-level where possible, within visually estimated but defined belt widths: 4 m wide for fishes > 20 cm TL (100 m2 area) on the initial swim-out, and 2 m wide for fishes < 20 cm TL (50 m2 area) on the swim back. Reef ledges and holes were also visually searched. The diver-observers also conducted a random swim of about

5,000 m^2 throughout the selected station area, recording by species or lowest recognizable taxon the presence of all fishes encountered.

A detailed description of the methods used for these surveys is at the NOAA Coral Reef Ecosystem Division (CRED) website at http://www.pifsc.noaa.gov/cred/eco_assess.php.

HCRI/NFWF Surveys

The survey methods employed were adapted from the rapid assessment techniques used by NOAA. Modifications of the these techniques for the benthic community were necessary because the HCRI/NFWF survey crew was limited to four persons due to personnel and boat space limitations, compared to crews of eight that normally conducted rapid assessments for NOAA surveys. However quantification of benthic organisms was achieved with greater precision in the HCRI/NFWF surveys by using photographic techniques that also provided permanent records of results.

The protocol followed for the HCRI/NFWF surveys is described in detail in Appendix A in Coles et al (2008). To summarize, two dives were made at each site: a preliminary reconnaissance survey lasting approximately one hour to record species occurrences, followed by second dive when quantitative measurements were made along transects to determine abundance of algae and fishes and size classes and abundance of reef corals. One dive team consisted of an algae (L. Giuseffi) and a coral specialist (S. L. Coles), and the other team of an invertebrate (M. Hutchinson) and a reef fish specialist (various DAR staff for Lānaʻi, Maui and Oʻahu; E. Brown of the U.S. National Park Service for Kalaupapa National Historic Park, Molokaʻi). On the reconnaissance surveys each specialist recorded the species that could be reliably identified in the field, photographed specimens using digital cameras, and collected algae and invertebrates for later identification in the laboratory. For the transect measurements, 3-25 m lines were deployed by the fish-invertebrate team, which made fish counts of species within size class ranges as described for the NOAA surveys, and invertebrate identifications and collections along all three transects. The coral-algal team followed and recorded algae and coral abundance and coral size class distributions along the first two transect lines using photo-quadrats. The coral specialist used a camera and platform with a frame area of 0.67 m^2 to photograph 24 quadrats along each of two transects for a total area measured of 16 m^2 per transect or 32 m^2 per site. The algae specialist used a smaller frame with an area of 0.16 m^2 to photograph 13 quadrats along each transect for a total sample area of 2.1 m^2 per transect and 4.2 m^2 per site. The reef fish species observed on the reconnaissance surveys were recorded, and the sizes of fishes occurring on the fish transects were estimated according to lengths corresponding to 5 cm size classes up to 85 cm. following the NOAA protocol.

The quadrat photographs obtained for the coral and algae transects were analyzed using Coral Point Count with Excel extension (CPCe) software (Kohler and Gill 2006) available from the National Coral Reef Initiative headquarters at Nova University (http://www.nova.edu/ocean/cpce/). Coral quadrat photos were cropped to a consistent area of 0.67 m^2 and enhanced to an optimal image where needed. The outline of each coral within the photo was then traced with the computer cursor and its area determined by the CPCe area analysis program. This process was repeated for all corals on the 24 quadrats for each transect, and the areas generated in the Excel spreadsheet output were converted by formula to an estimated average diameter for each coral colony. The diameters were then grouped by size classes of

0-1 cm, 1.1-5 cm, 5.1-10 com, 10.1-20 cm, 20.1-40 cm, 40.1-80 cm and 80.1-160 cm, similar to the size frequency analysis that has been undertaken by DAR surveys using visual estimates the field. In addition, the area measurement for each colony made in the HCRI/NFWF study was used to estimate of total coral cover and percent cover of the available substratum. Corals that were recognizably fragments of larger colonies or that did not lie totally within the quadrat photograph were excluded from the diameter size class analysis, but were included in the area estimates of total and percent coverage for the quadrats.

CPCe point count analysis was also used to estimate percent coverage of algae within the 0.16 m^2 algae photo quadrats. Fifty-five points were randomly projected on each photo, and the species or higher taxonomic category of the alga underlying each point was recorded where an alga was present, otherwise the substratum composition was noted for the point. The results were averaged for the total number of quadrats on the transect and summarized on the Excel output.

III. RESULTS

Total Taxa

The total number of taxa observed on the NOAA and NPS surveys and taxa observed or collected and identified from the HCRI/NFWF surveys are summarized in Table 4. NOAA and HCRI/NFWF results are shown in Figure 7. The NPS survey results are clearly not comparable to the other studies since species numbers are substantially fewer than for the other two studies which included sites near the NPS sites, and NPS results will not be considered further here. The NOAA and HCRI/NFWF results are also not strictly comparable, since the HCRI/NFWF study listed all taxa that could be identified from reconnaissance surveys throughout the site areas along with specimens collected for late identification in the laboratory, thus giving a more comprehensive sampling for the HCRI/NFWF study than the NOAA and NPS surveys that included only on-site observations. As a result, total taxa identified by the HCRI/NFWF study ranged from 127 at ʻŌkala on Molokaʻi to 181 at Poʻo Poʻo on Lānaʻi, compared to a range of 76 at Moku ʻAeʻae, Kauaʻi (KUA-3) to 124 at Halapē, Hawaiʻi (HAW-11) for those NOAA surveys where data for algae, invertebrates and fish are available. Also, data return for the NOAA surveys was erratic with only 9 of the 23 sites having complete data for algae, invertebrates and fish, while all data sets were complete for the HCRI/NFWF study. Invertebrate data for NOAA were limited to large macrooganisms, mostly echinoderms, identifiable in the field, while HCRI/NFWF invertebrate identifications included all field-identified organisms as well as those retained in 0.5 cm sieves of material washed from dead coral heads of ca. 10 cm diameter. The data for fishes is the most comparable between the NOAA and HCRI/NFWF studies, and the range in numbers of found at the 23 sites for the NOAA surveys (41-92) was similar as for the 10 HCRI/NFWF sites (40-86).

Algae

The species of algae identified for the NOAA surveys are listed in Appendix A and the relative abundances for each species in the 12 quadrats photographed and observed at each site are shown in Appendix B. A total of 76 taxa were identified, and numbers of taxa ranged 10-30 at the 14 NOAA sites surveyed, with unidentified turf algae the number one ranked taxa at all sites. Other taxa that were

relatively abundant and occurred frequently were *Jania* sp. and *Lobophora variegata* at 13 sites, unidentified Gelidiaceae at 12 sites, and *Neomeris annulata* and *Microdictyon setchellianum* at 10 sites.

The HCRI/NFWF reconnaissance surveys identified 138 algae taxa (Appendix C) in the vicinities of the ten surveyed sites, or more than 1.5 times the number of taxa that were identified at the 20 NOAA sites. Numbers per HCRI/NFWF site ranged from eight at ʻŌkala , Molokaʻi to 40 outside Kāpapa Island, Oʻahu. The most frequently found genera or species were *Jania* sp. (8 sites), *Asparagopsis taxiformis* and *Tolypiocladia glomerulata* (7 sites), *Acanthophora pacifica* (6 sites), *Amansia glomerata* and *Neomeris vanbosseae* (5 sites).

The findings of the HCRI/NFWF quantitative photoquadat surveys at the ten sites from Oʻahu to Maui-Molokini are shown as percent coverages in Table 5 and Figure 8 determined from point intercept analysis. Similar to the NOAA survey results, unidentified turf algae, which averaged from 50.2% to 71.8% cover at six of the ten sites, were the dominant taxa, followed by CCA. Calcareous algae was a major benthic component at Molokini, Mōkapu and Kāohikaipu where cover averaged 25.8%, 12.0%, and 12.0% respectively, and high calcareous algal cover was also found on single transects at Kaemi (25.1%) and Kāpapa (18.8%). Macroalgal cover was low at all sites except Kaemi, where the average was 17.9% for the two transects. All but one of the transects at the other sites had less than 5% macroalgal cover, and 12 of them had less than 2%.

Cyanobacteria (blue-green algae) were also in low abundance at most sites, with averages exceeding 5% at only four HCRI/NFWF sites, Molokini (11.6%), Mōkapu (6.3%), Nāmoku (7.8%), and Kāohikaipu (7.2%). Most of the identifiable genera or species averaged less than 1% for the two transects at each site. The exceptions were *Dictyopteris australis,* which averaged 15.2% and was a dominant component of the benthos at Kaemi, *Dictyota* spp. that averaged 4.0% at Nāmoku and 3.0% at Kāohikaipu, and *Padina* spp. that averaged 1.6% at Kaemi.

Macroinvertebrates

The macroinvertebrates, including corals and other cindarians, that were recorded at the 17 NOAA sites where results are available for benthic invertebrates are listed in Appendix D Data are from two sources: 12 sites where transect surveys results are available for large macroinvertebrates, mostly reef corals and echinoderms, and nine sites (Kaula 1 & 2, Lehua 1, 2 & 3, Molokaʻi-Mōkapu and Molokini 1, 2 & 3) where observations and collections of smaller invertebrates were made availlable by L. Scott Godwin (pers. comm.). A total of 157 taxa were recorded for the NOAA surveys,. Numbers of taxa per site ranged from 10 at Molokini Crater (MOK-3) in 2006 to 49 at Mōkapu, Molokaʻi (MOl-6) in 2005, averaging 20.7 for all the sites surveyed. (17 sites) The most frequently occurring species were the urchin *Echinostrephus* sp (11sites), the reef corals *Montipora capita, Montipora patula, Porites lobata*(10 sites)*,* and *Pocillopora meandrina* (9 sites) and the rock urchin *Tripneustes gratilla* (9 sites).

Numbers of non-coral taxa are listed in Appendix E for individual organisms that were counted within the NOAA transects. Of the 36 taxa occurring, numbers per site ranged from 11 at Poʻo Poʻo, Lānaʻi (LAN-06) to 59 at the Niʻihau site (NII-7), averaging 28 for all 12 sites. The most abundant organism at all sites

combined was the crab *Trapezia* sp. (57) followed by the urchins *Echinometra mathaei* (50) and *Echinostrephus* sp. (47) and the bivalve *Spondylus* sp. (23).

Many more macroinvertebrate taxa and species were identified for the HCRI/NFWF reconnaisance and transect surveys (Appendix F), which found a total of 294 taxa at the 10 sites, ranging from 41 taxa at Hulu Islet on Maui to 68 at Pu'u Pehe on Lāna'I, averaging 63 overall. As was the case for the NOAA surveys the most frequently occuring species were corals, *Pocillopora meandrina* (10 sites*) Montipora capitata* and *Pavona varians* (9 sites), and *Montipora patula* (8 sites) and the echinoderms, *Echinometra mathaei* and *Echinostrephus aciculatus* (8 sites).

Coral Surveys

The coral species, their size frequency distributions, and mean numbers of colonies per transect for the 19 NOAA sites where these data are available are shown in the figures in Appendix G. The same information is shown in Appendix H for the 10 HCRI/NFWF sites, along with estimates of benthic rugosity and mean total coral coverage for the two transects surveyed at each site. It was not possible to determine coral cover for the NOAA transects because the field technique in the NOAA surveys did not provide the necessary information, in contrast to the photo transect method used for the HCRI/NFWF study, which does allow determination of both areal and percent coverage.

Table 4. Numbers of taxa observed or collected at survey sites (X= no data available).

NPS Molokaʻi surveys 2004

Code	MOKAP	NAMOK	KUKAIWA	
Islet	Mōkapu	Nāmoku	Kukaiwaʻa	Mean
Algae	3	2	3	2.7
Invertebrates	5	6	6	5.7
Fish	20	28	25	24.3
Total	28	36	34	32.7

NOAA Surveys 2005-2006

Code	KAL-1	KAL-2	NII-7	LEH-1	LEH-2	LEH-3	LEH-1	LEH-2	LEH-3	KAU-3	KAU-3	MOL-6
Islet Site	Kaula Rock	Kaula Rock	Niʻihau	SE Lehua	Lehua Caldera	West Lehua	SE Lehua	Lehua Caldera	West Lehua	Moku ʻAeʻae	Moku ʻAeʻae	Mōkapu
Date	2006	2006	2006	2005	2006	2005	2006	2005	2006	2005	2006	2006
Algae	11	16	21	X	17	X	19	X	17	X	22	19
Invertebrates	23	21	19	41	33	16	X	X	X	X	13	49
Fish	53	62	47	92	91	75	62	72	71	69	41	69
Total	64	78	88	109	108	92	81	72	88	69	76	109
Code	MOL-7	LAN-6	LAN-6	MAI-2	MAI-10	MAI-20	MOK-1	MOK-2	MOK-3	HAW-11	HAW-20	
Islet Site	Mokomanu	Poʻo Poʻo	Poʻo Poʻo	Moku Holua	West Kaemi	Papanui o Kane	Molokini Rim	Molokini Northwest	Molokini Crater	Halapē (Keaoi)	Paokolani	
Date	2006	2005	2006	2005	2006	2006	2006	2006	2006	2006	2006	Mean
Algae	19	31	X	X	14	30	X	X	X	20	21	20
Invertebrates	21	17	X	17	20	17	12	16	10	25	15	20
Fish	65	70	67	64	72	74	70	83	56	79	63	68
Total	105	118	67	81	106	119	70	83	56	124	99	89

HCRI/NFWF Surveys 2007

Island	Oʻahu		Molokaʻi			Lanaʻi		Maui			
Code	KOAI	KAPAP	MOKAP	NAMOK	OKAL	POOPO	PUUPE	HULU	KAEM	MOLOK	
Islet	Kāohikaipu	Kāpapa	Mōkapu	Nāmoku	Ōkala	Poʻo Poʻo	Puʻu Pehe	Hulu	Kaemi	Molokini	Mean
Algae	18	40	24	29	8	30	16	40	30	15	25
Invertebrates	65	42	65	58	61	89	82	41	64	69	63
Fish	63	47	68	86	63	40	49	57	41	67	59
Total	146	129	157	173	126	159	147	138	135	151	146

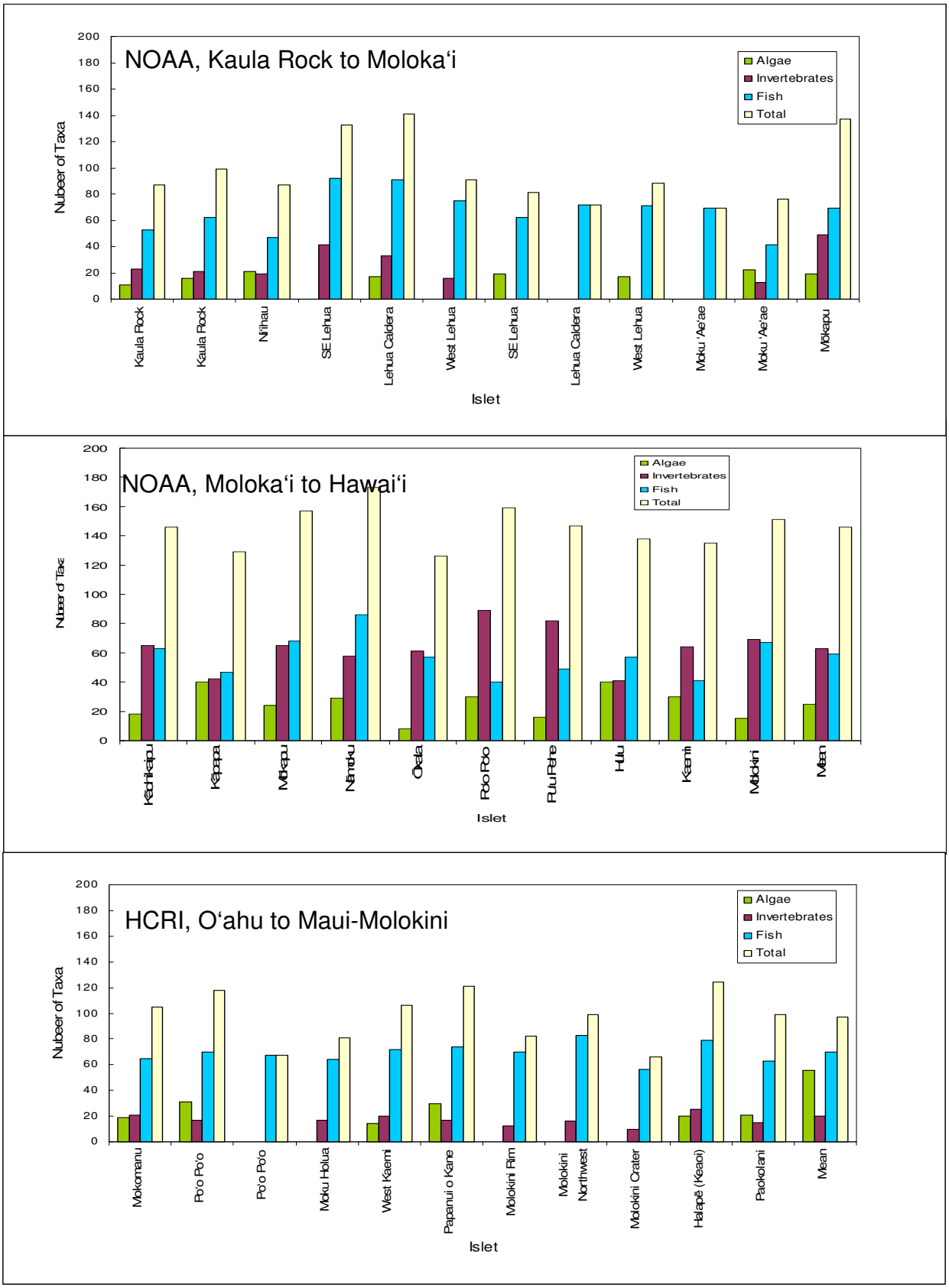

Figure 7. Numbers of algae, invertebrate and fish taxa identified from NOAA and HCRI/NFWF surveys

Table 5. Percent coverage of reef coral, algae and principal substrata at HCRI/NFWF islet sites.

	Po'o Po'o		Pu'u Pehe		Hulu		Kaemi		Molokini		Mōkapu		Nāmoku		'Ōkala		Kāohikaipu		Kāpapa	
(% Cover)	Tr. 1	Tr. 2	Tr. 1	Tr. 2	Tr. 1	Tr. 2	Tr. 1	Tr. 2	Tr. 1	Tr. 2	Tr. 1	Tr. 2	Tr. 1	Tr. 2	Tr. 1	Tr. 2	Tr. 1	Tr. 2	Tr. 1	Tr. 2
CORAL	1.6	3.5	19.3	20.8	3.8	6.5	1.2	2.3	34.0	30.8	7.6	8.1	12.0	6.9	5.5	11.2	8.1	6.7	24.4	37.6
MACROALGAE	1.1	1.9	0.8	0.1	1.4	2.7	21.2	14.6	1.1	1.1	0.9	1.1	2.3	6.3	0.5	0.7	2.5	3.4	1.9	4.2
CORALLINE ALGAE	1.0	0.5	1.3	0.9	12.4	11.6	2.4	25.1	26.5	21.5	20.0	23.3	5.3	7.6	8.2	3.0	11.7	12.3	18.8	5.2
TURF ALGAE	9.6	36.6	22.6	8.6	72.2	66.2	63.0	49.8	20.8	27.6	52.9	47.6	80.0	63.7	43.8	66.8	66.4	63.1	37.5	35.4
CYANOBACTERIA	0.0	0.0	0.3	0.2	1.9	1.6	3.0	4.6	6.4	16.9	7.0	5.6	6.3	9.4	5.6	2.6	6.0	8.4	1.1	0.6
HARD SUBSTRATUM	0.1	0.4	11.7	28.0	0.9	0.3	2.3	0.5	2.0	1.5	1.8	0.5	0.1	0.1	0.3	1.8	0.2	0.5		
SAND/SILT	85.1	56.8	24.2	24.7	6.1	10.1	5.6	2.8	4.4	2.4	1.6	0.0	0.0	0.1	0.5	3.1	3.8	2.1	14.0	10.3
UNKNOWN	0.3	0.2	1.5	1.8	1.2	0.8	0.0	0.0	0.0	0.0	0.8	0.4	0.0	0.2	0.7	0.2	0.0	0.1	0.2	0.1
MACROALGAE TAXA																				
Family Corallinaceae					0.3	0.2	0.4	0.2					0.1							
Crustose Coralline	0.1	0.1	1.2	0.9							19.7	22.9	5.2	7.6	8.1	3.0	11.5	12.0	17.3	4.9
Family Galaxauraceae	0.2	0.2			0.2	0.2													0.1	0.2
Family Liagoraceae	0.1		0.1			0.3													0.1	0.1
Acanthophora pacifica		0.7									0.7	1.0	0.1	0.2	0.3	0.7				
Amansia glomerata																			0.5	1.6
Asparagopsis taxiformis	0.7		0.5																	
Caulerpa sp.																			0.2	
Codium edule																				0.1
Dictyopteris australis					0.1	0.1	19.0	11.4												
Dictyota spp.					0.3	1.0	0.1	0.1	1.0	0.9	0.3	0.1	2.1	6.0	0.1	0.1	2.5	3.4	0.4	0.2
Gibsmithia hawaiiensis																				0.1
Halimeda sp.	0.1	0.9	0.2	0.1																
Jania sp.	0.8	0.5	0.1		0.1	0.3	0.2	0.1	0.1		0.2	0.4			0.1		0.1	0.3	1.4	0.4
Lobophora variegata								0.1	0.1	0.2									0.2	
Laurencia sp.																				1.4
Neomeris annulata		0.1			0.1	0.1														
Padina spp.							1.8	1.2					0.1	0.1						
Portieria hornemannii																			0.3	
Sargassum spp.					0.3		0.1													
Stypopodium flabelliforme					0.4	1.0	0.3	1.6												
Turbinaria ornata								0.2												
Total Identified Taxa	6	6	5	2	8	8	7	7	3	2	4	4	5	5	4	3	3	3	9	9

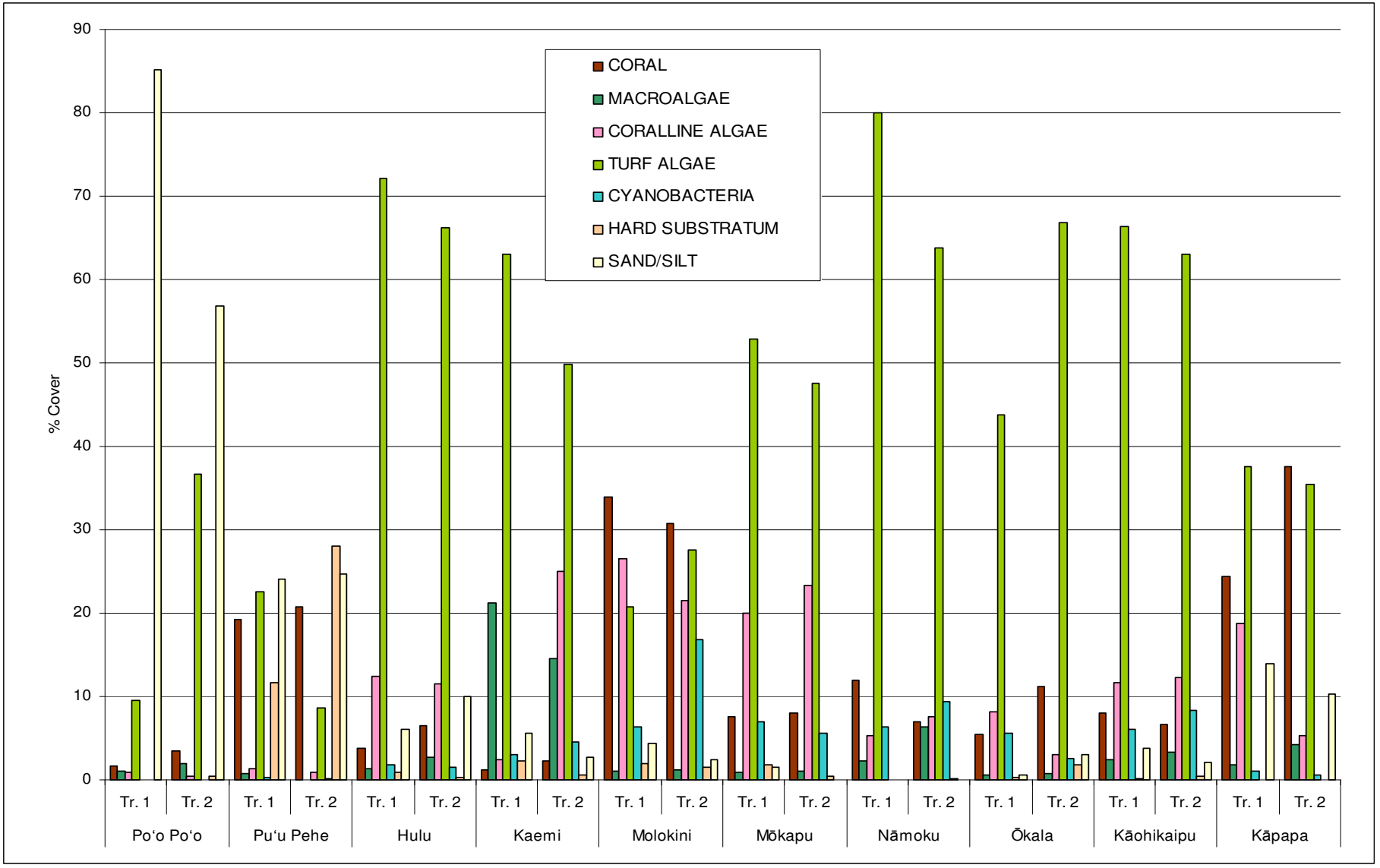

Figure 8. Percent coverage of reef coral, algae and principal substrata at HCRI/NFWF islet sites determined from algal sampling transects (Coles et al. 2007).

The coral transect information of Appendices G and H is summarized in Table 6 for the NOAA surveys and in Table 7 for the HCRI/NFWF surveys. A total of 26 species of corals or other cnidarians occurred on the NOAA transects, ranging from five at the Kaula Rock (KAL-1)and Niʻihau (NII-7) sites to 13 at the West Kaemi, Maui (MAI-10) site, Molokini Outer Rim (MOK-1) and Halapē, Hawaiʻi (HAW-11) sites. Mean numbers of colonies per m^2 ranged from 1.5 at the Niʻihau site (NII-7) to 53 at Kaula Rock Site 2 (KAL-2) and averaged 7.5 overall.

A total of 14 coral or other cnidarian species occurred on the transects of the 10 HCRI/NFWF sites, ranging from five species at Poʻo Poʻo on Lānaʻi and Kaemi and Hulu on Maui, to 10 species at Kapapa on Oʻahu. Mean numbers of colonies per transect ranged from 5.7 at Kaemi to 41 along the outside wall of Molokini, which also had the greatest mean coral cover of 32.4%. The lowest mean coral cover of 1.8% was measured at Kaemi off north Maui in an area that is subject to high turbulence and an unstable boulder substratum.

These data are further summarized in Tables 8 and 9, which show supplementary location and environmental information for both NOAA and HCRI/NFWF sites, total species and dominant species by numbers, total colonies for the two transects surveyed and the median size class which contained at least half of the colonies measured on the transects. *Porites lobata* and *Pocillopora meandrina* occurred at virtually all the sites and were the dominant species, ranking first by number of colonies at 12 and 10, respectively, on the 29 surveys. Although *Montipora capitata* and *Montipora patula* occurred at as many sites as *P. lobata* and *P. meandrina* they were much less abundant, and each was the dominant species at only 2-3 of the sites. Only *Pocillopora molokensis* and *Sinularia abrupta* were abundant enough to be dominant at a single site each.

The size class distributions for each species at each site are shown in detail in Appendices G and H and are summarized further in Figures 9 to 14 for NOAA surveys and in Figures 15 to 18 for HCRI/NFWF surveys. These show size class histograms combined for all species for both transects at each site, and cumulative frequency curves for subsequent size classes. Most of the distributions for both the NOAA are bell shaped, which suggests substantial survival of settled coral colonies into the 0.6-1.0 cm size class after recruitment, but may also be partly an artifact of not being able to fully differentiate between corals in the two smallest size classes using theNOAA field technique. This pattern pertains to 12 of the 19 sites for the NOAA surveys. One of the remaining sites (Niʻihau) shows an unusual size class distribution with the 20-40 cm diameter size range having more than one-third of the total 173 colonies measured at this site. The remaining NOAA sites show size class distributions strongly skewed to the left, indicating that coral sizes in the smallest class (0-0.5 cm diameter) made up the major portion of the frequency distributions and numbers of colonies decreased in subsequent size classes. This is a pattern representative of high recruitment levels and mortality with increasing coral size. These sites, located at the westernmost of the main Hawaiian Islands, also showed little to no survival to greater than 40 cm diameter, indicating that large adult corals are few to missing at these locations.

Table 6. Coral species and mean numbers of colonies per m^2 at NOAA coral survey stations.

	KAL1	KAL2	NII7	LEH1	LEH2	LEH3	KAŪ3	KAŪ3	MOL6	MOL7	LAN6	MAI2	MAI10	MAI20	MOK1	MOK2	MOK3	HAW11	HAW20
Species	06	06	06	05	05	05	05	06	06	06	05	05	06	06	05	05	05	05	06
Montipora capitata	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Montipora flabellata												x	x	x				x	
Montipora patula			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Pocillopora damicornis																		x	
Pocillopora eydouxi	x	x	x	x			x		x	x	x	x	x			x	x	x	x
Pocillopora ligulata		x							x	x									x
Pocillopora meandrina	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Pocillopora molokensis										x									
Porites brighami					x	x	x		x	x				x		x	x	x	
Porites compressa							x	x			x	x			x	x	x	x	x
Porites evermanni												x	x			x		x	x
Porites lobata	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x
Fungia scutaria				x									x			x			
Leptoseris incrustans					x						x				x	x			
Pavona duerdeni				x		x						x							x
Pavona maldivensis										x									
Pavona varians							x		x	x		x	x		x	x	x	x	x
Cyphastrea ocellina					x							x	x	x	x			x	
Leptastrea bewickensis	x	x													x				
Leptastrea purpurea							x			x	x		x		x	x	x		x
Psammacora stellata				x		x					x								
Tubastraea coccinea															x				
Palythoa sp.							x	x	x	x		x	x	x				x	
Zoanthus pacifica									x										
Antipathes sp.															x				
Cirripathes anguina															x				
Total Species	5	6	5	8	7	7	10	6	11	12	10	12	13	8	13	11	9	13	10
Mean Colonies/m^2	12	53	1.5	2.3	1.6	4.6	5.3	5.2	2.4	3.0	6.8	3.6	2.5	2.5	9.5	3.1	6.7	12.6	4.6

Table 7. Coral species, mean numbers of colonies, and total cover per m^2 at HCRI/NFWF coral survey stations.

	O'ahu		Moloka'i			Lāna'i		Maui		
	KOAHIKAIPU	KAPAPA	MOKAPU	'ŌKALA	NAMOKU	PUUPEHE	POOPOOO	KAEMI	HULU	MOLOKINI
Species	2007	2007	2007	2007	2007	2007	2007	2007	2007	2007
Montipora capitata	x	x	x		x	x	x	x	x	x
Montipora flabellata		x				x				
Montipora patula	x	x	x	x	x	x	x	x	x	x
Pocillopora meandrina	x	x	x	x	x	x	x	x	x	x
Pocillopora molokensis			x	x	x					
Porites compressa		x			x	x				
Porites evermanni		x	x	x	x	x				
Porites lobata	x	x	x	x	x	x	x	x	x	x
Pavona duerdeni	x	x								
Pavona varians	x	x		x		x				x
Leptastrea purpurea			x					x		
Psammacora stellata		x								
Palythoa caesiea	x		x	x		x			x	x
Sinularia abrupta				x						
Total Species	8	10	8	9	7	9	5	5	5	7
Mean Colonies/m^2	12.7	17.6	9.6	9.6	5.8	26.6	11.9	5.7	12.6	41.0
Mean % Cover	7.4	31.1	7.8	8.2	9.2	25.8	2.6	1.8	5.0	32.4

Table 8.Coral transect results for NOAA survey sites.

Island	Site #	Location	Year	Depth (ft)	Islet Dist. (m)	Total Species	Dominant Species	No. Colonies	Med. Size Class
Kaula	KAL-1&2	Kaula Rock	2006	29-37	35	6	P. meandrina	2630	<5
Niʻihau	NII-7	N side, W of Kikepa Pt.	2006	37-40	258	5	P. meandrina	173	5-10
Lehua	LEH-1	Lehua, SE side	2005	50	49	8	P. lobata	191	<5
	LEH-2	Lehua, inside caldera	2005	58	76	7	M. patula	157	<5
	LEH-3	Lehua, West side	2005	48	41	7	P. lobata	483	<5
Kauaʻi	KAU-3	Kilauea Pt.-Moku ʻAeʻae Islet	20055	35	326	10	M. capitata	455	<5
	KAU-3	Kilauea Pt.-Moku ʻAeʻae Islet	2006	29-30	326	6	M. capitata	509	5-10
Molokaʻi	MOL-6	Mōkapu Islet	2006	40-46	1	11	P. meandrina	266	5-10
	MOL-7	Mokomanu Islet	2006	41-46	327	12	P. meandrina	338	5-10
Lanaʻi	LAN-6	Poʻo Poʻo Islet	2005	48	77	10	P. lobata	460	<5
	LAN-6	Poʻo Poʻo Islet	2006	40-57	77	13	P. lobata	773	5-10
Maui	MAI-2	Moku Holua Islet	2005	na	139	11	P. meandrina	899	5-10
	MAI-10	Hakuheʻe Pt. - Kaemi Islet	2006	45-59	50	11	P. lobata	569	5-10
	MAI-20	Papanui o Kāne Islet	2006	44-50	388	8	P. lobata	130	5-10
Molokini	MOK-1	Molokini Outer Rim	2005	48	1	13	P. meandrina	783	10-20
	MOK-2	Molokini Northwest	2005	50	74	11	P. lobata	536	10-20
	MOK-3	Molokini Crater	2005	45	117	9	M. capitata	472	10-20
Hawaiʻi	HAW-11	Halapē (Keaoi Islet)	2005	na	98	13	P. meandrina	630	10-20
	HAW-20	Paokolani Islet	2006	29-40	94	10	P. lobata	418	5-10

Table 9. Coral transect results for HCRI/NFWF survey sites.

Island	Site #	Location	Year	Depth (m)	Islet Dist. (m)	Total Species	Dominant Species	No. Colonies	Med. Size Class
Oahu	KOAI	Kāohikaipu Islet	2007	8-12	148	8	P. meandrina	1007	<5
	KAPAP	Kāpapa Islet	2007	8-9	643	8	P. lobata	1019	<5
Molokaʻi	MOKAP	Mōkapu Islet	2007	13-22	10	8	P. molokensis	445	<5
	OKAL	ʻŌkala Islet	2007	14-19	20	9	Sinularia abrupta	714	<5
	NAMOK	Nāmoku	2007	11-22	26	7	P. meandrina	278	<5
Lanaʻi	PUUPE	Puʻu Pehe Islet	2007	8-11	45	9	M. patula	1280	<5
	POOPO	Poʻo Poʻo Islet	2007	17-18	20	5	P. lobata	569	<5
Maui	KAEM	Kaemi Islet	2007	6-12	48	5	P. meandrina	210	<5
	HULU	Hulu Islet	2007	6-15	33	5	P. lobata	327	<5
	MOLOK	Molokini Rim	2007	4-28	10	9	P. lobata	1693	<5

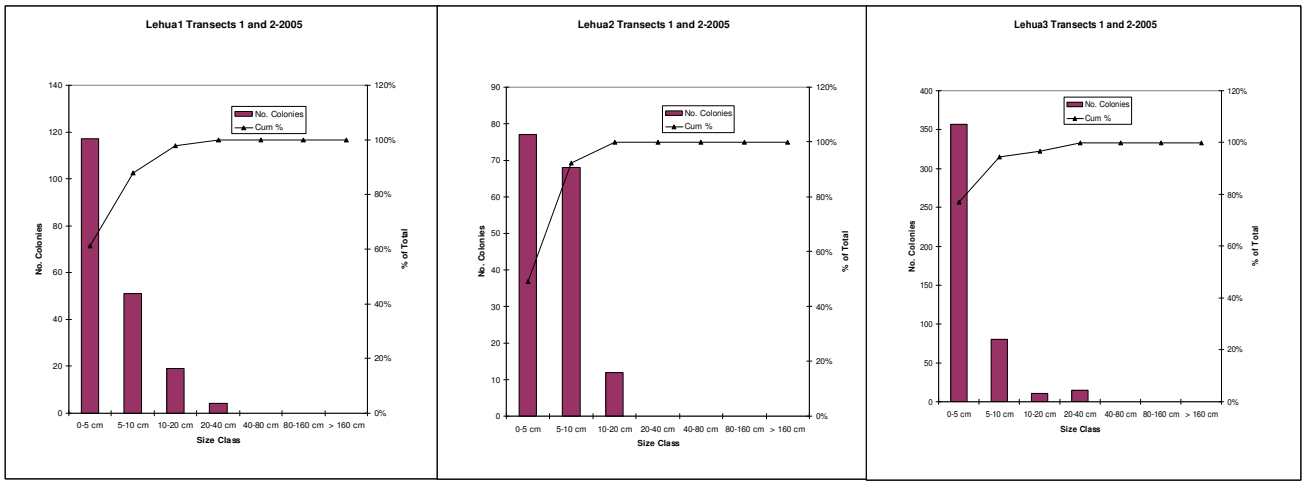

Figure 9. Size distributions of all corals at Lehua islet transects, 2005.

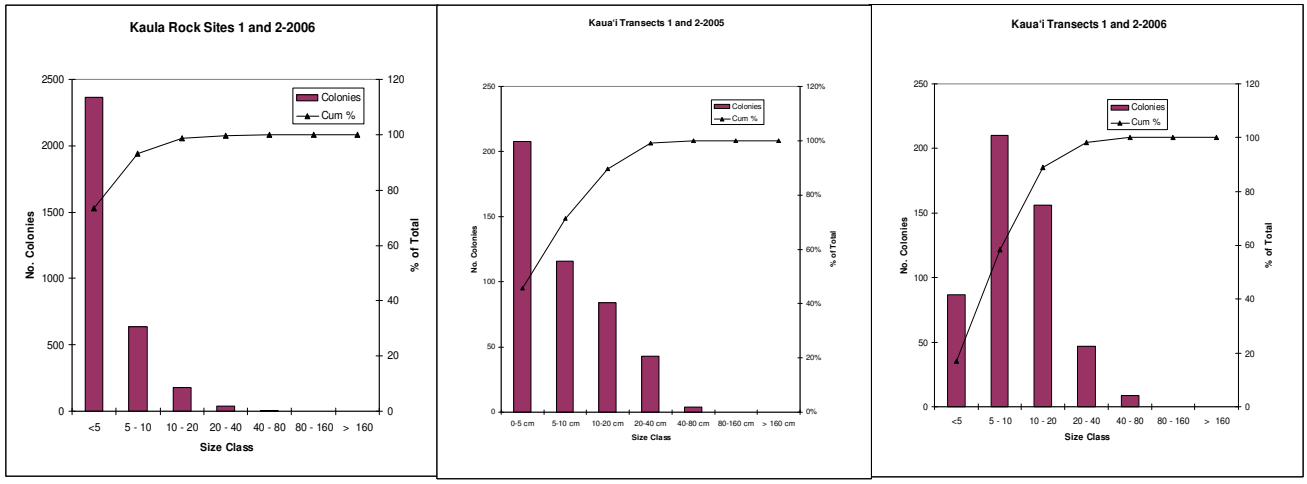

Figure 10. Size distributions of all corals at Kaula Rock in 2006 and Kaua'i Transects in 2005 and 2006.

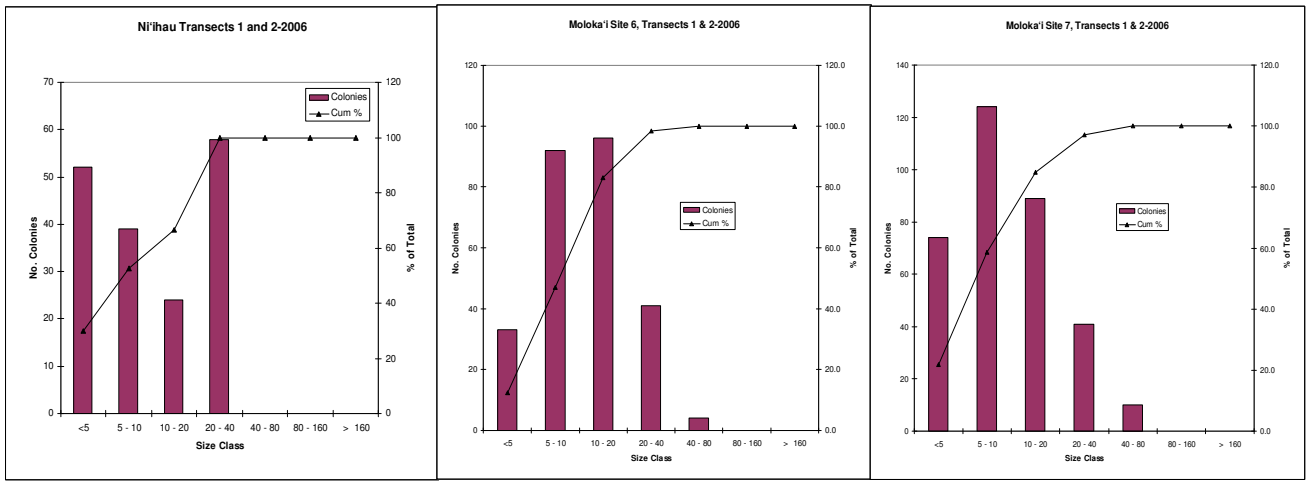

Figure 11. Size distributions of all corals at Ni'ihau, Moloka'i Mōkapu (MOL6) and Mokumanu (MOL7) Transects in 2006.

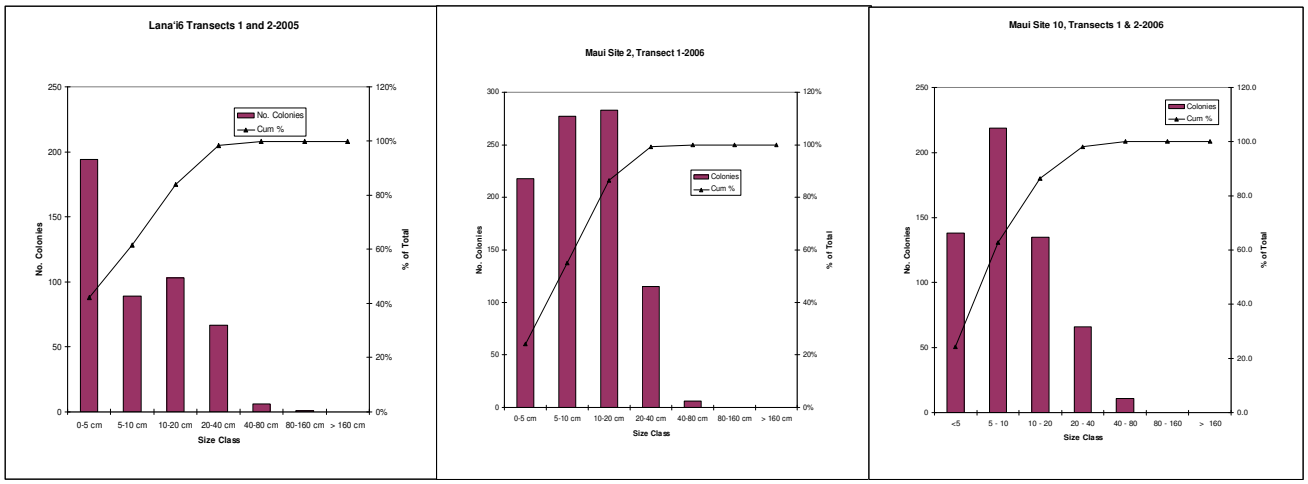

Figure 12. Size distributions of all corals at Lāna'i Site 6 (Po'o Po'o), Maui Site 2 (Moku Holua).) and Maui Site 10 (Kaemi Islet) in 2005

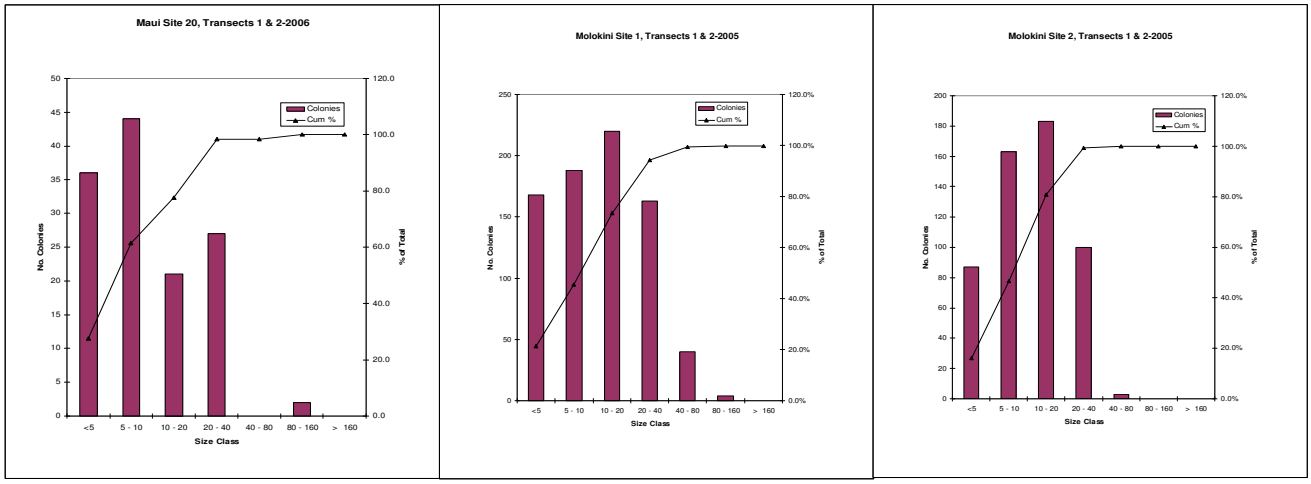

Figure 13. Size distributions of all corals at Maui Site 20 (Papanui o Kāne Islet) and Molokini Sites 1 and 2 transects in 2006.

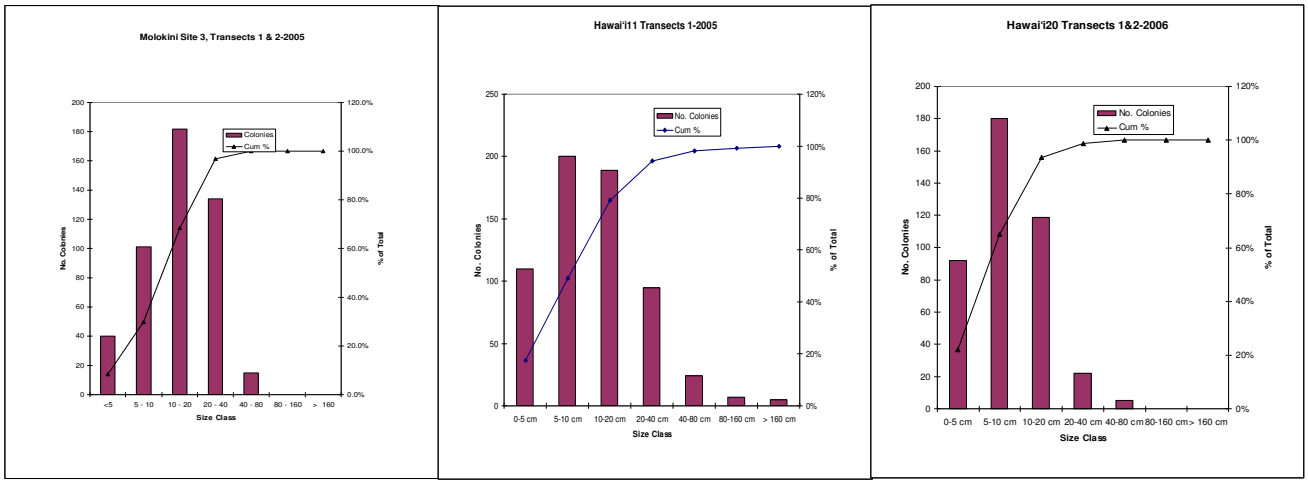

Figure 14 Size distributions of all corals at Molokini transects in 2006, Hawai'i 11 (Halapē) transects in 2005 and Hawai'i 20 (Paokalani Islet) transects in 2006.

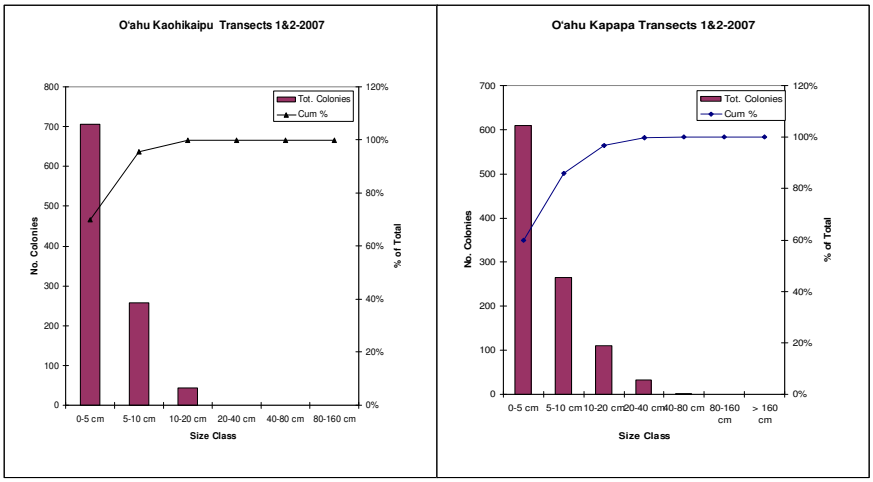

Figure 15. Size distributions of all corals at HCRI/NFWF Oʻahu Kāohikaipu and Kāpapa transects in 2007.

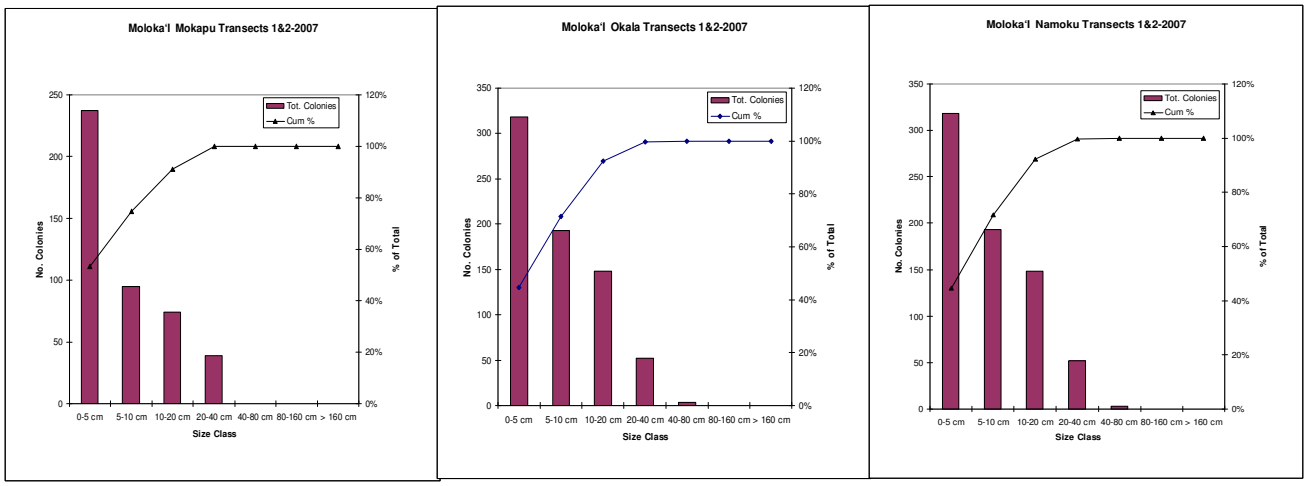

Figure 16. Size distributions of all corals at HCRI/NFWF Moloka'i, Mōkapu, ʻŌkala and Nāmoku sites in 2007.

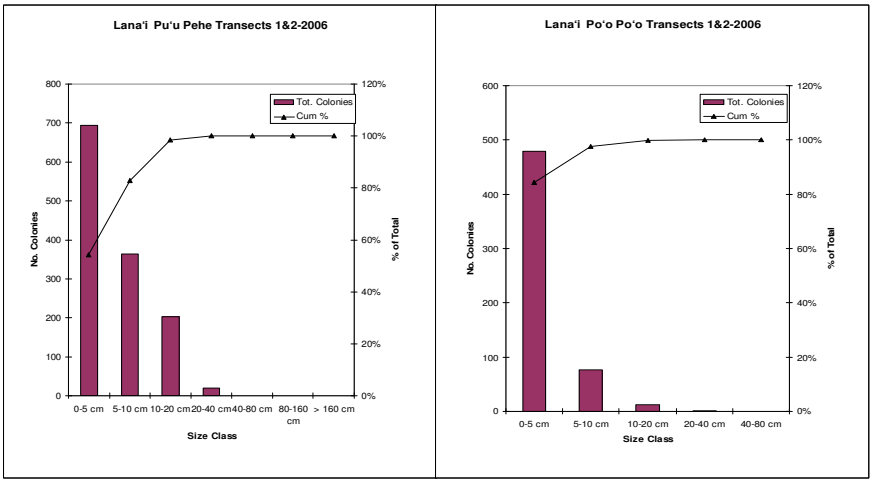

Figure 17. Size distributions of all corals at HCRI/NFWF Lānaʻi Puʻu Pehe and Poʻo Poʻo sites in 2007.

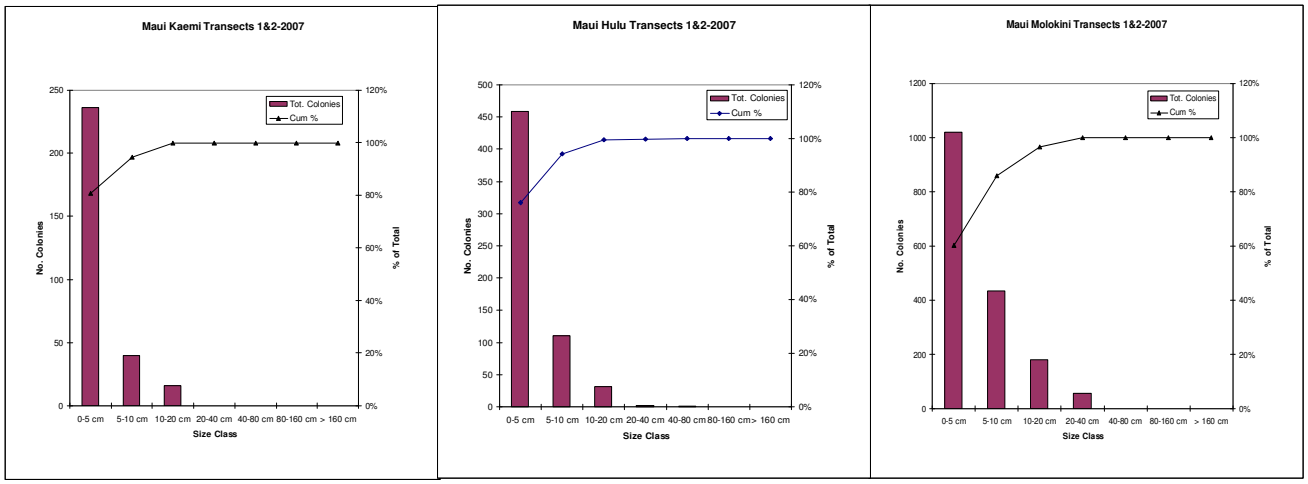

Figure 18. Size distributions of all corals at HCRI/NFWF Maui Kaemi, Hulu and Molokini sites in 2007.

All ten of the HCRI/NFWF sites (Figures 16 to 19) show a similar strongly left skewed size class distribution with most colonies counted in the 0-0.5 cm range, suggesting that these sites may have coral populations with relatively fewer large adult corals than was determined for sites from most of the NOAA surveys. However, it also is possible that the difference in distributions between these NOAA sites and the HCRI/NFWF sites is more related to differences in measurement techniques than to real differences between the coral population size distributions. In support of this conclusion is the fact that, with the exception of Kaula Rock, fewer colonies were counted on most of the NOAA transects, which averaged 473 per site, than on the HCRI/NFWF transects, which averaged 754 per site. Therefore, although the distributions suggest that relatively fewer corals were in the >40 cm size ranges, there were still substantial number of the larger older corals on the HCRI/NFWF transects. Second, the laboratory analysis of quadrat photographs used in the HCRI/NFWF study enabled a more precise determination of corals counted in the two smallest size classes than in the NOAA study. If both of the smallest size classes from the HCRI'NFWF surveys were combined, all sites from both surveys would show similar skewed distributions of dominance by the smallest size class.

Although the present data do not enable calculation of coral percent coverage values for the NOAA surveys, mean values for comparison from a number of sources are available in Friedlander et al. (2008) for remote islands such as Kaula Rock (2 surveys), Ni'ihau (17 surveys), Lehua (5 surveys), Molokini (63 surveys) and Kaho'olawe. These are compared in Figure 19 with coral percent cover means at the ten sites from the HCRI/NFWF surveys and an overall average of 19% based on 1,682 transects/sites throughout the MHI. Recognizing the limitation of comparing sites with results from two transects with much larger sample sizes, the results suggest that three of the HCRI/NFWF sites, Kapapa, Pu'u Pehe and Molokini Rim well exceeded the MHI mean and were comparable to means for three remote islands, while seven of the HCRI sites and three of the remote island averages did not.

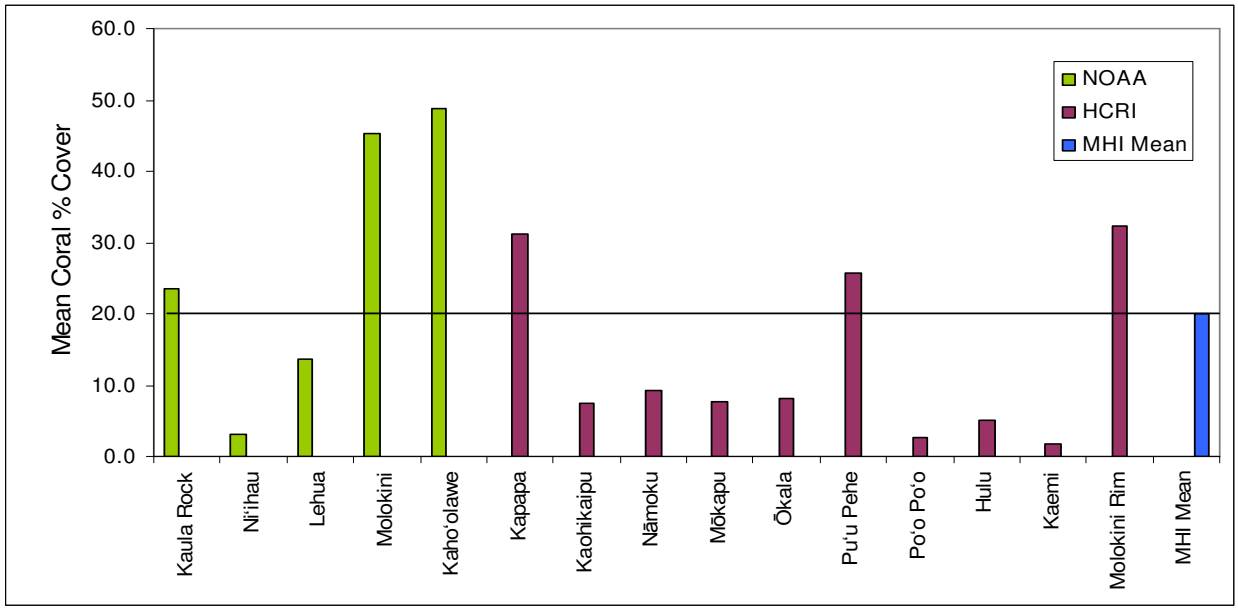

Figure 19. Comparison of HCRI/NFWF coral percent coverages with average values for select remote main Hawaiian Islands and MHI overall average.

Reef Fishes

A total of 28 sites were surveyed for reef fishes in the NOAA and HCRI/NFWF studies, 18 for the NOAA surveys, including five sites (Lehua 1-3, Kauaʻi 3 and Lānaʻi 6) that were surveyed in both 2005 and 2006, and ten sites for the HCRI/NFWF study in 2007. The fish species that were recorded on NOAA surveys from Kaula Rock to Molokaʻi are listed in Appendix I, those for the NOAA surveys from Lānaʻi to Hawaiʻi in Appendix J, and those for the HCRI/NFWF surveys in Appendix K. Numbers of fish species found at each site surveyed are shown in Figures 20 and 21. Values were quite consistent between the NOAA and HCRI/NFWF surveys, ranging from 41- 92 per site for the NOAA surveys with the highest numbers occurring at South Lehua, Molokini and Halapē, and 40-86 per site for the HCRI/NFWF surveys, with highest number occurring at Kāohikaipu, Oʻahu, and Nāmoku and Mōkapu Molokai. The most frequently occurring species were *Sufflamen bursa, Paracirrhites arcatus, Thalassoma duperrey, and Parupeneus multifasciatus,* which were all found at all sites on all sampling dates.

Mean biomass estimates for total fishes, primary consumers (herbivores), secondary consumers (plankton and small fish feeders), apex predators and target species that are subject to fishing pressure are shown in for the three transects at each site in Table 10 and Figures 22 and 23. Order of magnitude or more differences in biomasses were found among the sites for each category. For example, the highest mean total biomasses were determined on the west side of Lehua Rock (LEH-3) by the NOAA survey in 2005 (117 g/m^2) and outside of Kapapa Island off Oʻahu (107 g/m2) by the HCRI/NFWF survey in 2007. The lowest values occurred at The NOAA Kauaʻi Mokuʻaeʻae site (KAU-3) of 7.9 g/m^2 in 2006 and at the HCRI/NFWF Poʻo Poʻo site (8.5 g/m2) in 2007. The majority of the sites had mean biomasses

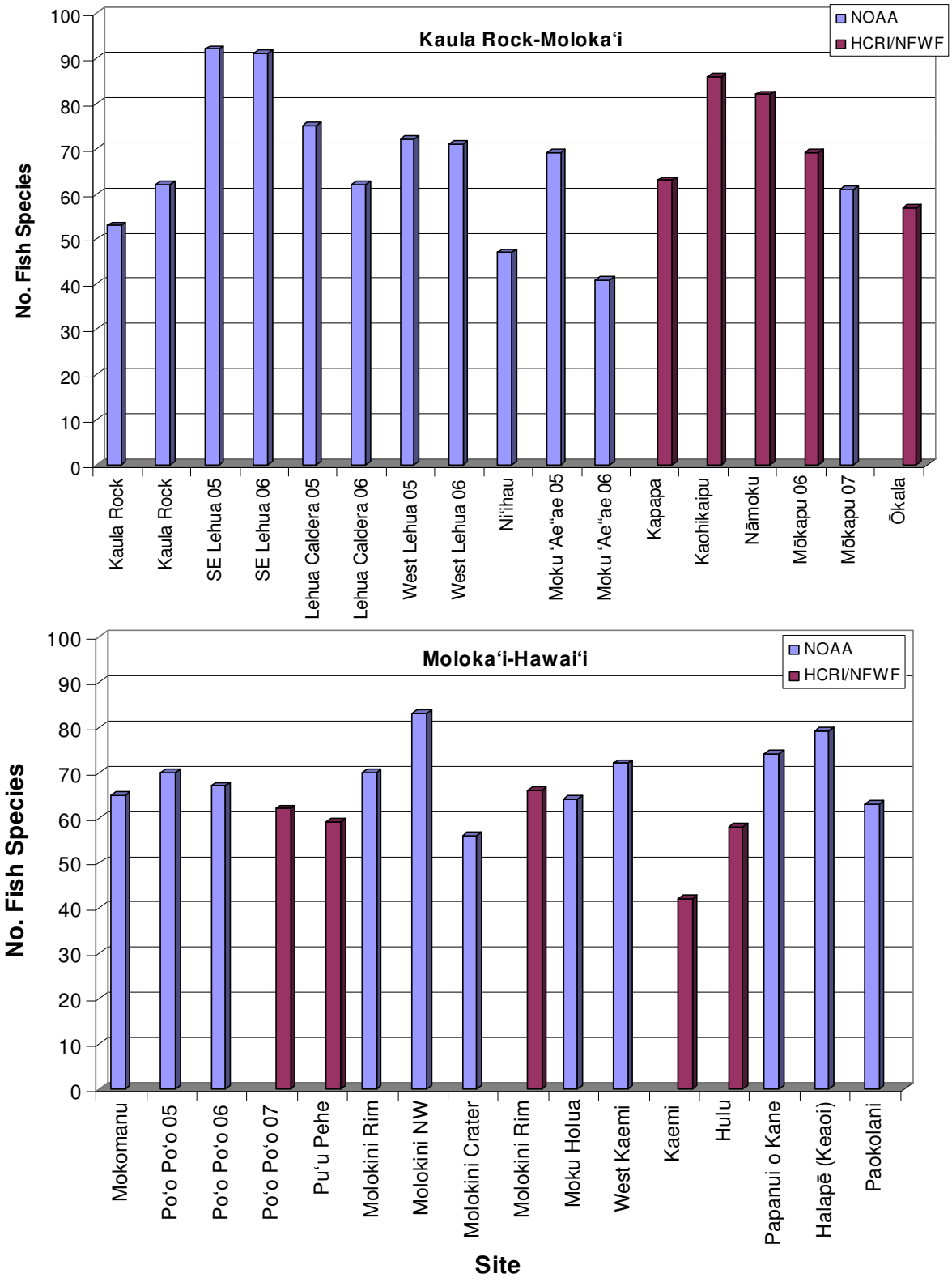

Figure 20. Number of fish taxa observed at NOAA (blue bars) and HCRI/NFWF (red bars) sites.

Table 10. Fish biomass averages for NOAA and HCRI/NFWF sites and mean values for the Main Hawaiian Islands. Bolded values exceed their respective group average for the MHI.

NOAA Site ID	Location	Total	Primary	Secondary	Apex	Target
KLA-1-06	Kaula Rock-NOAA	38.57	11.7	**26.9**	0	32.2
KLA-2-06	Kaula Rock-NOAA	17.85	14.3	3.6	0	14.3
LEH-1-05	Lehua, SE side-NOAA	31.66	17.3	13.7	0.7	24.0
LEH-1-06	Lehua, SE side-NOAA	**65.77**	**32.1**	**33.7**	0	**40.0**
LEH-2-05	Lehua, inside caldera-NOAA	**59.22**	20.7	**28.8**	**9.7**	**30.3**
LEH-2-06	Lehua, inside caldera-NOAA	**72.37**	**33.6**	**38.8**	0	**56.6**
LEH-3-05	Lehua, West side-NOAA	**116.98**	**25.6**	**88. 7**	**2.8**	**90.6**
LEH-3-06	Lehua, West side-NOAA	12.57	1.6	11.0	0	0
NII-7-06	N side, W of Kikepa Pt. -NOAA	44.2	17.7	**25.8**	0.7	**27.4**
KAI-3-05	Kilauea Pt.-Moku ‘Ae’ae Islet-NOAA	21.3	7.7	13.5	0	12.6
KAI-3-06	Kilauea Pt.-Moku ‘Ae’ae Islet-NOAA	7.9	0.7	7.1	0	1.0
OAH-Kao-07	Kaohikaipu-HCRI/NFWF	**62.9**	14.1	**48.2**	0.7	**27.5**
OAH-Kap-07	Kapapa-HCRI/NFWF	**107.4**	**73.3**	**34.1**	0	**80.0**
MOL-6-06	Mōkapu-NOAA	40.6	8.2	**32.4**	0	11.04
MOL-7-06	Ridge between Pelekunu Bay & Mokohola Islets-NOAA	**84.2**	16.8	**64.5**	**2.9**	**30.0**
MOL-Mok-07	Mokapu-HCRI	**57.4**	**38.5**	18.9	0	**31.3**
MOL-Oka-07	‘Ōkala -HCRI/NFWF	44.6	32.0	12.5	0	**39.4**
MOL-Nam-07	Namoku-HCRI/NFWF	**55.4**	**28.9**	9.6	**16.9**	**30.7**
LAN-6-05	Po‘o Po‘o-NOAA	42.1	19.8	18.9	**3.5**	16.7
LAN-6-06	Po‘o Po‘o-NOAA	36.4	19.8	14.8	1.8	10.2
LAN-Poo-07	Po'o Po'o-HCRI/NFWF	8.5	1.7	6.5	0.3	3.0
LAN-Puu-07	Pu‘u Pehe-HCRI/NFWF e	17.4	12.9	3.9	0.6	8.8
MOK-1-05	Molokini Outer Rim-NOAA	**87.9**	16.7	**56.7**	**14.5**	**47.3**
MOK-2-05	Molokini Northwest-NOAA	**97.4**	**33.9**	**55.4**	**8.2**	**39.5**
MOK-3-05	Molokini Crater-NOAA	24.2	20.7	3.6	0	20.4
MOK-Rim-07	Molokini Outer Rim	43.2	17.4	16.4	**9.4**	**23.5**
MAI-2-05	Moku Holua Islet-NOAA	28.2	16.8	11.1	0.2	13.7
MAI-10-06	Hakuhe‘e Pt. - Kaemi Islet-NOAA	**83.7**	**39.5**	**43.4**	0.8	**52.4**
MAI-20-06	Papanui o Kāne Islet-NOAA	**84.4**	**40.9**	**30.2**	**13.3**	**54.7**
MAI-Hul-07	Hulu-HCRI/NFWF	13.7	7.5	6.2	0	4.7
MAI-Kae-07	Kaemi-HCRI/NFWF	**50.9**	**42.8**	8.1	0	**46.2**
HAW-11-05	Halapē (Keaoi Islet) -NOAA	**68.8**	**35.4**	**25.4**	**7.9**	**40.6**
HAW-20-06	Paokolani Islet-NOAA	57.2	12.4	**43.2**	1.5	**29.8**
	All MHI	48.4	21.6	24.6	2.2	26.7
	No.> MHI Mean	15	12	17	10	19

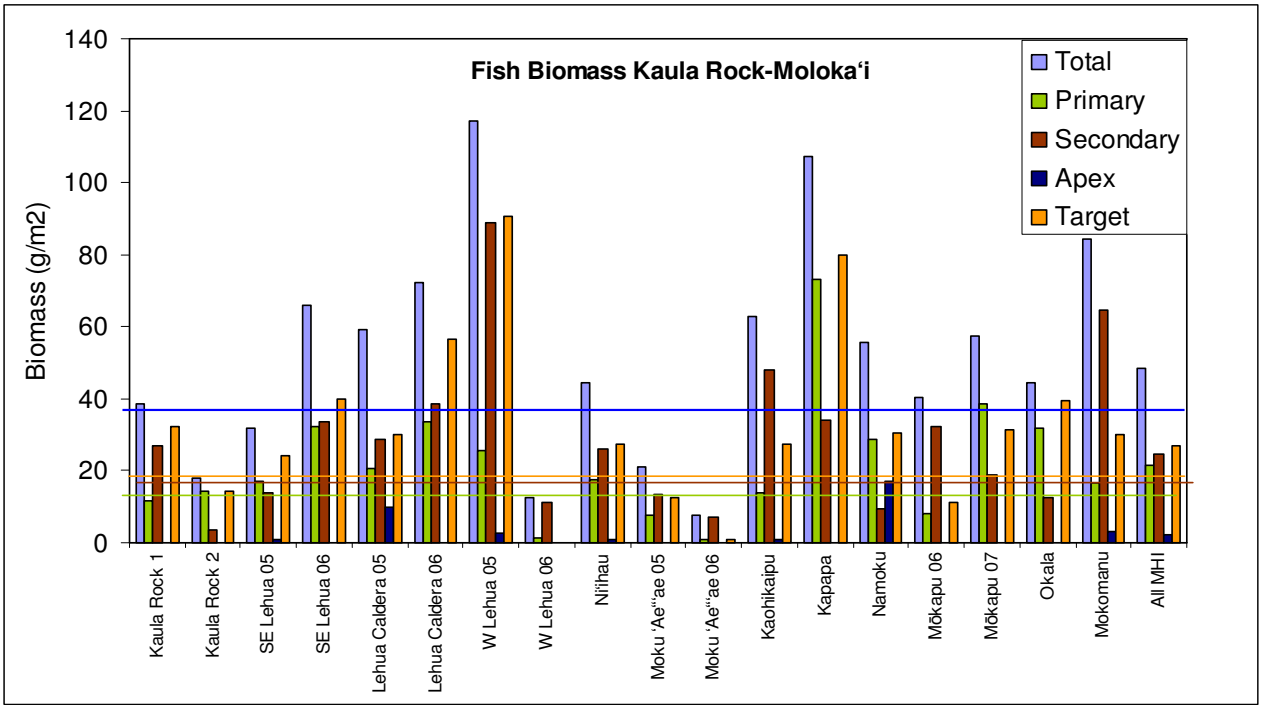

Figure 21. Fish biomasses at NOAA and HCRI/NFWF sites from Kaula Rock to Moloka'i.

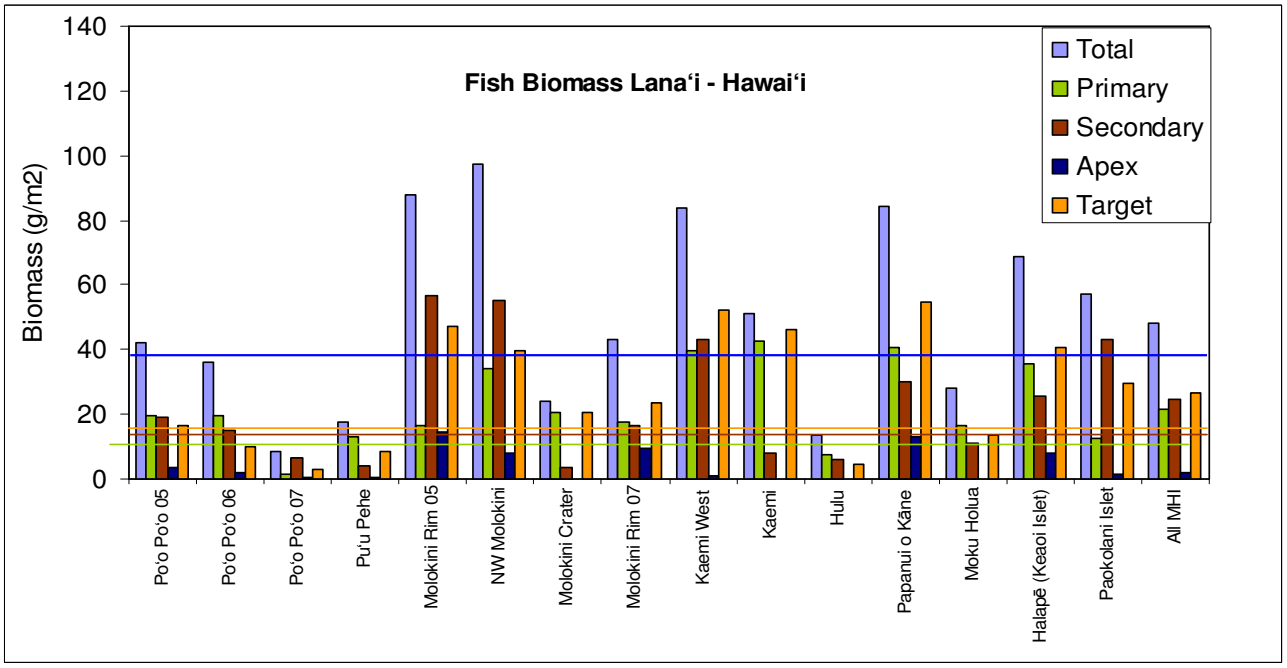

Figure 22. Fish biomasses at NOAA and HCRI/NFWF sites from Lāna'i to Hawai'i.

for the three transects that were higher than the means that have been determined throughout the Main Hawaiian Islands for total biomass (48.4 g/m^2), primary consumers (21.6 g/m^2) secondary consumers (24.6 g/m^2). These values were exceeded at 15 sites for total biomass, 11 sites for primary consumers, 16 sites for secondary consumers, 12 for apex predators, and 17sites for target species.

Similar ranges of biomasses were also found among sites for primary and secondary consumers, apex predators and target species, and most of these were highly correlated (Figure 23). Total biomass was significantly correlated ($p<0.05$) with primary consumer biomass (Pearson product moment coefficient $r = 0.66$), secondary consumers ($r = 0.86$), and target species ($r= 0.89$), and target species were also significantly correlated with primary ($r =0.72$) and secondary consumers ($r =0.76$). No significant correlations were found between fish total biomass and numbers of algae, invertebrates of fish species or with total number of coral colonies on site transects.

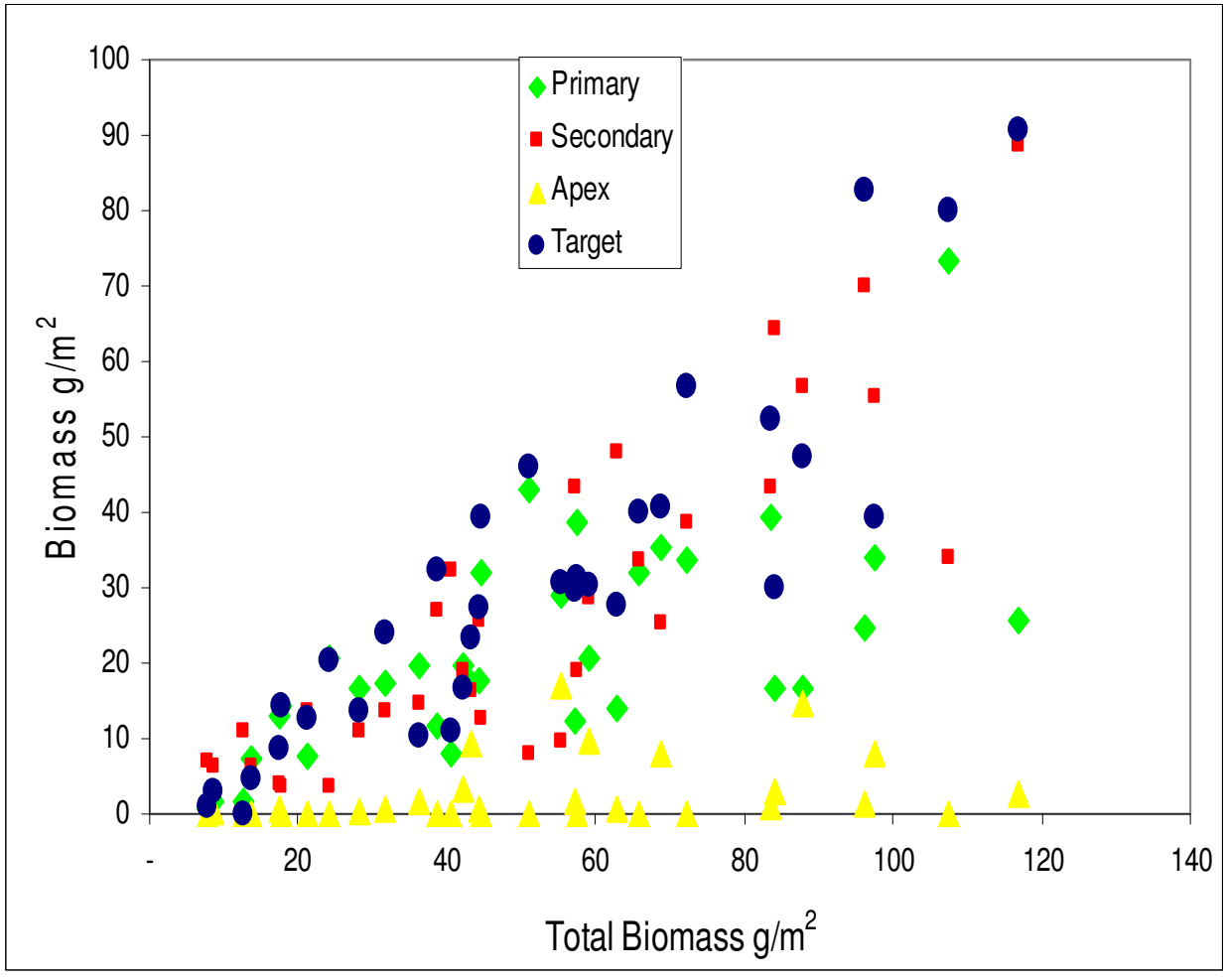

Figure 23. Mean total fish biomass plotted against primary and secondary consumer, apex predator and target species mean biomasses.

Introduced and Invasive Species

Tables 11 and 12 list the 22 recognized introduced or cryptogenic species per Carlton and Eldredge (2009) that were observed or collected at islet sites during NOAA and HCRI/NFWF surveys. For the NOAA surveys only one introduced invertebrate species and two introduced fish species fish were reported. The introduced octocoral *Carijoa riise*i, which was reported only on the NOAA surveys at the Mōkapu, Moloka'i site, is considered the most invasive marine invertebrate in Hawai'i and to endanger the survival of black coral beds in the 'Au'au channel between Maui and Lāna'i. The fishes *ta'au* (*Lutjanus fulvus*), *ta'ape* (*L. kasmira*) and *roi* (*Cephalopholis argus*), all introduced to Hawai'i in the 1950s, were widely distributed throughout most of the 18 NOAA sites surveyed, with *L. fulvus* occurring on 14 surveys, *L. kasmira* at 19 and *C. argus* on 13 surveys.

Nineteen introduced or cryptogenic invertebrates were found among the ten HCRI/NFWF/NFWF sites (Table 13). All but seven of these are listed as cryptogenic, i.e. neither demonstrably native nor introduced, but considered potentially introduced. Ten of the cryptogenic species were hydroids, most of which have been rarely and recently first reported in the Hawaiian Islands. All of these were found in low abundance and were a minor component of the total benthos at the sites where they occurred. Six of them (*Eudendrium* sp., *Antennella secondary, Plumularia strictocarpa, Sertularella tongensis, Tridentata humpferi* and *Tridentata ligulata*) have previously been reported from Bishop Museum introduced species surveys, mostly from O'ahu sites, especially off Waikīkī and Hawai'i Kai (Coles et al. 2002).

No introduced or invasive algal species occurred at any of the HCRI/NFWF sites, and the only invasive invertebrate found was the introduced snowflake octocoral *Carijoa* aff. *riisei*, which occurred at seven of the ten sites and was very abundant in caves at 'Ōkala in the Kalaupapa NHP and at a pinnacle near Po'o Po'o at Lāna'i. At other sites *Carijoa* was present as relatively small patches, usually under ledges or in subdued light, but it was found at all Neighbor Island sites except Hulu on Maui. Interestingly it did not occur at either of the O'ahu sites surveyed, despite its known abundance on O'ahu reefs (Kahng 2006).

Of the remaining six recognized introduced species only three were invertebrates: the ubiquitous hydroid *Pennaria disticha*, which occurred at half the sites, the serpulid polychaete *Salmacina disticha*, which was a minor benthic component at the three Moloka'i sites, and the bryozoan *Bugula dentata*, also occurring sparsely at two of the sites. The remaining introduced species were the three fishes found widely distributed throughout the main Hawaiian Islands by the NOAA surveys. *Lutjanus fulvus* occurred at four widely distributed sites, *L. kasmira* occurred at six of the ten sites, the *Cephalopholis argus* occurred at all three Kalaupapa NHP sites off Moloka'i and the Kāohikaipu site off O'ahu.

Table 11. Introduced or cryptogenic species observed or collected at NOAA islet sites.

Kaula Rock to Molokai

			Kaula1	Kaula2	Niʻihau	SE Lehua	SE Lehua	Lehua Crater	Lehua Crater	West Lehua	West Lehua	Moku ʻAeʻae	Moku ʻAeʻae	Mōkapu	Mokumanu
Family	*Scientific name*	Origin	05	06	06	05	06	05	06	05	06	05	06	06	06
TELESTIDAE	*Carijoa riisei*													x	
LUTJANIDAE	*Lutjanus fulvus*	Introduced				x	x	x			x	x			x
	Lutjanus kasmira	Introduced	x	x	x	x	x	x	x	x	x	x	x	x	x
SERRANIDAE	*Cephalopholis argus*	Introduced			x	x		x							x
		Total Species	1	1	2	3	2	3	1	1	2	2	1	2	3

Lānaʻi to Hawaiʻi

			Poʻo Poʻo	Poʻo Poʻo	Moku Holua	West Kaemi	Papanui O Kāne	Molokini Rim	NW Molokini	Molokini Crater3	Halape (Keaoi)	Paokalani	
Family	*Scientific name*	Origin	05	06	05	06	06	05	05	05	05	06	Total
LUTJANIDAE	*Lutjanus fulvus*	Introduced	x	x	x	x	x	x	x			x	14
	Lutjanus kasmira	Introduced			x	x	x		x		x	x	19
SERRANIDAE	*Cephalopholis argus*	Introduced	x	x	x	x	x	x		x	x	x	13
		Total Species	2	2	3	3	3	2	2	1	2	3	46

Table 12. Introduced or cryptogenic species observed or collected at HCRI/NFWF islet sites.

Taxa 1	Family	*Scientific name*	Origin	Po'o Po'o	Pu'u Pehe	Hulu	Kaemi	Molokini	Mōkapu	Nāmoku	'Ōkala	Kāohikaipu	Kāpapa	Total
HYDROZOA	AGLAOPHENIIDAE	*Lytocarpia phyteuma*	Cryptogenic	x	x									2
	CAMPANULARIIDAE	*Campanularia sp.*	Cryptogenic		x									1
	EUDENDRIIDAE	*Eudendrium sp.*	Cryptogenic	x	x									2
	HALOPTERIDIDAE	*Antennella secundaria*	Cryptogenic								x			1
	PLUMULARIIDAE	*Plumularia strictocarpa*	Cryptogenic						x	x				2
	SERTULARIIDAE	*Sertularella diaphana*	Cryptogenic								x			1
		Sertularella tongensis	Cryptogenic							x				1
		Tridentata borneensis	Cryptogenic	x				x						2
		Tridentata humpferi	Cryptogenic		x									1
		Tridentata ligulata	Cryptogenic						x					1
	HALOCORDYLIDAE	*Pennaria disticha*	Introduced		x	x	x	x				x		5
ANTHOZOA	RHIZANGIIDAE	*Culicia rachelfizhardingeae*	Cryptogenic	x										1
	TELESTIDAE	*Carijoa aff. riisei*	Introduced	x	x		x	x	x	x	x			7
POLYCHAETA	CHAETOPTERIDAE	*?Chaetopterus sp.*	Cryptogenic	x	x		x					x		4
	SERPULIDAE	*Salmacina dysteri*	Introduced						x	x	x			3
GASTROPODA	HIPPONICIDAE	*Hipponix australis*	Cryptogenic	x	x							x		3
NUDIBRANCHIA	FACELINIDAE	*Caloria indica*	Cryptogenic									x		1
ECTOPROCTA	BUGULIDAE	*Bugula dentata*	Introduced	x							x			1
			Invertebrates	8	8	1	3	3	4	4	5	4	0	40
OSTEICHTHYES	POMACENTRIDAE	*Abudefduf vaigiensis*	Cryptogenic	x	x				x	x				4
	LUTJANIDAE	*Lutjanus fulvus*	Introduced	x				x		x		x		4
		Lutjanus kasmira	Introduced	x	x	x		x	x	x				6
	SERRANIDAE	*Cephalopholis argus*	Introduced							x	x	x	x	4
			Fish	3	2	1	0	2	2	4	1	2	1	18
			Total Species	11	10	2	3	5	6	8	6	6	1	58

Uncommon, Unique or Endangered Species or Habitats

No recognized threatened or endangered species were observed or collected on the either the NOAA or the HCRI surveys. For the HCRI surveys sixteen species, five algae, five invertebrates and six fishes (Table 13) were found that are relatively uncommon or worthy of comment. *Padina melemele*, (Figure 24a) found at Puʻu Pehe, Poʻo Poʻo and Hulu, is a distinctive and rare species of algae found in deep or shaded locations and is recognizable by the bright golden color of its non-calcified outer surface (Huisman et al 2007). Other uncommon algae were *Halimeda distorta*, (Figure 24b) found at Puʻu Pehe and Poʻo Poʻo and *Caulerpa elongate* (Figure 24c) at Puʻu Pehe and Molokini. *Sporochnus dotyi,* found on these surveys only at Nāmoku is very rare. *Dictyopteris australis* is relative common on Hawaiian reefs but is worth noting for its very high abundance on rocks and hard surfaces at the Kaemi site (Figure 24d), the only location where it was found on these surveys. Of these five algae species observed or collected on the HCRI surveys, only *Padina melemele* was found on the NOAA surveys, at the two Kaula Rock sites and at Niʻihau (Table 14).

Regarding uncommon or unique invertebrates for the HCRI surveys, *Solanderia secunda* is an relatively large hydroid that resembles small pink sea fans and occurred under ledges at Poʻo Poʻo and Kāohikaipu. *Myriopathes ulex* (Figure 24e) is one of Hawaiʻi's commercially valuable black corals, and small colonies were found at Poʻo Poʻo and ʻŌkala. *Rhizopsammia verrilli* (Figure 24f) is a rare azooxanthellate cup coral that grows in subdued light and occurred in caves at "Cathedrals" at Puʻu Pehe and at ʻŌkala. *Sinularia densa* (=*Sinularia abrubta*) (Figure 24g) is one of only two alcyonid soft corals that occur in Hawaiʻi, and although it is not rare, it is seldom found in the abundance that it showed at ʻŌkala , where it was the dominant benthic organism and had a percent cover averaging 36% on Transect 1. *Vittaticella uberrima* (=*Savignyella lofonti*) (Figure 24h) is an unusual and distinctive bryozoan that is relatively common at the Molokini outer rim site, bit seldom seen elsewhere, and it was observed at Mōkapu, off Kalaupapa NHP. For the NOAA surveys two species are of interest, the relatively rare gorgonian *Acabaria bicolor* and the Black Coral *Myriopathes* sp., both of which were found only at the Mōkapu, Molokaʻi site..

None of the fishes observed on the HCRI surveys are rare but some are considered worth noting (Ivor Williams, pers. comm.). *Monotaxis grandoculis* (*mu*), which occurred at Molokini, Nāmoku , and Kāohikaipu (Table 13) is the only lethrinid species found in Hawaii and is prized as a food fish. This species was also recorded at 15of the 20 NOAA surveys (Table 14). *Parupeneus cyclostomus* (*moano kea*) is one of the less common Hawaiian goatfishes and was sighted at six of the ten HCRI locations surveyed and 13 of the 20 NOAA sites. The bandit angelfish *Desmoholacanthus arcuatus* is usually seen at depths greater than 30 m (Randall 1998), but was seen at less than 25 m at Mōkapu and ʻŌkala off Kalaupapa NHP and 12 of the NOAA sites. The saddleback butterflyfish *Chaetodon ephippium* (*kikākapu*) is not common in Hawaiʻi and was found with a variety of other butterflyfishes at Kāohikaipu off east Oʻahu and at Kaula Rock and the southeast Lehua NOAA site The distinctive flame wrasse *Cirrhilabrus jordani* was seen only at Poʻo Poʻo, and the yellowstriped wrasse *Coris flavovittata* (*hilu*) only at Kāohikaipu. The latter species also occurred at the southeast Lehua, Lehua Crater, and Mokuʻaeʻae NOAA sites.

Table 13. Uncommon or notable species observed or collected at HCRI/NFWF islet sites.

			Lana‘i		Maui			Moloka‘i			O‘ahu	
Taxa 1	Family	*Scientific name*	Po‘o Po‘o	Pu‘u Pehe	Hulu	Kaemi	Molokini	Mōkapu	Nāmoku	‘Ōkala	Kāohikaipu	Kāpapa
PHAEOPHYTA	DICTYOTACEAE	*Padina melemele*	x	x	x							
		Dictyopteris australis				x						
	SPOROCHNACEAE	*Sporochnus dotyi*							x			
CHLOROPHYTA	HALIMEDACEAE	*Halimeda distorta*	x	x								
	CAULERPACEAE	*Caulerpa elongata*		x			x					
			2	3	1		1	0	1	0	0	0
HYDROZOA	SOLANDERIIDAE	*Solanderia secunda*	x								x	
ANTHOZOA	ANTIPATHIDAE	*Myriopathes ulex*	x							x		
	DENDROPHYLLIIDAE	*Rhizopsammia verrilli*		x						x		
	ALCYONIIDAE	*Sinularia densa*							x	x		x
ECTOPROCTA	VITTATICELLIDAE	*Vittaticella uberrima*					x	x				
		Total Invertebrates	2	1	0	0	1	1	1	3	1	1
OSTEICHTHYES	LETHRINIDAE	*Monotaxis grandoculis*					x		x		x	
	MULLIDAE	*Parupeneus cyclostomus*	x	x	x				x	x	x	
	POMACANTHIDAE	*Desmoholacanthus arcuatus*						x		x		
	CHAETODONTIDAE	*Chaetodon ephippium*									x	
	LABRIDAE	*Cirrhilabrus jordani*	x									
		Coris flavovittata									x	
		Total Fishes	2	1	1		1	1	2	2	4	0
		Total Species	6	5	2	1	3	2	4	5	5	1

Table 14. Uncommon or notable species observed or collected at NOAA islet sites.

Kaula Rock to Moloka‘i

		Kaula1	Kaula2	Ni‘ihau	SE Lehua	SE Lehua	Lehua Crater	Lehua Crater	West Lehua	West Lehua	Moku ‘Ae‘ae	Moku ‘Ae‘ae
Family	*Scientific name*	06	06	06	05	06	05	06	05	06	05	06
DICTYOTACEAE	*Padina melemele*	x	x	x								
LETHRINIDAE	*Monotaxis grandoculis*	X	X		X	X	X	X	X	X	X	X
MULLIDAE	*Parupeneus cyclostomus*	X	X	X	X	X	X	X	X	X	X	X
POMACANTHIDAE	*Desmoholacanthus arcuatus*	X	X		X	X	X	X	X	X		
CHAETODONTIDAE	*Chaetodon ephippium*		X		X							
LABRIDAE	*Coris flavovittata*				X		X				X	

Lāna‘i to Hawai‘i

		Po‘o Po‘o	Po‘o Po‘o	Mōkapu	Mokumanu	Moku Holua	West Kaemi	Papanui O Kāne	Halape (Keaoi)	Paokalani	
Family	*Scientific name*	05	06	06	06	05	06	06	05	06	Total
DICTYOTACEAE	*Padina melemele*	x			x			x			6
LETHRINIDAE	*Monotaxis grandoculis*	x			X		x	x	x		15
MULLIDAE	*Parupeneus cyclostomus*		x					x			13
POMACANTHIDAE	*Desmoholacanthus arcuatus*			X		x	x		x		12
CHAETODONTIDAE	*Chaetodon ephippium*										2
LABRIDAE	*Coris flavovittata*										3

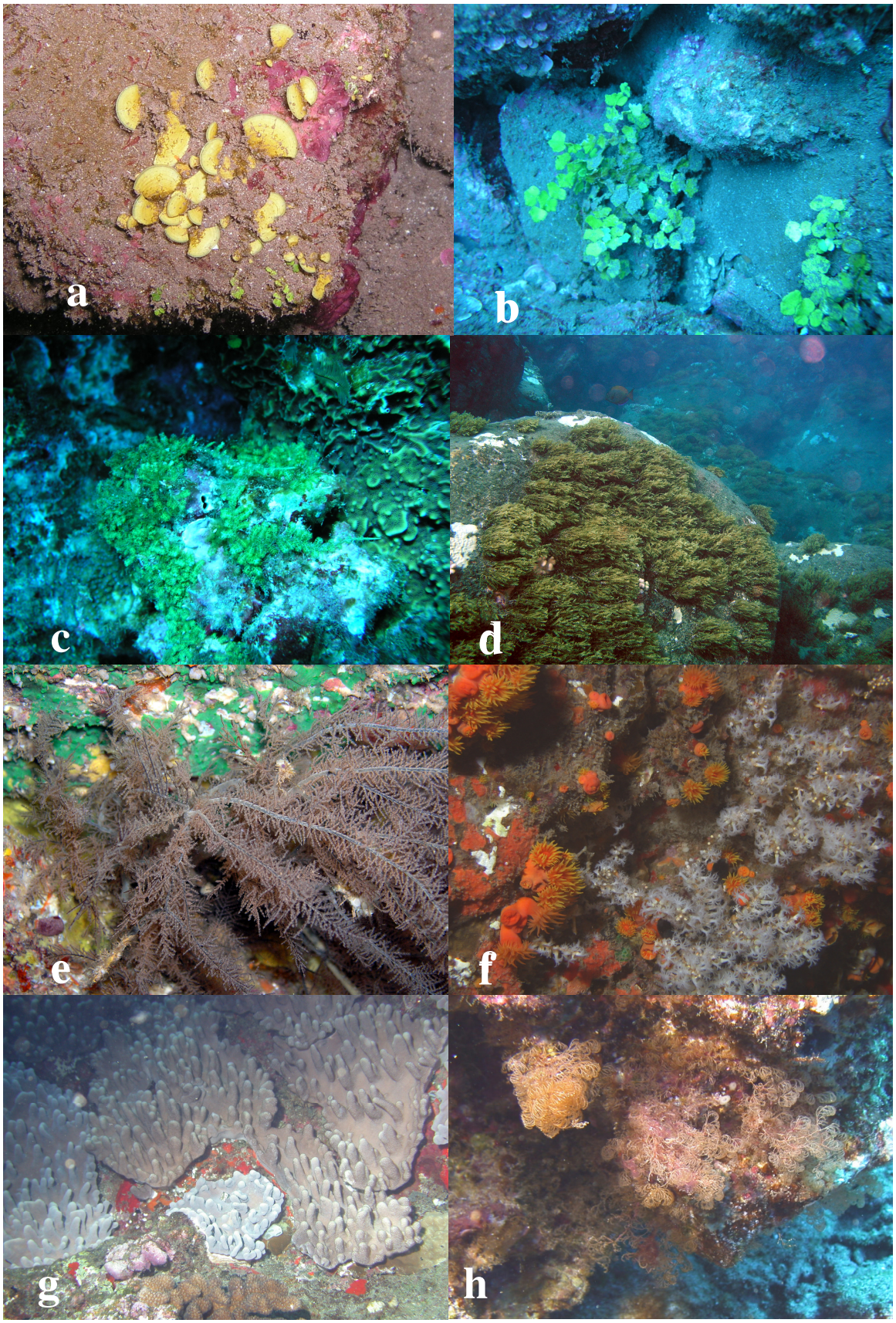

Figure 24. a: *Padina melemele*; b: *Halimeda distorta*; c: *Caulerpa elongata;* d: *Dictyopteris australis;* e: *Myriopathes ulex;* f: *Rhizopsammia verrilli* with *Carijoa riisei* (right*)*; g: *Sinularia densa*; h: *Vittaticella uberrima.*

IV. DISCUSSION

This report is the first to assemble the available information for marine reef biota that have been found in the vicinity of offshore islets throughout the main Hawaiian Islands and that can be used establish a baseline of environmental conditions for future evaluation and management of the resources of these remote areas. The information is drawn principally from two sources: 2005-2006 NOAA baseline surveys that conducted throughout the main Hawaiian Islands, and a 2007 study conducted by Bishop Museum for the Hawai'i Coral Reef Initiative and the National Fish and Wildlife Federation.

Since the purpose of this information is to provide replicable and reliable information that can used to do time series analysis for comparison with a set baseline, it is worthwhile to evaluate the quality and consistency of the methods used and the results obtained from these initial studies. Also, given that fieldwork conducted underwater is expensive and time consuming and usually requires highly trained researchers to conduct on-site surveys, an evaluation of the information gained in terms of the effort and resources required is in order.

The field methods used in the NOAA and the HCRI/NFWF studies were essentially the same for fish surveys. Both utilized random swims on which all observed species were recorded, and three 25-m belt transects on which larger fish were recorded on an initial swim along the transect and smaller fish on a return swim. Commonly called the CRED (Coral Reef Environmental Division) technique, this has become a standard for conducting fish surveys in Hawai'i, and all data were assembled and analyzed by Ivor Williams of the Hawai'i Department of Aquatic Resources. Not surprisingly, the results for fish species numbers and biomass estimates appear to be consistent between the NOAA and the HCRI/NFWF studies, despite the fact that the data were obtained by many different observers diving under a variety of field conditions.

By contrast, results for algae and invertebrate species numbers are quite inconsistent between the NOAA and the HCRI/NFWF surveys, and the quantitative results determined for algae and corals are not comparable because of different techniques used. Although the 10-31 algae taxa recorded per site at the 20 NOAA sites overlaps with 8-40 range for the 10 HCRI/NFWF sites, the overall 86 total algae recorded for the NOAA survey is nearly 40% less than the 138 total for the HCRI/NFWF studies. The differences were even greater for the invertebrates, where the NOAA surveys recorded 157 taxa compared to 294 for the HCRI/NFWF surveys, and numbers per site ranged 10-41 per NOAA site, compared with 41-68 per site for the HCRI/NFWF sites. This discrepancy is due primarily to having observations and collections for small invertebrates available for only nine of the 16 NOAA surveys where invertebrates were censused. Invertebrate reports for rest of the NOAA surveys were limited to field identifications along belt transects that recorded large, easily field-identified macro-organisms, mostly echinoderms. All ten HCRI/NFWF and nine of the NOAA surveys reported both on-site identifications from random swims throughout the sites and along transects and samples collected or retained from washing of residue from one small dead coral head per site later identified in the laboratory. The NOAA quantitative transects did record numbers of macroinvertebrates observed along transects, which the HCRI/NFWF study, recording only species presence, did not.

Different approaches were also taken in the studies for quantifying algae coverage. The NOAA surveys utilized two divers to photograph and make ranking estimates for each species that could be observed in quadrats along 12 m long transects. This data is difficult to summarize for a both a single transect and even more difficult to compare among transects or sites. As described, the method also requires the use of two trained algal experts in the field.

Both the NOAA and the HCRI/NFWF algal survey methods utilize photoquadrats, so both provide an image record of conditions at the time the survey that can be used for a variety of analyses and for future comparisons. Providing the surveys are done under at least moderately clear water conditions, the images obtained are sufficient to determine common algae species occurring in the quadrats. The HCRI/NFWF method requires only one diver who need not be an algae expert to obtain the images, which are later analyzed in the lab. This reduces the time constraint and number of field personnel required. The point intercept analysis of the images obtained can be done by one algae specialist for all quadrats and transects, providing greater consistency throughout a study. Expression of the point intercept results as percent cover by species and for total algae is a simple approach that provides a direct determination of means and variability that can be compared between locations and with time. Rankings of dominant species such in the NOAA method can still be done from the quadrat images, and it would be instructive to do both the NOAA and HCRI/NFWF analyses for a series of quadrats and compare the quality of data return per time required for the two approaches

The methods used for coral determinations in both the NOAA and the HCRI/NFWF surveys obtain data for determining size class distributions by species along belt transects. However the approaches differ greatly in the amount of time required to complete the measurements in the field and in the quality and replicability of the data obtained. The NOAA method requires a trained observer to make on-site judgements of approximate coral diameters using a measuring rod along the entire transect. No permanent record is obtained that can be checked or used as a reference, and the time required to complete a transect will obviously increase with the number of (usually small) corals that require measurement. The HCRI/NFWF method can be conducted in the field by a diver with no knowledge of reef coral species and the digital photo obtained provides a image of each coral colony in every quadrat that can be analyzed in the laboratory and stored for future reference. The technique for analysis by CPCe is easily learned and can be done by a novice after a short training. Moreover, the results obtained can be used to calculate total live and dead coral coverage and percent coverage by species. Coverage data are equally important as size class results and are not obtainable by the method used in the NOAA surveys.

Recognizing then that the NOAA and HCRI/NFWF results are not strictly comparable, any trends in species composition or abundances must be considered separately between the studies. For the NOAA surveys, the greatest number of algal species (31) occurred at the Lāna‘i Po‘o Po‘o site, followed by 30 species at Papa o Kāne near Maui (Table 4). Turf and crustose coralline algae ranked high for all of the sites surveyed.

For the HCRI/NFWF surveys the greatest number of algal taxa were at Kapapa and Hulu (40 species each) followed by Po‘o Po‘o and Kaemi (30 species each). As with the NOAA surveys results, by far the most abundant algal component at all sites was minute unidentified turf algae, which averaged 10% to 80% cover (Table 5, Figure 8) followed by crustose coralline algae, which averaged as high as 12 to 26% of the quadrat areas at five of the ten sites. Fleshy macroalgae was very low at all sites except Kaemi, where the average was 17.9% for the two transects. Most of the identifiable genera or species averaged less than 1% for the two transects at each site. The exceptions were *Dictyopteris australis,* which averaged 15.2% and was a dominant component of the benthos at Kaemi, *Dictyota* spp. that averaged 4.0% at Nāmoku and 3.0% at Kāohikaipu, and *Padina* spp. that averaged 1.6% at Kaemi.

The coral size distributions for the NOAA surveys shown in Figures 9-14 indicate healthy populations with good recruitment and survival into larger size classes at all sites except possibly for the Lehua caldera , which had only 157 colonies on the two transects and Ni‘ihau, which had only 173 colonies. The frequency histogram for Ni‘ihau has an unusual structure of fewer corals in the 10-20 range than in the 20-40 range, suggesting that the total numbers will decrease with time and senescence of the larger corals. The Lehua caldera had no corals larger than 20 cm diameter, suggesting that mortality is occurring at that site before full growth of corals is reached. The greatest numbers of colonies reported for the NOAA surveys was at Kaula Rock, where ca. 2400 of the total corals counted were in the 0-5 size class, suggesting that although recruitment at this site is very high, relatively few recruits survive into the larger size classes. The Kaua‘i transects are interesting in showing very contrasting size distributions between the 2005 survey, which is highly skewed to the left, and 2006, which is bell shaped with the most corals occurring in the 0.5-1.0 cm diameter range. Part of this variation may be due to observer inconsistency that cannot be verified because there is no permanent photo record, but it is more likely due to inconsistency in transect placement between 2005 and 2006. To help reduce this potential error, the beginning and end of each HCRI/NFWF coral transect was marked by surface buoys and coordinates recorded by GPS, and this information is provided in the HCRI/NFWF report (Coles et al. 2008).

The HCRI/NFWF coral analysis provides information for both size class distributions and percent coverage, which is useful in detecting differences among the HCRI/NFWF sites. Although all ten sites show a similar pattern of being highly skewed to the smaller size classes, contrasting patterns were found for coral cover, species compositions, and survival into the larger size classes, and often the contrasts were maximal for sites that were located near each other. For example, Pu‘u Pehe and Po‘o Po‘o, both in the lee of islets on the south shore of Lāna‘i, had very different coral coverages, composition and size distributions (Figure 17). Pu‘u Pehe was more typical of a thriving coral population, with nine hard and one soft coral species, total cover averaging 19-29% and diameters running up to 40 cm. Po‘o Po‘o, less than 5 km away and in a very similar physical environment in the lee of the islet, had a substratum largely covered by fine sediment, numerous sponges, only five species of coral with mean total cover of only 1.5-3.5%, and size class distributions largely in the 1-5 cm diameter range.

The Kaemi and Hulu sites (Figure 18) on North Maui both had low coral cover of 1-2% and 3-6% respectively with size class distributions concentrated in the 1-5 cm diameter range, but they contrasted somewhat in their coral species compositions, with only five hard and one soft coral occurring at Kaemi, compared to seven hard and one soft at Hulu. However, the principal contrast between benthic

organisms at the two sites was the 21-25% dominance of the substratum by macroalgae, mostly *Dictyopteris australis*, at Kaemi, compared to only 1-4% macroalgae cover at Hulu (Table 6). Again, these sites are in all respects similar in environmental characteristics and exposure to normally turbulent sea conditions. By contrast, the relatively sheltered conditions and high relief of the Molokini site on the southeast side of the crater rim supported the highest mean coral cover (31-34%) and mean colony densities (38-38 m^{-2}) of any site surveyed, with eight hard and one soft coral species and size distributions ranging up to the 40-80 cm diameter range.

The greatest consistency between the NOAA and the HCRI/NFWF surveys was for the fish species numbers and biomass estimates, and these data have been grouped together (Table 10, Figures 21-22) and compared with biomass means for total fish, primary and secondary consumers, apex predators and target species for the MHI provided by Ivor Williams. Two orders of magnitude or more differences in biomasses were found among sites for each category. For example, mean total biomass on the West Lehua-05 transects was nearly 15 times the mean value at the Moku ‘Ae’ae Islet-06 site, and primary consumers at the HCRI/NFWF Kapapa site was 550 times the mean at the same Moku ‘Ae’ae Islet-06 site. The high correlations of total fish biomass with primary consumers and target species biomass (Figure 23) throughout both studies, indicates similar relationship trends among the sites for the two lower trophic levels and for fishes subject to fishing pressure.

The mean values for each survey’s various fish biomass categories are compared in Table 10 and Figures 21-22 with mean values that have been determined by similar methods on NOAA/DAR surveys throughout the main Hawaiian Islands (MHI) (I Williams, pers. comm.). A substantial number exceeded MHI average biomass values in all categories. These included 15 estimates for total fish biomass, 12 for primary consumers, 17 for secondary consumers, 10 for apex predators and 19 for target species, the latter value perhaps indicating that most of the sites are remote from high commercial or sport fishing activity. The most outstanding site was the NOAA West Lehua site, which had the highest values for total biomass, secondary consumers and target species, and this site is one of the most remote surveyed. The second greatest biomass of primary consumers was found at the HCRI/NFWF Kaemi site off the north shore of Maui, and this area is also difficult to access most of the time because of high wind and waves that prevail in most seasons. The highest apex predator biomass was recorded at the HCRI/NFWF Namoku site on the north shore of Moloka‘i. Although relatively easy to access, this site may be protected by its proximity to the Kalaupapa Settlement and National Historic Park, which probably reduces the likelihood of fishing or spearing of large top level carnivore fishes. However, remoteness or inaccessibility is apparently not required prerequisites for high fish biomass. Surprisingly, the highest value for primary consumer biomass and second highest values for total fish and target species occurred at the site nearest a major population center, off Kāpapa Island, on a low relief reef subject to high wave turbulence just outside Kāne‘ohe Bay. This suggests that site characteristics of the reef environment can play a greater role in the size and abundance of fish populations than proximity to a potentially large fisher population. The Kāpapa site, lying outside of Kāne‘ohe Bay where northeast tradewinds result in turbulent wave conditions limiting boat operation, fishing and diving, may act to reduce fishing pressure and removal.

These results may be compared to biomass estimates obtained throughout the Hawaiian Islands (Williams et al. 2008) using the present transecting methods. Total fish biomass values for the MHI ranged 15.6-87.7 g/m^2 and were negatively correlated with local human population densities and shoreline accessibility for all but unfished species. For example, remote and inaccessible locations had 2.1-4.2 times the biomass of targeted fishes compared to accessible and populous areas, and total fish biomass at two remote locations was nearly three times that at the two most populous locations. By contrast there were no comparable differences between remote and accessible locations for lightly or negligibly targeted fishes. Similarly, stock assessments of fish populations in the MHI in comparisons with the relatively unfished NWHI suggest that that fishing rates in the MHI are nearly twice that which would support maximum sustainable yield (Friedlander et al. 2008). The relatively higher biomass values determined for the various groups for many offshore islets in the present study underscores their potential as refugia for maintaining fish populations in the MHI that should be protected. Interestingly, high biomass values were found for surveys throughout the MHI chain from Kaula Rock to Hawai‘i, with the exception of Lāna‘i, where none of the four surveys determined biomass values greater than MHI means, except apex predators for the NOAA Po‘o Po‘o 2005 survey.

Although three 25-m transects are probably insufficient to fully define fish composition and biomass for an area, the trends in mean biomass for these sites probably adequately represent the differences in the fish populations among the sites and indicate that substantial differences occurred. However, caution should be taken in considering that the values determined from this or any method represent absolute estimates of fish biomass. This is clearly indicated by the fact that the fish biomasses determined for the Molokai Mōkapu and Namoku sites for the National Park Service (NPS) in 2004 far exceeded the values determined by the HCRI/NFWF surveys of 2007, despite the fact that the HCRI/NFWF surveys found about three times the number of species at these sites than did the NPS surveys. For example, total biomass found at Ōkala by the 2004 NPS survey was 373 g/m^2, compared to 45 g/m^2 for the 2007 HCRI/NFWF survey. Recognizing that the surveys were done by different observers, this wide difference can mainly be explained by the fact that the two surveys were done with different methods. The method used for the NOAA and HCRI/NFWF surveys for the Table 10 comparisons makes two passes along 3-25 m transects, recording big fish on a fast outward swim, and small fish on a slow return swim. The NPS surveys were done by swimming slowly along a single 25m by 5m transect, taking 10-15 minutes to move down the line, which allows much more time for larger fish to pass over the transect belt and be included in the biomass estimates. Consequently although the total area surveyed per site for the NPS method was less than half of sites for the NOAA-HCRI/NFWF method, resulting in few species encountered, there was a greater likelihood of including schools of larger fish that resulted in higher biomass values (I. Williams, pers. comm.).

The above comparison emphasizes the fact that the methodology used for estimating fish population parameters, just as for algae, macroinvertebrates and corals, highly influences the results obtained. Comparisons between studies must therefore be made with caution and the methodology highly scrutinized for the bias that it may have imparted on the results.

V. MANAGEMENT CONSIDERATIONS

The results available for MHI offshore islets that have been surveyed indicate that many of these provide habitats and refuges that are in a relatively unexploited condition and may act as refuges that may maintain and replenish marine benthic and fish communities. A prime indicator of refuge potential is the biomass of fish communities (Table 10) where, of the 26 sites that were surveyed, 21 had biomass values that exceed MHI biomass means in at least one of the categories (i.e. total, primary consumers, secondary consumers apex predators or target species) and eight survey sites had values greater than means for all five categories. The characteristics of the islets considered most outstanding based on fish biomass and other parameters are listed in Table 15

Offshore islets and their surrounding waters are remote and therefore potentially less impacted than nearshore areas in the main Hawaiian Islands themselves. Marine and terrestrial species in offshore islets are often relatively diverse and abundant and their habitats are in more pristine condition. These factors make offshore islets prime candidates for conservation since it is easier to protect areas than to restore them after they are extensively damaged, especially when they are difficult for people to access.

Conservation strategies for marine areas adjacent to offshore islets should be considered in tandem with terrestrial conservation. One obvious reason is that most of Hawaii's offshore islets are already managed as State Seabird Sanctuaries, whose boundaries only extend down to the upper limit of the intertidal zone. Expanding the active management zone to include adjacent marine areas could be accomplished in many cases through coordinated actions by divisions of the Hawaii Department of Land and Natural Resources. Effective management also requires that terrestrial and adjacent marine areas be considered as interdependent ecosystems. Examples of the marine-terrestrial relationship include the fact that excessive soil erosion from degraded islets harms coral reefs, while at the same time terrestrial ecosystems depend on healthy seabird populations, which rely on abundant marine resources for food to provide essential nutrients for plant growth. Coordinated management of marine and terrestrial ecosystems is essential for the health of both.

Table 15 identifies ten offshore islets that should receive high management priority based on their marine resources and other significant factors. Three of these, in particular, stand out: Lehua, Molokini, and Kapapa. This report recommends that management agencies and adjacent communities consider strategies to conserve the outstanding resources around all ten islets. Given additional surveys and a better understanding of islet ecosystems, this list will surely expand in the future.

Identifying outstanding marine resources around offshore islets is relatively easy compared to devising practical and sustainable means of conservation. While specific conservation strategies are largely beyond the scope of this document, it should be noted that community-based rule-making and management, in concert with appropriate management agencies, can be a lasting and cost-effective strategy when local communities adjacent to the islets are relatively unified in purpose and feel a strong connection to the area. A key component for involving communities, and one which is often missing, is a good understanding by agencies of the human uses and cultural significance of the areas to local

Table 15. Summary of offshore islets with outstanding marine resources.

Islet	Fish biomass or diversity	Unique marine habitats or rare species	Expert opinion	Other significant factors
Lehua	Highest total biomass of total fish (2.4X MHI average), secondary consumers and target species for NOAA and HCRI/NFWF surveys Most (71-92) fish species	Caves, pinnacles Extensive *Sinularia densa* Grey reef and large shark species common Manta rays and cetaceans commonly seen in channel		State Seabird Sanctuary 3rd largest seabird colony in the MHI with 50,000 birds Humpback whale calving and feeding Hawaiian monk seal haul-out NOAA 2008 report cites lowest incidence of coral disease in MHI at Lehua, Niihau, and Kaula
(Oʻahu) *Kāpapa*	2nd highest biomass of total fish and target species Highest biomass of primary consumers (3.4X MHI average)	Most algae species (40) sighted for NOAA and HCRI/NFWF surveys Most coral species (10) 2nd highest density (17.6 colonies/m^2) Highest (31%) mean coral cover *Sinularia densa*		Under consideration for designation as State Seabird Sanctuary
(Oʻahu) *Kāohikaipu*	Biomass of total fish 1.3X MHI average	3rd highest coral density (12.7 colonies/m^2) *Solandaria secunda* *Monotaxis grandoculis* *Desmoholocanthus arcuatus*		State Seabird Sanctuary
(Molokaʻi) *Mōkapu*	2nd highest secondary consumer biomass (2.2X MHI average)	High cover of red *Clathria* sponge *Vittaticella uberrima* *Desmoholacanthus arcuatus*		State Seabird Sanctuary Just outside of Kalaupapa National Park

Table 15. (Cont.).

Islet	Fish biomass or diversity	Unique marine habitats or rare species	Expert opinion	Other significant factors
(Moloka'i) *'Ōkala*	Target species biomass 1.5X MHI average	Steep cliff with large cave with abundant *Rhizopsammia* High cover of *Sinularia densa* *Myriopathes ulex* *Rhizopsammia verrilli* *Parupeneus cyclostomus* *Desmoholacanthus arcuatus*		State Seabird Sanctuary Part of Kalaupapa National Park
(Moloka'i) *Namoku*	Highest total biomass of apex predators (7.7X MHI average) Greatest number of fish species (86) for NOAA & HCRI/NFWF surveys	*Sporochnus dotyi* *Sinularia densa* *Monotaxis grandoculis* *Parupeneus cyclostomus*		Part of Kalaupapa National Park Islet submerged at mid-low tide
(Maui) *Molokini*	3rd highest biomass of total fish (2.0X MHI average) 2nd highest biomass of apex predators (6.6X MHI average) 2nd highest number of fish species (83)	Wide variety of habitats from crater to outside rim Highest number of coral colonies/m^2 (41) Highest % coral cover (32.4) *Caulerpa elongate* *Vittaticella uberrima* *Monotaxis grandoculis* Abundant *Clathria* sponge		State Seabird Sanctuary Marine Life Conservation District no take zone within crater, but fishing permitted outside
(Maui) *Kaemi*	2nd highest biomass of primary consumers (2.0X MHI average)	Abundant *Dictyopteris australis*		State Seabird Sanctuary
(Maui) *Papanui O Kāne*	3rd highest biomass of apex predators (6.0X MHI average)	No information		State Seabird Sanctuary
(Hawai'i) *Keaoi*	All fish categories exceed MHI means 2nd highest number of fish species (79)	2nd highest number of coral colonies/m^2 (12.6) for NOAA sites		State Seabird Sanctuary Islet submerged at high tide

residents. Management agencies should make efforts to engage the communities and fill these data gaps prior to devising conservation strategies.

Several additional islets should be surveyed to provide a more complete picture of offshore islet marine resources. Islets of particular interest include those that are difficult to access and/or are within existing exclusion zones where fishing is limited. These areas potentially have more intact marine resources than islets where access is easy and unrestricted. High priority islets for standardized marine surveys include O‘ahu’s Mokumanu and Mokolea; Mokuho‘oniki and Kanahā off the east end of Moloka‘i; and Kaho‘olawe’s Ale‘ale and Pu‘ukoae. The islets east of Papanui O Kāne along Maui’s rugged northeast coast, Kapukaloa, Nanahoa, Kī‘ei, Moku naio and Kaneapua off west Lāna‘i and Moku puku and Pa'alaea off the north shore of the island of Hawai’i would also be worth surveying. Anecdotal evidence from many of these areas also indicates the presence of unusual species, unique marine habitats, and/or high fish biomass.

Additional marine surveys around Kaula are also warranted. Although the NOAA surveys at Kaula did not record exceptionally high fish biomass or many unusual species, these surveys were limited in duration and scope and a richer marine biota would be expected due to Kaula’s isolation, its surrounding military restriction zone, and the extensive shallow banks around the island. Additional features of Kaula that suggest a rich marine biota include one of the largest seabird colonies in the main Hawaiian Islands and the common occurrence of Hawaiian monk seals, humpback whales, and other marine mammals.

There is a compelling need for standardization of field and analysis techniques for surveys with goal of quantification. Fortunately this has been largely the case for fish surveys conducted by NOAA and DAR, and the results appear to be sufficiently consistent to make reliable MHI-wide comparisons. With the data that has accumulated to date, it would therefore seem practical to continue with this method as standard technique. However, a limitation of this report is its reliance on fish biomass data to identify outstanding marine areas due to the fact this was the only area where survey methodologies overlapped enough to draw robust conclusions. Future work should endeavor to standardize methods for surveying algae, corals, and other invertebrates and provide comparable data, collected at regular intervals, to allow assessment of all types of marine biodiversity and abundance and to detect trends over time. For corals and algae, we propose that the HCRI/NFWF methods be considered as potential standard field methodologies. The photographic techniques described, where conditions allow, are a means of rapidly acquiring data within the constraints of diving time limitations that provide a permanent visual record of benthic coverage at the time of the survey, and can be computer analyzed by someone easily trained in the use of CPCe software. The resulting data can include both size class and percent cover for corals and both relative abundance and percent cover for algae. When accompanied by sufficient on-site observation notes and voucher specimens, this approach enables a comprehensive summary of baseline conditions at the time of the survey.

For non-coral invertebrates, the question remains as to the level of effort to be directed toward obtaining a more comprehensive record of the species present at the site at the time of the survey. Where resources, time and expertise are available, it would ideal to conduct both thorough on-site observations and sampling of a substratum habitat for a more complete record of the invertebrates that may be present,

such as was done for the HCRI/NFWF surveys. However, this approach requires considerable more time in the laboratory sorting and identifying specimens and a level of taxonomic expertise for a variety of invertebrate groups that may exceed the resources of most surveys. On the other hand, the quantification of only a few large and readily recognizable species would seem to be of limited usefulness in clarifying baseline conditions or determining unusual or unique species or detecting introduced or potentially invasive species. The most feasible approach may be to direct more effort toward wide-area searches for special category invertebrates considered important, unique or introduced by field personnel trained in the recognition of such species.

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VII. REFERENCES

Carlton, J. E and L. G Eldredge. 2009. Marine Bioinvasions of Hawai'i: The Introduced and Cryptogenic Marine and Estuarine Animals and Plants of the Hawaiian Archipelago. Bishop Museum Bulletin xx. In press.

Coles, S.L., R.C DeFelice, and L.G Eldredge. 2002. Nonindigenous marine species introductions at Waikiki and Hawai'i Kai, O`ahu, Hawai'i. Bishop Museum Tech. Rep. 25: 1-245

Coles, S. L, L Giuseffi, and M. Hutchinson. 2008. Assessment of species composition, diversity and biomass in marine habitats and subhabitats around offshore islets in the Main Hawaiian Islands. Tech. Rep. No. 39, Bishop Museum, Honolulu.

Friedlander, A.M., and E. E. DeMartini. 2002. Contrasts in density, size, and biomass of reef fishes between the northwestern and the main Hawaiian islands: the effects of fishing down apex predators. Mar. Ecol. Progr. Ser. 230:253-264.

Friedlander A, G.S. Aeby, R. E. Brainard, E. Brown, A. Clark, S. Coles, E. E. DeMartini, S. Dollar, S. Godwin, C. Hunter, P. Jokiel, J. C. Kenyon, R. Kosaki, J. Maragos, P. S .Vroom, W. Walsh, I. Williams, and W. Wiltse. 2005. The state of coral reef ecosystems of the Main Hawaiian Islands. In: Waddel, J. E. (ed.). The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2005, p. 222-2691. NOAA Technical Memorandum NOS NCCOS 11. NOAA/NCCOS Center for Coastal Monitoring and Assessment's Biogeography Team. Silver Spring, MD

Friedlander A, G.S. Aeby, R. E. Brainard, E. Brown, K. Chaston, A. Clark, P. McGowan, T. Montgomery, W. Walsh, I. Williams, and W. Wiltse. 2008. The state of coral reef ecosystems of the Main Hawaiian Islands. In: Waddel, J. E. and A. M. Clarke (eds.). The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2005, p. 222-2691. NOAA Technical Memorandum NOS NCCOS 73. NOAA/NCCOS Center for Coastal Monitoring and Assessment's Biogeography Team. Silver Spring, MD

Kahng, S. E. 2006 Ecology and ecological impact of an alien octocoral, *Carijoa riisei*, in Hawai'i. Ph.D. thesis, University of Hawaii, Honolulu. 284 pp.

Kohler, K.E. and S.M. Gill, 2006. Coral Point Count with Excel extensions (CPCe): A Visual Basic program for the determination of coral and substrate coverage using random point count methodology. Computers and Geosciences 32: 1259-1269.

Williams, I. D, W. J. Walsh, R. E. Schoeder, A. M. Friedlandler, B. L. Williams and K. A. Stamoulis. 2008. Assessing the importance of fishing impacts on the Hawaiian coral reef fish assemblages along regional-scale human population gradients. Env. Cons. 1-12.

Appendix A

Algae Taxa Occurring on NOAA Transects

	KAL-1	KAL-2	NII-7	LEH-1	LEH-2	LEH-3	KAU-3	MOL-6	MOL-7	LAN-6	MAI-10	MAI-20	HAW-11	HAW-20
	2006	2006	2006	2006	2006	2006	2006	2006	2006	2005	2006	2006	2006	2006
A. t. falk										x				
Acanthophora pacifica								x		x		x		
Acetabularia sp.								x						
Actinotrichia fragilis			x									x		x
Amansia glomerata	x		x	x	x	x	x	x	x	x				
Amphiroa										x				
Asparagopsis taxiformis										x				
Blue-green	x	x	x	x	x	x	x	x	x	x				
Brown crusting				x										
Caulerpa nummalaria												x		
Caulerpa racemosa														
Caulerpa webbiana										x				
Caulerpa sp		x	x											x
CCA				x	x	x	x	x	x	x				
Chlorodesmis caespitosa						x						x		
Chondria									x	x				
Cladophora sp.										x				
Cladophoropsis sp.		x					x							
Codium arabicum														x
Codium edule						x						x		
Codium sp.	x													
Crustose coralline red algae											x	x	x	x
Cyanobacteria											x	x		
Dasya iridescens					x			x					x	
Dasya sp.							x			x	x			x
Dichotomaria marginata												x	x	x
Dictyopteris palagiogramma					x						x			x
Dictyosphaeria cavernosa										x				
Dictyosphaeria versluysii		x		x										
Dictyota ceylanica	x	x	x			x		x	x			x	x	
Dictyota friabilis	x	x	x	x	x	x		x	x			x	x	
Dictyota sp.				x	x	x	x	x	x	x	x	x		x
Galaxaura marginata										x				

	KAL-1	KAL-2	NII-7	LEH-1	LEH-2	LEH-3	KAU-3	MOL-6	MOL-7	LAN-6	MAI-10	MAI-20	HAW-11	HAW-20
	2006	2006	2006	2006	2006	2006	2006	2006	2006	2005	2006	2006	2006	2006
Galaxaura obtusata										x				
Galaxaura sp							x							
gelid		x	x	x	x	x	x	x	x	x		x		x
Gibsmithia hawaiiensis					x			x		x			x	
Griffithsia sp.	x													x
Halichrysis coalescens									x					
Halimeda discoidea							x					x		
Halimeda opuntia										x	x	x	x	x
Halimeda sp.							x							
Haloplegma duperreyi							x			x			x	x
Halymenia stipitata							x							
Heterosiphonia			x							x				
Hypnea valentiae														
Jania sp.	x	x		x	x	x	x	x	x	x	x	x	x	x
Laurencia parvipapillata										x				
Laurencia sp.		x					x						x	
Liagora sp.									x					
Lobophora varigata		x	x	x	x	x	x	x	x	x	x	x	x	x
Martensia flabelliformis							x						x	
Martensia sp.							x							
Melanamansia glomerata												x	x	x
Microdictyon setchellianum	x	x	x	x	x	x	x	x			x	x		
Microdictyon umbilicatum						x	x	x						
Neomartansia sp.								x						
Neomeris annulata	x		x	x	x		x			x	x	x	x	x
orange crusting											x			
Padina melemele	x	x	x						x	x		x		
Padina sp.			x	x		x	x		x		x	x		x
Peyssonnelia sp.											x			
Phyllodictyon sp.														x
Platoma ardreanum									x					
Portieria hornemannii										x		x		x
Predaea weldii			x										x	
Rhipidosiphon javensis		x			x	x		x	x	x				

	KAL-1	KAL-2	NII-7	LEH-1	LEH-2	LEH-3	KAU-3	MOL-6	MOL-7	LAN-6	MAI-10	MAI-20	HAW-11	HAW-20
	2006	2006	2006	2006	2006	2006	2006	2006	2006	2005	2006	2006	2006	2006
sand			x	x						x				
Sargassum sp.	x	x	x	x		x			x			x	x	
Siphonocladus tropicus													x	
Stypopodium flabelliforme		x	x		x							x		
Tolypiocladia glomerulata			x	x	x			x	x	x		x	x	
Trichogloea sp.												x		
Tricleocarpa fragilis												x		
Turbinaria ornata			x		x							x	x	
turf		x	x	x	x	x	x	x	x	x	x	x	x	x
Ulva sp.												x		
Ventricaria ventricosa			x		x					x				x
Total	11	16	21	17	19	17	22	19	19	31	14	30	20	21

Appendix B

Relative Abundances of Algae Taxa on NOAA Transects

	KAL-2					Photoquad							NII-7					Photoquad						
Algae	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Actinotrichia fragilis																			6					
Amansia glomerata															7					2			7	
Blue-green	4	5	5	6	5	5		6	3	6	3	4	7		3	2	2	4	3	3	8		3	2
CCA	5			7		7	7		7				10	6	2		8	4	2				8	10
Chlorodesmis caespitosa																								
Cladophoropsis			6																					
Codium edule																								
Dasya iridescens																								
Dictyopteris palagiogramma																								
Dictyosphaeria versluysii	6											7												
Dictyota ceylanica									4			8	4		5	3	6	3	5		7	4	6	6
Dictyota friabilis	3	6		4						5					4									
Dictyota sp.																								
gelid	2	3	4		4	2	5	4	2	3	2	3								5				
Gibsmithia hawaiiensis																								
Halimeda discoidea																								
Halymenia stipitata																								
Heterosiphonia																								4
Jania sp.						6	4	7				5												
Laurencia sp.							6																	
Lobophora varigata				3				8	6				3		6	6	5	5			5		5	3
Martensia flabelliformis																								
Microdictyon setchellianum		4	2	5	2	3	3	2		2	5	2					8		4					
Microdictyon umbilicatum																								
Neomeris annulata													8	4		8		8			6		8	
Padina melemele								5									7							99
Padina sp.													6			7					4	3		
Predaea weldii																								99
Rhipidosiphon javensis											6													
sand																					4			
Sargassum sp.		2	3	2	3	4	2	3		4	4		2	2		5	3	7		4	3	2		
Stypopodium flabelliforme			7	8	6				5			6					9							7
Tolypiocladia glomerulata																							2	
Turbinaria ornata																4		6						
turf	1	1	1	1	1	1	1	1	1	1	1	1	2	2	4	2	2	2	4	2	2	2	2	2
Ventricaria ventricosa																								99

	LEH-1													LEH-2											
Algae	1	2	3	4	5	6	7	8	9	10	11	12	random	1	2	3	4	5	6	7	8	9	10	11	12	random
Actinotrichia fragilis																										
Amansia glomerata	6		5				7				6						6		8	7	4	6		5		
Blue-green	8	7		4		8	5	7		6	2	2		2	2	4	3	3	3	3	2	5	3	4	4	
CCA	4	5	6	5	4	4	4	5	5	5	8	6		3	4	2	4	4	4		3				3	
Chlorodesmis caespitosa																										
Cladophoropsis																										
Codium edule																										
Dasya iridescens																										99
Dictyopteris palagiogramma																							6			
Dictyosphaeria versluysii													99													
Dictyota ceylanica																										
Dictyota friabilis	2	3		3	5	3	2	3			4	3		4	3	3	2	2	2	2	6	2	2	3	2	
Dictyota sp.	3	8		6		7			7	8	9			5		5		6	7	6	5					
gelid			4						4												9				8	
Gibsmithia hawaiiensis																										99
Halimeda discoidea																										
Halymenia stipitata																										
Heterosiphonia																										
Jania sp.	5	4				5	6	6			7			6	6	6	7		6	5	8	3	5	2	5	
Laurencia sp.																										
Lobophora varigata	10	6	7		2	6		8	2	7	10	5						5				7			6	
Martensia flabelliformis																										
Microdictyon setchellianum			8						6		5										7			6	9	
Microdictyon umbilicatum																										
Neomeris annulata					6									7		7	8	7				8	7		10	
Padina melemele																										
Padina sp.	9								8	9																
Predaea weldii																										
Rhipidosiphon javensis																										99
sand								2		2																
Sargassum sp.			3							4																
Stypopodium flabelliforme																								7		
Tolypiocladia glomerulata	7	2	2	2	3	1	3	4	3	3	3	4			5		5		5	4		4	4			
Turbinaria ornata																									7	
turf	1	1	1	1	1	2	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	

Ventricaria ventricosa														99																	
	LEH-3														KAU-3																
Algae	1	2	3	4	5	6	7	8	9	10	11	12	random		1	2	3	4	5	6	7	8	9	10	11	12	random				
Actinotrichia fragilis																															
Amansia glomerata	5	5	4	5	5																2	3		3							
Blue-green	2	3	2	2	2	3	3		2	2	2	4			2			3	3	5					2						
CCA	6	4		4	7	5		3	3			2				2	2	4							3						
Chlorodesmis caespitosa													99																		
Cladophoropsis																															
Codium edule													99																		
Dasya iridescens																															
Dictyopteris palagiogramma																															
Dictyosphaeria versluysii																															
Dictyota ceylanica		8							5	4	3	6																			
Dictyota friabilis												5																			
Dictyota sp.	4	2	3	3	6	6	4	4																							
gelid	7	9	5	7	4	7	5		6			7																			
Gibsmithia hawaiiensis																															
Halimeda discoidea															3						3	4									
Halymenia stipitata														99																	
Heterosiphonia																															
Jania sp.	8	6		8		4				3																					
Laurencia sp.																		2		4	4	2	2	4							
Lobophora varigata	3			6	3	2	2	2	4			3																			
Martensia flabelliformis																				2											
Microdictyon setchellianum											4								2	3				2							
Microdictyon umbilicatum													99																		
Neomeris annulata																								5							
Padina melemele																															
Padina sp.		7	6	9		8	6			5																					
Predaea weldii																															
Rhipidosiphon javensis													99																		
sand																															
Sargassum sp.													99																		
Stypopodium flabelliforme																															
Tolypiocladia glomerulata																															
Turbinaria ornata																															
turf	1	1	1	1	1	1	1	1	1	1	1	1			1	1	1	1		1	1	1	1	1	1	1					
Ventricaria ventricosa																															

	MOL-6												MOL-7											
Algae	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
A. t. falk																								
Acanthophora pacifica										4		6												
Acetabularia sp.										7														
Amansia glomerata		6		6									5		4	3	5				7			
Amphiroa																								
Asparagopsis taxiformis																								
Blue-green		8			6			5			5	7	4							4		6		7
CCA																								
Chondria																			4					
Dasya iridescens												99												
Dictyota ceylanica												9								3				
Dictyota friabilis		4	3	2	2	3	3	2	2	3	2	1								2	2	3	2	4
Dictyota sp.		5												3		6	6	3						
Galaxaura marginata																								
Galaxaura obtusata																								
gelid						6	5		8				7		5	7	3			5	6			6
Gibsmithia hawaiiensis												99												
Halichrysis coalescens																								99
Halimeda opuntia																								
Jania sp.		7		5	5	5	4	4	5		6	5	6	5	6		7	4	3	6	5	5	5	3
Liagora sp.																		5						
Lobophora varigata	5	3		4	4	2			4		3	4	3	2	3	2	4			7	4	4	3	5
Microdictyon setchellianum									7	6														
Microdictyon umbilicatum												99												
Neomartansia												99												
Neomeris annulata																								
Padina melemele															7									
Padina sp.																		6						8
Platoma ardreanum																								99
Portieria hornemannii																								
Rhipidosiphon javensis									9								8							
Sargassum sp.																5								
Tolypiocladia glomerulata									6	5		8		4										
turf																								

	LAN-6													MAI-2											
Algae	1	2	3	4	5	6	7	8	9	10	11	12	random		1	3	4	5	6	7	8	9	10	11	12	random
A. t. falk		3																								
Acanthophora pacifica													99										4			99
Amansia glomerata													99			3	2	1	1		1	1	2	4	3	
Amphiroa	3			4						4																
Asparagopsis taxiformis													99													
Blue-green																	3				3					
CCA					2	4		2	2	2	2	2				2	4	3	3			3	3	2	2	
Dasya iridescens																										
Dictyosphaeria cavernosa																										99
Dictyota friabilis																										
Dictyota sp.										5																
Galaxaura marginata													99													
Galaxaura obtusata																										
gelid													99			4					4					
Gibsmithia hawaiiensis													99													
Halimeda discoidea																										
Halimeda kanaloana															2											
Halimeda opuntia		4		2		3		3	3																	
Halymenia formosa																										
Hypnea valentiae																										
Jania sp.			2	3	3	2	3	4	4	3																
Laurencia parvipapillata																										
Laurencia sp.																										
Liagora sp.																										
Lobophora varigata								5																		
Martensia flabelliformis																										
Microdictyon setchellianum																										
Neomartansia																										
Neomeris annulata	4					5																				99
Padina melemele													99													
Padina sp.																										
Peyssonnelia sp.																								1	1	
Platoma ardreanum																										
Plocamium sandvicense																										99
Portieria hornemannii													99													
Rhipidosiphon javensis																										
Sargassum sp.								6																		
Spyridea filamentosa																										
Tolypiocladia glomerulata	2	2																								
Tricleocarpa fragilis																										
turf	1	1	1	1	1	1	1	1	1	1	1	1			1	1	1	2	2	1	2	2	1	3		

Species Name	MAI-10 1A1	1A2	1B1	1B2	1C1	1C2	2D1	2D2	2E1	2E2	2F1	2F2	Random
Acanthophora pacifica													
Actinotrichia fragilis													
Asparagopsis taxiformis													
Crustose coralline red algae		2	3	4	4	5	4		2	2	3	2	3
cyanobacteria				5		6							
Dasya iridescens													
Dasya sp				8									
Dichotomaria marginata													
Dictyopteris palagiogramma					6							5	
Dictyota sp		8		6		7		5		5	4		4
Halimeda discoidea													
Halimeda opuntia		5	4		5								
Haloplegma duperreyi													
Jania sp		7		7	2	8	6	4	4	4	5	4	
Laurencia sp													
Lobophora variegata		4	2	3		4	3		3	3	2	3	2
Martensia flabelliformis													
Melanamansia glomerata													
Microdictyon setchellianum													
Neomeris annulata		6							5				
orange crust						2		2					
Padina melemele													
Padina sp			5		7		5						
Peyssonnelia sp		3		2	3	3	2	3					
Phyllodictyon sp													
Portieria hornemannii													
Predaea weldii													
Tricleocarpa fragilis													
Turbinaria ornata													
turf algae		1	1	1	1	1	1	1	1	1	1	1	1
Ulva sp													
Ventricaria ventricosa													

Species Name	MAI-20 1A1	1A2	1B1	1B2	1C1	1C2	2D1	2D2	2E1	2E2	2F1	2F2	Random
Acanthophora pacifica						4							
Actinotrichia fragilis													
Asparagopsis taxiformis													
Caulerpa nummalaria													
Chlorodesmis caespitosa				12									
Codium arabicum													
Codium edule													
Crustose coralline red algae	2	4	2	3	1	1	1	1	2	2	2	3	
cyanobacteria			8		5	3			3		7	9	
Dichotomaria marginata													
Dictyopteris palagiogramma													
Dictyota ceylanica					3		3						
Dictyota friabilis	3		5		4	2		5	4	4	3	5	
Dictyota sp		5		9				6			6		
gelid				5									
Halimeda discoidea													
Halimeda opuntia													
Jania sp	5			4		5	4	4	6	5	4	6	
Laurencia sp													
Lobophora variegata	6	7	4				5	2		3		4	
Martensia flabelliformis													
Melanamansia glomerata								7					
Microdictyon setchellianum		3	7										
Neomeris annulata	8			11								8	
orange crust													
Padina melemele	7	8	6	6					8				
Padina sp				10			9		9				
Portieria hornemannii													
Sargassum sp	4	6	3	2	6		7	8	7			10	
Siphonocladus tropicus													
Stypopodium flabelliforme				7			8		5			7	
Tolypiocladia glomerulata							6	9		6	5	2	
Trichogloea sp		2											
Tricleocarpa fragilis		9		8									
Turbinaria ornata						6							
turf algae	1	1	1	1	2		2	3	1	1	1	1	

Species Name	HAW-11 1A 1	1A 2	1B 1	1B 2	1C 1	1C 2	2D 1	2D 2	2E 1	2E 2	2F 1	2F 2	Random	HAW-20 1A 1	1A 2	1B 1	1B 2	1C 1	1C 2	2D 1	2D 2	2E 1	2E 2	2F 1	2F 2	Random
Acanthophora pacifica																										
Actinotrichia fragilis														3							6					
Asparagopsis taxiformis																										
Caulerpa nummalaria																										
Caulerpa sp																								6		
Chlorodesmis caespitosa																										
Codium arabicum																										0
Codium edule																										
Crustose coralline red algae	2	2	2	2	2	2	2	2	2	2	2	2		1	2			3			2					
cyanobacteria																										
Dasya iridescens													0													
Dasya sp																					7					
Dichotomaria marginata													0										2			
Dictyopteris palagiogramma																7										
Dictyota ceylanica						3	3		3																	
Dictyota friabilis		3				4																				
Dictyota sp														6				7			3					
gelid															3	5	1	8	2	3		3				
Gibsmithia hawaiiensis													0													
Gracilaria sp																8										
Halimeda discoidea																										
Halimeda opuntia							4		5	4														5		
Haloplegma duperreyi													0					6	3		5	4				
Jania sp					4				4	5				4		4		5		4		6		4		
Laurencia sp													0													
Lobophora variegata					3									7		2		4			4	5		3		
Martensia flabelliformis								3																		
Melanamansia glomerata													0			6	2	2	4	2		2		2		
Microdictyon setchellianum																										
Neomeris annulata													0	8										7		
orange crust																										

Padina melemele																													
Padina sp														5									8		8	2			
Peyssonnelia sp																													
Phyllodictyon sp																									9				
Portieria hornemannii																3							7						
Predaea weldii										6																			
Sargassum sp			3	3																									
Siphonocladus tropicus													0																
Stypopodium flabelliforme																													
Tolypiocladia glomerulata				4					6	3																			
Trichogloea sp																													
Tricleocarpa fragilis																													
Turbinaria ornata													0																
turf algae	1	1	1	1	1	1	1	1	1	1	1	1		2	1	1		1	1	1	1	1	1	1	1				
Ulva sp																													
Ventricaria ventricosa																													0

Appendix C

Algae Taxa Present on HCRI/NFWF Surveys

		O‘ahu			Moloka‘i		Lanai		Maui		
Taxa	Scientific name	Kaohikaipu	Kapapa	Mōkapu	Namoku	‘Ōkala	Po’o Po’o	Pu’u Pehe	Hulu	Kaemi	Molokini
Chlorophyta	*Caulerpa elongata*							x			x
	Caulerpa nummularia			x							
	Caulerpa racemosa										x
	Caulerpa taxifolia								x		
	Chlorodesmis caespitosa									x	
	Cladophora sp.						x			x	
	Codium arabicum		x								
	Codium edule		x		x				x		
	Derbesia fastigiata									x	
	Dictyosphaeria cavernosa		x				x				
	Dictyosphaeria versluysii				x						
	Halimeda copiosa		x							x	x
	Halimeda discoidea		x					x			
	Halimeda distorta						x				
	Halimeda opuntia						x				
	Halimeda sp.				x				x		
	Microdictyon setchellianum				x				x	x	x
	Microdictyon umbilicatum			x				x	x		
	Neomeris annulata						x	x	x		
	Neomeris sp.										x
	Neomeris vanbosseae	x	x		x	x			x	x	
	Parvocaulis parvula			x			x			x	
	unknown #x64			x							
	unknown #x65			x							
	unknown #x86					x					
	unknown #x98				x						
	Ventricaria ventricosa						x				x
Cyanobacteria	*Hormothamnion enteromorphioides*	x						x			
	Lynbya cf. majuscula	x									
	Lyngbya confervoides						x				
	Lyngbya majuscula									x	
	Lyngbya sp.										x
	Microcystis sp.						x			x	x

		O‘ahu			Moloka‘i		Lanai		Maui		
Taxa	Scientific name	Kaohikaipu	Kapapa	Mōkapu	Namoku	‘Ōkala	Po’o Po’o	Pu’u Pehe	Hulu	Kaemi	Molokini
	Schizothrix calcicola	x								x	
	Schizothrix sp.	x									
	Unid. Cynaobacteria sp. x							x			
	Unid. Cynaobacteria sp. 2							x			
Cyanophyta	*Blennothrix cf. lyngbyacea*		x								
	Phormidium laysanense		x								
	Schizothrix calcicola							x			
	Spirocoleus sp.		x								
	Unid. Cyanophyta Sp. 62								x		
	unknown #x59			x							
	unknown #x60			x							
	unknown #x6x			x							
	unknown #x62			x							
	unknown #x83					x					
	unknown #x84					x					
	unknown #x9x				x						
	unknown #x92				x						
Phaeophyta	*Dictyopteris australis*									x	
	Dictyota bartayresiana		x					x	x		
	Dictyota ceylanica							x	x		
	Dictyota friabilis	x									x
	Dictyota sp.				x	x					
	Distromium flabellatum				x						
	Lobophora variegata	x		x	x						x
	Padina boryana		x						x	x	
	Padina melemele						x	x	x		
	Padina sp.									x	
	Padina spp.				x						
	Padina thivyae									x	
	Sargassum echinocarpum									x	
	Sargassum obtusifolium								x		
	Sargassum sp.				x						
	Sporochnus dotyi				x						
	Stypopodium flabelliforme	x							x	x	

		O‘ahu			Moloka‘i		Lanai		Maui		
Taxa	Scientific name	Kaohikaipu	Kapapa	Mōkapu	Namoku	‘Ōkala	Po’o Po’o	Pu’u Pehe	Hulu	Kaemi	Molokini
	Symploca hydnoides							x			
	Turbinaria ornata	x			x				x	x	
	Unid. Rhodophyta sp. 34						x				
Rhodophyta	*Acanthophora pacifica*	x	x	x	x		x		x		
	Actinotrichia fragilis		x				x		x		
	Akalaphycus setchelliae								x		
	Amansia glomerata	x	x	x	x		x				
	Asparagopsis taxiformis	x	x				x	x	x	x	x
	Botryocladiella skottsbergii				x						
	Ceramium borneense			x							
	Ceramium dumosertum		x		x				x		
	Ceramium fibriatum				x						
	Ceramium fimbriatum									x	
	Ceramium flaccidum		x						x		
	Ceramium sp.								x		
	Ceramium? Polysiphonia?		x								
	Chondrophycus parvipapillatus		x								
	Corallophila sp.						x				
	Crouania minutissima	x									
	Dasya iridescens			x			x				x
	Dichotomaria marginata						x		x		x
	Dichotomaria obtusata						x		x		
	Dotyella hawaiiensis								x	x	
	Dotyella sp.		x								
	Galaxaura obtusata		x						x	x	
	Galaxaura rugosa		x						x		
	Gelidium sp.		x								
	Gibsmithia hawaiiensis		x	x			x	x			x
	Griffithsia heteromorpha		x								
	Haloplegma duperreyi		x						x		
	Haloplegma duperryi				x		x				
	Halymenia stipitata		x	x							
	Herposiphonia parca								x		
	Herposiphonia secunda	x									

		O‘ahu			Moloka‘i		Lanai		Maui		
Taxa	Scientific name	Kaohikaipu	Kapapa	Mōkapu	Namoku	‘Ōkala	Po’o Po’o	Pu’u Pehe	Hulu	Kaemi	Molokini
	Herposiphonia sp.		x							x	
	Hypnea spinella	x									
	Hypoglossum barbatum				x				x		
	Hypoglossum sp.		x						x		
	Jania pumila						x		x		
	Jania sp.	x	x	x	x	x	x			x	x
	Laurencia sp.	x	x				x	x	x		
	Liagora sp. 46									x	
	Liagora sp. 47									x	
	Liagora sp. 48									x	
	Liagora sp.		x								
	Martensia flabelliformis			x							
	Martensia fragilis		x								
	Neosiphonia sp.				x						
	Neosiphonia sphaerocarpa		x								
	Peleophycus multiprocarpum		x								
	Phyllodictyon anastomosans		x								
	Polysiphonia flaccidissima		x								
	Polysiphonia sp.		x	x		x			x	x	
	Portieria hornemannii		x		x		x	x			
	Rhodymenia leptophylla								x		
	Scinaia furcata						x			x	
	Scinaia hormoides						x				
	Stenopeltis gracilis								x		
	Taenioma perpusillum				x						
	Tolypiocladia glomerulata	x	x	x	x	x			x	x	
	Tricleocarpa fragilis						x		x	x	
	Unid. Rhodophyta sp. 32						x				
	Unid. Rhodophyta sp. 33						x				
	Unid. Rhodophyta sp. #76								x		
	Unid. Rhodophyta sp. 68								x		
	unknown #x79			x							
	unknown #x80			x							
	unknown #x8x			x							

		O‘ahu			Moloka‘i		Lanai				
Taxa	Scientific name	Kaohikaipu	Kapapa	Mōkapu	Namoku	‘Ōkala	Po’o Po’o	Pu’u Pehe	Hulu	Kaemi	Molokini
	unknown #x82			x							
	unknown #2x5				x						
	unknown #2x6				x						
		18	40	24	29	8	30	16	40	30	15

Appendix D

Invertebrate Taxa Present on NOAA Surveys

Taxa without asterisks are from quantitative transect surveys; those with asterisks are from observations and collection data provided by L. Scott Godwin

	KAL-01	KAL-02	NII-07	LEH-01	LEH-02	LEH-03	KAU-03	MOL-06	MOL-07	LAN-06	MAI-02	MAI-20	MOK-1	MOK-2	MOK-3	HAW-11	HAW-20
Species	2006	2006	2006	2005	2005	2005	2006	2006	2006	2005	2005	2006	2005	2005	2005	2005	2006
PORIFERA																	
*Clathria sp.**	x	x		x		x							x				
*Stylinos sp.**	x			x	x	x		x					x				
*Spirastella vagabunda**								x									
*Dactylospongia sp.**																	
Leucetta sp. (white)								x									
Bubble Gum Sponge*								x									
Black Sponge 1*													x	x			
Black Sponge 2*															x		
Yellow Sponge*													x				
*Spongia oceania**															x		
*Dysidea herbacea**															x		
	2	1	0	2	1	2	0	4	0	0	0	0	4	1	3	0	0
HYDROZOA																	
*Gymangium hians**	x	x		x				x					x				
*Macrorhynchia philippina**													x				
*Dynamena sp.**													x				
	1	1	0	1	0	0	0	1	0	0	0	0	3	0	0	0	0
OCTOCORALLIA																	
Acabaria bicolor								x									
*Sarcothelia edmondsoni**		*x*			x			x				x					
*Carijoa riseii**								x				x					
	0	1	0	0	1	0	0	2	0	0	0	1	0	0	0	0	0
ACTINIARIA																	
Actiniaria unid. spp.								x	x								
	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
ZOANTHARIA																	
*Palythoa caesia**	x	x						x									
Palythoa sp.								x	x	x		x				x	
Protopalythoa sp.																x	
Zoanthidae unid. spp.			x		x		x										x
Zoanthus pacifica					x		x	x									
	1	1	1	0	2	0	2	3	1	1	0	1	0	0	0	2	1
SCLERACTINIA																	
Montipora capitata			x	x	x		x	x	x	x		x				x	x
Montipora flabellata												x				x	
Montipora patula			x	x	x		x	x	x	x		x				x	x

Species	KAL-01 2006	KAL-02 2006	NII-07 2006	LEH-01 2005	LEH-02 2005	LEH-03 2005	KAU-03 2006	MOL-06 2006	MOL-07 2006	LAN-06 2005	MAI-02 2005	MAI-20 2006	MOK-1 2005	MOK-2 2005	MOK-3 2005	HAW-11 2005	HAW-20 2006
SCLERACTINIA																	
Leptoseris incrustans				x	x					x							
Pavona duerdeni					x												x
Pavona maldivensis									x								
Pavona varians								x	x							x	x
Cyphastrea ocellina				x	x							x				x	
Leptastrea purpurea									x								x
Fungia scutaria																	
Pocillopora damicornis																x	
Pocillopora eydouxi			x					x	x	x						x	x
Pocillopora ligulata								x	x								
Pocillopora meandrina			x	x	x		x	x	x	x						x	x
Pocillopora molokensis								x	x								
Porites brighami				x	x			x	x	x		x				x	
Porites compressa							x			x						x	x
Porites evermanni										x						x	x
Porites lobata			x	x	x		x	x	x	x		x				x	x
Psammacora nierstraszi										x							
Psammacora stellata					x					x							
	0	0	5	7	9	0	5	9	11	11	0	6	0	0	0	12	10
ANTIPATHARIA																	
*Myriopathes sp.**								x					x				
*Cirrhipathes anguina**								x					x				
	0	0	0	0	0	0	0	2	0	0	0	0	2	0	0	0	0
POLYCHAETA																	
*Spirobranchus giganteus**	x	x		x	x	x		x					x				
*Loimia medusa**				x		x			x								
	1	1	0	2	1	2	0	1	1	0	0	0	1	0	0	0	0
GASTROPODA																	
*Drupa ricina**				x													
*Latirus nodatus**		*x*			x	x		x									
*Conus flavidus**				x	x	x											
*Conus lividus**				x	x	x											
*Conus abbreviatus**	x			x													
*Cerithium mutatum**				x	x												
*Cypraea tigris**				x	x									x			
*Quoyula madreporarum**								x									
*Pteraeolida ianthina**	x	x		x	x			x					x	x			

Species	KAL-01 2006	KAL-02 2006	NII-07 2006	LEH-01 2005	LEH-02 2005	LEH-03 2005	KAU-03 2006	MOL-06 2006	MOL-07 2006	LAN-06 2005	MAI-02 2005	MAI-20 2006	MOK-1 2005	MOK-2 2005	MOK-3 2005	HAW-11 2005	HAW-20 2006
GASTROPODA																	
*Halgerda terramtuentis**								x					x				
*Chromodoris vibrata**								x									
*Hexabranchus sanguineus**								x									
*Glossodoris rufomarginata**								x									
*Phyllidiella pustulosa**				x													
Unk Aeolidae*				x													
Unk Chromodorid*						x											
*Thorunna daniellae**				x													
*Chromodoris albopustulosa**				x													
*Phyllidia varicosa**				x													
*Hexabranchus sanguineus**																	
	2	2	0	12	6	4	0	7	0	0	0	0	2	2	0	0	0
BIVALVIA																	
Arcidae unident. sp.																	
*Arca ventricosa**					x												
Pinctada sp.																	
*Pinctada margaritifera**			x	x				x								x	
*Streptopinna saccata**								x									
Spondylus sp.			x	x	x		x	x	x							x	
Bivalvia unid. spp.			x														
	0	0	3	2	2	0	1	3	1	0	0	0	0	0	0	2	0
CEPHALOPODA																	
Octopus cyanea	x																
Octopus sp								x									
	x	0	0	0	0	0	0	x	0	0	0	0	0	0	0	0	0
CIRRIPEDIA																	
*Euraphia hembeli**								x					x				
	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0
DECAPODA																	
*Trapezia flavopunctata**	x			x	x	x		x					x				
*Trapezia bidentata**		x				x		x									
*Trapezia tigrina**				x													
Trapezia sp.			x	x			x	x	x		x	x				x	
*Calcinus elegans**	x	x			x	x		x									
*Calcinus hazletti**								x									
*Calcinus laurentae**				x	x	x											
Calcinus sp.								x	x								

Species	KAL-01 2006	KAL-02 2006	NII-07 2006	LEH-01 2005	LEH-02 2005	LEH-03 2005	KAU-03 2006	MOL-06 2006	MOL-07 2006	LAN-06 2005	MAI-02 2005	MAI-20 2006	MOK-1 2005	MOK-2 2005	MOK-3 2005	HAW-11 2005	HAW-20 2006
DECAPODA																	
*Ciliopagurus strigatus**		x															
Ciliopagurus strigatus																x	
Dardanus sp.																	
Diogenidae unid. spp.																	x
Paguridea unid. spp.			x	x	x		x									x	
*Stenopus hispidus**	x	x		x	x	x		x									
*Lysmata amboinensis**								x									
*Stegopontonia commensalis**															x		
	3	4	2	6	5	5	2	8	2	0	1	1	1	0	1	3	1
ECTOPROCTA																	
*Reteporellina denticulata**		x						x						x			
*Disporella violacea**								x									
	0	1	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0
ASTEROIDEA																	
Acanthaster planci	x	x										x					
Mithrodia fisheri		x		x				x									
Culcita novaeguineae	x		x					x									
Linckia multifora	x	x			x			x								x	
*Linckia guildingi**				x													
*Thromidia catalai**						x											
	2	1	1	1	1	1	0	2	0	0	0	0	0	0	0	1	0
OPHIUROIDEA																	
*Ophiocoma pica**	x	x		x	x	x							x	x			
*Ophiocoma erinaceus**														x	x		
*Ophiocoma dentata**	x			x													
Ophiocoma sp.																	
	2	1	0	2	1	1	0	0	0	0	0	0	1	2	1	0	0
ECHINOIDEA																	
Chondrocidaris gigantea																	
*Brissus latecarnatus**						x											
Eucidaris metularia	x		x	x	x								x	x		x	
Diadema paucispinum								x	x	x				x			
Diadema sp.											x	x					
Echinothrix calamaris	x	x		x	x	x				x				x	x		
*Echinothrix diadema**								x						x	x		
Echinothrix sp.			x	x			x				x	x				x	x

Species	KAL-01 2006	KAL-02 2006	NII-07 2006	LEH-01 2005	LEH-02 2005	LEH-03 2005	KAU-03 2006	MOL-06 2006	MOL-07 2006	LAN-06 2005	MAI-02 2005	MAI-20 2006	MOK-1 2005	MOK-2 2005	MOK-3 2005	HAW-11 2005	HAW-20 2006
ECHINOIDEA																	
?Pseudoboletia sp.																	
Pseudoboletia indiana																	
Toxopneustes sp.											x						
Tripneustes gratilla	x	x	x		x				x	x				x	x	x	
Tripneustes sp.											x						x
Echinometra mathaei	x	x	x	x	x		x			x				x	x	x	
*Echinometra oblonga**	x																
Echinometra sp.												x					
Echinostrephus aciculatus								x						x	x		
Echinostrephus sp.	x	x	x	x	x		x		x		x	x				x	x
Heterocentrotus mammilatus	x	x	x			x				x				x	x		
Heterocentrotus sp.																	
	7	5	6	5	5	3	3	3	3	5	5	4	1	8	6	5	3
HOLOTHUROIDEA																	
Actinopyga mauritiana	x											x					
Actinopyga obesa		x		x								x					
Holothuria atra	x			x				x	x					x	x		
Holothuria hilla															x		
Holothuria pervicax														2			
Holothuria sp.			x														
*Holothuria whitmaei**	x	x	x	x	x									x	x		
	3	2	2	3	1	0	0	1	1	0	0	2	0	4	3	0	0
Total Taxa	23	21	19	41	33	16	13	49	21	17	6	17	12	16	10	25	15

Appendix E

Numbers of Non-coral Invertebrate Taxa Present on NOAA Transects

	NII-07	LEH-01	LEH-02	KAU-03	MOL-06	MOL-07	LAN-06	MAI-02	MAI-10	MAI-20	HAW-11	HAW-20	Total
Species	2006	2005	2005	2006	2006	2006	2005	2005	2006	2006	2005	2006	
ACTINIARIA													
Actiniaria sp.					2	1							3
ZOANTHARIA													
Protopalythoa sp.											1		1
Zoanthidae	1		2	3								10	16
POLYCHAETA													
Loimia medusa					1	2							3
BIVALVIA													
Bivalvia unid. spp	1												1
Pinctada margaritifera	1	2									1		4
Spondylus sp.	7	6	1	4	1	1			2		1		23
CEPHALOPODA													
Octopoda sp.					1								1
DECAPODA													
Calcinus sp.					1	1			4				5
Ciliopagurus strigatus											1		1
Dardanus sp.									1				1
Diogenidae												1	1
Paguroidea	6	7	5	2							2		22
Trapezia sp.	6	8		4	4	6		4	6	9	10		57
ASTEROIDEA													
Acanthaster planci										1			1
Culcita novaeguineae	1				2								3
Linckia multifora			1		1						9		11
Mithrodia fisheri		1											1
ECHINOIDEA													
Diadema paucispinum					1	2	2						5
Diadema sp.								2		2			4
Echinometra mathaei	10	10	10	6			3		1		10		50
Echinometra sp.										3			3
Echinostrephus aciculatus					4				5				9
Echinostrephus sp.	9	10	10	5		1		3	2	2	3	2	47
Echinothrix calamaris							1		1				2
Echinothrix sp.	3	3		1				1		1	4	3	16
Eucidaris metularia	2		5								1		8
Heterocentrotus mammilatus	2						1						3
	NII-07	LEH-01	LEH-02	KAU-03	MOL-06	MOL-07	LAN-06	MAI-02	MAI-10	MAI-20	HAW-11	HAW-20	Total

Species	2006	2005	2005	2006	2006	2006	2005	2005	2006	2006	2005	2006	
ECHINOIDEA													
Toxopneustes sp.								1					1
Tripneustes gratilla	9		1			1	4				2		17
Tripneustes sp.								2				2	4
HOLOTHUROIDEA													
Actinopyga mauritiana										1			1
Actinopyga obesa		1								1			2
Holothuria atra		1			1	1							3
Holothuria sp.	1												1
Total Count	59	49	35	25	19	16	11	13	22	20	45	18	

Appendix F

Invertebrate Taxa Present on HCRI/NFWF Surveys

		O‘ahu		Moloka‘i			Lanai		Maui		Molokini
Taxa	Species	Kaohikaipu	Kapapa	Mōkapu	Namoku	‘Ōkala	Po’o Po’o	Pu’u Pehe	Hulu	Kaemi	
PORIFERA	*?Dactylospongia* sp.						x	x			
	Batzella sp.						x	x			
	cf. Axinyssa aculeata									x	
	Clathria sp.	x		x	x	x		x	x	x	x
	Hyrtios sp.						x				x
	Leucetta solida			x						x	
	Leucetta sp.							x			
	Mycale sp.						x				
	Spheciospongia vagabunda						x	x			
	Spongia oceania	x		x							
	Stylinos sp.						x				
	Timea sp.				x			x		x	
CALCAREA	*Leucetta solida*								x		
HYDROZOA	*Aglaephenia* sp.				x	x		x	x		
	Antennella secundaria					x					
	Campanularia sp.							x			
	Dynamena moluccana										x
	Dynamena sp.			x							
	Eudendrium sp.						x	x	x		
	Gymnangium hians	x		x				x		x	x
	Halecium sp.						x				
	Lytocarpia niger	x		x		x	x				x
	Lytocarpia phyteuma						x	x			
	Macrorhynchia philippina	x		x		x					x
	Pennaria disticha	x			x			x	x	x	x
	Plumularia strictocarpa			x	x						
	Sertularella diaphana					x	x	x			
	Sertularella tongensis				x						
	Solanderia secunda	x					x				
	Tridentata borneensis						x				x
	Tridentata humpferi							x			
	Tridentata ligulata			x							

		O‘ahu		Moloka‘i			Lanai		Maui		Molokini
Taxa	Species	Kaohikaipu	Kapapa	Mōkapu	Namoku	‘Ōkala	Po’o Po’o	Pu’u Pehe	Hulu	Kaemi	
OCTOCORALLIA	*Anthelia edmondsoni*	x	x	x			x	x	x		x
	Carijoa aff. *riisei*			x	x	x	x	x		x	x
	Sinularia densa				x	x					
	Sinularia sp.	x	x						x	x	
ACTINIARIA	*Aiptasia pulchella*						x				
ZOANTHARIA	*Palythoa caesia*	x	x	x		x	x	x	x	x	x
	Protopalythoa sp.						x				
	Protopalythoa spp.			x							
	Parazoanthus sp.								x	x	
	Zoanthus sp.	x	x	x							
	Zoanthus sp. B		x	x						x	
SCLERACTINIA	*Culicia rachelfizhardingeae*						x				
	Cyphastrea agassizi			x							
	Cyphastrea ocellina									x	
	Fungia scutaria		x				x				
	Leptastrea bewickensis				x		x	x			x
	Leptastrea purpurea			x							
	Leptastrea transversa	x									x
	Leptoseris incrustans	x						x			x
	Leptoseris sp.								x	x	
	Leptoseris tubulifera	x									x
	Montipora capitata	x	x		x	x	x	x	x	x	x
	Montipora flabellata	x	x					x	x	x	
	Montipora patula	x	x		x		x	x	x	x	x
	Pavona duerdeni	x	x					x	x		
	Pavona varians	x	x	x	x	x		x	x	x	x
	Pocillopora eydouxi		x		x	x	x		x	x	x
	Pocillopora meandrina	x	x	x	x	x	x	x	x	x	x
	Pocillopora molokensis			x	x	x					
	Porites compressa		x			x	x	x			
	Porites evermanni		x	x		x					
	Porites lobata	x	x	x	x	x	x	x	x	x	x

		O‘ahu		Moloka‘i			Lanai		Maui		Molokini
Taxa	Species	Kaohikaipu	Kapapa	Mōkapu	Namoku	‘Ōkala	Po’o Po’o	Pu’u Pehe	Hulu	Kaemi	
SCLERACTINIA	*Porites lutea*								x	x	
	Psammocora sp.								x		
	Psammocora stellata		x								
	Rhizopsammia verrilli					x		x			
	Tubastraea coccinea	x		x		x	x	x			
ANTIPATHARIA	*Antipathes* sp.										x
	Cirrhipathes anguina			x		x	x	x			x
	Myriopathes ulex					x	x				
NEMERTEA	*Baseodiscus cingulatus*			x							
PLATYHELMINTHES	*Pseudoceros ferrugineus*	x		x		x		x			
POLYCHAETA	*Chaetopterus* sp.	x								x	
	Glycera tesselata									x	x
	Loimia medusa			x		x		x			x
	Notopygos albiseta										x
	Opisthosyllis brunnea?									x	
	Pherecardia striata						x	x	x	x	x
	Phyllochaetopterus socialis			x							x
	Phyllodoce (Anaitides) madeirensis?									x	
	Phyllodoce (Phyllodoce) hiatti?									x	
	Polyophthalmus pictus				x						x
	Pseudovermilia occidentalis			x	x	x					x
	Salmacina dysteri			x	x	x					
	Spirobranchus giganteus						x	x		x	x
	Spirobranchus giganteus corniculatus	x	x	x	x	x			x		
	Trypanosyllis zebra										x
	Unid. Amphinomidae							x			
	Unid. Aphroditidae						x				x
	Unid. Chaetopteridae						x				
	Unid. Dorvilleidae						x				
	Unid. Glyceridae						x	x			
	Unid. Nereidae						x	x			
	Unid. Phyllodocidae						x	x			
	Unid. Polynoidae						x	x			

		O‘ahu		Moloka‘i			Lanai		Maui		Molokini
Taxa	Species	Kaohikaipu	Kapapa	Mōkapu	Namoku	‘Ōkala	Po’o Po’o	Pu’u Pehe	Hulu	Kaemi	
POLYCHAETA	Unid. Sigalionidae						x				
	Unid. Spintheridae						x	x			
	Unid. Spionidae						x				
	Unid. Syllidae						x	x			
SIPUNCULA	*Aspidosiphon* sp.						x				
GASTROPODA	*Cellana exarata*			x							
	Conus abbreviatus		x								
	Conus circumactus?				x						
	Conus flavidus				x				x	x	
	Conus imperialis?				x						
	Conus lividus?				x						
	Conus miles	x					x				
	Conus rattus						x				
	Conus sp.	x									
	Cypraea sp.						x				
	Cypraea isabella						x				
	Cypraea leviathan			x							
	Cypraea maculifera				x	x		x			
	Cypraea mauritiana		x								
	Cypraea tigris							x		x	x
	Drupa (Drupa) ricina		x								
	Drupa (Ricinella) rubusidaeus									x	x
	Drupa ricina							x		x	
	Drupa rubusidaeus	x	x	x		x					
	Drupa rupusidaeus							x			
	Engina sp?										x
	Hipponix australis	x					x	x			
	Latirus nodatus				x	x			x	x	
	Morula uva	x			x					x	
	Serpulorbis variabilis		x	x	x			x	x	x	
	Synaptocochlea concinna	x									
	Terebra guttata						x				
	Thais armigera	x									

		O‘ahu		Moloka‘i			Lanai		Maui		Molokini
Taxa	Species	Kaohikaipu	Kapapa	Mōkapu	Namoku	‘Ōkala	Po’o Po’o	Pu’u Pehe	Hulu	Kaemi	
GASTROPODA	*Tricolia variabilis*	x							x	x	x
	Unid. Bullidae						x				
	Unid. Columbellidae						x				
	Unid. Costellariidae						x				
	Unid. Hipponicidae										x
	Vexillum (Pusia) piceum										x
BIVALVIA	*Arca* sp.							x			
	Arca ventricosa			x			x				
	Barbatia divaricata						x				
	Isognomon perna?									x	
	Kellia rosea						x				
	Periglypta reticulata?						x				
	Pinctada margaritifera			x		x					x
	Spondylus violacescens	x				x		x			x
	Streptopinna saccata	x									
NUDIBRANCHIA	*Caloria indica*	x									
	Chromodoris vibrata			x							
	Dendrodoris ?nigra							x			
	Glossodoris rufomarginata			x		x			x	x	
	Halgerda terramtuentis						x	x			
	Hexabranchus sanguineus						x				
	Peltodoris fellowsi					x					
	Phyllidia pustulosa					x	x				
	Phyllidia varicosa					x	x		x		
	Pteraeolidia ianthina	x									x
	Tambja morosa							x			
	Unid. Phyllidiidae	x									
OPISTHOBRANCHIA	*Unid. ophiuroid*					x		x			
	Stylocheilus striatus										x
	Unid. Aplysiidae						x				
CEPHALOPODA	*Octopus cyanea*	x	x							x	
AMPHIPODA	Unid. amphilocid amphipod							x			
	Unid. caprellid amphipod							x			

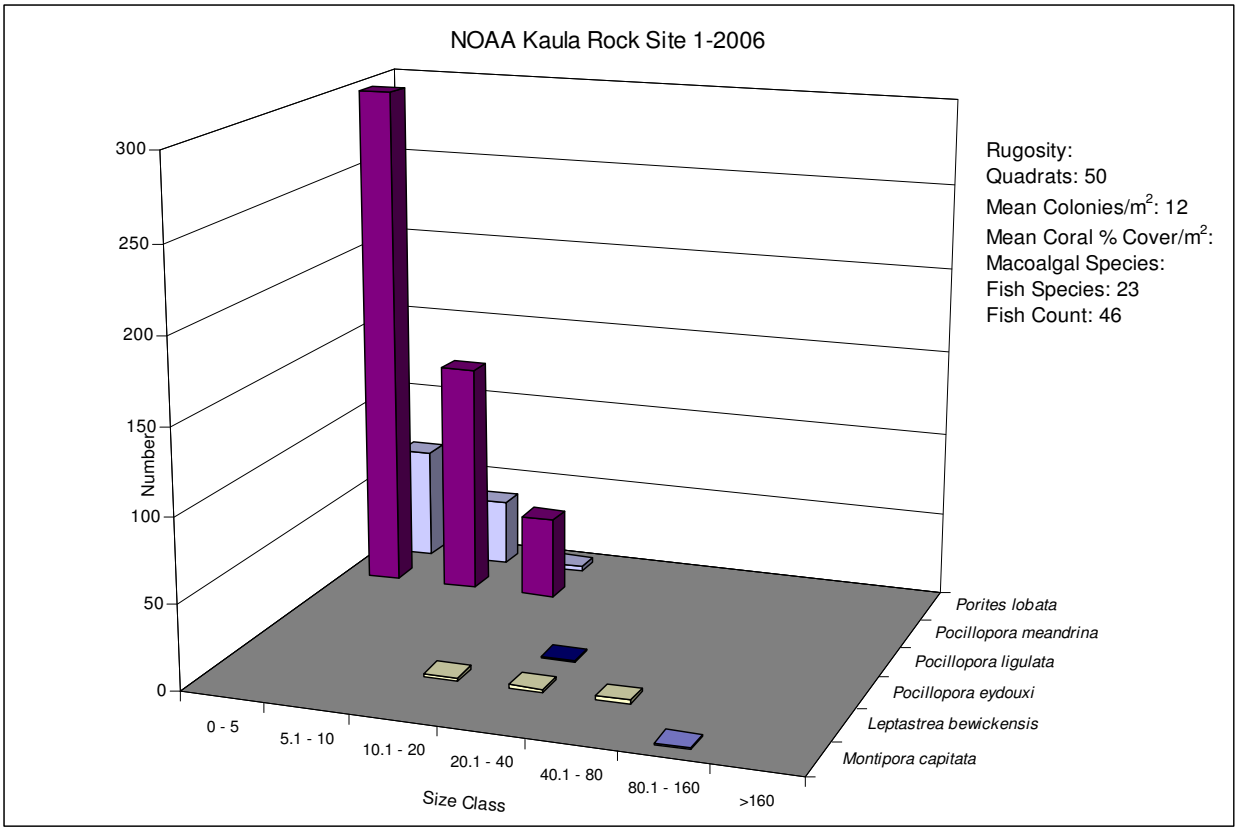
		O‘ahu		Moloka‘i		Lanai			Maui		Molokini
Taxa	Species	Kaohikaipu	Kapapa	Mōkapu	Namoku	‘Ōkala	Po’o Po’o	Pu’u Pehe	Hulu	Kaemi	
AMPHIPODA	Unid. Caprellidae	x									
	Unid. gamarid amphipod							x			
ISOPODA	*Colidotea edmondsoni*							x			
	Munna acarina?							x			
	Unid. janirid isopod							x			
	Unid. Joeropsid isopod							x			
TANAIDACEA	*Unid. munnid iopod*							x			
	Anatanais insularis?							x			
	Unid. tanaid							x			
DECAPODA	*Alpheus brevipes*		x		x					x	
	Alpheus clypeatus				x	x					
	Alpheus spp.								x	x	x
	Caecopilumnus crassipes				x						
	Calcinus argus?						x				
	Calcinus elegans		x							x	
	Calcinus guamensis	x		x	x						
	Calcinus haigae		x								
	Calcinus laurentae						x				
	Calcinus sp.							x			
	Chlorodiella laevissima	x			x						
	Chlorodiella cytherea	x		x							
	Ciliopagurus strigatus					x					
	Ciliopagurus strigatus?									x	
	Dardanus sanguinocarpus				x	x		x		x	
	Domecia hispida				x						
	Panulirus penicillatus					x		x			
	Percnon abbreviatum	x									
	Percnon planissimum								x	x	
	Perinea tumida	x	x	x	x	x			x	x	x
	Pilodius areolatus				x						
	Pilodius flavus	x				x					
	Platypodia semigranosa	x		x							
	Pseudolimera variolosa					x					

		O‘ahu		Moloka‘i			Lanai		Maui		Molokini
Taxa	Species	Kaohikaipu	Kapapa	Mōkapu	Namoku	‘Ōkala	Po’o Po’o	Pu’u Pehe	Hulu	Kaemi	
DECAPODA	*Pseudoliomera speciosa*				x						
	Saron neglectus?		x								
	Schizophorida hilensis						x				
	Simocarinus simplex?							x			
	Stenopus hispidus		x	x		x					
	Synalpheus paraneomeris			x	x						x
	Trapezia bidentata				x			x			
	Trapezia digitalis				x	x					
	Trapezia sp.		x	x	x		x				x
	Trapezia tigrina					x					
	Unid. Alpheidae	x									
	Unid. Callappidae						x				
	Unid. Diogenidae sp.								x	x	x
	Unid. Galatheidae	x									x
	Unid. Galatheiedae				x						
	Unid. Grapsidae						x				
	Unid. Majidae						x				
	Unid. Paguridae	x									
	Unid. Paleamonidae sp. 1								x	x	x
	Unid. Paleamonidae sp. 2									x	
	Unid. Paleamonidae sp. 3										x
	Unid. Paleomonidae		x		x						
	Unid. Palicidae						x				
	Unid. Pilumnidae	x					x				
	Unid. Xanthidae		x	x			x	x	x	x	x
CHELICERATA	Unid. Halacaridae			x		x					
ECTOPROCTA	*Bugula dentata*					x	x				
	Crisina radians			x	2	x					x
	Parasmittina sp.					x			x	x	x
	Reteporellina denticulata	x		x		x	x			x	x
	Triphyllozon sp.	x					x				
ASTEROIDEA	*Vittaticella uberrima*			x							x
	Acanthaster planci				x			x		x	

		O‘ahu		Moloka‘i			Lanai		Maui		Molokini
Taxa	Species	Kaohikaipu	Kapapa	Mōkapu	Namoku	‘Ōkala	Po’o Po’o	Pu’u Pehe	Hulu	Kaemi	
ASTEROIDEA	*Culcita novaeguineae*			x							
	Linckia multifora						x				
OPHIUROIDEA	*Mithrodia fisheri*			x							
	Ophiocoma sp.							x			
	Ophiactis modesta?						x				
	Ophiactis savignyi?						x				
	Ophiocoma erinaceus	x	x				x				x
	Ophiocoma pica	x			x						x
ECHINOIDEA	*Diadema paucispinum*							x			
	Echinometra mathaei	x	x	x	x		x	x	x	x	x
	Echinostrephus aciculatus	x	x	x	x	x	x	x			x
	Echinothrix calamaris	x	x	x	x	x	x	x	x		x
	Echinothrix diadema		x							x	x
	Eucidaris metularia			x			x	x			
	Heterocentrotus mammillatus	x			x				x		x
HOLOTHUROIDEA	*Tripneustes gratilla*	x	x				x		x	x	x
	Actinopyga mauritiana					x			x	x	
	Actinopyga obesa										x
	Holothuria (Halodeima) atra	x		x	x	x				x	
	Holothuria (Microthele) whitmaei		x	x		x					
ASCIDIACEA	*Polyplectana kefersteinii*						x				
	Aplidium crateriferum	x		x	x	x					
	Aplidium sp.					x				x	
	Aplidium sp. A						x				
	Aplidium sp. B							x	x		
	Didemnum sp.	x		x	x	x		x		x	
	Didemnum sp. 1		x								
	Didemnum sp.2									x	
	Unid. Ascidian			x		x				x	
		65	42	65	58	61	89	82	41	64	69

Appendix G.

Size Frequency Histograms by Species of Corals at NOAA Survey Sites



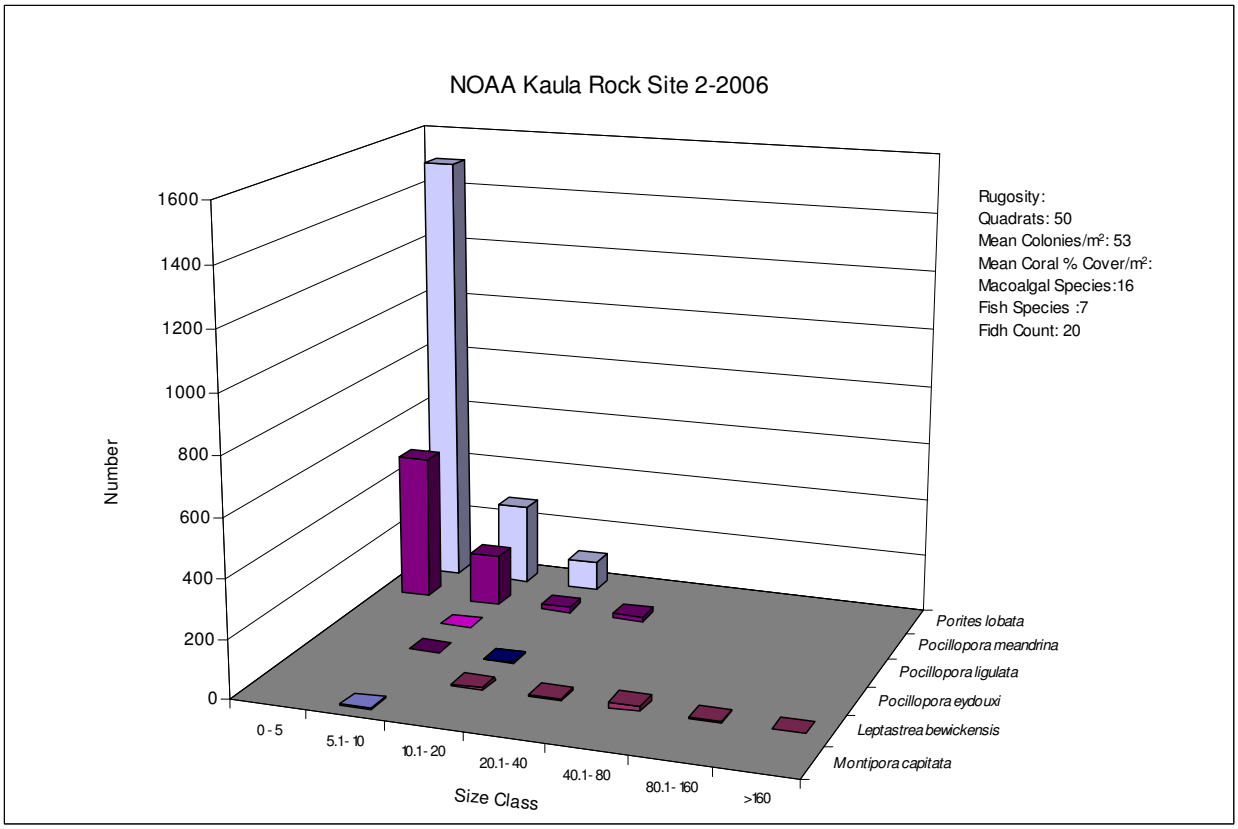


Figure G-1. Size class analysis for corals on NOAA Kaula Rock 2006 Transects

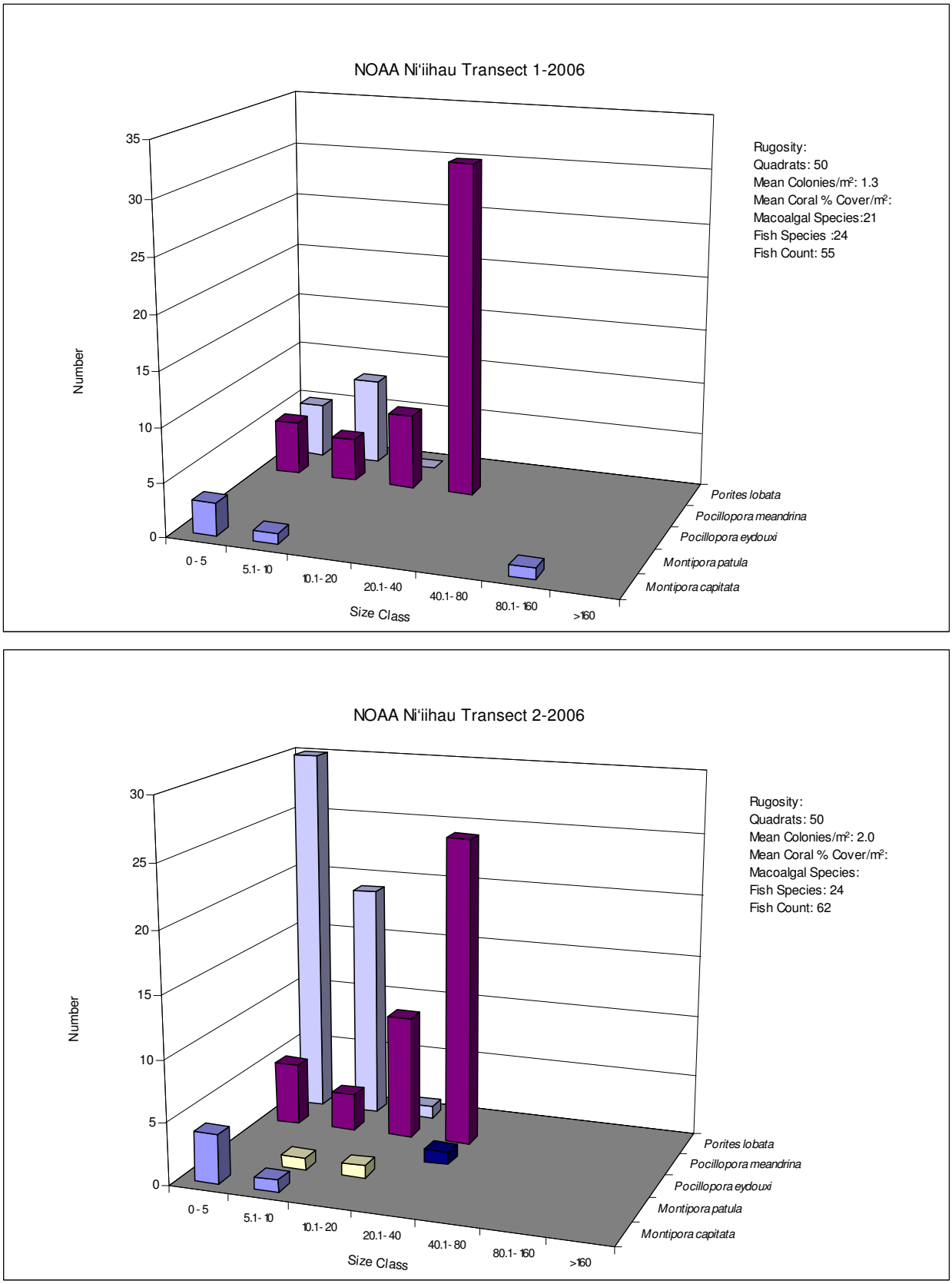
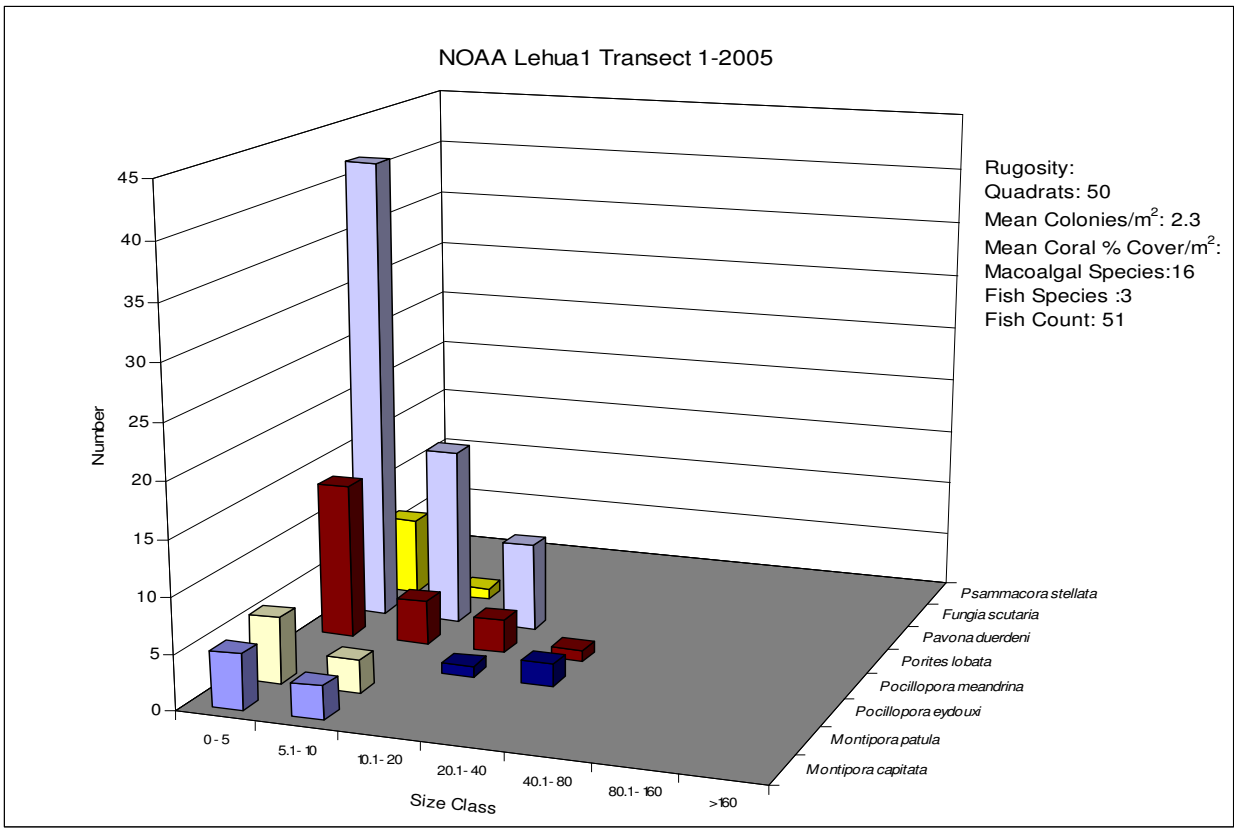


Figure G-2. Size class analysis for corals on NOAA Ni'ihau 2006 Transects



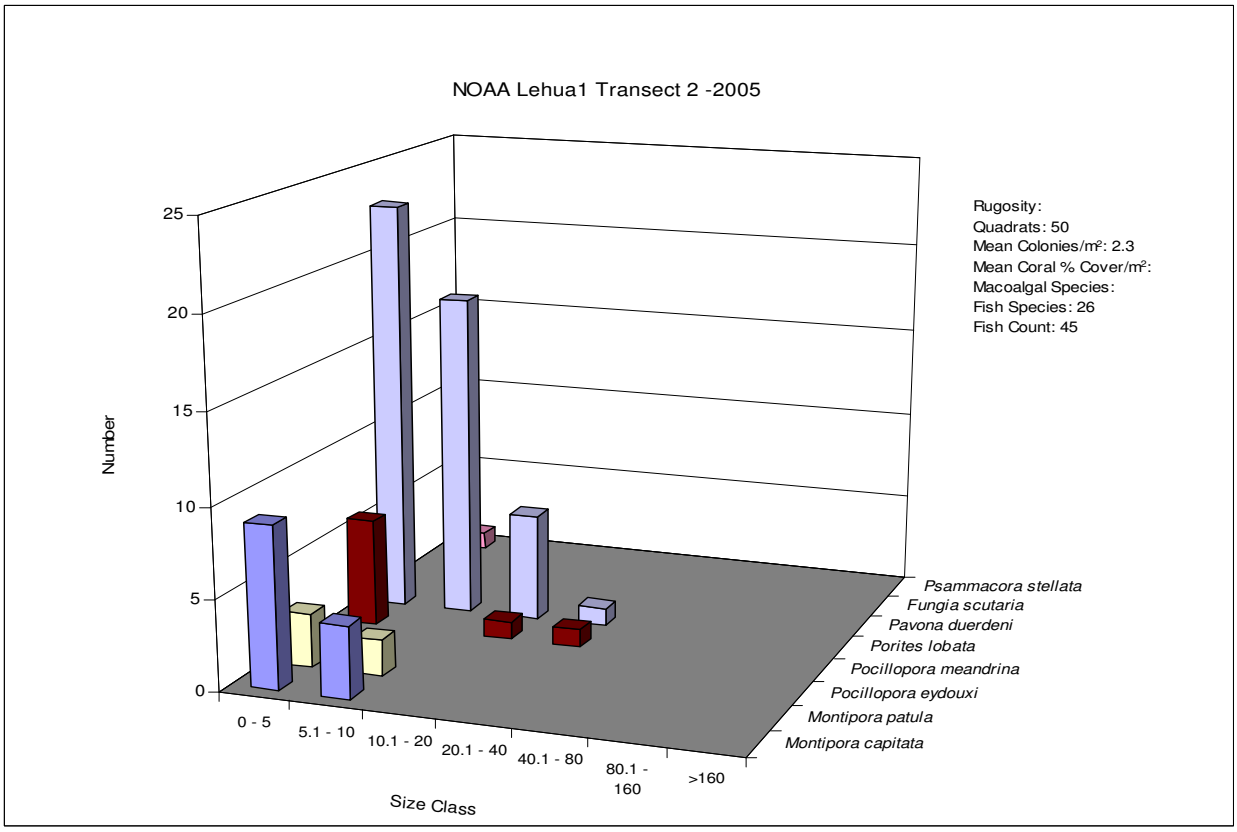
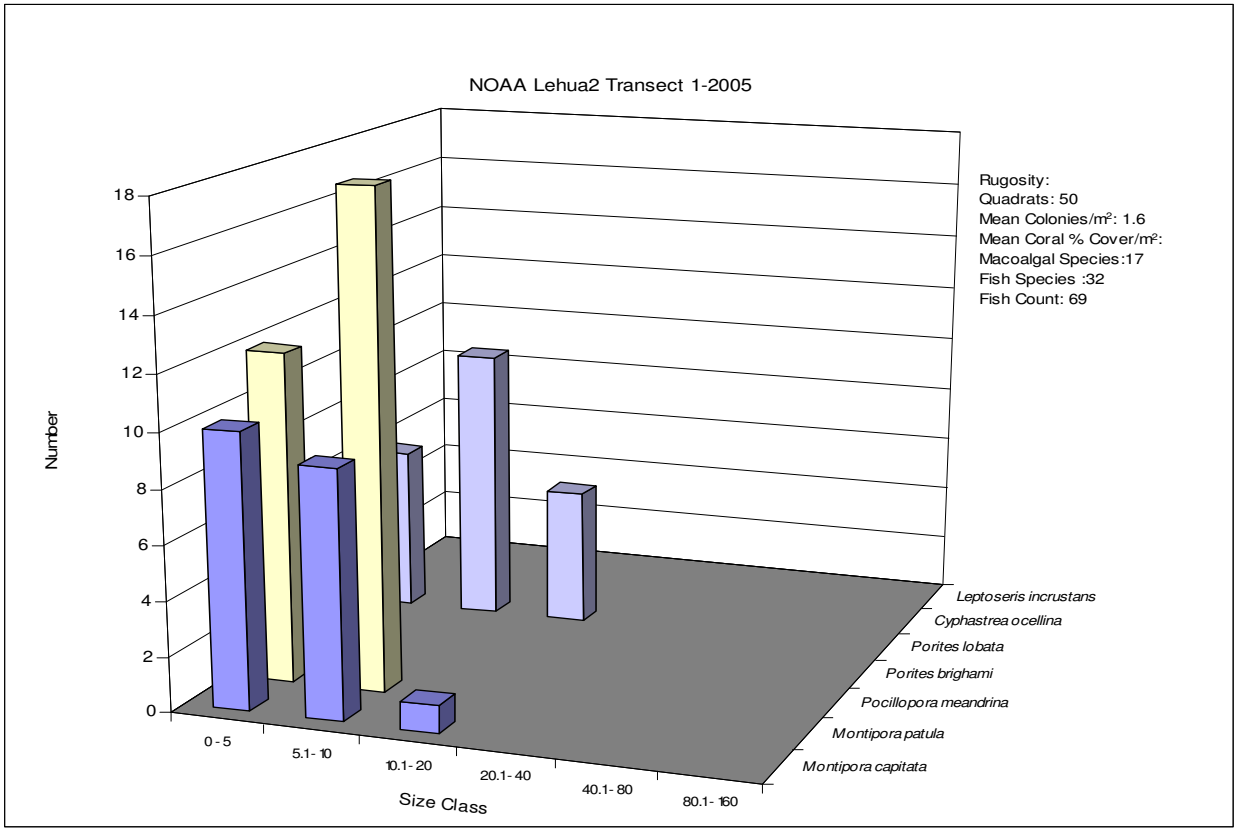


Figure G-3. Size class analysis for corals on NOAA Lehua1 2005 Transects



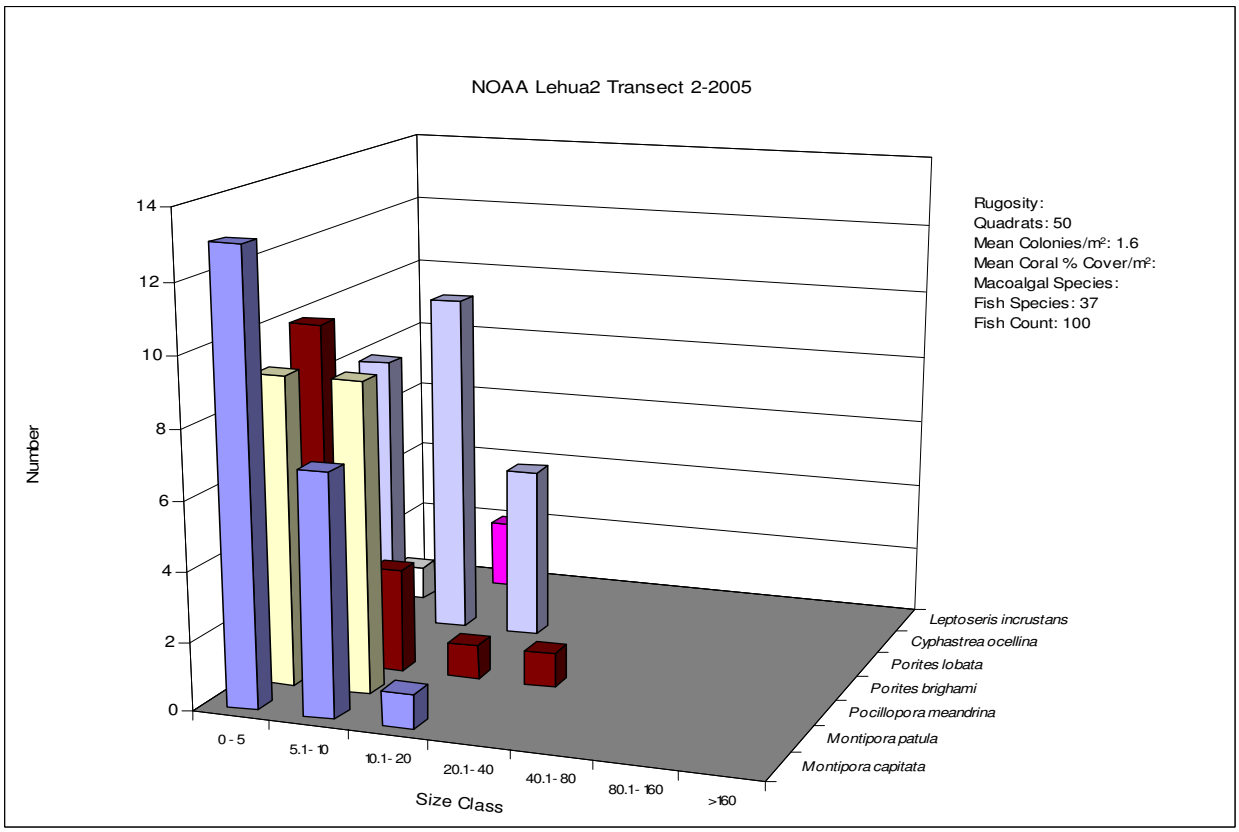
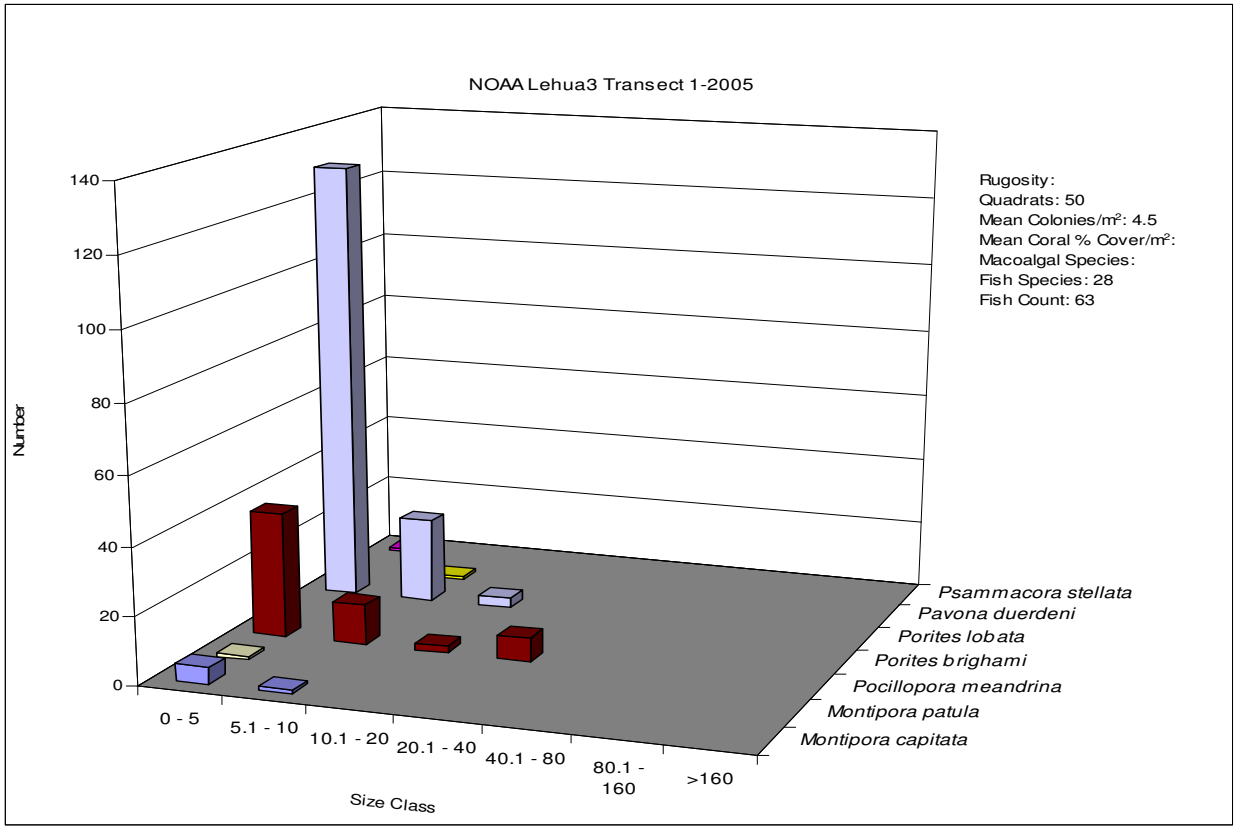


Figure G-4. Size class analysis for corals on NOAA Lehua2 2005 Transects



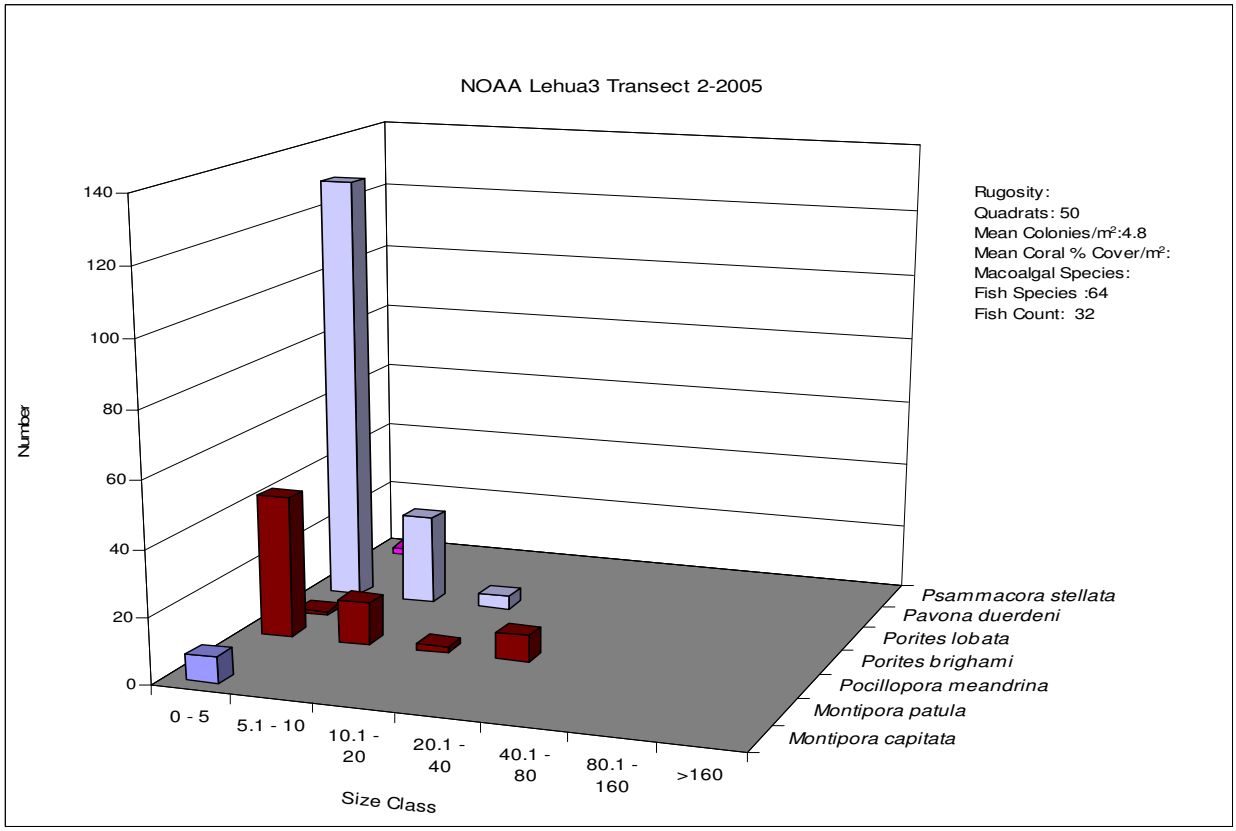


Figure G-5. Size class analysis for corals on NOAA Lehua3 2005Transects

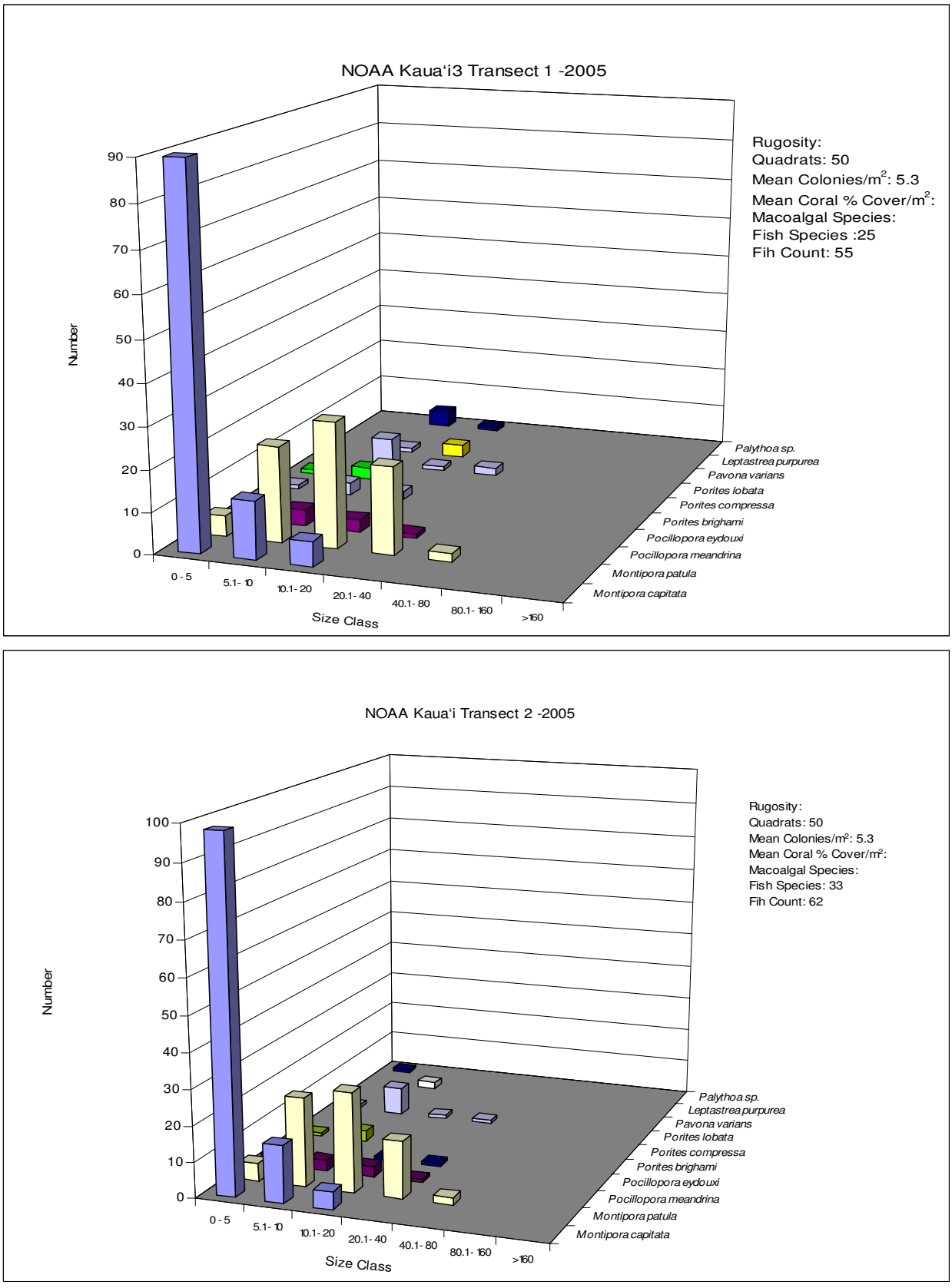


Figure G-6. Size class analysis for corals on NOAA Kaua'i3 2005Transects

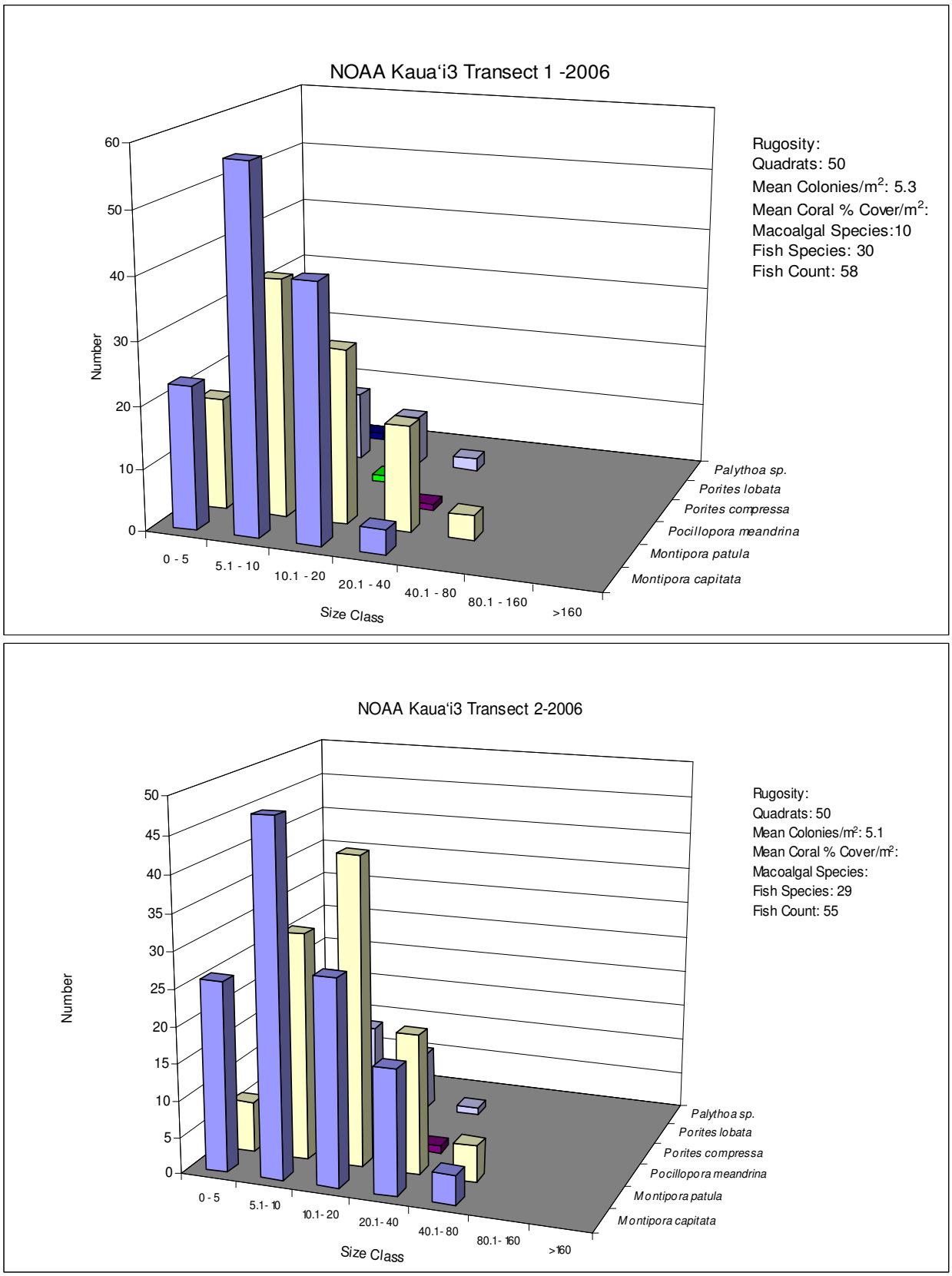
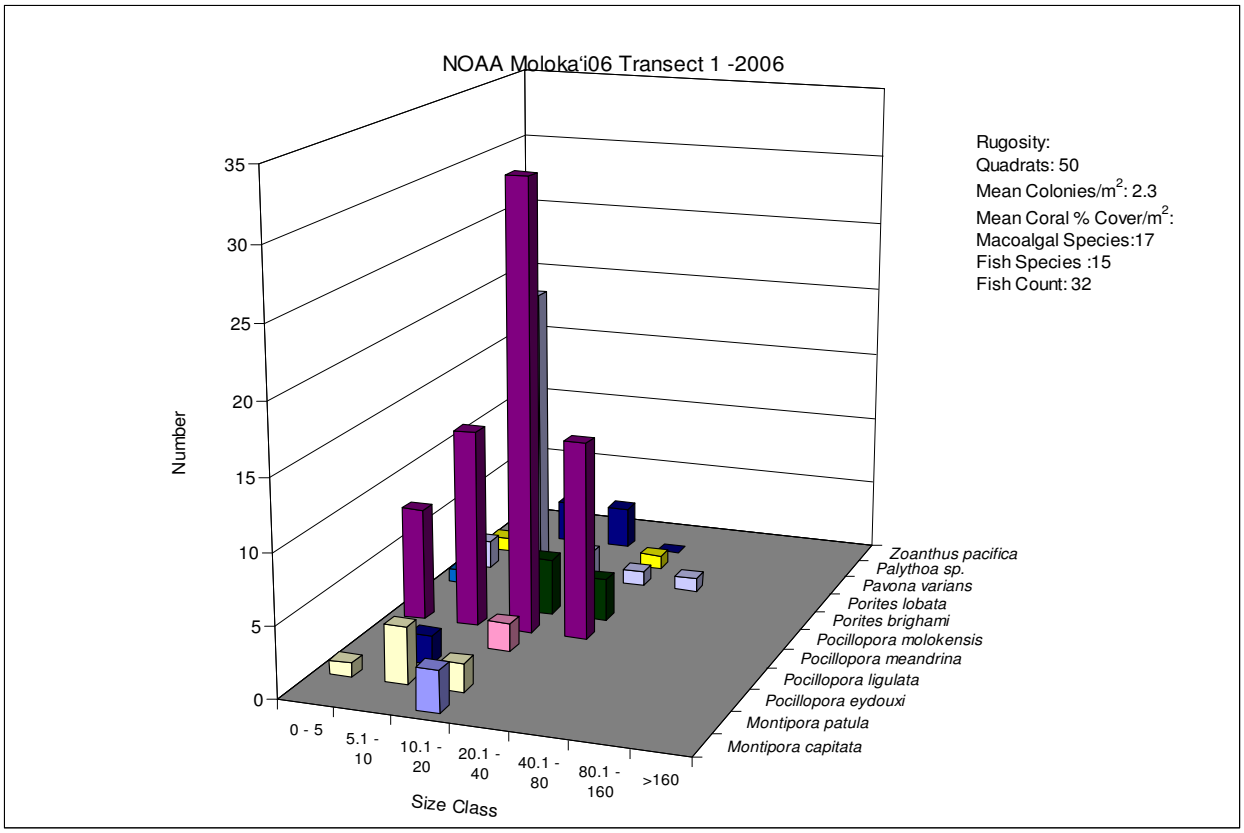


Figure G-7. Size class analysis for corals on NOAA Kaua'i3 2006Transects



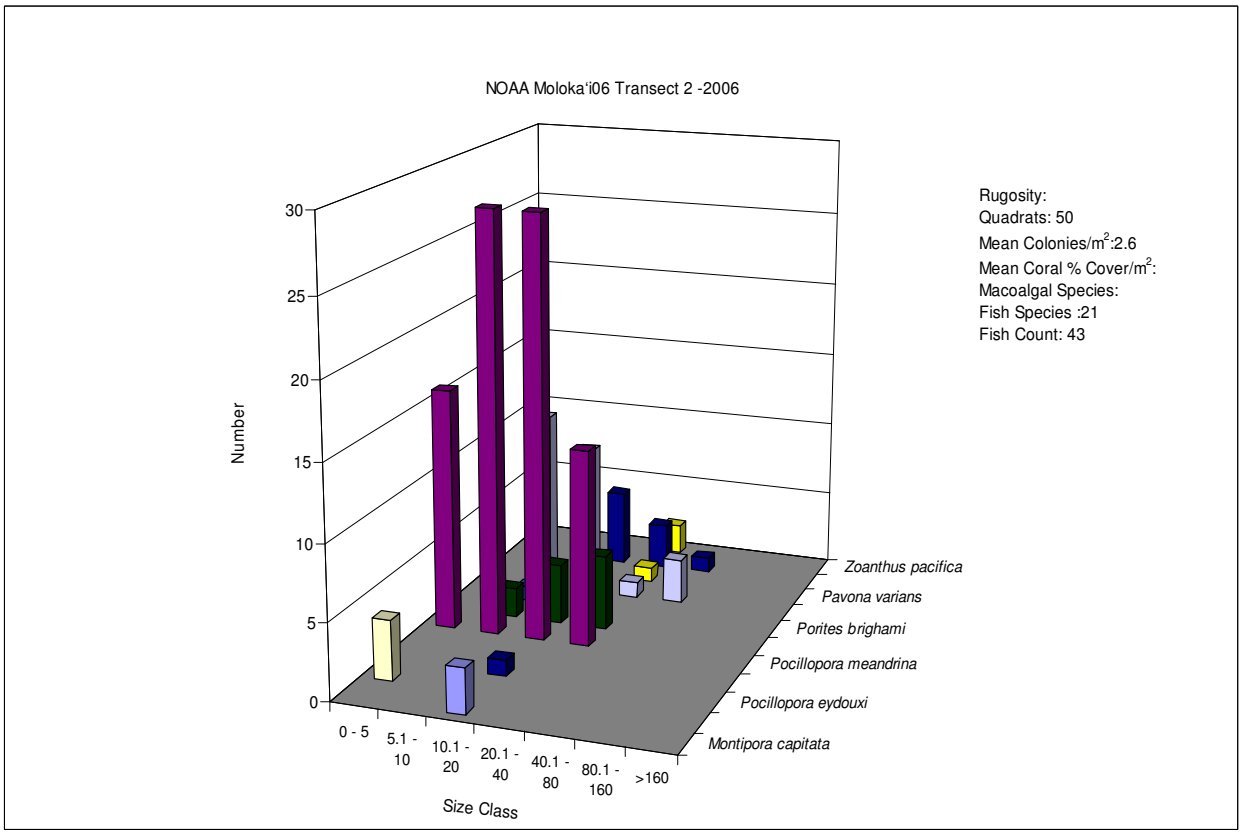
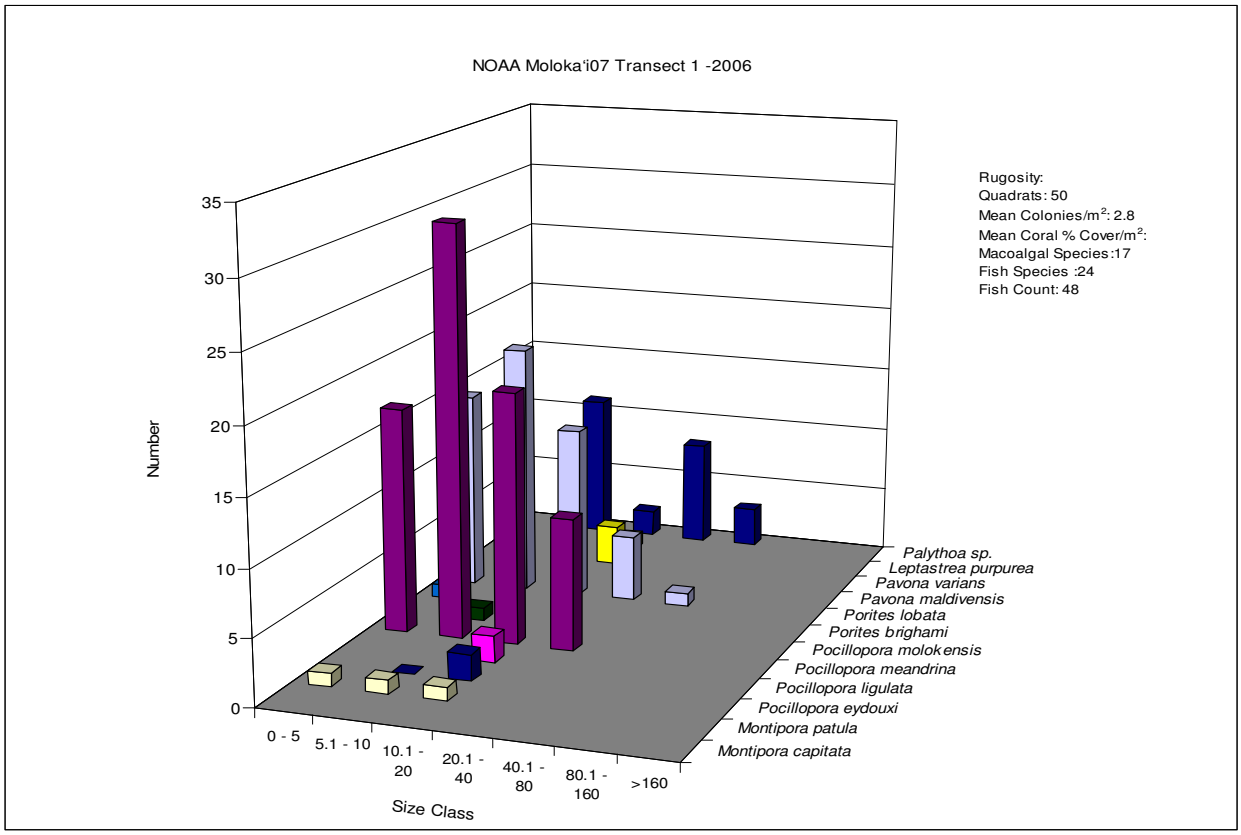


Figure G-8. Size class analysis for corals on NOAA Moloka'i6 2005Transects



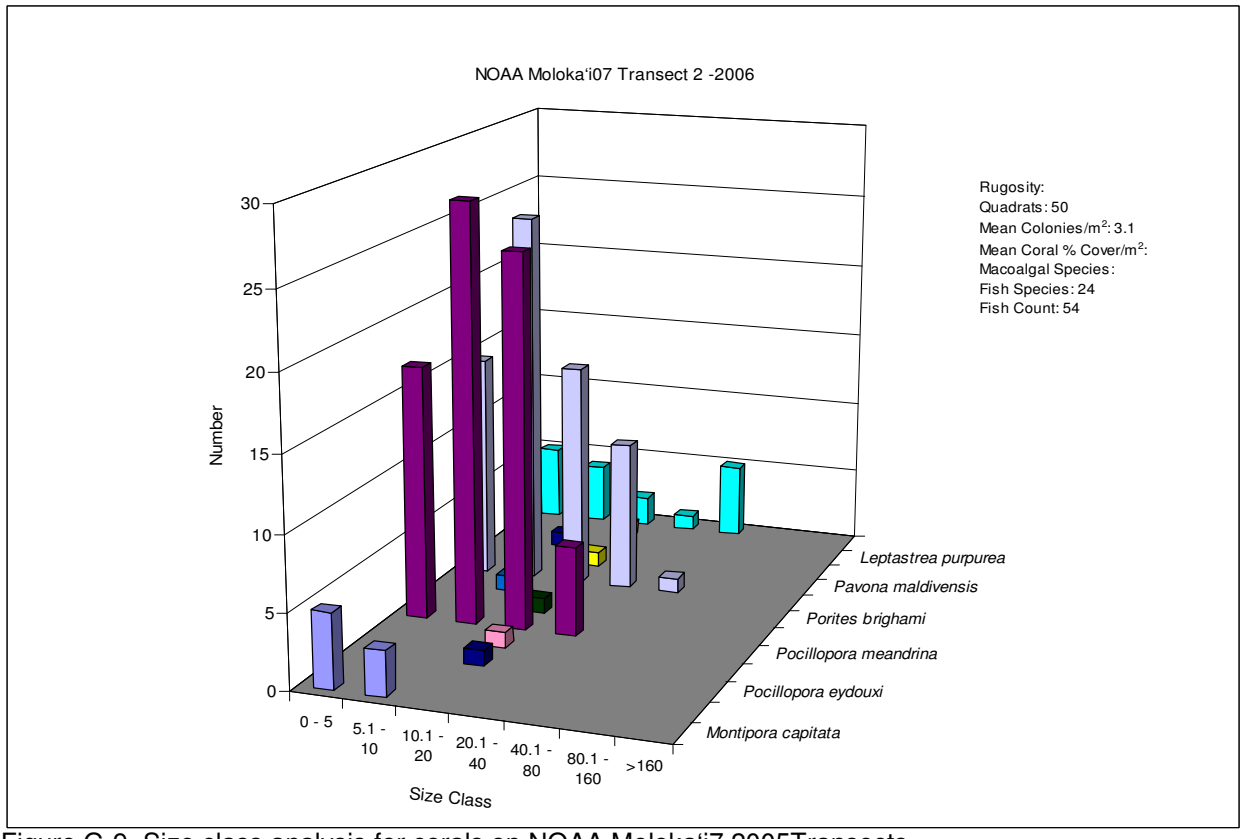


Figure G-9. Size class analysis for corals on NOAA Moloka'i7 2005Transects

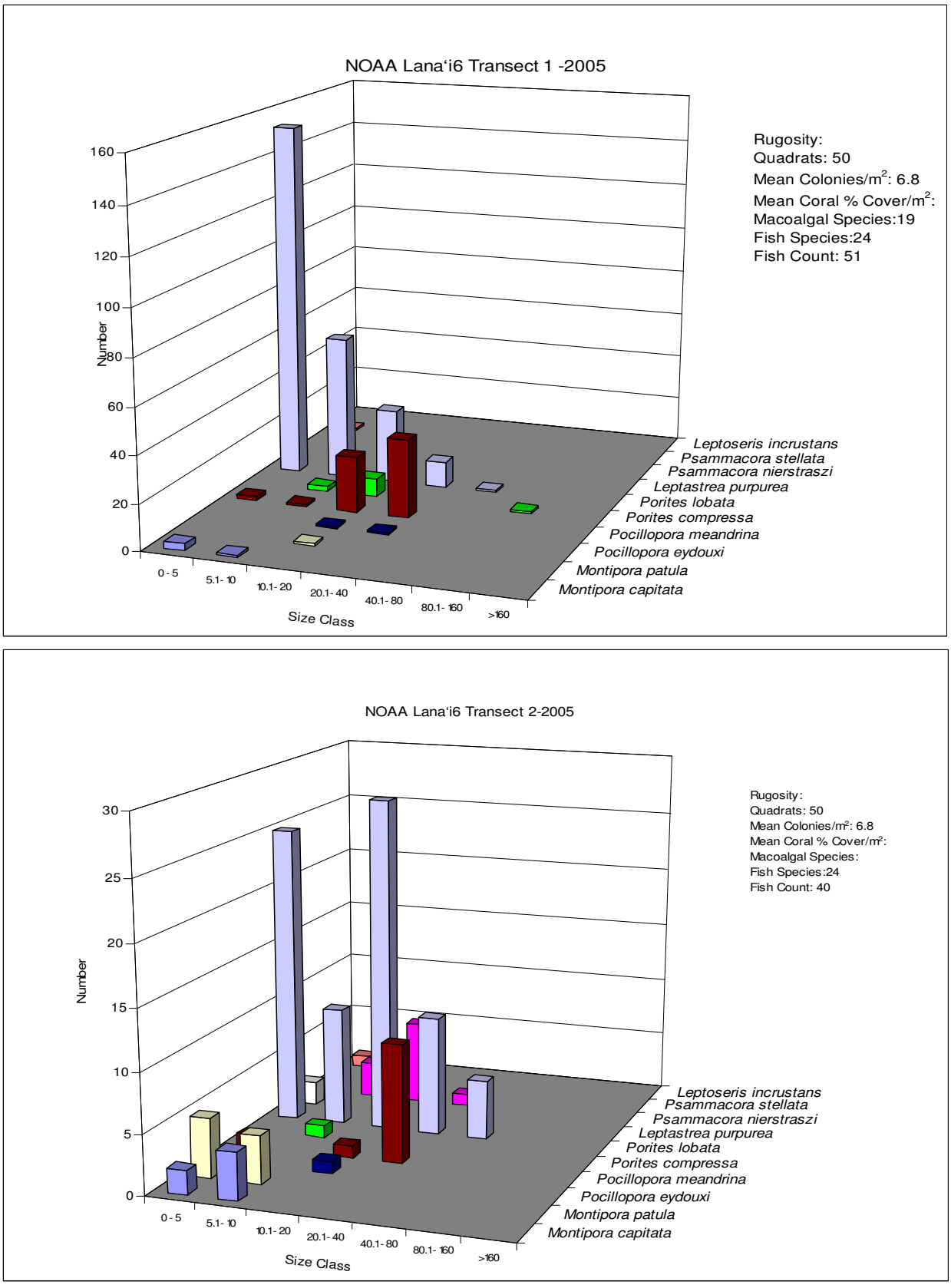


Figure G-10. Size class analysis for corals on NOAA Lana'i6 2005Transects.

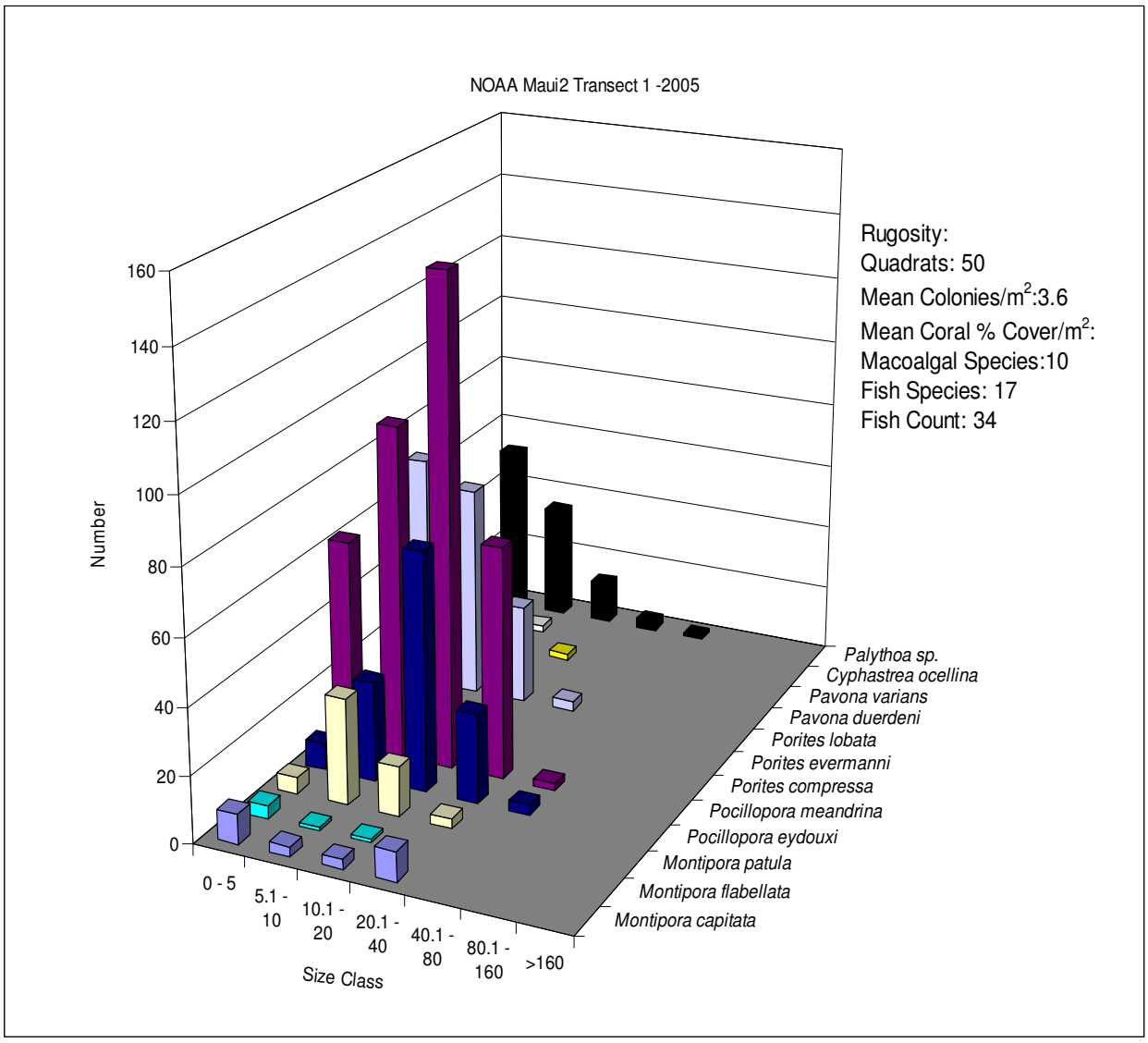


Figure G-11. Size class analysis for corals on NOAA Maui2 2005 Transect.

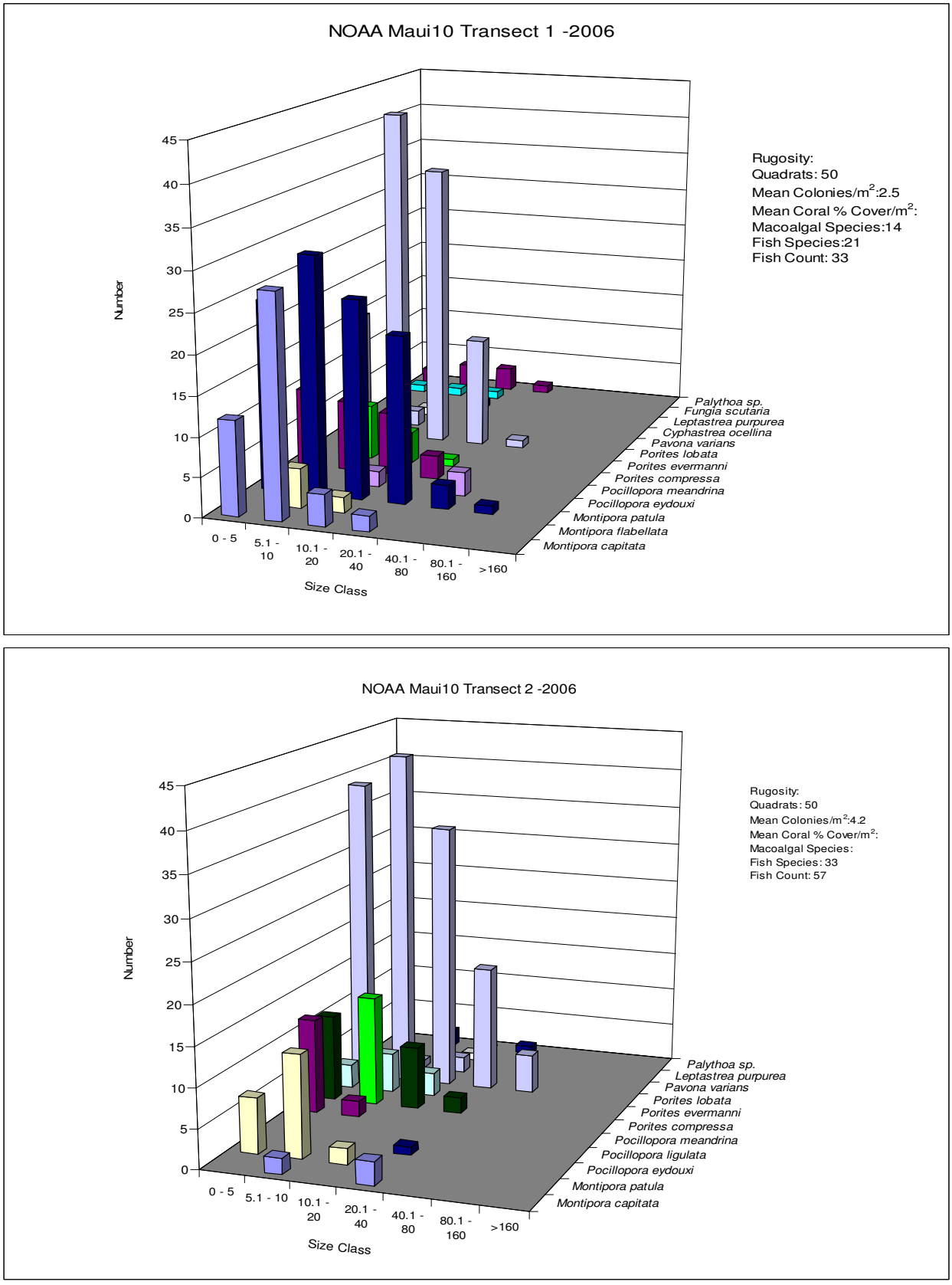


Figure G-12. Size class analysis for corals on NOAA Maui10 2006 Transects

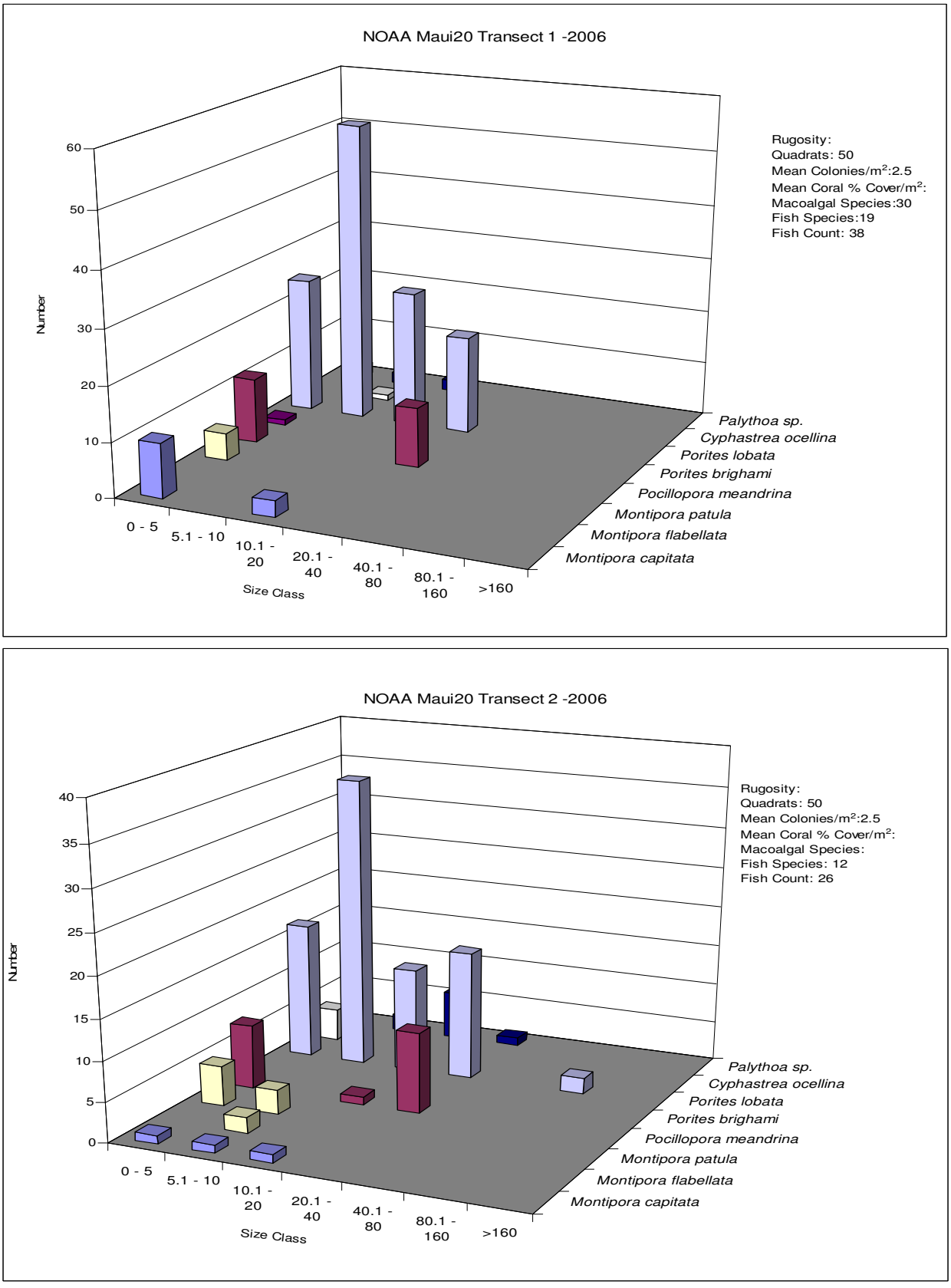
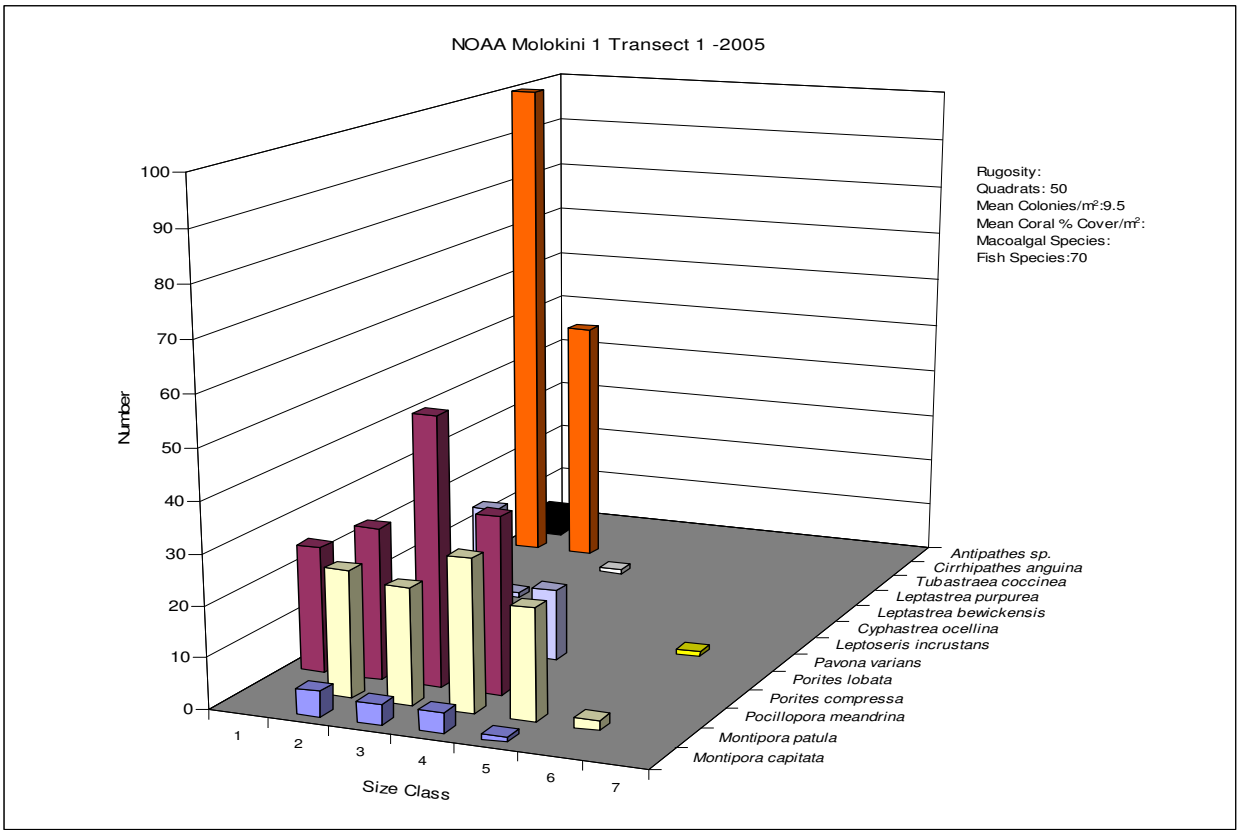


Figure G-13. Size class analysis for corals on NOAA Maui20 2006Transects



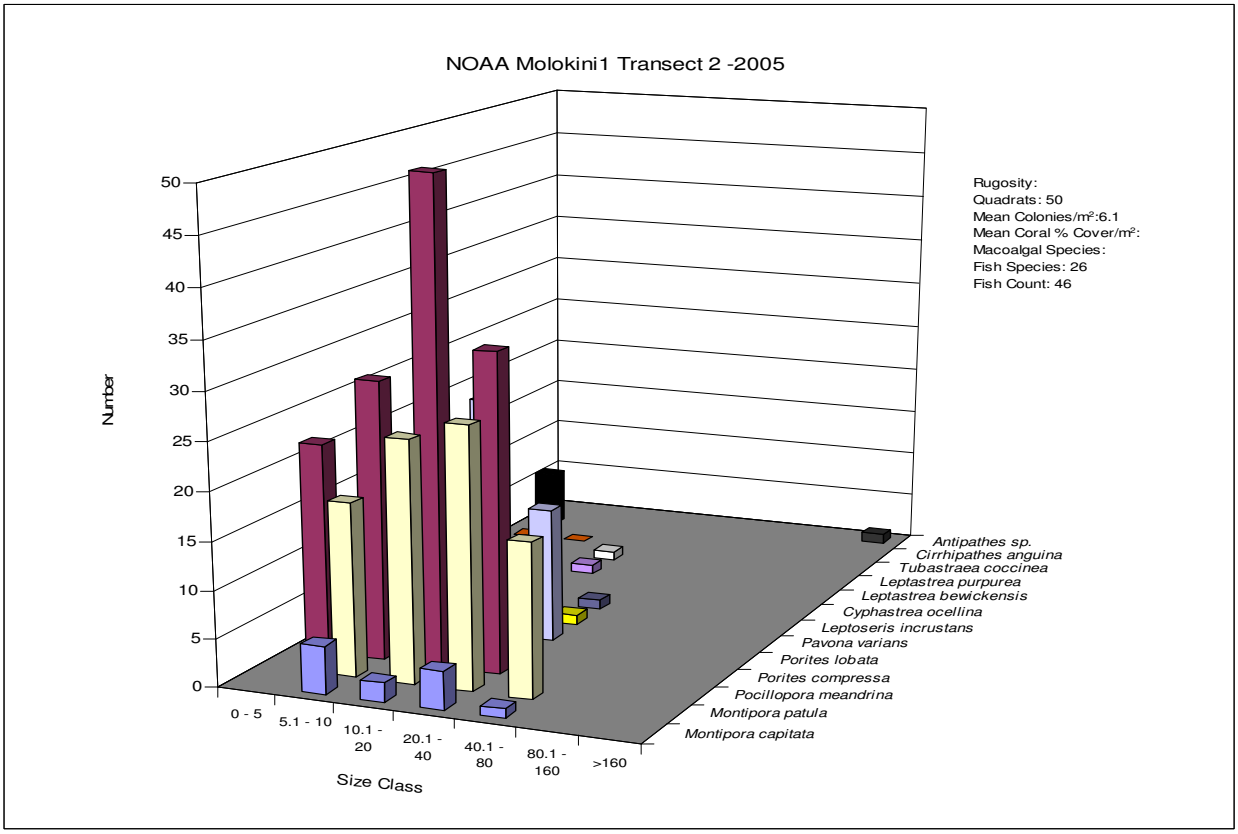
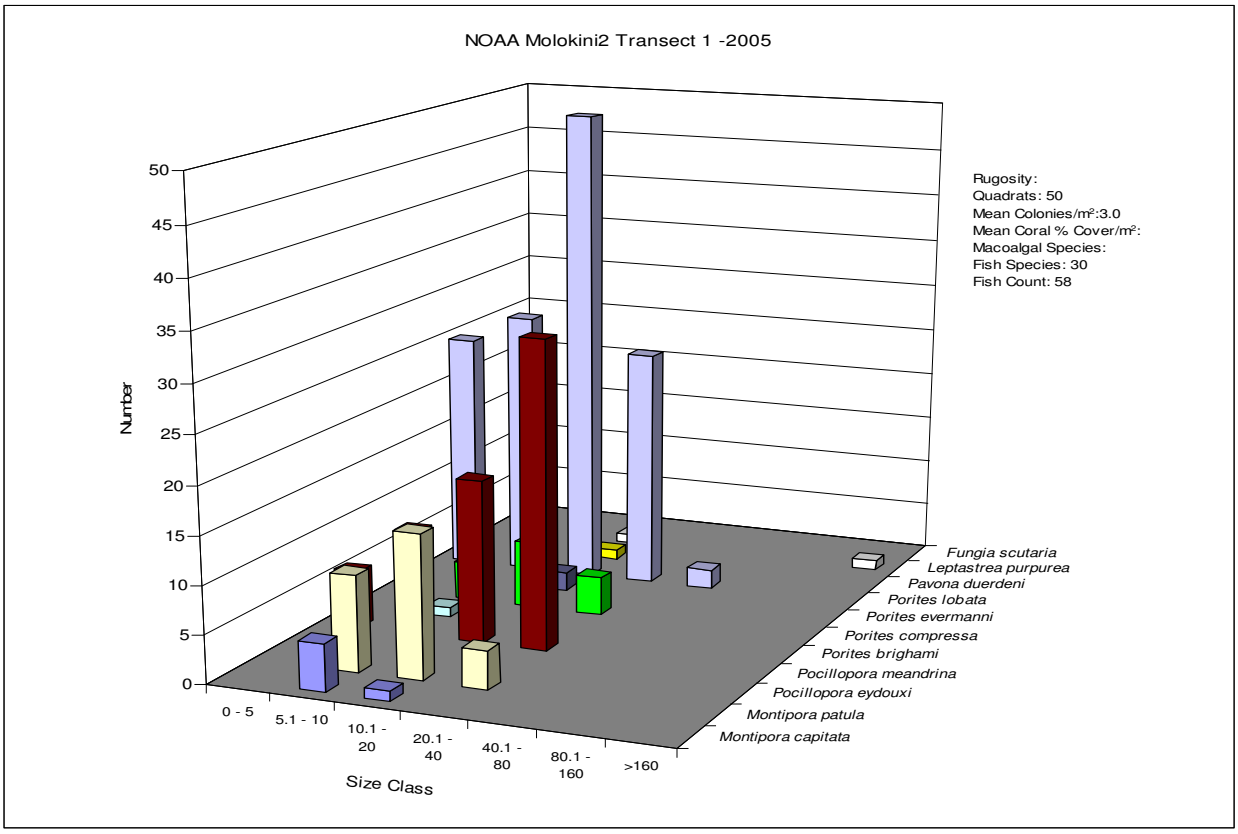


Figure G-14. Size class analysis for corals on NOAA Molokini1 2006Transects



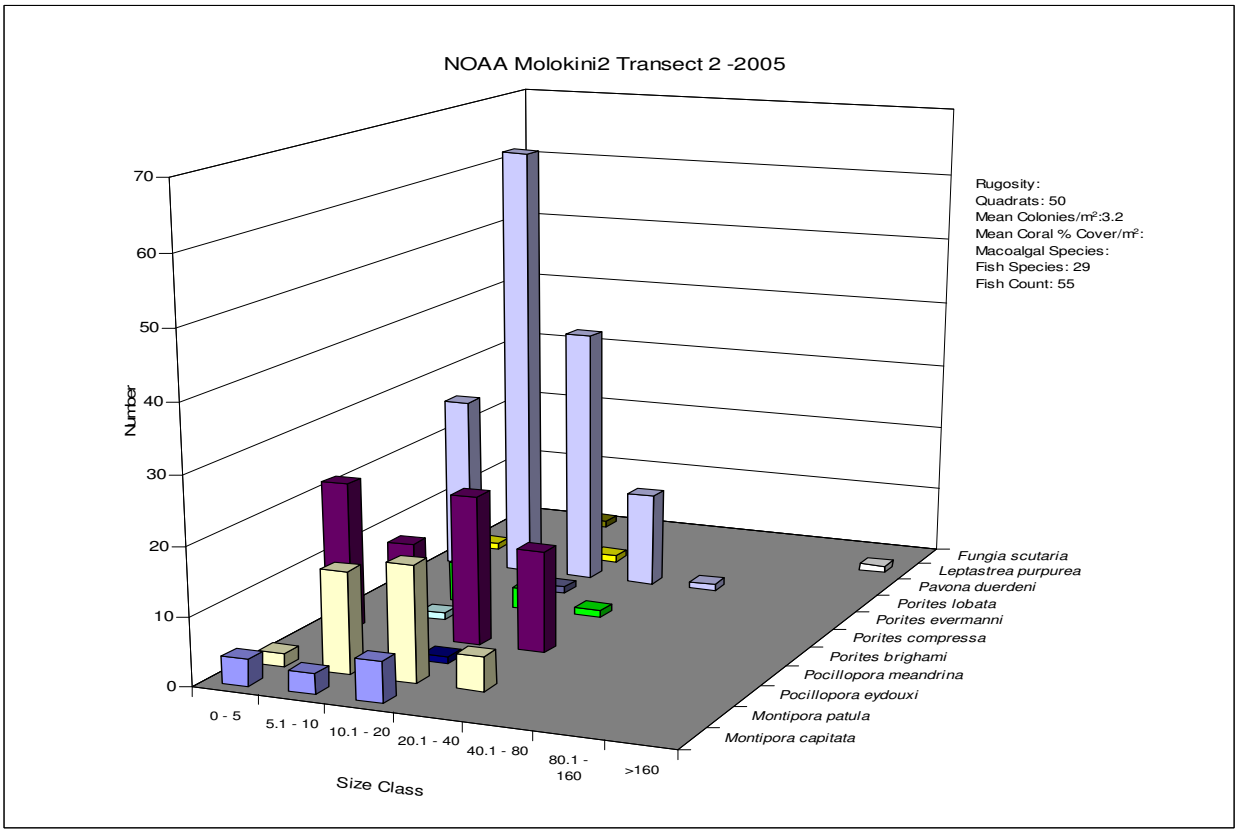


Figure G-15. Size class analysis for corals on NOAA Molokini2 2006Transects

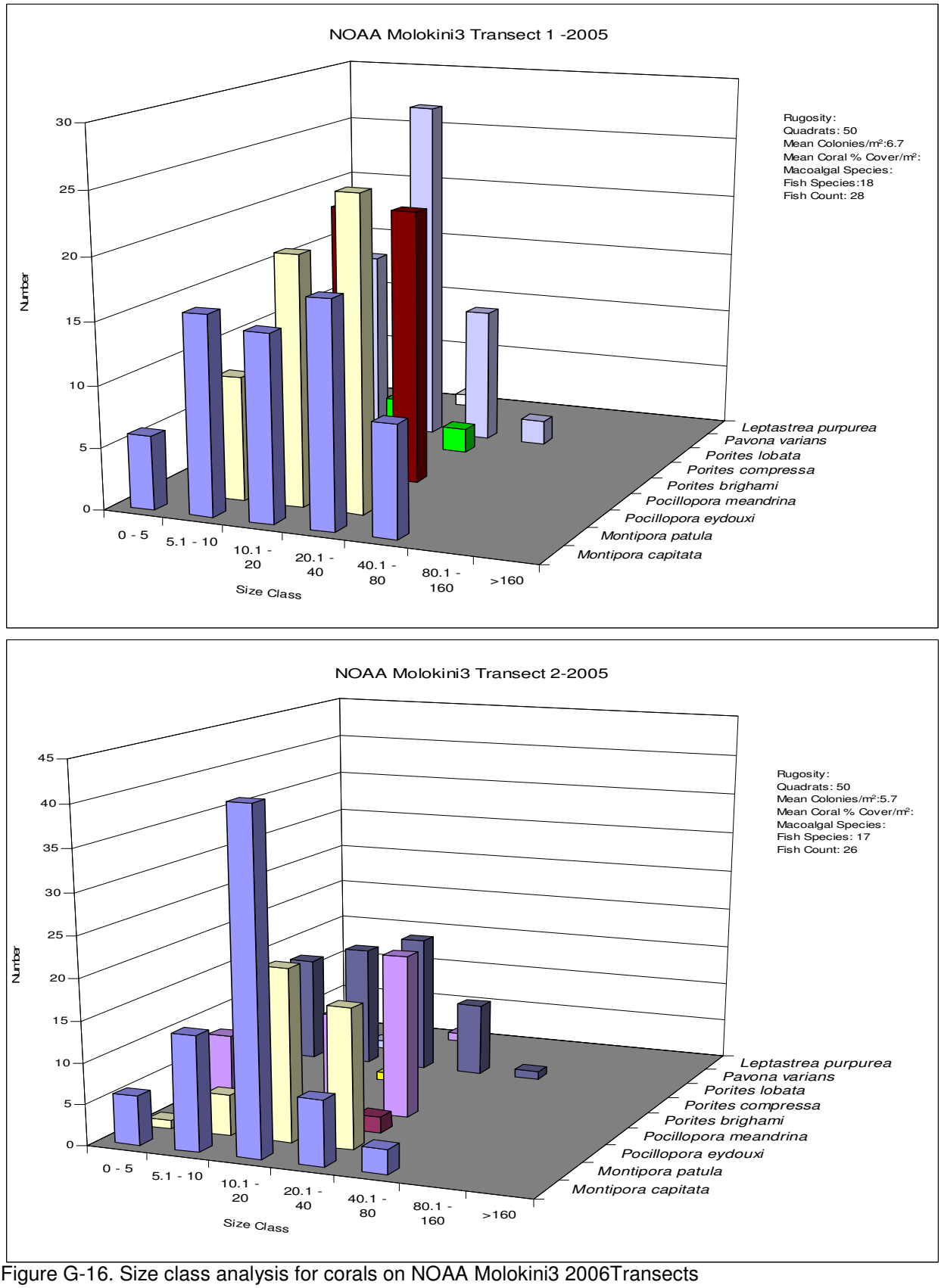


Figure G-16. Size class analysis for corals on NOAA Molokini3 2006Transects

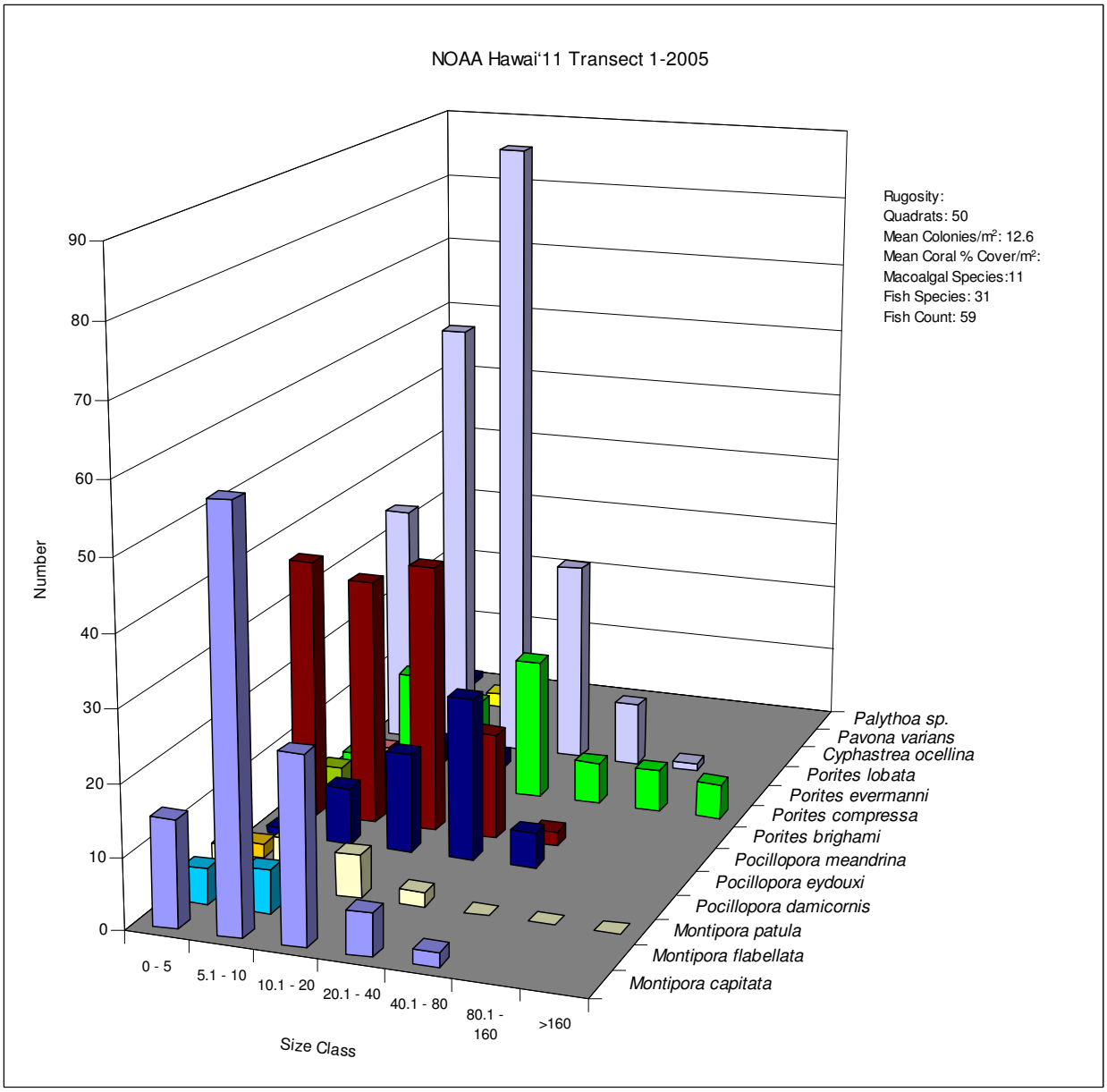
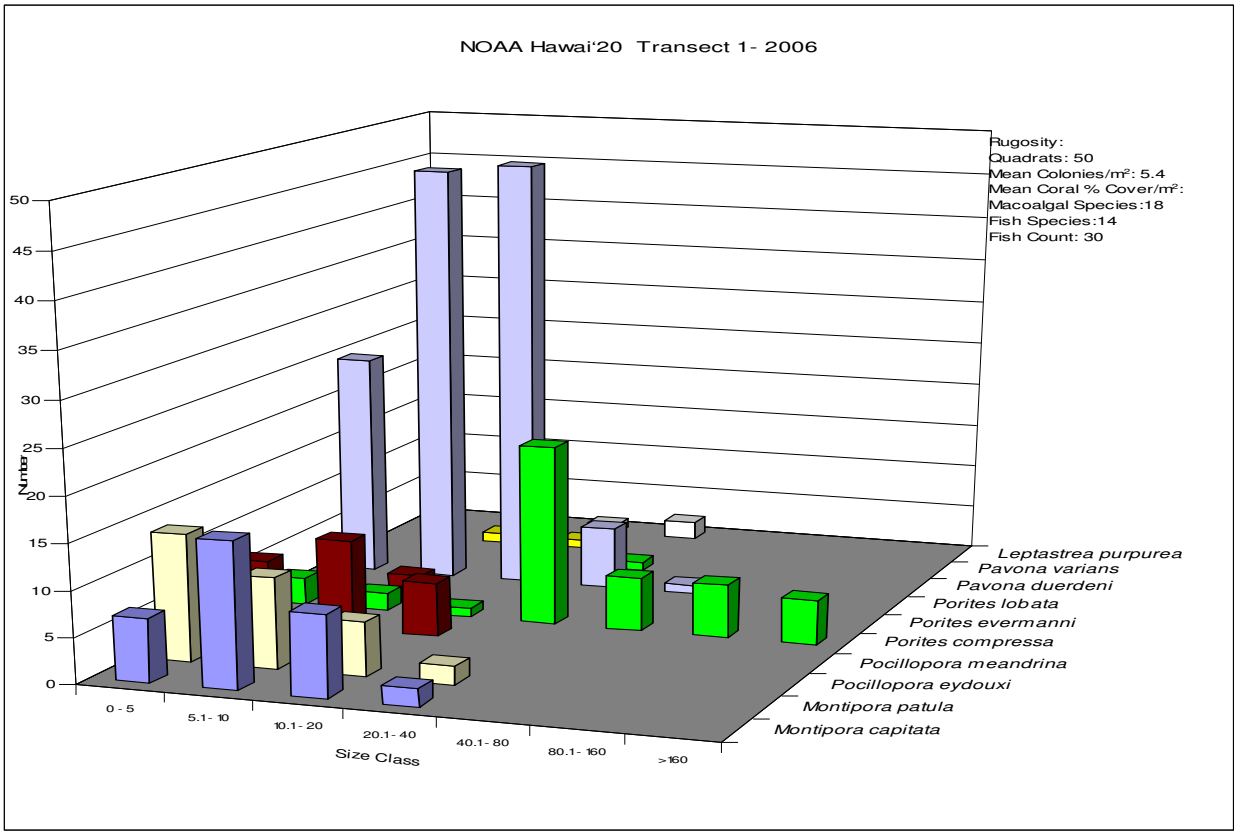


Figure G-17. Size class analysis for corals on NOAA Hawai'i11 2005Transect.



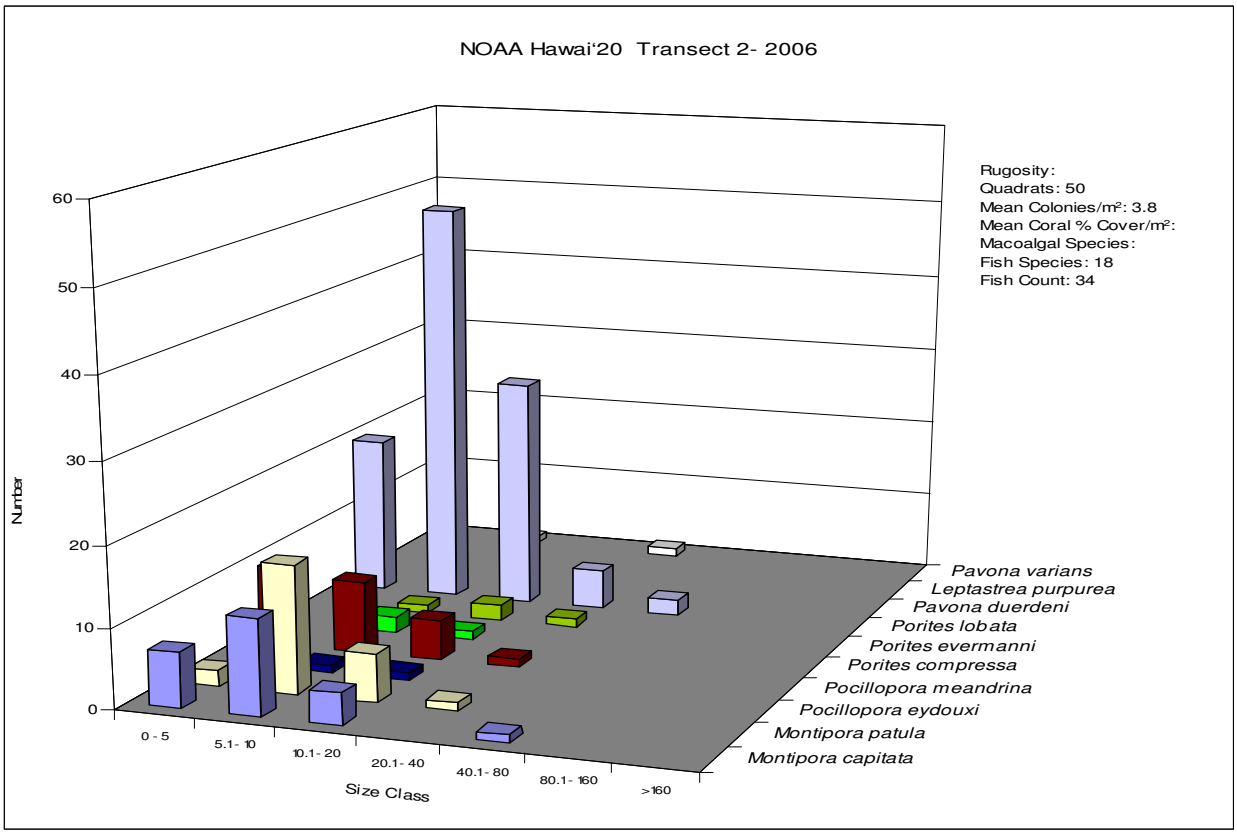
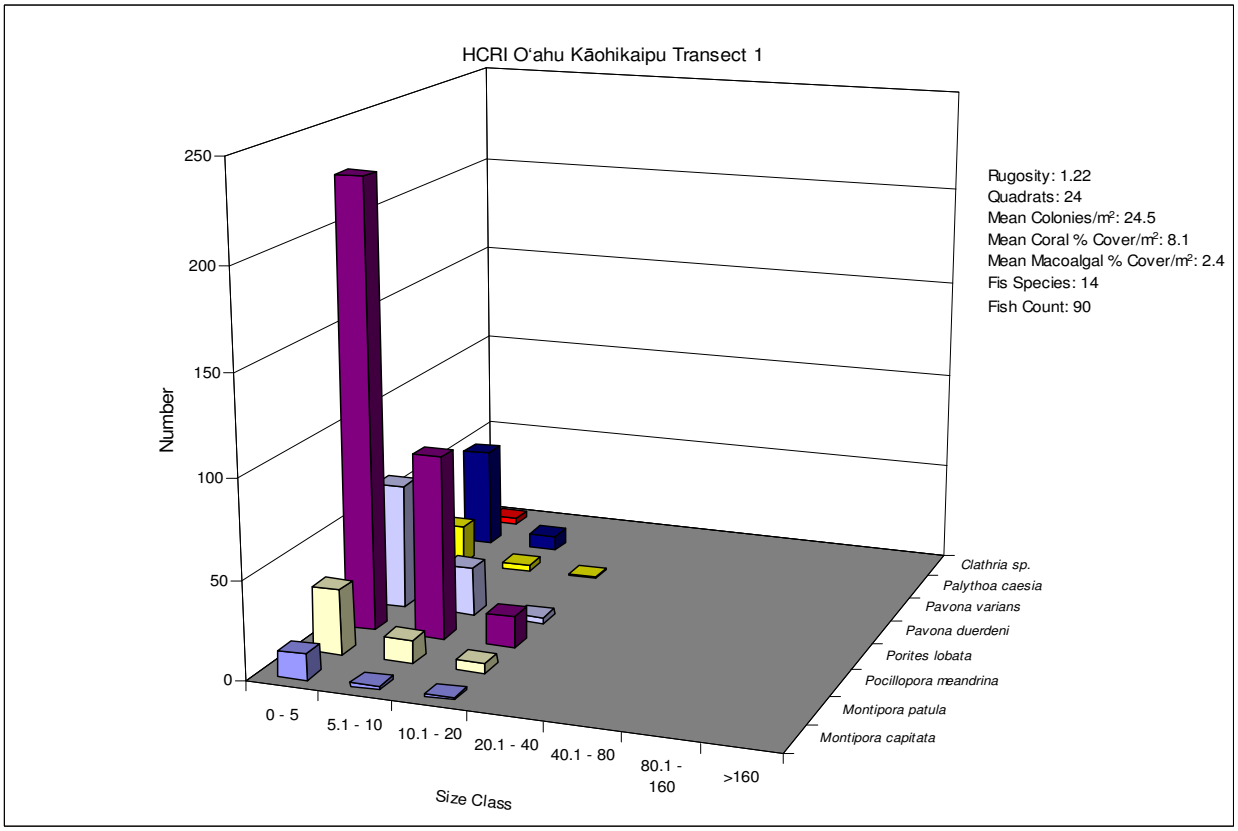


Figure G-18. Size class analysis for corals on NOAA Hawai'i20 2006 Transects.

Appendix H.

Size Frequency Histograms by Species of Corals at HCRI/NFWF Survey Sites



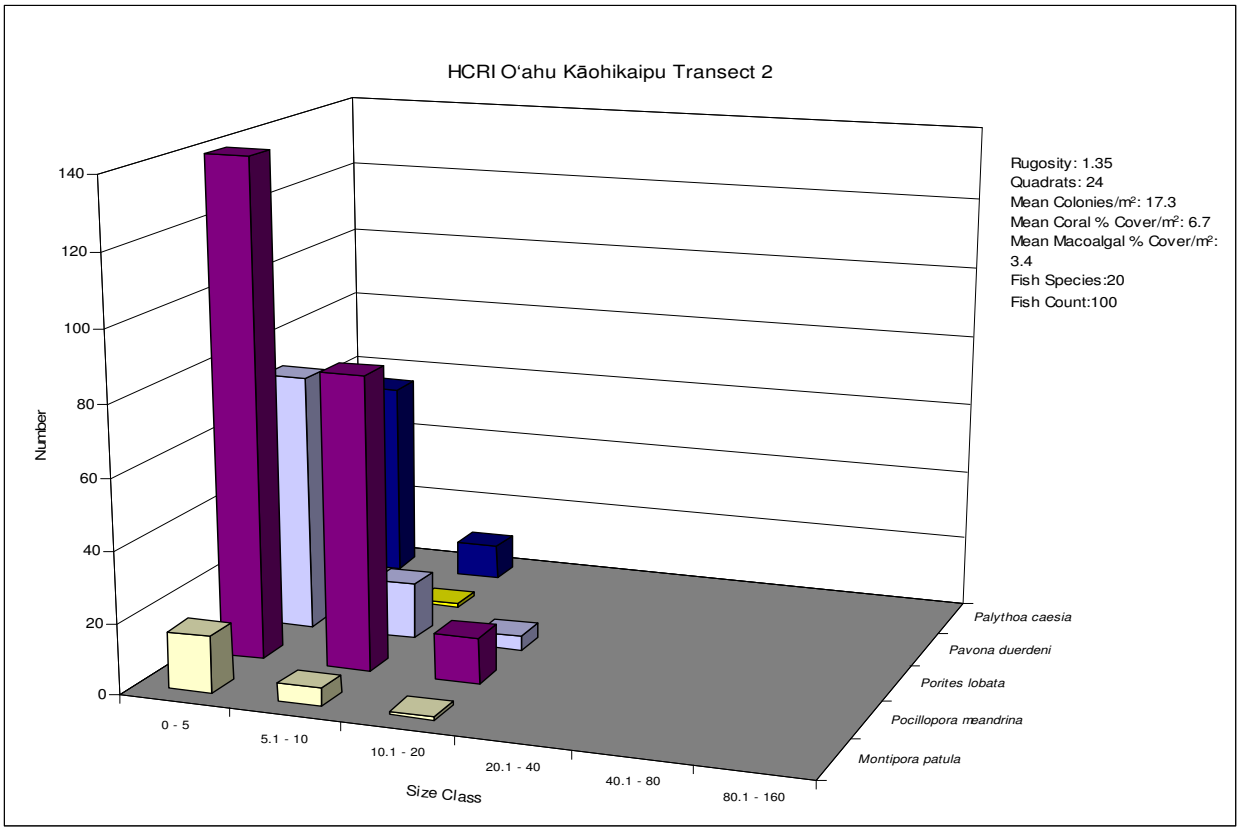
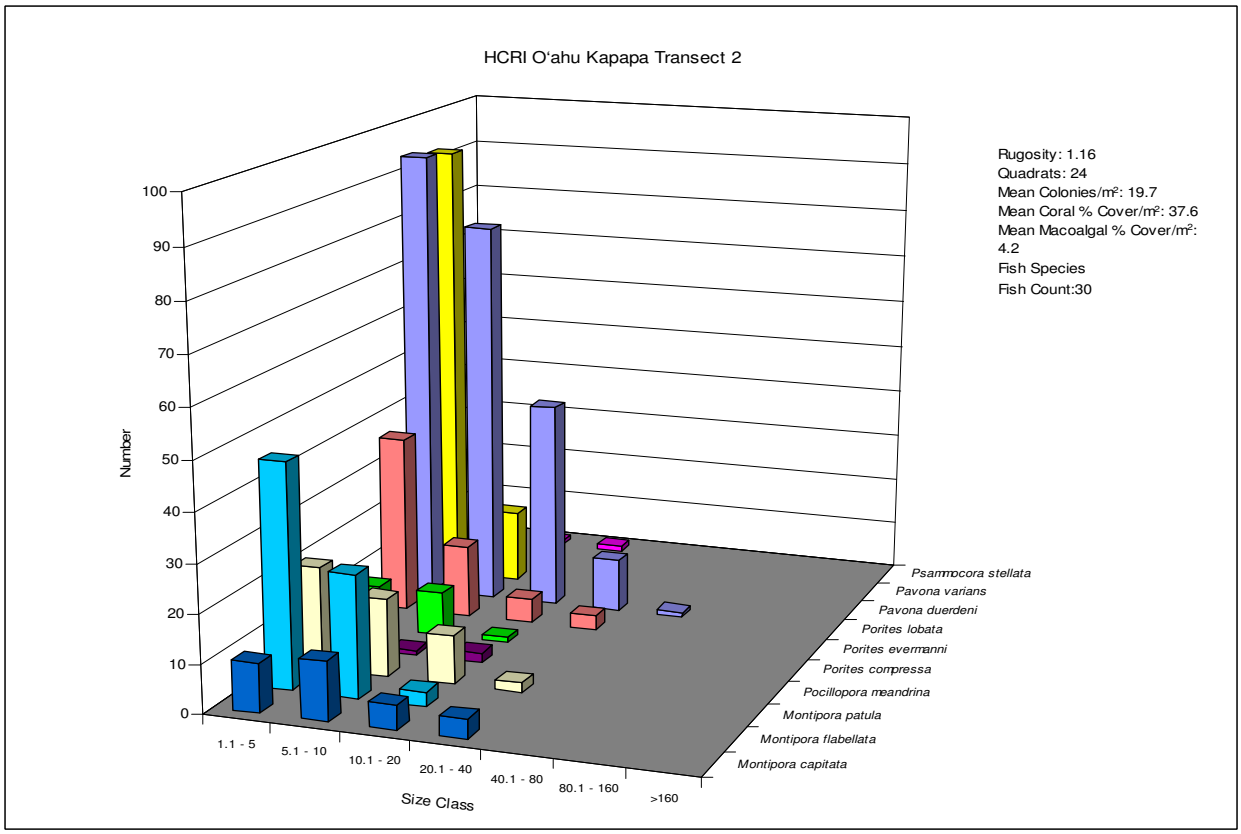


Figure H-1. Size class analysis for corals on HCRI/NFWF O'ahu Kāohikaipu 2007 Transects.



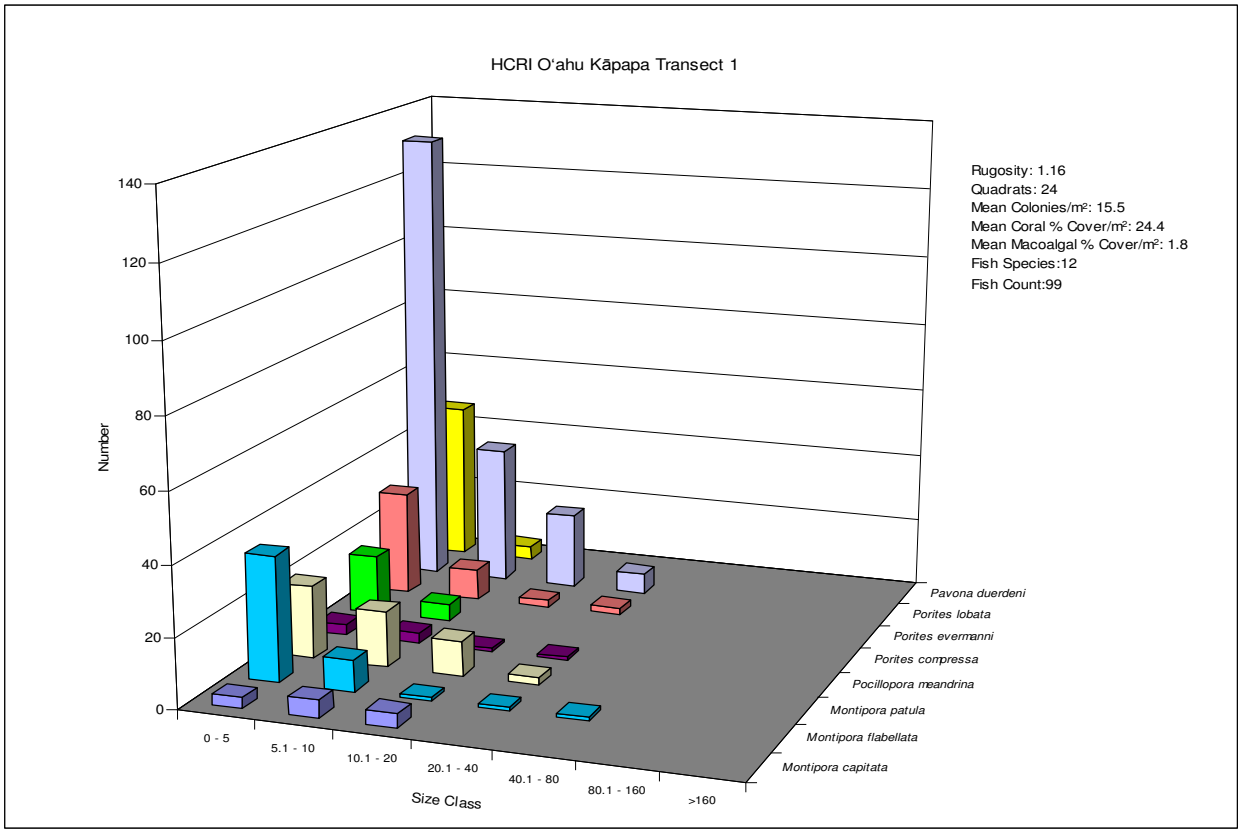
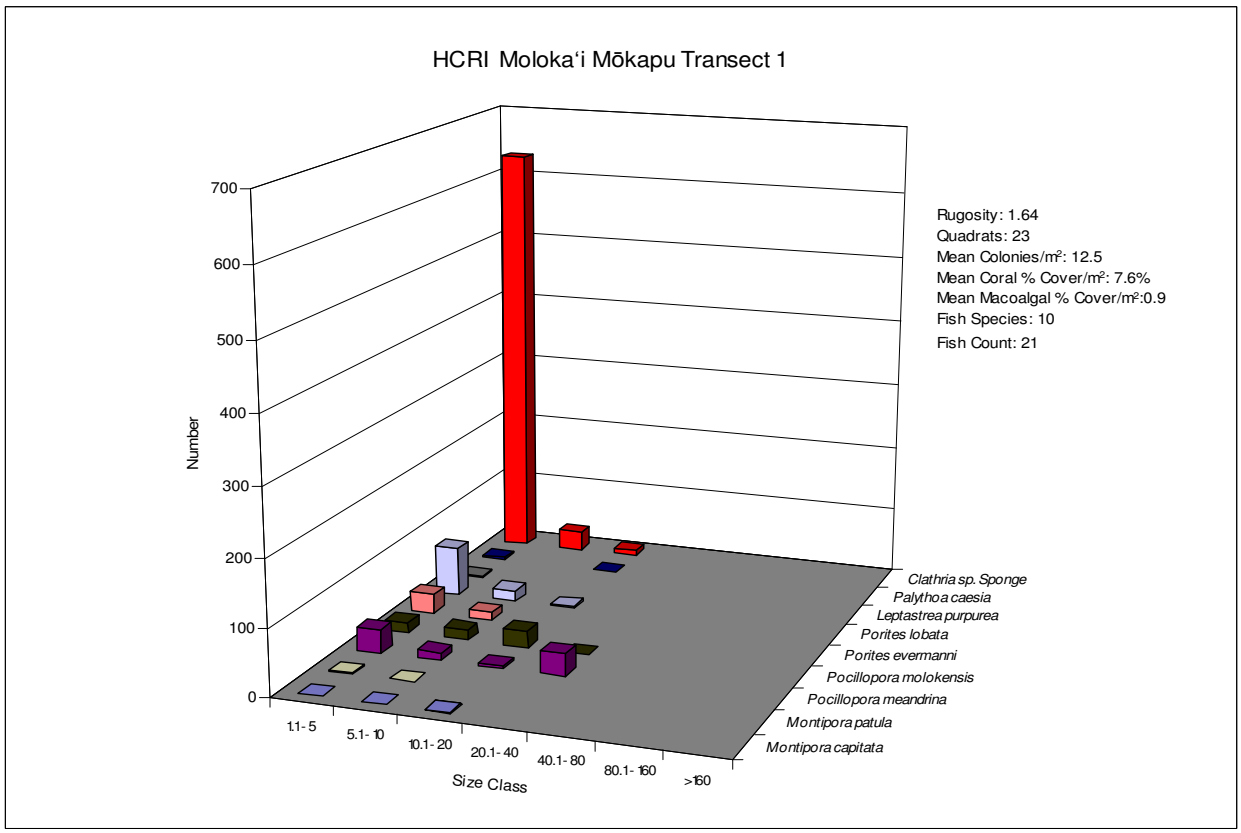


Figure H-2. Size class analysis for corals on HCRI/NFWF O'ahu Kāpapa 2007 Transects.



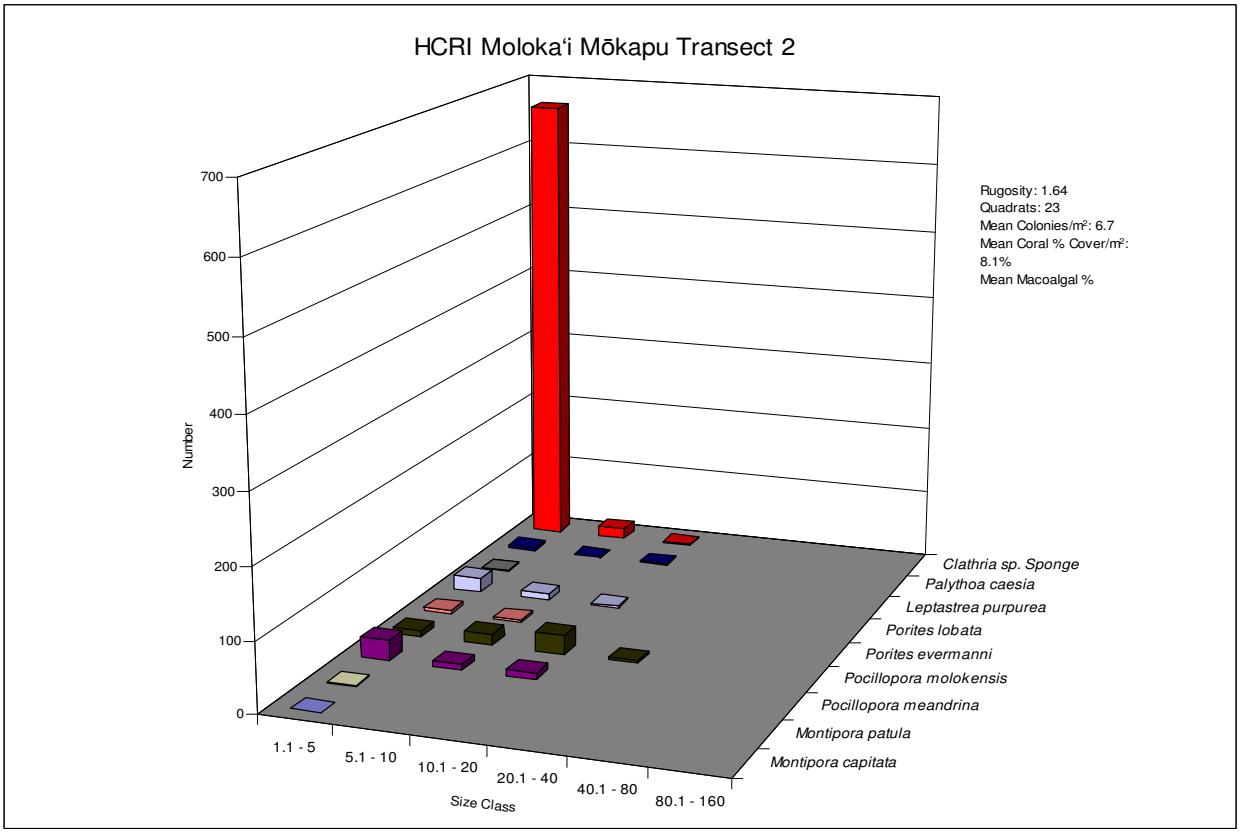


Figure H-3. Size class analysis for corals on HCRI/NFWF Moloka'i Mōkapu 2007 Transects.

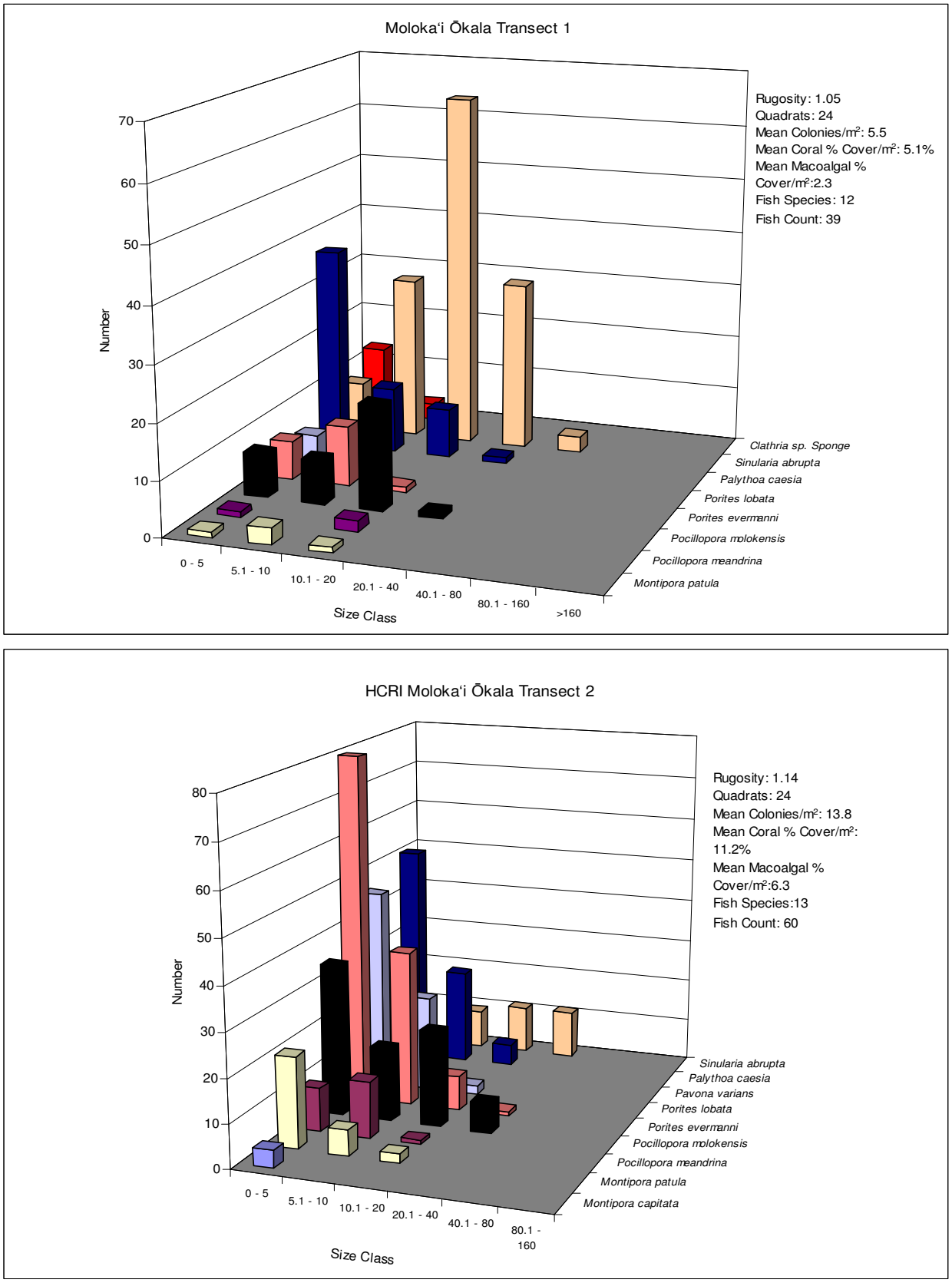


Figure H-4. Size class analysis for corals on HCRI/NFWF Moloka'i Ōkala 2007 Transects.

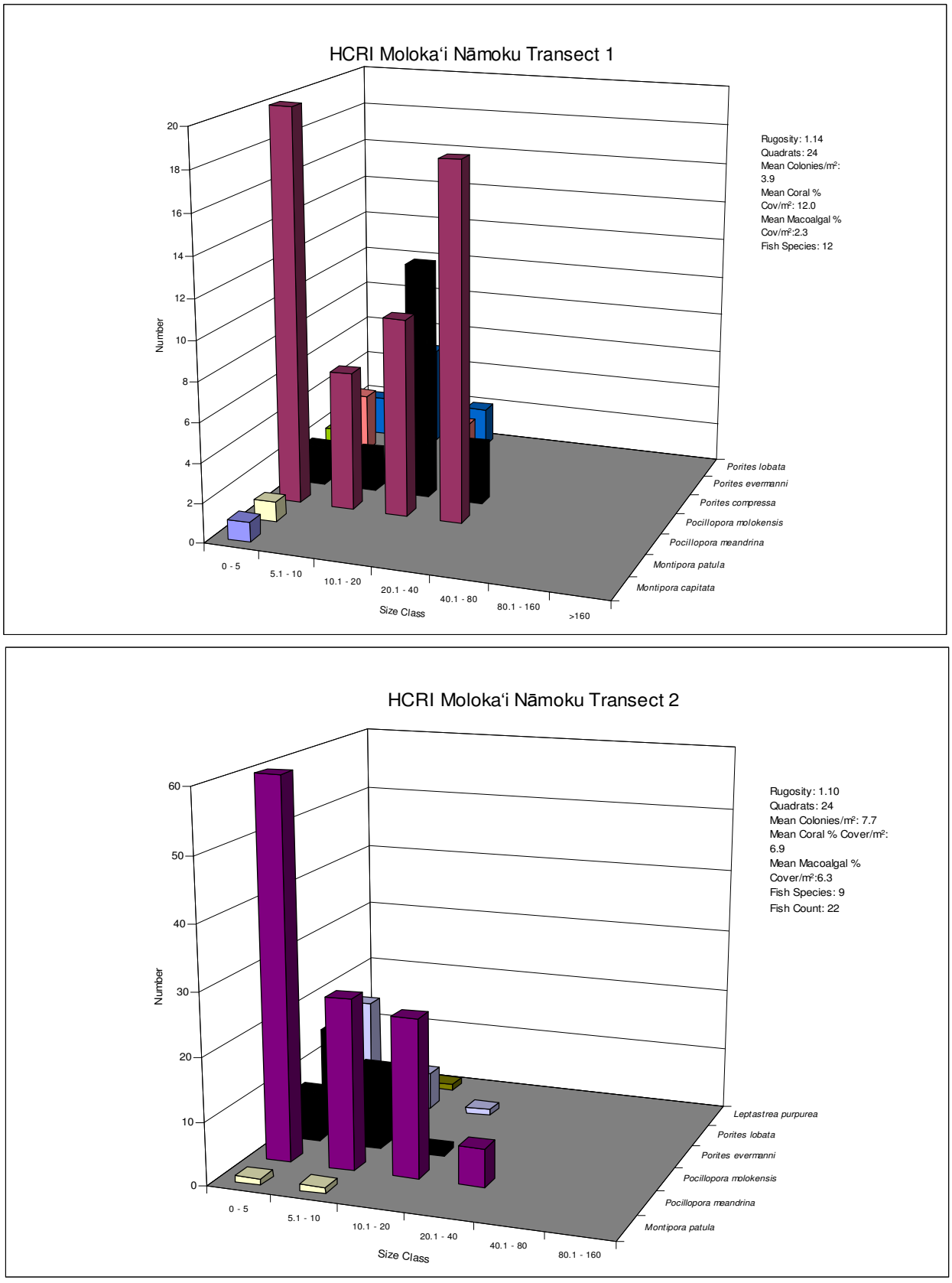


Figure H-5. Size class analysis for corals on HCRI/NFWF Moloka'i Nāmoku 2007 Transects.

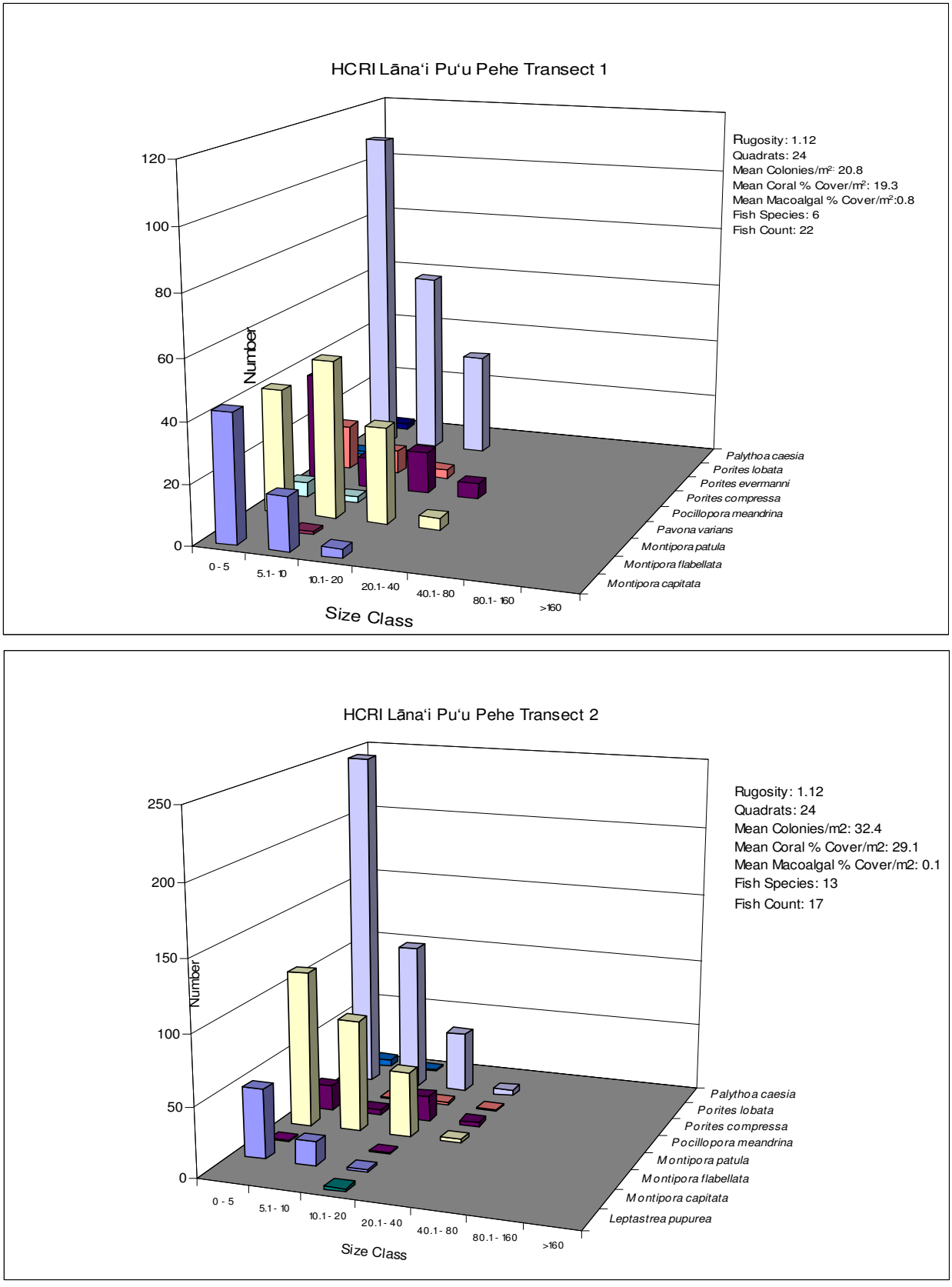


Figure H-6. Size class analysis for corals on HCRI/NFWF Lāna'i Pu'u Pehe 2007 Transects

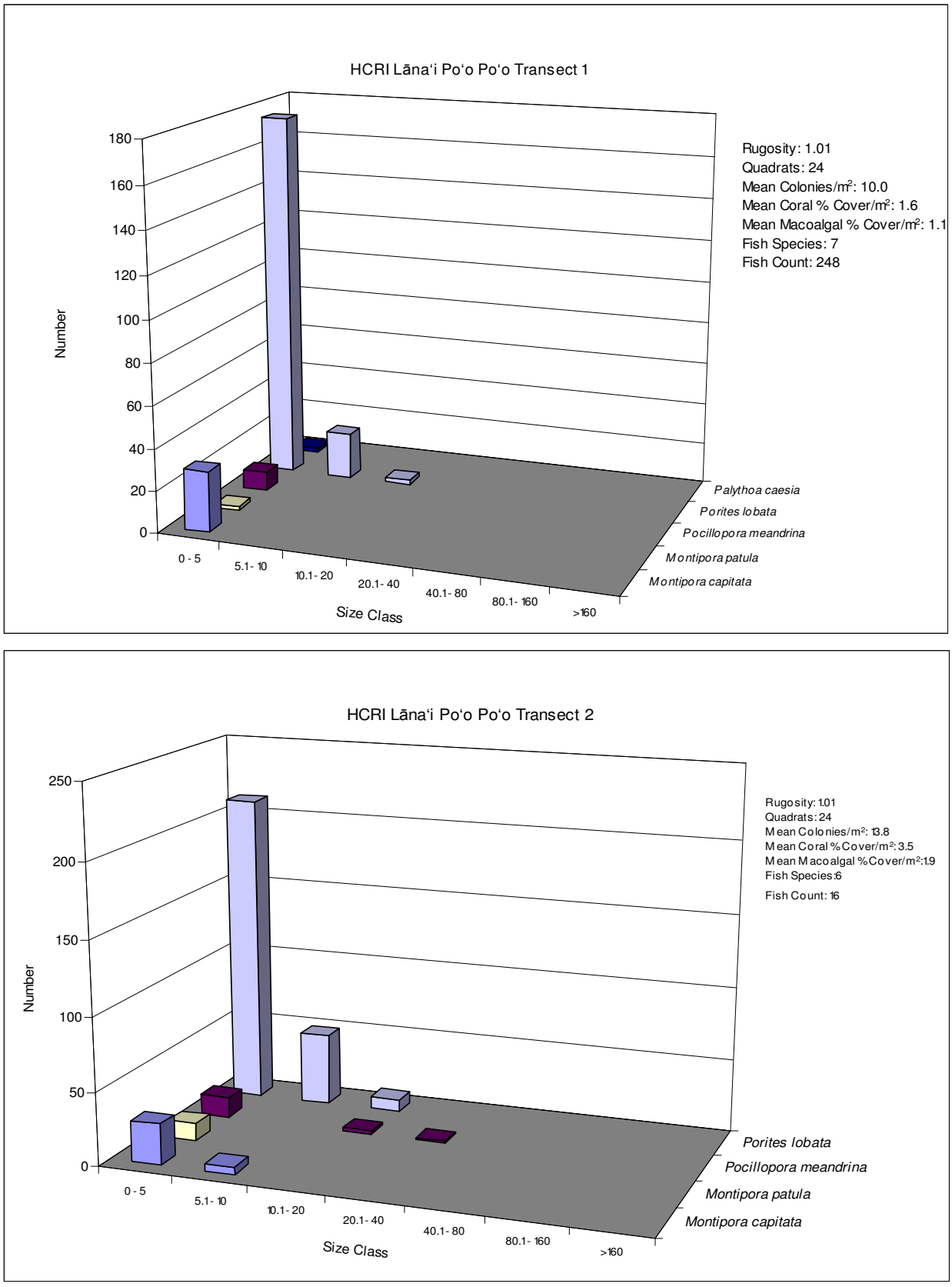


Figure H-7. Size class analysis for corals on HCRI/NFWF Lāna'i Po'o Po'o 2007 Transects

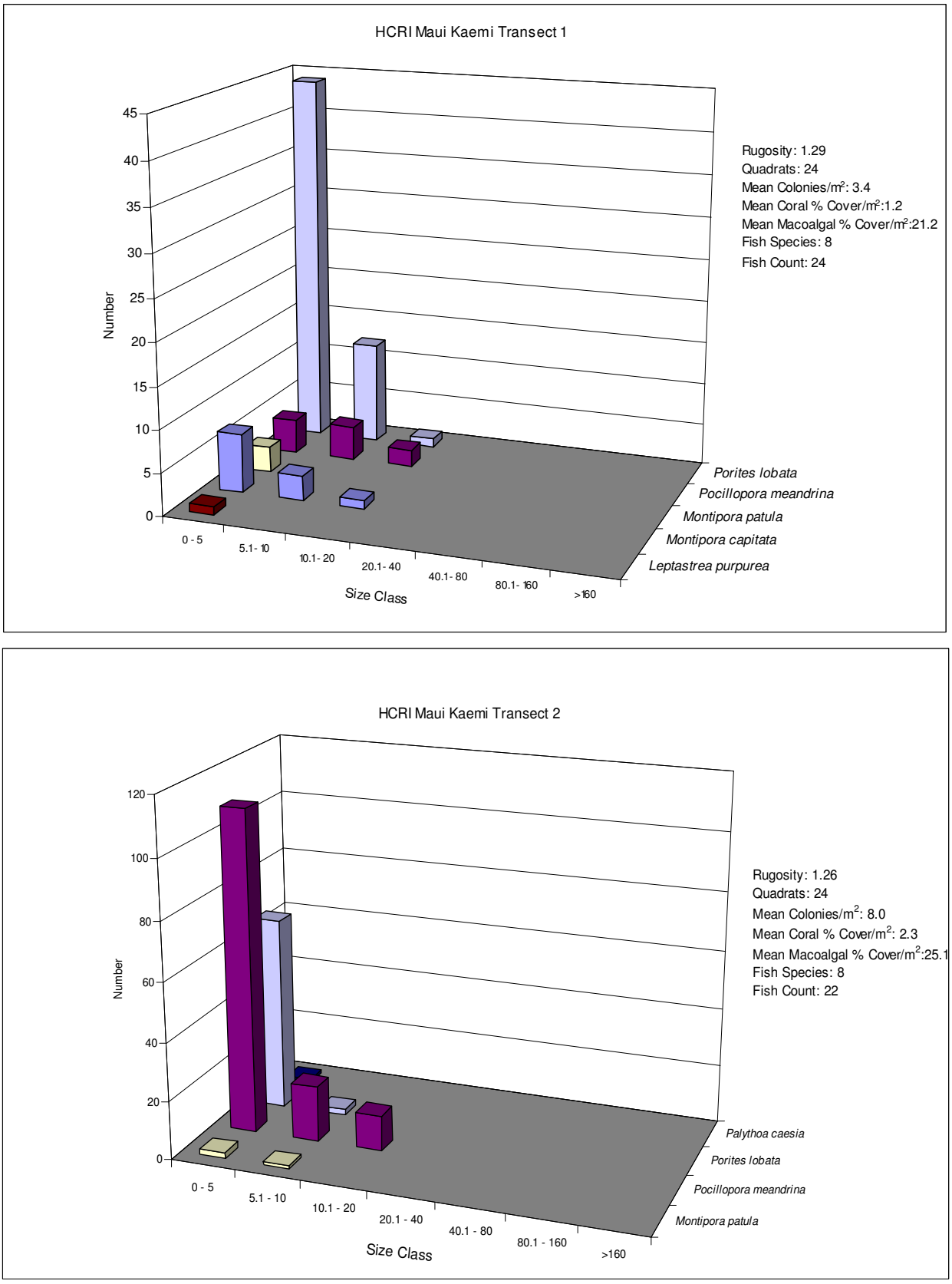


Figure H-8. Size class analysis for corals on HCRI/NFWF Maui Kaemi 2007 Transects

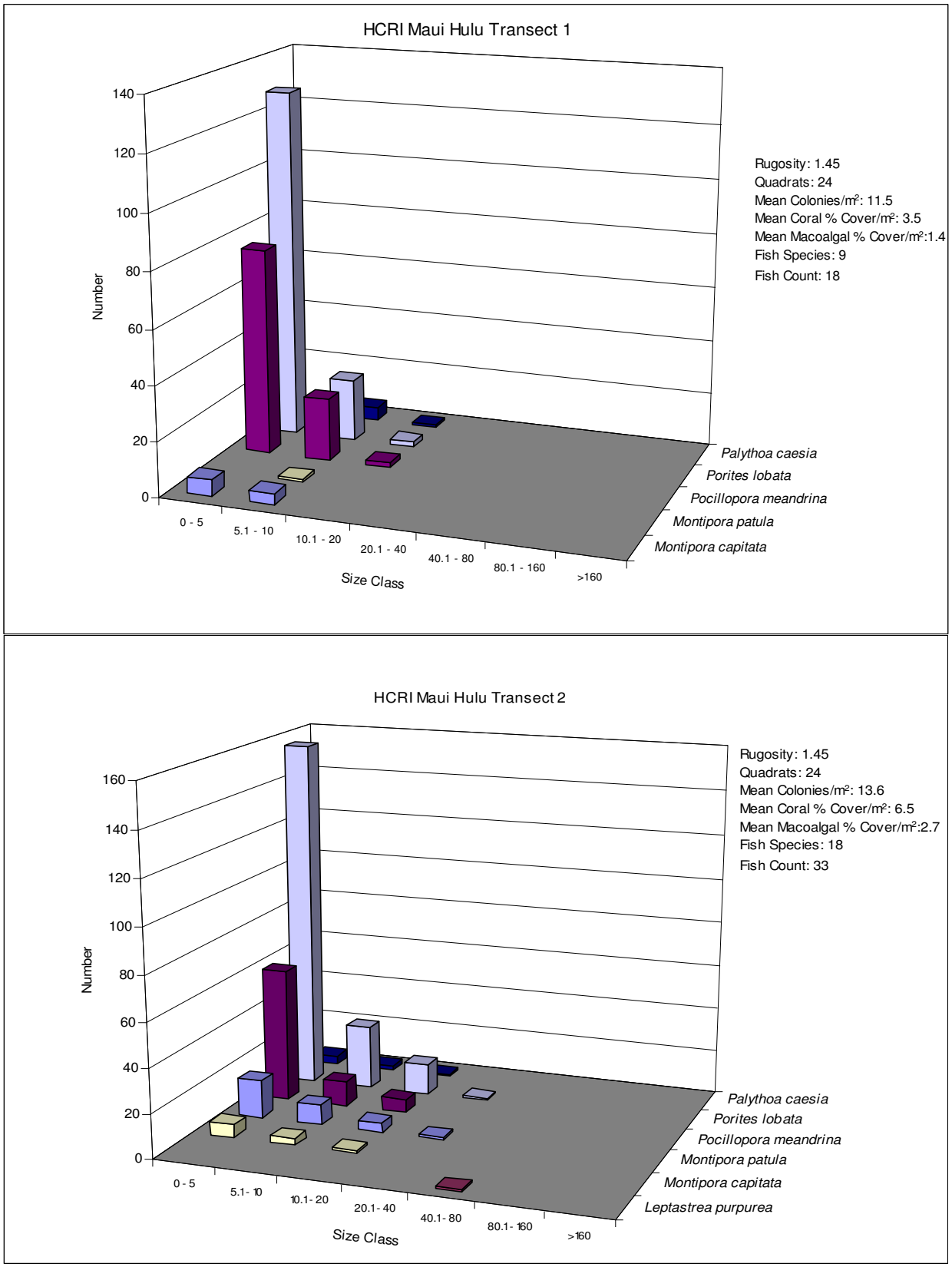
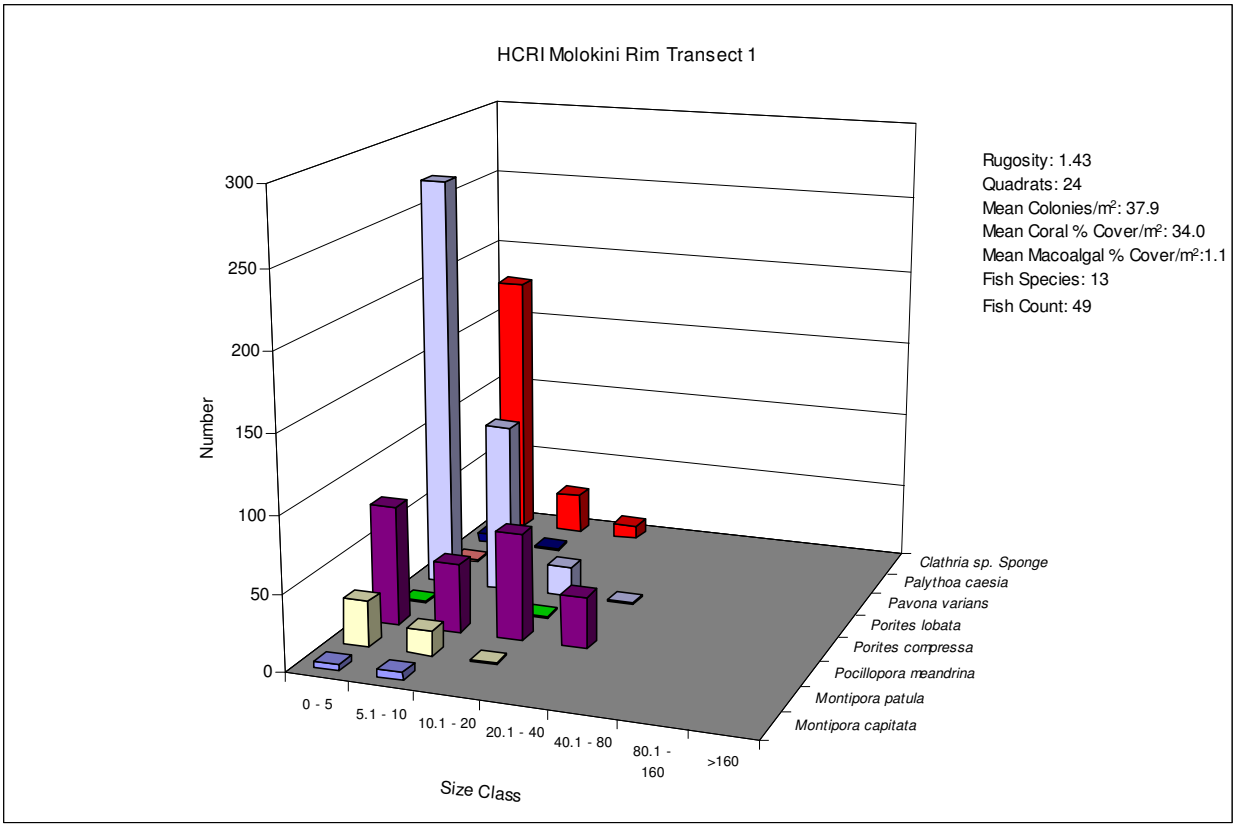
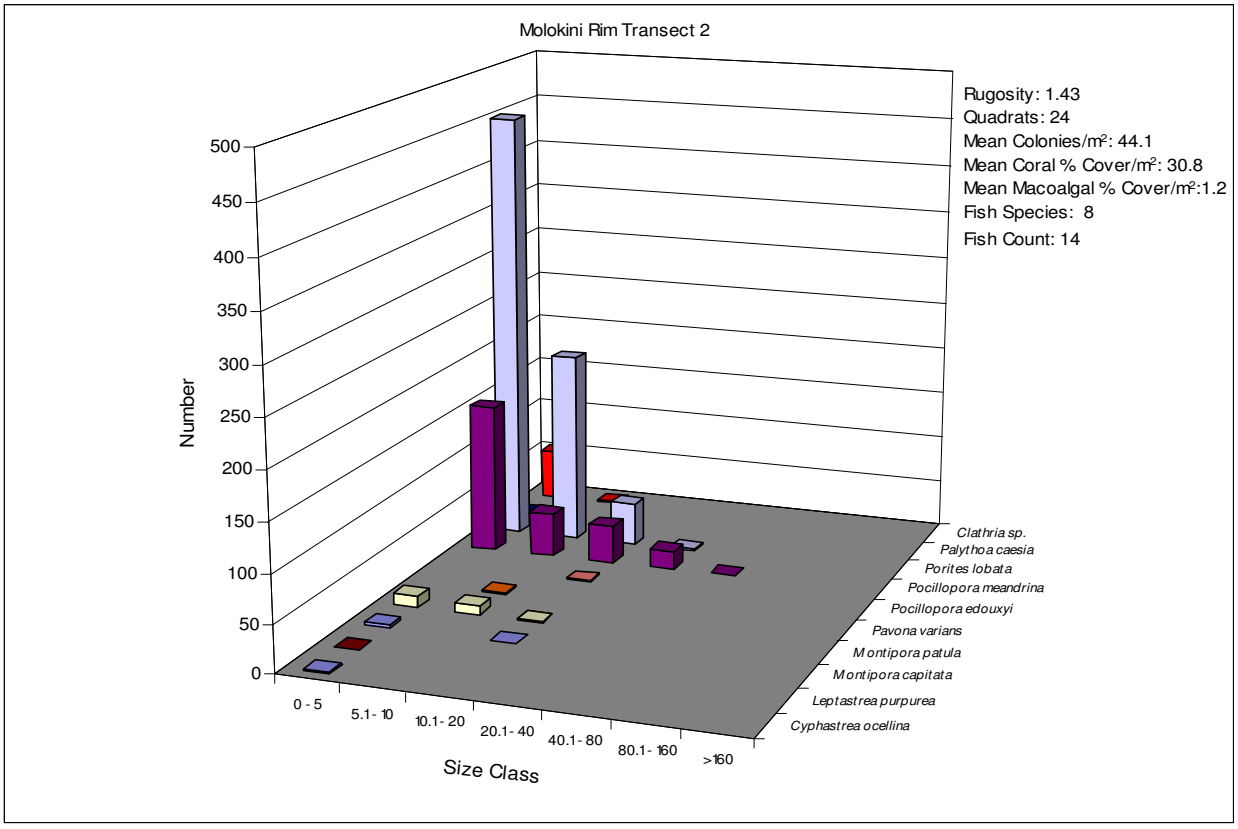


Figure H-9. Size class analysis for corals on HCRI/NFWF Maui Hulu 2007 Transects





FigureH-10. Size class analysis for corals on HCRI/NFWF Molokini Rim 2007 Transects

Appendix I.

Fish Species Occurring at NOAA Survey Sites from Kaula Rock to Moloka‘i

		KAL-1	KAL-2	NII-7	LEH-1	LEH-1	LEH-2	LEH-2	LEH-3	LEH-3	KAI-3	KAI-3	MOL-6	MOL-7
	Taxa	05	06	06	06	05	06	05	06	05	05	06	06	06
Acanthuridae	Acanthuridae sp.	x					x							
	Acanthurus blochii	x	x		x	x		x	x	x	x	x	x	x
	Acanthurus dussumieri	x	x	x	x	x	x	x	x	x	x		x	x
	Acanthurus guttatus		x			x								
	Acanthurus leucopareius	x	x			x		x	x	x	x	x	x	x
	Acanthurus nigrofuscus	x	x	x	x	x	x	x		x	x	x	x	x
	Acanthurus nigroris	x	x	x	x	x	x	x		x	x		x	
	Acanthurus olivaceus	x	x	x	x	x	x	x	x	x	x	x	x	x
	Acanthurus thompsoni		x		x	x	x							
	Acanthurus triostegus	x	x		x	x		x	x	x	x	x		
	Acanthurus xanthopterus		x					x						
	Ctenochaetus hawaiiensis		x		x	x				x				
	Ctenochaetus strigosus		x	x	x	x	x		x		x	x	x	x
	Naso brevirostris	x			x	x	x	x	x	x			x	
	Naso caesius								x					
	Naso hexacanthus	x			x	x			x	x			x	
	Naso lituratus	x	x	x	x	x	x	x	x	x	x	x	x	x
	Naso unicornis	x	x	x	x	x		x	x	x	x	x	x	
	Zebrasoma flavescens	x	x			x	x	x						
	Zebrasoma veliferum					x								
Apogonidae	*Apogon kallopterus*							x						x
Aulostomidae	*Aulostomus chinensis*					x				x			x	x
Balistidae	*Melichthys niger*		x		x	x		x	x	x			x	
	Melichthys vidua	x	x	x	x	x	x	x	x	x	x	x	x	x
	Rhinecanthus rectangulus	x	x			x		x	x	x				
	Sufflamen bursa	x	x	x	x	x	x	x	x	x	x	x	x	x
	Xanthichthys auromarginatus												x	
Blenniidae	*Cirripectes vanderbilti*	x							x	x		x		
	Exallias brevis								x	x			x	x
	Plagiotremus ewaensis			x	x		x		x		x	x		x
	Plagiotremus goslinei	x	x	x	x	x	x	x	x	x	x			x
Caracanthidae	*Caracanthus typicus*					x								
Carangidae	*Carangoides ferdau*			x										

		KAL-1	KAL-2	NII-7	LEH-1	LEH-1	LEH-2	LEH-2	LEH-3	LEH-3	KAI-3	KAI-3	MOL-6	MOL-7
	Taxa	05	06	06	06	05	06	05	06	05	05	06	06	06
	Carangoides orthogrammus		x				x							
	Caranx ignobilis						x							
	Caranx lugubris								x					
	Caranx melampygus	x	x				x	x	x	x	x	x		x
	Decapterus macarellus	x			x					x			x	
Carcharhinidae	*Carcharhinus amblyrhynchos*				x		x		x					x
	Carcharhinus galapagensis								x					
	Triaenodon obesus								x					
Chaetodontidae	*Chaetodon auriga*		x		x	x		x			x			
	Chaetodon ephippium		x		x									
	Chaetodon fremblii				x	x	x				x	x	x	x
	Chaetodon kleinii	x			x				x				x	
	Chaetodon lunula				x	x		x	x				x	x
	Chaetodon miliaris				x	x	x		x	x	x	x	x	
	Chaetodon multicinctus	x	x		x	x	x	x	x	x	x	x	x	x
	Chaetodon ornatissimus		x			x					x	x		x
	Chaetodon quadrimaculatus	x	x		x	x		x	x	x	x		x	x
	Chaetodon reticulatus													
	Chaetodon unimaculatus										x	x		
	Forcipiger flavissimus	x			x	x				x	x		x	x
	Hemitaurichthys polylepis								x					
	Hemitaurichthys thompsoni		x											
	Heniochus diphreutes	x							x					
Cirrhitidae	*Cirrhitops fasciatus*	x	x	x	x	x	x	x	x	x	x		x	x
	Paracirrhites arcatus	x	x	x	x	x	x	x	x	x	x	x	x	x
	Paracirrhites forsteri	x		x	x		x	x	x		x			x
Clupeidae	*Spratelloides delicatulus*							x						
Gobiidae	*Gobiidae* sp.						x				x			
Holocentridae	*Myripristis berndti*		x	x	x	x	x		x		x	x	x	x
	Myripristis kuntee			x	x	x			x					x
	Neoniphon sammara													x
	Neoniphon spp.					x				x				
	Sargocentron diadema					x	x						x	

		KAL-1	KAL-2	NII-7	LEH-1	LEH-1	LEH-2	LEH-2	LEH-3	LEH-3	KAI-3	KAI-3	MOL-6	MOL-7
	Taxa	05	06	06	06	05	06	05	06	05	05	06	06	06
	Sargocentron spiniferum		x		x									
	Sargocentron tiere			x										
	Sargocentron xantherythrum					x	x						x	
Kyphosidae	*Kyphosus bigibbus*						x							x
	Kyphosus cinerascens		x		x	x	x	x						
	Kyphosus sp.		x	x	x	x	x	x	x	x	x		x	x
	Kyphosus vaigiensis								x					
Labridae	*Anampses cuvier*				x	x	x	x			x			
	Bodianus bilunulatus	x	x	x	x	x	x	x	x	x	x	x	x	x
	Coris flavovittata				x		x				x			
	Coris gaimard	x	x		x	x	x	x			x			
	Coris venusta		x	x	x	x	x		x	x	x	x	x	
	Gomphosus varius					x								x
	Halichoeres ornatissimus	x		x	x	x	x		x		x		x	x
	Iniistius pavo				x									
	Labridae sp									x				
	Labroides phthirophagus		x		x					x	x		x	x
	Macropharyngodon geoffroy			x	x	x	x		x		x			
	Novaculichthys taeniourus				x	x								
	Oxycheilinus bimaculatus				x		x							
	Oxycheilinus unifasciatus							x					x	x
	Pseudocheilinus evanidus				x	x								
	Pseudocheilinus octotaenia				x									
	Pseudocheilinus tetrataenia			x	x	x	x		x		x		x	x
	Pseudojuloides cerasinus				x		x	x		x				
	Stethojulis balteata		x	x	x	x	x	x	x	x	x		x	x
	Thalassoma ballieui					x								
	Thalassoma duperrey	x	x	x	x	x	x	x	x	x	x	x	x	x
	Thalassoma purpureum	x	x			x		x	x	x			x	
	Thalassoma quinquevittatum	x	x											
	Thalassoma trilobatum	x	x			x			x	x			x	
Lethrinidae	*Monotaxis grandoculis*	x	x		x	x	x	x	x	x	x	x		x
Lutjanidae	*Aphareus furca*	x	x	x	x	x	x	x	x	x	x			

		KAL-1	KAL-2	NII-7	LEH-1	LEH-1	LEH-2	LEH-2	LEH-3	LEH-3	KAI-3	KAI-3	MOL-6	MOL-7
Lutjanidae	Taxa	05	06	06	06	05	06	05	06	05	05	06	06	06
	Aprion virescens		x	x	x		x	x		x				
	Lutjanus fulvus				x	x	x			x	x			x
	Lutjanus kasmira	x	x	x	x	x	x	x	x	x	x	x	x	x
Malacanthidae	*Malacanthus brevirostris*						x					x		
Microdesmidae	*Gunnellichthys curiosus*				x				x		x			
	Ptereleotris heteroptera											x		
Monacanthidae	*Cantherhines dumerilii*	x	x			x			x		x			
	Cantherhines sandwichiensis	x						x	x	x			x	
	Pervagor aspricaudus												x	x
Mullidae	*Mulloidichthys flavolineatus*				x	x		x		x		x		x
	Mulloidichthys vanicolensis					x								
	Parupeneus cyclostomus	x	x	x	x	x	x	x	x	x	x	x		
	Parupeneus insularis	x	x	x	x	x	x	x	x	x	x	x	x	
	Parupeneus multifasciatus	x	x	x	x	x	x	x	x	x	x	x	x	x
	Parupeneus pleurostigma			x	x	x	x	x		x	x	x		
Muraenidae	*Gymnothorax eurostus*									x				
	Gymnothorax flavimarginatus												x	
	Gymnothorax meleagris					x				x				
Myliobatidae	*Aetobatus narinari*					x								
	Ostracion meleagris		x							x				
Pinguipedidae	*Parapercis schauinslandi*				x									
Pomacanthidae	*Centropyge potteri*			x	x	x	x		x	x	x		x	x
	Desmoholacanthus arcuatus	x	x		x	x	x	x	x	x			x	
Pomacentridae	*Abudefduf abdominalis*				x	x		x		x	x	x		x
	Abudefduf sordidus							x	x					
	Abudefduf vaigiensis				x	x		x		x			x	x
	Chromis agilis				x					x	x		x	x
	Chromis hanui			x	x	x	x	x	x		x	x	x	x
	Chromis ovalis	x			x	x	x	x	x	x	x	x	x	x
	Chromis vanderbilti	x	x	x	x	x	x	x	x	x	x	x	x	x
	Chromis verater		x		x	x	x			x			x	x
	Dascyllus albisella				x	x	x		x		x			
	Plectroglyphidodon imparipennis	x	x	x	x	x	x	x	x	x	x	x	x	x

		KAL-1	KAL-2	NII-7	LEH-1	LEH-1	LEH-2	LEH-2	LEH-3	LEH-3	KAI-3	KAI-3	MOL-6	MOL-7
	Taxa	05	06	06	06	05	06	05	06	05	05	06	06	06
	Plectroglyphidodon johnstonianus	x	x	x	x	x	x	x	x	x	x		x	x
	Stegastes fasciolatus	x	x	x	x	x	x			x	x		x	x
Priacanthidae	*Priacanthus meeki*										x			x
Scaridae	*Calotomus carolinus*			x	x	x	x	x	x	x	x		x	
	Calotomus zonarchus			x										
	Chlorurus perspicillatus				x	x	x	x		x				
	Chlorurus sordidus	x			x		x	x	x		x			x
	Scarus dubius				x					x			x	
	Scarus psittacus			x	x	x	x						x	
	Scarus rubroviolaceus	x	x	x	x	x	x	x	x	x	x	x	x	x
Scorpaenidae	*Scorpaenopsis diabolus*								x					
	Sebastapistes coniorta					x							x	x
	Taenianotus triacanthus						x							
Serranidae	*Cephalopholis argus*			x	x		x							x
	Pseudanthias bicolor									x				
Sphyraenidae	*Sphyraena barracuda*				x	x								
	Saurida gracilis						x							
	Synodus sp.				x		x						x	
Tetraodontidae	*Arothron meleagris*		x										x	
	Canthigaster amboinensis			x							x			x
	Canthigaster coronata				x	x					x	x	x	x
	Canthigaster jactator			x		x	x		x		x	x	x	x
Zanclidae	*Zanclus cornutus*	x	x		x	x	x	x	x	x	x	x	x	x
	Species Count	53	62	47	92	91	75	62	72	71	70	42	69	65

Appendix J.

Fish Species Occurring at NOAA Survey Sites from Lāna‘i to Hawai‘i

	Taxa	LAN-6 05	LAN-6 06	MAI-2 05	MAI-10 06	MAI-20 06	MOK-1 05	MOK-2 05	MOK-3 05	HAW-11 05	HAW-20 06
Acanthuridae	*Acanthus acchilles/nigricans hybrid*		X							x	
	Acanthurus achilles	X	X		x					x	x
	Acanthurus blochii	X	X	x	x		x	x		x	x
	Acanthurus dussumieri	X	X	x	x	x		x		x	x
	Acanthurus guttatus		X								
	Acanthurus leucopareius			x	x	x				x	x
	Acanthurus nigricans		X				x	x		x	
	Acanthurus nigrofuscus	X	X	x	x	x	x	x	x	x	x
	Acanthurus nigroris			x	x					x	x
	Acanthurus olivaceus	X	X	x	x	x		x	x	x	x
	Acanthurus thompsoni	X	X		x					x	
	Acanthurus triostegus			x		x					x
	Ctenochaetus hawaiiensis				x		x	x		x	
	Ctenochaetus strigosus	X	X		x	x	x	x	x	x	
	Naso brevirostris		X						x		
	Naso hexacanthus	X	X		x		x	x		x	
	Naso lituratus	X	X	x	x	x	x	x	x	x	x
	Naso unicornis	X	X	x		x				x	x
	Zebrasoma flavescens	X	X		x	x	x	x	x	x	
	Zebrasoma veliferum	X	X	x	x						
Apogonidae	*Apogon kallopterus*	X								x	x
	Foa brachygramma										
Aulostomidae	*Aulostomus chinensis*				x	x	x	x			x
Balistidae	*Melichthys niger*	X	X	x	x			x	x	x	x
	Melichthys vidua	X	X	x	x		x	x	x	x	
	Rhinecanthus rectangulus					x					x
	Sufflamen bursa	X	X	x	x	x	x	x	x	x	x
	Sufflamen fraenatus	X		x	x	x					x
	Xanthichthys auromarginatus						x	x	x	x	
Blenniidae	*Cirripectes vanderbilti*					x					x
	Exallias brevis										
	Plagiotremus ewaensis				x			x			x
	Plagiotremus goslinei	X		x						x	x

		LAN-6	LAN-6	MAI-2	MAI-10	MAI-20	MOK-1	MOK-2	MOK-3	HAW-11	HAW-20
	Taxa	05	06	05	06	06	05	05	05	05	06
Carangidae	*Caranx ignobilis*						x	x		x	
	Caranx melampygus	X	X				x	x	x		x
	Decapterus macarellus	X		x							
	Scomberoides lysan		X								
	Selar crumenophthalmus					x					
Carcharhinidae	*Carcharhinus amblyrhynchos*					x					
	Triaenodon obesus						x	x			
Chaetodontidae	*Chaetodon auriga*	X		x				x	x	x	
	Chaetodon fremblii				x	x				x	
	Chaetodon kleinii	X	X				x	x	x		
	Chaetodon lunula	X	X			x	x	x	x	x	
	Chaetodon miliaris	X			x		x	x			
	Chaetodon multicinctus	X	X		x	x	x	x		x	
	Chaetodon ornatissimus	X	X	x		x	x	x	x	x	
	Chaetodon quadrimaculatus	X	X	x		x	x	x		x	x
	Chaetodon reticulatus						x				
	Chaetodon unimaculatus							x		x	
	Forcipiger flavissimus	X	X	x		x	x		x	x	x
	Forcipiger longirostris	X		x		x		x		x	
	Hemitaurichthys polylepis						x	x		x	
	Heniochus diphreutes						x	x			
Cirrhitidae	*Cirrhitops fasciatus*	X	X	x	x	x		x	x		x
	Oxycirrhites typus			x							
	Paracirrhites arcatus	X	X	x	x	x	x	x	x	x	x
	Paracirrhites forsteri	X	X		x	x		x		x	x
	Spratelloides delicatulus										x
Clupeidae	*Diodon hystrix*							x			
Diodontidae	*Fistularia commersonii*						x	x			
Gobiidae	*Bryaninops* sp.						x				
	Gobiidae sp.	X									
	Hyporhamphus acutus pacificus									x	
Hemiramphidae	*Myripristis amaena*									x	x
Holocentridae	*Myripristis berndti*	X	X		x	x	x	x	x	x	x

		LAN-6	LAN-6	MAI-2	MAI-10	MAI-20	MOK-1	MOK-2	MOK-3	HAW-11	HAW-20
	Taxa	05	06	05	06	06	05	05	05	05	06
	Myripristis kuntee					x	x	x	x	x	
	Neoniphon sammara	X				x		x			
	Sargocentron ensiferum							x			
	Sargocentron spiniferum							x			
	Sargocentron tiere					x				x	
	Sargocentron xantherythrum					x					x
Kyphosidae	*Kyphosus cinerascens*		X	x	x						x
	Kyphosus sp.	X		x	x	x	x		x	x	x
Labridae	*Anampses chrysocephalus*			x	x						
	Anampses cuvier					x		x	x		x
	Bodianus bilunulatus	X	X	x	x	x				x	x
	Coris gaimard		X	x		x		x	x	x	x
	Coris venusta		X	x	x						x
	Gomphosus varius	X	X	x	x	x	x	x	x	x	
	Halichoeres ornatissimus	X	X	x	x	x	x	x	x	x	x
	Labroides phthirophagus	X	X	x	x	x		x		x	x
	Macropharyngodon geoffroy		X	x		x	x	x		x	x
	Novaculichthys taeniourus								x	x	
	Oxycheilinus bimaculatus								x		
	Oxycheilinus unifasciatus	X	X		x	x			x	x	
	Pseudocheilinus evanidus	X	X	x			x	x	x	x	
	Pseudocheilinus octotaenia	X	X	x	x		x	x	x	x	
	Pseudocheilinus tetrataenia	X	X	x	x	x	x	x	x	x	
	Pseudojuloides cerasinus			x					x		
	Stethojulis balteata	X	X	x		x		x		x	x
	Thalassoma ballieui			x		x					x
	Thalassoma duperrey	X	X	x	x	x	x	x	x	x	x
	Thalassoma purpureum						x	x			
	Thalassoma trilobatum					x		x			
	Monotaxis grandoculis	X			x	x	x			x	
Lethrinidae	*Aphareus furca*		X	x	x	x	x	x		x	
	Aprion virescens			x	x				x		
Lutjanidae	*Lutjanus fulvus*	X	X	x	x	x	x	x			x
	Lutjanus kasmira			x	x	x		x		x	x

		LAN-6	LAN-6	MAI-2	MAI-10	MAI-20	MOK-1	MOK-2	MOK-3	HAW-11	HAW-20
	Taxa	05	06	05	06	06	05	05	05	05	06
Microdesmidae	*Aluterus scriptus*							x			
Monacanthidae	*Cantherhines dumerilii*	X				x	x	x	x	x	
	Cantherhines sandwichiensis			x			x	x		x	
	Pervagor aspricaudus							x	x		
Mullidae	*Mulloidichthys flavolineatus*				x	x					x
	Mulloidichthys vanicolensis		X		x	x					x
	Parupeneus cyclostomus		X		x			x			
	Parupeneus insularis		X		x	x	x			x	x
	Parupeneus multifasciatus	X	X	x	x	x	x	x	x	x	x
	Parupeneus pleurostigma		X						x		
	Parupeneus porphyreus										x
Muraenidae	*Gymnothorax flavimarginatus*	X				x		x			
	Gymnothorax melatremus						x	x			
	Gymnothorax meleagris			x	x			x	x		
	Gymnothorax sp.					x					
Oplegnathidae	*Oplegnathus punctatus*				x						
Ostraciidae	*Ostracion meleagris*	X					x				
Pinguipedidae	*Parapercis schauinslandi*								x		
Pomacanthidae	*Centropyge fisheri*						x	x	x		
	Centropyge potteri	X	X		x	x	x	x	x	x	x
	Desmoholacanthus arcuatus			x	x					x	
Pomacentridae	*Abudefduf abdominalis*			x	x	x	x			x	
	Abudefduf vaigiensis				x		x		x		
	Chromis agilis	X	X	x	x	x	x	x	x	x	
	Chromis hanui	X	X	x	x	x	x	x	x	x	x
	Chromis ovalis		X	x	x	x		x		x	x
	Chromis vanderbilti	X	X	x	x	x	x	x		x	x
	Chromis verater				x		x	x			
	Dascyllus albisella	X	X				x	x	x	x	
	Plectroglyphidodon imparipennis			x			x	x		x	x
	Plectroglyphidodon johnstonianus	X	X	x	x	x	x	x	x	x	x
	Stegastes fasciolatus	X	X	x	x	x	x	x	x	x	x
Priacanthidae	*Priacanthus meeki*				x	x					
Scaridae	*Calotomus carolinus*	X			x	x	x	x			x

		LAN-6	LAN-6	MAI-2	MAI-10	MAI-20	MOK-1	MOK-2	MOK-3	HAW-11	HAW-20
	Taxa	05	06	05	06	06	05	05	05	05	06
	Chlorurus perspicillatus					x				x	
	Chlorurus sordidus	x	x	x	x		x	x	x	x	x
	Scarus dubius				x	x				x	
	Scarus psittacus	x			x	x	x	x	x		
	Scarus rubroviolaceus	x	x	x	x	x	x	x	x	x	x
	Scarus sp.	x		x	x				x		
Scorpaenidae	*Scorpaenopsis cacopsis*										x
Serranidae	*Cephalopholis argus*	x	x	x	x	x	x		x	x	x
Sphyraenidae	*Sphyraena barracuda*						x				
Synodontidae	*Synodus binotatus*	x									
	Synodus sp.										x
Tetraodontidae	*Arothron hispidus*						x				
	Arothron meleagris	x	x				x	x			
	Canthigaster amboinensis	x	x	x		x			x		x
	Canthigaster coronata								x		
	Canthigaster jactator	x	x	x	x	x	x	x	x	x	
Zanclidae	*Zanclus cornutus*	x	x	x	x	x	x	x		x	x
	Species Count	70	67	64	72	74	70	83	56	79	63

Appendix K

Fish Species Occurring at HCRI/NFWF Survey Sites

Family	Species	OAH-Kao	OAH-Kap	MOL-Mok	MOL-Nam	MOL-Oka	LAN-Po'o	LAN-Pu'u	MAI-Hul	MAI-Kae	MOK-Rim
Acanthuridae	*Acanthurus achilles*							x			x
	Acanthurus blochii		x		x	x	x	x	x		x
	Acanthurus dussumieri			x	x	x	x		x	x	
	Acanthurus guttatus				x			x			
	Acanthurus leucopareius	x	x	x	x	x	x	x	x	x	x
	Acanthurus nigrofuscus	x	x	x	x	x	x	x	x	x	x
	Acanthurus nigroris	x		x	x	x					
	Acanthurus olivaceus	x	x	x	x	x	x	x			x
	Acanthurus triostegus	x	x		x		x	x	x		
	Acanthurus xanthopterus										x
	Ctenochaetus hawaiiensis										x
	Ctenochaetus strigosus	x	x	x	x	x			x	x	x
	Naso brevirostris			x	x						
	Naso hexacanthus	x		x	x	x	x				x
	Naso lituratus	x		x	x	x	x	x	x	x	x
	Naso unicornis		x	x	x	x	x	x	x	x	x
	Zebrasoma flavescens	x			x			x		x	x
	Zebrasoma veliferum				x						
Apogonidae	*Apogon sp.*		x								
Aulostomidae	*Aulostomus chinensis*	x		x				x			
Balistidae	*Canthidermis maculatus*							x			
	Melichthys niger	x		x		x		x			x
	Melichthys vidua	x		x	x	x	x	x			x
	Rhinecanthus aculeatus		x								
	Rhinecanthus rectangulus				x			x	x	x	
	Sufflamen bursa	x	x	x	x	x	x	x	x	x	x
	Sufflamen fraenatus	x		x		x			x		
	Xanthichthys auromarginatus			x				x			x
Blenniidae	*Blenniidae*		x								
	Cirripectes vanderbilti				x						
	Plagiotremus ewaensis				x						
Blenniidae	*Plagiotremus goslinei*		x		x				x	x	
Caracanthidae	*Caracanthus typicus*			x	x	x					
Carangidae	*Caranx melampygus*	x			x						x
	Decapterus macarellus	x		x	x				x		x
	Scomberoides lysan			x							
	Selar crumenophthalmus						x				
Carangidae	*Seriola dumerili*									x	
Carcharhinidae	*Triaenodon obesus*										x
Chaetodontidae	*Chaetodon auriga*		x		x	x	x				x
	Chaetodon ephippium	x									
	Chaetodon fremblii	x		x	x	x			x	x	
	Chaetodon kleinii	x		x							x

Family	Species	OAH-Kao	OAH-Kap	MOL-Mok	MOL-Nam	MOL-Oka	LAN-Po'o	LAN-Pu'u	MAI-Hul	MAI-Kae	MOK -Rim
Chaetodontidae	*Chaetodon lineolatus*		x								
	Chaetodon lunulatus			x	x						
	Chaetodon lunula	x	x		x	x	x	x	x		
	Chaetodon miliaris	x		x	x	x					x
	Chaetodon multicinctus	x		x	x	x			x	x	x
	Chaetodon ornatissimus	x			x		x	x	x		x
	Chaetodon quadrimaculatus	x	x	x	x	x		x	x	x	x
	Chaetodon unimaculatus	x	x			x		x			
	Forcipiger flavissimus	x		x	x	x			x	x	x
	Forcipiger longirostris				x						
	Hemitaurichthys polylepis										
Cirrhitidae	*Cirrhitops fasciatus*		x	x	x	x	x		x		
	Cirrhitus pinnulatus				x						
	Paracirrhites arcatus	x	x	x	x	x	x	x	x	x	x
	Paracirrhites forsteri				x	x	x	x	x		x
Hemiramphidae	*Hemiramphus depauperatus*				x						
Holocentridae	*Myripristis amaena*			x	x						
	Myripristis berndti			x	x	x			x	x	x
	Sargocentron xantherythrum			x							
Kuhliidae	*Kuhlia sandvicensis*						x				
Kyphosidae	*Kyphosus bigibbus*			x	x						
	Kyphosus cinerascens				x	x					x
	Kyphosus sp.	x	x					x	x		x
Labridae	*Anampses cuvier*								x	x	
	Anampses chrysocephalus			x							
	Bodianus bilunulatus	x	x	x	x	x	x	x	x	x	
	Cheilio inermis	x									
	Cirrhilabrus jordani						x				
	Coris flavovittata	x									
	Coris gaimard	x	x		x		x	x	x	x	x
	Coris venusta	x				x	x	x	x		
	Gomphosus varius	x	x		x			x			x
	Halichoeres ornatissimus	x	x	x	x	x	x		x	x	x
	Labroides phthirophagus	x	x	x	x	x	x	x	x		x
	Macropharyngodon geoffroy		x		x					x	
	Novaculichthys taeniourus	x	x								
	Oxycheilinus unifasciatus										
	Pseudocheilinus evanidus						x				
	Pseudocheilinus octotaenia		x			x		x			x
	Pseudocheilinus tetrataenia			x	x	x	x				
	Stethojulis balteata	x	x		x	x			x	x	
	Thalassoma ballieui		x								x
	Thalassoma duperrey	x	x	x	x	x	x	x	x	x	x

Family	Species	OAH-Kao	OAH-Kap	MOL-Mok	MOL-Nam	MOL-Oka	LAN-Po'o	LAN-Pu'u	MAI-Hul	MAI-Kae	MO-Rim
	Thalassoma lutescens										
Labridae	*Thalassoma purpureum*		x								
	Thalassoma trilobatum			x	x	x			x	x	x
Lethrinidae	*Monotaxis grandoculis*	x			x						x
Lutjanidae	*Aphareus furca*	x			x	x					x
	Aprion virescens				x						
	Lutjanus fulvus	x			x			x			x
	Lutjanus kasmira			x	x				x		x
Monacanthidae	*Cantherhines dumerilii*		x		x	x		x	x		x
	Cantherhines sandwichiensis			x	x	x				x	x
	Cantherhines verecundus			x							
Mullidae	*Mulloidichthys vanicolensis*			x					x		x
	Parupeneus bifasciatus	x			x	x	x	x	x	x	
	Parupeneus cyclostomus	x			x	x	x	x	x		
	Parupeneus multifasciatus	x	x	x	x	x	x	x	x	x	x
	Parupeneus pleurostigma				x						
	Parupeneus porphyreus				x				x		
Muraenidae	*Gymnothorax flavimarginatus*								x		x
	Gymnothorax meleagris							x			
	Gymnothorax undulatus		x								
Ostraciidae	*Ostracion meleagris*	x		x	x	x	x		x	x	
Pomacanthidae	*Centropyge potteri*	x		x		x					x
Pomacanthidae	*Desmoholacanthus arcuatus*			x		x					
Pomacentridae	*Abudefduf abdominalis*	x		x	x		x		x	x	
	Abudefduf sordidus				x				x	x	x
	Abudefduf vaigiensis			x	x						
	Chromis agilis	x		x	x	x		x			x
	Chromis hanui		x	x	x	x	x				x
	Chromis ovalis	x	x	x	x	x					
	Chromis vanderbilti	x	x	x	xx	x	x	x	x	x	x
	Chromis verater	x		x		x					x
	Dascyllus albisella										x
	Plectroglyphidodon imparipennis	x	x		x	x			x	x	x
	Plectroglyphidodon johnstonianus	x	x	x	x	x	x	x	x		x
	Plectroglyphidodon sindonis										x
	Stegastes fasciolatus	x	x	x	x	x		x	x	x	x
Priacanthidae	*Priacanthus meeki*								x		
Scaridae	*Calotomus carolinus*	x		x	x	x			x		
	Calotomus zonarchus	x	x								
	Chlorurus perspicillatus			x	x					x	
	Chlorurus sordidus		x		x			x	x	x	x
	Scarus dubius	x			x			x	x		x
	Scarus psittacus			x	x	x		x		x	x

Family	Species	OAH-Kao	OAH-Kap	MOL-Mok	MOL-Nam	MOL-Oka	LAN-Po'o	LAN-Pu'u	MAI-Hul	MAI-Kae	MOK-Rim
	Scarus rubroviolaceus			x	x	x	x	x	x	x	x
	Scarus sp.						x				
Scorpaenidae	*Dendrochirus barberi*				x						
	Scorpaenopsis cacopsis			x							
	Sebastapistes ballieui			x		x					
	Sebastapistes coniorta			x		x					
Serranidae	*Cephalopholis argus*	x	x		x	x	x	x	x		
Sphyraenidae	*Sphyraena barracuda*					x					
Tetraodontidae	*Arothron meleagris*	x		x				x			
	Canthigaster amboinensis		x	x					x	x	
	Canthigaster coronata	x		x							
	Canthigaster jactator	x	x	x	x	x	x	x	x	x	x
Zanclidae	*Zanclus cornutus*	x	x	x	x	x		x	x	x	x
	Species Count	63	47	68	86	63	40	49	57	41	65