

Integrating Community Perspectives into Reef Health Eco-Audits in Puerto Morelos, Mexico

By

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Submitted in partial fulfillment of the requirements for the degree

of

Master of Marine Management

at

Dalhousie University  
Halifax, Nova Scotia

December 2025

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### **List of Abbreviations Used**

MPA – Marine Protected Area

HRHP – Healthy Reefs for Healthy People

CONANP – National Commission of Natural Protected Areas

PMRNP – Puerto Morelos Reef National Park

AGRRA – Atlantic and Gulf Rapid Reef Assessment

UVC – Underwater Visual Census(es)

IUU Fishing – Illegal, Unreported, and/or Unregulated Fishing

LEK – Local Ecological Knowledge

## **Abstract**

Puerto Morelos, Quintana Roo, is a coastal port town with a community whose livelihoods are closely tied to the health of the Puerto Morelos Reef National Park (PMRNP) marine protected area. The local economy depends heavily on both tourism and fishing, making reef health central to community wellbeing. However, most existing literature and assessments of the reef's condition focus primarily on biological monitoring and governmental consultation. In collaboration with Healthy Reefs for Healthy People (HRHP), an environmental non-governmental organization that focuses on conservation of the Mesoamerican reef. HRHP produces periodic reports on reef health and management measures; reef health monitoring results are found in their "Report Cards", while evaluation of recommendations and implementation are in their "Eco-audits". This project focuses on establish a baseline study to integrate community perceptions into the Eco-Audit framework, specifically. Through semi-structured interviews with fish harvesters and dive guides, I gathered perceptions on the key pressures affecting the reef, local management practices, and local fish abundance, among other topics. The intended outcome of this project is to establish a process that explores how community perspectives can be integrated into reef health monitoring practices, using HRHP's Eco-Audit framework as the primary tool. By combining biological data with local knowledge, this research will ultimately provide a preliminary assessment of how the PMRNP and the surrounding MPA align with community priorities, values, and management goals.

## Acknowledgements

I want to extend a sincere thank you to GVI Mexico, their volunteers, and staff for hosting me as an intern and National Scholar. Without their support, I would not have been able to complete my data collection, and this project would not have been possible. A special thanks to GVI Mexico Director, Miguel Lozano, for connecting me with the fishing cooperative in Puerto Morelos. My time at GVI was an integral part of this project and a time of my life I will always cherish.

I am also extremely grateful to Healthy Reefs for Healthy People for allowing me to use their data and be a very small part of their efforts to conserve and preserve the Mesoamerican Reef and its species. I want to extend a thank you to Israel Muñoz and Nadia Rubio for their help and input in designing the project and its data collection and processing. A very special and important thank you to my academic supervisor, Mélina Soto, who let me create and propose this project from scratch, supporting me the entire way and offering her guidance. I am endlessly inspired by your work. Additionally, thank you to Omar Rivera for taking the time to be my second reader and providing feedback on my project.

Thank you to the Dalhousie Marine Affairs Program and the wonderful faculty who made my experience here so rewarding and memorable. To all my peers and friends from the Master of Marine Management class of 2025: I am so proud to know you and excited to see what you do next.

I would like to acknowledge that much of the work I carried out for this master's project took place in Quintana Roo, Mexico, on the ancestral and traditional territory of the Maya, specifically the Yucatec Maya. The Indigenous Peoples of Mexico are what make the country so rich in culture. This project began because I believe artisanal fish harvesters and other people Indigenous to the area of Puerto Morelos should have a say in how their reef is conserved and protected.

Finally, I want to thank my family. To my parents, thank you for the encouragement, support, and love throughout my entire academic journey. A very special thank you to my little sister Mariel, who is my absolute best friend on the planet. A huge thank you to my aunt, Daniella Guevara, who was once upon a time the director of the Puerto Morelos Reef National Park and the biggest inspiration for me to return to Puerto Morelos and pursue the project of my dreams. Los amo con todo el corazón!

## **1. Introduction**

### *1.1. Marine Protected Areas and Community Engagement*

Community and stakeholder engagement is widely recognized as a critical component of effective Marine Protected Area (MPA) management. Research demonstrates that MPAs are more likely to achieve their ecological and social objectives when they are developed and managed with meaningful involvement from local stakeholders and community members (Jameson et al., 2002; Rahman et al., 2022; Rudd et al., 2001). This is because by engaging local perspectives, it becomes possible to contextualize key aspects such as zoning and regulatory measures, ensuring that these tools align with the activities and social priorities of the surrounding community (Charles & Wilson, 2009; Nursey-Bray et al., 2024). A key purpose of any MPA is to promote the long-term conservation of marine ecosystems, ensuring that human activities occurring within these areas are compatible with the preservation of biodiversity and ecosystem functions (DFO, 2017; IUCN, n.d.).

The concept of Local Ecological Knowledge (LEK) is an emerging approach in ecological research that seeks information from non-scientist actors who are local to a given area. LEK is rooted in place-based, lived experience, often built over lifetimes and across generations through close relationships with the natural environment. Because of this, people who hold LEK may have a different and important connection to wildlife than scientists who work in an area temporarily, making their knowledge especially useful for ecological studies (Albuquerque et al., 2021; Anadón et al., 2009; Barbato et al., 2021; Huntington, 2000).

In marine contexts, fish harvesters are often consulted for their LEK, as they can provide insights into species movement patterns, abundances, and other ecological dynamics based on their constant and long-term interactions with marine species (Azzurro et al., 2011; Barbato et al., 2021; Colloca et al., 2020). Including LEK in marine conservation and management projects not only strengthens research outcomes but can also support more effective and meaningful co-management (Begossi et al., 2019).

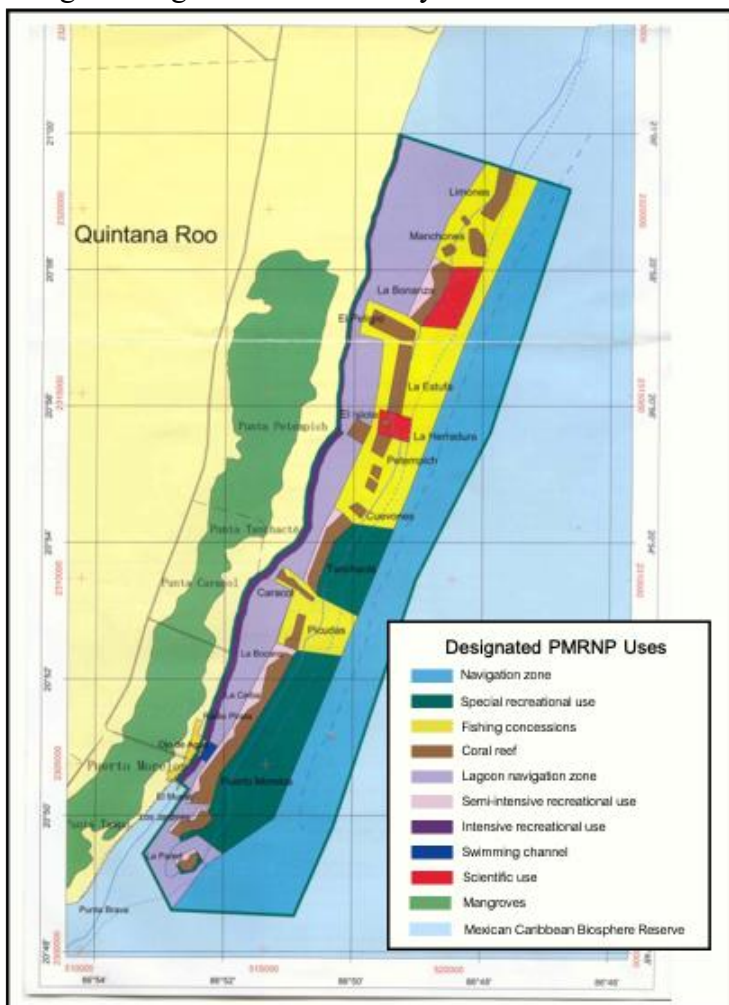
Consequently, MPA measures such as fisheries closures or recreational restrictions should be informed by the experience and expertise of Indigenous peoples and local residents. Their close and long-standing relationship with the ocean positions them as key actors in marine conservation, capable of contributing valuable insights to management objectives (Warrior et al., 2022).

In the case of Mexico, MPAs cover more than 25 percent of the country's Exclusive Economic Zone. In fact, 98% of the territorial sea of the Mexican Caribbean is located in MPAs, representing 99% of the reefs of Quintana Roo (Healthy Reefs for Healthy People, 2024). The majority of these are federally declared MPAs established through presidential decree or with the agreement of landowners willing to designate their areas as protected (Perera-Valderrama et al., 2023). There are currently 40 federal MPAs in Mexico, most of which include both marine and coastal elements (CONANP, 2024; DataMares, 2025; Ortiz-Lozano et al., 2017). These areas fall under the jurisdiction of the National Commission of Natural Protected Areas (CONANP in Spanish) and are governed by Mexico's General Law of Ecological Balance and Environmental Protection (CONANP, n.d.; DOF, 1988).

MPAs in Mexico frequently lack mechanisms for co-management and stakeholder inclusion (Ayer et al., 2018). However, there do exist a federal advisory council and subsidy programs for Natural Protected Areas (NPAs). The former is an initiative intended to establish local community participation as advisory councils that support the management and administration of local protected areas (CONANP, 2016a). An important point of discussion for these advisory councils is the publishing and updating of management plans, which are necessary for the effectiveness of MPA management (Convention on Biological Diversity, 2011; Middleton & Thomas, 2003). Subsidy programs are participatory programs implemented by the CONANP which attempt to strengthen the link between communities and their environment by ensuring sustainable use and management of natural resources in NPAs (CONANP, 2025). Various barriers continue to limit community participation for effective management of protected areas, chief among them a lack of institutional capacity and financial resources, which have led to conflict between conservation and development goals (Peña-Azcona et al., 2021).

## 1.2. Puerto Morelos Reef National Park

Despite barriers, communities in Mexico have proven they can be successful initiators of MPAs. Puerto Morelos Reef National Park (PMRNP) in Quintana Roo, Mexico (Figure 1) is a prime example of community-driven initiatives, where conservation measures were instigated by the people who depend on the MPA and its ecosystems (Carabias Lillo et al., 2000). Community-based MPAs like the PMRNP represent grassroots efforts to conserve marine environments that are central to local livelihoods and cultural identity. In many cases, these initiatives arise from a strong sense of responsibility and care for the ocean and are built upon collective action aimed at ensuring the long-term sustainability of livelihoods and traditions (Collier, 2020).



**Figure 1.** Map reprinted from CONANP of the PMRNP use zones and adapted by Anajose Reyes from Ladd & Collado-Vides (2013). Corresponding legend indicates designated use for each zone.

When stakeholders and rights holders are involved throughout all phases of the MPA process, this is referred to as co-governance or co-management (Carlsson & Berkes, 2005). Effective collaboration should incorporate local needs, knowledge, and rights at every stage of

decision-making. MPA processes roughly include identifying area of interest for a MPA, planning & design, official designation, and finally management & outcomes (Dehens & Fanning, 2018). However, this model remains lacking in Latin America, where financial and institutional capacity to support inclusive conservation is often limited (Perera-Valderrama et al., 2023; Pomeroy et al., 2004). Protected areas in Latin America and the Caribbean are underfunded, which results in unmet management costs due to financial gaps (Bovarnick et al., 2010).

In Mexico specifically, there was an action plan dedicated to analyzing the financial gap facing CONANP, which was last updated in 2015. The report showed that over the 2014-2028 period, CONANP would need an additional MXN \$ 961.28 million (or around a 3-fold increase) allocated by the Federal Expenditure Budget to effectively operate the protected area system (Bezaury-Creel, 2005; CONANP, 2016). Yet, *Noroeste Sociedad Civil para la Sustentabilidad Ambiental* reported that the 2025 Federal Expenditure Budget showed the lowest protected areas budget in the last 18 years (NOSSA, 2024). Limited funding for MPAs remains a challenge, especially for developing countries in the Caribbean (CBF, 2025), and can lead to ‘paper parks’, or MPAs that cannot financially sustain themselves and thus have ineffective management and staffing (Gill et al., 2017; Pascal et al., 2021)

This project focuses on the community surrounding the PMRNP, an MPA established in 1998 after pressure from the local community in the port town of Puerto Morelos (Rodríguez-Martínez, 2008). Situated in the northeastern region of the Yucatán Peninsula, the PMRNP lies within the Mexican Caribbean and encompasses a reef system that forms part of the greater Mesoamerican Reef. Historically, the surrounding community has relied heavily on artisanal fisheries in the reef and adjacent waters for both livelihood and food security (Salas Marquéz et al., 2013).

The management plan for PMRNP (Carabias Lillo et al., 2000) was developed with input from local actors and published in the year 2000. As a federally designated MPA, it falls under the jurisdiction of the CONANP (DOF, 2000a; Perera-Valderrama et al., 2023). Initial funding for the park's operations was sourced through visitor fees, which began to be collected in 2002 (Rodríguez-Martínez, 2008). There is a lack of recent literature on the execution of the PMRNP's management plan. Rodríguez-Martínez (2008) claims that despite the early involvement of local actors in shaping the park's management framework, engagement has dropped in the years since.

There have been no more recent published articles on the status of the park and its approval by local residents, highlighting a gap in the literature.

The PMRNP is also surrounded by another federally regulated MPA called the Mexican Caribbean Biosphere Reserve, which is the largest MPA in Mexico. The Reserve was established in 2016 and covers 5,754 hectares across several municipalities in Quintana Roo, including Puerto Morelos. The reserve encompasses five marine ecoregions and protects 50% of the Mesoamerican Reef System. The reserve includes seagrass beds and coral reefs that support high biodiversity (CONANP, 2016b). The biosphere reserve extends from behind the PMRNP outwards, as if connecting the space between the different protected areas that already existed. It has its own management program, and its designation seeks to safeguard key marine habitats and strengthen reef and fisheries conservation.

### *1.3. Artisanal Fishing*

Although many people hold local fishing permits or are permitted to subsistence fish, the only people permitted to fish commercially within the park and other surrounding areas, given their fishing concessions, are members of the local fishing cooperative (Pescadores de Puerto Morelos S.C.L.). This co-op was founded in 1995 with 17 members and has since grown to about 50 members total in the time since. The co-op provides income, food, and products for residents, as well as catering to growing tourism demand in Puerto Morelos and Cancúinn. Small-scale fishing co-ops also provide benefits to harvesters as they provide support and insurance to harvesters with the means to cope with environmental and socioeconomic crises such as declining catches, illness and death within families, natural disasters, and famine (Gobierno de México, 2020).

Fishing within the PMRNP (and all of Mexico) is regulated through federal laws and norms like the General Law of Sustainable Fishing and Aquaculture (DOF, 2007) and the National Fisheries Charter (IMIPAS, 2025). These include specifications on closed seasons and for capturing commercial species like snapper and spiny lobster, as well as quotes and allowable gear; these are all published through Mexico's Official Journal of the Federation (Rivera-Garibay et al., 2024; Salas Marquéz et al., 2013).

The Puerto Morelos Fishers' Cooperative holds a 20-year concession (since 1994) to harvest lobster and finfish across an area that includes the MPA, but when the park was established in 1998, members agreed to stop operating in nearly half of the shallow zones, a

restriction now codified in the management plan (DOF, 2000a). However, the decree of protection still allowed traditional fishing activities that had been carried out before its issuance to be maintained as long as they did not significantly affect the fish and mollusc populations of the area (Salas Marquéz et al., 2013; Vargas Márquez et al., 2003). The voluntary reduction in fishing efforts by the fishing cooperative reflected both conservation concerns and the co-op's economic diversification, as many members also work in tourism as operators or guides during closed or low fishing seasons.

The main fishing resource is spiny lobster and several species of fish such as groupers (Serranidae), snappers (Lutjanidae), hogfish (Labridae), ocean triggerfish (*Canthidermis sufflamen*), and mojarras (Gerreidae), among others. Fish harvesters have divulged that there is a seasonal variation in their income, and the official open lobster season is the most profitable (Salas Marquéz et al., 2013), lasting from July 1 to February 28. In past studies, harvesters have reported declining catches, with some stating that catches were larger in the 90s and even the late 2000s, compared to 2013 (Salas Marquéz et al., 2013). Fish harvesters are given permits based on season, which include finfish, lobster, and lionfish. Lionfish are not included in finfish permits as they are a fast-spreading invasive species in the area. Fishing these provides additional income for harvesters while helping control invasive populations (Quintana et al., 2023).

During lobster season, fish harvesters primarily use SCUBA diving fishing techniques with basic equipment, including wet suits and diving equipment (mask and snorkel), ice, coolers and fishing gear (hook/harpoon). Finfish harvesting is carried out using a longline or line.

Overall, fishing in PMRNP remains multi-species, seasonal, and regulated by zoning that designates where subsistence, commercial, and sport fishing can occur under strict gear and effort limitations. Sport fishing in this context refers to recreational fishing where harvesters are not allowed to sell catches commercially (Arce-Ibarra & Charles, 2008; Pavón, 2002). In Quintana Roo, many tourism service providers can be chartered for sport fishing trips in the reef area, essentially providing the fishing experience. Some species, with size and quantity limits, can be retained through sport fishing by the client or the sport fishing guide (DOF, 1994), while catch and release is also common practice (i.e. returning the fish after catching).

#### *1.4. Tourism*

As mentioned, tourism represents the principal source of income for Puerto Morelos, largely supported by its coastal location within the PMRNP and the presence of the Mesoamerican reef. The locality attracts both domestic and international visitors through marine-based activities permitted in the park, including snorkelling and diving (Cerutti-Pereyra et al., 2022). Tourism infrastructure is concentrated around the town center, the hotel zone, and eight wooden docks that accommodate small boats and yachts, including the fish harvesters' dock, which also provides access for tourist vessels (Salas Marquéz et al., 2013). Participants in the tourism industry who were targeted for interviews were all snorkelling and diving guides.

In addition to the fishing co-op, Puerto Morelos also has a nautical services co-op called the Puerto Morelos Tourist Services Cooperative. This was the first tourist cooperative in Puerto Morelos and the first to obtain permission to access certain areas of the National Park. Its main tourist services include snorkelling, sport fishing, boat tours, and SCUBA diving (Reyes Joaquín & Romano Gino, 2019). From personal observation and through my time in Puerto Morelos, most independent SCUBA dive and snorkel guides either own their own dive shops or work as contracted dive guides for independent dive shops.

Tourism in Puerto Morelos is regulated through a framework that links state tourism policy with federal environmental laws governing protected areas. The state of Quintana Roo's Law of Tourism defines nature-based tourism and requires operators to follow sustainability and safety standards, especially when activities depend on fragile ecosystems (POE, 2024). For operations that occur within an MPA, tourism must also comply with the General Law of Ecological Equilibrium and Protection of the Environment, which is the main legislation that governs MPAs in Mexico (DOF, 2000b). Rules are then implemented through the PMRNP Management Program (DOF, 2000), which designates zones for snorkelling, diving, and boat tours and outlines the permits and conduct expected from operators.

#### *1.5. Healthy Reefs for Healthy People and Project Aims*

This project was conducted in collaboration with the local NGO, Healthy Reefs for Healthy People. The Healthy Reefs for Healthy People (HRHP) initiative is a regional collaboration dedicated to the conservation and sustainable management of the Mesoamerican Reef. Since 2004, HRHP has produced periodic Report Cards on the Health of the Mesoamerican

Reef, documenting changes in reef condition and highlighting local management challenges and successes.

In response to the need for greater accountability and measurable progress, HRHP, in collaboration with the World Resources Institute and regional partners, launched the Eco-Audit in 2011. Distinct from the Report Card, the Eco-Audit is a systematic and transparent evaluation tool that assesses the degree of implementation of 28 recommended reef management actions originally proposed in the 2008 and 2010 Report Cards (Table 1). These actions are organized into seven themes: Marine Protected Areas, Ecosystem-based Fisheries Management, Coastal Zone Management, Sanitation and Sewage Treatment, Research, Education and Awareness, Sustainability in the Private Sector, and Global Issues.

By tracking progress across these themes, the Eco-Audit provides a comparative assessment of management performance among Mesoamerican Reef countries and highlights both achievements and areas needing improvement. Recent Eco-Audit results have documented significant regional milestones, including parrotfish protection legislation across all four Mesoamerican reef countries, advances in wastewater management in Honduras, and expanded education and monitoring programs through HRHP's AGRRA training network. The Eco-Audit serves as a monitoring and accountability mechanism but also as an opportunity for more effective and coordinated reef stewardship.

However, these audits do not directly incorporate community perspectives. In 2025, HRHP stated interest in redesigning its Eco-Audits to focus on a smaller set of critical indicators, thereby improving the precision and applicability of its assessments. The objective of this project is to employ qualitative research methods to capture the perspectives of local community members who depend on the reef for their livelihoods and interact with it daily. The intended outcome is to establish a baseline study that explores how community perspectives can be integrated into reef health monitoring practices, using HRHP's Eco-Audit framework as the primary tool. By combining biological data with local knowledge, this research aims to provide a preliminary assessment of how the PMRNP and the surrounding MPA align with community priorities, values, and management goals.

**Table 1.** Seven themes used in Healthy Reefs for Healthy People’s Eco-Audits, with each of the indicators used to score them.

<b>Theme</b>
<b>1 – Marine Protected Areas</b>
1a. Percent of a country’s territorial sea included in gazetted MPAs
1b. Percent of a country’s territorial sea included in fully protected zones
1c. Percent of mapped coral reef area included in fully protected zones
1d. Percent of MPAs with good management
1e. Percent of MPAs with good enforcement
1f. Generation of alternatives for fishers within the network of MPAs
<b>2 – Ecosystem-based Fisheries Management</b>
2a. Harmonizing fisheries regulations among countries
2b. Special regulations for grouper / spawning sites
2c. Protection of key grazers (parrotfish)
2d. Transform all open-access fisheries to rights-based sustainable fisheries management systems
<b>3 – Coastal Zone Management</b>
3a. Coastal zone planning regulations
3b. Watershed management plans related to coastal zone planning
3c. Mangrove extent as an indicator of the effectiveness of the coastal zone management plan implementation
<b>4 – Sanitation and Sewage Treatment</b>
4a. Standards for wastewater management/sewage treatment
4b. New infrastructure for sewage treatment (in the last 5 years)
4c. Reduce upstream watershed pollution sources (agriculture, livestock, urban/tourism, industrial, rural, deforestation) through better management practices, action plans and regulations in each sector
<b>5 – Research, Education, and Awareness</b>
5a. Standardized monitoring of coral reef health and information management (regional indicator)
5b. Economic valuation of coral reefs
5c. Availability of understandable information on reef condition and threats
5d. Interdisciplinary partnerships combine social and ecological research for management
<b>6 – Sustainability in the Private Sector</b>
6a. Voluntary eco-standards program for marine recreation providers
6b. Participation of coastal hotels in eco-certification schemes
6c. Adoption of seafood eco labeling programs
6d. Government incentives for conservation and sustainable businesses
6e. Private sector assistance to MPAs
<b>7 – Global themes</b>
7a. Mapping of potentially resilient reefs to warming seas / coral bleaching (regional indicator)
7b. Engagement in international/regional treaties that support conservation
7c. Adopt and expand a reward system for carbon sequestration and encourage a reduction

## **2. Methodology**

### *2.1. Location and context*

This study focuses on fish harvesters from the local co-op and SCUBA dive guides. Puerto Morelos is a small fishing community situated between the major tourist hubs of Cancún and Playa del Carmen, with most residents depending on tourism and the service industry for their livelihoods. The local economy is primarily service-based, with this sector accounting for 62% of revenue generated in the area (INEGI, 2018). Within this, ecotourism, nautical services, and fishing are especially significant. For these reasons, this project seeks perspectives from community members in these roles, asking how they can be incorporated into reef monitoring, both through engagement and recommendations and by comparing their views with qualitative data from environmental NGOs working in the MPA.

Puerto Morelos is divided into two distinct areas: the colonial side and the port side. The colonial side lies about a fifteen-minute drive inland from the port, connected by a narrow road that crosses extensive mangrove forests, which are also declared a natural protected area (CONABIO, 2013). This area is primarily home to residents, working families, and Indigenous communities of Mayan origin (population of ~2,500) (Data México, 2020), and it is where I lived during my stay in Puerto Morelos.

The port side, in contrast, is more oriented toward tourism, featuring public beaches, resorts, hotels, condominiums, and beachfront restaurants. The individuals interviewed for this project generally conduct their business on the port side, though most reside on the colonial side. The fishing cooperative, along with the majority of dive and snorkel shops, is also located on the port side, where boats depart from the pier into and beyond the boundaries of the PMRNP.

### *2.2. Qualitative Data Collection: Fish Harvester and Dive Guide Interviews*

The purpose of this project was to document local knowledge and perspectives on the National Park, as well as on the health of the reef and local marine species populations. To achieve this, I conducted interviews with individuals who spend the most time on and in the reef: fish harvesters and local SCUBA dive guides (Table 2). Because their livelihoods are directly tied to the reef ecosystem, their insights are particularly valuable for integrating local knowledge into monitoring practices.

Data were collected through semi-structured interviews based on a set of predetermined survey questions. While each participant was asked the same core questions, the format was intentionally open-ended to encourage participants to share broader reflections and related experiences. I further tailored interview questions according to each participant’s profession and expertise, as dive guides and fish harvesters engage with the reef in different ways (Table 3).

I initiated interviews with dive guides through contacts provided by my supervisor, Mélina Soto, Mexico coordinator for HRHP, who introduced me to several individuals in the area. Living in Puerto Morelos and interning with GVI Mexico, a local SCUBA dive-based NGO, also enabled me to build connections with other dive guides whom I then approached for participation. Additional participants were recruited using snowball sampling, as guides often suggested colleagues or friends who might be interested in participating.

**Table 2.** List of participant descriptors.

<b>Participant Descriptor</b>	<b>Total Participants Interviewed</b>
Guide	11
Co-op Fish Harvester	7
<b>Participant Gender</b>	
Male	8
Female	10
<b>Participant Age</b>	
25-34	5
35-44	4
45-54	5
55-64	1
65-74	2
<b>Participant Hometown</b>	
Puerto Morelos	7
Mexico (outside of PM)	9
Abroad	2

**Table 3.** General topics addressed in the semi-structured interview/survey guide. Other questions and topics were addressed in the interview guide but were excluded as they were outside the scope of this study.

Topics	Main Questions
Demographic information	Gender Where were you born? What year were you born?
Perceived decline in fish abundance	Do you know of any species or group of species that was once abundant and no longer is?
Perceived change in diversity	Do you think there used to be a greater variety of fish in what is now the PMRNP area?
Changes in specific sites or productivity	Do you know of any locations inside or near the PMRNP that used to be very productive or excellent for observing fish but no longer are?
Perceived causes of change	What do you think has caused the changes in fish abundance, variety, or size?
Perceptions of MPA effectiveness & management suggestions	Do you think the PMRNP helps increase fish abundance inside the park? Or outside of the park?  Do you think the park helps reduce illegal or harmful activities (e.g., illegal fishing or irresponsible tourism)?  What could the park do to improve resource management and fish abundance?

Access to the local fishing cooperative was facilitated by another supervisor at GVI Mexico, Director Miguel Lozano, who connected me with the co-op’s president and later supported ongoing communication with the vice-president. After maintaining contact for several weeks, I arranged interviews with members of the cooperative.

Eligible participants included anyone over the age of 18 who either identified as a dive or tourist guide working within the PMRNP or as a fish harvester affiliated with the Puerto Morelos Fishing Cooperative. Interviews ranged in duration from 20 minutes to one hour, depending on the level of detail provided by participants. All core questions were posed, with additional follow-up questions asked for clarification when necessary. The interview guide was adapted from a previous project (Mar Sustentable, Rufford Foundation Project 2021) and included input from its lead researcher, Nadia Rubio-Cisneros. Several questions were also influenced by the *Salas Márquez et al. (2013)* status report on artisanal fisheries in Puerto Morelos. Interview guides were reviewed and approved by the Marine Affairs Ethics Committee (see Annex I and II).

In total, 18 individuals participated in formal interviews: 10 dive guides, one boat captain, and 7 fish harvesters. In one case, two participants preferred to be interviewed together, and these were categorized as part of the dive guide sample. Except for one interview conducted entirely in English, all interviews were carried out in Spanish, my native language. Each

interview was both recorded and accompanied by written notes, with the prior consent of participants.

Fieldwork took place between May 25 and July 16, 2025. Interviews were conducted primarily between June 19 and July 1. Dive guide interviews were scheduled according to participant availability, as their work was dispersed across various sites in town. Interviews with fish harvesters were completed on July 1 at the cooperative office, where interested members attended and were interviewed consecutively.

### *2.3. Additional Consultation*

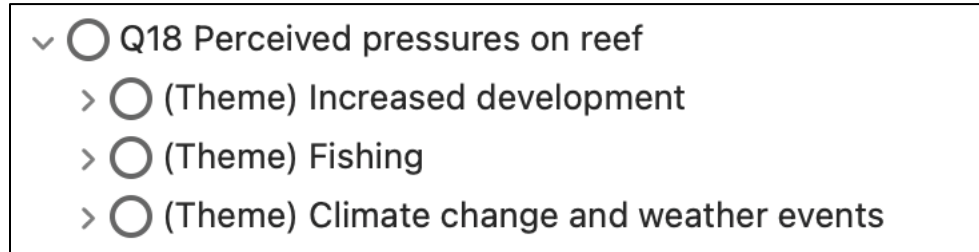
As a complement to this project, I met with the interim Director of the PMRNP, Octavio Granados González. Our meeting took place in his office, where he explained the logistics and regulations of the park, as well as the internal operations of the managing authority. The information provided during this consultation was incorporated into the introduction of this paper and later used to contextualize the results and inform the recommendations presented in the discussion.

### *2.4. Data Analysis: Coding Interviews*

All interview recordings were transcribed using OtterAI. Each transcript was then reviewed against the original audio to correct for any errors or misinterpretations by the program. No interview data was stored on the program's cloud; instead, all files were uploaded to my password-protected OneDrive account associated with Dalhousie University.

Transcripts were subsequently imported into NVivo for qualitative analysis. I applied an inductive coding approach, manually assigning codes to each interview (Figure 2). Initially, codes were organized according to the structure of the interview guide, with each question serving as a primary code. Responses were then compared across participants to identify commonalities and patterns. Certain questions elicited more discrete or numerical answers, such as those asking participants to identify species they perceived as declining in the reef. These responses were not grouped into thematic codes but rather set aside for later comparison with quantitative data.

Through multiple rounds of coding, broader themes emerged that connected responses across different questions. These themes highlighted the issues and topics most relevant to participants when discussing their experiences with the reef and the National Park.



**Figure 2.** Screenshot of an example code used for question 18 and subsequent themes identified based on participant responses.

## 2.4. Data Analysis: Comparing Qualitative and Quantitative Methods

### 2.4.1 Data sorting

Interviews included questions designed to identify which, if any, reef species participants perceived as declining. Responses were coded by taxonomic family and tallied by total number of mentions to highlight the species most frequently described as declining. Responses were also examined separately to compare differences between fish harvesters and guides.

Quantitative data were obtained from *Healthy Reefs for Healthy People* and represent fish biomass recorded between 2005 and 2023 across research sites in the Mexican Caribbean from Akumal to Cancun (Figure 3). Each data point was georeferenced to its specific sampling site. Data collection followed the Atlantic and Gulf Rapid Reef Assessment (AGRRA) protocol for coral reef monitoring, which is an underwater visual census (UVC) method that uses a subset of marine fish families as indicators of reef health (Lang et al., 2010). Consequently, families mentioned during interviews but not included in AGRRA were excluded from the quantitative dataset to allow for practical comparison.

Spatial selection of biomass data was conducted using QGIS. Sampling sites were retained if they fell within the general area where guides and fish harvesters from Puerto Morelos are known to carry out daily activities. This resulted in the inclusion of sites

ranging from Akumal to Cancún. For each site, family-level biomass values were averaged annually and plotted to assess temporal trends.

#### 2.4.2. Statistical Analysis

Biomass data (g/100 m<sup>2</sup>) were grouped by taxonomic family, and a simple linear regression model was fitted for each family to quantify temporal trends in biomass. This approach assumes a linear relationship between biomass and year. The model was fitted separately for each family using the `lm()` function in R and summarized with the `broom::tidy()` function to extract the slope estimate, its standard error, and p-value. These values provided both the magnitude and statistical confidence of biomass trends for each family.

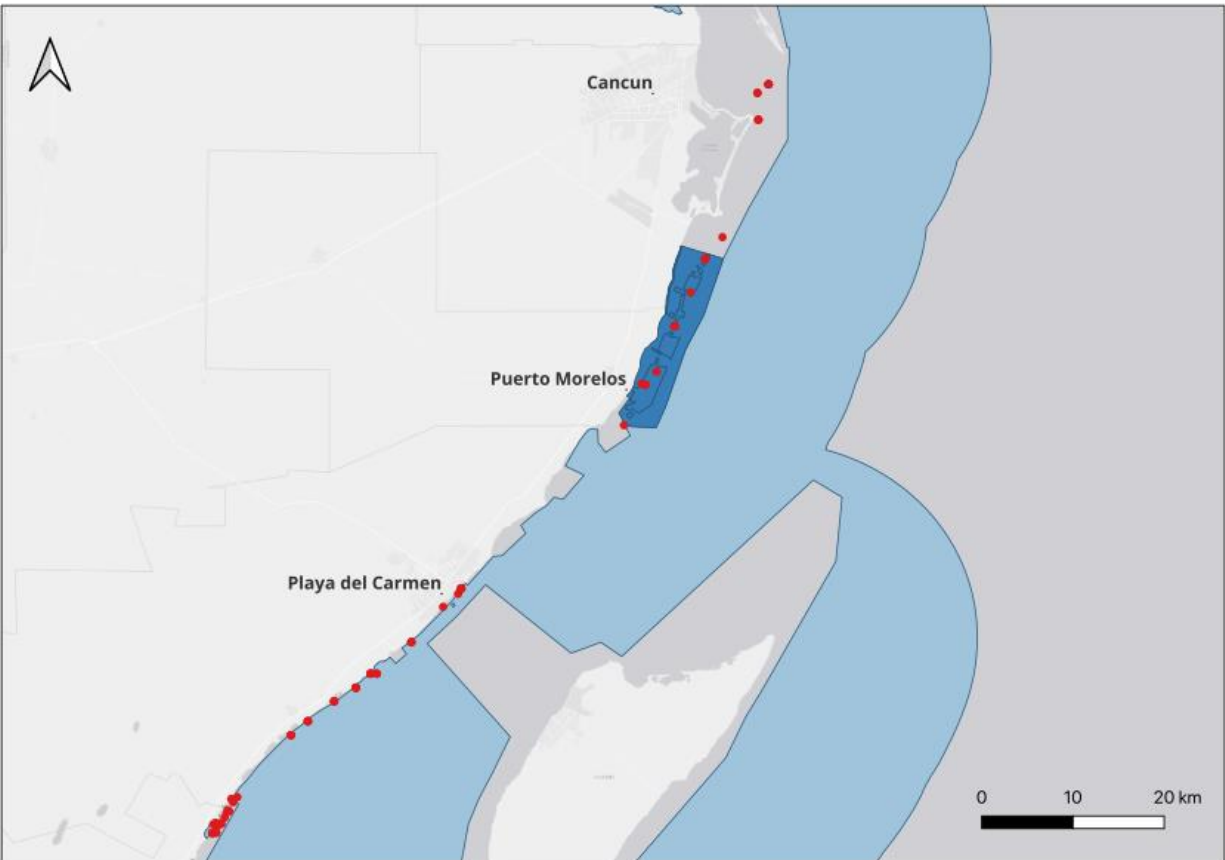
Families with fewer years of data or highly variable biomass estimates were still included to maintain consistency across the dataset, but standard errors were examined to identify potentially uncertain trends. The resulting slope values (expressed in g/100 m<sup>2</sup> per year) were used as the indicator of temporal biomass change.

#### 2.4.3. Integration with perception data

Interview data were analyzed to identify families most often described as “declining” in abundance or visibility by local harvesters and divers. Each time a family was mentioned as declining, it was recorded as one instance. These mentions were summed across all interviews to generate a frequency count of perceived decline per family. This approach is similar to methods used in Barbato et al. (2021), excluding the use of ratios and similarity percentages in data analysis. Because the biomass data came from only species recognized in the AGRRA protocol, any mentions of species outside of AGRRA were removed from further analysis.

The perception and biomass datasets were then merged by family name to align perceived decline frequency with biomass slope. This produced a comparative dataset allowing for quantitative evaluation of whether families perceived as declining corresponded to those showing statistically negative biomass trends.

All analyses and visualizations were conducted in R (v. 4.x) using the *tidyverse*, *broom*, and *ggplot2* packages.



**Figure 3.** Map of the study area with dark blue representing the PMRNP boundaries and light blue a portion of the Mexican Caribbean Biosphere Reserve. Red dots represent specific sites where biomass data were collected/provided by Healthy Reefs for Healthy People and used in this study.

**3. Results**

*3.1. Perceptions and insights on management and conservation*

This section of the project aims to identify ways in which LEK and perspectives can inform management of the MPA and surrounding marine areas. Five research topics were highlighted through different questions to participants, as explained below. Each question presented topics with subsequent themes elucidated from interviews. The purpose of presenting these specific themes is to emphasize the role community members and stakeholder engagement can play in benefiting and informing management and policies that affect the MPA and surrounding areas.

### 3.1.2. Impacts of Fishing on MPA and Surrounding Areas.

Participants offered mixed views on the role of fishing in and around the MPA. While some emphasized that fishing activities were well-regulated and largely sustainable, others pointed to challenges associated with illegal, unreported, and unregulated (IUU) fishing and the negative impacts of poorly monitored practices on the local cooperative.

#### *Fishing is Well Regulated*

Eight participants (two guides and six harvesters) believed that fishing within the MPA and its surrounding areas was ethical and appropriately managed. There was a consensus that the process and equipment used are not exploitative and that they rarely see IUU in the area because the local co-op strictly follows fishing seasons and regulations. As one participant put it:

“...when it's finfish season, we automatically stop diving. It's all fishing with line or longline during those four months of the ban. For us, we self-prohibit it because other cooperatives operate illegally during the four months of the ban.” [Participant P2]

These participants also noted that they rarely observed IUU fishing within the park itself, suggesting that management of artisanal fisheries has been relatively effective.

#### *IUU Fishing*

In contrast, five participants raised concerns about IUU fishing as a persistent problem. Some felt strongly that cooperative fishing should not occur within the MPA at all. Other accounts described issues such as underreporting catches, targeting species out of season, and even safety concerns about dive guides fishing during tours:

“We've seen them spearfishing with the divers, literally with the clients, while they're guiding, and they're spearfishing for lionfish, which in a way is fine, but it's putting people in a lot of danger when you're taking groups, teaching them that they can do that too.” [Participant G3]

At the same time, two participants were uncertain about whether fishing had any meaningful impacts on the park.

### *Negative Impacts on the Local Cooperative*

The most widespread concern was the impact of poorly regulated fishing on the artisanal fishers of the local cooperative. Eleven participants highlighted declining fish populations that directly affect the species harvested by co-op members. Four specifically linked these declines to IUU fishing, noting that harvesters outside of the co-op fish illegally, reducing the resources available within the co-op's concessions:

“When lobster season is closed, we respect the closed season, but they continue working in the Holbox area and all that. So, when it's lobster season for us, it's the minimum that arrives.” [Participant P4]

Sport fishing was also seen as a significant challenge: five participants described it as directly harmful to artisanal livelihoods, while eight emphasized that sport fishing in and around the area was poorly regulated and seldom monitored. This was mainly attributed to Sport fishers in the indiscriminate landing of fish of all sizes and species, including commercial species, and they were criticized for their lack of catch-and-release practices. The consensus among guides and harvesters is that sport fishing has overall negative impacts on the MPA:

“They don't have closed seasons; they don't have any. We're going out to fish for four or five months and then resting, no, not them – all year round... So, they fish all year round and don't have that, well, that catch-

and-release fishing regulation, right? They catch and take.” – [Participant P5]

### 3.1.3. Whether the MPA Reduces Harmful Activities.

Participants expressed mixed views on whether the MPA has been effective in reducing harmful activities. While some credited the park with improving regulation and environmental protection, others pointed to ongoing gaps, particularly with tourism and IUU fishing.

#### *The Park Helps Reduce Harmful Activities*

Six participants felt that the park has played an important role in curbing damaging practices. Three highlighted its role in regulating fishing: “And yes, it helps. Because it's a park. Because there's no fishing... So, everything, everything, the conch, the lobster, the fish.” [Participant P2]. Others pointed to improvements in tourism management, including reductions in irresponsible and excessive practices in tourism. One participant also emphasized that the establishment of the park has helped prevent excessive coastal development, stating that there was “a time when this was growing and it has somehow stopped, the excessive development.” [Participant G8].

#### *Improvements Needed*

At the same time, five participants stressed that management efforts require improvement if the park is to fully reduce harmful activities. Three of these focused on tourism, arguing that visitor pressure remains excessive despite its designation as a marine protected area. There was a sense of frustration, particularly from fish harvesters, as to the actual meaning of this being a “protected” area. As one explained:

“So, they tell us – there are talks and everything – and well, we're [fishing co-op] going to give up that part of the reef for protection. So, we stop

exploiting it, and suddenly we see tour guides bringing hundreds of people there. So, why do they call it a natural protected area? If they're destroying it. I also understand that's where the funds for the park come in, but even so, if you tell me that it's helped slow it down a bit – no, it's the opposite.” [Participant P1]

Two participants also believed that IUU fishing remains poorly monitored, undermining conservation goals. Another pointed out the challenge of ensuring guides follow best practices for protecting fish species when leading tours, emphasizing that management alone is insufficient without consistent compliance from users.

#### 3.1.4. Actions the Park Authority Can Take to Improve Management.

When asked how the park authorities could improve management in the MPA, participants identified four main areas for action: revising park limits and regulations, strengthening enforcement, improving stakeholder engagement, and addressing barriers to implementation.

##### *Changes in Park Limits and Regulations*

Several participants emphasized the need to reconsider the boundaries and regulations of the park. Six dive guides specifically advocated temporary closures or rest periods for snorkel and dive sites, arguing that this would reduce pressure on coral formations and species. This is a rotating site closure model used on the nearby island of Cozumel to provide reefs with rest and recovery (CONANP, 2019; Estrada-Saldívar et al., 2021). One guide explained:

“I think there are many ways they could improve, especially in the part of... rotating the diving sites, that is, they flat out prohibit us, ‘you know what? For two months, we are not going to go to such and such site, or for three months.’ Let them rotate.” [Participant G2].

Other suggestions included making lesser-known sites more accessible to guides and exploring new areas with tourism potential as a way of dispersing

visitor impacts. One participant also proposed creating fish refuges or expanding the park altogether.

### *Enforcement and Regulations*

Improved enforcement and surveillance were the most common concerns, mentioned by eight participants. Four participants argued that surveillance of activities in the MPA was insufficient and lacked urgency. Others noted broader challenges, such as a lack of alignment between the park authority's conservation goals and municipal or federal government priorities for economic growth. As one participant put it: "No matter how hard we try, and we are trying, if governments don't make more conscious decisions, we won't achieve much. And that's the number one concern." [Participant G2].

Additionally, two participants highlighted the need for stronger regulation of sport fishing, and one fish harvester went further, recommending that net fishing be banned outright since the co-op opts to use more targeted fishing methods.

### *Meaningful stakeholder and rightsholder engagement*

Three participants stressed the importance of deeper engagement between the CONANP and local communities. Fish harvesters expressed a desire to remain involved in projects and voiced frustration at being blamed for fish population declines. Guides, meanwhile, wanted better coordination with the fishing cooperative and other agencies, as well as better training and education opportunities for park guides. One guide also suggested initiating projects to monitor water quality in the park, reflecting a broader concern with ecosystem health.

### *Barriers to improving management*

Despite these recommendations, five participants acknowledged barriers to improving management. Four highlighted the park's limited resources, funding,

and personnel, which restrict its ability to expand or strengthen current practices. As one noted,

“The park, well, I think they do the best they can with what little they have. I think if they had more resources, they could do a lot more, and I feel they do have staff who are truly committed to keeping the park in good condition.” [Participant G9].

Although two participants remarked that enforcement in the PMRNP was still stronger than in nearby MPAs, showing that improvements and wins must be balanced against existing constraints.

### 3.1.5. Stakeholder Engagement.

When asked about engagement by the park authority (CONANP), participants emphasized both their interest in becoming more involved and the barriers that prevent meaningful participation. While some described current ways they contribute to park management and conservation, others stressed that opportunities for engagement remain limited.

#### *Fish Harvesters Seeking Greater Involvement*

Five of the seven fish harvesters interviewed expressed a strong desire to be more involved in conservation, park management, and related activities. Several explained that their collaboration with park guides often occurs indirectly, for example, through renting out their vessels. Others expressed frustration with limited opportunities, with one noting that he wanted to see earlier projects with fish harvesters continued:

“...we did two or three coral restoration projects, and that helps us see how our reef has changed. Because, as I said, I was born here in Puerto Morelos, and since it became a national park, we don't make the effort to go and visit it anymore, and we don't know what's going on. We just heard that the coral in that area has died and is turning white, and it does worry us a little.” [Participant P1]

### *Current Forms of Engagement*

Participants also described various ways they already contribute to the MPA's operations. Six guides reported regularly notifying CONANP of irregularities such as IUU fishing or guides breaking regulations, which they viewed as a form of active stewardship. Two noted that CONANP provides effective training and education for guides, which allows them to support conservation goals. Other examples included being invited to participate in monitoring projects, joining activist groups that challenge harmful development proposals, and collaborating with government institutions. One participant pointed out that the MPA itself was created through community involvement, while another explained that CONANP relies on community participation to function:

“Puerto Morelos is very small, so we all know each other and help each other. So, the relationship we have with them is important, and it has greatly helped maintain their practices as CONANP.” [Participant G10]

### *Barriers to community engagement*

Despite these contributions, eight participants identified barriers that undermine meaningful community involvement. Three cited irresponsible behaviour from some tour guides as limiting the value of engagement, while another three noted that opportunities often depend on their own initiative; guides must actively seek out ways to participate, since CONANP does not consistently reach out. Two participants emphasized that engagement could be a powerful tool for improving park management, but only if used more consistently and inclusively by the authority. Limited funding and resources at CONANP were also seen as major constraints, with three participants describing the agency as understaffed or underfunded:

“I feel like CONANP would need to have significantly more funding so they could hire more staff so that they would actually be able to enforce the rules of the park actively. If they go out in their boat twice a week for

an hour, they're missing a lot of rule breaks, and without proper enforcement, people just do whatever they want.” [Participant G7]

### 3.1.6. Perceived Pressures on the Reef

Participants identified a range of pressures affecting the reef and the health of its species. The most frequently cited concern was coastal development, followed by fishing activities and the broader impacts of climate change and extreme weather events.

#### *Increased Development*

Twelve of the eighteen participants described increased coastal development as one of the most significant pressures on the reef, with a total of forty-six mentions across all interviews. Development was commonly associated with economic growth and tourism, particularly through the construction of condominiums, hotels, and beachside resorts. The most prominent concern related to wastewater discharge: nine participants emphasized that developers lacked adequate infrastructure to handle sewage, often resulting in untreated wastewater being released directly into the ocean. As one participant explained,

“We don't really know where the wastewater from all the hotels goes. The acidity of the water and all that. If it goes into the mangroves, it goes into the sea, but ultimately, all the pollutants are what cause the most coral mortality.” [Participant P4].

Seven participants explicitly highlighted resort and hotel construction as a driver of reef decline, while others pointed to associated issues such as excessive tourism. In their view, the number of visitors permitted in the MPA placed additional strain on coral and fish populations. Fish harvesters in particular felt expressed uncertainty about the benefits of increased tourism

“ I can see the inevitable impact of tourism. It's either a bad thing or it's a good thing that causes harm, I don't know. Not only can we see the deterioration of the reef, but we can see it in the species here.” [Participant P5].

Five participants also raised concerns about habitat destruction from roads and construction over mangroves, which they described as critical habitats for reef species at certain life stages. Two further participants mentioned direct physical damage to the reef, recalling a recent incident where a ship's anchor dragged across coral formations.

### *Fishing*

Although a separate question addresses fishing in more detail, seven participants nonetheless mentioned it here as a pressure on the reef. Four, all of whom were dive guides, cited IUU fishing as a major problem, often pointing to evidence such as fishing lines and gear left at prohibited reef sites. Sport fishing was raised in three interviews, all with fish harvesters, who argued that its frequency and scale were excessive and harmful. One harvester also suggested that increasing numbers of fishers in surrounding areas had led to declines in fish abundance within the MPA itself.

### *Climate Change and Weather Events*

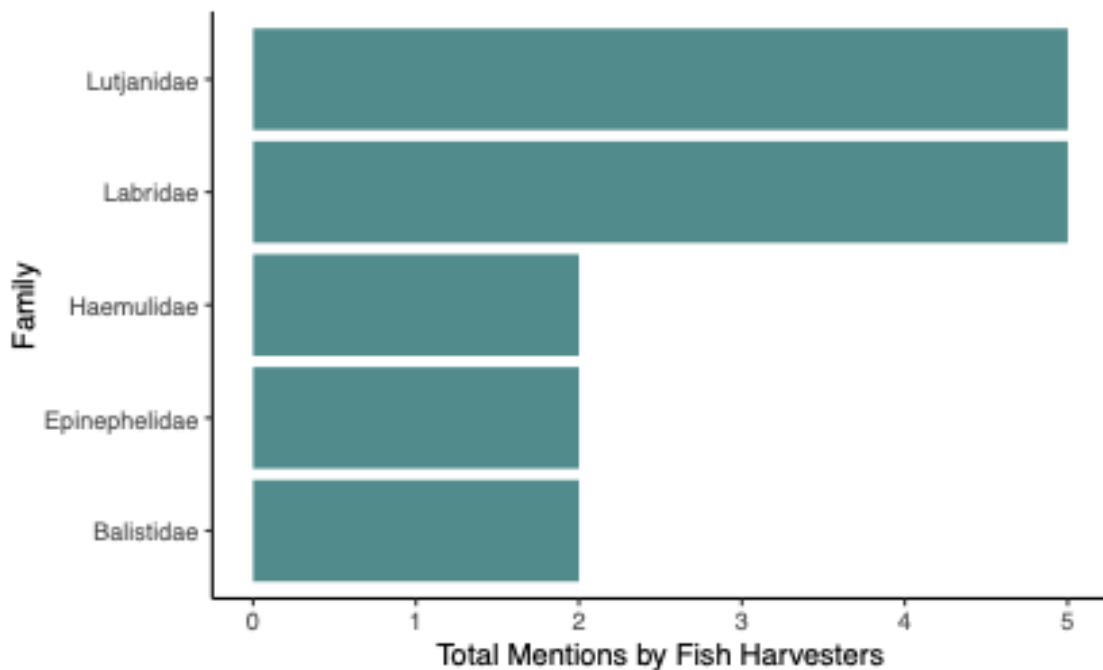
Climate change and weather-related disturbances were also frequently mentioned, raised in twelve interviews with a total of twenty-three mentions. Four participants highlighted the impacts of hurricanes and storms on reef ecosystems, while another four spoke specifically about warming ocean temperatures. Five participants described these pressures as interconnected, with climate change amplifying the effects of storms and other stressors. Coral bleaching and disease were cited by three participants, who linked declining coral cover to reduced habitat availability for reef species. As one explained, "I believe that the increase in sea temperature has a lot to do with it, which has caused the death of much of the reef and, consequently, obviously the fish population has decreased." [Participant G9].

### *3.2. Decline in local species*

Using data from only questions that addressed potential changes in fish populations over time, we recorded the number of times the decline of any species was mentioned or when no

decline was mentioned. Of a total of 97 references to shifts in fish populations, 93 described some sort of decline, whether by stating a specific species declining or a general opinion that populations in general were declining. Only 4 mentions described either no perceived change in fish populations or no alarming decline to worry about. These mentions came from three different participants, two of whom were fish harvesters and one a guide. It is difficult to elucidate the reason for such differing responses from the consensus, and this may require a larger sample size of participants to assess whether it is related to their personal profile or demographics.

From these same questions in the previous section, I identified which species families were most mentioned by participants to be declining. Lutjanidae, commonly known as snappers, was the most mentioned family to be declining in the area, with 14 total mentions, followed by Epinephelidae (Groupers), which had 11 total mentions, and Labridae (Hogfish) with a total of 9 mentions. The following families had 6 or fewer mentions. In total, 19 families were mentioned, with 6 being non-AGRRA families (Table 4). Fish harvesters in particular mentioned only Lutjanidae, Epinephelidae, Labridae, Muraenidae, Haemulidae, Scaridae, and Balistidae, which are of commercial importance (Figure 5).



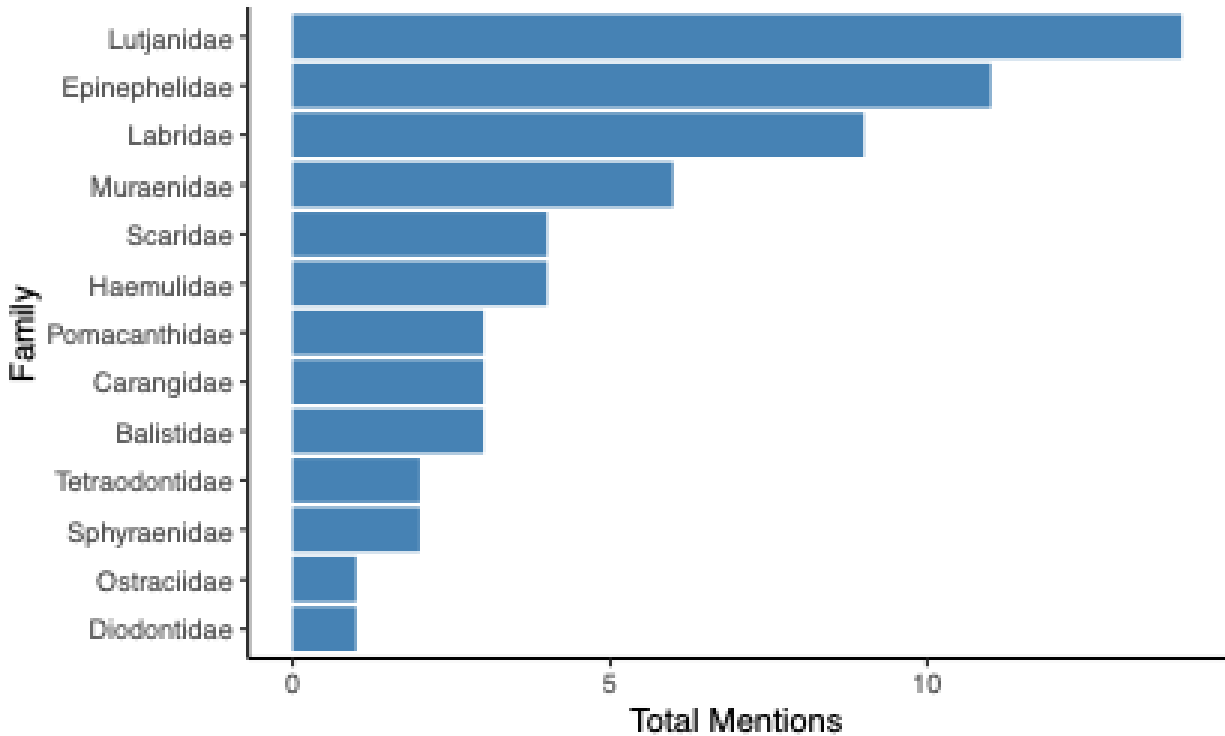
**Figure 5.** Frequency of fish harvester mentions of decline for each fish family (n = 7 participants). Families shown are those included in both interview responses and biomass estimates based on AGRRA protocols.

**Table 4.** Total participant mentions of decline for each family (n = 18 participants). Families shaded in grey are those that are not included in biomass estimates based on AGRRA protocols and were thus discarded for comparison to biomass data. Nephropidae is the only non-fish family, but was included for its commercial importance.

<b>Family</b>	<b>Total</b>
Lutjanidae	14
Epinephelidae	11
Labridae	9
Muraenidae	6
Haemulidae	4
Scarinae	4
Balistidae	3
Pomacanthidae	3
Carangidae	3
Nephropidae (Lobster)	2
Tetraodontidae	2
Sphyraenidae	2
Aulostomidae	2
Gerreidae	1
Mugilidae	1
Diodontidae	1
Soleidae	1
Ostraciidae	1

### 3.2.1. Integration of biomass and perception data

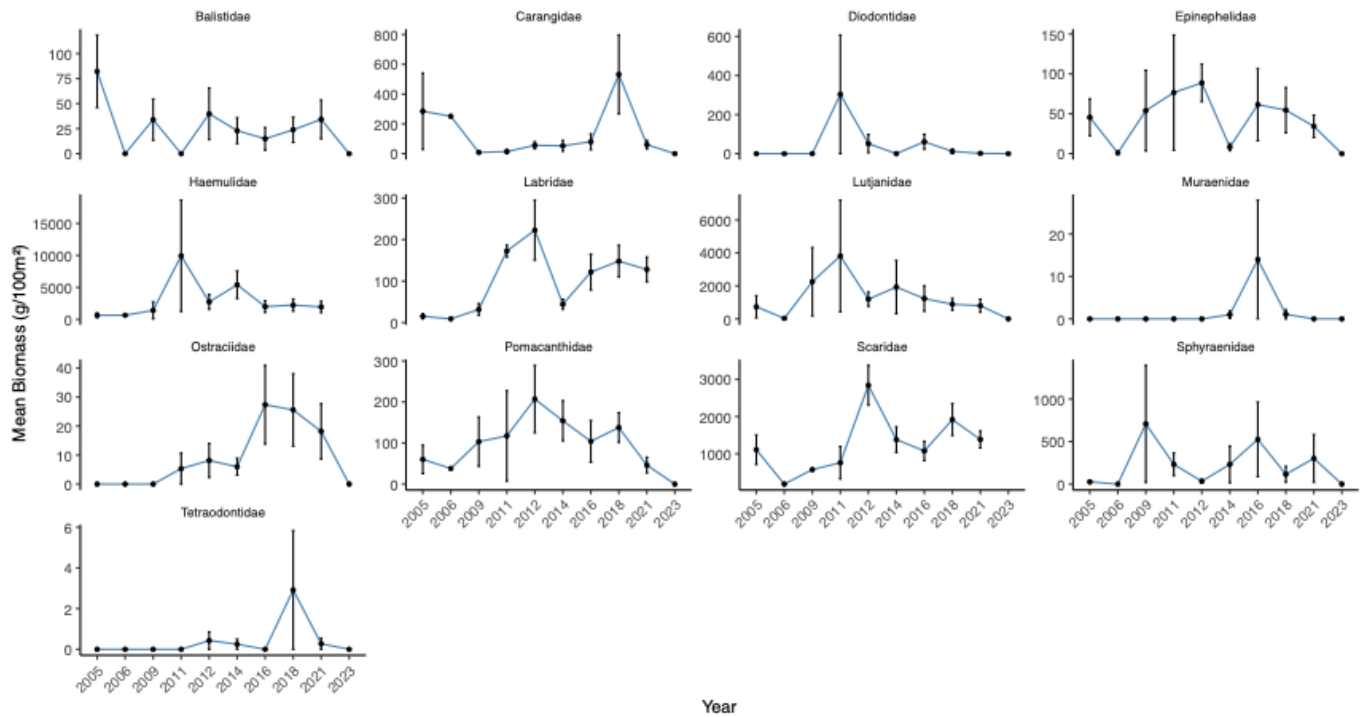
A total of 13 fish families were included in the comparison between long-term biomass trends and interview-based perceptions of decline. Interview data revealed that Lutjanidae (snappers), Epinephelidae (groupers), and Labridae (hogfish) were the most frequently mentioned as declining, with 14, 11, and 9 mentions, respectively (Figure 6). Other families, such as Muraenidae (moray eels), Haemulidae (grunts), and Scaridae (parrotfishes), were mentioned less frequently, while families like Ostraciidae and Diodontidae were each mentioned only once.



**Figure 6.** Frequency of participant mentions of decline for each fish family (n = 18 participants). Families shown are those included in both interview responses and biomass estimates based on AGRRA protocols.

Linear regression analyses of biomass across years revealed a wide range of slopes among families, indicating both positive and negative temporal trends (Figure 7; Table 5). Negative slopes correspond to declining biomass, while positive slopes represent increasing biomass through time. Among the families analyzed, Balistidae and Labridae showed statistically significant trends ( $p < 0.05$ ). Balistidae exhibited a significant decline in biomass (Table 5; slope =  $-3.55$  g/100 m<sup>2</sup> per year,  $p = 0.023$ ), whereas Labridae displayed a significant increase (slope =  $+7.42$  g/100 m<sup>2</sup> per year,  $p = 0.014$ ).

Although not statistically significant, both Lutjanidae (slope =  $-2.23$  g/100 m<sup>2</sup> per year) and Epinephelidae (slope =  $-0.85$  g/100 m<sup>2</sup> per year) exhibited negative slopes, indicating slight declining trends over time. These two families were also among the three most frequently mentioned as declining in interviews, suggesting partial alignment between community perceptions and biomass data. Conversely, families such as Haemulidae and Scaridae showed large positive slopes ( $+89.0$  and  $+29.5$  g/100 m<sup>2</sup> per year, respectively) and were less frequently mentioned.

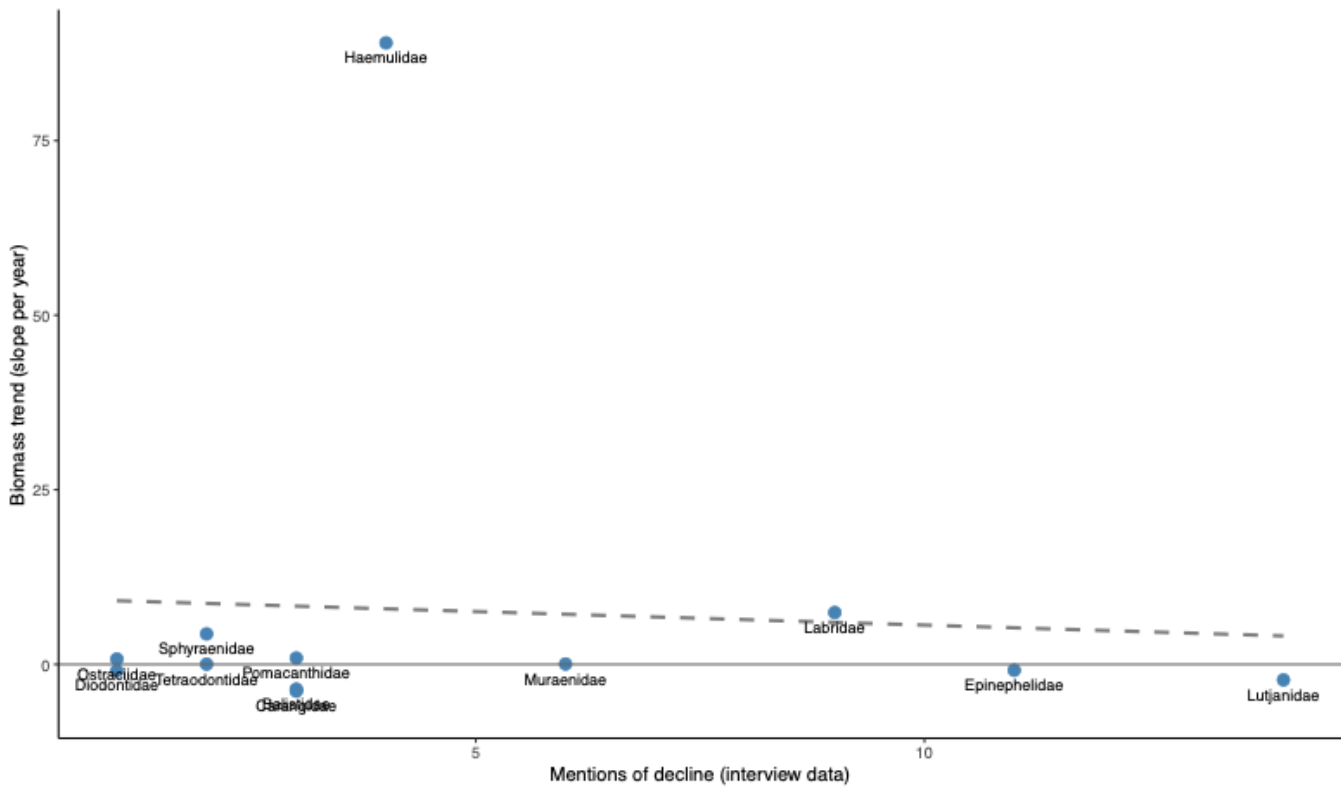


**Figure 7.** Mean biomass (g/100m<sup>2</sup>) by year for each fish family mentioned by participants. Error bars represent standard errors, and panels display individual family trends based on AGRRA biomass data.

**Table 5.** Summary of long-term biomass trends and frequency of perceived decline by fish family. Linear model slopes represent the average annual change in biomass (g/100 m<sup>2</sup> per year). Negative slopes indicate declining biomass through time. P-values correspond to the significance of the slope term;  $p < 0.05$  was considered significant.

Family	Mentions of Decline	Biomass Trend (Slope per Year)	SE (Slope)	p-value
Lutjanidae	14	-2.23	52.01	0.966
Epinephelidae	11	-0.85	1.69	0.618
Labridae	9	7.42	2.95	<b>0.014</b>
Muraenidae	6	0.05	0.18	0.781
Haemulidae	4	89	90.11	0.326
Scaridae	4	29.53	31.29	0.348
Balistidae	3	-3.55	1.53	<b>0.023</b>
Pomacanthidae	3	0.9	3.52	0.798
Carangidae	3	-3.83	12.82	0.766
Tetraodontidae	2	0.03	0.06	0.589
Sphraenidae	2	4.36	9.42	0.644
Diodontidae	1	-0.92	1.91	0.631
Ostraciidae	1	0.76	0.42	0.073

When the frequency of perceived decline was plotted against the empirical biomass slopes, no strong linear relationship emerged (Figure 8). Families with higher mentions of decline did not consistently exhibit stronger negative biomass trends, and the fitted regression line was non-significant. This suggests that while community members were attentive to certain ecologically and culturally important families showing slight declines (like Lutjanidae and Epinephelidae), overall perceptions of decline did not statistically align with observed biomass trends across all families.



**Figure 8.** Relationship between the frequency of perceived declines and long-term biomass trends by fish family. Each point represents one family, showing the number of interview mentions of decline (x-axis) and the corresponding linear model slope of biomass per year (y-axis). Negative slopes indicate declining biomass, while positive slopes indicate increasing trends. The dashed line represents the fitted linear regression between perception and biomass trend.

## 4. Discussion

This study set out to explore how LEK from fish harvesters and dive guides in Puerto Morelos can inform reef monitoring and reinforce community-based MPA management. Located between Cancún and Playa del Carmen, Puerto Morelos depends heavily on tourism and related services, including ecotourism and small-scale artisanal fishing. Understanding the perspectives of those who interact daily with the reef and rely on its health for their livelihoods is crucial to identifying pathways for more inclusive, adaptive management. By integrating qualitative interviews with long-term biomass data, this study sought to compare local perceptions on reef populations and change with ecological indicators, while highlighting how community members' knowledge and engagement can support co-management and monitoring within the Puerto Morelos Reef National Park.

### *4.1. Perceptions of Management and Conservation*

Participants offered nuanced and sometimes divergent views about the management of fisheries and conservation activities within the MPA. However, there was a consensus that conservation efforts in the area are more effective than in nearby MPAs in the Mexican Caribbean. This consensus was largely based on how participants perceived their own actions and habits within the park. Many participants described local fishing practices as more ethical and sustainable, emphasizing that the local cooperative is well-regulated as they implement and uphold self-regulation according to seasonal closures and gear restrictions. Most participants viewed the cooperative as a legitimate steward of local resources and expressed pride in their adherence to fishing rules, with harvesters even describing themselves as conservationists. Despite this, many dive guides still viewed fishing in the reef in general (including cooperative fishing) as an overall detrimental activity, with many of them explaining that they personally choose not to consume seafood for ethical reasons.

In contrast, many participants, both dive guides and harvesters, raised concerns about the persistence of IUU fishing and the risks posed by poorly monitored sport fishing practices in the area. It is worth highlighting that sport fishing was not a topic on the radar of my interview guide, nor was it integrated into any questions asked to the participants. Cudney-Bueno & Basurto (2009) illustrate those effective, locally crafted, and enforced rules (the core of a rights-based system) can collapse when communities lack the support from higher levels of governance to prevent poaching from outsiders. This is consistent with observed responses and their

emphasis on the lack of enforcement and regulation on sport fishing, which is a strong indicator of a building and common concern among community members that should elicit investigation and change from management authorities. This finding reflects broader tensions found in MPAs, where differing perceptions of fairness and enforcement can shape compliance and trust in management authorities (Gurney et al., 2021). The self-imposed rules and the concession of their fishing grounds many years ago, demonstrate a strong local ethic of conservation from the Puerto Morelos fishing cooperative. However, perceptions of unequal enforcement and lack of regulations can undermine these sentiments and lead to conflicts between stakeholders and managers that may result in less effective conservation overall (Fabinyi et al., 2015; Gurney et al., 2014, 2021).

Participants credited the park with curbing damaging fishing practices, yet some argued that unchecked tourism pressure, particularly from mass snorkelling and diving tours, continues to degrade reef habitats. For several fish harvesters, the notion of a “protected” area was met with skepticism, as they perceived ongoing degradation despite restrictions on their own activities. This finding resonates with critiques of “paper parks,” where formal protection exists without adequate enforcement or equitable regulation of all sectors (Di Cintio et al., 2023). This can undermine the credibility of the Global Biodiversity Framework 30x30 target of restoring and conserving 30% of the nation’s ecosystems by 2030 (CBD COP, 2022), where protected areas will contribute to the numerical goal of the target but may lack socio-ecological legitimacy.

Effective MPAs require not only ecological goals but also social legitimacy (Charles & Wilson, 2009), which is something that depends on consistent, transparent management and meaningful community participation, which has been known to function with sustained communication throughout the management process with local actors (Kageyama et al., 2025; Mason et al., 2020; Mbaiwa & Stronza, 2011). Fish harvesters have been seen before to support MPAs, with support often increasing when they are meaningfully involved throughout the MPA life-cycle (Di Cintio et al., 2024). Fish harvesters interviewed from the Puerto Morelos co-op seemed to convey that they willingly gave up part of their fishing concession to contribute to conservation but were subsequently overpoliced and left out by the park authority, appearing to lose some faith in the process and management. This is crucial because often ‘top-down’ MPA management and governance, as described above, does not encourage community participation

which can lead to lower compliance with MPA regulations thus reducing effectiveness of conservation measures (Bennett & Dearden, 2014; Gabela-Flores & Diedrich, 2021).

Therefore, community engagement becomes a necessary piece of successful MPA management. Because different actors and stakeholders value different aspects of marine resources and services, there must be more engagement with the local communities relying on MPAs to gauge what matters to them in terms of MPA design and what will help motivate them to become active participants in co-management efforts (Ferse et al., 2010; Kageyama et al., 2025; Masud & Kari, 2015).

#### *4.2. Stakeholder Engagement and Co-management Potential*

A recurring theme throughout the interviews was the desire for greater involvement in park management. Both fish harvesters and dive guides expressed a strong willingness to collaborate with the CONANP and many already contribute through informal monitoring, such as reporting IUU fishing or guiding visitors in responsible ways. However, opportunities for engagement were described as sporadic and dependent on individual initiative rather than institutional design. Participants emphasized that while they are sometimes consulted, they are rarely included in decision-making processes that affect their livelihoods. For example, one guide mentioned how they were frustrated with the CONANP's evaluation of conservation project proposals, citing that they feel like their monitoring proposals are often unfairly rejected.

One aspect to note about the PMRNP management plan is that management is supposed to be guided by Annual Operating Programs (AOPs), which are developed by MPA staff, reviewed by the advisory council, and overseen by CONANP, with the local MPA director responsible for their implementation and evaluation. While MPAs are managed locally, budgets and allowed activities are still decided federally (DOF, 1988; NOSSA, 2024; Perera-Valderrama et al., 2023).

AOPs have been created annually since 2003 and have undergone several formal auditing processes, yet the resulting reports are not published (M. Soto, personal communication 30 Oct. 2025). The advisory council is also expected to meet monthly with the MPA director to discuss needs and emerging issues, and it is unclear if this is still the case. This reflects a pattern seen before in MPAs, where local stakeholders may agree with conservation efforts and are active participants but lack cultural recognition or decision-making power (Hamilton, 2012; Martin et al., 2016). Improving co-management in Puerto Morelos would therefore require shifting from

consultation to collaboration, building structured mechanisms that value local experience, compensate participation, and strengthen communication between user groups and the park authority, because community members will often support bottom-up management processes when they feel more responsibility and beneficial outcomes from MPA management (Alcala & Russ, 2006; Gelcich et al., 2009).

Despite enthusiasm from community members to participate in monitoring and management, several participants recognized the structural barriers that limit the park's ability to improve management, such as insufficient funding, limited staff, and competing government priorities that favour tourism development over conservation. These constraints highlight that community engagement alone cannot replace institutional support. It is known that MPAs with higher funding and more personnel are more likely to perform better and successfully in meeting their conservation outcomes, with staff and capacity being the greatest predictors of successful outcomes (Gill et al., 2017). Additionally, multi-use MPAs, like the PMRNP, with adequate staff capacity are seen to perform nearly as well as no-take MPAs in terms of conservation (Gill et al., 2024).

After speaking directly with the PMRNP acting director, Octavio Granados González, who works for CONANP, he made it clear to me that there is no funding or support to update the management plan, which has been in place since 2000. They also deal with many issues of guides bringing in more tourists than the park has capacity for, with illegal distribution of park passes; these are only available when users pay the park fee to enter the MPA. Also keeping in mind that the park spans 21km along the coast, these factors compound and create immense pressure on local management, who are working with one vessel to meet all enforcement and monitoring needs, including reports of illegal activities from guides and fish harvesters.

Given that the CONANP's budget has been federally reduced for the last two years in a row (NOSSA, 2024), the prospect of increased funding or staffing is unlikely. It should be noted that the commitment expressed by local users suggests strong potential for developing participatory monitoring initiatives, in which guides and harvesters could contribute directly to ecological assessments and monitoring. Participatory research is based on creating bodies of knowledge using co-designed frameworks with folks who are most impacted by environmental issues (Jeanjean et al., 2023). This can be applied throughout stages and levels of research and monitoring including initial consultation, creation of research objectives, identifying research

methods, and providing feedback on management and outcomes (Ison et al., 2024; Kurle et al., 2022).

Guides are already more than willing to provide evidence and report illegal activities, while harvesters take it upon themselves to regulate their fishing practices, even eliminating net fishing from the cooperative's allowable gear. Another way to deal with capacity shortfall is something that many guides agreed to, and that is closing the park, or sections of it, for certain periods. Not only can this help the ecosystem in relieving touristic and fishing pressures (Estrada-Saldívar et al., 2021), but it would also relieve the park authority of the pressure of constant monitoring at all sections of the park.

#### *4.3. Local Knowledge as an Indicator of Reef Health*

Participants identified several pressures affecting the reef, including coastal development, fishing, and climate change. Among these, coastal development emerged as the most frequently cited concern, particularly in relation to untreated wastewater discharged from hotels and resorts. These observations align with the well-documented tourism boom in the Mexican Caribbean that began in the 1970s (Meyer-Arendt, 2009) and continues to bring millions of visitors to the region each year (Suchley & Alvarez-Filip, 2018), with tourism now contributing approximately 45-67% to its annual net benefits (Gauna et al., 2021). Land-based pollution is recognized as a major driver of coral decline in the Mexican Caribbean, largely due to dredging, coastal construction, and sewage inputs that increase sedimentation and nutrient loading (Arias-González et al., 2017, 2017; Baker et al., 2013).

Community members emphasized inadequate wastewater management as the most pressing issue related to coastal development. This concern is supported by existing studies showing that hotels and resorts in the region often operate with poorly designed or insufficient wastewater treatment systems. In fact, only about one-third of wastewater in the area is estimated to receive proper treatment (Bauer-Gottwein et al., 2011; Leal-Bautista et al., 2019). Ineffective wastewater treatment contributes to nutrient runoff and eutrophication, which are particularly harmful in Puerto Morelos due to the close physical and ecological connections between terrestrial systems and the nearby barrier reef (Murray, 2007; Salazar Vallejo & González, 1993). Importantly, participants recognized that these anthropogenic impacts extend beyond what the local park authority (CONANP) can address on its own.

Although fishing was mentioned as a source of pressure, it was discussed less frequently than tourism or coastal development, suggesting that local users perceive broader, cumulative impacts as more immediate threats to reef health. Climate-related factors, such as hurricanes, coral bleaching, and rising sea temperatures, were also widely acknowledged, indicating that residents view environmental change as a significant driver of reef degradation. Collectively, these insights demonstrate that LEK provides a nuanced, place-based understanding of ecosystem stressors. This knowledge complements scientific monitoring by offering fine-scale, real-time perspectives that can help managers identify and prioritize the most pressing issues.

Interviews also revealed a strong awareness of land–sea linkages and the direct effects of terrestrial human activity on reef systems. Community perspectives suggest that these connections are often underrepresented in marine management frameworks, which tend to focus on more immediate, localized threats (such as overfishing) while overlooking diffuse, large-scale drivers like changes in land use and climate change (Hughes et al., 2017; Mora et al., 2006).

The design of the PMRNP and surrounding MPAs may reflect this broader management bias. Managers often perceive direct stressors, such as overfishing, as more urgent to regulate, while complex issues like pollution and climate change receive less attention (Hughes et al., 2017; Wear, 2016). This may stem from institutional limitations: addressing general environmental problems often exceeds the capacity of local management authorities, particularly in areas with limited staff and funding. Additionally, as Wear (2016) notes, managers may possess greater influence over fisheries policies than over coastal development regulations.

Enforcement is also hindered by Mexico’s fragmented legislation for coastal and marine issues (Bezaury-Creel, 2005), with multiple government agencies involved in their management. Because of differing municipal and federal jurisdictions, CONANP has no authority over non-protected areas like coastal land zones. This political fragmentation leads to poor coordination of management authorities and local actors, which is needed for proper environmental governance (Bazant-Fabre et al., 2022; Newig & Fritsch, 2009)

Participants frequently emphasized that government priorities, such as economic growth, often conflict with conservation objectives pursued by residents and the park authority. In a tourism-dependent economy, balancing development and environmental protection is challenging, even when the impacts of coastal development on reef health are evident. This tension is particularly acute in Quintana Roo, where development remains a key driver of both

local environmental degradation and broader climate pressures (Guimaraes et al., 2021; Trégarot et al., 2024).

There were some results from interviews that sparked interest in considering the different demographics the participants belonged to. For example, a few participants – both harvesters and guides – expressed that they did not see any notable or worrisome change in fish populations over the years. It is difficult to elucidate the reason for such differing responses from the consensus that fish populations are generally declining, and this may require a larger sample size of participants to assess whether it is related to their personal profile or demographics.

Notably, all harvesters interviewed were male, while most dive guides I interviewed were female. This is also an important distinction to note and may be explored in future research investigation how gender could play a role in how these socio-ecological trends are perceived.

#### *4.4. Comparing Perceptions and Biomass Trends*

The integration of interview data with long-term biomass trends revealed both convergence and divergence between local perceptions and biomass data. Nearly all participants described some form of species decline, particularly among Lutjanidae (snappers), Epinephelidae (groupers), and Labridae (hogfish)—families that are ecologically and economically significant. Biomass data similarly indicated negative slopes for snappers and groupers, suggesting slight declining trends over time, while hogfish showed a significant increase in biomass. However, the overall relationship between perceived declines and empirical biomass trends was not statistically significant. While perceptions did not uniformly correspond with observed ecological change, perhaps this calls for increasing the number of participants and including other relevant community actors, where results may then differ.

Several explanations may account for this divergence. First, local perceptions are often shaped by spatially and temporally specific experiences (Gomes et al., 2025), such as observations near fishing grounds or dive sites, which may not align with the broader scale of ecological monitoring. Second, species detectability, behaviour, and survey limitations can influence biomass estimates (Bernard et al., 2013; Caldwell et al., 2016), while recall bias or strong personal and cultural connection to key species can amplify perceived declines (Adams et al., 2003; Aylesworth & Kuo, 2018; O'Donnell et al., 2012). Importantly, these differences should not be seen as contradictions but as complementary insights: observations from participants highlight socially salient species and areas that may warrant further scientific

investigation (data which was collected through surveys but not presented in this study), while empirical monitoring provides standardized evidence to contextualize those perceptions.

As literature suggests, integrating both forms of knowledge can therefore enhance understanding of reef dynamics and strengthen the interpretive power of monitoring programs to assess reef status (Berkes, 2007; Drew, 2005; Early-Capistrán et al., 2022). Sheppard et al. (2024) present the argument that when scientific data is limited or absent, especially for rare or endangered species, LEK can fill these information gaps and is crucial for guiding management decisions and adding a layer of social acceptance, thereby warranting further scientific investigation.

#### *4.5. Implications and Recommendations for Eco-Audits*

Findings from this study highlight the importance of participatory approaches in marine management. Both fish harvesters and dive guides possess practical ecological knowledge and a willingness to contribute to conservation efforts, yet current management structures in Puerto Morelos limit their ability to do so effectively.

The HRHP Eco-Audits centre on seven specific themes to evaluate reef management. There are opportunities to integrate community participation and input throughout each theme, using various engagement and outreach mechanisms to gather data. Specifically, this integration would (1) strengthen participatory monitoring and communication between NGOs, relevant management bodies, and user groups; (2) find gaps in enforcement equity and resource allocation to ensure that all sectors, including tourism and sport fishing, are held to consistent standards; and (3) promote coordinated land–sea management by incorporating local observations of pollution, runoff, and coastal development impacts, among other factors. All three recommendations should also be addressed under the seven themes already integral to the Eco-Audits within specific indicators. The main mechanism for this integration would ideally be one holistic survey or interview guide for community members that incorporates relevant themes, where responses can later be teased out to contribute to specific indicators. These themes and indicators are further outlined in the following section.

##### *4.5.1. Integrating Community Input into Eco-Audit Indicators*

Now that baseline data have been collected and key implications identified from community interviews and interactions, it is important to consider how such qualitative insights

can be systematically integrated into the Eco-Audit as an evaluative tool. The following section examines five of the seven themes to assess how community input and qualitative data can enhance the strength and contextual relevance of individual indicators (Figure 9). While there is potential for integration across all indicators, the focus here will be on those most directly related to the findings of this study, where local perspectives offer particular value in strengthening the assessment of management effectiveness and community inclusion.

### **MPAs**

Within the Eco-Audit framework, the theme of Marine Protected Areas includes indicators *1d. Percent of MPAs with good management* and *1e. Percent of MPAs with good enforcement*. The former evaluates whether MPAs possess a current management plan, sufficient staffing, and appropriate equipment, while the latter assesses the institutional capacity and political will to effectively enforce regulations. The primary data sources for these indicators are CONANP records and interviews with park directors.

Given that “good” management and enforcement are assessments that require many criteria (Himes, 2007), it is essential to incorporate the perspectives of those directly affected by MPA governance, namely, local users and resource-dependent communities. Integrating community-based evaluations of management performance, transparency, and responsiveness could strengthen these indicators. Rodrigues et al. (2024) found that stakeholder groups are often unsupportive of MPA management and enforcement due to a lack of satisfactory participation and their failure to deliver desirable social and ecological outcomes. Therefore, overall satisfaction of stakeholders can be gauged by using tools like focus groups or semi-structured interviews (Rodrigues et al., 2024; Yates et al., 2019). Additionally, as demonstrated in my interviews, these can help capture how communities perceive enforcement fairness, frequency, and potential sectoral biases (e.g., stricter enforcement toward fish harvesters than tourism operators). Findings from my project suggest that park users, drawing on years of experience and familiarity with the area, hold valuable insights regarding MPA management and enforcement and are generally willing to contribute to such assessments. Gathering insight from community users is bound to help find the most appropriate management interventions and therefore, should be considered in the evaluation of indicator effectiveness (Pajaro et al., 2010).

The MPAs theme also includes indicator *1f. Generation of alternatives for fishers within the network of MPAs*. This indicator is primarily informed by policy reviews and government documentation. It evaluates the degree to which fisheries management strategies establish alternative livelihoods for fishers and other community members whose income may be affected by fully protected zones. Specifically, it measures the implementation of national-level strategies that provide long-term economic alternatives through productive activities and/or payments for ecosystem services.

However, current assessments lack the perspectives of fish harvesters and other directly affected users. Measuring the success of management strategies aimed at livelihood diversification requires incorporating the views of those impacted by MPA establishment because they often have differing priorities on reef values like ecosystem services (Hicks et al., 2013). In my study, interviews with harvesters provided preliminary insights into how they perceive management practices in relation to their ability to maintain a sustainable livelihood after relinquishing parts of their fishing grounds within the PMRNP. Although we did not explicitly assess harvesters' satisfaction or awareness of available livelihood alternatives, future Eco-Audits should incorporate participatory documentation of local views on the accessibility, fairness, and cultural appropriateness of these alternatives (e.g., tourism). A study in Tanzania documented that alternative livelihood projects can fail because the alternative income could not compete with fishing, and their implementation lacked transparency and participatory beneficiary selection (Katikiro, 2016). The authors strongly recommended a bottom-up approach and assessing beneficiary satisfaction and sustainability. Thus, evaluating satisfaction levels and identifying barriers through participatory methods would enhance the robustness and inclusivity of this indicator.

### **Ecosystem-based fisheries management**

Theme Two focuses on the evaluation of ecosystem-based fisheries management within a given area, not necessarily designated as an MPA. Indicator *2d. Assesses the transformation of all open-access fisheries to rights-based sustainable fisheries management systems*, which includes determining the proportion of total catch managed under regulated, rights-based frameworks for the most economically valuable species or taxonomic groups.

The intent behind this indicator is to strengthen management practices that prevent IUU fishing, which are recognized by HRHP as undermining sustainability. Interviews conducted with fish harvesters and local guides revealed a prevailing perception that IUU fishing and unregulated sport fishing are infringing upon the rights and sustainability of legally managed, rights-based fisheries, such as those operated by the local fishing co-op.

These findings highlight the importance of incorporating community interviews to better understand perceptions of fairness, inclusion, and the effectiveness of existing rights-based systems, as perceptions of unfairness can lead to non-compliance (Newman, 2015). Such qualitative insights would provide valuable context for evaluating whether current access rights genuinely reflect community-based fisheries management, as envisioned by the indicator. At present, much of the data informing this indicator is derived from government and environmental NGO reports, which often exclude the perspectives of artisanal fish harvesters themselves. Including these voices would lead to a more comprehensive and socially grounded assessment of ecosystem-based fisheries management, while combating IUU fishing (Song et al., 2020).

### **Sanitation and Sewage Treatment**

Our study revealed that wastewater treatment emerged as one of the primary concerns related to coastal development and its impacts on the reef, according to participant responses. Eco-audit data for this theme currently rely heavily on the existence of infrastructure and policy frameworks for effective wastewater management. The strong concern expressed by participants suggests that community perspectives should also be considered, as they are valid concerns given that sewage is a major driver of reef decline, and a significant amount enters tropical waters untreated or poorly treated, despite existing policies (Wear & Thurber, 2015). Incorporating local awareness and perceptions of wastewater discharge sources, odours, and visible pollution events on the reef could provide valuable complementary data, as traditional ecological knowledge can be useful to pinpoint these specific reef disturbances (Stori et al., 2019). These qualitative insights would improve the evaluation of Indicator *4a. Standards for wastewater management and sewage treatment*, offering a more comprehensive understanding of how wastewater issues are experienced and perceived at the community level.

## **Research, Education, and Awareness**

This theme includes Indicator 5d. *Interdisciplinary partnerships combine social and ecological research for management*, which evaluates the extent to which integrated social–ecological studies are applied to improve the management of coral reefs and coastal zones within the MAR region.

A review of the literature available highlighted a gap in stakeholder and rightsholder engagement in the Puerto Morelos area. While biological monitoring provides essential information, it is overrepresented in studies assessing the health of the reef and is rarely complemented by community input, with (Rodríguez-Martínez, 2008) being the only recent published article. Most existing assessments of reef health, including HRHP’s Eco-Audits, rely predominantly on biological assessments and government records (HRHP 2021 Eco-Audit), with limited attention to primary source community perspectives. This gap presents an important opportunity to assess whether local voices are adequately represented in research partnerships and whether findings are effectively communicated back to the communities involved.

This study aligns closely with the objectives of this indicator, as it incorporates interviews with community members and includes plans to share results with them upon completion. Moving forward, future research could benefit from adopting a feedback loop approach, whereby researchers regularly re-engage with community members to identify emerging issues and challenge their own assumptions to ensure that socio-ecological research (including this study) remains responsive and participatory (Jackson et al., 2018). This approach is central to managing complex adaptive socio-ecological systems where regular re-engagement allows managers to identify and correct or prevent poor design or lack of trust in management (Quintana et al., 2021; Villaseñor-Derbez et al., 2022).

## **Sustainability in the private sector**

Many park guides expressed both approval of, and the need for improvements to the park authority’s educational materials directed at both visitors and guides themselves. This feedback suggests that park guides can serve the critical role of guides as frontline interpreters and their capacity to foster sustainable behaviours among tourists, making

them ideal evaluators of the effectiveness of educational materials and eco-standards (Lück, 2003; Moscardo et al., 2004).

Indicator 6a. *Voluntary eco-standards program for marine recreation providers* assesses the extent to which voluntary programs have been developed to promote environmental stewardship among those who depend on marine ecosystems, particularly coral reefs, for recreational activities. Specifically, this indicator measures the level of participation of marine recreation providers in initiatives that foster environmental sustainability and responsible reef use.

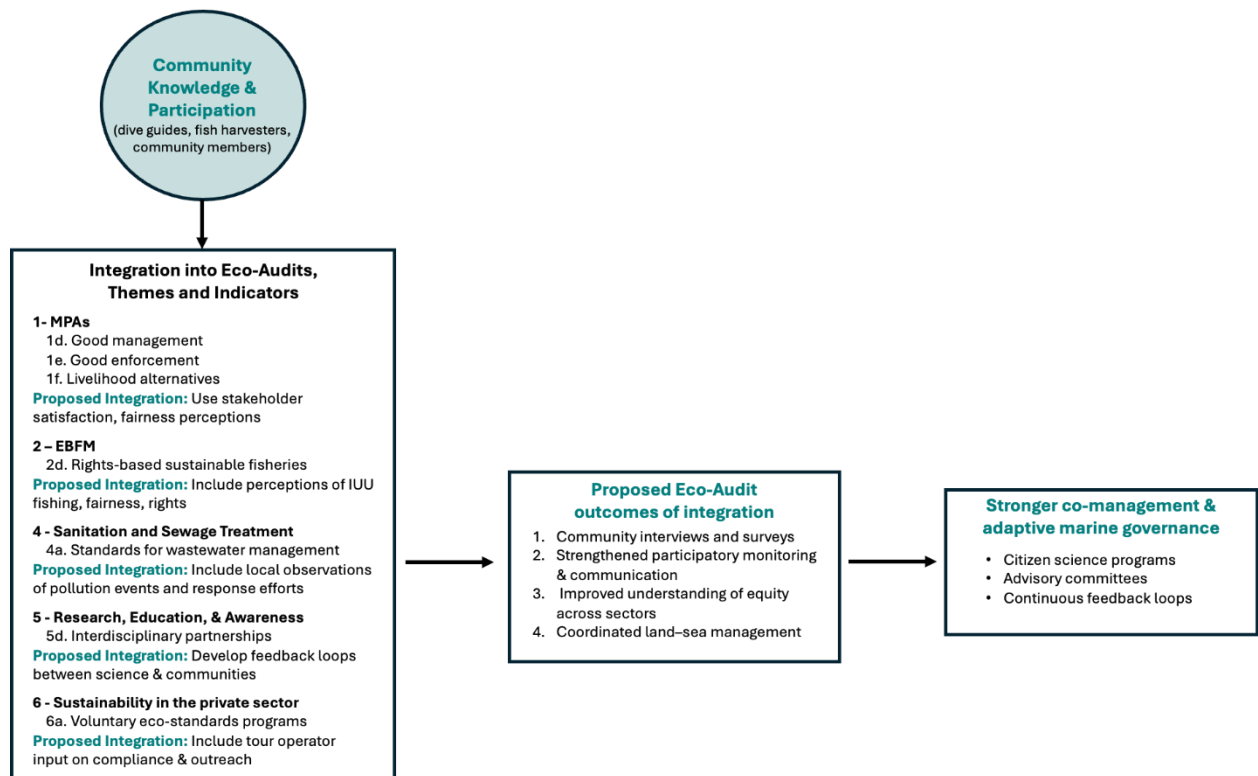
My findings indicate that park guides are generally enthusiastic about participating in CONANP's conservation activities but face limitations due to insufficient institutional mechanisms and communication channels. Given this context, it would be highly valuable to engage marine recreation providers directly in future Eco-Audit assessments of sustainability. Collecting their perspectives on the behaviour of other tour operators, particularly regarding compliance with regulations, contribution to conservation efforts, and the availability of opportunities to participate in environmental programs, would provide important qualitative data for evaluating this indicator and strengthening collaborative management efforts.

#### *4.6. Limitations and Future Directions*

This study was limited by its small sample size, short timeline, and the temporal mismatch between qualitative interviews and long-term biomass data. Perceptions also reflect individual experiences and may not represent the full diversity of local viewpoints, given that I was only able to interview seven of the ~50 members of the fishing co-op, and eleven dive guides from the entire town.

Future work could expand participatory approaches to include establishing and maintaining advisory committees and citizen-science monitoring programs, as well as combining UVC methods with community-based monitoring alongside fish harvesters. Participatory monitoring has strong potential in small-scale fisheries, offering not only continuous data collection but also empowering and inclusive processes when power dynamics are addressed (House et al., 2023). Recreational divers (such as dive guides) are already capable of reliably collecting reef species data, and studies have shown that volunteers and trained scientists

recorded similar species abundance and composition (Dumas et al., 2020; Vieira et al., 2020). Importantly, integrating harvesters' LEK into monitoring and decision-making supports more equitable and effective management (Hamelin et al., 2024). Such combined, participatory approaches could also feed into adaptive Eco-Audits that continuously assess reef health in terms of both ecological and social dimensions, ensuring management remains responsive to real-world change.



**Figure 9.** Flow diagram of the practical integration of community knowledge into the Eco-Audit theme/indicator framework. Proposed outcomes are also included.

## 5. Conclusion

Overall, this study demonstrates that fish harvesters and dive guides in Puerto Morelos hold valuable ecological knowledge that can inform MPA management and reef monitoring. Their perceptions reveal key social and ecological tensions between regulation and livelihood, enforcement and legitimacy, and scientific and experiential knowledge. While perceptions of

decline did not align perfectly with measured biomass trends, they reflect meaningful, place-based understandings of ecosystem change (Borges et al., 2024; Holland, 2022; Wickham et al., 2022). Integrating these insights into reef monitoring frameworks could strengthen social legitimacy and support for NGO's like HRHP. Eco-audits that incorporate community perspectives can help contribute to a more equitable and effective co-management model and recommendations for the Puerto Morelos Reef National Park and its surrounding protected area.

Finally, an important part of community-based work is returning to the community with results and further research proposals. I hope to return to Puerto Morelos to disseminate my research and continue meaningful integration of community perspectives into local marine management practices.

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## Appendix I

### Survey for Fish Harvesters Puerto Morelos Reef National Park (English Translation)

Locality \_\_\_\_\_ Survey taker \_\_\_\_\_ Date \_\_\_\_\_

Adapted from *Mar Sustentable, Proyecto Rufford Foundation 2021*

Interview of the day \_\_\_\_\_. Total number of interviews \_\_\_\_\_

1. Where were you born? \_\_\_\_\_
2. What year were you born? \_\_\_\_\_
3. Are you currently involved in fishing practices? Yes ( ) No ( )
4. Do you primarily fish in the Puerto Morelos Reef National Park (PMRNP) or the surrounding areas? \_\_\_\_\_
5. How many years of fishing experience do you have? \_\_\_\_\_
6. If you no longer fish, in what year did you stop fishing? \_\_\_\_\_
7. Currently, how many fishermen/boats do you estimate there are fishing in PMRNP? Many ( ) Few ( )
8. Currently, how many fishermen/boats do you estimate there are fishing in the area surrounding the PMRNP? Many ( ) Few ( )
9. What type of vessel did you use when you started fishing? (Boat, Canoe, Kayak, Sailboat, Barge, Kayak, etc.) \_\_\_\_\_
10. What type of vessel do you currently use? (Boat, Canoe, Kayak, Sailboat, Barge, Kayak, etc.) \_\_\_\_\_
11. What type of gear did you use when you started fishing? (Rope, pole, harpoon, net, etc.) \_\_\_\_\_
12. What type of gear do you use now? (Rope, pole, harpoon, net, etc.) \_\_\_\_\_
13. Since you started fishing in the area until now, have there been any changes in the distances from the fishing grounds you normally go to? Yes ( ) No ( )
  - a. Was this due to the establishment of the PMRNP? Yes ( ) No ( )
14. What is the most recent location where you have gone fishing in the PMRNP?  
\_\_\_\_\_

**15.** Do you know of any species that were once abundant in the PMRNP but are no longer?  
Yes ( ) No ( ) Don't Know ( )

If your answer was yes, please mention the species that you consider to be depleted.

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_
7. \_\_\_\_\_
8. \_\_\_\_\_
9. \_\_\_\_\_
10. \_\_\_\_\_

**16.** When you started fishing, was there a greater variety of fish in what is now the current PMRNP area? Yes ( ) No ( ) Don't Know ( )

**17.** Have you noticed any decrease in the size of the fish since then? Yes ( ) No ( ) Don't Know ( )

**18.** Do you know of any sites in the region that were once very productive for a particular fishery but are no longer so today? Yes ( ) No ( ) Don't Know ( )

If your answer was yes, please mention the site that was productive and the fishery that was abundant there in the past.

- |          |       |         |       |
|----------|-------|---------|-------|
| 1. Site  | _____ | Species | _____ |
| 2. Site  | _____ | Species | _____ |
| 3. Site  | _____ | Species | _____ |
| 4. Site  | _____ | Species | _____ |
| 5. Site  | _____ | Species | _____ |
| 6. Site  | _____ | Species | _____ |
| 7. Site  | _____ | Species | _____ |
| 8. Site  | _____ | Species | _____ |
| 9. Site  | _____ | Species | _____ |
| 10. Site | _____ | Species | _____ |

**19.** Do you know of any species that were not fished for consumption in the past and are now being caught and have a market? Yes ( ) No ( ) Don't Know ( )

a) Species \_\_\_\_\_ b) Reason \_\_\_\_\_

a) Species \_\_\_\_\_ b) Reason \_\_\_\_\_

a) Species \_\_\_\_\_ b) Reason \_\_\_\_\_

a) Species \_\_\_\_\_ b) Reason \_\_\_\_\_

**20.** Has the park/government authority contacted you to assist or give input on fisheries management?

Yes ( ) No ( ) If so, in what capacity \_\_\_\_\_

## Appendix II

### Survey for Tourist Guides in Puerto Morelos Reef National Park (English Translation)

Locality \_\_\_\_\_ Survey taker \_\_\_\_\_ Date \_\_\_\_\_

Adapted from *Mar Sustentable, Proyecto Rufford Foundation 2021*

Interview of the day \_\_\_\_\_. Total number of interviews \_\_\_\_\_

1. Gender
2. Where were you born? \_\_\_\_\_
3. What year were you born? \_\_\_\_\_
4. Do you currently work in the tourism sector? Yes ( ) No ( )
5. What is the main type of tourist activities/excursions you do?
6. How many years have you been working in tourism in the area?
7. If you no longer work in tourism, in what year did you leave?
8. Currently, how many boats do you estimate are carrying out tourist activities in the Park?  
< 20 ( ) 20-50 ( ) <50 ( ) Other \_\_\_\_\_
9. Since you started working in the area until now, has there been a noticeable change in the number of boats carrying out tourist activities in the area? Yes ( ) No ( ) Type \_\_\_\_\_
10. What type of vessel do you use to carry out your activities?
11. Since you started working in the area, have there been any changes in the places you usually go to for guided tours? Yes ( ) No ( )
  - a. If your answer was yes, was this due to the creation of the Puerto Morelos Reef National Park (PMRNP) ? Yes ( ) No ( )
12. Do you think the PMRNP has influenced the quantity or variety of marine species you see during your tours?  
Yes ( ) No ( ) Do not know ( )  
Briefly explain:
13. What is the most common place/site where you carry out your activities in the PNAPM?
  - a. Does this change based on season or customer interest?

**b.** Are there places they visit specifically because you know you are sure to see a particular species there?

1. Site \_\_\_\_\_ Species \_\_\_\_\_
2. Site \_\_\_\_\_ Species \_\_\_\_\_
3. Site \_\_\_\_\_ Species \_\_\_\_\_

**14.** Do you know of any species/group of species of fish that were once abundant in these places but are no longer so? Yes ( ) No ( ) Do not know ( )

If your answer was yes, please list the species you believe have become extinct

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_
7. \_\_\_\_\_
8. \_\_\_\_\_
9. \_\_\_\_\_
10. \_\_\_\_\_

**15.** When you started working in Puerto Morelos, was there a greater variety of fish in what is now the current area of the PMRNP? Yes ( ) No ( ) Do not know ( )

**16.** Since you started working as a tour guide, have you noticed any decrease in the size of the fish you observe during tours? Yes ( ) No ( ) Do not know ( ) Explain briefly:

\_\_\_\_\_

**17.** Do you know of any places within or near the PNAPM that used to be excellent for observing fish or marine life, but no longer are?

Yes ( ) No ( ) Do not know ( )

If your answer was yes, please list the sites and species that you used to see frequently in the past but are now seen less frequently:

1. Site \_\_\_\_\_ Especie \_\_\_\_\_
2. Site \_\_\_\_\_ Especie \_\_\_\_\_

3. Site \_\_\_\_\_ Especie \_\_\_\_\_

**18.** What do you think is the reason for the change in the quantity, variety, or size of fish you observe (if you have noticed any)?

- Overfishing
- Climate change
- Intensive tourism
- Pollution
- Park regulations
- Other:

Explain briefly:

**19.** Have you noticed that tourists are consuming species that were not previously fished for local consumption?

Yes ( ) No ( ) Do not know ( )

If you answered yes, could you mention which species and whether they are now captured for tourism purposes?

a) Species \_\_\_\_\_ b) Motive \_\_\_\_\_

a) Species \_\_\_\_\_ b) Motive \_\_\_\_\_

a) Species \_\_\_\_\_ b) Motive \_\_\_\_\_

a) Species \_\_\_\_\_ b) Motive \_\_\_\_\_

**20.** Do you know which sites within the park most commonly find lobsters and economically important finfish species?

**21.** During the breeding season for these species, do the visitor sites change? Yes ( )

No \_\_\_\_\_ Which ones? \_\_\_\_\_

**22.** Are you invited to participate in defining management plans or conservation actions in the park, or do you know of any service provider who has been invited?

**23.** Do you think that fishing, as an economic activity, could affect or alter the park?

24. Do you think the park helps improve the abundance of fish within the park?
25. Do you think the park helps improve the abundance of fish outside the park?
26. Do you think the park helps attract tourists?
27. Do you think the park helps reduce illegal or harmful activities such as illegal fishing or irresponsible tourism?