Honolua Bay Review:
A review and analysis of available marine, terrestrial and land-use information in the Honolua Ahupua'a Maui 1970- 2007

Prepared for Hawaii's Land-based Pollution Threats to Coral Reefs Local Action Strategy

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Executive Summary

Introduction

Honolua Bay is a popular recreational area for locals and tourists alike and offers some of the best snorkeling and surfing conditions on Maui. It is considered to have one of the most diverse, unique and abundant reef formations on Maui and provides habitat for atleast one species of rare coral, and is a resting ground for the green sea turtle. Honolua bay and adjoining Mokuleia Bay are designated a Marine Life Conservation District and protected from fishing and harvesting.

The watershed has a long history of diverse land uses that have influenced the condition of the Bay. These include grazing, agriculture, development activities, and the introduction of feral ungulates in the upper watershed. Until recently pineapple cultivation was the major land-use in the lower watershed. Public concern over perceived increases in sediment and chemical pollution associated with agricultural and development activities grew in the 1990's and continues today. Now that agriculture has ended, the community is concerned about the future of watershed and associated impacts on Honolua's reefs. In addition up to 600 snorkelers visit the Bay daily and there are no formal management measures or visitor facilities.

The diversity of Honolua's reefs and concerns about its health has lead to a plethora of research and monitoring projects in the Bay and the adjacent watershed. Studies have assessed the economic, cultural, and biological value of the bay and watershed separately. Several studies have focused on factors influencing the health of the coral reef ecosystem. However comparison between these studies is difficult because they have been conducted by different researchers using a variety of methods. There have been few attempts to synthesize and critically analyze all available information, including land-use and marine data. This has made it difficult for resource managers and scientists to identify research gaps and priorities in the bay and to focus management efforts.

The synthesis and critical analysis of available data and information on land use, runoff, water quality and the health of the coral reef ecosystem at Honolua Bay was identified as a priority project in Hawaii's Local Action Strategy to Address Land-Based Pollution Threats to Coral Reefs (LBPLAS). This report is limited to available literature for Honolua Ahupua'a published between 1970 and June 2007.

Trends in Land-Use

Until recently land-use within the Honolua Watershed had not changed considerably for 30 years. The main changes since 1976 have been a decrease in agricultural land with the end of pineapple cultivation (27% to 7% of total area), a 16% increase in the total area covered by forest, and a 5% increase in the area used for residential development.

It is likely that soil loss from pineapple fields decreased dramatically in the 1970's with the introduction of BMP's, and continued to decrease with the improvement of pineapple farming practices and installation of 22 BMP's between 1994 – 1996. Another reduction likely occurred in 2003 with the decrease in pineapple, and in 2006 when pineapple cultivation ended. However development activities also began on Honolua Ridge in 2004 and were a potential source of eroding soil.

Most of the watershed is forested (~83% or 2,509 acres) and approximately 74% (2,248.5 acres) of the entire watershed is protected through inclusion in the Pu'u Kukui Watershed Preserve (1,197 acres) and Makai Conservation Area (1,052 acres). Residential development comprises 7.9% (240 acres) of the watershed and 2.5% (76 acres) is golf course. 203 acres (6.7%) are zoned for agriculture. Thus any future land-use changes will occur in the land zoned for agriculture. There are no current plans to expand residential developments or golf courses however this could be proposed in the future. New agricultural uses, such as organic farming or grazing, are not currently planned but could also be proposed. It is likely a portion will be designated for parkland.

Management efforts should focus on restoring the lower watershed that was previously utilized for pineapple cultivation. Priority should be given to revegetating denuded/exposed areas that are eroding such as old pineapple roads, unpaved roads and trails, and badlands. ML&P with assistance from the community has already started revegetating an old pineapple field. Similar collaborative projects should be encouraged.

A watershed plan, that incorporates a unified vision for the Honolua Watershed, is urgently needed to better manage the area. Urgent action is needed to ensure the sustainable use of Honolua Bay for future generations.

Trends in Water Quality

MRC reported that water quality in Honolua Bay was relatively consistent since their monitoring program began in 1990 (MRC, 2007). They observed that the

Bay was consistently stratified both vertically and horizontally during that 16 year period. An upper layer of low salinity, high nutrient water was consistently present. This surface layer was influenced by groundwater, stream flow and inputs from land. In contrast the un-mixed lower layer of saltwater was not affected by freshwater input. Three zones were consistent within the bay: an inner zone with low salinity and high nutrients (Si, NO_3^-, PO_4^{3-}), a central zone with elevated nutrients (Si, NO_3^-, PO_4^{3-}) and an outer well mixed zone with oceanic conditions (low nutrients).

The geometric means of samples collected at all stations during the nineteen surveys showed that water quality parameters were generally in compliance with State water quality standards for wet embayments. The only exceptions were NO_3^-, turbidity and Chl *a* in near-shore waters. It is likely that there were changes in nutrient and sediment delivery to Honolua Bay even though water quality parameters have shown little change over the last 16 years. Changes in water quality parameters were difficult to detect because monitoring was undertaken only once a year and at irregular intervals, presenting a brief snapshot of water quality condition. Water samples were collected when freshwater was generally not flowing from Honolua Stream, at low-tide during periods of mild trade-winds and when there was little swell. Thus sampling conditions may not have been representative of the average conditions in the Bay. In addition the small number of samples (19 total over 16 years) makes it difficult to establish compliance with water quality standards. Routine monitoring is needed to assess compliance with water quality standards and changes in water quality conditions.

Because of the vertical and horizontal stratification within the bay monitoring could be limited to near-shore surface waters of the inner bay and Honolua Stream. At a minimum monitoring must occur during the summer and winter months, to capture dry and post-flood conditions. Replicate samples should also be analyzed to account for variability in water quality. It is recommended that bacteria levels are routinely monitored to ensure water quality meets human health and safety standards, and total suspended solids are analyzed.

Groundwater needs to be sampled periodically to determine background nutrient and contaminant concentrations. Long-term in-situ turbidity monitoring should also be implemented to assess the variability in sediment runoff and help quantify the impacts of sediment runoff on coral reef condition. This monitoring should be integrated with coral reef monitoring programs.

Near-shore water quality and bacteria monitoring should be incorporated into DOH's existing beach water quality monitoring program. Additional monitoring and research should continue to be supported by ML&P and other agencies. The use of volunteer monitoring programs must also be considered as both an outreach and data collection tool. Regardless of who leads the monitoring program, any future water quality monitoring must be subject to critical review to ensure that sampling and data collection support any water quality status/improvement claims.

Trends in Coral Reef Condition

Coral cover in Honolua Bay has generally decreased since the first surveys were conducted in 1974. It is difficult to compare coral cover data between studies because of differences in survey methods and survey sites. Because of this discrepancy only general trends were compared between different studies.

All studies concur that there are differences in species composition between the north and south reef. The north reef is dominated by *Porites* sp. while sediment resistant *Montipora* sp. are dominant on the southern reef. There is also agreement that sediments and wave action influence coral cover. High turbidity and sediment deposits in the inner bay have been observed consistently since 1974.

MRC did not observe any significant difference in coral cover between 1990 and 1992. They found that coral cover significantly decreased between 1992 – 2002 and increased slightly between 2002 - 2006. Because monitoring was infrequent MRC could not determine if there had been a gradual decrease in coral cover between 1992 – 2002 or if a single runoff event in 2002 caused the mortality.

The CRAMP data from 1994 – 2007 shows a steady decrease in coral cover during 1994 – 1999, stabilization occurring from 2000 – 2004, and then a decrease again in 2005 - 2007. This differs to MRC's observed increase in total coral cover from 2002 – 2006. This slight increase was caused by a significant increase in coral cover on only 2 transects that were not impacted by sediment runoff in 2002. Conversely coral cover decreased significantly on the shallow transect located nearest the shore on the southern inner reef. Cover did not change significantly on the other 5 transects.

Although there are differences between CRAMP and MRC data, the general trend is the same: coral cover has decreased since their monitoring programs started in 1994 and 1990 respectively. It appears that the large decrease in coral

cover observed by MRC in 2002 was cumulative rather than caused by a single runoff event. This emphasizes the importance and strength of regular coral reef monitoring.

In addition to the changes in coral cover Brown (2004) also found that there was low coral recruitment success on the northern reef flat. The low rates of recruitment, low growth and high mortality shown by his short-term studies indicated that future disturbances could further degrade the reef structure. He also predicted the southern reef flat was undergoing a "slow steady decrease in several abundant coral species" and that the remaining species showed no evidence of increasing cover. Unfortunately his prediction may be occurring on the reef flats in Honolua Bay.

It is apparent that erosion of soil and subsequent sedimentation events have caused declines in coral cover, impacted coral recruitment success, and are affecting the long-term condition of Honolua's reefs. In addition other anthropogenic variables, such as chemical pollutants and increasing human use, are likely contributing to the long-term decline in coral cover. Honolua's coral reefs have adapted to the bay's wave action, water circulation patterns and influx of stream and ground-water. However human activities are altering the reefs resilience to both natural and anthropogenic stressors. In order to stop this long-term decline in coral cover, management efforts must focus on reducing anthropogenic sources of stress.

The lack of quantitative data makes it difficult to determine the specific cause(s) of the long-term decline in coral cover. The continuation of long-term coral reef monitoring is critical. Future monitoring should utilize standard survey methods, such as the CRAMP protocol, to reduce discrepancies between long-term studies. The CRAMP protocol has been validated and is utilized State-wide and should be continued in Honolua Bay. If possible monitoring should be expanded to include at least one deep site on the reef slope (similar to other CRAMP sites). This would provide a better understanding of Bay-wide trends in coral condition. Alternatively MRC's monitoring program could be used to supplement CRAMP's limited survey sites. However this would require the use of comparable methods, including permanent quadrats by MRC.

As well as long-term benthic monitoring, long-term in-situ turbidity monitoring is urgently needed to help quantify the impacts of sediments on Honolua's coral reefs. It is also critical that coral recruitment rates continue to be monitored regularly.

Honolua Bay and has some of the highest fish assemblage characteristics (species diversity, species richness, number of individual and biomass) of reefs in the MHI (Friedlander *et al.* 2003). Based on the data reviewed in this report it is difficult to determine how the fish population has changed over time. None of the available reports assessed changes in the fish population and it is difficult to compare between studies because of differences in survey methodologies and changes in fish taxonomy. Long-term data has been collected by Friedlander/ CRAMP/DLNR-DAR (from 1998) and MRC (from 1990) and needs to be analyzed. This analysis was beyond the scope of this project and is recommended for future work.

Information Gaps

Information gaps for the marine and terrestrial ecosystem in the Honolua ahupua'a were identified during this review. Certain components of the ahupua'a have either not been studied or data was not accessible for review. Perceived information gaps are listed in groups below:

Stream Hydrology and Biology Gaps:

- Comprehensive survey of stream flora and fauna
- Quantity and quality of stream flow
- Watershed scale hydrological studies and modeling
- Stream monitoring program
- Effects of stream diversion on stream and marine biota

Marine Ecology Gaps:

- Comprehensive list of marine invertebrates (last surveyed in 1979)
- Comprehensive data on prevalence and occurrence of coral and fish disease
- Marine vertebrate surveys
- Comprehensive list of marine macroalgae
- Analyses of long-term fish data sets
- Cause(s) of coral cover decline
- Biological impacts of sedimentation and turbidity
- In-water monitoring of recreational impacts on coral reefs

Water Quality Gaps:

- Comprehensive long-term water quality data
- Long-term in-situ turbidity data at coral reef
- Location, quantity and quality (nutrients and contaminants) of groundwater input

- Fluxes of freshwater and nutrients from groundwater vs stream flow
- Quantity and quality of stream flow
- Integration of water quality and coral reef monitoring

Geospatial Information Gaps:

- GPS locations of early coral reef and fish surveys (many sites were identified by landmarks in the field)
- Detailed land-use maps

Recommendations

This study highlights the multitude and diversity of studies conducted in the Honolua Ahupua'a over the last 37 years and identifies gaps in knowledge for both the marine and terrestrial environment. The following recommendations are aimed at improving management of marine and terrestrial resources within the ahupua'a to ensure their sustainable use for future generations. Key recommendations include:

- Develop an integrated coastal area management plan
- Implement regular water quality monitoring, including:
    - Incorporate near-shore water quality monitoring, including total suspended solids, of Honolua Bay into the State's water quality monitoring program,
    - Incorporate bacterial indicator monitoring into DOH's beach monitoring program
    - Monitor the quantity and quality of groundwater,
    - Implement long-term turbidity monitoring, and
    - Monitor stream flow.
- Continue long-term coral reef monitoring (benthic, coral recruitment and turbidity)
- Support studies that address identified gaps in knowledge