

**Title:** Development of Coastal Margin Observation and Assessment System to Monitor the Water Quality in the Corpus Christi Bay

**Statement of Critical Regional Water Problems:**

Coastal areas in the U.S. are the home to a wealth of natural and economic resources. More than half of its population lives within the narrow coastal fringe that makes up 17 percent of the nation's contiguous land area. Texas alone has 2360 miles of shoreline, and two of the nation's top five ports, Houston and Corpus Christi. The two ports handle 50% of the nation's crude oil import (NDC, 2000). Estuarine systems associated with the Gulf coast provide economically important habitat for productive marine communities in one of the fastest growing U.S. regions. However, as the human population continues to increase along the coast, it further contributes to the modification of the natural state of these regions through the alteration of the land use pattern, diversion of river water for consumption and many other anthropogenic events. For example, hypoxia and phytoplankton blooms can result from excessive amounts of nutrient release from human-altered watersheds. Also, many of these coastal water bodies are also used for navigation purposes and therefore, events such as oil spills can deteriorate these ecosystems.

As these nearshore aquatic environments, often characterized as stochastic pulsed systems, are very dynamic in nature, it is not possible to understand these environments through discrete sampling. However, continuous in-situ monitoring can aid in our understanding. With the support of both state and federal funding, our research group at the Shoreline Environmental Research Facility (SERF, Corpus Christi, TX) is implementing a Coastal Margin Observation and Assessment System (CMOAS). The CMOAS is conceptualized as an environmental observatory that will supply surface current maps, vertical profiles of currents, meteorological observations and other real-time chemical and biological measurements within the water column. These measurements will be integrated with model predictions for use in coastal monitoring. This can facilitate oil spill response, natural resources recovery, and a host of other applications for state and federal agencies.

**Nature, Scope, and Objectives of the Research:**

A new scientific paradigm is evolving which involves real time environmental observations and assessment. State and federal research organizations are spearheading the development of large-scale environmental assessment systems designed to facilitate environmental and water-related research. The National Science Foundation's Biological, Geoscience, and Engineering directorates have taken the lead with the development of their respective programs (NEON- *National Ecological Observatory Network*, CUASHI-*Consortium of Universities for the Advancement of Hydrologic Science*, and CLEANER- *Collaborative Large-scale Engineering Analysis Network for Environmental Research*).

Our CMOAS is based on the Pioneer Array concept by significantly adapting an existing sensor network test bed located within Corpus Christi Bay (TX). This is a shallow embayment (averaging 3m in depth) subject to frequent natural and anthropogenic disturbances resulting in water column particles and sediment redistribution. Such disturbances are often associated with degradation of ecological integrity at varying scales across space and time. Storms influencing

current patterns, increased stream flow into estuaries, dramatic water quality changes, algal blooms, and anthropogenic activities (e.g., dredging, trawling) are considered events directly or indirectly resulting in increased water column particle suspensions, trace metals, organic contaminants, nutrients, and toxins from harmful algal blooms. Considering the range of space and timescales involved and the diverse nature of processes, these environments can only be characterized through the real time monitoring of this dynamics system from the integrated sensor-sensor deployment platforms in conjunction with modeling framework.

Our existing sensor-sensor network, which will form the backbone of the CMOAS, comprises a sensor test bed with a broad spectrum of operational sensors and three sensor deployment platforms. The first platform consists of two high frequency (HF) radar surface current mappers providing surface currents, wave height and direction in the Corpus Christi bay at one-square-km grid spacing. The second features multiple movable sensor-deployment platforms designed to observe environmental and meteorological parameters at the scale of the observation region, through time at high frequency to characterize environmental parameter flux and variability in response to external forcing. These sensor-deployment platforms will be separated by approximately 5 km within an ~100-square-km testbed. The third is a mobile platform that measures the same spectrum of environmental parameters ‘synchronously’ over a highly-resolved spatial regime.

Since there are inherent, practical limitations associated with the deployment of sensors and instrument platforms with sufficient or reasonable spatial resolution, we are trying to develop numerical models for evaluating the spatial distribution and 3D concentration profile of constituents. The network of environmental sensors will provide initialization conditions as well as values required in the data assimilation schemes. With the development of Coastal Ocean Dynamics Application Radar (CODAR) in the 1980s, our ability to observe real-time spatially-distributed current velocity time series was made possible. These real-time water current measurements have been used in the development of our data-driven constituent transport models to improve on nowcasting and forecasting results. But this radar information sometimes degrades under certain conditions (e.g., calm weather, ship movement), thus resulting in data gaps. These data gaps can be resolved using normal mode analysis or by data assimilation into a hydrodynamic model. The *objective* of this project is to develop a 2-dimensional (2-D) hydrodynamic model for Corpus Christi (CC) Bay which will assimilate radar data and would ultimately lead to a 3D model for the study area. The output of the 3D model will be compared with the observational data from acoustic Doppler current profilers (ADCPs) in order to develop a framework for the computational steering required for data assimilation. This project will focus on the development of 2D hydrodynamic model for CC Bay, output of which will be compared and validated against radar observations.

The ADvanced CIRculation (ADCIRC) Model for Coasts, Shelves, and Estuaries (Luettich et al., 1992) will be used for the development of hydrodynamic model for Corpus Christi Bay. It is a two-dimensional depth-integrated finite-element model. Finite element grid, originally developed by (Scheffner et al., 2003), will be modified in the area of interest with details added using Surface Modeling System (SMS) software. Coastline data and bathymetric data will be obtained from the Geophysical Data System (GeoDas), the National Oceanic and Atmospheric Administration (NOAA) database and U.S. Army Corps of Engineers (USACE)

surveys. Atmospheric and wind forcing information, collected from Windbird instruments (R.M. Young Company) at our Oso Bay monitoring platform, will be used for the whole computational domain. The amplitude, frequency and other parameters of tidal potential constituents will be determined for a specified time that the model will run using Le Provost Database (Westerink, J.J. et al, 1993). This model will capture the time variation of depth-averaged water velocities and water surface elevation for the whole computational domain. This model, together with HF radar, will provide valuable hydrodynamic information which can be used to drive our particulate fate and transport model to determine the fate and transport of conservative (e.g. salinity or dye) and non conservative variables (e.g. dissolved oxygen, suspended particle, nutrients etc.) to explain many environmentally-significant phenomena such as dispersion of oil spills, other chemical spills, hypoxia, etc.

A baseline study will also be made to determine the particle size distribution of the bay and to explore the other physical parameters like shear velocity, temperature, salinity, etc. This baseline study will provide the condition for the initialization of the real-time data-driven model. An IDACC (Integrated Data Acquisition Communications and Control) unit developed by our research group will be used to survey the variation of these water quality parameters in CC bay. The instruments integrated through this unit are a fluorescence sensor (SAFire by WETLABs), a CTD sensor (FastCAT by Sea-Bird Electronics) and a particle size analyzer (LISST 100 by Sequoia Scientific). Monitoring CC Bay at different seasons with this instrument suite will shed light into the different processes involved in phenomena such as hypoxia, phytoplankton blooms, etc.

### **Results Expected from this Project**

- A 2D hydrodynamic model for Corpus Christi Bay with comparisons to radar-measured surface current observations
- Seasonal variation and spatial distribution of various water quality parameters in CC Bay

### **References:**

- Luettich, R.A., Westerink, J.J., and Scheffner, N.W., (1992) "ADCIRC: An advanced three-dimensional circulation model for shelves, coasts, and estuaries Report 1: Theory and methodology of ADCIRC-2DDI and ADCIRC-3DL," Technical report DRP-92-6, US Army Engineer Waterways Experiment Station, Vicksburg, MS.
- NDC (2000). Waterborne Tonnage for Principal U.S. Ports. Navigation Data Center, U.S. Army Corps of Engineers.
- Scheffner, N.W., Carson, F.C., Rhee, J.P., Mark, D.J.,(2003) "Coastal erosion study for the open coast from Sabine Pass to San Luis Pass, Texas: Tropical storm surge frequency analysis," US Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

Westerink, J.J., Luettich, R.A., and Scheffner, N.W.,(1993).” ADCIRC : An advancede three-dimensional circulation model for shelves, coasts, and estuaries report 3: Development of a tidal constituent database for the western North Atlantic and Gulf of Mexico,” Technical Report DRP-93-2, US Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.