

Rapid Assessment of Kaloko/Honokohau and Pu'uhonua o Honaunau, West Hawai'i.

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1.0 Introduction

1.1 Overview of coral reefs - Main Hawaiian Islands

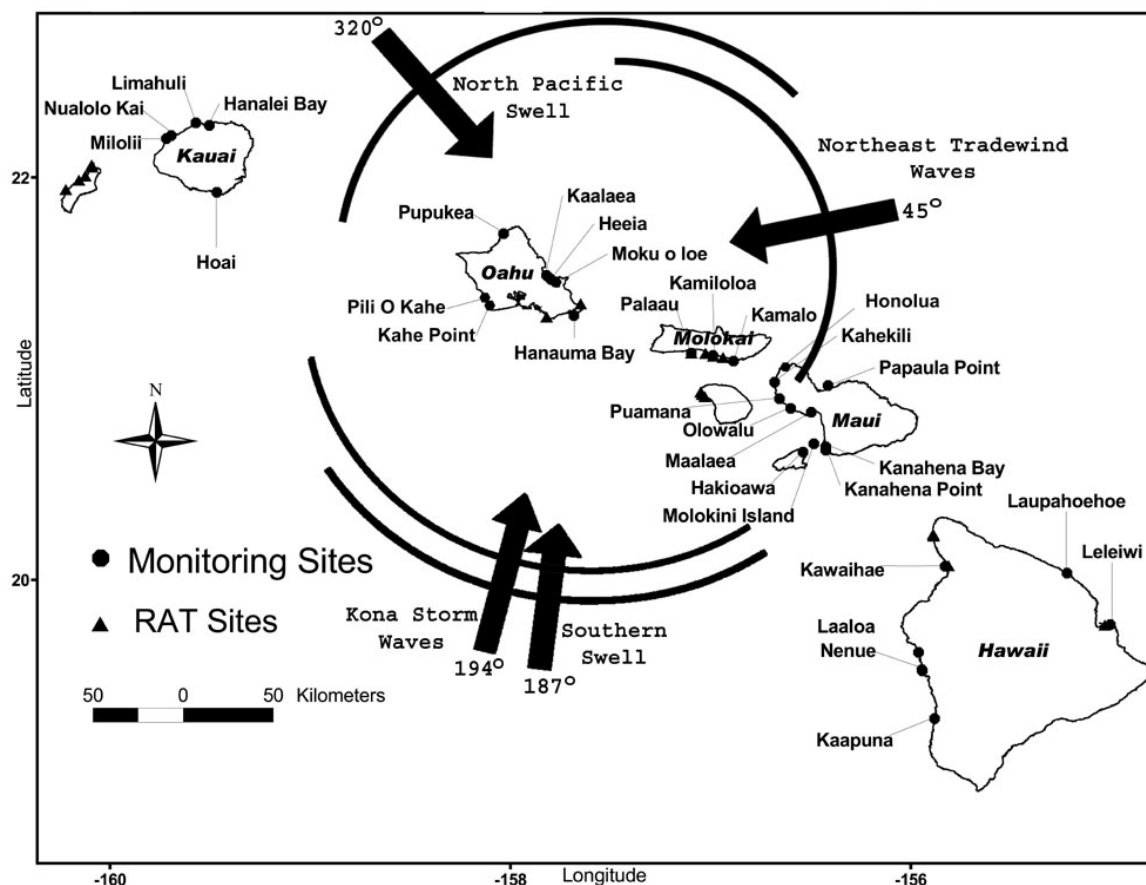


Fig.1-1. Map of the main Hawaiian Islands showing the 30 CRAMP monitoring sites (labeled by name) and the clusters for the 92 rapid assessment (RAT) sites. At each monitoring site there are two stations, one in shallow water (generally 3m) and one in deep water (generally 10m). General direction of waves influencing the Hawaiian Islands are also shown for reference (After Moberly and Chamberlain 1964). Two more sites were added (SE O'ahu, W. Maui) during 2004 to this array as part of this project.

The Hawai'i Coral Reef Assessment and Monitoring Program (CRAMP) has surveyed a number of sites throughout the state (Fig. 1.1) and has produced a systematic and broadly comprehensive description of the spatial differences and the temporal changes in Hawaiian reef coral communities in the main Hawaiian Islands (Jokiel et al. 2004). Information collected and analyzed to date (prior to the addition of Kaloko and Honaunau) describes the major ecological factors controlling the status of reef coral communities in the main eight Hawaiian Islands (Jokiel et al. 2004). Methodology is described in Brown et al. (2004).

Analysis of these temporal and spatial data demonstrate that numerous statistically significant environmental factors influence reef coral communities, so the situation is complex and no single environmental variable can be used to describe and explain changes in reef status. Analysis of the spatial data set revealed that various biological parameters (i.e. coral cover,

coral species richness, and coral diversity) show a significant relationship with the physical factors of rugosity, sediment composition, mean wave direction, mean wave height, rainfall and geologic age of the islands. Multivariate analysis identified four parameters (maximum wave height, geologic age, rugosity and percentage of silt) that are the most important in explaining variation in coral community structure. These observations are consistent with and amplify the findings of many previous classic studies:

- Maximum wave height is an index of storm wave damage to reefs. Dollar (1982) and Storlazzi et al. (2002) showed that waves in Hawai'i, can reach destructive levels that will damage corals and restrict species distribution patterns. Mean wave direction (expressed as compass bearing) showed a negative relationship with coral cover, species richness, and diversity. This is because major storm surf in Hawai'i (Fig.1.1) arrives along a gradient that roughly diminishes in a counter clockwise direction from the North (Moberly and Chamberlain 1964). The result is a positive correlation between wave direction and wave height. The largest and most frequent storm surf arrives during the winter North Pacific Swell (bearing 315°) with the less frequent and less damaging storm waves during the summer from the South Swell (bearing 190°) to the less severe Trade Wind Swell (bearing 45°) (Fig.1.1). Sites exposed to west and northwest swells on the older islands (e.g. Kaua'i and O'ahu) generally had lower coral coverage, species richness and diversity.
- Geologic age is a major factor influencing reef coral community structure as indicated by both the univariate and multivariate analysis. The Hawaiian Islands formed over the hot spot located near the southeast end of the archipelago and over millions of years have gradually moved to the northwest on the Pacific Plate (Clague and Dalrymple 1994). The islands are thus moving to higher latitude over time so there is a high correlation (0.95) between island age and latitude. Light and temperature conditions favorable to coral growth diminish with increasing latitude and increasing island age. Grigg (1982) previously demonstrated that coral growth and coral cover diminishes with latitude (=age) along the Hawaiian archipelago over the range from the island of Hawai'i (19°N) to Kure Atoll (28.5°N). The Jokiel et al. (2004) study was conducted over a smaller latitudinal range (19°N to 22°N), but with a much more extensive sample and shows the importance of island age or latitude on reef coral community structure within the main Hawaiian Islands.
- Statistical analysis of the data set showed rugosity is an important factor. Areas of antecedent high rugosity allow corals to attach and grow on higher substrata not influenced by sand and sediment movement along the bottom. Birkeland et al. (1981) and Rogers et al. (1984) observed that coral larvae preferentially recruited to vertical surfaces and suggested that this pattern also applied to areas of higher rugosity. As coral reef communities develop, the structure and continued accretion of the coral skeletons further increase rugosity. Thus, both physical and biological components are involved in development of high rugosity environments.
- Sediment components played a role in explaining variation in the coral assemblage characteristics. Percent organics, an indicator of terrigenous input, showed negative relationships with coral species richness and diversity. Higher percent organic content was also important in explaining decline in coral cover over time in the temporal analysis of

the monitoring site data. Other studies have determined that increased terrigenous input has an adverse impact on reef communities (Acevedo and Morelock 1988, Rogers 1990).

Patterns of change in coral cover observed in the CRAMP/RAT investigation are consistent with observations of other studies in Hawai'i. For example, coral coverage has declined at monitoring sites in Kāne'ohe Bay in the past 3 years, which is a continuation of a trend noted in the bay over the previous 20 years (Hunter and Evans 1993; Evans 1995, Stimson et al. 2001). Along the south shore of Moloka'i a large zone of damaged reef occurs in the middle portion of the coastline at Kamiloloa. This location has the lowest coral coverage of all monitoring stations in the state, but is located midway between two other south Moloka'i locations (Pala'au and Kamalo) that have very high coverage. This anomaly can be explained by increases in nearshore sedimentation due to historical overgrazing and poor land management practices (Roberts 2001). In addition, the construction of the Kaunakakai causeway appears to have played a role in blocking long-shore currents, thereby reducing the rate of sediment and nutrient removal. In contrast, an increase in coral was measured at Limahuli, Kaua'i, where the watershed is being effectively managed in a near pristine state. Average coral coverage for all 152 reef stations combined was $20.8\% \pm 1.7$ SE, with six species accounting for most of the coverage (20.3%). The six dominant species were: *Porites lobata* (6.1%), *Porites compressa* (4.5%), *Montipora capitata* (3.9%), *Montipora patula* (2.7%), *Montipora flabellata* (0.7%) and *Pocillopora meandrina* (2.4%).

1.2 Spatial Patterns

Variation in coral cover is best explained by rugosity, depth, percent fine sand, mean wave direction, rainfall, and geologic age. A positive relationship exists between coral cover and rugosity, depth, and percent fine sand. Coral cover has a negative relationship with mean wave direction, rainfall and geologic age.

Variation in coral species richness is best explained by rugosity, percent organics, mean wave direction and geologic age. Population within 5km also appears in the model but is marginally insignificant. A negative relationship exists between coral species richness and all of these parameters except for rugosity.

Coral diversity was not used as a response variable since coral diversity is low in Hawai'i and may not be an appropriate indicator of environmental conditions in this region. Hawaiian communities are often dominated by a few primary species where diversity does not decline with decreasing latitude as in other regions (Grigg, 1983). Due to geographic isolation, corals in Hawai'i are depauperate relative to the Indo-West Pacific. Only 16 genera containing 42 species have been documented from the Hawaiian Islands. Difficult field identification and detection of cryptic or deep species and low digital resolution may also reduce the predictive ability of diversity.

The multivariate BIOENV routine in PRIMER indicated that depth, maximum wave height, rugosity, and percent organics best explain community structure among all sites. These factors produced the highest matching coefficient (0.38) and accounted for a large portion of the pattern observed in the coral assemblages.

1.3 Temporal trends

A downward trend on Hawaiian coral reefs was measured at CRAMP sites and appears to be most prevalent in the central portion of the archipelago on the islands of O'ahu, Moloka'i and Maui. Most of the human population of Hawai'i resides on O'ahu (72%) and Maui (10%). Moloka'i has a lower human population, but suffers from extreme erosion and sedimentation of reefs along the south shore due to inadequate watershed management (Roberts 2001). Maui also suffers from impaired watersheds and population centers that are adjacent to major reef areas (West Maui Watershed Management Advisory Committee 1997). The islands of Kaua'i and Hawai'i have relatively low human population and show an increase in coral reef coverage. At Kaho'olawe, a former military target island, the condition of sediment-impacted reefs have held steady following the removal of all grazing animals, cessation of bombing, and a massive program of revegetation.

Turgeon et al. (2002, p. 53) reported "the consensus of many ecologists is that, with a few exceptions, the health of the near-shore reefs around the Main Hawaiian Islands remains relatively good ". On the other hand, some researchers, local fishermen and recreational divers with long-term experience observe that reefs in many areas of Hawai'i have declined over past decades. For example, Jokiel and Cox (1993) have noted degradation of Hawaiian reefs due to human population growth, urbanization and coastal development. Absence of the catastrophic short-term reef declines that have been noted in other geographic areas (e.g. Hughes 1994) can lead to the impression that Hawaiian reefs are in good condition. However, slow rates of decline will eventually result in severely degraded reefs. This decline will go undetected by researchers and managers without rigorous monitoring over a wide spatial array at time intervals measured in decades. The spatial patterns and temporal change of reef coral community structure in relation to human population that were observed in this study suggests that the rapidly growing human population of Hawai'i may be having an effect on the reefs. The observed decline of many coral reefs in Hawai'i over the short term is a cause for concern. A longer time series is needed because coral reefs can undergo natural oscillations with a period of decades (Done 1992). However, the declines observed to date in Hawai'i are mainly associated with areas of high human population or impaired watersheds, suggesting anthropogenic rather than natural causes.

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2.0 Methodology

2.1 Geographic coordinates

As part of the ongoing CRAMP QA/QC effort, an analysis of the accuracy of the GPS positioning protocol was undertaken. Using different approaches, the CRAMP positioning was found to generally fall into the sub-meter accuracy category, with the worst-case scenario being on the order of a few meters. The transects which are 25 m in length for fish and 10 meters for benthic surveys show communities that have high homogeneity at Kaloko/Honokohau, so this level of position accuracy is more than sufficient for the intended purposes of habitat mapping. Nevertheless, we have established that GPS co-ordinates provided for the starting point of the transects have very high positional accuracy.

Transects within each site are randomly selected by generating 100 random points onto habitat maps using GPS Pathfinder Office 2.8 (Fig. 2-1). To assure adequate coverage of different habitats and full representation of each site, a stratified design is employed. Points are stratified within depth ranges (<5m, 5 to 10m, and >10m) and habitat types. Not all habitat types are present at every site.

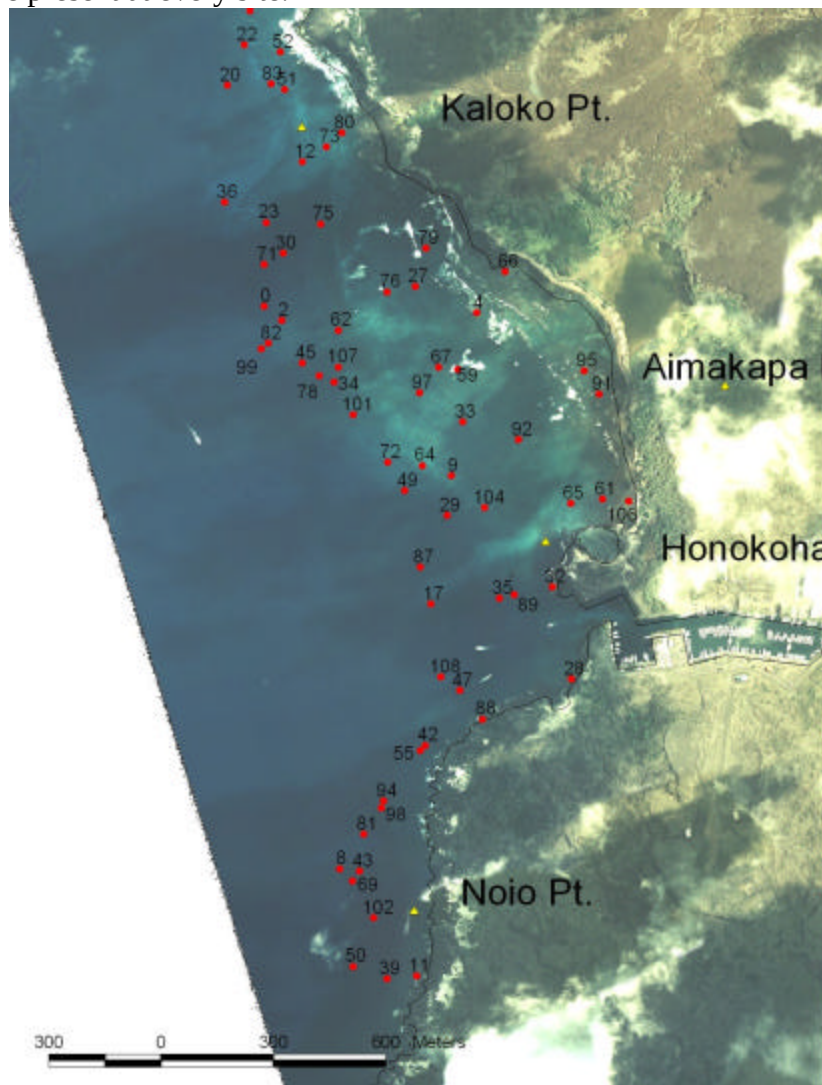


Fig. 2.1. Randomly generated points used in determining locations of transects.

Navigational GPS is used in the field to determine the position of each point. Positions are logged and a quick-fix is obtained at the float used to mark the beginning of each transect. A random numbers table generated in the software program "Excel" is used to determine which point will be surveyed and which direction the transect line will be laid. Transects follow isobaths to keep the depth consistent within each transect. Time, diving constraints, oceanic conditions and size of the area define the number of stations surveyed at each site. Specific stations may be purposely selected due to specific impact, habitats of interest, instrumentation/experiment placement, or prior survey data.

In order to assure accuracy and precision of GPS coordinates to link with fish and benthic data, several different replicate methods of obtaining positions were used. This redundancy allows for verification of position averages and quickfixes, with known positions (features and randomly generated points). Each of the 17 stations have accurately verified random points or documented distances and directions from random points (refer to #1, 2). Redundancy was further increased with known coordinates at 3 stations that had established features (tripod (Fig. 2.2) and receivers) (refer to # 4). Homogeneity of the environment surrounding the majority of rapid assessment technique (RAT) stations also works in favor of producing an accurate habitat quantification. This aspect was tested by linking the coordinate positions with the quantitative fish and benthic data within several hundred meters (refer to #5). Post processing including deletion of anomalous positions (refer to #7) and differential corrections (refer to #8) further reduced error.

Sub-meter accuracy is not necessary on a 10m to 25m transect unless stations will be used for temporal replication as with the Coral Reef Assessment and Monitoring (CRAMP) sites. Accuracy for the RAT stations are within <1 to 5 meters. This does not affect the correlation with the fish and benthic data which is on a larger scale.

Geographic positions were compared with USGS positions taken simultaneously. All locations are within a few meters of one another.

1) Random points with known coordinates were previously generated in ArcView and Pathfinder (Fig. 2.1). Eight of 17 points were surveyed directly on a random point. The vessel navigated to each waypoint using a Trimble GeoExplorer 3. Each station was marked with a pelican float. The exact position is therefore known prior to the gathering of 100 averaged positions. The weight of the float is positioned over the random point that was used to mark the start of each transect. Boat drift and difficulty in remaining in position was checked against quickfixes and random point coordinates for accuracy. These averages are used only as a backup to randomly generated positions and quickfixes. Where the start of the transect was moved due to depth constraints, a distance and direction to the float was recorded underwater and adjusted for in the post processing of the data. This occurred at RAT #12 and #13 (random point #37 and 34 respectively).

2) Any deviation from the random point at the surface was noted in distance and direction and recorded in the fieldbook (eg. RAT#13/random point #34 was 133m E of the generated point). This occurred at 5 stations due to depth constraints and surf conditions.

3) For redundancy, a quick fix was taken for each of the 17 Kaloko stations. For accuracy assessment, these were compared to known coordinates from randomly generated points and features with known coordinates. Quick fixes were also compared to averaged coordinates taken at each station. Without differential corrections, quick fixes are accurate to within 4 to 5 meters.

4) Three stations surveyed have previously known GPS coordinates. These are RAT #9, 10, and 11 (closest to random points 72,62,and 32 respectively). These include the USGS instrumentation tripod (Fig. 2.2) and two of the NPS/UH receiver sites. Transects began directly at receivers due to good connection access and 1m from the tripod using a weight as the anchor for the beginning of the transect line so as not to disturb instrumentation. These will be used to check the accuracy of quickfixes, averaged positions, and distance from random points. This verification is not reflected in the map below since lat/long and decimal degrees obtained have not as yet been converted into UTM's. This aspect of the analysis will however be reflected in the summary report to be completed once all data has been processed and analyzed.

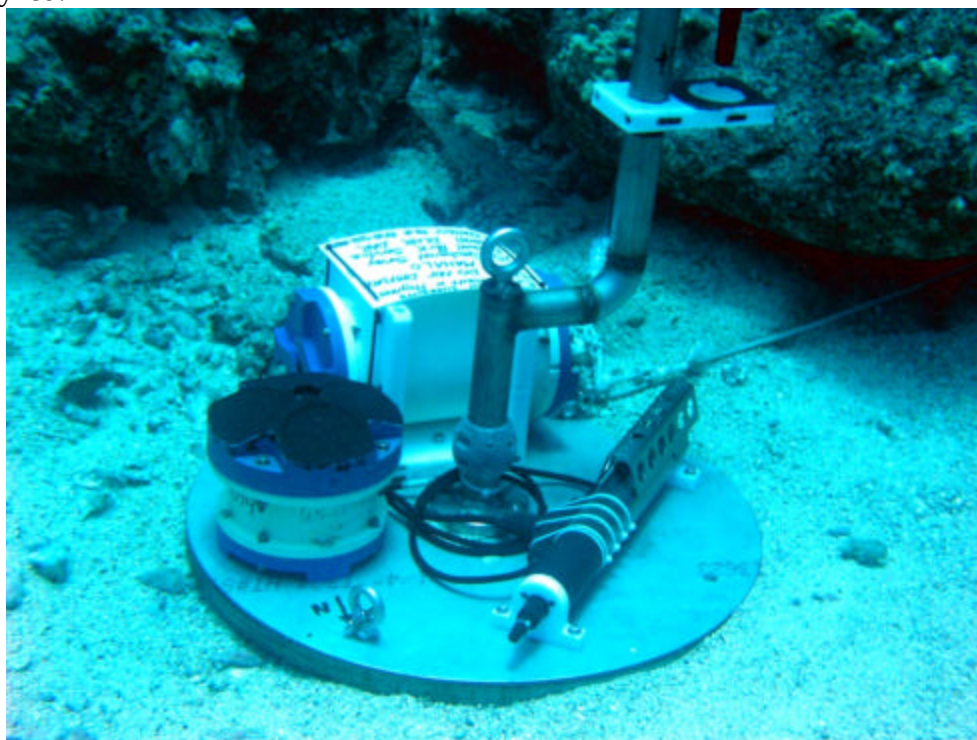


Fig.2.2 South USGS instrumentation tripod at rapid assessment station #9.

5) Fifteen of the 17 stations have homogeneous substrate within several hundred meters. The exceptions are stations #12 and #13 (random point #37 and 34 respectively) that are on a transitional zone that gradually increases in coral cover towards shore and sharply changes to a *Porites compressa* rubble habitat at 20m to 22m. These two heterogeneous anomalies are verified by quickfixes and measured deviations from generated points. Photo documentation of a broad area surrounding the transects were taken at these two stations.

- 6) The Dept. of Transportation requires all GPS units to be accurate to within 16 meters. Most of this error is associated with the vertical precision, which is not used in our rapid assessments. Horizontal precision is accurate to within several meters.
- 7) A total of 100 positions were taken at each station. Pathfinder allows deletion of individual positions. Positions greater than 3 meters from the first 20 fixes will be deleted. A defined boundary of 3 meters is created and all positions outside this boundary are deleted. Accuracy of the first 20 positions is the greatest as accuracy diminishes after 20 to 30 seconds of data gathering and since the boat maintains better position over the pelican float weight early on.
- 8) Differential post-processing corrections were applied to increase accuracy although at a 25m transect scale this is not necessary. Without selective availability there is presently accuracy within 10m but actual accuracy is usually within 1m (Dr. Everett Wingert, UH Cartographer).

2.2 Benthic

Biological characteristics of the coral reef community that may be sensitive to environmental degradation include coral cover, species richness and diversity. To identify these properties, a quantitative assessment protocol was established. This assessment technique is robust enough to detect relationships among environmental factors and spatial distributions of reef organisms. This protocol was designed to produce quantitative spatial data, consistent and comparable to data recorded at the CRAMP permanent monitoring sites to compare data between sites.

To optimize the power of the biological assessments, macroinvertebrates, fishes and algal functional groups (macroalgae, coralline and turf) are surveyed. All methods used are environmentally benign, not significantly altering the habitat or biota surveyed. SCUBA is used to conduct all surveys. Depth is recorded at each transect. RATs also measure topographical relief and replicate sediment samples are collected from each site.

To assess the characteristics of benthic populations, high resolution digital images are taken along a 10m transect using an Olympus 5050 zoom digital camera with an Olympus PT050 underwater housing. The camera is mounted to an aluminum monopod frame, 1.7m from the substrate to provide a 50x69 cm image. A 6 cm bar provides a measurement scale. The academic version of the software program PhotoGrid (Bird 2001) is used to quantify percent cover, richness and diversity of corals, algal functional groups and substrate cover. Images are downloaded and the 20 non-overlapping images from each 10m transect are imported into PhotoGrid where 50 randomly selected points are projected onto each image. This data is saved in a comma separated values (CSV) file, proofread in Excel and imported into a Microsoft Access XP relational database. Access data is queried and exported to statistical programs for analyses.

2.3 Fish

Fish populations are highly variable, requiring numerous transects to quantify absolute values of fish communities. Spatial and temporal variability can reduce statistical power by

increasing standard deviations. The rapid assessment technique (RAT) was designed to use quantitative, relative values to compare stations and sites relative to others. This can be calculated within a site, by island or statewide. In this manner, RATs can cover a large spatial region and keep costs and effort at a minimum, while maintaining statistical integrity by developing a large sample size. In addition, its design allows for statistical comparability with the more intensive, repeatable Coral Reef Assessment and Monitoring Program (CRAMP) transects.

To encompass as wide a spatial range as possible and to address the issue of spatial variability, a many but small sampling strategy was adopted (McCune and Lesica, 1992). The RAT is a trade-off between size and number of sampling units. This technique provides an efficient sampling design to assess extremely large areas. There are many advantages to selecting many, short transects over fewer transects of longer length (McCune and Grace, 2001).

- Cover of common species is more accurately and precisely estimated.
- Larger coverage of sites increases environmental representation.
- Smaller sampling units reduce bias against cryptic species by forcing visual contact to specific spots, avoiding selective species detection.
- Reduces overestimation of rare species.
- Sampling effort and efficiency are not compromised.

Fish populations were quantified using standard visual belt transects developed by Brock in 1954. Transect location was determined using pre-selected random points of areas of interest. A diver swam along one 25 m x 5 m transect (125m²) at each station recording species, quantity and total fish length. All fishes were identified to the lowest taxon possible. To eliminate observer variability, the same surveyor was used to tabulate fishes on all transects.

Total length was estimated to the nearest centimeter in the field and converted to biomass estimates, tons per hectare (t/ha) using length-weight fitting parameters. To estimate fish biomass from underwater length observations fitting parameters were obtained from the Hawai'i Cooperative Fishery Research Unit (HCFRU). Fitting parameters not available were obtained from Fishbase (www.fishbase.org) whose length-weight relationship is derived from over 1,000 references. A congener of similar shape within the genus was used in rare cases lacking information.

To convert between recorded total lengths (TL) and other length types (e.g. fork length FL) contained in databases, linear regressions and ratios from Fishbase linking length types were used. A predictive linear regression of logW vs. logL was used in most cases to estimate the fitting parameters of the length-weight relationship. Visual length estimates were converted to weight using the formula $W = a N L^b$ where W=weight in grams, L=standard length in mm, a and b are fitting parameter constants.

Any anomalous values were detected by calculating a rough estimate for a given body type. The general trend for a 10 cm fish of the common fusiform shape should be approximately 10 grams. Gross deviations were replaced with values from the alternate source.

Trophic levels for fish species were determined using published Fishbase data (www.fishbase.org). The trophic categories included: piscivores, herbivores, detritivores, mobile and sessile invertebrate feeders, and zooplanktivores. These were further merged into four main feeding guilds: piscivores, herbivores, invertebrate feeders, and planktivores.

2.4 Sediment

2.4.1 Sediment Composition

Approximately 500cc of sediment were collected along the transect at each site and secured in Fisher brand 9x18 cm sample bags. Replicate samples were collected at each transect. Sediment grain-size and composition were determined using standard geological methods (Parker, 1983, McManus, 1988, Craft et al., 1991). Samples were thoroughly homogenized. To determine the inorganic-organic carbon fraction, 10 grams of sediment were finely ground using a mortar and pestle. Subsamples were taken from each replicate to determine variability. Samples were then dried for 10 hrs. @ 100 °C to remove moisture, placed in a desiccator and weighed. To remove the organic fraction, samples were burned in a muffle furnace for 12 hrs. @ 500 °C, placed in a desiccator and weighed. For removal of carbonate material, samples were placed in a muffle furnace for 2 hrs. @1000 °C, cooled in a desiccator and weighed. The percent loss on ignition and carbonate fraction was calculated from this data.

2.4.2 Sediment Grain-size

Subsamples were taken from each of two replicate samples collected from each transect. Standard brass sieves were used to determine size fractions: 2.8 millimeters, 500 micrometers, 250 micrometers, 125 micrometers, and 63 micrometers (USA Standard Testing Sieve: A.S.T.M.E.-11 specifications). A brass catch pan was used to collect the silt/clay fraction. Five size fractions were determined: gravel, medium sand, fine sand, very fine sand, and silt/clay in accordance with the Wentworth scale (Folk 1974). Each size fraction was collected in pre-weighed Whatman 114 wet strength filters, air dried and weighed to determine the proportion of each size fraction. Extremely large pieces were removed prior to sorting to reduce variability and eliminate overweighting of some samples by a single piece of material.

2.4.3 Sediment Analysis

Microsoft Excel was used to calculate percentages. Univariate analyses were performed using the software program Minitab 13.0. Multivariate analysis techniques were performed using the statistical software programs, Multivariate Statistical Package (MVSP) 3.0 and PRIMER 5.0. Prior to statistical analyses, all sediment percentages were changed to proportions to normalize data and produce a continuous variable. These proportions were then transformed using an arcsine square root transformation useful in extreme proportions <0.2 or >0.8 such as with this data.

The gravel fraction was removed prior to analyses to reduce overweighting proportions of other size fractions by large material. To avoid multicollinearity, one size fraction (very fine sand) was removed from the analysis. Partial F-tests determined this grain-size to contribute the least in explaining sediment variability among sites.

Sediments were collected from 90 of the 152 stations at 50 sites. At stations where sediments were not collected, sediment data from stations at the same site with similar biota and

environmental conditions were substituted (>90%) using a similarity matrix. Stations not meeting substitution criteria were omitted from the analyses (15).

Five sediment parameters were used in analyses:

- loss on ignition (LOI) to determine content of organic material
- H_2CO_3 to determine carbonate fraction
- Medium sand fraction
- Fine sand fraction
- Silt/clay fraction

Simple linear regressions were used to determine correlations between two variables.

Principal Components Analysis (PCA) was used to define the position of stations in relation to the sediment variables.

2.5 Physical and biological parameters

The data extracted from the following parameters were used in spatial and multivariate analyses.

2.5.1 Waves

All wave variables were generated using significant wave height and mean wave direction from Naval Oceanographic WAM models downloaded during 2001 (www.navo.navy.mil). Hawai'i nowcasts are generated from bouys surrounding the Hawaiian Islands. Wave factors used in data analysis include; mean, minimum and maximum annual and seasonal wave heights and mean annual wave direction.

2.5.2 Terrestrial factors : Population, Watershed, Streams and Precipitation

Terrestrial variables used in statistical analyses included; population within 5 km and 10 km of each site, population within the adjacent watershed, watershed acreage, rainfall and perennial streams. All geographic Information system layers were obtained from the State of Hawai'i GIS database (www.state.hi.us/dbedt/gis). Natural resources and environmental layers included rainfall and watersheds. The geographic extent of the watershed layer encompasses the eight Main Hawaiian Islands while rainfall contours cover the six largest Hawaiian Islands. Watershed unit boundaries were originally generated in Arc/Info and GRID using USGS Digital Elevation Model data (1995). The State Department of Land and Natural Resources served as the original source of median annual precipitation data.

Physical features and basemap layers included; coastline, islets and perennial streams. The Commission on Water Resource Management, Hawai'i Stream Assessment Project provided the original perennial stream data (1993).

The data projection for all Island of Hawai'i layers was Universal Transverse Mercator, Zone 5. Projection conversions were applied to geographic coordinates for georeference compatibility using the ArcView extension, Hawai'i Datums and Projections and the software program, Corpscon. Distances were calculated utilizing the Spatial Analyst version 1.1 extension for ArcView GIS version 3.1.

2.5.3 Political boundaries and administrative layers included; census tracts and blocks and fisheries management areas. Population data was originally five county layers downloaded

from www.geographynetwork.com and merged into a single layer. The geographic extent of these 2000 census tracts and blocks covers the Main Hawaiian Islands.

Legal protection status

Protection ranks were assigned to each station based on geographically defined management status. Five types of marine protected areas were used in the rankings. Areas without legal protection were classified as open access stations.

- Rank 1: Full protection; Natural Area Reserves (NARs), Fisheries Management Areas (FMAs), Marine Life Conservation Districts and Kaho'olawe Island Reserve where fishing is strictly prohibited except for extremely limited indigenous use.
- Rank 2: Partial protection; Marine Life Conservation Districts (MLCDs) which allow very limited fishing and other consumptive uses. Specific gear restrictions or specific species closure may apply.
- Rank 3: Limited protection; Fisheries Replenishment Areas (FRAs) restricted aquarium fish collecting.
- Rank 4: No legal protection; open access; stations without geographically designated restrictions.

2.5.4 Topographic relief

Rugosity measurements to determine topographical relief and spatial complexity were conducted along each transect. A 15m chain marked at 1 m intervals with 1.3 cm links was draped along the length of the transect (10m) following the contours of the benthos. An index of rugosity was calculated using the ratio of the reef contour distance as measured by chain length, to the linear, horizontal distance (McCormick 1994).

2.5.5 Depth

Depth was determined at each transect with the use of an electronic depth sounder at the surface. To provide a range of depths along the entire transect a digital dive computer (Suunto) was used on the benthos.

2.5.6 Age of Islands

The geologic age of each site was estimated using the age of the source volcano in millions of years (Clague and Dalrymple, 1994). These data were determined using radiometric dating and paleontologic ages. Dated fossils and island age progression are consistent with this data.

References

- Clague, D. A., and G. B. Dalrymple. 1994. Tectonics, geochronology and origin of the Hawaiian Emperor Volcanic Chain. pp. 5-40. In: A Natural History of the Hawaiian Islands. Edited by E. A. Kay. University of Hawai'i Press.
- Fishbase webpage www.fishbase.org.
- McCormick, M. 1994. Comparison of field methods for measuring surface topography and their associations with a tropical reef fish assemblage. Marine Ecology Progress Series 112: 87-96.
- State of Hawai'i GIS data webpage
- United States Dept. of Navy webpage www.navo.navy.mil.

3.0 Kaloko/Honokohau (KAHO)

Seventeen fish transects were conducted over a three day period from April, 26th to April 28th, 2004 within the Kaloko/ Honokohau National Park boundary (Fig.3.1). Transect locations were selected using the following three criteria.

- Pre-determined randomly selected points
- Locations of geological or biological interest
- Previously established instrumentation stations

Kaloko/Honokohau Rapid Assessment Stations

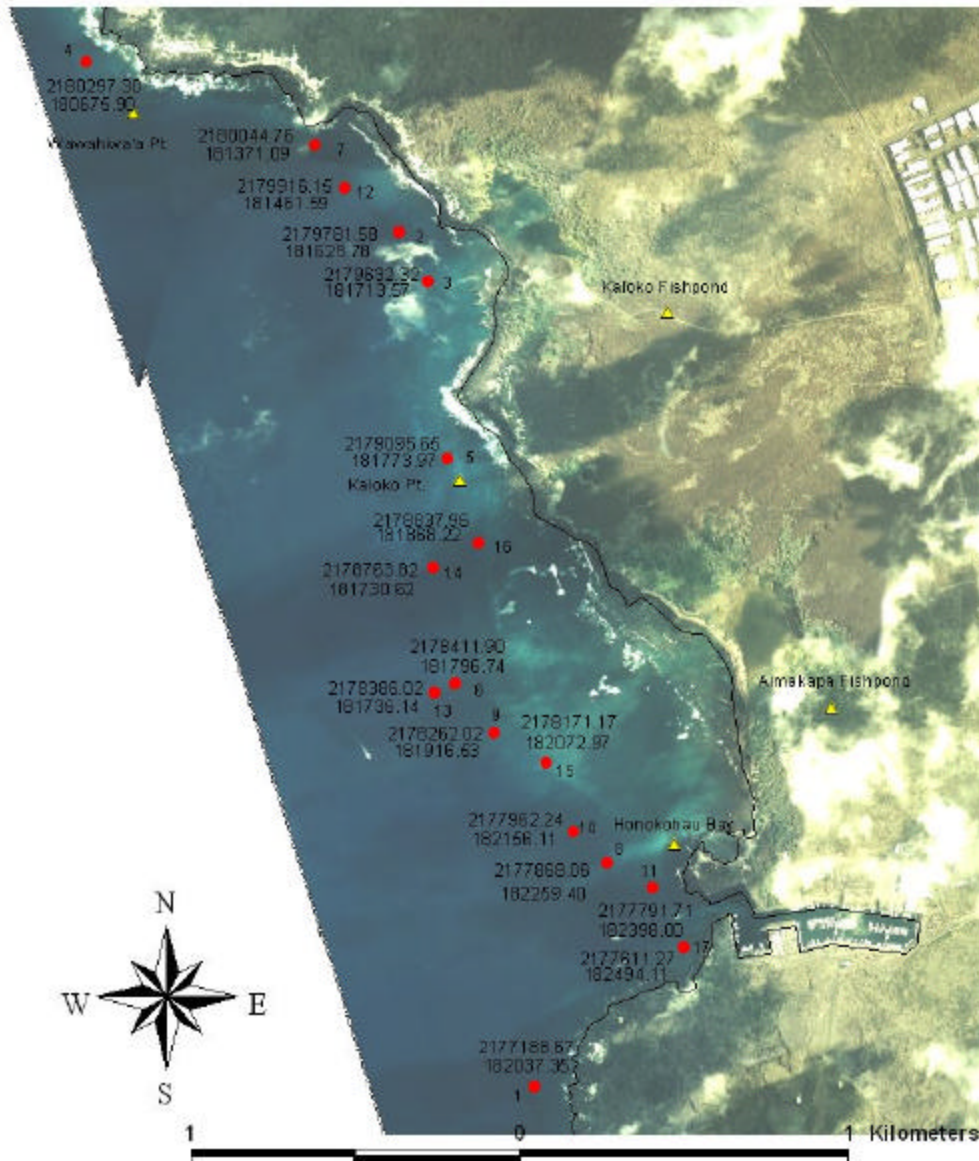


Fig 3.1 Map of rapid assessment stations at Kaloko/Honokohau

3.1 Benthic Data:

3.1.1 Coral communities

Coral cover ranged from less than 3% at the south USGS tripod site to over 50% at RAT station 10 (Figs. 3.2 & 3.3). Mean coral cover (23%) is similar to the statewide average of 22%. Also in concordance with statewide results, Kaloko/Honokohau reefs are mainly *Porites* reefs, comprised of *P. compressa* and *P. lobata*, although four *Porites* species were recorded from transects (Table 3.1). The dominant *P. lobata* ranged from 1% to over 40% with a site average of over 15%. A total of nine species from five genus were quantified from this site.

In contrast to most sites throughout the state, Kaloko/Honokohau has a high abundance of the endemic octocoral, *Anthelia edmonsoni* (4.4%), with extremely high cover of nearly 25% at transects 7 and 8. This species is common in many West Hawai'i locations. *Anthelia* is not included in calculations of total coral cover.

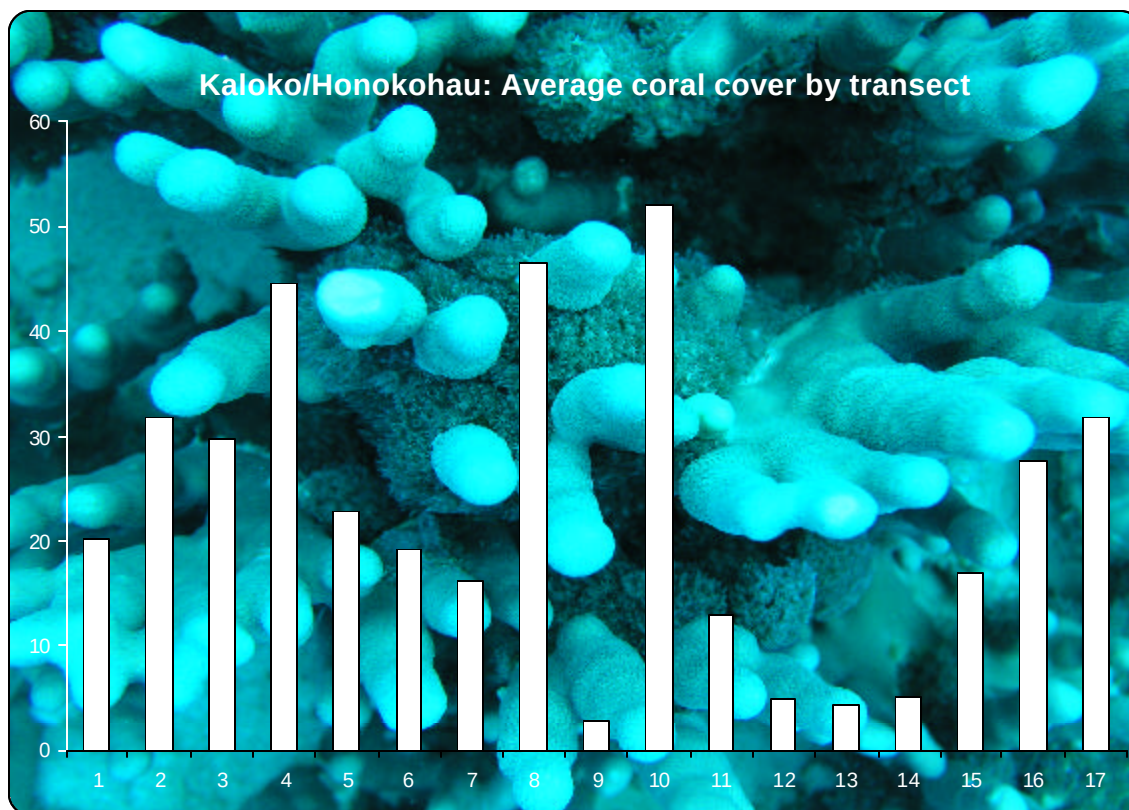


Fig.3.2. Mean coral cover by transect at Kaloko/Honokohau

Transect #	Cyphastrea ocellina	Leptastrea purpurea	Montipora capitata	Montipora patula	Pocillopora meandrina	Porites brighami	Porites compressa	Porites evermanni	Porites lobata	Total coral
1	0.0	0.4	0.8	0.0	6.0	0.0	0.2	0.0	12.8	20.2
2	0.0	0.0	0.0	0.0	2.8	0.0	7.0	6.2	15.8	31.8
3	0.0	0.0	0.0	0.0	1.2	0.0	0.4	0.0	28.2	29.8
4	0.0	0.0	0.4	0.0	20.6	0.0	0.0	0.0	23.6	44.6
5	0.0	0.0	0.6	0.0	0.2	0.0	0.0	0.0	22.0	22.8
6	0.0	0.2	0.2	0.0	0.2	1.6	0.2	0.0	16.8	19.2
7	0.0	0.0	0.0	0.0	0.0	0.0	12.8	0.0	3.4	16.2
8	0.0	0.0	0.0	0.2	0.0	0.0	39.2	0.0	7.2	46.6
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	2.8
10	0.0	0.0	0.0	0.0	0.0	0.0	12.0	0.0	40.2	52.2
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	12.6	13.0
12	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	1.0	5.0
13	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0	2.0	4.4
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.2	5.2
15	0.0	0.2	0.0	0.0	0.8	0.0	0.0	0.0	16.0	17.0
16	0.2	0.2	0.0	0.2	1.2	0.0	0.0	0.0	25.8	27.6
17	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	31.0	31.8
Mean %	0.0	0.1	0.1	0.0	2.0	0.1	4.6	0.4	15.7	23.0

Table 3.1. Percentages of coral cover by species and total coral cover by transect.

Kaloko/Honokohau Total coral cover (%)

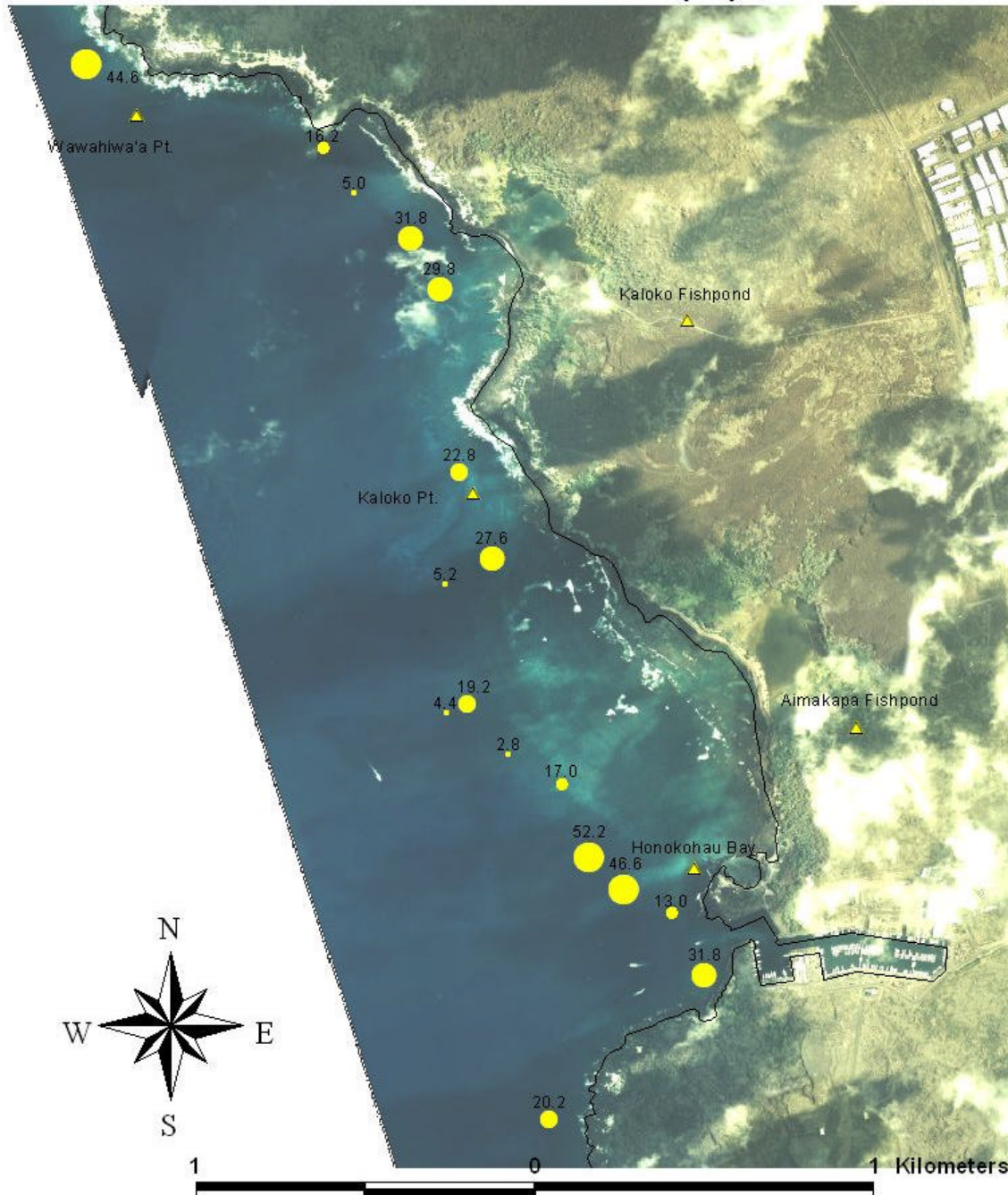


Fig. 3.3. Map of Kaloko/Honokohau showing gradation symbols increasing with coral cover and percent coral cover values by transect

3.1.2 Substrate cover

Substrate cover is dominated by turf algae (54%) and a large percentage of calcareous coralline algae (16%). Very low amounts of macroalgae (0.2%) and sand (2.1%) were quantified (Fig.3.4). Coralline algae, preferred for settlement by many coral species, provides substrate for coral larval recruitment.

3.1.3 Invertebrates

Five species of echinoderms were quantified by percent cover. The collector urchin, *Tripneustes gratilla* and the rock-boring urchin, *Echinometra mathaei* are common in this region, as they are throughout the state. The black sea cucumber, *Holothuria atra* is found in small numbers at this site.

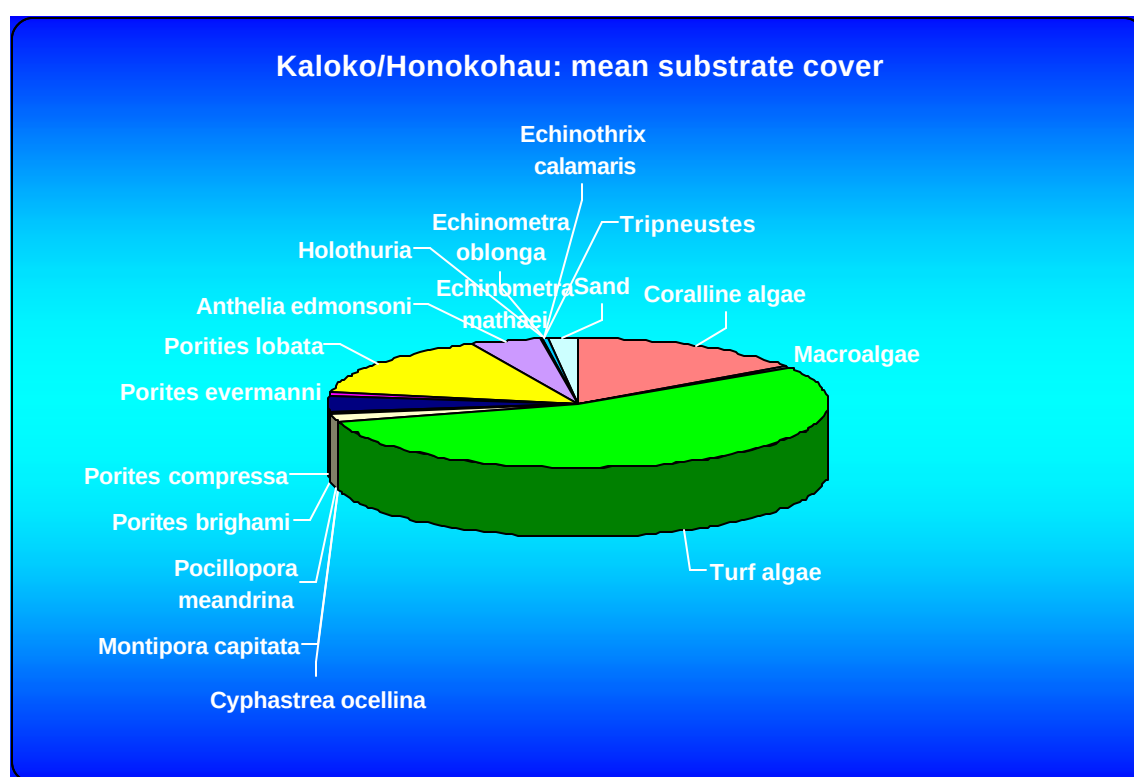


Fig.3.4. Average benthic cover of each substrate type at Koloko/Honokohau (n=17)

3.1.4 Observations

Substrate observations for each transect include species lists, dominant and unusual species, and substrate type. Transitional substrate changes and shifts in coral species and/or cover and their associated depths were also noted, as were local place names and identifying characteristics.

The Crown of Thorns seastar, *Acanthaster planci*, was directly observed on transects 1 and 3. Indirectly signs of recent visitation were found on transect 2 where small, dead, white *Pocillopora* colonies were highly visible. *Priacanthus meeki* (aweoweo) occurred in high numbers on transect 8. This is in concordance with an unusually large, recent recruitment of this species documented on most of the Main Hawaiian Islands. Coral recruitment plate

arrays were also located near this station. Two receiver sites and the USGS instrumentation station were also noted.

RAT #1) Species list:

Coral: *Porites lobata*, *Porites evermanni*, *Porites lichen*, *Montipora capitata*, *Pocillopora meandrina*, *Anthellia edmonsoni*, *Leptastrea purpurea*, *Pavona varians*, *Pocillopora edouxii*
algae: none

Inverts: *Acanthaster*, *Diadema*, *Echinothrix*

Observations: colonized boulders, mainly *Porites lobata*, and *Pocillopora meandrina*

RAT #2) Species list:

Coral: *Porites compressa*, *Porites lobata*, *Porites evermanni*, *Montipora capitata*, *Pocillopora meandrina*, *Anthellia edmonsoni*

Algae: none

Inverts: *Diadema*, *Echinothrix*

Observations: colonized pavement, several small *Pocillopora meandrina* white (*Acanthaster*)

RAT #3) Species list:

Coral: *Porites compressa*, *Porites lobata*, *Porites evermanni*, *Porites brighamii*, *Montipora capitata*, *Pocillopora meandrina*, *Pocillopora edouxii*

algae: *Neomeris annulata*

Inverts: *Diadema*, *Tripneustes gratilla*, *Echinometra mathaei*, *Acanthaster*

Observations: colonized pavement

RAT #4) Species list:

Coral: *Porites lichen*, *Montipora capitata*, *Leptastrea purpurea*, *Pocillopora edouxii*

Algae: *Asparagopsis taxiformis*, *Malamansia glomerata*

Inverts: *Diadema*, *Echinometra mathaei*

Observations: colonized pavement local name: Pyramid pinnacles

RAT #5) Species list:

Coral: *Porites compressa*, *Porites lobata*, *Porites evermanni*, *Montipora capitata*, *Pocillopora meandrina*, *Leptastrea purpurea*, *Palythoa tuberculosa*

Algae: *Asparagopsis taxiformis*

Inverts: *Tripneustes gratilla*, *Heterocentrotus mammilatus*, *Echinometra mathaei*, *Diadema*

Observations: near northern USGS instrument tripod, colonized pavement with sand channels and sand pockets

RAT #6) Species list:

Coral: *Porites compressa*, *Porites lobata*, *Porites evermanni*, *Montipora capitata*, *Pocillopora meandrina*, *Anthellia edmonsoni*

Algae: none

Inverts: *Culcita novaeguineae*, *Echinometra mathaei*, *Tripneustes gratilla*

Observations: colonized pavement and colonized boulders

RAT #7) Species list:

Coral: *Porites compressa*, *Porites lobata*, *Pocillopora meandrina*, *Anthellia edmonsoni*

Algae: none

Inverts: *Diadema*

Observations: reef rubble, scattered rock and coral in unconsolidated sediment

RAT #8) Species list:

Coral: *Porites compressa*, *Porites lobata*, *Montipora patula*, *Pocillopora meandrina*, *Anthellia edmonsoni*

Algae: *Asparagopsis taxiformis*

Inverts: *Tripneustes gratilla*

Observations: colonized pavement, high coral cover, mainly *Porites compressa*, recruitment plates, abundant *Priacanthus meeki* (aweoweo)

RAT #9) Species list:

Coral: *Porites lobata*, *Porites lichen*, *Montipora capitata*, *Pocillopora meandrina*

Algae: none

Inverts: *Diadema*

Observations: USGS southern Instrument Tripod, hardbottom surrounded by colonized boulders

RAT #10) Species list:

Coral: *Porites compressa*, *Porites lobata*, *Montipora capitata*, *Anthellia edmonsoni*, *Cycloceris*

Algae: *Neomeris annulata*

Inverts: *Diadema*, *Echinometra mathaei*

Observations: NPS receiver site, local name: Turtle Pinnacles, colonized pavement, high coral cover

RAT #11) Species list:

Coral: *Porites lobata*, *Montipora capitata*, *Pocillopora meandrina*

Algae: none

Inverts: *Tripneustes gratilla*, *Diadema*, *Heterocentrotus mammilatus*, *Echinometra mathaei*

Observations: NPS receiver, local name: Turtle Heaven, colonized boulders

RAT #12) Species list:

Coral: *Porites compressa*, *Porites lobata*, *Anthellia edmonsoni*

Algae: *Neomeris annulata*, *Asparagopsis taxiformis*

Inverts: *Diadema*

Observations: reef rubble, 10-15% coral (*P. compressa*, *P. lobata*) transition at 65'-75' below this rubble, coral cover increases shoreward to around 40%, *P. meandrina*, starts around 40' then changes to *P. meandrina*, *P. lobata* shoreward

RAT #13) Species list:

Coral: *Porites compressa*, *Porites lobata*, *Pocillopora meandrina*

Algae: none

Inverts: *Tripneustes gratilla* inshore: *Diadema*

Observations: reef rubble with coral (10-15%), transition to all *P. compressa* rubble at 60-65'

RAT #14) Species list:

Corals: *Porites lobata*, *Montipora capitata*, *Pocillopora meandrina*

Algae: *Neomeris annulata*

Inverts: *Diadema*, *Echinometra mathaei*

Observations: colonized boulders

RAT #15) Species list:

Corals: *Porites lobata*, *Pocillopora meandrina*, *Anthellia edmonsoni*

Algae: none

Inverts: *Diadema*, *Echinometra mathaei*

Observations: colonized pavement, on ledge edge then drops to 20' colonized boulders

RAT #16) Species list:

Corals: *Porites lobata*, *Porites evermanni*, *Montipora capitata*, *Pocillopora meandrina*

Algae: none

Inverts: *Echinometra mathaei*

Observations: colonized pavement

RAT #17) Species list:

Corals: *Porites lobata*, *Porites evermanni*, *Montipora capitata*, *Pocillopora meandrina*,
Anthellia edmonsoni

Algae none

Inverts: *Tripneustes gratilla*, *Heterocentrotus mammilatus*

Observations: colonized boulders

3.1.5 Sediments

Two sediment stations were selected at 12m and 18m depth from transect 4 and 12 (Fig. 3.1). Sub-samples were collected from each station and replicates used in the analysis. Sediment composition is similar for all parameters measured. Within site variation is lower than between site variation.

Organics are comparable to most other Big Island sites except for the two extremes, which range from 0.2% at Ka'apuna, a relatively recent 1950's lava flow to 23.6 at Pelekane Bay, which has experienced extensive sedimentation due to runoff and dredging of the adjacent Kawaihae Harbor. The mean percent organics at Kaloko (3.0%) is within the range of 87% of the 55 sites throughout the state, which fall between 3 and 5%. Kaloko has a very high percentage of carbonate (91.8%), ranking 2nd of 13 sites on the Island of Hawai'i, while terrigenous input is relatively low (5.1%) (Figs.3.5 and 3.6).

Unlike sediment composition, the sediment grain-size is very different at the two depths (12m and 18m) (Fig.3.7). The 12m station has more larger grain sizes (73.0%) and less silt/clay (1.2%) than the deeper station (42.6%, 2.9%). This is within the median range for West Hawai'i sites, which displays only two anomalies, Pelekane Bay on one extreme and Ka'apuna on the other.

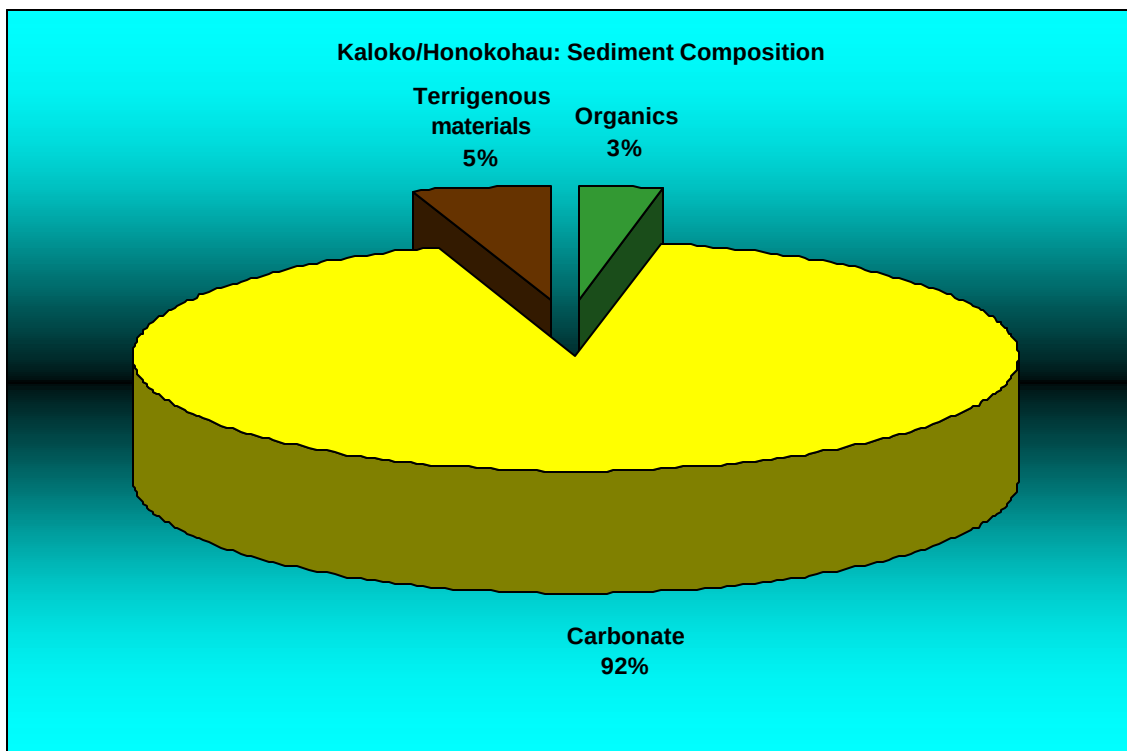


Fig. 3.5. Composition of sediments at Kaloko/Honokohau (% total)

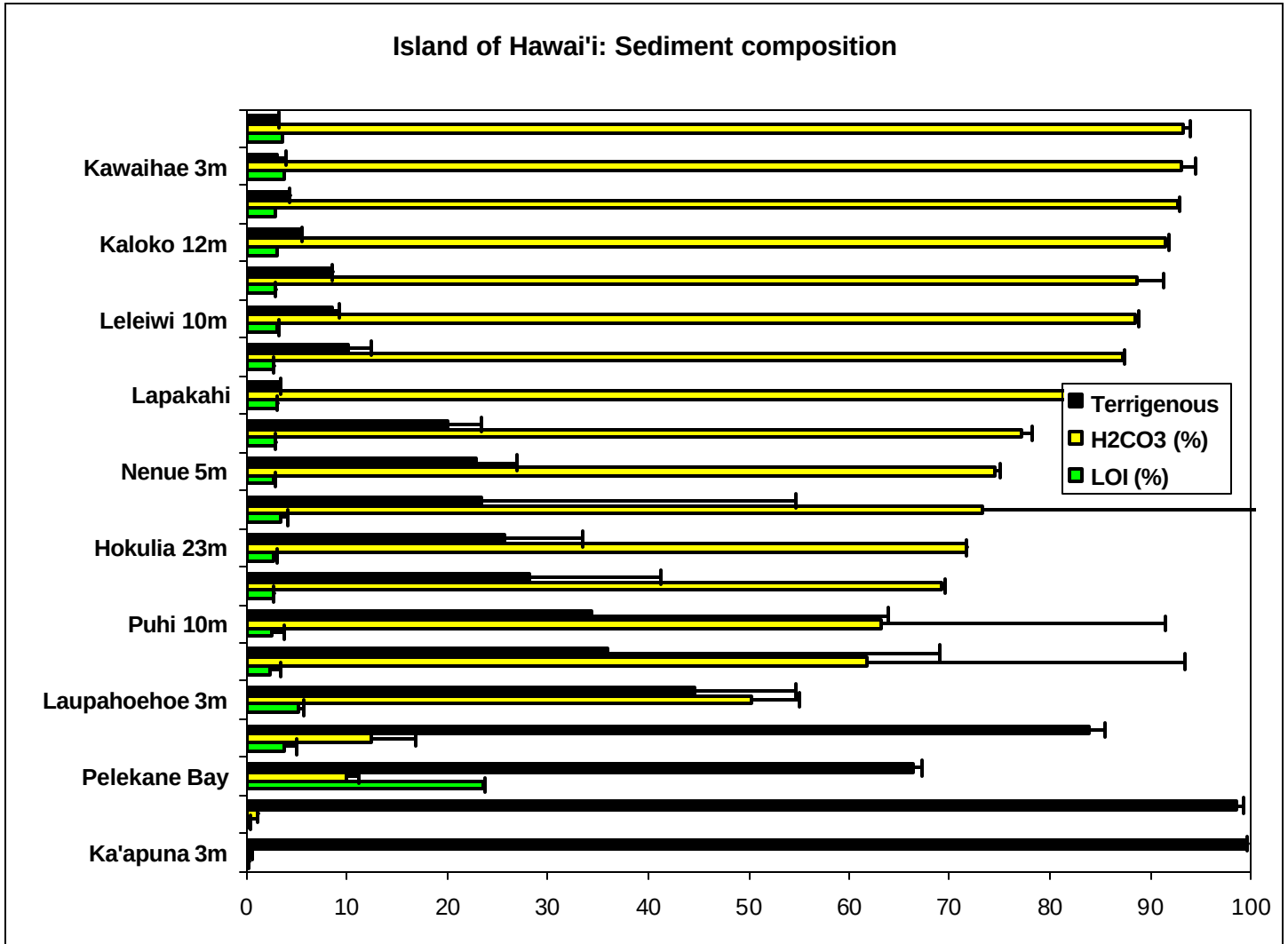


Fig. 3.6. Sediment composition at sites on the Island of Hawai'i.

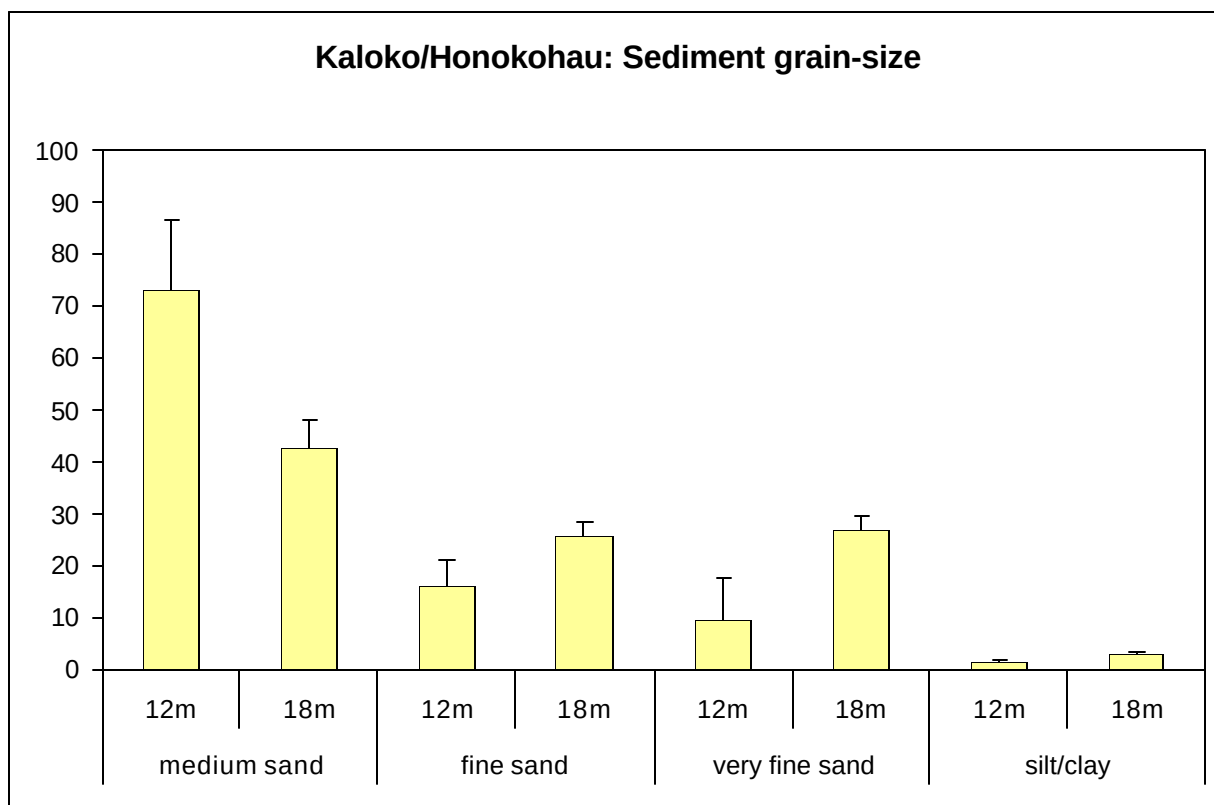


Fig. 3.7. Grain-size of sediments at Kaloko/Honokohau (% total)

3.2 Fish data

Results and Summaries of pooled transects

A total of 17 fish transects were conducted at Kaloko/Honokohau. All fish data was collected by a single surveyor to minimize observer variability. A total of 125m² was covered by each 25 x 5 m transect. Transect consistency is maintained to allow comparability with other transects conducted throughout the main Hawaiian Islands (see: statewide rankings).

3.2.1 Top species

Summary of top species: As expected, the most abundant species are the *Chromis* spp. since these planktivores are especially abundant along the Kona coast of the island of Hawai'i. The top fish species at Kaloko/Honokohau are extremely similar to the top species at the other 56 sites throughout the main Hawaiian Islands (70%). Seven of most commonly recorded species statewide are also among the 10 most abundant species at Kaloko/Honokohau including, *Acanthurus nigrofusus* (mai'i'i), *Ctenochaetus strigosus* (kole), *Zebrasoma flavescens* (lauipala), *Thalassoma duperrey* (hinalea lauili) and three *Chromis* spp (Fig.3.8, Table 3.2).

The two species with the highest biomass are the yellow tang, *Zebrasoma flavescens* (lauipala) and the orangespine unicornfish, *Naso lituratus* (umaumalei) (Fig. 3.9, Table 3.3). The high biomass of these species reflects the protection status at Kaloko/Honokohau, where aquarium fish collecting is strictly prohibited. The large biomass of the introduced species, *Cephalopholis argus* (roi), introduced by the state as a food fish in 1956 from Moorea, French

Polynesia, is due to the large individual size of fish recorded at this site. Similar to most sites throughout the state, high biomass of *Acanthurus nigrofuscus* (mai'i'i) are found here. An unusually large recruitment of *Priacanthus meeki* (aweoweo) was observed on most of the main Hawaiian Islands in the summer of 2003. Although this was not observed on the Kona coast of Hawai'i (pers. com Bill Walsh), this species ranks tenth in the top species for fish biomass observed at Kaloko/Honokohau.

Fish Data: Highest abundance

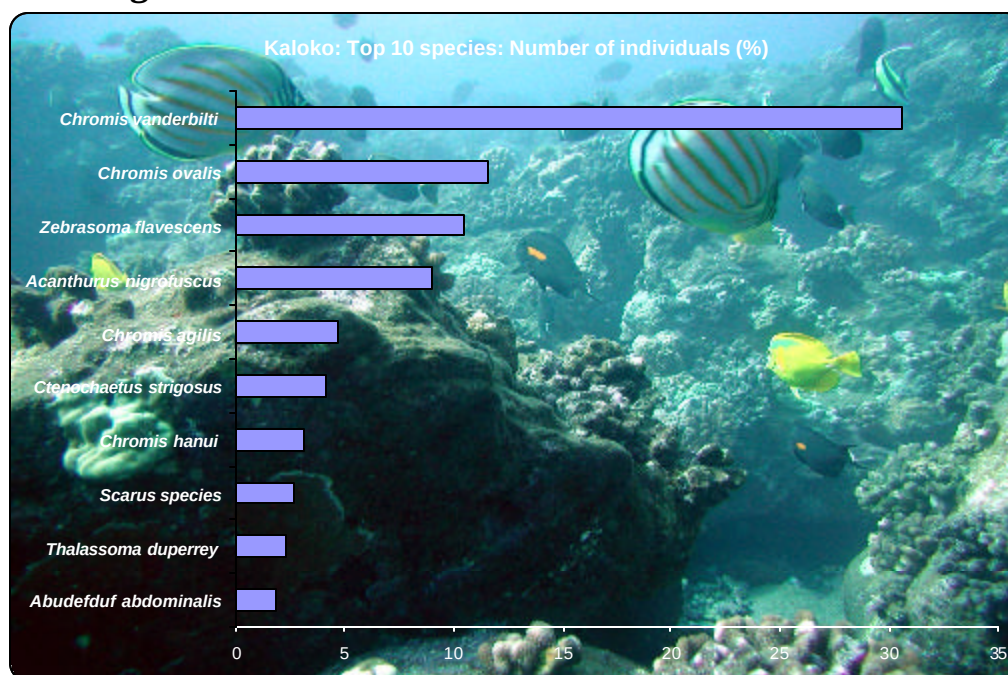


Fig. 3.8. Top 10 fish species with the highest abundance (mean number of individuals %).

Taxonomic Name	Common Name	Hawaiian Name	Mean number of individuals (hax1000)	Mean Biomass (t/ha)	Frequency of occurrence (%)
<i>Chromis vanderbilti</i>	Black-finned chromis		3.93	0.01	47.06
<i>Chromis ovalis</i>	Oval chromis		1.49	0	23.53
<i>Zebrasoma flavescens</i>	Yellow tang	lauipala	1.35	0.06	100.00
<i>Acanthurus nigrofuscus</i>	Lavendar tang	mai'i'i	1.16	0.03	100.00
<i>Chromis agilis</i>	Agile or Reef chromis		0.61	0	17.65
<i>Ctenochaetus strigosus</i>	Goldring surgeonfish	kole	0.54	0.02	58.82
<i>Chromis hanui</i>	Chocolate dip chromis		0.40	0	29.41
<i>Scarus species</i>	Parrotfish	uhu	0.34	0	41.18
<i>Thalassoma duperrey</i>	Saddle wrasse	hinalea lauwilli	0.31	0.01	70.59
<i>Abudedefduf abdominalis</i>	Hawaiian sergeant	mamo	0.24	0.02	5.88

Table 3.2. Top ten fish species with the highest abundance (mean number of individuals hax1000) are shown in descending order with their associated mean biomass (t/ha) and frequency of occurrence (%).

Fish Data: Greatest biomass

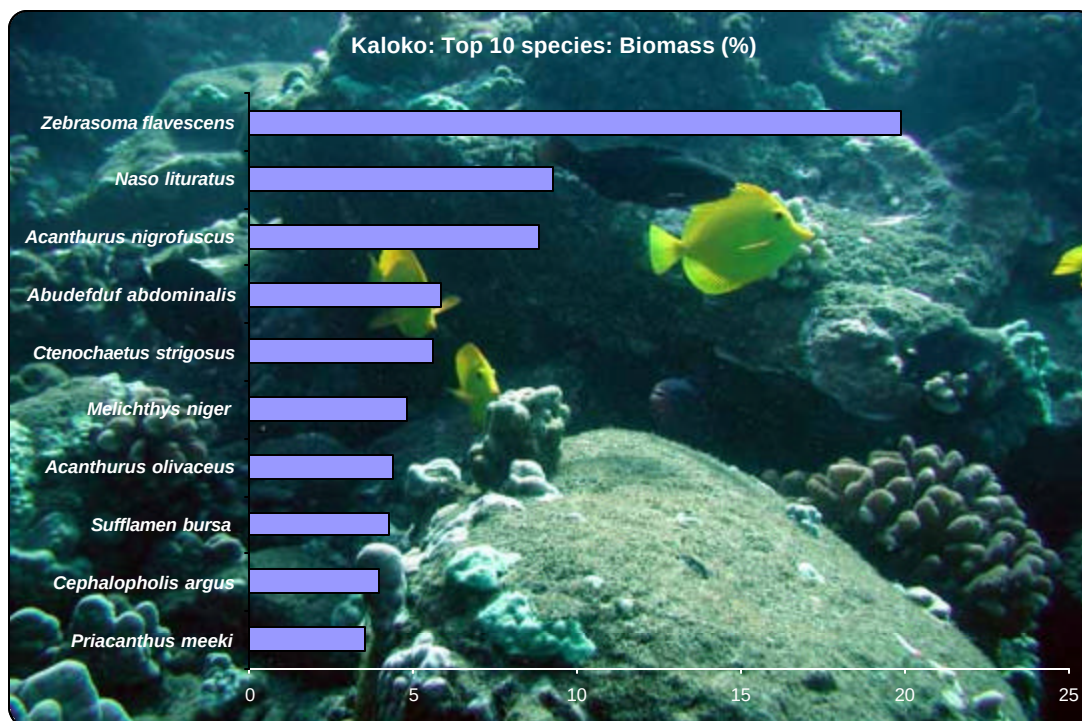


Fig. 3.9. Top 10 fish species with the greatest mean biomass (%).

Taxonomic Name	Common Name	Hawaiian Name	Mean Biomass (t/ha)	Mean number of individuals (ha x 1000)	Frequency of occurrence (%)
<i>Zebrasoma flavescens</i>	Yellow tang	lauipala	0.06	1.35	100
<i>Naso lituratus</i>	Orangespine unicornfish	umaumalei	0.03	0.19	76.47
<i>Acanthurus nigrofusus</i>	Lavendar tang	mai'i'i	0.03	1.16	100
<i>Abudedefduf abdominalis</i>	Hawaiian sergeant	mamo	0.02	0.24	5.88
<i>Ctenochaetus strigosus</i>	Gold-ring surgeonfish	kole	0.02	0.54	58.82
<i>Melichthys niger</i>	Black durgon	humuhumu'ele'ele	0.02	0.12	23.53
<i>Acanthurus olivaceus</i>	Orangeband surgeonfish	na'ena'e	0.01	0.1	52.94
<i>Sufflamen bursa</i>	Lei triggerfish	humuhumulei	0.01	0.16	58.82
<i>Cephalopholis argus</i>	Peacock grouper	roi	0.01	0.08	64.71
<i>Priacanthus meeki</i>	Hawaiian bigeye	aweoweo	0.01	0.23	5.88

Table 3.3 Top ten fish species with the greatest mean biomass (t/ha) are shown in descending order with their associated abundance (mean number of individuals (ha x 1000)) and frequency of occurrence (%).

3.2.2 Fish Data: Families of fishes

Summary of top families: The family with the greatest recorded number of individuals is *Pomacentridae*. Large numbers of individuals from four species of *Chromis* and two species of *Plectroglyphidodon* were recorded from this family. This is consistent with state rankings. Also consistent with the majority of sites throughout the state, *Acanthurids* ranked high in the number of individuals recorded (Fig. 3.10, Table 3.4).

Other families with high abundance include the *Labrids* and *Chaetodonts*. Of the 11 species recorded from the family *Labridae*, *Thalassoma duperrey* accounted for nearly 60% of the individuals encountered. Ten species of butterflyfish are included in the large number of *Chaetodontidae* observed on the transects. The planktivore, *Chaetodon kleinii*, the blacklip butterflyfish was recorded at 18 m depth on transect 12. This species is uncommon on transects statewide. *Heniochus diphreutes*, the pennant butterflyfish, observed at 12 m on transect 4 is also recorded from only a small percentage of sites statewide.

Eight of the families that rank in the top 10 in abundance are also within the top 10 families in biomass. The family with the greatest recorded biomass is *Acanthuridae* (Fig. 3.11, Table 3.4). *Acanthurus nigrofusus* (mai'i'i) accounted for the majority of fish in this family and was observed on all the transects conducted at this site. Other families with a large biomass recorded included *Balistidae* and *Pomacentridae*. Although *Chromis* accounted for the largest abundance of *Pomacentrids*, it did not significantly affect the biomass of this family due to the small size of these fishes. The large biomass of *Pomacentridae* was mainly influenced by a large school of *Abudefduf abdominalis* (mamo) recorded from transect 4. *Melichthys niger* accounted for 34% of the family *Balistidae*.

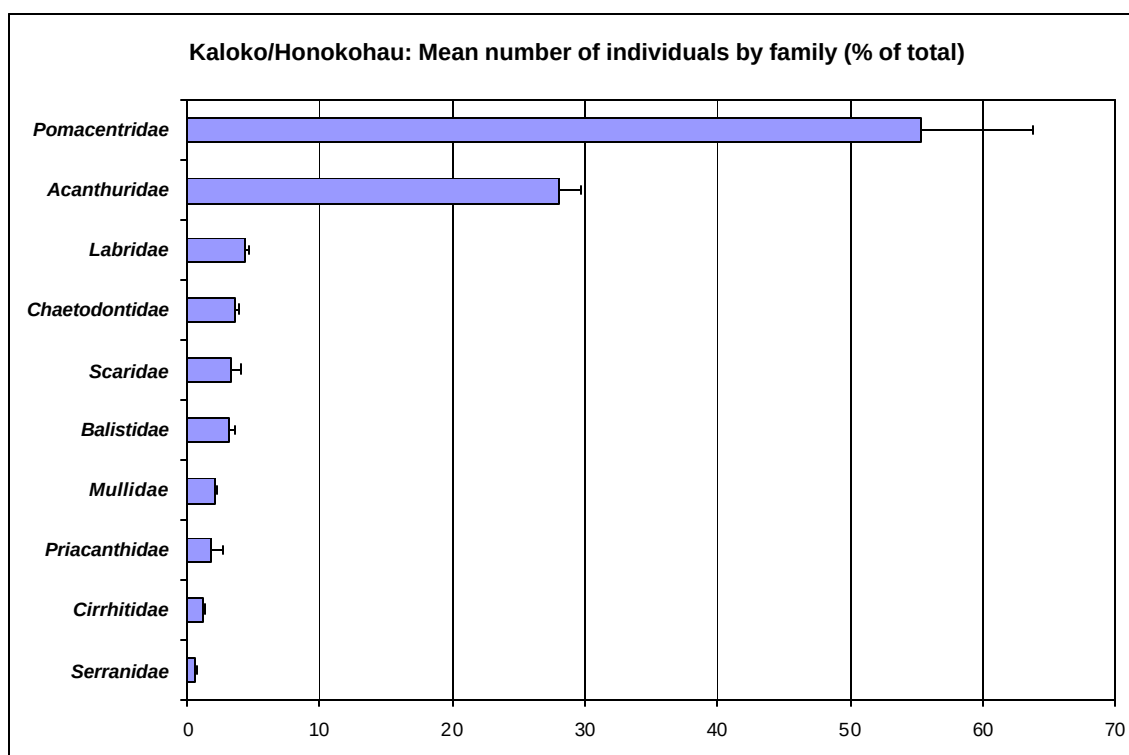


Fig. 3.10. Top 10 fish families with the highest abundance (mean number of individuals (% of total)).

Top 10 families: mean biomass (t/ha)			Top 10 families: mean number (hax1000)		
	mean	sd	family	mean	sd
<i>Acanthuridae</i>	0.156	0.07	<i>Pomacentridae</i>	6.78	8.44
<i>Balistidae</i>	0.044	0.04	<i>Acanthuridae</i>	3.44	1.73
<i>Pomacentridae</i>	0.036	0.07	<i>Labridae</i>	0.53	0.38
<i>Chaetodontidae</i>	0.018	0.02	<i>Chaetodontidae</i>	0.44	0.32
<i>Serranidae</i>	0.012	0.02	<i>Scaridae</i>	0.41	0.80
<i>Priacanthidae</i>	0.012	0.04	<i>Balistidae</i>	0.40	0.37
<i>Labridae</i>	0.010	0.01	<i>Mullidae</i>	0.26	0.20
<i>Scaridae</i>	0.009	0.01	<i>Priacanthidae</i>	0.23	0.93
<i>Mullidae</i>	0.004	0.01	<i>Cirrhitidae</i>	0.16	0.19
<i>Zanclidae</i>	0.002	0.00	<i>Serranidae</i>	0.08	0.08

Table 3.4. Top ten fish families with the greatest mean biomass (t/ha) and density (mean number of individuals (hax1000)) and standard deviations are shown in descending order.

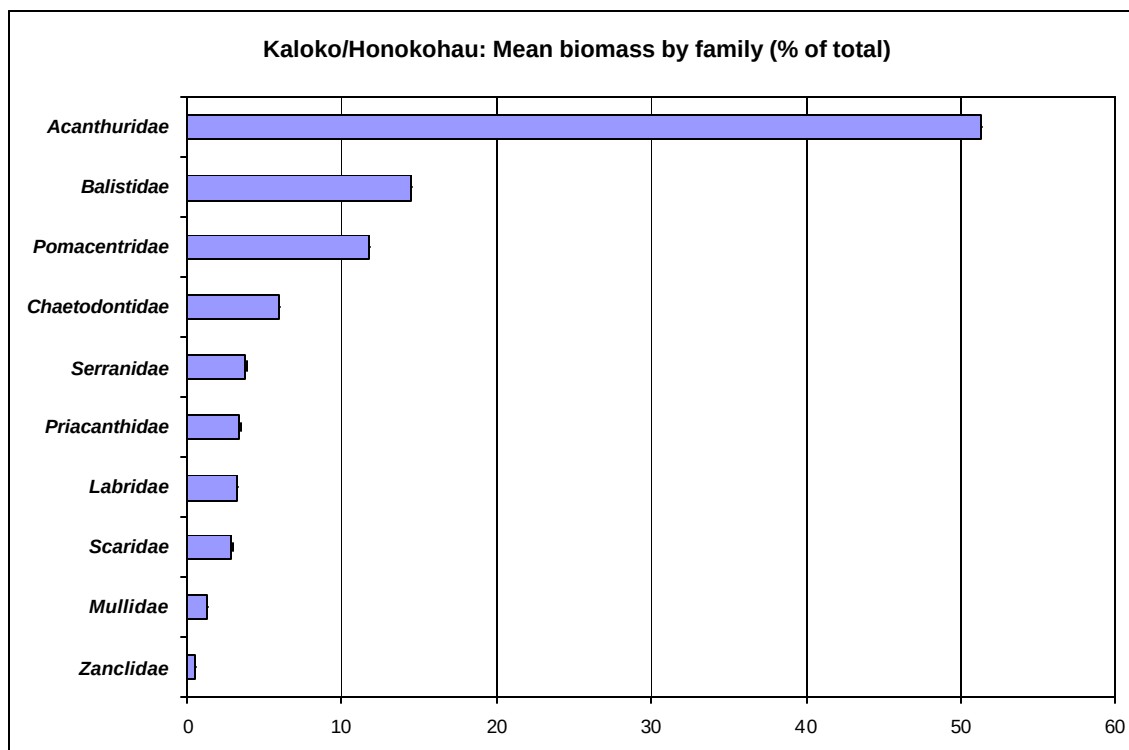


Fig. 3.11. Top 10 fish families with the greatest mean biomass (% of total).

3.2.3 Fish Data: Trophic levels

Summary of trophic levels: In the Main Hawaiian Islands, herbivorous fishes dominate, while piscivorous fishes are much less abundant in both numbers of individuals and biomass (Table 3.5). In sharp contrast, piscivores dominate in the northwestern Hawaiian Islands comprising nearly 75% of the fish populations. Much more typical of the Main Hawaiian Islands, the percentage of piscivores at Kaloko/Honokohau is only 4% of the total biomass. Planktivores make up 18% of the total and invertebrate feeders comprise 16%. Herbivores clearly dominate, with well over half of the total biomass (62%) (Fig.3.12). This is highly consistent with statewide averages for herbivorous fishes, which are only slightly lower

(59%). The large number of *Chromis* spp accounts for the high abundance of planktivores. Numerical densities follow an identical pattern as biomass with very few piscivores (Fig.3.13).

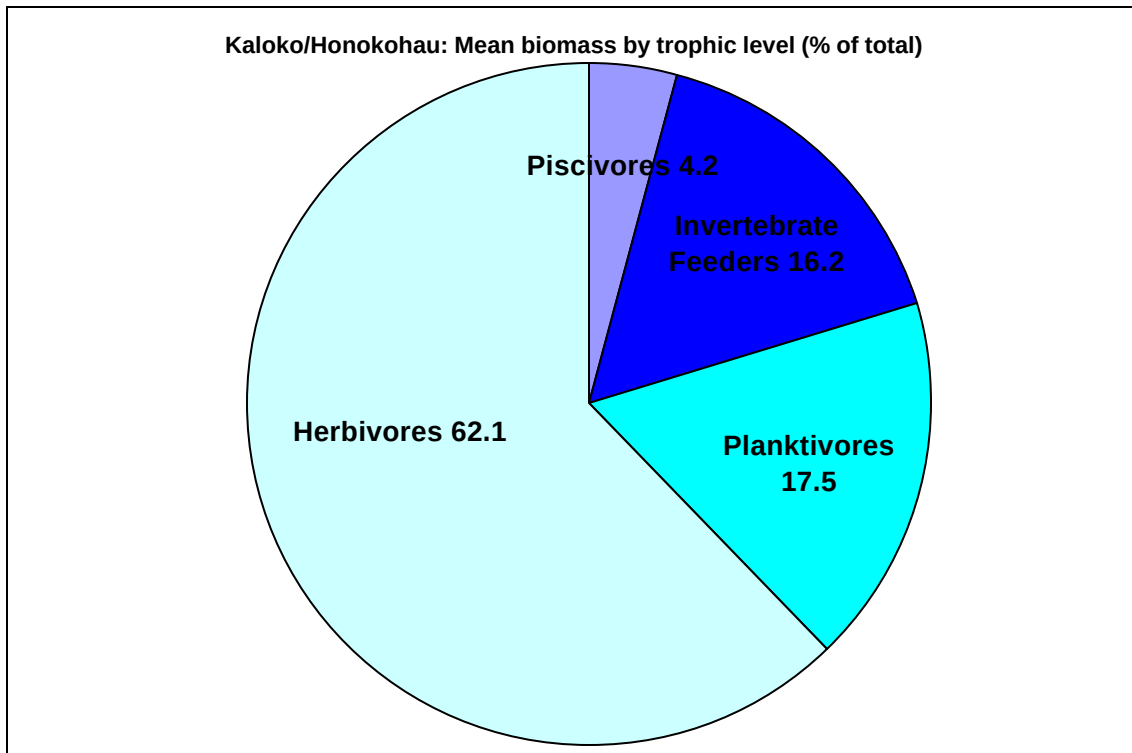


Fig. 3.12. Mean biomass (% of total) by trophic levels

Mean numbers of individuals by trophic level (hax1000)			Mean biomass by trophic level (t/ha)		
	mean	sd		mean	sd
Piscivores	0.13	0.09	Piscivores	0.01	0.02
Invertebrate Feeders	1.60	0.53	Invertebrate Feeders	0.05	0.03
Herbivores	4.07	2.29	Planktivores	0.05	0.10
Planktivores	7.05	8.47	Herbivores	0.19	0.10

Table 3.5. Mean biomass (t/ha) and density (mean number of individuals hax1000) by trophic levels and their standard deviations are shown in descending order.

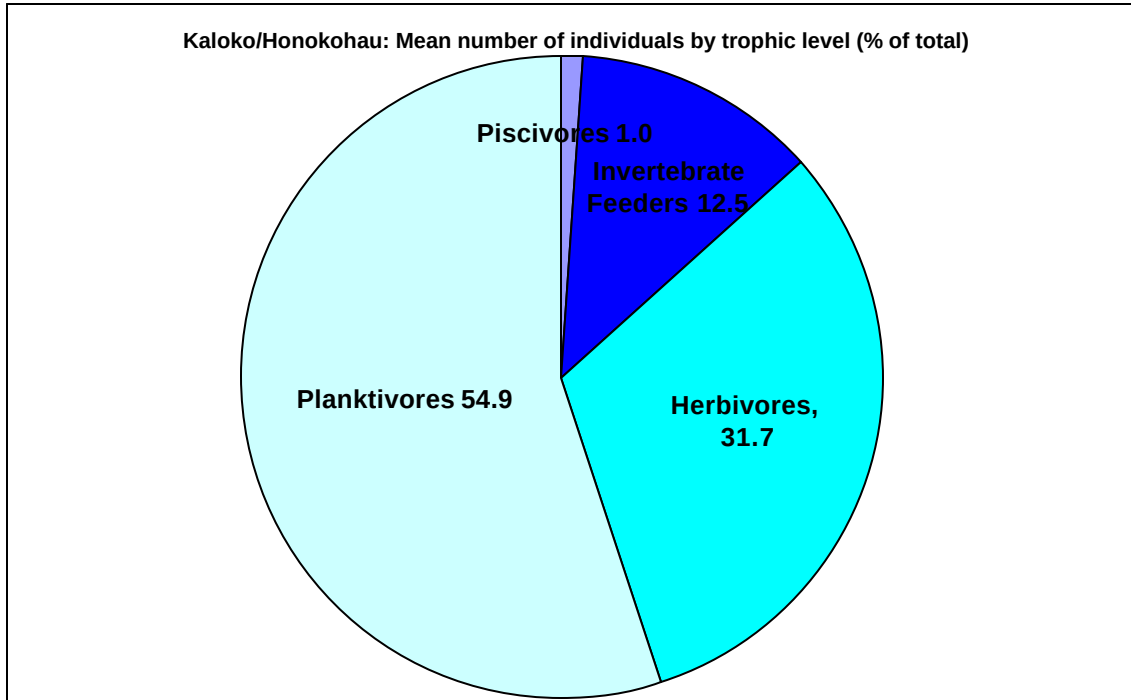


Fig. 3.13. Abundance (% of total) by trophic levels

3.2.4 Fish Data: Endemic status

Summary of endemic status: There is a low percentage of non-native species in both abundance and biomass at Kaloko/Honokohau (Fig.3.14, Table 3.6). Only two introduced species were recorded from this site, the alien snapper *Lutjanus kasmira* (ta'ape) and the introduced grouper, *Cephalopholis argus* (roi).

Twenty-one endemic species were recorded at Kaloko/Honokohau. Endemism at this site (25%) is remarkably similar to endemic rates for fishes found statewide (approx. 25%).

Consistent with the rest of the state, indigenous species found in both the Hawaiian Islands and the rest of the Pacific, comprise the majority of the abundance and biomass of fishes recorded at Kaloko/Honokohau.

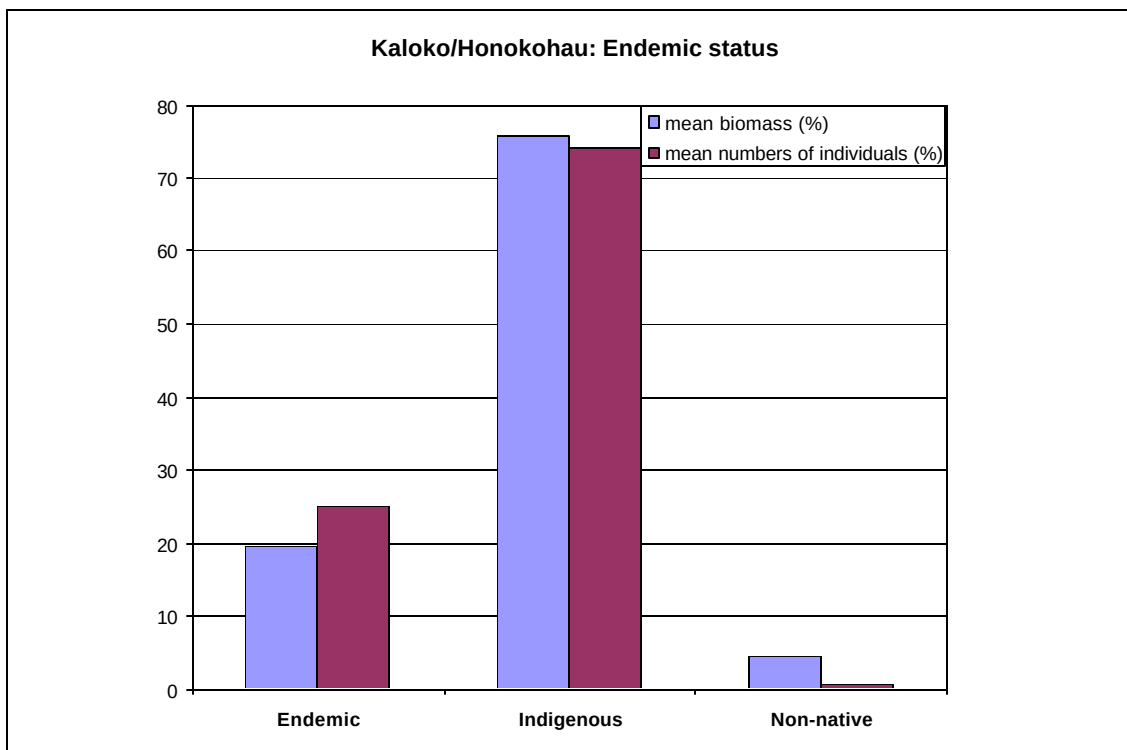


Fig. 3.14. Biomass (%) and number of individuals (%) by endemic status.

	Endemic status	
	mean biomass (t/ha)	mean numbers of individuals (ha x 1000)
Endemic	0.06	3.22
Indigenous	0.23	9.54
Non-native	0.01	0.09

Table 3.6. Mean biomass (t/ha) and mean number of individuals (ha x 1000) by endemic status.

3.2.5 Fish Data: Size classes

Summary of size classes: The high abundance of fishes in the smaller size class (42%) is due to the large numbers of *Chromis* which comprise only a very small percentage of the total biomass (2.3%). The largest size class shows the opposite effect where few fishes (5.3%) account for over a third (35%) of the total biomass. As was expected, the majority of fish biomass is in the 5-15 cm range (Fig. 3.15).

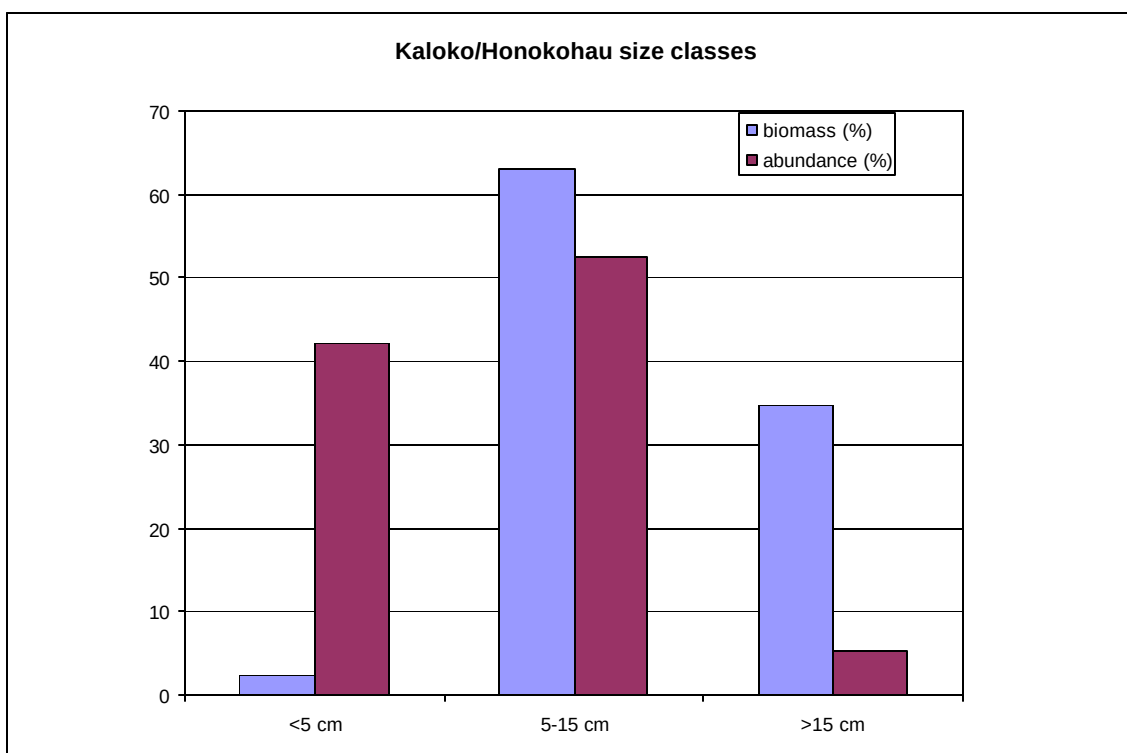


Fig. 3.15. Size classes of fishes by biomass (% of total) and abundance (% of total)

3.2.6 Fish Data: Summary.

Transect comparison summary: Fish populations are highly variable both spatially and temporally. Total counts ranged from 24 to 470 fishes per transect (Table 3.7). Differences in abundance, biomass and diversity are partially due to large, variable schools of *Chromis* as well as to differences in substrate type. Pooling transects gives a more representative picture of true populations within the entire sampling area, while individual transects provide data relative to other transects that can relate to physical and biological parameters (rugosity, sediments, coral cover etc.).

The average number of species observed on a transect was 17.5, slightly higher than the statewide average, and with high variability between stations. High standard deviations in abundance are due to observations of large schools of fish at some locations (Table 3.8). Although the mean values for numerical densities are higher at Kaloko/Honokohau than they are statewide, the biomass is lower. This is probably a reflection of the large schools of small-bodied *Chromis* found here.

Summary statistics by transect				Survey date: April, 29, 2004				
Transect	Depth (m)	Number of species	Total count	Total biomass	number ha x (1000)	biomass (t/ha)	Diversity	Evenness
1	11.8	17	312	3669.39	24.96	0.29	0.85	0.3
2	13.3	18	106	3497.02	8.48	0.28	2.27	0.78
3	12.1	21	266	3156.69	21.28	0.25	1.2	0.39
4	11.5	20	103	7560.59	8.24	0.60	2.1	0.7
5	8.2	13	24	2484.06	1.92	0.20	2.42	0.94
6	12.4	21	156	4614.76	12.48	0.37	1.84	0.6
7	17.3	16	142	2664.76	11.36	0.21	1.79	0.65
8	15.5	14	111	3822.72	8.88	0.31	1.87	0.71
9	14.5	16	121	4167.91	9.68	0.33	1.76	0.64
10	13.9	21	168	4467.02	13.44	0.36	2.06	0.68
11	7	22	147	4476.27	11.76	0.36	2.33	0.75
12	18.2	19	470	3210.41	37.6	0.26	1.09	0.37
13	18.2	21	138	2389.71	11.04	0.19	1.95	0.64
14	12.1	10	97	2242.44	7.76	0.18	1.65	0.72
15	3.9	17	119	4157.1	9.52	0.33	1.95	0.69
16	5.5	16	124	4797.28	9.92	0.38	1.99	0.72
17	2.7	15	128	4680.25	10.24	0.37	1.98	0.73

Table 3.7. Summary statistics by transect

Location: Transect	Depth (fsw)	Depth (m)	Rugosity	Latitude (WGS84)	Longitude (WGS84)	UTMEast Zone5 N	UTMNorth Zone5 N
RAT 1; random site 98	39	11.8	1.34	19.664500	-156.032167	182037.35	2177188.67
RAT 2; random site 60; 14 m	44	13.3	1.39	19.687833	-156.036500	181628.78	2179781.58
RAT 3; random site 68/18	40	12.1	1.36	19.686500	-156.035667	181713.57	2179632.32
RAT 4; random site 46; 11 m	38	11.5	1.8	19.692333	-156.045667	180675.90	2180297.30
RAT 5; random site 51	27	8.2	1.06	19.681667	-156.035000	181773.97	2179095.65
RAT 6; random site 99	41	12.4	1.24	19.675500	-156.034667	181796.74	2178411.90
RAT 7; near random pt 77	57	17.3	1.68	19.690167	-156.039000	181371.09	2180044.76
RAT 8; random site 87	51	15.5	1.9	19.670667	-156.030167	182259.40	2177868.06
RAT 9; S. Instrument	48	14.6	1.07	19.674167	-156.033500	181916.53	2178262.02
RAT 10; NPS receiver	46	13.9	2.06	19.671500	-156.031167	182156.11	2177962.24
RAT 11; NPS receiver	23	7.0	1.24	19.670000	-156.028833	182398.00	2177791.71
RAT 12; random site 37	60	18.2	1.38	19.689021	-156.038116	181461.59	2179916.15
RAT 13; random site 34	60	18.2	1.37	19.675257	-156.035240	181736.14	2178386.02
RAT 14; random site 12	40	12.1	1.81	19.678665	-156.035357	181730.62	2178763.82
RAT 15; random site 64	13	3.9	1.26	19.673372	-156.031994	182072.97	2178171.17
RAT 16; random site 76	18	5.5	1.45	19.679356	-156.034058	181868.22	2178837.96
RAT 17; random site 28	9	2.7	1.65	19.668387	-156.027887	182494.11	2177611.27

Overall summary statistics: Kaloko								
Avg Count of species	StDev of Count of species	Avg number ha x (1000)	StDev of number ha x (1000)	Avg of biomass (t/ha)	StDev of biomass (t/ha)	overall average diversity	StDev of diversity	Avg of evenness
17.47	3.36	12.86	8.2	0.31	0.1	1.83	0.43	0.65
Statewide								
16.91	6.75	9.82	7.91	0.6	1.28	1.94	0.59	0.7

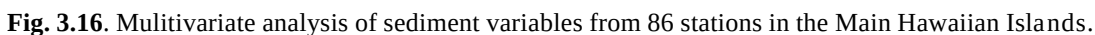
Table 3.8. Summary statistics and geographic location.

Statewide rankings: Among 56 locations surveyed, Kaloko/ Honokohau ranked 25th in average number of species found (17.5 species), 12th in abundance of fishes (19,600 per ha), 41st in biomass (0.31 t/ha), 41st in diversity (1.83), and 48th in evenness (0.65).

The most abundant species were the *Chromis* spp. The species with the highest biomass is *Zebrasoma flavescens*, the yellow tang, followed closely by *Naso lituratus*, the orangespine unicornfish, both highly prized species in the aquarium fish trade. The high biomass of these species reflects the prohibition of aquarium fish collection at this site.

3.3 Analyses

Both Kaloko/Honokohau stations (12m and 18m) lie on the outskirts of the center group encompassing the majority of sites (Fig.3.16). The only sediment variable distinguishing these two stations from the main group is the higher percentage of carbonate material. All grain-sizes and organics are consistent with the state averages. Kaloko/Honokohau does not fall within outlined sites with anomalous sediment characteristics.



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. Prog. Ser.* 230:253-264

Hawai'i State GIS Program. Office of Planning. 2004. www.hawaii.gov/dbedt/gis

Naval Oceanographic Office Official U.S. Navy website. 2004. www.navo.navy.mil.

4.0 Pu'uuhonua o Honaunau (PUHO)

Pu'uuhonua o Honaunau was minimally sampled due to time constraints. Data from three transects at comparable depths was collected on April 29th, 2004 to assess differences at the furthest extent of the National Park boundaries. Stations at approximately 12 meters were surveyed in the northern, middle and southern sections of the park (Fig.4.1) The following preliminary results will be recalculated to include future supplementary data.

Pu'uuhonua o Honaunau Rapid Assessment Stations

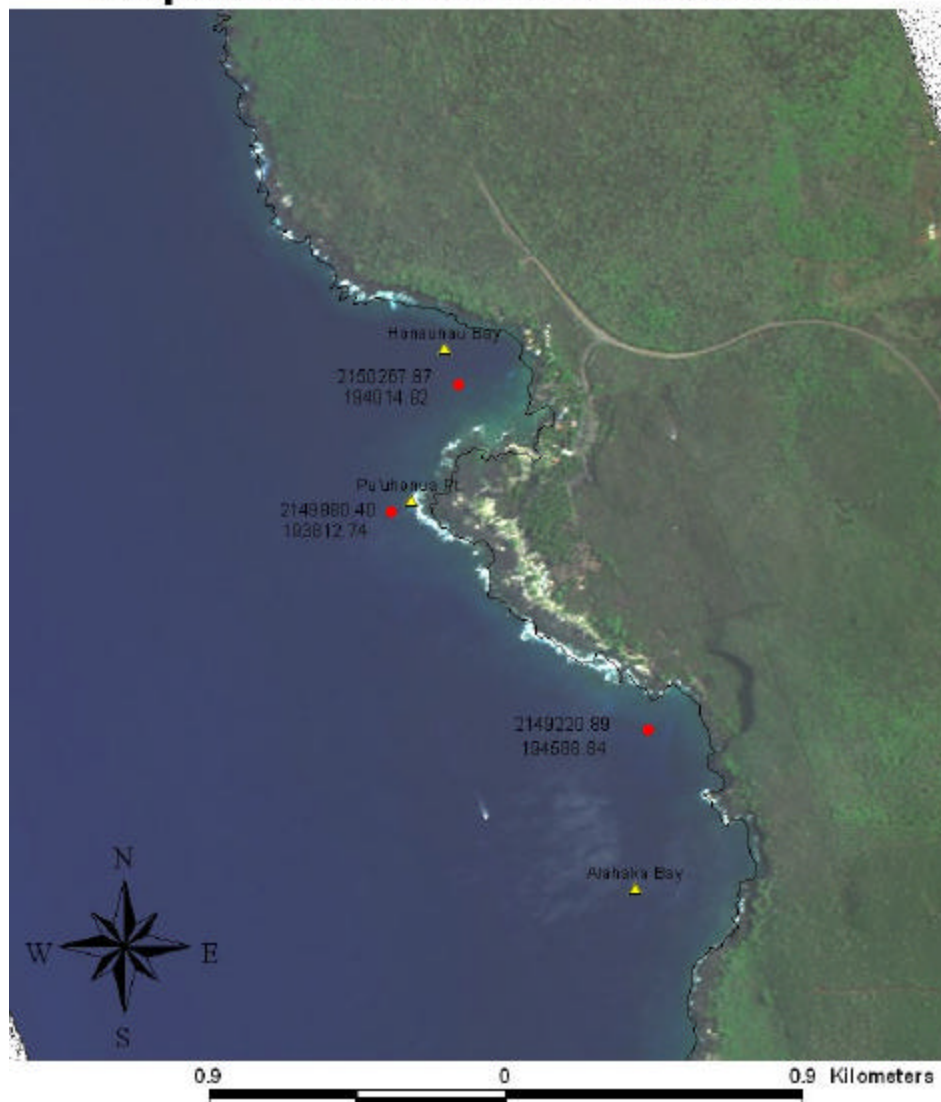


Fig 4.1 Map of rapid assessment stations at Pu'uuhonua o Honaunau.

4.1 Benthic Data:

4.1.1 Coral communities

High coral cover characterizes this site. Coral cover ranged from 21.4% at the middle transect to 67% at the northern most station (Figs. 4.2). Mean coral cover (45.8%) is much higher than the statewide average of 22%. In concordance with statewide results, Pu'u'honua o Honaunau reefs are mainly *Porites* reefs, comprised of *P. lobata*, *P. compressa* and *P. evermanni*, (Table 4.1). The dominant species, *P. lobata*, averaged nearly 30%. A total of eight species from three separate genus were quantified from this site.

Unlike Kaloko/Honokohau, Pu'u'honua o Honaunau has no recorded *Anthelia edmonsoni*, although this can probably be attributed to a small sample size. This species is common in many West Hawai'i locations.

Transect	<i>Mcapitata</i>	<i>Mpatula</i>	<i>Mstudereri</i>	<i>Pvarians</i>	<i>Pmeandrina</i>	<i>Pcompressa</i>	<i>Pevermanii</i>	<i>Plobata</i>	Total Coral cover
1	0.0	0.6	0.2	0.6	0.2	19.6	10.0	0.0	48.9
2	0.8	0.0	0.0	0.0	2.6	3.2	0.2	14.6	21.4
3	0.2	0.2	0.0	1.6	0.2	23.4	0.0	41.4	67.0
Site Average%	0.3	0.3	0.1	0.7	1.0	15.4	3.4	27.7	45.8

Table 4.1. Percentages of coral cover by species and total coral cover by transect.

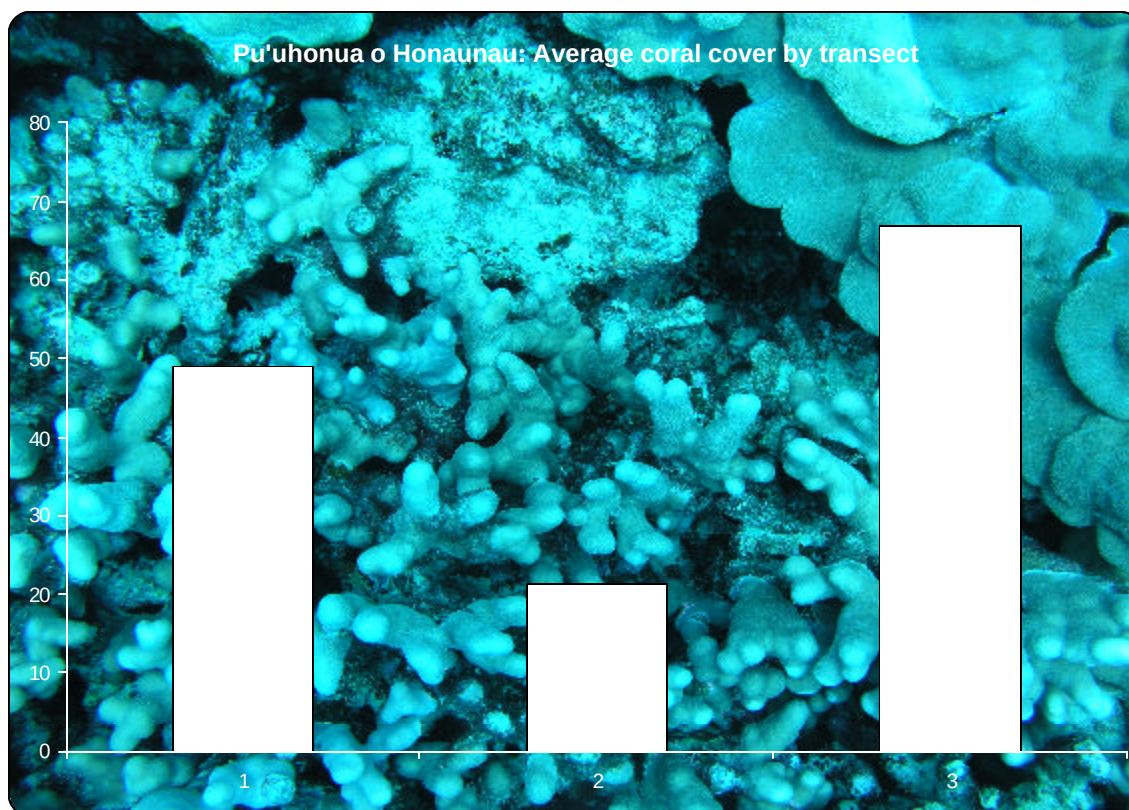


Fig.4-2. Mean total coral cover by transect at Pu'u'honua o Honaunau (n=3)

4.1.2 Substrate

Substrate cover is dominated by coralline algae (37%) and a large percentage of turf algae (14%). Very low amounts of macroalgae (0.2%) and sand (0.1%) were quantified (Fig.4.3). An abundance of calcareous, coralline algae is conducive to settlement by many coral species, providing substrate for coral larval recruitment.

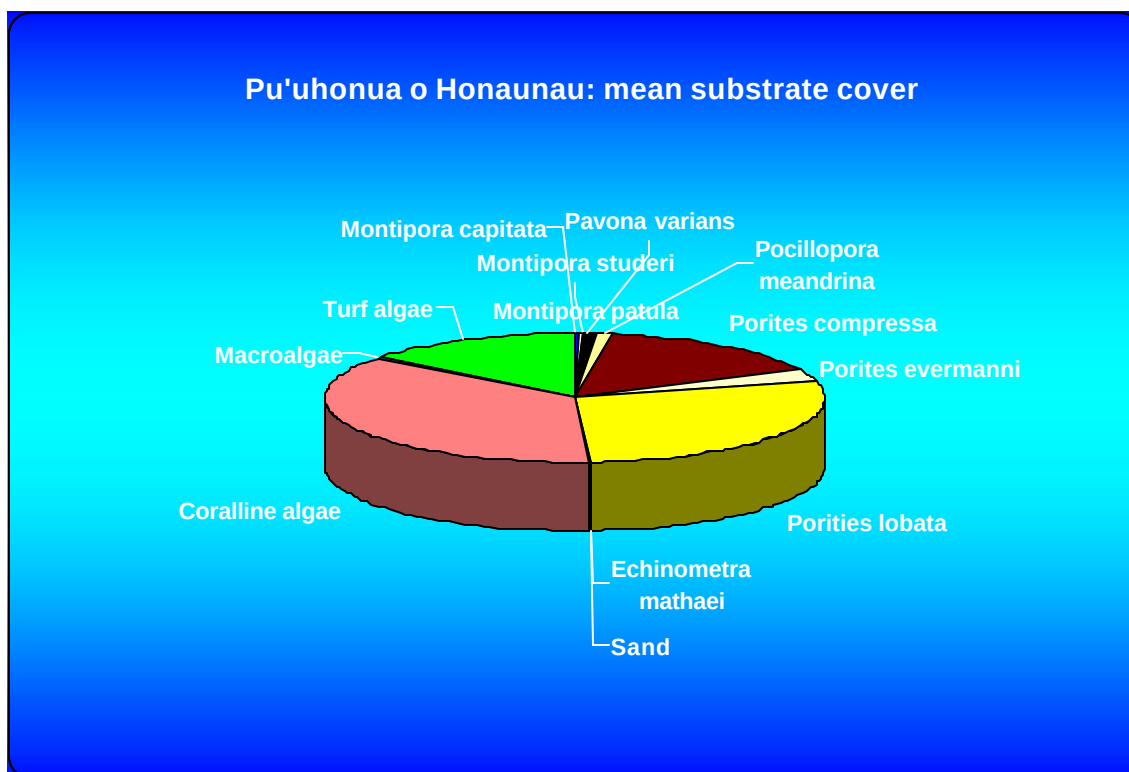


Fig. 4.3. Mean substrate cover at Pu'uuhonua o Honaunau

4.1.3 Invertebrates

Although several invertebrate species were recorded from casual observations in the surrounding area, only one species, the rock-boring urchin, *Echinometra mathaei* was quantified from the digital images

4.1.4 Observations

Substrate observations for each transect include species lists, dominant and unusual species, and substrate type. Transitional substrate changes and shifts in coral species and/or cover and their associated depths were also noted. Five Crown of Thorns seastars, *Acanthaster planci*, were observed from the middle transect. Unusual species include the round mushroom coral from the genus *Cycloceris*. Coral cover was observed to decrease rapidly beyond 15 meters, with *Porites compressa* rubble observed at depths at all stations. Macroalgae was only observed at the northern most station.

RAT #1) Species list:

Coral: *Montipora capitata* *Montipora patula* *Pocillopora meandrina*, *Porites compressa*, *Pavona varians*, *Cycloceris*

Macroalgae: none

Inverts: none

Observations: colonized pavement, high coral cover drops off with depth, rubble further down

RAT #2) Species list:

Coral: *Montipora capitata* *Pocillopora meandrina*, *Porites lobata*, *Porites compressa*, *Porites evermanni*, *Leptastrea purpurea*

Macroalgae: none

Inverts: *Acanthaster*, *Echinometra mathaei*

Observations: colonized pavement, high coral cover, 5 *Acanthaster* on 10m transect, drops off with depth, rubble further down

RAT #3) Species list:

Coral: *Montipora capitata* *Montipora patula* *Pocillopora meandrina* *Porites lobata* *Porites compressa*, *Pavona varians*

Macroalgae: *Caulerpa racemosa*, *Asparagopsis taxiformis*, *Turbinaria ornata*, *Halimeda*

Inverts: *Tripneustes gratilla*

Observations: colonized pavement, high coral cover, drops off with depth, mainly Pc on slope, rubble further down

4.2 Fish data

Results and Summaries of pooled transects

4.2.1 Top species

Summary of top species: The most abundant species are the *Chromis* spp. These planktivores are especially abundant along the Kona coast of the island of Hawai'i (Fig. 4.4, Table 4.2). Some of most commonly recorded species statewide are also among the 10 most abundant species at Pu'uhonua o Honaunau including, *Acanthurus nigrofusus* (mai'i'i), *Ctenochaetus strigosus* (kole), and *Lutjanus kasmira* (ta'ape)

The species with the highest biomass is the non-native snapper, *Lutjanus kasmira* (ta'ape) (Fig. 4.5, Table 4.3). Originally from the Marquesas, this species was introduced in 1958 by the state of Hawai'i for commercial purposes. It has not been widely accepted as a food fish among the local population. Another introduction that is among the top 10 species in biomass is *Cephalopholis argus* (roi), that was also introduced by the state as a food fish in 1956 from Moorea, French Polynesia. *Zebrasoma flavescens*, the yellow tang, that is popular in the aquarium trade, has the second highest biomass at this location. This is likely attributed to the prohibition of aquarium fish collection at this site.

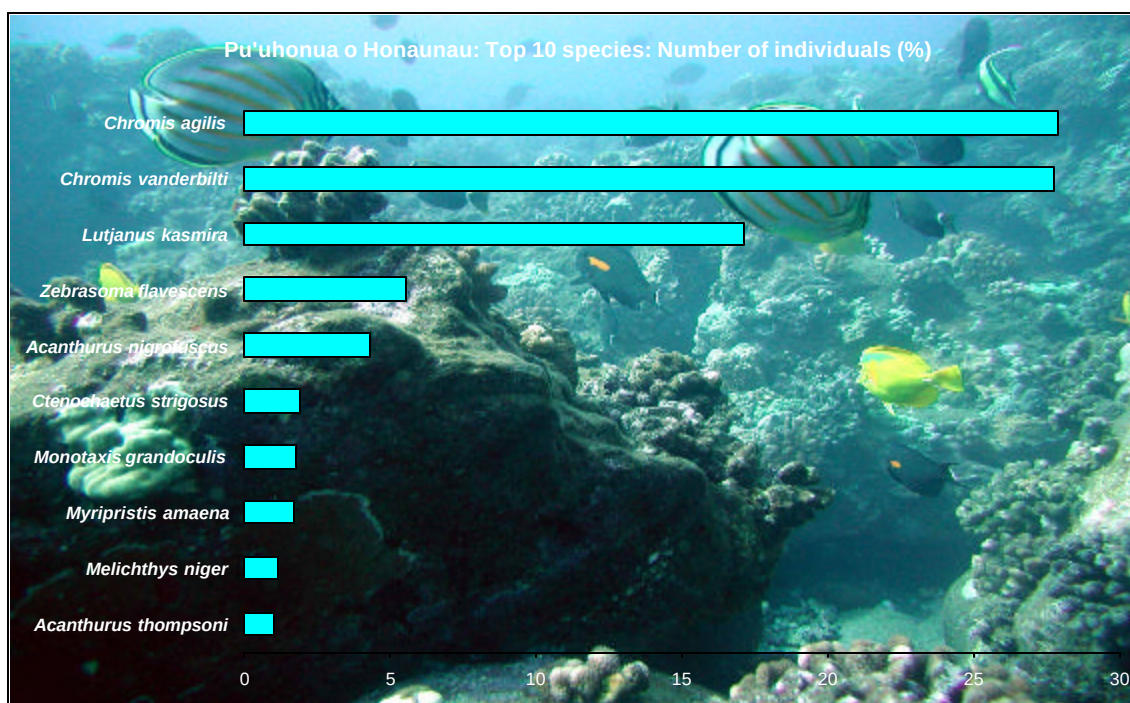


Fig. 4.4 Top 10 fish species with the highest abundance (mean number of individuals (%)).

Taxonomic Name	Common Name	Hawaiian Name	Mean density (hax1000)	Mean biomass (t/ha)	Frequency of occurrence (%)
<i>Chromis agilis</i>	Reef chromis		5.63	0.02	66.67
<i>Chromis vanderbilti</i>	Black-finned chromis		5.6	0.01	33.33
<i>Lutjanus kasmira</i>	Yellow lined snapper	ta'ape	3.47	0.09	33.33
<i>Zebrasoma flavescens</i>	Yellow tang	lauipala	1.12	0.07	100
<i>Acanthurus nigrofasciatus</i>	Lavendar tang	mai'i'i	0.88	0.01	66.67
<i>Ctenochaetus strigosus</i>	Goldring surgeonfish	kole	0.4	0.01	100
<i>Monotaxis grandoculis</i>	Bigeye emperor	mu	0.37	0.01	33.33
<i>Myripristis amaena</i>	Brick soldierfish	u'u	0.35	0.02	66.67
<i>Melichthys niger</i>	Black durgon	humuhumu'ele'ele	0.24	0.04	33.33
<i>Acanthurus thompsoni</i>	Thompson's surgeonfish		0.21	0.01	33.33

Table 4.2. Top ten fish species with the highest abundance (mean number of individuals hax1000) are shown in descending order with their associated mean biomass (t/ha) and frequency of occurrence (%)

Fish Data: Greatest biomass

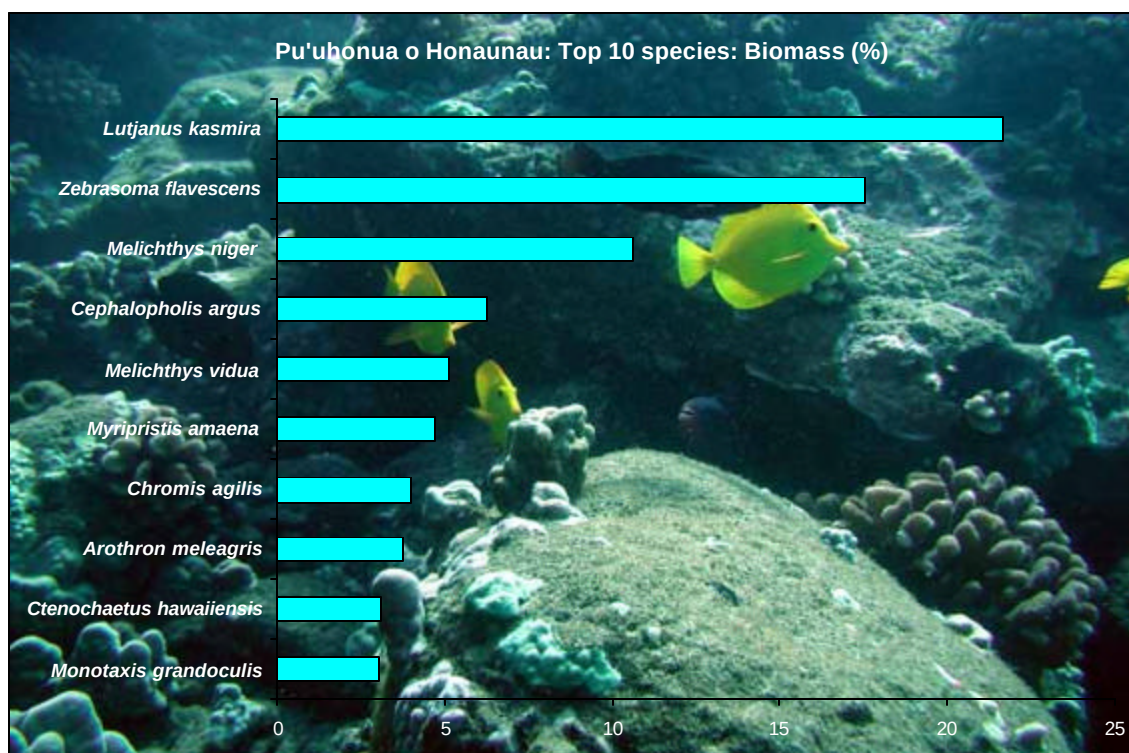


Fig. 4.5. Top 10 fish species with the greatest mean biomass (%).

Taxonomic Name	Common Name	Hawaiian Name	Mean biomass (t/ha)	Mean density (hax1000)	Frequency of occurrence (%)
<i>Lutjanus kasmira</i>	Yellow lined snapper	ta'ape	0.09	3.47	33.33
<i>Zebrasoma flavescens</i>	Yellow tang	lauipala	0.07	1.12	100
<i>Melichthys niger</i>	Black durgon	humuhumu'ele'ele	0.04	0.24	33.33
<i>Cephalopholis argus</i>	Peacock grouper	roi	0.03	0.16	100
<i>Melichthys vidua</i>	Pinktail triggerfish	Humuhumuhi'ukole	0.02	0.19	100
<i>Myripristis amaena</i>	Brick soldierfish	u'u	0.02	0.35	66.67
<i>Chromis agilis</i>	Reef chromis		0.02	5.63	66.67
<i>Arothron meleagris</i>	Spotted puffer	'o'opuhue	0.02	0.03	33.33
<i>Ctenochaetus hawaiiensis</i>	Black surgeonfish		0.01	0.13	33.33
<i>Monotaxis grandoculis</i>	Bigeye emperor	mu	0.01	0.37	33.33

Table 4.3. Top ten fish species with the greatest mean biomass (t/ha) are shown in descending order with their associated abundance (mean number of individuals hax1000) and frequency of occurrence (%).

4.2.2 Fish Data: Families of fishes

Summary of top families: The family with the greatest recorded number of individuals is *Pomacentridae*. Large numbers of individuals from four species of *Chromis* and two species of *Plectroglyphidodon* were recorded from this family. Along with *Pomacentridae*, six other families dominated the top ten in both abundance and biomass. These families include; *Lutjanidae*, *Acanthuridae*, *Chaetodontidae*, *Balistidae*, *Lethrinidae*, and *Holocentridae* (Fig. 4.6, Table 4.4).

The family with the greatest recorded biomass is *Acanthuridae*. *Acanthurus nigrofusus* (mai'i'i) accounted for the majority of fish in this family and was observed on all the transects conducted at this site. The remainder of the species in this family included a large school of *Acanthurus thompsoni*, recorded on the northern transect. Other families with a large number of fishes recorded included *Lutjanidae* and *Balistidae* (Fig. 4.7, Table 4.4). A single observation of 130 *Lutjanus kasmira* (ta'ape) recorded on the south transect accounted for the dominant status of this family, while *Melichthys* spp. were more evenly distributed on all transects. The relatively large number of six species of butterflyfish can be directly attributed to the high coral cover in this area.

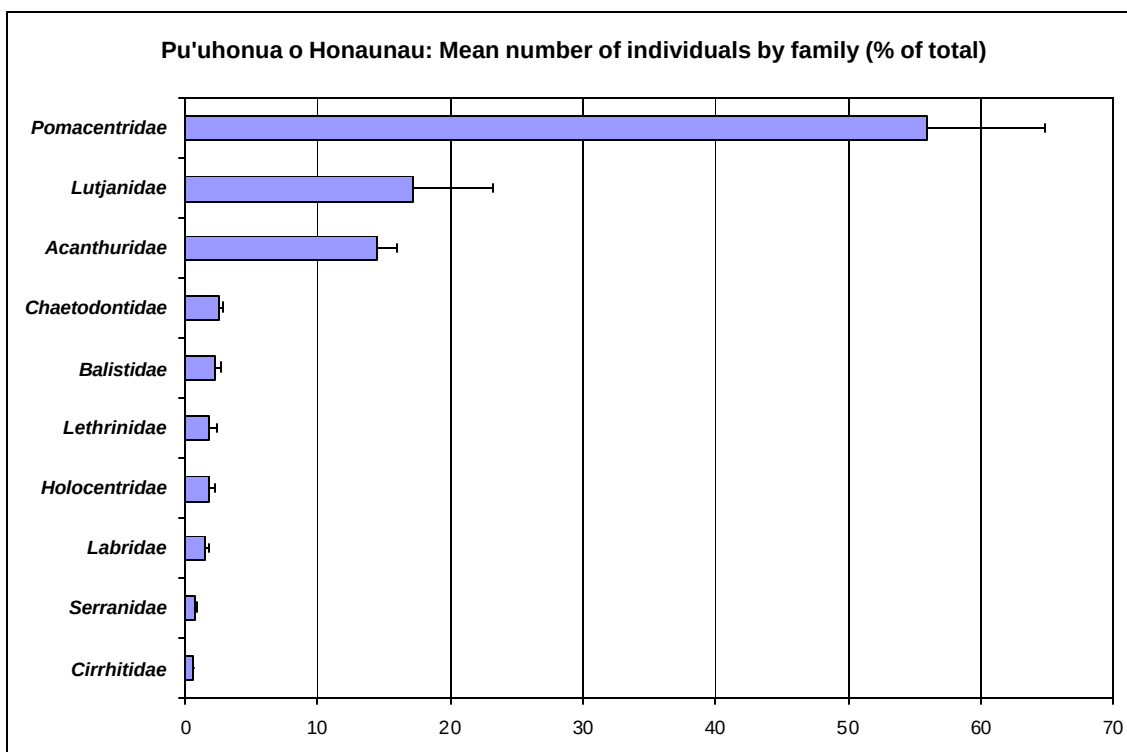


Fig. 4.6. Top 10 fish families with the highest abundance (mean number of individuals (%)).

Top 10 families: mean biomass (t/ha)			Top 10 families: mean number (hax1000)		
	mean	sd	family	mean	sd
<i>Scaridae</i>	0.01	0.01	<i>Cirrhitidae</i>	0.11	0.18
<i>Lethrinidae</i>	0.01	0.02	<i>Serranidae</i>	0.16	0.08
<i>Chaetodontidae</i>	0.02	0.01	<i>Labridae</i>	0.32	0.29
<i>Ostraciidae</i>	0.02	0.03	<i>Holocentridae</i>	0.37	0.32
<i>Holocentridae</i>	0.02	0.02	<i>Lethrinidae</i>	0.37	0.65
<i>Pomacentridae</i>	0.02	0.03	<i>Balistidae</i>	0.45	0.51
<i>Serranidae</i>	0.03	0.02	<i>Chaetodontidae</i>	0.51	0.33
<i>Balistidae</i>	0.07	0.08	<i>Acanthuridae</i>	2.93	1.48
<i>Lutjanidae</i>	0.09	0.16	<i>Lutjanidae</i>	3.47	6.00
<i>Acanthuridae</i>	0.13	0.08	<i>Pomacentridae</i>	11.28	9.01

Table 4.4. Top ten fish families with the greatest mean biomass (t/ha) and density (mean number of individuals hax1000) and standard deviations are shown in ascending order.

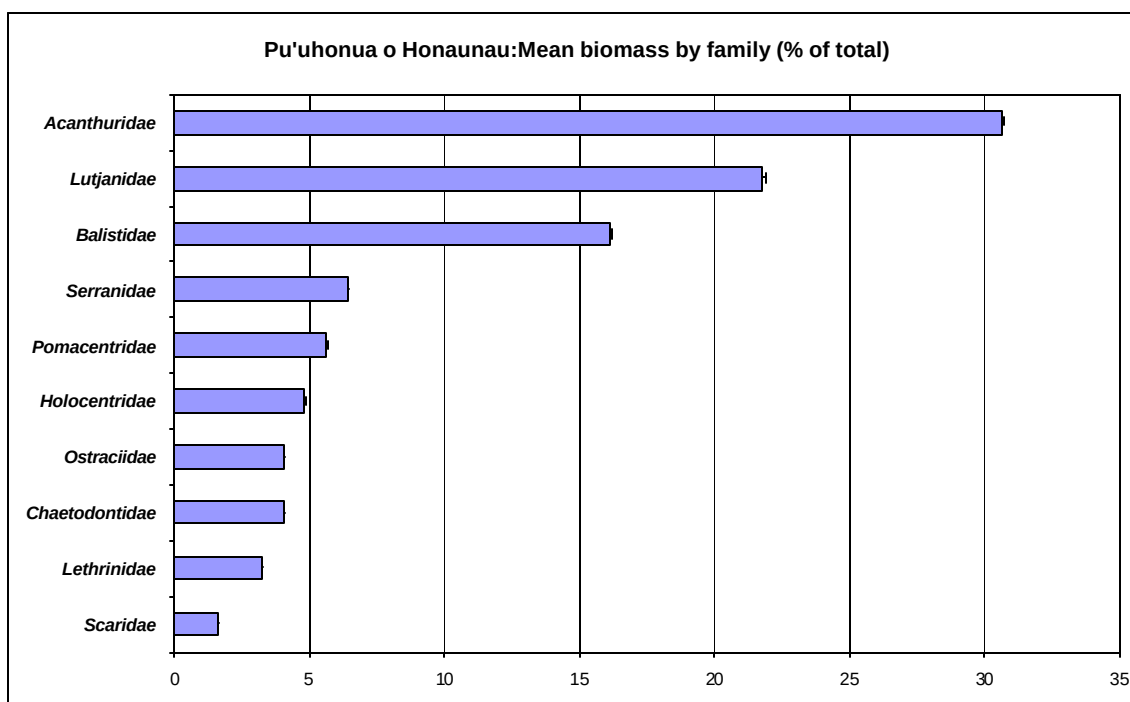


Fig. 4.7. Top 10 fish families with the greatest mean biomass (%).

4.2.3 Fish Data: Trophic levels

Summary of trophic levels: Typical of the main Hawaiian Islands, herbivorous fishes dominate while piscivorous fishes, especially apex predators are much less abundant. This is particularly evident in comparisons with the northwestern Hawaiian Islands where piscivores comprise nearly 75% of the fish population. The percentage of piscivores at Pu'uuhonua o Honaunau is only 6.6% of the total biomass while planktivores make up 12.4%. Invertebrate feeders comprise 34.7% of the total with herbivores dominating with nearly half of the total biomass (46.3%) (Fig. 4.8). This is much more consistent with statewide averages of herbivores which are slightly higher (59.1%) while the other trophic levels averages statewide are slightly lower.

The dominant status of planktivores in abundance can be attributed to the large number of *Chromis* spp. Piscivorous fish percentages are consistently lower in both abundance and biomass relative to other trophic levels (Fig. 4.9 and Table 4.5).

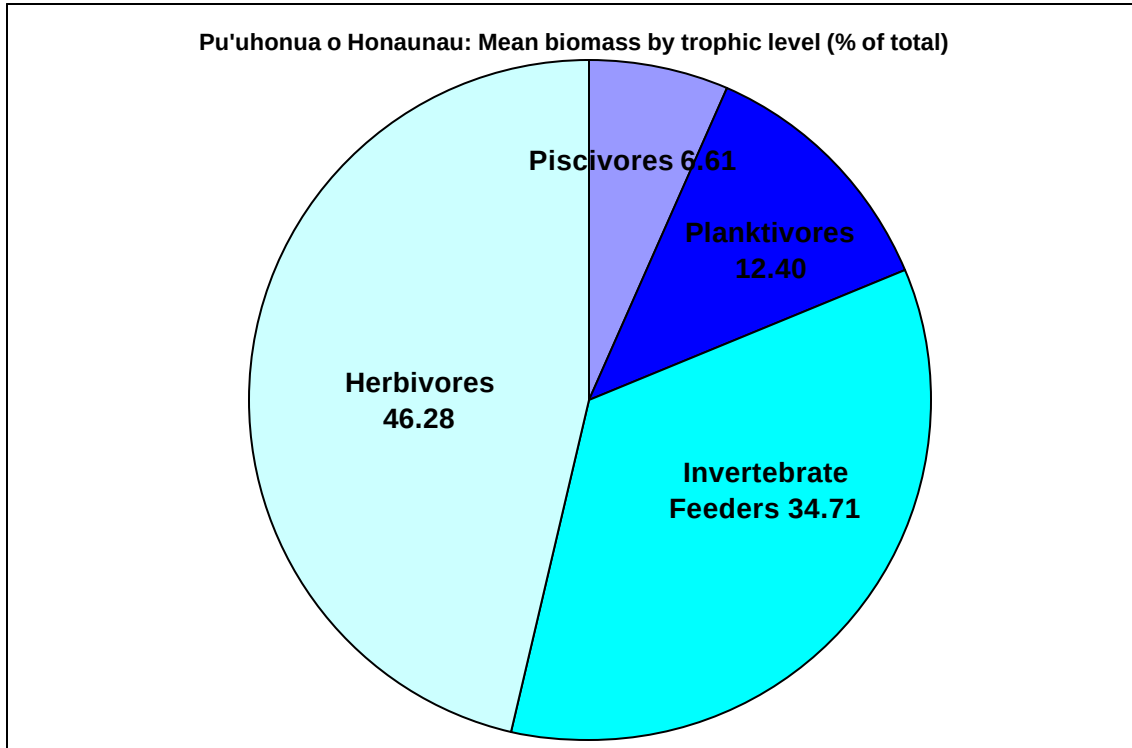


Fig. 4.8. Mean biomass (% of total) by trophic levels

Mean numbers of individuals by trophic level (hax1000)			Mean biomass by trophic level (t/ha)		
	mean	sd		mean	sd
Piscivores	0.27	0.26	Piscivores	0.03	0.02
Herbivores	3.25	2.00	Planktivores	0.05	0.04
Invertebrate Feeders	4.80	6.31	Invertebrate Feeders	0.14	0.16
Planktivores	11.87	9.03	Herbivores	0.19	0.15

Table 4.5. Mean biomass (t/ha) and density (mean number of individuals hax1000) by trophic levels and their standard deviations are shown in descending order.

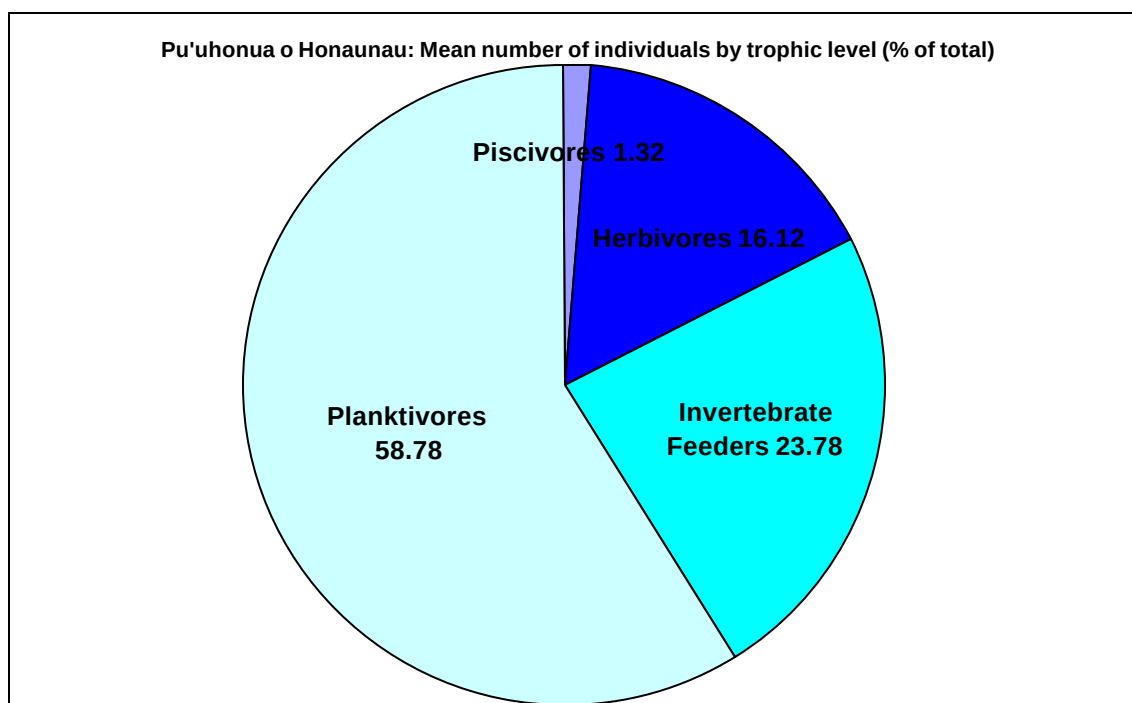


Fig. 4.9. Abundance (% of total) by trophic levels

4.2.4 Fish Data: Endemic status

Summary of endemic status: The high percentage of non-native species is mainly attributed to a single observation of a large school of *Lutjanus kasmira* (ta'ape). The introduced grouper, *Cephalopholis argus* also substantially contributed to the large biomass of non-native fishes since large individuals were found on all transects.

The low percentage of endemic species is mainly due to the high percentage of introduced species recorded (Fig. 4.10, Table 4.6). Four endemic species were recorded; *Thalassoma duperrey* (hinalea lau wili) commonly found in high abundance throughout the state, *Coris venusta*, *Chaetodon multicinctus*, and *Stethojulis balteata* (omaka). Additional transects should increase endemism percentages.

Indigenous species, found in the Hawaiian Islands as well as elsewhere in the Pacific, comprised the majority of the abundance and biomass of fishes recorded at Pu'uuhonua o Honaunau.

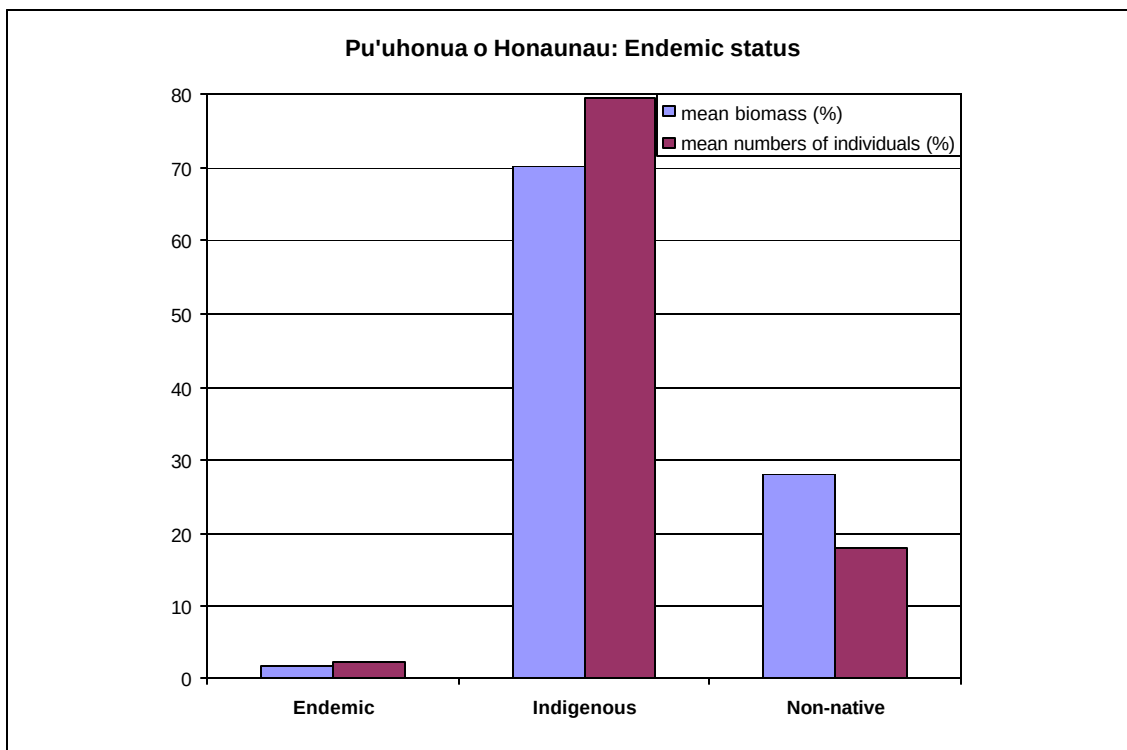


Fig. 4.10. Biomass (%) and number of individuals (%) by endemic status.

	Endemic status	
	mean biomass (t/ha)	mean numbers of individuals (ha x 1000)
Endemic	0.01	0.48
Indigenous	0.29	16.08
Non-native	0.11	3.63

Table 4.6. Mean biomass (t/ha) and mean number of individuals (ha x 1000) by endemic status.

4.2.5 Fish Data: Size classes

Summary of size classes: The high abundance of fishes in the smaller size class (37.2%) is due to the large numbers of *Chromis*. Although there are large numbers in the smallest size class, they comprise a very small percentage of the total biomass (0.9%). The opposite effect is represented in the largest size class where few fishes (2.4%) account for 21.2% of the total biomass. The majority of fish biomass is in the 5-15 cm range (Fig. 4.11).

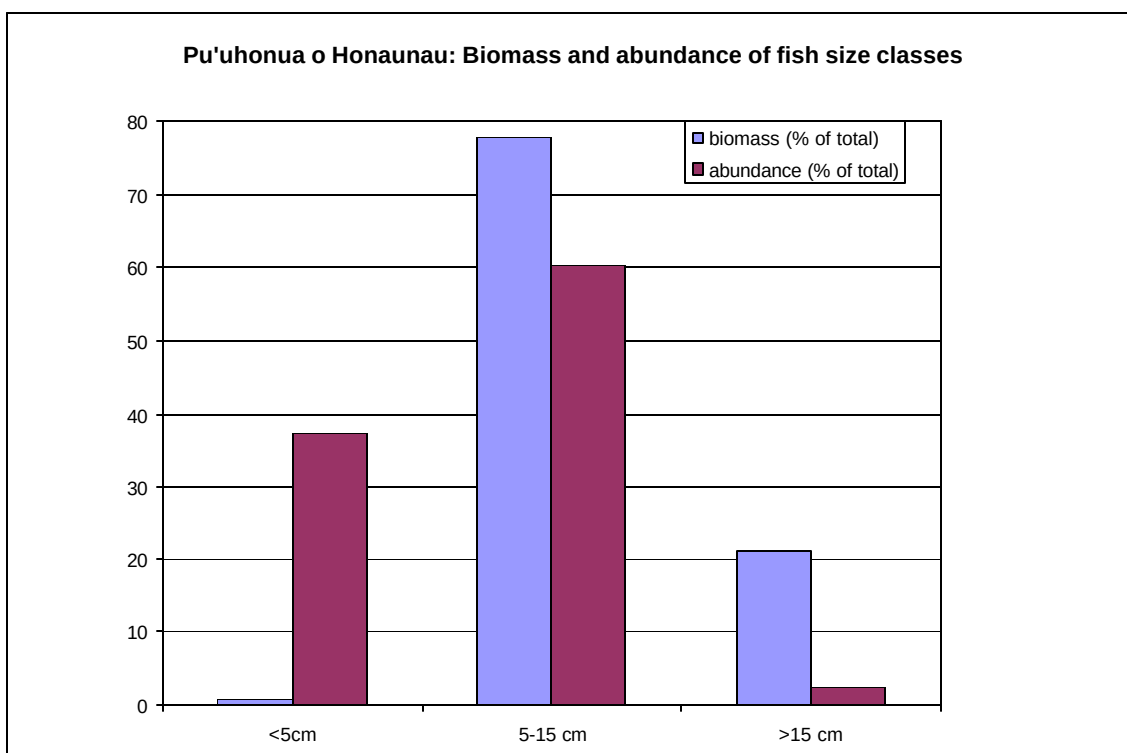


Fig. 4.11. Size classes of fishes by biomass (% of total) and abundance (% of total).

4.2.6 Fish Data: Summary

Transect comparison summary: Fish population statistics were similar among transects for biomass (Table 4.7). Differences in abundance are due to large, variable schools of *Chromis*. More species were encountered on the north transect.

The average number of species observed on transect was 18. High standard deviations in abundance are due to observations of large schools of fish at some locations (Table 4.8).

Summary statistics by transect

				Survey date: April, 29, 2004				
Transect	Depth (m)	Number of species	Total count	Total biomass	number ha x (1000)	biomass (t/ha)	Diversity	Evenness
1	13	15	193	5904.87	15.44	0.47	1.38	0.51
2	12.1	17	293	5100.88	23.44	0.41	1.17	0.41
3	12.7	22	271	4318.12	21.68	0.35	1.26	0.41

Table 4.7. Summary statistics by transect

Location: Transect	Depth (fsw)	Depth (m)	Rugosity	Latitude (WGS84)	Longitude (WGS84)	UTMEast Zone5 N	UTMNorth Zone5 N
1:south	43	13.0	1.90	19.414058	-155.908063	194588.84	2149220.89
2:middle	40	12.1	1.56	19.419892	-155.915552	193812.74	2149880.40
3:north	42	12.7	1.95	19.423420	-155.913692	194014.82	2150267.87

Overall summary statistics

Avg Count of species	StDev of Count of species	Avg number ha x (1000)	StDev of number ha x (1000)	Avg of biomass (t/ha)	StDev of biomass (t/ha)	overall average diversity	StDev of diversity	Avg of evenness
18	3.61	20.19	4.2	0.41	0.06	1.27	0.11	0.44

Table 4.8. Summary statistics and geographic location.

Statewide rankings: Among 56 locations surveyed, Pu'uhonua o Honaunau ranks 30th in average number of species found (18 species), 4th in abundance of fishes (12,900 per ha), 40th in biomass (0.41 t/ha), 52nd in diversity (1.27), and 54th in evenness (0.44).

4.3 Analyses

Within site differences are much smaller than between sites differences due to depth stratification. There should be higher variability with increased surveys at varying depths.

Pu'uhonua o Honaunau has fish populations most similar to Pu'ukole Point on Ni'ihau and Ho'ai, Kaua'i while Kaloko fish communities most resemble those of Hanalei Bay, Kaua'i and La'aloa, Hawai'i (Fig.4.12). Biomass and number of species are the two factors most strongly linking the sites.

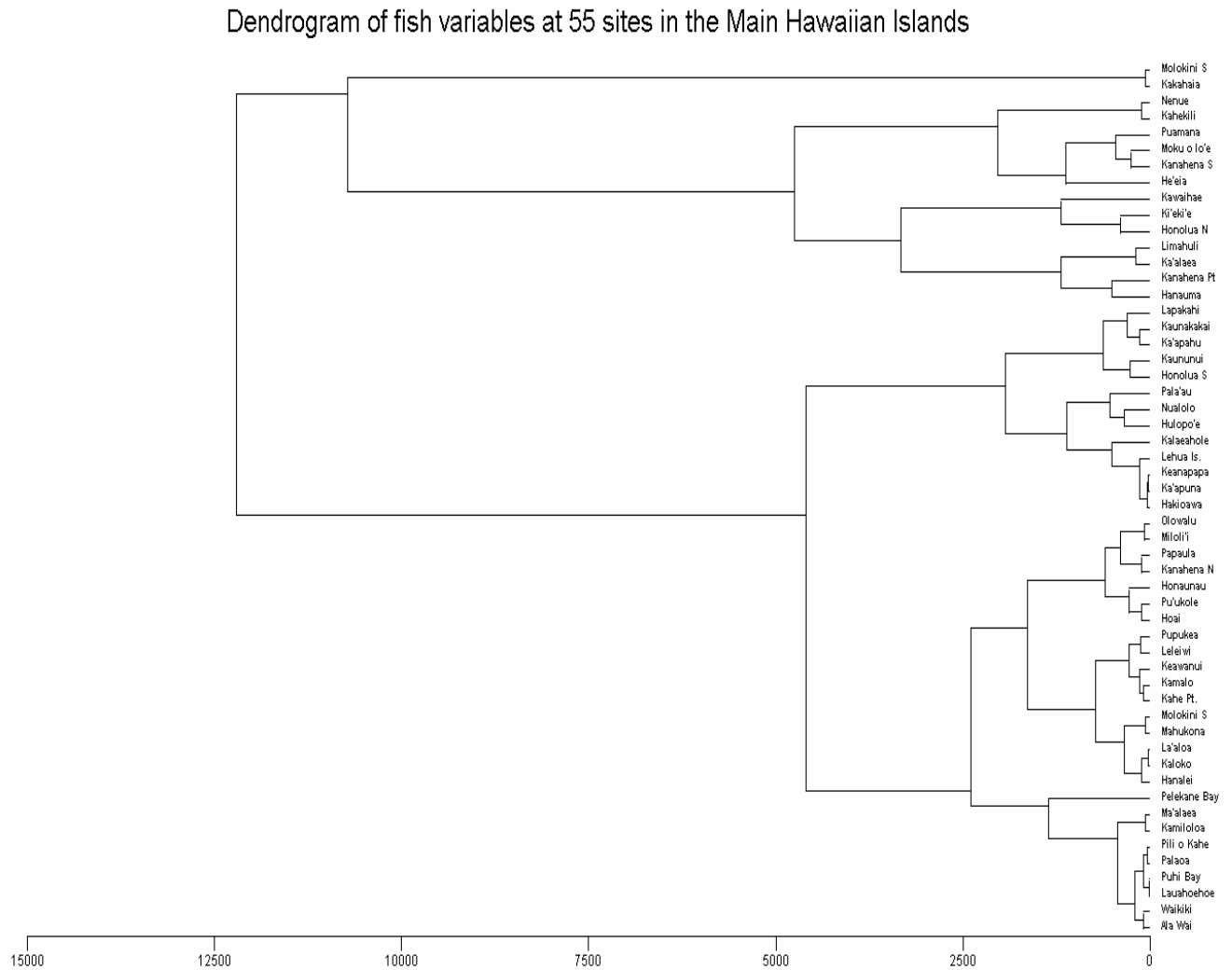


Fig. 4.12. Cluster analysis of fish parameters at sites statewide (n=55).

References

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- Friedlander, A., E. K. Brown, P. L. Jokiel, W. R. Smith, and K.S. Rodgers 2003. Effects of habitat, wave exposure, and marine protected area status on coral reef fish assemblages in the Hawaiian archipelago. *Coral Reefs* 22: 291-305.
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5.1 Data Summary: Kaloko/Honokohau

Seventeen stations were surveyed from April, 26th to April 28th, 2004 within the Kaloko/ Honokohau National Park boundary.

Benthic composition

Coral cover ranged from less than 3% to over 50% with an average coral cover of 23%, within 1% of statewide averages. A total of nine species from five genus were quantified from this site with *Porites lobata* and *Porites compressa* exhibiting the highest dominance, as is consistent with the rest of the state. In contrast to most sites throughout the state, but in concordance with other West Hawai'i sites, Kaloko/Honokohau has a high abundance of the endemic octocoral, *Anthelia edmonsoni*.

The substrate is dominated by turf algae and calcareous coralline algae, with little recorded macroalgae and sand.

The Crown of Thorns seastar, *Acanthaster planci*, is present, typical of the West Hawai'i coast. It was directly observed feeding on *Pocillopora* colonies.

Sediments

Although sediment composition is extremely similar between depths (12m and 18m), high variation in grain-size exists. Organic composition and grain-sizes falls within the median range for all 12 Big Island sites, while percent of carbonates (92%) is second only to Kawaihae.

Fish assemblage characteristics

Even with large sample sizes, variation in fish populations can be high. All fish data presented here are used as relative rather than absolute values for comparison between sites and islands.

Among 56 locations surveyed, Kaloko/ Honokohau ranked 25th in average number of species found (17.5 species), 12th in abundance of fishes (19,600 per ha), 41st in biomass (0.31 t/ha), 41st in diversity (1.83), and 48th in evenness (0.65).

The most abundant species were the *Chromis* spp. The species with the highest biomass is *Zebrasoma flavescens*, the yellow tang, followed closely by *Naso lituratus*, the orangespine unicornfish, both highly prized species in the aquarium fish trade. The high biomass of these species reflects the prohibition of aquarium fish collection at this site.

The family with the greatest recorded number of individuals is *Pomacentridae* due to mainly to the large numbers of individuals from four species of *Chromis*. *Acanthurids* also rank high in the number of individuals recorded. This is consistent with statewide rank.

Kaloko/Honokohau has a slightly higher mean number of species and larger numerical densities than the state average. In contrast, biomass (0.31 t/ha) is only half that of averages throughout the state. This can be partially attributed to the large number of small-bodied *Chromis*, common throughout West Hawai'i and partially to management regime. Fish assemblage characteristics similar to or lower than state averages is consistent with results found by Friedlander et al. (2003) using statewide CRAMP data. Partially protection was found to be no more effective than open access areas. Only sites fully protected from fishing were found to have statistically higher numerical and biomass densities, diversity, and richness. The Fisheries Replenishment Area (FRA) designation of the Kaloko/Honokohau National Park prohibits aquarium fish collection but permits other types of fishing activities.

This is highly consistent with our findings. High numbers and biomass of aquarium species with contrastingly lower numerical and biomass densities of food fish target species are evident at this site.

Nearly half of all fishes recorded fall in the smaller size class (<5cm). This can be attributed to the large numbers of *Chromis*.

A large number of butterflyfish species were observed on transects including the uncommon pennant butterflyfish and blacklip butterflyfish recorded from only a small percentage of sites statewide. *Priacanthus meeki* (aweoweo) is present in some abundance, in concordance with an unusually large, recent recruitment of this species documented on most of the Main Hawaiian Islands in the summer of 2003.

The percentage of piscivores at Kaloko/Honokohau is less than 5% of the total biomass, while herbivores make up over 60% of the total biomass. Piscivores comprise even less of numerical abundances, comprising only 1% of the total number of fishes. While typical of the Main Hawaiian Islands, this is in sharp contrast to percentages of feeding guilds in the Northwestern Hawaiian Islands.

Both terrestrial and marine endemism in the Hawaiian Islands is high compared to the rest of the world, due to geographic isolation which restricts gene flow and encourages speciation. Endemism is a biologically relevant attribute in examining fish assemblages. It relates to conservation of biodiversity, genetic connectivity and spatial patterns of recruitment. Historically, endemic comparisons have been based solely on presence/absence data due to unavailable quantitative data. Yet, endemism evaluations are more statistically meaningful when incorporating numerical and biomass densities which allow for elucidation of spatial patterns (Friedlander and DeMartini 2004).

Endemic rates at Kaloko/Honokohau with a numerical and biomass density average of 22.3% are consistent with published values for fish endemism (23.1%) based on the most comprehensive estimate of reef and shore fishes (Randall 1998) and endemism rates based on CRAMP/RAT data at 55 Main Hawaiian Island sites (23.0). This provides supporting evidence of a sample size large enough to determine endemic status.

Non-native species contributed an average of only 2.6% of the densities based on the occurrence of only two introduced species, *Lutjanus kasmira* (ta'ape) and *Cephalopholis argus* (roi).

The vast majority of fishes present are indigenous species found both in Hawai'i and elsewhere in the Pacific.

5.2 Data Summary: Pu'uhonua o Honaunau

This site was minimally sampled and will be recalculated as additional data is obtained. Data from three transects at comparable depths was collected on April 29th, 2004.

Benthic composition

Coral cover ranged from 21% to 67%, with the average coral cover (45.8%) much higher than the statewide average of 22%. In concordance with statewide results, The reefs are mainly *Porites* reefs, comprised of *P. lobata*, *P. compressa* and *P. evermanni* with the dominant species, *P. lobata*, averaging nearly 30% of the total substrate cover. The native octocoral, *Anthelia edmonsoni* was not recorded from this site. unlike many West Hawai'i locations. This may be attributed depth stratification and a small sample size, since all stations were located at similar depths.

The substrate is dominated by turf algae and coralline algae, with little recorded macroalgae and sand. Unusual species include the round mushroom coral, *Cycloceris*. Crown of Thorns seastars, *Acanthaster planci*, were observed in some abundance, typical of the West Hawai'i coast. Coral cover was observed to decrease rapidly beyond 15 meters, with *Porites compressa* rubble observed at greater depths.

Fish assemblage characteristics

Among 56 locations surveyed, Pu'uhonua o Honaunau ranks 30th in average number of species found (18 species), 4th in abundance of fishes (12,900 per ha), 40th in biomass (0.41 t/ha), 52nd in diversity (1.27), and 54th in evenness (0.44). Although little variation was found in biomass densities between stations, abundance varied considerably due to large schools of *Chromis*.

The most abundant species are the *Chromis* spp, which is typical along the Kona coast of the island of Hawai'i. Two introduced species are in the top ten species recorded at this site. *Lutjanus kasmira* (ta'ape) ranks first in biomass and *Cephalopholis argus* (roi) ranks 4th. The fact that *Zebrasoma flavescens*, the yellow tang, that is popular in the aquarium trade, has the second highest biomass at this location can probably be attributed to the prohibition of aquarium fish collection at this site.

The family with the greatest recorded number of individuals is *Pomacentridae* due to four species of *Chromis*. The family with the greatest recorded biomass is *Acanthuridae*, due to *Acanthurus nigrofuscus* (mai'i'i) which accounted for the majority of fish in this family, along with a single school of *Acanthurus thompsoni* recorded from few sites throughout the state. The large number of butterflyfish is consistent with the high coral cover found here.

The percentage of piscivores at Pu'uhonua o Honaunau is very low relative to herbivores. This is in concordance with statewide trophic level averages.

The high percentage of non-native species is mainly attributed to a single observation of a large school of *Lutjanus kasmira* (ta'ape) and large individual *Cephalopholis argus* found on all transects.

The large number of fishes in the smallest size class (<5cm) is attributed to large numbers of *Chromis*.