Using Remotely Sensed Data and Watershed and Hydrodynamic Models to Evaluate the Effects of Land Cover Land Use Change on Aquatic Ecosystems in Mobile Bay, AL

Session: Satellite Ocean and Coastal Applications—Current and Future

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1. Overview

Alabama coastal systems have been subjected to increasing pressure from a variety of activities including urban and rural development, shoreline modifications, industrial activities, and dredging of shipping and navigation channels. The impacts on coastal ecosystems are often observed through the use of indicator species. One such indicator species for aquatic ecosystem health is submerged aquatic vegetation (SAV). Watershed and hydrodynamic modeling has been performed to evaluate the impact of land cover land use (LCLU) change in the two counties surrounding Mobile Bay (Mobile and Baldwin) on SAV stressors and controlling factors (temperature, salinity, and sediment) in the Mobile Bay estuary. Watershed modeling using the Loading Simulation Package in C++ (LSPC) was performed for all watersheds contiguous to Mobile Bay for LCLU scenarios in 1948, 1992, 2001, and 2030. Remotely sensed Landsat-derived National Land Cover Data (NLCD) were used in the 1992 and 2001 simulations after having been reclassified to a common classification scheme. The Prescott Spatial Growth Model was used to project the 2030 LCLU scenario based on current trends. The LSPC model simulations provided output on changes in flow, temperature, and sediment for 22 discharge points into the estuary. These results were inputted in the Environmental Fluid Dynamics Computer Code (EFDC) hydrodynamic model to generate data on changes in temperature, salinity, and sediment on a grid throughout Mobile Bay and adjacent estuaries. The changes in the aquatic ecosystem were used to perform an ecological analysis to evaluate the impact on SAV habitat suitability. This is the key product benefiting the Mobile Bay coastal environmental managers that integrates the influences of temperature, salinity, and sediment due to LCLU driven flow changes with the restoration potential of SAVs. Data products and results are being integrated into NOAA's EcoWatch and Gulf of Mexico Data Atlas online systems for dissemination to coastal resource managers and stakeholders.

2. Research Objectives and Study Area

Objective 1: Develop and utilize Land Use scenarios for Mobile and Baldwin Counties, AL as input to models to predict the affects on water properties (temperature, salinity,) for Mobile Bay through 2030

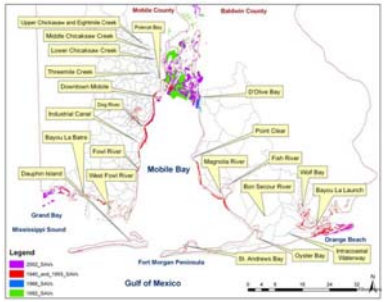
Objective 2: Evaluate the impact of land use change on seagrasses and SAV in Mobile Bay

Hypothesis: Urbanization will significantly increase surface flows and impact salinity and temperature variables that effect seagrasses and SAVs.

Science Questions:

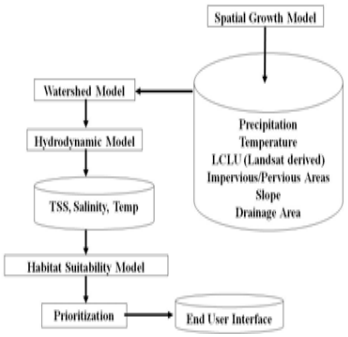
- How much will urbanization change flows, salinity and temperature within Mobile Bay?
- How important are increased fluctuations in temperature and salinity as a seagrass/SAV stressor?

Mobile Bay Study Area



3. Methodology

Watershed and hydrodynamic modeling has been performed for Mobile Bay to evaluate the impact of LCLU change in Mobile and Baldwin counties on the aquatic ecosystem. Watershed modeling using the Loading Simulation Package in C++ (LSPC) was performed for all watersheds contiguous to Mobile Bay for land use Scenarios in 1948, 1992, 2001, and 2030. The Prescott Spatial Growth Model (PSGM) was used to project the 2030 land use scenario based on observed trends. All land use scenarios were developed to a common land classification system developed by merging the 1992 and 2001 National Land Cover Data (NLCD). The LSPC model output provides changes in flow, temperature, and general water quality for 22 discharge points into the Bay. Theses results were inputted in the Environmental Fluid Dynamics Computer Code (EFDC) hydrodynamic model to generate data on changes in temperature, salinity and sediment values on a grid with four vertical profiles throughout the Bay's aquatic ecosystems. Outputs from the hydrodynamic model are used as inputs for the habitat suitability model for each land use scenario. The habitat suitability model is used to predict potential shifts of shallow water habitats over time, thus identifying areas of resilience or marginalization, and areas for protection, restoration or conservation measures.



Modeling Process

Models

PSGM is an Arc geographic information system (GIS) compatible application that allocates future growth into available land based on user-defined parameters. Inputs to the model are current land use and current projected population, employment, and road networks.

LSPC is a watershed model in C++ that has algorithms for simulating hydrology, sediment, and general water quality. Land use and weather text files are major inputs to drive the model.

EFDC is a hydrodynamic model that can be used to simulate salinity and temperature in aquatic systems. Finite-volume finite difference solution scheme to solve 3-D vertically hydrostatic equations of motion.

The **habitat suitability model** is a GIS model that is based on known factors limiting seagrasses/SAV growth such as salinity, temperature, and available light. These inputs are combined in a simple map algebra subroutine for a scored grid of habitat suitability for seagrasses/SAV.

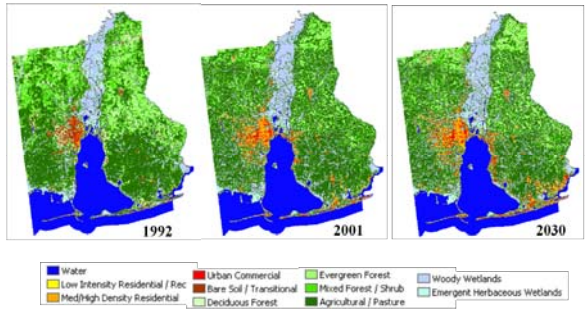
NLCD Class Remapping

Mobile and Baldwin Counties		
1992 Land Use Name	2001 Land Use Name	New Class Name
Water	Water	Water
Low Intensity Residental	Developed Open Space	Urban Low Density Residential/Recreational
Urban Recreational Grasses		
High Intensity Residental	Developed Low Intensity = high density residential	Urban Medium/High Density Residential
Comm/Ind/Transpotation	Developed Medium Intensity	Urban Commercial
	Developed High Intensity	
Bare Rock/Sand/Clay	Barren Land (Rock/Sand/Clay)	Bare Soil/Transitional
Quarries/Strip Mines/Gravel Pits		
Transitional		
Deciduous Forest	Deciduous Forest	Deciduous Forest
Evergreen Forest	Evergreen Forest	Evergreen Forest
Mixed Forest	Mixed Forest	Mixed Forest/Shrub
	Shrubs/Scrub	
Combined Grass/Pasture/Crop		Agriculture/Pastures
Grassland/Herbaceous	Grassland/Herbaceous	
Pasture/Hay	Pasture/Hay	
Row Crops	Cultivated Crops	
Woody Wetlands	Woody Wetlands	Woody Wetlands
Emergent Herbaceous Wetlands	Emergent Herbaceous Wetlands	Emergent Herbaceous Wetlands

1992 and 2001 Landsat derived National Land Cover Data (NLCD) were used for Mobile and Baldwin Counties to determine recent historical trends and to serve as baseline land use input data for spatial growth modeling and as inputs in watershed and hydrodynamic models. A remapping of the 1992 and 2001 NLCD classes to a common classification scheme allows comparison for 1992 to 2001 period and future land use projection scenarios. Classes in light red did not exist in both 1992 and 2001 NLCD classifications. The tan shaded column shows the remapped class names and groupings from the original LCLU classifications. A LCLU trends analysis was used to calibrate the Prescott Spatial Growth Model.

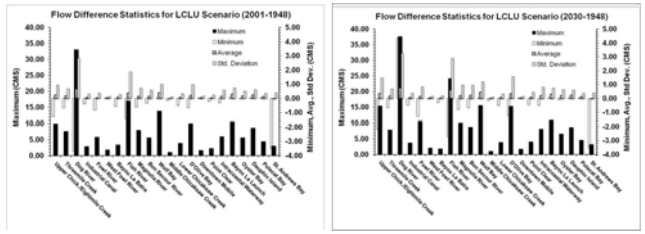
4. Modeling Results

Land Cover Land Use Scenarios



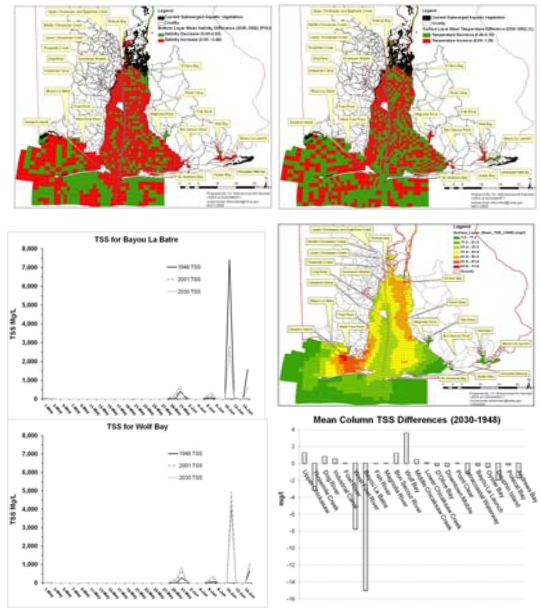
Source: Projected LCLU for 2030 with the PSGM

Stream Flow Changes



Source: LSPC Watershed Model

Salinity , Temperature, and TSS Changes



Source: EFDC Hydrodynamic Model

5. Habitat Suitability Analysis

The changes in the aquatic ecosystem were used to perform an ecological analysis to evaluate the impact of temperature, salinity, and TSS due to land use driven flow changes to produce SAV habitat suitability projections. This helps to predict potential shifts of shallow water habitats over time, thus identifying areas of resilience or marginalization, and areas that need protection, restoration or conservation measures.

6. Conclusions and Future Work

- Seagrasses and SAVs have significantly decreased in Mobile Bay over the past 60 years and are being stressed by increasing urbanization.
- LCLU changes are increasing freshwater flows into Mobile Bay and causing increased temperature, salinity, and TSS fluctuations.
- Higher sediment loads normally were strongly correlated with higher TSS levels, except in areas with a large extent of wetlands.
- More suitable SAV habitat is projected in portions of southwest Mobile Bay and decreasing habitat in the southeast area.
- Data products and results are being integrated into NOAA's EcoWatch and Gulf of Mexico Data Atlas online systems for dissemination to support decision making by coastal resource managers and stakeholders.

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