

Voluntary mechanisms to protect freshwater inflows in Texas

Introduction

Texas's rivers and streams carry sediment and nutrient-rich freshwater to the coast, nourishing wetlands and driving coastal and estuarine productivity. Unfortunately, freshwater inflows to the Texas coast are under immense stress due to increasing water demand, changing precipitation patterns, rising air temperatures, and development. Reduced and altered flows are a key contributor to freshwater and estuarine wetland loss (Feagin et al. 2020, Madewell et al. 2021) with implications to the numerous migratory bird, fishery, and other wildlife species that rely on these coastal habitats.



Figure 1. Waterbirds in West Galveston Bay, Texas.

Conventional strategies to safeguard freshwater resources for Texas estuaries pose numerous challenges including meeting the quantities of water necessary for environmental demands particularly as competition among water users increases in response to growing water scarcity. A novel management paradigm, “focused flows”, addresses these challenges by focusing limited freshwater resources in support of key estuarine habitats during drought, resulting in the use of significantly less volumes of water to maintain estuarine function and facilitating a region’s ecological recovery post-drought (Montagna et al. 2021).

Upper estuarine environments such as estuarine lakes, tidal streams, and tidal wetlands are ideal habitats for implementing focused flows because they are semi-enclosed, limited in size, and shallow (<2 m) making them more hydrologically and ecologically responsive to introduced freshwater with longer-lived responses. In fact, these characteristics heighten their vulnerability to drought, which through a lack of rainfall contributes to the excessive accumulation of salt in the water as freshwater evaporates. Fortunately, the proximity of these habitats to existing water supply infrastructure facilitates the introduction of freshwater for focused flows management.

Institutional water suppliers, including river authorities and irrigation districts, manage large volumes of freshwater resources through expansive networks of reservoirs and water supply canals. Through voluntary agreements with these water suppliers as well as private landowners, Texas Water Trade (TWT) and its partners have successfully demonstrated that the application of

focused flows using limited freshwater resources can in part address the impacts of water scarcity and drought on Texas's living natural resources.

Restoring Galveston Bay Oysters

In addition to supporting a \$20.8 million commercial fishery in Texas¹ (NOAA), the eastern oyster, *Crassostrea virginica*, provides numerous ecosystem services including habitat provision, water filtration, and protection against storms and erosion. Oyster reefs in Galveston Bay have historically supported a significant portion of the state's oyster fishery. However, oysters have been in decline due to various factors including drought, flood, storms, disease, and fishing pressure resulting in recent closures of multiple harvest areas throughout Galveston Bay by Texas Parks and Wildlife Department (TPWD) due to limited oyster abundances.

The harvest of oysters in estuarine lakes across the Texas coast is generally restricted, which has positive implications for oyster reef densities and reproductive output (Peters et al. 2017). Oysters are broadcast spawners releasing their gametes into the water column where fertilization occurs. After fertilization, larvae spend multiple weeks in the water before settling onto hard substrate allowing for the transport of oyster larvae from one region of the estuary to another. In conjunction with other restoration efforts, maintaining focused flows to enhance and protect oyster spawning stock in estuarine lakes during drought could serve a key role in bolstering oyster resilience across Texas estuaries.

West Galveston Bay

Over the past three years, TWT and Galveston Bay Foundation have been working toward efforts to augment freshwater inflows to West Galveston Bay (West Bay) and its watershed. The major source of freshwater inflows into West Bay stem from the various bayous occurring throughout the San Jacinto-Brazos Coastal Basin. While the region experiences 40-50 inches of average annual rainfall (BEG 1996), it lacks direct input from any major river, making its upper estuarine habitats particularly vulnerable to regional drought and changes in water management.

Carancahua Bayou and Lake

Carancahua Bayou is a six-mile-long tidal stream that flows into Carancahua Lake, a small (< 2 km²), semi-enclosed estuarine lake north of West Bay (Figure 4). Intertidal and subtidal oyster reefs are prominent throughout Carancahua Lake which are restricted to oyster harvest by the Texas Department of State Health Services. Several larger oyster



Figure 2. Intertidal oyster reefs in Carancahua Lake.

¹ Average represents annual dollars generated from commercial landings from 2013-2023.

reefs occur throughout West Galveston Bay which comprise oyster harvest area TX-9 and have been closed to harvest from 2022-2025.

Freshwater Inflows to Carancahua Bayou and Lake

From August through October 2024, TWT and GBF delivered a total of 422 AF of freshwater to a privately owned property with the ability to divert the freshwater into Carancahua Bayou and Lake. Salinity monitoring instruments were installed at four study sites (CB1-CB4, CL1) a month prior to the introduction of freshwater to collect baseline conditions and were routinely maintained to ensure data quality through late October. To expand the study's monitoring area, the instrument installed at Site CB4 in Carancahua Bayou was relocated to Site CL1 in Carancahua Lake in September. Daily precipitation was measured at a nearby meteorological station owned and maintained by the Galveston County Drainage District #1 (GCDD #1-9050; Figure 4).

Monthly rainfall totaled 8.8 inches in July 2024 in the region resulting in low salinity (< 5 ppt) across monitoring sites at the beginning of the study (Figure 4). Low monthly rainfall in August (0.24 inches) contributed to a rapid increase in salinity with sites

generally increasing in salinity with proximity to West Bay. Low rainfall persisted through late September, yet the study's introduction of freshwater into the system in late August resulted in a gradual moderation of salinity across sites with differences ranging from 5 to 10 ppt at study sites. Storm surges associated with Gulf Hurricanes Francine and Helene, respectively, forced high saline water from West Bay into Carancahua Bayou and Lake which temporarily contributed to elevated salinities. However, the introduced freshwater continued to moderate salinity across sites following storm events.

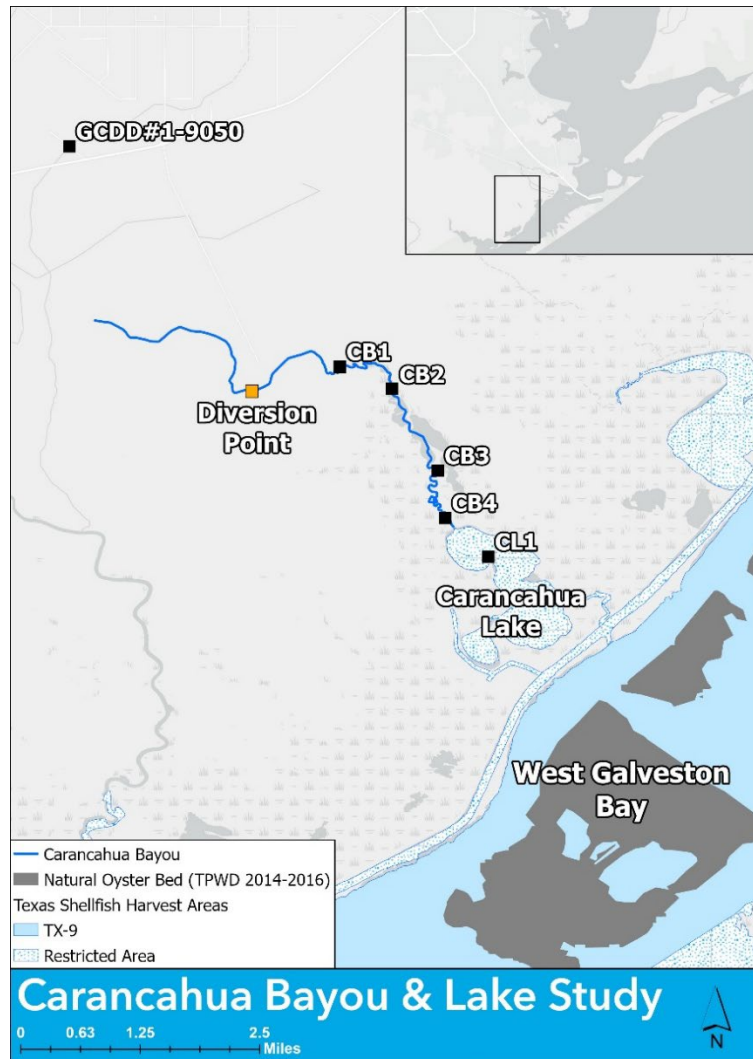


Figure 3. Study map with location of salinity monitoring stations in Carancahua Bayou (CB1-CB4) and Carancahua Lake (CL1) and meteorological station (GCD #1-9050).

Freshwater introduction ceased in October and in combination with limited rainfall (0.04 inches total) resulted in high salinity (>20 PSU) across stations by the end of the study period.

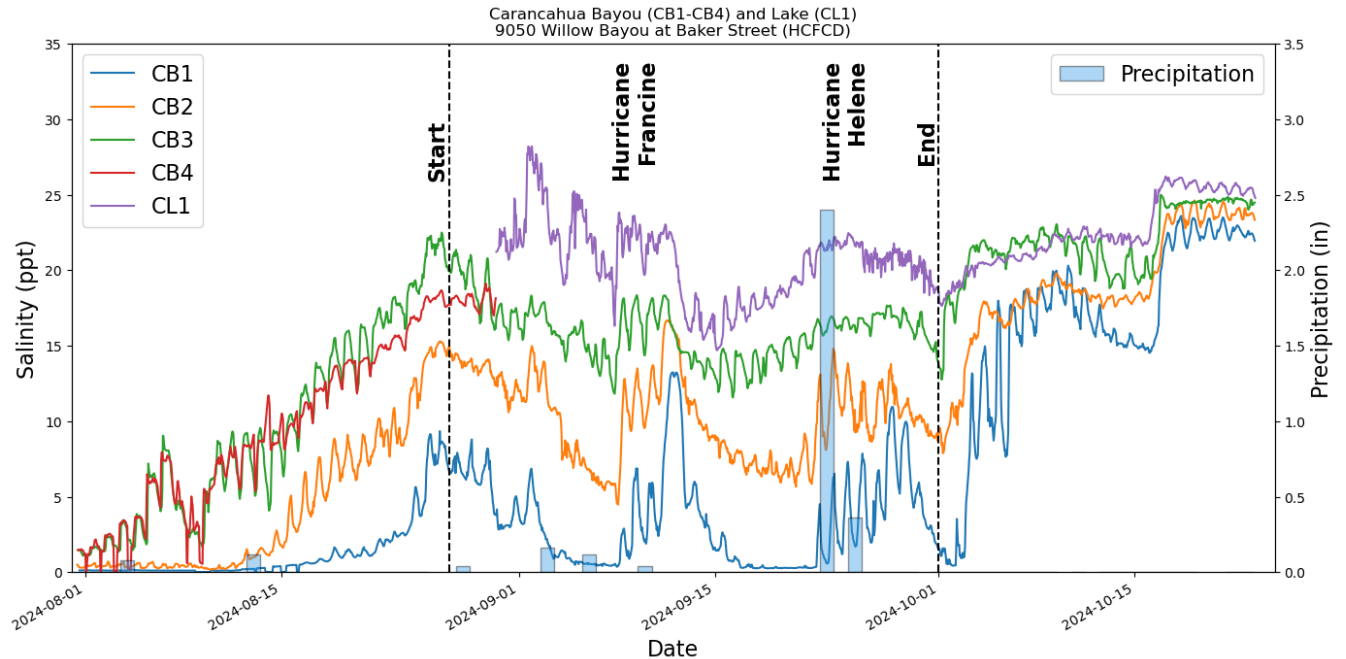


Figure 4. Salinity (ppt) across monitoring stations in Carancahua Bayou (CB1-CB4) and Carancahua Lake (CL1) and daily precipitation (inches) measured at meteorological station GCDD #1-9050 throughout the study period.

Implications for Oyster Management

Freshwater inflows are closely related to multiple factors that control oyster populations including predation, disease, drought, flood, and water management (Powell et al. 2003). The oyster disease, Dermo caused by the protozoan, *Perkinsus marinus*, is linked to freshwater inflows and salinity with implications for oyster populations and fisheries. Freshwater inflows and subsequent reductions in salinity have been shown to mitigate Dermo prevalence and severity in Texas estuaries (Silvy et al. 2020, Pollack et al. 2011). However, the net response of oysters to freshwater inflows is often complicated by immediate repercussions to oyster populations (e.g., oyster mortalities, reduced recruitment, etc.) resulting from large, episodic floods common in Texas.

The efficacy of smaller, controlled introductions of freshwater for reducing Dermo levels during dry periods is unclear. Savage et al. 2025 recommended maintaining salinity below 24.9 to moderate Dermo severity in Texas oyster populations. The current study's findings suggest that this type of salinity moderation can be achieved in the upper estuarine region of West Bay that is prone to elevated salinity during drought conditions. However, the practice has yet to be tested during drought when oysters in Galveston Bay are most impacted by high salinity and Dermo (Gaona-Hernandez 2025). Future iterations of the study should study Dermo response and reproductive fitness to a controlled addition of freshwater to understand the management practice's ability to



maintain healthy broodstock oyster reefs in estuarine lakes and inform the management of oyster populations on the Texas coast amidst growing water scarcity.

Conclusion

While water scarcity is increasingly impacting Texas estuaries and coastal resources, the utilization of focused flows management has proven to be effective at providing relief during dry periods. Voluntary water agreements providing water supplied by regional water authorities and delivered through irrigation infrastructure (reservoirs, irrigation canals, etc.) allow TWT and partners to augment inflow to estuarine environments creating habitat for species vulnerable to drought and water shortages. While water quality responses are temporary, these interventions can be scaled to maintain suitable water conditions and provide refuge during periods of drought—which is essential to an ecologically productive and protected Texas coast.

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