

## ANNUAL REPORT ON GEOTRACES ACTIVITIES IN MEXICO

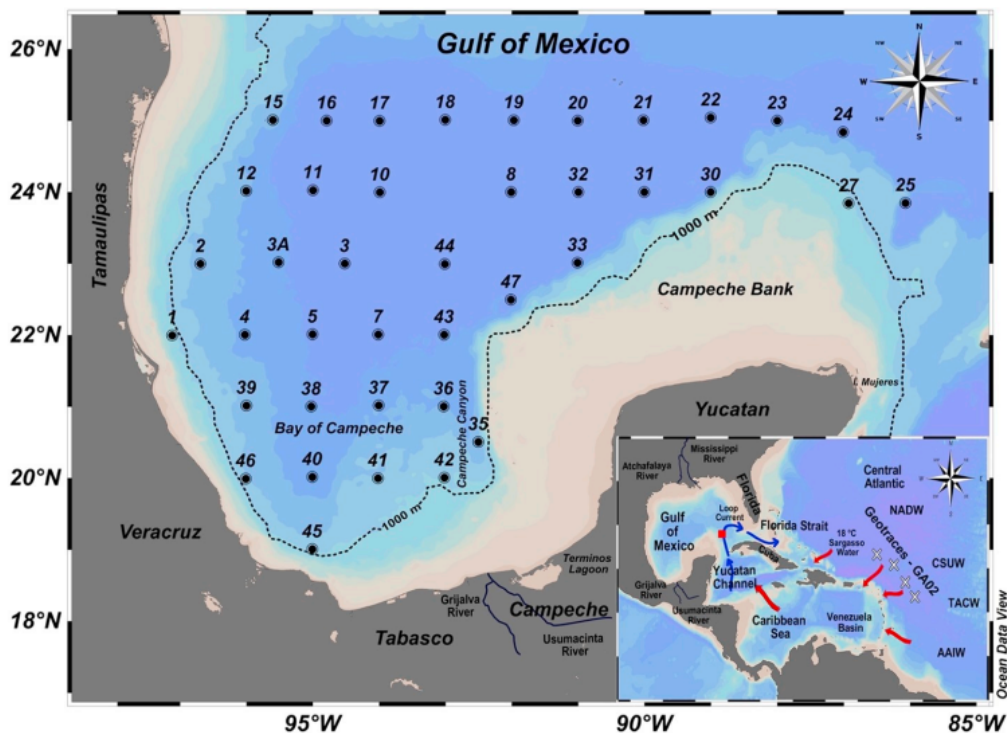
April 1st, 2015 to March 31st, 2020

### *GEOTRACES relevant scientific results*

- Cadmium is enriched in the upper 1000 m of the Gulf of Mexico (GoM)

Cadmium and phosphate were evaluated, for the first time, in the deep region of the Gulf of Mexico (Mexican side) and compared to data from selected stations of the GA02 GEOTRACES transect.

*Hernández-Candelario, I. del C., Lares, M.L., Camacho-Ibar, V.F., Linacre, L., Gutiérrez-Mejía, E. Pérez-Brunius, P. 2019. Journal of Marine Systems, 193, 27-45*



*Figure: Sampling stations for the XIXIMI-II cruise during July 2011 in the deep region of the GoM (bottom depth > 1000 m). The red arrows in the inset map represent the trajectory of the water masses entering the Caribbean Sea from the North Atlantic. The blue arrows represent the trajectory of the Loop Current. The red-filled square indicates the locations of the stations at the entrance of the GoM, and the white crosses indicate the stations of the GEOTRACES GA02 transect used for comparison (from the GEOTRACES Intermediate Data Product 2014, Mawji et al., 2015, Middag et al., 2018).*

Cadmium and phosphate showed an enrichment in the upper 500 m; however, the enrichment of Cd was more pronounced than that of phosphate as can be seen from the Cd-PO<sub>4</sub> relationship.

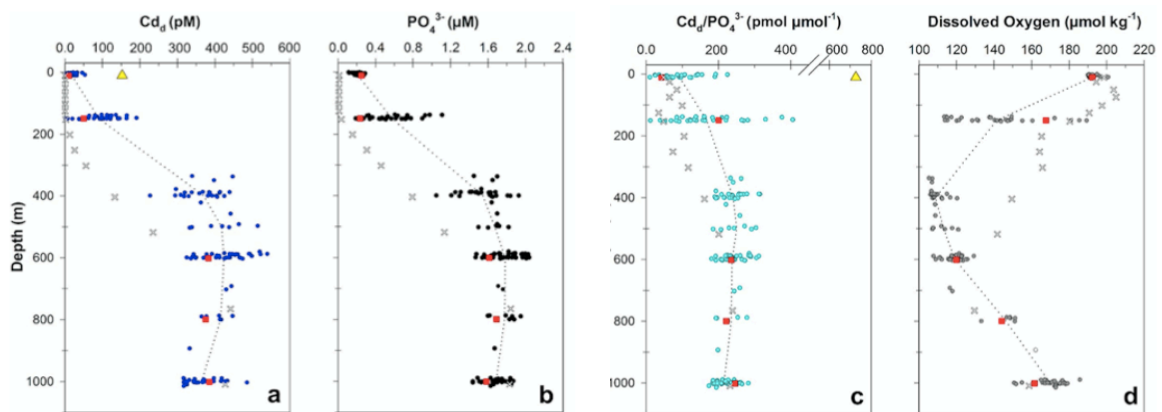


Figure: Vertical profiles of: a) dissolved cadmium concentrations ( $Cd_d$ ), b) phosphate concentrations ( $PO_4^{3-}$ ), c)  $Cd_d/PO_4^{3-}$  ratios, and d) dissolved oxygen concentrations in the GoM compared with average data from selected stations: inside the Loop Current (red-filled squares; 23-25 and 27; this study) and in the Western Central Atlantic (gray x-marks; PE28-PE31 GEOTRACES-GA02; Middag et al., 2018).

The variability exhibited by these variables was mainly controlled by biological and mesoscale processes.

### **GEOTRACES relevant cruises**

- After the 2010 Deepwater Horizon oil spill, Mexico realized that background information related to the southern (Mexican) part of the deep region of the Gulf of Mexico was needed to adequately evaluate the effects of the spill. Accordingly, since November 2010 Mexico have been conducting research cruises in this region to collect samples that were used for a variety of analyses, including dissolved V, Ni, Pb isotopes, Cd and nutrients, which were focused mainly on the Mexican deep zone (from the 1000 m isobath). The first three cruises (XIXIMI-1: November, 2010; XIXIMI-2: July, 2011; XIXIMI-3: February-March, 2013) were financed by the National Institute of Ecology and Climate Change (Instituto Nacional de Ecología y Cambio Climático), with the participation of the research institutions CICESE and IIO (Autonomous University of Baja California). Only dissolved V (XIXIMI-1 and -2) and V and Ni (XIXIMI-3) were included in the generated reports (<https://www.gob.mx/inecc/acciones-y-programas/cruceros-oceanograficos>). Dissolved Pb isotopes and Cd were also determined during the first two cruises, but were not included in the reports; however, the Cd data was later reported in an article (Hernández-Candelario et al., 2019, listed below) and the Pb isotopes measurements will be reported in a future article which is in preparation.
- In 2015, the research Consortium CIGoM was created to continue the geochemical, physical and biological studies previously carried out in the Gulf of Mexico, but this time with the participation of several Mexican research institutes (<https://cigom.org>). During this new research project, funded by the Fondo de Hidrocarburos de CONACyT/Secretaría de Energía, four additional cruises were conducted: XIXIMI-4

(August-September, 2015), XIXIMI-5 (June, 2016), XiXIMI-6 (August-September, 2017) and XIXIMI-7 (May-June, 2019). Among other variables, dissolved V, Ni, Cd, Pb and nutrients were included in this project.

- Cruise ExfiniFe conducted in Guaymas Basin, an oligotrophic region in the Gulf of California, aboard the *R/V Alpha Helix* from September 3 to 6, 2016, to carry out experiments on carbon fixation rates under different additions of dissolved Fe. This cruise was financed by the Mexican funding agency CONACyT.
- Cruise *R/V Oceanus* (May 18 to June 6, 2018) conducted to collect sediment cores from two stations off Mexico (Soledad and San Blas), several California stations in the Borderland Basins, and one on the Patton Escarpment. The cruise involved the collection of sediments, pore fluids, water samples and suspended particles to determine the relationship between U and Cr isotope compositions and the conditions under which they are deposited in continental margin sediments.

### ***New projects and funding***

- Implementation of oceanographic observation networks (physical, geochemical, ecological) for the generation of scenarios for possible contingencies related to the exploration and production of hydrocarbons in deep waters of the Gulf of Mexico. Project awarded to CIGoM (Mexico) and Coordinated by CICESE, with the collaboration of Centro de Investigación y de Estudios Avanzados, unidad Mérida, Universidad Nacional Autónoma de México, Centro de Ingeniería y Desarrollo Industrial, Universidad Autónoma de Baja California, Instituto Nacional de Ecología y Cambio Climático. PI: Juan Carlos Herguera (2015-2020).
- Atmospheric fluxes of bioactive metals and their solubility in the Gulf of California: a scene towards climate change. Multidisciplinary project financed by CONACyT (PI: Francisco Delgadillo Hinojosa; 2015-2020).
- Biological response of phytoplankton community to iron and vitamin B12 and their implication to the formation and persistence of Harmful Algal Blooms in Mexican coastal waters. Multidisciplinary project financed by CONACyT. PI: Mary Carmen Ruiz de la Torre (2017-2020).
- Mass balance of dissolved iron in Todos Santos Bay, Baja California: Biological responses of phytoplankton and biogeochemical implications. Project awarded by Universidad Autónoma de Baja California, Mexico. PI: Miguel Ángel Huerta Díaz (2018-2020).

### ***GEOTRACES-relevant publications***

- Valdivieso-Ojeda, J.A., Huerta-Diaz, M.A., Delgadillo-Hinojosa, F. (2020). Non-conservative behavior of dissolved molybdenum in hypersaline waters of the Guerrero Negro saltern, Mexico. *Applied Geochemistry*, 115, 104565. Doi: <https://www.x-mol.com/paperRedirect/1234993615158996992>
- Hernández-Candelario, I. del C., Lares, M.L., Camacho-Ibar, V.F., Linacre, L., Gutiérrez-Mejía, E. Pérez-Brunius, P. (2019) Dissolved cadmium and its relation to phosphate in the deep region of the Gulf of Mexico. *Journal of Marine Systems*, 193, 27-45. Doi: <https://doi.org/10.1016/j.jmarsys.2019.01.005>
- Batista Cruz, R.Y., Peiffer, L., Weber, B., Herguera García, J.C., Liotta, M., González Fernández, A., Barragan, R.M., Kretschmar, T.G. (2019). Geochemical characteristics of pore waters from sediment cores of the Wagner Basin, Gulf of California. *Applied Geochemistry*. Doi: <https://doi.org/10.1016/j.apgeochem.2019.104467>

- Acosta-Leal, M.L., Shumilin, E., Mirlean, N., Lounejeva-Baturina, E., Delgadillo-Hinojosa, F., Sánchez-Rodríguez, I., Borges-Souza, J.M. (2018). Intertidal geothermal hot springs as a source of trace elements to the coastal zone: A case study from Bahía Concepción, Gulf of California. *Marine Pollution Bulletin*, 128, 51-64. Doi: <https://doi.org/10.1016/j.marpolbul.2018.01.007>
- Muñoz-Barbosa, A., Segovia-Zavala, J.A., Huerta-Díaz, M.A., Delgadillo-Hinojosa, F., Torres-Delgado, E.V., Lares, M.L., Marinone, S.G., Gutiérrez-Galindo, E.A. (2017) Atmospheric iron fluxes in the northern region of the Gulf of California: Implications for primary production and potential Fe limitation. *Deep-Sea Research Part I*, 129, 69-79. Doi: <http://dx.doi.org/10.1016/j.dsr.2017.10.008>
- Félix-Bermúdez, A., Delgadillo-Hinojosa, F., Huerta-Díaz, M.A., Camacho-Ibar, V., Torres-Delgado, V. (2017). Atmospheric inputs of iron and manganese to coastal waters of the southern California Current System: Seasonality, Santa Ana Winds, and biogeochemical implications *Journal of Geophysical Research*. 122, 1-25. Doi: <https://doi.org/10.1002/2017JC013224>
- Gutiérrez-Mejía, E., Lares, M.L., Huerta-Díaz, M.A., Delgadillo-Hinojosa, F. (2016) Cadmium and phosphate variability during algal blooms of the dinoflagellate *Lingulodinium polyedrum* in Todos Santos Bay, Baja California Mexico. *Science of the Total Environment*, 541, 865-876. Doi: <http://dx.doi.org/10.1016/j.scitotenv.2015.09.081>
- Delgadillo-Hinojosa, F., Camacho-Ibar, V., Huerta-Díaz, M.A., Torres-Delgado, V., Pérez-Brunius, P., Lares, L., Marinone, S.G., Segovia-Zavala, J.A., Peña-Manjarrez, J.L., García-Mendoza, E., Castro, R. (2015) Seasonal behavior of dissolved cadmium and Cd/PO<sub>4</sub> ratio in Todos Santos Bay: A retention site of upwelled waters in the Baja California Peninsula, Mexico. *Marine Chemistry*, 168: 37-48. Doi: <http://dx.doi.org/10.1016/j.marchem.2014.10.010>
- Arcega-Cabrera F.E. del R., Garza-Pérez R., Noreña-Barroso E., Ocegüera-Vargas I. (2015) Impacts of geochemical and environmental factors on seasonal variation of heavy metals in a coastal lagoon Yucatan, Mexico. *Bulletin of Environmental Contamination and Toxicology* 94, 58-65. Doi: <https://doi.org/10.1007/s00128-014-1416-1>

### **Completed GEOTRACES theses**

- Hernández-Candelario, I. del C. (2019) Biogeoquímica del cadmio en la región profunda del Golfo de México. (PhD thesis – CICESE) <https://biblioteca.cicese.mx/catalogo/tesis/ficha.php?id=25343>
- Reyes-Bravo, M.M. (2019). Distribución horizontal y vertical de cobre disuelto en el Golfo de México. (MSc thesis - UABC)
- Félix-Bermúdez, A. (2018). Balance estacional de Fe y su interacción biológica en la Bahía de Todos Santos; un sistema con características retentivas, influenciado por la Corriente de California y surgencias costeras. (PhD thesis - UABC).
- Muñoz-Barbosa, A. (2017). Flujo atmosférico de hierro en el Golfo de California. (PhD thesis - UABC).
- Gutiérrez-Mejía, E. (2015) Biogeoquímica de cadmio y fosfato y su relación con el dinoflagelado *Lingulodinium polyedrum* en la Bahía de Todos Santos, Baja California, México. (PhD thesis - UABC).
- Andrade-Hernández, S. (2020). Distribución vertical de hierro disuelto y su relación con la biomasa fitoplanctónica en la región central del Golfo de California. (BSc thesis - UABC).
- Pérez-Mendieta, R. (2019). Variación espacio-temporal del aporte atmosférico de manganeso hacia la capa superficial del Golfo de California. (BSc thesis - UABC).

***GEOTRACES presentations in international conferences***

- Muñoz-Barbosa A., Segovia-Zavala J.A., Delgadillo-Hinojosa F., Huerta-Diaz M.A., Torres-Delgado E.V., Gutiérrez-Galindo E.A. (2015) Limitación esporádica por hierro: una posibilidad en la región norte del Golfo de California. X Congreso de Ciencias del Mar-Mar Cuba, La Habana, Cuba, November 16-20, 2015.
- Huerta-Diaz, M.A., Valdivieso-Ojeda, J.A., Delgadillo-Hinojosa, F., Segovia-Zavala, J.A. (2015) High molybdenum enrichments in the hypersaline region of Guerrero Negro, Baja California Sur, Mexico. ASLO Meeting 2015, Granada, Spain, February 22-27, 2015.

***Contributors to the report***

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