Reef Fish Stocks and Fishing Impacts in the Hawaiian Islands

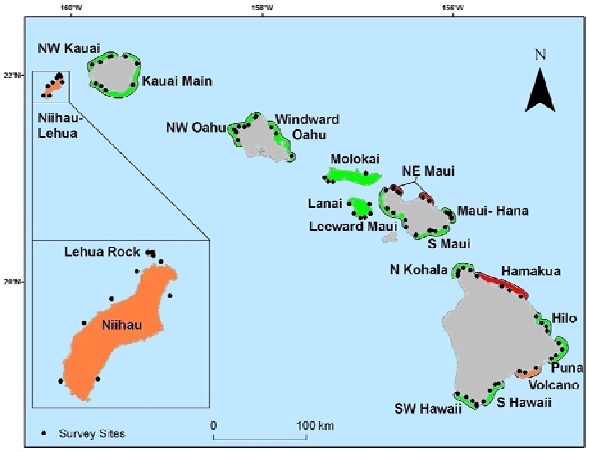
During 2005-6, staff of NOAA and DLNR-DAR participated in survey cruises to assess the status of coral reef ecosystems across the Main Hawaiian Islands (MHI). Survey sites were widely distributed throughout the MHI and included not only accessible and heavily populated places such as windward Oahu, but also remote and less developed places such as Niihau. The resulting data allows us to draw conclusions about the status of reef fish stocks in the MHI and to assess some of the factors driving differences among study locations.

Survey Sites and Study Locations

Across the MHI, 89 comparable coral reef sites were surveyed in 2005-6 (hard-bottom habitats 8 to 18 m deep). At each site, divers recorded coral and seaweed cover and counted fishes in replicate transects using the same methods throughout.

The 89 survey sites were grouped into 18 locations (see →), with each locations being either an island (e.g. Lanai, Molokai) or, where there were enough replicate sites to sub-divide further, a part of an island with broadly similar exposure, human population density and shoreline structure. For example, Maui sites were grouped into 4 locations: 'Leeward Maui' (leeward coastline with high human population density), 'South Maui' (exposed reefs with low human population density), 'NE Maui' (exposed rocky reefs with high shoreline cliffs), and 'Maui-Hana' (moderate to low human population density on SE of Maui island).

Human population density (the number of people living within 15 km of survey sites) varied between 39 at the Volcano region of the Big Island and 94 in Niihau, to 45,251 at Hilo and 66,504 in Windward Oahu. Therefore, the most populated regions had around one thousand times as many people as the least populated.



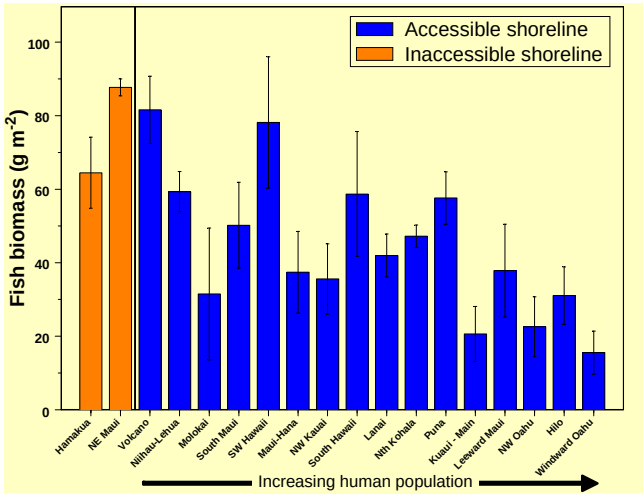
2005-6 Survey sites and study locations. Locations in red are where lack of road access and high cliffs means that shorelines were relatively 'inaccessible'. Locations in orange had very low human population density.

Relationships between fish stocks and human population density

There were large differences in fish assemblages among the MHI study locations. Biomass at locations with most fish (Volcano, NE Maui, South Big Island, all of which had ~80 gm^{-2}) was approximately 4-5 times that at the locations with least fish (the Oahu locations and Kauai, where biomass was between 16 and 20 gm^{-2}).

Among locations with accessible shorelines, fish biomass dramatically declined as local human population increased (see →). While that is strong evidence that humans adversely impact reef fish populations, it is important to note that people can and do impact reef fishes in multiple ways. Humans affect fishes directly by fishing, but also indirectly by damaging habitat or environmental quality (e.g. through pollution, sedimentation, or physical destruction of nearshore habitat). Better understanding of the relative importance of those different types of factors was one goal of this study.

One indication that fishing may be particularly important was that locations with inaccessible shorelines (Hamakua and NE Maui) had above average human population density, but also had among the healthiest fish stocks of all study locations (see →). That indicates that reef fishes can be abundant near moderate to large human populations (and the urbanization and shoreline development that comes with that), if it is difficult to access and therefore fish nearshore waters.



Fish biomass at MHI study locations. Locations ordered by human population density

Assessing the importance of fishing impacts by comparing trends among heavily–targeted and less desired fishes

Although a wide variety of coral reef fishes are taken by fishers, some species are much more heavily targeted than others, and some species, even if not prime fishery targets are particularly vulnerable to fishing impacts (large-bodied and slow growing species generally being most susceptible, especially if they are not naturally abundant species). Therefore, if fishing is the principal factor in fish biomass declines along human population gradients, human impacts should be most evident among the heavily targeted and vulnerable groups, whereas lightly targeted groups should be much less affected.

In contrast, because both target and non-target fishes are dependent on good habitat and environment quality, if biomass declines are symptomatic of habitat or environmental degradation at the more populated and developed areas, the impacts on fish communities should affect both heavily- and less-targeted species.

Fishery-target species include most surgeonfish, red fish (soldiers and bigeyes), goatfish, jacks and other large predators, large parrotfish, and large wrasse.

Non-target & lightly-targeted fishes include small wrasses, the brown surgeonfish, most hawkfish, benthic triggerfish, butterflyfish, and damselfish.

An expanded version of the information presented here is available in '*Assessing the importance of fishing impacts on Hawaiian coral reef fish assemblages along regional-scale human population gradients*', published in the journal Environmental Conservation [Vol. 35:261-271, 2008]. Copies of that article are available on request from ivor@hawaii.edu or darkona@hawaiiantel.net.

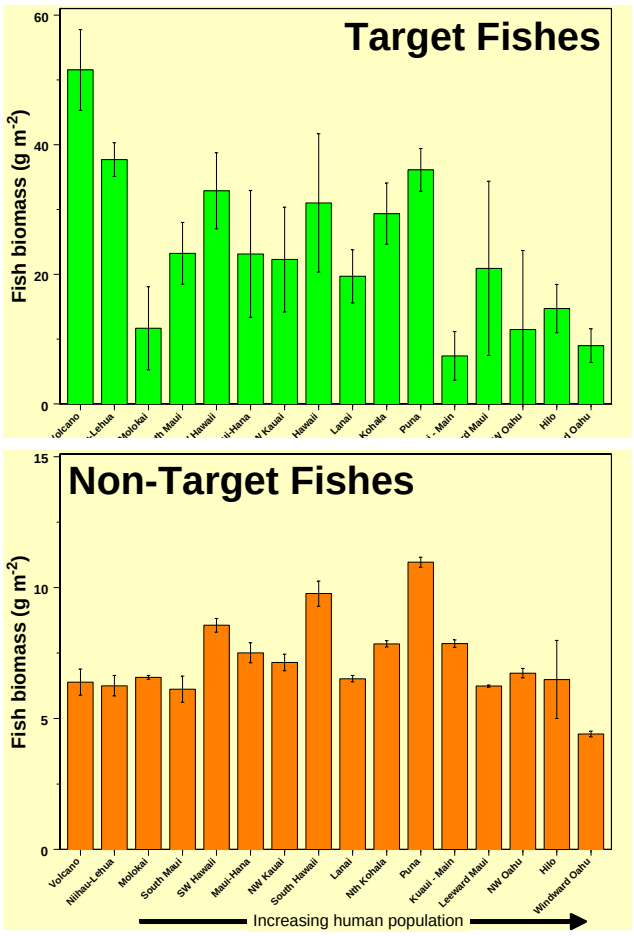
Human Impacts on Target and Non-Target Groups

Target and non-target fishes responded very differently to increasing human population density.

- Biomass of target fishes declined as local human population increased (see →). Downward biomass trends were clearest for large parrotfishes, red fishes (soldierfishes, bigeyes and large squirrelfishes), and apex predators (jacks, jobfish). Weakest effects were for large wrasses but even for those, highest biomass was at the two most remote locations (Volcano and Niihau) and lowest biomass was at heavily populated locations in Oahu.
- In contrast, there was no clear relationships between human population density and total non-target fish biomass (see →), or for any of the lightly-fished groups considered (e.g. small wrasse, hawkfishes, benthic triggerfishes, benthic damselfishes, butterflyfishes).

It seems unlikely that habitat or other environmental degradation would selectively and consistently affect target groups but have no evident effect on non-target groups across the same set of survey locations. Therefore, the real and substantial declines in target fish biomass along human population gradients must have been driven by some factor specific to targeted species - most likely increased fishing pressure as human population density increases.

It is important to recognize some limitations of this study and analysis. In particular, these results shouldn't be interpreted as evidence that onshore development and land alteration have had no impact on coral reef habitat or environmental quality in Hawaii. It is very possible, in fact seems self-evident, that habitat and environmental degradation has contributed to reef fish decline in some of the most populated and developed parts of the state such as south Oahu and parts of West Maui. However, most of the locations surveyed for this study had population densities that were 1/20th or less of that at Oahu and West Maui. It may be the case that severe habitat and environmental impacts are largely restricted to locations at the extreme end of the human population scale in Hawaii, and therefore that habitat and environmental impacts were too localized to be detected by this kind of region-wide analysis. Therefore, over the state as a whole, it seems likely that fishing is the prime driver of declining fish biomass as human population density increases, and that the impacts of habitat and other environmental degradation at heavily populated places will be additional stressors on top of the already significant impacts of intensive fishing there.



Trends in biomass of target and non-target species along human population gradients at locations with accessible shorelines.

Status of Oahu Reef Fish Populations

Oahu constitutes <10 % of the landmass of the MHI, but has > 70% of the population of the state. It is therefore inevitable that human development pressures on the nearshore environments are likely to be greatest around Oahu, but nevertheless, the differences in reef fish biomass between Oahu reefs and the healthier reefs in some other parts of the state was dramatic. In comparison to the remote and inaccessible reefs of Volcano, Niihau, NE Maui, and Hamakua, Oahu reefs had around 1/30th the biomass of large parrotfishes, 1/3rd the biomass of surgeonfishes, 1/10th the biomass of apex predators; and around 1/6th the biomass of goatfishes. The dearth of large parrotfishes is particularly troubling as those are believed to play a key role in preventing reefs from becoming overgrown by seaweeds. In fact, the severe depletion of large parrotfish on shallow Oahu reefs may be a large part of the reason why invasive seaweeds have taken over so many Oahu reefs in recent years. In addition, biomass of large individuals of target species, which are likely to be key breeding fishes, on Oahu reefs was only 2% of that at the remote and inaccessible reefs.

Conclusions

The partnership between NOAA and DLNR-DAR enabled the largest-scale assessment of MHI reef fish stocks to date. The resulting data provides clear evidence that target fishes are depleted around accessible and populated parts of the state, and strongly indicate that fishing is the main driver of reef fish declines at most parts of the state. Because the study assessed large-scale patterns in reef fish populations across the MHI, the results will tend to under-represent significant but localized human impacts on habitat and environmental condition, which are likely to be important at heavily urbanized places. Preventing severe habitat degradation from occurring remains vital because once habitats are substantially degraded, recovery is likely to be slow and difficult. In contrast, if fish populations are depleted but habitat quality is still good, relatively rapid recovery is possible if fishing pressure can be reduced sufficiently. Finally, although Oahu reef fish populations are severely depleted, there are also large relatively remote and inaccessible places in the MHI where fish stocks remain in good condition and where prime target fishes are still commonly encountered.

For more information or for a copy of the published study please contact Hawaii DAR Kona Office, at (808) 327 6226 [email: darkona@hawaiiantel.net].