

9. THE EFFECTS OF CORAL BLEACHING IN SOUTHERN TROPICAL AMERICA: BRAZIL, COLOMBIA, AND VENEZUELA

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SUMMARY

- Massive coral bleaching occurred in Southern Tropical America during unusually high sea surface temperatures in 2005. The timing of bleaching varied throughout the region.
- Surveys at 156 sites in Brazil, Colombia and Venezuela show that 2005 was the region's most severe bleaching year, with most bleaching in shallow zones, but the severity varied considerably.
- In Brazil, bleaching started at Itacolomis Reefs in April 2005, after the southern summer.
- In Colombia, reefs at Santa Marta started bleaching 6 months later in October, after the northern summer.
- In Venezuela, the peak bleaching intensity was in November-December 2005, two months later than in the west and north Caribbean. It affected up to 25% of coral colonies but varied greatly among surveyed sites, from 0 to 100%.
- Bleaching was observed in several coral species but only a few, such as *Acropora cervicornis*, *A. palmata*, and *Diploria labyrinthiformis*, suffered mortality.
- Coral reefs less affected by bleaching seem to be related to upwelling zones in the Caribbean.

INTRODUCTION

The Southern Tropical America (STA) Node of the GCRMN includes Costa Rica, Panama, Colombia, Venezuela, and Brazil, with reefs in Pacific, Caribbean and Atlantic waters. The Node is coordinated by the ‘Instituto de Investigaciones Marinas y Costeras’ (INVEMAR) in Colombia, with support from UNEP-CAR/RCU in Jamaica; the Node has been developing coral reef monitoring in this region since 1999.

Most coral reefs in the region have undergone major changes in the last 30 years, particularly during the 1980s, with considerable loss of live coral cover on many reefs and increasing dominance of algae. Nevertheless, high coral cover can still be found on many reefs on both the Caribbean coast (means between 20-40%) and the Pacific coast (means above 40%). Some changes were caused by ‘natural’ agents (ENSO events, bleaching, disease outbreaks, phytoplankton blooms), but others are clearly related directly to human activities (deforestation, increased sedimentation, coastal development, sewage pollution, over-fishing). The 1997-98 El Niño events had little effect on reefs in the region. Monitoring data from the 5 countries indicate that reefs of the STA region did not change significantly between 2000 and 2004. Mass coral bleaching was recorded in the region during 2005 although some reefs were not affected (e.g. Costa Rica). Thus, this report focuses on the effects of coral bleaching events in Brazil, Colombia, and Venezuela.



Map of the Southern Tropical America region.

Brazil

INTRODUCTION

The coral reefs of Brazil have low coral diversity (18 species with 6 endemic) and are discontinuously distributed in 5 major areas along the 2500 km western Atlantic coastline: Touros-Natal has extensive coastal knoll and patch reefs; Pirangi-Maceió has linear coastal reefs and higher species diversity; Todos os Santos Bay-Camamu; Porto Seguro-Cabrália; and the Abrolhos Region to the east and south. The National Marine Park of Abrolhos covers 900 km² and contains the richest coral reefs in Brazil, including the Timbebas Reefs (isolated coastal bank reefs), fringing reefs on offshore volcanic islands of the Abrolhos Archipelago, and the 'chapeirões', which are giant mushroom-shaped coral pinnacles 70 km offshore.

STATUS OF CORAL REEFS PRIOR TO 2005

The first record of coral bleaching was in the Abrolhos area of Eastern Brazil in 1994. In 1998, bleaching was observed in Bahia, north of Salvador City and in the Abrolhos, when sea surface temperatures (SSTs) increased in mid January and peaked between mid March and April, before declining in late May. The SSTs ranged between 29.5°C and 30.5°C; or 1-2°C higher than the long-term average summer maximum of 28.5°C. In 2003, two 'hot spots' occurred in Eastern Brazil (Tinharé and Abrolhos) when SSTs rose in mid February and were 1°C above the long term average in mid March; the hot spots dissipated in late April with up to 20% of coral colonies bleached in Tinharé, and 17% in Abrolhos (SST anomalies are based on 'HotSpot' charts in www.osdpd.noaa.gov/PSB/EPS/SST/climahot.html).

EFFECTS OF THE 2005 BLEACHING EVENT

Two reefs in Southern Bahia, Itacolomis and Abrolhos, were affected by increased SSTs in mid-March 2005 with a maximum rise of 0.75°C above the long-term average. The 'HotSpots' dissipated by the end of April, however, coral bleaching was observed on the Itacolomis Reefs during April, with up to 17% of colonies affected. About 28% of coral colonies were bleached on the Abrolhos reefs in early May. The coincidence of mass coral bleaching events in Eastern Brazil and high SSTs during the last 8 years strongly indicates that these temperature increases are the primary cause of bleaching in the region. Bleaching was mild in Bahia in 2006 with only 6.2±7.1% of colonies bleached on the Abrolhos fringing reefs, compared with 28.3±4.9% in 2005. Live coral cover increased from 11.4 ±5.0% (2005) to 13.5 ±3.5% (2006), with no rise in recent mortality. The amount of dead coral declined from 20.5% (2005) to 17.5% (2006).

Percentage of bleached coral colonies observed on Brazilian reefs in 2005 and 2006 from assessments performed using the AGRRA protocol.

| Reefs | Time of observation | Number reef sites | No. colonies observed | Percentage bleached colonies |
|------------|---------------------|-------------------|-----------------------|------------------------------|
| Itacolomis | April 2005 | 3 | 280 | 4.7 – 17.0 |
| Abrolhos | May 2005 | 3 | 399 | 23.5 – 33.3 |
| Abrolhos | March 2006 | 6 | 553 | 2.0 – 17.0 |

Colombia

INTRODUCTION

The Caribbean coast of Colombia has reefs on a 40 km wide continental shelf, which are strongly influenced by freshwater and sediment runoff, particularly from the Magdalena River, which is the largest river flowing into the Caribbean. The coral reefs cover more than 2800 km² and are scattered among 26 areas in 3 major groups. The mainland coast has fringing reefs on rocky shores, such as the Santa Marta and Urabá areas. There are many well-developed reefs around offshore islands, including the Islas de San Bernardo and Islas del Rosario, on the continental shelf, and oceanic reef complexes of the San Andrés Archipelago in the Western Caribbean. These are the best developed coral formations, including atolls, banks, barrier reefs, fringing reefs and patch reefs, and comprise more than 75% of Colombia's coral reefs. Pacific reefs are poorly developed, with only Gorgona Island having large coral formations.

STATUS OF CORAL REEFS PRIOR TO 2005

The Caribbean reefs were degraded by pollution, sedimentation, over-fishing, dynamite fishing, and coral mining during the 1980s, with mass mortality of gorgonians, coral bleaching, and declines in sea urchin (*Diadema antillarum*) populations. Bleaching was reported on Colombian Caribbean reefs in 1987, 1990, 1995 and 1998. The 1987 Caribbean-wide event affected the Santa Marta region, Rosario Islands and Bahía Portete (Guajira area), but was poorly documented. During 1990 and 1995, minor bleaching events were observed at Islas del Rosario and Chengue respectively. The 1997-98 El Niño event had little effect on Colombian Caribbean reefs. Coral bleaching affected less than 5% of coral colonies at sites monitored between 1998 and 2001, except in Chengue where it was 10%; but coral mortality was negligible. However, coral communities in Chengue were damaged in late 1999 by Hurricane Lenny, reducing coral cover from 35% to 31%. Colombian Caribbean reefs have changed little since the mid-1990s; coral cover has ranged between 31% and 35% in Chengue Bay, 28% and 32% at Rosario Islands, and 22% and 28% at San Andrés Island. Coral diseases affect less than 5% of coral colonies at all sites, except San Andrés, where 9.1% and 6.3% of colonies were affected in 1999 and 2001 respectively. Dark spot and white plague are the most common coral diseases on Colombia's Caribbean reefs.

IDENTIFICATION OF BLEACHING-SUSCEPTIBLE ZOOXANTHELLAE IN COLOMBIAN CORALS.

Bleached colonies of *Colpophyllia natans*, *Montastraea faveolata*, *M. annularis*, *Agaricia tenuifolia*, and *Porites astreoides* from the coral reefs near Cartagena, Colombia were examined with molecular techniques to identify bleaching resistance or susceptibility in the zooxanthellae; 41.7% of bleached corals contained zooxanthellae clades A, C and D. There were however, many different sub-types of zooxanthellae in clades A and C, with most of these types susceptible to bleaching in 2005. When colonies of *Montastraea faveolata* and *Diploria labyrinthiformis* were re-sampled after the bleaching event, the zooxanthellae were predominantly of thermally tolerant clade D, corresponding with predictions of thermal acclimation (from Maria Clara Hurtado, mar-hurt@uniandes.edu.co and Juan Armando Sánchez, juansanc@uniandes.edu.co)

EFFECTS OF THE 2005 BLEACHING EVENT

Surface waters in Colombia were unusually warm in 2005. The first increases in sea temperature along the Caribbean coast were observed in mid-May and peaked at 1.5-2.5°C higher than the monthly mean in the 3rd and 4th weeks of June. This coincided with the first observations of mass coral bleaching at Islas del Rosario.

The 2005 bleaching event was the most severe for the Colombian Caribbean in the last 25 years. The severity of bleaching varied between the 137 study sites: Rosario and San Bernardo suffered severe bleaching; San Andrés and Providencia were moderately affected; and Santa Marta experienced minimal bleaching. However, corals in the Santa Marta area bleached in October, 4 months after corals on reefs such as Islas del Rosario, which is 200 km to the southwest. This might have been a result of seasonal upwelling peaks that occurred early in the year and in July-August.

There was great variation between sites, with the cover of bleached coral and the proportion of bleached colonies ranging between 0.5-80% and 0.6-100% respectively. However, coral mortality was generally low with less than 5% variation between areas and stations. Most coral species showed some bleaching, especially those in water shallower than 10 m. The greatest bleaching mortality occurred at Islas del Rosario and Islas San Bernardo, mainly among colonies of *Acropora palmata*, *A. cervicornis*, *Diploria labyrinthiformis* and *Millepora alcicornis*. Extensive patches (> 100 m²) of recently dead *A. palmata* and *A. cervicornis* were observed. Subsequent mortality was also observed in tagged colonies that were re-examined two months after the peak of bleaching; some of these colonies were greater than 50 cm in diameter. However, most reefs that suffered bleaching had recovered within 6 months of the onset of the event.

IS COMPETITION FOR SPACE BETWEEN THE ENCRUSTING EXCAVATING SPONGE *CLIONA TENUIS* AND CORALS INFLUENCED BY HIGHER TEMPERATURES?

The rate of lateral overgrowth by excavating sponges was measured to see whether heat stress in corals may make them more susceptible to encroachment. There was no change in rate of lateral spread of the sponge *Cliona tenuis* growing over colonies of the corals *Diploria strigosa* and *Siderastrea siderea* at 5-6 m depths between June 2001 and July 2002, when there was no unusual warming, and in August 2004 and September 2005, which coincided with significant warming. Sponge spreading on *S. siderea* remained constant, but was more variable on *D. strigosa*, irrespective of whether there was partial or total bleaching of the corals. These experiments indicate that there may be differential susceptibility to excessive warming within and between coral species and perhaps between individual sponges (from Juan Carlos Márquez, juancmarquezh@gmail.com; Sven Zea, szea@invemar.org.co; and Mateo López-Victoria, Mateo.Lopez-Victoria@bio.uni-giessen).

Seagrass and mangrove communities monitored at Chengue Bay during 2005 did not show significant changes from the 2005 bleaching event. There was no bleaching in the Colombian Pacific at Malpelo Island in June and Gorgona Island in October.

The impacts of coral bleaching on the reefs of Colombia in 2005 are summarized in this table showing the effect on coral cover and the number of bleached colonies. The effects on the reefs varied considerably within sites with low resultant mortality.

| Colombian Caribbean Reefs | Sites Examined | Coral Cover Bleached | Coral Colonies Bleached | Coral Mortality |
|----------------------------------|-----------------------|-----------------------------|--------------------------------|------------------------|
| Islas del Rosario-Cartagena | 48 | 0.5-80% | 29-100% | 0-2% |
| Islas San Bernardo | 18 | 0.5-70% | 50-100% | 0-5% |
| San Andres | 30 | 1-15% | 7-60% | ? |
| Providencia | 29 | 1-10% | 0.6-54% | ? |
| Santa Marta-Parque Tayrona | 12 | 1-5% | 0-15% | 0-1% |

IMPACTS OF HURRICANES IN 2005

Hurricane Beta was a moderate category 1 hurricane that passed very close to Providencia and Santa Catalina Islands on 29 October 2005. When 20 sites were examined 15 days later, there was negligible damage to coral reefs, seagrass beds, beaches and mangroves; however, terrestrial vegetation and island infrastructure were severely damaged.

Venezuela

INTRODUCTION

The coast of Venezuela is 2875 km long and with most of this (67%) in the Caribbean where the reefs are found. There are no reefs along the Atlantic coast because of freshwater and sediment runoff, and upwellings. Nearshore coral reefs occur only in Morocoy National Park and adjacent areas (San Esteban, Turiamo and Ocumare de la Costa), with more than 30 coral species and reef growth to 20 m depth; and Mochima National Park and adjacent reefs (Coche and Cubagua islands), with more than 20 coral species to depths of 14 m. The best developed reefs are around the oceanic islands, especially at Archipelago de Aves, Archipelago Los Roques, La Orchila and La Blanquilla, which have 57 coral species growing to great depths e.g. 57 m.

STATUS OF CORAL REEFS PRIOR TO 2005

The oceanic reefs of Venezuela were once among the few virtually pristine reefs in the Caribbean, but surveys since 2003 showed sites varied between 18% and 51% mean coral cover. The exception was the coastal coral reefs at Parque Nacional Morrocoy (PNM), which were severely degraded in 1996, probably by chemical pollution or a severe phytoplankton bloom, followed by sudden oxygen depletion caused by a climate and oceanic anomaly. Coral cover dropped from 43% to less than 5% at the former CARICOMP reef site of Bajo Caiman. Subsequent CARICOMP surveys at Bajo Cayo Sombrero, one of the few reefs in the park with live corals, indicated that the coral community was in a relatively stable condition, with more than 35%

coral cover. Several coral diseases including yellow band, black band, white diseases, dark spots and ciliate infections had affected the corals.

The table shows the percentage of bleached colonies of zoanthids, octocorals and hard corals in Venezuela, between August 2005 and February 2006. The intensity is recorded as the surface area of the colony affected at oceanic reefs: Isla La Blanquilla (LB) and Parque Nacional Archipiélago Los Roques (Pnalr); and coastal reefs: Parque Nacional Morrocoy (PNM-RFSC) on the western coast and Parque Nacional Mochima (PNM) on the eastern coast that is influenced by upwelling. BCS is the CARICOMP site of Venezuela at PNM-RFSC, which was examined during each sampling period (n = number of colonies surveyed; N = number of sites surveyed at each location).

Surface area of the colony bleached %

| Time of observation | Location (N) | Coastal/Oceanic | <10 | 10-25 | 25-50 | 50-75 | 75-100 | Bleached Colonies % | n |
|---------------------|--------------|-----------------|-----|-------|-------|-------|--------|---------------------|-----|
| Aug-Sep 2005 | LB (1) | Oceanic | 0.0 | 1.7 | 0.4 | 0.9 | 0.7 | 3.7 | 461 |
| | Pnalr (2) | Oceanic | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 | 275 |
| | BCS (1) | Coastal | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 160 |
| | PNM-RFSC (3) | Coastal | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 352 |
| Nov-Dec 2005 | BCS (2) | Coastal | 5.6 | 4.1 | 4.6 | 0.5 | 11.7 | 26.5 | 196 |
| | PNM-RFSC (4) | Coastal | 2.2 | 2.1 | 1.7 | 0.8 | 3.4 | 10.2 | 715 |
| Jan-Feb 2006 | Pnalr (1) | Oceanic | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 643 |
| | PNM (1) | Coastal | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 181 |
| | BCS (1) | Coastal | 4.1 | 2.1 | 6.7 | 2.1 | 2.1 | 17.1 | 193 |

EFFECTS OF THE 2005 BLEACHING EVENT

There was no bleaching among 352 coral colonies at 3 coastal reef sites in August-September. However, there was minor bleaching at 3 oceanic sites, with 1% of 275 colonies affected at Parque Nacional Archipiélago de Los Roques and 4% of 461 colonies at Isla La Blanquilla, but bleaching usually affected less than 10% of the colony surface.

By November-December 2005, up to 25% of 715 coral colonies had bleached at 5 coastal sites in Parque Nacional Morrocoy, with hard corals, soft corals and zoanthids showing bleaching over more than 50% of their surface. Bleaching varied between species: there was 50% bleaching in *Montastraea franksi*; 48% in *M. faveolata*; 14% in *Colpopohyllia natans*; 50% in *Meandrina meandrites*; 16% in *Agaricia agaricites*; 7% in the hydrocoral *Millepora*; 65% in the encrusting octocoral *Erythropodium caribaeorum*; and 85% in the zoanthid *Palythoa mammillosa*.

Bleaching was still evident in January-February 2006 at one coastal reef site in Parque Nacional Morrocoy and 4 oceanic sites at Parque Nacional Archipiélago de Los Roques. Bleaching was not observed at Parque Nacional Archipiélago de Los Roques in the *Acropora palmata* zone (n =

643); however, about 10% of colonies of *Montastraea faveolata* were bleached at other depths. The bleached colonies showed recovery at the coastal site of Cayo Sombrero (BCS), going from 26% bleached (n = 196) in November-December to 17% (n = 193). Severely bleached corals (those with more than 75% of the surface bleached) dropped from 11% in August-September to less than 2% in January-February 2006. There was no bleaching seen at the other 3 coastal reef sites in Parque Nacional Mochima, probably because these sites are in the characteristic upwelling area of the eastern coast.

The 2005 bleaching event also affected other reefs in Venezuela; however, the peak bleaching intensity was 2 months later than other Caribbean sites to the west and north. Bleaching appeared to start on the oceanic reefs, although coastal reefs were eventually more severely affected. The Parque Nacional Mochima was least affected, probably because of the influence of upwelling and lower sea surface temperatures (23°C during surveys) compared with the other reefs (>27°C). Peak bleaching occurred in November-December 2005. There was no increase in the prevalence of coral diseases or loss of coral cover after the 2005 bleaching at any of the 5 monitoring sites.

CONCLUSIONS AND RECOMMENDATIONS

During the Southern and Northern Summers of 2005, the Southern Tropical America region experienced the most severe coral bleaching event for decades. Bleaching was widespread, occurring throughout the region from the oceanic reefs of Colombia in the Southwestern Caribbean to Brazilian reefs in the Western Atlantic. However, the severity of bleaching varied greatly and bleaching mortality was generally low. Nevertheless, extensive areas of *Acropora palmata* and *A. cervicornis* were killed in a few localities, highlighting that these are particularly vulnerable species. Some reefs had minor bleaching (e.g. Santa Marta, Colombia and Parque Nacional Mochima, Venezuela), which could be attributable to the seasonal upwelling in these areas. It is important to understand the differential response to widespread bleaching events so that more resistant coral reefs can be conserved to serve as future sources of larvae for recovery.

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