Environmental Baseline

Hokchi area

Contract: CNH-R01-L02-A2 2015

Produced by:

Institute of Marine Sciences and Limnology

Universidad Nacional Autónoma de México

To:

Hokchi Energy S.A. de C.V.

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Technical support

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6 RESULTS AND DISCUSSION

EXECUTIVE SUMMARY

In 2015, the company Hokchi Energy S.A. de C.V., in consortium with EyP Hidrocarburos y Servicios S.A. de C.V., was awarded to carry out the project consisting of the drilling of four oil wells in Area 2 of Bid 2 in Round 1, here called the Hokchi area and located off the coast of the state of Tabasco. For this reason, on January 7, 2016, Contract No. CNH-ROI -LOI-R01/2015 for the Extraction of Hydrocarbons under the Shared Production modality was signed between the National Hydrocarbons Commission (CNH) and Hokchi Energy S. A. de C. V. y EyP Hidrocarburos y Servicios.

In compliance with current regulations, the company Hokchi Energy S. A. de C. V. has requested to Universidad Nacional Autónoma de México, through the Institute of Marine Sciences and Limnology, to develop the Environmental Baseline (LBA) in the marine and coastal zone of the Hokchi oil block area and identify possible Preexisting Damages (environmental liabilities), prior to the development of oil activities to be carried out by the aforementioned company.

The marine study area has been defined as the area delimited by the same Hokchi area, in addition to the adjacent marine areas, up to 3 km north, east and west, and 15 km south. Likewise, based on the possible migration of pollutants from the drilling area of the four delineation wells due to marine currents, it is considered a coastal zone of environmental influence that ranges from the city of Frontera, Tabasco to Coatzacoalcos, Veracruz.

It is necessary to emphasize that the results obtained from the visits to the study area and their interpretation reflect the prevailing conditions in the area, only during the month of February 2016, and that most of the environmental factors discussed here present a variation throughout the different climatic seasons.

In addition to conducting a bibliographic research on the environmental aspects of the marine and coastal areas studied, an oceanographic cruise was carried out on board the B/O Justo Sierra, which in the first stage carried out a bathymetric survey and in the second stage,samples of water, sediment and organisms were collected, as well as information on some parameters that can be collected in the field. Visits were also made to the coastal zone of environmental influence by three groups of academics to demonstrate the current state of the nesting areas of sea turtles and mangroves, as well as for the diagnosis and analysis of the social and economic aspects in the region.

The water and sediment samples were characterized in terms of contaminants such as hydrocarbons, nutrients and metals, while the biological samples were identified, quantified, measured and weighed to calculate densities and know their diversity.

The salinity values along the water column show the presence of 2 or 3 water masses, which show the mixture between sea water and water from the continent. The contribution of nutrients (high concentrations according to the respective guidelines in phosphates, nitrates, nitrites and ammonium), leads to the area being considered mesotrophic to eutrophic based on the concentrations of chlorophyll a; as well as organic material that apparently favors a low biodiversity in macrobenthic organisms indicators of organic contamination, probably due to the transport of these materials from the continent.

In general terms, the concentrations of hydrocarbons and metals in water and sediment were at levels that suggest little possibility of toxic damage to the organisms that inhabit the area; however, some sites with concentrations that could cause damage to the biota were observed, according to international reference values.

In the visits to the coastal zone, damage to the beaches was observed due to the lack of vegetation cover that facilitates erosion, and different types of materials impregnated with hydrocarbons were also identified.

Likewise, the presence of two drilled wells was confirmed: Hokchi 1 and Hokchi 101, whose existence was previously recognized and communicated to the CNH through the letter addressed to the Commissioner President of the same CNH, dated April 4, 2016.

Finally, the following Preexisting Damages were identified:

- Oil infrastructure on the seabed consisting of the casing pipes of the Hokchi 1 and Hokchi 101 wells, the presence of which has been shown with indirect information derived from echosounders, seabed profilers and magnetometer, and confirmed by physical inspection of divers.
- Unidentified objects and registered through magnetic information that indicates the presence of foreign objects in the seabed, presumably corresponding to a pipeline, and underwater pipelines or cables.
- Hydrocarbon residues in the Hokchi zone of environmental influence, 200 km of monitored coastline, in the form of rock, rubber and gel with sizes ranging from centimeters to a couple of meters.
- Higher concentrations, in water, than those considered safe for the protection of aquatic life with regard to phosphates, nitrates, nitrites and ammonium according to the Ecological Water Quality Criteria CE-CCA-OOI/001/89.

- Concentrations of metals such as Fe, Zn and Cu, in some of the water sampling points in the Hokchi area, higher than the limits to avoid toxic effects in the organisms that inhabit the Hokchi area according to NOAA Screening Quick Reference Tables (Buchman, 2008).

- Hg concentration in sediments above the threshold to avoid toxic effects on biota at three points, taking as reference NOAA *Screening Quick Reference Tables* (Buchman, 2008).

- Different organic enrichment conditions where the central zone of the Hokchi area is slightly contaminated (Pearson and Rosemberg, 1978).

CHAPTER 1

INTRODUCTION

In 2015, the company Hokchi Energy S.A. de C.V., in consortium with EyP Hidrocarburos y Servicios, S.A. de C.V., was awarded in the corresponding tender to carry out the project that consists of drilling four oil wells in Area 2, Bid 2, and Round 1, hereby called the Hokchi Area and located off the coast of the state of Tabasco. For this reason, on January 7, 2016, Contract No. CNH-ROI -LOI-R01/2015 for the Extraction of Hydrocarbons under the Shared Production modality was signed between the National Hydrocarbons Commission (CNH) and Hokchi Energy S. A. de C. V. y EyP Hidrocarburos y Servicios.

Hokchi, with an approximate area of 40 km, is located in the oil province called Cuencas del Sureste, between the coordinates 2 ^{18} 36' 00.2" and 18 ^{39} 30.0' 93" north latitude and 18 $^{30.0}$ 93' 23" and 29.7^{30} 23' 29.7" west longitude, at a distance of approximately 30 km NW of the city of Paraíso and the port of Dos Bocas, on the coast of Tabasco, Mexico. The depth in this area is approximately 30 m. According to CNH, the Hokchi oil block contains 2P reserves of 61 million barrels of light oil and 29 billion cu ft of gas. In addition, it has been recognized that there are two drilled wells in the area: Hokchi 1 and Hokchi 101 (Figure 1.1), whose presence has been confirmed and communicated to the CNH through the letter addressed to the Commissioner President of the same CNH, dated April 4, 2016, and whose physical inspection is attached in Annex l.

In order to delimit the accumulation of oil and specify the geological interpretation of the area, and design a development plan that maximizes both the final recovery and the economic benefit of the project, four delineation wells will be drilled, each with strategic objectives (Figure 1.2). Drilling and subsequent analysis works will begin in the second half of 2016, with an approximate duration of 18 months. For its drilling, the positioning of a drilling equipment in two defined locations is contemplated, from which all the development wells and injectors in the area will be drilled and operated, if applicable.

According to their result and structural position, the wells will be used as producers or injectors in the field development stage. Likewise, depending on the national development plan and the possible location of the production platforms, the existing Hokchi-l and Hokchi-1 wells are not useful for the oil activities to be developed by the contractor.

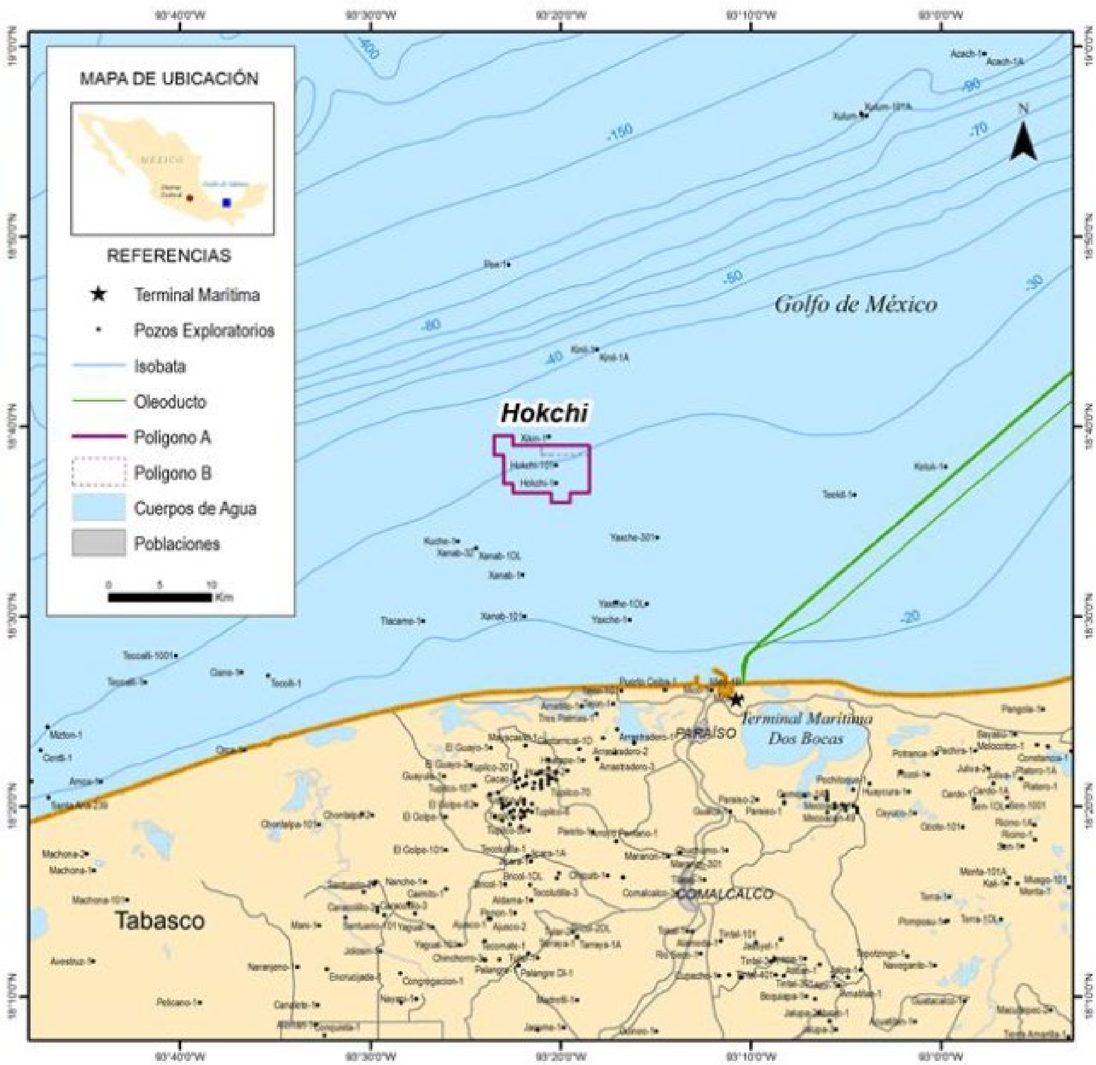

Figure 1.1. Geographic location, towns, states, and wells. Taken from the Hokchi Contract Area Evaluation Plan (Hokchi Energy S. A. de C. V. 2016).

In compliance with current regulations, the company Hokchi Energy S. A. de C. V. has requested to Universidad Nacional Autónoma de México, through the Institute of Marine Sciences and Limnology, to develop the Environmental Baseline (LBA) in the marine and coastal zone of the Hokchi oil block area and identify possible Preexisting Damages (environmental liabilities), prior to the development of oil activities to be carried out by the aforementioned company.

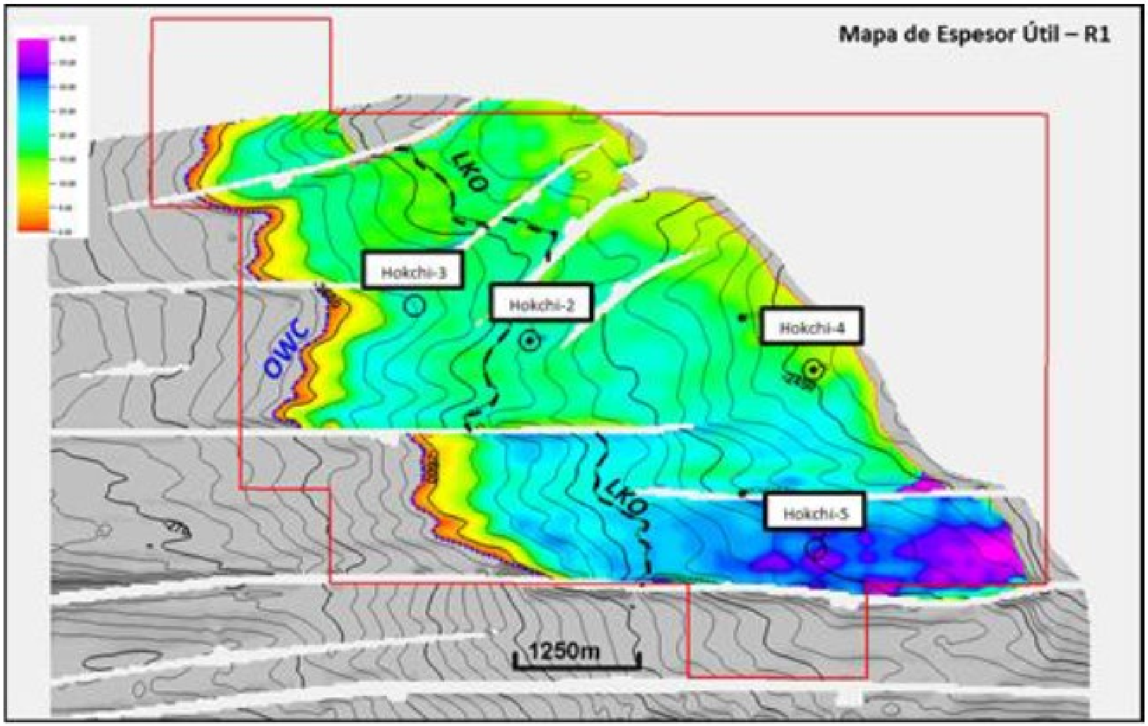

Figure 1.2. Figure 1.2 Position of each of the wells to be drilled. Structural map of the main storage rock R1, superimposed with the distribution of net thicknesses according to the color scale. The black dotted line corresponds to the lowest proven oil (LKO), verified through the Hokchi-1 well, while the blue dotted line represents the fluid contact (OWC), interpreted from the seismic information . Taken from the Hokchi Contract Area Evaluation Plan (Hokchi Energy S. A de C. V. 2016).

The structure of this document consists of eleven chapters according to the Guide to Define the Environmental Baseline prior to the start of the Petroleum Activities and the Environmental Baseline Development Plan, presented to the National Agency for Industrial Safety and Environmental Protection of the Hydrocarbons Sector, better known as the Security, Energy and Environment Agency (ASEA), in January 2016. The first chapter is an introduction where the context of the work carried out is presented. The second chapter describes the scope of the research, as well as the marine and coastal study area of environmental influence. The objective is defined in chapter three and the participating personnel and equipment employed are listed in chapter four.

In chapter five each and every method used in the investigation is described. Reference is made, in the first instance, to the work of data mining in the office, to later describe the field work on board the Oceanographic Vessel "Justo Sierra", covering a geophysical prospecting and taking samples of water, sediment and organisms, as well as that carried out in the coastal zone of environmental influence. Finally, the analytical methods for the study of the parameters required by the ASEA are presented.

The results of the analyzes described in chapter five are shown in chapter six, always following the order stipulated in the aforementioned Guide, while the registration and description of the environmental liabilities identified throughout the investigation for the study area are covered in chapter seven.

Likewise, the following chapters include the list of references (chapter 8), tables (chapter 9), figures (chapter 10) and annexes (chapter 11).

CHAPTER 2

OBJECTIVE

The purpose of all the activities developed is to define the Environmental Baseline (LBA) in the marine and coastal areas of the area corresponding to the Hokchi area, in the state of Tabasco, prior to the start of the oil activities that the Hokchi Energy companies will carry out. S. A. de C. V. and EyP Hidrocarburos y Servicios, as of the second semester of 2016. It is worth mentioning, as already indicated, that the reference framework to achieve this purpose has been the Guide to Define the Environmental Baseline prior to the start of the Petroleum Activities and the Environmental Baseline Development Plan, presented to the same ASEA. It should be noted that the physical and chemical analyzes of water and sediments have been carried out in laboratories accredited by the EMA and authorized by the ASEA and CNH.

Likewise, in the identification of pre-existing damages, both indirect information such as profilers and magnetic information have been used to locate foreign objects on the seabed as physical inspections in the existing wells in the Hokchi 1 and Hokchi 101 area were carried out. The chapter and the corresponding annexes illustrate the findings.

CHAPTER 3

SCOPE AND STUDY AREA

This Environmental Baseline contains bibliographic information on generalities of the study area in terms of meteorological and hydrodynamic factors, bathymetry, information on the biotic environment, ecosystem conservation and social and economic aspects. Likewise, data on bathymetry, water quality and sediments and an evaluation of the plantonic, benthic and fish communities corresponding to samples collected through an oceanographic campaign in the study area in February 2016 are presented. Finally, data are included on coastal wetlands, records of birds, sea turtles and mangroves in the coastal zone between the city of Frontera, Tabasco and Coatzacoalcos, Ver., in order to establish the environmental baseline of the referred area and establish current conditions

In terms of temporality, it is necessary to emphasize that, with the exception of the bibliographic information, the results obtained from the visits to the study area and their interpretation reflect the prevailing conditions in the area, only during the month of February 2016, and that most of the environmental factors discussed here present a variation throughout the different climatic seasons. In this sense, any future study that intends to make an environmental comparison must be carried out at the same time of year, as well as a thorough understanding of the environmental status of the Hokchi area requires monitoring that considers the changes of season.

Regarding the spatial scope, the study area is defined as the area delimited by the Hokchi area itself, in addition to the adjacent marine areas in which samples of water, sediments and organisms were collected and which are shown in the figure 3.1. Likewise, based on the possible migration of pollutants from the drilling area of the four delineation wells due to marine currents, it is considered a coastal area of influence that ranges from the city of Frontera, Tabasco to Coatzacoalcos, Veracruz.

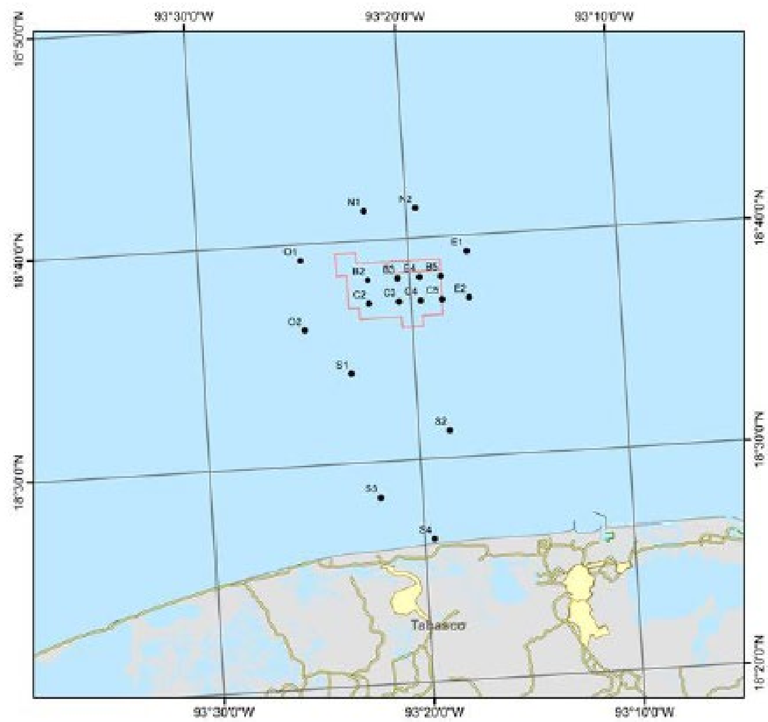

Figure 3.1. Approach to the study area at sea. The red polygon represents the Hokchi area and the points the collection sites.

Figure 3.2. Coastal zone of environmental influence of the activities to be carried out in the Hokchi area.

CHAPTER 4

STAFF AND EQUIPMENT

4.1 Participating staff

<u>Institute of Marine Sciences and Limnology</u>

<u>Institute of Marine Sciences and Limnology</u>

Dr. Carlos René Green Ruiz.- Coordinator

Dra. Rosalba Alonso Rodríguez

M. in C. León Felipe Álvarez Sánchez

Dr. Felipe Amezcua Martínez

M. in C. Raquel Briseño Dueñas

Dr. José Antonio Calderón Pérez

Dr. José Antonio Cruz Barraza

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Dr. Francisco Flores Verdugo

Dr. Samuel Gómez Noguera

Dra. María Nuria Méndez Ubach

Ing. Francisco Ponce Núñez

M. in C. Sergio Rendón Rodríguez

Dr. Martín Federico Soto Jiménez

Dr. Francisco Javier Flores de Santiago

Dr. Leonardo Moroyoqui Rojo

Dr. Erick Cristóbal Oñate González

Dra. Cristina Vega Juárez

Dra. Beatriz Yáñez Rivera

M. in C. Daniela Alvarado Zambrano

M. in C. Claire Coiraton

M. in C. Zaira Lizeth Hernández Inda

M. in C. Víctor Muro Torres

M. in C. Erik Jonathan Navarro Sánchez

M. in C. Guillermo Sánchez Rodríguez

M. in C. Roberto Velázquez Ochoa

Biol. Luis Javier Álvarez Bajo

Biol. Lucía Álvarez Castillo

Biol. Luz Adriana Botero Cobo

Biol. Karen Alejandra Díaz Álvarez

Biol. César Lobato Benítez

Biol. Anaid Muñoz Villafranca

Biol. María Yosahandy Vázquez Molina

Ecol. Mar. Pedro Alberto García Alvarado

IBQ. Raquel María Gutiérrez Tirado

IBQ. Ada Liliana Hernández González

IBQ Carmen Leonor Tripp Quezada

IBT. María Ilzael Castillo Torrecillas

Pas. Biol. Pesq. María de Jesús Ramírez Cervantes

Pas. Biol. Pesq. Allan Rosales Valencia

Pas. Biol. Pesq. Eduardo A. Tirado Alarcón

Institute of Geophysics (Check grades)

Dr. Carlos Modera Gutiérrez

Dr. William L. Bandy

M. in C. Daniel Armando Pérez Calderón

Ing. Miguel Ángel García Palacios

M. in C. Victor M. Ramón Márquez

M. in C. Sandra Valle Hernández

Ing. Geofis. Diego A. Agui lar Anaya

Ing. Geofis. María del Carmen Millán Motolinia

Fis. Elizabeth Andrómeda Pérez González

Fis. Ilzel lzunza Manrique

Ing. Geofis. Pas. José Omar Mateos Rodríguez

Pas. Ing. Geofis. Araceli Sánchez Salazar

Atmospheric Science Center

Dr. Jorge Zavala Hidalgo

M. in C. Lucía Pedraza Díaz

Lic. Argel Ramírez Reyes

Lic. Cuauhtémoc Silva Vega

University Program of Strategies for Sustainability

M. in C. Dalia Elizabeth Ayala Islas

Ing. Antonio Jacintos Nieves

M. in C. Rosalía Camacho Lomelí

Ing. José Luis Gutiérrez Padilla

M. in C. Mireya haz Gispert

QFB. Francisco José Reynoso Arreola

4.2 Equipment

The Institute of Marine Sciences and Limnology of UNAM has four locations (Mexico City, Mazatlán, Puerto Morelos and Ciudad del Carmen) in which it has qualified personnel and specialized laboratories in biology, sedimentology, chemistry, geochemistry and isotopy to perform the analyzes required in this proposal, in addition to having the cybernetic support that allows you to have access to various databases to search for electronic information. Likewise, personnel from the Institute of Geophysics, the Center for the Atmosphere and the University Program of Strategies for Sustainability participated in the preparation of this Environmental Baseline and had the computer equipment and software necessary for bathymetric analyzes, from pollutant dispersion model and analysis of social problems in the coastal area of influence.

In addition, UNAM owns the Justo Sierra Oceanographic Vessel (Figure 4.1), which has been used to carry out the oceanographic campaign. Said vessel, with capacity for 15 crew members and 21 scientists, has a policy that includes P&D (PANDI), with a coverage of US $ 6 million, as well as coverage for hull and machinery. The sampling equipment such as Niskin bottles, CTD, dredge, fish and zooplankton nets and trawl net are the property of UNAM.

Figure 4.1. Justo Sierra Oceanographic Vessel, owned by UNAM.

The water and sediment quality analyzes were carried out through the IDECA S. A. de C. V. and LAQMISA de C. V., authorized by the ASEA, which have the infrastructure required for each analysis according to their techniques accredited by the Mexican Accreditation Entity A. C. (EMA)

CHAPTER 5

METHODOLOGIES

According to the document "Guide to define the Environmental Baseline prior to the start of oil activities", issued by the ASEA, the preparation of this Environmental Baseline was carried out in four stages.

5.1. Cabinet data mining.

This stage consisted of a bibliographic review of the published information and/or available data on the regional and local context of the area, such as: public documents of the National Meteorological Service, the National Commission of Aquaculture and Fisheries, Secretary of Tourism, Secretary of Health, Ministry of Communications and Transport, CONABIO, ICML-UNINMAR, Applicable Marine and/or Coastal Ecological Planning Programs, research project reports, articles in specialized magazines, INEGI Statistical Yearbooks of Tabasco and Veracruz, etc.

5.1.1 Climate and meteorology

Meteorological records were obtained from the stations of the National Meteorological Service of the coastal region of Tabasco, with emphasis on station 27034 "Paraíso" (located 30 km SE of the Hokchi oil block), and information was obtained on the following parameters.

- Average annual temperature

- average monthly temperature

- mean annual rainfall

- average monthly rainfall

- relative humidity (monthly and yearly)

- annual average evaporation

- annual average cloudiness

- annual average cloudiness extreme events (cyclones, hurricanes, storms and tropical depressions, north winds)

- prevailing winds

- speed and direction of winds

- atmospheric pressure

5.1.2 Hydrodynamics and bathymetry.

As a result of various research projects, UNAM and other research institutions have generated and published information related to the hydrodynamics and bathymetry of the Gulf of Mexico. A search was made of the works that correspond to the Hokchi area and the adjacent environmental influence coast, in relation to:

- waves
- Ocean currents
- tides

5.1.3 Biotic Environment.

As a result of various research projects, UNAM, CONABIO and other research institutions have generated and published information on the flora and fauna existing on the coasts of the Gulf of Mexico. A search of bibliographic information related to the Hokchi area and the adjacent environmental influence coast was carried out in relation to:

-Composition and distribution of the terrestrial and aquatic communities of wetland, phytoplankton and zooplanktonic ecosystems in the area.

-Location, distribution, diversity and abundance of the flora and fauna species that make up the existing ecosystems, emphasizing those species that are in some category of protection and of ecological importance (national and international).

-Areas where contingencies can be generated on the population, its assets and/or the environment, including priority regions for conservation and environmentally sensitive sites.

-Migration routes of marine mammals and birds, seagrass beds, coastal dunes, turtle nesting beaches, protected natural areas, and coral reefs, protected areas, priority sites for the conservation of marine biodiversity, Important Areas for the Conservation of the Birds (AICAS), Priority Regions.

5.1.4 Identification of existing infrastructure and archaeological heritage.

The cabinet information was obtained for the coastal zone of environmental influence, which considers an initial analysis in the municipalities of Paraíso, Frontera in the state of Tabasco, and Coatzacoalcos in Veracruz.

The data in the first instance were those published by official sources of the Mexican government, giving priority to the 2010 Population Census and the 2014 Economic Census of the INEGI, as well as the historical data required from this same source. In this first instance of data mining in the office and due to the economic characteristics of the area of environmental influence, information from SAGARPA was consulted, specifically on the activities of fisheries and other relevant primary sector activities in the area.

In the second part of the search for cabinet data, the indices and indicators built by national and international institutions for the area of influence related to the analysis aspects (identification of existing infrastructure and archaeological heritage) were considered,Among which are consulted: degree of marginalization, marginalization index, human development index, competitiveness index, mainly.

The third consultation of cabinet data was in national and international social and economic research publications, which had studies up to five years old in the area of influence.

5.2. Field sampling development in the marine zone of the Hokchi area

In order to expand direct knowledge in the field about the Hokchi area and its vicinity to establish the environmental baseline prior to the oil activities that the company Hokchi SA de C. V. carried out in the Hokchi area, it was necessary to carry out field work that consisted of an oceanographic campaign aboard the Justo Sierra Oceanographic Vessel, which was called Hokchi I and consisted of three stages:

5.2.1 Stage 1.- Bathymetric survey

The first stage of the oceanographic campaign was carried out between February 6 and 10, 2016, according to the Campaign Plan of Stage 1 (Annex 2) and multibeam bathymetry, acoustic backscatter and high resolution seismic data were recorded using the echosounder systems on board the B/O Justo Sierra. Both Kongsberg EM300 30 kHz and EM3002 300 kHz multibeam echosounders were used in multibeam bathymetry and acoustic backscatter intensity measurements at the seabed surface.

Simultaneously, high resolution seismic data were obtained using the Kongsberg parametric echosounder (penetration or also referred to as subbottom profiler), model TOPAS PS18. The work logs for this stage are presented in Annex 2 and a complete report of the multibeam bathymetric survey is presented in Annex 2.

The positioning and movement of the boat are obtained using a differential GPS system, Seapath 200 from Konsberg/Seatex with a movement reference unit, MRU5. This system provides an integrated solution of position and reference of angular movements of the ship.

Figure 5.1 shows the course of the Hokchi I campaign in the Hokchi area. Prior to surveying the area, a preliminary echosounder was carried out in order to calibrate both multi-beam echosounders in a small area, located 22 km from the Hokchi area. Also a vertical profile of the speed of sound in the water column was acquired to be used during the hydroacoustic measurements in the block.

The hydrographic data survey in the Hokchi block has 93 lines oriented East - West, with a separation of 75 m, giving 100% coverage of the seabed with a 20% overlap between sweeps. Also 5 lines, oriented North South, were acquired as closure lines, which additionally serve as a quality control in the correlation between the high resolution seismic profiles. The data survey was carried out at an average speed of 6 knots (3 m/s).

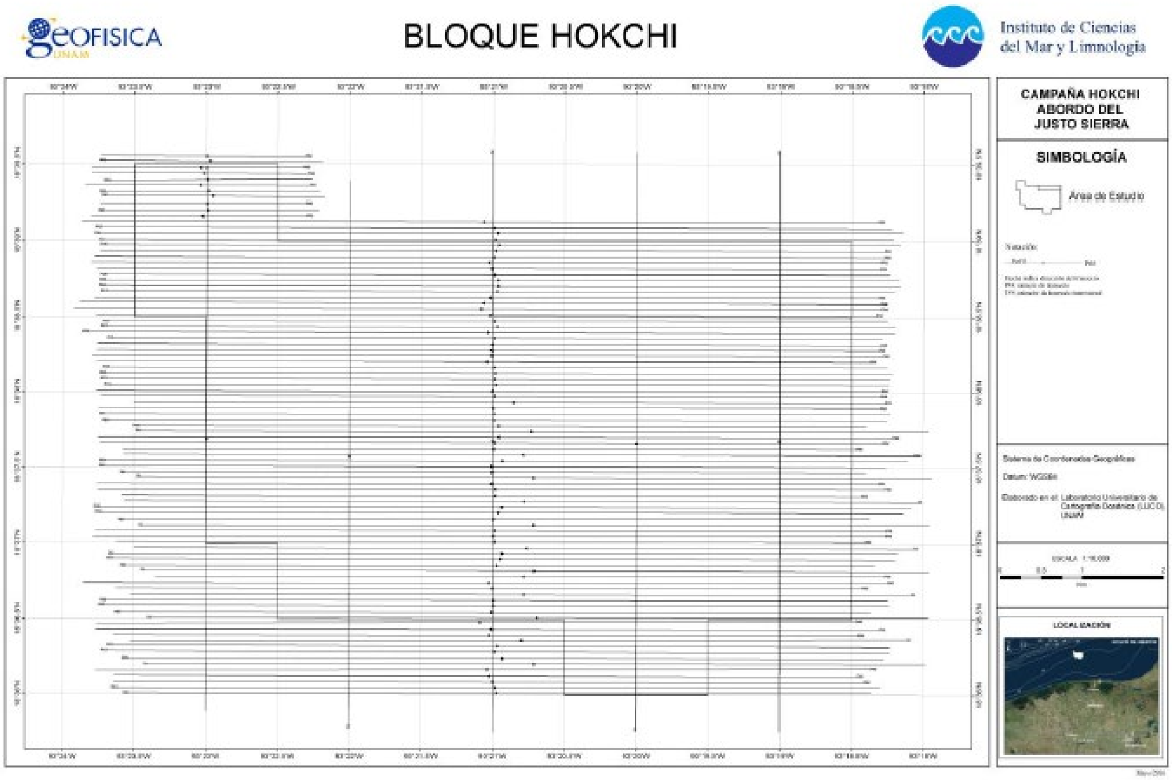


Figure 5.1. Hokchi-l hydroacoustic survey in the Hokchi area.

Of the 93 profiles in Figure 5.1, oriented in an East - West direction or vice versa, 82 of them have lengths of almost 10.5 km, covering an area of 64,785 km^2; the remaining 11 have an average length of 3.2 km and cover an area of 2.56 km^2. The five lines oriented north south and vice versa in Figure 5.1 that were used for the closure between seismic profiles, have an average length of 7.9 km and in the lengths of 93 $^{23.0}$ 93 ' W, 22.0 ^{93} 21.0' W, 93 $^{20.0}$ 93 .19.0' W, 93^0 20.0' w and 93 ^{0} 19.0' W.

Due to the existence of two exploratory wells drilled by PEMEX, named Hokchi-1 and Hokchi-1, the decision was made to carry out more detailed surveys of the seabed relief in both areas with the two multi-beam echosounders, EM300 and EM3002. For these two areas, three profiles with a north-south direction were made along 2.6 km and 25 m apart, at a speed of 4 knots.

5.2.2. Stage 2.- Collection of physical-chemical data and samples of water and sediments

In order to establish the sampling sites of water, sediment and organisms, in a representative way of the Hokchi area, a grid with a 2 km2 mesh was considered, which was superimposed on the polygon of the area (Figure 5.2), and selected 8 sampling sites in the center of internal quadrants 5.1, B2, 84, BS and B3, B4, B5, Cs (Table 5.1). Additionally, samples were taken from 10 sites in the marine area adjacent to the Hokchi area, which were distributed as follows:

- Two sites at a distance of 3 km west of the grid boundary.
- Two sites at a distance of 3 km to the east of the grid boundary.
- Two sites at a distance of 3 km north of the grid boundary.
- Four sites located in a southerly direction between the boundary of the grid and the coastline adjacent to the port of Dos Bocas, Tabasco.

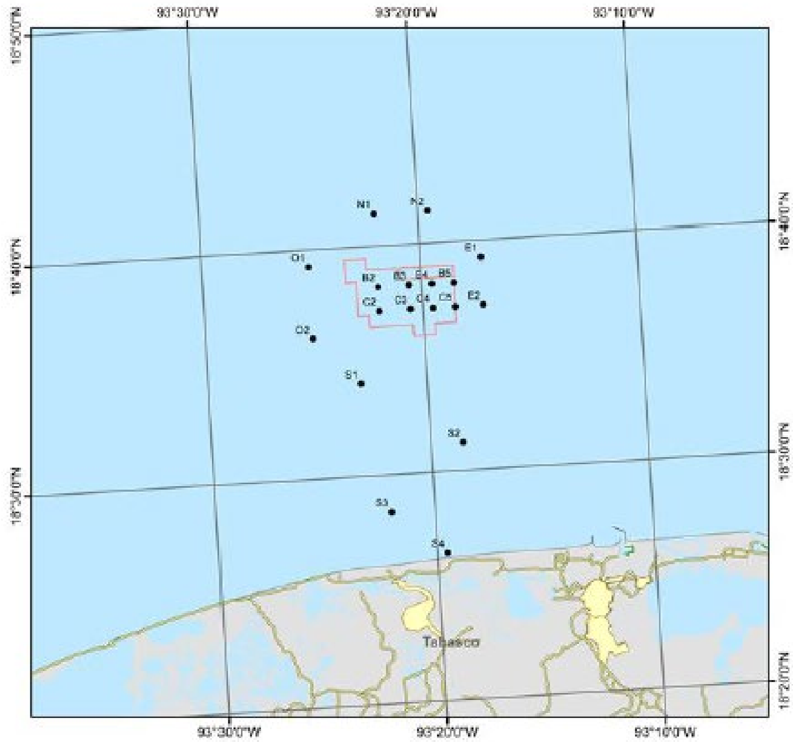


Figure 5.2. Location of sampling sites in the Hokchi area and its vicinity.

Table 5.1. Geographic coordinates of the sampling sites.

Sampling site code	North latitude	West longitude
B2	18° 38' 23.5"	93° 22' 01.0"
B3	18° 38' 23.5"	93° 20" 57.4"
B4	18° 38' 23.5"	93° 19' 54.8"
B5	18° 38' 23.5"	93° 18' 50.6"
C2	18° 37" 18.3"	93° 22' 01.0"
C3	18° 37" 18.3"	93° 20" 57.4"
C4	18° 37" 18.3"	93° 19' 54.8"
C5	18° 37" 18.3"	93° 18' 50.6"
N1	18° 41' 36.5"	93° 22' 01.0"
N2	18° 41' 36.5"	93° 19' 54.8"
O1	18° 39' 28.7"	93° 25' 15.7"

02	18° 36' 13.0"	93° 25' 15.7"
El	18° 39' 28.7"	93° 17" 20.9"
E2	18° 37" 18.3"	93° 17" 20.9"
S1	18° 34' 05.2"	93° 23' 5.2"
S2	18° 31' 24.5"	93° 18' 50.6"
S3	18° 28' 39.1"	93° 22' 01.0"
S4	18° 26' 47.0"	93° 19' 54.8"

Following the Campaign Plan for Stage 2 (Annex 3), at each sampling site we proceeded to:

-Filling in the sample sheet with data such as the sample site code, its geographical coordinates, date and time of the beginning and end of sampling, depth, wave conditions, light, cloud cover, etc. (Annex 4)

-Registration of depth (calculated from pressure), temperature, salinity (calculated from conductivity), dissolved oxygen and fluorescence in the water column, which were carried out with a C TD SEABIRD SBE 9 PLUS.

-Water intake with 4 Niskin bottles of 10 capacity in each of 3 levels (superficial, middle bottom and bottom, Table 5.2), to determine water quality parameters in the laboratory (Figure 5.3). The water samples were stored in plastic or glass containers, according to the analysis of organic compounds (hydrocarbons), nutrients or inorganic compounds (metals) (Annex 5), they were labeled and stored in the fourth freezer of the ship until their analysis at the laboratory. For the study of chlorophylls type a, b and c, 5 liters were collected in 5L polypropylene containers and 2.3 to 5 of water from each sample were filtered on Whatman glass fiber membranes of 47 mm diameter and 0.7 ytm of pore. Each filter was placed in an Eppendorf tube and subjected to freezing (-10 °C to -20 °C) until analysis.

Table 5.2 Surface, middle bottom and bottom sampling depths for each sampling site.

Sampling site	Surface	Middle seabed	Seabed
B2	2.0	12.0	25.0
B3	2.0	13.0	26.5
B4	3.2	12.0	24.0
B5	3.0	11.0	24.0
C2	2.5	10.0	24.0
C3	3.0	12.0	22.0
C4	2.5	10.0	22.0
C5	2.5	10.0	22.0
N1	2.5	20.0	36.0
N2	3.0	20.0	35.0
O1	3.0	18.0	33.0
O2	2.0	11.0	27.0
El	3.5	13.0	26.0
E2	3.0	10.0	22.0
51	2.5	11.0	23.0
S2	2.5	10	16
S3	2.3	9.0	17.0
S4	2.5	11.0	15.0

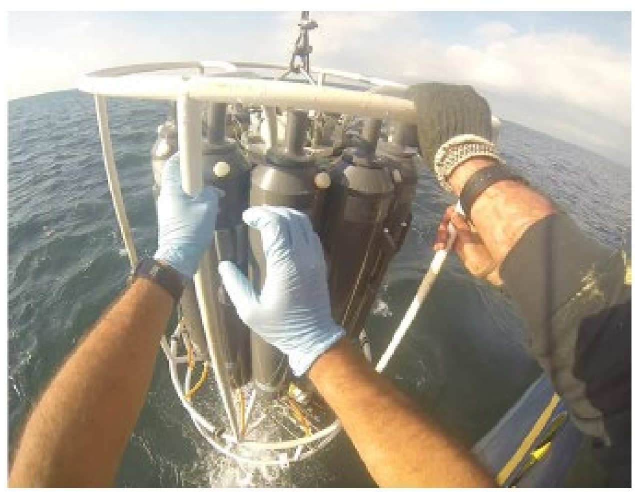


Figure 5.3. Water sampling with Niskin bottles of 10 l capacity each.

Surface sediment collection with a Smith Mclntyre type dredge, recovering the surface 10 cm to the center of the nucleator (avoiding contact with the metal walls), for subsequent geochemical and sedimentological analyzes (Figure 5.4). The samples were collected separately for the analysis of organic compounds (hydrocarbons), in glass bottles and a lid with aluminum foil, nutrients or inorganic (metals) in plastic bottles (Annex 5). The samples were labeled and stored in the ship's fourth freezer until analysis in the laboratory.

The containers required for the preservation, storage and transport of the different samples were provided by IDECA S. A. de C. V., in accordance with Annex 5.

Figure 5.4. Sediment sampling with a Smith Mclntyre dredge,

5.2.3. Stage 3.- Collection of samples of organisms.

Phytoplankton and zooplankton collections were carried out by trawling with specific nets. In the case of phytoplanon sampling, vertical drags were made with a nylon net of 22 micrometers mesh, 30 cm in diameter and 1 m in length. The samples were fixed with concentrated lugol for later analysis in the laboratory.

For zooplankton, oblique trawls were performed with a 0.6 m diameter bongo net, with a mesh size of 300 and 500 pm, equipped with General Oceanic digital flow meters previously calibrated to calculate the volume filtered by the nets, doing trawls of at least 10 minutes, pretending to drag the entire water column from the bottom to the surface at a speed of 1.0 m/sec (Figure 5.5). The collected samples were emptied into 500 cc flasks containing a quantity of formaldehyde that, when diluted in seawater, remained at a concentration of 4% for fixation and subsequent analysis. For this study, samples from the 300 pm mesh were used, so in all cases the mesh size defines the organisms.

Figure 5.5.- Collection of zooplankton with bongo nets.

A subsample was taken from each sediment sample for the analysis of the benthic fauna. For the meiofauna, a subsample was taken with a transparent acrylic tube with an internal diameter of 6.5 cm (33.18 cm2 of sampling area). The acrylic tube was introduced slowly in order not to disturb the sediment subsample. Once inserted, a rubber stopper was placed on the top and back of the acrylic tube to safely remove the subsample. Once extracted, the plugs were removed and the superficial 3 cm of sediment was extracted using an extruder. Each recovered sediment subsample was placed in a glass flask. 96% alcohol stained with rose bengal was added to the sample to facilitate subsequent separation of the organisms.

The rose bengal alcohol sediment sample was homogenized manually so that the entire sample was impregnated with the rose bengal stained alcohol. The necessary information was noted on the outside of the bottle, and in addition, a label of Albanene paper was also placed inside the bottle with the necessary information to identify the origin of the sample and date of collection.

Likewise, subsamples were obtained for the analysis of macrobenthic organisms, both from sediment sampling with the dredge and from shrimp nets. In the case of the dredged sediment, the subsamples consisted of one liter of sediment, which was sieved and preserved with a 4% formaldehyde solution (Figure 5.6), until its analysis in the laboratory.

Figure 5.6. Macrobenthos sampling: first sieving and sample storage

Additionally, 2 80 feet long shrimp trawls were carried out, with a 50 mm line in the terminal cone; 2-inch mesh size and 24 m toprope (Figure 5.7). The operating time of each trawl was 45 minutes at an average ship speed of 2.5 knots. For each trawl, the fish samples were separated and all organisms from each trawl were preserved. They were stored in labeled plastic bags for freezing, and later transferred to the laboratory.

Figure 5.7. Shrimp net cast.

5.3. Development of field sampling in the coastal zone of environmental influence of the Hokchi area

In addition to the Oceanographic Campaign that was carried out to take samples of water, sediment and organisms in the Hokchi area, three groups of specialist professionals made visits to the coastal area of influence, in order to:

a) Identify possible pre-existing environmental impacts on sea turtles and their nesting habitats (beach) and feeding-development (marine zone) and migratory routes of connectivity between these habitats.

b) Characterize the degree of development of mangroves in terms of forest parameters of the lagoon complexes of El Carmen-Pajonal-La Machona and Mecoacán, as a reference to the health status within the coastal strip of the state of Tabasco between Frontera (Usumacinta river) and Tonalá river.

c) Identification of existing infrastructure and archaeological heritage in the field.

5.3.1. Sea turtles

This investigation was organized in four stages described in Figure 5.8.

Figure 5.8. Methodological phases of the sea turtle component.

An on-site prospecting trip was organized from February 8 to 12, 2016 (Annex 6). The extension of the coastline subject to this study has an approximate distance of 200 km (Figure 5.9), and the surface from the Hokchi area was considered as a zone of environmental influence, with the lines crossed towards the coast on the border of Tabasco with Campeche (Rio San Pedro and San Pablo and the line to the Rio Coatzacoalcos, Ver.). For the route along the coast, a 4x4 all-terrain vehicle (quad bike) was used for patrolling on the beach and a pick-up truck for parallel displacement along local roads that connect the towns adjacent to the beach.

Figure 5.9. Environmental Influence Area and Hokchi Area.

Likewise, in the field, a semi-structured survey format was designed and applied, under the premise that this procedure has application in topics that can be investigated by observation method, analysis of documentary sources and other knowledge systems.

20 beach profile records were made according to the method proposed by Andrade and Ferreira (2006) based on the principle of communicating vessels. The field device consists of two graduated stations joined by a 1.5 m long plastic hose that is filled with water. The unevenness of the beach profile is expressed in terms of the displacement of water along the hose. The accumulated difference through the transect determines the topographic variation of the terrain (Figure 5.10).

During the on-site prospecting monitoring, in addition to the survey of the beach profiles, a zoning of the covered beaches was carried out in an east-west direction (Campeche to Veracruz).

Relevant observations of the physical characteristics of the beaches were also added, due to the anthropogenic coastal impacts, which have caused, among other modifications, erosion, loss of coastal dunes, changes in the beach slopes, the dispersion of waste caused by river avenues, accumulation of solid waste product of coastal anthropogenic activity, as well as hydrocarbon waste.

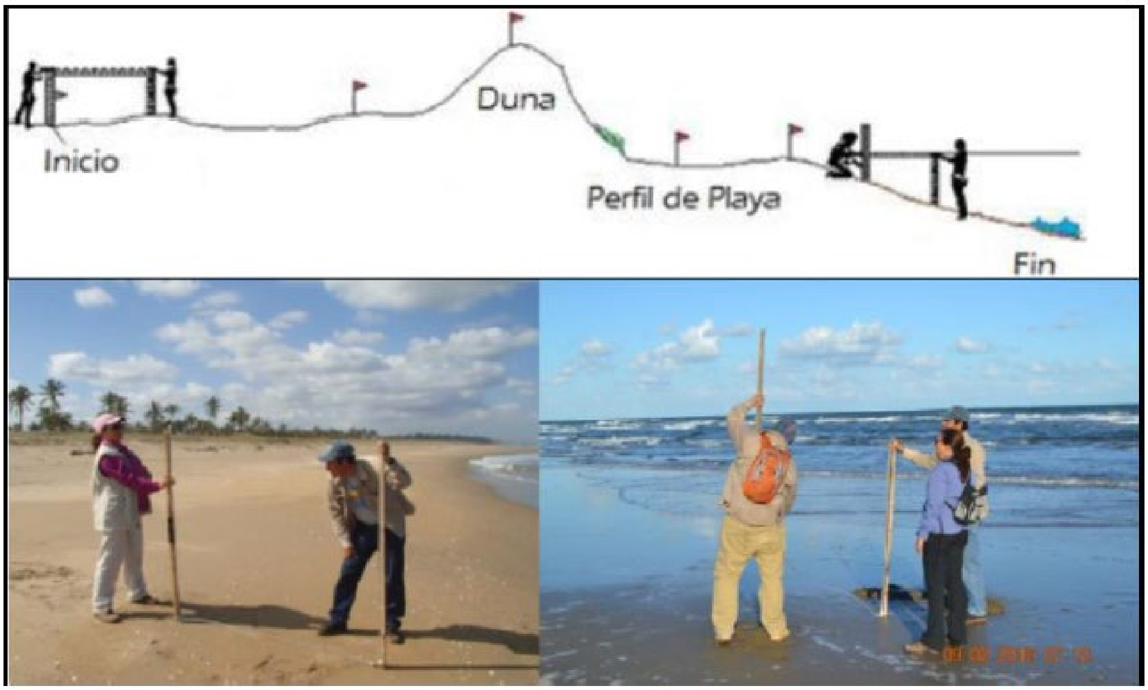


Figure 5.10. Diagram of the methodology to obtain the profiles of the beach with the communicating vessels method. Bottom photos, demonstration of obtaining the beach profile at two sites.

In addition to the documentary information on the vegetation of the dunes and beaches, a photographic survey of the representative species of the prospected site was carried out. A file was generated to identify species or groups found in the Hokchi area of environmental influence in the state of Tabasco and southern Veracruz to be compared with the lists published and consulted for this work.

Additionally, a photographic sample was prepared with the different types of hydrocarbon residues observed during the beach prospecting.

Qualitative annotations were made to define types of residues and persistence by zones, as well as the shapes and size of the hydrocarbon agglomerations found. Likewise, information on this topic was obtained through the interviews conducted during the prospecting of the study site.

5.3.2. Manglar

In order to obtain a classification of the mangrove forest in terms of forest structure, land verification tours were carried out along the hydrological system where the mangroves are located (coastal lagoons, estuaries and tidal veins, marshes, beaches and dunes). The most representative areas of the mangrove forest were selected in the most representative lagoon bodies of the region, such as the El Carmen Pajonal-La Machona and Dos Bocas-Paraíso-Mecoacán wetland complex. The methodology followed for this purpose is described in the "Baseline Study of wetlands distributed in the Coatzacoalcos-Frontera section, Tabasco state (Gulf of Mexico)" (Annex 7).

5.3.3. Identification of existing infrastructure and archaeological heritage in the field.

The field visit for the diagnosis and analysis of the social and economic aspects for the Hokchi Environmental Baseline was carried out from Monday, February 22 to Saturday, February 27, 2016.

Interviews and visits were conducted in the municipal capitals and coastal areas, mainly in the municipalities of Coatzacoalcos, Veracruz, as well as the municipalities of Cárdenas, Paraíso and Centla in Tabasco. The foregoing, because these municipalities are considered within the Environmental Baseline, as a zone of social and economic influence of the activities that the company will carry out. A. de C. V.

Interviews were conducted with municipal authorities of the four municipalities, as well as with Cooperative Fisheries, Ostricultural Societies and the general population. In the four municipalities, qualitative techniques were applied such as open and semi-structured interviews, as well as non-participant observation, with the aim of knowing the perception of the different communities on the impacts of oil projects in the region on fishing, tourism, the population indigenous.

A visit was made to the Pantanos de Centla Protected Natural Area, in the company of the tourism coordinator in the municipality. During this visit, the indigenous population of the region was interviewed.

5.4. Laboratory analysis

5.4.1. Water and sediment

In addition to being measured in the field, with the help of a CTD, salinity and turbidity were measured again in the accredited laboratory (IDECA S. A. de C. V.), using potentiometric techniques. The same accredited laboratory quantified the pH, using a potentiometer, and the content of total suspended solids (SS T), with the method of evaporation and calcination (Annex 8).

The accredited laboratory IDECA S. A. de C. V also performed the analysis of hydrocarbons, nutrients, heavy metals and chlorophylls a, b and c in water samples, and of organic carbon, organic matter, oxidation-reduction potential, granulometry, heavy metals and hydrocarbons in the sediment samples. The analytical techniques used, as well as the detection limits of the quantification method and practice, are presented in Annex 8.

It should be remembered that, in compliance with the Guide to Define the Environmental Baseline prior to the start of oil activities, which establishes that the analyzes must be carried out by a laboratory accredited by the Mexican Accreditation Entity (EMA), said analyzes were carried out carried out by the accredited laboratory IDECA S. A de C. V. together with Laboratorio de Química del Medio Industrial S. A. de C. V. (LAQMISA).

The accreditations by the EMA for both laboratories are presented in Annex 9. The water and sediment samples for said analyzes were delivered to the IDECA S. A. de C. V., in Mexico City (Annex 10).

5.4.2. Biota

Phytoplankton samples were observed under an inverted microscope at 200X in Utermohl cameras (Reguera et al., 2011). Dilutions were made according to abundance and all cells found in the sedimentation chamber were identified and counted. Photographs of the microalgae were taken under a microscope at 200X. The identification of phytoplankton was carried out with general literature and with publications on phytoplankton taxonomy from the Gulf of Mexico.

The biomass or total abundance (cells/^{m3}) was estimated by calculating the volume of the cylinder, considering the radius of the network and the height of the water column.

Each of the zooplankton samples was washed with abundant water to remove formaldehyde, each of the different groups present in the sample were separated, identified and quantified. To quantify the organisms present in each sample, first, the largest and least abundant organisms were separated, and in the case of the smallest and generally more abundant, the sample was divided successively, as many times as necessary, using the Folsom separator.. In all cases, the separation was carried out using a magnifying glass with light, and later the identification was carried out using stereoscopic or compound microscopes, as proposed by Smith (1977) and Boltovskoy (1999).

To determine the composition of the benthic macrofauna, the sediment samples were washed in the laboratory and sieved with a 0.5 mm mesh. All the sediment retained in the mesh was checked under a magnifying glass to separate the organisms contained in the sample and these were preserved in 70% ethyl alcohol. Organisms were reviewed under a LEICA S6E stereomicroscope and, when necessary, an OLYMPUS CH30 compound. The classifications proposed by Brusca and Brusca (2003) were used for the macrofauna groups and, in the case of the polychaete families, Fauchald (1977) and León-González et al. (2009). Additionally, some specimens of macrofauna organisms were obtained from the trawl nets, which were separated, measured, weighed and taxonomically identified.

To study the benthic meiofauna, once in the laboratory, each sample was sieved through 500 and 40 pm mesh sieves to separate the macrofauna (material retained on the 500 um sieve) and the meiofauna (material retained on the sieve from 40 um). The meiofauna were separated from the sediment manually by placing the sample in a checkered petri dish. The collected organisms were placed in 1 ml glass vials with 96% ethyl alcohol, until their subsequent analysis and quantification. Each group of meiofauna collected in each sampling site was quantified and its density was expressed in individuals/10 cm^2. In the case of annelids, polychaetes and oligochaetes, which break very easily, only the counting of the heads or the back was considered only at each site, that is, for each head or each back one organism was counted (Annex 11).

Regarding shrimp net trawls, fish were identified at the species level, measured (total length) with an actinometer to the nearest millimeter and weighed on a digital scale (01-2000 g) at 0.1 g. closest. With these measurements, matrices are generated from databases that include information on the station, depth and environmental parameters of salinity and temperature. With these matrices, descriptive and inferential statistical analyzes will be carried out (Annex 12).

CHAPTER 6

RESULTS AND DISCUSSION

6.1. Climate and meteorology

The climate of Tabasco is warm with maritime influence because it is located in the tropical zone with little elevation with respect to the mean sea level. The influence of the sea is notorious because it is found on the southern margin of the Gulf of Mexico, and with its scarce variability of relief, where the altitude is not exceeded 100 m, it allows the direct flow of the wind from the sea (INEGI, 2001).

6.1.1 Temperature

Towards the coastal zone, the climate is characterized by being warm humid with abundant rains in summer (INEGI, 2009). The thermal regime of the area oscillates on an annual average between 24 and 28 ° C. According to the records of the National Meteorological Service station 27034 "Paraíso", the lowest average annual temperature in the last five years was 26.2 ° C and corresponds to the year 2014; while the highest annual mean temperature was 27.4 ° C, which occurred in 2011 (Figure 6.1). The lowest monthly average (23.0 $^{29.2}$ C) occurred in January; on the contrary, the highest monthly average (6.2 ^{0} C) occurred in May (Figure 6.2). The maps of the distribution of the mean temperature by year show that in the Hokchi area the estimated average temperature varies between 26.6 and 27.4 ° C (Annex 13) in the last 5 years, and the monthly temperature maps show the temperatures lowest during January and highest during May (Annex 14).

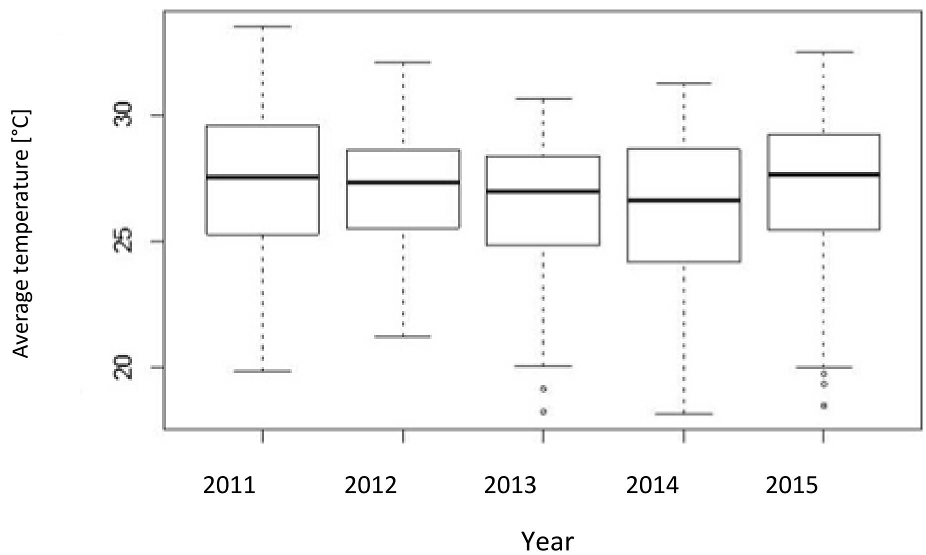


Figure 6.1. Average annual temperature of the meteorological station 27034 "Paraíso".

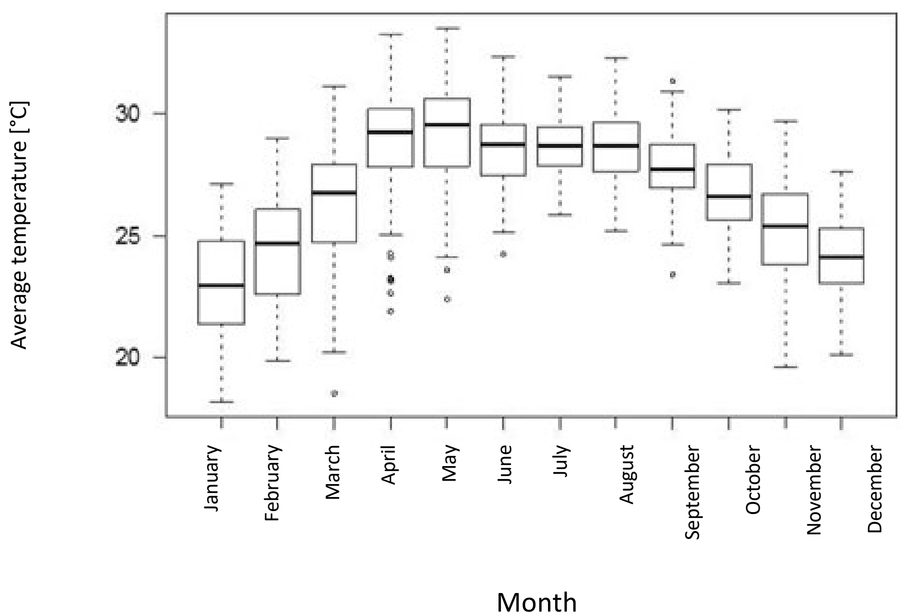


Figure 6.2. Average monthly temperature of the meteorological station 27034 "Paraíso".

6.1.2. 6.1.2 Precipitation

The maritime wind has as a consequence the high rainfall that is registered in the state, mainly in the rainy season that extends from June to October, with two maximum monthly averages in June and October (220.5 and 371.6 mm per month, respectively) .

In subsequent months, there are drizzles derived from the cold fronts that occur in the region, their occurrence on average 20 to 25 times per year. The dry season occurs between March and April, where the average precipitation drops to 40 mm in total per month (SMN, 2016).

The National Meteorological Service (SMN) indicates that the maximum annual average precipitation in the last 5 years (7 mm/d) occurred in 2013 (Figure 6.3), and in 2010 the lowest annual average value was calculated (4 mm/d). The maximum mean value of monthly precipitation occurs in October with 10.8 mrWd (Figure 6.4), while the minimum value occurs in April with 1.4 mm/d.

The rainfall maps indicate that the estimated annual average rainfall for the Hokchi Area ranges from 4 to 7 mm / d (Annex 15), and the maximum estimated monthly average is presented in October with averages of up to 11.0 mm / d and the lower estimated average. it was obtained in April with 1.0 mm / d (Annex 16).

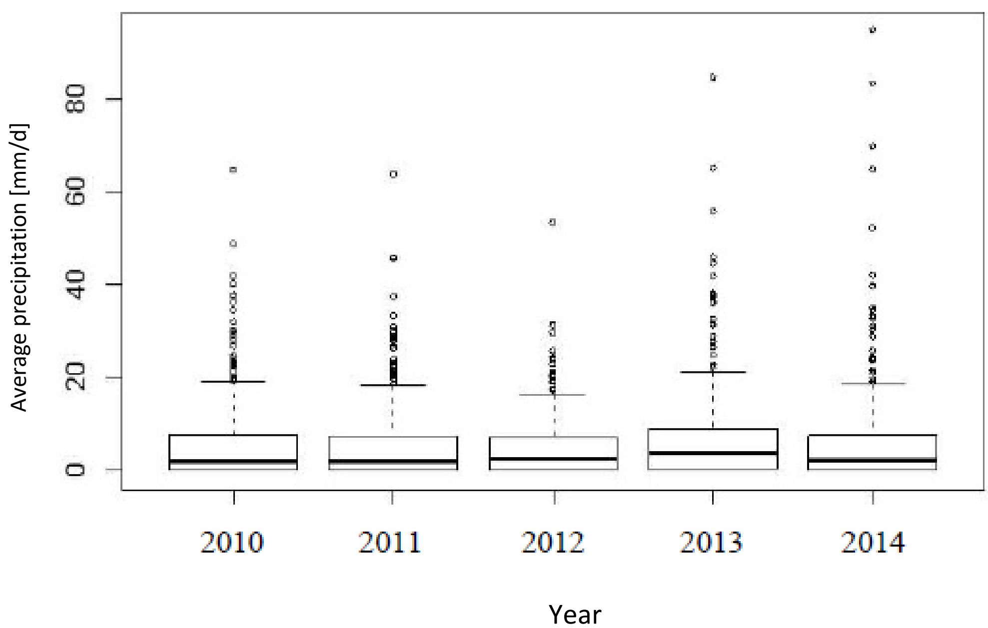


Figure 6.3. Average annual precipitation of the meteorological station 27034 “Paraíso”.

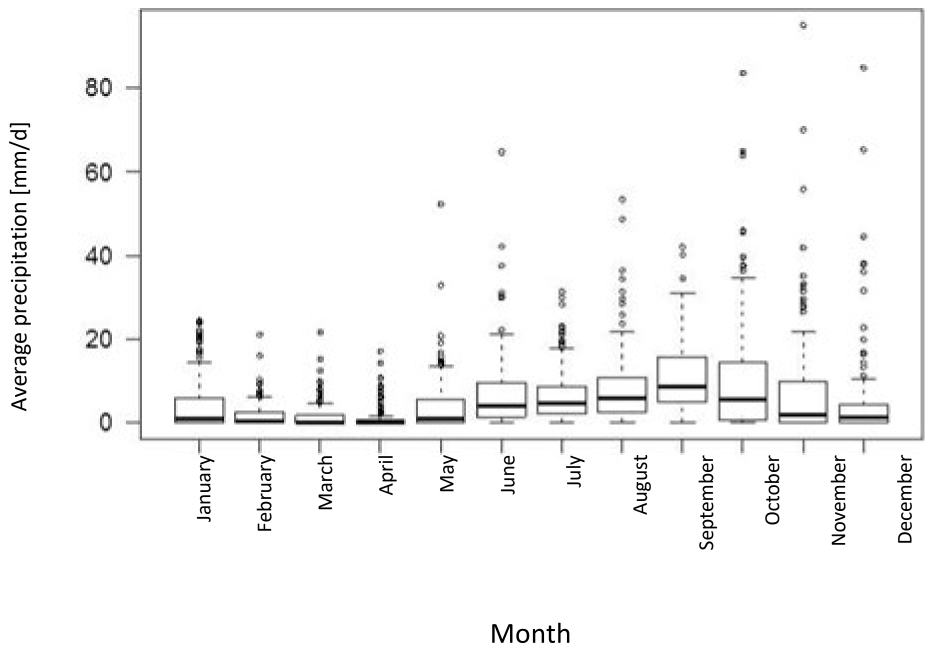


Figure 6.4. Average monthly precipitation of the meteorological station 27034 "Paraíso".

6.1.3. 6.1.3 Relative humidity

The presence of the maritime wind, near the coast, causes the relative humidity to remain in an interval of 75.5 - 78.3% of annual average in the "Paraíso" meteorological station (Figure 6.5). In the monthly analysis it found that in April the lowest average relative humidity (69.5 [83/9)] occurs, unlike January where the highest average relative humidity (6.6%) (Figure 6.6) is presented.

In the estimated distribution maps, a variability between 74 to 76% of annual relative humidity is observed between 2011 and 2015. Analyzing the monthly behavior, estimated values are observed from 68% (April) to 79% of relative humidity (January, September and December) (Annexes 17 and 18).

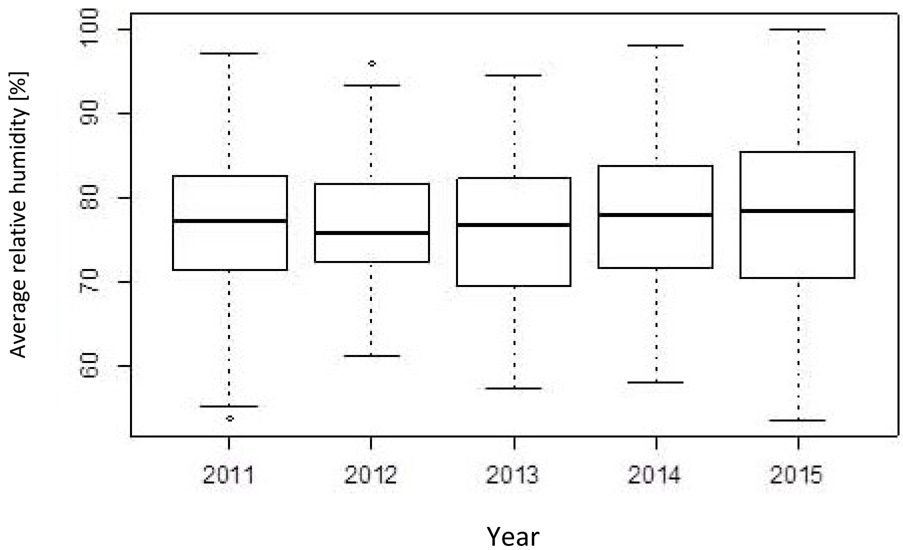


Figure 6.5. Average annual relative humidity of the meteorological station 27034 "Paraíso".

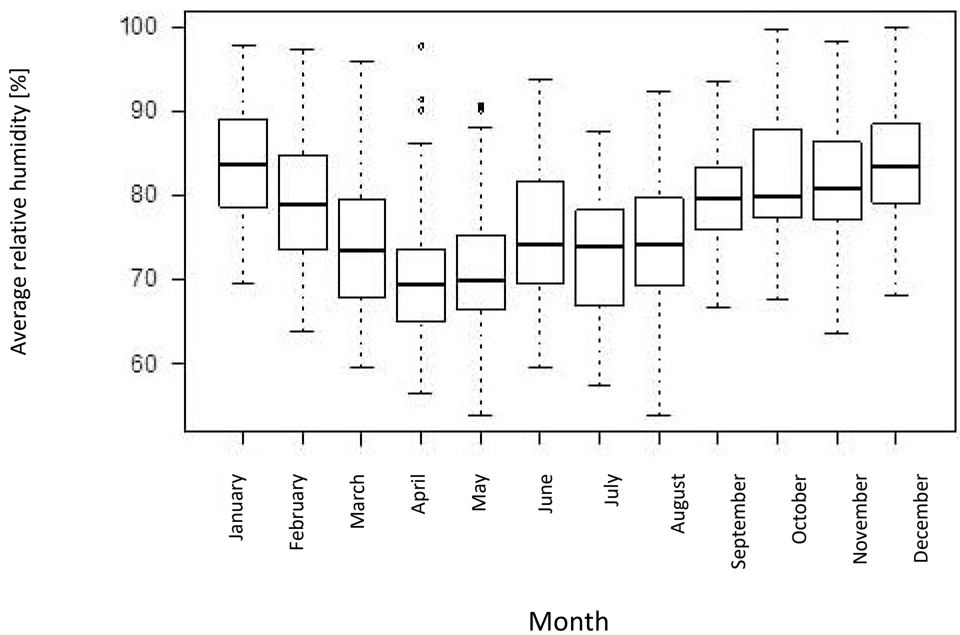


Figure 6.6. Average monthly relative humidity of the meteorological station 27034 "Paraíso".

6.1.4. 6.1.4 Evaporation

Actual evapotranspiration is the amount of water, expressed in mm, that is effectively evaporated from the soil surface and is transpired by the vegetation cover.

The real mean annual evapotranspiration, according to the Turc method (1961) with the data from 543 stations in a 35-year period (1945 - 1980), indicates that the annual mean value in the coastal region of the Paraíso municipality is 1400 to 1500 mm (Annex 19). Towards the east and west of the municipality of Paraíso, the average real evapotranspiration decreases (1300 - 1400 mm). To the south of the municipality and towards the state of Chiapas, evapotranspiration is even higher, being greater than 1500 mm.

6.1.5. Cloudiness

The cloud cover information is provided as a proportion of cloud cover, which is defined as the portion of the surface covered by clouds in relation to the surface that has no cover. The cloudiness ratio is derived from a 1 km resolution cloud mask. This mask was generated from the Earth's radiance and reflectance measurements recorded by the MODIS mission aboard the Terra and Aqua satellites.

According to the annual average cloudiness maps (Annex 20), cloud cover varies from 40 to 50% over the study area. In the monthly analysis the variability is 30% in April up to 60% cloud cover in January and September (Annex 21).

6.1.6. Extreme events

A total of 41 extreme meteorological events were registered in the study area (Table 6.1), in the period from 1867 to 2013. Of the events recorded, 18 were tropical depressions, 13 tropical storms and 3 category 1 hurricanes, while seven events did not have a category assigned (NOAA, 2016) (Annex

Table 6.1. Extreme weather events in the Hokchi area

Serial number	Season	Number	Name	Winds (kn)	Pressure	Category
1867200N19268	1867	2	Nameless	No data	No data	Without category
1876200N16293	1876	1	Nameless	No data	No data	Without category
1879254N14300	1879	8	Nameless	No data	No data	Without category
1880254N19267	1880	11	Nameless	No data	No data	Without category
1883260N19280	1883	8	Nameless	No data	No data	Without category
1891278N12277	1891	9	Nameless	No data	No data	Without category
1892267N17277	1892	9	Nameless	No data	No data	Without category
1898300N18299	1898	16	Nameless	30	0	Tropical depression
1902172N17268	1902	2	Nameless	30	0	Tropical depression
1902276N14266	1902	1	Nameless	60	0	Tropical storm
1922284N12285	1922	4	Nameless	45	0	Tropical storm
1922284N12285	1922	4	Nameless	70	0	70 Hurricane Category 1
1924170N18275	1924	1	Nameless	30	0	Tropical depression
1924170N18275	1924	1	Nameless	35	0	Tropical storm
1931223N14299	1931	3	Nameless	50	0	Tropical storm
1931252N15307	1931	7	Nameless	65	0	70 Hurricane Category 1
1932253N19267	1932	6	Nameless	35	0	Tropical storm
1935242N21274	1935	4	Nameless	50	0	Tropical storm
1936254N19266	1936	14	Nameless	25	0	Tropical depression
1936284N20269	1936	16	Nameless	35	0	Tropical storm
1941267N14300	1941	4	Nameless	30	0	Tropical depression
1941267N14300	1941	4	Nameless	40	0	Tropical storm
1942215N16275	1942	1	Nameless	30	0	Tropical depression
1944263N19276	1944	8	Nameless	60	0	Tropical storm
1944263N19276	1944	8	Nameless	70	0	70 Hurricane Category 1
1960174N19266	1960	1	Nameless	15	0	Tropical depression
1960192N13304	1960	2	Abby	25	No data	Tropical depression
1969290N17275	1969	26	Laurie	30	1006	Tropical depression
1980265N15283	1980	13	Hermine	60	993	Tropical storm
1989167N21266	1989	1	Nameless	25	0	Tropical depression
1998295N12284	1998	13	Mtch	20	1003	Tropical depression
1999277N20266	1999	11	Nameless	30	0	Tropical depression
2003271N19275	2003	17	Larry	50	997	Tropical storm
2007244N12303	2007	6	Felix	20	1007	Tropical depression
2008280N19268	2008	13	Framework	30	1005	Tropical depression
2008280N19268	2008	13	Framework	40	1002	Tropical storm
2011231N15278	2011	8	Harvey	30	1005	Tropical depression
2012215N12313	2012	5	Ernesto	60	992	Tropical storm
2012223N14317	2012	7	Helene	25	1011	Tropical depression
2013149N14264	2013	2	Barbara	30	1001	Tropical depression
2013167N12279	2013	2	Barry	30	1007	Tropical depression

Tropical Cyclones

The area under study can be considered as low risk due to the impact of tropical cyclones (Annex 22B), with a maximum probability of 20% of impact from category 1 hurricanes (Annex 22C) and 10% from category 2 hurricanes (Annex 22D) (CENAPRED, 2010a and 2010b). At the municipal level, the risk of impact from this type of meteorological event is "low" in the municipality of Centla and "very low" in the rest of the state of Tabasco (CENAPRED, 201 2012a) (Anexo22B).

Floods

Tabasco is a state with large floodplains that has historically been one of the regions that has suffered the most damage as a result of hydro-meteorological phenomena (Table 6.2), with historical flood records since 1579 (Álvarez and Tuñón, 2016). A more recent example of the above is the flood in October 2007, when in 17 municipalities of the state, about 62% of the territory was covered by water, leaving about 75% of the population affected in 679 localities due to a combination of natural elements (rainfall, runoff, hydrogeological characteristics, tides and the El Niño phenomenon) and anthropic (changes in land use and inadequate management of dams) (Perevochtchikova and Lezama, 2010).

In the continental zone adjacent to the Hokchi area, there are 1,591 km ^{2} of flooded areas, most of them in the municipalities of Centro and Huimanguillo. The municipalities of Centla, Paraíso, Comalcalco, Jalpa de Méndez, Cárdenas, Nacajuca, Cunduacán, Huimanguillo, Teapa and Macuspana present a "medium" vulnerability to flooding, while the Centro municipality presents a "high" index (CENAPRED, 2007) (Annex 22E).

Table 6.2. Historical floods in the state of Tabasco.

Year	Reference to the flood registered in the state of Tabasco
1782	Flood of Santa Rosa
1820	Big flood
1868	Continuous rains
1879	800 houses flooded
1886	Level: 13.71 msnm
1888	Ciclón inunda Villahermosa
1889	Flooded houses (155), dead and ships missing
1909	2,953 affected
1912	The Grijalva river overflows
1936	The Grijalva river overflows
1944	River and lagoons overflow
1955	Ciclón Janet
1969	The Grijalva river overflows
1973	The Grijalva river overflows
1980	Historical rainfall
1995	Cyclones Opal and Roxanne
1999	Overflow of us in the vicinity of Villahermosa due to the conjunction of hydrometeorological phenomena
2007	El Niño phenomenon and tropical cyclone Barbara
2008	Continuous rains
2010	Continuous rainfall and tropical cyclones Karl and Mathew

Droughts

The presence of drought episodes in the state of Tabasco is not a recurrent phenomenon and the precipitation indices tend to present normal conditions over time (SEMARNAT and CONAGUA, 2014). The distribution of rainfall for the period 1961-2010 has a minimum anomaly of 0.21%, with an annual increase rate of 2016 mm/year (Rivera-Hernández et al., 0). However, the presence of El Niño and La Niña climatic phenomena have a direct effect on the state's climatology, since dry periods are more noticeable during both phenomena, with a decrease in rainfall of 27% with the presence of El Niño and 36% with the presence of La Niña, while the wet period presents an increase in rainfall of 0.5% during El Niño and 8% during La Niña (Pereyra-Díaz et al., 2004).

The risk of drought by municipality in the continental area near the Hokchi area is consistent with the information cited above, since the municipalities of Centro, Nacajuca, Huimanguillo, Paraíso, Comalcalco, Cárdenas, Teapa, Jalapa, Cetla, Tlacotalpa and Macuspana present a "very low" irrigation of drought, while in the municipalities of Cunduacán and Jalpa de Méndez the risk is "low" (CENAPRED, 2012b) (Annex 22F).

6.1.7. Winds

According to the meteorological station located at the Carlos Rovirosa Pérez International Airport (MMVA, according to ICAO code), located 84 km southwest of the Hokchi area, the winds, in their annual averages, come from the East steadily (close to the 40% occurrence), with few variations coming from the Northeast and Southeast, and with an intensity that on average varies annually between 4.64 and 3.68 m / s (Figure 6.7).

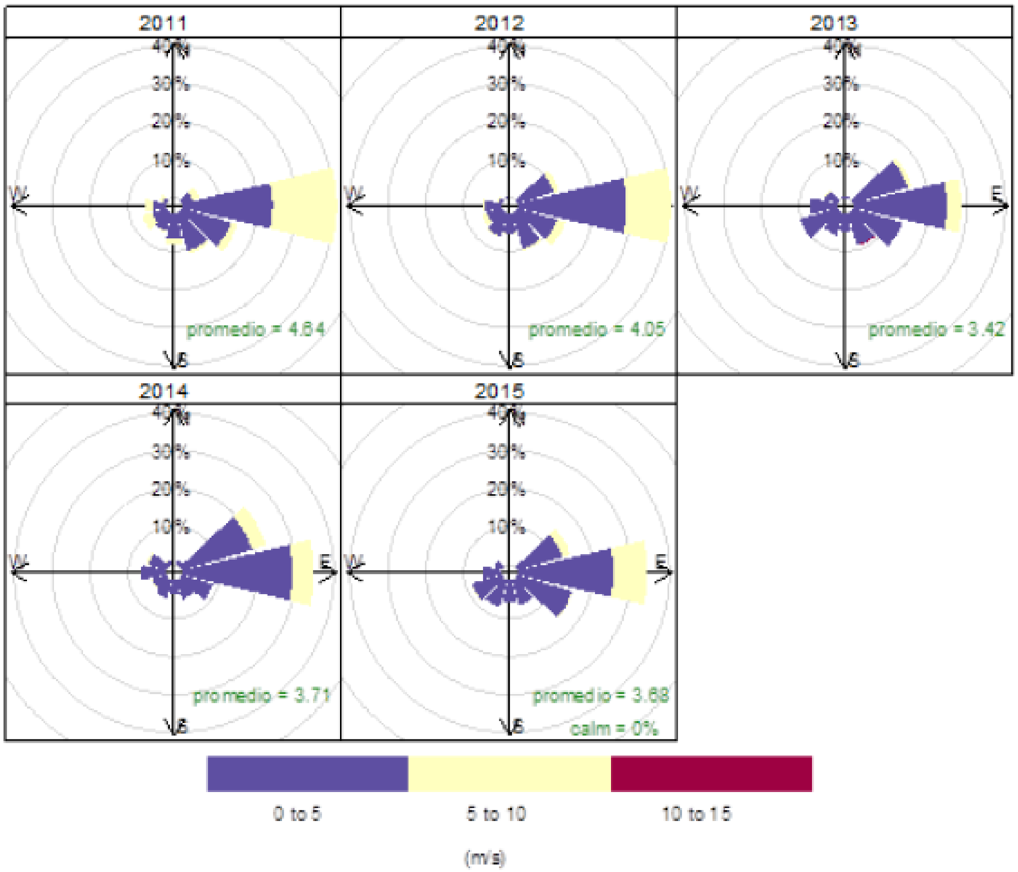


Figure 6.7. Compass rose for the annual average at MMVA airport

In the analysis of the monthly wind averages, it is observed that the prevailing wind in all the months comes from the East; However, the intensity of the winds varies throughout the year, being the months of June and July where they appear on average with greater intensity (4.21 to 4.44 m / s), unlike the months of September to January in where the variations are from (3.52 to 3.85 m / s) (Figure 6.8).

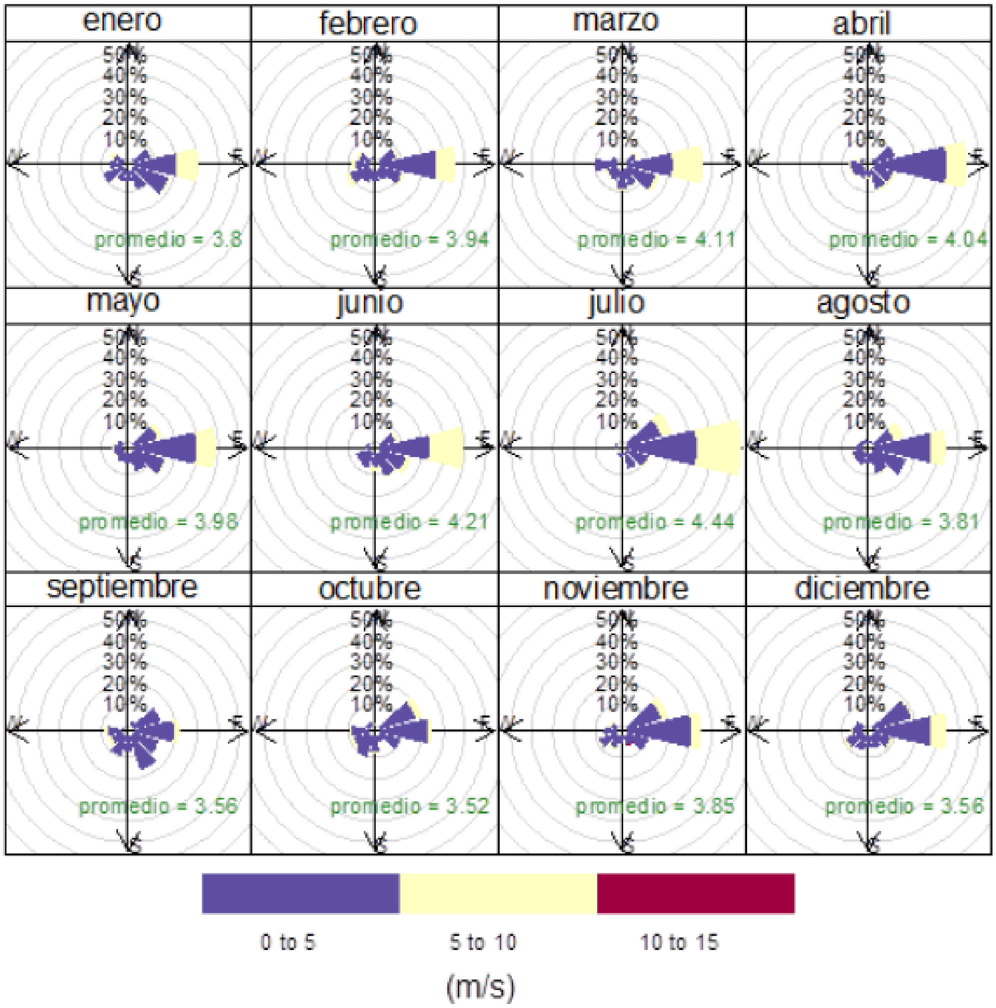


Figure 6.8. Wind rose for the monthly average at MMVA airport

6.1.8. atmospheric pressure

The historical atmospheric pressure values were obtained and processed from the data recorded by the meteorological station located at the Carlos Rovirosa Pérez International Airport.The measurements made by the airport pressure sensor were standardized according to the mean level of sea level. to obtain the standardized barometric pressure.

This processing ensures that pressure variations at the site are due to weather conditions, without depending on the actual altitude where the sensor is located.

The annual average of standardized barometric pressure ranges from 1011 7.1014 to 6.9 hPa, indicating mild low pressure conditions for most of the year (Figure 0.9).

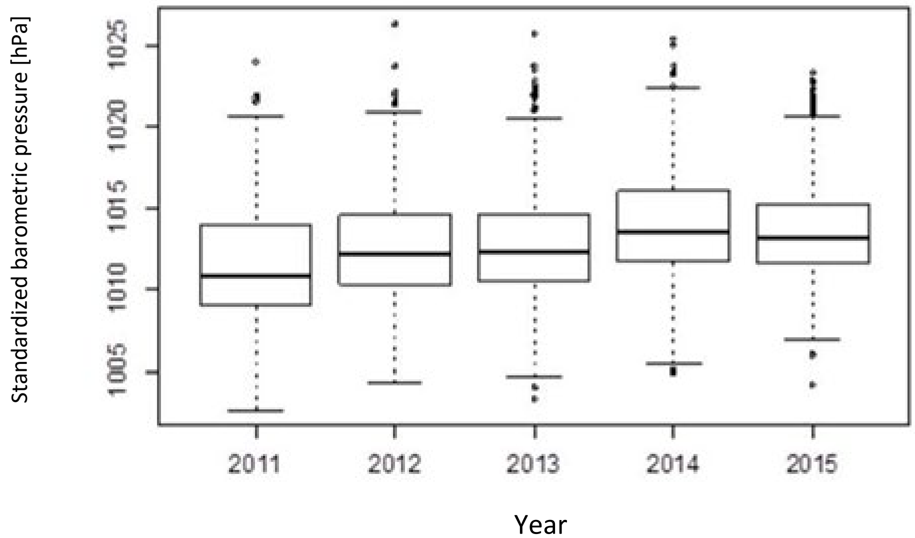


Figure 6.9. Annual average of standardized barometric pressure at MMVA airport

The monthly average (Figure 6.10) indicates that in the months of April to October there are low pressure conditions (1010.5 - 1012.4 hPa), unlike the months of November to February when there are slight high pressure conditions (1014.4 - 1016.7 hPa).

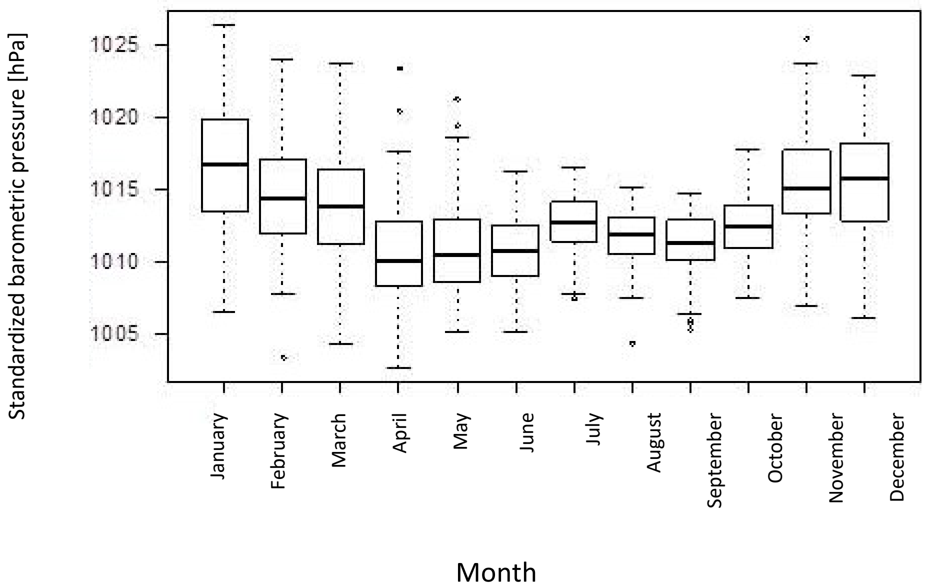


Figure 6.10. Monthly average of standardized barometric pressure at MMVA airport

6.2. Hydrodynamics and bathymetry

6.2.1. Ocean currents

The circulation of water masses in the Gulf of Mexico is determined by two semi-permanent characteristics: (1) the Lazo current in the eastern part, and (2) an anticyclonic circulation cell on the western border (Nowlin and McLellan, 1967 in Martínez-López and Pares-Sierra, 1998). The Loop Current moves from the Caribbean Sea to the Gulf of Mexico with an estimated water volume of 29-33 Sv (1Sv = 10^6 m^3 / s), while the anticyclonic cell moves into the Gulf of Mexico volumes between 8 -10 sV (Vidal et al., 1992 in Hérnandez-Aguilera, 2013). In addition to the Loop Current, there is another very intense current, known as the "West Border Current" or "Mexican Current", to the north on the west coast of the Gulf of Mexico, which is generated by the variation of the force of Coriolis with latitude, winds, and flow of water masses through the Yucatan Channel.

This current is generated by the detachment of an anticyclonic gyre of the Loop Current that moves towards the west and that disintegrates when it comes into contact with the continental slope, generating smaller cyclonic and anticyclonic gyres and that gives rise to the mass of Common Water of the Gulf (Monreal-Gómez et al., 2004) (Figure 6. 11)

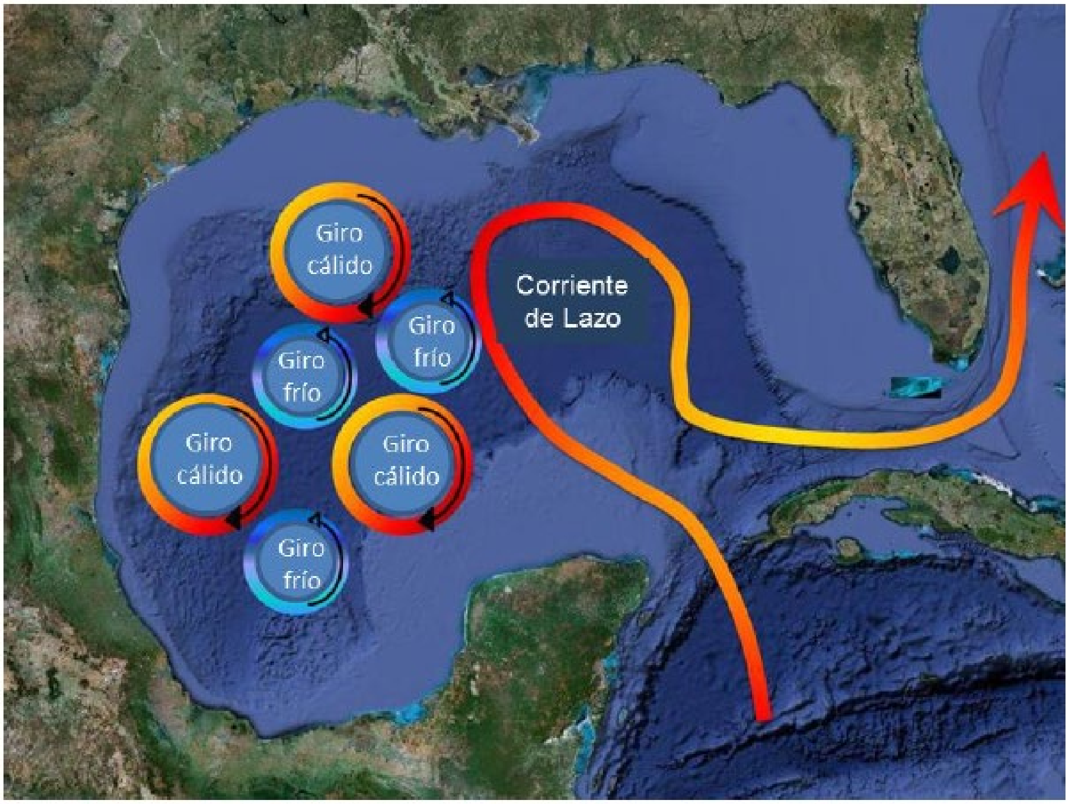


Figure 6.11. Lazo Current in the Gulf of Mexico. Taken from http://texaspelagics.com/gom-info/gom-loop/ , accessed May 26, 2016.

The Bay of Campeche, adjacent to the Hokchi area, is an area where cyclonic gyres commonly occur with diameters of approximately 150 km and speeds between 30-40 cm / s, generated by the cyclonic rotational of the wind effort, the encounter of anticyclonic gyres with the slope, the formation of the great anticyclonic gyre and the geometry of the coastline. It is also influenced by an intrusion current that is directed towards the south and the topography of the Campeche canyon, which favors the formation of turns due to the vertical movement of the water, along its axis (Monreal-Gómez et al., 2004).

In addition to the above, it should be mentioned that in the continental shelf zone (up to 200 m deep) of the Yucatan peninsula and the Bank of Campeche, surface currents move throughout the year in an east-west direction (Zavala -Hidalgo et al., 2003) since they respond directly to changes in the force and direction of the winds, being then the component of the force of the wind along the coast the parameter that defines in a greater way the dynamics of surface marine currents in the Hokchi area (Carrillo et al., 2007).

The average annual circulation pattern on the sea surface, where Hokchi is located, for the period 2010-2015 (Annex 23), has a very well defined pattern, with currents that come from the Yucatan Channel, moving in an east-west direction. and that run parallel to the coastline (Table 6.3), which coincides with the current dynamics reported by Zavala-Hidalgo et al. 2003 In the Hokchi area, currents that are more than 15 km from the coast begin to move north in a clockwise direction (anticyclone) while the currents closer to the mainland follow their course parallel to the line of coast. Towards the west, approximately 40 km from Hokchi, there is a cyclonic turn that ends up moving towards the northwest, on the coasts of Veracruz. In general, the highest current velocities (0.12-0.17 m / s) are recorded to the east (10-80 km away) from Hokchi and the lowest (0.003-0.04 m / s) to the west (27-75 km from distance) from the same, coinciding with that reported by Martínez-López and Pares-Sierra (1998), who indicate speeds of 0.03 m / s to 0.18 m / s-1 in the Bank of Campeche and the coast of Tabasco.

Table 6.3. Annual speeds of ocean currents in the southern portion of the Gulf of Mexico.

Year	Minimum V. (m/s)	Maximum V. (m/s)
2011	0.04	0.14
2012	0.02	0.17
2013	0.008	0.12
2014	0.009	0.16

2015	0.003	0.17

The behavior of the marine currents in the Hokchi area throughout the year has a homogeneous behavior, with few changes through the months (Table 6.4, Annex 24). The dynamics is the same as that described for the annual average surface geostrophic velocity, observing a dominant west-east movement, with surface currents that run parallel to the coastline, being the months of February, April, May and December the most stable in this aspect, since there are practically no cyclonic and / or anticyclonic gyres. For the rest of the months, currents less than 15 kilometers from the coast follow their path parallel to it, while those furthest from the continent begin to move northward, generating an anticyclonic turn northeast of the Hokchi field with speeds ranging from 0.03 to 0.27 m / s, this phenomenon being more notable in the months of January, March, June, September, October and November, while it is less noticeable in July and August. In the months of January, March, September and October, the presence of a cyclonic turn of the marine currents west-north of the Hokchi field with speeds of 0.03 to 0.17 m/s) is observed.

Table 6.4. Annual speeds of ocean currents in the southern portion of the Gulf of Mexico.

Month	**Minimum V. (m/s)**	**Maximum V. (m/s)**
January	0.006	0.19
February	0.015	0.46
March	0.002	0.18
April	0.05	0.23
May	0.029	0.27
June	0.004	0.26
July	0.015	0.33
August	0.002	0.27
September	0.009	0.27
October	0.002	0.25
November	0.01	0.28
December	0.02	0.32

The location of the highest speeds of surface currents changes throughout the months of the year, being located east of Hokchi in the months of January, May and August; to the north in the periods from February to April and from September to December); to the west on June and to the east and north in July. In the Hokchi area, the highest speed of currents is during May, running in an east-west direction and registering speeds of 0.22 m/s, while the lowest speed occurs in March, with an east-west direction and speeds of 0.04 m/s.

6.2.2. Pollutant dispersion model

In accordance with the Environmental Baseline Development Plan for the Hokchi oil field authorized by the ASEA, staff from the UNAM Atmospheric Sciences Center developed a pollutant dispersion model, analyzing the circulation and hydrological conditions based on the HYbrid Coordinate Ocean Model (HYCOM) ocean circulation model. The simulation that was analyzed for this study has a horizontal resolution of 1/25 of a degree, which allows modeling both deep-water conditions and those observed on the continental shelf. HYCOM version 2.2 was used, experiment 31.0 (hycom.org), which has an adequate domain of the proposed objectives. The full report is presented in Annex 25. This study focuses on the point located at 93 ^{20} 23.6 '18 "W 38 $^{05.3}$ 6.12'05.3" N, within the Hokchi area (Figure 6.12), which is located on the Bank of Campeche, off the coast of Tabasco. The maximum depth at the reference point is 25 m.

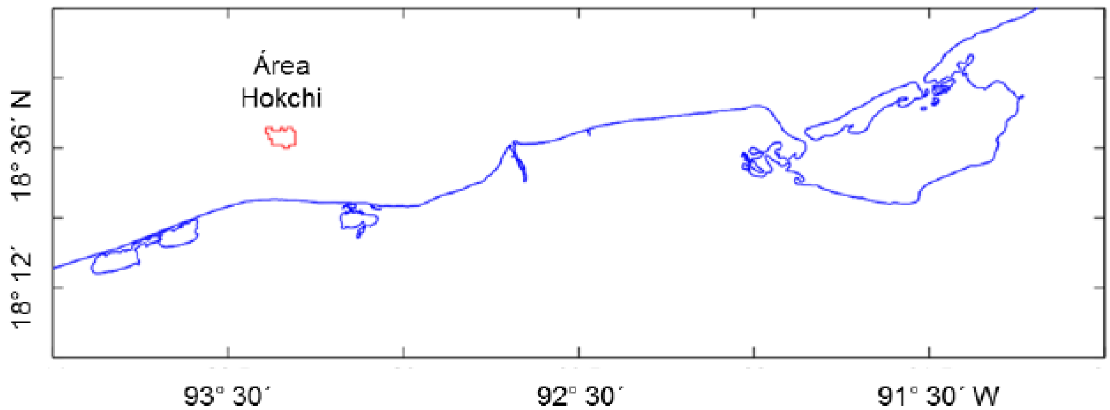


Figure 6.12. Location of the area in the Gulf of Mexico (in red). The coastline is represented by the blue line.

The results obtained with the model show a good indication of the intensity of the expected currents, as well as their causes, their direction and intensity. They also indicate which are the forcings that cause these currents in the region. A general analysis shows the following:

- The predominant currents are zonal, that is, with an east-west direction, in both directions. This is due to its proximity to the coastal area, which restricts currents perpendicular to the coast.

- The modeled currents show that the highest intensities are around 0.6 m/s; however, based on previous studies, these may be underestimated by up to 50%, because the wind forces are not of high frequency.

- The main force causing the currents in this area is the effort of the wind and secondly the waves trapped to the coast.

- The north in the study area are not so important in generating intense currents. This is because this area is located at the southern end of the Gulf where the north winds are not so intense (Osorio-Tai, 2015) and are also perpendicular to the coast. The factor that mainly affects currents in the region is the forcing associated with the impact of tropical cyclones and hurricanes.

- Because the region is very shallow, there is no significant shear in the currents; that is to say. that no situations are observed in which the surface currents have a different direction from the bottom currents in the zonal direction (east-west). In the north-south direction, perpendicular to the coast, shear is observed, associated with surface flows towards the coast (or from the coast) and bottom flows from the coast (or towards the coast). The north-south component indicates that the transport of spills on the surface can be directed towards the coast in a short time, mainly in autumn-winter and in summer associated with the occurrence of tropical cyclones.

- Since the most important currents are due to wind stress, they are generally stronger near the surface.

- The oil spill scenario simulations show that the region is affected by the convergence of currents, coming from the East (along the coast of Campeche) and from the West (along the coast of Tabasco), which generates an offshore flow. It is also observed that, depending on the winds, at times the oil would reach the coasts near the Hokchi region, but not at distant coasts. This shows a very particular behavior of this region.

6.2.3. Bathymetry

As a result of the multibeam bathymetric survey, carried out with the EM300 and EM3002 echosounders, two bathymetric charts (one for the data obtained with each echosounder) of the seabed in the Hokchi area were prepared, which are presented in Annex 2.

The bathymetric chart corresponding to the EM3002 echo sounder is presented below, because it is more sensitive and the required adjustments were made to eliminate the effect of the variation of the sea surface heights (Figure 6.13).

Figure 6.13 shows the bathymetric chart obtained with the EM3002 echo sounder logs. The spatial resolution of the chart has a cell size of 0.25 m due to the angular configuration of the echo sounding and the spacing between beams and between scans, where out-of-range depth values were invalidated.

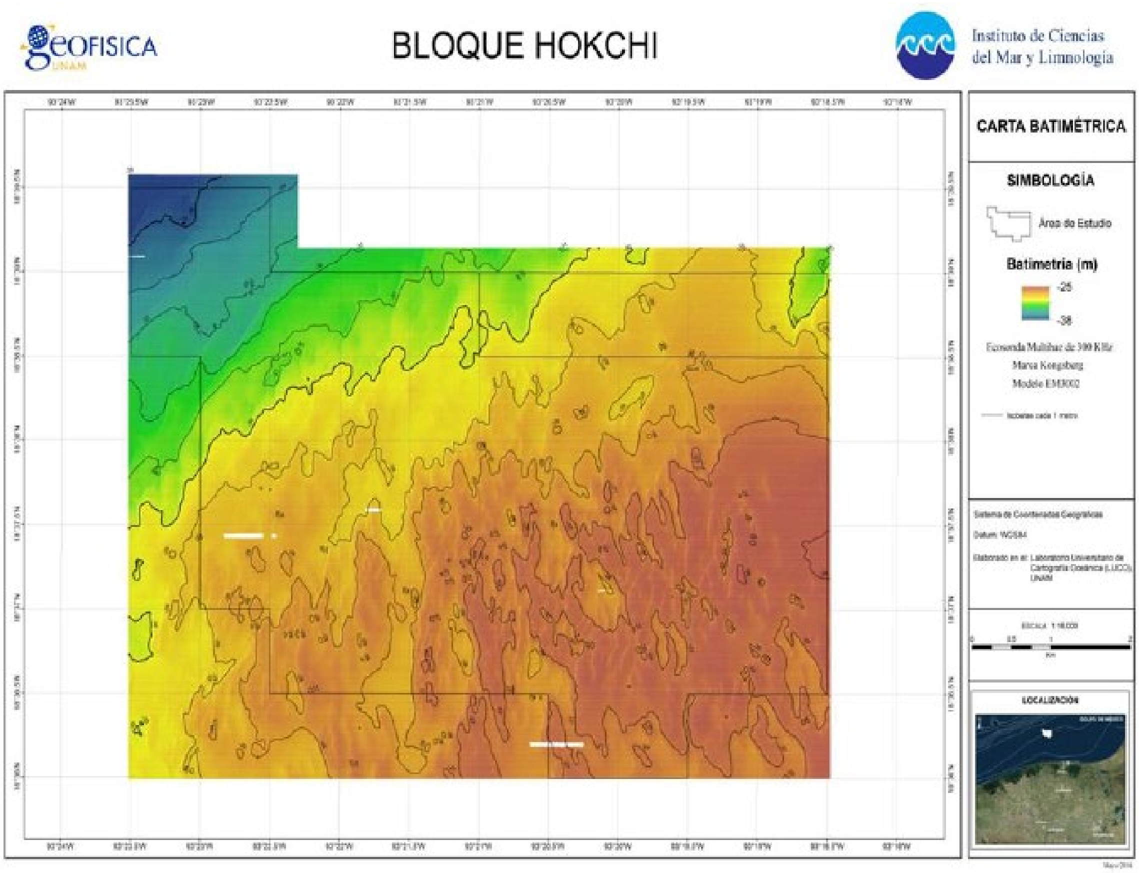


Figure 6.13. Multi-beam bathymetric chart based on data from the EM3002, 300 kHz echo sounder.

The chart shows depths from 23 m to 37 m, the SE sector being the shallowest part. The average depth is between 28 m to 30 m. The depth increases in a NW direction, with an average slope of 0.14%. Also, the letter shows that the slope is greater in the NW sector, approximately 0.2%.

A texture is observed in the bathymetric relief, formed by undulations with North - South orientations. These undulations are associated with the edges of depth jumps. The card also shows another texture in an East - West direction, which corresponds to the direction of the acquisition. This texture is due to the effect of the tide, and causes differences in relief of up to 60 cm between adjacent sweeps.

6.3. Water quality

6.3.1. Salinity, temperature, dissolved oxygen and temperature

Through the use of a CTD, salinity, temperature, dissolved oxygen and fluorescence were measured "in situ" during the oceanographic campaign carried out in February 2016. The values for these four parameters are homogeneous throughout the Hokchi area and in the adjacent marine area sampled (Table 6.5) and are characteristic of marine areas for the time of sampling. The salinity ranged between 32.4 Practical Salinity Units (UPS), on the surface of site 36.2, and 36.2 UPS, at the bottom of the water column at site 01. The temperature ranged from 22.7 to 24.6 ° C, both on the surface (E1 and O1 sites, respectively). This 1.9 ° C difference may be due to the time difference in which the data were collected. Site E1 was sampled at 6 am, while site O1 at 3 pm. Dissolved oxygen ranged from 4.0 ml/l, at the bottom of the SI site, to 5.2 ml/l, at the surface of the 02 site. Regarding fluorescence, in more than 50% of the sampling sites, the values were less than 0.2 mg/l along the water column, which means that there is little suspended material. The S3 site reached a value of 0.8 mg / l.

Obtaining the data of the four parameters by the CTD, allows to elaborate profiles of the values observed throughout the water column. These profiles are presented in Annex 26. As an example, the site profile is shown (Figure 6.14), in which it can be seen that, despite the small oscillations between the values of salinity, temperature, dissolved oxygen and fluorescence, when increasing the scale of the profile, it shows the presence of 2 or 3 bodies of water depending on the sampling site. A superficial layer to a depth that varies between 5 and 10 m with a lower density, with a mixed layer that reached 9 to 15 m, followed by an intermediate layer between said depth (9 to

15 m) and, depending on the sampling site, to the bottom or between 27 and 34 m. At the deepest sample sites, a third layer was observed beyond these last depths. The small changes between the parameters are the result of the mixing of seawater with freshwater contributions from the continent (mainly the Grijalva and Usumacinta rivers).

Table 6.5: Maximum and minimum surface and bottom values of physicochemical parameters obtained by means of the CTO.

	Surface				Seabed			
	Min	Site	Max	Site	Min	Site	Max	Site
Salinity (UPS)	32.4	02	34.6	N1	35.0	S3 S4	36.2	O1
6.1.1 Temperature	22.7	El	24.6	01	23.4	N2 N1 C3 S3	24.5	O1 El

						S4		
O dissolved (ml / l)	4.7	B3	5.2	O2	4.0	S1	4.6	C4
		B4				S2		C3
		E1						O2
		E2						
Fluorescence (mg / 1)	< 0.2	*	0.8	S3	< 0.2	*	0.4	C4
								C3

* More than 50% of the sites had fluorescence values lower than 0.2 mg/l, both on the surface and in the seabed.

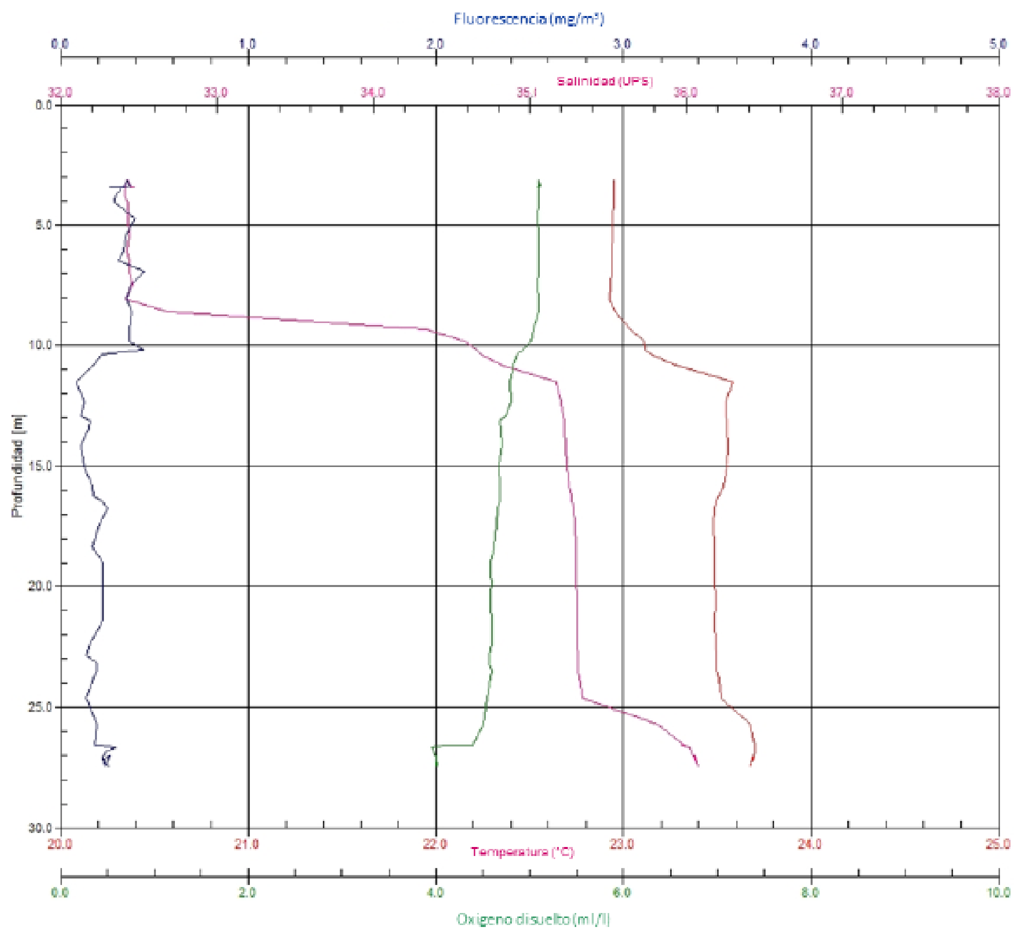


Figure 6.14. Salinity, temperature, dissolved oxygen and fluorescence profile of sampling site 02.

6.3.2. Hydrogen potential (pH), salinity, total suspended solids (TSS) and turbidity

The pH, salinity, total suspended solids and turbidity of the water samples, taken from 3 levels of the water column at each sampling site, were analyzed in the accredited laboratory of IDECA S. A. de C. V. The pH ranged between 8.3 and 8.5, which are normal values for seawater (Table 6.6, Annex 8). Regarding salinity, the values varied between 27.8 and 35.5 UPS, showing a difference with the values obtained "in situ" through the use of a CTD, which did not have any sample manipulation. The lower values obtained in the laboratory may be due to the manipulation of the samples or, where appropriate, to a dilution of seawater by fresh water from the continent.

Salt concentrations on the surface were always lower than those of the seabed samples, as expected due to their lower density. The concentration of total suspended solids ranged from the detection limit of the method used (5 mg/l) to 1 mg/L. No pattern is observed in the behavior of this parameter with respect to the distance from the coast. Turbidity ranged between 0.5 and 6.5 Nephelometric Turbidity Units (NTU), with the highest values in the bottom samples, indicating a possible carry-over and/or re-suspension of fine sediment or organic material at the water-sediment limit level.

Table 6.6. Maximum and minimum values of physicochemical parameters at three levels of the water column, obtained through chemical analysis in the laboratory.

		Minimum	Maximum	Average	Desv. Its T.
pH	Surface	8.3	8.5	8.4	0.0
	Mean	8.4	8.4	8.4	0.0
	Seabed	8.4	8.4	8.4	0.0
Salinity	Surface	27.8	35.5	33.3	2.1
(g/1)	Mean	27.9	36.5	34.2	2.5

	Seabed	31.6	37.5	35.3	1.6
SST	Surface	<5.0	73.0	46.6	15.0
(mg/l)	Mean	< 5.0	87.0	49.5	16.8
	Seabed	9.0	66.0	45.4	16.0
Turbidity	Surface	0.6	5.3	1.4	1.2
(UTN)	Mean	0.5	4.6	1.4	1.2
	Seabed	0.7	6.5	1.9	1.8

6.3.3. Chlorophylls a, b and c

The objective of this section is to determine the trophic condition of the study area by determining the photosynthetic pigments, chlorophyll a, b and c. Chlorophyll a is used as an estimate of phytoplankton biomass and is present in all phytoplankton groups; chlorophylls b and c are accessory pigments present in some groups of phytoplankton.

The practical limit of quantification of chlorophyll a, b and c, is 0.54 mg / m ^{3}. Chlorophyll a concentration at the surface at the sampling sites ranged from <0.54 to 1.53 mg / m ^{3}. Chlorophyll b normally (approximately 90% of cases) presented values lower than 0.54 mg/m • however, at the C3 site it reached a concentration of 3 mg/m. Chlorophyll c followed the same behavior, with a maximum of 1.46 mg/m ^{3}, at site 01 (Table 6.7, Annex 8). In medium water, chlorophyll a appeared between <0.54 mg/m and 3 mg/m $^{3.9}$, chlorophyll b between <3 and 54 mg/m $^{1.27}$ and chlorophyll c from <3 to 0.54 mg/m ^{3} (Figure 6.20). While, in the seabed, the concentration of chlorophyll a appeared in the range of <0.54 to 1.75 mg/m$^{0.54}$; chlorophyll b, from <1.18 to 3.3 mg/m$^{0.83}$ and chlorophyll c from <3 to 0.54 mg/m^{3}

Table 6.7.- Maximum and minimum values of chlorophylls a, b and c in three levels of the water column, obtained by chemical analysis in the laboratory.

		Minimum	Maximum	Average
Chlorophyll a	Surface	< 0.54	1.53	0.92
	Mean	< 0.54	3.90	1.09
	Seabed	0.58	1.98	1.05

Chlorophyll b	Surface	< 0.54	1.51	1.51
	Mean	< 0.54	1.27	1.10
	Seabed	< 0.54	1.18	0.88
Chlorophyll c	Surface	< 0.54	0.62	0.62
	Mean	< 0.54	1.10	0.86
	Seabed	< 0.54	1.46	1.15

* 63.5% of all the values were lower than the detection limit of the method, the average only considers the values above said value.

Productivity refers to the production of organic matter carried out by microalgae through photosynthesis. Regarding productivity, all the chlorophyll concentrations found in this study correspond, according to Tapia and Naranjo (2009), to productive waters. The trophic state of a body of water refers to a state within the eutrophication process, whether natural or anthropogenic. An oligotrophic state (<0.25 mg of chlorophyll a / m^3), is characterized by its low phytoplankton biomass, high water transparency and limited concentration of nutrients and humic substances. On the contrary, a eutrophic state (> 1.0 mg of chlorophyll a / m^3) implies a high algal biomass, reduced water transparency, high nutrient load and low concentration of humic substances. There is an intermediate state between the aforementioned extremes that is defined as a mesotrophic state (0.25 - 1.0 mg of chlorophyll a/m3).

Regarding the trophic state of the study area, using chlorophyll a as an indicator, according to Gaxiola-Castro et al. (2011) the concentrations of chlorophyll a on the surface indicate that the sites B3, C3, C4, S4, N2, C2, SI, NI, S1, 6.15, N1, E2, O1 and El correspond to mesotrophic waters and sites B4, 02, B5 and B2 to eutrophic waters (Figure 6.15).

For the midwater level, the chlorophyll a concentration of sites B3, C4 and C5 correspond to eutrophic waters, the rest of the sampling sites correspond to mesotrophic waters (Figure 6.15).

Finally, applying the same scale and also for chlorophyll a, for bottom waters the sites El, 02, NI, N1, C4, CS, 01, E2 and C5 correspond to mesotrophic waters, and the sites C2, 6.15, S4, B4, B5, S2, 82, SI and C3 correspond to eutrophic waters (Figure 6.15).

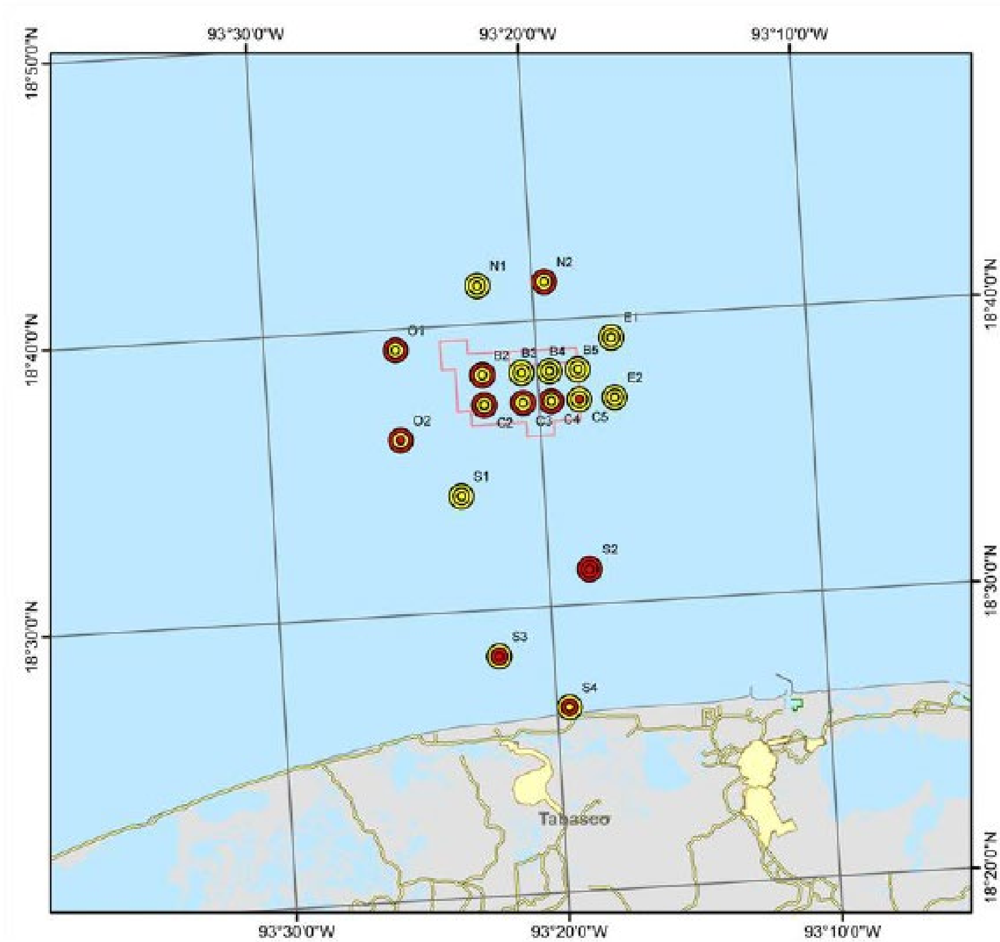


Figure 6.15. Classification of the trophic state in the three levels sampled, according to Lara-Lara et al. (2008), based on the concentration of chlorophyll a (mg / m ^{3}): yellow = mesotrophic, red = eutrophic. External circle: Seabed samples, medium circle = Medium seabed and internal circle = Surface.

The highest concentration of chlorophyll a occurred in midwater within the Hokchi area, followed by the concentrations found in the bottom in 50% of the sampled sites, this condition is related to the thermocline in this area where light penetrates throughout the water column (Signoret et al., 2006).

The oceanic zone of the Gulf of Mexico is recognized as oligotrophic (Lara-Lara et al., 2008); However, the shallow areas near the coast of the State of Tabasco, due to the contribution of fresh water from the fluvial systems, mainly from the Grijalva-Usumacinta system, belong to an area of high primary productivity (Yañez-Arancibia et al., 2007 ; Zetina-Rejón et al., 2015), which is corroborated by the results of the present study, in which the study area was classified according to the concentration of chlorophyll a as predominantly productive and a mesotrophic state (0.20 - 0.50 mg of chlorophyll a / m ^{3}). This trophic condition is corroborated by Manzano-Sarabia et al. (2008), who affirm that during most of the year the continental shelf of Tabasco is mesotrophic and that in autumn-winter conditions are eutrophic, reaching a chlorophyll a concentration of 1.66 mg/m3

The highest concentrations of chlorophyll b were in the C3 site on the surface, NI and N1 in medium water and C4 in the seabed, and indicate the possible presence of chlorophytes. However, in the analysis of phytoplankton in these sites, this type of organisms were not found, only central diatoms, pennates and dinoflagellates. The presence of this pigment may also be due to the presence of pigments from terrestrial plants contributed by river discharges.

At sites B5 (surface), B4 (medium water) and SI (bottom), detectable concentrations of chlorophyll c were found. This pigment is mainly found in diatoms and dinoflagellates. Phytoplankton analysis indicates that these groups dominate the phytoplankton community.

6.3.4. Hydrocarbons

The concentrations of polycyclic aromatic hydrocarbons (PAHs) were determined. monoaromatic (B TEX) and total oil (HTP) by the accredited laboratory IDECA SA de C. V.

In the case of the first two groups, all concentrations were lower than the detection limits of the methods used (Table 6.8, Annex 8), which in turn are lower than the minimum desirable effect level (LOEL, due to its acronym in English), suggested by Buchman (2008).

Table 6.8. Concentration of hydrocarbons in water. Values below the detection limits of the methods used were presented at all sites.

	Concentration (µg/l)	LOEL[1]	
		Acute [2]	Crónica[2]
Monoaromatic Hydrocarbons (BTEX)			
Benzene	0.040	5100	110
Toluene	< 0.045	630	215
Ethylbenzene	0.038	430	25
Xylene (three isomers)	0.039		
Polycyclic Aromatic Hydrocarbons (PAH - s)			
Naphthalene	0.160	2350	14
Acenaphthylene	< 0.050	300	
Acenaphthene	< 0.050	970	40
Fluorene	< 0.060	300	
Phenanthrene	0.052	77	46
Anthracene	< 0.066	300	
Fluoranthene	< 0.060	40	11
Piren	0.052	300	
Berzo (a) anthracene	0.097	300	
Chriseno	0.068	300	
Berzo (b) fluoranthene	0.080	300	
Berzo (k) fluoranthene	0.750	300	
Berzo (a) pyrene	0.123	300	
Indene (1, 2,3-cd) pyrene	0.092	300	
Dibenzo (a, h) anthracene	0.004	300	
Benzo (g, h, i) perylene	0.108	300	

[1] Minimum level of observable effect; [2] Exposure

Regarding the total petroleum hydrocarbons, the concentrations ranged between 0.013 and 0.45 mg/l (Table 6.9). Reference values for toxic effects are not suggested in the National Oceanic and Atmospheric Administration (NOAA) quick reference tables (Buchman 2008).

Table 6.9. Maximum and minimum values of total petroleum hydrocarbons at three levels of the water column (mg/l).

	Minimum	Maximum	Average	Std. Dev.
Surface	0.013	0.045	0.027	0.010
Mean	0.014	0.055	0.030	0.010
Seabed	0.014	0.045	0.029	0.011

6.3.5. Nutrients

Phosphorus (P) is present in coastal waters in dissolved and particulate form, and as an organic and inorganic fraction. In surface marine waters the phosphate concentration is generally very low (<0.031 mg P/l), primarily due to the capture of phosphate by primary producers.

In this work, the total phosphate concentration ranged from 0.011 to 0.081 mg/L, with an average of 1 and a standard deviation of 0.0337 mg/L (Table 0.013). No trend can be seen with respect to latitude (Figure 6.16) or longitude (Figure 6.17). The average levels of nitrites in the different sampled layers do not present significant differences. Although water quality standards have not established a definitive limit, values below 0.002 mg/L are considered safe values for the protection of aquatic life in coastal and marine environments (CECA, 1989). Based on these results, the phosphate concentration levels in this study were between 5.5 and 40 times higher than this reference value.

Table 6.10. Maximum and minimum nutrient values at three levels of the water column (mg/l).

		Minimum	Maximum	Average	Desv. Its T.
Phosphates	Surface	0.03	0.08	0.04	0.02

	Mean	0.01	0.05	0.03	0.01
	Seabed	0.01	0.08	0.03	0.01
N-Nitrates	Surface	0.07	0.26	0.11	0.05
	Mean	0.07	0.18	0.11	0.03
	Seabed	0.07	0.29	0.13	0.07
N-Nitrites	Surface	0.01	0.06	0.04	0.02
	Mean	0.01	0.06	0.04	0.01
	Seabed	0.03	0.07	0.05	0.01
Ammonium	Surface	0.01	0.22	0.11	0.07
	Mean	0.01	0.30	0.12	0.09
	Seabed	0.01	0.33	0.13	0.09

Nitrogen can be present in coastal waters in the form of organic and inorganic species, and in dissolved or particulate form. The sum of all these species makes up the total nitrogen (NT). Dissolved inorganic N (NID) is found as an oxidized species: as nitrates (N3-) and nitrites (NO &) and reduced species: ammonium (NH ^{2} +), ammonia (NH ^{3}) and nitrogen gas (N3). The inorganic forms of N (nitrates, nitrites, and ammonium) are used by primary producers to form amino acids in proteins that are eventually incorporated into the trophic chain.

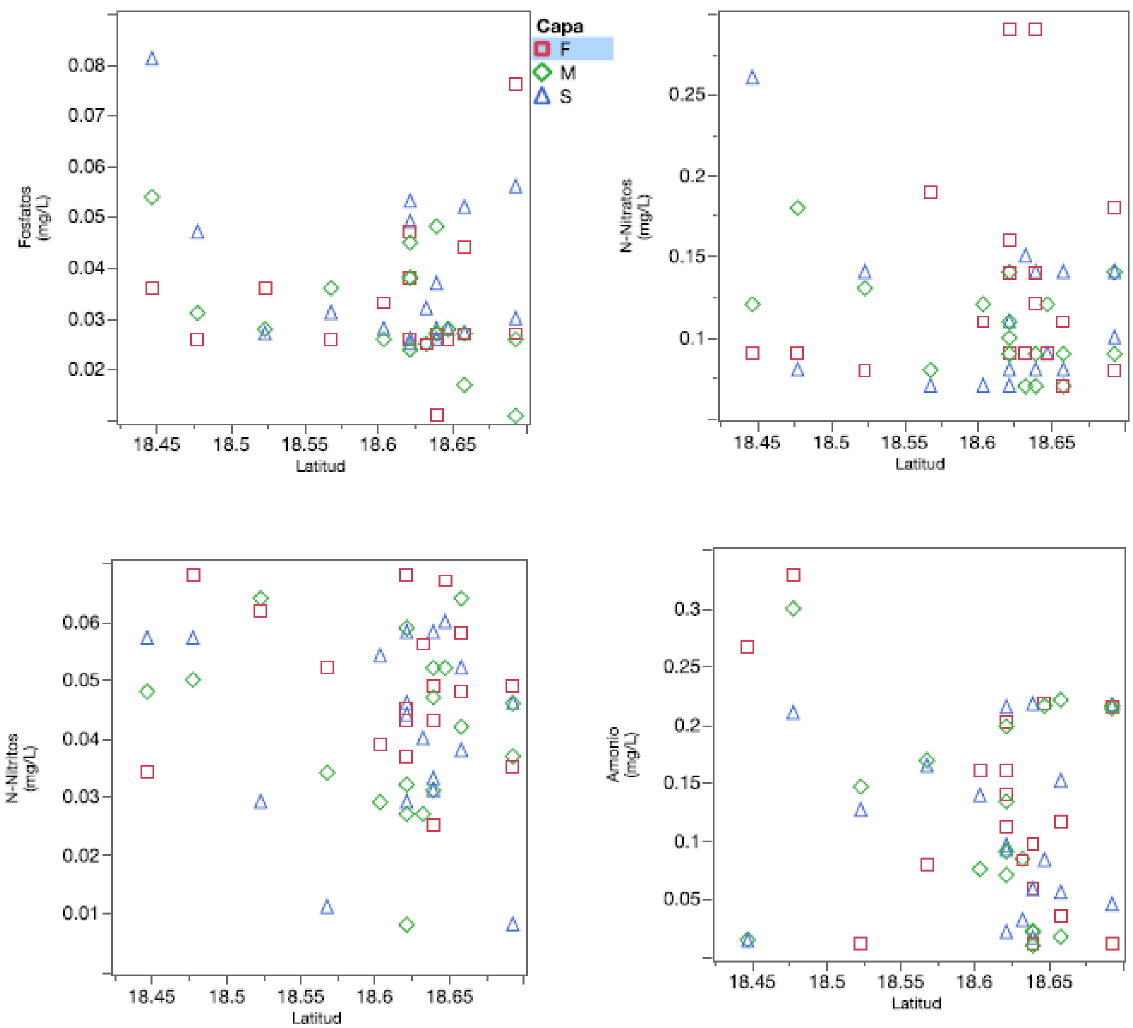


Figure 6.16. Variation of nutrient concentration levels as a function of latitude. Symbols represent depth of collection (red box Bottom, green diamond Medium water, blue triangle Surface).

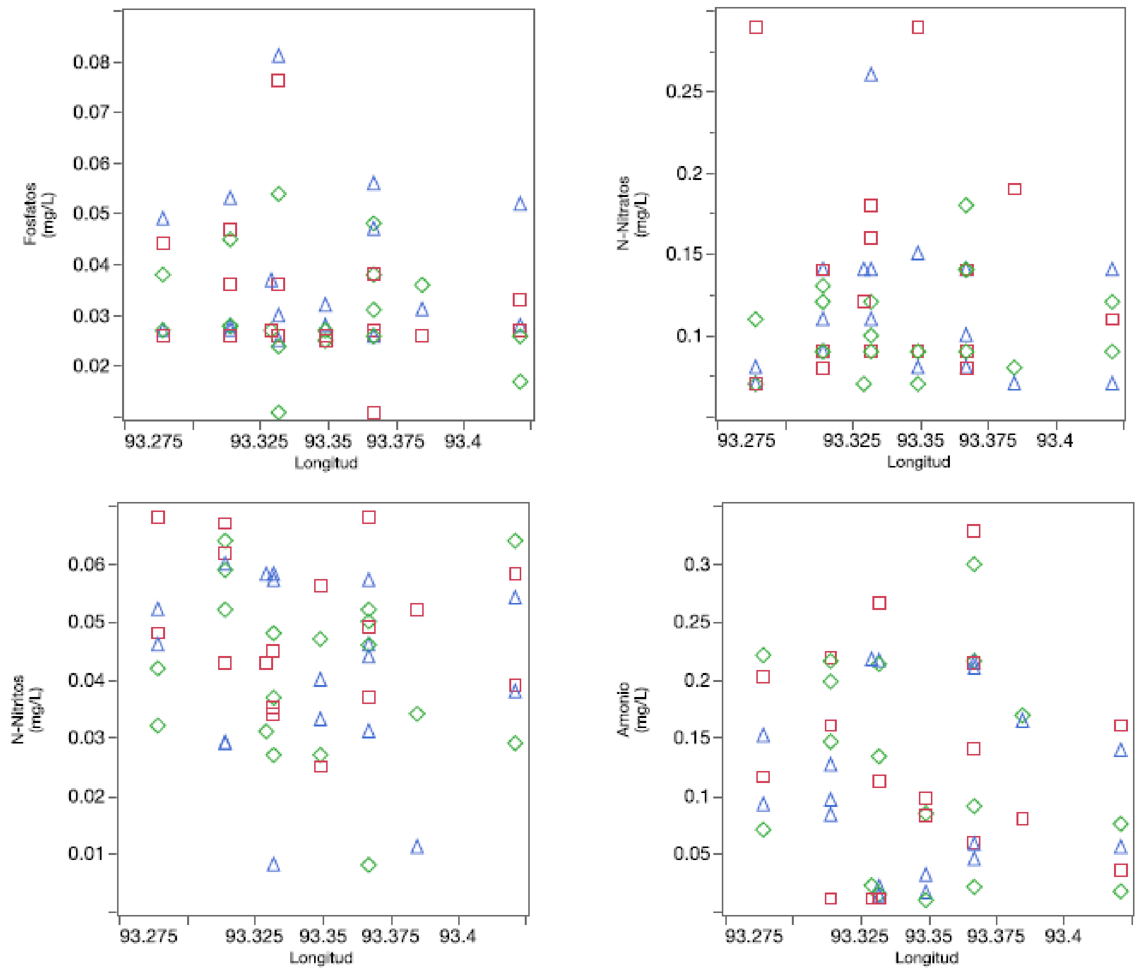


Figure 6.17. Variation of nutrient concentration levels as a function of length. Symbols represent depth of collection (red box Bottom, green diamond Medium water, blue triangle Surface).

Inorganic N is generally found in low amounts in coastal waters and is considered the limiting nutrient for primary production. This means that with adequate sunlight, N regulates the growth rate and amount of biomass of primary producers. If supply is increased of N, then the primary producers (plants, microalgae, macroalgae) will use this element and will grow faster.

In this work, the nitrate concentration levels averaged 0.118 and had a standard deviation of 0.05 mg/L, from 0.07 to 0.29 mg/L (Table 6).No trend can be seen with respect to latitude (Figure 6.16) or longitude (Figure 6.17). The average levels of nitrates in the different layers sampled do not present significant differences. Based on the guidelines of the Ecological Criteria for Water Quality CE-CCA-001/89, it is considered that values below 0.04 mg/L of nitrites are safe values for the protection of aquatic life in coastal and marine environments (CECA, 1989).

Based on these results, all nitrate concentration levels in this study were between 1.7 to 7.3 times higher than this reference value.

Nitrite concentration levels averaged 0.044 with a standard deviation of 0.015 mg/L, from 0.008 to 0.068 mg/L (Table 6.10). No trend can be seen with respect to latitude (Figure 6.16) or longitude (Figure 6.17). The average levels of nitrites in the different sampled layers do not present significant differences. Based on the guidelines of the Ecological Criteria for Water Quality CE-CCA-001/89, it is considered that values below 0.02 mg/L of nitrites are safe values for the protection of aquatic life in coastal and marine environments (CECA, 1989). Based on these results, the nitrite concentration levels in this study average 2.2 times (0.5 to 3.4) greater than the reference value. Nitrites in coastal waters are often interpreted as indicative of pollution of agricultural and/or urban origin.

Ammonium concentration levels averaged 0.12 with a standard deviation of 0.084 mg/l, from 0.01 to 0.328 mg/l (Table 6.10). According to Figure 6.16, a certain tendency to decrease in ammonium concentrations with respect to latitude (distance to the coast) is observed, which could be indicating the source of continental contribution. There is no trend in length (Figure 6.17). The average levels of nitrites in the different sampled layers do not present significant differences. Based on the guidelines of the Ecological Criteria for Water Quality CE-CCA-001/89, it is considered that values below 0.01 mg/L of ammonium are safe values for the protection of aquatic life in coastal and marine environments (CECA, 1989).

Based on these results, the ammonium concentration levels in this study average 12 times (1 to 33) greater than the reference value. Ammonia is nitrogen from the decomposition of organic matter, excretion produced by organisms, and/or fecal waste of human origin. Along with nitrogen, phosphorus is considered the limiting macronutrient for phytoplankton growth.

Based on the sum of the three forms of inorganic nitrogen (nitrates + nitrites + ammonium) it is possible to classify coastal environments as having High (> 1 mg/L), Medium (> 0.1, <1 mg/L) and Low pollution. (<0.1 mg/L). In the study area, these values average 0.28, varying from 0.124 to 0.56 mg/L, which is why they present an average nitrogen contamination.

The NOAA (National Oceanic and Atmospheric Administration) uses as a criterion of a high nutrient value for coastal eutrophication a concentration of total dissolved nitrogen (ND T)> 1.0 mg/L (Buchman 2008). However, in this study the determination of dissolved organic nitrogen was not carried out so the NDT cannot be calculated. In Figure 6.18 a summary of the enrichment ratios for each nutrient (concentration level of the nutrient/guide value according to the Agreement establishing the Ecological Criteria for Water Quality is presented (CECA, 1989). Virtually all analytes, in all samples, exceeded unity, but in particular ammonium and phosphate are well above their guideline values.

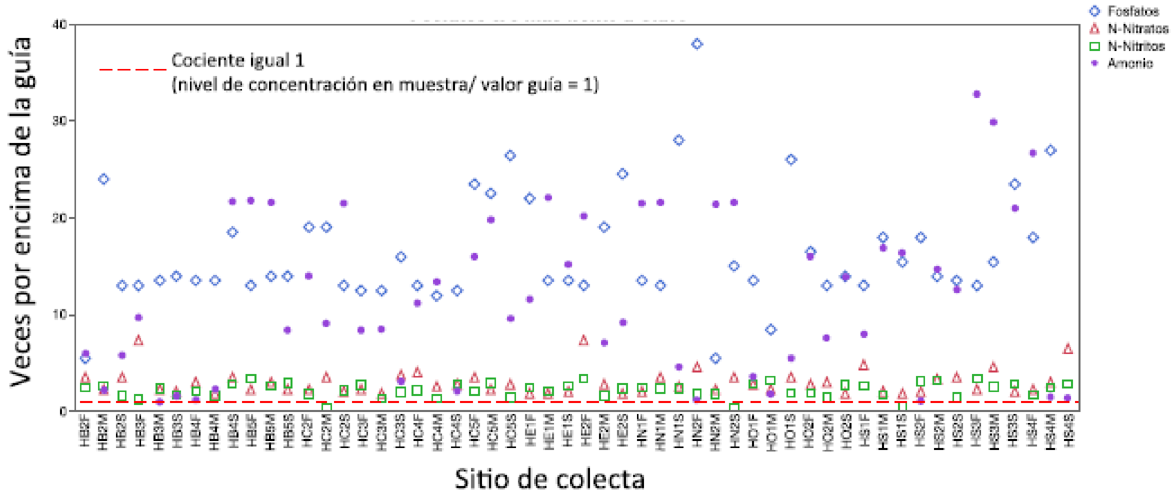


Figure 6.18. Relationship between the nutrient concentration level/guide value according to the Agreement establishing the Ecological Criteria for Water Quality (CECA, 1989). Value > 1 indicates that the nutrient concentration is above the guideline value.

6.3.6. Metals

The concentrations of Ba, Cd, Cu, Cr, Co, Sn, Fe, Hg, Ni, Pb, Si, Zn and V in surface, middle bottom and bottom water samples in the IDECA S.A. de C.V. accredited laboratory The results are shown in Annex 8 and Table 6.11. The concentrations of Ba, Cd and Cr in the different levels of the water column were lower than those suggested by Buchman (2008) as maximum limits to avoid damage to the biota due to chronic exposure to these elements.

Table 6.11. Maximum and minimum values of metals in three levels of the column of (mg/l).

		Minimum	Maximum	Average	Desv. Its T.	Sharp	Chronicle
Barium	Surface	0.01	0.01	0.01	0.00	1.00	0.20
	Mean	< 0.08	0.03	0.03			
	Seabed	< 0.08	0.01	0.01	0.00		
Cadmium	Surface	< 0.003	< 0.003			0.0400	0.0088
	Mean	< 0.003	< 0.003				
	Seabed	< 0.003	< 0.003				

Copper	Surface	0.08	0.09	0.08	0.00	0.0048	0.0031
	Mean	0.08	0.09	0.08	0.00		
	Seabed	0.07	0.10	0.09	0.01		
Chrome	Surface	0.01	0.01	0.01	0.00	1.10	0.05
	Mean	0.005	0.02	0.02		How	Cr (VI)
	Seabed	0.005	0.005				
Cobalt	Surface	< 0.02	< 0.02				0.001
	Mean	< 0.02	< 0.02				
	Seabed	< 0.02	< 0.02				
Tin	Surface	< 0.05	1.10	0.61	0.30		
	Mean	< 0.05	0.94	0.62	0.24		
	Seabed	< 0.05	1.08	0.67	0.25		
Iron	Surface	< 0.007	0.05	0.04	0.01	0.300	0.050
	Mean	< 0.007	0.05	0.04	0.02		
	Seabed	< 0.007	0.10	0.05	0.02		
Mercury	Surface	0.0002	0.0010	0.00	0.00	0.00180	0.00094
	Mean	0.0002	0.0012	0.00	0.00		
	Seabed	0.0002	0.0009	0.00	0.00		
Nickel	Surface	< 0.03	< 0.03			0.07400	0.00820
	Mean	< 0.03	< 0.03				
	Seabed	< 0.03	< 0.03				
Lead	Surface	< 0.01	< 0.01			0.21000	0.00810
	Mean	< 0.01	< 0.01				
	Seabed	< 0.01	< 0.01				
Silicates	Surface	4.96	25.90	10.05	5.13		
	Mean	1.72	26.84	9.60	6.17		
	Seabed	1.83	33.86	10.43	8.57		
Zinc	Surface	0.001	0.14	0.13	0.00	0.09000	0.08100
	Mean	0.001	0.13	0.07	0.09		
	Seabed	0.001	0.13	0.13			
Vanadium	Surface	< 0.2	< 0.2				0.05000
	Mean	< 0.2	< 0.2				
	Seabed	< 0.2	< 0.2				

In the case of Co, Ni, Pb and V, the concentrations were lower than the detection limit of the method used, which were slightly higher than what was stipulated as reference values to avoid damage to biota by chronic exposure and, specifically for Ni and Pb less than the value considered harmful if there was an acute exposure.

Fe and Hg concentrations ranged between the detection limit of the method (0.007 for Fe and 0.0002 mg/l) and 1 and 0.10 mg/l, respectively. The concentrations of these metals in water were normally lower than the guideline value suggested as a limit to avoid toxic damage during chronic exposure; However, sites S4 (surface), C2 (middle bottom), S3, S1, B5 and B3 (bottom) presented Fe values higher than the maximum limit to avoid damage to biota during acute exposure. Likewise, the B4 (surface) and NI (mean) sites showed the same behavior for Hg concentrations.

In general, Zn concentrations were lower than the guideline value to avoid damage from chronic exposure; however, sites S4, in its three levels, and S3, on the surface, presented values that exceed the level considered as a limit to avoid toxic effects from acute exposure. Cu concentrations ranged between 0.07 and 0.10 mg/l and in all cases were higher than the value considered harmful for organisms acutely exposed to this element.

6.4. Sediment quality

6.4.1. Organic matter (OM), total organic carbon (TOC) and oxide reduction potential (REDOX)

The organic matter and carbon content ranged between 0.32 and 2.82%, and 0.18 and 1.64%, respectively (Table 6.12, Annex 8). Although a defined geographic pattern is not observed in these concentrations, the highest values of these parameters occurred at the S1 sampling site, which is one of the most coastal sites, located south of the Hokchi area (approximately 12 km from the coast). In general, the values presented are typical of coastal environments, which reflect the contribution of continental material, in this case the river system.

Table 6.12. Maximum, minimum, average and standard deviation of physicochemical parameters in sediments.

	Minimum	Maximum	Average	Std. Dev.
Organic material (%)	0.32	2.82	1.23	0.48
Total organic carbon (%)	0.18	1.64	0.71	0.28
REDOX potential (mV)	59	186	162	30

Similarly, a minimum of the REDOX potential (59 mV) is observed at the S4 site, which is the closest to the continent (approximately 2 km). This reduced value is characteristic of areas with significant oxidation of organic material and is possibly associated with the contribution of said material by rivers.

6.4.2. Hydrocarbons

The concentrations of polycyclic aromatic hydrocarbons (PAHs) and total petroleum hydrocarbons (HTP) in sediments of the Hokchi area were quantified. In all cases, the concentrations were lower than the detection limits of the methods used (0.1026 and 0.3318, respectively) (Table The observed values of benzo (a) pyrene and benzo (b) fluoranthene are less than the threshold value for toxic effects (TEL); This means that there is no potential risk to the biota that inhabits these sediments, according to Buchman (2008).

Regarding the concentrations of dibenzoi (a, h) anthracene, benzo (a) anthracene, benzo (k) fluoranthene and indene (1,2,3-cd) pyrene, which were below the detection limit, they are lower than the level probable of effect (PEL); In other words, there is no high probability of toxic effect; however, it cannot be known if they are lower than TEL, so it cannot be assured that there are no potential toxic effects.

Table 6.13. Concentration of hydrocarbons in sediments.

	Concentration	TEL / T_{20}	PEL/T50

Polycyclic Aromatic Hydrocarbons (PAH ⁻ s)			
Berzo (a) pyrene	< 0.1026	0.08880	0.73600
Dibenzo (a, h) anthracene	< 0.1026	0.00622	0.11300
Berzo (a) anthracene	< 0.1026	0.07480	0.69300
Berzo (b) fluoranthene	< 0.1026	1.30000	
Berzo (k) fluoranthene	< 0.1026	0.07000	0.53700
Indene (1, 2,3-cd) pyrene	< 0.1026	0.06800	0.48800
Total petroleum hydrocarbons			
Average Fraction (Diesel)	0.3318		

6.4.3. Metals:

The concentrations of Ba, Co, Cd, Cu, Cr, Sn, Fe, Mn, Hg, Mo, Ni, Ag, Pb, Se, V and Zn in sediment of the study area were quantified by the accredited laboratory IDECA S. A. de C. V. All concentrations of Ba, Cd, Cu, Cr, Ni, Ag, Pb, V and Zn were lower than the detection limits of the methods used. In the case of Co, Fe, Mn, Se and Zn, these values are lower than those reported as natural base values for marine sediments (Buchman 2008). The concentrations of Sn and Hg ranged between 18.59 and 56.31 mg / kg, and <0.0243 (detection limit) and 0.9771 mg / kg, respectively. These concentrations, together with those obtained for Cr, were lower than the threshold value for toxic effects (TEL), except for sites S4 and B4, which showed values between TEL and PEL for Hg; and C5 with an intermediate value of Sn. Only, the S3 site presented a value above the probable toxic effect level (PEL) for Hg.

Table 6.14. Maximum, minimum, average and standard deviation of metals in sediment. Units in mg / kg.

	Maximum	Minimum	Average	Desv. Its T.	Bckgrd [1]	TEL[1]	PEL[1]
Barium	199.101	199.101			0.7	130	
Cobalt	10	2.19	5.011	1.572	10		
Cadmium	9.9551	9.9551			0.1-0.3	0.68	4.21
Copper	<24.887	<24.887			10-25	18.7	108
Chrome	19.9101	19.9101			7-13	52.3	160
Tin	56.31	18.59	33.112	12.977	5	48	
Iron	208.8	36.76	95.704	43.437	9900-18000		

Manganese	245.92	77.19	171.3661	47.511	400		
Mercury	0.9771	<0.0243	0.283	0.328	0.004-0.051	0.13	0.7
Molybdenum	6.51	0.87	2.849	1.376			
Nickel	<24.8877	<24.8877			9.9	15.9	42.8
Silver	19.9101	19.9101			< 0.5	0.73	1.77
Lead	<99.5507	<99.5507			4-17	30.24	112
Selenium	0.27	0.03	0.141	0.053	0.29		
Vanadium	<497.753	<497.753			50		
Zinc	<24.887	<24.887			7-38	124	271

Seabed (Bckgrd), Threshold Effect Level (TEL) and Probable Effect Level (PEL) taken from Buchman (1).

Since the concentrations of Ba, Cu, Ni, Pb and V are lower than the corresponding detection limits, it can be mentioned that these values are higher than the TEL, but it cannot be indicated if they are also higher than the PEL (level above of which, it is highly probable that there is a toxic effect).

On the other hand, the detection limit values of Cd and Ag are greater than the PEL, but it cannot be inferred whether the actual concentration in the sediment is greater or less than the TEL or PEL.

6.4.4. Granulometry and texture of sediments

Table 6.15 shows the results of the particle size analysis of the sediments sampled in the Hokchi area and its vicinity. As can be seen, the predominant size is less than 0.05 mm, corresponding to silts and clays, whose value varied between 46.4 and 73.2%, with an average of 59.4 and a standard deviation of 6.3%. The second component in percentage importance is the interval that defines very fine sands (0.05 to 0.1 mm), with an average of 20.5 and a standard deviation of 2.8. Based on the above, it is concluded that the sediment in the study area has a sandy silty texture. This is important, due to its implication in terms of adsorption of pollutants in the fine fraction (silts and clays), since in general, the values of metals and hydrocarbons do not show enrichment anywhere, nor was any pattern that associates their concentrations with sedimentary texture.

The sediments have a continental character, possibly due to the fluvial contribution in the area.

Table 6.15. Maximum, minimum, average and standard deviation of sediment size.

	Minimum	Maximum	Average	Desv. Its T.
Very coarse sand (2-1mm)	0.9	2.3	1.3	0.5
Coarse sand (1.0-0.5mm)	1.6	5.1	2.6	0.9
Medium sand (0.5-0.25mm)	2.6	9.6	5.1	2.0
Fine sand (0.25-0.10mm)	5.1	16.9	11.1	2.8
Very fine sand (.10- .05mm)	15.2	24.8	20.5	2.8
Silt and clay (<0.05mm)	46.4	73.2	59.4	6.3

6.5. Biota

6.5.1. Phytoplankton

The composition of phytoplankton in the Mexican portion of the Gulf of Mexico has been studied by environments, both marine and in coastal lagoons (Margalef, 1975), by groups (Licea et al., 2004; Hernández-Becerril et al., 2008; Krayesky et al. 2009; Licea et al., 2011; Parra-Toriz et al. 2011), by genera (Okolodkov, 2010; Parsons et al., 2012) and species (Okolodkov, 2008; Aké-Castillo et al., 1995). Studies have been done on harmful algal blooms formed by the dinoflagellate Karenia brevis, whose toxin directly affects fish (Borbolla-Sala et al., 2006; Merino-Virgilio et al., 2012) and oyster beds (P00t-Delgado et al., 2015).

In the state of Tabasco, phytoplankton studies have been carried out in the El Balsón and Las Ilusiones lagoons (CONABIO). There are records of algal blooms in Laguna del Carmen with the presence of Ceratium furca and fish mortality in Barra de Tupilco (Osorio-Sánchez and López-Pérez et al., 2009).

Terán-Suárez et al. (2006) report the results of phytoplankton analysis of the Carmen-Pajonal lagoon complex and the Mecoacán lagoon, identifying 15 species of dinoflagellates and one of diatoms. Among the most abundant species identified in this study are Pyrodinium bahamense, Ceratium furca, and Gambierdiscus toxicus. Another species that forms harmful algal blooms is the toxin-producing dinoflagellate Karenia brevis. (Terán y Suárez et al., 2006). Borbolla-Sala et al. (2006) present the results of phytoplankton and brief toxin analyzes of a Karenia brevis bloom in the coastal waters of Tabasco in 2005 and Merino-Virgilio et al. (2012) report an event of species of the Karenia genus in 2010 on the coasts of Veracruz.

The results of the oceanographic campaign carried out in February 2016 show that the most abundant group, considering all the collection sites, were the central diatoms (73%), followed by the pennate diatoms (21%) and the tecate dinoflagellates. (6%) (Figure 6.19). This high predominance of diatoms was observed in two studies of coastal lagoons in Tabasco (Santoyo and Signoret, 1981; De la Lanza and Gómez, 1999). Twenty-seven genera belonging to all the mentioned phytoplankton groups were found, the genera with the highest relative abundance (%) were the central diatoms Guinardia, Thalassionema, Skeletonema and Lauderia, and the thecate dinoflagellate Tripos (= Neoceratium = Ceratium) (Figure 6.20). This behavior has been reported in studies in coastal lagoons adjacent to the study area (De la Lanza and Gómez, 1999).

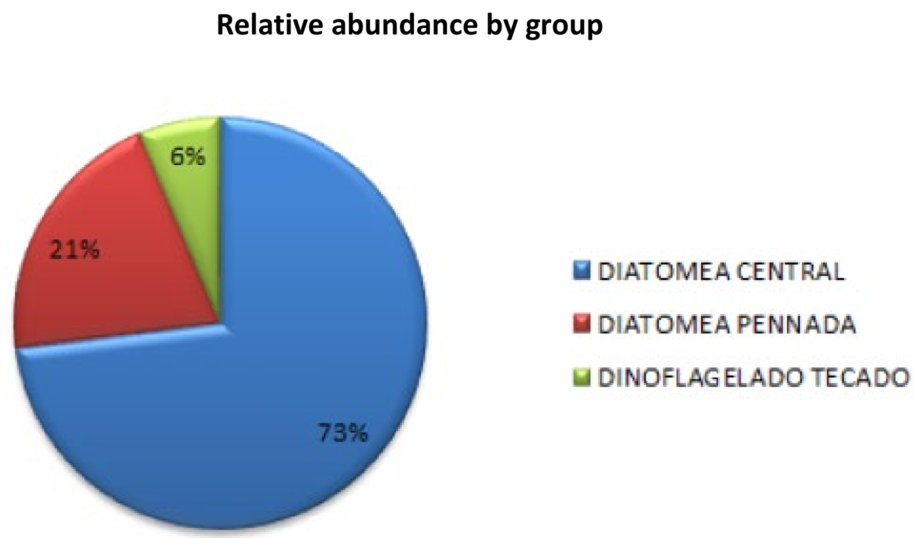


Figure 6.19. Relative abundance by group in the study area

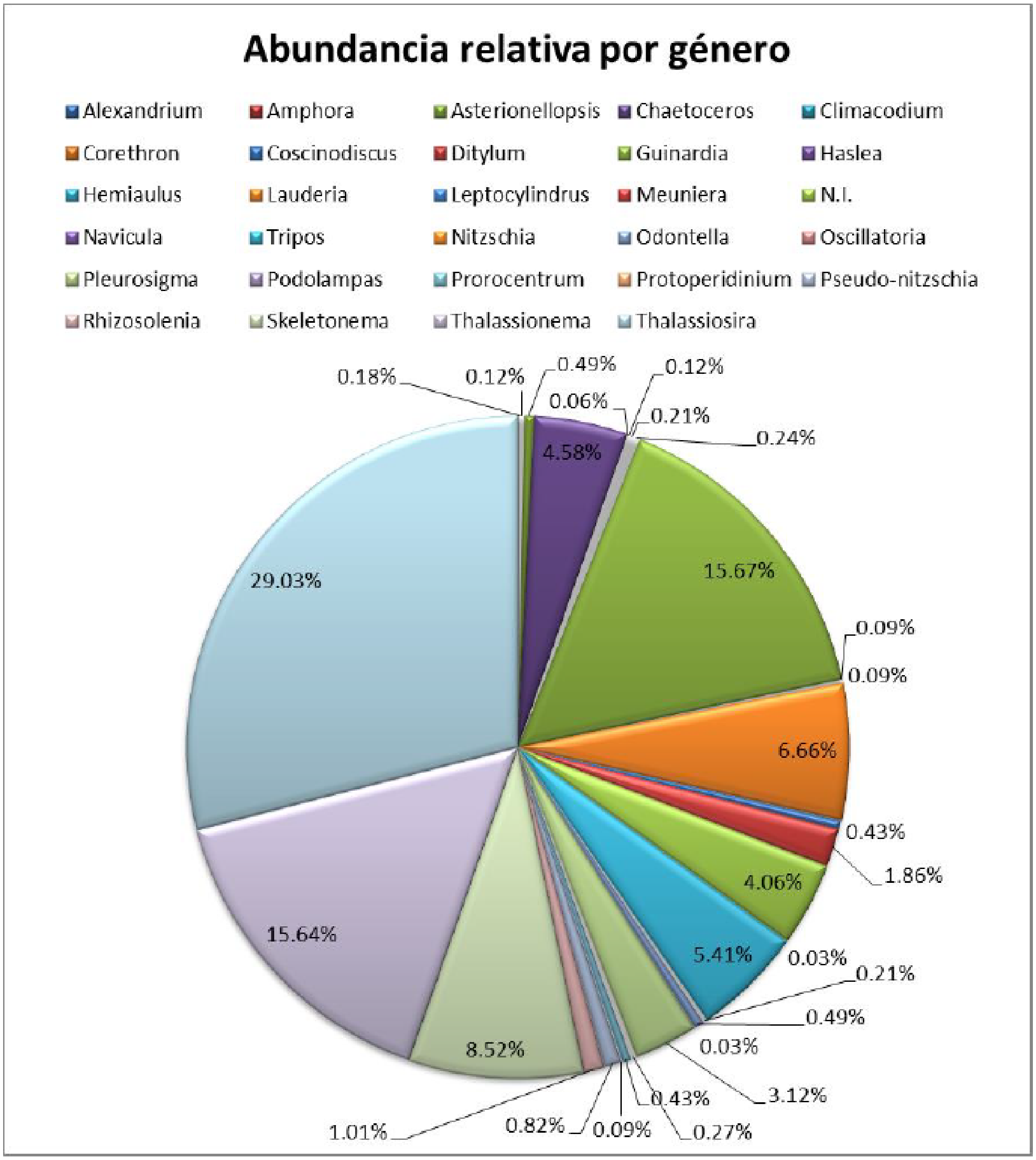


Figure 6.20. Relative abundance by gender at the sampling sites.

On the other hand, the sites with the highest total abundance (cells / m ^{3}) were the sites closest to the coast (S3 and S4), those with intermediate abundance were the sites within the polygon closest to the coast (C1, C3, C5, B2, S2, S1) in addition to the E2 and N2 sites, moderate abundance was found in the sites within the polygon, further from the coast and in the sites adjacent to the polygon (B3, B4, B5, C2, N1, 01 and 02), and, finally, the site with low abundance was El (Figure 6.21).

This gradient in terms of total abundance with respect to the coast is explained because it is an area adjacent to the tropical forest region, with high discharge of nutrients and sediments associated with the Grijalva-Usumacinta system (Yáñez-Arancibia and Day, 2004).

If the total abundance in cells/L is considered, there is an interval of 500-5,000 cells/L (it covers the categories from scarce to very abundant), with an average of I, 1,658 cells/L, which is considered abundant for marine waters (Tapia and Naranjo, 2009). Regarding the abundance found in lagoon systems in the study area, abundance is low, characteristic of the dry season and oligotrophic environments (De la Lanza and Gómez-Aguirre, 2008 and Lara-Lara et al.

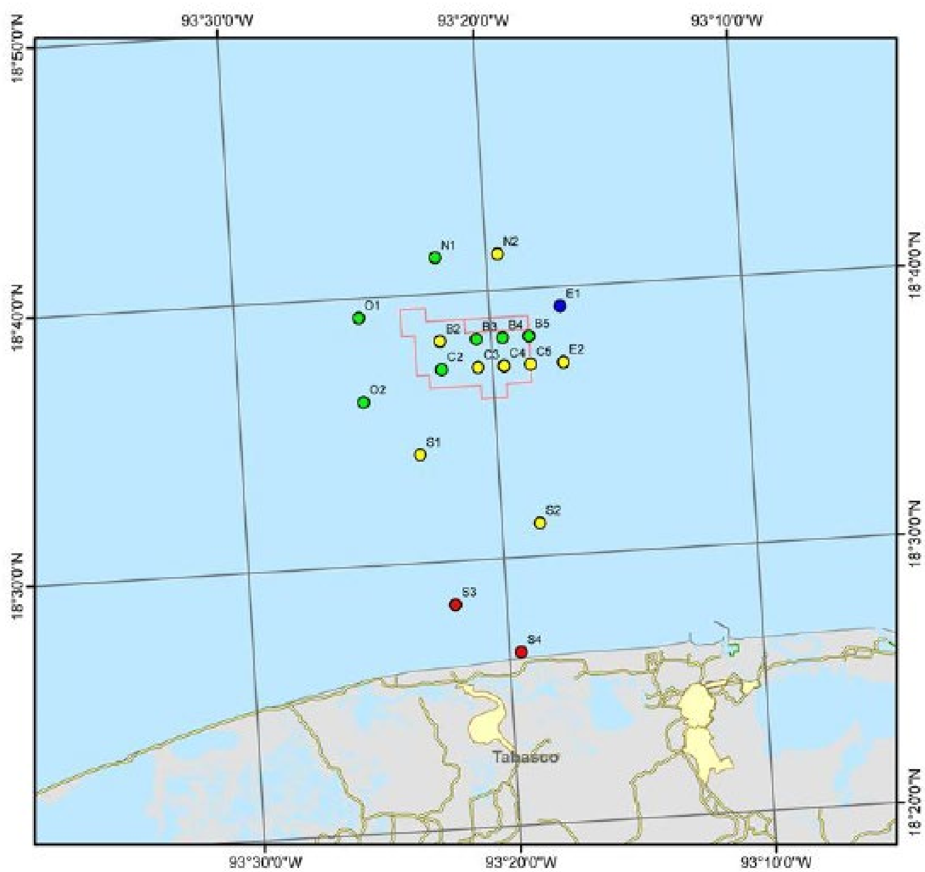


Figure 6.21. Total net phytoplankton abundance estimated for the collection sites (x106 cel/m3), blue = scarce, green = moderate, yellow = abundant and red = very abundant according to Tapia and Naranjo (2009).

Performing the analysis by collection sites, in the Sl-S1 sites the central diatoms presented the highest relative abundance with 67-85%, followed by the pennate diatoms with a relative abundance of 3-28%. The third group with the highest relative abundance was the thecated dinoflagellates with 2-24% (Figure 6.22).

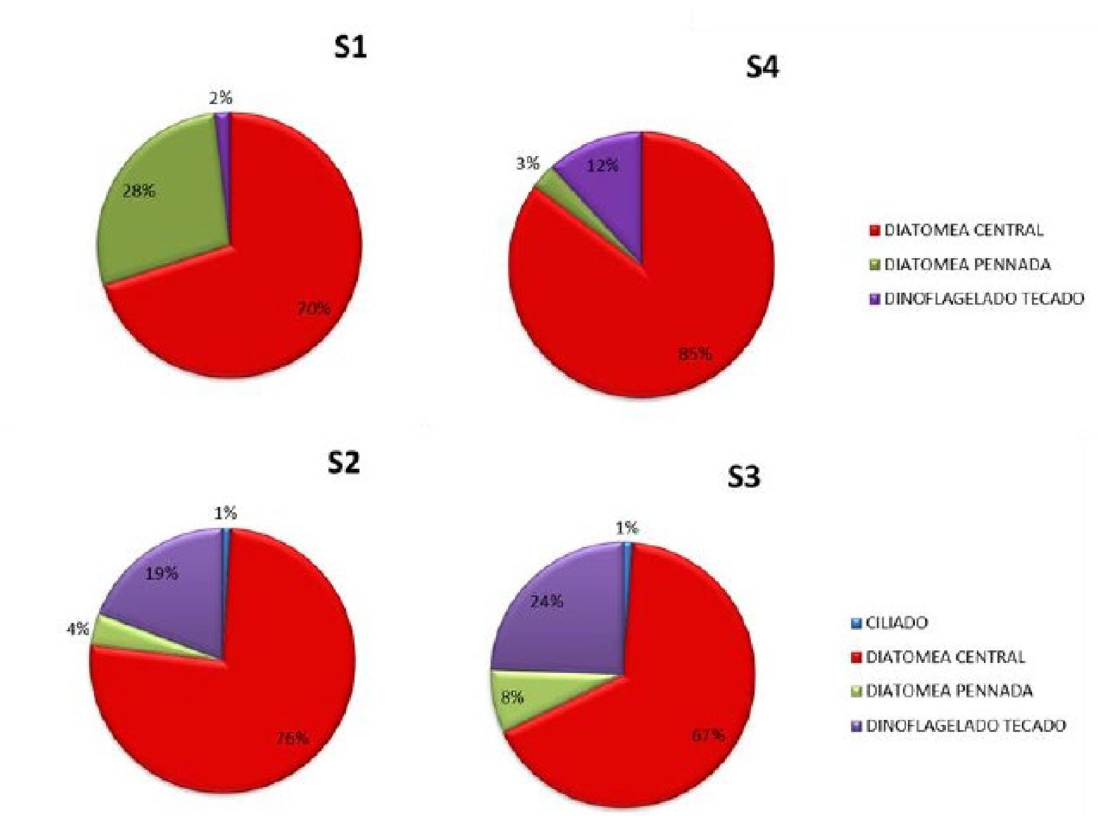


Figure 6.22. Relative abundance by group at sites 01 and 02.

At sites 83-86 and 10-14 the central diatoms had the highest relative abundance of 3% and pennate diatoms 4%, the third most important group were the thecate dinoflagellates with a relative abundance of 6.22 to

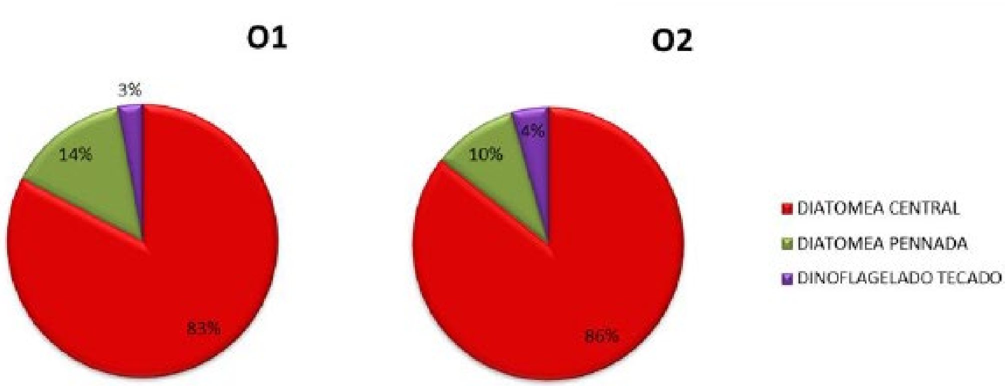


Figure 6.22. Relative abundance by group at sites 01 and 02.

At the NI and N1 sites, the relative abundance of the central diatoms was 63 to 97%, the pennate diatoms were in greater relative abundance at the NI site with 34% (Figure 6.23)

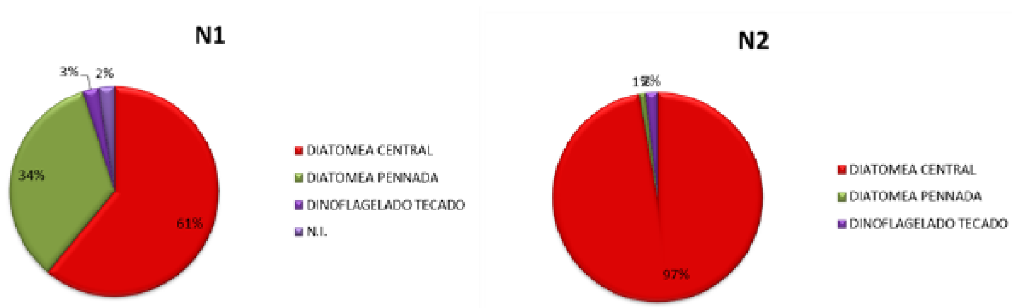


Figure 6.23. Relative abundance by phytoplankton groups at the N1 and N1 sites.

In the El and E2 sites the central diatoms presented a relative abundance of 70 and 81% respectively as well as 29 and 18% for pennate diatoms, the relative abundance of diroflagellates in both sites was 1% (Figure 6.24)

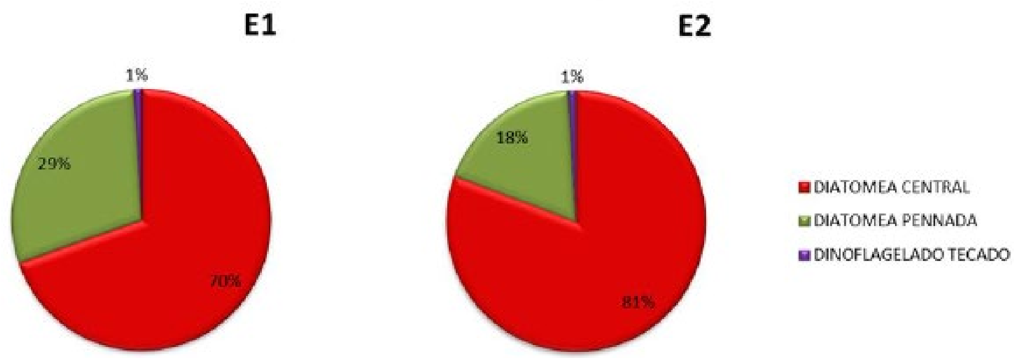


Figure 6.24. Relative abundance by phytoplankton groups at the N1 and E2 sites.

The relative abundance of the central diatoms in the B2, B3, B4 and B5 sites was 63-77% and of the pennadas 20-36%, that of the dinoflagellates 2 to 5%

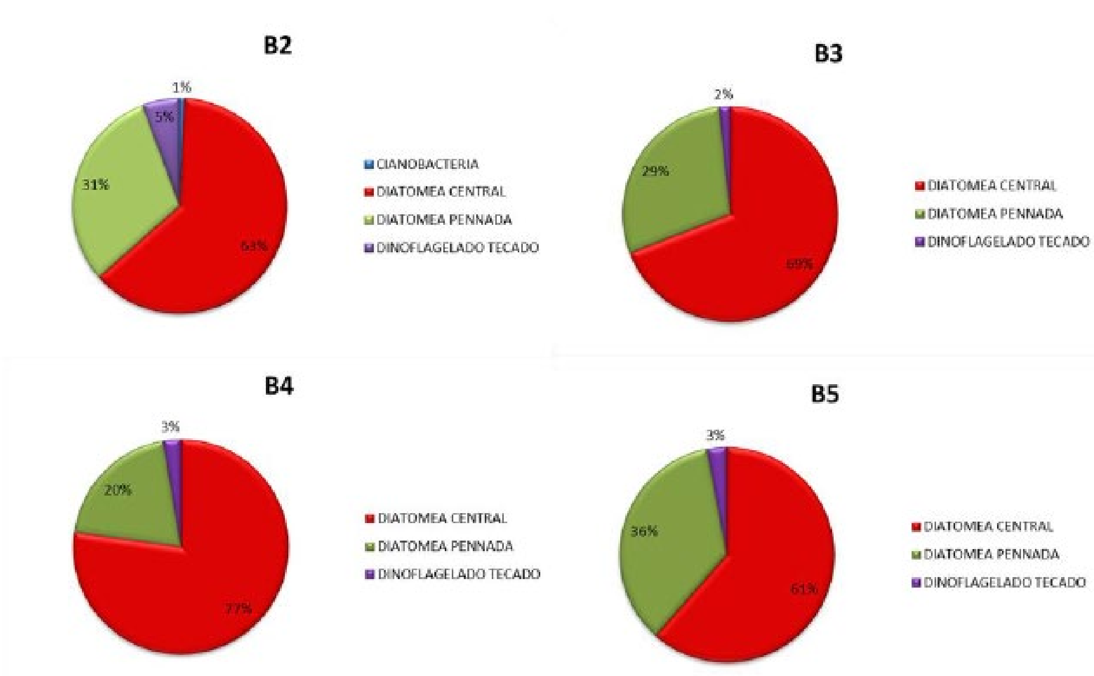


Figure 6.25. Relative abundance by groups by groups of phytoplankton at sites B2, B3, B4 and B5.

The relative abundance of the central diatoms at the C2, C3, C4 and C5 sites was 50-81%, of the pennate diatoms 10-50% and the thecated dinoflagellates 3 to 6.26% (Figure 6.26)

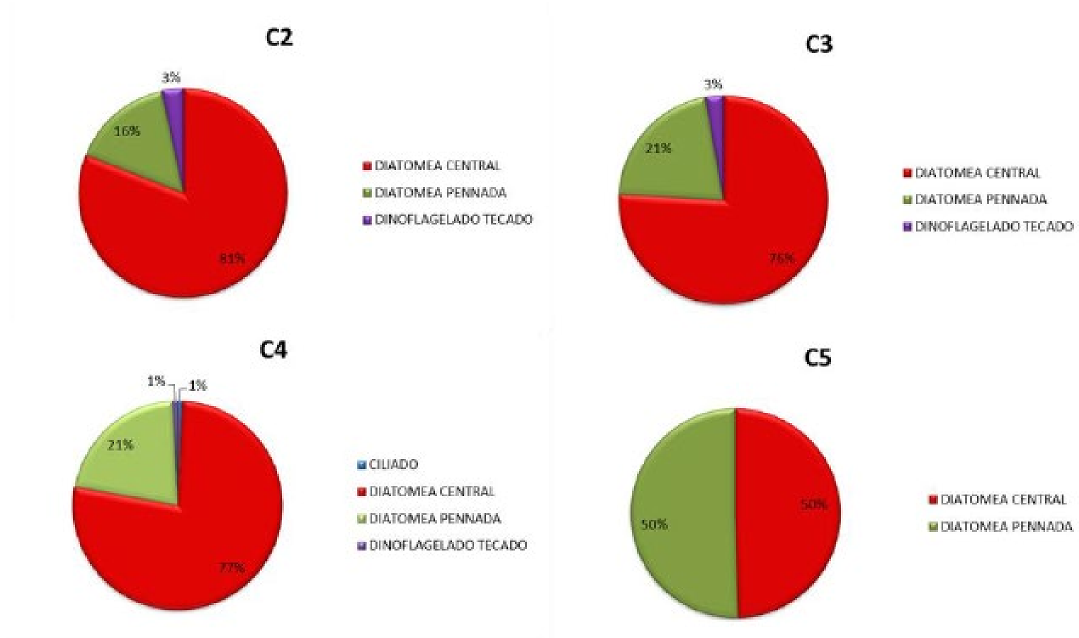


Figure 6.26. Relative abundance by groups of phytoplankton at sites C2, C3, C4 and C5.

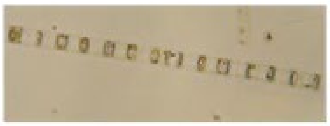
A total of 37 species were found (belonging to 27 genera), 19 species of central diatoms, 10 species of pennate diatoms, 7 species of thecate dinoflagellates and a species of cyanobacteria (Figure 6.27, Table 6.16). The recorded species show a typical composition of marine systems with a high relative abundance of diatoms followed by dinoflagellates.

The potentially harmful species found in the study were the diatom Pseudonitzschia spp., with relative abundances less than 5.6% and the dinoflagellate Alexandrium sp., found in a single sample with relative abundance of 1.8%.

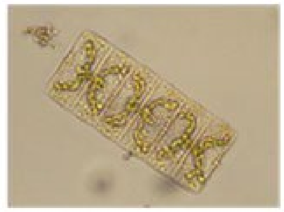
Tripos kofoidii

Lauderia sp.

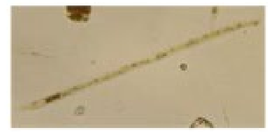
Pseudo-nitzchia sp.



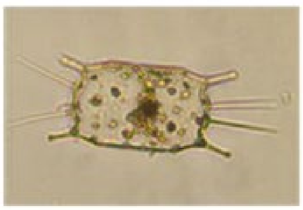
Skeletonema sp.



Meuniera membranacea



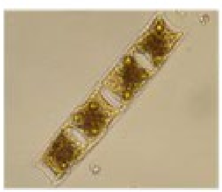
Rhizosolenia sp.



Odontella sp. 1

Thalassiosira sp. 2

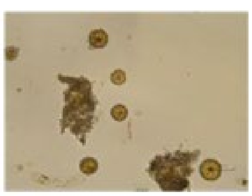
Odontella sp. 2



Hemiaulus sp.

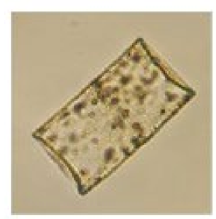
Guinardia striata

Hemiaulus sinensis



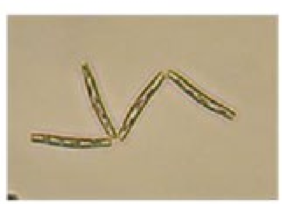
Hemiaulus sp.

Thalassiosira sp. 3

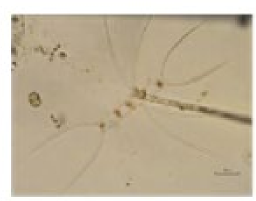


Guinardia flaccida

Ditylum brightwelli



Thalassionema nitzschioides



Chaetoceros sp.

Figure 6.27. Phytoplankton species found in water samples from the Hokchi area, collected during February 2016.

Table 6.16. List of phytoplankton species found at the Hokchi area sample sites in February 2016.

GROUP	GENDER	SPECIES
Cyanobacteria		
	Oscillatoria	sp,
CENTRAL DIATOM		
	Chaetoceros	*brevis*
	Chaetoceros	sp,
	Climacodium	sp,
	Corethron	sp,
	Coscinodiscus	sp,
	Ditylum	*brightzelli*
	Guinardia	*flaccid*
	Guinardia	sp,
	Guinardia	*striata*
	Hemiaulus	*sinensis*
	Hemiaulus	sp,
	Lauderia	sp,
	Leptocylindrus	*danicus*
	Meuniera	sp,
	Odontella	spp,
	Rhizosolenia	spp,
	Skeletonema	sp,
	Thalassiosira	spp,
Pennate diatom		

	Amphora	sp,
	Asterionellopsis	*glacialis*
	Chaetoceros	sp,
	Haslea	sp,
	Navicula	sp,
	Nitzschia	*sigma*
	Nitzschia	sp,
	Pleurosigma	sp,
	Pseudo-nitzschia	sp,
	Thalassionema	*nitzschioides*
THECADO DINOFLAGELLATE		
	Alexandrium	sp,
	Podolampas	sp,
	Prorocentrum	*gracile*
	Prorocentrum	*micans*
	Prorocentrum	sp,
	Protoperidinium	sp,
	Tripos	*kofoidii*

The species with the highest relative abundance> 25% were Thalassiosira sp., Thalassionema nitzschioides and Pleurosigma sp.

The abundance of phytoplankton found in this study agrees with the classification of the trophic state based on the concentration of chlorophyll a as mesotrophic and with the scale in which the area is identified as productive waters.

6.5.2. Zooplancton

In the samples obtained, a great diversity of organisms was found that were classified into 32 groups: Amphipods, Anthozoans, Brachyurus zoeas and megalopes, Carids, Copepods, Parasitic Copepods, Ctenophores, Coumaceans, Stomatopods, Euphasids, Hydromedusae, Isopods, Larvaceans (Oikopleura), Misids, Bivalve molluscs, Mol. Cephalopods, Mol. Gasterópodos, Mol. Gast. Heteropods and Pteropods, Ostracods, Pagurids, Fish eggs and larvae, Peneids Mysis and Postlarvae, Polychaetes, Porcelain zoeas, Portunidae megalopes and Juveniles, Ketognaths, Salpas, Sergestids, Sicyonia mysis and postlarvae, and Siphonophores (Annex 6.27).

When considering the total of organisms present in each sample, the number of individuals presented a minimum of 5,447, and was recorded in station S3; and a maximum of 141, 508, registered in station B3, whose location is shown in figure 5.2. The average number of organisms in the entire sampling area was 26,396. However, when estimating the relative abundance of organisms, that is, the number of organisms estimated per unit volume, it presented a minimum of 22 org./m, and was recorded at station C2; and a maximum of 3 org./m ^{592}, recorded at station B3. The average number of organisms per unit volume in the entire sample area was 122 org./m ^{3}. Table 6.17.

In almost all the stations the most abundant group was that of the copepods, except in the stations 01 and NI, in which the most abundant were the ostracods; and station O1, in which the most abundant group was that of the ketognaths.

Of the groups of organisms considered as indicators of organic contamination, only low abundant ctenophores were recorded at stations S2, S3, and S4, with 0.4, 0.3, and 1.8 org./m3.

All the groups that include organisms of commercial importance, such as fish, crustaceans (shrimp and crabs) and mollusks (squid and bivalves) were present in the entire sampling area.

Table 6.17.- The average number of organisms per unit of volume in the entire sampling area.

Sampling site	S4	S3	S2	S1	O2	C2	C3	C4	C5	E2	El	B5	B4	B3	B2	O1	N1	N2
Amphipods			4	33	46	173	68	231	355	436	291	547	632	741	1337	900	238	681
Anthozoans					75	53		28	52	63	45							
Brachyurus zoeas	5	42	11	2	7	8	2	6	24	45	31	108	287	424	250	224	249	531
Megalopic brachyurus				1						1	4	12	3		1	3		
Caridea	94	67	89	18	34	83	22	68	65	77	63	277	152	903	1129	918	565	612
Copepods	3298	3278	4562	3474	4221	3675	5349	2895	5438	4321	3498	6219	5211	84048	22433	28936	6776	9344
Parasitic copepods						3	16	11	5	6	4	8	9	64	32		32	
Cathenophores	275	57	73															
Cumaceous				1	2				1	6		1						
Stomatopods	1		7	4	3	15		1	6	6	5	29	5	40	85	42	17	35
Euphasids							2	5	5	8	4	20	11					
Hydromedusa				1	4					3	8	3	11	98			33	1
Isopods			2	4		1		3	1	3	2	2						
Larvaceos (Oikopleura)						91	77	43	217	437	692	1874	2378	543				
Lucifer	387	645	684	235	146	437	181	302	156	97	56	283	375	1001	2588	1646	994	2529
Misidos	98	32	124	10	74	243	32	265	164	158	24	26	19	26	44	64	17	89
Bivalve mollusks							28	53			9		4					
Mol. cephalopods			1					5		4			2	1		8		
Mol. Gastropods			22	45	29	58	74	150	143	365	298	451	541	10715	1147	401	880	
Mol. Gast. heteropods					14					11	5	23	36	53	32	24		
Mol. Gast. pteropods					543	129	329	87	54	64	73	287	397	752	1866	1099	282	845
Ostracods	563	653	652	2153	1863	733	1032	853	3278	893	2111	3276	2943	23709	21901	56872	10024	688
Pagurids						1				3								
Fish eggs		32	327	232	127	268	216	348	534	356	657	947	1281	480	160	384	128	144
Larval fish	68	45	43	68	132	165	38	58	64	56	63	158	87	303	697	265	544	695

Penis mysis	37	47	6	4	4	1		5	5	9	4	1	1					
Peneid Pee	5			1	8	8		5	3	5		1			1	16	2	1
Polychaetes		1	2	21	28	43	1	43	28	51	21	33	57	3	24		32	8
Porcelain zoeas				1		5		4	7	8	4	6	5					
Portunido megalopa	60		41	16	22	3	8	15	6	8	9	12	7	40	55	31	3	91
Portunidos Juv.			4	2				7	1	1			1					
Ketognaths	641	452	561	456	489	776	545	421	376	450	479	561	659	15369	12561	5655	3833	10919
Cylindrical salps					47	2	8	17	24	16	11	37		24	2	17	32	1
Begged	85	61	79	8	14	46	10	79	48	53	40	2	4	1827	1223	2052	305	390
Sicyonia Pis			2		1		1											
Sicyonia mysis	5				1				1	1								
Siphonophores	82	35	47	87	64	68	54	82	69	43	58	84	95	344	451	394	145	2
No. Org Total	5704	5447	7343	6877	7998	7088	8093	6090	11130	8064	8569	15288	15213	1E+05	68019	99951	25131	27606
Vol. Filtered out	149.7	166.5	197.6	215.5	198.0	323.6	196.6	224.2	207.7	156.2	174.9	241.3	231.0	239.2	225.6	252.2	125.6	173.7
Org/m3	38	33	37	32	40	22	41	27	54	52	49	63	66	592	301	396	200	159
Diversity Index H "	2.5	2.2	2.4	2.2	2.5	2.8	2.2	2.8	2.3	2.6	2.7	2.7	2.9	1.9	2.4	1.8	2.5	2.4

On the other hand, the diversity index (Shannon-VMener Index) is used in ecology to measure specific biodiversity. This index is normally represented as H' and is expressed as a positive number, which in most natural ecosystems varies between 0.5 and 5, although its normal value is between and 2; Values less than 3 are considered low and values greater than 2 are high. The diversity index obtained for each of the sampling stations was comprised between a minimum value of 1.78 and a maximum of H '= 2.91. In most cases, this index remained above 2.0, except in stations 1.78 and O1, with 1.92 and 1.92, respectively. The average for the entire sampling area was H '= 2.43, which, according to the aforementioned, is considered as a value within normal limits.

6.5.3. Benthos

<u>Meiobenthos</u>

In the sediment samples from the study area, the following animal groups of the meiobenthos were found: bivalves, mites, foraminfferos, nematodes, copepods, polychaetes, tanaidaceans, isopods, quinorhincs, ostracods and gastrotricks, the most frequent groups being nematodes, copepods and polychaetes, who occur in 100% of the sampling sites. They were followed by the quinorhincs (83.33% of the sampling site), foraminifera (44.44%), mites and bivalves (38.89%, each), gastrotricks (33.33%), isopods and tanaidaceans (5.55% each), and the ostracods (22.2%).

At site B5, the highest total density of meiofauna was found (143.46 ind 10cm $^{-2}$). It was followed by stations S1 (125.98 ind 10cm $^{-2}$) and E2 (92.53 ind 10cm $^{-2}$) (Table 6.18). While the sites with the lowest density were: 01 (14.77 ind 10cm $^{-2}$), S4 (17.18 ind 10cm $^{-2}$) and N2 (18.08 ind 10cm-2).

The group that presented the highest density value was the nematodes (477.70 ind cm $^{-2}$), followed by the copepods (358.65 ind 10cm $^{-2}$) and the polychaetes (177.52 ind 10cm $^{-2}$) (Table 6.18).

The sites with the highest biomass were SI (86.36 pg Corg S1-2) and 10cm (55.81 pg Corg B4-2), while the lowest values were presented at sites 10cm (3.66 corg 2 ocm-4.23) and N2 (2 corg 6.19 ocm-2) (Table 6.19).

The group that presented the highest biomass value was the polychaetes (144.15 pg Corg 10cm-2), followed by the nematodes (94.18 pg Corg 10cm -2) and the copepods (87.47 vg Corg 10cm-2) (Table 6.19).

Table 6.18.- Density (ind 10cm-2) of the meifauna groups found in the sampling sites of the Hokchi area.

Density (Ind 10cm $^{-2}$)												
Site	1	2	3	4	5	6	7	8	9	10	11	Total
B2	0.00	0.00	0.00	21.40	33.45	4.52	0.00	0.00	0.90	0.00	1.81	62.09
B3	0.00	0.00	0.00	14.47	25.62	15.07	0.00	0.00	0.30	0.00	2.11	57.56
B4	0.90	0.30	1.21	19.89	20.19	11.75	0.00	0.00	2.11	0.00	0.00	56.36
B5	0.60	0.60	0.30	76.25	44.91	19.29	0.00	0.00	0.90	0.60	0.00	143.46
C2	0.00	0.00	0.00	8.74	8.74	3.32	0.00	0.00	0.30	0.00	0.00	21.10
C3	0.00	0.00	0.00	18.99	44.30	4.52	0.00	0.00	0.30	0.00	1.21	69.32
C4	0.00	0.00	0.00	26.82	15.07	12.36	0.00	0.00	5.12	0.00	2.41	61.78
C5	0.00	1.21	3.32	39.78	15.07	11.15	0.00	0.00	2.41	0.60	0.00	73.54
E1	0.30	0.00	1.81	29.54	12.96	12.66	0.00	0.00	0.30	0.00	0.00	57.56
E2	0.00	0.60	2.11	40.69	20.80	22.91	0.00	0.00	3.62	0.00	1.81	92.53
N1	0.00	0.00	0.00	15.37	4.82	9.95	0.00	0.00	0.00	0.00	0.00	30.14
N2	0.30	0.00	0.00	3.01	12.96	1.81	0.00	0.00	0.00	0.00	0.00	18.08
O1	0.00	0.00	0.00	3.01	8.44	3.32	0.00	0.00	0.00	0.00	0.00	14.77
O2	0.00	0.00	0.00	58.77	14.47	6.63	0.00	0.00	0.90	0.30	2.11	83.18
S1	2.41	0.00	10.85	61.78	24.41	23.51	1.21	0.00	0.90	0.90	0.00	125.98
S2	0.90	2.71	4.22	16.58	39.18	4.22	0.00	11.75	0.60	0.00	0.00	80.17
S3	0.00	0.60	0.00	15.37	8.44	9.04	0.00	0.00	1.21	0.00	0.00	34.66
S4	0.60	1.21	1.21	7.23	4.82	1.51	0.00	0.00	0.60	0.00	0.00	17.18
Total	6.03	7.23	25.02	477.70	358.65	177.52	1.21	11.75	20.49	2.41	11.45	1099.46

1= Bivalvia, 2=Acari, 3= Foraminifera, 4=Nematoda, 5=Copepoda, 6=Polychaeta, 7—Tanaidacea, 8=唇 opoda, 9=Kinorhyncha, 10=0stracoda Y

Table 6.19.- Boimasa (gg Corg 10cm-2) the meifauna groups found in the sampling sites of the Hokchi area.

Biomass (µg Corg 10cm $^{-2}$)									
STATION	Nematode	Copepoda	Polychaeta	Tanaidacea	Isopoda	Kinorhyncha	Ostracoda	Gastrotricha	Total
B2	6.95	2.29	0.67	0.00	0.00	0.04	0.00	0.37	10.33
B3	4.48	11.20	1.34	0.00	0.00	0.01	0.00	0.28	17.31
B4	5.65	3.49	46.53	0.00	0.00	0.14	0.00	0.00	55.81
B5	15.11	4.37	7.40	0.00	0.00	0.03	0.64	0.00	27.55
C2	2.07	2.06	3.49	0.00	0.00	0.01	0.00	0.00	7.63
C3	7.12	2.65	3.70	0.00	0.00	0.01	0.00	1.65	15.12
C4	6.27	3.17	2.75	0.00	0.00	0.26	0.00	0.25	12.70
C5	5.03	1.45	4.73	0.00	0.00	0.15	0.37	0.00	11.72
El	5.04	2.63	2.49	0.00	0.00	0.01	0.00	0.00	10.16
E2	3.53	4.22	2.94	0.00	0.00	0.24	0.00	0.12	11.05
N1	4.39	1.27	5.73	0.00	0.00	0.00	0.00	0.00	11.40
N2	0.64	1.96	1.06	0.00	0.00	0.00	0.00	0.00	3.66
O1	0.22	8.34	0.65	0.00	0.00	0.00	0.00	0.00	9.22
O2	11.65	7.43	3.45	0.00	0.00	0.02	0.27	0.10	22.91
S1	9.81	27.61	47.18	0.89	0.00	0.08	0.79	0.00	86.36
S2	4.02	2.17	0.54	0.00	2.90	0.02	0.00	0.00	9.64
S3	1.44	0.48	2.21	0.00	0.00	0.10	0.00	0.00	4.23
S4	0.77	0.70	7.30	0.00	0.00	0.02	0.00	0.00	8.79
Total	94.18	87.47	144.15	0.89	2.90	1.14	2.07	2.78	335.58

It should be noted that not much information is available on the density, biomass and/or diversity of the meiofauna of the exclusive economic zone of the Gulf of Mexico. In September 1988, and April and November 1989, Escobar-Briones and Soto (1997) carried out a study of the benthic fauna in the western part of the Gulf of Mexico from the southern area of the Rio Bravo to the northern area of the Laguna de Tamiahua, at depths of 16-50 m, 50-100 m and 100-200 m. The biomass values observed in this study for the month of November 1989 were lower than the average value (18.64 µg C 10cm-2) registered for the Hokchi area in February 2016 (present study); whereas, the values for the months of September 1988 and April 1989 were significantly higher.

Likewise, Escobar et al. (1997) carried out an investigation on the benthic fauna in the western and southern areas of the Gulf of Mexico, off the coasts of Tamaulipas and Yucatán at depths between 196 m to 540 m. Similarly, the values reported by these authors for the coasts of Tamaulipas are much higher than those reported in the present work.

There are many factors that may be responsible for the differences observed between the works of Escobar and Soto (1997) and Escobar et al. (1997), and those found in this study. The spatial and temporal variation of the taxonomic composition, density and biomass of the meiofauna is strongly influenced by environmental factors, one of the most important being the contribution of organic matter through rivers, estuaries and lagoons. These contributions are normally higher during the rainy season, and it is comparatively stronger in the southern and western part of the Gulf of Mexico, where the most important rivers and lagoon systems in the area are found. Therefore, comparisons between studies carried out in different climatic stations or localities are not recommended.

Macrobenthos

Based on the analysis of the sediment samples collected in the oceanographic cruise in February 2016 in the Hokchi area and its surroundings, the faunal composition of the area comprises seven rows of macrobenthic invertebrates: annelids, crustaceans (Arthropoda), echinoderms, mollusks , nematodes, sipuncúlids and amphyoxes (Cephalochordata). The taxa identified are presented in the following list, indicated in bold and followed by their taxonomic authority:

Phylum Annelida

Clase Polychaeta

Subclase Errantia

Eunicide Order

Eunicidae Berthold, 1827

Dorvilleidae Chamberlin, 1919

Lumbrineridae Schmarda, 1861

Onuphidae Kinberg, 1865

Order Phyllodocida

Suborder Aphroditiformia

Pisionidae Ehlers, 1901

Polynoidae Kinberg, 1856

Suborder Glyceriformia

Glyceridae Grube, 1850

Goniadidae Kinberg, 1866

Suborder Nereidiformia

Nereididae Blainville, 1818

Pilargidae de Saint-Joseph, 1899

Syllidae Grube, 1850

Suborder Phyllodociformia

Phyllodocidae Örsted, 1843

Sedentary Subclass

Capitellida Order

Capitellidae Grube, 1862

Order Cirratulida

Cirratulidae Rickholt, 1851

Paraonidae Cerruti, 1909

Orden Cossurida

Cossuridae Day, 1963

Opheliida Order

Opheliidae Malmgren, 1867

Orbiniida Order

Orbiniidae Hartman, 1942

Orden Magelonida

Magelonidae Cunningham & Ramage, 1888

Sabellida Order

Sabellidae Latreille, 1825

Spionida Order

Spionidae Grube, 1850

Order Terebellida

Terebellidae Grube, 1850

Phylum Arthropoda

Subphylum Crustacea

Malacostraca class

Subclass Eumalacostraca

Superorder Peracarida

Orden **Cumacea** Kroyer, 1846

Orden **Isopoda** Latreille, 1817

Orden **Tanaidacea** Dana, 1849

Superorder Eucarida

Orden **Decapoda** Latreille, 1802

Clase Maxillopoda

Subclass Copepoda

Gymnoplea superorder

Orden Calanoida Sars, 1903

Phylum Echinodermata

Clase **Asteroides** De Blainville, 1830

Phylum Mollusca

Clase **Bivalvia** Linnaeus, 1758

Phylum Nematoda Rudolphi, 1808

Filo Sipuncula Rafinesque, 1814

Filo Cephalochordata Owen, 1846

In total, annelids represented 63.7% of the macrofauna (478 organisms), nematodes 28.2% (212 organisms), amphyoxes 3.2% (24 organisms) and crustaceans and Simpunculidae 2.2 (17 organisms in each phylum), the other groups were scarce. In general, the predominance of polychaete annelids was reflected in all stations, followed by nematodes, while the presence of the other groups was sporadic (Figure 6.28). Only two stations presented an equal proportion between these two taxonomic groups (C3 and S2), and only in two stations were more nematodes than polychaetes found (C2 and 02).

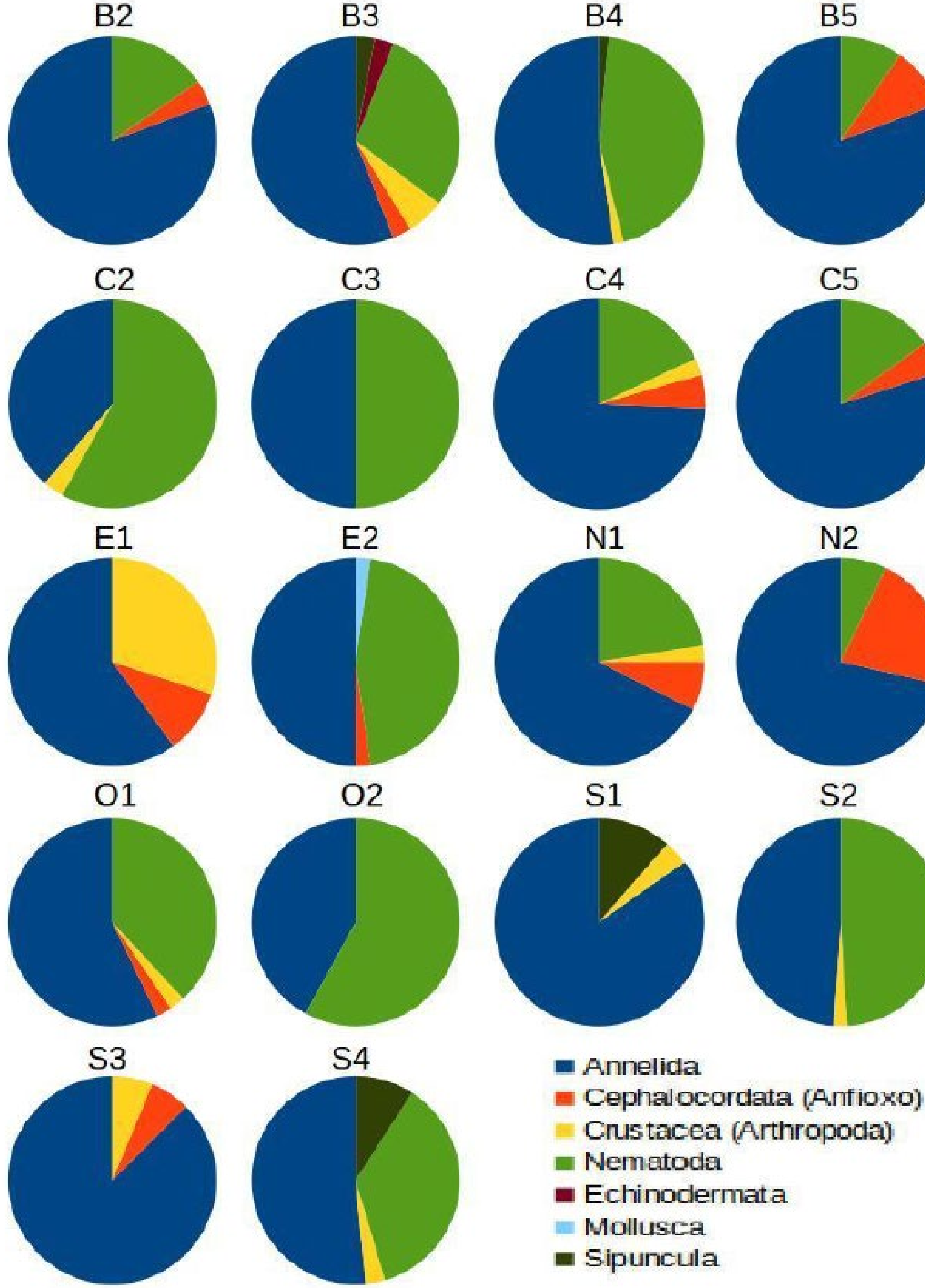


Figure 6.28. Relative abundance of benthic macrofauna rows by site.

In relation to the polychaetes, 22 families were collected, the best represented in terms of their abundance and incidence in the stations were, in decreasing order, Cirratulidae (99 individuals in 12 stations), Spionidae (87 individuals in 14 stations), Paraonidae (45 individuals at 12 stations), Glyceridae (41 individuals at 13 stations), Syllidae (36 individuals at 12 stations), Dorvilleidae (30 individuals at 13 stations) and Pisionidae (30 individuals at 9 stations) (Table 6.20, Figure 6.29).

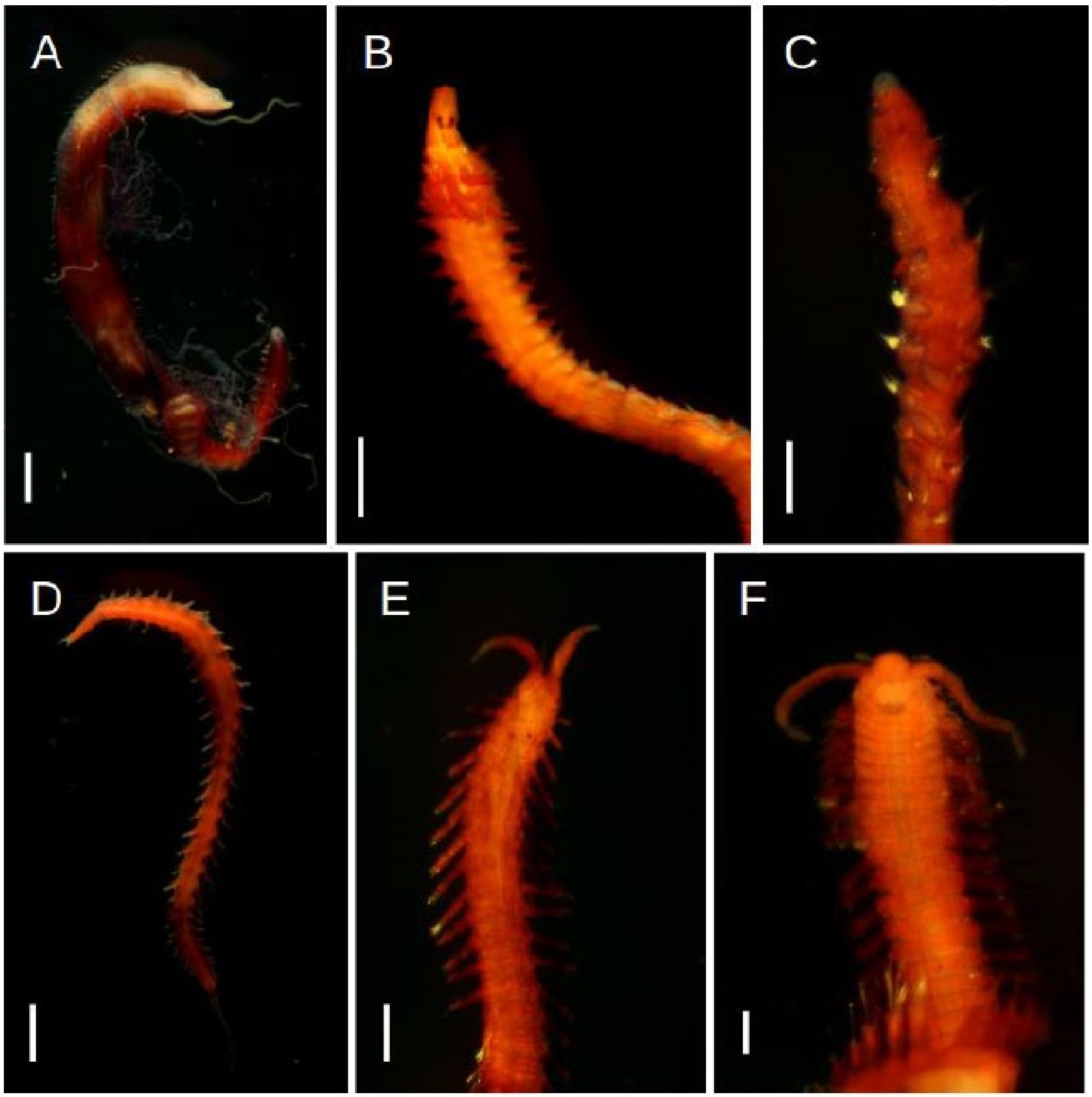


Figure 6.29. Representative families of polychaetes. A) Cirratulidae, B) Spionidae, C) Paraonidae, D) Glyceridae, E) Pisionidae, F) Dorvilleidae.

Table 6.20. Abundance of taxa of the benthic macrofauna (individuals by I).

	Seasons																		
Taxa	B2	B3	B4	B5	C2	C3	C4	C5	E1	E2	N1	N2	O1	O2	S1	S2	S3	S4	**Total**
Annelida																			
Capitellidae	0	0	1	1	2	1	0	0	0	0	3	4	0	1	7	0	0	0	*20*
Cirratulidae	29	10	6	14	5	7	9	9	0	3	0	0	0	4	0	2	1	0	*99*
Cossuridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	*5*
Dorvilleidae	1	0	1	3	0	1	1	2	0	3	3	1	1	0	0	4	2	7	*30*
Eunicidae	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	*1*
Glyceridae	1	0	3	2	0	3	2	1	1	5	6	6	6	1	0	4	0	0	*41*
Goniadidae	1	0	0	0	0	4	7	0	0	0	0	0	0	0	1	0	3	1	*17*
Lumbrineridae	0	0	2	0	0	0	0	0	1	0	0	0	0	0	5	0	1	0	*9*
Magelonidae	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	*2*
Nereididae	2	0	0	0	0	1	0	0	1	0	0	0	2	0	1	0	0	0	*7*
Orbiinidae	1	2	2	0	0	1	0	0	0	0	2	0	0	0	0	0	0	0	*8*
Onuphidae	1	0	0	1	0	0	0	0	0	0	1	0	0	1	0	1	1	0	*6*
Opheliidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	*1*
Paraonidae	2	0	8	0	1	2	4	1	1	3	0	0	2	2	18	0	1	0	*45*
Phyllodocidae	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	*2*
Pilargidae	0	2	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	*6*
Pisionidae	1	0	0	6	0	0	0	1	0	0	1	1	3	0	0	8	3	6	*30*
Polynoidae	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	*4*
Sabellidae	0	0	1	1	0	0	0	0	0	1	1	0	0	0	0	4	0	0	*8*
Spionidae	1	4	7	4	4	0	2	1	0	5	4	2	0	6	44	0	2	1	*87*
Syllidae	1	0	2	1	0	0	2	1	0	2	5	5	10	4	0	1	0	2	*36*
Terebellidae	0	0	1	9	0	0	2	0	0	0	0	1	0	1	0	0	0	0	*14*
Crustacea (Arthropoda)																			
Amphipoda	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	*3*
Calanoida	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*1*
Cumacea	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	*1*
Decapoda	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	*2*
Tanaidacea	0	0	0	0	0	0	1	0	3	0	0	0	2	0	0	2	1	1	*10*
Echinodermata																			
Asteroidea	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*1*
Mollusca																			
Bivalvia	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	*1*
Nematoda	8	10	29	5	18	20	7	3	0	20	9	2	16	29		24	0	12	*212*
Sipuncula	0	1	1	0	0	0	0	0	0	0	0	0	0	0	12	0	0	3	*17*
Cephalocordata (Anfioxo)	2	1	0	5	0	0	2	1	1	1	3	6	1	0	0	0	1	0	*24*
Total	*52*	*33*	*65*	*52*	*31*	*31*	*39*	*20*	*10*	*44*	*40*	*28*	*44*	*50*	*102*	*51*	*16*	*33*	*750*

The particular distribution of the abundance of polychaetes in each station was variable, which can be observed in annex 27. Station C2 stands out, where the lowest number of families (4 families) was registered, as well as the El station with the lowest abundance, since only one individual was registered in each of six families. The highest number of families was found at station 12 (1 2 families), while the highest abundance was recorded at station SI.

Annelids were the dominant component of the benthic macrofauna (Figure 6.28), which coincides with the records of Salazar-Vallejo and Londoño Mesa (2004) for different parts of the world. However, this study highlights the abundance of nematodes and the low abundance of crustaceans, echinoderms and mollusks. Nematodes are important as components of the meiofauna; however, eventually its size may exceed the limit between macro and meiofauna (0.5 mm). In the Sonda de Campeche, high abundances have been recorded (De Jesús-Navarrete 1993).

In general terms, the three dominant families of annelids were Cirratulidae, Spionidae and Paraonidae (Table 6.20, Annex 27). These organisms are inhabitants of areas impacted by excess organic matter in the sediment (Méndez 2002; Ferrando and Méndez 2011). In particular, cirratulidae, paraonidae, espionidae and cappelidae have been found in fattening pens for mariculture due to their great capacity to use available organic matter and quickly convert it into biomass (Díaz-Castañeda 2009).

The stations located in the center of the study area (B2, B3, B4, B5, C2, C3, C4 and C5) are characterized by a strong dominance of the family Cirratulidae and, in some cases, of the family Spionidae, with abundant higher than the other zones (Annex 27). According to the Pearson and Rosenberg (1978) model, contaminated areas are characterized by a great abundance of organisms from very few taxa, that is, a total dominance of indicator species is found. Cirratulidae and spionids are detritivores (Jumars et al. 2015), which confirms the nature of the sediment enriched with organic matter, as well as the great abundance of nematodes (Figure 6.30).

However, the presence of few individuals from other polychaete families indicates that it is an area slightly contaminated by organic matter (Méndez 2002; Ferrando and Méndez 2011).

With the exception of stations S1 and O2, the surrounding areas (S2, S3, S4, O1, El, E2, N1 and N2) are characterized by the presence of several families without high dominance, among which families with carnivorous habits stand out. such as Glyceridae, Sylliidae, Dorvilleidae, Pisionidae and Goniadidae Polynoidae (Figures 5-7). According to Pearson and Rosenberg (1978), clean zones are characterized by a large number of taxa with relatively low abundance, without dominance. The presence of polychaete organisms and carnivorous crustaceans at low densities indicates that they are species indifferent to contamination (Hily and Glémarec 1990), typical of uncontaminated areas (Méndez et al. 1998).

Stations S1 and O2 present large numbers of nematodes, sipuncúlids and detritivore polychaetes of the families Spionidae, Cirratulidae, Paraonidae and Capitellidae, as well as representatives of other families of polychaetes with different feeding habits (Jumars et al. 2015). These results suggest that it may be a transition zone between the central zone (slightly contaminated) and the surrounding areas (not contaminated) due to the mixture of pollution indicator species and clean areas (Méndez et al. Figure 1998 (Figure 6.30)

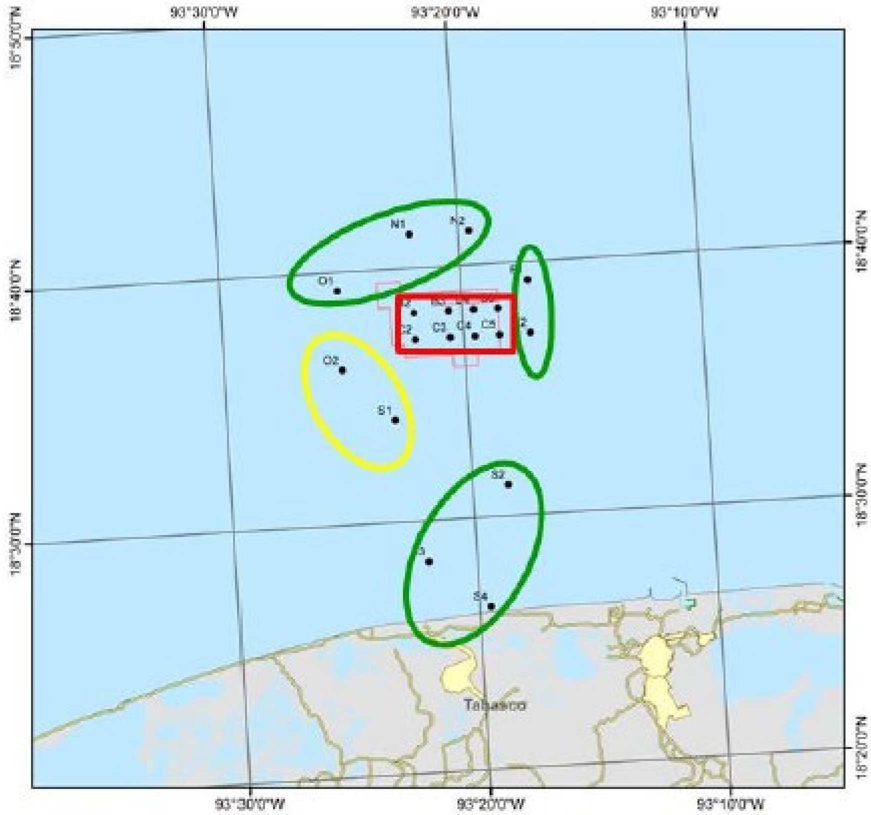


Figure 6.30. Study area showing the areas identified according to the Pearson and Rosenberg (1978) model, depending on the composition and abundance of the macrofauna. Green ovals = areas not organically contaminated; Yellow ovals = transition zone; red box = central area of Hokchi with slight organic enrichment.

Apparently, due to the macrobenthic fauna composition, the study area is subject to different conditions of organic enrichment: the slightly contaminated central area, the uncontaminated surrounding areas and the transition zone between the two. To establish the temporal pattern it is necessary to carry out detailed ecological studies at different times of the year.

Additionally, two shrimp net trawls were carried out, through which other macrobenthic organisms were obtained, such as bivalve shells of the genus *Pecten,* (Figure 6.31), which, although they are only remains that could be transported to the area through of currents, suggest the presence of this species in nearby waters or even within the explored quadrant.

Figure 6.31. Bivalve shells of the genus *Pecten* found in the second trawl.

Likewise, some crustaceans were caught, mainly commercial shrimp of the species Farfantepenaeus aztecus' ves, 1891 and a stomatopod that could not be identified due to the mistreatment it suffered during trawling (Table 6.21).

Table 6.21. Crustacean catch data.

SPECIES	Sex	Total length (mm)	Total weight (g)	Observations
F. aztecus	M	141	24.2	
F. aztecus	M	119	15.5	
F. aztecus	M	136	24.1	
F. aztecus	F	125	20.5	
F. aztecus	F	178	59.2	
F. aztecus	F	157	39.0	
F. aztecus	F	---	3.9	Just moved in.

The low presence of benthic macrofauna in trawls may be due to several factors. In a large number of localities close to the drag zone, the sediments collected on the bottom have a significant component of fine sands that are easy to move with the current, which together with the regime of winds and currents (north) suggests an important movement of the bottom sands, generating an unstable habitat for the settlement of a benthic macrofauna.

6.4.4. Necton

Peces (ictiofauna)

In total, 25 species of fish were caught, representing a total of 72.4 kilos and 723 organisms. Table 6.22 lists the species captured as well as their abundance and biomass.

Table 6.22: Species captured in both carryover along with the abundance and total biomass captured.

Species	**Common name**	**Abundance**	**Biomass (gr)**
Acanthostracion quadricornis	Boxfishes	20	3397.63
Aluterus monoceros	Little pig, trigger fish	1	884
Bagre marinus	Catfish, catfish.	3	883
Bothus ocellatus	Sole	18	895
Opisthonema oglinum	Sardine	4	186
Syacium micrurum	Sole,	21	1324
Dactylopterus volitans	Pez golondrina	3	490
Decapterus punctatus	Macarela falsa	76	3312

Diplectrum bivittatum	Guabina	18	926
Eucinostomus argenteus	Common two banded seabream	6	291
Eucinostomus melanopterus	Common two banded seabream	1	32
Petimba fistularia	Needle, big needle, pipe, flute, cornet	2	423
Tobacco fistula	Needle, big needle, pipe, flute, cornet	1	134
Lutjanus analis	Snapper	6	193
Lulanus synagris	Yellowtail snapper	8	1652
Menticirrhus littoralis	Gulf kingfish	1	531
Narcine brasiliensis	Torpedo ray	1	268
Prionotus ophryas	Yellowtail snapper	8	371
Rhomboplites aurorubens	Sea bream	198	10938
Scorpaena plumieri	Scorpion fish, stone fish.	1	607
Selar crumenophthalmus	Big-eyed horse mackerel, big-eyed horse mackerel	7	361
Sphyraena borealis	Barracuda	284	42781
Synodus foetens	Chile, lizard fish	1	65
Trachurus lathami	chicharito ojón	31	1370
Upeneus parvus	Chivito	3	97
TOTAL		723	72411.63

Although the effort was similar in both trawls, the number of species, abundance and biomass were higher in the first trawl. Figure 6.32 shows the natural logarithm of the abundance of each species by drag. In this it is observed that there is a greater number of species and an abundance in trawl 1.

The figure 6.33 shows the logarithm of the biomass in grams. It is appreciated from the same way that in the first drag was where more species were collected and there was a greater number of organisms collected.

In these results it can be observed that the dominant species in each Trawls were different, and even though these generally change, only 5 species were caught in both trawls.

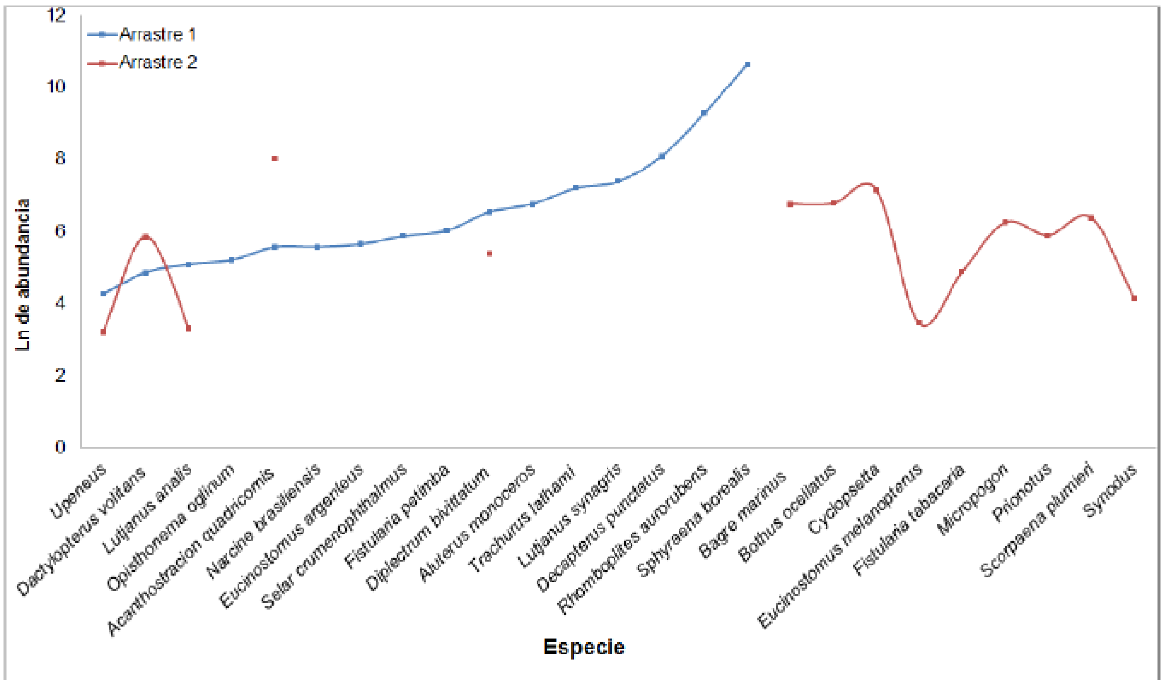


Figure 6.32. Ln of the abundance of fish collected during the 2 trawls.

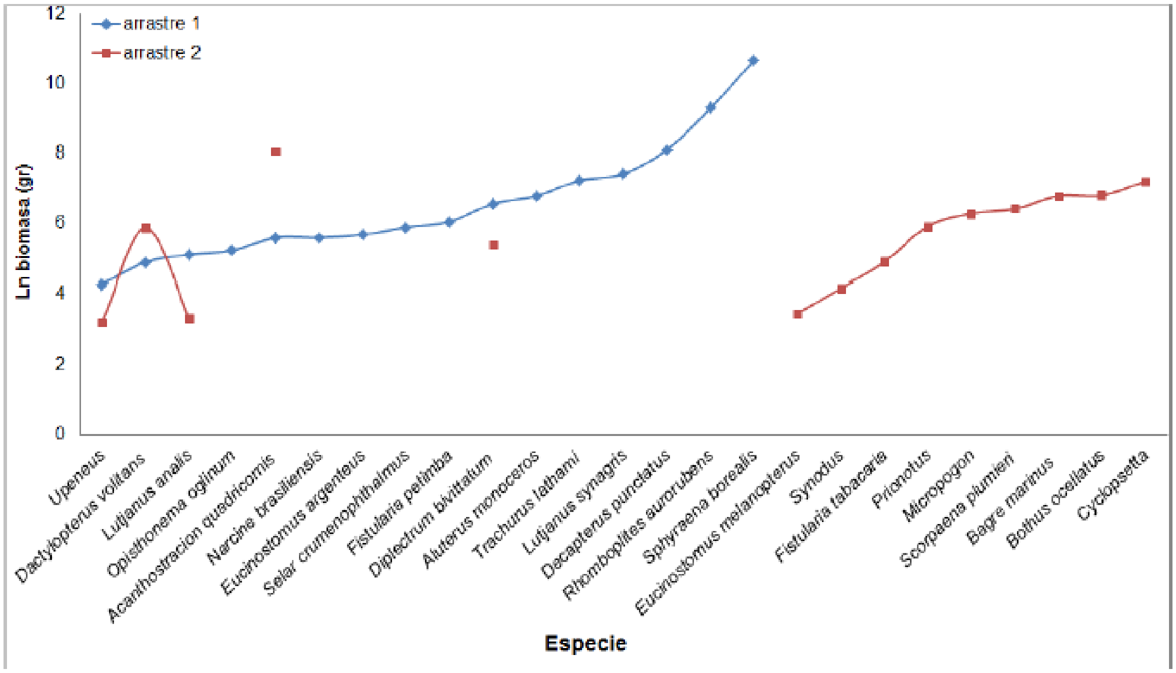


Figure 6.33. Ln of the biomass in grams of fish collected during the 2 trawls.

Table 6.23 lists the species captured in the first trawl, along with their abundance and percentage of contribution to the total, and table 6.24 shows the results of the diversity indices.

Table 6.23. Species caught in the first trawl (February 12, 2016 at 12:09 am), arranged according to their relative importance.

Species	N	%
Sphyraena borealis	284	44.24
Rhomboplites aurorubens	198	30.84
Decapterus punctatus	76	11.84
Trachurus lathami	31	4.83
Diplectrum bivittatum	14	2.18
Lutjanus synagris	8	1.25
Selar crumenophthalmus	7	1.09
Eucinostomus argenteus	6	0.93

Lutjanus analis	5	0.78
Opisthonema oglinum	4	0.62
Upeneus parvus	2	0.31
Petimba fistularia	2	0.31
Lactophrys tricomis	2	0.31
Narcine brasiliensis	1	0.16
Aluterus monoceros	1	0.16
Dactylopterus volitans	1	0.16
TOTAL	642	100

Table 6.24. Results of the diversity indices of the first carryover.

Symbol	**Index**	**Value**
S	Specific wealth	16
DMg	Margalef diversity	2.320
DMn	Menhinick diversity	0.631
A	Simpson index	0.308
d	Berger-Parker index	0.442
H’	Shannon-Wiener index	1.507
Hp	Weighted diversity index	0.655

Table 6.25 species caught in the 2 [6.26] drag, with its abundance and percentage contribution to the total and Table 6.26 are the results of the diversity indices for that drive are listed.

Table 6.25. Species caught in the 2nd trawl (February 12, 2016 at 8:27 p.m.), arranged according to their relative importance

Species	**N**	**%**
Syacium micrurum	21	25.93
Bothus ocellatus	18	22.22
Lactophrys tricomis	18	22.22
Prionotus	8	9.88

Diplectrum bivittatum	4	4.94
Bagre marinus	3	3.70
Dactylopterus volitans	2	2.47
Eucinostomus melanopterus	1	1.23
Upeneus parvus	1	1.23
Scorpaena plumieri?	1	1.23
Synodus	1	1.23
Lutjanus analis	1	1.23
Micropogon	1	1.23
Tobacco fistula	1	1.23
TOTAL	81	100

Table 6.26. Results of the diversity indices of the first carryover.

Symbol	**Index**	**Value**
S	Specific wealth	14
DMg	Margalef diversity	2.958
DMn	Menhinick diversity	1.556
λ	Simpson index	0.181
d	Berger-Parker index	0.259
H’	Shannon-Wiener index	1.989
Hp	Weighted diversity index	0.864

According to the previous results, it is observed that in the 2 ^{0} trawl zone, the diversity is greater, despite the fact that there are fewer species. This is because the equity of species is greater in the area of the second trawl. This means that in the 2 ^{0} trawl the species are distributed more evenly, while in the first trawl there was one species that clearly dominated, which was the barracuda (Sphyraena borealis).

When analyzing the data using multivariate analysis such as multidimensional scaling (MDS), it is observed that no groups are formed that differentiate both trawls (Figure 6.34).

This indicates that despite the fact that in the 2 ^{0} trawl the diversity is higher, the general composition of species between both sites does not vary in a statistically significant way.

Figure 6.34. MDS analysis of trawls carried out in the Gulf of Mexico.

The gray circles represent the data from the first drag, while the black boxes represent the data from the 2 ^{0} drag.

The foregoing is confirmed by the analysis of similarities (ANOSIM), which indicates that there are no significant differences between the species composition of trawl 1 with those of trawl 2 (R = O.OOI, p> 0.001).

Due to the fact that no significant differences were found, the SIMPER analysis was not carried out, since since there were no differences, it is not interesting to know which species were causing the differences.

The total number of species caught in both trawls was low, considering the fishing gear used (16 and 14, respectively), indicating an area strongly impacted by the anthropogenic activities that are carried out in that region of the country.

On the other hand, several of the species caught are of some commercial importance in the region, especially for artisanal fishing, in so-called "scale" fishing, which mainly catches demersal fish. From the above it can be deduced that it is an area with a dominance of demersal species, a low diversity and richness in general, and that the ichthyofauna throughout the studied area is the same.

Parasitic isopods

In the first trawl of the shrimp nets, 10 individuals of Parasitic isopods of the species Nerocila acuminata, attached to the fish Aluterus monoceros (Figure 6.35).

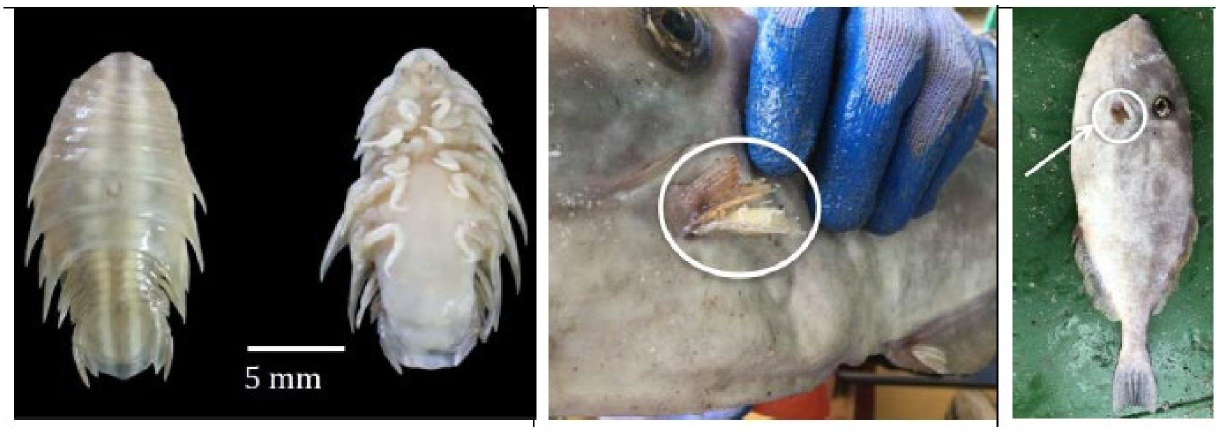


Figure 6.35. Parasitic isopods of the species *Nerocila acuminata*, attached to the *fish Aluterus* monoceros.

Squid

From the first drag, two squid individuals belonging to the species *Loligo pealei* Lesueur, 1821 (Figure 6.36) were collected, one with a length of 10.5 cm in total length and 6.5 cm in dorsal length of the mantle and the other also 10.5 cm in length. total length and 7.5 cm dorsal length of the mantle. Both represent a total biomass of 20.09 g fresh weight.

Figure 6.36. Squid specimen of the species *Loligo pealei* Lesueur, 1821 collected in the first trawl.

From the second drag, 10 squid individuals were collected that belong to the species Loligo pealei Lesueur, 1821 (Figure 6.37), with sizes ranging from 8 to 11.8 cm (with an average of 5.5 cm) in total length and 8 at 8 cm dorsal length of the mantle. All individuals represent a total biomass of 300 g fresh weight.

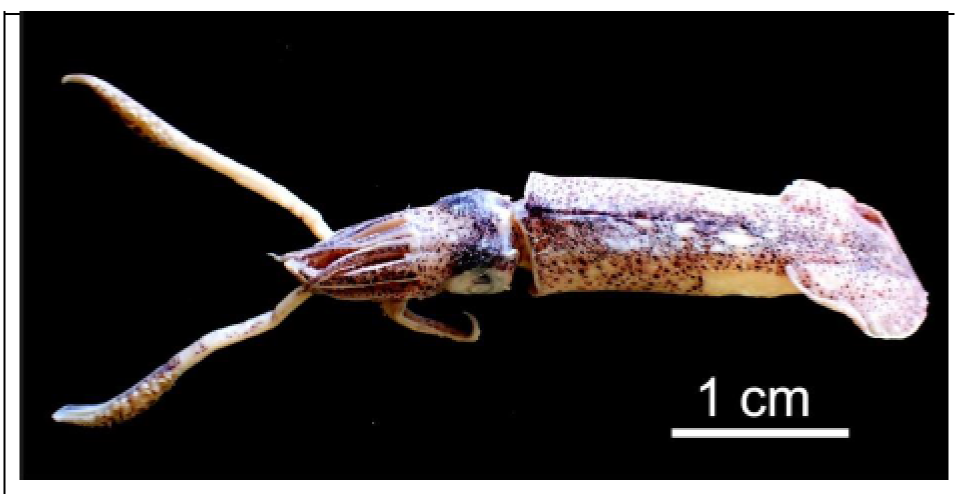


Figure 6.37. Squid specimen of the species *Loligo pealei* Lesueur, 1821 collected in the second trawl.

6.6. Sensitive areas and organisms

6.6.1. Sea turtles

DOCUMENTARY RESEARCH

The lack of monitoring and conservation programs for sea turtles in the Hokchi area of environmental influence was evidenced by the scant information published. However, the presence in said area of the five species of sea turtles reported for the Gulf of Mexico and Atlantic region was documented.

The species Lepidochelys kempÍi (olive ridley turtle), Chelonia mydas (white or green turtle), Eretmochelys imbricata (hawksbill turtle), Caretta caretta (loggerhead turtle) and Dermochelys coñacea (leatherback turtle) are referenced for this area.

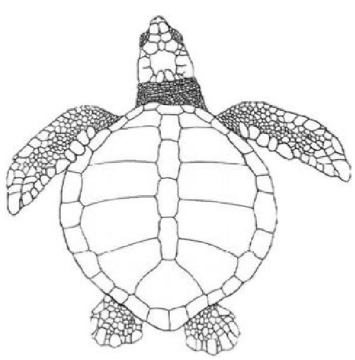
For the purposes of this study, the zone of environmental influence of the Hokchi area was divided into 13 sectors, the location of which is shown in figure 6.38. In O is the compilation of data by species and the location of the sea and beach records. In the latter habitat, the nesting records were differentiated from the strandings of sea turtles.

The distribution of historically recorded turtles was located according to the beach zoning carried out during the field survey carried out in February 2016, in order to compare both results. Records at sea, related to migratory routes and feeding and development habitats are shown at 0. On the map, it is highlighted that the marine-coastal zone in front of the El Carmen-La Machona and Mecoacán lagoons can be considered as feeding and development areas for sea turtles.

Figure 6.38. Zoning of the zone of environmental influence of the Hokchi area

Specific data from the documented sites for each species are described below:

***Lepidochelys kempii* (*olive ridley* turtle)**



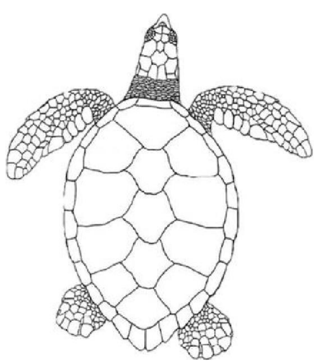
There are records for Playa Miramar (2004), Alacranes (1990) and Sánchez Magallanes in (1979) by Zurita et al., 2010, although Márquez and Fritts (1983) mention that no traces were observed for this species on the coasts of Tabasco. However, there were also unquantified traces due to the difficulty of the censuses. Despite forming arrivals during nesting, this species also has a solitary nesting behavior along the coasts of the Gulf of Mexico and up to the Yucatán peninsula (Guzmán-Hernández et al. 2007).

Table 6.27. Historical records of sea turtles according to the bibliography consulted. Where (Lk = Lepidochelys Kempii, Ei = Eretmochelys imbricata, Cm = Chelonia mydas, Cc = Caretta caretta, Dc = Dermochelys coñacea).

Status	Zone	In water					Nesting and turtles on the beach					Strandings				
		Lk	*Ei*	cm	*Cc*	*Dc*	*Lk*	*Ei*	cm	*Cc*	*Dc*	*Lk*	*Ei*	cm	*Cc*	*Dc*
Tabasco	A	X	X		X			X		X						
	B	X				X	X	X		X						
	C	X						X	X							
	D							X	X							
	E	X	X			X		X								
	F															
	G						X									
	H	X							X					X		
	I															
	J	X	XX		X											
	K	X	X		X		X	X	X							
VERACRUZ	L															
	M							X	X					X		

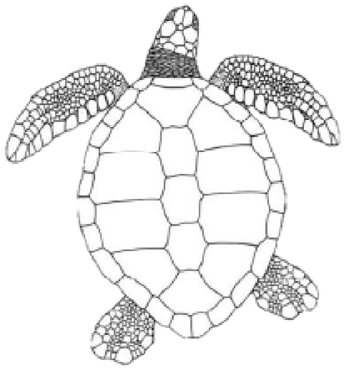
Figure 6.39. Records of the distribution pattern of sea turtles with satellite transmitters in the marine environment of the prospecting area. The polygon in red corresponds to the Hokchi area.

***Eretmochelys imbricata* (hawksbill turtle)**



Márquez and Fritts (1983) recorded 3 hawksbill turtle remains between Coaüacoalcos and El Carmen lagoon and a remainder in the Mecoacán bar. In 2010, two nests were recorded at La Estrella beach, one at Miramar, another at Sánchez Magallanes and three at Playa Azul in 1990 (Zurita et al., 2010) and at Frontera. Recent data includes two nests in 2013 and another two in 2014 on the beaches of Villa de Allende, between Rabón Grande and Arroyo El Gavilán, south of Coatzacoalcos Veracruz; and a hawksbill nesting on the beaches of Nuevo Centla Tabasco, within the Pantanos de Centla Biosphere Reserve in July 2015.

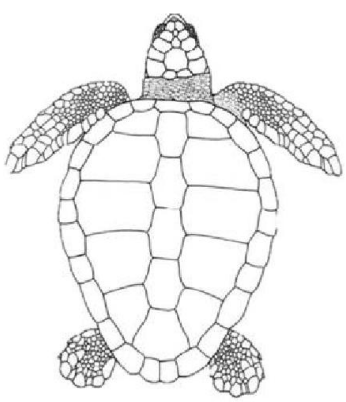
***Chelonia mydas* (white or green turtle)**



Márquez and Fritts (1983) observed in Tabasco medium-energy beaches and dunes of 1 to 8 m, with characteristics suitable for nesting habitat of the white turtle mainly. However, they noticed a coastal area deteriorated by industry and urbanism. In 8% of the beaches located between Coatzacoalcos and the El Carmen lagoon, between 1982 and 1983, they observed three predated nests. Zurita *et al.,* 2010, mentioned two nesting records more than five decades ago.

Between 2013 and 2014 and 2013, six nests occurred on the beaches of Villa de Allende between Rabón Grande and Arroyo el Gavilán, to the south of Coatzacoalcos Veracruz; one more to the south of Sánchez Magallanes and another to the east of Miramar beach in Tabasco. The last record is from July 2015, and reports a female trapped in a pool near the Arroyo Verde beach in Paraíso Tabasco, possibly she went out to nest and when she fell she was stranded.

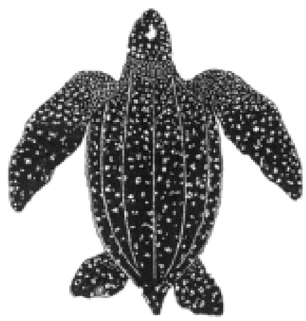
***Carena carena* (loggerhead turtle)**



Márquez and Fritts (1983) did not record loggerhead turtle nesting tracks in aerial surveys over Tabasco. However Zurita et al., 2010, report a report in the 1950s at Playa La Estrella and two, at Miramar beach in the 1960s

Dermochelys coriacea **(leatherback turtle)**

For leatherback turtles, there are only records of organisms feeding in the sea, there are no records of tracks or nesting on the beach in the state of Tabasco and in the south of Veracruz. The closest documented data come from Lechuguillas beach, Veracruz in 1998 (Zurita and Prado, 2007) and from three nests in Cayo Arcas during 2008.



Leatherback nests are considered occasional on the Caribbean coasts (Maldonado, 2005).

<u>Prospecting on Site</u>

A) Surveys

31 surveys were applied to coastal inhabitants in different places along the coast of Tabasco and southern Veracruz, in February 2016 (Figure 6.40).

Figure 6.40. Jasiel de la Cruz de la Cruz, wife and mother-in-law: residents of the Barra de Tupilco community, whose economic activity is the collection of vehicles that occupy the road of their property.

Of the total number of people interviewed, 94% were men and 6% women. Most of the men are engaged in fishing. Other activities were commerce, construction, petrochemicals, and copper production. The average age was 45 years. 90% of the people reported seeing sea turtles; mainly in the adult stage, although the first reports of hatchling sightings were also obtained on the beach and at sea.

In the integration of data from the interviews, the distribution update of the sea turtle sightings was obtained, along the coast of Tabasco and Veracruz, on land and in water, including nesting and stranding events (0).

In the same table, a comparison is made of the information collected in the bibliography and the results of the surveys. There are documented records in the bibliography and from surveys with points of agreement.

It is highlighted that some data, despite having an origin of up to 50 years ago, the use of habitat is still valid.

Table 6.28. Distribution of sea turtles in the area according to the results of the surveys (X) and the results of the documentary consultation (boxes in gray) (Lk = *Lepidochelys Kempii,* Ei = *Eretmochelys imbricata,* Cm = *Chelonia mydas,* Cc = *Caretta caretta,* De = *Dermochelys coriacea,* NI = Unidentified).

Status	**Zone**	**In water**					**Nests and nesting turtles on beach**					Strandings Playa						**Offspring (observations)**
		Lk	***Ei***	cm	***Cc***	***Dc***	***Lk***	***Ei***	cm	***Cc***	***Dc***	***Lk***	***Ei***	cm	***Cc***	***Dc***	***NI***	
Tabasco	**A**		X														X	
	B								X									
	C						X	X	X									
	D							X	X									
	E								X								X	
	F	X				X	X	X	X				X					Offspring
	G							X					X					
	H			X					X			X						
	I						X											
	J															X		
	K		X		X	X	X	X	X									hatchlings in july
VERACRUZ	**L**			x			X	X	X			X		X				hatchlings in the sea
	M							X	X				X	X				

B) Record of Nesting on the Tabasco coastline

Data compiled on nesting records in the survey area in site, come from the following sources: 1) from interviews conducted in the field, 2) from oral testimonies obtained in 2011, with a reference from 5 to 50 years ago, 3) data from monitoring done in southern Veracruz during 2013 and 2014 and 4) records in 2015 in the state of Tabasco (0 and 06.41

- Kemp's ridley turtle ***(Lepidochelys kempii)*** nesting reports in Miramar, Las Flores ranchería, Cuauhtemoctzin and the Pailebot. Total record of 5 nests.

- Hawksbill turtle ***(Eretmochelys imbricata)*** nesting records at Playa Miramar, Pico de Oro, Playa Varadero, Cuauhtemoctzin, Unión Tercera, Boxal and Las Palmitas (South of Veracruz). It is observed, according to the opinion of the testimonies obtained, that the frequency of nesting has decreased. As nesting periods, they mentioned during June or after Easter. 13 nests were counted, of which 6 occurred between 2014 and 2015.

- White or green turtle (Chelonia mydas) Nesting sightings with events at Miramar, Pico de Oro and Unión beaches

- ***Loggerhead turtle (Caretta caretta*** *)* no nesting information was obtained recently. The testimonies available are from fifty years ago on La Estrella and Miramar beaches with two records in total.

Figure 6.41. Nesting sites registered in the states of Tabasco and southern Veracruz

C) Distribution of strandings on the coast of Tabasco

Information was collected regarding the mortality of sea turtles based on the number of strandings on the beaches. A low rate of stranding was identified. In the surveys, recent sightings of dead olive ridley and white turtles were mentioned in front of the mouth of the Tonalá River and in front of the Sinaloa ejido, associated with the northern season. The geographic distribution of reported strandings is shown on the f0 map.

Figure 6.42. Distribution of sea turtle stranding in the states of Tabasco and Sur de Veracruz.

D) Records of sea turtles in the littoral zone

The marine area located in front of the mouth of the El Carmen lagoon was identified as a feeding area for the five species found in the Gulf of Mexico. With the information collected in the surveys, the presence of sea turtles within the lagoon and in the surrounding marine area was recorded (0),

- Kemp's ridley (***Lepidochelys kempii)*** sightings of specimens were reported mating off Unión Segunda, Central region of Tabasco.
- Hawksbill turtle ***(Eretmochelys imbricata)*** presence was identified in the marine area in front of La Estrella beach. Likewise, the inhabitants of Tonalá mentioned the existence of a rocky area in front of the Tortuguero town where they have been observed feeding
- White turtle ***(Chelonia mydas)***, information was obtained on the presence of this species in the marine area in front of La Redonda and Sánchez Magallanes, as well as the rocky area in front of Tortuguero south of Veracruz, the same area where there are reports of carey. In addition, it was mentioned having observed juvenile turtles inside the El Carmen lagoon.
- Loggerhead turtle ***(Caretta caretta)*** sightings were reported in the marine area off Sánchez Magallanes and at the mouth of the El Carmen lagoon.
- Leatherback turtle ***(Dermochelys coriacea)*** testimonies of sightings were recorded at sea off Sánchez Magallanes, the mouth of the El Carmen lagoon, and off Unión Tercera.

6.6.2. Manglar

Forest Structure

Tables 6.29 to 6.31 show the different parameters of the mangrove forest structure of the Carmen-La Machona lagoon complex.

Table 6.29. Mangrove structure of transect 1 in the El Carmen —Pajonal-La Machona lagoon complex. For location see coordinates in annex 7.

Species	**Density/ha**	Density	**Average diameter (cm)**	**Average Basal Area (cm^2)**	Absolute dominance (m2/ha)	**Average height (m)**
Avicennia germinans	779.986	70	24.521	695.878	54.278	11.42
Rhizophora mangle	222.853	20	13.090	163.661	3.647	7.5
Dead	111.427	10	15.358	191.881	2.138	
Total					60.063	

Table 6.30. Mangrove structure of transect 2 in the El Carmen —Pajonal-La Machona lagoon complex. For location see coordinates in annex 7.

Species	**Density/ha**	Density	**Average diameter (cm)**	**Average Basal Area (cm^2)**	Absolute dominance (m2/ha)	**Average height (m)**
Avicennia germinans	530.738	57.5	23.486	552.533	29.325	
Rhizophora mangle	323.058	35	15.188	229.876	7.426	11.06
Laguncularia racemosa	46.151	5	16.552	226.636	1.046	
Dead	23.076	2.5	24.191	459.638	1.061	
Total					38.858	

Table 6.31. Mangrove structure of transect 3 in the El Carmen —Pajonal-La Machona lagoon complex. For location see coordinates in annex 7.

Species	Density/ha	Density	Average diameter (cm)	Average Basal Area (cm ²)	Absolute dominance (m2/ha)	Average height (m)
Avicennia germinans	584.417	55	24.163	606.243	35.430	
Rhizophora mangle	371.902	35	14.597	251.326	9.347	13.03
Laguncularia racemosa	26.564	2.5	6.684	35.094	0.093	
Dead	79.693	7.5	7.958	71.434	0.569	
Total					45.439	

The mangrove complex of this lagoon system can be considered as a mature forest with a good degree of structural development, particularly high dominance (> 38 m^2 / ha) and relatively healthy with a natural mortality of 2.5 to 7.5% with the exception of the transect 1 that presents a slightly high mortality (10%) probably related to unsustainable extraction of wood. Even so, the presence of a high density of seedlings suggests areas with a tendency for rapid recovery. An important competition of the mangrove with coconut crops was detected.

Densities ranged from 923 to 1,114 shafts / ha, which indicates an open forest in a good state of conservation where from 55 to 70% the black mangrove *(A. germinans)* predominates with red mangrove *(R. mangle)* in second term with the 20 at 35% of the relative density and scarce presence of the white mangrove *(L. racemosa).*

The different areas presented the classic zonation with red mangrove *(R. mangle)* in a narrow strip adjoining the lagoon body (border-riparian type) seconded by a wide strip of black mangrove *(A. germinans)* and button mangrove (C. *erectus)* practically absent. Probably the absence of the buttonhole mangrove is due to its displacement by coconut crops.

<u>Foliar Cover</u>

Leaf covers ranged from 46.8 to 78% in transect 1, from 69.4 to 84.8% in transect 2, and in transect 3 from 66.6 to 85.2%, as can be seen in figures 6.43 to 6.52.

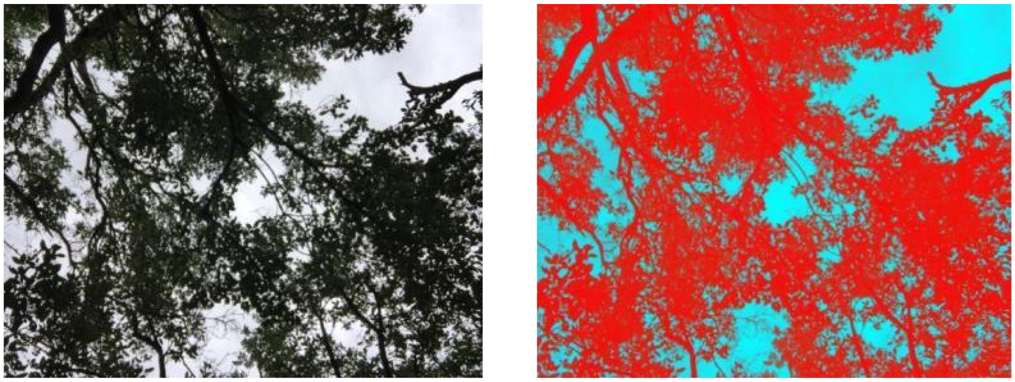


Figure 6.43. Transect 1 El Carmen- La Machona wetland complex (18 ^{17} 93'47.62N, 50 $^{68.9}$ 37.52'13.39W) 27.31% foliar coverage with an average of 27 ± 27.31 and a median of 27.

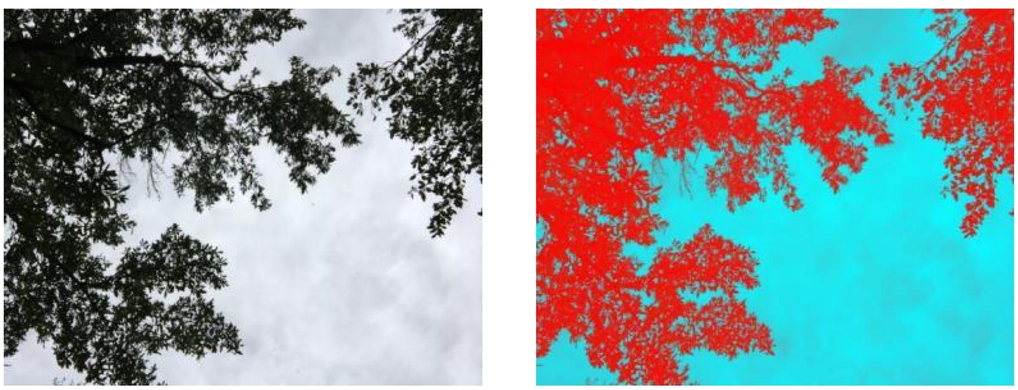


Figure 6.44. Transect 1 El Carmen- La Machona wetland complex (18 ^{17} 93'47.23N, 50 $^{46.8}$ 40.05'14.68W) 38.66% foliar coverage with an average of 24 ± 38.66 and a median of 24.

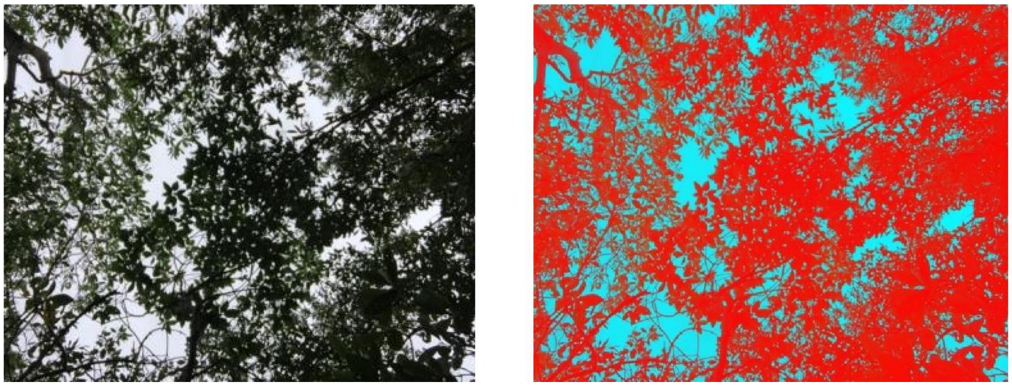


Figure 6.45. Transect 1 The El Carmen- La Machona wetland complex (18 ^{17} 93'47.29N, 50 $^{78.8}$ 47.13'12.75W) 41.46% of foliar coverage with an average of 30 ± 41.46 and a median of 30.

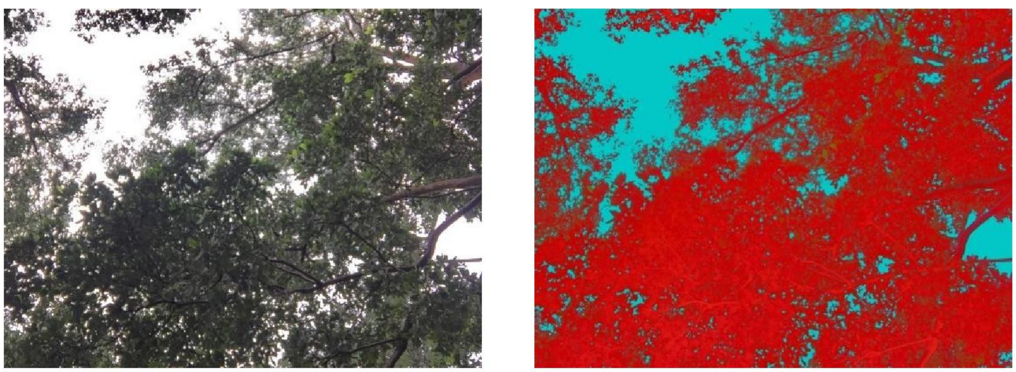


Figure 6.46. Transect 2 El Carmen- La Machona wetland complex (18 ^{18} 93'41.56N, 77.7 $^{73.72}$ 26.98'46.44W) 67% foliar coverage with an average of 35.72 ± 26.98 and a median of 67.

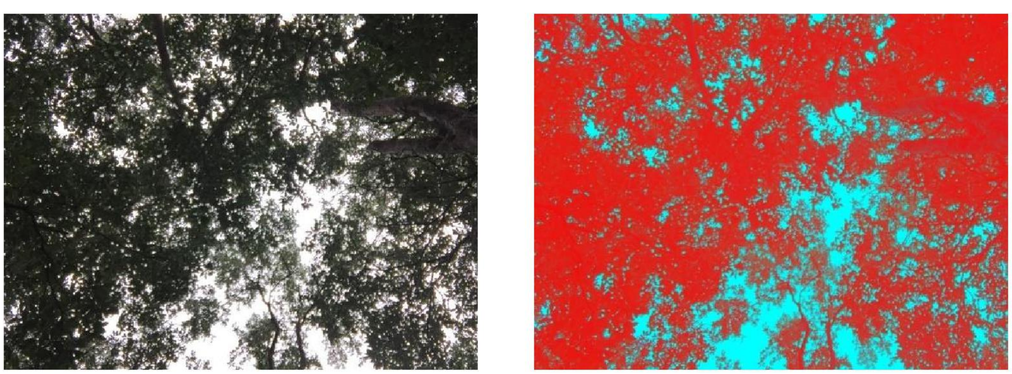


Figure 6.47. Transect 2 El Carmen- La Machona wetland complex (18 [18] 93'43.23N, 46 [84.8] 58.25'34.81W) 36.51% foliar coverage with an average of 44 ± 36.51 and a median of 44.

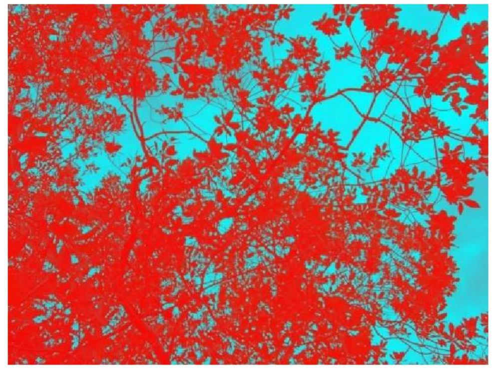


Figure 6.48. Transect 2 The El Carmen- La Machona wetland complex (18 [18] 93'41.86N, 69.4 [44.45] 34.56'46.88W) 32% leaf coverage with an average of 35.45 ± 34.56 and a median of 32.

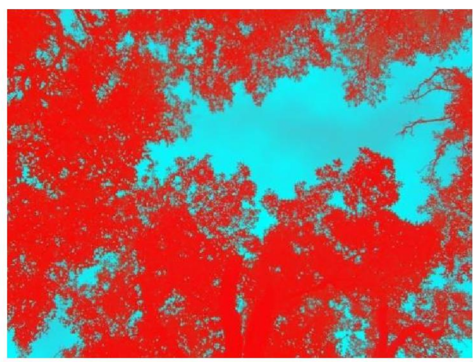


Figure 6.49. Transect 3 The El Carmen- La Machona wetland complex (18 [18] 93'47.62N, 46 [67] 36.88'16.14W) 31.45% foliar coverage with an average of 24 ± 31.45 and a median of 24.

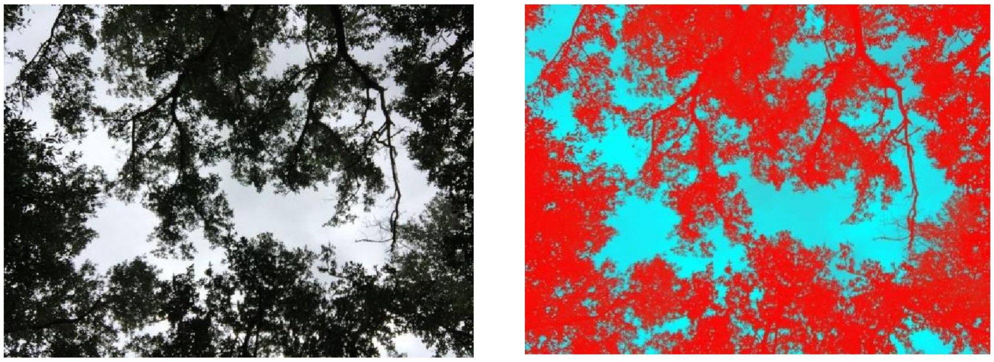


Figure 6.50. Transect 3 El Carmen- La Machona wetland complex (18 [18] 93'47.26N, 46 [66.6] 41.60'15.97W 25% foliar coverage with an average of 39.60 ± 39.71 and a median of 25.

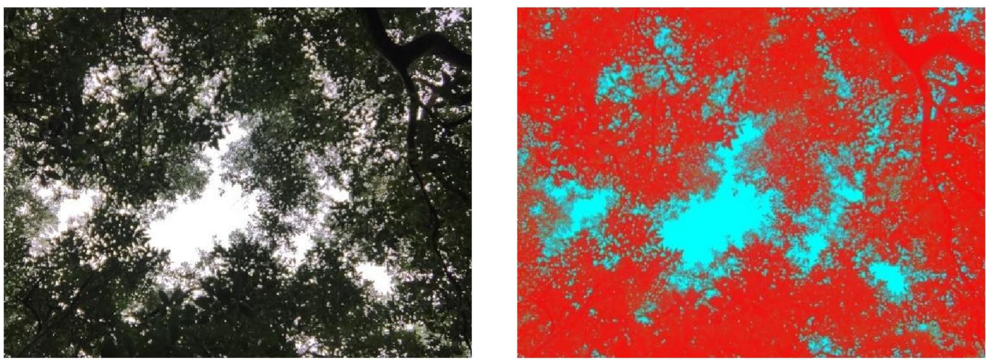


Figure 6.51. Transect 3 El Carmen- La Machona wetland complex (18 [18] 93'46.52N, 46 [79.5] 46.11'17.26W 33.63% foliar coverage with an average of 34 ± 33.63 and a median of 34

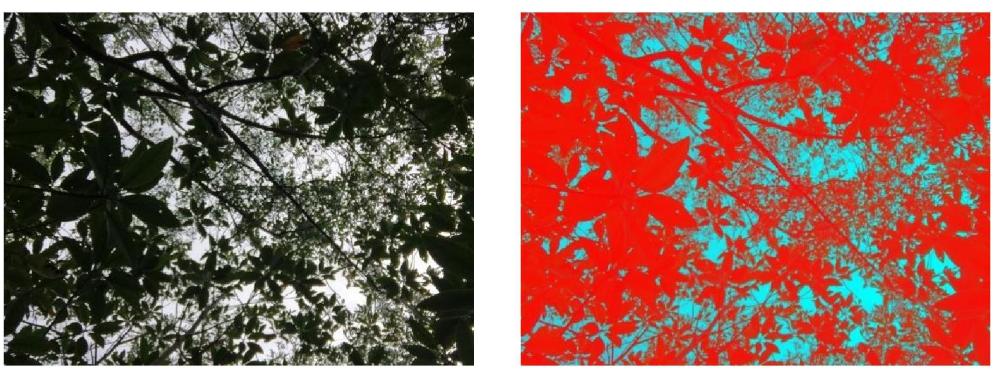


Figure 6.52. Transect 3 El Carmen- La Machona wetland complex (18 [18] 93'46.07N, 46 [85.2] 47.81'16.66W) 45.84% foliar coverage with an average of 27 ± 45.84 and a median of 27.

Based on these results, it can be concluded that from 50 to more than 80% of the three mangrove regions of Carmen-La Machona are covered by the canopy of the mangrove forest, which is indicative of a good degree of development as a forest. , with little disturbance with one exception (Transect 1), which indicates forest extraction activity, possibly due to its proximity to a town.

Average height (m)

The average height of the mangrove is an important parameter that defines the degree of development of the forest depending on the hydrological conditions of the site. In table 6.32, the average heights of the two dominant mangrove species can be observed; as well as in some cases of the coconut crops behind them. The location (latitude and longitude) of the lagoon sites from where the measurement was made is also indicated. For its location on maps, see annex 7.

Table 6.32 Average height of mangroves and palm trees in different wetland complexes

	Coordinates			
Name	**Latitude N**	**Longitude W**	**Species**	Average height (m)
The pajaral (Laguna El Carmen)	18°18'24.588	93°46'56.477	*Avicennia germinans*	Z62
Transect 1 Laguna El Carmen	18°17'48.510	93°50'08.549	*Rhizophora mangle*	Z5
			Avicennia germinans	11.42
Transect 2 Laguna El Carmen	18°18'39.731	93°46'36.191	*Rhizophora mangle*	11.06
Transect 3 Laguna El Carmen	18°18'40.722	93°46'18.330	*Rhizophora mangle*	13.03
Puerto Ceiba Pier Mecoacán	18°24'49.848	93°10'45.911	*Avicennia germinans*	12.89
Island-Bridge (Mecoacán)	18°25'16.871	93°08'57.179	*Rhizophora mangle*	9.64
Island before the Bridge (Mecoacán)	18°25'44.399	93°08'55.939	*Rhizophora mangle*	9.91
	18°25'44.328	93°08'55.79	*Palms*	15.22

The heights at Carmen-La Machona ranged from 11 to 13 m in height with the exception of one site (7.6 m) compared to the other sites located in Mecoacán that ranged from 9 to 12 m. This difference in height between both sites is consistent with the results of grouping basal areas/hectare (see below), which indicates a better development of the Carmen-La Machona mangrove forest compared to Mecoacán.

6.6.3. Water and sea birds

The coastal zone of influence of the Hokchi Area includes the north of the Pantanos de Centla, which together with the Laguna de Terminos, represents the largest corridor of wetlands in North America. These wetlands are located in the northeast of the state of Tabasco (17. 57 '45 "and 18. 39 '58 "N and 92. 06 '30 "and 92. 47 '58 "0) and occupy an area of 302 707 ha (Romero-Gil et al., 2000). Likewise, this area includes the Mecoacán, Julivá and Santa Anita lagoons, (18. 45 '33 "and 18. 27 '06 "N and 93. 25 '51 "and 92. 94 '43 "0) (Moreno-Cáliz et al., 2009), as well as the Laguna del Ostión, which is associated with the Coatzacoalcos river and extends to the region of Los Tuxtlas. The Laguna del Ostión is located north of the Coatzacoalcos River in the south of the state of Veracruz (18. 26 '68 "and 18. 09 '07 "N and 94. 70 '61 "and 94. 54' 06" 0) (Lara-Domínguez et al., 2009). Another lagoon system within the zone of influence of the Hokchi Area is the Machona - Carmen lagoon in the state of Tabasco (18 ^{0} 06 '43 "and 18 ^{0} 23' 16" N and 93 ^{0} 40 'and 93 ^{0} 52' 19 " 0). 06 '43 "and 18. 23 '16 "N and 93. 40 'and 93. 52 ^{19} 0 There is no information available on the avifauna of this last system since it is not a Protected Natural Area, Priority Terrestrial Region, Priority Marine Region, Priority Hydrological Region, Area of Importance for Bird Conservation, or a Ramsar site.

The Pantanos de Centla area is a Biosphere Reserve since 1992, it is part of the World Network of Biosphere Reserves of the UNESCO MAB Program, it is a Protected Natural Area (ANP), Area of Importance for the Conservation of the Aves (AICA) (Arriaga et al., 2000), Priority Marine Region, Priority Terrestrial Region, Priority Hydrological Region, RAMSAR Site since 1995 (Barba-Macías et al., 2006; Romero-Gil et al., 2000) and is considered one of the 13 wonders of Mexico and a World Heritage Site by UNESCO.

They are also part of the Central Migratory Corridor and the Mississippi of North American birds and there are around 328 species of which 64 (20%) are migratory, 8 (2%) are in some category of threat by the International Union for the Conservation of Nature (IUCN), 42 (13%) in some category of threat according to the Official Mexican Standard 059 (NOM-059) and 7 (2%) are endemic (Córdova-Avalos et al., 2009).

The Mecoacán, Julivá and Santa Ana lagoons by themselves are not protected natural areas, but variable percentages of their mangroves belong to other categories of protection due to their union with the Centla Pantanos: 27% of the mangroves are a Priority Terrestrial Region, 98% a Priority Marine Region, 67% a Priority Hydrological Region, 60% an Area of Importance for Bird Conservation and it is not a RAMSAR site. The aforementioned lagoons are a type of marine-coastal wetland with an estuarine system with an intertidal subsystem of the arboreal wetland class with mangroves and popal trees, so the birds that could be affected in the event of any contingency in any of the various fields Oil tankers in the area would be aquatic and marine birds (Annex 28). Based on the information that exists about the Centla Swamps on the avifauna present in this area, of 97 species that inhabit the area, 79 are found in the Act for the Conservation of Neotropical Migratory Birds (NMBCA) (Annex 28) proposed by the United States wildlife service and 7 are in the Official Mexican Standard 059 (NOM 059) under some protection status (Annex 28).

The size of the populations of the different species is not known with precision and there is no definitive information on the size of reproductive colonies. However, it should be noted that most of the region's jabirú storks nest in the Pantanos de Centla - Laguna de Terminos corridor (Correa-Sandoval and Luthin, 1988; Arriaga W. et al., 2000; Córdova-Avalos et al. ., 2009; Santiago Alarcón et al., 2011). And there are large reproductive colonies of mallard duck, American storks, and reddish herons.

Likewise, Córdova-Ávalos et al. (2009) found that the richness of bird species detected using integrity analysis and number of observed species, classified the Centla Pantanos as a wetland of international importance in the conservation of the tropical biodiversity of Mesoamerica.

On the other hand, the Ostión lagoon in Veracruz is a coastal marine wetland with an estuarine system with an intertidal subsystem associated with the Coatzacoalcos River in the coastal region of the Isthmus. The Ostión lagoon is in the municipality of Pajapan, which borders Coatzacoalcos. It has an area of approximately 1270 ha, receives fluvial input from the Metzapan, Temoloapan and Huazuntlán rivers and communicates with the Gulf of Mexico through the mouth of Jicalal. It has a barrier with flood plains and mangrove swamps with dune fields towards Coatzacoalcos flanked by an estuary, a lagoon and swamps. This chain of wetlands is classified as a Priority Terrestrial Region, Priority Marine Region and as a Priority Hydrological Region. It is part of the chain of wetlands from the south of Veracruz to the ANP of Los Tuxtlas. Among the aquatic birds at risk in the region are: the tiger heron *(Tiqñsoma mexicanum*, under special protection) and the real duck (Cairina moschata, classified as endangered). This lagoon has presumably been historically contaminated by oil activities in the region (Lara-Domínguez et al., 2009).

According to the existing information for the Los Tuxtlas ANP, there are 487 species in the area of which 99 are aquatic and marine (Annex 28). Of these 99 species, 95 are in the Act for the Conservation of Neotropical Migratory Birds (Annex 28) and 14 are in NOM-059 under some protection status (Annex 28).

Knowledge about the distribution of birds in the wetlands of the Hokchi area of influence will be used to prepare the corresponding Contingency Plan, in order to prioritize the protection of these ecosystems, although it is worth mentioning that the information presented in this section referring to birds is only bibliographic. For this reason, it is necessary to evaluate migratory behavior and sightings during a longer period and during the four seasons of the year. Also, it is important to note that this Hokchi area of influence is also the area of influence of multiple oil activities in the area.

6.6.4. Marine mammals

The literature on studies of marine mammals in the Gulf of Mexico, and specifically in the southern zone where the Hokchi area is located, are scarce. According to Manzanilla-Naim (1998), the species that frequent the coastal zone are the common tursion or tonina (Tursiops truncatas) and the manatee (Trichechus manatus), the latter considered in danger of extinction in Mexico. A manatee population has been reported in the coastal zone of Veracruz and Tabasco, in the Gulf of Mexico.

The largest population of these manatees is found in Tabasco, fluctuating between 300 and 573 individuals (López-Hernández 1997), possibly because it has extensive wetlands that are favorable habitats for them, such as the Centla Swamps and the Grijalva and Usumacinta rivers. (Colmenero 1986; Colmenero and Hoz 1986). According to Arriaga Weiss and Contreras Sánchez (1993) (cited by Ortega-Ortíz et al. 2004), the bodies of water with the highest abundance of these organisms in the area are Barra de Chiltepec, González and Grijalva rivers and Tabasquillo stream, in the northern part; and the rivers and lagoons San Antonio, San Pedrito, Chashchoc, Chacamax, Chablé and Usumacinta in the central and southern part.

Ortega-Ortíz et al. (2004) mention that the available habitat in some locations in the southern Gulf of Mexico for manatees and coastal dolphins has decreased due to the construction of structures for exploration, extraction and transportation of hydrocarbons, as well as structures associated with navigation. However, according to Manzanilla-Naim (1998), there are no reports about the effect of industrial, oil, urban, commercial, tourism and fishing activities in the Gulf of Mexico. It should be noted that several of these activities take place in the Hokchi area of environmental influence.

Likewise, it should be noted that the information presented in this section regarding marine mammals is only bibliographic. For this reason, it is necessary to evaluate migratory behavior and sightings during a longer period and during the four seasons of the year. Also, it is important to remember that Hokchi's zone of influence is also the zone of influence of multiple oil activities in the area.

6.6.5. Composition and distribution of terrestrial and aquatic communities

The climate of the region characterized by high temperatures, high humidity, as well as the presence of marine and terrestrial aquatic bodies have allowed the establishment of high biodiversity. According to the comparative table of species registered in the state of Tabasco and in the surroundings of the Hokchi field, 5,567 species have been registered throughout the state, which represents 5.6% of the total biodiversity of Mexico. Of which, 33.5% (1,867 species) have been found within an 6.33 km radius of the Hokchi field (Table 80.33).

It stands out in the vegetation, that adapted to aquatic systems, such as the popal, the mangrove and the tular. As well as different types of jungle, such as the high and low evergreen, and the medium and low sub-evergreen, where you can find characteristic trees of the jungle such as the ceiba, guapaque and canshan; of precious woods like cedar and mahogany; grasslands and fruit trees such as cacao, sapote, mamey, tamarind, orange, banana and soursop; in the icaco, coconut palm and majagua swamps. CONABIO.

Regarding the fauna, the presence of both marine and terrestrial fauna is evident, as well as that adapted to the characteristic ecotones of the marshes and estuaries, characteristic of the region. In the jungle and grassland areas you can find parrot, parrot, mound, calandria, thrush, deer, ocelot and various snakes; Otters, manatees, iguanas, turtles, and fish such as the alligator, catfish, snook and mojarra have been reported in rivers and lagoons; towards the sea it is common to find several species of shrimp, red snapper and snapper (CONABIO, 1998).

Table 6.33. Species registered in the state of Tabasco and in the surroundings of the Hokchi area (area of 80 km radius).

Taxonomic group	Known species in	**Known species in Tabasco**	**Species in the vicinity of the Hokchi field**
Bryophytes	1,482	8	8
Pteridophytes	1,067	187	22
Gymnosperms	150	6	1
Dicotyledonous angiosperms	19,065	2,352	554
Monocotyledonous angiosperms	4,726	839	171
Poriferous	268	3	3
Cnidarians	318	2	2
Helminths	550	110	21
Annelids	1,393	173	173
Mollusks	4,100	175	50
Echinoderms	503	41	41
Insects	47,800	344	89
Arthropods (not insects)	12,280	270	167
Peces	2,693	220	416
Amphibians	361	32	8
Reptiles	804	124	17
Birds	1,096	539	101
Mammals	535	142	23

Modified from CONABIO (1998), with information from the Biological Collections of the Institute of Biology and the Institute of Marine Sciences and Limnology, UNAM.

Species of ecological importance or in protection category

According to the Red List of Threatened Species (IUCN, 2015), in the 80 km radius area of the Hokchi field there are four critically endangered species, Dasyprocta mexicana (Black Agouti), with a population trend, in 2008, decreasing; while Epinephelus itajara (Giant grouper), and Decazyx esparzae and Quararibea yunckeri plants, their population trend is unknown.

In danger there are three species of plants Trichilia brevifiora, Recchia simplicifolia, Blepharidium guatemalense, of which their population trend is unknown. In the vulnerable category there are 8 species (Aegiphila monstrosa, Balantiopteryx io, Balistes capriscus, Hyporthodus flavolimbatus, Lutjanus campechanus, Megalops atlanticus, Potamocarcinus hartmanni, Thunnus obesus); Of these vulnerable species, only the freshwater crab (Potamocarcinus hartmanni) has a stable population trend, the rest show a downward trend in population.

360 species are in the least concern category (Figure 6.52) and four more species are considered near threatened.

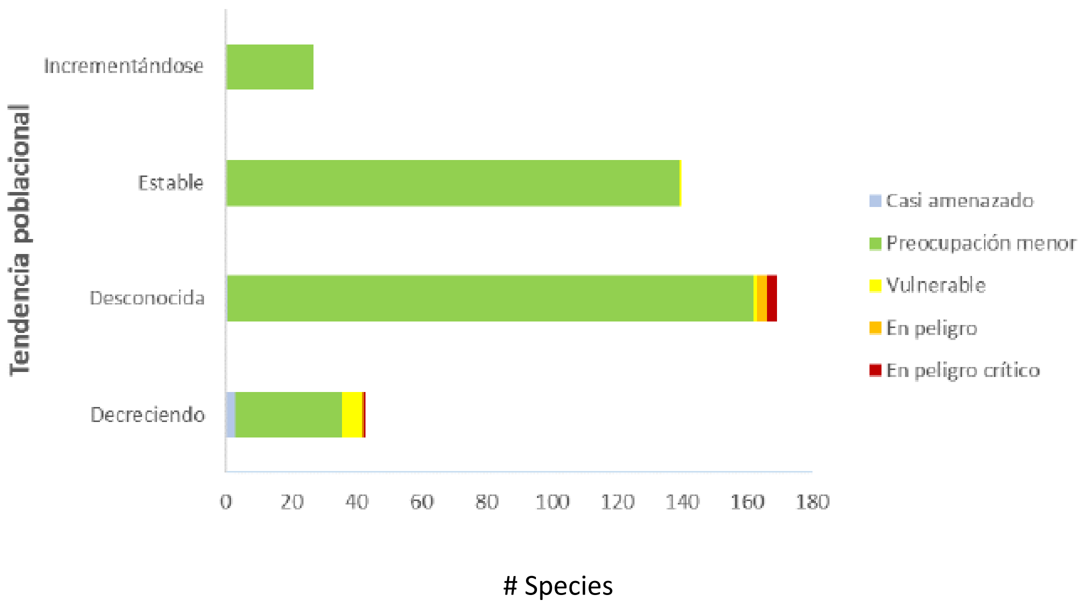


Figure 6.52. Threatened species according to the Red List of Threatened Species (IUCN, 2015)

6.6.6. Sensitive areas

<u>Regions and priority sites for conservation</u>

Protected Natural Areas (ANP) "are the areas of the national territory and those over which the nation exercises its sovereignty and jurisdiction where the original environments have not been significantly altered by human activity or that require preservation and restoration" (CONANP, 2014).

On the other hand, RAMSAR sites are wetlands that are important for the conservation of global biological diversity and for the sustenance of human life through the maintenance of the components, processes and benefits / services of their ecosystems (RAMSAR, 2014). The initial emphasis of the Convention was the conservation and wise use of wetlands especially as habitat for waterfowl, however, over the years the Convention has expanded its scope to encompass the conservation and wise use of wetlands in all their areas. aspects, recognizing that wetlands are extremely important ecosystems for the conservation of biodiversity and the well-being of human communities (SEMARNAT, 2013).

The Areas of Importance for the Conservation of Birds (AICAS), as their name indicates, are previously evaluated sites that are of significant importance for the conservation of birds (CONABIO, 2004). The AICAS are not sites that necessarily require legal protection, but are explicitly important areas according to the characteristics of the species they host, be they populations, community, distribution, habitat or because they include endemic species or in some category of risk. They can even be designated for being important places for scientific research (del Coro Arizmendi y Berlanga, 1996).

The Protected Natural Area with the category of Biosphere Reserve, RAMSAR site and Area of Importance for the Conservation of Birds "Pantanos de Centla" is located 59 km SE of the Hokchi field (Annex 30 a and b). It was created on August 6, 1992 by means of a federal decree and has an area of 302,706 ha (SEMARNAP, 2000).

The considerations for decreeing this area as a Biosphere Reserve are based on the biodiversity of species it possesses, the biological productivity it generates, its location in the delta of the Grijalva-Usumacinta river system, the existence of typical geoforms of low dunes, the presence of endemic and / or endangered species (manatee, crocodile, jaguar, among others) as well as being an important transit, nesting and lodging site for both migratory and resident aquatic birds (Official Gazette of the Federation, 1992).

The designation of the RAMSAR site is from June 22, 1995 and considers the Pantanos de Centla as one of the most important hydrological sites in Mexico since it has 110 bodies of fresh water (permanent and seasonal) important for fishing and flood regulation .

The presence of threatened aquatic flora and fauna, as well as the relevance of coastal lagoons in the life cycle of various marine species are other criteria that allowed the designation of this wetland as a RAMSAR site (RAMSAR-CONANP, 2016).

The proposal as an Area of Importance for the Conservation of Birds (AICA) is from May 1997 through CONABIO (CONABIO, 2004). It has an area of 502,782 ha and is adjacent to the AICA "Laguna de Terminos". The criteria for this designation are based on the presence of 66 species of migratory birds, the existence of important colonies of herons, and the fact that the Centla Swamps are the northern limit of the Jabirú distribution in this region.

Therefore, this AICA is considered a priority area by the Mexico-Canada-United States Tripartite Committee, the RAMSAR Convention and the North American Wetlands Conservation Council (CONABIO, 2004).

Like AICA, the Pantanos de Centla have the MEX-1 category indicating that the site contains at least one population of a species considered in the official lists of the country as threatened, endangered or vulnerable (NOM-ECOL, CIPAMEX), while BIRDLIFE INTERNATIONAL grants it the Al category, indicating the presence of threatened bird species worldwide (Vidal et. Al, 2009).

The vegetation of the "Pantanos de Centla" Biosphere Reserve is composed of grasslands, evergreen forest, hydrophilic vegetation and mangrove swamps (SEMARNAP, 2000). The flora is represented by: Bucida buceras (Pucte), Spondias mombin (Jobo), Tabebuia rosea (Palo de rosa, guayacán), Lonchocarpus hondurensis (Mata de gusano), Vatairea lundellii (Amargoso), Bursera simaruba (Chaca or palo mulato, palo chaca), Calophyllum brasiliense (Bari), Swietenia macrophylla (Mahogany), Cedrela odorata (Cedar), Rhizophora mangle (Red mangrove), Avicennia germinate (Black mangrove), Laguncularia racemosa (White mangrove), Conocarpus erectus (Button mangrove). Acoelorraphe wrightii (Florida palm), Ceiba pentandra (Pochote), Sabal mexicana (Guano round), Pithecellobium lanceolatum (Cockscomb), Typha latifolia (Espadaño), Eichhornia crassipes (Camalote, common water hyacinth), Nymphaea ampla (Leaf de sol), Cladium mariscus var. Jamaican (Junco), Pachira aquatica (Water sapote), Guazuma ulmifolia (Aquiche) (SIMEC, 2016).

The fauna of the site is made up of: Jabiru mycteria (Jabirú Stork), Mycteria americana (American Stork), Cochlearius cochlearius (Bucket Heron), Ajaia ajaja (Roseate Spatula), Cairina moschata (Mallard), Dendrocygna autumnalis (White-winged Pijije), Anas discors (Blue-winged Teal, crescent duck), Ardea herodias santilucae (Great Blue Heron), Tigrisoma mexicanum (Jojo, tiger heron), Ceryle torquata (Kingfisher), Aramus guarauna (Carrao), Butorides striata (Blue heron), Ardea alba (White heron), Jacana spinosa (Moorhen), Caracara plancus (Cara cara), Falco peregrinus (Peregrine Falcon), Eudocimus albus (White Ibis), Phalacrocorax brasilianus (Cormorant), Pandion haliaetus (Osprey), Rostrhamus sociabilis (Hawk-billed Hawk), Dasypus novemcin (Nine-banded armadillo), Trichechus manatus (Manatee), Panthera onca (Jaguar), Leopardus pardalis (Ocelot, tigrillo), Alouatta palliata (Black Saraguato), Odocoileus virginianus (White-tailed deer), Lontra longicaudis (River otter), Procyon lot or (Raccoon), Dermatemys mawii (White turtle), Kinosternon leucostomum (Pochitoque), Trachemys scripta (Turtle), Claudius angustatus (Chopontil turtle), Staurotypus triporcatus (Guao turtle), Chelydra serpentina (Lizard turtle), Rhinocle are), Iguana iguana (Green Iguana), Bothrops asper (Nauyaca real), Basiliscus vittatus (Toloque), Crocodylus moreletii (Marsh crocodile), Centropomus undecima lis (White snook), Cichlasoma fenestratum (Mojarra palette), Cichricamusoma urojarra), Atractosteus tropicus (Pejelagarto), Petenia splendida (Mojarra tenguayaca), Macrobrachium acanthurus (River shrimp), Macrobrachium carcinus (Pigua) (SIMEC, 2016).

The environmental problems detected in the area are due to urban development, oil exploitation, clandestine logging, illegal hunting, forest fires, expansion of the agricultural frontier, extensive livestock, water and soil contamination, and industrial development (SIMEC, 2016). However, it must be remembered that although there is a presence of oil infrastructure in this protected area, the existing regulation prevents the construction and start-up of new oil infrastructure, except for maintenance operations.

State Protected Natural Areas

In the continental area adjacent to the Hokchi area there are eight State Protected Natural Areas (CONABIO, 2015).

- Río Playa Ecological Reserve (Annex 30c): it is located 43 km southeast of the Hokchi area in the municipality of Comalcalco (Tabasco) and has an area of 711 ha with the presence of popales and tulares. It was decreed as an ecological reserve on June 14, 2004 (SAOP, 2007).

- Zone Subject to Ecological Conservation Finca Santa Ana: it is located 115 km south of the Hokchi area in the municipality of Pichucalco (Chiapas) and has an area of 553 ha with the presence of a dense forest cover that allows the capture, filtration and runoff of water of rain towards streams that feed the Pichucalco river. It was decreed as an ecological reserve on June 19, 1996 (SAOP, 2013).

- Laguna de las Ilusiones Ecological Reserve: it is located 77 km southeast of the Hokchi field in the Centro municipality (Tabasco) and has an area of 259 ha. It is an urban lagoon with the presence of native species and in danger of extinction. It was decreed as an ecological reserve on February 8, 1995 (SAOP, 2007). It presents pollution problems (CONAFOR, 2012).

- Area Subject to Ecological Conservation Laguna del Camarón: it is located 80 km southeast of the Hokchi area in the Centro municipality (Tabasco) and has an area of 70 ha. It is a lagoon with a flood zone with the presence of hydrophytic vegetation. It was decreed as an ecological reserve on June 5, 1993 (SAOP, 2007). It presents pollution problems (CONAFOR, 2012).

- YU-BALCAH Ecological Reserve (Forest of the Thousand Voices): it is located 118 km southeast of the Hokchi area in the municipality of Tacotalpa (Tabasco) and has an area of 572 ha. Presents vegetation of medium jungle of Canacoite and high jungle of Pío. It was decreed as an ecological reserve on June 10, 2000 (SAOP, 2007). It is in abandonment (CONAFOR, 2012).

- YUMKA Nature Interpretation Center: it is located 82.5 km southeast of the Hokchi area in the Centro municipality (Tabasco) and has an area of 1,714 ha. It presents an urban lagoon and medium evergreen forest vegetation. It was decreed as an ecological reserve on June 5, 1993 (SAOP, 2007). It has problems of loss of biodiversity and erosion (CONAFOR, 2012).

- Laguna La Lima Ecological Reserve: it is located 75 km southeast of the Hokchi area in the municipality of Nacajuca (Tabasco) and has an area of 36 ha. It has the presence of a lagoon and hydrophytic vegetation. It was decreed as an ecological reserve on February 8, 1995 (SAOP, 2007).

- Chontalpa Ecological Park: it is located 71 km southwest of Hokchi in the municipality of Cárdenas (Tabasco) and has an area of 277 ha. It presents vegetation of medium evergreen forest. It was decreed as an ecological reserve on February 8, 1995 (SAOP, 2007).

Biological Corridors

A biological corridor is defined as "a delimited geographic space that provides connectivity between landscapes, ecosystems and habitats, natural or modified, and ensures the maintenance of biological diversity and ecological and evolutionary processes" (Ramírez, 2003). In 1997, the Mesoamerican Biological Corridor (CBM) initiative was integrated, defining links between the protected areas of Central America and proposing low-impact developments to maintain the corridors between them (CONABIO, 2009a).

In Mexico, the implementation of the MBC began in 2002 (CONABIO, 2009a), with the aim of promoting the sustainable use and conservation of biodiversity in the southeast of the country (Eccardi, 2003).

The MBC has an approximate area of 769,000 km2 ranging from southeastern Mexico to Panama (Ramírez, 2003). In its portion of Mexico (MBC-M) it covers an area of approximately 199,916 km2 (CONABIO, 2014) in the states of Chiapas, Quintana Roo, Yucatán, Campeche, Oaxaca and Tabasco (CONABIO, 2009a), which represents about 26% of the area total CBM.

In the continental area adjacent to Hokchi there are three micro-regions belonging to the CBM-M (Annex 30d) (Rojas-Canales and Ríos-Valdez, 2012) covering an area of 18,814 km2 (9.5% of the total area of the CBM-M) (CONABIO, 2009a).

- Coastal Wetlands - Sierra de Huimanguillo: it is located 18 km south of the Hokchi field, distributed in the municipalities of Cárdenas, Comalcalco, Huimanguillo, Cunduacán, Jalpa de Méndez, Nacajuca and Paraíso (Tabasco) with an area of 8,431 km2 (CONABIO, 2014). The dominant soils are the Vertic Gleysol and Vertic Acrisol, with a predominant savanna vegetation with an important presence of crops and plantations. The topography is homogeneous, composed mainly of plains and strongly influenced by the Grijalva and Janapa rivers.

- In this corridor are the Priority Hydrological Regions Headwaters of the Tonalá River and Laguna de Terminos - Pantanos de Centla (Annex 30e), as well as the AICA Pantanos de Centla (CONABIO, 2012).

- Pantanos de Centla - Usumacinta Canyon: it is located 29 km south of Hokchi, distributed in the municipalities of Centla, Jonuta, Emiliano Zapata and Tenosique (Tabasco) with an area of 6,802 km2 (CONABIO, 2014). The dominant soils are Gleysols in their Eutric, Vertic and Humic variants with minor savanna-type vegetation, since most of the area corresponds to crops and plantations. The topography is homogeneous, composed mainly of plains and influenced by the Grijalva river. In this corridor there are the Priority Land Regions Pantanos de Centla, Lagunas de Catazajá-Emiliano Zapata and a narrow strip of the Lacandona region; Likewise, it includes the Priority Hydrological Regions Laguna de Terminos-Pantanos de Centla, Balancán and Río San Pedro, as well as the AICA Pantanos de Centla (CONABIO, 2012).

- Sierra de Tabasco: it is located 97 km south of the Hokchi field, distributed in the municipalities of Teapa, Tacotalpa and Macuspana (Tabasco) with an area of 3,581 km2 (CONABIO, 2014). The dominant soils are Gleysol and Fluvisol with vegetation of high evergreen and subperennial forest, popal, tular, as well as land for agricultural, livestock and forest use. The topography is mainly composed of plains in the center and north and mountains in the southern part with hydrological influence from the Macuspana, Tepetitlán, Pichucalco and Tacotalpa rivers. The corridor is part of the Priority Terrestrial Regions of El Manzanillal and Pantanos de Centla, of the Priority Hydrological Regions Laguna de Terminos-Pantanos de Centla and Río Tulija-Altos de Chiapas as well as the AICA Pantanos de Centla-Laguna de Terminos (CONABIO, 2012).

Priority Regions

The delimitation of Priority Regions arises as a strategy to concentrate the efforts of research and conservation of biodiversity in Mexico by CONABIO, taking as a reference regionalization analysis based on ecoregions and large landscape units that maintain the set of ecological conditions that prevail. at a certain geographical scale, habitat or areas with vital ecological functions and that present a high accumulation of species, sensitive species or ecological processes and environmental services in general (Arriaga et al., 2009).

Priority Land Regions (RTP): They are sites with a high value in the terrestrial biodiversity of the country. The environmental criteria considered for this category are: 1) extension of the area, 2) functional ecological integrity of the region, 3) importance as a biological corridor, 4) diversity of ecosystems, 5) extraordinary natural phenomena (localities of hibernation, migration or reproduction), 6) presence of endemisms, 7) specific richness, 8) centers of origin and animal diversification, 9) centers of domestication or maintenance of useful species. The threat criteria to biodiversity are 1) loss of the original surface, 2) fragmentation of the region, 3) changes in population density, 4) pressure on key or emblematic species, 5) concentration of species at risk and 6) improper handling practices. Likewise, criteria of opportunity for its conservation are considered as: 1) proportion of areas under some type of inadequate management, 2) importance of environmental services, and 3) presence of organized groups (Arriaga et al. 2009).

- The Pantanos de Centla Priority Terrestrial Region (Annex 30f) is located 31.5 km southeast of the Hokchi area in the municipalities of Centla, Centro, Jalpa de Méndez, Jonuta, Macuspana, Nacajuca, Palizada and Paraíso in Tabasco and the municipality of Carmen in Campeche , covering an area of 8,366 km2 and presenting the marshes as the dominant geoform. The vegetation present in this RTP are mangroves, savannas with scattered tree vegetation and lands for agricultural, livestock and forestry use (CONABIO, 2008d).

This region constitutes the largest wetland area in North America, serving as a refuge for numerous populations of migratory waterfowl, constituting the area with the largest jabiru population. Likewise, it is an important area for the breeding and feeding of species of commercial value and is a recipient of nutrients and pollutants transported by one of the largest hydrological systems in Mexico (Grijalva-Usumacinta) (CONABIO, 2008d).

The environmental problems detected are the desiccation of wetlands, the potential impact of oil extraction, the construction of hydroelectric plants on the Usumacinta River, the development of shrimp farms, logging, the development of road infrastructure and the contamination of bodies of water. (CONABIO, 2008d).

- The Manzanillal Priority Land Region is located 84 km south of Hokchi, in the municipalities of Centro and Teapa in Tabasco and Pichucalco, Reforma, Juárez and bctapangajoya in Chiapas, covering an area of 606 km^2 and presenting the coastal plains as the dominant geoform . The vegetation present in this RTP is sub-evergreen forest and lands for agricultural, livestock and forestry use (CONABIO, 200%).

This region represents the largest portion of the anocorte flooded forests (Bravaisia integerrima), also presenting areas of tulares, popales and zapotanales. By presenting flood conditions and a system of rivers that flow into the Usumacinta River, it presents an important diversity of freshwater turtles (CONABIO, 2008b). The environmental problem detected is the expansion of agricultural lands, the pollution generated by PEMEX plants and the drying up of flooded lands (CONABIO, 2008b).

Regiones Marinas Prioritarias de México. The environmental criteria considered for this category are: 1) functional ecological integrity, 2) habitat diversity, 3) endemisms, 4) species richness, 5) indicator species, 6) zones of migration, growth, reproduction or refuge and 7) relevant ocean processes (Ekman transport, turbulence , concentration, retention and enrichment that are associated with sites of reproduction, feeding and growth).

On the other hand, the economic criteria considered for the selection of these areas are: 1) species of commercial importance, 2) important fishing areas, 3) type of fishing organization, 4) important tourist areas, 5) type of tourism, 6) economic importance for other sectors (oil, industrial, mining, etc.) and 7) strategic resources (manganese nodules, cobalt, gas, oil, etc.). Finally, the threat criteria are the following: 1) modification of the environment (filling of flooded areas, reef fractures, formation of channels, fresh water discharges, etc.), 2) contamination, 3) remote effects (contribution of sediments, modifications of infiltration patterns, etc.) , 4) pressure on key species, 5) concentration of species at risk, 6) damage to the environment by boats, 7) introduced species, and 8) inappropriate management practices (Arriaga et al., 2009).

- The Hokchi area is located within the Pantanos de Centla-Laguna de Terminos Priority Marine Region (CONABIO, 1998) (Annex 30g). This RMP has an extension of 55,114 km ^{2}. It has beaches, dunes, lagoons, estuaries and islands and represents the most important continent-ocean water supply in Mexico. Oceanic dynamics is characterized by the constant presence of upwellings and the continuous supply of fresh water by rivers, estuaries and lagoons (CONABIO, 2008e). The marine specific richness of the Hokchi area of environmental influence is presented in Annex 31a. Although in the area there are quadrants of marine specific richness with values that range from 63 to 182; they dominate the wealth quadrants with intervals from 1 to 6 and 7 to 24, indicating low diversity in the area.

The plant biodiversity of the continental margin of the site includes sea grasses, mangroves, medium flood forest, high forest, popal, tular, reed beds, flooded palm grove and flooded thorn scrub with the presence of endemic species (Amaranthus greggii, Cithorexilum allephirum, Palafoxia spp.) And Indicators (red, white and black mangrove). The presence of algae of the genera Gracillaria and Bangia indicates the degree of conservation of the environment (CONABIO, 20089.

The fauna biodiversity of the site is represented by mollusks, polychaetes, crustaceans, fish, marine mammals and birds with the presence of endemic species (Strongylura hubbsi and Batrachoides goldmanii) and indicators, such as shrimp, snook, manatee, crocodile, alligator. Likewise, it is an area of refuge, feeding and reproduction of turtles, birds, fish, crustaceans, manatees, mammals and invertebrates (CONABIO, 2008e).

Intensive fishing activities organized in cooperatives, artisanal, crops, permit holders and free, are presented, with exploitation of oyster, crab, shrimp, mollusks, algae and fish (CONABIO, 2008e).

The environmental problems detected include the constant modification of the environment due to the felling of mangroves, filling of flood areas, diversion of channels, fresh water discharges, as well as damage by vessels (oil tankers, fishing boats) and environmental impacts from exploration and production activities. oil company. In the same way, there is contamination by solid waste, wastewater, oil, agrochemicals, fertilizers, metals and industrial waste, as well as negative impacts to the environment from oil activities (CONABIO, 20089.

Agricultural activity is carried out intensively in floodplain areas and there is a marked pressure from the fishing sector on white shrimp, clams and oysters. Several endangered species have been reported, such as the lizard, the Limulus polyphemus cacerolita and the Habenaria bractecens orchid. Species trafficking, illegal fishing and the introduction of tilapia have been reported.

In the same way, there is a lack of compliance with the legislation in the protected area of Laguna de Terms (closure, land uses other than what is established in the management plan, etc.) and a scarce integration of tourism and fishing policy between the states of Tabasco and Campeche (CONABIO, 2008e).

Priority Hydrological Regions (RHP): The criteria for delimiting these regions, based on biodiversity aspects, are similar to those of the RMP in relation to the environmental value of biotic and abiotic resources, with the economic value, as well as the risks and threats to which the basins are subject. hydrological, although these were adapted to the biological groups that occur in limnological environments, to the physical and chemical characteristics of the epicontinental water bodies, as well as to the ecosystems included in the entire hydrographic basin, from the watershed to the coastal zone (Arriaga et al., 2009).

- The Laguna de Terminos-Pantanos de Centla Priority Hydrological Region is located 21 km south of the Hokchi field, in the municipalities of Palizada, Jonuta, Centla, Macuspana, Centro, Nacajuca, Jalpa de Méndez, Comalcalco and Paraíso in Tabasco and Carmen in Campeche , covering an area of 12,681 km ^{2}. The dominant geoforms are plains of hills and depressions formed by alluvial deposits. The vegetation present is high evergreen and sub-evergreen forest, medium deciduous forest, low evergreen forest, popal, tular, reedbed, floodable thorn scrub, flooded inert scrub, flooded palm grove, natural and cultivated grassland, savanna and flooded palm grove (CONABIO, 2008c). In this area there are around 110 permanent and temporary epicontinental freshwater bodies; presenting, in addition, some representative morphogenic systems of the lowlands of Tabasco: fluvial plain, marsh plain and freshwater lagoon, littoral cord plain classified as high flood and low flood and coastal lagoon plain. This area represents the most important water supply in Mexico, from the continent to the coast and finally to the Sonda de Campeche (CONABIO, 2008c).

The problems detected are the felling of mangroves, filling of flooded areas, dredging, canals, effects of the oil industry (exploration and production), desiccation, deforestation due to livestock, construction of roads and hydroelectric plants in the Usumacinta River. Likewise, there is the modification of local hydrodynamics, hydrological alteration due to changes in the annual volumes of water bodies and loss of the coastline due to floods and the presence of human settlements (CONABIO, 2008c).

In the same way, pollution is presented by the influence of the city of Villahermosa and by activities of the oil industry, sewage, organic waste, agrochemicals, metals and pesticides. The introduction of invasive species (carp, mojarras, tilapias), livestock activities in flooded areas and the collection of endangered species (orchids, fish, birds, reptiles and mammals) have also been detected (CONABIO, 2008c).

- The Priority Hydrological Region Head of the Tonalá River is located 84 km southwest of Hokchi in the municipalities of Huimanguillo (Tabasco), Las Choapas (Veracruz) and Tecpatán (Chiapas) covering an area of 3,196 km^2. The vegetation present is riparian forest, high evergreen forest, tular, savanna; as well as natural and cultivated pasture (CONABIO, 2008a).

The Tonalá rivers and their tributaries Tancochapa, Xocuapan, Zanapa, el Blasillo and Chicozapote are located in this region, with a characteristic ichthyofauna made up of Astyanax fasciatus, Cathorops aguadulce, Cichlasoma helleri, C. meeki, C. octofasciatum, C. urophthalmus, Gobionellus boleosoma, Guavina guavina, Ictiobus meridionalis, Poecilia mexicana, P. petenensis, P. sphenops, Profundulus punctatus, Rhamdia laticauda, Rivulus tenuis and Sicydium gymnogaster. There is a crustacean (Lobithelphusa mexicana) endemic to the region and threatened species of fish due to habitat contamination (Strongylura hubbsi) and reptiles due to habitat modification (Chelydra serpentina, Crocodylus moreleti, Dermatemys mawii, Dermochelys coriacea, Kinosternon integrum, K. leucostomum, Rana brownorum, Staurotypus triporcatus and Trachemys scripta).

Likewise, the presence of the Batrachoides goldmani fish is an indicator of high concentrations of hydrocarbons (CONABIO, 2008a).

The problems detected in the region are the modification of the environment due to deforestation, contamination of agrochemicals and the exploitation of native fish and the introduction of invasive species (CONABIO, 2008a).

Priority Sites for Conservation

Sitios prioritarios marinos para la conservación de la biodiversidad. They are sites identified as priority for the conservation of marine biodiversity due to their physical, chemical, biological and geological characteristics. As well as the relevance of oceanographic processes such as upwelling, vertical mixing, waves, tides, currents and countercurrents, river discharges, turns or eddies, and meteorological and climatic phenomena (CONABIO et al., 2007).

- The Hokchi area is located within the Priority Marine Site (SMP) "Coastal Wetlands and Continental Shelf of Tabasco" in the Gulf of Mexico South marine ecoregion, adjacent to the "Pantanos de Centla" Protected Natural Area (Annex 30h) and is considered " very important "in the analysis of CONABIO et al. (2007) because it has the largest extension of wetlands (flooded areas) in the country (Annex 30i). These characteristics allow it to have a great diversity in terms of flora and fauna and allow it to be considered as one of the most representative ecosystems of the biosphere and hydrologically one of the most important sites in Mesoamerica, influencing the ecology from southern Mexico to northern Guatemala. Likewise, the site consists of several bodies of fresh water (permanent and seasonal) important for fishing and flood regulation (CONABIO 2007c).

It has an area of 10,245 km and presents a physiography of the coastal zone and continental shelf, with sandy beaches, continental islands, coastal lagoons, bars, estuaries, rivers, coastal dunes and flood plains. The habitats represented are: mangroves, marshes, swamps, floodable thorn scrub, flooded medium forest, high forest, popal, tular, reed, flooded palm grove, coastal dune vegetation and seagrass meadows, in addition to being a growth and reproduction area of marine mammals (CONABIO et al., 2007c).

Presents moderate tectonic activity, presence of sedimentary rocks and sediments of sand, silt, clay and mud. The dominant topography is plains and depressions with a broad continental shelf and emerging structures of islands, shallows and a bar that closes the lagoon (CONABIO et al., 2007C).

It is influenced by the presence of the Lazo current, with mixed tide and low to medium swell with prevailing winds from the northeast and southeast. The average temperature is 27.2 ° C, salinity of 13 - 34% o and an average depth of 1.5 - 4 m. It has an important contribution of fresh water through rivers, estuaries and lagoons and a permanent front of springs. There are turbulences and fronts, as well as concentration and enrichment of nutrients. Likewise, it is affected by the presence of the north, tropical storms and hurricanes (CONABIO et al., 2007c).

On the other hand, it presents an average transparency of 2.5 m wide in the photic zone, with a high concentration of nitrates and phosphates and a medium concentration of nitrites and silicates. Primary and secondary productivity, as well as eutrophication are considered high (CONABIO et al., 2007c).

The most represented taxonomic groups are phytoplankton, crustaceans, birds, mollusks, polychaetes, insects, fish, reptiles, marine mammals and algae with key species of red, white and black mangroves, snook, manatees, crocodiles and alligators (CONABIO et al. , 2007c).

The environmental services it generates are: refuge and feeding for estuarine-dependent species (crustaceans, fish, octopuses, lobsters, turtles, birds, manatees and invertebrates) and mangroves are soil fixers and serve as a refuge for epiphytes such as Achmea bracteata, parasites such as Phoradendron mucronatum, Helosis sp., some vines such as Passiflora coriacea and the characteristic mangrove fern Achrostrichum aureum (CONABIO et al., 2007c).

The environmental problem that it presents is due to oil, industrial, forestry, transport, agricultural and livestock activities, as well as the modification of the environment due to mangrove felling, filling of floodplains, diversion of channels and fresh water discharges. Likewise, it presents environmental impacts due to oil and gas exploration and production activities. Other sources of pollution are solid waste, sewage, oil, fertilizers, metals, industrial waste, burning and replacement of oil from outboard motors (CONABIO et al, 2007c).

Priority terrestrial sites for the conservation of biodiversity.

The priority terrestrial sites for the conservation of biodiversity are identified in this category due to the presence of one or several elements of biodiversity present, among which the following stand out: 1) critical vegetation types; 2) richness of plants; 3) Plants in NOM-059-Semarnat-2001; 4) Trees in NOM-059 Semarnat-2001; 5) Magueyes in NOM-059 Semamat-2001; 6) Resident birds; 7) presence of reptiles; 8) presence of amphibians; 9) presence of mammals and 10) species richness of vertebrates (CONABIO et al., 2007b)

- In the continental area adjacent to the Hokchi area, an analysis unit is located 91.5 km to the southwest, in the limits of Veracruz (municipalities of Agua Dulce and Las Choapas) and Tabasco (municipality of Huimanguillo) with the category of extreme priority, indicating this area allows meeting the conservation goals established for the different elements of biodiversity selected in the smallest area possible (CONABIO et al., 2007d). The specific land richness of the Hokchi area of environmental influence is presented in Annex 31b. Although in the area there are quadrants of marine specific richness with values that range from 63 to 182; they dominate the wealth quadrants considerably with intervals of 1 to 6 and 7 to 24.

Epicontinental aquatic priority sites for the conservation of biodiversity.

They are aquatic sites limited to a continent and considered a priority due to the presence of one or more elements of biodiversity: 1) habitat (condition of aquifers, presence of bodies of water etc); 2) vegetation; 3) species (migratory birds, endemic crustaceans and fish, presence of vegetation adapted to aquatic life, etc); 4) dynamics of human populations; 5) infrastructure development in the area; 5) land use; 6) invasive species and 7) water uses by productive sector (CONABIO and CONANP, 2010b).

- In the continental area adjacent to Hokchi a total of 261 hexagonal analysis units are located (Annex 30j), of which 133 have a MEDIUM priority, 36 have HIGH priority and 92 have extreme priority (CONABIO and CONANP, 201 Oa). Of this last category, the majority (46) are located in the coastal strip of the state of Tabasco, indicating the importance of wetlands, coastal lagoons, mangroves and flood plains, which provide food, shelter and nesting sites for many species (CONABIO et al., 2007a).

Priority sites for primate conservation

The priority sites for the conservation of primates in Mexico are those sites where the presence of one or more of the primate species present in Mexico is registered, such as the black howler monkey *(Alouatta pigra), the* mantled howler monkey *(Alouatta palliata mexicana)* and two subspecies of spider monkeys *(Ateles geoffroyi vellerosus and A. geoffroyi yucatanensis). They also* encompass potential distribution areas of these mammals due to the type and state of the eastente vegetation, recognizing three priority regions: 1) Guerrero-Oaxaca-Chiapas, 2) Yucatán Peninsula and 3) Veracruz-Tabasco (Tobón et al., 2012).

- In the continental area adjacent to the Hokchi field, the Veracruz-Tabasco region is located mainly, and to a lesser degree, the Guerrero-Oaxaca-Chiapas region, due to the border between the latter state and Tabasco. It covers an area of 3,307 km2, highlighting the area of the Centla Swamps as a habitat for primates (CONABIO et al., 2012). It is important to mention that in this region the negative effects of change in land use and fragmentation of ecosystems are very evident, together with the reduced extension of the remaining vegetation that serves as a habitat for primates (Tobón et al., 2012).

The beach as a habitat: Actual state

The coast of Tabasco is characterized by having the most important deltaic and estuarine systems of the Mexican perimeter of the Gulf of Mexico. This condition is decisive for the contribution of water and sediments to the marine area from the watershed of the largest rivers in Mexico, such as the Grijalva-Usumacinta. The sediments contributed by these rivers are the origin of the largest frontal dune plains in the country and contribute to Tabasco occupying the fourth place in dune surface. The barrier islands of the coast have been formed by the continuous succession of beach cords since the Holocene.

According to the General Diagnosis of the Coastal Dunes of Mexico, published in 2013 by the National Forestry Commission (CONAFOR) and the Secretariat of Environment and Natural Resources (SEMARNAT), in Mexico the dunes cover an area of 808,711 ha. between coastal dunes and inland dunes.

The 74,653 ha of dunes in Tabasco are predominantly frontal, although it also has transgressive dunes (Table 6.34) and representing 9.2% of the national total. Most of the dunes of Tabasco are in a poor state of conservation, which reduces their capacity to provide environmental services. The elimination of the original vegetation of the dunes has affected their natural dynamics, as a consequence, there is a decrease in the accumulation of sand because there are no adequate structures for its detention (branches and fronds) and substrate fixation (roots).

Table 6.34. Surface in hectares of the different types of dunes for the state of Tabasco.

Status	**Front Dunes**	**Plain of Front Dunes**	**Transgressive**	Water body	**Total**
Tabasco	145	72,225	2,115	168	74,653

Likewise, in the literature, it is described that the beach profiles in Tabasco are narrower than those of Tamaulipas and Veracruz. Sand samples from Tabasco beaches indicated a greater terrigenous character; fine to very fine sand size. The large sediment load from the Grijalva, Usumacinta and Tonalá rivers makes the coastal waters of the state turbid, inhibiting the precipitation of carbonates (Carranza-Edwards et al., 2004).

A field study was carried out to know the current state of the beaches in the Hokchi area of influence. To do this, the coast was divided into 13 areas arranged alphabetically from "A" to "M". In Table 6.35, the data for the following parameters are shown: 1) the extension of each area, geographical references to identify the beginning and end of each area, coordinates in UTM units, and the local names of the beaches (in some areas the end is the same as the beginning of the next one, so these tend to recur). Figure 6.53 shows the map with georeferenced zoning.

Table 6.35. Zoning of the study beach according to its physical characteristics.

STATUS	Zone	Location	Start coordinate		End coordinate		Long.
			E	N	E	N	km
Tabasco	A	Mouth of the river San Pedro (Grijalva) to Mouth of the river Usumacinta, beaches of Nuevo Centla, the star and the forest	555783.32	2062209.56	532757.16	2058602.22	23.7
	B	River Usumacinta mouth to Playa Miramar, beaches of Isla del Buey, Caracoles and Miramar	531714.20	2056893.88	522924	2045158	14.12
	C	Miramar Beach to Fraccionamiento Pico de Oro, Beaches Miramar and Pico de Oro	522924	2045158	513507	2040025	10.93
	D	Fractionation of Pico de Oro to Playa Azul, Pico de Oro beaches and Playa Azul.	513507	2040025	504048	2038205	9.71
	E	Playa Azul al Bellote mouth of the Mecoacán lagoon, Azul beach, Jalapita and La Bruja beaches.	504048	2038205	485868.18	2039061.33	18.48

STATUS	Zone	Location	Start coordinate		End coordinate		Long.
			E	N	E	N	km
	F	Breakwater Puerto de Dos Bocas to Unión Tercera, beaches of Paraíso, caracol, ranchería Las Flores, Playa Dorada, Amatillo, Unión Segunda and Unión Tercera	477337.50	2039107.43	459008	2038199	18.39
	G	Unión Tercera to Barra Tupilco, Unión Tercera, Juan Asulo, and Barra Tupilco beaches.	459008	2038199	449033	2036459	10.19
	H	Barra Tupilco to El Alacrán, Beaches of Barra Tupilco, La Redonda and El Alacrán	449033	2036459	435143	2032589	14.41
	I	El Alacrán to the Sinaloa ejido, pajonal lagoon, El Alacrán and Ejido Sinaloa beaches	435143	2032589	426513	2029569	9.21
	J	Ejido Sinaloa to Acapulquito, Barra de Laguna el Carmen, Ejido Sinaloa and Acapulquito beaches	426513	2029569	410572.49	2024244.69	16.87
	K	Villa Sánchez Magallanes to Ohoshal, Cuauhtemoctzin, beaches of Sánchez Magallanes el Pailebot, El Boxal, el Bari and Cuauhtemoctzin	410083.35	2023593.42	380668.39	2014157.16	31.11

STATUS	Zone	Location	Start coordinate		End coordinate		Long.
			E	N	E	N	km
VERACRUZ	L	Tonalá river mouth Tonalá to Guillermo Prieto, beaches of Tonalá, las palmitas, Tortuguero and Guillermo Prieto	380351.88	2014010.34	365721	2010680	15.15
	M	Guillermo Prieto to Villa Allende, Coatzacoalcos river mouth, Guillermo Prieto beaches, playa azul and Villa Allende	365721	2010680	351124.56	2008453.64	14.88

Figure 6.53. Zoning and beach profiles worked on the coast of Tabasco and South of Veracruz

Figure 6.54 shows the map with the georeferenced distribution of the survey of the 20 beach profiles made during the on-site survey. With the exception of P14 (Acapulquito), all the profiles presented a "gentle" slope. The escarpment of P14 was due to its location near a river mouth. Table 6.36 compiles the information obtained from each profile: 1) coordinates, 2) type of slope, 3) name of the locality and 4) size of the dune.

The average beach length (beach width) was 26.25 m. It was observed that the maximum beach width corresponds to P07 (Playa Caracol) with a (length of 48 m; and the minimum beach width corresponded to point P06 (Paraíso) with a length of 9.25 m.

It should be noted that in the beach segment of point P06 (Paraíso), a high concentration of solid waste was observed and an abundant presence of emulsified hydrocarbons mixed with the sand. Furthermore, the decrease in beach length observed in P06 may be related to the time the measurement was made, since the tide was rising. This factor could be decisive.


N
S
W
E
GOLFO DE MÉXICO
TABASCO
VERACRUZ
Reserva de la Biosfera
Pantanos de Centla
A
B
C
D
E
F
G
H
I
J
K
L
M
P 01
P 04
P 05
P 06
P 08
P 09
P 10
P 12
P 13
P 17
P 19
Nuevo Centla
Frontera
Miramar
Pico de Oro
Jalapita
Pto de Dos Bocas
Paraiso
Ejido Sinaloa
El Pailebot
Cuauhtemocin
Tonalá
Colorado
Agua Dulce
Villa Allende

Table 6.36. Georeferenced location and characteristics of the beach profiles obtained during the on-site survey.

PROFILE	UTM coordinates Plan 15Q		Nearby Location	Earring Type	Dune
	E	N			
P 01	543400	2058886	Star Beach	Soft	30 cm
P 02	528621	2051124	Playa Caracoles	Soft	30 cm
P 03	522924	2045158	Playa Miramar	Soft	Without dune
P 04	513507	2040025	Golden Peak	Soft	50 cm
P 05	504048	2038205	Blue Beach	Soft	2 m
P 06	493952	2038153	Paraíso	Soft	50 cm
P 07	476138	2038882	Playa Caracol	Soft	Without dune
P 08	473146	2038756	Amatillo	Soft	Without dune
P 09	459008	2038199	Third Union	Soft	30 cm
P 10	449033	2036459	La Redonda	Soft	30 cm
P 11	435143	2032589	The Scorpion	Soft	30 cm
P 12	426513	2029569	El Pajonal	Soft	1 m
P 13	415189	2025525	El Carmen	Soft	2m
P 14	410776	2024207	Acapulquito	Steep 2 m	
P 15	407508	2022819	Sánchez Magallanes	Soft	3m
P 16	399357	2020204	El Pailebot	Soft	1 m
P 17	389274	2016900	El Boxal	Soft	1 m
P 18	378605	2013720	Tonalá	Soft	2 m
P 19	365721	2010680	Guillermo Prieto	Soft	1.5 m
P 20	358769	2009217	Colorado, Allende	Soft	1m

Condition of the beach and observed alterations:

The following types of alterations were identified: 1) natural, such as the accumulation of organic waste from rivers; 2) natural erosion and 3) anthropogenic influences, such as contamination from residues from oil activity and from the activities of coastal communities; presence of removable or permanent structures and erosion due to anthropogenic effect (Figure 6.55).

Figure 6.55. Coast line with erosion effects

Figure 6.56 shows a mosaic of images that exemplify different types of waste such as wood, water lily and industrial waste found during the on-site prospecting on Tabasco beaches. The origin of these wastes is multifactorial and possibly indicates that they were transported by rivers to the mouths and distributed by marine currents, waves and tidal currents to end up deposited on the beach. These accumulations of residues affect the nesting process and the survival of the young on their way to the sea (Chacón, 2009).

Lily and Hydrocarbon in rock form

Garbage and Hydrocarbon mixed with the sand

Logs of old construction

Palm trees and hydrocarbon mixed with the sand

Figure 6.56. Accumulation of waste in the study area.

In table 6.37, information was compiled on the condition of the beach by zone and the predominant alterations in each segment

Table 6.37. Predominance of alterations by area.

STATUS	**Zone**	**Condition of the Beach and alterations**
Tabasco	A	Erosion, garbage, rubber and gel type hydrocarbon residues, oil installation (head)
	B	Erosion, garbage, hydrocarbon residues mixed in the sand, land transformed for livestock use

STATUS	Zone	Condition of the Beach and alterations
	C	Garbage, tourist cabins, dwellings, oil installations (well)
	D	Garbage, erosion, rock-like hydrocarbon residues, summer houses, tourist huts
	E	Erosion, garbage, hydrocarbon residues mixed in the sand, oil installation.
	F	Tourist cabins, close to Puerto de 2 Bocas, hydrocarbon residues mixed in the sand
	G	Erosion, garbage, hydrocarbon residues mixed in
	H	Erosion, garbage, road, houses and hydrocarbon residues mixed in solid and gel-like sand
	I	Mixed in sand and gel-like hydrocarbon residues
		Gel-type hydrocarbon waste
	K	Trash, erosion, geotube, hydrocarbon residue mixed in sand and gel type
VERACRUZ	L	Garbage, erosion, habitation houses
	M	Garbage, erosion, Pemex drainage

It was observed that on the southern coast of the state of Tabasco there are most of the oil installations, wells on land, wells near the coast and in shallow marine waters. In zones A, D and E, remains of hydrocarbons, stone type, gel type (emulsified) and slab type were observed from 1 to 20 cm.

In zones B, C, D and E, low amounts of hydrocarbon mixed with sand were observed along the coast, as well as a large amount of waste thrown by rivers, such as lilies, trunks, and palm trees., among others.

In zones B, D and E, stretches of eroded beach and anthropogenic activity with tourist palapas were observed mainly in zones C and D, as well as remains of inorganic garbage along the coast (Figure 6.57 and Figure 6.58).

Figure 6.57. Representative photographs of the effects of beach erosion

In the central part of Tabasco is the Puerto de Dos Bocas and some platforms in the sea. Great activity of boats was observed due to the proximity of the port. In all areas of the central coast, hydrocarbon residues mixed with the sand were observed in greater quantities than in other places. In zones H, I and J, rock-type hydrocarbon remains were found between 1 and 15 cm to greater than 30 cm and gel-type between 50 and 15 cm.

Tourist palapas and beach houses were affected by erosion, possibly due to the construction of breakwaters and breakwaters around Dos Bocas port.

In zones F, G, H and 1, portions of the beach were very affected by erosion. As a containment measure, stone and geotube barriers have been placed in some sections. In zone I the erosion has been such that it has affected the section of the coastal highway, it is worth mentioning that, like the southern part of the state, the beaches presented a large amount of inorganic trash remains along the coast (Figure 1).

In the north region of the state of Tabasco and south of the state of Veracruz, no nearby oil facilities were observed. The hydrocarbon residues found were of the consolidated stone-like type, with some pieces up to 2 m long.

Hydrocarbon residues mixed in the sand were observed in the southern part of zone K. On the beaches located between zones L and M, it was observed that the sand is found with less residue. In a section near the town of Sánchez Magallanes, a geotube was placed presumably to protect houses near the coast, however, during the tour in this area it was detected that most of them were destroyed by the combined effect of destruction of the frontal area of the beach and by natural erosion due to extraordinary tides.

In the southern zone of Veracruz, the effect of erosion was also observed in some sections of the beach (Figure 6.60). The enormous accumulation of inorganic waste along this coast is noteworthy, mainly near Sánchez Magallanes. Near the mouth of the Tonalá river, human settlements and rustic palapas were found for tourist use on the old dune area.

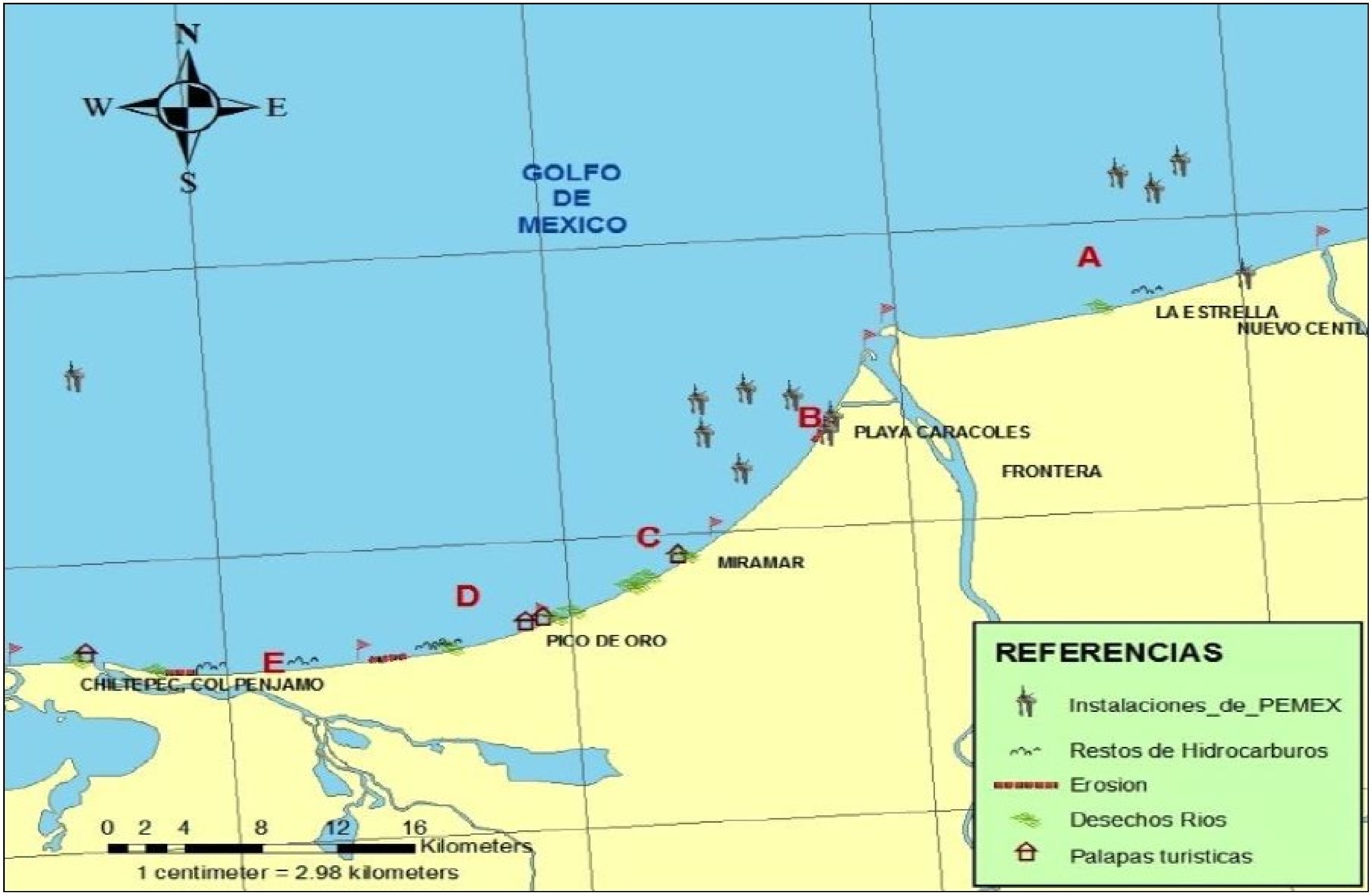


Figure 6.58. Disturbances in zones A, B, C, D and E, in the southern and central part of the state of Tabasco.

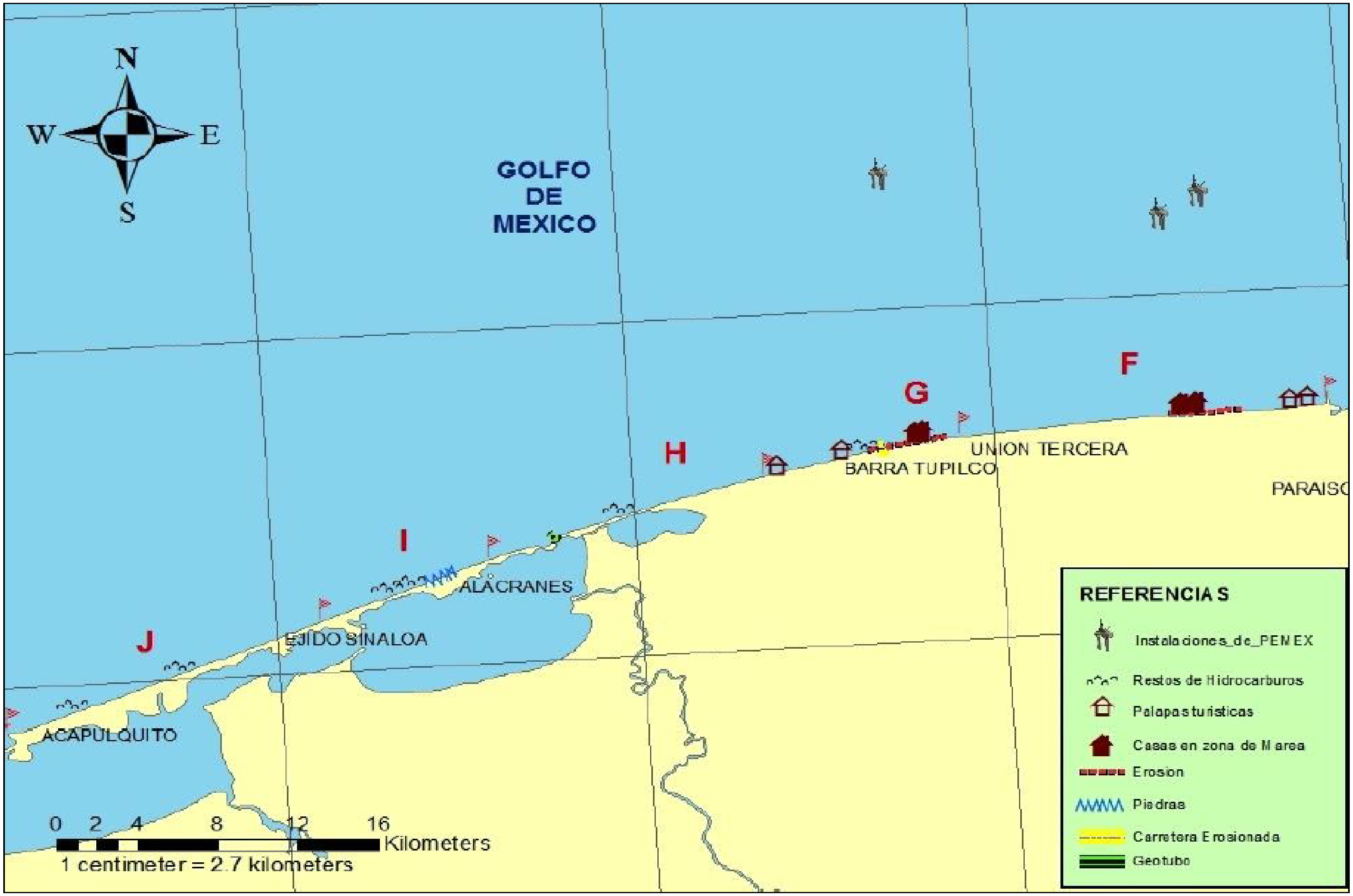


Figure 6.59. Disturbances observed in zones F, G, H, 1, J, in the central part of the state of Tabasco.

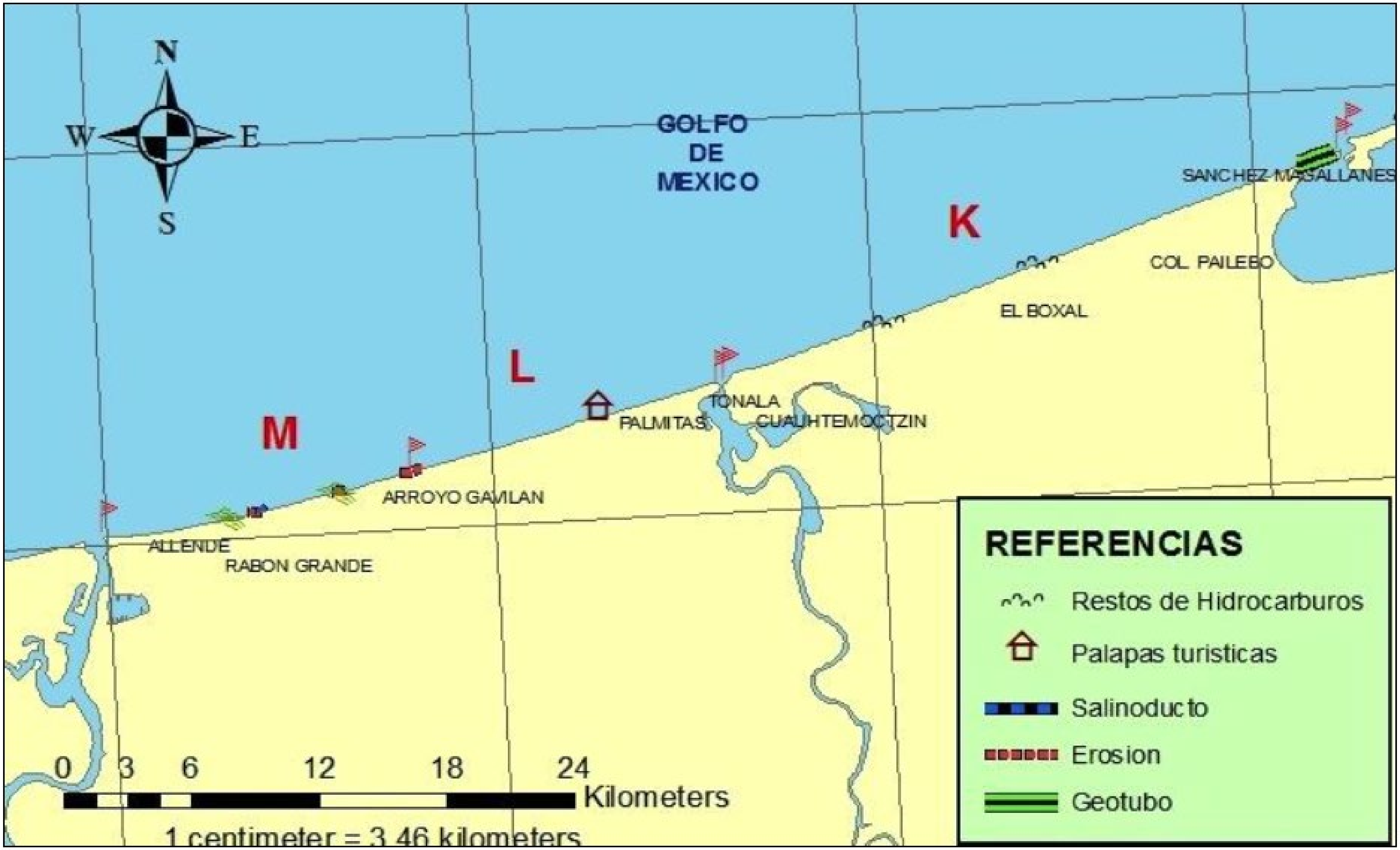


Figure 6.60. Disturbances observed in zones K, L, M, in the northern part of the states of Tabasco and southern Veracruz.

6.7. Identification of existing infrastructure

6.7.1. Municipality of Paraíso, Tabasco

According to the information compiled in the Municipal Diagnostics of the Community and Environment Support Program (PEMEX a, 2014), Paraíso borders the Gulf of Mexico and the municipality of Centla to the north; to the east with the municipalities of Centla and Jalpa de Méndez; to the south with the municipalities of Jalpa de Méndez and Comalcalco; to the west with the municipalities of Comalcalco, Cárdenas, and the Gulf of Mexico.

Regarding the information on more relevant social aspects, it is highlighted in the same reference document:

- Paraíso is one of the municipalities of Tabasco with a low degree of marginalization; it occupies the 16th place of the 17 mayors of the entity.

- At the national level, it is also located within the group that presents a low degree of marginalization and in the set of municipalities that have a very low degree of social backwardness, it occupies positions 2,055 and 2,210, respectively, among the 2,456 municipalities in the country.

- In relation to the 347 PEMEX-PACMA municipalities, it ranks 200 in marginalization and 237 in social backwardness, which places Paraíso in the group of municipalities that have intermediate quality of life conditions, observing the following characteristics: high population rate with food deficiency; high percentage of households that cook with wood or charcoal and without piped water; a high population of students per campus (possible overcrowding); a significant percentage of the economically active unemployed population; and a high number of environmental complaints.

- In accordance with the social development policy, Paraíso belongs to the National Crusade against Hunger and is an Urban Priority Attention Area.

The most relevant communication aspects are summarized in table 6.38.

Table 6.38. Length of the road network according to type of road (km).

Concept	Tabasco	%	Paraíso	%
Total road network	10,709	**100.00%**	352	**100.00%**
Paved federal road	596	5.57%	20	5.69%
Lined federal road	0	0.00%	13	0.00%
State paved feeder	3390	31.65%	93	26.36%
Lined state feeder	1,950%	18.21%	26	7.37%
Dirt road state feeder	ND	ND	ND	ND
Paved country roads	1,845	17.22%	110	31.41%
Lined rural roads	1,919	17.92%	43	12.29%
Rural dirt roads	887	8.09%	59	16.89%
Improved gaps	143	1.34%	0	0 00
Source: Prepared by INAP based on information from the Statistical Yearbooks by Federal Entity 2012, INEGI				

Related to cultural and recreational aspects, table 6.39 lists the existing infrastructure.

Table 6.39. Infrastructure for culture, sports and recreation (units).

Concept	Tabasco	Paraíso
Sport		
Sports infrastructure selected and registered with the Institute of Sports	931	53
Pools	12	0
Baseball fields	113	10
Football fields	190	10
Basketball courts	202	12
Volleyball courts	108	12
Sports centers and units	283	8
Gyms	15	0
Racetrack	1	0
Running tracks	7	1
Culture		
Public libraries	564	23
Books in Public Libraries	2,626.821	104.787
Users of Public Libraries	2,580,262	82,432
List of public libraries and total population (every 10,000 inhabitants)	2 5	2.7
Recreation		
Playgrounds for children	183	7
Source: Prepared by INAP based on information from the National Institute of Statistics and Geography (INEGI), Socio-demographic and Economic Information Bank, 2010.		

The infrastructure in health services is described in table 6.40.

Table 6.40. Public sector medical services.

Concept	Tabasco	Paraíso
Outpatient medical units	614	16
General hospitalization medical units	27	1
Specialized hospitalization medical units	6	0
Total external consultations granted	8.107,681	217,413
General inquiries	5499,648	147.149
Specialized consultations	1.105,453	23,385
Urgent consultations	870.893	32,375
Dental Consultations	431.687	14,504
Queries granted per inhabitant	**3.5**	**2.4**
Total doctors	5.300	125
Doctors per 1,000 inhabitants	**2.3**	**1.4**

Source: Prepared by INAP based on information from the 2013 Statistical Yearbooks by State; and CONAPO, population by municipality, projection for the year 2012 for the calculation of doctors per 1,000 inhabitants.

The general panorama related to educational aspects in the municipality is shown in table 6.41.

Table 6.41. Overview of education.

Concept	Tabasco	Paraíso
Total enrolled students	**651,780**	25,166
Total teaching staff	27,774	1,076
Students per teacher	23	23
Total short	5.052	150
Students by schools	129	168
Tole] aulas	26.897	947
Students per classroom	24	27
Libraries	185	3
Students per library	3.523	8,389
Laboratories	1,224	51
Students per laboratory	533	493
Talleres	837	34
Students per workshop	779	740
Annexes (courts. Squares. Computation. Etc.)	33.795	1,173
Students pe «annex.	19	21

Source: Prepared by INAP based on information from the Statistical Yearbooks by Federal Entity 2013, INEGI

Note: The information is expressed in terms of physical plant, since the same infrastructure can be used for the operation of several schools and shifts. It includes basic and upper secondary education of the school modality

6.7.2. Municipality of Centla, Tabasco

According to the information compiled in the Municipal Diagnostics of the Community and Environment Support Program (PEMEX b, 2014), Centla borders the Gulf of Mexico and the state of Campeche to the north; to the east with the municipalities of Jonuta, Macuspana and the state of Campeche; to the south with the municipalities of Macuspana and Centro; to the west with the municipalities of Centro, Nacajuca, Jalpa de Méndez, Paraíso and the Gulf of Mexico.

Regarding the information on more relevant social aspects, it is highlighted in the same reference document:

- Centla is, in reference to Tabasco, a municipality with a medium degree of marginalization; it occupies the 5th place of the 17 mayors of the entity.

- At the national level, it is within the group that presents a medium degree of marginalization, and in the set of municipalities that have a low degree of social backwardness; it occupies the positions 1, 243 and 2,456, respectively, among the 1,481 municipalities of the country.

- In relation to the 347 municipalities PEMEX-PACMA, it ranks 86th for marginalization and 118th for social backwardness. Centla has a significant presence of indigenous population (vulnerable population). Likewise, the following deficiencies are observed: high rates of the population with food deprivation and with wages below the minimum welfare; significant percentages of homes without access to information and communication technologies, with a certain level of overcrowding, that use firewood or charcoal for cooking, with dirt floors and unsafe roofs, without toilets and without piped water service; a high proportion of the unemployed economically active population and a high number of environmental complaints.

- In accordance with the social development policy, Centla is part of the National Crusade against Hunger, it is an Urban Priority Attention Zone and a Rural Priority Attention Zone.

The most relevant communication aspects are summarized in table 6.42.

Table 6.42. Length of the road network according to type of road (km).

Concept	Tabasco	%	Centla	%
Total road network	10,709	**100.00%**	**586**	**100.00%**
Paved federal road	596	5.57%	61	10.41%
Lined federal road	0	0.00%	0	0.00%
State paved feeder	3390	31.65%	172	29.40%
Lined state feeder	1,950%	18.21%	12	2.03%
Dirt road state feeder	ND	ND	ND	ND
Paved country roads	1,845	17.22%	172	29.29%
Lined rural roads	1,919	17.92%	118	20.18%
Rural dirt roads	887	8.09%	41	6.98%
Improved gaps	143	1.34%	10	1.71%
Source: Prepared by INAP based on information from the Statistical Yearbooks by Federal Entity 2012, INEGI				

Related to cultural and recreational aspects, table 6.43 lists the existing infrastructure.

Table 6.43. Infrastructure for culture, sports and recreation (units).

Concept	Tabasco	Centla
Sport		
Sports infrastructure selected and registered with the Institute of Sports	931	53
Pools	12	1
Baseball fields	113	5
Football fields	190	9
Basketball courts	202	9
Volleyball courts	108	9
Sports centers and units	283	19
Gyms	15	1
Racetrack	1	0
Running tracks	7	00
Culture		
Public libraries	564	15
Books in Public Libraries	2,626.821	83,405
Users of Public Libraries	2,580,262	122,489
List of public libraries and total population (every 10,000 inhabitants)	2 5	1.5
Recreation		
Playgrounds for children	183	8
Source: Prepared by INAP based on information from the National Institute of Statistics and Geography (INEGI), Socio-demographic and Economic Information Bank, 2010.		

The infrastructure in health services is described in table 6.44.

Table 6.44. Public sector medical services.

Concept	Tabasco	Centla
Outpatient medical units	614	32
General hospitalization medical units	27	2
Specialized hospitalization medical units	6	0
Total external consultations granted	8.107,681	297,781
General inquiries	5499,648	242,444
Specialized consultations	1.105,453	3,417
Urgent consultations	870.893	28,724
Dental Consultations	431.687	23,196
Queries granted per inhabitant	**3.5**	**2.9**
Total doctors	5.300	139
Doctors per 1,000 inhabitants	**2.3**	**1.3**

Source: Prepared by INAP based on information from the 2013 Statistical Yearbooks by State; and CONAPO, population by municipality, projection for the year 2012 for the calculation of doctors per 1,000 inhabitants.

The general panorama related to educational aspects in the municipality is shown in table 6.45.

Table 6.45. Overview of education.

Concept	Tabasco	Centla
Total enrolled students	**651,780**	32,856
Total teaching staff	27,774	1,424
Students per teacher	23	23
Total short	5.052	317
Students by schools	129	104
Tole] aulas	26.897	1,322
Students per classroom	24	25
Libraries	185	9
Students per library	3.523	3,651
Laboratories	1,224	45
Students per laboratory	533	730
Talleres	837	49
Students per workshop	779	671
Annexes (courts. Squares. Computation. Etc.)	33.795	1,863
Students pe «annex.	19	18

Source: Prepared by INAP based on information from the Statistical Yearbooks by Federal Entity 2013, INEGI

Note: The information is expressed in terms of physical plant, since the same infrastructure can be used for the operation of several schools and shifts. It includes basic and upper secondary education of the school modality

6.7.3. Municipality of Cárdenas, Tabasco

According to the information compiled in the Municipal Diagnoses of the Community and Environment Support Program (PEMEX c, 2014), Cárdenas borders to the north with the municipalities of Paraíso, Comalcalco and the Gulf of Mexico; to the east with the municipalities of Comalcalco, Cunduacán and the state of Chiapas; to the south with the municipality of Huimanguillo; to the west with the municipality of Huimanguillo and the Gulf of Mexico.

Regarding the information on more relevant social aspects, it is highlighted in the same reference document:

- Cárdenas is, in reference to Tabasco, it is one of the municipalities with a medium degree of marginalization; it ranks 11 out of 17 in the state.

- At the national level, it presents a medium degree of marginalization and a very low degree of social backwardness, occupying places 1,673 and 1,731, respectively, among the 2,456 municipalities of the country.

- In relation to the 347 municipalities PEMEX-PACMA, it occupies the 142nd place of marginalization and 153 of social backwardness, which places Cárdenas among the municipalities with medium quality of life conditions, observing the following characteristics: a high rate of population with deprivation food and salary below the minimum welfare; high percentages of homes with some degree of overcrowding, unsafe roofs, dirt floors, no toilet, no piped water, no information or communication technologies, and use of firewood or charcoal for cooking; a substantial number of consultations per year per inhabitant and of basic education students per campus; a small percentage of the employed population and a considerable number of environmental complaints.

- In accordance with the social development policy, Cárdenas belongs to the National Crusade against Hunger, is an Urban Priority Attention Area and is a municipality with High Job Loss.

The most relevant communication aspects are summarized in table 6.46.

Table 6.46. Length of the road network according to type of road (km).

Concept	Tabasco	%	Cardenas	%
Total road network	10,709	**100.00%**	1,092	**100.00%**
Paved federal road	596	5.57%	52	4.76%
Lined federal road	0	0.00%	0	0.00%
State paved feeder	3390	31.65%	33	30.41%
Lined state feeder	1,950%	18.21%	431	39.46%
Dirt road state feeder	ND	ND	ND	ND
Paved country roads	1,845	17.22%	160	14.65%
Lined rural roads	1,919	17.92%	66	6.05%
Rural dirt roads	887	8.09%	51	4.67%
Improved gaps	143	1.34%	0	0.00%
Source: Prepared by INAP based on information from the Statistical Yearbooks by Federal Entity 2012, INEGI				

Related to cultural and recreational aspects, table 6.47 lists the existing infrastructure.

Table 6.47. Infrastructure for culture, sports and recreation (units).

Concept	Tabasco	Cardenas
Sport		
Sports infrastructure selected and registered with the Institute of Sports	931	77
Pools	12	0
Baseball fields	113	12
Football fields	190	23
Basketball courts	202	12
Volleyball courts	108	24
Sports centers and units	283	3
Gyms	15	2
Racetrack	1	0
Running tracks	7	1
Culture		
Public libraries	564	51
Books in Public Libraries	2,626.821	231,964
Users of Public Libraries	2,580,262	128,140
List of public libraries and total population (every 10,000 inhabitants)	2 5	2.1
Recreation		
Playgrounds for children	183	6
Source: Prepared by INAP based on information from the National Institute of Statistics and Geography (INEGI), Socio-demographic and Economic Information Bank, 2010.		

The infrastructure in health services is described in table 6.48.

Table 6.48. Public sector medical services.

Concept	Tabasco	Cardenas
Outpatient medical units	614	59
General hospitalization medical units	27	2
Specialized hospitalization medical units	6	0
Total external consultations granted	8.107,681	980,647
General inquiries	5499,648	771,290
Specialized consultations	1.105,453	64,122
Urgent consultations	870.893	109,168
Dental Consultations	431.687	36,067
Queries granted per inhabitant	**3.5**	**3.8**
Total doctors	5.300	409
Doctors per 1,000 inhabitants	**2.3**	**1.6**

Source: Prepared by INAP based on information from the 2013 Statistical Yearbooks by State; and CONAPO, population by municipality, projection for the year 2012 for the calculation of doctors per 1,000 inhabitants.

The general panorama related to educational aspects in the municipality is shown in table 6.49.

Table 6.49. Overview of education.

Concept	Tabasco	Cardenas
Total enrolled students	**651,780**	**75,427**
Total teaching staff	27,774	3,036
Students per teacher	23	25
Total short	5.052	442
Students by schools	129	171
Tole] aulas	26.897	2,905
Students per classroom	24	26
Libraries	185	17
Students per library	3.523	4,437
Laboratories	1,224	137
Students per laboratory	533	551
Talleres	837	94
Students per workshop	779	802
Annexes (courts. Squares. Computation. Etc.)	33.795	3,148
Students pe «annex.	19	24

Source: Prepared by INAP based on information from the Statistical Yearbooks by Federal Entity 2013, INEGI

Note: The information is expressed in terms of physical plant, since the same infrastructure can be used for the operation of several schools and shifts. It includes basic and upper secondary education of the school modality

6.7.4. Regional infrastructure

Airports

The Carlos Rovirosa Pérez international airport is located 84 km southeast of the Hokchi field, in the municipality of Villahermosa, Tabasco. This airport, in 2015, moved 1,268,443 people on 15,817 flights with a total load of 3,230,728 kg, making it the 12th airport in Mexico with the highest influx.

The most used route was Mexico City - Villahermosa - Mexico City with 845,470 people mobilized (67%) in 8,694 flights (55%) (SCT, 2016).

Headlights

In the municipalities adjacent to Hokchi there are five lighthouses for maritime navigation, located in the municipalities of Paraíso (1 lighthouse) and Centla (4 lighthouses) (Annex 32). Likewise, in the Centro municipality (Villahermosa) there is a radiobeacon that operates within the Carlos Rovirosa Pérez airport.

Seaports

21 km southeast of Hokchi is Puerto Dos Bocas, which presents high altitude activities and cabotage (Annex 32). In 2014 this port mobilized 6,288,010 tons of products: 958,383 t (15%) as cabotage and 5,329,627 t (85%) as height. Of the total cargo, 93% (5,866,316 t) corresponded to oil and derivatives, 5.5% (343,994 t) was general cargo and 1.2% (77,700 t) were agricultural products. 86% of the cargo moved (5,424,294 t) corresponded to departures and/or exports and 14% (863.716 t) were entries and/or imports (SC T, 2015).

Roads and Vialities

In the continental area adjacent to Hokchi there are 7,100 km of roads and urban roads, of which 3,844 km (54%) correspond only to highways, of these 3,704 km (96.3%) are free traffic, 53.4 km (1.3%) of share and 4.2 km (0.1%); they are classified as restricted access. The remaining 81.8 km (2.12%) do not have any category assigned (Annex 32).

66.3% (2,546 km) of the highways are under state administration, 19% (730 km) municipal, 12% (461 km) federal and 100 km (2.6%) are private or with some other type of administration.

The main federal highways existing in the area are 180 (Matamoros Cancún), 184 (Oxkutzcab - Felipe Carrillo Puerto), 186 (Villahermosa - Chetumal), 187 (Paraíso - Raudales Malpaso) and 195 (Villahermosa - Tuxtla Gutiérrez) (INEGI,

6.8 Economic activities

The economic activities analyzed and developed for this report are activities related to fishing and tourism.

With regard to fishing activity, the information reported is based on the 2013 Aquaculture and Fisheries Statistical Yearbook of the National Aquaculture and Fisheries Commission (CONAPESCA), which has the most up-to-date information required. The information provided by this body is only at the national and state level.

The information referring to the tourist infrastructure was obtained from the State and Municipal Database System (SIMBAD), from the National Institute of Geography and Statistics (INEGI) corresponding to the year 2012. The information corresponding to SIMBAD is updated. Subsequently, this information was contrasted with the total municipal and state population, corresponding to the 2010 Population Count, to obtain indicators such as, supply of rooms and food preparation establishments by number of inhabitants. It was considered to take the population from the Population Count of 2010 and not from the Intercensal Count of 2015, due to its temporal proximity.

In relation to the sites of tourist interest, the information reported was obtained during field work through interviews with the population and municipal authorities.

6.8.1. Fishing and aquaculture

The state of Tabasco has almost 200 km of coastline that represents 1.8% of the national total. The state municipalities that cover the coastal zone are the three that are included in this analysis: Cárdenas, Paraíso and Centla.

The main coastal lagoon systems located in these municipalities are Carmen-Pajonal-Machona and Mecoacán. These bodies of water maintain diverse biological and ecological interactions, which makes this area an area with high ecological, cultural and socioeconomic value.

According to CONAPESCA (2013), aquacultural fisheries comprise the exploitation of fisheries in epicontinental reservoirs where commercial fishing is practiced, supported both by the systematic planting of offspring of species such as carp, tilapia, catfish and largemouth bass, produced by dependent aquaculture centers. of the state and federal governments, as well as those derived from the management of wild stocks of fish hatchlings, shrimp postlarvae, tadpoles and the like.

Aquaculture practices both in the country and in the state of Tabasco have been implemented as an alternative to fishing and to improvise various levels of fish production. In the case of the municipality of Paraíso, it has been seen that the conditions within the Mecoacán fisheries are significantly deteriorated, and the cooperatives are not producing a positive input for the local communities, therefore the fishermen have participated in the restructuring of their organizations fisheries as a measure of integrating employment and generating alternative inputs, such as aquaculture practices.

Extensive aquaculture in the coastal lagoons of Tabasco has been a very important activity for the economy of coastal communities, an example of this is the extensive cultivation of oyster (Crassostrea virginica), which covers not only 35.2% of the state's production, It also contributes 36.2% of national production (CONAPESCA, 2013) (Figure 6.61).

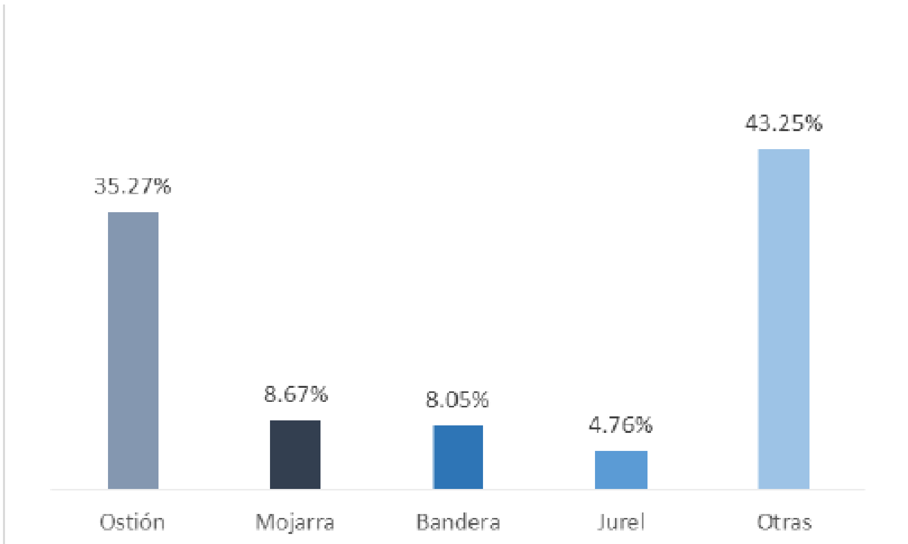


Figure 6.61. Participation of the main species in production, Tabasco, Own elaboration based on CONAPESCA, 2013

Fishing in the Tabasco lagoons has been done for more than 500 years using native techniques and in one-piece boats (cayucos) built with local trees. At present, the fishing fleet is made up mostly of fiberglass canoes and boats with 6-8m in length, which generally use an outboard motor between 6 and 15HP (Alejandro Espinoza-Tenorio, A., et al., 2015).

According to CONAPESCA in 2013, Tabasco ranked seventh at the national level in terms of fishing volume with 43,668 tons, equivalent to the

Through the analysis of the percentage participation of Tabasco in national fishing production, it is observed that in ten years the activity has decreased, with 3.7% in 2004, until it declined by more than one percentage point in 2013 with 2.5%.

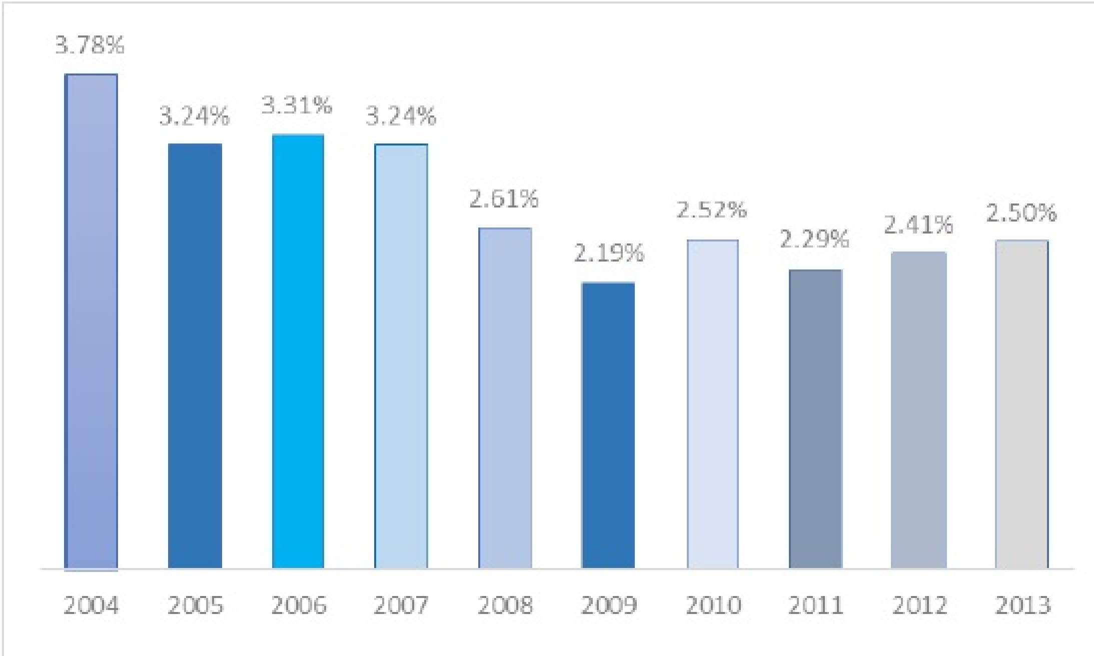


Figure 6.62. Percentage share of fishing in Tabasco in national production. Source: CONAPESCA.

In the work by Arias and Ireta (2009), it is mentioned that fishing begins to decline as a result of the entry of the PEMEX activity.

Regarding the volume of shrimp production, Tabasco did not participate significantly in the national production, with 462 tons, which was equivalent to 0.4% of the national total in 2013 (Table 6.50).

Table 6.50. Volume of shrimp production in landed weight (ton), Tabasco

Total	Open sea	Estuaries and bays	Culture

National	115,606	38,720	28,504	60,292
Tabasco	462	24	184	254

Source: Own elaboration based on CONAPESCA, 2013

In the work of Arias, J. and Ireta, H., (2009), the boom in shrimp fishing in Tabasco at the beginning of the eighties is pointed out, which was largely carried out in Centla, in the port of Frontera, with the capture of the line shrimp, seven barbs and trash. There was an industrial plant where shrimp production was processed. There were 26 shrimp fishing boats owned by the cooperatives, which later increased to 125 shrimp boats. However, due to the arrival of the oil fleet at the end of the eighties, the fishing debacle began in the entity. Proof of this is that in the aforementioned investigation it is mentioned that in 1988 800 million pesos were obtained from the sale of shrimp processed in the Tabasco industrial plant, contrary to this, in 2013, the value of shrimp production in Tabasco was $ 24,296 pesos. In addition to this, currently, according to CONAPESCA, in 2013 only one vessel was reported for shrimp fishing, compared to the 125 that operated in the 1980s.

Regarding the fishery production by aquaculture, the main species for the state of Tabasco in 2013, are the oyster with 81%, equivalent to 15,402 tons, as well as the mojarra and shrimp with 17.5% and 1.34% respectively (Table 6.51).

Table 6.51. Volume of aquaculture fishery production in live weight, by main species, Tabasco 1 (tons)

	Total	Open sea	Estuaries and bays	Culture
National	115,606	38,720	28,504	60,292
Tabasco	462	24	184	254

Total weight of the product when obtained from its natural environment; is determined based on the landed weight: applying factors of established by the National Institute of Fisheries. Source: Own elaboration based on CONAPESCA, 2013

In relation to vessels for deep-sea fishing, in the state of Tabasco CONAPESCA registered a total of 28 vessels for scale fishing

in 2013, while coastal vessels registered 6,279 active vessels (Table 6.52), which represent 22.4% of all vessels of this type on the Gulf and Caribbean littoral. Only one shrimp vessel was registered with a capacity of between 60-80 tons, with a length of 20-25 and with an age of between 21 and 30 years for the same year.

Table 6.52. Vessels registered by main fisheries.

	Big game fishing / 1						Riverine fishing / 2
	Total	subtotal	Shrimp	tuna	Sardine-Anchovy	Scale	
National total	76,096	2,041	1,180	83	68	710	74,055
Gulf Coast and the Caribbean	28,869	939	330	22	--	587	27,930
Tabasco	6,308	29	1	--	--	28	6,279

[1] Active vessels that are within the national registry of fishing and aquaculture.

[2] Vessels less than or equal to 10 meters in length and whose main activity is commercial fishing. Source: CONAPESCA.

Regarding the infrastructure for the docking of vessels, the data provided by CONAPESCA for 2013 report that the important fishing town of Sánchez Magallanes in the municipality of Cárdenas, registered 606 meters of docking length for riverine fishing; In the case of the town of Chiltepec within the municipality of Paraíso, 86 meters were recorded, also for riverine fishing activity.

For its part, in the municipal seat of Centla, in the port of Frontera, the docking infrastructure for boats reported 248 meters for riverine fishing, in addition to 400 meters and 94 meters in length for berthing shrimp and scale vessels respectively. (Table 6.53).

Table 6.53. Berthing length of national fishing ports by type of fishery, Gulf and Caribbean coastline, according to entity and port, 2013 (meters).

Coastline, Entity and port	Total	Fishing Tall				Riparian fishing
		tuna	Anchovy sardine	Shrimp	Scale	
Tabasco	2,010	--	--	400	94	1,516
Sánchez Magallanes	606	--	--	--	--	606
Chiltepec	86	--	--	--	--	86
Border	743	--	--	400	94	249
Barra de San Pedro	575	--	--	--	--	575

Source: Own elaboration based on CONAPESCA, 2013

In relation to the infrastructure for aquaculture production units, CONAPESCA reported 127 units for fattening throughout the state of Tabasco for 2013. Similarly, there were 35 shrimp aquaculture production units in the same year.

The fish industry includes infrastructure to carry out freezing and canning processes, as well as their reduction. For 2013, only 5 fish plants were reported in Tabasco, 4 for frozen and one was reported as "others".

In the field work, several industrial plants for freezing fish were observed in a state of abandonment (Figures 6.63 and

Figure 6.63. Abandoned ice factory in Chiltepec, municipality of Paraíso, Photography February 2016

Figure 6.64. Abandoned ice factory in Chiltepec, municipality of Paraíso, Photography February 2016

According to the 2013 Aquaculture and Fishing Statistical Yearbook, the population of fishermen in Tabasco is 18,148 people, the majority belonging to capture and aquaculture fisheries with 17,163 and only 985 belonging to the controlled systems. The latter include the production generated in facilities created for the cultivation of aquaculture species through the application of a technological model that relies on the exercise of various work routines, pumping water, feeding animals, fertilization, density control, among others.

It is important to mention that to a large extent the total fishing population of the state is concentrated in the municipalities of Cárdenas, Paraíso and Centla because they are the coastal territories of the entity and where the most important lake systems of the same are located.

Municipality of Cárdenas

The municipal participation of Cárdenas on a national scale in 2013 was 0.30% of the value of aquaculture production (22.4 million pesos), and 1.44 of the value of fishery production (177.7 million pesos), which is equivalent to 16 y 35% stake in the entity's securities, respectively, according to the PEMEX-PACMA diagnosis (PEMEXc, 2014).

Cárdenas registers an area of water bodies of 207.27 square kilometers and a coastline of 70 kilometers. This sector is considered to be one of the highest priority for the municipality, and aquaculture farms are mentioned as a strategic product for the development of its economy.

The main rivers and lagoons present in the municipality are the following:

Cardenas	
Lagoons	Rivers
Machona	Mezcalapa
Del Carmen	San Felipe
El Pajonal	Naranjeño
La Palma	Santana
Santa Teresa	Tonalá
Carmen	Sapodilla
Machona	

Municipality of Paraíso

Paraíso registered 0.12% of the value of the national capture production (8.7 million pesos), which meant 6% of the value of Tabasco, and 1.07% of the value of the national capture production (132 million pesos), which which was equivalent to 26% of the entity's value (PEMEXa, 2014).

The municipality registered in 2005, a surface of water bodies corresponding to 19.8% of its territory (80.89 square kilometers) and a coastline of 52 kilometers.

Paraíso	
Lagoons	Rivers
Mecoacán	Río González
La Machona	Arroyo Hondo
Tupilco Ostión Bridge La Encerrada or Amatillo	Runoff from the rivers Seco, El Corcho, Tupilco, Cocohital, El Corinto, Arroyo Verde and the Arroyo drain

Three palms	Verde
El Zorro	
Trawler	
Las Flores	
Lagartera Tilapa	
Sea cow	
The Link	

Municipality of Centla

In the municipality of Centla, and based on estimates prepared by INAP, a national participation of approximately 1.60% of the value of fishery production (198 million pesos) was observed, as well as 0.28% of the value of aquaculture production (21.3 million pesos), it was equivalent to 39 and 15% participation in the entity's securities, respectively (PEMEXb, 2014).

Centla registers an area of bodies of 7.3% of its territory 197.08 square kilometers) and has a coastline of 78 kilometers, so this sector is "strategic" for the economy of the municipality, however the reactivation of the port of Frontera and investment in infrastructure to increase productivity.

	Centla
Lagoons	Rivers
El Viento	Grijalva
Chichicastle	Usumacinta
El Tocoal	San Pedrito

Santa Anita	San Pedro
The Loncho	San Pablo
San Pedrito	

6.8.2. Tourism

Municipality of Cárdenas

The tourist offer of the municipality is divided into four main categories: lodging, food and beverage preparation establishments, services and tourist sites. In the case of lodging, the municipality of Cárdenas had 42 lodging establishments and 1,005 rooms in 2012, while the State had 10,923 establishments and 434,923 rooms. These figures result in an average of 24 rooms per lodging establishment for the municipality of Cárdenas and 25 rooms per lodging establishment for the entity. This means that the tourist accommodation offer in Cárdenas is similar to the average offer in Tabasco; Therefore, it could be considered as a tourist municipality on the state scale (SIMBAD-INEGI, 2012).

On the other hand, in terms of the supply of food and beverage preparation and service establishments, the municipality of Cárdenas had 96 establishments in 2012 and the state of Tabasco with 1,110. This number divided between the total municipal and state populations (INEGI, 2010) gives us an average of one establishment for every 2,588 inhabitants in Cárdenas and one establishment for every 2,020 inhabitants in the State; which means that the supply of food and beverage preparation establishments is greater in the State than in Cárdenas.

During the field visit to the municipality of Cárdenas during March 2016, eight tourist sites were found, among which 70 kilometers of coastline are recognized, including Playa Sánchez Magallanes and Barra de Santa Ana, 30 kilometers long; the Carmen-Pajonal-Machona lagoon system, El Pajaral island (where several species of birds nest) and the "Ensueño del Tópico" spa; as well as the Sánchez Magallanes fishing port and the oyster aquaculture farms.

There is also the Chontalpa Ecological Park that contains one of the last two remnants of the canacoite jungle (Bravaisia integerrima) in Mexico.

Finally, with regard to tourist services, the municipality of Cárdenas has a travel agency and does not have any type of car rental company; while the State has 56 and 13, respectively

Municipality of Paraíso

The tourist offer of the municipality is divided into four main categories: lodging, food and beverage preparation establishments, services and tourist sites. In the case of lodging, the municipality of Paraíso had 41 lodging establishments and 998 rooms in 2012, while the State had 434 establishments and 10,923 rooms. These figures give us an average of 24 rooms per lodging establishment for the municipality of Paraíso and 25 rooms per lodging establishment for the State. This means that the tourist accommodation offer in Paraíso is similar to the average offer in Tabasco; Therefore, it could be considered as a tourist municipality on the state scale (SIMBAD-INEGI, 2012).

On the other hand, regarding the supply of food and beverage preparation and service establishments, the municipality of Paraíso had 139 establishments in 2012 and the state of Tabasco with 1,108 (INEGI, 2010). This number divided between the total municipal and state populations gives us an average of one establishment for every 637 inhabitants in Paraíso and one establishment for every 2,022 inhabitants in the State; which means that the supply of food and beverage preparation establishments is three times greater in Paraíso than in Tabasco; so it can be considered as a tourist municipality at the municipal level.

During the field visit to the municipality of Paraíso in March 2016, 14 tourist sites were found, among which five beaches are recognized along the 52 kilometers of coastline that make up the municipality: Playa Bruja, Playa Varadero, Playa Dorada, El Paraíso Tourist Center and Barra de Tupilco crowned by the Cerro del Teodomiro. It also has the Mecoacán Lagoon, which includes the tourist inns of Puerto Ceiba and El Bellote and the tourist complex of Cangrejópolis. Also, Paraíso has the gastronomic corridors of Isla Rebeca and República de Paraíso and the fishing town of Chiltepec. Another tourist attraction is the Río Playa Ecological Reserve.

Finally, with regard to tourist services, the municipality of Paraíso has three travel agencies and three car rental companies; while the State has 56 and 13, respectively (SIMBAD-INEGI, 2012).

Municipality of Centla

The tourist offer of the municipality is divided into four main categories: lodging, food and beverage preparation establishments, services and tourist sites. In the case of accommodation, the municipality of Centla had 23 accommodation establishments and 250 rooms in 2012, while the State had 434 establishments and 10,923 rooms. These figures give us an average of 11 rooms per lodging establishment for the municipality of Paraíso and 25 rooms per lodging establishment for the State. This means that the tourist accommodation offer in Paraíso is less than the average offer in Tabasco, despite having the largest Biosphere Reserve in the state: the Pantanos de Centla (SIMBAD-INEGI, 2012).

On the other hand, regarding the supply of food and beverage preparation and service establishments, the municipality of Paraíso has 27 establishments and the state of Tabasco with 1,18. This number divided between the total municipal and state populations (INEGI, 2010) gives us an average of one establishment for every 3,782 inhabitants in Centla and one establishment for every 2,020 inhabitants in the State; which means that the supply of food and beverage preparation establishments is less in Centla than in Tabasco.

During the field visit to the municipality of Centla in March 2016, seven tourist sites were found, among which two beaches are recognized along the 78 kilometers of coastline that make up the municipality: Pico de Oro, which in turn is a gastronomic parador, and Playa Azul, which is the most frequented place for those who practice water sports, mainly diving, swimming in the open sea and fishing.

Likewise, it was observed that the tourist attraction with the greatest potential is the protected natural area of the Pantanos de Centla Biosphere Reserve, which is an ecotourism complex that consists of guided visits to the swamps, mangroves and rivers. Here there is an interpretation center: the Casa del Agua, or Uyotot Ja in Chontal, which is the only infrastructure in the entire Grijalva-Usumacinta Basin dedicated to sensitizing society about the ecological, cultural and economic values of the wetlands of this region and the jetty from which the collective ships sail. La Casa del Agua is the only Wetland Interpretation Center in the Mexican Republic that operates with the financial support of Pemex (Guía PEMEX, 2014).

Finally, with regard to tourist services, the municipality of Centla has a travel agency and does not have any car rental company; while the State has 52 and 15, respectively

6.9 Archaeological heritage

In the area adjacent to Hokchi there are two archaeological sites: Comalcalco, in the municipality of the same name, and La Venta in the municipality of Huimanguillo.

The archaeological zone of Comalcalco (Nahuatl: "in the comal's house") is located 38 km southeast of the Hokchi field. Founded and inhabited by the Mayan culture, the height of this site occurred between 200 BC. C. and 950 d. C, being considered as a central point in the trade routes of southern Mesoamerica since yokes and axes from Veracruz, lithic materials from Veracruz, Hidalgo and Guatemala and iconography from the central highlands have been found at the site (INAH, 2016a).

The archaeological site of La Venta is located 90 km southwest of the Hokchi area. This site is considered one of the first cities of ancient Mexico, it was inhabited by the Olmec culture, since 5,000 BC. C. and had its development period from 1200-400 BC (INAH, 2016b).

CHAPTER 7

IDENTIFICATION OF ENVIRONMENTAL LIABILITIES

This chapter is aimed at describing the different Pre-existing Damages identified in the Hokchi area according to contract CNH-R01-L02-A2/2015, and particularly its clause 13.4. The main Preexisting Damages are summarized below, which are mentioned and detailed in the following sections:

8. Oil infrastructure on the seabed consisting of the casing pipes of the Hokchi 1 and Hokchi 101 wells, the presence of which has been shown with indirect information derived from echosounders, seabed profilers and magnetometer, and confirmed by physical inspection of divers.
9. Unidentified objects and registered through magnetic information that indicates the presence of foreign objects in the seabed, presumably corresponding to a pipeline, and underwater pipelines or cables.
10. Hydrocarbon residues in the Hokchi zone of environmental influence, 200 km of monitored coastline, in the form of rock, rubber and gel with sizes ranging from centimeters to a couple of meters.
11. Higher concentrations, in water, than those considered safe for the protection of aquatic life with regard to phosphates, nitrates, nitrites and ammonium according to the Ecological Water Quality Criteria CE-CCA-OOI/001/89.
12. Concentrations of metals such as Fe, Zn and Cu, in some of the water sampling points in the Hokchi area, higher than the limits to avoid toxic effects in the organisms that inhabit the Hokchi area according to NOAA Screening Quick Reference Tables (Buchman, 2008).

13. Hg concentration in sediments above the threshold to avoid toxic effects on biota at three points, taking as reference NOAA Screening QuÍck Reference Tables (Buchman, 2008).
14. Different organic enrichment conditions where the central zone of the Hokchi area is slightly contaminated (Pearson and Rosemberg, 1978).

It is worth mentioning that in this effort all the information generated was used to determine the Environmental Baseline and its analysis has made it possible to distinguish from anomalous values in the water and sediments sampled in the area as well as infrastructure present on the seabed, as has been highlighted above in a summarized way. In all cases, detailed information is presented in the different annexes.

7.1 Structures on the seabed

7.1.1 Bathymetric survey

Based on information received from Petróleos Mexicanos (PEMEX), the existence of the Hokchi 1 and Hokchi 101 wells drilled by PEMEX in 2009 and 2011, respectively, is known. To verify its current status, a hydroacoustic evidence exploration was conducted in the Hokchi area, with a bathymetric survey carried out in February 2016. Specifically, a finer survey was carried out to identify submerged infrastructure in two specific areas in which there are reports of casing on the seabed in wells drilled by PEMEX (Table 7.1). The analysis of multibeam bathymetry data and acoustic backscattering intensity provide a high probability of the location of this submerged infrastructure associated with the wells reported by PEMEX (Annex 2).

Table 7.1. Location of the submerged infrastructure associated with the heads of the Hokchi 1 and Hokchi 101 wells.

well	Latitude N	Longitude W
Hokchi-1	18° 37' 01.4265"	93° 20' 12.349"
Hokchi-101	18 37'57.4317	93 ° 20' 12.47"

Figure 7.1 shows the location of the two wells reported by PEMEX. The Hokchi-1 well is located to the south and the Hokchi-101 well to the north.

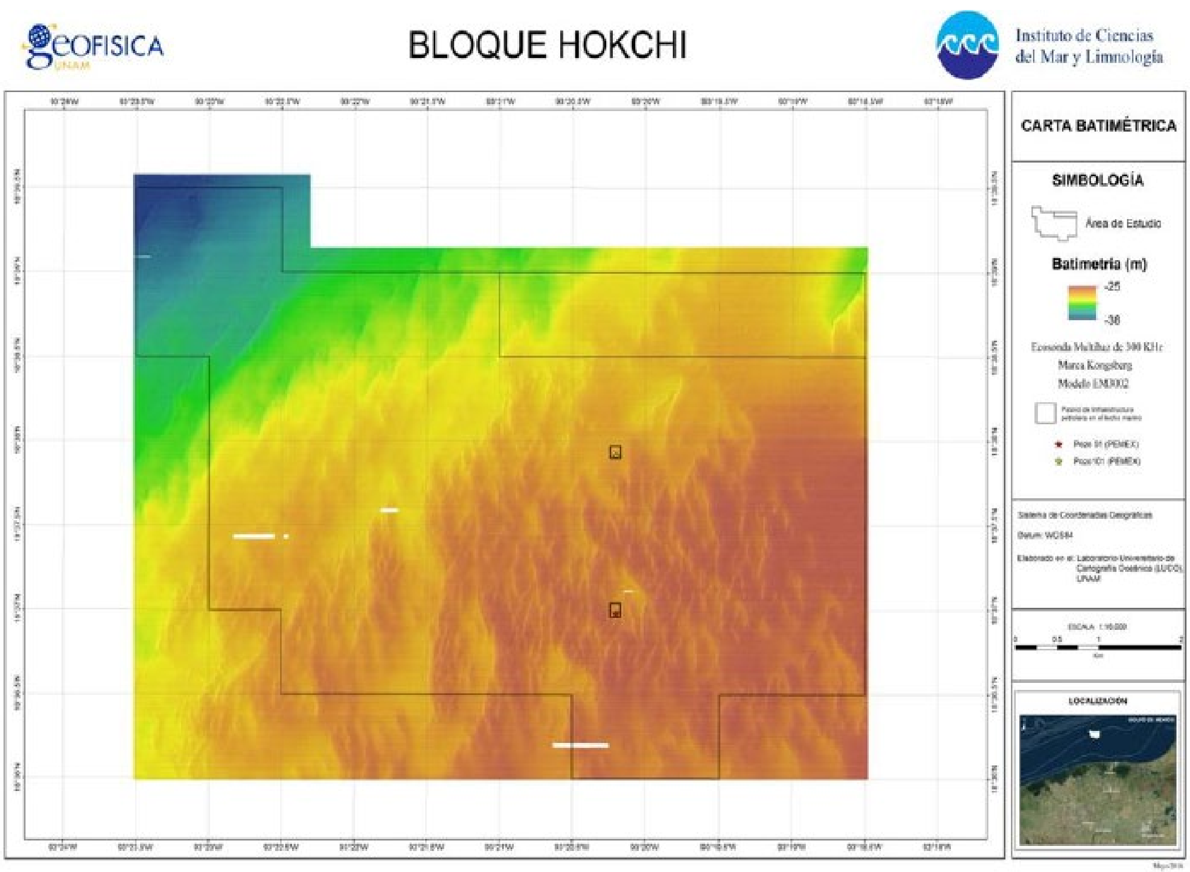


Figure 7.1. Location of the areas of the two wells reported by PEMEX within the Hokchi area.

Based on the coordinates of these two exploratory wells within the Hokchi area, two areas in the vicinity of each well are surveyed in greater detail to assess the possible presence of their infrastructure. The boundaries of each area are listed in the following table 7.2.

Table 7.2 Limits of the prospecting areas.

Corners	Hokchi-1 area	Hokchi-101 area
North	18 ° 37,500 'N	18 ° 38,500 'N
South	18 ° 36,500 'N	18 ° 37,500 'N
East	93° 19.500'W	93 ° 19,500 'W
West	93 ° 20,500 'W	93 ° 20,500 'W

Within each area, the multibeam bathymetry and acoustic backscatter intensity records from both echosounders are carefully examined. To find the bathymetric anomalies associated with this infrastructure on the seabed, each sweep is individually collated and analyzed to rule out errors. From this analysis, two outstanding bathymetric anomalies whose coordinates coincide in various profiles were revealed in the data from both echosounders. Furthermore, these anomalies are consistently detected by the external beams of each one of the echosounders, while in the central region near nadir they are not detected.

Infrastructure of the Hokchi-1 Well

Figures 7.2 show an extract from the bathymetric chart of the EM3002 echosounder, for the area of the Hokchi-l well. This image, in its upper central part, shows a bathymetric height of approximately 2.5 m in diameter with a height of 4 m above the seabed.

The set of coordinates, where the bathymetric anomaly associated with the Hokchi-l well was located in each of the lateral scans that was recorded, are listed in table 1.

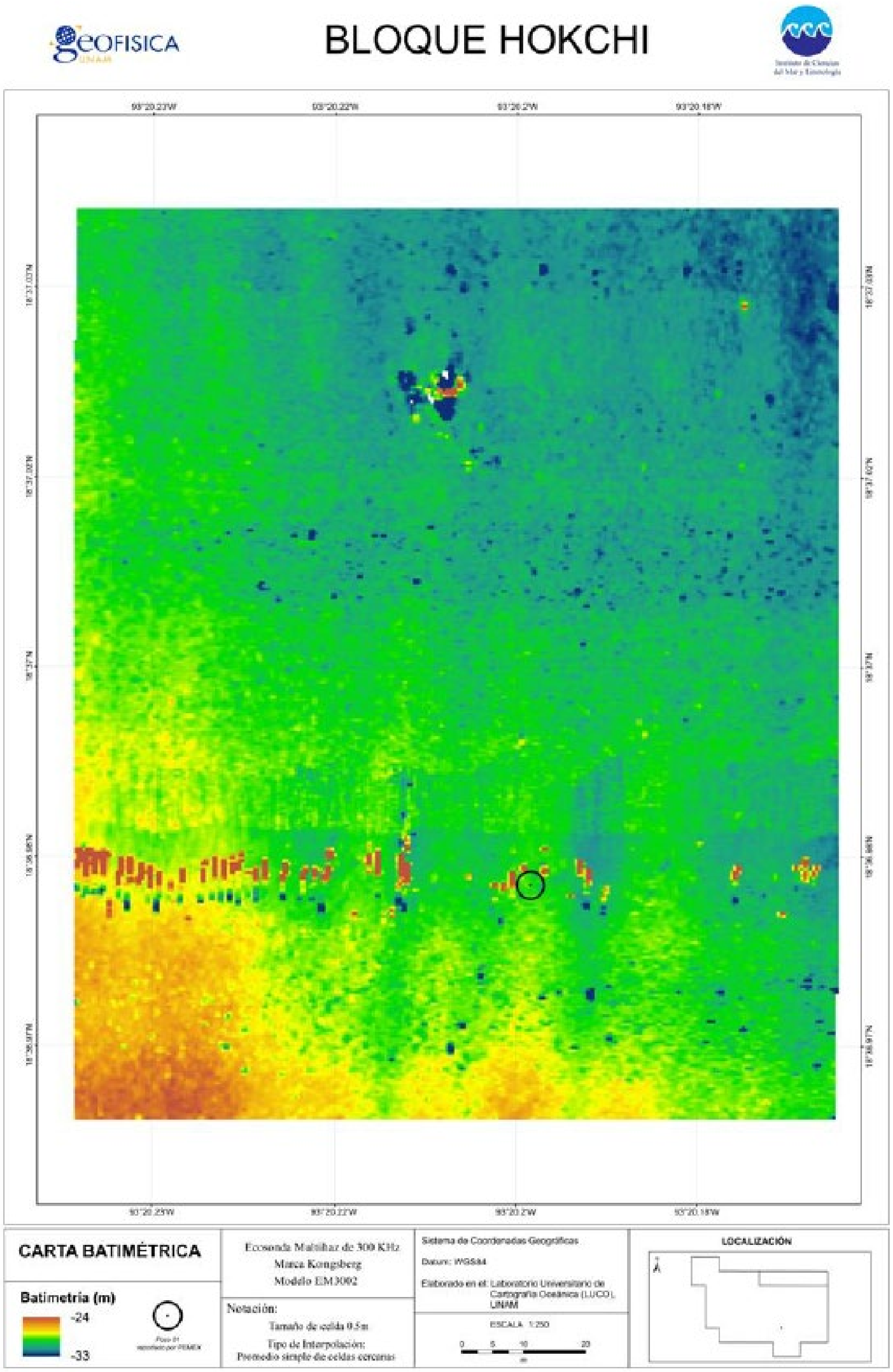


Figure 7.2. Figures 1 show an extract from the bathymetric chart of the EM3002 echosounder, for the area of the Hokchi-l well. The image marks the reported location of the Hokchi101 well (black circle) and the bathymetric anomaly found (black box).

Table 7.3. Location coordinates of the bathymetric anomaly associated with the Hokchi-1 well, in 3 bathymetric profile carried out in February 2016.

Latitude N	Longitude W	Depth (m)	Height (m)
18° 37.0236'	93° 20.20563'	27.7	2.5
18° 37.0235'	93° 20.20575'	27.8	2.5
18° 37.02366'	93° 20.2061'	27.7	2.5

Hokchi- 101 Well Infrastructure

Figure 7.3 shows the extract from the bathymetric chart of the EM3002 echo sounder. The central part of the image shows a bathymetric height of approximately 2 m in diameter and a height of 3 m above the seabed.

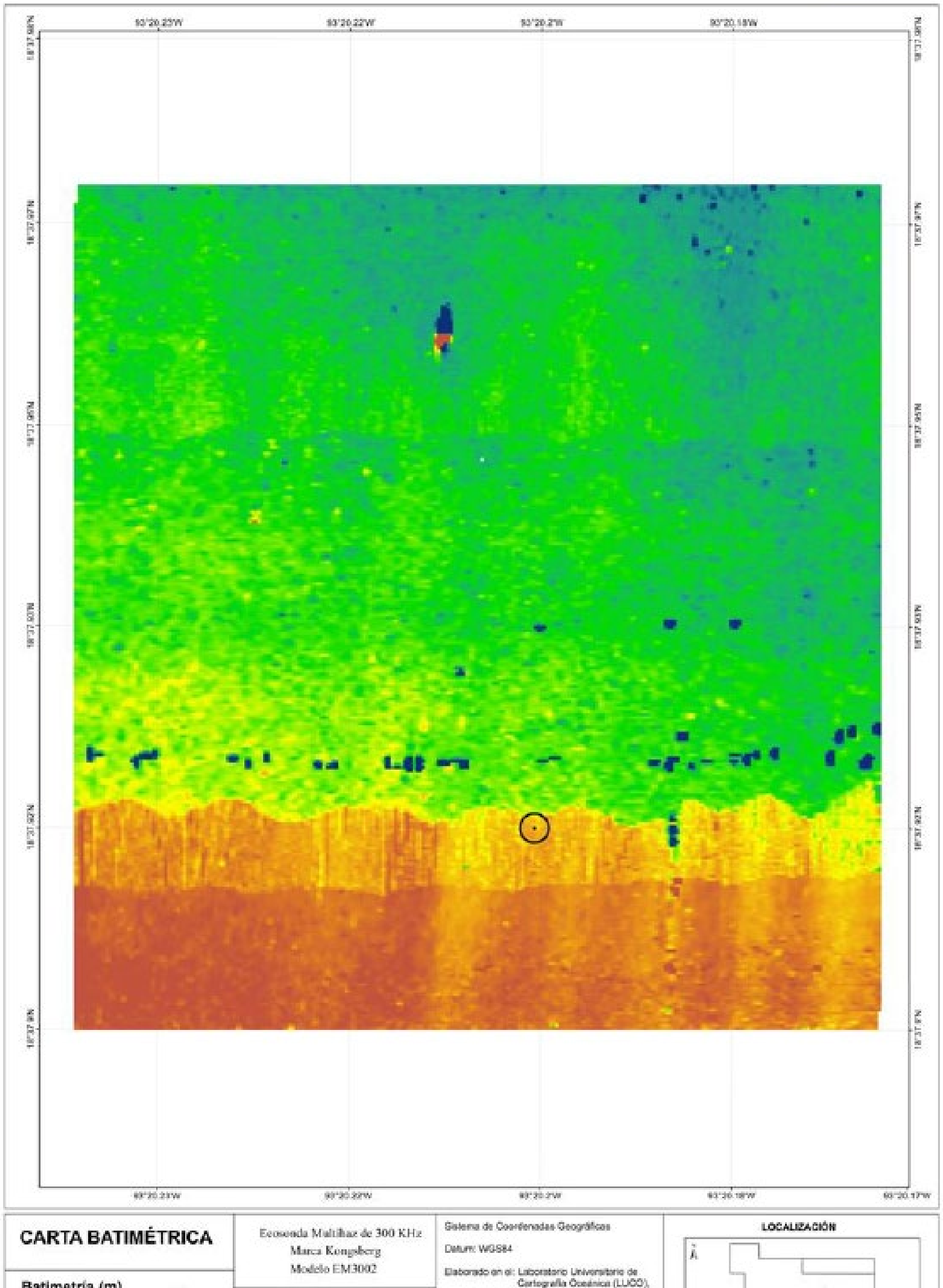
As with the anomaly at the Hokchi-l well location, this bathymetric top is consistently detected by the external beams of both echosounders, while in the nadir region there was no detection.

Table 7.4. Location coordinates of the bathymetric anomaly associated with the Hokchi-101 well, in 1 bathymetric profile carried out in February 2016.

Latitude N	Longitude W	Depth (m)	Height (m)
18 37.95698	93 20.20797	28.4	5.5

In order to reinforce the knowledge about the state of the casing of the two pre-existing wells, as well as the possible existence of any other object on the seabed of the Hokchi area, two other studies were carried out.

BLOQUE HOKCHI



CARTA BATIMÉTRICA

Ecosonda Multihaz de 300 KHz
Marca Kongsberg
Modelo EM3002

Batimetría (m)

-24

-33

Notación:

Tamaño de celda 0.5m

Tipo de Interpolación:
Promedio simple de celdas cercanas

Sistema de Coordenadas Geográficas

Datum: WGS84

Elaborado en el: Laboratorio Universitario de Cartografía Oceánica (LUCO), UNAM

ESCALA 1:250

0 5 10 20

m

LOCALIZACIÓN

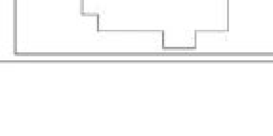


Figure 7.3. Figures 101 show an extract from the bathymetric chart of the EM3002 echosounder, for the area of the Hokchi-l well. The image marks the reported location of the Hokchi101 well (black circle) and the bathymetric anomaly found (black box).

Table 7.4 lists the set of coordinates for the Hokchi-l well bathymetric anomaly recorded in the lateral scans.

7.1.2. SBP geophysical prospecting

This study, carried out by OCEANEERING, consisted of a geophysical survey of the seabed profiler (SBP), which is presented in Annex 32, whose purpose was to identify the oil facilities located in the Hokchi area that consist of two wells, referred to as Hokchi 1 and Hokchi 101, whose geographic coordinates are 18 ° 3T01.4265 "N and 93 ° 20'12.349" W, and 18 ° 3T57.4317 "N and 93 ° 20'12.47" W, respectively. For this purpose, a side scan sonar, a shallow profiler and a magnetometer were used. The results obtained from this study are summarized below.

<u>Conditions of the infrastructure of the Hokchi Well —1</u>

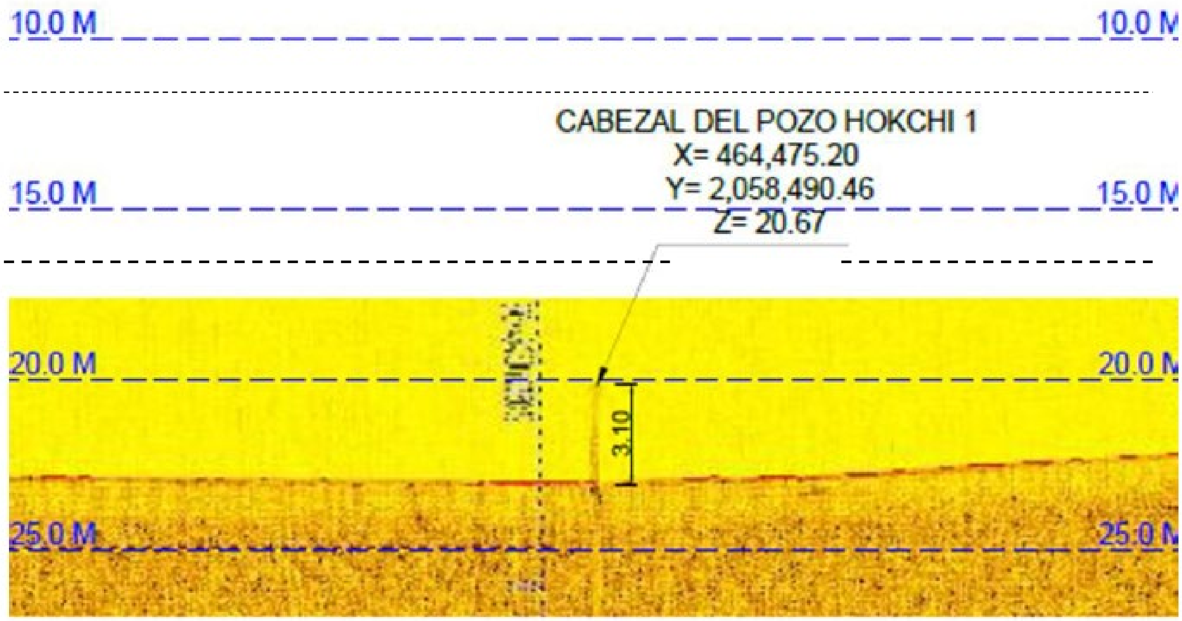
The Hokchi-1 well is located at coordinates 18 ° 37'01.4265 "N and 93 ° 20'12.349" W. These coordinates have been verified through a side scan sonar study that has located this well at the coordinates mentioned above and has allowed to identify that a portion of the casing is protruding from the seabed. Figure 7.4 shows both the location of Hokchi-l and the signal recorded by the side scan sonar, indicating the presence of the well.

Likewise, a shallow profiler log was used to confirm the position of the well, having found a linear object above the seabed, associated with the location of Hokchi-l. The image in figure 7.5 shows, without ambiguity, that a linear object with an approximate height of 3.10 m protrudes from the seabed, according to the resolution of the shallow profiler.

Figure 7.4. Signal recorded by the side scan sonar where the circle indicates the position of the Hokchi-l well and the anomaly referred to as Contac001 corresponds to an object protruding over the seabed.

Additionally, this event has been verified through a magnetometric record that has registered the presence of an object with high magnetic susceptibility, as shown in figure 7.6

These three elements: the side-scan sonar log, the shallow profiler and the magnetic anomaly, have located the Hokchi 1 well and confirmed that its coordinates are 18^{37} 01.4265'93.20 "N and 12.349^{0} 20'1 2.349 "W.



SOMERO PROFILER REGISTRATION

Figure 7.5. Information derived from the shallow profiler standing out over the coordinates (18 [37] 01.4265'93 "N and 20 [12.349] 3.10'12.349" W) a linear object, with an approximate height of 3.10 m above the seabed located in brown.

Conditions of the infrastructure of the Hokchi Well - 101

This well has been located at the coordinates (18 [37] 57.4317'93 "N and 20 20'12.47 'W) through a side scan sonar study and has identified that a portion of the casing is protruding from the seabed. Figure 7.7 shows both the location of the Hokchi-101 well, as well as the signal recorded by the side scan sonar, which indicates the presence of the referred well.

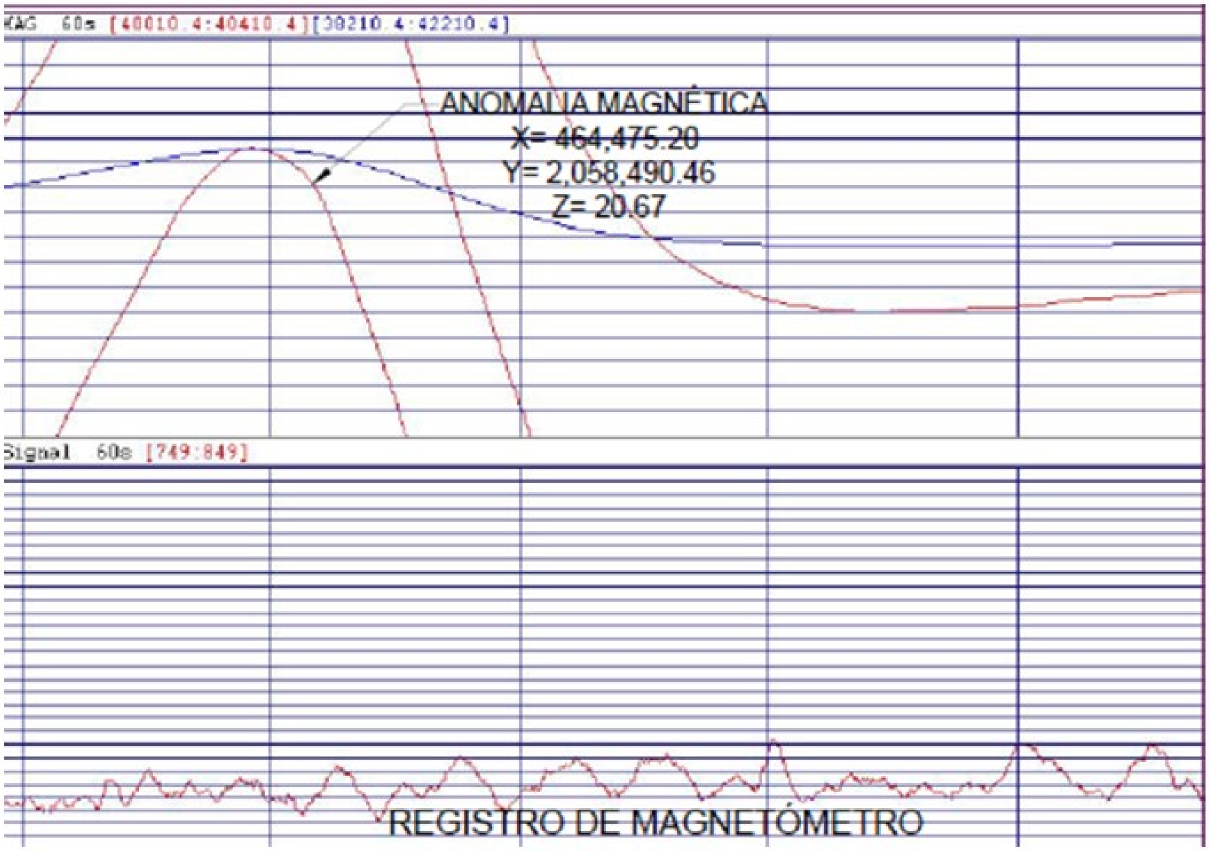


Figure 7.6. Magnetic anomaly associated with the Hokchi Well 1.

In this same location associated with the Hokchi-101 well, its position was confirmed using a shallow profiler, identifying a linear object above the seabed. The image in Figure 7.8 shows a linear object, with an approximate height of 3.80 m protruding from the seabed.

Similar to the Hokchi-l well, magnetometric information was recorded to confirm the location of the Hokchi-1 well. The figure 7.9 shows the result, appreciating that the magnetic anomaly coincides in its coordinates with those identified with the side scan sonar and the shallow profiler. This confirms the coordinates of Hokchi-101 at 18 ° 37'57.4317 "N and 93 ° 20'12.47 "W.

Figure 7.7. Side scan sonar image where the circle indicates the position of the Hokchi-101 well and the central anomaly corresponds to its location.

Unidentified objects

Using the marine magnetometer, it was possible to acquire data from the 2D magnetic field to which IGRF corrections were made. It was possible to identify a continuous magnetic anomaly on the northwestern side of the Hokchi area that, due to its characteristics, can be interpreted as a pipeline, which is buried 1.3 m, on average, below the seabed. The magnetic anomaly is oriented NW, has a distance of 819 m NW of the center of the study site, and a length of 435 m within the limits of the same area (Figure 7.10).

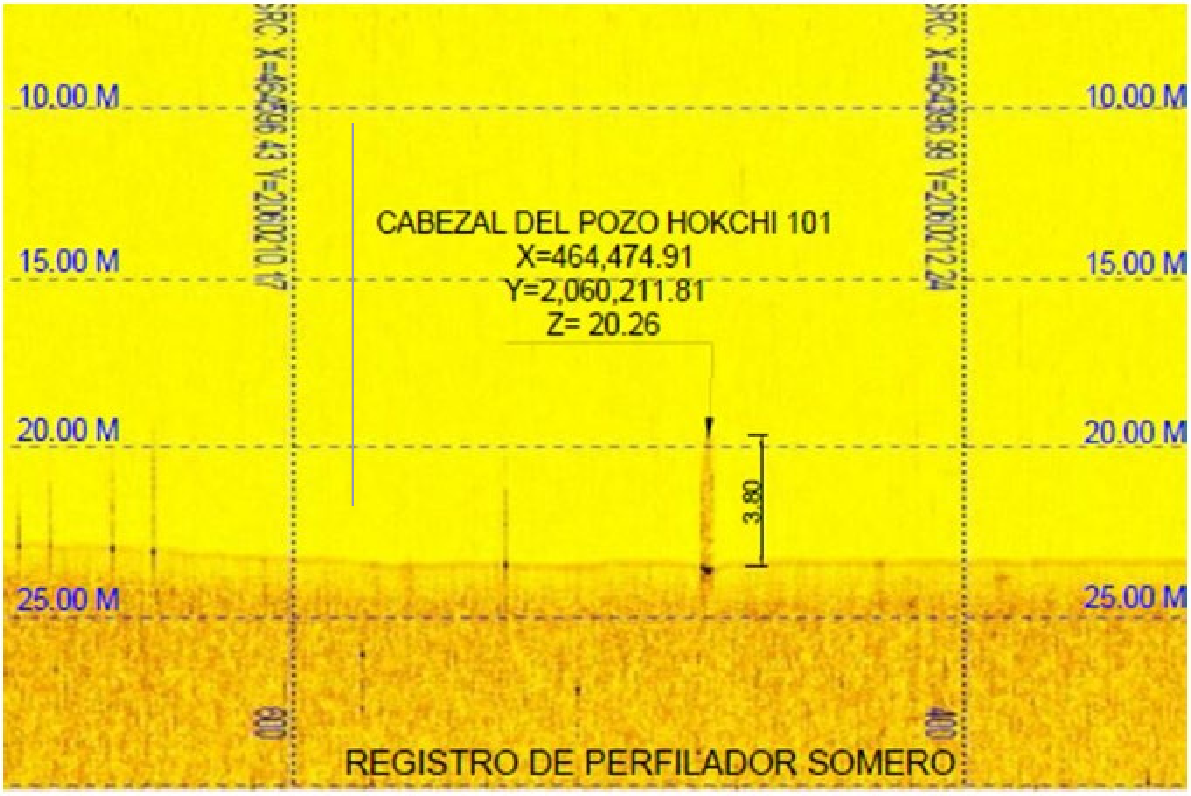


Figure 7.8. Shallow profiler information showing the seabed and a vertical object protruding over it. The approximate height of such an object is 3.80 m.

On the south side of the study area, two magnetic anomalies were identified that have a trend S-SW to E-NE, which due to their continuity characteristics suggest the possible existence of two ducts or cables, the first one is 850 m to the south of the area (Figure 7.11).

7.1.3_.3 Underwater visual inspection

An underwater visual inspection of the casing of the Hokchi-l and Hokchi-1 wells was carried out in March 101, by the company ALL IN SERVICES S. A. de C. V. and the results are presented in Annex 1. In summary, photographs of the pipe were taken (Figure 7.12, Annex 1) and soft marine growth was observed in both locations.

In addition, the Hokchi 101 well tubing shows concrete erosion (cracks between the cap and the conductor) and longitudinal and circumferential cuts by electric arc in the head body.

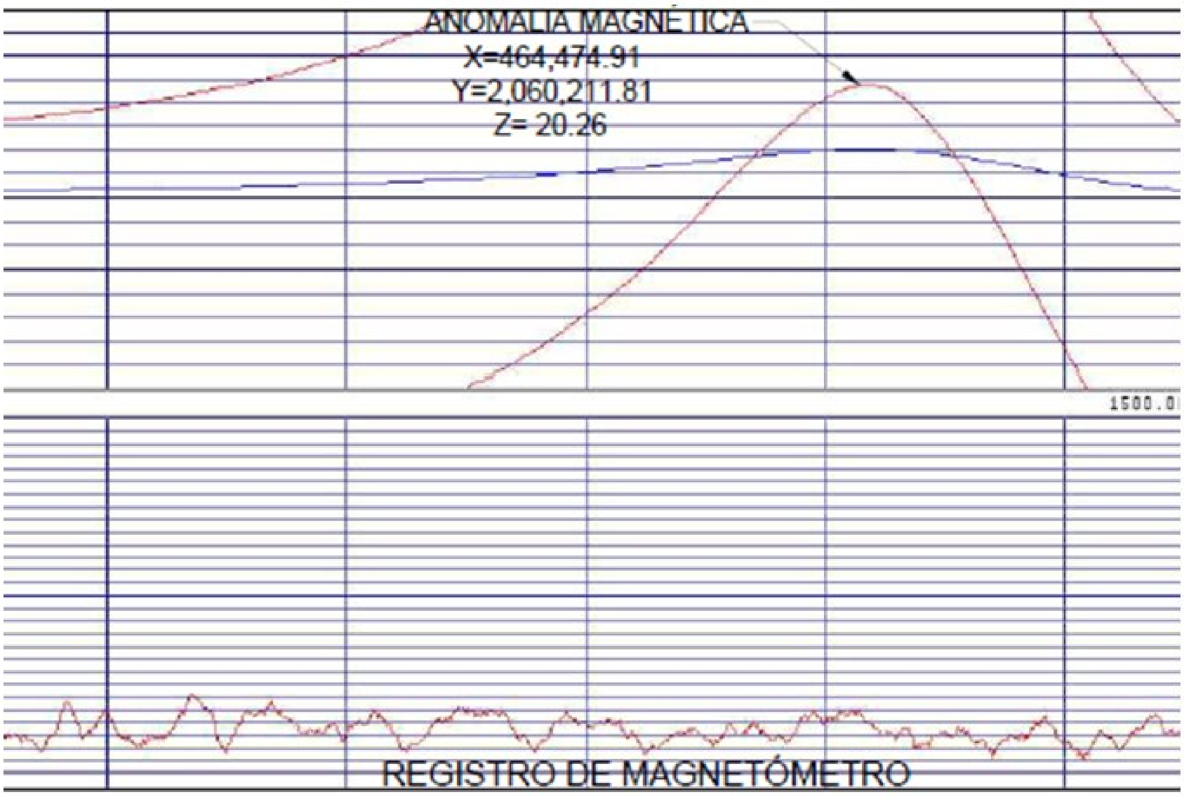


Figure 7.9. Magnetic anomaly associated with the casing above the seabed in Well Hokchi-101.

Hydrocarbon residues found during on-site prospecting

On the other hand, a tour was carried out on the coast defined as the Hokchi area of environmental influence and based on field observations made in February, a description of the physical characteristics observed in the different types of agglomerates of residual material is presented. of hydrocarbons. A categorization was made into three groups, which are described below in Table 7.5.

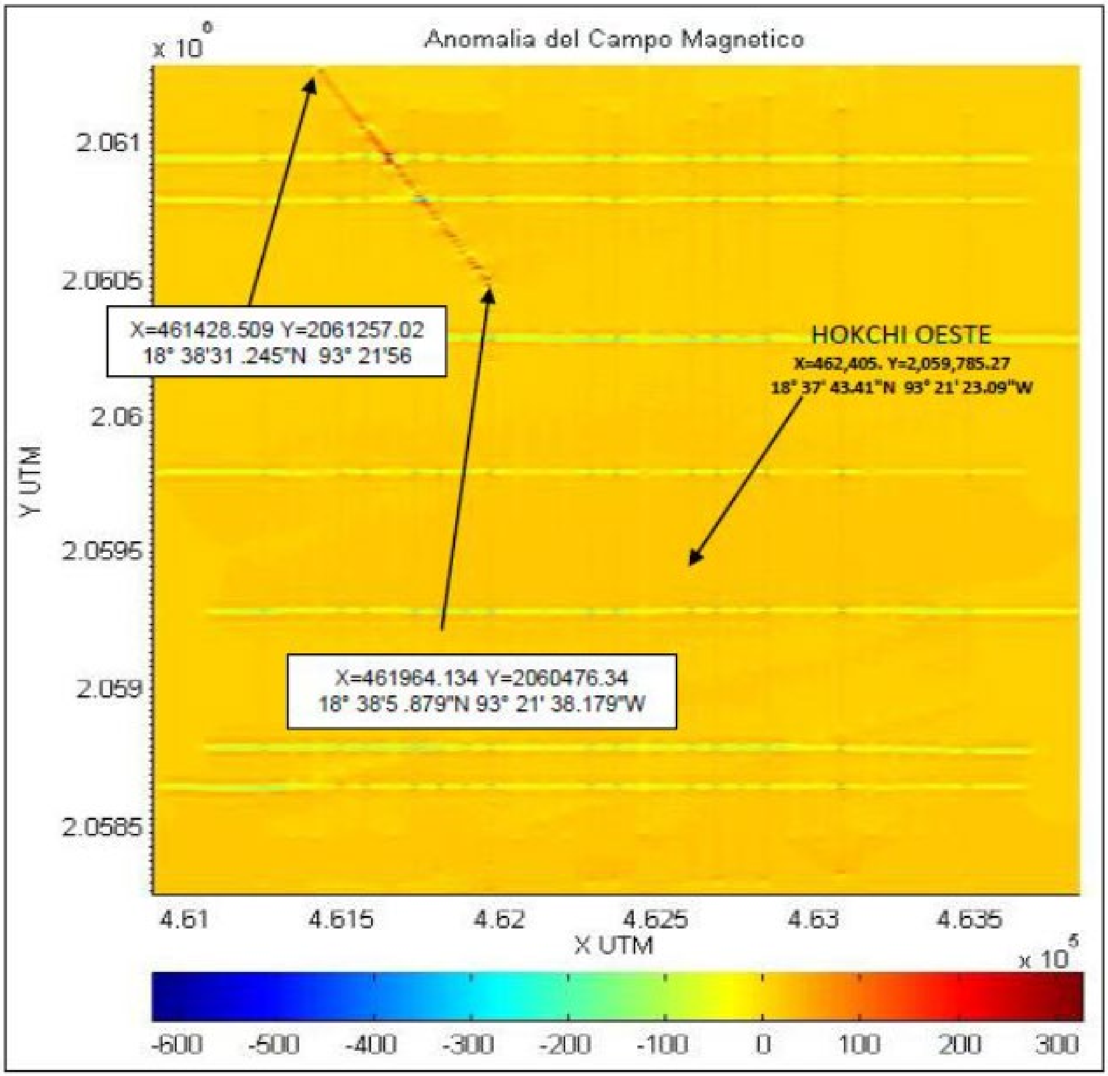


Figure 7.10. Magnetic anomaly map at the West Hokchi location.

During the monitoring it was identified that the local name for the hydrocarbon residues is "chapo", and it is associated with environmental, labor and health problems.

The presence of hydrocarbon agglomerations occurs over the 200 km of monitored cosb line (Hokchi environmental area of influence), and has documented in Table 7.5 and Figure 7.13. The size of the agglomerations observed varied from a few centimeters to a couple of meters.

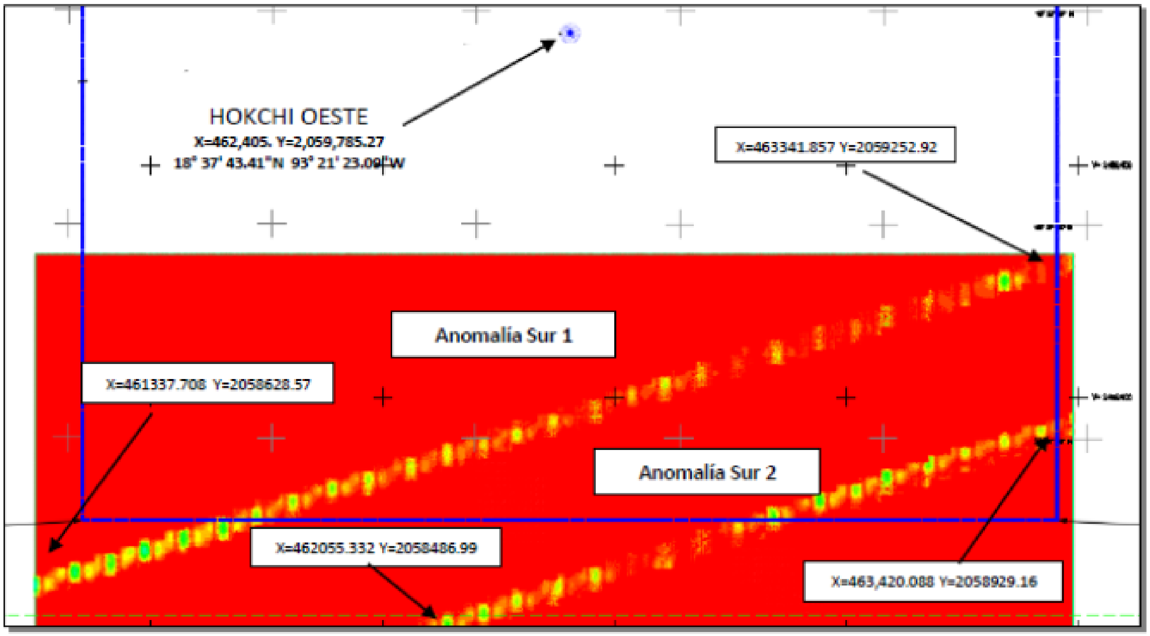


Figure 7.11. Map of magnetic anomalies south of the study area.

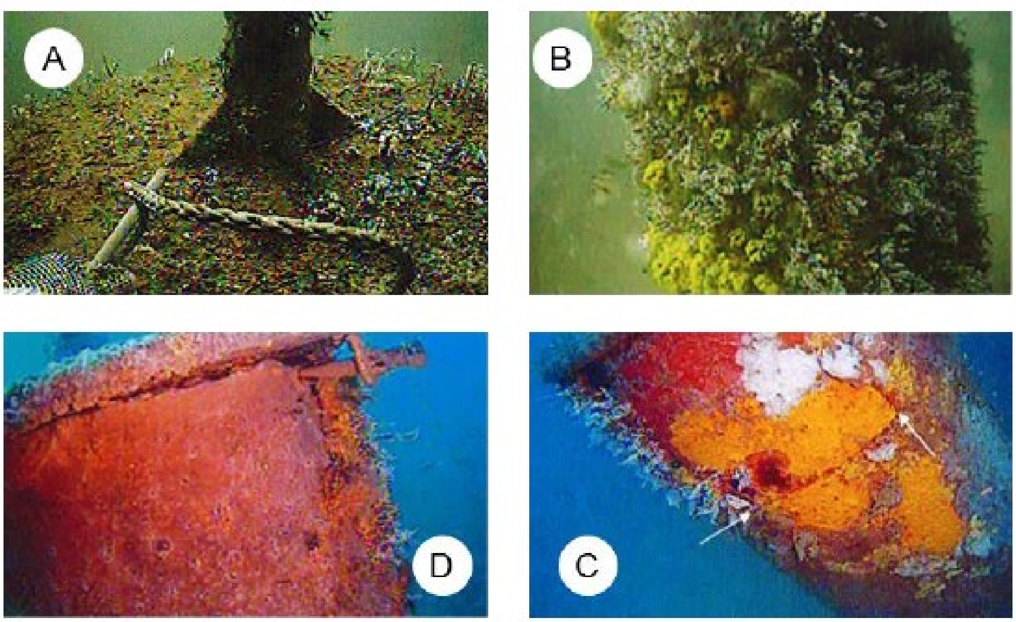


Figure 7.12.- Underwater photographs of wells Hokchi-1 and Hokchi-101. A) Upper part of the Hokchi-1 head (lifting platform); B) Hokchi-1 head body (soft marine growth); C) Upper part of the Hokchi-101 head (cracks between the cover and the conductor); D) Hokchi-101 head body (longitudinal and circumferential electric arc cuts).

Table 7.5. Graphic description of the different types of residual hydrocarbon material.

Type	Description	Representative Photo
Rock	Rigid solid state hydrocarbons, similar to a rock, of characteristic glossy black color, with no perceptible odor.	
Rubber	Hydrocarbons in flexible solid state, similar to a tire, of gloss black color, with perceptible odor Characteristic rubber of tar. They were observed at different densities along the entire monitored coastline.	
Gel	Hydrocarbon residue similar in constitution to a glossy brown pasty emulsion with a perceptible odor They were mainly observed, at different densities, on the coast between the Tonalá River and Paraíso, Tabasco.	

In the relationship between fisherman - presence of "chapo", it was observed that, as an emerging measure for the laying of riverine fishing nets, the inhabitants collect the "chapo" in the area of laying the net, in order to minimize interference with your fishing gear.

During the interviews, it was observed that the collected "chapo" accumulates in a place in the fisherman's house, without having any entity to collect it.

Figure 7.13. Representative photographs of the types of hydrocarbons present on the beach.

Environmental conditions in the Hokchi area

7.3.1. Water

Nutrients

As mentioned above (section 6.3.5), taking as reference the safe values for the protection of aquatic life in coastal and marine environments suggested in the guidelines of the Ecological Criteria for Water Quality CE-CCA-001/89 (CECA , 1989), for phosphates (0.002 mg / l), nitrates (0.04 mg / l), nitrites (0.02 mg / l) and ammonia (0.01 mg / l), it was observed that the concentrations of these nutrients in the water sampled in to the Hokchi area in February 2016, these values exceed from 5.5 to 40.0 times for phosphates, 1.7 to 7.3 times for nitrates, 0.5 to 3.4 times for nitrites and 1 to 33 times for ammonium (Figure 7.14).

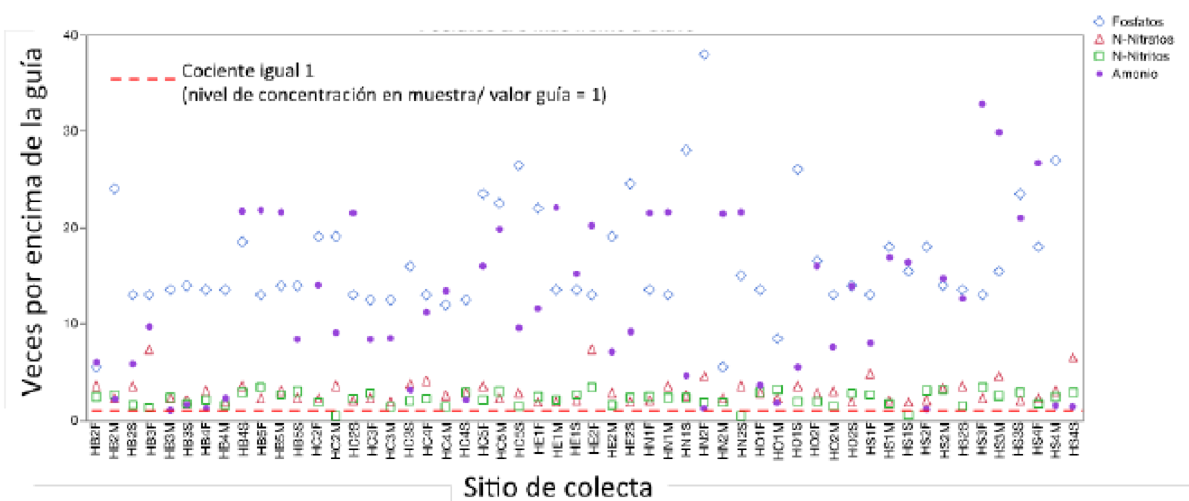


Figure 7.14. Relationship between the nutrient concentration level/guide value according to the Agreement establishing the Ecological Criteria for Water Quality (CECA, 1989).

Value > 1 indicates that the nutrient concentration is above the guideline value.

It is known that the potential sources of these nutrients are related to anthropogenic activities such as agriculture, livestock and human settlements, activities established in the continent, and that they can reach the coastal marine zone due to the fluvial contributions of the area's environmental influence zone. Hokchi. Phosphorus and nitrogen are considered limiting macronutrients for phytoplankton growth. When their concentrations rise, the populations of primary producers (mainly phytoplankton) grow, leading the ecosystem to a mesotrophic or even eutrophic state. The latter has been evidenced by the chlorophyll a values obtained in the water samples of this study, whose concentrations correspond, according to the classification of Lara-Lara et al. (2008), to both trophic states.

Metals

According to what is reported in sections 6.3.5 and 6.4.3 of this Environmental Baseline, sites were observed in the Hokchi area where the concentrations of some metals exceeded the values established in *NOAA Screening Quick Reference Tables* (Buchman, 2008), which are mentioned below.

The sites S4 (surface), C2 (middle bottom), S3, SI S1 and B5 (bottom) presented Fe values higher than the maximum limit to avoid damage to the biota during chronic exposure (0.05 mg/l), but less than those from an acute exposure (1 mg/l). Likewise, the B4 (surface) and NI (mean) sites showed the same behavior for Hg concentrations, 0.00094 and 0.00180 mg/l, for chronic and acute exposure, respectively.

The sites S4, in its three levels, and S3, on the surface, presented concentrations of Zn that exceed the level considered as a limit to avoid toxic effects from an acute exposure (0.09 mg/l). Cu concentrations ranged from 0.07 to 0.10 mg/l and in all cases they were higher than the value considered harmful for organisms acutely exposed to this element (0.0048 mg/l).

Sediment

<u>Metals</u>

Sites S4 and B4, for Hg, showed values between the threshold value to avoid toxic effects on biota (TEL, for acronym in English; 0.13 mg / kg) and the value from which it is probable that there is some toxic effect (PEL, for its acronym in English; 0.70 mg / kg), while in the C5 site it also presented a value higher than the TEL (48 mg / kg) and, in the guidelines used (Buchman, 2008), a value is not provided for the PEL.

For its part, the S3 site presented a value above the PEL for Hg (0.70 mg / kg).

Biota

According to the Pearson and Rosenberg (1978) model, for an area to be considered contaminated, there must be a great abundance of organisms from very few taxa; that is, there is a total dominance of indicator species and a low diversity.

According to the faunal composition of macrobenthos in the Hokchi area, it can be inferred that the area is subject to different conditions of organic enrichment, observing: (1) the slightly polluted central zone, (2) the uncontaminated surrounding zones, and (3) the transition zone between the two (Figure 7.15).

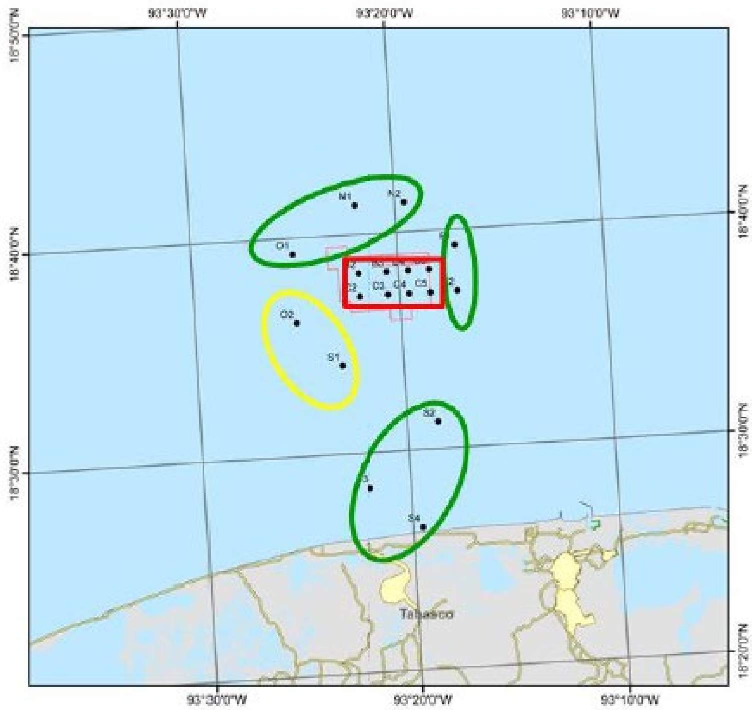


Figure 7. Study area showing the areas identified according to the Pearson and Rosenberg (1978) model, depending on the composition and abundance of the macrofauna. Green ovals = areas not organically contaminated; Yellow ovals = transition zone; red box = central area of Hokchi with slight organic enrichment.

The organic material in the area can be associated with the fluvial contribution of the region from the different activities carried out on the continent. For this reason and to establish the temporal pattern, it is advisable to carry out ecological studies at different times of the year.

Final note

It should be noted that the environmental liabilities indicated in sections 7.2 and 7.3 are subject to the variation in environmental conditions throughout the year and only reflect what was observed during the field visits carried out in February 2016. This season is characterized by no or little precipitation, so in rainy seasons a greater carry-on of pollutants from the continent is expected. The fluvial contribution at this time of year towards the Hokchi area is evidenced in annex 26, in which the salinity and temperature profiles are presented and the presence of two bodies of water can be observed. The superficial layer with lower salinity and the deep layer with higher salinity. Both separated by a mixing zone.

CHAPTER 8

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