THE APPLICATION OF OYSTER AND SEAGRASS MODELS TO EVALUATE ALTERNATIVE INFLOW SCENARIOS RELATED TO EVERGLADES RESTORATION

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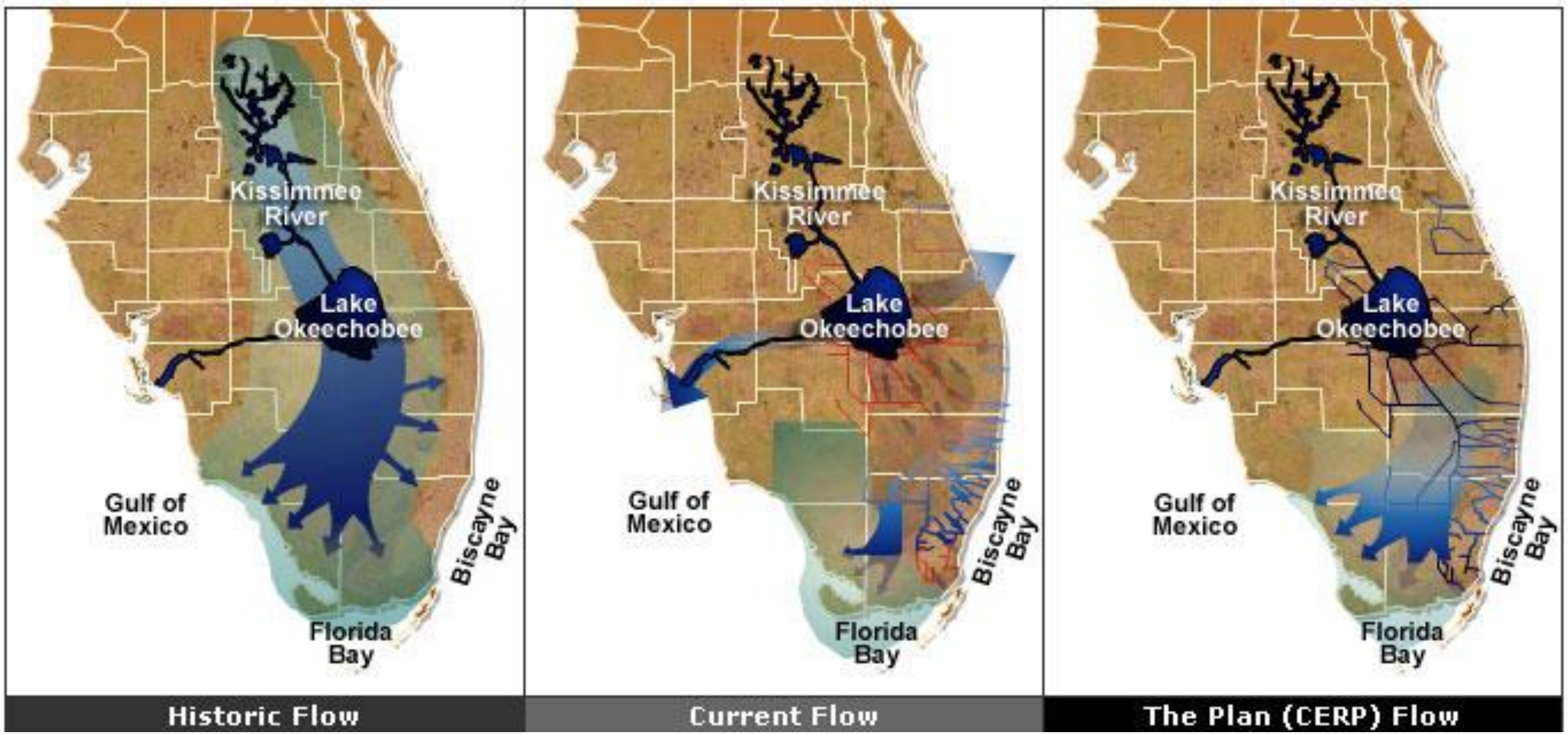
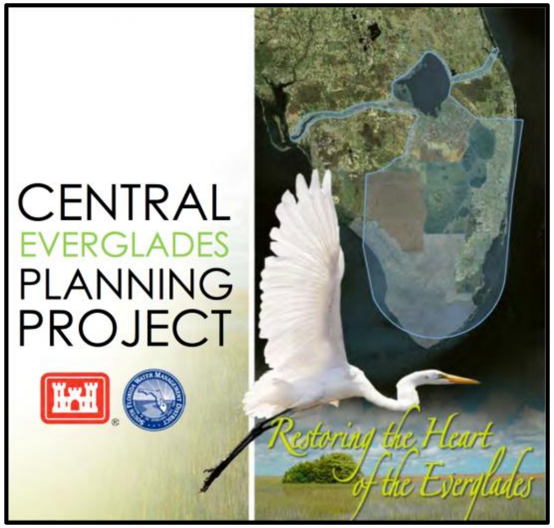
EVERGLADES RESTORATION

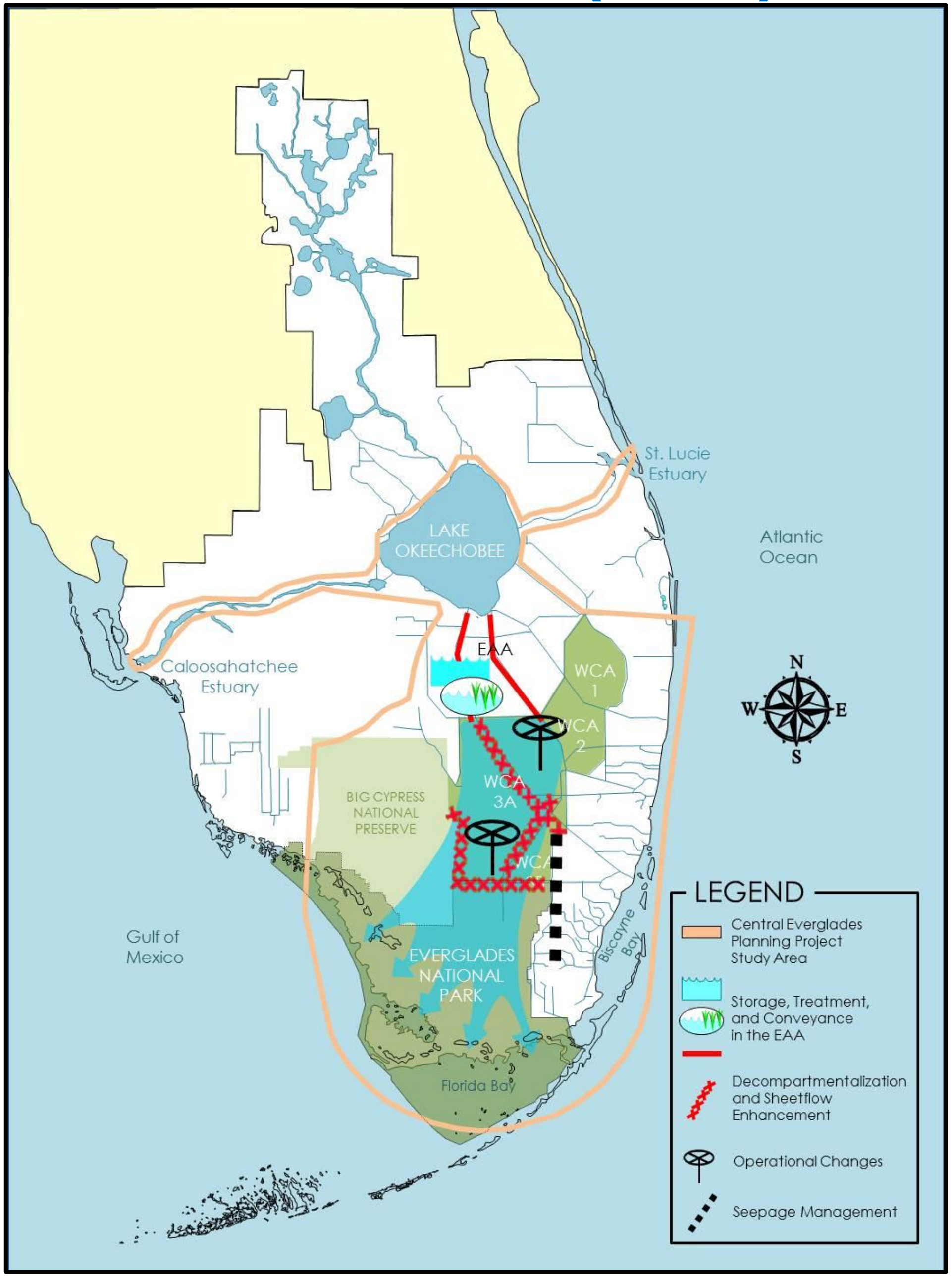
- South Florida is a heavily modified aquatic landscape
- System (1970's) designed for ~2,000,000 people
- Presently there are > 8,300,000 people
- 7700 km of canals, 1350 water structures, 70 pumping stations
- Agriculture, urbanization, development
- Excess freshwater released to sea for flood protection
- Damage to coastal aquatic ecology
- Estimated $13.5 billion cost to restore!

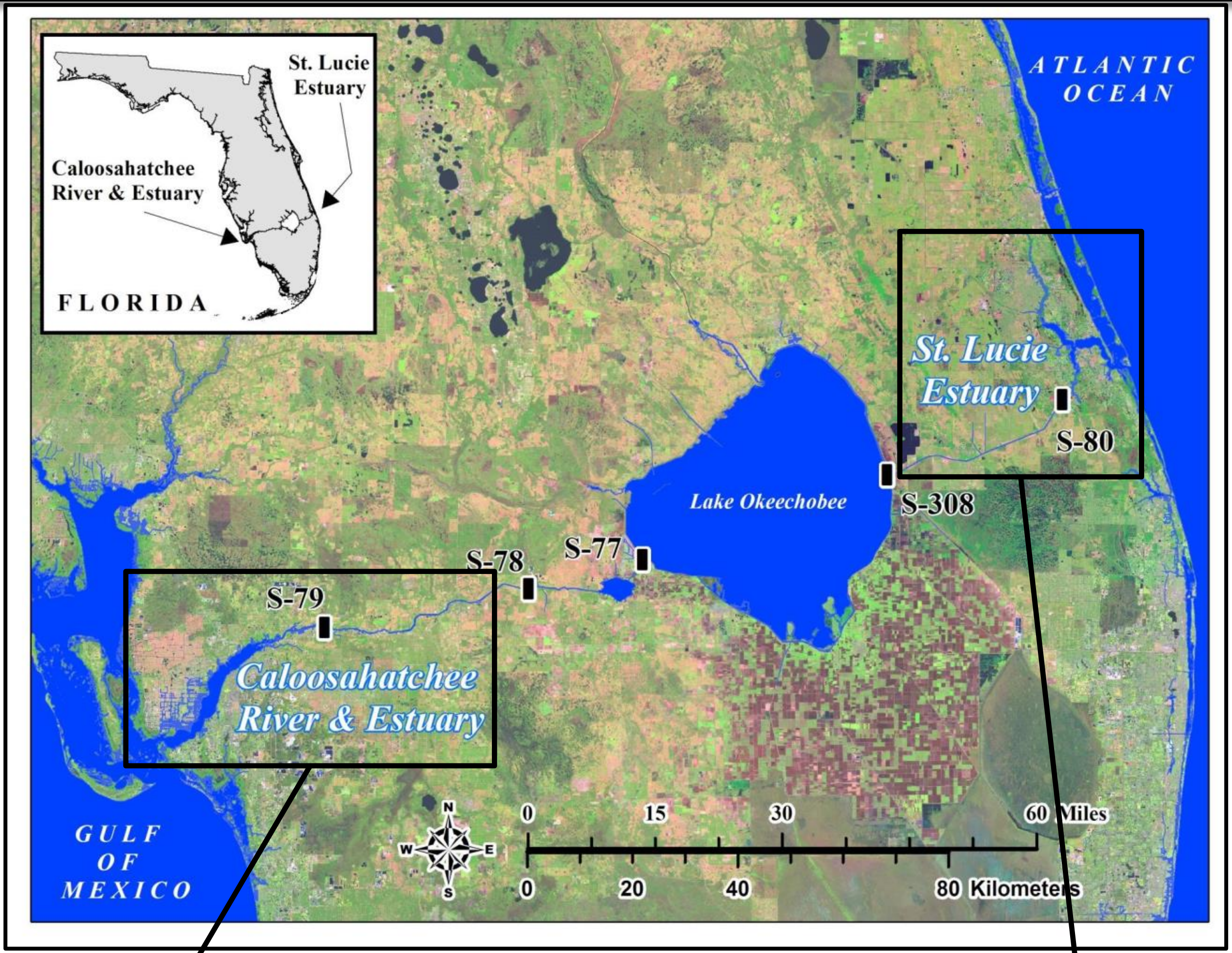


CENTRAL EVERGLADES PLANNING PROJECT (CEPP)

- **CEPP intended to advance restoration projects.**
- **Reduce Lake Okeechobee releases to coastal zone by diverting freshwater to the south.**
- **Stabilize salinity and water quality conditions for estuarine habitats.**
- **Integrated modeling to link watershed engineering projects, estuarine salinity, and biota.**







Caloosahatchee River Estuary (CRE)

- Watershed and river modified for agriculture, urbanization, flood control since 1880's
- Upstream boundary located at S-79, extends ~48 km to Sanibel Bridge
- 56 km^2; ~2.7 m depth; 5-60 d flushing time
- Oyster and seagrass habitats near mouth

St. Lucie River Estuary (SLE)

- Freshwater system until 1892; watershed modified for agriculture & urbanization
- North Fork, South Fork, Middle Estuary between water structures and inlet
- 29 km^2; ~2.4 m depth; 2-40 d flushing time
- Oyster habitat scattered; seagrass in SIRL

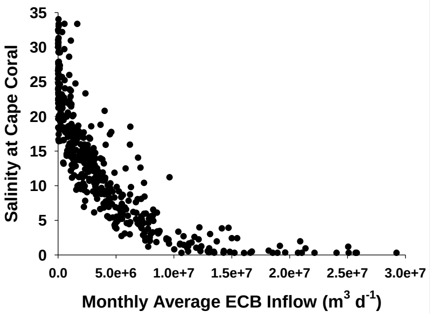
CEPP INTEGRATIVE MODELING FRAMEWORK

CEPP INFLOW SCENARIOS

Daily inflows 1965-2005
ECB, FWO, ALT4R scenarios
CRE = S79 at upstream limit
SLE = multiple tributary inflows

SALINITY PREDICTIONS

Hydrodynamic model
Statistical model
CRE =Cape Coral, Shell Point
SLE =US1, Boy Scout Island



ECOLOGICAL MODELS

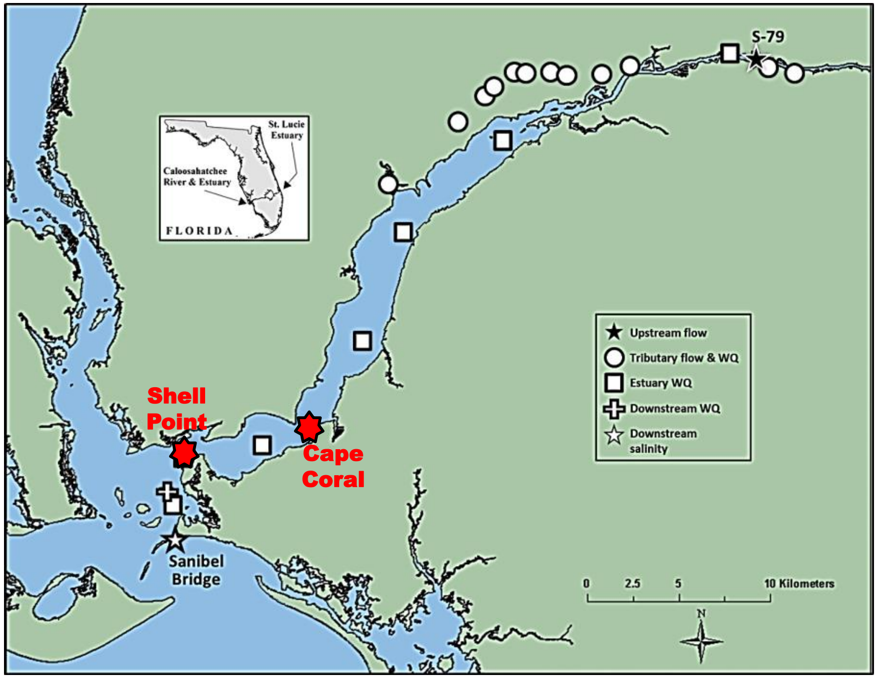
Cape Coral & US1 – Oyster
Shell Point – Oyster and *Halodule*
Boy Scout Island - *Syringodium*

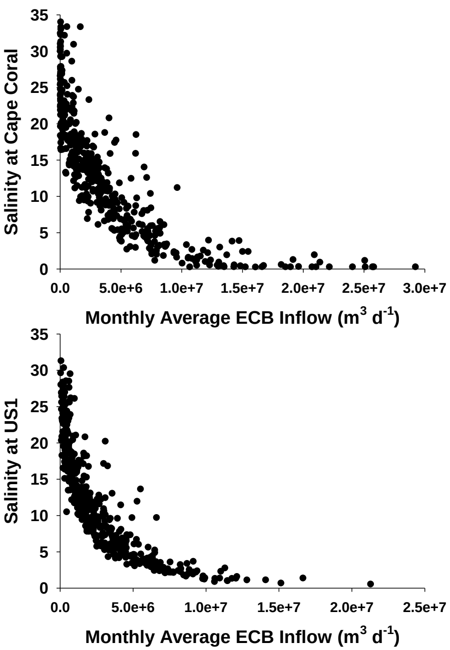
CEPP INFLOW SCENARIOS

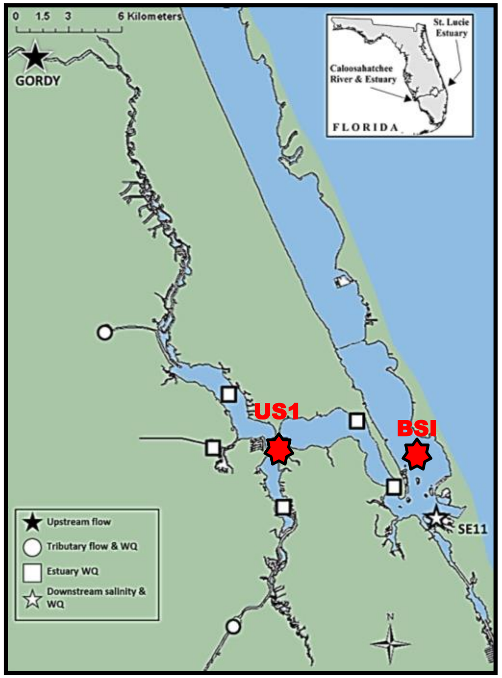
- The CEPP is partnership between the USACE and the SFWMD
- Expedite planning effort as part of the CERP
- Projects on publicly owned lands to redistribute water pathways
- 259 million m^3 of water to be captured and redirected southward
- Landscape-scale flows with Regional Simulation Model (RSM)
- Includes Indian River Lagoon South (SLE) and C-43 Reservoir (CRE)
- 41 y daily inflow scenarios (1965-2005) ECB, FWO, ALT4R
    - Existing Base Condition = present water system configuration
    - Future Without Project = future water system without CEPP but includes IRL-South (SLE) and C-43 Reservoir (CRE)
    - Alternative 4R = FWO including CEPP projects to capture water

ESTUARINE SALINITY PREDICTIONS

- Multivariate salinity time series modeling for CRE & SLE
- Hydrodynamic modeling + Intensive salinity monitoring
- Auto-regression + exogenous terms (inflow, rainfall, water level)
- Freshwater inflow from RSM coupled to contributions from tidal basin, rainfall, and tidal water level fluctuations
- Predict average daily salinity at multiple locations for 41 y (1965-2005)
- CRE = Cape Coral and Shell Point; SLE = US1 and Boy Scout Island (southern Indian River Lagoon)
- Inputs for oyster and seagrass models







MODELING ESTUARINE BIOTA

Estuary = partially enclosed coastal **basin** where **fresh** and **salt** water mix

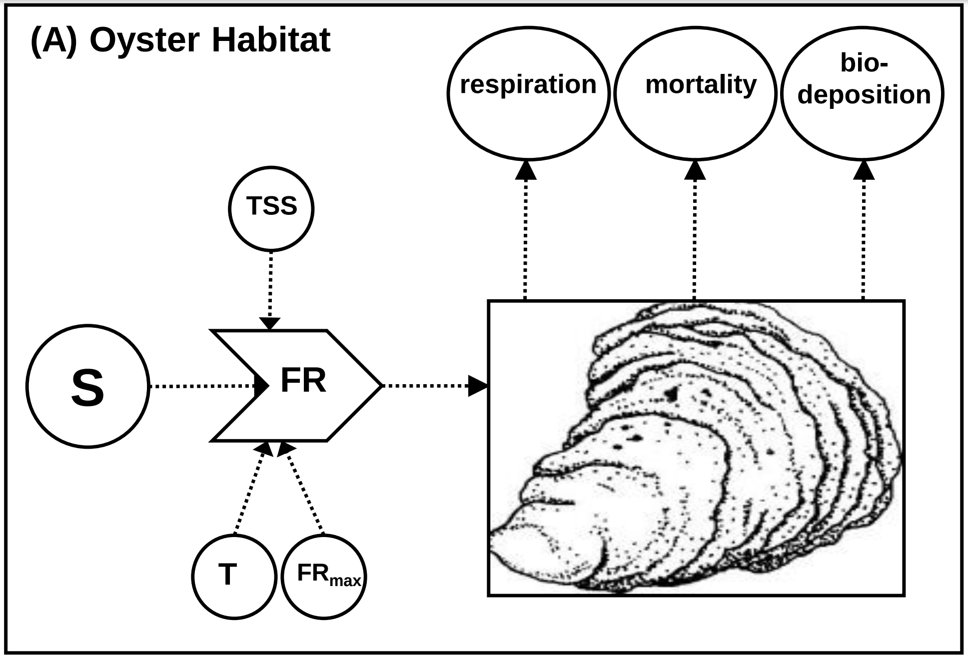
Hydrodynamics = rainfall, freshwater **flow**, wind events, **tides**, residual **circulation**

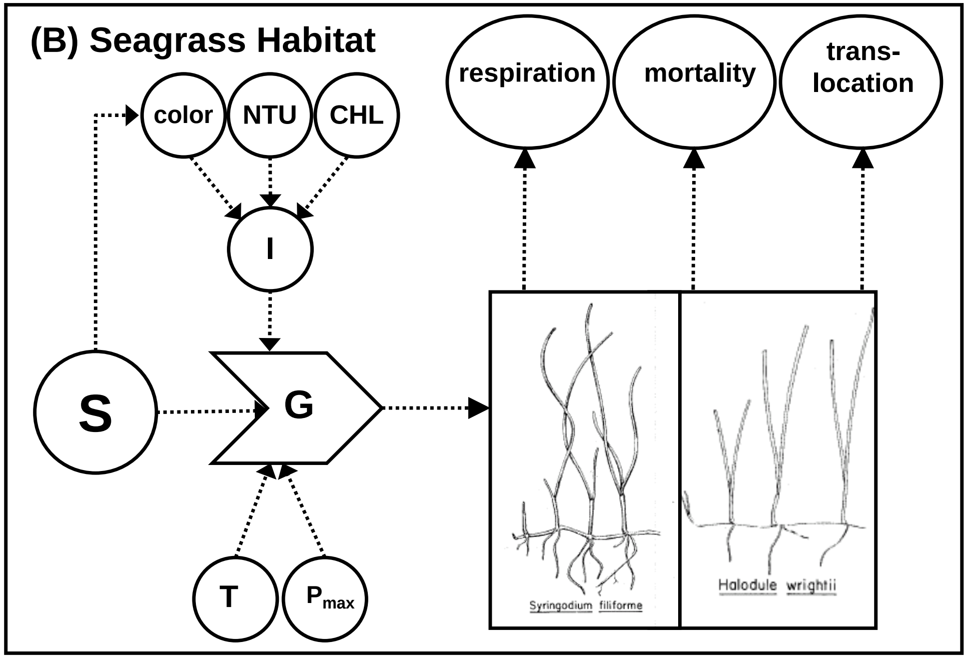
Factors = temperature, submarine **light**, day length, **salinity**, material **inputs**

Biogeochemistry = **SPONCH** cycling among phytoplankton, microbes, flora, fauna, water, sediments

Biota =SAV & oyster reefs (habitats) for invertebrates, resident fishes, transient fishes

OYSTER AND SEAGRASS CONCEPTUAL MODELS





ECOLOGICAL MODELS

- Process-based, deterministic simulation models of oyster and seagrass
- Model of individual adult oysters (*Crassostrea virginica*; # m^{-2})
- Growth varies with temperature, suspended solids, and salinity
- 10% of standing stocks added as larvae annually
- Loss terms include respiration, mortality, salinity stress, and bio-deposition
- Suspended solids held constant throughout 41 y simulations (f_{TSS} = 0.7)
- Three models (CC, SP, US1) identical except for initial standing stocks

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- Model of seagrass shoots (*Halodule wrightii, Syringodium filiforme*; # m^{-2})
- Growth varies with temperature, submarine light, and salinity
- Light varies with depth, chlorophyll *a* , color, and turbidity
- Chlorophyll *a* and turbidity held constant throughout 41 y simulation
- Color varies as inverse exponential function of salinity
- Loss terms include respiration, mortality, and translocation to roots
- *Halodule vs. Syringodium* models have different rate process parameters


ECOLOGICAL MODELS (cbuzzell@sfwmd.gov)

Estuaries and Coasts (2012) 35:1401–1415
DOI 10.1007/s12237-012-9533-8

Monitoring and Modeling of *Syringodium filiforme* (Manatee Grass) in Southern Indian River Lagoon

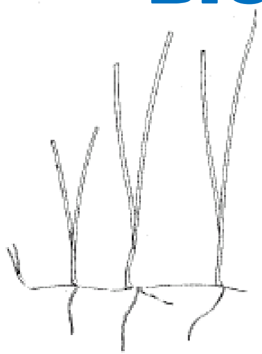
Christopher Buzzelli · Rebecca Robbins ·
Peter Doering · Zhiqiang Chen · Detong Sun ·
Yongshan Wan · Barbara Welch · Arthur Schwarzschild

Environ Model Assess (2013) 18:185–198
DOI 10.1007/s10666-012-9338-y

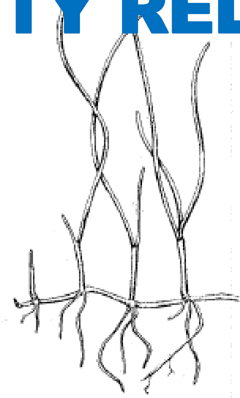
Predicting System-Scale Impacts of Oyster Clearance on Phytoplankton Productivity in a Small Subtropical Estuary

Christopher Buzzelli · Melanie Parker · Stephen Geiger ·
Yongshan Wan · Peter Doering · Daniel Haunert

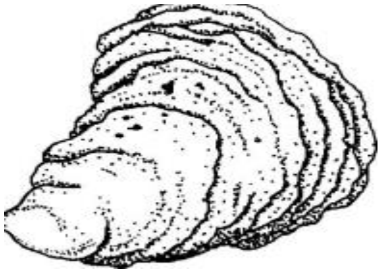
BIOTIC SALINITY RELATIONSHIPS

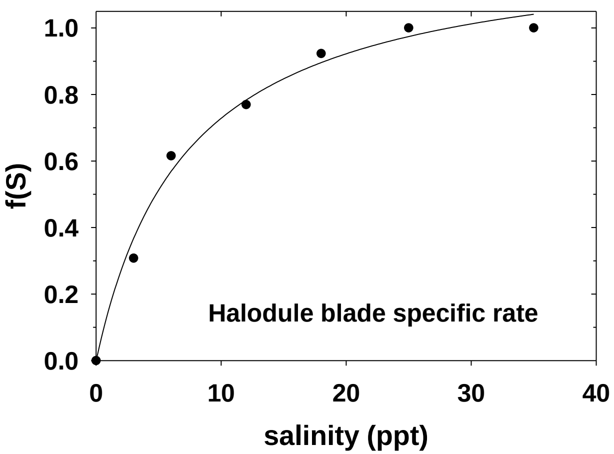


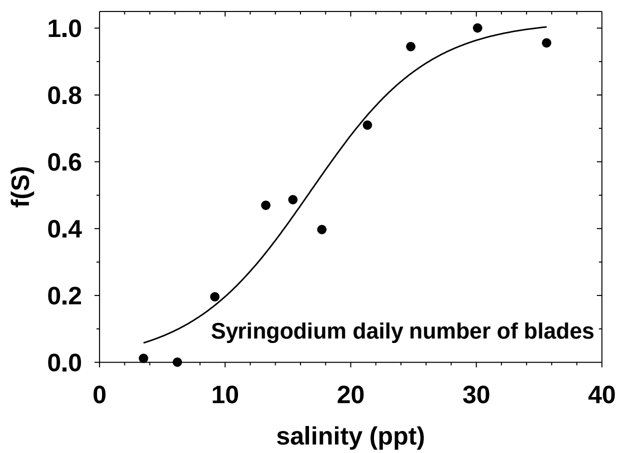
Halodule wrightii

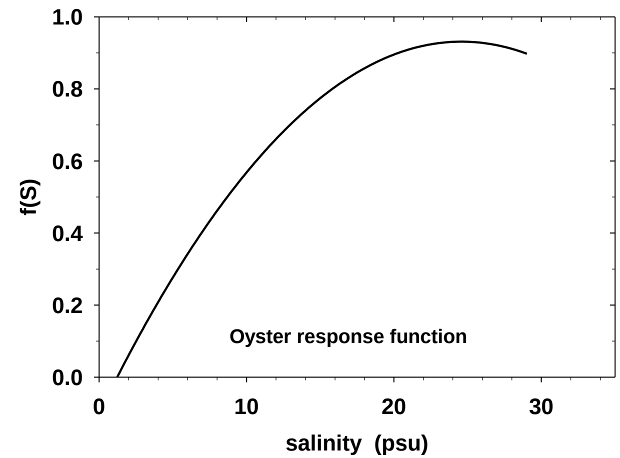


Syringodium filiforme

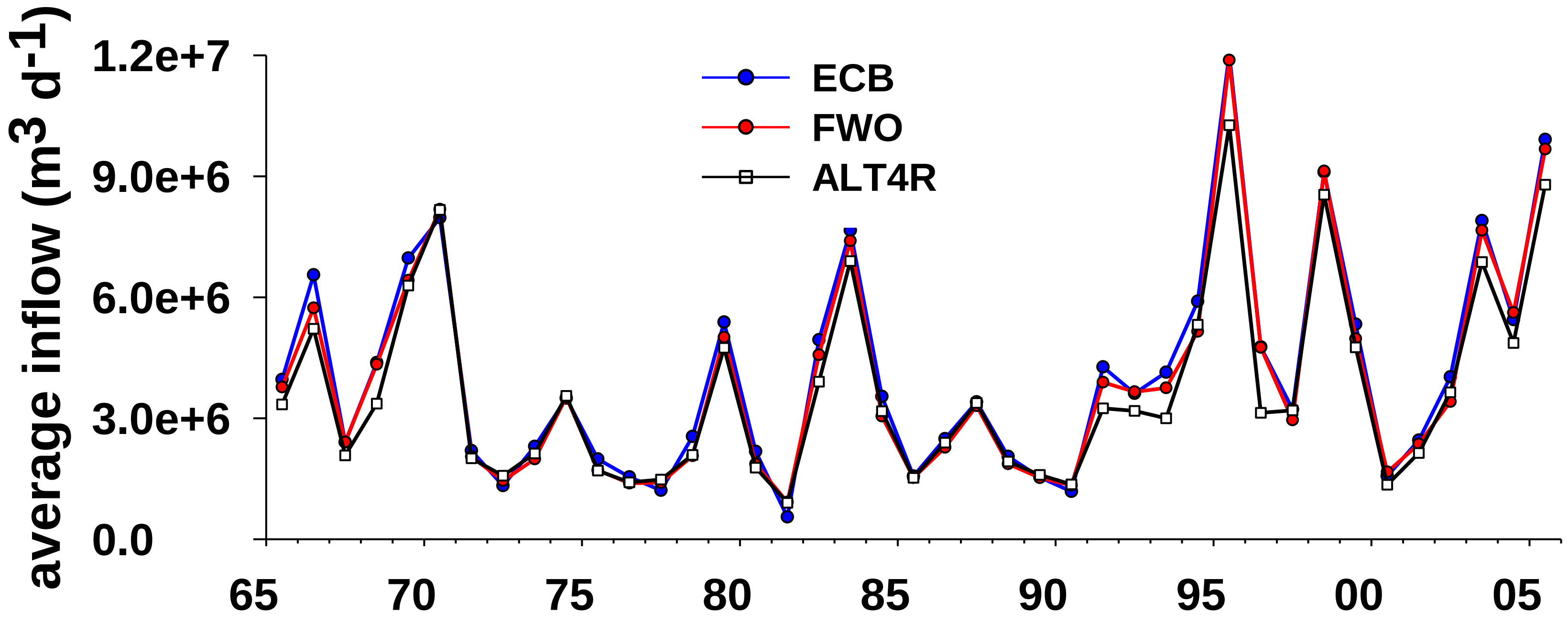


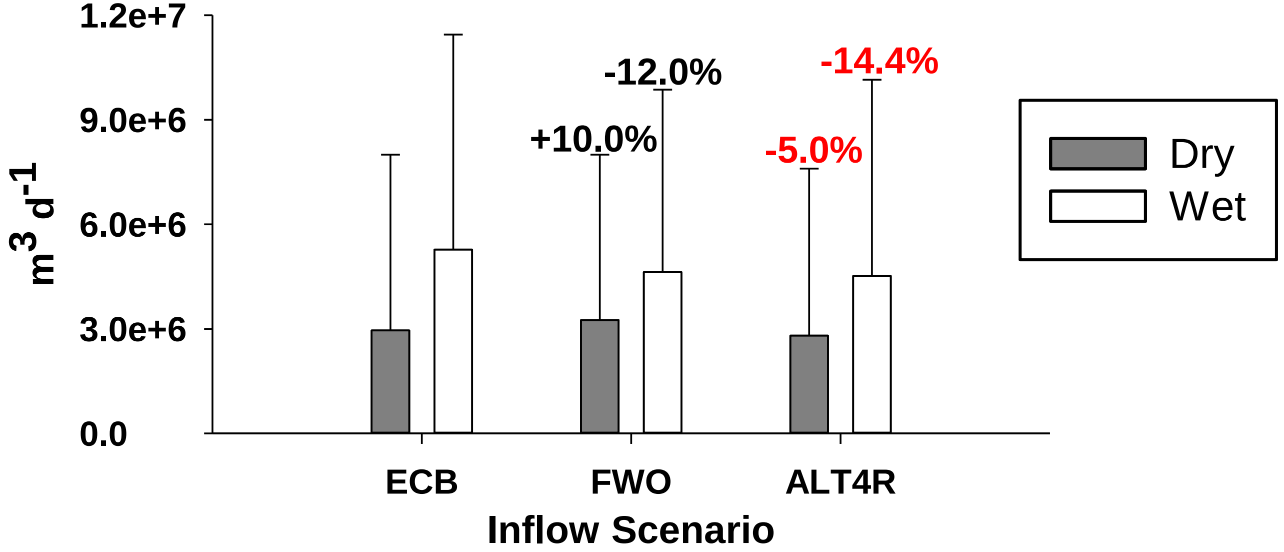




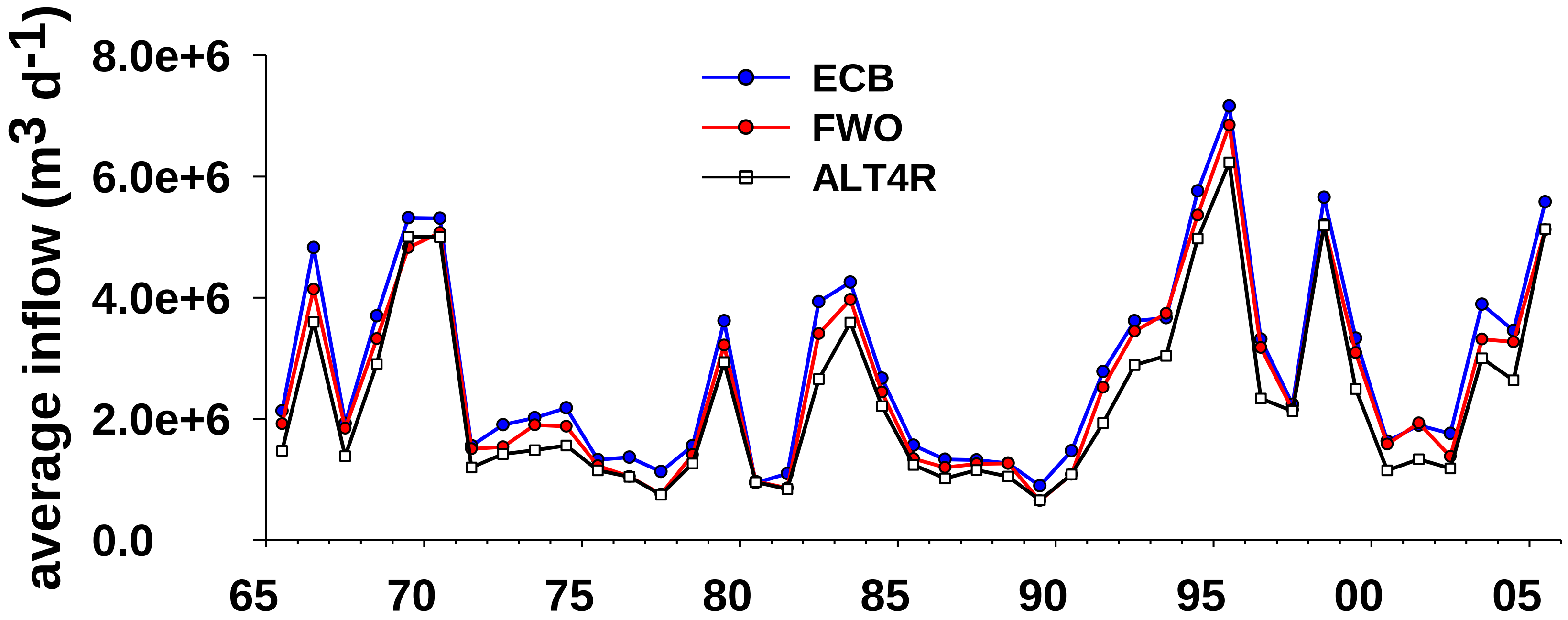


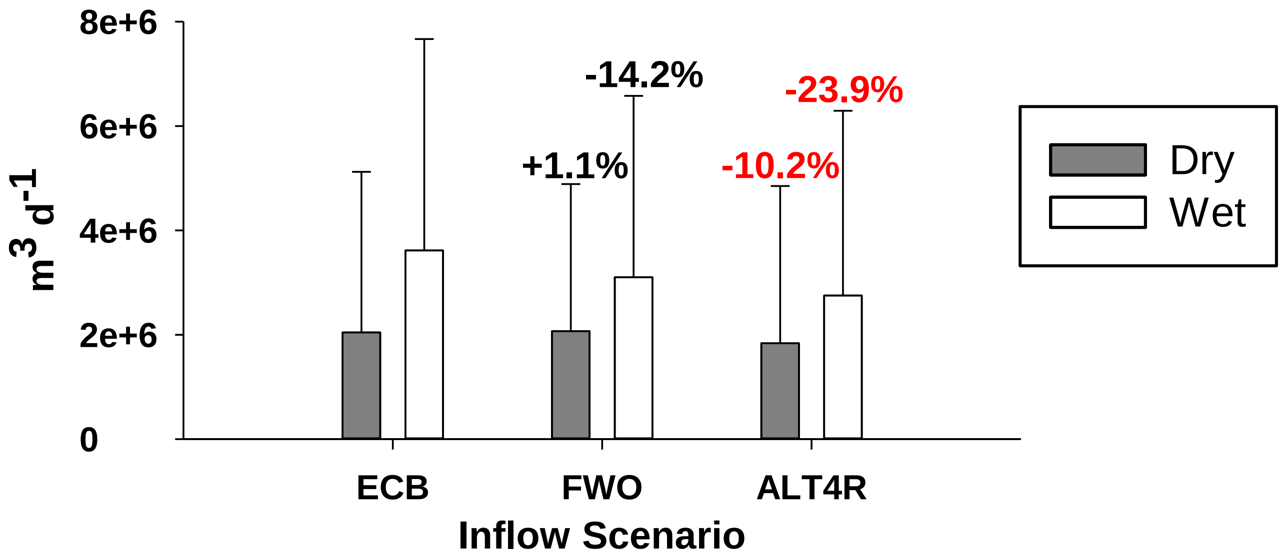
CEPP INFLOWS - CRE





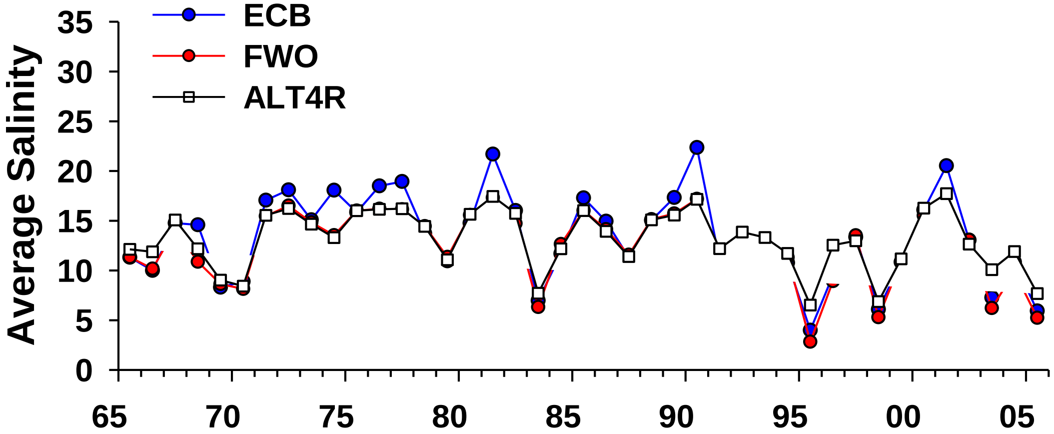
CEPP INFLOWS - SLE

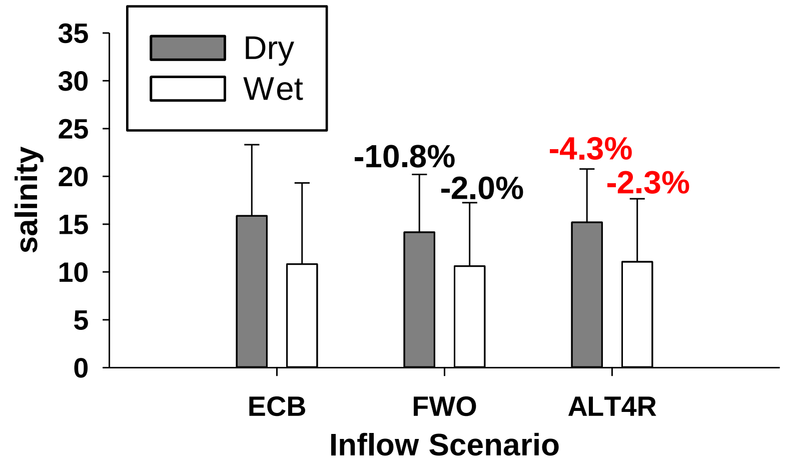




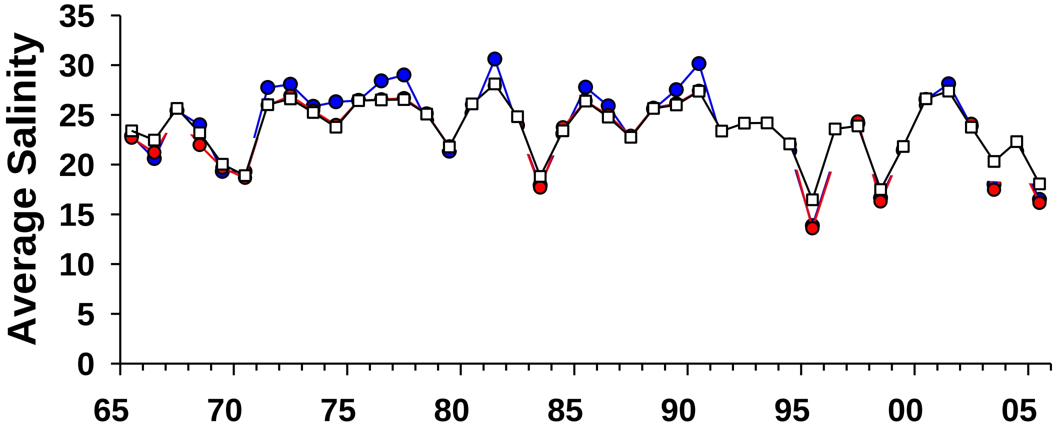
CEPP SALINITY PREDICTIONS - CRE

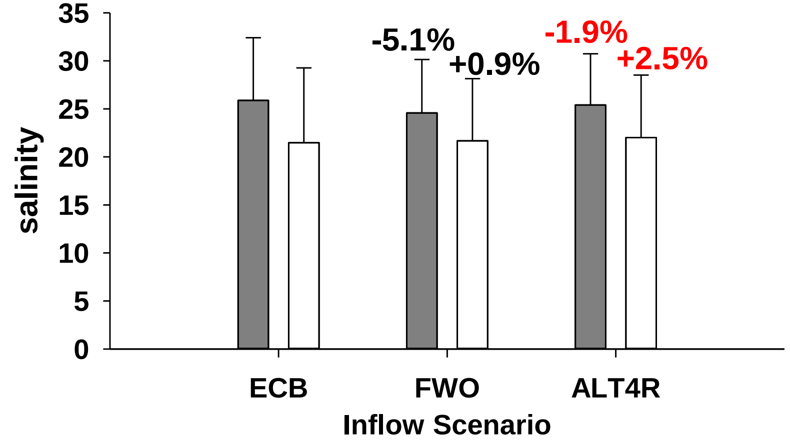
Cape Coral





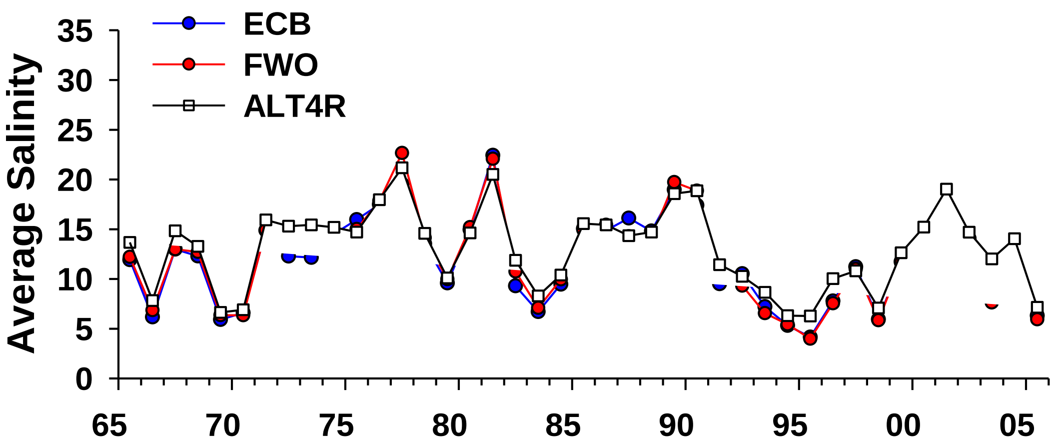
Shell Point

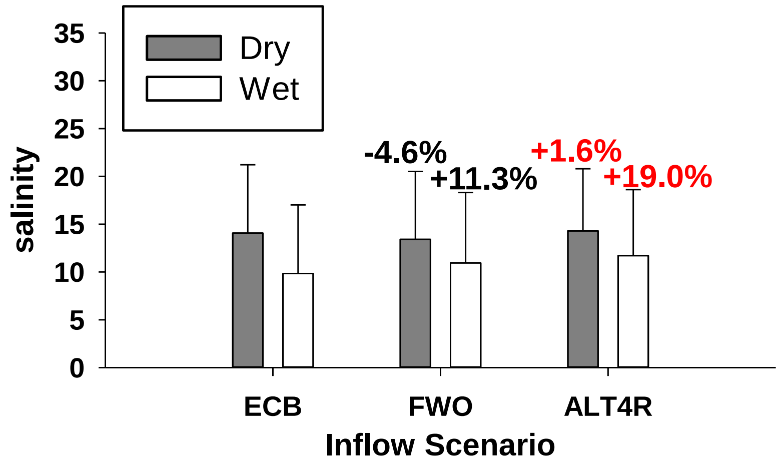




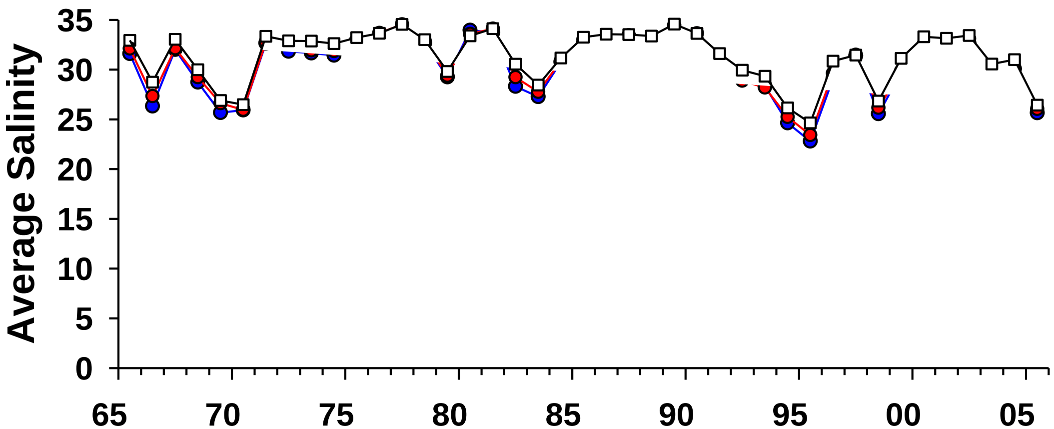
CEPP SALINITY PREDICTIONS - SLE

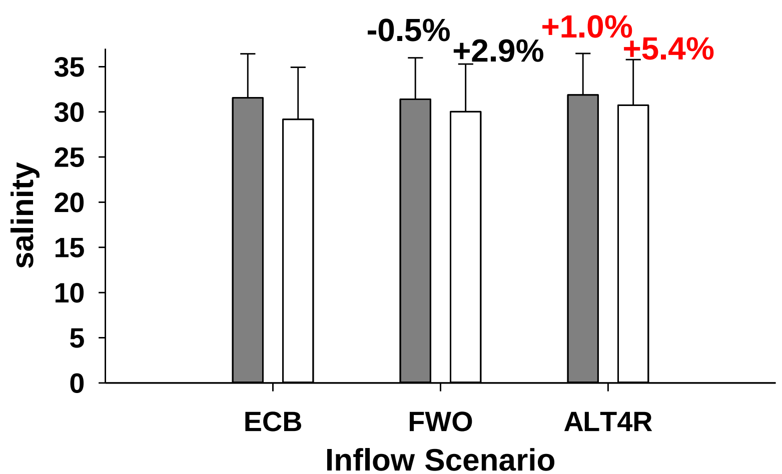
US1 Bridge



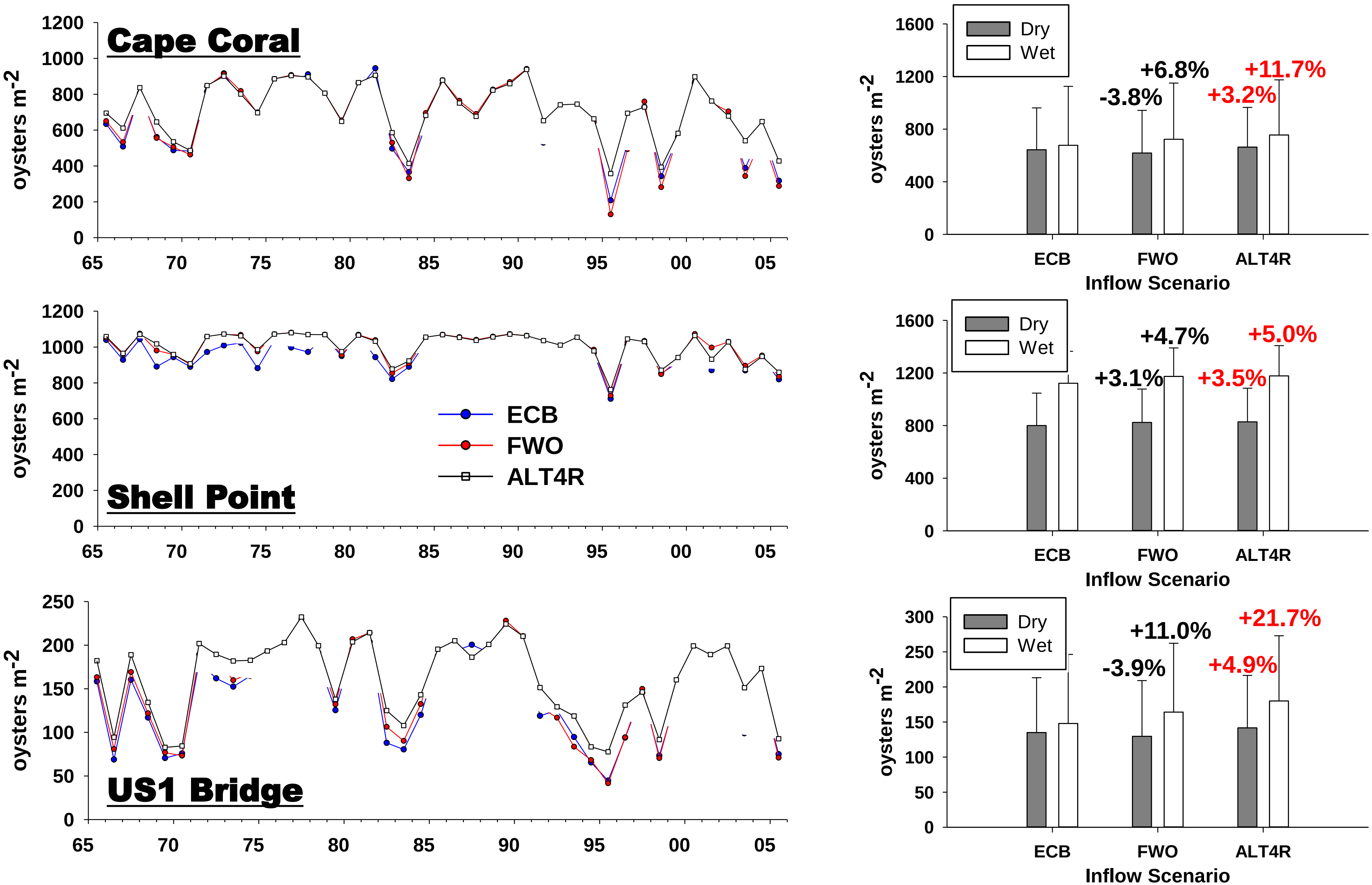


Boy Scout Island





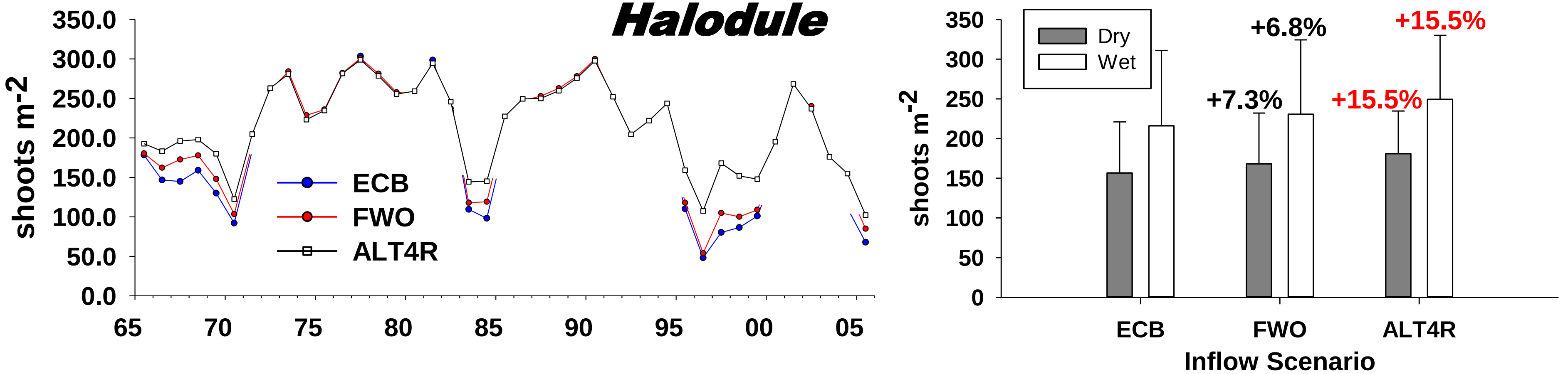
CEPP OYSTER MODEL RESULTS



CEPP SEAGRASS MODEL RESULTS

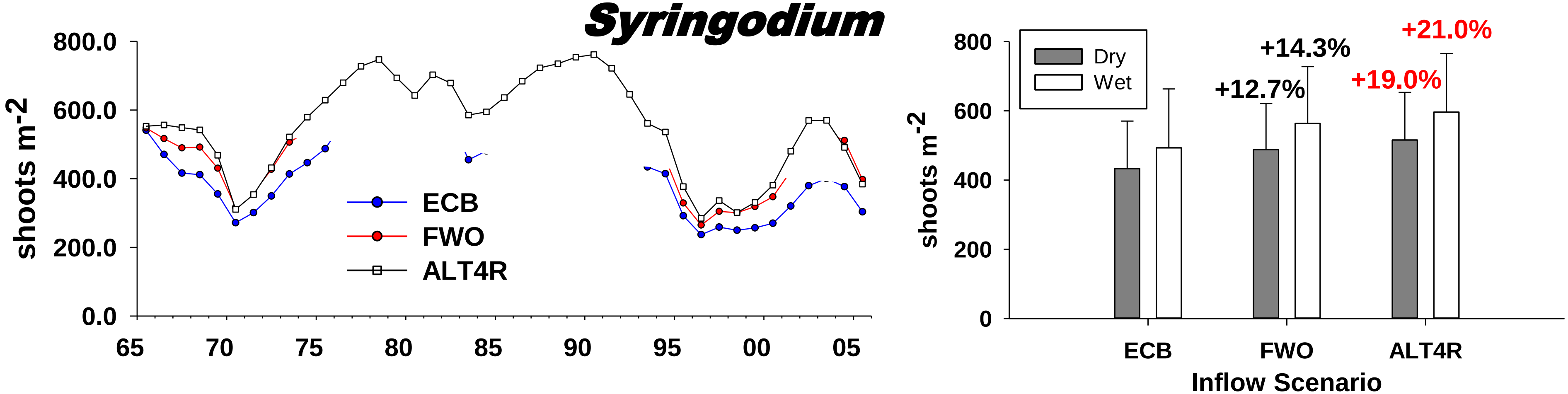
Shell Point

Halodule

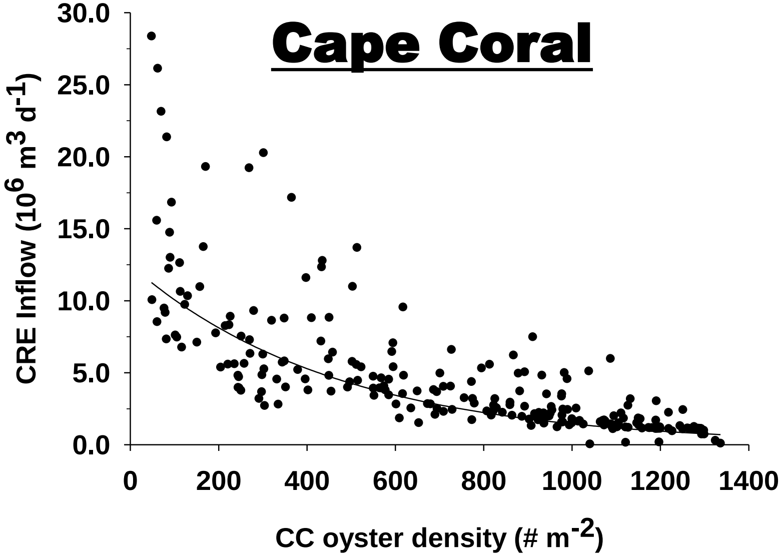


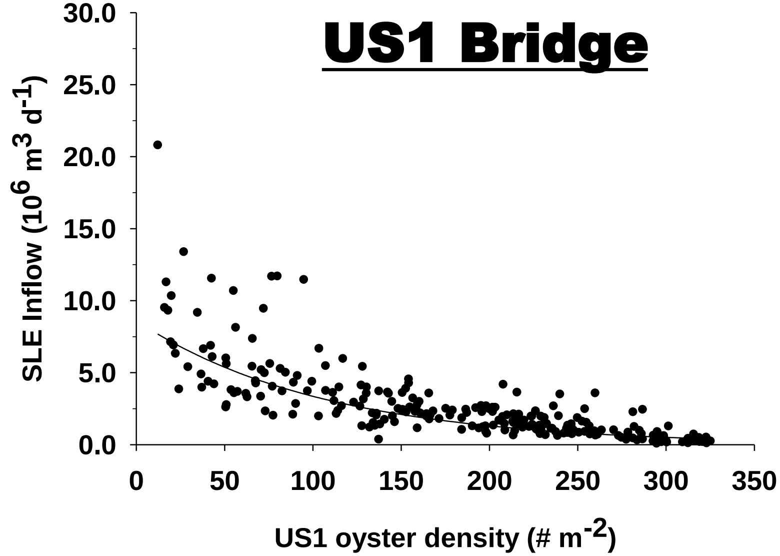
Boy Scout Island

Syringodium



CEPP ALT4R WET SEASON OYSTERS





	CRE	SLE
Equation	$Q_{CRE} = 12.5x10^6 * e^{(-0.002 * O_{CC})}$	$Q_{SLE} = 1.4x10^6 * e^{(-0.009 * O_{US1})}$
r^2	0.63	0.68
Oyster Density Range (# m^{-2})	200-800	50-200
Estimated Inflow (10^6 m^3 d^{-1})	2.5-8.4	1.4-5.5
Estimated Inflow (cfs)	1000-3351	560-2193

SUMMARY & SIGNIFICANCE

- **The Central Everglades Planning Project (CEPP) is a first increment in Everglades restoration designed to quantify the potential effectiveness of watershed engineering alternatives**
- **The CEPP relies upon an integrated modeling system which links watershed engineering projects to estuarine salinity predictions and estuarine habitats**
- **The effects of freshwater inflow diversions were greater for St. Lucie Estuary relative to the much larger Caloosahatchee River Estuary**
- **The densities of oysters and seagrass are greater in the wet season (May-Oct) vs. the dry season (Nov-Apr) in both estuaries**
- **Oysters and seagrass densities increased under the ALT4R scenario**
- **The ALT4R scenario dampened extreme inflows to the estuaries in the wet season thus creating freshwater availability for other parts of the Everglades and southern estuaries such as Florida Bay and Biscayne Bay**
- **Models useful to prescribe favorable inflows to the two estuaries**