DETERMINATION OF SITES OF INTEREST FOR THE IMPLEMENTATION OF THE OTEC SYSTEM (OCEAN THERMAL ENERGY CONVERSION) IN THE MEXICAN PACIFIC OCEAN

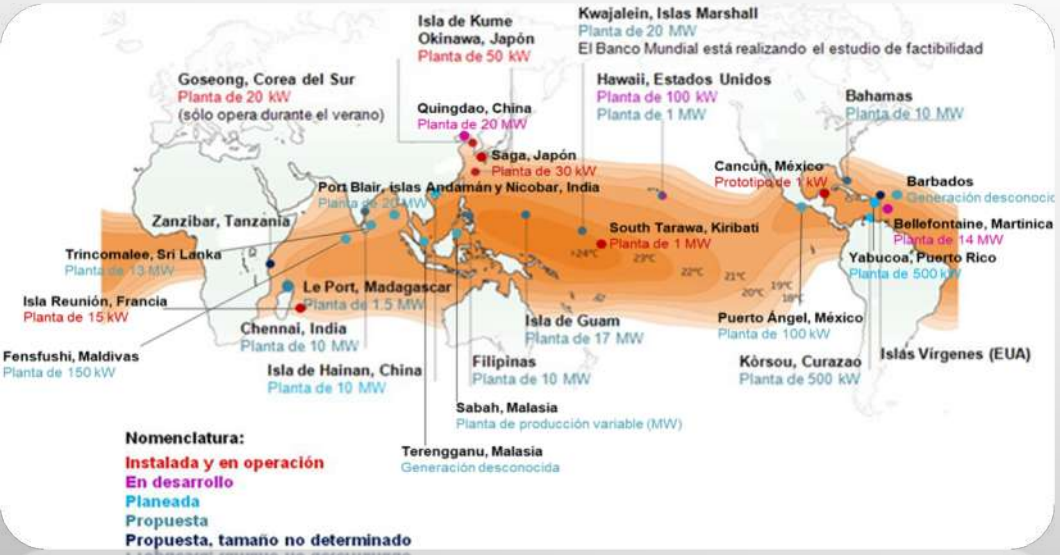
Alejandro García Huante[1,2], Erika Paola Garduño Ruíz[3,4], Ricardo Efraín Hernández Contreras[3] y Francisco Ponce Núñez[5]
[1]**Centro Mexicano de Innovación en Energía del Océano (CEMIE-Océano)**, alex_dodo@hotmail.com
[2]**Colegio de Postgraduados Campus Montecillo (COLPOS)**, garcia.alejandro@colpos.mx
[3]Centro Mexicano de Innovación en Energía del Océano (CEMIE-Océano), pao_quim@yahoo.com.mx
[4]Tecnológico de Estudios Superiores de Monterrey Campus Ciudad de México (ITESM-CCM), paola.garduno@tec.mx
[3]Centro Mexicano de Innovación en Energía del Océano (CEMIE-Océano), ricehcontreras@hotmail.com
[5]Instituto de Ciencias del Mar y Limnología, Unidad CU, fponce@cmarl.unam.mx

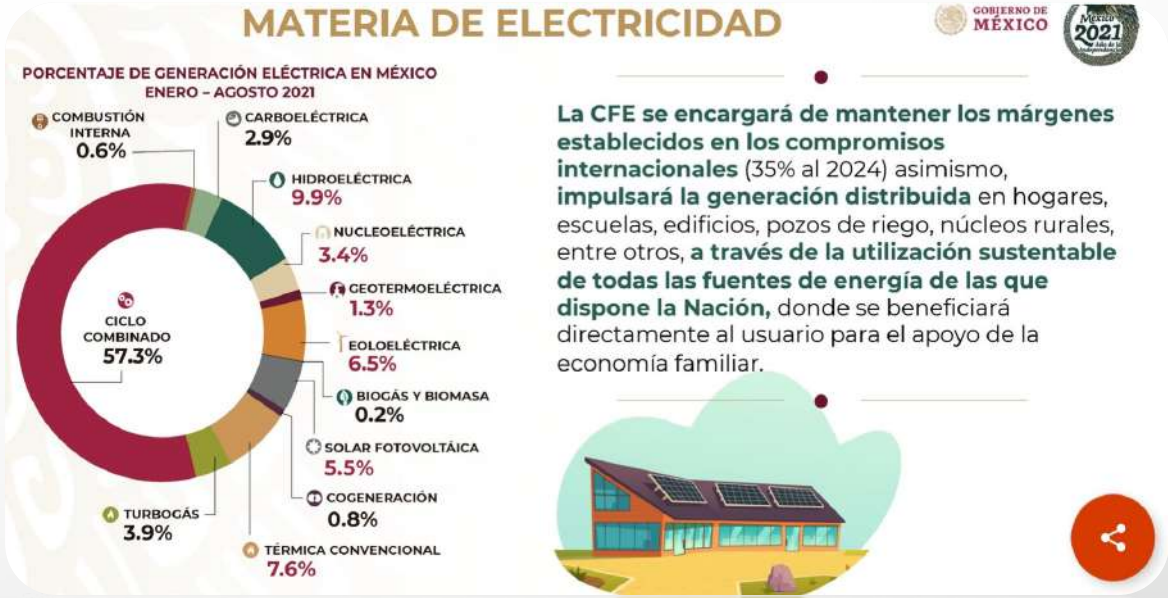
PAMEC 2024
Pan American Marine Energy Conference
Barranquilla, Colombia Jan 22-24, 2024

INTRODUCTION

Mexico currently generates electricity by 27% through renewables energies (an increase of 7% from the year 2019); however, it's particulary important to research and develop other power generation optiones thet meet current and projected national electricity demand, reducing social and environmental impacts.

One of the options that have been applied in the world is marine energy and the country, due to its oceanographic and geographical conditions, can exploit some of these technologies. One of these is thermal gradient energy (OTEC).

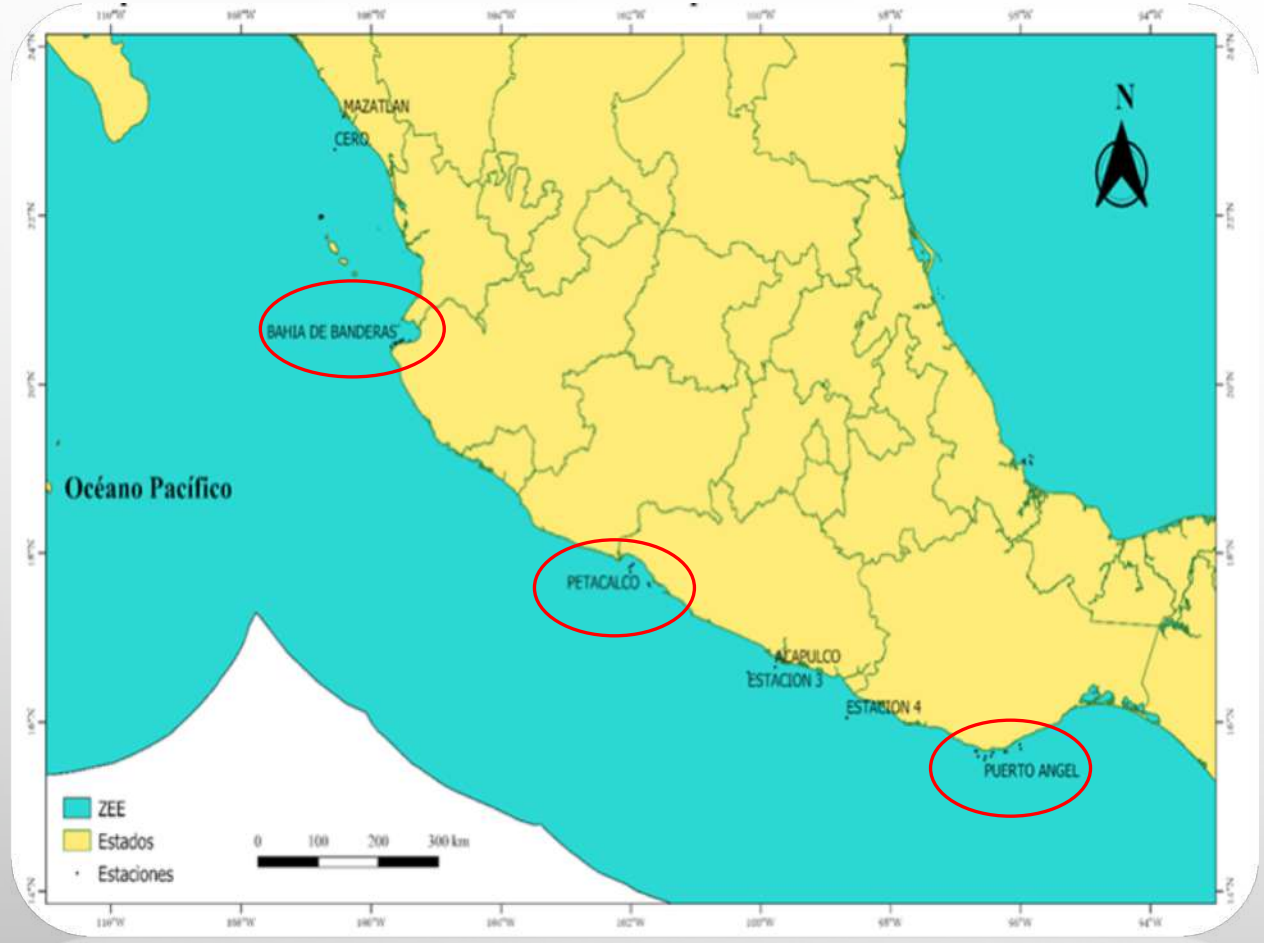




According to various researchers, for the OTEC system to operate normally, the following considerations are required: that the difference in temperature between the surface and the bottom be greater than or equal to 20°C, a maximum distance of 10 km between the coastline and the cold water pumping zone, bathymetric slope between 15° and 20°, low probability of extreme events (hurricanes or tsunamis), good accessibility and low ecological impact in the area

PAMEC 2024
Pan American Marine Energy Conference
Barranquilla, Colombia Jan 22-24, 2024

JUSTIFICATION



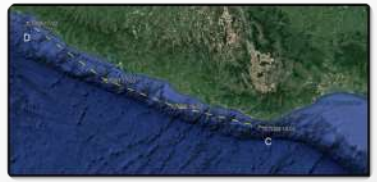
The central and southern areas of the Mexican Pacific Ocean have priority sites that meet the considerations described above, such as: (a) the area of **Bahía de Banderas** in the polygon that includes the towns of *Chimo to Playa Mismaloya*, corresponding to the state of **Jalisco**; (b) the **Petacalco** zone in the state of **Guerrero** and (c) the **Puerto Angel** area in **Oaxaca**, which includes the polygon from *Santiago Pinotepa Nacional to Bahía Tangolunda*. Various studies mention that the generation of net electrical power through OTEC in these areas can vary from ~80–200 MW with an operational persistence of 70-100% **(Hernández-Fontes et al., 2019; García-Huante, 2021 ; Garduño-Ruíz et al., 2021).**

For these reasons, it is of the utmost importance to carry out research and monitoring in the field by means of oceanographic cruises that corroborate the theoretical results, such as the temperature data in the oceanic vertical profile, the fine bathymetry and the type of sediments on the seabed of the sites. predominant. The results of these studies would give us sufficient certainty to determine the feasibility of a possible installation and operation of an OTEC plant in Mexico in the medium term.

PAMEC 2024
Pan American Marine Energy Conference
Barranquilla, Colombia Jan 22-24, 2024

GENERAL OBJECTIVE

Obtain a high resolution bathymetry with a Multibeam Echosounder on the continental slope, between the isobath of 500 and 1000 meters deep in the areas of (a) Bahía de Banderas, (b) Puerto Angel and (c) Petacalco; as well as to characterize its oceanographic conditions based on physicochemical, geological and benthic parameters.




(b)


(c)

PAMEC 2024
Pan American Marine Energy Conference
Barranquilla, Colombia Jan 22-24, 2024

OTEC-1 Oceanographic Campaign
CEMIE-O 2022 (March 9-20)

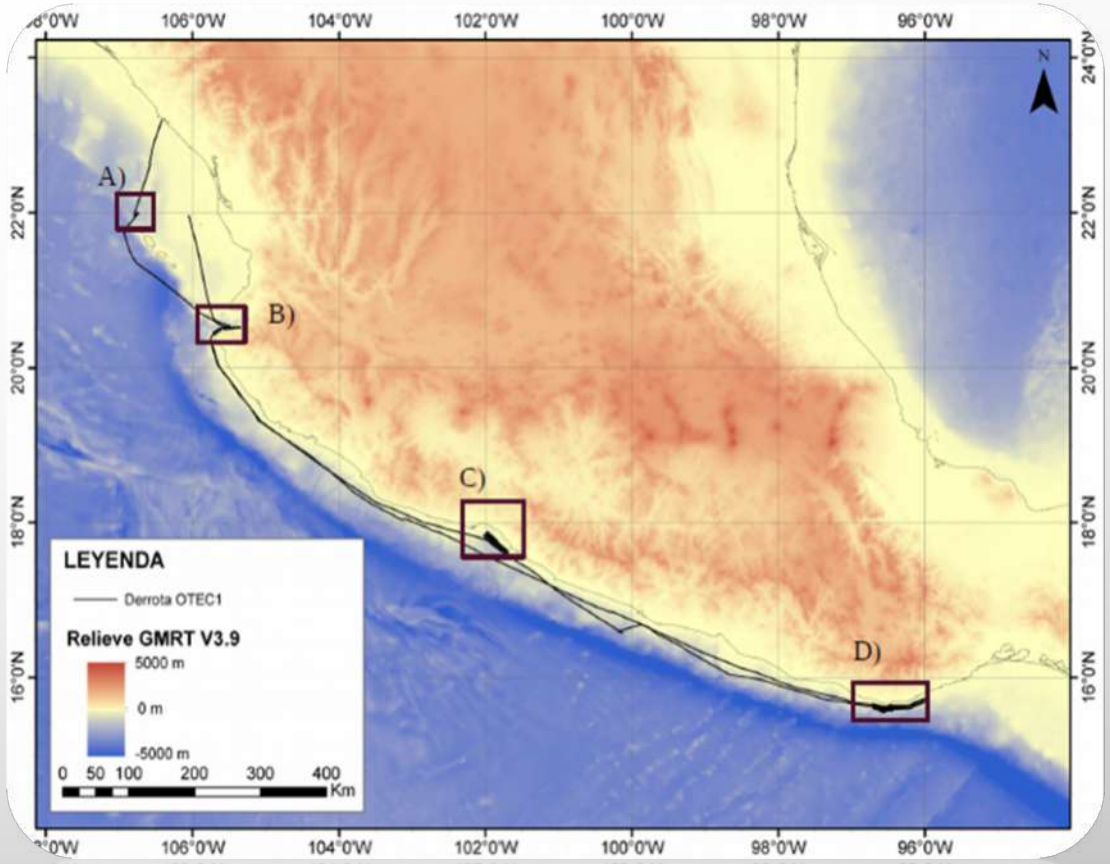
Alejandro García-Huante, Erika Paola Garduño-Ruíz, Víctor Enrique Luna-Gómez, Juan Francisco Bárcenas-Graniel, Francisco Ponce-Núñez, Ricardo Efraín Hernández-Contreras, Luz Adriana Arredondo-Godínez, Cecilia López-Chávez, Rogelio Joel Parcero-Sánchez y Miguel Ángel Alatorre-Mendieta.

METHODOLOGY

Multibeam/TOPAS echosounder for bathymetry

One of the objectives of the OTEC-1 cruise was to carry out a high resolution bathymetric mapping of the sites under study, to learn more about their underwater morphology and land their potential for the installation of an OTEC plant.

This section presents the EM300 multibeam echo sounder and MINOSX sound velocity profiler equipment for the bathymetric survey of the aforementioned sites, as well as a sample of the recorded data.



Technical characteristics of the equipment used: EM300 and MinosX

EM300 Multibeam Echosounder

The Kongsberg brand EM300 multibeam system is mounted in the hydroacoustic equipment gondola on the hull of the R/O El Puma.

Nominal frecuency	**30 kHz**
Depth	20 m - 5000 m
Best swath coverage	5.5 x depth
Accuracy	~ 0.5% depth
Beam configuration [TX x RX]	1° x 2° en Cruz de Mills
Maximum opening	150°
Beam pattern	Equiangular, Equidistant
Stabilization [Yaw, Pitch, Roll]	± 10°, ± 10°, ± 15°
Soundings (máx):	135
Pulses	CW
Ping rate (máx):	10 Hz
Pulse length	0.7 ms - 15 ms
Modes of operation	Very shallow, Shallow, Medium, Deep, Very Deep, Extra Deep
Backscatter intensity register	YES

MinosX Sound Speed Profiler

The MinosX Sound Velocity Profiler (AML Oceanographic) is a self-contained instrument that measures local sound velocity directly, in conjunction with temperature and pressure as it is lowered and raised. The register was configured to acquire a sound speed value every 0.5 dBar of pressure change. This instrument was placed in the protection frame of the CTD carousel aboard the B/O El Puma, so that a record of the speed of sound was obtained for each CTD bay of the cruise ship.

Serial number		**30916**	
Last calibration		13/08/2020	
Maximum depth		6000 m	
	Temperature	Pressure	Sound velocity
Measuring range	-5 -- 45 [°C]	0 – 6000 [dBar]	1375 – 1625 [m/s]
Response time	100 [ms]	10 [ms]	20 [ms]
Accuracy	0.005 [°C]	0.05 %	0.025 [m/s]
Precision	0.003 [°C]	0.03 %	0.006 [m/s]
Resolution	0.001 [°C]	0.02 %	0.001 [m/s]

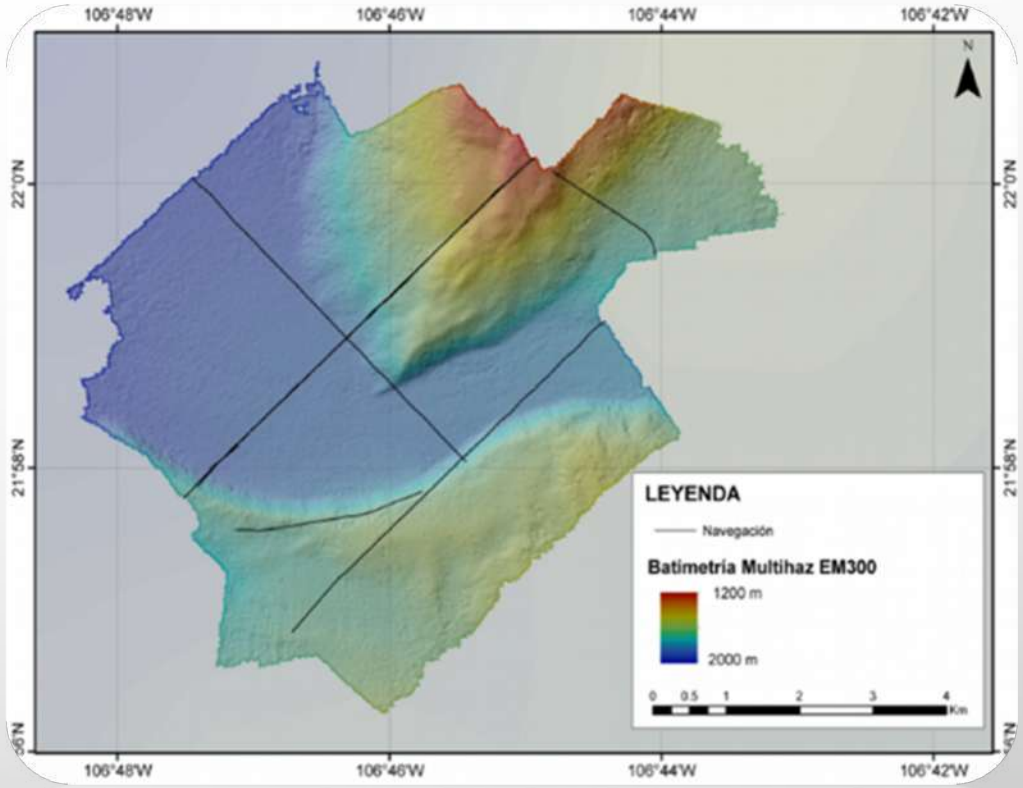
EM300 data distribution

During the OTEC-1 campaign, bathymetric surveys were carried out in four areas of the Mexican Pacific, as indicated in Figure 3. These sites are: A) Calibration; B) Bay of Banderas; C) Petacalco Bay; and D) Puerto Angel.

Site Calibration

At the first site, a survey known as "patch test" was carried out, which consists of the bathymetric record under specific conditions of speed and direction in several lines, in order to determine systematic errors in the EM300 equipment.

The figure shows the bathymetry and ship's course during the patch test survey in the area north of the Islas Marías. Approximately 16.5 nautical miles were sailed and an area of 42,096 km² was covered. In this test, no systematic errors were found that affect the performance of the multibeam.

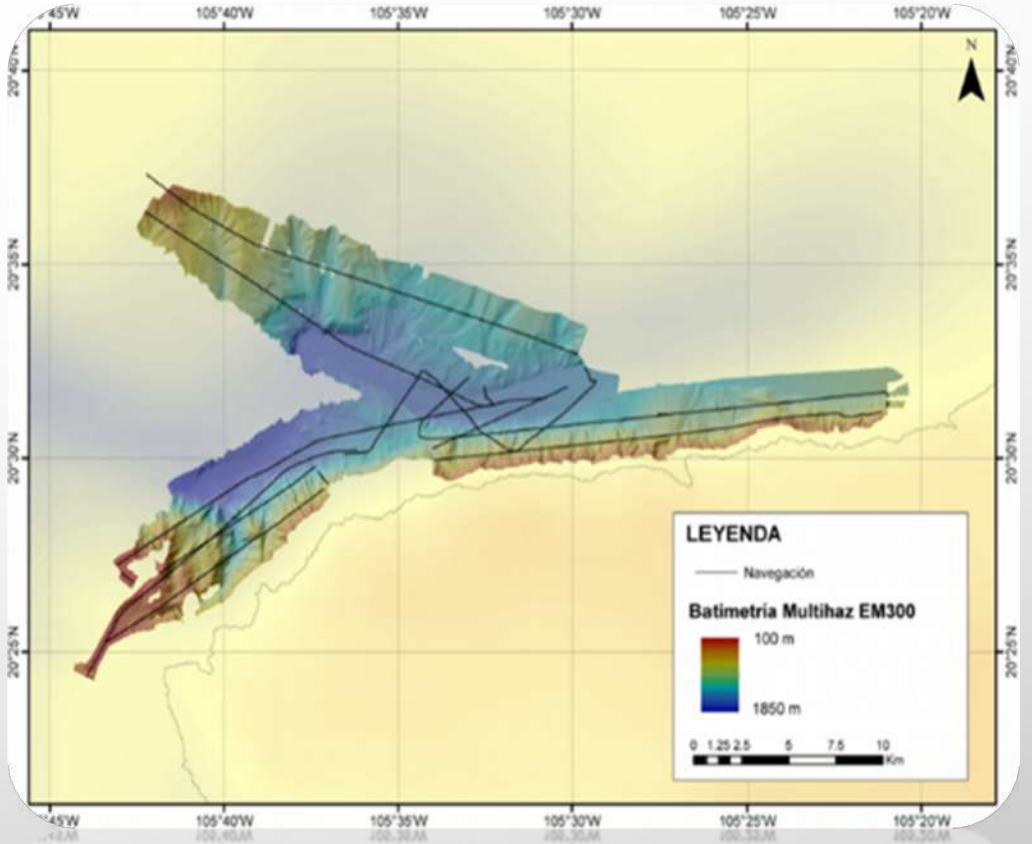


PAMEC 2024
Pan American Marine Energy Conference
Barranquilla, Colombia Jan 22-24, 2024

Bahía de Banderas

The first site of interest where a bathymetric survey was carried out was on the southern margin of Bahía de Banderas. In a first survey, navigation was carried out following lines parallel to the coastline with the aim of getting as close as possible to the newly acquired bathymetry. Available traffic data from the OTEC-1 cruise ship were incorporated into this set, with the aim of combining as much information as possible.

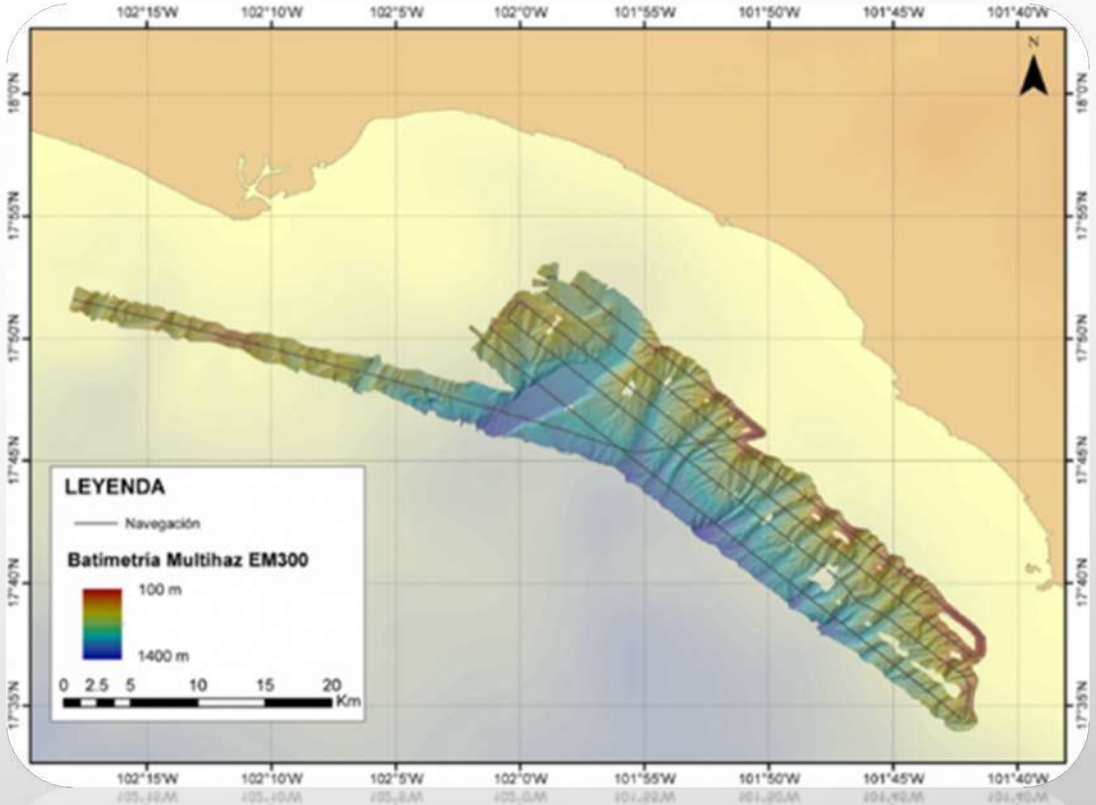
The figure shows the bathymetry and ship's course of the uplift in the southern margin area of Bahía de Banderas. Approximately 100 nautical miles were sailed and 263,161 km² of bathymetric data were covered with a resolution between 5 m and 25 m. Depths up to 1850 m were observed.



Petacalco

For this site, navigation was carried out in a NW direction, roughly following the coastline, with the aim of mapping the slope. This set of data is complemented by those collected by Dr. Arturo Carranza in 2006, in front of the mouth of the Balsas River.

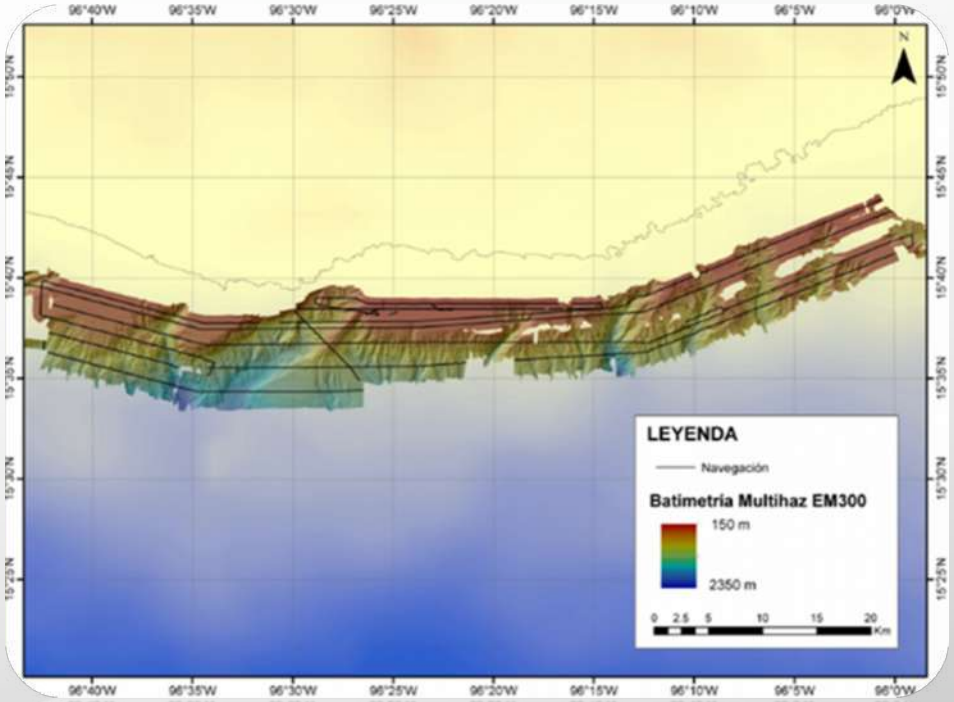
The figure shows the bathymetry and ship's course during the survey in the Bahía de Petacalco area. Approximately 134 nautical miles were sailed and 450.87 km² of bathymetric data were covered with a resolution between 5 m and 25 m. Depths up to 1400 m were observed.



Puerto Angel

For this site, navigation was carried out in three directions, looking for lines parallel to the coastline, with the aim of mapping the slope and continental shelf. In the western sector, they sailed in a NW-SE direction; in the center in a direction approximately E-W; and in the east in a SW-NE direction.

The figure shows the bathymetry and ship's course of the coast of the Puerto Angel area. Approximately 235 nautical miles were sailed and 622.2 km² of bathymetric data were covered with a resolution between 5 m and 30 m. Depths up to 2350 m were observed.

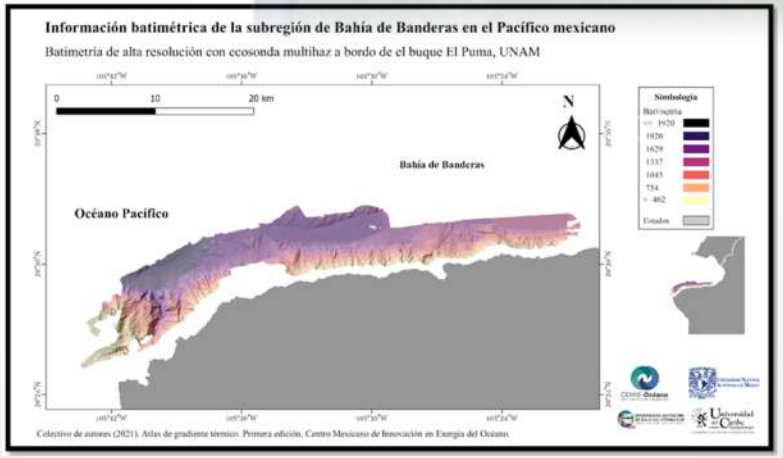


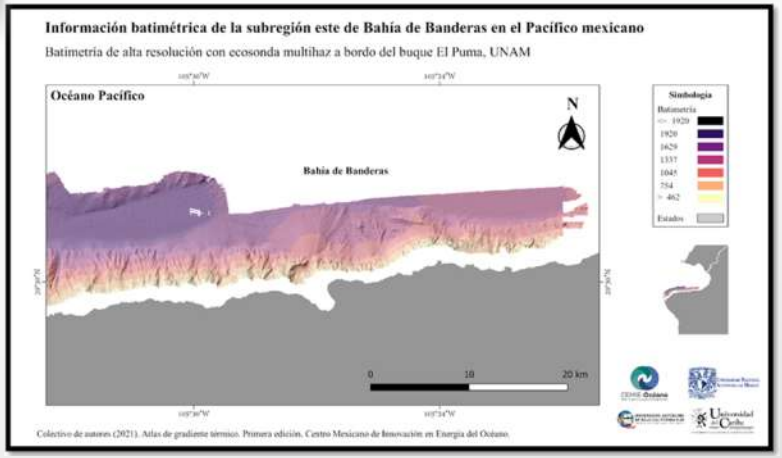
PAMEC 2024
Pan American Marine Energy Conference
Barranquilla, Colombia Jan 22-24, 2024

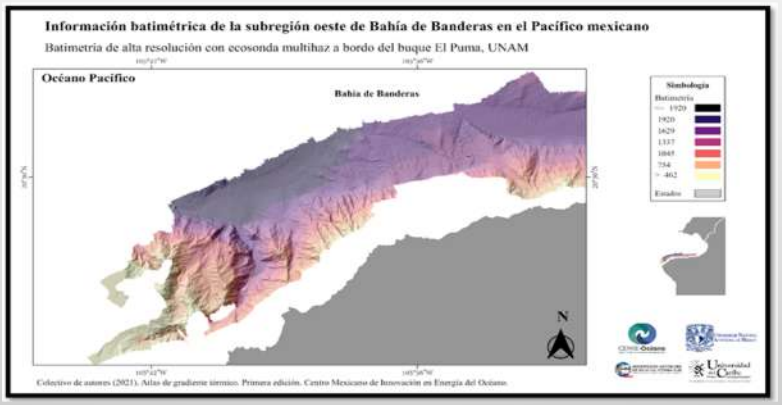
Bathymetry

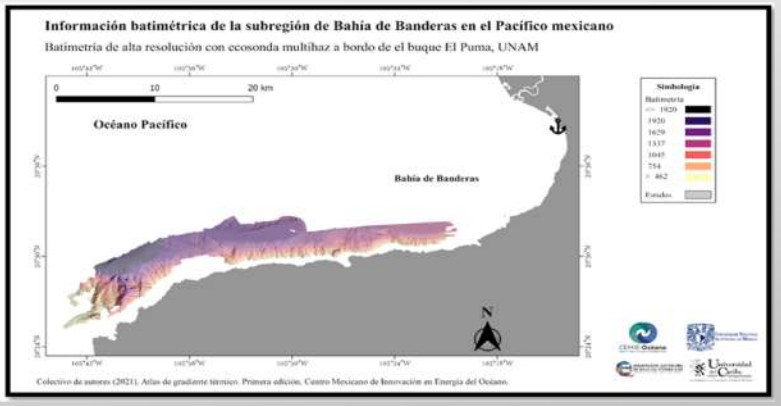
Bathymetric maps for each study area are shown in the next figures.

In **Bahía de Banderas** it is observed that the depths of interest (900m) for the implementation of **OTEC technology are between 3 and 4 km away from the coastline**. This would allow a decrease in the costs of piping and energy for pumping deep water, which is why it is a promising area, so detailed geomorphological studies must now be carried out to know the relevant engineering implementations for the hydraulic part.







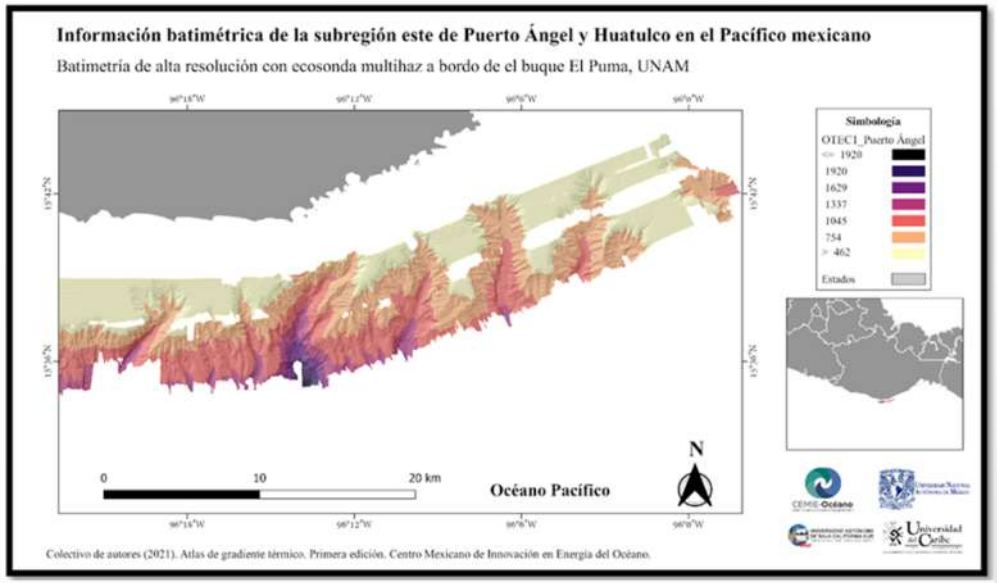


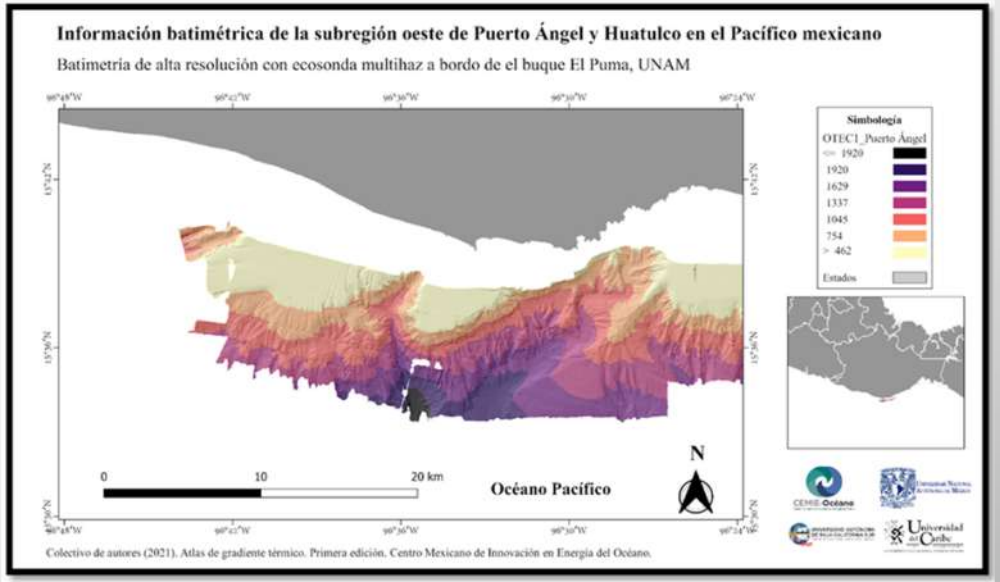
PAMEC 2024
Pan American Marine Energy Conference
Barranquilla, Colombia Jan 22-24, 2024

In the case of **Puerto Angel** and the surrounding areas, the shortest distance between the coastline and an a pumping zone (1000m) is located less than **4 km** off coast in front of Puerto Angel bay and in general average the isobath of 1000 m is 6.7 km from coast.

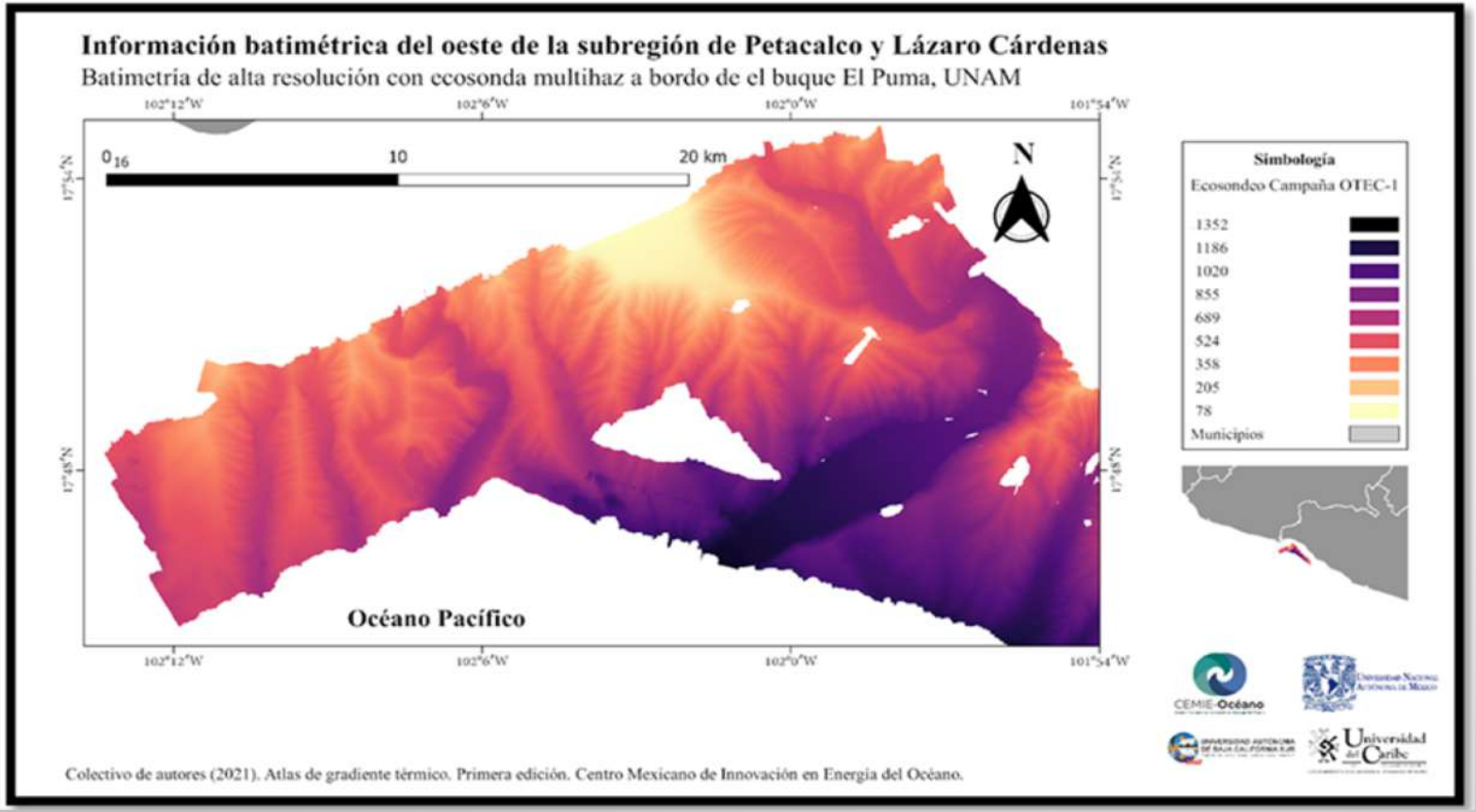
Although this represents a higher cost in terms of the length of the pipes and their assembly in the area compared to Bahía de Banderas, this area is of great interest because the thermal gradient is maintained throughout the year, despite weather seasonality.

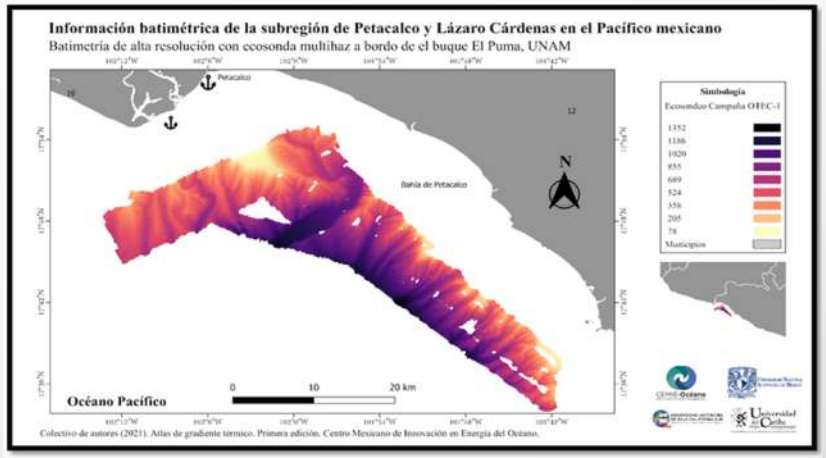
In this region a 20ºC thermal gradient can be obtained even above 1000 m depth in some areas, but the ideal way to maintain this temperature difference is to take the pipe to the highest depth.

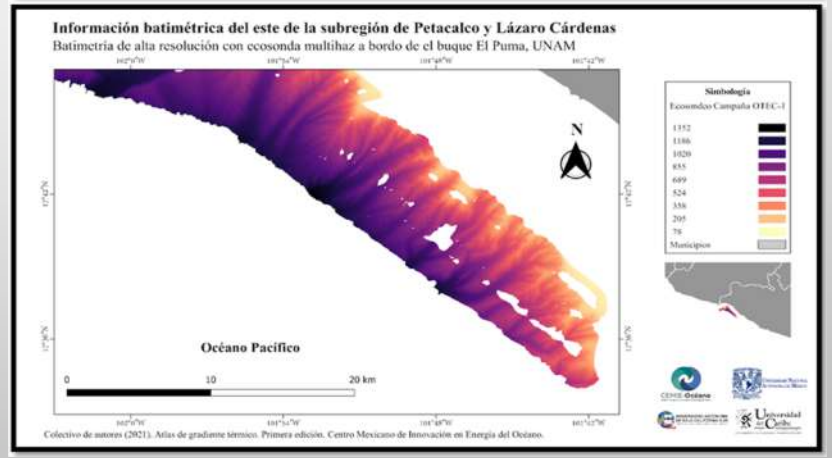




Finally, the area of **Petacalco**, Guerrero shows interesting areas where the closest distance to the coastline is around 21 km for the installation of pipes. However, a thermoelectric plant exists in this area so, in order to reduce costs for pipe installation, the hot water that comes out of the plant (approximately 60°C outlet) could be used as hot water and the surface water (between 24 and 26°C) as the colder water to be used in the plant's work cycle.







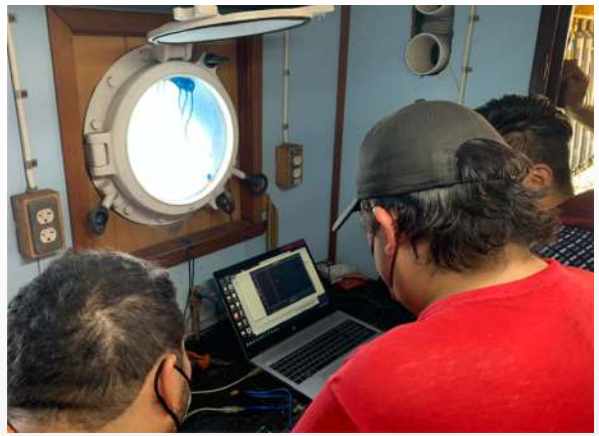
PAMEC 2024
Pan American Marine Energy Conference
Barranquilla, Colombia Jan 22-24, 2024

CONCLUDING REMARKS

During the OTEC-1 oceanographic cruise, bathymetry data were obtained to map the areas with the greatest potential for the installation of an OTEC-type ocean thermal energy plant. The depth within which the water reaches the appropriate temperature to generate a thermal gradient equal to or greater than 20°C with respect to surface water was identified in each zone. It was evidenced that these areas have a distance to the coastline less than that considered theoretically. From the bathymetric analysis, it was possible to determine the shortest distance from the coastline to the area where deep water reaches a thermal gradient equal to or greater than 20°C.

With the data obtained through the CTD cast, it was identified that the thermal gradient between surface water and deep water exceeds 20°C from a depth of 700 meters in Puerto Angel and Petacalco; and from 900 meters in Bahía de Banderas. On the other hand, the salinity profiles remained between 34 UPS - 35 UPS, with the halocline at 100 meters depth. The dissolved oxygen data showed that the greatest variability is found on the surface and, from approximately 120 meters deep, the concentrations begin to homogenize.

The three studied sites there are specific points with great potential for the installation of an OTEC plant. It is shown that, according to their bathymetry, **the areas with the shortest distance from the deep water intake to the coastline are:** (1) Bahía de Banderas, (2) Puerto Angel, and (3) Petacalco; and **according to their temperature**, the areas with the highest thermal gradient are: (1) Puerto Angel, (2) Petacalco and (3) Bahía de Banderas.



THANK YOU VERY MUCH, ANY QUESTIONS?

Alejandro García Huante alex_dodo@hotmail.com