#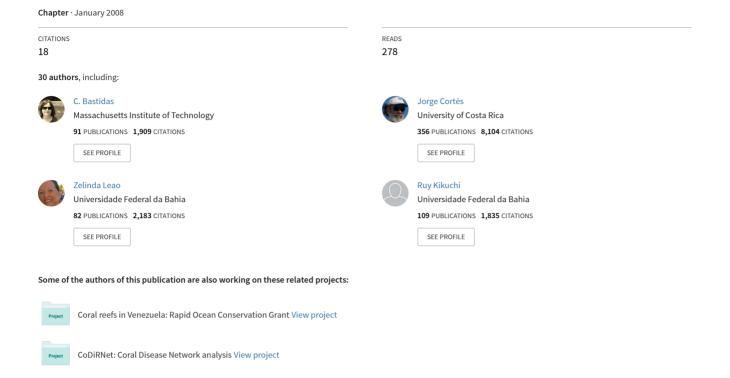 Status of coral reefs and associated ecosystems in Southern Tropical America: Brazil, Colombia, Costa Rica, Panamá and Venezuela.

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Project   CoDiRNet: Coral Disease Network analysis View project

20. Status of Coral Reefs and Associated Ecosystems in Southern Tropical America: Brazil, Colombia, Costa Rica, Panamá and Venezuela

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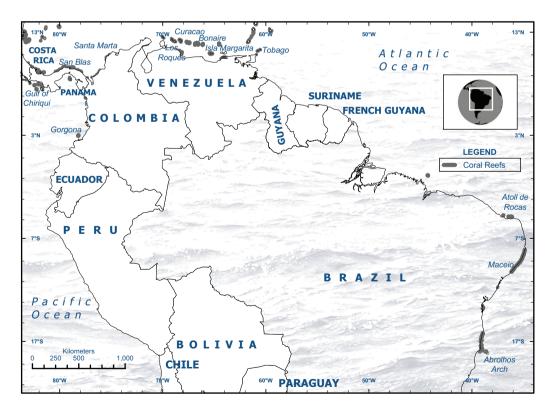
Summary

◗ Algae are the most abundant reef organisms in most of the countries; high coral cover occurs at numerous reef locations at the Caribbean (~70%) and Pacific (~95%) coasts;

◗ No major changes in live coral cover have been observed recently in the region; some localised decline and recovery trends are evident for each country;

◗ Coral reefs in the region experience many natural and human threats, and predictions suggest that nearly 50% of reefs are at very low risk of decline in 5-10 years, even considering global climate change, and around 40% of reefs could be under high risk of decline in the mid-long term (>10 years);

◗ Massive coral bleaching occurred in Southern Tropical America during 2005, but the severity varied across the region;

◗ Reef monitoring has increased, but there is low funding for monitoring programs in all countries; socioeconomic monitoring is restricted to Brazil;

◗ Information on reef fisheries from monitoring programs is scarce, however, the consensus is for depletion of coral reefs resources, particularly in the Caribbean;

◗ Seagrass and mangrove communities are mainly threatened by coastal development, sedimentation, pollution, and deforestation.

INTRODUCTION

The coastal environments in Southern Tropical America are characterized by strong land influences with numerous large rivers, including the Amazon, Orinoco and Magdalena, introducing large amounts of sediments that inhibit the development of extensive coral reefs. Rainfall is among the highest in the world, therefore water turbidity and sedimentation are high. Furthermore, there are several major upwellings (Perú, Gulf of Panamá, Gulf of Papagayo, eastern Colombian Caribbean, and eastern Venezuela) that also reduce reef growth. The best coral reefs are on the Caribbean coasts of Panamá and associated with islands off Colombia and Venezuela. Coral formations are comparatively smaller on the Pacific side, and occur principally along the Costa Rica-Panamá coast.

Brazil: Coral reefs occur along 2500 km of the coast on the mostly narrow East Brazil Shelf. This straight coastline is not affected by major rivers and coral reefs grow mostly parallel to the coast, including fringing as well as long bank reefs. The continental shelf widens in the south at Abrolhos Bank where there are the most southern reefs of the Atlantic. The Fernando de Noronha chain rises from the ocean floor to form the only atoll in the South Atlantic Ocean. Coral species diversity is low overall with only 18 species of hard corals, but 8 of these are endemic to Brazil. There are 6 major reef areas: North-eastern Brazil region with 1) Fernando de Noronha chain of oceanic banks, islands and Atol das Rocas, 2) Touros-Natal in the north-east with an extensive line of coastal knoll and patch reefs, and 3) Pirangi-Maceió in the north-east with more developed linear coastal reefs with more species; and Eastern Brazil with 4) Todos os Santos and Camamu Bays including the Tinharé and Boipeba islands, 5) Cabrália/

Porto-Seguro and 6) Itacolomis and Abrolhos. These last three have long fringing and bank reefs formed by mushroom-shaped pinnacles ('chapeirões') and have the highest coral species diversity.

Colombia: This is the only South American country with Caribbean (1700 km) and Pacific (1300 km) coastlines with coral reefs. There are about 2700 km² of coral reefs in the Caribbean, sparsely distributed among 26 discrete areas: 1) the mainland coast with fringing reefs on rocky shores (Santa Marta and Urabá areas); 2) continental shelf reefs around offshore islands (Rosario and San Bernardo archipelagos); and 3) the oceanic reef complexes of the San Andrés Archipelago in the Western Caribbean. These complexes have the best-developed coral formations and include atolls, bank, barrier, fringing and patch reefs, and contain more than 75% of Colombian coral reefs. Reefs on the Pacific coast are very poor, with Gorgona Island having the only large coral formations. There are a few reef patches in Ensenada de Utría and the oceanic Isla de Malpelo, 350 km off the coast, with coral growing to 35 m depth. Around 60 hard coral species are known from the Caribbean, and 18 from the Pacific.

Costa Rica: There are about 100 km² of coral reefs on the Caribbean and Pacific coasts. The 212 km long Caribbean coast consists mainly of high energy sandy beaches, with corals growing only in the southeast as fringing reefs growing on fossil carbonate outcrops: 1) Moín-Limón, which is being damaged by the largest port; 2) Cahuita National Park, which includes the largest and best studied fringing reef on the Caribbean coast; and 3) Puerto Viejo-Punta Mona, which has several reef formations. Pacific reefs are more abundant and distributed along the 1254 km coast, although they have low coral diversity and are relatively small in area covered. The principal Pacific reefs are near Santa Elena, Bahía Culebra, Parque Nacional Marino Ballena, Isla del Caño and Golfo Dulce, and also at the oceanic Isla del Coco 500 km offshore.

Panamá: The 2987 km coastline in the Caribbean and Pacific has approximately 290 km² of reefs, with 99% being in the Caribbean containing more than 70 hard coral species, whereas there are 25 species on the Pacific side. Caribbean coral reefs occur along almost all the coast in 3 major areas: 1) the western coast (Bocas del Toro-Rio Chagres), with the highest coral cover of the Caribbean side; 2) the central coast (Colón-Isla Grande), near the major industrial area and the most degraded Caribbean reefs (less than 4% coral cover); and 3) the eastern coast (San Blas or Kuna-Yala territory), with the most extensive and diverse reefs in Panamá. Most Pacific reefs occur on islands near the coast: 4) the Gulf of Chiriquí, the best fringing reefs in the eastern Pacific; and 4) the Gulf of Panamá, including reefs on Las Perlas archipelago, Taboga and Isla Iguana.

Venezuela: Reefs occur mainly in 3 Caribbean areas on the 2875 km Caribbean and Atlantic coastline: 1) the Morrocoy National Park and adjacent reefs (San Esteban, Turiamo and Ocumare de la Costa), with the best developed coral reefs on the coast (more than 30 coral species and reef growth to 20 m depth); 2) the Mochima National Park and adjacent reefs (Coche and Cubagua islands), with more than 20 coral species growing to 14 m; and 3) the oceanic islands, more than 100 km offshore, with the best reefs of Venezuela at Los Roques Archipelago (57 coral species, reef growth to more than 50 m), and also at Las Aves Archipelago, and Isla de Aves, Orchila and Blanquilla islands.

STATUS OF THE CORAL REEFS 2008

Monitoring data indicate that algae are the dominant organisms in most areas, nevertheless, high coral cover occurs on many reefs in the Caribbean and Pacific. Live coral cover on Caribbean-Atlantic reefs ranged 1–70% while algal cover ranged 4–80%. Pacific reefs had coral cover 0–95% and algal cover 13–86%. Despite trends of decline and recovery at the local scale for each country, reefs in this region have not undergone noticeable changes since 2004.

Region	Reef areas	Coral cover	Algal cover	Trend (s)
Atlantic North-eastern Brazil	3	1–29%	4–55%	LN, LD, LR
Atlantic Eastern Brazil	3	2–16%	7–62%	LN, LD
Caribbean Colombia	7	2–70%	23–80%	LN, LR, LD
Caribbean Costa Rica	3	8–26%	62–75%	LN, LR
Caribbean Panamá	11	15–29%	13–57%	GN, LD, LR
Caribbean Venezuela	2	3–51%	24–44%	GN, LR
Pacific Colombia	3	5–95%	13–60%	LD, LR
Pacific Costa Rica	4	0–37%	31–86%	LR, LD
Pacific Panamá	14	24–40%	37–57%	GN, LD, LR

This table summarises live coral cover and algal cover, and trends observed during 2003-2008 by monitoring programs of the STA-GCRMN Regional Node at all sites. GN=General No Change; GD=General Decline; GR=General Recovery; LN=Localised No change; LD= Localised Decline; LR=Localised Recovery.

Brazil: The medium-scale Brazilian national coral reef monitoring program using Reef Check compatible methodology monitored 8 localities between 2003–2008, 5 in Northeastern Brazil: Atol das Rocas, Fernando de Noronha island, Maracajaú, Tamandaré and Maragogi), and 3 in Eastern Brazil (Itaparica, Porto Seguro and Abrolhos). AGRRA detailed monitoring has been conducted at 5 Eastern Brazil reefs since 1999 (Todos os Santos Bay, Tinharé/Boipeba, Cabralia, Itacolomis and Abrolhos). In 2006, 28 new sites were added at Itacolomis and Abrolhos reefs using Marine Managed Areas Science protocols. Reef Check monitored sites show that nearshore, shallow reefs, less than 1 km from the coast, are in poor condition with less than 5% mean coral cover because of chronic land based stresses. Reefs further than 5 km from the coast, or deeper than 6 m, showed an increase in algal cover but also some local coral recovery, especially *Millepora* species. Increased protection has probably also contributed. Mild coral bleaching was observed in 2003 and 2005 along the 2000 km coast. All trophic levels of fish were significantly more abundant on fully protected, no fishing areas, than areas in general use or without enforcement.

Monitoring via the AGRRA methodology shows that reefs less than 5 km from the coast are in poor condition with a mean of less than 4% coral cover, and more than 40% cover of macroalgae (similar to cover in 2003). Reefs more than 5 km offshore and in Marine Protected Areas have more than 10% coral cover and less than 10% algal cover. Damage from sewage pollution, increased sedimentation and low water turbidity, as well as damage by tourists and over-exploitation can explain the condition. Coral cover has declined since 2003 at Itacolomis

and the Abrolhos area, from a maximum of 21% prior to 2003, to a maximum of 16% recently. The Abrolhos reefs are more remote from human pressures but have a higher incidence of coral diseases which have particularly affected the Brazilian-endemic coral, *Mussismilia braziliensis*.

Colombia: Pacific coral reefs are in better condition than those in the Caribbean, but there are wide variations in coral cover. Caribbean mean coral cover ranged from 5% (Banco de las Ánimas and Guajirata) to 40% (Urabá) and algal cover from 30.9% (Rosario Islands) to 51.2% (Santa Marta). In the Pacific coral cover average was 55% at Gorgona Island, and the highest algal cover was at 43% Malpelo Island. More data are in the Table below. The prevalence of coral diseases was low (<4.2%) in Caribbean reefs with White plague and Dark spots diseases predominating. There has been little recovery of reef organisms (long-spined sea urchin, *Diadema antillarum* and the Caribbean sea fan, *Gorgonia ventalina*) that suffered mass mortality several decades ago. Sea urchin density is higher in the Pacific, as high as 80 individuals per $20m^2$ on Gorgona Island. Coral cover in the Caribbean was essentially stable with only the Tayrona area showing a significant decrease. Some other reefs showed significant declines in coral species such as *Siderastrea siderea* and *Acropora palmata* on shallow reefs, and *Montastraea cavernosa* on deep reefs, but overall cover remained largely unchanged. In the Pacific Gorgona Island showed a significant decline in coral cover since 2004 but not at all depths. The major reductions in coral cover often coincided with extreme low tides exposing the corals. Some changes are evident at different depths of species, suggesting differential responses of corals to stresses. For instance, the 2005 bleaching event was the most severe for the Colombian Caribbean in the last 25 years, but the severity of bleaching varied between areas: Rosario and San Bernardo suffered severe bleaching; San Andrés and Providencia were moderately affected; and Santa Marta experienced minimal bleaching.

Costa Rica: Gandoca-Manzanillo National Wildlife Refuge on the Caribbean side now has high live coral cover, high densities of *Diadema antillarum* (> $0.6/m^2$) and low macro-algal cover. This indicates that corals have increased in abundance, possibly due to the recovery of sea urchins. In Cahuita National Park, at Meager Shoal, a 2% coral cover increase (from 15 to 17%) occurred between 2000 and 2004, with a decrease in coralline algal cover (17 to 5%). Coral colony diseases, injuries and bleaching have decreased from 24% in 2000 to 10% in 2004, but the park continues to be damaged by sediments with no significant recovery since the late 1970s. On the Pacific side, the invasive macro-alga, *Caulerpa sertularoides*, overgrows *Pollicopora* reefs killing the coral or reducing growth and resulting in flow-on disturbance effects. Algal densities were highest adjacent to areas with high concentrations of nutrients in the upwelling season, as well as near land runoff with heavy sedimentation. Recurrent red tides have killed more than 80% of the coral *Pavona clavus* at Viradores Reef with very low recent recovery. In Parque Nacional Marino Ballena small increases in coral cover from 5.9% to 7.8% were reported at Punta Uvita and at Las Tres Hermanas from 36.5% to 39.5% between 2003 and 2005, but decreases occurred in 2006 (4.9% and 34.3% respectively). Suspended sediments and nutrients are affecting the corals in the park, with sedimentation rates ranging from moderate (44 mg cm^{-2} day^{-1}) to heavy (117 mg cm^{-2} day^{-1}). These nutrients and sedimentation come from on-going land erosion enhanced by heavy rains. At Isla del Caño Biological Reserve coral cover in March 2007 was between 19.7 to 34.8% (mean 26.6±5.6 %), whereas at Isla del Coco, the coral cover was between 10% and 50% with most placed between 10 and 35%.

Panamá: Reefs along the Caribbean coast had mean coral cover of 20.1% (± 1.7 SE; n =11); lower than those on the Pacific coast, 35.1% (± 7.7; n = 14). Coral cover has changed little from 1999 to 2007 for both coasts. Similarly, coral cover for all Panamá sites was 30.6% (± 5.6); effectively stable over the last 9 years. Macroalgal (frondose and filamentous) cover increased significantly from 1999 to 2005 and declined in 2007 on Caribbean reefs (41.2% ± 5.5) while the cover on Pacific reefs declined from 57% (± 11.8) in 2003 to 52.8% (± 8.8) in 2007. Overall, there was no significant change from 2000 to 2008. Crustose coralline algae (CCA), a potential indicator of health, showed a slight but non-significant decrease in Caribbean reefs for the time period (1.9% ± 1.0 for 2007) while Pacific reefs showed a slight increase (6.8% ± 3.2) with no trend during the 9 years for Panamá (5.3% ± 2.3). Reefs with high cover of crustose coralline algae are a better habitat for new coral recruits and indicate a relative healthy environment. Reefs with high algal cover have been damaged by natural or human disturbances or may be under stress. This baseline dataset combines reefs under different initial conditions which allows assessment of long-term changes in response to natural or human disturbances. The initial idea was not to establish sites on the best reefs (pristine) but at different localities encompassing a gradient of degradation and habitats representative of the country.

Venezuela: The general condition of monitored reefs remained unchanged between 2003 and 2008, particularly coral and algal cover. However, coral diseases have increased drastically: in 2003 diseases were present at only 2 sites at 1.5% prevalence of infected colonies, currently diseases are present at all reef sites at 26% prevalence. The only example of localized recovery was Playa Caimán where there are no coral diseases and very low hard coral cover: cover of corals and sponges increased from 1.4 to 4.3% and 0.1 to 1.9% between 2003 and 2006. Caribbean Yellow band disease was the most prevalent coral disease (up to 22% on Cayo Norte) followed by infections by the ciliate, *Halofolliculina* sp. (up to 12%), and White syndrome (up to 5%). Most colonies affected by diseases (>95%) were the slow growing, massive reef framework building corals which may threaten the long-term recovery. Coral fish density (up to 135 individuals per 100 m²) were directly correlated with coral cover. However, on 2 reef sites with similar fish densities and high coral cover, the fish biomass on Los Roques was twice that on Morrocoy due to different species composition with large numbers of parrotfish and smaller predators influencing the biomass respectively. These are national parks and fishing is lower at Los Roques due to a small human population and stronger regulations. The 2005 bleaching only caused mild damage to these reefs compared with other Caribbean reefs, however, the potential impact of global climate change, diseases and over-fishing increase concern for the future. Oil exploitation offshore has added another potential threat for Venezuelan reefs.

CURRENT THREATS TO CORAL REEF BIODIVERSITY

Many natural and human threats occur throughout Southern Tropical America; the most significant threats are: over-fishing, sedimentation/siltation, tourism activities, deforestation and urban development. Among the most important 'natural' threats are algae proliferation, coral bleaching, global warming and ENSO events (although these are all linked to human activities). The high stress reefs are on the Caribbean coast of Panamá, and Pacific coast of Costa Rica. The least threatened reefs are in the Colombian Pacific. However, the future predictions for reefs in the region are relatively comforting: about 50% of reefs were considered as 'No Threatened Reefs' in the short term (5–10 years), while less than 35% were categorized as 'Critical Reefs'; and 40% of reefs could be threatened in the mid-term (>10 years).

Threats	AEB	ANB	CCO	CCR	CPA	CVE	PCO	PCR	PPA	Global score
A. 'Natural'										
1. Algal proliferation	5	5	3	5	4	4	1	5	3	35
2. Coral bleaching	2	1	5	3	3	4	4	5	5	32
3. Global warming	2	2	3	5	4	5	3	5	3	32
4. ENSO events	2	2	1	3	3	0	4	5	5	25
5. Phytoplankton blooms/red tides	2	2	1	0	3	3	1	5	5	22
6. Coral disease outbreaks	2	1	3	1	2	5	1	0	1	16
7. Low tide exposure	5	0	0	0	2	0	4	2	2	15
8. Earthquakes/landslides	0	0	0	5	2	0	2	3	2	14
9. *Diadema* mortality	0	0	3	5	4	1	0	0	0	13
10. Upwelling	0	0	1	0	2	2	2	2	4	13
11. Carbonate ion decrease to reduce calcification	2	?	?	0	2	1	?	4	1	10
12. Hurricanes/storms	0	1	4	0	1	0	0	0	0	6
13. *Acanthaster* proliferation	0	0	0	0	0	0	1	1	1	3
NATURAL IMPACT RATINGS	**22**	**14**	**24**	**27**	**32**	**25**	**23**	**37**	**32**	
B. Anthropogenic										
1. Over-fishing	4	4	5	5	5	4	2	5	4	38
2. Increased sedimentation/siltation	5	5	4	5	4	4	2	5	3	37
3. Tourism activities	4	3	4	5	5	4	2	5	5	37
4. Deforestation	5	5	3	5	4	4	2	5	3	36
5. Urban development	5	4	4	4	5	4	0	5	5	36
6. Fish extraction	3	4	5	3	4	3	2	5	4	33
7. Sewage pollution	4	4	4	4	4	2	0	5	3	30
8. Garbage pollution	4	5	3	3	4	2	1	3	5	30
9. Changes to river beds	1	4	3	3	4	4	1	4	2	26
10. Oil pollution	2	4	2	3	4	4	2	2	2	25
11. Dredging	2	2	2	4	3	3	0	4	3	23
12. Diving activities	2	2	2	3	3	1	2	4	3	22
13. Nautical activities	2	2	2	1	2	3	2	4	2	20
14. Coral extraction for curio trade	3	4	2	0	3	1	2	2	2	19
15. Heavy metal pollution	3	3	1	1	4	2	0	1	3	18
16. Industrial development	3	3	2	0	3	2	0	0	2	15
17. Dynamite fishing	2	4	4	0	0	0	0	0	2	12
18. Coral mining for construction	2	2	2	0	4	0	0	0	1	11
ANTHROPOGENIC IMPACT RATINGS	**56**	**64**	**54**	**49**	**65**	**47**	**20**	**59**	**54**	
TOTAL IMPACT RATINGS	**76**	**78**	**78**	**76**	**97**	**72**	**43**	**96**	**86**	

This lists the potential severity of natural and anthropogenic threats to coral reef biodiversity in Southern Tropical America within 2000–2008 was assembled by regional coral reef experts. A score of 5 indicates a very high risk of reef damage. AEB: Atlantic Eastern Brazil, ANB: Atlantic North-eastern Brazil, CCO: Caribbean Colombia, CCR: Caribbean Costa Rica, CPA: Caribbean Panamá, CVE: Caribbean Venezuela, PCO: Pacific Colombia, PCR: Pacific Costa Rica, PPA: Pacific Panamá. National experts rated threats to coral reef degradation as: 0=no threat; 1=low threat; 2=localised low threat; 3=average threat; 4=localised major threat; 5=general major threat.

Region	No Threatened Reefs (%)		Critical Reefs (%)		Threatened Reefs (%)	
	GC + HP	HP	GC + HP	HP	GC + HP	HP
Atlantic Northeastern Brazil	30	30	25	20	30	60
Atlantic Eastern Brazil	40	30	10	8	50	40
Caribbean Colombia	50	40	25	20	60	30
Caribbean Costa Rica	40	5	60	50	30	20
Caribbean Panamá	45	20	30	60	25	20
Caribbean Venezuela	50	40	30	20	60	30
Pacific Colombia	70	95	10	5	30	15
Pacific Costa Rica	30	20	70	60	40	30
Pacific Panamá	55	60	25	25	20	15

Regional experts assembled these predictions for coral reefs within Southern Tropical America Node under two scenarios: GC+HP = global change + human pressures; HP = only human pressures. These predictions are a cause for optimism about the future of these reefs. No Threatened Reefs: proportion of reefs at very low risk of decline in the short term (5–10 years). Critical Reefs= proportion of reefs under high risk of decline in the short term. Threatened Reefs= proportion of potential reefs under high risk of decline in the mid-long term (>10 years).

THE BRAZILIAN NATIONAL CORAL REEF MONITORING PROGRAM

The Brazilian National Coral Reef Monitoring Program started in 2002, and includes all major reef areas in Brazil. Surveys were conducted in 90 sites inside 12 reefs. Monitoring is conducted in 8 localities in those areas, including reefs inside protected areas with full protection (4) and sustainable use (4). Trained scientists and university students, as well as park managers, NGO personnel and dive volunteers were part of the teams. Data gathering is more detailed, but still compatible with the Reef Check protocols. New indicators were added to the standard Reef Check categories and fish, invertebrates and corals were recorded to the species level. These detailed data included results on coral and fish diversity, latitudinal differences in species abundances and detecting effects of different management strategies along 2000 km of the coast. The program is funded by the Ministry of Environment and Instituto Recifes Costeiros and coordinated by the Federal University of Pernambuco. Institutions supporting the monitoring/survey efforts: Atol das Rocas-ICMBIO; Noronha-ICMBIO and Atlantis Divers; Maracajau-IDEMA, UFRN and Maracajau Divers; Tamandaré and Maragogi- CEPENE/ICMBIO and Recifes Costeiros Project; Itaparica-PROMAR; Porto Seguro-Coral Vivo Project; Abrolhos-ICMBIO and Aratur Divers. Efforts were aligned with the Campaign for Conscious Conduct at Reef Environments of the Ministry of Environment (from Ana Lidia Bertoldi Gaspar, reefcheckbrasil@yahoo.com.br, Project Manager, Instituto Recifes Costeiros).

CURRENT MONITORING CAPACITY

Reef monitoring has been conducted in the region for more than 20 years and new programs have recently been established (SeaScape and MMAS). However the expansion of monitoring and the number of reefs monitored has been very slow since 2000. All countries in the region have strong professional capacity and generally good logistics for monitoring, but the principal restriction is a lack of consistent funding. Although ecological monitoring information is gathered by all countries, socioeconomic monitoring only occurs in Brazil.

Country Attributes	Costa Rica	Panamá	Colombia	Venezuela	Eastern Brazil	North-East Brazil
Marine research institutions	2	1	7	6	15	
Active coral reef researchers	8	6	28	6	30	
Reef monitoring programs	CARICOMP, CIMAR, Reef Check, Eastern Pacific SeaScape	CARICOMP, PCRMN, Eastern Pacific SeaScape	CARICOMP, SIMAC, Eastern Pacific SeaScape	CARICOMP, STA-GCRMN	AGRRA, Reef Check, MMAS	
Monitored reef localities	6	33	9	2	5	8
Reef monitoring stations	13	33	36	5	58	48
Years of reef monitoring	15	22	16	15	9	5
Monitored parameters	16	8	15	13	14	38 + 13 (biophysical / socioeconomic)
2003–2008 reef monitoring investment (US$)	90 000	182 000	180 000	25 000	50 000	155 184
Funding capacity for monitoring	Low	Low	Low	Low	Low	Low
Professional capacity for monitoring	High	High	High	High	High	High
Logistic capacity for monitoring	Medium	High	High	Medium	High	Medium
Socioeconomic monitoring	None	None	Scarce	None	Medium	Medium

This table shows the current reef monitoring capacity and activity in the countries of Southern Tropical America.

STATUS OF MANGROVES, SEAGRASSES AND FISHERIES: 2008

Brazil: Mangrove forests occur along the coast of Brazil in the lower segments of rivers; the north coast has more than 50% of all mangrove areas, especially in the states of Pará and Maranhão. The Pará mangroves are in the transition zone of the Amazon River and are well developed and very tall, reaching 45 m. Maranhão mangroves occupy both sides of São

Marcos Bay and are the most extensive and structurally complex in Brazil. These forests are largely intact because of low population density and poor accessibility. The north-eastern and eastern coast mangroves occur near dense populations (São Francisco River, Todos os Santos and Camamu Bays and Caravelas strandplain). *Rhizophora mangle* dominates but *Avicennia* and *Laguncularia racemosa* are common. Seagrasses occur in coastal areas with *Halodule wrightii* dominant. Seagrass beds are important nursery areas for reef fishes but are under threat, including sedimentation. Mangroves in Brazil come under the Ramsar convention, but are still heavily threatened by over-exploitation for timber, firewood and charcoal, and bark for tannin used to dye ship sails. They are also threatened by urban expansion, discharge of untreated sewage, industrial pollution and agricultural pesticides. Large areas were converted to rice cultivation or aquaculture, especially shrimp farming, leading to increased sediment flows to the adjacent coral reefs. In April 2008, the Minister of Environment signed an act banning the development of shrimp farms in all federal protected areas, which should improve protection for those ecosystems. Brazil has approved a GEF project 'Effective Conservation and Sustainable Use of Mangrove Ecosystems in Brazil', in association with NGOs to implement mangrove protected areas to safeguard fisheries resources. Over-fishing is threatening coral reefs and associated ecosystems, especially on the densely populated north-eastern coast where many small and medium scale fisheries operate on coral reefs. Indicator fish populations correlate directly with the level of fishing pressure, with fishing now moving down the food chain from the large predators (groupers, snappers and sharks) to trap fishing for national and international markets. The traps take herbivorous fishes (parrotfish and surgeonfish) and virtually all other reef fish groups as bycatch. Few attempts have been made to manage coral reef fisheries resources in Brazil, other than establishing protected areas.

Colombia: Colombia is tenth in the world for mangrove resources, with around 319 714 ha (Pacific coast has 233 404 ha or 73%; Atlantic coast has 86 310 ha), or almost 1% of the forest surface area of Colombia. There are 10 species in Colombia (*Rhizophora mangle*, *R. harrisonii*, *R. racemosa*, *R samoensis. Laguncularia racemosa*, *Conocarpus erectus*, *Avicennia germinans*, *A. tonduzii*, *Pelliciera rhizophorae*, *Mora oleifera*) growing on the Pacific coast but only 6 are found on the Caribbean coast (*R. mangle*, *R. harrisonii*, *L. racemosa*, *C. erectus*, *A. germinans*, *P. rhizophorae*). In dry very saline regions the black mangrove (*Avicennia germinans*) is dominant on the Caribbean coast (Alta Guajira), whereas the red mangrove (*Rhizophora* sp.) prevails in more continental waters. *Rhizophora* spp. dominate on the Pacific Coast. Colombia has 6 seagrass species, *Thalassia testudinum*, *Halodule wrightii*, *Syringodium filiforme*, *Halophila decipiens*, *H. baillonis* and *Ruppia maritima*, with a total cover in the Colombian Caribbean of more than 43 223 ha (or 0.12 % of the Colombian shelf). Only 2150 ha (5 %) are around the oceanic Archipelago of San Andrés and Providencia, 700 km off the Colombian coast; the remaining area is in nearshore waters and around nearby offshore islands. The Guajira Peninsula has more than 82% of the seagrasses. Seagrass distribution is not continuous along the continental coast, probably because of low salinity, high turbidity, high wave energy in shallow waters and different human uses of the coasts. The seagrass and mangrove communities are mainly threatened by human activities: habitat degradation, especially from boats, coastal development, illegal extraction, declining water quality, sedimentation, high salinity and deforestation (for mangroves). The slime fungus disease *Labyrinthula* sp. has been identified on *Thalassia* leaves in the Tayrona National Natural Park. Commercial species such as snappers, groupers and lobsters are scarce in the Caribbean, whereas fish densities are higher (10–21/60m^2) for groupers and snappers on Pacific reefs (especially Malpelo Island).

Costa Rica: The Caribbean coast has extensive seagrass beds but only 2 small mangrove forests. The main seagrass species are *Thalassia testudinum* and *Syringodium filiforme* while the main mangrove is *Rhizophora mangle*. The seagrass bed at Parque Nacional Cahuita and the mangrove forest at the Refugio Nacional de Vida Silvestre Gandoca-Manzanillo are being monitored via CARICOMP. Both are within protected areas thus the main threats are external: high sediment loads, pollution, and climate change. There are few small seagrass patches, mainly *Ruppia maritima*, on the Pacific, but extensive mangrove forests consisting mainly of *Rhizophora mangle* and *Avicennia* spp. The largest seagrass patches in Bahía Culebra were obliterated by a strong storm in the mid 1990s. The existing patches are threatened by habitat alteration. Mangrove forests are threatened by habitat degradation, illegal cutting, pollution, excessive sedimentation, reduction of water supply, and human encroachment. Similar to other parts of the world, fish stocks in Costa Rica are over-exploited. There are efforts in some Marine Protected Areas to stop fishing, legal (i.e. artisanal) and illegal, and there are some private initiatives to develop responsible fishing practices; but there are few government efforts. A major problem is that the governing board of the National Institute of Fisheries and Aquaculture is controlled by fishers. Until that changes, there is little chance of implementing sustainable uses of marine resources.

Venezuela: Mangroves are well distributed on the Venezuelan coast, except on the central coast, occupying 250 000 ha, especially in the deltas of the large rivers (San Juan, Neverí, Unare, Tuy, Aroa, Yaracuy, Tocuyo and Catatumbo) but most of the mangroves (73%) are in the Orinoco. Mangroves also occur around the large islands of Margarita and the archipelagos. Although protected by law, the 6 species reported are being affected by coastal development (logging and habitat destruction). Seagrass beds are less extensive than mangroves but still very ubiquitous, with the main beds where reefs and mangroves also occur. Most marine species are over-exploited, especially lobsters, groupers and queen conchs. For example, conch extraction was totally banned in 1991 but populations have not recovered, probably because of furtive harvesting. Lobster fishing is also banned from May to October, but sizes and the effort required suggest over-exploitation. Various edible gastropods have been replaced as each species becomes scarce in localities such as Morrocoy. The main problem for conservation of mangroves and seagrasses seems to be insufficient enforcement of regulations and over-exploitation of target species.

CONCLUSIONS:

It is difficult to generalise on the status of coral reefs in the STA region because the cover of algae and corals varies considerably at different spatial scales. Algae were the most abundant organisms for most areas, however, high coral cover can be found at numerous reef locations at the Caribbean (up to 70% cover) and Pacific (up to 95% cover). Despite trends in decline and recovery at local scales in each country, the reefs have been suffering from the same recent threats: mass coral bleaching, over-fishing, sedimentation/siltation, tourism activities, deforestation and urban development. Fortunately, the reefs have not undergone noticeable recent changes. Although reef monitoring has been conducted for more than 20 years, the number of sites is still very low and funding limitations mean that maintaining current programs is difficult. While traditional reef monitoring programs have focused on the structural components, other functional aspects such as the resistance and resilience should be included, especially with increasing climate change. Furthermore, socioeconomic monitoring should

be implemented to assess how human activities are affecting modern reefs. Thus integrated monitoring will assist in finding answers to mitigate reef decline, enhance coral recovery and improve the quality of life for local people. Since seagrasses and mangroves are also threatened by similar factors, similar protection and management strategies should be applied.

RECOMMENDATIONS:

Brazil: Many coral reef protection, management and recovery initiatives have been developed in Brazil, however, much effort is still needed for effective conservation of Brazilian reefs. Few actions have been implemented to manage reef fisheries in Brazil, other than establishing protected areas; only a small area is fully protected and there is inadequate enforcement. Sedimentation and pollution are chronic problems; and a combination of actions of protecting and rehabilitating riparian vegetation, conserving coastal areas, and implementing best practices for land use are necessary. As overseas and national tourism is growing rapidly, it is hoped that conservation will be become a major attraction.

Colombia: It is important that Colombia continues to develop long term monitoring after 10 years of SIMAC, because this is the most useful tool to detect temporal trends in coral reefs. Only a third of Colombian reefs are being monitored, therefore new areas need to be included to obtain a more complete picture of reef status. In addition, effective conservation and protection measures in the Colombian reefs are required to complement the monitoring. For instance, specific government policies and laws for coral reef sustainable management need to be developed in the next few years, as well as protecting natural parks and reserves through implementing effective management plans and law enforcement.

Costa Rica: Monitoring should continue at existing sites and new coral reefs should be included if more funds are available. Some monitoring should be carried out by park rangers (most reefs in Costa Rica are within Protected Areas). Unfortunately, monitoring is not in their job description and has become sporadic and voluntary. At least two people should be hired to dedicate time to monitoring in Protected Areas.

Panamá: Coral reefs in Panamá showed no major changes in coral cover when averaged, but there are some exceptions: some reefs showed significant decreases or increases in cover and these warrant further analysis to support management actions. The monitoring program should continue yearly and include new assessments such as fish diversity and biomass. Panamá has baseline data for almost all reefs in the Caribbean and Pacific for resource managers. However, coastal development is almost unstoppable, and is occurring at an accelerating rate along the entire coast. Marine reserves have been expanded recently but nearby developments may affect those areas.

Venezuela: The coral reefs require strengthened law enforcement for their protection as most large formations are already in protected areas. Thus, stronger involvement of authorities and education are probably the major needs and challenges for reef conservation. Isolated efforts of installing mooring buoys to avoid damage by boat anchoring have not been successful due to a lack of maintenance. Also, management decisions should be informed by the results from the monitoring of reef conditions.

DECLINE OF CALCIFICATION RATES OF THE ENDEMIC CORAL *MUSSISMILIA BRAZILIENSIS*: THERMAL STRESS ALERTS IN BRAZIL

Stresses to corals can often be detected in the calcareous skeletons of massive corals. Cores were taken from colonies of *Mussismilia braziliensis*, the major reef-builder in the Abrolhos region. Coral growth as linear extension, density bands and calcification rate were evaluated using computerized tomography techniques. The mean annual linear extension was 0.8 ± 0.05 cm per year; the calcification rate between 1924 and 2003 was 1.37 ± 0.23 g.cm^{-2}.y^{-1} and between 1979 and 2003 it was 1.24 ± 0.17 g.cm^{-2}.y^{-1}. Annual climate anomalies over 30 years show that the calcification rate was directly controlled by water temperatures and indicate a strong influence of El Niño events in the Abrolhos reefs. This 10% reduction in coral calcification in the last 25 years indicates that global climate changes are occurring in the South Atlantic Ocean and reducing the amount of calcium carbonate precipitated on the Abrolhos reefs (from Marilia Oliveira, mariliad@ufba.br, Federal University of Bahia, with funding support from CNPq, FAPESB, Conservation International-Brazil).

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coastal engineering, although some offshore reefs have good coral cover;