INVESTIGATION INTO HOUSTON SHIP CHANNEL SHOALING AT THE BAYPORT FLARE IN GALVESTON BAY

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INTRODUCTION

Sedimentation at the confluence of the Houston and Bayport Ship Channels (Bayport Flare) in the Upper Galveston Bay, along the Gulf Coast of Texas, USA, is a costly issue requiring frequent dredging (Figure 1). This shallow bay area is subject to high volumes of deep draft and barge vessel traffic (9,000 deep draft ship calls and 200,000 barge transits annually (PoH ,2017)) and natural forcing such as hurricanes (increased sediment influx from 2017 Hurricane Harvey in particular), cold fronts, wind waves and tidal fluctuations.

Figure 1 - Confluence of the two channels (Bayport Flare, highlighted in green) within the Upper Galveston Bay, Gulf Coast, TX. Colored pins show the locations of fixed ADCP deployments (red) and TCM (yellow)

METHODS

Hydrodynamic and sediment dynamic processes in the Upper Galveston Bay, particularly around the Bayport Flare, are being explored using measurements from vessel mounted and fixed Acoustic Doppler Current Profilers (ADCP), Optical Backscatter Sensors (OBS), Tilt Current Meters (TCM) as shown in Figure 1, as well as densely spaced sediment surface grab samples, core samples, and salinity profiles. These field measurements are used to assess the causes of the extremely high sedimentation rates (approximately 30 cm per year based on dredging records between 2013 and 2017) seen in the Bayport Flare. The effect of salinity on the flocculation and sedimentation of particles near the ship channels is also being explored through laboratory experimentation.

In-situ fixed measurements were deployed over a two-week duration, sampling intervals of the ADCP instruments and TCMs were 0.5 seconds, and 1 second respectively. In total, 20 vessel mounted ADCP measurements were conducted over a wide area around the Bayport Flare (example shown in Figure 2), measuring point-in-time velocity profiles and echosounder backscatter over the entire water column. These transects ranged from 0.3 to over 5 km in length and showed depth averaged tidal velocities ranging from 0.2 to 0.5 m/s during flood and ebb spring tides. Suspended sediment concentrations (SSC) were inferred from ADCP echosounder backscatter, using in-situ water samples for reference concentrations and a logarithmic relationship between SSC and backscatter amplitude.

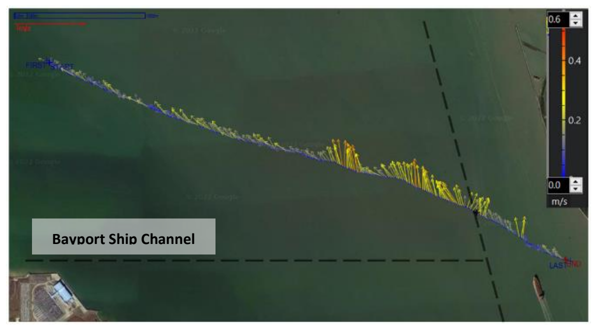

Figure 2 - Example vessel mounted ADCP run, north of the Bayport Ship Channel during a spring flood tide, with arrows showing depth averaged velocity vectors

A Sediment Trend Analysis (STA) was conducted using a GIS plugin (Poizot and Méar, 2010). This analysis uses the mean, standard deviation and skewness measured from each of the sediment surface grab samples to determine 'transport vectors' and ultimately a time averaged depiction of sediment transport, independent of any hydrodynamic measurements.

RESULTS

Preliminary results indicate that the perpendicular orientation of the Bayport Ship Channel to the dominant current flows during spring tidal conditions may have a significant effect on siltation. The STA for the study area showed that the San Jacinto Bay, which includes the Bayport Flare, is a sediment sink with sediment transport toward it from all sides (Figure 3).

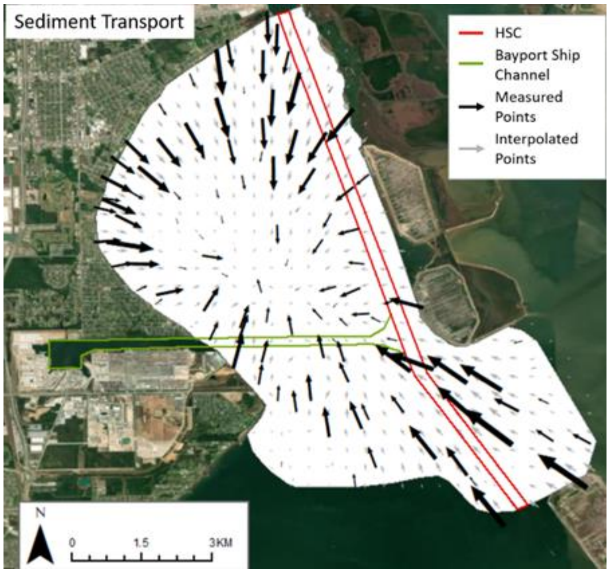

Figure 3 – STA results with sediment transport vectors for sample sites

Previous AdH modelling of the Upper Galveston Bay (USACE, 2019) shows a circulation pattern of residual bottom currents from tidal forcing only, that feed into the Bayport Flare from the surrounding shallow areas. However, fixed current velocity measurements over a two-week period in April 2022 show a different circulation pattern, with high SW wind activity during the deployment period resulting in elevated water levels and wind dominated current flow over the shallower areas away from the HSC, opposing the modelled residual circulation in some areas (Figure 4).

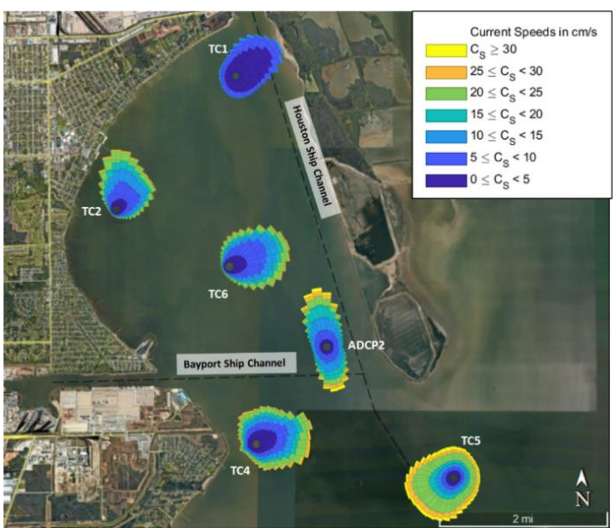

Figure 4 – Near bed current velocity roses measured over a two week deployment in April 2022. Bin position indicates direction from which the current is coming from

This indicates that modelling of tidal currents only may lead to misinterpretation of the true circulation patterns that drive sediment movement in the project area toward the Flare. Especially the effect of wind, waves, and ship wakes on sediment transport should be considered when designing mitigation measures.

FUTURE WORK

Other potential contributing mechanisms such as vessel wakes, propeller wash, salt wedge fluctuations, as well as weather driven events are under investigation.

Possible mitigation strategies, in line with Engineering-with-Nature principles, will be explored to influence the hydrodynamics of the surrounding area and limit the amount of sedimentation in critical areas, thus reducing the need for dredging activities.

REFERENCES

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Port of Houston (PoH) (2017): 2017 Year in Review. 111 Houston, TX 77029. Sourced from porthouston.com
USACE (2019): Houston Ship Channel Expansion Channel Improvement Project, Harris, Chambers, and Galveston Counties, Texas. Attachment 9. Sediment Training Options for Bayport Flare