

CORAL BLEACHING IN THE U.S. VIRGIN ISLANDS IN 2005 AND 2006

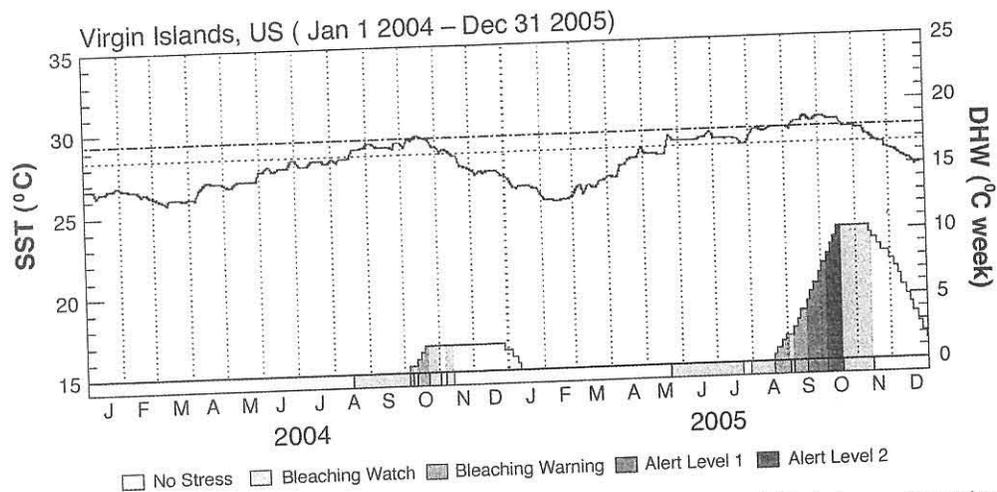
KIMBERLY WOODY, ANDREA ATKINSON, RANDY CLARK,
CHRIS JEFFREY, IAN LUNDGREN, JEFF MILLER, MARK MONACO,
ERINN MULLER, MATT PATTERSON, CAROLINE ROGERS, TYLER SMITH,
TONY SPITZAK, ROB WAARA, KEVIN WHELAN, BRIAN WITCHER AND
ALEXANDRA WRIGHT.

SUMMARY

- Severe coral mortality occurred in the U.S. Virgin Islands (USVI) between July and November, 2005 because of bleaching and disease; the average decline in hard coral cover was 51.5%;
- Sea surface temperatures exceeded the 29.5°C coral bleaching threshold for 12 weeks in 2005; maximum temperatures exceeded 30°C. The reefs suffered more thermal stress during this period than during the previous 20 years combined;
- Coral bleaching was observed between July and November, 2005; on average it affected more than 90% of the coral cover;
- Bleaching occurred in 22 coral species over a wide range of depths;
- The greatest bleaching-related mortality occurred in the genus *Agaricia*; bleaching also severely affected *Montastraea*, *Colpophyllia*, *Diploria* and *Porites*, but mortality in these species was usually the result of subsequent infection by white plague or white syndrome;
- Coral losses in late summer 2005 were more severe than any time in the last 40 years.

INTRODUCTION

The first indications of potential thermal stress to the corals of the USVI occurred in July 2005 with observations of bleached corals, and in August when satellite information provided by the National Environmental Satellite, Data, and Information Service (NESDIS) Coral Reef Watch indicated that sea surface temperatures (SSTs) in the north-eastern Caribbean were higher than normal. Temperatures continued to rise, producing more thermal stress during this single period than during the previous 20 years combined (Coral Reef Watch 2005, accessed 19 November 2007). The bleaching threshold of 29.5°C (83.3°F) was exceeded for about 12 weeks prior to 12 November 2005, with SSTs reaching just over 30°C; a full degree warmer than the previous year. This chapter discusses how monitoring efforts in the USVI captured the bleaching event of 2005 and demonstrates that several methods used to monitor the health of the reefs arrived at the same conclusion: coral cover on USVI reefs is declining.



Sea surface temperatures (SSTs) in 2005 exceeded those of 2004, especially between August and November (solid line) when they exceeded the coral bleaching threshold of 29.5°C in the USVI (dashed line). The accumulation of 'Degree Heating Weeks' (DHW) is shown along the X-axis in red along with the timing of bleaching watches and warnings issued in 2004 and the major alerts in 2005 from August to November. The thermal condition is categorized according to the five bleaching alert levels defined by Coral Reef Watch's Satellite Bleaching Alert. Source: http://coralreefwatch.noaa.gov/satellite/current/sst_dhw_series_usvirgin_cur.html

EFFECTS OF THE 2005 BLEACHING EVENT

Declines in coral cover and increases in macroalgae resulting from a variety of stresses including hurricanes and coral disease have been reported previously in the USVI. For example, major coral losses occurred in the 1970s and 1980s as a result of white band disease, killing more than 90% of *Acropora cervicornis* and *A. palmata* colonies, the primary shallow water reef building corals. However, the 51.5% decline in mean coral cover during the 12 months following the major 2005/06 bleaching and disease event was unprecedented. These losses occurred on well developed 'high' coral cover, high coral diversity reefs being monitored by the National Parks Service. Even deep reefs with high coral cover (>30% cover, >30 m) were affected by bleaching and disease.

National Park Service Inventory and Monitoring (NPS I&M) and US Geological Survey (USGS) scientists documented the effects of the 2005 bleaching and subsequent coral disease at long-term monitoring sites around St. John and St. Croix. An average of 90% of the coral cover bleached at 5 permanent sites (100 transects at depths between 4 m and 19 m) in St. John and St. Croix, including Virgin Islands National Park (VINP) and Buck Island Reef National Monument (BIRMN). By late 2005, many of the corals began to regain color; but then became infected by the white plague coral disease. In just one year, the average decline in coral cover at these sites was 51.5% (range 34.1% - 61.8%). There were massive declines in the major reef building coral species: the *Montastraea annularis* (complex) once comprised 80% of the total coral cover, but suffered a 51% decline compared with pre-2005 levels; the cover of *Agaricia agaricites*, *Colpophyllia natans* and *Porites porites* declined by 87%, 78%, and 48% respectively. However, there was no change in cover of *M. cavernosa*. While mortality of *A. agaricites* was directly attributable to bleaching, mortality in nearly all other coral species

resulted from subsequent infection of white plague disease. The average number of species per transect also declined by 21%.

Agency	Region	Category	% Bleaching	% Mortality
NPS I&M / USGS	St. Croix, St. John	Overall	90	51.5
		<i>A. agaricites</i>		87
		<i>C. natans</i>		78
		<i>M. annularis</i> (complex)		51
		<i>P. porites</i>		48
NPS / USGS	St. Croix, St. John	<i>Agaricia</i> spp.		87*
		<i>C. natans</i>		35*
		<i>Diploria</i> spp.		17*
		<i>M. annularis</i> (complex)		12/55*
		<i>P. porites</i>		15*
UVI	Region-wide	Overall	57	40
		<i>Montastraea</i> reef - total loss		70-90
		<i>Montastraea</i> reef - <i>Montastraea</i> loss		83-95
BB / NPS	St. Croix	October	53	
		December	28	
USGS	VINP	<i>A. palmata</i>		15/36
NPS	BIRNM	<i>A. palmata</i>	79.8	58.1

Summary of results of surveys conducted by several agencies (explained in the text) to determine the impacts of the 2005 bleaching / disease event in USVI. * indicates that percentages have been calculated as the proportion of the total number of colonies of each coral species surveyed. All other percentages have been calculated from coral cover data. Where two values are separated by /, the first value reports the percentage cover or proportion of colonies that suffered complete mortality, and the second reports the percentage of partial mortality.

The fate of 4153 coral colonies on the 100 transects was tracked by NPS and USGS. Colonies of *Agaricia* spp. were the most severely affected by bleaching with 87% mortality, and 35% of *C. natans*, 17% of *Diploria* spp. and 15% of *P. porites* colonies had died within 6 months of the peak bleaching in September 2005. The *M. annularis* (complex) initially exhibited substantial recovery from bleaching, but subsequently, there was high mortality as a result of white plague coral disease, with 12% of colonies dying completely and about 55% showing partial colony mortality.

Bleaching and mortality in territorial waters followed a similar pattern to that observed within the national parks. Researchers from the University of the Virgin Islands reported an average of 57% of the coral cover bleaching (74% of individual colonies) at a range of depths, which resulted in only a 4% decline in coral cover. However, there was a subsequent increase in tissue-eroding white syndrome, from 0.5% of colonies infected prior to and during bleaching, to 4% after the bleaching. This was probably responsible for a 40% decline in coral cover across the territory. In two deep (20-30 m) areas that formerly had high *Montastraea* cover (~36%), there was a 70-90% decline in total coral cover, resulting predominantly from the loss of *Montastraea* (83-95% cover loss).

At 30 m depth along this *Montastraea* reef system, NCCOS/Biogeography Branch (BB) and NPS recorded a significant decrease in average coral cover between 2005 and 2006, from 8.69% (± 1.6) in 2005 to 6.60% (± 1.3) in 2006, representing a 24% decline in coral cover. The difference between this estimate and the 70-90% decline described above is most likely explained by the patchy spatial distribution of corals along this reef system and differences in sampling techniques. The overall conclusion is that coral cover declined significantly between 2005 and 2006.

In October 2005, the BB and NPS BIRMN observed bleaching in 22 scleractinian coral species in north-eastern St. Croix, with nearly 53% of the coral cover bleached at 91 of 94 randomly selected sites (depth range 3-28 m). The average coral cover at these sites was 5.6%. Bleaching was widespread, with no obvious spatial pattern. Coral species most affected by the bleaching event included *D. labyrinthiformis*, *Agaricia* spp., *Mycetophyllia* spp., and *M. annularis*. By December 2005, bleaching was still evident, with colonies at 15 of 18 randomly selected sites still bleached. Only 28% of the 3.9% total coral cover was bleached, and an additional 4% colonized by cyanobacteria or other algae (i.e. recently dead), but there was evidence of corals recovering from bleaching.

The first time that bleached *A. palmata* colonies had been observed in the USVI was in July 2005, with 50% of 460 colonies in VINP, St. John showing some bleaching. This eventually resulted in 36% (± 7.4) of colonies suffering partial mortality and 15% (± 8.5) dying completely. Mortality of *A. palmata* rose during 2005, but was not always directly related to bleaching. Isolated incidences of disease and bleaching contributed to the rise in mortality. Bleaching was not followed by severe outbreaks of disease except at one site, Hawksnest Bay, where a combination of disease and bleaching caused greater mortality within 3 months than other stresses (e.g. predation, physical damage) had caused during the previous 2.5 years. All surviving colonies regained normal coloration by February 2006.

There was also extensive bleaching of *A. palmata* in 2005 at BIRMN, St. Croix. Bleaching was observed between August 2005 and January 2006, with greatest bleaching recorded at South Forereef in November 2005, where 79.8% (± 9.1) tissue bleached, followed by 58.1% (± 9.8) tissue mortality. The greatest tissue mortality (66.4% (± 8.7)), occurred at the Underwater Trail. There was 36.4% (± 12.5) tissue mortality at the North Bar. Colonies on the back-reef appeared to be more affected than colonies elsewhere, raising the possibility that reduced water flow and calmer conditions exacerbated the bleaching and resulted in greater mortality.

CONCLUSION

The coral bleaching/disease event of 2005 added to the historical impacts of other stresses (pollution, over-fishing, physical damage), resulting in major damage to the reefs of the USVI. Management actions to improve water quality, prevent over-fishing and reduce physical damage and overuse may create a foundation for better reef recovery and long-term survival.

AUTHOR CONTACTS

NOAA's Center for Coastal Monitoring and Assessment, Biogeography Branch: Kimberly Woody, Kimberly.Woody@noaa.gov; Randy Clark, Randy.Clark@noaa.gov; Chris Jeffrey, Chris.Jeffrey@noaa.gov; Mark Monaco, Mark.Monaco@noaa.gov. National Park Service, South Florida/Caribbean Network: Andrea Atkinson, Andrea_Atkinson@nps.gov; Jeff Miller, William_J_Miller@nps.gov; Matt Patterson, Matt_Patterson@nps.gov; Rob Waara, Rob_Waara@nps.gov; Kevin Whelan, Kevin_R_Whelan@nps.gov; Brian Witcher, Brian_Witcher@nps.gov; Alexandra Wright, sasha_wright@partner.nps.gov. National Park Service, Buck Island Reef National Monument: Ian Lundgren, Ian_Lundgren@nps.gov. US Geological Survey: Erinn Muller, emuller@fit.edu; Caroline Rogers, Caroline_Rogers@usgs.gov; Tony Spitzack, Tony_Spitzack@usgs.gov. University of the Virgin Islands: Tyler Smith, TSmith@uvi.edu.

REFERENCES

- Coral Reef Watch. NOAA Satellite and Information Service. 2005. Accessed 19 November 2007. <http://coralreefwatch.noaa.gov/caribbean2005/>.
- Herzlieb S, Kadison E, Blondeau J, Nemeth RS (2006). Comparative assessment of coral reef systems located along the insular platform south of St. Thomas, US Virgin Islands and the relative effects of natural and human impacts. Proc 10th Int Coral Reef Symp, Okinawa. 4-2:1144-1151.
- Jeffrey C, Clark R, Woody K, Menza C, Caldow C, Kendall M, Monaco M (2005). Coral bleaching and recovery observed at Buck Island, St. Croix, US Virgin Islands, October and December, 2005. http://ccma.nos.noaa.gov/products/biogeography/coral_bleaching/welcome.html. Accessed 20 November 2007.
- Lundgren I, Hillis-Starr Z (2007) (in review). Variation in *Acropora palmata* bleaching across benthic zones at Buck Island Reef National Monument (St. Croix, USVI) during the 2005 bleaching event. Bulletin of Marine Science.
- Menza C, Kendall M, Rogers C, Miller J (2007). A Deep Reef in Deep Trouble. Continental Shelf Research 27:2224-2230.
- Miller J, Waara R, Muller E, Rogers C (2006). Coral bleaching and disease combine to cause extensive mortality on reefs in the US Virgin Islands. Coral Reefs 25:418.
- Muller E, Rogers C, Spitzack A, van Woesik R (2007). Water temperature influences disease prevalence and severity on *Acropora palmata* (Lamarck) at Hawksnest Bay, St. John, US Virgin Islands. Coral Reefs. DOI 10. 1007/s00338-007-0310-2.
- Rogers CS, Miller J, Muller E, (and 22 others) (2007). Ecology of coral reefs in the US Virgin Islands. In Regal B and Dodge R (eds), Coral Reefs of the USA. 2007. Springer, in press.
- Whelan, KRT, Miller J, Sanchez O, Patterson M (2007). Impact of the 2005 coral bleaching event on *Porites porites* and *Colpophyllia natans* at Tektite Reef, US Virgin Islands. Coral Reefs 26:689-693.

GCRMN

GLOBAL CORAL REEF
MONITORING NETWORK

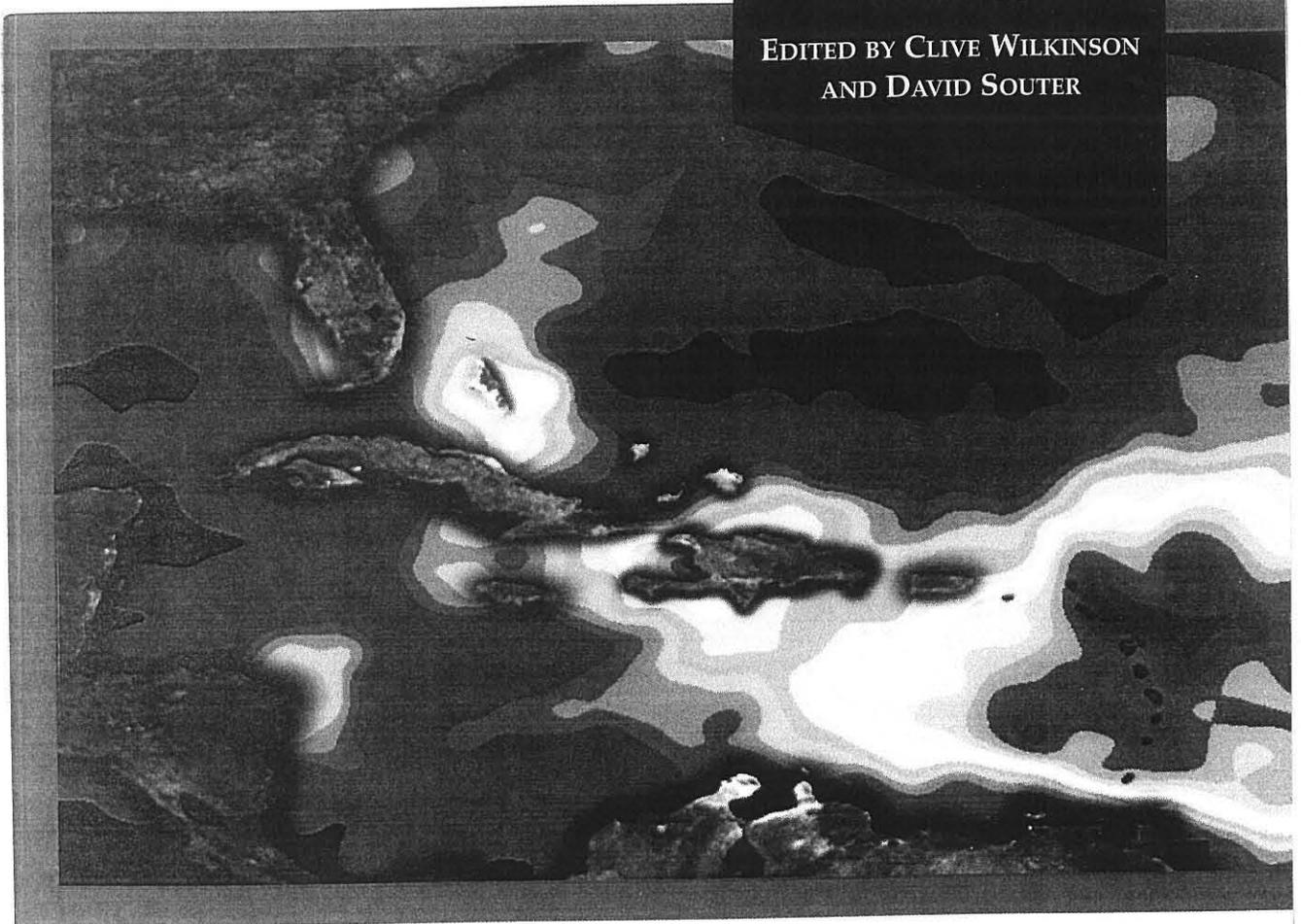
ICRI

INTERNATIONAL
CORAL REEF INITIATIVE



STATUS OF CARIBBEAN CORAL REEFS AFTER BLEACHING AND HURRICANES IN 2005

EDITED BY CLIVE WILKINSON
AND DAVID SOUTER



IUCN
The World Conservation Union

Reef &
Rainforest
RESEARCH CENTRE



ICRAN
International Coral Reef Action Network

Dedication: This book is dedicated to the many people who have worked on coral reefs to understand them and ensure that they exist for future generations. One of these deserves special mention; Len Muscatine retired from UCLA to his vineyard but did not have enough time to enjoy the fruit of his vines. We miss him. The book is also recognises the International Coral Reef Initiative and partners, and particularly those people in the USA, operating through the US Coral Reef Task Force, the US Department of State and the US National Oceanic and Atmospheric Administration, who continue to strive for greater recognition of the problems facing coral reefs and the need for urgent conservation efforts.

Note: The conclusions and recommendations of this book are solely the opinions of the authors and contributors and do not constitute a statement of policy, decision, or position on behalf of the participating organizations.

Front Cover: A stylized map of the maximum Degree Heating Week values observed across the Caribbean during 2005, indicating the highest level of accumulated thermal stress at each location (image from US National Oceanic and Atmospheric Administration Coral Reef Watch).

Inside Title Page: This image shows the 2005 maximum Degree Heating Week data used to create the image on the front cover, showing the maximum level of accumulated thermal stress at each location (explained on pages 38 and 39; image from US National Oceanic and Atmospheric Administration Coral Reef Watch).

Back Cover: A NOAA/Biogeography Branch diver with a 1 metre by 1 metre quadrat examining a bleached *Montastraea* colony at St Croix, US Virgin Islands (photo from NOAA Center for Coastal Monitoring and Assessment Biogeography Branch).

Maps were provided by UNEP-WCMC through ReefBase, The WorldFish Center; we thank them.

Citation: Wilkinson, C., Souter, D. (2008). Status of Caribbean coral reefs after bleaching and hurricanes in 2005. Global Coral Reef Monitoring Network, and Reef and Rainforest Research Centre, Townsville, 152 p.

© Global Coral Reef Monitoring Network
c/o Reef and Rainforest Research Centre,
PO Box 772
Townsville, 4810 Australia
Telephone: +61 7 47212699;
Facsimile: +61 7 47722808
www.gcrmn.org

ISSN 1447 6185