Development of Coupled Physical and Ecological Models for Stress-Response Simulations of the Apalachicola Bay

Co-Principal Investigators:

Mark Harwell, Ping Hsieh, Wenrui Huang, Elijah Johnson, Katherine Milla, Hongqing Wang, Glynnis Bugna, Kevin Dillon, Christine Hladik, and Jack Gentile

Outline

1. Background (Study site, Ecosystem diagnosis, Objective, etc.)
2. Methodology (Coupled Physical-Ecological Model System)
3. Current Progress (A. Hydrodynamic model; B. EPA WASP water quality model; C. River model; D. Ecological models (salt marsh, oyster, habitat suitability, landscape model)
4. Future Development

1. Background

Apalachicola Bay, Florida:

The Last Great Bay in USA

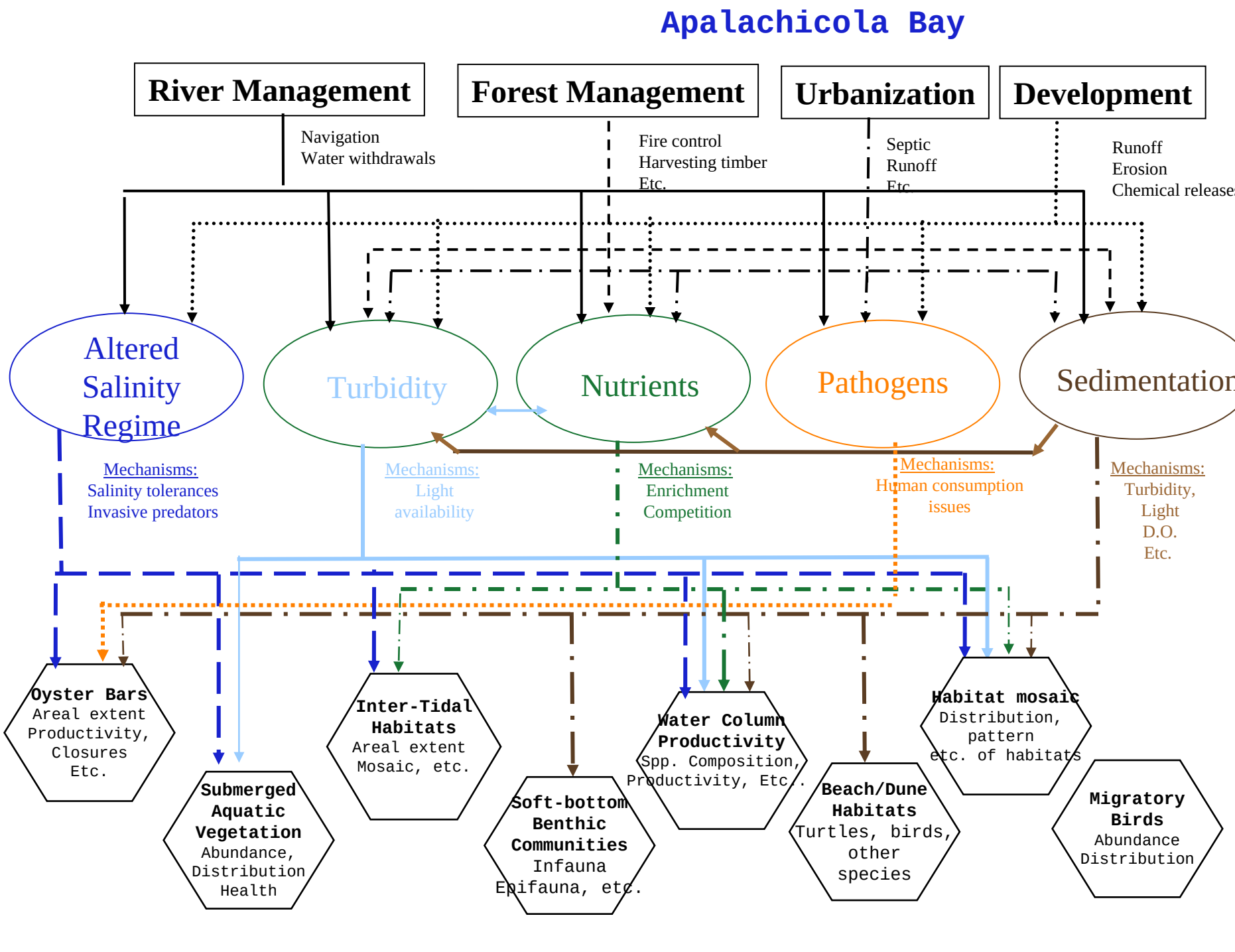

Apalachicola
Bay
Ecosystem
Florida LANDSAT
GeoCover 2000
http://geology.com/satellite/florida-satellite-image.shtml
Copyright 2005 - geology.com

Apalachicola Bay System

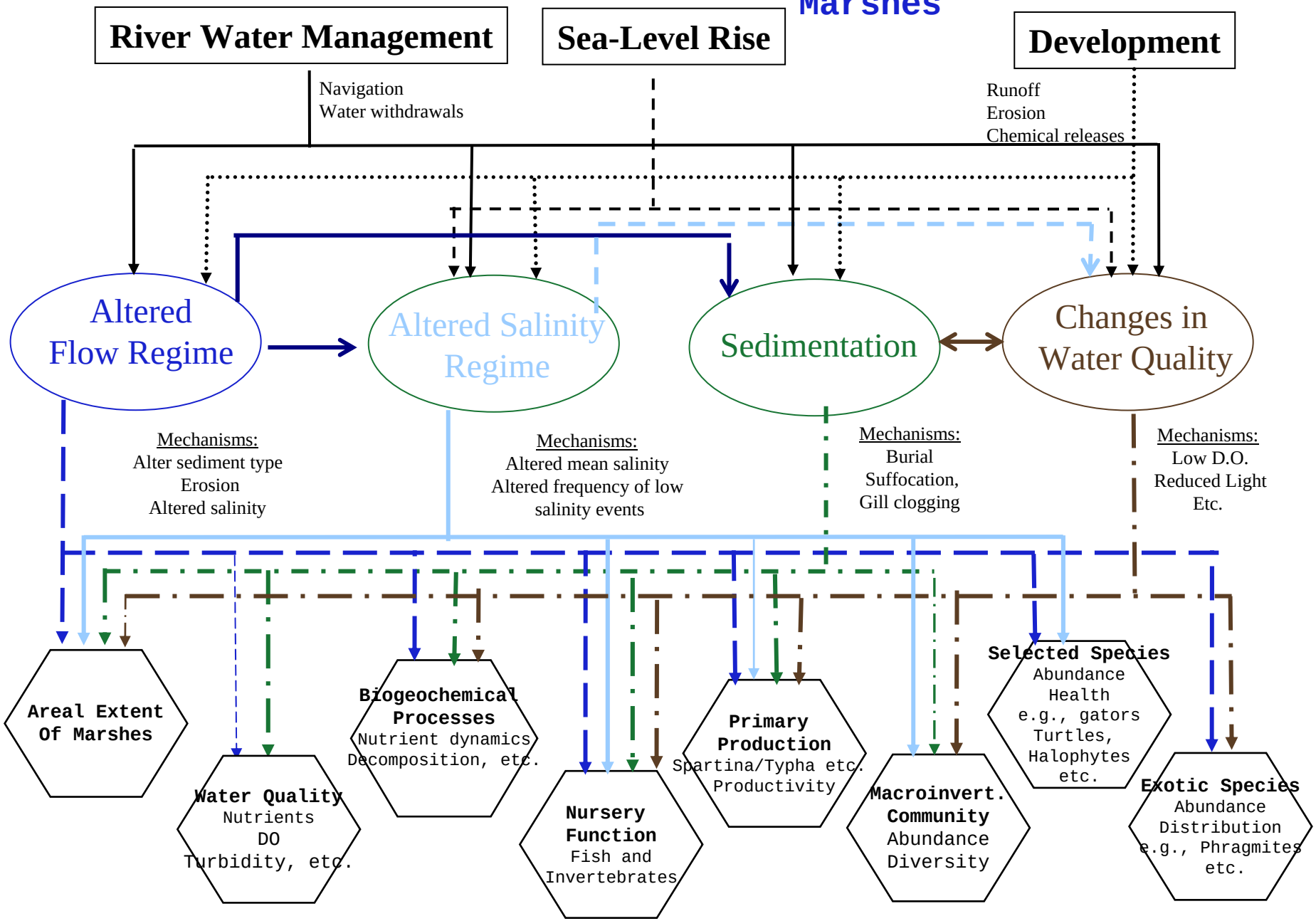
Valued Ecosystem Components (VECs) vs. Stressors

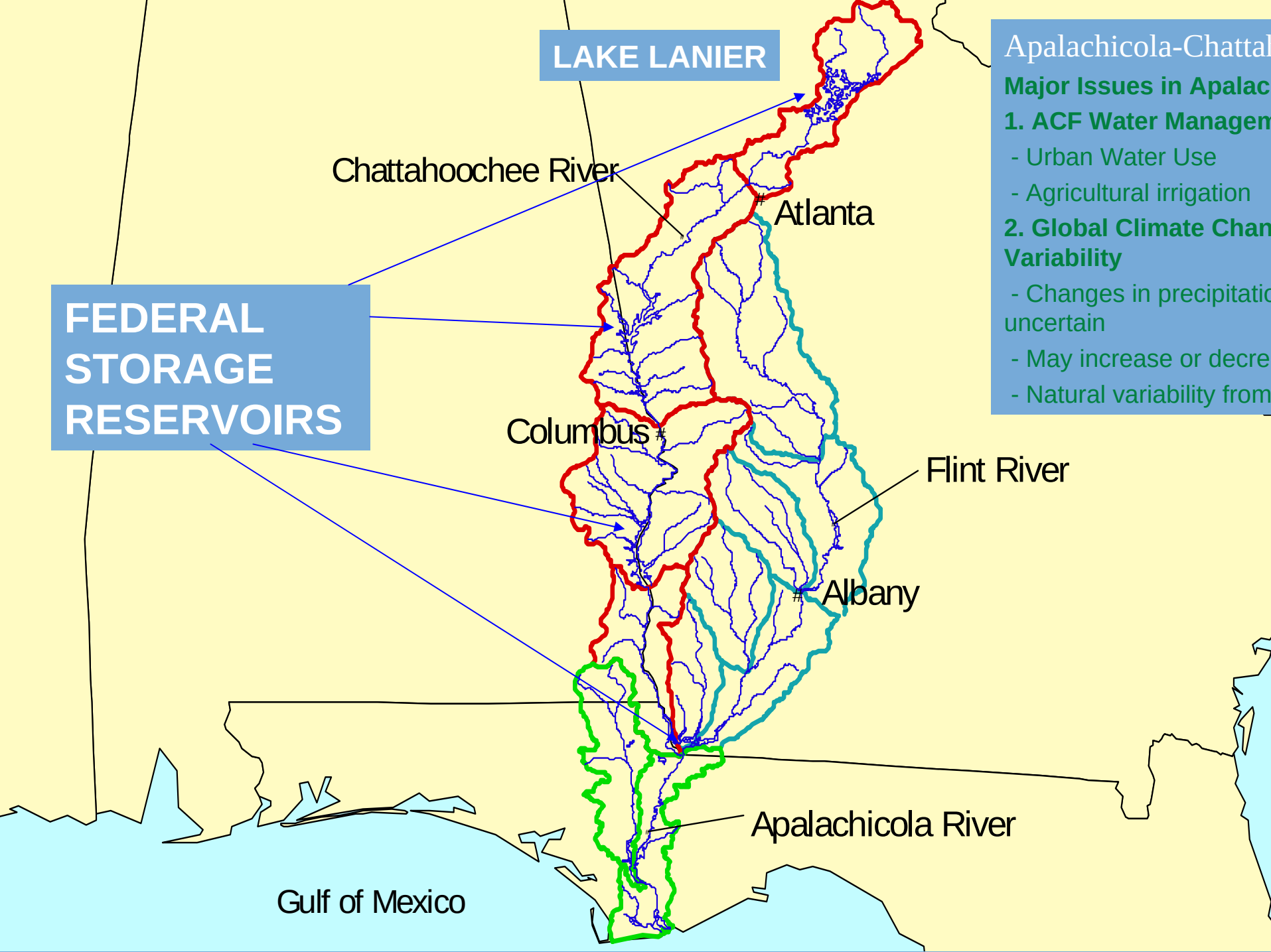
VECs: Oysters, recreational fisheries, salt marshes, and associated aesthetic, endangered, and recreational species of birds, fish, and invertebrates.

Stressors: Changes in salinity and turbidity, sea-level rise, nutrient inputs, tropical storms and hurricanes, and habitat alteration.


Apalachicola Bay
River Management
Navigation
Water withdrawals
Forest Management
Fire control
Harvesting timber
Etc.
Urbanization
Septic
Runoff
Etc.
Development
Runoff
Erosion
Chemical releases
Altered Salinity Regime
Turbidity
Nutrients
Pathogens
Sedimentation
Mechanisms:
Salinity tolerances
Invasive predators
Mechanisms:
Light availability
Mechanisms:
Enrichment
Competition
Mechanisms:
Human consumption issues
Mechanisms:
Turbidity,
Light
D.O.
Etc.
Oyster Bars
Areal extent
Productivity,
Closures
Etc.
Submerged Aquatic Vegetation
Abundance,
Distribution
Health
Inter-Tidal Habitats
Areal extent
Mosaic, etc.
Soft-bottom Benthic Communities
Infauna
Epifauna, etc.
Water Column Productivity
Spp. Composition,
Productivity, Etc..
Beach/Dune Habitats
Turtles, birds,
other
species
Habitat mosaic
Distribution,
pattern
etc. of habitats
Migratory Birds
Abundance
Distribution

Apalachicola Bay Salt and Freshwater Marshes

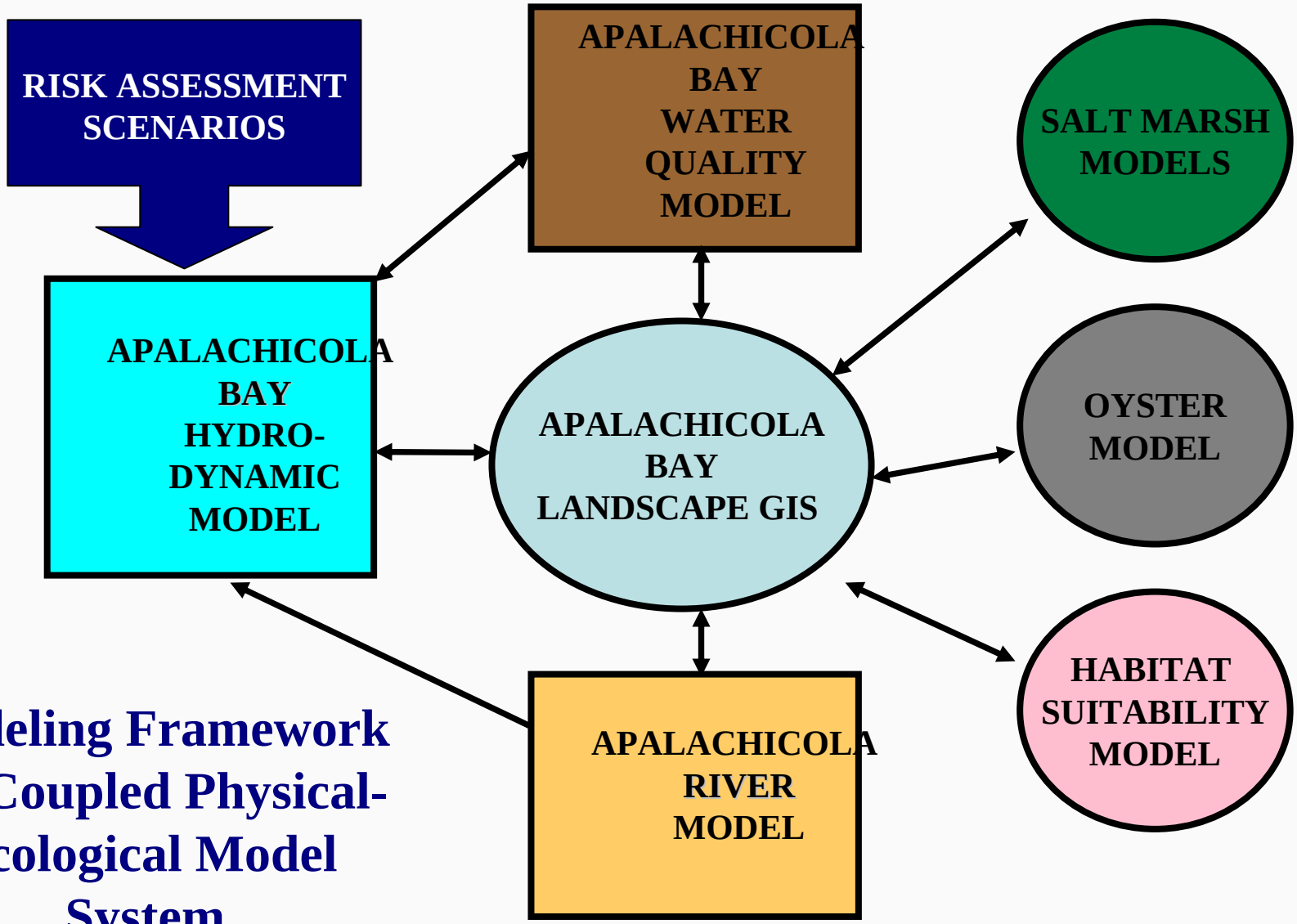



LAKE LANIER
Chattahoochee River
Atlanta
FEDERAL STORAGE RESERVOIRS
Columbus
Flint River
Albany
Apalachicola River
Gulf of Mexico
Apalachicola-Chattal
Major Issues in Apalac
1. ACF Water Managem
- Urban Water Use
- Agricultural irrigation
2. Global Climate Chan
Variability
- Changes in precipitatio
uncertain
- May increase or decre
- Natural variability from

Research Project Objective

To develop a coupled physical-ecological model of the Apalachicola Bay ecosystem that can be used as a quantitative tool to assess the ecosystem responses to natural and anthropogenic stressors.

2. Methodology



Modeling Framework for Coupled Physical-Ecological Model System

Research Tasks

1. Adopt 3-D hydrodynamic model to Apalachicola Bay (based on Princeton Ocean Model)
2. Interface hydrodynamic model with EPA WASP WQ Model
3. Calibrate River Flow Model to Apalachicola River
4. Ecological and WQ data gathering - using existing info, including high-resolution hyperspectral imaging
5. Develop ecological models for salt marsh, oysters, and landscape systems
6. Integrate data and models via GIS data layers
7. Conduct demonstration ecological risk assessment

3. Current Progress

A. 3D Hydrodynamic Model (Based on Princeton Ocean Mode, POM);

B. EPA WASP 6 Water Quality Model;

C. Apalachicola River Model

D. Ecological Models (Salt Marsh, Oyster, Habitat Suitability, Landscape).

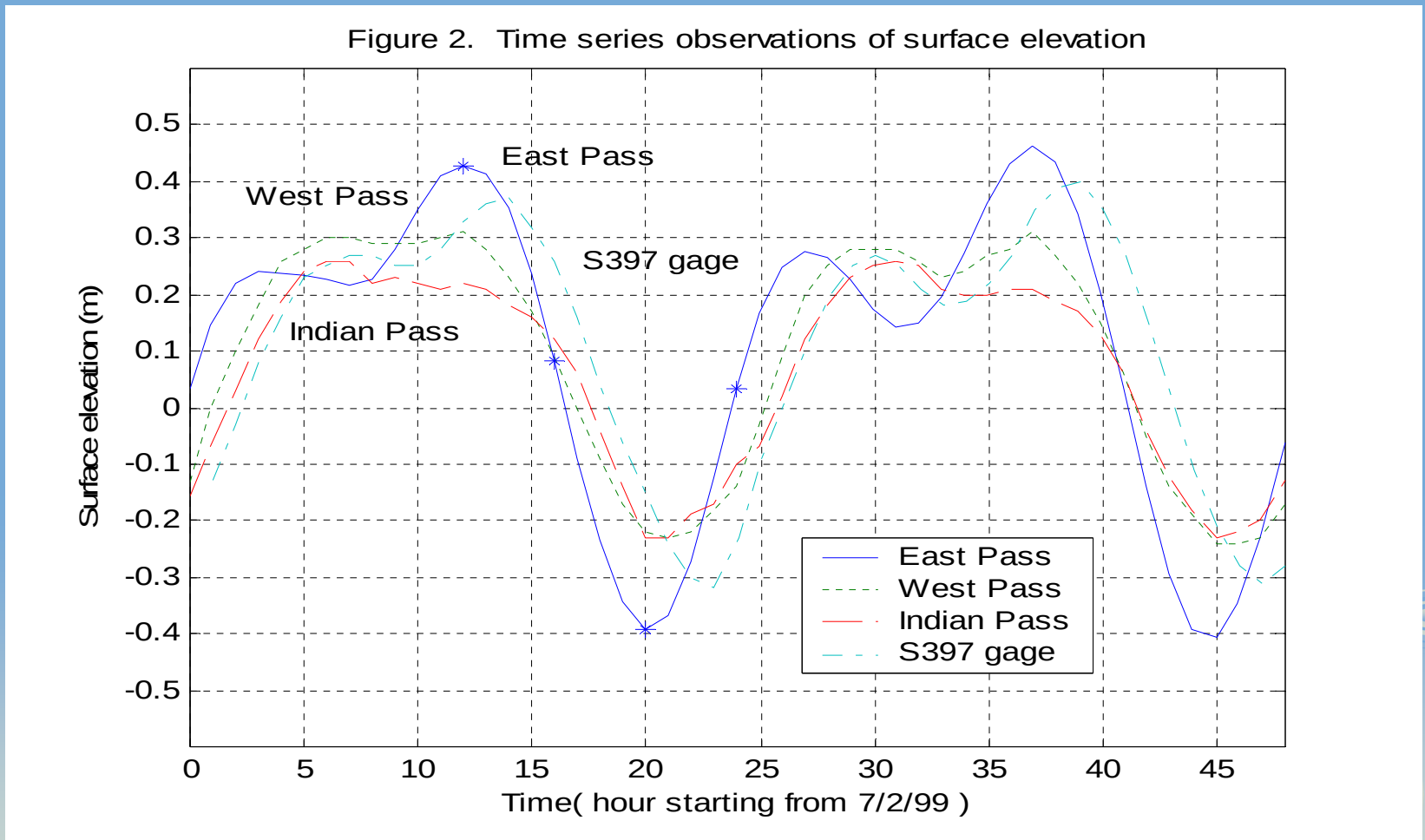
3-1.The Hydrodynamic Model

- Princeton Ocean Model (POM) (Blumberg and Mellor, 1987);
- Determine spatial and temporal changes in water surface elevation, circulation, salinity, temperature, and velocity in response to wind, tide, buoyancy and Coriolis force;
- Model parameters: bottom drag coefficient, bottom roughness, horizontal diffusion and viscosity, etc.;
- Calibrated and validated using field observations of hourly surface elevation and salinity at several stations in the Apalachicola Bay.

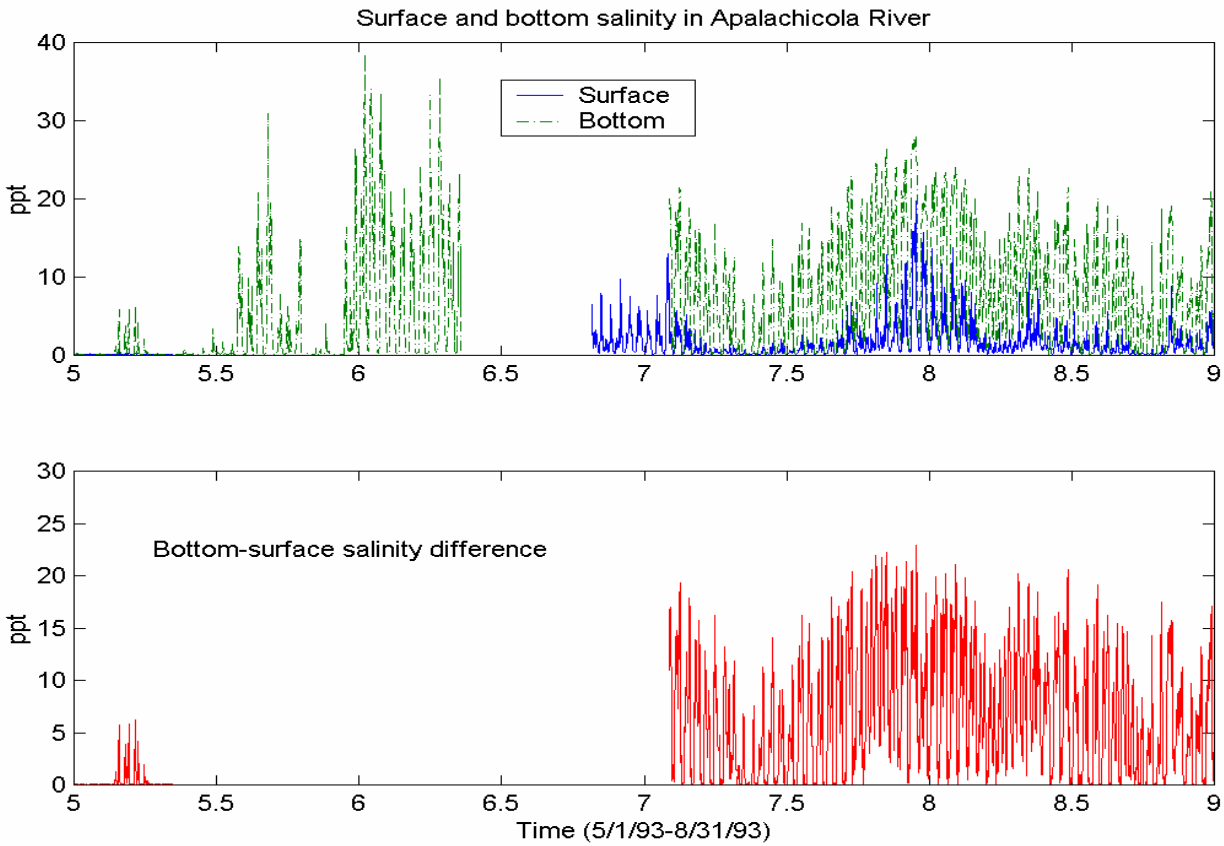
Characteristics of Apalachicola Bay

- Shallow water, multiple tidal boundaries;
- Strong freshwater discharge:
  Q_{min}=155 m^3, Q_{ave}=770 m^3, Q_{max}=2300 m^3.
- River discharge perpendicular to the estuarine axis and a long barrier island;
- Strong vertical stratification near the river mouth.

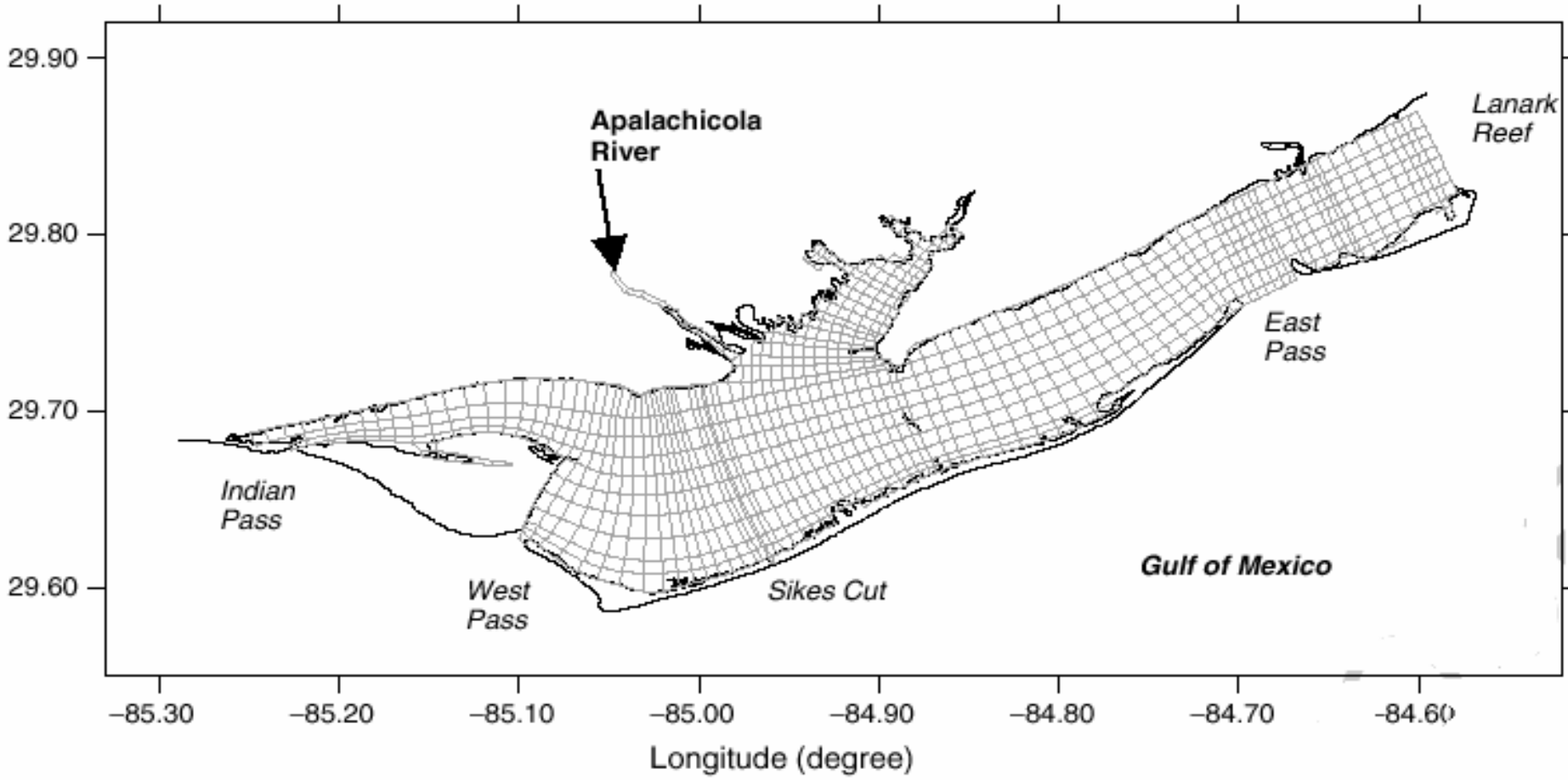
Multiple tidal forces with different amplitudes



Strong Vertical Stratification

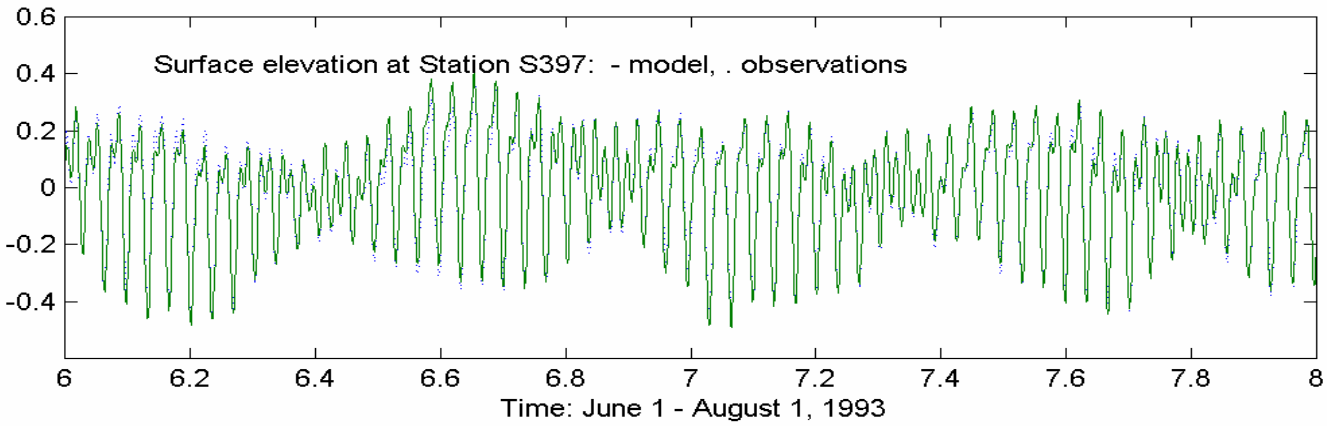


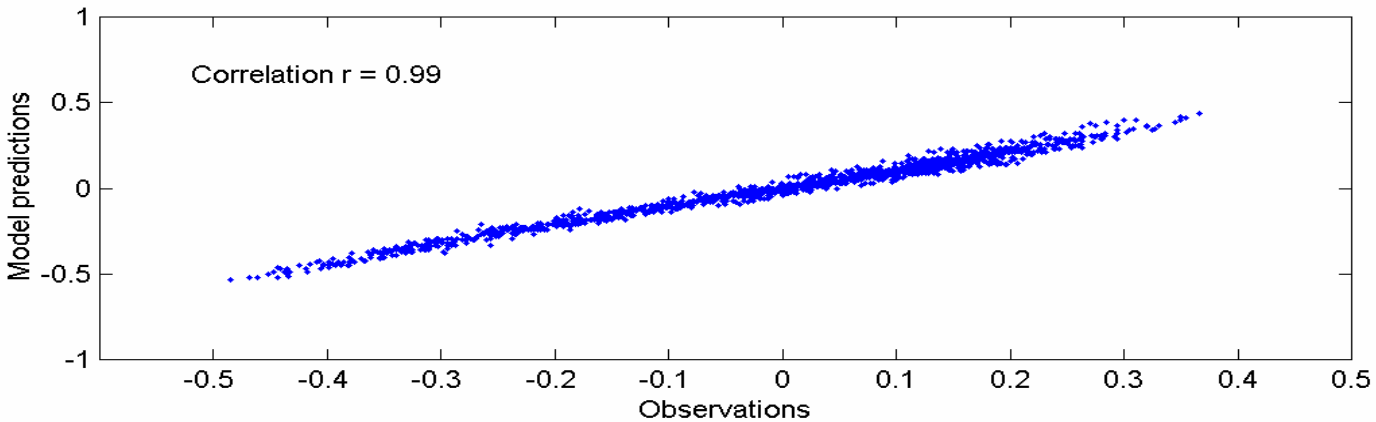
Model grid



Apalachicola Bay hydrodynamic model grid system

Model Calibration: Surface Elevation at S397





/dingo/.../genesis/rele2d/compele.m

Model Calibration: Salinity

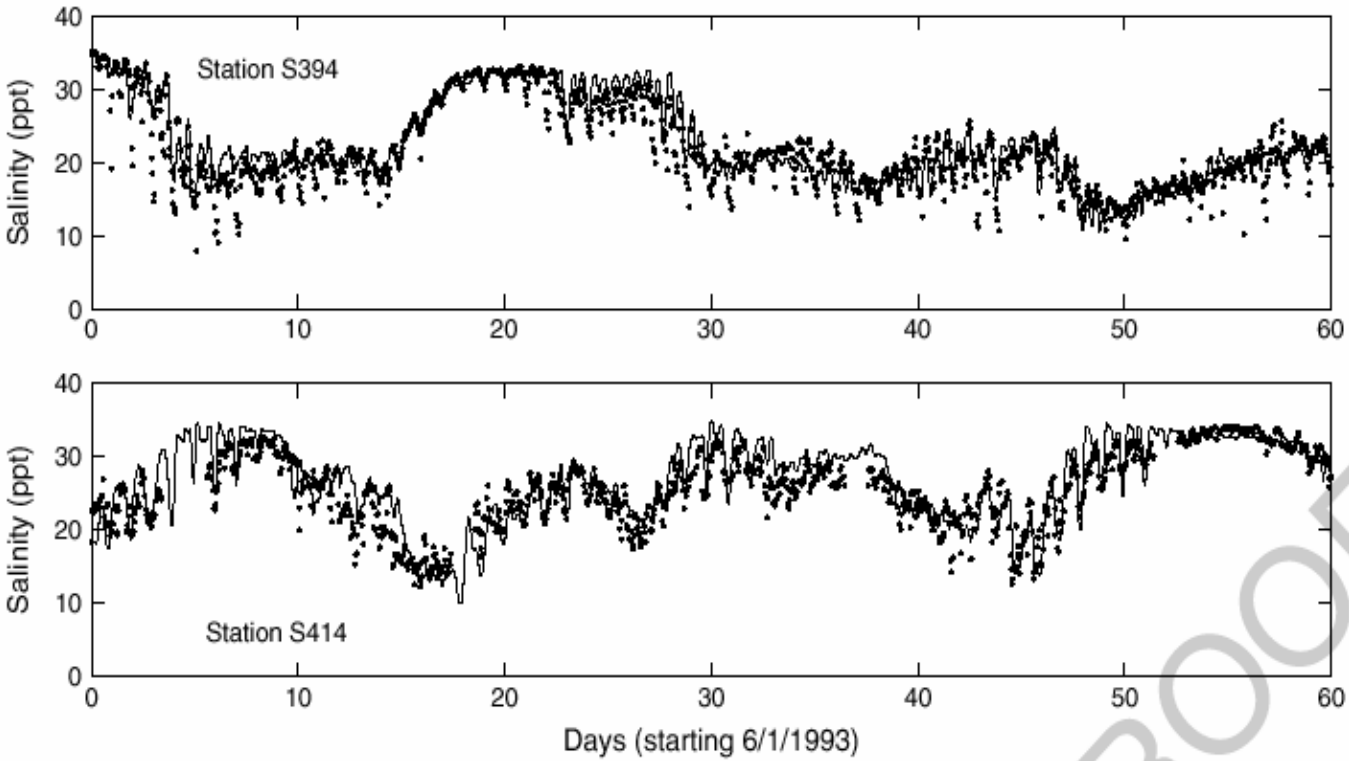
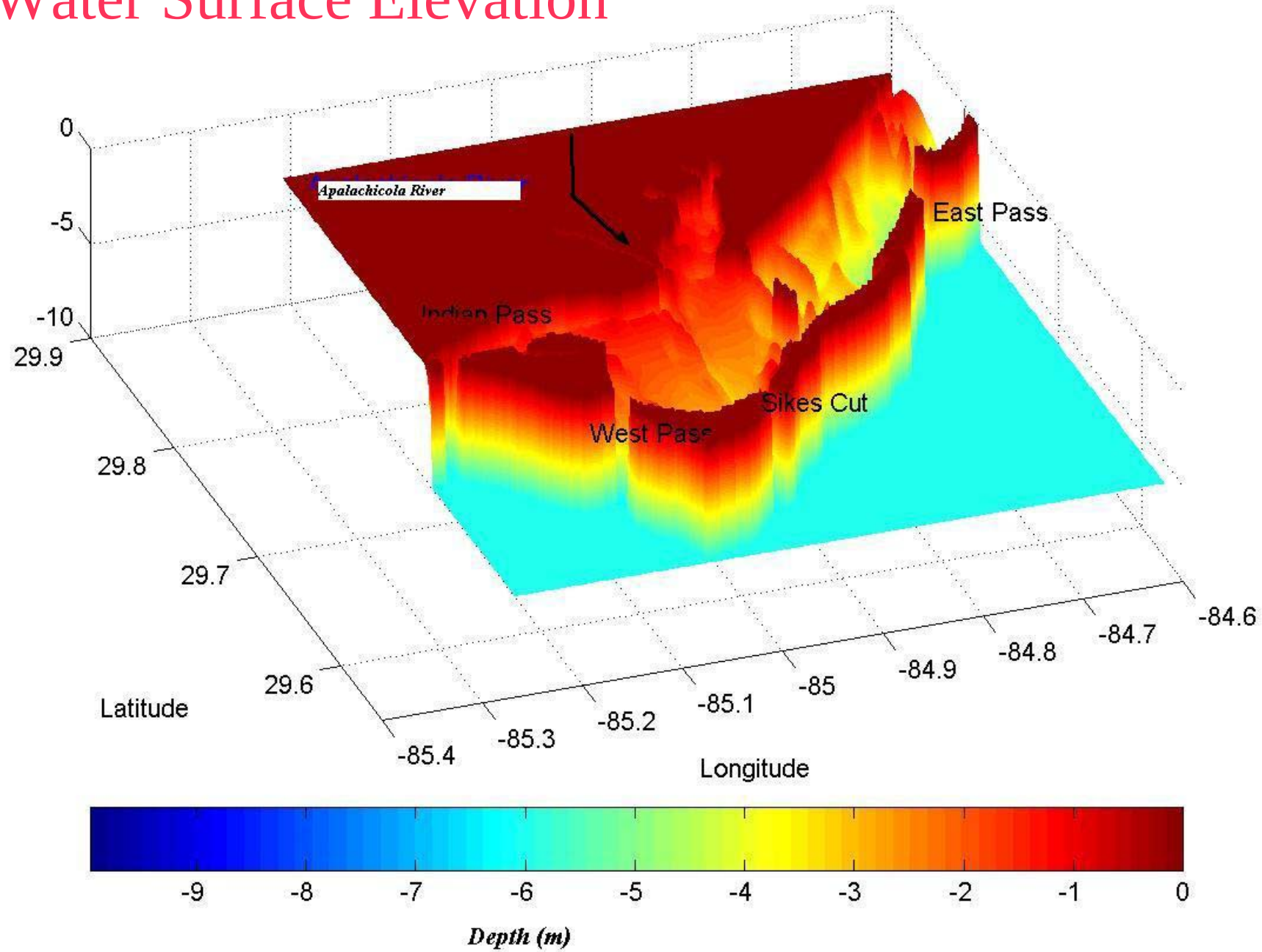
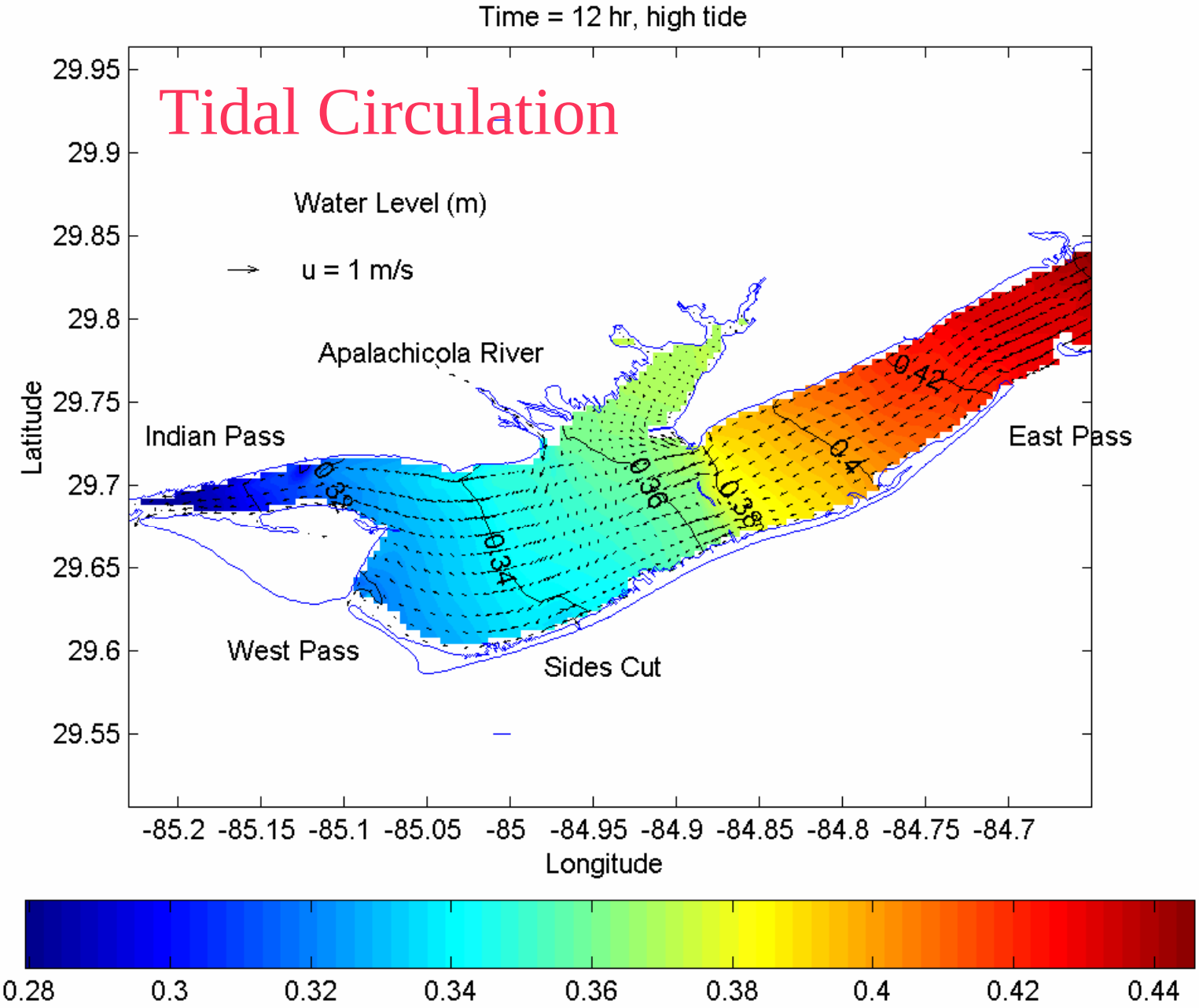


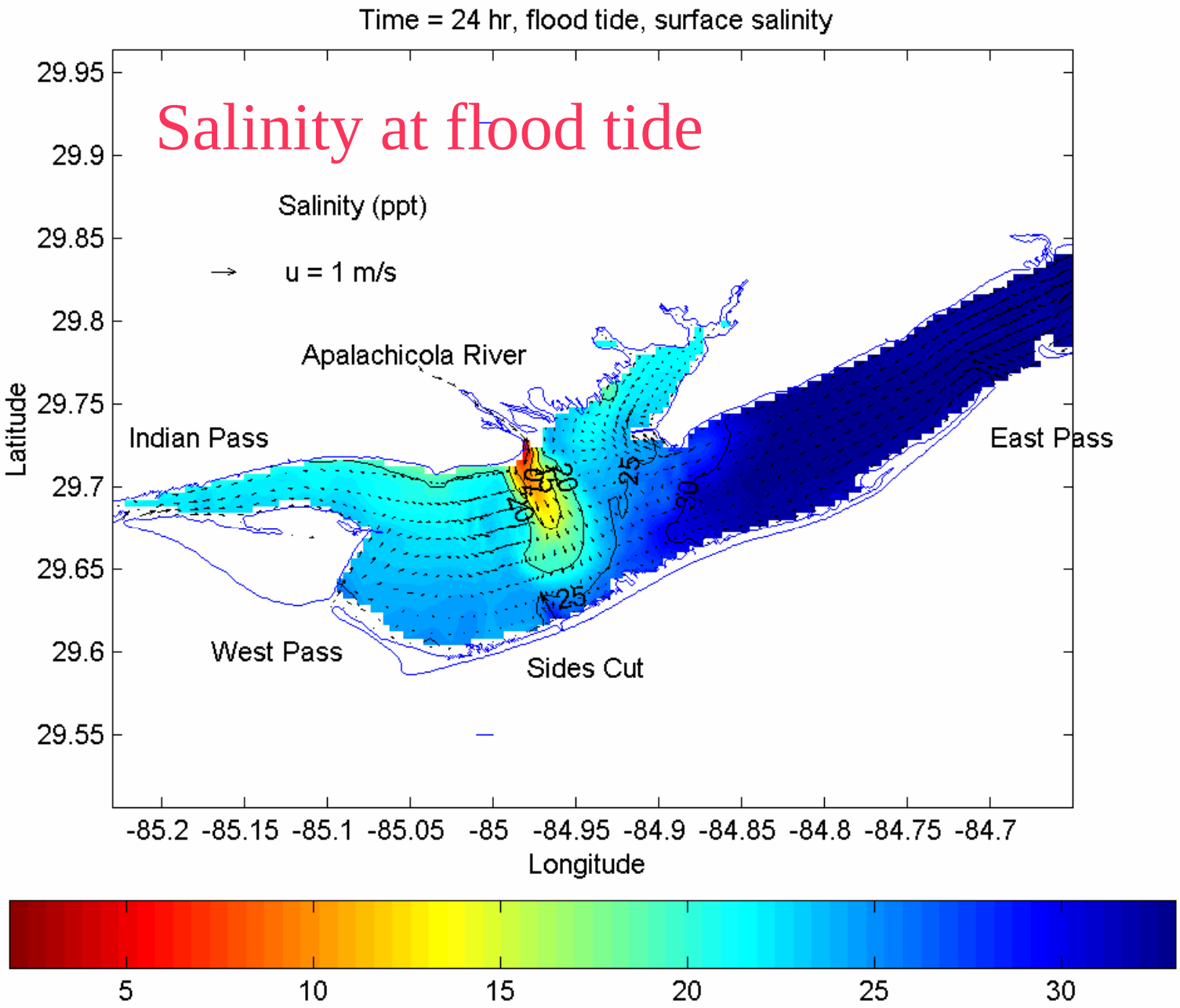
Figure 4. Comparison of model predictions of salinity with field observations

Water Surface Elevation

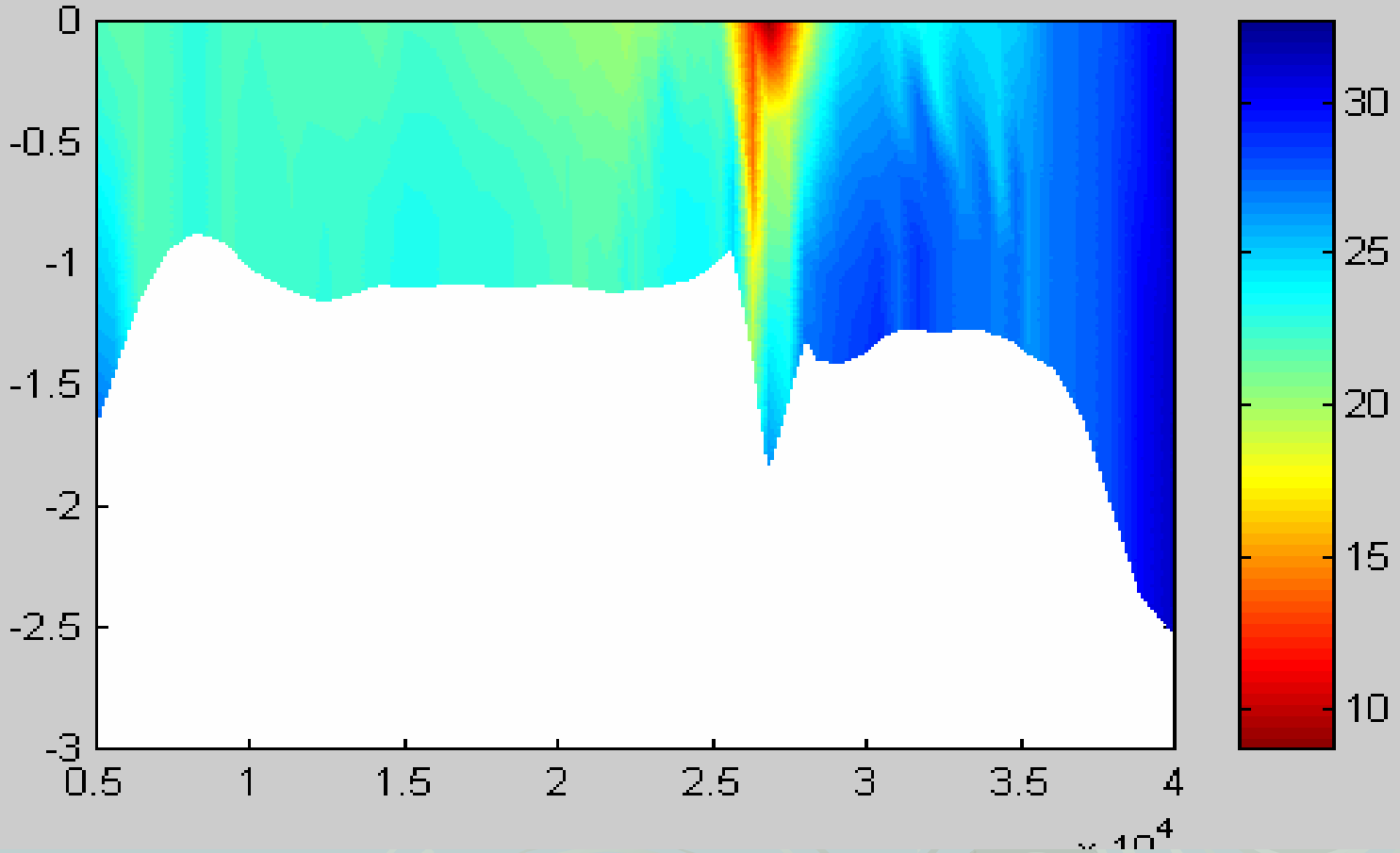


Tidal Circulation

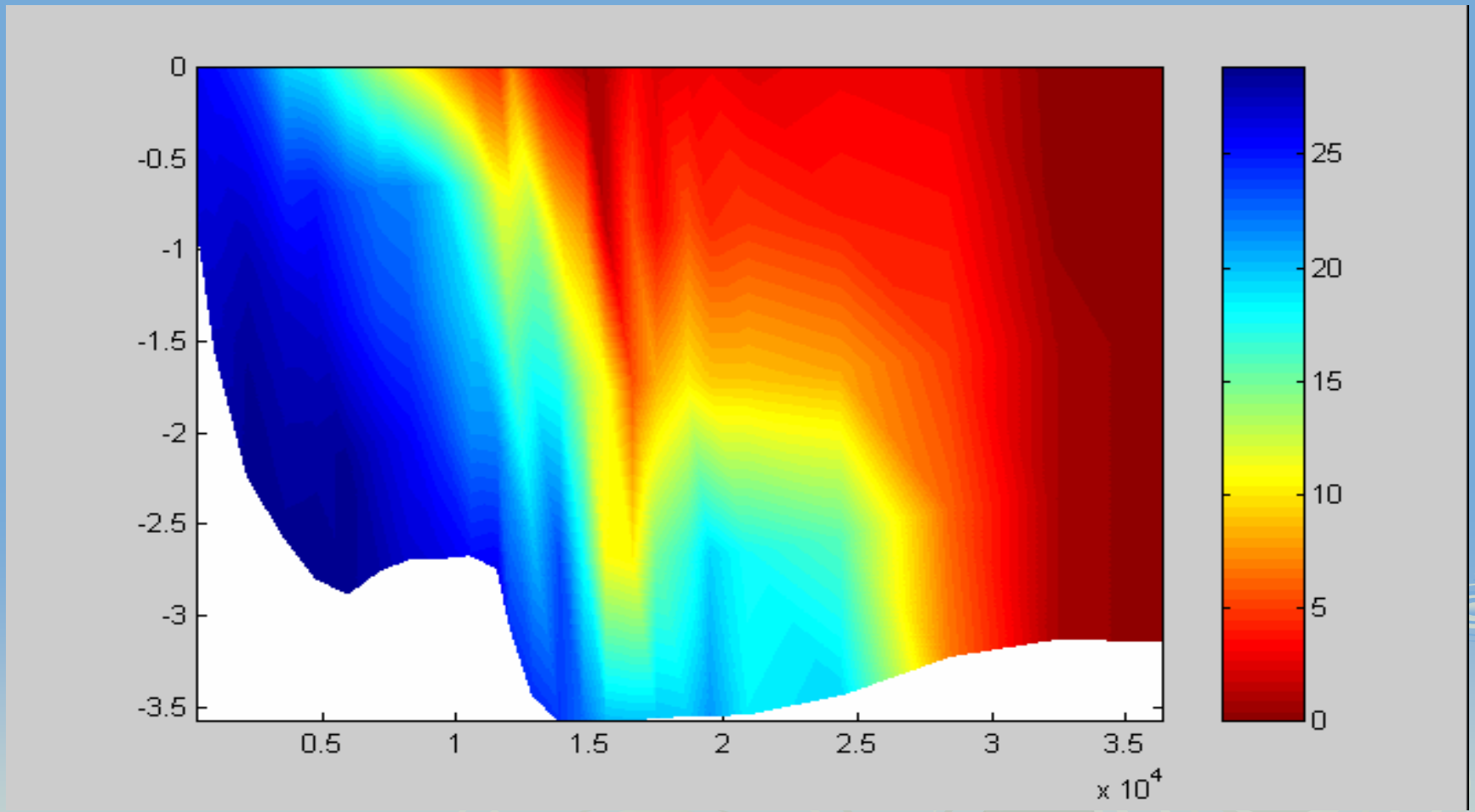



Time = 24 hr, flood tide, surface salinity
Salinity at flood tide
Salinity (ppt)
u = 1 m/s
Apalachicola River
Indian Pass
East Pass
West Pass
Sides Cut
Latitude
Longitude
29.95
29.9
29.85
29.8
29.75
29.7
29.65
29.6
29.55
-85.2 -85.15 -85.1 -85.05 -85 -84.95 -84.9 -84.85 -84.8 -84.75 -84.7
5
10
15
20
25
30

Vertical Salinity Stratification:
Cross Section from Western to Eastern Apalachicola Bay



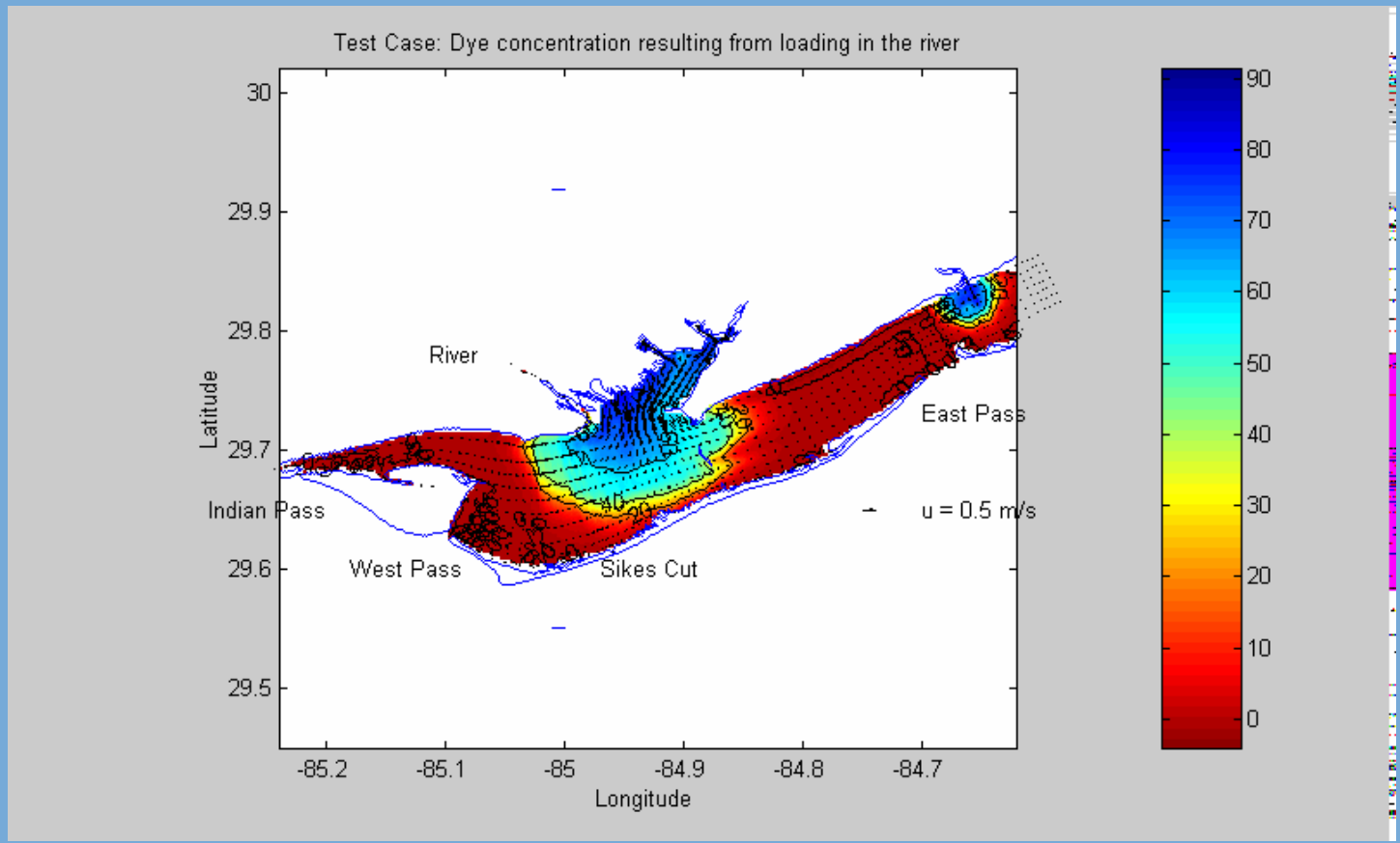
Vertical Salinity Stratification: Apalachicola Bay(left) to Apalachicola River (right)



3-2. Linkage between POM and WASP

1. Apalachicola POM converted to EFDC format that can be linked directly to WASP;
2. Model test simulations for dye concentration and sediment transport.

Model Test for Constant Dye Released from Apalachicola River



Model Test for Sediment Re-suspension