Hawaii Coral Reef Initiative

Coral Reef Assessment and Monitoring Program (CRAMP)

Final Report 1998-99

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I. OVERVIEW

Hawaii's valuable reefs are increasingly under environmental pressures. Management of our reefs is largely the responsibility of the State of Hawaii Department of Land and Natural Resources (DLNR), Division of Aquatic Resources (DAR), while research is largely the responsibility of the University of Hawaii (UH). One of the greatest frustrations to scientists and managers in Hawaii has been lack of information on mechanisms responsible for reef decline and lack of an integrated coral reef research and monitoring program. Scientific studies and surveys had been conducted piecemeal throughout the State with little consistency in methodology or large-scale experimental design. A second major problem facing Hawaii has been its geography. The Hawaiian Islands form an archipelago that extends over a vast area of the Pacific Ocean. Our vast reef resources are spread over thousands of miles of coastline on numerous islands. Managers and scientists in Hawaii have been faced with increasing evidence and a growing consensus among leading scientists that coral reefs throughout the world will undergo massive changes within the next few decades. The cause is increasing levels of anthropogenic atmospheric gasses that are responsible for global warming and a reduction in carbonate saturation in tropical surface waters (e.g. Hough-Guldberg, 1999, Kleypas et al. 1999, Wilkerson et al. 1999). The first factor is leading to increasingly severe mass bleaching and mass mortality of reef corals on a global scale. The second factor will result in a reduction in the ability of reef corals and other reef organisms to calcify, with possible dire consequences to existing populations. These impacts have been added onto the already documented world-wide decline due to other anthropogenic factors such as over-fishing, eutrophication, sedimentation etc.

Growing awareness of the value and plight of coral reefs led to development of the Coral Reef Initiative (CRI) at the national, international and local level. At the federal level, the CRI led to legislation aimed at securing funds for reef monitoring, and thereby directly promoted development of a comprehensive monitoring program for Hawaii. The Hawaii Coral Reef Assessment and Monitoring (CRAMP) was developed during 1997-98 by leading coral reef researchers and managers in Hawaii. The design was further refined during the international "Hawaii Coral Reef Monitoring Workshop" organized by the DAR in conjunction with the East-West Center and held in Honolulu during June 9-11, 1998 (Maragos and Grober-Dunsmore, 1999). The need for a coherent, integrated monitoring program for Hawaii using standard methods appropriate for our situation was clearly identified. In the first year of operation, CRAMP has resolved these issues (see Section II).

CRAMP has overcome the geographic barriers facing our island state through collaborative effort and modern communication technology. UH has excellent coral reef research groups presently operating at UH Manoa (Oahu), Maui Community College, and at UH Hilo. The UH groups share a common computer network, administrative, and fiscal system. The scientists and managers of DAR are working collaboratively with the UH groups on all of the main Hawaiian Islands. The UH/DAR scientists receive excellent assistance in their work from a variety of non-government organizations, other State agencies such as the Coastal Zone Management Office and Department of Health and Federal agencies such as the Fish and Wildlife Service and National Marine Fisheries Service.

At the research level CRAMP is designed to identify the controlling factors, both natural and anthropogenic, contributing to stability, decline or recovery of our reefs. CRAMP was designed as an integrated State-wide, UH/DAR system-wide coral reef research program, common data base and rapid information dissemination system that will provide the means for managers and researchers to detect and respond appropriately to environmental threats to our reefs. CRAMP also includes scientists and managers from the, Bishop Museum, Waikiki Aquarium and other organizations in an ongoing collaborative state-wide research and monitoring program. The design is such that CRAMP can address questions from a local to a global scale. At the local level, CRAMP is designed to determine statewide environmental trends. On the global scale, CRAMP has initiated the research needed to test the hypotheses that we are headed for a generalized long- term decline in coral cover. The CRAMP experimental design selected a wide range of research sites to provide answers to questions concerning acute and chronic localized impacts as well as regional trends. Historical techniques were evaluated for precision and statistical power to determine a standardized sampling protocol. The final CRAMP survey protocol employs digital video transects and fixed photoquadrats to address changes in overall cover of substrate types and growth, recruitment and mortality of benthic organisms. We also have developed a standard protocol for monitoring reef fish populations (see section IV).

GENERAL EXPERIMENTAL DESIGN - "PROBLEM FOCUSED" RESEARCH

CRAMP experimental design allows detection of changes that can be attributed to various factors such as overuse (overfishing, anchor damage, aquarium trade collection, etc.), sedimentation, nutrient loading, catastrophic natural events (storm wave impact), coastal construction, urbanization, global warming (bleaching), introduced species, algal invasions, and fish and invertebrate diseases. The experimental design provides vital information on all of the above issues, but the emphasis is on the major problems facing Hawaiian coral reefs as listed by managers and reef scientists during workshops and meetings held in Hawaii during 1997-1998. These are: overfishing, sedimentation, eutrophication and algal outbreaks. CRAMP experimental design gives priority to areas where baseline data relevant to these issues were previously collected. This program will continue to synthesize existing data into the experimental design, and conduct further work in order to test hypotheses concerning the role of various environmental factors in the ecology of coral reefs.

CRAMP researchers are quantifying changes that have occurred on coral reefs subjected to varying degrees of fishing pressure, sedimentation, and eutrophication. In addition, we are studying reefs that have experienced algal outbreaks. We are in the process of resurveying, updating and integrating existing ecological information on an array of coral reefs that have been designated as areas of concern or by managers and scientists.

STUDY SITES

Designated research sites were chosen from throughout the State of Hawaii with input from managers and scientists (see section II). These sites give us a good cross section of reef types found throughout the main Hawaiian Islands and allow testing of hypotheses involving the impact of factors noted above. Research sites include areas of primary concern originally designated by the DAR. Data taken in a standard and precise manner in a wide range of habitats allows us to describe the biology and ecology of reefs throughout the high islands, and allows us to develop and test basic scientific theories concerning factors controlling the structure and function of coral reefs. Sites were selected on Kauai, Oahu, Maui and Hawaii with regard to factors such as type of environmental stress, presence of historical data, degree of environmental degradation and/or recovery, and degree of wave exposure.

RESEARCH METHODOLOGY

CRAMP has developed a “standardized” transect protocol in order to enable between-site comparisons. We also re-survey some sites that have long term historical data sets. This requires using methods employed in the original surveys in order to detect long-term within-site changes in addition to the standard CRAMP protocol (see section III). Site-specific questions and problems inevitably result in use of numerous other techniques in specialized situations at each site.

DATA MANAGEMENT - INFORMATION DISSEMINATION

The revolution in computer/communication technology now allows us to collect, process, and summarize data in a form that is readily available for use by the research and management community. Perpetuity of information and access is insured through redundant archiving of information in systems with expected longevity (State of Hawaii GIS, Bishop Museum Hawaii Biol. Survey, web site). Our integrated system provides a means of rapid communication between scientists, managers, non-government organizations and private individuals. The database system is designed for ease of access by all. We are in the process of archiving and evaluating historical data sets made available by investigators participating in this project. Other data sets are being retrieved from the State of Hawaii Information Service Centralized Data Base, hard copies of old Hawaii Coastal Zone Data Base, various Environmental Impact Statements (summarized in UH Env. Center Database), theses, technical reports, final reports, etc. A major advantage is that we are gradually accumulating all existing relevant information in a single location that is easily accessed by individual investigators and resource managers.

CRAMP RECOGNITION AT THE REGIONAL MONITORING PROGRAM FOR HAWAII

After only one year of operation CRAMP is recognized as the regional coral reef monitoring program in the main islands of Hawaii. The Kahoolawe Island Reserve Commission (KIRC) is using standard CRAMP methodology at up to 16 sites on the Island of Kahoolawe to implement their approved Ocean Management Plan. The first site has been installed. The United States Geological Survey (USGS) will install up to 6 standard CRAMP monitoring sites on the island of Molokai (beginning in February 2000) in a partnership with the University of Hawaii and CRAMP. The United States Fish and Wildlife Service (FWS) has proposed collaboration with CRAMP to install two standard monitoring sites on the island of Midway (summer of 2000) for comparison and development of assessment techniques in the Northwest Hawaiian Islands. The Nature Conservancy is considering a proposal that would lead to installation of standard CRAMP monitoring sites in areas of special interest to their program. All of the above share the common CRAMP data base, use CRAMP methodology and exchange field scientists with CRAMP to insure proper training and uniform methodology.

YEAR 1 CRAMP "SPINOFF" PROGRAM - THE WEST HAWAII FISHERY REPLENTISHMENT AREAS INVESTIGATION

The Hawaii Island CRAMP component under Dr. Brian Tissot found it necessary to modify overall the CRAMP experimental design in response to a critical management need that arose at the onset of our program (see Section V). Legislation was passed just prior to the initiation of CRAMP to improve the management of fishery resources in west Hawaii by protecting a minimum of 30% of the west Hawaii coastline through the establishment of Fish Replenishment Areas (FRAs) -- marine reserves where aquarium fish collecting is prohibited. Based on scientific input, the West Hawaii Fishery Council proposed a network of nine FRAs that would close 35% of the West Hawaii coastline to aquarium collectors in order to minimize conflicts between the aquarium and dive tour industries and promote a sustainable fish harvest. These proposed regulations were passed unanimously by the Board of Land and Natural Resources in September 1999. Due to limited resources it was necessary to immediately focus Hawaii Island CRAMP monitoring efforts on this large network of marine reserves in order to conduct baseline surveys prior to closure of the reserves. A closure of this scale has been unprecedented in Hawaii. In view of our limitations and management priorities, it was necessary that CRAMP effort on the island of Hawaii during 1998-99 addressed the baseline conditions of the Kona coast FRA network. The experimental design required 24 sites along the West Hawaii Coastline that would be sampled repeatedly for fish populations. In order to detect differences in fish population in areas being used for collection versus closed areas, all surveys were restricted to the same type of habitat at each site. In contrast, CRAMP long-term monitoring sites on the other islands are selected to give us a wide cross-section of different habitats. The West Hawaii work focused on fish and were conducted within deeper (40-50 foot depth) habitats. The standard CRAMP transects are set at depths of 10 feet and 30 feet where possible. When additional funding became available in year 2 of the Hawaii Coral Reef Initiative, the West Hawaii FRA program was established as a separate entity and CRAMP initiated the process of installing five standard long-term CRAMP sites on the Island of Hawaii. Both projects are working closely together and share personnel and a common data base. The CRAMP sites are not redundant with the 24 West Hawaii sites. The five standard CRAMP sites will be the primary long-term sites and will continue to be monitored after the West Hawaii FRA project is completed. Differences in the sampling design of the two programs are dictated by differences in the questions being asked in each case. The West Hawaii program is focused on a specific issue of aquarium fish collecting, while CRAMP is focused on state-wide environmental trends and a wide range of environmental issues.

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II. CRAMP METHODS AND DATABASE

During the first year of this project the principal objectives for the methods and database were to:

1. Develop a standardized method for sampling coral reef benthic communities in Hawaiian waters.

2. Establish and survey a series of permanent transect sites throughout the main Hawaiian Islands using this method.

3. Enact a protocol for data analysis that follows a sequence from data capture in the field to analysis in the laboratory and finally to data storage and presentation of the results.

4. Design a database that could accommodate historical information on sites, bibliographic references to these sites, data from the benthic surveys, and future expansion for estimates of fish abundance, diversity and biomass as well as data collected by other agencies.

This document will report on the status of each of these objectives and outline future directions for the project in terms of methodology, database storage, and presentation of the results.

STANDARDIZED METHOD

The first objective was to develop a standardized method for sampling the benthos that could detect, with sufficient statistical power (Power>0.8 and $\alpha<0.05$), a 10% change in coral cover over sampling intervals. Appendix A describes the development and testing of the standard CRAMP method in detail. A summary of the most important points is as follows:

- Testing site-specific protocols and validation of methods in heterogeneous environments is a critically important step that must conducted prior to initiating monitoring programs. Our initial study examined the ability to detect change in coral cover among various methods for Hawaiian reefs. Transect lines of variable length (10m, 25m and 50m) with permanent pins at the endpoints were sampled at various sites using three methods: photoquadrats, visual census point-intercept quadrats and video transects, to measure coral cover. Sampling was repeated at several locations to estimate sampling precision, observer and method variability, and to calculate statistical power for these techniques.

- Power to detect change in coral cover with roughly equivalent sampling effort decreased dramatically when coral cover was greater than 20%. Fixed photoquadrats appeared to have the highest power for the least effort required.

Longer transects (e.g. 25m and 50m) increased power in homogeneous substrates versus shorter transects (e.g. 10m) that were more appropriate in heterogeneous habitats.

- Repeat photoquadrats and point-intercept quadrat data showed high variability and consequently low precision. Variability between observers analyzing the same data was low. Power analysis with current sample sizes indicated that these methods had low power in detecting small change (5-10%) in coral cover but precision can improved by restricting transect movement using pins at regular intervals along the line.

- Digital video transects appeared to be a viable sampling technique to detect change in coral cover (P>0.80) using 50 points per frame, 20-30 frames per 10m transect and 8-10 transects/depth. This method had the highest initial investment but yielded the largest quantity of data per unit of field effort. Fixed photoquadrats with the highest precision are recommended to address questions on recruitment, growth and mortality. Changes in substrate can be analyzed using a repeated measures ANOVA design with nesting of transect in depth and treating frames within a transect as sub samples to examine “observation” error.

SITES SURVEYED

A total of 22 sites have been surveyed to date that span a range of wave exposures, latitudinal gradients, legal protection status, human use patterns, presence of historical data, and management concerns (Figure 1). Descriptions of the actual sites surveyed as of January 2000 are listed in Table 1.

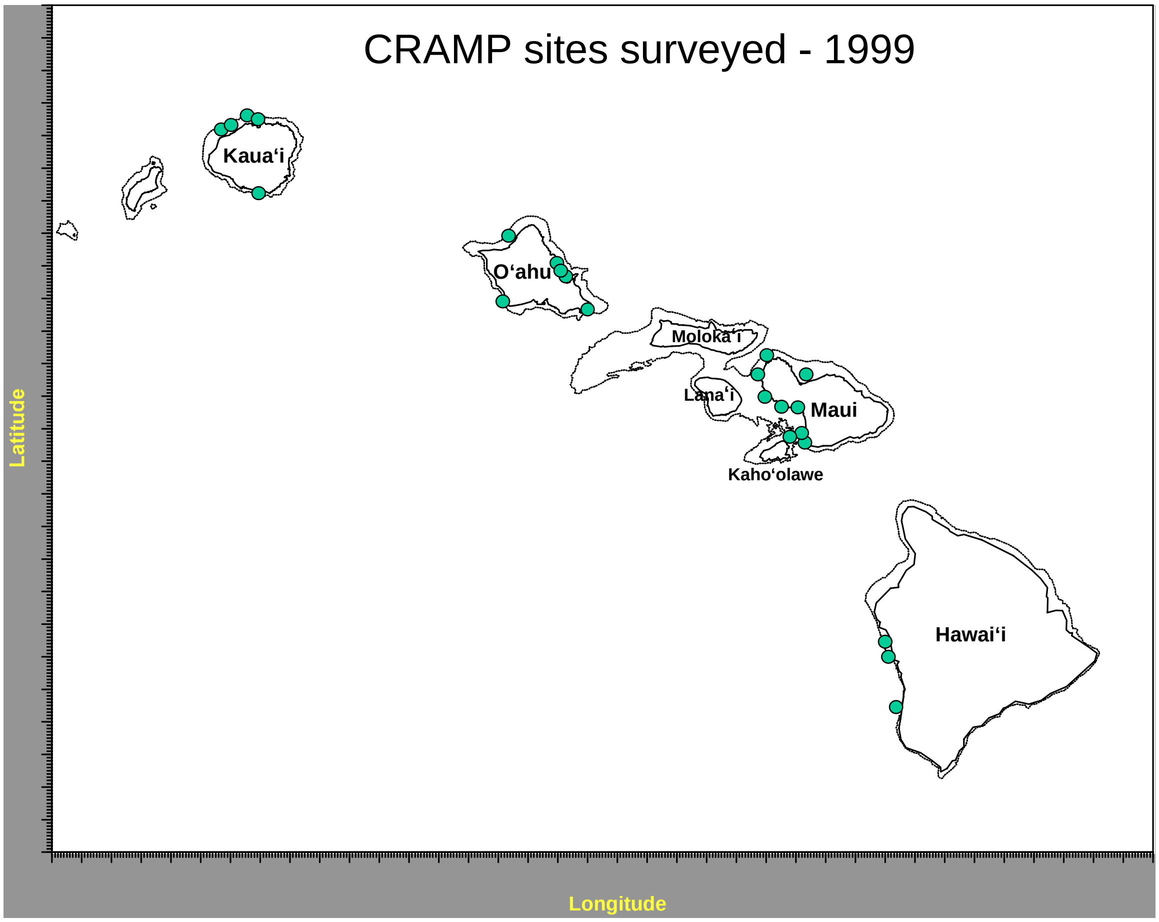

Figure 1: CRAMP sites surveyed during 1999. At each site there are a total of 20 digital video transects and 10 photoquadrats (10 transects and 5 photoquadrats at two depths).

Table 1: CRAMP sites surveyed as of January 2000

File 1:				N Latitude		W Longitude			
Site	**Island Code**	**Site Code**	**Depth (m)**	**Deg.**	**Minutes**	**Deg.**	**Minutes**	**Sampling Freq.**	**Survey Date**
Hawaii	Ha								
Kaapuna	Ha	Kpn	4.0	19	16.198	155	53.626	Annual	12/10/99
(1950 Lava Flow)			10.0	19	16.198	155	53.649	Annual	12/09/99
Nenui Pt.	Ha	Nen	5.0	19	30.733	155	57.473	Annual	12/10/99
			10.0	19	30.708	155	57.504	Annual	12/08/99
Laaloa	Ha	Laa	10.0	19	35.348	155	58.377	Annual	12/09/99
Maui	Ma								
Kanahena Bay	Ma	KaB	1.5	20	37.026	156	26.244	Annual	07/20/99
			3.0	20	36.991	156	26.327	Annual	07/17/99
Kanahena Pt	Ma	KaP	3.0	20	36.063	156	26.212	Annual	07/14/99
			10.0	20	36.050	156	26.295	Annual	07/14/99
Honolua	Ma	Hon	3.0	21	00.827	156	38.395	Annual	09/16/99
			3.5	21	00.948	156	38.382	Annual	09/16/99
Maalaea Harbor	Ma	MaH	3.0	20	47.378	156	30.607	Annual	08/17/99
			6.0	20	47.332	156	30.596	Annual	08/17/99
Olowalu	Ma	Olo	3.0	20	48.437	156	36.677	Annual	07/12/99
			7.0	20	48.281	156	36.700	Annual	07/12/99
Puamana	Ma	Pua	3.0	20	51.337	156	40.029	Annual	07/15/99
			13.0	20	51.264	156	40.149	Annual	07/12/99
Papaula Pt.	Ma	Pap	4.0	20	55.307	156	25.572	Annual	08/19/99
			10.0	20	55.462	156	25.571	Annual	08/19/99
Kahekili	Ma	Kah	3.0	20	56.257	156	41.595	Annual	07/16/99
			7.0	20	56.274	156	41.623	Annual	07/16/99
Oahu	Oa								
Hanauma Bay	Oa	Han	3.0	21	16.113	157	41.700	Annual	11/16/99
			10.0	21	16.055	157	41.643	Annual	11/16/99
Kahe (Point)	Oa	Kpo	3.5	21	21.396	158	07.974	Annual	10/07/99
Kahe (Pili O Kahe)		Kpi	3.5	21	22.391	158	08.553	Annual	11/23/99
Waiahole	Oa	Wai	2.0	21	28.610	157	49.851	Annual	07/28/99
			8.0	21	28.609	157	49.848	Annual	07/02/99
Heeia Kea	Oa	Hee	2.0	21	26.884	157	48.548	Annual	07/29/99
			8.0	21	26.884	157	48.547	Annual	08/10/99
Moku O Loe	Oa	Mok	2.0	21	26.209	157	47.223	Annual	09/06/99
			8.0	21	26.221	157	47.221	Annual	09/06/99

File 1:				N Latitude		W Longitude			
Site	**Island Code**	**Site Code**	**Depth (m)**	**Deg.**	**Minutes**	**Deg.**	**Minutes**	**Sampling Freq.**	**Survey Date**
Pupukea	Oa	Pup	3.5	21	40.525	158	02.597	Annual	09/02/99
			8.5	21	40.628	158	02.712	Annual	09/02/99
Kauai	Ka								
Limahuli (Haena)	Ka	Lim	1.0	22	13.489	159	34.755	Annual	06/07/99
			10.0	22	13.544	159	34.755	Annual	08/04/99
Hanalei	Ka	Han	3.5	22	12.656	159	30.727	Annual	06/07/99
			8.0	22	12.703	159	30.721	Annual	06/06/99
Milolii	Ka	Mil	3.5	22	08.778	159	43.562	Annual	08/02/99
			10.0	22	08.827	159	43.637	Annual	08/02/99
Nualolo Kai	Ka	Nua	3.5	22	09.641	159	42.102	Annual	08/03/99
			10.0	22	09.940	159	42.288	Annual	08/03/99
Hoai (Poipu)	Ka	Hoa	3.0	21	52.775	159	28.452	Annual	12/01/99
			10.0	21	52.697	159	28.477	Annual	08/05/99
Note: locations in bold were located using charts, others are differential GPS									

DATA ANALYSIS PROTOCOL: VIDEO

The video capture archiving flow chart (Figure 2) and following outline describe how the data is handled from capture in the field to storage at the Hawaii Institute of Marine Biology and finally to presentation on the web.

1. One digital videotape (1 hour tape) is used to capture 10 transects at a depth.

2. This tape is played back on the 1st computer using PhotoShop with the plug in Photo DV. Each transect consists of approximately 7500-9000 frames.

3. Sequential overlapping frames that form a transect are captured onto the hard disk in JPEG file format. Once all of the transects for each site have been recreated then the 10 transects consisting of ~50-60 images/transect are written to a CD-ROM.

4. Twenty randomly selected frames/transect are used in the 2nd computer with PointCount99. PointCount99 generates 50randomly located points on the screen. The observer identifies the substrate under the points to create a representation of the coral cover.

5. PointCount99 writes a Comma Separated Value (CSV) file that is generic text and readily available for a variety of programs.

6. This CSV file is imported into MS-Excel for proofreading.

7. After proofreading the data file then the CSV file is imported into MS-Access for storage into the CRAMP database.

8. Finally, summary information in the form of charts and tables will be posted on the Web and/or a GIS server for access. A logo or screen ID will be implanted on each piece of summary information so that whatever gets lifted off the web will still credit the original agency.

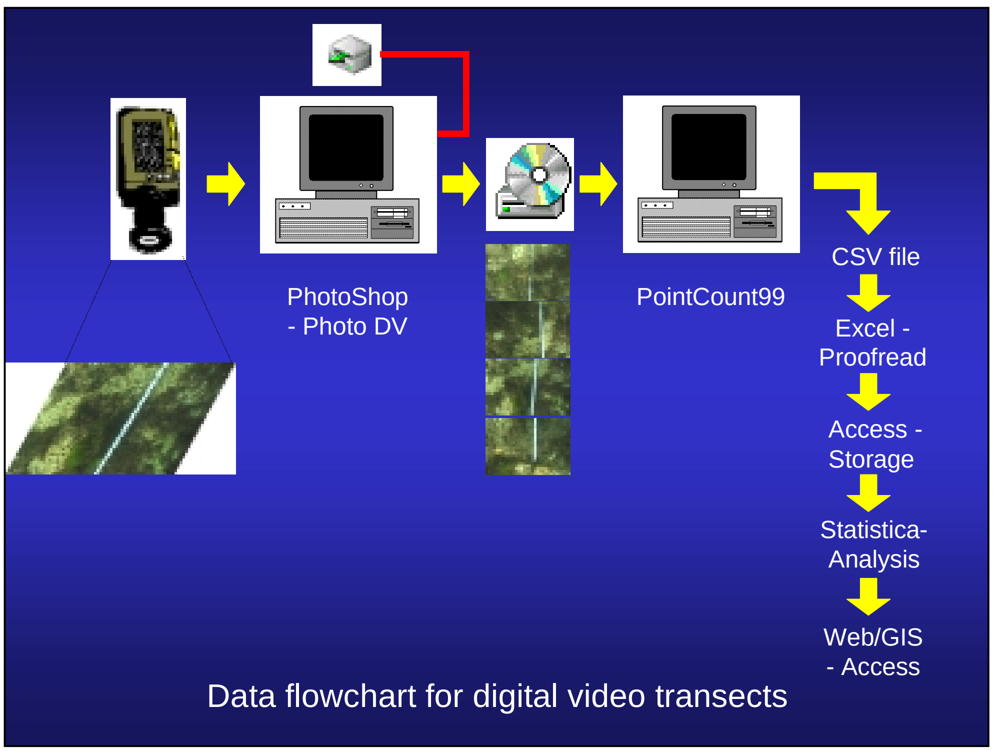

Figure 2: CRAMP data flowchart for digital video transects

Figure 3 is an example of the PointCount99 screen to show the 2 components for the data analysis. On the left are the identifying codes for the Hawaii version of this software. It is divided up into coral species and non-coral substrate types. The individual doing the analysis goes through the 50 randomly generated points on the image to the right and identifies the coral or substrate type under each intersection. These values are then recorded on the list in the left portion of the screen and later written to a file. At present the last step is problematic and results in a corrupted data file so the data analysis is held up at step #5. We hope to have this resolved by early 2000.

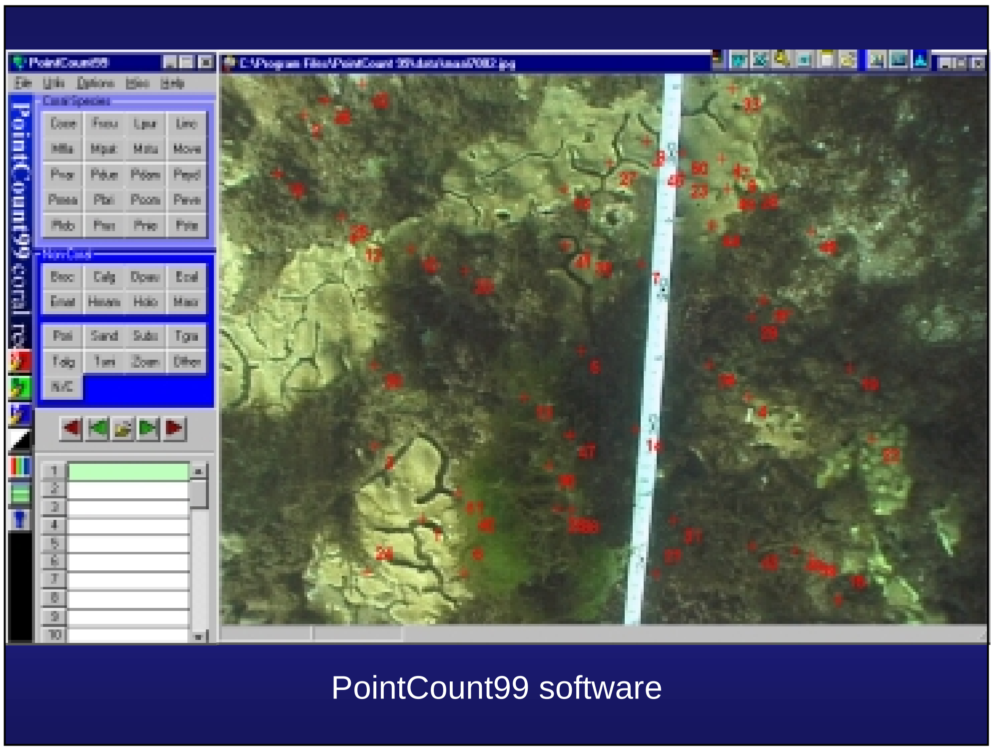

Figure 3: Screen example of PointCount99 displaying randomly generated points on the digital video image and the identification template for Hawaii on the left.

Since each transect is 10m in length then 20 randomly selected video frames or images, that are not overlapping, are processed to develop estimates for coral and substrate types. The statistical data analysis includes a repeated measures ANOVA design with nesting of transects in depth where frames per transect are treated as sub samples along a transect. At present the majority of the sites have been analyzed through the first 3 steps.

Figure 4 is an example of how the data might look after it is acquired from PointCount99. Using the Kahe data provided by Dr. Steve Coles of the Bishop Museum, total coral cover in the upper left-hand corner is tracked over time, noting large-scale events in the chart. Other coral species and substrate types can be illustrated to reflect changes in coral community structure (e.g. phase shift from coral dominated reef to algal dominated area).

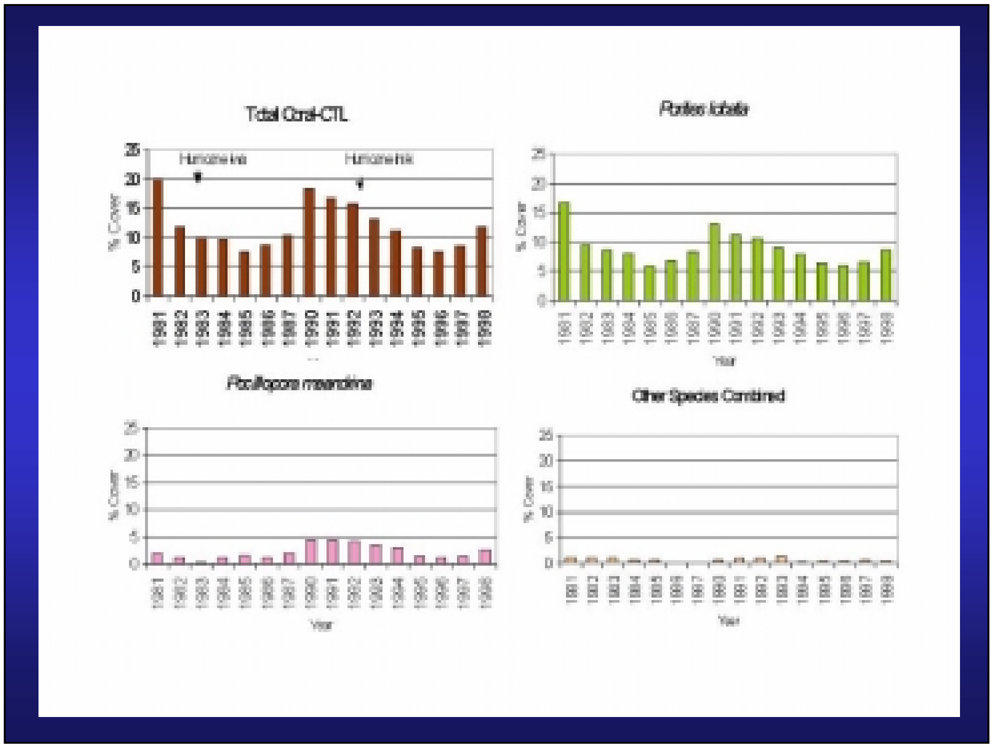

Figure 4: Kahe Pt. historical data showing temporal trends in total coral, *Porites lobata, Pocillopora meandrina,* and other species combined.

DATA ANALYSIS PROTOCOL: FIXED PHOTOQUADRAT

The flow chart (Figure 5) and following outline describe how the data is handled for fixed photoquadrats from capture in the field to storage at the Hawaii Institute of Marine Biology and finally to presentation on the web.

1. One roll of film is used to capture 5 photoquadrats at each depth with 2 exposures per photoquadrat.

2. Nikon Scan is used in the first computer to transfer the developed film to digital format on the hard drive.

3. A total of 225 quadrats have been established around the state and written to a CD-ROM.

4. Sigma Scan or Scion Image digitizes objects within the photoquadrat by tracing lines around coral and different substrate types. Then aerial coverage is computed for each object and compared with prior photos of the same site.

5. Scion Image, for example, writes a text file that is readily available for a variety of programs.

6. This text file is imported into MS-Excel for proofreading.

7. After proofreading, the data file is imported into MS-Access for storage into the CRAMP database.

8. Output from Access is imported into Statistica for statistical analysis using an ANOVA repeated measures design with 2D aerial coverage of the substrate types as the dependent variable.

9. Finally, summary information in the form of charts and tables will be posted on the Web and/or a GIS server for access. We intend to implant some kind of logo or ID on each piece of summary information so that whatever gets lifted off the web will still credit the original agency.

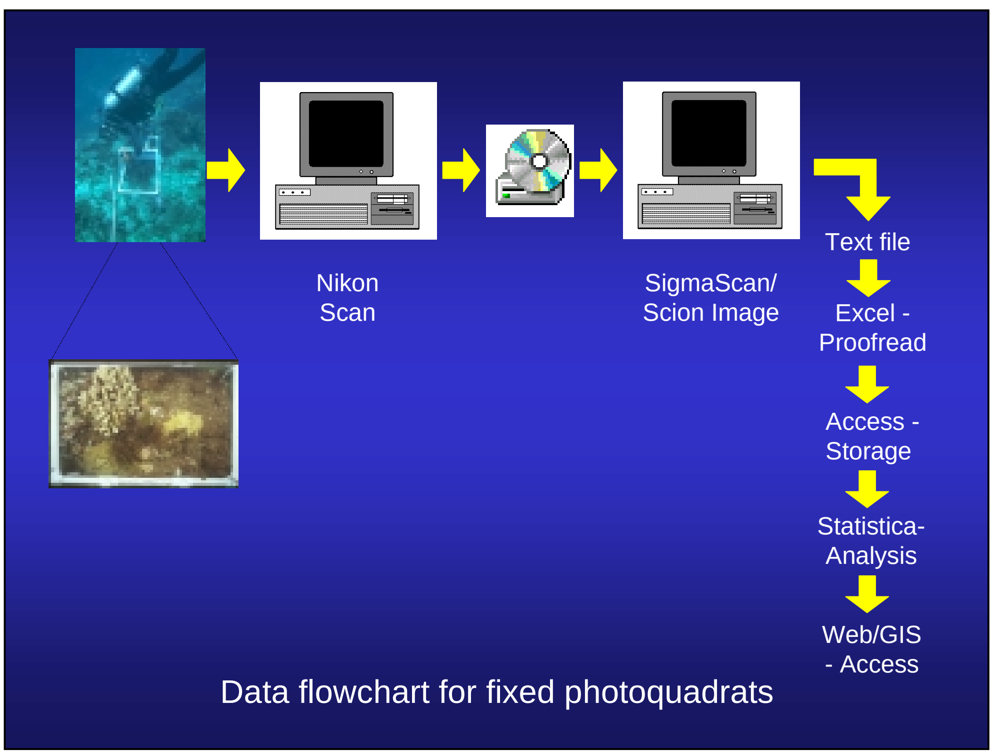

Figure 5: CRAMP data flowchart for fixed photoquadrats

DATABASE

Database information will include the following variables for each site. Tables and fields for the variables prefaced with an asterisk (*) are not available at present but they will be accommodated in future releases of the database.

1. Site statistics (e.g. Survey date, GPS coordinates and depth)

2. Coral and substrate cover (Point Count CSV file)

3. Coral growth, recruitment and mortality statistics from the photoquadrat data

4. Compatible with fish recruitment data collected by UH-Hilo, DAR and WSU-Vancouver

5. Sediment

6. Rugosity

7. Fish species richness, abundance, diversity and biomass

8. *Other data sources (e.g. ReefCheck, DLNR, Pacific Whale Foundation, Kahe Point, Kaneohe Bay sites)

9. *Algal species present

10. *Wave exposure rating/value for each site

The database was developed in MS-Access 97 for the PC. A relational format was used with the underlying structure illustrated in Figure 6. The database is structured so that historical information and current data are linked by location.

Each box represents a table with the corresponding fields listed within it. The first row of 4 tables deals with data collected on fish transects and is structured in a hierarchical fashion. Starting from the left there is location information for each study site such as latitude, longitude, island and conservation status. Surveys are conducted within a location and contain data on date, time and depth. Multiple transects are run on a given survey and for each transect there is detail information in the run table on species observed, number of individuals, and size estimates for each fish.

In the second row are tables that contain imported and historical information. The “historical collections” table lists information on what type of work has been done at various sites. Some of these sites are CRAMP sites but the majority are not. The “bibliography” table provides a list of references on research conducted in Hawaii. This table is being continuously updated with both published papers and gray literature reports. The first 2 tables will ultimately be linked through author but at present they are separate entities. We also hope to include EIS information into the "bibliography" table or establish a new table within the database for these references.

The final "Coral PointCount" table contains the data imported from PointCount via a CSV file and MS-Excel. In Excel the location information is input into the CSV file so that it will be linked into the main database after the import. This file not only contains substrate identification data for the 50 points but also includes X,Y coordinates and color information for the pixels as well as date, observer, and source file. This allows for images and random point locations to be recreated in case of file corruption.

Queries within the database organize the raw data into tables that can be readily exported into Statistica. The preferred method is to use Excel as the transfer medium due to field incompatibilities between Access and Statistica. For example, the date formats in Access are not interpreted correctly in Statistica. Statistics will be performed on the data set for homogeneity of variances and normality. If parametric statistics are appropriate then percent cover for various substrate types will be compared across sampling intervals using a repeated measures ANOVA design that incorporates nesting of transects within sites and locations. For sampling intervals that span a major episodic event then t-tests will be used to examine the pre and post coverage of substrate types.

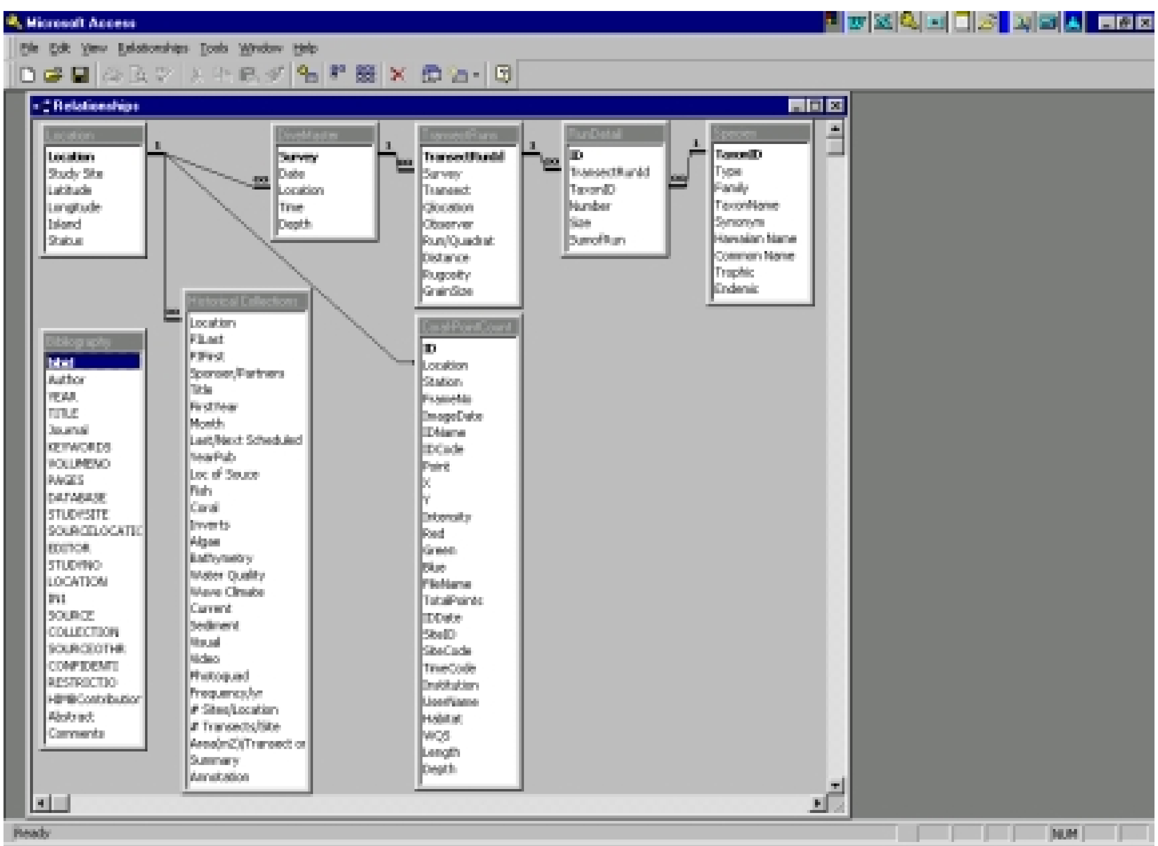

Figure 6: CRAMP database structure in MS-Access

FUTURE DIRECTIONS FOR YEAR 2

For year 2 the focus of our efforts will include the following:

1. Continue lab analysis in 2000 with the primary focus to derive coverage estimates for coral and substrate type. The majority of our effort will be concentrated in this area.

2. Sample additional sites in conjunction with other partners such as U.S. Geological Survey (USGS) on Molokai, DAR and Maui Community College (MCC) on Molokini, the Kahoolawe Island Reserve Commission (KIRC) on Kahoolawe, and DAR and University of Hawaii-Hilo on the big island of Hawaii. It is anticipated that a total of 26 sites will be added that will be CRAMP compatible. These additional sites will cover different gradients of wave exposure, sedimentation, human-use patterns, near shore development, and conservation status.

3. Initiate fish sampling protocol over existing CRAMP transects. The Oceanic Institute will take the lead on this program with support from the various federal and state agencies.

4. We plan to compare additional historical methods vs. the CRAMP protocol in order verify trends seen in previous work and continually evaluate our protocols. One series of studies will be conducted on Maui with Eric Brown and students from MCC. The focus of this work will be to compare video transects against visual quadrats (PPE) at several sites to ascertain historical trends from data using the old technique.

Another series of studies on Oahu will estimate sampling error and precision of photoquadrats, test inter- and intra-observer error in recording substrate types for digital video, and compare video transects against historical photoquadrats at Kahe Pt.

5. Finally, we will expand cooperative research projects with other programs in HCRI such as FACET, UH Algal survey, and West Hawaii Aquarium Fish Study.

III. USE OF HISTORICAL DATA

Use of historical data from Kaneohe Bay demonstrates the value of including sites with historical data. Transects originally established by Jim Maragos in 1971 (Maragos, 1972) were resurveyed in 1983 (Evans, Maragos and Holthus, 1986) and by Evans in 1990 (Hunter and Evans, 1993). CRAMP investigators (Eric Brown, Ku'ulei Rodgers, William Smith and Jessica Haapkyla) resurveyed the sites in 1999 using the same technique as in the original studies. Chris Evans directed the CRAMP team in re-locating transects and training the dive team so that protocols were consistent with earlier studies. The transects at 15 sites (two transects per site) were then geo-referenced using differential GPS. Repeated measurements of the same transect using different observers produced results that differed by less than 4 percent. Data from all surveys was entered into a common database. A summary of these data (mean total coral coverage and coverage by the algae *Dictyosphaeria cavernosa*) for the four surveys is shown as Fig. 1. These data are being subjected to further detailed analyses. At this point the following trends are apparent:

- The quantitative data are completely in agreement with qualitative observations made by investigators working on the nutrient-algae overgrowth problem. Various scientists have noted increasing coral coverage in the south basin and an increase in algal coverage in the middle sector of the bay since the 1990 survey (Drs. Cindy Hunter, John Stimson, Scott Larned, personal communication; also observations of P. L. Jokiel).

- These data are consistent with published accounts (Hunter and Evans, 1993) that suggested the alga *Dictyosphaeria cavernosa* was increasing in the middle sector.

- Invasive algae *Kappaphycus spp*. and *Gracilaria salicornia* occurred in insignificant amounts on these transects. *Kappaphycus alvarezii* was found on one transect with less than 4% coverage at Station 9 (located behind the Barrier Reef).

- *Gracilaria salicornia*, another invasive algae was rare on the coral transects. Only one transect contained this species (less than 1% at Site 2 in the south basin). *G. salicornia* is abundant locally on reef flats in the south basin, but apparently is not competing directly with corals on the reef edges and reef faces where the transects are located.

The above data can be used to support the following conclusions:

- Eutrophication - The observed increase in algae coverage since the removal of the sewer outfalls in 1979 corresponds to the increase in septic systems and cesspools on the watershed of this sector. Presumably there has been an associated increase in nutrient supply to the middle sector through increased ground water discharge. We are presently obtaining the data relative to this observation. Recommended management: implement plans are to extend the sewer mains into the highly populated areas in the middle sector and connect all users to the existing sanitary waste system.

- Alien species -The major algae species competing with the corals in Kaneohe Bay has been and continues to be the native “bubble alga” *Dictyosphaeria cavernosa*. The alien *Kappaphycus spp.* and *Gracilaria salicornia* have spread throughout the bay since their introduction (Rodgers and Cox, 1999), but are not competing with corals on a bay-wide scale although isolated patches of these algae may directly impact some corals. Survey data throughout the bay (Rodgers and Cox, 1999) supports this observations with alien species accounting for extremely low coverage (less than 1%) in most habitats.

The Maragos transects are of limited value since they were not originally designed as monitoring transects, but rather to show the vertical structure of the reef. Therefore, they run from areas of high coral coverage in the shallows through low coverage areas on the bottom. This creates a very high standard deviation for coral coverage and reduces the detection level. Standardized CRAMP transects were installed at a subset of these sites for future comparisons and to improve the level of detection.

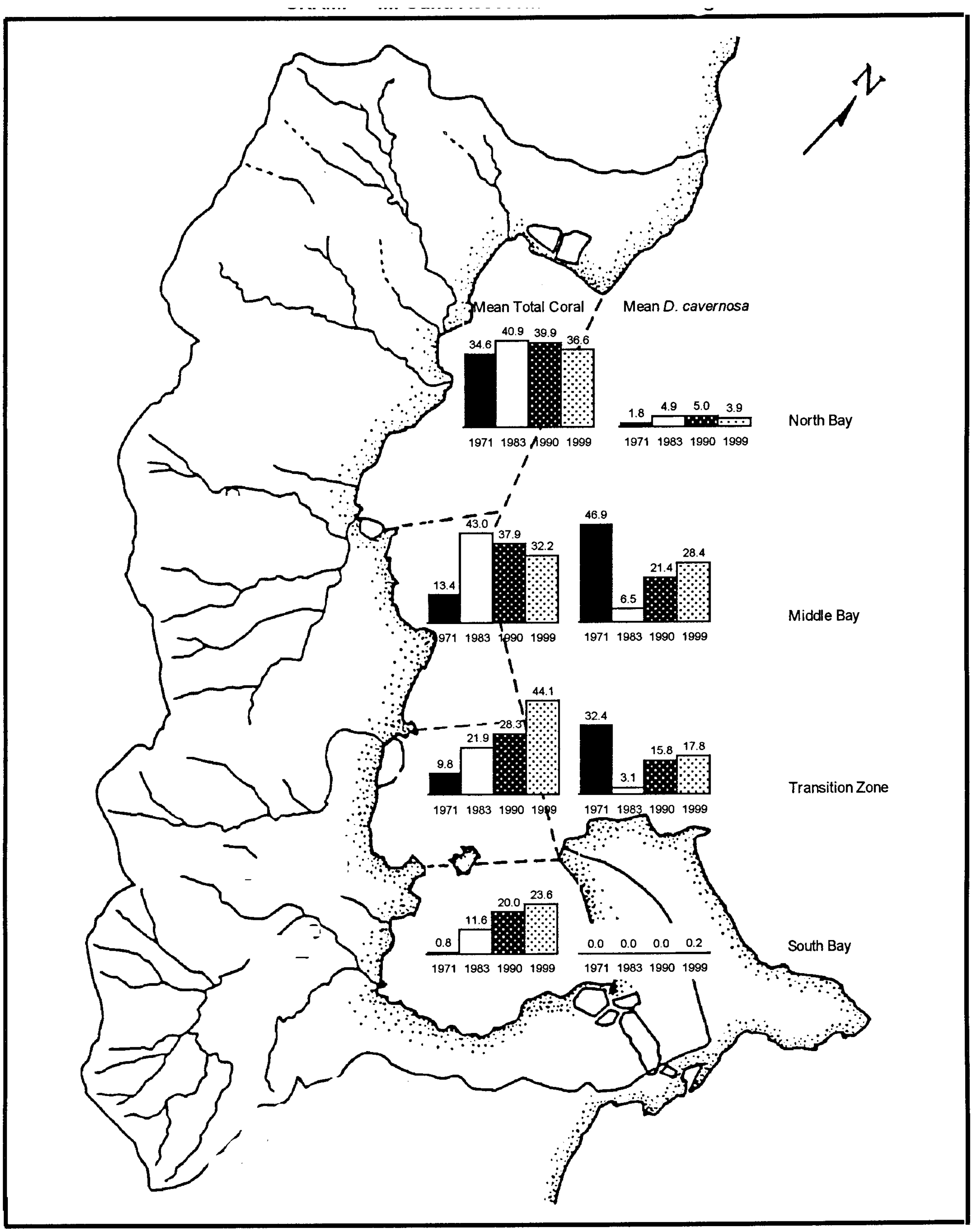

Figure 1: Changes in mean total coral coverage and the algae *Dictyosphaeria cavernosa* coverage in Kaneohe Bay, Oahu.

IV. DEVELOPMENT OF STANDARD FISH SURVEY TECHNIQUE

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INTRODUCTION

During FY98 initial studies were undertaken to develop a standard fish transecting technique. The initial development effort was conducted on the island of Kauai. During year 2 we will to extend these surveys to all of the sites.

FISH ASSEMBLAGES

Visual censuses of the fish assemblages associated with benthic habitat transects were conducted using a standard 25 x 5 m underwater visual belt transect survey method (Brock, 1954; Brock, 1982). A SCUBA diver swam each transect at a constant speed (~ 15 min/transect), identified to the lowest possible taxon all fishes visible within 2.5 m to either side of the centerline (125 m^2 transect area). Standard length (SL) of fish was estimated to the nearest centimeter. Live wet weight, W, of all fishes recorded in all censuses was estimated from the visually estimated SL using the relation $W = a(SL)^b$. Values of the fitting parameters a and b were derived from previous work of the Hawaii Cooperative Fishery Research Unit.

RESULTS

SAMPLE SIZE ANALYSIS

An "over sampling" effort of the reef fishes at Ho'ai Bay was conducted on 5 August 1999 to help determine the optimal number of 25 x 5 m transects conducted on that reef. Twelve 25 x 5 m transects were conducted in approximately 10 m of water. This study was also conducted to determine the optimal sample size for future work at other locations.

A technique developed by Bros and Cowell (1987) using the standard error of the mean to resolve statistical power was used to determine the number of samples needed based on number of species, number of individuals, biomass, diversity, and evenness. This method uses a Monte Carlo simulation procedure to generate a range of sample sizes versus power. The sample size at which a further increase in sample size does not substantially increase power (decreasing SEM) is taken as the minimum suitable number of samples. A program written by Doug Harper of the NMFS/SEFSC/Miami Laboratory was used to conduct this analysis. For number of species high and low standard error of the mean started to converge at 3 to 5 samples, for number of individuals convergence was achieved at ca. 5-7 transects (Fig. 1). Convergence for biomass occurred at ca. 7-9 transects while the number of samples required for diversity and evenness was between 5 and 7.

The relationship of sample size with accuracy of the mean was examined for number of species, number of individuals, and biomass from the 12 transects conducted at Ho'ai Bay. Sample means were compared to a theoretical population mean using the t-distribution:

$$t - \text{value} = \frac{\text{sample mean} - \text{population mean}}{\sqrt{\text{sample variance} / \text{sample size}}}$$

(Eckblad 1991). The equation was solved for sample size using various values of accuracy (accuracy = [sample mean - population mean]/sample mean). Using a Type I error rate of 0.10, the number of samples needed to detect changes in assemblage characteristic decreases rapidly with relatively slight losses in accuracy. A Type I error rate of 0.10 was chosen over the traditional 0.05 because failing to detect a change when one is actually occurring (Type II error) could lead to population collapse (Gibbs et al. 1998). This is the precautionary approach to management as mandated by the Magnuson-Stevens Fishery Conservation and Management Act.

The estimated number of samples needed to detect various levels of change varied greatly among the three parameters (mean abundance of species, individuals, and biomass). Figure 2 provides estimates of the number of samples needed to detect various levels of change in the mean abundance of species, individuals, and biomass. Using a Type I error rate of 0.10, the number of samples needed to detect changes decreases rapidly with only a slight decline in accuracy. Slightly more than one sample is required to detect a 20% change in number of species per census while ca. 8 transects are required to detect a 20% change in number of individuals. Again, biomass is highly variable with ca. 60 samples needed to detect a 20% change. Using a Type I error rate of 0. 20 substantially decreases the number of samples needed to detect change in the 10% to 20% range of accuracy. Slightly more than 1 sample is required to detect a 15% change in number of species per census while 7.7 censuses are required to detect a 20% change in number of individuals. Biomass is highly variable with 35 samples needed to detect a 20% change at Alpha = 0.2.

RETROSPECTIVE ANALYSIS OF HANALEI DATA

Visual fish censuses were conducted on twenty permanent 25 x 5 m transects previously established in Hanalei Bay in 1992 (Friedlander et al. 1997). Data collected in June 1999 were compared to surveys conducted on the same transects in June of 1993 and June of 1994. The fish assemblage characteristics showed very little change over the five-year period since the last survey was conducted with overall fish biomass increasing between 1994 and 1999 (Fig. 3).

The dominant species observed on Hanalei Bay transects during June of 1993, 1994, and 1999 appear in tables 1, 2, and 3. The endemic saddle wrasse (Thalassoma *duperrey)* and the introduced bluestripe snapper *(Lutjanus kasmira)* are the two most dominant species numerically in Hanalei Bay, although their order of dominance changes among years. All of the top ten species observed on transects in 1999 were also in the top ten in 1993 and 1994 except for the introduced blacktail snapper (*Lutjanus fulvus*) and the orangeband surgeonfish (*Acanthurus olivaceus*). The introduced blacktail snapper has increased in abundance in Hanalei Bay from being the 68 most dominant species (based on numerical IRD) in 1993, to 44 most dominant in 1994, to the fifth most dominant in 1999. Since the introduced bluestripe snapper is already the dominant species by weight in Hanalei Bay, the proliferation of another exotic snapper in the bay is cause for concern. These benthic carnivores have the potential to displace native species from preferred habitat, compete for valuable food resources, and can disrupt the integrity and balance of the overall ecological community.

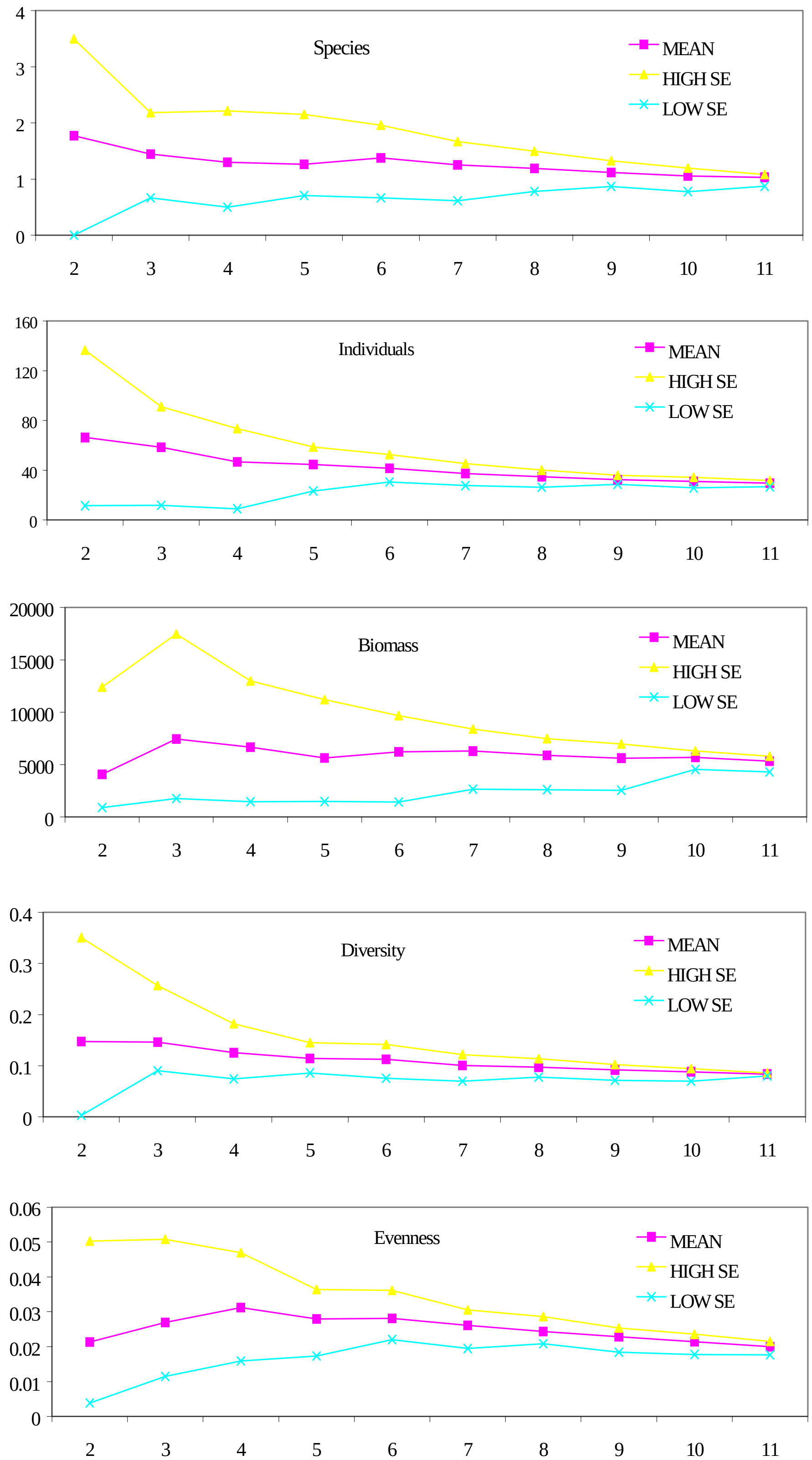

Figure 1. Sample size optimization for number of species, number of individuals, biomass, diversity, and evenness. Relationship between standard error of the mean (SEM) and sample size at Ho’ai Bay. Monte Carlo simulation procedure for sample size optimization described by Bros and Cowell (1987).

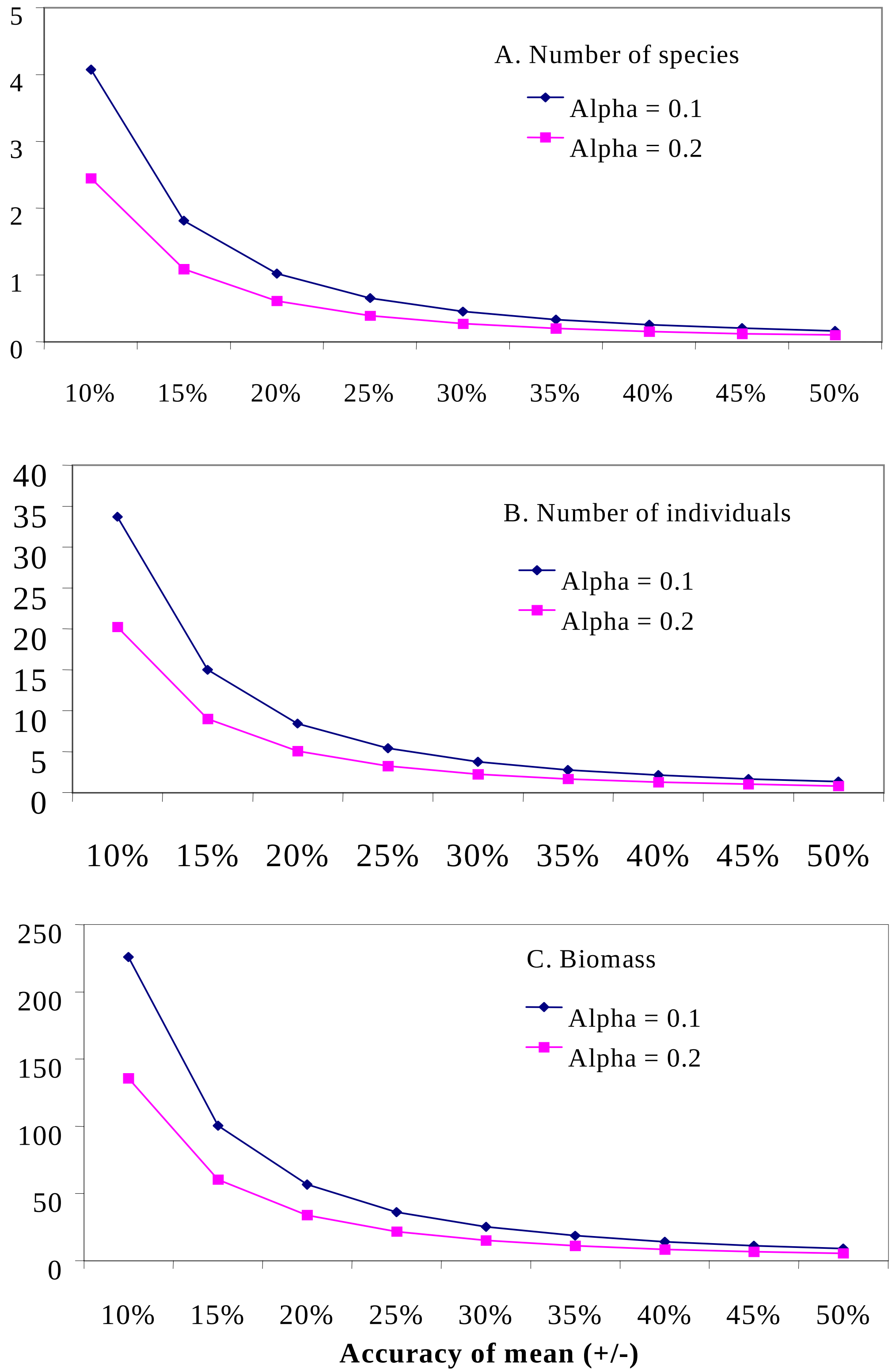

Figure 2. Estimated number of samples needed to detect changes in the mean A. number of species, B. number of individuals and C. biomass. N = 58, α = 0.10 and 0.20.

Table 1. Relative abundance, frequency of occurrence and index of relative dominance (frequency occurrence x relative abundance) for the 10 most common fish species observed on transects in June 1993 in Hanalei Bay. Number of transects = 20. Species ordered by IRD.

Species June 1993	Relative number	Relative frequency	IRD
Thalassoma duperrey	10.71	100	1071.6
Lutjanus kasmira	17.70	45	796.5
Acanthurus nigrofuscus	5.89	90	530.4
Ctenochaetus strigosus	5.48	80	439.0
Chromis vanderbilti	4.61	60	277.1
Scarus species	5.28	50	264.2
Acanthurus triostegus	3.60	55	198.1
Chromis ovalis	4.95	35	173.3
Stegastes fasciolatus	2.71	55	149.3
Acanthurus leucopareius	2.03	50	101.6

Table 2. Relative abundance, frequency of occurrence and index of relative dominance (frequency occurrence x relative abundance) for the 10 most common fish species observed on transects in June 1994 in Hanalei Bay. Number of transects = 20. Species ordered by IRD.

Species June 1994	Relative number	Relative frequency	IRD
Lutjanus kasmira	17.17	60	1030.2
Acanthurus triostegus	12.20	80	976.7
Thalassoma duperrey	9.15	100	915.3
Acanthurus nigrofuscus	4.37	85	371.9
Ctenochaetus strigosus	4.19	70	293.4
Acanthurus leucopareius	5.01	55	275.5
Chromis vanderbilti	4.47	60	268.5
Stegastes fasciolatus	2.9	70	204.6
Parupeneus multifasciatus	1.46	75	110.2
Chromis ovalis	2.57	35	90.0

Table 3. Relative abundance, frequency of occurrence and index of relative dominance (frequency occurrence x relative abundance) for the 10 most common fish species observed on transects in June 1999 in Hanalei Bay. Number of transects = 20. Species ordered by IRD.

Species June 1999	Relative number	Relative frequency	IRD
Thalassoma duperrey	8.98	100.00	898.4
Lutjanus kasmira	22.02	40.00	880.6
Ctenochaetus strigosus	5.08	70.00	355.2
Acanthurus nigrofuscus	3.94	80.00	315.5
Lutjanus fulvus	10.22	30.00	306.5
Chromis ovalis	8.40	35.00	294.0
Chromis vanderbilti	4.32	40.00	172.8
Acanthurus leucopareius	3.22	50.00	161.1
Acanthurus olivaceus	3.64	40.00	145.4
Parupeneus multifasciatus	2.06	65.00	133.7

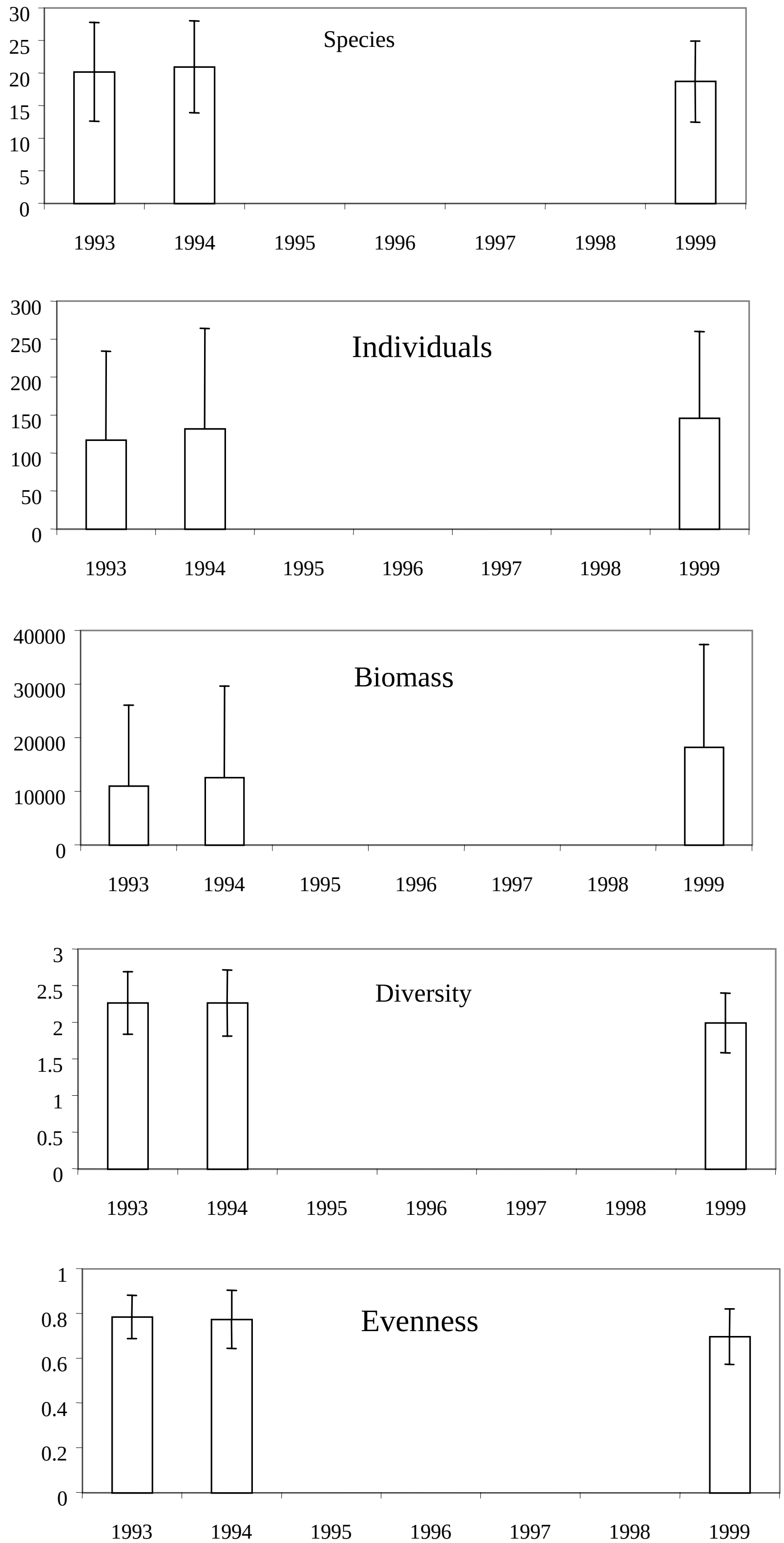

Figure 3. Comparison of fish assemblage characteristics in Hanalei Bay for June 1993, 1994, and 1999.

COMPARISON OF FISH ASSEMBLAGE CHARACTERISTICS AMONG CRAMP SITES

Detrended correspondence analysis (DCA) was used to identify clusters of similar transects in ordination space (Fig. 4). This type of ordination results in an arrangement of samples of species in a low-dimensional space such that similar samples are in close proximity to one another (Gauch, 1982). In this DCA, habitat variables do not influence the ordination; rather, stations with similar assemblage structure cluster together (Greenfield and Johnson, 1990). Transects within sites showed good concordance, and sites appeared to cluster by depth and habitat complexity. The inshore, lower complexity sites tended to cluster in the upper left portion of the figure while the higher complexity, offshore sites clustered towards the lower right portion of the figure. Offshore sites tended to have a wider spread in ordination space due to the greater species richness and diversity associated with these sites.

Fish assemblage characteristics varied among locations and habitats with the Limahuli offshore sites having the greatest number of individuals and highest biomass observed on fish transects around Kaua'i in 1999 (Fig. 5). Fish biomass at the Limahuli offshore site was more than twice that observed at the site with the second largest biomass (Ho'ai Bay offshore) and an order of magnitude greater than the inshore habitat at Limahuli. The high spatial heterogeneity of the habitat and the relatively light fishing pressure probably accounts for the high standing stock of fishes observed at this site. High surf during the winter months reduces fishing pressure even further and results in the area being a de facto reserve nearly half of the year. The Ho'ai Bay site in densely populated Poipu had a surprisingly high biomass (16.3 kg/ 100 m^2) as well as the greatest species richness observed at any site surveyed.

Fish biomass at the Limahuli offshore site was dominated by large mobile herbivores. Surgeonfishes were the most important family by weight observed at this site, followed by triggerfishes, and parrotfishes. The top five species by weight at this site were all members of the surgeonfish family. These included: *Acanthurus leucopareius, A. blochii, A. triostegus, Ctenochaetus strigosus, and A. nigrofuscus*, respectively. Nenue (*Kyphosus* spp.), which tend to feed on drift algae, was the dominant species observed on fish transects at the Ho'ai Bay offshore site accounting for nearly 19% of all fish observed by weight. This species was followed in importance by *Chromis ovalis*, a planktivorous damselfish that accounted for 15% of the fish biomass at the site. Along the Na Pali coast, the inshore Miloli'i, Nu'alolo Kai sites were dominated by surgeonfishes and triggerfishes while on the shallow Limahuli reef flat, small wrasses and surgeonfishes made up most of the fish biomass.

Overall, offshore habitats had higher values for all fish assemblage characteristics except evenness compared to inshore habitats (Table 4). Offshore biomass was more than twice that observed on transects in inshore habitats while species richness and number of individuals were also much higher offshore. The low spatial complexity and habitat heterogeneity associated with these inshore habitats are the primary reasons for these differences in fish assemblages.

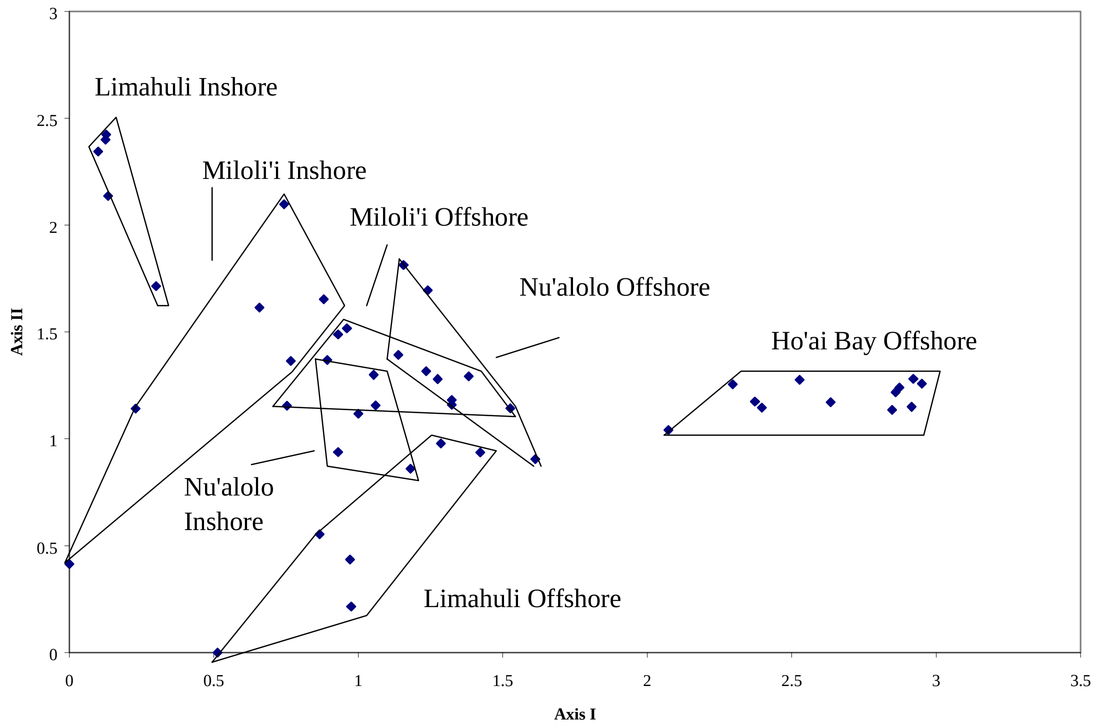

Figure 4. Detrended correspondence analysis (DCA) of fish transects (25 x 5 m) conducted at CRAMP survey sites on ***Kaua'i*** in 1999. Rare species are downweighted.

Table 4. Comparison of fish assemblage characteristics between inshore and offshore habitats at CRAMP study sites around Kaua'i in June 1999. Values are grand means per transect.

	Species	Number of individuals	Biomass (kg)	Diversity	Evenness
Inshore	16.00	137.67	12.57	2.03	0.75
Offshore	25.73	188.96	25.57	2.28	0.70

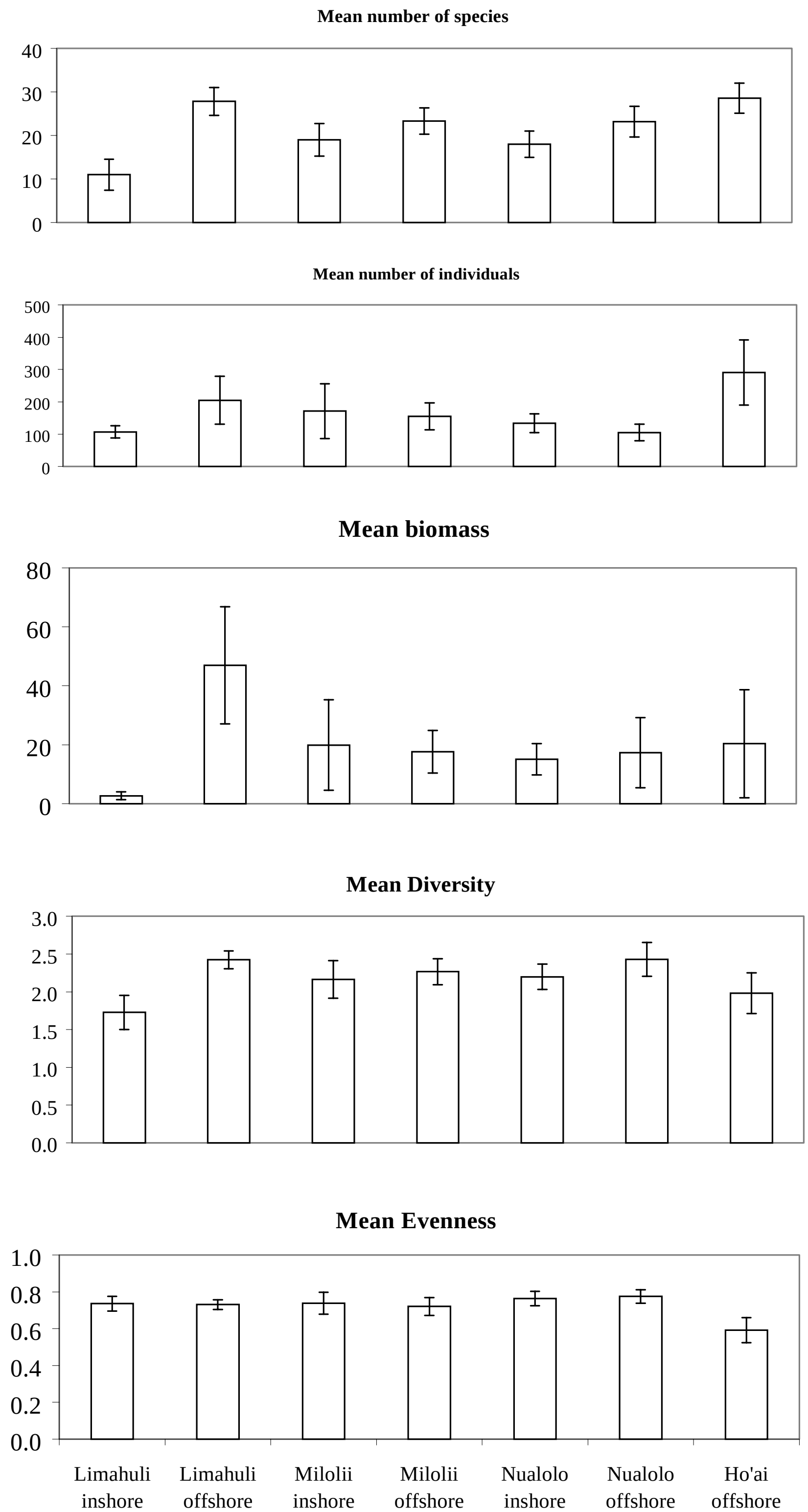

Figure 5. Comparison of fish assemblage characteristics by location and habitat for CRAMP sites surveyed in 1999. Values are transect (125 m^2) means with error bars representing one standard deviation of the mean.

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V. Hawaii Island CRAMP

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QUESTIONS ADDRESSED

On the island of Hawaii, overfishing by commercial, recreational, and subsistence fisherman is considered to be the most severe problem facing coral reefs. Along the Kona coast the major issue is collecting of reef fishes for the aquarium industry. In 1998 the state legislature passed a bill to improve the management of fishery resources in west Hawaii by protecting a minimum of 30% of the west Hawaii coastline through the establishment of Fish Replenishment Areas (FRAs) -- marine reserves where aquarium fish collecting is prohibited. Based on scientific input, the West Hawaii Fishery Council (a community-based group) proposed a network of nine FRAs that would close 35.2% of the West Hawaii coastline to aquarium collectors in order to minimize conflicts between the aquarium and dive tour industries and promote a sustainable fish harvest. These proposed regulations were passed unanimously by the Board of Land and Natural Resources in September 1999.

Accordingly, when we began our work in October 1998, our monitoring efforts became focused on this large network of marine reserves as the opportunity to conduct baseline surveys prior to closure of the reserves was unprecedented in Hawaii. Thus, our work in 1998-99 addressed the baseline conditions of the Kona coast FRA network as well as to provide ongoing estimates of aquarium collecting impacts.

APPROACH AND METHODS

The goal of our experimental design was to compare future FRA sites to those which remained open to aquarium fish collecting (impact sites) and those that were not subjected to fish collecting (control sites). To implement this design, we established 23 study sites where permanent transect lines were installed. These included 9 FRAs, 8 impact, and 6 control sites (Table 1; Figure 1). Five of the FRAs have a balanced design with all three treatments which will allow statistically powerful repeated-measure estimates of change in the abundance of all fish species relative to both control and impact areas.

Study sites were selected along the 235 km Kona coastline using a procedure which attempted to minimize among-site habitat variability but yet selected random locations within an area. A diver was towed behind a slow-moving vessel in the area of interest (Impact, FRA, or control) to search for areas suitable as study sites. Criteria for acceptable sites included a substratum dominated by finger coral (*Porites compressa*) at 30-50 foot depths. Finger coral typically dominated most areas of the Kona coast at these depths except along exposed headlands and on young lava flows. Within an area of suitable habitat and depth, a random longshore coordinate was chosen for the location of the study site and four permanent transects were established using a systematic H-shaped design centered on the coordinate (Figure 2). At each of the 23 sites, four 25 m transect lines were deployed using permanently installed eyebolts as geographic markers for the ends of each transect .

Study sites were located by differential GPS and fish densities of all observed species were estimated by visual strip transect search along each permanent transect line. Two pairs of divers surveyed each line, each pair searching two of the 25 m lines. The search of each line consisted of two divers, swimming side-by-side on each side of the line, surveying a column 2 m wide. On the outward-bound leg, larger planktivores and wide-ranging fishes within 4 m of the bottom were recorded. On the return leg, fishes closely associated with the bottom, juveniles, and fishes hiding in cracks and crevices were recorded. Each site was surveyed four times during our 1998-99 funding period and the data have been entered into the CRAMP relational database and verified.

We also began to estimate coral and macroalgal cover at each site using the standard photographic developed for state-wide reef surveys. Video transects have been taken at three sites. After initial analyses to verify methods we will be finishing surveying all sites by the end of 1999.

PRELIMINARY RESULTS

Our initial studies, which constitute baseline surveys before closure of the reserve system, confirmed that aquarium collectors are causing significant reductions in abundance of targeted fishes in four of the six proposed FRAs that had both control and impact sites (Figure 3). Overall, significant declines were found in the density of six aquarium species in the Honokohau FRA (-76%), Honaunau FRA (-61%), Red Hill FRA (-57%), and the Puako FRA (-27%). There were no significant differences between control and impact sites at the North Kohala or Kailua FRAs (Figure 3). Thus, our initial surveys confirm significant effects of aquarium collectors. Ongoing monitoring of these sites as the reserve system is implemented in late 1999 will provide an evaluation of the effectiveness of each reserve in the network to increase the density of aquarium fishes.

Of additional interest was large-scale spatial variation in density along the west Hawaii coastline (Figure 4). Our initial results confirm anecdotal observations that are well known in Kona: juvenile fish are more abundant at more southern study sites. Continued monitoring of these sites will allow us to compare time-series of these patterns in relation to changing collecting pressures and oceanographic circulation and derive population-level hypotheses of the connectedness between each reserve in the network. Thus, our work will allow an understanding of how the reserve system works which will provide valuable information for the establishment of future marine reserves in Hawaii and elsewhere.

Table 1. Description of permanent study site locations, treatments and depths. Abbreviations: FRA = Fish Replenishment Area; FMA = Fishery Management Area (no aquarium fish collecting); MLCD = Marine Life Conservation District (no take area); OPEN = aquarium fish collecting allowed.

NORTH KOHALA

Site	Location	Treatment	Type	Depth (ft.)
1	Lapakahi	Not Collected	MLCD	32-50
2	Kamilo	Collected	OPEN	36-49
3	Waiakailio Bay	Not Collected	FRA	40-47

PUAKO - ANAEHOOMALU

Site	Location	Treatment	Type	Depth (ft.)
4	Puako	Not Collected	FMA	30-34
5	Anaehoomalu	Not Collected	FRA	30-37
6	Keawaiki	Collected	OPEN	35-50

KAUPULEHU (NO ADEQUATE "CLOSED-CLOSED" CONTROL AVAILABLE)

Site	Location	Treatment	Type	Depth (ft.)
7	Kaupulehu	Not Collected	FRA	34-42
8	Makalawena	Collected	OPEN	31-37

KALOKO-HONOKOHAU

Site	Location	Treatment	Type	Depth (ft.)
9	Wawaloli Beach	Collected	OPEN	29-32
10	Wawaloli	Not Collected	FMA	41-50
11	Honokohau	Not Collected	FRA	37-46

KAILUA-KEAUHOU

Site	Location	Treatment	Type	Depth (ft.)
12	To Be Determined	--	OPEN	--
13	Papawai	Not Collected	FMA	29-44
14	S. Oneo Bay	Not Collected	FRA	32-47

RED HILL

Site	Location	Treatment	Type	Depth (ft.)
15	N. Keauhou	Not Collected	FRA	30-46
16	Kualanui Pt	Collected	OPEN	29-39
17	Red Hill	Not Collected	FMA	42-50

NAPOOPOO-HONAUNAU

Site	Location	Treatment	Type	Depth (ft.)
18	Keopuka	Collected	OPEN	28-47
19	Kealakekua Bay	Not Collected	MLCD	20-36
20	Ke'ei	Not Collected	FRA	31-49

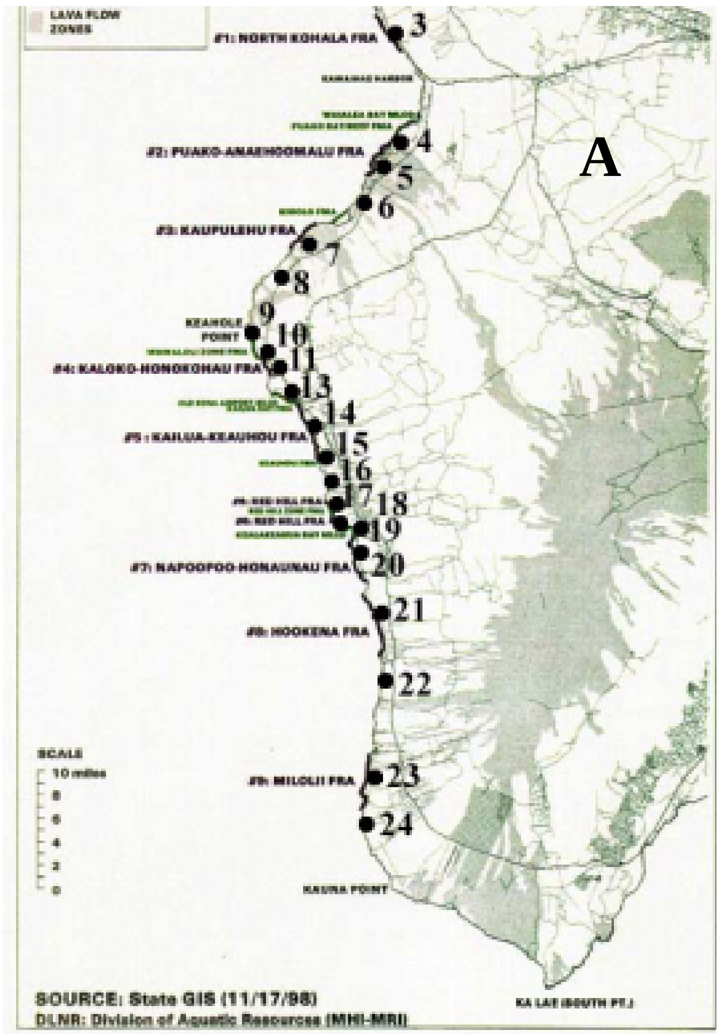
HOOKENA (NO ADEQUATE "CLOSED-CLOSED" CONTROL AVAILABLE)

Site	Location	Treatment	Type	Depth (ft.)
21	Hookena (Kalahiki)	Not Collected	FRA	31-39
22	Hookena (Auau)	Collected	OPEN	37-50

MILOLII (NO ADEQUATE "CLOSED-CLOSED" CONTROL AVAILABLE)

23	Milolii (Omakaa)	Not Collected	FRA	34-49
24	Milolii (Manuka)	Collected	OPEN	32-49

Figure 1. The Fish Replenishment Area network proposed by the West Hawaii Fishery Council in relation to study sites established and surveyed in 1998-99.



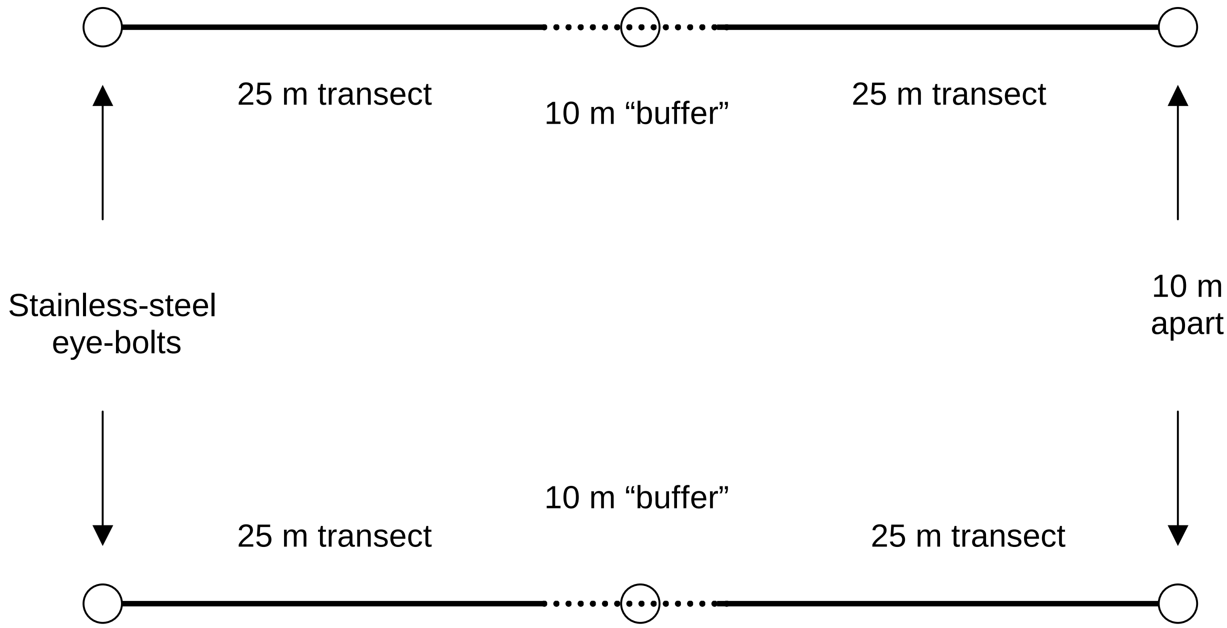


Figure 2. Design of transect layout used at permanent study sites. Two 60 m neutral-gray transect lines were positioned along six permanent stainless-steel eyebolts. Divers surveyed four 25 m transects separated by 10 m buffer areas between replicates.

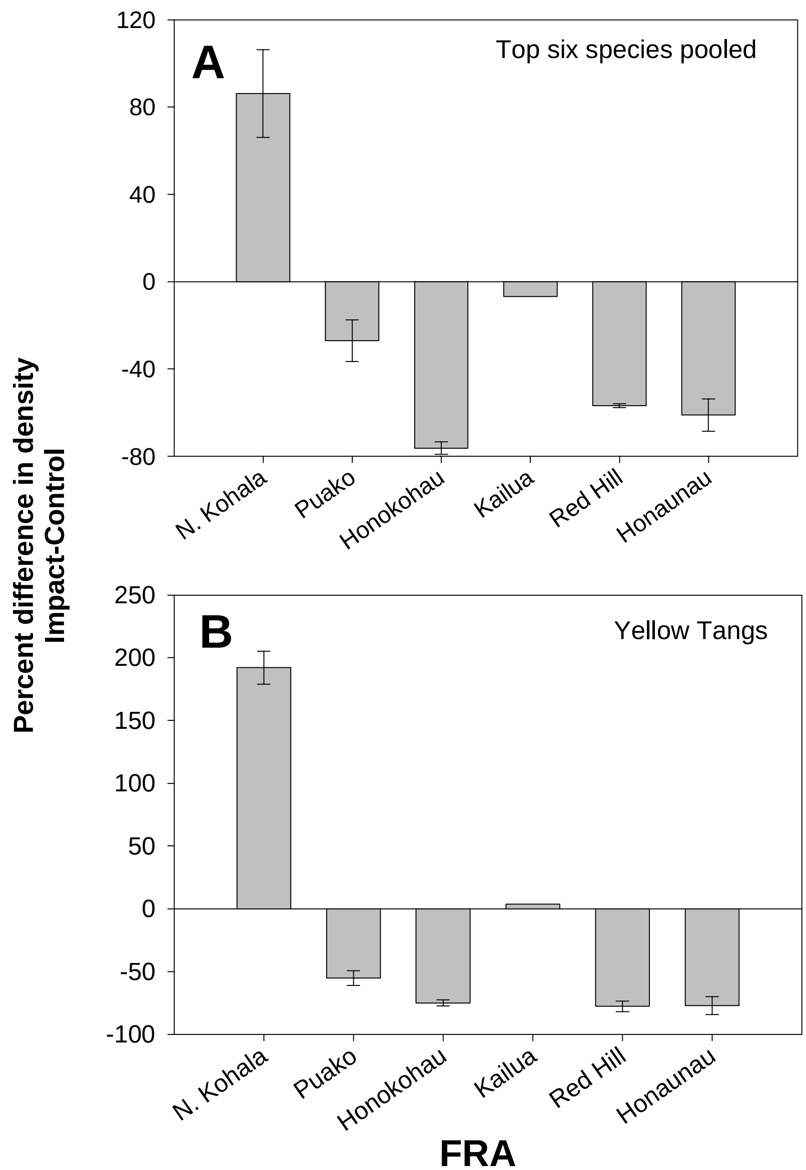


Figure 3. Estimates of aquarium fish collecting impacts in six FRAs prior to protected status in April 1999. **A**. The top six aquarium fish species pooled. These species were *Acanthurus achilles, Centropyge potteri*, *Forcipiger flavissumus, Naso lituratus, Zanclus cornutus,* and *Zebrasoma flavescens*, **B**. The most commonly collected species, yellow tangs (*Zebrasoma flavescens*).

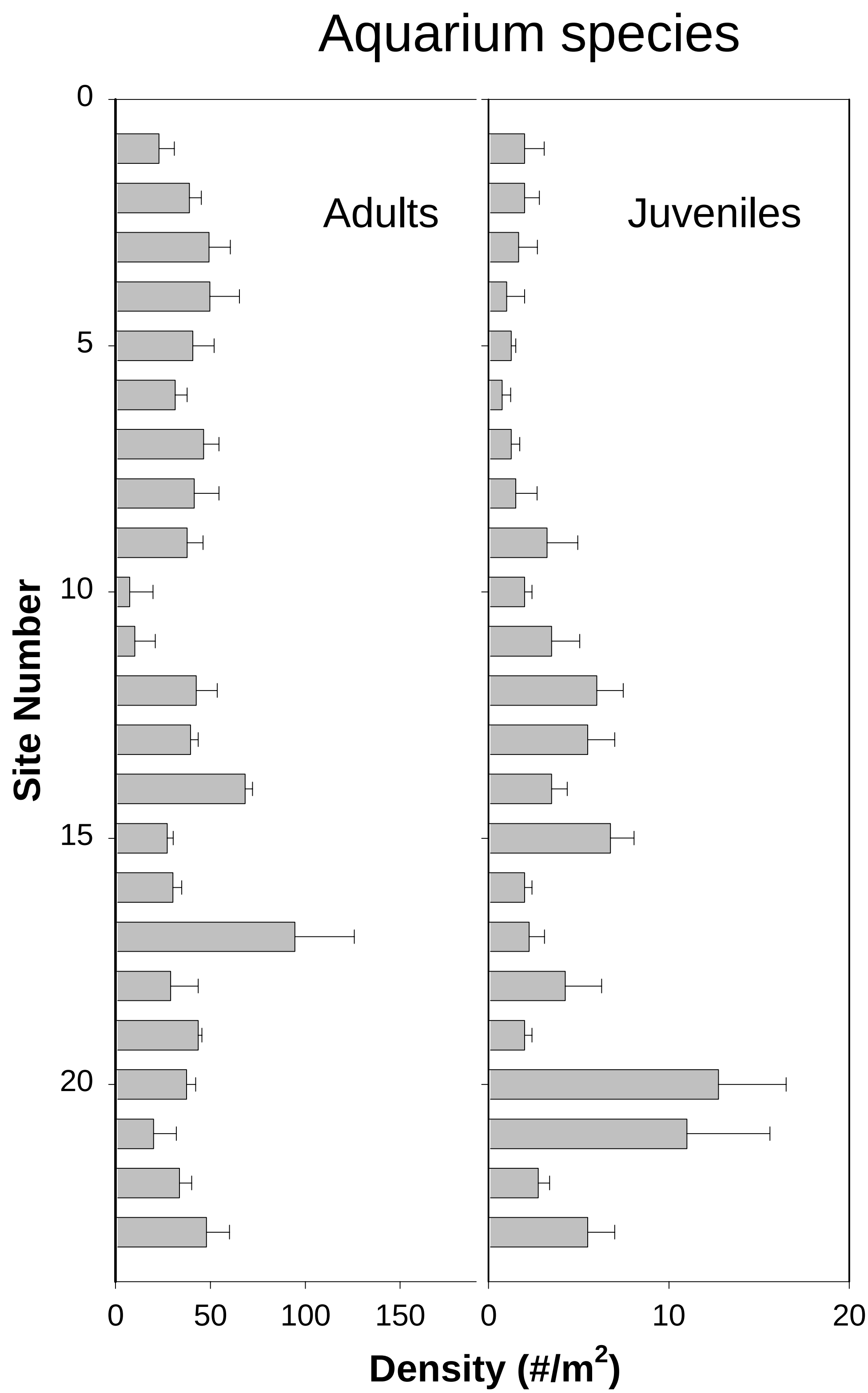


Figure 4. Spatial variation in adult and juvenile fish densities along the west Hawaii coastline during the April 1999 survey for the six most abundant aquarium species pooled.

IV. OVERVIEW OF COMMUNICATION ACTIVITY DURING FY 98

One of the central themes of the Hawaii Coral Reef Initiative is the integration of science with management and the development of public outreach programs and presentations that increase public awareness on the threats to coral reefs in Hawaii. Documented evidence of our intangible efforts in this area is listed below in sequential order.

January 27, 1999	CRAMP participated in planning meeting by Secretariat for Conservation Biology at East-West Center in response to direct request from Packard Foundation. Long-term goal is to develop program to co-ordinate and facilitate marine studies in Hawaii. Packard Foundation expressed desire to eventually support major marine initiative in Hawaii.
Jan 1999	Various CRAMP members participated in a series of planning meetings with the NOAA-NASA Coral Reef Mapping Project, which is a priority area under the evolving Coral Reef Task Force plan.
March 4, 1999	Jokiel was an invited speaker at Maui meeting of Center for Marine Conservation
March 5-6, 1999	Jokiel represented CRAMP at the Coral Reef Task Force meeting as an invited participant. CRAMP poster display was presented at the second US Coral Reef Task Force meeting with representation by various units of the CRAMP program including Hawaii Institute of Marine Biology, Windward Community College, Maui Community College and Bishop Museum. Drs. Jokiel, Krupp, Hunter and Eric Brown were present at the CRAMP poster session and explained the project to various Task Force members and participants as well as members of the general public. The CRAMP poster presentation was developed with in collaboration with Bishop Museum, Windward Community College, FACET (Cindy Hunter), and Eric Hochberg (SOEST).
April 14-16, 1999	Five members of CRAMP attended the International Conference on the Scientific Aspects of Coral reef Assessment, Monitoring and Restoration in Ft. Lauderdale, Florida. A poster session and several papers were presented.
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June 7-10, 1999	Jokiel represented CRAMP at the International Workshop on Remote Sensing on Coral Reefs held at the East-West Center.
July 4-9, 1999	Dr. Steve Coles represented CRAMP with our poster session at the Fourteenth Pacific Science Congress in Sydney Australia.
July 1999	Dr. David Krupp recently presented the CRAMP program (poster session, brochures) to the public at a meeting of the Kailua Bay Advisory Committee.
July 1999	Dr. David Krupp presented CRAMP to a workshop of the Science Teachers Association held at HIMB.
June-August 1999	During our Kauai survey in June and August we were assisted by volunteers from Save Our Seas and the Hāʻena Ahupuaʻa Alliance.
July 6, 1999	Meeting with DLNR personnel on Maui to discuss and organize the CRAMP effort on this island.
July 22, 1999	CRAMP held a full-day workshop at the main offices of the Department of Land and Natural Resources, Honolulu. DLNR brought in their marine biologists and managers from all the islands and included other staff from all relevant divisions. CRAMP presented all aspects of the program and gave a report of progress to date. The workshop then discussed problems and future directions. Other meetings took place on each island before we initiate a survey at a particular site or sites. We work hand-in-hand with the local management teams.
July 27-28, 1999	CRAMP and other members of HICRI presented the issues facing Hawaiian coral reefs at a special panel discussion during the 1999 Hawaii Conservation Conference (Hilton Hawaiian Village, Honolulu). This meeting was notable in that it represented the first time in the long history of these annual meetings that marine biologists were included. The Conference had previously been directed solely at terrestrial ecosystems.
August 7, 1999	CRAMP participated in the "Youth Stewards Conference" at Mokuleia, Oahu. Several hundred gifted students from throughout the State of Hawaii attended this meeting which is focused on environmental awareness and action. Paul Jokiel presented issues on coral reefs and described the role of CRAMP to the students.
August 16, 1999	Meeting with DLNR personnel on Maui to discuss and organize continuing CRAMP work on this island.

August 17, 1999	We again had an opportunity for scientists and managers from a broad spectrum of agencies to interact at a workshop designed to develop a strategic plan for the Hawaii Coral Reef Initiative. Managers and scientists from all organizations concerned with coral reefs were in attendance.
August 24, 1999	Jokiel traveled to Kauai for a meeting of managers, scientists and community groups focused on the Hanalei Heritage River and Hanalei estuary. Each group reviewed concerns about the local environment and future plans were developed.
September, 1999	On the Island of Maui, Eric Brown presented CRAMP at two public meetings (Lahaina on 9/16/99 and NOAA Sanctuary on 9/22/99).
Sept. 14, 1999	Meeting with DLNR personnel on Maui to discuss and organize continuing CRAMP work on this island.
Sept. 14-15, 1999	CRAMP participated with points of contact from all US Pacific and Atlantic reef areas in reviewing the final draft of the "Mapping Implementation Plan" of the Mapping and Information Synthesis Working Group of the US Coral Reef Task Force. This meeting was held at the Hilton Hawaiian Village in Honolulu, so was convenient for our members to attend. This plan will be presented to the Coral Reef Task Force at the October 1999 CRTF meeting, and asked that local and regional geographic priorities be defined to support the mapping of U. S. coral reefs.

MAPPING COMPONENT

The groundwork for a Pacific-wide coral reef mapping program is currently under development (see “A strategy to map U.S. State, Commonwealth, Territory, and Freely Associated State Coral Reef Ecosystems”. Coral Reef Task Force Mapping and Information Synthesis Working Group. March 5-6, 1999. 9 pp.). The Pacific mapping effort eventually will cost in the range of ten million to forty million dollars. Ultimately, remote-sensing data must be verified by ground-truthing using *in situ* methods. The results of a similar mapping effort in Florida have produced the Benthic Habitats of the Florida Keys CD-ROM and Atlas, representing over seven years of cooperative efforts and seven million dollars funding. Many of the lessons learned in the Florida project can be applied to future mapping in Hawaii and the Pacific, greatly reducing the expense associated with this daunting task (NOAA 1999). The Task Force also recommended that a detailed Mapping Implementation Plan (MIP) be presented at the October 1999 CRTF meeting, and asked that local and regional geographic priorities be defined to support the mapping of U. S. coral reefs. While Hawaii and the Pacific contain most of the reef area that will be mapped, we are deficient in an accurate and comprehensive habitat classification scheme (Holthus & Maragos, 1994; MEGIS 1999). This issue is beginning to be addressed by a collaborative multi-agency Pacific Marine Ecosystem Geographic Information System (MEGIS) Technical Working Group. The major problem is that we, as coral reef ecologists, have not clearly identified a quantitative and rational scheme for habitat classification in the Pacific. This quarter CRAMP made considerable progress in the development of a Hawaii Benthic Classification Scheme that will form the basis for classification in the Hawaii portion of the habitat mapping effort.

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COORDINATION WITHIN HCRI

Work with other HICRI components:

CRAMP effectively collaborated with the other 3 components of year 1 HCRI funding. We provided input to the decision making model being developed in Dr. Mark Ridgley's "Development of an Operational Methodology for Strategic Multi-objective Coral Reef Management" and participated in meetings and workshops at HIMB and at SSRI. The CRAMP program collaborated with Dr. George Roderick's "Genetic Status of Hawaiian Corals" by collecting all of the material used in the analyses. CRAMP workers collected corals from Oahu, Maui and Kauai. We have been developing algae sampling protocols in support of Dr. Cindy Hunter's project "Fine Scale Processes Affecting Health and Stability of Hawaiian Reefs". This project will continue during HCRI year 2 with increasing collaboration with CRAMP in developing the phycology data layer in the GIS for algae.