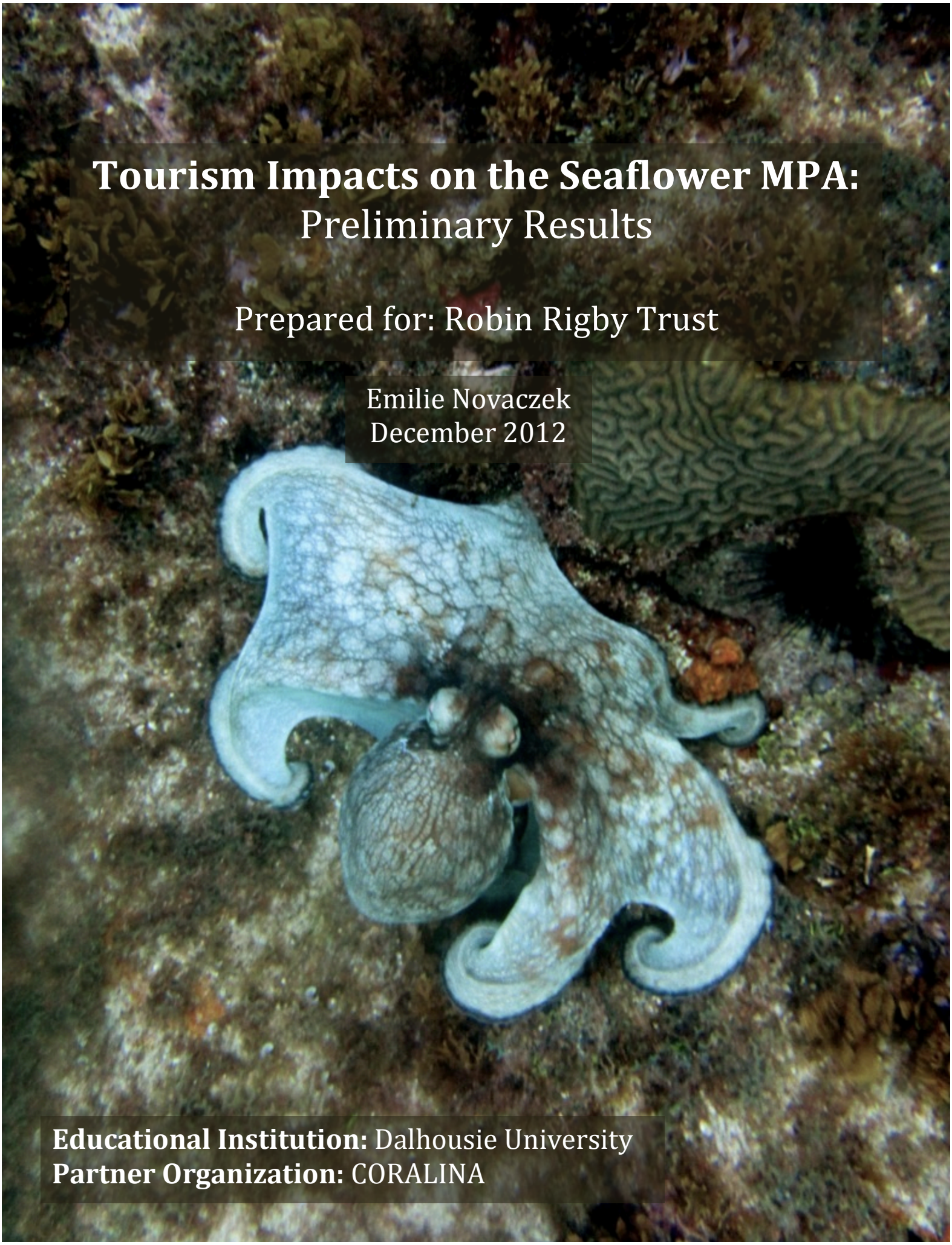

Tourism Impacts on the Seaflower MPA: Preliminary Results

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Cover photo: Common octopus spotted during San Andrés Reef Check Surveys (Emilie Novaczek, 2012).

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Abbreviations

CORALINA	Corporation for the Sustainable Development of the Archipelago of San Andrés, Providence and Santa Catalina
MPA	Marine Protected Area
OPSC	Old Providence and Santa Catalina

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1.0 Introduction

In tropical waters almost devoid of nutrients, coral reefs provide habitat and nourishment for nearly a quarter of all known marine life despite covering less than a quarter of a single percent of the ocean floor (Cesar, Burke & Pet-Soede, 2003; Souter & Linden, 2000). These incredible ecosystems are, however, facing a life-threatening suite of direct and indirect anthropogenic forces. Inland run-off (sediment, toxins and nutrient loading), coastal development, and over-fishing are among the many ways human activity is directly damaging coral reefs. As industrial development swells and the demand for fossil fuels continues to grow, global climate change is also exerting indirect pressure on coral reefs. Rising ocean acidity and surging temperatures associated with global warming have led to increases in coral disease, stress and bleaching events (Bellwood, Hughes, Folke & Nystrom, 2004; Brander, Beukering & Cesar, 2007; Cesar et al., 2003; Keller et al., 2009).

1.1 Coral Reefs in Crisis

According to the Reefs at Risk Threat Index created by the World Resource Institute, almost two-thirds of Caribbean reefs are currently threatened by human activities (2004). These threats are varied, however they are represented by three main causes: one third of Caribbean reefs are threatened by coastal development, one third by inland sediment & pollution and almost two thirds (60%) are overfished (World Resources Institute, 2004). The main pollution related threats to Caribbean waters are oil spills, untreated sewage and domestic solid waste (Gavio, Cantillo & Mancera, 2010). Recent research into the status of Caribbean reefs suggests that 40% of reefs in this region are under high risk of decline within this decade (Rodriguez-Ramirez et al., 2008).

The main response to the threats against coral reefs has been the creation of marine reserves or Marine Protected Areas (MPA). MPAs offer a range of benefits, including protection of critical habitat areas, preservation of biodiversity, tourism opportunities, enhanced production of target species, prevention of overfishing and enhancement of certain fisheries (Alison, Luchenco & Carr, 1998). Specific goals are essential to successful reserve management; for example, Alison et al. hypothesize that “biodiversity reserves and fishing refugia may be mutually exclusive” as these goals are most successfully realized with many small reserves and isolated large-scale reserves, respectively (1998, p. 87). What is clear, however, is that once goals are established, consistent monitoring and adaptive planning are crucial to reserve success (Alison et al., 1998; Baine, Howard, Kerr, Edgar & Toral, 2007). Protected or not, however, reefs near heavily populated centres show reduced recovery rates after chronic or acute damage events (Graham, Nach & Kool, 2011). Without education, coordinated coastal planning and pollution regulation, MPAs offer incomplete and often insufficient protection.

1.2 Valuing the Ecosystem

As-yet incomplete marine inventories indicate that over 93 000 unique species rely on coral reefs; however, experts estimate that the inclusion of undiscovered species could push this count well over 1 million (Martinez et al., 2007; Cesar et al., 2003). This productivity provides livelihoods for millions of people around the world and has earned coral reefs recognition from the IUCN World Conservation Strategy as "one of the essential global life support systems necessary for food production, health and other aspects of human survival and sustainable development" (Souter & Linden, 2000). As Brander et al. point out, however, the open access nature of coral reefs often subjects them to the *tragedy of the commons*; they are overused and undervalued in most decision-making (2007).

Over the last decade many researchers have worked diligently to provide an economic understanding of the vast, varied and complex resources provided by coral reefs. Valuation of coral reefs generally falls into three categories: direct use values (diving, snorkeling, viewing), indirect use values (coastal protection, habitat/nursery for fished species) and preservation values, which are the increases in human wellbeing derived from the existence of healthy and bio-diverse ecosystems (Brander et al., 2007). Widely accepted estimates put the global value of coral reef goods and services at approximately $30 billion USD in net annual benefits, including tourism, fisheries and coastal protection (Cesar et al., 2003). Depending on the method and scope of analysis, however, the world's coral reefs may be worth as much as $54 trillion USD annually (Souter & Linder, 2000). The World Resources institute (WRI) calculated these benefits by sector for the Caribbean region alone; annual fisheries revenues are estimated at $310 million USD, annual dive tourism revenue at $2.1 billion USD and shoreline protection services are estimated to fall between $700 million and $2.2 billion USD per year (2004). In the same study, WRI estimated potential losses to the Caribbean economy if coral reef degradation continues unchecked. Estimates total $860 million USD in projected annual losses by 2015: $95-140 million USD lost to declining fisheries, $100-300 million USD lost in decreased tourism and $140-420 million USD lost in coastline protection (WRI, 2004).

Beyond cultural significance and provision of food, coral reefs also provide economic opportunities as tourist attractions, both directly and indirectly. The white sands of the world's most coveted beaches are provided by the accompanying coral reefs. Divers, snorkelers and sport fishers seek out the most spectacular marine diversity hotspots for their holidays.

Coral reef recreation in the Caribbean has the highest mean value when compared to reef tourism around the world. It is no surprise then, that tourism –particularly marine tourism— figures prominently in Caribbean island economies (Brander et al., 2007). According to the European Commission, the Caribbean has become one of the world's most tourism dependent regions (Uyarra et al., 2005). Protected areas cover roughly

20% of Caribbean reefs, yet these areas attract roughly half of all the diving activity and related tourism. Although they account for only 10% of visitors, dive tourists make up 17% of tourism revenue in the Caribbean, making this industry a very important factor in tourism development planning (WRI, 2004).

As in much of the Caribbean, tourism is a main contributor to the San Andrés and OPSC (Old Providence & Santa Catalina) economies with roughly 300 000 visitors documented by the San Andrés airport annually (Secretaria de Turismo, 2011). Unlike the international tourism on most Caribbean islands, however, the San Andrés Archipelago almost exclusively serves Colombian nationals on all-inclusive "sun & sand" vacations (Baine et al., 2007). Tourism, especially targeted eco-tourism, offers economic benefits and may stimulate conservation efforts, however large-scale, unplanned tourism often accompanies income inequality, pollution and coral damage through direct tourist contact, anchor damage and sedimentation (Allison et al., 1998; Diedrich, 2007; Graham et al., 2011).

1.4 The study site

The Seaflower Marine Protected Area was created in 2005, and is administered by the Corporation for the Sustainable Development of the Archipelago of San Andrés, Old Providence and Santa Catalina (CORALINA) to preserve the region's vibrant coral reef, mangrove and seagrass communities (Mow et al., 2006). The Archipelago, nestled in the southwestern Caribbean Sea 150 km off the coast of Nicaragua, is home to 75% of Colombian coral reefs (Howard, Connolly, Taylor & Mow, 2002). The Seaflower MPA includes some of the best-developed and most productive coral reef systems in the region and is home to extremely bio-diverse and endemic reef communities (Rodriguez-Ramirez et al., 2008; Friedlander et al., 2003; Baine et al. 2007).

Figure 1. San Andrés Archipelago (Google Maps, 2012)

1.4.1 San Andrés

San Andrés, the largest island in the archipelago at 27 km^2, currently holds a population estimated to surpass 80 000. Official population density is 2 260 people per km^2, winning San Andrés the dubious title of most crowded island in the Americas, even before the addition of hundreds of thousands of annual tourists (Howard et al., 2002; Secretaria de Turismo, 2011). The population is ethnically divided between *Raizal* native islanders (descendants of enslaved settlers of the archipelago who maintain an African and Anglo-Puritan culture) and mainland Colombians (Friedlander et al., 2003).

After it was designated as Colombia's only free port in 1953, San Andrés experienced heavy immigration from the mainland, which transformed the island from a fishing and agricultural community to one focused on international trade and tourism almost overnight. The population shifted, putting Spanish-speaking Colombians in the majority over the English-speaking islanders, and resulting in the "economic and political marginalization of native islanders" (Howard et al., 2002, p. 155). In addition, the rapid development and change in the economic base caused a sharp decline in environmental health and incited heavy competition for natural resources (Howard et al., 2002). Gavio et al. describe the island as "highly dependent on tourism," however, population increased "with little or no land [planning], leading to chaotic coastal development" (2010, p. 1018). No longer Colombia's 'free port,' San Andrés now faces the challenge of evolving the economic base yet again while struggling with social inequalities and a tense cultural divide (Baine et al., 2007).

1.4.2 Old Providence & Santa Catalina

The neighbouring islands of Old Providence and Santa Catalina (OPSC) have experienced a much slower, less drastic transformation. Howard, Connolly, Taylor and Mow recognize Providence as "one of the least environmentally and culturally degraded spots in the Caribbean" (2002, p. 155).

This oasis is also home to one of the longest barrier reefs in the Americas, stretching over an area of 255km^2 of Caribbean coral habitat (Friedlander et al., 2003). With a recorded population of 4 200 on the 18km^2 island of Providence, the density –233 people per km^2– is a mere tenth of that seen in San Andrés (Howard et al., 2002; Baine et al., 2007). Tourism in OPSC is also a much different industry. Providence did not experience the influx of visitors and development that the free port designation brought to San Andrés. As a result, artisanal fishing is still a large part of the island economy and although dive and snorkel tourism have increased significantly over the past decade, many of the watersports that define the San Andrés coast are rare or absent (Friedlander et al., 2003).

1.4.3 Development of the Seaflower MPA

The design of the Seaflower MPA incorporated information from a unique combination of ecological and sociological studies, placing a priority on stakeholder engagement and culturally appropriate conservation measures (Friedlander et al., 2003). Over half of San Andrés residents are unemployed, while almost half the population lives below the internationally accepted poverty line, at less than $1/day (van't Hot & Connolly, 2001 quoted by Howard et al., 2002). Agricultural decline in the 1970s and the lack of planned commercial or tourism development, however, have left Providence with even higher unemployment rates than San Andrés. In 2007, 32% of the entire archipelago's working age population reported no income, and over half of workers reported receiving less than the minimum wage of $100 USD per month (Baine et al., 2007). In San Andrés sewage systems reach only 8% of the population, with no treatment before direct disposal into the sea (Gavio et al., 2010).

Creating an effective protected area with high compliance in this social and economic climate requires robust community consultation, participation and creative solutions. CORALINA is an extension of the Colombian government, the CAR (regional autonomous corporation) tasked with managing natural resources in the San Andrés Archipelago. The corporation's policies include community involvement in management decisions and protection of biodiversity with special attention to endangered species and essential coastal habitat (Baine et al., 2007). The creation of the Seaflower MPA exemplified community consultation in reserve planning; it was achieved though a 5-year zoning process with fishers, dive and watersports operators, fisheries managers, and other stakeholders (Howard et al., 2007).

While coral cover worldwide is declining, reef visitation is increasing significantly (Bell, Needham & Szuster, 2011). Coastal communities around the world, where 350 million depend on reefs directly for food and other services, are facing the same challenge: how to balance development with conservation (Hodgson & Liebeler, 2002). Tourism, if properly managed, offers an incredible opportunity to blend profit and preservation.

This paper offers the preliminary results of stakeholder consultation and Reef Check monitoring In San Andrés and OPSC. The goal of this research is to provide information, develop goals and support tourism management strategies for the Seaflower Marine Protected Area.

2.0 Tourism Operator Interviews

2.1 Scope

In San Andrés, the survey of tourism activities and watersports included leisure transport to Johnny Cay, Haynes Cay & Rose Cay, watersports (jetski, kite-surfing, wind-surfing, sunfish sailing, SCUBA, snorkeling) and bay tours and cruises (including mangrove, sting ray and sport fishing tours).

Old Providence and Santa Catalina have a much smaller tourism market; in this case the watersports were limited to SCUBA and snorkeling. Operators offering marine tours, sport fishing and leisure transport to Crab Cay were also included.

In both study sites swimming, beach use, leisure transport to distant cays (Bolivar, Albuquerque, etc), and all subsistence or commercial fishing were excluded from the survey.

2.2 Methods

Marine tour and recreational water sport operators (dive centers, snorkeling, bay tours, recreational fishing, tourist transport to nearby cays etc) were identified through local phone books, online searches, contact with tourism agencies and records provided by the San Andres Port Authority. Once identified, operators were contacted by phone or in person to schedule an interview time at their convenience.

Brief, semi-structured interviews were carried out face to face with owners or managers in their work place to provide high feedback rate, increase opportunity for operators to provide additional qualitative information and management suggestions and to increase connections between tourism operators and CORALINA staff. All questions were approved by the Dalhousie College of Sustainability Ethics Review and CORALINA MPA Project Coordinator Fanny Howard.

Participants were given the option of conducting the interview in Spanish or English. Simultaneous Spanish/English translation was provided by bilingual CORALINA staff members.

2.3 Results

2.3.1 San Andrés

Over a 4 week period, 31 owners, managers or senior staff were interviewed from tourism businesses who operate directly in the Seaflower Marine Protected area around San Andrés. This included all 13 dive operators and various tour providers including a wide rage of watersports and leisure transportation.

Over 98% of the 300 000 annual visitors to San Andrés spend time on the island's beaches and a wide array of leisure activities have been developed along the coastline to meet the demands of thousands of vacationers (Castano, 2011). In addition to swimming and sunbathing, roughly 1500 people enter the water daily during the low season to enjoy the Seaflower MPA through diving, snorkeling, reef-walking, sport fishing, wind-surfing, visits to neighbouring cays and a variety of other tours and watersports (Figure 2). During the high season, this figure more than doubles; according to operator estimates, there are at least 3 700 people on or in the water each day, excluding swimmers. The majority of visitors to the MPA are spending time on Johnny Cay and Acuario (Rose Cay & Haynes Cay), although bay tours, jetskis, semi-submarine tours and diving are also popular activities. Operators identified "High season" as July-August, January-December and the Easter holiday break. "Low season" spans the rest of the year.

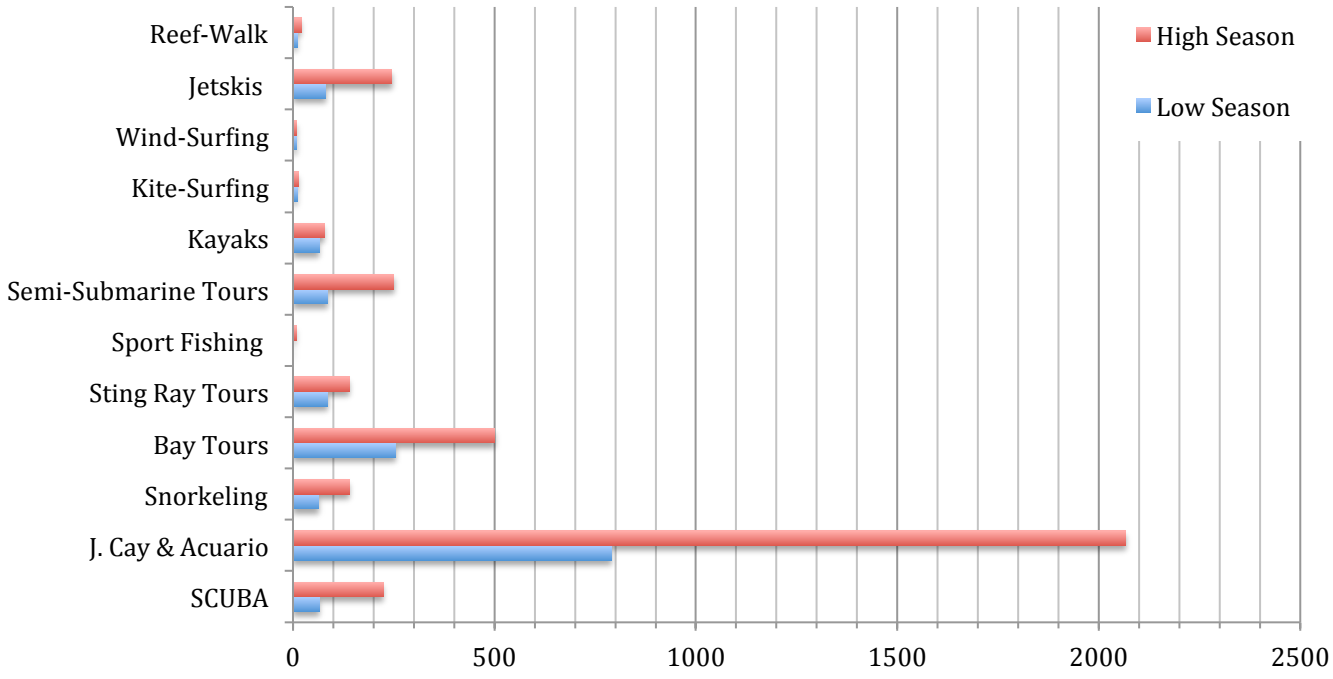

Figure 2: Estimated tourism traffic for marine recreation activities around San Andrés in 2012.

Operators were asked whether they provide a "user briefing" to tourists. This question aimed to provide a picture of how much, or what kind of information is provided to visitors before they enter and enjoy the Seaflower MPA. Of the 31 interviewees, 27 provide some kind of information or responsible visitor guidelines to their customers. Of the 4 who do not offer this kind of information, 2 were dive shops and 2 were general tour operators. The most consistent responses were from dive operators, the majority of whom begin each dive by reminding divers to watch their buoyancy and avoid disturbing substrate, knocking coral, etc. Diver briefs also often included restrictions on wearing gloves (which generally increase reef contact) and requests that divers collect any garbage found on site. Of 31 participants:

- 21 report asking users not to touch, bump or remove delicate coral.
- 14 report explaining that San Andrés sits within the Seaflower MPA.
- 12 report warning users against littering.
- 5 operators' briefings included additional information or warnings, including briefs on lionfish, discouraging dive gloves (they increase diver-reef contact frequency) or information about active conservation programs.

Visitor Information

"We ask customers not to litter but we often have a poor response. Tourists say that they are paying for these services and that they have bought the right to behave how they want."

"We talk about the corals, the types they see and about touching the corals. It can hurt the person as much as the coral! We ask them not to take anything and [we] explain that the area is under protection. It's hard though. Tourists often don't listen to the warnings and it seems like everything can be a souvenir. I've seen a woman leave the beach with a grocery bag full of sand to take home! She can't even get through the airport with something like that!"

"No [we don't provide a briefing]. I dive with 99% international people, from all over the world. Do I have to tell any Canadians, 'Don't break the corals'?"

"We talk about how the protected area, the biosphere reserve, covers the whole archipelago and some areas have restricted use rules. We ask divers not to leave any litter and pick up anything that they find. We warn them not to touch organisms and we're very careful to anchor on sand [if a mooring buoy isn't available]."

"I think it would help if the tourists knew more, if we had signs up here at the beach to let them know it's prohibited to remove the corals and everything. The jetski users need to know more too – they have no guides, no leaders. It's not safe."

The most visited sites for divers and snorkelers are Piramide, Bajo Bonito, Blue Wall, La Piscinita, El Faro and Velerito. The highest traffic areas, when other watersports and boat traffic are included, are Piramide and Little Reef, which fall in the path of boats carrying tourists to the popular Johnny Cay. Despite protection of a No-Entry MPA zone,

Little Reef is snorkeling site, permanent mooring site for the semi-submarine tours and frequently entered by passing boats and jet-skis.

The most frequently used dive sites for new divers (certification or Discover SCUBA mini-courses) are Piramide, Bajo Bonito and Montanita.

Dive operators were also asked if any sites seemed to be damaged by human impact:

- 11/13 dive operators described sites where they have noticed damage.
- 10 noted that Piramide is the most damaged site.
- 3 described damage at West View and 4 mentioned Little Reef.

Dive/Snorkel site: Piramide

"It [Piramide] was beautiful … Now, the yellowtail is gone. Not one here! You would see bermuda shark. Gone. Sometimes I will go, but the other dive shop they go every day, every day, every day! And the boats are coming through on top of you! The coral is broken, damaged because the semisubmarine go there, dive shop go there, snorkeling go there, everybody go there!"

"There is lots of spear gun fishing at Little Reef and Piramide. "

"Piramide is over-capacity. Little Reef has broken coral as well. Sites on the West from Dedos de Morgan and Reggae Nest are in better condition. These are deeper though and we don't take new divers.

"Piramide now is not pretty and there are too many people there.'

"The worst is over here: Piramide. That's the worst, I don't like to bring divers here."

"We don't use too much this one [Piramide] … they have a lot of fishes still but the coral is not good. We don't like to go because of that. This area, Cantil de Barco Hundido, we used to have a lot of fish, barracuda, but the speargun fishers I think they use to much there."

"Piramide is in bad shape. Some of the shallow reefs on the West side are over-used too. Lots of beginner divers."

"The problem over here [Piramide], it used to be healthy but now we have the semi-submersibles, we have the jet-skis, and the boats going to Acuario and Johnny Cay that have no training or knowledge about the corals. We have wave runners going on top of Little Reef, we have no limitations -- the most direct route from Acuario to Johnny Cay is right over Piramide, Little Reef and the rest of the Trilogy. "

"Right now, if I can, I stop all diving at Piramide [sic]. There are so many people here. If I can I stop the dive here - no more! The dive site is not the problem. The problem is how many people are using this place. You have many divers, many new divers. There are two big problems, some divemasters are taking 7 or 8 divers and just one divemaster. All they can really carry is two people! How can they look out for 7? . And then, on top of all these students, the guide is taking pictures!"

2.3.2 Old Providence & Santa Catalina

Eight marine tourism businesses were identified by CORALINA staff. Of these eight, six were contacted and interviewed. Participants included all three OPSC dive operators and three independent or family owned marine tour businesses providing boat tours, snorkeling and sport fishing. In total, the interview participants report an estimated 120 visitors using the MPA daily in the high season, and 30 in the low season. This translates into 26 boat trips per day in the high season and 10 boat trips in the low season. All operators report infrequent anchoring, due to high use of well-placed CORALINA mooring buoys.

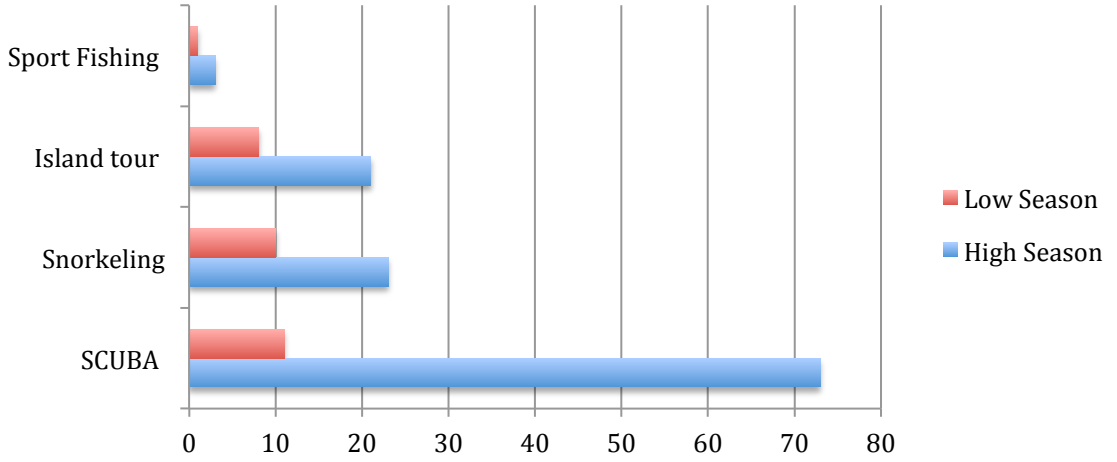

Figure 3: Estimated tourism traffic for marine recreation activities around OPSC in 2012.

The most used snorkel sites are Margarita Shoal (used by all 3 snorkel tours), Hippie's Place, Crab Cay and Morgan's Head (each mentioned by 2/3 snorkel tours). The most used dive sites are Turtle Rock and Felipe's Place.

Manta's City is used by all three dive operators for mini-courses and diver certification, although Bajo San Felipe and Tete's Place were also each mentioned by two of the three dive shops.

When asked which sites were in the best condition, most operators said all reefs were very healthy. If specific sites were named, they were part of long lists and no single site was mentioned more frequently than the rest. When asked about damage to OPSC reefs, Channel Reef was most frequently mentioned, although participants also mentioned Bajo San Felipe and Morgan's Head.

3.0 Reef Check

3.1 Methods

Surveys were completed on shallow reefs around San Andrés and OPSC following Reef Check protocol and using Reef Check recording formats. At each sample site four 20m transect lines were placed to capture coral reef patches (ie, avoiding sand, rock or seagrass). After surfacing for 20-30 minutes to allow fish to return to the transect area, a pair of divers descended to count target fish species within a 5 m wide belt along each transect line. When they surfaced, the next team descended to count target invertebrates within the same 5 m wide belt. Following the invertebrate team, two divers recorded the substrate type at discreet points every 50cm along the transect lines.

In San Andrés, 11 survey sites were selected from reefs all around the island (Figure 4). The proximity of REDCAM water quality monitoring sites, MPA zone, level of tourism activity and weather conditions all contributed to site selection. Low, medium and high use areas were sampled, including sites used for SCUBA certification courses, general SCUBA diving, snorkeling, semi-submarine tours, glass bottom boats and high traffic areas for boats and jetskis.

In OPSC, 8 sites were surveyed however weather conditions prevented surveys on the unsheltered South-West side of the island (Figure 5). The sites that were accessible were selected to provide data on sites used for SCUBA certification courses, general SCUBA diving and snorkeling tours.

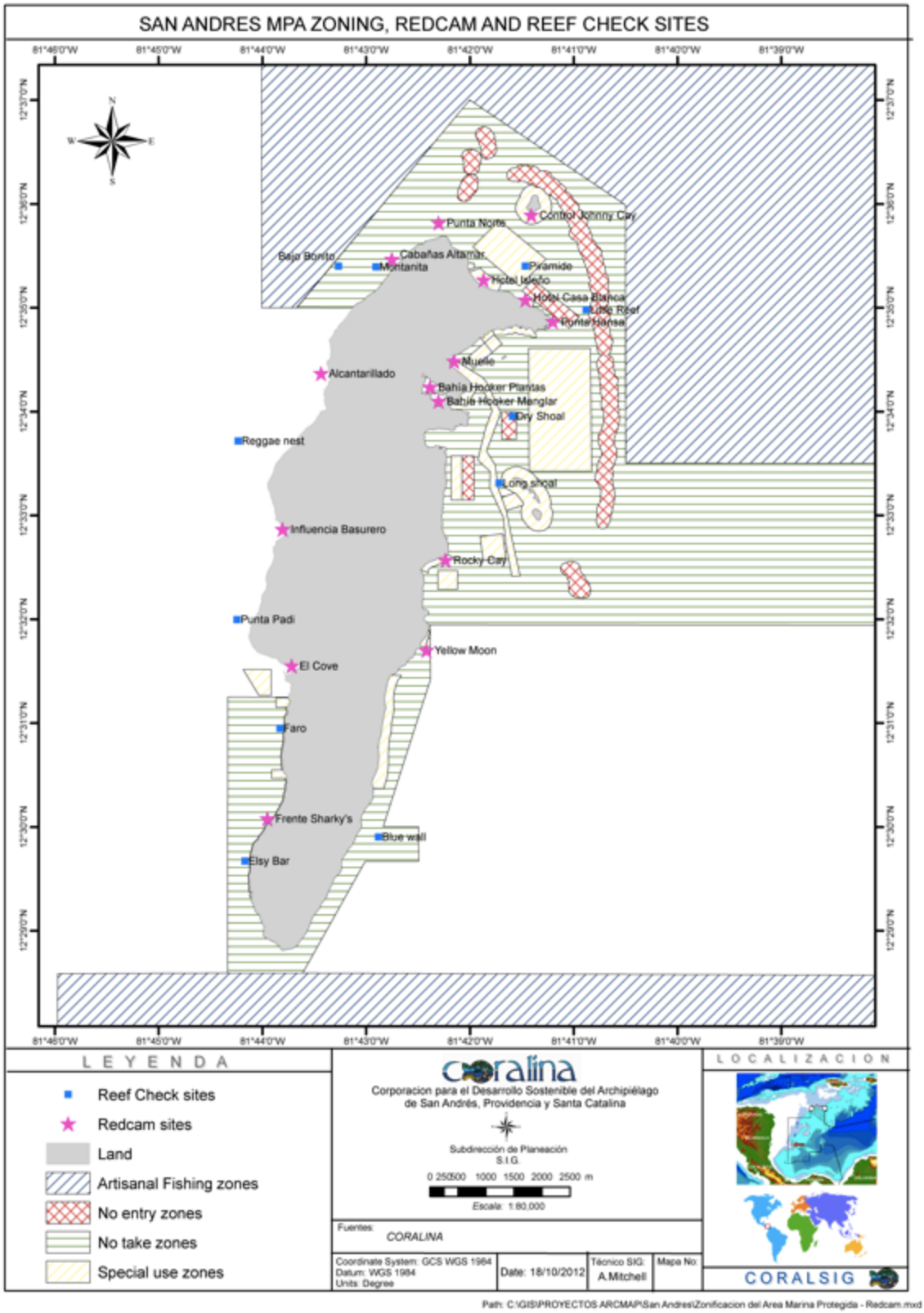

Figure 4. Reef Check survey sites around San Andrés, 2012.

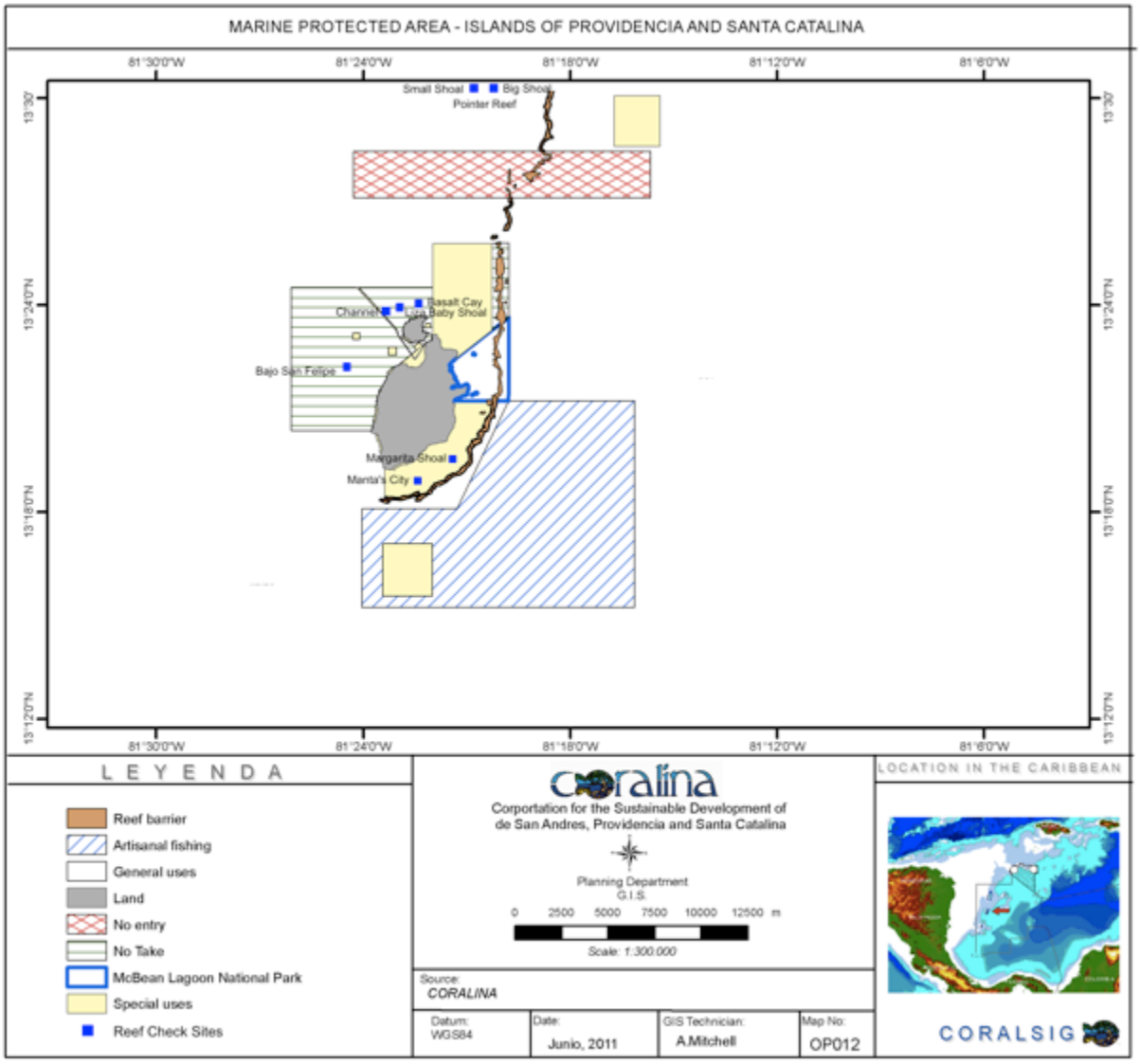

Figure 5. Reef Check survey sites around OPSC, 2012.

3.2 Results

3.2.2 Substrate

Substrate cover is classified by Reef Check as hard coral (HC), soft coral (SC), recently killed coral (RKC), nutrient indicator algae (NIA), sponge (SP), rock (RC), rubble (RB), sand (SD), or other (OT) which encompasses gorgonians, anemones, tunicates or any other living substrate cover.

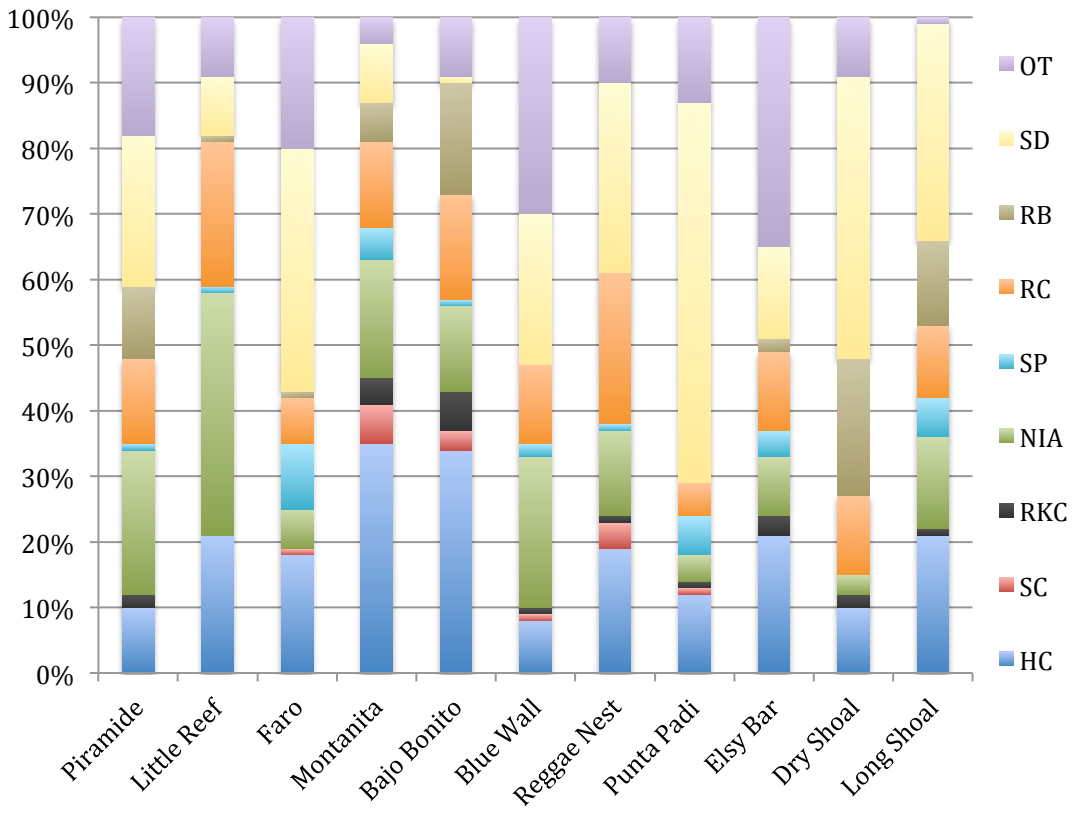

Figure 6. Percent substrate cover on San Andrés reefs, 2012
Note: Percent is calculated as a mean of four 20m transects; HC: Hard Coral, SC: Soft Coral, RKC: Recently Killed Coral, NIA: Nutrient Indicator Algae, SP: Sponge, RC: Rock, RB: Rubble, SD: Sand, OT: Other.

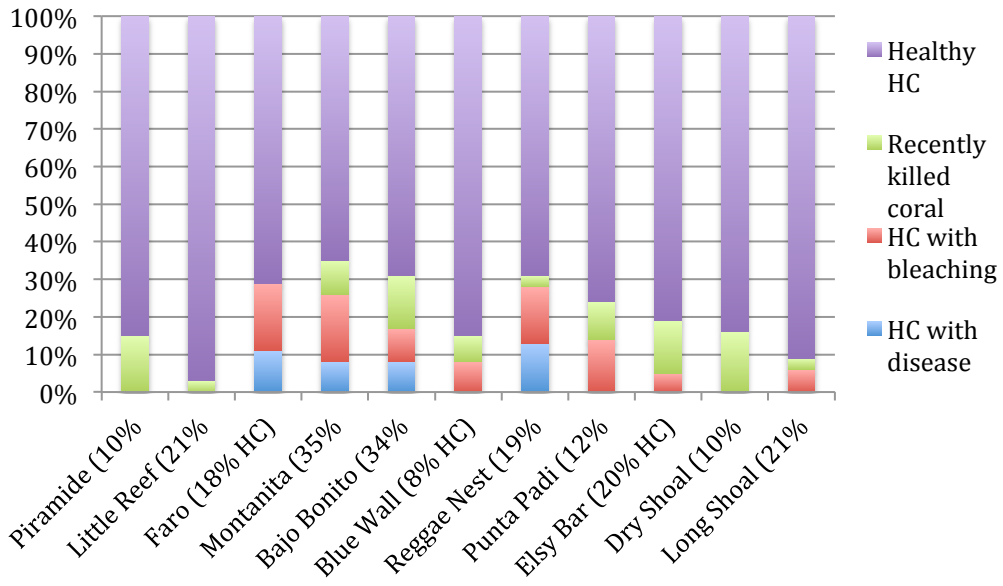

Figure 7. Hard coral condition on San Andrés reefs, 2012

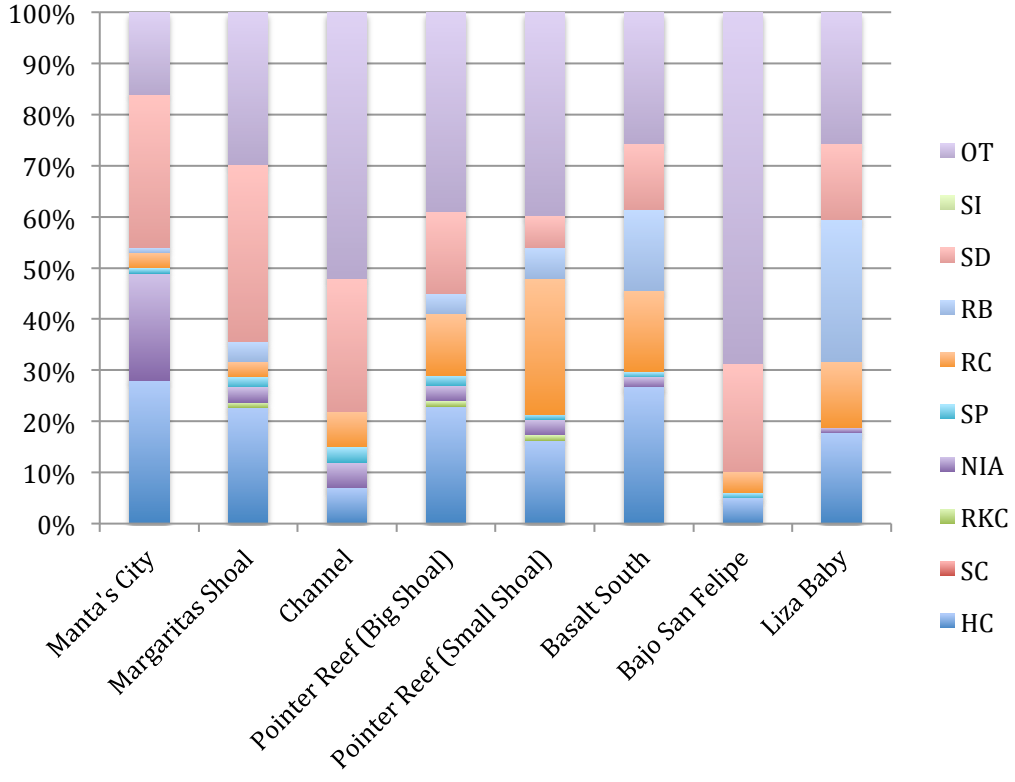

Figure 8. Percent substrate cover on OPSC reefs, 2012

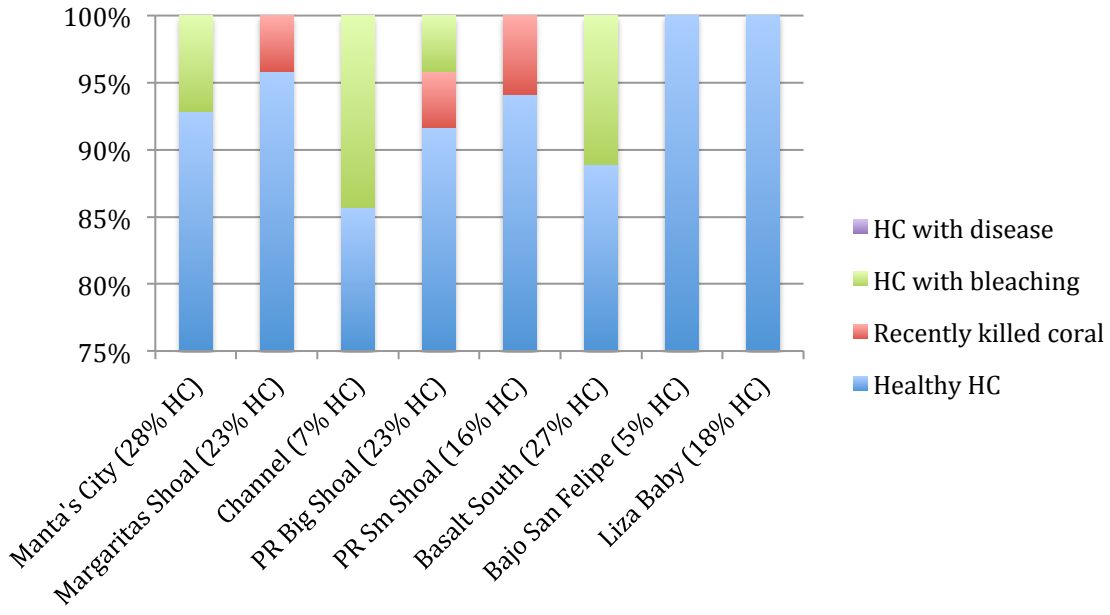

Figure 9. Hard coral condition on OPSC reefs, 2012.

3.2.3 Invertebrates

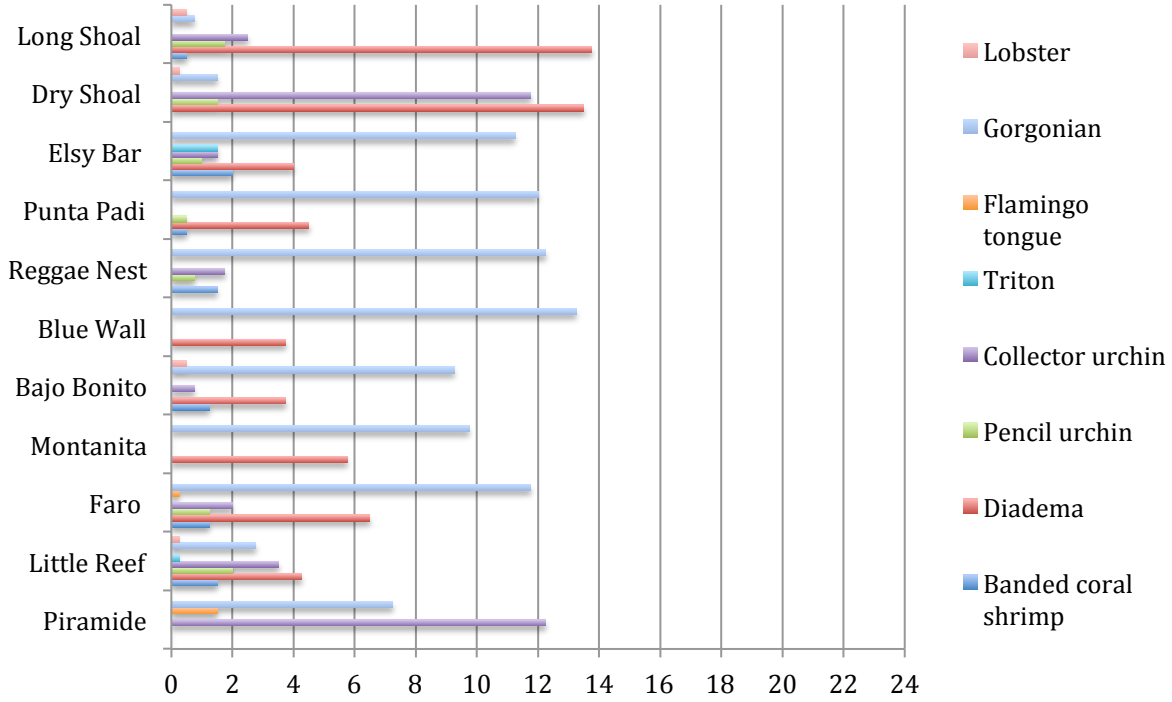

Figure 10. Reef Check invertebrate counts on San Andrés reefs, 2012 (average per 100m^2).

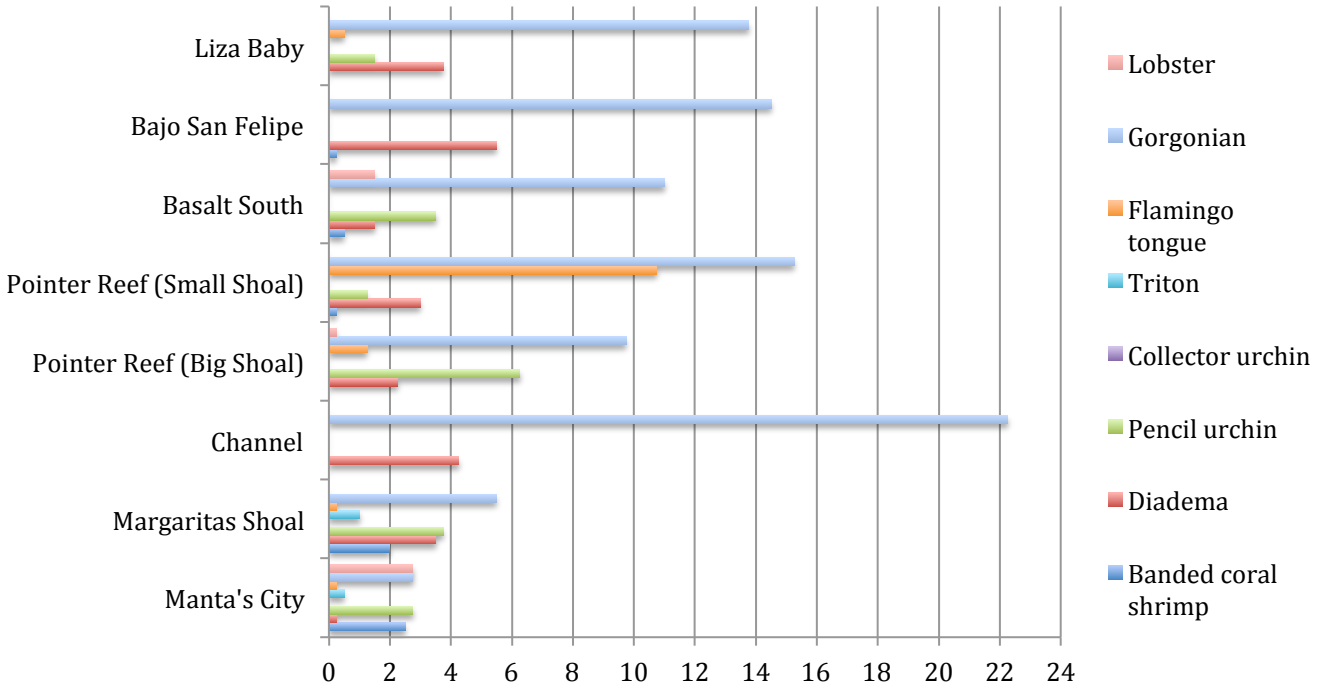

Figure 11. Reef Check invertebrate counts on OPSC reefs, 2012 (average per 100m^2)

3.2.4 Fish

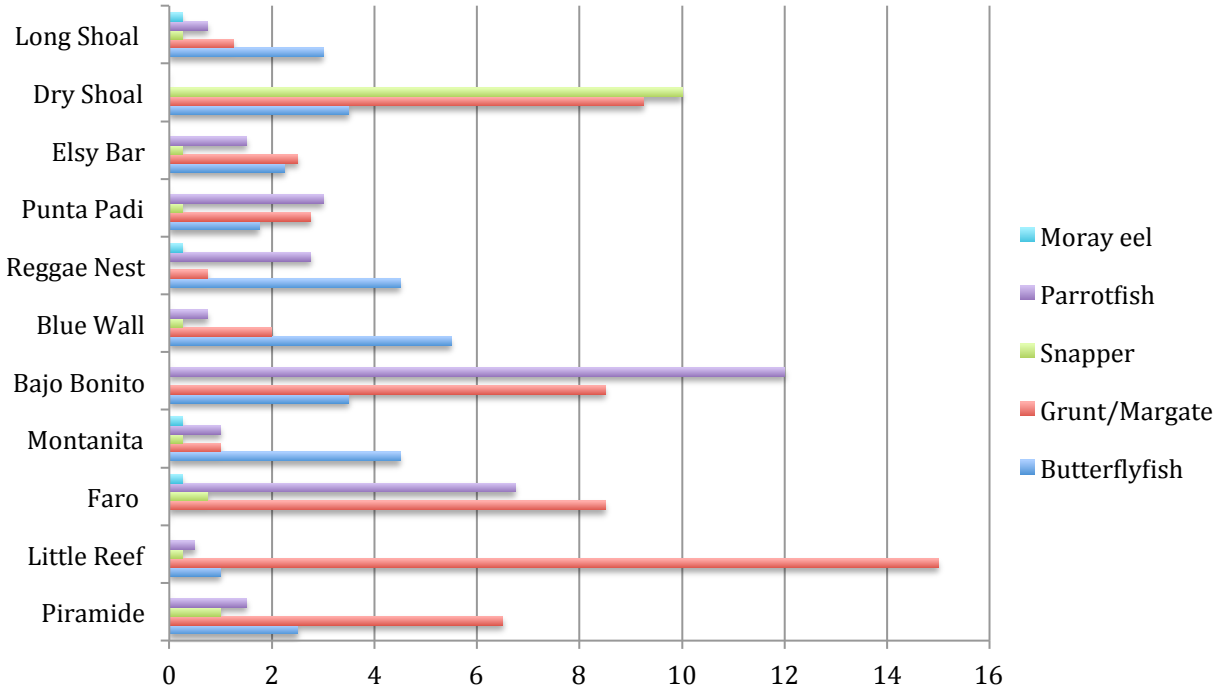

Figure 12. Reef Check fish counts on San Andrés reefs 2012 (average per 100m^2).

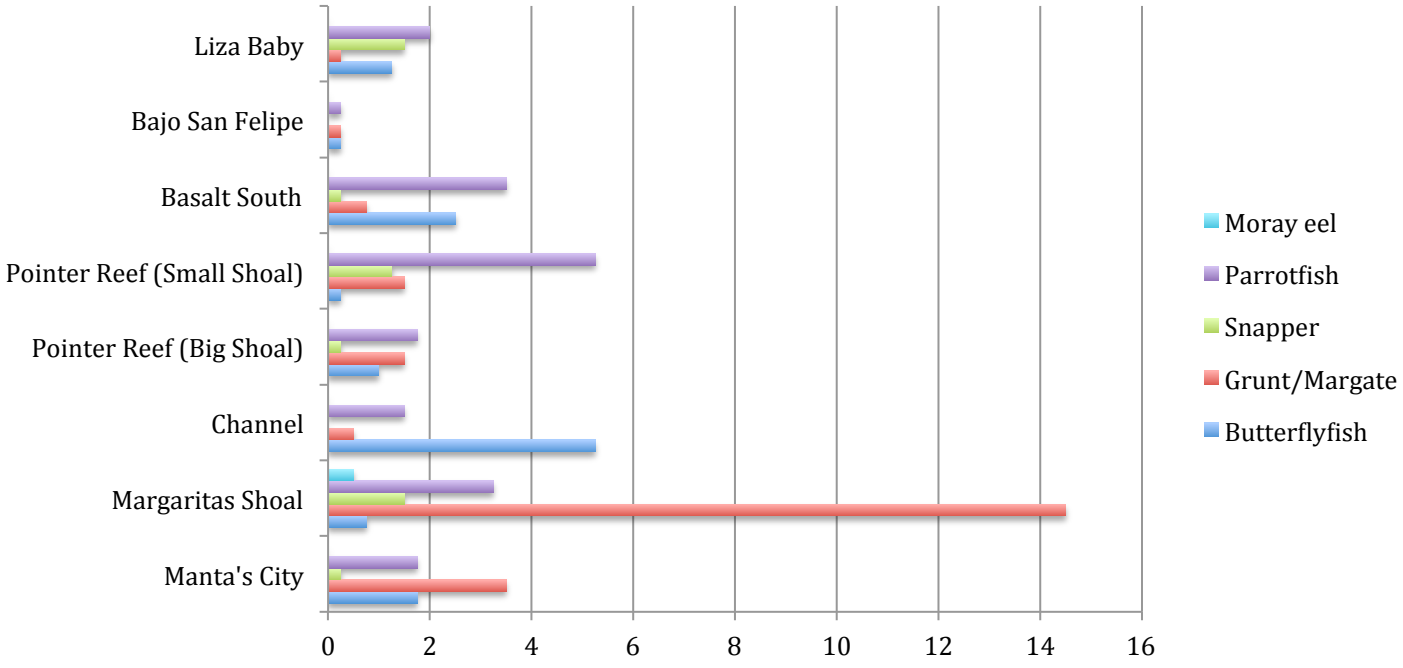

Figure 13. Reef Check fish counts on OPSC reefs 2012 (average per 100m^2).

4.0 Preliminary Discussion

Generally, the reefs of San Andrés and OPSC are in good condition, however over fishing was evident throughout the study. Grouper are a top predator fish, some reaching over a meter in length when they are full-grown. Their value as a food fish has led to high fishing intensity however slow growth and late maturity makes it very difficult for this species to recover. No grouper over 30cm were recorded at any of the 19 sample sites around San Andrés and OPSC, indicating that this species has been severely overharvested.

In 2002 Nassau Grouper, an endangered species, were found in only 8 of 162 reefs surveyed in the Caribbean region. A vast majority of the Nassau grouper spotted during those surveys (72%) were found on San Andrés and OPSC reefs (Hodgson & Liebeler, 2002). Ten years later, during these surveys, not a single Nassau grouper was recorded.

Assembling historic data for San Andrés and OPSC reefs proved difficult. Monitoring has been inconsistent and some records have been lost. Results from San Andrés reefs during these surveys have been averaged and compared to data collected by Nacor Boleanos during eight survey sites in 2000, seven in 2002 and two in 2007 (Figure 14). In general fish counts, especially indicators of overfishing (Grunt, Snapper, Parrotfish), have declined since 2000. More data is required to expand on this analysis. Morays were not included in these comparisons because they were not part of Reef Check surveys in 2000 and 2002.

Figure 14. Mean Reef Check fish counts on San Andrés reefs 2000-2012 (average per 100m^2).

Among OPSC reefs, historic data was only available for two sites: Channel and Bajo Bonito, compiled by Santiago Posada for CORALINA in 2002 (Figure 15 & 16). On these two reefs there is a marked decrease in indicator fish stocks between 2002 and 2012. Unfortunately, data for the intervening years were not available.

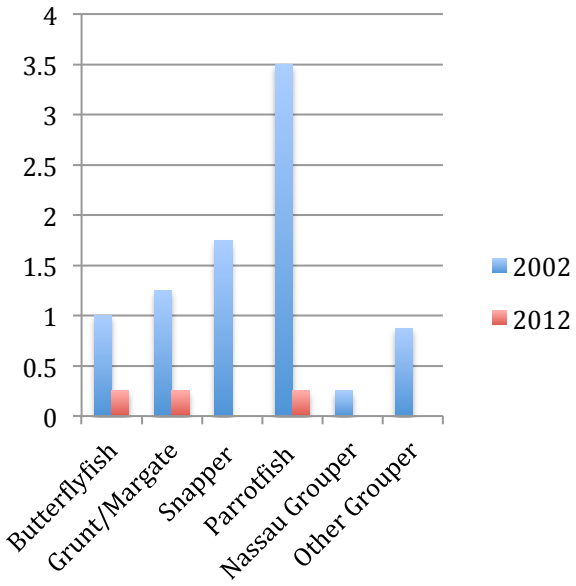

Figure 14. Reef Check fish counts for Bajo San Felipe, OPSC (average per 100m^2): 2002 & 2012.

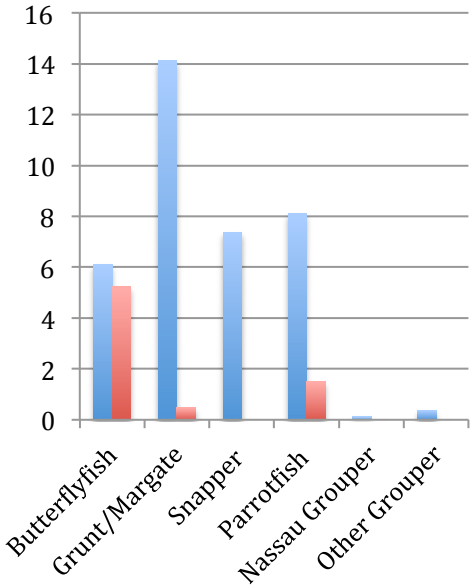

Figure 15. Reef Check fish counts for Channel Reef, OPSC (average per 100m^2): 2002 & 2012.

Invertebrate counts show similar results, however there is a slight increase for most species between 2007 and 2012. This may indicate that the creation of the Seaflower MPA (2005) has provided refuge for invertebrate population recovery. The increase in Diadema, black spiny urchins, is particularly important to reef health. Diadema are among the "reef gardeners" who help prevent algae from out-competing hard corals. Gorgonians are the only group to show an increase at all sites between 2000 and 2012 (Figure 17, 18 & 19).

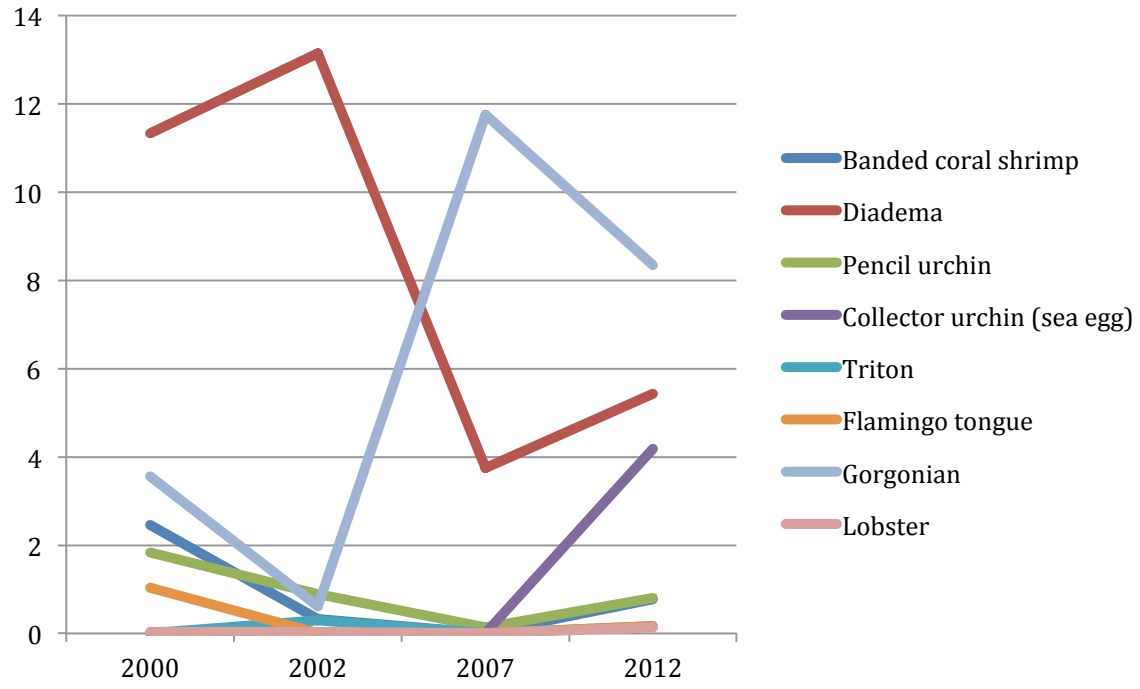

Figure 17. Reef Check invertebrate counts on San Andrés reefs 2000-2012 (average per 100m^2).

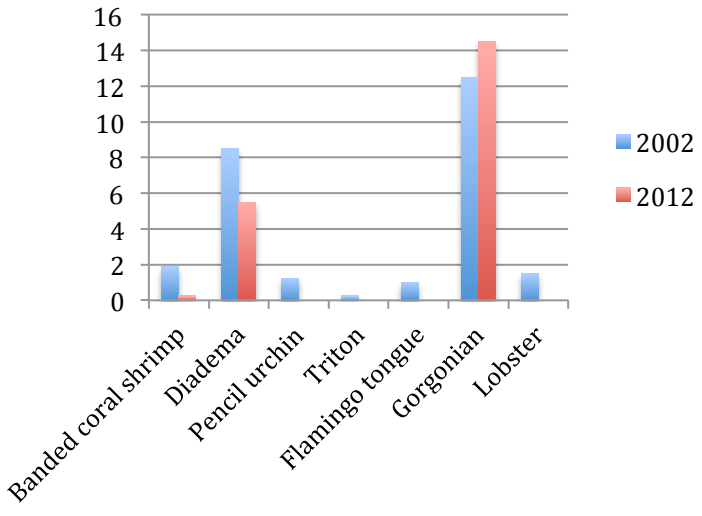

Figure 18. Reef Check invert. counts for Bajo San Felipe, OPSC (average per 100m^2): 2002 & 2012.

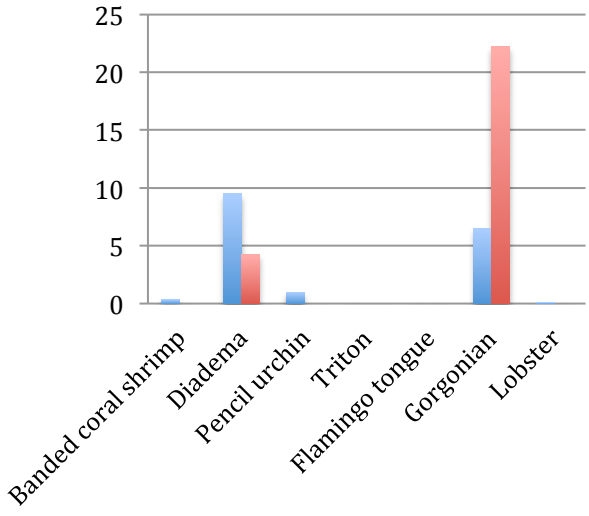

Figure 19. Reef Check invert. counts for Channel Reef, OPSC (average per 100m^2): 2002 & 2012.

Hard corals are the essential reef builders of these delicate ecosystems. Hard coral cover in the survey sites ranges from 5% to 35%. It should be noted that 100% coral cover is not the target for a "healthy" reef. Many of the healthiest reefs in the world have never had more that 30% hard coral cover (Hodgson & Liebeler, 2002). During the 1997-2002 global ReefCheck analysis period, Caribbean reefs fluctuated between an average of 20-30% hard coral cover (Hodgson & LIebeler, 2002). During our survey, most reefs fell between 18-35% hard coral cover. Four sites in San Andrés and two in OPSC recorded hard coral cover below 18% (Figure 6 & 8).

The lowest hard coral cover on San Andrés reefs was found at Blue Wall (8%) and Piramide (10%; Figure 6). Both sites were described as "high-use" by dive operators during interviews. Piramide also experiences extremely high boat traffic, and is the most frequently used site for new divers who are completing their PADI certification. Significantly, Piramide is also the site that is perceived as 'most damaged' by users. Substrate surveys at Piramide also recorded the third and fourth highest percentages of algae (22%), coral rubble (11%) and low invertebrate diversity (Figure 6 & 10). Zero lobster, triton, pencil urchin, Diadema urchin or banded coral shrimp were found at Piramide. Little Reef, which experiences the same high level of boat traffic, but very little diving or snorkeling, had a much higher percentage of hard coral cover (20%), and higher invertebrate diversity and density. However, Little Reef also had the highest percentage of algae cover (37%) of any site surveyed. Montanita, another site which is used frequently for new diver certification, has the highest hard coral cover of all San Andrés sites (35%) however that coral cover is affected by the highest incidence of bleaching for either island (18% of hard coral colonies are affected), low invertebrate diversity (only Diadema and gorgonians recorded) and low fish density (Figures 6, 7 and 10). A quick comparison of these three sites makes it clear that the impact of tourism traffic is not linear, nor is it easily divided by activity type.

In contrast with results from interviews and Reef Check surveys in San Andrés, the most used OPSC sites (Manta's City and Margarita Shoal) are also the ones that show high coral cover and healthy, diverse fish and invertebrate counts (Figure 8, 11, 13). While in San Andrés, the most used sites are also the most degraded (ex. Piramide), in Providence the general population and tourism market are still small enough that the best sites draw the most visitors without significant negative impact.

Channel Reef was the most frequently mentioned site when operators were asked about damaged coral, which is consistent with the Reef Check substrate results which show low hard coral cover (7%; Figure 1). Bajo San Felipe, the only site with less hard coral (5%), was also mentioned as a site where operators have noticed human impacts. Unfortunately, the most used dive sites (Turtle Rock, Felipe's Place) were not accessible for Reef Check surveys due to weather.

4.1 Further Analysis

This paper has presented preliminary results and discussion. Further comparison and statistical analysis of differences between sites, islands and over time will be conducted in order to provide the most useful analysis of marine tourism impacts for MPA management. Information from REDCAM water quality monitoring and population dynamics will also be incorporated. Activity maps created during tourism operator interviews will be combined using GIS software to provide an accurate picture of tourism and watersports in the Seaflower MPA.

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