Quarterly Progress Report

March 2025

Project Title

Sediment Mercury Concentrations in the Closed Area of Lavaca Bay and the Risk to Wildlife from Mercury Remobilization During Dredging

Contract # 041

Submitted to

Matagorda Bay Mitigation Trust

Principal Investigator

Jessica Dutton, Ph.D.

Department of Biology, Texas State University, San Marcos, TX

Co-Principal Investigator

Lindsay Prothro, Ph.D.

Department of Physical and Environmental Sciences, Texas A&M University – Corpus Christi.
Corpus Christi, TX

Prepared by

Jessica Dutton, Ph.D.

Project Summary

The Closed Area of Lavaca Bay is a mercury (Hg) Superfund site that is undergoing long-term environmental monitoring. The proposed Matagorda ship channel expansion project will dredge in the Closed Area and could remobilize Hg stored in sediment back into the bay. This study will investigate how sediment Hg concentrations vary with depth throughout the proposed dredging area and undertake lab-based toxicity and bioaccumulation experiments to determine whether the Hg-rich sediment is toxic to benthic organisms. Agencies can use the data to make informed decisions about how to dredge and dispose of the Hg-rich sediment to minimize its environmental impact.

Project Goals and Objectives

The goal of this project is to investigate sediment Hg concentrations in the Closed Area of Lavaca Bay (with a focus on the area that will be dredged) and determine whether sediment Hg concentrations are high enough to pose a threat to the health of benthic organisms if Hg is remobilized during the proposed dredging activities. This study can be broken down into six objectives:

Objective 1: Investigate how THg concentrations change with sediment depth to determine 1) at what depth the greatest THg concentrations are found; 2) how thick the Hg layer is; and 3) how THg concentrations vary spatially throughout the Closed Area.

Objective 2: Map the bay floor and investigate the relationship between sediment THg concentrations and sediment characteristics (grain size and organic matter content).

Objective 3: Use radioisotopes (^{210}Pb and ^{137}Cs) to create sediment age-depth profiles and determine sedimentation rates.

Objective 4: Speciate THg in the surface and Hg layer sediment to determine the MeHg concentration and percent MeHg and determine the bacterial composition of the sediment.

Objective 5: Calculate how much Hg could potentially be released into Lavaca Bay from the proposed dredging activities.

Objective 6: Determine whether sediment Hg concentrations are high enough to cause toxicity to benthic organisms (polychaete worms, amphipods, bivalves, gastropods) using laboratory-based toxicity tests and bioaccumulation experiments.

Project Update

This quarter we completed work on Objectives 1, 2, 3, 4, and 6.

<u>Objective 1</u>

All sediment cores for this project have been collected. 32 cores were collected in June 2023 and 28 cores were collected in May 2024 (Fig. 1). All the cores have been sectioned into 1 cm or 2 cm depth intervals and each depth interval has been subsampled for different analyses.

Figure 1. 2023 and 2024 sediment core collection locations. The yellow pins show the location of each core.

Out of the 60 cores, Hg analysis has been completed for 76.7% (n = 46) of them. The breakdown by year is as follows:

2023

- Number of cores subsampled for the different analyses = 32
- Number of cores that have been freeze dried = 28
- Number of cores that have had the Hg concentration measured in each depth interval = 28

2024

- Number of cores subsampled for the different analyses = 28
- Number of cores that have been freeze dried = 19
- Number of cores that have had the Hg concentration measured in each depth interval = 18

The Hg concentration in each sediment sample (190 – 220 mg) was measured using a Direct Mercury Analyzer (DMA-80; Milestone Inc., Shelton, CT) which utilizes thermal decomposition, amalgamation, and atomic absorption spectrophotometry. One set of quality control, including a blank, certified reference material (either MESS-4 marine sediment; PACS-3 marine sediment; DORM-5 fish protein; or ERM CE-464 tuna), and duplicate sample was included with every 10 samples analyzed.

<u>Objective 2</u>

CHIRP profiling

The two sets of CHIRP profiles that were collected in June 2024 from greater Lavaca Bay and from the Superfund site (Closed Area) in Lavaca Bay (Fig. 2) have undergone basic processing including bandpass filtering, automatic gain control, and preliminary depth conversion. Although these profiles require further refinement and noise reduction before being fully accurate and publication-worthy, preliminary interpretations of persistent sub-bottom reflections can be made at this time. The lithologic changes noted in the original core descriptions from the cores collected in 2023 and 2024 appear to be reflected in the CHIRP data, allowing tentative regional correlations to be conducted at this time, which will later be confirmed by detailed grain size analysis.

Key findings:
The Pleistocene surface is an erosional unconformity created by downcutting river channels during a sea level lowstand, and it is clearly visible at depth in the greater Lavaca Bay CHIRP profiles. It is marked by a strong acoustic impedance contrast created by the lithologic transition from the Pleistocene coastal plain clay deposits, below, to sandy bayhead delta deposits above, which show rapid landward migration as sea-levels rose following the last glacial period. The Pleistocene surface shallows toward the edges of Lavaca Bay; on the western margin, it rises to the level of the ship channel base, and on the eastern margin, the Pleistocene subcrops at even shallower depths in Cox and Keller bays. Although none of our long Lavaca Bay Chirp profiles directly connect with our Closed Area profiles, the upward trajectory of the Pleistocene surface in the direction of the Closed Area suggests that it could be captured in some of our cores there. Indeed, there is a relatively strong subsurface reflection in most of the Closed Area profiles, and it appears to correspond to a transition in nearby cores from clay or mud at their base to a more sand-rich layer above. However, further study is required to determine if this clay truly represents the Pleistocene surface or something younger—we will look to the results of the detailed grain size analysis and geochronological work for confirmation.

Another prominent surface appears approximately 3 – 5 m below the bay floor directly on either side of the ship channel, and shallows as it extends up to 2 km away from the ship channel before pinching out at the seafloor. The wedgelike feature that overlies this surface displays an internal fabric that demonstrates both subparallel draping reflections and packages of sigmoidal reflections that build outward from the channel. We interpret these features as levee complexes or overbank deposits built from continuous remobilization of sediment in the vicinity of ship traffic and/or routine dredging.

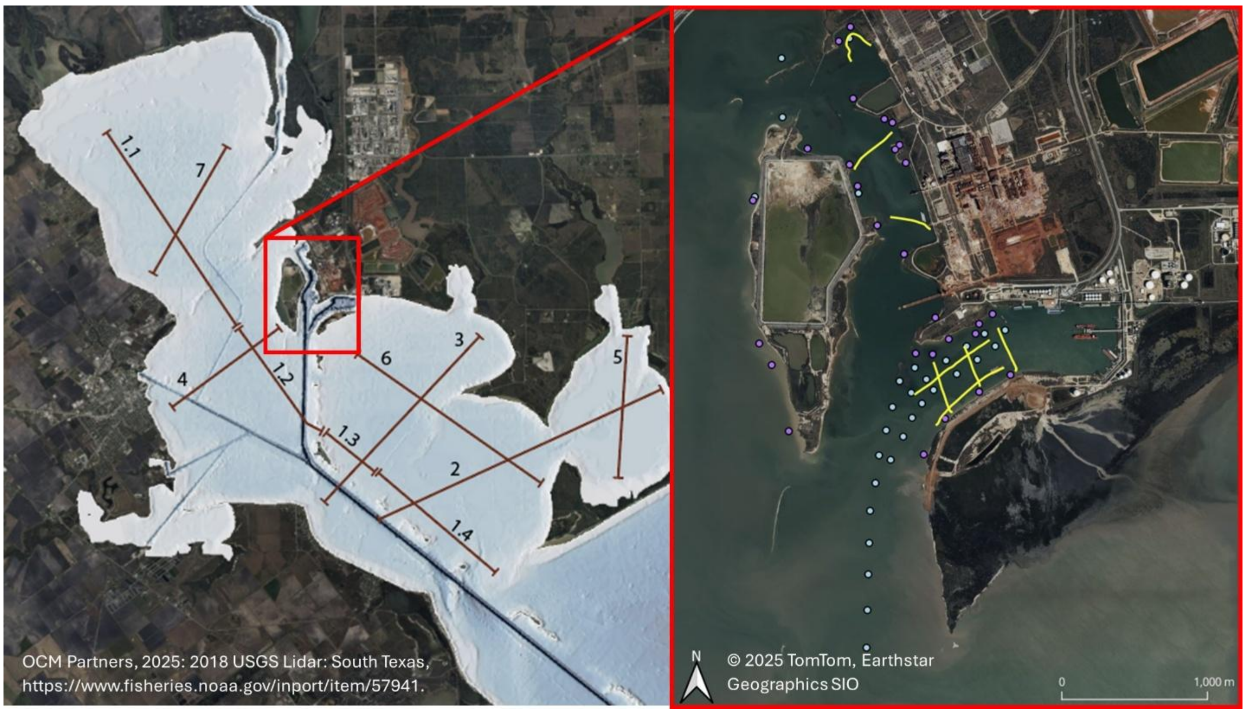

Figure 2. Location of greater Lavaca Bay CHIRP profiles (left) and Closed Area (Superfund site) CHIRP profiles displayed with 2023 core locations in blue and 2024 core locations in purple (right).

Grain size analysis

Work on this part of the project was behind schedule. To catch up, PI Dutton's group took over this part of the project in January 2025 and started completing the basic grain size analysis on all the 2023 and 2024 cores starting in early February 2025. To date, PI Dutton's group has completed grain size analysis on 19 cores collected in 2023 and 17 cores collected in 2024. Based on current productivity, we should be caught up by the due date for the next quarterly report (June 2025).

Basic grain size analysis was completed by washing sediment through a 63 µm mesh sieve to determine the percent coarse (sand and larger sized particles) versus clay (silt and clay sized particles). Between 5 and 5.5 g of dried sediment was rehydrated for 24 hours and washed through a 63 µm mesh sieve, after which the retained coarse fraction was dried at 105°C for 18 to 24 hours and weighed. Samples that had particles > 2 mm (e.g., gravel, small shells, or shell fragments) were passed through a 2 mm mesh sieve and the sediment retained in the mesh weighed. The weight of the coarse fraction (< 2mm) was then divided by the weight of the bulk sediment prior to rehydration to determine the percent coarse fraction. The percentage difference between the coarse fraction and 100 was the percent fine grain sediment. Quality control included a duplicate sample for one depth interval in each core.

Organic matter content

To date, organic matter content has been determined for 16 cores collected in 2023 and 16 cores collected in 2024.

The organic matter content in each depth interval from each core is determined using the loss-on-ignition (LOI) method. Freeze dried sediment is heated in an oven at 105°C for 1 hour to make sure there is no residual moisture. 3 – 3.5 g of weighed sediment is then burned in a muffle furnace at 550°C for 4 hours and allowed to cool overnight, after which it is weighed again. The percent organic matter content is then calculated using the follow equation:

$$\% \text{ organic matter content} = [(\text{weight}_{105} - \text{weight}_{550})/\text{weight}_{105}] * 100$$

where weight_{105} is the sample weight prior to burning and weight_{550} is the sample weight after burning. Quality control included a duplicate sample for two depth intervals in each core.

<u>Objective 3</u>

The sediment dating component of the project was also behind schedule and PI Dutton's group is now completing the work. All depth intervals from two cores (16 and 25) will be shipped to the Science Museum of Minnesota for ^{210}Pb and ^{137}Cs dating during the first week of April 2025. Prior to shipment, the salt will be removed from all samples, and the samples freeze dried, powdered, and packaged into individual tubes. Up to another eight cores will also be sent for analysis over the next few months.

<u>Objective 4</u>

Sediment microbial community

The sediment microbial composition is being investigated in 10 cores collected in 2023. For each core, depending on the thickness of the Hg layer, between five and 11 different depths have been investigated. In total, 68 samples have been included in the study and each sample has been analyzed twice. The forward primer sequence data has been collected, and the reverse primer sequence data collection should be finished within two weeks. The current analyses with fragments generated from the forward primer show an extreme diversity of sequences, including a tremendous number of our target organisms, the deltaproteobacteria. Abundances of most of the target sequences are below 1%. The reverse primer sequences will reduce the diversity by correcting large uncertainties and misreads at the sequence ends.

Mercury speciation to determine percent methylmercury in the sediment

43 of the samples used to determine the sediment microbial community composition have been shipped to the USGS Mercury Research Lab in Madison, WI to determine the methylmercury (MeHg) concentration. The MeHg analysis should be completed by May 2025 and PI Dutton plans to go the USGS lab to observe the analytical procedure.

<u>Objective 6</u>

Now that the Hg concentrations have been measured in most of the cores, PI Dutton's group have started planning the laboratory-based toxicity tests and bioaccumulation experiments. These experiments will start in June or July 2025.

Goals for the Next Quarter

- Continue to measure the Hg concentration in the remaining sediment cores (Objective 1)
- Correlate cores to CHIRP profiles to determine which lithologic intervals are clearly resolvable in the CHIRP data and refine the depth conversion on CHIRP profiles through calibration with major lithologic changes in cores to more accurately determine the spatial extent of clay and shell hash layers (Objective 2)
- Continue the grain size analysis and organic matter content analysis (Objective 2)
- Prepare and ship samples for ^{210}Pb and ^{137}Cs dating (Objective 3)
- Finish the sediment microbial community analysis (Objective 4)
- Complete the MeHg analysis (Objective 4)
- Finalize the experimental design and purchase supplies for the laboratory-based toxicity tests and bioaccumulation experiments (Objective 6)