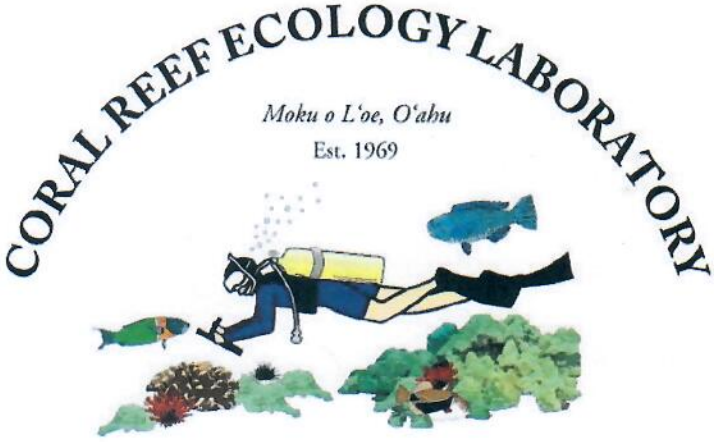
Hanauma Bay Biological Carrying Capacity Survey
2020/21 Annual Report

For:
City and County of Honolulu
Parks and Recreation Department
Hanauma Bay Nature Preserve
Honolulu, Hawai'i

Location:
100 Hanauma Bay Road
96825



HAWAIʻI INSTITUTE OF MARINE BIOLOGY
University of Hawai'i

Prepared for:
City and County of Honolulu: Parks and Recreation
Hawai'i Board of Land and Natural Resources

Prepared by:
Sarah J. L. Severino M.Sc.
Ku'ulei S. Rodgers Ph.D.
Andrew Graham
Anita Tsang
Yuko Stender M.Sc.
Matthew Stefanak

University of Hawai'i: Hawai'i Institute of Marine Biology
Coral Reef Ecology Laboratory/Coral Reef Assessment and Monitoring Program

June 2021

Environmental parameters such as wind direction and speed, wave direction and speed, tidal flux and swell are influential drivers in water clarity on reefs. Water clarity was also influenced by the number of visitors in each sector (Hanauma Bay Carrying Capacity Report 2018/19). During the COVID-19 closure, the most influential parameters on water clarity were tidal coefficient, mean wave period and wave height (Table 15). However, results are not intuitive for tidal coefficient and mean wave period, where the correlation showed an increase in water clarity as these two variables increase. The only strong significant correlation was the decrease in water visibility observed with increasing wave height (correl.coef: -0.202, $p<0.005$). After the reopening of Hanauma Bay to visitors, a similar unexplainable strong positive correlation with increased wind speed and increased water clarity was present. The strongest correlation with water clarity showed a decrease in water clarity as the visitor box office counts increased (correl.coef: -0.346, $p<0.001$, Table 15). However, a weaker significant correlation was seen between increasing the number of people in each sector at the time surrounding the water clarity measurement and increasing water clarity (correl.coef: 0.146, $p<0.05$, Table 15). Principal Components Analysis (PCA) and General Linear Models , provided with the similar results. PCA results explain box office counts, swimmer counts, wave direction, and mean wave period are responsible for the majority of variation in the data.

Table 15. Results of a non-parametric Kendall's tau correlation test between secchi distance human counts and environmental variables (* indicates a significant correlation ($p<0.05$)).

		Box Office Counts	Swimmer and Wader Counts	Tidal Coefficient	Wind Speed	Wind Direction	Wave Height	Wave Direction	Mean Wave Period
COVID-19 closure 2020	Correlation Coefficient			0.247*	0.175*	-0.07	-0.202*	0.147*	-0.244*
	Sig. (2-tailed)			0.001	0.013	0.324	0.004	0.038	0.001
Reopening (2020/21)	Correlation Coefficient	-0.346*	0.146*	0.051	0.307*	0.137	-0.056	-0.11	0.123
	Sig. (2-tailed)	<0.001	0.04	0.492	<0.001	0.066	0.456	0.138	0.099

Megafauna: Monk Seals

The goal of this study was to quantify the presence of the endangered Hawaiian monk seal at Hanauma Bay in the presence and absence of visitors to determine if visitor presence affects habitat use by monk seals.

Methods

Presence or absence of monk seals were documented over 19 days in 2018 when HBNP was open to the public and 29 days during the COVID-19 closure to the public in 2020 (4/28/20-12/1/20) and 13 days following the reopening of the Bay to the public. The number of monk seals present on each day was recorded along with time, location and activity (Appendix G).

An Independent-Samples Kruskal-Wallis Test was performed on non-normal data to determine any significant differences between the number of monk seals observed pre-closure, during the COVID-19 closure and after the reopening of the Bay to visitors at 25% capacity. A Kendall's tau correlation was used to determine whether the number of visitors influenced the number of monk seals.

Results and Discussion

Initial presence and absence of monk seals began during a pre-COVID study in 2018. When comparing monk seal presence during the COVID-19 closure in 2020 to that of the 2018 studies, there is a 44.2% increase in presence of monk seals in the bay (non-significant, Fig. 31). Monk seal presence was significantly greater during ($p<0.046$, 0.61 ± 0.14 monk seals per day) the closure when compared to reopening to the public (0.08 ± 0.07 monk seals per day). After the reopening, monk seal occurrence decreased by 87.3%. The box office human counts and presence of monk seals showed no distinct pattern or correlation ($p>0.134$), suggesting that monk seal habitat usage was not influenced by the number of visitors on the beach. Also worth noting is the ~1.5 year gap between pre-COVID and COVID-19 closure surveys which may also influence these results.

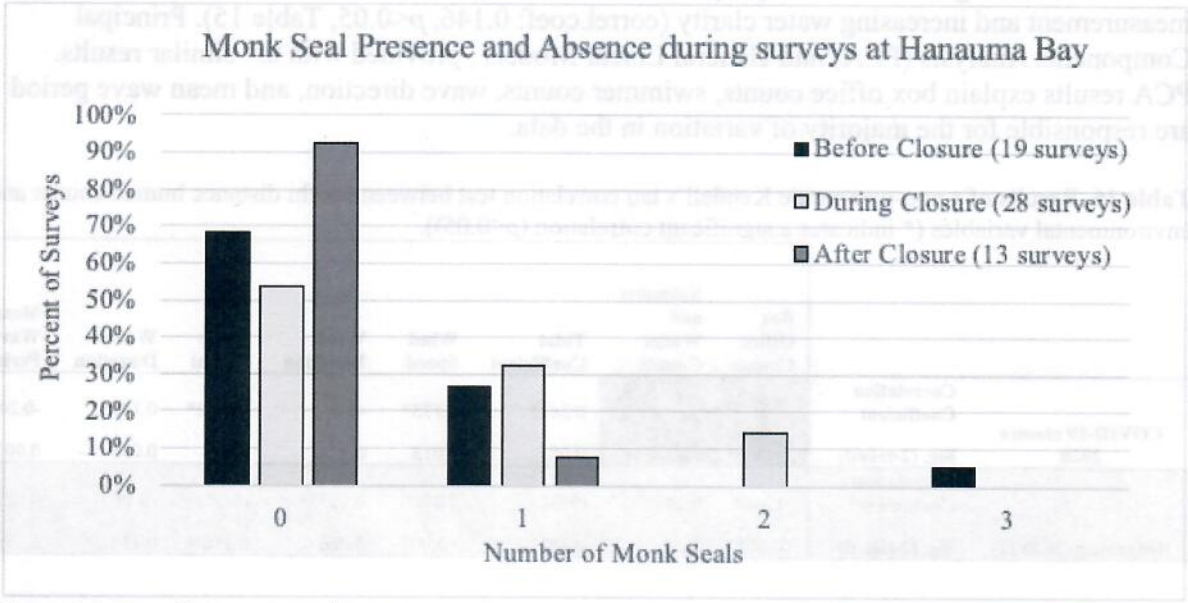


Figure 31. Hawaiian monk seal presence or absence during field surveys at Hanauma Bay comparing days open to the public (black bars) in 2018 and days closed during the COVID-19 closure (grey bars).

Megafauna: Green Turtles

The goal of this study was to quantify the presence of endangered green turtles at Hanauma Bay in the presence and absence of visitors to determine if visitor presence affects habitat use by green turtles (*Chelonia mydas*). George Balazs has worked with green turtles in Hawai'i since the early 70's at the University of Hawai'i and the National Oceanic and Atmospheric Administration. From the year 1992 through 2016, George recorded and tagged green turtles within Hanauma Bay. He recorded green turtle presence during the COVID-19 closure. To determine a pattern of usage by green turtles within the HBNP, Dr. Balazs' previous and current turtle counts during the COVID-19 closure were used. Dr. Balazs anecdotally reported a decrease in green turtle abundance at the Bay since his prior studies in the 90's. He also noted an increase in monk seal presence as compared to the 90's. Monk seals have been known to prey on green turtles in the Mediterranean Sea (Tonay et al., 2016) and Dr. Balazs has observed several

of these encounters within the Hawaiian Islands (pers. comm.). To separate predation and visitor disturbance, the relationship between the presence of monk seals and green turtles was examined further with preliminary data collected during the closure.

Methods

The presence of green turtles is recorded through *exsitu* out-of-water observations (Dr. Balazs) and *insitu* in-water observations (field team). Dr. Balazs was present for 12 of the 21 COVID-19 survey dates (5/12/20-12/1/20). On each observation date, 1-2 hours were spent in observation near the top of the walkway up to the theater. Surveys utilized a combination of normal vision and 10 x 50 binoculars. The field team also recorded sightings of turtles each day (18 field days during the closure and 13 after the reopening) with discussion after to ensure all turtles were counted and no turtles were counted multiple times. *Insitu* and *exsitu* counts were combined. Notes on the locations of the turtles were documented (Appendix H).

A Spearman's Rho correlation was used to assess a relationship between box office counts of humans or monk seal presence on green turtle presence. Box office counts were acquired from the City and County of Honolulu and represent the daily number of ticket sales.

Results and Discussion

The presence or absence of green turtles was documented over thirty-one field days. The influence of humans and monk seals on the presence of green turtles was examined during the closure, and after the reopening of the Bay at 25% capacity. No relationship was found between the number of people entering the HBNP per day and the number of green turtles sighted (Fig. 32a). The number of turtles present appears independent of the number of visitors to the Bay. The relationship between green turtles and Hawaiian monk seals during the COVID-19 closure showed a decrease in the number of green turtles when monk seals were present at Hanauma Bay, however, this was not statistically significant (Fig. 32b). When monk seals were present at the HBNP, green turtles were sparse. Overall, the presence of green turtles within the HBNP does not appear influenced by human counts, and more data needs to be collected to determine if green turtles are avoiding the Bay when monk seals are present. Due to small sample size of green turtles and Hawaiian Monk Seals, these results are anecdotal. Future studies should focus on observing over a larger period of time and space. Turtles and monk seals should be documented in offshore areas. Additionally, algal abundance should be recorded on the inner and outer reef to determine if lack of available food on the inner reef is responsible for the lack of turtle presence.

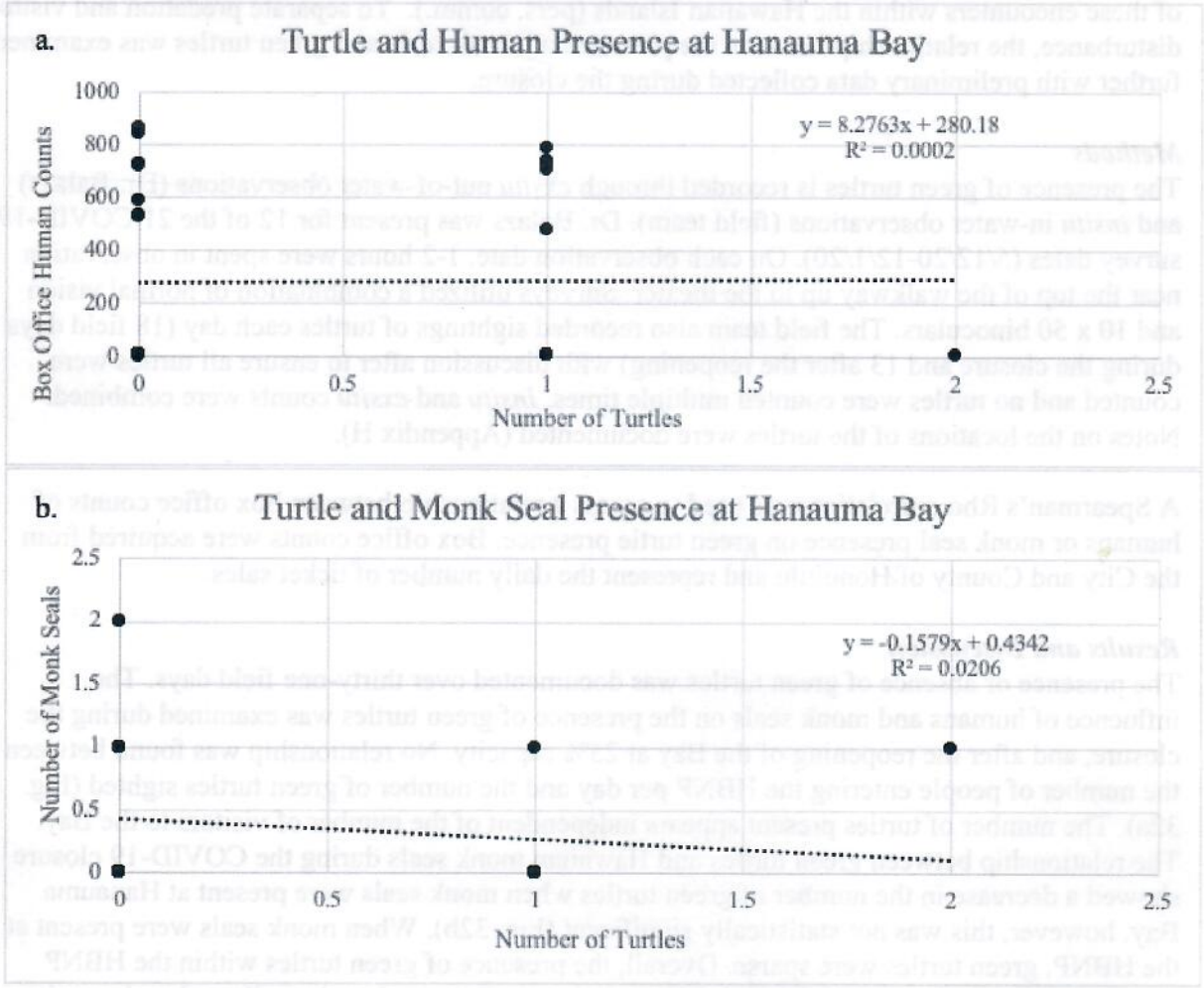


Figure 32. The presence of green turtles regressed against Human Counts acquired from the box office at Hanauma Bay (a) and the number of Hawaiian monk seals (b) at Hanauma Bay Nature Preserve during the COVID-19 closure.

Detailed Description and Outcomes of Research Activities:

Quarter 4- Task 3: Annual Inner Reef Flat Surveys

Permits for placement of pins marking permanent transects were approved by the Office of Conservation and Coastal Lands. Transect pins were installed in October 2019. Eight transects (Fig. 33; green rectangles) within the HBNP will be monitored annually for benthic composition, coral cover, and coral position (vertical or horizontal from substrate). Two transects (15 yd. x 5 yd.) are located in each experimental sector: KH, BD, CH, WB, and OFF. The beginning, end and outer boundaries are marked with an eye bolt to ensure relocation of repeat surveys.

EXECUTIVE SUMMARY

Experiments to quantify the extent of use of marine resources within Hanauma Bay Nature Preserve (HBNP) as they relate to visitor presence continue during the third year of the Hanauma Bay Biological Carrying Capacity study. Field experiments that take advantage of the COVID-19 closure to visitors continued through the closure and following the HBNP reopened to the public. The Hanauma Bay Nature Preserve was closed to visitors on March 16, 2020 in a statewide effort to prevent the spread of the COVID-19 virus. The Bay reopened to the public on December 2, 2020, (261 days, 8 ½ months) after the initial closure. During the closure, the Hanauma Bay Biological Carrying Capacity Study shifted its focus to determine the changes in fish and coral communities in the absence of visitors. This aligned with the goals and overall focus of the proposed Year 3 project to determine the carrying capacity of the Bay. This temporary closure provided the rare opportunity to examine differences in the biological communities with and without visitor impacts and separate other extraneous factors. Surveys were conducted on 35 days during the COVID-19 closure and 15 days after the reopening of the HBNP to the public at 25% capacity. Many surveys performed during the closure have continued with the recommencement of visitors to document changes in fish foraging patterns, fish behavior, coral growth, and water clarity. The following methodologies have been employed to achieve these objectives:

1) Non-invasive diver operated stereo video monitoring of fishes for minimum approach distance were used to quantify the distance between the surveyor/snorkeler and common species of fishes. This method continued post-closure to compare differences in approach distance with the return of visitors to the Bay.

2) A non-invasive video censusing technique to quantify fish foraging behavior of common species was employed during closure and continued following reopening. This strategy quantified the foraging rates of fishes to determine if fish feeding was altered in the presence of snorkelers.

3) Fish density and biomass surveys began late 2019 and continued through the closure and reopening of the Bay to examine community compositional shifts across differing visitor presence.

4) Growth rates of branching corals were collected during the closure and once visitors returned. A plastic-coated wire was tied around a coral branch and the distance between the wire and the branch tip was measured periodically.

5) A fluorescent censusing technique was used to determine the coral recruitment rates during the closure as a baseline for recruitment potential.

6) Sediment traps measured accumulation of sediment deposited on the bottom during the closure to compare to measurements during Year 1 while the Bay was open to the public. Sediment accumulation relates to coral health.

7) Water clarity measurements continued through the closure and reopening of the Bay to the public using the standard Secchi disk method.

8) The green turtle population was monitored and compared to prior records from NOAA observations.

9) Monk Seal encounters were logged as the number of individuals present.

At this time, results of fish density and biomass surveys, sediment accumulation, water clarity, coral bleaching, and megafauna have been completed. The data analysis and results of fish behavior utilizing non-invasive diver operated stereo video monitoring and fish foraging videos are ongoing. Preliminary data from fish behavior has been included in this report. Data collection of temperature within the inner reef flat will continue in Year 4 of the carrying capacity study.

Significant changes in density, biomass, size class, diversity, and evenness of fish populations were observed between (1) closed days (Tuesdays in 2019) to the public prior to the closure, (2) during the COVID-19 closure to the public, and (3) after the Bay was reopened to the public at 25% capacity. During the closure, all sectors increased in mean fish density, with the exception of Channel. A significant increase in fish density was observed within Keyhole sector during the closure, suggesting that fishes were expanding their range into Keyhole with the lack of visitor presence. Many of these fishes were herbivores, expanding their grazing range from Channel into Keyhole. Fishes were expanding their ranges from Channel, with the most rugose habitat, into other sectors with lower spatial complexity which may not provide ample protection from perceived threats such as humans while the Bay was open to the public. Similarly, all sectors increased in biomass during the closure, statistically significant in Backdoors and Keyhole, and fish biomass remained high after the reopening at 25% capacity. This suggests a greater number of larger fishes were present in Backdoors and Keyhole during the COVID-19 closure when compared to closed Tuesdays before the closure. Overall, the density and biomass of fishes increased significantly in the areas of the Bay most populated by snorkelers when open to the public.

The response of fishes to the absence of humans during the closure and after the reopening revealed family- and species-specific trends. While surgeonfishes increased in density and biomass during the closure and after the reopening of the bay, fishes such as butterflyfishes, snappers, and wrasses showed decreased density and biomass following the reopening of the Bay. Increases in the density and biomass of certain fish species during the closure, followed by decreases in density and biomass after the reopening suggests human avoidance behavior, even at 25% capacity of visitors, for these more sensitive species. Of the top overall species contributing to density, over half, seven of the thirteen experienced an increase in density during the closure to the public, followed by a decrease in density after the Bay was reopened: palenose parrotfish (*Scarus psittacus*, *uhu*), saddle wrasse (*Thalassoma duperrey*, *hīnālea lauwili*), belted wrasse (*Stethojulis balteata*, *ōmaka*), brighteye damselfish (*Plectroglyphidodon imparipennis*), blackspot sergeant (*Abudefduf sordidus*, *kūpīpī*), white spotted toby (*Canthigaster jactator*), and chubs (*Kyphosus spp.*, *nenue*). Of the twelve fish species with consistently high biomass, only one species, the yellowfin surgeonfish (*Acanthurus xanthopterus*, *pualu*), decreased in biomass following the closure of Hanauma Bay to visitors and continued to decrease after the reopening of the Bay to the public. Only two fish species, the previously mentioned yellowfin surgeonfish and the chub, significantly decreased in biomass following the reopening of the bay to visitors at 25% capacity. Unlike dominant fishes for biomass, many of the dominant fishes contributing to density experienced declines after the reopening of the Bay to the public, suggesting larger fishes may practice less avoidance behavior when compared to smaller fishes. By comparing density and biomass of fishes during and after the COVID-19 closure, the sensitivity of butterflyfishes, snappers, wrasses, and smaller size classes of fish were detected.

The majority of significant changes in fish population parameters were observed within Keyhole, the most heavily snorkeled area of the Bay. Keyhole significantly increased in mean fish density and biomass throughout the closure, and experienced significant decreases in the number of species of fishes (species diversity) and relative abundance of different species (species evenness). Fishes responsible for significant increases in both density and biomass within Keyhole were herbivorous convict tangs (*Acanthurus triostegus, manini*), which travel in large schools of up to 200 individuals, brown surgeonfishes (*Acanthurus nigrofuscus, māi'i'i*), and chubs. The large increase in density of these few individuals led to the decreases seen in both diversity and evenness of fish populations within Keyhole. Channel, the second most popular snorkeling area, experienced no changes in density or biomass of fishes throughout the study, but did experience a significant increase in fish diversity during the closure. This increase in diversity was followed by a significant decrease in diversity following the reopening of the Bay, which could be the result of more sensitive species sheltering from snorkelers. Backdoors experienced a significant increase in biomass following the closure to the public as a result of larger and greater numbers of chubs, brown surgeonfishes, and convict tangs. Backdoors experienced no other changes in population parameters over time. Witches Brew, the least snorkeled inshore area, experienced no significant differences in overall abundance, biomass, diversity, or evenness throughout the study. Overall, trends of increases in density of fishes during the closure with subsequent decreases in density in popular sectors following the reopening of the Bay to the public at 25% capacity, suggests fish distribution changes in response to visitors.

Sediment accumulation rates were compared between two sediment trap deployments in 2018 while open to the public and three sediment trap deployments in 2020 during the COVID-19 closure to the public. No significant differences in accumulation rates were detected, except for one transect, Witches Brew West. The significant increase in sediment accumulation within Witches Brew West during the COVID-19 closure was the likely the result of a large wood log washed into the area. The log was removed by the City and County within the week, however, prior to removal, it produced approximately 10 yd^2 area of broken corals and unconsolidated substrate. Results suggest sediment accumulation rates within the HBNP are heavily driven by natural processes, with very little anthropogenic influence.

Changes in water clarity were examined between open and closed days to the public in 2018, and, during and after the COVID-19 closure in 2020/21. The Bay was 56% clearer during the COVID-19 closure than on days open to the public in 2018, and 8.9% clearer during the COVID-19 closure than on Tuesdays in 2018 when closed to the public. Water clarity during the COVID-19 closure was not different from that of closed days to the public in 2018 in any sector except Witches Brew. The lack of a strong significant difference between the two closures, COVID-19 and Tuesdays in 2018, suggests that sediments are not being suspended in the water column for longer than 24 hours as once predicted with preliminary data. Within all sectors, water clarity was significantly greater during the COVID-19 closure when compared to after the reopening of the Bay to the public. After the reopening of the Bay at 25% capacity, water clarity decreased by 28.2%. However, water clarity was 12.2% clearer at 25% capacity of visitors when compared to days open to the public at full capacity (~3000 visitors/day) in 2018. Investigation into anthropogenic and environmental influence on water clarity found increasing box office visitor counts and wave height most influential in decreasing water clarity. The correlation between box

office visitor counts after the reopening of the Bay was stronger than the correlation between wave height during the closure. Overall, water clarity within the HBNP is more heavily driven by anthropogenic influence than environmental influence.

The abundance of monk seals and green turtles were documented throughout the closure and reopening to the public. There was a 44% increase in the presence of monk seals at the HBNP during the closure (non-significant) when compared to before the closure. After the Bay was reopened to the public at 25% capacity, the abundance of monk seals decreased by 87% (significant). Regardless, the box office human counts were not related to the monk seal presence at the HBNP. Similarly, the presence of green turtles was not influenced by the number of humans present on the beach, or the number of monk seals present. Monk seal and green turtle habitat usage was not influenced by the number of visitors at the HBNP when opened at 25% visitor capacity.

Annual coral bleaching (October 2020) and recovery (March 2021) surveys were conducted, and automatic water temperature sensors were downloaded (March 2021) and replaced. While the coral bleaching events in October of 2015 and 2019 produced similar rates of coral mortality, 9.8% and 8.2% respectively, no mortality was documented for the October 2020 bleaching event. This is consistent with 2019 Statewide surveys. All eight transects, except for Keyhole West and Channel West, experienced less bleaching and paling of corals when compared to previous years. Despite higher occurrence of bleaching within Keyhole and Channel West during 2020 surveys, results show no overall mortality. Corals most susceptible to bleaching in 2020 were the lace coral, ocellated coral, and rice coral. All but 5% of surveyed corals recovered completely by the April 2021 coral health surveys.

All sectors significantly decreased in average size of coral colonies from 2017 to April 2020. Since April 2020, no significant differences in average colony size within the inner reef flat of Hanauma Bay have been detected. The number of coral colonies found within each transect has fluctuated slightly within all transects following the rates of mortality produced by the 2014/15 bleaching event. Witches Brew was the only sector with large increases in the number of colonies in recent years. The largest corals recorded in 2015 were not present in later surveys and average size of coral colonies decreased significantly. Increased number of small sized colonies was attributed to partial mortality and fragmentation of larger colonies over time rather than new recruitment. Partial mortality was noted along surveys, and corals that remained appear to be fragments of what was once a larger colony. Although coral recruitment could be responsible for some increase in smaller size classes of corals, it appears more likely the result of partial mortality due to previous bleaching and/or physical breakage. Witches Brew not only experienced severe bleaching and paling in 2015 and 2019, but also suffered physical stress and breakage from a log in May 2020 which could contribute to the reduction of large colonies in this sector. Coral bleaching and coral cover surveys will continue as needed in response to stress events within the HBNP.

Outreach presenting the results from the first and second year of the Hanauma Bay Biological Carrying Capacity Study were brought to the public through the University of Hawai'i Sea Grant at Hanauma Bay Thursday night seminars (May 2020), University of Hawai'i's Voice of the Sea webinar series (Aug. 2020), University of Hawai'i's Advanced Topics in Marine Biology lecture

series (Sept. 2020), University of Hawai'i's Geography Department lecture series (Sept. 2020) and the National Oceanic and Atmospheric Administration Webinar Series (Nov. 2020). Results of water clarity and monk seal presence during the closure was included in a metadata analysis currently in review in the scientific peer-reviewed journal *Biological Conservation* titled, "Global COVID-19 lockdown highlights. Humans as both threats and custodians of the environment." Information from the carrying capacity study has also been disseminated through the media in 2020:

The Friends of Hanauma Bay Newsletter: FOLLOW UP: Ongoing Research at Hanauma Bay. 2021 Vol. 1: January-February.

The Friends of Hanauma Bay Newsletter: FOLLOW UP: Ongoing Research at Hanauma Bay. Vol. 5: September-December.

Scholastic Kids Press: Interview about the health of Hanauma Bay for article. Lucia Dong. December 2020.

Iolani Schools: Interview about the human impact on Hanauma Bay for school article. Mark Joshua Kawai Wagner. December 2020.

University of Arizona: Interview for journalism article on changes within Hanauma Bay during COVID-19 shutdown. Lex Horsey. December 2020.

SFGate: How a lockdown saved Hanauma Bay, one of Hawaii's natural treasures. Natasha Bourlin. November 2020.

Camp One Productions Inc.: Japanese documentary exploring the impacts of humans on marine resources within Hawai'i.

University of Hawai'i at Manoa TV: Journalism program interview on effects of COVID-19 on Hanauma Bay. Liam Thropp, undergraduate student, October 2020.

Chaminade University: Telephone interview discussing environmental change to coral reef environments. Mike Byrne, undergraduate student, October 2020.

University of Hawai'i: COVID-19 and the Results of Tourism Absenteeism on the Marine Ecosystem in Hanauma Bay. Natalie Coffee, graduate student, October 2020.

Hawai'i News Now: Hanauma Bay is recovering. Some want to limit crowds to further protect it. Jolanie Martinez, September 2020. https://www.hawaiinewsnow.com/2020/09/16/hanauma-bay-push-limit-crowds-even-afterparkreopens/#:~:text=Some%20want%20to%20limit%20crowds%20in%20the%20long%20run%20to%20further%20protect%20it,Close&text=HONOLULU%2C%20Hawaii%20(HawaiiNewsNow)%20%2D,and%20protect%20the%20bay's%20ecosystem

Hawai'i Magazine: Hanauma Bay Has Never Looked So Good. Catherine Toth Fox, September 2020. https://www.hawaiimagazine.com/content/hanauma-bay-has-never-looked-so-good

Star Advertiser: Hanauma Bay recovering since COVID-19 closure, new research shows. Mindy Pennybacker, August 2020. https://www.staradvertiser.com/2020/08/28/breaking-news/hanauma-bay-recovering-since-covid-19-closure-new-research-shows/

The Friends of Hanauma Bay Newsletter: FOLLOW UP: Ongoing Research at Hanauma Bay. Vol. 4: July-August.

Hawai'i Sea Grant: Zoominar for Hanauma Bay changes during Covid. Public forum. Hosted by Kanesa Seraphim, August 2020.

Hawai'i Public Radio: Hanauma Bay closure changes. Catherine Cruz "The Conversation", July 2020. https://www.hawaiipublicradio.org/post/conversation-whats-happened-hanauma-bay-covid-19-crisis

Hawaii News Now: During long closure, Hanauma Bay's waters have gotten crystal clear. Chavonnie Ramos, July 2020. https://www.hawaiinewsnow.com/2020/07/21/during-long-closure-hanauma-bays-waters-have-gotten-crystal-clear/

University of Hawai'i News: Hanauma Bay water clarity significantly improves without visitors. Sarah Hendrix, July 2020. https://www.hawaii.edu/news/2020/07/20/hanauma-bay-water-clarity/

KHON2 News: Hanauma Bay researcher says there appears to be more fish and clearer water. Lauren Day, June 2020. https://www.khon2.com/local-news/hanauma-bay-researcher-says-there-appears-to-be-more-fish-and-clearer-water/

The Friends of Hanauma Bay Newsletter: FOLLOW UP: Ongoing Research at Hanauma Bay. Vol. 3: May-June.

Star Advertiser: Brief absence of humans shows remarkable changes in Hanauma Bay. Mindy Pennybacker, May 2020. https://www.staradvertiser.com/2020/05/31/hawaii-news/brief-absence-of-humans-shows- remarkable-changes-in-hanauma-bay/

Star Advertiser: Free of visitors, scientists study coral, water quality, fish behavior at Hanauma Bay. May 2020. https://www.staradvertiser.com/2020/05/30/photo-gallery/free-of-visitors-scientists-study-coral-water-quality-fish-behavior-at-hanauma-bay/

Honolulu Civil Beat: The Coronavirus Has Been Good For Hanauma Bay. Brittany Lyte, April 2020. https://www.civilbeat.org/2020/04/the-coronavirus-has-been-good-for-hanauma-bay/

Star Advertiser: Hawaii researchers are studying whether human activity has a negative impact on fish and the reef at Hanauma Bay. Mindy Pennybacker, April 2020. https://www.staradvertiser.com/2020/04/29/hawaii-news/silver-linings-at-hanauma-bay/

The Friends of Hanauma Bay Newsletter: Ongoing Research at Hanauma Bay. Vol. 2: March-April.

This study was designed to determine the acceptable limits of human disturbance to the marine resources of Hanauma Bay Marine Life Conservation District by conducting an investigation of physical, social, environmental, and biological variables relating to the current usage of marine resources by visitors. This integrated, multi-year, comprehensive carrying capacity study will identify gaps and provide data and recommendations to managers to move towards sustainability of resources at the HBNP.