DELTA ECOSYSTEM FORECASTING SYSTEM

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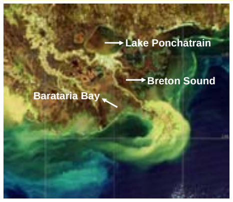
ABSTRACT

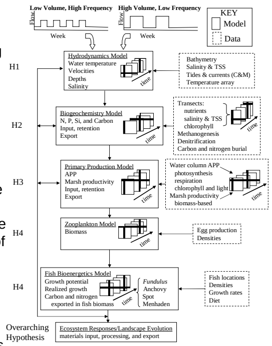


DELTA ecosystem forecasting study sites

The DELTA project seeks to develop and apply a series of linked simulation models that will allow tracking the effects of pulsed freshwater inputs through hydrodynamics, biogeochemical cycling, primary production, zooplankton dynamics, fish growth, and water quality dynamics. Each of these models necessarily operate on temporal and spatial scales appropriate for their dynamics; common development of these models will enable them to share information and be linked via the predictions of one model being used as input values for another model, and will be used to generate spatio-temporal maps of key state variables. The coordinated field sampling and modeling will enable development of a consistent set of data to ensure that the different models can be calibrated to the same conditions. Both field data and models will be used to evaluate the hypotheses that contrast how energy and nutrients are propagated up the food chain and exported under the many, small, and the fewer, large pulsing scenarios. As one part of knowledge-building efforts to guide restoration and recovery, it is proposed to evaluate the stability of former, current (i.e., Post Katrina), and potentially altered stable states within the context of human influences .

INTRODUCTION

The Mississippi River delta is one of the most impacted coastal ecosystems in the world. The immense challenges to promoting the resilience of this coastal region represents a laboratory to develop new technologies that reduce risks to both social and natural resources. The linked simulation models that we will develop will be used to generate spatio-temporal maps of key state variables. The coordinated field sampling and modeling will enable development of a consistent set of data to ensure that the different models can be calibrated to the same conditions. Both field data and models will be used to evaluate the hypotheses that contrast how energy and nutrients are propagated up the food chain and exported under the many, small and the fewer, large pulsing scenarios.



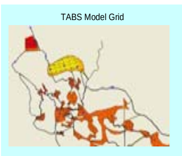
DELTA project flow chart. Hydrodynamics and Landscape models will serve as integrators of unit models. Bidirectional arrows indicate feedback loops.

OBJECTIVES

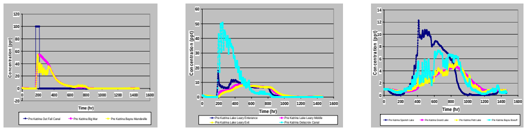
The main objective of the DELTA project is to understand the different types of pulsing scenarios on coastal ecosystem dynamics. The central hypothesis is that deltaic estuaries and wetlands are pulse-regulated ecosystems. The pattern and the magnitude of pulsed freshwater inputs are critical parameters controlling nutrient cycling, productivity, residence time and export, and trophic structure. This project will investigate pulsing of controlled river diversion structures at Caernarvon (Breton Sound), Davis Pond (Barataria Bay) and Bonnet Carre (Lake Pontchartrain). The project builds upon several modeling studies that have been carried out in these systems. We are developing a series of linked models from these various uncoordinated modeling efforts.

BRETON SOUND STUDIES

Within the previously funded PULSES project, Mashriqui and Justic implemented the TABS-MD model to the Breton Sound Estuary. This is a widely used USACE model that is built around a finite-element hydrodynamic (RMA2), water quality (RMA4) and sediment transport modules (SED2D) that are generally run in sequence.

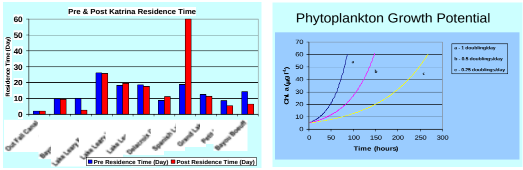


TABS model grid of the Breton Sound Estuary.



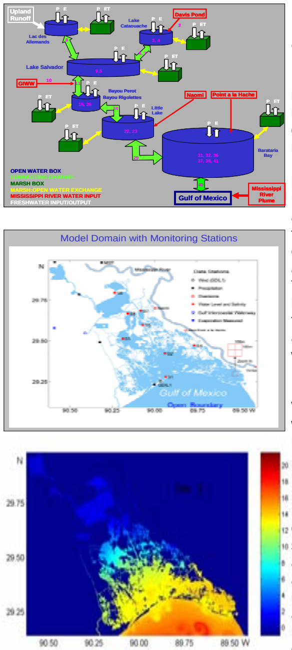
Tracer response curves for selected water bodies in the Breton Sound Estuary before the impact of Hurricane Katrina. A simulated tracer (100 ppt) was released at the Caernarvon diversion site over a period of 48 hours.

In a series of simulation experiments the investigators examined the impacts of Hurricane Katrina on water residence times in the Breton Sound Estuary. A simulated tracer (100 ppt) was released at the Caernarvon diversion site over a period of 48 hours. A comparison of calculated residence times for pre- and post-Katrina revealed that residence time of the Spanish Lake increased from 20 to 60 days. This is a major change that can lead to a significant increase in phytoplankton biomass, assuming that similar levels of nutrient and light limitations are attained. In contrast, the residence times decreased in Bayou Mandeville, Petit Lake and Bayou Boeuff, so the biomass of phytoplankton is expected to decrease in these areas.



Left – comparison of residence times (75% removal rate) in the Breton Sound estuary before and after Hurricane Katrina. Right – phytoplankton biomass accumulation (as Chlorophyll *a*) as a function of water residence times.

BARATARIA BAY STUDIES

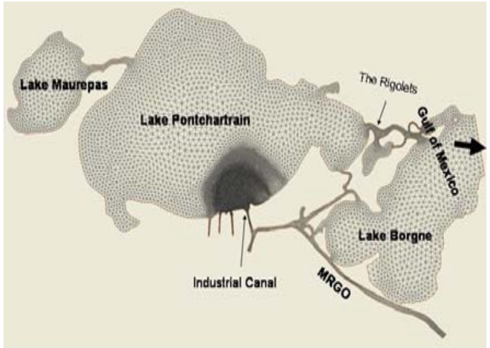


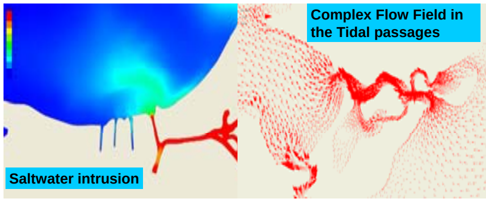
Top - 6-box model of the Barataria Bay. Middle – Model domain of a coupled hydrodynamic-biological 2-D model. Bottom - Barataria Bay salinity simulations using the 2-D finite difference hydrodynamic model.

Justic and Das developed a 6-box model describing essential physical and biological characteristics of major water bodies in the Barataria Basin. The hydrodynamic forcings include tides and freshwater inflows (precipitation, runoff, and diversions). A water quality module is nested within the 6-box hydrodynamic model. The module is to provide a conceptual and mathematical framework for the assessment of eutrophication in coastal watersheds and estuaries affected by the Mississippi River. The module includes nutrient kinetics of the Michaelis-Menten type, and multiple algal assemblages, whose productivity will be simultaneously limited by nutrient concentrations, nutrient ratios and ambient light intensity. We are currently integrating this water quality module with a high resolution 2-D finite-difference hydrodynamic model developed by Inoue et al. Comparisons will be made between the two models regarding their forecasting capabilities, size, complexity, and suitability for management applications. An expected advantage of the box model is that it will run much faster compared to a fully-coupled biological-hydrodynamic 2-D model. On the other hand, a 2-D model would allow assessments of the spatial aspects of nutrient/phytoplankton dynamics in the estuary, although only over weekly time scales.

LAKE PONCHARTRAIN STUDIES

Li developed a 3D hydrodynamic model covering Lake Maurepas, Lake Pontchartrain, and Lake Borgne using the Finite Volume Coastal Ocean Model (FVCOM). Two versions of different resolutions are implemented. The higher resolution model has a minimum of 150 m horizontal scale. Tides and saltwater are introduced from the northeast corner of Lake Borgne as well as from the southeast end of the MRGO. The model has 21833 triangular grids matching the coastlines. To validate the model, Li has also conducted several vessel-based ADCP surveys obtaining the detailed structures of the 3D flows at the Industrial Canal. Three mooring ADCPs have been deployed at the mouth of the IC, the Rigolet, and inside the IC.

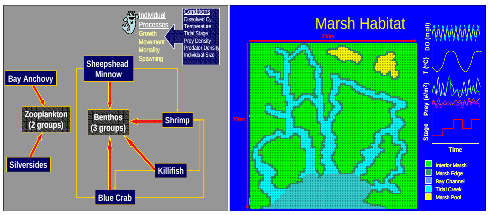




Model grids and sample results

INDIVIDUAL BASED MODELS

Sable and Rose developed a marsh community model based on a spatially-explicit, individual-based model. The models uses a 100 X 100 grid comprised of 4-m^2 cells. The population dynamics of six species are simulated: grass shrimp, inland silverside, sheepshead minnow, gulf killifish, bay anchovy, and blue crab. A one-hour time step was used for simulation of growth, mortality, reproduction, and movement for one year simulations. One of the inputs is water levels, which controls access to the marsh, this model can be used to simulate how pulses in river flow affect community dynamics and production.



Left – Schematic of the food web. Right - 200 meter by 200 meter swath of marsh, comprised of 10,000 cells. Five habitat types have been used to define the cells. Within each cell we simulate DO, daily temperature, prey densities, and tidal stage.

We will use this model as one means for integrating the results of the different project components, as an aid for designing field data collection, and for predicting the responses of the marsh community to river pulsing under current marsh conditions, degraded conditions, and projected future conditions after land building.