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Regional Environmental Monitoring and Assessment Program

Executive Summary

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Executive Summary

The Regional Environmental Monitoring and Assessment Program (R-EMAP) Study of Galveston Bay, Texas addresses the ecological health of this estuary by identifying benthic community structure, measuring toxicity of sediments, and measuring concentrations of various pollutants in the sediments. The R-EMAP Study of Galveston Bay was proposed after the EPA's 1991 EMAP Study of the Louisianian Province estuaries identified Galveston Bay as an area of concern. The sampling design and ecological indicators employed for the R-EMAP Study of Galveston Bay are based on the EMAP concept (a locally intensified EMAP sampling grid was used), but they are limited to one sampling event.

The purpose of this study was to characterize the condition of Galveston Bay as a whole, characterize conditions of four small bays in the Galveston Bay Complex, and determine the impacts of marinas.

For comparison of the main body of Galveston Bay with other systems and the Louisianian Province as a whole, twenty-nine randomly selected sites were chosen to represent 1305 square kilometers of surface area of Galveston Bay. Random sites are located in Galveston Bay (GB), Trinity Bay (TB), East Bay (EGB), and West Bay (WGB). In addition, a random sample was taken for each of four important small bays associated with Galveston Bay: Clear Lake (CL), Dickenson Bay (DKL), Moses Lake/Dollar Bay (MLDL), and Offat's Bayou (OB). Also, five marina sites (MA) were chosen to determine local marina influences (see Map 1). This study does not include an analysis of conditions in the upper Houston Ship Channel, the Trinity River, or any other major tributaries. The Louisianian Province EMAP Study consisted of 96 sites which represented 25,725 square kilometers of estuarine area. The Louisianian Province extends along the Gulf Coast from Anclote Anchorage, Florida to the Rio Grande, Texas.

A comparison of the EMAP Study of the Louisianian Province with the R-EMAP Study of Galveston Bay did provide insight into the differences between Galveston Bay and its Small Bay & Marina Sites, and the entire Louisianian Province. These comparisons revealed that the EMAP results were useful as a screening tool to determine which systems had toxic pollutants or biological impairment and therefore, should be studied in more detail.

The Sediment Quality Triad approach was used in this study to differentiate between degraded sites and undegraded sites. The Sediment Quality Triad consists of three components: Benthic Community Structure, Sediment Chemistry, and Sediment Toxicity. For this study, a degraded site is defined as a site which has at least two of the Sediment Quality Triad Components indicating degradation.

Benthic Community Component

Several metrics were used to determine the benthic community health. The Benthic Index (Engle and Summers, in press), the Benthic Diversity Index (the Shannon-Weiner Index), number of species per site and abundance of amphipods at each site proved useful in demonstrating that communities living in contaminated sediments had a community structure indicating poor conditions. The proportions of the two indices and the number of species in the Galveston Bay area were higher or similar to the proportions reported for the Louisianian Province in the 1993 EMAP Study. In contrast, amphipod occurrence in Galveston Bay sediments was significantly lower than in the entire Louisianian Province sediments. Small Bay and Marina Sites in Galveston Bay had no amphipods present and had much lower index values relative to Galveston Bay and the Louisianian Province sites. A degraded Benthic Component was found at 7 of 29 sites in Galveston Bay, and 8 of 9 Small Bay & Marina Sites (see Table 13).

Sediment Toxicity Component

Ampelisca abdita (the tube dwelling amphipod), and *Mysidopsis bahia* (a mysid shrimp) were used as the lab organisms to test toxicity. Toxicity was not seen when using mysid shrimp as a test organism, but toxicity was reported when using amphipods. Sites with toxic sediments included: Offat's Bayou, Dickenson Lake, and West Galveston Bay near Swan Lake (see Table 13). Toxicity was present at 3.5% of Galveston Bay area and 22% of Small Bay and Marina sites. Toxicity could not be associated with any of the measured parameters including presence or absence of natural amphipod populations present at each site. The only apparent similarity between sites displaying toxicity is that all three sites are located in the same general area of the bay.

Toxicity results revealed a low occurrence of acute toxicity in Galveston Bay sediments.

Sediment Chemistry Component

Sediment contaminants analyzed included 44 individual Polynuclear Aromatic Hydrocarbons (PAHs), High Molecular Weight PAHs and Low Molecular Weight PAHs, 20 polychlorinated biphenyl congeners, 24 pesticides (including DDT and its derivatives), 15 heavy metals, and 3 forms of butyltin. Sediment grain size, percent silt-clay content, total organic carbon, and acid volatile sulfides also were measured.

The contaminants were compared to established criteria including NOEL, ERL, and ERM. The range-low (ERL) criteria was established using the lower 10^{th} percentile of effects data for the metal or chemical. Concentrations equal to or above the ERL, but below the ERM, represent a possible-effects range within which effects would occasionally occur. The range-high (ERM) criteria was established using the 50^{th} percentile of the effects data. The concentrations equal to or higher than the ERM value represent a probable-effects range within which effects would frequently occur (Long, et al., 1995). The concentrations equal to the NOEL value is the highest level at which observed effects occur (MacDonald, 1992). In addition, anthropogenic enrichment of metals was measured. Enrichment was determined using regression equations for each metal against aluminum concentrations in the sediments.

In Galveston Bay, arsenic, copper, lead, nickel, and zinc exceed the ERL but not the ERM criteria at one or more sites sampled (Tables 2 & 3, Figure 21). NOEL values, but not ERL values, are exceeded at one or more sites for arsenic, chromium, lead, mercury, and zinc (Table 4). Sites with the most metals contamination include Offat's Bayou, Clear Lake, Moses Lake/Dollar Bay, and two Marina sites (Table 2, Maps 5 and 6). All of these sites are Small Bay and Marina sites, which were chosen, not randomly selected, so they are not included in comparisons of Galveston Bay with the Louisianian Province 1993 EMAP sampling area. However, several of the randomly sampled sites in Galveston Bay did have exceedences for arsenic, chromium, nickel, and zinc. Exceedences of chromium, copper, lead, nickel, and zinc for each site were almost always found at sites where the above metal concentrations, when compared to aluminum concentrations, indicated anthropogenic inputs.

The Galveston Bay area (represented by the 29 randomly chosen sites) has high chromium and nickel values distributed across a larger area than would be expected when compared to the entire Louisianian Province area. The percent of area with exceeded values in Galveston Bay were compared to the percent of area with exceeded values in the entire Louisianian Province as reported in Macauley, et al., 1995. Arsenic distributions in Galveston Bay were lower than expected when compared to the Louisianian Province, while zinc distributions were similar. Copper values above ERL values were found only at marina sites and in Offat's Bayou, but not in the randomly sampled area representing Galveston Bay, nor in the entire Louisianian Province area.

Tributyltin (TBT) is toxic to marine animals and is used in anti-fouling paint for boats, buoys, and

docks. TBT has been restricted for use in recent years to only larger boats in an effort to reduce the amount of TBT contamination in the marine environment. Values exceeding 1.0 ppb in the sediments are used as a screening criterion based on studies by Laughlin, et al. (1984). TBT concentrations are higher in Galveston Bay sediments than expected with values greater than 1.0 ppb occurring in 52% of the area, compared to 31% of the total Louisianian Province area. A significant relationship exists between butyltin concentrations in the sediments and butyltin concentrations in the water column.

Sites with high Dieldrin and Endrin concentrations in the sediments are located in upper Galveston Bay, Clear Lake and upper Trinity Bay.

For the Louisianian Province, Dieldrin and Endrin were found to exceed the ERL guidelines at 57% and 18%, respectively, of EMAP sites. Both Dieldrin and Endrin concentration exceedance by area are lower in Galveston Bay compared to the Louisianian Province. Dieldrin and Endrin ERL values were exceeded at 17% and 5% respectively in Galveston Bay, and 33% and 0% for the Small Bay and Marina sites. No other pesticides (including DDT and its associated metabolites) exceeded ERL values for either study.

Polynuclear Aromatic Hydrocarbons (PAHs) were examined for exceedance of NOEL, ERL, and ERM screening values. PAHs exceeding ERL values in Galveston Bay include only C3-fluorene at site TB5 in Trinity Bay where several active oil wells are located. PAHs exceeding NOEL, but not ERL, values in Galveston Bay include Acenaphthylene and High Molecular Weight PAHs only found at site TB5 in Trinity Bay. Distributions of Low Molecular Weight PAHs and High Molecular PAHs for Galveston Bay show that three sites have PAHs that are considerably higher than at the other sites in the Galveston Bay area.

C3-fluorene exceeded ERL criteria in 3% of Galveston Bay, which is similar to exceedences found in the entire area of the Louisianian Province. Also, the NOEL value for high Molecular Weight PAHs was exceeded at site TB5. In the Louisianian Province, only C3-fluorene ERL values and High Molecular Weight PAHs ERL values were exceeded.

Polychlorinated Biphenyl (PCB) concentrations in Galveston Bay did not exceed the sediment quality low-level ecological effects screening value of 22.7 ppb. In addition, only 1% of the Louisianian Province area had exceedences of PCBs in the sediments.

The major variables used to determine degraded sediment chemistry in Galveston Bay included metals, butyltins, PAHs, pesticides other than DDTs, and silt-clay content. These variables were compressed into one factor using Principal Components Analysis (PCA). Sites with the highest compressed significant environmental factor values for sediment chemistry include Offat's Bayou, Moses Lake/Dollar Bay, Clear Lake, four of the Marina sites, and two sites near large brine discharges in the Trinity Bay area (TB5 and GB6). Sites with the lowest significant environmental PCA factor values include GB5 and TB6 which are both areas with the highest percentages of sediment grain sizes representing sand. These sites could be areas of low deposition and/or high scour.

Site Degradation

For this study, a degraded site is defined as a site with at least two of the Sediment Quality Triad Components indicating degradation. A marginal site is defined as a site with a benthic index value from 4.0 to 5.1 (which represents a marginal benthic component) and with a degraded sediment chemistry component. Degraded and healthy site values were determined using Cluster Analysis. Heavy metal concentrations greatly influenced the determination of degraded sites for the Sediment Chemistry Component of the Triad.

The most degraded areas in the Galveston Bay Complex include seven Small Bay and Marina

sites and five randomly chosen sites in the open bay: Offat's Bayou (OB), Clear Lake (CL) and its marina sites, Lafayette Landing and South Shore (MA3 and MA4), Upper Galveston Bay at the Houston Yacht Club (MA2), Upper Galveston Bay near the upper Houston Ship Channel (GB1), Upper Galveston Bay near Smith Point (GB7), Moses Lake/Dollar Bay (MLDL), Dickenson Lake (DKL), mid-Trinity Bay (TB5) and Trinity Bay near the river mouth (TB8, TB9), and mid-East Galveston Bay (EGB5).