Characterization of dead zones and population demography of *Porites compressa* along a gradient of anthropogenic nutrient input at Kahekili Beach Park, Maui

Background

Coral reefs around Maui Island have experienced rapid and severe declines in coral cover over the past 10-15 years (Williams et al. 2008). A 2009- 2010 Maui Wide Study investigating colony scale dynamics showed that patterns and causes of coral decline are site specific. "Dead zones" or areas of nearly 100% mortality of the coral *Porites compressa* (Fig 1) have been observed at Kahekili Beach Park Maui, one of the degraded sites from the previous study. The site has a history of macro-algal blooms (Smith et al. 2005) and input of nutrient rich water via injection wells located at the Lahaina Wastewater Treatment facility just North of the site (Dailer et al. 2010). The goal of this study was to map the distribution of areas of low, intermediate and high levels of degradation and to monitor colonies to determine whether mortality is ongoing and if so to identify potential causes of mortality. Information on processes causing declines in coral coverage will allow more effective management to prevent, slow or reverse declines.

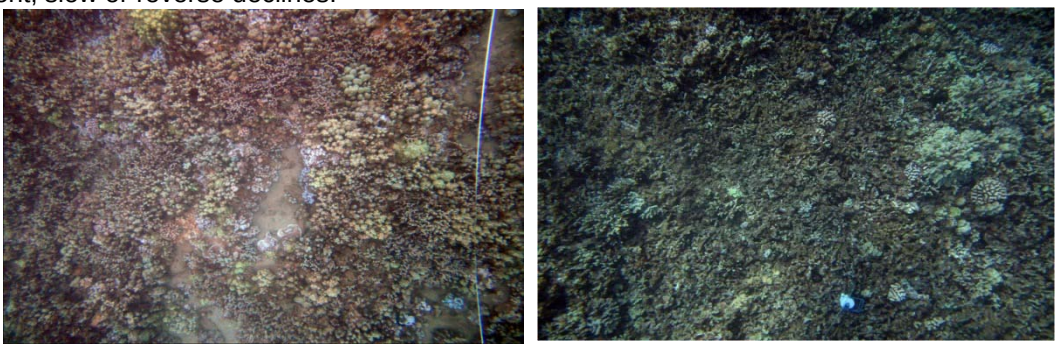

Figure 1. An area of normal coral coverage (left) and an example of a "dead zone" (right) characterized by lower coral coverage, fewer larger colonies, and higher coverage of *P. compressa* rubble and skeleton.

Methods

•Visual estimates of the amount of coral, coral rubble and skeleton and algae were recorded for each contiguous 5x5m^2 cell along the length of the reef (Fig 3).

•Surveys were conducted in June 2011 to quantify coral community size frequency distribution and environmental variables such as sediment composition, pH, salinity, temperature, wave action, coral disease, algal competition, and benthic coverage.

•Ten colonies each of the corals *P. lobata* and *P. compressa* were marked along each transect. Colonies were revisited and observed for signs of mortality, defined as loss of coral tissue, and causes of mortality every 1.5 months for a period of 6 months (Fig 2).

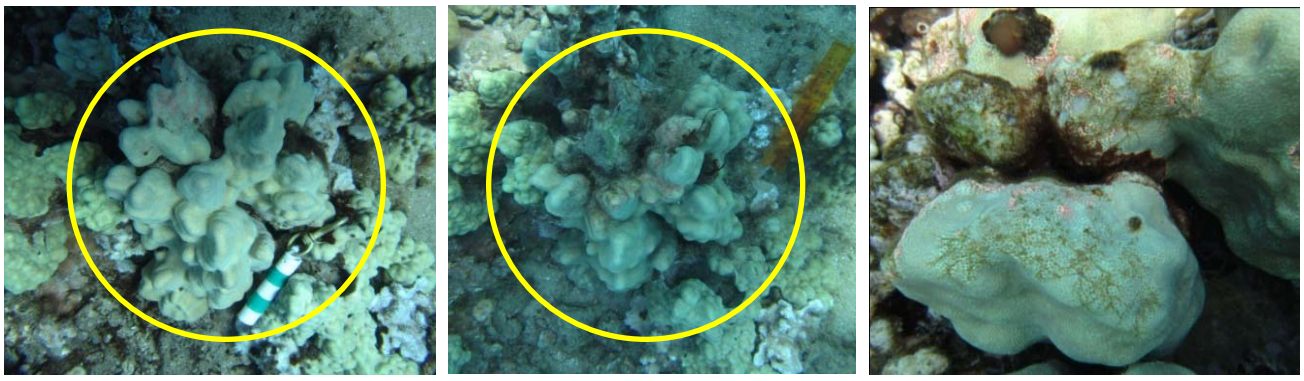

Figure 2. A *Porites lobata* colony in August 2011 (left) lost ~25% of its surface area by November 2011 (center). Tissue loss was associated with turf algal competition (right).

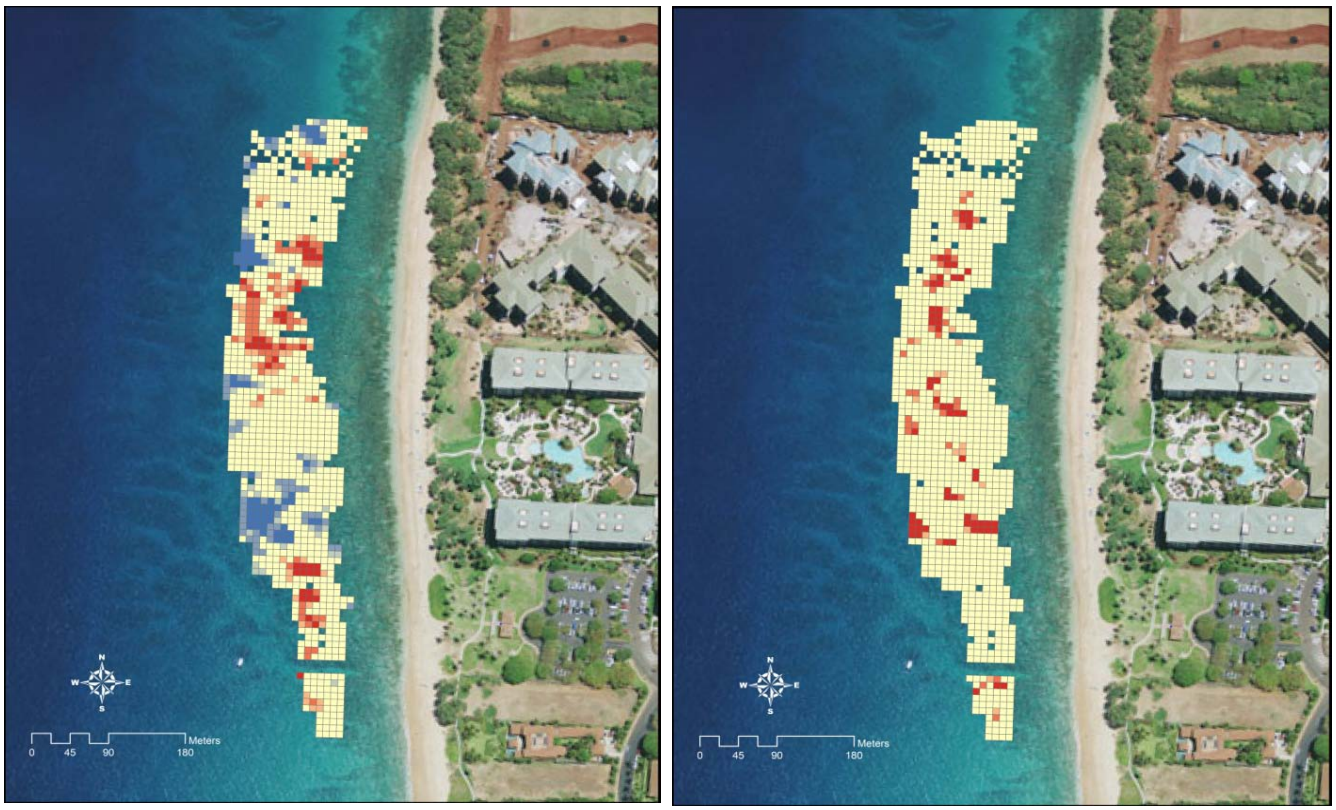

Figure 3. Maps of 5x5m^2 cells color coded by high (red) and low (blue) values of coral coverage (left), and high (red) values of *P. compressa* rubble coverage (right).

Conclusions

Spatial analysis of mapped cells (Fig 3) showed two types of "dead zones" along the reef at Kahekili Beach Park in North Kaanapali, Maui. The first type is characterized by low coral coverage (Fig 3 left), and moderate degradation covering relatively large areas. The second type of degradation is characterized by high *P. compressa* rubble coverage (Fig 3 right), and is severely degraded but occurs in smaller areas approximately 4-10m in maximum diameter. The recovery of these degraded areas does not appear to be limited by recruitment availability, but may be limited by survival of recruits in loose rubble.

Results based on observations of colonies over time (Fig 2) and surveys of environmental variables suggest that turf algal competition and overgrowth of live coral is an important factor in the mortality of coral in addition to macro-algal competition via seasonal and ephemeral blooms in 2001 and 2003. Results of spatial analyses show that there are more incidents of coral mortality and turf algal competition as you move from North to South along the reef. These findings provide us with a baseline of the distribution of degradation at Kahekili Beach Park as well as data related to the potential causes of mortality driving patterns of degradation.

Future Research

Continued observations of marked colonies will be made to obtain a full year of data on rates of mortality. These data are particularly important given the temporal/seasonal variation in rates and causes of mortality. Comprehensive water quality testing on finer spatial and temporal scales should be conducted. The findings from this study including the location, severity of degradation and rates of coral mortality can be used to guide these testing efforts. Analysis of long-term monitoring photoquadrats along CRAMP transect affected by "dead zone" should be conducted in order to determine whether origins of "dead zones" was chronic or catastrophic.

References

Dailer et al. 2010. Using $\delta^{15}N$ values in algal tissue to map locations and potential sources of anthropogenic nutrient inputs on the island of Maui, Hawaii, USA. Marine Pollution Bulletin 60(5): 655-67160(5): 655-671**.**

Ross et al. 2010. Quantifying causes of Maui coral decline. Department of land and Natural Resources, Honolulu, HI, p22.

Smith et al. 2005. Characterization of a large-scale ephemeral bloom of the green alga *Cladophora sericea* on the coral reefs of West Maui, Hawaii. Marine Ecology Progress Series 302: 77-91.

Williams et al. 2008. Status of Maui's coral reefs. Hawaii Division of Aquatic Resources Information Sheet. http://hawaii.gov/dlnr/dar/pus/MauiReefDeclines.pdf

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