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

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

TABLE OF CONTENTS

List of Tables

List of Figures

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*, *māiʻiʻi*), 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 Hawaiʻi Sea Grant at Hanauma Bay Thursday night seminars (May 2020), University of Hawaiʻi's Voice of the Sea webinar series (Aug. 2020), University of Hawaiʻi'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.

INTRODUCTION

Concerns relating to recreational impacts on reefs in Hawai‘i have increased. Interest in coral reefs as a recreational resource have also increased, yet inadequate data results in inadequate decisions. To understanding the impact of visitors on the marine resources of Hanauma Bay Nature Preserve (HBNP), a series of observational and manipulative experiments documenting the current and historical coral and fish assemblages are essential.

Tourism is O‘ahu’s number one industry with total tourist expenditures of $6.12 billion from January to September of 2018. Of the 4.5 million visitors to the island of O‘ahu in 2019, it is estimated that 80% participated in ocean recreational activities (DBEDT 2018, DBEDT 2013). A large percent of Hawai‘i’s reefs are located within close proximity to major urban centers and are easily accessible. Over 1,000 ocean recreation companies exist that use our marine resources. Use by residential and visitor populations have increased on both spatial and temporal scales, with documented damage to the reefs (Gulko 1998, Rodgers 2001). There are increasing concerns about sustainability and carrying capacities that have generated research within the industry (DBEDT 2000).

The HBNP is the most popular visitor snorkeling experience in the Hawaiian Islands. In 2017, 842,439 tourists and residents visited this Marine Life Conservation District (MLCD) established in 1967 (City and County Fiscal Records in Data Compilation Folder). Even no-take MLCDs can be of concern, due to resource damage and environmental degradation. These marine protected areas have become areas of concern for management including the HBNP. Funded studies on carrying capacities have indicted a growing concern for the resources in these areas (Brock 2000, Wanger 2001). Many facets of the tourism industry have successfully marketed these regions. MPAs have become an open invitation to the tourist industry. There has been much effort and expense applied to promoting the industry and although these businesses depend on reef health, sparse resources have been allotted to investigating the impacts on marine resources.

Direct and indirect impacts to marine resources can result from increased tourist use. Reef damage can cause changes in diversity and density of fish populations. Habitat destruction from trampling can affect fish nurseries, habitat for flora and fauna, coral recruitment sites and coral populations. The level of human use a reef community can withstand to assure sustainability is often defined as the carrying capacity of the region. It can serve as a benchmark to assess implemented management strategies. Due to the complexity of coastal marine ecosystems and spatial and temporal variation, it is extremely difficult to isolate specific impacts.

Trampling effects in Hawai‘i were first quantified by Rodgers in 2001. Direct cause and effect, manipulative field experiments coupled with calibrated observations of human use showed a strong relationship between coral growth and mortality and human trampling. Results found coral mortality can be low if the trampling impact is removed with a sufficient recovery period. However, most accessible near-shore environments throughout the state receive continuous chronic impacts with little or no time for undisturbed recovery. It was determined that even brief periods of intense trampling can significantly affect the growth of corals (Rodgers et al. 2003a).

The response of corals to breakage is size and species dependent. Smaller fragments have lower survivorship. Initial trampling produces the most damage. At the HBNP the existing corals are found in cracks and crevices, at depths greater than human height, on vertical substrate, and comprised of species that have strong skeletal strengths and morphologies not conducive to breakage (Year 1). The level of breakage for a species is consistent with the habitat they inhabit. Species colonizing protected, low energy regions typically exhibit significantly higher breakage rates from trampling than species inhabiting high wave energy environments (Rodgers et al. 2003b). Due to chronic heavy human use, corals at the HBNP are more consistent with areas of high wave energy consisting of lobate or encrusting corals. HBNP corals are among the species with the highest skeletal strength and most resistant morphologies. However, mechanical stress tests show coral skeleton is a weak biological material. The average weight of a human or kick of a fin can cause compressive (condense or press) or tensile (bend or stretch) coral breakage (Rodgers 2001). A transplantation study similar to the one conducted in Year 1 of this study was conducted in 2001 along a gradient of human use, using live corals (Rodgers 2001). The highest impact site received 350,000 visitors a year (Kahaluʻu Bay, Hawaiʻi) and had no remaining corals after eight months. This is strong supporting evidence, along with the level of breakage found in this study at the HBNP, that a reduction in the level of visitors will not relate to an increase in coral cover at any level above 200,000 visitors annually unless actions to reduce coral breakage and promote coral growth are implemented. Coral growth was affected but mortality was low at levels up to 50,000 visitors a year. Sites with a long history of high use such as at the HBNP have low coral cover of only a few percent in high use areas. The statewide average coral cover is 22% (Rodgers et al. 2015), which is similar to the outer reef (20%) of Hanauma Bay where it is too deep for visitors to touch or trample. In contrast, the inner reef flat where 98% of visitors snorkel has an average of 4% coral cover (Biological Carrying Capacity Study Year 1). This differs throughout the inner reef flat influenced by visitor presence, natural spatial complexity of the reef, depth, and exposure to waves (Backdoors: 0.7%, Keyhole: 0.5%, Channel: 11.7%, and Witches Brew (4.7%).

In 1977, the Hanauma Bay Beach Park Site Development Plan estimated the recommended carrying capacity at 1,350 visitors a day, nearly half a million visitors annually. This was based on the Bureau of Outdoor Recreation and U.S. Army Corps of Engineers' standards for beach capacity (Vieth and Cox, 2001). However, by 1999, this recommendation had been exceeded by five times. Today, management efforts have greatly reduced the number of visitors and possibly visitor damage by enforcing an educational program, parking limitations and a weekly beach closure. These efforts have decreased the visitor counts to an average of 3,000 visitors a day in 2018. Despite these management efforts the direct and indirect impacts resulting from visitor use have not been quantified. There has yet to be a long-term study documenting the sustainability of marine resources within the HBNP in relation to the average 3,000 daily visitors. A two-year carrying capacity study was conducted by Brock (2000). The City and County of Honolulu provided funding beginning in 2018 for a long-term annual study to determine the impacts to resources and solicit recommendations to improve the marine resources and visitor experience.

During Year 1 of the Hanauma Bay Biological Carrying Capacity study, coral skeletons were placed and monitored in 10 different locations throughout the Bay (Fig. 1) during June and October (2018) for 30-days to determine trampling pressure on the reef and quantify coral sustainability. Coral breakage results were coupled with documentation of human counts through monitoring visitor spatial, and temporal patterns and activity use in each sector. Overall mean percent loss of coral skeleton increased with the increase in number of visitors during the surveyed summer month of June and winter month of October. To complete the proposed objectives of the carrying capacity study and determine the impact of human use on biological populations to make informed recommendations, it was imperative we compare across a gradient of human use from high use sites (Keyhole) to low use sites (Witches Brew). The first year of research indicated damage to coral skeletons in high use sectors. This is strongly related to human trampling since other factors such as turtles and parrotfishes that can cause breakage can be found across sites. In Year 1, the influence of anthropogenic and environmental influences on water clarity and sediment accumulation on the reef were also investigated. Although water visibility was approximately 30% clearer on closed days to the public when compared to open days, some of the decreased water clarity was strongly related to changes in wind direction and speed and tidal fluctuations. Sediment accumulation, or sediment deposited onto the reef flat, increased significantly with the increasing proportion of visitors swimming and wading. The first year of the Hanauma Bay Biological Carrying Capacity study found coral breakage, suspended sediments, and sediment accumulation to increase with increasing visitor presence. It also found that existing coral communities strongly reflect chronic long-term disturbance by physical breakage.

Year 2 of the Biological Carrying Capacity Study incorporated a historical review of fishes and current fish surveys. The historical review of fishes within the HBNP found fish feeding to be more influential in changing metrics of fish density and biomss when compared to the influence of visitor counts. Increases in density and biomass of fishes were correlated with times of fish feeding, with decreases following the fish feeding ban. The composition of fishes on the inner reef flat also shifted with changes in fish feeding status. During fish feeding, the most dominant families were chubs (Kyphosidae, *nenue*), mullet (Mugilidae), flagtails (Kuhliidae, *āholehole*), file fish (Monacanthidae), hawkfish (Cirrhitidae), boxfishes (Ostraciidae), and cornetfish (Fistulariidae). After fish feeding, families in greater abundance were wrasses (Labridae), jacks (Carananididae), Tangs (Acanthuridae), parrotfishes (Scaridae) and snappers (Lutjanidae). Friedlander et al. (2018) also detected an increase in introduced snappers after fish feeding ceased. A few fish families overlapped between during and after fish feeding: goatfishes (Mullidae), butterflyfishes (Chaetodontidae) and chubs (Kyphosidae). Although it is difficult to separate the influence of fish feeding and the number of visitors on the historical fish populations at the HBNP each have had a significant influence on fish populations. Results of current fish populations were further explored in Year 3, with the closure of the Bay to visitors due to the COVID-19 virus.

Year 3 of the biological carrying capacity study continued to evaluate fish density, biomass, diversity, and behavior, in the absence of visitors during the COVID-19 closure. In addition to continued fish surveys, sediment accumulation and water clarity surveys were repeated through the COVID-19 closure to document baseline values in the absence of visitors and establish the influence of environmental variables such as wind speed and direction and wave height. Other surveys include documentation of coral recruits, adult coral growth rates, and presence of native Hawaiian Monk seals and green turtles during the closure to visitors. The COVID-19 closure of HBNP provided the unique opportunity to document fishes, corals and megafauna in the absence of visitor presence and document what changes may occur if visitor levels were reduced.

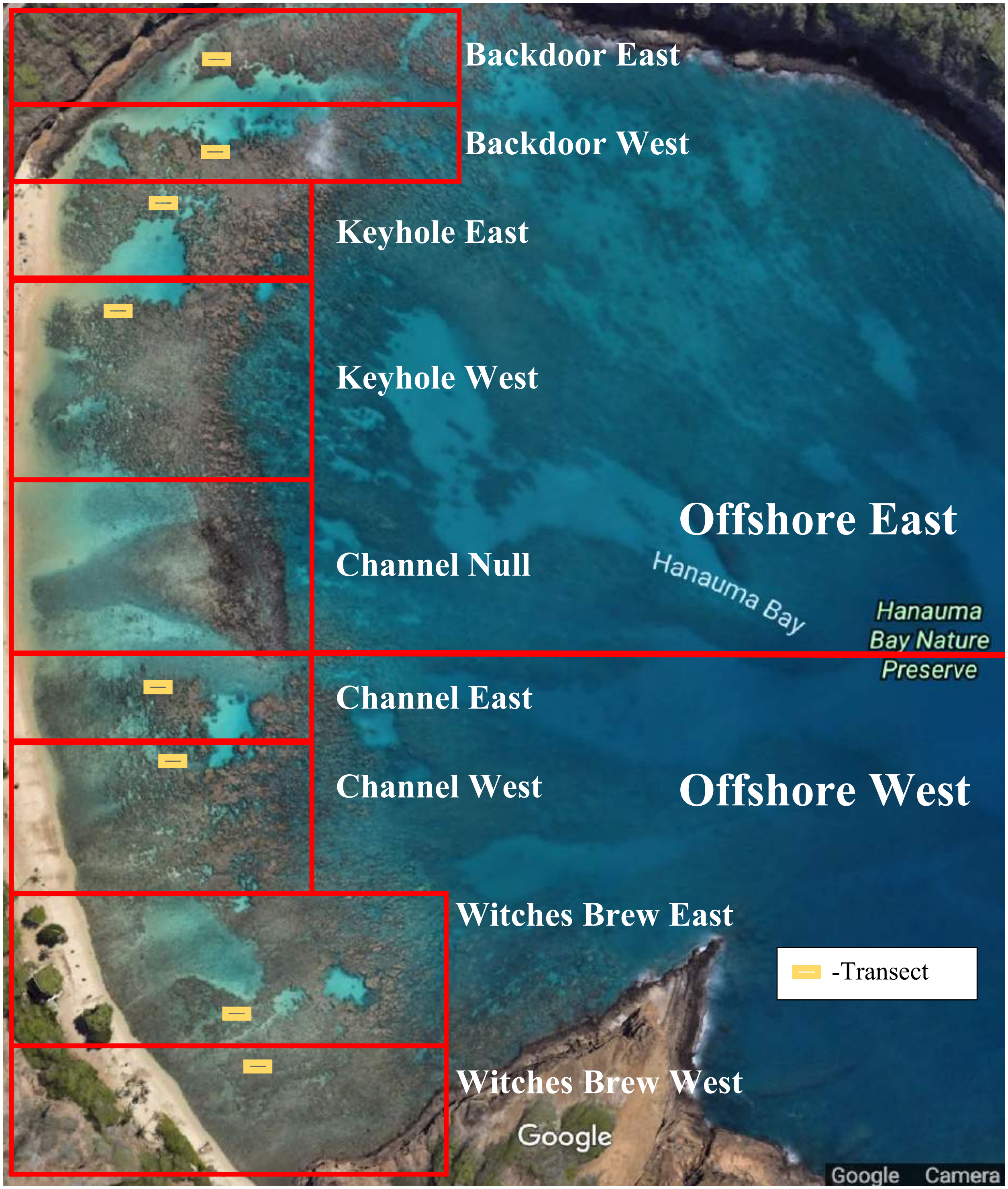


Figure 1. Eleven Sectors of Hanauma Bay used to separate visual human counts and activity: Backdoor East and West, Keyhole East and West, Channel Null, East and West, Witches Brew East and West, and Offshore East and West. Eight of the sectors have permanent transects (5 yd x 15 yd, yellow boxes). Transects are used for coral, fishes (extend shoreward in a 5 yd x 25 yd area), and sediment studies.

Projected Scope of Work Details from Project Work plan: Year 3 Hanauma Bay CC Study

Quarter	Task/Activity	Deliverables
1st: June – Sept. 2020	**Task 1:** Add to data compilation and annotated bibliography for Year 1 **Task 2:** COVID-19 Closure Surveys • Fish abundance and density surveys • Initial fish behavior studies • Initial coral recruit studies • Mark adult coral colonies for later growth measurements • Repeat sediment accumulation study from 2018 • Place sediment traps for determination of suspension study • Count green turtles and Hawaiian Monk seals **Task 3:** Annual Survey Inner Reef Transects • Annual monitoring of corals directly after peak coral bleaching season. **Task 4:** Temperature Logger Analysis • Download biannual data from temperature loggers.	Executive Summary of Quarter 1 and Workplan
2nd: Oct. – Dec. 2020	**Task 1:** Add to data compilation and annotated bibliography for Year 1 **Task 2:** COVID-19 Closure Surveys • Continue Fish abundance and density surveys • Perform fish behavior studies • Repeat coral recruit studies • Measure coral colony growth • Repeat continuing sediment accumulation study • Repeat sediment suspension study from 2018 • Continue counts of green turtles and Hawaiian Monk seals **Task 3:** Annual Survey Inner Reef Transects • Perform and analyze annual monitoring of corals during seasonal coral bleaching. **Task 4:** Temperature Logger Analysis • Analyze annual temperature data.	Progress reports on task and data collected from experiments.
3rd: Jan. – March 2021	**Task 1:** Add to data compilation and annotated bibliography for Year 1 **Task 2:** COVID-19 Closure Surveys • Fish abundance and density monitoring • Continue fish behavior studies • Analyze coral recruitment data • Continue coral growth measurements • Analyze sediment accumulation data • Analyze sediment suspension data • Count green turtles and Hawaiian Monk seals **Task 3:** Annual Survey Inner Reef Transects • Complete analysis for coral bleaching data **Task 4:** Temperature Logger Analysis • Download biannual data from temperature loggers. **Task 5:** Coral Reef Assessment and Monitoring Program (CRAMP) Survey • Perform yearly monitoring of CRAMP sites.	Executive Summary of Quarter 3 and Workplan
4th: April – June 2021	**Task 1:** Add to data compilation and annotated bibliography for Year 1 **Task 2:** COVID-19 Closure Surveys • Fish abundance and density analysis • Analyze fish behavior data • Coral growth analysis • Analyze counts of green turtles and Hawaiian Monk seals **Task 3:** Annual Survey Inner Reef Transects • Complete analysis of monitoring of corals after recovery from coral bleaching **Task 4:** Temperature Logger Analysis • Analyze yearly data from temperature loggers. **Task 5:** CRAMP Survey • Analyze data from annual long-term monitoring of CRAMP sites.	Final Report

Detailed Description and Outcomes of Research Activities:
Quarter 4- Task 1: Find sources and references of historical data.
A comprehensive review of recent and historical data was conducted using all available data sources acquired since the start of the biological carrying capacity study (May 2018). All published and unpublished literature found during this time was assembled and annotated bibliographies compiled (Appendix A). Articles and reports will be made available to City and County of Honolulu, University of Hawaiʻi SeaGrant, and Friends of Hanauma Bay on a flash drive at the end of Year 3. Since Year 1 of the biological carrying capacity study, the annotated bibliography and data compilation has been updated with recently published or recently located studies and/or data sources on fish behavior, different types of carrying capacity studies, exclusion cage studies, oxybenzone studies, toxoplasmosis and tourism impact studies from other parts of the world that relate to the HBNP. In Year 3 of the biological carrying capacity study, studies of fish foraging and behavior within the HBNP were added to the annotated bibliography. The intent of a compilation of historical and reference data is to compile all literature currently available for the HBNP in one location as a reference source and to help facilitate management planning needs. Included in the appendices of this report are the summaries of 74 articles encompassing research conducted at the HBNP and associated research. This literature search is vital in assisting both management and research efforts in saving considerable time in searching for and correlating existing information and preventing overlapping projects. The information collected here can also be used in future investigations or modeling of biological populations in nearshore waters within the reserve.

Detailed Description and Outcomes of Research Activities:
Quarter 4- Task 2: COVID-19 Closure Surveys
Fish: Density, Biomass, Diversity and Evenness
National parks and nature preserves that allow human visitation foster conservation efforts of the environment. Despite well intentions, these natural areas can experience chronic non-lethal disturbances (e.g. hiking, swimming, snorkeling), that can result in population changes within the residing fauna such as birds (Heil et al., 2007; Skagen et al., 1991), deer (Bonnot et al., 2013), caribou (Plante et al., 2018), and whales (Higham et al., 2016). Studies have documented changes in density and biomass due to avoidance behaviors of marine fishes in response to pressure from spearfishers in unprotected areas (Januchowski-Hartley et al., 2011, 2012; Stamoulis et al., 2019). Similarly, significant changes in density, biomass, species richness, and trophic structure have been reported in fish populations subject to non-lethal snorkeling disturbances of less than 200 visitors per day (Albuquerque et al., 2014; Dearden et al., 2010). However, there has not been the opportunity to document fish assemblages before, during, and directly after a long-term closure of a heavily trafficked Marine Life Conservation District (MLCD) until the COVID-19 closure of visitors to the Hanauma Bay MLCD. This is the first study to determine how fish populations within a heavily snorkeled MLCD shift in response to a long-term closure to visitors.

Methods
Fishes were surveyed along eight, 25 yd by 5 yd transects over three days, prior to the COVID-19 closure on Tuesdays when the Bay was closed to the public (11/19/19, 1/29/20, and 2/20/20), ten days during the COVID-19 closure (4/21/20, 5/12/20, 5/19/20, 5/26/20, 6/23/20, 6/30/20, 7/7/20, 10/28/20, 11/24/20, and 12/1/20), and five days after the COVID-19 closure (12/9/20,

12/16/20, 12/30/20, 1/13/21, and 1/20/21) . Two fish surveyors were calibrated to fish abundance and biomass prior to start of COVID-19 closure surveys. All belt transects were conducted over benthic transects (Fig. 1) and extend 25 yds toward shore. The fish surveyor spooled out the transect line and waited five minutes before starting the survey to allow fish to equilibrate. During the survey, the observer recorded fish species, size (total length TL in centimeter [cm]) and the number of individuals (Appendix B) All fishes within the linear 125 yd^2 area from the benthos to the surface were recorded. Biomass estimates were derived through total length estimated to the nearest cm in the field and converted to biomass (g/yd^2) using length-weight fitting parameters. In estimating fish biomass from underwater length observations, most fitting parameters are obtained from the Hawaiʻi Cooperative Fishery Research Unit (HCFRU) consistent with previous analyses. Locally unavailable fitting parameters are obtained from Fishbase (www.fishbase.org) where length-weight relationship was derived from over 1,000 references. Congeners of similar shape within certain genera were used in rare cases lacking information. Conversions between recorded total length (TL) and other length types were calculated. The three commonly used measures of fishes were standard length (excludes the caudal fin), total length (from tip of snout to tail tip), and fork length (from tip of snout to deepest notch of the tailfin). A predictive linear regression of logM vs. logL was used in most cases to estimate the fitting parameters of the length-weight relationship. Visual length estimates are converted to weight using the formula $M = a . L^b$ where M=mass in grams, L=standard length in mm and a and b are fitting parameters. Any anomalous values were detected by calculating a rough estimate for a given body type. The general trend for a 10 cm fish of the common fusiform shape should be approximately 10 g. Any gross deviations were replaced with values from the alternate source.

Trophic categories reflect trophic levels described in Friedlander et al. (2018) for comparability with other sites throughout the State of Hawaiʻi (Friedlander et al., 2018). This data is a compilation of over 25 datasets containing greater than 25,000 surveys collected between 2000 and 2017. The Hawaiʻi Monitoring and Reporting Collaborative (HIMARC) is a consortium of managers and researchers throughout the Hawaiian Islands that collectively contribute monitoring and assessment data to the largest searchable database for fishes in Hawaiʻi. Trophic categories include herbivores (algae eaters), invertebrate feeders (invertebrate eaters), zooplanktivores (animal plankton eaters), and piscivores (fish eaters). The Shannon Weiner diversity was calculated by the formula:

$$H' = \sum_{i=1}^{S} p_i \ln p_i$$

where S is the total number of species and P_i is the relative cover of species. Shannon Weiner diversity index (Shannon and Weaver 1963) considers both the number of species and the distribution of individuals among species. Buzas and Gibson's evenness (Harper 1999) was measured using E = eH/S to measure the evenness of fishes.

Term definitions

Density and Biomass

A measure of density: numerical (number of fishes) and biomass (weight of fishes) are included for each fish community factor. These are both important population parameters that address different aspects of the fish population structure. A station may have a large school of small fish or one very large fish with equal biomass but very different densities. By distinguishing between these two measures, additional information about the population is retained.

Diversity

Areas in high wave energy environments have previously been reported to maintain lower fish populations and exhibit lower species diversity in the Hawaiian Islands (Friedlander & Parrish 1998). This can be attributed to reduced habitat complexity in high energy environments. Diversity is an important factor in many ecological and conservation issues. It can be important in assessing the efficacy of management efforts. Reductions in diversity can be indicative of fishing pressure because it selectively removes specific species. Other anthropogenic impacts, such as eutrophication and sedimentation, can result in phase shifts that impact fish diversity. While diversity refers to how many different species there are, species evenness refers to how similar in numbers each species is. Mathematically it is defined as a diversity index, a measure of biodiversity which quantifies how equal the community is numerically. Thus, if there are 40 of one species, and 1000 of another, the community is not very even.

Due to lack of normality of the datasets and inability to correct with transformations, less powerful non-parametric statistical tests were applied. Non-parametric Independent Kruskal-Wallis tests were utilized for determining differences in biomass, density, diversity, and evenness across levels of visitor use (before, during and after the COVID-19 closure) and season (winter 2019/20, spring 2020, summer 2020, and winter 2020/21). Dunn's pairwise tests were carried out for differences between timepoints and seasons and adjusted using the Bonferroni correction. Non-parametric Kendall's tau correlations were utilized to assess the impact of visitor use on the density and biomass of fish families and on minimum size of fishes. Visitor use was quantified using box office counts provide by the City and County of Honolulu and *insitu* visual counts of nearby snorkelers concurrent with survey times. A series of four snorkeler counts during survey periods were conducted and the average was used to calculate correlations.

Results and Discussion

The following results compare surveys conducted before the COVID-19 closure on Tuesdays when the Bay was closed to the public, to those during the COVID-19 closure with no visitors, and after the COVID-19 closure when HBNP was reopened to the public at 25% capacity of visitors. Conducting surveys across three levels of visitor use allowed for the impact, or lack of impact, from visitors to be quantified for density, biomass, diversity and evenness of fish populations within the inner reef flat environment.

Keyhole changes in fishes across time periods

Keyhole, the most popular snorkeling sector (43% of snorkeling traffic), was the only sector with significantly higher overall density of fishes during the COVID-19 closure (0.99 ± 0.11 ind/yd^2, $p<0.006$) and after the reopening to the public (1.25 ± 0.2 ind/yd^2, $p<0.003$) when compared to before (0.44 ± 0.09 ind/yd^2) the closure (Fig. 2). Many surgeonfishes, butterflyfishes, and chubs migrated into Keyhole from other sectors of the inner reef flat following the closure to visitors. Likewise, the biomass of fishes within Keyhole was significantly greater during the COVID-19 closure when compared to before the closure ($p<0.003$). The biomass of fishes continued to be significantly greater in Keyhole after the reopening of the Bay to the public at 25% capacity ($p<0.002$). Several species contributed significantly to the increase in biomass and density observed within Keyhole: biomass (blackspot sergeant (*Abudefduf sordidus, kūpīpī,* $p<0.004$), ringtail surgeonfish (*Acanthurus blochii, pualu, p*<0.0032), brown surgeonfish (*Acanthurus nigrofuscus, ma'i'i'i, p*<0.02), orangespine unicornfish (*Naso lituratus, umaumalei, p*<0.002), bluestriped butterflyfish (*Chaetodon fremblii, kīkākapu, p*<0.039), bird wrasse (*Gomphosus varius, hīnālea 'akilolo* (F), *hīnālea 'i'iwi* (M) , *p*<0.009), and bluestripe snapper (*Lutjanus kasmira, ta'ape, p*<0.047) and density (orangespine unicornfish (*p*<0.027) and brown surgeonfish (*p*<0.026) (Fig. 3). Two families within Keyhole experienced significant decreases in density after the reintroduction of visitors to the Bay: wrasses and snappers. Wrasses and snappers are common within Hanauma Bay, yet some are quick to divert into the nearest crevice when spooked, explaining their decrease in density. In particular, the belted wrasse decreased significantly after the re-introduction of visitors at 25% capacity. The belted wrasse may have been exhibiting a human avoidance strategy that would not have otherwise occured on a closed Tuesday or during the COVID-19 closure (*Stethojulis balteata*, *omaka*, compared to before the closure: *p*<0.019, compared to during the closure: *p*<0.044)(Fig. 3). Keyhole also experienced significant declines in diversity (*p*<0.02) and evenness (*p*<0.02) of fishes after the reopening of the Bay to the public due to the increased dominance by surgeonfishes. During the closure and following the reopening of the Bay, Keyhole experienced extensive shifts in the community composition of fishes.

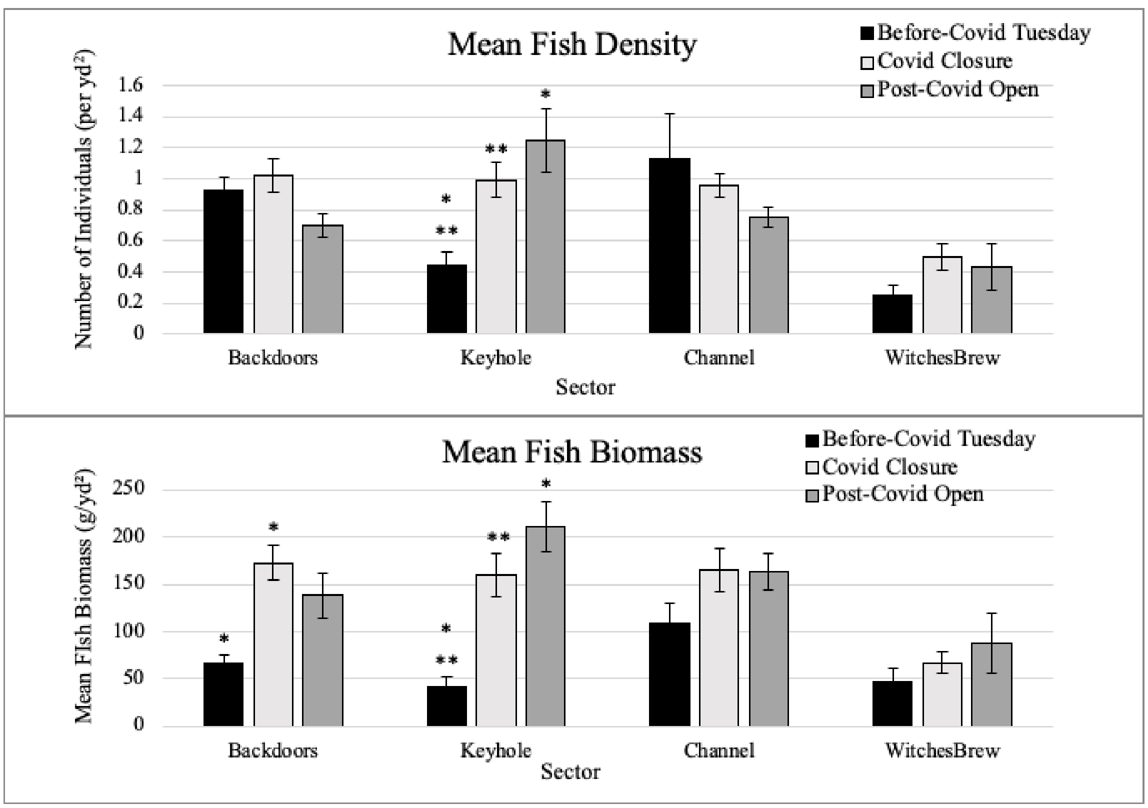


Figure 2. Mean density and biomass of fishes in each sector of Hanauma Bay comparing surveys conducted before the closure on closed Tuesdays, during the closure and after the reopening of the Bay to the public at 25% capacity of visitors. Asterix (*) represent significant pairwise comparisons (*p*<0.05) between visitor levels (ex. Both "Before-Covid Tuesday" and "Covid Closure" have two asterix, which symbolizes that they are significantly different from one another. "Before-Covid Tuesday" within Keyhole has a set of 2 asterix and 1 asterix meaning it is significantly different from "Covid Closure" and "Post-Covid Open" values, but "Covid Closure" and "Post-Covid Open" are not significantly different from one another). Error bars represent ± 1 standard error.

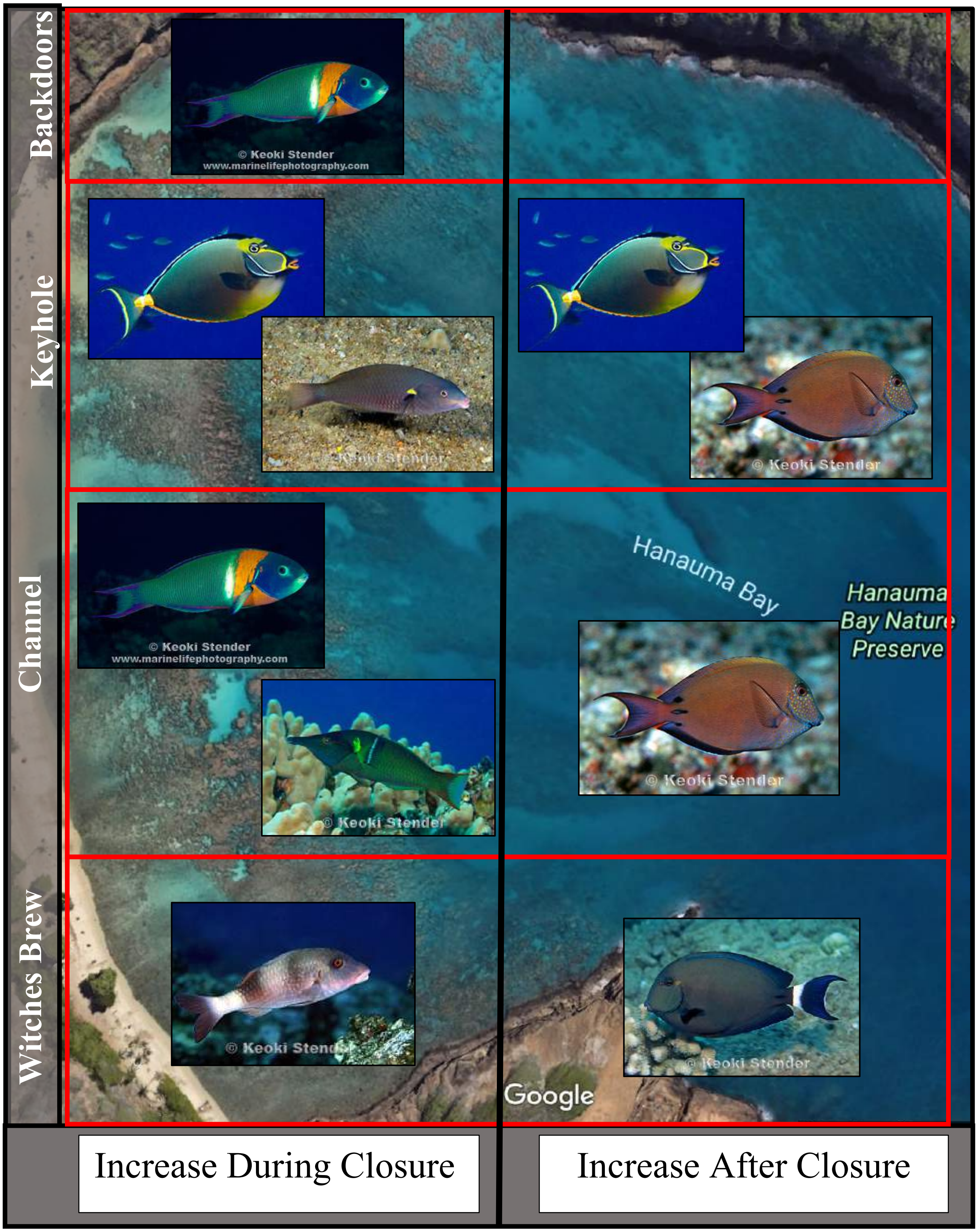


Figure 3. Significant ($p<0.05$) changes in fish density as compared to before the closure on a closed Tuesday to during the closure and after the the COVID-19 closure when opened at 25% capacity within the four sectors of Hanauma Bay in which fish surveys were performed (two transects 5 yd x 25 yd within each sector).

Channel changes in fishes across time periods
The second highest use sector, Channel (38% of snorkeling traffic), also experienced several species shifts between the three time periods. Although many fishes migrated into Keyhole after the closure of the Bay, no significant changes in density and biomass of fishes within Channel were detected (Fig. 2). However, changes on the family and species level were significant. The saddle wrasse (*Thalassoma duperrey, hīnālea lauwili,* Fig. 3) significantly increased in density (p<0.049) and biomass (p<0.005) during the closure when compared to before the closure. This could be in response to increased food availability, or expansion of their range with the lack of human interference. The orangespine unicornfish also increased in biomass during the closure (p<0.008). Similar to Keyhole, the brown surgeonfish increased in both density (p<0.038) and biomass (p<0.045) within Channel after the reopening of the Bay at 25% capacity (Fig. 3). This increase after the reintroduction of visitors to the Bay could be the result of less competition for space with territorial damselfish that may be too timid to guard their home ranges in the presence of humans. Conversely, butterflyfishes (p<0.02), wrasses (p<0.02) and snappers (p<0.04) significantly declined in biomass following the reopening of the Bay. The overall diversity of fishes within Channel increased during the closure (p<0.05), but subsequently decreased after the reintroduction of visitors (p<0.04), suggesting some of the more timid species may have gone into hiding in response to increased snorkeling activity. Communities within Channel shifted from having several different species of fishes present during the closure, to being more dominant in a few species, mostly surgeonfishes traveling in schools, after the reopening of the Bay to the public. It is likely that fishes, like butterflyfishes and wrasses, did not leave Channel after the reopening but retreated to shelter in response to the increased snorkeling activity.

Backdoors changes in fishes across time periods
The biomass of fishes within Backdoors (p<0.04) was significantly greater during the COVID-19 closure when compared to before the closure (Fig. 2). During the closure chubs migrated into Backdoors, possibly from offshore, in search of new food resources. After the reopening of the Bay, Chubs decreased to pre-closure densities within all sectors. Because the density of Chubs did not increase in other sectors of the inner reef flat after the reopening, they likely migrated offshore. Similarly, two species experienced significant decreases in biomass and density after the Bay was reopened to the public: reef triggerfish (*Rhinecanthus rectangulus*, *humuhumunukanukapuaʻa*, density: p<0.05, biomass: p<0.04) and saddle wrasse (density: p<0.05, biomass: p<0.03). It is unlikely that the reef triggerfish retreated to offshore environments after the reopening of the Bay due to their non-migratory nature. With a larger range, the saddle wrasse may have migrated offshore after the reopening of the Bay or practiced human avoidance by hiding in crevices. Although Backdoors did not receive as much snorkeling traffic as either Keyhole or Channel prior to the closure (~4%), following the reopening of the Bay to visitors, it increases to approximately 11% of snorkeling traffic, This increase in snorkeling frequency after the reopening of the Bay may be associated with the decreased density and biomass of some fish species within Backdoors.

Witches Brew changes in fishes across time periods
Witches Brew, the least popular snorkeling sector due to distance from entry and difficult ease of access, receives 8.5% of snorkeling traffic. This sector experienced no significant differences in overall density or biomass of fishes throughout the closure. However, changes in triggerfishes, a species of goatfish and surgeonfish were detected (Fig. 3). Triggerfishes significantly increased

during the closure ($p<0.03$), and subsequently decreased ($p<0.04$) following the reopening of the Bay to visitors. Similarly, a significant decrease in both abundance ($p<0.02$) and biomass ($p<0.02$) of the doublebar goatfish (*Parrupeneus insularis*, *munu*) occurred after reopening to the public. Based on these patterns, both triggerfishes and the double bar goatfish appear to exhibit human avoidance behavior. Conversely, Witches Brew also experienced a significant increase in the abundance ($p<0.02$) and biomass ($p<0.045$) of the ringtail surgeonfish following the Bay opened to the public. Although less direct impact from snorkelers occurs in Witches Brew, the impact of increased snorkeling activity in adjacent sectors may have contributed to the fish community shifts that occurred.

Significant shifts in species composition during the closure and after the reopening of the HBNP to the public at limited capacity were observed during this study. The following explains these shifts in more detail and in context to their ecological function.

Changes in Density of Fish Families

A comparison of the density of fishes was completed for each sector between the three visitor levels: before the closure on a closed Tuesday (less than 7 researchers/day), during the closure (less than 7 researchers per day), and after the reopening (approximately 720 visitors per day). Keyhole was the only sector to experience significant changes in density of fishes throughout the study period. The density of fishes within Keyhole were significantly greater during (0.99 ± 0.12 ind/yd^2, $p<0.005$) the closure when compared to before the closure on closed Tuesday's (0.44 ± 0.09 ind/yd^2). The density of fishes continued to be significantly greater in Keyhole (1.25 ± 0.20 ind/yd^2, $p<0.002$) after the reopening of the Bay to the public at 25% capacity (Fig. 2). This suggests a greater number of fishes were present in Keyhole during the COVID-19 closure when compared to closed Tuesdays prior to the closure. No overall changes in fish density were observed in Backdoors, Channel, or Witches Brew at differing visitor levels. The confounding influence of seasonality was assessed between winter 2019/20, spring 2020, summer 2020, and winter 2020/21 and changes in density between the seasons did not correspond to typical increases in primary production. Therefore, seasonality does not appear to be a driving factor in changes in fish density. Changes in reserve status more closely explain the pattern in density of fishes over the study period. To understand which fish families were responsible for changes in fish density between timepoints, the top fish families that contributed to overall fish density were evaluated for changes between levels of visitor presence. Within all three visitor levels, surgeonfishes dominated the inner reef flat in density, followed by wrasses, parrotfishes, damselfishes, and butterflyfishes. Although similar fish families contributed to the majority of the fish density during all timepoints, density of species within fish families fluctuated through differing visitor presence.

Table 1. Significant family-specific changes (p<0.05, highlighted in orange) occuring in the density of fishes within each sector of Hanauma Bay comparing surveys conducted before the COVID-19 closure on closed Tuesdays, during the closure, and after the reopening of the Bay to visitors at 25% capacity. Trends explain overall increase (↑) in population density, increase during the closure with a decrease after the reopening of the Bay to the public (∩), or no change (-).

		Mean Density (individuals per square meter)			
Family	**Sector**	**Before**	**During**	**After**	**Trend**
Surgeonfishes	Keyhole	2.92 ± 0.66	6.88 ± 1.01	10.62 ± 2.06	↑
Damselfishes	Keyhole	0.28 ± 0.07	0.59 ± 0.09	0.34 ± 0.03	∩
Wrasses	Backdoors	0.74 ± 0.09	0.64 ± 0.10	0.30 ± 0.06	∩
Butterflyfishes	Channel	0.25 ± 0.04	0.31 ± 0.04	0.12 ± 0.04	∩
Triggerfishes	Witches Brew	0.09 ± 0.04	0.23 ± 0.02	0.12 ± 0.02	∩
Chubs	Backdoors	0.04 ± 0.02	0.27 ± 0.05	0.14 ± 0.04	∩

Table 2. Significant differences (p<0.05) in density of top ten families comparing before the closure on a closed Tuesday, during the COVID-19 closure, and after the reopening of the Bay at 25% capacity. No pairwise comparisons reflect a significant difference that had too much variation to discern differences between timepoints. Information was collated from Independent-samples Kruskal Wallis tests with Dunn-Bonferroni pairwise comparisons.

Period with greater density of fishes	Sector	Fish Family	Significance
During the closure had more fish than before the closure.	Backdoors	Chubs	0.033
	Keyhole	Damselfishes	0.043
	Keyhole	Surgeonfishes	0.018
During the closure had more fish than after the closure.	Channel	Butterflyfishes	0.008
	Witches Brew	Triggerfishes	0.035
After the closure had more fish than before the closure.	Keyhole	Surgeonfishes	0.001
	Witches Brew	Triggerfishes	0.025
No pairwise comparisons.	Backdoors	Wrasse	0.036

The density of surgeonfishes (p<0.02) and damselfishes (p<0.045) within Keyhole were significantly greater during the closure (surgeonfishes: 6.9 ± 1.0 ind/yd^2, damselfishes: 0.6 ± 0.1 ind/yd^2) when compared to before the closure (surgeonfishes: 2.9 ± 0.7 ind/yd^2, damselfishes: 0.3 ± 0.1 ind/yd^2)(Fig. 4, Tables 1 & 2). Surgeonfishes continued with higher density after the reopening of the Bay to the public (10.6 ± 2.1 ind/yd^2, p<0.002, Table 1). Throughout all levels of visitor presence, the overall density of surgeonfishes remained similar (Fig. 4), suggesting that these fishes were shifting throughout the bay. During the closure, surgeonfishes dispersed from Channel into all other sectors, expanding their grazing range throughout the Bay. After the reopening, surgeonfishes continued to migrate into Keyhole from Backdoors and Channel. Damselfishes also increased significantly within Keyhole during the closure (Fig. 5, Tables 1 & 2). Some damselfishes shifted from Backdoors into Keyhole and Channel. After the reopening, all sectors decreased in density of damselfishes, likely due to seeking refuge in response to the increased snorkeling activity. Keyhole, the most popular snorkeling sector, experienced the largest decrease in damselfish density directly after the reopening of the Bay to visitors. Interestingly, this decrease in territorial damselfishes due to human avoidance may have allowed more surgeonfishes to graze within Keyhole after the reopening to visitors since damselfishes had abandoned guarding their home range from surgeonfishes when humans were present.

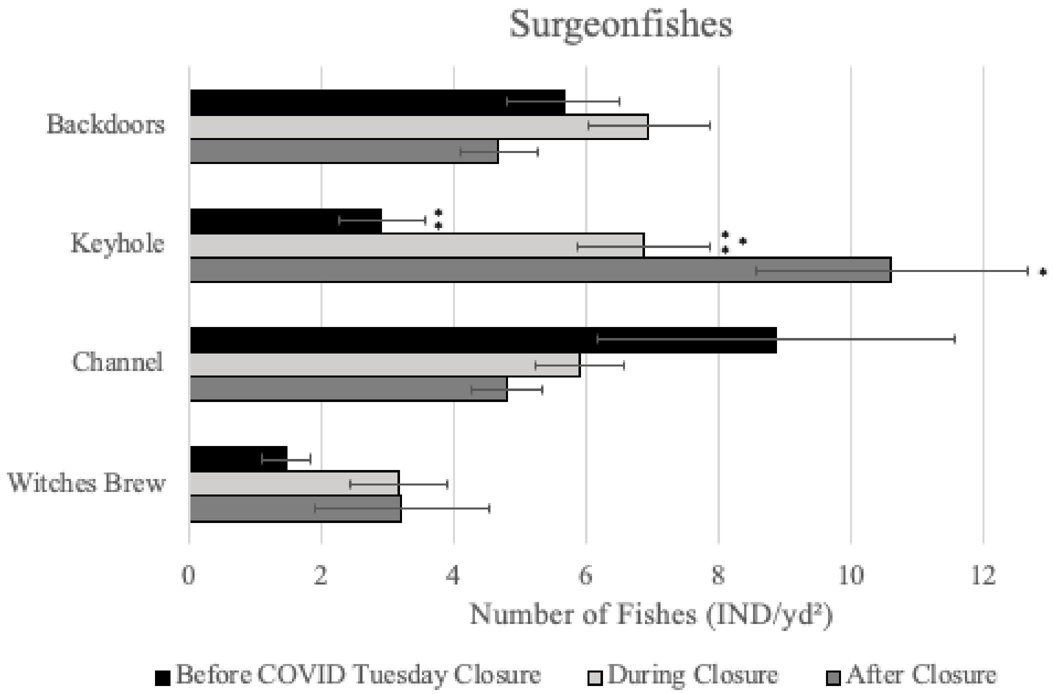


Figure 4. Mean number of Surgeonfish individuals before, during, and after the COVID-19 closure. Asterix (*) signify a significant difference between visitor levels ($p<0.05$). Error bars represent ± 1 standard error.

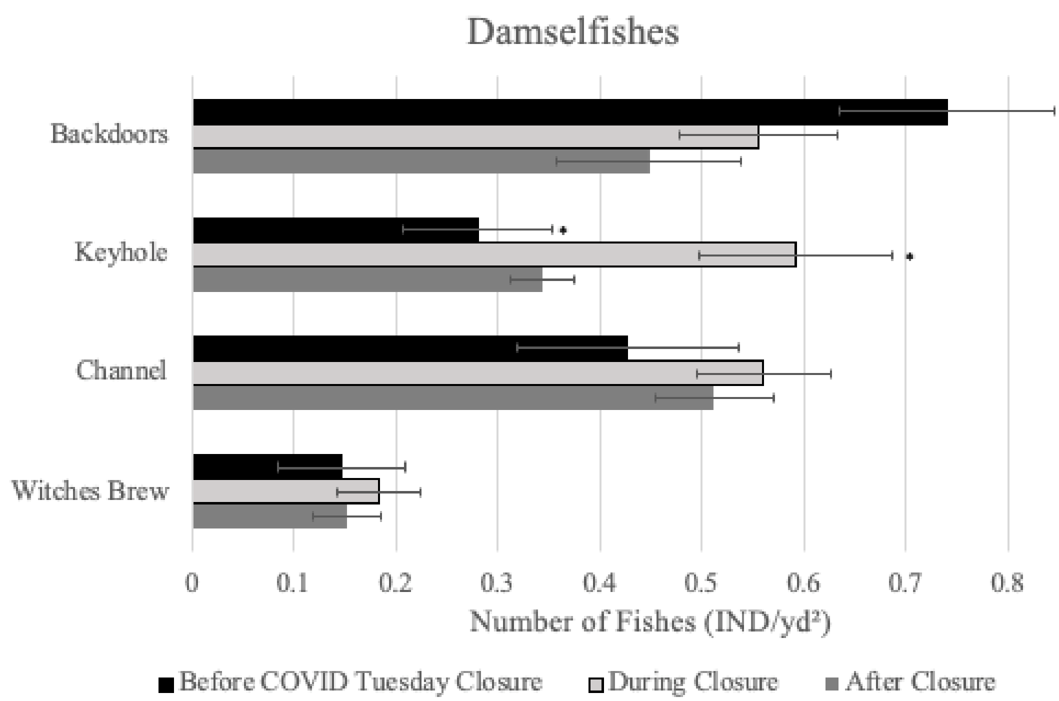


Figure 5. Mean number of Damselfish individuals before, during, and after the COVID-19 closure. Asterix (*) signify a significant difference between visitor levels ($p<0.05$). Error bars represent ± 1 standard error.

The density of chubs in Backdoors ($p<0.04$, (Fig. 6, Tables 1 &2)) and triggerfishes (Fig. 7) in Witches Brew ($p<0.03$) were significantly greater in density during the closure, when compared to before the closure (chubs in Backdoors: before 0.04 ± 0.02 ind/yd^2, and during 0.27 ± 0.05 ind/yd^2; triggerfishes in Witches Brew: before 0.09 ± 0.04 ind/yd^2, and during 0.23 ± 0.02 ind/yd^2). The large increase in chubs within Backdoors, and also Keyhole (non-significant), during the closure suggests chubs may have migrated into the inner reef from offshore looking for new sources of food that became less risky in the absence of visitors. After the closure, the density of chubs decreased to similar levels as before the closure but were more evenly distributed throughout the inner reef flat. Triggerfishes appeared to have moved from Backdoors, and possibly offshore, into Channel (non-significant) and Witches Brew during the closure. Following the reopening of the Bay to the public, triggerfishes within Witches Brew experienced significant (0.12 ± 0.02 ind/yd^2, $p<0.04$) declines in density. However, both sexes of the dominant triggerfishes within the Bay exhibit strong territorial behavior, so it may be more likely that they were hiding within their territories when snorkeler presence increased. Both chubs and triggerfishes experienced increases in density and range during the closure to the public, with subsequent decreases after the reopening of the Bay.

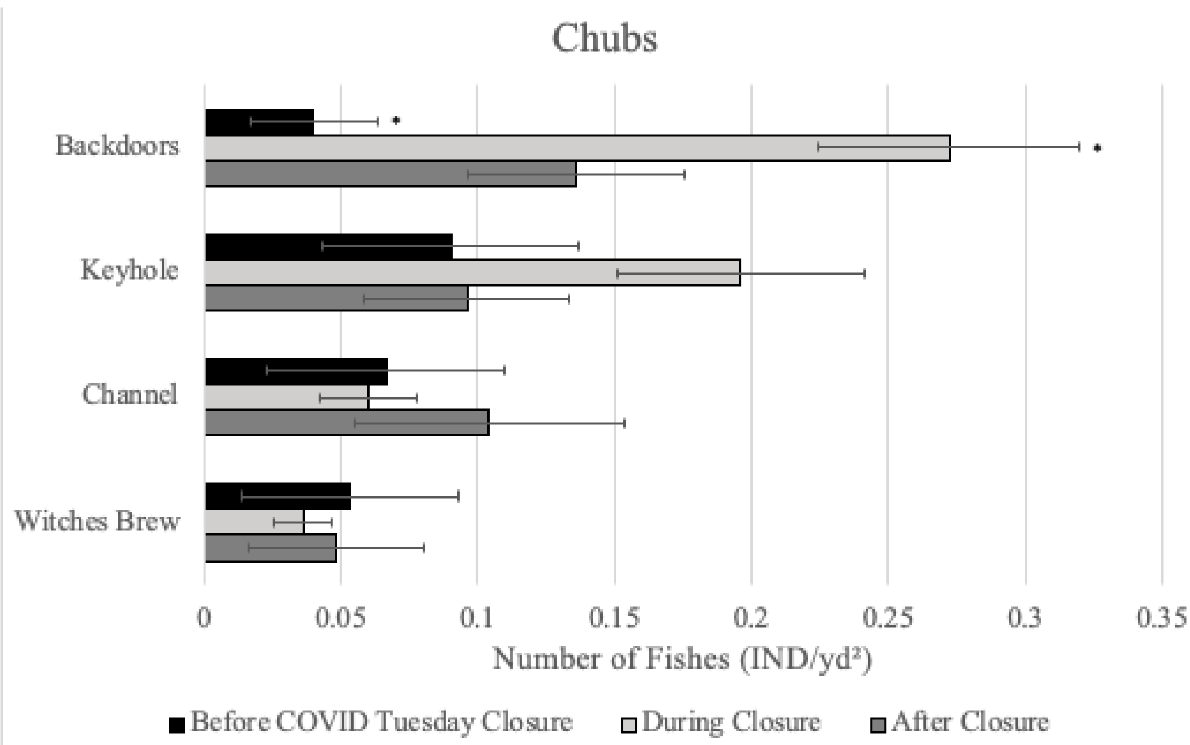


Figure 6. Mean number of Chubs individuals before, during, and after the COVID-19 closure. Asterix (*) signify a significant difference between visitor levels ($p<0.05$). Error bars represent ± 1 standard error.

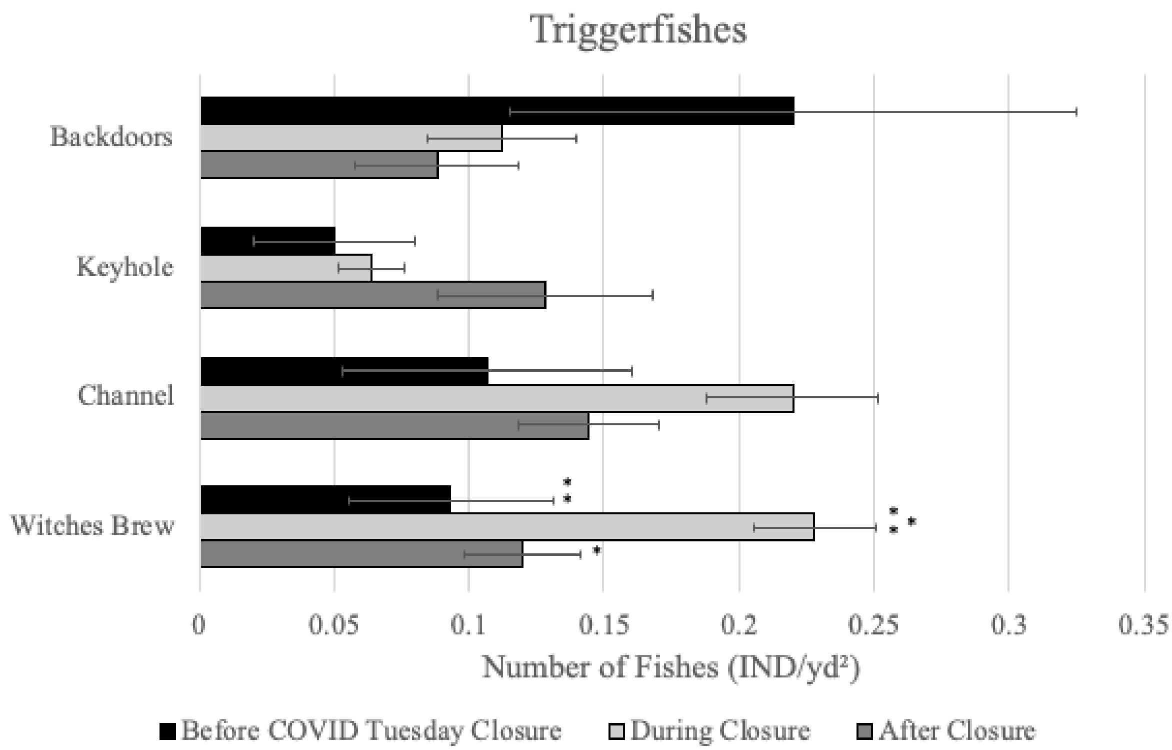


Figure 7. Mean number of Triggerfish individuals before, during, and after the COVID-19 closure. Asterix (*) signify a significant difference between visitor levels (p<0.05). Error bars represent ± 1 standard error.

Density of butterflyfishes increased during the closure within all sectors, suggesting fishes may have come in from offshore or were able to come out of shelter due to lack of visitors. Following the reopening of the Bay, Channel experienced significant decreased density of butterflyfishes (during: 0.31 ± 0.04 ind/yd^2, after: 0.12 ± 0.04 ind/yd^2, p<0.009, (Fig. 8, Tables 1 & 2). The density of butterflyfishes fell to pre-closure levels in all but Witches Brew, where the density of butterflyfishes increased. Butterflyfish density decreased by nearly half within the inner reef flat following the reopening, suggesting fishes were either hiding from snorkelers, or moved offshore. Human avoidance behavior of butterflyfishes was further supported by a significant negative correlation between the number of visitors and the density of butterflyfishes present along surveys. As the number of visitors to the HBNP increased, the density of butterflyfishes decreased significantly (correl.coef: -0.180, p<0.01). This explains their migration into Witches Brew, the least popular snorkeling sector, and Bay-wide reduction in density following the reintroduction of visitors to the HBNP. The reduction in density of butterflyfishes in the most popular snorkeling sectors following the reopening of the Bay suggests butterflyfishes are modifying their behavior in response to increased snorkeling activity.

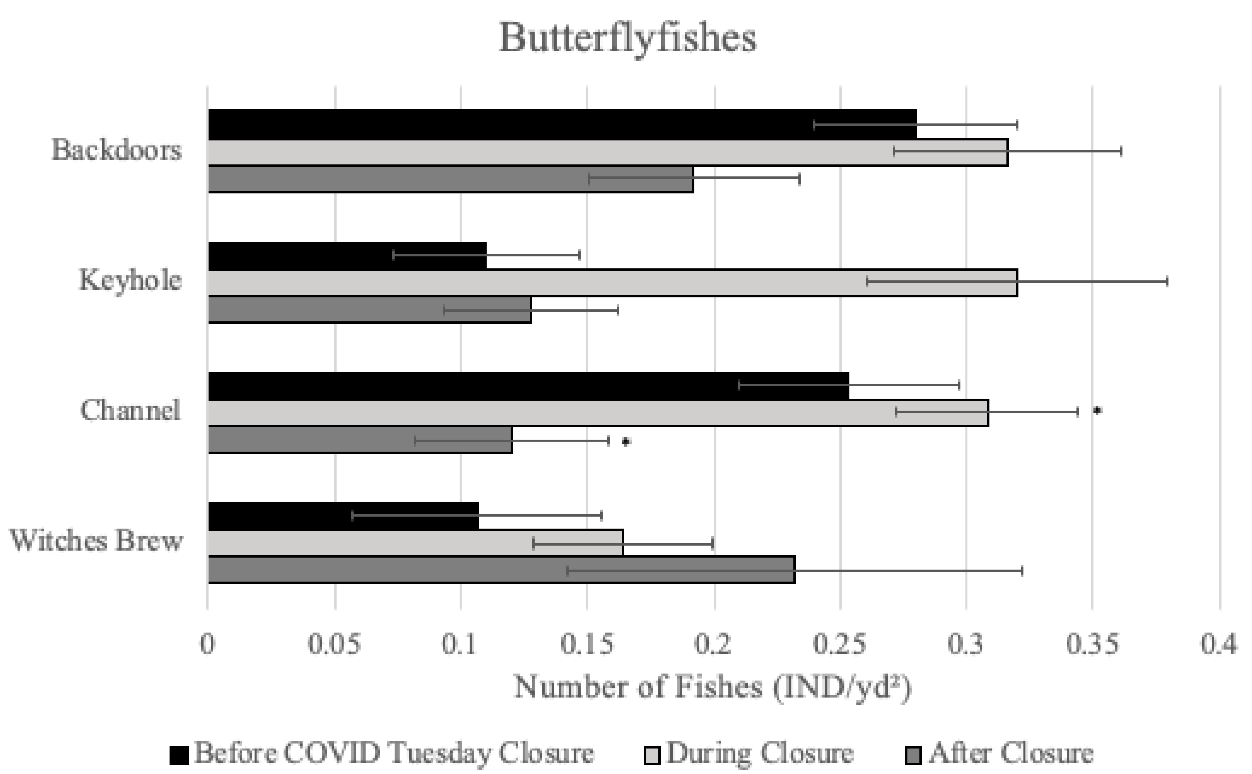


Figure 8. Mean number of Butterflyfish individuals before, during, and after the COVID-19 closure. Asterix (*) signify a significant difference between visitor levels (p<0.05). Error bars represent ± 1 standard error.

Wrasses within Backdoors also experienced significant differences in density throughout the differing visitor levels, however, no pairwise comparisons were significant (before: 0.74 ± 0.09 ind/yd^2, during: 0.64 ± 0.01 ind/yd^2, after: 0.30 ± 0.06 ind/yd^2, (Fig. 9, Table 1 & 2). The density of wrasses increased within all sectors, except for Backdoors, during the closure. Combined density of wrasses in all inner reef flat sectors increased following the closure likely as the result of increased comfort of shy species which allowed them to come out of hiding. After the reopening, all sectors decreased in density of wrasses, but remained in similar percentages within each sector. This could suggest that instead of fleeing into other sectors to escape visitors, the more wary species of wrasses found refuge within the sector they were currently in. The significant negative correlation between the number of visitors present at the HBNP and the density of wrasses supports the human avoidance theory (correl.coef: -0.187, p<0.01). As the number of visitors to the Bay increased, the density of wrasses observed along surveys decreased significantly. The reduction in density of wrasses within all sectors of the Bay and negative correlation with visitor counts suggests wrasses are modifying their behavior in response to increased snorkeling activity.

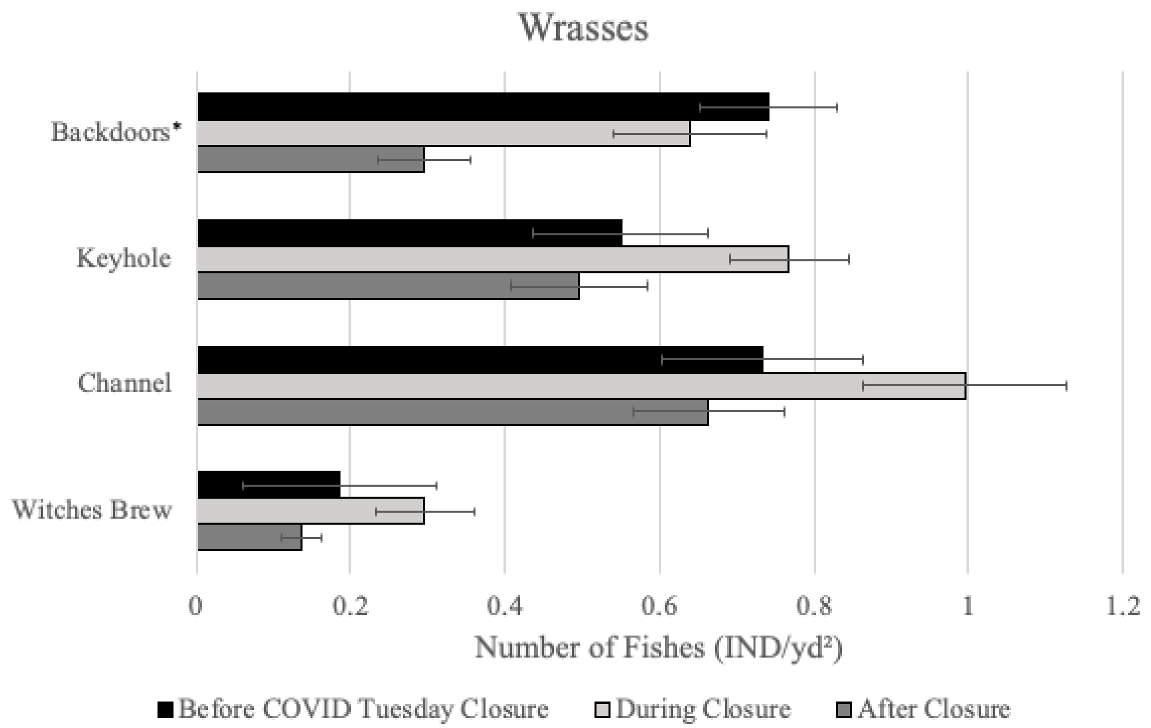


Figure 9. Mean number of Wrasse individuals before, during, and after the COVID-19 closure. Asterix (*) signify a significant difference between visitor levels (p<0.05). If no pair-wise comparisons were significant despite significant difference detected in the family over time, the asterix is next to the sector name. Error bars represent ± 1 standard error.

Shifts in several key families followed a trend of increased density during the closure with subsequent decreased density after the reopening of the Bay to the public. The majority of these shifts in density were of fishes migrating from the less popular snorkeling areas, Backdoors and Witches Brew, into more popular snorkeling areas, Keyhole and Channel. Although some fishes appear to have migrated from offshore, possibly chubs, the majority of fishes shifted throughout the inner reef flat, or, in the absence of visitors felt more comfortable coming out of hiding, and therefore were detected along surveys. The density of top fish families appears strongly influenced by the visitor presence within Hanauma Bay.

Changes in Density of Fish Species

Changes in the top species contributing to fish density were identified between levels of human use (Table 3 & Fig. 10). The two most abundant species for all levels of use were the convict tang (*Acanthurus triostegus*, *manini*) and the brown surgeonfish (*Acanthurus nigrofuscus*, *māi'i'i*). The convict tang remained in high density within the Bay throughout the changes in visitor levels (before: 0.23 ind/yd^2, during: 0.20 ind/yd^2, after: 0.22 ind/yd^2), yet it experienced a decrease in density following the reopening of the Bay within Channel (p<0.044). Because the convict tang did not decrease in overall density after the reopening of the Bay, it appears the fish may have dispersed from Channel sector into other sectors of the Bay. Convict tang travel in large schools of sometimes more than 200 individuals and need more grazing area, therefore, their transient population can lead to high variability between surveys. The brown surgeonfish significantly increased in density during the closure and remained in high density after the reopening within Keyhole (p<0.023) and Channel (p<0.038). Other surgeonfishes such as the orangespine unicornfish (Naso *lituratus*, *umaumalei,* Keyhole: p<0.027), ringtail surgeonfish (*Acanthurus blochii*, *pualu,* Witches Brew: p<0.004), and whitespotted surgeonfish (*Acanthurus guttatus*, *'api,* non-significant) followed a similar pattern: increasing in density during the closure and remaining in high density after the reopening. Interspecies relationships may be responsible for the continued increase in surgeonfishes following the reopening of the Bay to visitors. In the absence of humans, damselfishes may have been more comfortable guarding an area of substrate from other grazers, but with the reintroduction of visitors to the HBNP, the damselfishes may have retreated to hiding which allowed surgeonfishes to expand their grazing range further into areas that were "off-limits" during the pandemic. The yellowfin surgeonfish (*Acanthurus xanthopterus*, *pualu,* non-significant) was the only surgeonfish that decreased in density during the closure and continued to decrease further after the reopening. These fishes are more transient and migratory in nature and therefore have a much broader range. The transient nature of fishes increases the variability in density observed between surveys. Overall, most species of surgeonfishes were able to expand their grazing ranges throughout the entire reef flat of Hanauma Bay during the closure to visitors.

Of the top overall species contributing to density, 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 at 25% capacity: palenose parrotfish (*Scarus psittacus*, *uhu*, non-significant), saddle wrasse (*Thalassoma duperrey*, *hīnālea lauwili*, Backdoors: p<0.045), belted wrasse (*Stethojulis balteata*, *oʻmaka*, Keyhole: p<0.011), brighteye damselfish (*Plectroglyphidodon imparipennis*, non-significant), blackspot sergeant (*Abudefduf sordidus*, *kūpīpī*, non-significant) , white spotted toby (*Canthigaster jactator*, non-significant), and chubs (*Kyphosus spp*., *nenue*, non-significant) (Fig. 10). The belted wrasse, brighteye damselfish, and white spotted toby exhibit cryptic behavioral tendencies and thus retreat to hiding as snorkelers pass. Therefore, human avoidance theory explains the forementioned pattern throughout the pandemic for these species. The palenose parrotfish, saddle wrasse, blackspot sergeant, and chubs are not particularly known to be wary of visitors, yet the increase in density following the closure and decrease in density after the re-introduction of snorkelers suggests human avoidance tendencies. Although several species of surgeonfishes did not experience a decrease in density after the reopening of the Bay, almost half of the top contributors to density experienced decreased density following the reopening within the most heavily snorkeled sectors.

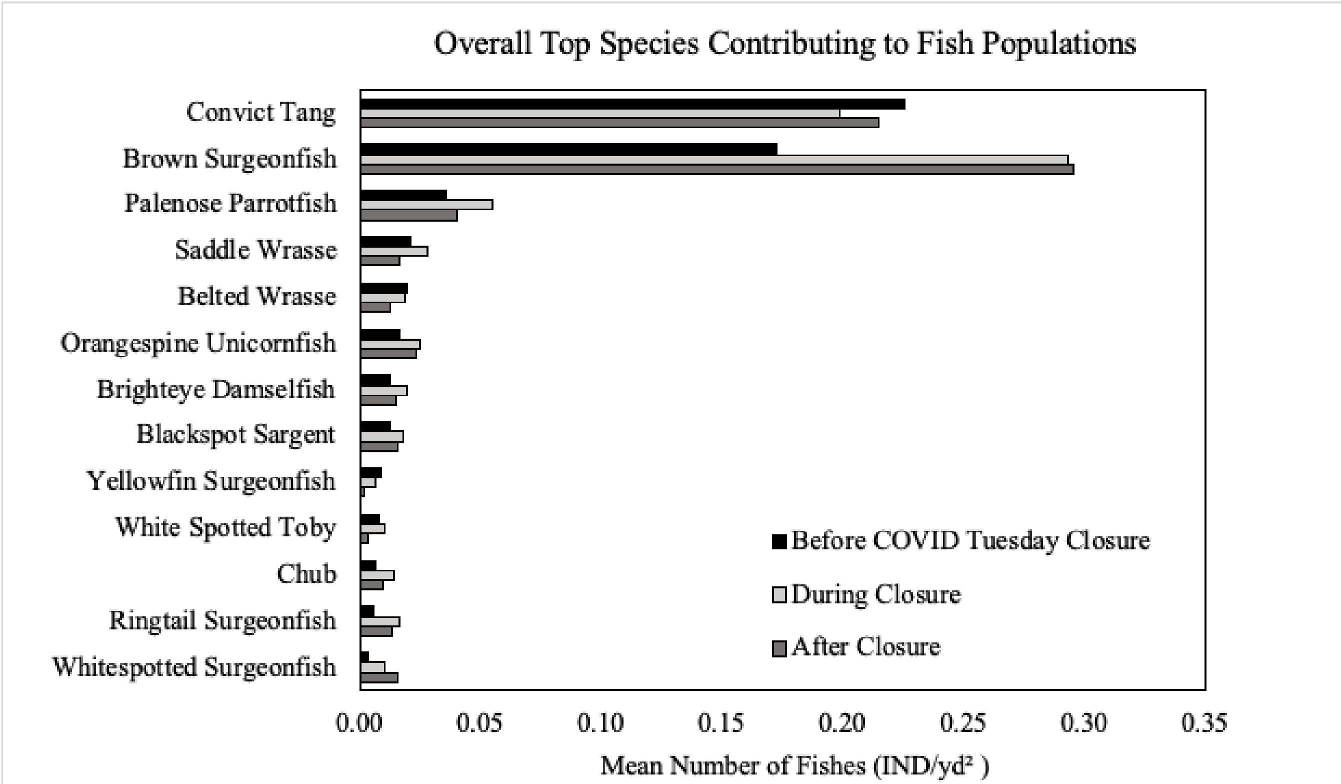


Figure 10. Mean number of fishes of overall top species before, during, and after the COVID-19 closure.

Less dominant fishes that experienced significant changes in density over the closure belong to the wrasse (1 spp.), goatfish (1 spp.), and triggerfish (2 spp.) families. Two of these fishes decreased in density following the reopening of the Bay to the public at limited capacity to visitors. The bird wrasse (*Gomphosus varius, hīnālea ʻiʻiwi, ʻakilolo,* $p<0.021$) within Channel and doublebar goatfish (*Parupeneus bifacsciatus*, *munu*, $p<0.013$) within Witches Brew experienced significant declines in density following the reopening of the bay to the public. Although no significant differences were found between timepoints, the reef triggerfish (*Rhinecanthus rectangulus*, *humuhumunukunukuapuaʻa*, $p<0.046$) in Backdoors and lagoon triggerfish (*Rhinecanthus aculeatus*, *humuhumunukunukuapuaʻa*, $p<0.034$) in Witches Brew also experienced significant changes in density throughout the three visitor levels. These four species are typically observed solo or within a mated pair, and all fall within the invertivorous trophic families, feeding mostly on benthic invertebrates. While more dominant herbivorous surgeonfishes thrived during the closure and after the reopening, more wary invertivorous fishes such as wrasses and goatfish appear to have declined with the return of visitors to the Bay.

Table 3. Significant differences (p<0.05) in density of fishes comparing before the closure on a closed Tuesday, during the COVID-19 closure, and after the reopening of the Bay at 25% capacity. No pairwise comparisons reflects a significant difference that had too much variation to discern differences between timepoints. Information was collated from Independent-samples Kruskal Wallis tests with Dunn-Bonferroni pairwise comparisons.

Period with greater density of fishes	Sector	Species	Common Name	Hawaiian Name	Significance
Before the closure had more fish than after the closure.	Keyhole	*Stethojulis balteata*	Belted Wrasse	ōmaka	0.019
	Channel	*Acanthurus triostegus*	Convict Tang	manini	0.044
During the closure had more fish than before the closure.	Keyhole	*Naso lituratus*	Orangespine Unicornfish	umaumalei	0.049
	Channel	*Thalassoma duperrey*	Saddle Wrasse	hīnālea lauwili	0.049
During the closure had more fish than after the closure.	Backdoors	*Thalassoma duperrey*	Saddle Wrasse	hīnālea lauwili	0.045
	Keyhole	*Stethojulis balteata*	Belted Wrasse	ōmaka	0.044
	Channel	*Gomphosus varius*	Bird Wrasse	hīnālea ‘i‘iwi, ‘akilolo	0.021
	Witches Brew	*Parupeneus bifasciatus*	Doublebar Goatfish	munu	0.013
After the closure had more fish than before the closure.	Keyhole	*Acanthurus nigrofuscus*	Brown Surgeonfish	māi‘i‘i	0.023
		Naso lituratus	Orangespine Unicornfish	umaumalei	0.033
	Channel	*Acanthurus nigrofuscus*	Brown Surgeonfish	māi‘i‘i	0.038
	Witches Brew	*Acanthurus blochii*	Ringtail Surgeonfish	pualu	0.02
After the closure had more fish than during the closure.	Witches Brew	*Acanthurus blochii*	Ringtail Surgeonfish	pualu	0.012
No pairwise comparisons	Backdoors	*Rhinecanthus rectangulus*	Reef Triggerfish	humuhumunu kunukuapua'a	0.046
	Witches Brew	*Rhinecanthus aculeatus*	Lagoon Triggerfish	humuhumunu kunukuapua'a	0.034

Changes in Density of Trophic Levels

In addition to changes in species composition, shifts in density of herbivorous and invertivorous fishes were significant between the changing visitor levels within Keyhole. Significantly less herbivorous fishes were seen in Keyhole before the closure (3.49 ± 0.79 ind/yd^2) when compared to during (8.20 ± 1.03 ind/yd^2, p<0.008) and after the closure (11.34 ± 2.07 ind/yd^2, p<0.003). This shift suggests that herbivorous fishes, like surgeonfishes and parrotfishes, expanded their grazing range into Keyhole with the absence of visitors. At 25% capacity of visitors, herbivore density did not decrease, thus the grazing behavior of herbivores was not altered at a lower capacity of visitors, or, herbivore populations had not had enought time to equilibrate to the new visitor levels. Similarly, density of invertivorous fishes within Keyhole were significantly lower before (0.88 ± 0.18 ind/yd^2) the closure when compared to during the closure (1.70 ± 0.17 ind/yd^2, p<0.03). After the closure, density of invertivores decreased (1.07 ± 0.16 ind/yd^2) to levels similar to before the closure: there were no significant difference in density of invertivores between surveys conducted before and after the closure. This could reflect an avoidance behavior exhibited by invertivores such as butterflyfishes, goatfishes, and wrasses. No changes in trophic composition were observed in piscivores or zooplanktivores within Keyhole. Likewise, no changes in trophic composition were detected in Backdoors, Channel, or Witches Brew. The only shifts in trophic composition throughout the study were observed within Keyhole of herbivorous and invertivorous fishes.

To assess the impact of seasonality on shifts in trophic composition, the density of herbivores, invertivores, piscivores, and zooplanktivores were compared between winter 2019/20, spring 2020, summer 2020, and winter 2020/21. The only sector with significant differences in trophic composition over the study period was Keyhole. Herbivore density within Keyhole increased significantly in spring 2020 (8.11 ± 1.35 ind/yd^2, $p<0.04$) and winter 2020/21 (11.13 ± 1.85 ind/yd^2, $p<0.01$) when compared to the previous winter prior to the pandemic (3.49 ± 0.79 ind/yd^2). It is less likely that the increase in herbivores, mainly surgeonfishes, was due to availability of new resources, or primary production, since these large increases in herbivores were seen in spring and the following winter, but not in the summer. Invertivores also increased significantly (2.03 ± 0.33 ind/yd^2, $p<0.03$) in spring 2020 when compared to the previous season of winter 2019/20 (0.88 ± 0.18 ind/yd^2). Many invertivores that followed this pattern also exhibit behaviors of predator and human avoidance strategies such as hiding, suggesting the increase in density observed in the spring could be the result of decreased threat by visitors at the Bay, rather than increased resource availability. If shifts in trophic composition were seasonally driven, these shifts would be seen more equally in all sectors of the Bay, rather than only in the most popular snorkeling sector of the Bay. Overall, the seasonal influence of summertime primary production does not appear to be strong driver of trophic compositional shifts.

Changes in Biomass of Fish Families

A comparison of the biomass of fishes was completed for each sector between the three visitor levels: before the closure on a closed Tuesday (less than 7 researchers/day), during the closure (less than 7 researchers per day), and after the reopening (approximately 720 visitors per day). Backdoors (172.8 ± 18.1 g/yd^2, $p<0.04$) and Keyhole (159.2 ± 22.8 g/yd^2, $p<0.003$) were significantly greater in biomass during the COVID-19 closure when compared to before the closure (Backdoors: 66.8 ± 10.4 g/yd^2, Keyhole: 41.9 ± 10.4 g/yd^2). Similar to the density, the biomass of fishes continued to be significantly greater in Keyhole (210.3 ± 26.7 g/yd^2, $p<0.002$) after the reopening of the Bay to the public at 25% capacity (Fig. 2). 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. No overall changes in fish biomass were observed in either Channel or Witches Brew at differing visitor levels. The confounding influence of seasonality was assessed between winter 2019/20, spring 2020, summer 2020, and winter 2020/21 and changes in biomass between the seasons did not correspond to typical increases in primary production. Therefore, seasonality does not appear to be a driving factor in changes in fish biomass. Changes in reserve status more closely explained the pattern in biomass of fishes over the study period.

Several dominant fish families experienced fluctuations in overall fish biomass with differing levels of visitor presence. Similar to density of fishes, biomass significantly increased during the closure for chubs (before: 3.7 ± 2.2 g/yd^2 , during: 30.8 ± 6.4 g/yd^2, $p<0.05$) in Backdoors, surgeonfishes (before: 25.3 ± 6.3 g/yd^2 , during: 87.9 ± 13.3 g/yd^2, p<0.004, Fig. 11, Table 4 & 5), wrasses (before: 1.3 ± 0.4 g/yd^2 , during: 4.2 ± 0.52 g/yd^2, p<0.004, Fig. 12), and butterflyfishes (before: 0.9 ± 0.3 g/yd^2 , during: 3.6 ± 0.7 g/yd^2, p <0.04, Fig. 13) within Keyhole, and triggerfishes within Witches Brew (before: 2.4 ± 1.0 g/yd^2 , during: 9.0 ± 1.2 g/yd^2, p <0.009, Fig. 14). Biomass of surgeonfishes within Keyhole continued to be significantly greater after the closure when compared to before the closure (after: 136.5 ± 30.0 g/yd^2, p <0.001, Fig. 10). Likewise, the biomass of goatfishes within Backdoors was significantly greater after the closure when compared to before the closure (before: 0.3 ± 0.3 g/yd^2, after: 3.9 ± 1.0 g/yd^2, p <0.04, Fig. 15). While surgeonfishes and goatfishes remained in high biomass following the reopening of the Bay, several families experienced significant decreases in biomass following the reintroduction of visitors to the HBNP: snappers (during: 4.4 ± 1.0 g/yd^2, after: 0 ± 0 g/yd^2, p <0.002, Fig.16) and wrasses (during: 4.2 ± 0.5 g/yd^2, after: 2.3 ± 0.5 g/yd^2, p <0.02, Fig. 12) in Keyhole and wrasses (during: 4.5 ± 0.9 g/yd^2, after: 2.0 ± 0.4 g/yd^2, p <0.02, Fig. 12), butterflyfishes (during: 2.9 ± 0.4 g/yd^2, after: 1.2 ± 0.4 g/yd^2, p <0.02, Fig. 13), and snappers (during: 1.9 ± 0.8 g/yd^2, after: 0 ± 0 g/yd^2, p <0.04, Fig. 16) in Channel. Snappers, wrasses, and butterflyfishes frequently go into hiding in response to a perceived threat. When the relationship between the number of visitors to the HBNP and the biomass of fish families was explored, all three of these families exhibited a negative correlation. As the number of visitors to the Bay increased (box office counts) the biomass of wrasses (correl.coef: -0.150, p<0.03), butterflyfishes (correl.coef: -0.154, p<0.03), and snappers (correl.coef: -0.310, p<0.001) decreased. Significant declines in the biomass of dominant fish families after the reopening of the HBNP were most obvious within the two most popular snorkeling sectors, Keyhole and Channel.

Table 4. Significant family-specific changes (p<0.05, highlighted in orange) occuring in the biomass of fishes within each sector of Hanauma Bay comparing surveys conducted before the COVID-19 closure on closed Tuesdays, during the closure, and after the reopening of the Bay to visitors at 25% capacity. Trends explain overall increase (↑) in population biomass, increase during the closure with a decrease after the reopening of the Bay to the public (∩), or no change (-).

		Mean Biomass (grams per square meter)			
Family	Sector	Before	During	After	Trend
Surgeonfishes	Keyhole	25.3 ± 6.3	87.9 ± 13.3	136.5 ± 30.0	↑
Wrasses	Keyhole	1.3 ± 0.4	4.2 ± 0.5	2.3 ± 0.5	∩
	Channel	1.8 ± 0.4	4.5 ± 0.9	2.0 ± 0.4	∩
Butterflyfishes	Keyhole	0.9 ± 0.3	3.6 ± 0.7	1.3 ± 0.4	∩
	Channel	2.3 ± 0.4	2.9 ± 0.4	1.2 ± 0.4	∩
Triggerfishes	Witches Brew	2.4 ± 1.0	9.0 ± 1.2	5.6 ± 1.3	∩
Chubs	Backdoors	3.7 ± 2.2	30.8 ± 6.4	13.0 ± 3.7	∩
	Keyhole	5.0 ± 2.9	32.2 ± 10.2	16.0 ± 7.5	∩
Goatfishes	Backdoors	0.3 ± 0.3	2.4 ± 0.7	3.9 ± 1.0	↑
	Channel	0.5 ± 0.3	4.9 ± 1.6	4.1 ± 1.4	∩
Snappers	Keyhole	0.3 ± 0.2	4.4 ± 1.0	0.0 ± 0.0	∩
	Channel	0.9 ± 0.4	1.9 ± 0.8	0.0 ± 0.0	∩

Table 5. Significant differences (p<0.05) in biomass of top ten families comparing before the closure on a closed Tuesday, during the COVID-19 closure, and after the reopening of the Bay at 25% capacity. No pairwise comparisons reflects a significant difference that had too much variation to discern differences between timepoints. Information was collated from Independent-samples Kruskal Wallis tests with Dunn-Bonferroni pairwise comparisons.

Period with greater biomass of fishes	Sector	Fish Family	Significance
During the closure had higher biomass of fish than before the closure.	Backdoors	Chubs	0.041
	Keyhole	Butterflyfishes	0.033
		Surgeonfishes	0.003
		Wrasses	0.003
	Channel	Wrasses	0.029
	Witches Brew	Triggerfishes	0.008
During the closure had higher biomass of fish than after the closure.	Keyhole	Snappers	0.001
		Wrasses	0.011
	Channel	Butterflyfishes	0.016
		Snappers	0.039
		Wrasses	0.011
After the closure had higher biomass of fish than before the closure.	Backdoors	Goatfishes	0.037
	Keyhole	Surgeonfishes	0
No pairwise comparisons.	Keyhole	Chubs	0.047
	Channel	Goatfishes	0.044

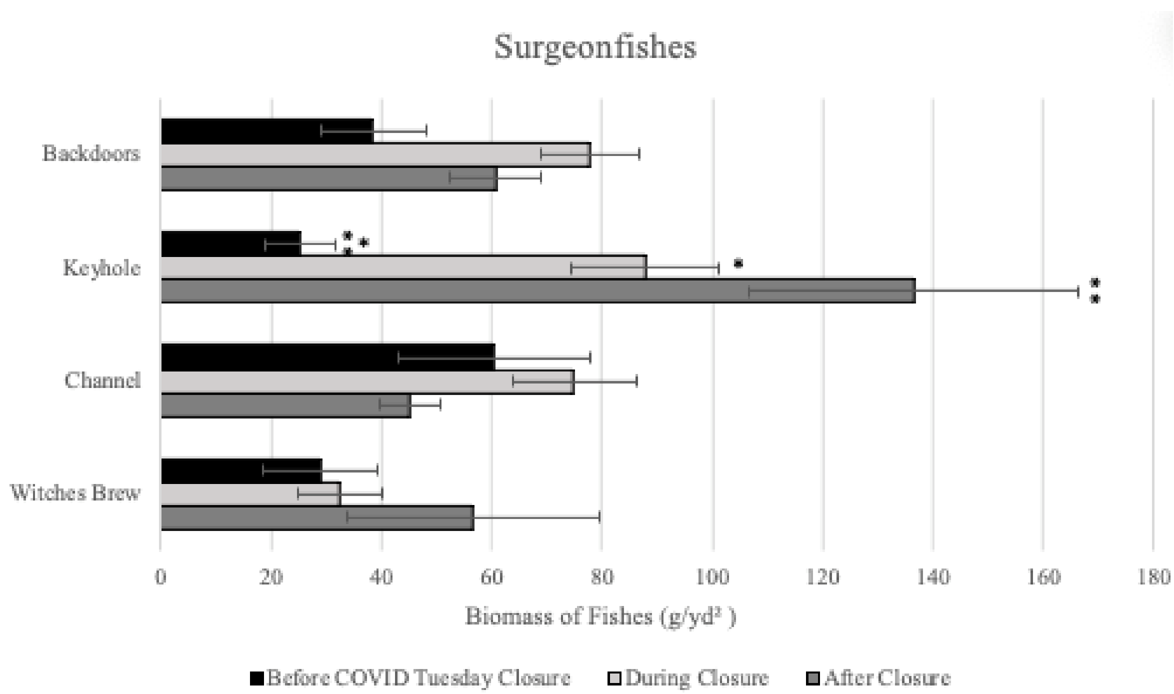


Figure 11. Mean biomass (g/yd^2) of Surgeonfishes before, during, and after the COVID-19 closure within each sector. Asterix (*) next to the bar signifies significant differences detected between visitor levels (p<0.05). Error bars represent ± 1 standard error.

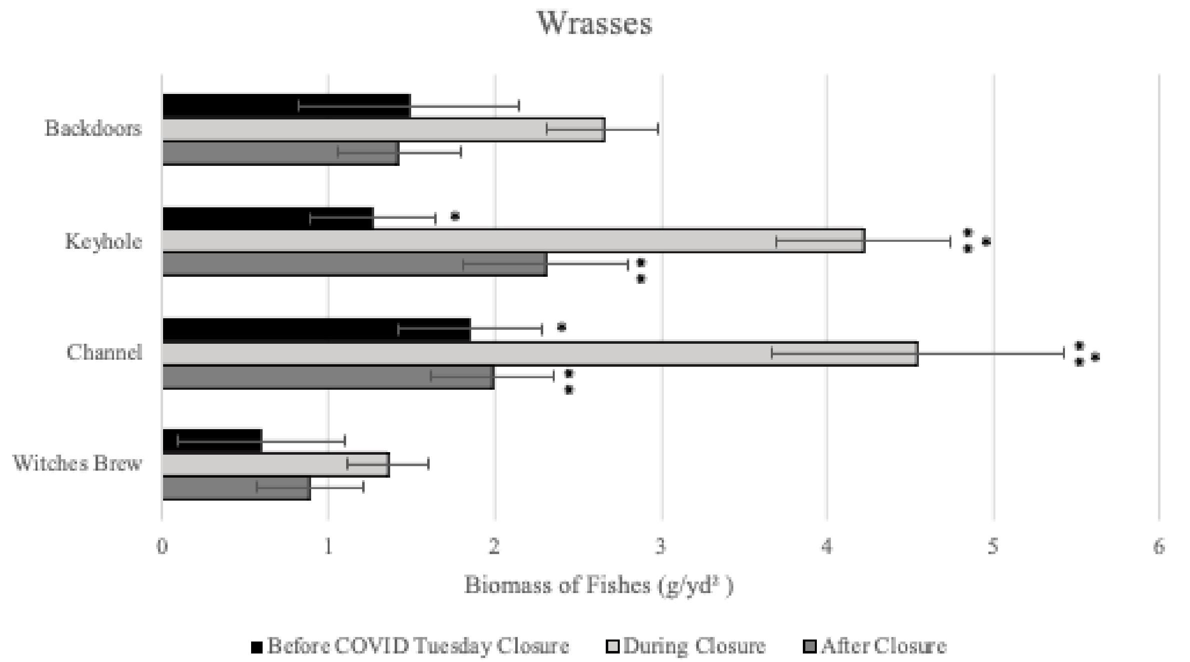


Figure 12. Mean biomass (g/yd^2) of Wrasses before, during, and after the COVID-19 closure within each sector. Asterix (*) next to the bar signifies significant differences detected between visitor levels (p<0.05). Error bars represent ± 1 standard error.

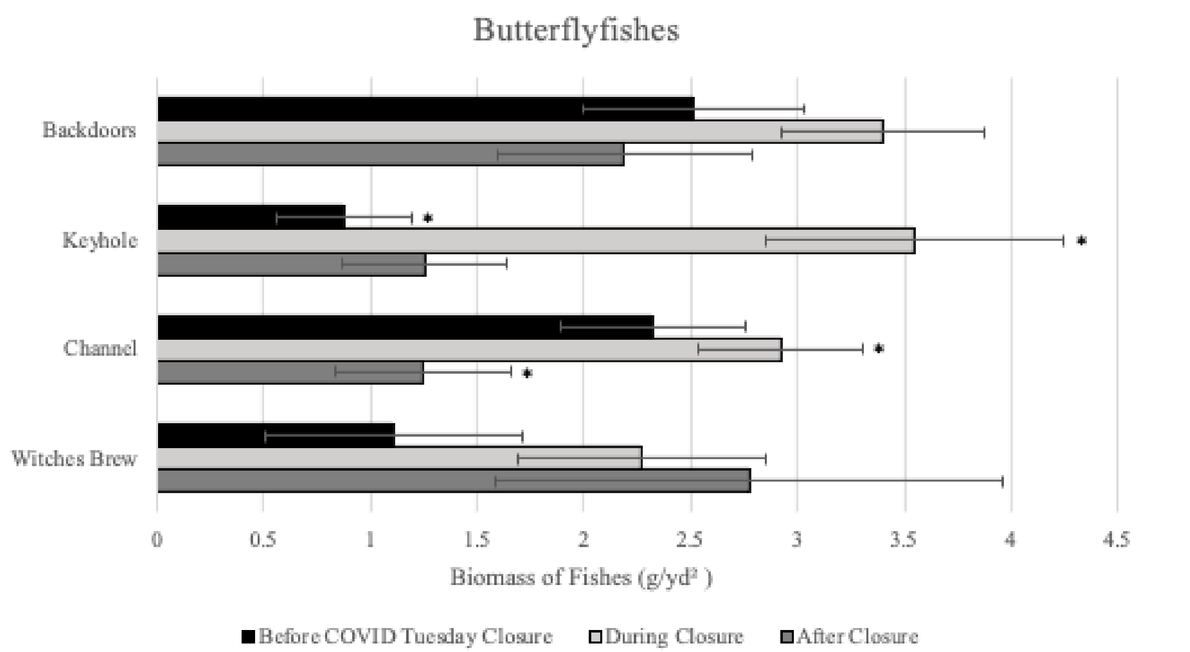


Figure 13. Mean biomass (g/yd^2) of Butterflyfishes before, during, and after the COVID-19 closure within each sector. Asterix (*) next to the bar signifies significant differences detected between visitor levels (p<0.05). Error bars represent ± 1 standard error.

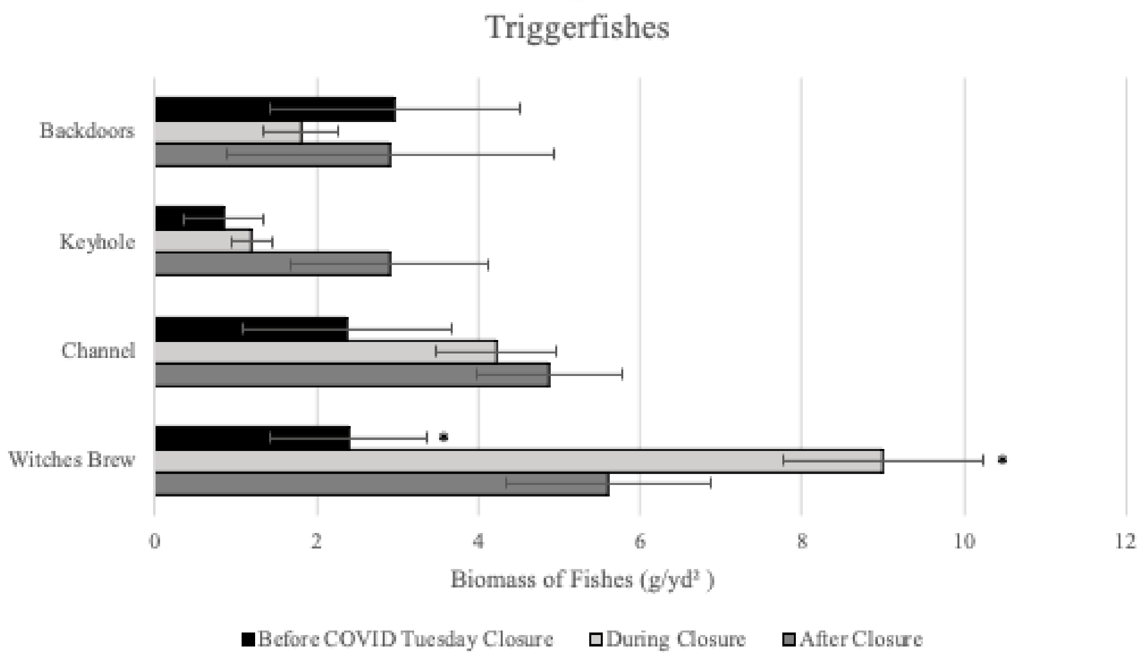


Figure 14. Mean biomass (g/yd^2) of Triggerfishes before, during, and after the COVID-19 closure within each sector. Asterix (*) next to the bar signifies significant differences detected between visitor levels (p<0.05). Error bars represent ± 1 standard error.

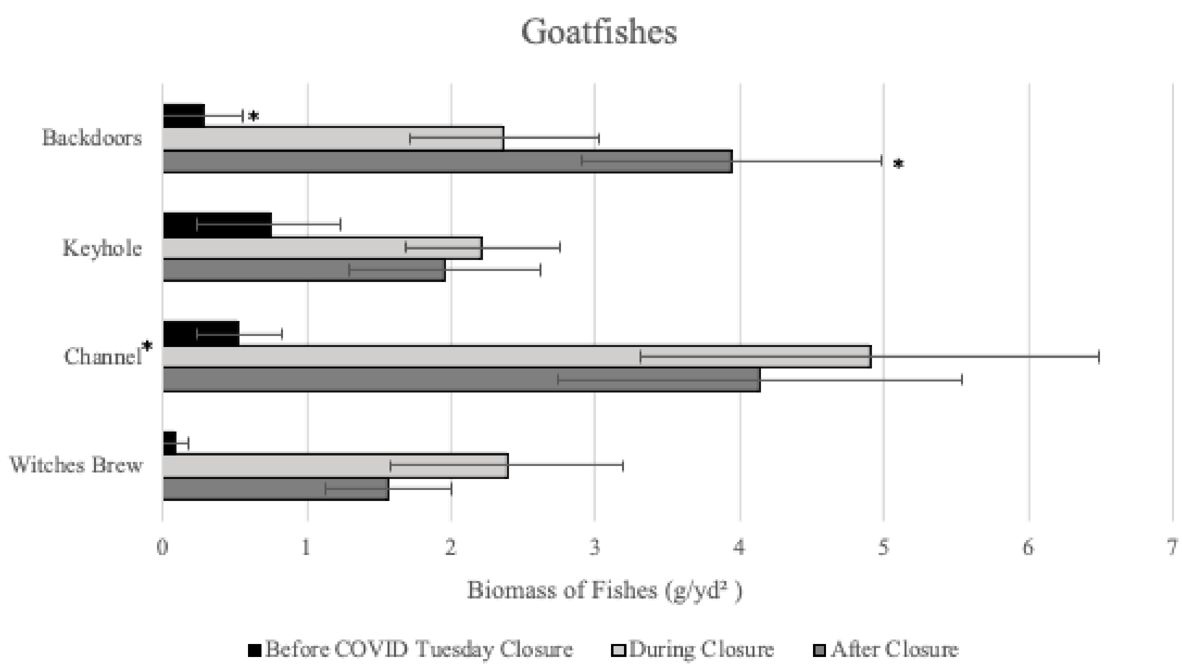


Figure 15. Mean biomass (g/yd^2) of Goatfishes before, during, and after the COVID-19 closure within each sector. Asterix (*) next to the bar signifies significant differences detected between visitor levels (p<0.05). If no pair-wise comparisons were significant despite significant difference detected in the family over time, the asterix is next to the sector name. Error bars represent ± 1 standard error.

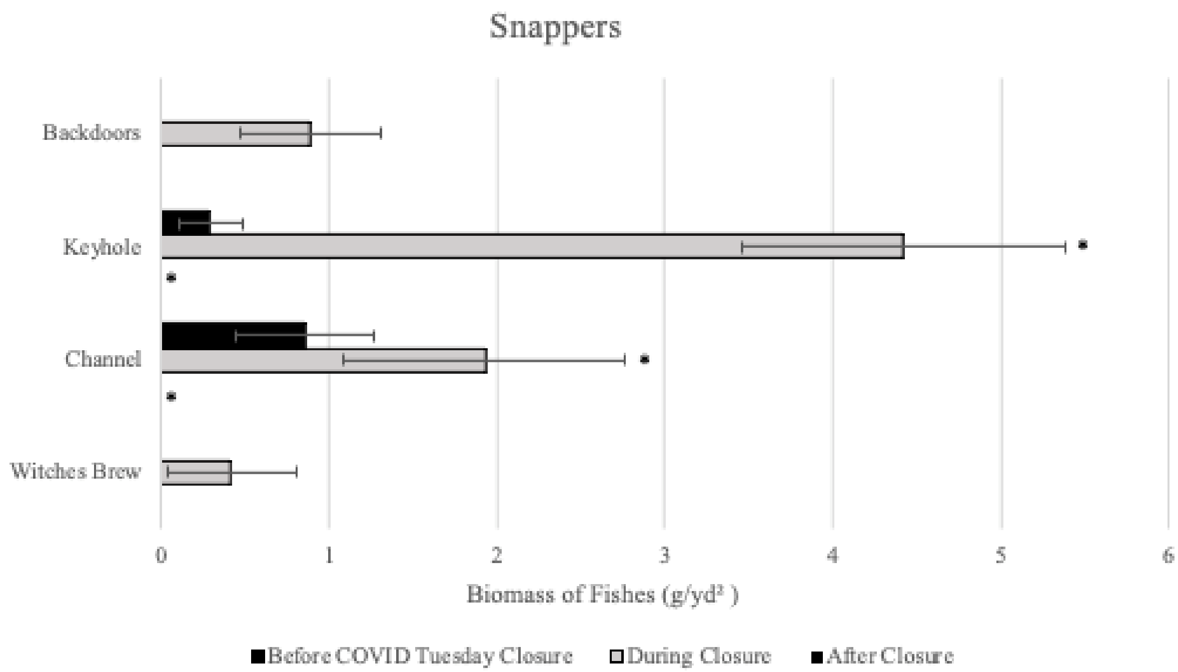


Figure 16. Mean biomass (g/yd^2) of Snappers before, during, and after the COVID-19 closure within each sector. Where bars are absent, no snappers were observed along transects. Asterix (*) next to the bar signifies significant differences detected between visitor levels (p<0.05). Error bars represent ± 1 standard error.

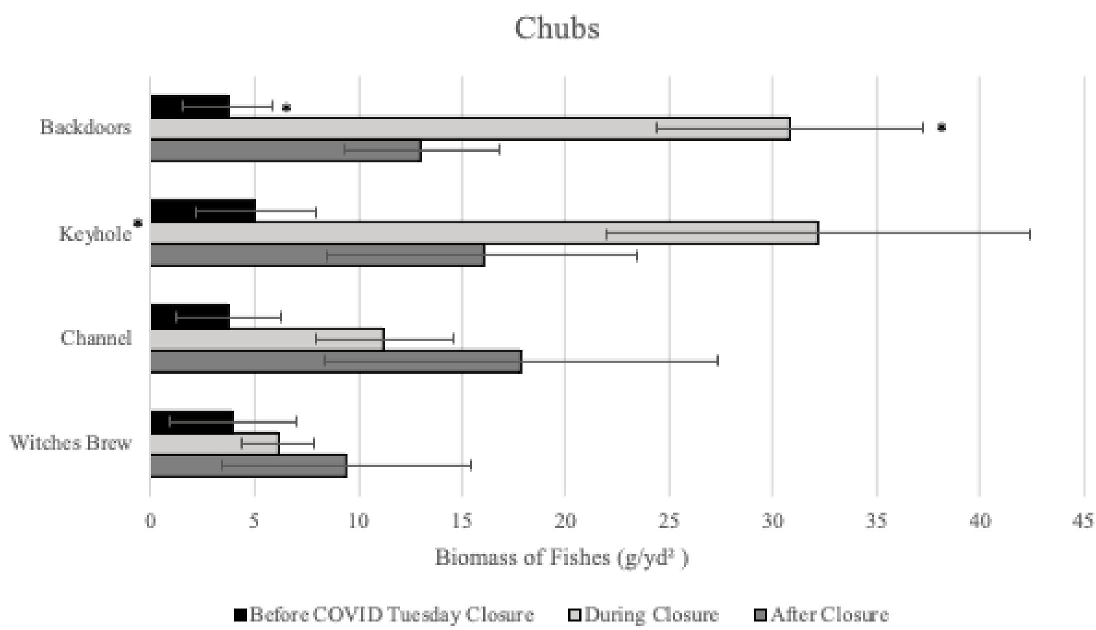


Figure 17. Mean biomass (g/yd^2) of Chubs before, during, and after the COVID-19 closure within each sector. Asterix (*) next to the bar signifies significant differences detected between visitor levels (p<0.05). If no pair-wise comparisons were significant despite significant difference detected in the family over time, the asterix is next to the sector name. Error bars represent ± 1 standard error.

Changes in Biomass of Fish Species

Changes in the top species contributing to biomass of fishes were identified between levels of human use (Fig. 18). Twelve species of fishes dominated the biomass during all three timepoints. Of these, eleven increased in biomass during the COVID-19 closure, when compared to before the closure. Only one species, the yellowfin surgeonfish, decreased in biomass following the closure of the HBNP to visitors and continued to decrease after the reopening of the Bay to the public (non-significant). Other fishes, such as the brown surgeonfish, chubs, the sailfin tang, and the black spot sargent decreased slightly after the reopening of the Bay to the public. Many fish species that experienced an increase in biomass during the closure, continued to increase in biomass after the reopening of the Bay at 25% capacity: the convict tang (non-significant), spectacled parrotfish (*Chlorurus perspicillatus*, *uhu uliuli*, non-significant), bluefin trevally (*Caranx melampygus*, *ʻomilu*, non-significant), ringtail surgeonfish (Keyhole: $p<0.032$, Witches Brew: $p<0.011$), and whitespotted surgeonfish (non-significant). Several other species increased in biomass during the closure and remain a similar biomass after the reopening: the brown surgeonfish (Keyhole: $p<0.02$, Channel: $p<0.046$), orangespine unicornfish (Keyhole: $p<0.002$, Channel: $p<0.01$), palenose parrotfish (non-significant), sailfin tang (*Zebrasoma veliferum*, *māneʻoneʻo*, non-significant), and blackspot sergeant (Keyhole: $p<0.004$). Only two fish species of the top contributors to biomass, the previously mentioned yellowfin surgeonfish (non-significant) and the chub (non-significant), decreased in biomass following the reopening of the bay to visitors at 25% capacity. Unlike dominant fishes for biomass, many of the dominant fishes within density experienced declines after the closure, this suggests larger fishes may have practiced less avoidance behavior from humans as compared to smaller fishes.

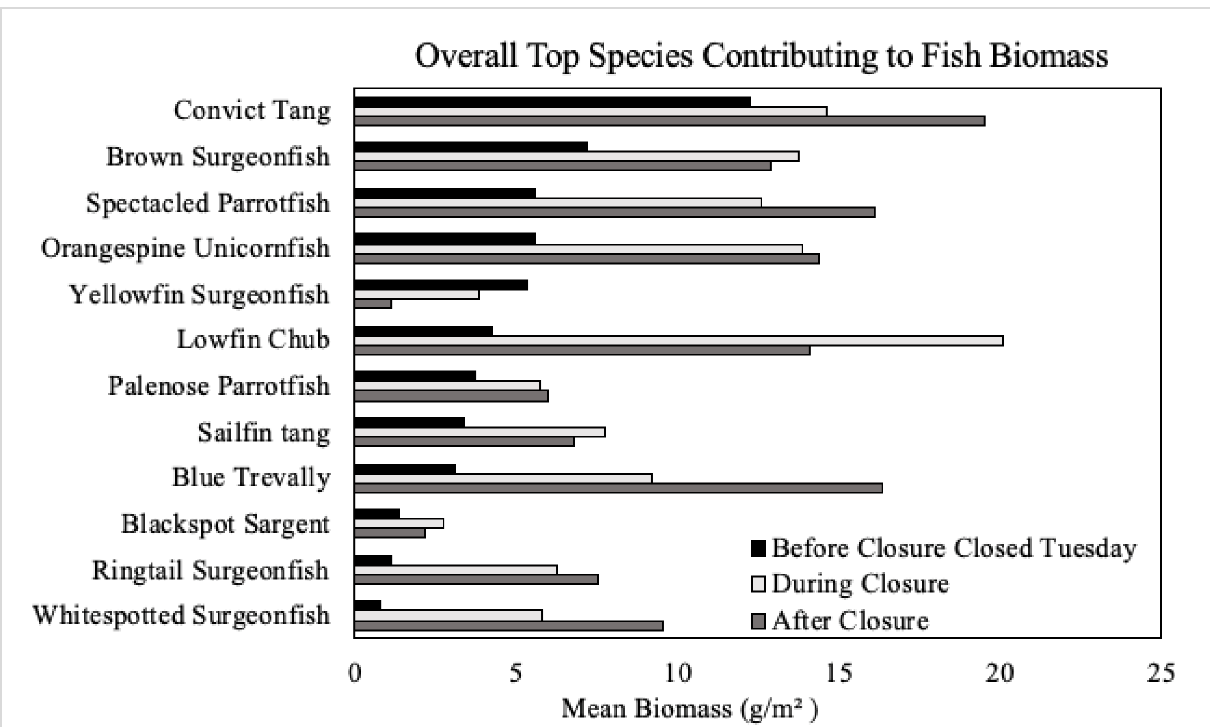


Figure 18. Overall top species contributing to fish biomass before, during and after the COVID-19 closure.

Other, less dominant fishes were examined for changes in biomass between visitor levels (Table 6). Eight species of fishes increased in biomass during the closure, when compared to before the closure, with three of these species remaining high in biomass after the reopening of the Bay to the public. No fishes had significantly greater biomass prior to the COVID-19 closure. Biomass significantly increased within Keyhole sector during the closure for the previously mentioned blackspot sergeant (p<0.005), ringtail surgeonfish (p<0.044), brown surgeonfish (p<0.045) and orangespine unicornfish (p<0.01), as well as the less dominant bluestripe butterflyfish (*Chaetodon fremblii*, *kīkākapu*, p<0.044), bird wrasse (p<0.007), and bluestripe snapper (*Lutjanus kasmira, ta'ape*, p<0.045). Channel sector also experienced significant increases in biomass of the orangespine unicornfish (p<0.008) and the saddle wrasse (*Thalassoma duperrey*, *hīnālea lauwili*, p<0.003). Several species of surgeonfishes remained in significantly greater biomass following the reopening of the Bay at 25% visitor capacity: ringtail surgeonfish (Keyhole: p<0.045, Witches Brew: p<0.004), brown surgeonfish (Keyhole: p<0.022, Channel p<0.041), and the orangespine unicornfish (Keyhole: p<0.002). Interestingly, the lagoon triggerfish in Channel (p<0.035) and the ringtail surgeonfish in Witches Brew (p<0.023) increased in biomass after the reopening of the Bay to the public when compared to during the closure. Only three species exhibited significant declines in biomass directly following the reopening of the Bay to visitors: the reef triggerfish (p<0.04), the saddle wrasse (Backdoors: p<0.02), and the doublebar goatfish (Witches Brew: p<0.02). The majority of species (73%) that experienced significant increases in biomass in response to the closure to the public experienced decreases after the reopening at limited visitor capacity. The significant decline in biomass observed in one species of triggerfish, wrasse, and goatfish following the reopening at limited capacity could suggest avoidance behavior of these more sensitive species. Again, the majority of significant differences observed throughout this study occur within Keyhole and Channel, the two most popular snorkeling sectors.

Table 6. Significant differences ($p<0.05$) in biomass of fishes comparing before the closure on a closed Tuesday, during the COVID-19 closure, and after the reopening of the Bay at 25% capacity. No pairwise comparisons reflects a significant difference that had too much variation to discern differences between timepoints. Information was collated from Independent-samples Kruskal Wallis tests with Dunn-Bonferroni pairwise comparisons.

Period with greater biomass of fishes	**Sector**	**Species**	**Common Name**	**Hawaiian Name**	**Significance**
During the closure had higher biomass than before the closure.	Keyhole	*Abudefduf sordidus*	Blackspot Sargent	kūpīpī	0.005
		Acanthurus blochii	Ringtail Surgeonfish	pualu	0.044
		Acanthurus nigrofuscus	Brown Surgeonfish	māiʻiʻi	0.045
		Chaetodon fremblii	Bluestripe Butterflyfish	kīkākapu	0.044
		Gomphosus varius	Bird Wrasse	hīnālea ʻiʻiwi, ʻakilolo	0.007
		Lutjanus kasmira	Bluestripe Snapper	ta'ape	0.045
		Naso lituratus	Orangespine Unicornfish	umaumalei	0.01
	Channel	*Naso lituratus*	Orangespine Unicornfish	umaumalei	0.008
		Thalassoma duperrey	Saddle Wrasse	hīnālea lauwili	0.003
During the closure had higher biomass than after the closure.	Backdoors	*Rhinecanthus rectangulus*	Reef Triggerfish	humuhumunukunukuapua'a	0.04
		Thalassoma duperrey	Saddle Wrasse	hīnālea lauwili	0.02
	Witches Brew	*Parupeneus bifasciatus*	Doublebar Goatfish	munu	0.02
After the closure had higher biomass than before the closure.	Keyhole	*Acanthurus blochii*	Ringtail Surgeonfish	pualu	0.045
		Acanthurus nigrofuscus	Brown Surgeonfish	māiʻiʻi	0.022
		Naso lituratus	Orangespine Unicornfish	umaumalei	0.002
	Channel	*Acanthurus nigrofuscus*	Brown Surgeonfish	māiʻiʻi	0.041
	Witches Brew	*Acanthurus blochii*	Ringtail Surgeonfish	pualu	0.004
After the closure had higher biomass than during the closure.	Channel	*Rhinecanthus aculeatus*	Lagoon Triggerfish	humuhumunukunukuapua'a	0.035
	Witches Brew	*Acanthurus blochii*	Ringtail Surgeonfish	pualu	0.023
No pairwise comparisons	Channel	*Gomphosus varius*	Bird Wrasse	hīnālea ʻiʻiwi, ʻakilolo	0.047

Changes in Size Classes of Fishes
The average size of fishes within the inner reef flat shifted significantly throughout the closure. Smaller fishes decreased in density, while larger fishes increased in density. The most notable change was seen in smaller fishes less than 10 cm in length, of which, the density was reduced by nearly half between surveys conducted before (19.1%) and during (10.3%) the COVID-19 closure. The density of this smallest size class was further reduced in surveys once the Bay was reopened to the public (4.4%) (Fig. 19). While some of these fishes appear to have grown into the 10-20 cm size class, others may have been prey to the larger fishes, mainly Jacks, entering the Bay during the closure. Once the Bay reopened to visitors, the number of smaller fishes decreases further, likely as the result of predator and human avoidance strategies. A non-parametric Kendall's Tau correlation strongly supports this theory. As the number of visitors to the HBNP increased (correl.coef: 0.563, $p<0.03$) and the number of people in the water snorkeling increased (correl.coef: 0.589, $p<0.03$), the minimum size of individual fishes also increased. This means that that smaller fishes were not present along surveys performed when visitors were present. This suggests that smaller size classes of fishes were hiding more often when more snorkelers were at the Bay and in the water. However, no correlation was found between minimum size of fishes and the number of other large predators, like monk seals. Over the three levels of use, a small increase was seen in fishes between 10 cm and 20 cm in length (before: 68.6%, during: 70.5%, after: 75.0%) and fishes greater than 30 cm in length (before: 4.4%, during: 7.8%, after: 8.9%). Significantly larger fishes were observed in Backdoors and Channel during (mean fish size; Backdoors: 20.2 ± 0.4 g/yd^2 ($p<0.001$), Channel: 19.3 ± 0.4 g/yd^2 ($p<0.003$) and after (mean fish size; Backdoors: 21.7 ± 0.7 g/yd^2 ($p<0.001$), Channel: 20.7 ± 0.7 g/yd^2 ($p<0.001$) the reopening of the Bay to visitors, when compared to before the closure (mean fish size; Backdoors: 14.8 ± 0.8 g/yd^2, Channel: 16.5 ± 0.7 g/yd^2). Both of these sectors are closest to open ocean channels, which may allow larger fishes to move more freely between the inner reef flat and outer reef flat that is higher in coral cover and receives much less visitor attention. Average size of individual fishes within Keyhole remained similar through the closure (before: 16.0 ± 0.9 g/yd^2 , during: 13.8 ± 0.4 g/yd^2), with a significant increase in size following the reopening of the Bay to the public (22.1 ± 0.9 g/yd^2, before: $p<0.001$, during: $p<0.001$). No significant changes in average size of fishes were noted in Witches Brew (before: 18.8 ± 1.1 g/yd^2, during: 19.0 ± 0.6 g/yd^2, after: 21.0 ± 1.0 g/yd^2). Overall, during the closure and after the reopening to the public, smaller fishes (<10 cm) decreased in density, likely due to human avoidance, and larger fishes (>10 cm) increased in density (Fig. 19).

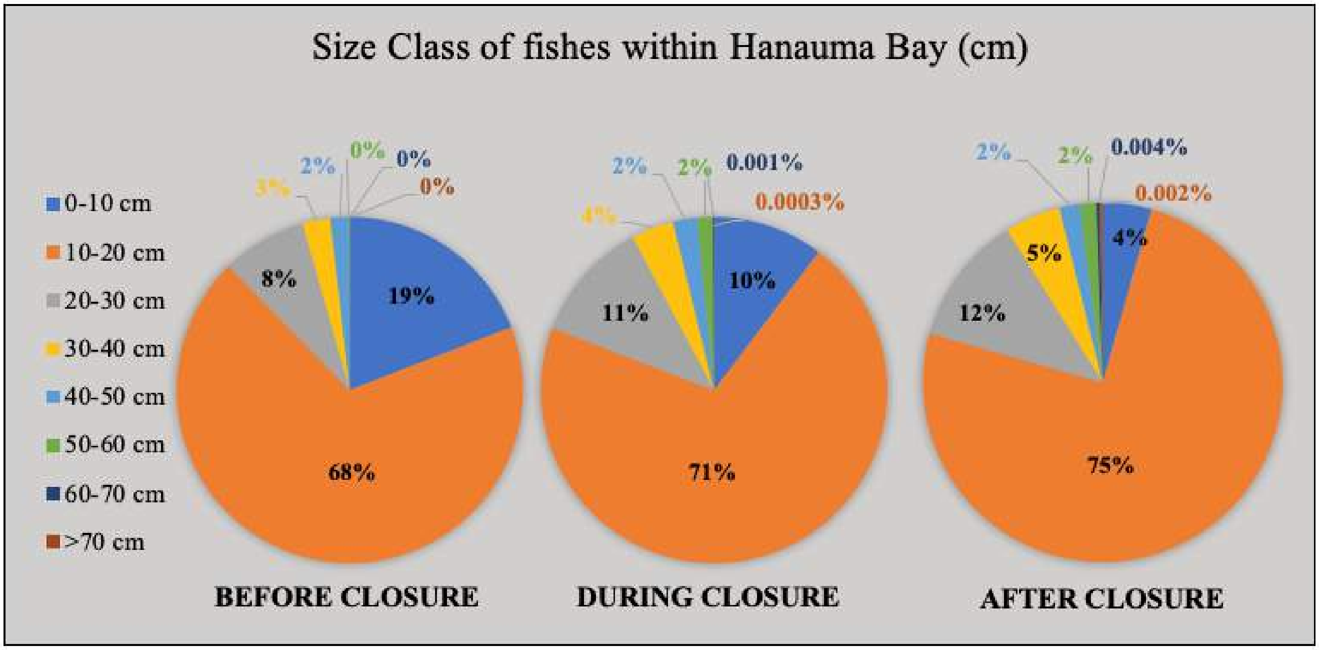


Figure 19. Size classes of fish individuals before, during, and after the COVID-19 closure.

Changes in Diversity of Fishes

Diversity of fishes, the relative number of species detected in surveys, was examined for changes influenced by visitor presence at the HBNP. Fish diversity was significantly lower after the reopening of the Bay to the public when compared to during the COVID-19 closure in both Keyhole ($p<0.02$) and Channel ($p<0.05$) sectors (Fig. 20). Channel also experienced significantly greater fish diversity during the closure when compared to before the closure ($p<0.04$). Keyhole and Channel are the two most heavily snorkeled areas of the Bay encompassing over 50% of snorkelers. These increased fish diversity could be the result of timid fish species being more comfortable swimming freely when visitors are not present. No changes in diversity were detected within Backdoors or Witches Brew. Reductions in species diversity between the COVID-19 closure and reopening of the Bay at limited capacity in the two most heavily trafficked sectors suggests that some of the more sensitive species may be practicing avoidance behavior of snorkelers.

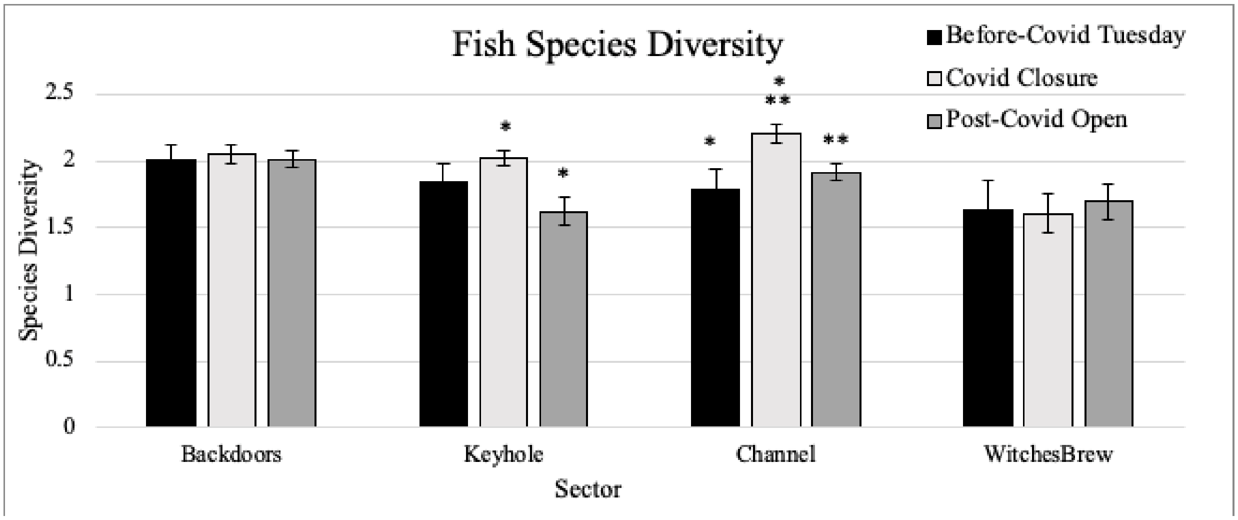


Figure 20. Mean diversity of fishes in each sector of Hanauma Bay comparing surveys conducted before, during, and after the COVID-19 closure. Asterix (*) represent significant pairwise comparisons (p<0.05) between visitor levels. Error bars represent ± 1 standard error.

Changes in Evenness of Fish Populations

The evenness of fish populations, or the abundance of different fish species relative to other species in their community, was examined between the three visitor levels. Evenness of fish species within Keyhole was significantly lower after the reopening of the Bay to the public at 25% capacity when compared to both closed Tuesdays before the pandemic (p<0.002) and during (p<0.02) the COVID-19 closure (Fig. 21). Dominance by large schools of surgeonfishes (Acanthurids) within Keyhole during the closure and following the reopening are likely responsible for decreases in evenness within the sector. All other sectors experienced no differences in evenness of fish populations between the three levels of use.

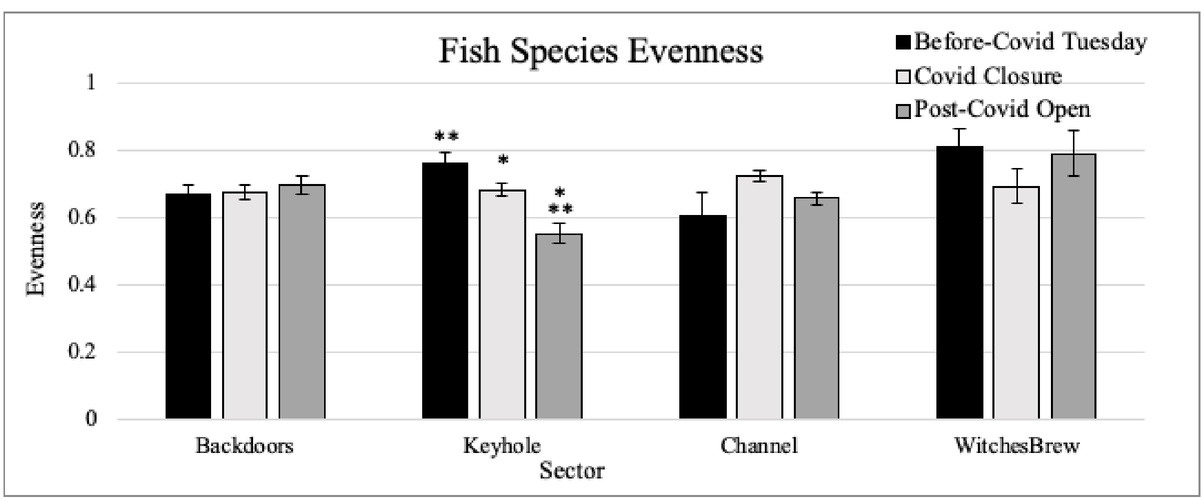


Figure 21. Mean evenness of fishes in each sector of Hanauma Bay comparing surveys conducted before, during, and after the COVID-19 closure. Letters represent significant pairwise comparisons (p<0.05) between visitor levels. Error bars represent ± 1 standard error.

Fish Density and Biomass Summary
In summary, significant changes in density, biomass, size class, diversity and evenness were observed between closed days to the public prior to the closure, during the COVID-19 closure to the public, and after the Bay was reopened to the public at 25% capacity:

Backdoors experienced a significant increase in the density of chubs (p<0.04) during the closure when compared to before the closure. Increases in chubs explains the significant (p<0.04) increase in overall biomass within Backdoors during the closure. Likewise, larger fishes were observed in Backdoors after the reopening of the Bay to the public when compared to before (p<0.001) and during (p<0.001) the closure. No differences were observed in trophic composition, diversity or evenness within the fish population at Backdoors over time.

Keyhole, the most popular snorkeling sector, experienced significant differences in density, biomass, average size, trophic, diversity and evenness between the three levels of visitor use. Overall, density of fishes was significantly greater during (p<0.006) and after (p<0.003) the closure when compared to before the closure. The density of surgeonfishes (p<0.02) and damselfishes (p<0.045) were significantly greater during the closure when compared to before the closure, and surgeonfishes remained greater (p<0.002) in density after the reopening to the public. These surgeonfishes migrated into Keyhole from all other inner reef flat sectors, but mainly from Channel. Similarly, overall biomass within Keyhole was significantly greater during (p<0.003) and after (p<0.002) the closure when compared to before. Despite this, significant declines in biomass of snappers (p<0.002, correl.coef: -0.310, p<0.001) and wrasses (p<0.02, correl.coef: -0.150, p<0.03) were observed following the reopening of the Bay to visitors. These declines were due to human avoidance strategies confirmed by significant negative correlations between biomass of these individuals and human counts. Differences in trophic composition density of herbivores (p<0.008) and invertivores (p<0.03) were significantly less before closure of the Bay to the public. Herbivores remained in significantly greater (p<0.003) abundance after the reopening of the Bay at limited capacity, but invertivores decreased to an abundance similar to before the closure, suggesting invertivores may be practicing human avoidance behavior. Some of the invertivores exhibiting avoidance behavior were snappers and wrasses. Average size class of fishes increased (p<0.001) following the reopening of the Bay to the public, which could be the result of smaller species seeking refuge in response to visitors. Keyhole also experienced significant declines in diversity (p<0.02) and evenness (p<0.02) of fishes after the reopening of the Bay to the public. During the closure, Keyhole experienced extensive shifts within the biological fish communities.

Channel, the second most popular snorkeling sector, experienced several significant declines in density and biomass of individual fish families. The density of butterflyfishes significantly (p<0.009) declined following the reopening of the Bay to the public. Human avoidance strategies by butterflyfishes was further supported by a significant negative correlation between the number of visitors to the Bay and decreased butterflyfish density (correl.coef: -0.180, p<0.01) and biomass (correl.coef: -0.154, p<0.03). Similarly, a significant decline (p<0.045) in invertivore density was observed between timepoints, but no pairwise comparisons were significant. Channel also experienced significant declines in the biomass of wrasses (p <0.02), butterflyfishes (p <0.02), and snappers (p <0.04) following the reopening of the Bay to the public. However, average size of individuals increased during (p<0.003) the closure and after (p<0.001) the closure when compared to before the closure. Diversity of fishes within Channel significantly increased ($p<0.05$) following the closure to the public, and subsequently significantly decreased ($p<0.04$) following the reopening of the Bay to the public. The biomass, density, and diversity of fishes within Channel show positive changes following the restriction of visitors to the Bay, with negative changes occurring after the HBNP was reopened to the public at 25% capacity. This could be the result of human avoidance behavior of sensitive fish species.

Despite no differences in overall density or biomass of fishes within Witches Brew, triggerfishes significantly ($p<0.03$) increased in density during the closure, and, subsequent significantly ($p<0.04$) decreased in density following the reopening of the Bay to the public. Similarly, triggerfishes were significantly ($p<0.009$) greater in biomass during the closure when compared to before the closure. Despite fluctuating density and biomass of triggerfishes within Witches Brew, no other parameter of the population was significantly different between the three visitor levels (no significant differences in trophic composition, size class, diversity, or evenness).

Substantial compositional shifts in fish families occurred throughout the study period in relation to visitor counts. Surgeonfishes, butterflyfishes, chubs, and damselfishes deliberately migrated into Keyhole, or, became more comfortable and less likely to seek shelter in the absence of visitors. Likewise, all sectors increased in biomass during the closure, significant in Backdoors and Keyhole, and fish biomass remained high after the reopening at 25% capacity. While surgeonfishes increased in density and biomass throughout the closure, fishes such as butterflyfishes, snappers, and wrasses showed decreased density and biomass following the reopening of the Bay, and furthermore, significantly decreased as the number of visitors to the Bay increased. Increased density and biomass of certain fish species during the closure, followed by decreased density and biomass after the reopening suggests human avoidance behavior, even at 25% capacity, for these more sensitive species. The majority of significant changes in fish population parameters were observed within the two most heavily snorkeled areas of the Bay, Keyhole and Channel. The relationship between fishes and direct human influence will be further investigated utilizing flight initiation distance (FID) methodology to quantify the change in avoidance behavior observed in fishes as visitor levels increased within the HBNP.

Fish: Diver Operated Stereo Video (Stereo-DOV)

Stereo-DOV surveys continued through the COVID-closure and the reopening of Hanauma Bay to determine differences in behavior with increasing presence of humans. These non-invasive monitoring techniques allowed for the calculation of flight initiation distance (FID) and minimum approach distance (dMAD) of reef fishes which have been used as a proxy for the level of stress the fish encounters in their environment. FID refers to the distance between the fish and observer when the fish begins to flee, while dMAD refers to the closest distance the observer can get to the fish on approach. Both FID and dMAD have been shown to increase with increasing stress from fishing pressure (Bellwood et al., 2012; Stamoulis et al., 2019) and tourism (Renfro, 2016). Although HBNP faces minimal fishing pressure from poaching, fishes may experience pressure from increased snorkeler presence, if the snorkeler is perceived as a threat. FID has been shown to increase when the perceived threat or disturbance stimuli (1) approach more directly, (2) approach more quickly, (3) are a larger size, (4) if distance to refuge is greater, and (5) if group size of threat is greater (Frid & Dill, 2002). Although FID is more commonly used, dMAD, a new measurement of wariness, was found to be less dependent on starting distance of the observer (Stamoulis et al., 2019), and therefore, was added to the analysis. Stamoulis et al. introduces dMAD as a compliment or alternative to the long-term measurement of FID (2019). By comparing the values of FID and dMAD between the COVID-closure when no visitors were present at the HBNP to that when it reopened to visitors, the perceived threat of visitors can be quantified. If visitors are considered a threat to the fishes within the HBNP, FID and dMAD will be greater once the Bay is open for visitors. Increased stress on fishes could be expressed in the diversion of time and energy away from fitness-enhancing activities such as feeding, parental care or mating displays (Madin et al., 2016).

Methods
Design of the stereo-DOV system was adapted from Goetze et al. (2019). Two GoPro Hero 8 Black cameras with housings were fixed to an aluminum base bar. Cameras record video at 1080 resolution at 60 frames per second with the lens set at linear. Cameras were inwardly converged at 4º to provide overlapping field of view (Goetze et al., 2019). Overlapping of cameras is essential for accuracy of length measurements. All measurements for the stereo-DOV set up can be found in Fig. 22. Two modifications were made to the stereo-DOV set-up during testing: (1) cameras were stabilized within housings using foam tape to eliminate movement of the cameras in the housings and (2) plexi-glass stabilizers built into the camera mount to prevent cameras from forward or backward movement during video capture. The stereo-DOV system was calibrated using the CAL software (SeaGIS) prior to initial surveys and periodically throughout the sampling period either in a swimming pool or in a clear, shallow area within Hanauma Bay.

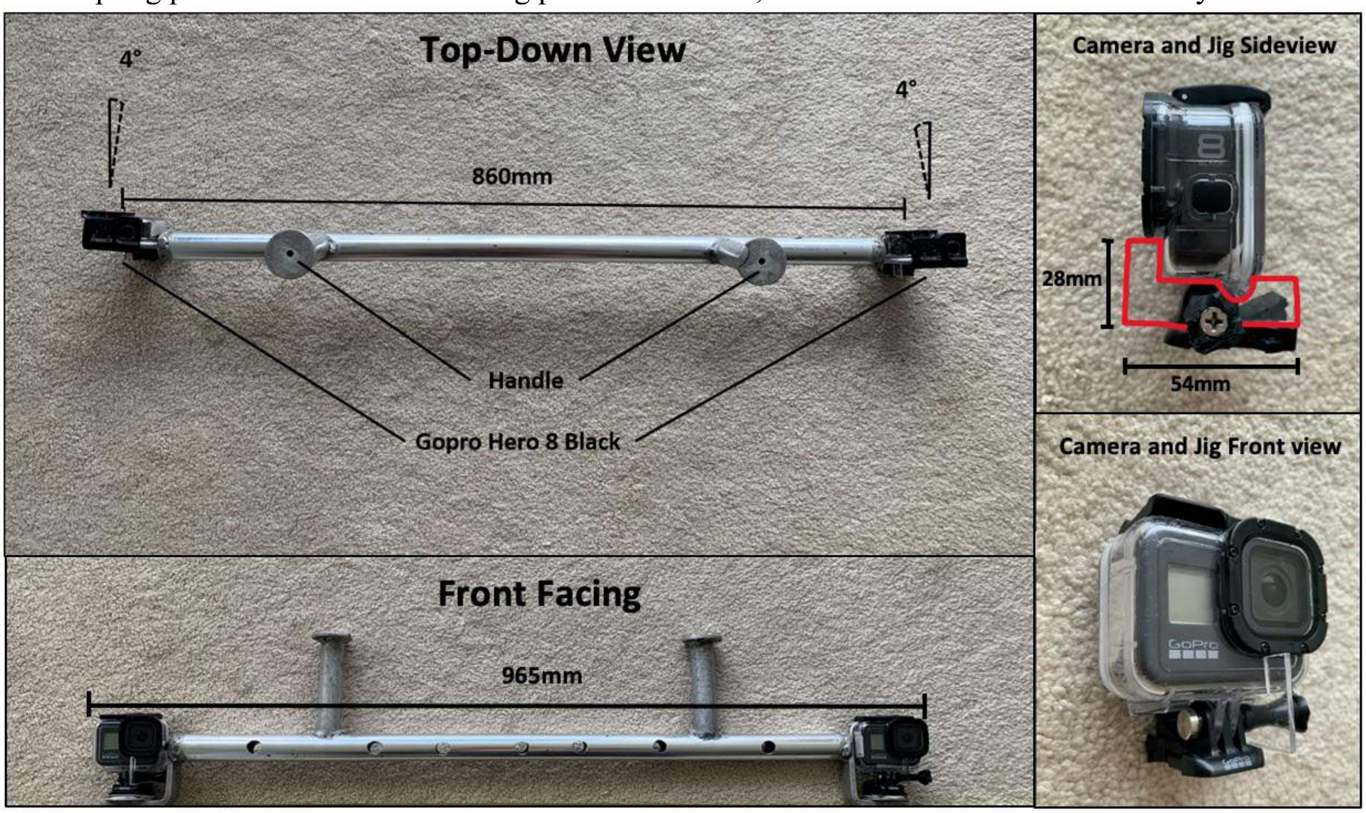


Figure 22. Stereo Diver Operated Video (stereo-DOV) system set up. Aluminum bar connecting two mounted GoPro Hero 8 Black cameras. Camera housings contain additional interior padding to eliminate movement of cameras with the housings and a plexiglass jig (outlined in red) on the exterior to eliminate any forward or backward movement.

Surveys of fish behavior were conducted using snorkeling within the inner reef flat of Hanauma Bay and adapted from Stamoulis et al. (2019). Surveys were conducted within the entire area of each sector (Backdoors, Keyhole, Channel, and Witches Brew). During COVID-closure surveys, stereo-DOV was conducted within a sector when the fish behavior diver was the only snorkeler in that sector. A few surveys had one other snorkeler in the sector. The buddy snorkeler kept a distance of at least 10 yd from the DOV and analyses will test for a 'buddy bias' to determine any influence on fish behavior. The fish behavior diver (hereafter 'observer') spent no longer than 45 minutes within each sector on each day of data collection. The amount of time in each sector was limited to avoid the fish becoming desensitized to the observer. The observer swam slowing within each sector until a targeted fish species was identified. The fish was then approached directly at a steady swimming speed (0.75-1 yd/sec) until the fish started to flee, or the observer could not get any closer to the fish (Fig. 23). Swimming speed varied slightly with environmental conditions such as waves, wind speed and tide. Stereo-DOV surveys targeted eight of the most common and popular fishes (Table 7) within the Bay, attempting to capture at least 20 encounters with each species in each major inshore sector (Backdoors, Keyhole, Channel, and Witches Brew) prior to the reopening of Hanauma Bay to the public. If observer encountered a school of fishes, only one of the targeted fishes was used in analysis. However, the number of fishes in the school was recorded and used as a cofactor in analyses.

Figure 23. Diver operating the stereo-DOV for a group of tangs. PC: Andre Seale

Table 7. The eight fishes targeted by stereo-DOV surveys to detect changes in fish behavior with increasing visitor presence at Hanauma Bay.

Common Name	**Species**	**Hawaiian Name**
Ringtail Surgeonfish	*Acanthurus blochii*	*pualu*
Brown Surgeonfish	*Acanthurus nigrofuscus*	*māi'i'i*
Convict Tang	*Acanthurus triostegus*	*manini*
Blue Trevally	*Caranx melampygus*	*omilu*
Orangespine Unicornfish	*Naso lituratus*	*umaumalei*
Palenose Parrotfish	*Scarus psittacus*	*uhu*
Redlip Parrotfish	*Scarus rubroviolaceus*	*pālukaluka*
Saddle Wrasse	*Thalassoma duperrey*	*hīnālea lauwili*

EventMeasure software (SeaGIS) was used to analyze stereo-DOV's. Species and attribute files were provided by Kostantinos A. Stamoulis, Ph.D., an expert on stereo-DOV census within the Hawaiian Islands. For each fish encountered, the following measurements were calculated:

(1) Starting Distance: the distance from the targeted fish when observer approach was initiated, indicated by a wiggle of the camera set up. At this time the (a) number of fish five body lengths from the targeted fish or size of entire school, (b) pre-approach fish behavior (passing or feeding), and (c) life stage of fish (initial, terminal, n/a) were recorded.

(2) Total fish length: the length of the fish from tip of the nose to dorsal tip of the tail.

(3) Flight Initiation Distance (FID): the distance from the fish as it begins to flee from the observer, often indicated by a quick jolt of the fish in swimming speed or rapid change in direction. Update to date include the addition of: flight behavior (spook, shelter, evade, flee, or none*)).
*Stamoulis et al. (2018) define the following flight behaviors as the following:

a. Spook: a large burst of speed.
b. Shelter: take shelter within substrate.
c. Evade: evasive maneuvers side to side and/or in and out of structure.
d. Flee: increase speed and swim away in a single direction, usually toward deep water.
e. None: no visible escape response.

(4) Minimum Approach Distance (dMAD): the closest distance between the observer and the fish within the survey time.

Flight initiation distance (FID) and minimum approach distance (dMAD) were transformed to fit assumptions of normality. For the ringtail surgeonfish, FID was transformed with a square-root and dMAD was transformed with the natural log. The palenose parrotfish data was transformed using the square root transformation for FID and reciprocal transformation for dMAD. Lastly, the saddle wrasse data was transformed using a reciprocal for FID and a cubed reciprocal for dMAD. Independent Samples T-tests were utilized to explore differences in FID and dMAD between days closed to the public and days open to the public. Pearson's correlation were utilized to explore the influence of in-water snorkeler counts, box office human counts (provided by C&C), the number of fish in the school targeted fish was observed with, the starting distance of the videographer, and the fish length on both FID and dMAD values. All prior mentioned statistics were carried out in IBM SPSS Statistics Version 25. Following these statistical analyses, FID for each species was tested using a generalized linear model (GLM) with gamma distribution and log-link function in R by Kosta Stamoulis, Ph.D.

Progress, Results, and Discussion

As of June 1st, video analysis for three species were completed: ringtail surgeonfish (*A. blochii*), palenose parrotfish (*S. psittacus*), and the saddle wrasse (*T. duperrey*). Video analysis of the remaining five species will continue into Year 4.

Changes in density and biomass of the ringtail surgeonfish help to understand the behavioral metrics observed throughout the study. The ringtail surgeonfish increased in both density and biomass throughout the Bay during the closure and continued to increase within Witches Brew after the reopening of the Bay at limited capacity. Ringtail surgeonfish migrated from Backdoors, Keyhole, and Channel into the least popular snorkeling area of Witches Brew once snorkelers returned to the Bay, which suggests some human avoidance behavior. With a significant increase in biomass of the ringtail surgeonfish into Witches Brew during the closure ($p<0.004$), the minimum distance between the observer and the fish (dMAD) upon approach decreased significantly (got closer) following the reopening of the Bay. It is possible that with the overall increase in biomass, the ringtail surgeonfish became less intimidated when approached by the observer. Additionally, the ringtail surgeonfish primarily feeds over sandy areas on algal films (Randall, 2010), and therefore, may be more comfortable in non-sheltered environments. No other sectors experienced significant changes in either dMAD or FID of the ringtail surgeonfish when comparing during the closure to after the reopening. Similarly, as the number of snorkelers in the surrounding water increased, the dMAD decreased significantly (correl.coef: -0.204, $p<0.013$). The same was true for box office counts (correl.coef: -0.168, $p<0.041$). Thus, as the number of people in the surrounding waters of the ringtail surgeonfish increased the minimum distance between the observer and the fish decreased. This supports the claim that the ringtail surgeonfish does not perceive humans as a threat in the HBNP. The distance from the fish when it first started to flee (FID) was found to be positively correlated with starting distance of the observer on the approach (correl.coef: 0.243, $p<0.003$) and the total fish length (correl.coef: 0.172, $p<0.037$). Further solidifying these results, the GLM also found FID to increase as starting distance ($p<0.012$) and fish length ($p<0.021$) increased. The greater the distance the observer was from the fish upon first approach and the larger the fish in total length, the further away the fish was from the observer when it first to flee. It is possible that the fish were more aware of the observer approaching them directly if there was a longer period of time or distance in the approach. Previous studies have found starting distance to be highly influential to FID and dMAD values. Likewise, larger fishes may feel more threatened by predators since there are less larger hiding spots on the reef for them when compared to smaller fishes. Overall, despite shifts in density and biomass from more popular to less popular sectors, the ringtail surgeonfish did not show avoidance behavior in response to the reintroduction of visitors to the HBNP at 25% visitor capacity based on analysis of flight initiation distance and minimum approach distance patterns.

Palenose parrotfish behavior caused fluctuations in density and biomass in response to visitor presence. While density and biomass increased in Channel throughout the closure and after the reopening, Keyhole and Witches Brew increased during the closure, and decreased after the reopening (non-significant). Backdoors did not increase in the number of individuals during the closure but experienced an increase in biomass of palenose parrotfishes during and after the closure (non-significant). Initial phase palenose parrotfishes often travel in large harems or schools, which can increase the variability of density and biomass between surveys. The two sectors that experienced increased density and biomass of palenose parrotfishes during the closure followed by decreased density and biomass after the reopening were the most and least popular snorkeling sectors, Keyhole and Witches Brew respectively. Despite these changes in density and biomass, the only significant difference detected was between the minimum approach distance in Channel ($p<0.18$). After the reopening of the Bay to visitors the minimum distance the observer could approach a palenose parrotfish in Channel sector decreased significantly. It is possible that with the increase in density and biomass of palenose parrotfishes within Channel sector following the reopening, they were more comfortable with a closer distance to an observer. However, the fishes approached were in similar sized schools during the closure and after the closure, so school size was not a likely factor. Both FID (correl.coef: 0.278, $p<0.002$) and dMAD (correl.coef: -0.210, $p<0.024$) were significantly correlated with starting distance of the observer. Interestingly, as the starting approach distance of the observer increased, the flight initiation distance also increased, but the minimum approach distance to the fish decreased. The fish appeared to notice the observer sooner but felt less threatened by the observers presence and were less likely to hide if the observer had a longer approach time. The GLM also found FID to increase with increasing starting distance ($p<0.007$). dMAD was also positively correlated with fish length (correl.coef: 0.185 , $p<0.046$), nearby snorkeling counts (correl.coef: 0.377, $p<0.0001$), and box office counts (correl.coef: 0.251, $p< 0.007$). Thus, as the palenose parrotfish increased in total length and the number of people in the water increased, the minimum distance the observer could approach the fish also increased. Similar to the ringtail surgeonfish, the palenose parrotfish may feel more threatened and flee sooner when it is larger in size (Stamoulis et al., 2019) because the available hiding spaces for larger fishes are not as available than those for smaller fishes, especially in areas that are less spatially complex (rugose) like Keyhole. The strong positive correlation with increasing minimum approach distance with increased number of nearby snorkelers may help to explain the large increase in density and biomass of palenose parrotfishes in Keyhole during the closure and subsequent decrease following the reopening to visitors. Human avoidance behaviors exhibited by palenose parrotfish were most obvious in the most popular snorkeling sector. The avoidance behavior of palenose parrotfish increased with the increasing number of snorkelers in nearby water and is reflected in density and biomass surveys.

The saddle wrasse is very common on the inner reef flat of Hanauma Bay. During the closure, it was more common, increasing in both density and biomass in all sectors (significant in Channel, $p<0.049$ density, $p<0.02$ biomass). This increase could be the result of saddle wrasses migrating from offshore reefs onto inshore reefs, or it could reflect a lack of hiding of saddle wrasses while the Bay was closed to snorkelers. After the reopening of the Bay at 25% visitor capacity, the density and biomass of saddle wrasses decreased in all sectors to levels similar to, or less than, those prior to the closure (significantly less in Backdoors after the reopening, $p<0.045$ density,

$p<0.02$ biomass). The dMAD of saddle wrasse was significantly shorter after the reopening when compared to during the closure within Channel ($p<0.003$), suggesting saddle wrasse perceive humans as a threat. Dissimilarly, the FID was longer after the reopening when compared to during the closure (non-significant). The saddle wrasse in Channel would took flight from a further distance but allowed the observer to come closer before fleeing completely when there were more snorkelers in the water. This could reflect the highly rugose environment of Channel allowing the fish to have ample nearby shelter from predators, and therefore, fish would need less time and distance to hide from a threat. Additionally, since both density and biomass of wrasses decreased after the reopening, it is possible that the sample population of saddle wrasse shifted with the introduction of snorkelers, and thus the most sensitive saddle wrasses were already seeking shelter or migrated to less popular offshore environments. Similar to Channel, in Keyhole, the FID was significantly longer with more snorkelers in the water ($p<0.021$). dMAD was also longer after the reopening to the public (non-significant). As discussed prior, Keyhole is the least rugose sector with much less available sheltering habitat. This could be responsible for the saddle wrasse startling and fleeing sooner in Keyhole than in Channel. The only significant correlation and GLM was found between the FID and starting distance (GLM $p<0.0001$). Opposite to the ringtail surgeonfish and palenose parrotfish, as the starting distance of the observer increased, the distance from the observer to the saddle wrasse when it first startled decreased (correl.coef: -0.201, $p<0.001$). The saddle wrasse allowed the observer to snorkel closer before fleeing if the approach happened from further away. Again, this could reflect a sample population of wrasses after the reopening that are more comfortable with snorkeler presence, while more sensitive saddle wrasses had already fled. After the reopening of the Bay at limited visitor capacity, the density and biomass of saddle wrasses decreased in all sectors and their flight response patterns became faster within Keyhole, the most popular snorkeling area.

Changes in density and biomass of targeted fish species in combination with analysis of their flight response behavior allowed for better understanding of the individualized response by fishes of the perceived threat of snorkelers. Although behavior of some fishes may appear unaltered with the reintroduction of snorkelers to the HBNP, like the ringtail surgeonfish, others seem to vary their avoidance depending on their surrounding habitat. The palenose parrotfish and saddle wrasse decreased in density and displayed increased avoidance behaviors concentrated in areas of less rugosity following the reopening of the Bay to the public. These species specific differences in perceived threat of snorkelers shape the feeding ecology, and thus the benthic composition that occur within the HBNP. To date, we have analyzed the behavior in response to snorkelers by two herbivores (ringtail surgeonfish and palenose parrotfish), and one invertivore (saddle wrasse). The analysis for the remaining four herbivores (brown surgeonfish, convict tang, orangespine unicornfish, and redlip parrotfish) and one piscivore (bluefin trevally) are ongoing and the ecological interpretation of their behaviors will be made available in the 2021 Year 4 bi-annual report.

Fish: Foraging

Non-invasive video censusing techniques were employed to quantify fish foraging behavior during closure and following the reopening of HBNP. Videos are currently being analyzed to quantify the foraging rates of fishes and determine how reduced human presence affects key behaviors of coral reef fishes and invertebrates. If the fishes show a decrease in herbivory rates, for example, when humans return to the bay, this would suggest that human presence indirectly restricts the ability of plant-eating (herbivorous) reef fishes to perform one of their key ecological functions (Madin et al., 2019; J. E. Smith et al., 2010) such as, controlling algae and providing space on the reef for new corals to grow (Hoey et al., 2011; Hughes et al., 2007). This has implications for the long-term persistence of coral reefs, since to survive, existing corals must grow, and new recruits must settle. Conversely, if no difference in these behaviors are detected when humans are absent when compared to when visitors are present in the bay, it suggests human presence does not significantly impact herbivorous fishes ecological functioning. Global studies have documented behavioral changes in fishes associated with increases in acoustic noise in laboratory experiments (Purser & Radford, 2011), diver interactions (Renfro, 2016) and fishing pressure (Bellwood et al., 2012; Stamoulis et al., 2019). HBNP experiences the most snorkeling traffic of any reef in the Hawaiian Islands and therefore, quantifying changes in fish foraging behavior during the COVID-closure and after visitors return to the Bay will allow for better understanding of the pressure humans place on fish communities.

Methods

We are collaborating with Dr. Elizabeth Madin's Marine Ecology and Conservation lab at the Hawai'i Institute of Marine Biology to collect, analyze, and manage the foraging data. Elizabeth Madin, Ph.D., is an expert in non-invasive camera trap video monitoring of foraging rates to document predator-prey interactions.

GoPro Hero 4 Session, Hero 5 Black, and Hero 7 Black cameras were used to record fish behavior with a field-of-view (FOV) boundary placed 3 yards in front of the camera. Cameras were set to 1080-pixel resolution for GoPro 4 Sessions and 720-pixel resolution for GoPro Hero 7 and Hero 5, with a frame rate of 60 fps and view set to "wide". Resolution settings were modified according to the camera model's battery life constraints.

Fish Foraging Field Methods

Foraging videos were collected in each of the eight permanent inshore transects of Hanauma Bay (Fig. 1). Video collection began June 2020 and continued through the reopening of Hanauma Bay to visitors (collection dates as of Nov 19th, 2020: 6/16/20, 6/23/20, 6/30/20, 7/7/20, 8/25/20, 9/29/20, 10/28/20, 11/24/20, 12/1/20, 12/9/20, 12/16/20, 12/30/20, 1/6/21, 1/14/21, 1/20/21, 3/5/21). Following re-opening to the public, foraging videos were collected on a weekly basis for the first month, and decreased for subsequent months. Number of snorkelers in each sector while cameras were recording was also documented. At each transect, suitable substrate for a FOV free of large objects blocking the camera was found. The camera was temporarily attached to the substrate using zip-ties (Fig. 24). A transect tape was used to locate an area three yards distant from the camera to place a marker (flagging tape or floating marker buoy) (Fig. 24). The researcher placed fingers in front of the camera view to depict the transect number and clearly point to the FOV marker in the video. Cameras were left undisturbed for 35 minutes. The following was recorded for each transect foraging video: location, site, transect, date, start time, camera number, maximum and minimum depth, FOV distance (normally 3 yards unless poor visibility), and hand signal number.

Figure 24. GoPro camera temporarily mounted to the substrate for fish foraging videos pointed toward a field-of-view (FOV) marker (pink flagging tape) representing a three-meter FOV.

Fish Foraging Analyses

The first five minutes of foraging videos were not used in analysis to allow fish to return to normal behavior. The next 10 minutes of the video was analyzed by a group of 10 individuals. Each individual analyzed 1 minute of each video from each date/site combination. This ensured standardization for any inter-observer variation between sites and time points. Observations of foraging and behavior have been recorded using excel spreadsheets. After filling out metadata columns (i.e., columns "video_observer, filename, substrate_primary (live_coral, dead_coral, sand, rubble), file_duration, observation_start_time"), the observer initiated the video and begins with the first fish on the screen. For each fish that entered the FOV, the video is paused and the exact enter time is recorded. If it is a school of one species of fish the time the first fish entered is recorded as the enter time. The fish is identified to the lowest taxonomic level possible, typically to species level. The video resumes and the observer watches only that one fish. The fish behavior is noted and, if feeding, the number of bites the fish takes iis counted and recorded. If it is a school of one species of fish that are feeding, the number of fish in the school is recorded and only counts of the bites of one fish in the school is enumerated to approximate bites per individual. When the fish leaves the FOV, the video is paused and the exact leave time is recorded. If it is a school of one species of fish, the last fish in the school to exit is recorded as the exit time. Fish behavior is then recorded for the fish or school and the amount of time (0-100%) the fish spent on each behavior (feeding, passing, guarding, resting, burrowing, attacking, attacked, cleaning, cleaned, following (for definitions of behaviors see Appendix C)). Once the fish disappears for more than 5 seconds, the video is rewound to the exact enter time as the previous fish, and the video was replayed until the next new fish enters. The process repeats itself until all fish in the FOV are recorded.

Progress as of June 1st, 2021

Foraging videos continue to be analyzed with an anticipated completion date of summer 2021. After which, data analysis will begin. Results will be made available in the Year 4 bi-annual report.

Coral: Recruitment

In the past decade coral reefs have been exposed to a continuous stream of natural and anthropogenic disturbances leaving many in a constant state of transition, unable to reach full recovery. As these disturbances increase in frequency and intensity, it is unlikely reefs will be able to maintain their community structure. Although adult corals may survive and recover from a disturbance, slowed growth (Coles et al., 1976; Weis, 2008) and reduced fecundity (Jokiel & Guinther, 1978; Weis, 2008) may result in decreased resilience. Assessment of adult coral colonies provide information on the immediate population, while assessment of abundance, growth, and mortality of newly settled recruits and juvenile corals provide information on the population trajectory that is critical in understanding and quantifying reef recovery following a disturbance.

Coral recruitment (Table 8) was assessed during the closure to visitors using a fluorescence census technique (FCT). The FCT utilizes the natural fluorescent proteins found in many species of Hawaiian corals to detect the smallest size classes which occur shortly after settlement that are often not visible without this technique. Coral recruitment was documented in each of six of the eight inshore permanent transects. Backdoors was not monitored do to turbulent unsuitable conditions. The majority of the corals within Hanauma Bay spawn from late spring into the summer months. This spawning typically occurs during nighttime hours (Kolinski & Cox, 2003). We are utilizing the FCT to determine rates of survival and/or mortality in corals recruiting to the horizontal surface of the substrate within the HBNP.

Table 8. Definitions of coral recruitment terminology:

Bleaching:	The loss of symbiotic zooxanthellae and/or pigmentation within a coral host in response to environmental stress (Fitt et al., 2001; Weis, 2008).
Juvenile:	A post-settlement coral colony with its greatest top-down surface area ≤ 10 cm^2.
Mortality:	The complete disappearance or recent death of a colony at the end of a census interval (S. R. Smith, 1992).
Recruitment:	The stage at which a post-settled coral becomes visible in the field (Birrell et al., 2008). Recruitment is not reversible.
Settlement:	Involves the attachment of coral larvae to the substratum. Settlement can be reversed, with larvae detaching and returning to pre-settlement behavior under unfavorable conditions (Birrell et al., 2008; Richmond, 1987; Vermeij et al., 2009).
Colony:	Any freestanding coral skeleton with living tissue. A colony divided by partial mortality into separate patches of living tissue, but structurally and genetically one entity, is considered to be one colony (Bak & Meesters, 1998).

Methods
The Fluorescence Census Technique (FCT) was used to examine the frequency of coral recruits and juveniles within Keyhole, Channel and Witches Brew permanent transects between April 10th, 2020 and May 26th, 2020. Backdoors was not analyzed due to high wave action interfering with the ability to accurately census the natural reef substrate with the FCT. Along each permanent transect (5 yd by 15 yd) three-15 yd transect lines were used, one on the center of the transect and one 2.5 yd from the center on either side. One FCT photograph was taken every yard along the transects for a total of 45 FCT photos per permanent transect (3.5 m^2 total area per transect).

Coral autofluorescence was captured using top-down photographs during daylight conditions made possible by shading and manipulation of camera settings. A Canon PowerShot G16 with a Canon WP-DC52 Waterproof housing was used with a NightSea yellow barrier filter, modified to fit over the lens of the camera within the waterproof housing. Synchronized to the camera shutter using a fiber optic cable, a Sea&Sea Underwater TTL/Auto Strobe (YS-110) was set on maximum power (Auto/Manual1: on, slave: on) and fitted with a BE series NightSea Excitation filter to emit a blue (460 nm) strobe light (Fig. 25). All equipment was fixed to a "dark box" as a guide for close-up images of photoquadrats capturing fluorescence in an area of 16 cm x 22 cm (Fig. 26). The "dark box" provided the proper shading conducive to capturing fluorescence under all ambient light conditions. Although camera settings were manipulated *in situ*, the addition of consistent shading (dark box) provided a more reliable photograph with less camera setting variability.

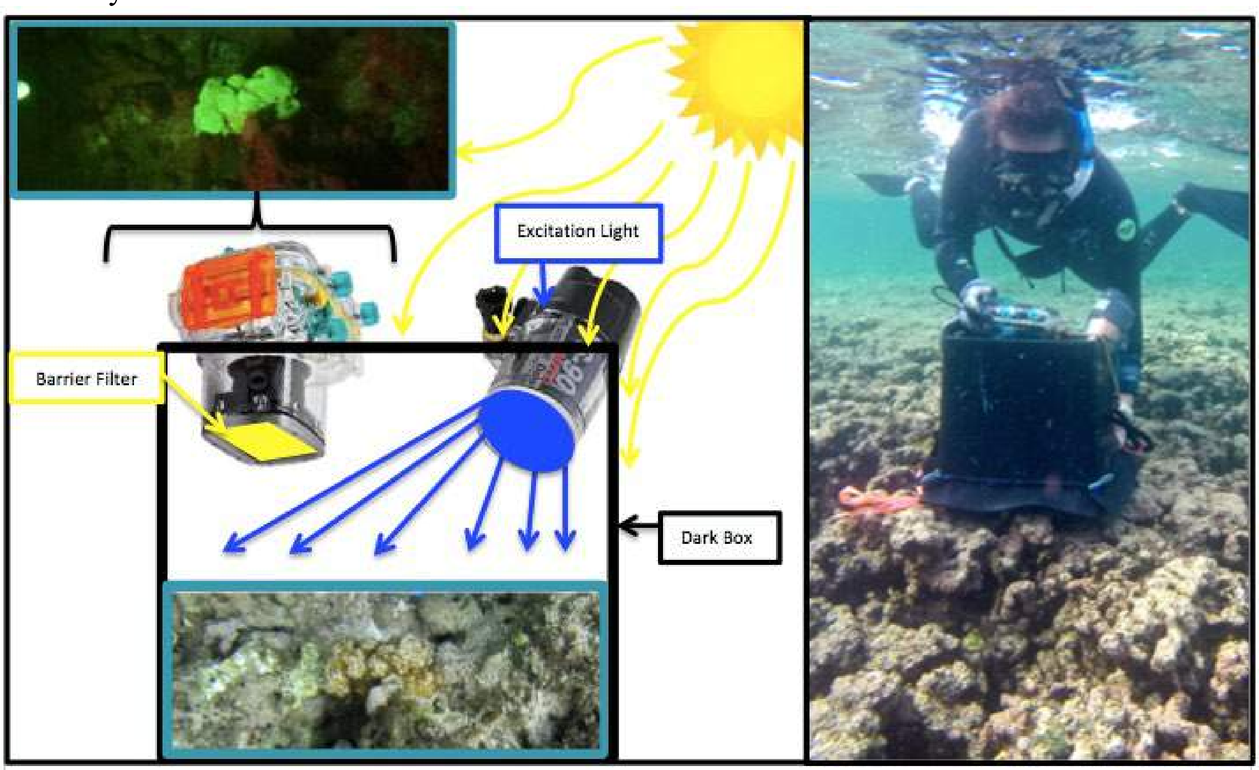


Figure 25. Equipment setup for fluorescent photography to identify coral recruits on natural reef substrate under daylight conditions.

The "dark box" was constructed from a modified 28-qt black rectangular garbage can[a] (the following super scripts correspond to Fig. 26). After modification, specifications of the dark box were as follows: Height: 29 cm, Length (top): 29 cm, Width (top): 21 cm. The dark box had two holes cut from the top, one centered for the camera lens (~10 cm x 7.5 cm)[b], and one on the left corner for the strobe (diameter = 8.5 cm)[c]. Two modified Sea & Sea Diffusers were attached to the black box to hold fiber optic cables in place: 1) glued onto the small end of a plastic planter pot and secured to black box using 2 zip ties, which held the fiber optic cable in front of strobe[d], 2) bolted under the top left corner of the hole for the camera lens, which held the fiber optic cable directly in front of the camera's flash[e]. Four 1.5 oz. fishing weights were attached, one on each corner, to the bottom of the black box[f], just above the attached garage door vinyl[g] which was zip tied along all bottom edges to minimize incoming light when shooting on uneven substrate. Rope handles were added to either side of the black box with handle holes for small bungee cords[h] attached to the camera and strobe for stability. The excitation filter[i] was mounted on a modified opaque plastic planter pot[j]. The bottom of the plastic planter pot was removed using a dremel tool, attached to a modified Sea & Sea diffuser[d] within the black box, and secured in the hole cut for the strobe[c]. The top of the pot (diameter of 10 cm) fit the excitation filter[i], with Velcro[k] added to secure the filter. A second Sea & Sea diffuser was cut to function as a holder for the fiber optic cable in front of the strobe[e]. The lens portion of underwater housing was wrapped in electrical tape[l] to minimize the influence of the flash (connected to the strobe) on the photograph. A piece of the yellow barrier filter[m] was cut to size (~3.4 cm x 4 cm with rounded edges) using a dremel tool and glued into the plastic top of a hair spray bottle (modified to 4.5 cm in diameter and wrapped in black electrical tape to keep its circular shape).

Photographic methods for this technique were adapted from previous studies: Roth & Knowlton (2009), Schmidt-Roach et al. (2008), Mazel (2005), and Piniak et al. (2005). All fluorescent photos were captured in Manual settings with both the macro mode and flash on. Other camera settings were determined by trial and error. Methods of choosing the best camera settings to capture the most coral fluorescence are dependent on environmental variables (time of day, cloud cover, etc.). Before quadrats were examined, the camera was fixed to the following settings: macro mode, flash on, ISO of 2500, aperture of *ƒ*/2.8, exposure value of -0.67, and shutter speed of 1/2000. Next, a photograph was taken of a nail painted with fluorescent nail polish acting as a fluorescent scale, and the output examined using the digital viewing screen. Camera settings were adjusted for weak fluorescence or, dark backgrounds.

Coral juveniles on *in situ* reef substrate were identified by examination of fluorescent photos. Fluorescent photos were examined for any organism exhibiting fluorescence and non-coral organisms (anemone) were noted. All corals were circled on the fluorescent photo. Following photo analysis, several attributes were recorded: genus and/or species, substrate type (sand, rubble, hard substrate), and FCT detection (yes, weak, no). In Winter 2021 surveys, FCTs will be paired with ambient light photos to accurately census the benthic substrate surrounding recruits and juveniles.

A non-parametric Kendall's tau correlation was performed to assess the relationship between coral recruitment and benthic cover of adult corals, crustose coralline algae, turf algae, macroalgae, sand, and rubble.

Figure 26. Configuration of 'dark box' setup for the fluorescence census technique. Letters in the figure correspond to the methodology text.

Results and Discussion

A total of 34 juvenile corals were present within the sample area (28 yrd^2, 3.5 yrd^2 total area per transect) of Hanauma Bay, giving an average density of 0.14 juveniles per square yard. The greatest number of coral juveniles and recruits were found on Keyhole West and Channel East transects (Table 9). All other transects exhibited little to no presence of coral juveniles or recruits. Benthic surveys from 2019 show that Keyhole West and Channel East have the lowest presence of sand (Table 10). However, the correlation between number of recruits and presence of sand was not significant. The non-parametric Kendall's tau correlation shows no significant relationship between coral recruitment and benthic cover of adult corals, crustose coralline algae, turf algae, macroalgae, sand, or rubble. If corals have the ability to recruit in Keyhole West and Channel East, they do not appear to be surviving to adulthood. These two sectors had the lowest adult coral cover from photoquadrats on horizontal surfaces (Table 10). It is possible that other stressors influence the survival of corals on these horizontal surfaces such as higher irradiance, exposure at low tide, and human interaction through touching or trampling. This study explains coral recruitment in Hanauma Bay at one timepoint and only along set transect areas. In the future, a more comprehesive study should be performed assessing coral recruitment throughout the inner reef flat over time. A study of this scale would require more resources and careful scheduling around swells and weather events.

This study marks the first analysis of the density and distribution of coral recruits and juveniles within Hanauma Bay's history. In comparison to other regions of the world, a density of 0.14 juveniles per square yard is low (Tamelander, 2002), yet several studies within the Hawaiian Islands found a recruitment density between 1.00 and 0.03 juveniles per square yard on artificial substrates (Brown, 2004). There are several possible explanations for low coral recruitment at a reef. First, low recruitment could be indicative of a recruitment limited reef, where corals are able to settle, but not survive to adulthood. Possible reasons for mortality following coral settlement at Hanauma could be lack of suitable substrate, corallivore predation, competition with algae, exposure to air at low tide, and/or extreme irradiance on the shallow reef flat. Second, coral recruitment in Hawaiʻi is episodic, and therefore, this short-span census did not capture new settlement or recruitment of corals. It did, however, document the survival of coral individuals from the previous years' coral reproduction events. Finally, very few studies have been performed documenting rates of coral recruitment on natural reef substrate. This study was the first within Hanauma Bay to document coral recruitment densities on natural reef substrate and can be used as a baseline for future studies.

Table 9. Number of recruits and juveniles found in Spring 2020 Fluorescent Census Technique surveys.

	Number of Recruits and Juveniles	
	Per Transect	**Per Square Yard**
Keyhole East	1	0.07
Keyhole West	14	1.07
Channel East	16	1.23
Channel West	3	0.21
Witches Brew East	0	0.00
Witches Brew West	0	0.00

Table 10. Percent cover of substrate in each transect during 2019 benthic surveys calculated from CoralNet annotations. "Other" category encompasses cover of sea cucumbers, urchins, zoanthids, macroalgae and unknown substrate.

	Adult Coral Cover	**CCA**	**Turf**	**Sand**	**Rock Rubble**	**Other**
Keyhole East	0.3	0.1	82.8	13.8	1.8	1.3
Keyhole West	0.1	0.1	82.7	9.0	7.4	0.8
Channel East	0.0	1.8	69.8	11.2	16.2	1.0
Channel West	1.6	0.2	68.6	21.8	7.8	0.1
Witches Brew East	1.1	0.0	63.1	32.6	3.1	0.2
Witches Brew West	1.5	1.7	73.3	15.0	7.7	0.8

Coral: Adult Coral Growth

Coral growth rates are influenced by a number of natural and anthropogenic factors. Water chemistry, temperature, depth, and light and nutrient availability collaboratively play a role in the rate at which a coral grows. At shallow depths, harsh levels of UV radiation can increase water temperatures creating a suboptimal environment for coral health. Water temperature influences the efficiency of coral symbionts to produce energy for the coral host and regulate the ability of corals to uptake calcium ions to produce new coral skeleton. Optimal growth of Hawaiian corals occurs at a water temperature of 27 °C (Jokiel & Coles, 1990). Increases in water temperature above summer ambient, but below the bleaching threshold of 1-2 °C greater than summer ambient temperatures, can still have sublethal effects with the potential to impair growth and reproduction of coral (Jokiel, 2008). Wave action and water movement also have optimal levels for coral growth. When wave action or water movement are too high, water temperatures may be lower and physical stress and breakage to corals may increase, and vice versa (Franklin et al., 2013). In addition to natural influencers of coral growth rates, coral growth is influenced by channelized storm runoff providing excess nutrients, decreased salinity, and fine particulate sediments to the ocean. This has become a common occurrence with the increase of development along most tropical coastlines. Elevated inorganic nutrients can reduce coral growth rates indirectly by increasing growth rates of nearby competing algae (Smith, 2003). Direct anthropogenic stressors also impact coral growth. Direct human influence by contact (Hawkins et al., 1999; Leujak & Ormond, 2008; Rodgers & Cox, 2002) and resuspension of sediments (Neil, 1990) while recreationally snorkeling and scuba diving has also been reported to greatly reduce coral growth. Coral growth rates reflect genetics and their environment. By studying environmental conditions on a reef concurrently with coral growth rates, researchers can identify which stressors, if any, are contributing to limiting growth of corals on a particular reef.

The Coral Reef Ecology lab has been conducting research within the HBNP since 1999. In the past three years, a comprehensive study of the inner reef flat to determine the biological carrying capacity within HBNP has been ongoing. The biological carrying capacity study seeks to determine the level of use the HBNP can support without further degrading natural resources. These natural resources include, but are not limited to, coral cover and health, fish abundance and biomass, and water clarity. Along with documenting biological resources, environmental factors have been examined (e.g. sedimentation, visual water clarity, wave height, speed and direction, wind speed and direction, etc.) As part of this study, researchers documented the rate of breakage to dead coral skeletons and regressed breakage rates against the number of visitors to quantify trampling pressure within the preserve. Results show higher breakage in most heavily trafficked areas. This next phase, documenting live coral growth rates, will allow researchers to determine the impact of human use on coral growth at differing anthropogenic levels. This work is important to increase the understanding of lethal, and sublethal effects to corals from visitors. Rates of coral growth in Hawaiʻi have been well studied throughout the years, however, this is the first study to document coral growth within the HBNP. Coral growth will continue to be measured following permit renewal by the Department of Land and Natural Resources Division of Aquatic Resources (DAR) (report due to DAR on April 14th, 2021).

Methods
A Special Activity Permit (SAP 2021-25) was authorized by the Department of Land and Natural Resources Division of Aquatic Resources to manipulate coral colonies to measure linear extension rates. Linear extension rates of corals are being tracked by tying a thin piece of wire around a coral branch and utilizing calipers to measure from the wire to the tip of the branch (Fig. 27). These measurements are taken several times within the permit year.

Growth surveys were performed on April 10th, April 29th, June 30th, July 7th in 2020 and March 15th and 21st in 2021. Cauliflower coral (*Pocillopora meandrina,* 11 colonies), Finger coral (*Porites compressa*, 4 colonies) and Plate and Pillar coral (*Porites rus*, 1 colony) colonies were identified in each sector of Hanauma Bay for documentation of linear growth of branches. Colonies have between 1 and 4 wire ties attached on separate branches of a singular colony. For colonies with several wire ties, a grand mean growth rate for the colony was calculated.

Figure 27. Example of a wire tie around a branch and the process of measuring adult coral growth with a caliper from wire ties around a cauliflower coral (*Pocillopora meandrina)* branch. photo credit: Andre Seale

Results and Discussion

A total of sixteen branching coral colonies were measured for linear extension growth rates over a period of 69 to 340 days and continue to be measured. Preliminary results show the highest growth rates occur in cauliflower corals (*P. meandrina*) found near Backdoors East (Fig. 28) (0.042 ± 0.03 mm/day, mean ± 1SD), Backdoors West (0.088 ± 0.064 mm/day), and Channel East (0.050 ± mm/day) (Table 11). Each of these transects border sources of open ocean water. Despite having the fastest growth rates within the Bay, average growth rates of cauliflower corals (0.029 ± 0.014 mm/day) within the Bay are lower than the standard average daily growth rate (0.08 mm/day) of cauliflower coral within Hawai‘i (Edmonson, 1929) (Table 12). A Plate and pillar coral (*Porites rus*) experienced growth rates greater than 0.1 mm per day, which is faster than the average growth rate of 0.022 mm per day observed by Grigg within Hawai‘i (1998) (Table 12). Preliminary observations are calculated based on growth rates (mm/day) over a period of 69 to 340 days. To establish higher confidence of true rates of growth, permit renewal is in process (SAP 2021-25) for wires attached to these corals used to measure linear extension growth within Hanauma Bay.

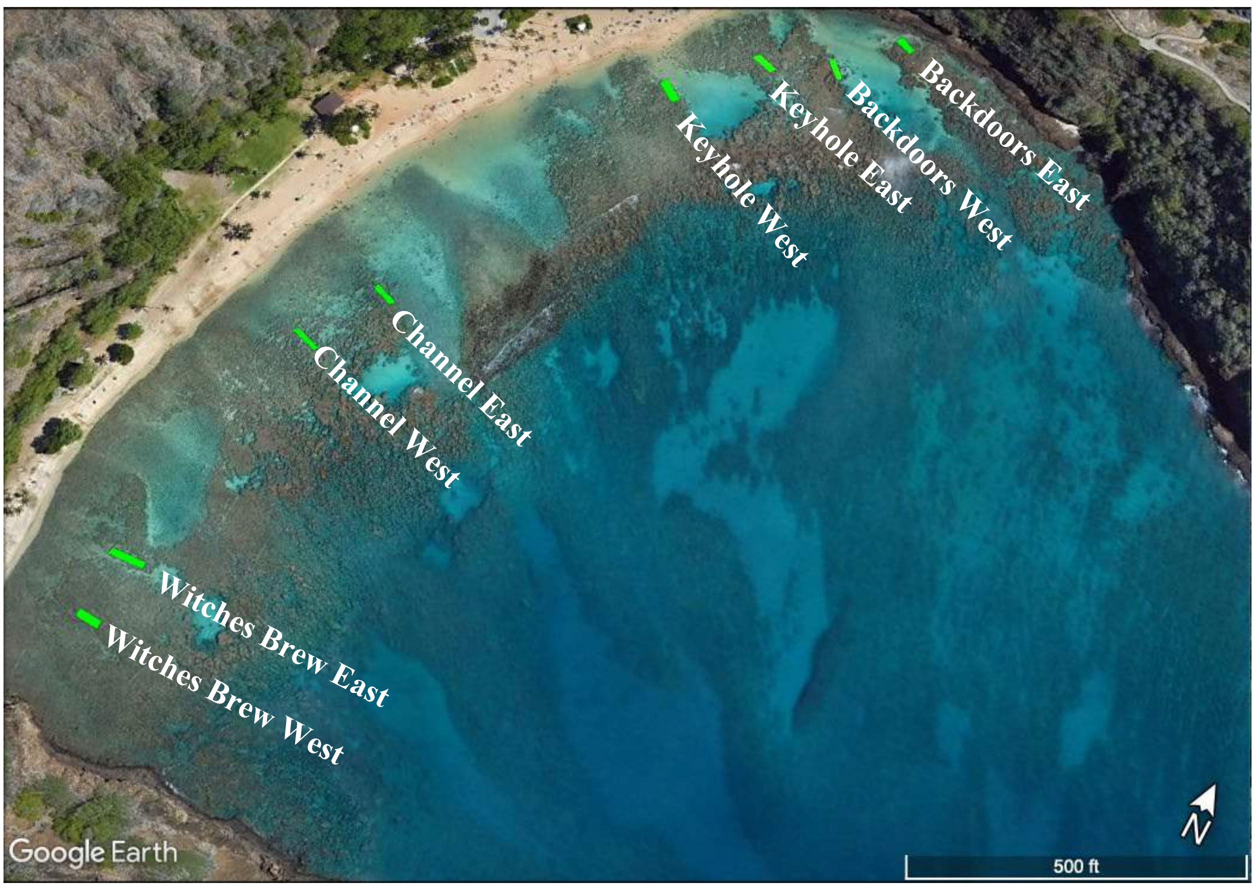


Figure 28. Eight Sectors of the inner reef flat of Hanauma Bay: Backdoor East and West, Keyhole East and West, Channel East and West, and Witches Brew East and West. Green rectangles outline the 5 m x 15 m transects encompassing or in close proximity to the corals with wire ties (not to scale).

Table 11. Average growth rate per day (mm/day) of select coral colonies within Hanauma Bay near permanent transects. Species codes: Pm = *Pocillopora meandrina* or Cauliflower coral, Pr = *Porites rus* or Plate and Pillar coral, Pc = *Porites compressa* or Finger coral. Missing growth rates (-) indicate that the colony growth rate cannot be calculated at this time but will be made available in the next report. Growth rates were compared to those found in the literature and assigned a red down arrow for growth rates less than found in historical literature (↓) and a green star for growth rates equal to those found in historical literature (★).

Location	Colony	Species	Number of colony branches with wire ties	Grand Mean average colony growth (mm) per colony per day	Growth rate compared to literature
Backdoors East	1	Pm	2	0.042	↓
Lat: 21.27267, Long: -157.694831	2	Pm	2	0.028	↓
Backdoors West	1	Pm	4	0.088	★
Lat: 21.272408, Long: -157.695092	2	Pm	2	0.002	↓
Keyhole East	1	Pm	3 total, one dead	0.016	↓
Lat: 21.272251, Long: -157.695456	2	Pm	2	-	-
	3	Pm	1	-0.002	↓
Keyhole West	0	-	-	-	-
Channel East	1	Pm	2	0.050	↓
Lat: 21.270349, Long: -157.696561	2	Pm	4	-0.002	↓
Channel West	1	Pm	1	0.035	↓
Lat: 21.269996, Long: -157.696788					
Witches Brew East	1	Pr	4	0.136	↓
Lat: 21.268756, Long: -157.696965	2	Pc	1	-	-
	3	Pc	1	-	-
	4	Pm	1	-	-
Witches Brew West	1	Pc	1	-0.171	↓
Lat: 21.268475, Long: -157.696934	2	Pc	1	0.071	↓
	3	Pc	1	-	-

Table 12. Average coral growth rates found within the literature for species of interest in this study.

Coral Species	Annual Growth Rate	Daily Growth Rate	Reference
Pocillopora meandrina	14.8 mm/yr	0.080 mm/day	(Edmondson, 1929)
Porites compressa	24.3 mm/yr	0.067 mm/day	(Custodio and Yap, 1997)
Porites rus	7.9 mm/yr	0.022 mm/day	(Grigg, 1998)

Sediment: <u>Accumulation</u>

Both environmental and anthropogenic mechanisms are responsible for increased sediment deposition. Increased wave height, tidal flux, and wind strongly influence the amount of sediment suspension, accumulation, and dispersal distance (Browne et al., 2013; Storlazzi et al., 2004). Other anthropogenic factors that can increase sediment accumulation are walking in or stirring up sand while snorkeling (Chabanet et al., 2005; Neil, 1990). Sediment accumulation is detrimental to corals, posing two main health threats. (1) Fine sediment on live coral tissue can smother corals or causes the coral to produce energetically expensive mucus to remove the sediment (Lamb et al., 2014; Zakai & Chadwick-Furman, 2002). This allocates energy away from food production, growth, and/or reproduction. If sediment deposition is a chronic disturbance, growth and reproductive success can be hindered (Buddemeier & Kinzie, 1976). (2) If the particles of sediment are large, as with sand, it may scour (Grigg, 1998) and damage coral tissue, leaving them more susceptible to loss of tissue, death, or infection by disease (Harvell et al., 2007; Pollock et al., 2014). Studying the accumulation of sediment concurrently with coral condition and the lack of visitor presence has allowed for the detection of threats from sediment accumulation and determination of whether sediment is environmentally or anthropogenically driven.

Measurements of sediment accumulation to the reef substrate were repeated during the COVID-19 closure, allowing for comparisons between 2018 and rates of sediment accumulation with no visitors present. The rate of sediment accumulation is an important indicator of coral stress within an environment (Neil, 1990). Sediment traps measuring the quantity of fine particulates and sand deposited onto the reef flat were used as a proxy for sediment deposition. Sediment accumulation measurements during the COVID-19 closure established a baseline of sediment accumulation driven solely by environmental conditions. The following results compare three sediment trap deployments during the COVID-19 closure to two sediment trap deployments while open to the public in 2018.

Methods

Sediment traps were deployed over three time periods during the COVID-19 closure to repeat the sediment accumulation study conducted in 2018 in the absence of visitor presence. The first set of sediment traps were deployed on April 21st, 2020 and collected on May 7th, 2020 for a total of 16 days in the field. The second deployment occurred on August 14th, 2020 and remained in the field for 11 days (8/25/20). The last deployment was over a period of 5 days from October 9th to the 13th, 2020. The short duration of the last deployment was based on trap capacity on previous deployments in some sectors. Both deployments in 2018 occurred while open to the public and traps were placed for between 15 and 29 days. Sedimentation was standardized to accumulation per day to account for traps that had not been out the full duration due to tampering. Each permanent transect contained two sediment traps, one at the beginning and one at the end of the 15 yd transects for a total of 16 traps. Sediment traps are 12 inches in height (ABS PVC with PVC plastic cap on bottom) with a 2-inch diameter mouth. A crosshatched piece of plastic was placed 2 inches below the mouth of the pipe to act as a ‘baffle’ and reduce wave action sediment resuspension outside the trap. Sediment trap design was based on those used in Bothner et al. (2006) and Storlazzi et al. (2011). Traps were affixed to natural holes in the reef using cable ties and are placed flush with the surface of the substrate. Prior to deployment, traps were kept out of the water and upon collection, capped (PVC cap) to avoid spilling sediment or water.

Sediments were filtered (Whatman 1114-185 Filter Circles, wet strengthened grade 114) and rinsed with 200 ml of freshwater to remove salt deposits, then left to air dry for two weeks post-collection. An average of three weights accounted for changes in humidity.

Non-parametric statistical tests were performed due to non-normality of the dataset. With transects pooled, an Independent-Samples Mann-Whitney U test was performed to determine a difference in overall sediment accumulation while the Bay was open to visitors. To assess the differences between sediment accumulation rates with survey dates pooled into (1) open to the public and (2) closed to the public, Independent-Samples Mann-Whitney U tests were conducted for each transect. An Independent-Samples Kruskal-Wallis Test was used to determine any significant differences in sediment accumulation between sampling date with sectors pooled.

Results and Discussion

Accumulation of sediment was compared between days open to the public and those closed to the public during the COVID-19 closure. No difference in rates of sediment accumulation were detected when all sectors of the Bay were pooled. Rates of sediment accumulation between each timepoint for each transect were not statistically different from one another, with the exception of Witches Brew West ($p<0.02$, Fig. 29). Witches Brew West accumulated three times the amount of sediment during the COVID-19 closure as compared to open days to the public in 2018.

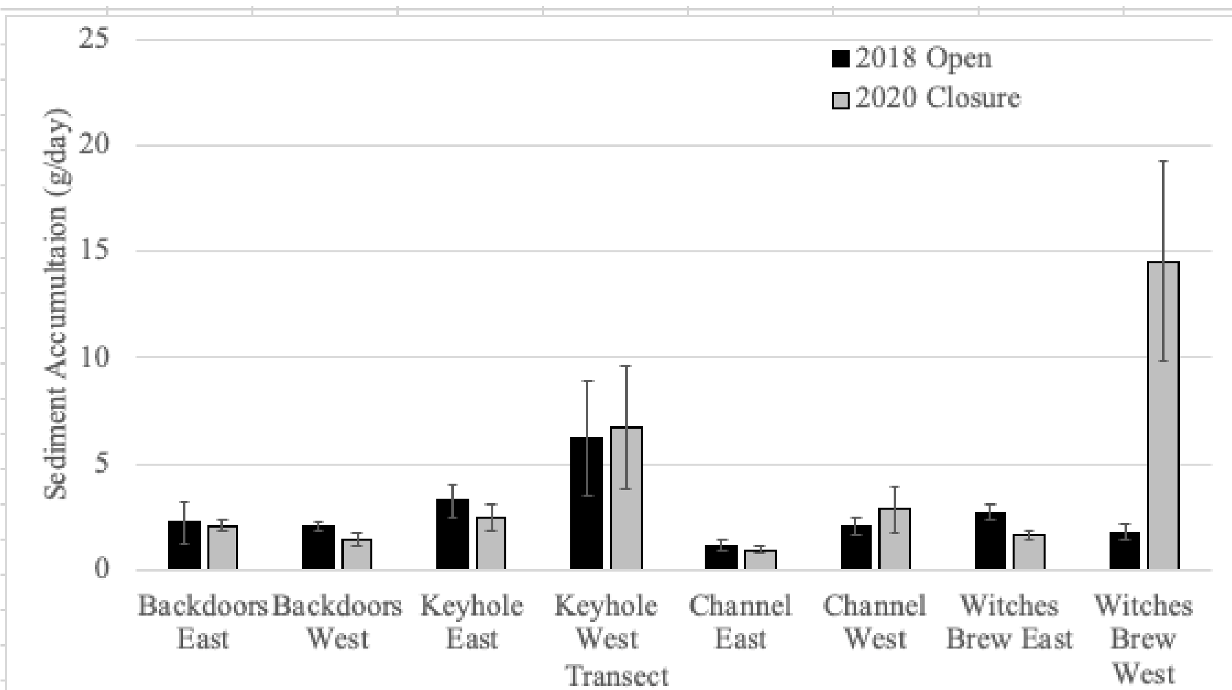


Figure 29. Sediment accumulation comparing two sediment trap deployments in 2018 (June & October) and three sediment trap deployments in 2020 during the COVID-19 closure (May, August & October). Asterix (*) represents a significant difference in sedimentation rates between open and closed timepoints ($p < 0.02$).

Shortly after the May 2020 sediment traps were collected, a large log (10 yd x 1 yd) floated into the reef, seaward of Witches Brew West. The log was removed by the City and County of Honolulu within the week. During the week the log remained in the Bay, a 10 yd^2 area of reef damage and substantial increases in unconsolidated substrate and rubble occurred. To determine impact on overall sediment accumulation within the Bay, rates of sediment accumulation were compared between survey dates. Mean sediment accumulation was greatest in August 2020 samples (6.33 ± 2.5 grams/day) when compared to all other months (Table 13). May 2020 had the lowest sediment accumulation (2.43 ± 0.7 grams/day) of all 2020 samples and significantly lower than rates of sediment accumulation when compared to August 2020 (p<0.05), October 2020 (p<0.03), and October 2018 (p<0.02). Because rates of sediment accumulation increased significantly following the log damage in Witches Brew West, it is highly likely that this disturbance contributed to the increased rates of sediment accumulation reported in this area (Fig. 29). The southern shore of O‘ahu typically receives less wave action during the summer months when compared to winter months. Anecdotally, the Bay experienced more wave action in summer 2020, which could have contributed to the higher levels of sedimentation observed during the closure. Additionally, If Witches Brew West is eliminated from October and August 2020 averages, the average sediment acumulation in October becomes 2.5 ± 0.4 g/day and August becomes 3.9 ± 1.4 g/day. These values are no different from levels of sedimention in 2018.

All transects, except for Witches Brew West, had similar rates of sediment accumulation when open to the public and closed during the COVID-19 closure, suggesting environmental influences may have a stronger impact on rates of sediment accumulation than visitor presence.

Table 13. Sediment accumulation divided by the number of days traps were deployed. Standard error (SE) represents ± 1 SE.

Sediment Accumulation (g) per day						
Sector/Location on transect		**2020 October**	**2020 August**	**2020 May**	**2018 October**	**2018 June**
Backdoors East	**Front**	1.95	2.12	1.11	2.11	0.13
	Back	2.61	2.96	1.91	4.73	1.90
Backdoors West	**Front**	1.77	1.02	0.59	2.43	2.01
	Back	2.17	2.24	0.93	2.21	1.48
Keyhole East	**Front**	3.43	5.06	1.75	5.60	2.43
	Back	2.02	1.82	0.75	2.96	2.12
Keyhole West	**Front**	5.13	20.85	5.73	13.90	5.69
	Back	2.66	4.08	1.84	3.01	2.07
Channel East	**Front**	1.16	0.99	0.40	1.31	0.93
	Back	0.92	1.48	0.63	0.65	1.73
Channel West	**Front**	6.09	4.86	1.01	2.89	2.60
	Back	1.54	-	0.89	1.27	1.55
Witches Brew East	**Front**	1.61	1.53	0.87	2.82	2.01
	Back	2.16	1.89	1.99	3.27	-
Witches Brew West	**Front**	6.58	7.62	9.43	2.69	1.65
	Back	17.99	36.49	9.03	1.02	1.84
	Average	**3.74**	**6.33**	**2.43**	**3.30**	**1.99**
	SE	**1.04**	**2.51**	**0.73**	**0.78**	**0.29**

<u>Sediment:</u> <u>Suspended</u>

Measurements of suspended sediments in the water column were repeated during the COVID-19 closure, allowing for comparisons between 2018 visual water clarity. Water clarity measurements are important indicators of coral reef condition. Corals utilize light to maintain their energy source. When water visibility is reduced, less light is recieved by corals thus decreasing the efficiency of symbionts to produce energy. Ultimately, this decreases the ability for corals to sustain themselves utilizing sunlight alone (Buddemeier & Kinzie, 1976). Water clarity can be a proxy for suspended sediments within the water column. The amount of suspended sediments can be greater in areas of high wave action, but also in areas of high visitor traffic (Neil, 1990). Snorkelers and waders can suspend sediment decreasing water clarity, as observed in Keyhole, where 50% of snorkeling and wading occurs (Hanauma Bay Carrying Capacity Annual Report 2018/19). Documentation of suspended sediments in the water column at the HBNP in the absence of visitors allowed for the determination of a baseline and evaluation of the influence of environmental factors on water clarity.

Methods

To determine water visibility across time and environmental conditions, secchi disk water clarity measurements were taken within the four sectors of Hanauma Bay. During surveys conducted in June and October of 2018, water visibility data was collected on six days closed to the public (8 observations per day) and 18 days open to the public (8 observations per day). During the COVID-19 closure, secchi disk measurements were repeated in the absence of visitors on 24 dates (4 observations per day) between April 21st and December 1st, 2020. Hanauma Bay reopened to the public on December 2nd, with limited capacity. Secchi disk measurements were collected on three days in December and three days in January (6 days, 4 observations per sector per day). To relate water clarity to visitor use, the number of snorkelers and waders in each area were quantified during measurements by four 10 minute counts that were later averaged. . Box office counts were also acquired from the City and County of Honolulu.

Environmental data on wind speed and direction was acquired from the National Oceanic and Atmospheric Administration (NOAA) station 1612340 located in Honolulu, HI, while wave height, direction and mean period was acquired from the closest NOAA buoy 51202 located off the windward side of Oʻahu at Mokapu Point. Wind and wave parameters were averaged over the previous 24 hrs prior to the water clarity measurement. Tidal coefficient was calculated as the difference in amplitude between the consecutive high tides and low tides, and acquired from tides4fishing.com.

To measure secchi disk water clarity, surveyor one holds the secchi disk while surveyor two swims away with the connected transect tape until the white secchi disk is no longer visible. Surveyor two records the distance at which they lose sight of the disk. The surveyor swims away from the disk and waits for 30 seconds before swimming toward the disk and stopping to record the distance at which the secchi disk is again visible.

Independent-samples Kruskal-Wallis tests with pairwise comparisons were performed to distinguish differences between the visual water clarity values of the four survey timepoints: Open to the public (2018), Closed Tuesdays (2018), COVID-closure (2020), and after the reopening (2020/21). Due to lack of normality in the dataset, a non-parametric Kendall's Tau correlation was utilized to quantify the relationship between visual secchi distance, counts of swimmers and waders, tidal coefficient, wind speed and direction, wave height, wave direction, and mean wave period. Principal Components Analysis and a General Linear Model were used to further explain environmental influence on visual water clarity.

Results and Discussion

On average, water clarity during the COVID-19 closure was 0.9 ± 0.5 yards clearer than water clarity on Tuesdays in 2018 when closed to the public, and 3.7 ± 0.5 yards clearer during the COVID-closure when compared to days open to the public in 2018 (Fig. 30). The Bay was 56% clearer during the COVID-19 closure than on a day open to the public, and 8.9% clearer during the COVID-19 closure than on Tuesdays in 2018 when closed to the public. 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. However, water clarity during the COVID-19 closure was not different from that of closed days to the public in 2018 in all sectors except Witches Brew, which had significantly greater water clarity during the COVID-19 closure when compared to closed Tuesdays in 2018 ($p<0.045$) (Table 14). The lack of a strong significant difference between the two closures, COVID-19 and Tuesdays in 2018, suggests that sediments were not being suspended in the water column for longer than 24 hours as once predicted with preliminary data. After the reopening of the Bay at 25% capacity (approximately 720 visitors per day), water clarity decreased an average of 2.9 ± 0.6 yards when compared to days closed to the public during the COVID-19 closure (28.2% reduction in water clarity), and 2.1 ± 0.5 yards when compared to Tuesdays when closed to the public in 2018 (21.8% reduction in water clarity). However, water clarity was 0.8 ± 0.5 yards greater when comparing days after reopening to the public at 25% capacity after the COVID-19 closure to water clarity when the Bay was operating at full capacity (~3000 visitors per day) in 2018 (increased water clarity by 12.2%). Regardless of these changes in average water clarity, Witches Brew was the only sector to experience a significant increase in water clarity when comparing open days to the public in 2018 and the reopening of the Bay after the COVID-19 closure. The lack of significant difference between water clarity at full capacity of visitors compared to 25% capacity of visitors suggests that the two different levels of visitor presence may stir up a similar amount of sediments into the water column.

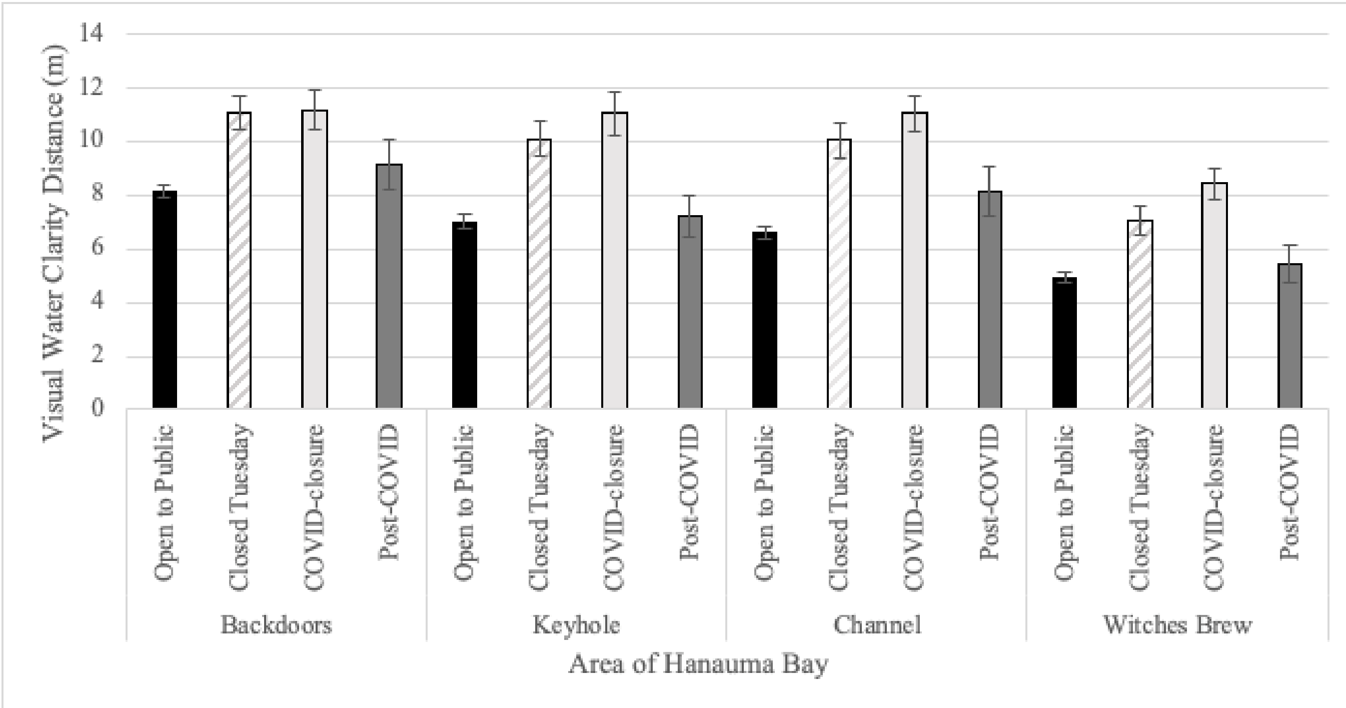


Figure 30. Visual water clarity distance measured using the Secchi Disk method. Open to the Public (18 days with 8 observations per day) and Closed Tuesdays (6 days with 8 observations per day) data was averaged over June and October from the findings of the 1st Annual Carrying Capacity Study. COVID-closure data represents 24 field days (4 observations per day) during the April/May 2020 closure. Standard error bars represent ± 1 SE.

Table 14. Water clarity results of non-parametric independent-samples Kruskal-Wallis tests comparing water clarity in 2018 to the 2020 COVID-19 closure and after the reopening of the Bay in December 2020 (* indicates a significant correlation (*p*<0.05)).

	Survey Period Comparison	**Reopening 2020/21**			**Open 2018**		**Closed 2018**
		Open 2018	**COVID-19 Closure 2020**	**Closed 2018**	**COVID-19 Closure 2020**	**Closed 2018**	**COVID-19 Closure 2020**
Sector	**Backdoors**	1.00	<0.001*	<0.001*	<0.001*	<0.001*	0.368
	Keyhole	1.00	<0.001*	<0.001*	<0.001*	<0.001*	1.00
	Channel	0.814	<0.001*	<0.001*	<0.001*	<0.001*	1.00
	Witches Brew	<0.001*	0.003*	1.00	<0.001*	<0.001*	0.041*

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.

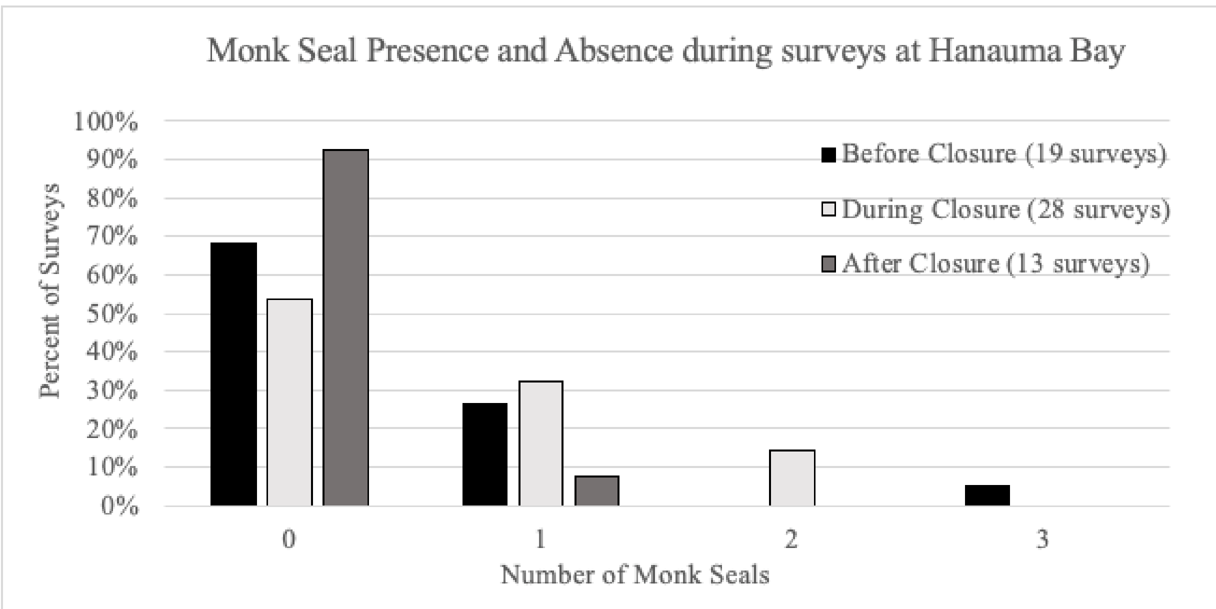


Figure 31. Hawaiian monk seal presence or absence during field surveys at Hanauma Bay comparing days open to the public (black bars) in 2018 and days closed during the COVID-19 closure (grey bars).

<u>**Megafauna:** Green Turtles</u>
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.

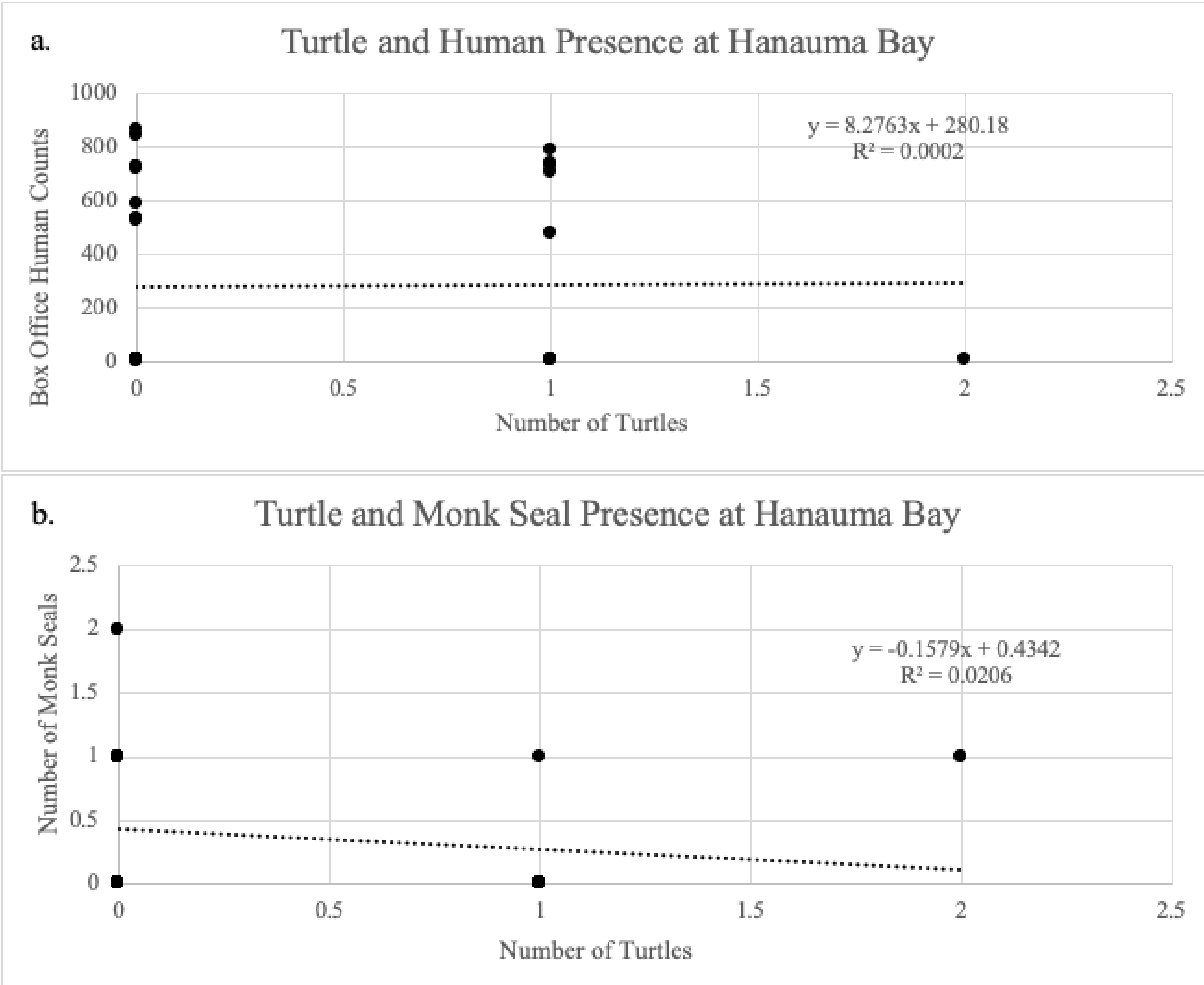
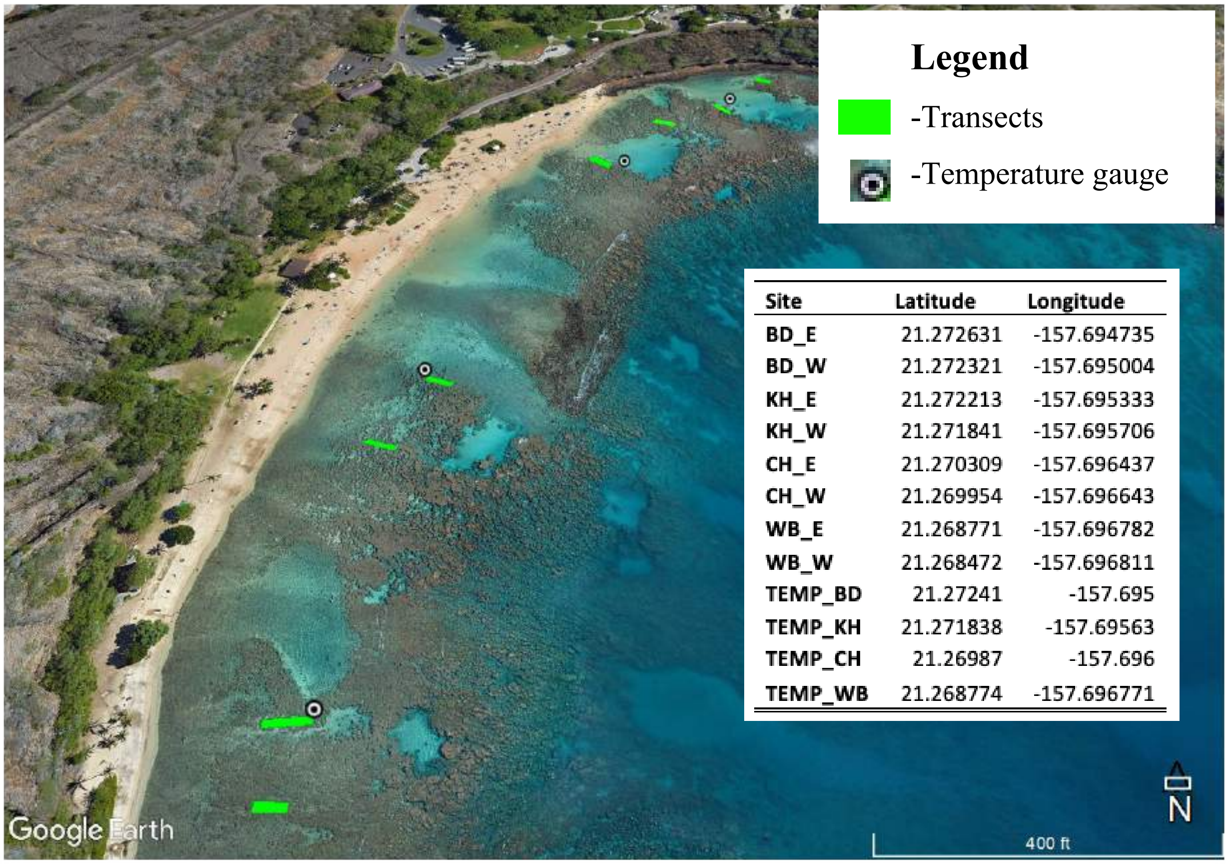


Figure 32. The presence of green turtles regressed against Human Counts acquired from the box office at Hanauma Bay (a) and the number of Hawaiian monk seals (b) at Hanauma Bay Nature Preserve during the COVID-19 closure.

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.



Site	Latitude	Longitude
BD_E	21.272631	-157.694735
BD_W	21.272321	-157.695004
KH_E	21.272213	-157.695333
KH_W	21.271841	-157.695706
CH_E	21.270309	-157.696437
CH_W	21.269954	-157.696643
WB_E	21.268771	-157.696782
WB_W	21.268472	-157.696811
TEMP_BD	21.27241	-157.695
TEMP_KH	21.271838	-157.69563
TEMP_CH	21.26987	-157.696
TEMP_WB	21.268774	-157.696771

Figure 33. Locations of long-term monitoring transects (green) and temperature (TEMP) loggers within east (E) and west (W) inner reef transects of Backdoors (BD), Keyhole (KH), Channel (CH) and Witches Brew (WB).

Coral Bleaching

Prior to 1996, coral bleaching events within the Hawaiian archipelago were small, localized, disturbances resulting from (1) decreased salinity during heavy rain events, (2) exposure at low tide, and/or (3) increased sedimentation; there are no quantitative or qualitative records of large scale bleaching prior to 1996 (Friedlander et al., 2008). However, since 1996, Hawai‘i has experienced several severe bleaching events (1996, 2002, 2004, 2014-2015, 2019 and 2020), all of which were triggered by extended periods of elevated SST greater than 1-2°C above the expected summer maximum, and further exacerbated by increased solar radiation coupled with low-wind speeds (Aeby et al., 2003; Bahr et al., 2015; Friedlander et al., 2008; Jokiel & Brown, 2004; Kenyon & Brainard, 2006); Hawai‘i's bleaching threshold occurs between 29°C and 30°C (Jokiel & Coles, 1990). Increased frequency of thermally induced coral bleaching events within Hawaiian waters are the result of increases in SST by 0.15°C per decade (Jokiel & Brown, 2004), but ultimately the result of increasing CO_2 released into the atmosphere (Eakin et al., 2009). Coral bleaching due to thermal stress is the ultimate threat to the survival of reefs. Selective survival and recovery of coral species least impacted by recurrent bleaching events will lead to major changes in coral community composition, and thus changes in ecosystem function for all reef dependent organisms.

Since 2015, the Coral Reef Ecology Lab has been documenting coral bleaching and recovery of corals within Hanauma Bay. This past October, sea surface temperatures within the Bay exceeded 28°C in each sector resulting in visible stress to corals (See section on temperature for further details). The following is an analysis of coral bleaching during the October 2020 thermal stress event and comparison to past events.

Methods
Directly after peak sea surface temperatures, visual coral surveys were conducted on each inner reef transect (October). Boundaries of the 5 yd by 15 yd transects were marked using transect tapes documenting every coral within the area. In addition to recording the size and species of each coral within transects, corals were given a health score of live, pale, bleached or recently dead (Table 16). A repeat survey will be conducted March 2021 to evaluate recovery.

Non-normality of the dataset led to the use of non-parametric tests. To distinguish differences in coral condition between years and sectors, Independent-Samples Kruskal-Wallis tests with paired comparisons were performed. To evaluate the thermal tolerance of corals within Hanauma Bay, an Independent-Samples Kruskal-Wallis Test with paired comparisons was applied across coral species and health conditions during the bleaching in October 2020.

Results and Discussion
Data collected directly after peak bleaching were used to distinguish patterns of coral bleaching and recovery comparing 2015, 2019 and 2020, transects and species. Coral bleaching was significantly greater in 2015 surveys when compared to 2019 ($p<0.001$) and 2020 ($p<0.001$) bleaching surveys. The 2015 bleaching event caused 44.5% of corals to bleach and 18.1% to pale, whereas, during the 2019 bleaching event paling (46.6%) was more prevalent than bleaching (21.5%). The opposite trend occurred during the 2020 bleaching event (bleaching: 33.6%, paling: 12.1%). Prevalence of paling was significantly higher in 2015 ($p<0.001$) and 2019 ($p<0.001$) surveys when compared to those performed in 2020. Despite dissimilarities in coral bleaching between years, cumulative average mortality was similar between 2015 and 2019 (2015: 9.80, 2019: 8.23%). No mortality was observed in the 2020 bleaching event.

During both 2015 and 2019 thermal stress events, Backdoors experienced the highest mortality (2015: 3.99%, 2019: 3.40%) and Keyhole experienced the lowest mortality (2015: 0.84%, 2019: 0.00%) within Hanauma Bay. While Channel experienced low mortality (0.29%) in 2015, during the 2019 bleaching event Channel had the highest mortality of all sectors (4.30%). Witches Brew experienced 3.24% mortality in 2015, with lower (0.53%) mortality in 2019. This may indicate an increase in survival of thermal stress with repeated exposure (Coles and Jokiel 1978, Hughes 2018). Increased resiliency after a bleaching event may result from coral associated symbiont community shift to more thermally tolerant symbionts (Baker et al. 2004, Berkelmans and van Oppen, 2006) or natural selection of coral species that are more tolerant to thermal stress (Hongo and Yamano 2013, Coles et al. 2018).

The distribution of paling and bleaching within the Bay differed between the 2015, 2019 and 2020 bleaching events (Fig. 34). In 2015, prevalence of coral bleaching was significantly different between sectors ($p<0.04$), but no pairwise comparisons were significant. Prevalence of bleaching (56.8%) and paling (19.6%) were greatest in Keyhole sector. Witches Brew also exhibited a high degree of bleaching (54.9%), but the least paling of any sector (13.8%). Backdoors (bleached: 36.1%, pale: 18.2%) and Channel (bleached: 31.2%, pale: 22.4%) also exhibited high prevalence of bleached and pale corals. During the 2019 bleaching event, Channel sector exhibited the highest prevalence of bleaching (33.8%), followed by Backdoors (23.5%), Witches Brew (16.0%) and Keyhole (12.5%). Paling was most prevalent in Backdoors (68.6%) and Keyhole (62.5%), followed by Channel (33.7%) and Witches Brew (21.8%). Witches Brew had significantly lower bleaching (16.0%) when compared to Channel (33.9%; $p<0.01$), and significantly lower prevalence of paling (21.8%) when compared to Backdoors (68.6%) ($p<0.001$) and Keyhole (62.5%; $p<0.02$). Channel (33.7%) also exhibited a significantly lower prevalence of paling when compared to Backdoors ($p<0.01$) and Keyhole ($p<0.05$). Similarly, in the 2020 bleaching event, Witches Brew exhibited the lowest bleaching prevalence (13.4%), which was significantly lower than both Keyhole (39.1%; $p<0.02$) and Channel (47.0%; $p<0.001$) sectors. Bleaching was greatest in Channel sector (47.0%), followed by Keyhole (39.1%), and Backdoors (34.7%). Differing from the 2019 bleaching event, in 2020 Channel sector had the highest prevalence of bleaching and paling (18.8%), with significantly greater paling when compared to both Backdoors (8.3%; $p<0.05$) and Witches Brew (6.5%, $p<0.002$). Keyhole (14.6%) sector had the second highest prevalence of paling in the 2020 bleaching event. Over the three bleaching events, the most bleached and least bleached sectors differ. In 2015, the entire Bay experienced a high prevalence of bleaching and paling, with Witches Brew and Keyhole the most affected. The next bleaching event in 2019 exhibited the highest bleaching in Channel and Backdoors. In the most recent bleaching event, 2020, bleaching was prevalent in all but Witches Brew West sector (Fig. 34). The differential bleaching seen between thermal stress events may be the result of a shift to more thermally tolerant species of corals and/or clades of symbiotic algae remaining in the Bay.

Table 16. Average (± 1 SE) coral condition within each sector during surveys performed directly after peak bleaching times for the past three coral bleaching events in the Main Hawaiian Islands. Transect references are as follows: BA = Backdoors East, BB = Backdoors West, KA = Keyhole East, KB = Keyhole West, CA = Channel East, CB = Channel West, WA = Witches Brew East, WB = Witches Brew West.

Survey Date	**Transect**	**average**	**SE**	**average**	**SE**	**average**	**SE**	**average**	**SE**
		Live (%)		**Bleach (%)**		**Pale (%)**		**Recently Dead (%)**	
10/15/2015	BA	32.2	7.00	40.9	7.50	25.2	5.20	1.70	1.00
	BB	51.3	13.7	31.3	11.1	11.3	4.00	6.30	6.30
	KA	21.8	10.7	58.2	12.0	17.3	4.70	0.90	0.90
	KB	23.8	7.00	55.4	8.80	20.0	6.60	0.80	0.80
	CA	37.5	9.20	33.8	8.20	23.8	6.50	0.00	0.00
	CB	53.5	8.20	26.5	6.70	19.4	6.40	0.60	0.60
	WA	18.2	5.30	65.5	7.10	16.4	4.20	0.00	0.00
	WB	37.9	7.60	44.4	7.80	11.2	3.90	6.50	3.20
10/19/2019	BA	9.10	6.30	13.6	7.50	70.5	9.70	6.80	5.00
	BB	0.00	0.00	33.3	33.3	66.7	33.3	0.00	0.00
	KA	0.00	0.00	0.00	0.00	100	0.00	0.00	0.00
	KB	50.0	28.9	25.0	25.0	25.0	25.0	0.00	0.00
	CA	34.9	7.40	44.2	7.7	20.9	6.30	0.00	0.00
	CB	21.4	11.4	23.6	11.3	46.4	13.3	8.60	5.90
	WA	61.8	7.60	25.3	7.00	11.8	4.80	1.10	1.10
	WB	61.4	7.40	6.80	3.80	31.8	7.10	0.00	0.00
10/20/2020	BA	73.9	10.3	9.40	6.60	16.7	9.00	0.00	0.00
	BB	40.0	16.3	60.0	16.3	0.00	0.00	0.00	0.00
	KA	59.1	14.2	22.7	11.8	18.2	10.9	0.00	0.00
	KB	33.3	16.7	55.6	15.5	11.1	7.30	0.00	0.00
	CA	51.6	10.0	30.8	8.70	13.6	5.80	0.00	0.00
	CB	12.9	7.40	63.2	11.3	23.9	9.90	0.00	0.00
	WA	62.5	7.00	26.7	5.80	12.9	4.00	0.00	0.00
	WB	99.7	0.20	0.10	0.10	0.20	0.20	0.00	0.00

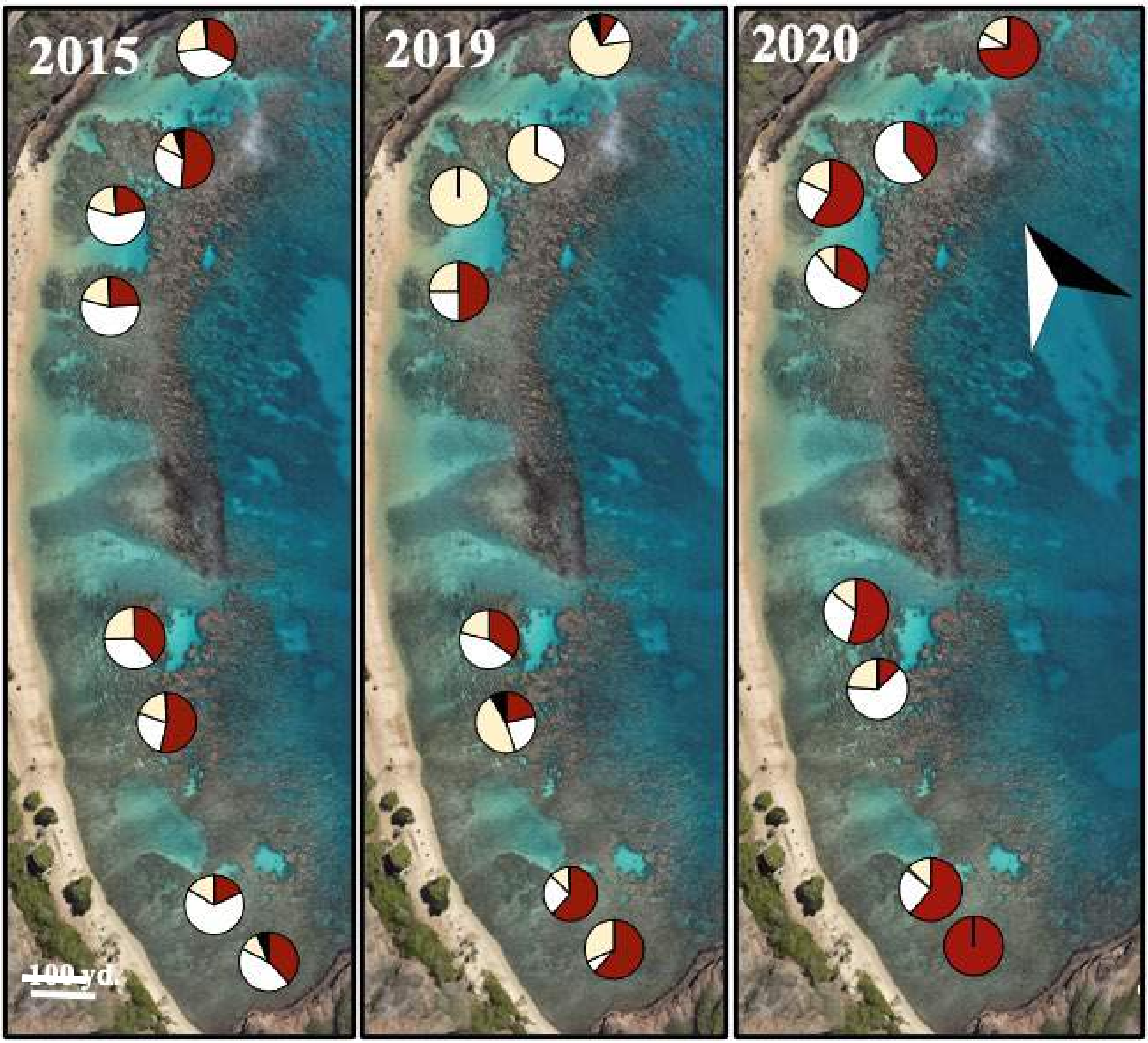


Figure 34. Comparison of coral bleaching (Live = red, Pale = yellow, Bleached = white, Dead = black) in Hanauma Bay between October 2015 (left), October 2019 (middle), and October 2020 (right).

Bleaching prevalence can also be attributed to the resiliency of different coral species. Lace (*Pocillopora damicornis*), Ocellated (*Cyphastrea ocellina*) and Rice (*Monitpora capitata*) coral were most susceptible to bleaching during the 2020 bleaching event (Figs. 35 & 36). Only one lace coral was noted along transects, and it was bleached. To evaluate the thermal tolerance of corals within Hanauma Bay, an Independent-Samples Kruskal-Wallis Test with paired comparisons was performed across coral species and health condition during October 2020. Species specific differences were found. Bleaching prevalence was significantly higher in Rice and Ocellated coral when compared to Finger (*Porites compressa*; Rice: $p<0.003$; Ocellated: $p<0.001$), Lobe (*Porites lobata*: Rice: $p<0.001$; Ocellated: $p<0.001$), Brown Lobe (*Porites evermanni*; Rice: $p<0.001$; Ocellated: $p<0.001$), Cauliflower (*Pocillopora meandria*; Rice: $p<0.001$; Ocellated: $p<0.001$), and False Brain coral (*Pavona varians*; Rice: $p<0.001$). Rice coral also had significantly higher bleaching prevalence when compared to Ocellated coral ($p<0.001$). During the 2020 coral bleaching event the Rice and Ocellated corals were most susceptible with over 40% bleaching within colonies (Fig. 34). Paling was observed in 10-20% of Rice, Finger, and Cauliflower corals within transects. No recently dead corals were noted in October 2020 surveys.

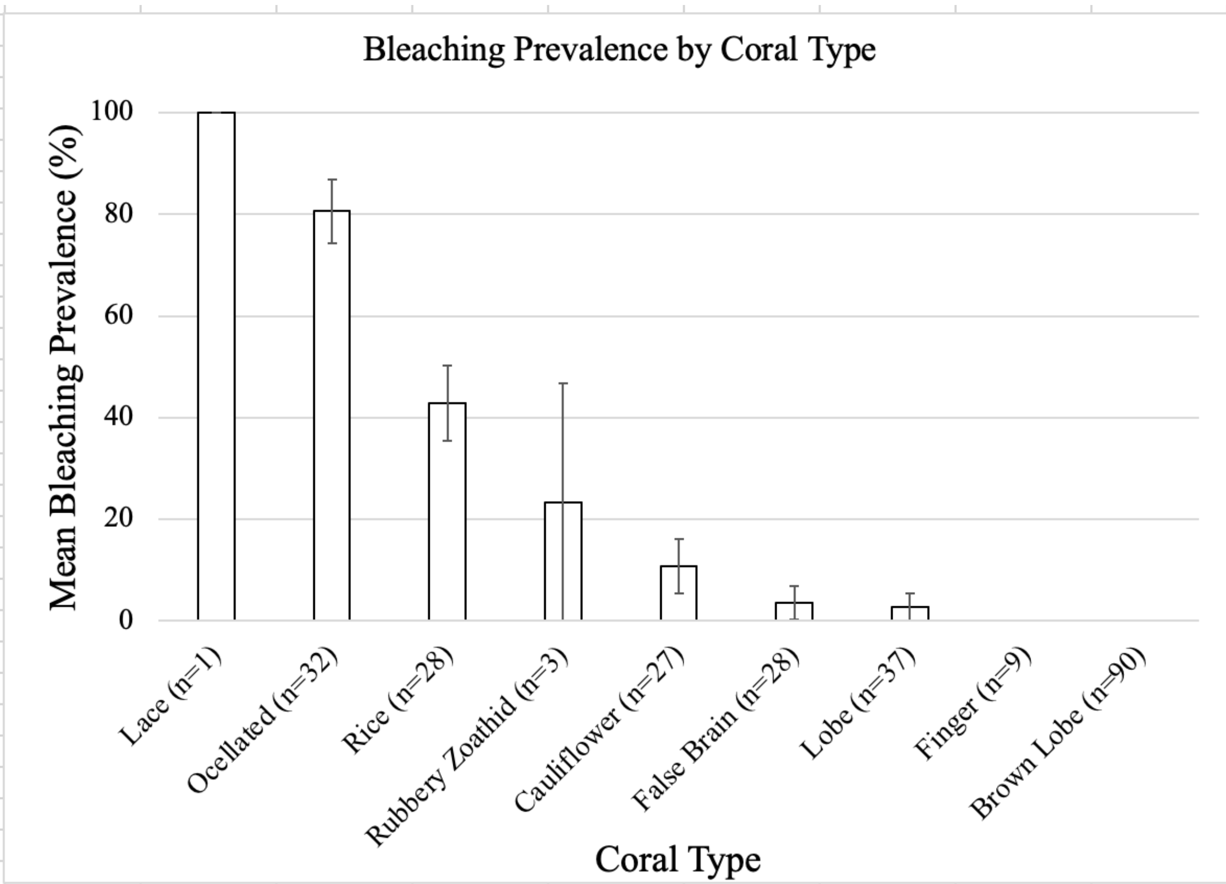


Figure 35. Bleaching presence in October 2020 in each coral type. Lace coral is a representative of one individual. Finger coral and brown lobe coral had no bleaching. Error bars represent ± 1 standard error.

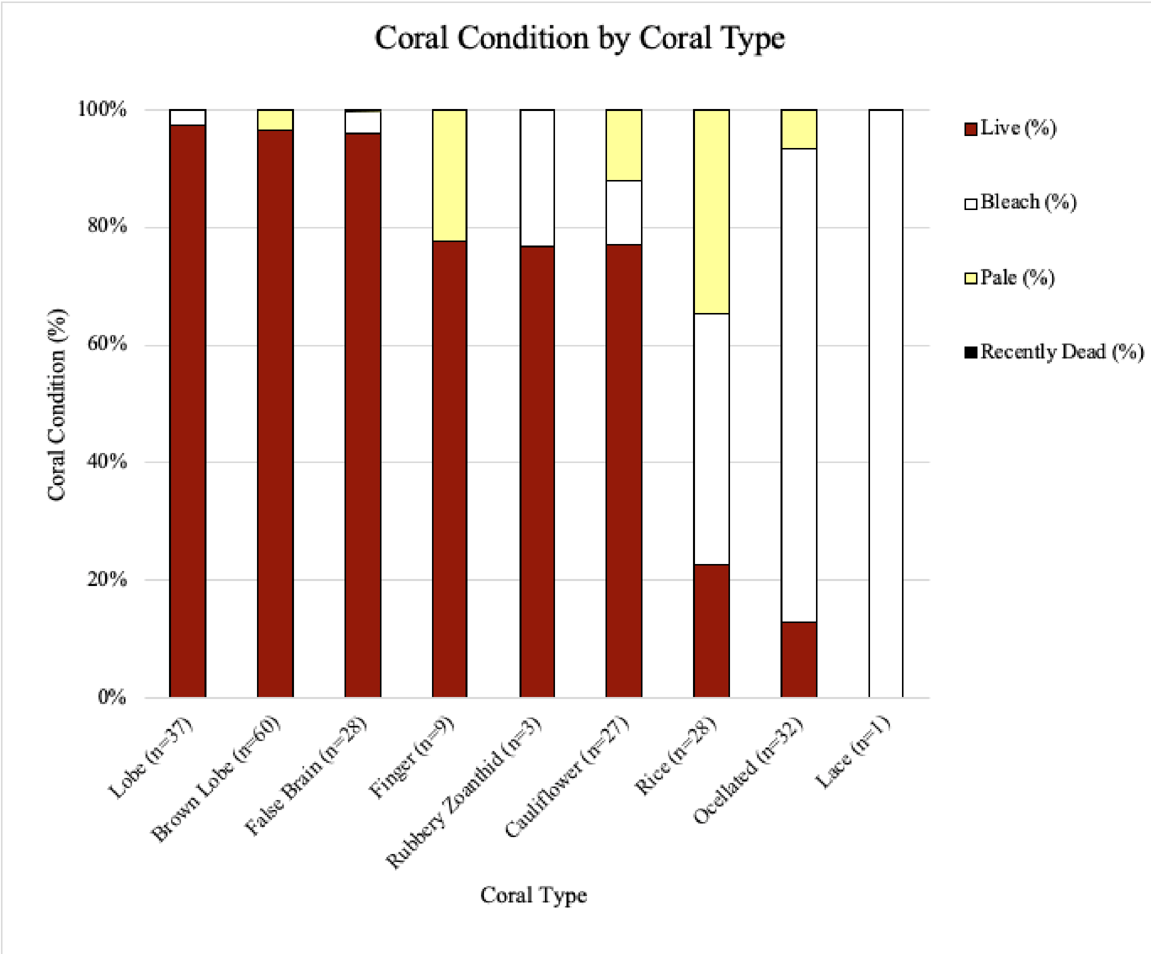


Figure 36. Coral condition during the October 2020 coral bleaching event.

As of March 2021, all but three species of corals recovered from bleaching and paling experienced during the October thermal stress event. Of the bleaching and paling that remained, it occurred in less than 5% of individuals. Paling within rice corals (*Montipora capitata*) remained in 3.7% of the total 27 colonies examined. Rice corals are typically the first species to show visible signs of stress during thermal bleaching events. Similarly, one of the four colonies of ocellated coral (*Cyphastrea ocellina*) recorded was still experiencing bleaching in April 2021 surveys (2.5% of the population along transects). Lastly, 2% of lobe corals (*Porites lobata*) still exhibited signs of paling after the six-month recovery period.

Coral bleaching events have become a frequent occurrence within the Main Hawaiian Islands since 2015. 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. All transects, with the exception of Keyhole West and Channel West, experienced less bleaching and paling of corals when compared to previous years. Despite higher occurrence of bleached individuals within Keyhole and Channel West during 2020 surveys, no mortality of individuals was observed. Corals most susceptible to bleaching in 2020 where the lace coral, ocellated coral, and rice coral. Statewide, different coral species showed a range of susceptibility, yet lace corals and rice corals appeared to pale and bleach more often than finger and lobe corals (Ritson-Williams & Gates, 2020). No information was found on the statewide susceptibility of ocellated corals. All but 5% of individuals recovered completely by April 2021 recovery surveys.

Coral Abundance and Size

Methods

Surveys were conducted October 2015, 2017, 2019, 2020, and 2021 (Table 9). Each colony within permanent transects (Fig. 19) was surveyed for size using the longest diameter (cm) and identified to species (Appendix I). Boundaries of the 5 yd by 15 yd transects were marked using transect tapes and documenting every coral..

The distribution of coral sizes was examined for each sector and compared across years with an Independent-samples Kruskal-Wallis test due to non-normality of size data.

Results and Discussion

From 2015 to March 2021, the community of corals shifted from domination by a few large corals, to a greater abundance of smaller corals (Table 17). The distribution of coral sizes were examined for each sector and compared across years. Size of coral colonies within Backdoors significantly decreased over time ($p<0.001$). Communities within Backdoors significantly decreased in average size of coral colony after the October 2017 ($p<0.03$) and 2019 ($p<0.008$) bleaching events. Since then, no change in average size of coral colony has been detected. Keyhole had significantly lower average coral colony size in April 2020 surveys when compared to 2015 ($p<0.014$) and 2017 ($p<0.03$) surveys. No change in average size was detected since April of 2020 within Keyhole. Coral communities within Channel significantly decreased in average size of coral colony after the October 2015 ($p<0.001$) bleaching event to the April 2016 recovery surveys and continued to decrease through January 2020 recovery surveys ($p<0.02$). Since then, no significant differences have been detected in average size of coral. Average size of coral colony within Witches Brew decreased significantly between all yearly surveys ($p<0.001$) until April 2020 and average size of individual has remained stable since. Overall, all sectors of the Bay have experienced a decrease in average size of coral colonies since 2017 (Fig. 37). Thermal stress causing bleaching events and physical breakage by trampling could have contributed to decreased average size in 2019 surveys. Although no significant increase was found, all sectors have increased in mean colony diameter since October 2020 surveys, with the exception of Witches Brew.

Table 17. Total number of colonies and mean longest diameter (cm) of coral colonies within each inshore transect comparing surveys conducted in October for years 2015, 2017, 2019 and 2020. SE represents ± 1 standard error.

		Backdoors East	Backdoors West	Keyhole East	Keyhole West	Channel East	Channel West	Witches Brew East	Witches Brew West	Total Number of Colonies	Mean
Number of Colonies	Oct-15	23	8	11	13	16	17	22	34	144	18
	Oct-17	13	8	14	6	26	25	40	50	182	23
	Oct-19	22	3	6	4	43	14	38	44	174	22
	Apr-20	23	7	14	9	23	22	59	67	224	28
	Oct-20	18	10	11	9	25	14	47	91	225	28
	Mar-21	19	5	12	8	23	6	32	115	220	28
Mean Size (cm)	Oct-15	30.2	18.1	43.2	28.8	39.7	65.9	46.1	34.6		38.3
	SE	6.2	7.5	17.2	8.7	8.7	15.1	11.4	5.6		
	Oct-17	62.3	23.1	37.1	19	33.2	35.5	30.6	14.9		32.0
	SE	22.3	5.9	11.3	7.5	6.7	7.4	5.4	1.6		
	Oct-19	35.9	22.7	13	33	19.3	42.6	31.4	10		26.0
	SE	5.6	10.7	5.6	9.7	5.8	15.3	5.6	1.13		
	Apr-20	15.7	10.9	4.1	12.6	36.3	24	13.7	10.5		16.0
	SE	3.7	3.8	1.2	2.3	12.3	9.7	3.7	1.8		
	20-Oct	33.8	10.5	17.7	19.1	39.4	16.9	37.0	18.5		24.1
	SE	12.6	4.7	4.4	7.8	13.3	5.8	7.9	1.8		
	Mar-21	33.9	22.6	15.9	19.4	28.1	49.7	18.9	11.0		24.9
	SE	7.3	9.4	4.4	5.8	7.8	24.6	6.2	1.3		

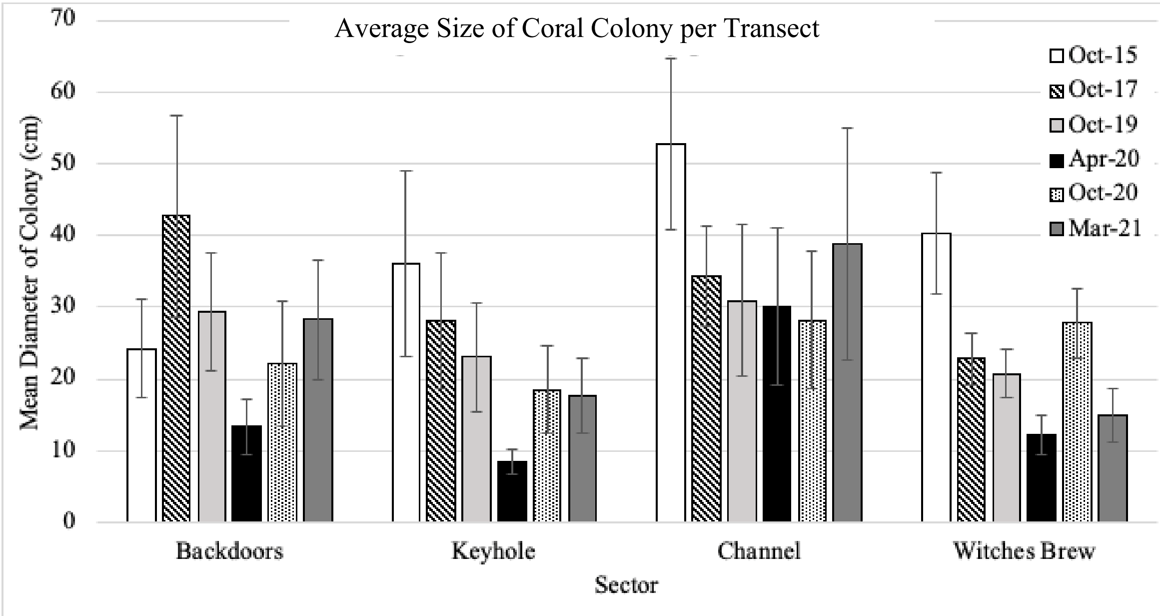


Figure 37. Mean longest diameter (cm) of coral colonies within inner reef flat sectors of the Hanauma Bay Nature Preserve comparing surveys conducted in October of 2015 2017, 2019, April 2020, October 2020, and March 2021.

The number of coral colonies found within each transect of the inner reef flat of Hanauma Bay fluctuated through the years. These fluctuations occur due to death of whole colonies, fragmentation of adult colonies, or new colony recruitment. Backdoors and Keyhole had the lowest number of coral colonies present within transects. Both sectors have flat low rugosity reefscapes, or spatial complexity of the reef, leaving corals to remain on only the edges of the reefs. The reef flats are not conducive to adult coral growth due to their lack of protection from trampling and exposure, or near exposure, at lowest tide. As previously discussed, Backdoors and Keyhole experienced some mortality during the 2015, 2017, and 2019 bleaching events, which are likely responsible for the slight fluctuations in the number of coral colonies over time (Fig. 38). Channel has more rugosity, which, provides protection for larger coral colonies from trampling and possibly more room for recruitment of new corals. Although the 2015 bleaching event did not impact Channel transects, the 2019 bleaching event caused 4.3% mortality, resulting in a large decrease in the number of coral colonies observed the following year. Witches Brew experienced the highest mortality during the 2015 bleaching event yet increased in number of colonies every year until April 2020 (Fig. 38). This is indicative of partial mortality leading to fragmentation of larger colonies into several smaller colonies. Within Witches Brew West, the number of colonies continued to increase into the present day surveys (Fig. 38). The large increase in the number of coral colonies within Witches Brew West after April 2020 was likely the result of a log that had been washed ashore in the area during May 2020. The log was removed after a week of floating in the area and could have damaged neighboring colonies during removal, or during low tide. Overall, the number of coral colonies within Hanauma Bay appears to remain stable in all but Witches Brew, where the number of colonies continue to increase, likely due to partial mortality of larger colonies.

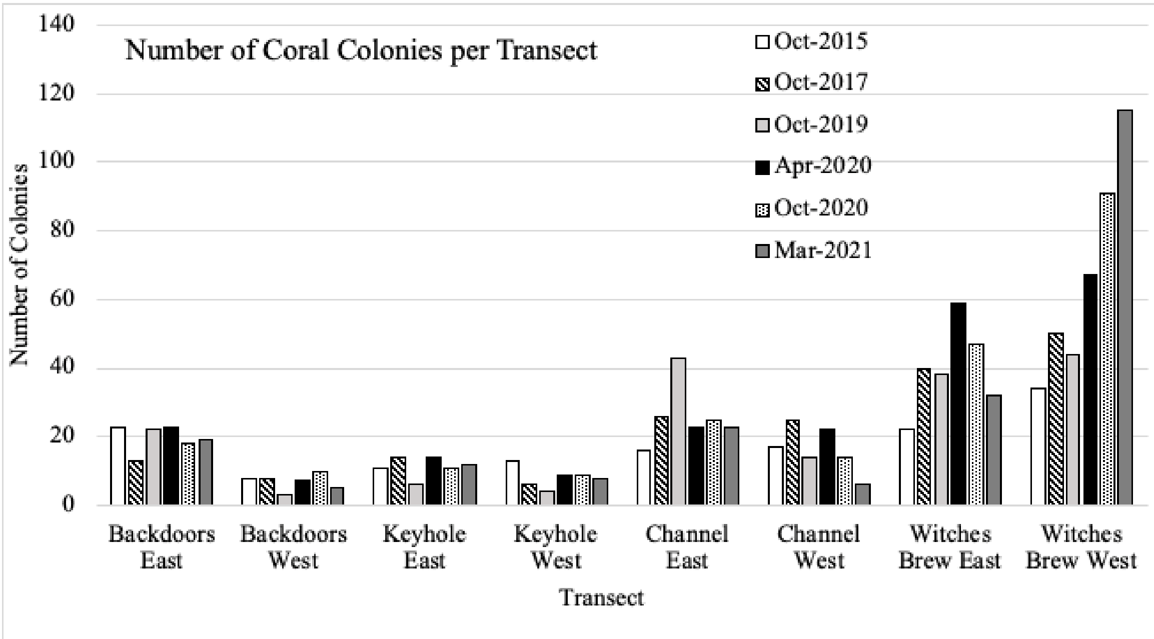


Figure 38. Number of coral colonies within inner reef flat sectors of the Hanauma Bay Nature Preserve compared across time (October of 2015 2017, 2019, April 2020, October 2020, and March 2021).

The relationship between colony size and number of colonies within each transect aids in understanding the trajectory of coral growth, recruitment, and mortality within a coral population. The relationship between mean colony size and the number of colonies was explored further by regressing the two variables. In 2015, as the number of colonies increased, the size of colonies increased, producing a positive relationship. The average number of colonies per transect was the lowest, but the average size of colonies was the largest of any year. Therefore, in 2015, Hanauma Bay coral communities consisted of few corals that were large in diameter. Since 2015 all years experienced a decrease in mean colony size coupled with increased number of individual coral colonies. Previous years' show the existence of large colonies along transects, thus, the smaller sizes reported in 2021 is due to partial or full mortality within the larger colonies. The sector with the largest number of coral colonies, Witches Brew, also exhibited smaller average colony size. As previously mentioned, extensive fragmentation has occurred in Witches Brew due to partial mortality by thermal stress of bleaching events and physical stress of log damage in April 2020. Backdoors and Channel transects have low numbers of coral colonies (Fig. 39), with the remaining colonies of medium to large size (average > ~30 cm diameter, Fig. 39). Although Backdoors does not provide natural refuge in rugosity for corals to grow where they cannot be trampled or stay submerged at lowest tide as in Channel, large corals continue to grow in Backdoors due to the unpopularity of snorkeling in this area and the high water motion. Increased water motion can provide some relief during bleaching events and/or aerial exposure by naturally facilitating evaporative cooling and allowing less heat to sink into a parcel of water. Overall, the larger corals that existed within Hanauma Bay have experienced partial mortality and fragmentation every year since 2015 due to both indirect stress of increasing water temperatures and direct stress of mechanical breakage.

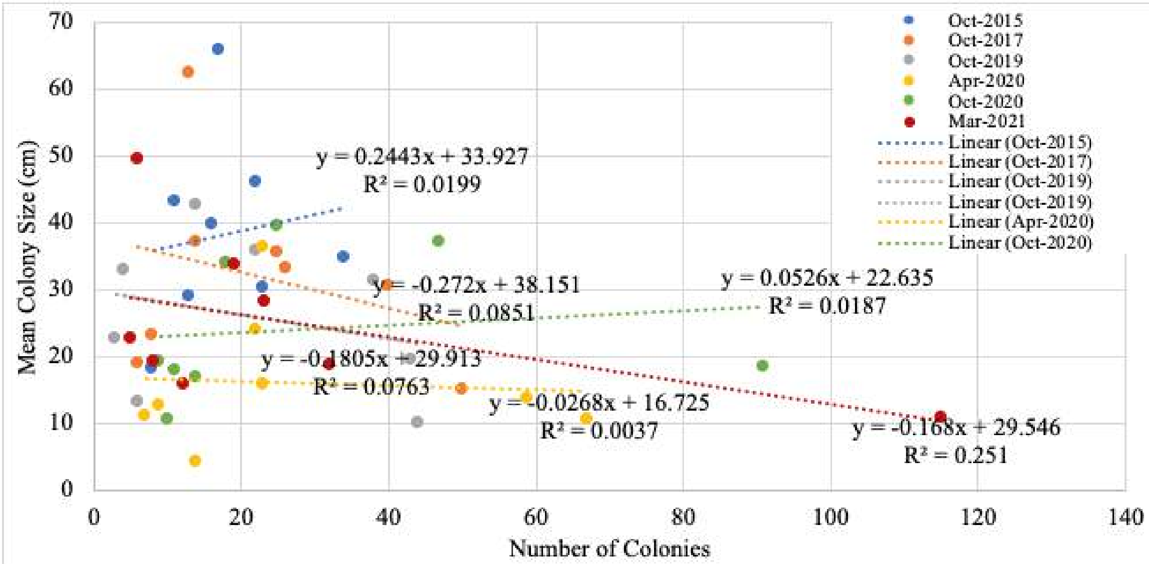


Figure 39. The average colony size regressed against the number of coral colonies found within each permanent transect of the inner reef flat of Hanauma Bay for each survey year.

All sectors significantly decreased in average size of coral colony from 2017 to April 2020 surveys. Since April 2020, there has been no significant differences in average size of coral colony within the inner reef flat of Hanauma Bay. The number of coral colonies found within each transect fluctuated slightly within all transects reflecting rates of mortality produced by bleaching events. Witches Brew was the only sector with large increases in the number of colonies in recent years. Because the largest corals recorded in 2015 were not present in later surveys and overall average coral colony size decreased significantly, the increase in number of colonies was attributed to partial mortality and fragmentation of larger colonies over time. 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 experienced severe bleaching and paling in 2015 and 2019, and physical stress and breakage by a floating log in May 2020 which could be responsible. Since 2015, corals within the inner reef flat of Hanauma Bay have decreased in average size of colony while increasing in average number of colonies present within transects. The larger coral colonies have experienced partial mortality and fragmentation due to global stressors, such as increased coral bleaching events, and local stressors, such as trampling, fin kicks, sediment smothering and physical damage by marine debris.

Detailed Description and Outcomes of Research Activities:
Quarter 4- Task 4: Temperature

Temperature Patterns

Methods

Temperature is monitored using Onset© data loggers with an accuracy of ± 0.53° C and range of -20° C to 70° C. Loggers are calibrated prior to placement by immersion in water baths outside natural ranges (0° C to 40° C). A certified thermometer and a digital temperature controller integrated in the water bath are used to replicate temperature readings during calibration. The loggers were secured in 6" x 12" hand-poured concrete "rocks" that mimic the benthic substrate and protect the loggers from solar irradiance and associated heating (Bahr et al., 2016) while providing concealment from human disturbance. Temperature gauges are programmed to record temperature at hourly intervals and downloaded quarterly in the field using HOBOware Pro.

In June 2019, temperature loggers were installed in all major sectors (Fig. 40) of the inner reef flat to related to the monitoring during the bleaching event. Data loggers were replaced and downloaded in October 2019. The Keyhole temperature logger malfunctioned and therefore is not included in this report.

Figure 40. Location of temperature loggers within the inner reef flat of the Hanauma Bay Nature Preserve (top photo). Example of concrete “rock” with temperature logger (bottom photo).

Results and Discussion

Coral bleaching and paling, or the loss of pigmentation, can be a sign of stress from temperature, sediments, freshwater, nutrients, or other factors (Rodgers et al. 2017). Jokiel and Coles (1990) determined the bleaching threshold for Hawaiian corals at 29-30 ºC, a 1-2 ºC increase above upper summer maximums (Jokiel 2004). However, coral bleaching is not a direct response to temperature. Circulation patterns and irradiance intensity and duration can exacerbate levels of bleaching. Other influential environmental factors include cloud cover, wind, and water clarity.

The National Oceanic and Atmospheric Administration (NOAA) Coral Reef Watch projected a Bleaching Watch through most of October and November of 2020 within the main Hawaiian Islands (Fig. 41). Sea surface temperatures remained between 1-2 ºC above normal monthly averages for most of June, July and August of 2020 (Pacific Climate Update, 8/28/20).

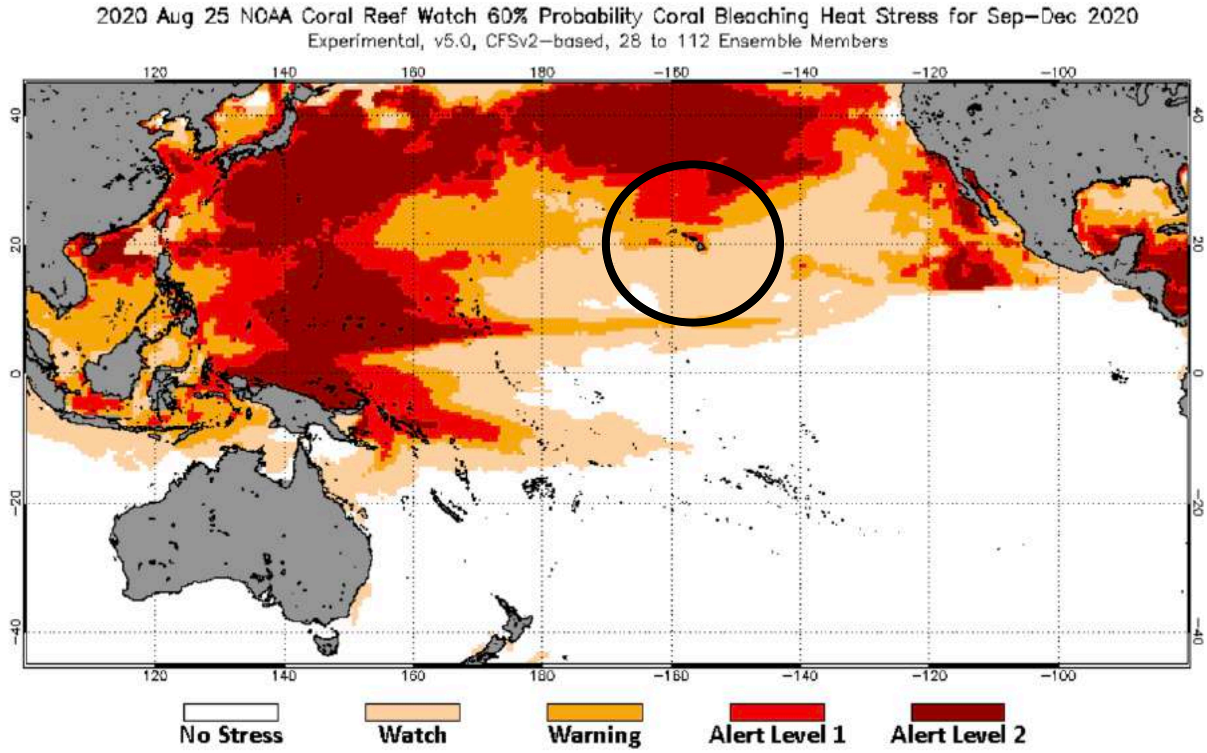


Figure 41 NOAA Coral Reef Watch's Four-Month Coral Bleaching Outlook of August 25, 2020 for the period September-December 2020 for the Pacific Region (Hawaiian Islands outlined with black circle).

Throughout the NOAA declared coral bleaching watch, temperature was recorded within the inner reef flat of Hanauma Bay. Water temperatures began to increase from a monthly mean of 25.9 ºC (± 0.06 ºC, 1 SE) in the beginning May 2020, and eventually rose to a monthly mean temperature of 27.7 ºC (± 0.04 ºC, 1 SE) by October (Fig. 42). Witches Brew experienced the highest mean temperatures and the longest time with waters greater than 29 ºC when compared to all other sectors (Fig. 42). Typically, the time above 29 ºC was limited to a few hours during peak irradiance (12 pm – 4 pm). Witches Brew experienced these thermal spikes on 16 non-consecutive days between June 27^{th}, 2020 and October 16^{th}, 2020. Backdoors and Keyhole experienced two thermal spikes of temperature above 29 ºC on October 2^{nd} and 3^{rd}, 2020. While Channel experienced two thermal spikes of temperature above 29 ºC on October 2^{nd} and 15^{th} of 2020. Overall average temperatures during the thermal stress event were coolest in Backdoors, Keyhole and Channel (all average 27.0 ºC) with slightly higher average temperatures in Witches Brew (27.2 ºC). By December all sectors returned to normal average daily temperatures (25.9 ºC ± 0.02 ºC, 1 SE, Fig. 43).

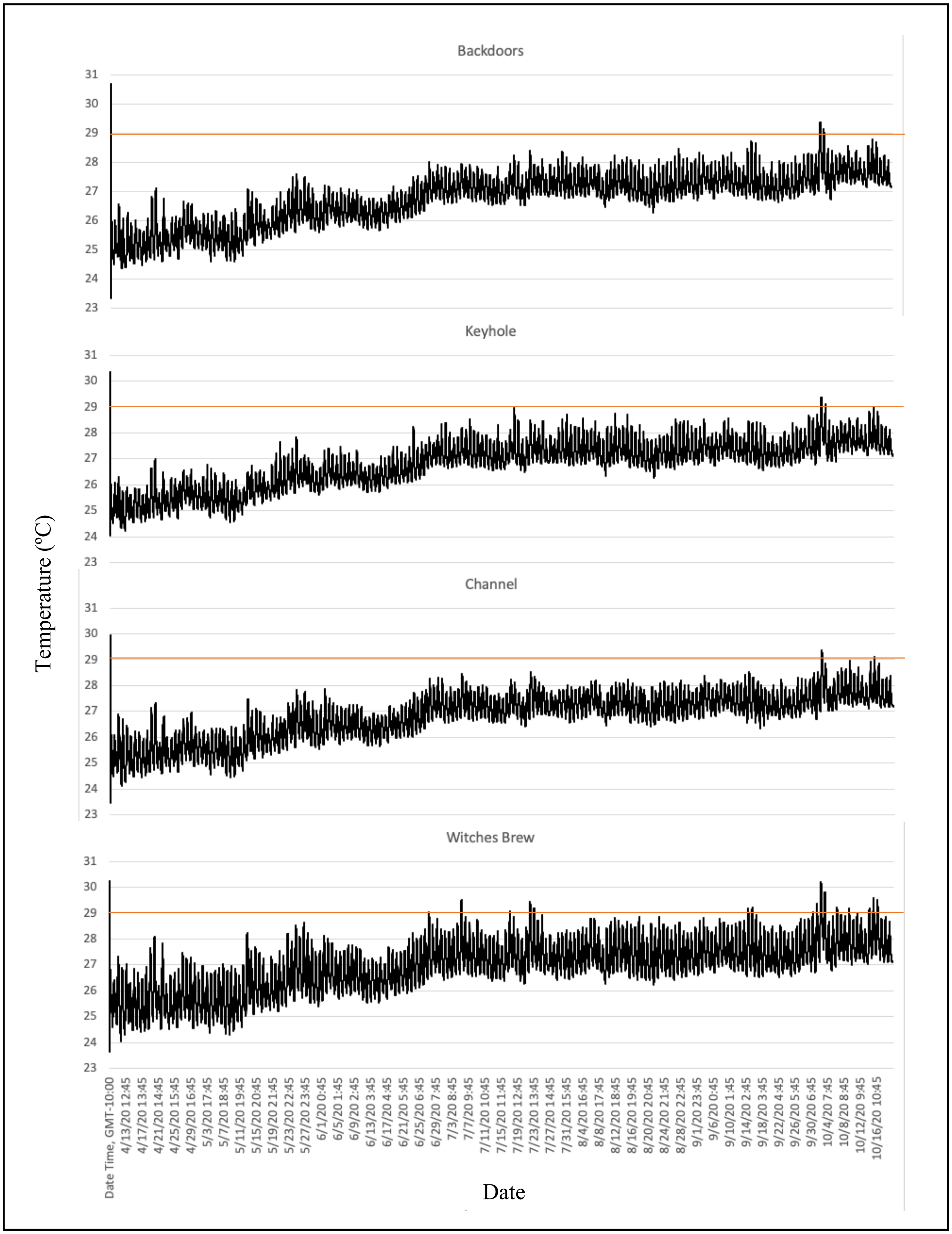


Figure 42. Temperature within each sector of the inner reef flat from April 13th, 2020 to October 16th, 2020. Red line at 29ºC depicts bleaching threshold.

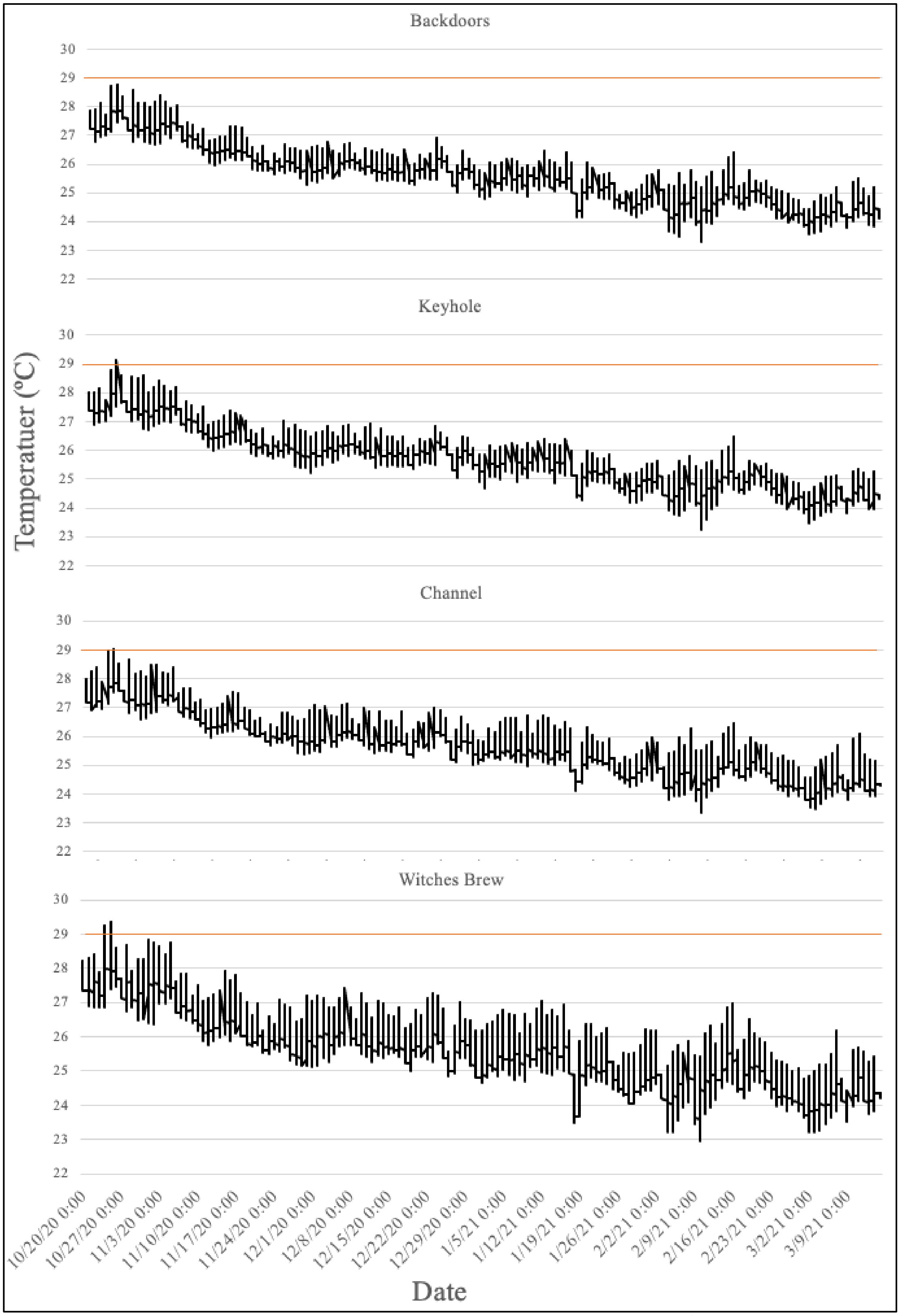


Figure 43. Temperature within each sector of the inner reef flat from October 20th 2020 to March 9th 2021. Red line at 29ºC depicts bleaching threshold.

Within Hanauma Bay, the overall circulation pattern brings water shoreward and westerly from Backdoors towards the southwest into Witches Brew (Rodgers et al., 2017) (Fig. 44). During all tide phases (incoming, outgoing, and mixed) and during both tradewind and south wind conditions this same pattern endures. As seawater enters the Bay it slows in velocity from 1 yd/sec down to 0.01 yd/sec at the shoreline (Fig. 44). Water parcels slow, allowing more heat to accumulate in the shallow shoreline and within a permanent eddy located in Witches Brew. The eddy trapping water parcels coupled with very little influx of open ocean water to Witches Brew are responsible for the slightly higher mean temperatures and increased frequency of temperature spikes observed during the thermal stress event (Fig. 42).

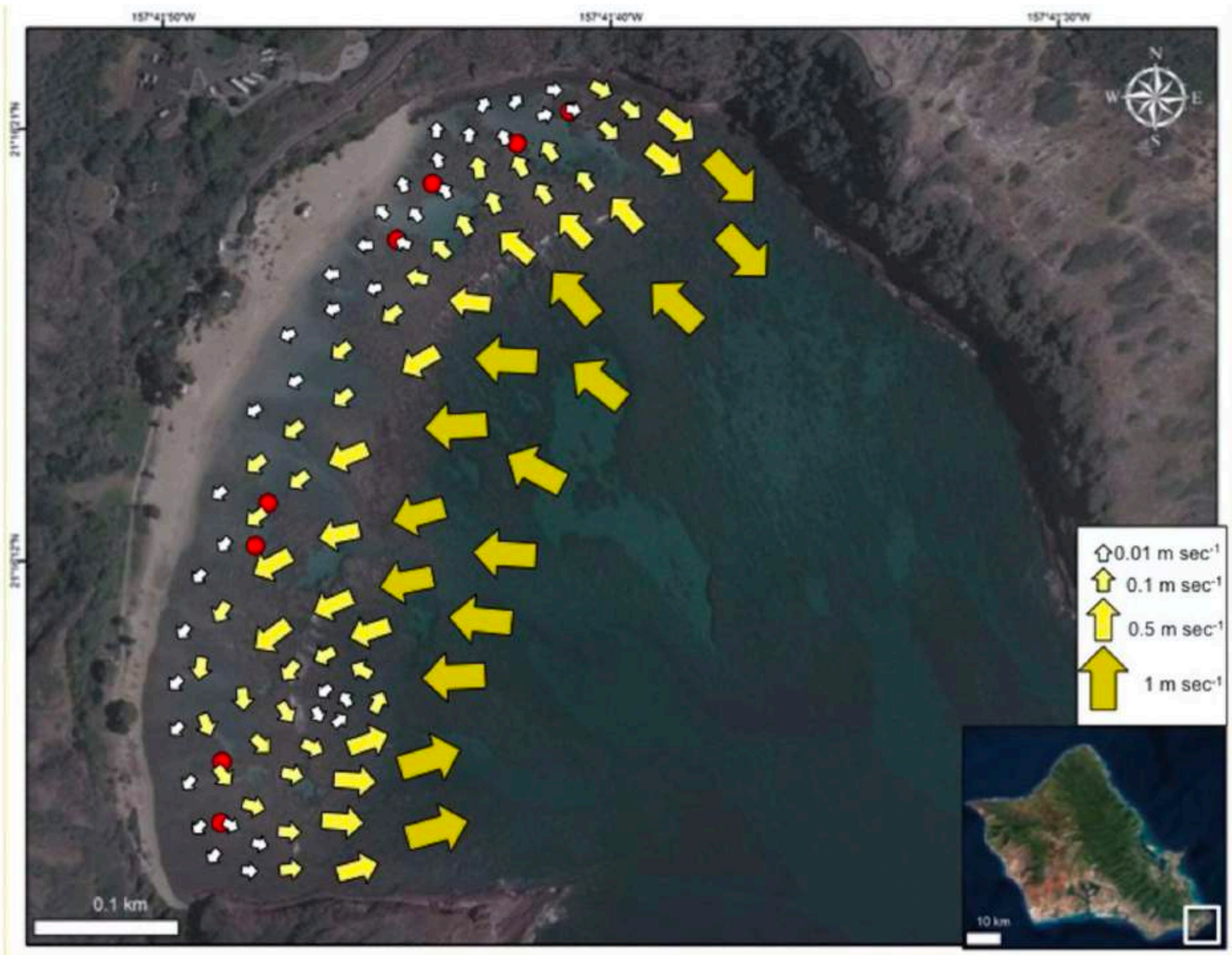


Figure 44. Circulation direction and velocity patterns within Hanauma Bay. Adapted from Rodgers et al. (2017).

Detailed Description and Outcomes of Research Activities:
Quarter 2- Task 5: Coral Reef Assessment and Monitoring (CRAMP) Survey
Monitoring of the Coral Reef Assessment and Monitoring Program (CRAMP) sites
Suspension of diving by the University of Hawai‘i’s dive safety program due to the COVID-19 virus prohibited CRAMP surveys. Subsequent monitoring will be conducted by the Division of Aquatic Resources.

DISCUSSION & FINDINGS

The inner reef flat of the HBNP is the most heavily snorkeled coral reef in Hawai‘i. Prior to the COVID-19 pandemic, the Bay received between 2,500 to 3,500 visitors per day with approximately 97% snorkeling within the inner reef flat . For the past three years, a series of quantitative surveys have been conducted to identify the present level of disturbance to the inner reef flat environment and its sustainability. Observational surveys include the analysis of fish and coral communities in the presence and absence of visitors and the impact of the 2019 and 2020 coral bleaching events. The COVID-19 closure created the rare opportunity for the study of fish density, biomass and behavior, coral recruitment and adult growth, sediment accumulation and water clarity, and the presence of megafauna in the absence of visitors within the HBNP. Many of these studies continued after the reopening of HBNP to the public and are instrumental in understanding the impact of visitors on the marine resources.

The fish communities shifted in density and biomass throughout the Bay during the COVID-19 closure and after the reopening of the Bay to the public. Density and biomass of fishes were significantly higher within Keyhole during and after the COVID-19 closure at 25% capacity when compared to before the closure on a closed Tuesday. With the reduction in visitor use on the inner reef flat, fishes expanded or shifted their ranges from offshore and between inshore sectors. The majority of significant changes in density and biomass of fish families were observed in Keyhole. Most notably, surgeonfishes expanded their grazing range from Channel into Keyhole during the closure and continued to migrate into Keyhole from Channel and Backdoors after the reopening of the Bay at 25% capacity of visitors. Despite surgeonfishes migrating from Channel into Keyhole during the closure, Channel did not experience any significant shifts in overall density or biomass. Butterflyfishes and wrasses increased in density across all sectors during the closure, suggesting they either migrated in from offshore, or more likely, felt less threated, and therefore, were less likely to seek shelter during surveys. After the reopening of the Bay, density of butterflyfishes and wrasses decreased to less than pre-pandemic values, suggesting a human-avoidance strategy. Damselfishes also experienced increased density in the two most popular snorkeling sectors, Keyhole (significant) and Channel (non-significant), during the closure. After the reopening of the Bay, damselfish density decreased within Keyhole, likely as the result of human avoidance, or, fish avoidance due to increased density of grazing surgeonfishes (non-significant). Surgeonfishes use grazing in large schools to intimidate damselfishes into giving up their territory for grazing. Following the closure, Backdoors also increased significantly in biomass, as the result of increasing density of chubs likely migrating in from offshore. Keyhole also experienced large increases in chubs following the closure, yet they were not significant. After the reopening of the Bay, the density of Chubs decreased in all sectors except Witches Brew where density remained similar. In addition to family compositional changes, the size of fishes was analyzed and the average size of fish increased significantly during the pandemic in all sectors except Witches Brew. When the relationship between fish size and the number of snorkelers nearby during the survey was examined, the minimum size of individual fishes increased as the number of snorkelers increased. This suggests that smaller fishes were fleeing more readily when there were higher numbers of snorkelers in the water. No significant correlation between minimum size of fishes and the number of monk seals present were detected.

Diversity of fishes was significantly less after the reopening of the Bay to the public in both Keyhole and Channel sectors, likely as the result of domination from surgeonfishes. During the

COVID-19 closure and after the reopening of the Bay, many changes were observed in the density, biomass, distribution, size-class, and diversity of fish families throughout the inner reef flat.

In summary, surgeonfishes, butterflyfishes, chubs, and damselfishes deliberately migrated into Keyhole, or, became more comfortable and less likely to seek shelter in the absence of visitors. Likewise, all sectors increased in biomass during the closure, significant in Backdoors and Keyhole, and fish biomass remained high after the reopening at 25% capacity. While surgeonfishes increased in density and biomass throughout the closure, fishes such as butterflyfishes, snappers, and wrasses showed decreased density and biomass following the reopening of the Bay, and furthermore, significantly decreased as the number of visitors to the Bay increased. Increased density and biomass of certain fish species during the closure, followed by decreased density and biomass after the reopening suggests human avoidance behavior, even at 25% capacity, for these more sensitive species. The majority of significant changes in fish population parameters were observed within the most heavily snorkeled area of the Bay, Keyhole. Overall, trends of increased density of fishes during the closure with subsequent decreases in density following the reopening of the Bay to the public at 25% capacity, suggests fish distribution changes in response to visitors.

Sediment accumulation rates were similar in all transects, with the exception of Witches Brew West. The increased sediment accumulation rates within Witches Brew West occurred after a large heavy log floated into the area and caused 10 yd^2 of damage to the reef, substantially increasing the presence of loose coral rubble. Keyhole sector also saw a decrease (non-significant) in sediment accumulation in both transects during the COVID-19 closure. Since most transects experienced a similar level of sedimentation while closed to the public when compared to open to the public, environmental factors are responsible for the majority of sediment accumulation.

Repeat surveys on water clarity (suspended sediments) show a significant increase in water clarity on COVID-19 closure days when compared to days open to the public (56%) and closed Tuesdays (9%) in 2018. Water clarity during the COVID-19 closure was not statistically 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 were 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. Unlike sediment accumulation, water clarity within the HBNP appears more heavily driven by anthropogenic influence than environmental influence.

Presence of Hawaiian monk seals and green turtles continued to be documented through the COVID-19 closure and reopening of the Bay. Utilizing previous monk seal presence data from 2018, a 44% increase in the presence of monk seals at the HBNP during the closure (non-significant) was documented. Following the reopening of the Bay at 25% visitor capacity, monk seal presences significantly decreased by 87%. The number of visitors to the HBNP following the reopening were not related to the monk seal presence according to statistical correlations. Monk seal habitat usage was not influenced by the number of visitors on the beach. 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. This suggests that monk seal and green turtle habitat usage within Hanauma Bay was not altered at 25% capacity of visitors. However, resting location shifted during the closure from the rocky ledge to the sandy beach.

The coral community within the HBNP experienced an 8.23% loss of coral cover following the bleaching event in October 2019. The majority of mortality occurred in Channel and Backdoors. Mortality did not appear associated with human use during the bleaching event as no corals suffered mortality within Keyhole sector, where 50% of swimmers and waders visit. Bleaching and paling prevalence within the Bay was significantly lower during the 2020 bleaching event when compared to the 2015 bleaching event. Unlike the 2015 and 2019 bleaching events, no mortality was noted in October 2020 surveys. Bleaching and/or paling was noted along all transects except Witches Brew West, despite Witches Brew experiencing the highest average temperatures of all sectors. Bleaching prevalence was highest in Channel West (63.2%) Backdoors West (60.0%), and Keyhole West (55.6%). The number of coral colonies within Keyhole is the lowest of all sectors with the highest reduction (50.0%) in mean colony size from 2015 to present. Witches Brew (30.2%), Channel (25.3%) and Backdoors (8.30%) all saw reductions in mean coral colony size from 2015 to present. With reductions in large colonies, the number of colonies within each transect has increase over the years, which may be the result of fragmentation from physical damage and trampling.

In response to the closure of the HBNP to visitors, the Bay experienced increased density and biomass of fishes and water clarity. Following the reopening of the Bay at 25% visitor capacity, many species of fishes, most notably butterflyfishes, wrasses and snappers decreased in density and water clarity decreased by 28.2%. Of the top overall fish species contributing to density, seven of the thirteen experienced an increased density during the closure to the public, followed by decreased density after the Bay was reopened. The majority of these changes in the density and biomass of fishes occurred within the most heavily snorkeled sector. Although some fishes did not appear to practice human avoidance behavior, mostly surgeonfishes, several families experienced decreases in response to 25% visitor capacity. It is unknown if the fish community would return to their pre-pandemic state if visitor capacity returned to normal. The increased water clarity at 25% visitor capacity could have several positive indirect influences on the Bay's coral populations if it were to continue long-term. Coral is a very slow growing animal, and therefore, no significant positive changes were detected over the year-long closure. However, if water clarity increased long-term, corals may experience accelerated growth rates due to increased rates of photosynthesis and/or less competition for energy use removing sediments from their tissues. Additionally, smaller particles of sand may be dropped onto tissues causing sand scour (breakage of the coral tissues) leaving them more susceptible to partial mortality or disease. For these reasons, if the Bay returns to full capacity, it is suggested that biological surveys continue to monitor the response of fish and coral populations.

Evidence from Years 1 through Year 3 of the HBNP Biological Carrying Capacity study that human use is a contributing factor to declines in coral cover and/or fish presence:

Fish:

- Significant increases in fish density and biomass have been observed in Keyhole sector, the most popular snorkeling sector, during the closure of HBNP to the public. (Yr 3).
- Smaller size classes of fishes were not present along fish surveys after the reintroduction of visitors to the HBNP, suggesting human avoidance behavior of smaller fishes in response to humans (Yr 3).
- As the number of visitors to the HBNP increased, the density and biomass of butterflyfishes and wrasses significantly decreased. Additionally, as the number of visitors increased, the biomass of snappers decreased significantly (Yr 3).
- Diversity of fishes was significantly lower in Keyhole and Channel, the two most popular snorkeling sectors, after the reopening of HBNP to the public at 25% capacity (Yr 3).

Water Clarity:

- Water clarity increased an average of 30% on days the HBNP is closed to the public. Human use explains part of the decreased visibility (Yr 1).
- Water clarity increased an average of 9% on COVID-19 closure days when compared to days closed to the public (~720 visitors per day) and 56% on COVID-19 closure days when compared to days open to the public (~3,000 visitors per day) (Yr 1, 2, & 3).

Megafauna:

- Presence of monk seals increased by 44% during the COVID-19 closure to visitors and decreased by 87% following the reopening of the Bay to visitors, suggesting visitors may be changing natural behaviors and habitat usage for monk seals at HBNP, but data collection should continue (Yr 3).

Corals:

- The breakage rate of corals is strongly related to the number of swimmers and waders in each sector (Yr 1).
- The greater the number of visitors in the water the lower the percent coral cover (Yr 1).
- The greater the number of visitors in the water the greater the reduction in mean coral colony size (Yrs 1, 2 & 3).
- The spatial distribution and abundance of corals on the shallow reef flat reflect the historic chronic impact from human use (Yr 1).
    - Corals grow in cracks and crevices and on vertical surfaces inaccessible to trampling impacts.
    - Low coral cover in high use regions.
    - High coral cover in areas beyond depths that can be accessed by snorkelers and waders.
    - Coral morphologies (lobate, encrusting) conducive to high impact areas.
    - Species of corals in exposed areas that exhibit stronger skeletal strengths.

Other factors in addition to human use that can contribute to low coral cover, sedimentation, and reduced water clarity.

- Wind direction and speed and tides are strongly correlated with water visibility and sediment accumulation (Yrs 1 & 3).
- Wave height is correlated with changes in water clarity (Yr 3).
- The 2014/15 statewide bleaching event reduced coral cover by 10% on the HBNP reef flat. Although the long-term monitoring stations show a severe drop following this bleaching event, the last two years have been stable.
- The reef flats in the sectors with low coral cover also have low spatial complexity, reducing available substrate for coral growth and recruitment (Yr 1).
- Corallivorous fishes and Parrotfishes appear to be contributing to breakage, evidenced by feeding scars on corals within HBNP during the COVID-19 closure.
- A large log floated into Witches Brew during the COVID-19 closure and resulted in a 10 yd^2 area of broken corals and unconsolidated substrate. This could contribute to mortality or partial mortality of coral colonies within this sector, as well as, increased rates of sediment accumulation.

Increasing duration, severity, and frequency of coral bleaching events pose the most imminent threat to the biological sustainability of the HBNP. With this comes a significant economic threat to the state of Hawaiʻi. The 2014/15 bleaching event showed lower coral mortality (9.8%) in the HBNP as compared to West Hawaiʻi (30-86%) or Kāneʻohe Bay (20%). This may be due to a number of factors including location, circulation patterns, or prior warming exposure. It is important to minimize any other anthropogenic impacts that may create additive synergistic effects. Maintaining optimum coral health can provide an added level of protection when environmental impacts occur. Sound management strategies based on scientific research will increasingly play a more important role. Data from this research can assist managers in making predictions to support planning efforts and implement effective conservation actions.

Management & Educational Recommendations

There has been great effort and expense applied to promoting the tourist industry, but sparse resources have been allotted to investigating the impact of the industry on the resources. Direct and indirect impacts result from increased tourist use of marine resources. Changes in diversity and abundance of fish populations can result from artificial feeding. Habitat destruction from trampling can affect fish nurseries, habitat for flora and fauna, recruitment sites and coral populations. Problems involving enforcement, insufficient data, regulatory unresponsiveness, loopholes in regulations, political will, multiple jurisdictions and new fishing technology complicate matters.

The Hanauma Bay Nature Preserve has been highly successful in many aspects of education and management. Incorporating this carrying capacity study attests to the commitment to continue to advance management, conservation, and educational strategies. Management approaches used in Hawaiʻi and recommendations specific to the Hanauma Bay Nature Preserve are outlined below. Jurisdiction to implement these recommendations are within the purview of different management agencies including the Department of Land and Natural Resources, Division of Aquatic Resources and the City and County of Honolulu's Parks and Recreation.

Various management strategies have been used throughout Hawaiʻi to address a plethora of problems related to anthropogenic impacts. These include spatial and temporal solutions as well as socio-economic factors.

- limiting access
- controlling the type of activities that can occur in protected areas
- designating specific days and times for use
- dispersing use among larger areas
- providing additional sites
- educating users
- exploring other options
- involving community groups
- rotating opening/closing periods
- self-monitoring of commercial users
- using visitor industry influence
- community reef tenure
- closed seasons
- no-take zones
- user fees at popular tourist marine reserves
- marine recreational fishing license for fees and reporting purposes
- increase size of marine protected areas (MPA's)
- additional MPA's
- increased research

Many of these solutions have been implemented at the HBNP with anecdotal success. Successive components of the carrying capacity study will include examination of the temporal and spatial aspects of these changes and their correlation to biological, environmental, and anthropogenic factors. For example, we determined whether fish populations changed following the cessation of fish feeding and whether biological shifts occurred in relation to visitor use (Year 2 BCC, Friedlander et al., 2018). It is extremely difficult to manage the resource since it is challenging to quantify. This is why it is imperative to manage the people instead.

Current recommendations to address coral sustainability and data gaps at the HBNP include:

Management recommendations:

- As visitor levels increase, conduct monitoring of fish and coral populations, and water clarity, to understand any significant responses to increased visitor levels.
- Place educational signage at 'safe entry' points from the beach. For example, a sign in front of the Keyhole sandy area indicating the safe entry into the water and reminding visitors to "Only stand where there is sand."
- Disperse users among other activities. These may include non-fee or fee based controlled nature hikes, children's programs, ocean films etc. All activities will provide education about the Hawaiian ecosystem or history.

Educational recommendations: Management has determined that few visitors utilize the current educational displays prior to their scheduled video time. They are currently working to include more interactive and engaging educational presentations.

- Place several large screen monitors around the periphery of the Sea Grant education video viewing room. Each monitor will display the educational video with subtitles in various common languages. Provide signs above each monitor in dominant languages for visitors to orient themselves for viewing in their language. Providing an easy way for people to view the video in subtitles of their preferred language may be more effective than having to seek out a headset in a language other than English.
- Place educational information signs along the sidewalk leading up to the ticket windows so visitors have another chance to become familiar with the reef environment while they wait in line for entry. Signs should include information on the living reef environment and step-by-step instructions for how to enter the Bay and proceed with snorkeling. Provide signs in both English and Japanese and other languages common to visitors. Cover sidewalk to provide shade and protection from the elements for visitors and to accommodate signage. Covered sidewalks and informational signage prior to entering the park will provide visitors with another opportunity to understand resource protection and personal safety.
- Create an informational webpage and resources for visitors to reference prior to arriving at the Bay. (Ex. https://dlnr.hawaii.gov/ecosystems/nars/maui/ahihi-kinau-2/)
- Educational materials and displays should include information on climate change (CC) impacts on coral reefs with clear direction and fun activities on actions to reduce carbon. The National Parks Service has a CC response strategy, action plan, and regional policies and strategies that include science, adaptation, mitigation, and communication.
- Place informational signs with interactive displays within the education center describing ongoing research within the bay: CRAMP, recruitment modules, biological carrying capacity study, DAR surveys. Knowledge of ongoing research will educate visitors, enrich their experience, and increase the likelihood of coral reef protection.

No recommendation is included at this time to decrease the number of visitors to the HBNP.A balance must be found between visitor levels and economic sustainability for the HBNP. However, this recommendation may not provide the Bay's natural resources with increased resiliency to much larger global stressors. This recommendation is based on a prior study at Kahaluʻu Bay on the island of Hawaiʻi showing the impact to growth and survivorship of corals along a gradient of human use (Rodgers 2001). The previous study concluded coral mortality was low at a level of 50,000 visitors annually and at 200,000 visitors/yr corals did not survive. Although corals cannot survive in some areas of the reef flats, there are healthy populations present in areas inaccessible to trampling even in high use areas. Larger coral populations exist in low use areas such as Witches Brew, on vertical surfaces in the Channel, and in deeper waters just offshore. In 2018, levels of use varied considerable between sectors. An inverse relationship was found between visitor use and coral cover. Due to accessibility, sandy areas and lifeguard proximity, the majority of visitors use the Keyhole and Channel sectors. This inherent separation provides some protection to the Backdoors and Witches Brew sectors thus, the best strategies to protect corals while allowing for a realistic level of visitation are outlined above.

ACKNOWLEDGEMENTS

We are extremely grateful to the City and County of Honolulu for supporting this research. We acknowledge Lynette Liu and Louis Chung in providing site access and accommodations. These surveys would not have been possible without the help of Coral Reef Ecology Lab members and volunteers: George Balazs, Kosta Stamoulis (Ph.D.), Aviv Suan, Elizabeth Madin (Ph.D.), Anita Tsang, Ji-Hoon Justin Han, Andrew Graham, Yuko Stender, Denise Oishi, Anke Roberts, Shannon Murphy, and Mathew Stefanak.

ANNUAL GOALS AND OBJECTIVES:

- Continue to review recent data and collate historical data
- Quantify changes in fishes, coral, sediment and megafauna during the COVID 19 closure and compare following reopening
- Resurvey inner reef transects established during the 2015/2016 bleaching event
- Provide wide scale assessment of coral physical condition, coral species and distribution
- Provide recommendations for carrying capacity to managers to develop management strategies and educational approaches
- Conduct community outreach lectures of results
- Develop final report

Hanauma Bay Research Timeline

Year 1:

- Social/Ecological Capacity:
    - Compiled and annotated recent and historical literature.
- Ecological Capacity:
    - Compiled historical data sets.
    - Conducted Assessments:
        - Quantified human use and identified high use areas of the inner reef flat as well as documenting human activities.
        - Quantified levels of human trampling on coral skeletons placed throughout the inner reef flat, sedimentation and water clarity, and determined the relationship to human use in each area.
    - Conducted Annual Monitoring:
        - Monitored corals within 8 transects established during the 2015/2016 coral bleaching event.
        - Resurveyed 3 yd and 10 yd CRAMP long-term monitoring sites.
        - Analyzed seawater temperature data.

Year 2:

- Ecological Capacity:
    - Conducted Assessments:
        - Fish abundance, biomass and species count surveys on inner reef flat.
        - Gathered historical fish data and visitor use data within Hanauma Bay and determined if there are any patterns over time.
    - Conducted Annual Monitoring:
        - Monitored corals within 8 transects established during the 2015/2016 coral bleaching event.
        - Analyzed seawater temperature data.

Year 3:

- Ecological Capacity:
    - Conduct Assessments:
        - Determine changes within HBNP between the COVID-19 closure and reopening to visitors in relation to:
            - Fish density, biomass and diversity
            - Fish behavior and foraging rates
            - Fish Flight Initiation distance
            - Adult coral growth rates
            - Coral recruitment and survival rates
            - Rates of sediment accumulation
            - Water clarity
            - Green turtle density
            - Hawaiian Monk Seal density
    - Conduct Annual Monitoring:

        - Annual monitoring of 8 inner reef transects established during the 2015/2016 coral bleaching event.
        - Annual survey of 3 yd and 10 yd CRAMP long-term monitoring sites.
        - Annual analysis of seawater temperature data.

Year 4:

- Social Capacity:
    - Social surveys conducted during peak season to determine the social carrying capacity.
    - Determine an effective educational plan for rapidly and effectively reaching multicultural visitors.
- Ecological Capacity Monitoring:
    - Annual monitoring of 8 inner reef transects established during the 2015/2016 coral bleaching event.
    - Annual survey of 3 yd and 10 yd CRAMP long-term monitoring sites.
    - Annual analysis of seawater temperature data.

Year 5:

- Facilities Capacity:
    - Anonymous survey of facilities crew to determine adequacy of facilities to accommodate current usage.
- Physical Capacity:
    - Calculate the number of people that can physically occupy Hanauma Bay while complying with health or safety codes.
- Ecological Capacity Monitoring:
    - Annual monitoring of 8 inner reef transects established during the 2015/2016 coral bleaching event.
    - Annual survey of 3 yd and 10 yd CRAMP long-term monitoring sites.
    - Annual analysis of seawater temperature data.

Budgetary Spending:

City and County of Honolulu			
Biological Carrying Capacity of Hanauma Bay Nature Preserve			
Project date 05/01/2020-4/30/2021			
Itemized Budget - Total Project Costs			
Categories	**Awarded**	**Total Expended**	**Available Balance**
A. Personnel			
Sarah Severino	$52,800	$48,000	
B. Fringe Benefits			
	$0		
Total Personnel	**$52,800**	**$52,000**	**$800**
C. Materials and Supplies	$6,545	$2,778	
Total Materials and Supplies Costs	**$6,545**	**$2,778**	**$3,767**
D. Total Direct Costs	$59,345	$54,778	**$4,567**
E. Indirect Costs 10%	$655	$655	**$0**
F. Total Direct and Indirect Costs	$60,000	$55,433	**$4,567**
G. Amount of This Request	**$60,000**		

Salary and Fringe

Stipend for Sarah J. L. Severino began 5/01/2020 and continues throughout this year. No fringe benefits are associated with a UH stipend.

Indirect costs

The indirect cost rate for 2020/21 has been negotiated between the State of Hawaiʻi and the University of Hawaiʻi at 10%.
http://www.ors.hawaii.edu/index.php/rates/83-quick-links/100-sponsor-specific-rates

Materials, Supplies & Software

The following table is a breakdown of the first semester of Year 3's materials and supplies costs:

Trans No.	Trans Date	Vendor	Description of Goods/Services	Total Cost Amount
1	2/4/20	Vistaprint	Educational signs for caging experiment	$180.65
2	2/6/20	Amazon	AA batteries	$13.28
3	3/9/20	City Mill	Supplies for equipment storage- tarp, rope	$166.28
4	4/7/20	Ebay	Sony HDR-AS20 HD POV Action Cam for fish behavior surveys	$313.48
5	4/24/20	Amazon	3/8" latex tubing 30 ft for transects to attach to substrate during surveys	$35.59
6	5/18/20	Amazon	polyethylene sheet for secchi disk	$39.78
7	5/19/20	GoPro	GoPro camera for fish behavior surveys	$731.46
8	6/11/20	Ebay refund	Camera refund of Sony HDR's	-$313.48
9	9/15/20	Amazon	Olympus TG digital camera (replacement of flooded camera) and two 1TB external hard drives (one for FID backup and one for Fish Foraging backup)	$764.24
10	8/10/20	SeaGIS	EventMeasure computer software for video analyses of FIDs	$843.81
11	8/10/20	International Transaction	transaction fee for EventMeasure software purchase (Australia)	$8.44
12	9/20/20	UH Information Technology Services	ESRI (map and spatial analysis program) and SPSS (statistical package) annual license renewal	$250.00
			TOTAL:	**$3,033.53**

LITERATURE CITED

Aeby, G. S., Kenyon, J. C., Maragos, J. E., & Potts, D. C. (2003). First record of mass coral bleaching in the Northwestern Hawaiian Islands. *Coral Reefs*, *22*(3), 256. https://doi.org/10.1007/s00338-003-0309-2

Albuquerque, T., Loiola, M., Nunes, J. A. C. C., & Reis-Filho, J. A. (2014). In situ effects of human disturbances on coral reef-fish assemblage structure: Temporary and persisting changes are reflected as a result of intensive tourism. *Marine and Freshwater Research*, *66*(1), 23–32. https://doi.org/10.1071/MF13185

Bahr, K. D., Jokiel, P. L., & Toonen, R. J. (2015). The unnatural history of Kāne'ohe Bay: coral reef resilience in the face of centuries of anthropogenic impacts. *PeerJ*, *3*, e950. https://doi.org/10.7717/peerj.950

Bahr, Keisha D., Jokiel, P. L., & Rodgers, K. S. (2016). Influence of solar irradiance on underwater temperature recorded by temperature loggers on coral reefs. *Limnology and Oceanography: Methods*, *14*(5), 338–342. https://doi.org/10.1002/lom3.10093

Bak, R. P. M., & Meesters, E. H. (1998). Coral population structure: The hidden information of colony size-frequency distributions. *Marine Ecology Progress Series*, *162*(Sebens 1987), 301–306. https://doi.org/10.3354/meps162301

Bellwood, D. R., Hoey, A. S., & Hughes, T. P. (2012). Human activity selectively impacts the ecosystem roles of parrotfishes on coral reefs. *Proceedings of the Royal Society B: Biological Sciences*, *279*(1733), 1621–1629. https://doi.org/10.1098/rspb.2011.1906

Birrell, C. L., McCook, L. J., Willis, B. L., & Diaz-pulido, G. A. (2008). Effects of benthic algae on the replenishment of corals and the implications for the resilience of coral reefs. *Oceanography and Marine Biology: An Annual Review*, *46*, 25–63.

Bonnot, N., Morellet, N., Verheyden, H., Cargnelutti, B., Lourtet, B., Klein, F., & Hewison, A. J. M. (2013). Habitat use under predation risk: Hunting, roads and human dwellings influence the spatial behaviour of roe deer. *European Journal of Wildlife Research*, *59*(2), 185–193. https://doi.org/10.1007/s10344-012-0665-8

Bothner, M. H., Reynolds, R. L., Casso, M. A., Storlazzi, C. D., & Field, M. E. (2006). Quantity, composition, and source of sediment collected in sediment traps along the fringing coral reef off Molokai, Hawaii. *Marine Pollution Bulletin*, *52*(9), 1034–1047. https://doi.org/10.1016/j.marpolbul.2006.01.008

Brown, E. (2004). *Reef Coral Populations: Spatial and Temporal Differences Observed on Six Reefs off West Maui*.

Browne, N. K., Smithers, S. G., & Perry, C. T. (2013). Spatial and temporal variations in turbidity on two inshore turbid reefs on the Great Barrier Reef, Australia. *Coral Reefs*, *32*(1), 195–210. https://doi.org/10.1007/s00338-012-0965-1

Buddemeier, R. W., & Kinzie, R. A. (1976). Coral growth. *Oceanographic Marine Biology Annual Review*, *14*, 183–225.

Chabanet, P., Adjeroud, M., Andrefouet, S., Bozec, Y. M., Ferraris, J., Garcia-Charton, J. A., & Schirmm, M. (2005). Human-induced physical disturbances and their indicators on coral reef habitats: A multi-scale approach. *Aquatic Living Resources*, *18*, 215–230. https://doi.org/10.1051/alr

Coles, S. L., Jokiel, P. L., & Lewis, C. R. (1976). Thermal Tolerance in Tropical Versus Subtropical Pacific Reef Corals. *Pacific Science*, *30*(2), 159–166.

Dearden, P., Theberge, M., & Yasué, M. (2010). Using underwater cameras to assess the effects of snorkeler and SCUBA diver presence on coral reef fish abundance, family richness, and

species composition. *Environmental Monitoring and Assessment*, *163*(1–4), 531–538. https://doi.org/10.1007/s10661-009-0855-3
Eakin, C. M., Lough, J. M., & Heron, S. F. (2009). Climate Variability and Change: Monitoring Data and Evidence for Increased Coral Bleaching Stress. *Coral Bleaching SE - 4*, *205*, 41–67. https://doi.org/10.1007/978-3-540-69775-6_4
Fitt, W. K., Brown, B. E., Warner, M. E., & Dunne, R. P. (2001). Coral bleaching: Interpretation of thermal tolerance limits and thermal thresholds in tropical corals. *Coral Reefs*, *20*(1), 51–65. https://doi.org/10.1007/s003380100146
Frid, A., & Dill, L. (2002). Human-caused Disturbance stimuli as a Form of Predation Risk. *Conservation Ecology*, *6*(1), 11. https://doi.org/10.1016/S0723-2020(86)80016-9
Friedlander, A., Aeby, G. S., Brown, E., Clark, A., Coles, S., Dollar, S., Hunter, C., Jokiel, P., Smith, J., Walsh, B., Williams, I., Wiltse, W., Hallacher, L., Morishige, C., Woolaway, C., Work, T., Oishi, F., & Tissot, B. (2008). *The State of Coral Reef Ecosystems of the Main Hawaiian Islands*.
Friedlander, A., Donovan, M., Koike, H., Murakawa, P., & Goodell, W. (2018). Spatial and temporal trends in Hawai'i's marine protected areas. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 48p.
Goetze, J. S., Bond, T., McLean, D. L., Saunders, B. J., Langlois, T. J., Lindfield, S., Fullwood, L. A. F., Driessen, D., Shedrawi, G., & Harvey, E. S. (2019). A field and video analysis guide for diver operated stereo-video. *Methods in Ecology and Evolution*, *10*(7), 1083–1090. https://doi.org/10.1111/2041-210X.13189
Grigg, R. W. (1998). Holocene coral reef accretion in Hawaii: A function of wave exposure and sea level history. *Coral Reefs*, *17*(3), 263–272. https://doi.org/10.1007/s003380050127
Harvell, D., Jordán-Dahlgren, E., Merkel, S., Rosenberg, E., Raymundo, L., Smith, G., Weil, E., & Willis, B. (2007). Coral disease, environmental drivers, and the balance between coral and microbial associates. *Oceanography*, *20*(1), 172–195.
Heil, L., Fernández-Juricic, E., Renison, D., Cingolani, A. M., & Blumstein, D. T. (2007). Avian responses to tourism in the biogeographically isolated high Córdoba Mountains, Argentina. *Biodiversity and Conservation*, *16*(4), 1009–1026. https://doi.org/10.1007/s10531-006-9040-y
Higham, J. E. S., Beijder, L., Allen, S., Corkeron, P., & Lusseau, D. (2016). Managing whalewatching as a non-lethal consumptive activity. Journal of Sustainable Tourism (in press). *Managing Whale-Watching as a Non-Lethal Consumptive Activity. Journal of Sustainable Tourism*, *16*, 246–260.
Hoey, A. S., Pratchett, M. S., & Cvitanovic, C. (2011). High macroalgal cover and low coral recruitment undermines the potential resilience of the world's southernmost coral reef assemblages. *PloS One*, *6*(10), e25824. https://doi.org/10.1371/journal.pone.0025824
Hughes, T. P., Rodrigues, M. J., Bellwood, D. R., Ceccarelli, D., Hoegh-Guldberg, O., McCook, L., Moltschaniwskyj, N., Pratchett, M. S., Steneck, R. S., & Willis, B. (2007). Phase Shifts, Herbivory, and the Resilience of Coral Reefs to Climate Change. *Current Biology*, *17*(4), 360–365. https://doi.org/10.1016/j.cub.2006.12.049
Januchowski-Hartley, F. A., Graham, N. A. J., Feary, D. A., Morove, T., & Cinner, J. E. (2011). Fear of fishers: Human predation explains behavioral changes in coral reef fishes. *PLoS ONE*, *6*(8). https://doi.org/10.1371/journal.pone.0022761
Januchowski-Hartley, F. A., Nash, K. L., & Lawton, R. J. (2012). Influence of spear guns, dive gear and observers on estimating fish flight initiation distance on coral reefs. *Marine*

Ecology Progress Series, *469*, 113–119. https://doi.org/10.3354/meps09971
Jokiel, P. L., & Brown, E. K. (2004). Global warming, regional trends and inshore environmental conditions influence coral bleaching in Hawaii. *Global Change Biology*, *10*(10), 1627–1641. https://doi.org/10.1111/j.1365-2486.2004.00836.x
Jokiel, P. L., & Coles, S. L. (1990). Response of Hawaiian and other Indo-Pacific reef corals to elevated temperatures. *Coral Reefs*, *8*, 155–162.
Jokiel, P. L., & Guinther, E. B. (1978). Effects of temperature on reproduction in the hermatypic coral Pocillopora damicornis. *Bulletin of Marine Science*, *28*(4), 786–789.
Kenyon, J. C., & Brainard, R. E. (2006). Second recorded episode of mass coral bleaching in the Northwestern Hawaiian Islands. *Atoll Research Bulletin*, *543*, 505–523.
Lamb, J. B., True, J. D., Piromvaragorn, S., & Willis, B. L. (2014). Scuba diving damage and intensity of tourist activities increases coral disease prevalence. *Biological Conservation*, *178*, 88–96. https://doi.org/10.1016/j.biocon.2014.06.027
Madin, E. M. P., Dill, L. M., Ridlon, A. D., Heithaus, M. R., & Warner, R. R. (2016). Human activities change marine ecosystems by altering predation risk. *Global Change Biology*, *22*(1), 44–60. https://doi.org/10.1111/gcb.13083
Madin, E. M. P., Precoda, K., Harborne, A. R., Atwood, T. B., Roelfsema, C. M., & Luiz, O. J. (2019). Multi-trophic species interactions shape seascape-scale coral reef vegetation patterns. *Frontiers in Ecology and Evolution*, *7*(APR), 1–11. https://doi.org/10.3389/fevo.2019.00102
Neil, D. (1990). Potential for Coral stress due to sediment resuspension and deposition by reef walkers. *Biological Conservation*, *52*(3), 221–227. https://doi.org/10.1016/0006-3207(90)90127-B
Piniak, G. A., Fogarty, N. D., Addison, C. M., & Kenworthy, W. J. (2005). Fluorescence census techniques for coral recruits. *Coral Reefs*, *24*(3), 496–500. https://doi.org/10.1007/s00338-005-0495-1
Plante, S., Dussault, C., Richard, J. H., & Côté, S. D. (2018). Human disturbance effects and cumulative habitat loss in endangered migratory caribou. *Biological Conservation*, *224*(May), 129–143. https://doi.org/10.1016/j.biocon.2018.05.022
Pollock, F. J., Lamb, J. B., Field, S. N., Heron, S. F., Schaffelke, B., Shedrawi, G., Bourne, D. G., & Willis, B. L. (2014). Sediment and turbidity associated with offshore dredging increase coral disease prevalence on nearby reefs. *PLoS ONE*, *9*(7). https://doi.org/10.1371/journal.pone.0102498
Purser, J., & Radford, A. N. (2011). Acoustic noise induces attention shifts and reduces foraging performance in three-spined sticklebacks (gasterosteus aculeatus). *PLoS ONE*, *6*(2). https://doi.org/10.1371/journal.pone.0017478
Randall, J. E. (2010). *Shore Fishes of Hawai'i*.
Renfro, B. (2016). *Impacts of diving tourists on coral reef community structure and herbivorous reef fish foraging behavior*. 78. http://etd.auburn.edu/handle/10415/5263
Richmond, R. H. (1987). Energetics, competency, and long-distance dispersal of planula larvae of the coral Pocillopora damicornis. *Marine Biology*, *93*, 527–533.
Ritson-Williams, R., & Gates, R. D. (2020). Coral community resilience to successive years of bleaching in Kāneʻohe Bay, Hawaiʻi. *Coral Reefs*. doi:10.1007/s00338-020-01944-4
Rodgers, K. S., Bahr, K. D., Jokiel, P. L., & Richards Donà, A. (2017). Patterns of bleaching and mortality following widespread warming events in 2014 and 2015 at the Hanauma Bay Nature Preserve, Hawaiʻi. *PeerJ*, *5*, e3355. https://doi.org/10.7717/peerj.3355

Roth, M. S., & Knowlton, N. (2009). Distribution, abundance, and microhabitat characterization of small juvenile corals at Palmyra Atoll. *Marine Ecology Progress Series*, *376*, 133–142. https://doi.org/10.3354/meps07787

Schmidt-Roach, S., Kunzmann, A., & Martinez Arbizu, P. (2008). In situ observation of coral recruitment using fluorescence census techniques. *Journal of Experimental Marine Biology and Ecology*, *367*(1), 37–40. https://doi.org/10.1016/j.jembe.2008.08.012

Skagen, S. K., Knight, R. L., & Orians, G. H. (1991). Human disturbance of an avian scavenging guild. *Ecological Applications*, *1*(2), 215–225. https://doi.org/10.2307/1941814

Smith, J. E., Hunter, C. L., & Smith, C. M. (2010). The effects of top-down versus bottom-up control on benthic coral reef community structure. *Oecologia*, *163*(2), 497–507. https://doi.org/10.1007/s00442-009-1546-z

Smith, S. R. (1992). Patterns of Coral Recruitment and Post-Settlement Mortality on Bermuda' s Reefs : Comparisons to Caribbean and Pacific Reefs. *American Zoologist*, *32*(6), 663–673.

Stamoulis, K. A., Harvey, E. S., Friedlander, A. M., Williams, I. D., Weng, K. C., Wiggins, C., Wagner, G. W., & Conklin, E. J. (2019). Flight behavior of targeted fishes depends on variables other than fishing. *Ecological Indicators*, *96*(August 2018), 579–590. https://doi.org/10.1016/j.ecolind.2018.09.006

Storlazzi, C. D., Field, M. E., & Bothner, M. H. (2011). The use (and misuse) of sediment traps in coral reef environments: Theory, observations, and suggested protocols. *Coral Reefs*, *30*(1), 23–38. https://doi.org/10.1007/s00338-010-0705-3

Storlazzi, C. D., Ogston, A. S., Bothner, M. H., Field, M. E., & Presto, M. K. (2004). Sediment resuspension and transport patterns on a fringing reef flat, Molokai, Hawaii. *Coral Reefs*, *23*(4), 559–569. https://doi.org/10.1007/s00338-004-0415-9

Tamelander, J. (2002). Coral recruitment following a mass mortality event. *Ambio*, *31*(7–8), 551–557. https://doi.org/10.1579/0044-7447-31.7.551

Tonay, A. M., Danyer, E., Dede, A., Öztürk, B., & Öztürk, A. A. (2016). The stomach content of a Mediterranean Monk Seal (Monachus monachus): finding of Green Turtle (Chelonia mydas) remains. *Zoology in the Middle East*, *62*(3), 212–216. https://doi.org/10.1080/09397140.2016.1202947

Vermeij, M. J. A., Smith, J. E., Smith, C. M., Vega Thurber, R., & Sandin, S. A. (2009). Survival and settlement success of coral planulae: independent and synergistic effects of macroalgae and microbes. *Oecologia*, *159*(2), 325–336. https://doi.org/10.1007/s00442-008-1223-7

Weis, V. M. (2008). Cellular mechanisms of Cnidarian bleaching: stress causes the collapse of symbiosis. *The Journal of Experimental Biology*, *211*(Pt 19), 3059–3066. https://doi.org/10.1242/jeb.009597

Zakai, D., & Chadwick-Furman, N. E. (2002). Impacts of intensive recreational diving on reef corals at Eilat, northern Red Sea. *Biological Conservation*, *105*, 179–187. https://doi.org/10.1016/S0006-3207(01)00181-1

Appendices.

Appendix A.
Hanauma Bay Annotated Bibliography

Bailey-Brock, J., Brock, R., Kam, A., Fukunaga, A., & Akiyama, H. (2007). Anthropogenic disturbance on shallow cryptofaunal communities in a marine life conservation district on Oahu, Hawaii. *International review of hydrobiology*, *92*(3), 291-300.

- LOCATION: Hanauma Bay, Oʻahu HI
- TYPE: Field Study
- In Text Citation: (Bailey-Brock et al. 2007)
- SUMMARY:
  - Analysis of cryptic invertebrate communities in coral rubble and sand from Hanauma Bay.
  - Rubble collected from areas used by waders had a greater diversity of cryptofauna than sand habitats.
    - Rubble may provide a greater variety of microhabitats and protection from tramping.
  - Found that disturbance by human trampling on shallow sands reduces the species richness of cryptofauna.
- Materials and Methods:
  - Five locations in three sections of the Bay were sampled July 1999.
    - Two 1-liter samples at depths of 0.5-0.6 m.
    - Three replicate cores collected within 30 cm of each of two sites and depths.
      - Site 1: Channel- shallow and deep.
      - Site 2: Backdoors- shallow and deep.
- Discussion:
  - The total infaunal taxa and abundance was greater in coral rubble samples than for any sand samples.
  - Large differences in diversity and abundance of taxa from sand samples in shallow vs. deep sites suggests that anthropogenic disturbance as well as physical disturbance shapes the composition of infaunal communities.
  - Sand-feeding goatfishes spend considerably more time feeding over sands in water depths of 2-4 m, than in sands at shallower depths (0.5-1.5 m) in Hanauma Bay on days when the By is closed to visitors.
- Conclusion:
  - Despite management efforts to conserve biological resources, wading and disturbance in the shallow sand areas have reduced the biodiversity and abundance of the interstitial fauna.
  - In areas too deep for waders, the biodiversity and abundance of interstitial and cryptofauna was found to be greater in Hanauma Bay than at other locations.

Brock, R., & Kam, A. (2000). Carrying capacity study for the Hanauma Bay nature preserve: final report. *Honolulu: Department of Parks and Recreation*. Carrying Capacity Study for the Hanauma Bay Nature Preserve Final Report

- LOCATION: Hanauma Bay, Oʻahu HI
- TYPE: Carrying Capacity Study
- In Text Citation: (R. E. Brock and Kam 2000)
- SUMMARY:
  - Background of Hanauma Bay:

    - Formation of the bay-geology.
    - History of ownership of the bay.
    - History of human activities becoming more popular in the bay.
    - Tourism and Hanauma Bay.
    - Negative impact on marine resources within the bay due to physical disturbance/trampling, humans entering water and shedding suntan oil and bacteria, human urine, bird feces, etc.
- GOAL: Determine the relationship between human use of the Hanauma Bay Nature Preserve as measured by the number of users and level of disturbance of marine biota and water quality for the purpose of managing the number of Park visitors at levels which protect and maintain the integrity of the Bay's marine communities.
- First Year Objectives:
    - Conduct initial overview inventory of marine biological resources and terrestrial influences affecting the Bay.
        - 6mo report: identifying marine biological resources and related social conditions, and recommend a preliminary level of use for the Bay based on the initial data.
        - 1yr report: recommendations on the level of use of the Bay is made based on the data to date.
    - Establish a scientific methodology for monitoring and analyzing the marine biological resources and water quality of the Bay.
    - Establish field experiments to determine the levels and sources of indicator bacteria and impact of human trampling on benthic biota.
    - Estimate basalt/coralline sediment at different depths in sand deposits to reconstruct changes in terrigenous input of the Bay.
    - Review related research and comparative analyses with data from the Bay and other resource areas similar to the Bay.
    - Prepare recommendations addressing resource management needs, practices and standards relating to continued monitoring, gathering and analyzing data from the Bay.
- The National Park Service (1997) has developed a framework protocol for determining human carrying capacity for application in parks; this process is known as the visitor experience and resource protection framework or VERP. VERP Framework Foundation:
    - Element 1: Assemble an Interdisciplinary Project Team: Includes both those who plan and those that implement a plan.
    - Element 2: Public Involvement Strategy.
    - Element 3: Develop Statement of Park Purpose, Significance, and Primary Interpretative Themes; Identify Planning Constraints.
    - Element 4: Analyze Park Resources and Existing Visitor Use.
    - Element 5: Describe a Potential Range of Visitor Experiences and Resource Conditions.
    - Element 6: Allocate the Potential Zones to Specific Locations in the Park.
    - Element 7: Select Indicators and Specify Standards for Each Zone; Develop a Monitoring Plan.
    - Element 8: Monitor Resource and Social Indicators.
    - Element 9: Take management Action.
- Materials and Methods:
    - Water Chemistry Sampling
    - Inventory and Monitoring of Marine Communities
        - Fish -25m transects.
        - Epibenthic -4x25m areas

        - Exposed sessile benthic forms (Corals/Sponges/ Macrothalloid Algae) - Point-Intersect method quadrats- 50 such points in 6 one-meter frames placed five-meters apart along the 25m fish transect.
        - Within each biotope, a number of permanently marked stations are stablished and quantitative studies conducted at each include a visual enumeration of fish, counts along benthic transect lines and cover estimate in benthic quadrats.
        - Notes taken on number, size and location of any threatened or endangered species (spinner porpoises, humpback whales or green sea turtles).
    - Visitor Use
        - Used daily log from toll gate separated by residents and non-residents.
        - Counts were taken various days of the week and time of the day.
            - If in the ocean, notes were taken on their activity: wading, swimming, viewing fish and location within the bay.
                - Bay was divided into (1) the inner Bay which included all shallow reef areas from shore to the fringing reef crest, and (2) areas seaward of the inner bay. Inner Bay was divided into three sections: the eastern third, the central third and western third.
    - Experiments to Determine Impact of Human Trampling on Benthic Biota
        - Design of experiment differentiates the impact of grazing fishes from human trampling on inner reef benthic communities.
            - 3 experimental treatments: (1) areas of bottom subject to human trampling and fish grazing (natural present situation), (2) an experimental are where human trampling does occur but fish grazing continues, and (3) where neither human trampling nor fish grazing can occur (using wire pens to keep herbivores out).
    - Basalt/Coralline Determinations
        - Driving 3.8 cm diameter x 122 cm long clear plastic tube into the sand.
        - In the laboratory sand samples are removed from different sections of the core, dried in an oven until constant weight, acidified to remove the carbonate (coralline) fraction, rinsed, re-dried and reweighed. The difference in the two weights represents the coralline fraction and the remainder is the basaltic fraction. Changes in these data may be used to infer changes in the input of basalt which may be related to changes in storm water runoff.
- Results and Discussion
    - Human Use:
        - Figure 1. Daily total number of visitors at the Hanauma Bay Nature Preserve from May 1, 1999 through April 30, 2000. Pg. 14
        - Figure 2. Monthly visitor counts depicted as total counts, residents, and non-residents.
        - Table 1. Breaks visitor logs into high use periods (summer months) and low use periods (winter/spring) and then breaks down into % on the beach, in water, wading, swimming, and outside of reef.
    - Water Quality:
        - Samples taken at High-high and Low-low per sample day. Surface, mid-water, and bottom (0.3 m to 1 m above substrate).
            - Comparison of a Tuesday (no visitors) with a Wednesday (visitors).
            - 40 locations through the bay, 27 taken along three mauka - makai transects and represent surface and deep samples. 10 from mid-water and 3 sample sites from areas with groundwater input evident along the shoreline at low tide.

            - Total Nitrogen and Orthophosphates higher in shallow sections with visitors. Figure 5 & 6.
            - Turbidity was higher in shallow sections with visitors, Figure 8.
        - Cost to process first series of water samples = $12,000
        - Pg. 20, Figure 3 shows sample sites. Table 2 shows mean water quality for each site.
    - Human Trampling
        - Benthic algal growth is much greater (will probably be significantly greater) in caged treatments (where substratum is not available for either human trampling or herbivorous fish grazing).
        - Algal growth was not much different from adjacent areas where people walk in treatments open to grazing fish but away from trampling (Pg. 52).
    - Microbial Studies:
        - Did not perform.
    - Marine Communities and Biotopes:
        - Sand Biotope- dominated by sand.
        - Boulder Biotope
            - Seaward of Witches Brew and along the submarine cliff near Toilet Bowl.
        - P. compressa
            - 2 deep locations.
        - P. lobata
            - Dominant biotope.
        - Spurs and Grooves
        - Inner Reef Flat
    - There is no biological evidence from this preliminary point in this study to suggest that the number of visitors should be increased or decreased over present levels.
        - Current use in year 2000 was 3,000 visitors per day.
- For Brock's Baseline he uses:
    - (1) Water quality sampling (ammonia nitrogen, nitrate+nitrite nitrogen, total nitrogen, total phosphorous, chlorophyll-a, nephalometric turbidity, dissolved oxygen, temperature, pH, salinity, silica and orthophosphorus.
    - (2) Inventory and Monitoring of Marine Communities: define major zones or biotopes present in the study area. Fish and benthic were taken within each biotope—never produced in a report.
    - (3) Assessed Visitor Use of Hanauma Bay
    - (4) Experiments
        - - Assessing the effects of fish feeding
        - -Determine impact of human trampling on benthic biota—cage experiment—never produced in a report.
        - -Basalt/Coralline Determinations in the Sand
- Assessment of Inner reef flat conditions:
    - "Four permanently marked sampling stations were established in the inner reef biotope. These are station 11 (east of the "keyhole" swimming area), station 14 (just west of the "keyhole"), station 17 offshore of the middle lifeguard tower and station 18 offshore of the west bathrooms. All of these stations were established at depth from 0.2 to about 1.5 m. Other than the coralline alga, *Porolithod onkodes*, most macroalgae or limu are not obvious in this biotope. Coralline algae

have a mean of 1 species per transect and a mean coverage of 4%. Seaweed or limu have a mean of four species per transect and a mean coverage of 1.6%. Corals are most often seen along the sides of depressions in the reef. The average number of coral species per transect is 3 and the mean coverage is 0.8%. Coral species seen in the inner reef biotope sample sites include *Porites lobata, Montipora verrucosa, Cyphastrea ocellina, Pocillopora meandrina,* and *P. damicornis.* Over the course of the May 1999-June 2000 sample period, there has been no change in the coverage of corals at these four inner reef flat stations."

"The most obvious species on the inner reef flat at Hanauma Bay are the fishes. The most abundant species include the sergeant major or mamo (*Abedefduf abdominalis*), chub or nenue (*Kyphosus bigibbus*), convict tang or Manini (*Acanthurus triostegus*), ringtail surgeonfish or pualo (*Acanthurus blochii*), blackspot sergeant or kupipi (*Abudefduf sordidus*), brown surgeonfish or ma'I'I'I (*Acanthurus nigrofuscus*), saddle back wrasse or hinalea lauwili (*Thalassoma duperrey*), and bluelined surgeonfish or ta'ape (*Lutjanus kasmiraI*). The mean number of species seen per transect is 19 and the mean number of individual fishes censused per tranect is 153 individuals. In terms of estimated standing crop, the average biomass per transect on the inner reef flat station is 410 g/m^2. Over the year, the most important contributors to this biomass were the nenue (*Kyphosus bigibbus*), pualo (*Acanthurus blochii*), Manini (*Acanthurus triostegus*), eyestripe surgeofish or palani (*Acanthurus dussumieri*) , orangespine surgeofish or umaumalei (*Naso lituratus*), ta'ape (*Lutjanus kasmira*), mamo (*Abudefduf abdominalis*), stareye parrotfish or ponuhunuhu (*Calotomus carolinus*), redlip parrotfish or palukaluka (*Scarus rubroviolaceus*), spectacle parrotfish or uhu uliuli (*Scarus perspicillatus*) and blue trevally or omilu (*Caranx melampygus*). A list of the species of fishes encountered in the inner reef area is given in Table 6."

"The standing crop of fish is significantly greater (P>0.0002) on Wednesdays (mean = 655 g/m^2) over the preceding Tuesdays (mean biomass = 381 g/m^2). This result is probably related to the feeding activities that were occurring on the days with visitors present, and were not occurring on the days when they were absent."

- MAJOR FINDINGS:
  - Water Quality:
    - Relatively high concentrations of these nutrients directly adjacent to the shoreline and the rapid decline in measured concentration with increasing distance from shore.
      - Nitrate nitrogen, total nitrogen, orthophosphorous and dissolved silica.
      - However, the elevated concentrations were similar or less than that measured in groundwater effluxing along the shoreline of completely undeveloped Hawaiian coastlines.
      - Nitrate nitrogen and ammonia nitrogen on all four sampling events in the inner and outer reef locations exceeded DOH standards.
      - Inner reef had significantly higher ammonia nitrogen and turbidity on days with visitors when compared to days without visitors, however fish were thought to be a sig. contributor of the ammonia.
      -
    - Turbidity was higher in shallower sections with more visitors (Figure 8).
      - Turbidity was out of compliance on three of the four sampling periods at inner bay locations
      -
  - Coral Cover 0.8% on inner reef flat transects.

- Algal growth was not much different from adjacent areas where people walk in treatments open to grazing fish but away from trampling (Pg. 52).
- Found that there was no biological evidence from their preliminary findings that the number of visitors should be increased or decreased over present levels.

- QUESTIONS:
  - Where is the report of their findings from cage experiments?

Brock, R. (1997). Hanauma Bay: A proposed study to determine human impact both today and in the future. (pg. 1-8)

- LOCATION: Hanauma Bay, Oʻahu HI
- TYPE: Proposal for Carrying Capacity Study
- In Text Citation: (R. E. Brock 1997)
- SUMMARY:
  - Proposal for carrying capacity study.
    - 1990 surveys found more than 6,700 visitors per day coming to the bay, but many estimates were between 10,000 and 12,000 people per day.
  - Proposed METHODS:
    - Permanent biological monitoring stations established in all major biotopes.
      - Monthly monitoring
    - Routine water quality monitoring
    - Hand operated coring attempted for marine sands of Hanauma Bay.
      - Looking for input from land- basaltic fraction.
      - Assumption that sedimentary material in a core is laid down sequentially through time with minimal reworking.

Brock, V. E. (1954). A preliminary report on a method of estimating reef fish populations. *The Journal of Wildlife Management*, *18*(3), 297-308.
A preliminary Report on a Method of Estimating Reef Fish Populations

- LOCATION: Hanauma Bay, Oʻahu HI
- TYPE: Method Development
- In Text Citation: (V. E. Brock 1954)
- SUMMARY:
  - Counted the number and species of fish present within Hanauma bay and various other locations.
- Materials and Methods:
  - Swim along a 500-yard line laid across the sea floor and count fish seen.
    - Survey distance was 1,500 ft. length by 20 ft. wide = 60,000 ft^2
  - Recorded estimated length, names of fish, family, notes on water depths, nature of bottom, and associated flora and invertebrate fauna.
  - A transformation of lengths into weights was made by the equation: $W = A (L^3)$
    - W = weight, L = estimated length, A = a species constant based on known weights nd lengths for the species involved.
- Results:
  - The pattern of distribution of species for the Hanauma Bay Station indicated that it was essentially a “windward” area.
    - *Zebrasoma flavenscens* was not common.
    - The weight of the fish in a school of opelu, *Decapterus pinnulatus* accounts for a large portion of the miscellaneous species.
  - Table 1. Hanauma Bay survey on 9/11/52
    - Number of fish counted = 819
    - Calculated weight Pounds = 137
    - Mean weight of fish = 0.17

- Calculated pounds per acre = 100
- Bottom = ½ over sand some rock and coral.

Brown, E. K., Cox, E., Jokiel, P. L., Rodgers, S. K. U., Smith, W. R., Tissot, B. N., Coles, S. L. & Hultquist, J. (2004). Development of benthic sampling methods for the Coral Reef Assessment and Monitoring Program (CRAMP) in Hawai'i. *Pacific Science*, *58*(2), 145-158.

- LOCATION: Main Hawaiian Islands
- TYPE: Method Development
- In Text Citation: (Brown et al. 2004)
- SUMMARY:
  - Longer transects had higher variability than shorter (10m) transects.
  - A within-habitat stratified random sampling design was implemented for the CRAMP design.
  - Fixed transects were chosen to reduce temporal variance and allow efficient resurveying under the high-wave-energy field conditions.
  - Method was designed to detect an absolute change of 10% in benthic cover with high statistical power using 50 points per frame, 20-30 frames per transect, and 8-10 transects per depth.
  - Fixed photoquadrats with high precision and high resolution were included in the design to allow detailed monitoring of coral/algal growth, recruitment and mortality.
  - OBJECTIVE OF CRAMP: Evaluate the conditions of the reef communities throughout the main Hawaiian Islands by describing spatial and temporal variation in Hawaiian reef communities in relation to natural and anthropogenic forcing functions.
    - CRAMP sites will continue to be monitored at regular intervals over the next century and will form the basis for evaluating long-term change on Hawaiian coral reefs.
  - 10 fixed transects at each 3m and 10m depth.
  - 5 randomly selected photoquadrats at each depth contour were established with one pin in each corner to ensure accurate repositioning of the frame.

Bryan, W. B., & Stephens, R. S. (1993). Coastal bench formation at Hanauma Bay, Oahu, Hawaii. *Geological Society of America Bulletin*, *105*(3), 377-386.

- LOCATION: Hanauma Bay, Oʻahu HI
- TYPE: Geological Field Study
- In Text Citation: (Bryan and Stephens 1993)
- SUMMARY:
  - Suggests that the formation of the bench at Hanauma Bay is the result of strongly differential rates of cliff retreat above and below the sharp wetting boundary associated with daily high tides.
  - Salt weathering above the level of daily wetting by high tides is a major factor in the cliff retreat that has formed the bench in Hanauma Bay. The bench reflects the daily upper limit of wetting by the present era.

Clark, A. M. (2016). Hawaii's Sustainable Marine Tourism Challenges and Opportunities. Hawaii Division of Aquatic Resources PowerPoint Presentation.

- LOCATION: Hanauma Bay, Oʻahu HI
- TYPE: PowerPoint Presentation
- In Text Citation: (Clark 2016)
- SUMMARY:
  - Hanauma Bay info:
    - 1988: 3 million visitors per year, 10-12,000 visitors per day. Feeding fish up to ½ ton bread per day.

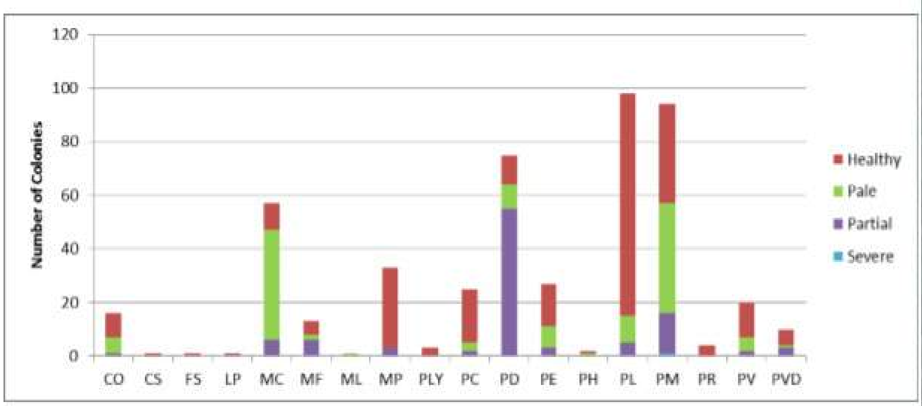
- Present: 3,000 – 5,7000 visitors/day, ban of fish feeding, entrance fee and parking limitations, mandatory visitor education/friends group.

Coffee, N. (2020). COVID-19 and the Result of Tourism Absenteeism on the Marine Ecosystem in Hanauma Bay, Oʻahu, Hawaiʻi. *University of Hawaiʻi Sustainable Tourism Class Paper.* 37pp.

- LOCATION: Hanauma Bay, Oʻahu HI
- TYPE: Review
- In Text Citation: (Coffee 2020)
- SUMMARY:
    - An argument that although there would be significant ecological benefits associated with keeping Hanauma Bay closed post-pandemic, it yields economic revenue and educational opportunities that are too significant to ignore.
    - 57.1% of survey participants believe that the Bay should have remained closed.
    - HBNP provides significant economic revenue, but more importantly an invaluable educational opportunity that the Bay's visitor center provides.

DAR Coral Bleaching Survey (2014), Brian Neilson, DLNR-Division of Aquatic Resources

- LOCATION: Hanauma Bay, Oʻahu HI
- TYPE: Field Study on Coral Bleaching
- In Text Citation: (Neilson 2014)
- SUMMARY:
    - Coral Bleaching Rapid Response Surveys Sept-Oct 2014
        - 47% of coral colonies within Hanauma Bay exhibited signs of bleaching.
            - CO, MC, MF, PD, PE, PL, PM and PV.
        - <1% showed signs of severe bleaching.
        - Bleaching was much less severe at Hanauma Bay compared to windward O'ahu sites.
        - 14 out of the 18 coral species surveyed exhibited signs of bleaching

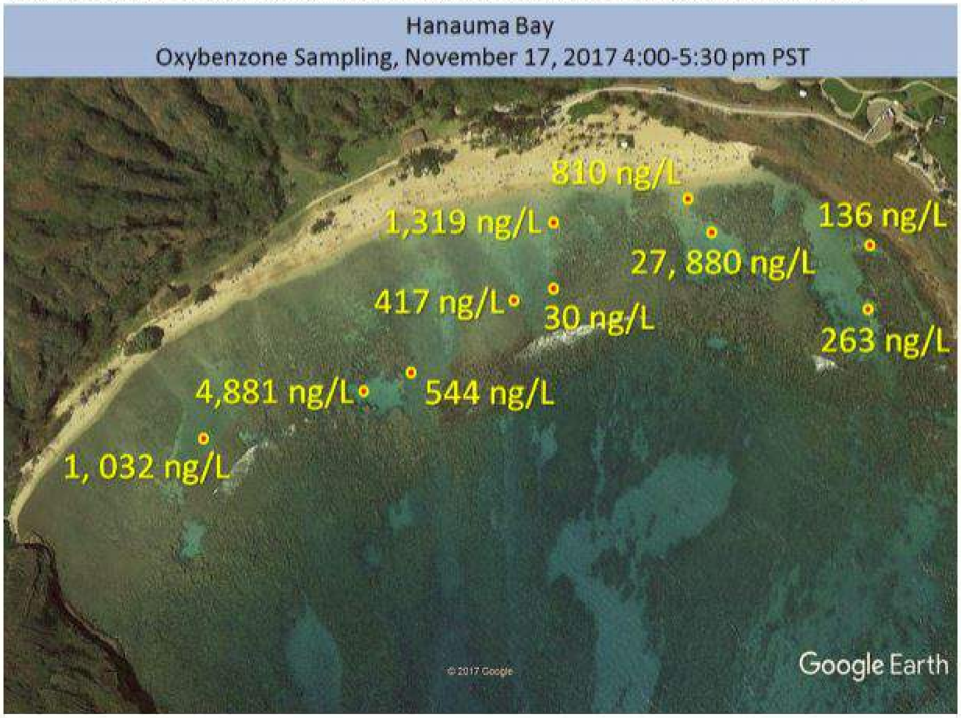


Downs, C. A., (2018). Baseline Measurement of Seawater for Oxybenzone Contamination at the Hanauma Bay Marine Life Conservation Districts. 7p.

- LOCATION: Hanauma Bay, Oʻahu HI
- TYPE: Field Study

- In Text Citation: (Downs 2018)
- SUMMARY:
    - Sampled 10 sites within Hanauma to provide baseline survey for oxybenzone pollution in the Bay.
    - Concentrations of oxybenzone ranged from 30 ng/L to 27,880 ng/L.

Concentration of Oxybenzone at each of sample sites in Hanauma Bay, Oahu, Hawaii.



Easton, W. H., & Olson, E. A. (1976). Radiocarbon profile of Hanauma Reef, Oahu, Hawaii. *Geological Society of America Bulletin*, *87*(5), 711-719.

- LOCATION: Hanauma Bay, Oʻahu HI
- TYPE: Field Study
- In Text Citation: (Easton and Olson 1976)
- SUMMARY:
    - 10 core holes through an active fringing reef within the bay provided 63 samples for which C^{14} dates were determined. The ages indicated that…
        - The reef started growing about 7,000 years ago.
        - Most of its vertical growth was during the interval from 5,800 to 3,500 radiocarbon years ago. Average upward growth at this time was 1 m/ 300 yr.
        - During the last 3,000 years, it advanced seaward at the rate of 1 m/ 45 years.
    - "Reef growth is primarily lateral or eve downward in channels and pockets, rather than directly upward, and so a vertical bore hole could pass down through a former wall of material of the same age for a distance, and it also could pass from older into younger material as it descends through an overhanging mass."
- INTRO:
    - Core taken from drill holes through the reef were dated by radiocarbon in order to determine (1) the age, (2) the pattern and rate of growth, (3) the reliability for radiometric dating of random samples from reefs, (4) the approximate time of the latest volcanic eruption before reef growth began, (5) the rate of rise of sea level, and (6) how consistent the dates are when using different chemical techniques and different materials from the same level.
- DISCUSSION:

- "During the past 3,000 yr, the reef grew seaward about 70 m and shoreward about 40 m, but the central area remained essentially unchanged."
    - Has the inner reef flat been stunted by lowering of sea-level. At a time when sea-level was higher, it grew vertically, but this paper suggests it can no longer grow vertically due to the lower sea-level that exists in the present.
- CONCLUSIONS:
  - Hanauma Bay Reef started to grow at least 7,000 radiocarbon years ago.
  - The reef consists largely of massive and branching corals intergrown with calcareous algae. In general, corals are most abundant in lower portions of the reef, and calcareous algae are most abundant in higher portions of the reef.
  - Between 3,500 radiocarbon years and the present, sea level and reef growth have risen at the rate of 1 m in 3,5000 yr.
  - Reef growth is primarily lateral or eve downward in channels and pockets, rather than directly upward, and so a vertical bore hole could pass down through a former wall of material of the same age for a distance, and it also could pass from older into younger material as it descends through an overhanging mass.
  - Single or sparse samples taken without knowledge of or regard to the geological features of reefs resembling Hanauma Reef are of doubtful value in determining the age of the reef.

Friedlander,A., Donovan, M., Koike, H., Murakawa, P., & Whitney, G. (2018). Spatial and temporal trends in Hawai'i's marine protected areas. *Aquatic Conservation: Marine and Freshwater Ecosystems*. 48p. Under Review.

- LOCATION: Main Hawaiian Islands
- TYPE: Metadata Analysis
- In Text Citation: (Friedlander et al. 2018)
- SUMMARY:
  - Twenty-five datasets, representing 1,031 individual surveys conducted through Hawaii since 2000 were used to compare fish assemblage characteristics amongst a subset of MPAs using a regulation-based protection classification scheme.
  - Fully and highly protected areas had significantly greater resource fish biomass compared with areas with intermediate, or low protection.
  - Long-term monitoring of select MPAs showed mixed and complex trajectories. Resource fish biomass increased after the establishment of the Hanauma Bay MLCD in 1967 but plateaued after ~15 years, followed by changes in assemblage structure from fish feeding and invasive species.
- RESULTS:
  - There were significant increases in resource fish biomass in Hanauma Bay after initial protection.
  - In early years (1960-70s) in Hanauma Bay, goatfishes (Mullidae) and parrotfishes (Scaridae) were most prevalent. In the late 1970s, chubs (Kyphosidae) showed a strong influence until the late 1990s, which likely resulted from an inc. in fish feeding during the time. Once fish feeding was banned in 1999, the family composition reverted to something resembled that in the 1960s, but with the addition of two invasive species from the families Serranidae (*Cephalophus argus*) and Lutjanidae (*Lutjanus kasmira*).

Friedlander, A.M., L.M. Wedding, E. Brown, M.E. Monaco. 2010. Monitoring Hawaii's Marine Protected Areas: Examining Spatial and Temporal Trends Using a Seascape Approach. NOAA Technical Memorandum NOS NCCOS 117. Prepared by the NCCOS Center for Coastal Monitoring and Assessment Biogeography Branch. Silver Spring, MD. 130 pp.

- LOCATION: Hanauma Bay, O'ahu, HI and other MPAs in Hawaii
- TYPE: Field Study
- In Text Citation: (Friedlander et al. 2010)
- SUMMARY:

- Using digital benthic habitat maps coupled with comprehensive ecological studies between 2002 and 2004, they examined the efficacy of all existing MLCDs using a spatially-explicit stratified random samplings design.
- Habitat complexity, protected area size and habitat diversity were the major factors in determining the effectiveness among MPAs.
- Coral species richness and cover was greater inside of the HBNP compared to adjacent open areas.
- Coral cover generally increased over time in the HBNP.
- Macroalgae cover was greater outside the MLCDs and increased over time, particularly adjacent to HBNP.
- Fish biomass did not change at HBNP during the 2002-2004 sampling period. But all other MLCD's did increase in biomass during this period of time.
- Fish biomass increased 32% outside HBNP although the absolute increase was very small (+0.05 t/ha).
- Apex predator biomass increased in HBNP as a result of increasing numbers and sizes of bluefin trevally jacks.

- RESULTS:

Table 7. Summary of seascape metrics derived from 2007 NOAA Biogeography Branch benthic habitat maps.

Hanauma Bay MLCD*	
Shannon's diversity index	0.85
Shannon's evenness index	0.62
Mean patch fractal dimension	1.47
* MLCD = Marine Life Conservation District.	

Table 8. Summary of marine reserve boundary analysis.

Hanauma Bay MLCD*	
Reserve perimeter (km)	3.19
Reserve area (km^2)	0.41
Perimeter to area ratio	7.78
* MLCD = Marine Life Conservation District.	

Table 9. Summary of seascape structure derived from LIDAR bathymetric grids for Hanauma Bay Marine Life Conservation District.

Hanauma Bay MLCD*					
Depth (m)		Rugosity		Slope (percent)	
Average depth	8.55	Average rugosity	1.01	Average slope	7.89
Standard deviation	6.67	Standard deviation	0.02	Standard deviation	8.58
Depth range	0 – 27.68	Rugosity range	1 – 1.45	Slope range	0 – 92.18
* MLCD = Marine Life Conservation District.					

Table 10. Geomorphic structure for the Hanauma Bay Marine Life Conservation District (MLCD) derived from NOAA benthic habitat maps.

Major Structure	Detailed Structure	Area (km^2)	Percentage
Coral Reef and Hard bottom	Aggregate Reef	0.07	18%
Coral Reef and Hard bottom	Individual Patch Reef	0.01	2%
Coral Reef and Hard bottom	Pavement	0.14	34%
Coral Reef and Hard bottom	Rock/Boulder	0.06	15%
Other Delineations	Land	0.01	2%
Unconsolidated Sediment	Sand	0.09	22%
Unknown	Unknown	0.03	7%

Table 11. Biological cover for the Hanauma Bay MLCD derived from NOAA benthic habitat maps.

Major Cover	Percent Cover	Area (km^2)	Percentage
Coral	10% - 50%	0.20	48%
Coral	50% - 90%	0.03	7%
Coralline Algae	50% - 90%	0.02	6%
Turf	50% - 90%	0.03	8%
Unclassified		0.01	2%
Uncolonized	90% - 100%	0.09	22%
Unknown		0.03	7%

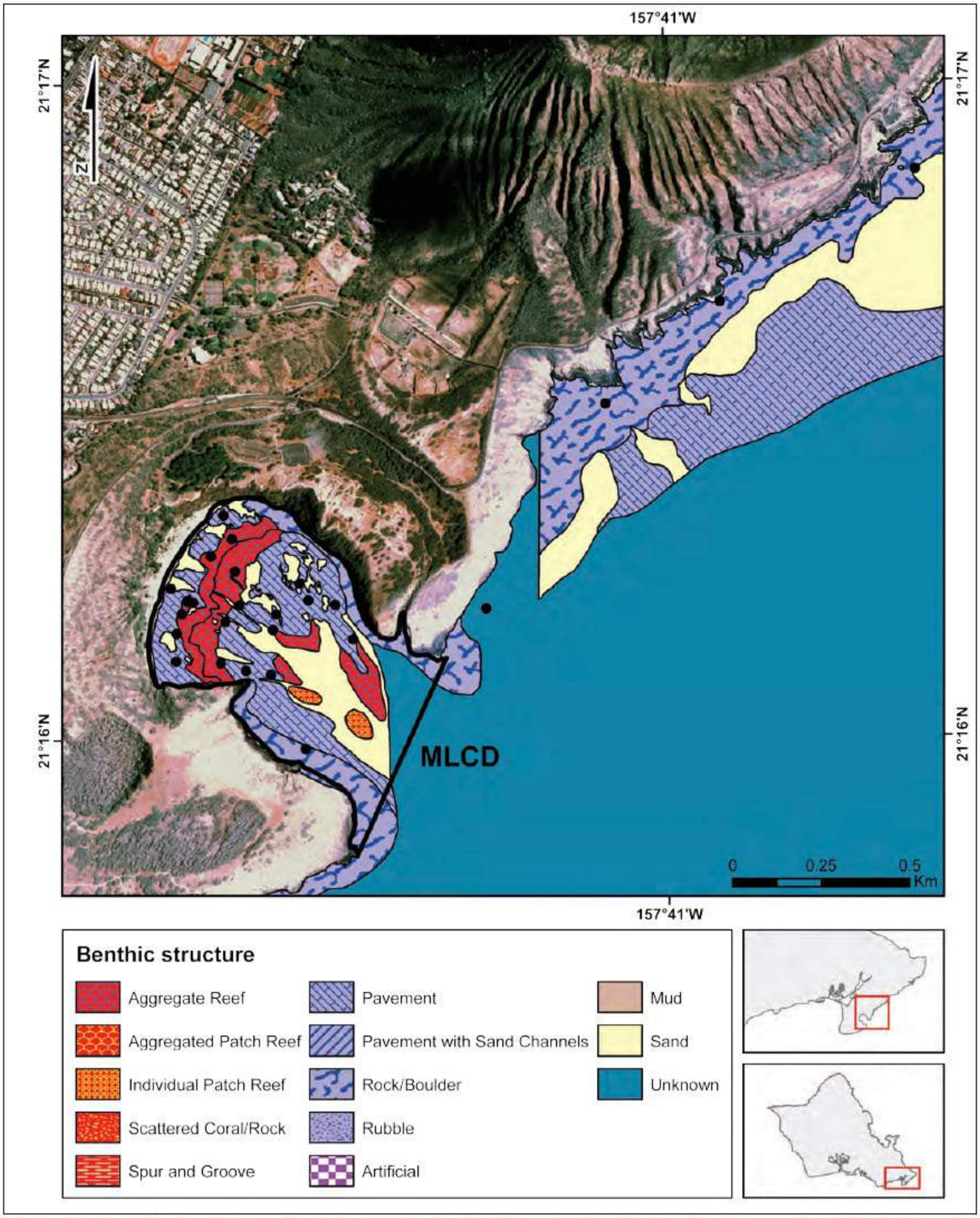


Figure 16. Sampling locations and benthic structure for the Hanauma Bay Marine Life Conservation District, Maunalua Bay and other adjacent open areas.

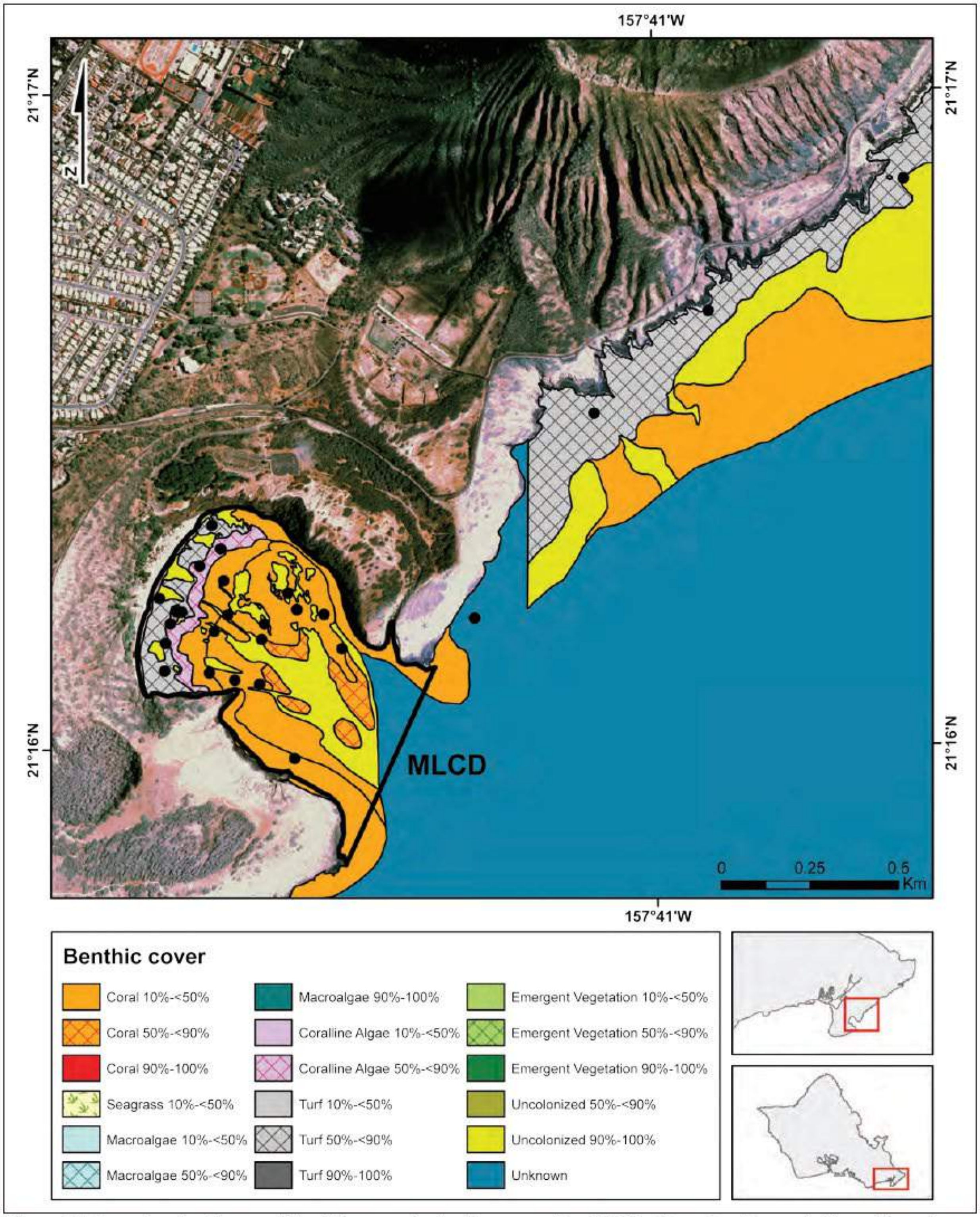


Figure 18. Sampling locations and benthic cover for the Hanauma Bay MLCD, Maunalua Bay and other adjacent open areas.

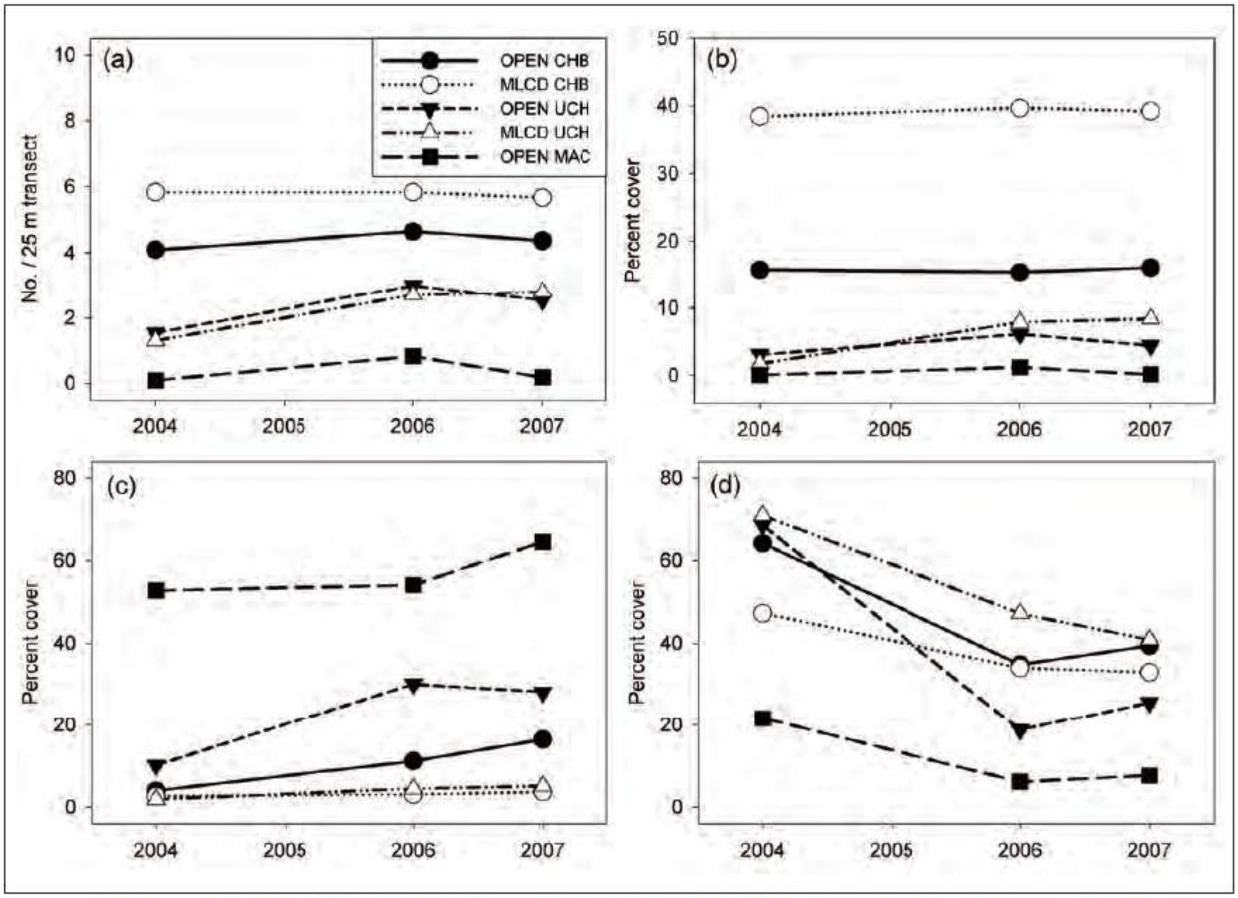


Figure 22. Temporal change in benthic communities at Hanauma Bay MLCD, Maunalua Bay and other adjacent open areas by habitat type from 2004-2007. (a) Mean species richness by year (b) Mean percent cover of coral (c) Mean percent cover of macroalgae (d) Mean percent cover of turf algae.

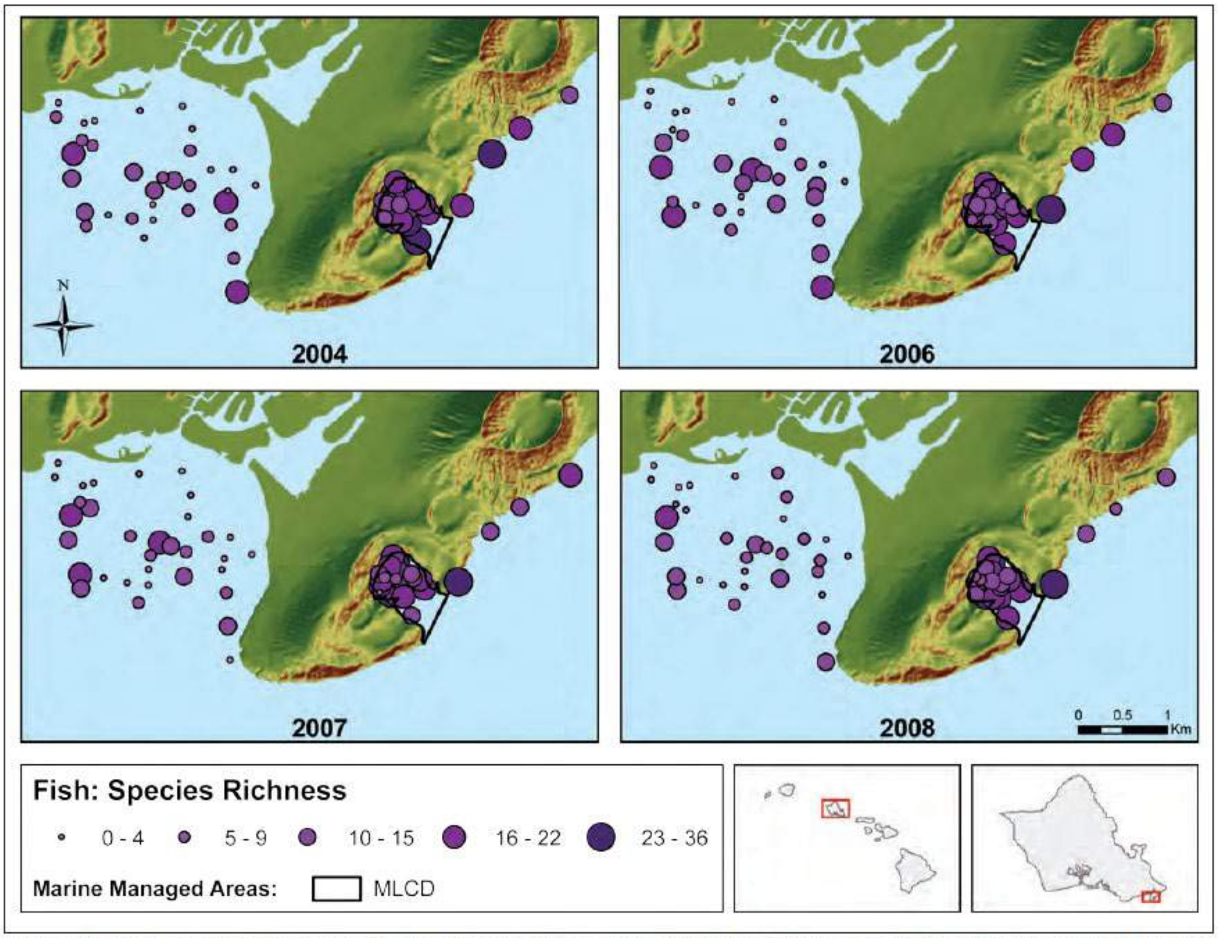


Figure 29. Fish species richness by individual transect for southeast Oahu study area including Hanauma Bay, Maunalua Bay and other adjacent open areas from 2004-2008. Classification based on natural breaks.

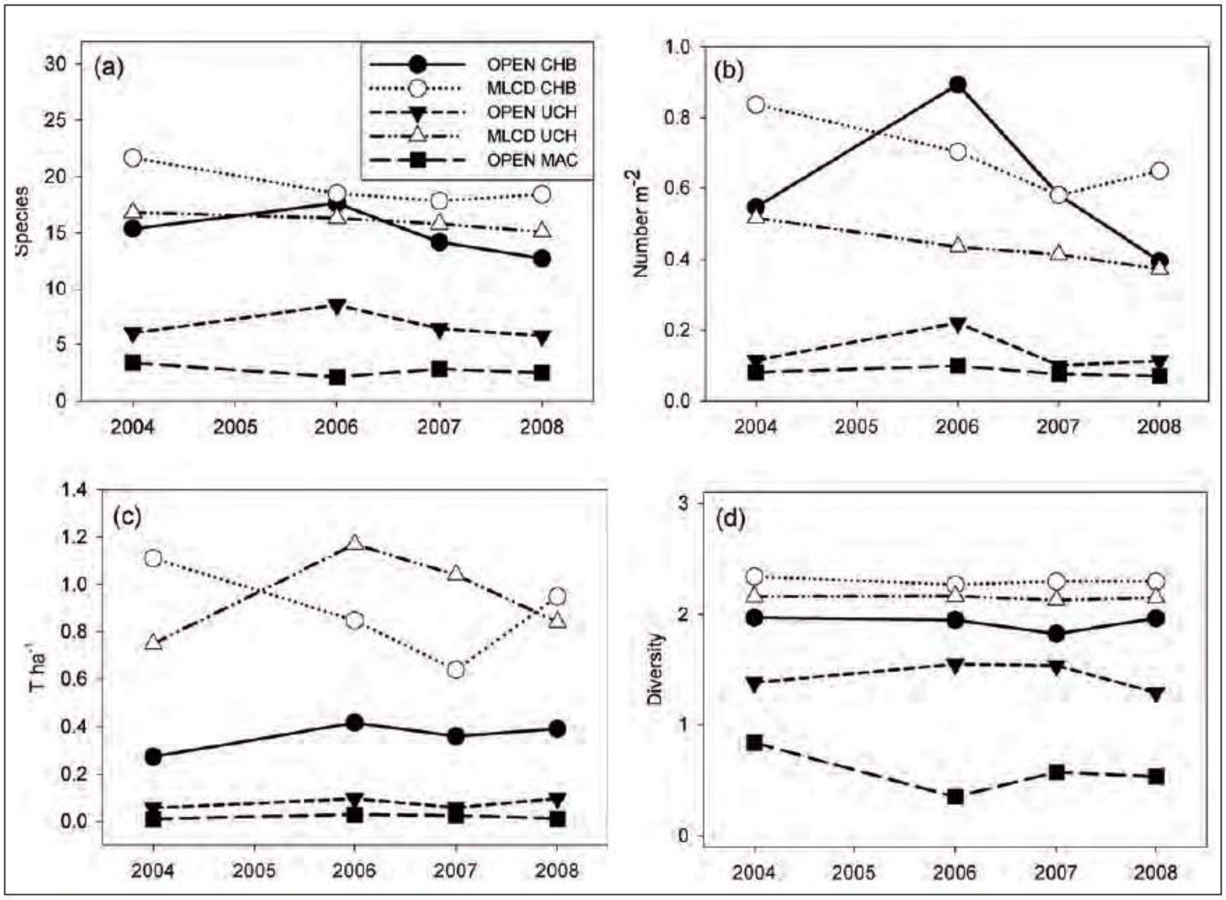


Figure 31. Temporal change in fish assemblages at Hanauma Bay MLCD, Maunalua Bay and other adjacent open areas ***by habitat type from 2004-2008. (a) Species Richness (b) Numerical Abundance (c) Biomass (d) Diversity.***

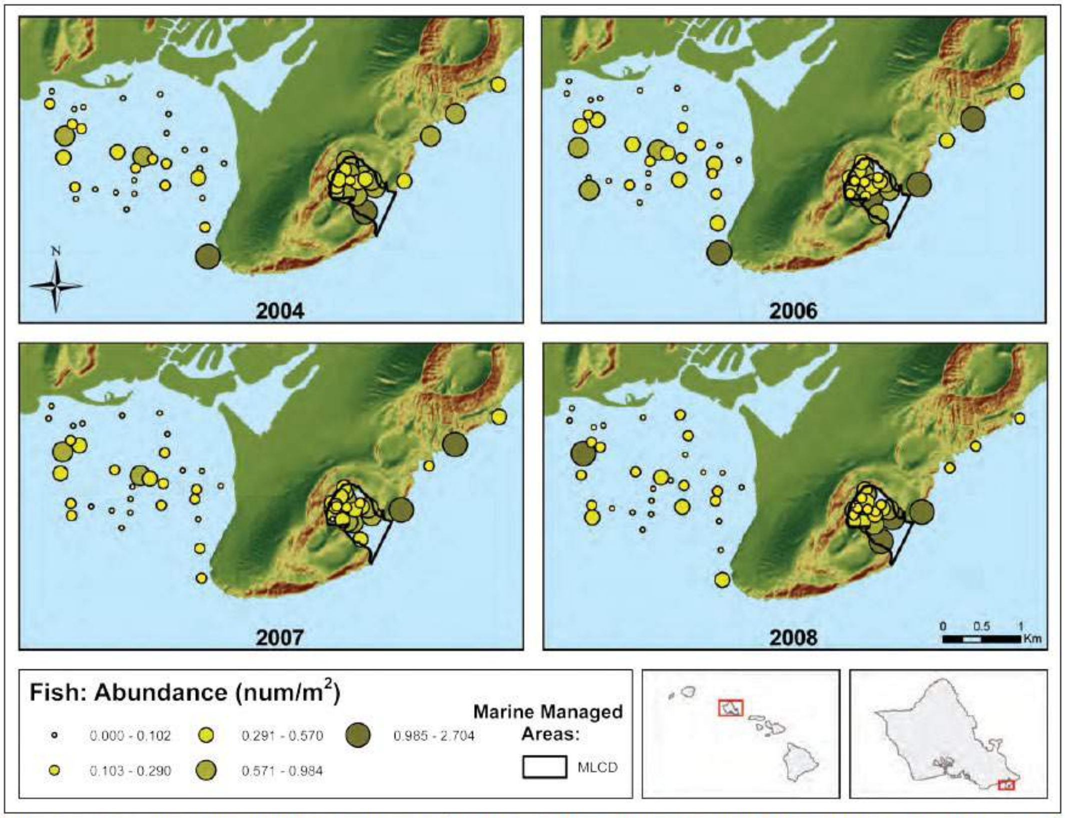


Figure 32. Fish abundance by individual transect for southeast Oahu study area including Hanauma Bay, Maunalua Bay and other adjacent open areas from 2004-2008. Classification based on natural breaks.

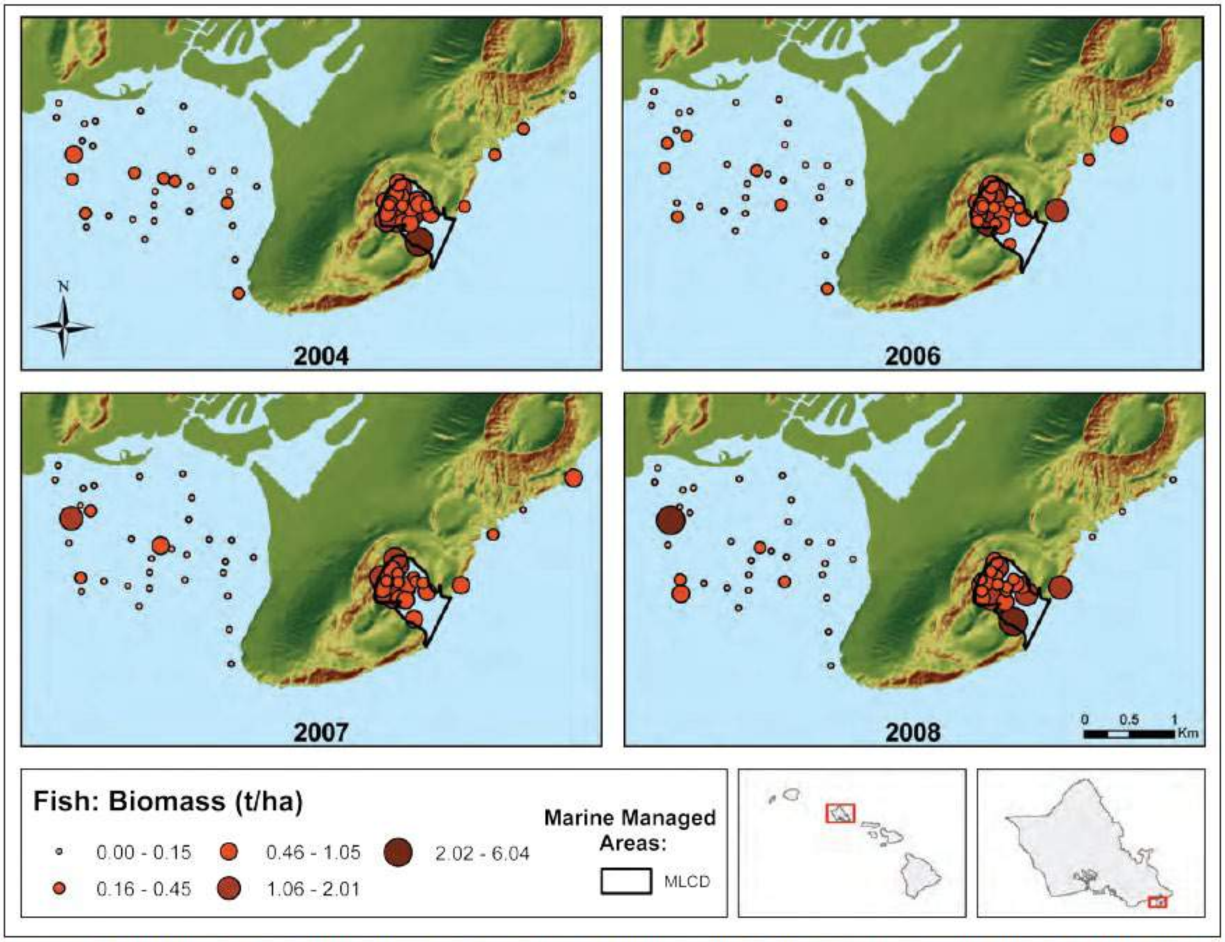


Figure 34. Fish biomass by individual transect for southeast Oahu study area including Hanauma Bay, Maunalua Bay and other adjacent open areas from 2004-2008. Classification based on natural breaks.

Friedlander, A. M., Brown, E. K., & Monaco, M. E. (2007). Coupling ecology and GIS to evaluate efficacy of marine protected areas in Hawaii. *Ecological Applications*, *17*(3), 715-730.

- LOCATION: Main Hawaiian Islands
- TYPE: Interpretation of Orthorectified Aerial Photography
- In Text Citation: (Alan M Friedlander, Brown, and Monaco 2007)
- SUMMARY:
  - A number of fish assemblage characteristics (e.g., species richness, biomass, diversity) vary among habitat types, but where significantly higher in MLCDs compared with adjacent fished areas across all habitat types.
  - Size of protected area was positively correlated with a number of fish assemblage characteristics.
- METHODS:
  - NOAA acquired and visually interpreted orthorectified aerial photography, IKONOS satellite imagery, and hyperspectral imagery for the near-shore waters (to 25 m depth).
  - Fish sampling methodology:
    - At each location standard underwater visual belt transect survey methods were taken in 25 m x 5 m transects.

Gardner, E. A. (1999). A Victim of Its Own Success: Can User Fees Be Used to Save Hanauma Bay. *Ocean & Coastal LJ*, *4*, 81.

- LOCATION: Hanauma Bay, Oʻahu HI
- TYPE: Literature Review of History behind user fees at Hanauma Bay
- In Text Citation: (Gardner 1999)
- SUMMARY:
    - The statutory purposes of establishing a MLCD are "specific to protecting and conserving marine resources." In contrast, the objective for establishing an underwater park is to "enhance recreational activities." These two objectives can conflict, and often lead to the detriment of the environment through over use, as demonstrated by the recent history of Hanauma Bay. The DLNR has suggested that recreational objectives should be a "secondary benefit" within MLCDs.
        - Direct quote from discussion of literature review.

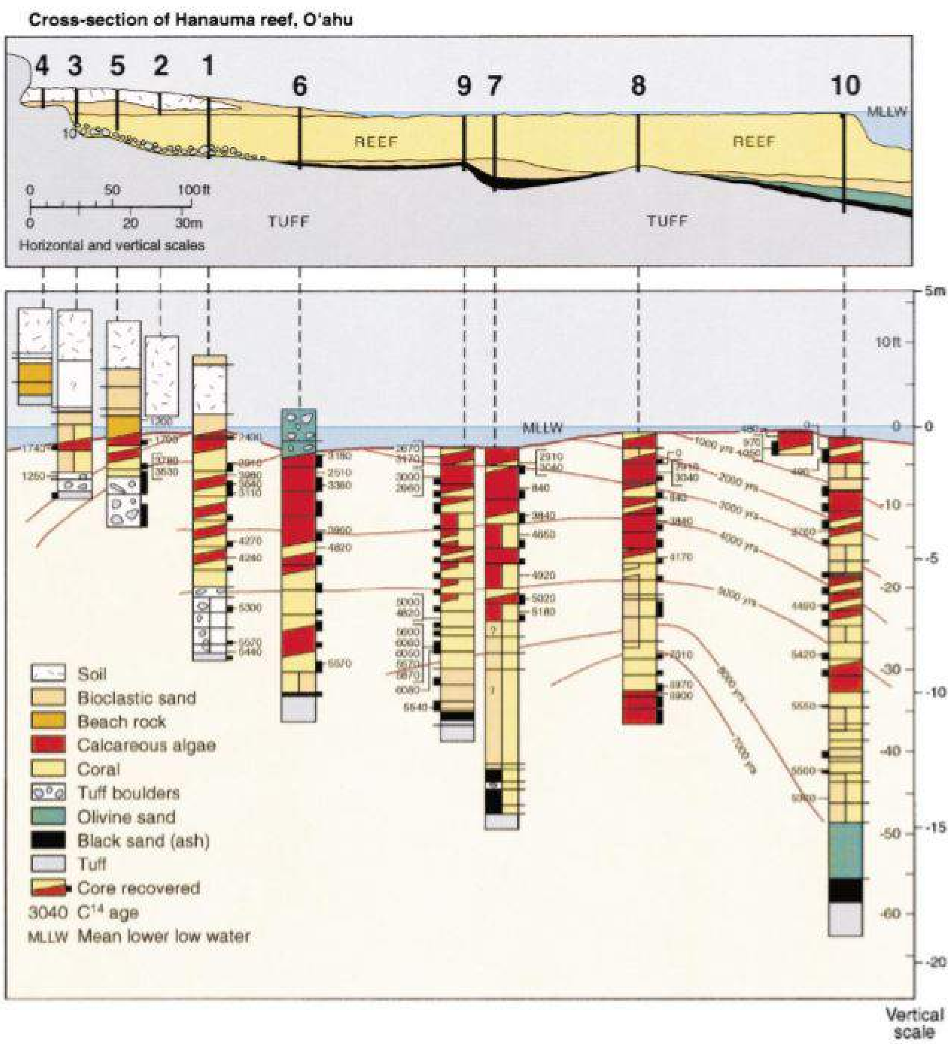
Grigg, R. W. (1998). Holocene coral reef accretion in Hawaii: a function of wave exposure and sea level history. *Coral Reefs*, *17*(3), 263-272.

- LOCATION: Oʻahu HI including Hanauma Bay
- TYPE: Field Study
- In Text Citation: (Grigg 1998)
- SUMMARY:
    - At wave sheltered stations in Hanauma Bay and Kaneohe Bay, rates of long term reef accretion are about 2.0 mm/yr.
- METHODS:
    - Four stations on the island of Oahu were chosen for study situated along a gradient of increasing exposure to significant wave energy.
        - Checker Reef in Kaneohe Bay
        - Hanauma Bay, Channel area and offshore, cores taken near keyhole.
        - Mamala Bay
        - Sunset Beach
    - Hanauma was the second-most sheltered site from wave energy selected for the study.
    - In 1967 10 cores were drilled through the shallow fringing reef by Easton and Olson. This work showed that the reef at Hanauma began growing about 7000 yr ago at 15 m depth when rising sea level flooded the bay. Initially rate of accretion was high (averaged 4.5 mm/y). Horizontal accretion seaward at the reef crest was even greater, averaging almost 20 mm/y. During the last 3000 years accretion has slowed to 1 mm/y. In the middle of the reef flat, the youngest dated material was found to be 2000 to 3000 years old, suggesting that sea level reached its present level at this time and prevented the growth of younger material, or that a higher sea level existed for a time in the middle Holocene allowing younger growth to accrete by that subsequently sea level fell back to its current level and physical and biological erosion removed younger material. Overall during the last 7000 years accretion is averaged at 2.0 mm/y.
- RESULTS:
    - Communities at the shallow site at Hanauma Bay are constrained by subaerial exposure.
    - 12 m depth community at Hanauma Bay was dominated by *Porites compressa* and *Porites lobata.* Their relative abundances are 55% and 45 %, respectively. The growth rate of *P. lobata* at this depth was 8.13 mm/y, about twice the rate of vertical reef accretion measured by Easton and Olson (1996).

Table 1 Community structure and growth of coral reefs at sites selected for study. Attributes of community structure are based on one 50 m transect at each station. Annual coral growth rates are averages of 10 colonies

Site	Depth (m)	Coral cover %	Coral diversity (H′)	Algal cover %	Bare limestone %	Sand %	Dominant coral, algae	Coral growth (mm/y)
Kaneohe Bay	1	2 ± 5	0.16	5	1	95	P.c.	Negligible
	2–5	69 ± 20	0.35	9	3	19	P.c. M.v.	7.66
Hanauma Bay	1	< 1	< 0.01	90	10	0	P.o.	Negligible
	12	73 ± 14	0.87	0	5	10	P.c. P.l.	8.13
Mamala Bay	1	6 ± 3	0.15	90	5	5	P.m.	Negligible
	12	10 ± 5	0.35	2	40	40	P.l.	10.1
Sunset Beach	1	9 ± 8	0.53	60	20	0	P.l.	Negligible
	12	15 ± 13	0.68	20	65	0	P.m.	8.08

P.l., *Porites lobata*; P.c., *Porites compressa*; M.v., *Montipora verrucosa*; P.m., *Pocillopora meandrina*; P.o., *Porolithon oncodes* (coralline algae)



Hanauma Bay Attendance Year 2016 & 2017

- LOCATION: Hanauma Bay, Oʻahu HI
- TYPE: Summary Table
- In Text Citation: (Hanauma Bay Attendance 2017)
- SUMMARY:
    - July appears to be the busiest month.
    - February appears to be the slowest month.
    - Approximately 3,000 visitors per day.

Hanauma Bay Nature Preserve
Daily Attendance Summary

FISCAL YEAR JULY' 15 - JUNE' 16

Month	Visitors Monthly #	Visitors Daily Avg #	Visitors YTD #
JUL	87,385	3,236	87,385
AUG	82,986	3,074	170,371
SEPT	50,059	2,176	220,430
OCT	59,728	2,389	280,158
NOV	56,584	2,176	336,742
DEC	70,225	2,809	406,967
JAN	68,955	2,652	475,922
FEB	47,301	2,365	523,223
MAR	74,659	2,872	597,882
APR	64,419	2,478	662,301
MAY	61,743	2,375	724,044
JUN	79,983	3,076	804,027
TOTAL	804,027		

FISCAL YEAR JULY' 16 - JUNE' 17

Month	Visitors Monthly #	Visitors Daily Avg #	Visitors YTD #
JUL	87,180	3,353	87,180
AUG	86,193	3,315	173,373
SEPT	62,682	2,411	236,055
OCT	66,134	2,449	302,189
NOV	60,227	2,409	362,416
DEC	67,886	2,611	430,302
JAN	67,129	2,685	497,431
FEB	58,208	2,531	555,639
MAR	74,953	2,776	630,592
APR	69,820	2,685	700,412
MAY	66,894	2,573	767,306
JUN	75,133	2,890	842,439
TOTAL	842,439		

Hanauma Bay Case Study (1989)

- LOCATION: Hanauma Bay, Oʻahu HI and various other sites.
- TYPE: Case Studies
- In Text Citation: (Hanauma Bay Case Study 1989)
- SUMMARY:
    - MLCD's are established to meet two competing goals: 1) to provide for the conservation of the resource, and 2) to promote the use of a resource.
- INTRODUCTION:
    - Site-specific problems:
        - Sedimentation: erosion of topsoil caused by disturbance of vegetation from people walking and other upland areas are sources of sedimentation.
        - Runoff: from paved parking lot carrying oily residues, rat, mongoose and domestic animal wastes to the bay waters. Water at this time was running from shower stalls directly into the bay in a steady stream. Direct drainage of wastewater from the food/snorkel gear rental concessions.
        - Water Quality: Often have high levels of fecal coliform bacteria. Sewer backups are frequent at restrooms down at beach. High levels of bacteria are presumably caused by bird and animal wastes and possibly from cesspools. – this is not necessarily a health hazard to humans, but instead they are indicative of potential health risks.
        - Garbage: Lots of plastic garbage found on shoreline.
        - Reef Trampling: Since the majority of snorkelers that go to Hanauma are new to the ocean environment, they sometimes cling to the reef for support or do not know any better than to step on it. "Although early benchmark data on the live coral populations of the inner reef are

scarce, the continuous trampling across the reef is considered damaging to what little live coral is left."

Hanauma Bay Coral Cover (1999 & 2000)

Summary of coral cover within the bay.

- LOCATION: Hanauma Bay, Oʻahu HI
- TYPE: Tables from photocopy of unknown source (pg. 162)
- In Text Citation: (Hanauma Bay Coral Cover 2000)
- SUMMARY:
    - Dominant coral species were P. lobata, M. patula, P. eydouxi, P. meandrina.

Video Transect data (3 m):

% Cover:	1999		2000		
Species	Mean	SD	Mean	SD	Diff.
Cyphastrea ocellina	0.0	0.0	0	0	0.0
Fungia scutaria	0	0	0	0	
Leptastrea purpurea	0.0	0.0	0	0	0.0
Montipora flabellata	0.3	0.5	0.2	0.4	-0.1
Montipora patula	0.3	0.7	0.8	1.8	0.5
Montipora studeri	0	0	0	0	
Montipora capitata	0.0	0.1	0	0	0.0
Pavona duerdeni	0	0	0	0	
Pavona maldivensis	0	0	0	0	
Pavona varians	0	0	0.1	0.2	0.1
Pocillopora damicornis	0	0	0	0	
Pocillopora eydouxi	0	0	0.8	1.9	0.8
Pocillopora ligulata	0	0	0	0	
Pocillopora meandrina	0.7	0.7	0.8	0.8	0.1
Porites brighami	0	0	0	0	
Porites compressa	0.0	0.0	0	0	0.0
Porites evermanni	0	0	0	0	
Porites lichen	0	0	0	0	
Porites lobata	22.3	8.8	23.1	9.0	0.8
Porites rus	0	0	0	0	
Psammocora nierstraszi	0	0	0	0	
Unknown Coral	0	0	0	0	
Total Coral	23.6	9.1	25.8	9.4	2.2
Species Richness:	8		6		-2
Species Diversity:	0.28		0.48		0.20
Macroalgae	0.9	2.0	0	0	-0.9

Benthic Habitat Data: 3 m

	Depth (m)	Rugosity	Sediment Composition (% wt.)		Sediment Grain Size (% wt.)			
			LOI	H_2CO_3	Gravel	Coarse	Fine	Silt
Mean	3	2.00	4.65	46.51	20.42	68.56	10.82	0.20
S.D.		0.35	0.34	0.88	4.00	2.83	1.16	0.01

Hanauma Bay Hawaii Symposium. Nov, 19, 1983.

- LOCATION: Hanauma Bay, Oʻahu HI
- TYPE: Abstract/Summary of Symposium Talks
- In Text Citation: (Hanauma Bay Hawaii Symposium 1983)
- SUMMARY:
    - Bruce A. Carlson said that surveys of the fish fauna of Hanauma Bay prior to its establishment as a MLCD in 1967 are virtually non-existent.
        - DAR, formerly Div. of Fish and Game, began conducting surveys from 1967 to present of this symposium.

Hanauma Bay Nature Preserve Final Revised Environmental Assessment and Negative Declaration, 1996. Prepared by Wilson Okamoto & Associates, Inc.

- LOCATION: Hanauma Bay, Oʻahu HI
- TYPE: Impact Statement
- In Text Citation: (Wilson Okamoto & Associates 1996)
- SUMMARY:
    - Concerns about declining water quality in the bay due to increased siltation, freshwater runoff and litter have been expressed as early as 1970. In 1988, turbidity, trash and oil films were observed during user survey studies conducted by Wilson Okamoto and Associates, Inc. Soil runoff from the unpaved trafficked areas has also been implicated as a possible cause of increased turbidity in the bay.

- Potential threats to the water quality observed in 1988:
    - Siltation from storm and shower runoff;
    - Freshwater mixed with soaps and lotions from open showers;
    - Sewage from periodically overflowing cesspools; and
    - Cooking oils and other waste from the concession which leach into the bay through cesspools.
- Marine life Habitat
    - Corals account for a very small percentage of bottom cover within the nearshore waters of the fringing reef. The only coral present in any abundance is the common star coral *Cyphastrea ocellina*.
    - Coral cover increases in the -6 to -25 ft range, with total cover reaching about 45%.
    - At depths of -25 ft and beyond corals dominate the bottom, covering close to 80% of the substrate. Dense thickets of finger coral predominate at these depths, but lobe coral is fairly abundant.

Harada, S. Y., Goto, R. S., & Nathanson, A. T. (2011). Analysis of lifeguard-recorded data at Hanauma Bay, Hawaii. *Wilderness & environmental medicine*, *22*(1), 72-76.

- LOCATION: Hanauma Bay, Oʻahu HI
- TYPE: Analysis of Rescue Events
- In Text Citation: (Harada, Goto, and Nathanson 2011)
- SUMMARY:
    - Lifeguard collected data documenting estimates of daily beach attendance and characteristics of rescue victims and events ranging from 2000-2007.
    - Lifeguards recorded attendance and activity at 12 pm, 2 pm, and 4 pm. The sum of the 3 daily estimates for the swimming and surfing groups were used to calculate daily counts of visitors entering the water and at risk for rescue.
- RESULTS:
    - Found an average of 7 rescues per 10,000 bathers.
    - Non-residents accounted for 88% of visitors and 98% of the rescue population.
    - 63.2% of rescues were made in “the slot” the swimming channel to offshore.

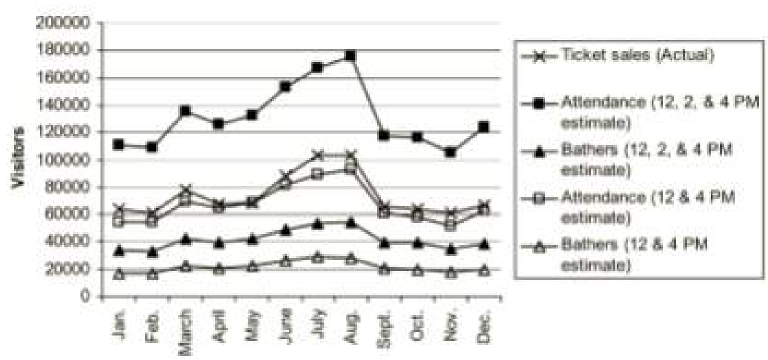


Figure 3. Comparison of lifeguard estimates of attendance and bathers with actual attendance based on ticket sales data averaged by month for years 2000 to 2007 at Hanauma Bay. Lifeguard estimates of attendance and bathers were calculated by summing estimates made at 3 available time points (12, 2, and 4 PM) and 12 and 4 PM time points. Lifeguard estimates summing all three and 12 and 4 PM time points differed from actual attendance by factors of 1.78 (SD = 0.08) and 0.91 (SD = 0.04), respectively. Trends in monthly ticket sales were highly correlated with lifeguard estimates of attendance (12, 2, and 4 PM, $R = 0.98$; 12 and 4 PM, $R = 0.98$) and bathers (12, 2, and 4 PM, $R = 0.97$; 12 and 4 PM, $R = 0.97$).

Jackson, J. (2007). Effects of Anthropogenic Physical Disturbance on Corals to Hanauma Bay. University of Hawaii at Manoa, Zoology Department. Hanauma Bay Directed Research Fall '07.

- LOCATION: Hanauma Bay, Oʻahu HI
- TYPE: Field Research Report and PowerPoint Presentation
- In Text Citation: (Jackson 2007)
- OBJECTIVE: Evaluate anthropogenic effects of visitors on corals inhabiting the relatively shallow area (0-3m) of the bay from the shoreline seaward out to 85m.
- SUMMARY:
  - Indicators examined: Percent coral cover, coral diversity (Shannon) and relative abundance of symbiotic organisms.
  - 5 transects in Keyhole, Channel, and Witches Brew inner reef.
  - Found coral cover to differ in the SW region from the NE and Center regions.
- METHODS:
  - 3 areas across the bay: Keyhole, Channel and Witches Brew
  - 5 Transects within each area
  - 85 m long, 5 m apart.
  - Photographs taken along transect every 5 m.
  - Photos were broken into 120 squares, all squares containing living coral were counted. Ratio of squares containing coral vs. squares that did not = percentage of coral cover.
  - Species were identified to lowest taxonomic group and counted. Invertebrate species were noted during the swim.
- RESULTS:
  - Shannon diversity index was determined by the total number of coral colonies per species. Combines the two quantifiable measures: (1) species richness (number of species in the community) and (2) abundance (total number of individuals in the sample).
    - SW had highest diversity index value (2.21) then NE (1.93), and Center (1.90).
  - Coral Species Abundance:
    - *Pocillopora meandrina* was most abundant in almost all regions, followed by *Porites lobata* and *Porites compressa*.
    - Coral cover was highest in the SW region (21%), followed by NE region (18%) and Center region (17%).
- Conclusion:
  - Most significant difference in coral diversity and cover was between SW and Center/NE regions
    - The SW area sees much less human traffic than center and NE regions.
    - The furthest SW transect held the greatest number of corals.
    - Claims the SW area has greater protection from surf and wind, less people because it has a less hospitable beach and less swimming space due to never having been dredged.
- Discussion:
  - Low coral abundance may not be entirely due to anthropogenic disturbance…
    - According to a geological study conducted by Easton and Olson in 1976, the rate of reef growth has slowed over the last 3,000 years and the youngest material from shallow limestone reef flat is approximately 480 +/- 100 years old.
    - Geological information indicates that during the past 300-500 years, corals have not been a dominant component of the near-shore shallow areas of Hanauma Bay (Bailey-Brock et al., 2007).

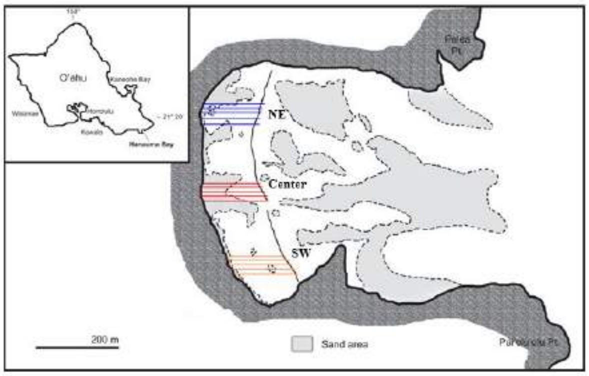
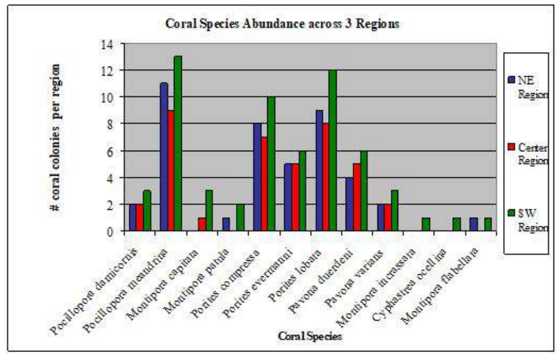


Figure 1: approximate locations of 3 sampled regions in Hanauma Bay
(map adapted from Bailey-Brock *et al* 2007)



Graph 2: Bar graph showing the abundance of each coral species identified across the three sampled regions of the Bay.

Coral Species	NE Region	Center Region	SW Region
Pocillopora damicornis	2	2	3
Pocillopora meandrina	11	9	13
Montipora capitata	0	1	3
Montipora patula	1	0	2
Porites compressa	8	7	10
Porites evermanni	5	5	6
Porites lobata	9	8	12
Pavona duerdeni	4	5	6
Pavona varians	2	2	3
Montipora incrassata	0	0	1
Cyphastrea ocellina	0	0	1
Montipora flabellata	1	0	1

Table 3: The total abundance of each coral species identified across the three sampled regions of the Bay.

Jayewardene, D. (2009). A factorial experiment quantifying the influence of parrotfish density and size on algal reduction on Hawaiian coral reefs. *Journal of Experimental Marine Biology and Ecology*, *375*(1-2), 64-69.

- LOCATION: Hanauma Bay, Oʻahu HI, Wawaloli & Keei, Big Island, HI
- TYPE: Field Study
- In Text Citation: (Danielle Jayewardene 2009)
- SUMMARY:
  - Small (<25 cm TL) parrotfishes at Hanauma:
    - Abundance = 2.9 ± 0.7 (#/ 100 m^2)
    - Biomass = 3.2 ± 1.1 (g/m^2)
  - Large (>25 cm TL) parrotfishes at Hanauma:
    - Abundance = 0.4 ± 0.1 (#/ 100 m^2)
    - Biomass = 2.3 ± 0.9 (g/m^2)
  - Both abundance and biomass of large and small parrotfishes at Hanauma were intermediate to the two other sites studied (Wawaloli – lowest, and Keei – highest).
  - Algal reduction rates at Hanauma were between 0-8% per day and were not significantly different between treatments where only small parrotfishes could graze, when compared to treatments available to all grazers.
- GOAL:

        - Use algal plots grown inside exclusion cages on reefs in the Main Hawaiian Islands to experimentally determine (1) how parrotfish density influence algal reduction rates and (2) whether large parrotfishes are more effective grazers than small parrotfishes.
- METHODS:
    - Parrotfish density at each site was empirically quantified using underwater visual census methods.
    - Between May 2005 – Oct. 2006, 6-8 separate visual surveys were carried out along 4 independent 4 x 4 x 25 m fixed belt transects at each site.
        - Number and size (length to nearest 5 cm)
        - Densities calculated from this by converting to weights using allometric length-weight conversion equation: $W = aSL^b$.
        - Background coral and algae abundance at each site was also recorded.
            - Photoquadrats along 10 randomly placed 20 m transects. 15 random images were taken per transect, and 20 random points analyzed per image.
    - Algal plots established at 10 m depth with fish exclusion cages.
        - Circular cages (30cm diameter) made of clothes wire frame covered with polypropylene mesh (1.3 cm x 1.3 cm) attached to substrate using cable ties. 16 cages at each site.
        - Cages placed for 8 months, after which algal biomass at all sites was higher within cages than on surrounding reef.
    - Algal plots exposed to grazing after 8 mo.
        - Half of cages had mesh removed completely, other cages had mesh replaced with 10.2 x 10.2 cm mesh to allow for small parrotfishes to graze.
        - Photoquadrats used to quantify algal reduction in experimental plots.
            - Daily photographs for 9 consecutive days after exposure.
            - 50 random points per image x3 for each image.
- RESULTS:
    - Algal community inside exclusion cages consisted primarily of filamentous spp. and grew to heights of 1-3 cm. Fleshy macroalgae were rare.
    - Algal reduction rates were positively related to both parrotfish density and size, and were up to 30% higher for large compared to small parrotfishes per unit biomass.
- DISCUSSION:
    - Across all sites, large parrotfishes were found to remove more algae per unit biomass compared to small parrotfishes.

Table 1
Density of small (<25 cm TL) and large (≥25 cm TL) parrotfishes at each of the three study sites expressed as number and biomass per unit area reef.

	Small parrotfishes (<25 cm TL)		Large parrotfishes (≥25 cm TL)	
	Abundance (#/100 m²)	Biomass (g/m²)	Abundance (#/100 m²)	Biomass (g/m²)
Wawaloli	0.6 ± 0.2	0.7 ± 0.3	0.1 ± 0.1	0.8 ± 0.4
Hanauma	2.9 ± 0.7	3.2 ± 1.1	0.4 ± 0.1	2.3 ± 0.9
Keei	4.0 ± 0.5	6.2 ± 0.7	0.9 ± 0.2	8.8 ± 1.6

Error values indicate ± SE.

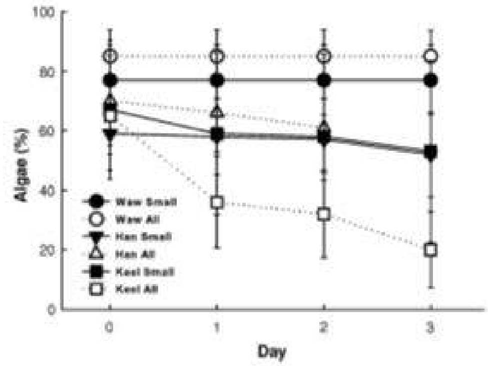


Fig. 3. Change in algal cover over a three day period in plots exposed to small (partial access plots) and all parrotfishes (full access plots) at the three study sites with different densities of parrotfishes. Error bars indicate ± SD.

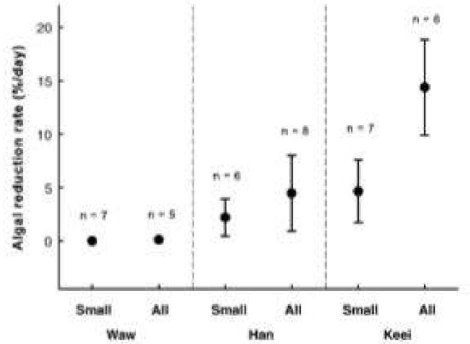


Fig. 4. Mean algal reduction rate (%/day) for plots exposed to small (partial access) and all parrotfishes (full access plots) at each of the three study sites. Error bars indicate 95% confidence interval.

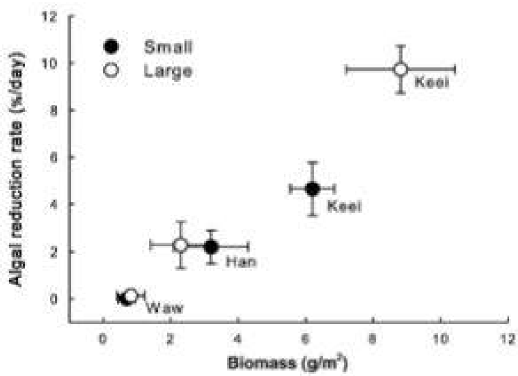


Fig. 5. Algal reduction rate (%/day) for small and large parrotfish in relation to their respective densities at each study site. Error bars for the y-axis and x-axis indicate ± SE.

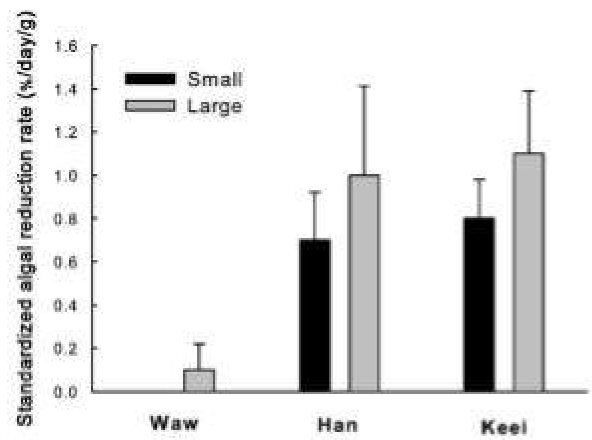


Fig. 6. The standardized algal reduction rate (%/day/g) for small and large parrotfish at the three study sites. Error bars indicate ± SE.

Jayewardene, D., Donahue, M. J., & Birkeland, C. (2009). Effects of frequent fish predation on corals in Hawaii. *Coral Reefs*, *28*(2), 499-506.

- LOCATION: Main Hawaiian Islands including a site at Hanauma Bay, Oʻahu HI
- TYPE: Field Study & Model
- In Text Citation: (D. Jayewardene, Donahue, and Birkeland 2009)
- SUMMARY:
    - Hanauma Bay Shallow:
        - 38 ± 6% total coral cover.
            - PC = 0% , PL = 19 ± 2 %, PM = 1 ± 0%
        - Bites:
            - # bites/m: PC = 0.2 ± 0.2, PL = 0 , PM = 0
            - # bites/ tile: small = 4 and large = 4
    - Hanauma Bay Deep:
        - 25 ± 2 % total coral cover
            - PC = 3 ± 1 %, PL = 20 ± 2 %, PM = 0%
        - Bites:
            - # bites/m: PC = 1.3 ± 0.5, PL = 0.9 ± 0.5 , PM = 0.2 ± 0.2
- GOAL:
    - To determine the role that corallivory by *C. dumerilii* and *A. meleagris* plays in influencing coral community structure in the Main Hawaiian Islands.

- METHODS:
  - March 2004 – Aug. 2005
  - 12 sites on 9 shallow coral reefs.
    - 2 “open” sites: Portlock and Wawaloli Beach
    - 7 “partial” management prohibiting lay nets: Puako, Anaehoomalu Bay, Wawaloli Fisheries Management Area, Wawaloli $FMA_{shallow}$, Papwai, Keei, and $Keei_{shallow}$).
    - 3 “no-take” MLCD: Hanauma Bay, Hanauma $Bay_{shallow}$, and Kealakakua Bay.
  - Coral abundance
    - 15 random photoquadrats (40 x 60 cm) along each 10 randomly located 20 m transects at each site. 20 random points per photograph.
  - Abundance of fish bites
    - Surveyed 5 independent 20 m transects within each 1,000 m^2 area. 10 quadrats (0.5 x 0.5 m) were randomly placed along each transects.
- RESULTS:
  - Abundance of lesions from fish bites on corals was quantified at nine shallow reefs in the main Hawaiian Islands.
    - Average 117 bite scars/m^2 on *Pocillopora meandrina* tissue from the barred filefish *Cantherhines dumerilii*.
    - Average 69 bite scars/m^2 on *Porites compressa* tissue, and 4 bites/m^2 on *Porites lobata* tissue from the spotted puffer *Arothron meleagris*.
      - Frequency of these bites on *P. compressa* declined exponentially with increasing coral cover.
  - Nubbins of two size classes (102 cm and 4-5 cm) were transplanted into the field at 6 sites.
    - Small nubbins were entirely consumed.
    - ≥ 4 cm nubbins were partially consumed and could recover.
    - At sites with high cover of *P. compressa*, nubbins were not preyed upon. At sites with < 5% *P. compressa* cover, nubbins were preyed upon.
  - Recovery from bites:
    - Bite lesions on *P. compressa* by *A. meleagris* fully recovered in 42 ± 2 days.
    - A model of risk of over predation (a second predation event before the first is healed) decreased exponentially with increase coral cover and increased linearly with increasing lesion healing time.
      - If there is low coral cover due to a disturbance, the risk of predation limiting the recovery of a coral population is high.
- DISCUSSION:
  - Bite frequency decreased exponentially with increasing abundance of coral prey.
  - Increased risk of corallivory at low coral cover could indicate an Allee effect (a decline in population growth rate at low density), limiting the recovery potential of coral populations.

Jokiel, P. L., Brown, E. K., Friedlander, A., Rodgers, S. K. U., & Smith, W. R. (2004). Hawai'i coral reef assessment and monitoring program: spatial patterns and temporal dynamics in reef coral communities. *Pacific Science*, *58*(2), 159-174.

- LOCATION: Main Hawaiian Islands
- TYPE: Field Monitoring
- In Text Citation: (Jokiel et al. 2004)
- SUMMARY:
  - Hanauma Bay was surveyed in 1999, 2000, and 2002 at 3 m and 10 m depth:
    - 3 meter: 23.6 (1999), 25.8 (2000), 21.8 (2002) percent coral cover.
    - 10 meter: 26.7 (1999), 27.0 (1999), 22.2 (2002) percent coral cover.

Komatsu, M., & Liu, J. C. (2007). Cross-cultural Comparison Between Japanese and Western Visitors for the Effectiveness of the Hanauma Bay Education Programme. *Tourism Recreation Research*, *32*(3), 3-12.

- LOCATION: Hanauma Bay
- TYPE: Social Study
- In Text Citation: (Komatsu and Liu 2007)
- SUMMARY:
  - Assessment of cross-cultural differences between Japanese and Western visitors to the visitor education program.
  - The educational film was effective for both visitor groups in terms of attitudinal and behavioral improvement toward marine conservation in the Bay, as well as enhancing visitor experience.
  - Western visitors were more likely to report higher ratings for education program and more pre-knowledge about conservation when compared to Japanese visitors.
  - Some suggestions made on how to incorporate cultural sensitivity in managing tourism sites:
    - More should be done to prepare visitors to expect to view the educational film as a part of their visit to the Bay.
    - Content of the film could be revised. The conservation behaviors: 'stand only on sand' and 'observe but don't touch the reef' were less likely to be followed by both visitor groups, compared to the other two points: 'don't touch the turtle' and 'watch the fish but don't feed them.'

Lankford, S., Inui, Y., Whittle, A., Luna, R., & Tyrone, D. (2005). Sustainability of coastal/marine recreation: Modeling social carrying capacity for Hanauma Bay, Hawaii. University of Hawaii.

- LOCATION: Hanauma Bay, Oʻahu HI
- TYPE: Social Carrying Capacity Study
- In Text Citation: (Lankford et al. 2005)
- SUMMARY:
  - Findings of this study suggest that perceived crowding may be an indicator of actual user counts, and that crowding negatively influences satisfaction levels.
  - "The Bay is exceeding the social carrying capacity (as measured in this study) when more than 3,200 (+/- 200 users) people per day use the Bay."
  - According to this study the social carrying capacity is 3,200 visitors per day.
  - Majority of visitors are beginner or intermediate snorkelers.
- INTRODUCTION:
  - Physical capacity is the amount of space available for the activity based on design and use levels.
  - Ecological or biological capacity is the ability of the resource to withstand recreational use without unacceptable damage to ecological components such as the water quality, reef bio-diversity and fish diversity.
  - Facility capacity involves additions to the recreation environment intended to support visitor needs.
  - Social capacity is the number and distribution of visitors that provide minimal acceptable recreation experiences.

Table 3.5: Snorkeling Skills and Frequencies to Snorkel

Statements	Total (%)	Residents (%)	Visitors (%)	t-test Value	Prob.
How would you describe your snorkeling expertise? [a]					
Professional	1.1	2.0	1.0		
Expert	5.9	12.9	4.5		
Advanced	16.1	27.7	13.8		
Intermediate	29.9	24.8	30.9		
Novice/Beginner	47.0	32.7	49.8		
$\bar{X}$	4.2	3.7	4.2	-4.313	0.000 [c]
How often do you snorkel?					
Never	24.6	12.7	27.0		
Not Often	43.1	34.3	44.9		
Sometimes	21.0	27.5	19.7		
Often	8.6	16.7	7.0		
Very Often	2.6	8.8	1.4		
$\bar{X}$	2.2	2.7	2.1	5.268	0.000 [c]

[a] Five-point Likert where 1 = professional, 2 = expert, 3 = advanced 4 = intermediate and 5 = novice/beginner.

[b] Measured on five-point Likert where 1 = never and 5 = very often.

[c] t-value is significant at $p < 0.01$. Where it is significant the mean values of residents and visitors groups are statistically different.

Mak, J., & Moncur, J. E. (1998). Political economy of protecting unique recreational resources: Hanauma Bay, Hawaii. *Ambio*, 217-223.

- LOCATION: Hanauma Bay, Oʻahu HI
- TYPE: Review
- In Text Citation: (Mak and Moncur 1998)
- SUMMARY:
  - Great review of the politics behind Hanauma Bay prior to 1997.
  - TIMELINE:
    - 1928
      - Deeded by Hawaiian princess Bernice Pauahi Bishop to the City and County of Honolulu and made into a public beach park.
    - 1967
      - Designated Hawai'i's first Marine Life Conservation District.
    - 1975
      - Half-million visitors/year.
    - 1977
      - Estimate of "recommended optimal use level" for Hanauma Bay was 1363 persons per day, with 330 person allotted for upper picnic area, 408 for the lower grassy area and 625 on the sandy beach (Wilson Okamoto & Associates, Inc., 1977).
        - Estimates derived using the Bureau of Outdoor Recreation and the U.S. Corps of Engineers Beach Capacity Standards of 50 persons per acre for the upper picnic area and 160 square feet per person for the lower grassy area and the beach.
    - 1985
      - 1.6 million visitors/year. (Wilson Okamoto & Associates, Inc., 1977)
    - Late 1980's
      - 2.8 million visitors/year, or over 7,5000 persons per day (State of Hawaii (1980-1990))
    - 1989
      - City's Department of Parks and Recreation (DPR) presented to the City Council an 8-point management plan.
        - Prohibited all tour vehicles from dropping off visitors at the park.
    - 1990
      - Hanauma Bay User Committee proposed industry self-regulation as an alternative to the 1989 City regulation. Committee members agreed not to use HB on Sundays and major holidays for six months beginning Feb, 18, 1990. This eventually fell through.

- 1990
    - June 12, 1990, the City Department of Parks and Recreation implemented the Hanauma Bay- General Plan.
        - Designed to restrict access to the bay, educate visitors on proper use of the bay, and improve facility at the bay.
        - Access to the park was restricted by…
            - Hiring traffic attendants to turn away cars after 300 stalls were filled and prevent illegal parking on the shoulders of the highway.
            - Prohibit tour companies from discharging passengers at the park past a 15-min sightseeing stop.
            - Closing the park on Wednesday mornings.
        - Education provided by the Friends of Hanauma Bay and the UH Sea Grant Extension Service co-operated to establish the Hanauma Bay Education Program (HBEP) August 1990.
- 1994, January 4th
    - City implemented a new rule limiting cabs to one passenger drop of per day because tour companies would drop off bus loads of tourists nearby and tell them to cab it into Hbay.
- 1994, October 31st
    - Smoking ban
- 1994
    - Started trying to wean off fish feeding (Alan Hong & State of Hawaii)
- 1995, July 1st
    - Charge admission to Hanauma Bay Nature Park
    - $5 nonresident tourist
    - Fees for commercial vehicles and taxis for the 15 min sightseeing.
    - Changes shortly after the bill passed…
        - Residents were charged $1
- 1996, January 9th
    - User fee collection ended.
- 1996, April 10th
    - Bill No. 1 reduced nonresident fees to $3 per person and everyone had to pay a $1 parking fee.

Maurin, P. (2008). *Informational exchanges among Hawaii marine stakeholders*.

- LOCATION: West Hawaii, Waianae, and Hanauma Bay, Oʻahu, HI
- TYPE: Review
- In Text Citation: (Maurin 2008)
- CHAPTER 5: Hanauma Bay MLCD
    - Road to Hanauma Bay was finished in 1927 making the bay more accessible to the public.
    - In 1964, a study by UH professor Ernst Reese estimated that 1,092 fish and 468 coral heads were being removed yearly.
    - "In 1997, yearly visitors to the Bay reached a peak of over 3 million." "Eight acres of beach area were being used by 10,000 visitors a day, making the Bay a victim of its own success. Water quality was visibly affected. By the end of the day a sheen of suntan lotion could be observed on the surface, and turbid waters diminished the value of the experience for all visitors. Parking lots were regularly overcrowded, and reefs were used as rest areas for snorkelers."
    - The stakeholders actively involved grew in 1990 to: Parks and Recreation, Honolulu City Council, Division of Land and Natural Resources, UH Sea Grant, Friends of Hanauma Bay, volunteers,

residents, tourists and, to a lesser degree, tour operators.

Table 4 – Timeline of Events at Hanauma Bay

Year	Event
1964	An activity survey at HB estimates a take of marine life in excess of a thousand fish specimens (1,092) and 468 coral heads per year by less than 12% of users.
1966	Proposal sent to the state Land Board recommending setting the Bay aside as an underwater sanctuary, based on 1964 HB activity survey.
1967	Designated as an Hawaii's first MLCD (no fishing, collecting of marine life or geological specimens)
1970	The Bay receives 209,997 visitors.
1980	Hanauma Bay yearly visitors surpass one million.
1981	City funds $1 million for infrastructure improvements and landscaping
1988	Visitor peak at 3.6 million per year, over 10,000 per day.
	Dept of Transportation enacts a ban on boats entering the Bay
1989	Newspaper articles detailing bay overuse and degradation appear in the front pages of Hawaii's largest newspaper.
	Sea Grant Extension proposes Education Program for the Bay.
1990	HB General Plan is drafted by the Honolulu Dept. of Parks and Recreation, recommending: Park hours for vehicular traffic, weekly half day closure of the Bay for maintenance, restriction of commercial tour activity, a visitor information center, control fish feeding, and the creation of HB Manager position.
	Grass-roots environmental organization Friends of Hanauma Bay founded to represent concerns of the local citizenry and to lobby the city government
	University of Hawaii at Manoa Sea Grant Extension Program develops the Hanauma Bay Education Program, with 1.5 FT staff and about 35 volunteers.
1992	New visitor center opens at the Bay
1993	City & County establishes a smoking ban at the Bay.
	Hanauma Bay Task Force presents its final report to state legislature, highlighting issues of environmental concern, including bay overuse, harmful bacteria levels in the water and not living up to the objectives of an MLCD.
1995	Entrance fee for non-residents enacted. Offices and concession built on upper park.
1996	City Council approves $3 admission fee for all out-of-state visitors over age of 12
1998	Hanauma Bay Education Center starts limited operations on the top park level and opens an informational beach kiosk, and staff expands to 3.5 staff and starts building up the volunteer base.
1999	Fish feeding ban enacted by City Council.
2000	Annual visitor levels drops to less than one million.
2002	New facilities open at the Bay ($13.5 million), including a large capacity theater showcasing educational film (translated into 7 languages), and park offices.
	HB Education Program grows to 5 FT staff and has over 75 volunteers.
2004	FOHB & Honolulu Visitors Bureau submit Smithsonian nomination for HB as example of sustainable tourism

Merrifield, M., & Aucan, J. (2009). Hanauma Bay Circulation Study Proposal.

- LOCATION: Hanauma Bay, Oʻahu, HI
- TYPE: Field Study Proposal
- In Text Citation: (Merrifield and Aucan 2009)
- SUMMARY:
    - Duration February 1, 2009 through January 31, 2012.
    - Seek to better understand the wave-generated rip currents at the inner reef as a function of incident wave and water level conditions. Would like to develop predictive tools to assess inner reef and outer bay circulations in response to different oceanic and meteorological conditions.
    - Use ADCP and drogues to measure the currents in Hanauma Bay.

Ong, L., & Holland, K. N. (2010). Bioerosion of coral reefs by two Hawaiian parrotfishes: species, size differences and fishery implications. *Marine biology*, *157*(6), 1313-1323.

- LOCATION: Hanauma Bay, Oʻahu, HI
- TYPE: Field Study
- In Text Citation: (Ong and Holland 2010)
- SUMMARY:

- Bioerosion rates were more influenced by parrotfish size, rather than feeding mode.
- Grazing by *Scarus rubroviolaceus* (a scraper) and *Chlorurus perspicillatus* (an excavator) encompassed 60% of the carbonate production of the fore reef area.
- Densities of different size classes of *S. rubroviolaceus* and *C. perspicillatus* within Hanauma Bay are available in Figure 2 and feeding preferences in Figure 3.

- GOAL: Quantify the Bioerosion rates of two similarly sized Hawaiian parrotfishes with two different feeding modes (*Scarus rubroviolaceus*- a scraper and *Chlorurus perspicillatus*- an excavator).
- METHODS:
  - Visual Census:
    - Feb. – Oct. 2006
    - Census of distribution and abundance of *S. rubroviolaceus* and *C. perspicillatus* on fore reef and reef shelf.
      - Numbers and Sizes (visual estimation of fork length in cm) recorded.
    - Transects 10 m wide and variable length.
      - 13 transects were conducted on the fore reef (lengths 27 – 132 m, width 10 m; depth <5 m).
      - 14 transects were conducted on the reef shelf (lengths: 57-168 m, width 10 m; depth 5 – 10 m).
  - Feeding Rates:
    - Behavioral observations were conducted from Sept. – Oct. 2002 and Feb- April 2003, in order to estimate feeding rates.
- RESULTS:
  - Feeding modes did not affect bioerosion rates but that bioerosion rates were size dependent, with the largest individuals (*S. rubroviolaceus* 45-54 cm FL) bioeroding up to 390± 67 kg per individual per year.
  - Onset bioerosion happens at 15 cm in length for both species.
- DISCUSSION:
  - First study to provide estimates of bioerosion by large parrotfishes in Hawaii.
  - Fish size was found to be the paramount determinant of bioerosion rates for the two species observed.

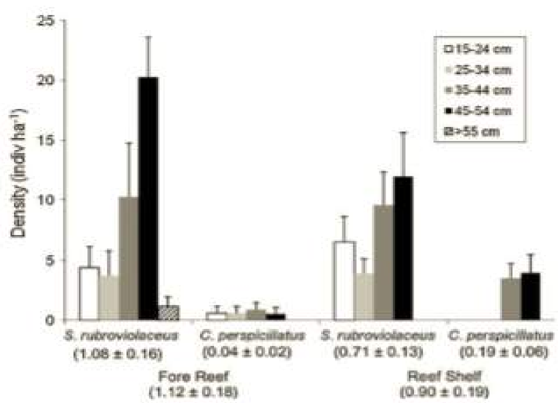


Fig. 2 Densities of *S. rubroviolaceus* and *C. perspicillatus* on the fore reef and reef shelf at Hanauma Bay. Calculated bioerosion rates (±SE, kg m^{-2} year^{-1}) for each species and for each reef zone are in *parentheses*

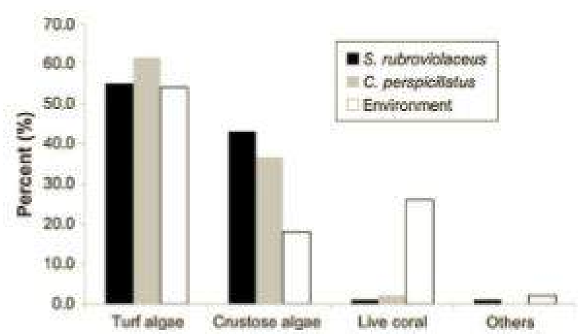


Fig. 3 Feeding preferences of *S. rubroviolaceus* ($n = 75$) and *C. perspicillatus* ($n = 82$) compared with availability in the environment ($n = 71$). Percent abundances of food type available in the environment are normalized for the size of the area of the fore reef and reef shelf

Oshiro, R., & Fujioka, R. (1995). Sand, soil, and pigeon droppings: sources of indicator bacteria in the waters of Hanauma Bay, Oahu, Hawaii. *Water Science and Technology*, *31*(5-6), 251.

- LOCATION: Hanauma Bay & Ala Moana Beach, Oʻahu, HI
- TYPE: Field Study

- In Text Citation: (Oshiro and Fujioka 1995)
- SUMMARY:
  - The major sources contributing to periodic high levels of bacteria in the waters of the Bay are contaminants of the beach sand, such as pigeon feces.
  - In contrast to the sand at Ala Moana Beach, the sand at Hanauma Bay was determined to contain considerably higher concentrations of fecal coliform, *E. coli*, and enterococci.
- METHODS:
  - Water samples collected from 3 sectors (east, middle, west).
  - Contaminants of sand such as land runoff (shower/cleaning water, rain) and mongoose and pigeon fecal droppings from Hanauma Bay were tested as possible contributors of indicator bacteria.
  - Standard membrane filtration technique was used to determine the conc. Of indicator bacteria in samples.
  - Selective media include mFC for fecal coliform, mTEC for *E. coli*, and mE for enterococci.
  - Sand samples were washed in equal volumes of 3.5% NaCl and mixed vigorously by hand, allowed to settle for 1-2 min, and supernatant was obtained. Two such elusions were required to remove more than 90% of bacteria from the sand. Supernatants were diluted and then membrane filtered.
- RESULTS:
  - Water samples:
    - Highest amount of fecal coliform in middle bay (1-103 CFU/100 ml), then eastern (0-45 CFU/100 ml), then western (1-8 CFU/100 ml).
    - Enterococci numbers at these same sites ranged from 2-24 CFU/100 ml at Hanauma Bay east, 0-104 CFU/100 ml at middle.
    - The highest concentrations of all indicator bacteria were recovered from the middle sector.
  - Sand samples:
    - Hanauma Bay sand contained much higher concentrations of fecal coliform, *E.coli*, and enterococci than the sand from Ala moana Beach.
    - In sand collected below two feet of water at Hanauma: 160 fecal coliform, 96 *E. coli* and 68 enterococci/100g.
    - In sand collected in surf zone at Hanauma: 320 fecal coliform, 44 *E. coli* and 192 enterococci/100g.
    - In dry sand at Hanauma: 184,000 fecal coliform, 160,000 *E. coli* and 32,000 enterococci/100g.
    - Farthest inland sands at Hanauma contained: 2,420,000 fecal coliform, 967,000 *E. coli* and 160,000 enterococci/100g.
- DISCUSSION:
  - As moisture content of the sand decreased and soil content increased (moving toward land), bacterial count increased.
  - In contrast to the sand at Ala Moana Beach, the sand at Hanauma Bay was determined to contain considerably higher concentrations of fecal coliform, *E. coli*, and enterococci.
    - Partially attributed to the high terrigenous content of sand at Hanauma.
  - Results of this study suggest that sand, contaminated with indicator bacteria, is the major source contributing to the periodic high levels of bacteria in the waters of Hanauma Bay.

Reynolds, E. (1990, May). Hanauma Bay baseline users survey. In *Proceedings of the 1990 Congress on Coastal and Marine Tourism* (Vol. 1, pp. 106-116).

- LOCATION: Hanauma Bay, Oʻahu, HI
- TYPE: User Survey
- In Text Citation: (Reynolds 1990)
- SUMMARY:

- Survey involved two parts: (1) Counting the number of people and vehicles entering the park and the number of people walking down or riding the tram to the beach. (2) Questionnaire given on random basis to beach visitors.
- Average number of visitors to the park per day was 6,707 with a range of 5,477 to 8,938, with 73.5% going down to the beach.
- Recommended that his survey should be performed at least once a year in alternating seasons order to effectively manage people using the bay.

Rodgers, K. S., Bahr, K. D., Jokiel, P. L., & Donà, A. R. (2017). Patterns of bleaching and mortality following widespread warming events in 2014 and 2015 at the Hanauma Bay Nature Preserve, Hawai ‘i. *PeerJ*, *5*, e3355.

- LOCATION: Hanauma Bay, Oʻahu, HI
- TYPE: Field Study
- In Text Citation: (Rodgers et al. 2017)
- SUMMARY:
    - Elevated temperature throughout the bleaching event was more influential in coral bleaching/mortality than high circulation or visitor use.
    - In 2014, Hawai'i DAR coral bleaching assessments determined 47% of corals exhibited signs of bleaching in the HBNP--mortality was not documented.
- OBJECTIVE: understand the spatial extent of bleaching mortality in Hanauma Bay Nature Preserve (HBNP), O'ahu, Hawai'i to gain a baseline understanding of the physical processes that influence localized bleaching dynamics. Quantify bleaching prevalence and subsequent mortality within the four major sectors of the HBNP and define how they relate to temperature and currents.
- METHODS:
    - Coral Surveys:
        - 4 Sectors of HBNP: Backdoors(BD), Keyhole (KH, Channel (CH), and Witches Brew (WB).
        - 2- 15 m x 5 m transects were surveyed in each sector. Depths <1 m. All coral colonies within the 75 m^2 area were counted.
        - Recorded: Coral species, Colony size, and Percent of colony that was live, pale, bleached, and recently dead.
        - Sites were repeatedly found using handheld Garmin Geko 201 GPS unit, graphic and written documentation of positions using triangulation, and underwater photographic imagery of distinct initial and concluding coral colonies on each transect.
    - Temperature:
        - HOBO temp Pro v2 Data Loggers in each of the 4 sectors took temp every 15 min. to calculate a mean mid-day difference among transects.
        - Data were used to calculate mean mid-day differences among transect temperatures.
    - Currents:
        - Whittle (2003)
        - Nearshore current patterns were determined using lagrangian current drogues.
    - Stats:
        - Bleaching prevalence was analyzed using a GLM with sector as a fixed factor and transect nested within sector.
        - Temp was treated with a repeated measures mixed model by location with transect nested within locations.
- RESULTS:
    - Bleaching Prevalence
        - Highest bleaching found in *Pavona varians* & *Pocillopora meandrina*
        - Bleaching prevalence was sig. Different among sectors with highest levels at keyhole and witches brew compared to back doors and channel.

- Colony size in all locations was similar, but number of colonies at WB was higher when compared to average number of cologies at BD and KH.
- Coral Mortality
  - Highest mortality at WB and BD. Lower mortality at KH and CH.
  - Recovery was slowest at WB.
  - Highest mortality rates seen in *Porites lobata* and *Pocillopora meandrina*.

Rodgers, K. S. (2005). Evaluation of Nearshore Coral Reef Conditions and Identification of Indicators in the Main Hawaiian Islands. A Dissertation Submitted to the Graduate Division of The University of Hawaii. (1-218 pg).

- LOCATION: Main Hawaiian Islands
- TYPE: Field Studies
- In Text Citation: (Rodgers 2005)
- SUMMARY pertaining to Hanauma Bay:
  - Found organic values close to 5%, ranking in the upper range of the majority of the stations, yet have very low levels of the silt/clay fraction typical of sedimented areas.
  - The following are possible explanations for the high organics and low silt/clay found at Hanauma Bay…
    - Low contribution of terrigenous material from the surrounding watershed.
    - Past or current history of fish feeding.
    - High fish biomass.

	LOI (%)		$CaCO_3$ (%)		Terrigenous (%)	
MOLOKA'I	mean	sd.	mean	sd	mean	sd
O'AHU						
Hanauma 3m	4.7	0.3	46.5	0.9	48.8	1.7
Hanauma 10m	5.0	0.1	59.0	1.5	36.1	3.2

Sanderson, S. L., & Solonsky, A. C. (1980, January). A COMPARISON OF 2 VISUAL SURVEY TECHNIQUES FOR FISH POPULATIONS. In *PACIFIC SCIENCE* (Vol. 34, No. 3, pp. 337-337). 2840 KOLOWALU ST, HONOLULU, HI 96822: UNIV HAWAII PRESS.

- LOCATION: Hawaiian Islands including Hanauma Bay
- TYPE: Field Study
- In Text Citation: (Sanderson et al. 1980)
- SUMMARY:
  - Comparison of two visual census techniques for describing and quantifying fish communities. Techniques were compared in terms of replicability, observer bias, minimal number of replicate surveys required to adequately represent the species composition of a specific fish community, daily variations in data, and sensitivity to distinctions between fish communities.
    - Brock Method
    - Jones and Thompson Method
      - More variable results, but could be due to observer bias.
- METHODS:
  - 11 days of fieldwork at Hanauma in 1979.
- RESULTS:
  - Mean number of species recorded per Brock survey and the mean number recorded per Jones and Thompson survey was no different at Hanauma Bay.

- Only results on comparison of methods. No results were given on fish biomass, abundance, or species richness.

Sano, M. E., Dickerson, B., Reynolds, B., Rosenfeld, C., Russell, S., Stender, G., Teshima-Miller, K. (1990). Hanauma Bay Ecological Survey: A Baseline Study Honolulu, Hawaii. *Marine Option Program, University of Hawaii.*

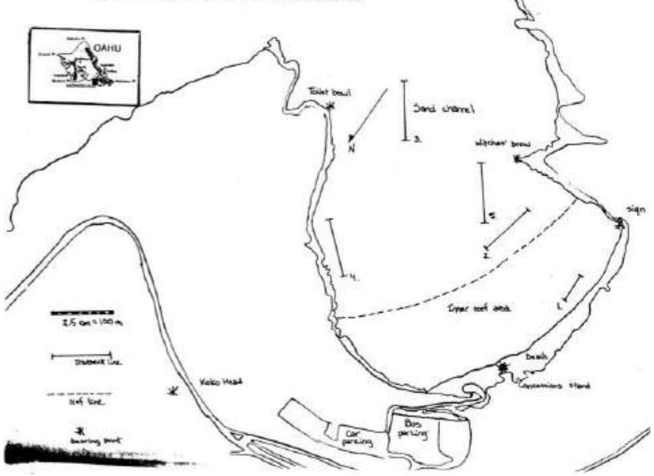
- LOCATION: Hanauma Bay, Oʻahu, HI
- TYPE: Field Study
- In Text Citation: (Sano et al. 1990)
- METHODS:
  - 5- 100 meter transects (except transect 1 was 50 m).
    - #1 was on inner reef flat, other 4 were located in deeper water.
  - Coral, invertebrates and algae were recorded
- RESULTS:
  - Transect #1: "Substrate was mostly reef rock, coral rubble, and a mixture of sand and coral rock. Very small patches of dead *Pocillopora sp.* were recorded. Three small patches (5-8 cm) of *Porites lobata* were also recorded, however, due to the nature of the point – intersecting method, they are not counted in the data assessment." Some *Leptastrea purpurea* were seen.
  - Transect #2: 20.36% coverage of *Porites lobata. Pocillopora meandrina* was often present, but dead- so was counted in "other".
  - Transect #3: All sand
  - Transect #4: Small patches of *Porites compressa* and *Pavona duerdeni*. *P. meandrina* was found along this transect, but was dead. *Montipora capitata* was the dominant species but had signs of bleaching. Several algae spp. were present.
  - Transect #5: *P. lobata* was the dominant species with small colonies of *P. compressa*.
  - Transect #6 & #7: Reef rock covered with algal mat.
- DISCUSSION:
  - *M. capitata* showed signs of bleaching on one transect and *P. meandrina* was found dead on several occasions.

Table 2

Average percent coverage of substrate

	Transect 1	2	3	4	5
Corals:					
Leptastrea purpurea	0.67	0.0	0.0	0.0	0.36
Montipora capitata	0.0	0.0	0.0	5.82	0.73
Montipora flabellata	0.0	0.0	0.0	0.0	0.36
Pavona duerdeni	0.0	0.36	0.0	0.0	0.0
Pavona varians	0.0	0.36	0.0	0.0	0.0
Pocillopora meandrina	0.0	0.73	0.0	0.37	0.73
Porites compressa	0.0	0.73	0.0	0.0	1.09
Porites lobata	0.0	20.36	0.0	0.73	6.18
Other invertebrates:					
Palythoa tuberculosa	0.0	1.45	0.0	0.0	0.36
Algae:					
Grateloupia filicina	0.0	0.0	0.0	0.44	0.0
Porolithon species	0.67	0.0	0.0	0.0	0.0
Sand	0.0	8.36	100.	41.45	20.73
Other *	98.67	67.64	0.0	50.90	68.36
Total average % of live coral	0.67	22.54	0.0	6.92	9.45

Figure 1. Map of study site with transect locations.



Sigall, B. (2013). Phone cable installation shut down Hanauma Bay. *Honolulu Star-Advertiser*.

- LOCATION: Hanauma Bay, Oʻahu, HI
- TYPE: News
- In Text Citation: (Sigall 2013)
- SUMMARY:
    - October 1956, trucks, barges, bulldozers and dynamiters came to Hanauma to extract coral to dig a trench for twin 1-inch cables.
    - Coral and water shot more than 60 ft into the air.
    - The water was filled with silt and covered in oil which did not clear till 10 days after the dredging stopped.

Smith, K. A., Rocheleau, G., Merrifield, M. A., Jaramillo, S., & Pawlak, G. (2016). Temperature variability caused by internal tides in the coral reef ecosystem of Hanauma bay, Hawai ʻi. *Continental Shelf Research*, *116*, 1-12.

- LOCATION: Hanauma Bay, Oʻahu, HI
- TYPE: Field Study
- In Text Citation: (Smith et al. 2016)
- GOAL:

    - Determine whether the proximity to a major semidiurnal internal tide generation site would lead to strong internal tide signatures within the bay, was verified by the presence of strong semidiurnal temperature variations in the lower layer during summer.
- METHODS:
    - March to June 2009
    - Currents, temp, and wave energy inside Hanauma bay were investigated using size Nortek acoustic Doppler current profilers (Aquadopps), two Nortek Acoustic Wave and Current profilers (AWACs) and a Hydroid REMUS-100 AUV.
    - All profilers recorded temp and pressure.
- CONCLUSIONS:
    - Semidiurnal internal tides generate over the ridge offshore of Makapu'u Point on the southeast corner of the island of O'ahu propagate into the shallow coral reef habitat of Hanauma Bay.
    - In spring (and likely winter) the energy associated with these internal tides causes fluctuations in currents but is accompanied by little change in temperature, due to the fact that the upper water column is well mixed.
    - In summer, intensified surface stratification allows the internal tide to cause temperature drops as large as 2.7°C in the bay.
    - Semidiurnal temp drops due to the internal tide occur consistently twice a day throughout May and June in 15 m water and are even present occasionally at depths as shallow as 5 m.

Stamoulis, K. A., Delevaux, J. M. S., Williams, I. D., Friedlander, A. M., Reichard, J., Kamikawa, K., & Harvey, E. S. (2018-Draft). Incorporating fish behavior improves accuracy of species distribution models.

- LOCATION: Hanauma Bay, O'ahu, HI & Pūpūkea, O'ahu
- TYPE: Field Study
- In Text Citation: (Stamoulis et al. 2018)
- SUMMARY:
    - Compared the accuracy of species distribution models (SDMs) which include minimum approach distance (MAD) as a predictor with SDMs that do not. Comparisons were made at 2 marine reserves on O'ahu within and outside of the reserves.
    - MAD varied between sites and was lower inside reserves than in fished areas, providing a proxy of fish wariness.
    - MAD was correlated to estimate fishing pressure, and greatly improved accuracy of SDMs when included as a predictor.
- INTRO:
    - MAD- "minimum approach distance"
        - The distance between the diver and the fish at its closest point
    - Fishing pressure directly increases fish wariness and decreases *true* fish biomass, while increased fish wariness may decrease *observed* fish biomass, due to survey diver avoidance.
- METHODS:
    - Samples collected inside and outside of two no-take marine reserves on O'ahu, Hanauma Bay and Pūpūkea, from June 2016 to May 2017.
    - Transect locations were randomly selected within management type (reserve and open) on hard-bottom habitats using ArcGIS.
    - 5 x 25 m belt transects on SCUBA—3 min per transect.
    - Stero-Dov system used two Canon high-definition video cameras mounted 0.7 m apart on a base bar inwardly converged at 7° to provide a standardized field of view.
    - Measurements of fish length, distance (range) and angle of the fish from the center of the camera system were obtained from imagery.
        - From which they calculated MAD of all targeted reef fishes.
- RESULTS:
    - At Hanauma Bay there were 572 observations inside the reserve and 167 outside.

- Three schools of greater than 50 individuals were recorded in Hanauma Bay reserve, the two large of the schools (n = 150, 75) consisting of *Acanthurus triostegus* and the third (n = 62) made up of *Acanthurus leucopareius.*
- Both marine reserves had significantly higher biomass of targeted fishes.
  - Ratio of mean targeted fish biomass inside the reserve vs. outside was 4.9 for Hanauma Bay and 1.5 for Pūpūkea.
- Reserve sites had lower MAD, though not significant.
- When MAD was included as a predictor, models were able to explain ~20% more of the variability in targeted fish biomass.
- MAD was significantly lower inside the reserve compared to open areas for Hanauma.

- DISCUSSION:
  - Fish body length had a positive relationship with MAD.
    - Optimal fitness theory predicts that as reproductive value increases, risk-taking should decrease (Clark, 1994).
  - MAD was positively correlated with estimated fishing pressure. Because high fishing pressure is associated with increased wariness and low biomass of targeted species, it is logical to assume maximum MAD where there is minimum biomass.

Stender, G., & Russell, S. (1991). Quantitative survey of fishes at Hanauma Bay, Oahu.

- LOCATION: Hanauma Bay, Oʻahu, HI
- TYPE: Economic Survey
- In Text Citation: (Stender and Russel 1991)
- SUMMARY:
  - 5- 100 m transects were conducted for fish surveys. Fish were counted 3 m out from either side of the transect tape.
  - Transect 1 (inner reef transect): A total of 139 fishes were observed, representing 28 spp. from 10 families. The average number of fishes per acre was 937.555 with an average biomass of 384.049 lbs. per acre.
    - Five dominant spp. by abundance were *Acanthurus triostegus, Thalassoma duperrey, Acanthurus xanthopterus Kyphosus bigibbus, Abudefduf sordidus,* and *Parupeneus multifasciatus.*
    - Five dominant spp. in biomass were *Acnthurus xanthopterus, Kyphosus biggibus, Chaenomugil leuciscus, Abudefduf sordidus,* and *Mugil cephalus*.
    - The 5 dominant spp. by abundance accounted for 68% of the standing crop.
  - See paper for fish survey results table.

van Beukering, P., & Cesar, H. S. (2004). Ecological economic modeling of coral reefs: Evaluating tourist overuse at Hanauma Bay and algae blooms at the Kihei Coast, Hawai'i. *Pacific Science*, *58*(2), 243-260.

- LOCATION: Hanauma Bay, Oʻahu, HI
- TYPE: Economic Survey
- SUMMARY:
  - The first ecological economic model of coral reefs in Hawai'i.
  - A survey on consumer and mostly on modeling economics.
  - The Hanauma Bay study showed that visitors are willing to pay much more for their experience (around $10) than they are currently doing and that the net benefits of the education program (around $100 million) greatly exceed the cost of the program (around $23 million) over time.
- Field survey methods:

- Purpose was to determine the average profile of each user group in terms of actual expenditure, directly attributable to the diving or snorkeling trip, the consumer surplus for this experience, and the willingness to pay for a healthier marine environment.

Vieth, G. R., & Cox, L. J. (2001). Sustainable Use Management of Hanauma Bay. *Department of Natural Resources and Environmental Management*, CTAHR—July 2001 (2 p.).

- LOCATION: Hanauma Bay, Oʻahu, HI
- TYPE: Review
- In Text Citation: (Vieth and Cox 2001)
- SUMMARY:
    - Found that nonresident user fees, if high enough, can be used to reduce the actual use of Hanauma Bay to capacity--which they coin at 1363 people per day (1977 Hanauma bay beach park site development plan).
    - Surveys of 43 U.S. mainland residents who visited Hanauma Bay found that it would take a user fee of $30 to $40 per day to discourage people from using the bay.

Figure 1. Hanauma Bay capacity and use.

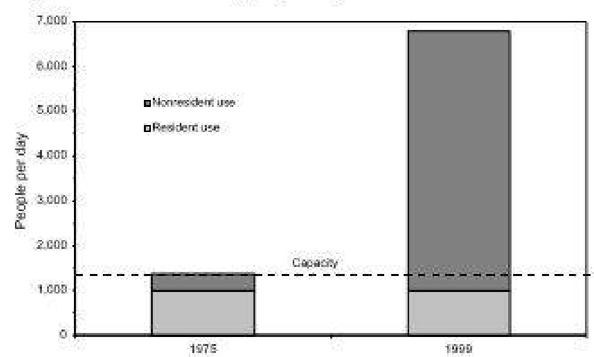
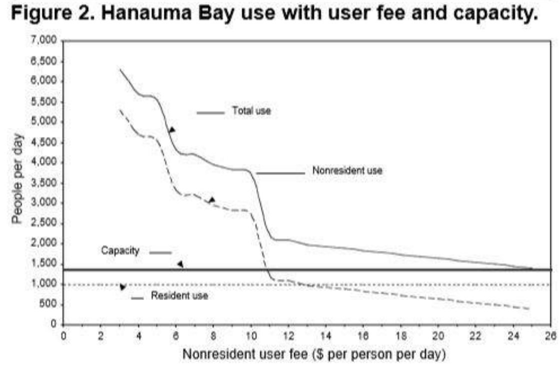


Figure 2. Hanauma Bay use with user fee and capacity.



Walton, M. M. (2013). Do marine protected areas facilitate coral reef ecosystem health? An investigation of coral disease and its associated factors in Oahu's marine life conservation districts (Doctoral dissertation, University of Hawai'i at Manoa).

- LOCATION: Hanauma Bay, Oʻahu, HI
- TYPE: Field Study
- In Text Citation: (Walton 2013)
- SUMMARY:
    - Field surveys were used to quantify coral disease prevalence, coral cover, macroalgal cover, fish abundance and diversity, and coral community size structure at each of the sites. Inorganic-organic carbon fractions of sediments and sediment grain size categories were also measured.
- METHODS:
    - Coral colony density was documented along the 10 m line by counting and recording all the coral colonies whose centers fell within 1 m on either side of the transect line.
        - Colonies were identified to species and placed into a size class bin.
    - Disease assessments were conducted within the same transect and each coral with disease was photographed. Coral colonies with diseased lesions were classified by lesion type: tissue loss, discoloration, or growth anomalies.
    - Coral disease prevalence was calculated as the total number of colonies of a specific coral species with a specific lesion type divided by the total number of colonies of that species (both healthy and diseased).
    - Reef fish abundance and diversity were recorded using a visual belt transect survey method along a 25 x 5 m belt transect. Fish were identified to the lowest taxonomic group, tallied, and assigned an

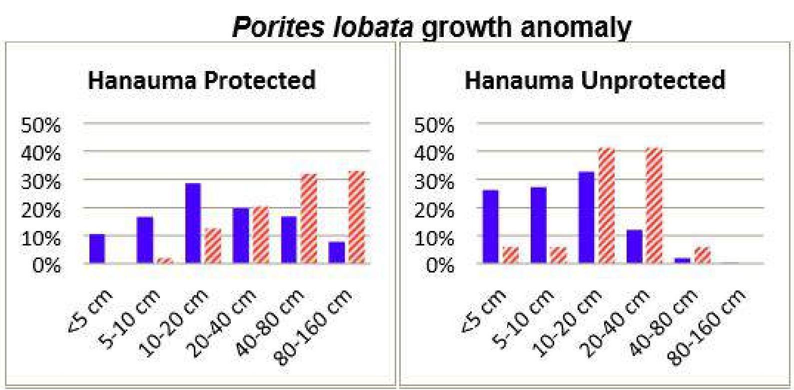
estimated total length (cm), then grouped into 6 trophic guilds: herbivores, mobile invertebrate feeders, sessile invertebrate feeders, piscivore, zooplanktivores, and detritivores.

- Sediment samples were collected at each transect. Composition and grain size were performed.

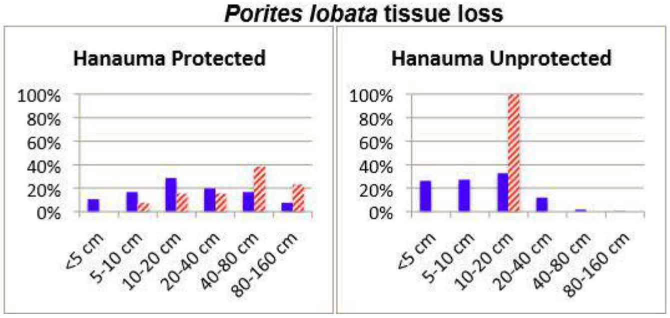
- RESULTS:
  - Hanauma bay had two out of the five lesion types that showed significantly higher prevalency in the MLCD compared to the adjacent control site: *Porites lobata* growth anomaly and *Porites lobata* tissue loss.
  - Hanauma also appeared to have overall more lesion types and prevalence than Pupukea or Waikiki MLCD's
  - Coral and fish species richness and evenness was similar across all 3 MLCD locations.
  - Hanauma sediment was ~92% carbonate, ~6% Terrigenous and ~3% Organic.
  - Herbivores were the most trophic guild in Hanauma.
- DISCUSSION:
  - The types of disease present and how prevalent the diseases were differed significantly between locations.
  - Hanauma had the highest amount of silt.
- Appendix B:
  - Mean coral cover for 2012-2013 was 32.43% and similar levels were recorded in 1992 (34.65%) and 1976 (37.65%) at 30 ft depth.

Table 5. Mean prevalence of five common diseases across protection boundaries at the three study locations. Standard errors in parentheses. * indicates a significant difference across the protection boundary based on a Kruskal-Wallis test (p<0.05).

Hanauma		
Lesion type	**Protected**	**Unprotected**
Porites lobata growth anomaly*	16.47 (1.79)	0.85 (0.36)
Porites lobata trematodiasis	10.83 (2.62)	2.77 (0.72)
Porites lobata tissue loss*	1.72 (0.50)	0.07 (0.04)
Porites lobata lesion with red filamentous alga*	3.64 (0.94)	5.67 (4.97)
Pocillopora meandrina tissue loss	3.04 (1.37)	3.62 (0.91)



***Porites lobata* tissue loss**



***Porites lobata* trematodiasis**

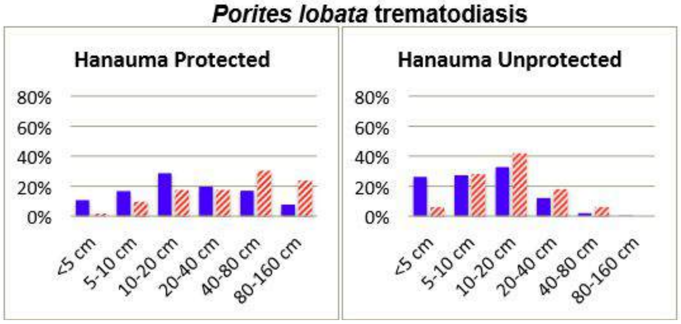


Table 11. Proportion (%) of organic, carbonate, and terrigenous materials. Sample statistics are overall mean ± standard deviation for each site.

Site	Organic	Carbonate	Terrigenous
Hanauma - Protected	3.1 ± 1.2	91.8 ± 7.7	5 ± 7.1

Table 12. Proportion (%) of sediment grain-size categories. Sample statistics are overall mean ± standard deviation for each site.

Site	Rubble	Gravel	Coarse sand	Fine sand	Silt
Hanauma - Protected	5.4 ± 2.0	24.6 ± 13.1	33.5 ± 9.0	21.2 ± 12.7	15.3 ± 9.7

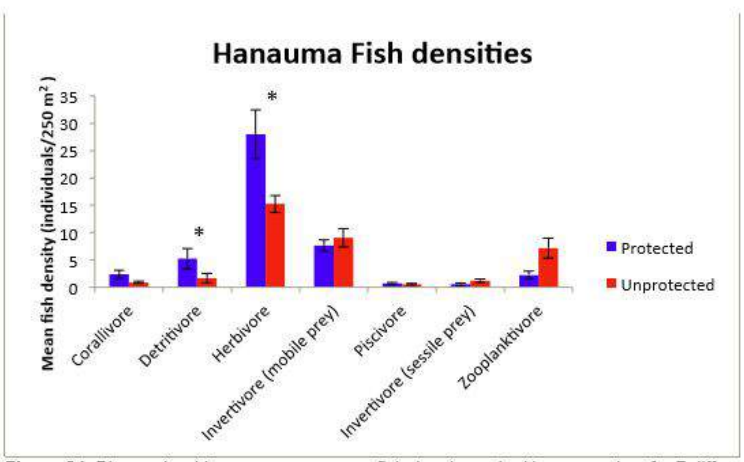


Figure 24. Blue and red bars represent mean fish density at the Hanauma sites for 7 different trophic guilds. Black lines indicate standard error and * indicates significant difference between protected and unprotected sites for that location (Kruskal-Wallis test, $p<0.05$).

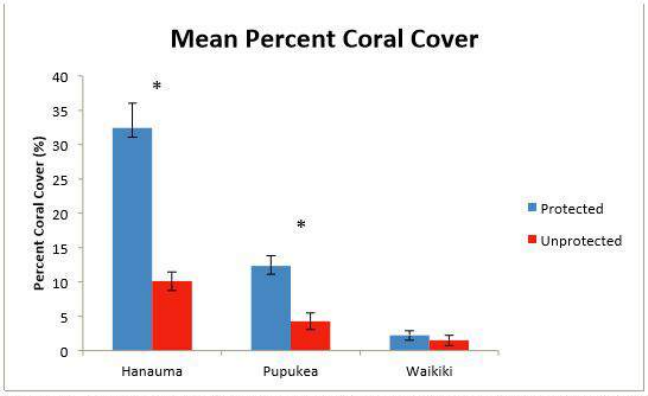


Figure 28. Blue (protected) and red (unprotected) bars represent mean percent coral cover at each of the locations. Black lines show standard error and * indicates significant difference between protected and unprotected sites for that location (Kruskal-Wallis test, $p<0.05$).

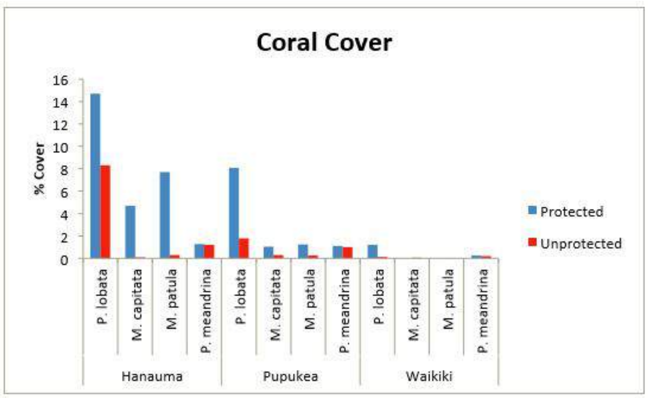


Figure 29. Blue (protected) and red (unprotected) bars represent mean percent coral cover for four of the most common coral species at each of the locations.

Table 18. Comparison with historical prevalence data from (Hunter 1999; Aeby et al. 2011c) for Hanauma sites. Prevalence is shown as a percentage followed by the standard error in parentheses where available.

Hanauma

	Porites Trematodiasis	*Porites* Growth anomaly	*Porites* Tissue loss
Hunter (Hanauma- Protected) 1992	N/A	41.7% (4.41)	N/A
Hunter (Hanauma- Protected) 1994	N/A	28.8% (8.98)	N/A
Hunter (Hanauma-Protected) 1998	N/A	35.0% (3.00)	N/A
Aeby (Hanauma Protected Deep) 2004-2005	0%	3.7%	1.1%
Aeby (Hanauma Protected Shallow) 2004-2005	1.4%	1.4%	1.4%
Aeby (Hanauma Unprotected) 2004-2005	4.4%	8.7%	1.6%
Walton (Hanauma-Protected) 2012-2013	10.8% (2.62)	16.5% (1.79)	1.7% (0.50)
Walton (Hanauma-Unprotected) 2012-2013	2.8% (0.72)	0.9% (0.36)	0.1% (0.04)

Table 19. Comparison with historical prevalence data from (Aeby et al., 2011c) for Pupukea sites. Prevalence is shown as a percentage followed by the standard error in parentheses where available.

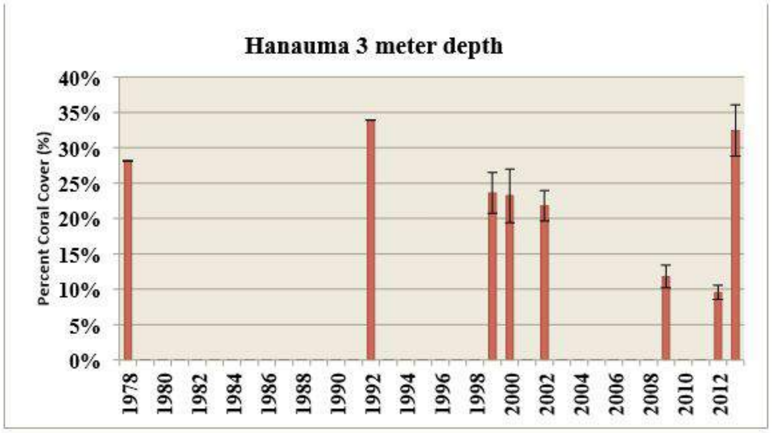


Figure 35. Historical data on mean coral cover at Hanauma Bay for a 3-meter depth spanning from 1978-2013. Data from 1978 (Anderson 1978), 1999 (Hunter 1999), 1999-2012 (CRAMP, unpublished), and 2013 (Walton, 2013). Where available standard error is shown with black bars. The data from (Walton, 2013) reports mean coral cover for surveys conducted at a mean depth of 5.5 meters.

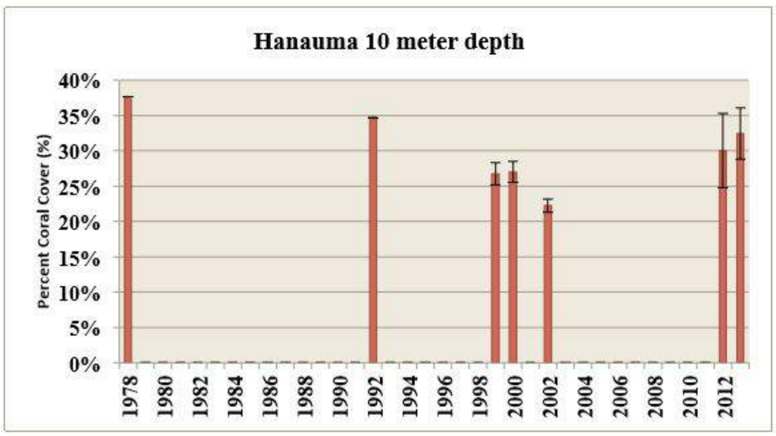


Figure 36. Historical data on mean coral cover at Hanauma Bay for a 10-meter depth spanning from 1978-2013. Data from 1978 (Anderson 1978), 1999 (Hunter 1999), 1999-2012 (CRAMP, unpublished), and 2013 (Walton, 2013). Where available standard error is shown with black bars. The data from (Walton, 2013) reports mean coral cover for surveys conducted at a mean depth of 5.5 meters.

Appendix C: Disease Prevalence Maps

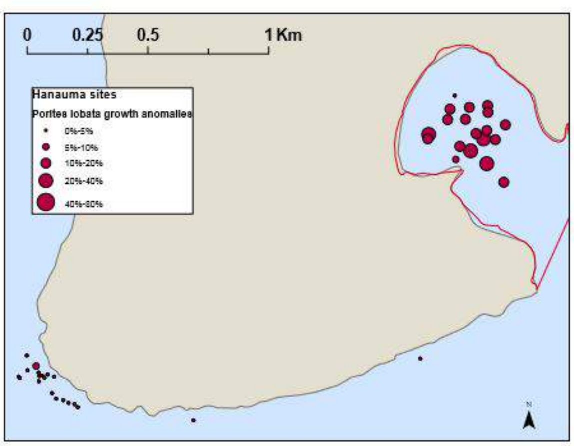


Figure 42. Prevalence of *Porites lobata* growth anomalies at the Hanauma sites. Red lines mark the boundary of the MLCD.

Wanger, J.R. (2001). Interpretive Education as a Conservation Tool at Hanauma Bay Nature Preserve, Hawaii. Master of Arts in Geography. University of Hawaii. 123p.

- LOCATION: Hanauma Bay, Oʻahu, HI
- TYPE: Social Study
- In Text Citation: (Wanger 2001)
- SUMMARY:
    - This thesis evaluates the degree of effectiveness of the Hanauma Bay Education Program as well as examines the historical events, decision making processes and interest group dynamics that have influenced the operation of HBEP.
- Interpretive Environmental Education at Hanauma Bay:
    - Trampling was in higher occurrence at all tidal levels when the education program was closed. While education program was open tramping presence appears to be around 6% of swimmers at low, average and high tide. Very low tide saw no tramplers while the education program was open.
- Conclusions:
    - Education efforts were found to contribute to increased awareness of rules and appropriate behavior within the preserve resulting in behavior modifications. This awareness, however, did not translate into an increased understanding of the Hanauma Bay environment.

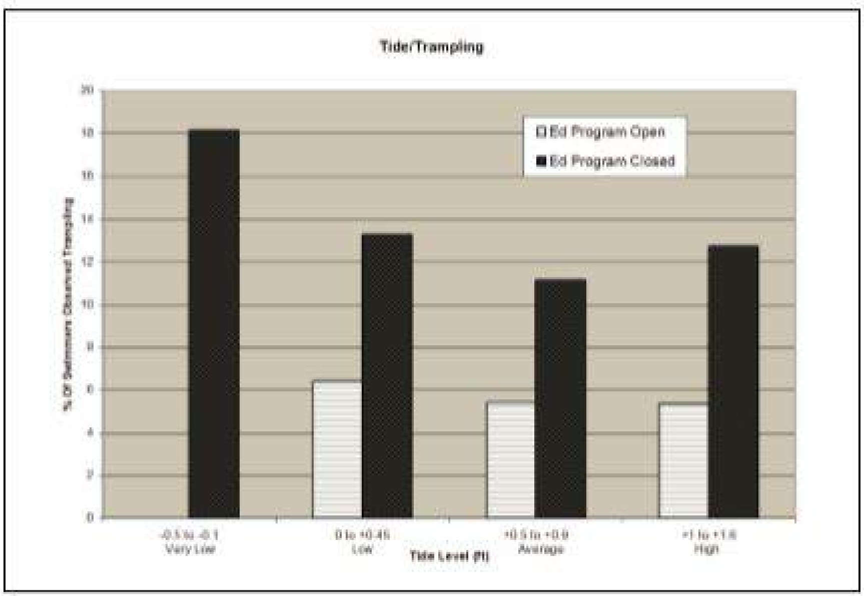


Figure 2. Trampling/ Tidal Aggregation. For each range of tide levels, average reef trampling levels are shown for both days when HBEP was open (n=218 observed trampling) and closed (n= 1,250 observed trampling). Error bars represent standard error between means. (Source: field observations, Open: 5/24, 27, 29 & Closed: 6/2, 7, 10). See data: ***Appendix I Tables 4 & 5.***

Wedding, L. M., Friedlander, A. M., McGranaghan, M., Yost, R. S., & Monaco, M. E. (2008). Using bathymetric LIDAR to define nearshore benthic habitat complexity: Implications for management of reef fish assemblages in Hawaii. *Remote Sensing of Environment*, *112*(11), 4159-4165.

- LOCATION: Hanauma Bay, Oʻahu, HI
- TYPE: Field Study
- In Text Citation: (Wedding et al. 2008)
- SUMMARY:

- Lidar-derived rugosity (4 m grid size) was found to be highly correlated with in-situ rugosity and was concluded to be a viable method for measuring rugosity in analogous coral reef environments.
- Lidar-derived rugosity was a good predictor of fish biomass and demonstrated a strong relationship with several fish assemblage metrics.
- No raw data tables or graphs in the paper, only statistical data.

- GOALS:
  - Determine whether lidar technology can provide effective rugosity measures on a coral reef in Hawaii.
  - To Examine the relationship between reef fish assemblage characteristics and LIDAR-derived rugosity.
- METHODS:
  - 33 transects surveyed in May 2004 using a stratified random design.
    - Several on the inner and outer reef.
  - Fish assemblages were assessed in a 25 m x 5 m belt transect at a constant speed. Fish were identified to the lowest possible taxon. Total length of fish was estimated to the nearest cm.
  - Rugosity:
    - Measured with brass chain.
- RESULTS:
  - Lidar-derived rugosity at the 4 m grid size had a sig. positive association with the *in situ* rugosity.
  - *In-situ* rugosity demonstrated strong positive correlations with abundance, diversity, richness and biomass of fishes.

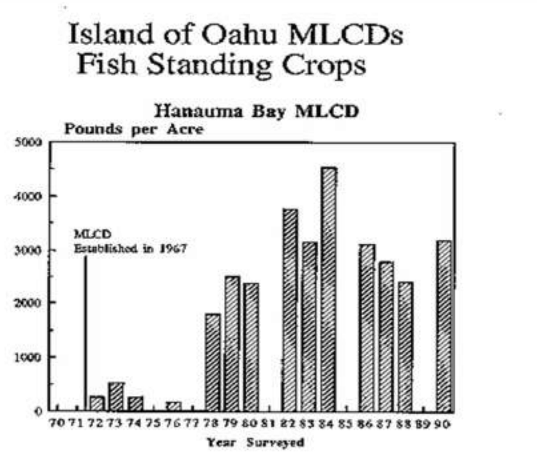
Whittle, A. G. (2003). *Ecology, abundance, diversity, and distribution of larval fishes and Schindleriidae (Teleostei: Gobioidei) at two sites on O'ahu, Hawai'i* (Doctoral dissertation, University of Hawaii at Manoa). Chapter 2.

- LOCATION: Hanauma Bay, Oʻahu, HI
- TYPE: Field Study
- In Text Citation: (Whittle 2003)
- SUMMARY:
  - Light traps deployed in Hanauma Bay over a 2.5 year period
    - Significantly more larval fishes caught in light traps moored over sand habitats vs. rubble, coral, or mixed habitats.
  - Currents measured with drogues
    - Pattern was shoreward and westerly.
  - Chapter 2: Physical Factors in Hanauma Bay
    - Examines the hypothesis that non-biological factors, such as substrate, currents, tides, lunar phase, season, waves, and temperature strongly affect larval ecology, abundance, diversity, and distribution.
- METHODS:
  - Light traps were deployed in 4 areas of Hanauma Bay over 33 nights between December 1999 and July 2002.
    - Tested the difference between different substrates: sand, coral, rubble, and mixed.
  - 6 drogues constructed of 1 m x 1 m x 0.5 m pvc piping with tarp tie-wrapped within the frame.
    - Drogues were individually marked with different color flags and weighted at the bottom with an 8 oz fishing weight.
    - Every 10 min. the position and angle of the drogue was recorded.
    - Recorded at incoming, outgoing, mixed tide, and calm days.
- RESULTS:
  - No significant lunar correlation with *Schindleria* catch data.
  - No significant lunar or monthly correlation with larval reef fish catch.
  - As the temperature and tidal range increased, the number of larval fishes caught increased.

- The *Schindleria* had a negative relationship with sea surface temperature and significant positive relationship with tidal range.
- DISCUSSION:
  - Adults of photopositive species (Mullidae, Acanthuridae, Synodontidate, Gobiidae, Blennidae) are present inside the Bay, but were rare or non-existent in light trap catches—therefore populations of these spp. within the Bay are likely structured by post-settlement processes such as migration, competition and predation.
    - This theory could be tested by mark-recapture studies and observation of juvenile and adults.

Island of Oahu MLCDs Fish Standing Crops

- LOCATION: Hanauma Bay, Oʻahu, HI
- TYPE: Table
- In Text Citation: (Island of Oahu MLCDs Fish Standing Crops 1990)
- SOURCE: Elizabeth Kumabe, SeaGrant



As you can see, surveys taken shortly after the establishment of the MLCD in 1967 show very low fish populations within the bay. The impressive number and diversity of fish you see today is due to the Hanauma's protected status.

Work Cited

Bailey-Brock, Julie et al. 2007. "Anthropogenic Disturbance on Shallow Cryptofaunal Communities in a Marine Life Conservation District on Oahu, Hawaii." *International Review of Hydrobiology* 92(3): 291–300.

Brock, Richard E. 1997. *Hanauma Bay: A Proposed Study to Determine Human Impact Both Today and in the Future*. Honolulu, HI.

Brock, Richard E, and Alan Kam. 2000. *Carrying Capacity Study for The Hanauma Bay Nature Preserve Final Report*. Honolulu, HI.

Brock, Vernon E. 1954. "A Preliminary Report on a Method of Estimating Reef Fish Populations." *The Journal of Wildlife Management* 18(3): 297–308.

Brown, Eric K et al. 2004. "Development of Benthic Sampling Methods for the Coral Reef Assessment and Monitoring Program (CRAMP) in Hawai'i." *Pacific Science* 58(2): 145–58.

Bryan, Wilfred B, and Robert S Stephens. 1993. "Coastal Bench Formation at Hanauma Bay, Oahu, Hawaii." *Geological Society of America Bulletin* 105(3): 377–86.

Clark, Athline M. 2016. "Hawaii's Sustainable Marine Tourism Challenges and Opportunities PowerPoint Preserntation."

Coffee, N. 2020. "COVID-19 and the Results of Tourism Absenteeism on the Marine Ecosystem in Hanauma Bay , Oʻahu , Hawai ʻ I." *University of Hawaiʻi Sustainable Tourism Class Pape*: 1–37.

Downs, Craig A. 2018. *Baseline Measurement of Seawater for Oxybenzone Contamination at the Hanauma Bay Marine Life Conservation District*.

Easton, W. H., and E. A. Olson. 1976. "Radiocarbon Profile of Hanauma Reef, Oahu, Hawaii." *Geological Society of America Bulletin* 87(5): 711–19.

Friedlander, A. et al. 2018. "Spatial and Temporal Trends in Hawai'i's Marine Protected Areas." *Aquatic Conservation: Marine and Freshwater Ecosystems*: 48p.

Friedlander, A. M., L.M. Wedding, E. Brown, and M.E. Monaco. 2010. "Monitoring Hawaii's Marine Protected Areas: Examining Spatial and Temporal Trends Using a Seascape Approach." *NOAA Technical Memorandum NOS NCCOS 117 Prepared by the NCCOS Center for Coastal Monitoring and Assessment Biogeography Branch. Silver Spring, MD.*: 130.

Friedlander, Alan M, Eric K Brown, and Mark E Monaco. 2007. "Coupling Ecology and GIS to Evaluate Efficacy of Marine Protected Areas in Hawaii." *Ecological Applications* 17(3): 715–30.

Gardner, Emily A. 1999. "A Victim Of Its Own Success: Can User Fees Be Used To Save Hanauma Bay?" *Ocean and Coastal Law Journal* 4: 81.

Grigg, R. W. 1998. "Holocene Coral Reef Accretion in Hawaii: A Function of Wave Exposure and Sea Level History." *Coral Reefs* 17(3): 263–72.

"Hanauma Bay Attendance." 2017.

Hanauma Bay Case Study. 1989. Honolulu, HI.

"Hanauma Bay Coral Cover." 2000.

"Hanauma Bay Hawaii Symposium." 1983. In Honolulu, HI.

Harada, Scott Y., Ralph S. Goto, and Andrew T. Nathanson. 2011. "Analysis of Lifeguard-Recorded Data at Hanauma Bay, Hawaii." *Wilderness and Environmental Medicine* 22: 72–76.

"Island of Oahu MLCDs Fish Standing Crops." 1990.

Jackson, J. 2007. *Effects of Anthropogenic Physical Disturbance on Corals to Hanauma Bay*. Honolulu, HI.
Jayewardene, D., M. J. Donahue, and C. Birkeland. 2009. "Effects of Frequent Fish Predation on Corals in Hawaii." *Coral Reefs* 28(2): 499–506.
Jayewardene, Danielle. 2009. "A Factorial Experiment Quantifying the Influence of Parrotfish Density and Size on Algal Reduction on Hawaiian Coral Reefs." *Journal of Experimental Marine Biology and Ecology*.
Jokiel, P. L. et al. 2004. "Hawai'i Coral Reef Assessment and Monitoring Program: Spatial Patterns and Temporal Dynamics in Reef Coral Communities." *Pacific Science* 58(2): 159–74.
Komatsu, Maki, and Juanita C. Liu. 2007. "Cross-Cultural Comparison Between Japanese and Western Visitors for the Effectiveness of the Hanauma Bay Education Programme." *Tourism Recreation Research* 32(3): 3–12.
Lankford, Samuel V et al. 2005. *Sustainability of Coastal/Marine Recreation: Modeling Social Carrying Capacity for Hanauma Bay, Hawaii.* Honolulu, HI.
Mak, J., and James E T Moncur. 1998. "Political Economy of Protecting Unique Recreational Resources: Hanauma Bay, Hawaii." *Ambio*: 217–23.
Maurin, P. 2008. "Informational Exchanges among Hawaii Marine Stakeholders."
Merrifield, M., and J. Aucan. 2009. *Hanauma Bay Circulation Study Proposal*.
Neilson, Brian. 2014. *DAR Survey Coral Bleaching Rapid Response Surveys*.
Ong, Ling, and Kim N. Holland. 2010. "Bioerosion of Coral Reefs by Two Hawaiian Parrotfishes: Species, Size Differences and Fishery Implications." *Marine Biology* 157(6): 1313–23.
Oshiro, R., and R. Fujioka. 1995. "Sand, Soil, and Pigeon Droppings: Sources of Indicator Bacteria in the Waters of Hanauma Bay, Oahu, Hawaii." *Water Science and Technology* 31(5–6): 251.
Reynolds, E. 1990. "Hanauma Bay Baseline User Survey." In *1990 Congress on Coastal and Marine Tourism*, , 106–16.
Rodgers, K. S. 2005. "Evaluation of Nearshore Coral Reef Conditions and Identification of Indicators in the Maine Hawaiian Islands." A Dissertation Submitted to the Graduate Division of The University of Hawaii.
Rodgers, Ku'ulei S., Keisha D. Bahr, Paul L. Jokiel, and Angela Richards Donà. 2017. "Patterns of Bleaching and Mortality Following Widespread Warming Events in 2014 and 2015 at the Hanauma Bay Nature Preserve, Hawai'I." *PeerJ* 5: e3355.
Sanderson, S Laurie et al. 1980. *A Comparison of Two Visual Survey Techniques for Fish Populations*. Honolulu, HI.
Sano, M. E. et al. 1990. Marine Options Program *Hanauma Bay Ecological Survey: A Baseline Study*. Honolulu, Hawaii.
Sigall, Bob. 2013. "Phone Cable Installation Shut down Hanauma Bay."
Smith, Katharine A. et al. 2016. "Temperature Variability Caused by Internal Tides in the Coral Reef Ecosystem of Hanauma Bay, Hawai'i." *Continental Shelf Research* 116: 1–12.
Stamoulis, K. A. et al. 2018. "Incorporating Fish Behavior Improves Accuracy of Species Distribution Models." *Draft*.
Stender, George, and Steve Russel. 1991. *Quantitative Survey of Fishes at Hanauma Bay, Oahu*. Honolulu, HI.
Vieth, Gary R, and Linda J Cox. 2001. *Sustainable Use Management of Hanauma Bay*.

Honolulu, Hawaii.
Walton, M. M. 2013. “Do Marine Protected Areas Facilitate Coral Reef Ecosystem Health? An investigation of Coral Disease and Its Associated Factors in Oahu’s Marine Life Conservation Districts.” Doctoral dissertation, University of Hawaii at Manoa.
Wanger, J.R. 2001. “Interpretive Education as a Conservation Tool at Hanauma Bay Nature Preserve.” University of Hawaii at Manoa, Geography Department.
Wedding, Lisa M. et al. 2008. “Using Bathymetric Lidar to Define Nearshore Benthic Habitat Complexity: Implications for Management of Reef Fish Assemblages in Hawaii.” *Remote Sensing of Environment* 112(11): 4159–65.
Whittle, A. G. 2003. ProQuest Dissertations and Theses “Ecology, Abundance, Diversity, and Distribution of Larval Fishes and Schindleriidae (Teleostei: Gobioidei) at Two Sites on O’ahu, Hawai’i.” https://search.proquest.com/docview/305327126?accountid=6180%0Ahttp://dw2zn6fm9z.search.serialssolution.com?ctx_ver=Z39.88-2004&ctx_enc=info:ofi/enc:UTF-8&rfr_id=info:sid/ProQuest+Dissertations+%26+Theses+Global&rft_val_fmt=info:ofi/fmt:kev:mtx:dissertati.
Wilson Okamoto & Associates, Inc. 1996. “Hanauma Bay Nature Preserve Final Revised Environmental Assessment and Negative Declaration.”

Hanauma Fish Studies

Brock, R. E., & Kam, A. (2000). *Carrying Capacity Study for The Hanauma Bay Nature Preserve Final Report*. Honolulu, HI.

- LOCATION: Hanauma Bay, Oʻahu, HI
- TYPE: Biological Study
- In Text Citation: (Brock 1954)
- SUMMARY:
    - *Zebrasoma flavenscens* was not common.
    - The weight of the fish in a school of opelu, *Decapterus pinnulatus* accounts for a large portion of the miscellaneous species.
    - Table 1. Hanauma Bay survey on 9/11/52
        - Number of fish counted = 819
        - Calculated weight Pounds = 137
        - Mean weight of fish = 0.17
        - Calculated pounds per acre = 100
        - Bottom = ½ over sand some rock and coral.

Stender, G., & Russel, S. (1991). *Quantitative Survey of Fishes at Hanauma Bay, Oahu*. Honolulu, HI.

- LOCATION: Hanauma Bay, Oʻahu, HI
- TYPE: Biological Study
- In Text Citation: (Stender and Russel 1991)
- SUMMARY:
    - Transect 1 (inner reef transect): A total of 139 fishes were observed, representing 28 spp. from 10 families. The average number of fishes per acre was 937.555 with an average biomass of 384.049 lbs. per acre. (43 g/m2)
        - Five dominant spp. by abundance were *Acanthurus triostegus, Thalassoma duperrey, Acanthurus xanthopterus Kyphosus bigibbus, Abudefduf sordidus,* and *Parupeneus multifasciatus.*
        - Five dominant spp. in biomass were *Acnthurus xanthopterus, Kyphosus biggibus, Chaenomugil leuciscus, Abudefduf sordidus,* and *Mugil cephalus*.
        - The 5 dominant spp. by abundance accounted for 68% of the standing crop.

Brock, R. E., & Kam, A. (2000). *Carrying Capacity Study for The Hanauma Bay Nature Preserve Final Report*. Honolulu, HI.

- LOCATION: Hanauma Bay, Oʻahu, HI
- TYPE: Biological Study
- In Text Citation: (Brock & Kam 2000)
- SUMMARY:
    - "The most obvious species on the inner reef flat at Hanauma Bay are the fishes. The most abundant species include the sergeant major or mamo (*Abedefduf abdominalis*), chub or nenue (*Kyphosus bigibbus*), convict tang or Manini (*Acanthurus triostegus*), ringtail surgeonfish or pualo (*Acanthurus blochii*), blackspot sergeant or kupipi (*Abudefduf sordidus*), brown surgeonfish or ma'I'I'I (*Acanthurus nigrofuscus*), saddle back wrasse or hinalea lauwili (*Thalassoma duperrey*), and bluelined surgeonfish or ta'ape (*Lutjanus kasmiraI*). The mean number of species seen per transect is 19 and the mean number of individual fishes censused per transect is 153 individuals. In terms of estimated standing crop, the average biomass per transect on the inner reef flat station is 410 g/m^2. Over the year, the most important contributors to this biomass were the nenue (*Kyphosus bigibbus*), pualo (*Acanthurus blochii*), Manini (*Acanthurus triostegus*), eyestripe surgeofish or palani (*Acanthurus dussumieri*) , orangespine surgeofish or umaumalei (*Naso lituratus*), ta'ape (*Lutjanus kasmira*), mamo (*Abudefduf abdominalis*), stareye parrotfish or ponuhunuhu (*Calotomus carolinus*), redlip parrotfish or palukaluka (*Scarus rubroviolaceus*), spectacle parrotfish or uhu uliuli (*Scarus perspicillatus*) and blue trevally or omilu (*Caranx melampygus*). A list of the species of fishes encountered in the inner reef area is given in Table 6."

"The standing crop of fish is significantly greater (P>0.0002) on Wednesdays (mean = 655 g/m^2) over the preceding Tuesdays (mean biomass = 381 g/m^2). This result is probably related to the feeding activities that were occurring on the days with visitors present, and were not occurring on the days when they were absent."

Friedlander, A. M., Brown, E. K., & Monaco, M. E. (2007). Coupling Ecology and GIS to Evaluate Efficacy of Marine Protected Areas in Hawaii. *Ecological Applications*, *17*(3), 715–730.

- LOCATION: Hanauma Bay, Oʻahu, HI
- TYPE: Biological Study
- In Text Citation: (Brock & Kam 2000)
- SUMMARY:
    - Size of protected area was positively correlated with a number of fish assemblage characteristics.

Jayewardene, D. (2009). A factorial experiment quantifying the influence of parrotfish density and size on algal reduction on Hawaiian coral reefs. *Journal of Experimental Marine Biology and Ecology*. https://doi.org/10.1016/j.jembe.2009.05.006

- LOCATION: Hanauma Bay, Oʻahu, HI
- TYPE: Biological Study
- In Text Citation: (Jayewardene 2009)
- SUMMARY:
    - Small (<25 cm TL) parrotfishes at Hanauma:
        - Abundance = 2.9 ± 0.7 (#/ 100 m^2)
        - Biomass = 3.2 ± 1.1 (g/m^2)
    - Large (>25 cm TL) parrotfishes at Hanauma:
        - Abundance = 0.4 ± 0.1 (#/ 100 m^2)
        - Biomass = 2.3 ± 0.9 (g/m^2)
    - Both abundance and biomass of large and small parrotfishes at Hanauma were intermediate to the two other sites studied (Wawaloli – lowest, and Keei – highest).

Ong, L., & Holland, K. N. (2010). Bioerosion of coral reefs by two Hawaiian parrotfishes: Species, size differences and fishery implications. *Marine Biology*, *157*(6), 1313–1323. https://doi.org/10.1007/s00227-010-1411-y

- LOCATION: Hanauma Bay, Oʻahu, HI
- TYPE: Biological Study
- In Text Citation: (Ong & Holland 2010)
- SUMMARY:
    - First study to provide estimates of bioerosion by large parrotfishes in Hawaii.
    - Fish size was found to be the paramount determinant of bioerosion rates for the two species observed.
    - Feeding modes did not affect bioerosion rates but that bioerosion rates were size dependent, with the largest individuals (*S. rubroviolaceus* 45-54 cm FL) bioeroding up to 390± 67 kg per individual per year.
    - Onset bioerosion happens at 15 cm in length for both species.

Stamoulis, K. A., Delevaux, J. M. . S., Williams, I. D., Friedlander, A. M., Reichard, J., Kamikawa, K., & Harvey, E. S. (2018). Incorporating fish behavior improves accuracy of species distribution models. *Draft*.

- LOCATION: Hanauma Bay, Oʻahu, HI
- TYPE: Biological Study
- In Text Citation: (Walton 2013)
- SUMMARY:
    - At Hanauma Bay there were 572 observations inside the reserve and 167 outside.
    - Three schools of greater than 50 individuals were recorded in Hanauma Bay reserve, the two large of the schools (n = 150, 75) consisting of *Acanthurus triostegus* and the third (n = 62) made up of *Acanthurus leucopareius.*
    - Both marine reserves had significantly higher biomass of targeted fishes.

    - Ratio of mean targeted fish biomass inside the reserve vs. outside was 4.9 for Hanauma Bay and 1.5 for Pūpūkea.
  - Reserve sites had lower MAD, though not significant.

Walton, M. M. (2013). *Do marine protected areas facilitate coral reef ecosystem health? An investigation of coral disease and its associated factors in Oahu's marine life conservation districts*. Doctoral dissertation, University of Hawaii at Manoa.

- LOCATION: Hanauma Bay, Oʻahu, HI
- TYPE: Biological Study
- In Text Citation: (Walton 2013)
- SUMMARY:
  - Herbivores were the most trophic guild in Hanauma.

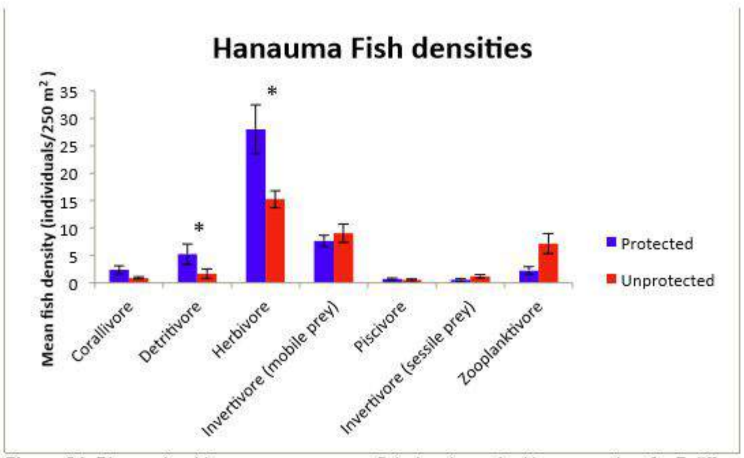


Figure 24. Blue and red bars represent mean fish density at the Hanauma sites for 7 different trophic guilds. Black lines indicate standard error and * indicates significant difference between protected and unprotected sites for that location (Kruskal-Wallis test, p<0.05).

  -

Brock, R. E., & Kam, A. (2000). *Carrying Capacity Study for The Hanauma Bay Nature Preserve Final Report*. Honolulu, HI.

Brock, V. E. (1954). A Preliminary Report on a Method of Estimating Reef Fish Populations. *The Journal of Wildlife Management*, *18*(3), 297–308. https://doi.org/10.2307/3797016

Friedlander, A. M., Brown, E. K., & Monaco, M. E. (2007). Coupling Ecology and GIS to Evaluate Efficacy of Marine Protected Areas in Hawaii. *Ecological Applications*, *17*(3), 715–730.

Jayewardene, D. (2009). A factorial experiment quantifying the influence of parrotfish density and size on algal reduction on Hawaiian coral reefs. *Journal of Experimental Marine Biology and Ecology*. https://doi.org/10.1016/j.jembe.2009.05.006

Ong, L., & Holland, K. N. (2010). Bioerosion of coral reefs by two Hawaiian parrotfishes: Species, size differences and fishery implications. *Marine Biology*, *157*(6), 1313–1323. https://doi.org/10.1007/s00227-010-1411-y

Stamoulis, K. A., Delevaux, J. M. . S., Williams, I. D., Friedlander, A. M., Reichard, J., Kamikawa, K., & Harvey, E. S. (2018). Incorporating fish behavior improves accuracy of species distribution models. *Draft*.

Stender, G., & Russel, S. (1991). *Quantitative Survey of Fishes at Hanauma Bay, Oahu*. Honolulu, HI.

Walton, M. M. (2013). *Do marine protected areas facilitate coral reef ecosystem health? An investigation of coral disease and its associated factors in Oahu's marine life conservation districts*. Doctoral dissertation, University of Hawaii at Manoa.

Annotated Bibliography for Carrying Capacity Studies:

Types of Carrying Capacities:

1) **Physical capacity** is the amount of space available for the activity based on design and use levels.
    a. Mak & Moncur (1997): A 1977 estimate of "recommended optimal use level" for Hanauma Bay was 1363 persons per day, with 330 persons allotted for the upper picnic area, 408 for the lower grassy area and 625 on the sandy beach. These estimates were derived using the Bureau of Outdoor Recreation and the U.S. Corps of Engineers Beach Capacity Standards of 50 persons per acre for the upper picnic area and 160 square feet per person for the lower grassy area and the beach.
2) **Ecological or biological capacity** is the ability of the resource to withstand recreational use without unacceptable damage to ecological components, such as the water quality, reef bio-diversity and fish diversity in Hanauma Bay.
    a. Brock & Kam (2000): There was no biological evidence from preliminary findings that the number of visitors should be increased or decreased over present levels. (3200 per day)
3) **Facility capacity** involves additions to the recreation environment intended to support visitor needs (ex. Bathroom and shower availability, trash cans, picnic tables, park benches, informational signs).
4) **Social capacity** is the number and distribution of visitors that provide minimal acceptable recreation experiences. What is acceptable of one may be viewed differently for another user. For example, a snorkeler to Hanauma Bay might term the visit as unacceptable due to both the advertising and expectations of being in a pristine marine park. Basically, her/his expectations were not met, and the place was too crowded. Yet, another snorkeler the same day did not perceive the Bay to be crowded and was quite pleased due to expectations of only seeing tropical fish.
    a. Lankford et al. (2005): "Hence, limiting use may be an effective tool to manage the Bay. The Bay is exceeding the social carrying capacity (as measured in this study) when more than 3,200 (+/- 200 users) people per day use the Bay. The number of visitors that provide acceptable recreation experiences may be less than 3,200."
    b. Reynolds (1990): Recommended that his survey should be performed at least once each year in alternating seasons in order to effectively manage people using the bay.
    c. Wanger (2001): Education efforts were found to contribute to increased awareness of rules and appropriate behavior within the preserve resulting in behavior modifications. This awareness, however, did not translate into an increased understanding of the Hanauma Bay environment.

SUPPORT:

Mak, J., & Moncur, J. E. (1998). Political economy of protecting unique recreational resources: Hanauma Bay, Hawaii. *Ambio*, 217-223.

- LOCATION: Hanauma Bay, Oʻahu HI
- TYPE: Review
- In Text Citation: (Mak and Moncur 1998)
- SUMMARY:

A 1977 estimate of "recommended optimal use level" for Hanauma Bay was 1363 persons per day, with 330 persons allotted for the upper picnic area, 408 for the lower grassy area and 625 on the sandy beach. These estimates were derived using the Bureau of Outdoor Recreation and the U.S. Corps of Engineers Beach Capacity Standards of 50 persons per acre for the upper picnic area and 160 square feet per person for the lower grassy area and the beach. Scientists have yet to determine a numerical carrying-capacity standard for the coral reefs and the marine ecosystem; indeed, it may not be possible to determine such a standard until more is known about the natural state of the marine ecosystem.

Brock, R. E., & Kam, A. (2000). *Carrying Capacity Study for The Hanauma Bay Nature Preserve Final Report*. Honolulu, HI.

- LOCATION: Hanauma Bay, Oʻahu, HI
- TYPE: Biological Study
- In Text Citation: (Brock & Kam 2000)
- SUMMARY:

"As defined in the contract between the City and County Department of Parks and Recreation and the University of Hawaii, the carrying capacity study for the Hanauma Bay Nature Preserve is to determine the type and level of visitor use that can be accommodated while sustaining acceptable resource and social conditions that complement the purpose of the Hanauma Bay Nature Preserve as measured by the number of users and level of disturbance to marine biota and water quality for the purpose of managing the numbers of Park visitors at levels which protects and maintain the integrity of the Bay's marine communities."

1. Conduct an initial overview inventory of the marine biological resources and terrestrial influences affecting the Bay;
2. At the end of the first 6 months, prepare a status report identifying marine biological resources and related social conditions, and recommend a preliminary level of use for the Bay based on the initial data.
3. Establish a scientific methodology for monitoring and analyzing the marine biological resources and water quality of the Bay.
4. Establish field experiments to determine the levels and sources of indicator bacteria and impact of human trampling on benthic biota of the Bay;
5. Review related research and comparative analyses with data from the Bay and other resource areas similar to the Bay;
6. Prepare recommendations addressing resource management needs, practices and standards related to continued monitoring, gathering and analyzing data from the Bay;
7. Prepare a first year final report in which recommendations on the level of use of the Bay is made based on the data to date.

Concept of Carrying Capacity:
In recent years concern over rising visitation and potential accompanying impacts on resources and visitor experience has led to the focus on the concept of human carrying capacity to be applied at selected parks in the National Park system. The National Parks Service (1997) has developed a framework protocol for determining human carrying capacity for application in parks; this process is known as the visitor experience and resource protection framework or VERP. The VERP process has application to any

natural area that receives human use and may have application to determining the human carrying capacity for Hanauma Bay.
-Analyze Park Resources and Existing Visitor Use: The objective here is to understand the park's resources and existing visitor use and experience. It is imperative that this analysis be documented. This element constitutes a major part of the effort of the present study.
-Describe a Potential Range of Visitor Experiences and Resource Conditions (potential prescriptive zones): Potential zones are described by different desired visitor experience opportunities and resource conditions that could be provided in a given park, consistent with the park's purpose and significance. The zone descriptions prescribe the appropriate kinds and levels of activity, development, and management.
-Allocate the Potential Zones to Specific Locations in the Park (prescriptive management zoning): In this element, the zones described in the previous element are assigned to specific locations in the park. The zoning scheme prescribes future conditions; it is not a description of existing conditions, although in some cases the continuation of existing conditions could be the desired future. If appropriate, the planning team should develop alternate zoning schemes and assess their beneficial and adverse impacts.
-Select Indicators and Specify Standards for Each Zone; Develop a Monitoring Plan: Indicators (i.e., specific, measurable variables that will be monitored) and standards (i.e., minimum acceptable conditions) are identified for each zone. A monitoring plan is developed that identifies priorities, methods, funding and staffing strategies and analysis requirements.
-Monitor Resource and Social Indicators: The park staff regularly monitors resource and social conditions in various zones. Staff and funding limitations will usually necessitate setting priorities and monitoring indicators only in the most critical areas.
-Take Management Action: When monitoring indicates that social or resource conditions are out of standard or are deteriorating towards a standard, management action must be taken.

For Brock's Baseline he uses:
(1) Water quality sampling (ammonia nitrogen, nitrate+nitrite nitrogen, total nitrogen, total phosphorous, chlorophyll-a, nephalometric turbidity, dissolved oxygen, temperature, pH, salinity, silica and orthophosphorus.
(2) Inventory and Monitoring of Marine Communities: define major zones or biotopes present in the study area. Fish and benthic were taken within each biotope—never produced in a report.
(3) Assessed Visitor Use of Hanauma Bay
(4) Experiments
- Assessing the effects of fish feeding
-Determine impact of human trampling on benthic biota—cage experiment—never produced in a report.
-Basalt/Coralline Determinations in the Sand

Assessment of Inner reef flat conditions:
"Four permanently marked sampling stations were established in the inner reef biotope. These are station 11 (east of the "keyhole" swimming area), station 14 (just west of the "keyhole"), station 17 offshore of the middle lifeguard tower and station 18 offshore of the west bathrooms. All of these stations were established at depth from 0.2 to about 1.5 m. Other than the coralline alga, *Porolithod onkodes*, most macroalgae or limu are not obvious in this biotope. Coralline algae have a mean of 1 species per transect and a mean coverage of 4%. Seaweed or limu have a mean of four species per transect and a mean

coverage of 1.6%. Corals are most often seen along the sides of depressions in the reef. The average number of coral species per transect is 3 and the mean coverage is 0.8%. Coral species seen in the inner reef biotope sample sites include *Porites lobata, Montipora verrucosa, Cyphastrea ocellina, Pocillopora meandrina,* and *P. damicornis.* Over the course of the May 1999-June 2000 sample period, there has been no change in the coverage of corals at these four inner reef flat stations."

"The most obvious species on the inner reef flat at Hanauma Bay are the fishes. The most abundant species include the sergeant major or mamo (*Abedefduf abdominalis*), chub or nenue (*Kyphosus bigibbus*), convict tang or Manini (*Acanthurus triostegus*), ringtail surgeonfish or pualo (*Acanthurus blochii*), blackspot sergeant or kupipi (*Abudefduf sordidus*), brown surgeonfish or ma'I'I'I (*Acanthurus nigrofuscus*), saddle back wrasse or hinalea lauwili (*Thalassoma duperrey*), and bluelined surgeonfish or ta'ape (*Lutjanus kasmiraI*). The mean number of species seen per transect is 19 and the mean number of individual fishs censused per tranect is 153 individuals. In terms of estimated standing crop, the average biomass per transect on the inner reef flat station is 410 g/m^2. Over the year, the most important contributors to this biomass were the nenue (*Kyphosus bigibbus*), pualo (*Acanthurus blochii*), Manini (*Acanthurus triostegus*), eyestripe surgeofish or palani (*Acanthurus dussumieri*) , orangespine surgeofish or umaumalei (*Naso lituratus*), ta'ape (*Lutjanus kasmira*), mamo (*Abudefduf abdominalis*), stareye parrotfish or ponuhunuhu (*Calotomus carolinus*), redlip parrotfish or palukaluka (*Scarus rubroviolaceus*), spectacle parrotfish or uhu uliuli (*Scarus perspicillatus*) and blue trevally or omilu (*Caranx melampygus*). A list of the species of fishes encountered in the inner reef area is given in Table 6."

"The standing crop of fish is significantly greater (P>0.0002) on Wednesdays (mean = 655 g/m^2) over the preceding Tuesdays (mean biomass = 381 g/m^2). This result is probably related to the feeding activities that were occurring on the days with visitors present, and were not occurring on the days when they were absent."

Zhang, L. Y., Chung, S. S., & Qiu, J. W. (2016). Ecological carrying capacity assessment of diving site: A case study of Mabul Island, Malaysia. *Journal of environmental management*, *183*, 253-259.

- LOCATION: Malaysia
- TYPE: Biological Assessment
- In Text Citation: (Zhang et al. 2016)
- SUMMARY:
    - Ecological carrying capacity is usually empirically determined with quadrat or photoquadrat survey being the most widely accepted method to get information on coral status of a dive site.

Table 1
Methods and results of previous studies determining carrying capacities for coral reefs around the world.

Capacity (no. of divers site^{-1} year^{-1})	Location	Methodology	Reference
4000–6000	Bonaire, The Netherlands Antilles	Used photoquadrat survey to establish the inverse relationship between diving frequency and coral coverage of a site and empirically determined carrying capacity by referring to the level of damage caused.	Dixon et al. (1993, 1995)
Max. 5000	Eastern Australia	Adopted what other studies said about carrying capacity.	Harriott et al. (1997)
5000–6000	Egypt, Bonaire and Saba	Correlated damage levels to reef (quadrat survey) at several environmentally similar sites with their diving intensities; carrying capacity is the point beyond which damage accumulates rapidly.	Hawkins and Roberts (1997)
5000–6000	Eilat, Israel.	Empirically determined by referring to the level of damage caused in existing sites.	Zakai and Chadwick-Furman (2002)
Max. 7000	Sodwana Bay, South Africa	Regressed diving intensity and other variables on coral damage index for each transect; arbitrarily accepted 10% increase in damage at 41% chance.	Schleyer and Tomalin (2000)
7000	St. Lucia	Empirically set by making reference to Schleyer and Tomalin (2000)	Barker and Roberts (2004)
13,000–14,000	Hurghada, Egypt	Predicted the optimal number of divers that can visit a reef based on the balance between dollar values of their spending subsidy versus the em-dollar equivalents of the metabolic stress they cause.	Serour and Kangas (2005)
15,600 visitors/beach	Ras Mohammed National Park, Egypt.	Counted tramplers and correlated trampler numbers with coral damage data obtained from transect survey.	Leujak and Ormond (2008)

Lankford, S., Inui, Y., Whittle, A., Luna, R., & Tyrone, D. (2005). Sustainability of coastal/marine recreation: Modeling social carrying capacity for Hanauma Bay, Hawaii. University of Hawaii.

- LOCATION: Hanauma Bay, Oʻahu HI
- TYPE: Social Carrying Capacity Study
- In Text Citation: (Lankford et al. 2005)
- SUMMARY:

"Within a recreational context (recreational carrying capacity is the level of use an area can withstand while providing sustained quality recreational experiences [Wagar 1964]), carrying capacity is further defined into the following (Shelby & Heberlein 1986):
1) **Physical capacity** is the amount of space available for the activity based on design and use levels. For example, there a certain number of boaters that can be supported in Hanauma Bay at a given time.
2) **Ecological or biological capacity** is the ability of the resource to withstand recreational use without unacceptable damage to ecological components, such as the water quality, reef bio-diversity and fish diversity in Hanauma Bay.
3) **Facility capacity** involves additions to the recreation environment intended to support visitor needs. For example, a boat ramp and parking area may be constructed to access the Bay.
4) **Social capacity** is the number and distribution of visitors that provide minimal acceptable recreation experiences. Social carrying capacity is the most difficult to define (Washburne 1982). What is acceptable of one may be viewed differently for another user. For example, a snorkeler to Hanauma Bay might term the visit as unacceptable due to both the advertising and expectations of being in a pristine marine park. Basically, her/his expectations were not met, and the place was too crowded. Yet, another snorkeler the same day did not perceive the Bay to be crowded and was quit pleased due to expectations of only seeing tropical fish.
The task for resource managers is to manage the recreation resource while considering all four carrying capacity issues identified above (Symmonds, Hammitt, & Quisenberry 2000)."
CONCLUSION: "Hence, limiting use may be an effective tool to manage the Bay. The Bay is exceeding the social carrying capacity (as measured in this study) when more than 3,200 (+/- 200 users) people per day use the Bay. The number of visitors that provide acceptable recreation experiences may be less than 3,200."

Needham, M. D., Tynon, J. F., Ceurvorst, R. L., Collins, R. L., Connor, W. M., & Culnane, M. J. W. (2008). Recreation carrying capacity and management at Pupukea Marine Life Conservation

District on Oahu, Hawaii. *Final project report for Hawai'i Division of Aquatic Resources, Department of Land and Natural Resources. Corvallis: Oregon State University, Department of Forest Ecosystems and Society*.

- SUMMARY:
  - **Recreation carrying capacity** can be defined as the amount of use that an area can support and still offer sustained quality of recreation based on social, environmental, and managerial attributes. In other words, it attempts to address the question "how much use is too much" (Manning, 1999).
    - **Environmental carrying capacity**, or the level at which biophysical resources of an area are significantly impacted by human use.
      - Indicators such as coral breakage, trampling, fish abundance, and water quality.
    - **Social carrying capacity** or the level of use beyond which social impacts and experiences such as crowding and user conflict are unacceptable.
      - Indicators such as encounters, crowding, conflict, noise and satisfaction.
    - **Facility carrying capacity** or the amount and type of facilities acceptable for accommodating a particular use level.

Da Silva, Alexandre. "Rules for commercial ocean sports sought." *Ka Leo O Hawaii.* April 1, 2004. www.kaleo.org

- SUMMARY:
  - Explores the concept of physical carrying capacity (number of individuals a beach can physically accommodate) and social carrying capacity (concentration of individuals above which beach users become uncomfortable- crowing perception).
    - Physical: determine by georeferenced digitized aerial photography.
    - Social: User counts, video images and over 200 interviews.

http://environment.gov.au/water/wetlands/publications/factsheet-limits-acceptable-change

Determining Acceptable limits of Change

- SUMMARY:

Challenges

The principle or concept of limits of acceptable change is useful, however, the process of defining limits of acceptable change can be challenging for a number of reasons. For example, there may be:

- insufficient data (for example, inadequate data, data gaps, absence of long-term data), which may mean that limits of acceptable change cannot be set for all parameters;
- limited understanding of the natural variability of the site including understanding of the natural dynamics, cyclical change and seasonality. This may mean that a comprehensive understanding of site character may not be possible for all sites;
- limited understanding of ecosystem or species resilience making it difficult to determine what the limits of acceptable change should be; and
- lack of understanding of what would actually constitute a change in ecological character (even when data is adequate) and therefore what the limit of acceptable change should be.

https://www.fs.fed.us/cdt/carrying_capacity/lac_system_for_wilderness_planning_1985_GTR_INT_176.pdf

- SUMMARY:
  - Limits of Acceptable Change (LAC) system: a framework for establishing acceptable and appropriate resource and social conditions in recreation settings.
    - Step 1: identification of area concerns and issues.
    - Step 2: opportunity classes are defined and described. Differences between opportunity classes are measured through indicators.
    - Step 3: representing resource and social conditions for which management is striving. Indicators should be capable of quantitative measurement.
    - Step 4: the existing condition of the resource and social conditions is inventoried. Data is recorded and mapped, and serve as the basis for the definition.
    - Step 5: The definition is compared across years. Basing the standard on inventory data helps ensure realism and also clarifies the nature and extent of management activity that will be required to achieve standards.
    - Step 6: identify alternate allocations of the area among the various opportunity classes. Because different allocations will require different types of management…
    - Step 7: …requires an analysis of the various cost and benefits of each alternative, in terms of environmental impacts and impacts on visitors as well as administrative costs.
    - Step 8: Cost and benefits of each alternative are evaluated and a final alternative is selected.
    - Step 9: implementation of the selected alternative and establishment of a monitoring program. Monitoring is particularly important as it provides feedback on the effectiveness of the management actions employed, alerting managers to the need to consider more rigorous application or the use of other measures.

Social CC Studies of Hbay

Komatsu, M., & Liu, J. C. (2007). Cross-cultural Comparison Between Japanese and Western Visitors for the Effectiveness of the Hanauma Bay Education Programme. *Tourism Recreation Research*, *32*(3), 3-12.

- SUMMARY:
  - Assessment of cross-cultural differences between Japanese and Western visitors to the visitor education program.
  - The educational film was effective for both visitor groups in terms of attitudinal and behavioral improvement toward marine conservation in the Bay, as well as enhancing visitor experience.
  - Western visitors were more likely to report higher ratings for education program and more pre-knowledge about conservation when compared to Japanese visitors.
  - Some suggestions made on how to incorporate cultural sensitivity in managing tourism sites:
    - More should be done to prepare visitors to expect to view the educational film as a part of their visit to the Bay.
    - Content of the film could be revised. The conservation behaviors: 'stand only on sand' and 'observe but don't touch the reef' were less likely to be followed by both visitor groups, compared to the other two points: 'don't touch the turtle' and 'watch the fish but don't feed them.'

Lankford, S., Inui, Y., Whittle, A., Luna, R., & Tyrone, D. (2005). Sustainability of coastal/marine recreation: Modeling social carrying capacity for Hanauma Bay, Hawaii. University of Hawaii.

- SUMMARY:
  - Findings of this study suggest that perceived crowding may be an indicator of actual user counts, and that crowding negatively influences satisfaction levels.
  - "The Bay is exceeding the social carrying capacity (as measured in this study) when more than 3,200 (+/- 200 users) people per day use the Bay."
  - According to this study the social carrying capacity is 3,200 visitors per day.
  - Majority of visitors are beginner or intermediate snorkelers.

Reynolds, E. (1990, May). Hanauma Bay baseline users survey. In *Proceedings of the 1990 Congress on Coastal and Marine Tourism* (Vol. 1, pp. 106-116).

- SUMMARY:
  - Survey involved two parts: (1) Counting the number of people and vehicles entering the park and the number of people walking down or riding the tram to the beach. (2) Questionnaire given on random basis to beach visitors.
  - Average number of visitors to the park per day was 6,707 with a range of 5,477 to 8,938, with 73.5% going down to the beach.
  - Recommended that his survey should be performed at least once each year in alternating seasons in order to effectively manage people using the bay.

Wanger, J.R. (2001). Interpretive Education as a Conservation Tool at Hanauma Bay Nature Preserve, Hawaii. Master of Arts in Geography. University of Hawaii. 123p.

- SUMMARY:
  - This thesis evaluates the degree of effectiveness of the Hanauma Bay Education Program as well as examines the historical events, decision making processes and interest group dynamics that have influenced the operation of HBEP.
- Interpretive Environmental Education at Hanauma Bay:
  - Trampling was in higher occurrence at all tidal levels when the education program was closed. While education program was open tramping presence appears to be around 6% of swimmers at low, average and high tide. Very low tide saw no tramplers while the education program was open.
- Conclusions:
  - Education efforts were found to contribute to increased awareness of rules and appropriate behavior within the preserve resulting in behavior modifications. This awareness, however, did not translate into an increased understanding of the Hanauma Bay environment.

Environmental CC Studies of Hbay:

Brock, R., & Kam, A. (2000). Carrying capacity study for the Hanauma Bay nature preserve: final report. *Honolulu: Department of Parks and Recreation*. Carrying Capacity Study for the Hanauma Bay Nature Preserve Final Report

- MAJOR FINDINGS:
  - Turbidity was higher in shallower sections with more visitors (Figure 8).
  - Algal growth was not much different from adjacent areas where people walk in treatments open to grazing fish but away from trampling (Pg. 52).
  - Found that there was no biological evidence from their preliminary findings that the number of visitors should be increased or decreased over present levels.

Appendix B. Fish Survey Data

Table 1. Fish species codes and life history traits utilized for calculating biomass and trophic information.

Family	SpeciesCode	TaxonName	Synonym	Hawaiian Name	Common Name	Trophic	consumer	Endemic	A	B	Mobility	Length Type	Source	Comments	Total Length to Fork Length conversion
Pomacentridae	ABAB	Abudefduf abdominalis		mamo	Sargent Major	Z		E	0.00038	2.61	S1	SL	HCFRU		0.77
Pomacentridae	ABSO	Abudefduf sordidus		ku¯pi¯pi¯	Blackspot Sargent	H		I	0.00038	2.61	S1	SL	HCFRU	ABAB USED	0.8
Pomacentridae	ABVA	Abudefduf vaigiensis		mamo	Indo-Pacific Sargent	Z		I	0.00038	2.61	S1	SL	HCFRU	ABAB USED	1
Acanthuridae	ACAC	Acanthurus achilles		pa¯ku‘iku‘i	Achilles Tang	H		I	0.00011	2.87	S1	SL	HCFRU		0.83
Acanthuridae	ACBL	Acanthurus blochii	A. mata	pualu	Ringtail Surgeonfish	H		I	0.00002	3.00	S2	SL	PEARL HARBOR STUDY	ACDU USED	0.79
Acanthuridae	ACDU	Acanthurus dussumieri		palani	Eye-stripe Surgeonfish	H		I	0.00002	3.00	S2	SL	PEARL HARBOR STUDY		0.79
Acanthuridae	ACGU	Acanthurus guttatus		'api	Whitespotted Surgeonfish	H		I	0.000044	3.08	S2	SL	HCFRU		0.81
Acanthuridae	ACLE	Acanthurus leucopareius		ma¯ikoiko	Whitebar Surgeonfish	H		I	0.000044	3.08	S2	SL	HCFRU		0.81
Acanthuridae	ACNC	Acanthurus nigricans			Whitecheck Surgeonfish	H		I	0.0001	2.85	S1	SL	HCFRU	ACNR USED	0.73
Acanthuridae	ACNF	Acanthurus nigrofuscus		ma¯i'i'i	Brown Surgeonfish	H		I	0.0001	2.85	S1	SL	HCFRU		0.76
Acanthuridae	ACNR	Acanthurus nigroris		maiko	Bluelined Surgeonfish	H		I	0.0001	2.85	S2	SL	HCFRU		0.76
Acanthuridae	ACOL	Acanthurus olivaceus		na'ena'e	Orangeband Surgeonfish	H		I	0.000036	3.05	S2	SL	HCFRU		0.75
Acanthuridae	ACTH	Acanthurus thompsoni			Thompson's Surgeonfish	Z		I	0.0001	2.85	S1	SL	HCFRU		0.75
Acanthuridae	ACTR	Acanthurus triostegus		manini	Convict Tang	H		E	0.0000055	3.45	S2	SL	HCFRU		0.8
Acanthuridae	ACXA	Acanthurus xanthopterus		pualu	Yellowfin Surgeonfish	H		I	0.000028	3.00	S2	SL	PEARL HARBOR STUDY		0.74
Myliobatidae	ATNA	Aetobatus narinari		hihimanu	Spotted eagleray	MI	C	I	0.00000437	3.13	T	TL	FISHBASE		1
Monacanthidae	ALSC	Aluterus scriptus			Blue Scrawled Filefish	H		I	0.000091	2.79	S2	TL	FISHBASE		1
Cirrhitidae	AMBI	Amblycirrhitus bimacula		pili ko'a	Twospot Hawkfish	MI		I	0.0000037	3.52	R	SL	HCFRU	CIFA USED	0.86
Labridae	ANCH	Anampses chrysocephalus			Psychedelic Wrasse	MI		E	0.0000062	3.30	S1	SL	HCFRU		0.85
Labridae	ANCU	Anampses cuvier		'o¯pule	Pearl Wrasse	MI		E	0.000013	3.19	S1	SL	HCFRU		0.82
Antennariidae	ANCO	Antennarius commersoni			Frogfish	P		I	0.00023984	2.79	R	SL	HCFRU	ANDR USED	0.73
Antennariidae	ANDR	Antennarius drombus			Hawaiian Freckled Frogfish	P		E	0.00023984	2.79	R	SL	HCFRU		0.83
Lutjanidae	APFU	Aphareus furca	Aphareus furcatus	wahanui	Smalltooth Jobfish	P		I	0.000015	2.96	T	SL	RALSTON	APRU USED	0.82
Apogonidae	APMA	Apogon maculiferus		'upa¯palu	Spotted Cardinalfish	MI		E	0.00002	3.11	R	SL	HCFRU		0.78

Apogonidae	APSP	Apogon species		'upa¯palu	Cardinalfish	MI		I	0.000028	3.03	R	SL	HCFRU	APKA USED	0.86
Apogonidae	APPE	Apogonichthys perdix		'upa¯palu	Wai¯kiki¯ Cardinalfish	MI		I	0.00003185	2.97	R	SL	HCFRU	FOA BRACHYGRAMMA USED	0.79
Pomacanthidae	APAR	Apolemichthys arcuatus			Bandit Angelfish	SI		E	0.00019158	2.78	S1	SL	HCFRU	DEAR USED	0.89
Lutjanidae	APVI	Aprion virescens		uku	Green Jobfish	P		I	0.000015	2.96	T	SL	HCFRU	APRU USED	0.81
Tetraodontidae	ARHI	Arothron hispidus		keke	Stripebelly Puffer	MI		I	0.00004	3.00	S1	SL	PEARL HARBOR STUDY		0.86
Tetraodontidae	ARME	Arothron meleagris		'o'opuhue	Spotted Puffer	C		I	0.00000006	4.36	S1	SL	HCFRU		0.86
Gobiidae	ASSE	Asterropteryx semipunctatus		'o'opu	Halfspotted goby	SI		I	0.00000693	3.25	S1	SL	HCFRU	GNAN USED	0.65
Atherinidae	ATIN	Atherinomorus insularum		iau	Silverside	Z		E							
Aulostomidae	AUCH	Aulostomus chinensis		nu¯nu¯	Trumpet	P		I	0.00000014	3.45	S2	SL	HCFRU		0.95
Blenniidae	BLGI	Blenniella gibbifrons			Bullethead Rickskipper	H		I	0.0000257	2.91	R	SL	Letourneur et al. 1998	CIRR. STIG. USED	0.78
Blenniidae	BLSP	Blenniidae			Blenny sp.	H		I	0.0000102	3.23	R	SL	HCFRU	EVPI USED	0.8
Labridae	BOAL	Bodianus albotaeniatus		a'awa	Hawaiian Hogfish	MI		E	0.000023	3.10	S2	SL	HCFRU		0.8
Bothidae	BOMA	Bothus mancus		pa¯ki'i	Peacock Flounder	MI		I	0.00005365	2.80	S1	SL	HCFRU		0.82
Ophidiidae	BRMU	Brotula multibarbata		palahoana	Large-eye Brotula	MI		I	0.00000242	3.24		SL	HCFRU		0.8
Scaridae	CACA	Calotomus carolinus			Stareye Parrotfish	H		I	0.0000087	3.29	S2	SL	HCFRU		0.8
Scaridae	CAZO	Calotomus zonarchus			Yellowbar Parrotfish	H		E	0.0000087	3.29	S2	SL	HCFRU		0.86
Monacanthidae	CADU	Cantherhines dumerilii		'o¯'ili	Barred Filefish	C		I	0.000009	3.26	S1	SL	HCFRU		0.85
Monacanthidae	CASA	Cantherhines sandwichiensis		'o¯'ili lepa	Squaretail Filefish	H		E	0.00029	2.59	S1	SL	HCFRU		0.85
Monacanthidae	CAVE	Cantherhines verecundus			Shy Filefish	H		E	0.00000902	3.26	S1	SL	HCFRU	CADU USED	0.85
Balistidae	CAMA	Canthidermis maculatus		humuhumu	Pelagic Triggerfish	Z		I	0.000198	2.71	H	SL	HCFRU	MENI USED	0.89
Tetraodontidae	CAAM	Canthigaster amboinensis			Ambon Toby	H		I	0.00262	2.21	S1	SL	HCFRU		0.83
Tetraodontidae	CACO	Canthigaster coronata			Crown Toby	SI		I	0.00025	2.63	S1	SL	HCFRU		0.83
Tetraodontidae	CAEP	Canthigaster epilampra			Lantern Toby	MI		I	0.00025	2.63	S1	SL	HCFRU	CAJA USED	0.83
Tetraodontidae	CAJA	Canthigaster jactator			HI Whitespotted	H		E	0.00025	2.63	S1	SL	HCFRU		0.83
Tetraodontidae	CARI	Canthigaster rivulata	C. rivulatus		Maze Toby	H		I	0.00025	2.63	S1	SL	HCFRU	CAJA USED	0.83
Caracanthidae	CATY	Caracanthus typicus	Caracanthus maculatus		Orbicular Velvetfish	MI		E	0.00023984	2.79	R	SL	HCFRU	Antennarius drombus used	0.83
Carangidae	CAFE	Carangoides ferdau		ulua	Barred Jack	MI		I	0.0043	2.16	T	SL	HCFRU		0.83
Carangidae	CAOR	Carangoides orthogrammus		ulua	Island Jack	P		I	0.0043	2.16	T	SL	HCFRU	CAFÉ USED	0.83
Carangidae	CAIG	Caranx ignobilis		'ulua aukea	Giant White Trevally	P		I	0.00003592	2.92	T	SL	HCFRU		0.95
Carangidae	CALU	Caranx lugubris		ulua la'uli	Black Trevally	P		I	0.00061129	2.50	T	SL	HCFRU		0.82
Carangidae	CAME	Caranx melampygus		omilu	Blue Trevally	P		I	0.000024	2.99	T	SL	HCFRU		0.93
Carangidae	CASE	Caranx sexfasciatus		pake 'ulua	Bigeye Trevally	P		I	0.000037	2.93	T	SL	FISHBASE		0.87

Carcharhinidae	CAAB	Carcharhinus amblyrhynchos		mano	Gray Reef Shark	P	A	I	0.00000784	3.05	T	TL	Letourneur et al. 1998		1
Carcharhinidae	CAGA	Carcharhinus galapagensis		mano	Galapagos Shark	P	A	I	0.00000784	3.05	T	TL	Letourneur et al. 1998	CAAB used	1
Carcharhinidae	CAML	Carcharhinus melanopterus		mano pa'ele	Blacktip Reef Shark	P	A	I	0.00000074	3.65	T	TL	FISHBASE		1
Pomacanthidae	CEFI	Centropyge fisheri			Fisher's Angelfish	H		E	0.00035	2.63	S1	SL	HCFRU	CEPO USED	0.9
Pomacanthidae	CEFL	Centropyge flavissima			Lemonpeel Angelfish	H		X	0.00035	2.63	R	SL	HCFRU	CEPO used	0.84
Pomacanthidae	CELO	Centropyge loriculus			Flame Angelfish	H		I	0.00035	2.63	R	SL	HCFRU		0.79
Pomacanthidae	CEPO	Centropyge potteri			Potter's Angelfish	H		E	0.00035	2.63	R	SL	HCFRU		0.84
Serranidae	CEAR	Cephalopholis argus			Blue-spotted Grouper	P		X	0.000016	3.02	S1	TL	LETOURNEUR ET AL. 1998		1
Chaetodontidae	CHAU	Chaetodon auriga		ki¯ka¯kapu	Threadfin Butterflyfish	SI		I	0.000027	3.12	S1	SL	HCFRU		0.85
Chaetodontidae	CHCI	Chaetodon citrinellus		Lauhau	Speckled Butterflyfish	C		I	0.00007706	2.89		SL	HCFRU	CHMI USED	0.81
Chaetodontidae	CHEP	Chaetodon ephippium		ki¯ka¯kapu	Saddleback Butterflyfish	MI		I	0.0000265	3.12		SL	HCFRU	CHAU USED	0.81
Chaetodontidae	CHFR	Chaetodon fremblii		ki¯ka¯kapu	Bluestripe Butterflyfish	SI		E	0.000095	2.84	S1	SL	HCFRU		0.83
Chaetodontidae	CHKL	Chaetodon kleinii		ki¯ka¯kapu	Blacklip Butterflyfish	Z		I	0.000077	2.89	S1	SL	HCFRU	CHMI USED	0.83
Chaetodontidae	CHLI	Chaetodon lineolatus		ki¯ka¯kapu	LinedButterflyfish	SI		I	0.000034	3.00	S1	SL	PEARL HARBOR STUDY	CHLI USED	0.85
Chaetodontidae	CHLU	Chaetodon lunula		ki¯ka¯kapu	Racoon Butterflyfish	SI		I	0.000034	3.00	S1	SL	PEARL HARBOR STUDY		0.84
Chaetodontidae	CHLT	Chaetodon lunulatus		kapuhili	Oval Butterflyfish	C		I	0.00004437	3.03	S1	SL	HCFRU		0.82
Chaetodontidae	CHMI	Chaetodon miliaris		lauwiliwili	Milletseed Butterflyfish	Z		E	0.000077	2.89	S1	SL	HCFRU		0.84
Chaetodontidae	CHMU	Chaetodon multicinctus		ki¯ka¯kapu	Multiband Butterflyfish	C		E	0.000049	3.01	S1	SL	HCFRU		0.83
Chaetodontidae	CHOR	Chaetodon ornatissimus		ki¯ka¯kapu	Ornate Butterflyfish	C		I	0.000048	3.07	S1	SL	HCFRU		0.82
Chaetodontidae	CHQU	Chaetodon quadrimaculatus		lau hau	Fourspot Butterflyfish	C		I	0.000029	3.16	S1	SL	HCFRU	CHUN USED	0.83
Chaetodontidae	CHRE	Chaetodon reticulatus			Reticulated Butterflyfish	C		I	0.00002859	3.16	S1	SL	HCFRU	CHUN USED	0.8
Chaetodontidae	CHTI	Chaetodon tinkeri			Tinkers Butterflyfish	SI		I	0.00002859	3.16		SL	HCFRU	CHUN USED	0.87
Chaetodontidae	CHTR	Chaetodon trifascialis		ki¯ka¯kapu	Chevron Butterflyfish	C		I	0.0000817	2.76	S1	TL	Letourneur et al. 1998	Converted to mm	1
Chaetodontidae	CHUN	Chaetodon unimaculatus		lau hau	Teardrop Butterflyfish	C		I	0.000029	3.16	S1	SL	HCFRU		0.82
Chanidae	CHCH	Chanos chanos		'awa	Milkfish	H		I	0.00001863	3.25	T	FL	LETOURNEUR ET AL 1998		0.75
Labridae	CHIN	Cheilio inermis		ku¯poupou	Cigar Wrasse	MI		I	0.000003	3.07	S2	TL	LETOURNEUR ET AL. 1998		1
Cheilodactylidae	CHVI	Cheilodactylus vittatus			Hawaiian Morwong	MI		I	0.00001389	3.12	S1	SL	HCFRU		0.8
Scaridae	CHPE	Chlorurus perspicillatus	Scarus perspicillatus	uhu uliuli	Spectacled Parrotfish	H		E	0.000046	2.98	S2	SL	HCFRU		0.89
Scaridae	CHSO	Chlorurus sordidus	Old name for spilurus	uhu	Bullethead Parrotfish	H		I	0.0000068	3.35	S2	SL	HCFRU	is C. spilurus	0.88
Scaridae	CHSP	Chlorurus spilurus	Scarus sordidus	uhu	Bullethead Parrotfish	H		I	0.0000068	3.35	S2	SL	HCFRU		0.88
Pomacentridae	CHAG	Chromis agilis			Agile Chromis	Z		I	0.000047	2.99	R	SL	HCFRU	CHOV USED	0.79
Pomacentridae	CHHA	Chromis hanui			Chocolate-dip Chromis	Z		E	0.000047	2.99	R	SL	HCFRU	CHOV USED	0.71

Pomacentridae	CHOV	Chromis ovalis			Oval Butterflyfish	Z		E	0.000047	2.99	R	SL	HCFRU		0.75
Pomacentridae	CHVA	Chromis vanderbilti			Blackfin Chromis	Z		I	0.000047	2.99	R	SL	HCFRU	CHOV USED	0.78
Pomacentridae	CHVE	Chromis verater			Threespot Chromis	Z		E	0.000047	2.99	R	SL	HCFRU	CHOV USED	0.78
Labridae	CIJO	Cirrhilabrus jordani			Flame Wrasse	Z		E	0.0025298	1.90	S1	SL	HCFRU	HAOR USED	0.82
Cirrhitidae	CIFA	Cirrhitops fasciatus		pili ko'a	Redbar Hawkfish	MI		I	0.0000037	3.52	R	SL	HCFRU		0.84
Cirrhitidae	CIPI	Cirrhitus pinnulatus	C. alternus; C. alternatus	po'o pa'a	Stocky Hawkfish	MI		I	0.000018	3.19	S1	SL	HCFRU		0.84
Blenniidae	CIOB	Cirripectes obscurus			Gargantuan Blenny	H		E	0.0000257	2.91	R	SL	Letourneur et al. 1998	CIRR. STIG. USED	0.78
Blenniidae	CIVA	Cirripectes vanderbilti			Scarface Blenny	H		E	0.0000257	2.91	R	SL	Letourneur et al. 1998	CIRR. STIG. USED	0.78
Congridae	COCI	Conger cinereus		pu¯hi u¯ha¯	Mustache Conger	P		I	0.00000409	2.86	R	SL	HCFRU		0.95
Labridae	COBA	Coris ballieui	C. rosea	hi¯na¯lea luahine	Lined Coris	MI		E	0.00000551	3.29	S1	SL	HCFRU	COFL used	0.83
Labridae	COFL	Coris flavovittata		hilu	Yellowstrip coris	MI		E	0.0000055	3.29	S2	SL	HCFRU		0.85
Labridae	COGA	Coris gaimard		hi¯na¯lea 'akilolo	Yellowtail Coris	MI		I	0.0000055	3.29	S1	SL	HCFRU	COFL USED	0.86
Labridae	COVE	Coris venusta			Elegant Coris	MI		E	0.0000085	3.21	S1	SL	HCFRU		0.86
Gobiidae	COSP	Coryphopterus sp.		'o'opu	Goby	H		I	0.0000102	3.23	S1	SL	HCFRU	EVEP USED	0.82
Acanthuridae	CTHA	Ctenochaetus hawaiiensis			Black Surgeonfish	D		I	0.000036	3.12	S1	SL	HCFRU	CTST USED	0.82
Acanthuridae	CTST	Ctenochaetus strigosus		kole	Goldring Surgeonfish	D		I	0.000036	3.12	S1	SL	HCFRU		0.8
Labridae	CYLE	Cymolutes lecluse			Sharp-Headed Wrasse	MI		E	0.00002347	2.98	S1	SL	HCFRU		0.86
Pomacentridae	DAAL	Dascyllus albisella		'a¯lo'ilo'i	Hawaiian Dascyllus	Z		E	0.000017	3.32	S1	SL	HCFRU		0.79
Carangidae	DEMA	Decapterus macarellus	D. pinnulatus	opelu	Mackerel Scad	Z		I	0.0000056	3.14	T	TL	FISHBASE		1
Carangidae	DESP	Decapterus species		'opelu	Mackerel Scad	Z		I	0.0000056	3.14	T	TL	FISHBASE		1
Scorpaenidae	DEBA	Dendrochirus barberi	D. chloreus; D. hudsoni		Hawaiian lionfish	MI		E	0.0000404	3.00	R	SL	HCFRU		0.79
Diodontidae	DIHO	Diodon holocanthus		'o'opu okala	Spiny Puffer	MI		I	0.00037	2.71	S1	SL	HCFRU		0.86
Diodontidae	DIHY	Diodon hystrix		ko¯kala	Porcupine	MI		I	0.00037	2.71	S1	SL	HCFRU	DIHO USED	0.86
Syngnathidae	DOEX	Doryrhamphus excisus			Bluestripe Pipefish	Z		I	0.0000036	2.75	S1	SL	HCFRU	DORY. MELANOPEURA USED	0.95
Muraenidae	ECNE	Echidna nebulosa		pu¯hi ka¯pa¯	Snowflake Moray	MI	C	I	0.00000067	3.21	S1	SL	HCFRU	GYM. STEINDACHNERI USED	0.95
Carangidae	ELBI	Elagatis bipinnulata		kamanu	Rainbow Runner	P		I	0.0001623	2.92	T	SL	SCHROEDER	converted to mm	0.71
Muraenidae	ENCA	Enchelynassa canina		puhi kauila	Viper Moray	P	C	I	0.0000012	3.12	R	SL	HCFRU	GYEU used	0.85
Tripterygiidae	ENAT	Enneapterygius atriceps			Hawaiian Triplefin	H		E	0.00000693	3.25	S1	SL	HCFRU	GNAN USED	0.65
Blenniidae	ENMA	Entomacrodus marmoratus		pa¯o'o	Marbled Blenny	H		E	0.00000301	3.54	R	SL	HCFRU	CIRR. STIG. USED	0.78
Labridae	EPIN	Epibulus insidiator			Slingjaw Wrasse	MI		I	0.00011601	2.81	S2	SL	HCFRU		0.79
Serranidae	EPQU	Epinephelus quernus		hapu'u	Hawaiian Grouper	P		E	0.00008001	2.87	S1	SL	HCFRU		0.85
Scombridae	EUAF	Euthynnus affinis		kawakawa	Wavy-back Tuna	P		I	0.000037	2.91	T	SL	FISHBASE	converted to mm	0.9

Pentacerotidae	EVAC	Evistias acutirostris			Whiskered Armorhead	MI		I	0.00054	2.49	T	TL	UENO		1
Blenniidae	EXBR	Exallias brevis		pa¯o'o kauila	Shortbodied Blenny	C		I	0.00000097	3.84	R	SL	HCFRU	PAAR USED	0.79
Fistulariidae	FICO	Fistularia commersonii			Cornetfish	P		I	0.0000036	2.75	S2	SL	HCFRU		0.85
Apogonidae	FOBR	Foa brachygramma		'upa¯palu	Bay Cardinalfish	MI		I	0.00003185	2.97	R	SL	HCFRU		0.82
Chaetodontidae	FOFL	Forcipiger flavissimus		lauwiliwilinukunuku'oi'oi	Forcepsfish	SI		I	0.0000099	3.17	S1	SL	HCFRU		0.85
Chaetodontidae	FOLO	Forcipiger longirostris		lauwiliwilinukunuku'oi'oi	Longnose Butterflyfish	MI		I	0.0000099	3.17	S1	SL	HCFRU	FOFL USED	0.85
Pomacanthidae	GEPE	Genicanthus personatus			Masked Angelfish	Z		E	0.0001916	2.78	S1	SL	HCFRU	DEAR used	0.8
Carangidae	GNSP	Gnathanodon speciosus		paopao	Yellow-barred Jack	MI		I	0.000056	2.84	T	SL	FISHBASE		0.87
Gobiidae	GNAN	Gnatholepis anjerensis			Eyebar goby	h		I	0.0000069	3.30	S1	SL	FISHBASE		0.8
Gobiidae	GOSP	Gobiidae species		'o'opu	Goby	SI		I	0.0000102	3.23	S1	SL	HCFRU	EVEP USED	0.82
Labridae	GOVA	Gomphosus varius		hi¯na¯lea 'i'iwi, 'akilolo	Bird Wrasse	MI		I	0.00023	2.49	S1	SL	HCFRU		0.82
Microdesmidae	GUCU	Gunnellichthys curiosus			Curious Wormfish	Z		I	0.00000057	3.55	S1	FL	LETOURNEUR ET AL 1998	PLAGIO. RHINO. USED	0.9
Muraenidae	GYZE	Gymnomuraena zebra	Echidna zebra	pu¯hi	Zebra Moray	MI	C	I	0.00000067	3.21	R	SL	HCFRU		0.85
Muraenidae	GYEU	Gymnothorax eurostus		pu¯hi	Stout Moray	MI	C	I	0.0000012	3.12	R	SL	HCFRU		0.85
Muraenidae	GYFL	Gymnothorax flavimarginatus		pu¯hi paka	Yellowmargin Moray	P	C	I	0.0000067	2.87	R	SL	HCFRU		0.85
Muraenidae	GYME	Gymnothorax meleagris		pu¯hi o¯ni'o	Whitemouth Moray	P	C	I	0.0000004	3.24	R	SL	HCFRU		0.85
Muraenidae	GYRU	Gymnothorax rueppelliae	G. petelli		Yellowhead Moray	MI	C	I	0.0000067	2.87	R	SL	HCFRU		0.85
Muraenidae	GYST	Gymnothorax steindachneri		pu¯hi	Steindachner's Moray	P	C	E	0.00000067	3.21	R	SL	HCFRU		0.85
Muraenidae	GYUN	Gymnothorax undulatus		pu¯hi laumilo	Undulated Moray	P	C	I	0.0000004	3.24	R	SL	HCFRU		0.85
Labridae	HAOR	Halichoeres ornatissimus		'o¯hua	Ornate Wrasse	MI		I	0.00253	1.90	S1	SL	HCFRU		0.86
Gobiidae	HANE	Hazeus nephodes			Cloudy goby	H		I	0.0000102	3.23	S1	SL	HCFRU	EVEP USED	0.82
Hemiramphidae	HEDE	Hemiramphus depauperatus		iheihe	Polynesian halfbeak	H		I	0.0002031	2.36	T	TL	FISHBASE	Hemiramphus brasiliensis used	1
Hemiramphidae	HESP	Hemiramphus species		iheihe	Halfbeak species	H		I	0.0002031	2.36	T	TL	FISHBASE	Hemiramphus brasiliensis used	1
Chaetodontidae	HEPO	Hemitaurichthys polylepis			Pyramid Butterflyfish	Z		I	0.00007706	2.89	S1	SL	HCFRU	CHMI USED	0.84
Chaetodontidae	HETH	Hemitaurichthys thompsoni			Thompson's Butterflyfish	Z		I	0.00007706	2.89	S1	SL	HCFRU	CHMI USED	0.84
Chaetodontidae	HEDI	Heniochus diphreutes			Pennantfish	Z		I	0.0000235	3.06	S1	TL	LETOURNEUR ET AL 1998		1
Priacanthidae	HECR	Heteropriacanthus cruentatus		'a¯weoweo	Glasseye	Z		I	0.000059	2.86	R	SL	HCFRU		0.84
Hemiramphidae	HYAC	Hyporhamphus acutus		iheihe	Acute halfbeak	H		I	0.0002031	2.36	T	TL	FISHBASE	Hemiramphus brasiliensis used	1
Scorpaenidae	IRSI	Iracundus signifer			Decoy Scorpionfish	MI		I	0.000012	3.32	R	SL	HCFRU	SCBA USED	0.8
Blenniidae	ISZE	Istiblennius zebra		pa¯o'o	Zebra Blenny	H		E	0.0000069	3.25	R	SL	HCFRU	GNAN USED	0.8
Kuhliidae	KUSA	Kuhlia sandvicensis		a¯holehole	Hawaiian Flagtail	Z		E	0.000015	3.12	R	SL	TESTER AND TANAKA 1953		0.8
Kyphosidae	KYBI	Kyphosus bigibbus		nenue	Brown Chub	H		I	0.000032	3.02	S2	SL	HCFRU		0.78
Kyphosidae	KYCI	Kyphosus cinerascens		nenue	Highfin Chub	H		I	0.000032	3.02	S2	SL	HCFRU	KYBI USED	0.78

Kyphosidae	KYSP	Kyphosus species		nenue	Lowfin Chub	H		I	0.000032	3.02	S2	SL	HCFRU	KYBI USED	0.78
Kyphosidae	KYVA	Kyphosus vaigiensis		nenue	Lowfin Chub	H		I	0.000032	3.02	S2	SL	HCFRU	KYBI USED	0.78
Labridae	LAPH	Labroides phthirophagus			HawaiianI Cleaner Wrasse	P		E	0.000011	3.00	R	SL	PEARL HARBOR STUDY		0.82
Ostraciidae	LAFO	Lactoria fornasini		makukana	Thornback Trunkfish	SI		I	0.00002544	3.18	S1	SL	HCFRU	OSME USED	0.83
Lutjanidae	LUFU	Lutjanus fulvus		to'au	Blacktail Snapper	MI		X	0.000019	3.00	S1	SL	PEARL HARBOR STUDY		0.82
Lutjanidae	LUKA	Lutjanus kasmira		ta'ape	Bluestripe Snapper	MI		X	0.0000018	3.57	S2	SL	HCFRU		0.84
Labridae	MAGE	Macropharyngodon geoffroy			Shortnose Wrasse	MI		E	0.000065	2.90	S1	SL	HCFRU		0.82
Malacanthidae	MABR	Malacanthus brevirostris			Banded Blanqullo	MI		I	0.00000409	2.86	S1	SL	HCFRU	COCI USED	0.87
Myliobatidae	MAAL	Manta alfredi			Manta Ray	Z	C	I	0.00000437	3.13	T	TL	FISHBASE	AETOBATIS NARINARI USED	1
Balistidae	MENI	Melichthys niger		humuhumu'el'ele	Black Durgon	H		I	0.0002	2.71	S1	SL	HCFRU		0.89
Balistidae	MEVI	Melichthys vidua		humuhumuhi'ukole	Pinktail Durgon	H		I	0.00046	2.58	S1	SL	HCFRU		0.89
Scorpididae	MIST	Microcanthus strigatus			Stripey	MI		I	0.000095	2.84	S1	SL	HCFRU	CHFR USED	0.85
Lethrinidae	MOGR	Monotaxis grandoculis		mu	Bigeye Emperor	MI		I	0.000011	3.23	S2	SL	HCFRU		0.85
Mugilidae	MUCE	Mugil cephalus			Striped Mullet	D		I	0.00007	2.89		SL	LEBER OI		0.81
Mullidae	MUFL	Mulloidichthys flavolineatus	Mulloides flavolineatus	weke	Yellowstripe Goatfish	MI		I	0.000041	2.89	S1	SL	HCFRU		0.85
Mullidae	MUPF	Mulloidichthys pflugeri	Mulloides pflugeri			P		I	0.00002	3.10	S2	SL	HCFRU	PAPO USED	0.85
Mullidae	MUVA	Mulloidichthys vanicolensis	Mulloides vanicolensis	weke 'ula	Yellowfin Goatfish	MI		I	0.0000094	3.20	S1	SL	HCFRU		0.85
Ophichthidae	MYMA	Myrichthys magnificus			Magnificent Snake Eel	MI		E	0.00000002	3.54		SL	HCFRU	SCUTICARIA TIGRINUS USED	0.9
Holocentridae	MYAM	Myripristis amaena	M. argyromus	'u¯'u¯	Brick Soldierfish	Z		I	0.00004864	2.96	R	SL	HCFRU		0.83
Holocentridae	MYBE	Myripristis berndti		'u¯'u¯	Bigscale Soldierfish	Z		I	0.000069	2.87	R	SL	HCFRU		0.83
Holocentridae	MYCH	Myripristis chryseres		'u¯'u¯	Yellowfin Soldierfish	Z		I	0.000069	2.87	R	SL	HCFRU	MYBE USED	0.83
Holocentridae	MYKU	Myripristis kuntee	M. mutiradiatus	'u¯'u¯	Epaulette Soldierfish	Z		I	0.000069	2.87	R	SL	HCFRU	MYBE USED	0.83
Holocentridae	MYVI	Myripristis vittata		'u¯'u¯	Whitetip Soldierfish	Z		I	0.000069	2.87	R	SL	HCFRU	MYBE USED	0.83
Acanthuridae	NASP	Naso		kala	Unicornfish sp.	H		I	0.00007774	2.84	S2	SL	HCFRU	NAUN USED	0.82
Acanthuridae	NAAN	Naso annulatus			Whitemargin Unicornfish	Z		I	0.00007774	2.84	T	SL	HCFRU	NAUN USED	0.8
Acanthuridae	NABR	Naso brevirostris		kala lo¯lo¯	Spotted Unicornfish	Z		I	0.00007774	2.84	T	SL	HCFRU	NAUN USED	0.9
Acanthuridae	NAHE	Naso hexacanthus		kala holo	Sleek Unicornfish	Z		I	0.00007774	2.84	S1	SL	HCFRU	NAUN USED	0.87
Acanthuridae	NALI	Naso lituratus		umaumalei	Orangespine Unicornfish	H		I	0.000022	3.10	S2	SL	HCFRU		0.82
Acanthuridae	NAUN	Naso unicornis		kala	Bluespine Unicornfish	H		I	0.000078	2.84	S2	SL	HCFRU		0.85
Microdesmidae	NEMA	Nemateleotris magnifica			Fire Dartfish	Z		I	0.0000458	2.72	S1	TL	LETOURNEUR ET AL 1998	PRIOLEPIS CINCTUS USED	1
Holocentridae	NEAU	Neoniphon aurolineatus	Flammeo scythrops	'ala'ihi	Goldline Squirrelfish	MI		I	0.00005836	2.84	S1	SL	HCFRU	NESA USED	0.85
Holocentridae	NESA	Neoniphon sammara	Flammeo sammara	'ala'ihi	Spotfin squirrelfish	MI		I	0.00005836	2.84	R	SL	HCFRU		0.85

Labridae	NOTA	Novaculichthys taeniourus			Rockmover	MI		I	0.000013	3.19	S1	SL	HCFRU	ANCU USED	0.85
Oplegnathidae	OPFA	Oplegnathus fasciatus			Barred knifejaw	MI		I	0.0000267	2.98	T	TL	UENO		1
Oplegnathidae	OPPU	Oplegnathus punctatus			Spotted Knifejaw	MI		I	0.000032	3.02	T	TL	UENO		1
Ostraciidae	OSME	Ostracion meleagris		moa	Spotted Boxfish	SI		I	0.000025	3.18	S1	SL	HCFRU		0.83
Ostraciidae	OSWH	Ostracion whitleyi			Whitley's Boxfish	SI		I	0.000025	3.18	S1	SL	HCFRU	OSME USED	0.83
Labridae	OXBI	Oxycheilinus bimaculatus	Cheilinus bimaculatus		Twospot Wrasse	MI		I	0.0000012	3.83	S1	SL	HCFRU		0.7
Labridae	OXUN	Oxycheilinus unifasciatus	Cheilinus unifasciatus; C. rhodochrous	po¯'ou	Ringtail Wrasse	P		I	0.000016	3.13	S1	SL	HCFRU		0.87
Cirrhitidae	OXTY	Oxycirrhites typus			Longnose Hawkfish	Z		I	0.00001813	2.98	S1	TL	LETOURNEUR ET AL 1998	CIRRHITICHTYS FALCO USED	1
Cirrhitidae	PAAR	Paracirrhites arcatus		pili ko'a	Arc-eye Hawkfish	MI		I	0.00000097	3.84	R	SL	HCFRU		0.87
Cirrhitidae	PAFO	Paracirrhites forsteri		hilu pili ko'a	Blackside Hawkfish	P		I	0.000026	3.08	R	SL	HCFRU		0.81
Pinguipedidae	PASC	Parapercis schauinslandi			Sand Perch	MI		I	0.0000164	2.95	S1	TL	LETOURNEUR ET AL 1998	PERAPERCIS CYLINDRIEA USED	1
Mullidae	PACY	Parupeneus cyclostomus	P. chyserydros	moano kea	Blue Goatfish	P		I	0.0000124	3.14	S2	SL	HCFRU		0.8
Mullidae	PAIN	Parupeneus insularis		munu	Doublebar Goatfish	MI		I	0.000011	3.21	S1	SL	HCFRU	PABI USED	0.86
Mullidae	PAMU	Parupeneus multifasciatus		moano	Manybar Goatfish	MI		I	0.000015	3.12	S1	SL	HCFRU		0.84
Mullidae	PAPL	Parupeneus pleurostigma		malu	Sidespot Goatfish	MI		I	0.000048	2.89	S1	SL	HCFRU		0.87
Mullidae	PAPO	Parupeneus porphyreus		ku¯mu¯	Whitesaddle Goatfish	MI		E	0.00002	3.10	S1	SL	HCFRU		0.82
Monacanthidae	PEAS	Pervagor aspricaudus			Lacefin Filefish	H		I	0.000091	2.79	S1	SL	HCFRU	PESP USED	0.82
Monacanthidae	PESP	Pervagor spilosoma		'o¯ili'uwi'uwi	Fantail Filefish	H		E	0.000091	2.79	S1	SL	HCFRU		0.82
Blenniidae	PLEW	Plagiotremus ewaensis			Ewa Blenny	P		E	0.00000057	3.55	R	FL	LETOURNEUR ET AL 1998	PLAGIO. RHINO. USED	0.9
Blenniidae	PLGO	Plagiotremus goslinei			Scale-eating Blenny	P		E	0.00000057	3.55	R	FL	LETOURNEUR ET AL 1998	PLAGIO. RHINO. USED	0.9
Belonidae	PLAR	Platybelone argalus	Belone platyura	'aha	Keeltail Needlefish	P		I	0.00000076	3.21	T	FL	FISHBASE	TYLOSURUS CROCODILUS USED	0.96
Pomacentridae	PLIM	Plectroglyphidodon imparipennis			Brighteye Damselfish	MI		I	0.000038	3.10	R	SL	HCFRU	STFA USED	0.8
Pomacentridae	PLJO	Plectroglyphidodon johnstonianus			Blue-eye Damselfish	C		I	0.000038	3.10	R	SL	HCFRU	STFA USED	0.8
Pomacentridae	PLSI	Plectroglyphidodon sindonis			Rock Damselfish	H		E	0.00003807	3.10	R	SL	HCFRU	STFA USED	0.8
Polynemidae	POSE	Polydactylus sexfilis			Threadfin	MI		I	0.00001744	3.00	S2	SL	PEARL HARBOR STUDY		0.7
Priacanthidae	PRME	Priacanthus meeki		'a¯weoweo	Hawaiian Bigeye	Z		E	0.000028	3.01	R	SL	HCFRU		0.84
Priacanthidae	PRSP	Priacanthus species		'a¯weoweo	Bigeye species	Z		I	0.000028	3.01	R	SL	HCFRU		0.84
Gobiidae	PREU	Priolepis eugenius		'o'opu	Noble Goby	SI		E	0.0000458	2.72	R	TL	LETOURNEUR ET AL 1998	P. CINCTUS USED	1
Apogonidae	PRKA	Pristiapogon kallopterus	A. snyderi	'upa¯palu	Iridescent Cardinalfish	MI		I	0.000028	3.03	R	SL	HCFRU	APKA OLD NAME	0.86
Apogonidae	PRTA	Pristiapogon taeniopterus		'upa¯palu	Bandfin Cardinalfish	MI		E	0.0000092	3.27	R	SL	HCFRU	APME OLD NAME	0.83
Holocentridae	PROL	Pristilepis oligolepis		'u¯'u¯	Spinyface Soldierfish	Z		I	0.000069	2.87	R	SL	HCFRU	MYAM used	0.83

Serranidae	PSBI	Pseudanthias bicolor			Bicolor Anthias	Z		E	0.00001266	3.09	S1	FL	LETOURNEUR ET AL 1998	P. HYPSELOSOMA USED	0.85
Serranidae	PSTH	Pseudanthias thompsoni			Hawaiian Anthias	Z		E	0.00001266	3.09	S1	FL	LETOURNEUR ET AL 1998	P. HYPSELOSOMA USED	0.85
Carangidae	PSDE	Pseudocaranx dentex		buta ulua	Thicklipped Jack	P		I	0.00001673	3.01	T	SL	Uchiyama and Tagami 1984	converted to mm	0.83
Labridae	PSEV	Pseudocheilinus evanidus		ma¯lamalama	Disappearing Wrasse	MI		I	0.000016	3.16	S1	SL	HCFRU	STBA USED	0.83
Labridae	PSOC	Pseudocheilinus octotaenia			Eightline Wrasse	MI		I	0.000016	3.16	S1	SL	HCFRU	STBA USED	0.83
Labridae	PSTE	Pseudocheilinus tetrataenia			Fourline Wrasse	MI		I	0.000016	3.16	S1	SL	HCFRU	STBA USED	0.83
Labridae	PSCE	Pseudojuloides cerasinus			Smalltail Wrasse	MI		I	0.000015	3.12	S1	SL	HCFRU	THDU USED	0.8
Gobiidae	PSMA	Psilogobius mainlandi		'o'opu	Hawaiian Shrimp Goby	SI		E	0.0000458	2.72	R	TL	LETOURNEUR ET AL 1998	PRIOLEPIS CINCTUS USED	1
Microdesmidae	PTHE	Ptereleotris heteroptera			Indigo Dartfish; Indigo hover goby	Z		I	0.00000693	3.25	S1	SL	HCFRU	GNAN USED	0.8
Scorpaenidae	PTSP	Pterois sphex			Hawaiian Turkeyfish	P		E	0.00001449	3.18	R	SL	HCFRU		0.8
Balistidae	RHAC	Rhinecanthus aculeatus		humuhumunukunukuapua'a	Lagoon Triggerfish	MI		I	0.000083	2.86	S1	SL	HCFRU	SUBU USED	0.87
Balistidae	RHRE	Rhinecanthus rectangulus		humuhumunukunukuapua'a	Reef Triggerfish	MI		I	0.000083	2.86	S1	SL	HCFRU	SUBU USED	0.87
Holocentridae	SADI	Sargocentron diadema	Adioryx diadema	'ala'ihi	Crown Squirrelfish	MI		I	0.000016	3.13	R	SL	HCFRU		0.87
Holocentridae	SAEN	Sargocentron ensiferum	Adioryx ensifer	'ala'ihi	Yellowstripe Squirrelfish	MI		I	0.00077604	2.46	R	SL	HCFRU	SATI USED	0.87
Holocentridae	SAPU	Sargocentron punctatissimum	Holocentrus lacteoguttatus	'ala'ihi	Peppered Squirrelfish	MI		I	0.00001614	3.13	R	SL	HCFRU	SADI USED	0.87
Holocentridae	SASP	Sargocentron spiniferum	Adioryx spinfer	'ala'ihi	Saber Squirrelfish	MI		I	0.00077604	2.46	R	SL	HCFRU		0.82
Holocentridae	SATI	Sargocentron tiere		'ala'ihi	Tahitian Squirrelfish	MI		I	0.00077604	2.46	R	SL	HCFRU		0.82
Holocentridae	SAXA	Sargocentron xantherythrum	Adioryx xantherythrus	'ala'ihi	Hawaiian Squirrelfish	MI		E	0.000015	3.15	R	SL	HCFRU		0.87
Synodontidae	SAFL	Saurida flamma		'ulae	Orangemouth Lizardfish	P		I	0.00000844	3.11	S2	SL	HCFRU	SAGR USED	0.79
Synodontidae	SAGR	Saurida gracilis		'ulae	Slender Lizardfish	P		I	0.00000844	3.11	S2	SL	HCFRU		0.79
Scaridae	SCSP	Scarus		uhu	Scarus sp.	H		I	0.0000086	3.31	S2	SL	HCFRU	SCPS USED	0.85
Scaridae	SCDU	Scarus dubius		lauia	Regal Parrotfish	H		E	0.0000086	3.31	S2	SL	HCFRU		0.85
Scaridae	SCPS	Scarus psittacus		uhu	Palenose Parrotfish	H		I	0.0000086	3.31	S2	SL	HCFRU	SCDU USED	0.85
Scaridae	SCRU	Scarus rubroviolaceus		pa¯lukaluka	Redlip Parrotfish	H		I	0.0000046	2.98	S2	SL	HCFRU	CHPE USED	0.89
Carangidae	SCLY	Scomberoides lysan	S. sancti-petri	lai	Leatherback	P		I	0.0000091	3.00	T	SL	PEARL HARBOR STUDY		0.8
Scorpaenidae	SCKE	Scorpaenodes kelloggi			Kellogg's Scorpionfish	MI		I	0.0000019	3.73	R	SL	HCFRU		0.83
Scorpaenidae	SCPA	Scorpaenodes parvipinnis			Lowfin Scorpionfish	MI		I	0.0000019	3.73	R	SL	HCFRU	S. KELLOGGI USED	0.83
Scorpaenidae	SCCA	Scorpaenopsis cacopsis		nohu	Titan Scorpionfish	P		E	0.000042	3.02	R	SL	HCFRU		0.84
Scorpaenidae	SCDI	Scorpaenopsis diabolus		nohu'omakaha	Devil Scorpionfish	P		I	0.000011	3.33	R	SL	HCFRU		0.84
Muraenidae	SCTI	Scuticaria tigrinus			Tiger Moray	P	C	I	0.00000002	3.54	R	SL	HCFRU		0.9
Scorpaenidae	SEBA	Sebastapistes ballieui	Scorpaena ballieui		Spotfin Scorpionfish	MI		E	0.00001231	3.32	R	SL	HCFRU		0.83
Scorpaenidae	SECO	Sebastapistes coniorta	Scorpaena coriorta		Speckled Scorpionfish	MI		I	0.00002105	3.20	R	SL	HCFRU		0.83

Carangidae	SECR	Selar crumenophthalmus	Trachurops crumenopthalmus	akule	Big-Eyed Scad	Z		I	0.00002198	3.23	T	TL	FISHBASE		1
Carangidae	SEDU	Seriola dumerili		kahala	Amberjack	P		I	0.000028	2.96	T	SL	HCFRU		0.86
Sphyraenidae	SPBA	Sphyraena barracuda			Barracuda	P		I	0.0000321	2.92	T	TL	FISHBASE		1
Sphyrnidae	SPLE	Sphyrna lewini		mano kihikihi	Scalloped Hammerhead shark	P		I	0.00000276	3.07	T	TL	CLARKE 1971		1
Pomacentridae	STMA	Stegastes marginatus	Pomacentrus jenkinsi		Pacific Gregory	H		I	0.000038	3.10	R	SL	HCFRU	STMA replaced STFA	0.8
Labridae	STBA	Stethojulis balteata		o¯maka	Belted Wrasse	MI		E	0.000016	3.16	S1	SL	HCFRU		0.83
Balistidae	SUBU	Sufflamen bursa		humuhumulei	Lei Triggerfish	MI		I	0.000083	2.86	S1	SL	HCFRU		0.87
Balistidae	SUFR	Sufflamen fraenatus		humuhumumimi	Bridled Triggerfish	MI		I	0.000083	2.86	S2	SL	HCFRU	SUBU USED	0.87
Synodontidae	SYBI	Synodus binotatus		'ulae	Twospot Lizardfish	P		I	0.0000066	3.16	S2	SL	HCFRU		0.85
Synodontidae	SYDE	Synodus dermatogenys		'ulae	Clearfin Lizardfish	P		I	0.00000527	3.21	S2	SL	HCFRU	SYUL USED	0.85
Synodontidae	SYLO	Synodus lobeli		'ulae	Lobel's Lizardfish	P		I	0.0000066	3.16	S2	SL	HCFRU	SYBI used	0.85
Synodontidae	SYSP	Synodus species		'ulae	Lizardfish	P		I	0.00000527	3.21	S2	SL	HCFRU	SYUL used	0.85
Synodontidae	SYUL	Synodus ulae		'ulae	Ulae Lizardfish	P		I	0.00000527	3.21	S2	SL	HCFRU		0.85
Synodontidae	SYVA	Synodus variegatus		'ulae	Variegated Lizardfish	P		I	0.0000066	3.16	S2	SL	HCFRU	SYUL used	0.85
Scorpaenidae	TATR	Taenianotus triacanthus			Leaf Scorpionfish	P		I	0.00006884	2.92		SL	HCFRU		0.85
Labridae	THBA	Thalassoma ballieui			Blacktail Wrasse	MI		E	0.000012	3.18	S2	SL	HCFRU		0.82
Labridae	THDU	Thalassoma duperrey		hi¯na¯lea lauwili	Saddle Wrasse	MI		E	0.000015	3.12	S1	SL	HCFRU		0.82
Labridae	THLU	Thalassoma lutescens			Sunset Wrasse	MI		I	0.000015	3.12	S1	SL	HCFRU	THDU USED	0.82
Labridae	THPU	Thalassoma purpureum		hou	Surge Wrasse	MI		I	0.00000897	3.23	S1	SL	HCFRU		0.82
Labridae	THQU	Thalassoma quinquevittatum			Fivestripe Wrasse	MI		I	0.000015	3.12	S1	SL	HCFRU	THDU USED	0.82
Labridae	THTR	Thalassoma trilobatum		a¯wela	Christmas Wrasse	MI		I	0.000036	2.97	S2	SL	HCFRU	THPU USED	0.82
Synodontidae	TRMY	Trachinocephalus myops		wele'a	Snakefish	P		I	0.00000527	3.21	S2	SL	HCFRU		0.85
Carcharhinidae	TROB	Triaenodon obesus		mano lalakea	Whitetip Reef Shark	P	A	I	0.00000058	3.38	T	TL	Letourneur et al. 1998		1
Belonidae	TYCR	Tylosurus crocodilus			Houndfish	P		I	0.00000076	3.21	T	FL	FISHBASE		0.96
Mullidae	UPAR	Upeneus arge		weke pueo	Nightmare Goatfish	MI		E	0.00000397	3.31	S2	FL	LETOUTNEUR ET AL 1998	U. VITTATUS USED	0.9
Mullidae	UPTA	Upeneus taeniopterus				MI				0.00					0
Balistidae	XAAU	Xanthichthys auromarginatus			Gilded Triggerfish	Z		I	0.00019824	2.71	S1	SL	HCFRU	MENI USED	0.89
Balistidae	XAME	Xanthichthys mento			Crosshatch Triggerfish	Z		I	0.00019824	2.71	S1	SL	HCFRU	MENI USED	0.89
Labridae	XYNI	Xyrichtys niger			Black Razor Wrasse	MI		I	0.00001	3.00	R	TL	FISHBASE	X. SPLENDENS USED	1
Labridae	XYNV	Xyrichtys niveilatus			White-side Razor Wrasse	MI		I	0.00001	3.00	R	TL	FISHBASE	X. SPLENDENS USED	1
Labridae	XYPA	Xyrichtys pavo			Peacock Razor Wrasse	MI		I	0.00001	3.00	R	TL	FISHBASE	X. SPLENDENS USED	1
Labridae	XYUM	Xyrichtys umbrilatus			Blackside Razor Wrasse	MI		E	0.00001	3.00	R	TL	FISHBASE	X. SPLENDENS USED	1

Zanclidae	ZACO	Zanclus cornutus	Z. canescens	kihikihi	Moorish idol	SI		I	0.000095	2.87	S1	SL	HCFRU		0.85
Acanthuridae	ZEFL	Zebrasoma flavescens		lau'i¯pala	Yellow Tang	H		I	0.00054	2.49	S1	SL	HCFRU		0.91
Acanthuridae	ZEVE	Zebrasoma veliferum		ma¯ne'one'o	Sailfin tang	H		I	0.00054	2.49	S1	SL	HCFRU	ZEFL USED	0.91
Labridae	BOBI	Bodianus bilunulatus	B. albotaeniatus	'a'awa	Hawaiian Hogfish	MI		E	0.000023	3.10	S2	SL	HCFRU		0.8
Pomacentridae	STFA	Stegastes fasciolatus	S. marginatus		Hawaiian Gregory	H		E	0.000038	3.10	R	SL	HCFRU	is S. marginatus	0.8
Mullidae	PABI	Parupeneus bifasciatus	P. insularis	munu	Doublebar Goatfish	MI		I	0.000011	3.21	S1	SL	HCFRU	is P. insularis	0.86
Apogonidae	APKA	Apogon kallopterus	Pristiapogon kallopterus	'UPAPALU	Iridescent Cardinalfish	MI		I	0.000028	3.03	R	SL	HCFRU		0.86

Table 2. Raw data from surveys of fishes within Hanauma Bay prior to the COVID-19 closure performed by Yuko Stender. Species codes refer to Appendix B, Table 1. Transect names have been shortened to the following: BA = Backdoors East, BB = Backdoors West, KA = Keyhole East, KB = Keyhole West, CA = Channel East, CB = Channel West, WA = Witches Brew East, WB = Witches Brew West.

Date	TRANSECT	DEPTH	SPECIES	Number	Average Length
19-Nov-19	CA	0.75	ABSO	3	15
19-Nov-19	CA	0.75	ABVA	1	12
19-Nov-19	CA	0.75	ACGU	2	22
19-Nov-19	CA	0.75	ACNF	22	12
19-Nov-19	CA	0.75	ACNF	18	10
19-Nov-19	CA	0.75	ACTR	1	10
19-Nov-19	CA	0.75	ACTR	145	12
19-Nov-19	CA	0.75	CAME	1	45
19-Nov-19	CA	0.75	CAME	1	28
19-Nov-19	CA	0.75	CHFR	1	10
19-Nov-19	CA	0.75	CHLU	1	15
19-Nov-19	CA	0.75	CHQU	1	12
19-Nov-19	CA	0.75	CHUN	2	14
19-Nov-19	CA	0.75	CTST	2	12
19-Nov-19	CA	0.75	CTST	3	15
19-Nov-19	CA	0.75	CTST	6	10
19-Nov-19	CA	0.75	GOVA	1	7
19-Nov-19	CA	0.75	KYSP	1	37
19-Nov-19	CA	0.75	KYSP	1	20
19-Nov-19	CA	0.75	LUFU	1	20
19-Nov-19	CA	0.75	LUKA	1	22
19-Nov-19	CA	0.75	NALI	1	22
19-Nov-19	CA	0.75	NALI	1	22
19-Nov-19	CA	0.75	NESA	1	18
19-Nov-19	CA	0.75	PAMU	1	20
19-Nov-19	CA	0.75	PLIM	2	4
19-Nov-19	CA	0.75	PLIM	2	5
19-Nov-19	CA	0.75	SCRU	1	40
19-Nov-19	CA	0.75	SCSP	1	12
19-Nov-19	CA	0.75	SCSP	1	25
19-Nov-19	CA	0.75	STBA	2	8
19-Nov-19	CA	0.75	STMA	1	5
19-Nov-19	CA	0.75	STMA	1	4
19-Nov-19	CA	0.75	THDU	2	12
19-Nov-19	CA	0.75	THDU	5	10
19-Nov-19	CA	0.75	THDU	2	5
19-Nov-19	CA	0.75	THDU	1	10
19-Nov-19	CA	0.75	ZEVE	1	23
19-Nov-19	CB	0.75	ABSO	1	16
19-Nov-19	CB	0.75	ACBL	2	32
19-Nov-19	CB	0.75	ACNF	13	12
19-Nov-19	CB	0.75	ACNF	6	10
19-Nov-19	CB	0.75	ACNF	3	12
19-Nov-19	CB	0.75	ACNF	2	14
19-Nov-19	CB	0.75	ACTR	1	5
19-Nov-19	CB	0.75	ACTR	1	6
19-Nov-19	CB	0.75	ACTR	47	12
19-Nov-19	CB	0.75	CAJA	2	5
19-Nov-19	CB	0.75	CHAU	2	18
19-Nov-19	CB	0.75	CHLU	1	15
19-Nov-19	CB	0.75	CHPE	1	47
19-Nov-19	CB	0.75	CHPE	1	45
19-Nov-19	CB	0.75	GOVA	1	8
19-Nov-19	CB	0.75	NALI	1	32
19-Nov-19	CB	0.75	NALI	1	24
19-Nov-19	CB	0.75	PAMU	1	8
19-Nov-19	CB	0.75	PAMU	1	14
19-Nov-19	CB	0.75	PLIM	4	5
19-Nov-19	CB	0.75	RHAC	1	15
19-Nov-19	CB	0.75	RHAC	1	20
19-Nov-19	CB	0.75	SCPS	5	16
19-Nov-19	CB	0.75	SCPS	2	24
19-Nov-19	CB	0.75	STBA	1	4
19-Nov-19	CB	0.75	STBA	2	6
19-Nov-19	CB	0.75	STBA	2	10
19-Nov-19	CB	0.75	STBA	2	8

19-Nov-19	CB	0.75	STBA	1	3
19-Nov-19	CB	0.75	STMA	1	3.5
19-Nov-19	CB	0.75	THDU	1	8
19-Nov-19	CB	0.75	THDU	1	7
19-Nov-19	CB	0.75	THDU	1	12
19-Nov-19	CB	0.75	THTR	1	20
19-Nov-19	CB	0.75	ZEVE	1	24
19-Nov-19	KA	1	ABAB	2	5
19-Nov-19	KA	1	ABSO	1	14
19-Nov-19	KA	1	ACBL	3	25
19-Nov-19	KA	1	ACNF	6	10
19-Nov-19	KA	1	ACNF	4	12
19-Nov-19	KA	1	ACNF	3	10
19-Nov-19	KA	1	ACNF	5	8
19-Nov-19	KA	1	ACTR	3	12
19-Nov-19	KA	1	ACTR	1	10
19-Nov-19	KA	1	CAJA	1	4
19-Nov-19	KA	1	CHAU	1	13
19-Nov-19	KA	1	CHOR	1	15
19-Nov-19	KA	1	GOVA	1	10
19-Nov-19	KA	1	KYSP	2	35
19-Nov-19	KA	1	KYSP	1	25
19-Nov-19	KA	1	KYSP	1	40
19-Nov-19	KA	1	LUKA	1	20
19-Nov-19	KA	1	MUFL	2	22
19-Nov-19	KA	1	NALI	2	22
19-Nov-19	KA	1	PAMU	1	20
19-Nov-19	KA	1	PLIM	1	4
19-Nov-19	KA	1	RHRE	1	20
19-Nov-19	KA	1	SCPS	1	25
19-Nov-19	KA	1	SCPS	1	12
19-Nov-19	KA	1	THDU	1	5
19-Nov-19	KA	1	THDU	2	13
19-Nov-19	KA	1	THDU	1	15
19-Nov-19	KA	1	ZEVE	1	30
19-Nov-19	KB	1	ABSO	3	13
19-Nov-19	KB	1	ACNF	10	12
19-Nov-19	KB	1	ACNF	3	14
19-Nov-19	KB	1	ACNF	26	10
19-Nov-19	KB	1	ACTR	4	13
19-Nov-19	KB	1	ACTR	1	11
19-Nov-19	KB	1	ACXA	4	35
19-Nov-19	KB	1	CAJA	1	5
19-Nov-19	KB	1	CAJA	2	4
19-Nov-19	KB	1	CAME	2	24
19-Nov-19	KB	1	CAME	1	30
19-Nov-19	KB	1	CHFR	1	11
19-Nov-19	KB	1	CHSO	1	25
19-Nov-19	KB	1	GOVA	1	10
19-Nov-19	KB	1	KYSP	3	30
19-Nov-19	KB	1	NALI	1	15
19-Nov-19	KB	1	SCPS	1	25
19-Nov-19	KB	1	SCPS	1	14
19-Nov-19	KB	1	SCRU	1	40
19-Nov-19	KB	1	STBA	1	6
19-Nov-19	KB	1	STBA	1	12
19-Nov-19	KB	1	STMA	3	12
19-Nov-19	KB	1	THDU	1	12
19-Nov-19	KB	1	THDU	3	15
19-Nov-19	KB	1	THDU	2	10
19-Nov-19	KB	1	ZEVE	1	25
19-Nov-19	KB	1	ZEVE	1	30
19-Nov-19	KB	1	ZEVE	2	24
19-Nov-19	WA	0.6	ABSO	1	16
19-Nov-19	WA	0.6	ACBL	1	32
19-Nov-19	WA	0.6	ACNF	2	12
19-Nov-19	WA	0.6	ACOL	1	28
19-Nov-19	WA	0.6	ACTR	1	10
19-Nov-19	WA	0.6	ACTR	24	14
19-Nov-19	WA	0.6	ACTR	3	12
19-Nov-19	WA	0.6	CADU	1	24
19-Nov-19	WA	0.6	CAJA	3	6

19-Nov-19	WA	0.6	CHLU	1	15
19-Nov-19	WA	0.6	NALI	1	30
19-Nov-19	WA	0.6	NAUN	1	28
19-Nov-19	WA	0.6	NEAU	1	42
19-Nov-19	WA	0.6	NOTA	1	3
19-Nov-19	WA	0.6	PLIM	2	6
19-Nov-19	WA	0.6	SCRU	1	46
19-Nov-19	WA	0.6	THDU	1	15
19-Nov-19	WB	0.6	ACXA	11	40
19-Nov-19	WB	0.6	CAJA	1	5
19-Nov-19	WB	0.6	CAJA	3	6
19-Nov-19	WB	0.6	CAME	1	33
19-Nov-19	WB	0.6	CAME	1	24
19-Nov-19	WB	0.6	CAOR	4	24
19-Nov-19	WB	0.6	CHAU	2	17
19-Nov-19	WB	0.6	CHEP	2	15
19-Nov-19	WB	0.6	NALI	1	23
19-Nov-19	WB	0.6	RHAC	1	20
29-Jan-20	BA	0.6	ABAB	1	7
29-Jan-20	BA	0.6	ABAB	1	6
29-Jan-20	BA	0.6	ABSO	1	15
29-Jan-20	BA	0.6	ABVA	1	9
29-Jan-20	BA	0.6	ACNF	8	14
29-Jan-20	BA	0.6	ACNF	1	10
29-Jan-20	BA	0.6	ACNF	10	12
29-Jan-20	BA	0.6	ACTR	2	15
29-Jan-20	BA	0.6	ACTR	4	12
29-Jan-20	BA	0.6	ACTR	30	10
29-Jan-20	BA	0.6	CAAM	1	7
29-Jan-20	BA	0.6	CAJA	1	3
29-Jan-20	BA	0.6	CAME	1	46
29-Jan-20	BA	0.6	CHAU	4	15
29-Jan-20	BA	0.6	GOVA	1	11
29-Jan-20	BA	0.6	GOVA	1	8
29-Jan-20	BA	0.6	NALI	1	25
29-Jan-20	BA	0.6	PAMU	1	20
29-Jan-20	BA	0.6	PAMU	1	8
29-Jan-20	BA	0.6	RHRE	1	22
29-Jan-20	BA	0.6	SCRU	1	40
29-Jan-20	BA	0.6	STBA	1	7
29-Jan-20	BA	0.6	STBA	1	8
29-Jan-20	BA	0.6	STMA	2	5
29-Jan-20	BA	0.6	STMA	3	7
29-Jan-20	BA	0.6	THDU	1	5
29-Jan-20	BA	0.6	THDU	1	7
29-Jan-20	BA	0.6	THTR	1	12
29-Jan-20	BA	0.6	ZACO	1	20
29-Jan-20	BA	0.6	ZEFL	1	16
29-Jan-20	BB	0.6	ABSO	1	14
29-Jan-20	BB	0.6	ABSO	1	16
29-Jan-20	BB	0.6	ACAC	1	18
29-Jan-20	BB	0.6	ACBL	1	24
29-Jan-20	BB	0.6	ACGU	2	16
29-Jan-20	BB	0.6	ACGU	3	18
29-Jan-20	BB	0.6	ACNF	7	14
29-Jan-20	BB	0.6	ACNF	6	12
29-Jan-20	BB	0.6	ACNF	9	15
29-Jan-20	BB	0.6	ACNF	8	12
29-Jan-20	BB	0.6	ACNF	17	10
29-Jan-20	BB	0.6	ACTR	1	12
29-Jan-20	BB	0.6	ACTR	7	14
29-Jan-20	BB	0.6	ACTR	1	15
29-Jan-20	BB	0.6	CAJA	1	6
29-Jan-20	BB	0.6	CHFR	1	11
29-Jan-20	BB	0.6	CHOR	2	17
29-Jan-20	BB	0.6	CHQU	1	10
29-Jan-20	BB	0.6	CTST	1	13
29-Jan-20	BB	0.6	GOVA	1	14
29-Jan-20	BB	0.6	GOVA	1	18
29-Jan-20	BB	0.6	KYSP	1	38
29-Jan-20	BB	0.6	NALI	2	22
29-Jan-20	BB	0.6	NALI	1	18

29-Jan-20	BB	0.6	PLIM	1	5
29-Jan-20	BB	0.6	PLIM	4	4
29-Jan-20	BB	0.6	RHRE	2	18
29-Jan-20	BB	0.6	RHRE	2	21
29-Jan-20	BB	0.6	RHRE	1	16
29-Jan-20	BB	0.6	SCPS	1	20
29-Jan-20	BB	0.6	SCPS	3	18
29-Jan-20	BB	0.6	SCPS	2	10
29-Jan-20	BB	0.6	SCRU	2	42
29-Jan-20	BB	0.6	SCRU	1	37
29-Jan-20	BB	0.6	STBA	1	6
29-Jan-20	BB	0.6	STBA	1	7
29-Jan-20	BB	0.6	THDU	2	11
29-Jan-20	BB	0.6	THDU	1	8
29-Jan-20	BB	0.6	THTR	1	8
29-Jan-20	BB	0.6	THTR	1	22
29-Jan-20	BB	0.6	THTR	1	15
29-Jan-20	BB	0.6	THTR	2	10
29-Jan-20	BB	0.6	ZEVE	1	31
29-Jan-20	BB	0.6	ZEVE	1	26
29-Jan-20	BB	0.6	ZEVE	1	24
29-Jan-20	BB	0.6	ZEVE	2	25
29-Jan-20	CA	0.6	ABSO	1	14
29-Jan-20	CA	0.6	ABSO	3	15
29-Jan-20	CA	0.6	ABVA	2	7
29-Jan-20	CA	0.6	ACNF	3	10
29-Jan-20	CA	0.6	ACNF	7	13
29-Jan-20	CA	0.6	ACNF	23	14
29-Jan-20	CA	0.6	ACNF	14	12
29-Jan-20	CA	0.6	ACTR	150	14
29-Jan-20	CA	0.6	ACTR	7	12
29-Jan-20	CA	0.6	ACXA	2	30
29-Jan-20	CA	0.6	ACXA	1	38
29-Jan-20	CA	0.6	CAJA	1	4
29-Jan-20	CA	0.6	CAJA	1	5
29-Jan-20	CA	0.6	CAJA	1	6
29-Jan-20	CA	0.6	CAJA	1	4
29-Jan-20	CA	0.6	CHAU	2	17
29-Jan-20	CA	0.6	CHFR	1	13
29-Jan-20	CA	0.6	CHPE	1	38
29-Jan-20	CA	0.6	CHQU	1	13
29-Jan-20	CA	0.6	CTST	1	15
29-Jan-20	CA	0.6	CTST	2	16
29-Jan-20	CA	0.6	GOVA	1	13
29-Jan-20	CA	0.6	KYSP	3	33
29-Jan-20	CA	0.6	LUFU	1	21
29-Jan-20	CA	0.6	LUKA	1	16
29-Jan-20	CA	0.6	NALI	1	26
29-Jan-20	CA	0.6	NALI	2	28
29-Jan-20	CA	0.6	NESA	1	16
29-Jan-20	CA	0.6	PLIM	1	5
29-Jan-20	CA	0.6	RHAC	1	22
29-Jan-20	CA	0.6	RHRE	1	20
29-Jan-20	CA	0.6	SCPS	1	16
29-Jan-20	CA	0.6	SCPS	1	25
29-Jan-20	CA	0.6	STBA	1	6
29-Jan-20	CA	0.6	STBA	4	7
29-Jan-20	CA	0.6	THDU	1	10
29-Jan-20	CA	0.6	THDU	1	12
29-Jan-20	CA	0.6	THDU	1	8
29-Jan-20	CA	0.6	THTR	1	12
29-Jan-20	CB	0.6	ABSO	1	15
29-Jan-20	CB	0.6	ACNF	2	15
29-Jan-20	CB	0.6	ACNF	2	10
29-Jan-20	CB	0.6	ACNF	7	14
29-Jan-20	CB	0.6	ACNF	13	12
29-Jan-20	CB	0.6	ACTR	1	14
29-Jan-20	CB	0.6	ACTR	3	13
29-Jan-20	CB	0.6	CACA	1	24
29-Jan-20	CB	0.6	CACA	1	31
29-Jan-20	CB	0.6	CAJA	1	6
29-Jan-20	CB	0.6	CAJA	1	4

29-Jan-20	CB	0.6	CAME	1	38
29-Jan-20	CB	0.6	CAME	1	32
29-Jan-20	CB	0.6	CHFR	1	13
29-Jan-20	CB	0.6	CHPE	1	39
29-Jan-20	CB	0.6	CHQU	2	14
29-Jan-20	CB	0.6	MUFL	1	18
29-Jan-20	CB	0.6	NALI	1	22
29-Jan-20	CB	0.6	NALI	1	26
29-Jan-20	CB	0.6	PAMU	2	16
29-Jan-20	CB	0.6	PLIM	3	4
29-Jan-20	CB	0.6	RHAC	1	23
29-Jan-20	CB	0.6	RHAC	1	19
29-Jan-20	CB	0.6	RHRE	2	21
29-Jan-20	CB	0.6	SCPS	1	15
29-Jan-20	CB	0.6	SCPS	4	18
29-Jan-20	CB	0.6	SCPS	3	17
29-Jan-20	CB	0.6	SCRU	1	45
29-Jan-20	CB	0.6	STBA	1	3
29-Jan-20	CB	0.6	THDU	1	16
29-Jan-20	CB	0.6	THDU	1	12
29-Jan-20	KA	0.5	ABSO	1	15
29-Jan-20	KA	0.75	ABSO	1	16
29-Jan-20	KA	0.5	ACBL	2	19
29-Jan-20	KA	0.5	ACBL	1	22
29-Jan-20	KA	0.5	ACBL	1	27
29-Jan-20	KA	0.5	ACDU	1	33
29-Jan-20	KA	0.5	ACLE	1	14
29-Jan-20	KA	0.6	ACNF	6	12
29-Jan-20	KA	0.6	ACNF	1	13
29-Jan-20	KA	0.6	ACNF	22	12
29-Jan-20	KA	0.6	ACNF	4	10
29-Jan-20	KA	0.6	ACNF	1	14
29-Jan-20	KA	0.6	ACTR	13	13
29-Jan-20	KA	0.6	ACTR	7	14
29-Jan-20	KA	0.6	ACTR	2	10
29-Jan-20	KA	0.6	ACTR	10	12
29-Jan-20	KA	0.75	ACXA	1	18
29-Jan-20	KA	0.75	CACA	1	26
29-Jan-20	KA	0.75	CHEP	2	15
29-Jan-20	KA	0.5	CHLU	1	13
29-Jan-20	KA	0.5	CTHA	1	25
29-Jan-20	KA	0.6	GOVA	1	10
29-Jan-20	KA	0.6	KYSP	1	26
29-Jan-20	KA	0.6	KYSP	1	32
29-Jan-20	KA	0.5	LUKA	1	19
29-Jan-20	KA	0.75	NALI	1	24
29-Jan-20	KA	0.75	NALI	2	30
29-Jan-20	KA	0.75	PABI	1	21
29-Jan-20	KA	0.6	RHRE	3	18
29-Jan-20	KA	0.6	SCPS	2	17
29-Jan-20	KA	0.6	SCPS	2	13
29-Jan-20	KA	0.75	STBA	2	6
29-Jan-20	KA	0.75	STBA	1	7
29-Jan-20	KA	0.75	STBA	3	10
29-Jan-20	KA	0.6	THDU	2	6
29-Jan-20	KA	0.5	THDU	1	15
29-Jan-20	KB	0.75	ABSO	1	15
29-Jan-20	KB	0.75	ABSO	1	15
29-Jan-20	KB	0.75	ACGU	1	15
29-Jan-20	KB	0.75	ACNF	5	14
29-Jan-20	KB	0.75	ACNF	16	12
29-Jan-20	KB	0.75	ACNF	17	12
29-Jan-20	KB	0.75	ACNF	1	15
29-Jan-20	KB	0.75	ACNF	1	10
29-Jan-20	KB	0.75	ACNF	7	14
29-Jan-20	KB	0.75	ACTR	1	12
29-Jan-20	KB	0.75	ACTR	2	14
29-Jan-20	KB	0.75	ACXA	4	43.5
29-Jan-20	KB	0.75	ACXA	1	32
29-Jan-20	KB	0.75	CAAM	2	8
29-Jan-20	KB	0.75	CACA	1	22
29-Jan-20	KB	0.75	CHAU	1	14

29-Jan-20	KB	0.75	CHFR	1	12
29-Jan-20	KB	0.75	CHLU	1	15
29-Jan-20	KB	0.75	CHOR	1	15
29-Jan-20	KB	0.75	CTST	1	16
29-Jan-20	KB	0.75	GOVA	1	15
29-Jan-20	KB	0.75	GOVA	1	10
29-Jan-20	KB	0.75	MUFL	1	18
29-Jan-20	KB	0.75	NALI	1	25
29-Jan-20	KB	0.75	NALI	1	22
29-Jan-20	KB	0.75	NESA	1	16
29-Jan-20	KB	0.75	PAMU	1	18
29-Jan-20	KB	0.75	PAMU	1	20
29-Jan-20	KB	0.75	PLIM	1	4
29-Jan-20	KB	0.75	RHRE	1	18
29-Jan-20	KB	0.75	SCPS	10	20
29-Jan-20	KB	0.75	STBA	1	13
29-Jan-20	KB	0.75	STBA	3	8
29-Jan-20	KB	0.75	STBA	1	6
29-Jan-20	KB	0.75	STMA	2	8
29-Jan-20	KB	0.75	THDU	1	12
29-Jan-20	KB	0.75	THDU	1	15
29-Jan-20	KB	0.75	THDU	1	10
29-Jan-20	KB	0.75	THTR	1	12
29-Jan-20	KB	0.75	THTR	1	22
29-Jan-20	KB	0.75	ZEVE	2	24
29-Jan-20	WA	0.5	ABSO	2	16
29-Jan-20	WA	0.5	ABSO	1	15
29-Jan-20	WA	0.5	ACBL	1	28
29-Jan-20	WA	0.5	ACNF	5	12
29-Jan-20	WA	0.5	ACNF	5	14
29-Jan-20	WA	0.5	ACOL	1	28
29-Jan-20	WA	0.5	ACTR	1	5
29-Jan-20	WA	0.5	ACTR	2	10
29-Jan-20	WA	0.5	ACTR	1	12
29-Jan-20	WA	0.5	ACTR	7	14
29-Jan-20	WA	0.5	CAFÉ	1	23
29-Jan-20	WA	0.5	CAME	1	26
29-Jan-20	WA	0.5	CAME	1	29
29-Jan-20	WA	0.5	CAME	1	24
29-Jan-20	WA	0.5	CHIN	1	25
29-Jan-20	WA	0.5	KYSP	1	29
29-Jan-20	WA	0.5	KYSP	1	44
29-Jan-20	WA	0.5	KYSP	1	30
29-Jan-20	WA	0.5	NALI	1	29
29-Jan-20	WA	0.5	NALI	1	23
29-Jan-20	WA	0.5	PAMU	1	16
29-Jan-20	WA	0.5	PLIM	2	4
29-Jan-20	WA	0.5	RHAC	2	22
29-Jan-20	WA	0.5	SCPS	4	17
29-Jan-20	WA	0.5	SCPS	2	18
29-Jan-20	WA	0.5	STBA	1	6
29-Jan-20	WA	0.5	STBA	1	8
29-Jan-20	WA	0.5	THDU	1	10
29-Jan-20	WA	0.5	THDU	1	15
29-Jan-20	WA	0.5	THDU	3	13
29-Jan-20	WA	0.5	THDU	1	20
29-Jan-20	WA	0.5	THDU	1	12
29-Jan-20	WB	0.5	ABAB	1	3
29-Jan-20	WB	0.5	ACTR	7	15
29-Jan-20	WB	0.5	ACXA	1	32
29-Jan-20	WB	0.5	CAJA	1	4
29-Jan-20	WB	0.5	CAME	4	18
29-Jan-20	WB	0.5	CAME	1	23
29-Jan-20	WB	0.5	CAME	1	26
29-Jan-20	WB	0.5	CHAU	2	16
29-Jan-20	WB	0.5	KYSP	1	34
29-Jan-20	WB	0.5	NALI	8	28
29-Jan-20	WB	0.5	NALI	2	22
29-Jan-20	WB	0.5	NALI	5	24
29-Jan-20	WB	0.5	RHAC	2	20
29-Jan-20	WB	0.5	RHAC	1	23
29-Jan-20	WB	0.5	STBA	1	5

11-Feb-20	BA	0.6	ABSO	5	16
11-Feb-20	BA	0.6	ABVA	1	7
11-Feb-20	BA	0.6	ACAC	1	20
11-Feb-20	BA	0.6	ACGU	1	18
11-Feb-20	BA	0.6	ACNF	1	7
11-Feb-20	BA	0.6	ACNF	20	12
11-Feb-20	BA	0.6	ACNF	22	13
11-Feb-20	BA	0.6	ACTR	52	14
11-Feb-20	BA	0.6	CAJA	1	4
11-Feb-20	BA	0.6	CHEP	1	15
11-Feb-20	BA	0.6	CHFR	2	13
11-Feb-20	BA	0.6	CHLU	1	15
11-Feb-20	BA	0.6	CHSO	2	13
11-Feb-20	BA	0.6	GOVA	1	6
11-Feb-20	BA	0.6	GOVA	2	10
11-Feb-20	BA	0.6	GOVA	1	14
11-Feb-20	BA	0.6	NALI	1	24
11-Feb-20	BA	0.6	PLIM	3	4
11-Feb-20	BA	0.6	SCPS	2	13
11-Feb-20	BA	0.6	SCRU	1	45
11-Feb-20	BA	0.6	STBA	1	5
11-Feb-20	BA	0.6	STMA	2	4
11-Feb-20	BA	0.6	STMA	1	9
11-Feb-20	BA	0.6	STMA	1	5
11-Feb-20	BA	0.6	THDU	1	15
11-Feb-20	BA	0.6	THDU	1	12
11-Feb-20	BA	0.6	THTR	1	12
11-Feb-20	BA	0.6	ZACO	2	16
11-Feb-20	BA	0.6	ZEFL	1	14
11-Feb-20	BA	0.6	ZEVE	1	35
11-Feb-20	BB	0.6	ABSO	2	15
11-Feb-20	BB	0.6	ACGU	2	18
11-Feb-20	BB	0.6	ACNF	7	14
11-Feb-20	BB	0.6	ACNF	36	12
11-Feb-20	BB	0.6	ACTR	1	8
11-Feb-20	BB	0.6	ACTR	1	12
11-Feb-20	BB	0.6	ACTR	1	6
11-Feb-20	BB	0.6	ACTR	1	15
11-Feb-20	BB	0.6	ACTR	1	10
11-Feb-20	BB	0.6	CHQU	2	13
11-Feb-20	BB	0.6	CTST	1	16
11-Feb-20	BB	0.6	GOVA	1	7
11-Feb-20	BB	0.6	KYSP	1	38
11-Feb-20	BB	0.6	NALI	1	25
11-Feb-20	BB	0.6	NALI	1	23
11-Feb-20	BB	0.6	NALI	1	23
11-Feb-20	BB	0.6	PLIM	6	4
11-Feb-20	BB	0.6	RHRE	3	8
11-Feb-20	BB	0.6	RHRE	1	20
11-Feb-20	BB	0.6	RHRE	1	10
11-Feb-20	BB	0.6	SCPS	7	10
11-Feb-20	BB	0.6	SCPS	30	15
11-Feb-20	BB	0.6	SCPS	10	6
11-Feb-20	BB	0.6	SCPS	1	20
11-Feb-20	BB	0.6	SCPS	4	12
11-Feb-20	BB	0.6	SCRU	1	39
11-Feb-20	BB	0.6	STBA	4	6
11-Feb-20	BB	0.6	THDU	1	12
11-Feb-20	BB	0.6	THDU	4	8
11-Feb-20	CA	0.75	ABAB	2	13
11-Feb-20	CA	0.75	ABSO	1	20
11-Feb-20	CA	0.75	ACBL	3	31
11-Feb-20	CA	0.75	ACNF	8	13
11-Feb-20	CA	0.75	ACTR	2	10
11-Feb-20	CA	0.75	ACTR	100	15
11-Feb-20	CA	0.75	ACXA	1	28
11-Feb-20	CA	0.75	CAJA	1	5
11-Feb-20	CA	0.75	CHMI	1	13
11-Feb-20	CA	0.75	CHPE	1	56
11-Feb-20	CA	0.75	CHPE	1	46
11-Feb-20	CA	0.75	CHQU	2	13
11-Feb-20	CA	0.75	CTST	1	15

11-Feb-20	CA	0.75	CTST	1	13
11-Feb-20	CA	0.75	GOVA	1	20
11-Feb-20	CA	0.75	GOVA	1	18
11-Feb-20	CA	0.75	NALI	1	28
11-Feb-20	CA	0.75	NALI	1	23
11-Feb-20	CA	0.75	SCPS	1	15
11-Feb-20	CA	0.75	SCPS	1	13
11-Feb-20	CA	0.75	SCRU	1	41
11-Feb-20	CA	0.75	STBA	1	10
11-Feb-20	CA	0.75	STMA	2	8
11-Feb-20	CA	0.75	THDU	1	13
11-Feb-20	CA	0.75	THDU	1	15
11-Feb-20	CA	0.75	THTR	1	18
11-Feb-20	CA	0.75	ZEVE	2	28
11-Feb-20	CB	0.75	ACNF	15	13
11-Feb-20	CB	0.75	ACTR	1	13
11-Feb-20	CB	0.75	ACTR	1	5
11-Feb-20	CB	0.75	CAJA	1	5
11-Feb-20	CB	0.75	CHFR	1	15
11-Feb-20	CB	0.75	CTST	2	13
11-Feb-20	CB	0.75	GOVA	1	13
11-Feb-20	CB	0.75	HAOR	1	13
11-Feb-20	CB	0.75	LUFU	1	25
11-Feb-20	CB	0.75	PABI	1	15
11-Feb-20	CB	0.75	SCPS	2	13
11-Feb-20	CB	0.75	STBA	3	10
11-Feb-20	CB	0.75	STBA	2	13
11-Feb-20	CB	0.75	STBA	1	8
11-Feb-20	CB	0.75	THDU	1	13
11-Feb-20	CB	0.75	THTR	1	23
11-Feb-20	CB	0.75	ZEVE	3	31
11-Feb-20	KA	0.6	ABSO	4	15
11-Feb-20	KA	0.6	ACBL	1	24
11-Feb-20	KA	0.6	ACNF	10	12
11-Feb-20	KA	0.6	ACNF	9	14
11-Feb-20	KA	0.6	ACTR	2	12
11-Feb-20	KA	0.6	ACTR	2	14
11-Feb-20	KA	0.6	ACTR	2	4
11-Feb-20	KA	0.6	ACTR	4	10
11-Feb-20	KA	0.6	CHAU	1	16
11-Feb-20	KA	0.6	GOVA	1	12
11-Feb-20	KA	0.6	NALI	1	23
11-Feb-20	KA	0.6	NALI	1	25
11-Feb-20	KA	0.6	SCPS	2	16
11-Feb-20	KA	0.6	STBA	1	10
11-Feb-20	KA	0.6	STBA	1	7
11-Feb-20	KA	0.6	STBA	1	8
11-Feb-20	KA	0.6	THDU	1	14
11-Feb-20	KA	0.6	THDU	2	5
11-Feb-20	KB	0.6	ABSO	1	16
11-Feb-20	KB	0.6	ACBL	1	27
11-Feb-20	KB	0.6	ACNF	18	14
11-Feb-20	KB	0.6	ACNF	15	12
11-Feb-20	KB	0.6	ACTR	1	12
11-Feb-20	KB	0.6	ACTR	4	14
11-Feb-20	KB	0.6	CTST	1	15
11-Feb-20	KB	0.6	NALI	1	23
11-Feb-20	KB	0.6	PLIM	6	4
11-Feb-20	KB	0.6	STBA	5	10
11-Feb-20	KB	0.6	STBA	1	10
11-Feb-20	KB	0.6	THDU	1	13
11-Feb-20	KB	0.6	THDU	1	15
11-Feb-20	KB	0.6	THDU	1	8
11-Feb-20	KB	0.6	THTR	3	8
11-Feb-20	WA	0.5	ABSO	1	16
11-Feb-20	WA	0.5	ACNF	5	12
11-Feb-20	WA	0.5	ACTR	4	13
11-Feb-20	WA	0.5	ACTR	5	14
11-Feb-20	WA	0.5	CHLU	1	14
11-Feb-20	WA	0.5	NALI	1	24
11-Feb-20	WA	0.5	PLIM	1	5
11-Feb-20	WA	0.5	RHAC	1	22

11-Feb-20	WB	0.5	ACTR	1	14
11-Feb-20	WB	0.5	STBA	1	8

Table 3. Raw data from surveys of fishes within Hanauma Bay during the COVID-19 closure performed by Anita Tsang. Species codes refer to Appendix B, Table 1. Transect names have been shortened to the following: BA = Backdoors East, BB = Backdoors West, KA = Keyhole East, KB = Keyhole West, CA = Channel East, CB = Channel West, WA = Witches Brew East, WB = Witches Brew West.

Date	TRANSECT	SPECIES	Number	Average Length
21-Apr-20	BA	ABAB	8	8
21-Apr-20	BA	ABAB	1	13
21-Apr-20	BA	ABSO	1	20
21-Apr-20	BA	ABSO	1	23
21-Apr-20	BA	ACAC	1	25
21-Apr-20	BA	ACGU	1	20
21-Apr-20	BA	ACGU	1	18
21-Apr-20	BA	ACNF	10	12
21-Apr-20	BA	ACNF	55	13
21-Apr-20	BA	ACTR	6	15
21-Apr-20	BA	ACTR	3	10
21-Apr-20	BA	ACTR	3	13
21-Apr-20	BA	CAJA	2	5
21-Apr-20	BA	CAME	2	45
21-Apr-20	BA	CAME	1	50
21-Apr-20	BA	CHFR	1	15
21-Apr-20	BA	CHFR	1	13
21-Apr-20	BA	CHOR	2	15
21-Apr-20	BA	CHQU	3	13
21-Apr-20	BA	CHSP	10	20
21-Apr-20	BA	GOVA	1	6
21-Apr-20	BA	GOVA	2	20
21-Apr-20	BA	GOVA	1	10
21-Apr-20	BA	KYSP	2	45
21-Apr-20	BA	NALI	2	30
21-Apr-20	BA	OSME	1	8
21-Apr-20	BA	PAIN	1	20
21-Apr-20	BA	PAIN	2	18
21-Apr-20	BA	PAIN	3	25
21-Apr-20	BA	PAIN	4	12
21-Apr-20	BA	PLIM	5	4
21-Apr-20	BA	SCPS	10	13
21-Apr-20	BA	SCPS	3	17
21-Apr-20	BA	SCRU	1	55
21-Apr-20	BA	SCRU	2	50
21-Apr-20	BA	STBA	1	6
21-Apr-20	BA	STBA	1	11
21-Apr-20	BA	STMA	1	10
21-Apr-20	BA	STMA	1	8
21-Apr-20	BA	THDU	1	18
21-Apr-20	BA	THDU	1	8
21-Apr-20	BA	THDU	1	10
21-Apr-20	BA	THTR	3	12
21-Apr-20	BA	THTR	1	18
21-Apr-20	BA	ZACO	2	15
21-Apr-20	BA	ZEVE	1	40
21-Apr-20	BA	ZEVE	3	27
21-Apr-20	BB	ABSO	5	13
21-Apr-20	BB	ABSO	2	18
21-Apr-20	BB	ACGU	1	29
21-Apr-20	BB	ACGU	2	27
21-Apr-20	BB	ACGU	1	18
21-Apr-20	BB	ACGU	1	15
21-Apr-20	BB	ACLE	1	14
21-Apr-20	BB	ACNF	35	13
21-Apr-20	BB	ACNF	30	11
21-Apr-20	BB	ACTR	2	4
21-Apr-20	BB	ACTR	4	14
21-Apr-20	BB	CACA	1	27
21-Apr-20	BB	CAJA	1	6
21-Apr-20	BB	CAJA	1	7

21-Apr-20	BB	CHEP	1	17
21-Apr-20	BB	CHOR	1	13
21-Apr-20	BB	CHSP	1	28
21-Apr-20	BB	CTST	1	17
21-Apr-20	BB	CTST	1	20
21-Apr-20	BB	CTST	1	15
21-Apr-20	BB	GOVA	3	13
21-Apr-20	BB	KYSP	1	40
21-Apr-20	BB	KYSP	2	30
21-Apr-20	BB	KYSP	1	25
21-Apr-20	BB	KYSP	2	27
21-Apr-20	BB	LUFU	1	28
21-Apr-20	BB	NALI	1	30
21-Apr-20	BB	NALI	1	25
21-Apr-20	BB	NALI	2	28
21-Apr-20	BB	PLIM	1	5
21-Apr-20	BB	PLIM	2	5
21-Apr-20	BB	RHRE	1	15
21-Apr-20	BB	RHRE	2	9
21-Apr-20	BB	SCPS	2	25
21-Apr-20	BB	SCPS	2	15
21-Apr-20	BB	SCPS	1	23
21-Apr-20	BB	SCPS	1	28
21-Apr-20	BB	SCPS	2	17
21-Apr-20	BB	SCRU	1	28
21-Apr-20	BB	SCRU	1	55
21-Apr-20	BB	SCRU	2	45
21-Apr-20	BB	STBA	2	8
21-Apr-20	BB	STBA	1	4
21-Apr-20	BB	STBA	1	11
21-Apr-20	BB	STMA	1	9
21-Apr-20	BB	STMA	2	8
21-Apr-20	BB	THDU	1	13
21-Apr-20	BB	THDU	1	10
21-Apr-20	BB	THTR	2	18
21-Apr-20	BB	ZEVE	3	25
21-Apr-20	BB	ZEVE	4	28
21-Apr-20	CA	ABAB	1	18
21-Apr-20	CA	ABSO	1	18
21-Apr-20	CA	ACGU	1	27
21-Apr-20	CA	ACNF	20	13
21-Apr-20	CA	ACNF	30	10
21-Apr-20	CA	ACTR	2	18
21-Apr-20	CA	ACTR	3	12
21-Apr-20	CA	ACTR	7	13
21-Apr-20	CA	ACTR	3	3
21-Apr-20	CA	ACXA	1	30
21-Apr-20	CA	ACXA	2	28
21-Apr-20	CA	BOAL	1	45
21-Apr-20	CA	CAJA	1	3
21-Apr-20	CA	CAJA	3	6
21-Apr-20	CA	CHAU	1	9
21-Apr-20	CA	CHFR	1	15
21-Apr-20	CA	CHMI	2	13
21-Apr-20	CA	CHPE	1	40
21-Apr-20	CA	CHSP	2	15
21-Apr-20	CA	CHSP	1	20
21-Apr-20	CA	CHSP	1	23
21-Apr-20	CA	CHUN	2	12
21-Apr-20	CA	CTST	2	13
21-Apr-20	CA	CTST	3	20
21-Apr-20	CA	CTST	2	18
21-Apr-20	CA	GOVA	1	13
21-Apr-20	CA	GOVA	1	7
21-Apr-20	CA	MUFL	1	20
21-Apr-20	CA	MUFL	1	25
21-Apr-20	CA	NALI	4	27
21-Apr-20	CA	NALI	1	30
21-Apr-20	CA	OSME	2	6
21-Apr-20	CA	PAIN	1	13
21-Apr-20	CA	PAIN	1	5
21-Apr-20	CA	PLIM	1	6

21-Apr-20	CA	PLIM	2	4
21-Apr-20	CA	PLIM	4	5
21-Apr-20	CA	RHAC	1	25
21-Apr-20	CA	RHRE	2	20
21-Apr-20	CA	RHRE	1	18
21-Apr-20	CA	SCPS	1	12
21-Apr-20	CA	STBA	1	9
21-Apr-20	CA	STBA	1	3
21-Apr-20	CA	STBA	4	5
21-Apr-20	CA	STBA	7	7
21-Apr-20	CA	STMA	3	6
21-Apr-20	CA	THDU	2	11
21-Apr-20	CA	THDU	6	3
21-Apr-20	CA	THDU	4	8
21-Apr-20	CA	THDU	1	23
21-Apr-20	CA	THDU	3	12
21-Apr-20	CA	THTR	1	18
21-Apr-20	CA	THTR	1	5
21-Apr-20	CA	ZEVE	1	28
21-Apr-20	CB	ABSO	1	13
21-Apr-20	CB	ACBL	1	28
21-Apr-20	CB	ACDU	1	28
21-Apr-20	CB	ACNF	25	12
21-Apr-20	CB	ACNF	17	10
21-Apr-20	CB	ACTR	3	10
21-Apr-20	CB	ACTR	1	18
21-Apr-20	CB	ACTR	1	3
21-Apr-20	CB	ACTR	1	12
21-Apr-20	CB	ACXA	1	28
21-Apr-20	CB	CHAU	2	13
21-Apr-20	CB	CHEP	1	17
21-Apr-20	CB	CHMI	1	15
21-Apr-20	CB	CHQU	1	12
21-Apr-20	CB	CHSP	1	18
21-Apr-20	CB	CHSP	1	23
21-Apr-20	CB	CTST	1	18
21-Apr-20	CB	GOVA	1	18
21-Apr-20	CB	GOVA	1	17
21-Apr-20	CB	MUFL	1	28
21-Apr-20	CB	NALI	3	25
21-Apr-20	CB	NALI	1	25
21-Apr-20	CB	NALI	1	30
21-Apr-20	CB	NALI	1	27
21-Apr-20	CB	OSME	2	7
21-Apr-20	CB	OSME	1	5
21-Apr-20	CB	PLIM	4	5
21-Apr-20	CB	PLIM	5	4
21-Apr-20	CB	RHAC	1	18
21-Apr-20	CB	RHRE	1	20
21-Apr-20	CB	RHRE	1	16
21-Apr-20	CB	SCPS	3	18
21-Apr-20	CB	STBA	3	8
21-Apr-20	CB	STMA	2	8
21-Apr-20	CB	THDU	1	3
21-Apr-20	CB	THDU	3	13
21-Apr-20	CB	THDU	1	5
21-Apr-20	CB	THDU	4	18
21-Apr-20	CB	THTR	1	18
21-Apr-20	CB	THTR	1	4
21-Apr-20	CB	ZEVE	1	25
21-Apr-20	CB	ZEVE	1	27
21-Apr-20	KA	ABSO	1	15
21-Apr-20	KA	ABSO	1	20
21-Apr-20	KA	ABSO	3	18
21-Apr-20	KA	ACBL	2	28
21-Apr-20	KA	ACBL	2	27
21-Apr-20	KA	ACGU	1	25
21-Apr-20	KA	ACLE	1	20
21-Apr-20	KA	ACNF	10	11
21-Apr-20	KA	ACNF	20	14
21-Apr-20	KA	ACNF	28	13
21-Apr-20	KA	ACTR	4	13

21-Apr-20	KA	ACTR	2	15
21-Apr-20	KA	ACXA	1	30
21-Apr-20	KA	ACXA	1	40
21-Apr-20	KA	ACXA	1	28
21-Apr-20	KA	CAME	1	30
21-Apr-20	KA	CHOR	1	18
21-Apr-20	KA	GOVA	1	7
21-Apr-20	KA	GOVA	1	12
21-Apr-20	KA	LUKA	1	25
21-Apr-20	KA	LUKA	1	28
21-Apr-20	KA	NALI	1	27
21-Apr-20	KA	NALI	5	28
21-Apr-20	KA	NALI	1	25
21-Apr-20	KA	NAUN	1	25
21-Apr-20	KA	OSME	2	8
21-Apr-20	KA	PAMU	1	18
21-Apr-20	KA	PLIM	1	6
21-Apr-20	KA	RHRE	1	18
21-Apr-20	KA	SCPS	1	28
21-Apr-20	KA	SCPS	1	25
21-Apr-20	KA	SCPS	2	10
21-Apr-20	KA	SCPS	1	20
21-Apr-20	KA	SCRU	1	30
21-Apr-20	KA	SCRU	1	45
21-Apr-20	KA	STBA	1	11
21-Apr-20	KA	STBA	2	9
21-Apr-20	KA	STBA	1	8
21-Apr-20	KA	THDU	1	18
21-Apr-20	KA	THDU	4	9
21-Apr-20	KA	THDU	1	12
21-Apr-20	KA	ZEVE	1	30
21-Apr-20	KA	ZEVE	3	28
21-Apr-20	KB	ABSO	1	18
21-Apr-20	KB	ABSO	2	17
21-Apr-20	KB	ACBL	2	27
21-Apr-20	KB	ACBL	2	25
21-Apr-20	KB	ACBL	2	28
21-Apr-20	KB	ACLE	2	15
21-Apr-20	KB	ACNF	20	15
21-Apr-20	KB	ACNF	45	12
21-Apr-20	KB	ACNF	75	11
21-Apr-20	KB	ACTR	1	5
21-Apr-20	KB	ACTR	8	12
21-Apr-20	KB	ACTR	1	15
21-Apr-20	KB	ACXA	1	40
21-Apr-20	KB	CACA	1	25
21-Apr-20	KB	CAME	1	45
21-Apr-20	KB	CAME	1	55
21-Apr-20	KB	CHAU	2	18
21-Apr-20	KB	CHAU	4	18
21-Apr-20	KB	CHFR	1	15
21-Apr-20	KB	CHFR	1	12
21-Apr-20	KB	CHLU	1	15
21-Apr-20	KB	CHQU	2	15
21-Apr-20	KB	CTST	1	18
21-Apr-20	KB	KYSP	1	40
21-Apr-20	KB	KYSP	1	30
21-Apr-20	KB	LUKA	1	25
21-Apr-20	KB	NALI	1	24
21-Apr-20	KB	NALI	5	27
21-Apr-20	KB	NAUN	1	25
21-Apr-20	KB	NAUN	1	27
21-Apr-20	KB	OSME	4	8
21-Apr-20	KB	OSME	1	9
21-Apr-20	KB	PAIN	3	17
21-Apr-20	KB	PLIM	1	5
21-Apr-20	KB	PLIM	5	6
21-Apr-20	KB	RHRE	1	18
21-Apr-20	KB	SCLY	1	40
21-Apr-20	KB	SCPS	3	15
21-Apr-20	KB	SCPS	3	18
21-Apr-20	KB	SCRU	1	35

21-Apr-20	KB	SCRU	1	55
21-Apr-20	KB	SCRU	2	45
21-Apr-20	KB	STBA	1	8
21-Apr-20	KB	STMA	3	7
21-Apr-20	KB	STMA	1	10
21-Apr-20	KB	THDU	6	18
21-Apr-20	KB	THTR	2	18
21-Apr-20	KB	THTR	2	15
21-Apr-20	KB	THTR	1	11
21-Apr-20	KB	ZEVE	2	30
21-Apr-20	KB	ZEVE	2	28
21-Apr-20	WA	ABSO	1	18
21-Apr-20	WA	ACBL	1	30
21-Apr-20	WA	ACNF	6	13
21-Apr-20	WA	ACNF	5	15
21-Apr-20	WA	ACTR	14	13
21-Apr-20	WA	ACTR	3	4
21-Apr-20	WA	CAJA	1	5
21-Apr-20	WA	CAJA	1	4
21-Apr-20	WA	CAJA	1	6
21-Apr-20	WA	LUFU	1	20
21-Apr-20	WA	PLIM	6	5
21-Apr-20	WA	RHAC	1	25
21-Apr-20	WA	SCPS	1	18
21-Apr-20	WA	STBA	1	10
21-Apr-20	WA	THDU	3	18
21-Apr-20	WA	THDU	3	13
21-Apr-20	WA	THDU	1	5
21-Apr-20	WB	ACTR	3	5
21-Apr-20	WB	CAJA	2	6
21-Apr-20	WB	CAME	1	25
21-Apr-20	WB	CAME	1	45
21-Apr-20	WB	CHAU	2	23
21-Apr-20	WB	GYME	1	80
21-Apr-20	WB	OSME	1	6
21-Apr-20	WB	RHAC	1	25
21-Apr-20	WB	RHAC	2	20
21-Apr-20	WB	RHAC	1	18
21-Apr-20	WB	STBA	1	9
21-Apr-20	WB	STBA	1	6
21-Apr-20	WB	THDU	1	9
12-May-20	BA	ABAB	4	5
12-May-20	BA	ABSO	1	13
12-May-20	BA	ABSO	1	20
12-May-20	BA	ABSO	1	15
12-May-20	BA	ACNF	7	9
12-May-20	BA	ACNF	5	13
12-May-20	BA	ACNF	2	6
12-May-20	BA	ACTR	1	15
12-May-20	BA	ACTR	1	11
12-May-20	BA	ACTR	1	8
12-May-20	BA	ACTR	1	9
12-May-20	BA	ACTR	1	13
12-May-20	BA	CAAM	1	5
12-May-20	BA	CAJA	2	5
12-May-20	BA	CAME	1	20
12-May-20	BA	CHOR	1	18
12-May-20	BA	GOVA	1	13
12-May-20	BA	KYSP	1	30
12-May-20	BA	KYSP	1	28
12-May-20	BA	MUFL	1	23
12-May-20	BA	RHAC	1	23
12-May-20	BA	RHRE	2	13
12-May-20	BA	RHRE	1	20
12-May-20	BA	RHRE	1	18
12-May-20	BA	STBA	3	9
12-May-20	BA	STMA	3	10
12-May-20	BA	STMA	1	6
12-May-20	BA	THDU	2	9
12-May-20	BA	THTR	1	18
12-May-20	BA	THTR	2	11
12-May-20	BA	THTR	5	13

12-May-20	BA	THTR	6	8
12-May-20	BB	ABSO	3	18
12-May-20	BB	ACGU	1	27
12-May-20	BB	ACGU	2	13
12-May-20	BB	ACGU	2	20
12-May-20	BB	ACNF	7	6
12-May-20	BB	ACNF	13	12
12-May-20	BB	ACNF	27	8
12-May-20	BB	ACTR	16	13
12-May-20	BB	ACTR	40	18
12-May-20	BB	ACXA	1	35
12-May-20	BB	CHFR	1	13
12-May-20	BB	CHLU	1	18
12-May-20	BB	CHPE	1	38
12-May-20	BB	CHQU	1	11
12-May-20	BB	GOVA	1	12
12-May-20	BB	GOVA	1	9
12-May-20	BB	GOVA	2	7
12-May-20	BB	KYSP	1	28
12-May-20	BB	KYSP	1	38
12-May-20	BB	KYSP	4	35
12-May-20	BB	MUFL	1	26
12-May-20	BB	MYBE	1	27
12-May-20	BB	NALI	3	20
12-May-20	BB	NALI	2	25
12-May-20	BB	PLIM	2	5
12-May-20	BB	SCPS	2	9
12-May-20	BB	SCPS	1	15
12-May-20	BB	SCPS	2	13
12-May-20	BB	SCRU	2	40
12-May-20	BB	SCRU	1	50
12-May-20	BB	STBA	2	7
12-May-20	BB	STMA	1	7
12-May-20	BB	THDU	1	6
12-May-20	BB	THDU	2	12
12-May-20	BB	THDU	3	9
12-May-20	BB	THTR	2	11
12-May-20	CA	ABSO	1	18
12-May-20	CA	ABSO	1	15
12-May-20	CA	ABSO	1	20
12-May-20	CA	ACBL	1	13
12-May-20	CA	ACNF	2	15
12-May-20	CA	ACNF	27	11
12-May-20	CA	ACNF	14	13
12-May-20	CA	ACTR	4	9
12-May-20	CA	ACTR	1	3
12-May-20	CA	ACTR	8	13
12-May-20	CA	ACTR	4	11
12-May-20	CA	ACXA	1	45
12-May-20	CA	CAJA	2	6
12-May-20	CA	CHAU	2	20
12-May-20	CA	CHLU	1	15
12-May-20	CA	CHOR	1	18
12-May-20	CA	CHPE	1	40
12-May-20	CA	CTST	2	15
12-May-20	CA	CTST	2	13
12-May-20	CA	GOVA	1	25
12-May-20	CA	MOGR	1	11
12-May-20	CA	NALI	1	34
12-May-20	CA	NALI	2	30
12-May-20	CA	NALI	1	27
12-May-20	CA	PAIN	1	9
12-May-20	CA	PLIM	3	4
12-May-20	CA	RHRE	2	13
12-May-20	CA	SCRU	1	40
12-May-20	CA	SCRU	1	55
12-May-20	CA	SCRU	3	45
12-May-20	CA	STBA	7	6
12-May-20	CA	STBA	3	11
12-May-20	CA	STBA	1	2
12-May-20	CA	STBA	1	9
12-May-20	CA	STMA	1	7

12-May-20	CA	THDU	3	4
12-May-20	CA	THDU	2	11
12-May-20	CA	THDU	3	15
12-May-20	CA	THDU	1	18
12-May-20	CA	THDU	1	6
12-May-20	CA	ZEVE	2	30
12-May-20	CA	ZEVE	2	23
12-May-20	CB	ABSO	1	15
12-May-20	CB	ABSO	1	18
12-May-20	CB	ABSO	1	13
12-May-20	CB	ACNF	25	11
12-May-20	CB	ACNF	15	13
12-May-20	CB	ACTR	3	3
12-May-20	CB	ACTR	1	2
12-May-20	CB	ACXA	1	30
12-May-20	CB	CAJA	2	5
12-May-20	CB	CAJA	1	6
12-May-20	CB	CAME	1	45
12-May-20	CB	CAME	1	27
12-May-20	CB	CAME	1	40
12-May-20	CB	CAME	1	28
12-May-20	CB	CHAU	1	20
12-May-20	CB	CHAU	1	18
12-May-20	CB	CHFR	3	12
12-May-20	CB	CHLU	1	16
12-May-20	CB	CTST	2	4
12-May-20	CB	CTST	1	13
12-May-20	CB	GOVA	1	20
12-May-20	CB	GOVA	1	25
12-May-20	CB	GOVA	1	11
12-May-20	CB	LUFU	1	28
12-May-20	CB	NALI	1	40
12-May-20	CB	NALI	2	30
12-May-20	CB	NALI	1	35
12-May-20	CB	NALI	1	25
12-May-20	CB	PACY	1	18
12-May-20	CB	PAIN	2	25
12-May-20	CB	PAIN	1	18
12-May-20	CB	PLIM	6	4
12-May-20	CB	RHAC	1	20
12-May-20	CB	RHAC	1	15
12-May-20	CB	RHRE	2	18
12-May-20	CB	RHRE	1	15
12-May-20	CB	SCPS	8	11
12-May-20	CB	SCPS	5	12
12-May-20	CB	SCPS	3	14
12-May-20	CB	STBA	5	6
12-May-20	CB	STBA	3	4
12-May-20	CB	STMA	1	7
12-May-20	CB	THDU	1	20
12-May-20	CB	THDU	2	11
12-May-20	CB	THDU	3	3
12-May-20	CB	THDU	5	5
12-May-20	CB	THDU	1	18
12-May-20	CB	THTR	1	17
12-May-20	CB	ZEVE	1	25
12-May-20	CB	ZEVE	1	27
12-May-20	KA	ABSO	1	13
12-May-20	KA	ABSO	3	18
12-May-20	KA	ABSO	1	20
12-May-20	KA	ACBL	1	27
12-May-20	KA	ACGU	4	23
12-May-20	KA	ACGU	1	27
12-May-20	KA	ACLE	1	23
12-May-20	KA	ACNF	7	8
12-May-20	KA	ACNF	15	10
12-May-20	KA	ACNF	4	12
12-May-20	KA	ACTR	1	13
12-May-20	KA	CAAM	1	7
12-May-20	KA	CAJA	1	5
12-May-20	KA	CHAU	1	20
12-May-20	KA	CHLU	1	30

12-May-20	KA	CHLU	1	15
12-May-20	KA	CHQU	2	10
12-May-20	KA	GOVA	2	18
12-May-20	KA	GOVA	1	7
12-May-20	KA	KYSP	2	45
12-May-20	KA	NALI	2	27
12-May-20	KA	NALI	1	35
12-May-20	KA	NALI	1	23
12-May-20	KA	NALI	1	37
12-May-20	KA	PAMU	1	17
12-May-20	KA	PLIM	3	5
12-May-20	KA	RHRE	1	21
12-May-20	KA	STBA	2	8
12-May-20	KA	STBA	1	11
12-May-20	KA	STBA	1	12
12-May-20	KA	SYUL	1	20
12-May-20	KA	THDU	2	13
12-May-20	KA	ZEVE	2	27
12-May-20	KA	ZEVE	1	40
12-May-20	KB	ABSO	2	18
12-May-20	KB	ABSO	1	13
12-May-20	KB	ACBL	2	27
12-May-20	KB	ACGU	1	25
12-May-20	KB	ACNF	4	9
12-May-20	KB	ACNF	20	13
12-May-20	KB	ACNF	26	11
12-May-20	KB	ACTR	2	4
12-May-20	KB	ACTR	2	3
12-May-20	KB	CHAU	1	18
12-May-20	KB	GOVA	1	9
12-May-20	KB	GOVA	3	6
12-May-20	KB	GOVA	1	18
12-May-20	KB	KYSP	1	50
12-May-20	KB	LUKA	2	27
12-May-20	KB	LUKA	1	25
12-May-20	KB	NALI	1	35
12-May-20	KB	NALI	2	27
12-May-20	KB	NALI	3	30
12-May-20	KB	PAIN	2	23
12-May-20	KB	PLIM	15	4
12-May-20	KB	PLIM	2	5
12-May-20	KB	SCPS	2	13
12-May-20	KB	SCPS	1	11
12-May-20	KB	STBA	5	8
12-May-20	KB	STBA	1	11
12-May-20	KB	STBA	1	17
12-May-20	KB	STBA	1	12
12-May-20	KB	STMA	5	6
12-May-20	KB	THDU	2	8
12-May-20	KB	THDU	1	20
12-May-20	KB	THDU	1	18
12-May-20	KB	THDU	1	13
12-May-20	KB	THTR	2	18
12-May-20	KB	THTR	2	23
12-May-20	WA	ABSO	1	18
12-May-20	WA	ACBL	1	20
12-May-20	WA	ACNF	10	11
12-May-20	WA	ACNF	5	13
12-May-20	WA	ACNF	5	8
12-May-20	WA	ACOL	1	27
12-May-20	WA	ACTR	3	13
12-May-20	WA	ACTR	9	4
12-May-20	WA	ACTR	5	3
12-May-20	WA	CAJA	1	5
12-May-20	WA	CAME	1	23
12-May-20	WA	GOVA	1	20
12-May-20	WA	GOVA	1	11
12-May-20	WA	KYSP	1	45
12-May-20	WA	NALI	1	9
12-May-20	WA	NALI	2	27
12-May-20	WA	NALI	1	23
12-May-20	WA	NAUN	2	7

12-May-20	WA	NAUN	1	8
12-May-20	WA	PAIN	1	25
12-May-20	WA	PAIN	1	13
12-May-20	WA	PAIN	1	23
12-May-20	WA	PLIM	3	4
12-May-20	WA	RHAC	2	23
12-May-20	WA	RHAC	1	27
12-May-20	WA	SCPS	5	12
12-May-20	WA	STBA	2	7
12-May-20	WA	STBA	4	9
12-May-20	WA	STBA	2	6
12-May-20	WA	THDU	1	11
12-May-20	WA	THDU	1	20
12-May-20	WB	ACBL	1	25
12-May-20	WB	ACTR	35	13
12-May-20	WB	ACTR	20	18
12-May-20	WB	ACTR	70	15
12-May-20	WB	CACA	1	20
12-May-20	WB	CAJA	1	7
12-May-20	WB	CAJA	1	5
12-May-20	WB	CHAU	2	23
12-May-20	WB	CHQU	2	13
12-May-20	WB	KYSP	1	50
12-May-20	WB	MUFL	1	27
12-May-20	WB	NALI	1	30
12-May-20	WB	NALI	1	27
12-May-20	WB	PAIN	1	23
12-May-20	WB	PAIN	1	25
12-May-20	WB	RHAC	1	20
12-May-20	WB	RHAC	1	23
12-May-20	WB	RHAC	1	25
12-May-20	WB	SCPS	7	20
12-May-20	WB	SCPS	1	30
12-May-20	WB	SCPS	12	18
12-May-20	WB	THTR	1	20
12-May-20	WB	THTR	1	20
19-May-20	BA	ABSO	2	15
19-May-20	BA	ABVA	2	12
19-May-20	BA	ACGU	2	23
19-May-20	BA	ACNF	15	10
19-May-20	BA	ACNF	15	13
19-May-20	BA	ACTR	1	20
19-May-20	BA	ACTR	6	15
19-May-20	BA	ACTR	9	13
19-May-20	BA	ACTR	6	9
19-May-20	BA	CHOR	1	15
19-May-20	BA	CHQU	1	15
19-May-20	BA	CHSP	1	13
19-May-20	BA	CHSP	1	23
19-May-20	BA	GOVA	1	13
19-May-20	BA	KYSP	1	45
19-May-20	BA	NALI	1	23
19-May-20	BA	PAIN	2	20
19-May-20	BA	SCPS	1	13
19-May-20	BA	SCRU	1	50
19-May-20	BA	STBA	1	6
19-May-20	BA	STMA	1	12
19-May-20	BA	THDU	1	18
19-May-20	BA	THDU	1	13
19-May-20	BA	ZACO	1	17
19-May-20	BA	ZACO	1	15
19-May-20	BA	ZEFL	2	13
19-May-20	BA	ZEFL	1	15
19-May-20	BB	ABSO	1	15
19-May-20	BB	ACGU	2	23
19-May-20	BB	ACNF	10	13
19-May-20	BB	ACNF	18	12
19-May-20	BB	ACNF	15	15
19-May-20	BB	ACTR	1	13
19-May-20	BB	CHAU	1	15
19-May-20	BB	CHAU	1	18
19-May-20	BB	CHPE	1	50

19-May-20	BB	GOVA	1	18
19-May-20	BB	KYSP	2	28
19-May-20	BB	KYSP	1	50
19-May-20	BB	NALI	1	30
19-May-20	BB	NALI	2	27
19-May-20	BB	SCPS	1	15
19-May-20	BB	SCRU	1	55
19-May-20	BB	SCRU	1	50
19-May-20	BB	SCRU	1	25
19-May-20	BB	SCRU	3	45
19-May-20	BB	THDU	2	13
19-May-20	BB	ZEVE	1	45
19-May-20	CA	ACBL	1	27
19-May-20	CA	ACBL	2	28
19-May-20	CA	ACNF	13	11
19-May-20	CA	ACNF	12	15
19-May-20	CA	ACNF	15	13
19-May-20	CA	ACNF	3	18
19-May-20	CA	ACTR	9	18
19-May-20	CA	ACTR	1	3
19-May-20	CA	ACTR	2	11
19-May-20	CA	ACTR	6	15
19-May-20	CA	CAJA	1	4
19-May-20	CA	CHQU	1	13
19-May-20	CA	CHQU	1	11
19-May-20	CA	CTST	2	17
19-May-20	CA	CTST	1	18
19-May-20	CA	GOVA	1	20
19-May-20	CA	LUFU	1	25
19-May-20	CA	NALI	1	30
19-May-20	CA	NALI	2	28
19-May-20	CA	PAIN	1	20
19-May-20	CA	PLIM	1	5
19-May-20	CA	RHAC	1	17
19-May-20	CA	RHRE	1	17
19-May-20	CA	SCPS	1	20
19-May-20	CA	SCRU	1	35
19-May-20	CA	SCRU	1	45
19-May-20	CA	STBA	1	5
19-May-20	CA	STBA	1	7
19-May-20	CA	THDU	1	20
19-May-20	CA	THDU	1	11
19-May-20	CA	THDU	1	13
19-May-20	CA	THDU	1	5
19-May-20	CA	THDU	1	8
19-May-20	CB	ABSO	1	18
19-May-20	CB	ABSO	1	15
19-May-20	CB	ACBL	3	30
19-May-20	CB	ACBL	7	28
19-May-20	CB	ACNF	18	12
19-May-20	CB	ACNF	5	13
19-May-20	CB	ACNF	10	11
19-May-20	CB	ACTR	2	13
19-May-20	CB	ACTR	3	11
19-May-20	CB	ACTR	1	15
19-May-20	CB	ACXA	1	35
19-May-20	CB	CACA	1	28
19-May-20	CB	CAJA	4	6
19-May-20	CB	CAJA	2	5
19-May-20	CB	CHAU	2	15
19-May-20	CB	CHLU	1	17
19-May-20	CB	KYSP	1	50
19-May-20	CB	KYSP	1	45
19-May-20	CB	LUFU	1	25
19-May-20	CB	NALI	3	30
19-May-20	CB	NALI	1	27
19-May-20	CB	PLIM	1	6
19-May-20	CB	PLIM	1	4
19-May-20	CB	RHAC	1	24
19-May-20	CB	RHRE	1	17
19-May-20	CB	RHRE	1	15
19-May-20	CB	RHRE	1	20

19-May-20	CB	SCPS	5	18
19-May-20	CB	SCPS	3	20
19-May-20	CB	STBA	2	3
19-May-20	CB	STMA	1	7
19-May-20	CB	THDU	1	18
19-May-20	CB	THDU	1	20
19-May-20	CB	THDU	2	7
19-May-20	KA	ABSO	1	15
19-May-20	KA	ACLE	1	22
19-May-20	KA	ACNF	12	11
19-May-20	KA	ACNF	13	12
19-May-20	KA	ACNF	5	15
19-May-20	KA	CHAU	1	15
19-May-20	KA	CHFR	1	13
19-May-20	KA	CHSP	2	27
19-May-20	KA	KYSP	1	25
19-May-20	KA	KYSP	3	28
19-May-20	KA	KYSP	1	30
19-May-20	KA	LUKA	1	26
19-May-20	KA	MUFL	1	28
19-May-20	KA	NALI	2	28
19-May-20	KA	PLIM	1	5
19-May-20	KA	RHRE	1	20
19-May-20	KA	THDU	1	9
19-May-20	KA	THDU	1	11
19-May-20	KB	ABSO	1	20
19-May-20	KB	ABSO	3	15
19-May-20	KB	ACBL	1	32
19-May-20	KB	ACBL	2	30
19-May-20	KB	ACNF	30	13
19-May-20	KB	ACNF	20	12
19-May-20	KB	ACNF	8	15
19-May-20	KB	ACTR	27	11
19-May-20	KB	ACTR	1	12
19-May-20	KB	ACTR	10	9
19-May-20	KB	CAJA	1	5
19-May-20	KB	CAME	1	25
19-May-20	KB	CHAU	2	20
19-May-20	KB	CHLU	3	12
19-May-20	KB	CHQU	2	14
19-May-20	KB	GOVA	1	13
19-May-20	KB	GOVA	1	22
19-May-20	KB	LUFU	1	27
19-May-20	KB	LUKA	3	27
19-May-20	KB	LUKA	1	23
19-May-20	KB	NALI	1	28
19-May-20	KB	PAIN	3	15
19-May-20	KB	PAIN	1	23
19-May-20	KB	PAIN	1	18
19-May-20	KB	PAIN	1	18
19-May-20	KB	PLIM	2	5
19-May-20	KB	RHRE	1	17
19-May-20	KB	SCPS	2	13
19-May-20	KB	SCPS	8	11
19-May-20	KB	SCRU	1	45
19-May-20	KB	SCRU	1	50
19-May-20	KB	THDU	1	18
19-May-20	KB	THDU	1	18
19-May-20	KB	THTR	2	13
19-May-20	KB	ZEVE	1	28
19-May-20	KB	ZEVE	1	30
19-May-20	WA	ABSO	1	15
19-May-20	WA	ACBL	1	45
19-May-20	WA	ACBL	1	30
19-May-20	WA	ACNF	1	14
19-May-20	WA	ACNF	1	12
19-May-20	WA	ACTR	4	20
19-May-20	WA	ACTR	30	15
19-May-20	WA	ACTR	1	18
19-May-20	WA	ACTR	1	12
19-May-20	WA	ACTR	5	13
19-May-20	WA	ACTR	1	9

19-May-20	WA	CHAU	1	18
19-May-20	WA	RHAC	1	18
19-May-20	WB	ACTR	8	4
19-May-20	WB	ACTR	5	3
19-May-20	WB	NALI	1	27
19-May-20	WB	RHAC	2	23
19-May-20	WB	RHAC	1	25
19-May-20	WB	STBA	1	5
19-May-20	WB	THDU	1	6
26-May-20	BA	ABSO	1	20
26-May-20	BA	ABVA	4	11
26-May-20	BA	ACGU	1	25
26-May-20	BA	ACGU	1	27
26-May-20	BA	ACNF	20	13
26-May-20	BA	ACNF	5	15
26-May-20	BA	ACNF	10	9
26-May-20	BA	ACTR	1	18
26-May-20	BA	ACTR	9	12
26-May-20	BA	CHQU	1	12
26-May-20	BA	GOVA	1	22
26-May-20	BA	KYSP	1	35
26-May-20	BA	NALI	1	25
26-May-20	BA	PLIM	1	5
26-May-20	BA	SCPS	2	12
26-May-20	BA	SCPS	3	18
26-May-20	BA	STBA	2	6
26-May-20	BA	STBA	2	10
26-May-20	BA	STMA	1	8
26-May-20	BA	STMA	1	9
26-May-20	BA	THDU	2	18
26-May-20	BA	THDU	1	6
26-May-20	BA	THDU	2	13
26-May-20	BA	THDU	1	11
26-May-20	BA	ZACO	2	10
26-May-20	BA	ZACO	3	15
26-May-20	BA	ZEVE	2	28
26-May-20	BB	ABSO	3	15
26-May-20	BB	ABSO	1	12
26-May-20	BB	ACGU	1	15
26-May-20	BB	ACGU	5	25
26-May-20	BB	ACNF	10	15
26-May-20	BB	ACNF	68	13
26-May-20	BB	ACNF	50	11
26-May-20	BB	ACTR	5	3
26-May-20	BB	ACTR	31	15
26-May-20	BB	ACTR	60	13
26-May-20	BB	ACTR	2	5
26-May-20	BB	CAJA	3	5
26-May-20	BB	CAJA	2	4
26-May-20	BB	CAME	1	60
26-May-20	BB	CHAU	3	15
26-May-20	BB	CHLU	3	15
26-May-20	BB	CHPE	1	45
26-May-20	BB	CHQU	2	13
26-May-20	BB	CTST	1	23
26-May-20	BB	GOVA	1	12
26-May-20	BB	GOVA	1	25
26-May-20	BB	GYFL	1	115
26-May-20	BB	KYSP	4	45
26-May-20	BB	KYSP	2	40
26-May-20	BB	KYSP	1	50
26-May-20	BB	KYSP	1	30
26-May-20	BB	LUFU	1	25
26-May-20	BB	NALI	3	27
26-May-20	BB	NALI	3	30
26-May-20	BB	PAIN	1	20
26-May-20	BB	PLIM	2	3
26-May-20	BB	PLIM	3	4
26-May-20	BB	RHRE	2	18
26-May-20	BB	RHRE	1	15
26-May-20	BB	RHRE	1	10
26-May-20	BB	SCPS	2	12

26-May-20	BB	SCPS	1	15
26-May-20	BB	SCRU	1	55
26-May-20	BB	SCRU	2	45
26-May-20	BB	SCRU	1	50
26-May-20	BB	STBA	5	11
26-May-20	BB	STMA	1	7
26-May-20	BB	THDU	1	15
26-May-20	BB	THDU	2	11
26-May-20	BB	THDU	1	18
26-May-20	BB	THTR	1	12
26-May-20	BB	THTR	1	11
26-May-20	BB	ZEVE	1	20
26-May-20	BB	ZEVE	2	25
26-May-20	CA	ABSO	1	13
26-May-20	CA	ABSO	2	15
26-May-20	CA	ACBL	1	27
26-May-20	CA	ACNF	50	13
26-May-20	CA	ACNF	25	15
26-May-20	CA	ACTR	3	5
26-May-20	CA	ACTR	2	3
26-May-20	CA	ACXA	1	33
26-May-20	CA	ACXA	1	35
26-May-20	CA	CAJA	2	5
26-May-20	CA	CHAU	1	18
26-May-20	CA	CHAU	1	12
26-May-20	CA	CHEP	1	15
26-May-20	CA	CHFR	1	13
26-May-20	CA	CHLU	1	18
26-May-20	CA	CHPE	2	45
26-May-20	CA	CHPE	2	50
26-May-20	CA	CHPE	1	30
26-May-20	CA	CHSP	3	13
26-May-20	CA	CHSP	3	17
26-May-20	CA	CTST	3	15
26-May-20	CA	CTST	1	13
26-May-20	CA	GOVA	3	18
26-May-20	CA	GOVA	1	20
26-May-20	CA	LUFU	3	25
26-May-20	CA	NALI	1	32
26-May-20	CA	NALI	1	30
26-May-20	CA	PAIN	2	17
26-May-20	CA	PAIN	1	23
26-May-20	CA	PAIN	1	18
26-May-20	CA	PLIM	2	3
26-May-20	CA	PLIM	1	2
26-May-20	CA	RHRE	3	15
26-May-20	CA	RHRE	1	17
26-May-20	CA	RHRE	2	20
26-May-20	CA	SCPS	3	15
26-May-20	CA	SCPS	3	18
26-May-20	CA	STBA	2	6
26-May-20	CA	STBA	1	7
26-May-20	CA	STBA	1	9
26-May-20	CA	THDU	2	15
26-May-20	CA	THDU	2	6
26-May-20	CA	THDU	2	12
26-May-20	CA	ZEVE	1	30
26-May-20	CA	ZEVE	1	25
26-May-20	CB	ABSO	1	15
26-May-20	CB	ABSO	1	17
26-May-20	CB	ACGU	1	23
26-May-20	CB	ACNF	5	15
26-May-20	CB	ACNF	20	12
26-May-20	CB	ACNF	1	6
26-May-20	CB	ACTR	1	5
26-May-20	CB	ACTR	3	3
26-May-20	CB	ACTR	4	13
26-May-20	CB	ACTR	1	15
26-May-20	CB	CAJA	1	6
26-May-20	CB	CHAU	2	15
26-May-20	CB	GOVA	1	20
26-May-20	CB	KYSP	1	45

26-May-20	CB	LUFU	1	27
26-May-20	CB	NALI	1	30
26-May-20	CB	NALI	1	33
26-May-20	CB	NALI	1	26
26-May-20	CB	PLAR	6	27
26-May-20	CB	PLIM	6	4
26-May-20	CB	SCPS	1	17
26-May-20	CB	SCPS	1	13
26-May-20	CB	STBA	1	7
26-May-20	CB	STBA	1	3
26-May-20	CB	STBA	1	5
26-May-20	CB	THDU	1	11
26-May-20	CB	THDU	3	3
26-May-20	CB	THDU	2	12
26-May-20	KA	ABSO	1	15
26-May-20	KA	ABSO	1	18
26-May-20	KA	ACBL	1	30
26-May-20	KA	ACBL	1	28
26-May-20	KA	ACBL	1	35
26-May-20	KA	ACGU	1	20
26-May-20	KA	ACGU	1	27
26-May-20	KA	ACLE	1	18
26-May-20	KA	ACLE	1	15
26-May-20	KA	ACNF	10	15
26-May-20	KA	ACNF	50	13
26-May-20	KA	ACTR	1	14
26-May-20	KA	ACTR	1	3
26-May-20	KA	ACTR	30	15
26-May-20	KA	ANCU	1	25
26-May-20	KA	CAJA	2	4
26-May-20	KA	CAJA	1	5
26-May-20	KA	CHAU	1	15
26-May-20	KA	CHFR	1	12
26-May-20	KA	CHFR	1	15
26-May-20	KA	CHLU	2	15
26-May-20	KA	CHQU	2	13
26-May-20	KA	CHSP	1	28
26-May-20	KA	CHSP	1	25
26-May-20	KA	GOVA	1	11
26-May-20	KA	GOVA	1	17
26-May-20	KA	KYSP	2	45
26-May-20	KA	LUKA	1	23
26-May-20	KA	NALI	1	30
26-May-20	KA	NALI	1	27
26-May-20	KA	PAIN	1	23
26-May-20	KA	PLIM	1	4
26-May-20	KA	SCPS	1	23
26-May-20	KA	SCRU	1	45
26-May-20	KA	SCRU	1	50
26-May-20	KA	SCRU	1	55
26-May-20	KA	THDU	3	11
26-May-20	KA	THDU	1	17
26-May-20	KA	THDU	2	15
26-May-20	KA	THTR	1	17
26-May-20	KA	THTR	1	23
26-May-20	KA	ZEVE	3	28
26-May-20	KB	ABSO	4	15
26-May-20	KB	ACBL	1	27
26-May-20	KB	ACNF	35	11
26-May-20	KB	ACNF	20	13
26-May-20	KB	ACNF	15	15
26-May-20	KB	ACTR	2	3
26-May-20	KB	CAJA	1	5
26-May-20	KB	CAJA	1	7
26-May-20	KB	CHEP	2	15
26-May-20	KB	CHQU	1	15
26-May-20	KB	CHQU	1	13
26-May-20	KB	GOVA	1	13
26-May-20	KB	GOVA	1	15
26-May-20	KB	GOVA	1	25
26-May-20	KB	GOVA	1	23
26-May-20	KB	KYSP	1	45

26-May-20	KB	KYSP	1	27
26-May-20	KB	LUKA	2	25
26-May-20	KB	NALI	2	30
26-May-20	KB	NALI	2	28
26-May-20	KB	PLIM	2	3
26-May-20	KB	PLIM	7	4
26-May-20	KB	RHRE	1	19
26-May-20	KB	SCPS	11	12
26-May-20	KB	SCPS	21	14
26-May-20	KB	STBA	2	7
26-May-20	KB	STBA	1	12
26-May-20	KB	STMA	1	11
26-May-20	KB	STMA	1	8
26-May-20	KB	THTR	1	13
26-May-20	WA	ABSO	1	15
26-May-20	WA	ABSO	1	15
26-May-20	WA	ACNF	5	15
26-May-20	WA	ACNF	7	13
26-May-20	WA	ACTR	1	4
26-May-20	WA	ACTR	7	3
26-May-20	WA	ACTR	1	9
26-May-20	WA	CAJA	1	6
26-May-20	WA	CAJA	1	5
26-May-20	WA	CHAU	2	17
26-May-20	WA	CHLU	1	18
26-May-20	WA	CHLU	1	13
26-May-20	WA	NALI	1	28
26-May-20	WA	NALI	2	25
26-May-20	WA	PAIN	1	17
26-May-20	WA	PAIN	1	13
26-May-20	WA	PLIM	5	4
26-May-20	WA	RHAC	1	27
26-May-20	WA	RHAC	1	18
26-May-20	WA	RHAC	1	23
26-May-20	WA	RHAC	1	25
26-May-20	WA	SCPS	6	15
26-May-20	WA	SCPS	1	13
26-May-20	WA	SCPS	1	20
26-May-20	WA	STBA	2	6
26-May-20	WA	STBA	1	13
26-May-20	WA	THDU	1	18
26-May-20	WA	THDU	1	15
26-May-20	WA	THDU	2	13
26-May-20	WB	ACBL	2	40
26-May-20	WB	ACTR	15	12
26-May-20	WB	ACTR	25	15
26-May-20	WB	ACTR	35	14
26-May-20	WB	CAME	1	40
26-May-20	WB	CHAU	2	17
26-May-20	WB	CHQU	1	13
26-May-20	WB	KYSP	1	45
26-May-20	WB	NALI	3	25
26-May-20	WB	RHAC	1	23
26-May-20	WB	SCPS	1	23
26-May-20	WB	SCRU	1	50
26-May-20	WB	THTR	1	23
23-Jun-20	BA	ABSO	2	17
23-Jun-20	BA	ABSO	1	15
23-Jun-20	BA	ABVA	2	8
23-Jun-20	BA	ABVA	1	4
23-Jun-20	BA	ACGU	1	25
23-Jun-20	BA	ACGU	1	13
23-Jun-20	BA	ACGU	1	18
23-Jun-20	BA	ACNF	20	13
23-Jun-20	BA	ACNF	2	15
23-Jun-20	BA	ACTR	3	11
23-Jun-20	BA	ACTR	7	12
23-Jun-20	BA	ACTR	4	16
23-Jun-20	BA	ANCU	1	23
23-Jun-20	BA	CAME	2	45
23-Jun-20	BA	CHOR	1	17
23-Jun-20	BA	CHQU	1	13

23-Jun-20	BA	CHQU	1	11
23-Jun-20	BA	GOVA	1	22
23-Jun-20	BA	KYSP	1	45
23-Jun-20	BA	NALI	1	27
23-Jun-20	BA	PLIM	1	4
23-Jun-20	BA	PLIM	1	5
23-Jun-20	BA	SCPS	2	15
23-Jun-20	BA	SCPS	9	13
23-Jun-20	BA	SCRU	1	45
23-Jun-20	BA	STMA	1	11
23-Jun-20	BA	STMA	1	9
23-Jun-20	BA	STMA	1	8
23-Jun-20	BA	THDU	1	23
23-Jun-20	BA	ZEFL	2	17
23-Jun-20	BB	ABSO	1	17
23-Jun-20	BB	ACBL	1	25
23-Jun-20	BB	ACGU	2	25
23-Jun-20	BB	ACGU	1	17
23-Jun-20	BB	ACNF	15	12
23-Jun-20	BB	ACTR	1	12
23-Jun-20	BB	ACTR	3	13
23-Jun-20	BB	CHAU	1	17
23-Jun-20	BB	CHLU	1	15
23-Jun-20	BB	CHPE	1	50
23-Jun-20	BB	CHPE	1	45
23-Jun-20	BB	CHSP	1	23
23-Jun-20	BB	CTST	1	17
23-Jun-20	BB	KYSP	1	35
23-Jun-20	BB	KYSP	1	28
23-Jun-20	BB	NALI	1	32
23-Jun-20	BB	NALI	1	25
23-Jun-20	BB	SCPS	5	20
23-Jun-20	BB	SCPS	15	15
23-Jun-20	BB	SCRU	1	45
23-Jun-20	BB	ZACO	2	15
23-Jun-20	BB	ZEVE	1	27
23-Jun-20	BB	ZEVE	1	40
23-Jun-20	CA	ABSO	2	18
23-Jun-20	CA	ABSO	1	20
23-Jun-20	CA	ACBL	1	40
23-Jun-20	CA	ACBL	1	28
23-Jun-20	CA	ACNF	6	15
23-Jun-20	CA	ACNF	20	12
23-Jun-20	CA	CAJA	1	6
23-Jun-20	CA	CAME	1	28
23-Jun-20	CA	CAME	1	24
23-Jun-20	CA	CHAU	2	15
23-Jun-20	CA	CHFR	2	13
23-Jun-20	CA	CHLU	1	15
23-Jun-20	CA	CHPE	1	55
23-Jun-20	CA	CHPE	1	45
23-Jun-20	CA	CTST	1	17
23-Jun-20	CA	CTST	1	15
23-Jun-20	CA	GOVA	1	7
23-Jun-20	CA	KYSP	1	45
23-Jun-20	CA	KYSP	1	50
23-Jun-20	CA	NALI	2	25
23-Jun-20	CA	NALI	1	30
23-Jun-20	CA	PAIN	1	20
23-Jun-20	CA	PAIN	1	17
23-Jun-20	CA	PAIN	2	27
23-Jun-20	CA	PAMU	1	17
23-Jun-20	CA	PLAR	20	28
23-Jun-20	CA	PLIM	5	4
23-Jun-20	CA	RHRE	1	17
23-Jun-20	CA	RHRE	1	20
23-Jun-20	CA	SCPS	5	15
23-Jun-20	CA	STBA	3	7
23-Jun-20	CA	STMA	1	12
23-Jun-20	CA	THDU	7	5
23-Jun-20	CA	THDU	2	15
23-Jun-20	CA	THDU	1	17

23-Jun-20	CA	ZEVE	2	27
23-Jun-20	CB	ABSO	1	18
23-Jun-20	CB	ABSO	1	15
23-Jun-20	CB	ABSO	1	25
23-Jun-20	CB	ACBL	3	30
23-Jun-20	CB	ACNF	5	15
23-Jun-20	CB	ACNF	16	12
23-Jun-20	CB	ACXA	7	40
23-Jun-20	CB	CACA	1	25
23-Jun-20	CB	CAJA	2	5
23-Jun-20	CB	CEAR	1	32
23-Jun-20	CB	CHLU	1	15
23-Jun-20	CB	CHSP	1	22
23-Jun-20	CB	GOVA	1	23
23-Jun-20	CB	GOVA	1	15
23-Jun-20	CB	NALI	3	32
23-Jun-20	CB	PAIN	1	25
23-Jun-20	CB	PAIN	2	17
23-Jun-20	CB	PAIN	1	20
23-Jun-20	CB	RHRE	1	15
23-Jun-20	CB	RHRE	2	20
23-Jun-20	CB	SCPS	5	15
23-Jun-20	CB	SCPS	1	15
23-Jun-20	CB	SCRU	1	55
23-Jun-20	CB	THDU	1	17
23-Jun-20	CB	THDU	3	11
23-Jun-20	KA	ABSO	2	17
23-Jun-20	KA	ACBL	1	28
23-Jun-20	KA	ACLE	1	20
23-Jun-20	KA	ACNF	5	10
23-Jun-20	KA	ACNF	5	15
23-Jun-20	KA	ACNF	10	12
23-Jun-20	KA	ACTR	1	17
23-Jun-20	KA	CACA	1	30
23-Jun-20	KA	CAJA	2	7
23-Jun-20	KA	CAME	1	35
23-Jun-20	KA	CHAU	1	17
23-Jun-20	KA	CHFR	1	13
23-Jun-20	KA	CHLU	1	17
23-Jun-20	KA	CHQU	2	15
23-Jun-20	KA	CHSP	1	28
23-Jun-20	KA	GOVA	1	27
23-Jun-20	KA	GOVA	1	20
23-Jun-20	KA	GOVA	1	6
23-Jun-20	KA	GOVA	1	17
23-Jun-20	KA	LUKA	1	28
23-Jun-20	KA	LUKA	1	33
23-Jun-20	KA	MUFL	1	35
23-Jun-20	KA	NALI	2	28
23-Jun-20	KA	NALI	1	35
23-Jun-20	KA	OSME	1	8
23-Jun-20	KA	PAIN	1	20
23-Jun-20	KA	PAIN	1	17
23-Jun-20	KA	RHRE	1	20
23-Jun-20	KA	THDU	1	15
23-Jun-20	KA	THDU	1	17
23-Jun-20	KA	ZEVE	1	35
23-Jun-20	KA	ZEVE	1	40
23-Jun-20	KA	ZEVE	1	30
23-Jun-20	KB	ABSO	2	18
23-Jun-20	KB	ACBL	1	32
23-Jun-20	KB	ACBL	1	35
23-Jun-20	KB	ACBL	1	45
23-Jun-20	KB	ACNF	20	13
23-Jun-20	KB	ACNF	5	15
23-Jun-20	KB	ACTR	3	5
23-Jun-20	KB	ACTR	1	7
23-Jun-20	KB	ACTR	10	15
23-Jun-20	KB	ACTR	25	17
23-Jun-20	KB	ACTR	5	20
23-Jun-20	KB	ACXA	1	45
23-Jun-20	KB	CAJA	2	7

23-Jun-20	KB	CAJA	1	5
23-Jun-20	KB	CHQU	2	13
23-Jun-20	KB	GOVA	1	18
23-Jun-20	KB	GOVA	1	11
23-Jun-20	KB	GOVA	1	13
23-Jun-20	KB	GOVA	1	25
23-Jun-20	KB	KYSP	1	45
23-Jun-20	KB	NALI	1	40
23-Jun-20	KB	NALI	1	27
23-Jun-20	KB	NALI	2	30
23-Jun-20	KB	SCPS	1	12
23-Jun-20	KB	SCPS	3	15
23-Jun-20	KB	SCPS	3	20
23-Jun-20	KB	SCPS	2	22
23-Jun-20	KB	STBA	2	7
23-Jun-20	KB	STBA	1	5
23-Jun-20	KB	THDU	1	11
23-Jun-20	KB	THDU	1	19
23-Jun-20	KB	THTR	1	18
23-Jun-20	WA	ABSO	2	17
23-Jun-20	WA	ACBL	1	30
23-Jun-20	WA	ACBL	1	28
23-Jun-20	WA	ACNF	4	15
23-Jun-20	WA	ACTR	2	5
23-Jun-20	WA	ACTR	10	10
23-Jun-20	WA	ACTR	3	3
23-Jun-20	WA	ACTR	3	17
23-Jun-20	WA	ACTR	2	15
23-Jun-20	WA	ACTR	10	13
23-Jun-20	WA	CAME	2	28
23-Jun-20	WA	CAME	1	27
23-Jun-20	WA	CHLU	1	13
23-Jun-20	WA	KYSP	1	45
23-Jun-20	WA	PAIN	2	15
23-Jun-20	WA	PAIN	1	28
23-Jun-20	WA	PLIM	1	5
23-Jun-20	WA	RHAC	1	25
23-Jun-20	WA	RHAC	2	23
23-Jun-20	WA	RHAC	1	27
23-Jun-20	WA	SCPS	2	12
23-Jun-20	WA	SCPS	10	13
23-Jun-20	WA	SCPS	35	15
23-Jun-20	WA	SCPS	6	20
23-Jun-20	WA	SCRU	1	50
23-Jun-20	WA	SCRU	1	55
23-Jun-20	WA	STBA	1	7
23-Jun-20	WA	THDU	1	20
23-Jun-20	WB	NALI	1	25
23-Jun-20	WB	RHAC	1	23
23-Jun-20	WB	RHAC	1	20
23-Jun-20	WB	RHAC	2	25
23-Jun-20	WB	RHRE	1	15
30-Jun-20	BA	ABSO	1	21
30-Jun-20	BA	ABSO	1	18
30-Jun-20	BA	ABVA	1	6
30-Jun-20	BA	ACGU	1	18
30-Jun-20	BA	ACGU	1	25
30-Jun-20	BA	ACGU	1	23
30-Jun-20	BA	ACNF	30	12
30-Jun-20	BA	ACNF	15	15
30-Jun-20	BA	ACNF	20	9
30-Jun-20	BA	ACTR	15	13
30-Jun-20	BA	ACTR	4	15
30-Jun-20	BA	ACXA	2	40
30-Jun-20	BA	ACXA	2	30
30-Jun-20	BA	CAJA	1	4
30-Jun-20	BA	CAME	2	55
30-Jun-20	BA	CAME	1	50
30-Jun-20	BA	CEAR	1	25
30-Jun-20	BA	CHEP	1	13
30-Jun-20	BA	CHLI	2	23
30-Jun-20	BA	CHLU	1	13

30-Jun-20	BA	CHOR	1	13
30-Jun-20	BA	GOVA	1	17
30-Jun-20	BA	GOVA	2	7
30-Jun-20	BA	KYSP	1	45
30-Jun-20	BA	KYSP	1	50
30-Jun-20	BA	NALI	1	42
30-Jun-20	BA	PAIN	1	19
30-Jun-20	BA	PAIN	1	17
30-Jun-20	BA	PLIM	3	5
30-Jun-20	BA	RHRE	1	23
30-Jun-20	BA	SCPS	10	12
30-Jun-20	BA	SCPS	1	20
30-Jun-20	BA	SCPS	8	15
30-Jun-20	BA	STBA	1	8
30-Jun-20	BA	STMA	1	11
30-Jun-20	BA	STMA	1	12
30-Jun-20	BA	THDU	1	20
30-Jun-20	BA	THDU	1	7
30-Jun-20	BA	THDU	2	11
30-Jun-20	BA	ZACO	2	15
30-Jun-20	BA	ZEFL	1	17
30-Jun-20	BA	ZEVE	1	50
30-Jun-20	BA	ZEVE	3	43
30-Jun-20	BB	ABSO	1	18
30-Jun-20	BB	ACBL	2	28
30-Jun-20	BB	ACGU	4	25
30-Jun-20	BB	ACGU	5	23
30-Jun-20	BB	ACGU	1	17
30-Jun-20	BB	ACNF	50	12
30-Jun-20	BB	ACNF	30	13
30-Jun-20	BB	ACTR	2	2
30-Jun-20	BB	ACTR	1	14
30-Jun-20	BB	CAME	2	55
30-Jun-20	BB	CEAR	1	45
30-Jun-20	BB	CEAR	1	50
30-Jun-20	BB	CHPE	1	45
30-Jun-20	BB	CTST	1	18
30-Jun-20	BB	CTST	2	15
30-Jun-20	BB	GOVA	2	10
30-Jun-20	BB	GOVA	3	13
30-Jun-20	BB	KYSP	1	25
30-Jun-20	BB	KYSP	3	45
30-Jun-20	BB	KYSP	1	27
30-Jun-20	BB	NALI	1	22
30-Jun-20	BB	NESA	1	25
30-Jun-20	BB	PAIN	1	15
30-Jun-20	BB	PLIM	1	5
30-Jun-20	BB	RHRE	1	22
30-Jun-20	BB	SCPS	4	9
30-Jun-20	BB	SCRU	1	50
30-Jun-20	BB	STBA	2	11
30-Jun-20	BB	STBA	1	8
30-Jun-20	BB	STMA	1	12
30-Jun-20	BB	THDU	2	12
30-Jun-20	BB	THTR	1	13
30-Jun-20	BB	THTR	1	23
30-Jun-20	CA	ABSO	1	12
30-Jun-20	CA	ABSO	1	13
30-Jun-20	CA	ABSO	1	14
30-Jun-20	CA	ABVA	1	15
30-Jun-20	CA	ACBL	1	24
30-Jun-20	CA	ACNF	10	15
30-Jun-20	CA	ACNF	30	12
30-Jun-20	CA	ACTR	1	12
30-Jun-20	CA	ACTR	2	5
30-Jun-20	CA	ACTR	2	3
30-Jun-20	CA	CAJA	2	5
30-Jun-20	CA	CHAU	1	12
30-Jun-20	CA	CHAU	2	15
30-Jun-20	CA	CHLU	1	17
30-Jun-20	CA	CHOR	2	15
30-Jun-20	CA	CHPE	4	45

30-Jun-20	CA	CHPE	1	48
30-Jun-20	CA	CHPE	1	40
30-Jun-20	CA	CHSP	1	20
30-Jun-20	CA	CHSP	4	17
30-Jun-20	CA	CTST	2	13
30-Jun-20	CA	CTST	3	15
30-Jun-20	CA	GOVA	1	18
30-Jun-20	CA	GOVA	1	25
30-Jun-20	CA	LUFU	1	30
30-Jun-20	CA	NALI	2	28
30-Jun-20	CA	NALI	2	27
30-Jun-20	CA	NALI	1	32
30-Jun-20	CA	RHAC	1	18
30-Jun-20	CA	SCPS	2	12
30-Jun-20	CA	THDU	2	13
30-Jun-20	CA	THDU	2	22
30-Jun-20	CA	THDU	3	17
30-Jun-20	CA	ZACO	2	14
30-Jun-20	CB	ABSO	1	15
30-Jun-20	CB	ACNF	5	15
30-Jun-20	CB	ACNF	20	12
30-Jun-20	CB	ACNF	20	10
30-Jun-20	CB	ACNF	1	9
30-Jun-20	CB	ACTR	1	15
30-Jun-20	CB	ACTR	1	1.5
30-Jun-20	CB	CAJA	4	5
30-Jun-20	CB	CAJA	1	7
30-Jun-20	CB	CHLU	1	15
30-Jun-20	CB	CHPE	1	45
30-Jun-20	CB	GOVA	1	7
30-Jun-20	CB	MUFL	1	30
30-Jun-20	CB	NALI	1	27
30-Jun-20	CB	PLIM	1	5
30-Jun-20	CB	RHRE	1	13
30-Jun-20	CB	SCPS	1	18
30-Jun-20	CB	SCRU	1	45
30-Jun-20	CB	STBA	1	9
30-Jun-20	CB	STBA	1	11
30-Jun-20	CB	STMA	2	8
30-Jun-20	CB	THDU	1	9
30-Jun-20	CB	THDU	2	18
30-Jun-20	CB	THDU	4	12
30-Jun-20	CB	THDU	1	6
30-Jun-20	CB	ZEVE	1	22
30-Jun-20	KA	ABSO	1	23
30-Jun-20	KA	ABSO	2	18
30-Jun-20	KA	ABSO	2	15
30-Jun-20	KA	ACGU	1	25
30-Jun-20	KA	ACLE	1	23
30-Jun-20	KA	ACNF	10	11
30-Jun-20	KA	ACNF	25	13
30-Jun-20	KA	ACNF	30	12
30-Jun-20	KA	ACTR	1	18
30-Jun-20	KA	ACTR	19	15
30-Jun-20	KA	ACTR	18	13
30-Jun-20	KA	ACTR	2	2
30-Jun-20	KA	ACTR	1	10
30-Jun-20	KA	CACA	1	28
30-Jun-20	KA	CHFR	2	15
30-Jun-20	KA	CHLU	1	15
30-Jun-20	KA	CHUN	2	15
30-Jun-20	KA	GOVA	1	18
30-Jun-20	KA	GOVA	1	20
30-Jun-20	KA	GOVA	1	17
30-Jun-20	KA	KYSP	1	28
30-Jun-20	KA	KYSP	1	25
30-Jun-20	KA	KYSP	1	32
30-Jun-20	KA	MUFL	2	25
30-Jun-20	KA	MUFL	1	20
30-Jun-20	KA	NALI	1	32
30-Jun-20	KA	PAIN	1	25
30-Jun-20	KA	RHAC	1	24

30-Jun-20	KA	SCPS	1	25
30-Jun-20	KA	SCPS	10	12
30-Jun-20	KA	SCPS	1	28
30-Jun-20	KA	SCPS	1	20
30-Jun-20	KA	STBA	1	9
30-Jun-20	KA	THDU	4	12
30-Jun-20	KB	ABSO	1	15
30-Jun-20	KB	ABSO	1	18
30-Jun-20	KB	ACBL	2	30
30-Jun-20	KB	ACBL	1	40
30-Jun-20	KB	ACLE	1	13
30-Jun-20	KB	ACNF	30	11
30-Jun-20	KB	ACNF	2	15
30-Jun-20	KB	ACNF	25	13
30-Jun-20	KB	ACTR	5	18
30-Jun-20	KB	ACTR	8	13
30-Jun-20	KB	ACTR	5	3
30-Jun-20	KB	ACTR	1	9
30-Jun-20	KB	ACTR	16	15
30-Jun-20	KB	GOVA	1	15
30-Jun-20	KB	GOVA	1	13
30-Jun-20	KB	KYSP	1	45
30-Jun-20	KB	KYSP	1	50
30-Jun-20	KB	KYSP	1	55
30-Jun-20	KB	LUKA	1	28
30-Jun-20	KB	MUFL	1	25
30-Jun-20	KB	NALI	3	28
30-Jun-20	KB	PLIM	2	5
30-Jun-20	KB	SCPS	2	12
30-Jun-20	KB	SCPS	2	20
30-Jun-20	KB	SCRU	1	55
30-Jun-20	KB	STBA	2	11
30-Jun-20	KB	STBA	1	6
30-Jun-20	KB	THDU	1	15
30-Jun-20	KB	THTR	1	9
30-Jun-20	KB	THTR	1	15
30-Jun-20	KB	ZEVE	1	30
30-Jun-20	WA	ABSO	1	17
30-Jun-20	WA	ABSO	2	15
30-Jun-20	WA	ACBL	2	28
30-Jun-20	WA	ACBL	1	23
30-Jun-20	WA	ACNF	5	12
30-Jun-20	WA	ACNF	1	15
30-Jun-20	WA	ACOL	1	30
30-Jun-20	WA	ACTR	14	15
30-Jun-20	WA	ACTR	4	3
30-Jun-20	WA	ACTR	1	12
30-Jun-20	WA	CAJA	4	5
30-Jun-20	WA	CAJA	2	6
30-Jun-20	WA	CAME	1	23
30-Jun-20	WA	CAME	2	25
30-Jun-20	WA	CHAU	1	13
30-Jun-20	WA	CHLU	2	12
30-Jun-20	WA	CHLU	1	12
30-Jun-20	WA	CHLU	1	16
30-Jun-20	WA	CHSP	1	15
30-Jun-20	WA	KYSP	1	40
30-Jun-20	WA	KYSP	1	45
30-Jun-20	WA	LUFU	1	45
30-Jun-20	WA	NALI	2	23
30-Jun-20	WA	NALI	1	25
30-Jun-20	WA	NALI	1	45
30-Jun-20	WA	PAIN	1	30
30-Jun-20	WA	PAIN	3	13
30-Jun-20	WA	PAIN	2	20
30-Jun-20	WA	RHAC	2	23
30-Jun-20	WA	SCLY	2	35
30-Jun-20	WA	SCPS	7	13
30-Jun-20	WA	SCPS	1	20
30-Jun-20	WA	STBA	1	8
30-Jun-20	WA	STBA	3	7
30-Jun-20	WA	THDU	3	15

30-Jun-20	WA	THDU	3	13
30-Jun-20	WB	ACTR	1	4
30-Jun-20	WB	ACTR	1	1
30-Jun-20	WB	ACTR	2	5
30-Jun-20	WB	ACTR	3	3
30-Jun-20	WB	CHAU	2	17
30-Jun-20	WB	CHLU	1	7
30-Jun-20	WB	PLIM	1	4
30-Jun-20	WB	RHAC	1	23
30-Jun-20	WB	SCLY	1	40
30-Jun-20	WB	STBA	1	3
30-Jun-20	WB	STBA	1	5
07-Jul-20	BA	ABSO	1	18
07-Jul-20	BA	ABVA	2	12
07-Jul-20	BA	ABVA	1	9
07-Jul-20	BA	ACAC	1	24
07-Jul-20	BA	ACBL	1	15
07-Jul-20	BA	ACGU	1	27
07-Jul-20	BA	ACNF	15	13
07-Jul-20	BA	ACNF	10	11
07-Jul-20	BA	ACNF	5	15
07-Jul-20	BA	ACTR	1	6
07-Jul-20	BA	ACTR	31	12
07-Jul-20	BA	ACTR	80	15
07-Jul-20	BA	CHAU	3	15
07-Jul-20	BA	CHQU	2	13
07-Jul-20	BA	GOVA	1	12
07-Jul-20	BA	KYSP	1	50
07-Jul-20	BA	KYSP	3	45
07-Jul-20	BA	NALI	1	23
07-Jul-20	BA	PAIN	1	18
07-Jul-20	BA	PLIM	2	5
07-Jul-20	BA	RHRE	1	17
07-Jul-20	BA	RHRE	1	15
07-Jul-20	BA	SCPS	1	17
07-Jul-20	BA	STBA	1	6
07-Jul-20	BA	STBA	1	9
07-Jul-20	BA	STMA	1	15
07-Jul-20	BA	STMA	2	13
07-Jul-20	BA	STMA	1	11
07-Jul-20	BA	THDU	2	6
07-Jul-20	BA	THDU	1	15
07-Jul-20	BA	THDU	1	20
07-Jul-20	BA	THDU	3	12
07-Jul-20	BA	THTR	1	23
07-Jul-20	BA	ZEFL	1	15
07-Jul-20	BA	ZEFL	1	13
07-Jul-20	BA	ZEVE	2	25
07-Jul-20	BB	ABSO	1	20
07-Jul-20	BB	ACGU	1	23
07-Jul-20	BB	ACGU	1	27
07-Jul-20	BB	ACNF	6	15
07-Jul-20	BB	ACNF	20	11
07-Jul-20	BB	ACNF	15	13
07-Jul-20	BB	ACTR	3	12
07-Jul-20	BB	ACTR	3	15
07-Jul-20	BB	ACXA	1	30
07-Jul-20	BB	CACA	1	20
07-Jul-20	BB	CAJA	1	6
07-Jul-20	BB	CAJA	1	5
07-Jul-20	BB	CHLU	1	15
07-Jul-20	BB	CHOR	1	13
07-Jul-20	BB	CHPE	1	55
07-Jul-20	BB	CHPE	3	45
07-Jul-20	BB	CTST	3	15
07-Jul-20	BB	GOVA	1	15
07-Jul-20	BB	GOVA	1	24
07-Jul-20	BB	GOVA	1	18
07-Jul-20	BB	KYSP	3	40
07-Jul-20	BB	KYSP	1	50
07-Jul-20	BB	KYSP	2	35
07-Jul-20	BB	KYSP	1	28

07-Jul-20	BB	KYSP	2	30
07-Jul-20	BB	LUKA	1	25
07-Jul-20	BB	MUFL	1	28
07-Jul-20	BB	MUFL	1	25
07-Jul-20	BB	NALI	1	32
07-Jul-20	BB	NALI	1	35
07-Jul-20	BB	NALI	1	30
07-Jul-20	BB	NALI	3	27
07-Jul-20	BB	PLIM	1	5
07-Jul-20	BB	RHRE	1	12
07-Jul-20	BB	SCPS	1	23
07-Jul-20	BB	SCRU	1	35
07-Jul-20	BB	THDU	1	22
07-Jul-20	BB	THTR	1	11
07-Jul-20	BB	THTR	1	14
07-Jul-20	BB	THTR	1	12
07-Jul-20	CA	ABSO	2	15
07-Jul-20	CA	ABVA	1	17
07-Jul-20	CA	ABVA	1	15
07-Jul-20	CA	ACBL	6	27
07-Jul-20	CA	ACBL	1	28
07-Jul-20	CA	ACGU	2	25
07-Jul-20	CA	ACGU	1	25
07-Jul-20	CA	ACNF	60	12
07-Jul-20	CA	ACTR	1	3
07-Jul-20	CA	ACTR	1	4
07-Jul-20	CA	ACTR	1	13
07-Jul-20	CA	CAJA	3	5
07-Jul-20	CA	CAJA	4	6
07-Jul-20	CA	CAME	1	45
07-Jul-20	CA	CHPE	2	50
07-Jul-20	CA	CHPE	2	54
07-Jul-20	CA	CHQU	1	15
07-Jul-20	CA	CHSP	1	20
07-Jul-20	CA	CTST	2	15
07-Jul-20	CA	CTST	1	17
07-Jul-20	CA	CTST	2	14
07-Jul-20	CA	GOVA	1	14
07-Jul-20	CA	GOVA	1	9
07-Jul-20	CA	KYSP	1	50
07-Jul-20	CA	KYSP	2	45
07-Jul-20	CA	NALI	1	30
07-Jul-20	CA	NALI	2	28
07-Jul-20	CA	NALI	2	27
07-Jul-20	CA	PLAR	6	20
07-Jul-20	CA	PLAR	2	25
07-Jul-20	CA	PLIM	9	5
07-Jul-20	CA	SCRU	1	50
07-Jul-20	CA	STBA	2	6
07-Jul-20	CA	STBA	1	9
07-Jul-20	CA	STMA	1	7
07-Jul-20	CA	STMA	1	7
07-Jul-20	CA	THDU	1	20
07-Jul-20	CA	THDU	1	12
07-Jul-20	CA	THDU	1	17
07-Jul-20	CA	THDU	1	7
07-Jul-20	CA	THDU	2	9
07-Jul-20	CA	THTR	3	22
07-Jul-20	CA	ZEVE	1	20
07-Jul-20	CA	ZEVE	1	28
07-Jul-20	CB	ABSO	2	17
07-Jul-20	CB	ABSO	1	15
07-Jul-20	CB	ACBL	2	30
07-Jul-20	CB	ACBL	1	28
07-Jul-20	CB	ACNF	30	12
07-Jul-20	CB	ACTR	3	15
07-Jul-20	CB	ACTR	2	3
07-Jul-20	CB	CAJA	1	5
07-Jul-20	CB	CAME	1	35
07-Jul-20	CB	CAME	1	50
07-Jul-20	CB	CHAU	2	15
07-Jul-20	CB	CHLU	1	15

07-Jul-20	CB	CTST	1	13
07-Jul-20	CB	GOVA	1	11
07-Jul-20	CB	GOVA	1	25
07-Jul-20	CB	GOVA	1	18
07-Jul-20	CB	GOVA	1	12
07-Jul-20	CB	MUFL	1	24
07-Jul-20	CB	NALI	2	27
07-Jul-20	CB	NALI	1	30
07-Jul-20	CB	NALI	1	33
07-Jul-20	CB	PAIN	1	28
07-Jul-20	CB	PAIN	1	20
07-Jul-20	CB	PLAR	3	20
07-Jul-20	CB	PLAR	3	28
07-Jul-20	CB	PLIM	5	5
07-Jul-20	CB	RHAC	1	20
07-Jul-20	CB	RHRE	1	18
07-Jul-20	CB	RHRE	2	20
07-Jul-20	CB	SCPS	1	25
07-Jul-20	CB	STBA	1	6
07-Jul-20	CB	THDU	2	11
07-Jul-20	CB	THDU	2	14
07-Jul-20	CB	THDU	1	20
07-Jul-20	CB	THDU	1	18
07-Jul-20	CB	ZEVE	1	28
07-Jul-20	CB	ZEVE	1	32
07-Jul-20	KA	ABSO	3	15
07-Jul-20	KA	ABSO	1	18
07-Jul-20	KA	ABSO	1	14
07-Jul-20	KA	ACBL	2	30
07-Jul-20	KA	ACBL	1	32
07-Jul-20	KA	ACBL	1	27
07-Jul-20	KA	ACLE	1	18
07-Jul-20	KA	ACNF	30	12
07-Jul-20	KA	ACNF	10	15
07-Jul-20	KA	ACTR	1	3
07-Jul-20	KA	ACTR	2	15
07-Jul-20	KA	ACTR	1	12
07-Jul-20	KA	ACTR	1	17
07-Jul-20	KA	ACTR	2	14
07-Jul-20	KA	CAJA	2	5
07-Jul-20	KA	CHAU	1	13
07-Jul-20	KA	GOVA	1	21
07-Jul-20	KA	KYSP	1	26
07-Jul-20	KA	KYSP	1	50
07-Jul-20	KA	MUFL	1	24
07-Jul-20	KA	MUFL	1	22
07-Jul-20	KA	NALI	1	35
07-Jul-20	KA	NALI	3	28
07-Jul-20	KA	NALI	2	30
07-Jul-20	KA	RHRE	1	15
07-Jul-20	KA	SCPS	1	18
07-Jul-20	KA	SCPS	2	15
07-Jul-20	KA	SCPS	2	13
07-Jul-20	KA	STBA	1	8
07-Jul-20	KA	STBA	1	7
07-Jul-20	KA	STMA	1	7
07-Jul-20	KA	THDU	3	12
07-Jul-20	KA	THDU	1	11
07-Jul-20	KA	THDU	1	14
07-Jul-20	KA	THDU	2	7
07-Jul-20	KA	THTR	1	23
07-Jul-20	KA	THTR	1	12
07-Jul-20	KA	ZEVE	2	30
07-Jul-20	KB	ABSO	2	18
07-Jul-20	KB	ABSO	1	15
07-Jul-20	KB	ACBL	1	30
07-Jul-20	KB	ACBL	1	28
07-Jul-20	KB	ACNF	10	13
07-Jul-20	KB	ACNF	50	12
07-Jul-20	KB	ACTR	1	3
07-Jul-20	KB	ACTR	1	5
07-Jul-20	KB	ANCU	1	24

07-Jul-20	KB	CAAM	1	6
07-Jul-20	KB	CAJA	1	6
07-Jul-20	KB	CAME	1	28
07-Jul-20	KB	CHAU	2	15
07-Jul-20	KB	CHFR	1	13
07-Jul-20	KB	CHLU	3	15
07-Jul-20	KB	CHQU	1	15
07-Jul-20	KB	CHQU	1	11
07-Jul-20	KB	CHQU	2	13
07-Jul-20	KB	CHSP	1	11
07-Jul-20	KB	GOVA	1	25
07-Jul-20	KB	GOVA	1	13
07-Jul-20	KB	KYSP	1	58
07-Jul-20	KB	KYSP	1	55
07-Jul-20	KB	KYSP	2	50
07-Jul-20	KB	LUKA	1	25
07-Jul-20	KB	NALI	1	35
07-Jul-20	KB	PAIN	3	12
07-Jul-20	KB	PAIN	3	20
07-Jul-20	KB	PAIN	1	15
07-Jul-20	KB	PLIM	2	4
07-Jul-20	KB	RHRE	2	15
07-Jul-20	KB	SCPS	13	13
07-Jul-20	KB	SCRU	1	55
07-Jul-20	KB	SCRU	1	60
07-Jul-20	KB	STBA	4	7
07-Jul-20	KB	STMA	1	9
07-Jul-20	KB	STMA	1	11
07-Jul-20	KB	THDU	1	13
07-Jul-20	KB	THDU	1	12
07-Jul-20	KB	THDU	1	6
07-Jul-20	KB	THDU	1	18
07-Jul-20	KB	THTR	1	25
07-Jul-20	KB	THTR	1	11
07-Jul-20	KB	ZEVE	3	28
07-Jul-20	KB	ZEVE	1	45
07-Jul-20	WA	ABSO	1	14
07-Jul-20	WA	ACBL	1	29
07-Jul-20	WA	ACOL	1	27
07-Jul-20	WA	ACOL	1	30
07-Jul-20	WA	ACTR	12	13
07-Jul-20	WA	ACTR	15	15
07-Jul-20	WA	ACTR	1	16
07-Jul-20	WA	ACTR	1	3
07-Jul-20	WA	CHQU	2	13
07-Jul-20	WA	CHSP	1	24
07-Jul-20	WA	CHSP	1	23
07-Jul-20	WA	NALI	1	18
07-Jul-20	WA	NALI	1	28
07-Jul-20	WA	RHAC	1	23
07-Jul-20	WA	RHAC	1	25
07-Jul-20	WA	RHAC	1	20
07-Jul-20	WA	SCPS	2	20
07-Jul-20	WA	SCPS	4	15
07-Jul-20	WA	SCPS	6	13
07-Jul-20	WA	THDU	1	18
07-Jul-20	WB	ACTR	150	15
07-Jul-20	WB	CAJA	1	6
07-Jul-20	WB	CHAU	2	17
07-Jul-20	WB	KYSP	1	45
07-Jul-20	WB	NALI	1	18
07-Jul-20	WB	NALI	1	23
07-Jul-20	WB	NALI	2	25
07-Jul-20	WB	NALI	1	28
07-Jul-20	WB	RHAC	1	23
07-Jul-20	WB	RHAC	2	25
07-Jul-20	WB	RHAC	1	20
07-Jul-20	WB	SCRU	1	50

Appendix C. Fish foraging protocol

Background

Hanauma Bay on Oahu, Hawaii is a Marine Nature Preserve and a popular tourist attraction for snorkelers and SCUBA divers. Typically, Hanauma Bay receives ~3000 visitors per day throughout the year or approximately 1 million visitors per year. However, the COVID-19 lockdown has brought that number to zero. The shutdown has provided the perfect opportunity for us to observe the ecological consequences of visitor presence within the bay by comparing fish and invertebrate behaviors in the bay with and without visitors.

Goal

The goal of this project is to understand if and how the fish and invertebrate communities respond behaviorally to this difference in the presence of humans, and therefore how the tiny pathogen that causes COVID-19 indirectly affects coral reef ecosystems.

Objective

Identify fish and invertebrate presence and quantify organisms' time spent engaged in different activities.

1) Fieldwork protocol

Methods were adapted from Madin et al. (2019).

Camera settings

We use GoPro Hero (specifically Hero 4 Session, Hero 5 Black, and Hero 7 Black) cameras to record fish behavior with a field-of-view boundary placed 3 meters in front of the camera (except where noted in datasheets). Cameras are set to 1080-pixel resolution for GoPro 4 Sessions and 720-pixel resolution for GoPro Hero 7 and Hero 5, with a frame rate of 60 fps and view set to "wide". Some of the cameras will run out of battery very quickly when running on the highest resolution, therefore resolution settings are sometimes modified according to the camera model's battery life constraints.

Location

The study is conducted at each of the eight Coral Reef Ecology Lab's permanent transects in the shallow back reef at Hanauma Bay. Each of the four zones in the bay (from N to S: Backdoors, Keyhole, Channel, Witches Brew) has two transects from N to S: A, B).

Method

1. Locate the first marker (bolt) of the Coral Reef Ecology Lab's permanent transect at each site. This bolt (and temporarily-attached float or flagging tape) will serve as the video's focal point (and the field of view (FOV) marker for later video analysis). Temporarily clip the end of the transect tape to the transect bolt.
2. Find suitable substrate for recording video: Choose an area that the camera view towards the transects bolt/marker will not be impeded by a large object (e.g., highly rugose reef structure). If the area between the camera and the FOV marker is not clear, fish will be lost behind larger reef structures during the analysis.
3. Plan where to put the camera: Lock the transect tape at a 3-meter distance and swim around in a 3-meter radius circle towards where you would ideally like to place the camera. Once you have found a location that is clear and provides suitable attachment substrate *exactly at the 3-meter mark on the transect*, set the transect down.

4. Using zip-ties, attach camera to (dead) reef substrate at the 3-meter mark of the transect facing the the FOV marker (i.e., the permanent transect bolt and temporary float or flagging tape).
5. Turn the camera on to start recording.
6. Place fingers in front of the lens to indicate which transect you are filming, numbered in sequential order from the first transect of the day to the last (i.e., first transect would be 1 finger; last would be 5 fingers followed by 3 fingers).
7. Swim toward the FOV marker and point downwards to clearly indicate where it is for the video analyst; this will help that person clearly identify the end of the FOV during analysis.
8. Roll up the transect tape and unclip it.
9. Swim away; either proceed to setting out additional camera(s) or return to land. Either way, as soon as back on land, record metadata on waterproof paper. Metadata fields to be recorded are:
    1. Location
    2. Site
    3. Transect
    4. Date
    5. Start time (ie, exact time of day when video recording began)
    6. Camera # (each camera has a number; needed for determining which video is from which transect)
    7. Max depth (the max depth of the substrate within the FOV)
    8. Min depth (the min depth of the substrate within the FOV)
    9. FOV distance (this will always be 3m unless visibility necessitates a 2m FOV marker; the reduced FOV will then need to be calculated and accounted for in at the analysis stage)
    10. Hand signal # (this is redundancy for ensuring that video footage is match to the correct transect)
10. Return after 35 minutes from the start of the video to collect the camera and temporary FOV marker. This allows for 30 minutes of useful video following a 5-minute ‘buffer’ period at the start of the video over which diver interference effects diminish.

Analysis

The first 5 minutes of video will not be used in analysis. This allows the fish to return to normal behavior before data are collected. The subsequent video will be partitioned between video analysts (observers), where each observer receives a pre-determined duration of video from each date/site combination. This ensures that whatever inter-observer variation exists is evenly distributed across the study’s sites and time points.

The tentative effort distribution (pending video analyst volunteer numbers) will be that each observer receives 1 minute of video from each date/site combination. With a total of 10 video analyst volunteers, that will allow for processing of the first 10 min of usable data from each date/site combination. The remaining 20 minutes of video will remain unprocessed until/unless a larger volunteer pool is available at a later date.

References

Madin, E. M., Precoda, K., Harborne, A. R., Atwood, T. B., Roelfsema, C. M., & Luiz, O. J. (2019). Multi-trophic species interactions shape seascape-scale coral reef vegetation patterns. *Frontiers in Ecology and Evolution*, *7*, 102.

2) Video processing protocol

Method

We will be using an Excel spreadsheet to record and analyze GoPro video from Hanauma Bay. We shared three other files with you to complete the fish behavior analysis:

1. Hanauma Bay Gopro Video: “CameraTrap_HBay_Channel_TransectA_2020_04_28_Part1”
2. Excel Data Template: “HanaumaBay_COVID19_GoProVideo_DataExtraction_template”
3. Excel Metadata: “HanaumaBay_COVID19_GoProVideo_DataExtraction_metadata”

You will watch the Hanauma Bay GoPro video and populate the Excel data template with the associated data. If the column name is unclear, take a look at the metadata spreadsheet for explicit definitions. Throughout this document, when we say “fish”, we mean both fish and invertebrates. Importantly, ***never*** add or delete any columns!

General process:

1. Open the Excel Data Template. You will be filling in ALL columns, starting with column “video_observer” and ending with column “following”; columns “notes” and beyond are only to be filled in as needed. See “HanaumaBay_COVID19_GoProVideo_DataExtraction_metadata.csv” for additional details of what to put in each column.

2. After filling out metadata columns (i.e., columns “video_observer” through “observation_start_time”), begin the video and wait for first fish to enter. If a fish is already on the screen, start with that one. If more than one fish is already on the screen, pick one to start with, then go back to the start of the video and continue in this way until all the existing fish have been recorded.

3. When a fish enters, pause video and record **exact** “organism_enter_time” on spreadsheet in MMSS. For example, if a fish entered the video at the 9 minutes and 36 second mark, record “936” in the “organism_enter_time” column.

4. Then, accurately identify the fish down to the species level and record the “common_name”, “genus”, and “species”. To identify species of fish, see the identification protocol below.

5. Un-pause video; watch ONLY that fish. Observe and take note of the behavior of fish. If feeding, count the number of bites the fish is taking.

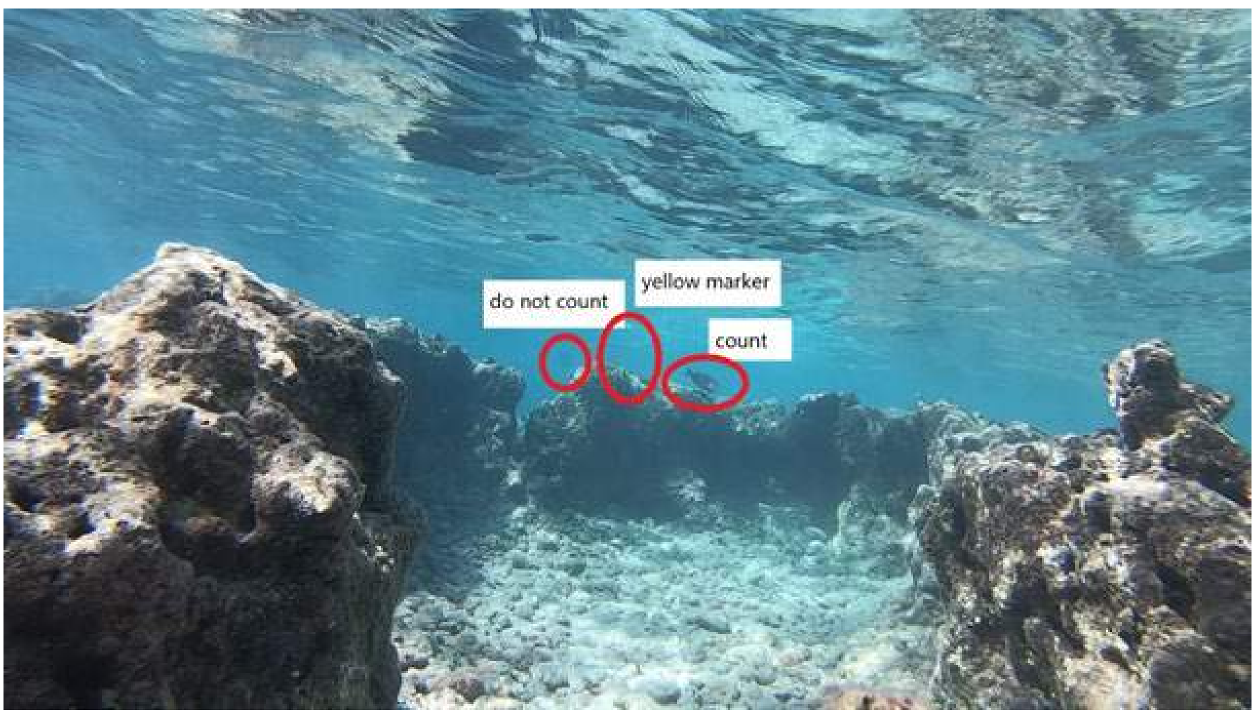
6. When fish leaves the field of view, pause video and record the **exact** leave time (MMSS), bites (if feeding), and % of time (1-100%) that each behavior was done. For example, if the fish leaves the field of view at 10 minutes and 6 seconds, record “1006” in the “organism_leave_time” column. If the fish was feeding for the full 30 seconds it was in your field of view. Record “100” in the feeding column and leave the value for all other activities blank. Next, record the number of bites (e.g., “20”) in the “bites_per_individual” column. When finished, double check that the column “total_activity_time” contains ***only*** the value 100 (with no blanks); if blanks or other numbers found, go back and correct before finishing.

7. Once the fish disappears for more than 5 seconds (see Notes below), rewind video to exact enter time of previous fish (i.e. 9 minutes and 36 seconds). We need to count all fish in the field of view. When you first start recording, there may be multiple fish in the frame at the moment you are to start recording. In that case, repeat the same process as above for all unrecorded fish. Once you have counted all fish in that frame, unpause video and wait for next fish to enter, then repeat the process above.

Notes:

1. 1) We are only observing fish that are in the cameras field of view and are only three meters away from the camera. The 3-meter mark is represented by a floating marker (usually a buoy with a string, sometimes it is yellow marking tape). We will have to use our best judgement to observe and record fish that are in front of that marker. Any fish that is clearly behind that marker, you pretend it is not

there and you do not have to count it. However, if the fish swims in front of the marker you will have to start to count and record the fish. Below are some examples:



2. If same individual fish re-enters within <u>5 seconds</u> of leaving, consider it a single occurrence and don't start a new line. If it disappears and reappears after more than 5 seconds, even what is likely the same fish should get a new line (then we can filter in analysis stage if needed).

3. Sometimes you will encounter a school of fish. If the fish is in a group of the same species, estimate how many are in the group and record that number in the "number" column. Proceed recording the rest of the information as normal. In schools of fish in which individuals appear to be feeding, count the bites for one individual, and enter this value (the total number of bites will be calculated in analyses when multiplied by the number in the group).

4. The "phase" column should only be completed for phase changing species (wrasse and parrotfish), options are juvenile; initial phase (IP) or terminal phase (TP). A good resource to identify the phase changing species can be found here.

Identification

Invertebrates:

We are only recording sea urchins and sea cucumbers broadly as a functional group and do not need to name species. For sea urchins, simply choose "urchin" in in column "common_name" and put "unknown" in both columns "genus" and "species". For sea cucumbers, simply choose "cucumber" in column "common_name" and put "unknown" in both columns "genus" and "species".

Fish:

Accurately identifying the correct fish species is important. We have a few resources for you to accurately identify fish species in Hawaii. The first is a cheat sheet we compiled with the most common fish species you will most likely encounter. The second resource for you is a PowerPoint presentation containing a detailed list of species with pictures and can be found here. The last resource is a helpful website that categorizes the marine wildlife of Hawaii and can be found here.

We understand that many of you are learning your Hawaii fish species. The easiest way to accurately identify the fish species is to look at the cheat sheet first and look at the fish **family** (e.g., butterflyfishes, chub, damselfishes, etc.) to get an idea of the fish you are observing. Then when you know the family, you can examine each **species name** using the associated link to identify the target fish. This list is sorted from most abundant species within each family to least abundant, so the ones at the top of the list are more likely to be the species you are looking at. However, you will also see rare fish sometimes (those farther down on the list), so you should work your way from the top of the list to the bottom (within each fish family) until you find the right one. Once you have IDed the species, fill in the rest of the columns. Take the time to get the species names right and you will find that it will be slower at first, but will speed up as you learn the different species you'll encounter.

*****Important***** If you are unable to ID a fish to genus or species, fill in column "common_name" as "familycommonname_unidentified" (example: "wrasse_unidentified") and put "unknown" in both columns "genus" and "species" If you are completely stumped on the fish ID, please put "unknown" in the columns "common_name", "genus", and "species". However, make sure to record all other columns (i.e. "organism_enter_time", "organism_leave_time" and primary activity columns).

Quantifying behavior

We are recording fish behavior in 10 different categories. Each behavior is defined in detail below:

- **Feeding**: when mouth contacts the substrate. It often (but not always) is accompanied by obvious body jerks that look like it's 'bouncing off' the substrate. Here is a fairly clear example of a surgeonfish feeding (not all fish you will observe will be this obvious when feeding, but this gives you an idea of what you're looking for): CameraTrap_HBay_Channel_TransectA_2020_04_28_Part1_1650.mov. Note: if it's grainy when viewed online, you'll need to download it using the "···" menu on the right hand side so you can clearly see the feeding behavior.

- **Passing**: swimming when not engaged in any other apparent activity even if they're just hovering about (e.g. feeding, attacking, cleaning, etc.).

- **Guarding**: mostly stationary and hovering around the same spot, but clearly watching all other fish that pass by; primarily displayed by territorial damselfishes who aim to defend their home algal patch from intruders.

- **Resting**: completely stationary on the seafloor; mostly only displayed by things like sting (or other) rays, flatfish like flounders, etc.; rarely seen.

- **Burrowing**: digging its body into the sand and/or remaining partially covered by sand.

- **Attacking**: chasing or biting another animal; aggressive displays that do not result in two animals physically connecting (e.g., via a bite) is still considered attacking.

- **Attacked**: the recipient of an attack, as described above.

- **Cleaning**: feeding on the outside of an organism's body or inside its mouth; only displayed by a few species of small wrasses.

- **Cleaned**: the recipient of cleaning, as described above.

- **Following**: staying continuously under, immediately next to, or actually attached to another, larger fish; only displayed by a small number of species such as remoras, usually to follow sharks.

Estimating percent of time in an activity

To estimate the percent of time for an activity, you count the whole process. For example, for feeding, it's not just what percent of time the fish is actually biting, but also includes the time that the animal appears to be searching for food. So, in the case of a surgeonfish feeding, you'd count both the "search" (moving around, checking along the substrate for food to bite) and "handling" time (actually biting the substrate).

Screenshots/video grabs

Sometimes camera traps capture interesting/rare behaviors or organisms. If you feel an event or a species is unusual or interesting, feel free to take a screenshot and/or video grab. This is a great way to keep track of things that are fun to show in presentations and so on, so use this option liberally.

The naming convention for screenshots/videos grabs is as follows; please follow this exactly when creating them: videofilename_timeintovideo
(i.e."CameraTrap_HBay_Channel_TransectA_2020_04_28_Part1_1649.png").

Department of Land and Natural Resources
DIVISION OF AQUATIC RESOURCES
1151 Punchbowl Street, Room 330
Honolulu, HI 96813

Suspense: _______________

TO:	**FOR:**
1) Suzanne D. Case - Chairperson	[X] Signature(s)
2)	[ ] Approval
3)	[ ] Approval as to Form
4)	[ ] Review and Comments:
5)	[ ] Appropriate Action:
6)	[ ] Return to : **DAR-ROOM 330-Cathy Gewecke**
	[ ] **DE and Permit for Permittee and File**

REMARKS:

Special Activity Permit (SAP 2021-25) that authorizes Sarah Severino of the Hawaii Institute of Marine Biology, Coral Reef Ecology Lab, Project Coordinator, for the manipulation of regulated organisms (coral colonies) in a regulated area (Hanauma Bay Marine Life Conservation District (MLCD)) and the altering of sand, rock, or other geological features, through the placement of marine instruments, to determine the limiting factor of coral growth and the impact of human use on coral growth at differing anthropogenic levels on the reef flat environment of Hanauma Bay MLCD, by documenting growth rates as they differ between areas and tracking the linear extension rates of coral colonies.

This research is important to understanding the lethal as well as sublethal effects to corals from visitors. Research days will mainly occur on Tuesdays, but work may be conducted on other days (if necessary); all research days must be coordinated with Hanauma Bay Nature Park staff. The researchers will track linear extension rates of corals by tying a very thin piece of wire around a branch of the coral and using calipers to measure from the wire to the tip of the branch several times over a year span. No corals will be collected. Approximately four (4) colonies at each site would have their linear extension rates tracked for a total of approximately forty-eight (≈ 48) colonies total of the following species: Pocillopora meandrina, Porites compressa and Porites rus. Researchers may additionally place marine instruments (e.g. sediment traps, clod cards, recruitment tiles, cameras). This study is the next phase of the Hanauma Bay Biological Carrying Capacity study.

Contact Person: ___Brian Neilson
Phone: ___X-70106___

Signature:___________________________
Date: 5/15/2020

DAVID Y. IGE
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES

POST OFFICE BOX 621
HONOLULU, HAWAII 96809

May 15, 2020

TO: Division of Aquatic Resources File

THROUGH: Suzanne D. Case, Chairperson

FROM: Brian J. Neilson, Administrator
Division of Aquatic Resources

SUBJECT: Declaration of Exemption from the Preparation of an Environmental Assessment under the Authority of Chapter 343, HRS, and Chapter 11-200, HAR, for a Special Activity Permit to Sarah Severino, Hawaii Institute of Marine Biology, Coral Reef Ecology Lab, Project Coordinator.

The following permitted activities are found to be exempted from preparation of an environmental assessment under the authority of Chapter 343, HRS and Chapter 11-200, HAR:

Project Title: Special Activity Permit to Sarah Severino, Hawaii Institute of Marine Biology, Coral Reef Ecology Lab, Project Coordinator, for the manipulation of regulated organisms (coral colonies) in a regulated area (Hanauma Bay Marine Life Conservation District (MLCD)) and the altering of sand, rock, or other geological features, through the placement of marine instruments, to determine the limiting factor of coral growth and the impact of human use on coral growth at differing anthropogenic levels on the reef flat environment of Hanauma Bay MLCD, by documenting growth rates as they differ between areas and tracking the linear extension rates of coral colonies.

Permit Number: SAP 2021-25

Project Description: The research permit, as described below, would allow for the manipulation of regulated organisms (coral colonies) in a regulated area (Hanauma Bay Marine Life Conservation District (MLCD)) and the altering of sand, rock, or other geological features, through the placement of marine instruments, from May 15, 2020, through May 14, 2021, to determine the limiting factor of coral growth and the impact of human use on coral growth at differing anthropogenic levels on the reef flat environment of Hanauma Bay MLCD, by documenting growth rates as they differ between areas and tracking the linear extension rates of coral colonies. Research days will mainly occur on Tuesdays, but work may be conducted on other days (if necessary); all research days must be coordinated with Hanauma Bay Nature Park staff. The altering of any sand, coral, rock, or other geological feature in Hanauma Bay MLCD is prohibited under section 13-28-2, Hawaii Administrative Rules, unless authorized by a permit issued under section 187A-6, Hawaii Revised Statutes.

The researchers for this project have been conducting the Hanauma Bay Biological Carrying Capacity study for the last several years; thus far in the study the researchers have determined the rate of breakage to dead coral skeletons and regressed this breakage against the number of visitors in each sector to try to quantify trampling pressure. This next phase of the study will allow the researchers to determine the impact of human use on coral growth at differing anthropogenic levels. This is important to understanding the lethal as well as sublethal effects to corals from visitors.

Activities. Permittee is authorized for the manipulation of regulated organisms (coral colonies) in a regulated area (Hanauma Bay Marine Life Conservation District (MLCD)) and the altering of sand, rock, or other geological features, through the placement of marine instruments, as listed in Table 1 on Page 1 of the permit. The objective of the project is to determine the limiting factor of coral growth and the impact of human use on coral growth at differing anthropogenic levels on the reef flat environment of Hanauma Bay MLCD, by documenting growth rates as they differ between areas and tracking the linear extension rates of coral colonies. Research days will mainly occur on Tuesdays, but work may be conducted on other days (if necessary); all research days will be coordinated with Hanauma Bay Nature Park staff (lynette.liu@honolulu.gov) at least 24 hrs. in advance. Researchers will conduct studies along transects in five sites in Hanauma Bay: Backdoors, Keyhole, Channel, Witches Brew, and Offshore (see map at end of permit for locations/transects of the corals that will be tracked). The researchers would track linear extension rates of corals without having to sacrifice them at the end, by tying a very thin piece of wire around a branch of the coral and using calipers to measure from the wire to the tip of the branch several times over a year span. No corals will be collected. The researchers would conduct the tracking of linear extension rates with the following species already in place on the reef flat of Hanauma Bay and then compare the growth rates they observe to those around the state: *Pocillopora meandrina*, *Porites compressa* and *Porites rus*. Approximately four (4) colonies at each site would have their linear extension rates tracked for a total of approximately forty-eight (≈ 48) colonies total. The colonies are all small (10 to 25 cm) with the exception of the one *Porites rus* colony which is 1m in length and 0.8m in width. Researchers may additionally place marine instruments (e.g. sediment traps, clod cards, recruitment tiles, cameras) near the coral colonies that are being tracked.

Permittee will mitigate for the spread of invasive species/disease/parasites between areas of surveying (see Special Conditions H. Other Collection Guidelines: Aquatic Invasive Species.) Survey or collection equipment will be inspected and disinfected between surveying or sampling different areas (or if transporting gear or tools from a different area or island), to mitigate for the spread of invasive species/disease/parasites. Efforts will be made by permittee and authorized assistants to ensure that activities are conducted in such a manner as the process does not result in any additional harm to surrounding marine organisms. Efforts will be made by permittee and authorized assistants to distribute collection activities across shoreline/reef flat/benthic areas, so as not to consolidate the impacts of collection in one location (if applicable). Efforts will be made by permittee and authorized assistants to communicate with the public that have inquiries about the surveying activities or methodology. Permittee and authorized assistants will clearly state the overall objective of the project, that these activities require permits, and that the methods the researchers are employing are not approved for recreational activities but research or education **ONLY**.

Gear. Permittee and authorized assistants will use wire to wrap sections of branching coral fragments and calipers to measure coral growth. Permittee may additionally place sediment traps to measure sediment accretion, clod cards to measure water-motion, recruitment tiles to measure settlement of marine organisms or cameras for photo-documentation.

Marine Instruments. Researchers may place the following marine instruments near the coral colonies that are being tracked: (A) 2 sediment traps (12 in. height with 2 in. diameter), (B) clod cards (~3 in. x 2 in.) to measure integrated relative water-motion, or (C) recruitment tiles to track recruitment and survival of new corals or (D) cameras for photo-documentation (see Figure 2 at end of permit). By placing arrays of recruitment tiles (C) the researcher will be able to look at which invertebrates and corals prefer to settle where there is high or low sediment (brown dots), sunlight, or predation (purple urchin). Marine instruments will be placed in sand or on hard substrate (live rock) only and will be weighted down or attached to the substrate with dive weights, zip ties, stakes or eyebolts. Researchers will ensure all materials (marine instruments, dive weights, stakes or eyebolts etc.) are transported out to the sites safely, utilizing BMPs to ensure buoyancy of materials during transport and prevent any contact with the reef, other than the sites where measurements will be collected. Marine instruments will not be in place longer than 30 days.

Coordination with Hanauma Bay Nature Park Staff. Field work schedules and specific sites for surveys will be coordinated and shared with the Hanauma Bay Nature Park staff to minimize interactions with other potential researchers or park staff while permitted activities are being conducted in the Hanauma Bay MLCD. Permittee will contact Hanauma Bay Nature Park staff for coordination of research activities (lynette.liu@honolulu.gov).

Consulted Parties: Brian Neilson, Administrator, DAR (Oahu), Catherine Gewecke, Aquatic Biologist, DAR (Oahu)

Exemption Determination: After reviewing §11-200-8, HAR, including the criteria used to determine significance under §11-200-12, HAR, DLNR has concluded that the activities under this permit would have minimal or no significant effect on the environment and that issuance of the permit is categorically exempt from the requirement to prepare an environmental assessment based on the following analysis:

1. All activities associated with this permit have been evaluated as a single action. Since this permit involves an activity that is precedent to a later planned activity, i.e., the repeated methodology

throughout the permit period, the categorical exemption determination here will treat all planned activities as a single action under §11-200-7, HAR.

2. The Exemption Class #5 Scientific Research with no Serious or Major Environmental Disturbance, Appears to Apply. § 11-200-8(a)(5), HAR, exempts the class of actions that involve "basic data collection, research, experimental management, and resource evaluation activities which do not result in a serious or major disturbance to an environmental resource." This exemption class has been interpreted to include research activities, such as those being proposed.

The proposed activities here appear to fall squarely under the exemption class identified under HAR §11-200-8(a)(5), and as described under the 2015 DLNR under exemption class #5, exempt items #13 and #15 respectively, which includes "research or experimental management actions that the Department declares are designed specifically to monitor, conserve, or enhance native species or native species' habitat" and the conducting of "…aquatic life surveys, inventory studies, new transect lines, photographing, recording, sampling, collection…".

As discussed below, no significant disturbance to any environmental resource is anticipated. Thus, so long as the below considerations are met, an exemption class should include the action now contemplated.

3. Cumulative Impacts of Actions in the Same Place and Impacts with Respect to the Potentially Particularly Sensitive Environment Will Not be Significant. Even where a categorical exemption appears to include a proposed action, the action cannot be declared exempt if "the cumulative impact of planned successive actions in the same place, over time, is significant, or when an action that is normally insignificant in its impact on the environment may be significant in a particularly sensitive environment." §11-200-8(b), HAR. To gauge whether a significant impact or effect is probable, an exempting agency must consider every phase of a proposed action, any expected primary and secondary consequences, the long-term and short-term effects of the action, the overall and cumulative effect of the action, and the sum effects of an action on the quality of the environment. §11-200-12, HAR.

Significant cumulative impacts are not anticipated as a result of this activity, and numerous safeguards further ensure that the potentially sensitive environment of the project area will not be significantly affected. All activities will be conducted in a manner that does not diminish marine resources, qualities, and ecological integrity, or have any indirect, secondary, cultural, or cumulative effects.

Since no significant cumulative impacts or significant impacts with respect to any particularly sensitive aspect of the project area are anticipated, the categorical exemptions identified above should remain applicable.

4. Overall Impacts will Probably have a Minimal or No Significant Effect on the Environment. Any foreseeable impacts from the proposed activity will probably be minimal, and further mitigated by general and specific conditions attached to the permit. Specifically, all research activities covered

by this permit will be carried out with strict safeguards for the natural, historic, and cultural resources, other applicable law and agency policies and standard operating procedures**.**

Conclusion. Upon consideration of the permit to be approved by the Chairperson, being delegated signatory authority on behalf of the Board of Land and Natural Resources at its meeting of October 24, 2008, the potential effects of the above listed project as provided by Chapter 343, HRS, and Chapter 11-200, HAR, have been determined to be of probable minimal or no significant effect on the environment and exempt from the preparation of an environmental assessment.

Suzanne D. Case

May 18, 2020

Suzanne D. Case, Chairperson
Board of Land and Natural Resources

Date

Special Activity Permit
<u>No. 2021-25</u>

Department of Land & Natural Resources
DIVISION OF AQUATIC RESOURCES
1151 Punchbowl Street, Room 330
Honolulu, Hawaii 96813

Date Issued: May 15, 2020

Valid not longer than May 14, 2021

SPECIAL ACTIVITY PERMIT

The Department of Land and Natural Resources hereby grants permission for certain activities involving aquatic organisms belonging to the people of Hawaii, under Section 187A-6, Hawaii Revised Statutes, and other applicable laws.

The Permittee is
Name: Sarah Severino
Title: Project Coordinator
Affiliation: HIMB/Coral Reef Ecology Lab
Address: Hawaii Institute of Marine Biology
Coral Reef Ecology Lab
P.O. Box 1346
Honolulu, HI 96744

This permit is issued, subject to the general and special conditions, for the manipulation of regulated organisms (coral colonies) in a regulated area (Hanauma Bay Marine Life Conservation District (MLCD)) and the altering of sand, rock, or other geological features, through the placement of marine instruments, to determine the limiting factor of coral growth and the impact of human use on coral growth at differing anthropogenic levels on the reef flat environment of Hanauma Bay MLCD, by documenting growth rates as they differ between areas and tracking the linear extension rates of coral colonies. This research is important to understanding the lethal as well as sublethal effects to corals from visitors. Research days will mainly occur on Tuesdays, but work may be conducted on other days (if necessary); all research days must be coordinated with Hanauma Bay Nature Park staff.

Common Name	Scientific Name	Number Specimen	Locations: See Special Conditions II.B.
Cauliflower coral	*Pocillopora meandrina*	≈ 36 colonies (each 10 - 25 cm diameter) (no collections will occur; wire will be wrapped around coral branches to track linear extension rates)	Hanauma Bay Marine Life Conservation District (MLCD) (Oahu)
Finger coral	*Porites compressa*	≈ 11 colonies (each 10 - 25 cm diameter) (no collections will occur; wire will be wrapped around coral branches to track linear extension rates)	Hanauma Bay Marine Life Conservation District (MLCD) (Oahu)
Plate and pillar coral	*Porites rus*	≈ 1 colony (each 1 diameter) (no collections will occur; wire will be wrapped around coral branches to track linear extension rates)	Hanauma Bay Marine Life Conservation District (MLCD) (Oahu)

I. GENERAL CONDITIONS:

A. This permit does not make the Department of Land and Natural Resources or the State of Hawaii liable in any way for any claim of personal injury or property damage to the permittee or assistants which may occur during any activity conducted under this permit; moreover, the permittee and all assistants agree to hold the State harmless against any and all claims of personal injury, death or property damage resulting from activities of the permittee or any assistant.

B. This permit conveys a privilege to engage in only those activities under the jurisdiction of the Department of Land and Natural Resources. The permittee is responsible for complying with all applicable County, State, and Federal requirements. The permit does not convey any privilege of access over or through private property.

C. The permittee and each assistant are individually responsible and accountable for their actions while conducting activities authorized under this permit; additionally, the permittee is responsible and accountable for the actions of the permittee's assistants.

D. This permit is not transferable or assignable. Any person whose name does not appear on this permit and is conducting any activity described herein is subject to prosecution for violation of State laws.

E. The permittee may request changes to the permit. Any such request to make changes to the permit must be made in writing and received by the Department at least thirty days prior to the change. The addition of new assistants will require each individual to sign the Attachment on page 10, 11 or 12 stating that they have read, understood, and agree to abide by all general and special permit conditions. No change may be implemented without written approval from the Department.

F. The permittee may request to:
   1. Add assistants to the permit;
   2. Add another permittee or replace an existing permittee in the manner stated above; and
   3. Change the activities authorized under this permit.

G. The permittee or their assistant(s) must have with them a copy of this permit while conducting activities authorized by this permit.

H. This permit authorizes collection of organisms protected by Federal law only with prior appropriate Federal authority, which must be described on Page 1 of this permit (if applicable).

I. This permit does not authorize the sale of any collected organism.

J. This permit expires on the date indicated on Page 1. **If no renewal is needed**, the permittee must return this permit with al signature sheets (to the address listed on the upper left corner of page 1, c/o Cathy Gewecke) and additionally email a **PDF version of a final report** (to catherine.a.gewecke@hawaii.gov) with complete information on all activities authorized under this permit (see Special Conditions, **Section H. Annual Report**) within **three months (90 days) after** the expiration date. **If renewal is needed**, permittee must submit a **PDF**

version of a final report to the Division **one month (30 days) prior** to the expiration date for DAR biologists to review, in addition to turning in expired permit with signatures no later than the regular **three months (90 days) after expiry date**. If complete report cannot be submitted **one month (30 days) prior** to the expiration date, the permittee will submit a short synopsis of research conducted (PDF version- **one month (30 days) prior** to the expiration date) in past year including information on quantities, genus species and activities conducted, and submit full report no later than the regular **three months (90 days) after expiry date**.

K. The permittee and assistants agree to provide access to data obtained under authority of this permit upon request of the Division of Aquatic Resources, and to provide to the Division a copy of each report, published for distribution, prepared with data obtained under this permit. The permittee agrees to provide the Division of Aquatic Resources access to organisms obtained and held under this permit for on-site inspection.

L. The permittee agrees to notify the island office of the Division of Conservation and Resources Enforcement at least 24 hours prior to any authorized activity being conducted in the field. Please provide the permittee name, the permit number, the date, time, and location of the planned activity, and contact information.

M. A violation of any terms or condition of this permit or any violation of State law not covered by this permit may result in revocation of the permit and other penalties as provided by law. In addition, the Department may consider any such violation as grounds for denying any future application for this or any other permit issued by the Department.

II. SPECIAL CONDITIONS

A. **General Statement**: This permit authorizes for the manipulation of regulated organisms (coral colonies) in a regulated area (Hanauma Bay Marine Life Conservation District (MLCD)) and the altering of sand, rock, or other geological features, through the placement of marine instruments, to determine the limiting factor of coral growth and the impact of human use on coral growth at differing anthropogenic levels on the reef flat environment of Hanauma Bay MLCD, by documenting growth rates as they differ between areas and tracking the linear extension rates of coral colonies. Research days will mainly occur on Tuesdays, but work may be conducted on other days (if necessary); all research days must be coordinated with Hanauma Bay Nature Park staff.

B. **Locations**: All activity will occur within waters of Hanauma Bay Marine Life Conservation District (MLCD)(Oahu), as listed in Table 1 on Page 1. Researchers will conduct studies in treatment plots in five sites in Hanauma Bay: Backdoors, Keyhole, Channel, Witches Brew, and Offshore (see map at end of permit for locations of corals that will be tracked). Activities authorized under this permit are limited to waters of the State of Hawaii and are expressly prohibited at the following locations:

Island of MAUI	**Island of KAUA‘I**	**Island of HAWAI‘I**
Kahului Harbor FMA[1]	Ahukini Pier FMA	Areas within the West Hawaii
Honolua-Mokuleia MLCD[2]	Hanamaulu Bay FMA	Regional Fishery Management Area:
Molokini MLCD	Kapaa Canal FMA	
Ahihi-Kinau NAR[3]	Waikaena Canal FMA	(1) Ka‘ūpūlehu Marine Reserve
	Waimea Pier & Bay FMA	(2) North Kohala Fish Replenishment

Island of LANA'I Manele Harbor FMA Manele-Hulopoe MLCD **Island of MOLOKA'I** Kaunakakai Harbor FMA **Island of O'AHU** Ala Wai Canal FMA Coconut Island MLR Diamond Head SFMA Haleiwa Harbor FMA Heiea Kea FMA Kapalama Canal FMA Paiko Lagoon Wildlife Refuge Pupukea MLCD Waialua Bay FMA Waikiki MLCD	Hāʻena CBSFA[8] **Island of HAWAI'I** Hilo Bay FMA Kailua Bay FMA Kawiahae Harbor FMA Kealakekua Bay MLCD Keauhou Bay FMA Kiholo Bay FMA Kona Coast FMA Old Kona Airport MLCD Lapakahi Bay MLCD Puako FMA Waiakea PFA[5] Wailea Bay MLCD Wailuku River FMA Wailoa River FMA Waiopae Tidepools MLCD **Island of KAHO'OLAWE** Restricted 2 nautical mile boundary Zone A and Zone B surrounding Kaho'olawe	Area (FRA[6]) (3) Puakō-ʻAnaehoʻomalu FRA (4) Kaloko-Honokōhau FRA (5) Kailua-Keauhou FRA (6) Red Hill FRA (7) Nāpoʻopoʻo-Hōnaunau FRA (8) Hoʻokena FRA (9) Kaʻohe Beach FRA (Pebble Beach), (10) Miloliʻi FRA (11) Kikaua Point-Mākoleʻā Point Netting Restricted Area (NRA[7]) (12) Nenue Point–Kealakekua Bay NRA (13) Hanamalo Point–Kanewaʻa Point NRA (14) Kanonone–Kalīpoa NRA

FMA[1] = Fisheries Management Area, MLCD[2] = Marine Life Conservation District, NAR[3] = Natural Area Reserve (DOFAW), MLR[4] = Marine Laboratory Refuge, PFA[5] = Public Fishing Area, FRA[6] = Fish Replenishment Area, NRA[7] = Netting Restricted Area, CBSFA[8] =Community-Based Subsistence Fishing Area

C. **Activities**. Permittee is authorized for the manipulation of regulated organisms (coral colonies) in a regulated area (Hanauma Bay Marine Life Conservation District (MLCD)) and the altering of sand, rock, or other geological features, through the placement of marine instruments, as listed in Table 1 on Page 1. The objective of the project is to determine the limiting factor of coral growth and the impact of human use on coral growth at differing anthropogenic levels on the reef flat environment of Hanauma Bay MLCD, by documenting growth rates as they differ between areas and tracking the linear extension rates of coral colonies. This research is important to understanding the lethal as well as sublethal effects to corals from visitors. Research days will mainly occur on Tuesdays, but work may be conducted on other days (if necessary); all research days will be coordinated with Hanauma Bay Nature Park staff (lynette.liu@honolulu.gov) at least 24 hrs. in advance. Researchers will conduct studies along transects in five sites in Hanauma Bay: Backdoors, Keyhole, Channel, Witches Brew, and Offshore (see map at end of permit for locations/transects of the corals that will be tracked). The researchers would track linear extension rates of corals without having to sacrifice them at the end, by tying a very thin piece of wire around a branch of the coral and using calipers to measure from the wire to the tip of the branch several times over a year span. No corals will be collected. The researchers would conduct the tracking of linear extension rates with the following species already in place on the reef flat of Hanauma Bay and then compare the growth rates they observe to those around the state: *Pocillopora meandrina*, *Porites compressa* and *Porites rus*. Approximately four (4) colonies at each site would have their linear extension rates tracked for a total of approximately forty-eight (≈ 48) colonies total. The colonies are all small (10 to 25 cm) with the exception of the one *Porites rus* colony which is 1m in length and 0.8m in width. Researchers may additionally place marine instruments (e.g. sediment traps, clod cards, recruitment tiles, cameras) near the coral colonies that are being tracked. The researchers have been conducting the Hanauma Bay Biological Carrying Capacity study for the last several years; thus far in the study the researchers have determined the rate of breakage to dead coral skeletons and regressed this breakage against the number of visitors in each sector to try to quantify trampling pressure. This next phase of the study will allow the researchers to determine the impact of human use on coral growth at differing anthropogenic levels. This is important to understanding the lethal as well as sublethal effects to corals from visitors.

Permittee will mitigate for the spread of invasive species/disease/parasites between areas of surveying (see Special Conditions H. Other Collection Guidelines: Aquatic Invasive Species.) Survey or collection equipment will be inspected and disinfected between surveying or sampling different areas (or if transporting gear or tools from a different area or island), to mitigate for the spread of invasive species/disease/parasites. Efforts will be made by permittee and authorized assistants to ensure that activities are conducted in such a manner as the process does not result in any additional harm to surrounding marine organisms. Efforts will be made by permittee and authorized assistants to distribute collection activities across shoreline/reef flat/benthic areas, so as not to consolidate the impacts of collection in one location (if applicable). **Discretion should be used to avoid conflicts with the public during authorized activities**. Efforts will be made by permittee and authorized assistants to communicate with the public that have inquiries about the surveying activities or methodology. Permittee and authorized assistants will clearly state the overall objective of the project, that these activities require permits, and that the methods the researchers are employing are not approved for recreational activities but research or education **ONLY**.

D. **Gear.** Permittee and authorized assistants will use wire to wrap sections of branching coral fragments and calipers to measure coral growth. Permittee may additionally place sediment traps to measure sediment accretion, clod cards to measure water-motion, recruitment tiles to measure settlement of marine organisms or cameras for photo-documentation.

E. **Marine Instruments.** Researchers may place the following marine instruments near the coral colonies that are being tracked: (A) 2 sediment traps (12 in. height with 2 in. diameter), (B) clod cards (~3 in. x 2 in.) to measure integrated relative water-motion, or (C) recruitment tiles to track recruitment and survival of new corals or (D) cameras for photo-documentation (see Figure 2 at end of permit). By placing arrays of recruitment tiles (C) the researcher will be able to look at which invertebrates and corals prefer to settle where there is high or low sediment (brown dots), sunlight, or predation (purple urchin). Marine instruments will be placed in sand or on hard substrate (live rock) only and will be weighted down or attached to the substrate with dive weights, zip ties, stakes or eyebolts. Researchers will ensure all materials (marine instruments, dive weights, stakes or eyebolts etc.) are transported out to the sites safely, utilizing BMPs to ensure buoyancy of materials during transport and prevent any contact with the reef, other than the sites where measurements will be collected. Marine instruments will not be in place longer than 30 days.

F. **Coordination with Hanauma Bay Nature Park Staff.** Field work schedules and specific sites for surveys will be coordinated and shared with the Hanauma Bay Nature Park staff to minimize interactions with other potential researchers or park staff while permitted activities are being conducted in the Hanauma Bay MLCD. Permittee will contact Hanauma Bay Nature Park staff for coordination of research activities (lynette.liu@honolulu.gov).

F. Coral Activities: Activities under this permit shall abide by the following conditions.

1. Coral - the Permittee must notify DAR Oahu (587-2270) within 24 hours of:

   i. Any instance of major damage caused to coral or other marine natural resources, because of collection or other research activities conducted under this permit.

2. Fragmentation - This permit **does not authorize** fragmentation of coral colonies

3. Rare Species - The following *Porites* species require special permission from the Division prior to collection under this permit: *Porites pukoensis, Porites duerdeni, Porites studeri*. The following *Montipora* species require special permission from DAR prior to collection under this permit: *Montipora dilitata*. The following *Pocillopora* species require special permission from DAR prior to collection under this permit: *Pocillopora ligulata, Pocillopora molokensis*.

4. **No impact-causing activities will be conducted on (or immediately adjacent to) any intact, attached coral colony measuring larger than 1 m x 1 m x 1 m. Specific efforts will be made to avoid damage to any large colonies of living coral.**

G. Other Collection Guidelines:

1. Collecting generally - the Permittee must give notice, in form specified by the Department (email or phone call), to DAR (catherine.a.gewecke@hawaii.gov) and to the Department's Division of Conservation and Resources Enforcement (DOCARE, 808-643-3567), at least 24 hours prior to initial commencement of any series of collection activities taken place under this permit.

2. An **Aquatic Invasive Species (AIS) Mitigation Plan** will be filed with the Division prior to conducting any collection under this permit. The Plan will include methods and protocols to minimize AIS or disease movement through gear, supplies and activities of the permittee. Permittee must take actions to verify that collection tools have been disinfected before use if previously used in collection activities.

   Invasive Species/Disease: All collection or survey gear deployed must be visually checked for invasive algae/sponges/other organisms and disinfected with 10% bleach solution for 10 minutes before deployment in alternate location if collecting between multiple watersheds/distinct reef areas (or if transporting gear or tools from a different area or island). If collection gear cannot be bleached, gear must be thoroughly rinsed with fresh water and dried in sun for 24 hours before deployment in alternate location, sterilized with another viable method or alternate sampling gear should be utilized. If sampling disease or anomalous growth specimens, gear should be sterilized between each specimen or new collection gear should be used. The following species remain a concern to the division: Alien invasive algae (*Kappaphycus spp*., *Eucheuma* *denticulatum*, *Gracilaria salicornia*, *Acanthophora spicifera, Hypnea musciformis* and *Avrainvillea amadelpha*), Coral disease (*Montipora* White Syndrome, *Porites* trematodiasis, *Montipora* white syndrome, *Porites* tissue loss syndrome, and *Porites* spp. and *Montipora* spp. tumors, Montipora spp. growth anomaly), Orange keyhole sponge (*Mycale armata/grandis).*

3. No organism other than those listed on this permit will be collected or impacted by any activities conducted under this permit.

4. Collecting and transport activities under authority of this permit must be supervised directly, on site, by either the permittee or their authorized assistants (who must be a signatory of this permit

5. Gear and Methods: Use of any chemical substances pursuant to Section 188-23, Hawai‘i Revised Statutes, electrical shocking devices, or explosives remains expressly prohibited.

6. Use of Organisms: Organisms collected under authority of this permit may not be used for personal consumption or sale; organisms collected under this permit may not be traded, bartered or loaned to other individuals, institutions or entities;

   a. Written approval must be obtained from the Division prior to

      i. Purchasing or any other acquisition of regulated organisms (regardless of origin) from any other party,

      ii. Exchanging or donating any organisms collected under this permit to any other person, party or organization (unless authorized by this permit);

H. **Annual Report**: Upon 90 days’ post expiration of the permit or 30 days prior to expiration of the permit (depending on **renewal** or **non-renewal** status), the permittee must provide to DAR a final written report summarizing the results of the collection activity carried out under this permit and (if available/applicable) analysis of the data.

1) The annual report should provide a written explanation as to how the collection of or activity with a fully protected or regulated marine species for scientific, education, management or propagation purposes is benefiting the State of Hawai’i in general and specifically, the improved management of the species or related species.

2) The final report must include;

   a. **Genus-species and total quantities and sizes**, of all regulated and non-regulated specimens collected under this permit.

   b. **Results of chemical, genetic, physiological, histological, pathological or statistical analysis of data** (if available/applicable).

c. **GPS coordinates (decimal degrees) of location of each sample taken or action conducted and associated geographic location** (e.g. windward side or east side of Patch Reef 8, or north side of Lilipuna Pier). Multiple samples collected in one single area can be geo-referenced by a single GPS point and associated geographic location.

If GPS is not available: Make accurate note of your sampling location in field and obtain GPS location from Google Earth after field sampling:

i. Click "Tools" in the top line menu and open Options.

ii. In the "3D View" tab, **find** the "Show Lat/Long" section. Change the default from Degrees, Minutes, Seconds to **Decimal Degrees**.

iii. Next, click the pushpin icon in the menu; click and drag the pushpin that appears to the point on the map from which you wish to obtain a GPS coordinate:
(e.g.: Lat: 21.441646, Long: -157.799076)

iv. Enter GPS coordinate into spreadsheet with associated sampling information (species, amount, size).

d. Photo-documentation of a **representative example of coral colony with wire tag attached (with scale for size);** Photo-documentation of a **representative examples of marine instruments, if placed (with scale for size); and** Photo-documentation of a **representative example of coral growth or coral breakage (sublethal effects to corals from visitors) – if possible.**

Each representative example should include the following photos: For example of **coral colony with wire tag attached**, photo-documentation should include: two (2) **photos of coral colony with wire tag attached; one photo of entire colony and one close-up photo of fragment with wire attached (with scale for size);** For example of examples of **marine instruments, if placed**, photo-documentation should include: one (1) **photo of each type of marine instrument (e.g. e.g. sediment traps, clod cards, recruitment tiles, cameras) placed underwater (with scale for size) and**; For example of **coral growth or coral breakage (sublethal effects to corals from visitors),** photo-documentation should include: two (2) **photos of representative examples of coral growth or breakage (with scale for size), if possible.**

e. Dispositions of the samples (e.g. on display; released/returned to the ocean/stream; died/composted).

3) An inventory of the regulated organisms (dead or alive) kept by the permittee, or any assistant, at the end of the report period, must accompany the annual report.

4) The annual report is due at the Division's Honolulu office **one month (30 days) before expiration** of the permit **if renewal is needed** or **within three months (90 days) after expiration** of the permit **if renewal is not needed** or as otherwise instructed by the Division.

I. **OWNERSHIP OF BIOGENETIC RESOURCES.** The State holds legal title to the natural resources and biogenetic resources gathered from state lands, including submerged lands. See Haw. Op.Atty.Gen. Opinion No. 03-03 (April 11, 2003). Biogenetic resources refer to the genetic material or composition of the natural resources and other things connected to, or gathered from public lands. See Davis v. Green, 2 Haw. 327 (1861); United States v. Gerber, 999F.2d 1112 (7th Cir. 1993).

J. **Use of Tissue Samples, Organisms, Parts of Organisms or Aquatic Resources (collected under this permit).** The permittee may not convey in any fashion (including, but not limited to, selling, trading, or giving) any tissue samples, organisms, parts of organisms or aquatic resources to any person or party in Hawai`i that does not already have a permit from the Department authorizing possession of same resources and without written approval from DAR. Organisms taken under authority of this permit may be used for scientific study or educational purposes **ONLY**, except as authorized by prior written approval of DAR.

Suzanne D. Case

SUZANNE D. CASE, Chairperson
Department of Land and Natural Resources

cc: (x) DOCARE
(x) DAR – Oahu

SIGNATURES AND AGREEMENT

By my signature below, I acknowledge receipt and understanding of the general and special conditions of this Special Activity Permit. Further, I agree to abide by all of these conditions when conducting activities authorized by this permit.

PRINCIPAL PERMITTEE: [signature]
Sarah Severino

DESIGNATED ASSISTANTS:

Signature:	[signature]	Signature:	____
Print Name:	Dr. Ku'ulei Rodgers	Print Name:	____
Signature:	____	Signature:	____
Print Name:	____	Print Name:	____
Signature:	____	Signature:	____
Print Name:	____	Print Name:	____
Signature:	____	Signature:	____
Print Name:	____	Print Name:	____
Signature:	____	Signature:	____
Print Name:	____	Print Name:	____
Signature:	____	Signature:	____
Print Name:	____	Print Name:	____

ATTACHMENT FOR DESIGNATED ASSISTANTS ONLY

Primary Permittee: Sarah Severino

I, being the primary permittee, hereby acknowledge the addition of the following designated assistants.

[signature] 5/15/20

Sarah Severino Date

ADDITIONAL DESIGNATED ASSISTANTS

We, the undersigned, have read, understand, and agree to all conditions stipulated in the above Special Activity Permit.

Signature ________________ Print Name: ________________

Signature ________________ Print Name: ________________

Signature ________________ Print Name: ________________

Signature ________________ Print Name: ________________

Signature ________________ Print Name: ________________

Signature ________________ Print Name: ________________

Signature ________________ Print Name: ________________

Signature ________________ Print Name: ________________

Signature ________________ Print Name: ________________

Signature ________________ Print Name: ________________

ATTACHMENT FOR DESIGNATED ASSISTANTS ONLY

Primary Permittee: Sarah Severino

I, being the primary permittee, hereby acknowledge the addition of the following designated assistants.

[signature] 05/15/20

Sarah Severino Date

ADDITIONAL DESIGNATED ASSISTANTS

We, the undersigned, have read, understand, and agree to all conditions stipulated in the above Special Activity Permit.

Signature ________________________ Print Name: ________________________

Signature ________________________ Print Name: ________________________

Signature ________________________ Print Name: ________________________

Signature ________________________ Print Name: ________________________

Signature ________________________ Print Name: ________________________

Signature ________________________ Print Name: ________________________

Signature ________________________ Print Name: ________________________

Signature ________________________ Print Name: ________________________

Signature ________________________ Print Name: ________________________

Signature ________________________ Print Name: ________________________

Figure 1. Map of Transect/Study Locations. Green rectangles indicate the locations within the inner reef flat at Hanauma Bay of long-term monitoring transects and colonies that will be wrapped with wire around a branch of the coral to track linear extension rates; transects were established during the 2015/2016 coral bleaching event in Hawaii. Grey/white rectangles indicate the locations of experimental plots for caged and non-caged experiments from a previously proposed project but will not be included in this study. The small camera symbol indicates the location for a proposed underwater camera.

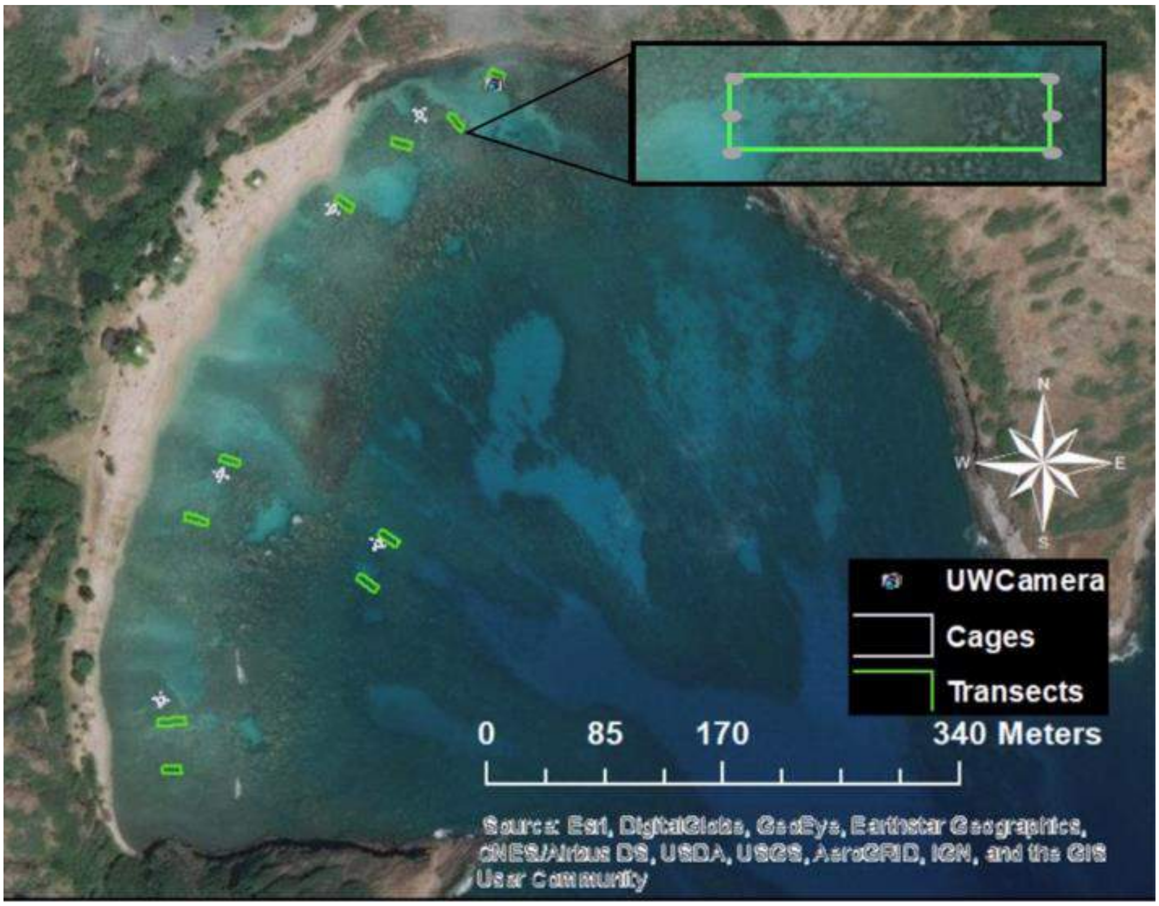
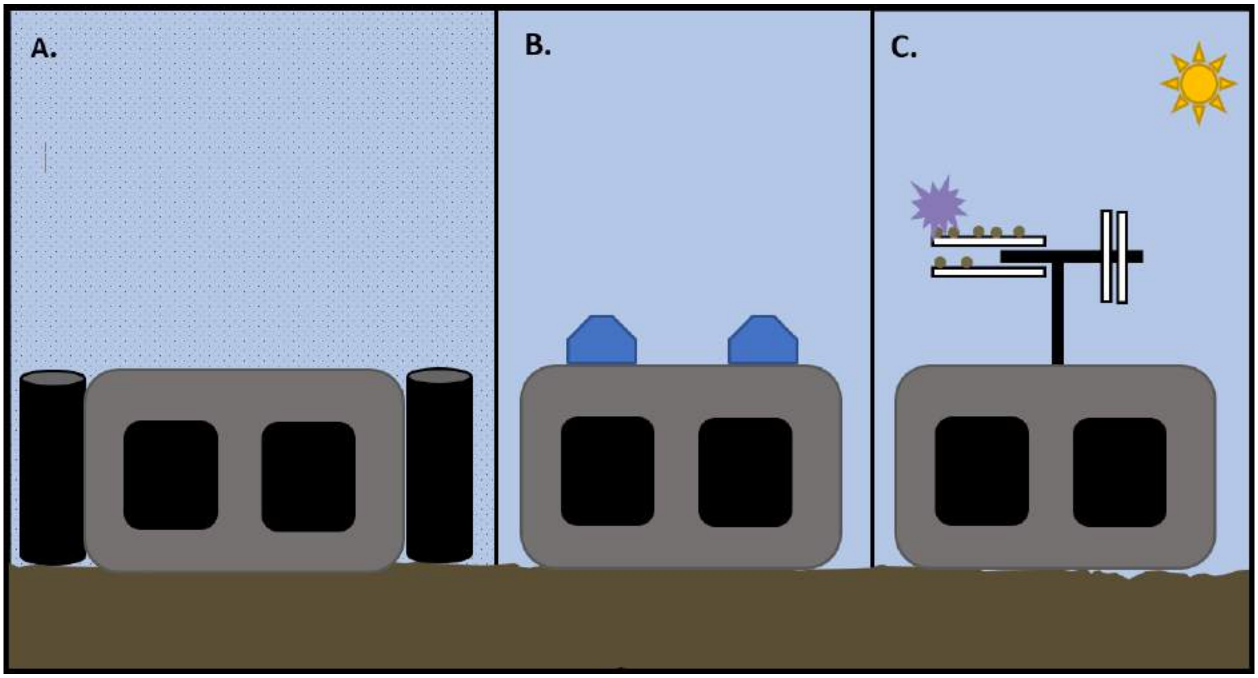


Figure 2. Marine Instruments. Researcher may place the following marine instruments near the coral colonies that are being tracked: (A) 2 sediment traps (12 in. height with 2 in. diameter), (B) clod cards (~3 in. x 2 in.) to measure integrated relative water motion, (C) recruitment tiles to track recruitment and survival of new corals or (D) cameras for photo-documentation (not pictured). By placing arrays of recruitment tiles (C) the researcher will be able to look at which invertebrates and corals prefer to settle where there is high or low sediment (brown dots), sunlight, or predation (purple urchin). Note: Figure includes cinderblock as base for marine instruments; after reevaluation, the researcher has determined that cinderblocks are not necessary, and marine instrument will instead be placed directly on substrate in each area (live rock or sand).



Appendix D cont. Coral Locations and Photos

Backdoors East Corals (2 Corals):

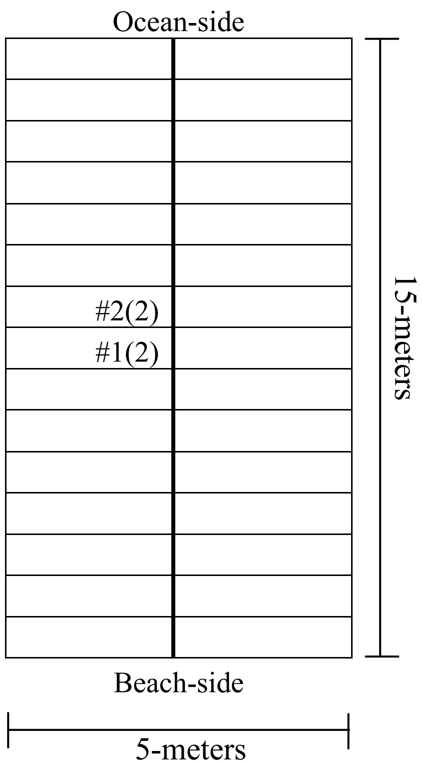


Figure 1. Backdoors East transect with two corals with two wire ties on each colony. Transects are 5 m x 15 m in area, with each cell representing a 1 m x 2.5 m area of reef. Coral locations along transect are approximate and the number (#) corresponds to photos following this figure within the appendix while the number in parentheses denotes the number of wire ties on the colony.

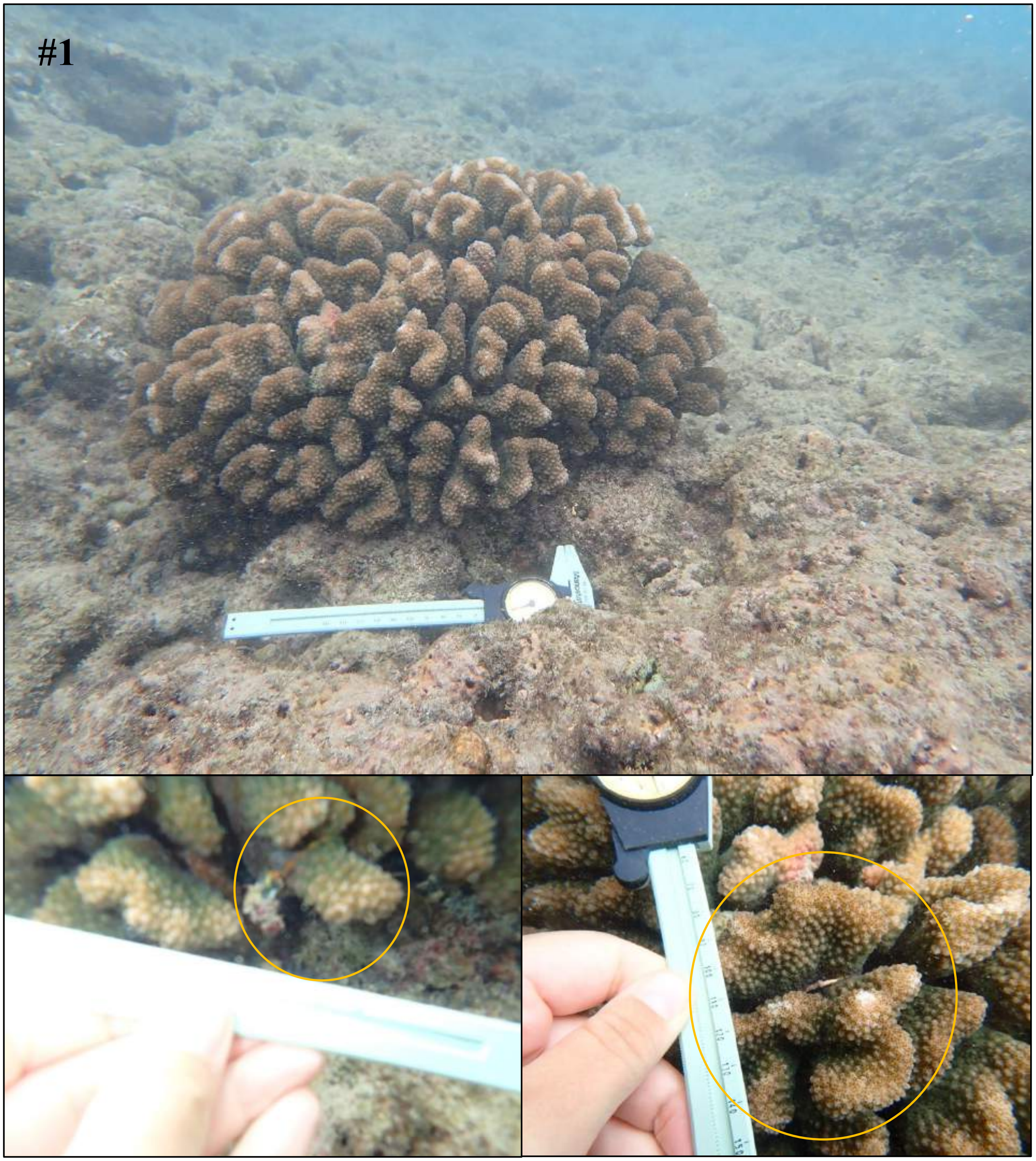


Figure 2. Backdoors East *P. meandrina* number 1 colony with two wire ties (bottom left and right photos).

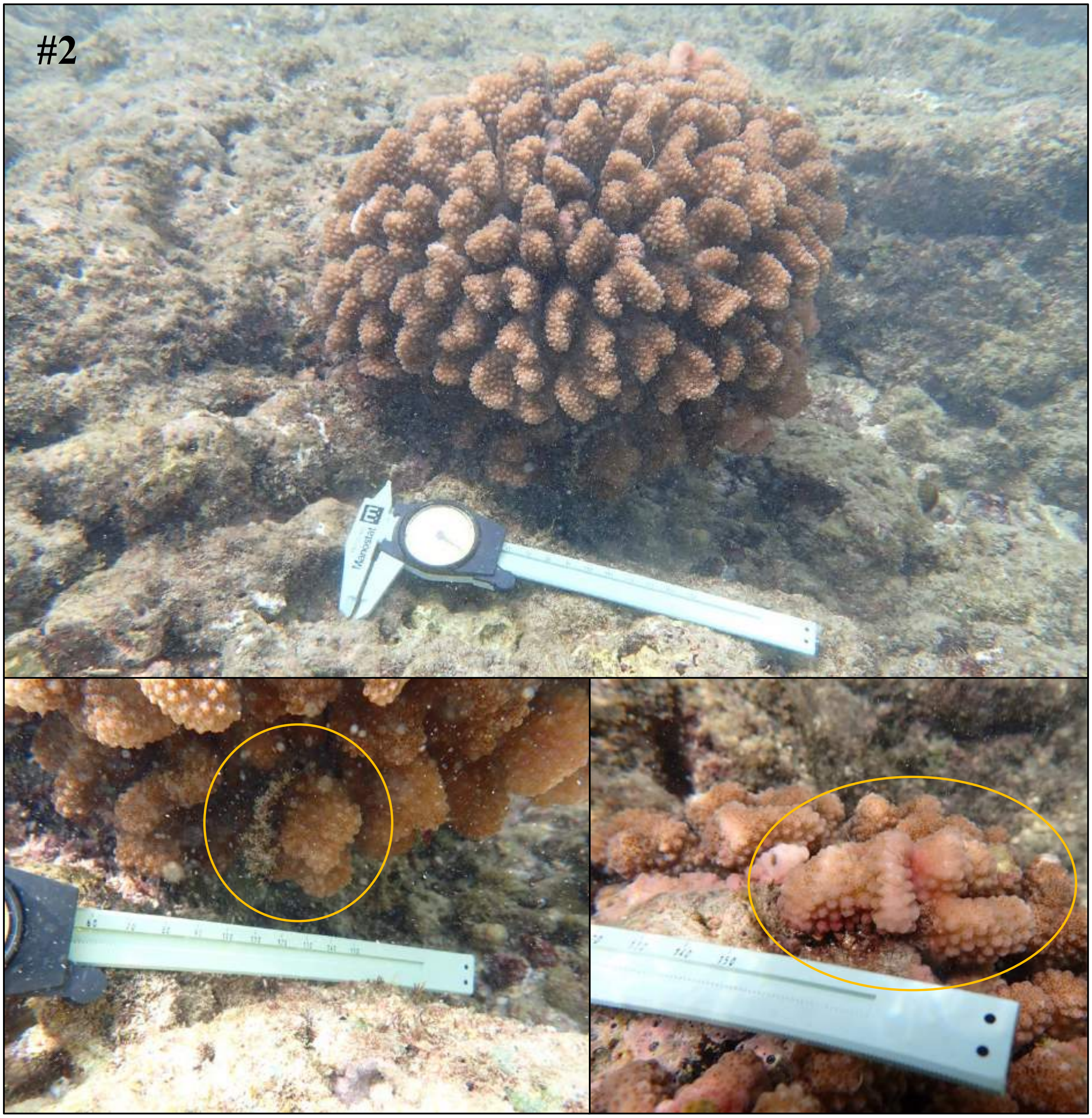


Figure 3. Backdoors East *P. meandrina* number 2 colony with two wire ties (bottom left and right photos).

Backdoors West Corals (2 Corals Total):

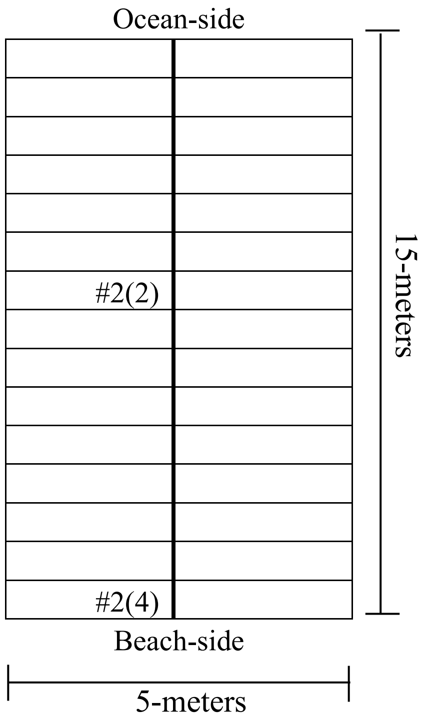


Figure 4. Backdoors West transect with two total corals. Transects are 5 m x 15 m in area, with each cell representing a 1 m x 2.5 m area of reef. Coral locations along transect are approximate and the number (#) corresponds to photos following this figure within the appendix while the number in parentheses denotes the number of wire ties on the colony.

Figure 5. Backdoors West *P. meandrina* number 1 colony with four wire ties (bottom four photos).

Figure 6. Backdoors West *P. meandrina* number 2 colony with two wire ties (bottom left and right photos).

Keyhole East Corals (3):

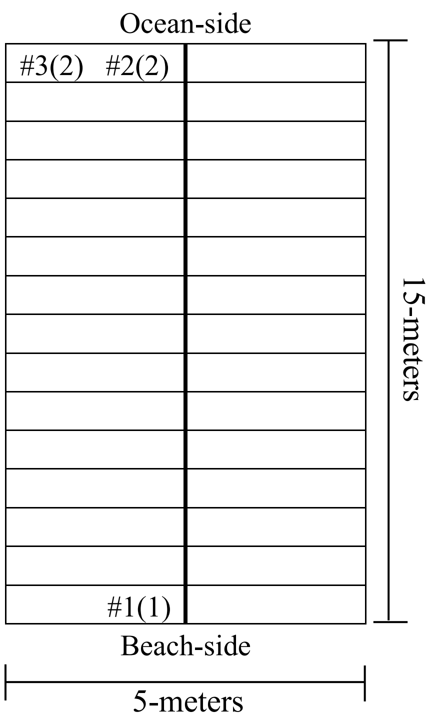


Figure 7. Keyhole East transect with three total corals. Transects are 5 m x 15 m in area, with each cell representing a 1 m x 2.5 m area of reef. Coral locations along transect are approximate and the number (#) corresponds to photos following this figure within the appendix while the number in parentheses denotes the number of wire ties on the colony.

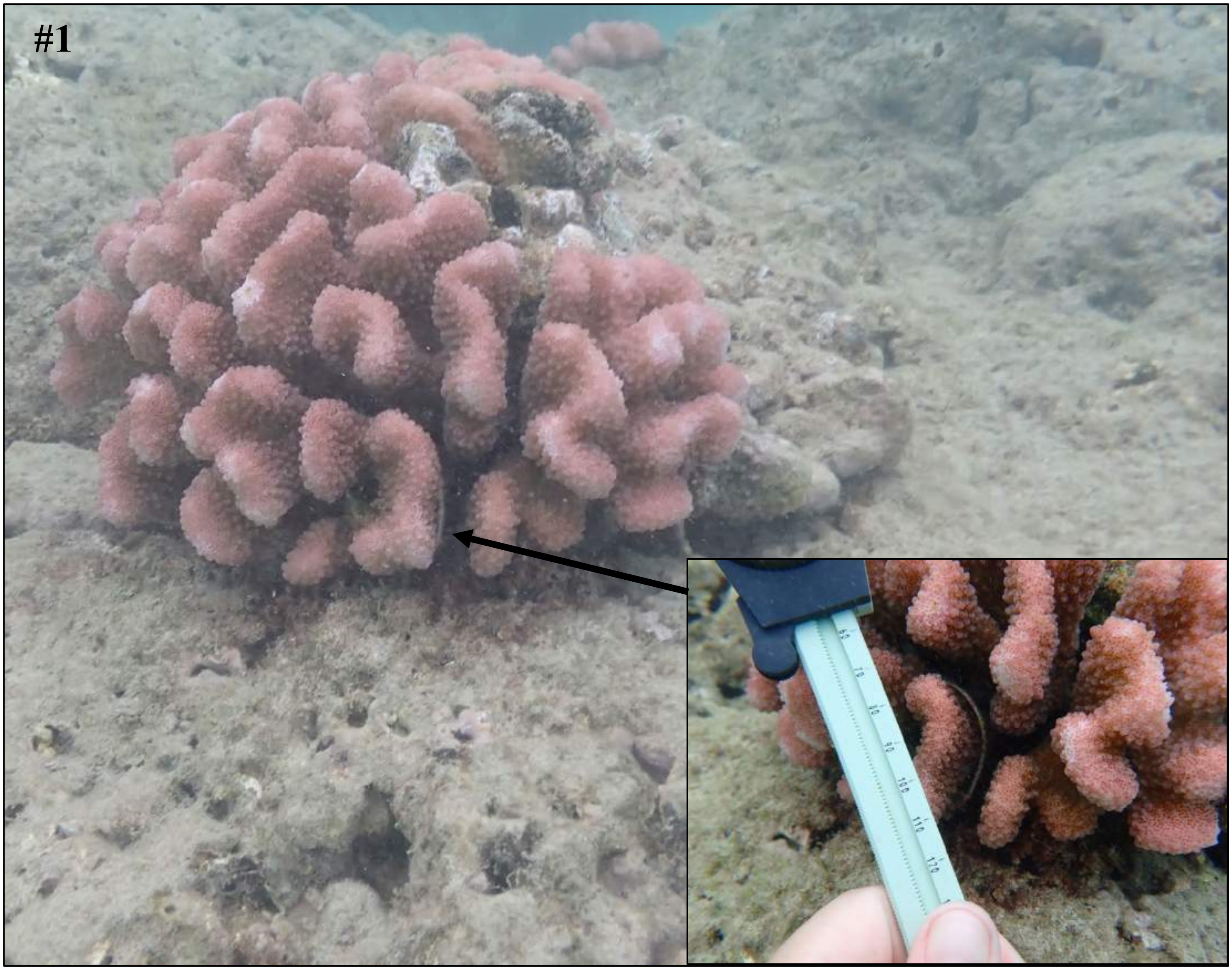


Figure 8. Keyhole East *P. meandrina* number 3 colony with one wire tie (bottom right photo).

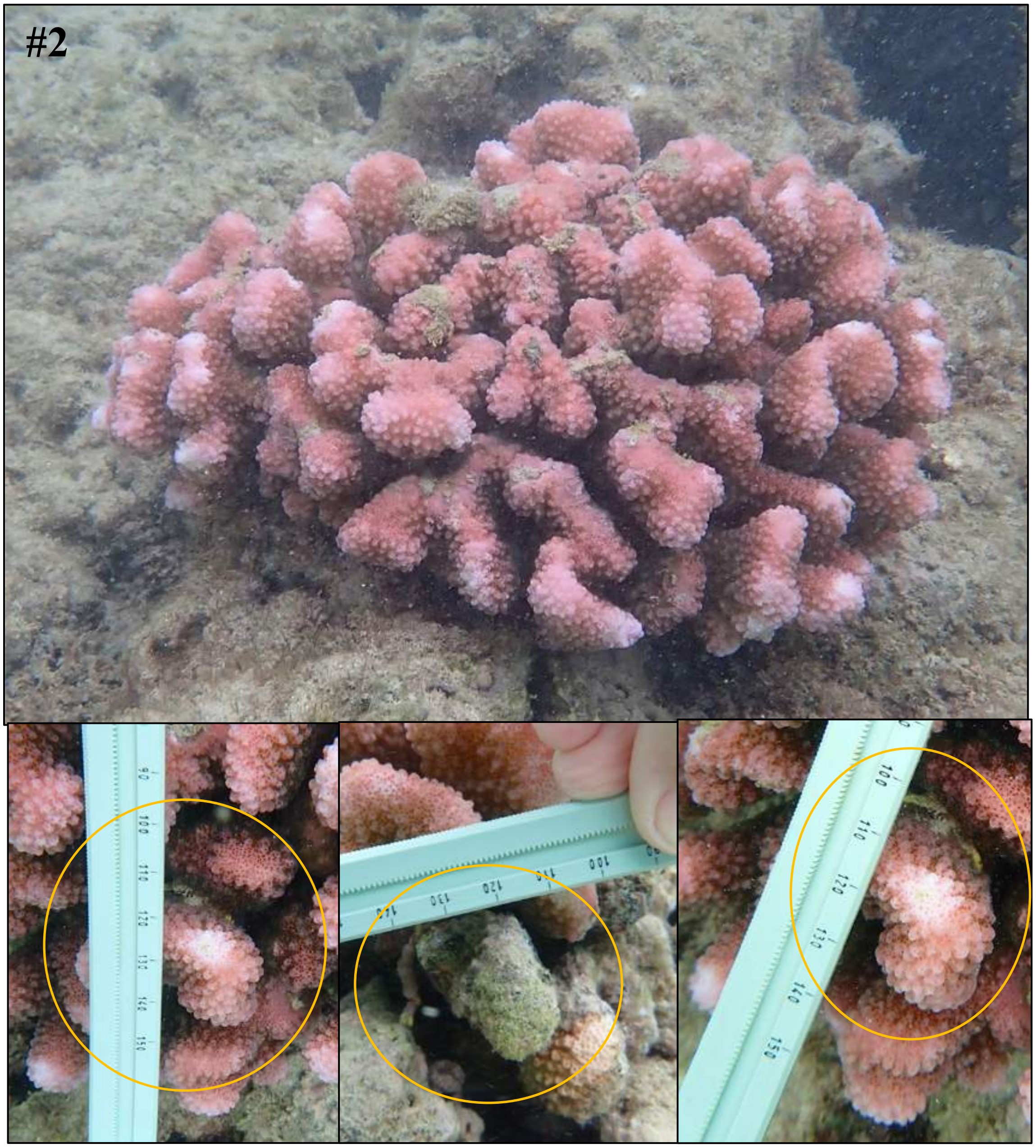


Figure 9. Keyhole East *P. meandrina* number 1 colony with two live wire ties (bottom left and right photos) and one deceased wire tie around a branch (bottom middle photo).

Figure 10. Keyhole East *P. meandrina* number 2 colony with two wire ties (bottom left and right photos).

Channel East Corals (2 Total):

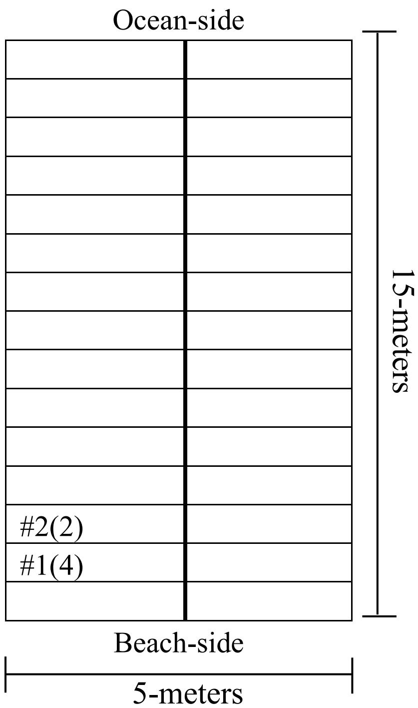


Figure 11. Channel East transect with two total corals. Transects are 5 m x 15 m in area, with each cell representing a 1 m x 2.5 m area of reef. Coral locations along transect are approximate and the number (#) corresponds to photos following this figure within the appendix while the number in parentheses denotes the number of wire ties on the colony.

Figure 12. Channel East *P. meandrina* number 1 colony with four wire ties (two shown in photos).

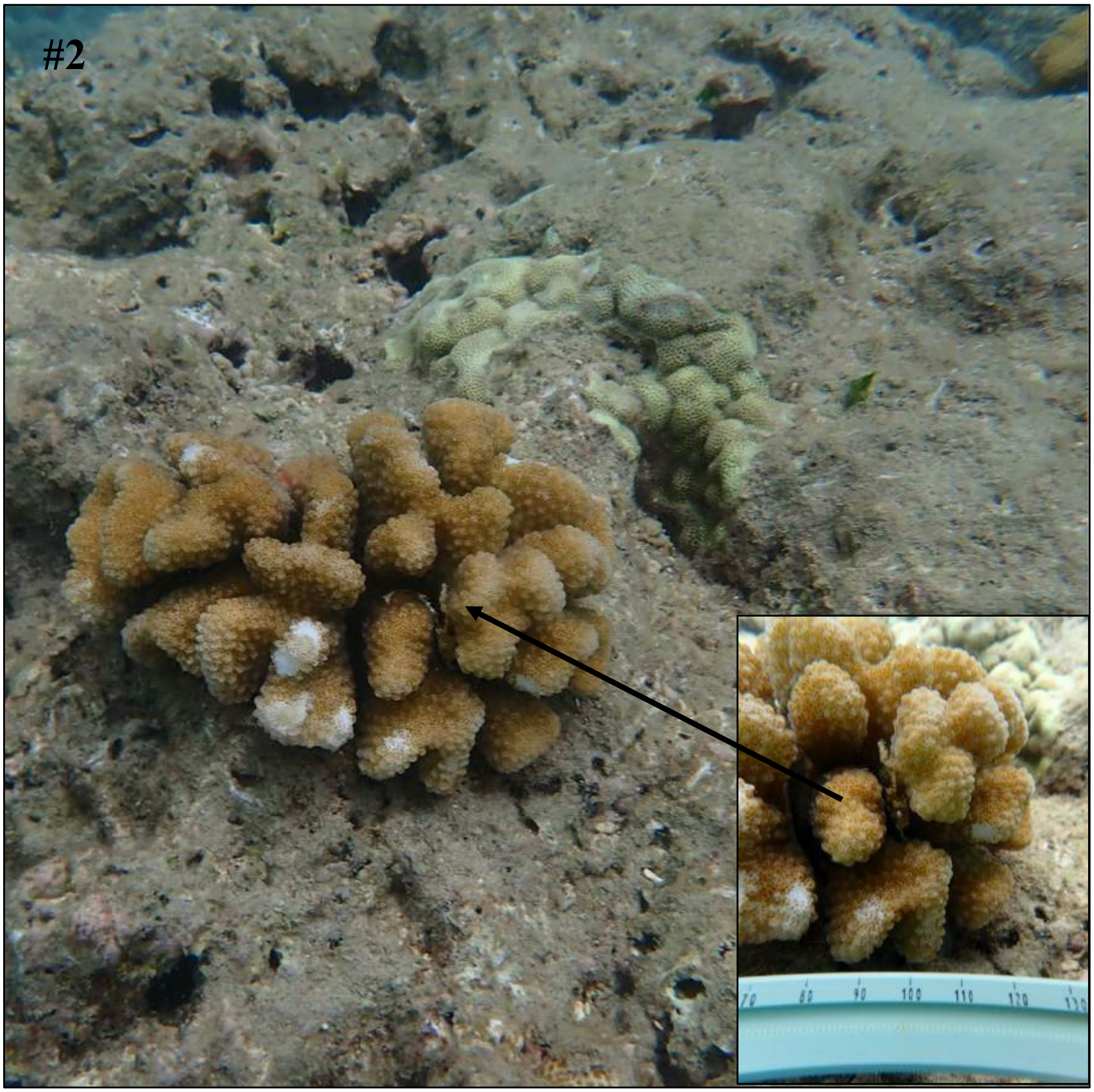


Figure 13. Channel East *P. meandrina* number 2 colony with two wire ties (one shown in photos).

Channel West Coral (1):

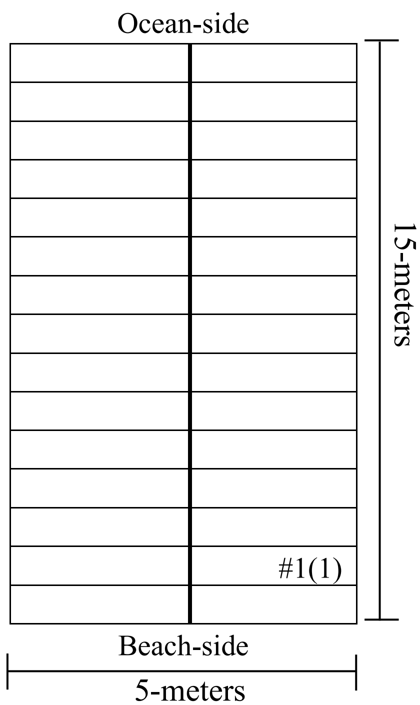


Figure 14. Channel West transect with one coral. Transects are 5 m x 15 m in area, with each cell representing a 1 m x 2.5 m area of reef. Coral locations along transect are approximate and the number (#) corresponds to photos following this figure within the appendix while the number in parentheses denotes the number of wire ties on the colony.

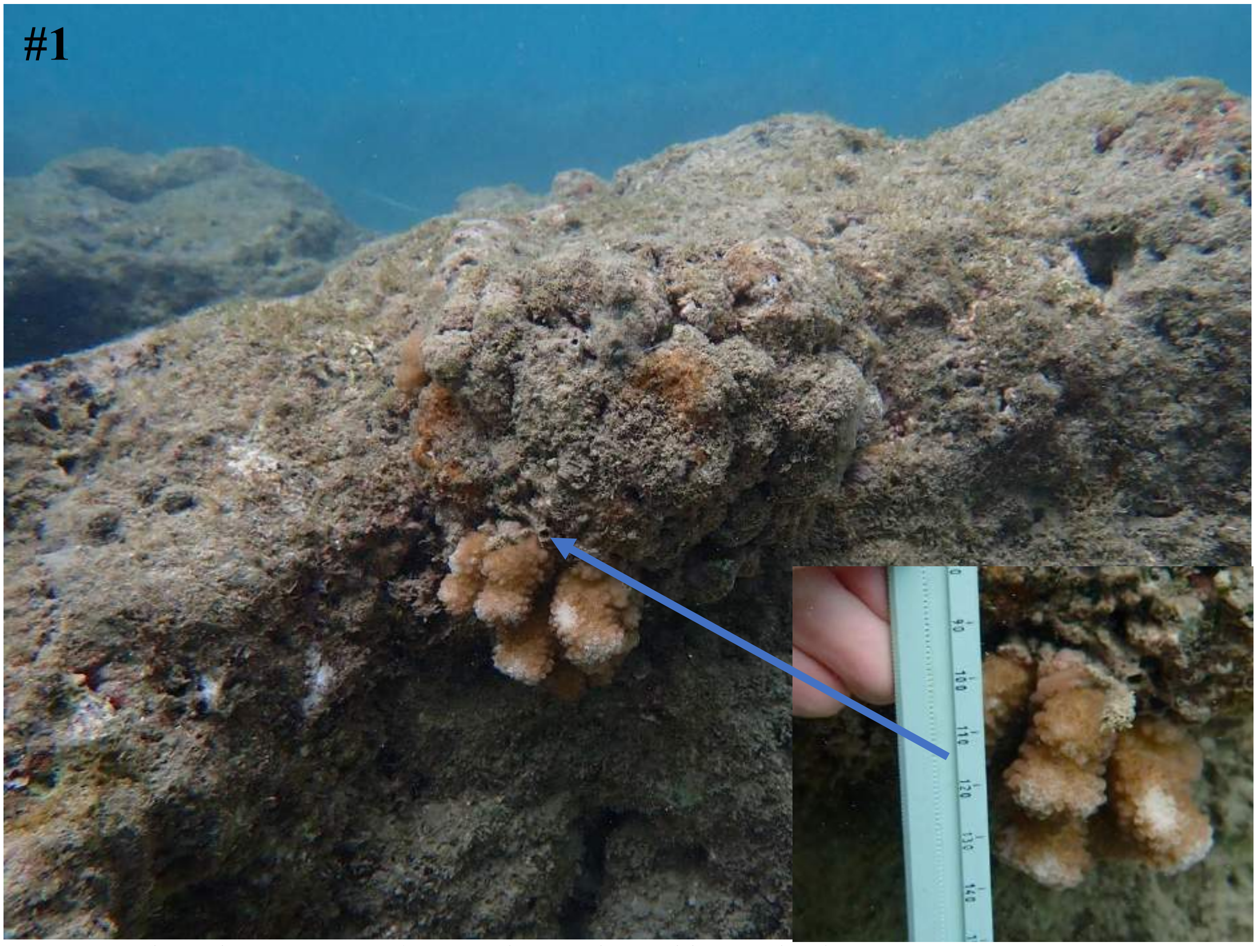


Figure 15. Channel West *P. meandrina* number 1 colony with one wire tie.

Witches Brew East Coral (4):

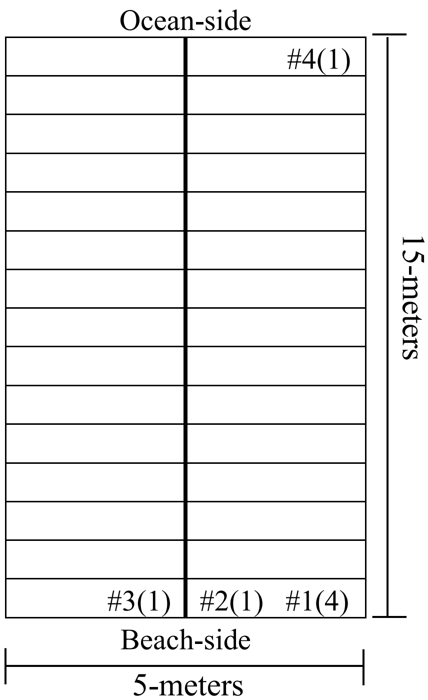


Figure 16. Witches Brew East transect with four total corals. Transects are 5 m x 15 m in area, with each cell representing a 1 m x 2.5 m area of reef. Coral locations along transect are approximate and the number (#) corresponds to photos following this figure within the appendix while the number in parentheses denotes the number of wire ties on the colony.

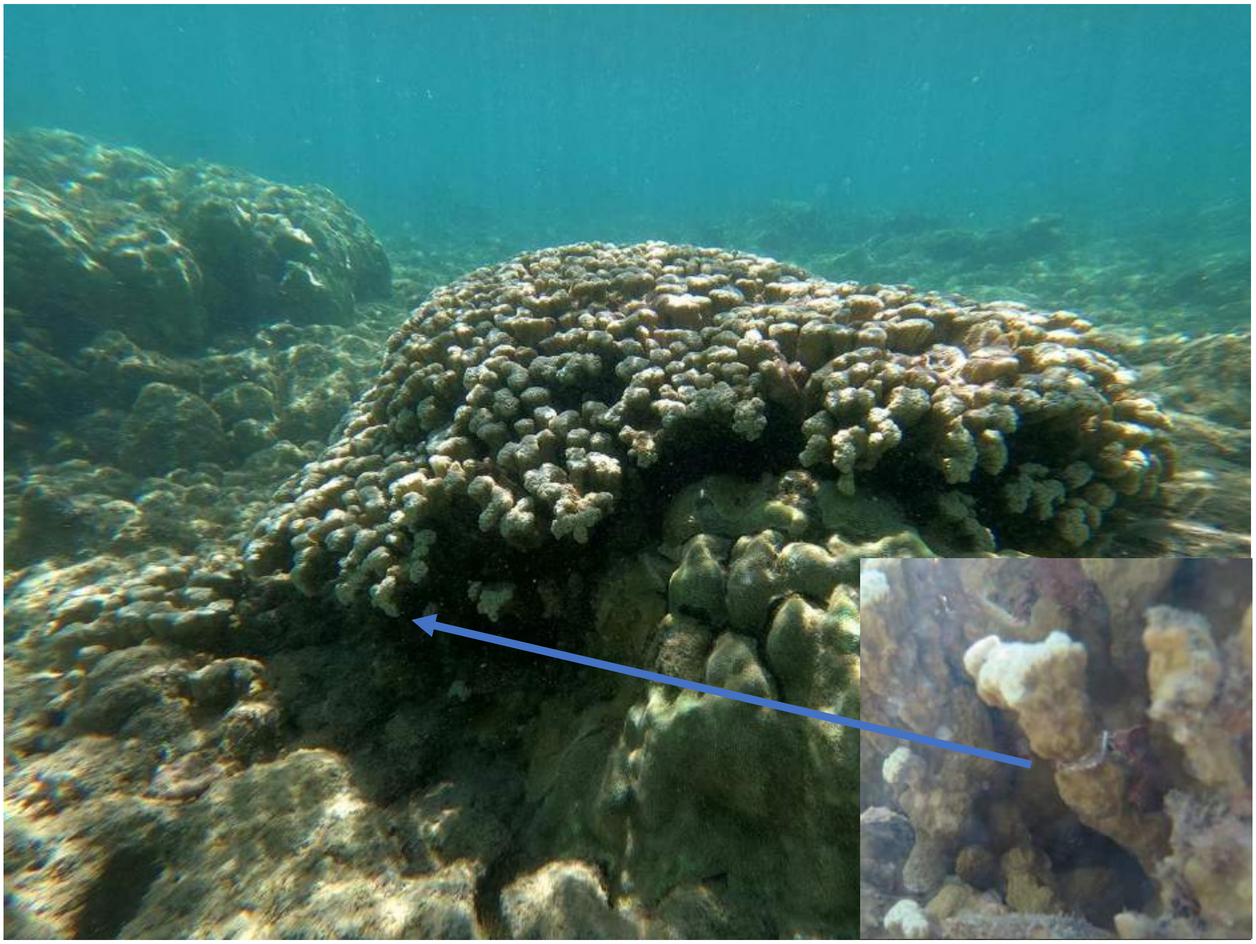


Figure 17. Witches Brew East *P. rus* colony number 1 with four wire ties (one tie shown in bottom right).

Witches Brew West Coral (3):

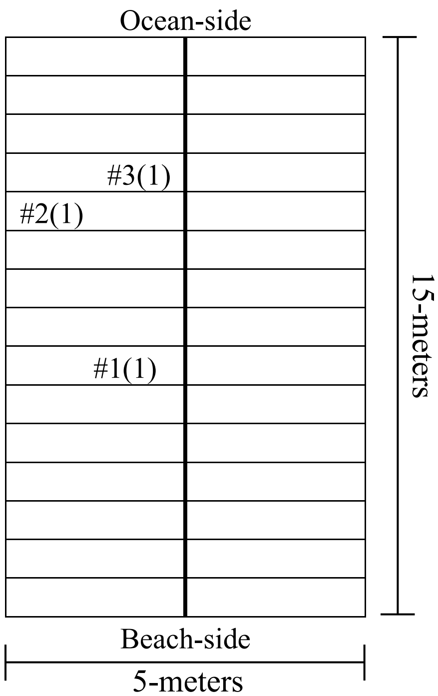


Figure 18. Witches Brew West transect with three total corals. Transects are 5 m x 15 m in area, with each cell representing a 1 m x 2.5 m area of reef. Coral locations along transect are approximate and the number (#) corresponds to photos following this figure within the appendix while the number in parentheses denotes the number of wire ties on the colony.

Appendix B. Raw Data

Table 1. Coral growth measurements over time (mm) using a caliper. Species codes: Pocillopora meandrina or Cauliflower coral, Pr = Porites rus or Plate and Pillar coral, Pc = Porites compressa or Finger coral. Missing growth rates (as indicated by NM) indicate that the colony growth measurement cannot be calculated at this time. Colonies that could not be located or branches that were dead are highlighted in grey.

Latitude	Longitude	Sector	Number of Colonies	Colony Number	Species	Full Colony Size (cm)	Number of Wires	Wire Number	Day 1: 4/29/20	Day 69: 7/7/2020	Day 327: 3/22/2021
21.2727	-157.695	Backdoors East	2	1	Pm	65x70	2	1	NM	23	29
								2	25	34	32
				2	Pm	55x26	2	1	15	20	19
								2	33	34	41
									Day 1: 4/29/20	**Day 69: 7/7/2020**	**Day 327: 3/22/2021**
21.2724	-157.695	Backdoors West	2	1	Pm	36x25	4	1	15	19	31
								2	NM	NM	70
								3	13	15	33
								4	2	20	36
				2	Pm	25x24	2	1	NM	33	34
								2	NM5	45	45
									Day 1: 4/10/20	**Day 88: 7/7/2020**	**Day 340: 23/16/21**
21.2723	-157.695	Keyhole East	3	1	Pm	35x25	3 total, one dead	1	41	40	52
								2	NM	NM	42
								3	NM	NM	dead
				2	Pm	25x25	2	1	NM	NM	30
								2	NM	NM	35
				3	Pm	30x30	1	1	33.5	NM	33

Table 1 cont.

Latitude	Longitude	Sector	Number of Colonies	Colony Number	Species	Full Colony Size (cm)	Number of Wires	Wire Number			
21.2719	-157.696	Keyhole West	none								
									Day 1: 4/10/20	**Day 81: 6/30/2020**	**Day 340: 3/16/21**
21.2703	-157.697	Channel East	2	1	Pm	15x15	2	1	NM	25	38
								2	NM	25	couldn’t find
				2	Pm	20x20	4	1	NM	25	25
								2	NM	22	21
								3	NM	NM	43
								4	NM	NM	50
									Day 1: 4/10/20	**Day 81: 6/30/2020**	**Day 340: 3/16/21**
21.27	-157.697	Channel West	1	1	Pm	10x10	1	1	NM	23	32
									Day 1: 4/21/20	**Day 70: 6/30/2020**	
21.2688	-157.697	Witches Brew East	4	1	Pr	1.15m x 0.8m x 0.25m	4	1	NM	32	NM
								2	10	NM	NM
								3	30	42	NM
								4	34	41	NM
				2	Pm	43x40	1	1	18	NM	NM
				3	Pc		1	1	28	NM	NM
				4	Pc		1	1	18	NM	NM
									Day 1: 4/21/20	**Day 70: 6/30/2020**	
21.2685	-157.697	Witches Brew West	2	1	Pc		1	1	32	20	NM
				2	Pc		1	1	22	27	NM

Appendix E. Sediment trap accumulation.

Table 1. Sediment trap accumulation and weights for traps deployed in October 2018.

Hanauma October 2018								
Site Name		**# Days in Field**	**Day #1 Actual**	**Day #2 Actual**	**Day #3 Actual**	**Average**	**SD**	**Sediment accumulation per day**
Backdoors East	Front	29	61.226	61.145	61.238	61.2	0.051	2.11
	Back	29	137.258	137.149	137.278	137.2	0.069	4.73
Backdoors West	Front	29	70.547	70.48	70.545	70.5	0.038	2.43
	Back	29	64.062	64.005	64.058	64.0	0.032	2.21
Keyhole East	Front	29	162.507	162.383	162.481	162.5	0.065	5.60
	Back	29	85.839	85.734	85.755	85.8	0.056	2.96
Keyhole West	Front	29	403.377	402.793	403.256	403.1	0.308	13.90
	Back	29	87.307	87.23	87.314	87.3	0.047	3.01
Channel East	Front	15	19.723	19.692	19.717	19.7	0.016	1.31
	Back	29	18.844	18.816	18.837	18.8	0.015	0.65
Channel West	Front	29	83.723	83.641	83.7	83.7	0.042	2.89
	Back	29	36.748	36.709	36.735	36.7	0.020	1.27
Witches Brew East	Front	29	81.886	81.794	81.872	81.9	0.050	2.82
	Back	29	94.914	94.818	94.909	94.9	0.054	3.27
Witches Brew West	Front	29	77.947	77.868	77.935	77.9	0.043	2.69
	Back	29	29.499	29.466	29.513	29.5	0.024	1.02

Table 2. Sediment trap accumulation and weights for traps deployed in June 2018.

Hanauma June 2018								
Site Name		**# Days in Field**	**Day #1 Actual**	**Day #2 Actual**	**Day #3 Actual**	**Average**	**SD**	**Sediment accumulation per day**
Backdoors East	Front	29	3.729	3.712	3.714	3.72	0.009	0.13
	Back	19	36.139	36.087	36.087	36.10	0.030	1.90
Backdoors West	Front	29	57.6	59.636	57.553	58.26	1.189	2.01
	Back	26	37.72	39.747	37.681	38.38	1.182	1.48
Keyhole East	Front	29	69.741	71.775	69.679	70.40	1.193	2.43
	Back	29	60.681	62.75	60.646	61.36	1.205	2.12
Keyhole West	Front	29	164.38	166.378	164.3	165.02	1.177	5.69
	Back	29	59.361	61.397	59.315	60.02	1.189	2.07
Channel East	Front	29	27.114	27.094	27.099	27.10	0.010	0.93
	Back	29	50.309	50.256	50.265	50.28	0.028	1.73
Channel West	Front	29	75.398	75.371	75.121	75.30	0.153	2.60
	Back	29	44.946	44.925	44.932	44.93	0.011	1.55
Witches Brew East	Front	29	58.301	58.276	58.284	58.29	0.013	2.01
	Front	29	47.885	47.855	47.865	47.87	0.015	1.65
Witches Brew West	Back	29	53.273	53.243	53.246	53.25	0.017	1.84
	Front	15	26.631	26.615	26.62	26.62	0.008	1.77

Table 3. Sediment trap accumulation and weights for traps deployed in 2020 during the COVID-19 closure.

Hanauma 2020		April 2020		August 2020		October 2020		
Site Name		**No. Days in Field**	**Sediment accumulation per day**	**No. Days in Field**	**Sediment accumulation per day**	**No. Days in Field**	**Sediment accumulation per day**	**Average**
Backdoors East	Front	16	1.11	11	2.12	5	1.95	1.73
	Back	16	1.91	11	2.96	5	2.61	2.49
Backdoors West	Front	16	0.59	11	1.02	5	1.77	1.13
	Back	16	0.93	11	2.24	5	2.17	1.78
Keyhole East	Front	16	1.75	11	5.06	5	3.43	3.41
	Back	16	0.75	11	1.82	5	2.02	1.53
Keyhole West	Front	16	5.73	11	20.85	5	5.13	10.57
	Back	16	1.84	11	4.08	5	2.66	2.86
Channel East	Front	16	0.40	11	0.99	5	1.16	0.85
	Back	16	0.63	11	1.48	5	0.92	1.01
Channel West	Front	16	1.01	11	4.86	5	6.09	3.99
	Back	16	0.89	11	-	5	1.54	1.22
Witches Brew East	Front	16	0.87	11	1.53	5	1.61	1.33
	Front	16	1.99	11	1.89	5	2.16	2.01
Witches Brew West	Back	16	9.43	11	7.62	5	6.58	7.88
	Front	16	9.03	11	36.49	5	17.99	21.17

Appendix F. Water clarity measurements.

Table 1. Secchi disk water clarity raw data from June 2018.

DATE:		Backdoor		Keyhole		Channel		Witches Brew			
		East	**West**	**East**	**West**	**East**	**West**	**East**	**West**		
6/1/18	**Time**	12:02	12:11	12:23	12:30	12:46	12:52	1:08	1:16	**Obs1:**	**TD**
	Cloud Cover (%)	90	90	50	20	30	30	5	5	**Obs2:**	**RA**
	Observation:	partial sun	partial sun	sun	sun	sun	sun	sun	sun		
	Obs1:Secchi distance away (m)	5.2	6.7	6.5	10.4	8.6	5.8	6.5	5		
	Obs1:Secchi distance toward (m)	4.9	5.4	5.6	11	8.2	5.2	6.3	4.5		
	Obs2:Secchi distance away (m)	5	9	7.4	7.8	7.7	7.3	7.6	5.9		
	Obs2:Secchi distance toward (m)	4	4.9	3.2	5	5.4	4.3	4.3	3.1		
6/5/18	**Time**	8:40	8:50	9:08	9:24	10:32	10:46	11:18	11:38	**Obs1:**	**AM**
	Cloud Cover (%)	0	5	40	50	60	50	40	40	**Obs2:**	**AF**
	Observation:	sun	sun	sun	sun on 1st/ cloudy on 2nd	cloud cover	sun	sun	sun		
	Obs1:Secchi distance away (m)	10.6	8.9	7.4	11.2	9.8	10.4	8.05	7.34		
	Obs1:Secchi distance toward (m)	9.9	8.65	6.7	10.4	9.7	8.9	7.3	6.8		
	Obs2:Secchi distance away (m)	9.7	8.4	7.2	10.5	8.7	8.5	8.8	6.7		
	Obs2:Secchi distance toward (m)	8.9	7.6	6.3	8.8	8.1	7.4	7.1	5.9		
6/6/18	**Time**	12:17	12:30	12:00	12:50	1:26	1:20	1:42	1:48	**Obs1:**	**SS**
	Cloud Cover (%)	30	30	30	30	40	40	50	50	**Obs2:**	**TD**
	Observation:	sun	sun	partial sun	partial sun	partial sun	partial sun	partial sun	partial sun		
	Obs1:Secchi distance away (m)	7.3	8.4	8.4	10	9.1	6.4	6.9	6.2		
	Obs1:Secchi distance toward (m)	6.4	9.7	8.2	8.4	9.1	6	5.7	5.6		
	Obs2:Secchi distance away (m)	8.2	7.8	6.7	8.3	6.8	3.1	4.9	5.7		
	Obs2:Secchi distance toward (m)	8	8.5	6	8.2	7	5	4.2	5.4		
6/7/18	**Time**		12:40		12:24		12:06		11:51	**Obs1:**	**SS**
	Cloud Cover (%)	10	10	20	20	80	80	80	80	**Obs2:**	**AR**
	Observation:	sun	sun	sun	sun	partial sun	partial sun	sun	sun		
	Obs1:Secchi distance away (m)	8.4	9.2	7.1	6	7.7	7.8	6.6	5.1		
	Obs1:Secchi distance toward (m)	8.6	9	7.3	5.7	6.9	7	5.4	4.8		
	Obs2:Secchi distance away (m)	8.4	9.2	7	5.9	6.3	5.8	5.6	5.2		
	Obs2:Secchi distance toward (m)	7.6	9.6	7.2	5.6	6.6	5.6	5.1	4.8		
6/8/18	**Time**	12:08		12:30	12:46	1:10	1:26	1:41	1:52	**Obs1:**	**SS**
	Cloud Cover (%)	50	50	50	50	75	75	75	75	**Obs2:**	**RA**
	Observation:	partial sun	partial sun	partial sun	partial sun	partial cloud	partial cloud	partial cloud	partial cloud		
	Obs1:Secchi distance away (m)	5.1	6.1	3.4	5.1	5	4.6	3.9	3.7		
	Obs1:Secchi distance toward (m)	4.6	5.9	2.9	4.9	4.8	4.5	3.7	3		
	Obs2:Secchi distance away (m)	4.6	5.4	3.3	4.9	5	5.3	3.8	3.4		
	Obs2:Secchi distance toward (m)	4.6	6.1	2.4	4.9	5.1	4.6	3.2	2.1		

DATE:		Backdoor		Keyhole		Channel		Witches Brew			
		East	West	East	West	East	West	East	West		
6/10/18	**Time**	10:45	10:58	11:07	11:15	11:58	11:54	11:39	11:29	**Obs1:**	**SS**
	Cloud Cover (%)	20	10	10	10	10	10	10	10	**Obs2:**	**SD**
	Observation:	sun	sun	sun	sun	sun	sun	sun	sun		
	Obs1:Secchi distance away (m)	5.2	5.5	4.8	5.1	5.9	4.6	3.7	4.1		
	Obs1:Secchi distance toward (m)	5.2	5.3	4.7	5	5.3	3.7	3.2	3.9		
	Obs2:Secchi distance away (m)	5	6.1	5.1	5	4	4.7	3.2	3.1		
	Obs2:Secchi distance toward (m)	4.6	4.9	4.3	4.8	4.2	4.1	3.1	2.9		
6/12/18	**Time**			11:40		12:30	1:00	2:00		**Obs1:**	**TD**
	Cloud Cover (%)	20	20	20	20	80	90	90	90	**Obs2:**	**HR**
	Observation:	sun	sun								
	Obs1:Secchi distance away (m)	5.7	5.8	5.4	5.9	4.2	4.8	3.9	2.1		
	Obs1:Secchi distance toward (m)	4.9	5.2	4.3	5.5	3.8	4.7	2.9	2.2		
	Obs2:Secchi distance away (m)	5.2	5.2	5.1	5.9	5.7	6.2	3.8	3		
	Obs2:Secchi distance toward (m)	5.3	5.4	3.8	5.7	5.3	5.8	3.5	2.6		
6/16/18	**Time**	1:32	1:23	1:16	1:07	12:07	12:27	12:38		**Obs1:**	**SS**
	Cloud Cover (%)	20	20	20	20	40	50	50	50	**Obs2:**	**AR**
	Observation:	sun	sun	sun	sun	hazy	cloud	sun	sun		
	Obs1:Secchi distance away (m)	6.3	6.5	6	6.4	7.4	6.3	9	6.5		
	Obs1:Secchi distance toward (m)	5.5	6.2	5.6	5.7	6.9	6.3	8.5	6.4		
	Obs2:Secchi distance away (m)	5.6	6.6	5.3	5.9	6.7	5.3	8.2	6.6		
	Obs2:Secchi distance toward (m)	5.4	6.1	5.2	6	6.8	5.6	7.2	7.5		
6/17/18	**Time**	8:53	9:00	9:10	9:18	9:33	9:42	9:54	10:15	**Obs1:**	**SS**
	Cloud Cover (%)	10	10	10	10	30	75	50	50	**Obs2:**	**DS**
	Observation:	sun	sun	sun	cloud	cloud cover	cloud	sun	cloud		
	Obs1:Secchi distance away (m)	11	13.8	13.6	10.6	8.6	10.5	10.9	9.8		
	Obs1:Secchi distance toward (m)	10.6	13.2	13.1	9.9	8.6	10.1	10.6	9.6		
	Obs2:Secchi distance away (m)	11.5	13.4	12	12.1	9.4	8.9	9.8	8.9		
	Obs2:Secchi distance toward (m)	10.8	13.2	12.2	10.8	9.4	7.6	10	8.9		
6/19/18	**Time**	9:31	9:24	9:15	9:05	9:58	10:05	10:21	10:28	**Obs1:**	**AF**
	Cloud Cover (%)									**Obs2:**	**SF**
	Observation:	sun	sun	sun	sun	sun	sun	sun	sun		
	Obs1:Secchi distance away (m)	13.8	18.6	15.7	16.9	15.3	14.4	11.9	10.1		
	Obs1:Secchi distance toward (m)	14.1	19.5	15.8	17.1	15.1	14.6	10.9	9.8		
	Obs2:Secchi distance away (m)	16.25	17.9	16.1	16.5	14.19	14.3	12.2	11.2		
	Obs2:Secchi distance toward (m)	17.1	16.7	15.9	16.2	14.25	15.5	10.7	8.9		
6/20/18	**Time**	12:10	12:15	12:20	12:24	12:37	12:42	12:50	12:55	**Obs1:**	**SS**
	Cloud Cover (%)	20	20	20	20	20	20	20	20	**Obs2:**	**RA**
	Observation:	sun	sun	sun	sun	sun	sun	sun	sun		
	Obs1:Secchi distance away (m)	9.5	11.7	8.2	3.5	5.5	4.9	7.2	5.9		
	Obs1:Secchi distance toward (m)	8.5	11.5	8.3	3.3	5.1	5.1	6.7	5.8		
	Obs2:Secchi distance away (m)	7.9	10.8	7	2.4	6	4.5	6	5.1		
	Obs2:Secchi distance toward (m)	7.5	8.5	5.8	2.1	4.4	3.9	4.4	4.2		
6/28/1	**Time**	11:47		12:00PM	12:05	12:15	12:20	12:30	12:36	**Obs1:**	**SS**

DATE:		Backdoor		Keyhole		Channel		Witches Brew			
		East	West	East	West	East	West	East	West		
	Cloud Cover (%)	100	100	100	100	100	100	100	100	Obs2:	AR
	Observation:										
	Obs1:Secchi distance away (m)	6.9	6.4	5.5	6.4	7	6.5	5.2	4.7		
	Obs1:Secchi distance toward (m)	6	6.1	5.1	6.8	6.6	6.1	5.8	4.3		
	Obs2:Secchi distance away (m)	7.9	7.2	5.3	6.4	5.5	5.1	5	4.1		
	Obs2:Secchi distance toward (m)	7.1	7.4	5.1	5.4	4.9	5.2	4.7	3.9		

Table 2. Secchi disk water clarity raw data from October 2018.

Date:		Backdoor		Keyhole		Channel		Witches Brew		Offshore		
		East	West	East	West	East	West	East	West	East	West	
10/5/18	Time	12:09	12:22		12:45	12:57	1:08		1:30			Obs1:SS
	Cloud Cover	0	0	10	0	0	0	0	0			Obs2:AR
	Observation:			cloud	sun	sun	sun	sun	sun			
	Obs1:Secchi distance away (m)	6.9	8	5.5	6.7	10.8	5.3	3.2	2.7			
	Obs1:Secchi distance toward (m)	7.2	7.8	5.8	5.6	10.7	4.3	2.8	1.9			
	Obs2:Secchi distance away (m)	5.3	7.4	6.9	5.4	9.2	4.1	3.5	2.3			
	Obs2:Secchi distance toward (m)	5.7	7.4	5.8	4.9	8.5	3.4	3.2	1.8			
10/8/18	Time	11:42	11:47	11:55	12:05	12:17	12:30	12:47	1:02			Obs1:SS
	Cloud Cover	10	10	50	50	50	50	50	50			Obs2:AR
	Observation:	sun	sun	cloud	cloud	sun/cloud	cloud	cloud	cloud/sun			
	Obs1:Secchi distance away (m)	7.9	10.1	7.6	6.4	6.3	6.4	5.2	4.2			
	Obs1:Secchi distance toward (m)	7.4	9.6	7	6.6	6	5.3	3.9	3.5			
	Obs2:Secchi distance away (m)	7.7	8.8	7	5.3	5.2	4.9	4.6	4.4			
	Obs2:Secchi distance toward (m)	7.4	8.5	5.8	5.9	6.1	4.7	3.8	3.5			
10/9/18	Time	10:57	11:01	11:28	11:35	12:15	12:20	12:44	12:49	10:18	10:30	Obs1:SS
	Cloud Cover	30	30	50	75	95	50	20	20	50	50	Obs2:HG
	Observation:	sun	sun	sun	sun	cloud	sun	sun	sun	cloud	cloud	
	Obs1:Secchi distance away (m)	11.5	11.8	10.1	9.4	7.5	8.8	6.1	5.1	9.1	8.7	
	Obs1:Secchi distance toward (m)	11.2	11.7	9.7	8.9	7	8.2	5.8	5.8	9.3	8.3	
	Obs2:Secchi distance away (m)	11.8	11.4	10.5	8.3	9.6	8.3	6.2	5.8	9.3	8.7	
	Obs2:Secchi distance toward (m)	11.6	11.1	10.1	8.1	9.3	8.1	5.9	5.5	8.9	8.3	
10/10/18	Time	11:42	11:47	11:55	12:01	12:13	12:21	12:35	12:43			Obs1:SS
	Cloud Cover	60	50	50	50	75	75	50	50			Obs2:AR
	Observation:	cloud	sun	sun	cloud	cloud/sun	cloud	sun	sun			
	Obs1:Secchi distance away (m)	8.5	8.7	7.8	7.7	7.6	6.1	4.7	5.3			
	Obs1:Secchi distance toward (m)	7.9	7.4	7.9	7.8	7.9	6.1	5.1	5.1			
	Obs2:Secchi distance away (m)	8.2	8.9	8	9.2	8.4	6.7	5.1	4.7			
	Obs2:Secchi distance toward (m)	6.7	7.9	7	6.2	6.1	4.5	5.1	4.3			
10/11/18	Time	11:35	11:54	12:04	12:11	12:27	12:35	12:47	12:57			Obs1:SS
	Cloud Cover	15	15	15	15	25	40	40	40			Obs2:HG
	Observation:	sun	sun	sun	sun	sun	sun	sun	sun			
	Obs1:Secchi distance away (m)	9.3	10.6	7.8	6.9	7.6	8.1	5.8	4.4			
	Obs1:Secchi distance toward (m)	8.6	11.2	7.3	5.8	7.1	7.5	5.7	4.3			
	Obs2:Secchi distance away (m)	8.8	10	9.5	7.6	8.3	8.1	6.3	4.1			

Date:		Backdoor		Keyhole		Channel		Witches Brew		Offshore		
		East	**West**	**East**	**West**	**East**	**West**	**East**	**West**	**East**	**West**	
	Obs2:Secchi distance toward (m)	8.5	9.7	8.9	7.1	7.1	7.7	5.8	3.9			
10/12/18	**Time**	11:34	11:42	11:51	11:59	12:14	12:22	12:39	12:47			**Obs1:SS**
	Cloud Cover	50	50	50	50	50	75	75	100			**Obs2:AR**
	Observation:	cloud	cloud	sun	sun	cloud	cloud	cloud	cloud			
	Obs1:Secchi distance away (m)	10.1	10.4	9.3	9.5	10.5	7.1	5.7	4.8			
	Obs1:Secchi distance toward (m)	10.5	10.4	8.5	10.1	10.3	7.5	4.9	4.1			
	Obs2:Secchi distance away (m)	8.7	11.1	8.6	10.3	8.4	6.9	5.1	3.9			
	Obs2:Secchi distance toward (m)	9.3	10.3	8.6	10.4	7.5	6.5	5.1	4.6			
10/14/18	**Time**	11:59	12:05	12:13	12:22	1:01	1:11	1:20	1:34	12:30	12:51	**Obs1:SS**
	Cloud Cover	10	20	20	20	10	10	20	20	10	10	**Obs2:AT**
	Observation:	sun	sun	sun	sun	sun	sun	sun	sun	sun	sun	
	Obs1:Secchi distance away (m)	11.1	13.6	10.5	9.4	8.5	5.7	4.1	3.6	11.1	13.5	
	Obs1:Secchi distance toward (m)	10.5	12.6	9.8	8	8.1	5.6	3.9	2.5	11.5	13.7	
	Obs2:Secchi distance away (m)	8.15	11.6	10.9	9.2	6.9	5.2	3.5	3	11.9	13	
	Obs2:Secchi distance toward (m)	8.1	12	10.9	9.5	6.9	5.2	3.5	2.9	12.4	12.9	
10/16/18	**Time**	8:48	8:45	9:03	9:19	9:52	9:54	10:07	10:10	8:04	8:00	**Obs1:AR**
	Cloud Cover	20	20	10	10	10	10	20	20	20	20	**Obs2:HG**
	Observation:	sun	sun	sun	sun	sun/cloud	sun	sun	sun	sun	sun	
	Obs1:Secchi distance away (m)	12.2	12.4	8.5	10.1	10.9	9.3	7.1	4.2	24.1	27.3	
	Obs1:Secchi distance toward (m)	12.7	12.2	7	9.4	10.5	8.5	6.6	4.1	24.1	27.5	
	Obs2:Secchi distance away (m)	13.4	12.7	10.4	9.6	12.4	9.9	7.1	4.8	24.3	27.6	
	Obs2:Secchi distance toward (m)	13.2	12.4	10.7	9.4	12.3	9.6	6.8	4.5	24.1	27.2	
10/20/18	**Time**	11:33	11:39	11:46	11:53	12:05	12:12	12:21	12:33			**Obs1:SS**
	Cloud Cover	20	20	30	20	20	20	50	50			**Obs2:AF**
	Observation:	sun	sun	sun	sun	sun	sun	cloud	cloud			
	Obs1:Secchi distance away (m)	7.5	10	7.8	7.1	10.5	6.4	6.1	4.6			
	Obs1:Secchi distance toward (m)	7.1	9.2	7.9	7.1	9.3	5.7	4.9	4.5			
	Obs2:Secchi distance away (m)	7.5	8.2	7.5	7.8	9.8	7.6	5	5.2			
	Obs2:Secchi distance toward (m)	7.2	7	6.6	5.9	8.5	6.5	4.2	3.5			
10/21/18	**Time**	11:56	12:03	12:10	12:16	12:26	12:33	12:42	12:48			**Obs1:SS**
	Cloud Cover	95	95	80	70	50	50	50	50			**Obs2:AT**
	Observation:	Cloud	Cloud	cloud	cloud	sun	sun	sun	sun			
	Obs1:Secchi distance away (m)	6.7	6.5	4.9	4.6	7.1	4.4	3.9	4.2			
	Obs1:Secchi distance toward (m)	6.9	6.1	4.6	4.1	7.5	5.4	3.3	3.8			
	Obs2:Secchi distance away (m)	7.4	7.2	6.1	5.1	7.1	5.5	3.4	4			
	Obs2:Secchi distance toward (m)	7.5	7.3	5.8	5.2	7.1	5.5	3.5	3.6			
10/23/18	**Time**	10:41	10:30	10:19	10:27	9:25	9:34	9:50	9:57	9:02	9:22	**Obs1:HG**
	Cloud Cover	20	20	20	25	50	60	85	85	70	70	**Obs2:RK**
	Observation:	sun	sun	sun	sun	sun	sun	cloud/sun	cloud/sun	sun/cloud	cloud	
	Obs1:Secchi distance away (m)	11.5	10.5	10.8	12.2	12.2	11.6	11.1	8.4	13.2	11.5	
	Obs1:Secchi distance toward (m)	11.3	10.4	10.6	12.1	11.8	11.5	10.8	8.2	12.11	11.2	
	Obs2:Secchi distance away (m)	11.4	11.3	11.2	13.2	12.4	15.6	11.3	9.4	13.6	17.9	
	Obs2:Secchi distance toward (m)	11	11	10	12.8	11.8	15.2	11.1	9.2	13.4	16.8	
10/2	**Time**	11:37	11:44	11:51	11:58	12:10	12:19	12:30	12:37			**Obs1:SS**

Date:		Backdoor		Keyhole		Channel		Witches Brew		Offshore		
		East	West	East	West	East	West	East	West	East	West	
	Cloud Cover	25	25	80	20	10	10	10	20			Obs2:AR
	Observation:	sun	sun	sun	sun	sun	sun	sun	sun			
	Obs1:Secchi distance away (m)	11.3	9.9	8.9	8.6	7.9	6.4	4.8	3.9			
	Obs1:Secchi distance toward (m)	11	10.1	8.7	8.9	7.8	6.1	4.8	4			
	Obs2:Secchi distance away (m)	10.3	9.2	7.2	8.9	8.6	7.3	4.6	4.2			
	Obs2:Secchi distance toward (m)	9.9	9.8	6.4	9.05	8.1	5.1	4.3	3.6			

Table 3. All secchi disk water clarity data with environmental parameters. Reserve status includes during the COVID-19 Closure (COVID), after the reopening to the public (postCOVID), open to the public in 2018 (open) and closed to the public in 2018 (ClosedTuesdays).

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
COVID	4/21/20	1046	Channel	12.7	0	0	82	3.1972	119.24	2.49979592	135.040816	11.5342857	5.79081633
COVID	4/21/20	1046	Channel	11.9	0	0	82	3.1972	119.24	2.49979592	135.040816	11.5342857	5.79081633
COVID	4/21/20	1046	Channel	12.1	0	0	82	3.1972	119.24	2.49979592	135.040816	11.5342857	5.79081633
COVID	4/21/20	1046	Channel	11.9	0	0	82	3.1972	119.24	2.49979592	135.040816	11.5342857	5.79081633
COVID	4/21/20	1126	Keyhole	10.2	0	0	82	3.1972	119.24	2.49979592	135.040816	11.5342857	5.79081633
COVID	4/21/20	1126	Keyhole	9.3	0	0	82	3.1972	119.24	2.49979592	135.040816	11.5342857	5.79081633
COVID	4/21/20	1126	Keyhole	10.7	0	0	82	3.1972	119.24	2.49979592	135.040816	11.5342857	5.79081633
COVID	4/21/20	1126	Keyhole	9.8	0	0	82	3.1972	119.24	2.49979592	135.040816	11.5342857	5.79081633
COVID	4/21/20	1205	Backdoor	13.2	0	0	82	3.1972	119.24	2.49979592	135.040816	11.5342857	5.79081633
COVID	4/21/20	1205	Backdoor	13.1	0	0	82	3.1972	119.24	2.49979592	135.040816	11.5342857	5.79081633
COVID	4/21/20	1205	Backdoor	11.3	0	0	82	3.1972	119.24	2.49979592	135.040816	11.5342857	5.79081633
COVID	4/21/20	1205	Backdoor	11.5	0	0	82	3.1972	119.24	2.49979592	135.040816	11.5342857	5.79081633
COVID	4/21/20	1302	WitchesBrew	8.2	0	0	82	3.1972	119.24	2.49979592	135.040816	11.5342857	5.79081633
COVID	4/21/20	1302	WitchesBrew	8.7	0	0	82	3.1972	119.24	2.49979592	135.040816	11.5342857	5.79081633

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
COVID	4/21/20	1302	WitchesBrew	8.7	0	0	82	3.1972	119.24	2.49979592	135.040816	11.5342857	5.79081633
COVID	4/21/20	1302	WitchesBrew	7.8	0	0	82	3.1972	119.24	2.49979592	135.040816	11.5342857	5.79081633
COVID	4/28/20	1121	Channel	17.9	0	0	53	4.0124	99.72	5.25040816	59.5918367	7.18040816	5.19040816
COVID	4/28/20	1121	Channel	16.2	0	0	53	4.0124	99.72	5.25040816	59.5918367	7.18040816	5.19040816
COVID	4/28/20	1121	Channel	15.3	0	0	53	4.0124	99.72	5.25040816	59.5918367	7.18040816	5.19040816
COVID	4/28/20	1121	Channel	16.8	0	0	53	4.0124	99.72	5.25040816	59.5918367	7.18040816	5.19040816
COVID	4/28/20	851	Keyhole	18	0	0	53	4.0124	99.72	5.25040816	59.5918367	7.18040816	5.19040816
COVID	4/28/20	851	Keyhole	18.7	0	0	53	4.0124	99.72	5.25040816	59.5918367	7.18040816	5.19040816
COVID	4/28/20	851	Keyhole	17.4	0	0	53	4.0124	99.72	5.25040816	59.5918367	7.18040816	5.19040816
COVID	4/28/20	851	Keyhole	16.8	0	0	53	4.0124	99.72	5.25040816	59.5918367	7.18040816	5.19040816
COVID	4/28/20	942	Backdoor	18.5	0	0	53	4.0124	99.72	5.25040816	59.5918367	7.18040816	5.19040816
COVID	4/28/20	942	Backdoor	16.3	0	0	53	4.0124	99.72	5.25040816	59.5918367	7.18040816	5.19040816
COVID	4/28/20	942	Backdoor	17.2	0	0	53	4.0124	99.72	5.25040816	59.5918367	7.18040816	5.19040816
COVID	4/28/20	942	Backdoor	18	0	0	53	4.0124	99.72	5.25040816	59.5918367	7.18040816	5.19040816
COVID	4/28/20	1209	WitchesBrew	11.6	0	0	53	4.0124	99.72	5.25040816	59.5918367	7.18040816	5.19040816
COVID	4/28/20	1209	WitchesBrew	9.5	0	0	53	4.0124	99.72	5.25040816	59.5918367	7.18040816	5.19040816
COVID	4/28/20	1209	WitchesBrew	11.6	0	0	53	4.0124	99.72	5.25040816	59.5918367	7.18040816	5.19040816
COVID	4/28/20	1209	WitchesBrew	10.1	0	0	53	4.0124	99.72	5.25040816	59.5918367	7.18040816	5.19040816
COVID	5/8/20	1240	Channel	8.3	0	0	102	5.8388	86.04	5.6555102	98.7346939	8.53367347	5.6555102
COVID	5/8/20	1240	Channel	8.4	0	0	102	5.8388	86.04	5.6555102	98.7346939	8.53367347	5.6555102
COVID	5/8/20	1240	Channel	8.7	0	0	102	5.8388	86.04	5.6555102	98.7346939	8.53367347	5.6555102
COVID	5/8/20	1240	Channel	7.6	0	0	102	5.8388	86.04	5.6555102	98.7346939	8.53367347	5.6555102
COVID	5/8/20	1136	Keyhole	11.7	0	0	102	5.8388	86.04	5.6555102	98.7346939	8.53367347	5.6555102
COVID	5/8/20	1136	Keyhole	12.2	0	0	102	5.8388	86.04	5.6555102	98.7346939	8.53367347	5.6555102
COVID	5/8/20	1136	Keyhole	11.8	0	0	102	5.8388	86.04	5.6555102	98.7346939	8.53367347	5.6555102

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
COVID	5/8/20	1136	Keyhole	13.3	0	0	102	5.8388	86.04	5.6555102	98.7346939	8.53367347	5.6555102
COVID	5/8/20	1038	Backdoor	15.9	0	0	102	5.8388	86.04	5.6555102	98.7346939	8.53367347	5.6555102
COVID	5/8/20	1038	Backdoor	16.6	0	0	102	5.8388	86.04	5.6555102	98.7346939	8.53367347	5.6555102
COVID	5/8/20	1038	Backdoor	14.1	0	0	102	5.8388	86.04	5.6555102	98.7346939	8.53367347	5.6555102
COVID	5/8/20	1038	Backdoor	13.8	0	0	102	5.8388	86.04	5.6555102	98.7346939	8.53367347	5.6555102
COVID	5/8/20	1337	WitchesBrew	4.6	0	0	102	5.8388	86.04	5.6555102	98.7346939	8.53367347	5.6555102
COVID	5/8/20	1337	WitchesBrew	5.1	0	0	102	5.8388	86.04	5.6555102	98.7346939	8.53367347	5.6555102
COVID	5/8/20	1337	WitchesBrew	5.1	0	0	102	5.8388	86.04	5.6555102	98.7346939	8.53367347	5.6555102
COVID	5/8/20	1337	WitchesBrew	4.7	0	0	102	5.8388	86.04	5.6555102	98.7346939	8.53367347	5.6555102
COVID	5/12/20	1057	Channel	13.2	0	0	52	4.4716	62.04	5.49408163	65.2244898	8.35408163	5.63857143
COVID	5/12/20	1057	Channel	11.4	0	0	52	4.4716	62.04	5.49408163	65.2244898	8.35408163	5.63857143
COVID	5/12/20	1057	Channel	12.4	0	0	52	4.4716	62.04	5.49408163	65.2244898	8.35408163	5.63857143
COVID	5/12/20	1057	Channel	12.1	0	0	52	4.4716	62.04	5.49408163	65.2244898	8.35408163	5.63857143
COVID	5/12/20	837	Keyhole	21.5	0	0	52	4.4716	62.04	5.49408163	65.2244898	8.35408163	5.63857143
COVID	5/12/20	837	Keyhole	20.7	0	0	52	4.4716	62.04	5.49408163	65.2244898	8.35408163	5.63857143
COVID	5/12/20	837	Keyhole	19.2	0	0	52	4.4716	62.04	5.49408163	65.2244898	8.35408163	5.63857143
COVID	5/12/20	837	Keyhole	19.1	0	0	52	4.4716	62.04	5.49408163	65.2244898	8.35408163	5.63857143
COVID	5/12/20	901	Backdoor	18.7	0	0	52	4.4716	62.04	5.49408163	65.2244898	8.35408163	5.63857143
COVID	5/12/20	901	Backdoor	18.3	0	0	52	4.4716	62.04	5.49408163	65.2244898	8.35408163	5.63857143
COVID	5/12/20	901	Backdoor	17.6	0	0	52	4.4716	62.04	5.49408163	65.2244898	8.35408163	5.63857143
COVID	5/12/20	901	Backdoor	18.2	0	0	52	4.4716	62.04	5.49408163	65.2244898	8.35408163	5.63857143
COVID	5/12/20	1143	WitchesBrew	11.4	0	0	52	4.4716	62.04	5.49408163	65.2244898	8.35408163	5.63857143
COVID	5/12/20	1143	WitchesBrew	11.4	0	0	52	4.4716	62.04	5.49408163	65.2244898	8.35408163	5.63857143
COVID	5/12/20	1143	WitchesBrew	11.2	0	0	52	4.4716	62.04	5.49408163	65.2244898	8.35408163	5.63857143
COVID	5/12/20	1143	WitchesBrew	10	0	0	52	4.4716	62.04	5.49408163	65.2244898	8.35408163	5.63857143

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
COVID	5/19/20	1222	Channel	9.3	0	0	70	3.1816	98.8	5.29326531	56.122449	6.53489796	5.17469388
COVID	5/19/20	1222	Channel	8.7	0	0	70	3.1816	98.8	5.29326531	56.122449	6.53489796	5.17469388
COVID	5/19/20	1222	Channel	9.5	0	0	70	3.1816	98.8	5.29326531	56.122449	6.53489796	5.17469388
COVID	5/19/20	1222	Channel	7.5	0	0	70	3.1816	98.8	5.29326531	56.122449	6.53489796	5.17469388
COVID	5/19/20	1117	Keyhole	8	0	0	70	3.1816	98.8	5.29326531	56.122449	6.53489796	5.17469388
COVID	5/19/20	1117	Keyhole	8.4	0	0	70	3.1816	98.8	5.29326531	56.122449	6.53489796	5.17469388
COVID	5/19/20	1117	Keyhole	8.2	0	0	70	3.1816	98.8	5.29326531	56.122449	6.53489796	5.17469388
COVID	5/19/20	1117	Keyhole	8	0	0	70	3.1816	98.8	5.29326531	56.122449	6.53489796	5.17469388
COVID	5/19/20	1030	Backdoor	10.8	0	0	70	3.1816	98.8	5.29326531	56.122449	6.53489796	5.17469388
COVID	5/19/20	1030	Backdoor	11.1	0	0	70	3.1816	98.8	5.29326531	56.122449	6.53489796	5.17469388
COVID	5/19/20	1030	Backdoor	8.4	0	0	70	3.1816	98.8	5.29326531	56.122449	6.53489796	5.17469388
COVID	5/19/20	1030	Backdoor	6.8	0	0	70	3.1816	98.8	5.29326531	56.122449	6.53489796	5.17469388
COVID	5/19/20	1317	WitchesBrew	4.1	0	0	70	3.1816	98.8	5.29326531	56.122449	6.53489796	5.17469388
COVID	5/19/20	1317	WitchesBrew	4.3	0	0	70	3.1816	98.8	5.29326531	56.122449	6.53489796	5.17469388
COVID	5/19/20	1317	WitchesBrew	3.1	0	0	70	3.1816	98.8	5.29326531	56.122449	6.53489796	5.17469388
COVID	5/19/20	1317	WitchesBrew	3.5	0	0	70	3.1816	98.8	5.29326531	56.122449	6.53489796	5.17469388
COVID	5/26/20	1014	Channel	10.7	0	0	66	3.3756	189.72	4.80877551	141.387755	9.36816327	5.72938776
COVID	5/26/20	1014	Channel	11.5	0	0	66	3.3756	189.72	4.80877551	141.387755	9.36816327	5.72938776
COVID	5/26/20	1014	Channel	12.5	0	0	66	3.3756	189.72	4.80877551	141.387755	9.36816327	5.72938776
COVID	5/26/20	1014	Channel	11.5	0	0	66	3.3756	189.72	4.80877551	141.387755	9.36816327	5.72938776
COVID	5/26/20	816	Keyhole	15.1	0	0	66	3.3756	189.72	4.80877551	141.387755	9.36816327	5.72938776
COVID	5/26/20	816	Keyhole	15.6	0	0	66	3.3756	189.72	4.80877551	141.387755	9.36816327	5.72938776
COVID	5/26/20	816	Keyhole	17.7	0	0	66	3.3756	189.72	4.80877551	141.387755	9.36816327	5.72938776
COVID	5/26/20	816	Keyhole	16.5	0	0	66	3.3756	189.72	4.80877551	141.387755	9.36816327	5.72938776
COVID	5/26/20	900	Backdoor	13.6	0	0	66	3.3756	189.72	4.80877551	141.387755	9.36816327	5.72938776

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
COVID	5/26/20	900	Backdoor	14.4	0	0	66	3.3756	189.72	4.80877551	141.387755	9.36816327	5.72938776
COVID	5/26/20	900	Backdoor	12.5	0	0	66	3.3756	189.72	4.80877551	141.387755	9.36816327	5.72938776
COVID	5/26/20	900	Backdoor	13.1	0	0	66	3.3756	189.72	4.80877551	141.387755	9.36816327	5.72938776
COVID	5/26/20	1102	WitchesBrew	10.7	0	0	66	3.3756	189.72	4.80877551	141.387755	9.36816327	5.72938776
COVID	5/26/20	1102	WitchesBrew	10.4	0	0	66	3.3756	189.72	4.80877551	141.387755	9.36816327	5.72938776
COVID	5/26/20	1102	WitchesBrew	10.4	0	0	66	3.3756	189.72	4.80877551	141.387755	9.36816327	5.72938776
COVID	5/26/20	1102	WitchesBrew	10.8	0	0	66	3.3756	189.72	4.80877551	141.387755	9.36816327	5.72938776
COVID	5/28/20	848	Channel	11.1	0	0	54	3.5604	88.56	4.46877551	155.244898	7.62836735	5.04755102
COVID	5/28/20	848	Channel	11.9	0	0	54	3.5604	88.56	4.46877551	155.244898	7.62836735	5.04755102
COVID	5/28/20	848	Channel	12.5	0	0	54	3.5604	88.56	4.46877551	155.244898	7.62836735	5.04755102
COVID	5/28/20	848	Channel	13.1	0	0	54	3.5604	88.56	4.46877551	155.244898	7.62836735	5.04755102
COVID	5/28/20	1131	Keyhole	11.6	0	0	54	3.5604	88.56	4.46877551	155.244898	7.62836735	5.04755102
COVID	5/28/20	1131	Keyhole	10.8	0	0	54	3.5604	88.56	4.46877551	155.244898	7.62836735	5.04755102
COVID	5/28/20	1131	Keyhole	13	0	0	54	3.5604	88.56	4.46877551	155.244898	7.62836735	5.04755102
COVID	5/28/20	1131	Keyhole	13.1	0	0	54	3.5604	88.56	4.46877551	155.244898	7.62836735	5.04755102
COVID	5/28/20	1055	Backdoor	14	0	0	54	3.5604	88.56	4.46877551	155.244898	7.62836735	5.04755102
COVID	5/28/20	1055	Backdoor	14.4	0	0	54	3.5604	88.56	4.46877551	155.244898	7.62836735	5.04755102
COVID	5/28/20	1055	Backdoor	12.4	0	0	54	3.5604	88.56	4.46877551	155.244898	7.62836735	5.04755102
COVID	5/28/20	1055	Backdoor	13.4	0	0	54	3.5604	88.56	4.46877551	155.244898	7.62836735	5.04755102
COVID	5/28/20	947	WitchesBrew	10.4	0	0	54	3.5604	88.56	4.46877551	155.244898	7.62836735	5.04755102
COVID	5/28/20	947	WitchesBrew	9.6	0	0	54	3.5604	88.56	4.46877551	155.244898	7.62836735	5.04755102
COVID	5/28/20	947	WitchesBrew	11.5	0	0	54	3.5604	88.56	4.46877551	155.244898	7.62836735	5.04755102
COVID	5/28/20	947	WitchesBrew	11.4	0	0	54	3.5604	88.56	4.46877551	155.244898	7.62836735	5.04755102
COVID	6/9/20	1200	Channel	10.6	0	0	66	3.3292	104	5.00469388	75.6530612	7.76306122	5.51306122
COVID	6/9/20	1200	Channel	10.3	0	0	66	3.3292	104	5.00469388	75.6530612	7.76306122	5.51306122

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
COVID	6/9/20	1200	Channel	10.2	0	0	66	3.3292	104	5.00469388	75.6530612	7.76306122	5.51306122
COVID	6/9/20	1200	Channel	9.8	0	0	66	3.3292	104	5.00469388	75.6530612	7.76306122	5.51306122
COVID	6/9/20	1005	Keyhole	14.1	0	0	66	3.3292	104	5.00469388	75.6530612	7.76306122	5.51306122
COVID	6/9/20	1005	Keyhole	13.9	0	0	66	3.3292	104	5.00469388	75.6530612	7.76306122	5.51306122
COVID	6/9/20	1005	Keyhole	12.6	0	0	66	3.3292	104	5.00469388	75.6530612	7.76306122	5.51306122
COVID	6/9/20	1005	Keyhole	11.9	0	0	66	3.3292	104	5.00469388	75.6530612	7.76306122	5.51306122
COVID	6/9/20	1045	Backdoor	10.1	0	0	66	3.3292	104	5.00469388	75.6530612	7.76306122	5.51306122
COVID	6/9/20	1045	Backdoor	10.5	0	0	66	3.3292	104	5.00469388	75.6530612	7.76306122	5.51306122
COVID	6/9/20	1045	Backdoor	8.5	0	0	66	3.3292	104	5.00469388	75.6530612	7.76306122	5.51306122
COVID	6/9/20	1045	Backdoor	8.1	0	0	66	3.3292	104	5.00469388	75.6530612	7.76306122	5.51306122
COVID	6/9/20	1130	WitchesBrew	10.1	0	0	66	3.3292	104	5.00469388	75.6530612	7.76306122	5.51306122
COVID	6/9/20	1130	WitchesBrew	10.7	0	0	66	3.3292	104	5.00469388	75.6530612	7.76306122	5.51306122
COVID	6/9/20	1130	WitchesBrew	7.4	0	0	66	3.3292	104	5.00469388	75.6530612	7.76306122	5.51306122
COVID	6/9/20	1130	WitchesBrew	7.2	0	0	66	3.3292	104	5.00469388	75.6530612	7.76306122	5.51306122
COVID	6/16/20	1101	Channel	8.1	0	0	56	5.6608	74.2	6.83489796	81.3673469	8.12285714	5.75469388
COVID	6/16/20	1101	Channel	6.9	0	0	56	5.6608	74.2	6.83489796	81.3673469	8.12285714	5.75469388
COVID	6/16/20	1101	Channel	8.6	0	0	56	5.6608	74.2	6.83489796	81.3673469	8.12285714	5.75469388
COVID	6/16/20	1101	Channel	6.9	0	0	56	5.6608	74.2	6.83489796	81.3673469	8.12285714	5.75469388
COVID	6/16/20	901	Keyhole	10	0	0	56	5.6608	74.2	6.83489796	81.3673469	8.12285714	5.75469388
COVID	6/16/20	901	Keyhole	10.5	0	0	56	5.6608	74.2	6.83489796	81.3673469	8.12285714	5.75469388
COVID	6/16/20	901	Keyhole	11.2	0	0	56	5.6608	74.2	6.83489796	81.3673469	8.12285714	5.75469388
COVID	6/16/20	901	Keyhole	12.3	0	0	56	5.6608	74.2	6.83489796	81.3673469	8.12285714	5.75469388
COVID	6/16/20	932	Backdoor	12.4	0	0	56	5.6608	74.2	6.83489796	81.3673469	8.12285714	5.75469388
COVID	6/16/20	932	Backdoor	11.9	0	0	56	5.6608	74.2	6.83489796	81.3673469	8.12285714	5.75469388
COVID	6/16/20	932	Backdoor	12	0	0	56	5.6608	74.2	6.83489796	81.3673469	8.12285714	5.75469388

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
COVID	6/16/20	932	Backdoor	10.8	0	0	56	5.6608	74.2	6.83489796	81.3673469	8.12285714	5.75469388
COVID	6/16/20	1020	WitchesBrew	8.5	0	0	56	5.6608	74.2	6.83489796	81.3673469	8.12285714	5.75469388
COVID	6/16/20	1020	WitchesBrew	8.2	0	0	56	5.6608	74.2	6.83489796	81.3673469	8.12285714	5.75469388
COVID	6/16/20	1020	WitchesBrew	6.6	0	0	56	5.6608	74.2	6.83489796	81.3673469	8.12285714	5.75469388
COVID	6/16/20	1020	WitchesBrew	7.6	0	0	56	5.6608	74.2	6.83489796	81.3673469	8.12285714	5.75469388
COVID	6/30/20	940	Channel	9.7	0	0	68	3.3116	100.875	4.62918367	52.8163265	8.21469388	5.40306122
COVID	6/30/20	940	Channel	9	0	0	68	3.3116	100.875	4.62918367	52.8163265	8.21469388	5.40306122
COVID	6/30/20	940	Channel	11.4	0	0	68	3.3116	100.875	4.62918367	52.8163265	8.21469388	5.40306122
COVID	6/30/20	940	Channel	11.6	0	0	68	3.3116	100.875	4.62918367	52.8163265	8.21469388	5.40306122
COVID	6/30/20	1230	Keyhole	6.4	0	0	68	3.3116	100.875	4.62918367	52.8163265	8.21469388	5.40306122
COVID	6/30/20	1230	Keyhole	5.2	0	0	68	3.3116	100.875	4.62918367	52.8163265	8.21469388	5.40306122
COVID	6/30/20	1230	Keyhole	7.4	0	0	68	3.3116	100.875	4.62918367	52.8163265	8.21469388	5.40306122
COVID	6/30/20	1230	Keyhole	8	0	0	68	3.3116	100.875	4.62918367	52.8163265	8.21469388	5.40306122
COVID	6/30/20	1145	Backdoor	7.4	0	0	68	3.3116	100.875	4.62918367	52.8163265	8.21469388	5.40306122
COVID	6/30/20	1145	Backdoor	6.6	0	0	68	3.3116	100.875	4.62918367	52.8163265	8.21469388	5.40306122
COVID	6/30/20	1145	Backdoor	7.6	0	0	68	3.3116	100.875	4.62918367	52.8163265	8.21469388	5.40306122
COVID	6/30/20	1145	Backdoor	7.6	0	0	68	3.3116	100.875	4.62918367	52.8163265	8.21469388	5.40306122
COVID	6/30/20	1020	WitchesBrew	8.1	0	0	68	3.3116	100.875	4.62918367	52.8163265	8.21469388	5.40306122
COVID	6/30/20	1020	WitchesBrew	7.2	0	0	68	3.3116	100.875	4.62918367	52.8163265	8.21469388	5.40306122
COVID	6/30/20	1020	WitchesBrew	8.9	0	0	68	3.3116	100.875	4.62918367	52.8163265	8.21469388	5.40306122
COVID	6/30/20	1020	WitchesBrew	9.3	0	0	68	3.3116	100.875	4.62918367	52.8163265	8.21469388	5.40306122
COVID	7/7/20	1220	Channel	6.3	0	0	77	3.778	71.08	4.3276087	75.173913	5.62326087	4.77934783
COVID	7/7/20	1220	Channel	5.5	0	0	77	3.778	71.08	4.3276087	75.173913	5.62326087	4.77934783
COVID	7/7/20	1220	Channel	8.4	0	0	77	3.778	71.08	4.3276087	75.173913	5.62326087	4.77934783
COVID	7/7/20	1220	Channel	9.8	0	0	77	3.778	71.08	4.3276087	75.173913	5.62326087	4.77934783

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
COVID	7/7/20	1130	Keyhole	14.1	0	0	77	3.778	71.08	4.3276087	75.173913	5.62326087	4.77934783
COVID	7/7/20	1130	Keyhole	12.8	0	0	77	3.778	71.08	4.3276087	75.173913	5.62326087	4.77934783
COVID	7/7/20	1130	Keyhole	15.8	0	0	77	3.778	71.08	4.3276087	75.173913	5.62326087	4.77934783
COVID	7/7/20	1130	Keyhole	15.5	0	0	77	3.778	71.08	4.3276087	75.173913	5.62326087	4.77934783
COVID	7/7/20	1015	Backdoor	10.9	0	0	77	3.778	71.08	4.3276087	75.173913	5.62326087	4.77934783
COVID	7/7/20	1015	Backdoor	11.8	0	0	77	3.778	71.08	4.3276087	75.173913	5.62326087	4.77934783
COVID	7/7/20	1015	Backdoor	14.4	0	0	77	3.778	71.08	4.3276087	75.173913	5.62326087	4.77934783
COVID	7/7/20	1015	Backdoor	14.2	0	0	77	3.778	71.08	4.3276087	75.173913	5.62326087	4.77934783
COVID	7/7/20	1320	WitchesBrew	7.1	0	0	77	3.778	71.08	4.3276087	75.173913	5.62326087	4.77934783
COVID	7/7/20	1320	WitchesBrew	7.4	0	0	77	3.778	71.08	4.3276087	75.173913	5.62326087	4.77934783
COVID	7/7/20	1320	WitchesBrew	6.5	0	0	77	3.778	71.08	4.3276087	75.173913	5.62326087	4.77934783
COVID	7/7/20	1320	WitchesBrew	6	0	0	77	3.778	71.08	4.3276087	75.173913	5.62326087	4.77934783
COVID	7/17/20	1125	Backdoor	7.9	0	0	61	3.3596	78	5.01354167	75.8125	9.259375	6.33958333
COVID	7/17/20	1125	Backdoor	9.2	0	0	61	3.3596	78	5.01354167	75.8125	9.259375	6.33958333
COVID	7/17/20	1125	Backdoor	10.3	0	0	61	3.3596	78	5.01354167	75.8125	9.259375	6.33958333
COVID	7/17/20	1125	Backdoor	10.1	0	0	61	3.3596	78	5.01354167	75.8125	9.259375	6.33958333
COVID	7/17/20	1100	Keyhole	10.4	0	0	61	3.3596	78	5.01354167	75.8125	9.259375	6.33958333
COVID	7/17/20	1100	Keyhole	8.1	0	0	61	3.3596	78	5.01354167	75.8125	9.259375	6.33958333
COVID	7/17/20	1100	Keyhole	10.7	0	0	61	3.3596	78	5.01354167	75.8125	9.259375	6.33958333
COVID	7/17/20	1100	Keyhole	10.1	0	0	61	3.3596	78	5.01354167	75.8125	9.259375	6.33958333
COVID	7/17/20	935	Channel	14.9	0	0	61	3.3596	78	5.01354167	75.8125	9.259375	6.33958333
COVID	7/17/20	935	Channel	13.6	0	0	61	3.3596	78	5.01354167	75.8125	9.259375	6.33958333
COVID	7/17/20	935	Channel	16.4	0	0	61	3.3596	78	5.01354167	75.8125	9.259375	6.33958333
COVID	7/17/20	935	Channel	16	0	0	61	3.3596	78	5.01354167	75.8125	9.259375	6.33958333
COVID	7/17/20	900	WitchesBrew	12.3	0	0	61	3.3596	78	5.01354167	75.8125	9.259375	6.33958333

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
COVID	7/17/20	900	WitchesBrew	12.1	0	0	61	3.3596	78	5.01354167	75.8125	9.259375	6.33958333
COVID	7/17/20	900	WitchesBrew	13.9	0	0	61	3.3596	78	5.01354167	75.8125	9.259375	6.33958333
COVID	7/17/20	900	WitchesBrew	13.2	0	0	61	3.3596	78	5.01354167	75.8125	9.259375	6.33958333
COVID	7/21/20	1315	Backdoor	10.4	0	0	87	4.6652	67.88	5.51571429	65.4285714	8.38122449	6.0377551
COVID	7/21/20	1315	Backdoor	10.1	0	0	87	4.6652	67.88	5.51571429	65.4285714	8.38122449	6.0377551
COVID	7/21/20	1315	Backdoor	13.1	0	0	87	4.6652	67.88	5.51571429	65.4285714	8.38122449	6.0377551
COVID	7/21/20	1315	Backdoor	11.1	0	0	87	4.6652	67.88	5.51571429	65.4285714	8.38122449	6.0377551
COVID	7/21/20	1230	Keyhole	9.8	0	0	87	4.6652	67.88	5.51571429	65.4285714	8.38122449	6.0377551
COVID	7/21/20	1230	Keyhole	9.4	0	0	87	4.6652	67.88	5.51571429	65.4285714	8.38122449	6.0377551
COVID	7/21/20	1230	Keyhole	11.4	0	0	87	4.6652	67.88	5.51571429	65.4285714	8.38122449	6.0377551
COVID	7/21/20	1230	Keyhole	11.2	0	0	87	4.6652	67.88	5.51571429	65.4285714	8.38122449	6.0377551
COVID	7/21/20	1135	Channel	12.5	0	0	87	4.6652	67.88	5.51571429	65.4285714	8.38122449	6.0377551
COVID	7/21/20	1135	Channel	10.4	0	0	87	4.6652	67.88	5.51571429	65.4285714	8.38122449	6.0377551
COVID	7/21/20	1135	Channel	12.2	0	0	87	4.6652	67.88	5.51571429	65.4285714	8.38122449	6.0377551
COVID	7/21/20	1135	Channel	12.4	0	0	87	4.6652	67.88	5.51571429	65.4285714	8.38122449	6.0377551
COVID	7/21/20	1050	WitchesBrew	10.1	0	0	87	4.6652	67.88	5.51571429	65.4285714	8.38122449	6.0377551
COVID	7/21/20	1050	WitchesBrew	10.4	0	0	87	4.6652	67.88	5.51571429	65.4285714	8.38122449	6.0377551
COVID	7/21/20	1050	WitchesBrew	12.1	0	0	87	4.6652	67.88	5.51571429	65.4285714	8.38122449	6.0377551
COVID	7/21/20	1050	WitchesBrew	11.5	0	0	87	4.6652	67.88	5.51571429	65.4285714	8.38122449	6.0377551
COVID	8/14/20	1130	Backdoor	9.4	0	0	46	3.5608	73.84	6.18142857	51.2653061	9.73265306	6.50938776
COVID	8/14/20	1130	Backdoor	8.6	0	0	46	3.5608	73.84	6.18142857	51.2653061	9.73265306	6.50938776
COVID	8/14/20	1130	Backdoor	9.3	0	0	46	3.5608	73.84	6.18142857	51.2653061	9.73265306	6.50938776
COVID	8/14/20	1130	Backdoor	9.3	0	0	46	3.5608	73.84	6.18142857	51.2653061	9.73265306	6.50938776
COVID	8/14/20	1040	Keyhole	8.3	0	0	46	3.5608	73.84	6.18142857	51.2653061	9.73265306	6.50938776
COVID	8/14/20	1040	Keyhole	7.4	0	0	46	3.5608	73.84	6.18142857	51.2653061	9.73265306	6.50938776

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
COVID	8/14/20	1040	Keyhole	8	0	0	46	3.5608	73.84	6.18142857	51.2653061	9.73265306	6.50938776
COVID	8/14/20	1040	Keyhole	7.8	0	0	46	3.5608	73.84	6.18142857	51.2653061	9.73265306	6.50938776
COVID	8/14/20	840	Channel	14.1	0	0	46	3.5608	73.84	6.18142857	51.2653061	9.73265306	6.50938776
COVID	8/14/20	840	Channel	15.1	0	0	46	3.5608	73.84	6.18142857	51.2653061	9.73265306	6.50938776
COVID	8/14/20	840	Channel	13.4	0	0	46	3.5608	73.84	6.18142857	51.2653061	9.73265306	6.50938776
COVID	8/14/20	840	Channel	13.2	0	0	46	3.5608	73.84	6.18142857	51.2653061	9.73265306	6.50938776
COVID	8/14/20	930	WitchesBrew	7.6	0	0	46	3.5608	73.84	6.18142857	51.2653061	9.73265306	6.50938776
COVID	8/14/20	930	WitchesBrew	6.5	0	0	46	3.5608	73.84	6.18142857	51.2653061	9.73265306	6.50938776
COVID	8/14/20	930	WitchesBrew	7.5	0	0	46	3.5608	73.84	6.18142857	51.2653061	9.73265306	6.50938776
COVID	8/14/20	930	WitchesBrew	7	0	0	46	3.5608	73.84	6.18142857	51.2653061	9.73265306	6.50938776
COVID	8/25/20	1100	Backdoor	8.3	0	0	57	4.1128	96.84	4.46591837	87	6.96897959	4.96755102
COVID	8/25/20	1100	Backdoor	8.6	0	0	57	4.1128	96.84	4.46591837	87	6.96897959	4.96755102
COVID	8/25/20	1100	Backdoor	9.4	0	0	57	4.1128	96.84	4.46591837	87	6.96897959	4.96755102
COVID	8/25/20	1100	Backdoor	9	0	0	57	4.1128	96.84	4.46591837	87	6.96897959	4.96755102
COVID	8/25/20	1140	Keyhole	8.9	0	0	57	4.1128	96.84	4.46591837	87	6.96897959	4.96755102
COVID	8/25/20	1140	Keyhole	8.2	0	0	57	4.1128	96.84	4.46591837	87	6.96897959	4.96755102
COVID	8/25/20	1140	Keyhole	7.9	0	0	57	4.1128	96.84	4.46591837	87	6.96897959	4.96755102
COVID	8/25/20	1140	Keyhole	7.6	0	0	57	4.1128	96.84	4.46591837	87	6.96897959	4.96755102
COVID	8/25/20	840	Channel	9.6	0	0	57	4.1128	96.84	4.46591837	87	6.96897959	4.96755102
COVID	8/25/20	840	Channel	8.8	0	0	57	4.1128	96.84	4.46591837	87	6.96897959	4.96755102
COVID	8/25/20	840	Channel	9.6	0	0	57	4.1128	96.84	4.46591837	87	6.96897959	4.96755102
COVID	8/25/20	840	Channel	9.4	0	0	57	4.1128	96.84	4.46591837	87	6.96897959	4.96755102
COVID	8/25/20	910	WitchesBrew	8.5	0	0	57	4.1128	96.84	4.46591837	87	6.96897959	4.96755102
COVID	8/25/20	910	WitchesBrew	6.7	0	0	57	4.1128	96.84	4.46591837	87	6.96897959	4.96755102
COVID	8/25/20	910	WitchesBrew	8	0	0	57	4.1128	96.84	4.46591837	87	6.96897959	4.96755102

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
COVID	8/25/20	910	WitchesBrew	8.1	0	0	57	4.1128	96.84	4.46591837	87	6.96897959	4.96755102
COVID	9/1/20	1125	Backdoor	10.4	0	0	84	4.968	70.52	7.08875	76.3541667	8.0225	5.75875
COVID	9/1/20	1125	Backdoor	10.1	0	0	84	4.968	70.52	7.08875	76.3541667	8.0225	5.75875
COVID	9/1/20	1125	Backdoor	9.6	0	0	84	4.968	70.52	7.08875	76.3541667	8.0225	5.75875
COVID	9/1/20	1125	Backdoor	9.3	0	0	84	4.968	70.52	7.08875	76.3541667	8.0225	5.75875
COVID	9/1/20	1040	Keyhole	10.9	0	0	84	4.968	70.52	7.08875	76.3541667	8.0225	5.75875
COVID	9/1/20	1040	Keyhole	10.5	0	0	84	4.968	70.52	7.08875	76.3541667	8.0225	5.75875
COVID	9/1/20	1040	Keyhole	10.7	0	0	84	4.968	70.52	7.08875	76.3541667	8.0225	5.75875
COVID	9/1/20	1040	Keyhole	8.1	0	0	84	4.968	70.52	7.08875	76.3541667	8.0225	5.75875
COVID	9/1/20	930	Channel	9.8	0	0	84	4.968	70.52	7.08875	76.3541667	8.0225	5.75875
COVID	9/1/20	930	Channel	9.2	0	0	84	4.968	70.52	7.08875	76.3541667	8.0225	5.75875
COVID	9/1/20	930	Channel	9.6	0	0	84	4.968	70.52	7.08875	76.3541667	8.0225	5.75875
COVID	9/1/20	930	Channel	9.4	0	0	84	4.968	70.52	7.08875	76.3541667	8.0225	5.75875
COVID	9/1/20	900	WitchesBrew	13.1	0	0	84	4.968	70.52	7.08875	76.3541667	8.0225	5.75875
COVID	9/1/20	900	WitchesBrew	14.7	0	0	84	4.968	70.52	7.08875	76.3541667	8.0225	5.75875
COVID	9/1/20	900	WitchesBrew	14.8	0	0	84	4.968	70.52	7.08875	76.3541667	8.0225	5.75875
COVID	9/1/20	900	WitchesBrew	13	0	0	84	4.968	70.52	7.08875	76.3541667	8.0225	5.75875
COVID	9/15/20	845	Backdoor	17.1	0	0	88	3.2896	75.56	3.1826	66.98	8.9168	5.0124
COVID	9/15/20	845	Backdoor	15.8	0	0	88	3.2896	75.56	3.1826	66.98	8.9168	5.0124
COVID	9/15/20	845	Backdoor	17.6	0	0	88	3.2896	75.56	3.1826	66.98	8.9168	5.0124
COVID	9/15/20	845	Backdoor	17.8	0	0	88	3.2896	75.56	3.1826	66.98	8.9168	5.0124
COVID	9/15/20	935	Keyhole	16.5	0	0	88	3.2896	75.56	3.1826	66.98	8.9168	5.0124
COVID	9/15/20	935	Keyhole	17.5	0	0	88	3.2896	75.56	3.1826	66.98	8.9168	5.0124
COVID	9/15/20	935	Keyhole	19.4	0	0	88	3.2896	75.56	3.1826	66.98	8.9168	5.0124
COVID	9/15/20	935	Keyhole	19.1	0	0	88	3.2896	75.56	3.1826	66.98	8.9168	5.0124

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
COVID	9/15/20	1030	Channel	15.6	0	0	88	3.2896	75.56	3.1826	66.98	8.9168	5.0124
COVID	9/15/20	1030	Channel	14.5	0	0	88	3.2896	75.56	3.1826	66.98	8.9168	5.0124
COVID	9/15/20	1030	Channel	15.4	0	0	88	3.2896	75.56	3.1826	66.98	8.9168	5.0124
COVID	9/15/20	1030	Channel	15.2	0	0	88	3.2896	75.56	3.1826	66.98	8.9168	5.0124
COVID	9/15/20	1115	WitchesBrew	11.6	0	0	88	3.2896	75.56	3.1826	66.98	8.9168	5.0124
COVID	9/15/20	1115	WitchesBrew	11.2	0	0	88	3.2896	75.56	3.1826	66.98	8.9168	5.0124
COVID	9/15/20	1115	WitchesBrew	10	0	0	88	3.2896	75.56	3.1826	66.98	8.9168	5.0124
COVID	9/15/20	1115	WitchesBrew	10.2	0	0	88	3.2896	75.56	3.1826	66.98	8.9168	5.0124
COVID	9/22/20	850	Backdoor	9.4	0	0	65	3.4524	61.24	4.704375	55.5208333	8.38395833	5.41104167
COVID	9/22/20	850	Backdoor	8.8	0	0	65	3.4524	61.24	4.704375	55.5208333	8.38395833	5.41104167
COVID	9/22/20	850	Backdoor	9.4	0	0	65	3.4524	61.24	4.704375	55.5208333	8.38395833	5.41104167
COVID	9/22/20	850	Backdoor	9.2	0	0	65	3.4524	61.24	4.704375	55.5208333	8.38395833	5.41104167
COVID	9/22/20	930	Keyhole	10.2	0	0	65	3.4524	61.24	4.704375	55.5208333	8.38395833	5.41104167
COVID	9/22/20	930	Keyhole	10.7	0	0	65	3.4524	61.24	4.704375	55.5208333	8.38395833	5.41104167
COVID	9/22/20	930	Keyhole	11.2	0	0	65	3.4524	61.24	4.704375	55.5208333	8.38395833	5.41104167
COVID	9/22/20	930	Keyhole	11.6	0	0	65	3.4524	61.24	4.704375	55.5208333	8.38395833	5.41104167
COVID	9/22/20	1015	Channel	13.8	0	0	65	3.4524	61.24	4.704375	55.5208333	8.38395833	5.41104167
COVID	9/22/20	1015	Channel	14.2	0	0	65	3.4524	61.24	4.704375	55.5208333	8.38395833	5.41104167
COVID	9/22/20	1015	Channel	13.5	0	0	65	3.4524	61.24	4.704375	55.5208333	8.38395833	5.41104167
COVID	9/22/20	1015	Channel	13.3	0	0	65	3.4524	61.24	4.704375	55.5208333	8.38395833	5.41104167
COVID	9/22/20	1055	WitchesBrew	7.5	0	0	65	3.4524	61.24	4.704375	55.5208333	8.38395833	5.41104167
COVID	9/22/20	1055	WitchesBrew	6.3	0	0	65	3.4524	61.24	4.704375	55.5208333	8.38395833	5.41104167
COVID	9/22/20	1055	WitchesBrew	7.3	0	0	65	3.4524	61.24	4.704375	55.5208333	8.38395833	5.41104167
COVID	9/22/20	1055	WitchesBrew	6.5	0	0	65	3.4524	61.24	4.704375	55.5208333	8.38395833	5.41104167
COVID	10/9/20	855	Backdoor	7.4	0	0	35	2.7832	81.12	5.41333333	37.3541667	10.6439583	6.86729167

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
COVID	10/9/20	855	Backdoor	7.3	0	0	35	2.7832	81.12	5.41333333	37.3541667	10.6439583	6.86729167
COVID	10/9/20	855	Backdoor	7.4	0	0	35	2.7832	81.12	5.41333333	37.3541667	10.6439583	6.86729167
COVID	10/9/20	855	Backdoor	6.7	0	0	35	2.7832	81.12	5.41333333	37.3541667	10.6439583	6.86729167
COVID	10/9/20	930	Keyhole	8.6	0	0	35	2.7832	81.12	5.41333333	37.3541667	10.6439583	6.86729167
COVID	10/9/20	930	Keyhole	7.5	0	0	35	2.7832	81.12	5.41333333	37.3541667	10.6439583	6.86729167
COVID	10/9/20	930	Keyhole	8.3	0	0	35	2.7832	81.12	5.41333333	37.3541667	10.6439583	6.86729167
COVID	10/9/20	930	Keyhole	7.3	0	0	35	2.7832	81.12	5.41333333	37.3541667	10.6439583	6.86729167
COVID	10/9/20	1015	Channel	7.3	0	0	35	2.7832	81.12	5.41333333	37.3541667	10.6439583	6.86729167
COVID	10/9/20	1015	Channel	6.3	0	0	35	2.7832	81.12	5.41333333	37.3541667	10.6439583	6.86729167
COVID	10/9/20	1015	Channel	6.6	0	0	35	2.7832	81.12	5.41333333	37.3541667	10.6439583	6.86729167
COVID	10/9/20	1015	Channel	6.4	0	0	35	2.7832	81.12	5.41333333	37.3541667	10.6439583	6.86729167
COVID	10/9/20	1050	WitchesBrew	3.8	0	0	35	2.7832	81.12	5.41333333	37.3541667	10.6439583	6.86729167
COVID	10/9/20	1050	WitchesBrew	2.9	0	0	35	2.7832	81.12	5.41333333	37.3541667	10.6439583	6.86729167
COVID	10/9/20	1050	WitchesBrew	3.3	0	0	35	2.7832	81.12	5.41333333	37.3541667	10.6439583	6.86729167
COVID	10/9/20	1050	WitchesBrew	2.2	0	0	35	2.7832	81.12	5.41333333	37.3541667	10.6439583	6.86729167
COVID	10/13/20	1015	Backdoor	9.9	0	0	77	3.605	133.291667	5.36061224	108.020408	8.31938776	5.41204082
COVID	10/13/20	1015	Backdoor	8.9	0	0	77	3.605	133.291667	5.36061224	108.020408	8.31938776	5.41204082
COVID	10/13/20	1015	Backdoor	8.5	0	0	77	3.605	133.291667	5.36061224	108.020408	8.31938776	5.41204082
COVID	10/13/20	1015	Backdoor	8.8	0	0	77	3.605	133.291667	5.36061224	108.020408	8.31938776	5.41204082
COVID	10/13/20	1050	Keyhole	6.9	0	0	77	3.605	133.291667	5.36061224	108.020408	8.31938776	5.41204082
COVID	10/13/20	1050	Keyhole	6.5	0	0	77	3.605	133.291667	5.36061224	108.020408	8.31938776	5.41204082
COVID	10/13/20	1050	Keyhole	7.5	0	0	77	3.605	133.291667	5.36061224	108.020408	8.31938776	5.41204082
COVID	10/13/20	1050	Keyhole	6.8	0	0	77	3.605	133.291667	5.36061224	108.020408	8.31938776	5.41204082
COVID	10/13/20	1130	Channel	8.6	0	0	77	3.605	133.291667	5.36061224	108.020408	8.31938776	5.41204082
COVID	10/13/20	1130	Channel	7.9	0	0	77	3.605	133.291667	5.36061224	108.020408	8.31938776	5.41204082

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
COVID	10/13/20	1130	Channel	7.5	0	0	77	3.605	133.291667	5.36061224	108.020408	8.31938776	5.41204082
COVID	10/13/20	1130	Channel	7.9	0	0	77	3.605	133.291667	5.36061224	108.020408	8.31938776	5.41204082
COVID	10/13/20	920	WitchesBrew	9.5	0	0	77	3.605	133.291667	5.36061224	108.020408	8.31938776	5.41204082
COVID	10/13/20	920	WitchesBrew	8.1	0	0	77	3.605	133.291667	5.36061224	108.020408	8.31938776	5.41204082
COVID	10/13/20	920	WitchesBrew	8	0	0	77	3.605	133.291667	5.36061224	108.020408	8.31938776	5.41204082
COVID	10/13/20	920	WitchesBrew	8.9	0	0	77	3.605	133.291667	5.36061224	108.020408	8.31938776	5.41204082
COVID	11/6/20	915	Backdoor	7.3	0	0	46	2.59	108.44	5.52816327	102.244898	11.3236735	6.01346939
COVID	11/6/20	915	Backdoor	7.7	0	0	46	2.59	108.44	5.52816327	102.244898	11.3236735	6.01346939
COVID	11/6/20	915	Backdoor	6.7	0	0	46	2.59	108.44	5.52816327	102.244898	11.3236735	6.01346939
COVID	11/6/20	915	Backdoor	6.6	0	0	46	2.59	108.44	5.52816327	102.244898	11.3236735	6.01346939
COVID	11/6/20	950	Keyhole	6.4	0	0	46	2.59	108.44	5.52816327	102.244898	11.3236735	6.01346939
COVID	11/6/20	950	Keyhole	5.7	0	0	46	2.59	108.44	5.52816327	102.244898	11.3236735	6.01346939
COVID	11/6/20	950	Keyhole	6.3	0	0	46	2.59	108.44	5.52816327	102.244898	11.3236735	6.01346939
COVID	11/6/20	950	Keyhole	5.9	0	0	46	2.59	108.44	5.52816327	102.244898	11.3236735	6.01346939
COVID	11/6/20	1025	Channel	9.4	0	0	46	2.59	108.44	5.52816327	102.244898	11.3236735	6.01346939
COVID	11/6/20	1025	Channel	8	0	0	46	2.59	108.44	5.52816327	102.244898	11.3236735	6.01346939
COVID	11/6/20	1025	Channel	7.8	0	0	46	2.59	108.44	5.52816327	102.244898	11.3236735	6.01346939
COVID	11/6/20	1025	Channel	6.8	0	0	46	2.59	108.44	5.52816327	102.244898	11.3236735	6.01346939
COVID	11/6/20	1100	WitchesBrew	4.3	0	0	46	2.59	108.44	5.52816327	102.244898	11.3236735	6.01346939
COVID	11/6/20	1100	WitchesBrew	3.5	0	0	46	2.59	108.44	5.52816327	102.244898	11.3236735	6.01346939
COVID	11/6/20	1100	WitchesBrew	4.2	0	0	46	2.59	108.44	5.52816327	102.244898	11.3236735	6.01346939
COVID	11/6/20	1100	WitchesBrew	3.8	0	0	46	2.59	108.44	5.52816327	102.244898	11.3236735	6.01346939
COVID	11/17/20	815	Backdoor	12.2	0	0	89	3.1884	73.52	4.6355102	69.5918367	8.01204082	5.32326531
COVID	11/17/20	815	Backdoor	12.6	0	0	89	3.1884	73.52	4.6355102	69.5918367	8.01204082	5.32326531
COVID	11/17/20	815	Backdoor	13.4	0	0	89	3.1884	73.52	4.6355102	69.5918367	8.01204082	5.32326531

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
COVID	11/17/20	815	Backdoor	11.9	0	0	89	3.1884	73.52	4.6355102	69.5918367	8.01204082	5.32326531
COVID	11/17/20	840	Keyhole	10.5	0	0	89	3.1884	73.52	4.6355102	69.5918367	8.01204082	5.32326531
COVID	11/17/20	840	Keyhole	10.8	0	0	89	3.1884	73.52	4.6355102	69.5918367	8.01204082	5.32326531
COVID	11/17/20	840	Keyhole	10.7	0	0	89	3.1884	73.52	4.6355102	69.5918367	8.01204082	5.32326531
COVID	11/17/20	840	Keyhole	10	0	0	89	3.1884	73.52	4.6355102	69.5918367	8.01204082	5.32326531
COVID	11/17/20	920	Channel	17.2	0	0	89	3.1884	73.52	4.6355102	69.5918367	8.01204082	5.32326531
COVID	11/17/20	920	Channel	17.6	0	0	89	3.1884	73.52	4.6355102	69.5918367	8.01204082	5.32326531
COVID	11/17/20	920	Channel	18.1	0	0	89	3.1884	73.52	4.6355102	69.5918367	8.01204082	5.32326531
COVID	11/17/20	920	Channel	16.5	0	0	89	3.1884	73.52	4.6355102	69.5918367	8.01204082	5.32326531
COVID	11/17/20	955	WitchesBrew	10.9	0	0	89	3.1884	73.52	4.6355102	69.5918367	8.01204082	5.32326531
COVID	11/17/20	955	WitchesBrew	9.7	0	0	89	3.1884	73.52	4.6355102	69.5918367	8.01204082	5.32326531
COVID	11/17/20	955	WitchesBrew	10	0	0	89	3.1884	73.52	4.6355102	69.5918367	8.01204082	5.32326531
COVID	11/17/20	955	WitchesBrew	9.4	0	0	89	3.1884	73.52	4.6355102	69.5918367	8.01204082	5.32326531
COVID	11/24/20	930	Backdoor	5	0	0	52	4.6724	74.24	8.93958333	69.7708333	9.386875	6.64041667
COVID	11/24/20	930	Backdoor	4.8	0	0	52	4.6724	74.24	8.93958333	69.7708333	9.386875	6.64041667
COVID	11/24/20	930	Backdoor	4.4	0	0	52	4.6724	74.24	8.93958333	69.7708333	9.386875	6.64041667
COVID	11/24/20	930	Backdoor	4.2	0	0	52	4.6724	74.24	8.93958333	69.7708333	9.386875	6.64041667
COVID	11/24/20	855	Keyhole	6.2	0	0	52	4.6724	74.24	8.93958333	69.7708333	9.386875	6.64041667
COVID	11/24/20	855	Keyhole	6	0	0	52	4.6724	74.24	8.93958333	69.7708333	9.386875	6.64041667
COVID	11/24/20	855	Keyhole	6.4	0	0	52	4.6724	74.24	8.93958333	69.7708333	9.386875	6.64041667
COVID	11/24/20	855	Keyhole	6.5	0	0	52	4.6724	74.24	8.93958333	69.7708333	9.386875	6.64041667
COVID	11/24/20	1100	Channel	5.6	0	0	52	4.6724	74.24	8.93958333	69.7708333	9.386875	6.64041667
COVID	11/24/20	1100	Channel	6.4	0	0	52	4.6724	74.24	8.93958333	69.7708333	9.386875	6.64041667
COVID	11/24/20	1100	Channel	6.2	0	0	52	4.6724	74.24	8.93958333	69.7708333	9.386875	6.64041667
COVID	11/24/20	1100	Channel	6.5	0	0	52	4.6724	74.24	8.93958333	69.7708333	9.386875	6.64041667

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
COVID	11/24/20	1020	WitchesBrew	5.5	0	0	52	4.6724	74.24	8.93958333	69.7708333	9.386875	6.64041667
COVID	11/24/20	1020	WitchesBrew	3.8	0	0	52	4.6724	74.24	8.93958333	69.7708333	9.386875	6.64041667
COVID	11/24/20	1020	WitchesBrew	4.7	0	0	52	4.6724	74.24	8.93958333	69.7708333	9.386875	6.64041667
COVID	11/24/20	1020	WitchesBrew	4.9	0	0	52	4.6724	74.24	8.93958333	69.7708333	9.386875	6.64041667
COVID	12/1/20	830	Backdoor	12.9	0	0	77	2.8456	104.6	4.88354167	202.583333	11.035625	7.18104167
COVID	12/1/20	830	Backdoor	13.4	0	0	77	2.8456	104.6	4.88354167	202.583333	11.035625	7.18104167
COVID	12/1/20	830	Backdoor	12.2	0	0	77	2.8456	104.6	4.88354167	202.583333	11.035625	7.18104167
COVID	12/1/20	830	Backdoor	11.3	0	0	77	2.8456	104.6	4.88354167	202.583333	11.035625	7.18104167
COVID	12/1/20	800	Keyhole	9.1	0	0	77	2.8456	104.6	4.88354167	202.583333	11.035625	7.18104167
COVID	12/1/20	800	Keyhole	8.9	0	0	77	2.8456	104.6	4.88354167	202.583333	11.035625	7.18104167
COVID	12/1/20	800	Keyhole	10.2	0	0	77	2.8456	104.6	4.88354167	202.583333	11.035625	7.18104167
COVID	12/1/20	800	Keyhole	10.8	0	0	77	2.8456	104.6	4.88354167	202.583333	11.035625	7.18104167
COVID	12/1/20	1000	Channel	12.4	0	0	77	2.8456	104.6	4.88354167	202.583333	11.035625	7.18104167
COVID	12/1/20	1000	Channel	12.7	0	0	77	2.8456	104.6	4.88354167	202.583333	11.035625	7.18104167
COVID	12/1/20	1000	Channel	12.7	0	0	77	2.8456	104.6	4.88354167	202.583333	11.035625	7.18104167
COVID	12/1/20	1000	Channel	11.8	0	0	77	2.8456	104.6	4.88354167	202.583333	11.035625	7.18104167
COVID	12/1/20	920	WitchesBrew	9.5	0	0	77	2.8456	104.6	4.88354167	202.583333	11.035625	7.18104167
COVID	12/1/20	920	WitchesBrew	9.4	0	0	77	2.8456	104.6	4.88354167	202.583333	11.035625	7.18104167
COVID	12/1/20	920	WitchesBrew	9.3	0	0	77	2.8456	104.6	4.88354167	202.583333	11.035625	7.18104167
COVID	12/1/20	920	WitchesBrew	9.1	0	0	77	2.8456	104.6	4.88354167	202.583333	11.035625	7.18104167
PostCOVID	12/9/20	1020	Backdoor	7.1	743	2.5	64	3.0724	93.68	7.74306122	283.285714	12.6961224	7.43673469
PostCOVID	12/9/20	1020	Backdoor	6.3	743	2.5	64	3.0724	93.68	7.74306122	283.285714	12.6961224	7.43673469
PostCOVID	12/9/20	1020	Backdoor	6.7	743	2.5	64	3.0724	93.68	7.74306122	283.285714	12.6961224	7.43673469
PostCOVID	12/9/20	1020	Backdoor	6.5	743	2.5	64	3.0724	93.68	7.74306122	283.285714	12.6961224	7.43673469
PostCOVID	12/9/20	918	Keyhole	6.8	743	19.25	64	3.0724	93.68	7.74306122	283.285714	12.6961224	7.43673469

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
PostCOVID	12/9/20	918	Keyhole	6.6	743	19.25	64	3.0724	93.68	7.74306122	283.285714	12.6961224	7.43673469
PostCOVID	12/9/20	918	Keyhole	6.9	743	19.25	64	3.0724	93.68	7.74306122	283.285714	12.6961224	7.43673469
PostCOVID	12/9/20	918	Keyhole	5.7	743	19.25	64	3.0724	93.68	7.74306122	283.285714	12.6961224	7.43673469
PostCOVID	12/9/20	1100	Channel	8.1	743	21	64	3.0724	93.68	7.74306122	283.285714	12.6961224	7.43673469
PostCOVID	12/9/20	1100	Channel	7.8	743	21	64	3.0724	93.68	7.74306122	283.285714	12.6961224	7.43673469
PostCOVID	12/9/20	1100	Channel	7.3	743	21	64	3.0724	93.68	7.74306122	283.285714	12.6961224	7.43673469
PostCOVID	12/9/20	1100	Channel	6.1	743	21	64	3.0724	93.68	7.74306122	283.285714	12.6961224	7.43673469
PostCOVID	12/9/20	1142	WitchesBrew	4.4	743	3.25	64	3.0724	93.68	7.74306122	283.285714	12.6961224	7.43673469
PostCOVID	12/9/20	1142	WitchesBrew	3.9	743	3.25	64	3.0724	93.68	7.74306122	283.285714	12.6961224	7.43673469
PostCOVID	12/9/20	1142	WitchesBrew	4.1	743	3.25	64	3.0724	93.68	7.74306122	283.285714	12.6961224	7.43673469
PostCOVID	12/9/20	1142	WitchesBrew	3.3	743	3.25	64	3.0724	93.68	7.74306122	283.285714	12.6961224	7.43673469
PostCOVID	12/16/20	1408	Backdoor	9.2	702	10.75	86	3.8652	65.24	6.6525	320.041667	11.541875	6.3025
PostCOVID	12/16/20	1408	Backdoor	8.9	702	10.75	86	3.8652	65.24	6.6525	320.041667	11.541875	6.3025
PostCOVID	12/16/20	1408	Backdoor	9.5	702	10.75	86	3.8652	65.24	6.6525	320.041667	11.541875	6.3025
PostCOVID	12/16/20	1408	Backdoor	10.4	702	10.75	86	3.8652	65.24	6.6525	320.041667	11.541875	6.3025
PostCOVID	12/16/20	1447	Keyhole	6	702	29	86	3.8652	65.24	6.6525	320.041667	11.541875	6.3025
PostCOVID	12/16/20	1447	Keyhole	5.9	702	29	86	3.8652	65.24	6.6525	320.041667	11.541875	6.3025
PostCOVID	12/16/20	1447	Keyhole	7.4	702	29	86	3.8652	65.24	6.6525	320.041667	11.541875	6.3025
PostCOVID	12/16/20	1447	Keyhole	6.4	702	29	86	3.8652	65.24	6.6525	320.041667	11.541875	6.3025
PostCOVID	12/16/20	1315	Channel	11.5	702	17.5	86	3.8652	65.24	6.6525	320.041667	11.541875	6.3025
PostCOVID	12/16/20	1315	Channel	11.1	702	17.5	86	3.8652	65.24	6.6525	320.041667	11.541875	6.3025
PostCOVID	12/16/20	1315	Channel	10.1	702	17.5	86	3.8652	65.24	6.6525	320.041667	11.541875	6.3025
PostCOVID	12/16/20	1315	Channel	11	702	17.5	86	3.8652	65.24	6.6525	320.041667	11.541875	6.3025
PostCOVID	12/16/20	1300	WitchesBrew	5.1	702	4.75	86	3.8652	65.24	6.6525	320.041667	11.541875	6.3025
PostCOVID	12/16/20	1300	WitchesBrew	4.7	702	4.75	86	3.8652	65.24	6.6525	320.041667	11.541875	6.3025

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
PostCOVID	12/16/20	1300	WitchesBrew	4.5	702	4.75	86	3.8652	65.24	6.6525	320.041667	11.541875	6.3025
PostCOVID	12/16/20	1300	WitchesBrew	4.5	702	4.75	86	3.8652	65.24	6.6525	320.041667	11.541875	6.3025
PostCOVID	12/18/20	1415	Backdoor	6.4	724	5.5	67	3.3992	56.8	7.08428571	140.897959	10.3465306	6.50102041
PostCOVID	12/18/20	1415	Backdoor	6.7	724	5.5	67	3.3992	56.8	7.08428571	140.897959	10.3465306	6.50102041
PostCOVID	12/18/20	1415	Backdoor	6.9	724	5.5	67	3.3992	56.8	7.08428571	140.897959	10.3465306	6.50102041
PostCOVID	12/18/20	1415	Backdoor	6.4	724	5.5	67	3.3992	56.8	7.08428571	140.897959	10.3465306	6.50102041
PostCOVID	12/18/20	1320	Keyhole	4.5	724	20	67	3.3992	56.8	7.08428571	140.897959	10.3465306	6.50102041
PostCOVID	12/18/20	1320	Keyhole	3.9	724	20	67	3.3992	56.8	7.08428571	140.897959	10.3465306	6.50102041
PostCOVID	12/18/20	1320	Keyhole	4.4	724	20	67	3.3992	56.8	7.08428571	140.897959	10.3465306	6.50102041
PostCOVID	12/18/20	1320	Keyhole	4.3	724	20	67	3.3992	56.8	7.08428571	140.897959	10.3465306	6.50102041
PostCOVID	12/18/20	1234	Channel	6.6	724	53.5	67	3.3992	56.8	7.08428571	140.897959	10.3465306	6.50102041
PostCOVID	12/18/20	1234	Channel	5.7	724	53.5	67	3.3992	56.8	7.08428571	140.897959	10.3465306	6.50102041
PostCOVID	12/18/20	1234	Channel	6	724	53.5	67	3.3992	56.8	7.08428571	140.897959	10.3465306	6.50102041
PostCOVID	12/18/20	1234	Channel	6.3	724	53.5	67	3.3992	56.8	7.08428571	140.897959	10.3465306	6.50102041
PostCOVID	12/18/20	1145	WitchesBrew	6.7	724	10	67	3.3992	56.8	7.08428571	140.897959	10.3465306	6.50102041
PostCOVID	12/18/20	1145	WitchesBrew	5.9	724	10	67	3.3992	56.8	7.08428571	140.897959	10.3465306	6.50102041
PostCOVID	12/18/20	1145	WitchesBrew	6.3	724	10	67	3.3992	56.8	7.08428571	140.897959	10.3465306	6.50102041
PostCOVID	12/18/20	1145	WitchesBrew	6	724	10	67	3.3992	56.8	7.08428571	140.897959	10.3465306	6.50102041
PostCOVID	1/6/21	1135	Backdoor	9.5	720	7	60	2.92416667	80.625	5.60458333	343.3125	13.9370833	6.48104167
PostCOVID	1/6/21	1135	Backdoor	10.2	720	7	60	2.92416667	80.625	5.60458333	343.3125	13.9370833	6.48104167
PostCOVID	1/6/21	1135	Backdoor	10.1	720	7	60	2.92416667	80.625	5.60458333	343.3125	13.9370833	6.48104167
PostCOVID	1/6/21	1135	Backdoor	10.3	720	7	60	2.92416667	80.625	5.60458333	343.3125	13.9370833	6.48104167
PostCOVID	1/6/21	1219	Keyhole	7.3	720	47.25	60	2.92416667	80.625	5.60458333	343.3125	13.9370833	6.48104167
PostCOVID	1/6/21	1219	Keyhole	7.5	720	47.25	60	2.92416667	80.625	5.60458333	343.3125	13.9370833	6.48104167
PostCOVID	1/6/21	1219	Keyhole	8.9	720	47.25	60	2.92416667	80.625	5.60458333	343.3125	13.9370833	6.48104167

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
PostCOVID	1/6/21	1219	Keyhole	8.6	720	47.25	60	2.92416667	80.625	5.60458333	343.3125	13.9370833	6.48104167
PostCOVID	1/6/21	1307	Channel	4.9	720	25.75	60	2.92416667	80.625	5.60458333	343.3125	13.9370833	6.48104167
PostCOVID	1/6/21	1307	Channel	4.6	720	25.75	60	2.92416667	80.625	5.60458333	343.3125	13.9370833	6.48104167
PostCOVID	1/6/21	1307	Channel	6	720	25.75	60	2.92416667	80.625	5.60458333	343.3125	13.9370833	6.48104167
PostCOVID	1/6/21	1307	Channel	5.7	720	25.75	60	2.92416667	80.625	5.60458333	343.3125	13.9370833	6.48104167
PostCOVID	1/6/21	1350	WitchesBrew	3.3	720	6.75	60	2.92416667	80.625	5.60458333	343.3125	13.9370833	6.48104167
PostCOVID	1/6/21	1350	WitchesBrew	3.6	720	6.75	60	2.92416667	80.625	5.60458333	343.3125	13.9370833	6.48104167
PostCOVID	1/6/21	1350	WitchesBrew	4.1	720	6.75	60	2.92416667	80.625	5.60458333	343.3125	13.9370833	6.48104167
PostCOVID	1/6/21	1350	WitchesBrew	4	720	6.75	60	2.92416667	80.625	5.60458333	343.3125	13.9370833	6.48104167
PostCOVID	1/13/21	1407	Backdoor	8.2	525	7.5	89	4.8444	191.32	5.01040816	206.836735	12.914898	8.71306122
PostCOVID	1/13/21	1407	Backdoor	8.9	525	7.5	89	4.8444	191.32	5.01040816	206.836735	12.914898	8.71306122
PostCOVID	1/13/21	1407	Backdoor	9.9	525	7.5	89	4.8444	191.32	5.01040816	206.836735	12.914898	8.71306122
PostCOVID	1/13/21	1407	Backdoor	9.6	525	7.5	89	4.8444	191.32	5.01040816	206.836735	12.914898	8.71306122
PostCOVID	1/13/21	1323	Keyhole	8.2	525	32.75	89	4.8444	191.32	5.01040816	206.836735	12.914898	8.71306122
PostCOVID	1/13/21	1323	Keyhole	8.5	525	32.75	89	4.8444	191.32	5.01040816	206.836735	12.914898	8.71306122
PostCOVID	1/13/21	1323	Keyhole	7.8	525	32.75	89	4.8444	191.32	5.01040816	206.836735	12.914898	8.71306122
PostCOVID	1/13/21	1323	Keyhole	8	525	32.75	89	4.8444	191.32	5.01040816	206.836735	12.914898	8.71306122
PostCOVID	1/13/21	1238	Channel	9	525	19.25	89	4.8444	191.32	5.01040816	206.836735	12.914898	8.71306122
PostCOVID	1/13/21	1238	Channel	9.4	525	19.25	89	4.8444	191.32	5.01040816	206.836735	12.914898	8.71306122
PostCOVID	1/13/21	1238	Channel	11.5	525	19.25	89	4.8444	191.32	5.01040816	206.836735	12.914898	8.71306122
PostCOVID	1/13/21	1238	Channel	11.1	525	19.25	89	4.8444	191.32	5.01040816	206.836735	12.914898	8.71306122
PostCOVID	1/13/21	1154	WitchesBrew	9.4	525	5.5	89	4.8444	191.32	5.01040816	206.836735	12.914898	8.71306122
PostCOVID	1/13/21	1154	WitchesBrew	7.8	525	5.5	89	4.8444	191.32	5.01040816	206.836735	12.914898	8.71306122
PostCOVID	1/13/21	1154	WitchesBrew	7.7	525	5.5	89	4.8444	191.32	5.01040816	206.836735	12.914898	8.71306122
PostCOVID	1/13/21	1154	WitchesBrew	7.9	525	5.5	89	4.8444	191.32	5.01040816	206.836735	12.914898	8.71306122

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
PostCOVID	1/20/21	1140	Backdoor	12.8	534	10.75	44	3.9896	80.08	8.59979167	134.104167	10.4002083	7.330625
PostCOVID	1/20/21	1140	Backdoor	11.6	534	10.75	44	3.9896	80.08	8.59979167	134.104167	10.4002083	7.330625
PostCOVID	1/20/21	1140	Backdoor	13.4	534	10.75	44	3.9896	80.08	8.59979167	134.104167	10.4002083	7.330625
PostCOVID	1/20/21	1140	Backdoor	13.3	534	10.75	44	3.9896	80.08	8.59979167	134.104167	10.4002083	7.330625
PostCOVID	1/20/21	1227	Keyhole	9.8	534	31.75	44	3.9896	80.08	8.59979167	134.104167	10.4002083	7.330625
PostCOVID	1/20/21	1227	Keyhole	9.5	534	31.75	44	3.9896	80.08	8.59979167	134.104167	10.4002083	7.330625
PostCOVID	1/20/21	1227	Keyhole	9.7	534	31.75	44	3.9896	80.08	8.59979167	134.104167	10.4002083	7.330625
PostCOVID	1/20/21	1227	Keyhole	10	534	31.75	44	3.9896	80.08	8.59979167	134.104167	10.4002083	7.330625
PostCOVID	1/20/21	1315	Channel	8.8	534	22.5	44	3.9896	80.08	8.59979167	134.104167	10.4002083	7.330625
PostCOVID	1/20/21	1315	Channel	8.5	534	22.5	44	3.9896	80.08	8.59979167	134.104167	10.4002083	7.330625
PostCOVID	1/20/21	1315	Channel	9	534	22.5	44	3.9896	80.08	8.59979167	134.104167	10.4002083	7.330625
PostCOVID	1/20/21	1315	Channel	9.6	534	22.5	44	3.9896	80.08	8.59979167	134.104167	10.4002083	7.330625
PostCOVID	1/20/21	1355	WitchesBrew	6.2	534	5.25	44	3.9896	80.08	8.59979167	134.104167	10.4002083	7.330625
PostCOVID	1/20/21	1355	WitchesBrew	5.8	534	5.25	44	3.9896	80.08	8.59979167	134.104167	10.4002083	7.330625
PostCOVID	1/20/21	1355	WitchesBrew	5.9	534	5.25	44	3.9896	80.08	8.59979167	134.104167	10.4002083	7.330625
PostCOVID	1/20/21	1355	WitchesBrew	5.4	534	5.25	44	3.9896	80.08	8.59979167	134.104167	10.4002083	7.330625
Open	10/5/18		Backdoors	6.9		0	75	2.47791667	157.1125	2.58333333	6.8125		7.02083333
Open	10/5/18		Backdoors	7.2		0	75	2.47791667	157.1125	2.58333333	6.8125		7.02083333
Open	10/5/18		Backdoors	5.3		0	75	2.47791667	157.1125	2.58333333	6.8125		7.02083333
Open	10/5/18		Backdoors	5.7		0	75	2.47791667	157.1125	2.58333333	6.8125		7.02083333
Open	10/8/18		Backdoors	7.9		3	105	3.35625	114.4125	3.66666667	7.45833333		7.9375
Open	10/8/18		Backdoors	7.4		3	105	3.35625	114.4125	3.66666667	7.45833333		7.9375
Open	10/8/18		Backdoors	7.7		3	105	3.35625	114.4125	3.66666667	7.45833333		7.9375
Open	10/8/18		Backdoors	7.4		3	105	3.35625	114.4125	3.66666667	7.45833333		7.9375
ClosedTuesday	10/9/18		Backdoors	11.5		0	106	3.55378151	108.647059	3.75	8.64583333		8.8125

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
ClosedTuesday	10/9/18		Backdoors	11.2		0	106	3.55378151	108.647059	3.75	8.64583333		8.8125
ClosedTuesday	10/9/18		Backdoors	11.8		0	106	3.55378151	108.647059	3.75	8.64583333		8.8125
ClosedTuesday	10/9/18		Backdoors	11.6		0	106	3.55378151	108.647059	3.75	8.64583333		8.8125
Open	10/10/18		Backdoors	8.5		16	101	3.6012605	110.647059	3.75	8.16666667		8.8125
Open	10/10/18		Backdoors	7.9		16	101	3.6012605	110.647059	3.75	8.16666667		8.8125
Open	10/10/18		Backdoors	8.2		16	101	3.6012605	110.647059	3.75	8.16666667		8.8125
Open	10/10/18		Backdoors	6.7		16	101	3.6012605	110.647059	3.75	8.16666667		8.8125
Open	10/11/18		Backdoors	9.3		0	91	3.30416667	142.029167	3	8.95833333		9.25
Open	10/11/18		Backdoors	8.6		0	91	3.30416667	142.029167	3	8.95833333		9.25
Open	10/11/18		Backdoors	8.8		0	91	3.30416667	142.029167	3	8.95833333		9.25
Open	10/11/18		Backdoors	8.5		0	91	3.30416667	142.029167	3	8.95833333		9.25
Open	10/12/18		Backdoors	10.1		0	79	3.24978903	153.734177	2.63829787	8.93617021		9.42553191
Open	10/12/18		Backdoors	10.5		0	79	3.24978903	153.734177	2.63829787	8.93617021		9.42553191
Open	10/12/18		Backdoors	8.7		0	79	3.24978903	153.734177	2.63829787	8.93617021		9.42553191
Open	10/12/18		Backdoors	9.3		0	79	3.24978903	153.734177	2.63829787	8.93617021		9.42553191
Open	10/14/18		Backdoors	11.1		0	52	2.74166667	241.866667	2	7.70833333		8.79166667
Open	10/14/18		Backdoors	10.5		0	52	2.74166667	241.866667	2	7.70833333		8.79166667
Open	10/14/18		Backdoors	8.15		0	52	2.74166667	241.866667	2	7.70833333		8.79166667
Open	10/14/18		Backdoors	8.1		0	52	2.74166667	241.866667	2	7.70833333		8.79166667
ClosedTuesday	10/16/18		Backdoors	12.2		0	33	5.4425	81.7666667	2.95833333	18.3541667		9.39583333
ClosedTuesday	10/16/18		Backdoors	12.7		0	33	5.4425	81.7666667	2.95833333	18.3541667		9.39583333
ClosedTuesday	10/16/18		Backdoors	13.4		0	33	5.4425	81.7666667	2.95833333	18.3541667		9.39583333
ClosedTuesday	10/16/18		Backdoors	13.2		0	33	5.4425	81.7666667	2.95833333	18.3541667		9.39583333
Open	10/20/18		Backdoors	7.5		3	62	3.56458333	139.325	2.54166667	31.8541667		9.79166667
Open	10/20/18		Backdoors	7.1		3	62	3.56458333	139.325	2.54166667	31.8541667		9.79166667

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
Open	10/20/18		Backdoors	7.5		3	62	3.56458333	139.325	2.54166667	31.8541667		9.79166667
Open	10/20/18		Backdoors	7.2		3	62	3.56458333	139.325	2.54166667	31.8541667		9.79166667
Open	10/21/18		Backdoors	6.7		2	73	4.89497908	101.054393	2.9375	29.6666667		9.375
Open	10/21/18		Backdoors	6.9		2	73	4.89497908	101.054393	2.9375	29.6666667		9.375
Open	10/21/18		Backdoors	7.4		2	73	4.89497908	101.054393	2.9375	29.6666667		9.375
Open	10/21/18		Backdoors	7.5		2	73	4.89497908	101.054393	2.9375	29.6666667		9.375
ClosedTuesday	10/23/18		Backdoors	11.5		0	91	4.17875	80.7875	2.97916667	16.3333333		6.875
ClosedTuesday	10/23/18		Backdoors	11.3		0	91	4.17875	80.7875	2.97916667	16.3333333		6.875
ClosedTuesday	10/23/18		Backdoors	11.4		0	91	4.17875	80.7875	2.97916667	16.3333333		6.875
ClosedTuesday	10/23/18		Backdoors	11		0	91	4.17875	80.7875	2.97916667	16.3333333		6.875
Open	10/24/18		Backdoors	11.3		3	95	4.5325	69.6583333	3.52083333	23.0416667		6.625
Open	10/24/18		Backdoors	11		3	95	4.5325	69.6583333	3.52083333	23.0416667		6.625
Open	10/24/18		Backdoors	10.3		3	95	4.5325	69.6583333	3.52083333	23.0416667		6.625
Open	10/24/18		Backdoors	9.9		3	95	4.5325	69.6583333	3.52083333	23.0416667		6.625
Open	10/5/18		Backdoors	8		7	75	2.47791667	157.1125	2.58333333	6.8125		7.02083333
Open	10/5/18		Backdoors	7.8		7	75	2.47791667	157.1125	2.58333333	6.8125		7.02083333
Open	10/5/18		Backdoors	7.4		7	75	2.47791667	157.1125	2.58333333	6.8125		7.02083333
Open	10/5/18		Backdoors	7.4		7	75	2.47791667	157.1125	2.58333333	6.8125		7.02083333
Open	10/8/18		Backdoors	10.1		25	105	3.35625	114.4125	3.66666667	7.45833333		7.9375
Open	10/8/18		Backdoors	9.6		25	105	3.35625	114.4125	3.66666667	7.45833333		7.9375
Open	10/8/18		Backdoors	8.8		25	105	3.35625	114.4125	3.66666667	7.45833333		7.9375
Open	10/8/18		Backdoors	8.5		25	105	3.35625	114.4125	3.66666667	7.45833333		7.9375
ClosedTuesday	10/9/18		Backdoors	11.8		0	106	3.55378151	108.647059	3.75	8.64583333		8.8125
ClosedTuesday	10/9/18		Backdoors	11.7		0	106	3.55378151	108.647059	3.75	8.64583333		8.8125
ClosedTuesday	10/9/18		Backdoors	11.4		0	106	3.55378151	108.647059	3.75	8.64583333		8.8125

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
ClosedTuesday	10/9/18		Backdoors	11.1		0	106	3.55378151	108.647059	3.75	8.64583333		8.8125
Open	10/10/18		Backdoors	8.7		15	101	3.6012605	110.647059	3.75	8.16666667		8.8125
Open	10/10/18		Backdoors	7.4		15	101	3.6012605	110.647059	3.75	8.16666667		8.8125
Open	10/10/18		Backdoors	8.9		15	101	3.6012605	110.647059	3.75	8.16666667		8.8125
Open	10/10/18		Backdoors	7.9		15	101	3.6012605	110.647059	3.75	8.16666667		8.8125
Open	10/11/18		Backdoors	10.6		1	91	3.30416667	142.029167	3	8.95833333		9.25
Open	10/11/18		Backdoors	11.2		1	91	3.30416667	142.029167	3	8.95833333		9.25
Open	10/11/18		Backdoors	10		1	91	3.30416667	142.029167	3	8.95833333		9.25
Open	10/11/18		Backdoors	9.7		1	91	3.30416667	142.029167	3	8.95833333		9.25
Open	10/12/18		Backdoors	10.4		9	79	3.24978903	153.734177	2.63829787	8.93617021		9.42553191
Open	10/12/18		Backdoors	10.4		9	79	3.24978903	153.734177	2.63829787	8.93617021		9.42553191
Open	10/12/18		Backdoors	11.1		9	79	3.24978903	153.734177	2.63829787	8.93617021		9.42553191
Open	10/12/18		Backdoors	10.3		9	79	3.24978903	153.734177	2.63829787	8.93617021		9.42553191
Open	10/14/18		Backdoors	13.6		13	52	2.74166667	241.866667	2	7.70833333		8.79166667
Open	10/14/18		Backdoors	12.6		13	52	2.74166667	241.866667	2	7.70833333		8.79166667
Open	10/14/18		Backdoors	11.6		13	52	2.74166667	241.866667	2	7.70833333		8.79166667
Open	10/14/18		Backdoors	12		13	52	2.74166667	241.866667	2	7.70833333		8.79166667
ClosedTuesday	10/16/18		Backdoors	12.4		0	33	5.4425	81.7666667	2.95833333	18.3541667		9.39583333
ClosedTuesday	10/16/18		Backdoors	12.2		0	33	5.4425	81.7666667	2.95833333	18.3541667		9.39583333
ClosedTuesday	10/16/18		Backdoors	12.7		0	33	5.4425	81.7666667	2.95833333	18.3541667		9.39583333
ClosedTuesday	10/16/18		Backdoors	12.4		0	33	5.4425	81.7666667	2.95833333	18.3541667		9.39583333
Open	10/20/18		Backdoors	10		4	62	3.56458333	139.325	2.54166667	31.8541667		9.79166667
Open	10/20/18		Backdoors	9.2		4	62	3.56458333	139.325	2.54166667	31.8541667		9.79166667
Open	10/20/18		Backdoors	8.2		4	62	3.56458333	139.325	2.54166667	31.8541667		9.79166667
Open	10/20/18		Backdoors	7		4	62	3.56458333	139.325	2.54166667	31.8541667		9.79166667

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
Open	10/21/18		Backdoors	6.5		22	73	4.89497908	101.054393	2.9375	29.6666667		9.375
Open	10/21/18		Backdoors	6.1		22	73	4.89497908	101.054393	2.9375	29.6666667		9.375
Open	10/21/18		Backdoors	7.2		22	73	4.89497908	101.054393	2.9375	29.6666667		9.375
Open	10/21/18		Backdoors	7.3		22	73	4.89497908	101.054393	2.9375	29.6666667		9.375
ClosedTuesday	10/23/18		Backdoors	10.5		0	91	4.17875	80.7875	2.97916667	16.3333333		6.875
ClosedTuesday	10/23/18		Backdoors	10.4		0	91	4.17875	80.7875	2.97916667	16.3333333		6.875
ClosedTuesday	10/23/18		Backdoors	11.3		0	91	4.17875	80.7875	2.97916667	16.3333333		6.875
ClosedTuesday	10/23/18		Backdoors	11		0	91	4.17875	80.7875	2.97916667	16.3333333		6.875
Open	10/24/18		Backdoors	9.9		17	95	4.5325	69.6583333	3.52083333	23.0416667		6.625
Open	10/24/18		Backdoors	10.1		17	95	4.5325	69.6583333	3.52083333	23.0416667		6.625
Open	10/24/18		Backdoors	9.2		17	95	4.5325	69.6583333	3.52083333	23.0416667		6.625
Open	10/24/18		Backdoors	9.8		17	95	4.5325	69.6583333	3.52083333	23.0416667		6.625
Open	10/5/18		Keyhole	5.5		67	75	2.47791667	157.1125	2.58333333	6.8125		7.02083333
Open	10/5/18		Keyhole	5.8		67	75	2.47791667	157.1125	2.58333333	6.8125		7.02083333
Open	10/5/18		Keyhole	6.9		67	75	2.47791667	157.1125	2.58333333	6.8125		7.02083333
Open	10/5/18		Keyhole	5.8		67	75	2.47791667	157.1125	2.58333333	6.8125		7.02083333
Open	10/8/18		Keyhole	7.6		73	105	3.35625	114.4125	3.66666667	7.45833333		7.9375
Open	10/8/18		Keyhole	7		73	105	3.35625	114.4125	3.66666667	7.45833333		7.9375
Open	10/8/18		Keyhole	7		73	105	3.35625	114.4125	3.66666667	7.45833333		7.9375
Open	10/8/18		Keyhole	5.8		73	105	3.35625	114.4125	3.66666667	7.45833333		7.9375
ClosedTuesday	10/9/18		Keyhole	10.1		0	106	3.55378151	108.647059	3.75	8.64583333		8.8125
ClosedTuesday	10/9/18		Keyhole	9.7		0	106	3.55378151	108.647059	3.75	8.64583333		8.8125
ClosedTuesday	10/9/18		Keyhole	10.5		0	106	3.55378151	108.647059	3.75	8.64583333		8.8125
ClosedTuesday	10/9/18		Keyhole	10.1		0	106	3.55378151	108.647059	3.75	8.64583333		8.8125
Open	10/10/18		Keyhole	7.8		63	101	3.6012605	110.647059	3.75	8.16666667		8.8125

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
Open	10/10/18		Keyhole	7.9		63	101	3.6012605	110.647059	3.75	8.16666667		8.8125
Open	10/10/18		Keyhole	8		63	101	3.6012605	110.647059	3.75	8.16666667		8.8125
Open	10/10/18		Keyhole	7		63	101	3.6012605	110.647059	3.75	8.16666667		8.8125
Open	10/11/18		Keyhole	7.8		53	91	3.30416667	142.029167	3	8.95833333		9.25
Open	10/11/18		Keyhole	7.3		53	91	3.30416667	142.029167	3	8.95833333		9.25
Open	10/11/18		Keyhole	9.5		53	91	3.30416667	142.029167	3	8.95833333		9.25
Open	10/11/18		Keyhole	8.9		53	91	3.30416667	142.029167	3	8.95833333		9.25
Open	10/12/18		Keyhole	9.3		65	79	3.24978903	153.734177	2.63829787	8.93617021		9.42553191
Open	10/12/18		Keyhole	8.5		65	79	3.24978903	153.734177	2.63829787	8.93617021		9.42553191
Open	10/12/18		Keyhole	8.6		65	79	3.24978903	153.734177	2.63829787	8.93617021		9.42553191
Open	10/12/18		Keyhole	8.6		65	79	3.24978903	153.734177	2.63829787	8.93617021		9.42553191
Open	10/14/18		Keyhole	10.5		50	52	2.74166667	241.866667	2	7.70833333		8.79166667
Open	10/14/18		Keyhole	9.8		50	52	2.74166667	241.866667	2	7.70833333		8.79166667
Open	10/14/18		Keyhole	10.9		50	52	2.74166667	241.866667	2	7.70833333		8.79166667
Open	10/14/18		Keyhole	10.9		50	52	2.74166667	241.866667	2	7.70833333		8.79166667
ClosedTuesday	10/16/18		Keyhole	8.5		0	33	5.4425	81.7666667	2.95833333	18.3541667		9.39583333
ClosedTuesday	10/16/18		Keyhole	7		0	33	5.4425	81.7666667	2.95833333	18.3541667		9.39583333
ClosedTuesday	10/16/18		Keyhole	10.4		0	33	5.4425	81.7666667	2.95833333	18.3541667		9.39583333
ClosedTuesday	10/16/18		Keyhole	10.7		0	33	5.4425	81.7666667	2.95833333	18.3541667		9.39583333
Open	10/20/18		Keyhole	7.8		21	62	3.56458333	139.325	2.54166667	31.8541667		9.79166667
Open	10/20/18		Keyhole	7.9		21	62	3.56458333	139.325	2.54166667	31.8541667		9.79166667
Open	10/20/18		Keyhole	7.5		21	62	3.56458333	139.325	2.54166667	31.8541667		9.79166667
Open	10/20/18		Keyhole	6.6		21	62	3.56458333	139.325	2.54166667	31.8541667		9.79166667
Open	10/21/18		Keyhole	4.9		38	73	4.89497908	101.054393	2.9375	29.6666667		9.375
Open	10/21/18		Keyhole	4.6		38	73	4.89497908	101.054393	2.9375	29.6666667		9.375

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
Open	10/21/18		Keyhole	6.1		38	73	4.89497908	101.054393	2.9375	29.6666667		9.375
Open	10/21/18		Keyhole	5.8		38	73	4.89497908	101.054393	2.9375	29.6666667		9.375
ClosedTuesday	10/23/18		Keyhole	10.8		0	91	4.17875	80.7875	2.97916667	16.3333333		6.875
ClosedTuesday	10/23/18		Keyhole	10.6		0	91	4.17875	80.7875	2.97916667	16.3333333		6.875
ClosedTuesday	10/23/18		Keyhole	11.2		0	91	4.17875	80.7875	2.97916667	16.3333333		6.875
ClosedTuesday	10/23/18		Keyhole	10		0	91	4.17875	80.7875	2.97916667	16.3333333		6.875
Open	10/24/18		Keyhole	8.9		82	95	4.5325	69.6583333	3.52083333	23.0416667		6.625
Open	10/24/18		Keyhole	8.7		82	95	4.5325	69.6583333	3.52083333	23.0416667		6.625
Open	10/24/18		Keyhole	7.2		82	95	4.5325	69.6583333	3.52083333	23.0416667		6.625
Open	10/24/18		Keyhole	6.4		82	95	4.5325	69.6583333	3.52083333	23.0416667		6.625
Open	10/5/18		Keyhole	6.7		163	75	2.47791667	157.1125	2.58333333	6.8125		7.02083333
Open	10/5/18		Keyhole	5.6		163	75	2.47791667	157.1125	2.58333333	6.8125		7.02083333
Open	10/5/18		Keyhole	5.4		163	75	2.47791667	157.1125	2.58333333	6.8125		7.02083333
Open	10/5/18		Keyhole	4.9		163	75	2.47791667	157.1125	2.58333333	6.8125		7.02083333
Open	10/8/18		Keyhole	6.4		251	105	3.35625	114.4125	3.66666667	7.45833333		7.9375
Open	10/8/18		Keyhole	6.6		251	105	3.35625	114.4125	3.66666667	7.45833333		7.9375
Open	10/8/18		Keyhole	5.3		251	105	3.35625	114.4125	3.66666667	7.45833333		7.9375
Open	10/8/18		Keyhole	5.9		251	105	3.35625	114.4125	3.66666667	7.45833333		7.9375
ClosedTuesday	10/9/18		Keyhole	9.4		0	106	3.55378151	108.647059	3.75	8.64583333		8.8125
ClosedTuesday	10/9/18		Keyhole	8.9		0	106	3.55378151	108.647059	3.75	8.64583333		8.8125
ClosedTuesday	10/9/18		Keyhole	8.3		0	106	3.55378151	108.647059	3.75	8.64583333		8.8125
ClosedTuesday	10/9/18		Keyhole	8.1		0	106	3.55378151	108.647059	3.75	8.64583333		8.8125
Open	10/10/18		Keyhole	7.7		190	101	3.6012605	110.647059	3.75	8.16666667		8.8125
Open	10/10/18		Keyhole	7.8		190	101	3.6012605	110.647059	3.75	8.16666667		8.8125
Open	10/10/18		Keyhole	9.2		190	101	3.6012605	110.647059	3.75	8.16666667		8.8125

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
Open	10/10/18		Keyhole	6.2		190	101	3.6012605	110.647059	3.75	8.16666667		8.8125
Open	10/11/18		Keyhole	6.9		138	91	3.30416667	142.029167	3	8.95833333		9.25
Open	10/11/18		Keyhole	5.8		138	91	3.30416667	142.029167	3	8.95833333		9.25
Open	10/11/18		Keyhole	7.6		138	91	3.30416667	142.029167	3	8.95833333		9.25
Open	10/11/18		Keyhole	7.1		138	91	3.30416667	142.029167	3	8.95833333		9.25
Open	10/12/18		Keyhole	9.5		132	79	3.24978903	153.734177	2.63829787	8.93617021		9.42553191
Open	10/12/18		Keyhole	10.1		132	79	3.24978903	153.734177	2.63829787	8.93617021		9.42553191
Open	10/12/18		Keyhole	10.3		132	79	3.24978903	153.734177	2.63829787	8.93617021		9.42553191
Open	10/12/18		Keyhole	10.4		132	79	3.24978903	153.734177	2.63829787	8.93617021		9.42553191
Open	10/14/18		Keyhole	9.4		165	52	2.74166667	241.866667	2	7.70833333		8.79166667
Open	10/14/18		Keyhole	8		165	52	2.74166667	241.866667	2	7.70833333		8.79166667
Open	10/14/18		Keyhole	9.2		165	52	2.74166667	241.866667	2	7.70833333		8.79166667
Open	10/14/18		Keyhole	9.5		165	52	2.74166667	241.866667	2	7.70833333		8.79166667
ClosedTuesday	10/16/18		Keyhole	10.1		0	33	5.4425	81.7666667	2.95833333	18.3541667		9.39583333
ClosedTuesday	10/16/18		Keyhole	9.4		0	33	5.4425	81.7666667	2.95833333	18.3541667		9.39583333
ClosedTuesday	10/16/18		Keyhole	9.6		0	33	5.4425	81.7666667	2.95833333	18.3541667		9.39583333
ClosedTuesday	10/16/18		Keyhole	9.4		0	33	5.4425	81.7666667	2.95833333	18.3541667		9.39583333
Open	10/20/18		Keyhole	7.1		110	62	3.56458333	139.325	2.54166667	31.8541667		9.79166667
Open	10/20/18		Keyhole	7.1		110	62	3.56458333	139.325	2.54166667	31.8541667		9.79166667
Open	10/20/18		Keyhole	7.8		110	62	3.56458333	139.325	2.54166667	31.8541667		9.79166667
Open	10/20/18		Keyhole	5.9		110	62	3.56458333	139.325	2.54166667	31.8541667		9.79166667
Open	10/21/18		Keyhole	4.6		108	73	4.89497908	101.054393	2.9375	29.6666667		9.375
Open	10/21/18		Keyhole	4.1		108	73	4.89497908	101.054393	2.9375	29.6666667		9.375
Open	10/21/18		Keyhole	5.1		108	73	4.89497908	101.054393	2.9375	29.6666667		9.375
Open	10/21/18		Keyhole	5.2		108	73	4.89497908	101.054393	2.9375	29.6666667		9.375

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
ClosedTuesday	10/23/18		Keyhole	12.2		0	91	4.17875	80.7875	2.97916667	16.3333333		6.875
ClosedTuesday	10/23/18		Keyhole	12.1		0	91	4.17875	80.7875	2.97916667	16.3333333		6.875
ClosedTuesday	10/23/18		Keyhole	13.2		0	91	4.17875	80.7875	2.97916667	16.3333333		6.875
ClosedTuesday	10/23/18		Keyhole	12.8		0	91	4.17875	80.7875	2.97916667	16.3333333		6.875
Open	10/24/18		Keyhole	8.6		161	95	4.5325	69.6583333	3.52083333	23.0416667		6.625
Open	10/24/18		Keyhole	8.9		161	95	4.5325	69.6583333	3.52083333	23.0416667		6.625
Open	10/24/18		Keyhole	8.9		161	95	4.5325	69.6583333	3.52083333	23.0416667		6.625
Open	10/24/18		Keyhole	9.05		161	95	4.5325	69.6583333	3.52083333	23.0416667		6.625
Open	10/5/18		Channel	10.8		77	75	2.47791667	157.1125	2.58333333	6.8125		7.02083333
Open	10/5/18		Channel	10.7		77	75	2.47791667	157.1125	2.58333333	6.8125		7.02083333
Open	10/5/18		Channel	9.2		77	75	2.47791667	157.1125	2.58333333	6.8125		7.02083333
Open	10/5/18		Channel	8.5		77	75	2.47791667	157.1125	2.58333333	6.8125		7.02083333
Open	10/8/18		Channel	6.3		58	105	3.35625	114.4125	3.66666667	7.45833333		7.9375
Open	10/8/18		Channel	6		58	105	3.35625	114.4125	3.66666667	7.45833333		7.9375
Open	10/8/18		Channel	5.2		58	105	3.35625	114.4125	3.66666667	7.45833333		7.9375
Open	10/8/18		Channel	6.1		58	105	3.35625	114.4125	3.66666667	7.45833333		7.9375
ClosedTuesday	10/9/18		Channel	7.5		0	106	3.55378151	108.647059	3.75	8.64583333		8.8125
ClosedTuesday	10/9/18		Channel	7		0	106	3.55378151	108.647059	3.75	8.64583333		8.8125
ClosedTuesday	10/9/18		Channel	9.6		0	106	3.55378151	108.647059	3.75	8.64583333		8.8125
ClosedTuesday	10/9/18		Channel	9.3		0	106	3.55378151	108.647059	3.75	8.64583333		8.8125
Open	10/10/18		Channel	7.6		112	101	3.6012605	110.647059	3.75	8.16666667		8.8125
Open	10/10/18		Channel	7.9		112	101	3.6012605	110.647059	3.75	8.16666667		8.8125
Open	10/10/18		Channel	8.4		112	101	3.6012605	110.647059	3.75	8.16666667		8.8125
Open	10/10/18		Channel	6.1		112	101	3.6012605	110.647059	3.75	8.16666667		8.8125
Open	10/11/18		Channel	7.6		96	91	3.30416667	142.029167	3	8.95833333		9.25

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
Open	10/11/18		Channel	7.1		96	91	3.30416667	142.029167	3	8.95833333		9.25
Open	10/11/18		Channel	8.3		96	91	3.30416667	142.029167	3	8.95833333		9.25
Open	10/11/18		Channel	7.1		96	91	3.30416667	142.029167	3	8.95833333		9.25
Open	10/12/18		Channel	10.5		97	79	3.24978903	153.734177	2.63829787	8.93617021		9.42553191
Open	10/12/18		Channel	10.3		97	79	3.24978903	153.734177	2.63829787	8.93617021		9.42553191
Open	10/12/18		Channel	8.4		97	79	3.24978903	153.734177	2.63829787	8.93617021		9.42553191
Open	10/12/18		Channel	7.5		97	79	3.24978903	153.734177	2.63829787	8.93617021		9.42553191
Open	10/14/18		Channel	8.5		86	52	2.74166667	241.866667	2	7.70833333		8.79166667
Open	10/14/18		Channel	8.1		86	52	2.74166667	241.866667	2	7.70833333		8.79166667
Open	10/14/18		Channel	6.9		86	52	2.74166667	241.866667	2	7.70833333		8.79166667
Open	10/14/18		Channel	6.9		86	52	2.74166667	241.866667	2	7.70833333		8.79166667
ClosedTuesday	10/16/18		Channel	10.9		0	33	5.4425	81.7666667	2.95833333	18.3541667		9.39583333
ClosedTuesday	10/16/18		Channel	10.5		0	33	5.4425	81.7666667	2.95833333	18.3541667		9.39583333
ClosedTuesday	10/16/18		Channel	12.4		0	33	5.4425	81.7666667	2.95833333	18.3541667		9.39583333
ClosedTuesday	10/16/18		Channel	12.3		0	33	5.4425	81.7666667	2.95833333	18.3541667		9.39583333
Open	10/20/18		Channel	10.5		61	62	3.56458333	139.325	2.54166667	31.8541667		9.79166667
Open	10/20/18		Channel	9.3		61	62	3.56458333	139.325	2.54166667	31.8541667		9.79166667
Open	10/20/18		Channel	9.8		61	62	3.56458333	139.325	2.54166667	31.8541667		9.79166667
Open	10/20/18		Channel	8.5		61	62	3.56458333	139.325	2.54166667	31.8541667		9.79166667
Open	10/21/18		Channel	7.1		65	73	4.89497908	101.054393	2.9375	29.6666667		9.375
Open	10/21/18		Channel	7.5		65	73	4.89497908	101.054393	2.9375	29.6666667		9.375
Open	10/21/18		Channel	7.1		65	73	4.89497908	101.054393	2.9375	29.6666667		9.375
Open	10/21/18		Channel	7.1		65	73	4.89497908	101.054393	2.9375	29.6666667		9.375
ClosedTuesday	10/23/18		Channel	12.2		0	91	4.17875	80.7875	2.97916667	16.3333333		6.875
ClosedTuesday	10/23/18		Channel	11.8		0	91	4.17875	80.7875	2.97916667	16.3333333		6.875

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
ClosedTuesday	10/23/18		Channel	12.4		0	91	4.17875	80.7875	2.97916667	16.3333333		6.875
ClosedTuesday	10/23/18		Channel	11.8		0	91	4.17875	80.7875	2.97916667	16.3333333		6.875
Open	10/24/18		Channel	7.9		89	95	4.5325	69.6583333	3.52083333	23.0416667		6.625
Open	10/24/18		Channel	7.8		89	95	4.5325	69.6583333	3.52083333	23.0416667		6.625
Open	10/24/18		Channel	8.6		89	95	4.5325	69.6583333	3.52083333	23.0416667		6.625
Open	10/24/18		Channel	8.1		89	95	4.5325	69.6583333	3.52083333	23.0416667		6.625
Open	10/5/18		Channel	10.8			75	2.47791667	157.1125	2.58333333	6.8125		7.02083333
Open	10/5/18		Channel	10.7			75	2.47791667	157.1125	2.58333333	6.8125		7.02083333
Open	10/5/18		Channel	9.2			75	2.47791667	157.1125	2.58333333	6.8125		7.02083333
Open	10/5/18		Channel	8.5			75	2.47791667	157.1125	2.58333333	6.8125		7.02083333
Open	10/8/18		Channel	6.3		62	105	3.35625	114.4125	3.66666667	7.45833333		7.9375
Open	10/8/18		Channel	6		62	105	3.35625	114.4125	3.66666667	7.45833333		7.9375
Open	10/8/18		Channel	5.2		62	105	3.35625	114.4125	3.66666667	7.45833333		7.9375
Open	10/8/18		Channel	6.1		62	105	3.35625	114.4125	3.66666667	7.45833333		7.9375
ClosedTuesday	10/9/18		Channel	7.5		0	106	3.55378151	108.647059	3.75	8.64583333		8.8125
ClosedTuesday	10/9/18		Channel	7		0	106	3.55378151	108.647059	3.75	8.64583333		8.8125
ClosedTuesday	10/9/18		Channel	9.6		0	106	3.55378151	108.647059	3.75	8.64583333		8.8125
ClosedTuesday	10/9/18		Channel	9.3		0	106	3.55378151	108.647059	3.75	8.64583333		8.8125
Open	10/10/18		Channel	7.6		43	101	3.6012605	110.647059	3.75	8.16666667		8.8125
Open	10/10/18		Channel	7.9		43	101	3.6012605	110.647059	3.75	8.16666667		8.8125
Open	10/10/18		Channel	8.4		43	101	3.6012605	110.647059	3.75	8.16666667		8.8125
Open	10/10/18		Channel	6.1		43	101	3.6012605	110.647059	3.75	8.16666667		8.8125
Open	10/11/18		Channel	7.6		56	91	3.30416667	142.029167	3	8.95833333		9.25
Open	10/11/18		Channel	7.1		56	91	3.30416667	142.029167	3	8.95833333		9.25
Open	10/11/18		Channel	8.3		56	91	3.30416667	142.029167	3	8.95833333		9.25

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
Open	10/11/18		Channel	7.1		56	91	3.30416667	142.029167	3	8.95833333		9.25
Open	10/12/18		Channel	10.5		38	79	3.24978903	153.734177	2.63829787	8.93617021		9.42553191
Open	10/12/18		Channel	10.3		38	79	3.24978903	153.734177	2.63829787	8.93617021		9.42553191
Open	10/12/18		Channel	8.4		38	79	3.24978903	153.734177	2.63829787	8.93617021		9.42553191
Open	10/12/18		Channel	7.5		38	79	3.24978903	153.734177	2.63829787	8.93617021		9.42553191
Open	10/14/18		Channel	8.5		49	52	2.74166667	241.866667	2	7.70833333		8.79166667
Open	10/14/18		Channel	8.1		49	52	2.74166667	241.866667	2	7.70833333		8.79166667
Open	10/14/18		Channel	6.9		49	52	2.74166667	241.866667	2	7.70833333		8.79166667
Open	10/14/18		Channel	6.9		49	52	2.74166667	241.866667	2	7.70833333		8.79166667
ClosedTuesday	10/16/18		Channel	10.9		0	33	5.4425	81.7666667	2.95833333	18.3541667		9.39583333
ClosedTuesday	10/16/18		Channel	10.5		0	33	5.4425	81.7666667	2.95833333	18.3541667		9.39583333
ClosedTuesday	10/16/18		Channel	12.4		0	33	5.4425	81.7666667	2.95833333	18.3541667		9.39583333
ClosedTuesday	10/16/18		Channel	12.3		0	33	5.4425	81.7666667	2.95833333	18.3541667		9.39583333
Open	10/20/18		Channel	10.5		27	62	3.56458333	139.325	2.54166667	31.8541667		9.79166667
Open	10/20/18		Channel	9.3		27	62	3.56458333	139.325	2.54166667	31.8541667		9.79166667
Open	10/20/18		Channel	9.8		27	62	3.56458333	139.325	2.54166667	31.8541667		9.79166667
Open	10/20/18		Channel	8.5		27	62	3.56458333	139.325	2.54166667	31.8541667		9.79166667
Open	10/21/18		Channel	7.1		31	73	4.89497908	101.054393	2.9375	29.6666667		9.375
Open	10/21/18		Channel	7.5		31	73	4.89497908	101.054393	2.9375	29.6666667		9.375
Open	10/21/18		Channel	7.1		31	73	4.89497908	101.054393	2.9375	29.6666667		9.375
Open	10/21/18		Channel	7.1		31	73	4.89497908	101.054393	2.9375	29.6666667		9.375
ClosedTuesday	10/23/18		Channel	12.2		0	91	4.17875	80.7875	2.97916667	16.3333333		6.875
ClosedTuesday	10/23/18		Channel	11.8		0	91	4.17875	80.7875	2.97916667	16.3333333		6.875
ClosedTuesday	10/23/18		Channel	12.4		0	91	4.17875	80.7875	2.97916667	16.3333333		6.875
ClosedTuesday	10/23/18		Channel	11.8		0	91	4.17875	80.7875	2.97916667	16.3333333		6.875

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
Open	10/24/18		Channel	7.9		53	95	4.5325	69.6583333	3.52083333	23.0416667		6.625
Open	10/24/18		Channel	7.8		53	95	4.5325	69.6583333	3.52083333	23.0416667		6.625
Open	10/24/18		Channel	8.6		53	95	4.5325	69.6583333	3.52083333	23.0416667		6.625
Open	10/24/18		Channel	8.1		53	95	4.5325	69.6583333	3.52083333	23.0416667		6.625
Open	10/5/18		WitchesBrew	3.2		11	75	2.47791667	157.1125	2.58333333	6.8125		7.02083333
Open	10/5/18		WitchesBrew	2.8		11	75	2.47791667	157.1125	2.58333333	6.8125		7.02083333
Open	10/5/18		WitchesBrew	3.5		11	75	2.47791667	157.1125	2.58333333	6.8125		7.02083333
Open	10/5/18		WitchesBrew	3.2		11	75	2.47791667	157.1125	2.58333333	6.8125		7.02083333
Open	10/8/18		WitchesBrew	5.2		20	105	3.35625	114.4125	3.66666667	7.45833333		7.9375
Open	10/8/18		WitchesBrew	3.9		20	105	3.35625	114.4125	3.66666667	7.45833333		7.9375
Open	10/8/18		WitchesBrew	4.6		20	105	3.35625	114.4125	3.66666667	7.45833333		7.9375
Open	10/8/18		WitchesBrew	3.8		20	105	3.35625	114.4125	3.66666667	7.45833333		7.9375
ClosedTuesday	10/9/18		WitchesBrew	6.1		0	106	3.55378151	108.647059	3.75	8.64583333		8.8125
ClosedTuesday	10/9/18		WitchesBrew	5.8		0	106	3.55378151	108.647059	3.75	8.64583333		8.8125
ClosedTuesday	10/9/18		WitchesBrew	6.2		0	106	3.55378151	108.647059	3.75	8.64583333		8.8125
ClosedTuesday	10/9/18		WitchesBrew	5.9		0	106	3.55378151	108.647059	3.75	8.64583333		8.8125
Open	10/10/18		WitchesBrew	4.7		16	101	3.6012605	110.647059	3.75	8.16666667		8.8125
Open	10/10/18		WitchesBrew	5.1		16	101	3.6012605	110.647059	3.75	8.16666667		8.8125
Open	10/10/18		WitchesBrew	5.1		16	101	3.6012605	110.647059	3.75	8.16666667		8.8125
Open	10/10/18		WitchesBrew	5.1		16	101	3.6012605	110.647059	3.75	8.16666667		8.8125
Open	10/11/18		WitchesBrew	5.8		2	91	3.30416667	142.029167	3	8.95833333		9.25
Open	10/11/18		WitchesBrew	5.7		2	91	3.30416667	142.029167	3	8.95833333		9.25
Open	10/11/18		WitchesBrew	6.3		2	91	3.30416667	142.029167	3	8.95833333		9.25
Open	10/11/18		WitchesBrew	5.8		2	91	3.30416667	142.029167	3	8.95833333		9.25
Open	10/12/18		WitchesBrew	5.7		10	79	3.24978903	153.734177	2.63829787	8.93617021		9.42553191

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
Open	10/12/18		WitchesBrew	4.9		10	79	3.24978903	153.734177	2.63829787	8.93617021		9.42553191
Open	10/12/18		WitchesBrew	5.1		10	79	3.24978903	153.734177	2.63829787	8.93617021		9.42553191
Open	10/12/18		WitchesBrew	5.1		10	79	3.24978903	153.734177	2.63829787	8.93617021		9.42553191
Open	10/14/18		WitchesBrew	4.1		13	52	2.74166667	241.866667	2	7.70833333		8.79166667
Open	10/14/18		WitchesBrew	3.9		13	52	2.74166667	241.866667	2	7.70833333		8.79166667
Open	10/14/18		WitchesBrew	3.5		13	52	2.74166667	241.866667	2	7.70833333		8.79166667
Open	10/14/18		WitchesBrew	3.5		13	52	2.74166667	241.866667	2	7.70833333		8.79166667
ClosedTuesday	10/16/18		WitchesBrew	7.1		0	33	5.4425	81.7666667	2.95833333	18.3541667		9.39583333
ClosedTuesday	10/16/18		WitchesBrew	6.6		0	33	5.4425	81.7666667	2.95833333	18.3541667		9.39583333
ClosedTuesday	10/16/18		WitchesBrew	7.1		0	33	5.4425	81.7666667	2.95833333	18.3541667		9.39583333
ClosedTuesday	10/16/18		WitchesBrew	6.8		0	33	5.4425	81.7666667	2.95833333	18.3541667		9.39583333
Open	10/20/18		WitchesBrew	6.1		6	62	3.56458333	139.325	2.54166667	31.8541667		9.79166667
Open	10/20/18		WitchesBrew	4.9		6	62	3.56458333	139.325	2.54166667	31.8541667		9.79166667
Open	10/20/18		WitchesBrew	5		6	62	3.56458333	139.325	2.54166667	31.8541667		9.79166667
Open	10/20/18		WitchesBrew	4.2		6	62	3.56458333	139.325	2.54166667	31.8541667		9.79166667
Open	10/21/18		WitchesBrew	3.9		1	73	4.89497908	101.054393	2.9375	29.6666667		9.375
Open	10/21/18		WitchesBrew	3.3		1	73	4.89497908	101.054393	2.9375	29.6666667		9.375
Open	10/21/18		WitchesBrew	3.4		1	73	4.89497908	101.054393	2.9375	29.6666667		9.375
Open	10/21/18		WitchesBrew	3.5		1	73	4.89497908	101.054393	2.9375	29.6666667		9.375
ClosedTuesday	10/23/18		WitchesBrew	11.1		0	91	4.17875	80.7875	2.97916667	16.3333333		6.875
ClosedTuesday	10/23/18		WitchesBrew	10.8		0	91	4.17875	80.7875	2.97916667	16.3333333		6.875
ClosedTuesday	10/23/18		WitchesBrew	11.3		0	91	4.17875	80.7875	2.97916667	16.3333333		6.875
ClosedTuesday	10/23/18		WitchesBrew	11.1		0	91	4.17875	80.7875	2.97916667	16.3333333		6.875
Open	10/24/18		WitchesBrew	4.8		16	95	4.5325	69.6583333	3.52083333	23.0416667		6.625
Open	10/24/18		WitchesBrew	4.8		16	95	4.5325	69.6583333	3.52083333	23.0416667		6.625

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
Open	10/24/18		WitchesBrew	4.6		16	95	4.5325	69.6583333	3.52083333	23.0416667		6.625
Open	10/24/18		WitchesBrew	4.3		16	95	4.5325	69.6583333	3.52083333	23.0416667		6.625
Open	10/5/18		WitchesBrew	2.7		2	75	2.47791667	157.1125	2.58333333	6.8125		7.02083333
Open	10/5/18		WitchesBrew	1.9		2	75	2.47791667	157.1125	2.58333333	6.8125		7.02083333
Open	10/5/18		WitchesBrew	2.3		2	75	2.47791667	157.1125	2.58333333	6.8125		7.02083333
Open	10/5/18		WitchesBrew	1.8		2	75	2.47791667	157.1125	2.58333333	6.8125		7.02083333
Open	10/8/18		WitchesBrew	4.2		0	105	3.35625	114.4125	3.66666667	7.45833333		7.9375
Open	10/8/18		WitchesBrew	3.5		0	105	3.35625	114.4125	3.66666667	7.45833333		7.9375
Open	10/8/18		WitchesBrew	4.4		0	105	3.35625	114.4125	3.66666667	7.45833333		7.9375
Open	10/8/18		WitchesBrew	3.5		0	105	3.35625	114.4125	3.66666667	7.45833333		7.9375
ClosedTuesday	10/9/18		WitchesBrew	5.1		0	106	3.55378151	108.647059	3.75	8.64583333		8.8125
ClosedTuesday	10/9/18		WitchesBrew	5.8		0	106	3.55378151	108.647059	3.75	8.64583333		8.8125
ClosedTuesday	10/9/18		WitchesBrew	5.8		0	106	3.55378151	108.647059	3.75	8.64583333		8.8125
ClosedTuesday	10/9/18		WitchesBrew	5.5		0	106	3.55378151	108.647059	3.75	8.64583333		8.8125
Open	10/10/18		WitchesBrew	5.3		6	101	3.6012605	110.647059	3.75	8.16666667		8.8125
Open	10/10/18		WitchesBrew	5.1		6	101	3.6012605	110.647059	3.75	8.16666667		8.8125
Open	10/10/18		WitchesBrew	4.7		6	101	3.6012605	110.647059	3.75	8.16666667		8.8125
Open	10/10/18		WitchesBrew	4.3		6	101	3.6012605	110.647059	3.75	8.16666667		8.8125
Open	10/11/18		WitchesBrew	4.4		0	91	3.30416667	142.029167	3	8.95833333		9.25
Open	10/11/18		WitchesBrew	4.3		0	91	3.30416667	142.029167	3	8.95833333		9.25
Open	10/11/18		WitchesBrew	4.1		0	91	3.30416667	142.029167	3	8.95833333		9.25
Open	10/11/18		WitchesBrew	3.9		0	91	3.30416667	142.029167	3	8.95833333		9.25
Open	10/12/18		WitchesBrew	4.8		6	79	3.24978903	153.734177	2.63829787	8.93617021		9.42553191
Open	10/12/18		WitchesBrew	4.1		6	79	3.24978903	153.734177	2.63829787	8.93617021		9.42553191
Open	10/12/18		WitchesBrew	3.9		6	79	3.24978903	153.734177	2.63829787	8.93617021		9.42553191

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
Open	10/12/18		WitchesBrew	4.6		6	79	3.24978903	153.734177	2.63829787	8.93617021		9.42553191
Open	10/14/18		WitchesBrew	3.6		2	52	2.74166667	241.866667	2	7.70833333		8.79166667
Open	10/14/18		WitchesBrew	2.5		2	52	2.74166667	241.866667	2	7.70833333		8.79166667
Open	10/14/18		WitchesBrew	3		2	52	2.74166667	241.866667	2	7.70833333		8.79166667
Open	10/14/18		WitchesBrew	2.9		2	52	2.74166667	241.866667	2	7.70833333		8.79166667
ClosedTuesday	10/16/18		WitchesBrew	4.2		0	33	5.4425	81.7666667	2.95833333	18.3541667		9.39583333
ClosedTuesday	10/16/18		WitchesBrew	4.1		0	33	5.4425	81.7666667	2.95833333	18.3541667		9.39583333
ClosedTuesday	10/16/18		WitchesBrew	4.8		0	33	5.4425	81.7666667	2.95833333	18.3541667		9.39583333
ClosedTuesday	10/16/18		WitchesBrew	4.5		0	33	5.4425	81.7666667	2.95833333	18.3541667		9.39583333
Open	10/20/18		WitchesBrew	4.6		2	62	3.56458333	139.325	2.54166667	31.8541667		9.79166667
Open	10/20/18		WitchesBrew	4.5		2	62	3.56458333	139.325	2.54166667	31.8541667		9.79166667
Open	10/20/18		WitchesBrew	5.2		2	62	3.56458333	139.325	2.54166667	31.8541667		9.79166667
Open	10/20/18		WitchesBrew	3.5		2	62	3.56458333	139.325	2.54166667	31.8541667		9.79166667
Open	10/21/18		WitchesBrew	4.2		0	73	4.89497908	101.054393	2.9375	29.6666667		9.375
Open	10/21/18		WitchesBrew	3.8		0	73	4.89497908	101.054393	2.9375	29.6666667		9.375
Open	10/21/18		WitchesBrew	4		0	73	4.89497908	101.054393	2.9375	29.6666667		9.375
Open	10/21/18		WitchesBrew	3.6		0	73	4.89497908	101.054393	2.9375	29.6666667		9.375
ClosedTuesday	10/23/18		WitchesBrew	8.4		0	91	4.17875	80.7875	2.97916667	16.3333333		6.875
ClosedTuesday	10/23/18		WitchesBrew	8.2		0	91	4.17875	80.7875	2.97916667	16.3333333		6.875
ClosedTuesday	10/23/18		WitchesBrew	9.4		0	91	4.17875	80.7875	2.97916667	16.3333333		6.875
ClosedTuesday	10/23/18		WitchesBrew	9.2		0	91	4.17875	80.7875	2.97916667	16.3333333		6.875
Open	10/24/18		WitchesBrew	3.9		5	95	4.5325	69.6583333	3.52083333	23.0416667		6.625
Open	10/24/18		WitchesBrew	4		5	95	4.5325	69.6583333	3.52083333	23.0416667		6.625
Open	10/24/18		WitchesBrew	4.2		5	95	4.5325	69.6583333	3.52083333	23.0416667		6.625
Open	10/24/18		WitchesBrew	3.6		5	95	4.5325	69.6583333	3.52083333	23.0416667		6.625

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
Open	6/1/18		Backdoors	5.2		35	65	4.65371901	73.6652893	6.70833333	9.97916667		8.39583333
Open	6/1/18		Backdoors	4.9		35	65	4.65371901	73.6652893	6.70833333	9.97916667		8.39583333
Open	6/1/18		Backdoors	5		35	65	4.65371901	73.6652893	6.70833333	9.97916667		8.39583333
Open	6/1/18		Backdoors	4		35	65	4.65371901	73.6652893	6.70833333	9.97916667		8.39583333
ClosedTuesday	6/5/18		Backdoors	10.6		0	44	3.99918367	113.281633	7.35416667	14.5208333		7.75
ClosedTuesday	6/5/18		Backdoors	9.9		0	44	3.99918367	113.281633	7.35416667	14.5208333		7.75
ClosedTuesday	6/5/18		Backdoors	9.7		0	44	3.99918367	113.281633	7.35416667	14.5208333		7.75
ClosedTuesday	6/5/18		Backdoors	8.9		0	44	3.99918367	113.281633	7.35416667	14.5208333		7.75
Open	6/6/18		Backdoors	7.3		36	45	4.33428571	80.8612245	7.02083333	13.64583		7.9375
Open	6/6/18		Backdoors	6.4		36	45	4.33428571	80.8612245	7.02083333	13.64583		7.9375
Open	6/6/18		Backdoors	8.2		36	45	4.33428571	80.8612245	7.02083333	13.64583		7.9375
Open	6/6/18		Backdoors	8		36	45	4.33428571	80.8612245	7.02083333	13.64583		7.9375
Open	6/7/18		Backdoors	8.4		30	51	4.22780083	107.858921	6.75	12.6458333		7.9375
Open	6/7/18		Backdoors	8.6		30	51	4.22780083	107.858921	6.75	12.6458333		7.9375
Open	6/7/18		Backdoors	8.4		30	51	4.22780083	107.858921	6.75	12.6458333		7.9375
Open	6/7/18		Backdoors	7.6		30	51	4.22780083	107.858921	6.75	12.6458333		7.9375
Open	6/8/18		Backdoors	5.1		13	59	3.75206612	93.0909091	5.125	11.8125		7.79166667
Open	6/8/18		Backdoors	4.6		13	59	3.75206612	93.0909091	5.125	11.8125		7.79166667
Open	6/8/18		Backdoors	4.6		13	59	3.75206612	93.0909091	5.125	11.8125		7.79166667
Open	6/8/18		Backdoors	4.6		13	59	3.75206612	93.0909091	5.125	11.8125		7.79166667
Open	6/10/18		Backdoors	5.2		6	80	4.25731707	75.7235772	6.78723404	13.5531915		7.76595745
Open	6/10/18		Backdoors	5.2		6	80	4.25731707	75.7235772	6.78723404	13.5531915		7.76595745
Open	6/10/18		Backdoors	5		6	80	4.25731707	75.7235772	6.78723404	13.5531915		7.76595745
Open	6/10/18		Backdoors	4.6		6	80	4.25731707	75.7235772	6.78723404	13.5531915		7.76595745
ClosedTuesday	6/12/18		Backdoors	5.7		0	96	4.98974359	72.4871795	6.04166667	11.1875		7.875

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
ClosedTuesday	6/12/18		Backdoors	4.9		0	96	4.98974359	72.4871795	6.04166667	11.1875		7.875
ClosedTuesday	6/12/18		Backdoors	5.2		0	96	4.98974359	72.4871795	6.04166667	11.1875		7.875
ClosedTuesday	6/12/18		Backdoors	5.3		0	96	4.98974359	72.4871795	6.04166667	11.1875		7.875
Open	6/16/18		Backdoors	6.3		17	85	3.66182573	154.182573	3.79166667	13.6458333		8.08333333
Open	6/16/18		Backdoors	5.5		17	85	3.66182573	154.182573	3.79166667	13.6458333		8.08333333
Open	6/16/18		Backdoors	5.6		17	85	3.66182573	154.182573	3.79166667	13.6458333		8.08333333
Open	6/16/18		Backdoors	5.4		17	85	3.66182573	154.182573	3.79166667	13.6458333		8.08333333
Open	6/17/18		Backdoors	11		45	75	3.08962656	168.290456	3	14.9583333		8.29166667
Open	6/17/18		Backdoors	10.6		45	75	3.08962656	168.290456	3	14.9583333		8.29166667
Open	6/17/18		Backdoors	11.5		45	75	3.08962656	168.290456	3	14.9583333		8.29166667
Open	6/17/18		Backdoors	10.8		45	75	3.08962656	168.290456	3	14.9583333		8.29166667
ClosedTuesday	6/19/18		Backdoors	13.8		0	60	3.7553719	112.665289	2.97916667	6.08333333		8.95833333
ClosedTuesday	6/19/18		Backdoors	14.1		0	60	3.7553719	112.665289	2.97916667	6.08333333		8.95833333
ClosedTuesday	6/19/18		Backdoors	16.25		0	60	3.7553719	112.665289	2.97916667	6.08333333		8.95833333
ClosedTuesday	6/19/18		Backdoors	17.1		0	60	3.7553719	112.665289	2.97916667	6.08333333		8.95833333
Open	6/20/18		Backdoors	9.5		39	57	3.75884774	103.473251	2.97916667	6.0625		9
Open	6/20/18		Backdoors	8.5		39	57	3.75884774	103.473251	2.97916667	6.0625		9
Open	6/20/18		Backdoors	7.9		39	57	3.75884774	103.473251	2.97916667	6.0625		9
Open	6/20/18		Backdoors	7.5		39	57	3.75884774	103.473251	2.97916667	6.0625		9
Open	6/28/18		Backdoors	6.9		48	75	5.11643836	69.5525114	7.97916667	7.5625		8.47916667
Open	6/28/18		Backdoors	6		48	75	5.11643836	69.5525114	7.97916667	7.5625		8.47916667
Open	6/28/18		Backdoors	7.9		48	75	5.11643836	69.5525114	7.97916667	7.5625		8.47916667
Open	6/28/18		Backdoors	7.1		48	75	5.11643836	69.5525114	7.97916667	7.5625		8.47916667
Open	6/1/18		Backdoors	6.7		35	65	4.65371901	73.6652893	6.70833333	9.97916667		8.39583333
Open	6/1/18		Backdoors	5.4		35	65	4.65371901	73.6652893	6.70833333	9.97916667		8.39583333

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
Open	6/1/18		Backdoors	9		35	65	4.65371901	73.6652893	6.70833333	9.97916667		8.39583333
Open	6/1/18		Backdoors	4.9		35	65	4.65371901	73.6652893	6.70833333	9.97916667		8.39583333
ClosedTuesday	6/5/18		Backdoors	8.9		0	44	3.99918367	113.281633	7.35416667	14.5208333		7.75
ClosedTuesday	6/5/18		Backdoors	8.65		0	44	3.99918367	113.281633	7.35416667	14.5208333		7.75
ClosedTuesday	6/5/18		Backdoors	8.4		0	44	3.99918367	113.281633	7.35416667	14.5208333		7.75
ClosedTuesday	6/5/18		Backdoors	7.6		0	44	3.99918367	113.281633	7.35416667	14.5208333		7.75
Open	6/6/18		Backdoors	8.4		36	45	4.33428571	80.8612245	7.02083333	13.64583		7.9375
Open	6/6/18		Backdoors	9.7		36	45	4.33428571	80.8612245	7.02083333	13.64583		7.9375
Open	6/6/18		Backdoors	7.8		36	45	4.33428571	80.8612245	7.02083333	13.64583		7.9375
Open	6/6/18		Backdoors	8.5		36	45	4.33428571	80.8612245	7.02083333	13.64583		7.9375
Open	6/7/18		Backdoors	9.2		30	51	4.22780083	107.858921	6.75	12.6458333		7.9375
Open	6/7/18		Backdoors	9		30	51	4.22780083	107.858921	6.75	12.6458333		7.9375
Open	6/7/18		Backdoors	9.2		30	51	4.22780083	107.858921	6.75	12.6458333		7.9375
Open	6/7/18		Backdoors	9.6		30	51	4.22780083	107.858921	6.75	12.6458333		7.9375
Open	6/8/18		Backdoors	6.1		13	59	3.75206612	93.0909091	5.125	11.8125		7.79166667
Open	6/8/18		Backdoors	5.9		13	59	3.75206612	93.0909091	5.125	11.8125		7.79166667
Open	6/8/18		Backdoors	5.4		13	59	3.75206612	93.0909091	5.125	11.8125		7.79166667
Open	6/8/18		Backdoors	6.1		13	59	3.75206612	93.0909091	5.125	11.8125		7.79166667
Open	6/10/18		Backdoors	5.5		6	80	4.25731707	75.7235772	6.78723404	13.5531915		7.76595745
Open	6/10/18		Backdoors	5.3		6	80	4.25731707	75.7235772	6.78723404	13.5531915		7.76595745
Open	6/10/18		Backdoors	6.1		6	80	4.25731707	75.7235772	6.78723404	13.5531915		7.76595745
Open	6/10/18		Backdoors	4.9		6	80	4.25731707	75.7235772	6.78723404	13.5531915		7.76595745
ClosedTuesday	6/12/18		Backdoors	5.8		0	96	4.98974359	72.4871795	6.04166667	11.1875		7.875
ClosedTuesday	6/12/18		Backdoors	5.2		0	96	4.98974359	72.4871795	6.04166667	11.1875		7.875
ClosedTuesday	6/12/18		Backdoors	5.2		0	96	4.98974359	72.4871795	6.04166667	11.1875		7.875

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
ClosedTuesday	6/12/18		Backdoors	5.4		0	96	4.98974359	72.4871795	6.04166667	11.1875		7.875
Open	6/16/18		Backdoors	6.5		17	85	3.66182573	154.182573	3.79166667	13.6458333		8.08333333
Open	6/16/18		Backdoors	6.2		17	85	3.66182573	154.182573	3.79166667	13.6458333		8.08333333
Open	6/16/18		Backdoors	6.6		17	85	3.66182573	154.182573	3.79166667	13.6458333		8.08333333
Open	6/16/18		Backdoors	6.1		17	85	3.66182573	154.182573	3.79166667	13.6458333		8.08333333
Open	6/17/18		Backdoors	13.8		45	75	3.08962656	168.290456	3	14.9583333		8.29166667
Open	6/17/18		Backdoors	13.2		45	75	3.08962656	168.290456	3	14.9583333		8.29166667
Open	6/17/18		Backdoors	13.4		45	75	3.08962656	168.290456	3	14.9583333		8.29166667
Open	6/17/18		Backdoors	13.2		45	75	3.08962656	168.290456	3	14.9583333		8.29166667
ClosedTuesday	6/19/18		Backdoors	18.6		0	60	3.7553719	112.665289	2.97916667	6.08333333		8.95833333
ClosedTuesday	6/19/18		Backdoors	19.5		0	60	3.7553719	112.665289	2.97916667	6.08333333		8.95833333
ClosedTuesday	6/19/18		Backdoors	17.9		0	60	3.7553719	112.665289	2.97916667	6.08333333		8.95833333
ClosedTuesday	6/19/18		Backdoors	16.7		0	60	3.7553719	112.665289	2.97916667	6.08333333		8.95833333
Open	6/20/18		Backdoors	11.7		39	57	3.75884774	103.473251	2.97916667	6.0625		9
Open	6/20/18		Backdoors	11.5		39	57	3.75884774	103.473251	2.97916667	6.0625		9
Open	6/20/18		Backdoors	10.8		39	57	3.75884774	103.473251	2.97916667	6.0625		9
Open	6/20/18		Backdoors	8.5		39	57	3.75884774	103.473251	2.97916667	6.0625		9
Open	6/28/18		Backdoors	6.4		48	75	5.11643836	69.5525114	7.97916667	7.5625		8.47916667
Open	6/28/18		Backdoors	6.1		48	75	5.11643836	69.5525114	7.97916667	7.5625		8.47916667
Open	6/28/18		Backdoors	7.2		48	75	5.11643836	69.5525114	7.97916667	7.5625		8.47916667
Open	6/28/18		Backdoors	7.4		48	75	5.11643836	69.5525114	7.97916667	7.5625		8.47916667
Open	6/1/18		Keyhole	6.5		269	65	4.65371901	73.6652893	6.70833333	9.97916667		8.39583333
Open	6/1/18		Keyhole	5.6		269	65	4.65371901	73.6652893	6.70833333	9.97916667		8.39583333
Open	6/1/18		Keyhole	7.4		269	65	4.65371901	73.6652893	6.70833333	9.97916667		8.39583333
Open	6/1/18		Keyhole	3.2		269	65	4.65371901	73.6652893	6.70833333	9.97916667		8.39583333

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
ClosedTuesday	6/5/18		Keyhole	7.4		0	44	3.99918367	113.281633	7.35416667	14.5208333		7.75
ClosedTuesday	6/5/18		Keyhole	6.7		0	44	3.99918367	113.281633	7.35416667	14.5208333		7.75
ClosedTuesday	6/5/18		Keyhole	7.2		0	44	3.99918367	113.281633	7.35416667	14.5208333		7.75
ClosedTuesday	6/5/18		Keyhole	6.3		0	44	3.99918367	113.281633	7.35416667	14.5208333		7.75
Open	6/6/18		Keyhole	8.4		377	45	4.33428571	80.8612245	7.02083333	13.64583		7.9375
Open	6/6/18		Keyhole	8.2		377	45	4.33428571	80.8612245	7.02083333	13.64583		7.9375
Open	6/6/18		Keyhole	6.7		377	45	4.33428571	80.8612245	7.02083333	13.64583		7.9375
Open	6/6/18		Keyhole	6		377	45	4.33428571	80.8612245	7.02083333	13.64583		7.9375
Open	6/7/18		Keyhole	7.1		277	51	4.22780083	107.858921	6.75	12.6458333		7.9375
Open	6/7/18		Keyhole	7.3		277	51	4.22780083	107.858921	6.75	12.6458333		7.9375
Open	6/7/18		Keyhole	7		277	51	4.22780083	107.858921	6.75	12.6458333		7.9375
Open	6/7/18		Keyhole	7.2		277	51	4.22780083	107.858921	6.75	12.6458333		7.9375
Open	6/8/18		Keyhole	3.4		289	59	3.75206612	93.0909091	5.125	11.8125		7.79166667
Open	6/8/18		Keyhole	2.9		289	59	3.75206612	93.0909091	5.125	11.8125		7.79166667
Open	6/8/18		Keyhole	3.3		289	59	3.75206612	93.0909091	5.125	11.8125		7.79166667
Open	6/8/18		Keyhole	2.4		289	59	3.75206612	93.0909091	5.125	11.8125		7.79166667
Open	6/10/18		Keyhole	4.8		175	80	4.25731707	75.7235772	6.78723404	13.5531915		7.76595745
Open	6/10/18		Keyhole	4.7		175	80	4.25731707	75.7235772	6.78723404	13.5531915		7.76595745
Open	6/10/18		Keyhole	5.1		175	80	4.25731707	75.7235772	6.78723404	13.5531915		7.76595745
Open	6/10/18		Keyhole	4.3		175	80	4.25731707	75.7235772	6.78723404	13.5531915		7.76595745
ClosedTuesday	6/12/18		Keyhole	5.4		0	96	4.98974359	72.4871795	6.04166667	11.1875		7.875
ClosedTuesday	6/12/18		Keyhole	4.3		0	96	4.98974359	72.4871795	6.04166667	11.1875		7.875
ClosedTuesday	6/12/18		Keyhole	5.1		0	96	4.98974359	72.4871795	6.04166667	11.1875		7.875
ClosedTuesday	6/12/18		Keyhole	3.8		0	96	4.98974359	72.4871795	6.04166667	11.1875		7.875
Open	6/16/18		Keyhole	6		238	85	3.66182573	154.182573	3.79166667	13.6458333		8.08333333

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
Open	6/16/18		Keyhole	5.6		238	85	3.66182573	154.182573	3.79166667	13.6458333		8.08333333
Open	6/16/18		Keyhole	5.3		238	85	3.66182573	154.182573	3.79166667	13.6458333		8.08333333
Open	6/16/18		Keyhole	5.2		238	85	3.66182573	154.182573	3.79166667	13.6458333		8.08333333
Open	6/17/18		Keyhole	13.6		292	75	3.08962656	168.290456	3	14.9583333		8.29166667
Open	6/17/18		Keyhole	13.1		292	75	3.08962656	168.290456	3	14.9583333		8.29166667
Open	6/17/18		Keyhole	12		292	75	3.08962656	168.290456	3	14.9583333		8.29166667
Open	6/17/18		Keyhole	12.2		292	75	3.08962656	168.290456	3	14.9583333		8.29166667
ClosedTuesday	6/19/18		Keyhole	15.7		0	60	3.7553719	112.665289	2.97916667	6.08333333		8.95833333
ClosedTuesday	6/19/18		Keyhole	15.8		0	60	3.7553719	112.665289	2.97916667	6.08333333		8.95833333
ClosedTuesday	6/19/18		Keyhole	16.1		0	60	3.7553719	112.665289	2.97916667	6.08333333		8.95833333
ClosedTuesday	6/19/18		Keyhole	15.9		0	60	3.7553719	112.665289	2.97916667	6.08333333		8.95833333
Open	6/20/18		Keyhole	8.2		387	57	3.75884774	103.473251	2.97916667	6.0625		9
Open	6/20/18		Keyhole	8.3		387	57	3.75884774	103.473251	2.97916667	6.0625		9
Open	6/20/18		Keyhole	7		387	57	3.75884774	103.473251	2.97916667	6.0625		9
Open	6/20/18		Keyhole	5.8		387	57	3.75884774	103.473251	2.97916667	6.0625		9
Open	6/28/18		Keyhole	5.5		408	75	5.11643836	69.5525114	7.97916667	7.5625		8.47916667
Open	6/28/18		Keyhole	5.1		408	75	5.11643836	69.5525114	7.97916667	7.5625		8.47916667
Open	6/28/18		Keyhole	5.3		408	75	5.11643836	69.5525114	7.97916667	7.5625		8.47916667
Open	6/28/18		Keyhole	5.1		408	75	5.11643836	69.5525114	7.97916667	7.5625		8.47916667
Open	6/1/18		Keyhole	10.4		269	65	4.65371901	73.6652893	6.70833333	9.97916667		8.39583333
Open	6/1/18		Keyhole	11		269	65	4.65371901	73.6652893	6.70833333	9.97916667		8.39583333
Open	6/1/18		Keyhole	7.8		269	65	4.65371901	73.6652893	6.70833333	9.97916667		8.39583333
Open	6/1/18		Keyhole	5		269	65	4.65371901	73.6652893	6.70833333	9.97916667		8.39583333
ClosedTuesday	6/5/18		Keyhole	11.2		0	44	3.99918367	113.281633	7.35416667	14.5208333		7.75
ClosedTuesday	6/5/18		Keyhole	10.4		0	44	3.99918367	113.281633	7.35416667	14.5208333		7.75

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
ClosedTuesday	6/5/18		Keyhole	10.5		0	44	3.99918367	113.281633	7.35416667	14.5208333		7.75
ClosedTuesday	6/5/18		Keyhole	8.8		0	44	3.99918367	113.281633	7.35416667	14.5208333		7.75
Open	6/6/18		Keyhole	10		377	45	4.33428571	80.8612245	7.02083333	13.64583		7.9375
Open	6/6/18		Keyhole	8.4		377	45	4.33428571	80.8612245	7.02083333	13.64583		7.9375
Open	6/6/18		Keyhole	8.3		377	45	4.33428571	80.8612245	7.02083333	13.64583		7.9375
Open	6/6/18		Keyhole	8.2		377	45	4.33428571	80.8612245	7.02083333	13.64583		7.9375
Open	6/7/18		Keyhole	6		277	51	4.22780083	107.858921	6.75	12.6458333		7.9375
Open	6/7/18		Keyhole	5.7		277	51	4.22780083	107.858921	6.75	12.6458333		7.9375
Open	6/7/18		Keyhole	5.9		277	51	4.22780083	107.858921	6.75	12.6458333		7.9375
Open	6/7/18		Keyhole	5.6		277	51	4.22780083	107.858921	6.75	12.6458333		7.9375
Open	6/8/18		Keyhole	5.1		289	59	3.75206612	93.0909091	5.125	11.8125		7.79166667
Open	6/8/18		Keyhole	4.9		289	59	3.75206612	93.0909091	5.125	11.8125		7.79166667
Open	6/8/18		Keyhole	4.9		289	59	3.75206612	93.0909091	5.125	11.8125		7.79166667
Open	6/8/18		Keyhole	4.9		289	59	3.75206612	93.0909091	5.125	11.8125		7.79166667
Open	6/10/18		Keyhole	5.1		175	80	4.25731707	75.7235772	6.78723404	13.5531915		7.76595745
Open	6/10/18		Keyhole	5		175	80	4.25731707	75.7235772	6.78723404	13.5531915		7.76595745
Open	6/10/18		Keyhole	5		175	80	4.25731707	75.7235772	6.78723404	13.5531915		7.76595745
Open	6/10/18		Keyhole	4.8		175	80	4.25731707	75.7235772	6.78723404	13.5531915		7.76595745
ClosedTuesday	6/12/18		Keyhole	5.9		0	96	4.98974359	72.4871795	6.04166667	11.1875		7.875
ClosedTuesday	6/12/18		Keyhole	5.5		0	96	4.98974359	72.4871795	6.04166667	11.1875		7.875
ClosedTuesday	6/12/18		Keyhole	5.9		0	96	4.98974359	72.4871795	6.04166667	11.1875		7.875
ClosedTuesday	6/12/18		Keyhole	5.7		0	96	4.98974359	72.4871795	6.04166667	11.1875		7.875
Open	6/16/18		Keyhole	6.4		238	85	3.66182573	154.182573	3.79166667	13.6458333		8.08333333
Open	6/16/18		Keyhole	5.7		238	85	3.66182573	154.182573	3.79166667	13.6458333		8.08333333
Open	6/16/18		Keyhole	5.9		238	85	3.66182573	154.182573	3.79166667	13.6458333		8.08333333

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
Open	6/16/18		Keyhole	6		238	85	3.66182573	154.182573	3.79166667	13.6458333		8.08333333
Open	6/17/18		Keyhole	10.6		292	75	3.08962656	168.290456	3	14.9583333		8.29166667
Open	6/17/18		Keyhole	9.9		292	75	3.08962656	168.290456	3	14.9583333		8.29166667
Open	6/17/18		Keyhole	12.1		292	75	3.08962656	168.290456	3	14.9583333		8.29166667
Open	6/17/18		Keyhole	10.8		292	75	3.08962656	168.290456	3	14.9583333		8.29166667
ClosedTuesday	6/19/18		Keyhole	16.9		0	60	3.7553719	112.665289	2.97916667	6.08333333		8.95833333
ClosedTuesday	6/19/18		Keyhole	17.1		0	60	3.7553719	112.665289	2.97916667	6.08333333		8.95833333
ClosedTuesday	6/19/18		Keyhole	16.5		0	60	3.7553719	112.665289	2.97916667	6.08333333		8.95833333
ClosedTuesday	6/19/18		Keyhole	16.2		0	60	3.7553719	112.665289	2.97916667	6.08333333		8.95833333
Open	6/20/18		Keyhole	3.5		387	57	3.75884774	103.473251	2.97916667	6.0625		9
Open	6/20/18		Keyhole	3.3		387	57	3.75884774	103.473251	2.97916667	6.0625		9
Open	6/20/18		Keyhole	2.4		387	57	3.75884774	103.473251	2.97916667	6.0625		9
Open	6/20/18		Keyhole	2.1		387	57	3.75884774	103.473251	2.97916667	6.0625		9
Open	6/28/18		Keyhole	6.4		408	75	5.11643836	69.5525114	7.97916667	7.5625		8.47916667
Open	6/28/18		Keyhole	6.8		408	75	5.11643836	69.5525114	7.97916667	7.5625		8.47916667
Open	6/28/18		Keyhole	6.4		408	75	5.11643836	69.5525114	7.97916667	7.5625		8.47916667
Open	6/28/18		Keyhole	5.4		408	75	5.11643836	69.5525114	7.97916667	7.5625		8.47916667
Open	6/1/18		Channel	8.6		148	65	4.65371901	73.6652893	6.70833333	9.97916667		8.39583333
Open	6/1/18		Channel	8.2		148	65	4.65371901	73.6652893	6.70833333	9.97916667		8.39583333
Open	6/1/18		Channel	7.7		148	65	4.65371901	73.6652893	6.70833333	9.97916667		8.39583333
Open	6/1/18		Channel	5.4		148	65	4.65371901	73.6652893	6.70833333	9.97916667		8.39583333
ClosedTuesday	6/5/18		Channel	9.8		0	44	3.99918367	113.281633	7.35416667	14.5208333		7.75
ClosedTuesday	6/5/18		Channel	9.7		0	44	3.99918367	113.281633	7.35416667	14.5208333		7.75
ClosedTuesday	6/5/18		Channel	8.7		0	44	3.99918367	113.281633	7.35416667	14.5208333		7.75
ClosedTuesday	6/5/18		Channel	8.1		0	44	3.99918367	113.281633	7.35416667	14.5208333		7.75

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
Open	6/6/18		Channel	9.1		230	45	4.33428571	80.8612245	7.02083333	13.64583		7.9375
Open	6/6/18		Channel	9.1		230	45	4.33428571	80.8612245	7.02083333	13.64583		7.9375
Open	6/6/18		Channel	6.8		230	45	4.33428571	80.8612245	7.02083333	13.64583		7.9375
Open	6/6/18		Channel	7		230	45	4.33428571	80.8612245	7.02083333	13.64583		7.9375
Open	6/7/18		Channel	7.7		183	51	4.22780083	107.858921	6.75	12.6458333		7.9375
Open	6/7/18		Channel	6.9		183	51	4.22780083	107.858921	6.75	12.6458333		7.9375
Open	6/7/18		Channel	6.3		183	51	4.22780083	107.858921	6.75	12.6458333		7.9375
Open	6/7/18		Channel	6.6		183	51	4.22780083	107.858921	6.75	12.6458333		7.9375
Open	6/8/18		Channel	5		268	59	3.75206612	93.0909091	5.125	11.8125		7.79166667
Open	6/8/18		Channel	4.8		268	59	3.75206612	93.0909091	5.125	11.8125		7.79166667
Open	6/8/18		Channel	5		268	59	3.75206612	93.0909091	5.125	11.8125		7.79166667
Open	6/8/18		Channel	5.1		268	59	3.75206612	93.0909091	5.125	11.8125		7.79166667
Open	6/10/18		Channel	5.9		156	80	4.25731707	75.7235772	6.78723404	13.5531915		7.76595745
Open	6/10/18		Channel	5.3		156	80	4.25731707	75.7235772	6.78723404	13.5531915		7.76595745
Open	6/10/18		Channel	4		156	80	4.25731707	75.7235772	6.78723404	13.5531915		7.76595745
Open	6/10/18		Channel	4.2		156	80	4.25731707	75.7235772	6.78723404	13.5531915		7.76595745
ClosedTuesday	6/12/18		Channel	4.2		0	96	4.98974359	72.4871795	6.04166667	11.1875		7.875
ClosedTuesday	6/12/18		Channel	3.8		0	96	4.98974359	72.4871795	6.04166667	11.1875		7.875
ClosedTuesday	6/12/18		Channel	5.7		0	96	4.98974359	72.4871795	6.04166667	11.1875		7.875
ClosedTuesday	6/12/18		Channel	5.3		0	96	4.98974359	72.4871795	6.04166667	11.1875		7.875
Open	6/16/18		Channel	7.4		160	85	3.66182573	154.182573	3.79166667	13.6458333		8.08333333
Open	6/16/18		Channel	6.9		160	85	3.66182573	154.182573	3.79166667	13.6458333		8.08333333
Open	6/16/18		Channel	6.7		160	85	3.66182573	154.182573	3.79166667	13.6458333		8.08333333
Open	6/16/18		Channel	6.8		160	85	3.66182573	154.182573	3.79166667	13.6458333		8.08333333
Open	6/17/18		Channel	8.6		232	75	3.08962656	168.290456	3	14.9583333		8.29166667

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
Open	6/17/18		Channel	8.6		232	75	3.08962656	168.290456	3	14.9583333		8.29166667
Open	6/17/18		Channel	9.4		232	75	3.08962656	168.290456	3	14.9583333		8.29166667
Open	6/17/18		Channel	9.4		232	75	3.08962656	168.290456	3	14.9583333		8.29166667
ClosedTuesday	6/19/18		Channel	15.3		0	60	3.7553719	112.665289	2.97916667	6.08333333		8.95833333
ClosedTuesday	6/19/18		Channel	15.1		0	60	3.7553719	112.665289	2.97916667	6.08333333		8.95833333
ClosedTuesday	6/19/18		Channel	14.19		0	60	3.7553719	112.665289	2.97916667	6.08333333		8.95833333
ClosedTuesday	6/19/18		Channel	14.25		0	60	3.7553719	112.665289	2.97916667	6.08333333		8.95833333
Open	6/20/18		Channel	5.5		301	57	3.75884774	103.473251	2.97916667	6.0625		9
Open	6/20/18		Channel	5.1		301	57	3.75884774	103.473251	2.97916667	6.0625		9
Open	6/20/18		Channel	6		301	57	3.75884774	103.473251	2.97916667	6.0625		9
Open	6/20/18		Channel	4.4		301	57	3.75884774	103.473251	2.97916667	6.0625		9
Open	6/28/18		Channel	7		315	75	5.11643836	69.5525114	7.97916667	7.5625		8.47916667
Open	6/28/18		Channel	6.6		315	75	5.11643836	69.5525114	7.97916667	7.5625		8.47916667
Open	6/28/18		Channel	5.5		315	75	5.11643836	69.5525114	7.97916667	7.5625		8.47916667
Open	6/28/18		Channel	4.9		315	75	5.11643836	69.5525114	7.97916667	7.5625		8.47916667
Open	6/1/18		Channel	5.8		148	65	4.65371901	73.6652893	6.70833333	9.97916667		8.39583333
Open	6/1/18		Channel	5.2		148	65	4.65371901	73.6652893	6.70833333	9.97916667		8.39583333
Open	6/1/18		Channel	7.3		148	65	4.65371901	73.6652893	6.70833333	9.97916667		8.39583333
Open	6/1/18		Channel	4.3		148	65	4.65371901	73.6652893	6.70833333	9.97916667		8.39583333
ClosedTuesday	6/5/18		Channel	10.4		0	44	3.99918367	113.281633	7.35416667	14.5208333		7.75
ClosedTuesday	6/5/18		Channel	8.9		0	44	3.99918367	113.281633	7.35416667	14.5208333		7.75
ClosedTuesday	6/5/18		Channel	8.5		0	44	3.99918367	113.281633	7.35416667	14.5208333		7.75
ClosedTuesday	6/5/18		Channel	7.4		0	44	3.99918367	113.281633	7.35416667	14.5208333		7.75
Open	6/6/18		Channel	6.4		230	45	4.33428571	80.8612245	7.02083333	13.64583		7.9375
Open	6/6/18		Channel	6		230	45	4.33428571	80.8612245	7.02083333	13.64583		7.9375

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
Open	6/6/18		Channel	3.1		230	45	4.33428571	80.8612245	7.02083333	13.64583		7.9375
Open	6/6/18		Channel	5		230	45	4.33428571	80.8612245	7.02083333	13.64583		7.9375
Open	6/7/18		Channel	7.8		183	51	4.22780083	107.858921	6.75	12.6458333		7.9375
Open	6/7/18		Channel	7		183	51	4.22780083	107.858921	6.75	12.6458333		7.9375
Open	6/7/18		Channel	5.8		183	51	4.22780083	107.858921	6.75	12.6458333		7.9375
Open	6/7/18		Channel	5.6		183	51	4.22780083	107.858921	6.75	12.6458333		7.9375
Open	6/8/18		Channel	4.6		268	59	3.75206612	93.0909091	5.125	11.8125		7.79166667
Open	6/8/18		Channel	4.5		268	59	3.75206612	93.0909091	5.125	11.8125		7.79166667
Open	6/8/18		Channel	5.3		268	59	3.75206612	93.0909091	5.125	11.8125		7.79166667
Open	6/8/18		Channel	4.6		268	59	3.75206612	93.0909091	5.125	11.8125		7.79166667
Open	6/10/18		Channel	4.6		156	80	4.25731707	75.7235772	6.78723404	13.5531915		7.76595745
Open	6/10/18		Channel	3.7		156	80	4.25731707	75.7235772	6.78723404	13.5531915		7.76595745
Open	6/10/18		Channel	4.7		156	80	4.25731707	75.7235772	6.78723404	13.5531915		7.76595745
Open	6/10/18		Channel	4.1		156	80	4.25731707	75.7235772	6.78723404	13.5531915		7.76595745
ClosedTuesday	6/12/18		Channel	4.8		0	96	4.98974359	72.4871795	6.04166667	11.1875		7.875
ClosedTuesday	6/12/18		Channel	4.7		0	96	4.98974359	72.4871795	6.04166667	11.1875		7.875
ClosedTuesday	6/12/18		Channel	6.2		0	96	4.98974359	72.4871795	6.04166667	11.1875		7.875
ClosedTuesday	6/12/18		Channel	5.8		0	96	4.98974359	72.4871795	6.04166667	11.1875		7.875
Open	6/16/18		Channel	6.3		160	85	3.66182573	154.182573	3.79166667	13.6458333		8.08333333
Open	6/16/18		Channel	6.3		160	85	3.66182573	154.182573	3.79166667	13.6458333		8.08333333
Open	6/16/18		Channel	5.3		160	85	3.66182573	154.182573	3.79166667	13.6458333		8.08333333
Open	6/16/18		Channel	5.6		160	85	3.66182573	154.182573	3.79166667	13.6458333		8.08333333
Open	6/17/18		Channel	10.5		232	75	3.08962656	168.290456	3	14.9583333		8.29166667
Open	6/17/18		Channel	10.1		232	75	3.08962656	168.290456	3	14.9583333		8.29166667
Open	6/17/18		Channel	8.9		232	75	3.08962656	168.290456	3	14.9583333		8.29166667

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
Open	6/17/18		Channel	7.6		232	75	3.08962656	168.290456	3	14.9583333		8.29166667
ClosedTuesday	6/19/18		Channel	14.4		0	60	3.7553719	112.665289	2.97916667	6.08333333		8.95833333
ClosedTuesday	6/19/18		Channel	14.6		0	60	3.7553719	112.665289	2.97916667	6.08333333		8.95833333
ClosedTuesday	6/19/18		Channel	14.3		0	60	3.7553719	112.665289	2.97916667	6.08333333		8.95833333
ClosedTuesday	6/19/18		Channel	15.5		0	60	3.7553719	112.665289	2.97916667	6.08333333		8.95833333
Open	6/20/18		Channel	4.9		301	57	3.75884774	103.473251	2.97916667	6.0625		9
Open	6/20/18		Channel	5.1		301	57	3.75884774	103.473251	2.97916667	6.0625		9
Open	6/20/18		Channel	4.5		301	57	3.75884774	103.473251	2.97916667	6.0625		9
Open	6/20/18		Channel	3.9		301	57	3.75884774	103.473251	2.97916667	6.0625		9
Open	6/28/18		Channel	6.5		315	75	5.11643836	69.5525114	7.97916667	7.5625		8.47916667
Open	6/28/18		Channel	6.1		315	75	5.11643836	69.5525114	7.97916667	7.5625		8.47916667
Open	6/28/18		Channel	5.1		315	75	5.11643836	69.5525114	7.97916667	7.5625		8.47916667
Open	6/28/18		Channel	5.2		315	75	5.11643836	69.5525114	7.97916667	7.5625		8.47916667
Open	6/1/18		WitchesBrew	6.5		13	65	4.65371901	73.6652893	6.70833333	9.97916667		8.39583333
Open	6/1/18		WitchesBrew	6.3		13	65	4.65371901	73.6652893	6.70833333	9.97916667		8.39583333
Open	6/1/18		WitchesBrew	7.6		13	65	4.65371901	73.6652893	6.70833333	9.97916667		8.39583333
Open	6/1/18		WitchesBrew	4.3		13	65	4.65371901	73.6652893	6.70833333	9.97916667		8.39583333
ClosedTuesday	6/5/18		WitchesBrew	8.05		0	44	3.99918367	113.281633	7.35416667	14.5208333		7.75
ClosedTuesday	6/5/18		WitchesBrew	7.3		0	44	3.99918367	113.281633	7.35416667	14.5208333		7.75
ClosedTuesday	6/5/18		WitchesBrew	8.8		0	44	3.99918367	113.281633	7.35416667	14.5208333		7.75
ClosedTuesday	6/5/18		WitchesBrew	7.1		0	44	3.99918367	113.281633	7.35416667	14.5208333		7.75
Open	6/6/18		WitchesBrew	6.9		22	45	4.33428571	80.8612245	7.02083333	13.64583		7.9375
Open	6/6/18		WitchesBrew	5.7		22	45	4.33428571	80.8612245	7.02083333	13.64583		7.9375
Open	6/6/18		WitchesBrew	4.9		22	45	4.33428571	80.8612245	7.02083333	13.64583		7.9375
Open	6/6/18		WitchesBrew	4.2		22	45	4.33428571	80.8612245	7.02083333	13.64583		7.9375

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
Open	6/7/18		WitchesBrew	6.6		14	51	4.22780083	107.858921	6.75	12.6458333		7.9375
Open	6/7/18		WitchesBrew	5.4		14	51	4.22780083	107.858921	6.75	12.6458333		7.9375
Open	6/7/18		WitchesBrew	5.6		14	51	4.22780083	107.858921	6.75	12.6458333		7.9375
Open	6/7/18		WitchesBrew	5.1		14	51	4.22780083	107.858921	6.75	12.6458333		7.9375
Open	6/8/18		WitchesBrew	3.9		9	59	3.75206612	93.0909091	5.125	11.8125		7.79166667
Open	6/8/18		WitchesBrew	3.7		9	59	3.75206612	93.0909091	5.125	11.8125		7.79166667
Open	6/8/18		WitchesBrew	3.8		9	59	3.75206612	93.0909091	5.125	11.8125		7.79166667
Open	6/8/18		WitchesBrew	3.2		9	59	3.75206612	93.0909091	5.125	11.8125		7.79166667
Open	6/10/18		WitchesBrew	3.7		6	80	4.25731707	75.7235772	6.78723404	13.5531915		7.76595745
Open	6/10/18		WitchesBrew	3.2		6	80	4.25731707	75.7235772	6.78723404	13.5531915		7.76595745
Open	6/10/18		WitchesBrew	3.2		6	80	4.25731707	75.7235772	6.78723404	13.5531915		7.76595745
Open	6/10/18		WitchesBrew	3.1		6	80	4.25731707	75.7235772	6.78723404	13.5531915		7.76595745
ClosedTuesday	6/12/18		WitchesBrew	3.9		0	96	4.98974359	72.4871795	6.04166667	11.1875		7.875
ClosedTuesday	6/12/18		WitchesBrew	2.9		0	96	4.98974359	72.4871795	6.04166667	11.1875		7.875
ClosedTuesday	6/12/18		WitchesBrew	3.8		0	96	4.98974359	72.4871795	6.04166667	11.1875		7.875
ClosedTuesday	6/12/18		WitchesBrew	3.5		0	96	4.98974359	72.4871795	6.04166667	11.1875		7.875
Open	6/16/18		WitchesBrew	9		4	85	3.66182573	154.182573	3.79166667	13.6458333		8.08333333
Open	6/16/18		WitchesBrew	8.5		4	85	3.66182573	154.182573	3.79166667	13.6458333		8.08333333
Open	6/16/18		WitchesBrew	8.2		4	85	3.66182573	154.182573	3.79166667	13.6458333		8.08333333
Open	6/16/18		WitchesBrew	7.2		4	85	3.66182573	154.182573	3.79166667	13.6458333		8.08333333
Open	6/17/18		WitchesBrew	10.9		10	75	3.08962656	168.290456	3	14.9583333		8.29166667
Open	6/17/18		WitchesBrew	10.6		10	75	3.08962656	168.290456	3	14.9583333		8.29166667
Open	6/17/18		WitchesBrew	9.8		10	75	3.08962656	168.290456	3	14.9583333		8.29166667
Open	6/17/18		WitchesBrew	10		10	75	3.08962656	168.290456	3	14.9583333		8.29166667
ClosedTuesday	6/19/18		WitchesBrew	11.9		0	60	3.7553719	112.665289	2.97916667	6.08333333		8.95833333

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
ClosedTuesday	6/19/18		WitchesBrew	10.9		0	60	3.7553719	112.665289	2.97916667	6.08333333		8.95833333
ClosedTuesday	6/19/18		WitchesBrew	12.2		0	60	3.7553719	112.665289	2.97916667	6.08333333		8.95833333
ClosedTuesday	6/19/18		WitchesBrew	10.7		0	60	3.7553719	112.665289	2.97916667	6.08333333		8.95833333
Open	6/20/18		WitchesBrew	7.2		26	57	3.75884774	103.473251	2.97916667	6.0625		9
Open	6/20/18		WitchesBrew	6.7		26	57	3.75884774	103.473251	2.97916667	6.0625		9
Open	6/20/18		WitchesBrew	6		26	57	3.75884774	103.473251	2.97916667	6.0625		9
Open	6/20/18		WitchesBrew	4.4		26	57	3.75884774	103.473251	2.97916667	6.0625		9
Open	6/28/18		WitchesBrew	5.2		24	75	5.11643836	69.5525114	7.97916667	7.5625		8.47916667
Open	6/28/18		WitchesBrew	5.8		24	75	5.11643836	69.5525114	7.97916667	7.5625		8.47916667
Open	6/28/18		WitchesBrew	5		24	75	5.11643836	69.5525114	7.97916667	7.5625		8.47916667
Open	6/28/18		WitchesBrew	4.7		24	75	5.11643836	69.5525114	7.97916667	7.5625		8.47916667
Open	6/1/18		WitchesBrew	5		13	65	4.65371901	73.6652893	6.70833333	9.97916667		8.39583333
Open	6/1/18		WitchesBrew	4.5		13	65	4.65371901	73.6652893	6.70833333	9.97916667		8.39583333
Open	6/1/18		WitchesBrew	5.9		13	65	4.65371901	73.6652893	6.70833333	9.97916667		8.39583333
Open	6/1/18		WitchesBrew	3.1		13	65	4.65371901	73.6652893	6.70833333	9.97916667		8.39583333
ClosedTuesday	6/5/18		WitchesBrew	7.34		0	44	3.99918367	113.281633	7.35416667	14.5208333		7.75
ClosedTuesday	6/5/18		WitchesBrew	6.8		0	44	3.99918367	113.281633	7.35416667	14.5208333		7.75
ClosedTuesday	6/5/18		WitchesBrew	6.7		0	44	3.99918367	113.281633	7.35416667	14.5208333		7.75
ClosedTuesday	6/5/18		WitchesBrew	5.9		0	44	3.99918367	113.281633	7.35416667	14.5208333		7.75
Open	6/6/18		WitchesBrew	6.2		22	45	4.33428571	80.8612245	7.02083333	13.64583		7.9375
Open	6/6/18		WitchesBrew	5.6		22	45	4.33428571	80.8612245	7.02083333	13.64583		7.9375
Open	6/6/18		WitchesBrew	5.7		22	45	4.33428571	80.8612245	7.02083333	13.64583		7.9375
Open	6/6/18		WitchesBrew	5.4		22	45	4.33428571	80.8612245	7.02083333	13.64583		7.9375
Open	6/7/18		WitchesBrew	5.1		14	51	4.22780083	107.858921	6.75	12.6458333		7.9375
Open	6/7/18		WitchesBrew	4.8		14	51	4.22780083	107.858921	6.75	12.6458333		7.9375

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
Open	6/7/18		WitchesBrew	5.2		14	51	4.22780083	107.858921	6.75	12.6458333		7.9375
Open	6/7/18		WitchesBrew	4.8		14	51	4.22780083	107.858921	6.75	12.6458333		7.9375
Open	6/8/18		WitchesBrew	3.7		9	59	3.75206612	93.0909091	5.125	11.8125		7.79166667
Open	6/8/18		WitchesBrew	3		9	59	3.75206612	93.0909091	5.125	11.8125		7.79166667
Open	6/8/18		WitchesBrew	3.4		9	59	3.75206612	93.0909091	5.125	11.8125		7.79166667
Open	6/8/18		WitchesBrew	2.1		9	59	3.75206612	93.0909091	5.125	11.8125		7.79166667
Open	6/10/18		WitchesBrew	4.1		6	80	4.25731707	75.7235772	6.78723404	13.5531915		7.76595745
Open	6/10/18		WitchesBrew	3.9		6	80	4.25731707	75.7235772	6.78723404	13.5531915		7.76595745
Open	6/10/18		WitchesBrew	3.1		6	80	4.25731707	75.7235772	6.78723404	13.5531915		7.76595745
Open	6/10/18		WitchesBrew	2.9		6	80	4.25731707	75.7235772	6.78723404	13.5531915		7.76595745
ClosedTuesday	6/12/18		WitchesBrew	2.1		0	96	4.98974359	72.4871795	6.04166667	11.1875		7.875
ClosedTuesday	6/12/18		WitchesBrew	2.2		0	96	4.98974359	72.4871795	6.04166667	11.1875		7.875
ClosedTuesday	6/12/18		WitchesBrew	3		0	96	4.98974359	72.4871795	6.04166667	11.1875		7.875
ClosedTuesday	6/12/18		WitchesBrew	2.6		0	96	4.98974359	72.4871795	6.04166667	11.1875		7.875
Open	6/16/18		WitchesBrew	6.5		4	85	3.66182573	154.182573	3.79166667	13.6458333		8.08333333
Open	6/16/18		WitchesBrew	6.4		4	85	3.66182573	154.182573	3.79166667	13.6458333		8.08333333
Open	6/16/18		WitchesBrew	6.6		4	85	3.66182573	154.182573	3.79166667	13.6458333		8.08333333
Open	6/16/18		WitchesBrew	7.5		4	85	3.66182573	154.182573	3.79166667	13.6458333		8.08333333
Open	6/17/18		WitchesBrew	9.8		10	75	3.08962656	168.290456	3	14.9583333		8.29166667
Open	6/17/18		WitchesBrew	9.6		10	75	3.08962656	168.290456	3	14.9583333		8.29166667
Open	6/17/18		WitchesBrew	8.9		10	75	3.08962656	168.290456	3	14.9583333		8.29166667
Open	6/17/18		WitchesBrew	8.9		10	75	3.08962656	168.290456	3	14.9583333		8.29166667
ClosedTuesday	6/19/18		WitchesBrew	10.1		0	60	3.7553719	112.665289	2.97916667	6.08333333		8.95833333
ClosedTuesday	6/19/18		WitchesBrew	9.8		0	60	3.7553719	112.665289	2.97916667	6.08333333		8.95833333
ClosedTuesday	6/19/18		WitchesBrew	11.2		0	60	3.7553719	112.665289	2.97916667	6.08333333		8.95833333

Reserve Status	Date	Time	Site	Secchi Distance (m)	Box Office Count	Sector Count	Tide Coefficient	Wind Speed (knt)	Wind Direction (deg)	Wave height (Ft)	Wave Direction (deg)	Peak Wave Period (sec)	Mean Wave Period (sec)
ClosedTuesday	6/19/18		WitchesBrew	8.9		0	60	3.7553719	112.665289	2.97916667	6.08333333		8.95833333
Open	6/20/18		WitchesBrew	5.9		26	57	3.75884774	103.473251	2.97916667	6.0625		9
Open	6/20/18		WitchesBrew	5.8		26	57	3.75884774	103.473251	2.97916667	6.0625		9
Open	6/20/18		WitchesBrew	5.1		26	57	3.75884774	103.473251	2.97916667	6.0625		9
Open	6/20/18		WitchesBrew	4.2		26	57	3.75884774	103.473251	2.97916667	6.0625		9
Open	6/28/18		WitchesBrew	4.7		24	75	5.11643836	69.5525114	7.97916667	7.5625		8.47916667
Open	6/28/18		WitchesBrew	4.3		24	75	5.11643836	69.5525114	7.97916667	7.5625		8.47916667
Open	6/28/18		WitchesBrew	4.1		24	75	5.11643836	69.5525114	7.97916667	7.5625		8.47916667
Open	6/28/18		WitchesBrew	3.9		24	75	5.11643836	69.5525114	7.97916667	7.5625		8.47916667

Appendix G. Hawaiian Monk Seal Observations

Table 1. Presence/absence and notes from monk seal sightings during the COVID-19 Closure.

Year	**Date**	**Notes:**
2020	28-Apr	1 monk seal
2020	7-May	2 monk seals
2020	12-May	
2020	19-May	2 monk seals: 1 keyhole (here when arrived, gone by 10 am), 1 channel (showed up around 9 am and gone by 10 am)
2020	26-May	
2020	28-May	
2020	9-Jun	
2020	16-Jun	1 monk seal keyhole
2020	23-Jun	
2020	30-Jun	
2020	7-Jul	1 monk seal keyhole, entered around 11 am, still there at 3 pm when we left.
2020	17-Jul	1 monk seal swimming
2020	21-Jul	1 monk seal in channel/witches brew around 12 pm
2020	4-Aug	
2020	14-Aug	1 monk seal arrive around 9 am and left soon after
2020	18-Aug	
2020	25-Aug	
2020	1-Sep	2 monk seal onbackdoors beach at 8 am and still there at 2 pm when leaving.
2020	15-Sep	1 monk seal on backdoors rocks at 8 am and still there at 1 pm when leaving.
2020	22-Sep	
2020	29-Sep	
2020	9-Oct	1 monk seal
2020	13-Oct	1 monk seal in channel around 11 am
2020	20-Oct	2 monk seals, one on rocks for entire field day and second came in aorund 11 am and left shortly after.
2020	28-Oct	1 monk seal on rocks
2020	6-Nov	
2020	17-Nov	
2020	24-Nov	
2020	1-Dec	
2020	8-Dec	
2020	9-Dec	
2020	16-Dec	
2020	18-Dec	1 monk seal

Table 2. NOAA Hawaiian Monk Seal Sightings for 2020

Date of Sighting	Time (of initial sighting)	Beach Name / Reported Location	Location Details	Seal Size Class	Seal Sex	Beach Position (1=land, 0=in water)	Seal ID	Sighting Notes
1/1/20	17:43	TOILET BOWL	in the toliet bowl	unknown	unknown	1		Obs:Mike Skarlize 808-255-5335. PC Mike reporting a "smaller sized" seal at the toliet bowl near HB. HMS has tags but couldn't read them. he will send photos.
1/17/20	8:05	HANAUMA BAY	North End of the Hanauma Bay	Adult	Male	1	RW22	Obs:Ron W. . Verified By: Abigail. Stub tag, Male, and right anterior NB.. PC Ron W. reports HMS at Hanauma bay on North End. 0820 Abigail enroute. Hanauma bay staff notified of HMS responder. 906 Abigail arrived on scene. 917 Abigail calls to report SRA set up by lifeguards, working on ID'ing. at 1200 Kelsey and trainee will be arriving at h-bay for volunteer training. HMS ID as RV08 Buster by Intern Abigail. ID'd by male, stub, and right eye scar. 1208- Theresa arrives. 1225 Danielle arrives. 1226 Abby calls to inform me of mistaken ID. After waiting for seal to move and show more of its body, responder noted male, stub tag, and NB at right antieror. ID changed to correct- RW22. Kelsey to stay until 1700 unless otherwise stated. Connor expected to arrive 1430.
1/18/20	8:51	HANAUMA BAY	Toilet Bowl Side	Adult	Male	1	RW22	Obs:Chile . Verified By: Lauren. stub tag, male, right anterior bleach spot. Public caller reported HMS on sand near Toilet Bowl at Hanauma Bay at 0851. SRA was set up by Hanauma Bay members. I called Hanauma Bay at 0906 with ETA. Kelsey and Lauren arrived at 1030. HMS was identified as RW22 by male, stub tag, and right anterior natural bleach spot. Nicole to releive at 1300. 1707 HB closing. HMS is still on the beach.
1/20/20	9:13	HANAUMA BAY	left side of bay	Adult	Male	1	RW22	Obs:Bob B Hanauma 808-255-7170. Verified By: Nicole G. and Grandpa. IDed by bleach mark, stub and MALE. Volunteer Bob B from Hanauma bay relaying message from lifeguard that hms just hauled out on sand. Grandpa dispatched. NGrandpa relieved by nicole at 1427. Nicole and grandpa both confrim the seal is RW22; confrimed by stub, male , and natural bleach mark. 1712 RW22 is still at Hanauma Bay, Nicole is leving due to HB closing.
1/31/20	8:59	HANAUMA BAY	Left side of beach	Adult	Male	1	RV08	Obs:Anta . Verified By: Abigail Bearce. ID by male, lack of tags, and left eye scar.. H-bay staff Anta calls to report HMS on sand substrate on east (left) side of Hanauma Bay. Intern Abigail en-route. ETA 30 min. H-bay staff notified. SRA made by ranger. 950 Intern Abigail has arrived. Intern Lauren notified to relieve intern abigail at 1200. 1012 Abigail calls to report HMS as Buster RV08 by no tags, male, and left eye scar. Kate Behrens arrived at 1454 to relieve Lauren. Lauren Left site at 1458; seal still present. 1723 Kate leaft Hanauma Bay with SRA up and no rope. Seal still present.

2/15/20	9:35	TOILET BOWL	Near toilet bowl, not accessible to public	Juvenile	Male	1	RK24	Obs:Lakoa 808-778-4689. Tag web & pos added.Verified By: Dannielle Caron. Public caller Lakoa reported HMS on beach near Toilet Bowl, not accessible to public. Danielle arrived at 1030. Danielle ID'd HMS as RK24 by rear flipper tag K24.
2/19/20	11:40	HANAUMA BAY		Adult	Male	1	RW22	Obs:Ocean Safety 808-723-8101. Verified By: Nicole. nb behind RFF, male and stub. Ocean Saftey reporting a HMS at HB on left hand side. 1235 Lennette reporting same. Grandpa responding. Onsite unable to ID. Nicole to relieve at 1500. Nicole at HB. 1604 RW22 male, stub and nb on right side behind RFF. 1725 HB closing, Nicole departing.
2/20/20	8:47	HANAUMA BAY	Toilet bowl side of the beach.	Adult	Male	1	RW22	Obs:Hanauma Bay Staff 808-768-6861. Verified By: Danielle. nb behind RFF, male, stub tag with W. H-bay staff call to report HMS at Hanuama bay on toilet bowl side of the beach. Intern danielle responding. arrived 948. SRA w/ropes and signs up. Grandpa relieving at 1400.Unable to ID. Confirmed RW22 by nb behind RFF and W stub tag, male. 1405 Grandpa there and Elle leaving. 1654 Grandpa leaving. HB closing, seal on beach. 1800 Carissa reporting HMS is still on the beach
2/23/20	9:45	HANAUMA BAY	all the way to left side if facing ocean	Adult	Male	1	RW22	Obs:Brook Public 808-285-2292. Verified By: Gina Walker. NB on right side. Public caller Brook reports a seal on the and at Hanauma Bay all the way to the left side if facing the ocean. Gina responding. Leslie relieving. 1230: Gina leaving. SRA moved d/t tide. Staff watching until Leslie arrives. 1357: Leslie at site. 1711: Leslie leaving the beach.
2/29/20	7:52	HANAUMA BAY	Toilet bowl side, north end past lifeguard tower	Adult	Male	1	RW22	Obs:Haunama Bay Staff 808-233-8345. Verified By: Nicole Giannetti. Male, piece of right tag, right anterior natural bleach. Hanauma Bay staff reported HMS on north end of beach, just past lifeguard tower near toilet bowl. SRA erected by Hanauma Bay Staff. Leslie was dispatched and arrived at 0935. Nicole was dispatched and arrived at 1312. Nicole departing 1652 because Hanauma Bay closing. SRA still up. Hanauma Bay said they would remove.
3/2/20	8:57	HANAUMA BAY	toilet bowl side	Adult	Male	1	RW22	Obs:Bob Hanauma 808-768-0000. Verified By: Nicole. Piece of tag with a W, male parts, NB on right side. Bob from the beach desk at Hanauma Bay reporting hms on the toilet bowl side. Grandpa responding. Nick responding; Intern nicole arrived at 1418 to cover for nick. nicole leaving 1714.
3/4/20	14:15	HANAUMA BAY		unknown	unknown	1		Obs:Colleen Heyer 808-734-4038. 1458 PC Colleen reporting 2 HMS at HB in the water since about 1415 interacting. They just came to the waterline and people are really close. 1505 The are back in the water. 1548 Lanette reporting they have hauled out onto sand and HB staff is setting up a SRA. Agrees to late to send anyone.
3/4/20	14:15	HANAUMA BAY		unknown	unknown	1		Obs:Colleen Heyer 808-734-4038. 1458 PC Colleen reporting 2 HMS at HB in the water since about 1415 interacting. They just came to the waterline and people are really close. 1505 The are back in the water. 1548 Lanette

								reporting they have hauled out onto sand and HB staff is setting up a SRA. Agrees to late to send anyone.
3/9/20	12:20	HANAUMA BAY		unknown	unknown	1		Obs:Liz Ah Quinn 253-961-3417. Departed Date & time: 30920, 1228. Volunteer Liz at Hanauma Bay reporting hms just hauled in, she will set up sra. Nico notified. Volunteer Nicole responded at 1357 and no hms present.
3/9/20	12:29	HANAUMA BAY		unknown	unknown	1		Obs:Liz Ah Quinn 253-961-3417. Hanauma Bay lifeguards told Liz that a mom and pup size hms swam up but left because of the tourist.
3/9/20	12:29	HANAUMA BAY		unknown	unknown	1		Obs:Liz Ah Quinn 253-961-3417. Hanauma Bay lifeguards told Liz that a mom and pup size hms swam up but left because of the tourist.
3/11/20	13:04	HANAUMA BAY	far right end	unknown	unknown	0		Obs:Ola Lau 303-819-2587. PC Ola reporting 2 HMS at HB just hauled on on sand. Nick responding. 1321 Lanette at HB reporting same. Putting up SRA. 1345 NIck arriving at HB. Nicole will releive at 1500. Both seals went into the water at1400 interacting for 45 mins, departed around 1500, Nick left at 1500. Nicole leaving at 1525
3/11/20	13:04	HANAUMA BAY	far right end	unknown	unknown	0		Obs:Ola Lau 303-819-2587. PC Ola reporting 2 HMS at HB just hauled on on sand. Nick responding. 1321 Lanette at HB reporting same. Putting up SRA. 1345 NIck arriving at HB. Nicole will releive at 1500. Both seals went into the water at1400 interacting for 45 mins, departed around 1500, Nick left at 1500. Nicole leaving at 1525
3/15/20	8:38	TOILET BOWL		Adult	Male	0	RW22	Seen while scuba diving.
3/16/20	15:26	HANAUMA BAY	toilet bowl side	Adult	Male	1	RW22	Obs:Ola Public 303-819-2587. Verified By: Ola Public. NB right side by fore flipper. Public caller reports a seal on the sand at Hanauma Bay Toilet Bowl Side. Cones around seal but people going inside cones. Seal ID'd as Kolohe RW22 by NB to right side by fore flipper. Caller will stay with seal. 1600: No responder available and area is being closed down early.
5/10/20	12:46	TOILET BOWL	Toilet Bowl area	unknown	unknown	1		Obs:Brian Public 808-868-9368. Public caller Brian reportws a seal seen at Hanauma Bay Toilet Bowl area while hiking. Seal ID'd as RW22 by stub tag and natural bleach to right pectoral area behind right fore flipper.
5/15/20	14:52	TOILET BOWL	toliet bowl	unknown	unknown	1		Obs:Brian . PC Brian reporting 2 HMS at HB toliet bowl 1st one has tag K25, other can't ID.
5/15/20	14:52	TOILET BOWL	toliet bowl	Juvenile	Male	1	RK24	Obs:Brian . Tag web & pos added.Verified By: Brian. PC Brian reporting 2 HMS at HB toliet bowl 1st one has tag K25, other can't ID.

Appendix H. Green Turtle Observations

Table 1. Presence/absence and notes from monk seal sightings during the COVID-19 Closure.

COVID	2020	17-Jul	2 turtles in keyhole
COVID	2020	21-Jul	0
COVID	2020	4-Aug	0
COVID	2020	14-Aug	0
COVID	2020	18-Aug	0
COVID	2020	25-Aug	0
COVID	2020	1-Sep	0
COVID	2020	15-Sep	0
COVID	2020	22-Sep	0
COVID	2020	29-Sep	1 turtle Backdoor
COVID	2020	9-Oct	0
COVID	2020	13-Oct	0
COVID	2020	20-Oct	0
COVID	2020	28-Oct	1 turtle Backdoor
COVID	2020	6-Nov	1 turtle in Channel
COVID	2020	17-Nov	0
COVID	2020	24-Nov	1 turtle in Channel
COVID	2020	1-Dec	1 turtle outside the inner reef flat
Tuesday	2020	8-Dec	
Open	2020	9-Dec	1 turtle in Channel
Open	2020	16-Dec	1 turtle in Channel
Open	2020	18-Dec	0

Appendix I. Coral survey raw data from permanent inner reef flat transects.

Table 1. Coral bleaching and abundance surveys from 2015 to present. Site codes are as follows: 1a BD = Backdoors East, 1b BD = Backdoors West, 2a KH = Keyhole East, 2b KH = Keyhole West, 3a CH = Channel East, 3b CH = Channel West, 4a WB = Witches Brew East, 4b WB = Witches Brew West. Species codes are the collowing: Pl = *Porites lobata*, Pc = *Porites compressa*, Pe = *Porites evermanni*, Pm = *Pocillopora meandrina*, Pc = *Pavona varians*, Co = *Cyphastrea ocellina*, Mc = *Montipora capitata*, Mp = *Montipora patula*, Pt = *Palythoa tuberculosa*, Pr = *Porites rus*.

Hanauma Bay			**Observer Ku'ulei Rodgers**						
Date	**Site**	**Species**	**Size**	**Live (%)**	**Bleach (%)**	**Pale (%)**	**Recently Dead (%)**	**other (abraded)**	**Notes:**
10/13/20	1a BD	Pe	10	100	0	0	0	0	
10/13/20	1a BD	Pe	20	100	0	0	0	0	
10/13/20	1a BD	Pe	30	0	0	100	0	0	
10/13/20	1a BD	Pe	10	100	0	0	0	0	
10/13/20	1a BD	Pe	5	100	0	0	0	0	
10/13/20	1a BD	Pe	7	100	0	0	0	0	
10/13/20	1a BD	Pe	22	100	0	0	0	0	
10/13/20	1a BD	Pe	45	100	0	0	0	0	
10/13/20	1a BD	Pe	200	100	0	0	0	0	
10/13/20	1a BD	Pe	15	100	0	0	0	0	
10/13/20	1a BD	Pe	40	100	0	0	0	0	
10/13/20	1a BD	Pe	5	100	0	0	0	0	
10/13/20	1a BD	Pd	3	0	100	0	0	0	
10/13/20	1a BD	Pt	12	100	0	0	0	0	
10/13/20	1a BD	Pt	150	30	70	0	0	0	
10/13/20	1a BD	Pm	25	100	0	0	0	0	
10/13/20	1a BD	Pc	5	0	0	100	0	0	
10/13/20	1a BD	Pc	5	0	0	100	0	0	
10/13/20	1b BD	Pm	45	100	0	0	0	0	
10/13/20	1b BD	Pm	4	100	0	0	0	0	
10/13/20	1b BD	Pm	30	100	0	0	0	0	
10/13/20	1b BD	Pm	2	100	0	0	0	0	
10/13/20	1b BD	Co	4	0	100	0	0	0	
10/13/20	1b BD	Co	3	0	100	0	0	0	
10/13/20	1b BD	Co	7	0	100	0	0	0	
10/13/20	1b BD	Co	2	0	100	0	0	0	
10/13/20	1b BD	Co	4	0	100	0	0	0	
10/13/20	1b BD	Co	4	0	100	0	0	0	
10/13/20	2a KH	Pm	5	100	0	0	0	0	
10/13/20	2a KH	Pc	10	100	0	0	0	0	
10/13/20	2a KH	Co	5	10	90	0	0	0	
10/13/20	2a KH	Pm	45	100	0	0	0	0	
10/13/20	2a KH	Pm	10	100	0	0	0	0	
10/13/20	2a KH	Pm	45	100	0	0	0	0	
10/13/20	2a KH	Mc	25	10	0	90	0	0	
10/13/20	2a KH	Mc	10	10	0	90	0	0	
10/13/20	2a KH	Mc	10	10	70	20	0	0	
10/13/20	2a KH	Mc	15	10	90	0	0	0	
10/13/20	2a KH	Pm	15	100	0	0	0	0	
10/13/20	2b KH	Pm	45	100	0	0	0	0	
10/13/20	2b KH	Pm	5	0	100	0	0	0	
10/13/20	2b KH	Co	3	0	100	0	0	0	
10/13/20	2b KH	Pm	55	100	0	0	0	0	
10/13/20	2b KH	Co	3	0	100	0	0	0	
10/13/20	2b KH	Pm	50	100	0	0	0	0	
10/13/20	2b KH	Co	5	0	100	0	0	0	
10/13/20	2b KH	Pm	2	0	50	50	0	0	
10/13/20	2b KH	Pm	4	0	50	50	0	0	
10/13/20	3a CH	Pe	5	0	0	100	0	0	
10/13/20	3a CH	Mc	300	90	0	10	0	0	
10/13/20	3a CH	Pm	100	100	0	0	0	0	
10/13/20	3a CH	Pm	100	0	0	0	0	0	
10/13/20	3a CH	Co	5	100	0	0	0	0	

10/13/20	3a CH	Mc	150	90	0	10	0	0	
10/13/20	3a CH	Pl	50	100	0	0	0	0	
10/13/20	3a CH	Co	5	0	100	0	0	0	
10/13/20	3a CH	Co	8	0	50	50	0	0	
10/13/20	3a CH	Co	2	0	0	100	0	0	
10/13/20	3a CH	Pm	3	100	0	0	0	0	
10/13/20	3a CH	Pm	6	100	0	0	0	0	
10/13/20	3a CH	Pm	10	100	0	0	0	0	
10/13/20	3a CH	Mc	60	0	80	20	0	0	
10/13/20	3a CH	Mc	30	0	90	10	0	0	
10/13/20	3a CH	Mc	20	10	50	40	0	0	
10/13/20	3a CH	Pv	10	100	0	0	0	0	
10/13/20	3a CH	Pv	25	100	0	0	0	0	
10/13/20	3a CH	Pv	5	100	0	0	0	0	
10/13/20	3a CH	Pv	15	100	0	0	0	0	
10/13/20	3a CH	Pv	60	100	0	0	0	0	
10/13/20	3a CH	Co	5	0	100	0	0	0	
10/13/20	3a CH	Co	3	0	100	0	0	0	
10/13/20	3a CH	Co	5	0	100	0	0	0	
10/13/20	3a CH	Co	4	0	100	0	0	0	
10/13/20	3b CH	Co	5	0	100	0	0	0	
10/13/20	3b CH	Co	4	10	90	0	0	0	
10/13/20	3b CH	Mc	35	60	5	35	0	0	
10/13/20	3b CH	Co	6	0	100	0	0	0	
10/13/20	3b CH	Co	10	20	80	0	0	0	
10/13/20	3b CH	Co	8	90	10	0	0	0	
10/13/20	3b CH	Co	3	0	90	10	0	0	
10/13/20	3b CH	Mc	85	0	10	90	0	0	
10/13/20	3b CH	Mc	20	0	10	90	0	0	
10/13/20	3b CH	Mc	25	0	10	90	0	0	
10/13/20	3b CH	Mc	10	0	100	0	0	0	
10/13/20	3b CH	Co	10	0	90	10	0	0	
10/13/20	3b CH	Co	10	0	100	0	0	0	
10/13/20	3b CH	Co	5	0	90	10	0	0	
10/13/20	4a WB	Pc	20	100	0	0	0	0	
10/13/20	4a WB	Pc	15	100	0	0	0	0	
10/13/20	4a WB	Pl	100	100	0	0	0	0	
10/13/20	4a WB	Pl	150	100	0	0	0	0	
10/13/20	4a WB	Pl	200	100	0	0	0	0	
10/13/20	4a WB	Pl	40	100	0	0	0	0	
10/13/20	4a WB	Pl	50	100	0	0	0	0	
10/13/20	4a WB	Pl	60	100	0	0	0	0	
10/13/20	4a WB	Pl	80	100	0	0	0	0	
10/13/20	4a WB	Pl	30	100	0	0	0	0	
10/13/20	4a WB	Mc	35	0	80	20	0	0	
10/13/20	4a WB	Pl	40	100	0	0	0	0	
10/13/20	4a WB	Pl	300	100	0	0	0	0	
10/13/20	4a WB	Pl	5	100	0	0	0	0	
10/13/20	4a WB	Pl	10	100	0	0	0	0	
10/13/20	4a WB	Pl	25	100	0	0	0	0	
10/13/20	4a WB	Co	20	0	90	10	0	0	
10/13/20	4a WB	Co	5	0	100	0	0	0	
10/13/20	4a WB	Pm	3	100	0	0	0	0	
10/13/20	4a WB	Pl	25	100	0	0	0	0	
10/13/20	4a WB	Pl	20	100	0	0	0	0	
10/13/20	4a WB	Pl	15	100	0	0	0	0	
10/13/20	4a WB	Pl	20	100	0	0	0	0	
10/13/20	4a WB	Co	4	0	100	0	0	0	
10/13/20	4a WB	Mc	25	90	10	0	0	0	
10/13/20	4a WB	Pv	10	0	90	10	0	0	
10/13/20	4a WB	Mc	60	90	10	0	0	0	
10/13/20	4a WB	Mc	7	60	5	35	0	0	
10/13/20	4a WB	Mc	35	0	90	10	0	0	
10/13/20	4a WB	Pm	25	100	0	0	0	0	
10/13/20	4a WB	Pm	10	0	0	100	0	0	

10/13/20	4a WB	Mc	60	0	50	50	0	0	
10/13/20	4a WB	Pm	15	0	0	100	0	0	
10/13/20	4a WB	Mc	25	0	0	100	0	0	
10/13/20	4a WB	Pm	10	0	90	10	0	0	
10/13/20	4a WB	Mc	5	0	90	10	0	0	
10/13/20	4a WB	Mc	5	0	90	10	0	0	
10/13/20	4a WB	Mc	5	0	90	10	0	0	
10/13/20	4a WB	Mc	5	0	90	10	0	0	
10/13/20	4a WB	Mc	10	0	30	70	0	0	
10/13/20	4a WB	Mc	20	0	50	50	0	0	
10/13/20	4a WB	Mc	10	100	0	0	0	0	
10/13/20	4a WB	Pl	40	100	0	0	0	0	
10/13/20	4a WB	Pl	30	100	0	0	0	0	
10/13/20	4a WB	Pl	20	100	100	0	0	0	
10/13/20	4a WB	Pl	25	100	0	0	0	0	
10/13/20	4a WB	Pl	10	100	0	0	0	0	
10/13/20	4b WB	Pe	10	100	0	0	0	0	
10/13/20	4b WB	Pe	5	100	0	0	0	0	
10/13/20	4b WB	Pe	30	100	0	0	0	0	
10/13/20	4b WB	Pe	20	100	0	0	0	0	
10/13/20	4b WB	Pe	25	100	0	0	0	0	
10/13/20	4b WB	Pe	10	100	0	0	0	0	
10/13/20	4b WB	Pe	15	100	0	0	0	0	
10/13/20	4b WB	Pe	15	100	0	0	0	0	
10/13/20	4b WB	Pe	15	100	0	0	0	0	
10/13/20	4b WB	Pe	10	100	0	0	0	0	
10/13/20	4b WB	Pe	10	100	0	0	0	0	
10/13/20	4b WB	Pe	10	100	0	0	0	0	
10/13/20	4b WB	Pe	40	100	0	0	0	0	
10/13/20	4b WB	Pe	30	100	0	0	0	0	
10/13/20	4b WB	Pe	15	100	0	0	0	0	
10/13/20	4b WB	Pe	10	100	0	0	0	0	
10/13/20	4b WB	Pe	10	100	0	0	0	0	
10/13/20	4b WB	Pe	10	100	0	0	0	0	
10/13/20	4b WB	Pl	10	100	0	0	0	0	
10/13/20	4b WB	Pl	15	100	0	0	0	0	
10/13/20	4b WB	Pl	150	100	0	0	0	0	
10/13/20	4b WB	Co	4	100	0	0	0	0	
10/13/20	4b WB	Co	5	80	0	20	0	0	
10/13/20	4b WB	Pe	10	100	0	0	0	0	
10/13/20	4b WB	Pv	15	90	10	0	0	0	
10/13/20	4b WB	Pc	30	100	0	0	0	0	
10/13/20	4b WB	Pv	20	100	0	0	0	0	
10/13/20	4b WB	Pv	20	100	0	0	0	0	
10/13/20	4b WB	Pv	15	100	0	0	0	0	
10/13/20	4b WB	Pv	30	100	0	0	0	0	
10/13/20	4b WB	Pm	10	100	0	0	0	0	
10/13/20	4b WB	Pc	15	100	0	0	0	0	
10/13/20	4b WB	Pt	10	100	0	0	0	0	
10/13/20	4b WB	Pe	40	100	0	0	0	0	
10/13/20	4b WB	Pl	30	100	0	0	0	0	
10/13/20	4b WB	Pv	30	100	0	0	0	0	
10/13/20	4b WB	Pv	5	100	0	0	0	0	
10/13/20	4b WB	Pc	15	100	0	0	0	0	
10/13/20	4b WB	Pv	5	100	0	0	0	0	
10/13/20	4b WB	Pc	10	100	0	0	0	0	
10/13/20	4b WB	Pe	15	100	0	0	0	0	
10/13/20	4b WB	Pe	15	100	0	0	0	0	
10/13/20	4b WB	Pe	15	100	0	0	0	0	
10/13/20	4b WB	Pe	15	100	0	0	0	0	
10/13/20	4b WB	Pe	15	100	0	0	0	0	
10/13/20	4b WB	Pe	15	100	0	0	0	0	
10/13/20	4b WB	Pe	15	100	0	0	0	0	
10/13/20	4b WB	Pe	15	100	0	0	0	0	
10/13/20	4b WB	Pe	15	100	0	0	0	0	

10/13/20	4b WB	Pe	15	100	0	0	0	0	
10/13/20	4b WB	Pe	15	100	0	0	0	0	
10/13/20	4b WB	Pe	15	100	0	0	0	0	
10/13/20	4b WB	Pe	15	100	0	0	0	0	
10/13/20	4b WB	Pv	10	100	0	0	0	0	
10/13/20	4b WB	Pv	20	100	0	0	0	0	
10/13/20	4b WB	Pv	15	100	0	0	0	0	
10/13/20	4b WB	Pv	15	100	0	0	0	0	
10/13/20	4b WB	Pv	25	100	0	0	0	0	
10/13/20	4b WB	Pv	10	100	0	0	0	0	
10/13/20	4b WB	Pl	10	100	0	0	0	0	
10/13/20	4b WB	Pl	30	100	0	0	0	0	
10/13/20	4b WB	Pl	50	100	0	0	0	0	
10/13/20	4b WB	Pl	5	100	0	0	0	0	
10/13/20	4b WB	Pl	10	100	0	0	0	0	
10/13/20	4b WB	Pl	15	100	0	0	0	0	
10/13/20	4b WB	Pl	15	100	0	0	0	0	
10/13/20	4b WB	Pl	40	100	0	0	0	0	
10/13/20	4b WB	Pl	20	100	0	0	0	0	
10/13/20	4b WB	Pl	50	100	0	0	0	0	
10/13/20	4b WB	Pe	45	100	0	0	0	0	
10/13/20	4b WB	Pe	20	100	0	0	0	0	
10/13/20	4b WB	Pe	10	100	0	0	0	0	
10/13/20	4b WB	Pe	15	100	0	0	0	0	
10/13/20	4b WB	Pe	15	100	0	0	0	0	
10/13/20	4b WB	Pe	10	100	0	0	0	0	
10/13/20	4b WB	Pe	5	100	0	0	0	0	
10/13/20	4b WB	Pe	10	100	0	0	0	0	
10/13/20	4b WB	Pe	10	100	0	0	0	0	
10/13/20	4b WB	Pe	10	100	0	0	0	0	
10/13/20	4b WB	Pe	10	100	0	0	0	0	
10/13/20	4b WB	Pe	20	100	0	0	0	0	
10/13/20	4b WB	Pe	15	100	0	0	0	0	
10/13/20	4b WB	Pe	15	100	0	0	0	0	
10/13/20	4b WB	Pv	10	100	0	0	0	0	
10/13/20	4b WB	Pv	20	100	0	0	0	0	
10/13/20	4b WB	Pv	30	100	0	0	0	0	
10/13/20	4b WB	Pv	50	100	0	0	0	0	
10/13/20	4b WB	Pv	10	100	0	0	0	0	
10/13/20	4b WB	Pv	10	100	0	0	0	0	
10/13/20	4b WB	Pv	10	100	0	0	0	0	
10/13/20	4b WB	Pv	10	100	0	0	0	0	
4/3/20	1a BD	Pe	10	100	0	0	0	0	
4/3/20	1a BD	Pe	15	100	0	0	0	0	
4/3/20	1a BD	Pe	5	100	0	0	0	0	
4/3/20	1a BD	Pe	4	100	0	0	0	0	
4/3/20	1a BD	Pe	12	100	0	0	0	0	
4/3/20	1a BD	Pe	6	100	0	0	0	0	
4/3/20	1a BD	Pl	10	100	0	0	0	0	
4/3/20	1a BD	Pl	15	100	0	0	0	0	
4/3/20	1a BD	Pl	5	100	0	0	0	0	
4/3/20	1a BD	Pl	10	100	0	0	0	0	
4/3/20	1a BD	Pl	5	100	0	0	0	0	
4/3/20	1a BD	Pl	5	100	0	0	0	0	
4/3/20	1a BD	Pl	6	100	0	0	0	0	
4/3/20	1a BD	Pd	6	100	0	0	0	0	
4/3/20	1a BD	Pd	5	100	0	0	0	0	
4/3/20	1a BD	Pd	7	100	0	0	0	0	
4/3/20	1a BD	Pt	15	100	0	0	0	0	
4/3/20	1a BD	Pt	60	100	0	0	0	0	
4/3/20	1a BD	Pc	5	100	0	0	0	0	
4/3/20	1a BD	Pm	25	100	0	0	0	0	
4/3/20	1a BD	Pt	40	100	0	0	0	0	
4/3/20	1a BD	Pm	20	100	0	0	0	0	
4/3/20	1a BD	Pt	70	100	0	0	0	0	

4/3/20	1b BD	Co	4	0	0	100	0	0	
4/3/20	1b BD	Pm	14	100	0	0	0	0	
4/3/20	1b BD	Co	2	0	0	100	0	0	
4/3/20	1b BD	Mp	10	100					
4/3/20	1b BD	Pm	15	100					
4/3/20	1b BD	Pm	1	100					
4/3/20	1b BD	Mp	30	100					
4/3/20	2a KH	Pm	15	100	0	0	0	0	
4/3/20	2a KH	Pl	2	100	0	0	0	0	
4/3/20	2a KH	Pl	2	100	0	0	0	0	
4/3/20	2a KH	Pl	2	100	0	0	0	0	
4/3/20	2a KH	Pl	2	100	0	0	0	0	
4/3/20	2a KH	Pm	10	100	0	0	0	0	
4/3/20	2a KH	Pm	12	100	0	0	0	0	
4/3/20	2a KH	Pm	3	100	0	0	0	0	
4/3/20	2a KH	Pv	1	100	0	0	0	0	
4/3/20	2a KH	Pv	2	100	0	0	0	0	
4/3/20	2a KH	Pv	2	100	0	0	0	0	
4/3/20	2a KH	Pv	1	100	0	0	0	0	
4/3/20	2a KH	Pv	2	100	0	0	0	0	
4/3/20	2a KH	Pl	1	100	0	0	0	0	
4/3/20	2b KH	Pm	10	100	0	0	0	0	
4/3/20	2b KH	Pm	5	100	0	0	0	0	
4/3/20	2b KH	Pm	12	100	0	0	0	0	
4/3/20	2b KH	Pm	15	100	0	0	0	0	
4/3/20	2b KH	Mc	6	100	0	0	0	0	
4/3/20	2b KH	Mc	25	100	0	0	0	0	
4/3/20	2b KH	Mc	5	100	0	0	0	0	
4/3/20	2b KH	Mc	20	100	0	0	0	0	
4/3/20	2b KH	Pt	15	100	0	0	0	0	
4/3/20	3a CH	Pl	10	100	0	0	0	0	almost all corals vertical
4/3/20	3a CH	Pl	10	100	0	0	0	0	
4/3/20	3a CH	Pl	10	100	0	0	0	0	
4/3/20	3a CH	Co	2	100	0	0	0	0	
4/3/20	3a CH	Pb	2	0	0	100	0	0	
4/3/20	3a CH	Pl	70	100	0	0	0	0	bite marks
4/3/20	3a CH	Pb	10	50	0	50	0	0	
4/3/20	3a CH	Co	2	0	0	100	0	0	
4/3/20	3a CH	Co	2	0	0	100	0	0	
4/3/20	3a CH	Pm	5	100	0	0	0	0	
4/3/20	3a CH	Co	2	0	0	100	0	0	
4/3/20	3a CH	Mc	100	100	0	0	0	0	
4/3/20	3a CH	Mc	150	100	0	0	0	0	
4/3/20	3a CH	Mc	15	100	0	0	0	0	
4/3/20	3a CH	Mc	7	100	0	0	0	0	
4/3/20	3a CH	Mc	5	50	0	0	0	50	some abrasion
4/3/20	3a CH	Pv	165	100	0	0	0	0	
4/3/20	3a CH	Co	7	0	0	100	0	0	
4/3/20	3a CH	Mp	30	0	0	0	0	100	abrasion
4/3/20	3a CH	Pv	20	100	0	0	0	0	
4/3/20	3a CH	Pv	5	100	0	0	0	0	
4/3/20	3a CH	Co	5	100	0	0	0	0	
4/3/20	3a CH	Mc	200	100	0	0	0	0	
4/3/20	3b CH	Mp	5	100		0	0	0	
4/3/20	3b CH	Co	3	0	0	100	0	0	
4/3/20	3b CH	Mc	30	100	0	0	0	0	
4/3/20	3b CH	Pl	40	100	0	0	0	0	
4/3/20	3b CH	Pl	10	100	0	0	0	0	
4/3/20	3b CH	Pl	10	100	0	0	0	0	
4/3/20	3b CH	Pl	20	100	0	0	0	0	
4/3/20	3b CH	Pl	5	100	0	0	0	0	
4/3/20	3b CH	Co	2	100	0	0	0	0	
4/3/20	3b CH	Co	2	100	0	0	0	0	
4/3/20	3b CH	Co	2	100	0	0	0	0	
4/3/20	3b CH	Co	8	100	0	0	0	0	

4/3/20	3b CH	Co	6	100	0	0	0	0	
4/3/20	3b CH	Lp	8	100	0	0	0	0	
4/3/20	3b CH	Mp	200	100	0	0	0	0	
4/3/20	3b CH	Mc	100	100	0	0	0	0	
4/3/20	3b CH	Mc	50	100	0	0	0	0	
4/3/20	3b CH	Mc	10	100	0	0	0	0	
4/3/20	3b CH	Mc	5	100	0	0	0	0	
4/3/20	3b CH	Co	2	0	0	100	0	0	
4/3/20	3b CH	Pm	5	100	0	0	0	0	
4/3/20	3b CH	Pm	6	100	0	0	0	0	
4/3/20	4a WB	Pl	5	100	0	0	0	0	
4/3/20	4a WB	Pl	10	100	0	0	0	0	
4/3/20	4a WB	Pl	20	100	0	0	0	0	
4/3/20	4a WB	Pl	15	100	0	0	0	0	
4/3/20	4a WB	Pl	5	100	0	0	0	0	
4/3/20	4a WB	Pl	20	100	0	0	0	0	
4/3/20	4a WB	Pv	5	100	0	0	0	0	
4/3/20	4a WB	Pv	10	100	0	0	0	0	
4/3/20	4a WB	Pv	5	100	0	0	0	0	
4/3/20	4a WB	Pv	15	100	0	0	0	0	
4/3/20	4a WB	Pv	5	100	0	0	0	0	
4/3/20	4a WB	Pv	15	100	0	0	0	0	
4/3/20	4a WB	Pb	6	100	0	0	0	0	
4/3/20	4a WB	Pl	2	100	0	0	0	0	
4/3/20	4a WB	Pl	5	100	0	0	0	0	
4/3/20	4a WB	Pl	30	100	0	0	0	0	
4/3/20	4a WB	Pl	10	100	0	0	0	0	
4/3/20	4a WB	Pl	8	100	0	0	0	0	
4/3/20	4a WB	Pl	10	100	0	0	0	0	
4/3/20	4a WB	Pl	6	100	0	0	0	0	
4/3/20	4a WB	Pl	10	100	0	0	0	0	
4/3/20	4a WB	Pl	2	100	0	0	0	0	
4/3/20	4a WB	Pl	15	100	0	0	0	0	
4/3/20	4a WB	Mc	12	100	0	0	0	0	
4/3/20	4a WB	Mc	3	100	0	0	0	0	
4/3/20	4a WB	Mc	2	100	0	0	0	0	
4/3/20	4a WB	Pm	2	0	0	100	0	0	
4/3/20	4a WB	Co	3	100	0	0	0	0	
4/3/20	4a WB	Pv	5	100	0	0	0	0	
4/3/20	4a WB	Mc	20	100	0	0	0	0	
4/3/20	4a WB	Pm	5	100	0	0	0	0	
4/3/20	4a WB	Pm	3	100	0	0	0	0	
4/3/20	4a WB	Co	2	100	0	0	0	0	
4/3/20	4a WB	Co	2	100	0	0	0	0	
4/3/20	4a WB	Pm	2	100	0	0	0	0	
4/3/20	4a WB	Mp	20	100	0	0	0	0	
4/3/20	4a WB	Mp	10	100	0	0	0	0	
4/3/20	4a WB	Mp	25	100	0	0	0	0	
4/3/20	4a WB	Mp	3	0	0	0	0	100	abrasion
4/3/20	4a WB	Pm	2	100	0	0	0	0	
4/3/20	4a WB	Pm	5	100	0	0	0	0	
4/3/20	4a WB	Pd	5	100	0	0	0	0	
4/3/20	4a WB	Pd	7	100	0	0	0	0	
4/3/20	4a WB	Pd	3	100	0	0	0	0	
4/3/20	4a WB	Pd	3	0	100	0	0	0	
4/3/20	4a WB	Pm	5	100	0	0	0	0	
4/3/20	4a WB	Pm	5	100	0	0	0	0	
4/3/20	4a WB	Pm	3	100	0	0	0	0	
4/3/20	4a WB	Pm	4	100	0	0	0	0	
4/3/20	4a WB	MC	60	0	0	100	0	0	
4/3/20	4a WB	Mc	25	100	0	0	0	0	
4/3/20	4a WB	Pm	5	100	0	0	0	0	
4/3/20	4a WB	Pl	90	100	0	0	0	0	
4/3/20	4a WB	Co	3	100	0	0	0	0	
4/3/20	4a WB	Co	5	100	0	0	0	0	

4/3/20	4a WB	Mc	15	100	0	0	0	0	green pigment
4/3/20	4a WB	Co	5	100	0	0	0	0	
4/3/20	4a WB	Pd	5	100	0	0	0	0	
4/3/20	4a WB	Pl	200	100	0	0	0	0	
4/3/20	4b WB	Pl	30	100	0	0	0	0	
4/3/20	4b WB	Pl	5	100	0	0	0	0	
4/3/20	4b WB	Pl	5	100	0	0	0	0	
4/3/20	4b WB	Pl	100	100	0	0	0	0	
4/3/20	4b WB	Pv	40	100	0	0	0	0	
4/3/20	4b WB	Pv	10	100	0	0	0	0	
4/3/20	4b WB	Pv	5	100	0	0	0	0	
4/3/20	4b WB	Pv	20	100	0	0	0	0	
4/3/20	4b WB	Pl	5	100	0	0	0	0	
4/3/20	4b WB	Pl	5	100	0	0	0	0	
4/3/20	4b WB	Pv	10	100	0	0	0	0	
4/3/20	4b WB	Pv	5	100	0	0	0	0	
4/3/20	4b WB	Pv	7	100	0	0	0	0	
4/3/20	4b WB	Pc	4	100	0	0	0	0	
4/3/20	4b WB	Pc	10	100	0	0	0	0	
4/3/20	4b WB	Pl	10	100	0	0	0	0	
4/3/20	4b WB	Pl	40	100	0	0	0	0	
4/3/20	4b WB	Pl	20	100	0	0	0	0	
4/3/20	4b WB	Pl	10	100	0	0	0	0	
4/3/20	4b WB	Pl	10	100	0	0	0	0	
4/3/20	4b WB	Pl	15	100	0	0	0	0	
4/3/20	4b WB	Pl	10	100	0	0	0	0	
4/3/20	4b WB	Pc	3	100	0	0	0	0	
4/3/20	4b WB	Pc	5	100	0	0	0	0	
4/3/20	4b WB	Pc	2	100	0	0	0	0	
4/3/20	4b WB	Pc	5	100	0	0	0	0	
4/3/20	4b WB	Pc	3	100	0	0	0	0	
4/3/20	4b WB	Pc	5	100	0	0	0	0	
4/3/20	4b WB	Pt	5	100	0	0	0	0	
4/3/20	4b WB	Pl	10	100	0	0	0	0	
4/3/20	4b WB	Pl	5	100	0	0	0	0	
4/3/20	4b WB	Pl	10	100	0	0	0	0	
4/3/20	4b WB	Pl	10	100	0	0	0	0	
4/3/20	4b WB	Pt	10	100	0	0	0	0	
4/3/20	4b WB	Pl	5	100	0	0	0	0	
4/3/20	4b WB	Pc	5	100	0	0	0	0	
4/3/20	4b WB	Pc	3	100	0	0	0	0	
4/3/20	4b WB	Pc	3	100	0	0	0	0	
4/3/20	4b WB	Pc	2	100	0	0	0	0	
4/3/20	4b WB	Pv	10	100	0	0	0	0	
4/3/20	4b WB	Pl	5	100	0	0	0	0	
4/3/20	4b WB	Pl	3	100	0	0	0	0	
4/3/20	4b WB	Pl	5	100	0	0	0	0	
4/3/20	4b WB	Pl	3	100	0	0	0	0	
4/3/20	4b WB	Pc	5	100	0	0	0	0	
4/3/20	4b WB	Pc	6	100	0	0	0	0	
4/3/20	4b WB	Pv	3	100	0	0	0	0	
4/3/20	4b WB	Pc	5	100	0	0	0	0	
4/3/20	4b WB	Pc	2	100	0	0	0	0	
4/3/20	4b WB	Lp	3	100	0	0	0	0	
4/3/20	4b WB	Lp	4	100	0	0	0	0	
4/3/20	4b WB	Pv	20	100	0	0	0	0	
4/3/20	4b WB	Pv	10	100	0	0	0	0	
4/3/20	4b WB	Pv	5	100	0	0	0	0	
4/3/20	4b WB	Pv	5	100	0	0	0	0	
4/3/20	4b WB	Pv	15	100	0	0	0	0	
4/3/20	4b WB	Pc	5	100	0	0	0	0	
4/3/20	4b WB	Pc	5	100	0	0	0	0	
4/3/20	4b WB	Pc	5	100	0	0	0	0	
4/3/20	4b WB	Pc	5	100	0	0	0	0	
4/3/20	4b WB	Pc	5	100	0	0	0	0	

4/3/20	4b WB	Pc	5	100	0	0	0	0	
4/3/20	4b WB	Pl	60	100	0	0	0	0	
4/3/20	4b WB	Pv	6	100	0	0	0	0	
4/3/20	4b WB	Pm	10	100	0	0	0	0	
4/3/20	4b WB	Pl	10	100	0	0	0	0	
4/3/20	4b WB	Pl	10	100	0	0	0	0	
10/8/19	1a BD	Pe	40	0	0	100	0	0	
10/8/19	1a BD	Pe	80	0	0	100	0	0	
10/8/19	1a BD	Pe	30	0	0	100	0	0	
10/8/19	1a BD	Pe	15	0	0	100	0	0	
10/8/19	1a BD	Pe	25	0	100	0	0	0	
10/8/19	1a BD	Pe	45	0	0	0	100	0	
10/8/19	1a BD	Pe	15	100	0	0	0	0	
10/8/19	1a BD	Pe	45	0	100	0	0	0	
10/8/19	1a BD	Pe	30	0	0	50	50	0	bite marks
10/8/19	1a BD	Pe	30	0	0	100	0	0	
10/8/19	1a BD	Pe	45	0	0	100	0	0	
10/8/19	1a BD	Pe	50	0	0	100	0	0	
10/8/19	1a BD	Pe	10	0	0	100	0	0	
10/8/19	1a BD	Pe	5	0	0	100	0	0	
10/8/19	1a BD	Pe	25	0	0	100	0	0	
10/8/19	1a BD	Pe	15	0	0	100	0	0	
10/8/19	1a BD	Pe	20	100	0	0	0	0	
10/8/19	1a BD	Pm	5	0	100	0	0	0	
10/8/19	1a BD	Pm	100	0	0	100	0	0	
10/8/19	1a BD	Pt	95	0	0	100	0	0	
10/8/19	1a BD	Pm	35	0	0	100	0	0	
10/8/19	1a BD	Pt	30	0	0	100	0	0	
10/8/19	1b BD	Pm	40	0	0	100	0	0	
10/8/19	1b BD	Pm	25	0	0	100	0	0	
10/8/19	1b BD	Plichen	3	0	100	0	0	0	
10/8/19	2a KH	Pm	25	0	0	100	0	0	bright purple/pink
10/8/19	2a KH	Plichen	3	0	0	100	0	0	
10/8/19	2a KH	Pm	2	0	0	100	0	0	
10/8/19	2a KH	Pl	8	0	0	100	0	0	bite marks
10/8/19	2a KH	Pm	5	0	0	100	0	0	pink
10/8/19	2a KH	Pm	35	0	0	100	0	0	pink
10/8/19	2b KH	Pm	7	0	100	0	0	0	
10/8/19	2b KH	Pt	50	100	0	0	0	0	
10/8/19	2b KH	Pm	30	0	0	100	0	0	
10/8/19	2b KH	Pm	45	100	0	0	0	0	
10/8/19	3a CH	Mc	200	0	0	100	0	0	
10/8/19	3a CH	Pm	5	0	100	0	0	0	
10/8/19	3a CH	Pm	10	0	100	0	0	0	
10/8/19	3a CH	Pm	15	0	100	0	0	0	
10/8/19	3a CH	Co	5	0	100	0	0	0	
10/8/19	3a CH	Co	5	0	100	0	0	0	
10/8/19	3a CH	Co	5	0	100	0	0	0	
10/8/19	3a CH	Co	10	0	0	100	0	0	
10/8/19	3a CH	Pl	40	0	0	100	0	0	fish bites
10/8/19	3a CH	Pv	5	100	0	0	0	0	cracks
10/8/19	3a CH	PV	10	100	0	0	0	0	cracks
10/8/19	3a CH	Pv	5	100	0	0	0	0	
10/8/19	3a CH	Co	10	100	0	0	0	0	
10/8/19	3a CH	Pm	8	0	100	0	0	0	
10/8/19	3a CH	Co	5	100	0	0	0	0	
10/8/19	3a CH	Pm	4	0	100	0	0	0	
10/8/19	3a CH	Co	5	100	0	0	0	0	abraded
10/8/19	3a CH	Co	8	0	0	100	0	0	
10/8/19	3a CH	Co	10	0	100	0	0	0	
10/8/19	3a CH	Pm	15	100	0	0	0	0	
10/8/19	3a CH	Pl	25	100	0	0	0	0	
10/8/19	3a CH	Pm	20	100	0	0	0	0	
10/8/19	3a CH	Pl	30	100	0	0	0	0	
10/8/19	3a CH	Lp	5	100	0	0	0	0	

10/8/19	3a CH	Mp	30	100	0	0	0	0	
10/8/19	3a CH	Mc	70	0	0	100	0	0	
10/8/19	3a CH	Pv	5	100	0	0	0	0	
10/8/19	3a CH	Pv	50	100	0	0	0	0	
10/8/19	3a CH	Mc	10	0	0	100	0	0	
10/8/19	3a CH	Co	5	0	100	0	0	0	
10/8/19	3a CH	Pm	2	0	100	0	0	0	
10/8/19	3a CH	Co	5	0	0	100	0	0	
10/8/19	3a CH	Co	3	0	0	100	0	0	
10/8/19	3a CH	Co	2	0	0	100	0	0	
10/8/19	3a CH	Pm	5	0	100	0	0	0	
10/8/19	3a CH	Co	3	0	100	0	0	0	
10/8/19	3a CH	Mc	150	100	0	0	0	0	
10/8/19	3a CH	Co	5	0	100	0	0	0	
10/8/19	3a CH	Co	3	0	100	0	0	0	
10/8/19	3a CH	Co	7	0	100	0	0	0	
10/8/19	3a CH	Co	4	0	100	0	0	0	
10/8/19	3a CH	Pm	6	0	100	0	0	0	
10/8/19	3a CH	Co	3	0	100	0	0	0	
10/8/19	3b CH	Pm	15	0	100	0	0	0	
10/8/19	3b CH	Mc	150	0	0	50	50	0	
10/8/19	3b CH	Mp	50	0	0	100	0	0	
10/8/19	3b CH	Mp	60	0	0	100	0	0	
10/8/19	3b CH	Mp	180	0	0	100	0	0	
10/8/19	3b CH	Mp	10	0	0	100	0	0	
10/8/19	3b CH	Mp	15	0	0	100	0	0	
10/8/19	3b CH	Lp	2	100	0	0	0	0	
10/8/19	3b CH	Mp	5	100	0	0	0	0	
10/8/19	3b CH	Mc	80	100	0	0	0	0	
10/8/19	3b CH	Co	5	0	0	100	0	0	
10/8/19	3b CH	Pm	15	0	30	0	70	0	
10/8/19	3b CH	Co	5	0	100	0	0	0	
10/8/19	3b CH	Pm	5	0	100	0	0	0	
10/8/19	4a WB	Pl	30	100	0	0	0	0	
10/8/19	4a WB	Pl	40	100	0	0	0	0	
10/8/19	4a WB	Pl	30	100	0	0	0	0	
10/8/19	4a WB	Pl	10	100	0	0	0	0	
10/8/19	4a WB	Pl	10	100	0	0	0	0	
10/8/19	4a WB	Pl	15	100	0	0	0	0	
10/8/19	4a WB	Pl	10	100	0	0	0	0	
10/8/19	4a WB	Pl	15	100	0	0	0	0	
10/8/19	4a WB	Pl	30	0	100	0	0	0	
10/8/19	4a WB	Pl	25	0	0	100	0	0	
10/8/19	4a WB	Pl	20	100	0	0	0	0	
10/8/19	4a WB	Pl	25	100	0	0	0	0	
10/8/19	4a WB	Pl	50	100	0	0	0	0	
10/8/19	4a WB	Pl	5	100	0	0	0	0	
10/8/19	4a WB	Pl	15	100	0	0	0	0	
10/8/19	4a WB	Pl	25	100	0	0	0	0	
10/8/19	4a WB	Mc	25	0	0	100	0	0	
10/8/19	4a WB	Pl	40	100	0	0	0	0	fish bites
10/8/19	4a WB	Pl	80	50	0	50	0	0	
10/8/19	4a WB	Pl	100	50	0	50	0	0	
10/8/19	4a WB	Pl	120	50	0	50	0	0	
10/8/19	4a WB	Mc	20	0	0	100	0	0	
10/8/19	4a WB	Pl	150	100	0	0	0	0	
10/8/19	4a WB	Pl	60	100	0	0	0	0	
10/8/19	4a WB	Pl	25	100	0	0	0	0	
10/8/19	4a WB	Pm	5	0	100	0	0	0	
10/8/19	4a WB	Pm	5	0	100	0	0	0	
10/8/19	4a WB	Pm	5	0	100	0	0	0	
10/8/19	4a WB	Pm	10	0	100	0	0	0	
10/8/19	4a WB	Mc	100	0	60	0	40	0	
10/8/19	4a WB	Pm	15	0	100	0	0	0	
10/8/19	4a WB	Pm	10	0	100	0	0	0	

10/8/19	4a WB	Pm	5	0	100	0	0	0	
10/8/19	4a WB	Pm	4	0	100	0	0	0	
10/8/19	4a WB	Pl	15	100	0	0	0	0	
10/8/19	4a WB	Pl	15	100	0	0	0	0	
10/8/19	4a WB	Pl	15	100	0	0	0	0	
10/8/19	4a WB	Pl	15	100	0	0	0	0	
10/8/19	4b WB	Pl	7	0	0	100	0	0	
10/8/19	4b WB	Pl	20	0	0	100	0	0	
10/8/19	4b WB	Pl	5	100	0	0	0	0	
10/8/19	4b WB	Pl	10	100	0	0	0	0	
10/8/19	4b WB	Pl	5	100	0	0	0	0	
10/8/19	4b WB	Pl	5	100	0	0	0	0	
10/8/19	4b WB	Pl	5	100	0	0	0	0	
10/8/19	4b WB	Pl	10	100	0	0	0	0	
10/8/19	4b WB	Pl	5	100	0	0	0	0	
10/8/19	4b WB	Pl	5	100	0	0	0	0	
10/8/19	4b WB	Pl	5	100	0	0	0	0	
10/8/19	4b WB	Pl	10	100	0	0	0	0	
10/8/19	4b WB	Pl	10	100	0	0	0	0	
10/8/19	4b WB	Pl	10	100	0	0	0	0	
10/8/19	4b WB	Pl	5	0	0	100	0	0	
10/8/19	4b WB	Pl	15	100	0	0	0	0	
10/8/19	4b WB	Pl	5	0	0	100	0	0	
10/8/19	4b WB	Pl	10	100	0	0	0	0	
10/8/19	4b WB	Pl	10	100	0	0	0	0	
10/8/19	4b WB	Pl	2	100	0	0	0	0	
10/8/19	4b WB	Pl	5	100	0	0	0	0	
10/8/19	4b WB	Pl	10	100	0	0	0	0	
10/8/19	4b WB	Pl	15	0	0	100	0	0	
10/8/19	4b WB	Pl	15	100	0	0	0	0	
10/8/19	4b WB	Pt	30	0	0	100	0	0	
10/8/19	4b WB	Pl	15	100	0	0	0	0	
10/8/19	4b WB	Pl	35	100	0	0	0	0	
10/8/19	4b WB	Pl	5	100	0	0	0	0	
10/8/19	4b WB	Pl	5	0	0	100	0	0	
10/8/19	4b WB	Lp	5	100	0	0	0	0	
10/8/19	4b WB	Pl	5	0	0	100	0	0	
10/8/19	4b WB	Pl	5	0	0	100	0	0	
10/8/19	4b WB	Pl	5	100	0	0	0	0	
10/8/19	4b WB	Pl	10	0	0	100	0	0	
10/8/19	4b WB	Pl	10	0	0	100	0	0	
10/8/19	4b WB	Pl	35	0	0	100	0	0	
10/8/19	4b WB	Pl	5	100	0	0	0	0	
10/8/19	4b WB	Pl	15	100	0	0	0	0	
10/8/19	4b WB	Pl	5	100	0	0	0	0	
10/8/19	4b WB	Pl	10	0	0	100	0	0	
10/8/19	4b WB	Pl	10	0	100	0	0	0	
10/8/19	4b WB	Pl	10	0	100	0	0	0	
10/8/19	4b WB	Pl	6	0	0	100	0	0	
10/8/19	4b WB	Pl	8	0	100	0	0	0	
10/31/17	1a BD	Pl	35	100	0	0	0	0	
10/31/17	1a BD	Pl	130	100	0	0	0	0	
10/31/17	1a BD	Pl	10	100	0	0	0	0	
10/31/17	1a BD	Pl	90	100	0	0	0	0	
10/31/17	1a BD	Pl	40	100	0	0	0	0	abraded
10/31/17	1a BD	Pl	30	100	0	0	0	0	
10/31/17	1a BD	Pl	15	100	0	0	0	0	
10/31/17	1a BD	Pl	5	100	0	0	0	0	
10/31/17	1a BD	Pl	300	100	0	0	0	0	
10/31/17	1a BD	Pl	10	100	0	0	0	0	
10/31/17	1a BD	Pe	30	100	0	0	0	0	
10/31/17	1a BD	Pl	35	100	0	0	0	0	
10/31/17	1a BD	Pl	80	100	0	0	0	0	
10/31/17	1b BD	Pv	30	100	0	0	0	0	
10/31/17	1b BD	Pv	50	100	0	0	0	0	

10/31/17	1b BD	Pv	15	100	0	0	0	0	
10/31/17	1b BD	Pc	15	100	0	0	0	0	
10/31/17	1b BD	Pc	10	100	0	0	0	0	
10/31/17	1b BD	Pe	45	100	0	0	0	0	
10/31/17	1b BD	Mc	5	70	30	0	0	0	
10/31/17	1b BD	Mc	15	80	20	0	0	0	
10/31/17	2a KH	Pm	4	100	0	0	0	0	
10/31/17	2a KH	Co	7	100	0	0	0	50	
10/31/17	2a KH	Pm	18	100	0	0	0	50	
10/31/17	2a KH	Mc	50	70	30	0	0	50	
10/31/17	2a KH	Mc	50	70	30	0	0	50	
10/31/17	2a KH	Pl	15	100	0	0	0	50	
10/31/17	2a KH	Pm	10	100	0	0	0	50	
10/31/17	2a KH	Pm	5	10	90	0	0	0	
10/31/17	2a KH	Pm	35	100	0	0	0	0	
10/31/17	2a KH	Mc	150	100	0	0	0	0	
10/31/17	2a KH	Co	5	10	90	0	0	20	
10/31/17	2a KH	Mc	50	90	10	0	0	0	
10/31/17	2a KH	Mc	100	100	0	0	0	20	
10/31/17	2a KH	Mc	20	90	10	0	0	0	
10/31/17	2b KH	Pm	10	100	0	0	0	0	
10/31/17	2b KH	Co	5	50	50	0	0	0	
10/31/17	2b KH	Pm	40	30	70	0	0	0	
10/31/17	2b KH	Pm	4	100	0	0	0	0	
10/31/17	2b KH	Pm	10	100	0	0	0	0	
10/31/17	2b KH	Mc	45	90	10	0	0	0	
10/31/17	3a CH	Pm	15	10	90	0	0	0	
10/31/17	3a CH	Co	2	10	90	0	0	0	
10/31/17	3a CH	Co	10	10	90	0	0	0	
10/31/17	3a CH	Co	5	100	0	0	0	0	in crevice so not bleached from temps?
10/31/17	3a CH	Pm	10	100	0	0	0	0	
10/31/17	3a CH	Co	5	50	50	0	0	0	
10/31/17	3a CH	Co	5	10	90	0	0	0	
10/31/17	3a CH	Co	5	10	90	0	0	0	
10/31/17	3a CH	Pm	5	100	0	0	0	0	
10/31/17	3a CH	Pe	15	100	0	0	0	0	
10/31/17	3a CH	Mc	35	40	60	0	0	0	
10/31/17	3a CH	Mc	80	50	50	0	0	0	
10/31/17	3a CH	Mc	10	80	20	0	0	0	
10/31/17	3a CH	Mc	95	90	10	0	0	0	
10/31/17	3a CH	Mc	5	50	50	0	0	0	
10/31/17	3a CH	Mc	10	40	60	0	0	0	
10/31/17	3a CH	Mc	50	50	50	0	0	0	
10/31/17	3a CH	Mc	100	60	40	0	0	0	
10/31/17	3a CH	Mc	50	60	40	0	0	0	
10/31/17	3a CH	Mp	100	100	0	0	0	0	
10/31/17	3a CH	Mp	70	100	0	0	0	0	
10/31/17	3a CH	Pe	10	100	0	0	0	0	
10/31/17	3a CH	Mc	65	80	20	0	0	0	
10/31/17	3a CH	Co	5	0	100	0	0	0	
10/31/17	3a CH	Mp	30	100	0	0	0	0	
10/31/17	3a CH	Mc	70	90	10	0	0	0	
10/31/17	3b CH	Pl	30	100	0	0	0	0	
10/31/17	3b CH	Mc	150	80	20	0	0	0	
10/31/17	3b CH	Mc	100	80	20	0	0	0	
10/31/17	3b CH	Co	5	20	80	0	0	0	
10/31/17	3b CH	Co	5	20	80	0	0	0	
10/31/17	3b CH	Mc	10	95	5	0	0	0	
10/31/17	3b CH	Co	2	0	100	0	0	0	
10/31/17	3b CH	Mc	60	90	10	0	0	0	
10/31/17	3b CH	Mc	40	95	5	0	0	0	
10/31/17	3b CH	Mc	10	90	10	10	0	0	
10/31/17	3b CH	Mc	15	90	10	0	0	0	
10/31/17	3b CH	Mc	25	90	10	0	0	0	

10/31/17	3b CH	Mc	80	70	30	0	0	0	
10/31/17	3b CH	Mc	20	90	10	0	0	0	
10/31/17	3b CH	Mc	100	90	10	0	0	0	
10/31/17	3b CH	Mc	20	80	20	0	0	0	
10/31/17	3b CH	Mc	25	80	20	0	0	0	
10/31/17	3b CH	Mc	40	80	20	0	0	0	
10/31/17	3b CH	Mc	50	70	30	0	0	0	
10/31/17	3b CH	Mc	10	90	10	0	0	0	
10/31/17	3b CH	Mc	25	90	10	0	0	0	
10/31/17	3b CH	Mc	45	80	20	0	0	0	
10/31/17	3b CH	Co	10	10	90	0	0	0	
10/31/17	3b CH	Co	5	10	90	0	0	0	
10/31/17	3b CH	Co	5	10	90	0	0	0	
10/31/17	4a WB	Pc	40	100	0	0	0	0	
10/31/17	4a WB	Pc	60	100	0	0	0	0	
10/31/17	4a WB	Pc	15	100	0	0	0	0	
10/31/17	4a WB	Pc	75	100	0	0	0	0	
10/31/17	4a WB	Mc	15	90	10	0	0	0	
10/31/17	4a WB	Pc	100	100	0	0	0	0	
10/31/17	4a WB	Pc	10	100	0	0	0	0	
10/31/17	4a WB	Pc	25	100	0	0	0	0	
10/31/17	4a WB	Pc	10	100	0	0	0	0	
10/31/17	4a WB	Pc	80	100	0	0	0	0	
10/31/17	4a WB	Pc	50	100	0	0	0	0	
10/31/17	4a WB	Pc	60	100	0	0	0	0	
10/31/17	4a WB	Pc	10	100	0	0	0	0	
10/31/17	4a WB	Pc	15	100	0	0	0	0	
10/31/17	4a WB	Pc	20	100	0	0	0	0	
10/31/17	4a WB	Pc	20	100	0	0	0	0	
10/31/17	4a WB	Mc	5	90	10	0	0	0	
10/31/17	4a WB	Co	5	10	90	0	0	0	
10/31/17	4a WB	Pm	10	100	0	0	0	0	
10/31/17	4a WB	Pc	10	100	0	0	0	0	
10/31/17	4a WB	Pc	20	100	0	0	0	0	
10/31/17	4a WB	Pc	30	100	0	0	0	0	
10/31/17	4a WB	Pc	10	100	0	0	0	0	
10/31/17	4a WB	Pm	5	10	90	0	0	0	
10/31/17	4a WB	Co	5	10	90	0	0	0	
10/31/17	4a WB	Pc	10	100	0	0	0	0	
10/31/17	4a WB	Pc	20	100	0	0	0	0	
10/31/17	4a WB	Pl	120	100	0	0	0	0	
10/31/17	4a WB	Pm	10	100	0	0	0	0	
10/31/17	4a WB	Pc	5	100	0	0	0	0	
10/31/17	4a WB	Co	15	10	90	0	0	0	
10/31/17	4a WB	Mc	15	10	90	0	0	0	
10/31/17	4a WB	Pl	140	100	0	0	0	0	
10/31/17	4a WB	Mc	60	10	90	0	0	0	
10/31/17	4a WB	Mc	20	30	70	0	0	0	
10/31/17	4a WB	Mc	10	20	80	0	0	0	
10/31/17	4a WB	Co	5	10	90	0	0	0	
10/31/17	4a WB	Mc	80	30	70	0	0	0	
10/31/17	4a WB	Pm	5	0	100	0	0	0	
10/31/17	4a WB	Pm	5	0	100	0	0	0	
10/31/17	4b WB	Co	10	70	30	0	0	0	
10/31/17	4b WB	Pc	15	100	0	0	0	0	
10/31/17	4b WB	Pc	20	100	0	0	0	0	
10/31/17	4b WB	Pc	10	100	0	0	0	0	
10/31/17	4b WB	Pl	50	100	0	0	0	0	
10/31/17	4b WB	Pl	10	100	0	0	0	0	
10/31/17	4b WB	Pl	15	100	0	0	0	0	
10/31/17	4b WB	Pl	20	100	0	0	0	0	
10/31/17	4b WB	Pl	10	100	0	0	0	0	
10/31/17	4b WB	Pc	10	100	0	0	0	0	
10/31/17	4b WB	Pc	5	100	0	0	0	0	
10/31/17	4b WB	Pc	5	100	0	0	0	0	

10/31/17	4b WB	Pc	5	100	0	0	0	0	
10/31/17	4b WB	Pt	15	100	0	0	0	0	
10/31/17	4b WB	Pc	50	100	0	0	0	0	
10/31/17	4b WB	Pc	10	100	0	0	0	0	
10/31/17	4b WB	Pc	10	100	0	0	0	0	
10/31/17	4b WB	Pc	15	100	0	0	0	0	
10/31/17	4b WB	Pc	20	100	0	0	0	0	
10/31/17	4b WB	Pc	25	100	0	0	0	0	
10/31/17	4b WB	Pc	15	100	0	0	0	0	
10/31/17	4b WB	Pc	10	100	0	0	0	0	
10/31/17	4b WB	Pc	25	100	0	0	0	0	
10/31/17	4b WB	Pc	45	100	0	0	0	0	
10/31/17	4b WB	Pc	10	100	0	0	0	0	
10/31/17	4b WB	Pc	5	100	0	0	0	0	
10/31/17	4b WB	Pc	10	100	0	0	0	0	
10/31/17	4b WB	Pc	15	100	0	0	0	0	
10/31/17	4b WB	Pc	20	100	0	0	0	30	
10/31/17	4b WB	Pc	5	100	0	0	0	30	
10/31/17	4b WB	Pc	10	100	0	0	0	30	
10/31/17	4b WB	Pc	10	100	0	0	0	30	
10/31/17	4b WB	Pc	15	100	0	0	0	30	
10/31/17	4b WB	Pc	10	100	0	0	0	30	
10/31/17	4b WB	Pt	25	10	90	0	0	30	
10/31/17	4b WB	Pl	40	100	0	0	0	30	
10/31/17	4b WB	Pl	25	100	0	0	0	30	
10/31/17	4b WB	Pc	10	100	0	0	0	30	
10/31/17	4b WB	Pc	15	100	0	0	0	30	
10/31/17	4b WB	Pc	25	100	0	0	0	30	
10/31/17	4b WB	Pc	10	100	0	0	0	30	
10/31/17	4b WB	Pc	5	100	0	0	0	30	
10/31/17	4b WB	Pc	5	100	0	0	0	30	
10/31/17	4b WB	Pc	5	100	0	0	0	30	
10/31/17	4b WB	Pc	5	100	0	0	0	30	
10/31/17	4b WB	Pc	5	100	0	0	0	30	
10/31/17	4b WB	Pc	5	100	0	0	0	30	
10/31/17	4b WB	Pc	10	100	0	0	0	30	
10/31/17	4b WB	Pc	10	100	0	0	0	30	
10/31/17	4b WB	Pc	10	100	0	0	0	30	
11/22/16	1a BD	Pl	20	100	0	0	0	0	
11/22/16	1a BD	Pl	85	100	0	0	0	0	fishbites
11/22/16	1a BD	Pl	15	100	0	0	0	0	fishbites
11/22/16	1a BD	Pl	15	100	0	0	0	0	fishbites
11/22/16	1a BD	Pl	5	100	0	0	0	0	fishbites
11/22/16	1a BD	Pl	5	100	0	0	0	0	fishbites
11/22/16	1a BD	Pl	15	100	0	0	0	0	
11/22/16	1a BD	Pl	15	100	0	0	0	0	
11/22/16	1a BD	Pl	25	90	0	10	0	0	
11/22/16	1a BD	Pl	10	100	0	0	0	0	
11/22/16	1a BD	Pl	20	100	0	0	0	0	
11/22/16	1a BD	Pl	5	100	0	0	0	0	
11/22/16	1a BD	Pl	30	80	0	20	0	0	
11/22/16	1a BD	Pl	10	50	0	50	0	0	
11/22/16	1b BD	Pl	5	100	0	0	0	0	
11/22/16	1b BD	Pm	15	100	0	0	0	0	
11/22/16	1b BD	Pl	5	100	0	0	0	0	
11/22/16	1b BD	Pm	35	100	0	0	0	0	
11/22/16	2a KH	Pl	5	100	0	0	0	0	
11/22/16	2a KH	Pl	20	50	0	0	0	50	
11/22/16	2a KH	Pl	5	50	0	0	0	50	
11/22/16	2a KH	Pl	5	50	0	0	0	50	
11/22/16	2a KH	Pl	10	50	0	0	0	50	
11/22/16	2a KH	Pl	10	50	0	0	0	50	
11/22/16	2a KH	Pl	5	50	0	0	0	50	
11/22/16	2a KH	Pm	40	100	0	0	0	0	
11/22/16	2a KH	Pm	20	100	0	0	0	0	

11/22/16	2a KH	Pv	15	100	0	0	0	0	
11/22/16	2a KH	Mc	70	80	0	0	0	20	not reef flat/in depression
11/22/16	2a KH	Mc	90	80	0	0	0	0	
11/22/16	2a KH	Mc	110	80	0	0	0	20	
11/22/16	2b KH	Pm	5	100	0	0	0	0	
11/22/16	2b KH	Pm	5	100	0	0	0	0	
11/22/16	2b KH	Pm	30	100	0	0	0	0	
11/22/16	2b KH	Pm	3	100	0	0	0	0	
11/22/16	2b KH	Pm	7	100	0	0	0	0	
11/22/16	2b KH	Pm	3	100	0	0	0	0	
11/22/16	2b KH	Pm	5	100	0	0	0	0	
11/22/16	2b KH	Mc	40	60	0	0	0	40	
11/22/16	2b KH	Co	2	100	0	0	0	0	
11/22/16	3a CH	Pl	20	100	0	0	0	0	
11/22/16	3a CH	Pl	10	100	0	0	0	0	
11/22/16	3a CH	Pl	15	100	0	0	0	0	
11/22/16	3a CH	Pl	20	100	0	0	0	0	
11/22/16	3a CH	Pl	15	100	0	0	0	0	
11/22/16	3a CH	Pl	15	100	0	0	0	0	
11/22/16	3a CH	Pl	15	100	0	0	0	0	
11/22/16	3a CH	Pl	15	100	0	0	0	0	
11/22/16	3a CH	Pl	15	100	0	0	0	0	
11/22/16	3a CH	Pl	45	100	0	0	0	0	
11/22/16	3a CH	Pm	10	100	0	0	0	0	
11/22/16	3a CH	Pm	5	100	0	0	0	0	
11/22/16	3a CH	Pm	5	100	0	0	0	0	
11/22/16	3a CH	Pm	10	100	0	0	0	0	
11/22/16	3a CH	Pt	5	100	0	0	0	0	
11/22/16	3a CH	Mc	80	100	0	0	0	0	
11/22/16	3a CH	Mc	100	100	0	0	0	0	
11/22/16	3a CH	Mc	45	100	0	0	0	0	
11/22/16	3a CH	Mc	30	50	0	50	0	0	
11/22/16	3b CH	Pm	2	100	0	0	0	0	
11/22/16	3b CH	Mc	180	50	50	0	0	0	white edges
11/22/16	3b CH	Mc	10	100	0	0	0	0	white edges
11/22/16	3b CH	Mc	50	100	0	0	0	0	white edges
11/22/16	3b CH	Mc	40	100	0	0	0	0	white edges
11/22/16	3b CH	Mc	120	100	0	0	0	0	white edges
11/22/16	3b CH	Pe	15	100	0	0	0	0	
11/22/16	3b CH	Pe	10	100	0	0	0	0	
11/22/16	3b CH	Co	2	100	0	0	0	0	
11/22/16	3b CH	Co	4	100	0	10	0	0	
11/22/16	3b CH	Co	5	100	0	0	0	0	
11/22/16	3b CH	Co	7	100	0	0	0	0	Notes
11/22/16	3b CH	Co	5	50	50	0	0	0	probably sand abrasion
11/22/16	3b CH	Co	5	50	50	0	0	0	probably sand abrasion
11/22/16	3b CH	Co	5	50	50	0	0	0	probably sand abrasion
11/22/16	3b CH	Co	10	50	50	0	0	0	probably sand abrasion
11/22/16	3b CH	Co	10	20	80	0	0	0	probably sand abrasion
11/22/16	3b CH	Co	5	50	50	0	0	0	probably sand abrasion
11/22/16	3b CH	Co	5	50	50	0	0	0	probably sand abrasion
11/22/16	3b CH	Co	5	50	50	0	0	0	probably sand abrasion
11/22/16	3b CH	Co	5	50	50	0	0	0	probably sand abrasion
11/22/16	3b CH	Co	5	50	50	0	0	0	probably sand abrasion
11/22/16	3b CH	Co	5	50	50	0	0	0	probably sand abrasion
11/22/16	3b CH	Co	5	50	50	0	0	0	probably sand abrasion
11/22/16	3b CH	Co	5	50	50	0	0	0	probably sand abrasion
11/22/16	3b CH	Co	5	50	50	0	0	0	probably sand abrasion
11/22/16	3b CH	Co	5	50	50	0	0	0	probably sand abrasion
11/22/16	4a WB	Pm	10	100	0	0	0	0	
11/22/16	4a WB	Pc	15	50	0	0	0	50	
11/22/16	4a WB	Co	10	80	20	0	0	0	
11/22/16	4a WB	Pl	10	100	0	0	0	0	
11/22/16	4a WB	Pl	10	100	0	0	0	0	
11/22/16	4a WB	Pl	15	100	0	0	0	0	

11/22/16	4a WB	Pl	15	100	0	0	0	0	
11/22/16	4a WB	Pl	20	100	0	0	0	0	
11/22/16	4a WB	Pl	10	100	0	0	0	0	
11/22/16	4a WB	Pl	20	100	0	0	0	0	
11/22/16	4a WB	Pl	15	100	0	0	0	0	
11/22/16	4a WB	Pl	15	100	0	0	0	0	
11/22/16	4a WB	Pl	15	100	0	0	0	0	
11/22/16	4a WB	Pl	15	100	0	0	0	0	
11/22/16	4a WB	Pl	45	100	0	0	0	0	
11/22/16	4a WB	Pl	45	100	0	0	0	0	
11/22/16	4a WB	Pl	80	100	0	0	0	0	
11/22/16	4a WB	Pl	10	100	0	0	0	0	
11/22/16	4a WB	Pl	55	100	0	0	0	0	
11/22/16	4a WB	Pl	40	100	0	0	0	0	
11/22/16	4a WB	Pl	60	100	0	0	0	0	
11/22/16	4b WB	Pe	65	100	0	0	0	0	
11/22/16	4b WB	Pc	60	100	0	0	0	0	
11/22/16	4b WB	Pc	10	100	0	0	0	0	
11/22/16	4b WB	Pc	45	100	0	0	0	0	
11/22/16	4b WB	Pc	5	100	0	0	0	0	
11/22/16	4b WB	Pc	10	100	0	0	0	0	
11/22/16	4b WB	Pc	15	100	0	0	0	0	
11/22/16	4b WB	Mc	120	80	20	0	0	0	
11/22/16	4b WB	Pl	40	100	0	0	0	0	
11/22/16	4b WB	Pl	80	100	0	0	0	0	
11/22/16	4b WB	Pl	60	100	0	0	0	0	
11/22/16	4b WB	Pl	20	100	0	0	0	0	
11/22/16	4b WB	Pl	100	100	0	0	0	0	
11/22/16	4b WB	Pl	100	100	0	0	0	0	
11/22/16	4b WB	Pl	150	100	0	0	0	0	
11/22/16	4b WB	Pl	40	100	0	0	0	0	
11/22/16	4b WB	Pl	15	100	0	0	0	0	
11/22/16	4b WB	Pl	30	100	0	0	0	0	
11/22/16	4b WB	Pl	80	100	0	0	0	0	
11/22/16	4b WB	Pl	170	100	0	0	0	0	
11/22/16	4b WB	Pl	190	100	0	0	0	0	
11/22/16	4b WB	Pl	30	100	0	0	0	0	
11/22/16	4b WB	Pl	20	100	0	0	0	0	
11/22/16	4b WB	Pl	50	100	0	0	0	0	
11/22/16	4b WB	Pl	60	100	0	0	0	0	
11/22/16	4b WB	Pl	80	100	0	0	0	0	
11/22/16	4b WB	Pl	40	100	0	0	0	0	
11/22/16	4b WB	Pl	10	100	0	0	0	0	
11/22/16	4b WB	Pl	40	70	0	0	0	30	
11/22/16	4b WB	Pl	15	70	0	0	0	30	
11/22/16	4b WB	Pl	25	70	0	0	0	30	
11/22/16	4b WB	Pl	30	70	0	0	0	30	
11/22/16	4b WB	Pl	30	70	0	0	0	30	
11/22/16	4b WB	Pl	40	70	0	0	0	30	
1/12/16	1a BD	Pl	5	100	0	0	0	0	
1/12/16	1a BD	Pl	10	100	0	0	0	0	
1/12/16	1a BD	Pl	95	100	0	0	0	0	
1/12/16	1a BD	Pl	110	100	0	0	0	0	
1/12/16	1a BD	Pl	10	100	0	0	0	0	
1/12/16	1a BD	Pl	15	100	0	0	0	0	
1/12/16	1a BD	Pl	10	100	0	0	0	0	
1/12/16	1a BD	Pl	55	100	0	0	0	0	
1/12/16	1a BD	Pl	10	100	0	0	0	0	
1/12/16	1a BD	Pl	10	100	0	0	0	0	
1/12/16	1a BD	Pl	10	100	0	0	0	0	
1/12/16	1a BD	Pl	60	100	0	0	0	0	
1/12/16	1a BD	Pl	40	80	0	20	0	0	
1/12/16	1a BD	Pt	75	100	0	0	0	0	
1/12/16	1a BD	Pt	200	90	10	0	0	0	
1/12/16	1a BD	Pt	450	95	5	0	0	0	

1/12/16	1a BD	Pm	50	100	0	0	0	0	
1/12/16	1a BD	Pv	15	100	0	0	0	0	
1/12/16	1a BD	Pv	10	100	0	0	0	0	
1/12/16	1a BD	Pl	15	100	0	0	0	0	
1/12/16	1a BD	Pv	5	100	0	0	0	0	
1/12/16	1b BD	Mp	45	100	0	0	0	0	
1/12/16	1b BD	Mc	25	60	0	0	0	40	
1/12/16	1b BD	Pm	10	100	0	0	0	0	
1/12/16	1b BD	Co	3	20	0	0	0	80	
1/12/16	1b BD	Co	7	80	0	0	0	20	
1/12/16	1b BD	Pr	40	100	0	0	0	0	
1/12/16	1b BD	Pr	25	100	0	0	0	0	
1/12/16	1b BD	Pl	20	100	0	0	0	0	
1/12/16	1b BD	Pl	15	100	0	0	0	0	
1/12/16	2a KH	Mp	130	70	0	0	0	30	
1/12/16	2a KH	Mc	20	50	0	0	0	50	
1/12/16	2a KH	Pm	25	100	0	0	0	0	
1/12/16	2a KH	Mc	100	50	0	0	0	50	
1/12/16	2a KH	Pm	30	95	0	0	5	0	
1/12/16	2a KH	Pr	10	90	0	0	0	10	
1/12/16	2a KH	Pl	15	90	0	0	0	10	
1/12/16	2a KH	Mc	25	100	0	0	0	0	
1/12/16	2a KH	Pm	20	100	0	0	0	0	
1/12/16	2b KH	Co	12	90	0	0	0	10	
1/12/16	2b KH	Pm	7	100	0	0	0	0	
1/12/16	2b KH	Pm	10	100	0	0	0	0	
1/12/16	2b KH	Pm	25	100	0	0	0	0	
1/12/16	2b KH	Mc	40	100	0	0	0	0	
1/12/16	2b KH	Mc	10	100	0	0	0	0	
1/12/16	2b KH	Pc	25	60	0	0	0	40	
1/12/16	2b KH	Pc	45	50	0	0	0	5	
1/12/16	2b KH	Co	10	50	0	0	0	50	
1/12/16	2b KH	Pm	25	100	0	0	0	0	
1/12/16	2b KH	Pm	20	95	0	0	0	5	
1/12/16	3a CH	Pc	20	50	0	0	0	50	
1/12/16	3a CH	Pl	65	30	0	0	0	70	
1/12/16	3a CH	Pl	25	20	0	0	0	80	
1/12/16	3a CH	Pl	40	10	0	0	0	90	
1/12/16	3a CH	Co	3	50	0	0	0	50	
1/12/16	3a CH	Co	4	10	0	0	0	90	
1/12/16	3a CH	Co	10	30	0	0	0	70	
1/12/16	3a CH	Co	10	10	0	0	0	90	
1/12/16	3a CH	Pl	60	20	0	0	0	80	
1/12/16	3a CH	Pl	5	100	0	0	0	0	
1/12/16	3a CH	Pc	15	50	0	0	0	50	
1/12/16	3a CH	Pc	10	60	0	0	0	40	
1/12/16	3a CH	Pc	30	100	0	0	0	0	
1/12/16	3a CH	Pl	5	100	0	0	0	0	
1/12/16	3a CH	Pl	25	10	0	0	20	70	
1/12/16	3a CH	Pm	40	100	0	0	0	0	
1/12/16	3a CH	Mc	100	90	0	0	0	10	
1/12/16	3a CH	Mc	40	90	0	0	0	10	
1/12/16	3a CH	Mc	15	80	0	0	0	20	
1/12/16	3a CH	Mc	15	90	0	0	0	10	
1/12/16	3a CH	Pm	60	100	0	0	0	0	
1/12/16	3b CH	Pm	25	100	0	0	0	0	
1/12/16	3b CH	Pl	30	80	0	0	0	20	
1/12/16	3b CH	Pl	15	95	0	0	0	5	
1/12/16	3b CH	Pl	10	90	0	0	0	10	
1/12/16	3b CH	Pl	20	100	0	0	0	0	
1/12/16	3b CH	Pl	40	100	0	0	0	0	
1/12/16	3b CH	Mc	90	90	0	10	0	0	
1/12/16	3b CH	Co	5	100	0	0	0	0	
1/12/16	3b CH	Co	10	80	0	0	0	20	
1/12/16	3b CH	Mc	50	100	0	0	0	0	

1/12/16	3b CH	Mc	105	100	0	0	0	0	
1/12/16	3b CH	Pc	20	80	0	0	0	20	
1/12/16	3b CH	Pl	15	100	0	0	0	0	
1/12/16	3b CH	Pl	60	100	0	0	0	0	
1/12/16	3b CH	Pl	45	100	0	0	0	0	
1/12/16	3b CH	Pl	40	100	0	0	0	0	
1/12/16	3b CH	Co	5	100	0	0	0	0	
1/12/16	3b CH	Mc	95	100	0	0	0	0	
1/12/16	3b CH	Mc	80	100	0	0	0	0	
1/12/16	3b CH	Mc	75	100	0	0	0	0	
1/12/16	3b CH	Mc	110	100	0	0	0	0	
1/12/16	3b CH	Co	10	100	0	0	0	0	
1/12/16	3b CH	Co	5	90	0	0	0	10	
1/12/16	4a WB	Co	5	100	0	0	0	0	
1/12/16	4a WB	Mc	120	90	0	0	0	10	
1/12/16	4a WB	Mc	15	80	0	0	0	20	
1/12/16	4a WB	Mc	60	80	0	0	0	20	
1/12/16	4a WB	Mp	30	100	0	0	0	0	
1/12/16	4a WB	Mp	60	100	0	0	0	0	
1/12/16	4a WB	Mc	5	100	0	0	0	0	
1/12/16	4a WB	Mc	100	100	0	0	0	0	
1/12/16	4a WB	Mc	15	100	0	0	0	0	
1/12/16	4a WB	Pl	40	100	0	0	0	0	
1/12/16	4a WB	Pl	35	100	0	0	0	0	
1/12/16	4a WB	Pl	55	100	0	0	0	0	
1/12/16	4a WB	Pl	5	100	0	0	0	0	
1/12/16	4a WB	Mc	40	40	0	60	0	0	
1/12/16	4a WB	Pl	40	100	0	0	0	0	
1/12/16	4a WB	Pl	50	100	0	0	0	0	
1/12/16	4a WB	Co	5	100	0	0	0	0	
1/12/16	4a WB	Pl	150	100	0	0	0	0	
1/12/16	4a WB	Pl	10	100	0	0	0	0	
1/12/16	4a WB	Pl	20	100	0	0	0	0	
1/12/16	4a WB	Pl	40	100	0	0	0	0	
1/12/16	4a WB	Pl	50	100	0	0	0	0	
1/12/16	4a WB	Pl	45	100	0	0	0	0	
1/12/16	4a WB	Pl	35	20	0	80	0	0	
1/12/16	4b WB	Pl	20	60	0	0	0	40	
1/12/16	4b WB	Pl	20	60	0	0	0	40	
1/12/16	4b WB	Co	4	100	0	0	0	0	
1/12/16	4b WB	Pl	10	90	0	0	0	10	
1/12/16	4b WB	Pl	10	90	0	0	0	10	
1/12/16	4b WB	Pl	12	95	0	0	0	5	
1/12/16	4b WB	Pl	17	95	0	0	0	5	
1/12/16	4b WB	Pl	10	100	0	0	0	0	
1/12/16	4b WB	Pl	5	100	0	0	0	0	
1/12/16	4b WB	Pl	12	90	0	0	0	10	
1/12/16	4b WB	Pl	20	80	0	0	0	20	
1/12/16	4b WB	Pl	20	90	0	0	0	10	
1/12/16	4b WB	Pl	10	100	0	0	0	0	
1/12/16	4b WB	Pl	20	100	0	0	0	0	
1/12/16	4b WB	Pl	15	80	0	0	0	20	
1/12/16	4b WB	Pl	25	10	80	0	10	0	
1/12/16	4b WB	Pl	30	20	70	0	10	0	
1/12/16	4b WB	Pl	30	100	0	0	0	0	
1/12/16	4b WB	Pl	25	15	65	0	20	0	
1/12/16	4b WB	Pl	50	10	80	0	10	0	
1/12/16	4b WB	Pl	20	100	0	0	0	0	
1/12/16	4b WB	Pl	30		90	0	10	0	
1/12/16	4b WB	Pl	15	90	0	0	0	10	
1/12/16	4b WB	Pl	15	90	0	0	0	10	
1/12/16	4b WB	Pl	15	100	0	0	0	0	
1/12/16	4b WB	Pl	20	90	0	0	0	10	
1/12/16	4b WB	Pl	25	100	0	0	0	0	
1/12/16	4b WB	Pl	10	80	0	0	0	20	

1/12/16	4b WB	Pl	5	90	0	0	0	10	
1/12/16	4b WB	Pl	10	90	0	0	0	10	
1/12/16	4b WB	Pl	55	100	0	0	0	0	
1/12/16	4b WB	Pl	45	10	70	0	0	20	
1/12/16	4b WB	Pl	10	100	0	0	0	0	
10/20/15	1a BD	Pl	50	10	70	0	20	-	
10/20/15	1a BD	Pl	25	0	50	50	0	-	
10/20/15	1a BD	Pl	15	0	90	0	10	-	
10/20/15	1a BD	Pl	20	0	60	40	0	-	
10/20/15	1a BD	Pl	10	0	20	80	0	-	
10/20/15	1a BD	Pl	60	20	30	50	0	-	
10/20/15	1a BD	Pl	30	30	60	10	0	-	
10/20/15	1a BD	Pl	20	90	0	10	0	-	
10/20/15	1a BD	Pl	150	0	80	10	10	-	
10/20/15	1a BD	Pl	25	20	50	30	0	-	
10/20/15	1a BD	Pl	10	10	20	70	0	-	
10/20/15	1a BD	Pl	20	0	80	20	0	-	
10/20/15	1a BD	Pl	40	50	0	50	0	-	
10/20/15	1a BD	Pl	35	50	0	50	0	-	
10/20/15	1a BD	Pl	20	50	0	50	0	-	
10/20/15	1a BD	Pl	35	70	10	20	0	-	
10/20/15	1a BD	Pl	10	80	0	20	0	-	
10/20/15	1a BD	Pl	10	80	0	20	0	-	
10/20/15	1a BD	Pm	50	50	50	0	0	-	
10/20/15	1a BD	Pl	10	0	100	0	0	-	
10/20/15	1a BD	Pc	10	100	0	0	0	-	
10/20/15	1a BD	Pm	25	30	70	0	0	-	
10/20/15	1a BD	Pl	15	0	100	0	0	-	
10/20/15	1b BD	Pm	15	80	20	0	0	-	
10/20/15	1b BD	Pl	70	0	30	20	50	-	
10/20/15	1b BD	Pl	10	0	100	0	0	-	
10/20/15	1b BD	Pl	10	100	0	0	0	-	
10/20/15	1b BD	Co	5	50	30	20	0	-	
10/20/15	1b BD	Co	10	60	30	10	0	-	
10/20/15	1b BD	Pl	10	30	40	30	0	-	
10/20/15	1b BD	Pl	15	90	0	10	0	-	
10/20/15	2a KH	Pm	15	0	100	0	0	-	
10/20/15	2a KH	Mc	60	0	50	50	0	-	
10/20/15	2a KH	Pm	10	0	80	20	0	-	
10/20/15	2a KH	Pl	20	10	60	30	0	-	
10/20/15	2a KH	Pm	5	0	90	10	0	-	
10/20/15	2a KH	Pm	40	0	80	20	0	-	
10/20/15	2a KH	Mc	120	70	0	30	0	-	
10/20/15	2a KH	Mc	180	80	0	20	0	-	
10/20/15	2a KH	Pm	15	0	90	0	10	-	
10/20/15	2a KH	Pm	5	0	90	10	0	-	
10/20/15	2a KH	Pv	5	80	0	0	0	-	20% abraded
10/20/15	2b KH	Mc	70	70	20	10	0	-	
10/20/15	2b KH	Pm	5	0	90	0	10	-	
10/20/15	2b KH	Pm	40	20	60	20	0	-	broken (Hobo marker)
10/20/15	2b KH	Pm	25	30	70	0	0	-	
10/20/15	2b KH	Pm	30	10	60	30	0	-	
10/20/15	2b KH	Pm	5	10	80	10	0	-	
10/20/15	2b KH	Pm	5	10	80	10	0	-	
10/20/15	2b KH	Co	5	80	10	10	0	-	
10/20/15	2b KH	Mc	100	10	80	10	0	-	
10/20/15	2b KH	Pm	0	0	100	0	0	-	
10/20/15	2b KH	Co	0	40	40	20	0	-	
10/20/15	2b KH	Pc	60	10	20	70	0	-	
10/20/15	2b KH	Pc	30	20	10	70	0	-	
10/20/15	3a CH	Pm	20	20	40	40	0	-	
10/20/15	3a CH	Pc	5	0	20	80	0	-	
10/20/15	3a CH	Pc	10	0	20	80	0	-	
10/20/15	3a CH	Pm	30	40	40	20	0	-	
10/20/15	3a CH	Mc	60	10	40	50	0	-	

10/20/15	3a CH	Pm	30	90	0	10	0	-	
10/20/15	3a CH	Pl	50	90	0	10	0	-	
10/20/15	3a CH	Mc	150	20	50	30	0	-	
10/20/15	3a CH	Pc	45	20	0	0	0	-	80% abraded
10/20/15	3a CH	Pv	40	90	0	10	0	-	
10/20/15	3a CH	Pv	15	70	30	0	0	-	
10/20/15	3a CH	Mc	70	50	30	20	0	-	
10/20/15	3a CH	Mc	20	0	90	10	0	-	
10/20/15	3a CH	Mc	15	10	80	10	0	-	
10/20/15	3a CH	Pm	50	0	100	0	0	-	
10/20/15	3a CH	Pc	30	90	0	10	0	-	
10/20/15	3b CH	Mc	200	80	10	10	0	-	
10/20/15	3b CH	Pm	30	60	20	20	0	-	
10/20/15	3b CH	Mc	60	10	0	90	0	-	Mc purple
10/20/15	3b CH	Pm	10	10	10	80	0	-	
10/20/15	3b CH	Mc	80	10	70	20	0	-	
10/20/15	3b CH	Mc	10	90	10	0	0	-	
10/20/15	3b CH	Mc	15	90	10	0	0	-	
10/20/15	3b CH	Mc	30	90	10	0	0	-	
10/20/15	3b CH	Mc	40	90	10	0	0	-	
10/20/15	3b CH	Mc	200	20	50	30	0	-	
10/20/15	3b CH	Mc	150	90	0	10	0	-	
10/20/15	3b CH	Mc	65	50	30	20	0	-	
10/20/15	3b CH	Pm	40	20	80	0	0	-	
10/20/15	3b CH	Pm	55	40	40	10	10	-	
10/20/15	3b CH	Mp	100	10	80	10	0	-	
10/20/15	3b CH	Pl	20	80	0	20	0	-	
10/20/15	3b CH	Co	15	70	20	10	0	-	
10/20/15	4a WB	Pl	25	10	50	40	0	-	Pavona duerdeni not on transect but almost completely bleached in WB area
10/20/15	4a WB	Mc	250	70	20	10	0	-	
10/20/15	4a WB	Mc	100	20	40	40	0	-	
10/20/15	4a WB	Mc	60	50	40	10	0	-	
10/20/15	4a WB	Mc	40	20	70	10	0	-	
10/20/15	4a WB	Mc	10	0	100	0	0	-	
10/20/15	4a WB	Mc	75	60	20	20	0	-	
10/20/15	4a WB	Pv	10	0	100	0	0	-	
10/20/15	4a WB	Pv	10	0	80	20	0	-	
10/20/15	4a WB	Pv	10	0	100	0	0	-	
10/20/15	4a WB	Pv	5	0	100	0	0	-	
10/20/15	4a WB	Pv	80	10	80	10	0	-	
10/20/15	4a WB	Pv	40	20	60	20	0	-	
10/20/15	4a WB	Pv	5	0	80	20	0	-	
10/20/15	4a WB	Pv	5	0	100	0	0	-	
10/20/15	4a WB	Mc	30	70	10	20	0	-	
10/20/15	4a WB	Pv	10	0	100	0	0	-	
10/20/15	4a WB	Pv	35	0	100	0	0	-	
10/20/15	4a WB	Mc	30	0	20	80	0	-	
10/20/15	4a WB	Mc	60	50	10	40	0	-	
10/20/15	4a WB	Mc	50	0	80	20	0	-	
10/20/15	4a WB	Co	75	20	80	0	0	-	
10/20/15	4b WB	Pl	60	0	0	0	100	-	
10/20/15	4b WB	Pc	10	100	0	0	0	-	
10/20/15	4b WB	Pc	5	20	50	30	0	-	
10/20/15	4b WB	Pc	15	100	0	0	0	-	
10/20/15	4b WB	Pl	35	50	0	50	0	-	
10/20/15	4b WB	Pl	10	80	10	10	0	-	
10/20/15	4b WB	Pl	40	0	100	0	0	-	
10/20/15	4b WB	Pl	20	0	70	0	30	-	
10/20/15	4b WB	Pl	10	100	0	0	0	-	
10/20/15	4b WB	Pl	15	0	0	100	0	-	
10/20/15	4b WB	Pl	20	80	0	20	0	-	
10/20/15	4b WB	Pl	85	0	80	0	20	-	

10/20/15	4b WB	Pl	20	0	90	0	10	-	
10/20/15	4b WB	Pl	60	0	70	0	30	-	
10/20/15	4b WB	Pl	30	0	100	0	0	-	
10/20/15	4b WB	Pl	45	0	90	0	10	-	
10/20/15	4b WB	Pl	40	0	90	0	10	-	
10/20/15	4b WB	Pl	100	90	0	10	0	-	
10/20/15	4b WB	Pl	10	100	0	0	0	-	
10/20/15	4b WB	Pl	90	100	0	0	0	-	
10/20/15	4b WB	Pl	15	0	80	20	0	-	
10/20/15	4b WB	Pl	10	0	100	0	0	-	
10/20/15	4b WB	Pl	5	0	90	10	0	-	
10/20/15	4b WB	Pl	35	0	100	0	0	-	
10/20/15	4b WB	Pl	25	0	100	0	0	-	
10/20/15	4b WB	Pl	35	0	100	0	0	-	
10/20/15	4b WB	Pl	80	100	0	0	0	-	
10/20/15	4b WB	Pl	25	50	0	50	0	-	
10/20/15	4b WB	Pl	30	0	100	0	0	-	
10/20/15	4b WB	Pl	10	0	90	0	10	-	
10/20/15	4b WB	Pl	10	100	0	0	0	-	
10/20/15	4b WB	Pl	150	100	0	0	0	-	
10/20/15	4b WB	Pl	15	40	0	60	0	-	
10/20/15	4b WB	Pv	10	80	0	20	0	-	