

Socio-environmental impact assessment of flat fishing in Campeche and Yucatan, Mexico

Final report

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Table of Contents

Executive Summary	4
1. Introduction	5
2. Objective	6
2.1. Specific objectives	6
3. Study Area	6
3.1. Los Petenes Biosphere Reserve, Campeche.....	7
3.2. Ria Lagartos Biosphere Reserve, Yucatán	9
4. Methodology	13
4.1. Mixed Methods Approach	13
4.2. Local Knowledge	13
4.3. Interviews	13
4.4. Participatory GIS	14
4.5. Revision of secondary sources of information	14
4.6. Conflict analysis	15
4.7. Social Capital Analysis through Network Analysis.....	16
4.8. Organization analysis and strategic planning.....	18
5. Results	19
5.1. Data summary	19
5.2. Users of flat fishing areas	20
5.2.1. Internal actors from San Francisco de Campeche.....	20
5.2.2. Internal actors from San Felipe-Rio Lagartos, Yucatán	22
5.2.3. External actors (from other states or countries)	24
5.3. Flats fishing areas and vulnerable habitats	24
5.3.1. Participative GIS in Campeche	24
5.3.2. Participative GIS in San Felipe.....	29
5.4. Conflict analysis through respondents perception	35
5.4.1. Types of Conflicts.....	35
5.4.2. Evidence of conflicts	37
5.4.3. Conflict consequences	38
5.5. Social Capital Analysis through Network Analysis.....	40
5.5.1. Social Capital analysis of Campeche through Network Analysis	40

5.5.2.	Social Capital of San Felipe through Network Analysis	43
5.6.	Organization analysis through SWOT Analysis.....	45
5.6.1.	Campeche SWOT Analysis	45
5.6.2.	San Felipe SWOT Analysis.....	49
6.	Conclusions	54
6.1.	Los Petenes Campeche	54
6.2.	San Felipe Yucatan.....	56
7.	Conflict resolution strategic plan.....	57
7.1.	Socio-environmental research component.....	57
7.2.	Component for the development and integration of micro-regions	58
7.3.	Component of social cohesion for community action	59
7.4.	Component of education and outreach.....	60
7.5.	Component of sustainable uses and practices in flat marine areas.....	61
7.6.	Component of Social Participation in control and surveillance	61
8.	Bibliography	63
9.	Photographic collection	66

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Executive Summary

The coastal areas of the Yucatan and Campeche coasts consists primarily of wetland areas important and of interest to communities. Such natural systems provide various ecosystem goods and services for the well-being of people and livelihoods. In particular, the shallow water habitats, called flats, offer the opportunity for sustainable fishing activities in harmony with the environment.

However, the increasing human population growth is also increasing habitat use by multiple activities from diverse sectors which are further leading to environmental impacts on natural resources and increasing competition and conflicts amongst users in coastal areas. Thus, users from diverse productive and recreational activities follow independent and uncoordinated management schemes may cause socio-environmental conflicts in coastal communities. For instance, within the recreational fishing sector, there are concerns that bad fishing practices and unsustainable fishing gear used by different groups is affecting fish populations (Palomo and Perez 2022). The same occurs between and amongst other sectors, generating areas where multiple users from diverse sectors benefit from ecosystems services.

Hence, this study evaluates the social and environmental interactions faced by groups of users who carry out artisanal fishing, recreational fishing, and tourism activities in two areas of the Yucatan Peninsula adjacent to Biosphere Reserves (Los Petenes, Campeche and Ria Lagartos, Yucatan). The flats in the coastal zone are characterized by being the only ones where a catch-and-release fishing for game species, mainly tarpon (*Megalops atlanticus*), is carried out. This species is associated with fragile wetland areas surrounded by mangrove vegetation and rocky reefs, where commercial fishers and nature tourism service providers generate important benefits for the coastal communities.

Through surveys and interviews with different stakeholders and users (i.e., artisanal fishers, recreational fishing and tourism promoters, authorities) involved in managing and regulating natural resources, a network analysis was carried out to observe user relationships that could drive socio-environmental synergies or conflicts and identify resolutions. The strengths and weaknesses analysis scheme (SWOT) were also applied to understand the root causes of the conflicts and the areas of opportunity and improvement. Local knowledge on the distribution of the main target species of commercial and recreational interest was generated, as well as the identification of the most fragile habitats or those threatened by socio-environmental impacts.

Six strategic proposals for conflict resolution emerged from the analysis, focusing on community-based approaches to resource management. The main vision is a paradigm shift to strengthen local governance at multiple levels and increase collaboration with local communities. The first step would bring resource managers and other institutions closer to the communities for dialogue and knowledge exchange on challenges and opportunities. It will also be important to increase knowledge through environmental education awareness and outreach programs. One of the most critical measures to ensure conservation and management will be the monitoring, control, and surveillance of fishing activities (recreational and artisanal), with the community's participation and promotion of good fishing practices. There are also opportunities to improve tourism and recreational activities and the need to professionalize nature guides to provide better service.

1. Introduction

The states of Yucatan and Campeche consists of various natural protected areas (NPA) that support various types of economic and recreational activities. Fishing activities is the main source of income but also food production in various coastal communities. In addition, recreational activities are divided into two types: nature-based tourism (boating, bird-watching, gastronomical) and recreational and game fisheries. One of these least studied types of recreational fishing in this area is fly fishing or flats fishing, which has been carried out for more than 20 years in estuaries and bays of coastal wetlands of Los Petenes Biosphere Reserve in Campeche and the Ria Lagartos Biosphere Reserve in San Felipe. This activity is carried out on a catch-and-release basis and is considered a sustainable activity that promotes responsible fishing (Ault and Luo, 2013) to ensure fish survival (Dalynchuk 2013) of tarpon (*Megalops atlanticus*), bonefish (*Albula vulpes*), permit (*Trachinotus falcatus*), and snook (*Centropomus undecimalis*). These species are highly dependent on healthy habitats for healthy populations and fisheries (Perez et al 2021).

In recent years, coastal ecosystems have been impacted by various anthropogenic factors, such as pollution, urban growth, illegal fishing, and conflicts between resource users. Mainly, nature tourism guides refer to the damage caused by illegal fishing in which gillnets are used in the channels and mouths of estuaries between mangroves, which captures all types of species that use these habitats as sites of refuge, reproduction, and feeding (Aguilar Cordero et al., 2014), generating an increase in bycatch and discards, which affect the entire trophic chain (Hilborn, and Hilborn, 2012).

Therefore, the use of resources in a shared area (Perez 2019) by users who carry out diverse activities generates complications in social and economic relations and leads to social conflicts in recreational fisheries (Perez 2014) and the degradation of ecosystems due to incompatible or competitive uses of the same resource or area in common (Voyer, et al., 2017).

In this evaluation we gathered local knowledge using multiple methods to document the following:

- Identify the key actors involved in the fishing and tourism activities of each community.
- The social dynamics of flats fishing and other activities in protected and adjacent areas Los Petenes and Dzilam (Campeche) de Bravo-Río Lagartos (Yucatan).
- The status on the natural ecosystems in protected and adjacent areas Los Petenes (Campeche) and Dzilam de Bravo-Río Lagartos (Yucatan).
- The spatial and temporal distribution of flats species, fishing areas, and vulnerable habitats.
- The existing socio-environmental conflicts associated to the ecosystems used by the flats fishery and other users.
- Management strategies identified by multiple users to mitigate social-ecological impacts and improve their commercial and recreational activities.

The purpose of this study was to conduct an environmental impact assessment (EIA) of the current conditions of flats fishing in the eastern coast (Campeche) and north of the Yucatan peninsula (Yucatán). Specifically, identify the main actors that use and exploit natural resources, determine their social dynamics, and related conflicts as well as their perception of ecosystem vulnerabilities related to their use. With the help of the users themselves, we were able to document

proposals as strategic lines of action that will allow a more organized and sustainable management of the resources, preferably in a co-management scheme following an overall conclusion of needs.

2. Objective

Conduct a socio-environmental evaluation using mixed methods to evaluate status of the flats fishery the conflicts amongst users (recreational fisheries, artisanal fisheries, and tourism recreation activities) and habitat use of flats areas in Campeche and Yucatan to devise a strategic plan to improve the flats fishery.

2.1. Specific objectives

- Characterize the flats fishery and other activities in terms of users, resource base, fishing areas, fishing methods, management and economy carried out in the coastal shallow areas of interest.
- Identify and generate maps on the spatial and temporal distribution of flats species, fishing areas, and habitats (location of habitats, which species and life stages use them and relative health of the habitats).
- Identify socio-environmental conflicts among the main users.
- Analyze the interactions among main users as a component of their social capital.
- Incorporate the socio-environmental conflicts into a geographic information system that allows identifying areas of high fragility, threatened or at risk.
- Collaborate with user groups (including managers of protected areas and other local authorities) to devise management strategies to mitigate social-ecological impacts and improve commercial and recreational activities.

3. Study Area

This research project was carried out in the states of Campeche and Yucatán. In Campeche, it covered the communities of San Francisco de Campeche and Isla Arena. Both communities are in the area of influence of the Los Petenes Biosphere Reserve (RBLP) to the west of the Yucatan Peninsula. In Yucatan, the communities of San Felipe and Río Lagartos were included, both of which are located within the Ría Lagartos Biosphere Reserve (RBRL). The communities in both states are characterized by the fact that artisanal commercial fishing and recreational tourism activities are carried out in shallow areas associated with mangroves.

The RBLP was declared a protected natural area in May 1999 and is considered a unique biogeographic area home to various complex ecosystems that share characteristics with wetland systems similar to those found in Cuba and the Florida Peninsula. It is adjacent to San Francisco de Campeche, the capital of Campeche.

For its part, the RBRL was declared a protected natural area in 1999. Within this area is the community of Río Lagartos, which is the head of the municipality of the same name, and the community of San Felipe in the far west, which stands out for its importance as the leading flat fishing site of the reserve. This protected natural area is located in the northeast of the state of

Yucatan. Both study areas are considered sites of importance for conservation, which are included in the Ramsar Convention.

In these sites come together commercial fishers who catch various species of fish, mollusks and crustaceans of high commercial value; users of recreational services such as recreational anglers and tourists carry out various activities through ecotourism service providers. A biophysical description of each study area is presented below.

3.1. Los Petenes Biosphere Reserve, Campeche

Los Petenes Natural Protected Area in Campeche, obtained its Biosphere Reserve (LPBR) title on May 24, 1999. Its total 282,857 hectares includes a coastal stripe and a marine area up to 12 nautical miles in the southeast of the Gulf of México, between the limits of Campeche and Yucatan states (CONANP-SEMARNAT, 2006) (Figure 1).

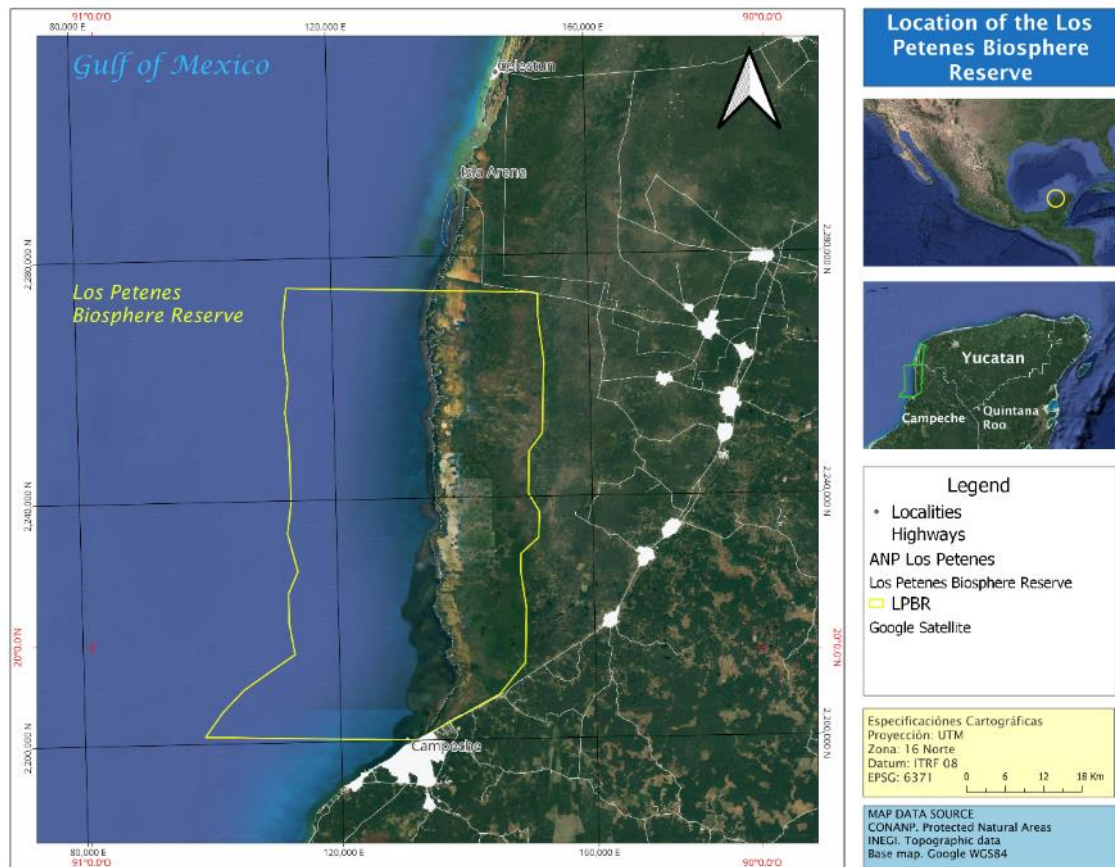


Figure 1. Location of the Los Petenes Biosphere Reserve

The Maya name of “Petén” refers to an ecological community in the coastal wetland. A Peten is formed by medium forest tree species developing around a freshwater spring of subterranean origin forming a habitat with island form. This habitat is characterized by high

productivity and is used by various aquatic birds, reptiles, mammals, mollusks, fish, and crustaceans for feeding, reproductive, rest, growth, or reproductive purposes.

The zoning of Los Petenes NPA consists of a core area covering 64,282 Ha whose primary purpose is to protect the Petenes systems since most of them are found in this zone. This zone restricts all types of extractive and non-extractive activities. The Buffer Zone has an area of 218,575 Ha, subdivided into the following Subzones (Figure 2):

- Preservation Subzone. Corresponds to the floodable coastal strip where the mangrove fringe, “blanquiales”, and estuaries are found. It has an area of 15,407 ha.
- SUNTR- Subzone of Sustainable Use of Natural Terrestrial Resources (I and II). It has an area of 23,250 ha and corresponds to the land surface covering the southern and eastern portions. Tourism, extractive (logging), and agricultural activities, among others, are conducted in these areas.
- SUMR- Subzone of Sustainable Use of Marine Resources. Corresponds to the western zone of the LPBR whose limit is up to 12 nautical miles, approximately at a depth of 10 meters. This zone has marine pastures and commercial and recreational fishing and tourism activities (boats and kayaks). It has an area of 181,919 Ha.
- Human Settlement Subzone. It has an area of 90.3 Ha and represents those areas in which urban infrastructure has been developed, thus modifying the environment. Corresponds to the town of San Francisco Kobén to the east of the reserve and the housing infrastructure and tourist services adjacent to Campeche.
- Core Subzone. The core zone has an area of 64,282 hectares in which the conservation of biodiversity and ecosystems is prioritized. Use for research and management purposes only.

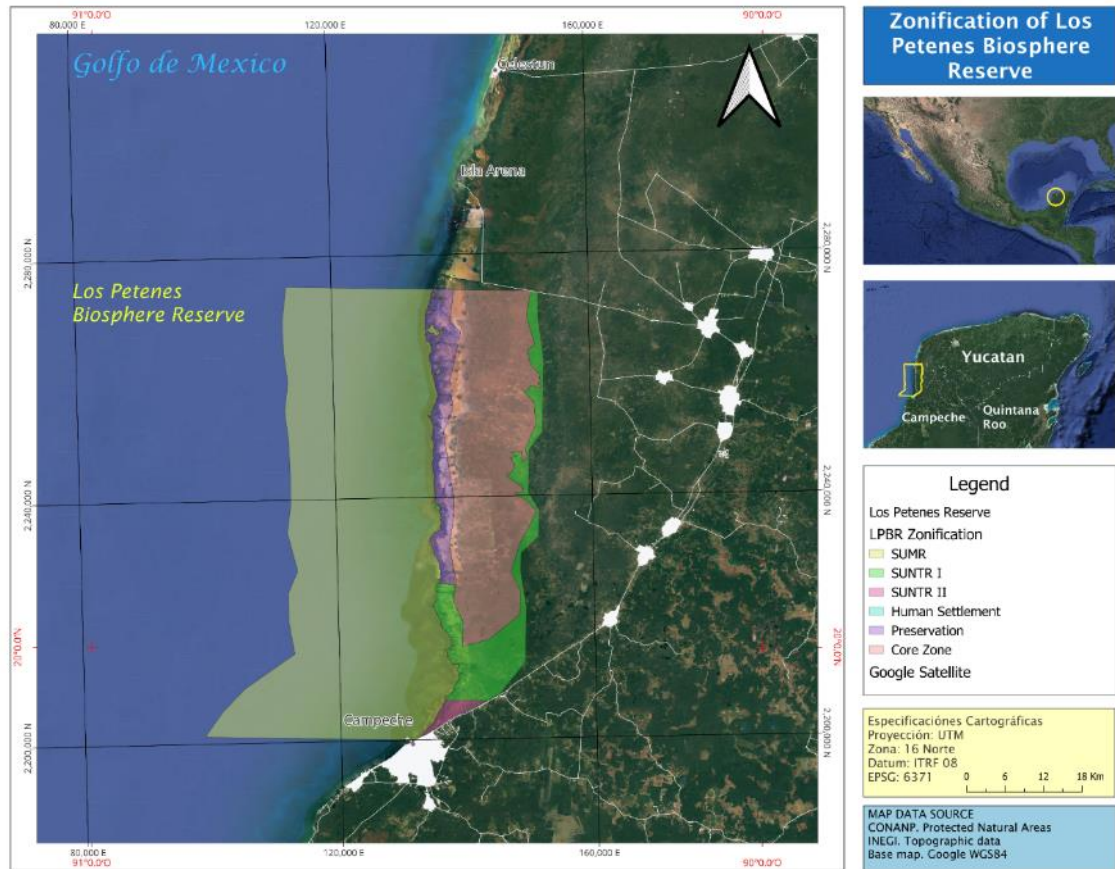


Figure 2. Zoning of Los Petenes Biosphere Reserve

Two nature contemplation tourism activities were identified. These activities are Kayak rides in the Campeche area and up to the Mogotes area. The second is boat rides from Isla Arena to the north of Los Petenes, to observe local fauna and flora. Most of these activities are practiced by local people with their own kayak or rent from providers, thus the activities are not developed or regulated.

3.2. Ria Lagartos Biosphere Reserve, Yucatán

Ría Lagartos NPA was decreed with this Biosphere Reserve (RLBR) category on May 21, 1999. It covers an area of 60,347.82 hectares, of which 39.24% are core areas and 60.76% are buffer zones. The reserve is located on the eastern coastal strip of the state of Yucatán, bordered to the north by the Gulf of Mexico, to the south by the municipalities of Tizimín, Río Lagartos, and San Felipe, to the east by Quintana Roo, and to the west by the municipality of San Felipe (INE, 1999).

The RLBR is 270 km from the city of Mérida. Access to the reserve is via highways that connect to the towns of San Felipe, Rio Lagartos, Las Coloradas, and El Cuyo. Among the ecosystems found in Ría Lagartos are mangrove zones, medium sub-evergreen forest, low deciduous forest, coastal dune vegetation, petenes, and savannahs represented by tulares, grasslands, and reed beds. The reserve has two ecoregions: the Mexican mangroves and the dry forests of Yucatán.

San Felipe is a municipality made up of 17 localities and has an area of 450 km², which represents 1.32% of the territory of the state of Yucatán. It has a medium level of marginalization, and its population according to the 2010 population and housing census (INEGI, 2021) is 1,840 inhabitants, of which 51% are men and 49% are women. Coastal fishing is the most important activity in the community of San Felipe, with 68% of the population participating, which is organized mainly by fishing production cooperatives.

Tourism in San Felipe it's the second most important activity, which contributes to the municipality's economy by offering natural attractions such as beaches and cenotes (INE, 1999). It is also one of the access points to the Ría Lagartos Biosphere Reserve to the west of the polygonal zone, and it borders the eastern limits of the Dzilam de Bravo State Reserve (Figure 3).

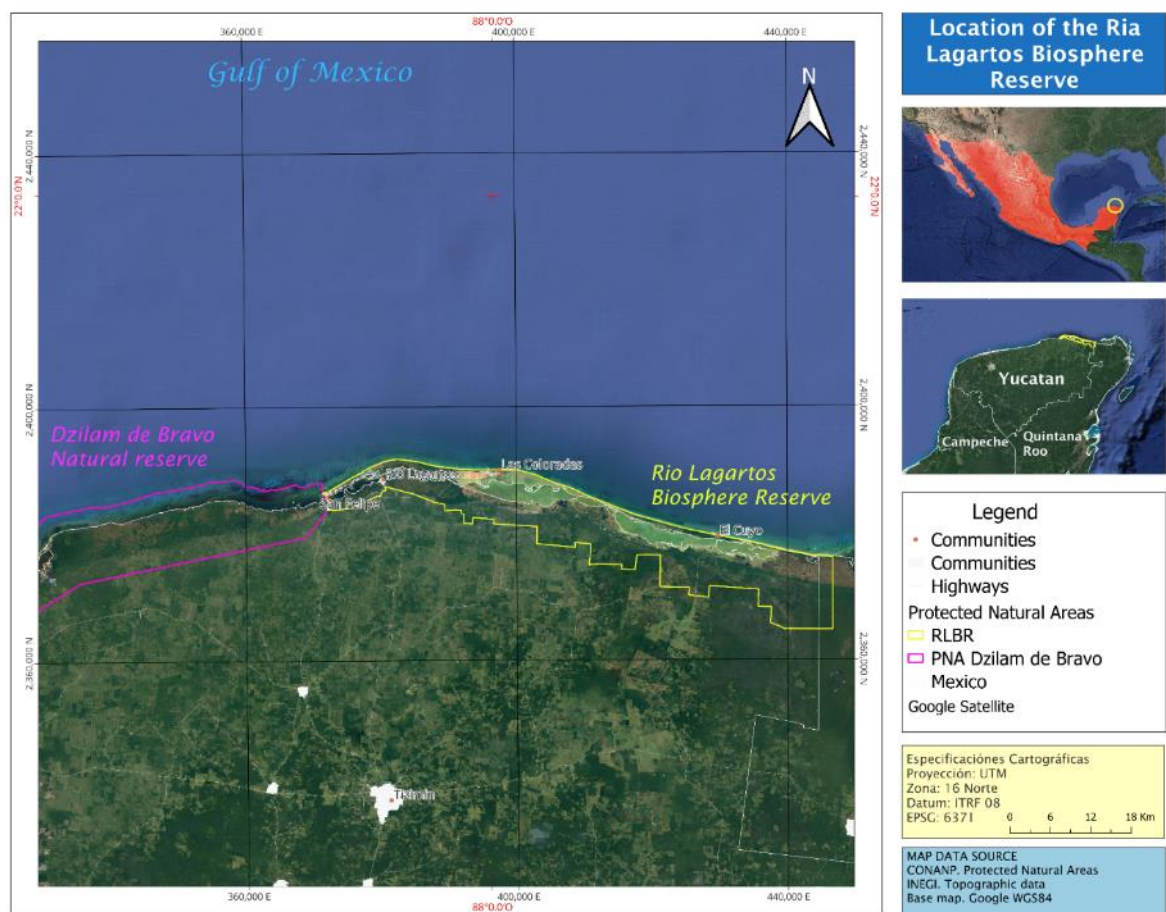


Figure 3. Location of San Felipe between the reserves of Ría Lagartos and the state reserve of Dzilam de Bravo.

The reserve receives approximately 30,000 visitors per year. The main visiting seasons correlate with traditional vacation periods in the country, such as Easter, summer and winter. Among the attractions are boat trips to visit nearby Isla Cerritos, an ancient commercial point of the Itzaes, located 5 km west of San Felipe. It is speculated that this was the commercial point of fish

and seafood to Chichén Itzá. It is also possible to visit the beach area in front of the community and ecotourism tours for bird watching in the estuary and canals between the mangrove (Aguilar-Cordero, et al., 2012). It is worth noting that there are recreational and deep-sea fishing trips, especially fly fishing, in the area bordering the community of San Felipe to the west, which is by promoters of flat fishing and independent guides from the community. Lodging is limited, with one three-star hotel and two rustic cabins. It is worth noting that much of the tourism in San Felipe is for day visits, since the neighboring community of Rio Lagartos, 13 km away, attracts the most overnight tourism with at least seven 1 to 5-star hotels.

According to the zoning of the Natural Protected Areas of Dzilam de Bravo and the RLBR, the following image shows the area for recreational activities such as recreational fishing and boating, highlighted with a buffer of 300 meters from the shore, according to the estimates of service providers. The eastern portion of this area overlaps the subzones of the polygon of the Ria Lagartos Reserve and the western portion is located in front of the coasts of the Dzilam NPA (Figure 4).

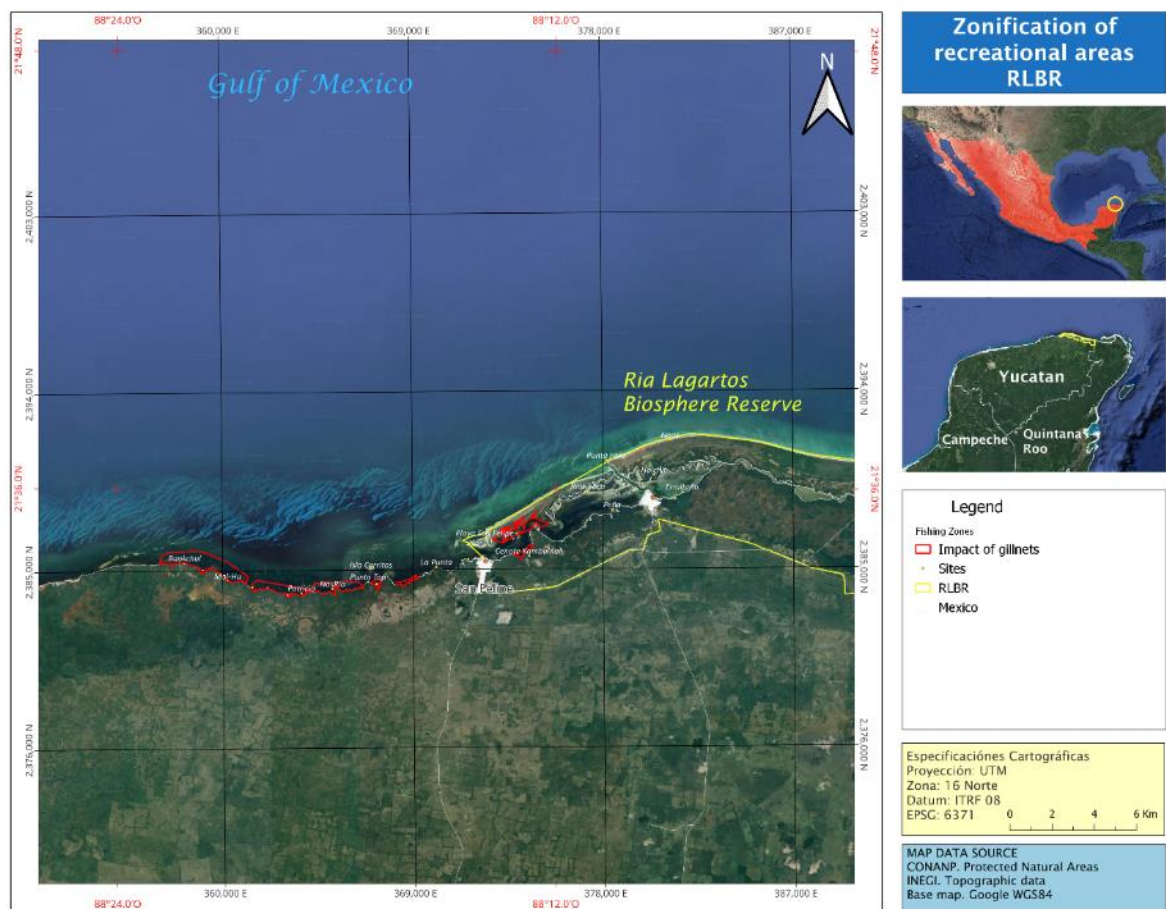


Figure 4. Recreational areas and zoning of the Ria Lagartos Biosphere Reserve

The area where these recreational activities take place includes the brackish water estuary that has a contribution of fresh water from the subsoil, forming shallow areas of the marine fringe

and mangrove swamps of the coastal wetlands and islets of Ría Lagartos, both in the eastern part facing the mouths as in the west towards Dzilam de Bravo. This zone encompasses both state and federal reserves. However, the state reserve does not have the authority to establish management measures in marine areas under federal jurisdiction, so they are not considered in the zoning. Table 1 describes the subzones of Ría Lagartos Reserve where the flat fishing occurs, including the following subzones and their characteristics.

Table 1. Characteristics of flat fishing zones in RLBR.

Ria Lagartos Biosphere Reserve	Characteristics
Beach - Turtle Sanctuary	Beach preservation and protection
Restoration Zone - Ria	Conservation and protection zones where ecosystem restoration activities are allowed.
Core Zone 1 San Felipe-Río Lagartos - Ria	Research and scientific collection, forestry sanitation, cleaning activities aimed at preserving ecosystems, inspection and surveillance, environmental education and guided tours for environmental education are allowed.

BEACH - TURTLE SANCTUARY. These beaches were decreed by the Federal Government as a sea turtle nesting protection zone, recognized as one of the main arrival zones for hawksbill turtles (*Eretmochelys imbricata*) and the only one in the state of Yucatan for white turtles (*Chelonia mydas*).

RESTORATION ZONE. Restoration zones are the priority sites for reforestation programs and will be carried out simultaneously in each of the proposed sites. The restoration process should include the removal of all significant obstacles that have been created and that impede the flow of water into the mangroves and between the watersheds. In this case, it is important to point out that in the short term, they should reestablish flows through culverts and water crossings in the access roads to San Felipe, Río Lagartos, Las Coloradas (at the height of the Peten Tucha watershed) and El Cuyo. Freshwater wells should be restored to near-original conditions and pumping should be controlled to prevent brackish water intrusion. It is also important to implement a monitoring system to recommend medium- and long-term flow restoration actions.

CORE ZONE I (SAN FELIPE-RÍA LAGARTOS). It has an area of 1,342.769 ha, bordered to the north by a buffer strip of restricted use of 50 m, which adjoins the estuary. To the south, there is a 50-meter buffer zone for restricted use and a 500-meter buffer zone for moderate use that runs parallel to the reserve's border and the San Felipe-Río Lagartos highway. To the east and west, there

is a 50 m restricted-use buffer zone and a 300 m moderate-use buffer zone that runs parallel to the Tizimín-Río Lagartos and San Felipe-Panaba roads, respectively. This zone contains an important portion of low thorny forest rich in orchids, epiphytes, and endemic and endangered cacti, such as *Mammillaria gaumeri*. There are also mangrove flood zones bordering the estuary.

4. Methodology

4.1. Mixed Methods Approach

This research will use a mixed method approach that includes literature review to gather scientific knowledge to characterize coastal marine areas and fieldwork on local knowledge through key informants in coastal communities. The approaches offered by this methodology are essential to propose alternatives in managing resources through the empowerment of the local community (Perez, et al., 2014; 2019; 2023 unpublished; Davis and Wagner, 2003). This approach aims to collect qualitative and quantitative information from direct and indirect sources, which includes the ecological, biological, and socioeconomic characterization of coastal wetlands, using the information available in databases such as Scopus and Web of Science, as well as reports or management plans for protected natural areas.

4.2. Local Knowledge.

Various studies use local ecological knowledge, described by Olson and Folke (2001) as the knowledge possessed by a specific group of people about their local ecosystems, in which organisms and their environment interact. These concepts are incorporated into the research of social systems and ecosystems, providing useful knowledge to science for more comprehensive management of fisheries and their conservation (Boubekri, et al., 2022).

Information derived from local knowledge is one of the most widely used methods in social studies, in environments where scientific data or relevant information (social, fishing, or tourism statistics) is not available or is difficult to obtain at certain levels of local scale. (Zetina-Rejón, et al., 2022).

To obtain it, a participatory approach of the main users and actors involved in a natural system is required, which allows the construction of local knowledge. Given that most of the information is qualitative, to address the complex structure of social networks, local knowledge has been used to generate data from which inferences can be drawn about the impacts between ecosystems and social systems (Cisneros-Montemayor, et al., 2020).

4.3. Interviews

Face-to-face semi-structured interviews were conducted with key informants to gather their perceptions of the current state of natural resources and natural or anthropogenic impacts on ecosystems. Likewise, face-to-face workshops were held with key informants to inform them about the objectives of this project and the importance of including their local knowledge, about the ecosystem management of coastal habitats and their concerns.

To identify local needs addressing environmental degradation and deterioration of fish populations in shad habitats, a general Strengths, Weaknesses, Opportunities and Threats (SWOT) Analysis was conducted (Cowx et al., 2010).

A questionnaire was applied to identify socio-environmental conflicts among the main users and conduct a social network analysis. The questionnaire includes 80 questions in six sections: General data and individual perspectives of the areas studied; SWOT analysis, perception of conflicts among users, network information, conflict resolution ideas, resources, and habitat distribution. In addition, the questionnaire included open and closed-response questions with Likert scale of 5 variables, a contact matrix for network information, and local scale maps for information on fishing areas and their resources to be filled by respondents.

4.4. Participatory GIS

A Geographic Information System (GIS) will be integrated to characterize the coastal and marine ecosystems in the study areas. The first phase is based on the geographic characterization from sources of various thematic layers (biotic and abiotic factors, human settlements, geographic limits, vegetation).

The second phase is to use a participatory GIS approach (Bryan, 2015). The objective is to enrich the GIS information from users to map local knowledge of fishing and tourism sites, the most fragile, conflictive, or threatened areas. This way, local knowledge and stakeholders' perspectives interested in the spatial use and management of their resources will be integrated.

The process is carried out together with the interviews and surveys applied to users of the resources in the study areas. At the end of each interview, a map of the main marine-coastal areas is shown, and they are asked to indicate the location of the following zones:

- a) artisanal fleet fishing zones,
- b) recreational fishing zones,
- c) fragile or conservation zones, and
- d) threatened coastal ecosystems, or that present some conflict in their use.

To allow us to gather a complete picture of potential or present socio-environmental conflicts, respondents were asked to provide in-depth answers on relevant aspects of the uses of space and natural resources in the area.

Subsequently all this information is digitized and integrated into a GIS for presentation on maps. Inspections will be made to the study areas to complete the field work to obtain detailed geographic information on the sites.

4.5. Revision of secondary sources of information

The secondary sources of information considered in this project will be obtained from management programs, scientific articles, technical reports, logs, and documented records of activities relevant to the objectives of this study.

4.6. Conflict analysis

A socio-environmental conflict occurs when at least two types of actors with a certain awareness of identity or users of the environment enter competition for natural resources or for their spaces and there is an incompatibility between them. According to conflict theory, a conflict between actors is generally only the tip of an iceberg whose greater volume corresponds to a structural conflict that masks antagonistic interests, values, principles, needs and visions. The interaction between these antagonistic users manifests itself to acquire or exercise power that may be expressed in aggressive actions. However, it is more commonly perceived as a situation where there are winners and losers, or as a belief that one of the parties hinders the interests of the other (Ortiz et al. 2011). For a conflict to develop, it is necessary to have a social climate that favors it and generally a factor that triggers it.

Among socio-environmental conflicts there are three types of conflicts (Ortiz, 2001):

- Conflicts are due to scarcity of natural resources or goods, where their availability is restricted or limited for some actors and prevents them from meeting their needs or demands, also known as resource competition conflicts.
- Identity conflicts, where, as a consequence of the degradation or loss of a vital resource, a group is forced to move and thus lose its identity manifested in its cultural integrity and group cohesion; or, when because of incompatible uses in the same space, these conflicts are manifested as competition for space with the mentioned consequences.
- Conflicts due to relative deprivation, where, due to environmental problems, a group is limited in its capacity to take advantage of or produce well-being and wealth, thus giving rise to feelings of insecurity and discontent, as well as accentuating the gaps between those who achieve economic achievements and those who do not. Also known as competition for habitat conflicts.

Interviews focused on local knowledge will be used to assess the perception of the main actors regarding the biological and ecological impacts of natural systems and their exploitation or use. Five questions were included in the interview to support our conflict perception analysis, and guided actors to:

- Describe which actions or attitudes of other groups in the area impact their activities.
- Reveal if disagreements with other groups exist, and if the disagreements were about:
a. the extraction of the same natural resources, b. the use of the same geographic areas although for the use of different resources or, c. the use of the same habitats or ecosystems.
- Suggest which actions make evident the opposing interests between the groups (for example, violence, aggressions, denunciations, interference between their activities); and define in what way these disagreements hinder their interests (for example, via loss of clients, loss of catches, pollution, loss of equipment or others).

Once the conflict arises several evidences may be present: If there are only verbal quarrels they are known as aggressions, if the confrontation involves physical force between people or with their property it is considered violence, if the regular operation of the activities of those involved is

impeded it causes interference and finally, the conflict leads those involved to resort to verbal or written formal or informal denunciation of activities before the authorities it is presented as reports.

Finally, often, the manifestation of the evidence of conflict does not lead to an assessment of the cost they generate, and only when these costs are explicit more pressure exist to solve the conflict. This can be done by analyzing the consequences, which in this case include: monetary losses, loss of the quality of the site under use or of the resource used, accidents or loss of life or equipment, increased social unrest with illegal activities or the increase in restrictive regulations for the use of resources.

4.7. Social Capital Analysis through Network Analysis

People's assets refer to the possession, control or mobilization of material and symbolic resources that enable the individual to develop in society. This involves physical, financial, human, social, natural, political and cultural capital. Conceptualizing, understanding and analyzing these assets is a key element in minimizing vulnerability and creating dynamic situations of well-being (Filgueira 2001). Social capital or assets refer to a collective attribute that includes relationships, bonds of trust, reciprocity, networks, etc.

In social systems, the interaction between actors allows the exchange of information and resources that favor the response to changes that alter the system (Thomas et al 2013). These interactions also determine the social capital that allows people to organize among themselves, build trust and work collectively to make decisions on issues of common interest and on the governance of the resources they share and on which they depend (Bodin and Prell 2011, Brondizio et al. 2009). Social capital plays an important role in social networks and the way communities deal with conflict resolution, poverty, vulnerability, or taking advantage of new opportunities. Social capital is an attribute of individuals and their relationships for the way in which they resolve and face their conflicts (Ostrom, and Ahn, 2009).

Connectivity, understood as the structure and strength with which such actors interact, confers a condition of resilience that increases when the human, physical and financial capitals of actors alone are not sufficient to solve any challenge or disturbance in the system. In social-ecological systems, connectivity is a principle of resilience that is expressed as interconnections at different spatial and temporal scales that allow recovery after a disturbance or by constraining locally the spread of the disturbance (Dakos et al. 2015).

One way of observing connectivity between actors is to see it as networks, where each connected component in the system is an actor or node (which may be an individual, an organization, or a business) and each interaction is a link (which may be information, trust, equipment, opinions, experiences, norms). In the analysis of social networks as natural capital, three types of social links are identified according to Aldrich (2012): bonding (strong links with people in the immediate network), bridging (weak links with people from another social group) and linking (links with people representing institutions or organizations in a position of authority).

In recreational fisheries the use of social networks has been studied from several perspectives: among boat captains as communication tools that mediate against the negative social and ecological effects of the use of fishery resources (Mueller et al. 2008), among recreational anglers and recreational fishing guides as a way to increase their catch and business success (Birendra et al 2018) or to complement catch information and build a user profile (Givios et al. 2018), to develop natural resource co-management capabilities (Plummer and Fitz-Gibbon 2006, Holdsworth and Walshe 2011). However, the development of networks between the different actors of recreational fisheries (i.e., scientists, managers, public policy makers, representatives, and NGOs) is considered a pending objective in the sector that will favor the understanding of recreational fisheries from their conception as socio-ecological systems, as expressed in the World Conference on Recreational Fisheries (Arlinghaus 2013).

The network analysis shows the direct relationships between various actors, which make up a symmetric node matrix of related elements. Each row i in the matrix shows the initial nodes that are related to nodes in each column j . Therefore, the elements of the matrix indicate the relationship between each pair of actors in the network. The presence of an interaction between actors i and j is represented by a 1 ($a_{ij} = 1$) and its absence by a 0 ($a_{ij} = 0$).

Once the binary matrix is generated, the UCINET software (V. 6.629) is applied to analyze the network structure (Zinoviev, 2018), graph it, and identify its properties (i.e. density, average ratios per node, clustering). Actors incorporated in the network, mainly include those interviewed, and additionally include those referred by the former. When nicknames are mentioned during the surveys that could not be verified, they are included as new actors; however, the total number of real actors participating in the network could, still be underestimated.

If network properties obtained show high condition of interconnexion among similar nodes (e.g. fishers), these connected nodes will have better opportunities to resolve and face their conflicts as a group with a common intention. For example, if recreational fishers are better connected through clubs, they could influence local politicians to develop public politics that strength inspection and surveillance actions in conservation areas; if recreational fishing service providers are better connected, they could influence local tourism authorities to enhance marketing strategies to attract international fishers.

To identify actors with high indicators of connectivity (Freeman, 1979) is crucial to recognize those who elevate the overall centrality of the network and can act as mediators in sending and receiving messages, giving or receiving advice, passing on rumors, providing novel information and influencing group decision making; that is, they hold some level of power and authority among the group (Wasserman and Faust 1994). This information can be used to strengthen the connectivity of the networks by inviting the most central nodes to be communicators of conservation initiatives or sustainable use of the flats.

4.8. Organization analysis and strategic planning

An analysis of Strengths, Weaknesses, Opportunities and Threats (SWOT analysis) was conducted after engaging in informal multi-stakeholder discussions at each community to: 1) Deepen the socio-environmental conflicts that the actors encounter the management and use of their coastal resources, particularly in fly-fishing areas; 2) analyze their productive activities as organizations to identify internal and external strengths and weaknesses, and 3) propose a plan of strategies that allow them to improve their activities.

This evaluation considered a SWOT Analysis because it is a qualitative tool that allows defining and contextualizing a problem and/or situation in a locality based on four analysis frameworks: Strengths, Opportunities, Weaknesses and Threats (Alberich et al., 2009). This technique was used by Cowx in 2002 for recreational fishing around the world and identified options for its future development. Its main finding was that effective management of recreational fisheries consists of coherence between three components: science, management and policy, which operate within an integrated social, political and economic framework; in their absence, problems will emerge driven by market economies that promote unsustainable fisheries.

For its implementation, a section on strengths, weaknesses, opportunities, and threats was included in the surveys to analyze the performance of the actors. Likewise, in some cases, a workshop with focus groups was organized to apply the SWOT analysis technique.

A strategic plan was developed following the results of SWOT analysis and conflict analysis. Diverse strategies were designed and aggregated in six components (Chapter 7. Conflict resolution strategic plan) and their implementation temporality was established. These components were the following:

1. Socio-environmental research
2. Integration of Micro-regions
3. Social cohesion
4. Education and outreach
5. Sustainable uses
6. Social participation and surveillance

To acknowledge of the relevancy of the strategies, three participatory workshops were performed (one for Campeche, one in San Felipe and another in Rio Lagartos) to present the final results. Each participant was asked to rank his priority of strategies using a Likert scale according to their implementation, and additional strategies could be mentioned and incorporated. To compile the individual responses, an average value of ranking was obtained and aggregated in the Conflict Resolution Strategic Plan section.

5. Results

5.1. Data summary

This section presents the results of the interviews conducted in both locations (San Francisco de Campeche in Campeche, and San Felipe in Yucatán).

Information was collected from multiple users from the communities of San Francisco de Campeche that operate in Los Petenes and San Felipe-Ria Lagartos fishing flats, other social actors that live in Quintana Roo, Veracruz, or other countries were mentioned in the interviews. Thus, for this study they were considered external to the locations. Other roles correspond to local environmental authorities, harbor authorities, and natural science researchers.

Table 2. Sample of social actors' participation in network analysis.

Sites	n	Avg. age	Participation in network analysis			
			Commercial fishers	Fly fishing sector	Tourism service providers	Others
Campeche	54	46	22	11	6	15
Yucatán	48	41	26	6	7	9
External	12	NA	0	5	5	2

The general statistics on the connectivity of the two networks of RLBR and LPBR are shown in Table 3. The comparative analysis of social network statistics between the two reserves allows us to recognize in which site there is greater cohesion between groups of users in the areas of interest and therefore where a better joint response to common needs would be expected. In the RBRL there are better conditions of connectivity of the network actors than in the LPBR: in the first reserve the first three indicators (Avg Degree, Deg Centralization and Density) have almost double the value than in the second reserve. That is, network members in RLBR have less variation in their connectivity levels and their individual actors have more links with the rest of the network members. In RBLP, on the other hand, almost twice as many actors are required to connect network members (Diameter and Avg distance) and there are microgroups of actors more interconnected with each

other (Modularity) than with the rest in the network. This last characteristic favors *bottlenecks* in the communication or transmission of information or the centralization of power in a few prominent individuals. Particular results will be discussed in more depth in the network analysis section of each study site.

Table 3. Network statistics in study sites

Network statistics	Campeche (LPBR)	San Felipe (RLBR)
Avg Degree	2.438	4.721
Deg Centralization	0.157	0.298
Density	0.039	0.079
Diameter	7	4
Medium clustering	0.106	0.166
Compactness	0.230	0.380
Modularity	0.534	0.347
Avg distance	3.458	2.598

5.2. Users of flat fishing areas

To determine the scope of an intervention or social project in the coastal zone, it is important to identify the social actors that have an interest in or will be impacted by the actions to be carried out. Stakeholders can be divided into internal and external, depending on their location in the work zone (Moreno-Casasola 2005). For this study, the stakeholders interviewed at the sites were considered internal because they are users of the reserves. External stakeholders do not live or operate within the reserves and eventually hire internal service providers to carry out some activities. This activity is mostly carried out by international fly fishers, who are considered in this study as external actors from other states and countries.

5.2.1. Internal actors from San Francisco de Campeche

Small-scale fishers

San Francisco de Campeche is the capital city of the state of Campeche. It has a population of 294,077 people, representing 31.7% of the state's total (INEGI, 2021). In this coastal city, the fishing sector is estimated at 4,350 fishers (<https://datos.gob.mx/>), which includes fishers from other smaller neighboring communities (e.g. Isla Arena, Lerma, Chimay, Hampolol, among others). CONAPESCA identifies 833 economic units, which are represented by individuals or associations. It is estimated that 60% are fishing permits for individuals with between 1 and 4 boats, which is why they are commonly called "permisionarios".

There are no records of the number of fishers accessing Los Petenes flats, but it is known that there has been an uncontrollable increase in poachers and cloned boats operating illegally. One study estimate that at least 1,700 boats use the Petenes as their fishing grounds (Crespo and Nava, 2020).

Recreational anglers and tourism

Regarding recreational fisheries, it is necessary to differentiate fly fishing from other types of fishing. Fly fishing in Campeche requires the services of a service provider because it mainly attracts international fishers who are the ones who carry out this activity under the catch-and-release modality. This fishery is carried out on board boats, frequently flat-bottomed, or it can also be carried out from kayaks or from the shoreline. The main target of this fishery is tarpon (*Megalops atlantics*) that inhabit mangrove areas along the shoreline, rias and petenes, but also open marine waters. These areas are also known as flats habitats. On the other hand, there are local fishers who fish recreationally for corvina, jack mackerel, and other species, both in flat areas. The latter generally consume what they catch, with the exception of tarpon, which is usually caught by spinning.

We found there is a sport fishers association in the state of Campeche, which has approximately 150 members, as well as six recreational fishing service providers (Table 4).

Table 4. Recreational Fishing Service Providers and fly fishers in Campeche. Numbers in parenthesis correspond to social actor in network analysis. Through interviews with service providers and fly fishing guides, it was estimated that the number of fly fishing anglers in Los Petenes is between 100 and 150 anglers per year.

Service provider name or role	Site	Representative code
Campeche Tarpon (41)	San Francisco de Campeche	AH
Cooperativa Isla Valor	Isla Aguada	JD
Mangrove ling	San Francisco de Campeche	VMR
Servicios Ecoturísticos Carey	Isla Arena	IM
Snookinn Hunting and Fishing	Champton	FS
Tarpon Town Anglers (11)	San Francisco de Campeche	RJC
Adventour (13)	San Francisco de Campeche	TNB
Sabalín Tarpon (69)	San Francisco de Campeche	
Campeche Recreational Fishing Association (83)	San Francisco de Campeche	JC
Asociación de Pescadores Deportivos de Campeche (24)	San Francisco de Campeche	AP
Recreational fishing club (67)	San Francisco de Campeche	ME

Fly fishing fisher (12)	San Francisco de Campeche	AC
Fly fishing fisher (20)	San Francisco de Campeche	JA
Fly fishing fisher (22)	San Francisco de Campeche	JAA
Fly fishing fisher (23)	San Francisco de Campeche	FMG

Some recreational fishing service providers, such as Campeche Tarpon and Tarpon Town, offer kayak rentals and boat tours in the mangrove areas of Los Petenes Campeche. However, this activity is not very well developed, so we did not obtain information on the services. On the other hand, local people do go on their own kayak tours as a recreational activity in the nearby area known as Los Mogotes.

Regarding the nature tourism that takes place in Isla Arena, although this community belongs to the state of Campeche, it is located within the Ría Celestún Biosphere Reserve, whose administration is carried out in the state of Yucatán. Tour operators enter to Isla Arena and Celestun estuary for bird watching.

5.2.2. Internal actors from San Felipe-Rio Lagartos, Yucatán

Small-scale fishers

In San Felipe 300 artisanal fishers have been counted, according to the 2022 census of the Secretariat of Sustainable Fisheries and Aquaculture (SEPASY, 2022). In San Felipe, 300 artisanal fishers have been counted, according to the 2022 census of the Secretariat of Sustainable Fisheries and Aquaculture (SEPASY, 2022), which corresponds to approximately 14% of the total population registered in the census in 2020, which was 2,011 people (Inegi, 2020). A 60% of the fishers belong to one of the two cooperatives and the rest are fishers who work for permit holders or are "free" fishers who do not belong to any association.

The main commercial fishing species are lobster (*Panulirus argus*), octopus (*Octopus vulgaris*), and grouper (*Epinephelus morio*). The fishing zones cover depths greater than two meters, so they do not interfere with the flats. However, some resources sold for bait, such as sardines or crabs and seahorse crab (e.g. *Limulus polyphemus*) for bait, are caught in shallow coastal areas.

Recreational anglers and tourism

The area to the west of San Felipe is the main area for fly fishing, where mangrove estuarine ecosystems predominate. The target species of this fishery is mainly tarpon (*Megalops atlanticus*), although other species such as snook (*Centropomus sp.*), bonefish (*Albula vulpes*), barracuda (*Sphyraena sp.*) and occasional species such as permit (*Trachinotus falcatus*) are also caught.

Twelve local recreational fishing guides were identified, with eight in San Felipe and four in Rio Lagartos. Five of them are grouped in a cooperative called Fly Fishing San Felipe y Naturaleza,

founded in 2008. The guides range in age from 23 to 56 years old, with an average age of 41. The busiest months for tarpon fishing are from May to September. A total of 13 fly fishing boats were counted that provide flat fishing services (fly fishing, trolling, or spinning techniques) between San Felipe and Rio Lagartos.

In total, 13 fly-fishing boats were counted, four of which belong to the tourist services operator Mena Tours in San Felipe. These boats are 18 feet with 4-stroke engines and space for two fishers and the guide. Four belong to Rio Lagartos Adventures in Rio Lagartos, which are 23-footers with 4-stroke engines. The guides are relatives of the owner of the company. On the other hand, in the San Felipe cooperative, there are five 23-foot boats with two-stroke engines. One of the guides from the cooperative works independently (San Felipe Adventure) and the other four work with the Mena Tours company at the San Felipe hotel. Other companies that offer fly fishing tours are Alcatraz tours and freerides local guides. (Table 5).

In San Felipe, three people are dedicated to the service of boat tours in the Isla Cerritos area, the beaches in front of the community and flamingo watching in the Rio Lagartos estuary.

Table 5. Recreational Fishing Service Providers and fly fishers in San Felipe. Numbers in parenthesis correspond to social actor in network analysis.

Service provider name or role	Site	Representative code
San Felipe y Naturaleza (16)	San Felipe	Business owner/guide
Mena Tours (18)	San Felipe	Business owner/guide
Alcatraz Tours (25)	San Felipe	Business owner/guide
Independent Fly-fishing provider (15)	San Felipe	Business collaborator/guide
Ria Lagartos Adventure (19)	Río Lagartos	Business owner/guide
San Felipe y Naturaleza (26)	San Felipe	Business owner/guide

5.2.3. External actors (from other states or countries)

Fly fishing service providers and practitioners interviewed mentioned five external actors that they considered relevant for the promotion of the recreational fishing activity in the region (Table 6). These are organizations with an international reach that are the link that attracts the international fly anglers. Due to the indirect information provided and time limitations it was not possible to include them in the survey. However, they were included as individual actors in the social network analysis presented above.

Table 6. Recreational Fishing Service Providers and fly fishers in San Felipe. Numbers in parenthesis correspond to social actor in network analysis.

Service provider name	Business type	Representative role
Yucatan Fly fishing (65)	Local (Quintana Roo Local)	Business owner/guide
Fly fishing provider (94)	International	Outfitter-Concierge
Washington Flyfishing Club (95)	International	ONG
Tarpon Club Holbox Holbox (100)	Local (Quintana Roo Local)	Business owner and guide
Salmon Fly (101)	International	ONG

5.3. Flats fishing areas and vulnerable habitats

5.3.1. Participative GIS in Campeche

The results of applying Geographic Information Systems (GIS) based on mapping local knowledge, allowed the generation of various thematic maps of habitats, target species used, and the state of ecosystems. The information provided here represents the areas that users, according to their activity and experience, identify in their environment.

Los Petenes Bathymetry

A portion of the Bathymetry map of the Coastal Zone of the Yucatan Peninsula, published by the Consortium for Gulf of Mexico Research (CIGOM) as part of the Environmental Baseline Atlas of the Gulf of Mexico, was digitized. This zonation presents depths from 1 to 10 meters in the marine littoral of the LPBR (Figure 13).

The perception of most users, whether artisanal fishers, recreational fishers, or tourism operators, refer to the zones in which they find certain species according to the depth at which they

are found. This is because the depth in front of Los Petenes is very shallow and gradual. Also, because spatial information was available to digitize the bathymetric layer of the Campeche coast, the characteristics of the species of interest and capture areas were associated with this information. In this way, a better fit was obtained in the location of the fishing resources identified and indicated on the maps presented during the interviews.

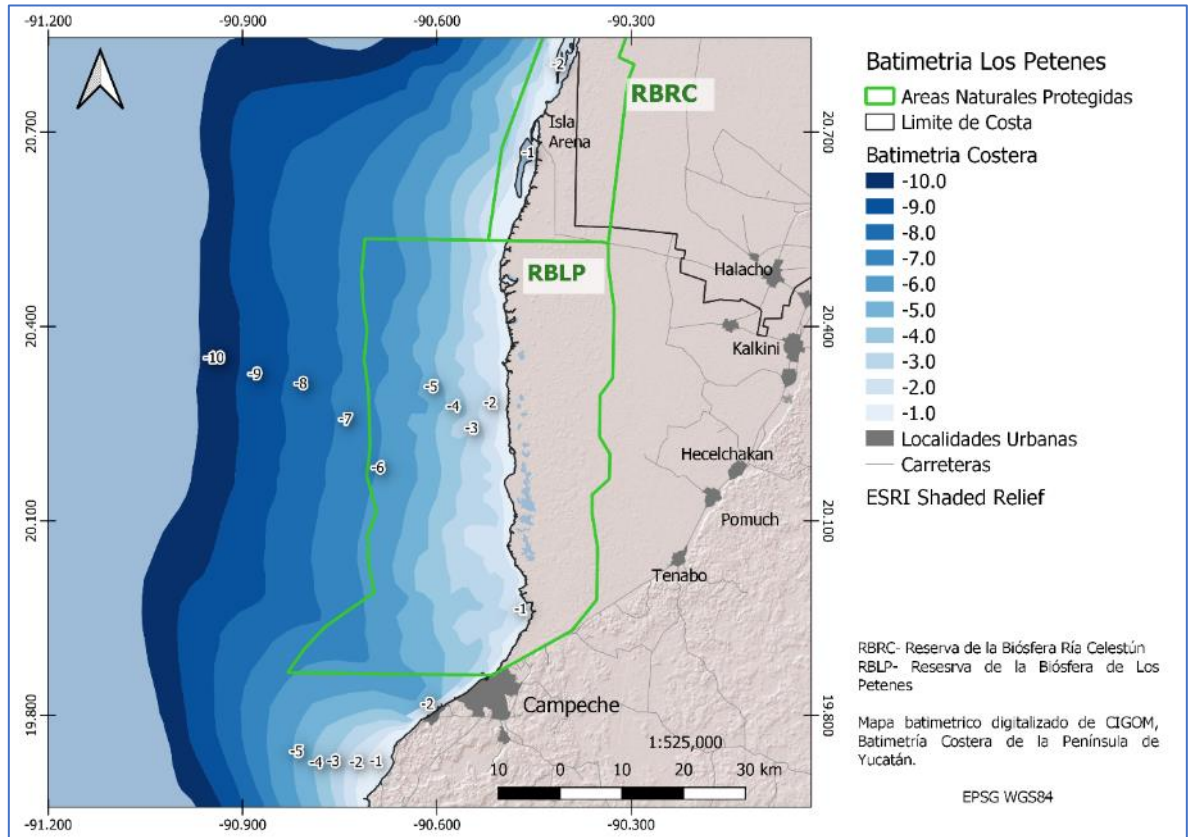


Figure 13. Bathymetric composition of the coasts of Campeche. Adapted from the bathymetric map of the Yucatan Peninsula

Recreational Fishing Areas

Fishing in the flats of Los Petenes area has been practiced by international anglers and promoted by small local groups for more than 20 years. In recent years there has been a greater presence of foreign anglers, mostly from the United States of America.

The main target species for flat fishing is small tarpon. This is caught in the nearby mangrove zones at a distance of no more than 300 meters from the shoreline, and in the rivers and canals is conducted in small boats with a maximum of two anglers, as traditionally done in other places, and covers the entire length of the Petenes coast, where depths range from 1-2 m. Most tarpon caught are smaller than 10 pounds, however, it is also possible to find larger tarpon up to 30 or 40 pounds, especially during the spring and summer seasons.

Some fishing guides in the flats reported areas where it is possible to find small tarpon, a mixture of large and small tarpon, and some areas where large tarpon have dominated, according

to the temporal behavior of the species. In Figure 14, four recreational fishing areas are shown within the BRLP. In the northernmost area it is more frequent and possible to capture big tarpon, while in the center area (purple polygon) there is a mixed size area for tarpons which is one of the most frequented areas by fly fishers. Local guides refer that it's most frequent to see baby tarpons in the southeast area, close to the spot known as Mogotes. It also coincides with being an area that, due to its distance from the urban center, presents greater conservation. The area further south, named mixed species, is common fishing for bass, tarpon, barracuda or jacks, commonly with other styles of fishing such as spinning.

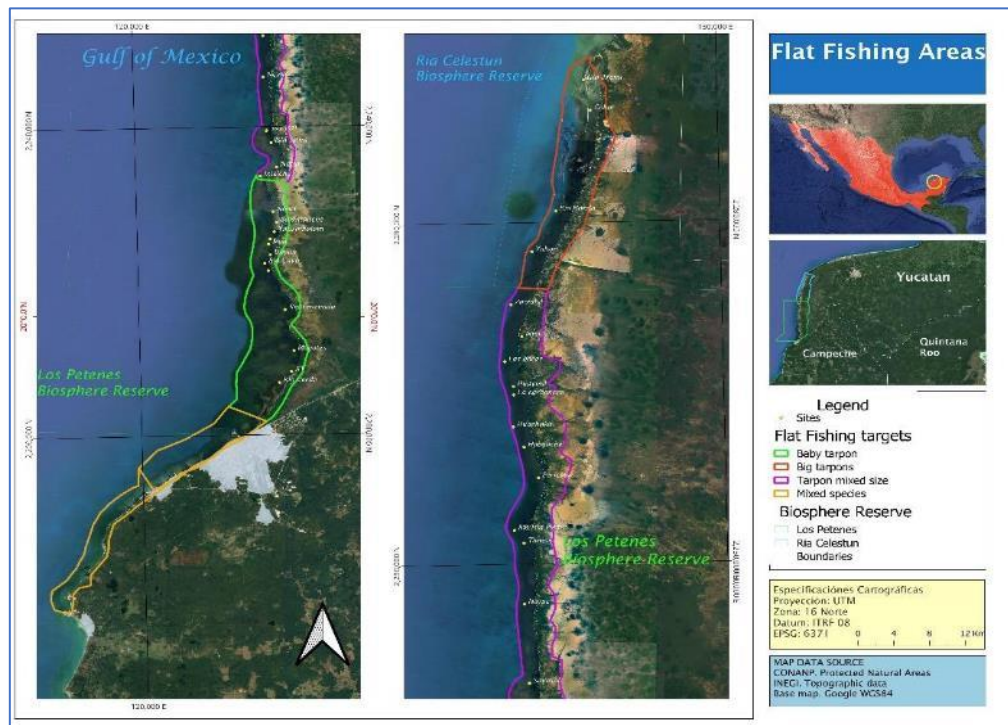


Figure 14. Flats fishing areas in Los Petenes Campeche.

Artisanal Fishing Areas

Artisanal fishing is characterized by making daily trips from the coastline to a depth of 20 m. The artisanal fishery targets distinct species. Artisanal fishing targets different species. Among these species, the capture of Moorish crabs (*Menippe mercenaria*) in shallow areas with traps stands out, since they develop well in the extensive mangrove and sea grass covers, of which the *Thalassia* sp. and *Spyringodium* sp. stand out.

There is also speckled trout (*Cynoscion nebulosus*) fishing in the vicinity and longline fishing on various finfish species in depths starting from the meter isobath. Octopus fishing is another important economic activity in the area, which is carried out up to 25 mt depths. Most of the fisheries that take place here have regulations on the capture volume and closed periods. According to the Los Petenes management program, commercial fishing activities must be carried out outside to this zone, however there is fishers who fish into the reserve polygon. Figure 15 shows the most

relevant fishing areas for commercial species and their location with respect to the MPA polygon and the main locations.

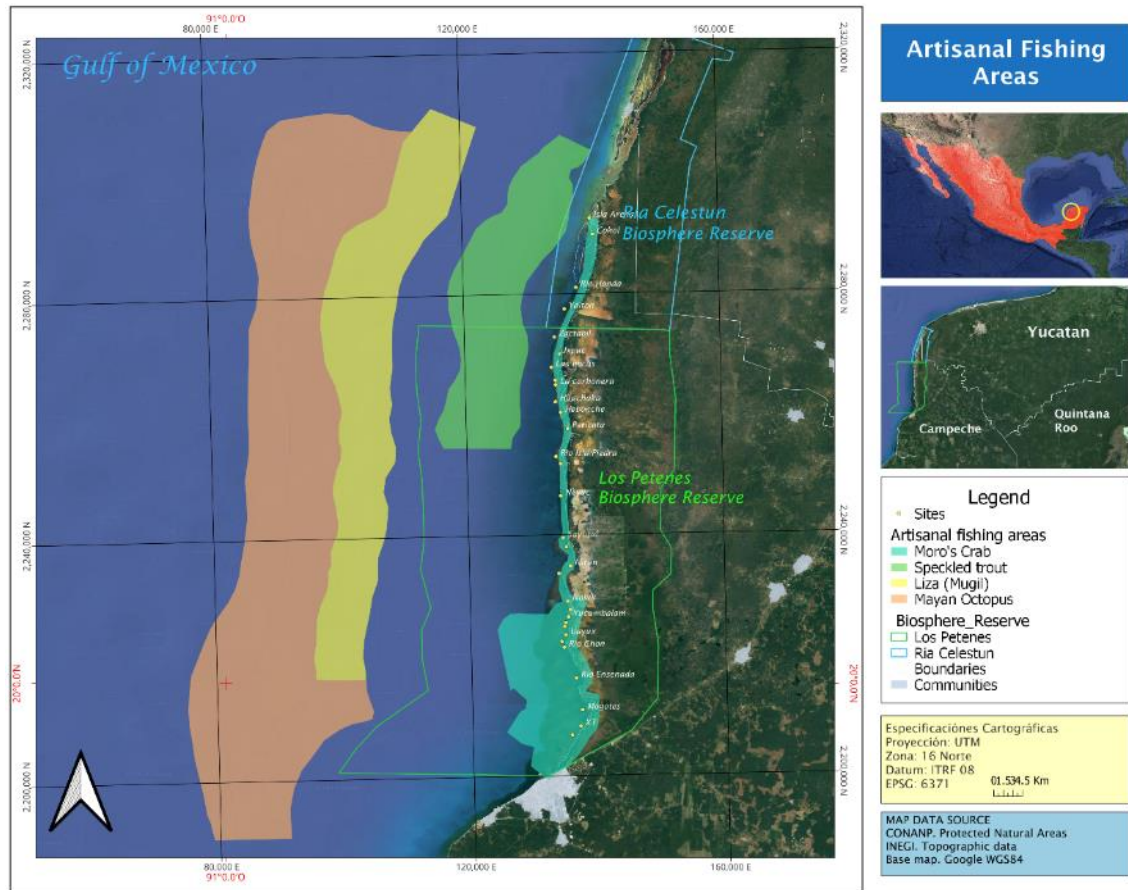


Figure 15. Artisanal fishing areas for the most important commercial species

Tourist Activity Areas

Two nature-based tourism activities were found in the area of Los Petenes, in San Francisco de Campeche. The first were kayak excursions from the city boardwalk to the north, entering the mangroves of the Los Petenes reserve, to the site called Los Mogotes, less than 10 km away. This area is the closest to the city and presents wetland ecosystems in which there is a great diversity of birds and marine species. This activity is usually carried out by the inhabitants of the city as a way of carrying out recreational activities, however some service providers rent kayaks to tourism that is interested in it. The second refers to boat trips from Isla Arena to the north of Los Petenes and canals of the Celestún Reserve, to observe the local fauna and flora.

In figure 16, reference is made to these zones, showing the coverage of tourist activities and their relationship with the natural reserve polygons. It should be noted that although Isla Arena belongs to the state of Campeche, its biophysical environment is part of the Ria Celestún Biosphere, which is why its tourist activities are carried out in this natural reserve.

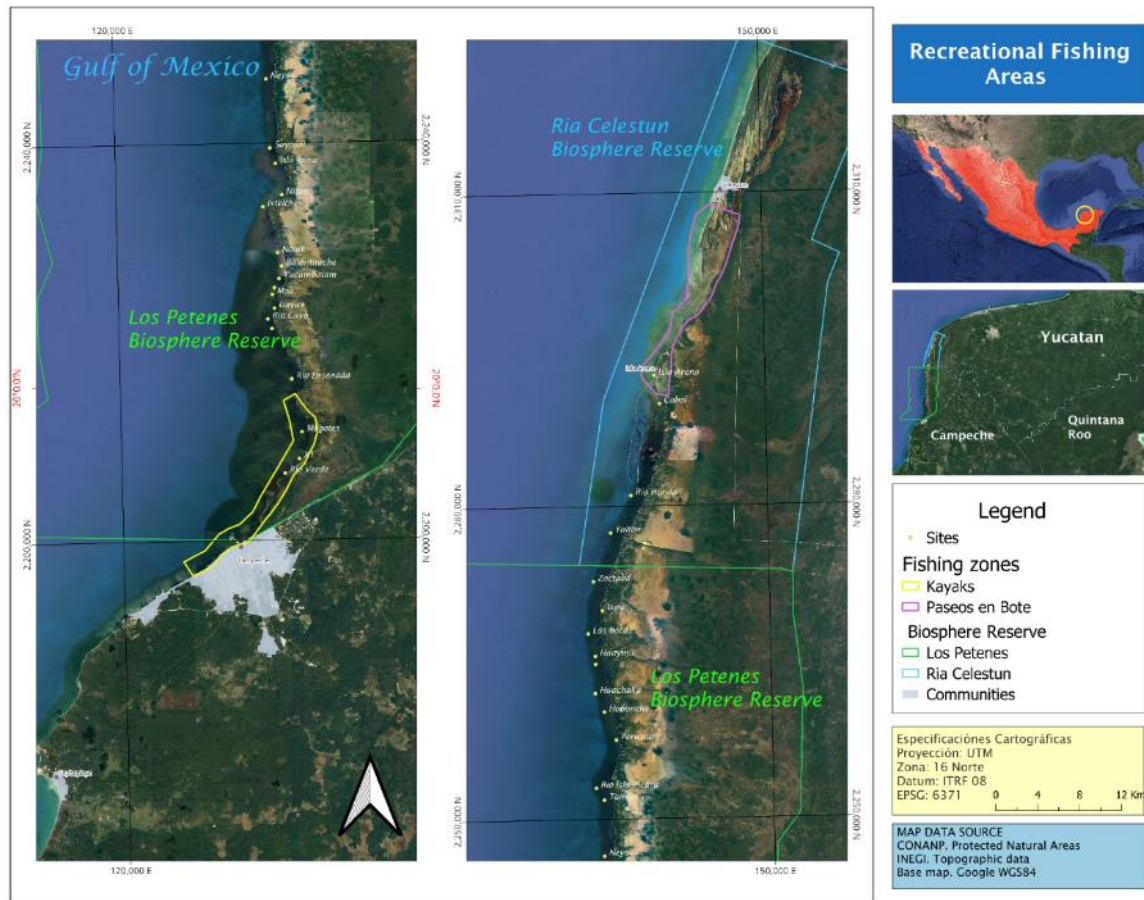


Figure 16. Tourist activity zones of two communities in the state of Campeche related to the Petenes Biosphere.

Fragile or conserved areas

The LPBR has received different anthropogenic and environmental impacts. Regarding the forest cover, it suffers from the cutting of mangrove branches, but so far it is not a problem of great magnitude. However, inland there is concern about the impact of cutting commercial timber species and extracting firewood, which affects forest cover, as documented in the reserve management plan (CONANP, 2009). Although it does not receive a direct impact since there are no human settlements in the reserve, the negative effects of the fragmentation of ecosystems or the contamination produced by the effluents from the drainage of the city of Campeche have recently been observed, so that in the entire marine area there is no swimming is recommended.

The greatest impacts are observed by illegal fishing with seine nets that obstruct the water channels between the mangroves. There is an area between the sites of Taman and Rio Chon (Figure 17), with a higher frequency of this activity. In the southern area of Los Petenes, kayaking, flat fishing, and artisanal fishing are sometimes carried out, which would have a greater impact on tourism. The area up to Isla Piedra is frequented by fishers who place illegal nets at the mouth of

the channels between the mangroves. On the other hand, the most conserved area is the northern portion, which has little presence of artisanal fishers and is seen to be more conserved (Figure 17).

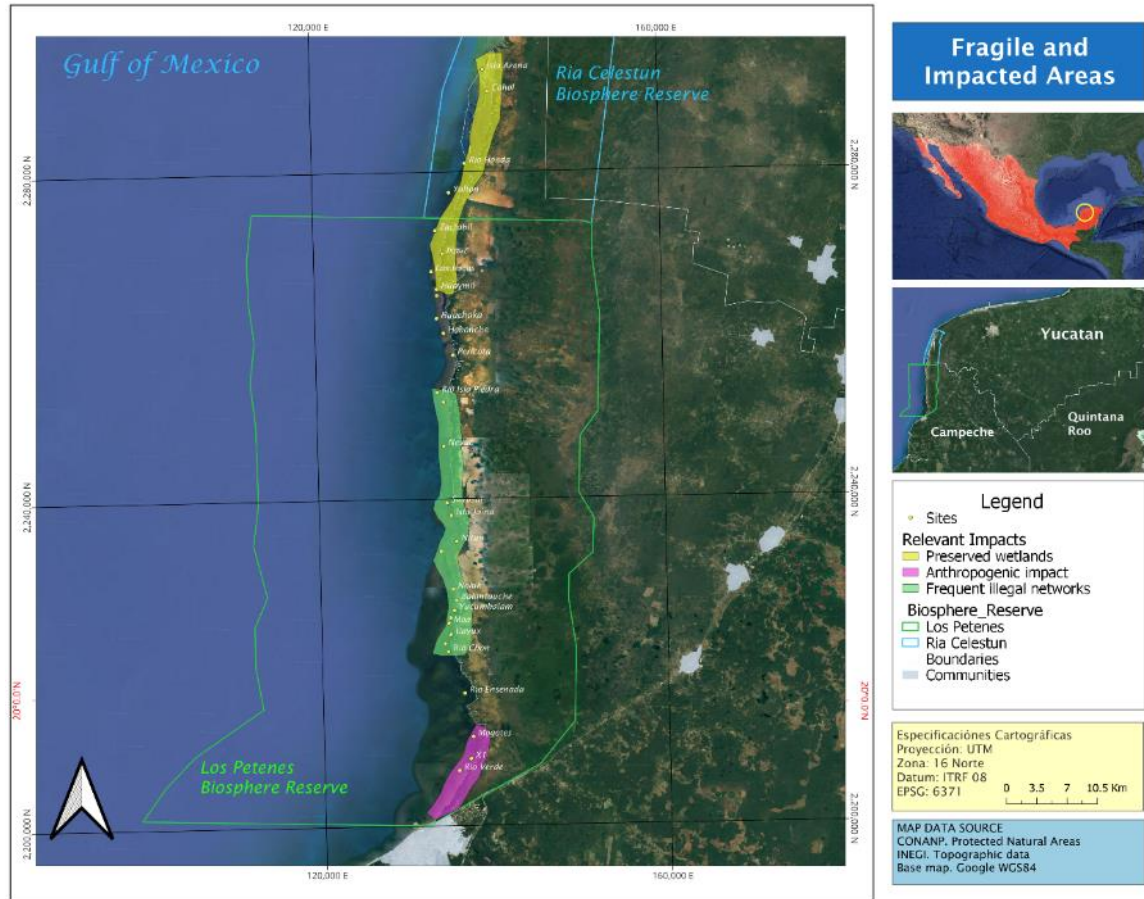


Figure 17. Fragile and impacted areas of the mangrove zones in Los Petenes Biosphere Reserve

5.3.2. Participative GIS in San Felipe

Recreational Fishing Areas

In this evaluation we registered three main fishing areas for recreational fisheries through a participative Geographic Information System (GIS) in San Felipe. The entire area extends 15 km west of the coastline from the community of San Felipe (Figure 18). For flats fishing, this area comprises 5.9 km² that includes the coastline of 15.4 km of strip mangrove and a buffer region of 300 m of the coastline in which flat fishing is practiced. In this area, guides target baby tarpon that ranged in size from 5 up to 30 pounds. It is important to emphasize that this area to the west of San Felipe is outside the limits of the Ria Lagartos biosphere polygon.

The following map (Figure 18) shows the location of different target species for recreational fishing. Flat fishing is supported mainly by the presence of tarpon along the entire coastline, between the mangrove channels and generally at 300 m distance (Figure 18-a). However, it is also possible to find big tarpon in certain areas in the early summer months (Figure 18-b). Other common recreational fishing species are barracuda, which are caught with a technique similar to trolling, and snook, which can be found year-round and in almost the entire fishing area (Figure 18-c).

This fishing area is known as “Actam Chuleb” and is part of the special use subzone of the Dzilam de Bravo Municipal Reserve. It is a marine portion of the coastal strip with wetlands and numerous channels, which is not part of the reserve polygon. Historically, in the years of 1999, it was named a protected zone by the initiative of the community of San Felipe, to reduce the fishing pressure on species of commercial and recreational interest. He got his municipal decree and was recognized by the state of Yucatan. However, every marine area is under federal jurisdiction, so it did not have a federal decree (Aguilar-Cordero, et al., 2012). Currently the community of San Felipe has organized to request its decree as a marine refuge area by federal authorities. Its objective is to ensure that the fishing populations recover due to its function as a natural nursery, offering refuge to the species that use the channels of the estuary and the mangroves as feeding and reproduction areas.

The most relevant conflicts in this area are associated with illegal fishermen who place gillnets in the channels between mangroves. Later on, a map of the areas where this bad practice has been observed the most will be shown.

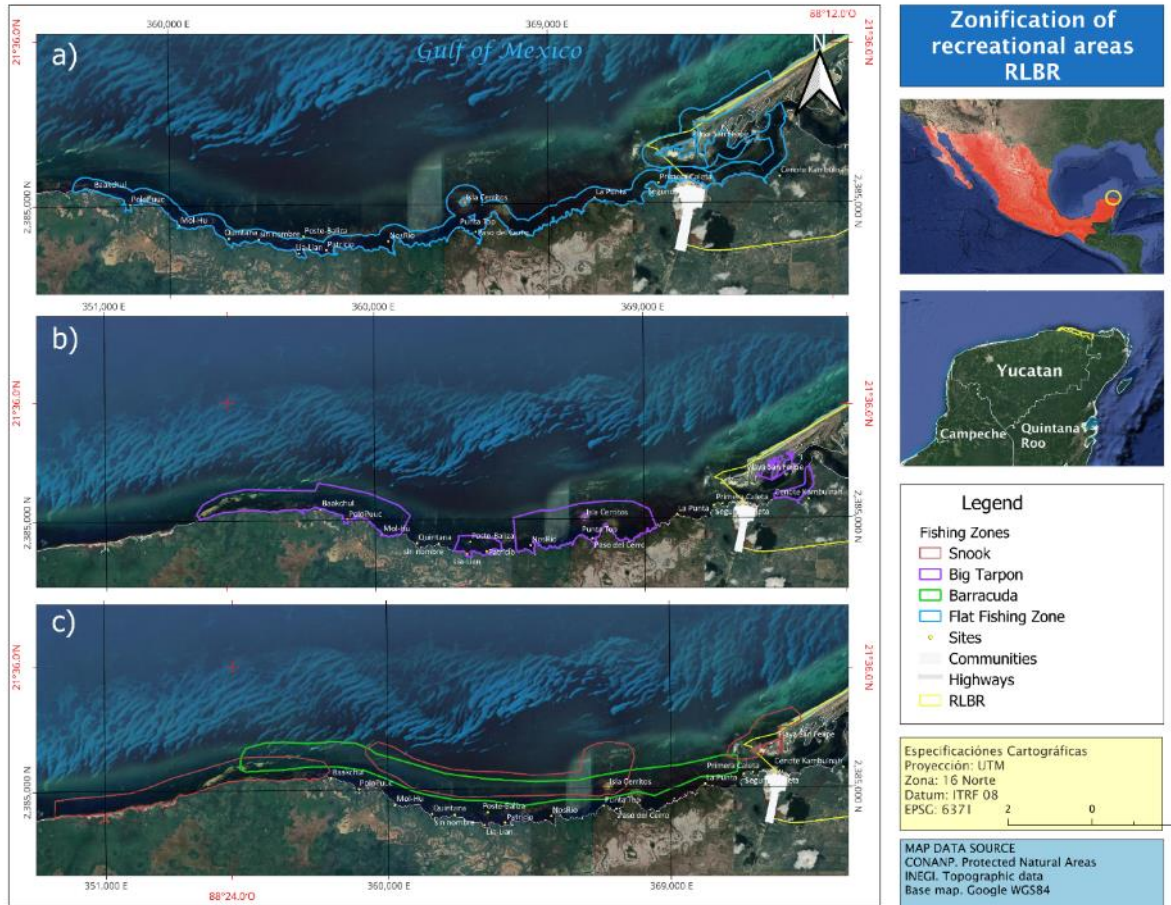


Figure 18. Different zones of target species for Recreational Fishing in San Felipe.

Artisanal Fishing Areas

The main species that sustain the artisanal fishery in San Felipe are lobster (*P. argus*), octopus (*O. vulgaris*), grouper (*E. morio*), as well as carangids such as jacks (*Caranx sp.*), and snappers (*Lutjanus griseus*). Although there are no strictly delimited areas for species of commercial interest. Figure 19 shows the most frequented areas for lobster capture by divers, multispecies net areas (“redes”) and zones where jacks capture is most frequent

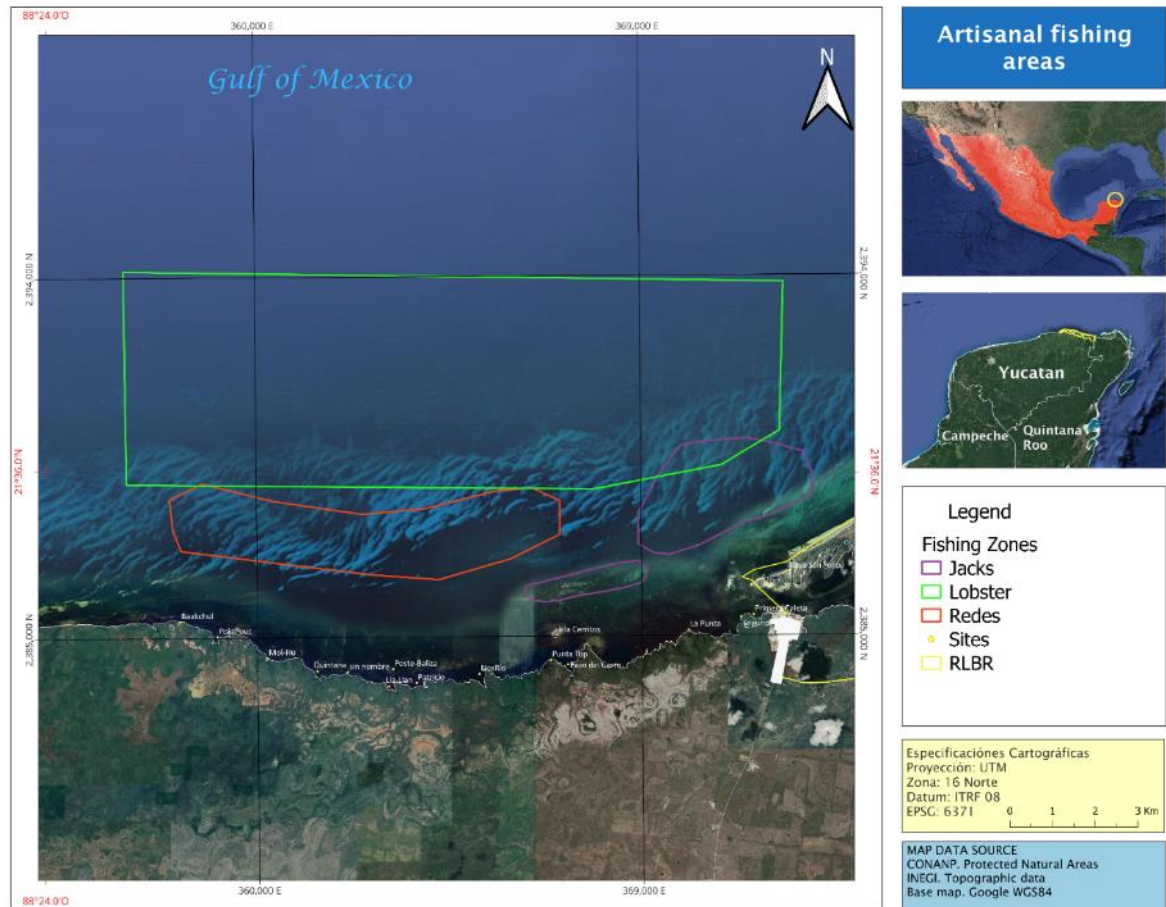


Figure 19. Artisanal fishing areas of diverse species in San Felipe.

Tourist Activity Areas

Tourism in San Felipe is one of the activities with the least impact on the environment. This activity consists of transporting tourists in fishing boats adapted for tourism, through the coastal areas of shallow water wetlands, to appreciate the biodiversity of seabirds, mangroves, islets, and beaches. One of the most interesting points is known as Cerritos Island, which presents historical vestiges of the ancient Maya, probably used as a ceremonial and trade center (Figure 20). Regarding the regulation of tourism, the administration of the protected natural area (CONANP) are the responsible authorities of the records and permits of tour operators in the area.

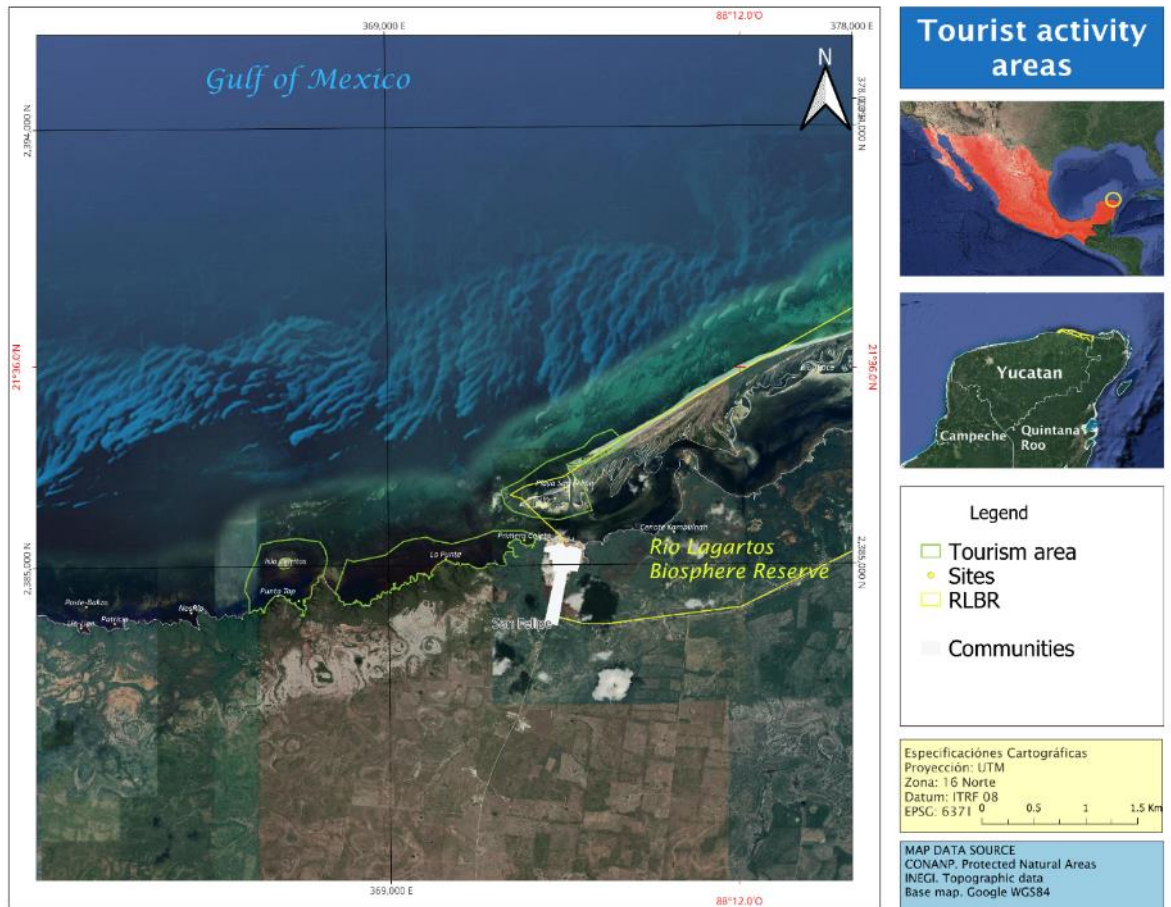


Figure 20. Tourist activity areas in San Felipe

Most Impacted Areas

The growing pressure of urban development in San Felipe is one of the main threats to the mangrove ecosystems that surrounds the community. With information from Google Earth, it is possible to track the urban growth of the community. The area covered by the community of San Felipe in 1985 was 24 hectares; by 2006 it was 36 hectares (50% increase in 21 years); and by 2022 it was 62 hectares (158% increase compared to 1985). This situation responds to the fact that San Felipe is surrounded by wetlands known as "ciénegas", and therefore depends on solid waste landfill to build more houses.

Regarding impacts on wetland areas (flats), the marine ecosystem is affected by using gill nets or purse seines. Their use is not permitted in these areas, as they impede the passage of various species that shelter in the mangroves, causing the mortality of resultant populations that have not reached their reproductive stage. The gear also damages the seagrasses and mangroves. This activity is most often carried out during the northern months (September to February), when

conditions for fishing are adverse. It is carried out mostly by free or illegal fishers and due to the absence of authorities in charge of monitoring fishing activities and environmental protection, it is considered a latent and growing problem. The map in Figure 21 highlights the polygons of the areas considered to be the most fragile ecosystem, due to the high frequency of sightings of gillnets reported by flat fishing guides and tour operators.

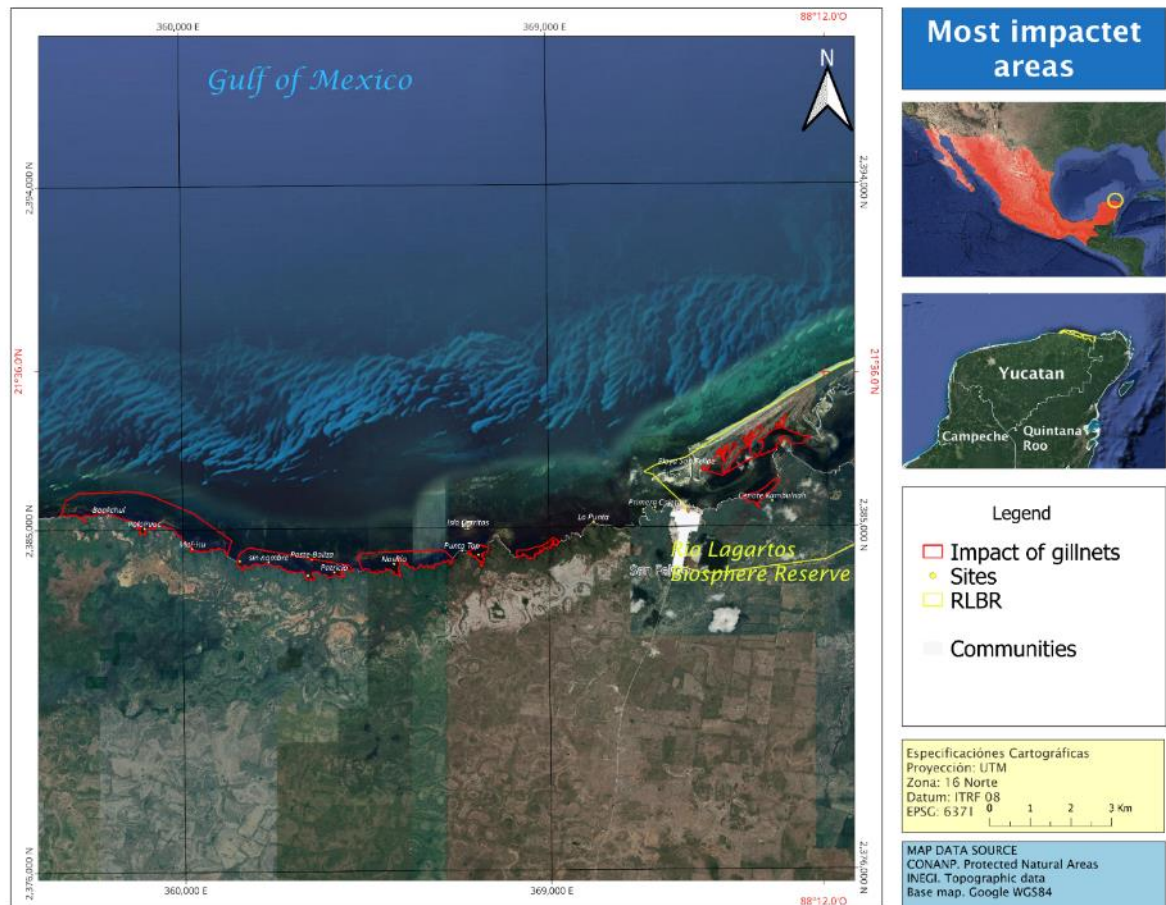


Figure 21. Areas of greatest impact from the use of gillnets in San Felipe

5.4. Conflict analysis through respondents perception

Through the perception of recreational and artisanal fishers, the social and environmental conflicts that are perceived in the study areas were characterized. Conflicts between commercial and recreational fishers are associated with competition for the same fishing resources of interest, space and the impact of activities on ecosystems (i.e. use of fishing nets).

These conflicts are evidenced through different forms of expression among users, which affects the management and performance of their activities, whether they are recreational anglers and artisanal fishers. Likewise, reference is made to the different consequences that these conflicts have caused.

5.4.1. Types of Conflicts

For the state of Campeche and Yucatán, the types of user conflicts categorized in the following sectors are presented:

- Commercial fisher (F): Belongs to a group with or without catch permits (e.g. could be a fisher that works within a fishing cooperative or for a permit holder).
- Tourism service providers (T): Belongs to a group that offers trips to observe nature and/or recreational fishery trips
- Others (O). Local environmental authorities, harbor authorities, and nature science researchers.

In the area of Los Petenes in Campeche, three types of conflict were registered: Competition for space, between artisanal and fly fiat fisheries; Competition for the use of habitats, recognized by the three sectors and competition for the same resource, between artisanal and recreational fishers (Figure 22).

According to respondents in Campeche (n=22) most important conflict is regarding the use of the same habitat (mangrove areas) by commercial fishers and recreational fishers (Figure 22). The mangrove areas in the Petenes cover the entire coastline, so flats anglers who catch tarpon and sea bass may coincide with commercial mor's crab and sea bass fishers. There is no defined zone of this area since it can occur in the entire mangrove strip of Los Petenes. It should be noted that recreational fishing in this area involves a very small number of boats compared to the artisanal fleet, so for commercial fishers, anglers on the flats is not a significant conflict. In general, they do not occupy areas so close to the mangroves and at such a shallow depth. Recreational anglers report that when approached by commercial fishers of finfish or moro's crab, they prefer to seek other fishing grounds so as not to interfere with their activities.

The main threat identified in these conflicts comes from illegal fishing that makes use of gillnets, placing itself in the channels of water flows between the mangroves, where various species are captured for sale and consumption, generally species in small sizes, affecting wild populations. Flats fishers have seen these nets and found dead tarpon fish among the mangroves, a situation for which they have made reports and requested more vigilance from the responsible authorities.

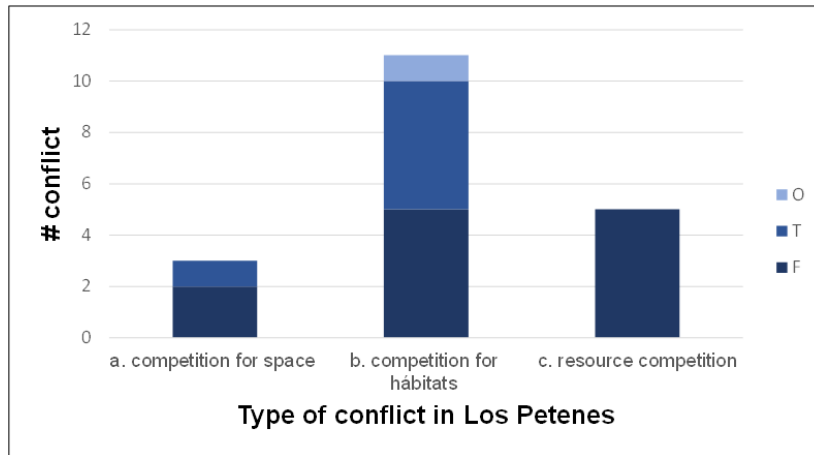


Figure 22. Type of conflicts in Los Petenes according to respondents.

In the case of Yucatán, the types of conflicts were categorized in the same way and by the same user sectors described above. From the interviews, in Yucatán (n=21) they reported that there is competition for habitats between commercial and recreational fishers but also for resources of commercial value between commercial fishers (Figure 23).

Competition for habitats in the case of flat anglers occurs when artisanal fishers place nets in mangrove areas and obstruct water flows to capture various species. This could be affecting the tarpon populations, which are the most caught by anglers in San Felipe.

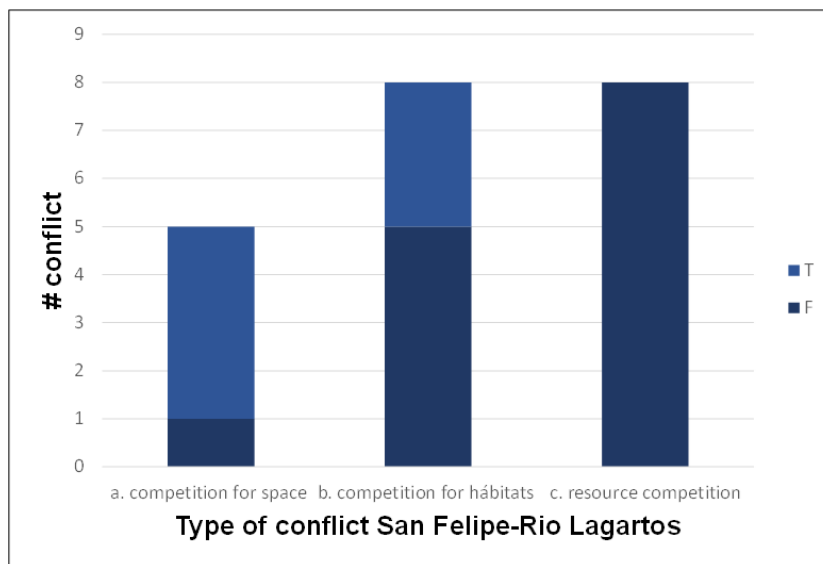


Figure 23. Type of conflicts in San Felipe according to respondents.

5.4.2. Evidence of conflicts

Results of conflicts are considered in this evaluation as the different evidence of conflicts between or amongst groups. We registered and categorized four types of evidences in the communities of Campeche and San Felipe: aggression, reports, violence and interference (Figure 23 and Figure 25). Users mentioned they made or filed formally and informally reports to authorities (port, environmental or municipal). These reports were made due interference of their activities (when they coincide in the sites they are forced to move to another location). This is: In the voice of an interviewee from San Felipe "early in the morning, sometimes commercial fishers and we (recreational fishing guide) coincide in the site we select for our activity. Clearly it is not possible to successfully carry out both activities simultaneously, so the user who last reached the place (whether artisanal or recreational fisher) decides to look for another site where to operate".

At both sites, there have been attacks and violence between fishers with permits and illegal fishers, in what is considered more of a physical conflict that stands out in the absence of authorities to monitor the activity. In other words, these attacks have been the result of no having the support of the authorities in the face of complaints of illegal fishing, which are frequently reported.

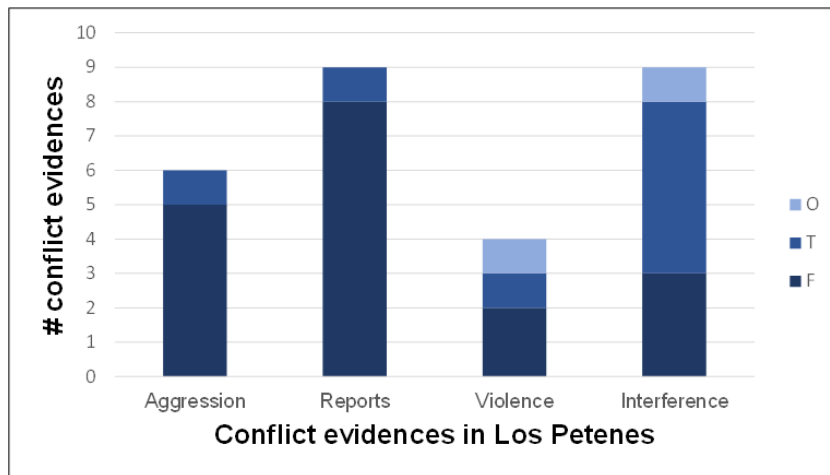


Figure 24. Type of conflict evidences in Los Petenes according to respondents.

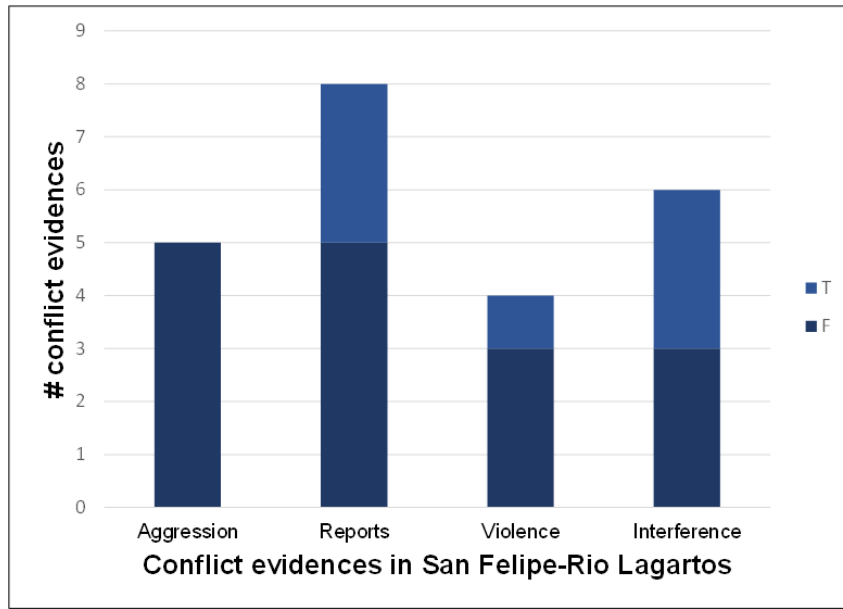


Figure 25. Type of conflict evidence in San Felipe according to respondents.

5.4.3. Conflict consequences

Conflicts in the different sectors analyzed cause consequences that affect other users, the resource or the resource system. The consequences were categorized as: i) lower catch/income and fewer customers, ii) environmental contamination, iii) death of resources of interest (target species), iv) loss of equipment, v) accidents, vi) illegality and vii) usage restrictions.

Respondents of both sites (Figure 26 and Figure 27) agreed on the loss of catches and profits from touristic activities (recreational fishers decide to leave the activity in places where they coincide with commercial fishers) as the most important consequence of the conflicts.

In the case of Campeche, the consequences of conflicts between recreational and commercial fishers are mainly the loss of organisms caused by illegal commercial fishers using gillnets. As a consequence of the above, the fly fishing guides have observed death tarpon and other species juveniles and adults in the gillnets. In the case of Isla Arena tour operators, they argued that commercial fishers in the Ria Celestún cause the flamingos to move away from traditional sighting areas.

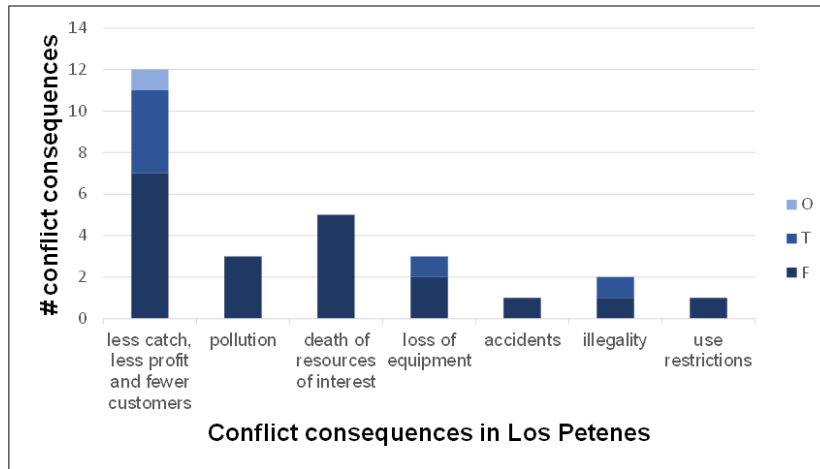


Figure 26. Type of conflict consequences in Los Petenes according to respondents.

Regarding the consequences of conflicts in Yucatán, the use of illegal chinchorro nets that destroy a great diversity of fish that use the mangrove ecosystems as a refuge and of trawl nets in seagrasses that cause deterioration in the seafloor. Situation that is pushing fishermen to travel further to keep their average expected catch.

Likewise, Cooperative fishers claim that non-native fishers hired by independent permit holders show a predatory attitude in their fishing activities and that family links of permit holders with municipal authority promoted inequality among fishers.

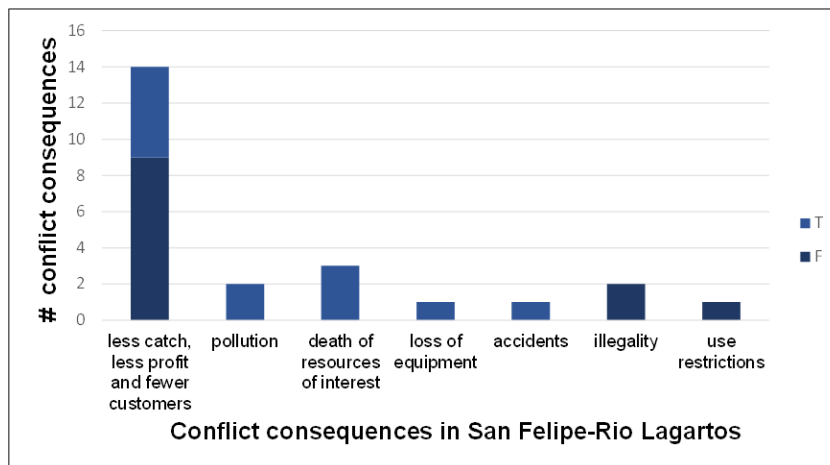


Figure 27. Type of conflict consequences in San Felipe according to respondents.

5.5. Social Capital Analysis through Network Analysis

The primary data were collected through surveys and structured interviews of recreational fishers, recreational fisheries guides, tourism service providers and other actors related to the use and conservation of flats.

There are no reliable records of people who participate in recreational fishing, as well as catalogs of recreational fishing providers. According to NOM-017-PESC-1994 it is mandatory to obtain a recreational fishing permit if the activity is carried out from a boat. However, in the absence of strict surveillance of this rule, these permissions are not always acquired. Two scenarios have been observed: fishermen only obtain permits if they participate in tournaments and the tournament rules oblige it (Campeche) or tournament participants know that no authority will monitor the rules and 80% of them will do not obtain the recreational fishing permits (Yucatan). Therefore, there is no direct way to know how many recreational fishers there are other than an approximation using the number of permits. For this reason, the sampling consisted of two variants of chain referral sampling (Heckathorn 1997). The initial sample was accessed through key informants (e.g. known recreational fishers that catch in the flats), and a second snowball sample was obtained through contacts in the second round of questioning and other flats users for commercial or recreational purposes. The survey was applied to all those who agreed to answer questions about the people involved in the use of flats. An estimated 70% of those mentioned during surveys agreed to participate. A quantitative survey of 50 persons (commercial fishers, fishing guides, tourism service providers, recreational fishers, and environmental local authorities) was conducted to collect network information in May, July and August 2022 at the two studied sites. All those interviewed were asked to name the other persons with whom they share information, materials, contacts or receive support to perform recreational fisheries, provide tourism services or perform conservation activities of fishery resources or natural areas in study sites. The contact lists were cross-checked, and duplicates were removed. A link was assigned between two actors if at least one mentioned the other as an actor with whom they have contact. Confidentiality was maintained by replacing names with code numbers.

The network actor classification included different sites:

- San Francisco de Campeche (Camp) site1 (LPBR)
- Isla Arenas (Camp) site1 (LPBR)
- San Felipe (Yuc) site 2 (RLBR)
- Río Lagartos (Yuc) site 2 (RLBR)
- External from study areas (Quintana Roo, Veracruz, International)

5.5.1. Social Capital analysis of Campeche through Network Analysis

Social network information collected from artisanal commercial fishers and recreational fishing service providers, says that both groups do not have robust social networks among them or with fisheries and tourism authorities (national, regional, or local). The absence of trust between the different internal actors to discuss and address common objectives can be a contextual condition that magnifies the conflicts that arise with other actors operating illegally in protected

areas; i.e., with the diver fishers. As explained in section 3.2, in the RBLP there is little cohesion between social actors of the same group and there is a tendency towards modularity that centralizes the flow of information in actors that act as bottlenecks.

The only consistent interaction from fishers is with NPA (CONANP authorities) and other environmental authorities to obtain financial support for biodiversity conservation projects of sea turtles and mangroves in Los Petenes and with fisheries authorities (CONAPESCA) to obtain fishing permits. This shows that in the RBLP the greatest emphasis on the management of its resources in the flats is linked to biological conservation and poor collaboration between actors dedicated to the use of habitats or resources. This polarized scenario in the conservation of protected areas makes it difficult for social capital in the RBLP to be strengthened for the sustainable use of its habitats. Among fishers it seems that there is no network to take decisions or plan actions that improve their activities; they only sometimes share opinions about the absence of surveillance, clear fishing permit allocation, and government support. This reflects a weakness of strong ties with people in the immediate network (bonding) and the same occurs in the recreational fishing sector.

For recreational fishing services providers, most interactions are with intermediaries that provide advertising (bridging), but also, they have few contacts with local tourism authorities: SEMAR, CONANP, CONAPESCA, and port authorities for navigation permit purposes, to report illegal fishing, and to request financial assistance to inform about their services and for international travel (linking).

As can be seen in Figure 28 and Table 7, five nodes show the highest indicators of centrality in the network and aggregate most of the links with other nodes. The degree of centrality indicates the number of actors to which an actor is directly linked. It is an indicator that is often used as a reflection of the governance and communication links between actors and their institutions.

Regarding the most relevant actors, their roles include the three selected types of users: a very well-known node that provide tourism services (node 13), a commercial fishing permit holder (node 10) in the flats of Campeche and the harbor captain (node 62) stand out. The other actors maintain their links as a means to facilitate navigation procedures and generate knowledge of fishery resources in the study site. Identifying these actors as part of the social capital of the place makes it possible to recognize who may be the people who facilitate the transmission of knowledge, government initiatives or ideas for mobilizing interests. On the other hand, identifying isolated nodes (orange nodes) where five represented local fly fishing promoters and fishers, makes it possible to target inclusion efforts at people who are not represented in collective actions and who are unlikely to receive information on government events and actions that impact them.

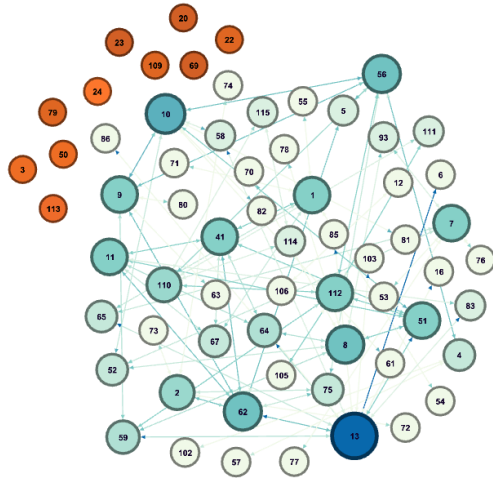


Figure 28. Los Petenes Actor Network. Each circle is a node corresponding to one respondent. Node size depends on its connectivity in the network. Orange circles are isolated nodes.

Table 7. Most relevant actors' characteristics of Los Petenes network

Node_actor label	Actor	Characteristics		
		Degree centrality	Closeness	Betweenness
13	Fly fishing service provider	24	0.408	757.397
10	Commercial fishing permit holder	16	0.395	529.768
62	Harbor captain	14	0.389	508.806
56	Fisheries researcher	14	0.354	544.117
8	Tourism service provider	14	0.337	326.246

5.5.2. Social Capital of San Felipe through Network Analysis

In the RBRL, the closer interconnections between the actors in the network do include the different harvesting and conservation sectors more equitably. This may be due to the fact that the communities of San Felipe and Rio Lagartos have achieved a higher level of cohesion that allows them to include a variety of interests.

Social network of respondents is mainly connected with federal authorities from the Rio Lagartos Biosphere Reserve and CONAPESCA for permit requests, with the former also for touristic capacity building. Contacts with environmental and fisheries authorities from the State are only to obtain equipment or financial support.

Among the members of the touristic cooperative, one of its leaders is responsible for networking with the ecotourism sector (Yucatan state authorities and peninsular ecotourism services) and the other leader is responsible for networking with the fishing sector (municipal authorities with Yucatan state and peninsular ecotourism services), the third group is formed by antique commercial fishers whose interactions with authorities depend on the other two groups.

Most of the respondents mentioned having contact with colleagues from Rio Lagartos, some of them to increase collaboration in tours with a variety of attractions, to communicate about government support, or to be informed about the presence of illegal fisheries or illegal tours and navigation within the ria.

Among the informants that belong to the same sector in the same locality, there are poor interactions. The only reason they interact is for nautical problems in meetings organized by the San Felipe Alcalde.

Figure 12 and Table 8 show seven nodes with the highest indicator values of centrality in the network. These nodes include three tourism services providers, two commercial fishing permit holders, and two authorities (one captain in charge of navigation and environmental authority in charge of the natural protected area from CONANP).

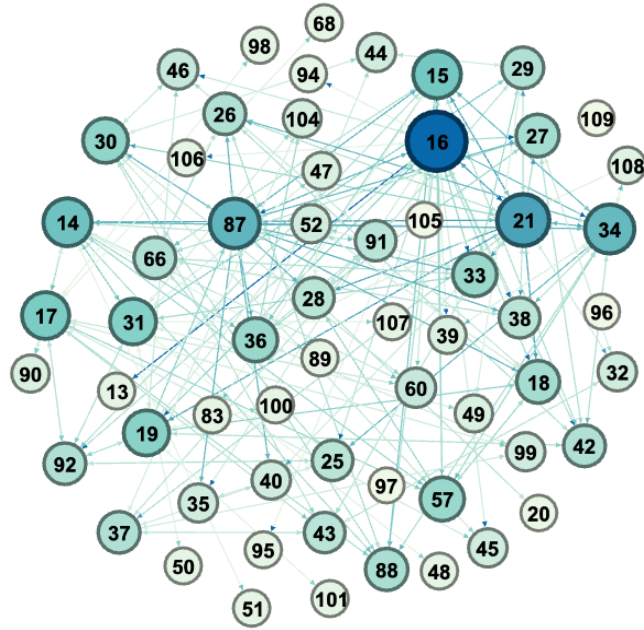


Figure 29. San Felipe Actor Network. Each circle is a node corresponding to one respondent. Node size depends on its connectivity in the network.

Table 8. Most relevant actors' characteristics of San Felipe- Rio Lagartos network

Node_actor label	Actor	Characteristics		
		Degree centrality	Closeness	Betweenness
16	Fly fishing service provider	44	0.533	748.740
21	Harbor captain	31	0.554	460.056
87	Environmental authority	27	0.495	229.019
34	Tourism service provider	26	0.491	218.070
14	Commercial fishing permit holder	24	0.5	484.334
15	Fly fishing service provider	23	0.486	211.889
17	Commercial fishing permit holder	22	0.437	333.017

For both sites analyzed, it is evident that the closest links are with actors with different actors in the same hierarchical level (bridging) for commercial purposes or for administrative

procedures with actors in higher hierarchical level (linking), not between actors in the same group to coordinate and make decisions or take actions for the benefit of a common good (bonding). According to Drew (2022), when people connect to other people through bridging they gain access to new social circles, thus increase their social capital. On the other side, connections with people in power and government are essential for grassroots community groups to get things done, as well as for governments to most effectively support the communities that they represent.

5.6. Organization analysis through SWOT Analysis

For the SWOT Analysis, strengths and weaknesses were considered as internal factors as the opportunities and threats as external factors that influence a user's activity. The SWOT Analysis consisted of 34 questions (12 strengths, 7 weaknesses, 8 for threats, and 7 opportunities) was presented to the respondents to score from 1 to 5 for the option that better expressed their agreement (1 as total disagreement, 2 for disagreement, 3 neutral, 4 agreement, 5 total agreement). For each category, an average value given by the interviewees was calculated and a total average, the latter by element (n=34) and by category of the respondent (n=3).

In Campeche, on March 4, 2022, a workshop was held with recreational fishing promoters and local anglers that integrate the NGO "Asociación Civil de Pesca Recreativa de Campeche". This meeting addressed various factors that make up the SWOT analysis of the recreational fishing sector, such as issues on socio-ecological problems, development opportunities for the recreational fishing sector, government management and the geographic areas where they operate.

Regarding San Felipe, information from a participatory workshop on June 26, 2021 on fly fishing management was incorporated into the SWOT analysis. A group of four fly fishing guides (with more than 10 years of experience) and a promoter of tourism and fly fishing from San Felipe were invited to discuss the conditions in which fly fishing is practiced. Guiding questions in the discussion included topics about: the main attraction in San Felipe to practice fly fishing (strengths), identified needs to improve service offer and service quality (opportunities), environmental, social, and management conditions that can influence fly fishing practice (weaknesses) and, environmental, social and management conditions that can influence fly fishing services (threats).

To elaborate the SWOT matrix, a strategy analysis was performed using the information from both instruments (questionnaire and workshop). Four strategies were of interest: maximize both strengths and opportunities (1), minimize weaknesses and maximize opportunities (2), maximize strengths and minimize threats (3) and minimize both weaknesses and threats (4).

5.6.1. Campeche SWOT Analysis

Table 9 shows results of the SWOT analysis of productive activities in Los Petenes Campeche flats (San Francisco de Campeche and Isla Arena), including scores by actor classification. The classification following the same methodology presented above, however, and since the actors dedicated to tourism and fly fishing share the same common interest and needs, which is to provide a service to visiting tourism, they were grouped together for this analysis.

Commercial fishers recognized among their strengths their fishing experience and internal group organization (with job satisfaction) that allowed them to continue against natural and social critical times.

Their weaknesses are related to poor investment opportunities, and poor market abilities that prevent them from distributing their products outside very few centralized intermediaries and antique equipment to perform their activities. Consistently they recognized that the major cost of their operation is fuel, and although they sustain that their infrastructure and equipment are adequate for their productive activities, these results are not consistent with the review of Vidal et al (2021) about government budgets for this sector without capital investment plans for infrastructure needs and sectoral or social priorities.

Fishers think that their threats include the capacity to fish legally, with permits to operate and navigate, and the deterioration of naturally rich habitats by anthropic activities.

In general, commercial fishers do not think that their productive activity has an optimistic future since there are no incentives from the government, a lack of surveillance, and poor local interest by politicians in the sector. However, they emphasize the fact that fishing products maintain a continuous demand within the region but also nationally and internationally.

Only two respondents have innovated in their productive activities offering processed seafood products or using shells for jewelry distributed locally to visits. Few of them support the idea that there is the possibility of making strategic alliances for growth, which could be more related to the very limited acquired capacities to innovate.

Table 9. Results of SWOT Analysis in Los Petenes Campeche flats (F. Commercial fishers, T. Tourism actors including recreational fishing guides, O. other actors, such as local environmental authorities, harbor authorities, and nature science researchers). Avg. Average. Average. 1 total disagreement, 2 disagreement, 3 neutral, 4 agreement, 5 total agreement.

	Actor classification			
	F	T	O	Avg.
n	7	6	1	
Strengths				
Perception of a successful business/cooperative	4	3	2	4
Business/cooperative that allows to maintain the profits of the members	4	3	3	4
Business/cooperative that has grown in sales or service offering	4	3	3	4
Business/cooperative that is fair	4	3	3	3
Business/cooperative that allows entry of younger members	4	4	4	4
The company is recognized by authorities, buyers and customers	3	4	4	4
Members have experience and knowledge	3	4	5	4
High quality products and services are offered	4	4	3	4
The distribution network of products or services is well consolidated	4	3	3	4
The product or service offered is very specialized	3	4	4	3
The members of the company or cooperative are very well organized	5	3	3	4
The members of the company or cooperative are comfortable working in it	5	3	4	4
Average	4	3	3	4
Weaknesses				
The market for our products and services has a favorable trend	3	4	4	3
There is a lot of interest and effort to conserve ecosystems	3	4	4	3
There is more support to develop the sector of the company or cooperative	1	2	3	1
There is the possibility of making strategic alliances for growth	2	4	4	3
New market segments have appeared	3	3	4	2
Rapid technological evolution has favored our work	4	4	4	4
There are new customers for the offer of our products or services	3	4	4	3
Average	3	4	4	3

Table 9. (Cont.) Results of SWOT Analysis in Los Petenes Campeche flats (F. Commercial fishers, T. Tourism actors including recreational fishing guides, O. other actors, such as local environmental authorities, harbor authorities, and nature science researchers). Avg. Average. Average. 1 total disagreement, 2 disagreement, 3 neutral, 4 agreement, 5 total agreement.

	Actor classification			
	F	T	O	Avg.
n	7	6	1	
Threats				
There is a lot of competition and there is increasingly	3	3	3	3
The current competition is extremely aggressive	3	4	3	3
The legislation of the sector does not allow growth	4	3	3	3
The species or attractions offered have deteriorated	3	3	2	2
Our products or services are less and less demanded	2	2	2	2
The impacts of man are what most affect the availability of products and services	4	4	4	4
Natural phenomena are what most affect areas of productive importance	3	4	4	3
People from other communities conducting the same activities are what most affect the areas of productive importance	4	3	2	3
Average	3	3	3	3
Opportunities				
The profits allow the current operation, but not the investment to grow	3	2	2	3
Fuel costs are the ones that affect the operation the most	4	5	5	4
The costs of the bait are the ones that affect the most	4	3	4	2
Equipment costs are the most affecting	3	4	4	3
The products or services offered are extremely limited	3	2	3	2
The infrastructure and equipment for the operation are old or damaged	2	3	2	3
Internal management has limited capabilities	3	3	3	2
Average	3	3	3	3

Among the recreational service providers, their recognized strengths are that they have developed tour and advertising capacities to provide private services mainly to fishers from USA and Canada. Fly fishing and spinning are demanded to catch tarpon and snook in mangrove waters in Los Petenes and, barracuda, jacks, and snappers in inshore marine waters. In some areas, such as Champoton, juvenile permits are caught; however, because this last resource is also of interest for commercial fishing, the populations have decreased. They consider themselves well organized, with modern infrastructure, and real-time advertising worldwide (some of them promote their services in tournaments and exhibition events in Denver and Texas every year).

Their weaknesses are in their poor social networks, their individualistic operation, and their poor enthusiasm to organize local or regional events to attract national and local recreational fishers. All of them are small-scale businesses with 3 or 4 guides that operate seasonally; thus, they have to search for other destinations to keep customers and their guides year-round. Their poor peer organization increases the probability to saturate the fishing areas. Additionally, these actors ensure that the absence of direct flights to Campeche and the high costs of their recreational services for nationals limits their growth opportunities.

Recreational fishing service providers assure that their threats are related to habitat destruction and resource depletion by illegal fishers using nets in mangrove areas and the increased commercial fishing effort by irresponsible fishers from other states, mainly Tabasco and Veracruz. Other factors related to health contingency, travel alerts, and meteorological events have provoked market decline. They are concerned about the rising cost of fuel, which has increased their cost of travel.

Their opportunities are related to their new clients through intermediaries that promote fly fishing around the world (e.g., Yellow Dog Flyfishing Adventures) and social networks. They find an increasing interest in juvenile tarpon catch and release fishing.

In contrast to the productive actors, the researcher interviewed considers that both commercial fishing and tourism services in the flats are far from being successful businesses in the state, the former due to the overexploitation of resources and the latter due to the absence of organization and promotion to be carried out in marine areas.

5.6.2. San Felipe SWOT Analysis

Table 10 shows the SWOT analysis of productive activities in San Felipe-Ria Lagartos flats, including scores by actor classification. For this study area, it is evident a great agreement among respondents, thus the analysis could be aggregated among social actors. 90% of respondents agreed on strengths regarding the goods and services they offer, firstly with the perception of good quality of their habitats, natural resources, and products, followed by the idea that these offers are well recognized by authorities and clients, that their internal capacities and knowledge within the business are consolidated and well organized (especially fly fishing services that are practiced almost exclusively), and that satisfied employees are working in their business (83%). The least agreement was found in considering that the sales or offer of services supply equitable benefits in business and that sales have grown in the last decade (72 %).

Regarding the weaknesses, the respondents agreed that the fuel cost is the highest in their operations (80%), nor the bait nor the fishing gear. About the fact that earnings only allow covering operational costs there was consistent disagreement. Few respondents accepted that their infrastructure is old or damaged (with more than ten years of operation) and that they have limited management capabilities. Fly fishing service providers ensure that there is a need to increase linkages with external tour operators.

Among the threats, 90 % of respondents agreed that there is abundant competition in their activities, apparently mainly by migrants. Also, there is a major agreement in the effect of anthropogenic impacts on availability of natural resources of both commercial and recreational interest (e.g. use of illegal fishing gears such as gillnet, spatial overlap of fishing activities that drown the resources of tourist attraction), but also by natural events such as hurricanes and red tides. The least agreement among respondents was in considering that their products and services are less demanded (40%).

Finally, it seems that there is a shared optimistic scenario among respondents regarding opportunities. More than the 80% expressed that there is favorable market trend in their services and products (more new customers), that there is interest in the conservation of the ecosystems

under use, and that there is a possibility of making strategic alliances to have access to new markets (as in the Riviera Maya) and that the use of GPS and social networks have favored business. The least agreement was in considering that there is new government support to develop the fishing and recreational sectors (60%).

Table 10 SWOT analysis of productive activities in San Felipe flats, including scores by actor classification (F. Commercial fishers, T. Tourism actors including recreational fishing guides, Avg. Average. 1 total disagreement, 2 disagreement, 3 neutral, 4 agreement, 5 total agreement).

	Actor classification		
	F	T	Avg.
n	2	4	
Strengths			
Perception of a successful business/cooperative	4	4	4
Business/cooperative that allows to maintain the profits of the members	4	4	4
Business/cooperative that has grown in sales or service offering	4	4	4
Business/cooperative that is fair	4	4	4
Business/cooperative that allows entry of younger members	4	4	4
The company is recognized by authorities, buyers and customers	4	4	4
Members have experience and knowledge	5	4	4
High quality products and services are offered	5	5	5
The distribution network of products or services is well consolidated	5	5	5
The product or service offered is very specialized	5	4	4
The members of the company or cooperative are very well organized	5	4	4
The members of the company or cooperative are comfortable working in it	5	5	5
Average	4	4	4
Weaknesses			
The market for our products and services has a favorable trend	3	4	3
There is a lot of interest and effort to conserve ecosystems	2	3	2
There is more support to develop the sector of the company or cooperative	2	3	3
There is the possibility of making strategic alliances for growth	2	2	2
New market segments have appeared	3	3	3
Rapid technological evolution has favored our work	3	3	3
There are new customers for the offer of our products or services	2	3	3
Average			

Table 10. (Cont.) Results of SWOT Analysis in San Felipe flats (F. Commercial fishers, T. Tourism actors including recreational fishing guides, O. other actors, such as local environmental authorities, harbor authorities, and nature science researchers). Avg. Average. Average. 1 total disagreement, 2 disagreement, 3 neutral, 4 agreement, 5 total agreement.

	Actor classification		
	F	T	Avg
n	2	4	
Threats			
There is a lot of competition and there is increasingly	3	4	4
The current competition is extremely aggressive	2	3	3
The legislation of the sector does not allow growth	3	3	3
The species or attractions offered have deteriorated	2	4	3
Our products or services are less and less demanded	2	3	2
The impacts of man are what most affect the availability of products and services	5	5	5
Natural phenomena are what most affect areas of productive importance	4	3	3
People from other communities conducting the same activities are what most affect the areas of productive importance	3	4	3
Average	3	3	3
Opportunities			
The profits allow the current operation, but not the investment to grow	5	4	4
Fuel costs are the ones that affect the operation the most	5	4	4
The costs of the bait are the ones that affect the most	4	2	3
Equipment costs are the most affecting	5	3	4
The products or services offered are extremely limited	4	4	4
The infrastructure and equipment for the operation are old or damaged	4	4	4
Internal management has limited capabilities	4	4	4
Average	4	4	4

The workshops complemented the SWOT Analysis and indicated the quality, natural and cultural attraction of San Felipe was superior to Rio Lagartos, but they emphasize that the adequate management of tourism activities such as recreational fishing or nature contemplation tourism, must be accompanied by vigilance to protect the species, especially in reproductive and breeding areas.

Table 11. Results from the workshop activities in San Felipe addressing SWOT conditions.

Strengths/ Opportunities	<ul style="list-style-type: none"> ➤ Disseminate the natural and cultural wealth of San Felipe through promoters in networks. ➤ Promote San Felipe as a fly fishing destination for tarpon and other species.
Strengths/ Threats	<ul style="list-style-type: none"> ➤ Improve the angler's experience by offering the knowledge of the local guide. ➤ Manage the certification of tourism and adventure guides. ➤ Promote savings strategies to prevent the closing of the activity due to contingencies. ➤ Training for mitigation and response actions to meteorological phenomena ➤ Manage environmental impact studies related to the salt industry and make timely complaints. ➤ Request control and fumigation campaigns if pest damage to the mangrove is observed.
Weaknesses/ Opportunities	<ul style="list-style-type: none"> ➤ Request control and fumigation campaigns if pest damage to the mangrove is observed. ➤ Plan a commission scheme for recreational fishing promoters. ➤ Promote and participate in surveillance programs in the fishing zone to conserve the habitat. ➤ Publicize lodging services in San Felipe and Río Lagartos. ➤ Implement training courses for guides and exchange with guides from other places. ➤ Rescue of Actam Chuleb management program. ➤ Manage training workshops for guides in customer service and English proficiency. ➤ Invest own resources in the improvement of the fly fishing guide's image.
Weaknesses/ Threats	<ul style="list-style-type: none"> ➤ Promoting positive fishing experiences in San Felipe. ➤ Increase the ANP's management capacity and surveillance personnel. ➤ Request the update of the NPA management program to include the boundaries of the fishing area.

The results obtained in this SWOT Analysis do not include those mentioned by Cowx et al., (2010) for other recreational fisheries in the world, such as having among its strengths an expansive network of people dedicated to lobbying and managing the conservation objectives of recreational fishing, or that recreational fishing revenues are transparently invested in conservation programs. It also mentions adopting the ecosystem approach to fisheries management as an area of opportunity, which allows linking recreational fishing with conservation objectives.

However, in the regional context, the following results of the experiences gathered in this workshop are mentioned:

Strengths.- Although Mexico has some particular regulatory instruments for the management of recreational fishing that apply to all territory under sovereignty (i.e. Norma Oficial Mexicana NOM-017-PESC-1994) (Vidal-Hernández and Garcia-Lagler 2022) , some technical issues such as the size of fish caught and the need to include non-pelagic species such as some caught in the study sites should be included to lay the foundations for responsible management.

Weaknesses- Lack of understanding of the factors that constrain fish populations and paucity of information on the economic value of the fishery. The biological and ecological knowledge about the most important recreational fishing species in the study areas (*Megalops atlanticus*) is very limited. The spp is mentioned only once in the National Fishing Chart (DOF July 26, 2022) as an associated species to the common snook (*Centropomus undecimalis*). Additionally, fisheries research authorities (INAPESCA) do not have any project to assess the status of this resource. Thus, neither the factors that define its population's health nor its value as a demanded resource for the recreational fishing activity is information taken into account for the management of their habitats.

Opportunities- There are some recreational fisheries social actors and general population members interested in supporting environmental and conservation campaigns in the region. This human and financial capital could be used to promote educational and extension programs to enhance degraded stocks and habitats.

Threats- Common anthropogenic disturbances in coastal waters of Campeche and Yucatan are water quality deterioration (Pollution, eutrophication), habitat degradation and fragmentation, and overexploitation. How these disturbances affect shallow marine and estuarine environments is not clear enough, but indirect evidence of negative impact could be assumed since artisanal fishers report constantly decreasing profits in their activities and offset by abundant illegal fishing activities (use of destructive fishing gears and failure to observe fishing closures).

Absence of a public policy that emphasizes the importance of recreational fisheries activities in regional waters and a lack of administrative authorities that enforce legislation of these activities. (Poor and constantly decreasing budget or presence of trained personnel) (Vidal et al. 2021).

6. Conclusions

6.1. Los Petenes Campeche

Campeche's human and natural system is composed of multiple mosaics that show complexity in the way surrounding communities use and manage their resources. Los Petenes is a large reserve of significant importance because of the ecosystem support and regulation services it provides to the entire ecosystem. The reserve's provisioning services also offer diverse products that are used by the communities, such as fishing for various species or the mangrove for the construction of fishing gear. The reserve has seagrass ecosystems that allow for the productivity of the food chain of fish, mollusks, and crustaceans. It also offers cultural services that give identity to fishing communities, such as Isla Arena, and the opportunity to offer recreational activities such as flat fishing for tarpon, snook, or barracuda, as well as boat or kayak trips through its mangrove landscapes and associated marine fauna.

However, the anthropogenic impacts are numerous, and there is a notable lack of management and control of fishing activities (legal and illegal) by the competent authorities, as well as a lack of internal organization of artisanal fishers. Artisanal fishers can be classified into two profiles, those called "old guard", who are older and more experienced fishers, who have fishing permits and respect fishing prohibitions to a greater extent, such as closed seasons and the fishing gear allowed; On the other hand, the new generations of fishers are observed, who frequently do not have their permits and who, in general, are less committed to respecting fishing regulations, taking advantage of the lack of surveillance and sanctions to operate. Specifically, in the city of Campeche, it is speculated that serious social problems such as the lack of job opportunities, corruption, and vices are the precursors for young people to participate in illegal fishing, to obtain quick access resources, using the product of the capture in illegal markets.

This has serious effects on the marine and Los Petenes ecosystems, since illegal fishing is usually by diving with a compressor, in 27-foot boats in which up to 15 fishers travel, according to reports from the fishers themselves. The effects of illegal fishing are observed in the increasingly low volumes of catches, which have led to the collapse of the catch of the red grouper (*E. moori*) and the Mayan octopus (*O. maya*) populations, which are caught illegal, throwing various objectives to the seabed (especially blocks), to provide refuges to capture mollusks when they seek refuge in the cavities of these materials.

Other impacts on ecosystems are caused by fishers who place gill nets in the canals of the mangrove zone to take advantage of the tides to capture all types of marine organisms, often fish in early stages of development, affecting the recruitment of wild populations. Other practices that damage the mangrove consist of pruning branches to submerge them off the coast and thus form attractants for various marine species, which are then encircled with nets and captured.

The analysis of natural capital of the users of the flat fishing areas shows a reduced number of relevant actors in individual connectivity within the network and lower values of the general connectivity indicators of the network. Only one of the actors specifically related to flyfishing (#13) is well connected with other internal users. The large size of the marine area within the reserve, with only two access points from land that are far apart, probably facilitates the arrival from the sea

of any number of users who have little need to interact with each other. The other relevant actors have links with other actors within their inner circle, i.e., more bonding than bridging or linking, which is also reflected in a high modularity indicator.

The means by which fishers and tourism providers communicate with their authorities or vice versa are scarce. The lack of communication between the fishing and tourism authorities, the reserve, or the port captaincy, translates into a lack of control to regulate any fishing and tourism activities in the area. This was reflected in the analysis of fishers's networks in Campeche, where fishers do not have full knowledge of the people and institutions in charge of fishing permits, surveillance, conservation, or research, among other issues.

On the other hand, flats users who provide fly fishing services do have closer contact with five promoters of the activity in other states or internationally. This scenario of scarce local connectivity and preference for external connectivity for the sole purpose of commercializing recreational activities is undoubtedly an area of opportunity for the sustainable management of flats, otherwise it will be unlikely to reach an understanding of the activity with a vision of ecosystem-based management as expressed by Arlinghaus in his 2013 manuscript.

Regarding tourism and recreational activities, such as fly fishing in flats and ecotourism tours, recreational fishing guides perceive themselves affected by illegal fishing activities in mangrove areas, but not by the impacts of recreational fishing on fishers or ecosystems. According to the common areas between artisanal and recreational fishers, there are no intense conflicts between them. The most important impact was from illegal fishers using illegal gear or nets in the mangrove areas, which affect the ecosystems promoted by recreational fishers and nature tourism. Among the users in the reserve, there is agreement on the evidence of some conflicts over the use of highly productive habitats (spring discharge channels in the mangroves), although some isolated cases of aggression and violence have occurred, the most worrisome evidence are the reports made to local authorities that have not been addressed and, moreover, generate an atmosphere of greater distrust in the land-based sites to access the reserve. All the interviewees also agree that these conflicts are affecting with some magnitude their ability to obtain good catches or to provide tarpon flyfishing services to users who expect the highest quality, although it seems to be an issue that has not reached thresholds that could exceed independent measures of conflict avoidance.

The analysis of the perception of the different users in Campeche about their productive activity in the flats shows that the tourist service providers (including flyfishing) and other actors are more pessimistic about their situation than the commercial fishers, since they emphasize their weaknesses and the threats they face, more than their strengths and opportunities. On the other hand, commercial fishers in this site do not recognize opportunities for improvement in almost any of the ideas about the market, support for development by the authorities or the presence of new buyers.

There are many areas of opportunity to consider improvements in the management, protection, and conservation of natural resources. The government should create opportunities for the sector to bring users (artisanal and recreational fishers) closer to the authorities and administrators. The promotion of participatory workshops would allow users to identify the natural

factors they have in common for the need to better conserve their resources, as contrary practices directly affect their livelihoods and the well-being of their families.

6.2. San Felipe Yucatan

Most respondents agreed to recognize that RBRL presents ecosystem in good conditions hence the benefit of ecosystems to fishing populations and other species of tourism attraction. Particularly, they trust in the idea that the “Actam Chuleb” local protected area is a unique opportunity to mitigate overfishing capacity in the area; however, very poor interaction among them and poor capacity to make consensual agreements to define strategies to protect the area beyond the speech.

Regarding recreational flat fishing, Fishing guides, and service providers should receive more training in various subjects, such as administration, English language skills, visitor services, training as nature guides, and mastering fish capture and release management techniques. The main impact currently in the fishing area, which directly affects the users of the system, is the use of illegal nets that capture all types of marine species in the mangrove areas, damaging not only species of sporting interest, but also commercial species of interest to the fishing sector and the delicate ecosystem balance of these habitats, as areas of refuge, feeding, and reproduction of marine species.

San Felipe shallow waters area and inshore waters at the easter end of Dzilam de Bravo reserve seem to show the highest overlapping zones among different users. Each group of users is aware of the impact caused to natural coastal and marine resources and ecosystems by other groups (destructive fishing gears, noisy activities, improper boat cleaning practices, and so on), however, the interlinked family ties (including the family of the municipal authorities) in such a small community prevents them to report illegal or inadequate operations, also for fear of reprisals.

The analysis of natural capital of the users of the flat fishing areas in San Felipe shows a greater number of relevant actors in individual connectivity within the network and higher values of the general connectivity indicators of the network than in Campeche. In this case, two actors related to flyfishing (#16 and 15) are well connected with other internal users, although not with the same magnitude; the first actor doubles in connectivity to the second. For this network, the environmental authorities of the reserve do have a relevant role in the overall connectivity of the network. Those interviewed commented on their leadership in regularizing and increasing the training of tourism service providers. On the other hand, an initiative designed by a previous harbor master to implement an instrument of fishing planning that included license plates regularization has not succeeded due to his removal. Up to now, his successor does not seem very concerned about ordering something in the community.

According to the respondents, local authority (alcalde municipal) raises the power to transgress federal regulations by endorsing the local needs for short-term solutions. The scenario that, up to now, does not effectively include the protection of natural resources or marine coastal ecosystems. This reality is favored by the presence of political parties that benefit from social

fragmentation, weaken connectivity between members of a society, and favor the entry of illicit groups (Briscoe et al. 2014).

Although since 2020, the Tourism Development Plan of the Municipality of San Felipe, Yucatán; identified several needs for the development of the sector, today service providers perceive that the promotion of the activity only depends on them. And that the advice Tourist Advisory of the Municipality of San Felipe is still a pending issue.

The analysis to know the perception of the different users in Yucatan about their productive activity in the flats shows that the tourist service providers (including flyfishing) perceive several anthropogenic threats that affect the productivity and quality of the habitats they use. On the other hand, commercial fishers in this site claim to have new development opportunities because they recognize that they have several strengths and opportunities, probably due to the possibility of selling their products to buyers from the Riviera Maya and Holbox.

It is very important to create community participation spaces that include not only reserve managers, San Felipe and Rio Lagartos guides, and recreational fishing operators, but also representatives from commercial fishing groups, port and municipal authorities, and representatives from other tourism services. The purpose is to create agreements so that the users of the areas can minimize the effects that may occur and can contribute their objectives and metrics for the planning and implementation of management measures that will benefit their users.

Finally, some actions were suggested by the interviewed actors in order to gather ideas that allow generating a strategic plan in the short term. The objectives of this plan are to implement objectives of environmental education, conservation and habitat protection, implementation of sustainable fishing practices, social participation in monitoring, control and surveillance actions in order to improve the way in which users involved in the governances of the LPBR and RLBR.

7. Conflict resolution strategic plan

The strategic plan of conflict resolution is based on a set of objectives structured by components. These are focused on the development of governance capacities of the communities within or in the immediate vicinity of the protected natural areas (RBLP and RBRL).

For this proposal ST (short-term) refers to less than 3 years, MT (medium-term) between 3 and 6 years and LT (large-term) greater than 6 years. Additionally, the strategy tables indicate the average priority range for the communities of Campeche and Yucatán (0 least relevant - 4 most relevant), based on the participatory workshops of the project results (NR means “Not required”).

7.1. Component of Socio-environmental research

It is necessary to deepen the research on marine and coastal ecosystems, in order to obtain a broader knowledge of how societies make use of natural resources and the way in which they impact them, according to the different uses and policies established for their use.

Goal. Improve knowledge of marine and coastal ecosystems through targeted studies on their structure, functioning, use and conservation.

Objective. Update priority research lines in the study areas, integrating the local knowledge, scientific and socioeconomic knowledge to facilitate management and decision making for sustainable use, as well as carry out basic research on priority species.

Strategies	Terms	Campeche	Yucatán
Update the priority lines of research of the NPA management programs, with the social, academic and government sectors, in order to update knowledge on scientific research needs.	ST	4	2
Enter into collaboration agreements with research institutions, educational centers and civil society organizations to propose lines of research leading to the solution of problems and decision making.	MT	3	3.75
Implement projects on the biology and ecology of target species of commercial or recreational interest, as well as species considered in some category of special protection, that include community participation.	LT	3	4
Update information on the use, conservation and restoration actions of marine and coastal ecosystems and fishing resources that include community participation	MT	2.5	3.25
Update information on coastal processes based on phenomena associated with climate change (e.g. erosion), sargassum upwelling as well as for artificial infrastructure installation.	ST	1.5	3.25
Estimate effective carrying capacity for tourism activities in the flat marine areas.	MT	1	4

7.2. Component for the development and integration of micro-regions

The spatial design of the micro-regions based on local communities makes it possible to characterize the productive systems integrated into the ecological, social, and local governance systems, facilitating the implementation of administrative mechanisms and management actions for decision makers.

Goal. Design a small-scale intersectoral regionalization proposal to generate clarity on the areas of exploitation and conservation and facilitate the implementation of control actions.

Objective. Promote the regionalization of micro-regions according to the local knowledge and use of ecosystem goods and services of their users.

Strategies	Terms	Campeche	Yucatán
Promote community participation through the identification of micro-regions of priority marine areas for conservation and fishery use.	ST	4	2.5
Delimit regions that, because of their ecosystemic importance in supplying supporting and regulating services, should be protected, and restored for the benefit of local communities.	MT	3.5	3.75
Determine effective micro-regions and areas of importance for commercial and recreational fishing, tourism, and buffer activities, with the participation of authorities and users of marine systems.	MT	2.5	4.25

7.3. Component of social cohesion for community action

Effective public participation only occurs because of building cohesive communities, where numerous different factors contribute to shape social relationships, and conflict resolution spaces exist. It is necessary to reinforce the forms of interaction within the groups, with groups from other sectors and with the authorities to firstly, identify the problems they share and secondly, to design integrated strategies that allow their resolution.

Goal. To develop a strategy that creates a robust collaborative social scenario among stakeholders to promote social cohesion that allows habitat conservation and problem resolution.

Objective Encourage the creation of collaborative scenarios in the communities and among users of the areas of interest to favor habitat conservation and conflict resolution.

Strategies	Terms	Campeche	Yucatán
Identify national and international social networks among different sectoral stakeholders (recreational guides, recreational fishers, cooperative fishers) that could induce pressure to preserve the quality of the habitats	ST	4	3
Implement training programs and technical support that allow increasing the capacities of human resources in aspects of management, administration, tourism services, among other needs identified in the communities.	MT	4	2.25
Train well-recognized members of the social network structure (with high connectivity) on leadership and conflict resolution to increase community participation, on communication skills to broadcast topics about nature conservation concerns	MT	3.5	3.5

7.4. Component of education and outreach

Education and knowledge dissemination strengthen the informed participation of social actors in local governance and facilitate the implementation of voluntary measures to generate habits and behaviors that enable ecosystem-based management.

Goal. To develop an educational program about conservation, sustainable use of coastal ecosystems and management.

Objective. To increase education and awareness about the ecological importance of seagrass flats and about their fragility in the face of practices (fishing and tourism) that impact their quality and threaten the ecosystem's integrity.

Strategies	Terms	Campeche	Yucatán
Establish collaboration between environmental management and educational sectors in the region to develop divulgation material and educational programs about those topics.	ST	4	2.5
Select important topics of coastal habitat deterioration of which divulgation material is absent. (e.g. use of artificial structures in seagrass bed, pollution caused by domestic oil and of chlorine in fishing activity) and contribute to their distribution	ST	3.5	3.25
To communicate to recreational fishers and guides information about sizes of first maturity of target species in the tournaments (trout, barracuda, snook, groupers, snappers, African pompano, tarpon and others) and other regulatory elements related with environmental conservation and fishing activities.	ST	4	NR
To contribute to the divulgation of the most common practices of natural resource use in flats that contribute to their deterioration.	ST	3.5	3.75
Design and deliver courses on proper capture and release techniques to increase post-capture survival.	ST	4	NR
Compile divulgation material of coastal and marine habitats uses and create a database with it accessible to stakeholders.	ST	2.5	3.25
Expand mechanisms for disseminating information on the importance and fragility of coastal resources and ecosystems in public media and community events (local festivals, fairs, patron saint festivals, and others).	ST	NR	2.5

7.5. Component of sustainable uses and practices in flat marine areas

The design and implementation of recreational fishing codes promotes the conservation of marine and coastal species and habitats, mainly in fragile areas, such as flat marine areas. To ensure their sustainable development, it is mandatory to reinforce the implementation of practices that prevent the overexploitation of stocks, the deterioration of their habitats and increase the success of the recreational experience.

Goal. To promote sustainable recreational fishing practices in flats habitats.

Objective. Implement strategies that favor conservation in non-extractive activities in flat marine areas.

Strategies	Terms	Campeche	Yucatán
To put together descriptive packages of tourist services in Isla Arena and San Felipe that include lodging	ST	4	2
To strengthen tourism-related services in San Francisco de Campeche, Isla Arena, San Felipe y Rio Lagartos	ST	3.5	4
To promote sustainable flyfishing activities in Los Petenes y San Felipe flats marine areas in international tournament	ST	3	1
To estimate the economic value of non-extractive activities in Los Petenes y San Felipe flats marine areas	ST	2.5	2
To promote experience-sharing events between certified tour operators and experienced recreational fishers	ST	2	3
Restore hydrological flows that communicate with springs on the coast that attract tarpon and thus avoid saturation of flyfishing fishermen in the same places.	MT	NR	2

7.6. Component of Social Participation in control and surveillance

Educated social participation provides direct benefits to the sustainability of marine and fishery resources, particularly in preventing and overcoming illegal and destructive fishing through voluntary actions that include organized monitoring programs, community surveillance and, internal agreements of fishing quotas.

Goal. Strengthen monitoring control and surveillance schemes for the conservation of flat marine and mangrove areas

Objective. To build monitoring and surveillance capacities in flats and mangrove areas.

Strategies	Terms	Campeche	Yucatán
Promote fishing refuge areas for all users in most vulnerable and fragile sites, particularly in the inlet and outlet channels of water flows in mangroves (i.e., avoid casting nets, gillnets, and flow blocking).	ST	4.5	3
Promote surveillance and monitoring schemes for the conservation of flats and mangrove resources, strengthening the presence of the relevant authorities and promoting community participation.	ST	4.5	4
Strengthen the community training about fishing surveillance through financial instruments (e.g., funds, trusts) that induce to voluntary participation.	MT	3	2.25
Strengthen the knowledge of the authorities and the communities about the legal and administrative processes that must be followed to ensure the due process in cases of illegal acts.	MT	NR	4

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9. Photographic collection



COMPONENTES DE INVESTIGACIÓN SOCIOAMBIENTAL

ESTRATEGIAS:	INVESTIGACIÓN		SOCIOAMBIENTAL	
	RELEVANCIA	PARTECIPACIÓN	RELEVANCIA	PARTECIPACIÓN
1. LINEAS PRIORITARIAS DE INVESTIGACIÓN	●●●●	●●●●	●●●●	●●●●
2. CONVENIOS DE COLABORACIÓN	●●●●	●●●●	●●●●	●●●●
3. PROYECTOS DE ESPECIES OBJETIVO	●●●●	●●●●	●●●●	●●●●
4. INFORMACIÓN DE FENÓMENOS COSTEROS	●●●●	●●●●	●●●●	●●●●
5. INFORMACIÓN DE ECOSISTEMAS	●●●●	●●●●	●●●●	●●●●
6. CAPACIDAD DE CARGA	●●●●	●●●●	●●●●	●●●●

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