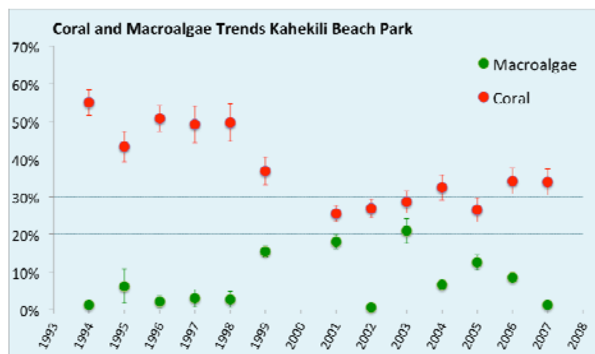
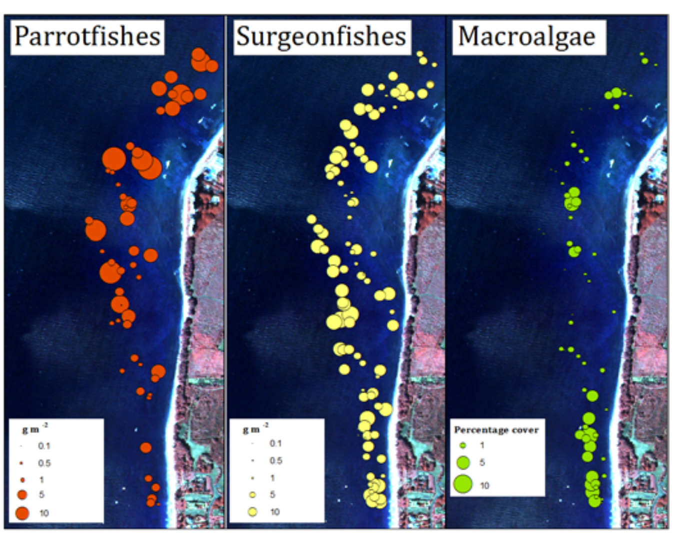
Kahekili Herbivore Fishery Management Area—Interim Monitoring Results

Background. In response to concerns about the long-term decline of local coral reefs, the state of Hawaii created the Kahekili Herbivore Fishery Management Area (KHFMA) along an approximately 2-mile stretch of coastline in Ka'anapali, West Maui (see picture right). The KHFMA, which was established in July 2009, involves a form of management that is unique within Hawaii, namely protection of coral reef herbivores (i.e., surgeonfishes, parrotfishes, chubs, and sea urchins), which may not be killed, injured, or harvested within the FMA boundaries. The goal of the KHFMA is to restore natural grazing processes and ultimately, therefore, to increase the local reef's ability to resist and recover from excessive algal growth that is detrimental to corals. The KHFMA does not in any way restrict fishing of other types of finfish or invertebrates. To further promote grazing by local fish stocks, feeding of fishes, other than for legal fishing, is also banned within the KHFMA.

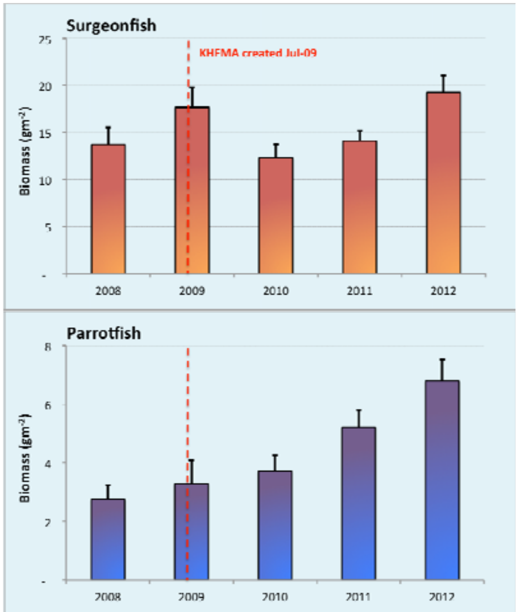
In the years immediately leading up to the creation of the KHFMA, summertime blooms of the invasive red alga *Acanthophora spicifera*, had become regular occurrences on the Kahekili reef (see pictures below). Large-scale seasonal blooms of other algal species, such as the green alga *Cladophora sericea*, had also been documented in preceding years, including in 1999 and 2001, and apparently also at other times since at least the mid-1980s. Of particular concern was the decline in coral cover evident in long-term monitoring data from transects in front of Kahekili Beach Park: from ~55% in 1994, when monitoring began, to ~30% in the years prior to the establishment of the KHFMA. The decline in coral cover coincided with the period beginning in 1999 during which summertime macroalgal blooms were commonly observed (see figure below). Although the causes and consequences of those algal blooms are complex, it is reasonable to expect that protection of reef herbivores can reduce the severity and frequency of algal blooms and, therefore, can help to check and potentially reverse the downward trend in condition of Kahekili reefs.



Pictures show examples of algal blooms at Kahekili in (left) 2005 and (right) 2001. Photos R. Sparks, J. Smith Figure at right shows trends in coral and macroalgal cover prior to creation of the KHFMA. Note that decline in coral cover coincides with the period in which summer algal blooms were regular occurrences.



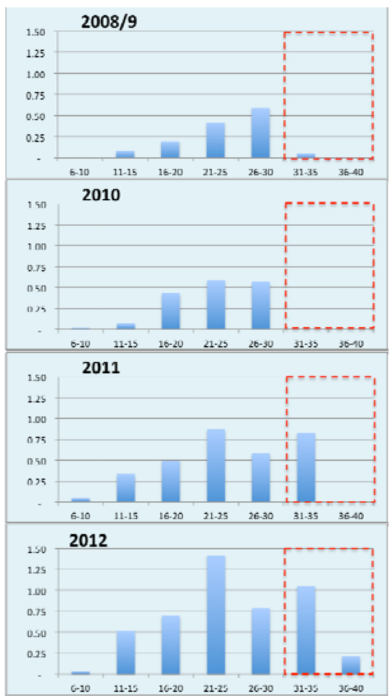
Coral reef monitoring within the KHFMA. Because it is highly desirable to have baseline data before a management action is implemented, the Hawai'i DAR (HDAR) in partnership with the University of Hawai'i began a comprehensive monitoring program at Kahekili in January 2008. That program has been maintained using consistent methods and survey design, but it has been implemented by HDAR and NOAA Pacific Islands Fisheries Science Center personnel since 2010. Monitoring involves 1–2 "rounds" per year, generally spring and late summer, with each round comprising co-located surveys of fishes, urchins, and benthos (e.g., corals and algae) at~80–100 haphazardly located sites. The figure to the left shows data from April 2012: each bubble represents a survey site, and size of bubble corresponds to either biomass or cover (%).



Interim monitoring results. Monitoring data were gathered between January 2008 and September 2012, i.e., up to ~3 years after creation of the KHFMA. It is important to note that long-term studies of coral reef closures have tended to show that full recovery of most groups can take many years. Surgeonfishes appear to have particularly long trajectories of recovery, possibly related to their longevity. Because some surgeonfishes can live for > 40 years, pristine stocks include biomass accumulated over multiple decades. Parrotfishes, which have shorter lifespans, seem to reach peak biomass sooner, but, even then, it may take a decade or more. Here are the main monitoring results to date:

- No clear overall trend in biomass of surgeonfishes (<- upper figure)
- Consistent upward trend in biomass of parrotfishes (<- lower figure), which more than doubled between 2009 and 2012 (3.3 ± 0.8 gm^{-2} [mean ± SE] to 6.8 ± 0.7 gm^{-2}).
- Increases in parrotfish biomass have not been distributed evenly across the KHFMA, and, in particular, there has been little or no recovery of parrotfish biomass in the shallow, nearshore reef areas adjacent to Kahekili Beach Park.

Bullethead Parrotfish (*Chlorurus spilurus*) initial phase (upper photo) and terminal phase (lower photo). Photos J.E. Randall. Figure to the right shows steady increase in contibution of large individuals to total species biomass.



Bullethead Parrotfish size trends. The number of large indivduals of this species, which is the most abundant parrotfish recorded during monitoring surveys, has steadily increased since the KHFMA was established. Its max size is ~40 cm, but in 2008–09, fishes > 30 cm were rarely recorded. By 2011 and particularly 2012, large individuals (≥30–35 cm) have become relatively common (see fig <-). This pattern is consistent with a protection effect, i.e., reduced mortality rates that mean that more fishes are reaching older and larger life stages. Recovery of large parrotfishes is potentially significant ecologically, too, as the deep excavating bites made by those large fishes are believed to be especially important in promotion of the conditions that allow corals to thrive.

Looking ahead. The mechanisms by which protection of herbivores could increase reef resilience and coral recovery involve (i) promotion of benign algal forms that tend to dominate in heavily grazed environments (e.g., crustose coralline algae [CCA], which are important for coral settlement), and (ii) reduction of algae that can overgrow, smother, or otherwise negatively affect corals (generally upright macroalgae and dense turfs). As described above, full effects of the KHFMA on fishes and on relatively slow-growing corals will only become evident over a period much longer than three years. However, there are already indications that sustained increases in parrotfish biomass will lead to increased CCA cover. Specifically, survey results show a strong positive relationship between total parrotfish biomass and total CCA cover (see fig ->; each point represents average parrotfish biomass and CCA cover in one survey round).