

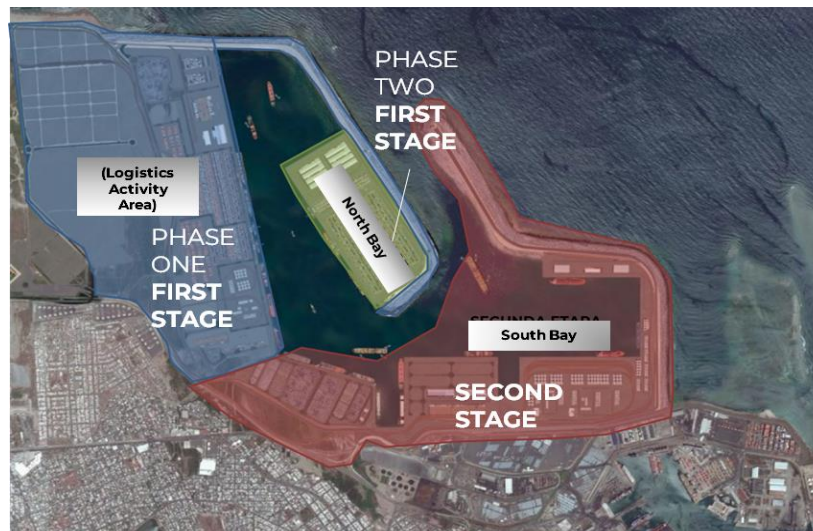


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“Expansion and modernization of the Veracruz Port”

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SECRETARÍA DE COMUNICACIONES Y TRANSPORTES



**VERACRUZ**

COORDINACIÓN GENERAL  
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## I Project Description

The Veracruz Port expansion and modernization project (Stage 1: 2014-2020) takes into consideration the construction of both internal and external port constructions including 5 (five) specialized terminals: Fluids, loose containerized cargo, containers specialized, agricultural loads, mineral loads and for future sessions 2 (two) additional docks. The project considers the construction of a customs area, roads and 2 (two) double stowage capacity railways in order to move the loads from the bays: logistics, north and south, the means of transportation are connected to the consumption and production centers located in the central and north-central area of Mexico and with access to the United States of America.

1

The project has a surface of 407 hectares and is composed of:

- a. A west breakwater of 4.25 km, a marginal wharf of 2.8 km, turning basins: main one of 600 m and inner shunting space of 550 m in diameter, a navigation canal of 2km and an access canal of 2.27 km. Depth: 15.5 m. and 28 marine buoys.
- b. Special port services: 5 specialized terminals and a customs area.
- c. General port services: systems: electric, hydraulic and fireproof, lighting, control and surveillance.
- d. Land access: railways, and inner roads.
- e. Storage courtyards next to terminals: 43.34 Ha.





## II Introduction - Project highlights

The project aims to increase the loading capacity up to 66 million tons per year -including movement of the south bay load, which comprises the current port- and offer port services according to the users' needs. As a response to commercial demand and sea transport, both activities need a higher level of draught and a larger infrastructure for both the loads and vessels respectively. This is the reason why the project considers for the infrastructure to provide increased depth in the water areas, increased intermodal service, larger storage surface, agile product inspection and modernized terminals.

## III Goals and Objectives/ Business Problem

In 2019 the Veracruz docks area reached maximum port infrastructure capacity by handling 29 million tons with limited navigation infrastructure for ships exceeding 320 m in length. This temporary saturation is caused by the lack of infrastructural port growth surface - limited by the urban city limits- lack of intermodal service capacity for the unloading of merchandise and the obsolete infrastructure it relays on -118 years since its construction-, these were the factors both exogenous and endogenous that demanded making the decision of carrying on with the expansion and modernization of the Veracruz Port in the Bahía de Vergara (Vergara Bay), north of the current port location.

### Objective

Increase port capacity and improve port services under a sustainable development scheme.







## Goals

- a) Infrastructure and services for specialized terminal at the marginal wharf:
  - i. Containers: first phase 41.4 Ha and 700 m for dock space, second phase: 31.05 Ha and 350 m for dock space.
  - ii. Fluids: 14.7 Ha and 300 m for dock space.
  - iii. Agricultural load: 10.0 Ha and 300 m for dock space.
  - iv. Mineral load: 10.0 Ha and 300 m for dock space.
  - v. Semi specialized mixed load: 18.30 Ha and 550 m for dock space.
- b) Higher number of berthing positions: north bay: 7, south bay: 19
- c) Arrival of vessels with greater length. North bay: 15.5 m..
- d) Railway service efficiency.

3

Construction of port rail beltway: Santa Fe: 19.5 km. Comprised of 2 (two) roads that will enable the unloading of merchandise coming from different segments through the Kansas City Southern de Mexico (KCSM) line and Ferromex. With this infrastructure the FFCC traffic is reduced in the urban area.

- e) To promote the Strategic In-bond Facilities or RFE (Free Trade Zone).  
comprised of 210 Ha, with basic service infrastructure, in order to operate as a transformation and distribution center with all the benefits of an RFE.
- f) Sustainable development.





The Veracruz port was built under the criteria of and aiming towards environmental sustainability, for instance: Modification of the Nationally Protected Area Polygon (Parque Nacional Sistema Arrecifal Veracruzano (PNSAV)) was increased from 54,000 Ha to 65,000 Ha and the creation of 3 (three) Environmental Management Units or UMA (Unidades de Manejo Ambiental) with surface of 71 Ha and their maintenance.

g) Customs modernization.

A 17.3 Ha construction surface, 50 inspection posts for imports, 15 automated inspection entry points and 10 exit points, 4 substations and general use buildings.

h) Logistics Bay, RFE or ZAL (Free Trade Zone).

A 345 Ha surface -that includes an RFE of 210 Ha-, facilities to for companies to settle and establish for added value to import and export merchandise.

## IV Discussion

### Background

The Veracruz port expansion and modernization started back in the year 2000 under the management of the Administración Portuaria Integral de Veracruz (APIVER) with permission from the authorities of the three government systems. The port and maneuvering services were already in demand of a larger number of docks and a increased vessel length, broader maneuvering surfaces and load storage, better performance at port operations and agile merchandise inspection. In sights of this situation, the increase in







cargo movement and the imminent port saturation resulted in the project being endorsed by the public and private sectors thus creating the largest investment in the National Port System of Mexico of Mexico.

## **Objectives and Methodology**

The objectives of the expansion and modernization consist of increasing the cargo movement capacity, improving productivity and efficiency at terminals, establishing RFE tax conditions to stimulate loading services, increasing the intermodal courtyard capacity, maximize the use of the ZAL (Free Trade Zone) and minimize the environmental impact.

In order to set up the construction site for the port expansion and modernization, diverse research was done over the course of more than 10 years at the project site and in the influence area including studies in the fields of: hydrodynamics, geotechnics, sediment transport, water quality, sea and wind currents, tidal behavior, hydraulic molding, marine flora and fauna, hydrometeorological conditions and sand granite characteristics among others.

Model studies were made in order to analyse the capacity and function of the design options proposed for the infrastructure. The following are some of such studies:

- a. Vessel piloting and steering simulator -navigation canal design-
- b. Protection elements design simulator.
- c. Sediment movement simulator.





- d. Research on hydraulic model optimization.
- e. Hydrodynamics measurement equipment.
- f. Reef detection and labeling system.
- g. Sheet pile design and protection.
- h. Sea life research.

### **Hardware/Software used**

- I. For the dredging and fill up activities a real-time monitoring system was used to prevent bordering reefs from silting up.
- II. Shoreline profile research.
- III. Bathymetry at PNSAV.

### **Project cost**

Investment of approximately 2 billion dollars for the first stage with private funding resources, federal tax resources and APIVER's own resources.

Public investment: \$ 607.68 million dls (From 2008 to June, 2020)

Private investment: \$ 755.92 million dls (From 2015 to June, 2020)

Belonging to the public sector are the basic, strategic, infrastructure works such as the acquisition of the port reserve, the fishermen compensation, protection works, common use roads, dredging construction, agricultural cargo loading decks, mineral cargo and





common use docks, as well as a supply of basic services at the base of the Terminal, besides mitigation measures and project compensation.

Belonging to the private sector, through contracts and partial rights concessions, is the funding of the terminals equipment and infrastructure construction at 100%.

7

### **Performance Measures**

The most important measurable criteria taken into account regarding the evaluation of the project are, first, the modernization of port infrastructure involving the three cargo segments which the Veracruz port is leader of in the Gulf of Mexico: cars, containers and agricultural load and, second, having an increased capacity to handle mineral load, generic cargo and fluids.

- i. Terminal capacity for containers: 1.5 MTEU's and yet to expand 1.0 MTEU's.
- ii. Agricultural storage capacity of 63,000 tons.
- iii. Mineral storage capacity of 340,000 tons.
- iv. Petrol-chemical fluids capacity 900,000 barrels (103,728 tons)

### **How the project fulfills the award criteria**

The Veracruz port expansion and modernization project fulfills the AAPA's adjudication criteria through innovative methods in design, engineering and construction, as well as through working on environmental aspects under a sustainable development scheme and also by reaching both the implementation and budget goals.





## Design/Innovation

Due to the fact that the project took place on the bahía Vergara (Vergara bay), part of the Veracruz port, next to the reef known as Punta Gorda, the preliminary studies were important to determine the navigation canal as well as for the placement and construction of the West breakwater. During the implementation of this work real-time observation and measuring tasks were done to ensure the proper working of the environmental measures. The design of these external port constructions was the project's most important aspect since the environmental feasibility was the biggest challenge.

## Constructive Method

The Veracruz port modernization gave birth to the port's infrastructure construction back in 2015 starting with the west breakwater, which was built with basaltic rock, by directly pouring it offshore using a hinged bottom vessel (Ganguil). Protective elements were made "in situ" for the breakwater's armor in weights of 3, 9, 12 and 20 tons and were put in their final positions by cranes and with the help of divers for the below-sea-level areas. A concrete-base wave deflecting parapet wall was built using a movable formwork with a maximum height of 8.0 m. During the rock pouring, an anti-dispersion sediment mesh was put in place to avoid unintentional spreading towards reef areas.





Simultaneously, while the the breakwater was under construction, the fill up retention wall was built with a base of steel sheet pile, driven by pneumatic hammers, comprised of a main panel inserted at -29.0 m and a secondary panel at -15.7, joined together by steel bar tensors. Once the sheet piling was at an advanced stage, rock-fills were built from the land to the sea in the fill up areas in order to contain the dredging byproducts. The construction dredging was made with a cut and suction dredger, starting at the navigation canal and basins, going deep up to a minimum of 15.0 m, using all the dredged material to fill up all of the areas for the new terminals along the 2.8 km berthing front. After filling up all the new terrain areas taken up by the sea, they were compacted through the dynamic compaction process consisting of letting a 15 ton mass fall from a height of 25 m into a setup that allowed us to cover the entire fillings area.

Once the terrain was compacted, the new transferee enterprises built their own specialized terminals, and at the same time APIVER built the docks at the terminals' berthing fronts with 50 m long by 35 m wide modular structure consisting of steel piles and stilts filled up with reinforced concrete, with a superstructure made of a reinforced concrete slab base, also equipped with fenders and defenses; as well as the main and secondary roads, railways, safe water services, voice and data, electrical power, drainage, signaling both and land and sea. Currently, operations have already started involving the Veracruz port modernization which makes this compellingly important project a reality.





## V Conclusions

With the construction of both inner and outer port sites, corresponding to the first stage of the Veracruz port expansion and modernization, we were able to reach the project goals: guarantee the 66 million tons loading capacity through modern terminals, port services suitable for the sea transport demands, higher logistical and intermodal service capacity and agile merchandise inspection with modern customs facilities.

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The Veracruz port will continue monitoring and supervising the continuity of these goals and environmental commitments, assuring the balance between port activity and marine diversity. With this project, the Veracruz port became the single, most important infrastructural enterprise in Mexico.







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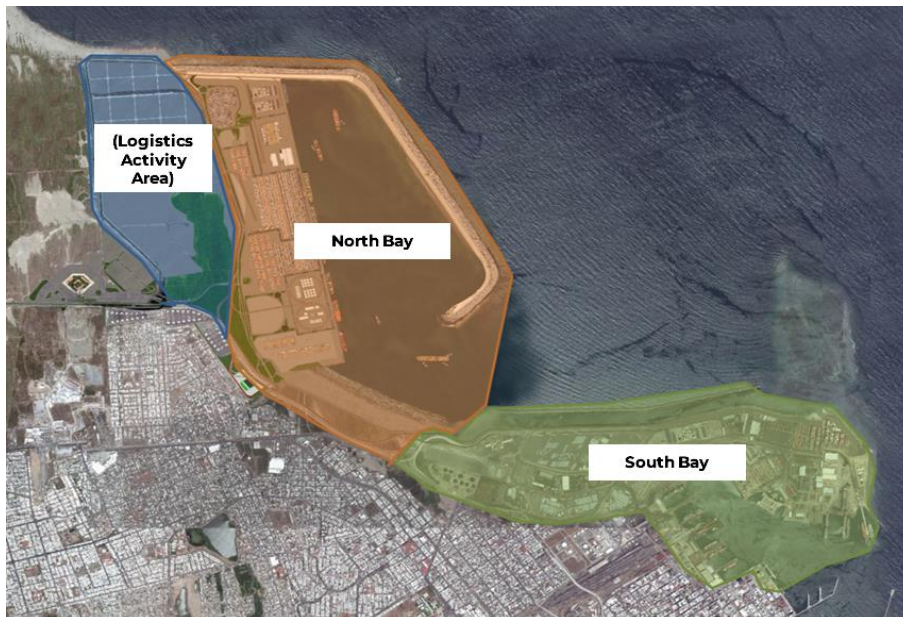




**Appendix 01**

Stages in the expansion process

**Image A.** Bays: North and South and Logistics Bay (ZAL)

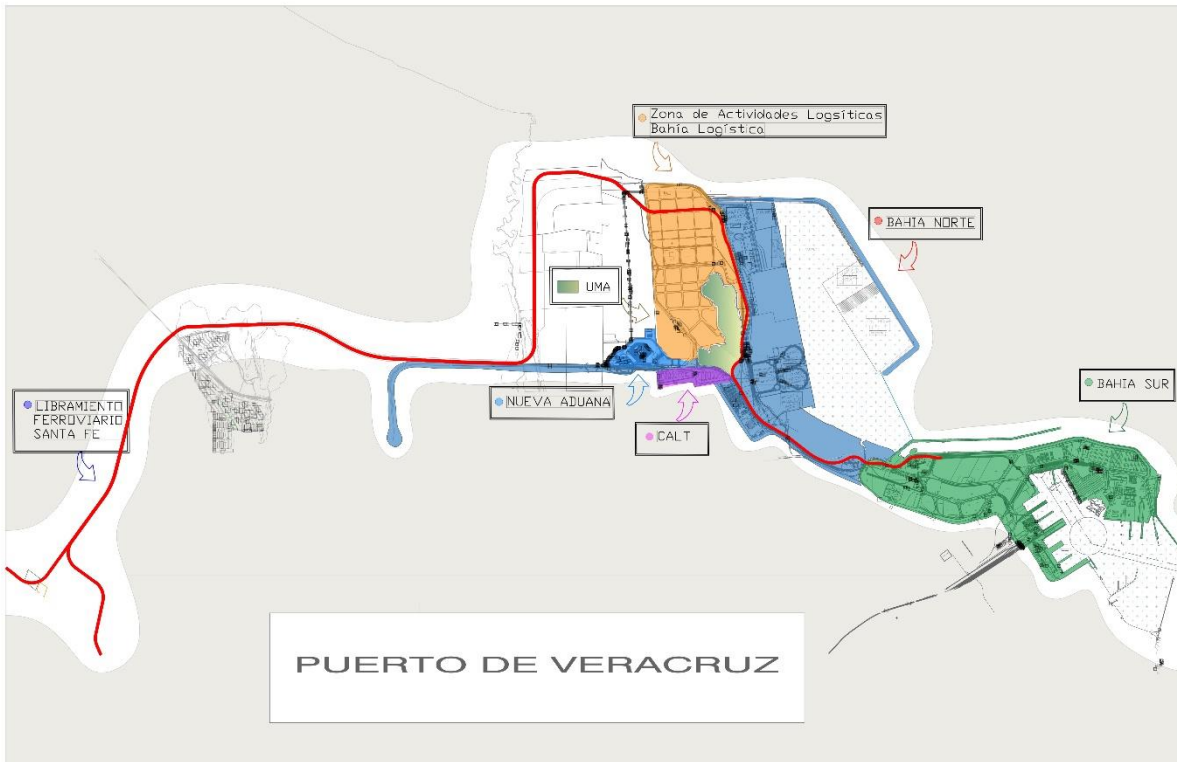


**Image B.** Stages in the expansion process





**Image C.** Areas of the modernization of the port of Veracruz



- Santa-Fe's railway bypass
- South bay
- North bay
- Transport Logistical Attention Center
- Logistics Bay (Free Trade Zone)







**Appendix 02**

Project images

**Image D.** Aerial view of the expansion project terminals from north to south.



**Image E.** Aerial view of the Fluids Specialized Terminal.





**Image F.** Logistics Bay or ZAL (Free Trade Zone)



**Image G.** View from the southern section of the west breakwater to the port's expansion terminals.







**Image H.** Customs of the new port of Veracruz



**Image I.** View of the North Bay Access Bridge



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**Image J.** Access zone to the Transport Logistical Attention Center



**Image K.** View of the Transport Logistical Attention Center





## Appendix 03

### Project:

Research on shoreline profile changes

### Institute:

Oculus

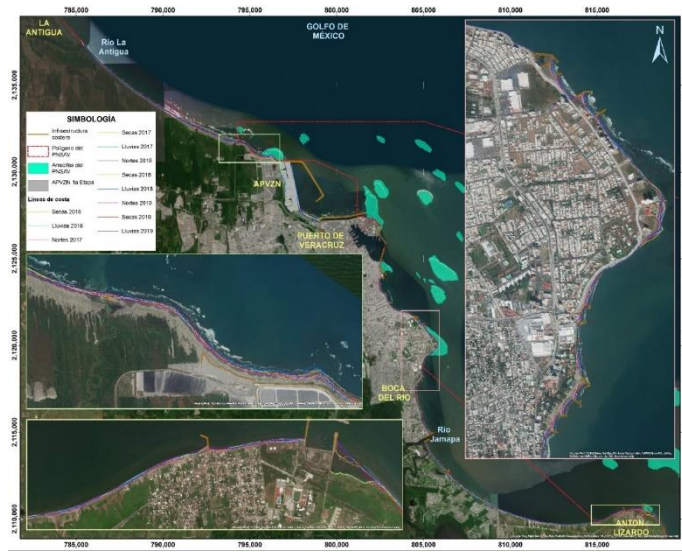
### Objective:

To watch the behavior of the shoreline profile dynamic as a consequence of the expansion works, therefore, a historical reconstruction of the coastline within the project's influence area was made to determine the coastline tendency before its construction and to monitor the coastline's evolution throughout the project's duration.

### Instruments:

For this particular analysis, generated images of each one of the littoral cells were used for each specific season. This research allowed us to determine the area of study regarding the shoreline, and enabling the spotting of erosion and accretion areas within balance during the period of analysis, since the results are quantified based on the changes identified in terms of coastline variations. The digitization of the shoreline was done through Geographical Information Systems or SIG (Sistemas de información Geográfica), mounting images of each one of the littoral cells and the shoreline with the help from the SIG's editing tools. In Image 1 we can appreciate all of the digitized shorelines differentiated by season and year, gathering 11 lines so far.





**Image 1.** Digitized shorelines since 2016 up to 2019.

Finally, a general comparison was made between the shorelines to observe their tendency during the 4-year period (2016-2019) (Image 3). We used the DSAS (Digital Shoreline Analysis System) program developed by the United States Geological Survey (USGS) which allowed us to calculate the horizontal variation that the different historical lines have had (Table 1).

**Table 1.** General comparison between cells

DATA	Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	System
<b>Minimum value</b> (m/year)	-12.60	-54.17	-8.8	-2.75	-5.86	-54.17
<b>Maximum value</b> (m/year)	+15.48	+71.35	+3.87	+4.92	+53.63	+71.35
<b>Average</b>	+0.52	-7.35	-0.23	+0.56	+0.27	-0.36
<b>Median</b>	+0.35	+1.18	+0.14	+0.33	-0.58	+0.05
<b>Standard deviation</b>	4.64	24.16	1.7	1.31	5.02	8.46

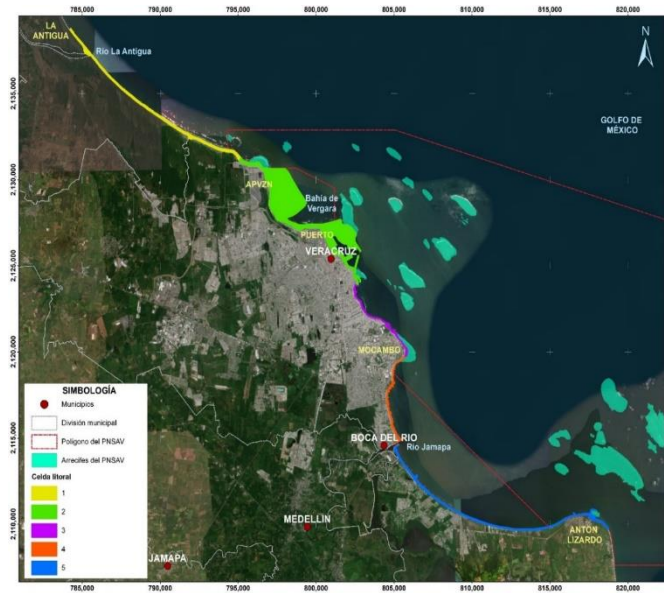






## Results

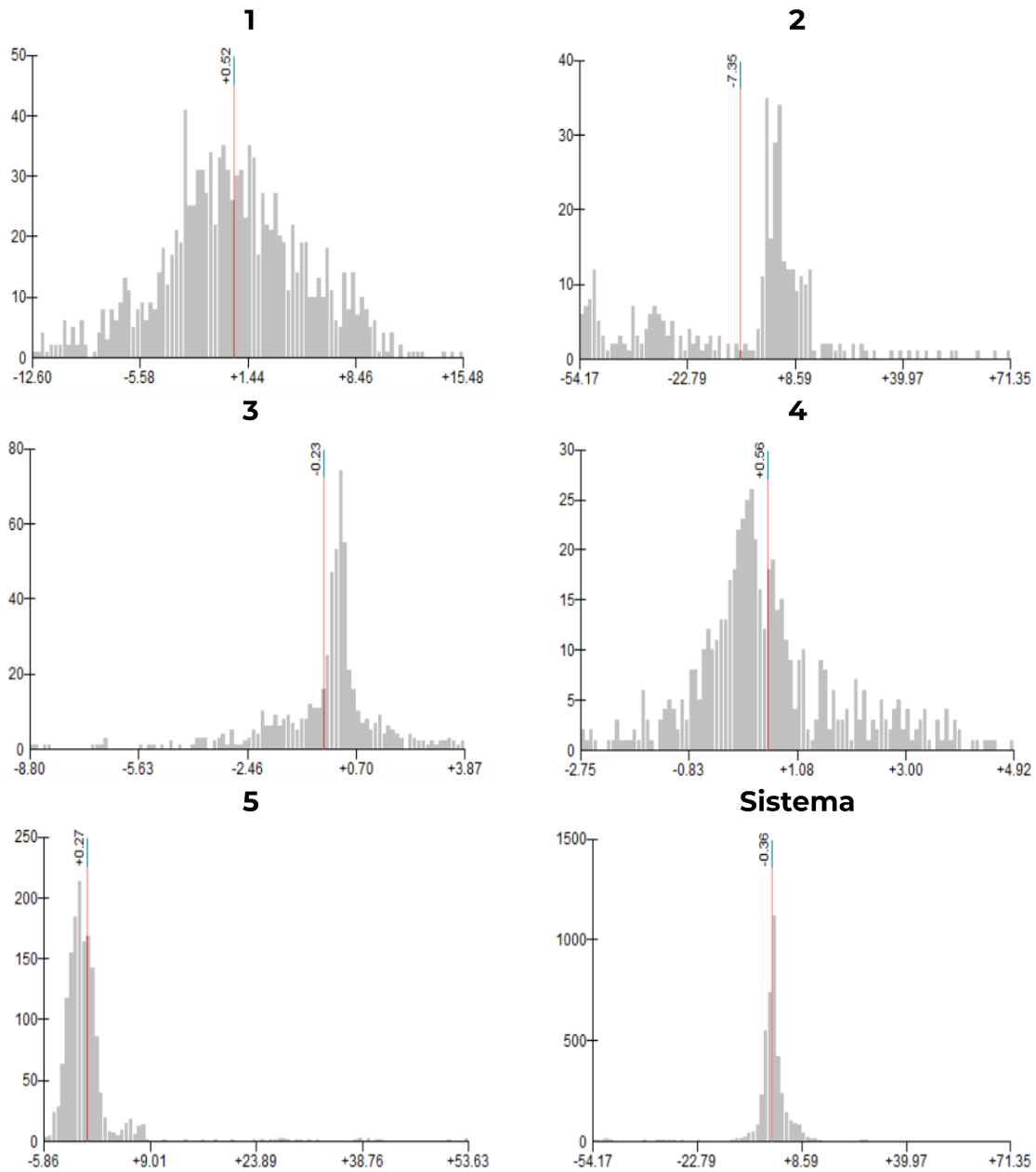
The research area encompasses a beach strip of at least 100 m wide from La Antigua river's mouth and up to the town of Antón Lizardo with an approximate length of 50 Km. The research area is at the same time split into five "littoral cells" categorized by the presence protection coastal works, coral reefs and water bodies that modify the littoral behavior.



**Image 2.** Monitoring littoral cells

Three yearly seasons were taken into consideration (regional features) under which the shoreline profile behavior would be observed. These seasons were: Nortes (High winds), Secas (Dry) and finally Lluvias (Rainy). Since 2016 and up to 2019 11 seasons have been covered.





**Image 3.** Shoreline analysis

A tendency towards balance was found (no more than a 10 m variation during the 4 years of analysis), with a maximum retraction of 54 m/year (southern section in Vergara due to





dredging in the navigation canal). Besides, with a expansion of little over 70 m/year (fill up area for the new port's terminals). An extension of the shoreline is present at the northern section of the east breakwater (up to 13.23 m/year). With the help of SIG's tools, a methodology was established to determine the sediments Volumetric Exchange Rate or TCV (Tasa de Cambio Volumétrica) for the five littoral cells. When the pixel value is negative, it means sediment was lost in that area and when it's positive it means sediment was gained. Creating a comparison for the Rainy season between 2016 and 2019, it was possible to determine which areas presented erosion, accretion or if there is balance on the beach during the monitoring (Table 2).

**Table 2.** Analyzed profiles balance, gain and loss statuses .

<b>DATA</b>	<b>Cell 1</b>	<b>Cell 2</b>	<b>Cell 3</b>	<b>Cell 4</b>	<b>Cell 5</b>
Minimum Value	-32.11	-66.75	-23.59	-6.86	-28.07
Maximum Value	+11.25	+18.88	+5.1	+14.78	+10.53
Average	-0.64	+1.88	-0.56	+0.21	+0.10
Total Sum	-8,665	+71,022	-1,471	+685	+1,555
Standard Deviation	3.17	4.6	2.15	1.02	1.65
Status	<b>Loss</b>	<b>Gain</b>	<b>Loss</b>	<b>Balance</b>	<b>Balance</b>

**Recommendations:**

As a result of said project, it was recommended to continue with shoreline profile research in order to prove the project's long-term impact on the shoreline.







## Appendix 04

### Project:

Dredging activities follow up (first stage)

### Institute:

ARGO, Consultores

### Objective:

To obtain the suspended particles characterization and current patterns

### Instruments:

The mobile sediment monitoring component makes use of an Acoustic Doppler current profiler mounted on a vessel with an outboard motor which generates a 59.4 Km track and encompasses a surface of roughly 3.46 Ha within the waters in which the expansion project's polygon is inserted (Vergara bay) as well as the reefs within the influence area.

### Results

To carry out said activities, environmental details and generalities in the expected dredging and filling up activities were analyzed, including bathymetry features, hydrodynamic behavior and sediment transportation, material meant to be dredged, the dredging areas and material pouring as well as the Extraction and Pouring of Sand Work Program (Programa de trabajo para las actividades de extracción y vertimiento de arena)(Image 4).



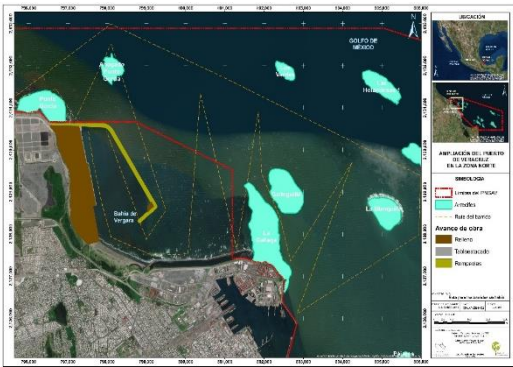


The activities for the first stage dredging started on August 14<sup>th</sup> 2017 and concluded on July 20<sup>th</sup> 2018. During this period, over 14 million cubic meters were dredged with the aim of enabling the access canal and the turning basins for the new port at -15 m deep.

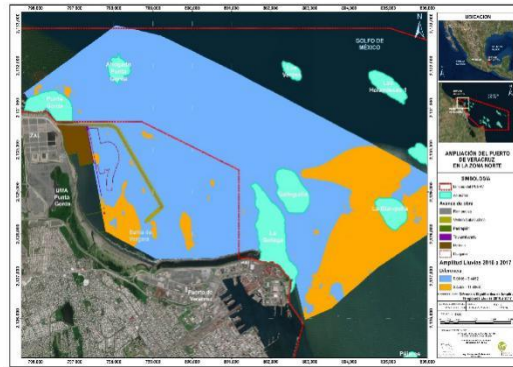
**Table3.** Analysis of interaction between dredging activities and sediment dispersion.

Research campaign	Rainy	High Winds	Dry
<b>2016 - 2017</b>	There was no dredging effect that seemed to increase the sediment concentration.		
<b>2017 - 2018</b>		No meaningful differences were detected at the fill up sites although they did appear on the area parallel to the coastal external face of the west breakwater.	The inner parts of the bay were the fill up and dredging were carried out presented higher sediment values but on isolated areas and without exceeding the authorized development work areas.

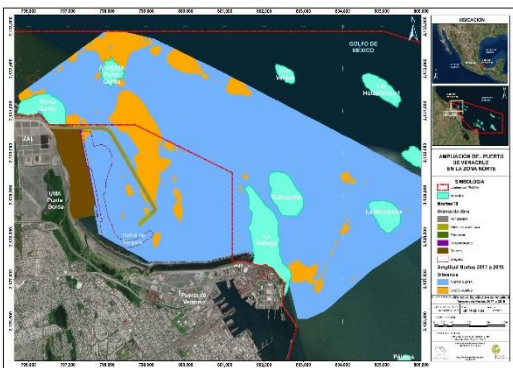




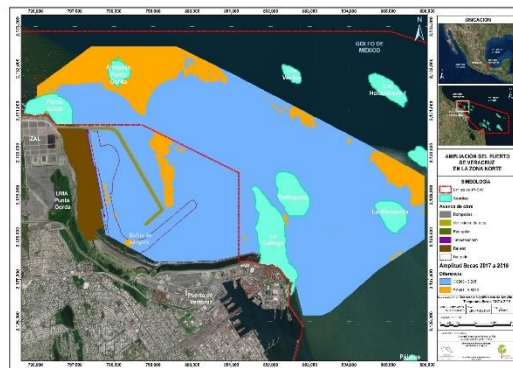
**Image 4.** Project's dragado area



**Image 5.** Rain difference 2016-2017



**Image 6.** High Winds difference 2017-2018



**Image 7.** Dry difference 2017-2018

### Recommendations

To continue monitoring the behavior of suspended particles and their range during the upcoming depth rectification activities.





## Appendix 05

### Project:

Elaboration of bathymetry for influence area

### Institute:

Tecóceano

### Objective:

Redesign the project's navigation canal

### Instruments:

The fulfillment of this task corresponded to the navigation canal proposal for the vessel's entry to the new Veracruz port.

The *Propuesta Actualizada del Canal de Navegación para la Primera Etapa del Nuevo Puerto de Veracruz* (Veracruz's new port first stage navigation canal updated proposal) is based on the results obtained by the high-resolution bathymetry using a multibeam ecosounder of the 65,516-47-08.05 Ha comprising the PNSAV as well as the technical requirements to operate and maneuver the vessels.

### Results

Thanks to it, we were able to define all the reef formations existing within the natural protected area including the non-emerging reefs previously unidentified. These non-emerging reefs are structures that do not reach the surface due to their higher points being



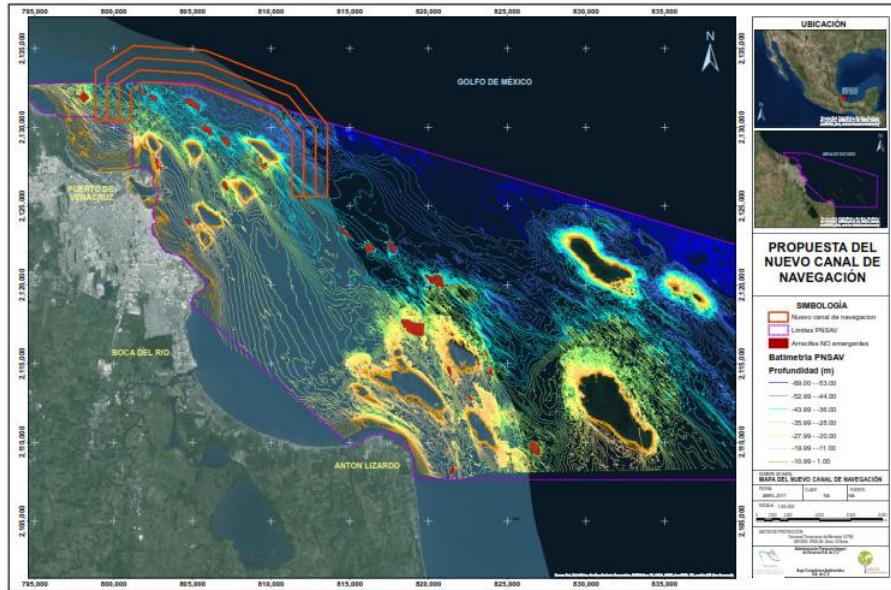


found between 9 and 15 meters deep as well as presenting a slow growth rate, probably due to the depth in which they develop. This peculiar form of development without “emerging” or reaching the surface makes their detection and labeling rather difficult. That’s why non-emerging reefs in the PNSAV, prior to this research, were known by fishermen as aggregation spots for fish but hadn’t been delimited and described until the study done by the APIVER in tandem with the PNSAV authorities.

As a result of the previously mentioned, we went from 28 reefs, six keys or islands, including 4 non-emerging reefs at the PNSAV in the “Decreto que modifica al diverso por el que se declara Área Natural Protegida, con el carácter de Parque Marino Nacional, la zona conocida como Sistema Arrecifal Veracruzano, ubicada frente a las costas de los municipios de Veracruz, Boca del Río y Alvarado del Estado de Veracruz Llave, con una superficie de 52,238-91-50 hectáreas, publicado los días 24 y 25 de agosto de 1992” (DOF, 2012) to a total of 45 reef formations. Starting with the environmental authority's requirement and derived from this study, the expansion project navigation canal updated proposal was formulated, thus respecting the recently identified reef formations.







**Image 8.** Project's navigation canal.







## Appendix 06

### Project:

Research on MARINE LIFE: Rescue, relocation and survival monitoring of coral reef colonies.

### Institute:

Universidad Veracruzana

### Objective:

To evaluate the rescue, relocation and survival monitoring operations of the coral reef colonies.

### Instruments:

These operations were done by qualified divers who were well versed in the topic, also noting that the regional fishing sector was involved the operations as well.

### Results

The coral reef rescue and relocation operations were split into two stages. The first stage took place between November 2014 and May 2015, while the second one took place between July 2015 and March 2016. A total of 46,182 coral reef colonies were rescued and relocated. In both stages the predominant colony genus was *Siderastrea* (97.9%) and the colony genera *Pseudiplora* (1.3%), *Oculina* (0.7%) and the hydrozoan *Millepora* (0.1%) were also present but in much lower proportions.





On the first stage, the colonies were relocated according to their size, and moved to concrete plates (5 cm max diameter) and onto a natural substratum (6 to 10 cm max diameter). For the second stage, the colonies were only fixed on substratum (over 5 cm max diameter).

The survival monitoring has been carried out uninterruptedly so far with the five-year monitoring about to finish as required by the environmental authority. The environmental indicators resulting of this study correspond to survival and prevalence.

As far as the main results for the colonies relocated during the first stage, we have observed colonies dying on both the natural substratum and concrete plates; however, the presence of the *Siderastrea* genus recruitment is still observed, mainly at the plates installed at the relocation site, being that in the most recent report (April 2020) 313 coral recruitment (colonies smaller than 2 cm diameter) were identified. As far as survival, we continue to report a decrease, the latter being lower on the substratum (-3%) than on the plate colonies (-5%) (Image 10).



**Image 09-10.** *Siderastrea* sp. recruitment on concrete plates installed at the Rincón.



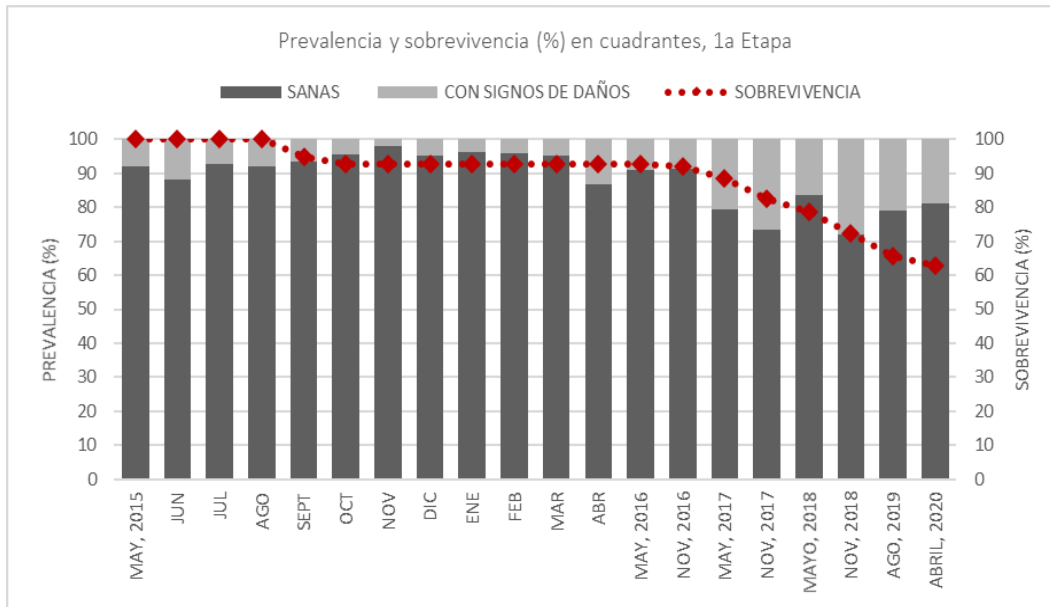


Image 11. Substratum relocated coral reef colonies' survival and prevalence (%). April 2020.

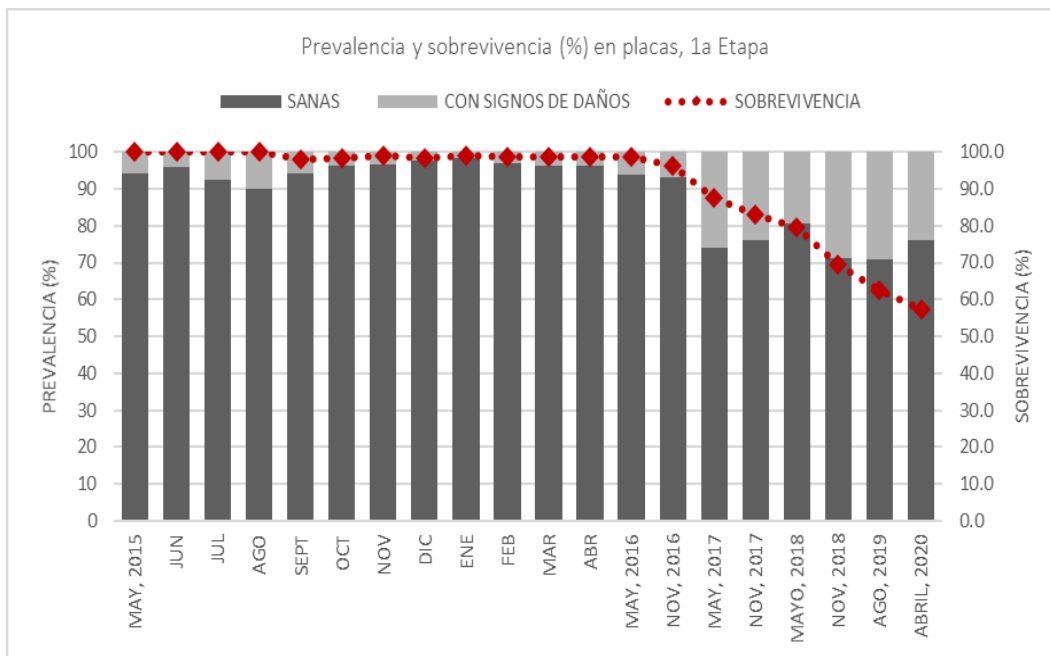
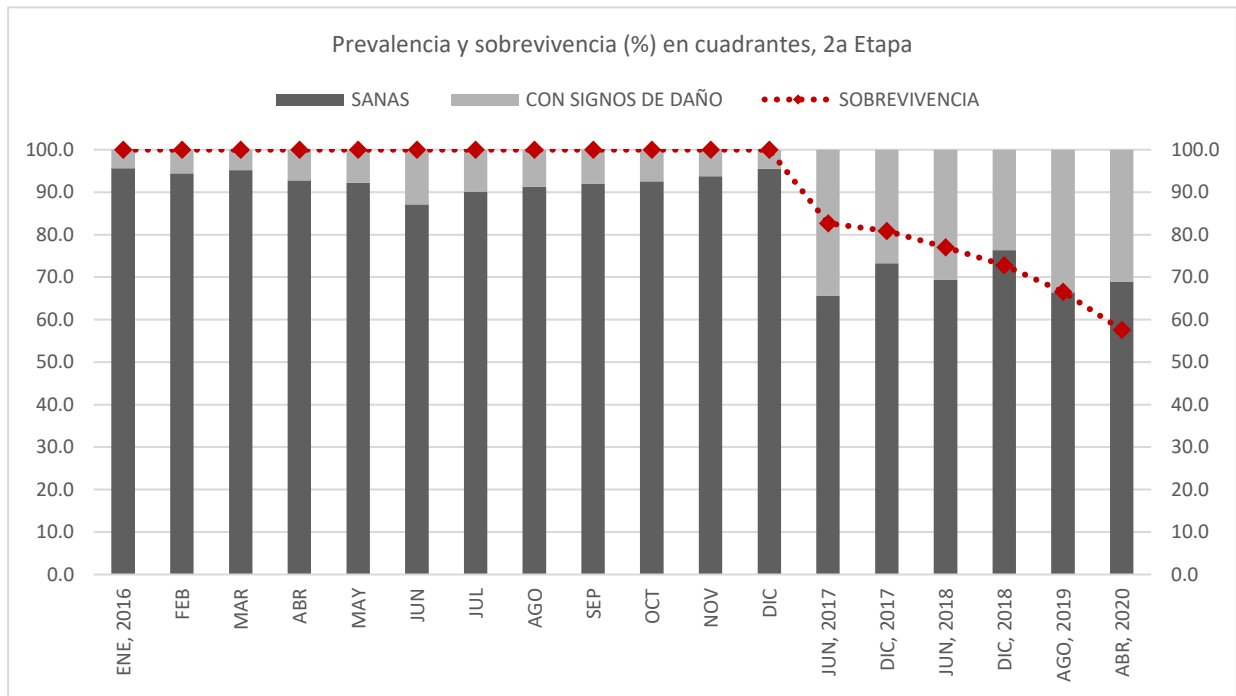


Image 12. Plate relocated coral reef colonies' survival and prevalence(%). April 2020.





From the indicators that have had a follow up, we can observe that the prevalence was lower when compared to the immediate prior period (-3%) while the survival continues to present a 9% increase when compared to the previous monitoring (Image 13).



**Image 13.** Substratum relocated coral reef colonies' survival and prevalence (%). Second Stage. April 2020.

**Recommendations:**

To continue the Marine life monitoring to ensure that anthropogenic impact is not causing environmental deterioration due to project implementation.





## Appendix 07

### Project:

Hydraulic model study for west breakwater crown wall width optimization

### Objective:

To verify limit conditions of wave overflow above the breakwater's crown wall.

### Institute:

Instituto Mexicano del Transporte (IMT)

### Period:

June 2016

### General project considerations:

- a. Elements involved: Laboratorio de Hidráulica Marina (Marine Hydraulics Lab)
- b. Given conditions: 35 m long, 4.90 m wide and 1.20 m deep wave canal, which was positioned at the side transverse section of the canal 25 m away from the wave generator.
- c. Restrictions: the rehearsals were done at a scale of 1:40.5 in periods of 10 and 12 seconds taking into consideration a wave height of 6.4 m and a crown wall width of 13.91 m with storm levels and mean low water.

### Method:

Overtopping rehearsals with wave overflow according to Leo Franco.







**Instruments:**

Capacitive sensor for wave measurement, wave canal in hydraulics lab, core-loc scale models.

**Study description:**

Rehearsals were made within the hydraulic model to define the minimum crown wall width in the west breakwater and measure the pressure levels on the opposite parapet. The transversal sections for the construction the west breakwater was analyzed starting at chaining 0+000 up to chaining 4+245.

Results: A 18.91 m crown wall width was recommended from chaining 0+680 to 1+200 and a crown wall width reduction to 14.18 m from chaining 1+220 to 4+245.



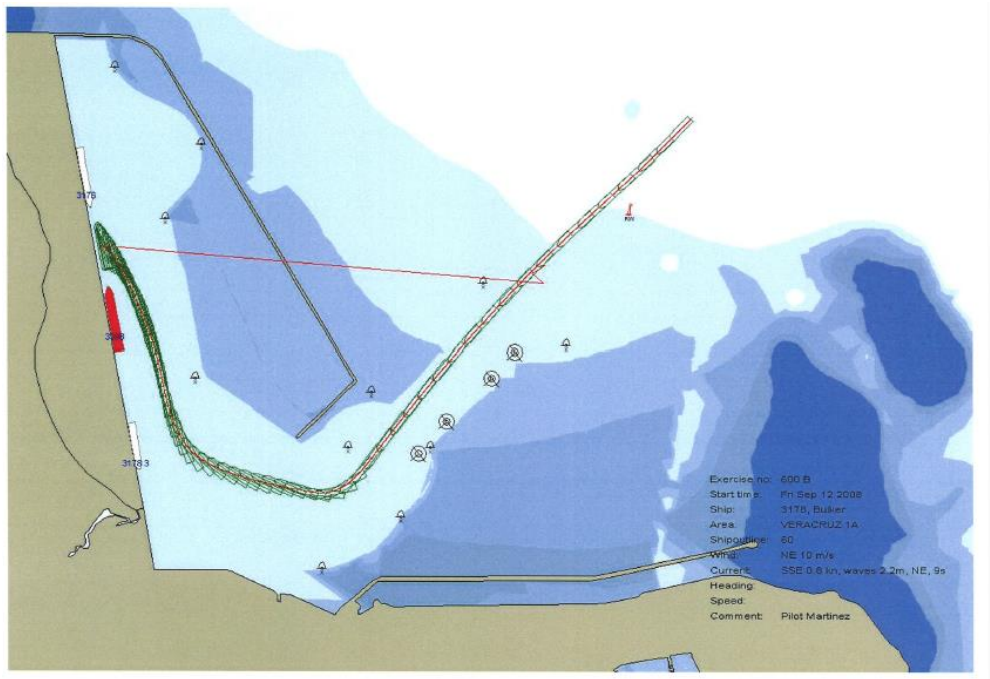
**Image 14.** Ship tracking at the expansion project.



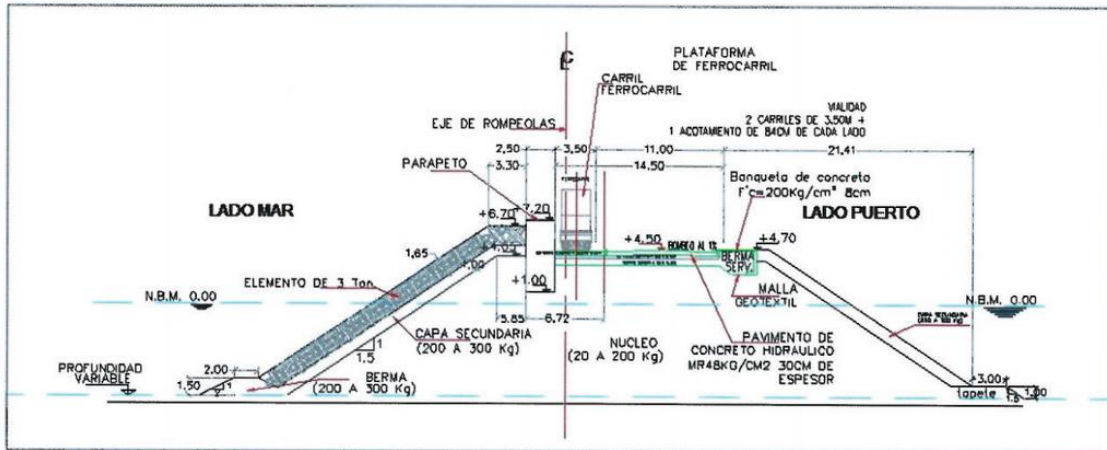




**Image 15.** Ship tracking the expansion project



**Image 16.** Cross-section of the west breakwater





## Appendix 08

### Project:

Wave agitation research to define starting date for construction activities at specialized containers terminal the Veracruz port expansion.

### Objective:

Define the optimal length of the west breakwater to enable the beginning of construction work at specialized containers terminal and dredging of the port's inner area.

### Institute:

Instituto Mexicano del Transporte (IMT)

### Period:

October 2016

### General project considerations:

a. Elements involved: refraction, diffraction, bottom drag, reflection, wave to wave non-linear interaction, frequency propagation and directional propagation.

b. Given conditions: 7 km marine front up to bathymetric curve -30 m encompassing the new Veracruz port expansion referred to mean low water with ellipsoid WGS84 and with a Zone UTM14 coordinate system.





c. Restrictions: For the seasonal regimen, it is noted that due to the breakwater's current construction condition, the vessel's permissible effectiveness with a wave height of 0.3 m is 79.6 % for spring, 80.1 % for summer, 79.7% for autumn and 79.8 % for winter.

**Method:** Boussinesq's Equations Models.

**Instruments:** Directional wave measuring buoy (located in the outer port)

### **Study description:**

We created wave agitation numerical models that allowed us to define the optimal length of the west breakwater which in turn will enable us to start construction work at specialized containers terminal.

Results: It is recommended to analyses the sediment disposal system to avoid as much as possible the deposition of said sediments in the dredged areas.

### **Recommendations:**

Constant monitoring of the sediment disposal system is recommended to avoid as much as possible the deposition of said sediments in the dredged areas.





**Image 17.** Agitation coefficient with a direction of N30° and a 1 m wave height.





## Appendix 09

### Project:

Real-time vessel maneuverability study. Initial stage of operations at Nuevo Puerto de Veracruz, Ver.

39

**Objective:** to practice the entry and exit at specialized containers terminal. port with the virtual vessels and tugboats using the simulation equipment under different simulated physical conditions that intervene in the specialized containers terminal. port entries and exits during its first stage and with these results determine the restrictions and recommendations so that we can have a better understanding of real life situations that could potentially come up and be able to respond adequately.

### Institute:

Instituto Mexicano del Transporte (IMT) <https://www.gob.mx/imt>

**Period:** May 2018

### General project considerations:

a) Involved elements: different vessel up to a Neopanamax boat maximum size, also 2 or 3 tugboats type ASD 5000 HP Z-Drive Tug depending on conditions.

d. Given conditions: the simulation is done in a 162 m wide canal signalized with buoys and a length of 4.5 km up to the center of the turning basin which has an approximate diameter of 550 m, a shallow water effect, squats, sinking and bank effect (side suction),







e. with action of wind on free surfaces or the vessel's superstructures, with boat interaction between maneuvers in the narrow canal, causing waves and gusts. This also applies for the tugboats so we are also taking into account that these variables affect the them during the maneuvering.

40

f. Restrictions: wind speed in the access canal must not be greater than 6.0 input knots and 8.0 output knots. Maneuvering must not be done if sustained winds surpass the 20.0 knots or if the southeast winds are greater than 15.0 nodes. Only vessels type Neopanamax and up to that size are allowed to transit.

g. Capacity: the size of the vessel must be Neopanamax with dimensions of 366 m of total length by 32 m wide and a draught not larger 13.5

**Method:** tridimensional model

### **Recommendations:**

The following recommendations are based on discussions and brainstorming sessions at the end of every simulation day between all parties involved, the information provided by 42 simulation runs, and the evaluation performed by the FORCE Technology captain and the pilots after each run.

- Assisting ASD tugs at the new terminal should be done by using the on-the-line method.
- Tug masters should be trained in the use of on-the-line method.





- Ships must adopt a minimum angle between the axis of the channel and the heading of the ship during the approach to the main channel.
- During arrivals, ships should already be aligned to the channel orientation at least 0.4' from buoy #1. To ensure a safe approach to the channel, the ship has to adopt a course as close as possible to the axis of the channel. This will minimize the final adjustments to some few degrees ( $< 15^\circ$ ). As a rule of thumb, it is suggested that the ship has already adopted this course when at a distance of 0,4' from buoy #1.
- Own ship's speed between buoys #15 and #20 should never exceed 4 kn.
- Own ship's speed between buoys #2 and #10 should be between 5 kn and 6 kn.
- During departures, it must be ensured that ships manoeuvre in the widest part of the basin.
  - Use an extra tug in stand-by mode during the familiarization process.



**Image 18.** Maneuverability simulation





## Appendix 10

**Project:** Statistical study about wind characteristics to determine effectiveness percentages on cranes in charge of driving and inserting the sheet piles at the specialized containers terminal for the Veracruz port expansion.

42

**Objective:** Determine the seasonal and annual percentages of effectiveness for the cranes in charge of driving and inserting the sheet piles at the specialized containers terminal.

Institute: Instituto Mexicano del Transporte (IMT) <https://www.gob.mx/imt>

**Period:** October 2016

### General project considerations:

- a. Involved elements: sheet piling cranes
- b. Given conditions: the seasonal and yearly percentages that yield better and safer operational conditions will be submitted to analysis.
- c. Restrictions: due to safety regulations, the sheet piling cranes must not operate while winds of 30km/hr or greater are present.
- d. Capacity: not mentioned.

**Method:** Mathematical model

**Instruments:** statistical studies regarding wind characteristics in the form of seasonal and





annual developments from the National Oceanographical and Meteorological Stations Grid or RENEOM (Red Nacional de Estaciones Oceanográficas y Meteorológicas) and the Oceanic Wave Behavior Atlas of Mexico or ATLOOM (Atlas de Oleaje Oceánico elaborado por el Instituto Mexicano de Transporte).

Study description: analyzing the RENEOM and ATLOOM charts to determine the annual and seasonal level of effectiveness for cranes in charge of the driving and insertion of sheet piles.

Results: Results deriving from the wind statistical analysis will be reported with the aim of determining the annual and seasonal level of effectiveness for cranes in charge of the driving and insertion of sheet piles.

Recommendations: it is recommended to use the RENEOM information (96.64 annual effectiveness).

Equipment: we only used the information correlated to the statistical registry of annual and seasonal wind velocity as a tool to determine the deployment of cranes at times when wind velocity is not critical. This information is obtained from the RENEOM's meteorological station and the information encompassed in the ATLOOM.







**Appendix II**

**Load capacity projection for the port of Veracruz 2019 – 2043**

The annual installed capacity to be found with the project during the total evaluation horizon is the one described in Table 4.



**Table 4.** Annual installed capacity of the project

Capacidad instalada del área del puerto ampliada									
Año	Carga total	Carga general	Contenedores	Granel mineral	Granel agrícola	Fluidos	Fluidos derivados del petróleo	Vehiculos	Petroleo
2019	22,750	0	12,500	1,706	2,844	0	5,000	700	0
2020	22,750	0	12,500	1,706	2,844	0	5,000	700	0
2021	22,750	0	12,500	1,706	2,844	0	5,000	700	0
2022	22,750	0	12,500	1,706	2,844	0	5,000	700	0
2023	22,750	0	12,500	1,706	2,844	0	5,000	700	0
2024	22,750	0	12,500	1,706	2,844	0	5,000	700	0
2025	22,750	0	12,500	1,706	2,844	0	5,000	700	0
2026	23,450	0	12,500	1,706	2,844	0	5,000	1,400	0
2027	25,157	0	12,500	3,413	2,844	0	5,000	1,400	0
2028	25,157	0	12,500	3,413	2,844	0	5,000	1,400	0
2029	25,157	0	12,500	3,413	2,844	0	5,000	1,400	0
2030	28,001	0	12,500	3,413	5,688	0	5,000	1,400	0
2031	28,001	0	12,500	3,413	5,688	0	5,000	1,400	0
2032	28,001	0	12,500	3,413	5,688	0	5,000	1,400	0
2033	28,701	0	12,500	3,413	5,688	0	5,000	2,100	0
2034	28,701	0	12,500	3,413	5,688	0	5,000	2,100	0
2035	28,701	0	12,500	3,413	5,688	0	5,000	2,100	0
2036	28,701	0	12,500	3,413	5,688	0	5,000	2,100	0
2037	28,701	0	12,500	3,413	5,688	0	5,000	2,100	0
2038	28,701	0	12,500	3,413	5,688	0	5,000	2,100	0
2039	28,701	0	12,500	3,413	5,688	0	5,000	2,100	0
2040	42,302	1,102	25,000	3,413	5,688	0	5,000	2,100	0
2041	42,302	1,102	25,000	3,413	5,688	0	5,000	2,100	0
2042	42,302	1,102	25,000	3,413	5,688	0	5,000	2,100	0
2043	42,302	1,102	25,000	3,413	5,688	0	5,000	2,100	0

Cifras en miles de toneladas

The load-care capacity for each of the terminals is presented in a staggered manner and is consistent with the investment program and predicted demand.

Source: Capacity programming based on offer predicted Project provided by APIVER (Cost-Benefit Analysis of the expansion project).

