Social alienation and environmental decline in a coral reef: Challenges to coastal management in the Mexican Caribbean

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A B S T R A C T

Tourism is the primary economic activity on the Riviera Maya in Quintana Roo, Mexico. The area's main attractions are the fringing coral reefs along the coast and the myriad white sand beaches produced by them. Rapid growth of tourism and supporting industries generates jobs and a steady flow of immigrants, increasing demand for housing and services. It also increases pressure on coastal and marine resources through impacts such as pollution, overfishing, coastal zone modification, etc. In this context, Akumal a small tourism-support town associated to the coastal tourism center Akumal Beach, was selected to assess its level of dependence and appropriation of marine resources. A two-pronged approach included a characterization of the town's population socio-economic indicators, as well as their use and perception of easily identifiable marine resources (coral reef, fish and water quality), applying surveys with close-ended questions. And the second approach was the interview of key local business owners and tours operators to establish their vulnerability to coral reef degradation, and their disposition towards conservation efforts. The relationships between community involvement and resource appropriation, as well as, socioeconomic indicators and local perceptions about the past, present and future condition of marine resources were explored using redundancy analysis (RDA), and additionally important variables identified were tested for significance with a Chi-squared test. Surveys highlighted two socioeconomic factors: its high employment rate (90%) with 80% working directly in tourism (but earning average wages 25% lower than the regional average), and the heavy out-of-state immigration. Surveys also brought up two phenomena among newcomers: deterritorialization (or social alienation), consisting in lack of involvement by the local community in decision-making processes, scarce participation in natural resources use, and shifting-baselines associated to ignorance of current resource condition. Interviews with local stakeholders found that they felt only partially vulnerable in a hypothetical situation of total reef loss, and were open to support conservation efforts as long as transparency and full cooperation from all stakeholders was ensured. The measures recommended to coastal managers, broadly applicable to the Mexican Caribbean, focus on development of local strategies addressing the root causes of social mistrust and misperceptions, leading to environmental degradation.

1. Introduction

Coral reefs, when present, are crucial ecosystems for coastal communities. They provide protection against hurricane damage and beach erosion, support both subsistence and commercial fisheries, generate beach sand, and are the focus of income-generating recreational opportunities such as snorkeling and scuba diving (Moberg and Folke, 1999; Wilkinson, 2004; Barbier et al., 2011). Anthropogenic impacts on

these ecosystems during centuries of exploitation are diverse and profound (Jackson, 1997; Cramer et al., 2012): Degradation of the environmental services humans depend on; threats to reef community ecological condition; changes in reef species spatial distribution; increases in the gap between rich and poor nations; and reduction in the capacity of coral reef systems to absorb, transform and adapt to external disturbances (Fox et al., 2006; Levin and Lubchenco, 2008; Srinivasan et al., 2008). Supporting and rebuilding the functionality of a coral reef
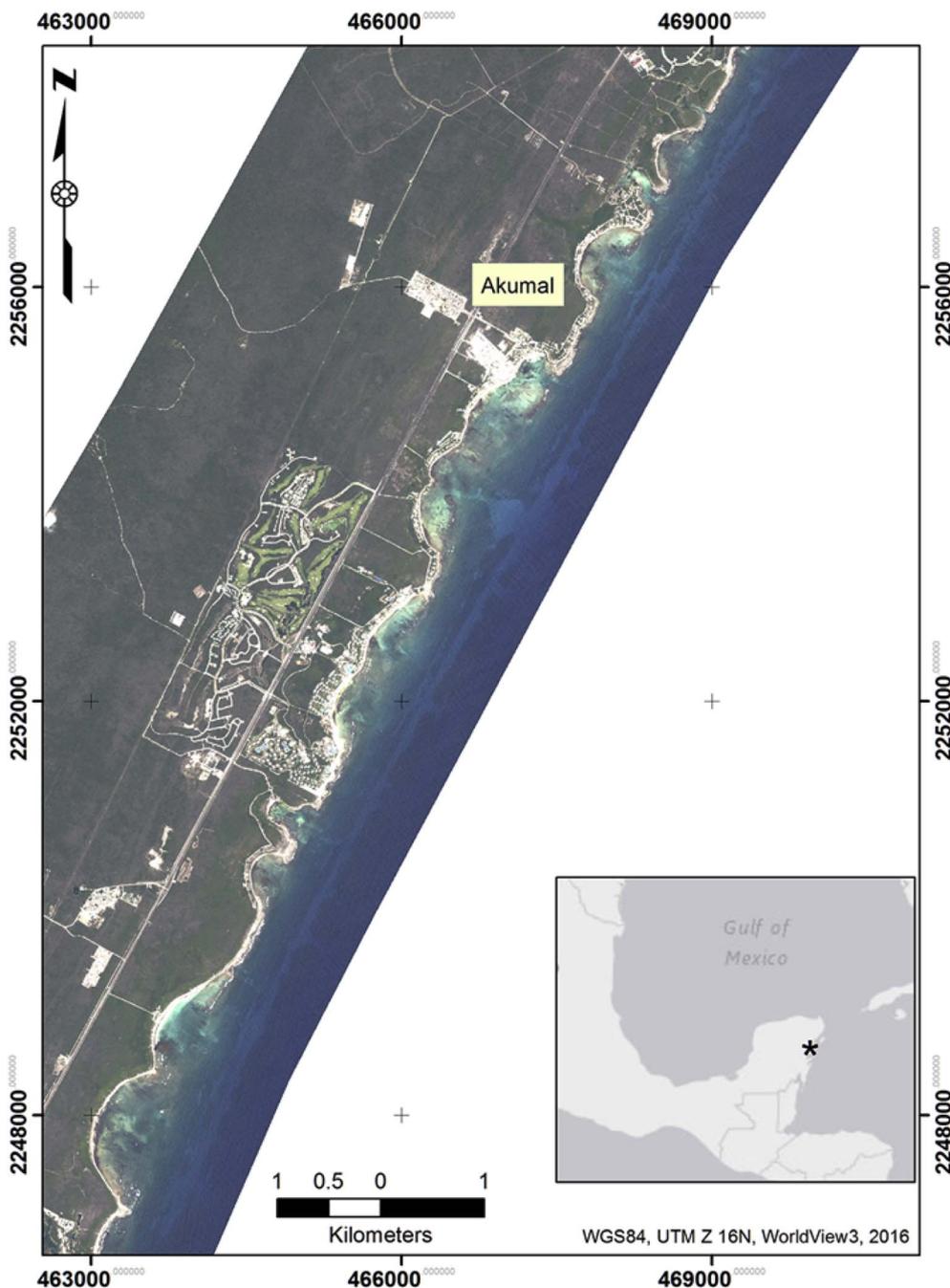

Fig. 1. Study Area, Akumal, Quintana Roo, México.

system and its ability to cope with external stresses requires complete understanding of existing social and ecological systems since system stability depends on their interaction (Walker et al., 2012). Since local stress agents impacts on coastal ecosystems are easier to identify and manage than global agents such as climate change, improving ecosystem resilience is often approached through local or regional management actions, which are more easily measured and improved (Knowlton and Jackson, 2008; Côté and Darling, 2010; Ostrom, 2010; Jackson et al., 2014).

Significant coral reef degradation, coral cover decline and dominant coral species shifts have been documented in Mexico (and the greater Caribbean region) over the last four decades; indeed, coral cover loss has been as high as 79% (Almada-Villela et al., 2002; Gardner et al., 2003; Alvarez-Filip et al., 2009; Carriquiry et al., 2013). Particularly notable impacts have been a steadily growing dominance of macroalgae and loss of the refuge ecological function with a consequent decline in

fish biomass (Knowlton and Jackson, 2008; Alvarez-Filip et al., 2009; Cinner et al., 2009; Jackson et al., 2014). Direct anthropogenic threats to reef fish populations include overfishing, marine habitat transformation and loss, sedimentation, pollution from wastewater discharge, recreational uses and introduction of alien species. Ecosystems and their associated fisheries in the Mexican Caribbean are clearly in a critical situation (Bryant et al., 1999; Bellwood et al., 2004; Brown et al., 2006; Pollock et al., 2011; Jackson et al., 2012, 2014).

Caribbean fisheries are experiencing ecological impacts, but no reports have been forthcoming on the significant social implications of this decline since the region's economy no longer depends directly on fishing. However, the primary economic activity in the region is tourism- and trade-related services, both directly or indirectly dependent on the continued existence of healthy coral reefs (INEGI, 2015a). It is unlikely that the regional economy will be able to avoid the effects of coral reef ecosystem decline much longer.

Most of the state of Quintana Roo's economy (85.8%) involves tertiary activities. The main tourist destination in Mexico, and Latin America overall, receiving approximately 15.7 million visitors annually, expected to increase (Borge, 2015; INEGI, 2015a; CONCANACO, 2016). Coastal tourism industry development consists of direct activities such as construction of hotels, resorts, marinas and golf courses, as well as extensive support infrastructure in the form of highways and the urban centers needed to house the working population and their support services (e.g. Cancun, Playa del Carmen, Puerto Morelos and Tulum). Smaller towns (populations in the hundreds to thousands) exist to sustain the myriad beach resorts strung along the coast between larger population centers.

A community's perception of a resource, and the values it associates with the resource, influence attitudes towards it, and consequently how the resource is utilized and managed (Cinner and Pollnac, 2004). This also holds true for the coral reef system in Quintana Roo, which is, in a sense, the community's social and economic foundation. The present study addresses the question of: How one of this resort support towns in the coastal zone of Quintana Roo depends on, and appropriates its marine resources? The first specific objective is to characterize the socio-economic indicators of the population and to establish the relationship between the community and their perceptions and attitudes towards the marine resources. The second objective is to gauge the economic prospects of local stakeholders towards a total reef degradation situation and their disposition to support conservation efforts. The answers are useful in defining local and regional management challenges for reef resilience and discussing possible management approaches associated to reef degradation. Resource managers can incorporate them into decision-making processes to address specific problems within the community, and potentially use them in developing projects focused on increasing reef system resilience while enhancing reef environmental services and benefits to the local population.

2. Methods

2.1. Study Area

Akumal, located 27 km north of Tulum, is a tourism support town of 1310 inhabitants −370 households- (INEGI, 2016) associated to Akumal Beach, which is considered a hidden jewel of the Riviera Maya for its beaches, scuba diving spots and the presence of sea turtles in the bay (Fig. 1). Tourism in Akumal accounts for 10% of employment in the Riviera Maya and is the principal source of income for Tulum Municipality (CUIAC et al., 2015).

The coral reef located just offshore forms part of the fringing reef system of Quintana Roo, which in turn is the northern extent of the world's second largest barrier reef, the Mesoamerican Barrier Reef System (SAM) (Almada-Villela et al., 2002). Akumal reef has been described and evaluated (Jordán, Dahlgren and Dahlgren, 1993; Gutiérrez-Carbonell et al., 1995), and its condition monitored and defined in various reports. Over the last 15 years, Akumal reef has lost 77% of its coral cover (from 28% down to an average of 6.4%), macroalgae cover has increased to an average of 50%, average coral disease incidence is 10% of coral colonies, and rugosity as well as reef structure has decreased significantly due to both coral mortality and a shift in coral species dominance. Fish communities are depleted and at critical levels, with very low abundance and biomass among key commercial species, and low abundance and biomass of key herbivores. Seawater nutrient and fecal bacteria levels exceed U.S. Environmental Protection Agency and Mexican Official Norms, and coastal zone development, almost exclusively tourist infrastructure, has doubled (Garza-Pérez, 1999; Piñera et al., 2009; Mata-Lara, 2012; García-Guzmán, 2013; López-Patoni, 2014; Hernández-Terrones et al., 2015; Aranda, 2016; Naranjo-García, 2016; Molina, 2016).

2.2. Socio-economical and marine resources perception assessments

On site research was conducted in Akumal, Quintana Roo, Mexico, in 2015. A random design consisting of 150 surveys (14.5% of the total population) was applied in the community to collect socioeconomic data and personal perceptions. The respondents ranged from housewives and students to employees and independent workers, trying to include all different sectors of the population, The instrument was composed of twenty-three close-ended questions addressing areas such as: Use of, interactions with and dependence on coral reefs; knowledge of, attitudes towards and perceptions of marine resources; and demography (age, income, time of residence, education level); Socioeconomic indicators were extracted from the demography questions, and used to assess specific system aspects, such as community social development level and condition, and economic security (the questionnaire is available –in spanish-upon request to the authors).

Additionally, semi-structured interviews of the main service providers (dive shops, hotels, restaurants) were conducted to define their business profiles, perceptions of the marine resources, involvement in environmental protection or conservation initiatives, and opinions on future hypothetical situations. Unfortunately, not all of the prominent service providers were able or willing to participate, resulting in only 7 of 13 attempted interviews being conducted. Local geographical and demographic data (e.g. population density, housing characteristics and level of education) were gleaned from online platforms and publications of the National Institute of Statistics, Geography and Informatics (INEGI, 2016).

2.3. Relationship between socioeconomic indicators and environmental perceptions

The data gathered by the surveys to the local population were tabulated categorically following the format of the answers options (Supplementary Material 1). Canonical redundancy analysis (RDA) is the direct extension of multiple regression to the modelling of multivariate response data, combining the concepts of ordination and regression. It allows to perform a direct comparison of two data matrices (Legendre and Legendre, 1998). RDAs were run to explore the relationship between: a) appropriation of marine resources by the community and their perception of the reef importance, decision making, management and participation in conservation activities; b) socioeconomic indicators such as age, gender, time of residence in Akumal, population education level, and wage (income) levels, and marine resources perceptions (water quality, reef fish communities condition and coral reef condition) in three timeframes (perception of the past, present and future).

These analysis used the original data of categorical answers; and an additional Chi-squared test for independence was run, to test for significant association between categorical variables, but given the frequency distribution of the data regarding socioeconomic variables, two categories were implemented to ensure a similar proportion of the population in each; time of residence was divided between those who had lived in Akumal less than 10 years, and those who had lived there more than 10 years; Education level was classified into those who had studied up to middle school, and those with a higher education level; Monthly income categories were ≤ $5000 and > $5000 pesos (~$250 USD). Marine resource perceptions in the past, present and future were recorded in four categories based on answers: 0 = Do not know; 1 = Poor condition; 2 = Regular and 3 = Good (Fig. 2).

2.4. Interviews with service providers

The data gathered by the semi-structured interviews with prominent service providers was not included on the statistical analysis; these data was used to contextualize the perceptions and perspectives of long-standing business and employers about the current and future social,
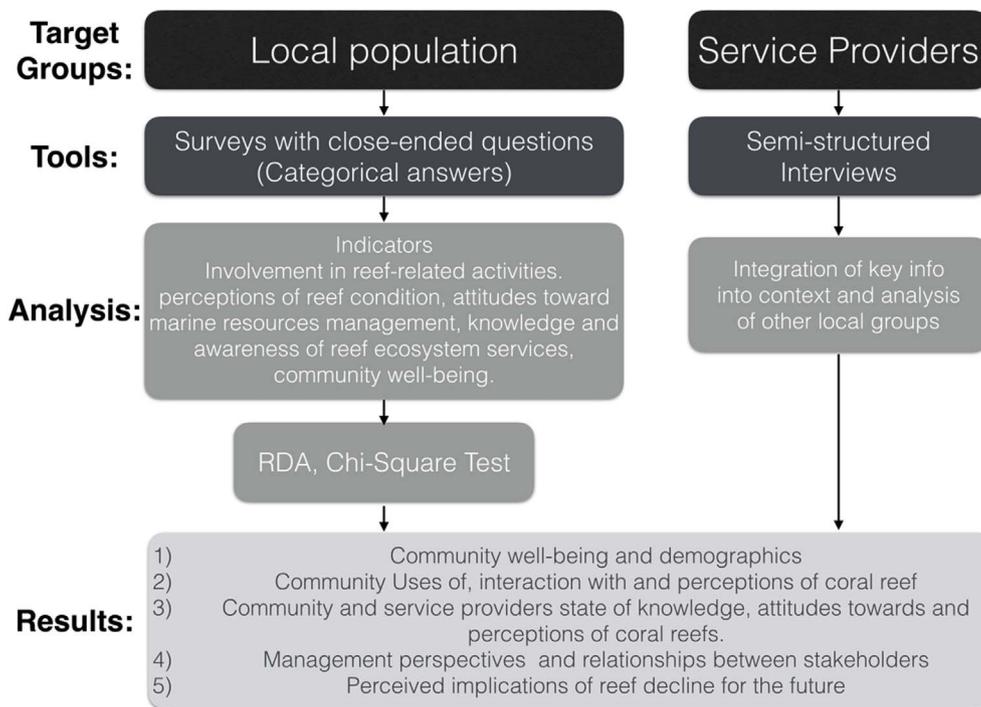
Fig. 2. Methodological approach to generating data on demography and population and service provider perspectives in Akumal.

economic and environmental situations, as well as, to establish their level of commitment to the conservation of the resources they directly depend on.

3. Results and discussion

3.1. Community wellbeing and demographics

Most households in Akumal (96.4%) had electrical power, tap water, a toilet and floors other than bare dirt; conditions placing the community at a level 14% higher than the national average. Only 64% of the population had access to health care services, while the national average is 82% (CONEVAL, 2014; OECD, 2016). More than 90% of the surveyed population had a job (30% more than the national average), 80% of which were tourism-related. Although the employment rate was high, over 50% of the employed earned less than $5000 pesos ($250 USD/month, -hence the categorical division on wages- (Fig. 3a). This amount is 25% lower than the regional average (INEGI, 2015a). Education level is low, as 75% has a maximum of basic or secondary (junior high) school (Fig. 3e), against the 82% average for these levels in Mexico (SEP, 2013); according to an OECD analysis (2017) for Mexico, people with higher education (high school and university) have salaries 56% higher than those with lower education. Education level might be one of the reasons for the proportion of wages lower than regional average.

Akumal's population is largely young with almost two thirds (62%) between 18 and 35 y.o., and a fifth (20%) between 36 and 45 y.o. (Fig. 3c). This age profile is linked to the high number (70%) of out-of-state immigrants, mainly from the towns of Sotuta de Peón and Kantunil in the neighboring state of Yucatan. Time of residence data was divided in two groups: those who had lived in Akumal more than 10 years (43%), and those who had lived there less than 10 years (57%); indeed, in the latter group 67% had lived in Akumal for less than one year (Fig. 3d). People migrate to Akumal in search of work in response to a lack of employment opportunities in their hometowns (Fraga-Berdugo, 2012), and increasing demand for labor in the continuously growing Riviera Maya tourist corridor (Sosa et al., 2015). Some of these support towns along Quintana Roo's coast have become full-fledged cities (*i.e.* Cancún, Playa del Carmen and Puerto Morelos), where the population growth was initially correlated to the increase in hotel rooms (during the 1980's and 1990's), but in the last couple of decades these cities' growth-rate is much higher, related to the expansion of economic activities in services, business and utilities for the local population (CONAPO, 2014; INEGI, 2016).

3.2. Community use of, interactions with and dependence on the coral reef

Akumal is a coastal community indirectly reliant on marine resources, since their livelihood depend on tourism attracted by the beach and coral reef aesthetics. Community participation in marine activities, and thus interaction with the coral reef, was very low; most survey respondents (60–90%) said they do not engage in activities such as snorkeling, boat trips, fishing or scuba diving. A majority (62%) said they could swim and enjoyed the beach (72%), but almost half (43%) had low levels of interaction (performing these activities less than 3 times a month). Those who use the beach and sea more frequently, do so because their work is related to these resources (e.g. snorkel tour guide), and not for pleasure.

Over half (54.2%) the respondents said they ate fish or seafood once a week, or about 5.2 kg annually. This fish consumption rate placed the local population far below the world average (19 kg/person/yr), about half the national average (10.4 kg/person/yr), and even lower than the regional average for the Caribbean (9 kg/person/yr) (CONAPESCA, 2010; SAGARPA, 2015; FAO, 2016). Several factors probably contributed to this low rate. Pork is an integral ingredient in traditional local cuisine, and, partially to supply this demand, the states of Quintana Roo and Yucatan are the top two pork producing states in the country (INEGI, 2015b). The relatively low monthly income level at Akumal (25% lower than the regional average) also likely affected fish consumption since fish and seafood are more expensive than pork or other meats.

Communities heavily reliant on a single resource system are more vulnerable to externally-induced changes to that system (Bailey and Pomeroy, 1996). The Akumal community's low intensity and frequency of coral reef interaction, together with the low rate of direct consumption of marine resources such as fish, highlight its low direct
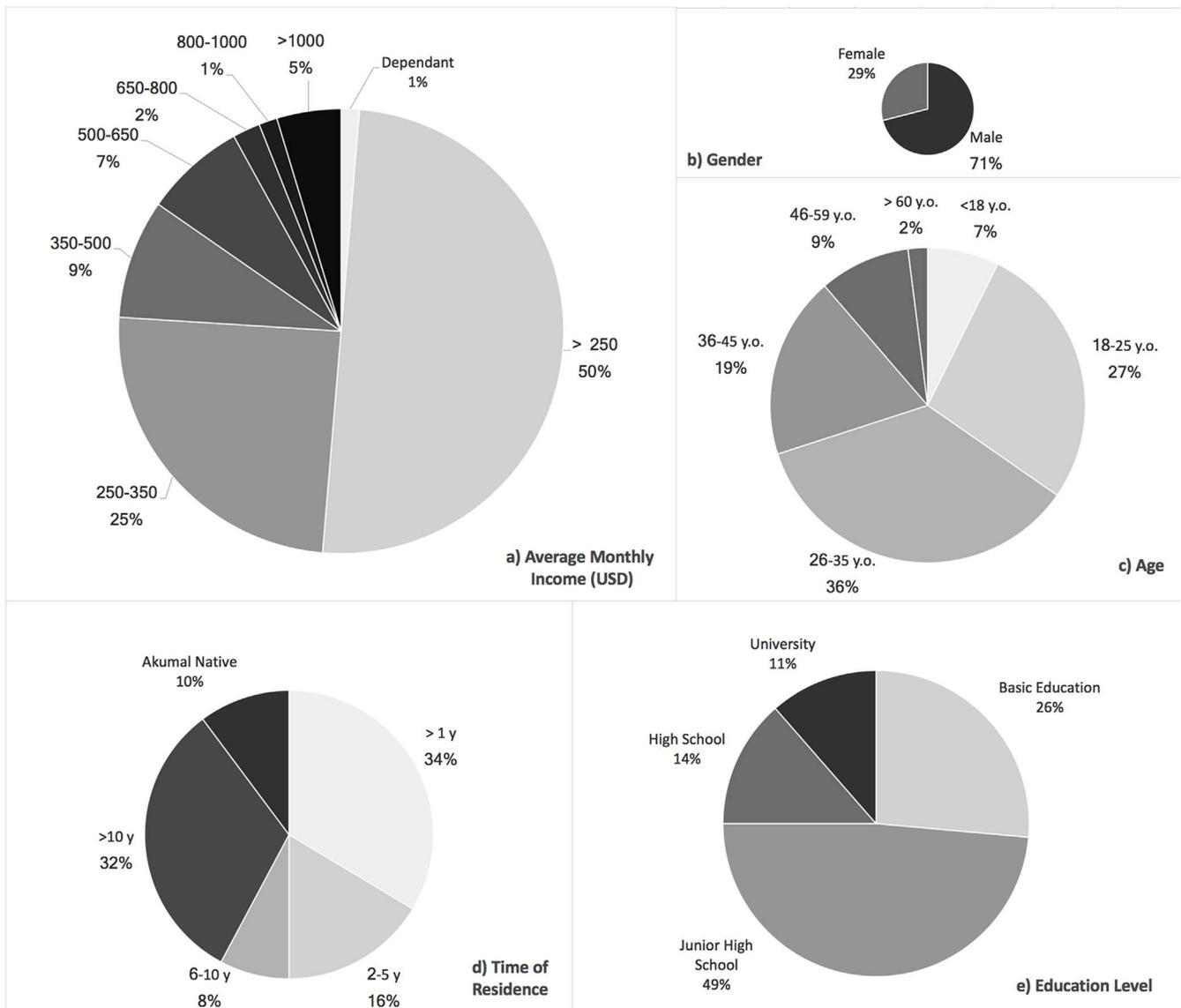
Fig. 3. Main demographic and socioeconomic indicators extracted from surveys to local population.

dependence on the coral reef. Although many tourist services (e.g. snorkeling and dive tours) directly involve the coral reef, the critical condition of the reef and its resources does not yet seem to have impacted these activities.

This perceived lack of impact of reef degradation over the economic activities might, in the one hand, give tourism-related workers a false sense of security about their current employment and the *status quo* of the tourist interest about the reef, favoring the development of social vulnerability -the result of exposure of groups of people or individuals to stress as a result of the impacts of environmental change- (Adger, 2000). Responsible (and integral) coastal management shall incorporate vulnerability reduction practices to avoid disruption to livelihoods and loss of security (Adger, 2000; Marshall et al., 2009). In the other hand, there is the shifting baseline phenomenon (Sheppard, 1995; Pauly, 1995; Sáenz-Arroyo et al., 2005; Pinnegar and Engelhard, 2008), which can be applied to Akumal and broadly to Quintana Roo tourism, where very few people (locals and visitors) are aware of the magnitude of the environmental change; and most tourists, accept the appeal of the current environmental condition and aesthetics as normal (*i.e.* coastal zone anthropization, coral/algae cover ratio, beach width, water quality, fish-diversity and abundance), thus apparently decreasing this social vulnerability until a (not determined yet) threshold of

environmental degradation and tourist perception and awareness is reached, and Akumal ceases to be attractive.

An additional concern, is the possible social conflict in this coastal zone, if and when this threshold of environmental degradation is reached; it certainly could entail loss of jobs, while the main reason for immigration to this region is precisely the lack of employment opportunities on the immigrants' places of origin.

3.3. Community and service providers knowledge of, attitudes towards and perceptions of the coral reef

One way to understand how communities value their territory (natural environment), is to study their perceptions about environmental problems and their commitment to solving them (Castillo et al., 2009). Akumal community members recognized the importance of the reef for the whole community -not only for divers and fishermen- (88%), and of a healthy reef for attracting tourists (92%). Most of those surveyed (79%) acknowledged that threats to the coral reef include hurricanes, coastal development and pollution (particularly sewage discharge). Several also associated an increase in tourists to greater reef damage, coastal solid waste generation and water pollution. But only 62% thought that coral reefs serve as a barrier against storms and
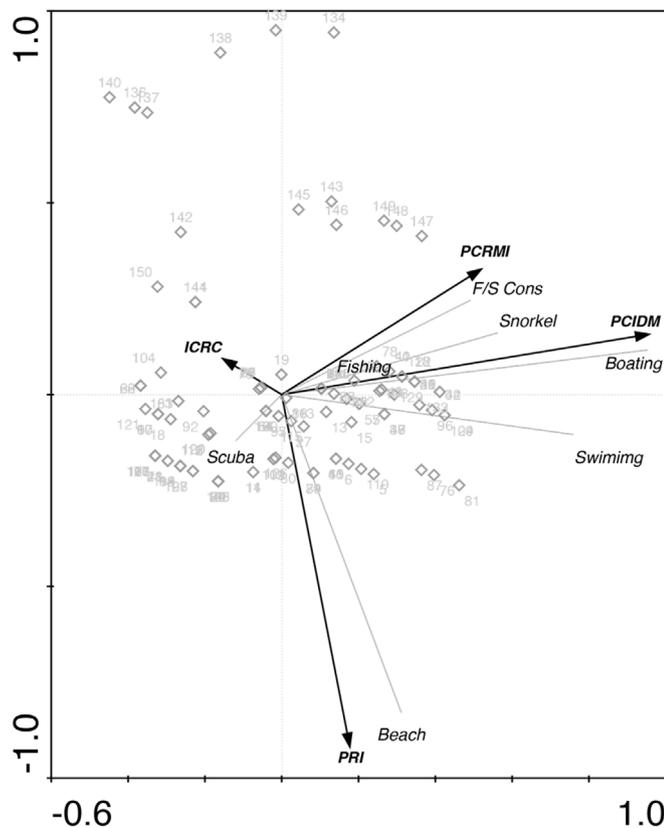
Fig. 4. RDA triplot ordination diagram, assessing the relationship between marine resources appropriation (response variables, grey lines): F/S cons, fish and seafood consumption, participation in Snorkel, SCUBA, Fishing, Boating, Sea-swimming and Beach-going by the community in Akumal (survey responders, grey square dots), and their participation in coral reef conservation activities (PRI), as well as their perceptions of community participation in reef management initiatives (PCRMI), decision making (PCIDM), and importance of coral reef for the community (ICRC) (explanatory variables, black arrows).

erosion. Other causes of reef damage, such as coral bleaching, invasive species and climate change, were not widely recognized by the respondents.

The statistical relationship between the community appropriation of marine resources and their attitudes towards them, was approached using a RDA including the levels of use of resources (beach going, swimming, snorkeling, boating, fishing, SCUBA diving and seafood-fish consumption) and the perception of community involvement in decision making, coral reef importance, management initiatives, and participation in coral reef conservation activities. In this analysis, the only significant variable (p = 0.012, defined by a Montecarlo Permutation test with 999 random permutations, under full model), was the perception of Community Involvement in Decision Making; the first two axis of the RDA triplot explained 66.6% and 25.1% of the total variability, for a total explanation of 100% when combining the four axis (Fig. 4, Table 1).

From Fig. 4, we can relate the perceptions of greater community involvement in decision making and reef management initiatives to those individuals participating more frequently in fishing, boating, snorkeling, and fish and seafood consumption. The perception of the importance of the coral reef for the community is more related to individuals who use the beach, swim at sea and SCUBA dive; and of note is the relationship between individuals who participate less in the resource appropriation activities (except for SCUBA) and their greater involvement in coral reef (environmental) conservation activities, such as beach cleaning, environmental education, recycling, etc.

The community acknowledged different possible threats to the coral reef, but did not have an accurate perception of the marine

Table 1
Summary of the main ordination diagnostics calculated by RDA of appropriation of resources and perception of community involvement.

Axes	1	2	3	4	Total variance
Eigenvalues:	0.027	0.010	0.002	0.001	1
Perceptions-Socioeconomics correlations:	0.246	0.266	0.134	0.112	
Cumulative percentage variance					
of Perceptions data:	2.7	3.7	3.9	4.0	
of Perceptions-Socioeconomics relation:	66.6	91.7	96.6	100.0	
Sum of all eigenvalues					1
Sum of all canonical eigenvalues					0.040

environment being in critical condition. The coral reef condition in Akumal has been defined as poor and critical, and the reef fish community has a critically-low biomass (Garza-Pérez et al., 2004; López-Patoni, 2014; Kramer et al., 2015; Aranda, 2016; Molina, 2016); declines in water quality have been reported in several studies in the area, including presence of coliform bacteria and high levels of nutrients (Barrera and Nahamira, 2004; Mutchler et al., 2007; Baker et al., 2010; Metcalfe et al., 2011; Hernández-Terrones et al., 2015; Kramer et al., 2015; Naranjo-García, 2016). Only 18% of the respondents considered seawater quality to be poor and reef condition to be bad; and only 14% considered the fish communities to be in poor condition. This translates to an average of 16% of the population having an accurate perception of the current condition of Akumal's marine resources.

The most common perception was that overall environmental conditions were worse than a decade ago. Their inaccurate perception could influence their disinterest in taking action and weak sense of concern about this problem. If communities value their natural environment based on their perceptions of environmental problems and their commitment in solving them (Castillo et al., 2009), then the apparent value that Akumal community members place on the coral reef, fisheries and the marine environment is generally not high.

The second RDA explored the statistical relationship between socioeconomic indicators and resource condition perception; time of residence and income level were defined as significant variables (p values = 0.006 and 0.024 respectively) by a Montecarlo Permutation test with 999 random permutations, under full model; where the first two axis explained 62.2% and 19.9% of the total variability, for a total explanation of 97.6% when combining the four axis (Fig. 5, Table 2). Longer times of residence, higher education levels and income, female gender and greater age were associated with more accurate perceptions of previous fish and coral community condition, and present and past seawater quality levels. Time of residence and education level were only slightly associated with better understanding of current fish and coral community conditions and future general reef resources condition.

An additional analysis -Chi-square test-, using the significant variables defined by the Montecarlo permutation test in the RDA, along with education level, identified the significant relationship between respondents who had lived for longer in Akumal and a perception of better marine resources condition in the past (5–10 years ago), it also revealed significant relationships between higher levels of education and wages to the more accurate perception of the resources in the future (Table 2). Although the general perception of this group was relatively accurate (the resources condition is worse now than it was in the past), it is broadly erroneous, but fairly uniform among these respondents (Table 3). That 83.7% of the surveyed population held a perception of natural resource conditions distant from reality could be due to multiple factors identified in the surveys and interviews: Lack of information from government, scientists and NGOs working in the area; lack of community involvement, a generally low education level, and again, the shifting-baseline perception of the newly arrived immigrants,
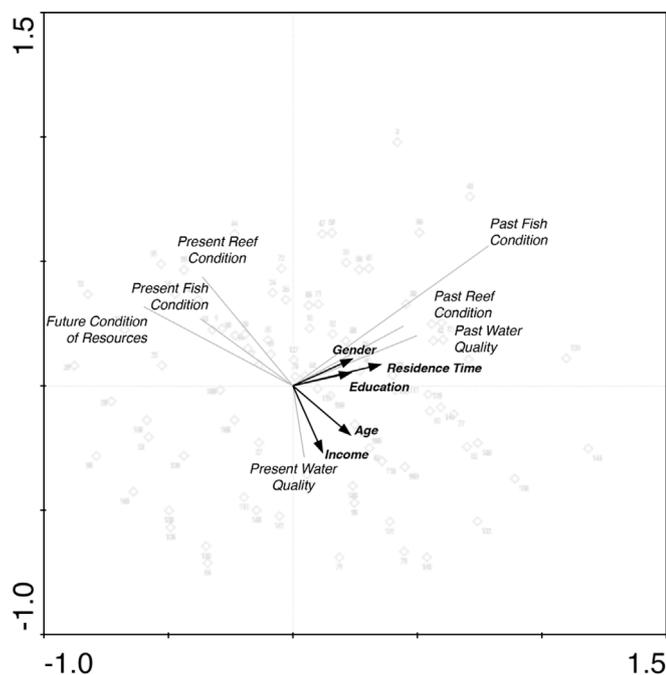
Fig. 5. RDA triplot ordination diagram, assessing the relationship between perception of marine resources condition in Akumal (response variables, grey lines), socioeconomic variables (explanatory variables, black arrows), and the ordination of the survey respondents (grey square dots).

Table 2
Summary of the main ordination diagnostics calculated by RDA of perception of marine resources condition and socioeconomic variables.

Axes	1	2	3	4	Total variance
Eigenvalues:	0.049	0.014	0.011	0.003	1
Perceptions-Socioeconomics correlations:	0.48	0.261	0.235	0.149	
Cumulative percentage variance					
of Perceptions data:	4.9	6.3	7.4	7.7	
of Perceptions-Socioeconomics relation:	62.2	80.1	94	97.6	
Sum of all eigenvalues					1
Sum of all canonical eigenvalues					0.079

influencing local ecological knowledge, specifically: generational amnesia, where knowledge extinction occurs because younger generations are not aware of past biological conditions (Papworth et al., 2009).

Interviews with service providers highlighted their more accurate perception of marine resources condition in Akumal. At least half perceived the poor condition of fish communities (50%) and seawater quality (62.5%). In contrast, only 25% considered the coral reef condition to be bad. A clear majority (> 75%) believed that general marine resources condition had worsened over the previous ten years. The more accurate understanding of marine resources condition among the surveyed businesses (in contrast to the local population) may be due to the high proportion (86%) of them offering snorkeling tours as part of their services, and the daily contact they have had with the marine environment over many years (most of the surveyed businesses have been operating in Akumal for more than ten years).

The survey data analysis (RDA and Chi-squared) defined a trend of low interaction with and erroneous perceptions of marine resources; this emphasize the interview results pointing to the presence in Akumal of the social phenomenon of deterritorialization. Defined as an absence of strong social, political and cultural links between a population and the space it inhabits, this phenomenon implies deconstruction of the territorial identity from a place of origin and construction of a new one

Table 3
A χ^2 test defined the significant variables (* p value = 0.01) explaining perception of marine resources: Time of residence was associated with past condition, and education level and income level with future condition.

Perceptions		Residence time		Education		Income	
		χ^2	p	χ^2	p	χ^2	p
Present	Water quality	2.220	0.5279	4.657	0.1987	2.847	0.4158
	Coral reef condition	3.914	0.2709	1.545	0.6720	6.671	0.0832
	Fish condition	2.102	0.5515	5.130	0.1625	2.728	0.4355
Past	Water quality	11.638	0.0087*	1.787	0.6178	1.912	0.5908
	Coral reef condition	12.905	0.0048*	5.645	0.1302	3.846	0.2786
	Fish condition	22.805	< 0.001*	0.661	0.8824	1.383	0.7095
Future	Future condition of marine resources	4.166	0.2441	14.575	0.0022*	19.650	0.0002*

* = significance level at 1%.

for the destination. It is often associated with tourism development (Hiemaux and Lindón, 2004; Herner, 2009; Fraga-Berdugo, 2012). In Akumal, this social alienation from the natural resources on which the community depends (although indirectly) is probably associated with the low level of resources appropriation, the low value placed on the marine environment, and a lack or very slow adoption of local customs. The latter is a symptom of the tenuous, halting assembly of a local identity which is dampened by a high immigration rate and a utilitarian view of the territory as primarily representing a means of employment and income to support extended families in the workers' points of origin.

Anecdotally, another type of immigrants arriving to the big support-towns (now cities), who may in some cases have different socio-economic backgrounds (higher-education, higher income and entrepreneurship possibilities), and seeking a different life-style from their hometowns (big cities like Mexico City, Guadalajara and Monterrey), end up being consumed by their new work-situations, re-adopting their previous fast-paced life, and not having a frequent or even a constant interaction with the coastal and marine resources in the area. Introducing yet more factors to the deterritorialization, local identity loss and environmental detachment among the population in this coastal area.

3.4. Management perspectives and relationships between stakeholders

The most urgent actions needed, identified by the survey respondents, is the improvement of water quality management and wastewater treatment prior to discharge. Over 90% said they would support management strategies focused on strengthening enforcement of existing environmental laws, prohibiting disposal of untreated wastewater into the aquifer, improving waste management facilities, and installing sufficient sewage and water treatment plants for homes and businesses. Interviewees noted that some local efforts have been made towards solving this problem (private funds were even committed at one point), but stakeholder momentum has been dampened by a lack of municipal and state government support in the form of matching funds to build a water treatment plant and sewage network.

A high proportion (83%) of the survey respondents supported recent implementation (DOF, 2015) of the Fishing Refuge Zone in Akumal (a management tool similar in legal terms to a No-Take Marine Reserve). Although most were unaware of its existence before the survey, 88% said they would support implementation of additional Marine Protected

Areas (MPAs) in this or other regions. Very few respondents (< 5%) believed that MPAs do not help protect marine resources; their perception was that MPAs existed only on paper and produced no real actions or results.

The results of the interviews indicate that Akumal community members do have a certain environmental awareness and perceive the negative pressure tourists exert on marine resources. Although they acknowledge that the most intense impact is in Akumal Bay, where the number of users far exceeds the system carrying capacity, there is a general sentiment against controlling the number of tourists entering the bay. Based on studies, the Wildlife Office (Direccion General de Vida Silvestre - DGVS) of the Ministry of the Environment and Natural Resources (Secretaría de Medio Ambiente y Recursos Naturales - SEMARNAT) has suggested a carrying capacity quota of 189 daily users in Akumal Bay, with no more than six people in the bay waters at a time (SEMARNAT, 2014). If they are aware of this target, local service providers certainly do not honor it; daily use rates range from 800 (in low season) to 2000 (in high season) (SEMARNAT, 2016). Respondents claimed that setting use quotas would directly impact their businesses since snorkeling in the bay is one of the main income-generating water sports for the local economy.

The relationship between different Akumal stakeholder groups is strained due to existing conflicts of interest, power struggles and lack of communication. Local community members felt they are not integrated into either decision-making processes or management actions. They were consequently unaware of what policy decisions have been made. Further complicating this dynamic is the recent creation of community tourist services cooperatives (some legal and others not). The intent is to profit directly from tourist services instead of working as employees, a sign of the community's incipient self-empowerment in the use of local resources. Survey results highlighted two situations: community interest in participating in the decision-making process and dissatisfaction at being excluded from it. However, a positive attitude towards decision-making process participation is not a guarantee of active involvement and participation (Martínez-Calderon, 2012). In Akumal, community members exhibit a clear lack of initiative and involvement in this process.

Another factor affecting governance in Akumal is the misperception, based on a past leadership role, of the local NGO, Centro Ecológico Akumal (CEA), as an organ of authority. This NGO's vision and mission include interaction and integration with the public and regional culture. The interviews exposed a deterioration in the relationship between CEA and the local population in recent years. This was caused by waning efforts at communication by CEA after the head of the board of directors left and a partial turnover in staff. An additional perception was that CEA functions as a business center focused on generating revenue for its owners, without helping the community.

This may not be the case in all localities of the Mayan Riviera or Quintana Roo, where there have been some success examples of community participation, as the implementation the Xcalak Reef National Marine Park in 2000, and several fishing refuge zones. But this community involvement is usually preceded by strong leadership capacity building and outreach efforts (CONANP, 2004; Kanan-Kay, 2016).

Different stakeholders have and promote opposing points of view, revealing the deficiency in communication between actors and a lack of integration of local people into the management and decision-making process. This is symptomatic of the underlying problem of a lack of viable resource use management plans at all governance levels (local, municipal, state, federal), which, in tandem with the prevailing social discord, is exacerbating environmental problems. Tackling serious environmental challenges will remain a distant goal until resolution is reached in social challenges such as deterritorialization and consequent lack of a strong local identity, absence of both a sense of collective responsibility, communication and trust between stakeholders and the local people, and development of sound strategies by established stakeholders to include newcomers. From this perspective, not only for

Akumal but for the Riviera Maya and Quintana Roo's coastal zone, even if environmental programs and projects are developed that could help improve natural resources condition, they will be hindered by these social challenges and the dissociation of local perceptions of resources conditions from reality.

Community perceptions determine the value given to natural resources, and significantly affect how those resources are managed (Nazarea et al., 1998). To bridge the gap between community perceptions and reality in the Quintana Roo's coastal zone, efforts are needed to foment social cohesion, promote a sense of belonging, and include a broader spectrum of actors in the decision-making process. By understanding these problems, resource managers can design and propose actions aimed at addressing these considerations and thus construct a social foundation with the capacity to successfully implement conservation strategies (Cinner and Pollnac, 2004; McClanahan et al., 2006; Aldon et al., 2011).

3.5. Perceived implications of reef decline for the future

A portion of the service provider semi-structured interview was intended to assess the economic impact on businesses of a hypothetical situation of total coral cover loss. This question's significance lays in its assessment of the probable participation of certain interest groups in decision-making processes, and actions for environmental protection, under the hypothetical assumption of a direct impact on the resources they rely on. Approximately 80% of Akumal's population work directly in tourism services, therefore, could the local Akumal economy survive such a drastic impact on the resource they depend on most? All the service providers said during their interviews that they would be affected to some extent, but only 12% said it would cause them to close. The remaining 88% of respondents stated they would have to modify the services they offer (e.g. increasing sinkhole diving-snorkeling tours), but believed their businesses would remain solvent. In terms of business tolerance to financial losses caused by decreased tourism due to a reef die off, 75% stated they could withstand losses of 15–30% of current earnings, 12.5% could tolerate up to a 40% loss, and the remaining 12.5% could sustain losses of only 5–10%. The service providers acknowledged also their hypothetical disposition to fund reef conservation initiatives now and in the near-future, but only under strict agreement of collective participation and transparent accounting for clear-goal projects.

Uncertainty was the common denominator of the perceptions of both community members and service providers about the future condition of Akumal's marine resources. Most respondents believed that future resources condition will largely depend on implementing actions focused on marine resources recovery. Overall, they believe resource condition could improve in future if the government supports conservation actions, development is planned and regulated, and particularly if strict waste water discharge treatment measures are implemented. Community members and service providers both acknowledged that future resource condition, and by association local economic conditions, will be much worse if significant changes are not made in the relationship between interest groups, unsustainable tourism industry growth, and the disjuncture between community actors and the decision-making process.

Interactions between society, economy and the environment are complex, and require that all stakeholders be involved to reach a common understanding of relevant issues (Snethlage et al., 2012). This commitment to communication and collaboration brings integration of different perspectives and needs, solution implementation, and mitigation of problems that would otherwise worsen. The benefits of greater inclusiveness and transparency in local planning and decision-making are unquestioned. If implemented, they can reduce the stress caused by influential groups in interested sectors, improve community perceptions of service delivery (Blair, 2000), and help achieve greater support and participation rates (Gaventa and Valderrama, 1999).

Should Akumal stakeholders attain a better-organized marine resources user base and improve governance practices in favor of actions for sustainable coastal zone management, they could decrease pressure on their reef and even augment the economic benefits it provides the community.

4. Conclusions

The diversity of factors involved, exemplified in Akumal, make the Quintana Roo's coastal zone a complex management scenario. A growing tourism industry has created a high employment rate and generated heavy out-of-state immigration. Average time of residence in Akumal is short, and short-term residents are largely younger. This leads to an absence of strong social, political and cultural links to the territory, and ultimately to both deterritorialization and shifting-base-line phenomena, with consequences such as lack of a sense of be-longing, low use of marine resources (e.g. low participation in bay/ beach activities, low fish and seafood consumption), and strong mis-perceptions about reef and marine environment condition, leading to the absence of an objective value set relating to the reef.

Attaining marine resources conservation in Akumal is not hindered by low environmental awareness since community members recognized many of the potential threats facing the reef (e.g. increased tourism) and the most urgent problems (i.e. those with the greatest impact on marine resources as lack of wastewater treatment), it is rather chal-lenged by a deficient communication dynamic between stakeholders, resource managers and local community members caused by in-sufficient outreach from government authorities, scientists and NGOs in the area, and lack of community interest and involvement. This has led to social conflicts as the exclusion of the local population from local governance and the mistrust grown between the community and the NGO, CEA; as well as unclear and disconnected governance practices leading to a further lack of trust that indirectly generate even greater pressure on marine resources. Increasing the involvement of the com-munity in decision making, changing institutional perspectives towards a more inclusive approach and addressing the most pressing problem, sewage and waste management, seems to be the only way to avoid a future collapse of the coral reef and a potential impact on the local economy.

Key local actors and resource managers can play crucial roles in regaining the trust of community members, local businesses and local authorities. Urgently needed are adaptive management approaches re-sponsive to both the ecosystem and social system. In this context, social acceptance of any management strategy both in Akumal as well as in the Quintana Roo's coastal region is essential for its successful im-plementation and evolution. If local communities are informed and involved, they will be more susceptible to support conservation stra-tegies since the different stakeholder groups are already en-vironmentally aware and open to supporting conservation measures if these criteria are met.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx. doi.org/10.1016/j.ocecoaman.2018.01.032.

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