Oceanic methane concentrations in three Mexican regions

Macías-Zamora, J. V.[1]*, Castro-Morales, K.[1,2], Burke, R.[3] and Rivera-Ibarra, F. S.[1]

[1]Instituto de investigaciones Oceanológicas, Km. 103 Carretera Tijuana-Ensenada
[2] now at: School of Environmental Sciences, University of East Anglia, Norwich, UK
[3] Ecosystems Research Division, National Exposure Research Laboratory, U.S. Environmental Protection Agency, Athens, Georgia, USA
*vmacias@uabc.mx

The role of methane as green-house gas

Methane (CH_4) is a important atmospheric gas with a potent role as an infrared trapping molecule. It is about 300 times more effective for trapping IR radiation than CO_2 on a molecule per molecule basis.
Methane concentration has been slowly increasing and it has duplicated its concentration over the last 200 years (Figure 1).

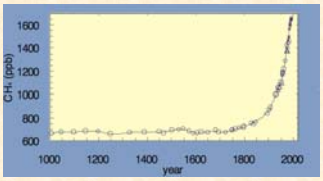


Figure 1. Atmospheric methane concentration vs. time (Lowe and Etheridge, 2001)

Methane in the oceans

Although the CH_4 contribution to the atmosphere by the oceans is relatively minor (< 2%; *Reeburgh, 2007*), it has a large uncertainty and it has been stated that highly productive coastal regions are responsible for as much as 75% of the total CH_4 oceanic emissions to the atmosphere (*Bange et al., 1998*).

Two facts make the study of CH_4 in the oceans a necessity. First, its concentration appears to be related to hypoxic and anoxic waters around the world. The distribution of waters with low oxygen is increasing due to anthropogenic processes (*Naqvi et al., 2009*).
Second, there is a risk of destabilization of the large deposits of CH_4 hydrates that are trapped in many oceans around the world (*Westbrook et al., 2009).*

There are other activities at regional scale that have proven to be of significant importance as contributors to the CH_4 budget such as (i.e. rice paddies and dairy farms), however its contribution to global budgets and new sources are still unknown.
The origin of CH_4 in the ocean is mainly from two sources: hydrothermal and biogenic. In surface ocean waters, there is a slight supersaturation of CH_4 with respect to atmospheric concentration. However, the origin and presence of CH_4 in oxygenated waters is still in debate, this is referred as to "the methane paradox". The presence of CH_4 in oxygenated waters has been explained after being released from anoxic microenvironments such as organic particulate matter, from digestive tracts of zooplankton and from its production in pore water from sediments, particularly in shallow basins.

Sampling areas

We have measured the dissolved methane concentration in three different areas in coastal waters off Baja California. Each area has a particular characteristic and, consequently, all the CH_4 fluxes are related to different sources and processes.

The study areas are:

1) The coastal Pacific region near the international border and from this area to Punta Banda, Baja California representing the Mexican sector of the Southern California Bight, SCBMex (Figure 2).

2) The IMECOCAL region, from the port of Ensenada to the south of Punta Santa Eugenia (Figure 3).

3) Northern part of the Gulf of California, sampled during the "sill's" 3rd leg campaign (Figure 4).

Sampling areas

A B

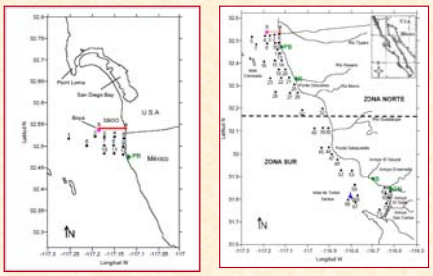


Figure 2. A) coastal region of the border area Mexico – USA during rainy event and, B) SCBMex after a rainy event.

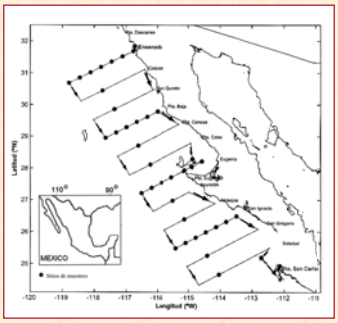


Figure 3. Sampling grid at the IMECOCAL region. Methane was collected during the months of April and July, 2006

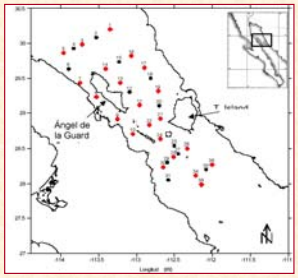


Figure 4. Sampling grid in the Gulf of California. Methane was collected during the months of April and July, 2004

Methods and Materials

Water samples were collected using Niskin bottles at different standard depths and transferred to amber glass bottles, poisoned with 1.5 ml of $HgCl_2$ to avoid biological activity. All samples were hermetically sealed and stored in a cool dark place until further analysis.

For CH_4 extraction, we used the gas-water phase equilibrium method (*McAulliffe, 1971; Capasso e Inguaggiato, 1998*) at standard temperature (25 °C) and pressure (1 atm). We used He zero grade as inert gas phase.

The quantification of CH_4 was carried out in a HP-6890 Gas Cromatograph equiped with FID detector.

An external calibration was used with 7 different gas concentration mixtures (CH_4:He) using a NIST traceable CH_4 standard (Scott-Marrin Inc.).

Results and discussions

The results of CH_4 supersaturation (%) at the border coastal area (Figure 5) after a rain event showed a higher values apparently from the high loads of organic material acting as anoxic micro environments.

A B C

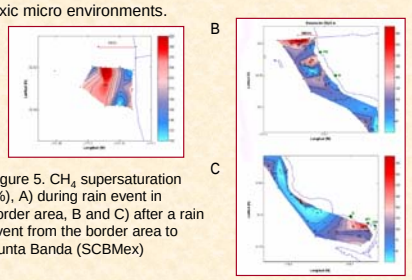


Figure 5. CH_4 supersaturation (%), A) during rain event in border area, B and C) after a rain event from the border area to Punta Banda (SCBMex)

In the Gulf of California, the largest concentration measured occurred around 50 m depth. Surprisingly, the Gulf of California water mass appears to transport the largest methane concentrations in the area in a southward direction (Figure 7).

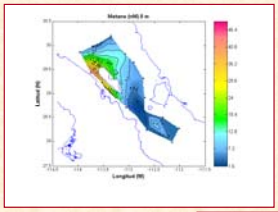
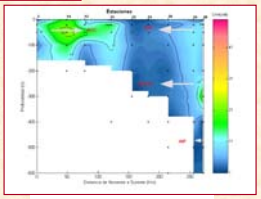


Figure 6. Surface CH_4 concentration (nM) in the sills region of the upper Gulf of California

Figure 7. Vertical section of CH_4 concentration (nM) along the sills region from north to south. The main water masses are shown:

AGC - Gulf of California water,
ASE - Subequatorial water,
ASSST - Sub superficial, subtropical water mass.
AIP - Pacific Intermediate water mass.



North South

Air-sea CH_4 fluxes comparison for the three zones (positive values are outflux from the ocean)

Border area	Area (km^2)	Mean CH_4 flux density ± 1 σ [a] (μmol m^{-2} d^{-1})	Mean CH_4 annual emissions ± 1 σ (10^3 kg CH_4 yr^{-1})
1st sampling period	12.9	138.2±3.6[b]	10.4±1.0
2nd sampling period, border area	15.7	32.4±3.3[c]	3.0±0.3
2nd sampling period (all stations)	120.7	22.6±2.3	15.9±1.6
August-Sept-04 Gulf of California		200.0	
April 2006 IMECOCAL sites		3.9±10.3	
July 2006 IMECOCAL sites		0.14±1.03	

Take home message

The largest CH_4 fluxes were measured at the Gulf of California. This is expected due to the larger productivity characteristic in this region. In the border area, CH_4 was used as a tracer of wastewater inflows to the coast. The constant particulate organic material discharged in the wastewater flows acts as suitable microenvironments for local CH_4 production in oxygenated waters of the region.

References

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