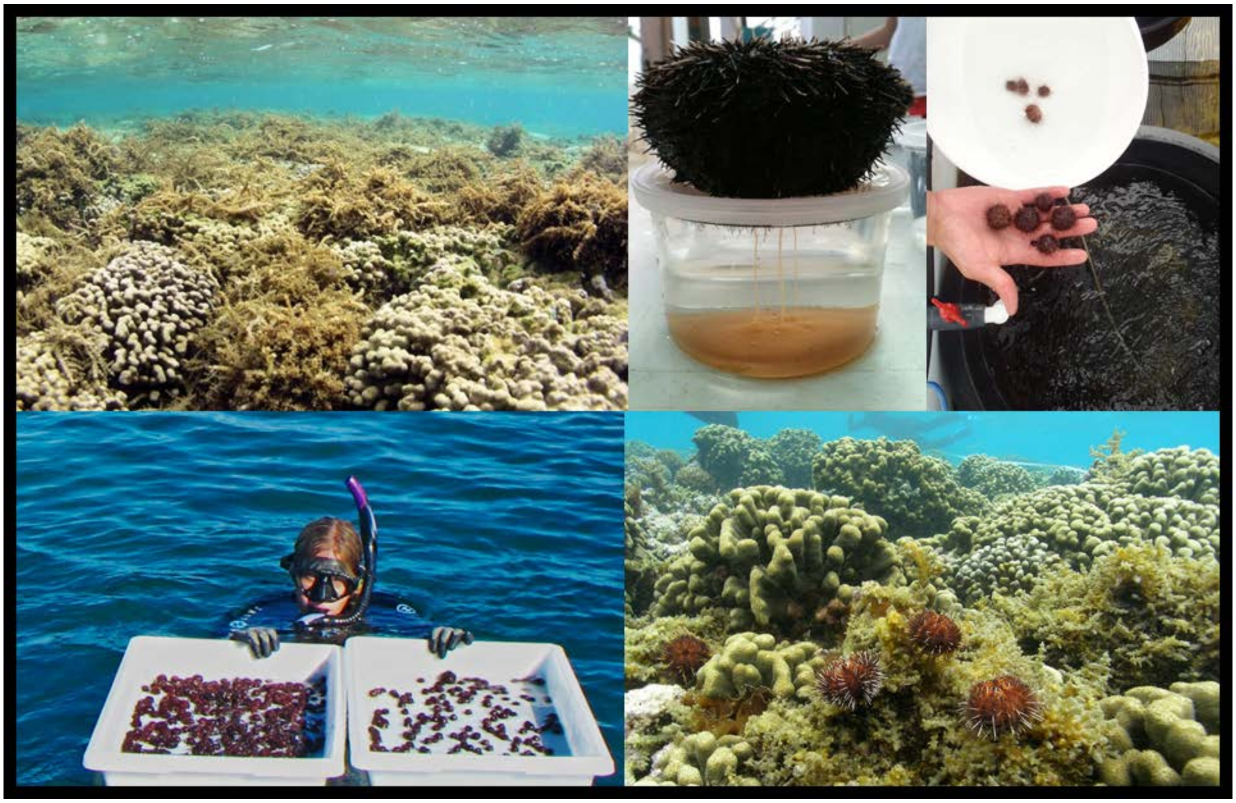
Cape Flattery Settlement Restoration Project: Restoring Reefs in Kāne‘ohe Bay



PROGRESS REPORT

Division of Aquatic Resources

Aquatic Invasive Species Team

June-December 2017

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RESTORATION PLAN ACTIONS IMPLEMENTED

During the June to December 2017 reporting period, urchin production declined. Work continued on a coral reattachment pilot project to utilize corals of opportunity within Kāne‘ohe Bay. In addition, a proposal for He’eia Watershed Reef Restoration was presented to the Trustees and agreement was reached to begin the planning stages of the project.

As of February 15, 2017, all remaining priority reefs (Reefs 20, 24, 28, 30, 31, 38 and 41) have been stocked with target numbers of urchins. Outplanting will continue on newly identified priority reefs. Additionally, monitoring and photo documentation of the coral reattachment pilot project will continue as well as the planning phase of the He’eia Watershed Reef Restoration. Table 1 shows the project progress to date, and planned timeframes for future activities. Figure 1 shows the location and progress of priority reefs.

Table 1: Work plan progress

Action	Who is responsible	Timeframe	Progress	Accomplishments	Notes
Conduct baseline monitoring surveys	Monitoring Coordinator, Project Technicians	March – May 2016	Complete	2016 SNAP patch reef assessment completed 4/2016; Marker 12 assessment completed 5/2016	
Prioritize reef restoration efforts	DAR Aquatic Biologist, Trustees	March 2016, November 2016	Complete	Prioritization complete	Reefs 14, 16, 26, 27, 29, P1, P3, and P5A added to priority list in February 2017.
Outplant native sea urchins to restoration area.	Project Technicians, DAR Urchin Hatchery	April 2016 - end of project	In progress	Since the last reporting period, 912 urchins have been released on newly prioritized reefs	Targets reached for priority reefs on February 15, 2017. Outplanting has continued on newly prioritized reefs.
Bi-annual reporting to the Cape Flattery trustee council.	Monitoring Coordinator, DAR Aquatic Biologist	May & December through end of project	In progress	December 2017 progress report submitted to trustee council	
Follow-up monitoring of coral and algae conducted annually.	Monitoring Coordinator, Project Technicians	March – April, through end of project	Complete	Follow-up monitoring for 2017 completed on March 23, 2017	Annual monitoring planned March 2018
Maintenance of outplanted urchins	Monitoring Coordinator, Project Technicians	April 2017- end of project	Upcoming		2018 monitoring will determine maintenance areas
Identification of and continuation on future priority reefs	DAR Aquatic Biologist, Trustees	January 2017- end of project	Complete	Reefs 14, 16, 26, 27, 29, and three fringing reef areas identified	

Figure 1: Invasive algae control progress on priority reefs in Kāne'ohe Bay.

		2016 SNAP Survey				2017 SNAP Survey					
Priority	**Reef**	**Area Surveyed (m^2)**	**Area of Coral (m^2)**	**Area of *Eucheuma/ Kappaphycus* (m^2)**	**Area of *Gracilaria/ Acanthophora* (m^2)**	**Area Surveyed (m^2)**	**Area of Coral (m^2)**	**Area of *Eucheuma/ Kappaphycus* (m^2)**	**Area of *Gracilaria/ Acanthophora* (m^2)**	**Target number of urchins needed (2 urchins/m^2 of algae)**	**Number of urchins needed to reach target (as of May 2017)**
1	**Marker 12**	275,764	149,101	2,684	17,538	255,897	138,459	1,579	11,074	40,444* (*Increased to 60,000)	0
2	**44**	50,115	46,039	1,257	33	50,425	37,827	252	99	2,580	0
3	**43**	24,833	24,727	1,229	0	24,833	24,833	218	0	2,458	0
4	**41**	25,893	24,752	5,877	173	25,893	24,618	3,227	13	12,100	0
5	**40**	4,645	4,618	784	0	4,645	4,615	733	0	1,568	0
6	**38**	9,707	8,646	692	7	9,707	7,603	582	210	1,398	0
7	**31**	22,233	21,686	182	0	23,233	18,736	193	0	364	0
8	**30**	21,528	20,386	422	0	21,528	20,663	75	0	844	0
9	**28**	16,541	14,530	425	1,942	16,541	14,802	88	167	4,734	0
10	**24**	12,155	10,780	21	0	12,176	10,787	46	0	42	0
11	**20**	3,316	3,284	1	0	3,316	3,166	27	29	2	0
Control	**15**	8,570	8,458	1,753	0	8,570	8,463	1,594	0	N/A	N/A
Control	**9**	32,404	27,162	290	0	32,014	27,653	73	0	N/A	N/A
Control	**23**	5,017	4,996	208	0	5,017	5,009	60	9	N/A	N/A
TOTALS		**517,738**	**369,165**	**15,825**	**19,693**	**493,795**	**346,842**	**8,747**	**11,601**	**91,036**	**0**

Table 2: Reef characteristics and progress on priority reefs in Kāneʻohe Bay.

URCHIN HATCHERY

In order to rear *Tripneustes gratilla* in the hatchery, wild broodstock urchins are harvested to collect gametes. During the period from June-December 2017, Flattery staff assisted with 5 urchin spawning events, resulting in 152 wild urchins being spawned. For each spawning event, staff collect adult urchins from the wild and transport them to the hatchery at the Ānuenue Fisheries Research Center. There, Flattery staff assist with spawning the urchins and collecting gametes so that the spawning event can be completed quickly and efficiently.

From June-December 2017, 21,323 liters of phytoplankton were produced to feed urchin larvae, and 918.51 kg of macroalgae were produced to feed juvenile urchins. In total, 8,593,000 larvae were produced and moved into tanks for the settlement and grow-out phases during this reporting period. Of those, 912 (0.0001%) grew to transplantation size (~10mm) and were released onto priority reefs.

Table 3: DAR Urchin Hatchery monitoring metrics for June-December 2017

	Food production		Urchin production		
Date	**Phytoplankton produced (l) (for urchin larvae)**	**Macroalgae produced (kg) (for urchin juveniles)**	**Broodstock urchins**	**Number of larvae moved into settlement/grow out phase (x1000)**	**Number of hatchery urchins outplanted**
June 2017	3,286	123.5	0	2,019	0
July 2017	4,704	152.82	60	0	576
Aug 2017	2,152	67.7	0	1,306	0
Sept 2017	2,852	197.06	40	0	336
Oct 2017	3,729	120.83	26	1,486	0
Nov 2017	1,680	150.19	26	1,530	0
Dec 2017	2,920	124.1	0	2,252	0
Totals	21,323	918.51	152	8,593	912

URCHIN OUTPLANTING

Urchins were outplanted onto newly prioritized reefs during this period. The target number of urchins for all of the initially identified priority reefs was met on February 15, 2017. Following completion of the priority reefs, work progressed on the additional priority reefs (see "Restoration Plan Actions Implemented" section), resulting in target numbers of urchins outplanted being reached on Reef 16. Currently, Reef 14 is in progress; once the target number of urchins are met on Reef 14, urchins will be deployed on reefs 26 (1,835 urchins), 27 (3,735 urchins), 29 (5,803 urchins), P1 (40,346 urchins), P3 (3,430 urchins), and P5A (122 urchins), respectively (Figure 1). Table 4 shows the urchin releases that have occurred from June 2017-December 2017, including the number and destination of the urchins and the hours contributed by Flattery and DAR civil service staff.

Table 4: Urchin transplants for June-December 2017

Date	Urchin source	Reef Number	Number of Urchins Released	Area treated (m^2)	Work Hours	Flattery team members	DAR team members	Total Hours
7/8/17	**Hatchery**	**16**	**158**	**79**	**3**	**1**	**3**	**4**
7/12/17	**Hatchery**	**14**	**418**	**209**	**3**	**0**	**3**	**9**
9/26/17	**Hatchery**	**14**	**336**	**168**	**2**	**1**	**2**	**6**
Totals			**912**	**456**	**8**			**19**

CORAL REATTACHMENT PILOT STUDY

In March 2017, a proposal for a coral reattachment pilot study was submitted to the Division chair for approval. The project uses “corals of opportunity”- loose fragments generated by boat groundings, invasive algae, or other outside forces - to restore denuded areas in Kāneʻohe Bay. The pilot study is aimed at assessing methodology and identifying the most successful species and fragment size for successful restoration. In addition, the pilot study integrates cutting-edge technology using still photography and Agisoft software to create 3D photomosaics of the restoration plots over the course of the experiment, in order to create a visual representation of coral growth and reef complexity over time, which can be used for data collection, presentations, and outreach.

Two 5 m x 5 m restoration plots were deployed on denuded areas of the P1 fringing reef priority site and Marker 12 on May 10-11, 2017. Initial data were collected May 15-16. The protocol was developed by the Monitoring Coordinator, and the supplies and gear were assembled and purchased by the Technician. In total, approximately 860 fragments of opportunity were reattached, measured, and photo documented for photomosaic analysis. Additional monitoring occurred in August 2017 and photographs were taken to create 3D photomosaics.

HE’EIA WATERSHED REEF RESTORATION

In August 2017, a proposal for enhancing coral recovery on He’eia reef through watershed restoration was presented to the Trustees (Appendix A). Restoring the Heʻeia watershed will alleviate land-based stressors on reef habitats and promote the recovery and recruitment of coral colonies in Kāneʻohe Bay. It was unanimously agreed on to allow funding of the design phase to move forward (Appendix B).

In September 2017 and December 2017 Flattery staff and DAR technicians worked with HIMB researchers in collecting baseline data for the He'eia reef in conjunction with ongoing mangrove removal efforts in the area. This monitoring includes the collection of physical (sediment depth and grain size composition, temperature, salinity, total suspended solids, nutrients, and chlorophyll) and biological data (fish count, abundance, and diversity and benthic substrate photos). Further monitoring with HIMB researchers is planned.

OTHER PROGRESS

Flattery funds were used to pay for a new dive ladder for the boat, supplies for reef markers for Kāneʻohe Bay patch reefs, Access Database class for team members, and other project-related supplies.

Appendix A

He‘eia Watershed Restoration Proposal

Enhancing Coral Recovery on He‘eia Reef Through Watershed Restoration

Photo: Manuel Mejia

Prepared For
The Cape Flattery Settlement Trustees

Prepared by
The Division of Aquatic Resources
and
The Hawai‘i Coral Reef Initiative

July 2017

Summary

This document is a proposal for the design and implementation of restoration activities in the He‘eia watershed. This project would be included as an addition to the Cape Flattery restoration plan. He‘eia watershed is located on the windward side of O‘ahu, extending from the Ko‘olau range to the He‘eia fishpond where it meets Kāne‘ohe Bay. Industrialized agriculture and urbanization in this area have negatively affected the watershed and near-shore coral reefs since the mid-nineteenth century. Restoring the He‘eia watershed will alleviate land-based stressors on reef habitats and promote the recovery and recruitment of coral colonies in Kāne‘ohe Bay.

The objectives of the proposed restoration activities in the He‘eia watershed are to decrease nutrient and sediment loads, reduce freshwater pulses during storm events, and enhance the recovery of bleached corals on nearshore reefs. These objectives will be met by designing and engineering stream channels, floodplains, wetlands, and sediment collection areas to increase retention and filtering of sediments and nutrients, and decrease peak stream discharge during storm events. In addition, these actions will reduce one of the major drivers of invasive algae (nutrients) and reduce the primary habitat for invasive algae colonization (areas with high sedimentation).

The He‘eia watershed is an ideal restoration location for a variety of reasons, including the high need for coral restoration activities in Kāne‘ohe Bay, as well as strong community support and collaboration and ongoing scientific research and monitoring in the area. This project would also complement and enhance the invasive algae control project currently funded through the Flattery Trust Fund.

Introduction

The connection between ridge to reef, or mauka to makai, is a prominent concept in Hawai'i where it has been demonstrated that the health of the reef is highly dependent on the condition of adjacent watersheds (Rodgers et al. 2012). Land-based source pollutants in the form of sediment, nitrogen, phosphorous, organic pollutants, heavy metals, pathogens, and freshwater cause major disruptions to coral reef ecosystems (Rodgers et al 2012, Richmond et al. 2007, Oleson et al. 2017). In Hawaiʻi, the land-based sources of stress are located short distances from the ocean; therefore, functioning watersheds are essential to filter and retain pollutants upland before they reach the reef.

Heʻeia is one of few ahupua'a, self-sustaining ancient Hawaiian land division managed from the mountains to the sea (mauka to makai), that still is managed with limited urban development. It is the center of major community-led revitalization efforts of natural, cultural, and economic aspects of the ahupuaʻa, with projects occurring in the upper, middle, and lower watershed and fish pond. Heʻeia was also recently designated as a NOAA National Estuarine Research Reserve (NERR) and protects over 1,300 acres of the watershed, estuary and near-shore habitat. In addition, the Nature Conservancy in collaboration with Kākoʻo ʻŌiwi and NOAA are restoring native wetland habitat by removing six acres of mangroves and replanting native species. Kākoʻo ʻŌiwi and partners are also working to restore wetland kalo (taro) to not only provide sustainable agriculture, but also function as sediment and nutrient traps to protect adjacent reefs.

Coral reefs in Kāneʻohe Bay have been impacted by a variety of stressors associated with land-based activities including sedimentation, nutrients, pollution, and freshwater run-off (Richmond 1997, Bahr et al. 2015). Land-based nutrient and sediment input have the potential to create large algae blooms in the bay, which can stress corals and other reef inhabitants (Hunter and Evans 1995; Stimson et al. 1996). Additionally, sediment retention on reefs creates ideal habitat for invasive algae to colonize, such as *Gracilaria salicornia* (Gorilla ogo) and *Acanthophora spicifera* (prickly seaweed). A recent study examined the cumulative impacts of Hawaiʻi's nearshore areas and found Kāneʻohe Bay to be one of the most impacted in the state. Driving this cumulative impact score was mainly high levels of urban runoff, nutrients, sewage, sediment loads, and fish harvest (Lecky 2016). Many of these stressors are expected to increase with increased ocean water temperatures, sea-level rise and more severe and frequent storm events. Despite these impacts, Kāneʻohe Bay still contains some of the highest coral cover on O'ahu. Managers are committed to restoring and preserving corals in the bay and have proposed a wide-range of actions to meet the challenges associated with climate change and help coral recover from recent bleaching events (Rosinski et al. 2017).

In order to reduce land-based stressors to coral reefs in Kāneʻohe Bay, restoration activities are needed in the lower Heʻeia watershed to reduce sediment, nutrients, and pollutants reaching the reef. Although there are multiple wetland and stream restoration plans currently being developed and implemented, an in-depth restoration plan and design for the lower watershed has not yet been developed. We propose a stream restoration project for the lower 250 acre wetland area and 1.5 miles of stream channel that would include restoration design and implementation.

The He‘eia watershed is an ideal restoration location for a variety of reasons, including the high need for coral restoration activities in Kāne‘ohe Bay, as well as strong community support and collaboration and ongoing scientific research and monitoring in the area. This project would also complement and enhance the invasive algae control project currently funded through the Cape Flattery restoration plan.

Watershed Related Impacts to Corals

Land use and management can directly affect the amount of sediment, nutrients, and freshwater that are deposited on the reef (Correll et al. 1992, McCulloch et al. 2003, Messina and Biggs 2016, Young et al. 1996). Although coral reef ecosystems may depend on some of these inputs (nutrients, sediment, freshwater) the amount and frequency they are delivered can shift the balance from a thriving ecosystem to disturbed (Richmond et al. 2007). Corals are impacted by these stressors in terms of their ability to grow, settle, and reproduce (Richmond et al. 2007), ultimately affecting coral reef species diversity and richness (Friedlander et al. 2008).

Sediment impacts
Sedimentation has been identified as one of the greatest and most persistent threats to coral reefs, and is known to degrade nearshore reef systems (Richmond et al. 2007, Risk 2014, Stender et al. 2014, Gil et al. 2016, Shelton and Richmond 2016). The amount of sediment delivered to nearshore reefs depends on the condition of the watershed upstream; therefore, one of the main goals of watershed restoration is typically to prevent erosion (Yochum 2016). Taking action to reduce sedimentation is of strong interest in Hawai‘i because much of the sediment here is fine grain volcanic sediment, which have been found to be particularly detrimental to corals (Jokiel et al. 2014, Perez et al. 2014, Risk 2014). In general, sedimentation is often easier and cheaper to manage than nutrient reduction, and has been shown to be beneficial for reefs, agricultural lands, and landowners (Risk 2014, Chabot et al. 2016, Gil et al. 2016, Oleson et al. 2017).

Nutrient impacts
Nutrient enrichment (typically nitrogen and phosphorous) is primarily driven by terrestrial runoff (Gil et al. 2016) and is another persistent stressor on nearshore coral reefs (Risk 2014). Sediments may also provide a sustained release of nutrients over time. Increased nutrients cause phytoplankton blooms and create hypoxic conditions for corals, which can become quickly overgrown by algae (Kroon et al. 2014). High nutrient levels are also linked to reductions in coral bleaching temperature thresholds, increased coral disease and bleaching instances, and increased bioerosion rates (Risk 2014). Hunter and Evans (1995) observed an increase in the macroalgae species *D. cavernosa* in Kāne‘ohe Bay, which they attributed to nutrient release due to sedimentation, land-based run-off, or dumped waste from recreational boaters. Work by Stimson et al. (1996) supported the hypothesis that nutrients stored in sediment contribute to the seasonal growth rate of the

macroalgae *D. cavernosa*, highlighting the importance of sediments as a persistent source of nutrients to the bay.

Freshwater impacts

Freshwater is an important component of any nearshore reef system, and the amount of freshwater discharged onto a reef from a given watershed can have profound effects on the community structure. In general, reefs are acclimated to handle a given amount of freshwater stress, but extreme changes in salinity due to freshwater flux in either direction can have a detrimental effect on corals (Kroon et al. 2014). In Kāneʻohe Bay, periodic freshwater storm events have killed corals and other benthic organisms due to sustained low salinity in reefs. Stream channelization in Kāneʻohe Bay watersheds have led to increased freshwater storm surges and more frequent freshwater kills in recent years (Hunter and Evans 1995). A recent freshwater kill was documented in northern Kāneʻohe Bay in 2015, resulting in a substantial mortality event of corals (22.5% reduction) and other benthic fish and invertebrates within the impact zone (Bahr et al. 2015).

Invasive algae impacts

Invasive algae impacts to coral reefs can also be exacerbated by sedimentation and nutrient inputs to Kāneʻohe Bay. Invasive algae have been shown to degrade physical coral reef habitat by overgrowing and smothering corals (Stimson et al. 2001, Vermeij et al. 2009, Martinez et al. 2012; Conklin and Smith 2005), which in turn blocks light, promotes coral disease, increases sediment accumulation, creates localized hypoxia/hyperoxia conditions, decreases pH, and alters nutrient cycling as well as the epifaunal community of the reef (Fukunaga et al. 2014, Martinez et al. 2012, Murphy 2012, Fukunaga et al. 2014). Growth and propagation of invasive algae in the bay can increase due to nutrient enrichment and sedimentation associated with increased freshwater runoff. In addition, invasive algae such as *Gracilaria salicornia* can survive under low irradiance and high sedimentation conditions that might otherwise limit growth or survival of corals (Martinez et al. 2012). These characteristics may allow invasive algae to proliferate and outcompete corals in Kāneʻohe Bay.

Watershed Function

Wetlands and stream ecosystems provide a natural buffer for trapping and reducing runoff into near shore reefs. If these ecosystems are properly functioning, water transport should slow and allow sediment, nutrients and pollutants to dissipate before entering the ocean. Wetlands and streams enhanced with meanders, floodplains, structure, and native vegetation can slow surface water movement, deposit sediment, and uptake nutrients. Overall, this contributes to decreased storm runoff, sediment loads and nutrients inputs.

Watershed restoration has been shown to decrease sedimentation and increase reef health in various locations around Hawaiʻi and the Pacific. Restoring ecological processes that regulate runoff and erosion modify the hydrology of a watershed to retain sediments through riparian vegetation, floodplains, and wetlands (Gumiere et al. 2011). For example, the reefs in Pelekane Bay, Hawaiʻi, were found to be severely degraded in 1996 due to high sedimentation caused by deforestation, overgrazing, and development in the adjacent watershed. However, when the reefs were resurveyed in 2012 following the implementation of watershed stabilization initiatives (including the installation of sediment check dams, ungulate control, and replanting of native vegetation) coral cover in the degraded areas had increased, indicating that reduced sediment allowed the reefs to begin to recover (Stender et al. 2014).

Watersheds can also contribute to coral bleaching recovery. DAR recently completed a rigorous analysis of the coral restoration activities used to help corals affected by the 2014 and 2015 bleaching events to recover. Watershed restoration focused on sediment and nutrient reduction was identified as one of the primary management actions that can help corals recover from coral bleaching events (Rosinski et al. 2017).

Project Objectives

The overall conservation goal of this project is to reduce stressors to coral reef habitats in order to promote recovery and recruitment of coral colonies. The He‘eia Watershed Restoration objectives are to:

- Enhance the recovery of He‘eia reef corals impacted by the 2014 and 2015 bleaching events
- Decrease sediment and nutrient loads to He‘eia reef
- Reduce invasive algae cover at He`eia reef
- Reduce freshwater pulses in He‘eia stream during storm events that could result in freshwater coral kills occurring at He‘eia reef

The proposed restoration activities will meet these objectives by designing and engineering stream channels, floodplains, wetlands, and sediment collection areas to increase retention and filtering of sediments and nutrients, and decrease peak stream discharge during storm events. In addition, these actions will reduce one of the major drivers of invasive algae (nutrient input) and diminish the primary habitat for invasive algae colonization (areas with high levels of sediment).

To jumpstart the coral recovery expected from the watershed restoration actions, corals of opportunity will be relocated to He’eia reef. These corals of opportunity are coral colonies that have broken off of the reef slope and fallen upside down in the lower sediment where the coral tissue is destined for mortality. These corals will be harvested in a manner leaving behind large amounts of calcified dead portions of the corals to allow for natural colonization and expansion of the reef. Salvaged coral colonies will be evaluated and monitored and the relative success of the transplants will guide the overall amount of coral used in this effort. Reattachment of broken coral colonies has been used widely as a strategy for restoring reefs and large ship groundings (Bruckner and Bruckner 2001, Schittone 2010). Coral transplantation studies that have been undertaken in Kaneohe Bay, Oahu, have been successful due to the high coral cover, low wave action, and specific water chemistry of the bay, which allows corals transplanted within the bay to thrive (Maragos 1974, Naughton & Jokiel 2001).

Proposed Activities

Restoration Site: He‘eia Watershed

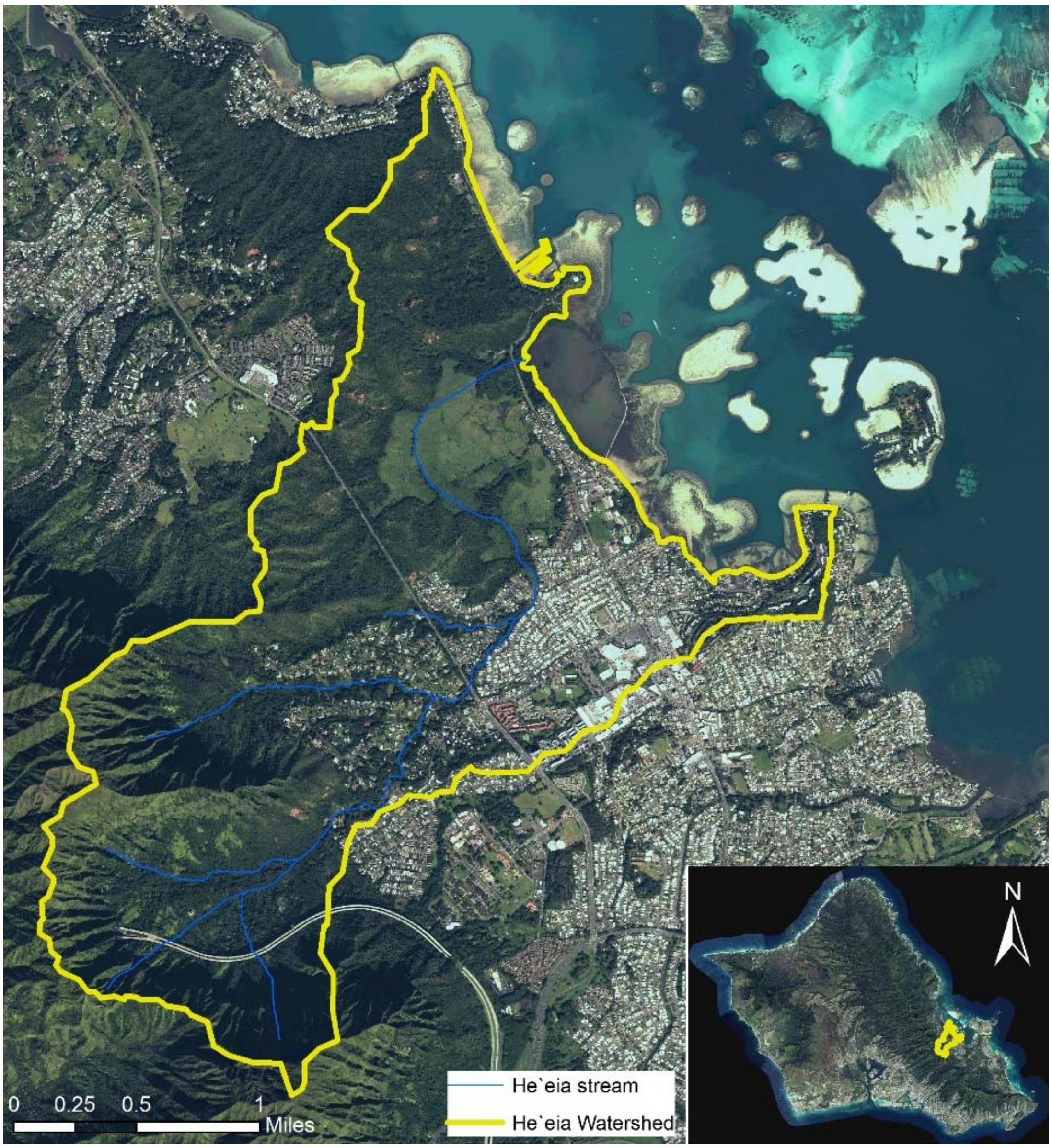

Fig.1. He‘eia watershed, Kāne‘ohe Hawai‘i.

Site Description

He‘eia watershed is located on the windward (north-east) side of O‘ahu and spans approximately 2,800 acres, extending from the Ko‘olau range to the 75 acre He‘eia fishpond where it meets Kāne‘ohe Bay (Fig.1). Prior to western settlement, the watershed was one of the most agriculturally productive areas on O‘ahu. The constant availability of fresh water from mountain springs allowed for kalo (taro), ‘uala (sweet potato), ‘ulu (breadfruit), and mai‘a (banana) cultivation. Traditional Hawaiian agricultural practices had a low impact on the watershed and caused very little erosion compared to the industrialized techniques that arose with the introduction of sugarcane in the mid-nineteenth century. During this time, great networks of irrigation ditches were constructed and land was plowed, flooded, and compressed by farm animals to increase water holding capacity (Devaney et al. 1982, Jokiel 1991). As the sugar industry declined, extensive rice farming emerged as the next commercial crop. From the 1880’s to the 1920’s, terraces, abandoned lo‘i, and unused marshlands were converted to thriving rice paddies, pineapple fields, and cattle grazing, altering the natural landscape of the watershed further. In addition to industrialized agriculture, improved roads leading into Kāne‘ohe from Honolulu brought increased residential development. Population growth and urbanization in the Kāne‘ohe region began to grow in the 1930’s, subsequently leading to increased sedimentation in the bay (Devaney et al. 1982).

The benthic cover of the fringing reef extending out from the He‘eia fishpond follows a general gradient ranging from terrestrial derived fine silt with patches of invasive and native algae and rubble, to sparse coral cover and sand, to high coral cover at the reef edge and slope (Fig.2). The distance between the stream mouth and the fishpond wall to the reef edge ranges from approximately 25 m to 200 m. Corals along the reef edge appear to be in similar condition to those on offshore patch reef sites. Coral cover, especially that of *Montipora capitata, Porites compressa,* and *Pocillopra damicornis*, extends inward on the reef flat for a variable distance but abruptly ends in a line parallel to the reef edge. The highly tolerant coral species *Leptastrea purpurea* is the only exception in coral distribution, growing directly on the fishpond wall and nearby on scattered rubble. Sediment plumes extending from the stream mouth and mākāhā (sluice gate) can be seen in aerial photographs of the area and may influence coral distribution. A distinct band of dead coral lies between the reef slope and the reef flat. Regions of recent dead coral skeletons may have occurred following the 2014 and 2015 widespread bleaching events that caused approximately 20% mortality of corals in Kāne‘ohe Bay.

He‘eia Management

There are several community organizations that manage the He‘eia watershed and adjacent fishpond. These organizations have incredible community support, hosting thousands of students and volunteers to engage in restoration and cultural practices in the watershed and fish pond. Hui o Ko‘olaupoko, Papahana Kuaola, Hui Ku Maoli Ola, and Ke Kula o Samuel M. Kamakau manage the upper watershed and have been carrying out erosion control and riparian replanting projects in the upper He‘eia stream. Kāko‘o ‘Ōiwi manages the lower watershed and are working to restore traditional agriculture practices and ecological productivity. Kāko‘o ‘Ōiwi is partnering with The Nature Conservancy and NOAA to remove the six acres of mangroves in the lower watershed. Paepae o He‘eia manages the fish pond in the lower watershed and estuary; they are working to restore the fishpond wall and enhance fisheries productivity.

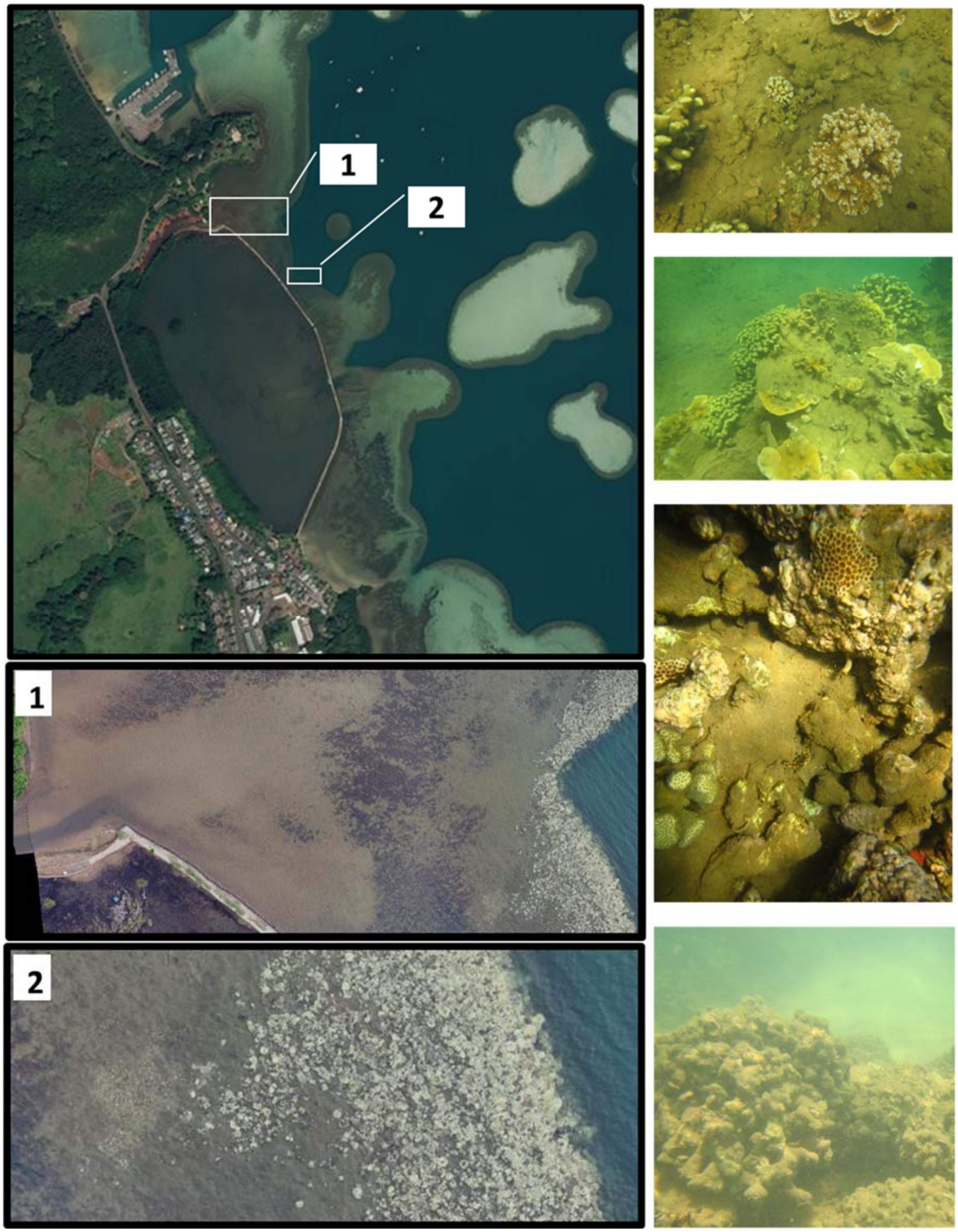
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Fig.2. He‘ei reef and He’eia stream outlet (inset 1). Bleached coral colonies are evident in aerial photos taken in 2015 (inset 1 and 2). Sediment settling on and around the coral colonies at He‘eia reef (right panel).

Restoration Design

The watershed restoration design would be carried out by the U.S. Forest Service National Watershed Restoration Team along with partners at Kāko‘o ‘Ōiwi, USFWS, NOAA, DLNR, TNC, and USGS to accomplish the following design elements:

- Data Compilation: hydrology, stream gauges, peak storm flows, sediment transport, etc.
- Watershed Analysis: identify and locate sediment sources, evaluate stream crossings, map invasive species, evaluate and locate stream diversions, develop and prioritize projects and cost estimates.
- Survey and design: Use existing site plans in addition to LiDAR data, total station site survey, and hydraulic modeling to develop a conceptual restoration design. Hold a series of participatory planning meetings to ensure all restoration objectives are captured in the conceptual plan (e.g. sediment capture and kalo lo‘i production).
- Permit design package: Develop permit package including conceptual wetland and stream design in order to complete permit applications.
- Permitting: Complete any needed permits (e.g. Army Corp of Engineers 404 and 401 permits, NEPA, State permits).
- Contract Package: Develop contract package for restoration implementation including heavy equipment and operators.

Restoration Implementation

The restoration implementation phase will be carried primarily by contractors, U.S. Forest Service Restoration Team and Kāko‘o ‘Ōiwi who will provide oversight and construction management assistance to accomplish the following:

- Native fish relocation: Native fish and invertebrates will be trapped/captured to mitigate impacts during construction. This will occur in the construction areas prior to in-stream/wetland work.

- Stream/Wetland Construction: Work with heavy equipment and operators to implement the restoration design. This will entail the reconstruction and rehabilitation of the lower He‘eia stream channel, floodplain, and wetland using heavy equipment. In addition, scalping and removal of invasive grasses will be carried out.

- Invasive plant removal (e.g. California grass) and riparian planting: This will be an ongoing task of continued replanting and invasive species control.

Monitoring

Watershed Monitoring
Monitoring will occur in coordination with the mangrove removal project where physical and biological features will be measured before, during and after the proposed restoration activities. A full monitoring plan will be developed for trustee approval prior to implementation. Watershed monitoring will encompass stream flow, sedimentation, nutrients, pollutants, biodiversity, native fish presence, invertebrates, macroalgae, and vegetation.

Physical monitoring will entail the following:

- Aerial photo/LiDAR/GIS time series analysis before, during, after restoration
- Stream discharge
- Stream channel and estuary sediment
- Channel morphology

Biological monitoring will be as follows:

- Re-vegetation success
- Fish and aquatic biota
- Terrestrial wildlife

Coral Reef Monitoring
Standardized transect surveys will be conducted by the Division of Aquatic Resources in collaboration with the University of Hawai‘i. Baseline surveys have already been conducted on reefs immediately adjacent to the He‘eia watershed and fixed, long-term study sites have been established. Surveys include fish counts, percent coral estimates, sediment depth, and water chemistry monitoring (a full reef monitoring plan will be provided to the Trustees for review).

Project Partners
Kāko‘o ‘Ōiwi, The Nature Conservancy, U.S. Fish and Wildlife Service, NOAA, U.S. Forest Service, Department of Land and Natural Resources, Hawai‘i Coral Reef Initiative

Timeline
Assuming full funding, the estimated timeline would be two years. Year one would entail planning, design, and permitting phase, with implementation occurring the following year.

Budget

Design	
Personnel	$114,600
Travel	$7,000
Subtotal	$121,600
Implementation	
Equipment	$461,020
Travel	$8,000
Subtotal	$469,020
TOTAL	$590,620

Budget Detail

Budget detail for He‘eia watershed restoration design

DESIGN PHASE		Compile existing WA analyses and hydrologic data	WA Analysis	He'eia Wetland and Stream Corridor Restoration	Wetland and Stream Corridor Restoration Permitting	Contract Package	Implementation Assistance	*Effectiveness Monitoring Assistance*	Total Days/Units	Cost per Hum Expen
	Cost/Day	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Quantity**	**Total**	**Cost**
Watershed Project Lead	$ 920	5	5	7	5	2	15	2	41	$ 37,720
Engr. Civil	$ 920	0	2	5	2	6	0	0	15	$ 13,800
Project Fisheries Bio.	$ 920	7	10	12	7	4	15	3	58	$ 53,360
Hydrologist	$ 920	0	5	2	0	0	0	0	7	$ 6,440
Engr. Tech II	$ 656	0	0	5	0	0	0	0	5	$ 3,280
Travel										$ 7,000
TOTAL										**$ 121,600**

Appendix A

Implementation Budget detail:

Budget detail for He‘eia watershed restoration implementation

Item	#1 Excavator 60,000 lbs	#2 Excavator 80,000 lbs	Rubber Tracked Dumper	#1 Rock Truck	#2 Rock Truck	#1 Dump Truck	#2 Dump Truck	Water Pumps & Turbidity Control	Labor	Planting & Erosion Control (per acre)	Misc. Materials & Supplies		Totals
Cost per Day	$ 2,200	$ 2,600	$ 2,400	$ 2,600	$ 2,600	$ 1,500	$ 1,500	$ 600	$ 850	$ 1,600	$ 1,000	$ -	
Project Phase													
Move in / out													
Days	in/out	in/out	in/out	in/out	in/out	in/out	in/out	in/out	in/out	in/out	in/out	$ -	$ -
Cost	$ 2,000	$ 2,000	$ 1,000	$ 2,000	$ 2,000	$ 200	$ 200	$ 500	$ -	$ -	$ -	$ -	$ 9,900
Lower He'eia Stream Reconstruct/ Estuary Rehab.													
Days	14	14	8	10	10	8	8	8	8	0	2	0	90
Cost	$ 30,800	$ 36,400	$ 19,200	$ 26,000	$ 26,000	$ 12,000	$ 12,000	$ 4,800	$ 6,800	$ -	$ 2,000	$ -	$ 176,000
He'eia Stream Channel and Floodplain Reconstruct above Esturary													
Days	12	12	12	12	12	5	5	8	8	0	4	0	90
Cost	$ 26,400	$ 31,200	$ 28,800	$ 31,200	$ 31,200	$ 7,500	$ 7,500	$ 4,800	$ 6,800	$ -	$ 4,000	$ -	$ 179,400
Riparian Planting and Invasive Plant Species Control													
Days	0	0	6	0	0	0	0	0	15	22	6	0	49
Cost	$ -	$ -	$ 14,400	$ -	$ -	$ -	$ -	$ -	$ 12,750	$ 35,200	$ 6,000	$ -	$ 68,350
Diversion Structure Reconstructio n and Diversion Ditch Rehab.													
Days	2	0	0	0	0	0	0	2	2	0.2	1	0	7.2
Cost	$ 4,400	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,200	$ 1,700	$ 320	$ 1,000	$ -	$ 8,620
Fish Traps													
Days	0	0	0	0	0	0	0	0	15	0	6	0	21
Cost	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 12,750	$ -	$ 6,000	$ -	$ 18,750
Totals	$ 63,600	$ 69,600	$ 63,400	$ 59,200	$ 59,200	$ 19,700	$ 19,700	$ 11,300	$ 40,800	$ 35,520	$ 19,000		**$ 461,020.00**

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September 22, 2017

Trustee group resolution regarding M/V Cape Flattery restoration actions

Bruce S. Anderson
Division of Aquatic Resources
Hawai'i Department of Land and Natural Resources

Michael Fry
Environmental Contaminant Coordinator
Pacific Region
U.S. Fish and Wildlife Service

Mathew Parry, Fishery Biologist
Pacific Islands Region Restoration Center
National Oceanic and Atmospheric Administration

SUBJECT: Trustee group concurrence on M/V Cape Flattery restoration plan amendment.

Under the terms of the Consent Decree that resolved the responsible party's natural resources liabilities in this matter, the Trustees have agreed to jointly make decisions regarding the use of settlement funds for projects.

The Trustees (State of Hawai'i, Division of Aquatic Resources; NOAA Fisheries; U.S. Fish and Wildlife Service) are in concurrence to evaluate the use of funds for initial planning of watershed restoration actions to enhance and recover corals in Kāne'ohe Bay by reducing land-based source of coral stress (sediment, nutrients, freshwater pulses) leading to increased corals. The restoration plan will also evaluate the use of coral outplants to enhance coral recovery on adjacent reefs.

Trustee group resolution regarding M/V Cape Flattery restoration actions pg 2/2

Concurred in by the following as the designated representatives of their agencies:

Bruce S. Anderson, Ph.D., Administrator
Division of Aquatic Resources
Hawai'i Department of Land and Natural Resources

Michael Fry, Ph.D., Environmental Toxicologist
Environmental Contaminant Coordinator
Pacific Region
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Mathew Parry, Ph.D., Fishery Biologist
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