Mapping the Risk Reduction Benefits of Coral Reef Conservation

According to the U.S. Geological Survey (USGS) report, Rigorously Valuing the Role of U.S. Coral Reefs in Coastal Hazard Risk Reduction, the degradation of near-shore habitats, particularly coral reefs, increases the risk of flooding in coastal communities. However, mitigation and protective prioritization often fails to account for the economic protection of natural or nature-based solutions and instead opts for artificial defenses like seawalls.

The 2020 publication, FEMA's Building Community Resilience with Nature-Based Solutions: A Guide for Local Officials – which supports the interagency National Mitigation Investment Strategy – identifies nature-based solutions as a cost-effective approach to prevent natural hazards from becoming costly disasters. FEMA's Hazus Program provides risk assessment tools and data for communities interested in analyzing the risk reduction benefits of nature-based solutions. The Hazus Team recently worked with the U.S. Coral Reef Task Force to map coastal flood losses avoided due to coral reef protection across Hawaii (Figure 1), and results from this project can help guide future nature-based mitigation initiatives.

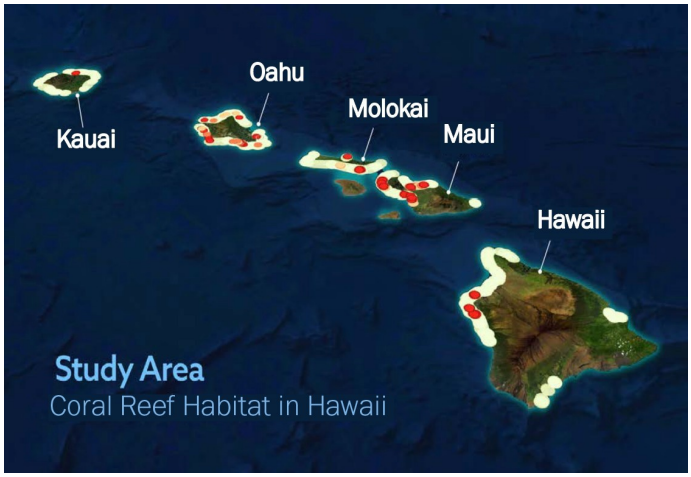

Figure 1: Coral Reef Habitat in Hawaii

The study area includes coral reef habitat, highlighted in yellow, along the coastlines of five Hawaiian Islands: Kauai, Oahu, Molokai, Maui, and Hawaii.
Red and orange dots indicate areas that would benefit from coral reef protection.

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The U.S. Coral Reef Task Force is an interagency organization tasked with conserving coral reef habitats along U.S. coasts. Learn more about their mission at www.coralreef.gov.

The USGS documented the risk reduction benefits of coral reefs across Hawaii in 2019 using Census block exposure information to compare flood losses with full and reduced coral reef habitat. FEMA's Hazus Team built on this study by completing a detailed structure-level flood analysis using the Hazus Flood Assessment Structure Tool (FAST) to identify areas where coral reef conservation would lead to the highest economic benefit for the five main islands of Hawaii.

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Interested in using FAST for risk assessment? View a recent webinar showcasing the tool, then download the tool here.

The FAST tool is an open-source and simplified method for calculating flood losses using depth and structure data provided by a user. FEMA used the U.S. Army Corps of Engineers National Structure Inventory (NSI v2), combined with tax assessor data from the Island of Oahu to develop the input structure data. USGS depth grids for 10-, 50-, 100-, and 500-year wave-energy return periods for scenarios with full and reduced coral reefs (top 1 meter of reef lost) were used for input flood hazard data. The availability of NSI data with structure specific vulnerability attributes required by FAST allows state and local planners to more accurately estimate flood risk by identifying potential flood depths at the exact location of a structure.

The multi-return period, with- and without-reef scenario coastal flood depth data allow planners to annualize flood risk– an important metric for communicating risk to diverse stakeholders. (Please note that loss results from this study are aggregated for display purposes, but input data were structure-specific.)

Results from this study estimate an annual value of over $300 million for reef protection across the five main islands of Hawaii (Table 1). The exposed building value reduced by coral reef protection is over $600 million, indicating a 50% flood loss ratio in Hawaii's reef-adjacent coastal communities. The statewide reef protection value estimated by this analysis is 10% smaller than the value estimated by the previous USGS study, a difference driven by the new use of structure-specific inventory data.

Table 1: Risk Reduction Benefits of Coral Reef Protection in Hawaii by Island and Type of Analysis

Island	Annual Losses Avoided(Site Specific Inventory)	Annual Losses Avoided(Aggregated Inventory)
Maui	$71,975,099	$112,716,317
Hawaii	$125,254	$23,997,824
Oahu	$210,365,606	$200,942,259
Molokai	$25,169	$42,071
Kauai	$24,451,385	$5,854,742
Total	**$306,942,513**	**$343,553,213**

Risk reduction benefits of coral reef protection estimated using site-specific data are compared with a previous USGS study using aggregated data. Aggregated inventory may overestimate statewide risk reduction benefits by 10%, but underestimate benefits in some areas.

Flood losses estimated using the baseline or aggregated inventory data provide inconsistent results across the State and are dependent on the Census block geometry of each island. The structure-specific results described here emphasize the importance of detailed building-level data for flood risk assessment.

The use of structure-specific inventory identifies locations where cost savings from coral reef protection would be the most beneficial (Figure 2). Mapped risk reduction locations serve as an important tool to help mitigation planners select sites for projects or additional study. For instance, results from three locations on the Island of Maui demonstrate the significant reduction in 10-year flood extent driven by coral reef protection and highlight neighborhoods where the annual risk reduction value of coral reef protection reaches nearly $5 million (Figure 3).

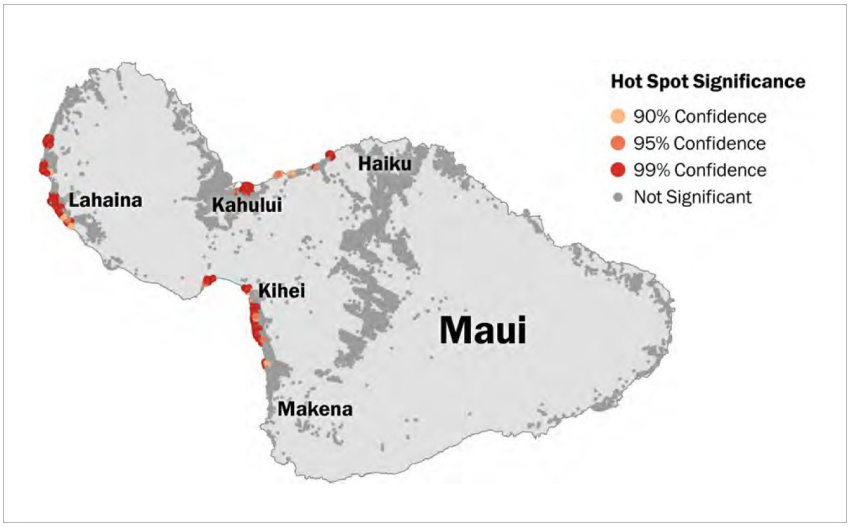

Figure 2: Optimal Locations for Coral Reef Protection on Maui

A Getis-Ord Gi hot spot analysis identifies statistically significant spatial clusters of high and low risk reduction benefits by comparing losses avoided at each structure with its neighbors. Clusters of high benefits indicate areas optimal for mitigation investment through coral reef protection.*

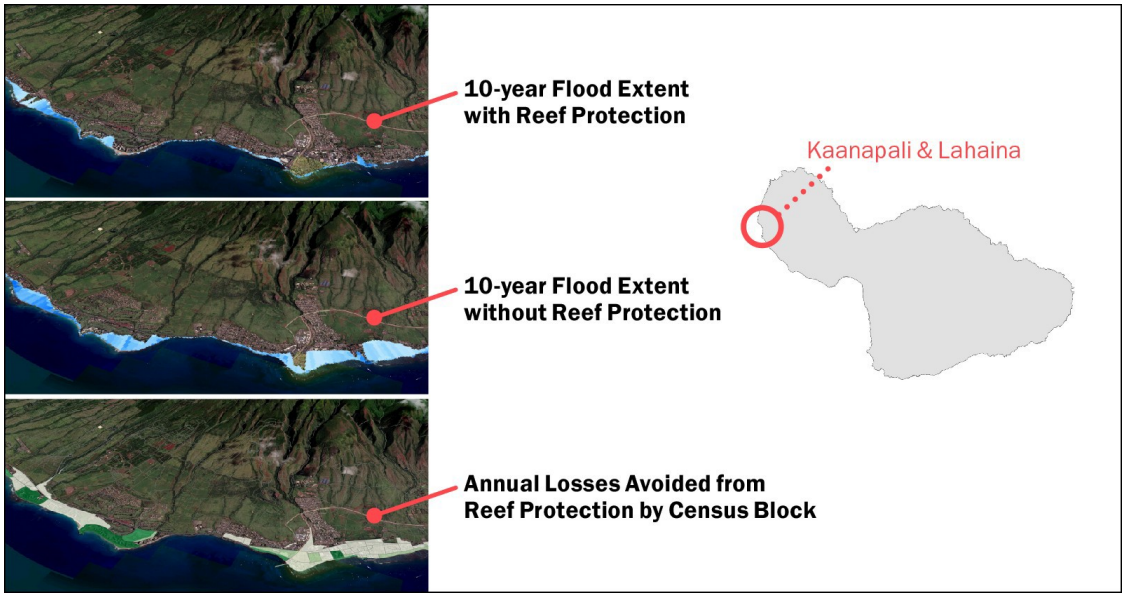

Figure 3a: Risk Reduction Benefits of Coral Reefs on Maui – Kaanapali

Changes in flood extent and annual flood losses avoided due to coral reef protection at Kaanapali and Lahaina identified as optimal for reef mitigation investment by a hot spot analysis.

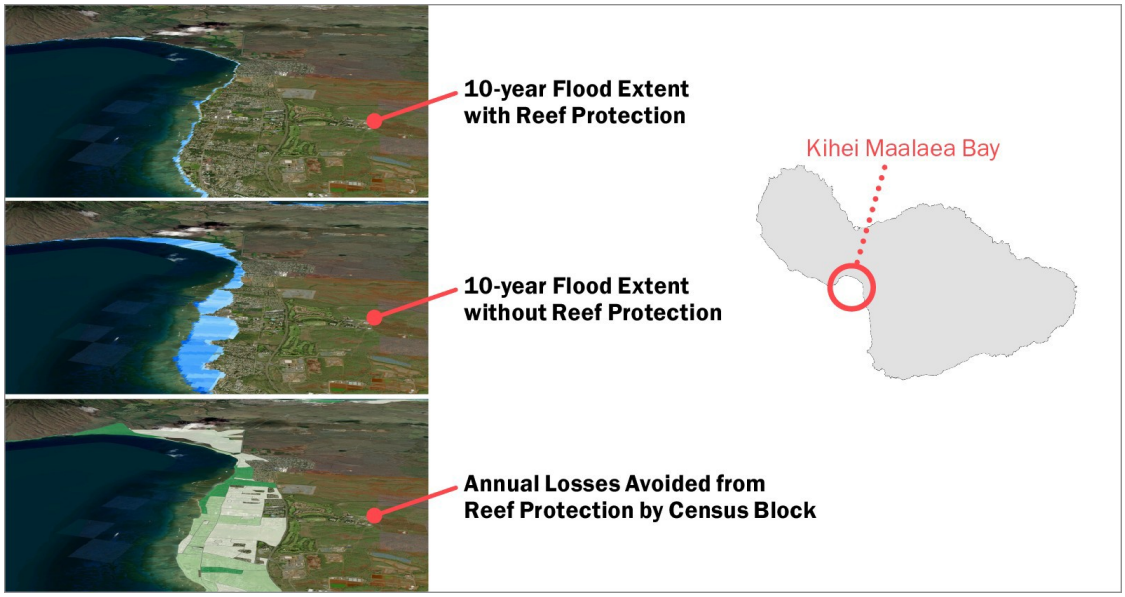

Figure 3b: Risk Reduction Benefits of Coral Reefs on Maui – Kihei

Changes in flood extent and annual flood losses avoided due to coral reef protection at Kihei Maalaea Bay identified as optimal for reef mitigation investment by a hot spot analysis.

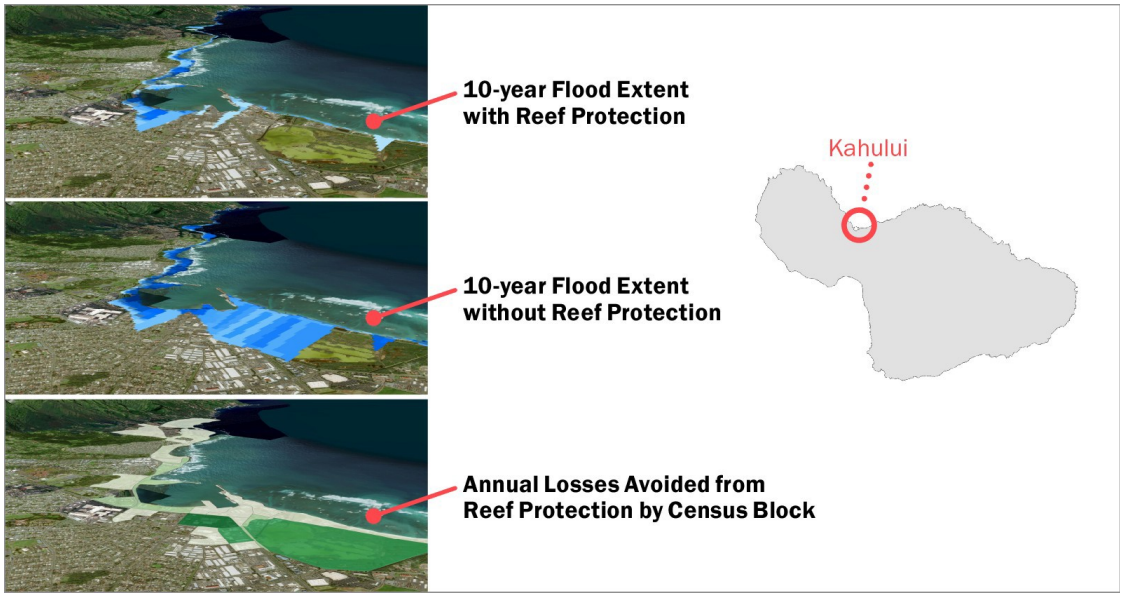

Figure 3c: Risk Reduction Benefits of Coral Reefs on Maui – Kahului

Changes in flood extent and annual flood losses avoided due to coral reef protection at Kahului identified as optimal for reef mitigation investment by a hot spot analysis.

FEMA's Hazus Program will continue working with the U.S. Coral Reef Task Force to quantify the benefits of coral reef conservation for risk management across the United States and emphasize using structure-specific inventory data wherever possible.

Additionally, communities with coral reef habitats can combine the methods from this study with more accurate local building information to significantly improve the accuracy of risk assessment results. The Hazus Team (FEMA-Hazus-Support@fema.dhs.gov) provides tools and guidance to support communities interested in identifying the benefits of similar nature-based solutions, especially for those interested in mitigation funding opportunities through FEMA Programs like Building Resilient Infrastructure and Communities (BRIC), the Hazard Mitigation Grant Program (HMGP), and Public and Individual Assistance (PA, IA).