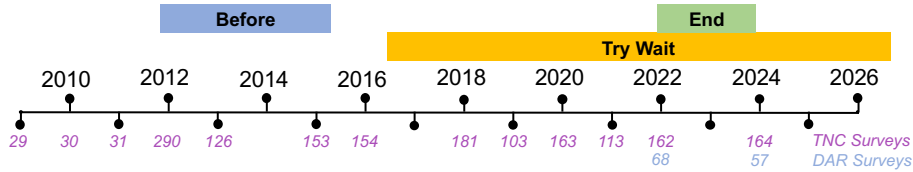


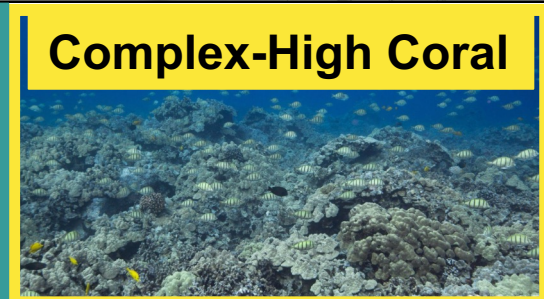
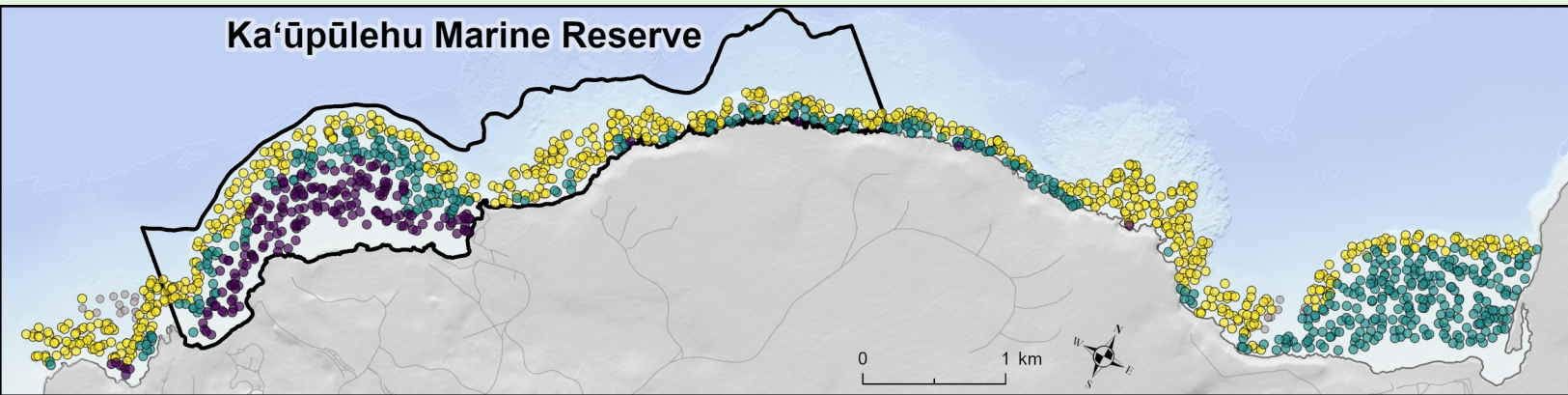
Measuring and comparing change in resource fishes within the 10-year Try Wait area

Co-produced results were based on 1622 underwater surveys



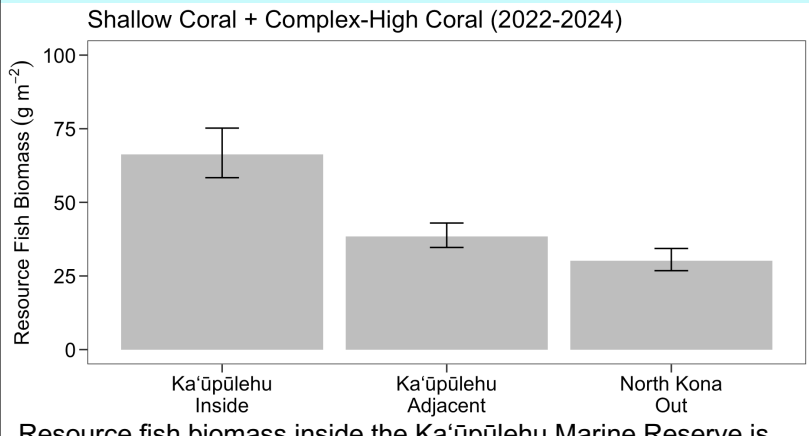
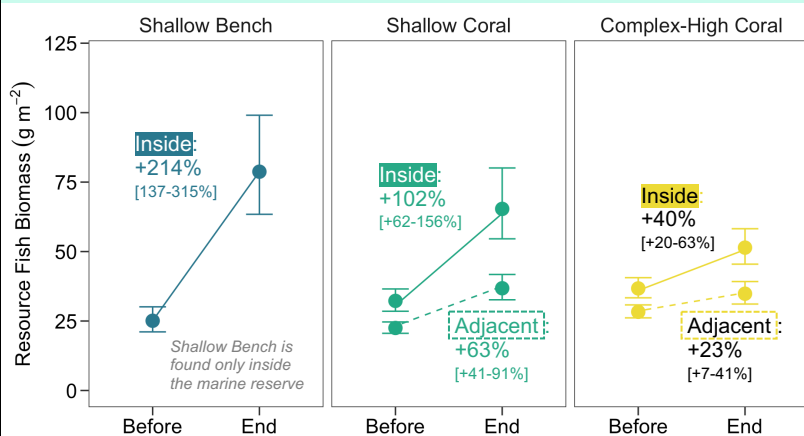
An innovative approach to co-production between community stewards, agency biologists, and academic and non-profit partners used 17 years of underwater reef surveys to understand patterns and trends of resource fish biomass (fisheries species of Ka'upulehu). 1497 underwater surveys have been conducted by TNC in Ka'upulehu since 2009, with 125 additional surveys by DAR in the North Kona moku outside the reserve between 2022-2024. Sample sizes are in timeline above and survey points are mapped below by habitat type.

Reefs across Ka'upulehu, Kūki'o, and adjacent areas include 3 major habitats, based on quantitative assessment of depth, complexity, and coral cover



Resource biomass increased inside and in adjacent areas for all 3 habitats. Change was greater inside for Shallow Coral

Recent resource biomass inside Ka'upulehu Marine Reserve is greater than surrounding reefs of North Kona



Resource fish biomass increased by 19 g m⁻² [80% CI: 6-34 g m⁻²] more inside the reserve than in adjacent areas for Shallow Coral. Values listed on the graph are estimated mean change in biomass (points) with 80% credible intervals (brackets and vertical lines).

Resource fish biomass inside the Ka'upulehu Marine Reserve is 118% higher [80% CI: 83-163%] than reefs across other areas of the North Kona moku, and 42% [80% CI: 31-51%] higher than reefs adjacent to the reserve of similar habitats. Vertical lines are 80% credible intervals.

Methods: Co-producing research

There are a number of open conversations around how data are incorporated in community-based management process in Hawai'i and elsewhere that include challenges such as how to create pathways for including multiple ways of knowing, and data sovereignty and sharing. Likewise, when, how, and who reports on the data and how this dynamic permeates management processes is unclear, as is who stands behind the conclusions, and how other groups perceive how conclusions were reached. To try and overcome these challenges, the following methods were employed to co-produce this research:

Build trust

Community stewards, state agency, and NGO and academic partners came together in person over 10+ sessions, all data stayed in the room

Shared questions

Everyone's ideas were shared and heard, and common questions/goals were found

Transparent data quality evaluation

Shared understanding of data limitations, filters, and quality corrections were cogenerated and agreed upon

Co-develop data analysis & interpretation

Data were analyzed live in real time and discovery and interpretation was shared by all 4 groups

Methods: Underwater Surveys

SCUBA divers trained in scientific diving conducted transect-based surveys of reefs in Ka'ūpūlehu from 2009 to 2024 with TNC, and across the North Kona moku from 2022-2024 with DAR using similar methods. One or two divers observed all conspicuous reef fish species on a 25x5 meter belt transect and recorded the species and total length. Another diver followed the fish observer and took photos of the benthos at regular intervals along the transect that were later analyzed to quantify percent cover of coral and other benthic groups. All data were checked for quality and errors following established protocols by the Hawai'i Monitoring and Reporting Collaborative. These methods are standard and widely accepted methods used throughout Hawai'i and worldwide as a reliable methodology for assessing reef fish assemblages.



Methods: Choosing an indicator of management effectiveness

Resource fish biomass was identified as an appropriate metric for evaluating the effectiveness of the temporary closure of fishing in the reserve. Resource fish biomass is an estimate of the overall weight of fish per a given area that is comprised of species that are important to the fishery. Resource species were identified by comparing available sources of fisheries dependent data (e.g., creel surveys), with the greatest emphasis given to a creel survey conducted prior to the closure in 2013. In total, 77 species were included.

Methods: Identifying Habitat Types

Each of the 1494 underwater surveys across all years were assigned a value of depth, habitat complexity, and coral cover based on a dataset that is available for the entire West Hawai'i coastline from remotely sensed data and other sources (see Donovan et al. 2023 *Proc B*). All three metrics were considered together in a statistical model (model-based multivariate clustering) that identifies groupings in the data. This method revealed 4 distinct habitat types, with one being relatively less frequent. Subsequent analyses focused on the 3 more dominant habitat types that were named based on their dominant features:

Shallow Bench: shallow (5-18 ft), lower coral cover (26-42%), mid complexity

Shallow Coral: shallow (5-20 ft), moderate coral cover (33-44%), mid complexity

Complex High Coral: all depths (5-65 ft), high coral cover (35-65%), very high complexity

Methods: Evaluating effectiveness of temporary fisheries closure

A 'Before-After-Control-Impact' analysis framework was applied that follows best practice for conservation impact assessment. Data from 2012-2015 was categorized as 'Before' and data from 2022-2024 was categorized as 'End' and was used analogous as 'After' in the impact assessment methodology. The 'Impact' was the temporary closure of the fishery so included the data from inside the reserve, and the 'Control' was the data adjacent to the reserve where it is assumed the adjacent area was subject to the same environmental variation as the reserve. The assessment was conducted as a Bayesian Gamma linear model with resource fish biomass as a response variable and the predictors before-after, control-impact, and their interaction. Flat priors were used and models were run with 3 chains and 4,500 post-warmup samples of the posterior distribution. All models were checked for convergence and assumptions, including posterior predictive checks. Posterior distributions were summarized for plotting with non overlapping 80% intervals used to evaluate evidence for an effect. Relative percent change in biomass between the reserve and adjacent areas were calculated across the entire posterior and then summarized to find the mean and 80% credible interval.

Methods: Comparing recent biomass to adjacent areas

To evaluate how resource fish biomass at the end of the temporary closure compared to the broader North Kona moku, additional surveys conducted by DAR using similar methods were included. Depth, habitat complexity, and coral cover from the remotely sensed data sources were attributed to the DAR survey sites and the habitat type was predicted from the earlier habitat clustering model. Data were then subset to include similar habitats found both inside and outside the reserve. A Bayesian Gamma linear model with resource fish biomass as a response variable and a predictor with three levels: inside the reserve, adjacent areas, and surveys from the remainder of North Kona. Model fitting and checking was the same as the impact assessment, and again non-overlapping 80% intervals of the posterior were used to evaluate evidence of higher biomass within the reserve.