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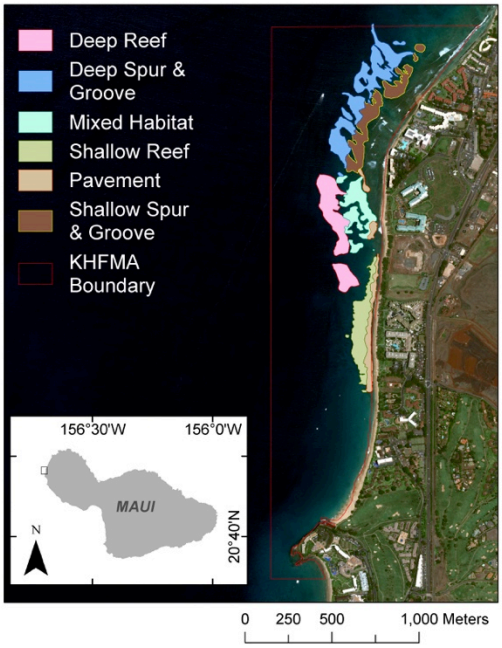
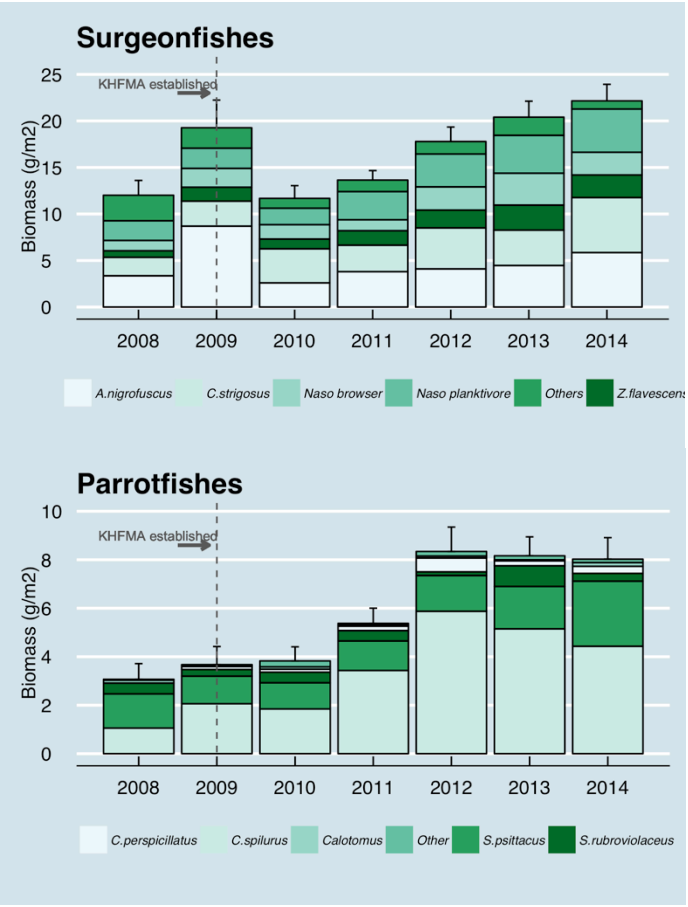
# *Results Brief*:

## 5 Years of Protection at Kahekili Herbivore Fisheries Management Area

**Summary.** In response to concerns about long-term declines on local reefs, in 2009, the State of Hawaii established the Kahekili Herbivore Fisheries Management Area (KHFMA) in Ka'anapali, West Maui. Within the KHFMA, herbivorous fishes and sea urchins are protected, with the goal of restoring natural grazing processes and thereby ultimately increasing the reef's ability to resist and recover from excessive algal growth. Over the first 5 years of closure, parrotfish biomass increased by 138%, and surgeonfish biomass by 42%. Likely as a response to increased herbivory, there has been a concurrent increase in crustose coralline algae (CCA) that is preferred habitat for coral settlement and growth. Following a period of decline, coral cover has stabilized and even slightly increased in recent years. These encouraging early results indicate that a more naturally resilient reef ecosystem is developing at the KHFMA, but sustained protection will be necessary before the full effects of this form of management will be known.



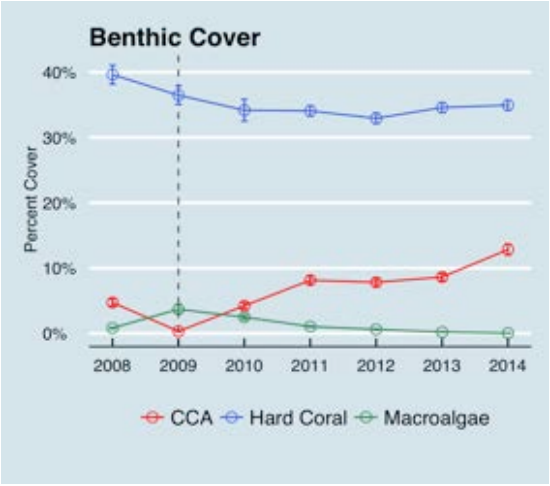

Coral reef monitoring within the KHFMA. The Hawai'i Division of Aquatic Resources (HDAR) in partnership with the University of Hawai'i began a comprehensive monitoring program of coral reef areas within the KHMFA in January 2008 (~18 months prior to the closure). Subsequently, that program has been maintained using consistent methods and survey design - since 2010 as a partnership between HDAR and NOAA Pacific Islands Fisheries Science Center. Monitoring involves 1–2 rounds per year, generally in spring and late summer, with each round comprising co-located surveys of fishes, sea-urchins, and benthic habitat (e.g., corals and algae) at~80–100 haphazardly located sites. The figure above shows the coral reef areas within the KHFMA, classified into 6 reef types. Summary results from the KHFMA monitoring program and additional survey work by HDAR at other locations in Maui County are presented below.




Trends in protected fish families after 5 years of closure. Increases in 2-yr average biomass between the pre-closure period 2008–9 and the most recent post-closure period 2013–14 are evident for both surgeonfish and parrotfish:

- Surgeonfish biomass increased by 42%. While the net overall change is relatively small, there has been a steady increase in biomass in all years from 2010 onwards. Much of that increase has been of smaller-bodied species including yellow tang (*Zebrasoma flavescens*) and *kole* (*Ctenochaetus strigosus*). Mean biomass of browsing *Naso* species, e.g. *kala* (*Naso unicornis*) has also increased, but the change so far is not statistically significant.
- Parrotfish biomass has more than doubled, increasing by 138%. Most of that increase has been of two species, the bullethead and palenose (*Chlorurus spilurus* and *Scarus psittacus*), but larger bodied species - redlip and spectacled (*S. rubroviolaceus* and *C. perspicillatus*) – have been more frequently encountered in recent years.

Other long-term studies of coral reef closures have shown that full recovery can take many years, and that surgeonfishes, which can live for > 40 years, tend to have particularly long trajectories of recovery. Further increases in herbivorous fish biomass are expected, particularly for surgeonfishes and the larger-bodied and longer-lived parrotfishes, if the protections are continued.

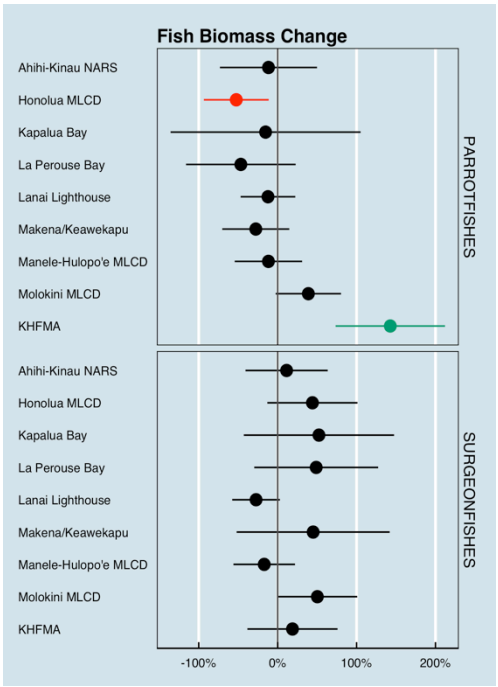



Trends in coral and algal communities after 5 years of closure.
As noted above, sustained protection over many more years will be necessary to properly assess the full impacts of herbivore management at the KHFMA. This is particularly true for corals, which grow relatively slowly. However, there have already been some changes to benthic communities within the KHFMA that are consistent with the expected beneficial effects of herbivore protection.

- Cover of crustose coralline algae (CCA) has increased from 2.5% in 2008-9 to 12.8% in 2013-14. Coral will tend to grow and recruit more readily on reefs with abundant CCA.
- Cover of macroalgae (i.e. 'large' fleshy algae that will tend to inhibit coral growth and recruitment) has remained low throughout the monitoring period, declining to negligible levels over the last few years.

Increased CCA cover and the decline of macroalgae signal a shift in the benthic algal community towards one that is more beneficial for coral settlement and growth. The response of the coral assemblage inevitably lags behind those changes, and therefore it is difficult to predict the ultimate effects of herbivore management at KHFMA on corals. However, after declining between 2008 and 2010 (i.e. one year prior to closure till one year post closure), hard coral cover has since stabilized. Over the last 2 years there has even been a small uptick in coral cover (from 32.9% in 2012, to 34.9% in 2014). It is, however, too early to know if that increase in coral cover represents the start of a meaningful longer-term trend.

Changes in the KHFMA compared to wider patterns across Maui Nui.
Clearly there are larger-scale factors that influence the condition of fish and benthic communities in the KHFMA and beyond. It is therefore important to compare change within the KHFMA with what is happening more widely. One way to do that is to use data from other long-term monitoring surveys conducted by HDAR and partners over the same time period. For example, the figure to the right shows percent change (and 95% confidence interval) in biomass ($g/m^2$) of parrotfishes and surgeonfishes between 2008-9 and 2013-14 at the 8 locations surveyed by HDAR's 'resource fish' monitoring program and inside the KHFMA. For consistency with that larger survey program, the data used are only for fishes >15cm long and some lightly targeted surgeonfishes are excluded. Out of the 9 locations, the only significant increase in parrotfishes across the 5-yr time interval was at the KHFMA. There have been no significant changes in surgeonfish biomass at any survey location. A similar assessment of benthic changes at 9 Maui locations showed no clear overall trend for CCA, which significantly declined at 2 locations and increased at 2. By far the largest change in CCA was at Kahekili – an increase of ~ 10%; the increase at the other location was ~2%. Therefore, it appears that the positive changes inside the KHFMA since its creation are not part of a larger pattern occurring widely across Maui's reefs.




Looking ahead. Protection of herbivores could increase reef resilience and coral recovery by promoting benign algal forms that tend to dominate in heavily grazed environments (e.g., crustose coralline algae, which are important for coral settlement), and by reducing algae that can overgrow, smother, or otherwise negatively affect corals (generally upright macroalgae and dense turfs). As described above, the full effects on fishes and on relatively slow-growing corals will only become evident over a longer time period, but there are encouraging signs that herbivore management at KHFMA is leading to the positive changes that will ultimately underpin resilience and recovery of the coral assemblage within the protected area. Given the timescales of recovery, sustained compliance with KHFMA regulations and continued ecological monitoring will be necessary to assess the effectiveness of this management initiative.

For more information about the KHFMA survey program, the results, or the statistical analysis, please contact Russell Sparks of HDAR (russell.t.sparks@hawaii.gov) or Ivor Williams of NOAA Pacific Islands Fisheries Science Center (ivor.williams@noaa.gov).