Session V-Room A3

THE IMPACTS OF ASSIMILATIVE CAPACITY OF RESERVOIRS ON COASTAL INFLOWS

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Lake Livingston, a multipurpose reservoir, is situated amongst mixed pine and hardwood forests in southeast Texas. In 1969 the reservoir was created when the Lake Livingston Dam was constructed. Due to impoundment, the Trinity River was divided into two sections; the Upper and Lower Trinity. The goal of the Impacts of Assimilative Capacity of Reservoirs on Coastal Inflows project was to assess assimilative capacity of the Lake Livingston reservoir and related impacts on freshwater inflows to the Galveston Bay estuary. This project sampled inflow from the Upper Trinity to the north and outflow from the Lower Trinity south of the Lake Livingston Dam to quantify nutrient and suspended sediment concentrations, deployed a GPS drifter to track flow patterns and currents, and collected depth profiles to determine degree of stratification.

Water quality sampling was conducted in partnership with the United States Geological Survey during six sampling events between May 2016 and August 2018. Samples were collected during base, moderate, and high flow conditions. This project utilized a Microstar Drifter equipped with Globalstar Simplex telemetry to collect coordinates at 10 second intervals. The drifter was released on five occasions at the far north end of Lake Livingston. The results suggest that the Lake Livingston Reservoir, an artificial impoundment, is a nutrient and sediment sink. This presentation will detail project methodology and sample design for water quality sampling, collection of depth profiles, and drifter deployment. In addition, a summary of the data will be presented, with findings about nutrients, lake flow patterns, and depth profiles. This project will also discuss the incorporation of web based interactive stakeholder outreach materials that visually demonstrate project results and sampling efforts.

Session V-Room A3

MONITORING FRESHWATER INFLOW AND NUTRIENT AND SEDIMENT LOADING INTO GALVESTON BAY

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Estuaries depend on freshwater inflows and sediment transport to support healthy ecosystems and diverse biological communities. Conversely, floods and an abundance of associated sediment and nutrient inflows to estuaries can have adverse ecological effects on these same ecosystems. In Texas, the quantity of water and sediment flowing to bays and estuaries is often influenced by periodic flooding or withdrawals, diversions, and retention in reservoirs. To provide adequate information to determine the effects of various inflow conditions, it is important to accurately quantify the amount of freshwater, suspended sediment, and nutrients entering an estuarine system.

The U.S. Geological Survey (USGS), in cooperation with the Texas Water Development Board (TWDB) and the Galveston Bay Estuary Program (GBEP), is developing a coastal network to monitor freshwater inflow as well as sediment and nutrient loading into Texas bays and estuaries. In Galveston Bay, this monitoring program focuses on the two largest inflows to the bay, the San Jacinto River and the Trinity River. Monitoring on the San Jacinto River is in early stages of development but builds on the methods and technology utilized at other USGS monitoring sites along the coast. In the Trinity River, freshwater inflow and nutrient and sediment concentrations have been monitored since 2009. This effort has resulted in a continuous record of streamflow and suspended-sediment concentrations since 2014 and a dataset to date of approximately 110 nutrient samples collected over a range of hydrologic conditions. Data obtained from sites on the Trinity River prior to 2016 indicated that at elevated flows a large part of the volume released from Lake Livingston, an upstream reservoir, does not reach Galveston Bay through the main channel of the Trinity River. Additional data were collected between 2016 and 2019 to improve the current (2019) understanding of the streamflow patterns in the lower reaches of the Trinity River and determine the effects of these flow patterns on nutrient and sediment loading into Galveston Bay. Discharge was measured, and nutrient and suspended-sediment samples were collected at multiple locations in the lower Trinity River watershed over a range of hydrologic conditions. Preliminary results indicate that when discharge at upstream stations exceeds approximately 20,000 cubic-feet per second, water from the main channel of the Trinity River is diverted into Old River Lake and surrounding wetlands. Under these high-flow conditions, when nutrient and sediment loading are also typically the highest, most of the freshwater inflow travels through Old River Lake, resulting in an alternative flow path that may be the primary delivery pathway for a large portion of the nutrients and sediment that enter Galveston Bay. Preliminary results also suggest that Old River Lake may play a substantial role in regulating nutrient and sediment supply into Galveston Bay. Thus, additional data collection, such as continuous monitoring in Old River Lake, can improve our understanding of the variability of freshwater inflow and nutrient and sediment loading from the Trinity River into Galveston Bay.

Session V-Room A3

THE CHANGING HYDROLOGY OF THE TRINITY RIVER

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The Trinity River accounts for a majority of the freshwater inflows into Galveston Bay. It also serves as a vital water resource, providing drinking water to approximately half of the citizens of Texas while fueling America's energy coast. Over the decades, the hydrology of the Trinity River has changed dramatically. The rapid urbanization of the DFW area, along with the construction and operation of flood control reservoirs, water supply systems, and wastewater treatment plants has forever altered the river. However, the impacts of these alterations, while significant, are not always intuitive. Rather than dewatering the system, there is currently more water than ever; a phenomenon which will be explored and explained. In addition, the past five years have proven to be wetter than normal, with a growing perception that flooding has also become more common. Statistically speaking, this is not observed in historical trends, although mid-range flows as well as base flows have significantly increased. This is important background information as the basin begins the process of flood planning pursuant to Senate Bills 7 and 8.

It is also important to ask how changing weather patterns could further impact or exacerbate the observed changes. Given the uncertainty surrounding predicted future meteorology, the scientific community must recognize the limitations of our knowledge and embrace tools that work within those limitations; tools like adaptive management that allow for the assimilation of better and deeper datasets as we learn more. These tools and this mindset will be imperative to charting a course that effectively balances the basin and bay's myriad needs.

Session V-Room A4

CHANGES IN THE WATER QUALITY AND MICROBIAL COMMUNITY IN GALVESTON BAY FOLLOWING THE EXTREME FLOODING EVENT PRODUCED BY HURRICANE HARVEY

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Hurricane Harvey was a category 4 storm that made landfall near Rockport, TX (USA) which stalled out over southeast Texas releasing 1.29 x 10^{11} m^3 of precipitation over five days over the Houston-Gulf coast region. The floodwaters delivered a significant influx of terrigenous dissolved organic matter, organic pollutants and nutrients along with terrestrial and freshwater associated microbes. Over the 24 days following the storm, samples were collected along a transect extending from the mouth of the San Jacinto River to the Gulf of Mexico. Our research goal was to determine the effects the storm water runoff (polluted from sewage, pesticides, oil) had on the microbial ecology of the Bay. Immediately after the flooding, the salinities in Galveston Bay decreased to 0-5 psu relative to pre-Harvey salinities of 20-30 psu. The generally dominant bacteria of the marine coastal community were replaced by microorganisms of terrestrial, sedimentary, and freshwater origin. Water treatment facilities and petrochemical plants were compromised due to the heavy flooding in the region. This led to increased concentrations of nutrients, polycyclic aromatic hydrocarbons, pharmaceuticals and biocides (cotinine, carbamazepine, carbamazepine-epoxide, and prednisone) across Galveston Bay immediately following the storm. In the 4 weeks following the storm, concentrations of nutrients and organic pollutants began to decrease coinciding with rising salinities as the freshwater was flushed into the Gulf of Mexico and seawater began moving back into the Bay. Successive blooms of chlorophytes, diatoms, and dinoflagellates occurred similar to post-storm communities from past hurricanes that have impacted estuarine systems along the Gulf of Mexico. The eukaryotic community changed substantially following Harvey and did not recover to pre-Harvey conditions during our study period, suggesting a longer recovery time compared to the prokaryotes. Although the water quality parameters and microbial community showed signs of returning to pre-Harvey conditions within the month following the flood event, long-term impacts need to be measured in the years following the flood.

Session V-Room A4

DRAMATIC RESPONSE AND SLOW SALINITY RECOVERY OF GALVESTON BAY TO HURRICANE HARVEY: OBSERVATION AND MODELLING

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Hurricane Harvey, one of the worst hurricanes that hit the U.S. in recent history, poured record-breaking rainfall across the Houston metropolitan area. Based on a comprehensive set of data from various sources, we present the dramatic response of Galveston Bay to this extreme event, including long-lasting elevated water level, extraordinary strong along-channel velocity, sharp decreases in salinity with long recovery time, and huge river plumes. With a freshwater fraction method, the freshwater load into the bay during Harvey is estimated to be 11.1×10^9 m^3, about 3 times the bay volume, which had completely freshened the entire bay.

A hydrodynamic model that reproduces the observed response of the bay very well is used to estimate the salinity recovery time (T_R) as a measure of the system resiliency. Over the entire bay, the T_R had a mean of about two months, but with great spatial variability ranging from less than 10 days near the bay entrance to over three months in the inner part of the bay. The spatial variation, which appears consistent with the changes in the phytoplankton community in the bay, can be explained by different contribution of exchange flow and tidal pumping on salt influx, with the latter being the dominant mechanism promoting salt influx and salinity recovery at the bay entrance. A series of numerical experiments with different amounts of stormwater reveals that the T_R exhibits a non-linear relationship with the stormwater input, with the rate of increase in T_R decreasing with increasing stormwater.

Session V-Room A4

RESILIENCE OF ESTUARINE PELAGIC COMMUNITIES TO CATASTROPHIC NATURAL DISASTERS

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Hurricanes are climatically-induced natural disasters affecting coastal wetland ecosystems. Recorded impacts of heavy rainfall and floodwater discharge caused by hurricanes often result in intense large-scale ecosystem disturbance. Rapid response to hurricanes and subsequent assessment and restoration of ecosystems require better understanding of the processes and responses of key ecosystem components to the storms. In September 2008 and August 2017, Hurricanes Ike and Harvey caused catastrophic impacts in Galveston Bay, Texas. The major impacts include storm surge of Hurricane Ike and extreme flooding by Hurricane Harvey. During 2008-2009 and 2017-2018 we collected data in the bay including zooplankton, water temperature, salinity, Chl-a, dissolved oxygen and pH etc. In this study, we compared the responses of estuarine pelagic communities to Hurricanes Ike and Harvey to examine the resilience of pelagic communities to the disturbance and estimate the restoration of estuarine ecosystems. Preliminary analyses showed that the hydrographic conditions and zooplankton communities exhibited different post-storm patterns to the two hurricanes. We explore the potential processes from the perspective of disturbance caused by hurricanes. This study has laid the foundation in terms of zooplankton and hydrography fostering response and recovery of estuarine ecosystems to next natural disasters.

Session V-Room A4

CYCLONE DRIVEN SEDIMENT FLUX WITHIN AN URBAN ESTUARY: IMPACT OF HURRICANE HARVEY ON GALVESTON BAY

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Hurricane Harvey delivered ~100 cm of rain in 5 days, across the heavily urbanized and industrialized bayous that drain urban Houston, Texas into the upper reaches of Galveston Bay, including the San Jacinto River and the Houston Ship Channel (SJR/HSC). The SJR/HSC has experienced up to 3 m of subsidence in the past century and with at least half of this new accommodation space filled with contaminated sediment. The sediment deficit within the SJR/HSC is likely, at least in part due to the number of dams and reservoirs within the lower drainage basins of the SJR. These reservoirs include Lake Houston and the Barker and Addicks Reservoirs (BAR), which are 15 and 50 km, respectively, from the confluence of Buffalo Bayou and the SJR/HSC. Controlled releases from the BAR resulted in continual high discharges across Buffalo Bayou for weeks after the storm, resulting in the delivery of a prolong pulse of flood water into the SJR/HSC. Analyses of a series of ~75 push cores revealed that Hurricane Harvey deposited ~141 million tons of sediment within GB and this sediment contained ~6 tons of mercury (Hg), in average, tripling the surface concentration of mercury in the sediment within the upper half of the bay. It is estimated that ~5 tons of the Hg deposited in GB came from the scoured sediments of Buffalo Bayou. Anthropogenic alterations of the bay created the enhanced subsidence in the SJR, that allowed for the preservation of over 2 m of heavily contaminated sediments and was the source of the 6 tons of Hg delivered to the bay. The creation and controlled releases of the BAR both prolonged the flooding for 44 days in contrast to the 7-day flood in the other local distributaries, and also enhanced the impact of the flood waters. Taken together, these factors dramatically enhanced the impact of Hurricane Harvey, making it both a natural and man-made.