BISCAYNE BAY NUTRIENT LOADS AND WATER QUALITY BOX MODEL

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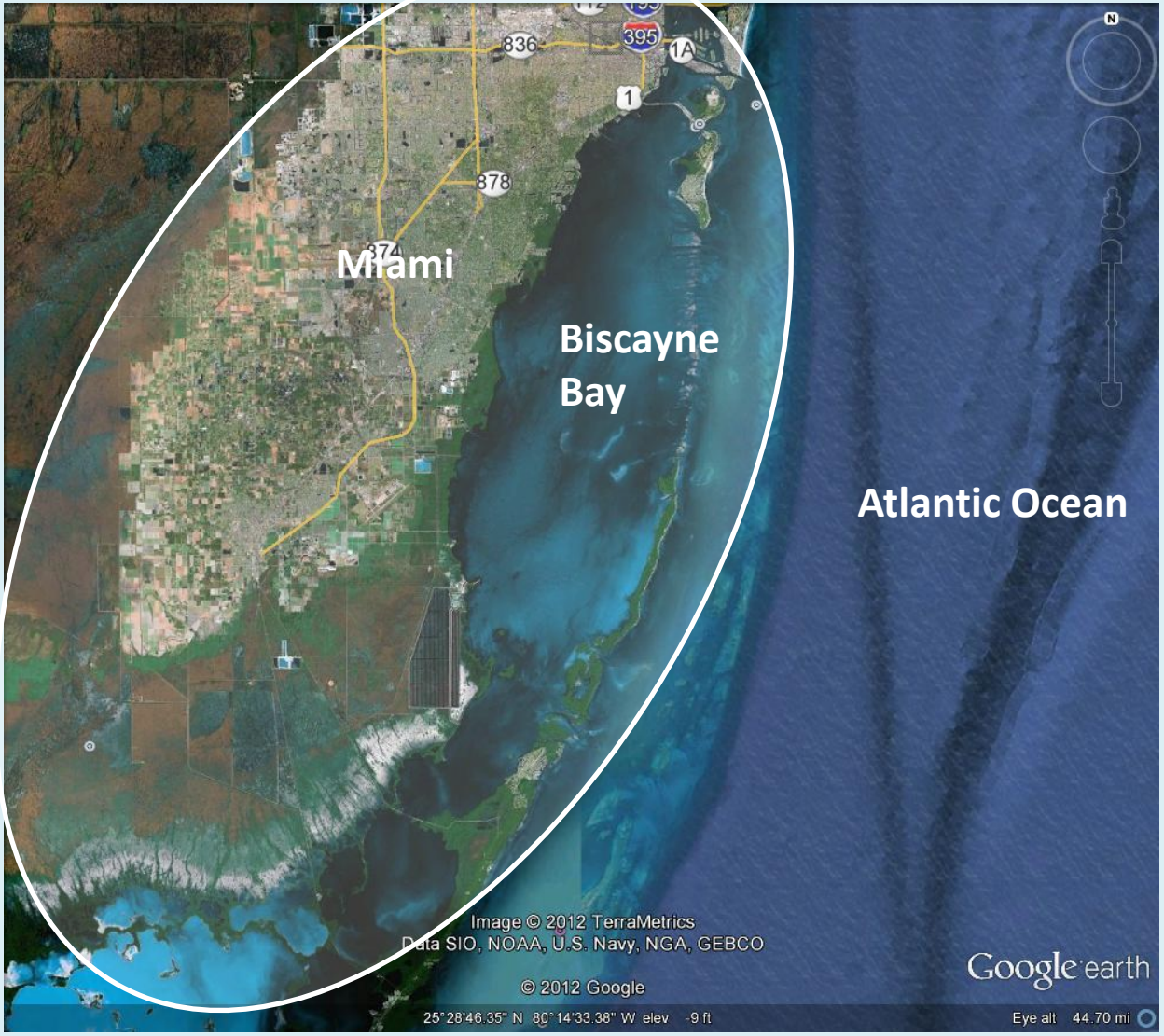
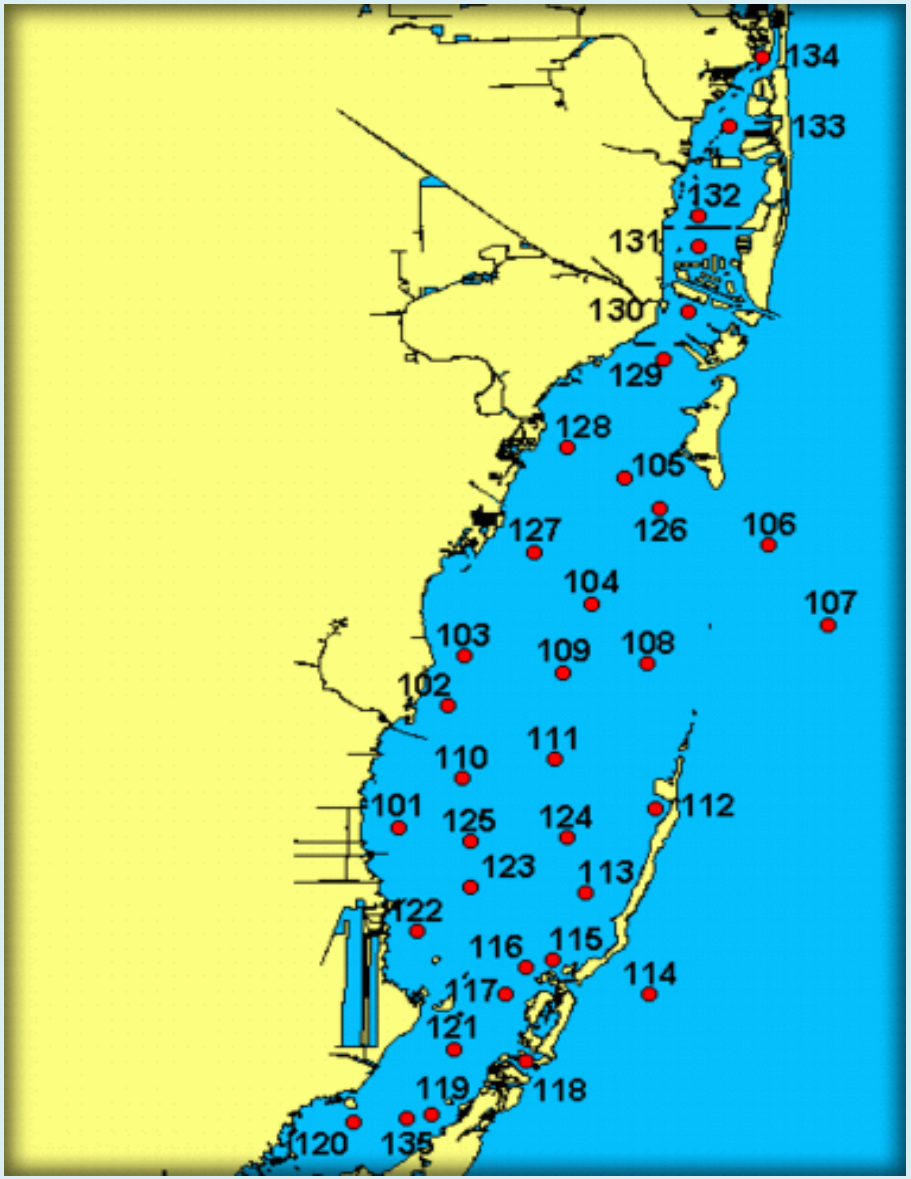
Study Objectives

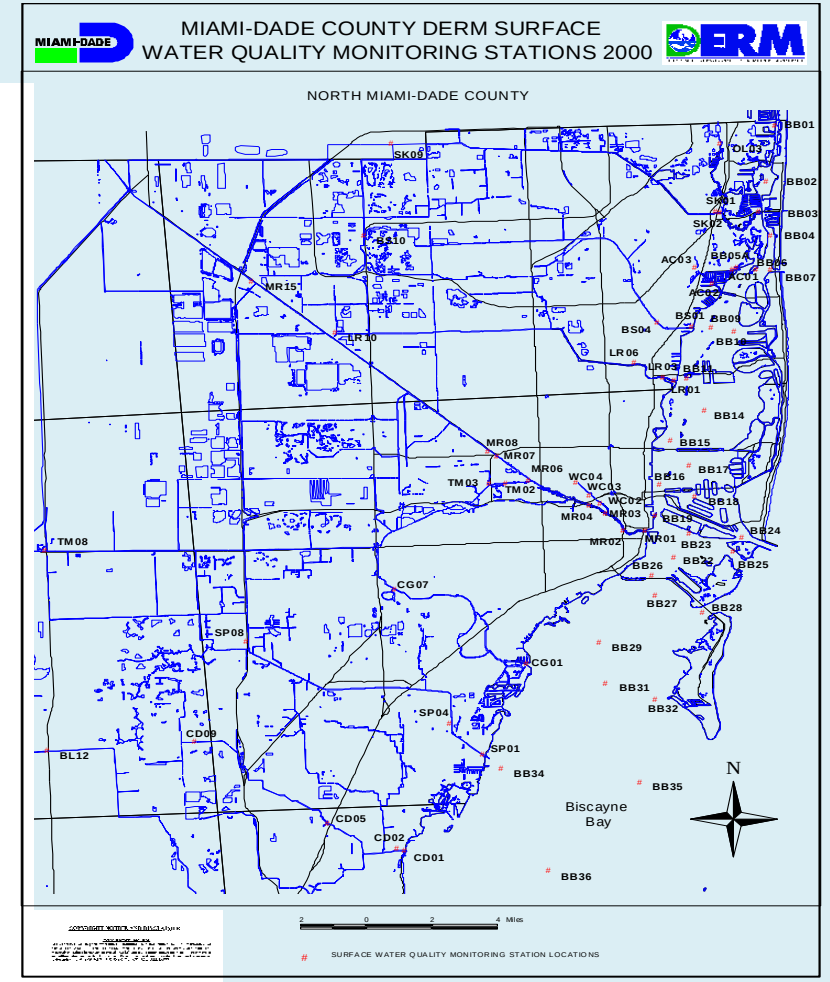
- Divide Biscayne Bay for box model use
- Estimate existing freshwater and nutrient loads to each box
- Upgrade an existing salinity box model for nutrient calculations
- Calibrate and run model for various load scenarios
- Compare to existing data and results of other studies
- Estimate the effects of changing land use

General Study Area



Existing Water Quality Data





Existing Water Budget Data

Receiving Water (box)	Revised Drainage Basin Used in This Study	SFWMD Basins Comprising Drainage Basin	SFWMD Canal	SFWMD Structure	DERM Canal Stations	Open Water Monitoring Stations	
						SERC-FIU	DERM
North Central Inshore (NCI)	Coral Gables Waterway, Brickell, Snapper Creek, Cutler Drain	Tamiami East* / Coral Gables Waterway*, DA-1, C-2 / Snapper Creek / Area B*, C-100 / Cutler Drain / DA-3 / Area B*	C-3, C-2, C-100	G93, S22, S123, CD02	CG07, SP04	126, 127, 128, 129	BB27, BB29, BB31, BB32, BB35, BB34
South Central Inshore (SCI)	Black Creek, Princeton Canal, Military Canal, Mowry Canal	Military, C-102 / DA-4*, C-103 / North Canal / Florida City Canal, C-111* / DA-4*	S20G, C-102, C-103	S21, S21A, S20F	BL-03, PR-03, MI-02, MW-04	101,102, 103, 110, 122	BB41
Card Sound	South Card Sound	Model Land / DA-4* (Turkey Point Power Plant)	L-31E ditch	S-20	None	135, 121	BB47, BB48
Barnes Sound and Manatee Bay	Manatee Bay	C-111*	C-111	S197	AR03	1, 2, 3, 4	BB50, BB51

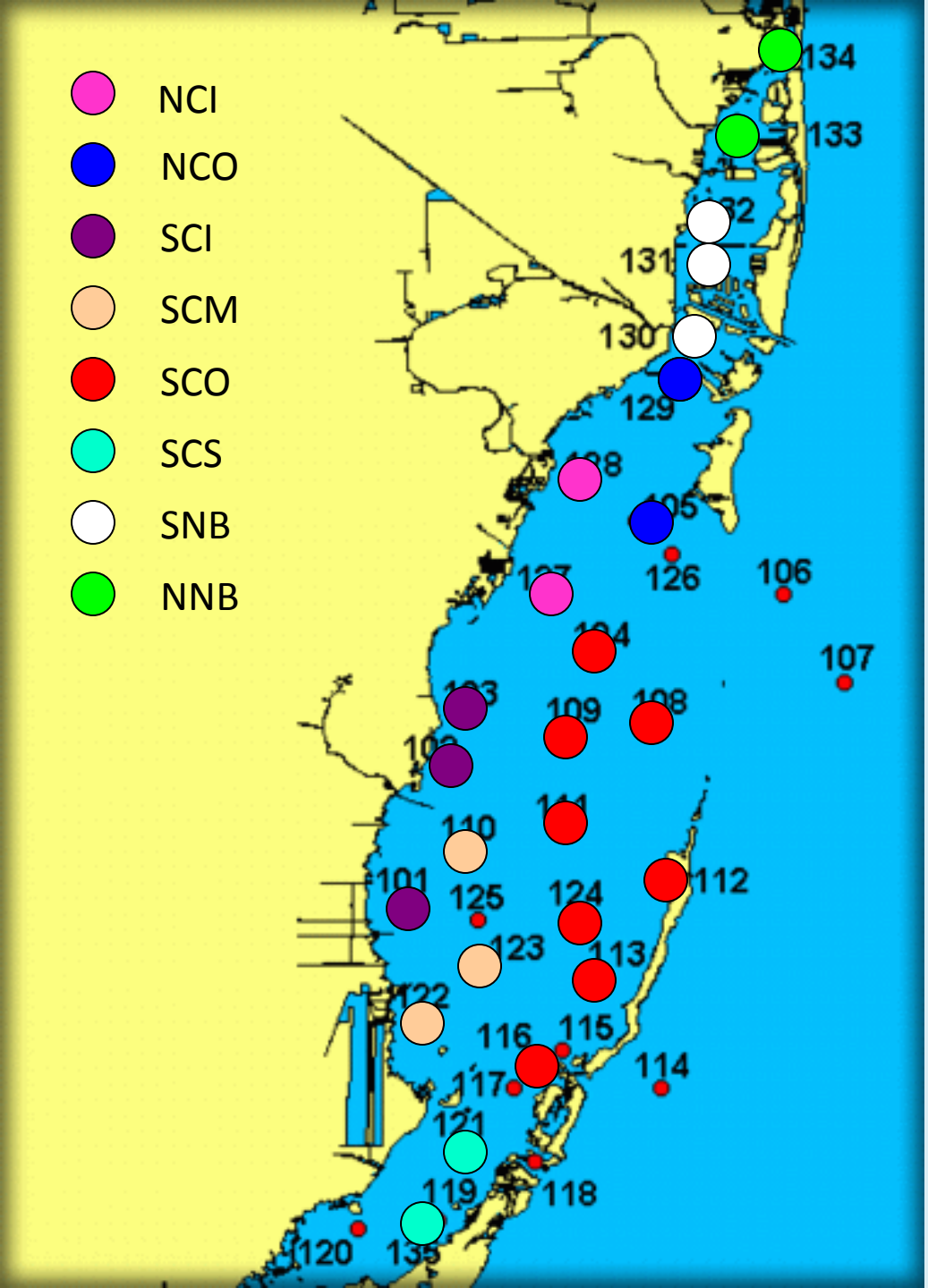
Box Model Domain Development

- Biscayne Bay divided into boxes using bathymetry/geography and areas of similar water quality from a Principal Components Analysis
- Important:
  - Domain of box model is Biscayne Bay
  - Watershed basins not part of box model
  - Watershed basin loads aggregated by box

Principal Component Analysis (PCA)

- PCA used to identify areas of similar water quality
- 4 methods used to develop clusters
  - PC extraction
  - Euclidean distance
  - Varimax rotation
  - Oblique solution

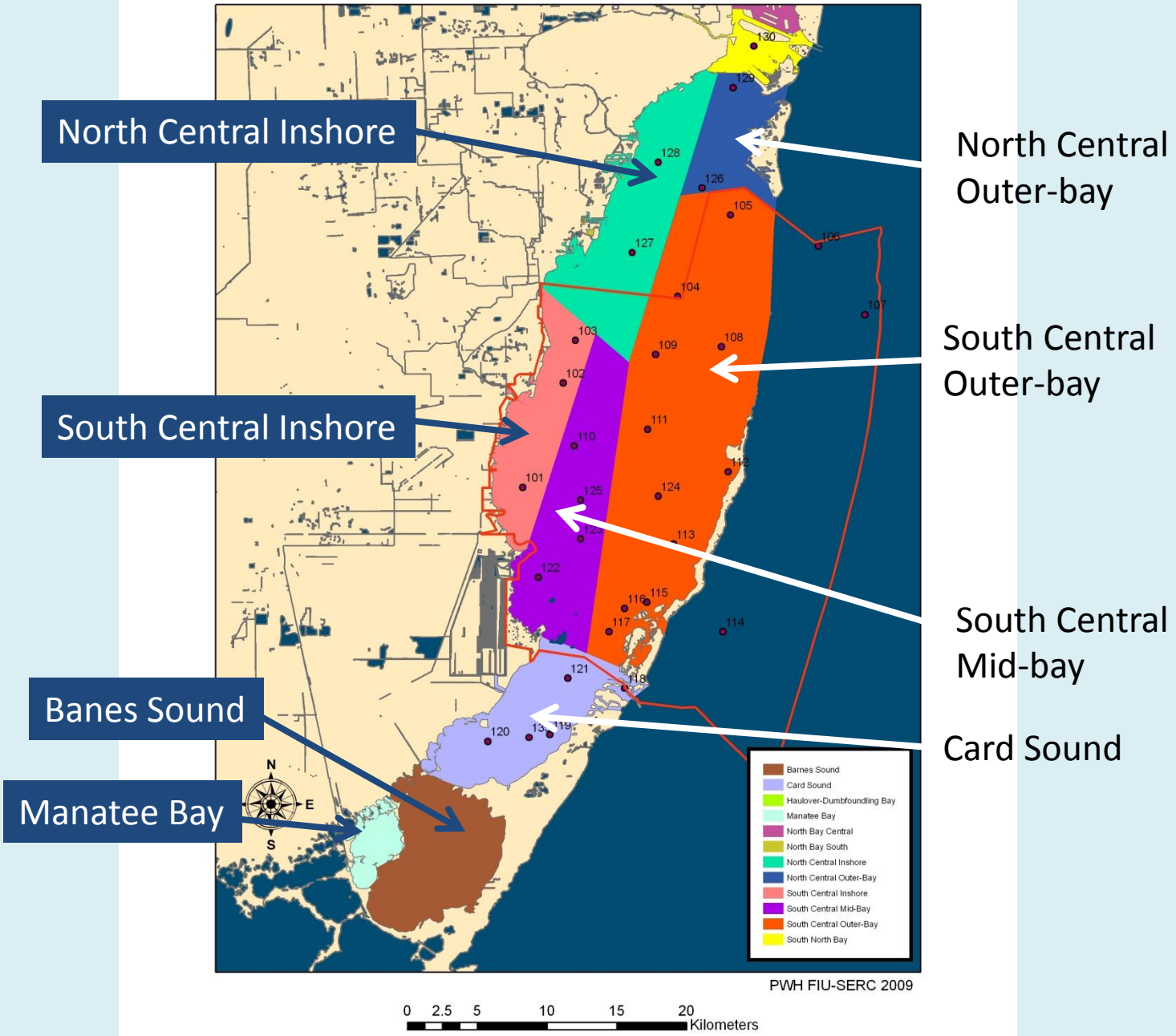
Final Classification Scheme

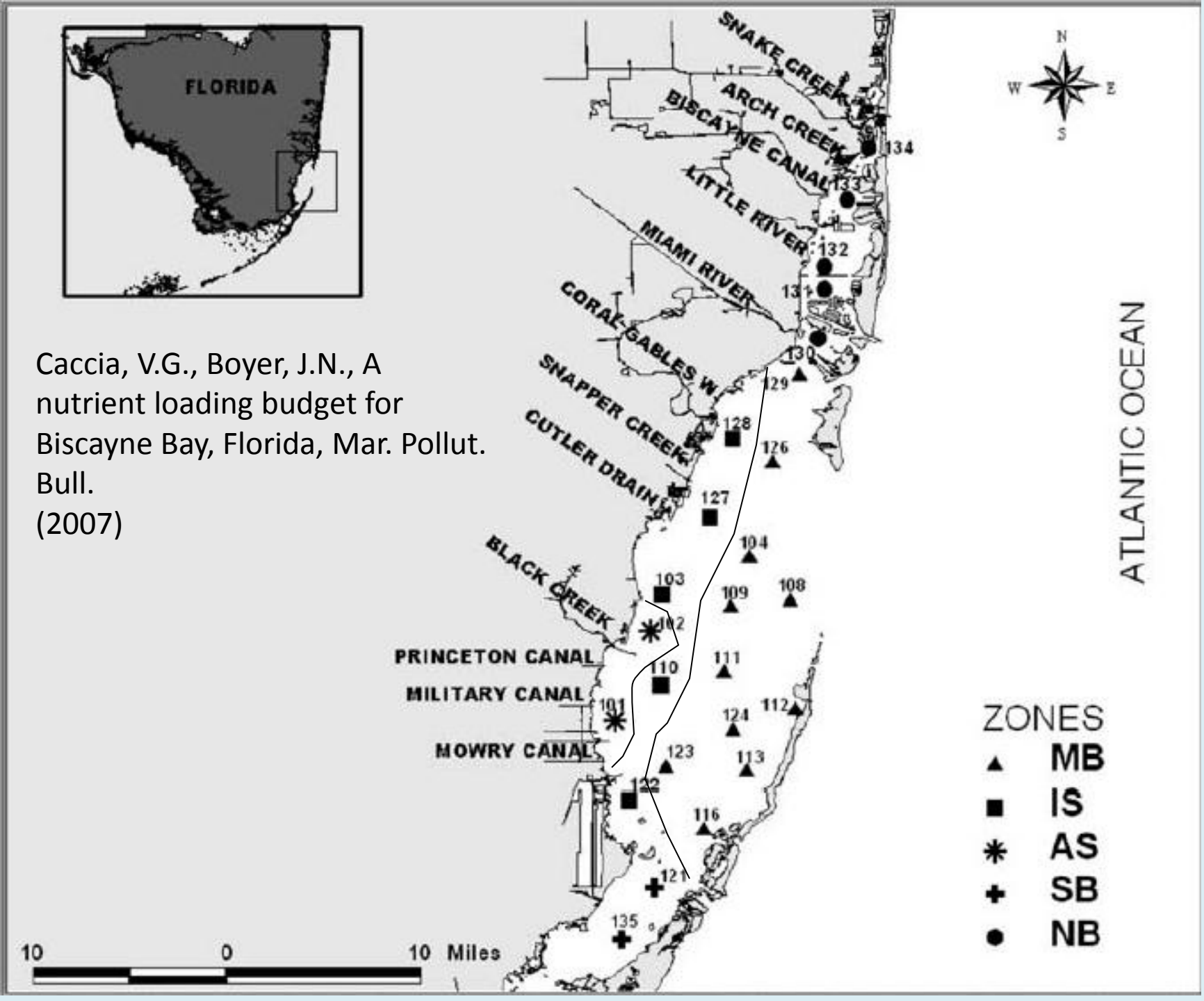


Similar to classification of Florida Bay by Briceno & Boyer (2010) and Caccia and Boyer (2007)

Biscayne Bay Load Boxes

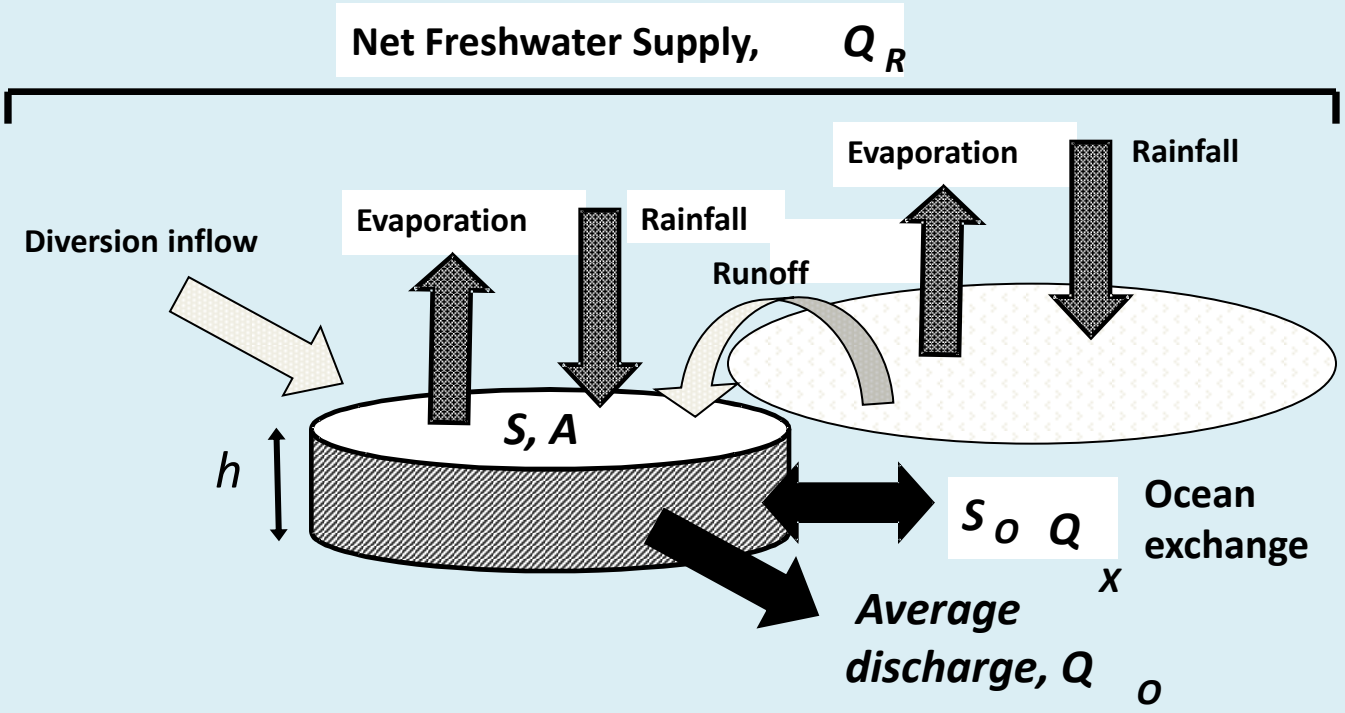
Stations for Barnes Sound and Manatee Bay not shown.

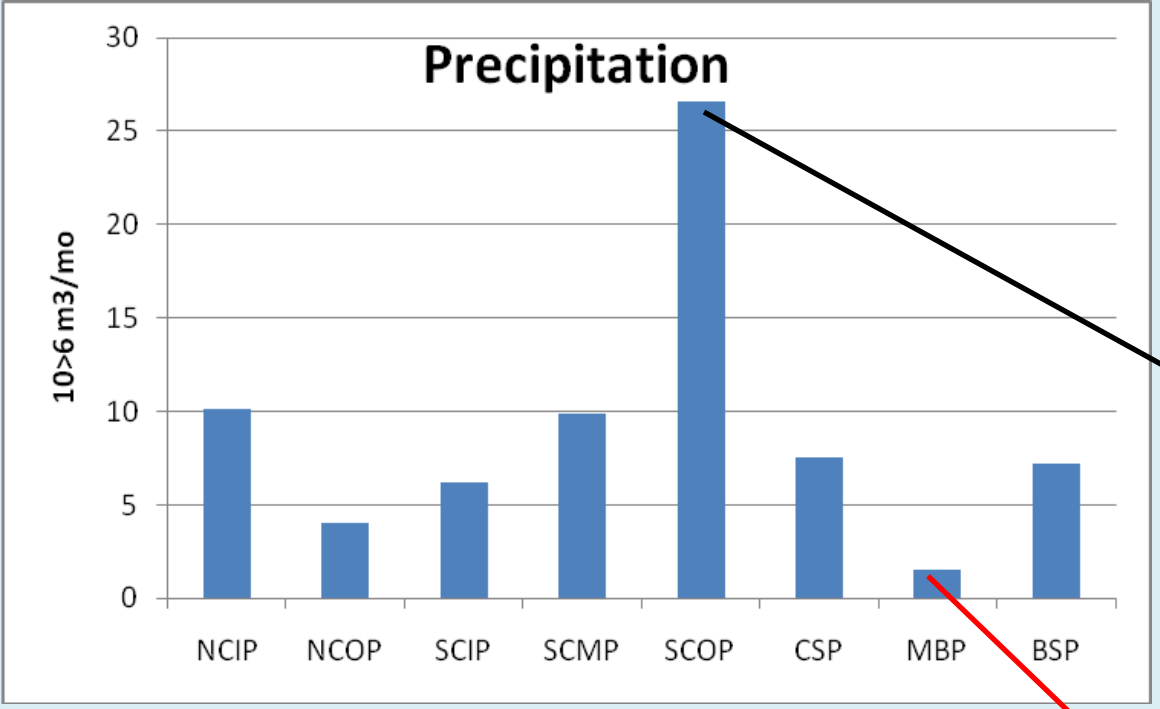


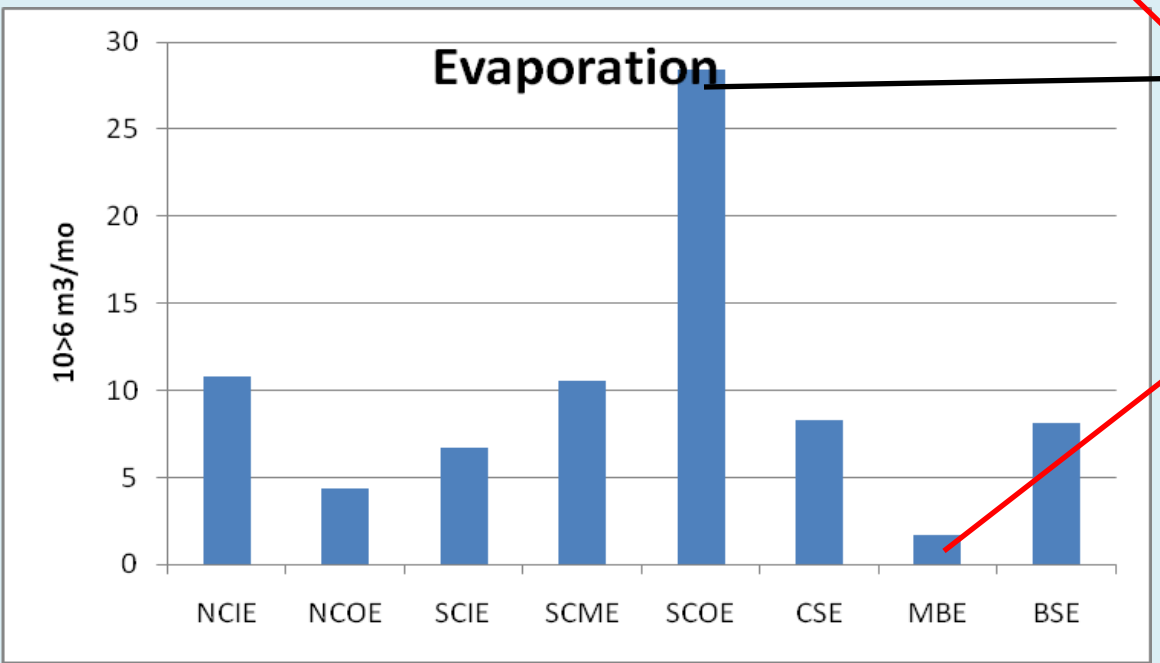


Caccia, V.G., Boyer, J.N., A nutrient loading budget for Biscayne Bay, Florida, Mar. Pollut. Bull.
(2007)

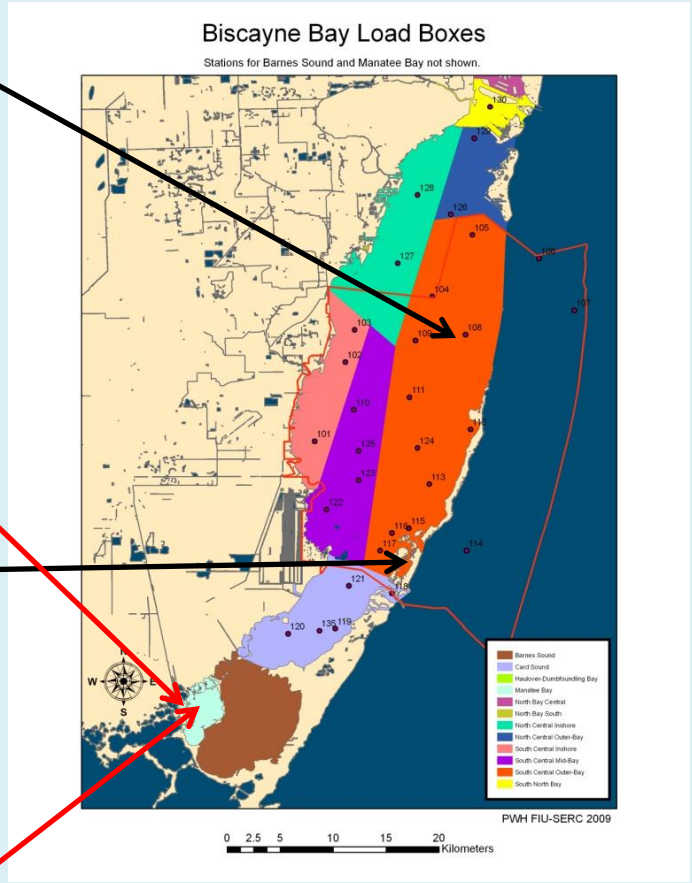
Water Budget – Single Box



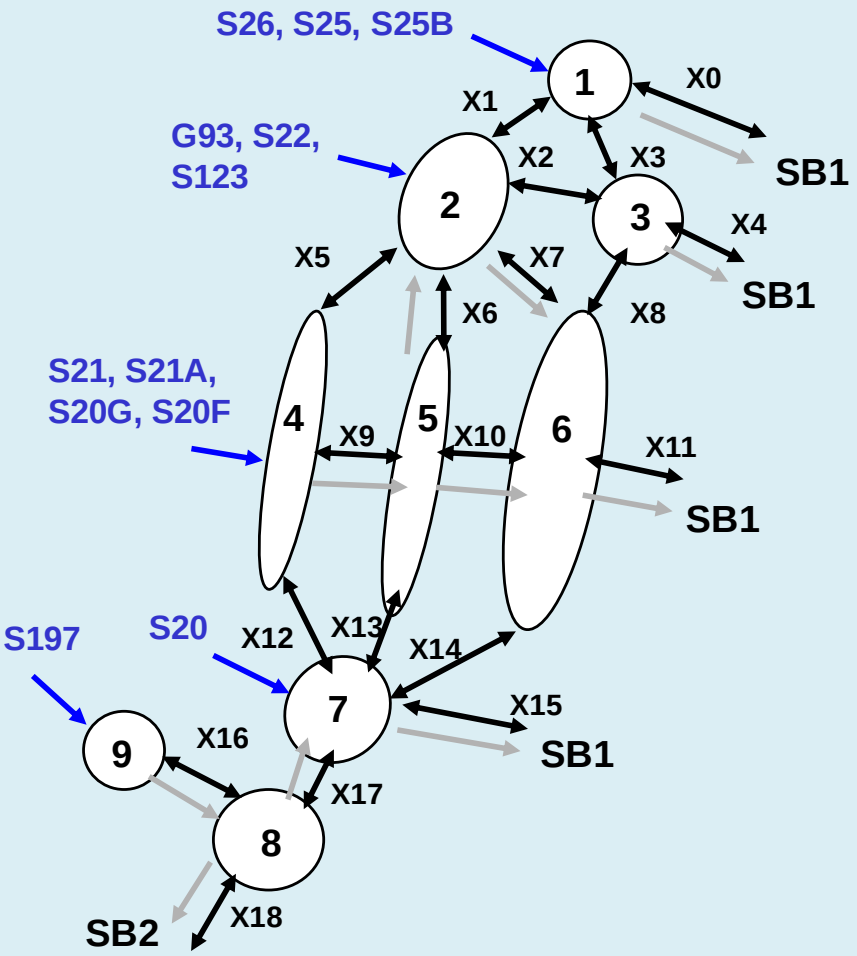


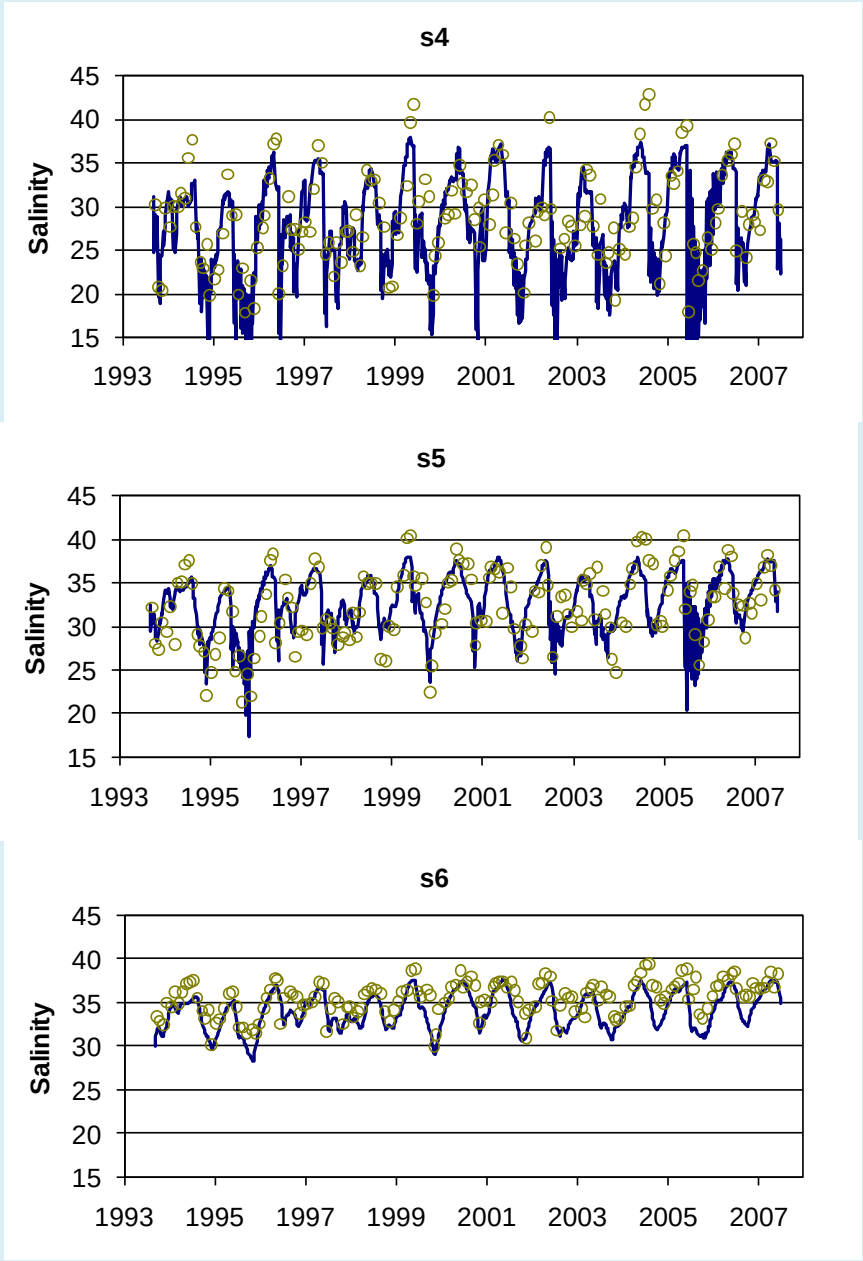


Precip & evap: highly area-dependent



Step 1: Calibrate Salinity, Estimate Exchange Flux

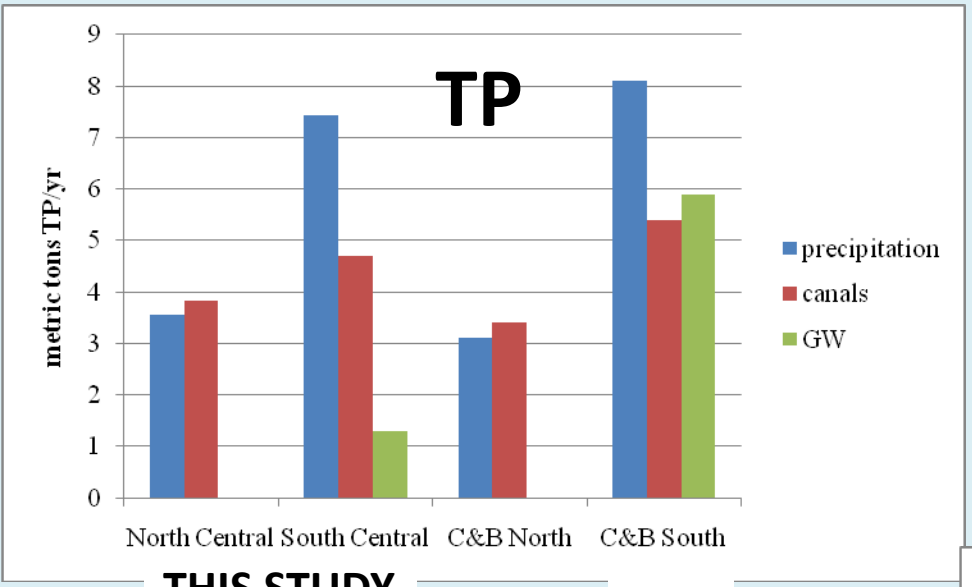




Nutrient Loads

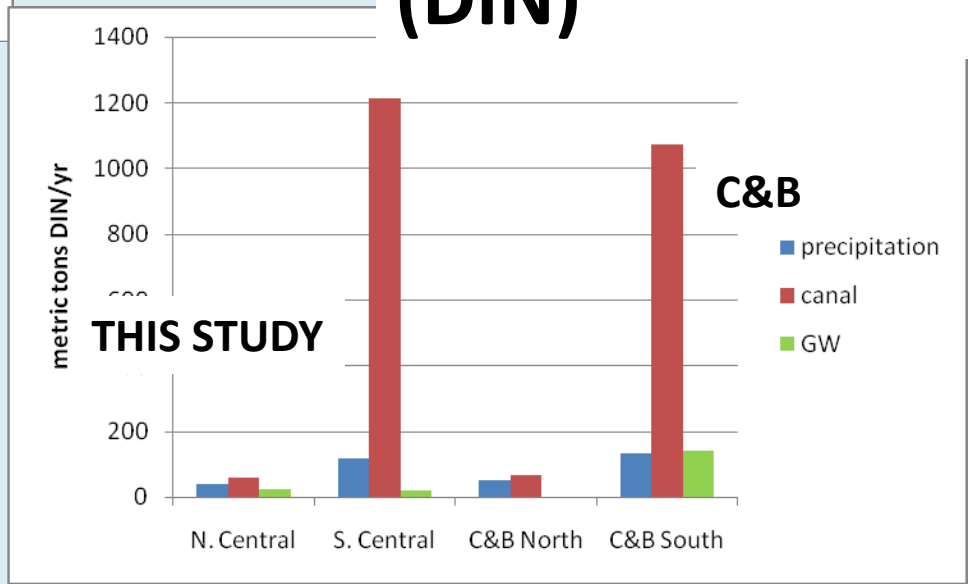
- Focusing on loads to nearshore basins and NOx
- North Central Inshore (NCI) – predominately urban and built-out
- South Central Inshore (SCI) – mostly active agriculture (high fertilization) with encroaching urban

Compare Loads to Caccia and Boyer (2007)



Note: Boxes differ in size between studies but are similar

Dis. Inorganic N (DIN)



Nutrient Loading Simulations

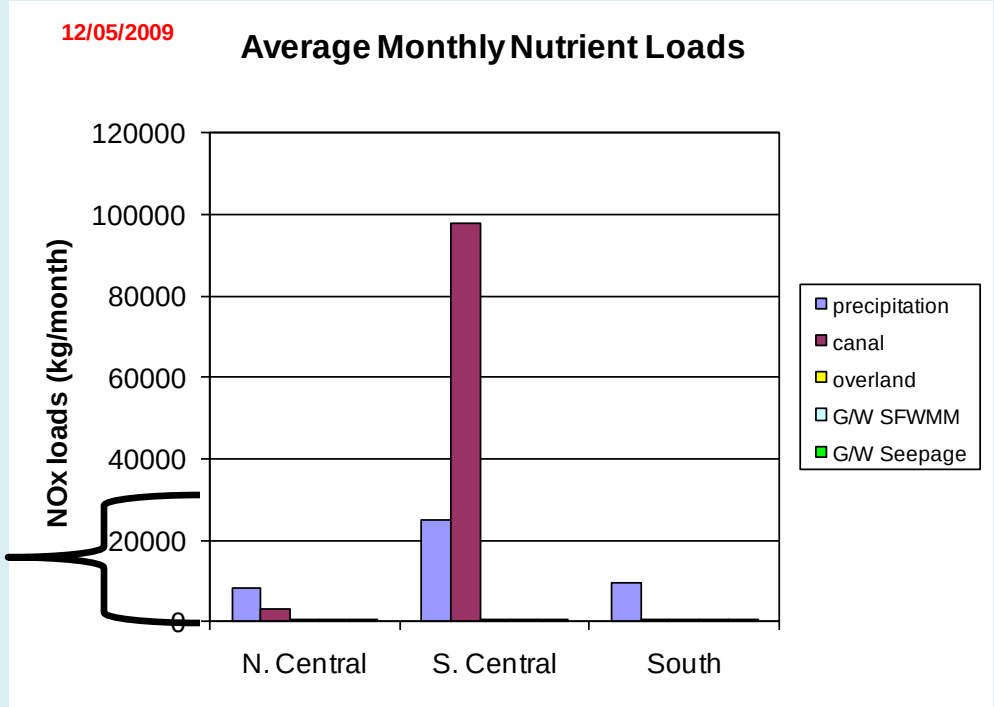
- Tot. Phosphorous
  - Base Case
  - No Load
  - 2X Load
- NOx*
  - Base Case
  - Atmospheric Load minus 45%
  - Post Development Loads
- DIN
  - Base Case
  - Calibrated Denitrification Rate
  - Post Development Loads

*** Only NOx discussed today at INTECOL**

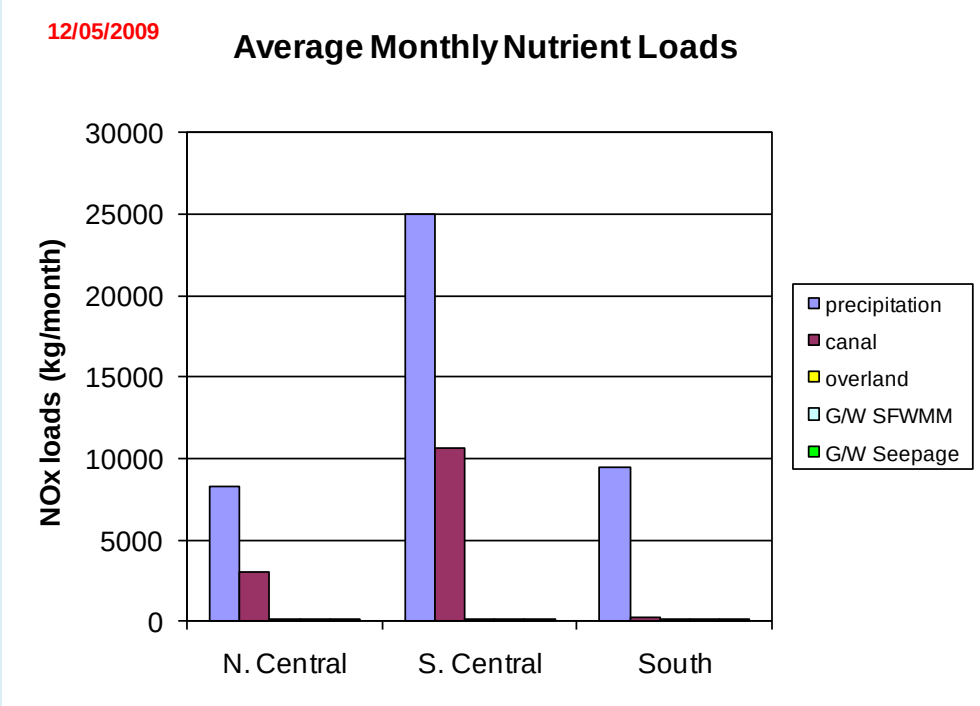
NOx

Existing Conditions

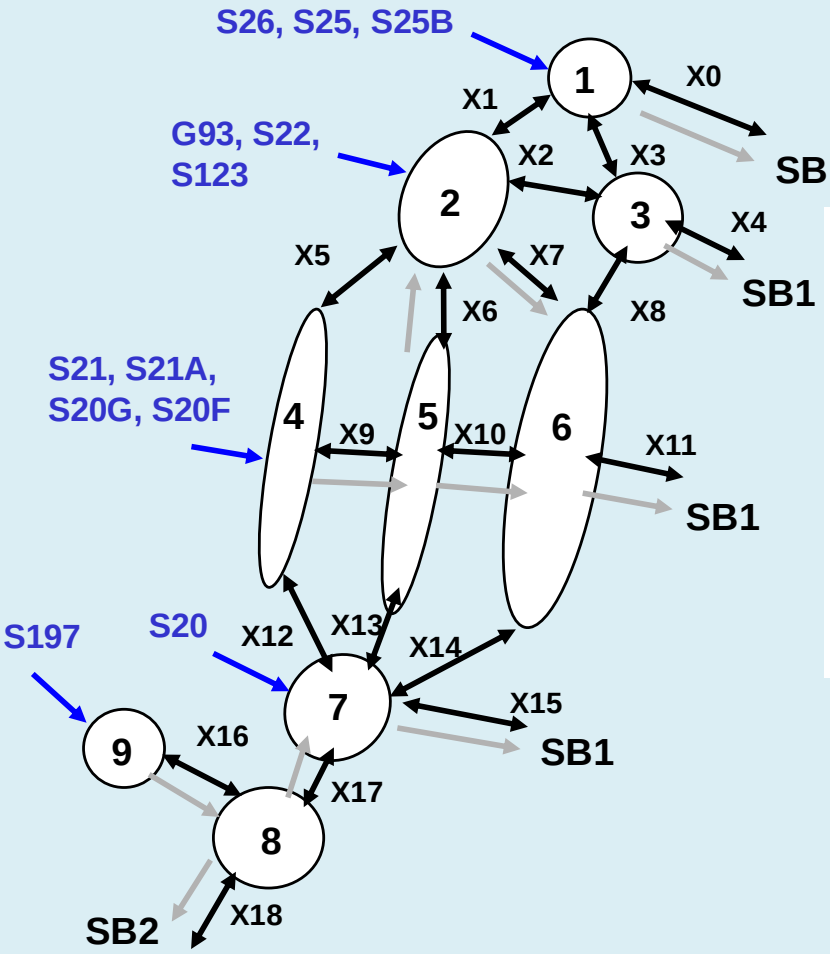
Scale of plot below

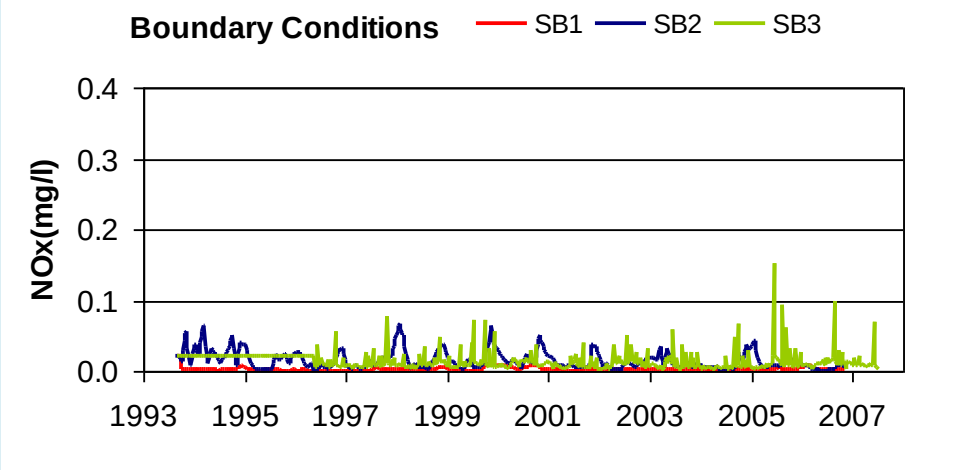


Development Build-out

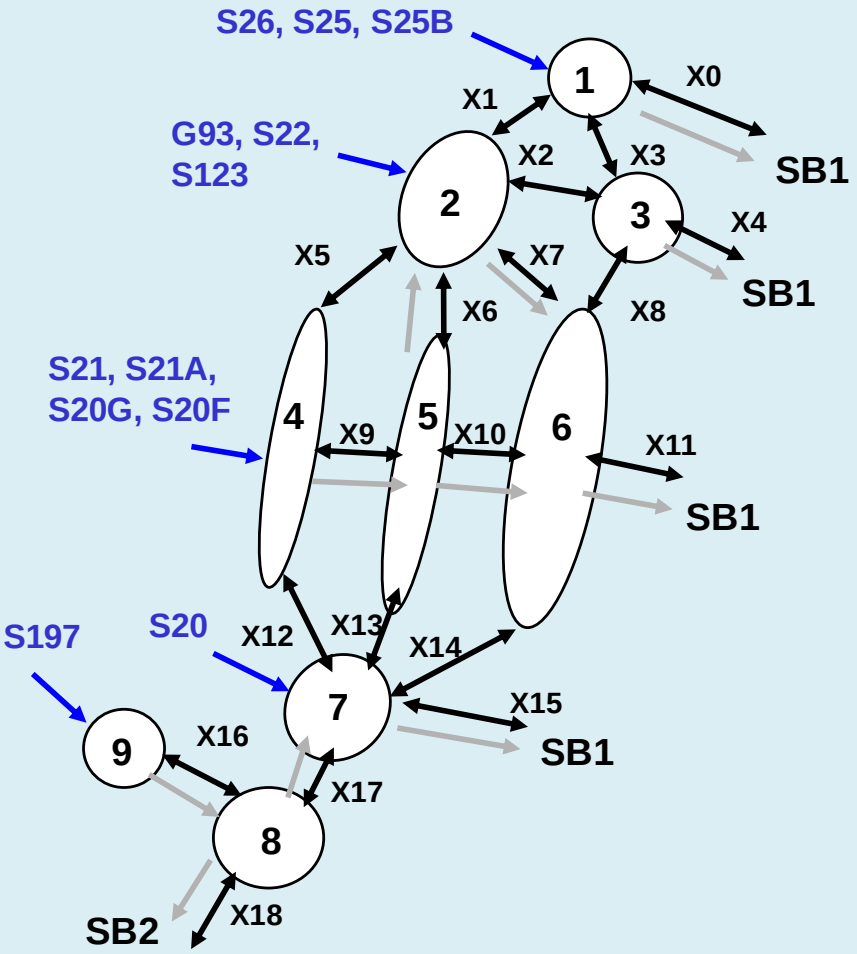


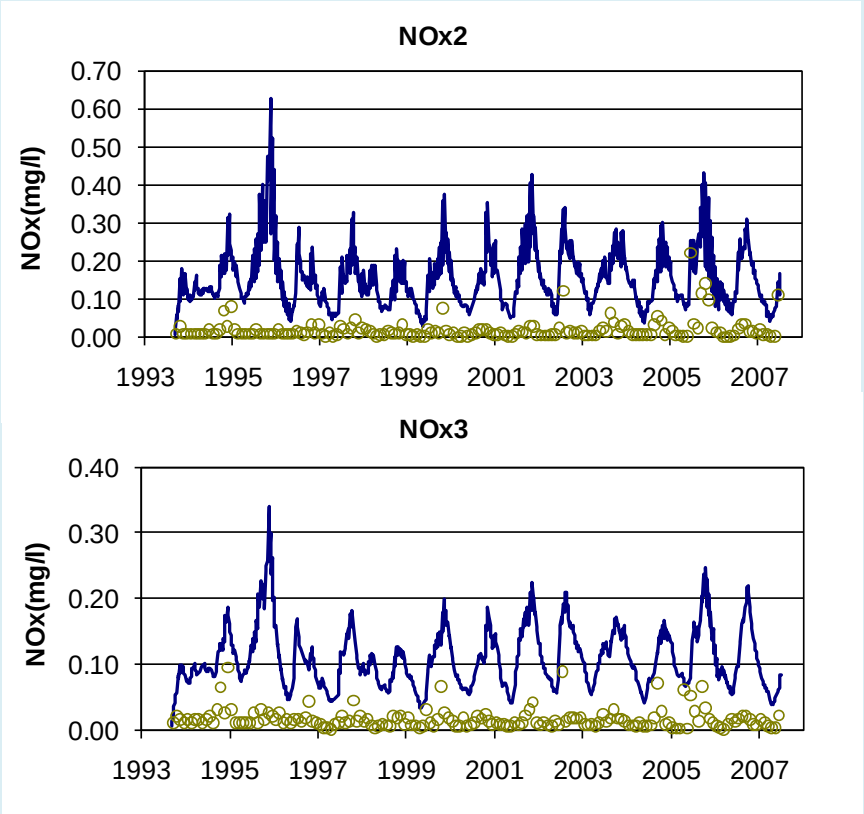
Model Output: Existing Conditions, NOx



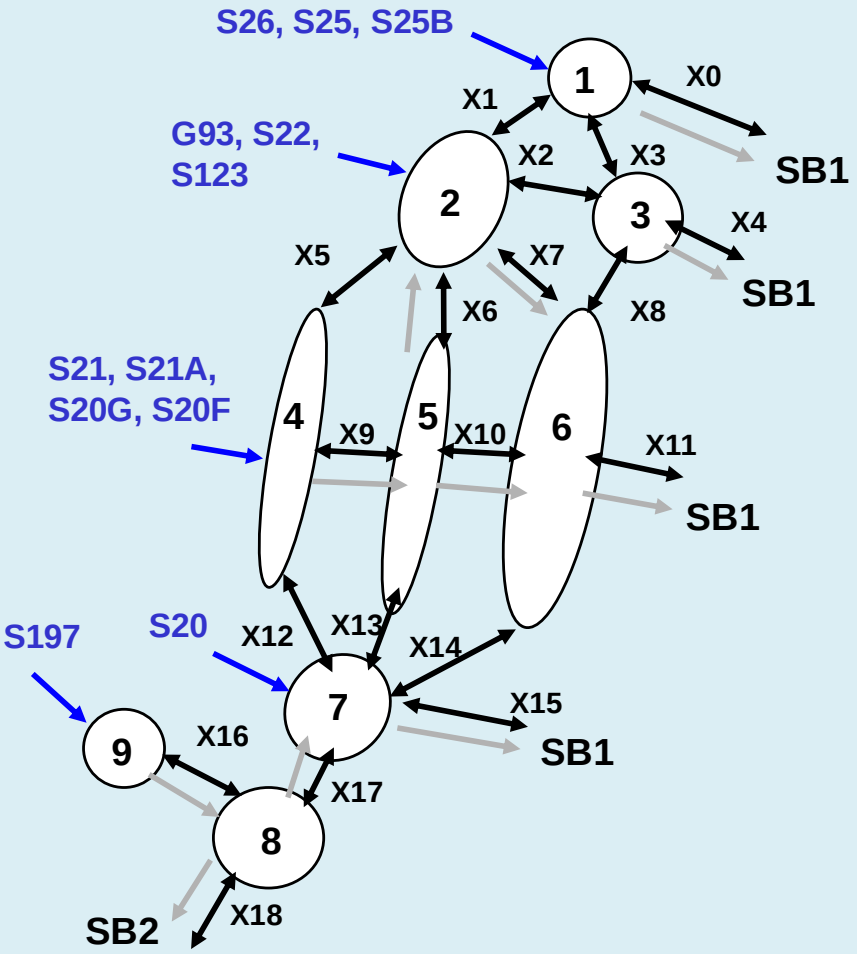


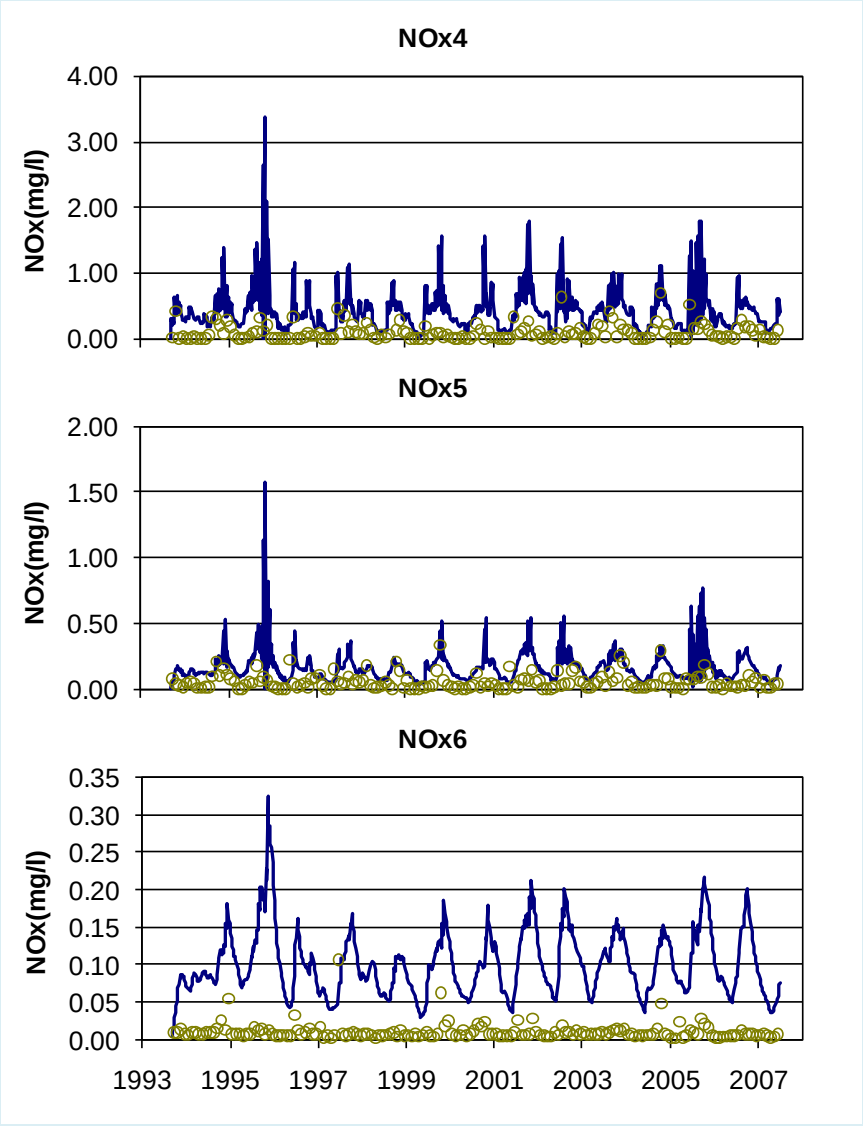
Existing Condition Simulation- NOx



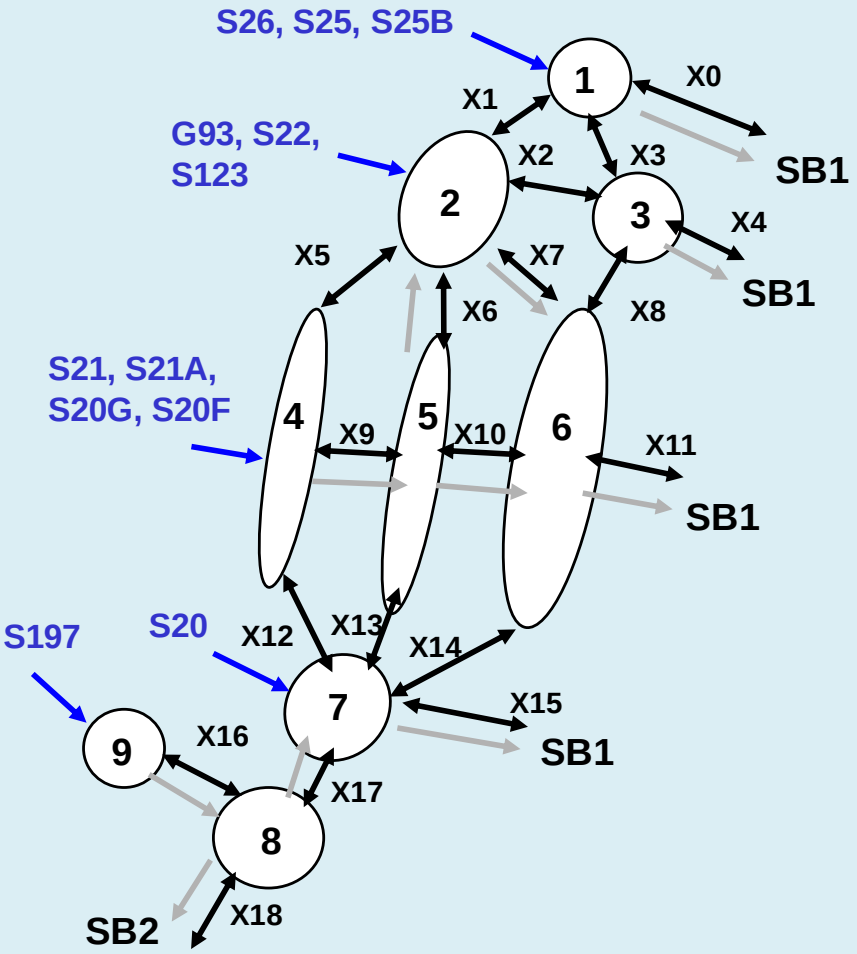


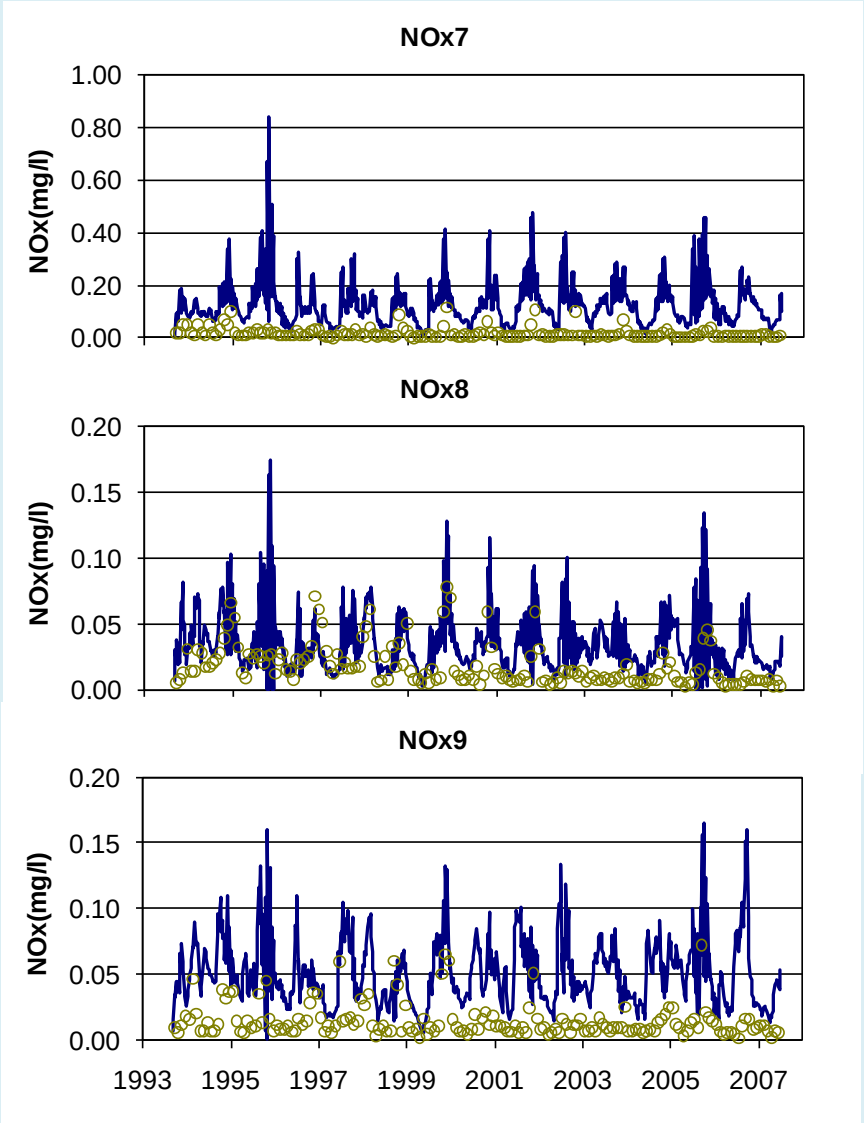
Existing Condition Simulation- NOx





Existing Condition Simulation- NOx



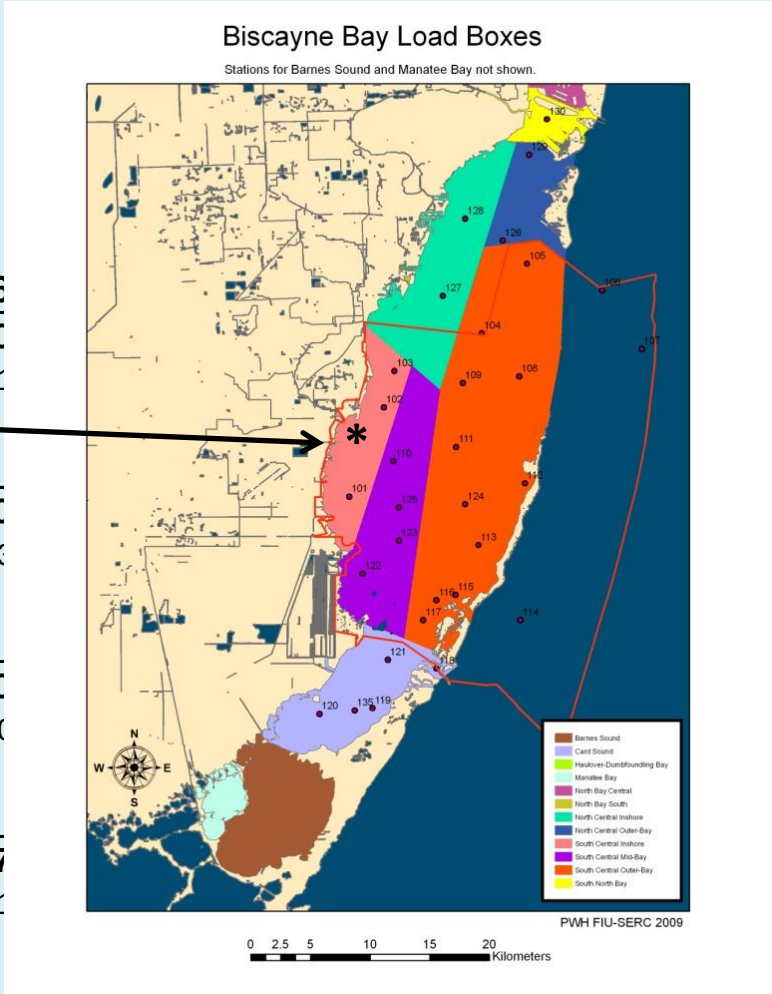


NOx Nitrogen - South Central Inshore Box

1. Base Case
2. Atmospheric Load minus 45%
3. Post Development Loads

NOx (mg/l)

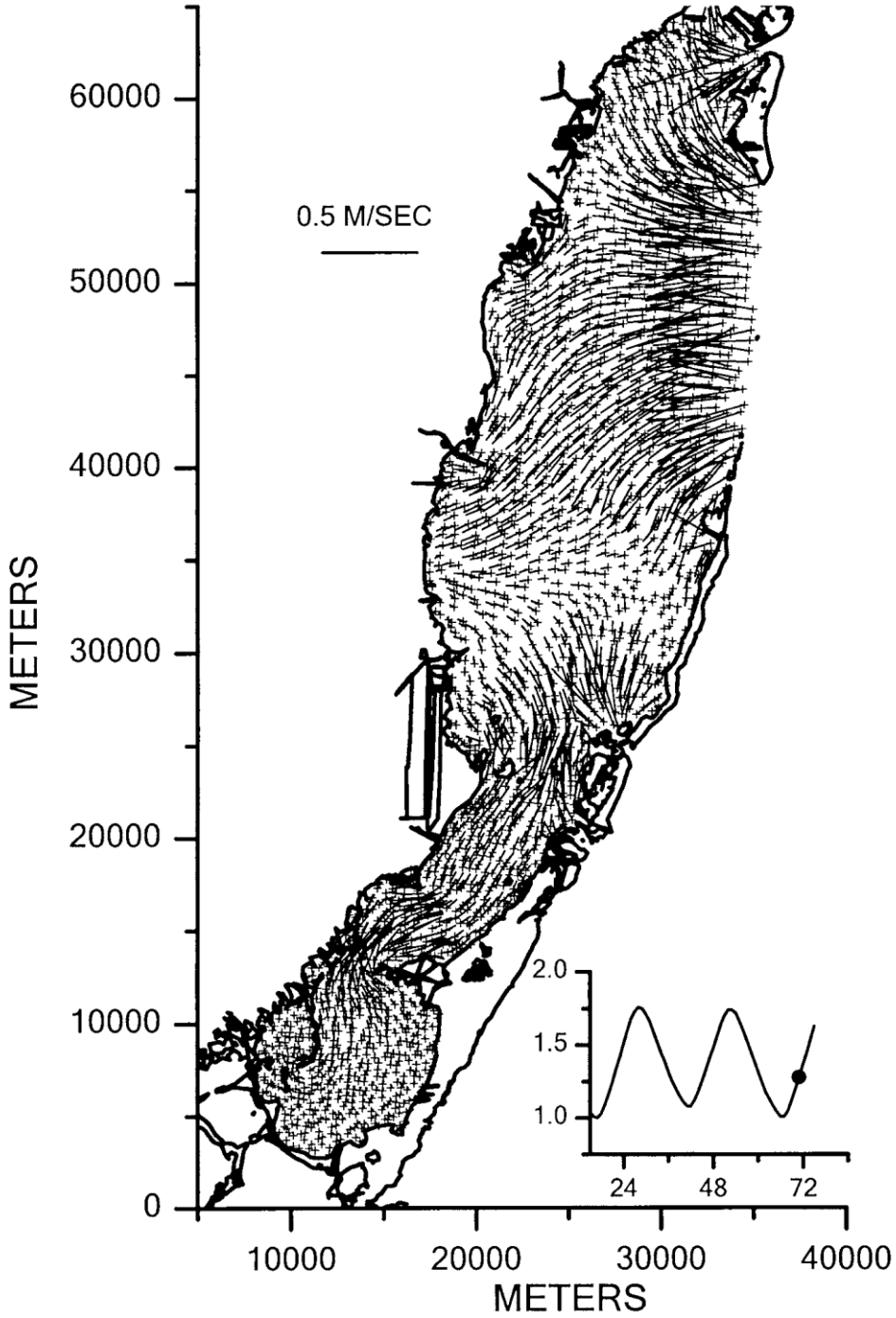
DATA	NOx2	NOx3	NOx4	NOx5	NOx6
avg	**0.0198**	**0.0165**	**0.0985**	**0.0563**	**0.010**
std	0.0274	0.0153	0.1237	0.0595	0.011
			*		
Base Case					
avg	**0.1549**	**0.1082**	**0.4230**	**0.1662**	**0.100**
std	0.0796	0.0464	0.3361	0.1240	0.043
Rain -45%					
avg	**0.1876**	**0.0958**	**0.4409**	**0.2048**	**0.120**
std	0.0942	0.0406	0.3247	0.1323	0.050
Post Dev.					
avg	**0.0629**	**0.0514**	**0.0825**	**0.0617**	**0.047**
std	0.0304	0.0239	0.0519	0.0321	0.021



The case of the missing NOx…

Hypotheses

- The model is wrong
- Base case NOx estimated loads too high
- Measured NOx box-averaged concentrations too low
- Assumed rate of denitrification/transformation of N is too low
- Biological uptake of N (macroalgae, epiphytes)
- Circulation patterns wash nutrients out of Bay



Biscayne Bay Simulation Model Wang, Luo, Ault (2003)

Biscayne Bay

Symptoms of Eutrophication

- Low dissolved oxygen
- Decreased clarity
- Increased chlorophyll a concentrations
- Phytoplankton blooms (nuisance or toxic)
- Problematic epiphyte growth
- Problematic macroalgae growth
- Submerged aquatic vegetation (SAV) community change or loss
- Emergent or shoreline vegetation community changes or loss
- Coral or hardbottom community changes or loss
- Fish kills

From FL Dept of Environmental Protection, nutrient criteria development studies

Summary

- Time-varying nutrient loads to Biscayne Bay have been developed
- Some uncertainty in some water budget loads, ex. GW
- Nothing new in loads – elevated NOx loads in South Central due to ag, elevated NHx in North Central due to urban; DIN dominated by high Nox

Summary

- Mass balance calculations have been implemented for Biscayne Bay hydrology/salinity box model
- Nutrient box model was able to simulate response of the Bay to various scenarios of nutrient loads

Summary

- High NOx from South Central canals not showing up in water quality data – several hypotheses for reason
- Box model shows promise for continued study of Biscayne Bay nutrients

Thanks!