Session 30

Coral bleaching: monitoring, management responses and resilience

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Bleaching and catastrophic mortality of reef-building corals along west Hawai‘i island: findings and future directions

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Abstract In the fall of 2015, leeward reefs of Hawai‘i Island suffered catastrophic coral mortality due to widespread and severe coral bleaching. During this event, the prevalence of coral bleaching and associated health conditions were quantified at 8 permanent monitoring sites from South Kona to North Kohala. Post-bleaching benthic cover was compared at 26 permanent monitoring sites using standardized image analyses. Special surveys were conducted to assess post-bleaching mortality for the coral species, *Pocillopora meandrina* and *Porites evermanni*. Survey results indicated that overall coral bleaching prevalence averaged 53.3%, and resulted in an average coral cover loss of 49.7%. Regional differences in bleaching prevalence and subsequent coral mortality were not detected. High post-bleaching mortality was detected for the coral species, *P. meandrina*, *P. evermanni*, and *Porites lobata*. Analyses are underway to compare site-specific coral morality with available oceanographic, watershed, and reef fish community datasets in order to inform state managers of possible local management strategies.

Keywords: coral bleaching, local management, *Porites lobata*, *Porites evermanni*, *Pocillopora meandrina*, Hawai‘i Island, mass mortality

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Introduction

Large-scale coral bleaching events are increasingly causing mass coral mortality and associated reef declines globally, and will likely intensify in the coming decades (Hoegh-Guldberg et al. 2007; Yara et al. 2014; Schoepf et al. 2015). From August to November 2015, extreme and prolonged thermal stress conditions occurred within West Hawaiʻi coastal waters, with water temperatures exceeding 30° C at several monitoring sites (Eakin 2016; W Walsh pers. comm.). Beginning in August 2015, a massive coral bleaching event affected the majority of coral species across nearshore reef zones from Ka Lae in the north to Upolu Point in the south. The severity of this event was unprecedented for Hawaiʻi Island (Walsh et al. 2013); less severe events in 2006 and 2014 primarily affected the Northwestern Hawaiian Islands (Kenyon and Brainard 2006) and certain areas of the Main Hawaiian Islands (Bahr et al. 2015). To better understand the impact of this event and inform the development of local management strategies, coral bleaching prevalence and severity surveys were conducted just after the forecasted peak thermal stress (Eakin 2016), and post-bleaching coral mortality was assessed post-bleaching in the spring of 2016.

Materials and Methods

Coral bleaching surveys

From 9 October to 13 November 2015, coral bleaching surveys were conducted at 8 permanent monitoring sites (Table 1) using methods described in Couch et al. 2014. Three 10 m^2 belt transects were surveyed per site, and all coral colonies (≥ 5cm diameter) within each belt were scored for bleaching condition and severity, including white bleaching (BL) and pale bleaching (PL). During surveys, a progression of algal turf presence on bleached coral colonies was also scored (TF/BL), and was characterized as a light turf initially colonizing the coral mucus layer, which typically progressed to a denser algal turf assemblage colonizing recent coral mortality (Fig. 1). The severity of bleaching condition and algal turf presence was scored based on the percent of the colony affected. Bleaching prevalence data was tested for normality and homogeneity of variance assumptions, and compared by site and region (north, central, south) using a one-way ANOVA (Minitab 14). A single grab water sample was collected and filtered (Whatman brand, GF/F) at each site adjacent to the reef substrate from 6 November to 1 December 2015, and analyzed at the Univ. of Hawaiʻi at Hilo EPSCoR Analytical Lab for total dissolved phosphorus and total dissolved nitrogen.

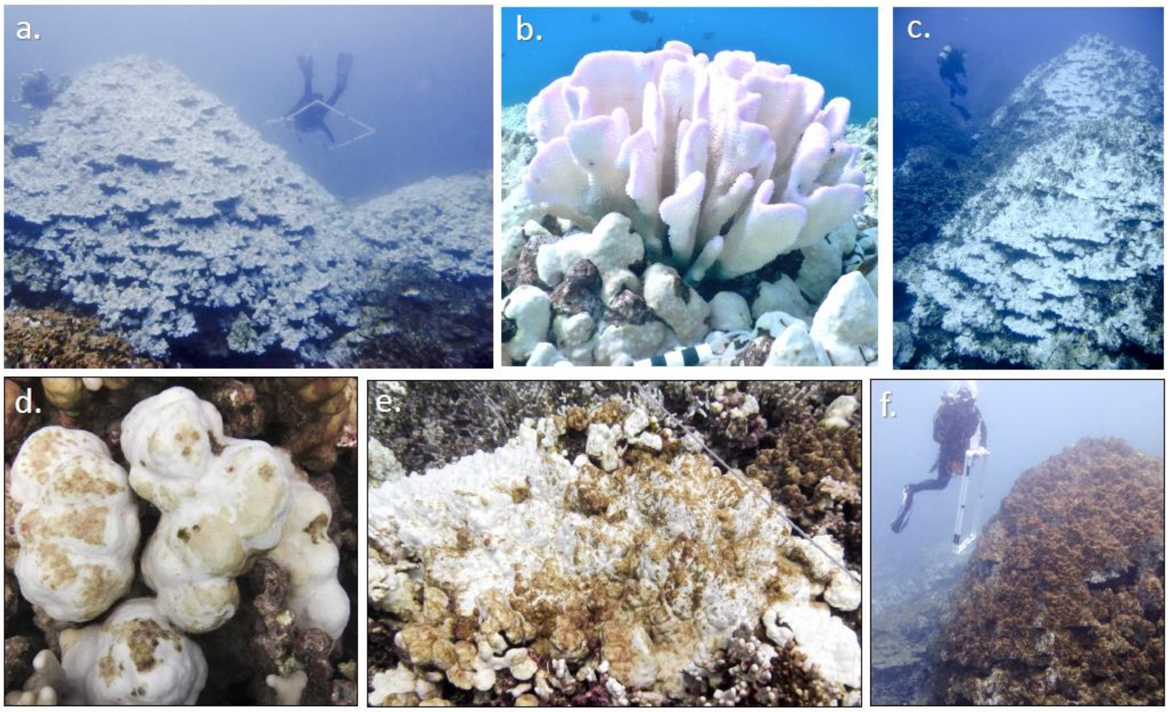

Fig 1 Images from coral bleaching survey sites in West Hawai'i during the fall 2015 coral bleaching event; a) severely bleached *Porites evermanni* colonies at N. Keauhou, b) severely bleached *Pocillopora eydouxi* and *Porites lobata* colonies at Honokōhau, c) initial algal turf colonization on *P. evermanni* at N. Keauhou; d) and e) initial algal turf colonization on *P. lobata* at Honokōhau, and f) algal turf colonization of recently dead *P. evermanni* at N. Keauhou (post-bleaching mortality)

Post-bleaching coral cover surveys

Benthic cover was assessed at 26 permanent monitoring sites from January to April 2016. Benthic images (0.30 m^2) were collected at each meter along four 25 m transects at each site (Table 1). Benthic taxa below 20 stratified random points in each image were identified to the lowest possible taxonomic level using Coral Point Count with Excel extensions (CPCe) software, version 4.1 (Kohler and Gill 2006; Walsh et al. 2013). To estimate post-bleaching mortality, coral cover (%) was compared between 2014 and 2016 for each transect, then averaged for each site. Relative coral cover change (i.e. loss) was calculated for each transect as: $(x = (\frac{\text{2016 coral cover \% } - \text{2014 coral cover \%}}{\text{2014 coral cover \%}})*100)$, and was averaged by site. Change in coral cover (%) between 2014 and 2016 was compared using a paired t-test, and differences in relative coral cover loss between sites and regions were compared using a one-way

Table 1 Results of fall 2015 coral bleaching surveys, and spring 2014 and 2016 benthic cover surveys. Sites are listed from North to South. Change in coral cover is expressed as mean relative coral loss (± SE), and 2014 and 2016 datasets were compared using a paired t-test. Statistical differences in coral cover between 2014 and 2016 are represented as, * $p \leq 0.05$, ** $p \leq 0.005$, and *** $p \leq 0.001$. Significant differences between sites are represented by superscripts ([a, b, c])

Site	Mean Depth (m)	Latitude	Longitude	Coral Bleaching Survey Date	Benthic Cover Survey Dates (2014;2016)	Total Bleaching Prevalence (Mean ± SE %)	Severe Bleaching Prevalence (Mean ± SE %)	Pre-bleaching Coral Cover: 2014 (Mean ± SE %)	Post-bleaching Coral Cover: 2016 (Mean ± SE %)	Relative Coral Loss: 2014-2016 (Mean ± SE %)
Lapakahi	11	20.16000	-155.90018		3/14/2014; 1/13/2016			12.8 % ± 3.1 %	5.6% ± 1.6%	-55.4% ± 11.4% * (a)
Kamilo	11	20.08102	-155.86808		4/14/2014; 1/13/2016			34.9 % ± 1.8 %	17.9% ± 1.6%	-48.7% ± 3.8% *** (ab)
Waiakaʻīlio	14	20.07392	-155.86452	10/20/2015	4/14/2014; 1/13/2016	51.3% ± 2.8%	42.2% ± 2.3%	43.2 % ± 3.8 %	23.7% ± 2.2%	-44.8% ± 3.8% * (abc)
Puakō	10	19.96988	-155.84880	10/23/2015	4/07/2014; 2/04/2016	55.8% ± 5.8%	42.2% ± 4.4%	32.2 % ± 4.5 %	11.0% ± 0.8%	-64.2% ± 4.3% * (a)
Anaeho'omalu	10	19.95275	-155.86617		4/07/2014; 2/04/2016			24.1 % ± 1.5 %	12.3% + 1.4%	-49.2% ± 5.6% ** (ab)
Keawaʻiki	14	19.89112	-155.91007		4/07/2014; 2/04/2016			17.5 % ± 3.1 %	14.7% ± 2.1%	-14.3% ± 6.5% (bc)
Kaʻūpūlehu	12	19.84395	-155.98097		4/14/2014; 4/05/2016			27.0 % ± 6.6 %	14.2% ± 3.9%	-47.6% ± 4.3% * (abc)
Makalawena	10	19.79650	-156.03288		4/14/2014; 2/01/2016			46.1 % ± 3.3 %	24.1% ± 5.9%	-49.3% ± 8.5% ** (ab)
Unualoha Point	12	19.74251	-156.05575		4/14/2014; 2/01/2016			38.8 % ± 3.3 %	18.4% ± 1.7%	-52.7% ± 1.6% ** (a)
Wawaloli Open	10	19.70888	-156.04950		4/04/2014; 1/14/2016			51.3% ± 5.4%	18.6% ± 1.5%	-61.6% ± 7.5% * (a)
Wawaloli FMA	14	19.70001	-156.04991		4/04/2014; 1/14/2016			42.0% ± 3.2%	24.9% ± 2.4%	-40.8% ± 2.4% *** (abc)
Honokōhau	12	19.67098	-156.03033	10/9/2015	4/03/2014; 1/14/2016	47.3% ± 4.7%	36.7% ± 4.1%	53.2% ± 3.4%	26.2% ± 1.0%	-49.9% ± 4.7% * (ab)
Papawai	11	19.64725	-156.02298		2/21/2014; 2/09/2016			47.7% ± 2.5%	18.0% ± 3.4%	-61.6% ± 7.9% * (a)
Old Kona Airport	14	19.16730	-155.91325		2/21/2014; 2/02/2016			57.2% ± 2.0%	26.7% ± 4.6%	-52.9% ± 9.2% * (a)
S. Oneo Bay	11	19.63120	-155.99300	10/16/2015	2/21/2014; 4/05/2016	66.4% ± 10.8%	52.1% ± 6.3%	46.0% ± 3.3%	24.8% ± 4.5%	-45.7% ± 9.5% * (abc)
N. Keauhou	12	19.56838	-155.96935	10/15/2015	4/07/2014; 4/07/2016	45.1% ± 2.5%	32.2% ± 1.0%	31.9% ± 3.9%	16.4% ± 3.0%	-49.8% ± 4.0% *** (ab)
Kualanui Point	11	19.54827	-155.96230		4/01/2014; 3/24/2016			64.5% ± 1.6%	22.2% ± 3.0%	-65.4% ± 5.1% ** (a)
Acropora Gardens	8	na	na		1/17/2014; 4/19/2016			25.0% ± 6.2%	7.4% ± 2.4%	-71.0% ± 6.8% * (ab)
Red Hill	14	19.50528	-155.95288		4/07/2014; 3/24/2016			41.2 % ± 3.9%	17.8% ± 2.6%	-57.3% ± 3.8% ** (a)
Keopuka	11	19.48292	-155.94600		2/21/2014; 2/17/2016			16.8 % ± 3.9%	5.7% ± 1.9%	-68.8% ± 4.2% * (a)
Kealakekua Bay	8	19.47930	-155.93278	10/13/2015	2/21/2014; 2/17/2016	49.2% ± 2.6%	38.5% ± 2.7%	25.7% ± 3.3%	12.1% ± 3.0%	-53.2% ± 8.4% * (ab)
Keʻei	11	19.46282	-155.92680		2/21/2014; 2/17/2016			32.8% ± 2.4%	19.0% ± 2.6%	-41.5% ± 8.3% * (abc)
Kalahiki	11	19.36915	-155.89740	10/27/2015	1/17/2014; 4/07/2016	50.9% ± 3.3%	35.1% ± 5.3%	44.2% ± 3.0%	24.8% ± 4.1%	-42.5% ± 10.6% * (ab)
Auʻ Au, Hoʻokena	14	19.29788	-155.88988		1/17/2014; 3/29/2016			34.2% ± 2.6%	19.6% ± 3.7%	-43.5% ± 8.1% * (abc)
Omakaʻa, Miloliʻi	14	19.16730	-155.91325	11/13/2015	2/21/2014; 3/22/2016	60.4% ± 9.6%	34.9% ± 5.6%	34.1% ± 4.4%	18.1% ± 2.6%	-46.3% ± 5.1% * (abc)
Manukā	12	19.07672	-155.90397		2/21/2014; 3/22/2016			39.4% ± 4.7%	35.3% ± 5.4%	-11.4% ± 5.6% (c)
					Overall Mean	**53.3% ± 2.4%**	**39.1% ± 1.8%**	**37.1% ± 1.4%**	**18.4% ± 0.86%**	**-49.6% ± 1.8% *** **

ANOVA (following assumptions tests) with Tukeys pairwise comparisons at a family error rate of 0.05 (Minitab 14). Change in coral cover for the common coral species, *Porites lobata* and *Porites compressa,* was compared for the 8 coral bleaching survey sites using a paired t-test (Minitab 14), then was qualitatively compared to observed bleaching prevalence to infer whether bleaching recovery had occurred (statistical comparisons were not made due to differing survey methods used to determine bleaching prevalence and change in coral cover).

Species-targeted post-bleaching surveys

Pocillopora meandrina

Based on qualitative observations, severe coral bleaching affected the common coral species, *Pocillopora meandrina*; however, due to low densities at permanent monitoring sites, post-bleaching mortality was not adequately detected for this species using image analysis methods. In December 2015, 8 sites with a high density of *P. meandrina* were selected for rapid health surveys. At each site, a team of two divers surveyed an approximately 10 m wide belt (5 m per diver) for 45 minutes, and scored each observed *P. meandrina* colony with: % bleached, % healthy/live (non-bleached), % new dead (post-bleaching mortality), and % old dead (previous mortality). Old dead colonies were eliminated from analyses, and colony scores were pooled and averaged by site. Based on observations suggesting continued mortality of *P. meandrina*, an additional follow-up survey was conducted at the Kealakekua Bay site in June 2016.

Porites evermanni

Severe coral bleaching was also observed for the locally common coral species, *Porites evermanni*, but mortality was not adequately detected at permanent monitoring sites due to low abundance along transects. To quantify *P. evermanni* post-bleaching mortality, a previously mapped reef area, adjacent to the North Keauhou permanent monitoring site, with a relatively high density of *P. evermanni* colonies was surveyed in June 2016. A team of 4 divers swam in an irregular belt pattern to score each colony, including maximum diameter, height, and % live coral tissue. Live *P. evermanni* surface area was compared to the results of the 2014 mapping survey, and mean % live coral tissue was compared between years using a t-test (Minitab 14).

Results

Coral bleaching surveys

Overall mean coral bleaching prevalence (including corals ≥ 5 cm with pale or white bleaching) was 53.3 % ± 2.4 % (mean ± SE), and ranged from 45.1 % ± 2.5 % (N. Keauhou) to 66.4 % ± 10.8 % (S. Oneo) (Table 1). Severe coral bleaching prevalence (including corals ≥ 5 cm with ≥ 25% of a colony exhibiting white bleaching) was 39.1 % ± 1.8 %, and ranged from 32.2 % ± 1.0 % (N. Keauhou) to 52.1 % ± 6.3 % (S. Oneo). Significant differences among sites or regions (north, central, and south) were not detected for total or severe coral bleaching prevalence. Based on coral mortality estimates obtained from pre- and post-bleaching coral cover surveys, coral bleaching severity may have continued to increase post-survey.

The prevalence of severe (> 50% of colony affected) algal turf colonization of bleached corals, characterized as light mucus layer colonization progressing to a denser colonization of recent coral mortality, ranged from 5.1 % ± 1.5 % (Honokōhau) to 14.2 % ± 4.2 % (Puakō). Algal turf colonization of bleached colonies was weakly positively correlated with total dissolved nitrogen (TDN) (Pearson correlation= 0.660, p=0.075). TDN ranged from 2.5 µm, (Waiakaʻīlio) to 47.8 µm (S. Oneo). No relationship was detected between algal turf colonization prevalence and total dissolved phosphorus (TDP), which was primarily non-detected values (< 0.5 µm), with a single detected value at N. Keauhou (0.75 µm).

Post-bleaching coral cover surveys

As a result of post-bleaching mortality, West Hawaiʻi monitoring sites had a significant loss in coral cover, averaging -49.6 % ± 1.8 % between 2014 and 2016 (p ≤ 0.001) (Table 1). A significant loss in coral cover was observed at 22 of 24 total survey sites. Only two sites, Keawaʻiki (-14.3 % ± 6.5%) and Manukā (-11.4 % ± 5.6%) did not have a significant loss in coral cover following the 2015 bleaching event. Mean relative coral cover loss ranged from -11.4 % ± 5.6 % (site Manukā) to -71.0 % ± 6.8% (site Acropora Gardens), and significant variation among sites was only detected for two sites, both with the least relative coral cover loss; sites Manukā (-11.4 % ± 5.6 %) and Keawaʻiki (-14.3% ± 6.5%) (Table 1). Relative coral cover loss exceeded -60.0 % at six sites including sites Puakō, Wawaloli (Open), Papawai, Kualanui Point, Acropora Gardens, and Keopuka (Table 1). Regional differences were not significant, with similar mean relative coral cover loss for north (-46.7 % ± 3.2 %), central (-53.5 % ± 2.7 %) and south sites (-49.2 % ± 3.0 %) in West Hawai‘i.

A significant decline in live cover (%) from 2014 to 2016 as a result of post-bleaching mortality was detected for species, *Porites lobata* and *P. compressa*, with a mean relative loss in *P. lobata* cover of -55.7 % ± 4.7 % ($p \leq 0.001$), and a mean relative loss in *P. compressa* cover of -32.9 % ± 4.7 % ($p \leq 0.001$) (Table 2). Change in coral cover was qualitatively compared to coral bleaching prevalence to infer possible coral bleaching recovery. For *P. lobata*, minimal bleaching recovery likely occurred with similar bleaching prevalence (58.0 % ± 4.1 %) and post-bleaching mortality (-55.7 % ± 4.7 %) observed. For the endemic coral species, *P. compressa*, partial bleaching recovery may have occurred, with bleaching prevalence averaging 54.3 % ± 4.3 % and mean relative coral cover loss averaging -32.9 % ± 4.7 %. Notably, for one survey transect (site Makalawena- transect D), a large assemblage of the coral species, *Porites rus,* bleached severely in 2015, then regained normal tissue coloration in 2016. Loss in coral cover (%) of *P. rus* was not detected along this transect (2014 = 28.9%; 2016 = 27.0%), and recovery was also noted for the expansive *P. rus* assemblage surrounding this transect, suggesting that this species may have relatively higher thermal-stress tolerance.

Species-targeted post-bleaching surveys

Pocillopora meandrina

Severe post-bleaching mortality was documented for the coral species, *P. meandrina* (Table 3). The mean proportion of colonies with partial post-bleaching mortality (≥ 5% tissue loss) averaged 95.5% ± 2.7% and colonies with total post-bleaching mortality (= 100% tissue loss) averaged 77.6 % ± 6.7. On average, only 2.9 % ± 1.6 % of colonies had ≥ 90% non-bleached live tissue present during the December 2015 survey. A follow-up survey in May 2016 at the Kealakekua Bay site indicated that the proportion of *P. meandrina* colonies with total post-bleaching mortality had further increased to 88.9 %. Focused predation by the corallivorous snail, *Drupella* spp., and the Crown-of-Thorns starfish, *Acanthaster planci*, on surviving *P. meandrina* colonies was observed at Kealakekua Bay and other sites, and likely contributed to continued mortality of *P. meandrina* after the bleaching event.

Table 2 Change in coral cover (%) from 2014 to 2016 for the common coral species, *Porites lobata* and *P. compressa* (mean ± SE), following the 2015 coral bleaching event. Coral bleaching prevalence for each species was determined during fall 2015 bleaching surveys. Statistical differences in coral cover (%) by species from 2014 to 2016 are represented as, * $p \leq 0.05$, ** $p \leq 0.005$, and *** $p \leq 0.001$

Site	*P. lobata* pre-bleaching cover: 2014 (%)	*P. lobata* post-bleaching cover: 2016 (%)	*P. lobata* bleaching prevalence (%)	Relative change in *P. lobata* cover (%)	*P. compressa* pre-bleaching cover: 2014 (%)	*P. compressa* pre-bleaching cover: 2016 (%)	*P. compressa* bleaching prevalence (%)	Relative change in *P. compressa* cover (%)
Waiakaʻīlio	27.9% ± 2.6%	11.9% ± 1.2%	52.4% ± 1.0%	-57.5% ± 2.6% **	14.1% ± 1.5%	11.3% ± 1.4%	67.0% ± 2.7%	-19.2% ± 6.8%
Puakō	20.7% ± 3.0%	5.6% ± 2.2%	59.1% ± 11.0%	-73.2% ± 7.8% *	10.8% ± 3.3%	4.8% ± 1.6%	66.9% ± 9.0%	-57.5% ± 13.1%
Honokōhau	31.2% ± 2.5%	11.0% ± 1.3%	48.1% ± 4.1%	-64.2% ± 4.7% **	20.4% ± 1.6%	15.0% ± 1.5%	42.6% ± 7.3%	-26.7% ± 3.4% **
S. Oneo	23.7% ± 5.0%	9.0% ± 1.4%	69.9% ± 15.7%	-59.3% ± 5.9% *	18.7% ± 1.6%	13.6% ± 3.5%	84.5% ± 6.2%	-27.2% ± 15.6%
N. Keauhou	9.2% ± 1.9%	7.4% ± 1.2%	50.3% ± 13.6%	-10.0% ± 25.4%	22.2% ± 4.1%	8.9% ± 1.8%	50.4% ± 12.3%	-59.7% ± 6.1% *
Kealakekua Bay	15.6% ± 2.9%	5.5% ± 1.4%	40.4% ± 1.6%	-65.6% ± 7.7% *	8.9% ± 3.3%	6.3% ± 3.1%	49.3% ± 3.3%	-33.6% ± 12.6% *
Kalahiki	27.7% ± 4.5%	9.9% ± 2.1%	60.4% ± 15.4%	-61.9% ± 9.4% *	15.9% ± 2.2%	13.9% ± 5.2%	34.1% ± 10.5%	-17.7% ± 20.1%
Omakaʻa Bay	18.2% ± 1.7%	8.3% ± 0.5%	81.6% ± 6.0%	-53.9% ± 2.9% *	12.1% ± 3.4%	9.0% ± 2.8%	43.6% ± 14.1%	-21.5% ± 10.8%
Overall Mean	**21.8% ± 1.6%**	**8.6% ± 0.6%**	**58.0% ± 4.1%**	**-55.7% ± 4.7% *** **	**15.4% ± 1.2%**	**10.3% ± 1.1%**	**54.3% ± 4.3%**	**-32.9% ± 4.7% *** **

Table 3 Results of Dec. 2015 post-bleaching coral surveys targeting the coral species, *Pocillopora meandrina*. The proportion of colonies with ≥ 90% non-bleached tissue, ≥ 5% post-bleaching mortality, and 100% post-bleaching mortality are presented. Overall means were weighted according to the number of colonies surveyed at each site

Site	Survey Date	Mean Depth (m)	Colonies Surveyed	Latitude	Longitude	Proportion of colonies with ≥ 90 % non-bleached live tissue present	Proportion of colonies with partial post-bleaching mortality (≥ 5 % tissue loss)	Proportion of colonies with total post-bleaching mortality (= 100% tissue loss)
Mahukona	12/18/2015	3	**131**	20.18354	-155.90079	5.1%	92.3%	35.9%
South Mahaiʻula	12/16/2015	16	**390**	19.78270	-156.05264	11.5%	80.8%	67.6%
Keahole Point	12/16/2015	6	**546**	19.72657	-156.06114	0.7%	98.8%	91.9%
Papawai Bay	12/16/2015	7	**504**	19.64725	-156.02298	0.3%	99.4%	90.5%
Kealakekua Bay	12/15/2015	3	**267**	19.47992	-155.93306	3.1%	96.5%	74.9%
North Keopuka	12/15/2015	3	**315**	19.48836	-155.95065	0.8%	99.6%	82.7%
ʻAuʻAu Crater	12/15/2015	11	**214**	19.29808	-155.88931	0.7%	99.3%	52.1%
			2367	**Overall Mean (weighted)**		**2.9% ± 1.6%**	**95.5% ± 2.7%**	**77.6% ± 6.7%**

Kealakekua Bay (Resurvey)	5/24/2016	3	19.47992	-155.93306	**0.4%**	**97.3%**	**88.9%**

Porites evermanni

Following the bleaching event, total live surface area of *P. evermanni* decreased from 1879 m^2 to 140.2 m^2, a loss of approximately 92.5% of live coral cover, and live colony size frequency was severely truncated (Fig. 2), with only 41 live colonies observed in 2016 and total mortality observed for the largest size classes of colonies (> 20 m^2 surface area). Mean colony live tissue (%) decreased significantly from 2014 to 2016 ($p \leq 0.001$), averaging 81.7 % ± 0.7 % mean live tissue for 193 live colonies in August 2014, and 3.1 % ± 0.8 % mean live tissue for 41 colonies in June 2016. The catastrophic mortality of this species, which was also observed qualitatively in other reef areas of West Hawaiʻi, resulted in the loss of numerous exceptionally old and large colonies (Figs. 1 and 2).

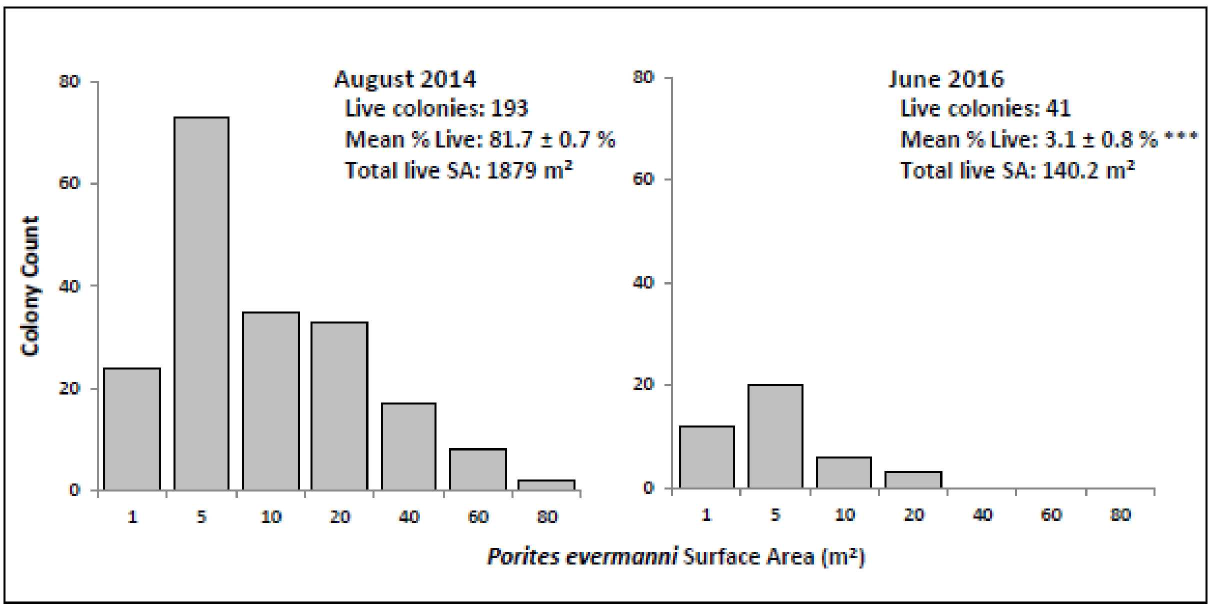

Fig 2 Results of the August 2014 and June 2016 surveys of an approximately 300m x 200m reef area adjacent to the N. Keauhou permanent monitoring site, with a high density of the coral species, *Porites evermanni*. Size and percent live tissue for *P. evermanni* colonies were scored at a survey depth of 8-15 m. (*** $p \leq 0.001$)

Discussion

The 2015 coral bleaching event resulted in catastrophic coral mortality for West Hawaiʻi reefs, with a loss of approximately half of the total stony coral cover present in 2014. This study documents a significant loss in coral cover at 22 of 24 permanent monitoring sites, with 6 sites experiencing a relative coral cover loss of more than 60%. Natural coral recovery from this event will likely require decades of recruitment and regrowth in order to resemble previous coral assemblages, and the effects of this massive-scale habitat loss on coral-associated reef species will be elucidated in the coming years.

Catastrophic loss in live cover was documented for the locally common, massive coral species, *P. evermanni*, and for the formerly abundant species, *P. meandrina*. For *P. meandrina*, continued mortality was documented after the bleaching event, due in part to *Drupella* spp. and *A. planci* predation, suggesting that coral predator management may be an important consideration for enhancing post-bleaching coral recovery.

Based on the comparison of bleaching prevalence data with coral cover changes, minimal bleaching recovery occurred for the common coral species, *Porites lobata*, while the endemic coral species, *P. compressa*, had lower post-bleaching mortality relative to bleaching prevalence, and may have partially recovered. A large bleached assemblage of *P. rus* (documented for a single transect and the surrounding reef area), regained a healthy coloration following the 2015 bleaching event with minimal coral cover loss. This evidence of thermal stress tolerance for *P. compressa* and *P. rus* could play a role in structuring future coral communities in West Hawai‘i, as seasonal elevated water temperatures will likely continue to drive changes in reef composition.

Seasonal algal turf colonization, presumably within the coral mucus layer, was previously observed in West Hawai‘i for the coral species, *Porites evermanni*, with initial algal turf colonization (and concurrent coral tissue paling) occurring during the late summer months, followed by mucus/turf sloughing and coral recovery in subsequent cooler months (L Marrack, pers. comm.). In this study, the initial light algal turf colonization on bleached coral colonies was presumed to be a similar state of mucus colonization; however, minimal sloughing and recovery of normal coral tissue coloration was observed following the 2015 bleaching event, except for a single documented example, which occurred on a monitored colony of *P. evermanni* at Kawaihae (J Henshaw and R Most, pers. comm.). In this study, the weak positive association of TDN with algal turf colonization prevalence on bleached coral colonies suggests that coastal watersheds may be an important consideration for local management during and after a bleaching event (Wooldridge and Done 2009; Wiedenmann et al. 2013), and highlights the need for more comprehensive water quality sampling, particularly for sites with minimal watershed information.

Future analyses of coral bleaching and mortality datasets will include comparisons with available oceanographic (sea surface temperature, light stress damage indices), watershed (nutrients), and reef fish assemblage datasets available for each site (Williams et al. 2008; Eakin 2016; PIFSC 2016). Findings will be used to inform local managers of best practices to promote coral recovery from this and future bleaching events.

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