<u>Progress Report – Integrated Monitoring of MHI Williams & Walsh</u>

A. Grant Number: **?**

B. Amount of Grant: **$130,385**

C. Project Title: **INTEGRATED MONITORING OF CORAL REEFS OF WEST HAWAI'I: DEVELOPING A WHOLE REEF & ECOSYSTEM APPROACH FOR THE MAIN HAWAIIAN ISLANDS**

D. Grantee: **Hawaii Coral Reef Initiative – Research Program**

E. Award Period: From: **Jan 1st 2005** To: **December 31st 2005**

F. Period Covered by this Report: From: **Jan 1st 2005** To: **May 15th 2005**

G. Summary of Progress and Expenditures to Date:

l. Work Accomplishments: (as related to project objectives and schedule for completion)

a. Provide a brief summary of progress, including results obtained to date, and their relationship to the general goals of the grant;

(integrated monitoring grant)

The primary objectives of the 'integrated-monitoring' projects, all of which will contribute to the development of a MHI monitoring strategy for DAR, are to: (1) develop a toolkit of survey methods' (2) conduct extended field trials of those methods in West Hawaii; and (3) develop a data environment including an Access database and ArcInfo GIS system. A secondary objective, which can only be initiated once the data-gathering phase is completed, is to use the data gathered by the project to assess the relative importance of a range of potentially important natural and anthropogenic factors affecting reef condition.

Work to date has been principally on objectives (1) and (3), i.e. methods development and data environment development.

Method (1): Target Group: Large/Mobile 'Resource Fish'

Previous monitoring in West Hawaii had focused on small, site-attached species which are targeted by the aquarium trade. Methods appropriate for those groups, which involve short, intensively-surveyed, fixed transects, appear to be powerful and robust for those groups of fishes, and data gathered by the monitoring program within recent years have proved to be effective for detecting small to moderate levels of change in those groups, e.g. (Tissot, et al. 2004). However, two drawbacks of such an approach are that (i) laying out fixed transects prior to counting fish involves some disturbance to large, mobile and/or skittish fishes, and (ii) a consequence of detailed surveying of small and frequently semi-cryptic fishes is that only relatively small areas can be surveyed per unit time (200m^2 per 40-minute survey per dive pair using this method), and therefore relatively less abundant fishes tend anyway to be rarely encountered in such surveys (Table 1). Key groups of fishes (which we here term 'resource fish') including large parrotfish, surgeonfish, emperors and jacks, although regularly observed on surveyed reefs, were only rarely recorded on survey transects (e.g. only 3 >30cm jacks were counted over the course of 510 surveys during 2003 and 2004, Table 1). Our aim therefore was to supplement the fine-scale fixed-transect method by developing a complementary method focused specifically on 'resource fishes' (limited to >15cm TL). The chief requirements of the method were to (i) cover more ground per survey and (ii) reduce disturbance associated with laying out transect lines prior to beginning the survey. Two potential methods were trialed: (i) a 'serial transect' method involving two divers swimming in parallel each carrying out 3 serial 25m * 4m transects, with transect width estimated visually and transect length set by divers laying out 25m long ropes as they swim; and (ii) a 7 minute timed swim, which similarly involved divers swimming in pairs, counting all 'resource fishes', this time within a visually-estimated 5m wide belt in front of each diver. Both methods cover substantially more ground than the fixed transect method and both required substantially lower effort in terms of time (Table 1). Many more resource fish were counted in these methods, e.g. mean fish >30cm per fixed survey per dive pair was approximately 2 fish per survey; in serial transect surveys more than 10 fish were counted per pair, and in the timed swims, more than 22 such fish were recorded per survey on average (Table 1). Groups which were rarely encountered in fixed surveys were regularly recorded in both 'resource fish' methods. For example, 3 30cm+ jacks recorded over the course of 510 fixed transect survey dives carried out in 2003 and 2004 – in contrast, such fishes were observed on 2 out of 8 trial surveys of the timed swim method (Table 1). We are now proceeding with extended field trials of the timed swim method.

Table 1. Comparison of effectiveness of 3 survey approaches at surveying large (>30cm TL) fish. Data from fixed transects comes from DAR's long term monitoring in 2003 and 2004. Results for 'resource fish' methods (i.e. 'serial transects' and 'timed swim') come from field trials conducted in early 2005.

	Fixed Transect (2*25m*2m)/diver	**~Serial Transects** (3*25m*4m)/diver	**Timed Swim** (7 min 5m-belt)/diver
Area Covered	200 m^2	600 m^2	1500 m^2
Effort (dive pair)	40 minutes	25 minutes	15 minutes
(n = trial dives)	510	8	8
Fish > 30cm /survey	2.2 ± 2.7	10.5 ± 13.6	22.4 ± 17.9
Encounter Rates			
Parrotfish	22%	37.5%	100%
Large Surgeonfish	9%	37.5%	62.5%
Large *Naso*	5%	50%	37.5%
Emperors	4%	50%	37.5%
Jacks	<1%	None	25%

Field trials:
Extended field trials have begun in West Hawaii: by May 15th, 30 'resource fish' surveys have been conducted at a total of12 sites.

Method (2): 'Large-scale' benthic characterization.

Methods to detect small to moderate levels of change in cover of key taxonomic groups (e.g. in cover of specific coral species) are already well established in Hawaii. For a variety of reasons, including the need to utilize fixed survey units in order to maximize power to detect small-to-moderate change (Ryan, Heyward 2003) and the need for accurate identification at low taxonomic level, small fixed survey units (e.g. 25m long by 60cm wide photo transects in West Hawaii) have been utilized to date. Future monitoring programs in Hawaii will certainly include that sort of approach, but our aim in this project is to supplement those precise and accurate small-scale methods with an approach appropriate for what we term 'benthic characterization' of physically larger reef areas such as the proposed 300m*50m 'integrated monitoring' units. 'Benthic characterization' is intended to be a broadly descriptive approach capable of simply generating information suitable for improved understanding of fish distribution and community structure, and adequate to identify gross change in reef condition, such as might be associated with mass bleaching events or overgrowth by invasive algaes. The small-scale approach we have used to date involves photographs taken from a height of 75cm, each photo still covering an area of approximately 0.25 m^2. The consequence of such small sampling units is that it is logistically difficult to sample large reef areas– an unfeasible number of images would have to be taken to adequately sample such areas. Two general approaches to larger-areas benthic surveying were trialed: (i) large footprint photographs, taken from 2m and 4m high in the water column (4m high photographs encompass approximately a 25 times larger area than are covered in the small-scale survey approach we have previously utilized in Hawaii); and (ii) a variant on the visual survey approach of (Long, et al. 2004). At this stage of methods development, our objective was to determine whether visual and high-photograph surveys give sufficient accuracy and precision of benthic cover estimation in comparison to what can be achieved by photographs taken from close in to the substrate. 8 3*2m plots within the Koloko-Honokohau integrated monitoring area were surveyed visually and by means of photographs taken from 4m above the substrate (1 photo per plot), from 2m above the substrate (4 non-overlapping photos per plot), and cover estimates from those heights were compared with what we assumed to be accurate cover estimates: determined from images taken from 1m above the substrate (16 images per plot). 3 observers estimated cover of (a) *Porites* finger coral (*P. compressa*, *P. duerdeni*); (b) *Porites* boulder coral (*P. lobata*, *P. lutea*); and (c) all coral combined using those methods (Figure 1). Additionally, observers identified coral 'habitats' in those groups, habitats includes live and dead coral as well as holes and crevices. From the perspective of quantifying habitats likely affecting fish communities, a more important measure may actually be 'habitat' rather than live cover. All 3 observers tended to underestimate coral cover in photographs taken from higher in the water column (presumably because of lower resolution in such photographs), e.g. mean *Porites* finger coral cover estimated from 1m-high photographs was 16%, mean estimate from 4m-high photographs was 12% (Figure 1). Differences were smaller for other coral groups and largely disappeared when we attempted to quantify habitat type rather than actual living coral cover (Figure 1).

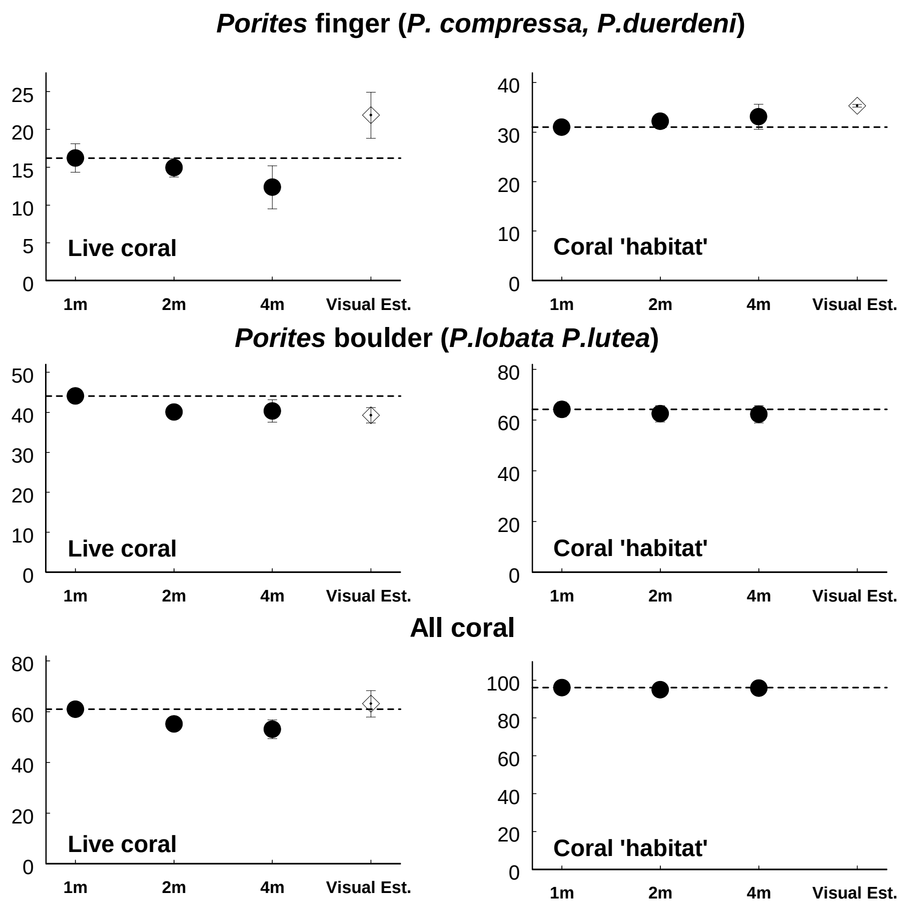

Figure 1 Accuracy (estimated mean in comparison to 1m-high photographs) and precision (standard error) of benthic cover estimates taken from 2m and 4m above substratum, and derived from visual surveys.

Visual estimates were also broadly as accurate as 4m-high surveys (Figure 1), but among-observer variability (standard error in figure 1) was higher in visual estimation than in 4m-high photographs.

Our next step (to be carried out in second half f this year) will be to develop a sampling approach for the proposed 300m*50m integrated monitoring units based around digital photo surveys taken form 4m above the substrate. Image analysis will be designed so that both live cover and coral habitat information can be recorded.

GIS/Database Development

Data layers integrated into the West Hawaii GIS system to date include (i) LIDAR (point depths); (ii) NOAA benthic habitat maps of Hawaii (Coyne, et al. 2003), and (iii) boundaries of marine managed areas of West Hawaii. Derived layers based on (i) and (ii) include, respectively, (iv) bathymetry and substrate complexity; and (v) habitat diversity have also been added into the system. This work is at a very early stage, but Figure 2 demonstrates an example of the kind of use we expect to be able to make of this new data environment.

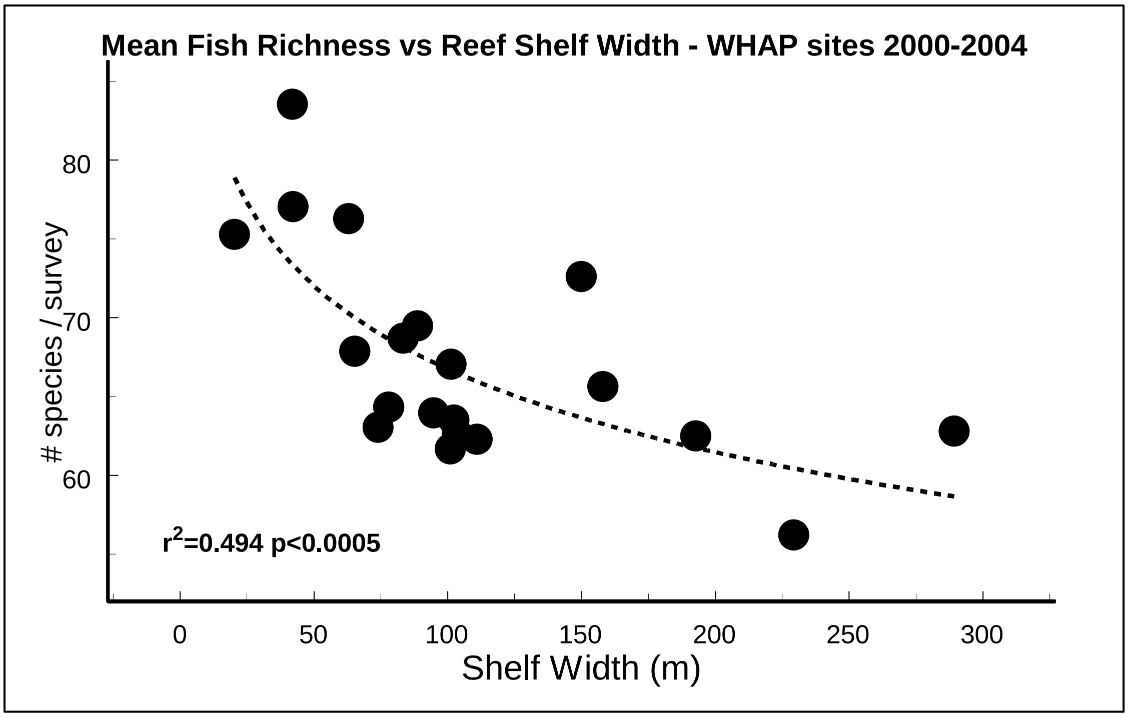

Figure 2. Mean fish species richness at survey sites in West Hawaii derived from fixed-transect surveys between 2000 and 2004 plotted against shelf width (being distances between 20ft and 60ft depth contours at survey sites).

Survey sites on narrow shelves had higher species richness than sites located on wide shelves. In particular, the impact of narrow shelves was particularly pronounced at sites with very narrow shelves (Figure 2). Our working hypothesis is that shelf-width is a proxy measure of 'habitat compression'; i.e. that sites with narrow shelves tend to have multiple habitat types (shallow boulder and pavement zones, reef shelf, reef slope, sand flats) in close proximity. We intend to further explore the importance of habitat compression and habitat diversity on fish communities later in the project.

The recently-developed DAR fish survey database has been trialed in Kona and subsequently introduced to DAR offices in Maui during the period covered by this report. To date quality-control (i.e. error checking) functionality appears to work very well.

Other work by Williams in this period

[Not specific to 'integrated monitoring' project]. Two research papers submitted to *Marine Ecology Progress Series*, one on influence of observer experience level on quality of underwater visual census data, and another on the effect of more than 2 decades of rotational fishery-closure at the Waikiki Diamond-Head Fishery Management Area. Both papers come out of analyses of DAR long-term monitoring data. Additionally, Williams continued to work with biological staff of DAR to analyze ecological data including: on status of Black Coral populations around Maui; on trends in bottomfish catches following the introduction of fishery closure areas; on trends in abundance of Hi'hi'wai (*Neritina granosa*) recruitment in 'I'ao and Honoman'u streams on the Island of Maui, Hawai'i.

b. Provide a brief summary of work to be performed during the next year of support, if changed from the original proposal; and indication of any current problems or favorable or unusual developments; and any other significant information pertinent to the type of project support by COP, or as specified by the terms and conditions of the grant.

Only change from original proposal is that 'physical structure' and 'mobile invertebrate' surveys, originally scheduled for first half of 2005, will, instead, be conducted in 3rd quarter 2005.

2. Applications:

a. Publications, presentations, workshops;

<u>Presentations</u>

(1) 'Integrated Monitoring of Main Hawaiian Islands - Project outline'. Ivor Williams, HCRI-RP 1st quarterly meeting, Honolulu Hawaii Jan 2005

(2) 'Integrated Monitoring of Main Hawaiian Islands –Methods Toolkit'. Ivor Williams, HCRI-RP 2nd quarterly meeting, Honolulu Hawaii May 5th 2005

<u>Publications</u>

(these are papers I have submitted this year – they are not specific to the integrated monitoring project, but as my whole salary seems to be included in this grant, perhaps these should also be included?)

(1) *Effects of rotational closure on coral reef fishes in the Waikiki-Diamond Head Fishery Management Area, Oahu, Hawaii*. ID Williams, Wj Walsh, A Miyasaka, AM Friedlander. In Review Marine Ecology Progress Series

(2) Impact *of observers' experience-level on counts of fishes in underwater visual surveys*. ID Williams, Wj Walsh, BN Tissot, LE Hallacher. In review Marine Ecology Progress Series

b. Applications to management or research;

None to date.

c. Data and/or information products;

(the database was developed by an external contractor using money from a NOAA-monitoring grant given to DAR, but I was heavily involved in the development of it – so my time in this year to date contributed to it's development)

(1) MS Access Fish Survey Database – now being used by DAR field staff to store and analyze survey data.

d. Partnerships established with other federal, state, or local agencies, or other research institutions (other than those already described in the original proposal).

None.

3. Expenditures:

a. *Describe expenditures scheduled for this period..*
b. *Describe actual expenditures this period.*

Could Beth please provide these numbers?

c. Explain special problems, differences between scheduled and actual expenditures, etc.

Delayed initiation of project as a result of problems in resolving oversight of diving operations involving UH Hilo students. The main consequence of that delay for project expenditure was that the monitoring/GIS technician didn't begin working until Feb 17th and so salary costs for the period were lower than scheduled.

Prepared By:

Signature of Principal Investigator *Date*

References

Coyne MS, Battista TA, Anderson M, Waddell J, Smith W, Jokiel P, Kendall MS, Monaco ME (2003) NOAA Technical Memorandum NOS NCCOS CCMA 152 (On-line). Benthic Habitats of the Main Hawaiian Islands. NOAA

Long BG, Andrews G, Suharsono YGW (2004) Sampling accuracy of reef resource inventory technique. Coral Reefs 23: 378-385

Ryan DAJ, Heyward A (2003) Improving the precision of longitudinal ecological surveys using precisely defined observational units. Environmetrics 14: 283-293

Tissot BN, Walsh WJ, Hallacher LE (2004) Evaluating Effectiveness of a Marine Protected Area Network in West Hawai'i to Increase Productivity of an Aquarium Fishery. Pacific Science 58: 175-188