Examining the impacts of marine tourism in the Seaflower MPA of San Andrés, Colombia

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ABSTRACT

San Andrés attracts roughly 400 000 tourists annually to white sand beaches and coral reefs. The island sits within the Seaflower Marine Protected Area, which covers 75% of Colombia's coral reefs, including the western Caribbean biodiversity hotspot and provides habitat for 192 IUCN red list species. A study of marine tourism was requested by MPA managers to support policy, monitoring and enforcement decisions. This paper uses quantitative and qualitative information on tourism activity types, user density and coral reef condition to provide baseline information on the local tourism industry and its relationship with shallow reefs. Data was collected through interviews with marine tour operators and shallow reef transects following Reef Check protocols.

There are up to 3700 visitors on the water every day during the high season, including SCUBA divers, snorkelers, kite surfers, sail boats, cruise ships, etc. It is clear that the impact of tourism is not linear nor is it easily divided by activity type. However spatial and historical analyses indicate that San Andrés reefs have been significantly changed by tourism development. High traffic areas showed lower hard coral cover, increased algal growth, increased coral rubble and low invertebrate diversity. This research offers valuable insight into where managers should focus time and resources. Speed-boat operators carry the vast majority of tourists, and represent a high impact community who could be targeted with environmental education campaigns. The highest traffic and highest damage area occurs in the San Andrés Bay, an area that would benefit from increased vigilance and enforcement of no-entry zones. Tourism policy recommendations suggested and supported by many operators during interviews include limiting speed-boat and jet ski permits, and establishing activity-specific regulations (ex. PWC best practices).

This paper represents a baseline study, providing a platform for additional research. Further historical and comparative analyses are required to understand the area more completely.

Figures

Terms & Acronyms

CAR	Regional Autonomous Corporation (Colombian environmental governing body)
CORALINA	Corporation for the Sustainable Development of the Archipelago of San Andrés, Providence and Santa Catalina
GIS	Geographic Information System
MPA	Marine Protected Area
OPSC	Old Providence and Santa Catalina
PADI	Professional Association of Diving Instructors
PWC	Personal water craft; includes Jet-skis, Wave-Runners

1.0 Introduction

1.1 Overview

Over 350 million people around the world depend on reefs directly for food and other ecosystem goods and services. However, while coral cover worldwide is declining, reef visitation is increasing significantly (Bell, Needham & Szuster, 2011). Coastal communities around the world are facing the same challenge: achieving a balance between development and conservation (Hodgson & Liebeler, 2002).

The Seaflower Marine Protected Area was created in 2005, and is currently 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 et al., 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 highly endemic reef communities (Rodriguez-Ramirez, 2008; Friedlander et al., 2003; Baine et al. 2007).

Protected areas, defined by the IUCN as "a clearly defined geographical space, recognized, dedicated and managed … to achieve the long term conservation of nature with associated ecosystem services and cultural values," cover only 20% of

Caribbean reefs however these areas attract roughly half of all the diving activity and related marine tourism (WRI, 2004; Dudley, 2008). San Andrés Island brings in roughly 400 000 visitors annually to experience the white sand beaches and coral reefs of the Seaflower Marine Protected Area (Secretaria de Turismo, 2011). Tourism, if properly managed, may offer a promising opportunity to blend profit and preservation.

This paper examines marine tourism density, frequency, activity type and the quality of information given to visitors. These measures of marine tourism are compared spatially with reef condition through ArcMap GIS software for the San Andrés region. Historical Reef Check data from San Andrés and the neighbouring islands of Old Providence are also compared to demonstrate change over time and comparative analysis between San Andrés and other reefs in the region.

1.2 Purpose

This research was requested by the Seaflower MPA in the San Andrés Archipelago to support ecosystem management decisions. Before this study, there was no data collected on tourism activity mapping or the quality of information provided to visitors. This study also contributes to a more complete view of reef condition throughout the archipelago and offers a preliminary examination of the relationship between marine tourism and reef health for the area. Examining tourism activity patterns and possible relationships between coral conditions, user density and activity type allows MPA managers to make informed decisions on

zoning enforcement, sustainable tourism planning and activity-specific management and policy building.

1.3 Research Question

This study focuses on the question: Can we identify the impacts of marine tourism based on activity type or user density? To answer, this paper examines marine tourism density, frequency, activity type and the quality of information given to visitors before they enter the Seaflower MPA.

2.0 Literature Review

2.1 Coral Reefs in Crisis

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 et al., 2003; Souter & Linden, 2000). However, these incredible ecosystems are facing a life-threatening suite of direct and indirect anthropogenic impacts. Inland run-off (sediment, toxins and nutrient loading), coastal development, and over-fishing are among the many ways human activities are 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 anthropogenic carbon dioxide emissions have led to increases in coral disease, incidence of coral stress, and rising frequency and severity of coral bleaching events (Bellwood et al., 2004; Brander et al., 2007; Cesar et al., 2003; Keller et al., 2009).

According to the Reefs at Risk Threat Index created by the World Resource Institute, almost two-thirds of Caribbean reefs are currently threatened directly 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 (WRI, 2004). The main pollution related threats to Caribbean waters

are oil spills, untreated sewage and domestic solid waste (Gavio et al., 2010). More 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 et al., 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 et al., 2007). Extensive and often site-specific study is required to further understand the interactions between human populations and coral reefs.

2.2 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). However, as Brander et al. (2007) point out, 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.

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 Resource 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 continued 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).

2.3 Marine Tourism

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 economies with roughly 400 000 visitors documented by the San Andrés airport annually (Secretaria de Turismo, 2011). Unlike the international tourism market on most Caribbean islands, however, the San Andrés Archipelago almost exclusively serves Colombian nationals on all-inclusive "sun & sand" vacations (Baine et al., 2007). Large-scale tourism often accompanies income inequality, pollution and coral damage through direct tourist contact, anchor damage and sedimentation. Well managed and targeted eco-tourism may offer lasting economic benefits and stimulate conservation efforts (Allison et al., 1998; Diedrich, 2007; Graham et al., 2011).

2.4 Seaflower Marine Protected Area

The creation of this protected area faced unique challenges. San Andrés, the largest island in the archipelago at 27 km^2, currently holds a population estimated to surpass 80 000 (Figure 1). Conservative estimates put population density at 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 native islanders (descendants of enslaved settlers of the archipelago who maintain an African and Anglo-Puritan culture) and mainland Colombians (Friedlander et al., 2003).

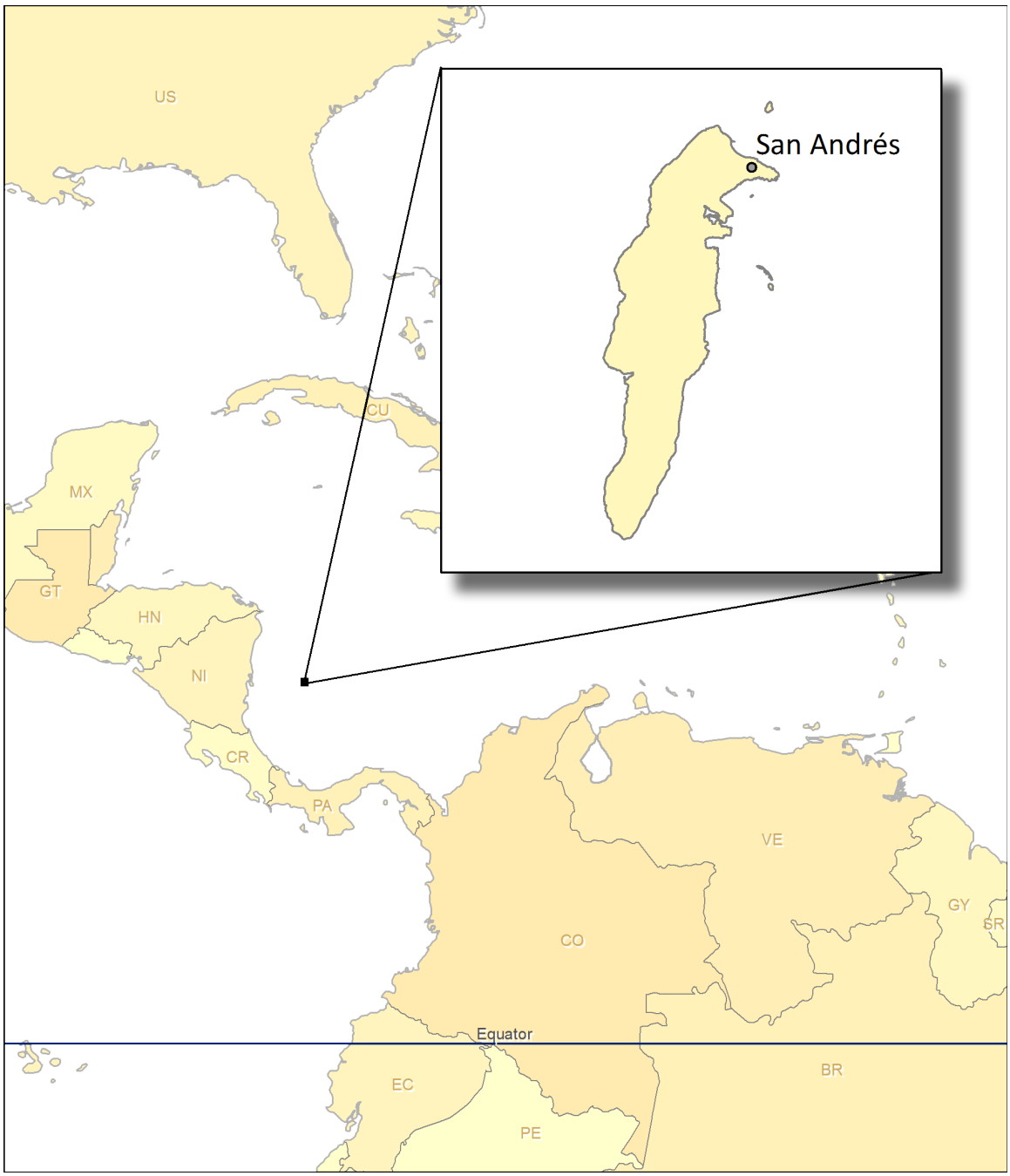

Figure 1. San Andrés Island.

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 within a few short years. 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 simultaneously struggling with social inequalities and an often tense cultural divide (Baine et al., 2007).

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).

OPSC 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, 2003). With a recorded population of 4 200 on the 18km^2 island of Providence, the density is a mere tenth of that seen in San Andrés (Howard et al, 2002; Baine et al., 2007). 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 around OPSC (Friedlander, 2003).

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).

Creating an effective protected area with high compliance in this social and economic climate requires robust community 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). Despite this recent attention to marine governance, most coastal development is still characterized by an 'open access regime,' with little long term planning and almost no attention to sensitive areas such as the shallow reefs, mangroves and sea grass beds (Baine et al., 2007).

3.0 Methods

3.1 Scope

The survey of tourism activities and watersports included leisure transport to nearby cays (Johnny Cay, Haynes Cay & Rose Cay in San Andrés; Crab Cay in OPSC), watersports (PWC, kite-surfing, wind-surfing, sunfish sailing, SCUBA, snorkeling), bay tours and cruises (including mangrove, sting ray and sport fishing tours). Swimming, beach use, leisure transport to distant cays (Bolivar & Albuquerque), and all subsistence or commercial fishing were excluded from the survey.

3.2 Tourism Operator Interviews

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 in-person with tourism operators in their work place. The first half of the interview collected tourist numbers, activity maps and reports of reef condition. These questions were approved by the Dalhousie College of Sustainability Ethics Review and CORALINA

MPA Project Coordinator, Fanny Howard. A second set of questions were delivered by CORALINA staff to collect stakeholder opinions on MPA management and enforcement. Participants were given the option of conducting the interview in Spanish or English. Simultaneous Spanish interpretation was provided by bilingual CORALINA staff members when required.

3.3 ReefCheck

Surveys were completed on shallow reefs around San Andrés and OPSC following Reef Check protocol and 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.

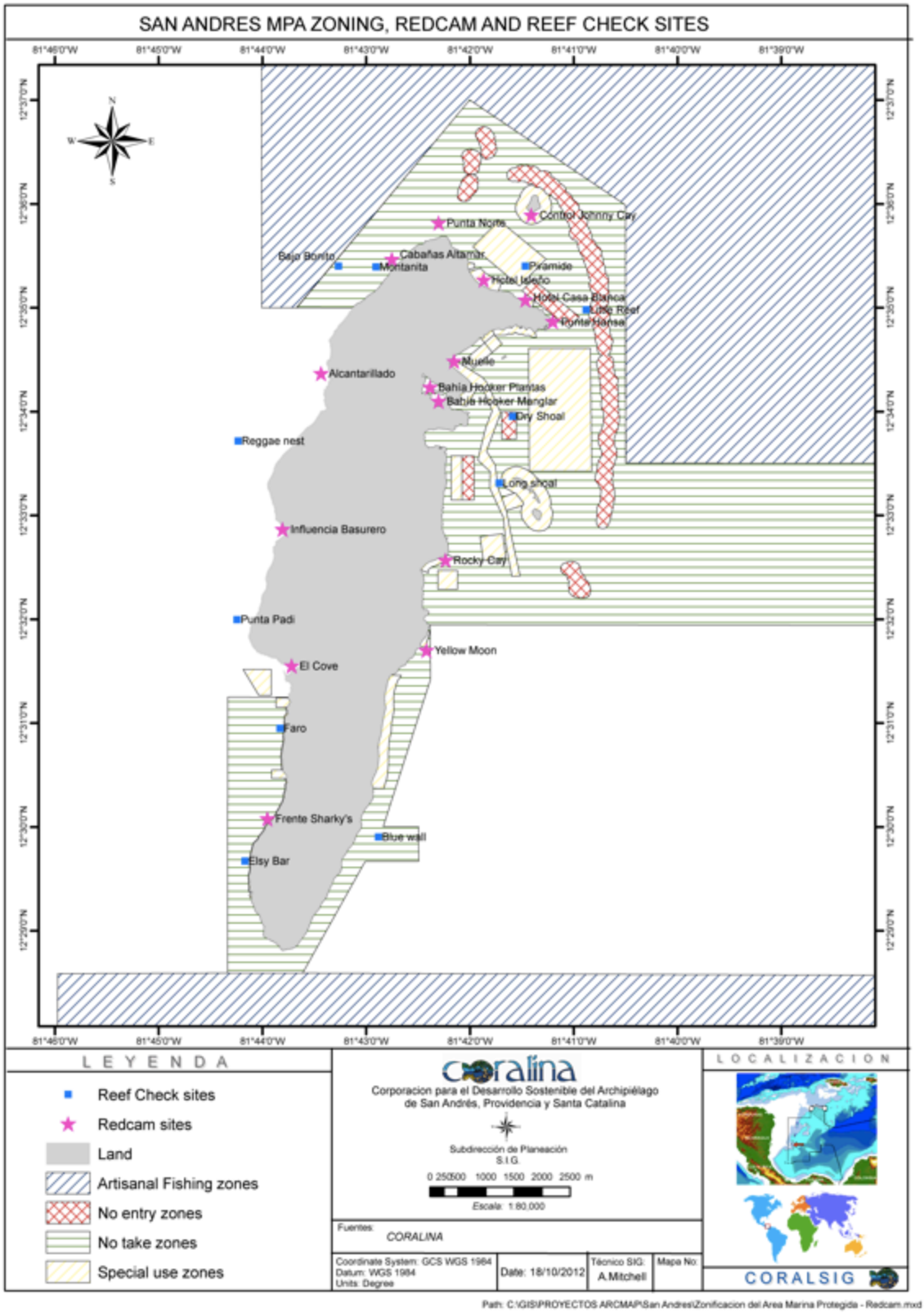

Figure 2. Reef Check survey sites around San Andrés, 2012.

In San Andrés, 11 survey sites were selected from reefs all around the island (Figure 2). The 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 PWCs (Jet-skis, Wave-Runners).

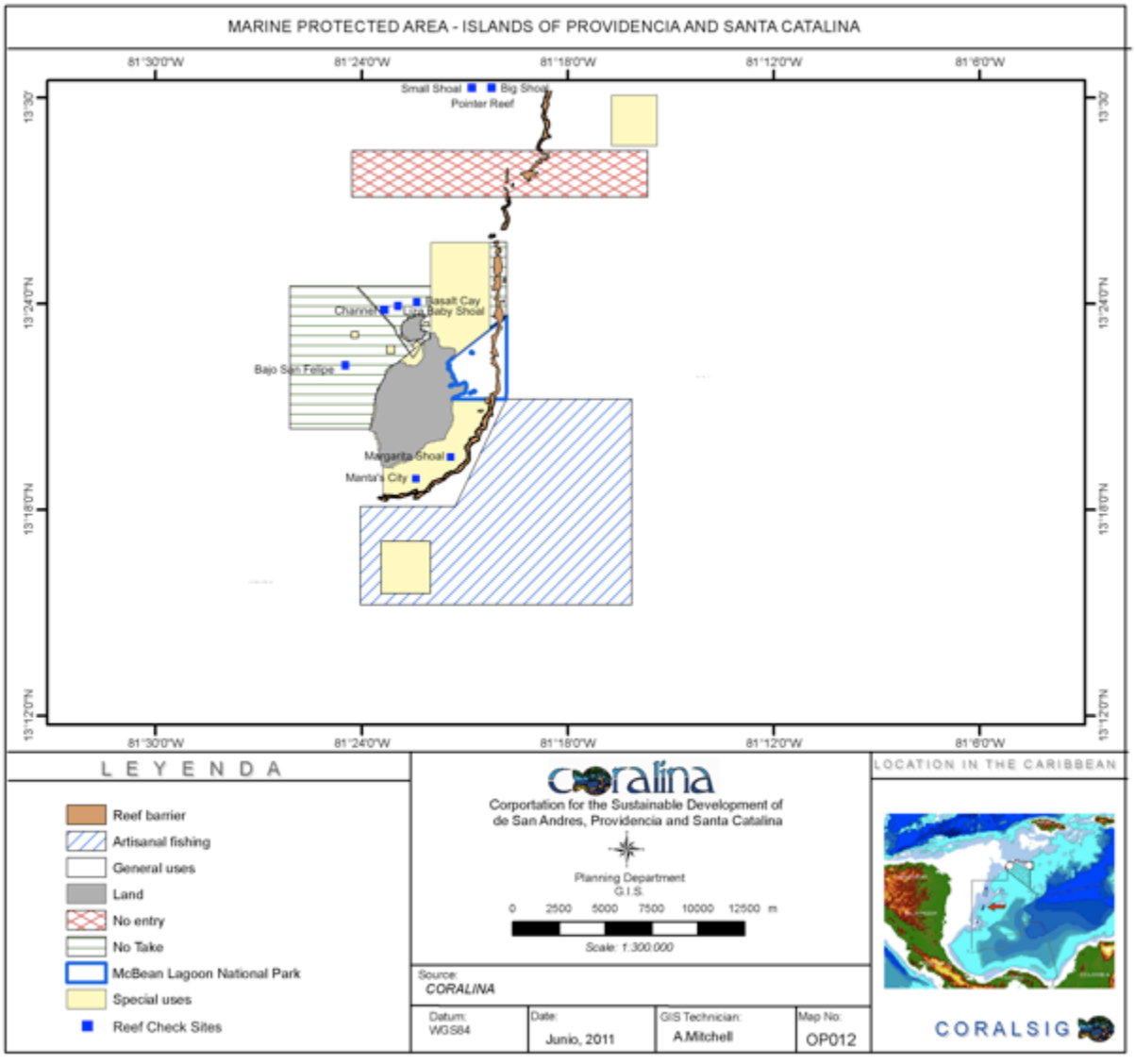

Figure 3. Reef Check survey sites around OPSC, 2012.

In OPSC, 8 sites were surveyed however weather conditions prevented surveys on the unsheltered South-West side of the island (Figure 3). The sites that were accessible were selected to provide data on sites used for SCUBA certification courses, general SCUBA diving and snorkeling tours.

3.4 Data Analysis in GIS

Operator generated activity maps from the interviews were scanned, geo-referenced and all tourism activity patterns were traced into ArcMap. Information on the number of daily users for each activity was also added to the spatial data set. All activities were mapped individually and converted into raster maps. Reef Check variables were imported into ArcMap using GPS coordinates collected during surveys and overlayed spatially with the tourism activity data.

Density maps indicating total visitors per day and total watercraft per day were also generated by merging all activity data. Interpolation of tourism density data was completed with the ArcMap natural neighbor function, which smooths the borders between high and low use areas without predicting values for unreported areas.

3.5 Limitations

Historical data on the condition of coral reefs within in the Seaflower MPA was difficult to assemble. Records have not been consistently updated and several

data sets have gone missing during staff turnover. As a result, this paper offers only a limited look at change over time for these reefs.

Spatial GIS analysis was completed for data collected around San Andrés Island. Information collected on reef condition and tourism activities in OPSC are used here for comparison, however the small sample size (only 6 tourism operators) and restrictions on time and resources prohibited full GIS analysis. Water quality information was not integrated into the study at this point, however efforts were made to make this addition feasible in additional research. San Andrés REDCAM water quality monitoring sites were mapped in relation to Reef Check survey sites (Figure 2) to simplify later amalgamation.

4.0 Results

4.1 Operator Interviews: San Andrés

Over a four-week period, 32 owners, managers or senior staff were interviewed from tourism businesses who operate directly in the Seaflower Marine Protected area around San Andrés. All known operators were reached. This included dive operators and various tour providers including a wide rage of watersports and leisure transportation. Operators identified "High season" as July-August, January-December and the week long Easter holiday. "Low season" spans the rest of the year.

Excluding swimmers and beach-goers, 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. During the high season, this figure more than doubles; according to operator estimates there are roughly 3 700 people on or in the water each day. The majority of visitors to the MPA are spending time on Johnny Cay and Acuario, although bay tours, PWCs, semi-submarine tours and diving are also popular activities.

Operators were asked whether they provide a user briefing or environmental information 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. Almost all tourism operators (27 of 32) report providing some kind

of information or responsible visitor guide to their customers, however fewer than half mention the existence of the Marine Protected Area or the Biosphere Reserve. 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 the reef. 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 invasive lionfish, discouraging dive gloves or information on conservation programs.

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 a snorkeling site, often part of semi-submarine tours and frequently entered by passing boats and PWCs.

The most frequently used dive site for new divers (certification or Discover SCUBA mini-courses) is Piramide, followed by 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.

When all activity types were mapped and layered, daily tourism traffic in San Andrés waters totaled almost 3700 visitors per day in the high season (Figure 4). Over 2000 of those visitors are concentrated in the San Andrés bay, mainly on water-taxis to Johnny Cay and Acuario, however the same region is also used by hundreds of visitors on cruise tours and PWCs (Figure 5).

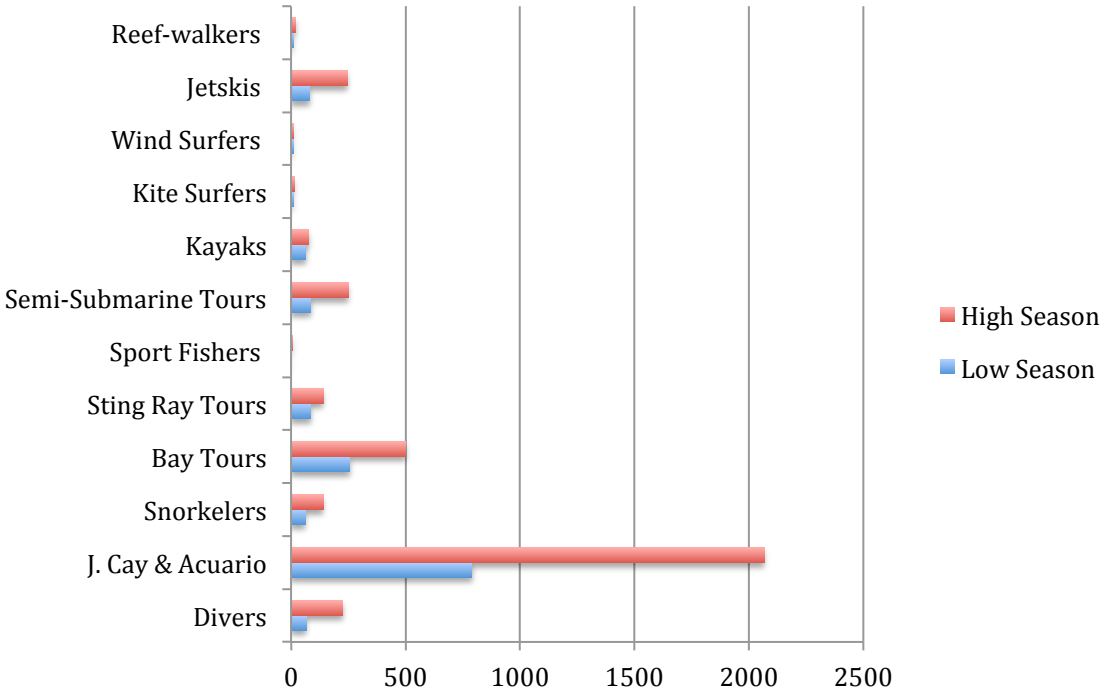

Figure 4. Tourism operator estimates of daily visitors according to activity type for San Andrés waters, for low and high season.

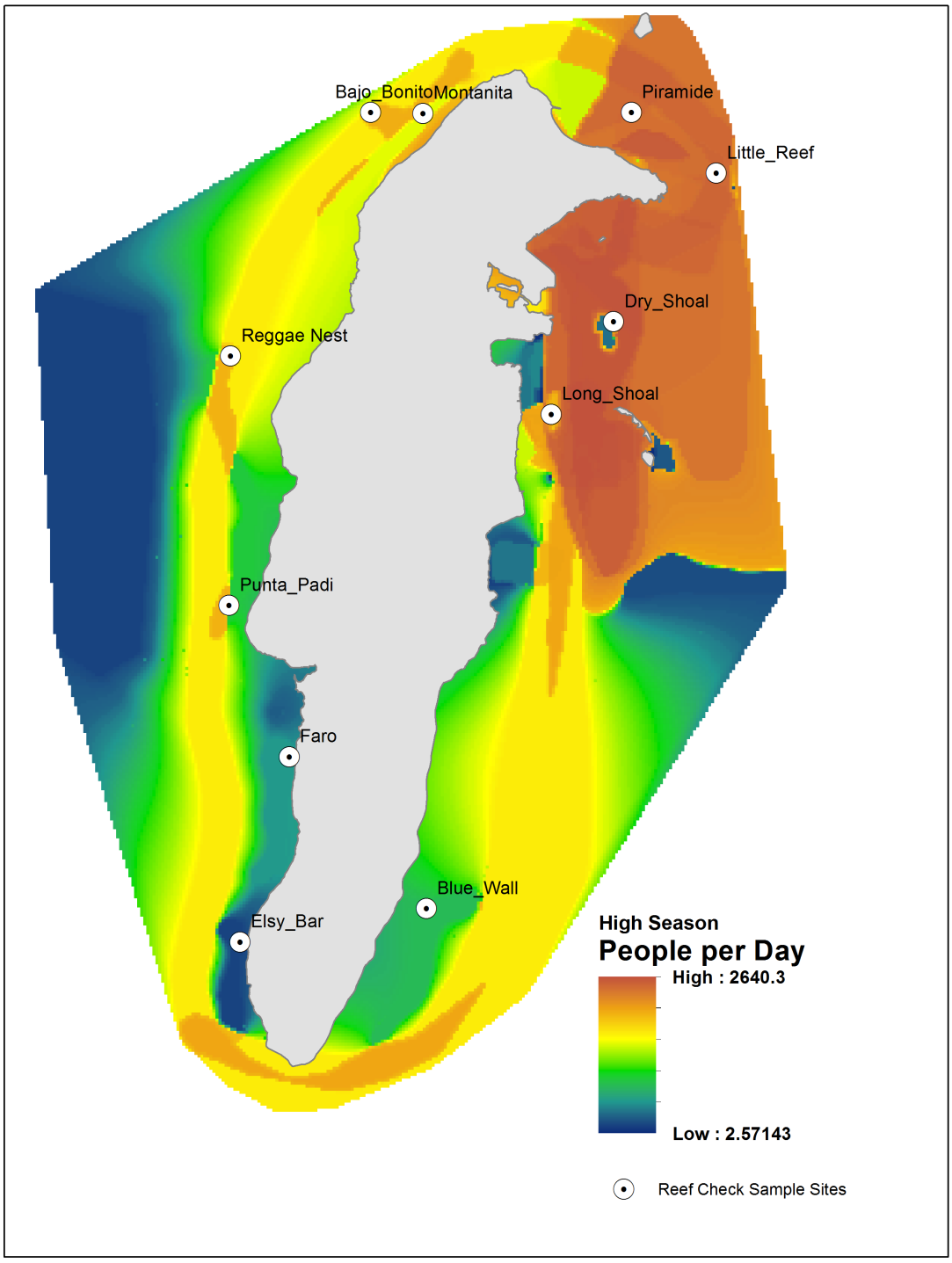

Figure 5. Tourism used density illustrated in people per day for San Andrés waters in the high season.

4.2 Operator Interviews: Old Providence and 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.

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 (Figure 3).

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.

4.3 Reef Check

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.

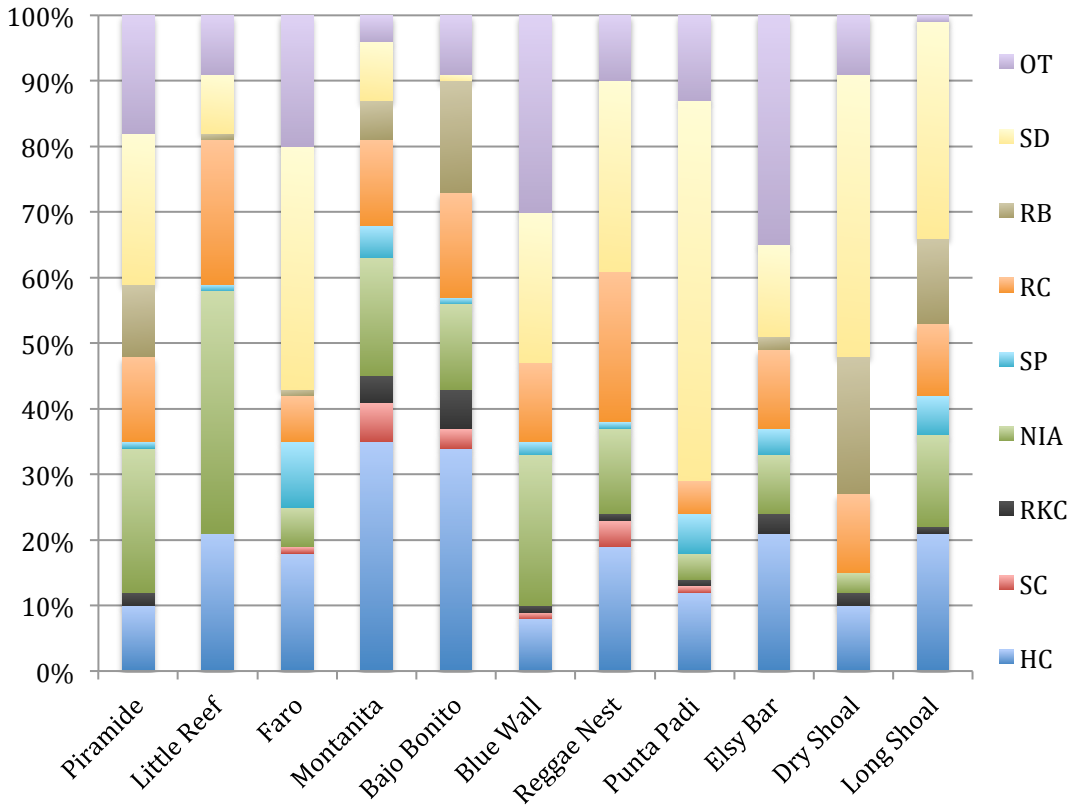

Figure 6. Percent substrate cover on San Andrés reefs, 2012

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.

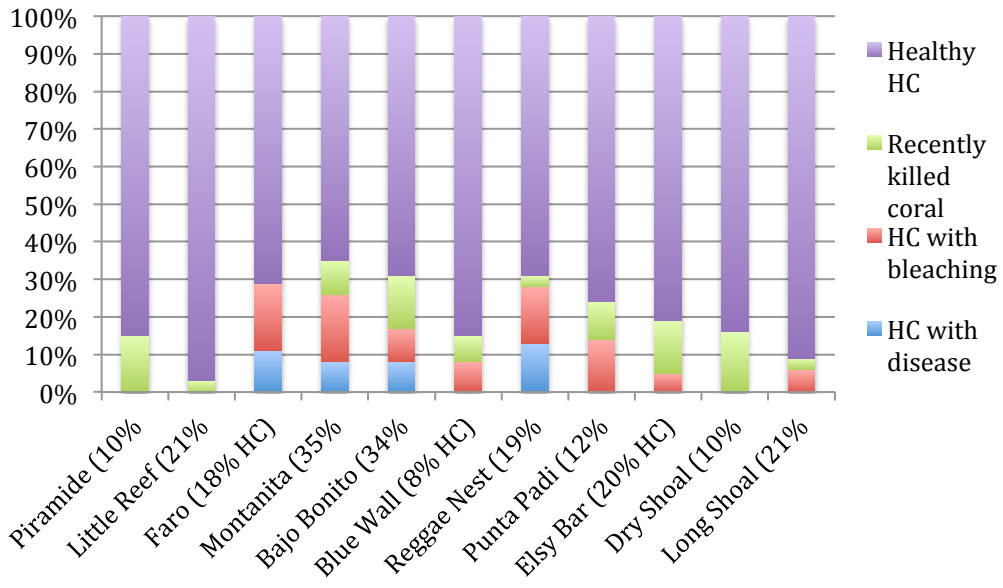

Figure 7. Hard coral condition on San Andrés reefs, 2012

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%; Figure 6) and low invertebrate diversity (Figure 8). Zero lobster, triton, pencil urchin, Diadema urchin or banded coral shrimp were found at Piramide.

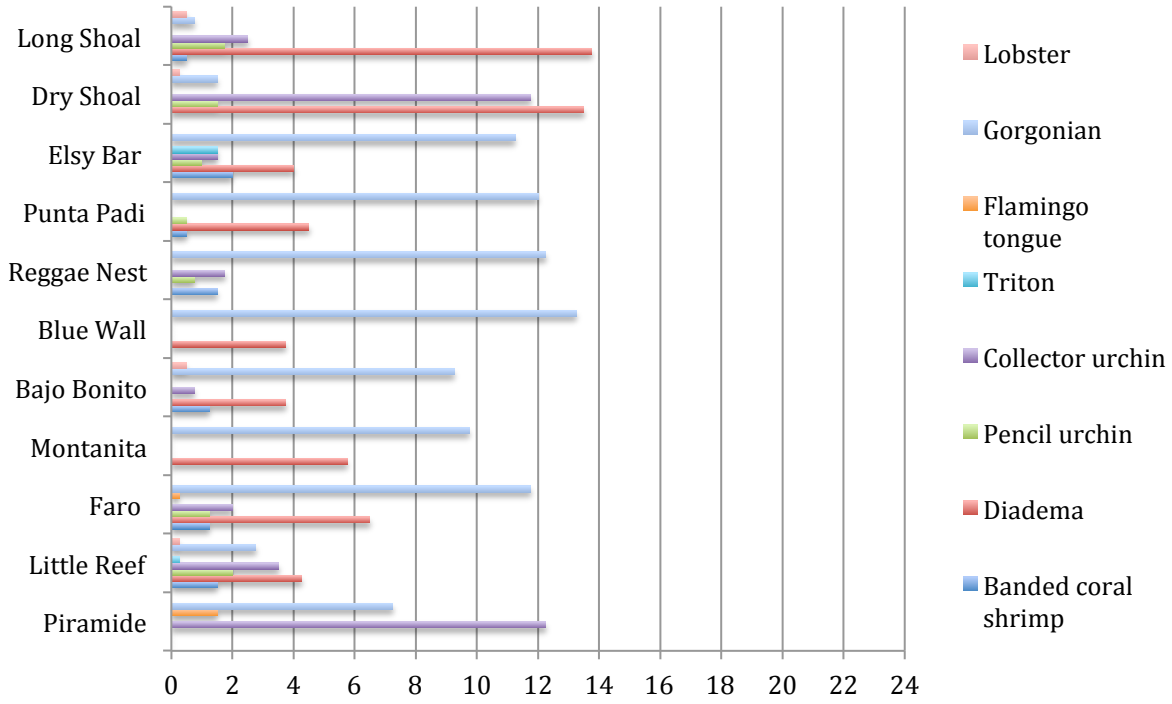

Figure 8. Reef Check invertebrate counts on San Andrés reefs, 2012 (average per 100m^2).

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; Figure 7), low invertebrate diversity (only Diadema and gorgonians recorded; Figure 8) and low fish density (Figure 9).

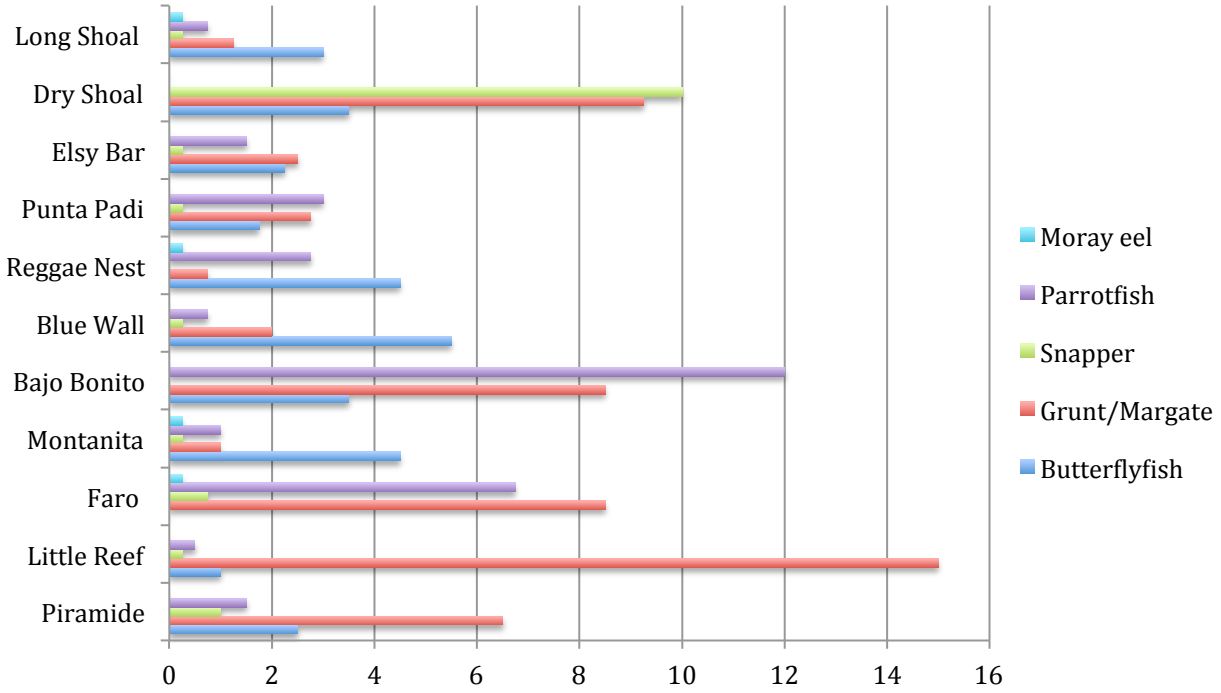

Figure 9. Reef Check fish counts on San Andrés reefs 2012 (average per 100m^2).

In OPSC, 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 8). Bajo San Felipe, the only site with less hard coral (5%), was also mentioned as a site where operators have noticed human impacts.

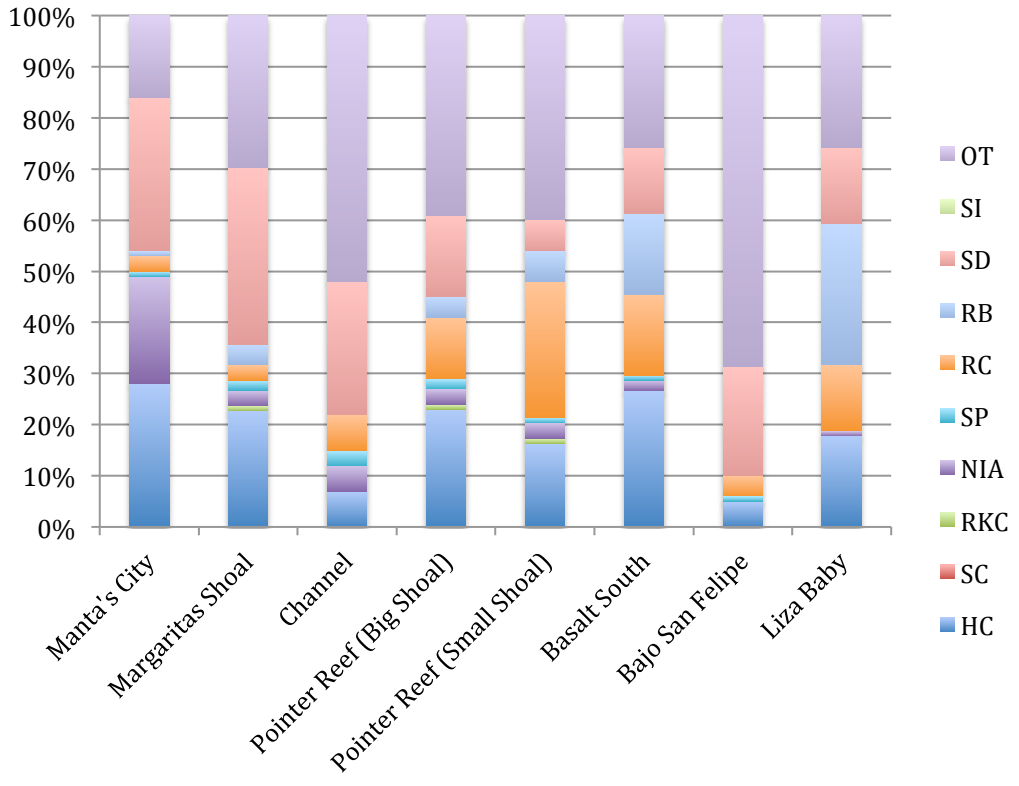

Figure 10. Percent substrate cover on OPSC reefs, 2012

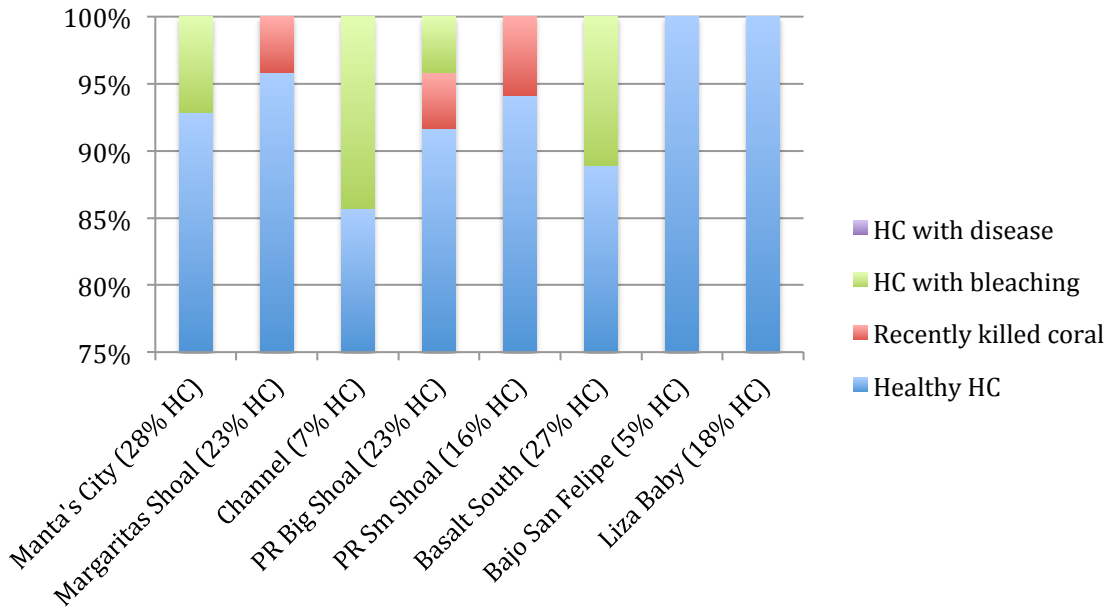

Figure 11. Hard coral condition on OPSC reefs, 2012.

Channel reef also showed very low invertebrate diversity; only Diadema urchins and gorgonians were recorded (Figure 12). This may be related to tourism (Channel was reported by operators as a high use area), invertebrate collection for food, or weather conditions at the time of survey.

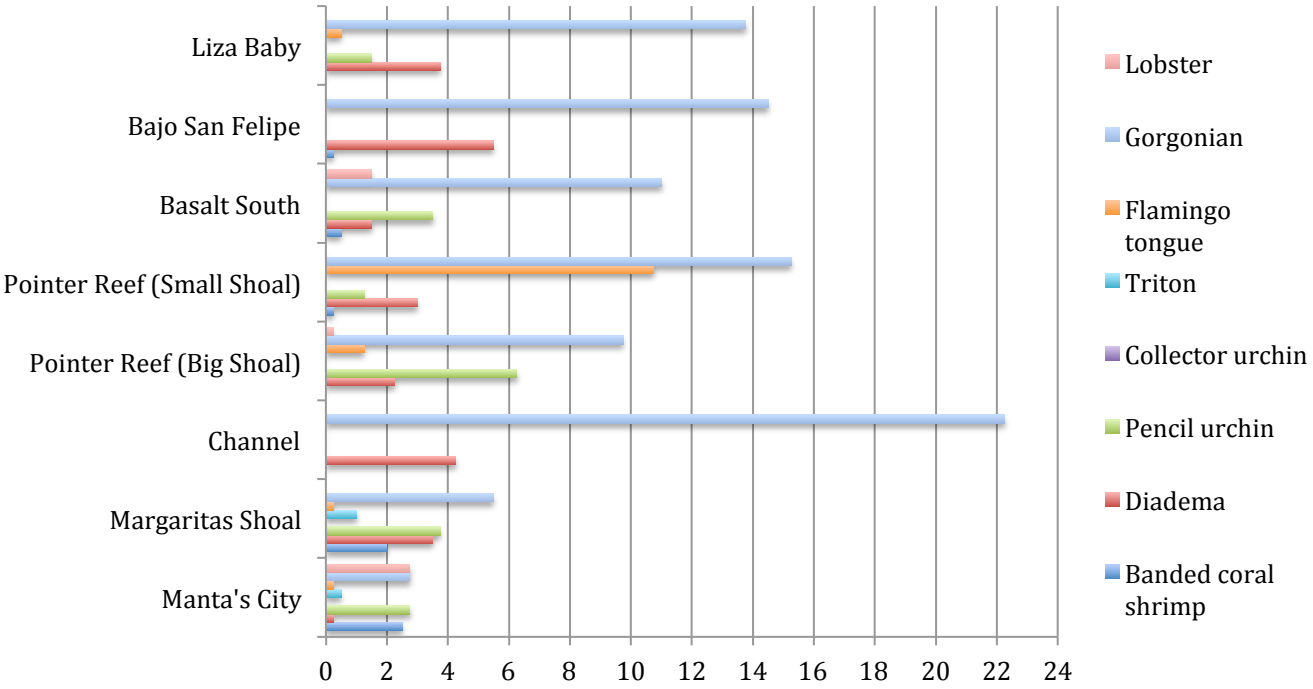

Figure 12. Reef Check invertebrate counts on OPSC reefs, 2012 (average per 100m^2)

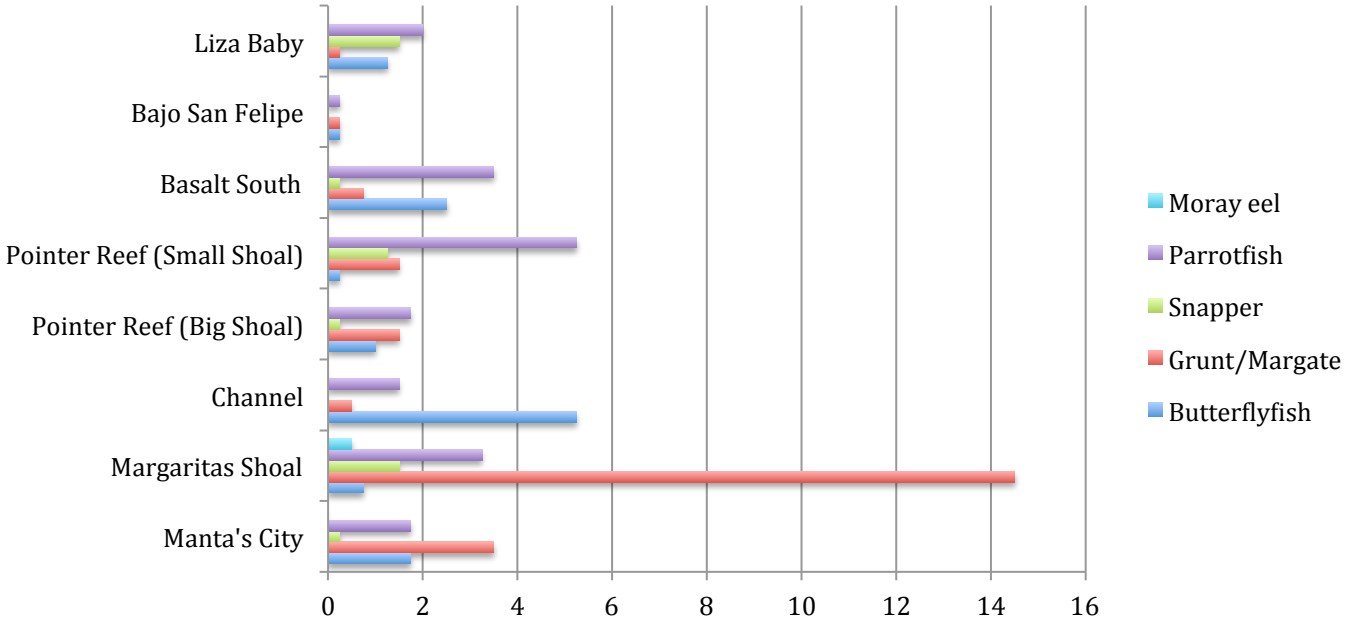

Figure 13. Reef Check fish counts on OPSC reefs 2012 (average per 100m^2).

5.0 Discussion

Generally, the reefs of San Andrés Island and OPSC are in good condition based on the indicator assessed in this study. However species decline, likely due to a combination of over-fishing and habitat degradation was observed throughout the study. Grouper are top predators, some reaching over a meter in length at maturity. Their value as a food fish has led to high fishing intensity and slow growth combined with late maturity makes it very difficult for this species to recover (Hodgson & Liebeler, 2002). No grouper over 30cm was recorded at any of the 19 Reef Check sample sites, indicating that this species has been severely overharvested in San Andrés Archipelago. Between 1997 and 2001 Nassau Grouper, an endangered species according to the IUCN Red List, were found in only 8 of 162 reefs surveyed in the entire Caribbean region. A vast majority of the Nassau grouper spotted during those surveys (76 of 106 total) were found on San Andrés and OPSC reefs (Hodgson & Liebeler, 2002). Ten years later, during this survey, not a single Nassau grouper was found during ReefCheck surveys in the area.

Spiny lobster were found at four San Andrés sites during the survey, at a density of only $0.13/100m^2 \pm 0.23$ (compared to $0.6/100m^2 \pm 0.69$ in 2001) suggesting that these species are also under pressure from over fishing. In this, San Andrés is not unique; overfishing has eliminated spiny lobsters from shallow reefs throughout Caribbean and Pacific reefs. In 2001, surveys on 83% of shallow reefs around the world recorded zero spiny lobster (Hodgson & Liebeler, 2002). Over the last decade Spiny lobster populations have decreased dramatically. It is likely that the loss of spiny lobsters to overfishing is exacerbated by high volume tourism. This

study suggests tourism is negatively impacting much needed spiny lobster reef habitat in the high traffic areas.

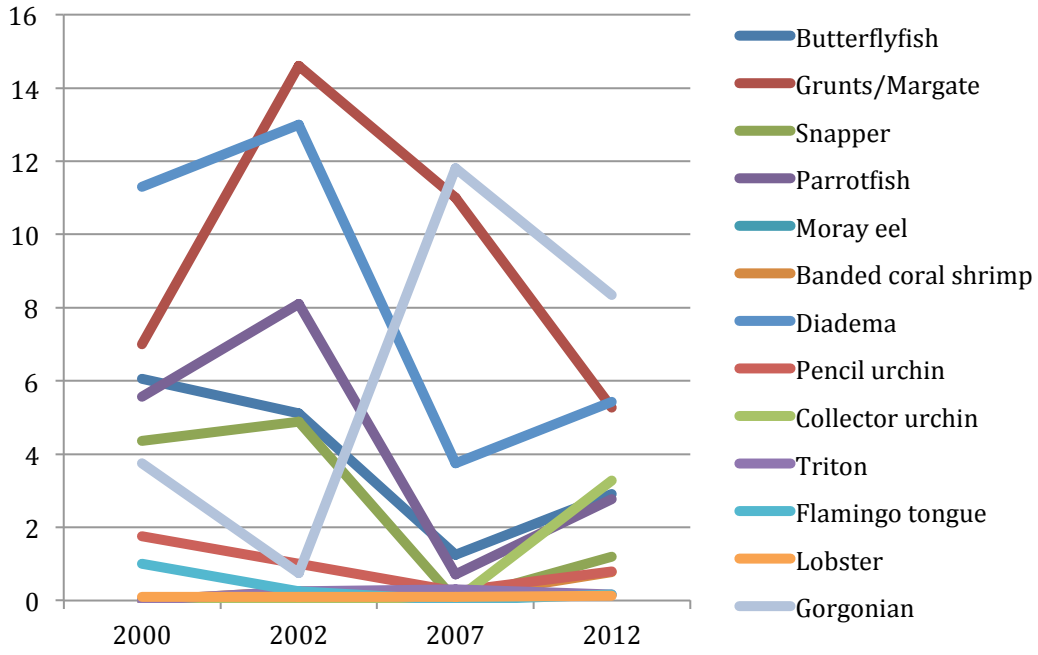

Figure 14. Species density (average per 100m^2) on San Andrés reefs in 2000, 2002, 2007, 2012; historical data provided by CORALINA.

Many species support the tourism industry in San Andrés. Parrotfish, with their large size and bright colours are popular among divers but they are also reef herbivores. Through algal grazing they prevent algae populations overtaking coral colonies and they produce white sand for nearby beaches. A single adult parrotfish produces about 90kg of sand every year (Thurman & Webber, 1984 p 446). Beach tourism is a major source of revenue for San Andrés. Almost 75% of tourists surveyed in 2011 said they would not be interested in visiting the island if there

were no beaches and almost 60% said they would not return if erosion reduced beaches by half (Castano, 2011). When reefs are subject to heavy fishing, predators like the now absent grouper are often fished out first, followed by herbivores like the parrotfish (Hodgson & Liebeler, 2002). Reef Check protocol only records parrotfish over 20cm in order to focus data collection on the reproducing, adult population. Parrotfish abundance in the Atlantic and Caribbean region declined between 1997 and 2001 from a high of 13.2 per 100 m^2 ± 24.0 in 1998 to a low of 5.1 per 100 m^2 ± 4.3 in 2001 (Hodgson & Liebeler, 2002). Data collection using the same methodology by CORALINA for 2000, 2001 and 2007 indicates a similar decreasing trend in parrotfish abundance (Figure 14). During our study, parrotfish over 20cm were recorded at a density of only 2.8 per 100m^2 ± 3.6 on San Andrés reefs. This suggests that the decline noted between 1997 and 2001 may have slowed slightly, however parrotfish are still being removed from the reef faster than they can be replaced. This is a serious cause for concern; reef herbivores are closely linked to reef health and reef resilience to global changes like ocean acidity and mass bleaching (Hughes et al., 2010).

Hard corals are the essential reef builders of these delicate ecosystems. Hard coral cover in the survey sites ranged 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 may have never had more that 30% hard coral cover. During the 1997-2002 global Reef Check analysis, 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 three in OPSC

recorded hard coral cover below 18% (Figures 7 & 11). This suggests that change over time is very site specific. Although average coral cover in the Archipelago is relatively stable, some sites (Piramide & Blue Wall in San Andrés; Channel Reef & Bajo San Felipe in OPSC) are well below historical averages. Coral disease rates are relatively low in the sample sites however White Band disease and Aspergillus are not uncommon in San Andrés. Based on this survey, about 9.5% of San Andrés coral colonies have been affected by recent bleaching.

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 (Figures 11, 12, 13). While in San Andrés, the most used sites are also the most degraded (e.g. Piramide), in Providence it seems that the general population and tourism market are still small enough that the best sites draw the most visitors without significant negative impact. Recently killed coral and coral rubble is low in about half the survey sites (1%-5%). A higher percentage (10%-23%) of dead and damaged coral was found in five of the shallower areas that experience a greater mix of activities, more new divers (certification and mini-courses) and higher boat traffic. Protected or not, however, reefs near heavily populated centres show reduced recovery rates after chronic or acute damage events (Graham et al., 2011).

5.1 Recommendations

During the interview process, many operators offered recommendations for CORALINA or highlighted challenges they see in the management of the Seaflower

MPA. Recommendations came mainly from dive shops, who are the most consistently engaged community in MPA enforcement or conservation projects. Only one tour operator and two watersports operators offered suggestions.

Recommendations included below are those of the author and combine interview and Reef Check results to provide practical suggestions for further MPA management. Eight recommendations are outlined, centered around three broad categories of education and outreach, reef rehabilitation, and MPA compliance and enforcement.

Education & Outreach

Recommendation #1: Visitor Awareness

Create standardized user briefings for operators to deliver to MPA visitors to increase awareness and understanding of conservation goals in the area.

Fewer than half of tourism operators explain to visitors that San Andrés sits within the Seaflower MPA or warn visitors not to litter while in the MPA. Only half of operators caution users to be careful of delicate coral.

> "Yes, 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."
>
> – Speed boat Operator

> "Yes, 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 explain that the area is under protection. It's hard though. Tourists are often indifferent 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!"

– Snorkel Tour Operator

"Yes, of course. We talk about 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 we have to anchor. "

– Dive Shop

Recommendation #2: Visitor Awareness

Increase educational and conservation material available to visitors. This may include signage at high-use beaches (Sprat Bight, Acuario, J. Cay) or brochures and posters at hotels or airport arrival gates.

"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."

– Snorkel Tour Operator

Recommendation #3: Operator Awareness

Investment of environmental education resources for speed-boat operators to Johnny Cay and Acuario. This group of operators accounts for the majority of marine traffic, interacts with the vast majority of MPA visitors and pass over shallow reefs (Piramide, Little Reef), hundreds of times every day. This a high impact group for CORALINA to target with environmental education resources.

Reef Rehabilitation

Recommendation #4: Recovery at Piramide Reef

Enforce closure of Piramide for coral recovery. Increase coral transplantation efforts during closure. Coral recovery should be monitored, and community members consulted to determine an appropriate length of closure period, no less than 6 months.

> "Right now, if I can, I stop all diving here (Piramide). 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."
>
> – Dive Shop

> "The problem over here (Piramide), it used to be healthy, but now we have the semi-submersibles, we have the PWCs, 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 Pyramide, LIttle Reef and the rest of the Trilogy. Those are very shallow reefs so there must be a way, some kind of demarcation because if you look right here, everyone is using the same place. You have wave runner rentals on both sides, you have two semi-submersibles that go right there and hundreds of boats running to Johnny Cay."
>
> – Dive Shop

> "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 semi-submarine go there, dive shop go there, snorkeling go there, everybody go there!"
>
> – Dive Shop

Enforcement & Compliance

Recommendation #5: Target Areas for MPA Enforcement

Increased patrols and enforcement for No-Entry & Special Use Zones (N, O) in the San Andrés Bay region, where activity is highest and damage to shallow reefs is the greatest.

> "You can be in Piramide with a group of beginners and there are boats and jet skis over head – that can be very dangerous. We need to decide if a site is a dive site and manage it that way."
>
> – Dive Shop

Recommendation #6: Stakeholder participation

Require monthly time donations from tour operators within the MPA.

CORALINA has supplied materials and extensive training to dive shops and the MPA supports all marine tourism. In return, they can make a small time commitment to support coral transplantation, lionfish hunting or mooring buoy maintenance.

> "We need some compromise though -- it's not fair that all the users are not active participants in management. That must be written somewhere. I am a dive centre, we should say to everyone, "Ok you have a dive centre in town? You have to spend at least 2 hours in coral transplantation or some kind of community work instead of going to the club and having a beer and talking about how good your diving is." Some compromise, so that everyone is working a little bit, instead of blaming everyone, we just need to get to work.
>
> – Dive shop

Recommendation#7: Limit watercraft licensing

Limit further licensing for tourist transport boats, water-taxis and PWCs.

Speedboats and small yachts transport of tourists, mainly to Johnny Cay and Acuario, make up the majority of tourism activity in the Seaflower MPA.

Speed boat activity presents the risk of anchor damage and propeller damage to benthic habitat and organisms, acoustic disturbance of birds and marine organisms (of particular concern for dolphins and other cetaceans) and pollution via fuel leak and solid waste left by visitors (Davenport & Davenport, 2006). In the Seaflower MPA, speedboat water taxis take up to 170 trips a day, mainly across the San Andrés bay to Johnny Cay and Acuario. This means disturbance is virtually continuous for organisms in this area. If managers can begin by limiting this activity, and perhaps reduce traffic through alternative livelihood and environmental education projects in the future, it will serve to reduce the heaviest tourism related pressure on shallow reefs in the region.

Recommendation: PWC best practices & standard operation requirements **Require standards of operation for PWCs within the MPA,** that may include but are not limited to:

- All PWCs must be accompanied by or driven by a local guide.
- Enforce MPA zones for PWCs and require operators to communicate zoning to tourists.
- Require operators to mark shallow coral in PWC areas to prevent grounding.

PWCs have been repeatedly observed and reported in restricted areas of the MPA, including shallow reefs and mangroves. Of the four PWC operators who participated in interviews, only one provides a guide who drives the PWC and one

has flags to mark shallow coral. The majority of PWCs are completely unrestricted and unguided, including the island's major PWC operator, who rents over 70% of the islands PWCs.

PWCs typically run on inefficient two stroke engines, which are unregulated for GHG emissions and release up to 30% of their fuel into the water during operation. These vehicles allow tourists to travel at very high speeds in shallow waters, however PWCs have very long stopping distances (up to 150m). This not only poses a threat to shallow corals, but also to turtles, dolphins, swimmers, and snorkelers who are sharing the water. In the USA, PWCs account for 40% of all boating accidents, and in Bermuda turtles deaths have been reported due to impact with PWCs and speed boats (Davenport & Davenport, 2006).

> "The elkhorn and brain corals are dying here. Sometimes there is gasoline in the water from the jet-skis. When I started, there were no jet-skis in the bay at all. The boats are always coming through this area too (points to no-entry buoys and marks them on the map). There is no policing, so they use this area every day. We see them fishing, and taking tourists sport fishing just off the beach here all the time."
>
> – Snorkel Tour Operator

> "The captain of the port and the coast guard have been talking about reducing activity on the main beach (near Casa Cultura) because there are too many boats and jet-skis-- the result is that more jet skis are coming down to the Rocky Cay beach. We are just moving the pressure, not solving any problems."
>
> – Watersports Operator

> "I think the jet-skis must have a leader, someone from the island and then the tourist follow … It is difficult to know where the channel is, these tourists do not know, they need a guide. These tourist people, they think the whole ocean is all the same. They end up on the shallow coral and crash! And little reef, here, is the love child of CORALINA. We work so hard on the transplants. And then here comes a jet-ski!"
>
> – Dive Shop

"The jet-ski users need to know more too – they have no guides, no leaders. It's not safe."

– Watersports Operator

6.0 Conclusion

Based on the results of this study, high volume tourism, as seen at Piramide and Little Reef, accompanies low coral cover, low invertebrate diversity, increased rubble and high algal cover. This may be the result of general stress from boat noise, pollution and diver interference. In the specific case of Piramide, high levels of rubble were observed within and around the study site. Tourism operator reports suggest that this is due to boat, PWC and semi-submarine groundings directly damaging the reef. These impacts contribute to habitat degradation and reduce the resilience of coral ecosystems to acute weather or anthropogenic events. However tourism is only one of many factors affecting coral reefs, and it would be shortsighted to imply that all changes that have occurred in San Andrés are the result of the tourism industry alone. In addition to global changes like rising temperatures and increasing ocean acidification, reefs in San Andrés are affected by an extremely dense population; sewage outfall, coastal development, terrestrial run-off, and overfishing are all current threats to these coral communities. However, results from OPSC reefs suggest that these communities are healthier and more resilient to some climate related pressure than San Andrés reefs. This suggests that, as presented in this research, the level of human activity is a key determinant in the integrity of the ecosystem.

This paper presents a baseline study and a platform for further research. Information on water quality, more comprehensive historical analysis and regional comparisons should be incorporated and efforts to provide a more detailed

exploration of coral reef resilience would be very valuable to manager decision-making.

7.0 Works Cited

Allison, G., Lubchenco, J., Carr, M. (1998). Marine reserves are necessary but not sufficient for marine conservation. *Ecological Applications, 8*(1), 79-92.

Baine, M., Howard, M., Kerr, S., Edgar, G., Toral, V. (2007). Coastal and marine resource management in the Galapagos Islands and the Archipelago of San Andrés: Issues, problems and opportunities. *Ocean & Coastal Management, 50,* 148-173.

Bell, C., Needham, M., Szuster, B. (2011). Congruence among encounters, norms, crowding and management in a Marine Protected Area. *Environmental Management, 48*, 499-513.

Bellwood, D., Hughes, T., Folke, C., Nystrom, M. (2004). Confronting the coral reef crisis. *Nature, 429,* 827-833.

Brander, L. M., Beukering, P. V., & Cesar, H. (2007). The recreational value of coral reefs: A meta-analysis. *Ecological Economics, 63*, 209-218.

Castano, J. (2011). Development of payments for ecosystem services. MA Thesis. Brandeis University. Print.

Cesar, H., Burke, L., Pet-Soede, L. (2003). The economics of worldwide coral reef degradation. (Technical Report). Cesar Environmental Economics Consulting, Holland.

Davenport, J., Davenport, J. (2006). The impact of tourism and personal leisure transport on coastal environments: A review. *Estuarine, Coastal and Shelf Science, 67*, 280-292.

Diedrich, A. (2007). The impacts of tourism on coral reef conservation awareness and support in coastal communities in Belize. *Coral Reefs, 26,* 985-996.

Dudley, N. (ed.) (2008) Guidelines for Appling Protected Areas Management Categories. IUCN: Gland, Switzerland. p.8-9. Retrieved from http://www.unep-wcmc.org/about-protected-areas_163.html.

Friedlander, A., Nowlis, J., Sanchez, J., Appeldoorn, R., Usseglio, P. McCormick, S., Bejarano, S., Mitchell-Chui, A. (2003). Designing effective Marine Protected Areas in Seaflower Biosphere Reserve, Colombia based on biological and sociological information. *Conservation Biology, 17*(6), 1769-1784.

Gallo, F., Martinez, A., Rios, J. (2001a). Carrying capacity for dive sites. (CORALINA Internal Document). Universidad Tecnológica de Pereira, Colombia.

Gallo, F., Martinez, A., Rios, J. (2001b). Effects of scuba diving on coral formations at San Andrés Island. (CORALINA Internal Document). Universidad Tecnológica de Pereira, Colombia.

Gavio, B., Cantillo, S, Mancera, J. (2010). Historical analysis (2000-2005) of the coastal water quality in San Andrés Island, Seaflower Biosphere Reserve, Caribbean Colombia. *Marine Pollution Bulletin*, *60,* 1018-1030.

Graham, N. A. J., Nash, K. L., & Kool, J. T. (2011). Coral reef recovery dynamics in a changing world. *Coral Reefs, 30,* 283-294.

Hodgson, G., & Liebeler, J. (2002). The global coral reef crisis: 5 years of ReefCheck. California: ReefCheck Foundation.

Howard, M., Connolly, E., Taylor, E., Mow, J. (2002). Community-based development of multiple-use Marine Protected Areas: Promoting stewardship and sharing responsibility for conservation in the San Andrés Archipelago, Colombia. *Gulf and Caribbean Research, 14*(2), 155-162.

Howard, M., Taylor, E., Charis, S., Taylor M., Prada, M., Penaloza, V, Hawkins, E., Garcia, M., Heron, P., Mitchell, A., Hudgson, R. (2007). The community-based zoning process to establish the Seaflower Marine Protected Area, San Andrés Archipelago, Colombia. *Gulf and Caribbean Fisheries Institute, 59,* 437-444.

Hughes, T., Graham, N., Jackson, J., Mumby, P., Steneck, R. (2010). Rising to the challenge of sustaining coral reef resilience. *Trends in Ecology & Evolution, 25* (11), 633-642.

Keller, B., Gleason, D., McLeod, E., Woodley, C., Airame, S., Causey, B., Friedlander, A., Grober, Dunsmore, R., Johnson, J., Miller, S., Steneck, R. (2009). Climate change, coral reef ecosystems and management options for Marine Protected Areas. *Environmental Management, 44,* 1069-1088.

Martinez, M., Intralawan, A., Vazaquez, G., Perez-Maqueo, O., Sutton, P., Landgrave, R. (2007). The coasts of our world: Ecological, economic and social importance. *Ecological Economics, 63,* 254-272.

Mow, J., Taylor, E., Howard, M., Baine, M., Connolly, E., Chiquillo, M. (2006). Collaborative planning and management of the San Andrés Archipelago's coastal and marine resources: A short communication on the evolution of the Seaflower marine protected area. *Ocean & Coastal Management, 50,* 209-222.

Mow, J. M. M., Taylor, E., Howard, M., Baine, M., Conolly, E., & Chiquillo, M. (2007). A

short communication on the evolution of the Seaflower marine protected area. *Ocean & Coastal Management, 50,* 209-222.

Rodriguez-Ramirez, A., Bastidas, C., Cortes, J., Guzman, H., Leao, Z., Garzon-Ferreira, J. … Sanchez, J. (2008). Status of coral reeds and associated ecosystems in southern tropical America: Brazil, Colombia, Costa Rica, Panama and Venezuela. Global Coral Reef Monitoring Network. Retrieved from http://www.gcrmn.org/ publications.aspx.

Secretaria de Tourismo. (2011). Comparativo turistas nacionales llegados enero-julio 2011 vs 2010. Gobernacion Archipelago de San Andrés y Santa Catalina. Unpublished.

Souter, D., Linden, O. (2000). The health and future of coral reef systems. *Ocean & Coastal Management, 43,* 657-688.

Thurman, V., Webber, H. (1984). *Marine Biology*. Columbus Ohio: Bell and Howell Company.

Uyarra, M., Cote, I., Gill, J., Tinch, R., Viner, D., Watkinson, A. (2005). Island-specific preferences of tourists for environmental features: implications of climate change for tourism-dependent states. *Environmental Conservation, 32*(1), 11-19.

World Resources Institute. (2004). *Reefs at risk in the Caribbean.* Washington, DC: Burke, L. & Maidens, J.