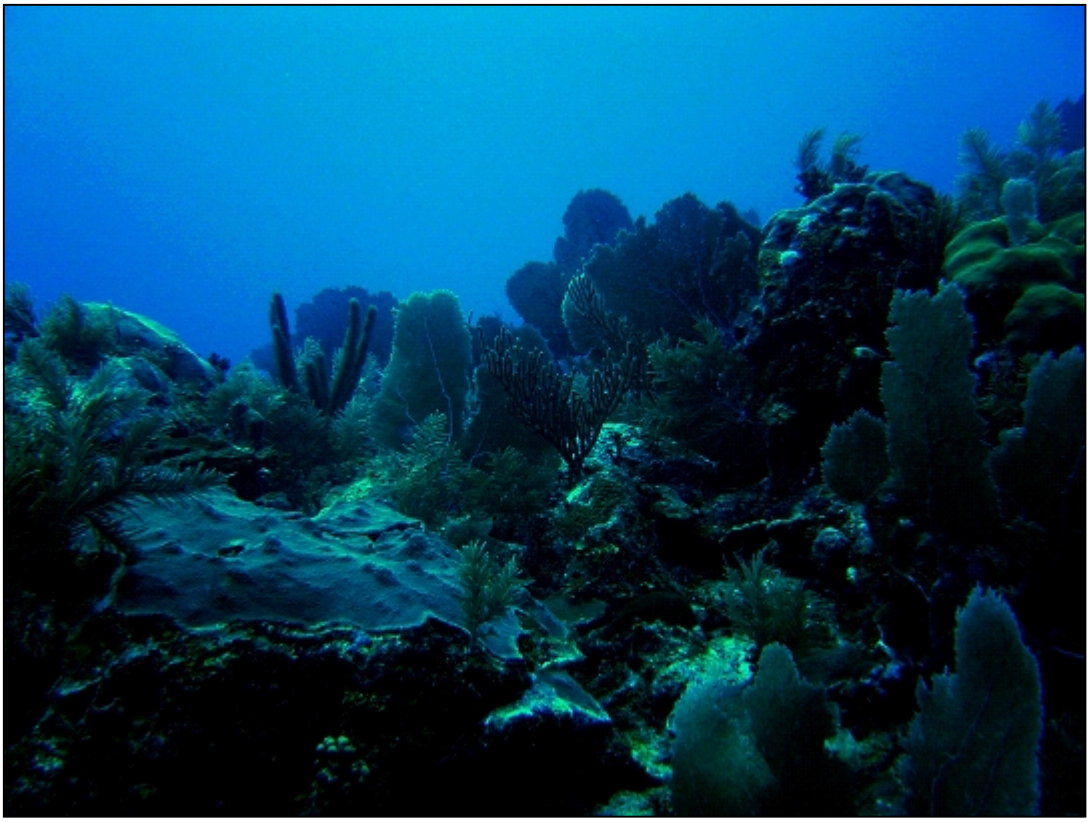
SIAN KA'AN CORAL REEF CONSERVATION PROJECT MEXICO 2003 – SUMMARY REPORT



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September 2004

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This report is available in both Spanish and English translations

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Acknowledgments

Coral Cay Conservation's work in Sian Ka'an would not have been possible without the support of many individuals and organisations, particularly: The people of Punta Allen, Pescdores de Vigia Chico, Vigia Grande, Las Boyas, The Staff of the UNESCO Sian Ka'an Biosphere Reserve, The British Embassy Mexico City, Luis Rendon, Helen Pippard, The logistics staff and volunteers all of whom made the project possible: Duncan Ayling, Jared Thorpe, Leonie Banks, Mark Glendinning, Peter Andrew, Jonathan Lees, Laura Deegan, Mike Lanning, Richard Surma, Gordon Smith, Annabel Gardner, Tomas Crossland, Bonnie Knox, Anna Burt.

1. Introduction

This report provides results and a summary of work undertaken by Coral Cay Conservation (CCC) in collaboration with *La Comisión Nacional de Áreas Naturales Protegidas* the collaboration was termed; The Sian Ka'an Coral Reef Conservation Project (SKCRCP). The summary report has been prepared for the people of Punta Allen, Pescdores de Vigia Chico, Vigia Grande, Las Boyas, and the other tourism cooperatives within Punta Allen. A full report (Walker et al, 2004) can be obtained form CCC.

Founded in 1986, Coral Cay Conservation is dedicated to '*providing resources to protect livelihoods and alleviate poverty through the protection, restoration and sustainable use of coral reefs and tropical forests*' in collaboration with government and non-governmental organisations (NGOs) within a host country. CCC does not charge the host country for the services it provides and is primarily self-financed through a pioneering volunteer participatory scheme whereby international volunteers are given the opportunity to join a phase of each project in return for a financial contribution towards the project costs.

The coral reefs and coastal marine habitats of the Sian Ka'an United Nations Educational, Scientific and Cultural Organisation (UNESCO) Biosphere Reserve are of vital national and international importance, both ecologically and economically.

The three-month SKCRCP had four aims:

1. To apply the recently developed regional Mesoamerican Barrier Reef System Synoptic Monitoring Program (MBRS SMP) for selected sites within the Ascension Bay area of the UNESCO SKBR. This will provide regional decision makers with up to date information on the biological condition of the local reefs.

2. To collect data on the status of coral mortality and diseases to submit to the World Conservation Monitoring Centre (WCMC) - United Nations Environment Program (UNEP) Western Atlantic Coral Disease Database. Also to the interactive database- www.reefbase.org.

3. To use the collected data to develop a simple local environmental management plan for Pescdores de Vigia Chico's snorkelling eco-tourism.

4. To provide conservation and environmental education opportunities for the local community, particularly within the four schools of Punta Allen.

Coral Cay Conservation achieved this by surveying each patch reef using methods developed by the Mesoamerican Barrier Reef System Synoptic Monitoring Program, but introducing an advanced species list for live substrate and invertebrates to allow for more powerful statistical analysis.

1.1 Project Background

Reefs on the Pacific and Atlantic coasts of Mexico are under pressure from tourism activities including boat groundings, alteration to the coastal fringe, potential loss of mangrove and the resulting loss of protection from storms. Mexico's main coral reef areas include the Pacific coast, Baja California and offshore islands, the underdeveloped reefs of the Revillagigedo Islands (restricted due there cool water temperatures) and the extensive fringing reef off the Yucatan peninsular. These Yucatan reefs include off shore islands and the Banco Chinchorro atoll, continuing south as part of the MBRS. Expanding tourism in Quintana Roo is a major threat and as an effect reefs in the north of Yucatan are generally supporting low coral cover (17%) with coral diseases continuing to be present in the area. Recent coral bleaching events and storm damage have also further reduced reef health. These impacts represent extensive long and short-term threats to the ecological balance and health of reef ecosystems. If left unchecked they will ultimately lead to reduced income for coastal communities and other stakeholders relying on fishing and marine-based tourism. Furthermore, any natural or human impacts on reef health will inevitably affect other countries in Mesoamerica, and *vice versa*, since the marine resources are linked through currents and the functioning of the system transcends geo-political boundaries.

Activities of late have greatly enhanced the existing knowledge of reefs, and Mexican reefs have received considerable attention from government and NGOs conducting coral reef research and monitoring in the country. During 2001, the *Mesoamerican Caribbean Reef Eco-region Expedition* was organised by The World Wide Fund for Nature (WWF) along with researchers from Amigos de Sian Ka'an and SEMARNAP (Mexico), Coastal Zone Management Institute and Belize Audubon Society (Belize), Honduras Coral Reef Fund and DIGEPESCA (Honduras). The overall aim was to assess the reefs from Mexico to Honduras (Table 1). This expedition was the first time regional scientists had collaborated on coral reef surveys of the entire Mesoamerican Reef System from Mexico to Honduras.

Table 1. Summary of the 2001 *Mesoamerican Caribbean Reef Eco-region Expedition* averaging coral data from 36 sites in 4 regions (developed from Amada-Villela, et al. 2002).

Sub-Region	Coral Species	% Coral Cover	% Juveniles per m^2	% Coral Disease	% Recent mortality
North Quintana Roo	24.5	24.5	12.2	3.0	2.7
Sian Ka'an/Ambergris	26.4	20.3	7.0	3.7	1.1
Belize	26.5	12.9	7.6	2.3	1.9
North Honduras	27.6	10.1	6.9	4.4	1.8
Overall	26.7	15.2	7.5	3.4	1.6

1.2 Sian Ka'an UNESCO Biosphere Reserve

The Sian Ka'an UNESCO Biosphere Reserve located between $19^0$05'20-$20^0$06'N and $87^0$30'-$87^0$58'W, off the east coast of the Yucatan Peninsula, Quintana Roo (Figure 1) was declared a Biosphere Reserve in 1986 and inscribed as a World Heritage Site in 1987 (Salvat, et al. 2002). The reserve covers approximately 6,808 km^2 and is Mexico's third largest protected area.

Sian Ka'an is described as the largest effective nature reserve in Mexico and protects one of the most unspoiled expanses of wetland in Mesoamerica (Salvat, et al. 2002). Sian Ka'an lies on a partially emerged coastal limestone plane which forms part of the extensive barrier reef system. Approximately 1,000 people live in the reserve, in either small family ranches along the coast or in the reserve's two fishing settlements, Javier Rojo Gómez (Punta Allen) and Punta Herrero. At present the main economic activities are fishing of lobster and finfish, small-scale agriculture and ranching.

Figure 1. UNESCO- SKBR – reefs illustrated in orange

Use of the coastal zone for tourism practices is the main motivating factor for long-term conservation plans for the reserve. Major threats to the area include:

- Uncontrolled growth of tourism development

- Inadequate waste disposal
- Oceanic waste and ship dumping
- Use of unconventional fishing gear with associated negative impacts
- Over-fishing of commercial marine species
- Illegal hunting
- Forest fires
- Soil erosion

2. Results

A total of 167 transects covering 10,020 m^2 were undertaken by the SKCRCP between September and December 2003, using the MBRS SMP methods (see Walker et al, 2004 for a decription of full methods). This comprised of six point intercept transects and eight belt transects at each of the 12 sites within Ascension Bay. A total of 14,294 individual species, substrate or coral mortality records were recorded. All maps reproduced in this report have been sourced from Reef base (http://reefbase.org) and enhanced using MapInfo or ERDAS imagine.

2.2 Habitat descriptions and distribution

A total of six statistically discreet habitat groups were defined from the data set collected during the SKCRCP across the 12 sites, using PRIMER. Table 2 describes the distribution of habitats across the 12 survey sites.

Table 2. Percentage cover of the six benthic classes across each of the 12 sites surveyed during the SKCRCP

Site	% cover	Habitat label
1. Sol	20	2. Shallow lagoonal environment with exposed substrate / sparse *Halimeda* and *Dictyota*
	20	4. Shallow sandy *Halimeda* and *Dictyota* dominated substrate with sparse gorgonians and sponges.
	60	5. Shallow dominated with algae
2.Chenchomac	17	1. Moderate depth bedrock with sparse gorgonians and hard corals
	17	4. Shallow sandy *Halimeda* and *Dictyota* dominated substrate with sparse gorgonians and sponges.
	66	6. Deep mixed reef dominated by *Montastraea* and *Porites astreoides* with sponge coverage
3.Chenchomac 2	13	1 Moderate depth bedrock with sparse gorgonians and hard corals
	37	5. Shallow dominated with algae
	50	6. Deep mixed reef dominated by *Montastraea* and *Porites astreoides* with sponge coverage
4. La Colonia	17	3. Shallow sandy lagoonal environment with sparse mixed gorgonians and *Montastraea*
	83	6. Deep mixed reef dominated by *Montastraea* and *Porites astreoides* with sponge coverage
5. Punta Allen	8	1. Moderate depth bedrock with sparse gorgonians and hard corals
	25	2. Shallow lagoonal environment with exposed substrate / sparse *Halimeda* and *Dictyota*

	25	3. Shallow sandy lagoonal environment with sparse mixed gorgonians and *Montastraea*
	33	4. Shallow sandy *Halimeda* and *Dictyota* dominated substrate with sparse gorgonians and sponges.
	8	6. Deep mixed reef dominated by *Montastraea* and *Porites astreoides* with sponge coverage
6. Mike's Reef	12.5	2. Shallow lagoonal environment with exposed substrate / sparse *Halimeda* and *Dictyota*
	50	3. Shallow sandy lagoonal environment with sparse mixed gorgonians and *Montastraea*
	25	4. Shallow sandy *Halimeda* and *Dictyota* dominated substrate with sparse gorgonians and sponges
	12.5	5. Shallow dominated with algae
7. Dani's Buoy	50	2. Shallow lagoonal environment with exposed substrate / sparse *Halimeda* and *Dictyota*
	25	4. Shallow sandy *Halimeda* and *Dictyota* dominated substrate with sparse gorgonians and sponges.
	25	5. Shallow dominated with algae
8. Niccehabin	100	3. Shallow sandy lagoonal environment with sparse mixed gorgonians and *Montastraea*
9. El Faro	20	2. Shallow lagoonal environment with exposed substrate / sparse *Halimeda* and *Dictyota*
	80	3. Shallow sandy lagoonal environment with sparse mixed gorgonians and *Montastraea*
10. El Barco	20	1. Moderate depth bedrock with sparse gorgonians and hard corals
	10	2. Shallow lagoonal environment with exposed substrate / sparse *Halimeda* and *Dictyota*
	60	3. Shallow sandy lagoonal environment with sparse mixed gorgonians and *Montastraea*
	10	4 Shallow sandy *Halimeda* and *Dictyota* dominated substrate with sparse gorgonians and sponges.
11. Mike's reef 2	25	1. Moderate depth bedrock with sparse gorgonians and hard corals
	75	4. Shallow sandy *Halimeda* and *Dictyota* dominated substrate with sparse gorgonians and sponges.
12.Dani's Buoy 2	60	1. Moderate depth bedrock with sparse gorgonians and hard corals
	40	4. Shallow sandy *Halimeda* and *Dictyota* dominated substrate with sparse gorgonians and sponges.

2.3 Coral disease, bleaching and mortality

Across the 12 sites a total of seven species of hard coral were affected by seven diseases, a further seven were affected by coral bleaching, and one species, *Diporoa strigosa*, was recorded to have been predated by parrot fish.

Table 3. Species of hard coral affected by disease, bleaching or parrotfish predation a cross the 12 sites surveyed by the SKCRCP.

	Black band disease			*Bleaching*									*Yellow band disease*	*Yellow Bloch disease*	*Parrotfish predation*		*Red band disease II*	*White band dieses*	*Dark spot disease*	*Patchy necrosis/white pox*
	Montastraea annularis	*Porites astreoides*	*Solenastrea bournoni*	*Agaricia agaricites*	*Diploria labyrinthiformis*	*Madracis mirabilis*	*Millepora alcicornis*	*Montastraea annularis*	*Porites astreoides*	*Porites furcata*	*Siderastrea radians*	*Solenastrea bournoni*	*Montastraea annularis*	*Siderastrea radians*	*Diporia strigosa*	*Porites astreoides*	*Montastraea annularis*	*Acropora prolifera*	*Solenastrea bournoni*	*Acropora palmarta*
1. Sol		●	●																	●
2. Chenchomac				●				●	●		●									
3. Chenchomac 2					●	●	●													
4. La Coloni			●	●				●	●											
5. Punta Allen												●	●						●	
6. Mike's Reef	●			●				●		●		●	●						●	
7. Dani's Buoy 2										●					●	●	●	●		
8. Niccehabin	●							●				●	●							
9. El Faro								●												
10. El Barco								●				●	●							
11. Dani's Buoy 2				●					●			●		●						
12. Mikes Reef 2												●								

2.4 Fish Populations

Of the 66 species listed as target species for the SKCRCP survey programme 48 were recorded across the 12 sites during survey dives. Surveys failed to record queen angelfish (*Holacanthus ciliaris*), four species of Scaridae, five Serranidae and five Balistoidae and Monacanthidae. Encouragingly, all five species of butterflyfish (Cheatodontidae) were recorded at Dani's Buoy 2. Despite the absence of banded (*Cheatodon striatus*) and longsnout butterflyfish (*C. aculeatus*), Chenchomac recorded an abundance of 9.3 individual butterflyfish per $100m^2$ (Table 5). Consistently common species recorded across the 12 sites include blue tang (*Acanthurus coeruleus*), yellowtail snapper (*Ocyurus chrysurus*) and bar jack (*Caranx ruber*), as one would expect on most Caribbean reefs. Surveys at Sol recorded individual abundance of 572.9 Acanthuridae per $100m^2$. Fish

abundance at this site was generally high, with 222.9 Lutjanidae and 193.8 Haemulidae abundance per 100m^2 (Table 5).

Table 4. Abundance per 100m^2 of each target species of fish recorded across the 12 sites during the SKCRCP. Totals marked bold indicate total mean abundances greater than the regional mean abundance for Atlantic and Caribbean reefs according to Hodgson and Liebeler (2002).

Species	2. Chenchomac	4. La Colonia	3. Chenchomac 2	5. Punta Allen	6. Mike's Reef	7. Dani's Reef	8. Niccehabin	1. Sol	11. Dani's Reef 2	9. El Faro	10. El Barco	12. Mikes Reef 2
Cheatodontidae												
Reef Butterflyfish	0.5	0.4	0.0	0.1	0.5	0.5	0.4	0.0	1.1	0.0	1.0	0.0
Longsnout Butterflyfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
Foureye Butterflyfish	6.7	3.0	0.0	4.2	5.2	1.7	1.1	0.0	2.4	1.9	0.5	1.7
Banded Butterflyfish	0.0	0.0	0.0	0.5	0.0	0.9	0.2	0.0	0.9	0.0	0.2	1.2
Spotfin Butterflyfish	2.1	0.2	0.0	0.4	0.7	0.3	0.4	0.0	0.2	2.9	0.7	0.2
Total	**9.3**	**3.5**	0.0	**5.3**	**6.4**	**3.3**	2.0	0.0	**4.8**	**4.8**	2.4	**3.1**
Scaridae												
Stoplight Parrotfish	2.6	0.7	0.0	1.8	1.7	0.2	1.9	12.5	1.5	4.3	1.4	1.4
Redband Parrotfish	0.7	2.0	0.0	1.0	1.2	0.0	0.4	0.0	1.3	1.0	0.7	1.7
Redtail Parrotfish	0.5	0.2	0.0	0.3	0.7	0.2	0.7	2.1	0.7	0.2	0.7	0.7
Princess Parrotfish	1.0	1.5	0.0	0.6	1.9	0.0	0.7	4.2	2.8	1.4	0.0	1.2
Striped Parrotfish	0.5	0.6	0.0	0.4	0.0	0.6	1.3	2.1	2.6	4.3	0.5	1.7
Blue Parrotfish	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2
Total	**5.2**	5.0	0.0	4.1	5.5	0.9	5.0	**20.8**	**8.9**	**11.4**	3.3	6.9
Lutjanidae												
Cubera Snapper	0.0	0.0	0.3	0.0	0.0	0.0	0.0	20.8	0.0	0.0	0.0	0.2
Mahogany Snapper	0.2	0.0	0.3	0.6	0.7	0.0	0.4	6.3	0.6	1.0	0.0	0.7
Mutton Snapper	0.0	0.0	0.3	0.8	1.2	0.0	0.2	2.1	0.6	0.0	0.0	0.0
Dog Snapper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.2	0.0	0.0	0.0
Lane Snapper	0.0	0.0	0.0	0.0	0.0	0.2	0.0	14.6	0.6	0.2	0.0	0.0
Red Snapper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.2	0.0	0.0
Grey Snapper	0.0	0.0	0.3	1.7	0.0	0.0	0.9	2.1	0.2	0.5	0.0	0.0
Schoolmaster	1.2	0.2	17.0	20.8	1.4	8.2	1.1	97.9	0.4	0.5	0.0	0.7
Yellowtail Snapper	9.5	7.8	16.3	3.2	2.9	3.2	3.1	72.9	8.9	1.9	11.4	7.4
Total	**11.0**	8.0	**34.7**	**27.1**	6.2	**11.5**	5.7	**222.9**	**11.3**	4.3	**11.4**	9.0
Acanthuridae												
Doctorfish	0.7	0.9	1.7	2.9	0.2	8.9	12.0	158.3	1.9	1.4	2.4	1.9
Blue Tang	9.3	11.9	12.7	11.8	4.5	30.2	21.7	387.5	14.8	13.3	2.1	8.1
Ocean Surgeonfish	3.8	5.4	0.7	4.4	3.3	7.6	1.5	27.1	5.7	1.2	2.4	5.7
Total	13.8	18.1	15.0	19.1	8.1	46.7	35.2	572.9	22.4	16.0	6.9	15.7
Serranidae												

Tiger Grouper	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nassau Grouper	0.2	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.5	0.0
Red Hind	0.0	0.0	0.0	0.1	0.2	0.3	0.9	2.1	0.2	0.0	0.2	0.2
Rock Hind	0.5	0.0	0.0	0.0	0.2	0.0	0.2	0.0	0.0	0.5	0.0	0.0
Yellowfin grouper	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	**1.2**	0.0	0.0	0.1	**0.5**	**0.3**	**1.1**	**4.2**	0.2	**0.5**	**0.7**	0.2
Haemulidae												
French Grunt	1.7	0.7	3.7	54.7	8.8	3.0	3.9	45.8	4.3	2.9	1.9	1.2
Bluestriped Grunt	0.2	0.6	2.3	70.9	11.2	2.1	4.1	20.8	2.0	0.5	1.9	0.7
Smallmouth Grunt	0.0	0.0	0.0	1.5	0.0	0.2	0.0	0.0	0.0	0.2	0.0	0.0
Caesar Grunt	1.0	0.0	9.7	47.8	9.5	7.9	2.8	110.4	2.6	1.2	2.9	0.2
Spanish Grunt	0.5	0.0	0.3	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.5
Striped Grunt	0.0	0.0	0.0	0.0	0.2	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Sailors Choice	0.0	0.0	0.7	2.6	0.2	0.0	0.4	2.1	0.0	3.3	29.5	0.0
Tomtate	0.0	0.0	0.0	0.9	1.2	0.0	0.6	0.0	0.0	2.6	0.2	0.0
White Margate	0.0	0.0	0.3	0.0	0.0	0.0	0.0	4.2	0.0	0.0	0.0	0.0
Porkfish	1.9	0.4	0.0	0.3	3.8	0.3	0.4	8.3	0.4	0.2	0.7	0.2
Black Margate	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.2	0.0	0.0
Total	5.2	1.7	17.0	**178.7**	**35.0**	13.5	12.4	**193.8**	9.3	11.2	**37.1**	2.9
Other												
Bar Jack	6.7	2.8	6.7	2.1	6.4	12.4	13.1	20.8	2.0	2.9	6.4	1.7
Barracuda	1.0	0.0	0.3	0.0	0.0	0.0	1.9	0.0	0.0	0.0	0.2	0.2
Spanish Hogfish	1.7	0.7	0.7	0.6	2.4	0.3	0.2	0.0	0.9	0.5	0.2	0.5
spotted trunkfish	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Queen Triggerfish	0.7	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Hogfish	0.2	0.2	0.0	0.0	0.5	0.3	0.0	0.0	0.0	0.0	0.2	0.2
Rock Beauty	3.8	2.0	0.3	0.0	0.2	0.2	0.4	0.0	1.9	0.2	0.0	0.7
Grey Angelfish	1.4	0.0	0.3	1.0	0.7	1.1	0.9	0.0	0.9	1.4	0.2	0.5
French Angelfish	0.0	0.0	0.0	1.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	15.5	6.1	8.3	4.9	10.7	14.2	16.5	20.8	5.7	5.0	7.4	4.0

2.5 Standing stock biomass

Figure 2 shows the relative percent biomass structure for commercially exploited fish families across each site. Although no general trend can be observed, some families were recorded at all sites, namely Lutjanidae, Haemulidae and Acanthuridae.

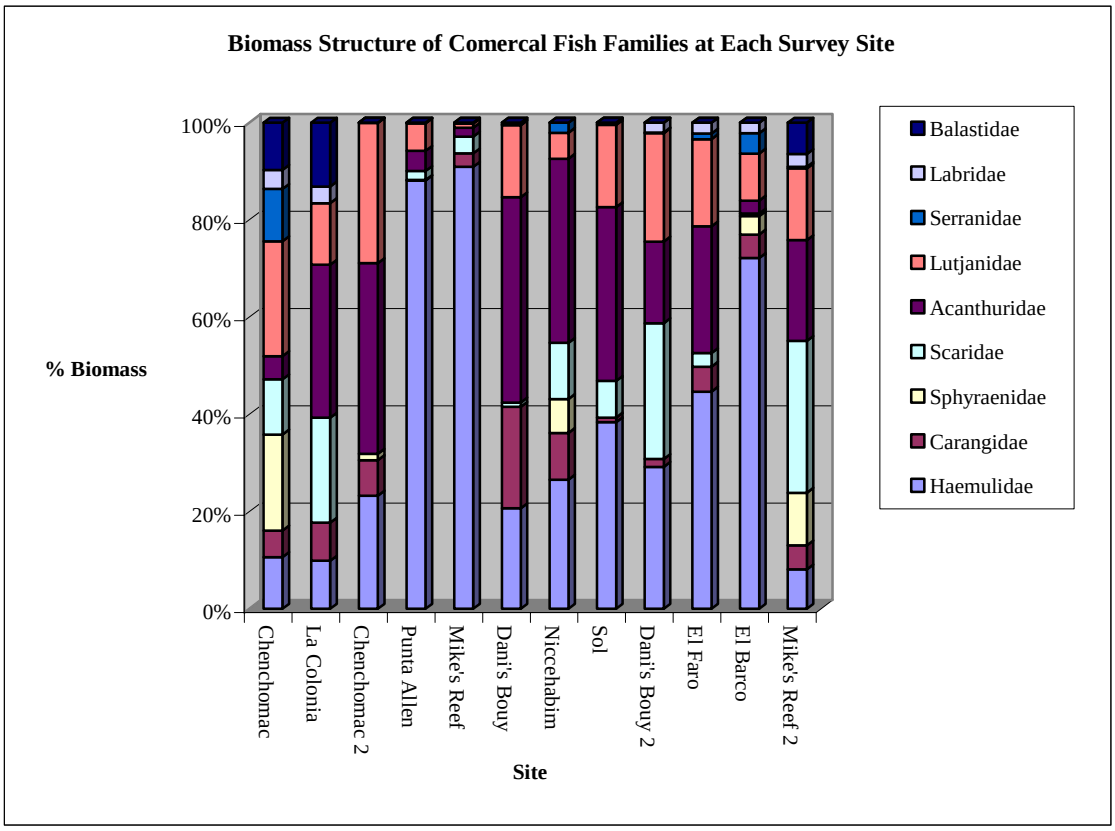

Figure 2. Biomass structure of commercial fish families at each site

2.6 Invertebrate Populations

Of the six target groups or species of invertebrates surveyed, urchins were the most abundant with common, pencil or *Diadema* spp occurring at every site. Sol recorded a mean abundance of 3.5 urchins per $100m^2$ and encouragingly, the regionally scarce tritons trumpet (*Charonia variegata*) was recorded at Punta Allen, Mike's Reef, Niccehabim, Sol and Mike's Reef 2 (Table 5). Lobster (*Panulirus argus*) were also recorded at 9 of the 12 sites.

Table 5. Total abundance per $100m^2$ of each target species of invertebrate recorded across the 12 sites during the SKCRCP. Totals marked in bold indicate total mean abundances greater than the regional mean abundance for Atlantic and Carribean reefs between 1997-2001 (Hodgson and Liebeler 2002).

species	Chenchomac	La Coloni	Chenchomac 2	Punta Allen	Mikes Reef	Dani 's Bouy	Niccehabim	Sol	Dani Buoy 2	El Faro	El Barco	Mike's Reef 2
Banded coral shrimp	**2.4**	0.9	0.0	0.5	1.0	0.6	0.6	0.0	0.4	**2.1**	0.2	0.0
Diadema spp.	0.5	0.4	1.3	0.3	0.0	0.3	1.1	3.5	0.4	0.5	0.2	0.0
Flamingo tongue	0.0	0.0	0.0	0.0	0.7	0.0	0.7	0.0	0.0	0.0	0.0	0.0
Lobster	0.0	**0.6**	0.0	**1.2**	**1.9**	**0.5**	**1.1**	0.0	**0.4**	**0.5**	0.2	**0.7**
Pencil urchins	0.7	0.2	3.3	0.8	1.4	0.2	0.6	0.2	0.2	0.2	0.2	0.2
Triton shell	0.0	0.0	0.0	**0.1**	**0.7**	0.0	**0.2**	**0.8**	0.0	0.0	0.0	**0.2**

2.7 Management Value

Harding et al (2003) and Harding et al (in press) have developed a simple, unique and effective method of assigning relative conservation management value to areas of reef within a region using certain biological variables. Results based on these methods of data analysis have been developed for the 12 sites included in the SKCRCP. These results are represented by a simple colour coded GIS (Fig 3). This tool allows a visual reference to be made to the location of each survey site and its relative conservation management value. Table 6 briefly summarises the major biological characteristics (reef health indicators) of each of the 12 survey sites and gives each site a 'score' in terms of the number of occasions a site's biological attributes exceed the mean values (except in the case of disease/bleaching where a >average value is scored with a 0).

Table 6. Summary of the conservation management value, and biological status of each of the 12 sites within Ascension Bay.

Site	No of different habitat classes	Hard coral cover	Coral mortality	Species richness and diversity	Conservation Management rating
Sol	3 shallow habitats	17.51%	$0.13m^2$ of black band disease	Medium species richness and diversity	Low
Chenchomac	3 moderate to deep habitats	Highest of all 12 sites, 26.46%	Low with no evidence of disease	Highest of all 12 sites	High
Chenchomac 2	3 habitats	Low at 8.13%	No evidence of disease. Some bleaching		Low
La Colonia	2 habitats	17.89%	Bleaching	Higher than the mean across all 12 sites	Medium
Punta Allen	Highest amount	Lowest at	Small amount of	Low	Low

	of different habitats.	5.05%	yellow band disease, dark spot disease and evidence of coral bleaching		
Mike's Reef	4 habitats	11.42	% Black band, yellow band and dark spot disease as well as bleaching.	Higher than average.	Medium
Dani's Buoy	3 habitats	Low at 5.77%	Red band disease II, white band disease	Lowest of all 12 sites.	Low
Niccehabin	1 habitat	12.28%	Bleaching and evidence of black band disease	Higher than average	Medium
El Faro	2 habitats	Quite low at 10.69%	Lowest, some bleached coral	High	High
El Barco	4 habitats.	Low	Evident bleaching. Yellow band disease	Lower than overall average	Low
Mike's Reef 2	2 habitats	11.74%	Small incidences of bleaching.	High	High
Dani's Buoy 2	2 habitats		Bleaching and yellow blotch disease	Higher than average	High

Using this ranking system, three sites, Chenchomac, Dani's Buoy 2 and Mike's Reef 2 all have >5 reef indicators greater than the calculated averages across all sites. Chenchomac has all six of the reef indicators greater than the calculated averages across all habitats, and is therefore arguably of the greatest conservation management value. Hard coral cover was the highest at this site at 26.46%, with 66% of the surveys undertaken at Chenchomac classified as, and assigned the habitat label of *Deep mixed reef dominated by Montastraea and Porites astreoides with sponge.* Chenchomac 2, Sol Punta Allen, Dani's Buoy and El Baco all score low in this management-rating scheme. These results are represented by a simple colour coded GIS (Fig. 3). This tool allows a visual reference to be made to the location of each survey site and its relative conservation management value.

Figure 3. Basic geographical information system (GIS) representing the relative conservation management values of the 12 sites surveyed by the SKCRCP. Green represents a High conservation management value, yellow a Medium and red a Low in accordance with the methods described by Harding et al 2003.

2.8 Species List

A total of 101 species of fish were recorded by the SKCRCP from 35 families during survey and non-survey diving. Thirty one species of macro algae and 45 species of coral were recorded Fish species diversity was high considering all surveys and nearly all diving was confined to reefs shallower than 10m.

2.9 Environmental Education Programme

CCC held a formal open day to introduce themselves to the local community of Punta Allen. This was then followed by approaching the four schools within the community and offering a structured, marine based environmental education programme. CCC was welcomed into the community and the schools undertook the marine awareness education as detailed in Table 7 below.

Table 7. Summary of the SKCRCP schools environmental education program.

Date	School	Activity/ education program
15/10/03	Jardin de Infancia (JI)	What is a coral Started building a 3-D coral reef, explaining characteristics of different reef creatures.
20/10/03	Primaria (PR)	Introduction to Coral Reefs, what kind of organisms are they? Coral Reefs around the world, with a little quiz Associated habitats to coral reefs (Mangroves and sea grass beds) and their importance.
22/10/03	Guarderia (GR)	Introduction to key spp with pictures, and painting activities.
29/10/03	JI	Finish 3-D reef. Introduction to 'where different animals live in the reef' and relate it with the 3-D model
30/10/03	PR	Reef Biodiversity - Important Spp. - Food chains - Spp. I.D. games
5/11/03	GR	Painting activities on 'Marine creatures'
7/11/03	Tele-Secundaria (TS)	Introduction to Coral Reefs, what kind of organisms are they? Coral Reefs around the world, with a little quiz Associated habitats to coral reefs (Mangroves and seagrass beds) and their importance.
12/11/03	JI	Creation of 'Marine Creature' with *Papier Marcher*
12/11/03	PR	Threats and problems of the reef - Natural - Anthropogenic - Sustainable use of resources - Reserve of the Biosphere Sian Ka'an.
18/11/03	PR	Day out on the Reef
20/11/03	TS	Reef Biodiversity - Important Spp - Food chains - Spp I.D. games
02/12/03	JI	Creating marine animals with geometric figures (colour paper). Last day at JI
04/12/03	PR	Evolution and adaptation on the reef, followed by a slide show. Last day in the PR

Guarderia (2-4 years old)
Jardín de Infancia (4-6 years old)
Primaria (6-12 years old)
Tele-secundaria (12-16 years old)

Through a grant from the British Foreign and Commonwealth Office a specifically designed poster entitled "Life on the Coral Reef" was produced in Spanish (Fig. 4). The poster illustrates the main species to be found in the Mesoamerican reef environment, and highlights the main threats facing coral reefs within the region.

Figure 4. Reef Environmental education poster designed for school children. Funded with a grant by the Foreign and Commonwealth office of the UK government.

Figure 5. Preparing for the day of snorkelling with Primaria

3 Management recommendations

The biggest perceived threat to the UNESCO SKBR is from those engaged in tourism activities (Salvat et al, 2002). Tourism is now recognized as both the largest and fastest growing industry in the world. Of course tourism suffers glitches on its path of growth, but the trend is one of increase, with the human population having ever-greater amounts of disposable income and time. Tourism now generates 11% of global gross domestic product, employs 200 million people worldwide and engages 700 million tourists annually. These figures are predicted to double by 2020. The resources of the UNESCO SKBR are a great draw to the tourist, but unless managed carefully and in a sustainable manner, they will not provide a long-term financial and social gain to the area. For this very reason it is important that the patch reefs of Ascension Bay utilised by snorkelers are managed in the most sustainable way possible. Figure 6 illustrates a model developed for Hol Chan Marine Park, Belize. A reef without proper management will deteriorate to such an extent divers and snorkelers will not wish to use the reef, and will go elsewhere. The model shows that the number of users increases till the year 2024, generating increased levels of revenue in the short term. After that the number begins to decline as divers and snorkelers see the ecological consequences caused by lack of management. In the "with" management scenario, the number of snorkelers and divers will stay constant, thus maintaining a constant revenue for the local area.

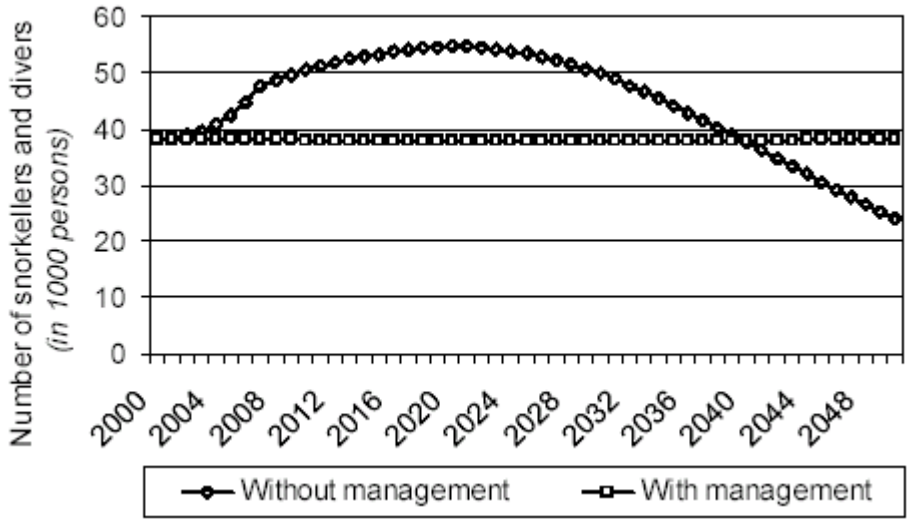

Figure 6. Model to show number of snorkellers and divers to visit Ho Chan Marine Park, Belize, in "with management" and "without management" scenarios. *Source: Cesar and Walker, 2003.*

The following are a summary of management measures that need to be implemented to decrease snorkeler related impacts to the 12 patch reefs surveyed by the SKCRCP.

- ***Limit the number of visitors to each site***: By restricting the total number of visitors to each of the 12 sites, physical impact and damage caused by careless

snorkelers can be minimised. Zakai et al (2002) suggest from their work that a similar reef environment in Eilat could support a carrying capacity of 5,000 - 6,000 divers per site per year. The authors of this report suggest that this figure is reduced to account for the general greater impact sustained by snorkelers than divers (Cesar and Walker, 2003) and recommend a total of no more than 4,000 snorkelers per site per year. This equates to approximately 12 snorkelers per day using each site.

- ***Distribute the number of snorkelers between sites***: By equally distributing the snorkeling related pressure, the impacts will be more evenly distributed, thus allowing the reef environment more chance of recovery (CORAL, 2002).
- ***Ensure all snorkelers wear buoyancy aids****:* By respecting the UNESCO SKBR regulation and ensuring all snorkelers wear buoyancy aids, the risk of physically damaging delicate corals and marine life is minimised. This policy has proved to be successful in other regions of the world (Fenner, 2001).
- ***Ensure that all boats are moored to buoys***: By ensuring all snorkel tour boats are properly moored, there becomes no need for anchoring. Thus the risk of damage to the reef is reduced.
- ***Ensure that Reserve user fees are directed towards buoy installation and maintenance***:
- ***Site closure***: The authors of this report recommend that the sites Chenchomac and Mike's Reef 2 be closed to snorkelling and extractive activities such as fishing. Both sites have excellent conservation management value as confirmed by the research under taken during the SKCRCP. These sites are also relatively deep so have less value to snorkellers. By managing these two sites as small community run Marine Protected Areas (MPAs), the sites will help to increase recruitment of coral and other species such as lobster and finfish to these and other reefs within the area. Thus, helping to maintain local fishery stock and coral recruitment and abundance on the reefs utilised by the snorkellers.
- ***Ensure that all snokelers are led by guides****:* The supervision of snorkelers in the water will allow for greater control over potentially damaging activities such as collecting curio or careless damage to coral and living substrate.
- ***Pre snorkel briefings***: Guides should be encouraged to give group briefing on the boat before snorkellers are allowed to enter the water. These briefings should be informative and concise and encourage snorkelers to be aware of their fragile surroundings and not touch or collect anything.
- ***Control land based pollution and coastal development***:
- ***Implement a long-term monitoring programme:*** CCC will offer to undertake this monitoring programme to assess the long terms effects of this snorkel based tourism in the UNESCO SKBR. CCC will provide suggestions on how to manage the effects. CCC will continue and expand on the surveying, monitoring and education work it started during this three-month pilot phase.

4 Conclusion

Tourism as an industry can either act as the saviour to a natural resource by realising its potential economic value or it can be the cause of final degradation through uncontrolled and unmanaged over-development or exploitation. The difference between these two contrasting outcomes is simply the way in which tourism develops. If developed sustainably the best-case scenario will be brought about. If developed unsustainably, then tourism will be the downfall of the natural resource. In turn, the definition between sustainable and unsustainable is not a clear one. Instead the development can be judged on the concept of maximum tolerable change, the basis for the idea of carrying capacity. If development causes changes and degradation in excess of a certain level, then this is deemed unacceptable or non-sustainable. If changes and degradation are underneath this level then this can be viewed as acceptable or sustainable. Such a level or borderline is sometimes referred to as the carrying capacity. Often the difference of the severity of impacts depends upon the degree to which development plans are mitigated against in the planning stage. The people of Punta Allen depend directly on the reef of Ascension Bay for their livelihoods, both from snorkel tourism and fisheries. This study indicated that by regional Caribbean standards the generally high abundance of key indicator species of reef health suggests that the reefs are of Ascension Bay are in good, healthy, productive condition. At least three of the sites surveyed can be classed as having special conservation importance. The potential revenue generated by this valuable and scarce resource can amount to $1,000s per year, in the form of tourism and fisheries potential. The aim is to harness this potential revenue while maintaining a healthy productive environment. This is possible if the key stakeholders, such as the fishing community of Punta Allen and those that manage the UNESCO SKBR, to implement the science driven management recommendations. If the recommendations suggested as a result of the SKCRCP are implemented there should be little reason that potential impacts can't be mitigated against, and the local reef environment should remain productive indefinitely.

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