Informing management action in the West Hawai'i Habitat Focus Area based on resilience to climate change

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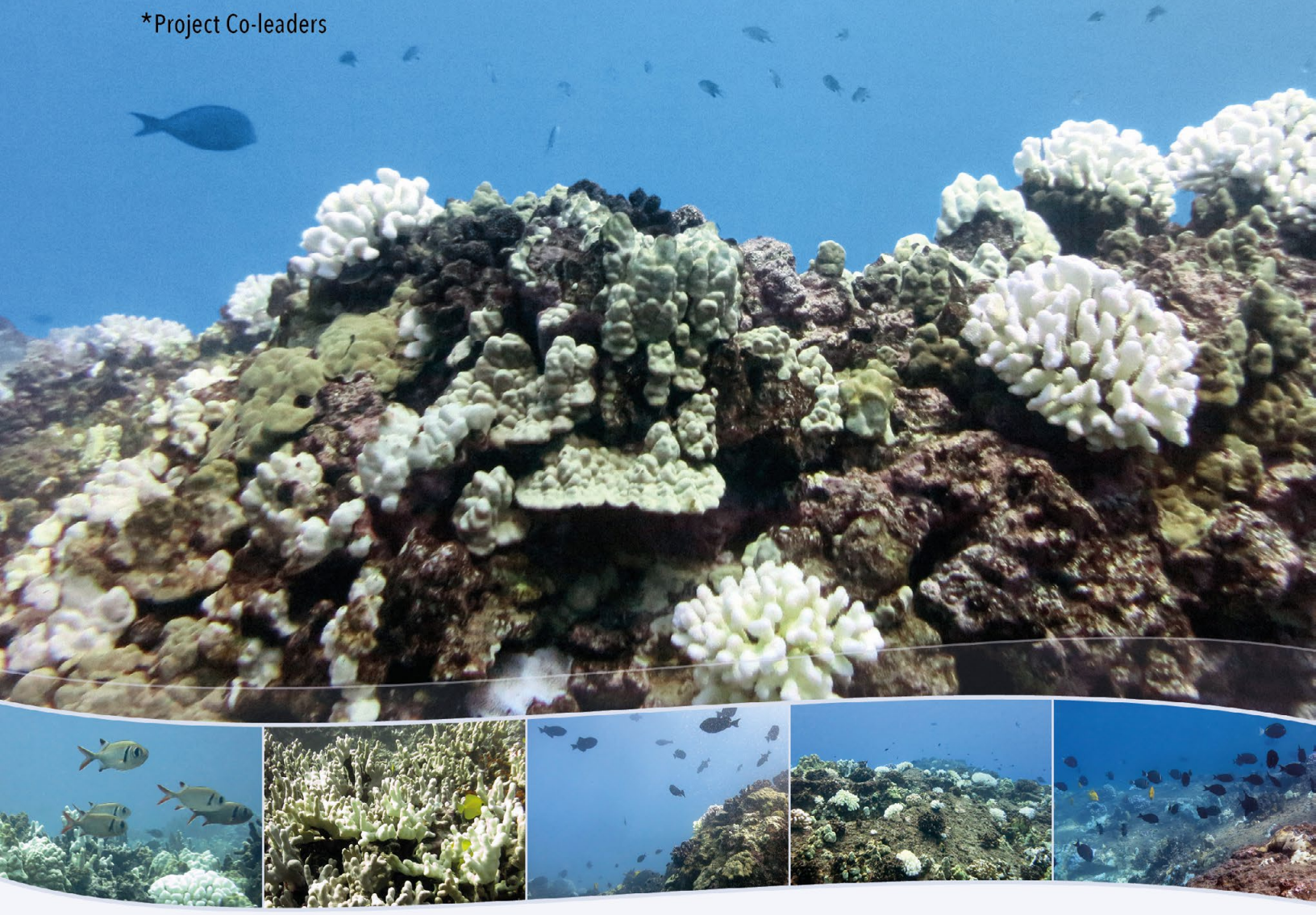
*Project Co-leaders



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National Marine Sanctuaries

NOAA Coral Reef Conservation Program

The Nature Conservancy

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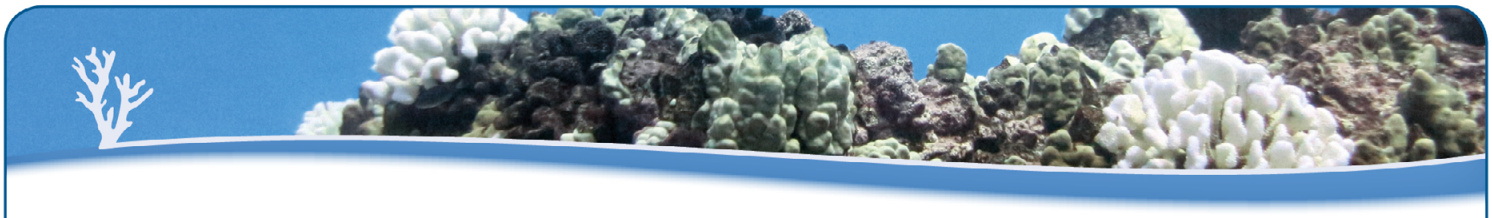

Project Summary

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Introduction - The NOAA Coral Reef Conservation Program (CRCP), NOAA Habitat Blueprint, and Sentinel Site Program have an overlapping Focus Area on the west side of the Island of Hawai'i that includes the South Kohala coastline (Figure 1). The Habitat Blueprint and Sentinel Sites focus areas have merged into a single effort. In addition, the NOAA Hawaiian Islands Humpback Whale National Marine Sanctuary and the West Hawai'i Integrated Ecosystem Assessment Program both support and are supported by the focus area initiative. Nearly a quarter of the coral and fish species in Hawai'i are endemic (i.e., can only be found in the Hawaiian Islands) and South Kohala contains one of the longest contiguous coral reefs in the state. Coral reefs are of critical importance to the communities and environment of West Hawai'i, and supporting the resilience of reefs is a goal within many management plans in the area.

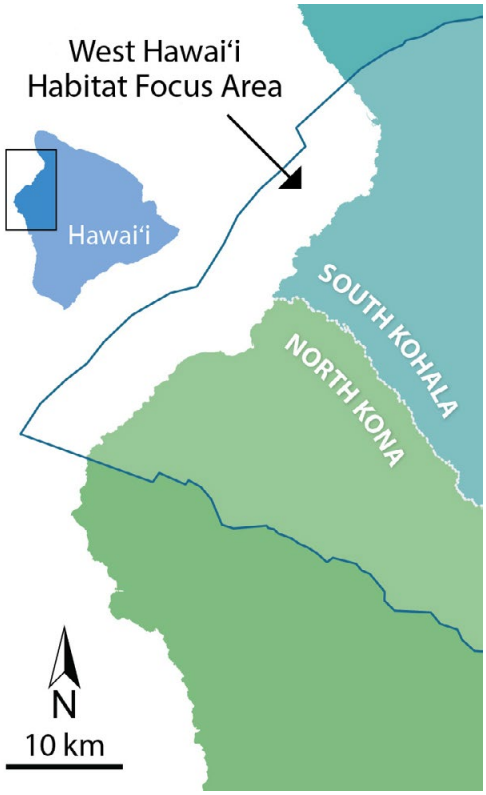
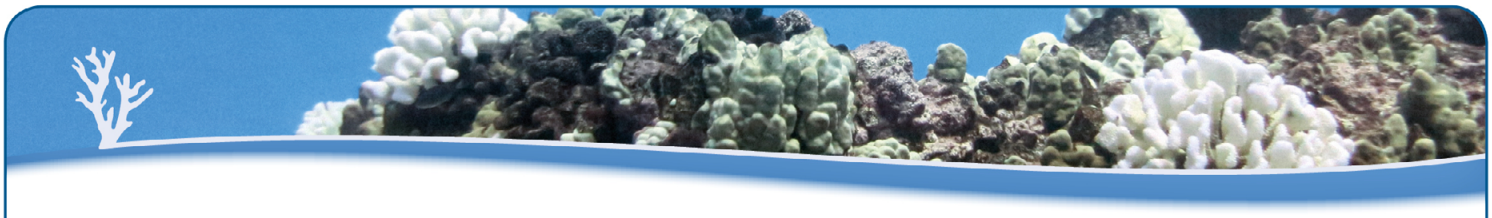


Figure 1. Location of West Hawai'i Habitat Focus Area along the West Hawai'i coastline.

Coral reef resilience is the capacity of a reef to resist or recover from degradation and maintain provision of ecosystem goods and services. Resilience-based management of coral reefs can include understanding location specific resilience potential and then targeting and tailoring appropriate actions to preserve or restore resilience. The assessments involve measuring or assessing resilience indicators (e.g., coral disease, coral recruitment and herbivorous fish biomass) and producing an aggregate score that identifies resilience potential for all sites as relative to the site with the highest (assessed) resilience.

Our project team assessed the relative resilience of reef sites at two depths along priority areas of South Kohala and North Kona in October of 2015. The surveys were conducted as a collaborative effort with the Hawai'i Division of Aquatic Resources (DAR), The Nature Conservancy, NOAA Coral Reef Ecosystem Program, and community organizations. While conducting the resilience surveys, the project team also assessed coral bleaching prevalence and severity as well as coral disease prevalence. By October 2015, NOAA Coral Reef Watch confirmed that West Hawai'i experienced greater thermal stress than anywhere else in the Hawaiian Archipelago that year. Our team returned in October 2016 to assess recovery from the bleaching. Our team then held meetings with stakeholders and community members through 2017 to discuss suggested potential management actions that would support the resilience of coral reefs in the Focus Area. This project summary presents the highlights of our research and work during each of the three project years.

Objectives - Study objectives included: 1) Assess the percentage of corals affected by bleaching and severe (>50% of colony) bleaching and by coral diseases in 2015; 2) Assess the percentage cover of major benthic



including corals, macroalgae, coralline algae, and other (i.e., turf algae and unconsolidated substrate) in 2015; 3) Assess the relative resilience of coral reefs at two depths and compare resilience potential among survey sites, 4) Determine the primary drivers of differences in resilience potential between sites (3 and 4, based on 2015 survey data), 5) assess recovery from bleaching in 2016 at all sites initially surveyed in 2015, and 6) develop suggestions for potential management actions based on coral reef resilience to climate change.

Methods - Field surveys were conducted at 20 reef areas, which included surveys of both shallow (5-7 m) and deep (12-15 m) sites. Eighteen of these sites are in the Habitat Focus Area and two are south. Surveys were conducted October 13-23, 2015. Survey methods included belt transects, quadrats and photo-quadrats, and are standard methods used by this team and other researchers to survey coral reefs in Hawai‘i and the Pacific. The resilience indicators included coral cover, coral recruitment, coral diversity, bleaching resistance, macroalgae cover, rugosity and herbivorous fish biomass.

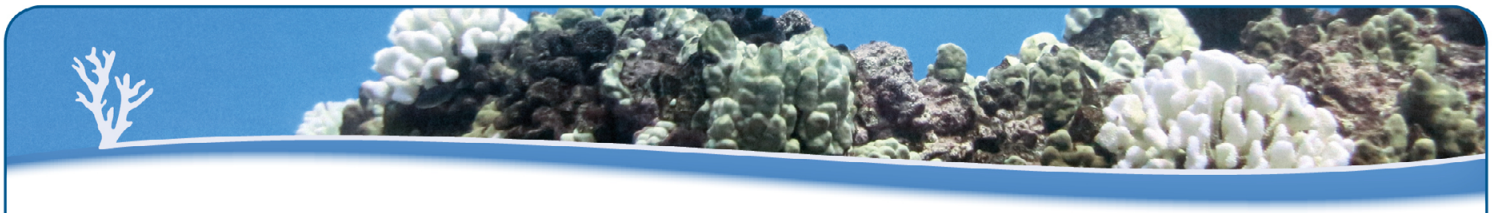
Scores for these indicators were normalized to values of 0-1 by dividing all scores by the greatest score. Indicator scores were then averaged for each depth at each site, and those values normalized to values of 0-1 expressing resilience as a decimal percentage of the site with the greatest average score for the indicators. Sites were then ranked from highest to lowest score for both depths and put into these relative classes: high (scores that are >1 sd (standard deviation) above avg (average), medium-high (<avg±1sd and >avg), medium-low (<avg and >avg-1sd), and low (<avg-1sd). A canonical analysis of principal coordinates (‘CAP analysis’) was used to examine which indicators were driving differences in resilience potential.

The 20 sites surveyed in October 2015 were re-surveyed in October 2016 and 2017 to assess changes in coral cover and density.

To identify management opportunities that could support resilience at survey locations, data on anthropogenic stress were compiled from a collaboration with the West Hawai’i IEA and the Ocean Tipping Points Project. Data layers on stress used in the analyses presented here include: fishing, development, invasive algae, invasive fish, habitat modification, nitrogen flux, phosphorus flux, total effluent, and sedimentation. The anthropogenic stress data were then combined with the scores for relative resilience and individual resilience indicators. Criteria were then set to identify management opportunities and reef areas where such actions would support resilience.

Results - *Obj. 1 – 2015 Bleaching and Disease:* An average (±1sd) of 68.41 ± 15.23% of shallow and 59.96 ± 17.66% of deep corals were partially or fully bleached. Survey sites in South Kohala had worse bleaching than those in North Kona.

Amongst the most affected sites were shallow regions at Kanekanaka, Kawaihae and Ohai’ula where 80-85% of the corals severely bleached. Preliminary results suggest that some South Kohala reefs experienced 55-99% coral mortality due to bleaching in 2015. Algal overgrowth (primarily by filamentous turf) of recently dead and severely bleached corals ranged from 10-60% except at Keawaiki (3%). Diseases observed include: Porites Growth Anomalies, Montipora Growth Anomalies, Porites Tissue Loss Syndrome, Pocillopora Tissue Loss Syndrome and Porites Trematodiasis. Disease prevalence (all diseases) was slightly greater among the shallow than deep reef areas and was also more variable among the shallow than deep reef areas. Average disease prevalence was 6.50 ± 4.02% among the shallow reef areas and 5.31 ± 2.88% among the deep reef areas.



Obj. 2 – Benthic Cover: At both depths and across all sites, macroalgae was <1%, crustose coralline algae cover was <25%; and >40% of the substrate was made up by 'other' (i.e., turfing algae and unconsolidated substrate). Average coral cover in the shallow reef areas was 28.24 ± 9.16% and in the deep reef areas was 22.67

± 10.70%. Coral cover was highest (>35%) in the shallow areas at Kalaemanō (50%), Keanapukalua (42%), and Mākole'ā (39%). Coral cover was highest (>30%) in the deep areas at Honokōhau (54%), Laehou (41%), Makalawena (32%), and Keonenui (32%). Twenty-seven coral species were observed in total. Coral species richness varied among sites from 6 (Honokōhau – Deep) to 15 coral species ('Ōhae'ula Deep).

Obj. 3 – 2015 Relative Resilience:

<u>Shallow</u> – Normalized resilience scores ranged from 0.52 to 1.00. Two sites were assessed as having high relative resilience, 8 medium-high, 7 medium-low, and 3 low. The 2 sites with high relative resilience are Laehou and Kumukea; these sites are in central and southern South Kohala (Figure 1). The 3 sites with low relative resilience are 'Ōhae'ula, Kanekanaka Pt, and Puakō; these sites are in northern South Kohala (Figure 1). Generally, resilience scores were lower in South Kohala and higher in North Kona.

<u>Deep</u> – Normalized resilience scores ranged from 0.55 to 1.00. Two sites were assessed as having high relative resilience, 9 medium-high, 6 medium-low, and 3 low. The 2 sites with high relative resilience are Laehou and Kīholo; these are adjacent sites in central South Kohala (Figure 2). The 3 sites with low relative resilience are Kawaihae, Kapalaoa, and Lulahala Pt; these sites are in central and northern South Kohala, respectively (Figure 2). As with the shallow reef areas, there is a general pattern that values for all resilience indicators are lower in South Kohala and higher in North Kona.

Obj. 4 –2015 Resilience Drivers: To understand how indicator scores influenced resilience scores we used a cannonical analysis of principal coordinates ('CAP analysis') to examine whether high scores for some indicators are consistently associated with high resilience (and low scores for some indicators are associated with low resilience).

<u>Shallow sites</u>: Bleaching resistance, and to a lesser extent high herbivorous fish biomass, coral recruitment and low coral disease, contributed to high and medium-high resilience potential at shallow sites.

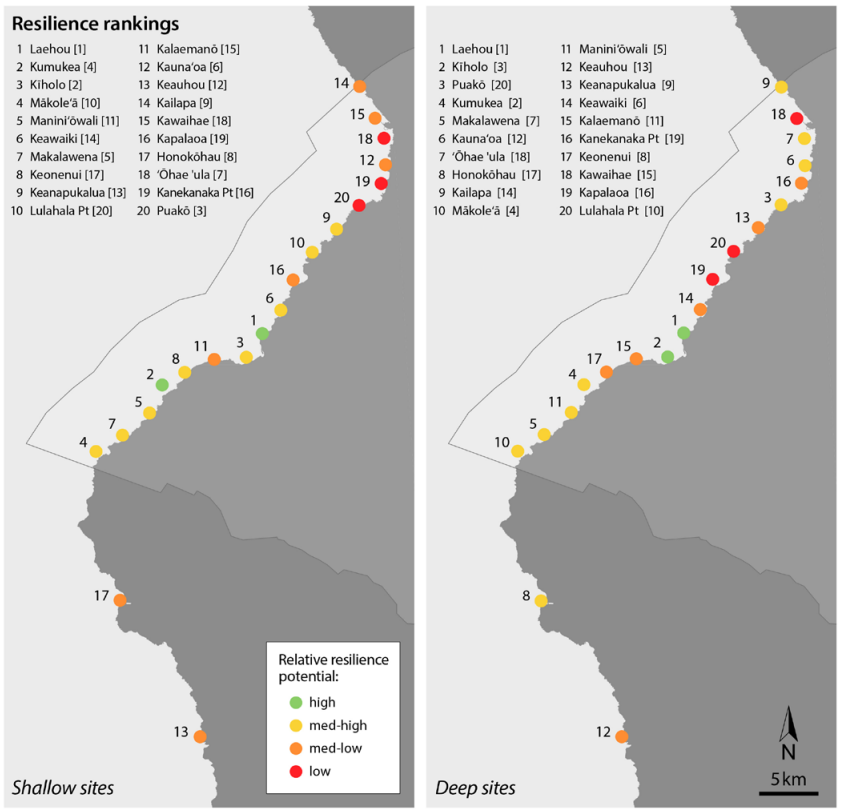


Figure 2. Resilience assessment results for shallow and deep reef areas along the South Kohala (north) and North Kona (south, see Figure 1) coastlines of Hawai'i Island. The polygon shape defines the boundaries of the NOAA Habitat Blueprint West Hawai'i Focus Area. Bracketed values represent the resilience rank for the other depth.

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Low bleaching resistance, herbivorous fish biomass and coral recruitment contributed to medium-low and low resilience potential at shallow sites.

<u>*Deep Sites*</u>: High coral recruitment, and to a lesser extent high coral cover and coral diversity and low macroalgae cover, contributed to high and medium-high resilience potential at deep sites. Low coral recruitment and coral diversity and low herbivorous fish biomass contributed to medium-low and low resilience potential at deep sites.

Obj. 5 – 2015 Bleaching Event Recovery in 2016 and 2017: Survey data suggest that roughly half of the coral tissue that was severely bleached in 2015 died due to bleaching in the months after the 2015 thermal stress event (Figure 3). However, many coral recruits were observed during 2016 and 2017 surveys suggesting that reefs are starting to recover.

Coral loss between 2015 and 2016 was greatest where severe bleaching prevalence in 2015 was highest. Declines in coral cover (percent of the reef area made up by corals) and coral density (number of coral colonies per unit area) were greater in the northern survey sites and lesser in the southern sites.

In the shallow reef areas, coral cover decreased from 28% in 2015 to 20% in 2017. Average coral cover decline was 8% and the largest decline observed was 21%. In the deep reef areas, coral cover decreased from 23%% in 2015 to 16% in 2017. Average coral cover decline was 6% and the largest decline observed was 37%.

Though cover decreased on average in both depths, average coral density hardly changed. The density of coral colonies in 2015 in the shallows was 12.8 colonies/m and was 11.2 colonies/m in 2016. The density of coral colonies in 2015 in the deep was 14.3 colonies/m and was 14.7 colonies/m in 2016. The most likely explanation for coral density not declining with coral cover is that bleaching mostly caused partial rather than whole colony mortality.

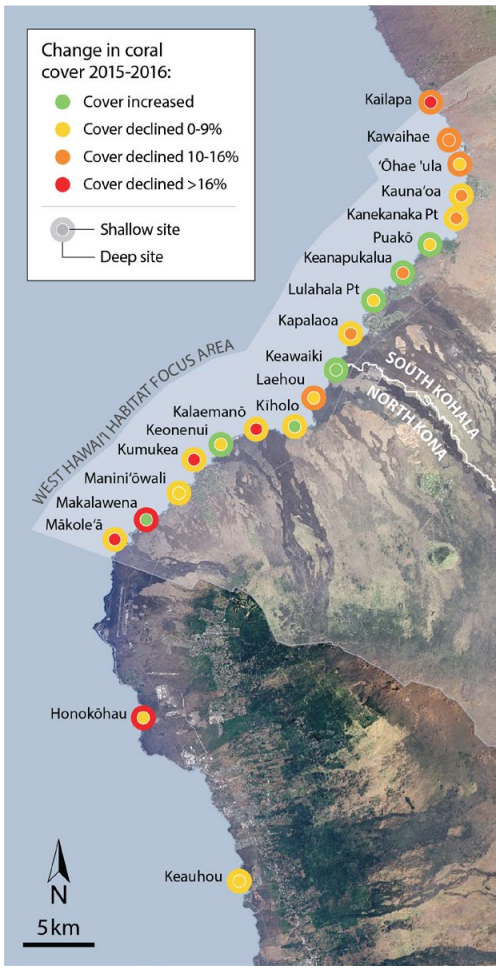


Figure 3. Coral cover changes between October, 2015 and October, 2016 caused by the severe coral bleaching event in West Hawai'i in 2015.

Macroalgae, which can often increase following coral mortality and then inhibit coral recovery, did not increase as coral cover decreased. Macroalgae cover was <1% in 2015 and was also <1% in 2016.

<u>Potential Management Opportunities</u> - The project team identified potential management actions to support or improve resilience at low resilience sites and maintain resilience potential at high resilience sites. High resilience sites are more likely to persist as disturbance frequencies increase under climate change so are considered priority targets for management opportunities.

Our team identified target sites for management opportunities by examining the resilience scores, resilience indicator scores, and anthropogenic stress data (see Figure 4). A reef location was identified as a target for a potential management opportunity if either the shallow or the deep site within the area met set criteria. This is because the kinds of management actions that may eventually be implemented, such as efforts to improve water quality, would likely affect both depths anyway. The criteria are named below by the type of potential management opportunity, and results are summarized in Figure 5.

Prioritize for ***C****onservation* – These sites have high relative resilience and not currently protected within MPAs or similar place-based management. Three sites met these criteria and could be considered priorities for conservation: Laehour, Kumukea, and Kiholo.

Support ***R****ecovery* – These sites have medium-high or high relative resilience, medium-low or low bleaching resistance and medium-high or high herbivore biomass. Four sites met these criteria and could be considered priorities for supporting recovery: Keanapukalua, Ohae'ula, Lulahala Pt, and Puako.

Manage ***W****ater quality* – These sites have medium-high or high relative resilience and occurrence of Effluent, Phosphorous, and Nitrogen stressors. More sites met the criteria for this management action than for any of the other potential actions identified in this study – 11 sites are suggested targets for managing water quality (see Figure 5).

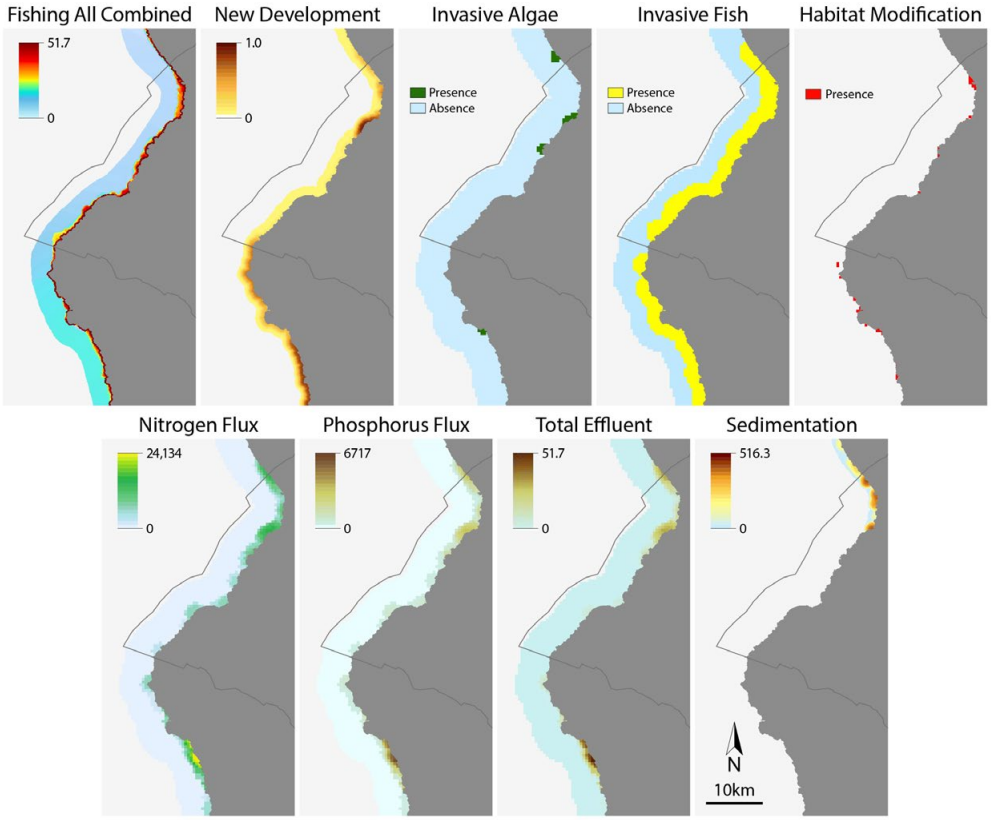
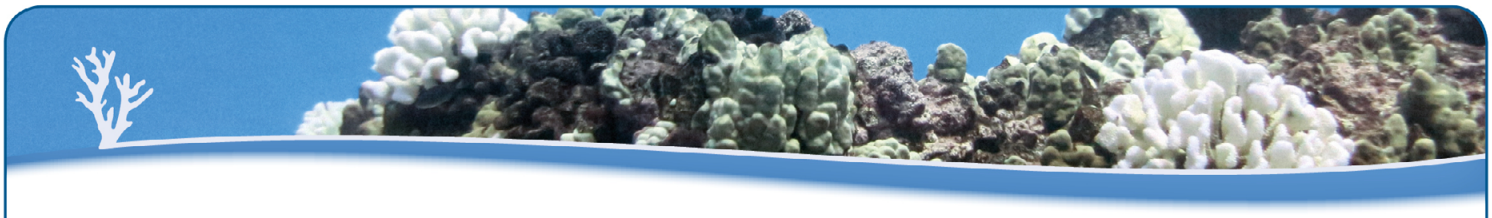


Figure 4. Anthropogenic stressors in West Hawai'i, compiled by team members working on the Ocean Tipping Points project and the West Hawai'i IEA.



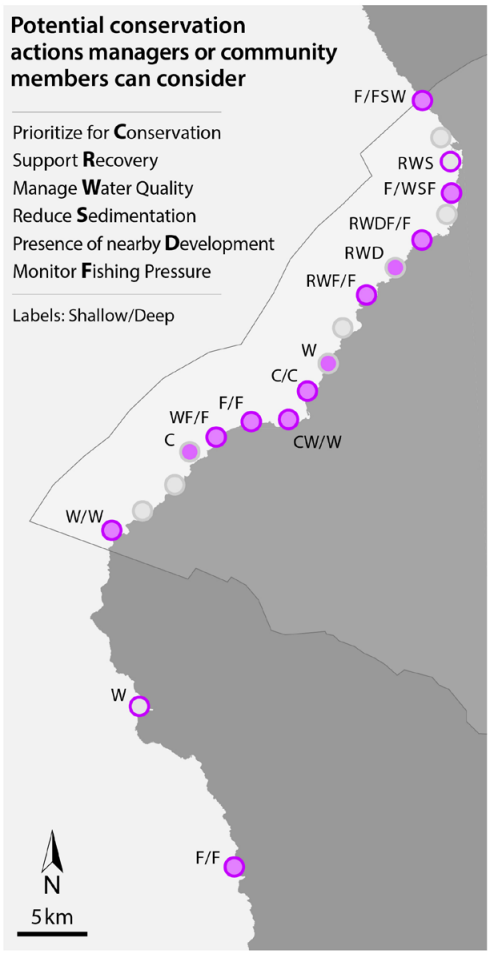
*Reduce **S**edimentation* – These sites have medium-high or high relative resilience and Sedimentation stress. Three sites met these criteria and could be priorities for reducing sedimentation: Kauna'oa, Kailapa, and Ohae'ula.

*Presence of nearby **D**evelopment* – These sites have medium-high or high relative resilience and coastal development is present. Two sites met these criteria and could be priorities for monitoring the effects of development on the local reefs: Keanapukalua and Puako.

*Monitor **F**ishing Pressure* – These sites have fishing total annual catch at >10 kg/ha (total annual catch based on all methods). Seven sites met these criteria and could be priorities for monitoring fishing pressure and effects of relatively high fishing pressure on the local reefs (Figure 5).

Communication and Next Steps: The project results and potential management and conservation actions managers or community members can consider were discussed among the project partners, including Hawai'i DAR. Project results were also presented to communities in west Hawai'i in meetings with communities and in a West Hawai'i Science Symposium that was open to the public. Further, project results were presented in the NOAA Science Seminar series at PIFSC in Honolulu. The action options identified during this project represent progress towards NOAA Habitat Blueprint's goal of reducing vulnerability of communities and natural resources to the effects of climate change. The Blueprint program and partners will continue to develop these and other products to inform management decisions.

Project Reports: Parts of this project summary are an excerpt from NOAA CRCP Technical Memorandum 26, which covers project objectives 1-4, and includes a Site Summaries section. Site Summaries are 1-page summaries for each survey site that present the site name origin, coordinates and resilience ranks, photographs, resilience indicator scores, a benthic community pie chart, bleaching/ disease prevalence values, and coral and fish species list.



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