Coupling Statistical Models with Paleoecological Information - A Synthesis of Pre-drainage Hydrology and Salinity Estimates in the Greater Everglades Ecosystem

Past, Present & Future Hydrology: Modeling & Application
GEER 2010
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Paleo Work Plan in Everglades National Park (ENP)

- Use paleoecological information and empirical statistical analysis to develop independent estimates of pre-drainage hydrology and salinity (2006-current)
- Compile all estimates in a synthesis of pre-drainage conditions using a weight-of-evidence approach (2010-2012)
- Incorporate climate change to estimate the pre-drainage salinity regime in a higher sea level environment (future)

Progress To-Date

New since GEER 2008

Core Location	Faunal Assemblages		Age Model	CWP	LRM
	Basic	Cluster			
Bob Allen Mudbank	√ (USGS & FIU)		√		√ (FIU)
Crocodile Point	√	√	√	In progress	In progress
Mud Creek Core	√	Not quantitative			
Park Key	√	√	√	√	1900 data gap
Pass Key	√		Post 1900		
Rankin Bight	In progress		√		
Rankin Basin	√	√	full	√	√
Russell Bank	√	√	full	√	√
Schooner Bank	In progress		In progress		
Taylor Creek	√	√	√	√	√
Whipray Basin	√	√	full	√	√

USGS

Work Completed To-date and Upcoming (Funded)

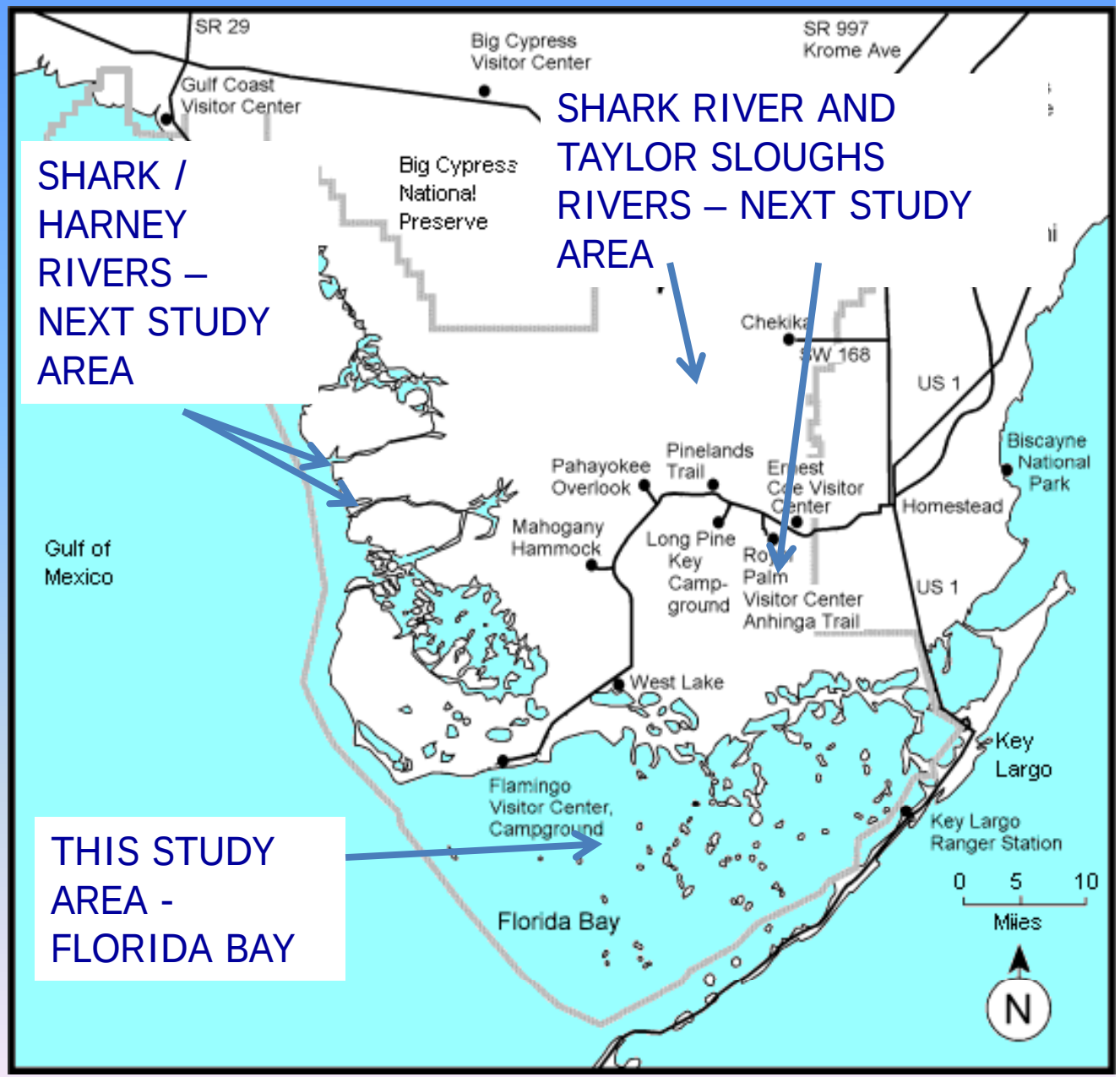
- Focus – Florida Bay, Shark / Harney Rivers, Shark River and Taylor Sloughs
- 4 cores analyzed to-date, all in the Bay –This Presentation
- 1 more core ahead for the Bay, then a synthesis of all 5
- 3 cores upcoming in Shark / Harney, then a synthesis
- 2 cores in Shark River and Taylor Sloughs

Multiple Partners – Funding and Participation

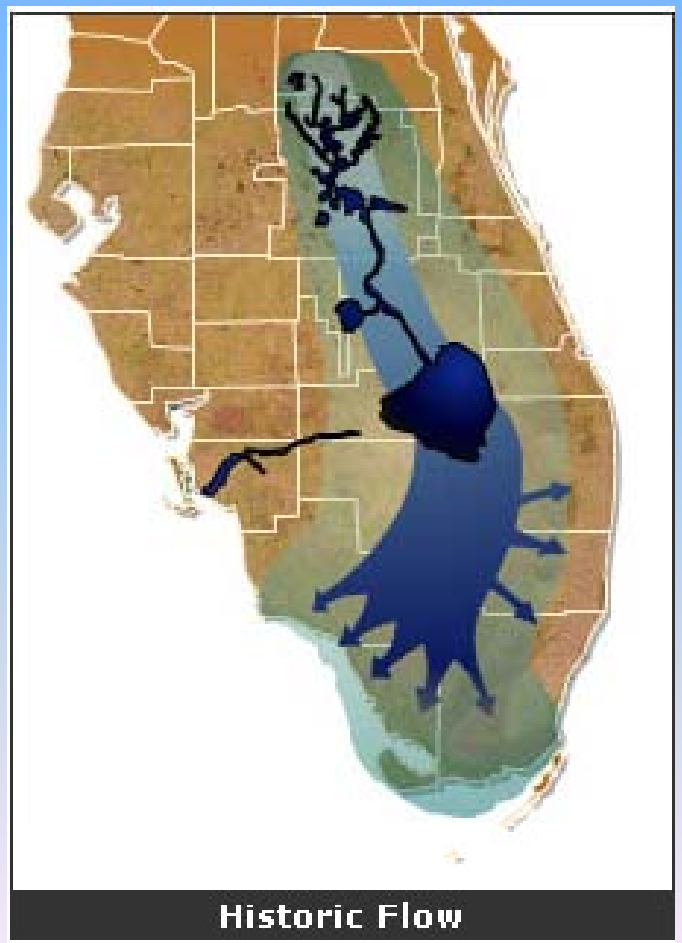
- CESI / ENP
- USGS
- RECOVER
- FIU

FIU | FLORIDA INTERNATIONAL UNIVERSITY

Study Area – Everglades National Park

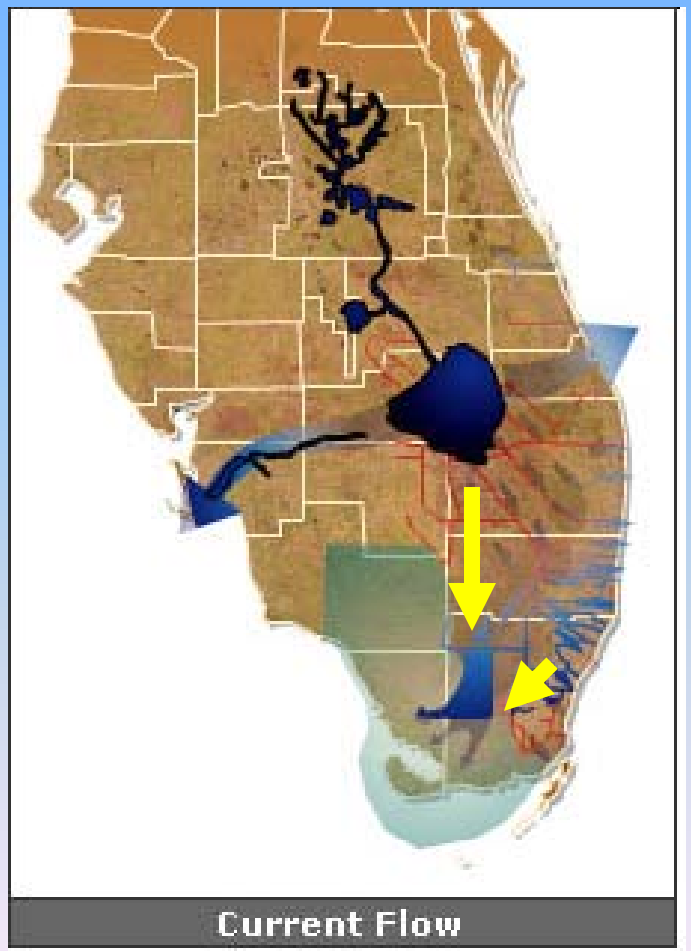


The Problem – Freshwater Reduction to the Everglades



Historic Flow

SOURCE: WWW.EVERGLADESPLAN.ORG

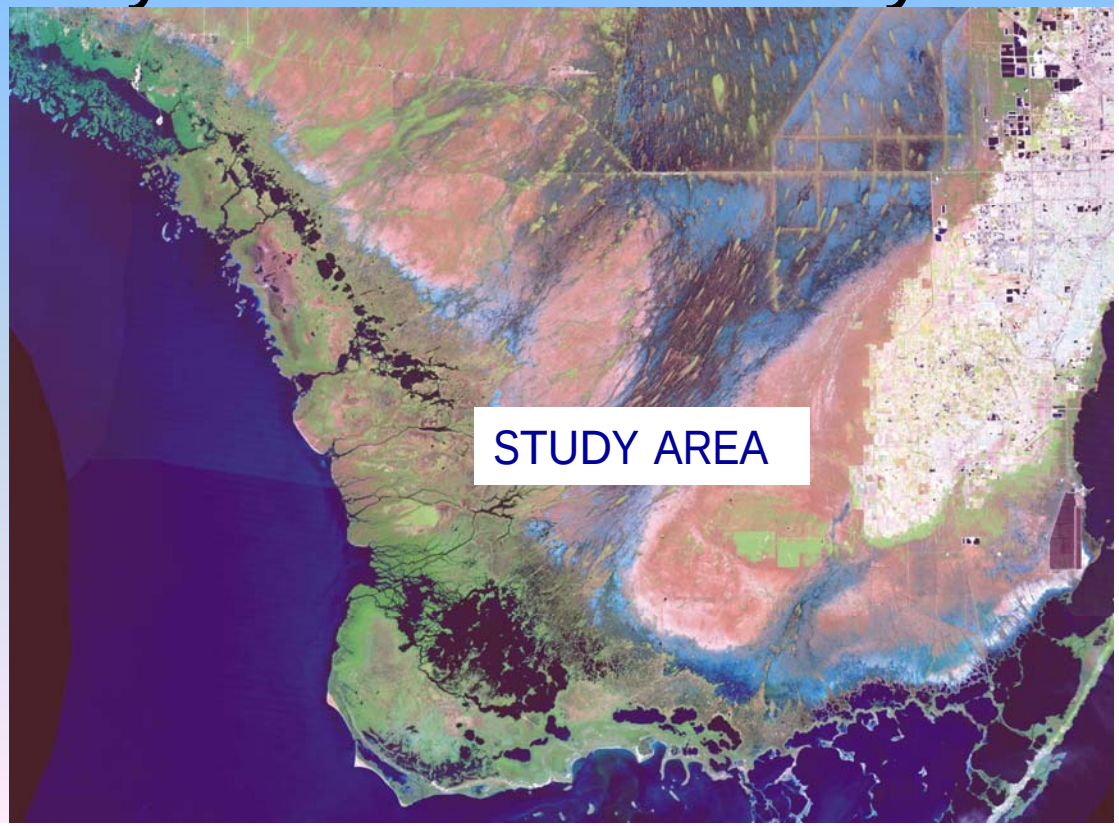


Current Flow

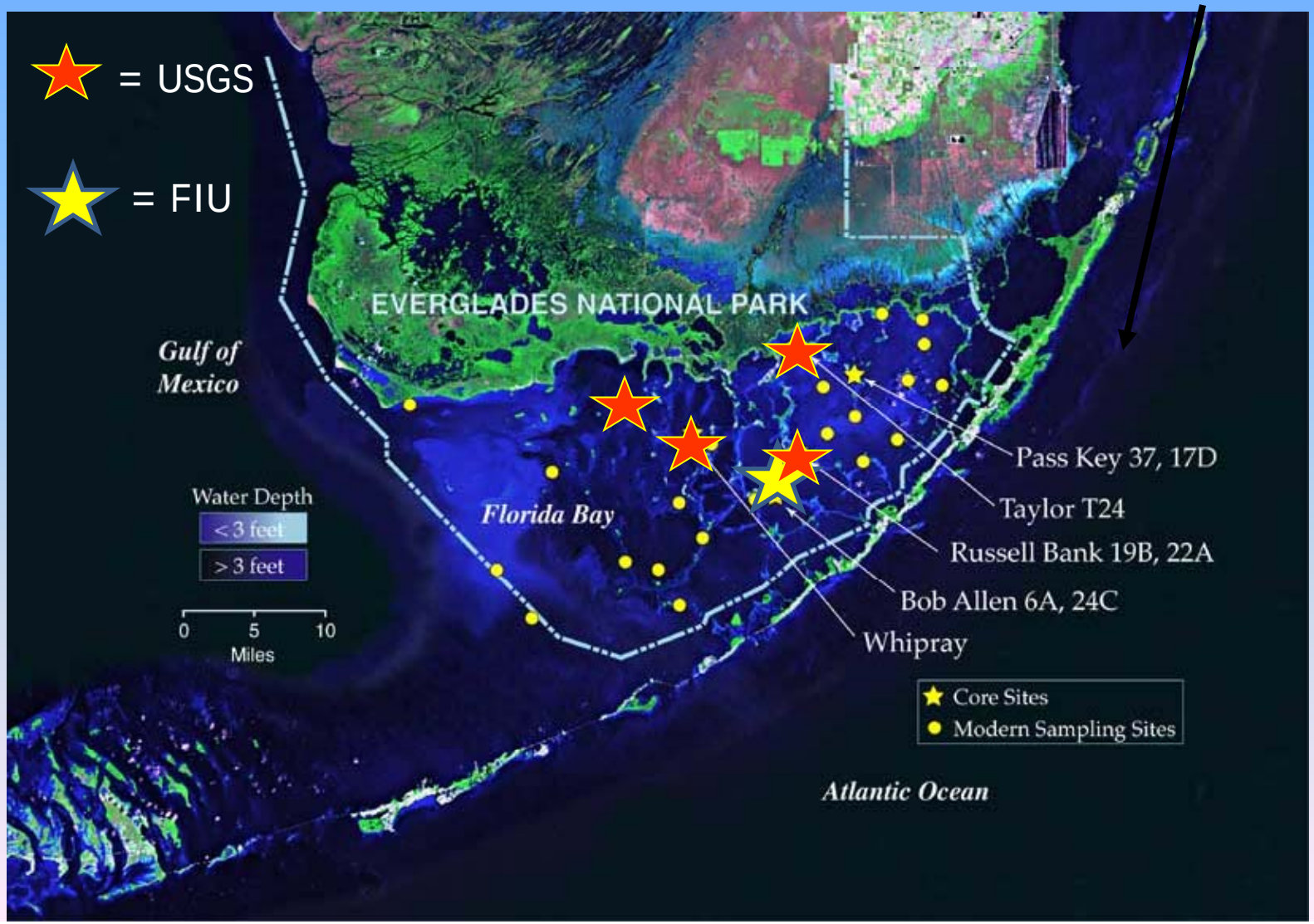
SOURCE: WWW.EVERGLADESPLAN.ORG

Available Data in Everglades National Park

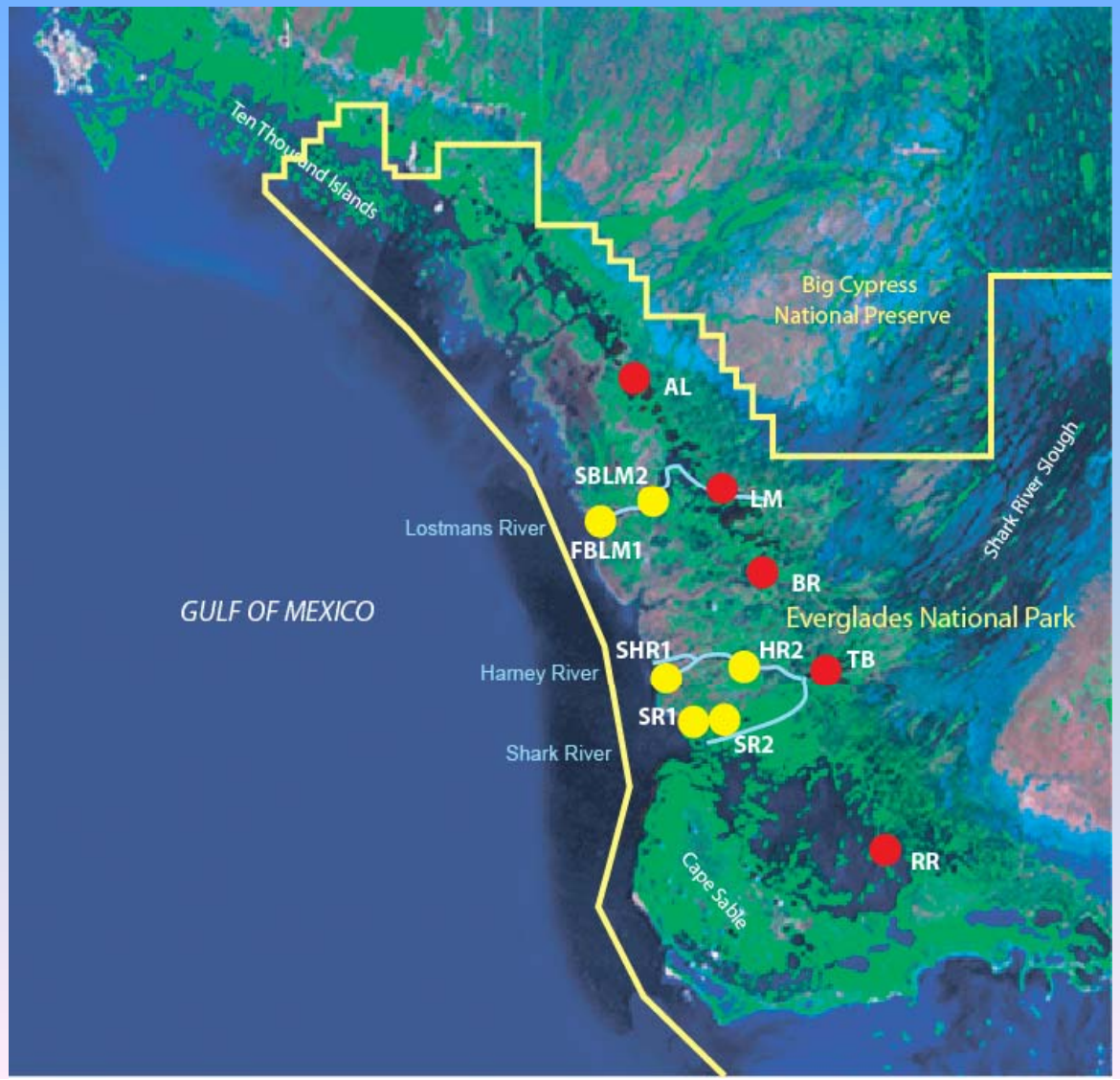
- Sediment cores
- Stage and flow in Everglades
- Salinity in Florida Bay and Shark / Harney Rivers



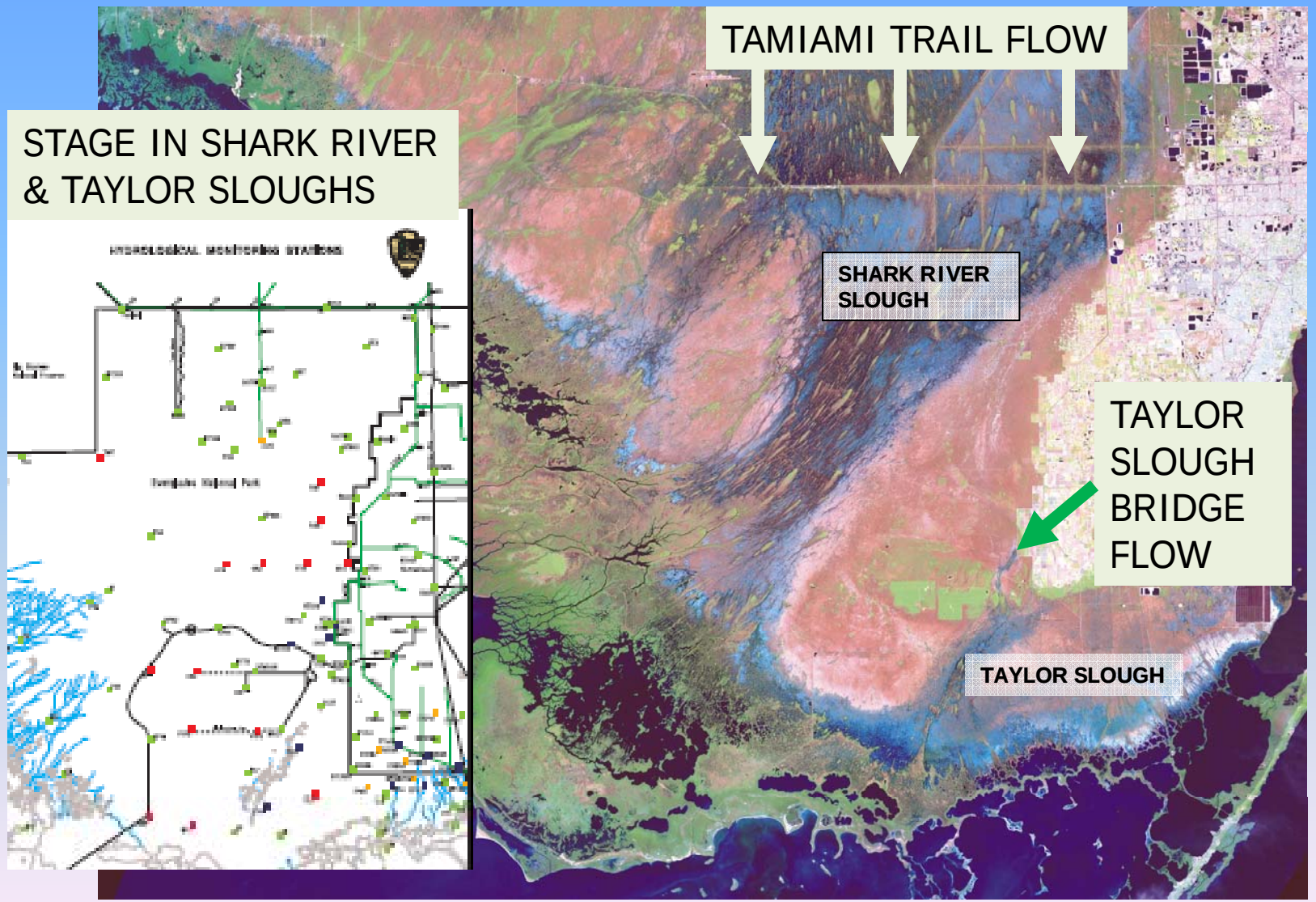
Florida Bay Paleoecological Data: USGS/FIU Sediment Cores

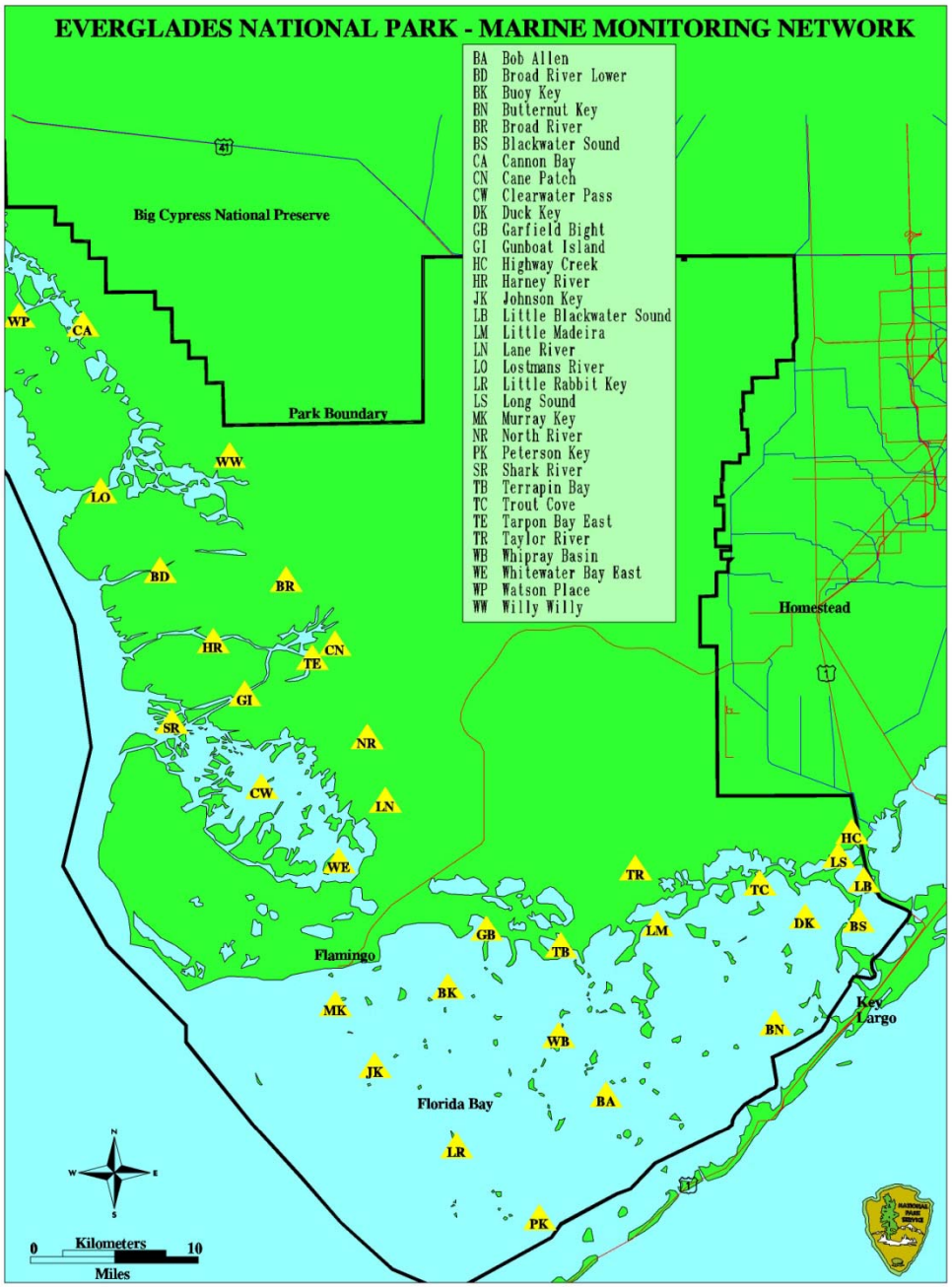


Shark / Harney Rivers Paleo Data: USGS Sediment Cores



Stage and Flow Data

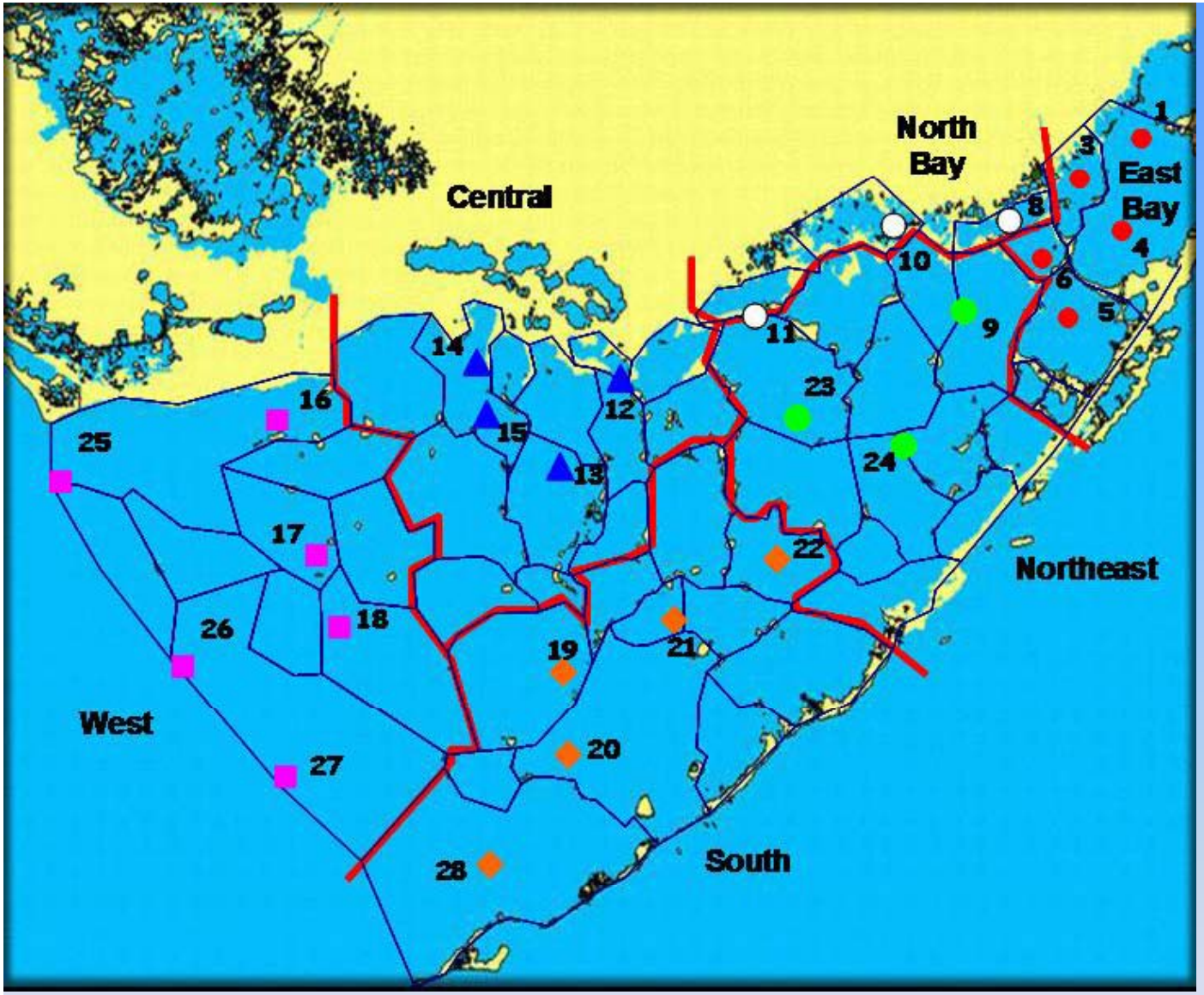




Existing Salinity Data

Everglades National Park Marine Monitoring Network Stations

Existing Salinity Data

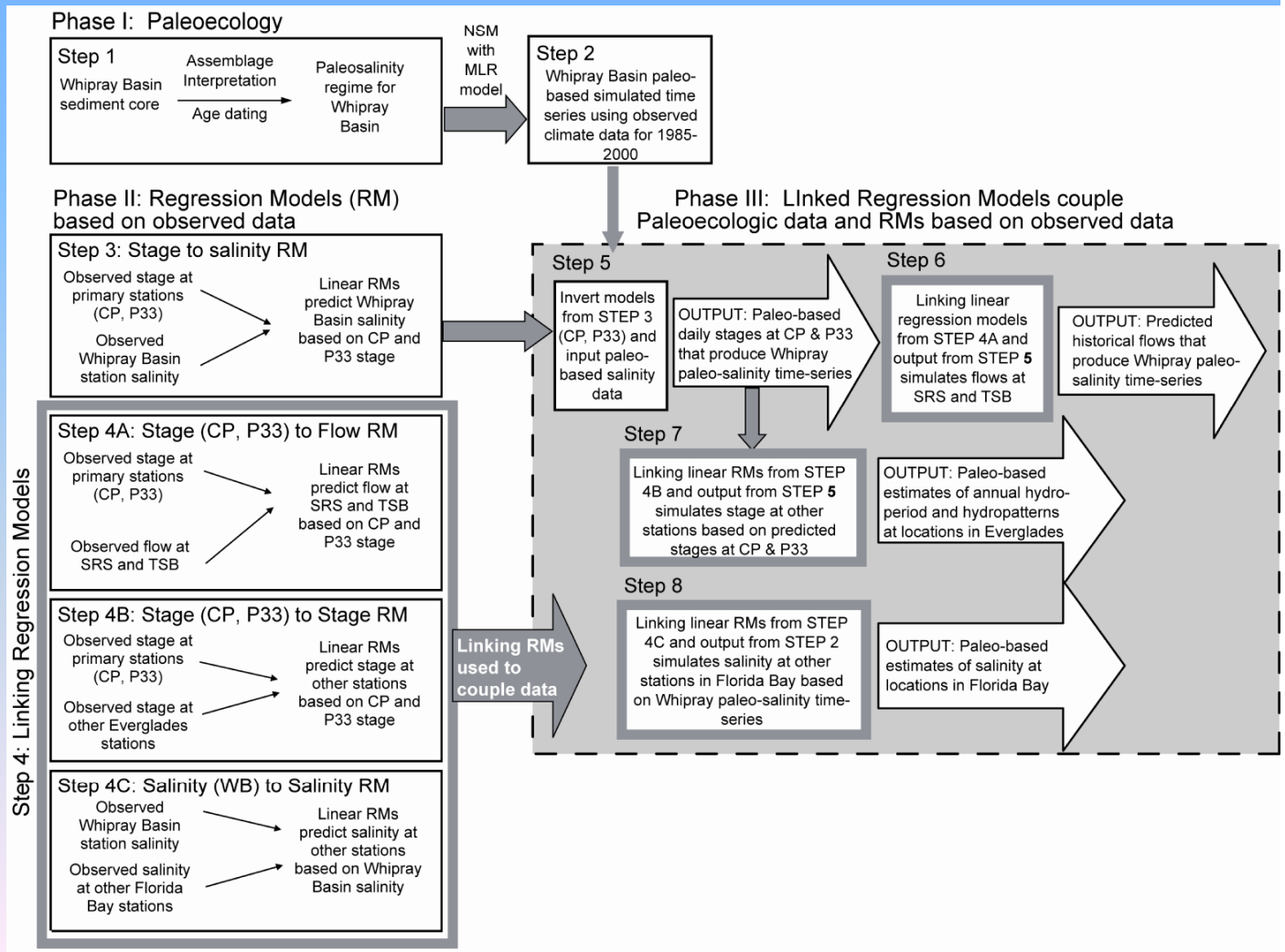


- **SERC / FIU monthly grab samples – water quality**
- **FATHOM nutrient model regions from PCA**

Paleosalinity Procedure

- **3 Phases**
- **8 Steps**
- **Jan 2009**

Estuaries And Coasts



Products

- Paleo-based estimates of
  - Salinity in Florida Bay
  - Stage in Shark River and Taylor Sloughs
  - Flow at Tamiami Trail and Taylor Slough Bridge required to achieve these conditions
  - Resultant flows in creeks for input to FATHOM
- ‘Paleo-based’ hydrology means estimate of hydrology needed to meet circa 1900 salinity conditions given current operating conditions

Florida Bay Paleo- Analyses Completed To-date

Florida Bay Cores	Associated Salinity Data Station
Whipray Basin	**MMN WB**
Bob Allen Key	MMN BA
Rankin Lake	**MMN BK**
Russell Bank	**SERC 22**
Park Key	N/A
Crocodile Point	N/A
Taylor Creek T24	**MMN LM**

= USED FOR SYNTHESIS

= SUPPORTING INFORMATION

Step 1 – Develop Paleosalinity

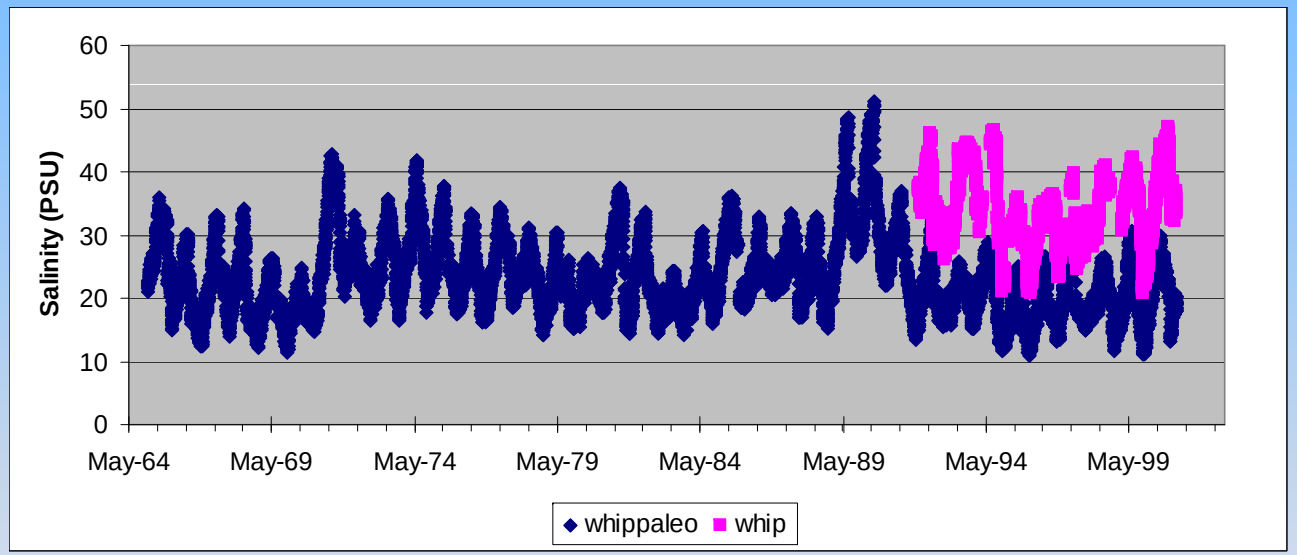
- Use sediment core analysis to estimate circa 1900 average salinity
  - Age models
  - *Casuarina*
  - Faunal assemblage characterization
- Use NSM 4.6.2 and MLR salinity models as base for time series
  - Add or subtract bias to/from NSM/MLR time series
  - Mean value of adjusted NSM/MLR = paleosalinity
  - NSM/MLR daily variability supplies the variation around the adjusted mean

*** Bias is removed from NSM462 before MLR simulation**

Salinity Comparison

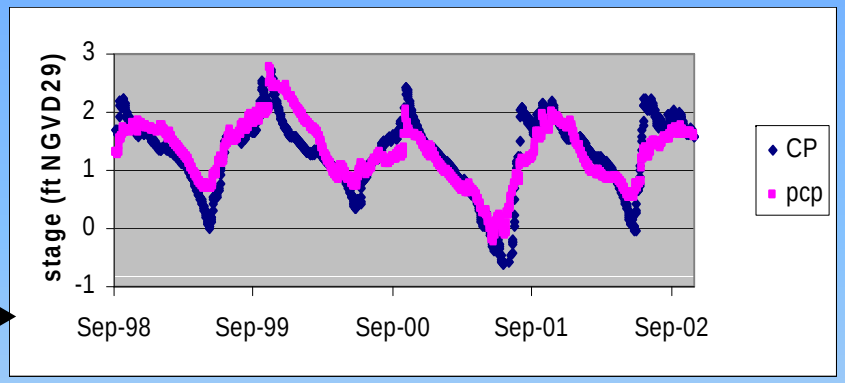
Core	Station	Observed Salinity POR Mean	Paleosalinity From Core	NSM462 / MLR Salinity* (1965-2000)
Whipray Basin	WB	36.4	23.4	31.9
Rankin Lake	BK	35.2	27.7	30.4
Russell Bank	SERC22	32.1	28.2	28.1
Taylor Creek T24	LM	24.2	15.4	17.7

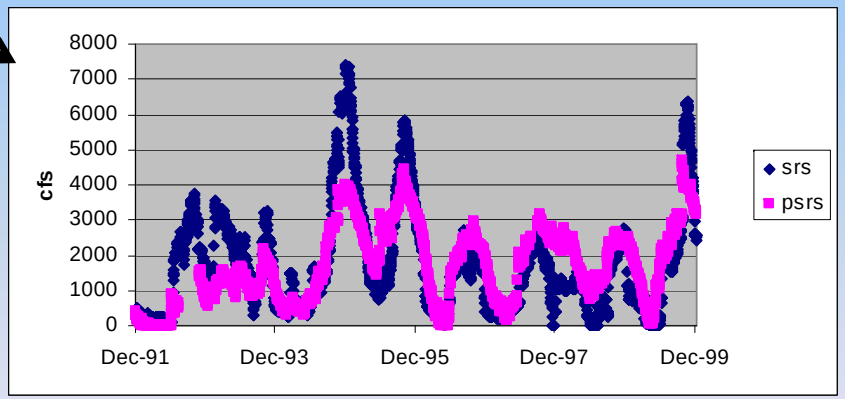
Whipray Basin Paleosalinity Simulated vs. Observed



Step 2 - Develop Linking Regression Models

- Salinity as *f* (CP and P33)
- Inverse – CP and P33 as *f* (salinity)
- Flow as *f* (CP and P33)
- Stage @ other stations as *f* (CP and P33)
- Salinity @ other stations as *f* (salinity subject location)

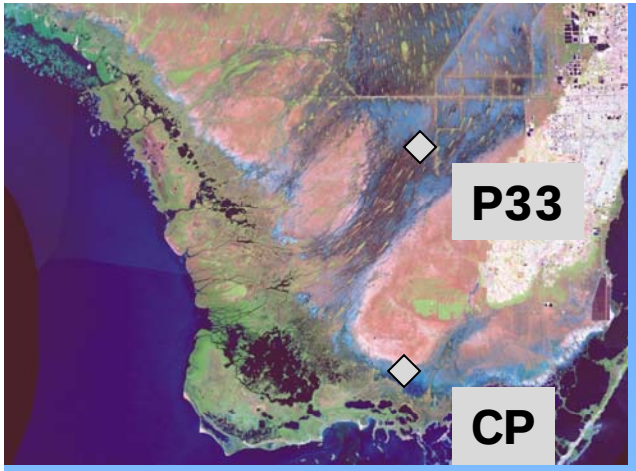




Step 3 – Input Paleosalinity, Turn Crank, Produce 1965-2000 Simulations

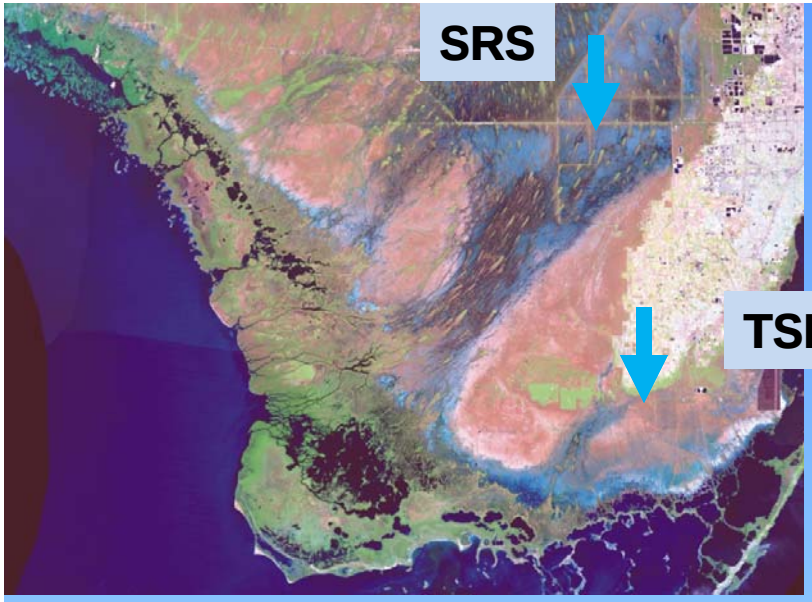
Output of Various Models

- Flow at Tamiami Trail and Taylor Slough Bridge
- Stage throughout Shark River and Taylor Sloughs
- Salinity throughout Florida Bay
- Creek flows into NE FL Bay



Model Output – Stage at Primary Stations (CP, P33)

Stage Station	Paleosalinity Input Data	Paleo Mean (m)	paleo-obs (m)	paleo: observed
P33	Whipray Basin	2.48	0.55	1.28
	Rankin Lake	2.18	0.25	1.12
	Russell Bank	2.27	0.21	1.10
	Taylor T24	2.29	0.45	1.27
CP	Whipray Basin	0.99	0.60	2.54
	Rankin Lake	0.61	0.22	1.73
	Russell Bank	0.65	0.22	1.49
	Taylor T24	0.63	0.27	1.75

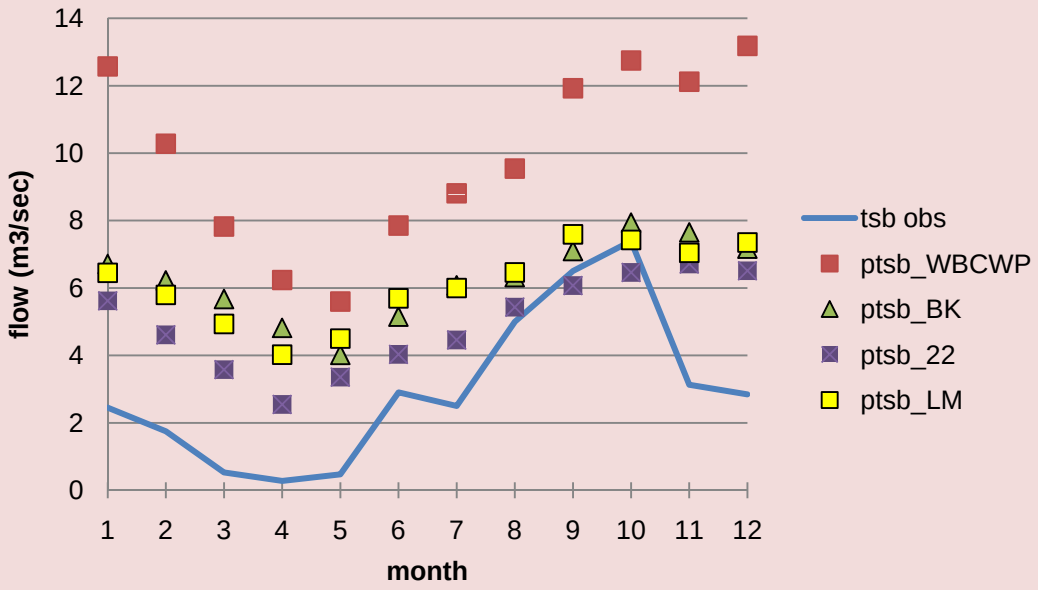


Model Output: Mean Flow

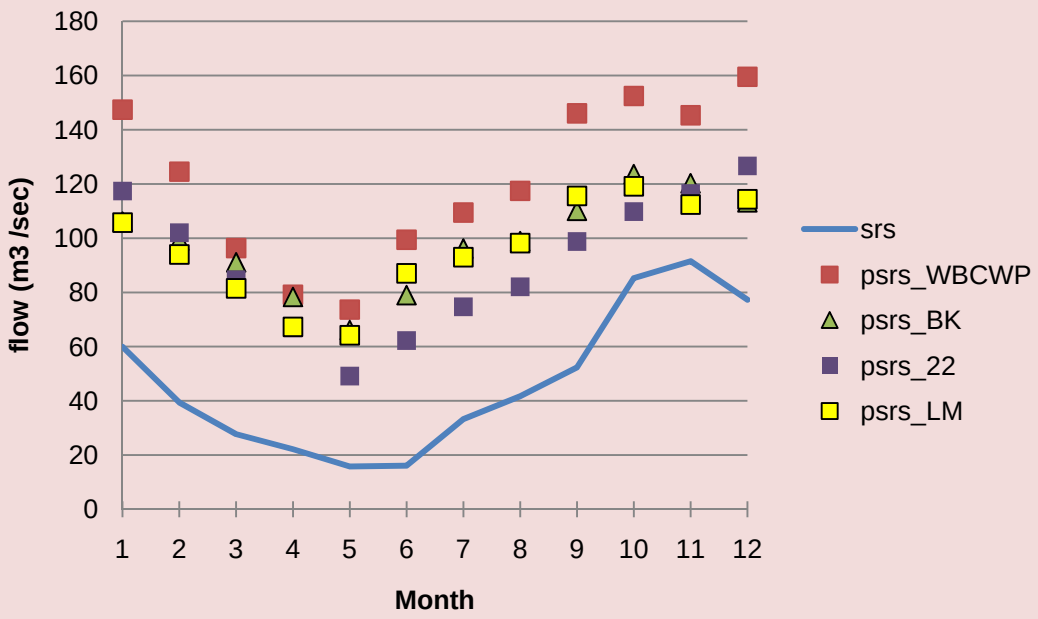
Flow Station	Paleosalinity Input Data	Mean Flow (m^3/sec)	paleo: observed
SRS	Whipray Basin	115.8	2.73
	Rankin Lake	96.9	2.28
	Russell Bank	90.82	1.92
	Taylor T24	86.04	2.10
TSB	Whipray Basin	8.9	3.99
	Rankin Lake	5.5	2.40
	Russell Bank	5.5	2.40
	Taylor T24	4.92	3.67

Monthly Average Flow Comparison

Taylor Slough Bridge

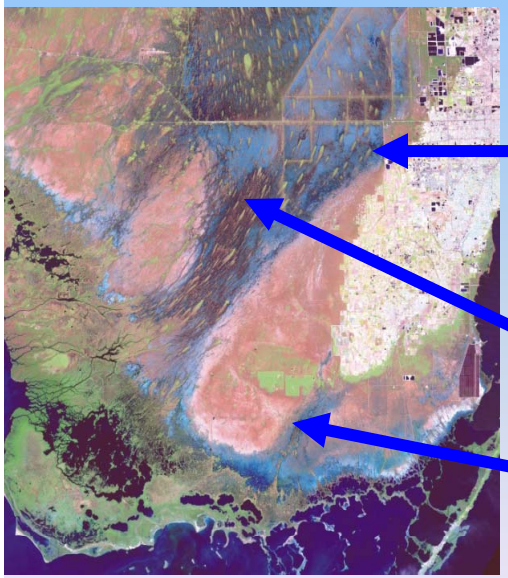


Tamiami Trail (srs)



DRY WET

Model Output: Stage Difference (paleo-observed) at Other Stations in Everglades



Station	Location	WB paleo diff(m)	Rankin paleo diff (m)	Russell paleo diff (m)	Taylor paleo diff (m)
G3273	Shark River Slough	0.37	0.38	0.37	0.44
NP206	Shark River Slough	0.51	0.43	0.4	0.53
TSH	Taylor Slough	0.44	0.30	0.19	0.25

Output: Paleo-based Salinity Regime in Florida Bay

- Paleo-salinity in FL Bay was modeled by regression models and by FATHOM
- Good agreement between regression models and FATHOM output
- Difference between observed salinity and paleo-based salinity ranges from 2 – 12 ppt/psu
- Largest difference is in near-shore embayments
- Smallest difference is at west FL Bay stations

Paleo-based Salinity Regime

Exist | Whipray | Rankine | Russell | Taylor T24

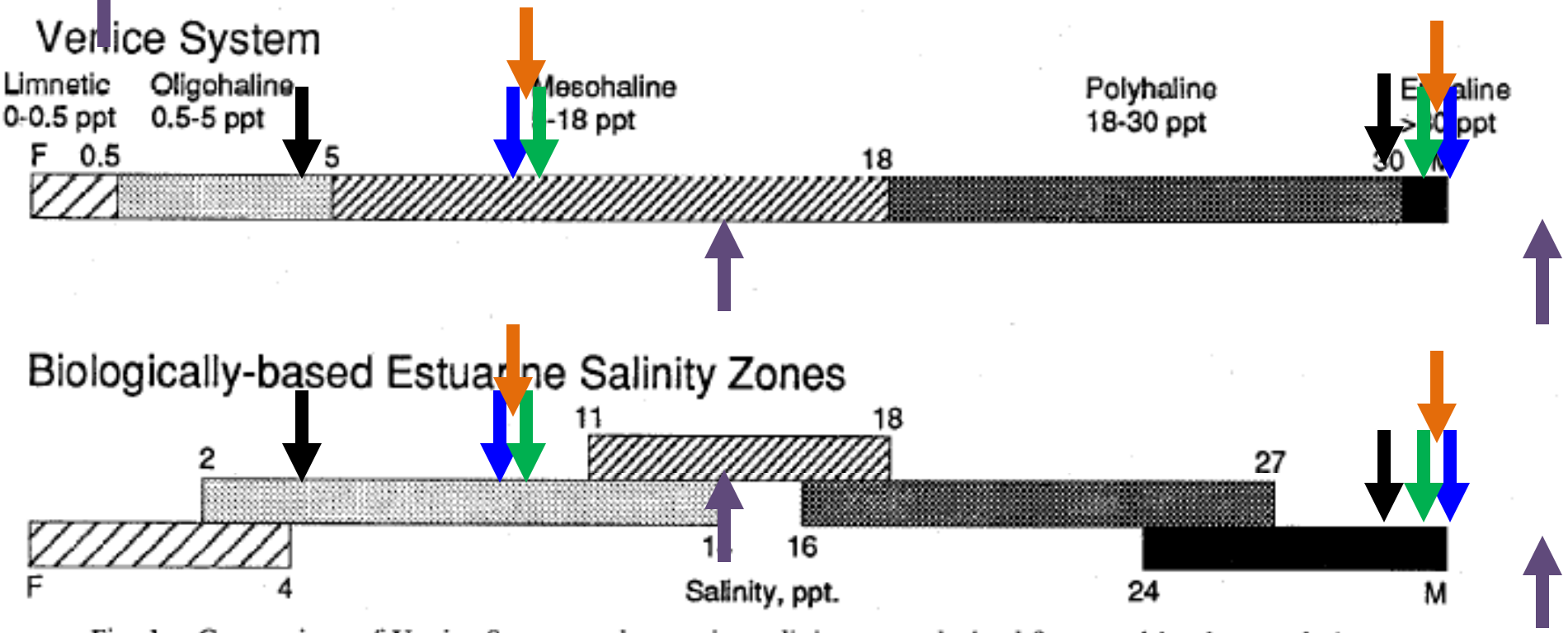
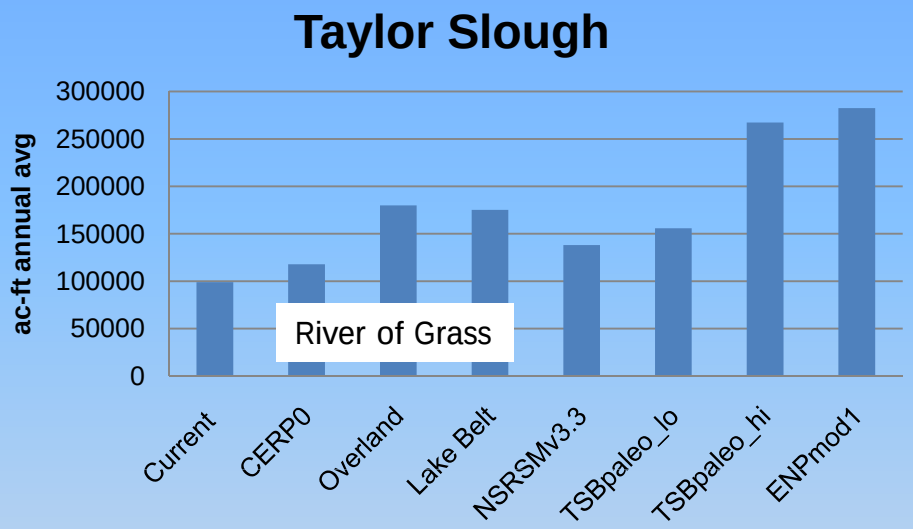


Fig. 1. Comparison of Venice System and estuarine salinity zones derived from multivariate analysis.

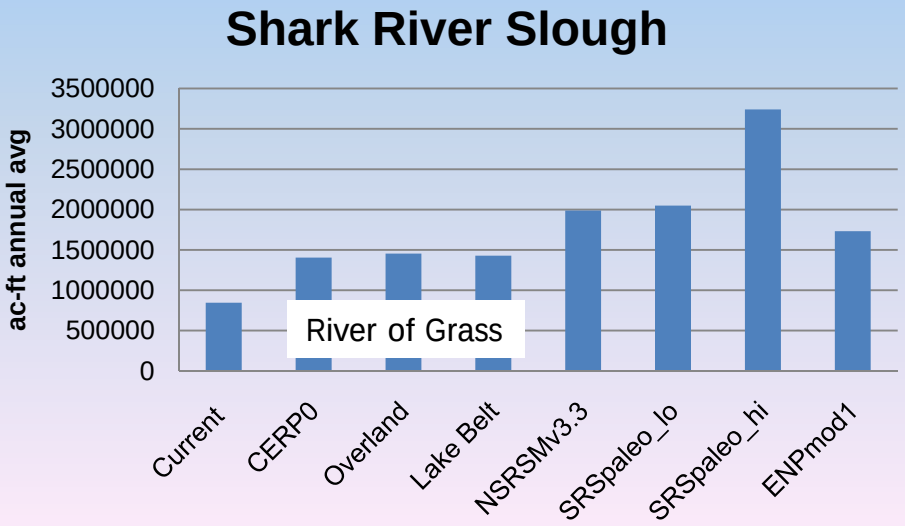
SOURCE: Bulger, Hayden, Monaco, Nelson, McCormack-Ray;
Estuaries Vol. 16, No. 2, p. 311-322 June 1993

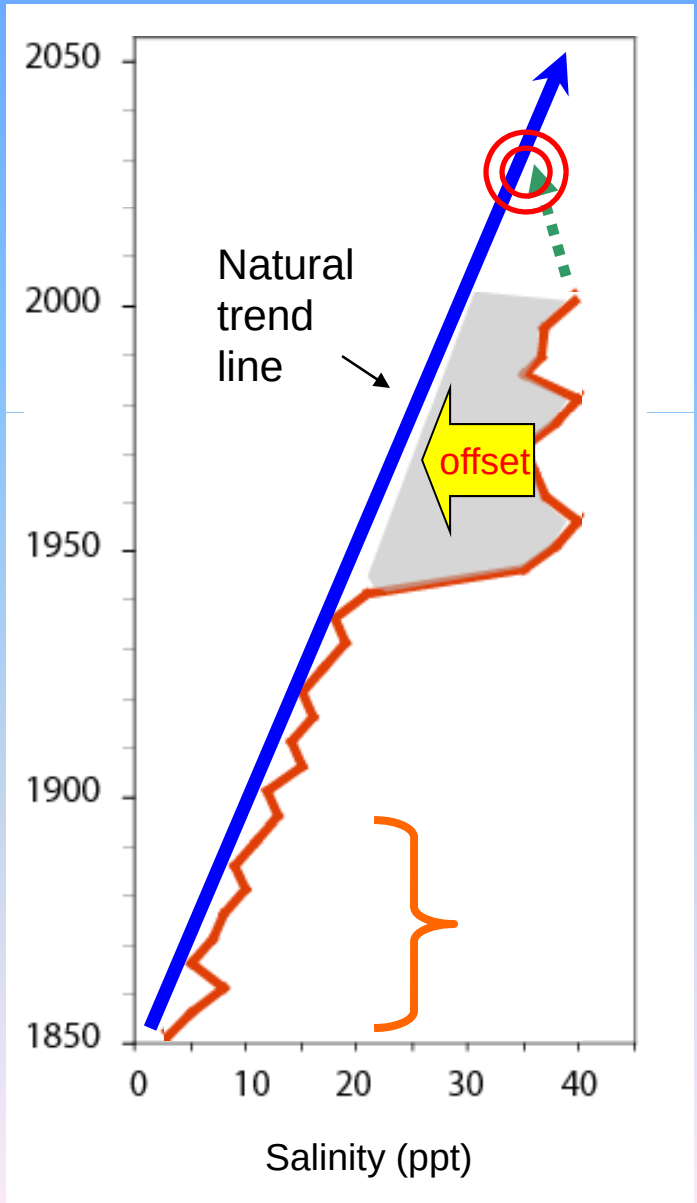
Comparison to Current Flow Target Alternatives



See: Bob Johnson Plenary
8:30-10 AM Wed.

Ed Brown Presentation
4:40-5 PM Tue.





CLIMATE CHANGE GOAL: Determine the offset needed for salinity restoration targets taking into account irreversible anthropogenic changes and SLR

Summary – Findings To-date

- The use of sediment faunal characterizations with regression models has proved to be a useful tool for linking paleosalinity data to upstream hydrology in the Everglades
- Consistent results from paleo evaluations to-date
- The time has come to interpret the results as a package

Summary – Findings To-date

- Currently:
  - Average Everglades stage is about 0.25 - 0.5 m lower.
  - Taylor Slough flow deficit is >>> than the deficit in Shark River Slough during the dry season.
  - Florida Bay salinity is about 2 – 12 psu higher.
- Upcoming work in Shark / Harney Rivers and Shark River / Taylor Sloughs will validate or modify these findings.

Summary - Findings To-date

- Establishing pre-drainage salinity regime requires about 2 – 2.25 times more freshwater than the current flow regime.
- Result is a more estuarine Florida Bay - mesohaline to polyhaline as opposed to euryhaline current condition
- Restoring flow regime restores hydroperiod and pattern in SRS, TS
- Range of paleo estimates is in line with other estimates of pre-drainage hydrology

Photo by A. Gelber via D. Deis

THANK YOU!

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