

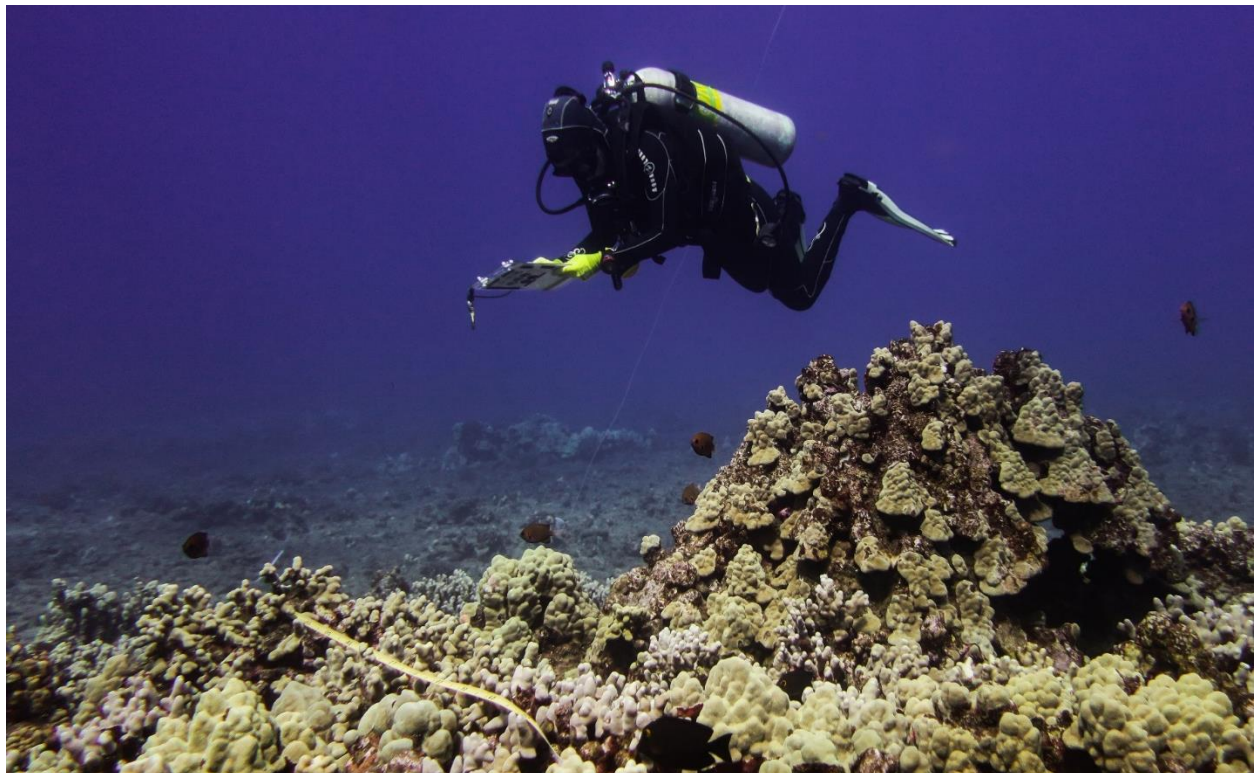
Coral Bleaching Surveys Standard Operating Protocol

NOAA ECOSYSTEM SCIENCES DIVISION FALL 2019

Overview

In collaboration with the Hawaii Coral Bleaching Collaborative, NOAA's Ecosystem Sciences Division is joined a multi-institution effort to document the extent and severity of coral bleaching in the main Hawaiian Islands. The goal was to lay the groundwork for tracking coral response and recovery through time by rapidly assessing bleaching stress in as many of Hawaii's coral reefs as possible. Data from NOAA will be collated with similar data collected by partners throughout the state to determine the severity and extent of the Fall 2019 bleaching event. This dataset can provide insight as to which factors enhance coral resilience to bleaching, identify where coral appear most susceptible to bleaching, and inform active intervention and emerging restoration methods to help maintain Hawaii's corals into the future.

In addition to rapid surveys to assess bleaching stress, NOAA Ecosystem Sciences Division also conducted Structure-from-Motion (SfM) photogrammetry surveys at fixed sites, which were surveyed previously in 2019 prior to the bleaching event. These reef mosaics offer a detailed picture from which it can be assessed how individual coral colonies endure, succumb, or potentially recover from bleaching stress. This SOP describes the methods used by the NOAA Ecosystem Sciences Division to 1) conduct rapid visual assessment bleaching surveys, 2) execute SfM surveys at fixed sites, and 3) collect and classify photoquadrat imagery.



Gear Required

Topside	Underwater
GPS unit loaded with: <ul style="list-style-type: none">● random site coordinates● fixed site coordinates	One 30-m transect tape
Site list of coordinates	Surface marker float with 50-m dive reel
Site map	Photoquadrat monopod
Dive and Navigation Information datasheet	Canon G9x camera in housing
Randomized list of depths per depth strata	Small gray card
	Bleaching survey data sheet
	Underwater slate
	<i>For fixed sites, also bring:</i>
	Drum
	Canon SL2 camera
	Large gray card
	SfM datasheet
	Scale bars
	Rebar caps

Site Selection

Rapid visual assessment surveys can be done at any site (including fixed sites). The objective was to assess bleaching extent and severity quickly and at as many sites as possible using this protocol. Site selection described below is the approach used by NOAA ESD and it not a requirement to execute a rapid assessment.

Random sites

Random sites were stratified by existing RAMP depth bins (deep, moderate, and shallow) and consolidated, hard bottom habitat. Sites were named with a site ID (combination of a standard 3-letter island code and a 4-number site code preceded by a “B”; i.e. OAH-B1908).

Upon arrival at each random site, a small boat depth sounder was used to record the depth of the random point at the site. Divers used depth sounder’s depth as the target depth for the transect placement. If possible, divers inspected the site from the surface by snorkeling to determine whether the substrate at the survey location was reef habitat with a minimum of 25% hard bottom habitat. Surveys were not conducted in sand habitats. If no suitable reef habitat is found, the site was aborted and the team relocated to the next site.

If the site depth needed to be adjusted, for example, because the original GPS coordinates position the site in the wrong depth stratum, divers referred to the list of random depths for

each depth strata rather than choosing the depth. Topside, the new site coordinates were recorded on the GPS unit while noting the original coordinates and the depth.

Divers worked with the small boat coxswain to log waypoint on the GPS unit while the divers were conducting the survey (label the new waypoint with the sites name followed by the letter A). The GPS coordinates for the site location were recorded on the Dive and Navigation Information Sheet, along with habitat type, and other site information at the end of each dive. When uploading GPS points at the end of the field day, the “A” was removed from the site names.

Reef Habitat Type	Code
Aggregate reef	AGR
Aggregate patch reef	APR
Aggregate patch reefs	APS
Pavement	PAV
Pavement with patch reefs	PPR
Pavement with sand channels	PSC
Boulder/rock	ROB
Reef rubble	RRB
Spur and groove	SAG

Fixed Sites

Fixed sites that were surveyed during NOAA’s Hawaiian Reef Assessment and Monitoring Program (HARAMP) mission in 2019 were re-surveyed during the bleaching surveys. These included both NOAA ESD fixed OCC (Oceanography and Climate Change team) sites and Scripps Institute of Oceanography (SIO) fixed sites. OCC sites were relocated by searching for conspicuous instrument deployments. SIO sites often were identified by a rebar stake. Survey teams used site notes and orthophotos from HARAMP or other means to locate the fixed site plot and plot center. If there was difficulty in relocating the fixed site, notes were taken on the Dive Navigation sheet.

Fixed site names remained constant from HARAMP 2019.

Survey Methods

Rapid Visual Bleaching Assessments

If conducting Rapid Assessment at a fixed site, do the rapid assessment after collecting SfM imagery. Start the transect tape at the edge of the spiral for greatest overlap of photoquadrats and SfM imagery.

- Topside, take a picture using the photoquadrat camera (Canon G9x camera) of the coral bleaching datasheet with site ID clearly visible
- After descending to the site, diver 1 ties off pam float
- Diver 1 (coral bleaching surveyor) lays out 30m transect line along depth contour
- Diver 2 (photoquadrat photographer; no coral ID skills needed): grey balances camera, takes a photo of the grey card for future use in post-processing imagery, and follows Diver 1 taking photographs 1m above the substrate every meter with the Canon G9x for a total of 30 photos.
- Diver 1 returns to the 7 meter mark on the transect, hovers a few meters above the substrate, and conducts a visual survey covering a 7m radius cylinder. If visibility is limited, the surveyor should swim around the cylinder to best estimate coverage
- *Coral bleaching survey metrics recorded (see sample datasheet below):*
 - For the entire cylinder, record:
 - Percent live coral cover for reef **overall**
 - Percent of coral cover that is bleached (any severity)
 - Average severity of bleached cover
 - For the **5** most abundant taxa in the cylinder, record:
 - Percent live cover of the taxa - the cover for each taxon should equal the recorded total live coral cover for the reef
 - Percent of taxa cover that is bleached (any severity)
 - Average severity of bleached cover
 - Maximum severity of bleached cover
 - Cover is scored to nearest 5%, or nearest 1% when less than 10% or greater than 90%
 - Average bleaching severity is scored from 1-4:
 - 1 = Starting to pale
 - 2 = Most of colonies have significant pigmentation loss
 - 3 = Most colonies bleached white
 - 4 = Most colonies experiencing bleaching mortality
- Diver 2 reels up the tape while Diver 1 completes the coral assessment

CORAL BLEACHING OBSERVATIONS

ISLAND: <u>044</u>	DATE: <u>10/8/19</u>	DEPTH (ft): <u>32-36</u>	HABITAT TYPE: <u>PSC</u>
SITE: <u>3084</u>	DIVER: <u>BNA</u>	GPS ID: <u>A</u>	WAYPOINT ID: <u>B3084</u>
LATITUDE: <u> </u>	LONGITUDE: <u> </u>	IMAGERY COLLECTED:	
AREA SURVEYED (m ²): <u>~150m²</u>		<input checked="" type="checkbox"/> PHOTOQUADS <input type="checkbox"/> SfM	

% TOTAL CORAL COVER: <u>20%</u>	% OF TOTAL CORAL BLEACHED: <u>5%</u>	AVERAGE BLEACHING SEVERITY (1-4): <u>1</u>
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DOMINANT CORAL TAXA

TAXON*	PLUT	PL03	PMEA	MPAT	MCAP
% COVER	<u>5%</u>	<u>5%</u>	<u>3%</u>	<u>5%</u>	<u>34.2%</u>
% BLEACHED	<u>20%</u>	<u>20%</u>	<u>10%</u>	<u>50%</u>	<u>50%</u>
AVE / MAX SEVERITY (1-4)	<u>1 / 4</u>	<u>1 / 4</u>	<u>0 / 1</u>	<u>1 / 2</u>	<u>1 / 2</u>

* Identify to finest taxonomic resolution possible

NOTES:
DIVE 4

Sample coral bleaching datasheet.

Fixed Site Structure-from-Motion Surveys

- Diver 1 goes to center of the plot and holds drum upright and still.
- Diver 2 attaches camera to line and swims away from Diver 1 until the line is unspooled from the drum.
- Diver 2 grey balances Canon SL2 camera, shoot the datasheet with the site ID visible, and shoot the 'sky'/blue water. While shooting the benthos, Diver 2 swims in circles of decreasing diameter as the line wraps around the drum, until very close to Diver 1. Diver 2 then untethers the camera from the line and Diver 1 moves away from the center of the circle so Diver 2 can image the center of the plot.
- Divers swap roles. Diver 1 re-tethers the camera and swims back out until the line is unspooled and begins swimming in the opposite direction while Diver 2 holds the drum. Diver then shoots sky/blue water to indicate the end of the survey.
- Diver 1 untethers camera and Diver 2 spools the loose line around the drum.
- The rapid visual assessment for bleaching as described above is conducted, starting the transect tape at the outer edge of the spiral and running the tape across the diameter of the spiral.

Photoquadrat Imagery Analysis

Photographs were analyzed using CoralNet, an online repository and resource for benthic image analysis maintained by the University of California, San Diego (Beijbom *et al.* 2015). Ten points were randomly overlaid on each image, and the benthic component under each point was identified to the lowest possible taxonomic level (see table below for full labelset). Coral taxa were identified to the species level when possible, note that two labels exist for each coral taxon: a bleached and non-bleached option. Percent cover of live coral cover and percent of coral cover that was bleached, for overall coral cover and for the five most dominant taxa, was calculated per site.

Full list of ESD Hawaii Bleaching source labels and short codes by functional group.

Short Code	Name	Function Group
*ASPP	CRED-Asparagopsis spp	Algae
*AVSP	CRED-Avrainvillea spp	Algae
*BGMA	CRED-Blue-green macroalga	Algae
*BRMA	CRED-Brown macroalgae	Algae
*CAUL	CRED-Caulerpa spp	Algae
*DICO	CRED-Dictyopteris/Dictyota spp	Algae
*DICT	CRED-Dictyosphaeria spp	Algae
*EMA	CRED-Encrusting macroalgae	Algae
*GRMA	CRED-Green macroalgae	Algae
*HALI	CRED-Halimeda spp	Algae
*LOBO	CRED-Lobophora spp	Algae
*MICR	CRED-Microdictyon spp	Algae
*NEOM	CRED-Neomeris spp	Algae
*PADI	CRED-Padina spp	Algae
*PESP	CRED-Peyssonnelia spp	Algae
*RDMA	CRED-Red macroalgae	Algae
*UPMA	CRED-Upright macroalgae	Algae
*ACYT	Acropora cytherea	Hard coral
*ACYT_BL	Acropora cytherea bleached	Hard coral
*AGEM	Acropora gemmifera	Hard coral
*AGEM_BL	Acropora gemmifera bleached	Hard coral
*COCE	Cyphastrea ocellina	Hard coral
*COCE_BL	Cyphastrea ocellina bleached	Hard coral
*CORAL	Coral	Hard coral
*CORAL_BL	Coral bleached	Hard coral
*LBEW	Leptastrea bewickensis	Hard coral
*LOSC	Lobactis scutaria	Hard coral
*LOSC_BL	Lobactis scutaria bleached	Hard coral
*LPUR	Leptastrea purpurea	Hard coral
*LTRA	Leptastrea transversa	Hard coral

*MCAP	Montipora capitata	Hard coral
*MCAP_BL	Montipora capitata bleached	Hard coral
*MFLA	Montipora flabellata	Hard coral
*MFLA_BL	Montipora flabellata bleached	Hard coral
*MPAT	Montipora patula	Hard coral
*MPAT_BL	Montipora patula bleached	Hard coral
*PCOM	Porites compressa	Hard coral
*PCOM_BL	Porites compressa bleached	Hard coral
*PDAM	Pocillopora damicornis	Hard coral
*PDAM_BL	Pocillopora damicornis bleached	Hard coral
*PDUE	Pavona duerdeni	Hard coral
*PDUE_BL	Pavona duerdeni bleached	Hard coral
*PGRA	Pocillopora grandis (eydouxi)	Hard coral
*PGRA_BL	Bleached Pocillopora grandis (eydouxi)	Hard coral
*PLIG	Pocillopora ligulata	Hard coral
*PLIG_BL	Pocillopora ligulata bleached	Hard coral
*PLOB	Porites lobata	Hard coral
*PLOB_BL	Porites lobata bleached	Hard coral
*PLUT	Porites lutea	Hard coral
*PLUT_BL	Porites lutea bleached	Hard coral
*PMAL	Pavona maldivensis	Hard coral
*PMAL_BL	Pavona maldivensis bleached	Hard coral
*PMEA	Pocillopora meandrina	Hard coral
*PMEA_BL	Pocillopora meandrina bleached	Hard coral
*PMON	Porites monticulosa	Hard coral
*PMON_BL	Porites monticulosa bleached	Hard coral
*PNIE	Psammocora nierstraszi	Hard coral
*PRUS	Porites rus	Hard coral
*PRUS_BL	Porites rus bleached	Hard coral
*PSTE	Psammocora stellata	Hard coral
*PVAR	Pavona varians	Hard coral
*PVAR_BL	Pavona varians bleached	Hard coral
*CCAH	CRED-CCA growing on hard substrate	Hard Substrate
*CCAR	CRED-CCA growing on rubble	Hard Substrate
*HARD	CRED-Hard substrate	Hard Substrate
*RUB	CRED-Rubble substrate	Hard Substrate
*TURFH	CRED-Turf growing on hard substrate	Hard Substrate
*TURFR	CRED-Turf growing on rubble	Hard Substrate
*MOBF	CRED-Mobile fauna	Other
*SHAD	CRED-Shadow	Other
*TAPE	CRED-Tape	Other
*UNK	CRED-Unclassified/Unknown	Other
*WAND	CRED-Wand	Other

*AMNE	CRED-Anemone	Other Invertebrates
*ANTI	CRED-Wire and black coral	Other Invertebrates
*BI	CRED-Bivalve	Other Invertebrates
*BRY	CRED-Bryozoan	Other Invertebrates
*OCTO	CRED-Octocoral	Other Invertebrates
*SP	CRED-Sponge	Other Invertebrates
*TUN	CRED-Tunicate	Other Invertebrates
*UI	CRED-Unclassified sessile invertebrate	Other Invertebrates
*ZO	CRED-Zoanthid	Other Invertebrates
*SED_SAND	Sand and sediment	Soft Substrate