Coral Bleaching in the Bonaire National Marine Park 2016-2020

Eckrich, Caren, Roxanne Liana Francisca, Hannah Sima Rempel, Emil Ren

Abstract

Mass coral bleaching is becoming more frequent and widespread and poses a major threat to coral reefs worldwide. Mass coral bleaching is a response to thermal stress triggered by high Sea Surface Temperatures (SSTs) or ultraviolet radiation attributed to changing regional and global climate patterns. Since 2016, STINAPA Bonaire has surveyed the severity of coral bleaching in the Bonaire National Marine Park at 10 sites on the leeward coast. Each year, corals exhibited signs of thermal stress including paling, partial bleaching, and fully bleaching, but no mortality. Since 2016, the year with the lowest percentage of corals affected was 2018 (9%) and the year with the highest percent of corals affected was 2020 (61%). Corals deeper in the water column were more susceptible to thermal stress in all years, but susceptibility trends by site were not consistent throughout the study. While addressing the global-scale causes of coral bleaching is daunting, STINAPA Bonaire monitors the severity of coral bleaching and helps develop local management strategies that may improve the resistance and resilience of coral reefs in the Bonaire National Marine Park to climate change.

Key words: *Bonaire National Marine Park, coral bleaching, reef resilience, El Niño Southern Oscillation, Caribbean*

Introduction

Reefs worldwide are under increasing levels of anthropogenic pressure from threats including overfishing, sedimentation and pollution from coastal development, unsustainable tourism, and climate change (Jackson et al. 2014). In the Caribbean, average hard coral cover decreased from 50% to 17% between 1977 and 2010 and the region is undergoing a phase shift towards algae-dominated reefs (Gardner et al. 2003, Jackson et al. 2014). Bonaire's average hard coral cover on the reef slope is still comparatively high at 20-24% (De Bakker et al. 2017).

In the past few decades there has been a notable rise in the frequency and intensity of mass coral bleaching events triggered by high Sea Surface Temperatures (SSTs) (Hoegh-Guldberg 1999, Heron et al. 2016). In the tropics, SSTs are increasing at a rate of 1-2°C per century (Hoegh-Guldberg 1999), making coral bleaching one of the major coral reef management concerns of the 21st century. Mass coral bleaching is a major disturbance that can cause high levels of coral mortality and may make corals more susceptible to disease in the following year, decrease coral spawning success, and may alter coral community composition depending on the severity of bleaching (Hoegh-Guldberg 1999, Swain et al. 2016).

Maintaining and managing the coral reefs of Bonaire to prevent further degradation is an integral aspect of the management of the island not only for environmental, aesthetic and cultural values, but also because at least one-third of the island's Gross Domestic Product (GDP) is generated by tourism and 50-70% of the economy is directly or indirectly dependent on tourism (DEZA 2008, IUCN 2011, Schep et al. 2012).

Resilience

Resilience is defined as the ability of an ecosystem, such as a coral reef, to maintain its original ecological community and physiological structure or to recover to that state following a disturbance (Holling 1973) The resilience of a reef is dependent on the frequency and severity of disturbances (such as boat groundings, high ocean temperatures, coastal development, or hurricanes) as well as the integrity of the reef community and structure prior to the disturbance. Factors that promote reef resilience include high coral cover, recruitment of juvenile corals, an abundance of predatory fishes as well as herbivorous fishes, reef invertebrates, and low macroalgae cover (Edwards et al. 2011, Jackson et al. 2014, Diaz-Pulido et al. 2020). Evidence supports that managing chronic stressors such as coastal development, pollution, and overfishing are imperative to facilitating coral reef resilience (Jackson et al. 2014). In recent years the coral reefs of Bonaire have shown clear signs of being resilient and the majority of reef sites are classified as being medium to highly resilient (IUCN 2011, Steneck and Wilson 2019).

Mechanism of Coral Bleaching

Mass coral bleaching is a stress response triggered by high SSTs and levels of irradiance; however, pollutants or chemicals, sedimentation or bacterial infections may cause localized, smaller-scale coral bleaching (Dove & Hoegh-Guldberg 2006). These stressors impair the symbiotic relationship between the coral host and endosymbiotic photosynthetic algae of the family *Symbiodiniaceae***.** When SSTs exceed the average annual highs by 1°C or more for a series of weeks the thermal stress disrupts *Symbiodinacea*'s photosynthetic process and they produce reactive oxygen species that are harmful to cellular tissue (Hawkins & Davy 2012). In response, the coral host may expel or digest the *Symbiodinacea* from its tissues (Dove & Hoegh-Guldberg 2006; Fujise et al. 2014). *Symbiodinacea* are what give coral tissue its pigmentation and when corals expel the algae their white, calcium carbonate skeleton becomes visible, which gives the coral colonies a 'bleached' appearance. Corals may recover from bleaching and take up new *Symbiodinacea* into their tissues if the intensity and duration of the thermal stress is not too great. However, following a bleaching event, corals are also more vulnerable to disease, predation and competition and may have reduced reproductive capacity (Swain et al. 2016). The susceptibility of a reef to mass coral bleaching depends on a combination of biological factors such as the composition of the coral community and associated clades of *Symbiodinacea* and physical factors such as the severity of thermal stress, the levels of irradiance and the degree of mixing in the water column. It is important to monitor bleaching events in order to both effectively manage and protect reefs during and following a bleaching event, as well as to track the frequency and intensity of bleaching events over time.

Adaptation to Coral Bleaching

Coral taxa and their assemblage of associated *Symbiodinacea* clades differ in their susceptibility to thermally induced bleaching (Oliver & Palumbi 2011; Swain et al. 2016). The resilience of a coral colony to bleaching is dependent not only on the coral animal itself, but also the community of microbial symbionts that it hosts, such as *Symbiodinacea* which collectively make up the coral holobiont. Some corals may host a diverse array *Symbiodinacea* clades, while others show high specificity for a single clade and may therefore be less adaptable to altered environmental conditions. Following a bleaching event, corals may take up new combinations of *Symbiodinacea* clades that confer increased thermal tolerance, allowing the coral holobiont to adapt over time in what is known as the Adaptive Bleaching Hypothesis (Buddemeier & Fautin 1993; Thompson et al. 2014).

Predicting & Monitoring Coral Bleaching Events

NOAA's Coral Reef Watch uses satellite imagery to monitor anomalously high SSTs over time in a unit called Degree Heating Weeks (DHWs) in order to predict when and where coral bleaching may occur and to alert local management and research agencies. DHWs are a measure of accumulated thermal stress based on the number of weeks SSTs exceed the average annual maximum by 1°C or more. Significant coral bleaching is likely at 4 DHWs, and widespread bleaching and mortality is likely at 8 DHWs. STINAPA biologists monitor the DHWs for Bonaire during the warmest months of the year and use this information to alert the community of the bleaching risk and also to determine when to survey.

Each year, when the SST began to drop, STINAPA Bonaire surveyed the intensity of coral bleaching at ten sites on the leeward side of Bonaire, including two sites on Klein Bonaire. This report is intended to disseminate those findings to the public, stakeholders and regional management agencies and may also be used for comparisons for past and future bleaching events.

Methods

STINAPA Bonaire personnel surveyed the severity of coral bleaching across 10 sites on the leeward coast of Bonaire and Klein Bonaire annually in November or early December from 2016-2020. The leeward sites from north to south were Playa Funchi, the Rei Willem-Alexander No-Dive Reserve (hereafter referred to as RWA Reserve), Karpata, Oil Slick Leap, Reef Scientifico, Kas di Regatta, Invisibles and Vista Blue; the Klein Bonaire sites from east to west were Ebo's Special and Mi Dushi (Figure 1 and Appendix Table 1).

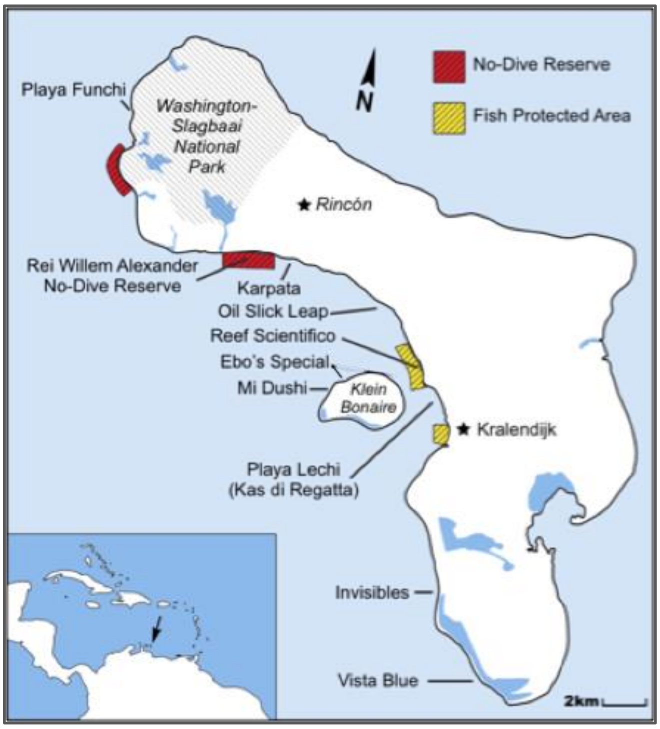

Fig. 1. Map of the 10 coral bleaching survey sites on the leeward coast of Bonaire and Klein Bonaire. See Appendix 1 for site coordinates.

In 2016-2019, the severity of thermal stress was determined from quadrat photographs taken from two 30 m belt transects at depths of 10 and 25 m (n = 15 quadrats per transect). Four sites were also surveyed at 5 m in 2017, 2019 and 2020. The other six sites did not have abundant corals in the shallows. In 2020, videos were taken for permanent records, but the severity of thermal stress was recorded using line intercept data from two 10 m transects at each depth. Percent coral bleaching was calculated as the percentage of colonies with pale, partially bleached or fully bleached tissue, except for in 2018 where it was calculated as the percentage of tissue of individual corals that were pale, partially or fully bleached. The severity of coral bleaching was categorized on a 0-4 scale according to the recommendation of *A Global Protocol for Assessment and Monitoring of Coral Bleaching* as follows: 0) Unbleached, 1) Pale tissue present, 2) Partially bleached, 3) Fully bleached, 4) Mortality estimated to be due to bleaching (Oliver et al. 2004).

All analyses were conducted using R version 3.6.2 (R Core Team 2019). A linear regression was used to analyze differences in the percent coral bleaching by year, site and depth (n = 2 transects per depth). The initial model was fit with a three-way interaction among year, site and depth, but was dropped from the model as none of the interactions were significant ($p>0.10$). Percent coral bleaching was square-root transformed to meet normality assumptions. A Kruskal-Wallis test was used to determine if there were significant differences in average percentage of observed colonies that bleached by species among sites in 2020 (n=10 sites). Coral species with less than three total observations were excluded from this analysis, due to insufficient sampling observations to make reliable estimates. A Dunn Test was used for post-hoc comparisons of significant differences between species.

Results

Bleaching patterns by year, site, and depth

Since 2016, corals in the BNMP have been affected by thermal stress every year, though bleaching severity varied among years, sites, coral species, and depths (Fig. 2-4). In 2016 (26%), 2018 (9%) and 2019 (24%), the mean percent of corals showing signs of bleaching at 10 and 25 m depth was considerably less than in 2017 (55%) and 2020 (61%; Fig. 2B). In all years, a greater percentage of deeper corals were affected than shallow corals (Fig. 2B). When comparing sites each year, certain sites were more affected than others, especially in 2019 when more corals were affected at Karpata, Invisibles and Ebo's Special than the other seven sites (Fig. 3). However, these three sites did not stand out in other years and therefore no site-specific generalizations can be made from these data.

Based on a linear regression analysis, there were no significant differences in coral bleaching among sites and years (Fig 2A; p-value>0.10). However, there was a significant, positive relationship between coral bleaching across the observed depths of 5, 10, and 25m (Fig 2B; $F_{(1,100)}$=13.8152, p-value<0.001). On average, there was a 0.12% increase in the percent coral bleaching with every 10m increase in depth, after accounting for site and year.

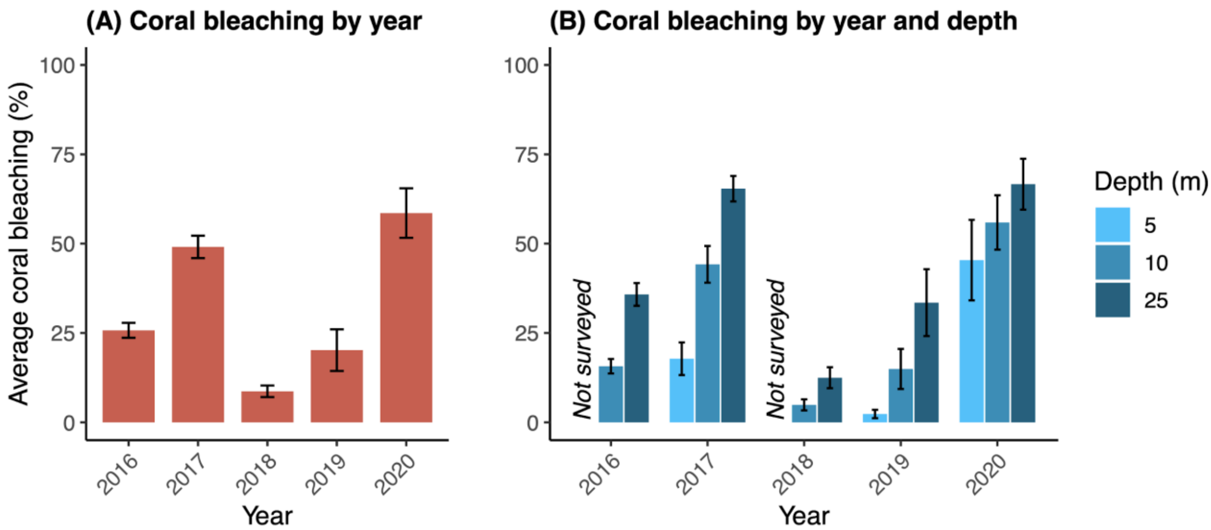

Fig. 2. The average percentage (± SEM) of corals affected by bleaching in the Bonaire National Marine Park by (A) year and (B) year and depth in 2016-2020 across sites (*n* = 10 sites). Percentage of corals affected include pale, partially bleached, and fully bleached corals. No bleaching-attributed coral mortality was observed. In 2016 and 2018, bleaching was not surveyed at 5 m depth.

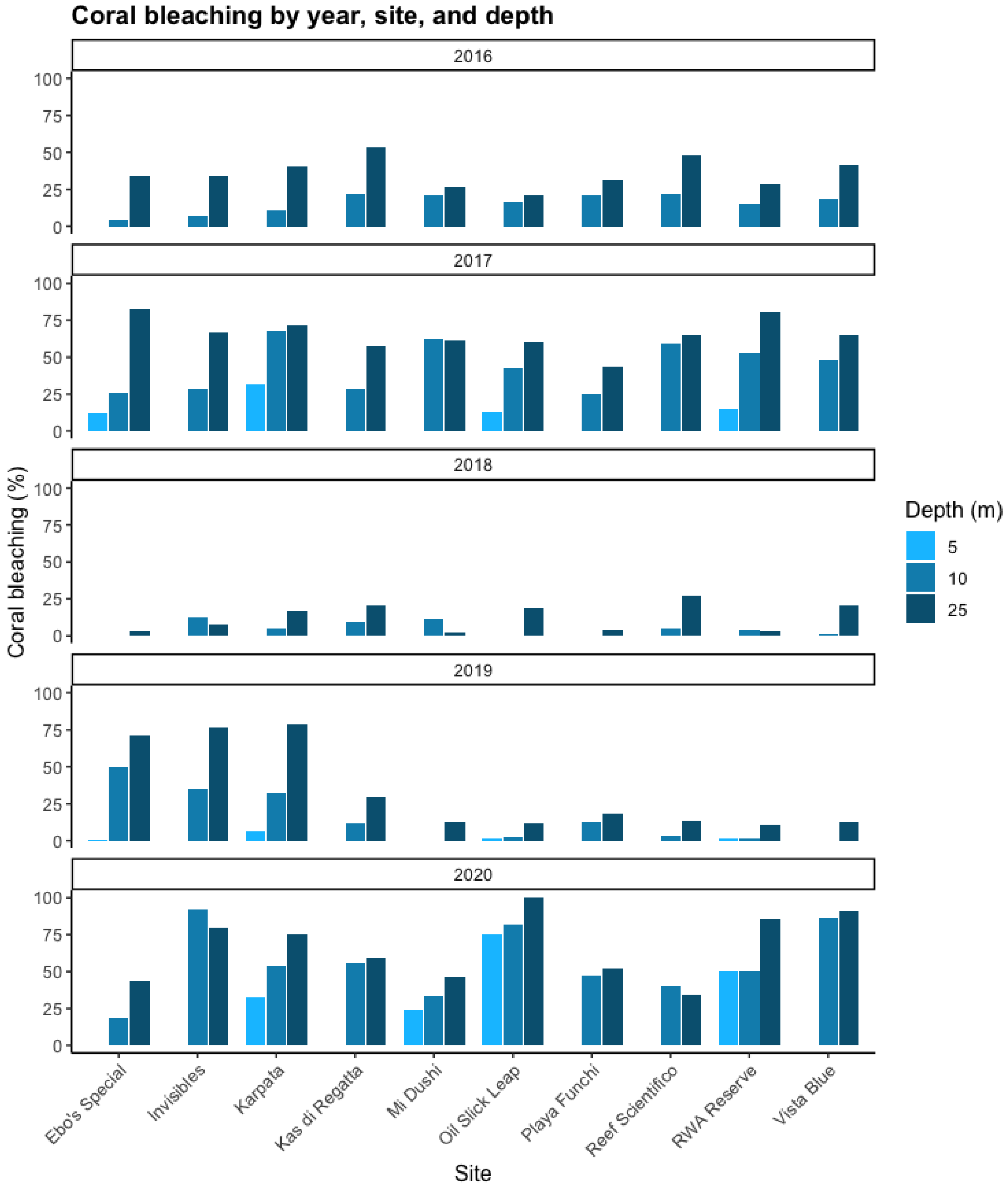

Fig. 3. The percentage of corals affected by bleaching in the Bonaire National Marine Park by site and depth in 2016-2020 (n = 2 transects per depth). Percentage of corals affected include pale, partially bleached and fully bleached corals. No coral mortality was recorded. Percent coral bleaching is calculated as the number of colonies that bleached in all years but 2018, where it was calculated as the percent area of coral that bleached. In 2016 and 2018, bleaching was not surveyed at 5 m depth.

Bleaching patterns among coral species

In 2020, trends in bleaching susceptibility by species suggest that certain species of corals are more susceptible to high SSTs and bleaching than other species, with species in the genera *Orbicella* and *Agaricia* (Boulder, Mountainous star and Lettuce corals) being the most susceptible and *Madracis* species being the least susceptible (Yellow pencil and Ten-rayed star corals) (Fig. 4). Coral species codes are listed in Table 2 of the Appendix.

Based on Kruskal-Wallis test, there were significant differences among the percentage of coral colonies that bleached by species in 2020 across observed sites (Kruskal-Wallis $\chi^2_{(14)}$= 31.256, p-value = 0.005103). Based on a post hoc Dunn Test, *Orbicella faveolata* corals had a significantly greater percentage of colonies that bleached than *Madracis auretenra*, *Madracis decactis*, *Montastraea cavernosa*, and *Siderastrea siderea* coral species (p-values=0.008, 0.008, 0.004, and 0.016, respectively).

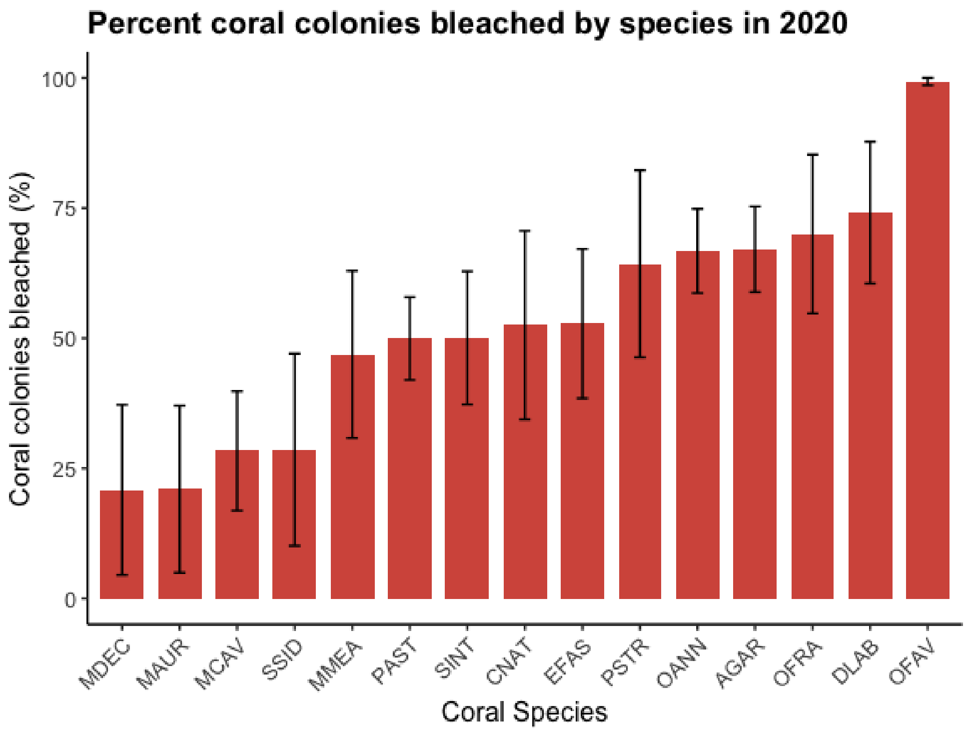

Fig. 4. The average percentage (± SEM) of coral colonies affected by bleaching in the Bonaire National Marine Park by species in 2020 across sites (*n* =10 study sites). Percentage of corals affected include pale, partially bleached and fully bleached corals. No coral mortality was observed. Coral species where less than 3 individuals of a given species were observed across the entire 2020 dataset were excluded from this figure as there were not enough observations to reliably estimate average percent bleaching. Table 2 in the Appendix includes the scientific and common names of the species codes listed here.

Discussion

The first global bleaching event from 1998-1999 caused an estimated 16% mortality in corals worldwide, with average mortality ranging from 5-10% in the Caribbean (Wilkinson 2002, Wilkinson & Souter 2008). Furthermore, a 2005 mass bleaching event in the Caribbean caused mortality of up to 27% of corals in some areas. Fortunately, Bonaire had relatively low mortality during the 2005 event (C. Eckrich, personal observ.). In 2010, Bonaire's reefs suffered from a coral bleaching event that resulted in approximately 10% mortality of corals at 10m depth (Steneck et al. 2011). A 'third global bleaching event' started in mid-2014 and lasted for three years, until mid-2017. Many coral reefs suffered widespread bleaching multiple years in a row during this event, the longest and perhaps most damaging coral bleaching event on record. Since 2016, coral paling and partial to full bleaching of corals have occurred every year on Bonaire's reefs to varying severity, but luckily SSTs dropped before notable mortality occurred. It is important to note that in 2018, coral bleaching was calculated based on the percentage of pale or bleached tissue on colonies while in other years it was calculated as the number of colonies with any pale or bleached tissue. These differences in methods may result in slightly lower estimates of percent bleaching in this compared to other years, though the data were included as they still provide important information on the relative intensity of coral bleaching among surveyed sites for the purposes of general comparisons.

Managing bleaching

Bonaire's reefs continue to show high levels of resilience to disturbances such as high SSTs. However, the pressures on marine ecosystems and, in particular, coral reefs are increasing at an unprecedented rate. The Bonaire National Marine Park is under multiple sources of stress, not only from high SSTs and climate change, but also damage caused by unsustainable tourism activities, pollution from coastal development, untreated wastewater seepage, and uncontrolled runoff. Thus, it is imperative that we continue to closely monitor and manage reef resilience. While we cannot manage the global-scale causes of coral bleaching, we must strive at a local scale to protect the integrity of Bonaire's reefs so they remain resilient in the face of future disturbances.

Reef resilience may be improved through effective fisheries management, wastewater treatment, responsible coastal development and sustainable tourism, as well as educational and outreach activities that increase the awareness of the importance of nature management and resilient coastal ecosystems. The Bonaire government and STINAPA have taken concrete steps to help facilitate coral resilience and recovery and enforce policies to protect Bonaire's coral reefs. Spearfishing was banned in 1971, all corals were protected in 1975, anchoring was banned and permanent mooring buoys were installed in 1978, fish protected areas were established in 2008, and many fish species, including all parrotfish, were protected in 2010 (Executive Council of the Bonaire Island Territory 2010). Many of these management initiatives are believed to facilitate reef resilience and recovery from stressors such as bleaching (Edwards et al. 2011, Steneck et al. 2019). Additionally, a wastewater treatment plant was constructed and began operating in 2015 to reduce coastal pollution, following marine management recommendations made by the IUCN Climate Change and Coral Reefs Working Group (IUCN 2011). Lastly, to foster sustainable tourism and recreation, all who dive in the

Bonaire National Marine Park must have a diver orientation and are prohibited from touching or removing any marine life or objects. As the resident population of Bonaire grows and tourism resumes (after Covid-19 travel restrictions), Bonaire's government and STINAPA must continue to adopt policies and legislation that safeguards coral reefs, one of Bonaire's most valuable natural resources, in the face of rising climate change related threats.

Acknowledgements

This report was made possible through the hard work of many dedicated STINAPA staff, interns, and volunteers including Paulo Bertuol, Ramon de Leon, Mackenzie Stoeltje, Allessandro Corubolo, Thijs van Wuijckhuijse, Lola Salvador, Romy Geertsma, Paul Berezinski, Niels den Toom, Tatiana Zanardi, Alcides Falanghe, and Jeffrey Gerrits.

References

Buddemeier RW & Fautin DG (1993) Coral bleaching as an adaptive mechanism: A testable hypothesis. *Bioscience* 43(5) 320–326.

DEZA (2008) Department of Economic and Labour Affairs Island Territory of Bonaire. *The Bonaire economic note.*

De Bakker, DM, Van Duyl FC, Bak RP, Nugues MM, Nieuwland G & Meesters EH (2017) 40 Years of benthic community change on the Caribbean reefs of Curaçao and Bonaire: the rise of slimy cyanobacterial mats. *Coral Reefs*, *36*(2), 355-367.

Diaz-Pulido G, McCook LJ, Dove D, Berkelmans R, Roff G, Kline DI, Weeks S, Evans RD, Williamson DH, Ove Hoegh-Guldberg O (2020) Doom and Boom on a Resilient Reef: Climate Change, Algal Overgrowth and Coral Recovery. PLOS One 4(4): 1-9.

Dove SG and Hoegh-Guldberg O (2006). Coral bleaching can be caused by stress. The cell physiology of coral bleaching. In: Ove Hoegh-Guldberg, Jonathan T. Phinney, William Skirving, Joanie Kleypas. *Coral Reefs and Climate Change: Science and Management*. American Geophysical Union, Washington. pp. 55–71.

Edwards HJ, Elliott IA, Eakin CM, Irikawa A, Madin JS, Mcfield M, Morgan JA, Van Woesik R, Mumby PJ (2011) How much time can herbivore protection buy for coral reefs under realistic regimes of hurricanes and coral bleaching? Glob Change Biol 17:2033–2048.

Executive Council of the Bonaire Island Territory (2010) Island Resolution Nature Management Bonaire. Section III– Protection of Animal and Plant Species.

Fujise L, Yamashita H, Suzuki G, Sasaki K, Liao LM, Koike K (2014) Moderate Thermal Stress Causes Active and Immediate Expulsion of Photosynthetically Damaged Zooxanthellae (Symbiodinium) from Corals. *PLoS ONE*. 9(12): e114321.

Gardner TA, Côté M, Gill JA, Grant JA and Watkinson AR (2003) Long-Term Region-Wide Declines in Caribbean Corals. Science 301(5635): 958–960.

Hawkins TD and Davy SK (2012) Nitric Oxide Production and Tolerance Differ Among Symbiodinium Types Exposed to Heat Stress. *Plant Cell Physiol*. 53(11): 1889–1898. doi:10.1093/pcp/pcs127.

Heron SF, Maynard JA, Hooidonk Rv, Eakin M (2016) Warming Trends and Bleaching Stress of the World's Coral Reefs 1985–2012.

Hoegh-Guldberg O (1999) Climate change, coral bleaching and the future of the world's coral reefs. Marine Freshwater Research 50: 839–66.

Holling CS (1973) Resilience and stability of ecological systems. Annual Review of Ecological Systems 4: 1-23.

IUCN (2011) Coral Reef Resilience Assessment of the Bonaire National Marine Park, Netherlands Antilles. Gland, Switzerland: IUCN. 51pp.

Jackson JBC (author), Donovan MK, Cramer KL, Lam VV (editors; 2014). Status and Trends of Caribbean Coral Reefs: 1970-2012. *Global Coral Reef Monitoring Network, IUCN, Gland, Switzerland.*

NOAA (2016, February 23) El Niño prolongs longest global coral bleaching event. Retreived from http://www.noaa.gov/media-release/el-ni-o-prolongs-longest-global-coral-bleaching-event. Accessed February 20, 2017.

NOAA (2015, October 8) NOAA declares third ever global coral bleaching event. Retreived from http://www.noaanews.noaa.gov/stories2015/100815-noaa-declares-third-ever-global-coral-bleaching-event.html. Accessed February 20, 2017.

NOAA (2018, March 19) Coral Bleaching During & Since the 2014-2017 Global Coral Bleaching Event. Retrieved from https://coralreefwatch.noaa.gov/satellite/analyses_guidance/global_coral_bleaching_2014-17_status.php. Accessed February 21, 2019.

NOAA Coral Reef Watch (2019) updated twice-weekly. NOAA Coral Reef Watch 50-km Satellite Virtual Station Time Series Data for Aruba, Bonaire and Curacao, 2017-2019. Silver Spring, Maryland, USA: NOAA Coral Reef Watch. Data set accessed 2019-01-07 at https://coralreefwatch.noaa.gov/vs/ts_figures/ts_2yr/2017_2018/2017_2018_ts_abc_islands.png.

Oliver J, Marshal P, Setiasih N and Hansen L (2004) A Global Protocol for Assessment and Monitoring of Coral Bleaching, World Wildlife Fund, Bali.

Oliver TA and Palumbi SR (2011) Many corals host thermally resistant symbionts in high-temperature habitat. *Coral Reefs* 30: 241–250.

Schep S, Brander L, Van Beukering, Wolfs E (2012) The touristic value of nature on Bonaire. A multiple valuation techniques approach, in assignment of the Ministry of Economic Affairs the Netherlands.

Steneck RS, Arnold SN, Boenish R, De Leon R, Mumby PJ, Rasher DB, Wilson MW (2019) Managing recovery resilience in coral reefs against climate-induced bleaching and hurricanes: a 15 year case study from Bonaire, Dutch Caribbean. Frontiers in Marine Science. Jun 7;6:265.

Steneck RS, Arnold S & H DeBey (2011) Status and Trends of Bonaire's Coral Reefs 2011 & Cause for Grave Concerns. *Report to STINAPA Bonaire*.

Steneck RS and Wilson M (2019) Status and Trends of Bonaire's Reefs in 2019: managing to stay healthy but concerns remain. *Report to STINAPA Bonaire.*

Swain TD, Vega-Perkins JB, Oestreich WK, Triebold C, Dubois E, Henss J, Baird A, Siple M, Backman V and Marcelino L (2016) Coral bleaching response index: a new tool to standardize and compare susceptibility to thermal bleaching *Global Change Biology* 22: 2475–2488. DOI: 10.1111/gcb.13276.

Thompson, JR, Rivera, HE, Closek, CJ, & Medina, M (2014) Microbes in the coral holobiont: partners through evolution, development, and ecological interactions. *Frontiers in Cellular and Infection Microbiology*, 4, 176. http://doi.org/10.3389/fcimb.2014.00176.

Wilkinson C (2002) Status of coral reefs of the world: 2002. *Australian Institute of Marine Science,* Townsville, Australia.

Wilkinson C & Souter D (editors; 2008) Status of coral reefs after bleaching and hurricanes in 2005. *Global Coral Reef Monitoring Network and Reef and Rainforest Research Centre*, Townsville, Australia.

Appendix

Table 1. List of the 10 coral bleaching survey sites on the leeward coast of Bonaire and Klein Bonaire including coordinates in decimal degrees.

Site	Location	Latitude	Longitude
Playa Funchi	WSNP	12.28237	-68.41490
Rei Willem Alexander No Dive Reserve	Leeward, N	12.22054	-68.36222
Karpata	Leeward, N	12.21961	-68.35239
Oil Slick Leap	Leeward, N	12.19995	-68.30863
Reef Scientifico	Leeward, Central	12.17218	-68.28924
Playa Lechi	Leeward, Central	12.15749	-68.28061
Invisibles	Leeward, S	12.07973	-68.28056
Vista Blue	Leeward, S	12.03938	-68.26389
Mi Dushi	Klein Bonaire	12.15992	-68.32585
Ebo's Special	Klein Bonaire	12.16578	-68.31925

Table 2. List of coral species codes and associated scientific and common names, in order of most to least affected by bleaching in 2020. Coral species where three colonies or less were observed across the entire dataset were excluded as there were not enough observations to reliably estimate percent bleaching for these species.

Coral Species Code	Scientific Name	Common Name
OFAV	*Orbicella faveolata*	Mountainous star coral
DLAB	*Diploria labyrinthiformis*	Grooved brain coral
OFRA	*Orbicella franksi*	Boulder star coral
AGAR	*Agaricia (Undaria) spp.*	Lettuce corals
OANN	*Orbicella annularis*	Boulder star coral
EFAS	*Eusmilia fastigiata*	Smooth flower coral
CNAT	*Colpophillia natans*	Boulder brain coral
SINT	*Stephanocoenia intersepta*	Blushing star coral
PAST	*Porites astreoides*	Mustard hill coral

MMEA	*Meandrina meandrites*	Maze coral
SSID	*Siderastrea siderea*	Massive starlet coral
PSTR	*Pseudodiploria strigosa*	Symmetrical brain coral
MCAV	*Montastraea cavernosa*	Great star coral
MAUR	*Madracis auretenra*	Yellow pencil coral
MDEC	*Madracis decactis*	Ten-rayed star coral