PARKSWATCH
Strengthening Parks to Safeguard Biodiversity

Park Profile – Mexico
Laguna de Términos Flora and Fauna Protection Area

Date of most recent on-site evaluation: November 2002
Date of publication: May 2003
Location: Gulf of Mexico in the State of Campeche
Year created: 1994
Area: 705,017 hectares
Ecoregion: Mangroves and Wetlands of the Yucatán and Gulf of Mexico Atlantic Mangrove Complexes and part of Yucatán moist forests
Habitat: Wetlands, marshes, mangroves, estuaries, tropical forests and salt marshes

Summary

Description

Laguna de Términos Flora and Fauna Protection Area is located in the costal zone of Campeche State, between San Pedro River and San Pablo River towards the west, in the municipalities of Carmen, Palizada and Champoton. It terms of water volume, sediment load, and extension, it is the largest estuarine-lagoon system in Mexico. The protection area is also part of the coastal plain ecological complex that controls the deltaic process of the mouths of the Grijalva-Usumacinta Rivers. Its marshes and wetlands, with those of Pantanos de Centla Biosphere Reserve (which is to the immediate west of the protection area), form one of the most important coastal ecosystems in Mesoamerica, with notable natural productivity and biodiversity. The area is a mosaic of aquatic and terrestrial vegetation, critical habitat for commercially important fish species, and an important nesting site for marine turtles and migratory birds.

Biodiversity

Laguna de Términos is biologically rich. Within the reserve, there are 15 vegetative associations, with a total of 374 species. Threatened floral species found in the reserve include the *Bletia purpurea*, *Bravaisia integerrima, B. tublifora*. Endangered flora species found within the reserve include *Habenaria bractescens*. Several other species have special consideration but are not classified as threatened or endangered and include red mangrove (*Rhizophora mangle)*, black mangrove (*Avicennia germinans*), white mangrove (*Laguncularia racemosa*) and buttonwood (*Conocarpus erecta*). There is also high fauna diversity, thanks in part to the productive and abundant vegetation. Fauna estimates suggest

that there are at least 1,468 species (both terrestrial and aquatic). Among the aquatic mammals, in the reserve one can find bottlenose dolphins (*Tursiops truncatus*), and manatees (*Trichechus manatus*). Endangered species include jaguar (*Panthera onca*), black-handed spider monkey (*Ateles geoffroyi*), American crocodile (*Cocodrylus acutus*) and Morelet's crocodile *(C. Moreletii*). The hawksbill turtle (*Eretmochelys imbricata*), green turtle (*Chelonia midas*) and Kemp's Ridley turtle (*Lepidochelys kempi*) are under special protection.

Threats

ParksWatch determined that Laguna de Términos Flora and Fauna Protection Area is **critically threatened**, meaning that urgent solutions are needed to protect and maintain its biological diversity. The main threats affecting the area include petroleum exploration in the "Sonda" of Campeche, expanding grazing activities, traditional agriculture employing slash and burn techniques, illegal uses of forestry products such as mangroves, unregulated fishing, and contamination.

Description

Physical description

Laguna de Términos is located in the coastal zone of southwestern Campeche, between San Pedro and San Pablo Rivers, along the Gulf of Mexico. It is spread across the municipalities of Carmen, Palizada, and Champoton and is 705,017 hectares (CONANP 2000). The continental shelf in front of Laguna de Términos is part of the Bay of Campeche geologic province, which is a marine extension of the Macuspana-Tabasco Basin and the "Sonda" of Campeche. The lagoon bed is made up of non-uniform materials of lake and marsh origin, mostly of high clay content and low permeability. The lagoon bed's characteristics do not allow for significant water percolation and there is no significant underground water storage (INE 1997; Gío-Argáez 1996).

The Gulf of Mexico's coastal zone is the location of one of the most important hydrological systems, made up of the Mezcapala, Grijalva and Usumacinta Rivers. This has led to the formation of a lagoon-estuarine fluvial system that also includes the Palizada, Champán and Candelaria Rivers; the littoral lagoons Pom-Atasta, Puerto Rico, San Carlos and Del Corte; and the lagoons Del Este-San Francisco-El Vapor, Balchacah, Chacahito, and Panlao (Gómez-Pompa *et al*. 1995; INE 1997; INIREB-T y Gob-T 1988; Kumpf 1999).

In the Gulf of Mexico, Términos Lagoon is the largest lagoon because it has the largest volume of water. It is shallow, with an average depth of 4 meters. It has two mouths, or openings, connecting it to the sea: Puerto Real and Carmen (Contreras 1993). The watershed, including the lagoon systems, is approximately 2,007 km^2. Puerto Real, is approximately 3.2 km wide and 14 meters deep. The other mouth, Carmen, is approximately 3.8 km wide and 18 meters deep.(Gómez-Pompa *et al*. 1995; De La Lanza y Cáceres 1994). This wetlands system, along with those of Tabasco, forms the most important coastal ecosystem in Mesoamerica (Chávez *et al.* 1988).

Mangroves of Laguna de Términos

The climate of the protected area is either hot, subhumid or hot, humid depending on the particular location. Puerto Real is hot and subhumid with summer rains. The area surrounding the lagoon is also hot, subhumid, and it is the most humid part of the protected area. And, the Palizada, Pom-Atasta, San Pedro River area is hot, humid with intense summer rains. The average annual temperature is 27.2°C, with maximum averages reaching 35.8°C and minimum annual average of 18.6°C (Gío-Argáez 1996; INE 1997).

There are three climatic seasons in the area: the rainy season is from June to November; the "Nortes" season is from October to February and is characterized by northern winds and occasional rain; the dry season is from February to May. The monthly precipitation that begins in June gradually increases to more than 100 mm per month during October and November.

Laguna de Términos Protection Area is found within the mangroves and wetlands of the Yucatán and Gulf of Mexico Atlantic mangrove complexes ecoregions (Dinerstein *et al.* 1995; Sullivan y Bustamantes 1999). The protected area harbors a wide diversity of vegetation and floral associations. There is aquatic and terrestrial vegetation, as well as coastal dune vegetation, swamp vegetation, mangroves, flooded vegetation, lowland forest, palms, and spiny scrubs. In addition, there is riparian vegetation, medium tall forest, secondary forests, and even beds of sea grasses (Arriaga *et al.* 2000; CONABIO 2003).

Since the before the Spanish arrived, this area has been a center of activity, which included the eastern branch of Usumacinta River (Palizada), Laguna de Términos, and Gulf of Mexico. The region was a convergence of three commercial routes: 1) the route used by Mayan boats from Yucatan to Central America; the terrestrial routes of the Nahua traders from Tenochtitlan in central Mexico; and river routes from different towns in Tabasco towards the lagoon (INE 1997).

Within the protected area, there are archeological ruins, but they have not been sufficiently studied. There are small mounds, some of which have already been ransacked. In the ejido (communal-lands) of Puerto Rico, the road that passes through mangroves is made of large oyster shells and compacted sand. It is thought that this road was used to transport goods coming off the boats and ships from the Gulf of Mexico. Another interesting fact is that after the Spanish conquest, the region was not considered important and was ignored. This allowed the English pirates to use the lagoon as a refuge. Apparently, it was a good one, because by 1597 there were more than 200 pirates settled in the lagoon.

Geographic location of Laguna de Términos Flora and Fauna Protection Area

Biodiversity

There are many vegetation types in Laguna de Términos, including: high evergreen forest, high semi-evergreen forest, medium semi-deciduous forest, low evergreen forest, costal dunes, mangroves, reed beds, floodable spiny scrubland, floodable spineless scrubland, phanerogamous flooded vegetation, aquatic vegetation, sub aquatic vegetation. Different habitats include dunes, swamps, estuaries, mangroves, salt marshes, and fresh and salt-water ponds. There are 84 flora families with a total of 374 species. Typical species include red mangrove (*Rhizophora mangle*), black mangrove (*Avicennia germinans*), white mangrove (*Laguncularia racemosa*) and buttonwood (*Conocarpus erectus*)—all of these are under special protection. Other species like pine pink (*Bletia purpurea*), *Bravaisia integerrima* and *B. tubiflora* are threatened. The orchid species *Habenaria bractescens* is an endangered species, according to the Official Mexican Norms 059 of Ecology, 2001 (NOM-059-ECOL-2001) that lists the species considered threatened to some degree (D.O.F 2001).

It is estimated that the mangroves around Términos Lagoon receives at least 33% of the migratory birds that follow the Mississippi migratory route. In addition, the mangroves are known to be good for fixation of mud banks (Zarur 1961, Rzedowski 1986).

The main species of the meadows of sea grasses found in some of the fluvial-lagoon systems is turtle grass (*Thalassia testudinum*). In the Candelaria-Panlau system found in the interior, there are widgeon grasses (*Ruppia maritime*). The coastal dunes are an important component of the protected area, and they are found on the northern limit. The dunes harbor species such as Coccoloba *humboldtii*, and *Schizachyrium scoparium*.

Conserved mangroves within the protected area

Fauna

There are at least 1,468 fauna species (terrestrial and aquatic) found within the protected area, 30 of which are endemic to Mexico. There are approximately 89 that are threatened to some degree, and 132 of them have been identified as commercially important. Much of the fauna in Laguna de Términos is endemic to the semitropical-Caribbean region. For some South American species, the protected area represents their northern limit. There are also several "northern" species, such as the white-tailed deer and a number of rodents (INE 1997; CONABIO 2003).

There are 74 registered insect species of 16 families—this shows that additional insect studies are needed, as this is not a complete inventory. There are 109 reptiles reported for the region from 16 families: 69 are found within Términos Lagoon, 9 in Palizada, 7 in the jungle-savannah ecosystems, and 24 in the Tabasco-Campeche swamp system.

In the Tabasco-Campeche region, 279 bird species have been recorded of 49 families. Seventy-seven of these species are found in the mangroves and on the coasts, ten are found in the fluvial-lagoon systems, and 70 in the forest-savannah ecosystems. The ecosystems of the protected area play an important ecological role, as they serve as resting, nesting, and nursery sites for many migratory birds. Some species include the Jabiru stork (*Jabiru mycteria*), which is considered endangered; the wood stork (*Mycteria americana*), which has special status under the Mexican protection system and is listed under Appendix I of the Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES 2003); northern pintail (*Anas acuta*), cinnamon teal (*Anas cyanoptera*), white-fronted Amazon (*Amazona albifrons*), American Wigeon (*Mareca americana*), and kingfisher (*Chloroceryle* sp.). There are 110 non-migratory birds. Some of these birds are predatory birds and because of their diet and feeding habits, are important factors in regulating prey species such as insects, frogs, crustaceans, fish, reptiles, and small animals.

There are 134 registered mammal species, from 27 families. Some species include the manatee (*Trichechus manatus*), jaguar (*Panthera onca*), ocelot (*Leopardus pardalis*), margay (*Leopardus wiedii*), and the black-handed spider monkey (*Ateles geoffroyi*). All of these mentioned species are endangered species and are listed among some category with CITES (NOM-059-ECOL-2001; CITES 2003; UICN 2002). Other species, like the bottle-nosed dolphin (*Tursiops truncatus*) receive special protection.

A manatee

A crocodile

Wetlands in Campeche and Tabasco are of great importance for aquatic reptiles like the American crocodile (*Crocodylus acutus*), Morelet's crocodile (*Crocodylus moreletii*) and brown caiman (*Caiman crocodilus fuscus*) that live in the swamps, mangrove zones, and around Términos Lagoon (INE 1997; Valtierra 2001). The crocodiles and sea turtles are of commercial importance, and therefore have seen their populations severely decline. The sea turtles that visit the zone and the beaches are hawksbill turtle (*Eretmochelys imbricata*), green sea turtle (*Chelonia mydas*) Kemp's Ridley turtle (*Lepidochelys kempi*). The hawksbill turtle and the green sea turtle are considered endangered species in Mexico (NOM-059-ECOL-2001) and Kemp's Ridley receives special protection.

Fish are also well represented in the lagoon. There are 367 species of 101 families registered. Common species include *Anguila rostrata, Belonesox belizanus, Dorosoma anale, Gambusia echeagarayi, G. sexradiata, Ictalurus meridionalis* and *Lepisosteus tropicus*. Of all the species, only 125 are found in the lagoon-estuarine system and 102 species have some commercial importance (Yañez-Arancibia *et al*. 1985).

The protected area is also an important nursery and feeding ground for several commercially important species of the Sonda of Campeche. There are seven economically important crustaceans, including white shrimp (*Penaeus setiferus*), pink shrimp (*P. duorarum*) brown shrimp (*P. aztecus*), seabob (*Xiphopenaeus kroyeri*) and three species of crabs (*Callinectes sapidus, C. rathbunae* and *C. similis*). The white, pink and brown shrimp are especially reliant on the lagoon because of their biological cycle. The lagoon serves as feeding and nursery grounds for larva and adolescent shrimp.

Management

The waters of Laguna de Términos were declared state property on January 19, 1979. On June 6, 1994, it was declared Laguna de Términos Flora and Fauna Protection Area, with an area of 705,017 hectares (its current size). The management program was published in March of 1997. It is very complete and all encompassing and it follows the guidelines established for protected areas management in Mexico. It lies between the 19° 10' 40.22" northern latitude and 92° 28' 12.80" western longitude.

The National Commission of Natural Protected Areas (CONANP), which is part of the Ministry of the Environment and Natural Resources (SEMARNAT), is responsible for administering and managing the reserve. Laguna de Términos has 19 employees: a director, sub-director, an administrator, two project managers, two technicians responsible for community relations and environmental education, two geographers, three maintenance workers, a boat operator, and six general reserve workers (CONANP 2000, CONANP 2001).

The reserve's infrastructure is found on the island where Cuidad del Carmen is located, which has infrastructure and services similar to that of any large city. Some institutions that have presence in the area include Autonomous University of Campeche, the University of Carmen, the research station of the Institute of Ocean and Lake Sciences of the National Autonomous University of Mexico (UNAM), the Geographic Institute of UNAM, the Southern Border College, the National Polytechnic Institute, the Autonomous Metropolitan University, PRONATURA, the National Commission of Water, the Marine Secretary, and SEMARNAT.

The protected area has five different management zones that regulate the lagoon's resources and their use. The management program describes the zones and permitted, prohibited uses in detail. Zone I is restricted management. This zone includes intact mangrove and tropical forests that have had little or no anthropogenic alterations. Wildlife reproduce and feed in this zone. Scientific research, environmental education, and low-impact ecotourism are permitted as long as these activities do not modify or alter the conditions within the zone.

Zone II is low-level management zone. Including in this zone are mangroves, swamps and forested areas that have been altered or impacted in some way by humans. There are rural communities that carry out agricultural activities, raise livestock, or petroleum activities. In this zone, these activities are of low-impact and are subjected to strict regulation. Also, within this zone, research is encouraged in order to apply integrated management and sustainable resource use.

Zone III is the intense management zone. It is located in non-flood zones, where natural resource use is intense and has lead to ecosystem alteration, modification, and even destruction. Permitted activities include a wide-variety of economic activities subject to strict regulation.

Zone IV is designated for areas of urban development and communal territories. This zone includes the majority of the human settlements are located, such as Carmen municipality—which has the greatest human population within the protected area. Within this zone, urban development plans are to be established and implemented.

The last zone is reserved for bodies of water. All bodies of water within the protected area's boundaries are designated as Zone V. The main activities in this zone include commercial fishing, fishing for consumption, and sport fishing. According to the management program, exploitation of this resource should be rational and should not occur in feeding or nursery grounds of commercially important species. Feeding and nursery grounds of species such as the aquatic birds and sea turtles are protected. Infrastructure installation or other construction is prohibited these acts would interfere with the natural current flows or if they would change the coastline in any way (INE 1997).

The financial resources come from CONANP; annually, $80,000 is assigned to the protected area. Mexican Petroleum (PEMEX) has also provided financing because it has installations in the protected area. In 2001, it donated one million dollars (Pemex Bulletin 2002). There are other financial sources, such as the United National Development Program (UNDP) with help from the Global Environmental Facility (GEF).

Human influence

Laguna de Términos covers three municipalities: Carmen with 136,034 habitants, Palizada with 7,162 habitants, and Champotón with 71,836 people (Note: these data come from the 1990 census). Therefore, as of 1990, there were a total of 215,032 people living within the protected area. Carmen is the most populated municipality and it is one of the two most economically important regions in Campeche State. It has the most important commercial sector in the state and is a significant employment center for PEMEX. In Palizada, the principal economic activities are fishing and ranching. Subsistence agriculture and seasonal fruit harvests are also important in the area. Shrimp farming is also expanding and is attracting new settlers to Carmen Island and other surrounding communities. The towns and rural communities found in the reserve are legally established communities because they existed prior to the declaration of the protected area (INE 1997).

The main soil use is agriculture and ranching; while in the marine zone, there is fishing and oil and natural gas extraction/transportation. Off the protected area's coast is the continental shelf called "Sonda" of Campeche. This is where 95% of Mexico's crude oil and 80% of its natural gas is found (INE 1997).

The lagoon is accessed by a federal highway from Villahermosa to Carmen City, passing through Sabancuy. There are also many secondary roads around the lagoon. From Carmen City, it is possible to reach Palizada and Sabancuy by water. Carmen Island is connected to the Mexican mainland by two large bridges (Unidad is 3.22 km long and Zacatal is 3.9 km long).

A bridge in the lagoon that connects to Pantanos de Centla reserve.

An access road to Laguna de Términos, with garbage along the sides

In Carmen City, which is within the reserve's boundaries, one will find all the infrastructure and services of any large city: offices, hotels, hospitals, universities, restaurants, telephone, internet, airport, bridges, and highways, just to name a few. And, more importantly, the city is the center of the country's petroleum activity. This fact is of concern to the reserve's management, because the petroleum industry attracts further industrial development, both micro and macro, and more people who demand homes and more resources.

Tourism within Laguna de Términos has not been well development, mostly because Carmen Island has been relatively isolated until recently. With the construction of the bridges connecting Carmen Island with the mainland has brought with it the discussion of the ecotourism potential. One important impediment to developing ecotourism in the area is the petroleum activity within the reserve. If PEMEX increases its production and builds additional infrastructure, the ecosystem will be further impacted and the scenery will be scarred.

Conservation and research

Several institutions carry out research activities and conservation projects in the reserve. The following list provides the name of the institution and the focus of their project(s).

- The Institute of Ocean and Lake Sciences of the National Autonomous University of Mexico (UNAM) studies the fluvial systems and river deltas, fish life cycles, management systems for wetlands.
- The Geography Institute of UNAM uses satellite images to study the geomorphology of the littoral systems.
- The Autonomous Metropolitan University of Unidad Iztapalapa and its Hydro Resources Department carries out studies of coastal ecosystems.
- The Science Faculty of UNAM has promoted research on animals in Laguna de Términos like ichthyoplankton, crustaceans, shrimp, and clams.
- The cartography of the reserve has been elaborated with help from PEMEX's corporate system of geographic information, and the marine portion has been mapped because of PEMEX's Exploration and Production program.
- The Autonomous University of Carmen was the responsible for coordinating the Management Program of Laguna de Términos.
- The Autonomous University of Carmen also manages a botanic garden (20 hectares). This garden was established in the year 2000 in order to conserve, preserve, and study vegetation from the region. The garden also serves to educate the local community about natural resources, and that the resources are an essential component to a healthy life and that they are essential for future generations (Cárdenas y Alderete 2002).
- The *Cultura del Agua*, or "Water Culture" Program is dedicated to describing, explaining and interpreting the local lagoon and river people's social systems during the XIX and XX centuries.
- The non-governmental organization, Biocenosis A.C., is working in coordination with the reserve's management to characterize the Sabancuy Bay of Campeche in order to lay the foundations for its re-categorizing as an independent protected area. The receive funding from TELMEX for this project.
- Marea Azul is another conservation organization that is working to conserve the hawksbill turtle (*Eretmochelys imbricata*) and its habitat in Chacahito, Laguna de Términos. They also rescue and rehabilitate confiscated wildlife for reintroduction into their natural habitat.

Threats

The most significant threats to biological conservation within Laguna de Términos Flora and Fauna Protection Area are:

- Petroleum exploration and production (PEMEX)
- Contamination of the fluvial-lagoon systems by bacteria and agrochemicals
- Population growth and land use changes
- Wetland destruction to establish shrimp farms
- Deforestation and habitat destruction
- Wildlife poaching and illegal fishing
- Exotic species introduction
- Hurricanes

Petroleum exploration and production by PEMEX

The state-owned company's operations within the protected area are a constant threat to the ecosystem for several reasons. First, habitat is destroyed in order to install infrastructure, drill oil wells, and to construct pipelines. Second, oil spills, whether they are large scale or rather insignificant, are a constant threat. The locals realize that the petroleum activity could affect their quality of life in the future.

Area where pipelines cross Laguna de Términos

PEMEX installations in the protected area

Contamination of the fluvial-lagoon systems by bacteria and agrochemicals

Untreated wastewater (a.k.a. black water), industrial wastewater, runoff from agricultural fields and runoff from riparian communities have caused widespread water contamination. Some studies have documented fecal contamination and have detected the presence of the following bacteria: Citrobacter, Enterobacter, Escherichia (E-coli) and Pectobacterium (Rodríguez y Romero 1980; Lizarraga-Partida *et. al.* 1983). Irrigation systems have been identified as being improperly designed; runoff is commonly contaminated with pesticides, antibiotics and fertilizers.

Population growth and land use changes

The region's economic development, fueled by the fishing and petroleum industries, has created intense demographic and social dynamics. One of the direct effects has been increased population, especially in Carmen City. The larger population has converted land from its natural state into developed land. Yet, because the development has not occurred in a regulated, organized fashion, the infrastructure to deal with contamination coming from these larger human populations has not developed.

Wetland destruction to establish shrimp farms

Wetlands and mangroves are being destroyed to construct shrimp farms. These farms, or in some cases ponds, are unregulated and have been constructed without prior ecological studies or capacity studies. While there is a lack of data regarding the amount of habitat converted to shrimp farms in Laguna de Términos, worldwide, it is estimated that more than 765,000 hectares of mangrove have been destroyed for this reason.

Deforestation and habitat destruction

The main productive activities that are affecting the ecosystem are agricultural activities like rice production, and grazing. Intensive rice production requires not only space (and therefore destruction of habitat) but also water; water is taken and decreases the volume going from Candelaria River to Términos Lagoon. Slash and burn clearing techniques are used to add lands for extensive grazing and agriculture. This technique destroys valuable ecological areas and, in the case of grazing, does not produce high-quality products. Forestry activities are not considered to be among the main destructive activities for the area, although illegal logging does occur. The target species is the mangrove, which locals use in an unsustainable way. Mangrove is a preferred wood for home construction and is used to make charcoal for cooking.

Mangrove areas and forest destroyed for agricultural and grazing activities

Wildlife poaching and illegal fishing

Because Federal Environmental Protection Procurator's Office (PROFEPA) does not maintain consistent presence in the area, illegal fishing and hunting regularly occurs. Those engaging in poaching and illegal fishing claim that it is done for auto-consumption. Some of the animals most affected by poaching include the crocodiles, the manatee, Neotropical otter (*Lontra longicaudis*), sea turtles, freshwater turtles, jaguar and ocelot.

Introduction of exotic species

Native flora has been affected and eliminated in some cases by exotic plants, such as extensive commercial plantations of coco. In the bodies of water, there have been a growing number of observations of the invasive water hyacinth (*Eichhornia crassipes*). Exotic fish have also been introduced into the lagoon and its tributaries. Several species of tilapia have been introduced such as *Orechromis mossambicus, O. niloticus, Tilapia rendalli*. These species are a source of competition for native fish, they adapt quickly, and they have fast reproduction.

Hurricanes

Laguna de Términos Protection Area is not considered to be in a high-risk hurricane zone. But, if a hurricane were to hit this area, the results could be devastating. Remember that in front of Laguna de Términos Flora and Fauna Protection Area is the Sonda of Campeche continental shelf where the majority of the petroleum exploration and extraction in Mexico occurs. If a hurricane were to damage this infrastructure, including the oil platforms in the sea, an oil spill may result. In addition, in the zone, oil is also loaded onto tankers. All of this becomes an even more severe threat for the protected area in the face of a hurricane.

Recommended Solutions

Petroleum exploration and production by PEMEX

The management program should clearly define the zones where industrial infrastructure and development is permitted, because as the management program is currently written, it is not clear. The reserve's management and PROFEPA should monitor PEMEX's and the other related private industries' compliance with established environmental regulations. They should sanction the industries if and when they do not comply, and they should require mitigation activities as necessary.

Contamination of the fluvial-lagoon systems by bacteria and agrochemicals

The reserve's management, in coordination with a research institution or some other organization, should establish permanent water quality monitoring in the lagoon and in the coastal waters. That established, they should make pertinent recommendations to the local governments, to PEMEX, and other industries found to be contaminating the fluvial-lagoon systems with untreated wastewater and runoff. They should promote environmentally friendly, natural fertilizers and provide training for local agriculturalists to use them to reduce agrochemical use.

Population growth and land use changes

Growing population in Carmen City is a new challenge to maintaining urban equilibrium, that is, in maintaining healthy social, cultural, and natural environments. Some strategies to deal with growing populations include establishing urban planning, which would help guide where development occurs within the protected area.

With regard to land use changes, it is important that the reserve's management and the local government of Carmen Municipality coordinate and collaborate in allocating the resources provided by PEMEX (PEMEX pays the municipality a fee as mitigation for its activities in the lagoon). Carmen Municipality received 13 million dollars in the year 2002 from PEMEX for potable water projects, pluvial drainage and sanitizing, road repair, rehabilitating the historic center, urbanization for home programs, and resources for programs in the fishing sector. They also donated 3.9 million dollars worth of products, such as asphalt and fuel.

Wetland destruction for shrimp farming

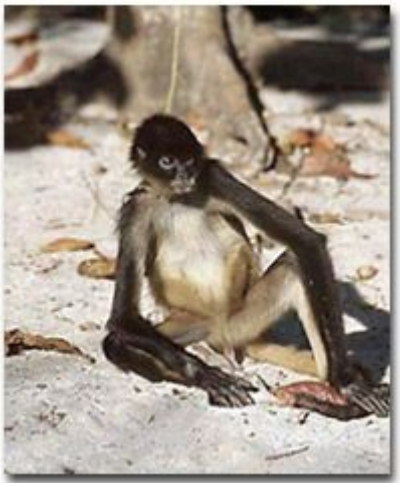
According to the management program, and because of the widely documented negative impacts (see www.redmanglar.org), shrimp farming installations and infrastructure should not be permitted in a protected area. This published position should be monitored and enforced by the reserve's staff and personnel from PROFEPA. Mangroves and wetlands have been identified as critical ecosystems and they should be protected.

Deforestation and habitat destruction

Some of the recommendations mentioned in the management program should be implemented. First, promoting intensive cattle farming with initial investment and training to implement it properly would help stop the extensive ranching and would help stop habitat destruction. Second, deforested mangroves should be reforested. And, third, forest management programs should be implemented in the protected area. Currently, the lack of forestry regulations leaves a lot open for interpretation and each individual logger, whether he/she is logging for auto consumption or for commercial sale, implements his/her own methods and techniques. ParksWatch also recommends a fire prevention and control program in the reserve and surrounding areas.

Wildlife poaching and illegal fishing

Poaching does occur in many communities for auto consumption. Yet, poaching is also carried out by professional hunters or sport hunters who go after species like crocodiles, monkeys, or jaguars. They take advantage of the lack of personnel in the area to hunt. Fishing is unregulated or with improper management when it is regulated. This has lead to the proposal of creating fishing cooperatives, which would develop clear rules for sustainable fishing. Within this proposal, there is also a suggestion to create fishing quotas, establish fishing zones in areas that would not harm the ecosystem, and to monitor and inspect fishing activities by the authorities (PROFEPA).



*Black-handed spider monkey (*Ateles geoffroyi*) captured from the wild to be tied up as a pet*

A tool that could be very useful but that has not been used in the lagoon is signage. The signs should clearly state that the lagoon is part of a protected area and that certain activities are considered against the environmental regulations and therefore illegal.

Introduction of exotic species

Because coco plantations are a traditional economic activity of the lagoon habitants, studies are needed to determine why the plantations have become infected with the lethal yellowing disease and what should be done to stop the disease. Efforts to maintain the existing coco plantations healthy will help ensure that new land will not be cleared to plant more coco to replace those plants lost to the disease.

Hurricanes

PEMEX has considered hurricanes as a threat to its petroleum activities, and has even developed a *Hurricane Emergency Response Plan*. The last time PEMEX implemented its plan was in 2002 with “Isidoro.” They temporarily reduced their production, postponed their exportation activities, and reduced their own use of natural gas. While their efforts are commendable, the threat posed by hurricanes to the petroleum installations and the possibility of an oil accident cannot be underestimated. In the event of such an accident, the lagoon, the coast, and the ecosystems would be severely and negatively impacted. The reserve management should maintain communication with PEMEX and have a coordinated action plan with the company in place, ready to be implemented in case of such a disaster.

Conclusions

Through this evaluation, it has become apparent that the state-owned petroleum and natural gas company, PEMEX, has the greatest influence on the area and is the greatest threat to Laguna de Términos Flora and Fauna Protection Area and its biodiversity. At the same time, PEMEX is one of Mexico’s economic pillars and its activity in this area and off of the Sonda de Campeche is

essential. It is estimated that there are 20 years of production left. This means that during that time, the area will continue to attract additional industrial activity and the population will grow. All of this has consequences for the natural environment.

This petroleum boom also represents an opportunity for the protected area's management. According to the General Law of Ecological Equilibrium and Environmental Protection (LGEEPA), the management can promote coordinated efforts between the reserve and the industry.

Civil society's participation has been impressive regarding PEMEX's planned activities within the protected area. There is awareness and participation on the part of the residents and NGOs and this has been essential for stopping some projects that are environmentally unfriendly and that could threaten human health and quality of life. There have been public protests and demonstrations against PEMEX projects, citing the ecosystem destruction and quality of life degradation seen in other PEMEX sites.

Residents are organized and the civil society is a strong force. This has made PEMEX realize that they must work with civil society. They consider the opinions of the reserve's management, conservation organizations, and research institutions when developing their projects in order to minimize the negative impacts on the environment and to propose mitigating actions when necessary. This same participatory model should be adopted by other private industries related to the petroleum industry in the region.

Another emerging threat is the shrimp farms. In short, shrimp farms should not be established in the area. There are numerous studies from other countries demonstrating the negative effects of shrimp farms: mangrove ecosystem destruction, hydrodynamic alterations, water pollution due to the antibiotics and other medicines used, and higher mortality rates of other organisms living nearby. A proposed solution to this is to develop appropriate technology to cultivate native fish species (cichlids) and crustaceans (such as the soft-shelled crab) instead. Funds for such an endeavor would be available from Carmen Municipality and from PEMEX.

A solution to the threats to mangroves (human activity, urban expansion, and illegal logging) could be to inform and apply the new reforms to the Federal Penal Code. The new Code outlines the increased penalties for those people affecting wetlands and coastal forests, such as mangroves. For example, the Code states that anyone who damages, drains, or fills wetlands, mangroves, lagoons, estuaries, or marshes within a protected area could receive up to 10 years in prison without parole. PROFEPA should also monitor the communities' uses of flora and fauna, ensuring that the uses, either timber or wildlife, are not commercial or for-profit.

ParksWatch has determined that Laguna de Términos Flora and Fauna Protection Area is **critically threatened** and urgent solutions are needed to protect and maintain its biological diversity.

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