Is Acropora palmata really coming back? an analysis from Los Roques, Venezuela

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Ten years ago, we studied the distribution and status of Acropora palmata at archipelago Los Roques because the actual status of this species at Los Roques was unclear in this archipelago after its regional collapse. In that opportunity we aimed to produce a baseline study for this species in Los Roques combining population genetics with demographic data. At that time, our results suggested that this species had the potential to come back at least in 6 out of 10 surveyed sites. This conclusion was based upon high abundance, low disease prevalence, high genetic diversity and a dominance of sexual reproduction in these populations. However, we recognized that the potential of recovery could be hindered depending on local and regional threats. In 2014, the status of this species was re-evaluated by increasing the number of sites from 12 to 106 and by identifying and targeting local and global threats that may affect population recovery. The results from this new survey showed that A. palmata had a restricted distribution being only present in 15% of the surveyed sites. Large stands of old dead colonies were common throughout the archipelago; which demonstrates that this species has lost almost 60% of its original distribution over the past decades. In most cases live colonies were large adults(~ 2m height); however, partial mortality and degradation of living tissues were found in 45% of the colonies. Moreover 44.78% of them were located on degraded reefs. In the past 8 years, two massive bleaching events occurred in Los Roques, the last one was known to decrease coral cover to unprecedented levels in the the archipelago. These events might have produced significant mortality for this species for signs of recent mortality was also common across sites. In addition, a growing local tourism industry, which has become massive and the concomitant increase of pressure on ecosystems goods and services are both becoming a problem of serious concern. Our results suggest that increasing use conflicts within the MPA and global threats such as ocean warming could prevent the recovery of this vulnerable species in Los Roques.

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IS *ACROPORA PALMATA* REALLY COMING BACK? AN ANALYSIS FROM LOS ROQUES, VENEZUELA

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ABSTRACT

Ten years ago, we studied the distribution and status of *Acropora palmata* at archipelago Los Roques because the actual status of this species at this site was unclear after its regional collapse. In that opportunity we aimed to produce a baseline study for this species in Los Roques combining population genetics with demographic data. At that time, our results suggested that this species had the potential to come back at least in 6 out of 10 surveyed sites. This conclusion was based upon high abundance, low disease prevalence, high genetic diversity and a dominance of sexual reproduction in these populations. However, we recognized that the potential of recovery could be hindered depending on local and regional threats. In 2014, the status of this species was re-evaluated by increasing the number of sites from 12 to 106 and by identifying local and global threats that may affect population recovery. The results from this new survey showed that *A. palmata* had a restricted distribution being only present in 15% of the surveyed sites. Large stands of old dead colonies were common throughout the archipelago; which demonstrates that this species has lost almost 50% of its original distribution over the past decades. In most cases live colonies were large adults (~2m height); however, partial mortality and degradation of living tissues were found in 45% of the colonies. Moreover 44.78% of them were located on degraded reefs. In the past 8 years, two massive bleaching events occurred in Los Roques, the last one was known to decrease coral cover to unprecedented levels in the the archipelago. These events might have produced significant mortality for this species for signs of recent mortality was also common across sites. In addition, a growing local tourism industry, which has become massive and the concomitant increase of pressure on ecosystems goods and services are both becoming a problem of serious concern. Our results suggest that increasing local threats within the protection zones of the MPA and global threats such as ocean warming could prevent the recovery of this vulnerable species in Los Roques.

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INTRODUCTION

The western Atlantic is the second largest coral reef bioprovince on earth (Veron 1995). This region extends from the eastern coast of Brazil up to Bermuda, nevertheless the largest and most diverse reefs occurs within the Caribbean basin (Birkerland 1997). During the past five decades, Caribbean coral reefs have been exposed to a great deal of impacts which have challenged their resilience on local and regional scales (Gardner et al. 2003, 2005, Bellwood et al. 2004). Recently, Jackson et al. (2014) showed that; with only few exceptions, the status of coral reefs in this region is critic. Such accelerated deterioration of coral reef ecosystems has been attributed to overfishing and the increasing input of nutrients combined with bleaching and epizootic events that have produced massive die-offs of keystone reefs organisms (Jackson et al. 2014). The combination of these local and global threats has significantly reduced the populations of major reef-building coral species to critic levels thereby jeopardizing the recovery of depauperated reefs (Jackson 2001, Jackson et al. 2001, Gardner et al. 2003; Hughes et al. 2003; Halpern et al. 2007; Knowlton & Jackson 2008).

In recent times, Marine Protected Areas (MPAs) have been proposed to confront the coral reef crisis for they are supposed to increase resilience (Done 2001). Several studies have shown that MPAs are useful tools for managing coral reef fisheries, particularly exploited fish stocks (Russ 2002, Halpern, 2003), effectively increasing the abundance, individual size and overall biomass of reef fish (Polunin & Roberts 1993, Russ 2002, Halpern 2003, Evans & Russ 2004, Williamson et al. 2004). MPAs have also enhanced stocks of exploited coral reef invertebrates (Kelly et al. 2000, Halpern, 2003, Ashworth et al. 2004, Uthicke et al. 2004) and reduced the prevalence of coral diseases as well (Cohelo & Manfrino 2007; McClanahan, 2008; Page et al. 2009). However, the actual role and the effectiveness of MPAs to protect coral reef-building species

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such as *Acropora palmata* from global threats such as bleaching and global warming remain controversial.

The Elkhorn coral *Acropora palmata* is a hermaphroditic broadcast spawner which grows 5-10 cm year^{-1} and forms complex and heterogeneous reef frameworks (Adey, 1975; Bak & Criens, 1981; Highsmith 1982; Szmant 1996). For hundreds of years, *A. palmata* was a wide-spread and conspicuous coral reef builder species in shallow and intermediate reef habitats in Barbados (Pandolfi & Jackson, 2006) and the western Caribbean (Geister, 1977; Aronson & Precht, 2001); providing shelter to a myriad of species (Precht & Miller, 2001). During the 80s a massive mortality event produced a regional decline of these populations flattening shallow habitats with a concomitant reduction of species diversity because of loss of spatial heterogeneity (Aronson & Precht, 1997; Bruckner, 2002).

In view of the sudden decline of *Acropora palmata*, its former role as a keystone structural species in Caribbean coral reefs (Bruckner, 2002; Patterson et al. 2002) and its current critical status, this species is currently listed under the United States Endangered Species Act as 'threatened' (cos.fws.gov/speciesProfile/profile/species) and was included in the IUCN Red List of threaten species as critically endangered (CR) based on evidence showing significant reductions of its populations from local to regional scales (Aronson et al. 2008). Almost four decades after the mortality event, it remains unclear whether *A. palmata* populations are recovering or continue declining. While several studies have shown evidence of moderate recovery in different sites (Grober-Dunsmore et al. 2006; Mayor et al. 2006), others still claim that this species has failed to recover or that it is far from recovering its former role as major reef builder of shallow habitats in the Caribbean (Knowlton et al. 1990; Porter et al. 2001; Bruckner 2002; *Acropora* Biological Review Team, 2005).

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In 2002, we started a coral reef monitoring program in Los Roques National Park (LRNP) aimed to determine the status of these ecosystems and to follow up temporal changes in the coral community structure. In 2005 ten reef sites were surveyed with the purpose of collecting demographical (i.e., abundance, size structure, partial mortality and prevalence of diseases) and genetic (i.e., allele diversity and patterns of connectivity) data to determine whether *Acropora palmata* had a good prognosis for recovery in LRNP (Zubillaga et al. 2008). This study was extremely valuable for establishing a base line from which the status of these populations could be compared in the future.

While MPAs did not seem to prevent this species to collapse in the past, they might help to improve chances of recovery by reducing the deleterious effects of local threats in the future. The 2005 study, provided new evidence suggesting that *Acropora palmata* had the potential of recovering in LRNP, for the abundance of this species was above the Caribbean standards; whereas the prevalence of white band disease and partial mortality were lower (Zubillaga et al. 2008). The authors also found high allelic diversity, moderate to high levels of connectivity; and more importantly, low proportion of clone mates within these populations. Nevertheless, according to Zubillaga et al. (2008), the combined negative effects of local and global threats might hinder and even prevent this species to regain its former status in Los Roques. Consequently, the urgent need of an appropriate management of Los Roques was recognized, given the rapid increase in tourism and other human activities in the archipelago (Zubillaga et al. 2008).

In addition, former conclusions about the status of *Acropora palmata* in Los Roques came from a limited number of sites. Therefore, more extensive surveys were needed in order to have a better idea of the recovery potential of this species. In this paper we provide the first large-scale survey of *A. palmata* conducted in Los Roques, which estimates the abundance and the health status of these populations at a scale of thousand of kilometres. We also determined the spatial distribution of local anthropogenic threats within the MPA zoning. Finally, we discuss the relevance of two large massive bleaching events recorded in Los Roques during 2005 and 2010 as potential drivers of recent mortality in these populations.

MATERIAL AND METHODS

Study area

Los Roques National Park (LRNP) is an oceanic archipelago located 160 km north of the Venezuelan coast (11°44'26''-11°58'36'' N, 66°32'42'-66°57'26''W; Fig. 1). The reef system encompasses more than 50 coralline cays with fringing reefs, patch reefs, over 200 sand banks, and extensive mangrove forests and seagrass beds (Weil, 2003). LRNP was the first MPA in Latin America, decreed as a National Park in 1972. In 1991, the zoning and use regulations were established prioritizing the protection of marine turtles and migratory birds nesting sites. The MPA zoning encompasses nine different use-zones, from which four include coastal-marine habitats making LRNP a multi-use MPA. These zones range from high protection (Integral Protection Zone, PI and Primitive Marine Zone, PM), were only scientific research or managed non-extractive activities are allowed, to medium (Marine Managed Area, MMA) and low protection (Recreational, R and Tourism services, TS) levels were recreational activities and artisanal fisheries are permitted. According to this zoning, human activities are mostly concentrated within the northeast main island, Gran Roque, and the nearby cays (Fig 1).

Surveys of *Acropora palmata*

To determine the distribution and abundance of *Acropora palmata*, visual censuses were conducted between April and November 2014, encompassing 106 sites across the archipelago. These sites covered a suite of different habitats including windward (exposed) and leeward (protected) cays; fringing and barrier reefs, reef patches and mixed seagrasses and sand habitats within the lagoon. At each site, four observers conducted the visual surveys by doing free dives along shallow to intermediate habitats (1-12 m depth) covering a 20 m width x 400-1000 m long area. The length of the belt-transects varied according to the extent of the same type of habitat. At each transect the starting and end points were geo-referenced with a Garmin 60S GPS. Within each belt-transect, depth, number of colonies, presence/absence of partial mortality and disease signs were annotated. Dead stand colonies of *A. palmata* as well as poorly eroded or recently dead fragments accumulations were also recorded. Habitat characterization was assessed qualitatively on the basis of main substrate, dominant benthic species and abundance of other massive and soft coral species, while habitat health condition was categorized into Excellent, Good, Regular and Degraded, on the criteria of live coral cover, macroalgae cover and sedimentation. All the permits necessary to work within MPA were processed and accepted by the Governmental Venezuelan authorities (i.e., Ministerio del Poder Popular para el Ambiente-Oficina de Diversidad Biológica. Oficio No. 0323 and Territorio Insular Francisco de Miranda. Autorización Provisional No. 006).

Local threats distribution

In our analysis we included land-band pollution (LBP), touristic beach activities (TBA), diving (D) and spiny lobster fishing grounds (F) as local threats for they are frequent in LRNP and also because they are known to have a myriad of negative effects on coral populations (Frabricius, 2005). Information about location of these threats, as well as their relative importance was obtained through interviewed questionnaires and semi-structured interviews administered to different stakeholders (Cavada-Blanco, F. unpublished data). The surveyed sampling size varied depending on the size of each stakeholder group. Thus, we surveyed 100% of dive operators (N = 3); 58.3% of lodges (N = 35), 100% of touristic transportation cooperatives (N = 2) and 35% of licensed fishermen (N = 200).

Spatial Analysis

To assess representativeness of *Acropora palmata* according to the protection status of the MPA zoning, we performed a GAP analysis (Jennings, 2000) using the species distribution and MPA zoning as layers. A vector layer of the dead stands occurrence area was also built to evaluate the percentage of occurrence area and habitats lost within the archipelago. To visualize the spatial distribution of local anthropogenic threats and determine the distance between the occurrence of *A. palmata* and these threats; a distance matrix was calculated using the centroids of areas occupied by *A. palmata* as the input layer and each threat as the target layer. Layers were built and visualized using QGIS 2.4 Chugiak and spatial analysis were performed using R package sp (Pebesma et al. 2015).

RESULTS

Abundance and distribution of *Acropora palmata* across LRNP

Our surveys covered a total area of 6.723,45 Km^2. Only sixty-seven *Acropora palmata* colonies were observed on 15% of the surveyed sites representing an area of occurrence of 1,348.4 Km^2 or 6% of the total area of the MPA. The frequency of occurrence was extremely low with density values ranging from 0.001 to 0.05 colonies per every 100 m (Fig. 2). The incidence of recent partial mortality was conspicuous across sites ranging between 33% and 100%, the exception being the colonies located in the exposed reefs located along the eastern barrier, which showed no signs of partial mortality (Fig. 2). In average, the majority of the colonies were located on seaward reefs (61.2%) although the number of colonies varied greatly between sites in both seaward and leeward reefs (2.5 and 0.9 times the average, respectively, Fig. 3a).

Five different types of habitats were described (Table 1). The most frequent and characteristic habitat of *Acropora palmata* in Los Roques was composed of pavement substrate, dominated by *Pseudoplexaura* spp. and *Plexaura* spp with scattered colonies of *Diploria laborynthiformis*, *D. clivosa*, *Colpophyllia natans* and *Porites astreoides* (Table 1). Over 50% of the habitats were categorized either as in excellent (26.7%) or degraded (33%) overall health condition (Fig. 3b). Large dead stands of *A. palmata* were counted on 23% of the surveyed sites, which represents a 51.3% loss of the historic distribution on the archipelago (Fig. 4).

Our results show that 61% of the total area covered by *Acropora palmata* belongs to primitive marine zones, whereas 29.7% were observed inside the least protected areas such as the recreational and marine managed zones (Fig. 5). Furthermore, the frequency of partial mortality incidence was greater (74.7%) within the least protected areas. Most of the touristic, diving and lobster fishing activities were carried out inside the integral protection and primitive marine zones (Fig. 6). Within the recreational zone *A. palmata* was commonly found at Francisquí and La Pista in Gran Roque, both sites being less than 1 Km apart from one diving site and the main source of land-based pollution. This species was also frequent at Noronquí, La Venada and Espenquí, all these sites being less than 1 Km apart from two touristic activities sites. Inside the protected zones, 85% of sites with *A. palmata* were less than 5 Km apart from at least one of the threats considered; the only exception being land-based pollution. (Table 2).

DISCUSSION

This paper represents the first large-scale survey of *Acropora palmata* conducted at LRNP covering more than 6700 Km^2 over 106 sites and providing additional information to previous studies conducted in Los Roques during the past 7 years (Zubillaga et al. 2005, 2008; Porto-Hannes et al. 2015). This study complements with previous reports and helps to better understand the status of this species by evaluating the spatial distribution of local threats and the species representativeness according to the protection zoning of the MPA.

The results indicated that this species has a very limited distribution within Los Roques (6% of the total MPA area) with densities bellow 0.05-0.001 colonies/100 m^2 displaying variable but frequent partial mortality. Densities reported in this study are below previous surveys conducted in Los Roques (i.e., 0.4-32 colonies x 100 m^2, Zubillaga et al. 2008) but similar to the ones recorded across the Caribbean, where an 80-98% loss of individuals have been reported since 1980. In this region, the density of *A. palmata* has remained below 1 colony per 10 m^2 since its decline (Bruckner 2002; *Acropora* Biological Review Team, 2005) and only a few sites have densities above that [(e.g., Colombia: 6 colonies per 10 m^2, Mexico: 7.6 colonies per 10 m^2 (Jordán-Dahlgren 1992), and Florida: 8–10 colonies per 10 m^2 (Bruckner 2002)].

Our results suggest that populations of *Acropora palmata* might have recently declined in Los Roques for colonies with clear signs of recent mortality were observed in different sites. While the reasons for this apparent reduction are not clear, the 2010 bleaching event which dropped live coral cover to unprecedented levels across Los Roques (Bastidas et al. 2010) may have actually impacted these populations. Extensive mortality on *A. palmata* populations after massive bleaching and epizootic events has recently been reported in the US Virgin Islands (Muller et al. 2008; Miller et al. 2009) and the Florida Keys (Williams & Miller 2012). In 2014, during a period of abnormal ocean warming, large stands of *A. palmata* bleached and died across the Florida reef track (Williams, 2015), further indicating that this species is still extremely susceptible to bleaching.

In a recent study, Randall and van Woesik (2012) modelled the effects of SST on the prevalence of WBD in *Acropora palmata* and *A. cervicornis* in the wider Caribbean. They found that decade-long climate-driven changes in SST, increases in thermal minima, and the breach of thermal maxima have all played significant roles in the spread of WBD. As temperatures increase over time, vulnerability thresholds (28.5 °C) may be gradually breached for *A. palmata*, resulting in bleaching and disease (Randall & van Woesik, 2012). During the 2010 bleaching event, SST in Los Roques stayed above 28.5 °C for several months (Bastidas et al. 2010). Thus, suggesting that both bleaching and coral diseases have been important drivers of mortality for *A. palmata* populations on local and regional spatial scales.

Similar to previous reports (Zubillaga et al. 2008), we observed large stands of old-dead *A. palmata* cemented and covered by calcareous coralline algae in 23% of our sites, further indicating that this species has lost about 51% of its past distribution. Likewise, several studies have reported declines on the order of 97% in the Florida Keys, Jamaica, Dry Tortugas, Belize and St Croix (*Acropora* Biological Review Team, 2005) and Puerto Rico (Weil et al. 2003). The status of the habitat of this species was variable; most colonies being found on healthy and/or heavily degraded reefs where recent loss of live coral cover was evident and widely spread. This result is consistent with observations of extensive coral loss recorded after the 2010 bleaching event across the Caribbean region (Brant & McManus, 2009).

Despite recent mortality was conspicuous in our surveys, sites along the eastern barrier still hold healthy colonies showing the highest densities of *A. palmata* in Los Roques. Whilst this species was observed in sandy bottoms and sheltered-shallow sites as reported before in Los Roques (Zubillaga et al. 2008) and across the whole Caribbean (*Acropora* Biological Review Team, 2005), the majority of these colonies were most likely found growing on pavement in wave-exposed habitats and showed no signs of diseases, health problems and/or recent and old partial mortality. This result indicate that this species might still have the potential to recover in Los Roques depending on the adoption management actions that reduce the impacts of local threats. However, more information at local scales is needed to assist the recovery of acroporids, including survival and fecundity by age, sexual and asexual recruitment and population dynamics. Especial attention is needed to evaluate the importance of habitat variables to recruitment and survivorship in sink populations (Bruckner, 2002). Further research is also needed into disease etiology, and effectiveness of current restoration methods (Aronson et al. 2008).

In Los Roques, the distribution of *Acropora palmata* overlapped with common local threats such as diving (Hawkins et al. 1992, 1993, 1999, Barker et al. 2004), tourisms (Hawkins & Roberts, 2004) and land-based pollution which are all known to have a series of deleterious effects on corals (Fabricius, 2005), further highlighting the need for management measures in order to aid the recovery of this populations. According to Aronson et al. (2008) the loss of habitat at the recruitment stage due to algal overgrowth and sedimentation; predation by snails; mortality by endolithic sponges; ship groundings, anchor damage, trampling, and marine debris have been responsible for local demise of this species. Additional local threats for this species include fisheries, human development, changes in native species dynamics (competitors, predators, pathogens and parasites), invasive species, dynamite and chemical fishing, land-based pollution, sedimentation, and human recreation and tourism activities (Aronson et al 2008).

According to Zubillaga et al (2008), the apparent success of recovery by *Acropora palmata* at LRNP at the time the study was performed, might be the result of the lack of severe anthropogenic impacts (sedimentation, coastal development, sewage, etc.), hurricanes, storms, and emerging coral diseases (i.e., white pox and patchy necrosis), which have been recognized as major threats to the remaining populations in the Florida Keys and the US Virgin Islands (Patterson et al. 2002; Bythell et al. 2004; Patterson and Ritchie 2004; Rogers et al. 2005). While some of these threats are still infrequent in Los Roques (e.g. diseases, snails, storms and hurricanes), human pressures such as land-based pollution, algal blooms and illegal fishing of parrotfishes seem to have recently increased and might be becoming a serious problem (Cavada-Blanco, F. unpublished data). Thus, urgent plans aimed to reduce the potential effects of these local threats on endangered coral species such as *A. palmata* are desperately needed. Specifically, the management plan and zoning of LRNP must be revised in the short term. Special attention to human population growth and the concomitant increasing demand on ecosystem goods and services within the MPA must be a short-term priority (Cavada-Blanco, F. unpublished data).

In conclusion, our results indicate that *Acropora palmata* has a restricted distribution across LRNP and most of its original distribution has been already lost. While healthy populations of this species can still be found along the eastern Barrier and a limited number of sites across the archipelago, the combination of increased local threats and global threats impacts susceptibility such as bleaching events, are having profound negative effects and unpredictable impacts on these populations. Combined, these results highlight the importance of developing specific conservation and management actions to protect this species at LRNP.

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TABLES

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Table 2. Average distance (centroids) between *Acropora palmata* occurrence sites and identified local threats.

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Figure 2. Abundance and health status of *Acropora palmata* per occurrence site in LRNP.

Figure 3. Abundance of *Acropora palmata* colonies according to wave exposure (A) and habitat overall health condition (B).

Figure 4. Occurrence sites of *Acropora palmata* live and dead colonies within LRNP

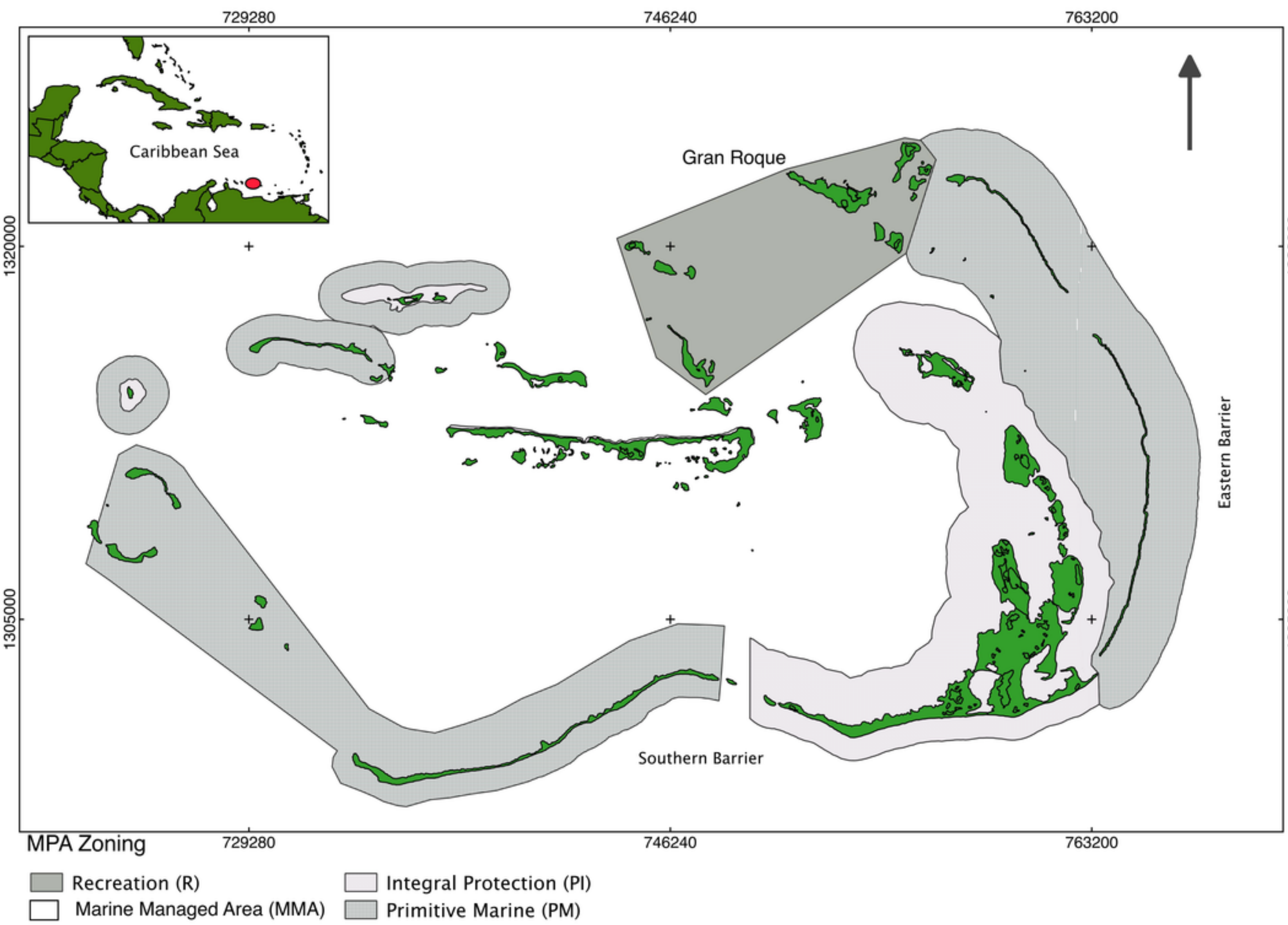
Figure 5. Total area covered by Acropora palmata across different zonation areas

Figure 6. Spatial distribution of Acropora palmata against local threats within LRNP.

1

Area of Study

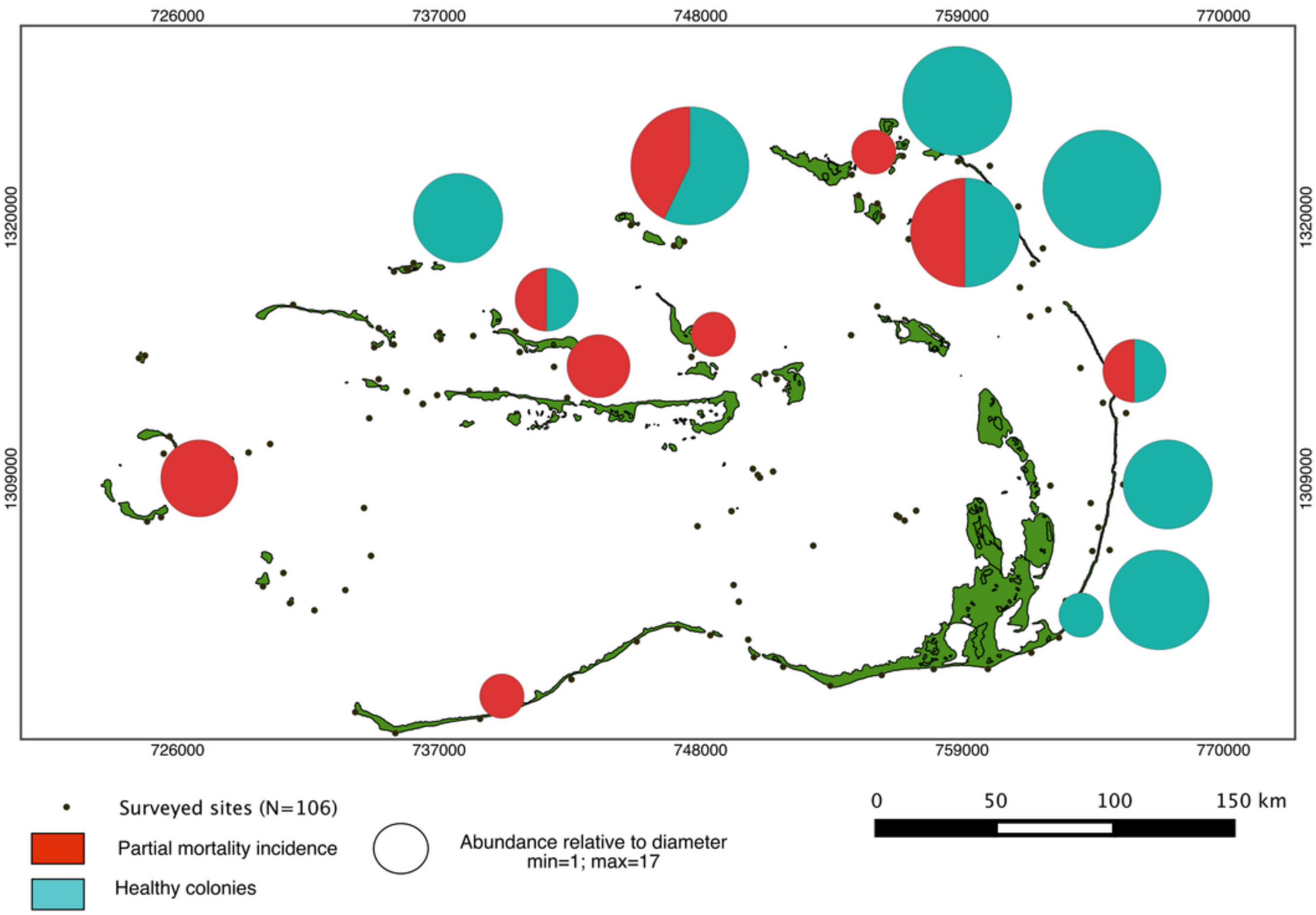
Map of Los Roques National Park (LRNP) and coastal-marine zoning of the MPA.



2

Abundance and health status of Acropora palmata

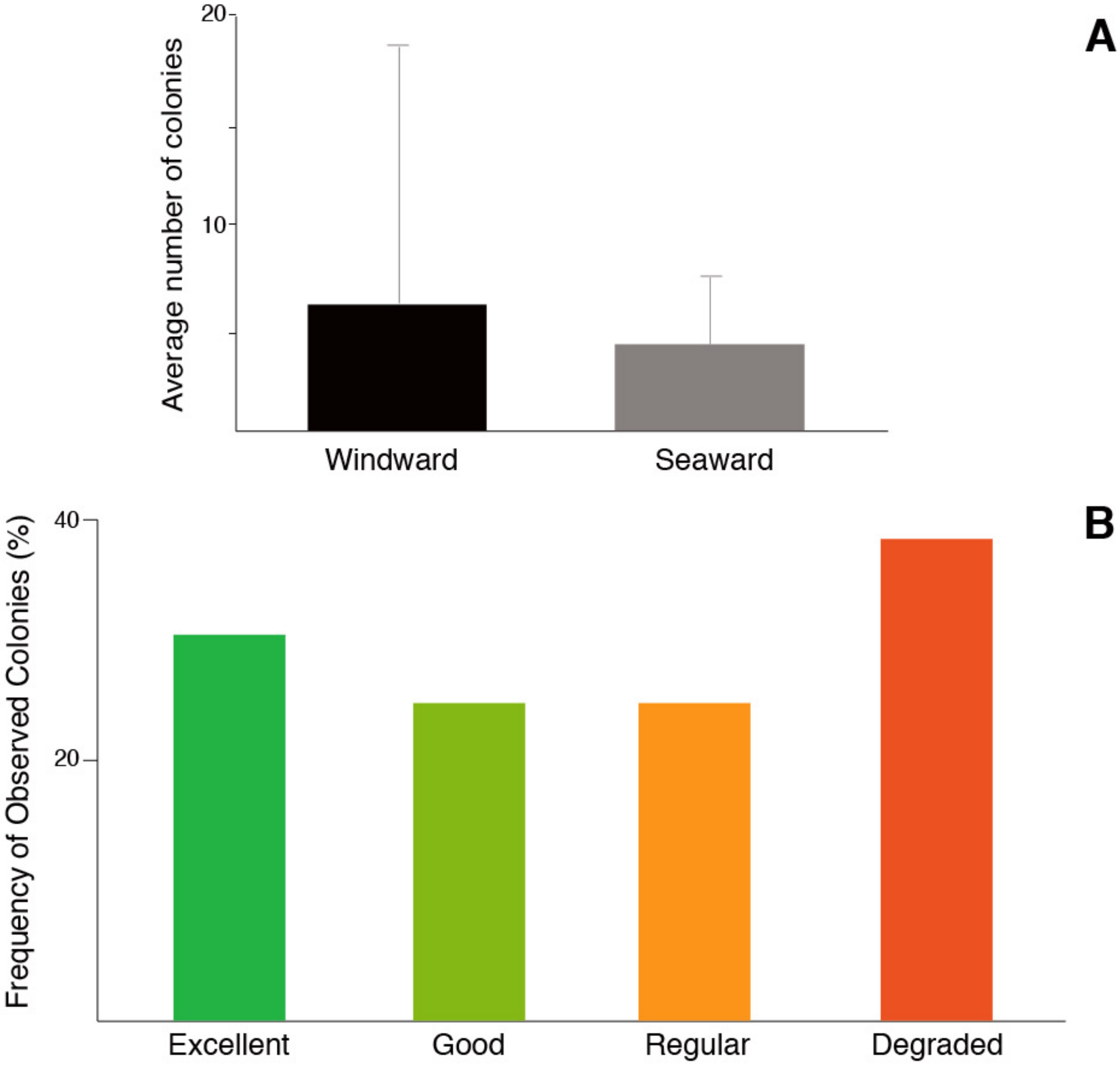
Abundance and health status of Acropora palmata per occurrence site in LRNP.



3

Abundance of Acropora palmata colonies according habitats

Abundance of Acropora palmata colonies according to wave exposure (A) and habitat overall health condition (B).



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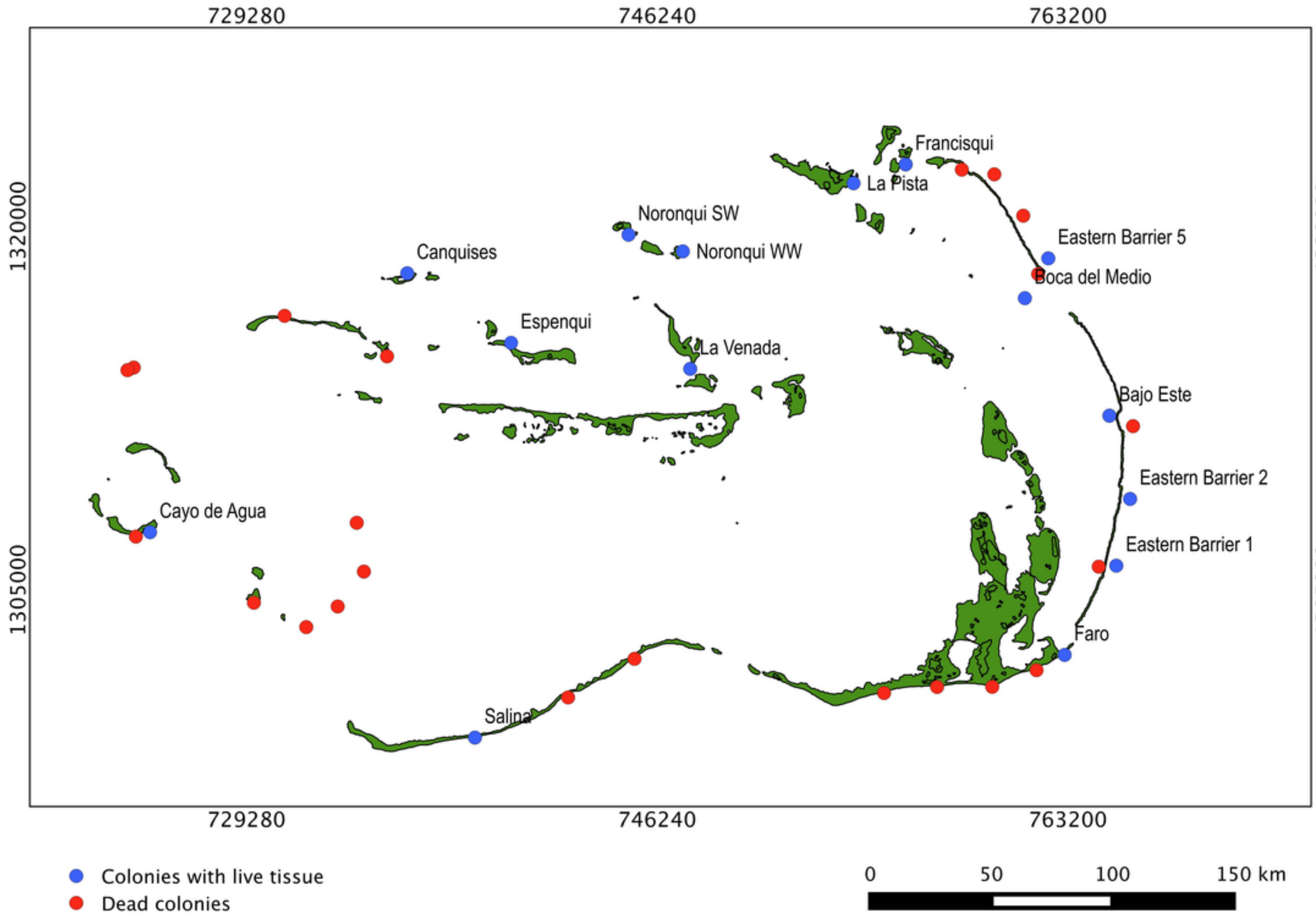
Occurrence sites of Acropora palmata live and dead colonies

Occurrence sites of Acropora palmata live and dead colonies within LRNP



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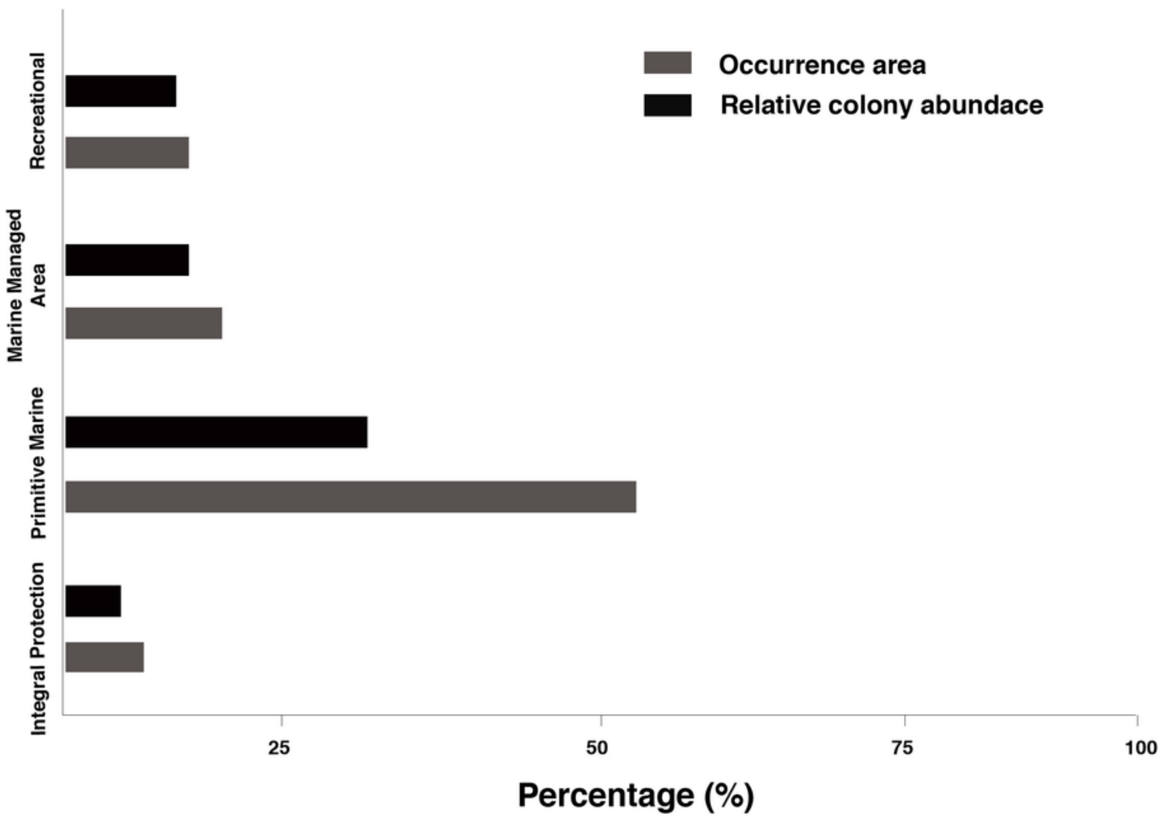
Total area covered by Acropora palmata

Total area covered by Acropora palmata across different zonation areas



6

Spatial distribution of Acropora palmata and its local threats

Spatial distribution of Acropora palmata against local threats within LRNP.

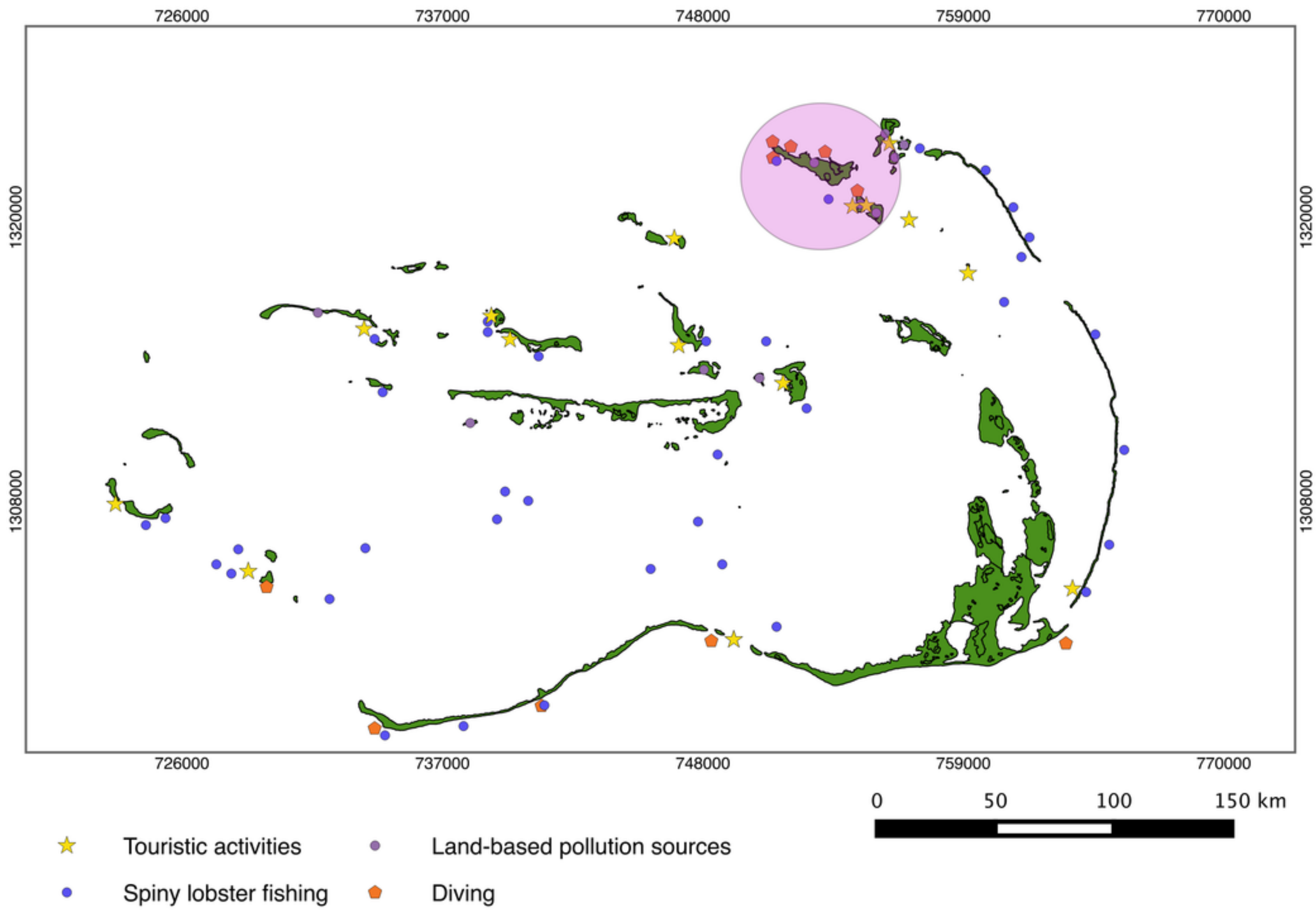


Table 1 (on next page)

Acropora palmata habitat types

Acropora palmata habitat types in Los Roques National Park

Table 1. *Acropora palmata* habitat types in Los Roques National Park

Main Substrate	Dominant Species/Group	Description
Sand	*Acropora cervicornis*	Sand flats with dense patches of *Acropora cervicornis*, and *A. cervicornis* rubble. Presence of scattered massive coral species such as *Diploria labyrinthiformis, clivosa* and *strigosa*, *Colpophyllia natans*, *Orbicella annularis* and *Porites astreoides*. Few gorgonians such as *Pseudopterogorgia* spp and *Gorgonia ventalina*. Calcareous algae such as *Halimeda* sp and *Turbinaria* sp are rare.
	Scattered massive corals	Sand flats or smooth slopes with scattered large (more than 1 m height) colonies of *Diploria labyrinthiformis, clivosa* and *strigosa*, *Colpophyllia natans*, *Siderastrea siderea*, *Orbicella annularis, Porites porites* and *Porites astreoides*. Calcareous algae like *Halimeda* sp and *Turbinaria* sp are also present.
	Soft corals	Sand flats with dense patches of *Pseudopterogorgia* and *Plexaura flexuosa* with scattered colonies of *Diploria strigosa* and *Orbicella annularis* mixed with octocoral patches.
Consolidated Reefs	*Orbicella annularis*	Flat or smooth slopes of large and consolidated (< 2 m height) *Orbicella annularis* colonies (no distinction can be made between ramets and genets) with scattered colonies of *Acropora cervicornis*, *Diploria labyrinthiformis, clivosa* and *strigosa*, *Colpophyllia natans*, *O. faveolata* and *Porites astreoides*. Fewer gorgonians such as *Pseudopterogorgia* spp and *Gorgonia ventalina* and abundant incrusting and tube-like sponges. Abundant calcareous algae.
Pavement		With or without rubble. Presence of scattered coral species like *Diploria labyrinthiformis, clivosa* and *strigosa*, *Colpophyllia natans*, *Orbicella annularis* and *Porites astreoides, A. cervicornis* and *palmata* growing as incrusting morphotypes. Few soft corals like *Pseudopterogorgia* spp and *Gorgonia ventilata*. Presence of calcareous algae like *Halimeda* sp and *Turbinaria* sp

Table 2(on next page)

Average distance (centroids) between Acropora palmata and identified local threats.

Average distance (centroids) between Acropora palmata occurrence sites and identified local threats.

Table 2. Average distance as centroids between *Acropora palmata* occurrence sites and identified local threats.

	Threats			
Occurrence Sites	Fishing grounds	LBP	Diving sites	Touristic activities
Bajo Este	21.08	17.52	20.83	19.84
Boca del Medio	19.01	12.79	18.26	16.80
Canquises	17.23	15.81	19.10	16.08
Cayo de Agua	21.75	27.31	25.23	23.73
Espenqui	14.33	13.01	16.16	13.13
Faro	22.09	22.37	21.46	21.64
Francisqui	18.92	8.20	15.87	15.10
La Pista	17.77	7.39	14.18	13.81
La Venada	13.42	9.54	13.77	11.45
Noronquí SW	15.74	10.25	14.86	12.88
Noronquí WW	15.29	9.08	13.93	12.19
Salina	17.56	23.70	18.90	20.27
Eastern Barrier 1	22.17	21.14	21.92	21.50
Eastern Barrier 2	22.03	19.91	21.83	21.17
Eastern Barrier 5	20.11	13.30	19.19	17.86

LBP: Land-based Pollution