

RESILIENCE BASED MANAGEMENT CASE STUDY

Kahekili Herbivore Fisheries Management Area

West Maui, Hawai'i

An area based management tool protecting herbivores to enhance reef resilience.

The Issue

The coral reef ecosystems at Kahekili in West Maui have experienced a persistent decline in coral cover over recent decades, marked by repeated ephemeral macroalgae blooms since the late 1980's. These algal blooms are thought to be linked to land-based nutrient pollution originating from various sources including landscaping, agriculture, and a wastewater reclamation facility. The overexploitation of key reef herbivores such as parrotfish and surgeonfish, popular target species for fishers in Hawai'i, exacerbates the proliferation of algae.

In addition to local stressors, the reefs at Kahekili have been affected by bleaching events associated with warming oceans. The competitive relationship between algae and coral for space becomes particularly pronounced following disturbances such as bleaching events and cyclones. Algae is faster growing than coral, however in a healthy reef environment herbivorous grazers keep the algae growth in check, allowing time and space for coral recruitment and growth.¹ In heavily grazed areas algae types that facilitate coral recruitment (crustose coralline algae (CCA) and sparse turfs) tend to dominate.² But when the diverse group of fish and invertebrates that graze on algae are overfished, larger macroalgae overgrow the coral preventing recruitment and causing adult coral death.

Actions Taken

In response to declining coral cover and recurring macroalgal blooms, the State of Hawai'i established the Kahekili Herbivore Fisheries Management Area (KHFMA) in 2009 along a 3km stretch of coastline. Within the KHFMA the take of herbivorous reef grazers is prohibited:

- Surgeonfishes (*Acanthuridae*)
- Parrotfishes (*Labridae*, tribe: *Scarinae*)

How the Programme Addresses Resilience Based Management?



Figure 1: The Kahekili Herbivore Fisheries Management Area contributes to the community, governance and ecosystem components of resilience based management.

By enabling herbivore populations to recover, excessive algal growth is reduced, allowing corals a better chance of recovering from disturbance events, and improving resilience. Through targeted compliance, education and stewardship actions, the KHFMA protects ecosystem resilience and promotes behaviour change. The KHFMA utilises area-based management to reduce local fishing impacts and protect diversity of species and habitats. It is an innovative approach to reef rehabilitation that is supported by strengthened legal and policy frameworks. Through collaboration with the West Maui Ridge to Reef Initiative that employs pollution management and erosion control strategies, the KHFMA contributes to an integrated management approach to reef resilience.

- Chub (*Kyphosidae*)
- Sea urchins (*Echinoidea*).

However, fishing for non-herbivorous species is still allowed. Fish feeding within the KHfMA is also prohibited to help promote grazing. The KHfMA was implemented with the aim to prevent excessive algae growth from competing with corals by restoring natural grazing processes. Surveys were conducted at KHfMA and comparison sites around Maui, starting 19 months prior to reserve establishment and continued until present.

To address the nutrient pollution, the West Maui Region (including KHfMA catchment) became a 'priority site' for the state coral management program in 2010. The West Maui Ridge to Reef Initiative facilitates collaborative watershed planning and restoration among local partners.

How Successful Has It Been?

KHfMA has successfully increased herbivore biomass to a level sufficient to shift the benthic habitat to a state of low macroalgae cover and increased CCA, substantially improving the conditions for coral growth and reproduction.

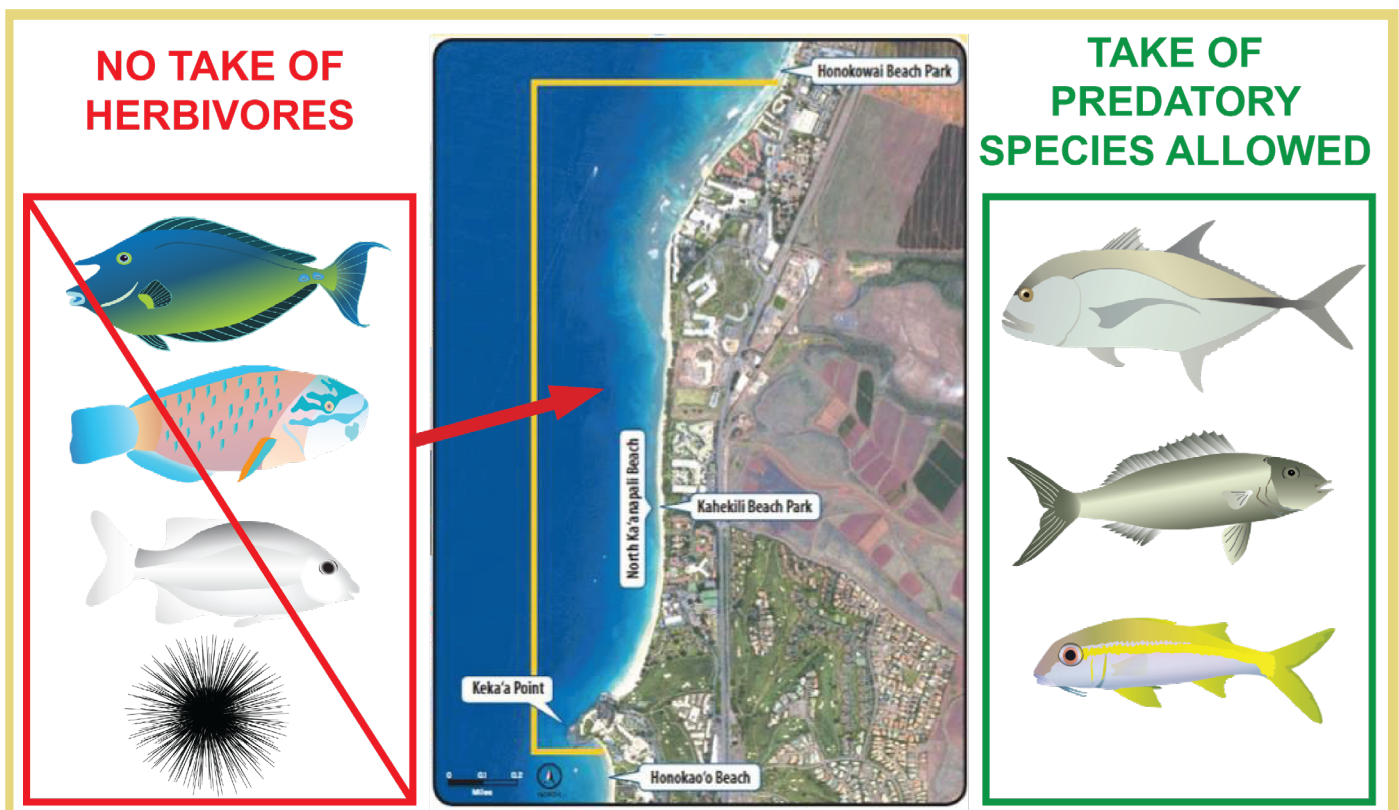


Figure 2. Map of Kahekili Herbivore Fisheries Management Area. Herbivorous fish and invertebrate illustrations from C. Thurber, J. Woerner, T. Saxby & J. Hawkey, Integration and Application Network (ian.umces.edu/media-library)



When herbivores are abundant, dominant algae are often cropped turf and crustose coralline algae



When there are few herbivores, dense or upright seaweed develops, that can overgrow, stress or kill coral.

Herbivore fish abundance and biomass, particularly parrotfish, responded to protection faster than anticipated. Within five years parrotfish populations had substantially increased, with concurrent increases in CCA and reductions in heavy turf and macroalgae.³

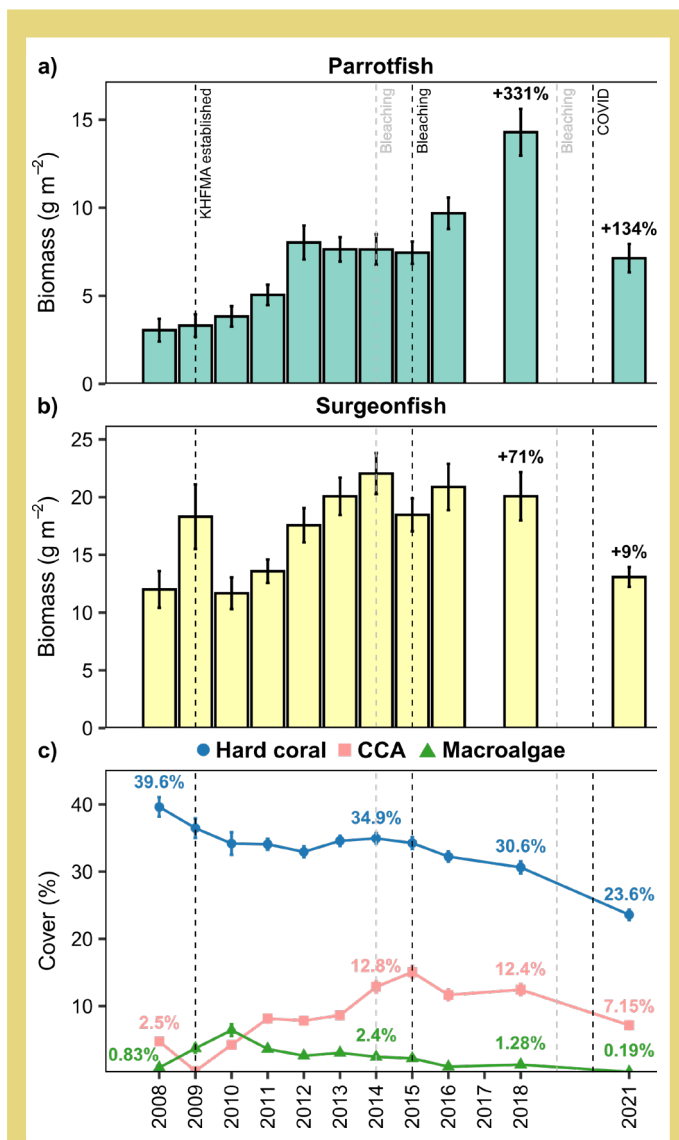


Figure 3: a & b) Trends in herbivorous fish biomass in the KHFMA since 2008 c) Trends in benthic composition in the KHFMA since 2008. Dashed lines indicate the timing of key events, KHFMA establishment, bleaching and the Covid-19 pandemic. From Kindiger T (2023) PIFSC IR⁵

There is evidence that the reserves establishment has halted the decline in coral cover, though the two bleaching events that have occurred since reserve establishment have complicated the use of coral cover as a success measurement.

Despite promising initial increases in herbivore biomass, particularly the parrotfish family, the reserve has not been established long enough for full recovery. It can take decades for reef fishes to recover post reserve establishment, and surgeonfish are often among the slowest to recover.⁴

Due to the relatively slow growth of corals and time required for recruitment, coral recovery will inevitably lag behind recovery of fish populations. Though the rapid changes observed in parrotfish biomass and benthic algae composition are already contributing to enhanced reef resilience.

Poaching within the KHFMA has inhibited full recovery of herbivore levels. Despite increases in overall herbivore biomass, there was no change in some of the larger bodied target species. Post Covid – 19, parrotfish and surgeonfish biomass has declined to levels lower than in 2018, likely due to poaching. Associated with the recent reductions in herbivore biomass, CCA and coral cover have also declined, highlighting the close link between herbivory and reef resilience.

Key Challenges and Lessons Learnt

Herbivore fish populations can respond to protection much faster than initially expected, with immediate improvement in macroalgae and CCA cover.

The recent reductions in parrotfish biomass, thought to be linked to poaching, have reversed increases in CCA that had previously been observed, highlighting the importance of continual investment in compliance and education. On a small reef such as Kahekili, it only takes a few poaching events to reverse the gains in herbivore biomass accrued over many years of no take. This has taught the following lessons:

- Both long-term and high-compliance closure will be necessary for complete recovery of herbivory inside the KHFMA
- Education aimed at promoting the successes of the KHFMA and building the communities understanding of the reasoning and benefits for protecting herbivores is a crucial part of successful protection. The more community support for the reserve, the more compliance, the better the ecosystem resilience gains of the reserve will be.
- If through education you can change community acceptance of illegal fishing and increase shame on those who decide to break the rules for their short-term gains at the expense of the community, you can improve compliance.

- Ideally herbivore protection areas would be larger – if the areas are larger, the gains will be bigger, and poaching events will have less of an overall impact on herbivore biomass.

Given the relatively slow growth of corals and need for successful recruitment events it will likely be decades before the impacts of herbivore protection are fully evident. Future survey programs aiming to measure the effectiveness of herbivore management should keep in mind these long timelines when allocating resources and incorporate process studies such as coral recruitment, growth and mortality into monitoring programs to enable early detection of positive impacts.

Lead Organisation

Hawaii Department of Land and Natural Resources, Division of Aquatic Resources

Partners

NOAA National Marine Fisheries Service, NOAA Pacific Islands Fisheries Science Center Coral Reef Ecosystem Division

West Maui Ridge to Reef Initiative

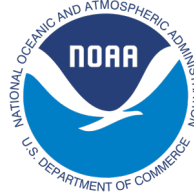


Photo Credit: Hawai'i DLNR, Division of Aquatic Resources

References

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- 2 Rasher DB, Engel S, Bonito V, Fraser GJ, Montoya JP, Hay ME (2012) Effects of herbivory, nutrients, and reef protection on algal proliferation and coral growth on a tropical reef. *Oecologia* 169: 187–198
- 3 Williams ID, White DJ, Sparks RT, Lino KC, Zamzow JP, Kelly ELA, et al. (2016) Responses of Herbivorous Fishes and Benthos to 6 Years of Protection at the Kahekili Herbivore Fisheries Management Area, Maui. *PLoS ONE* 11(7)
- 4 McClanahan TR (2014) Recovery of functional groups and trophic relationships in tropical fisheries closures. *Mar Ecol Prog Ser* 497: 13–23
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