

Setting Restoration Targets in Florida Bay Using Paleoecology and Salinity/Hydrology Models

Session: Estuarine Ecosystems Restoration

**4th National Conference on Ecosystem Restoration
Estuarine Ecosystems Restoration Session
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**Frank Marshall, CLF
Lynn Wingard, USGS
Patrick Pitts, USFWS**

Study Area

Everglades Ecosystem

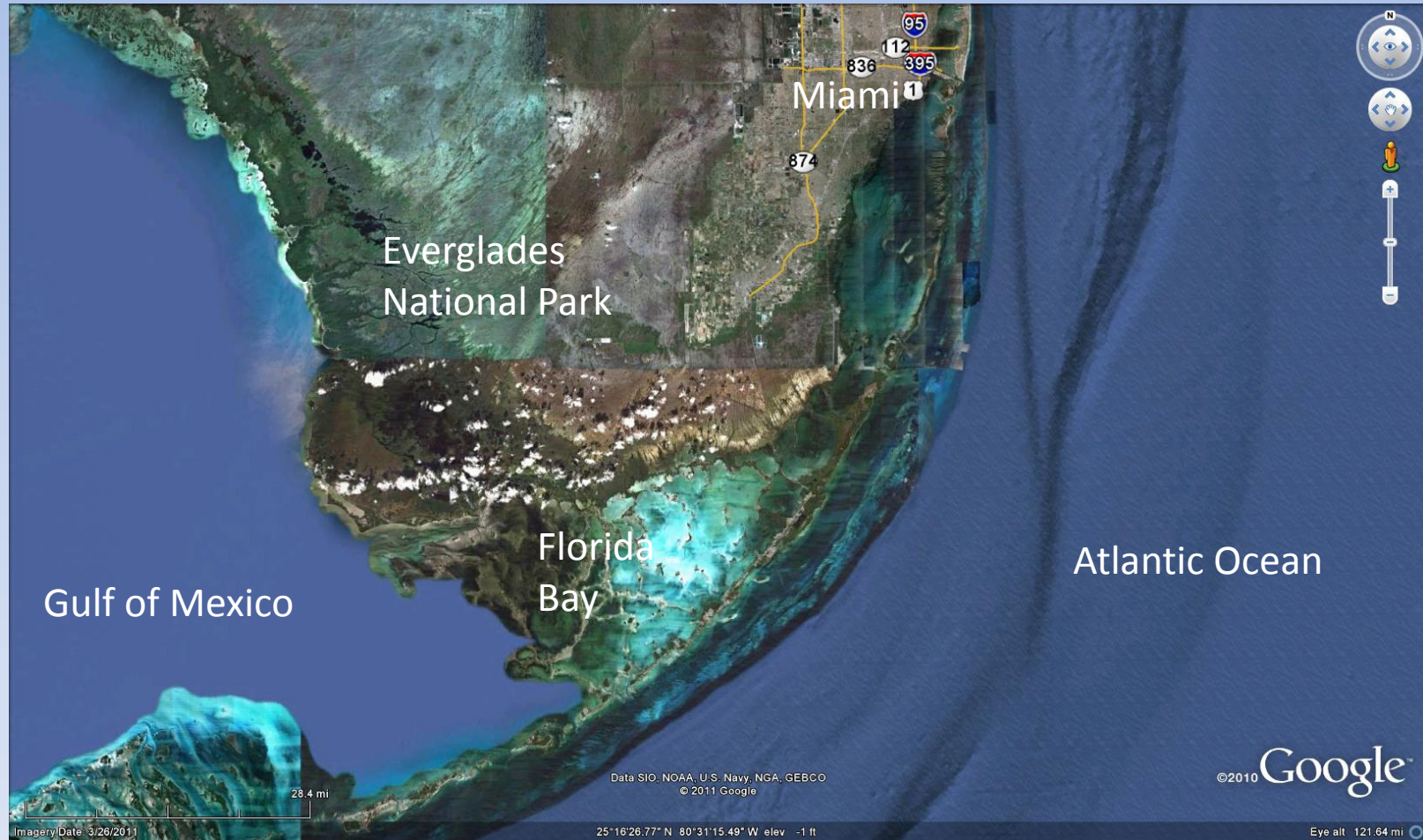
- Globally unique combination of hydrology and water-based ecology
- Freshwater wetlands directly connected to estuaries connected to:
 - Atlantic Ocean
 - Florida Straits
 - Gulf of Mexico
- i.e. hydrology and salinity are tightly coupled to each other and to the ecology

Study Area

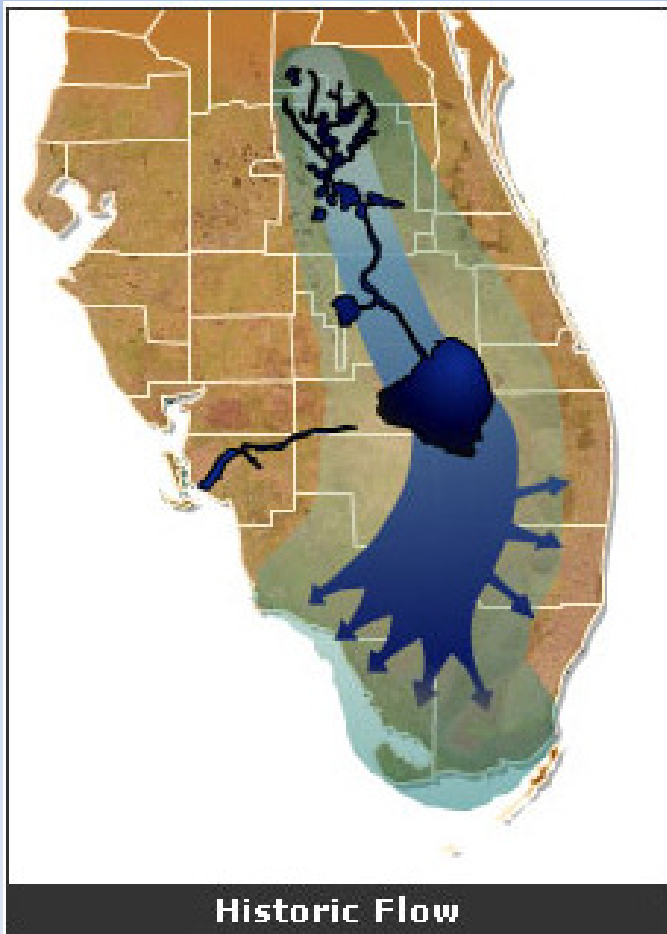
Everglades Ecosystem

- Anthropogenic impacts due to water management:
 - Reduced flows
 - Reduced hydroperiods
 - Higher salinity regimes and increased occurrence of hypersalinity
 - Impacted ecosystems
- Remains of (altered) natural system are ‘protected’ in Everglades National Park – our Study Area
- Goal of Everglades restoration:
restored hydrology, salinity and resultant water-based ecosystem

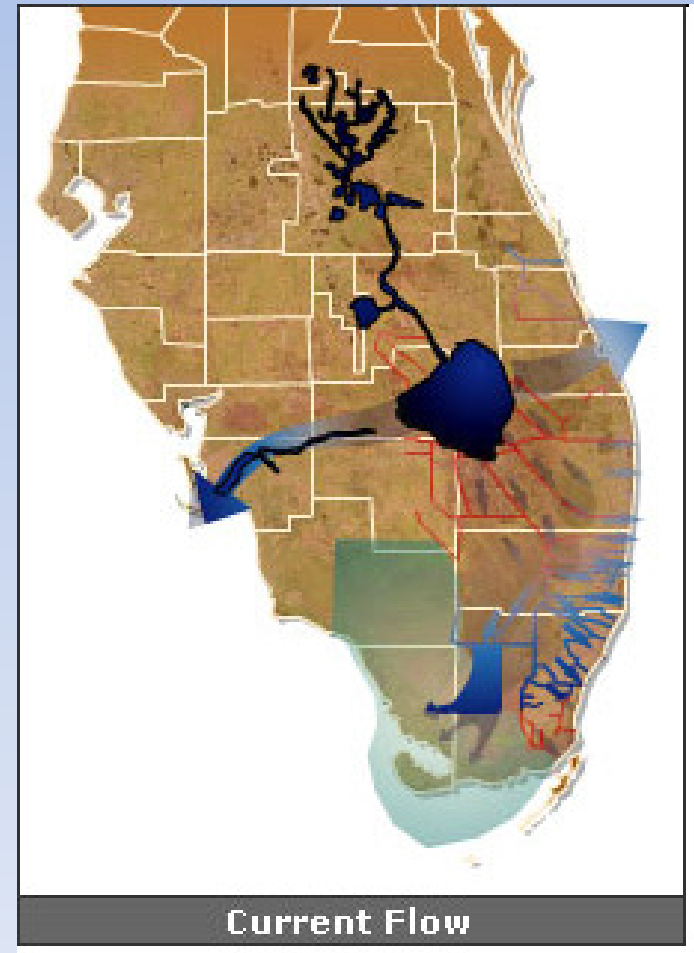
Overview of Study Area



The Problem – Freshwater Diversion From the Everglades



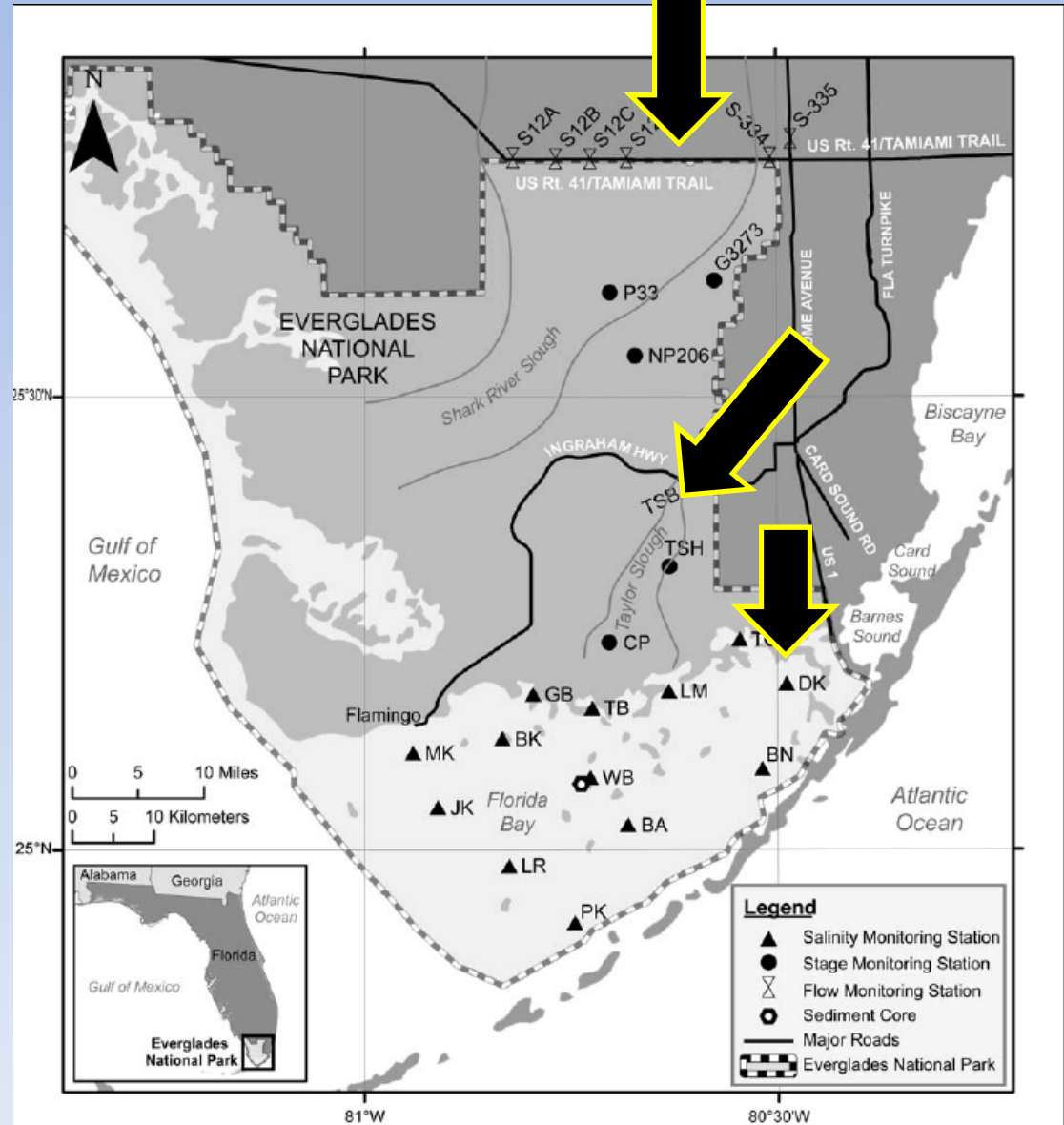
SOURCE: WWW.EVERGLADESPLAN.ORG



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Important Features for This Study

Flow is key parameter in management of water in south Florida

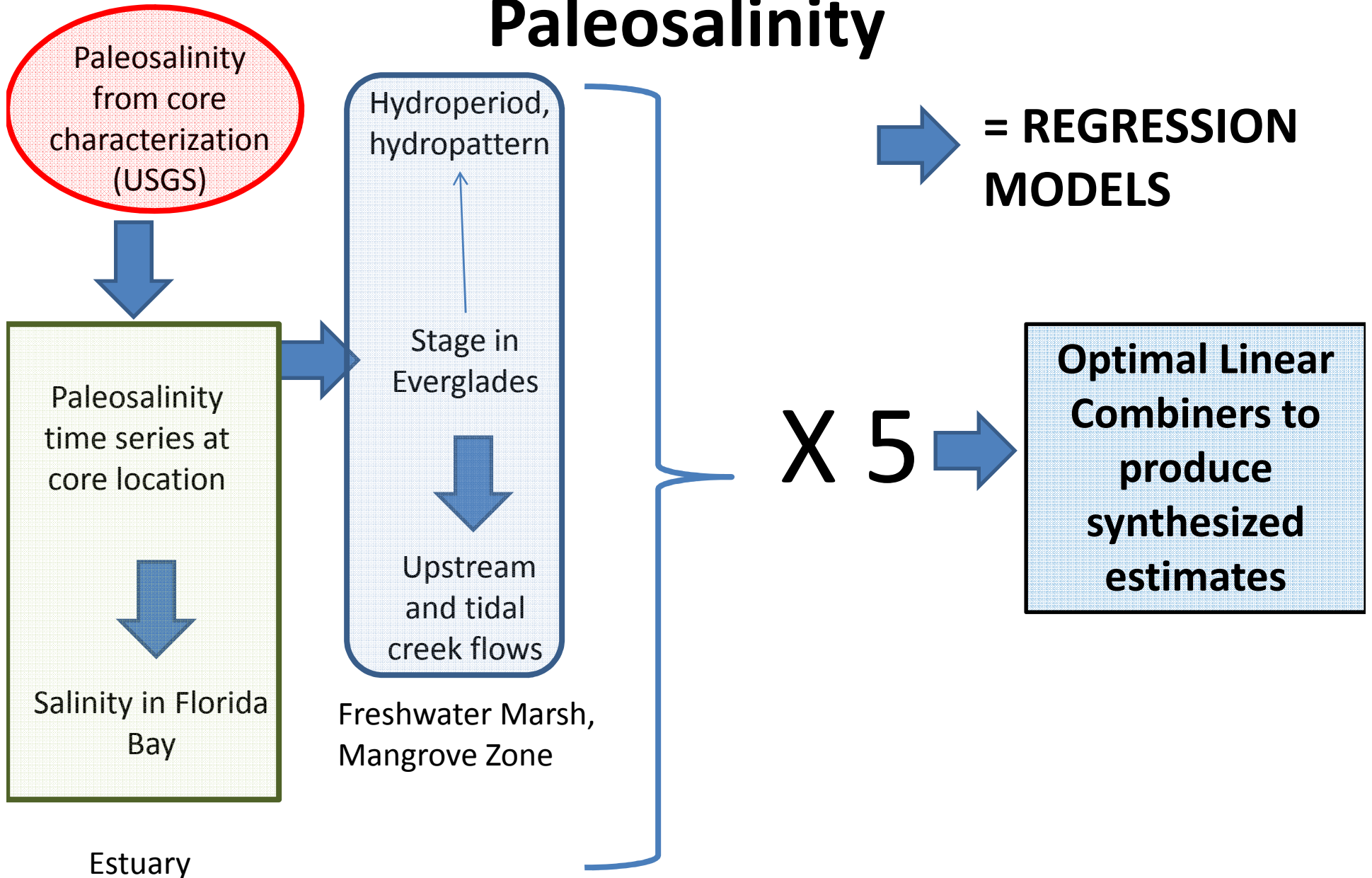


Current Status of Paleosalinity Analyses in Florida Bay

- 5 sediment core analyses in Florida Bay completed over last 5 years:
 - Whipray Basin
 - Rankin Lake
 - Taylor T24
 - Russell Bank
 - Crocodile Point
- Synthesis of all 5 analyses was recently completed
- Funded has been provided by:
 - RECOVER
 - USGS
 - ENP

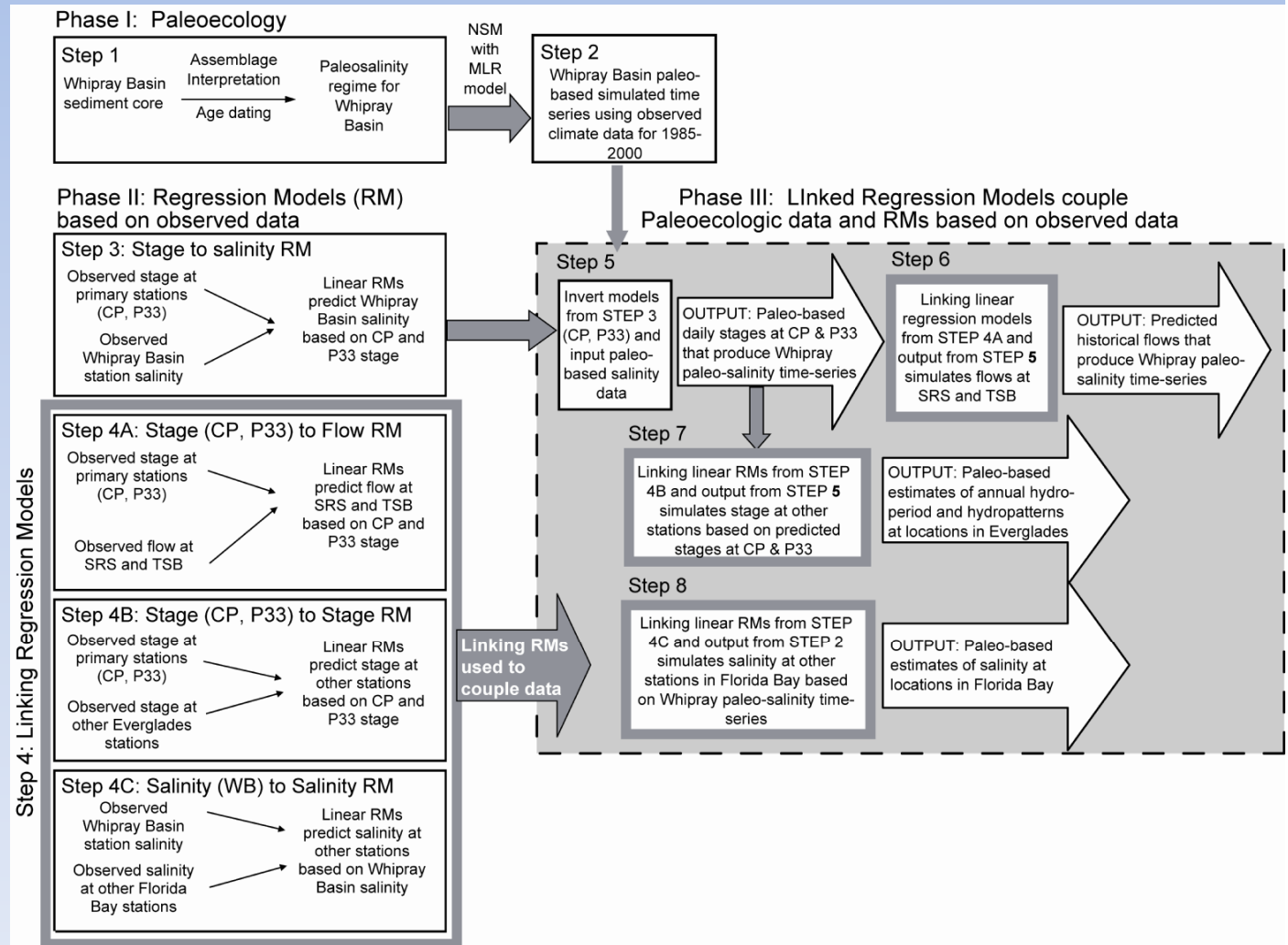


Procedure for Synthesizing Paleosalinity

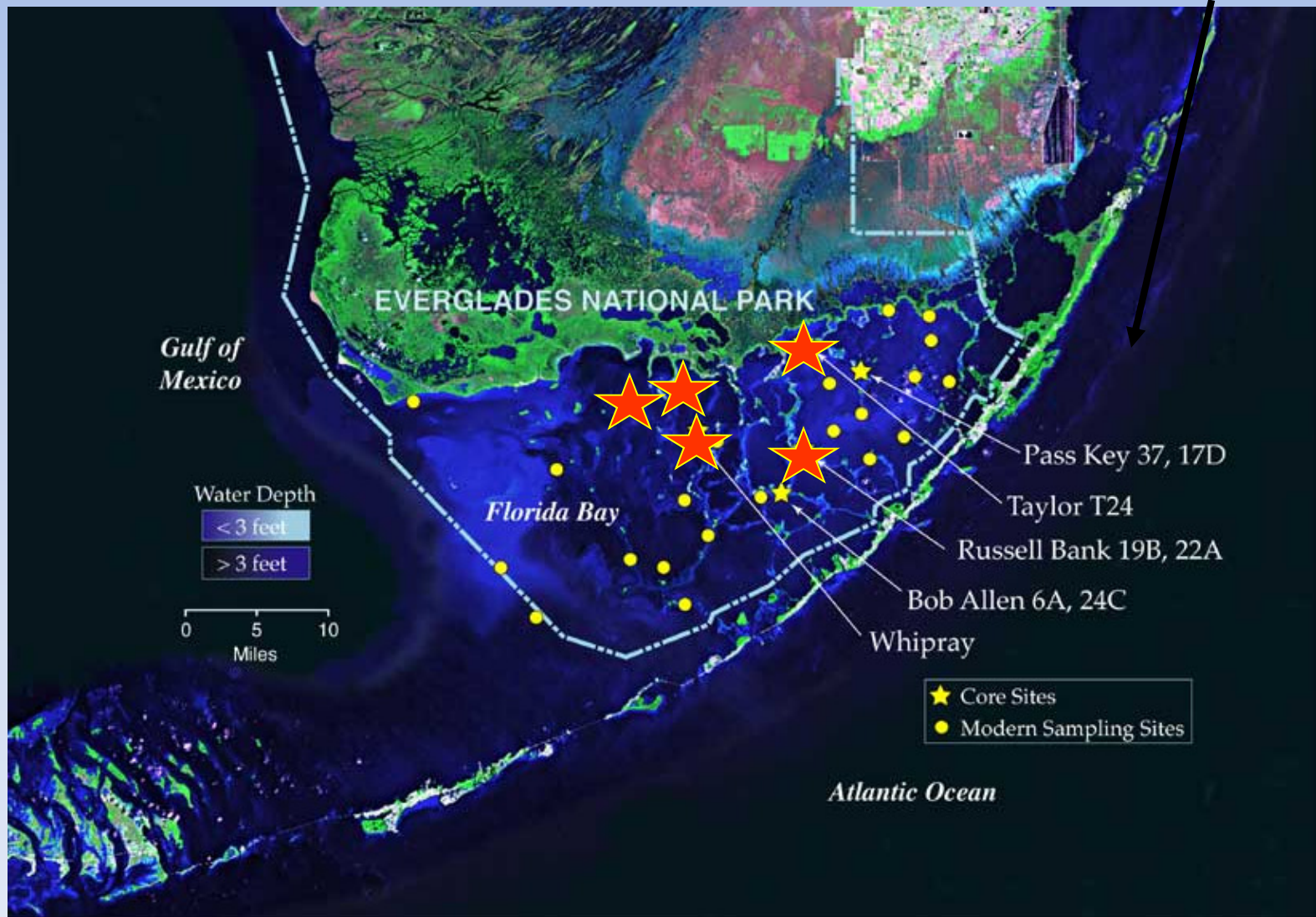


Detailed Paleosalinity Procedure

See Jan 2009
Estuaries
And
Coasts



Florida Bay Paleoecological Data - USGS Sediment Cores



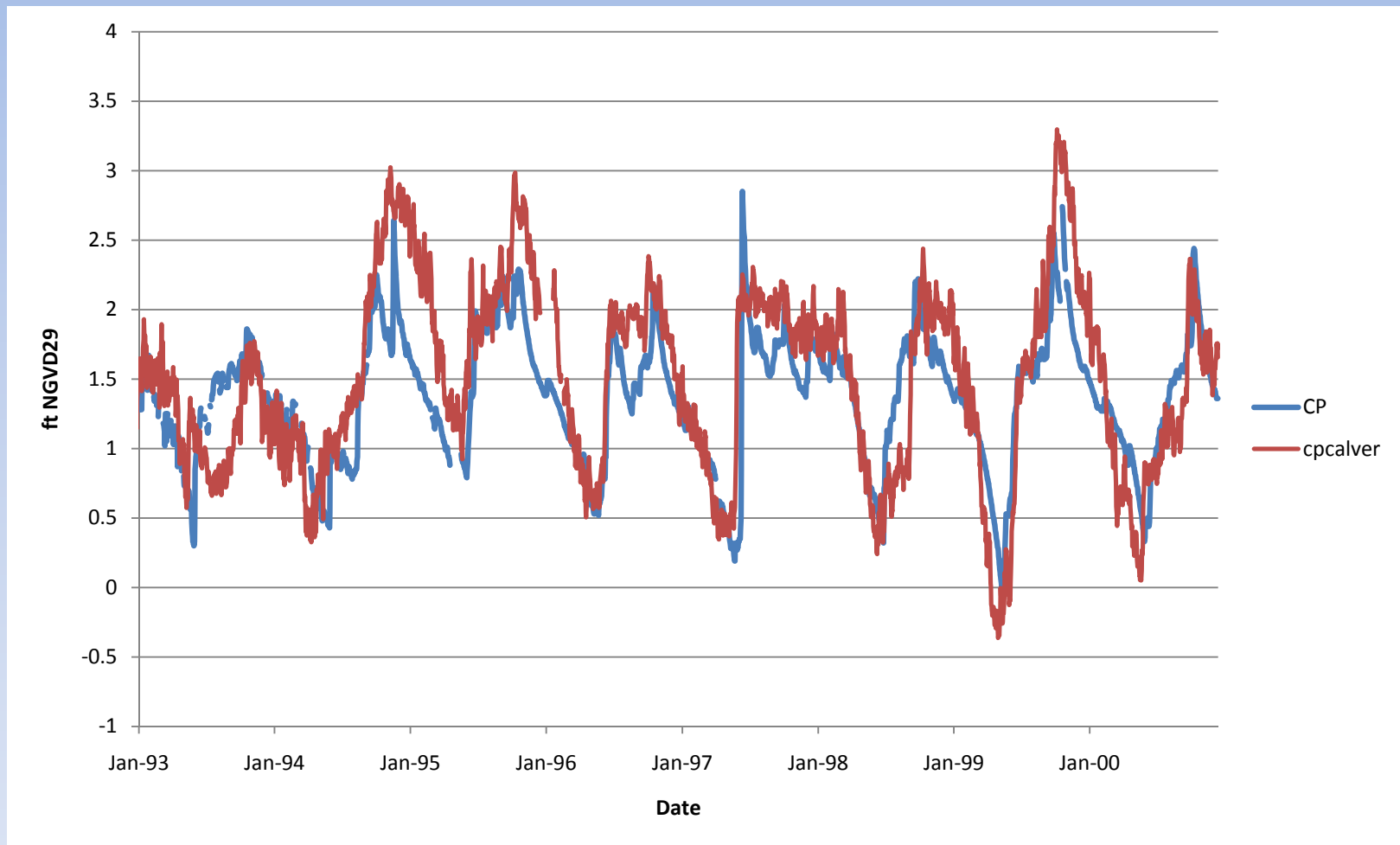
Paleoecology Characterization

- Mollusks from core are identified and counted
- Salinity of fauna based on modern analogue data
- CONFIDENT Estimate: 36 taxa, ten or more observations, 95% CI of less than 5
- FULL Estimate: 36 taxa from CONFID + additional 35 taxa with any associated salinity data.

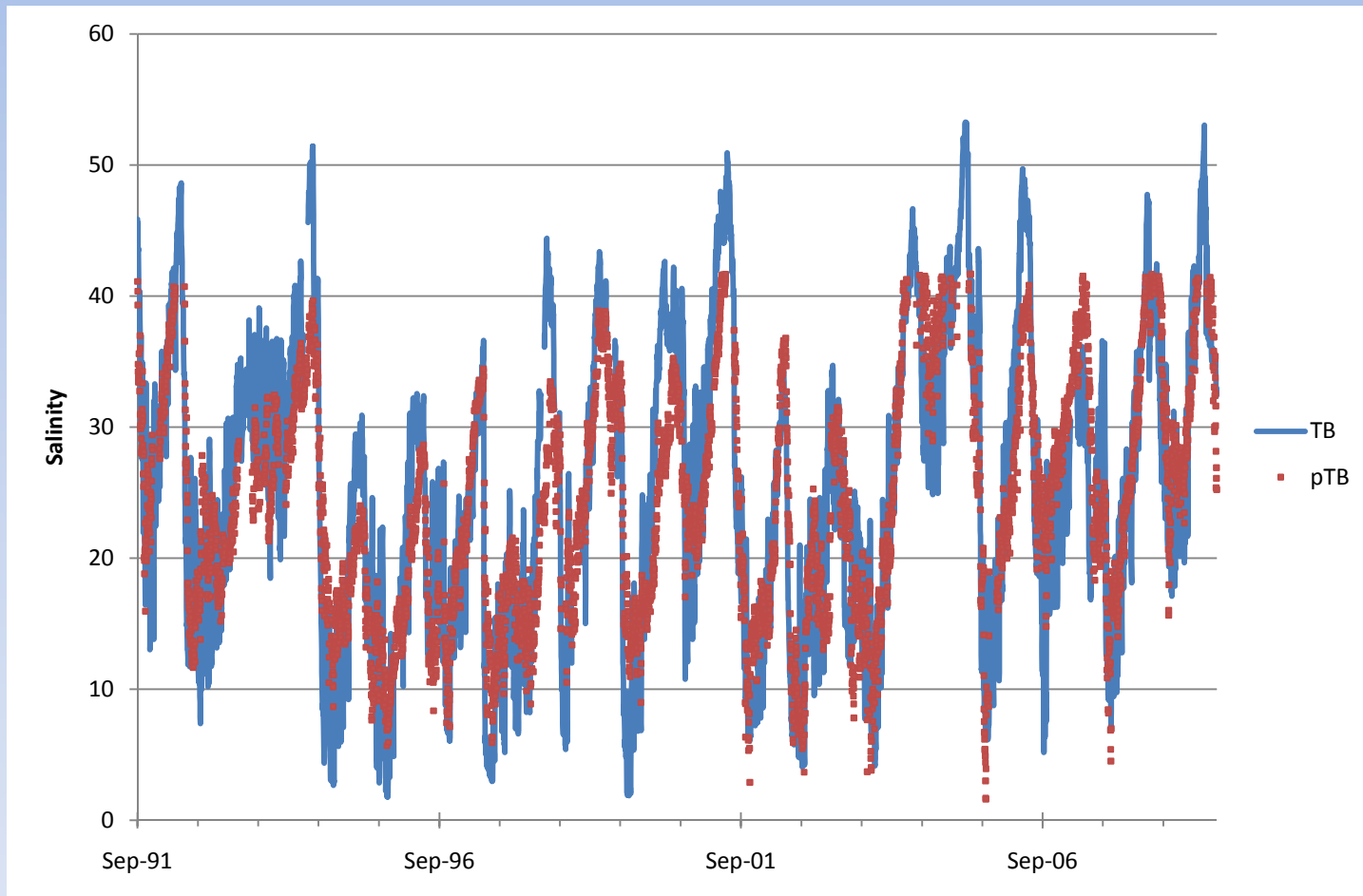
System of Hydrology/Salinity Regression Models

- Includes models for salinity, stage, and flow
- Trend in data (sea level rise, other effects) included where significant
- Flow models now include power terms
- Updates for synthesis produced a more robust system of hydrology/salinity models

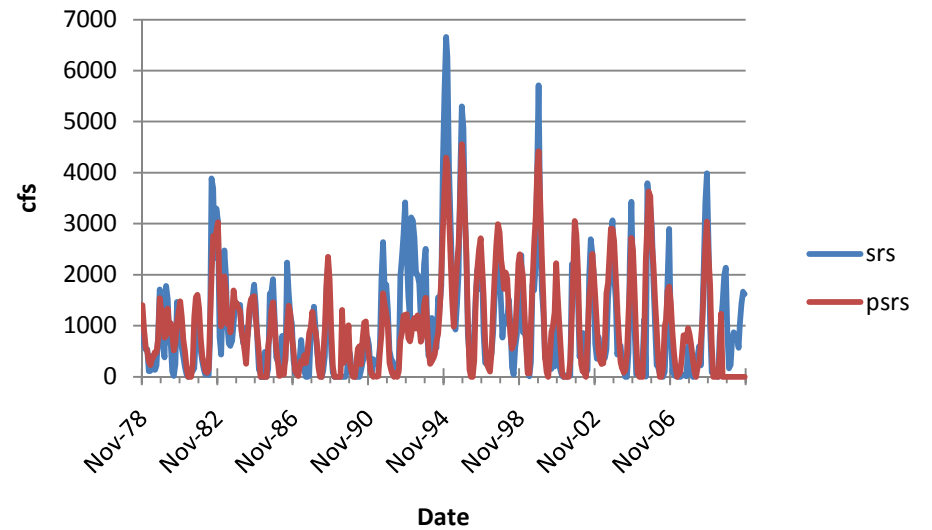
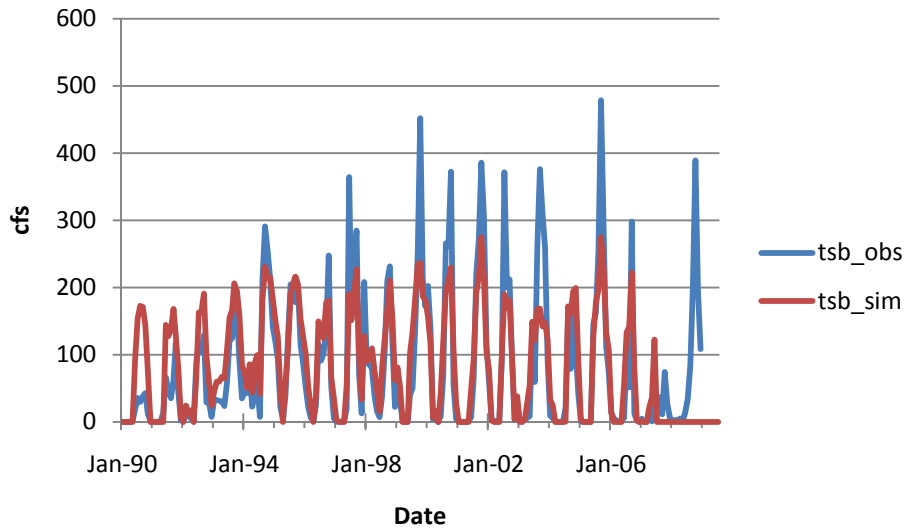
Cal/Ver Plots – Updated Stage Models



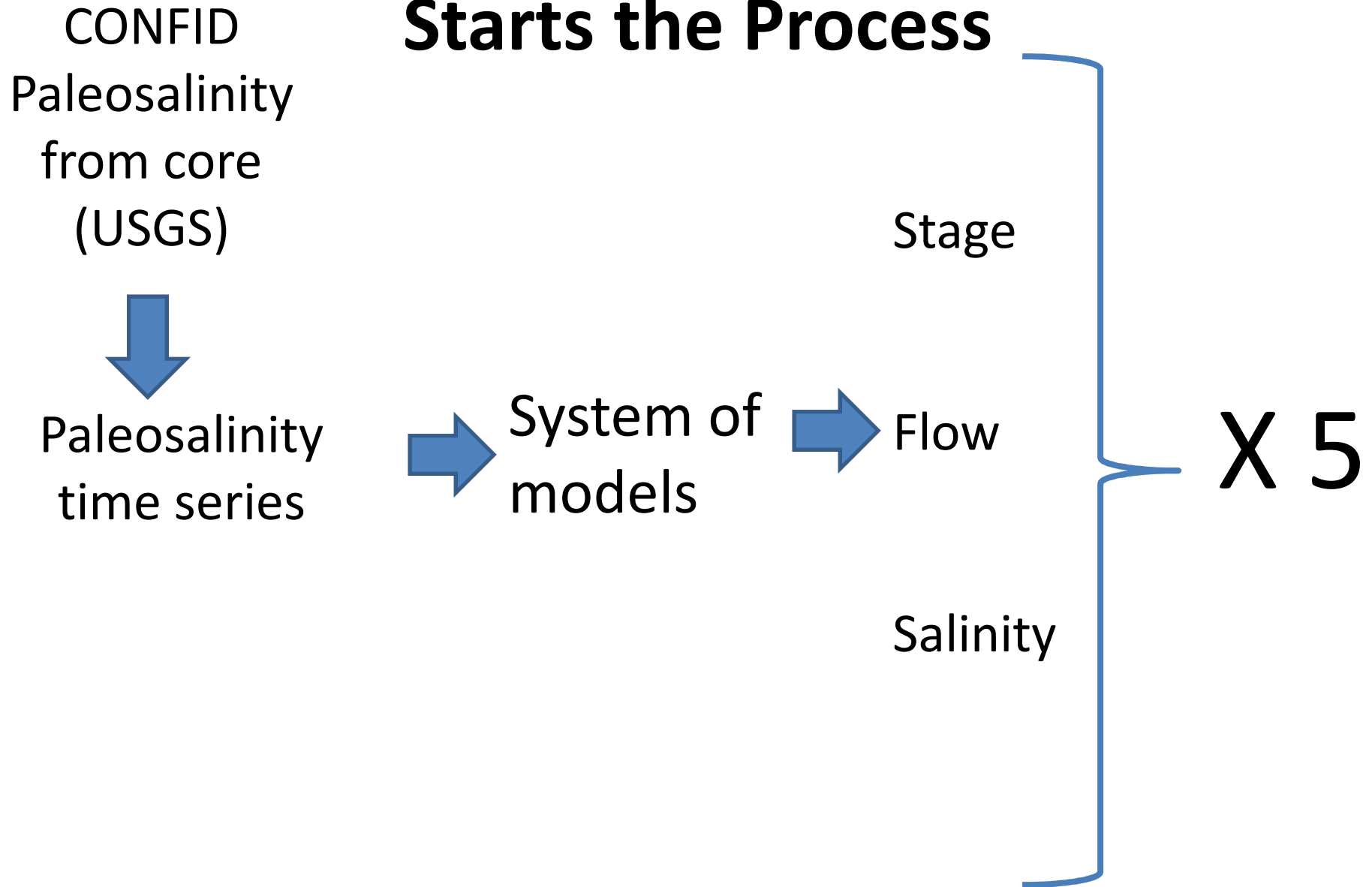
Cal/Ver Plots –Salinity Models



Cal / Ver Plots – Updated Flow Models



Sediment Core Paleosalinity Starts the Process



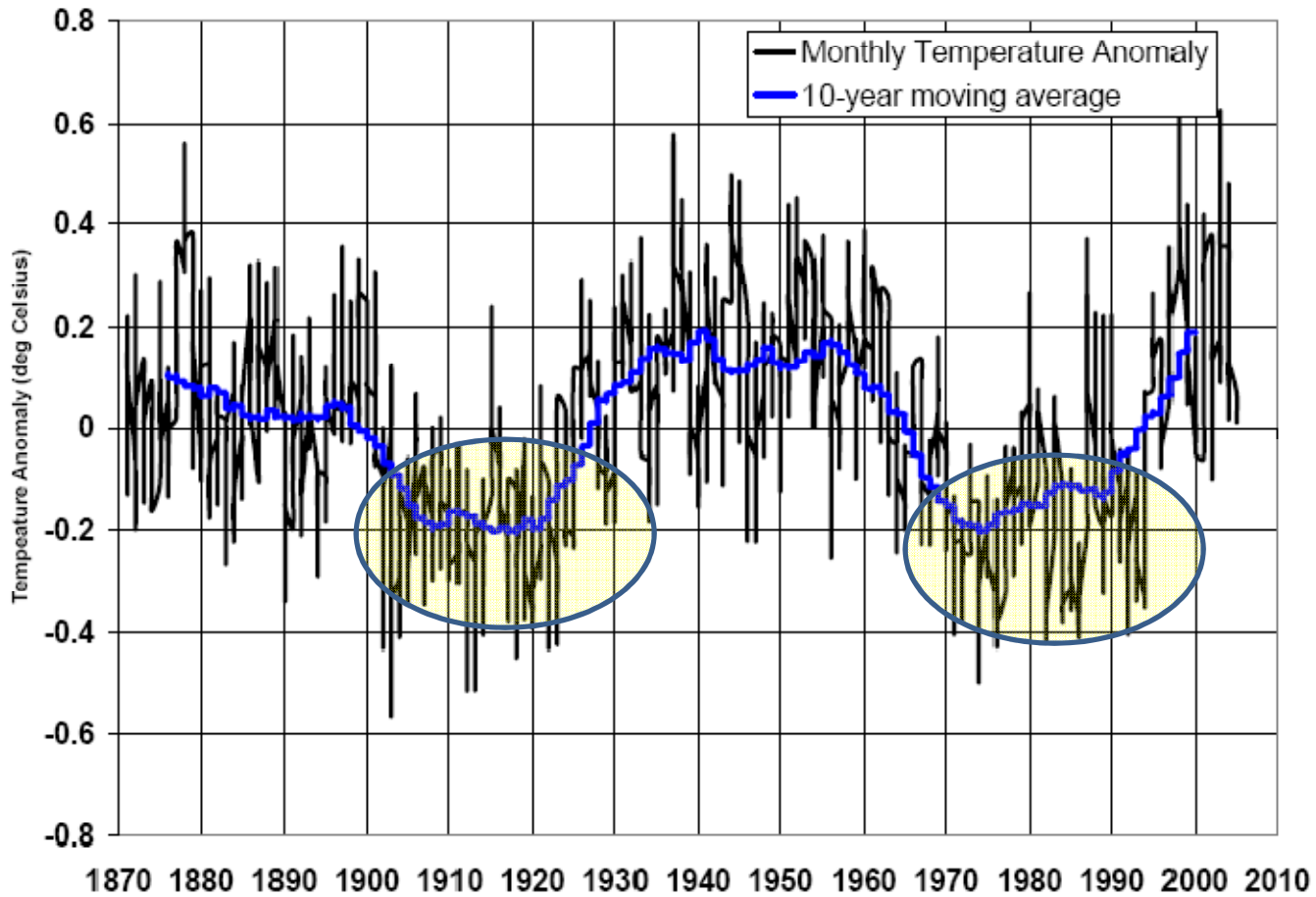
Start w/Salinity - Mean Salinity

Paleo = circa 1900 = Pre-drainage

Core	Time Step	Observed	Hydrology model- based salinity	Paleo FULL	Paleo CONFID
Whipray Basin	Daily	36.4	31.9	30.6	29.5
Rankine Lake	Daily	35.2	30.4	28.3	28.3
Taylor T24	Daily	24.2	17.7	16.5	8.5
Russell Bank	Monthly	33.5	28.1	28.5*	26.4*
Crocodile Point	Monthly	33.2	27.6	28.8	26.5

* distance adjusted

Why Circa-1900 Salinity?



North Atlantic Sea Surface
Temperature

Obeysekera et al, 2006

Products For Each of the 5 Analyses

- Paleo-based stage throughout freshwater marshes and mangrove zone (12 stations)
- Upstream paleo-based flow (Shark River, Taylor River)
- Downstream paleo-based creek discharges (5 creeks)
- Paleo-based salinity throughout Florida Bay (17 stations)

Synthesis of Output

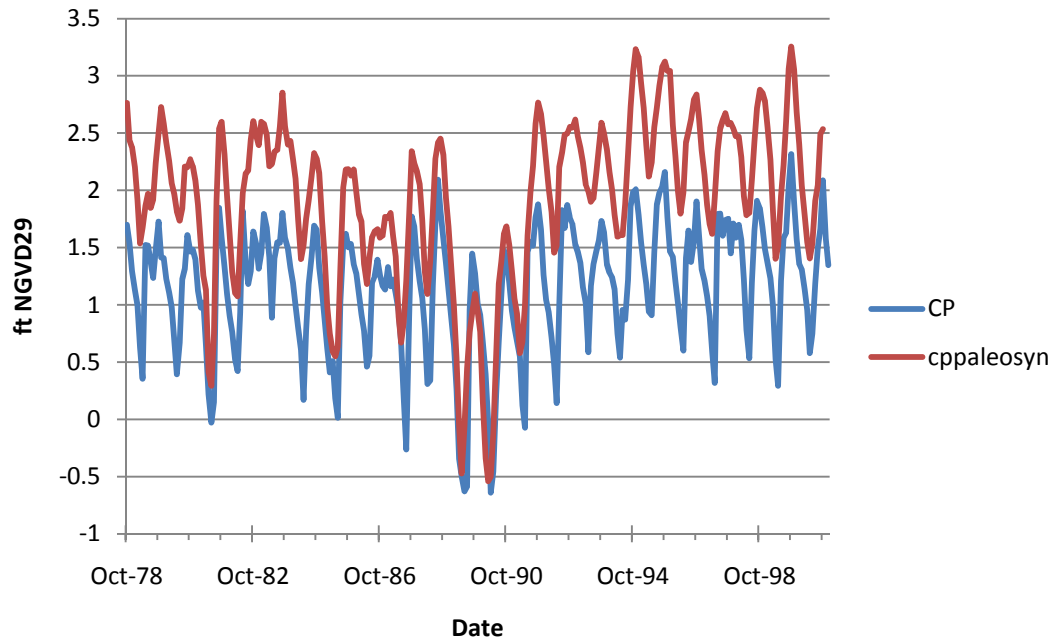
- Output of all 5 analyses combined
- Optimal Linear Combiner methodology
- Output from each model weighted by Mean Squared Error (MSE) from cal/ver run
- Then they are combined (summed)
- Synthesized output: single time series for all parameters using information from all 5 analyses

CP Stage MSE Optimal Linear Combiner Procedure

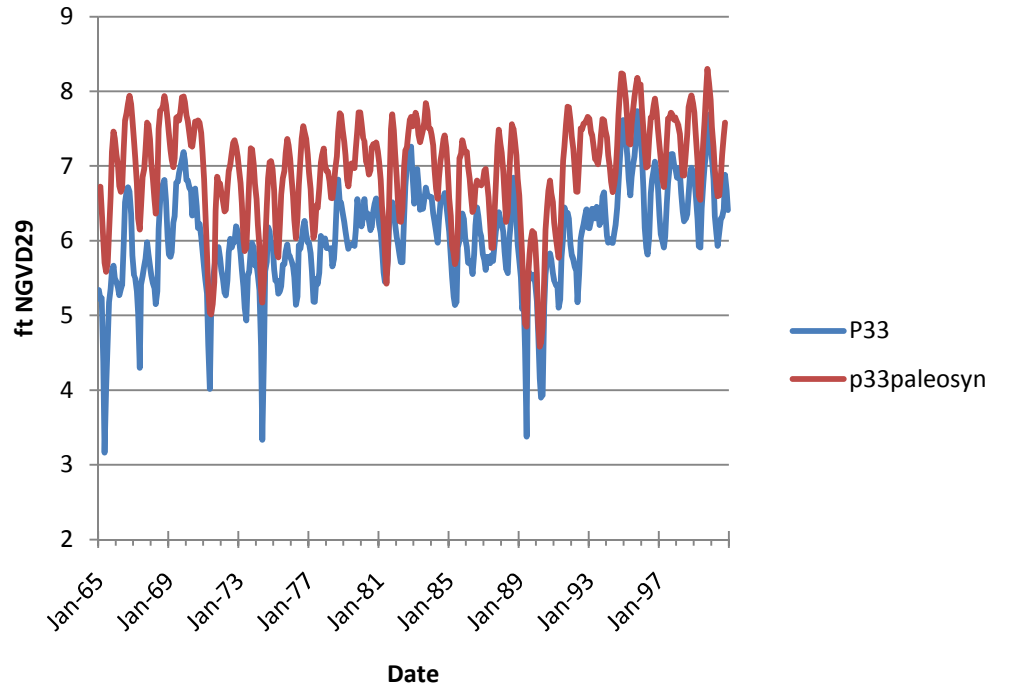
Core Label	CP MSE	CPMSEtotal/CP MSE	(CPMSEtotal/CP MSE)/SUM(CPMSEtotal/CP MSE)	CONFID Cppaleo avg	CoLD * CoLE
Whipray Basin	0.12	24.53	0.31	2.07	0.64
Rankine Lake	0.07	38.96	0.49	1.85	0.90
Taylor T24	1.78	1.64	0.02	2.11	0.04
Russell Bank	0.29	10.13	0.13	1.93	0.25
Crocodile Point	0.66	4.42	0.06	1.47	0.08
	2.92	79.69			1.91

Synthesized CP = 1.91

Synthesized Paleo-based Stage

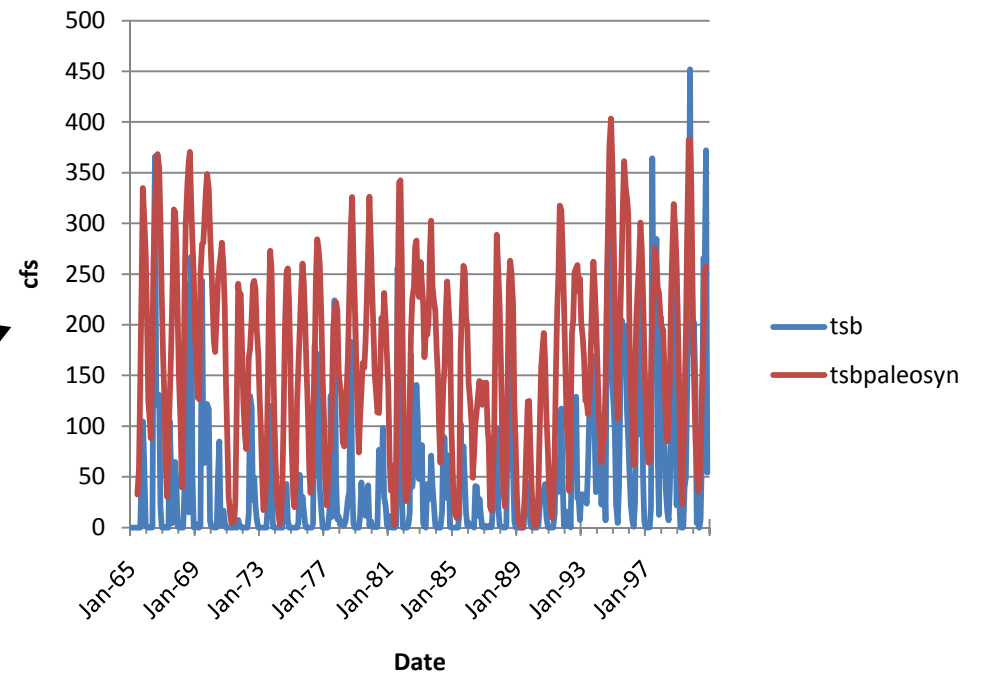
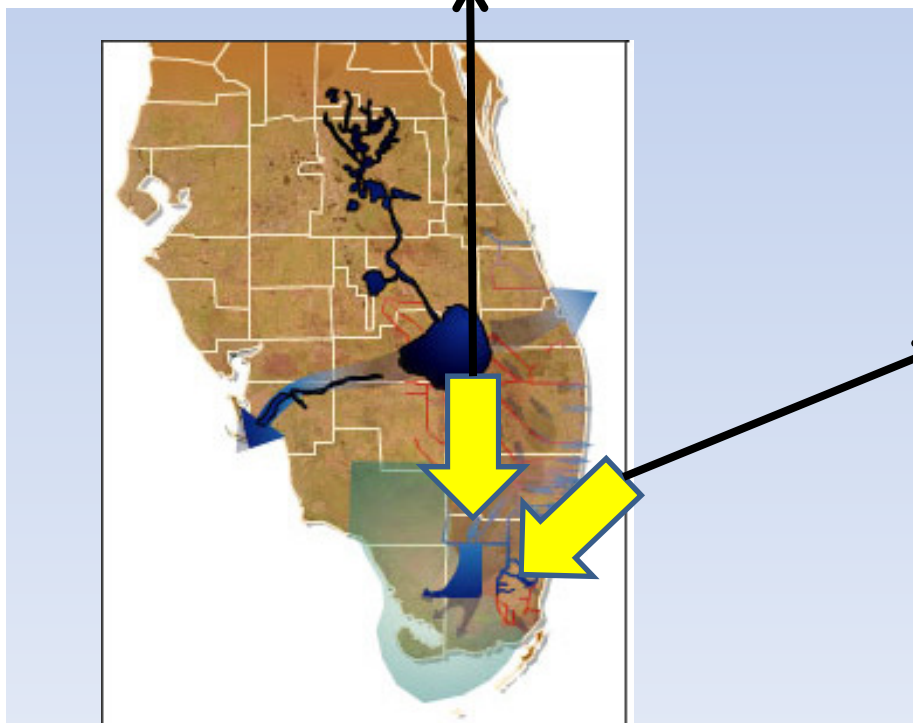
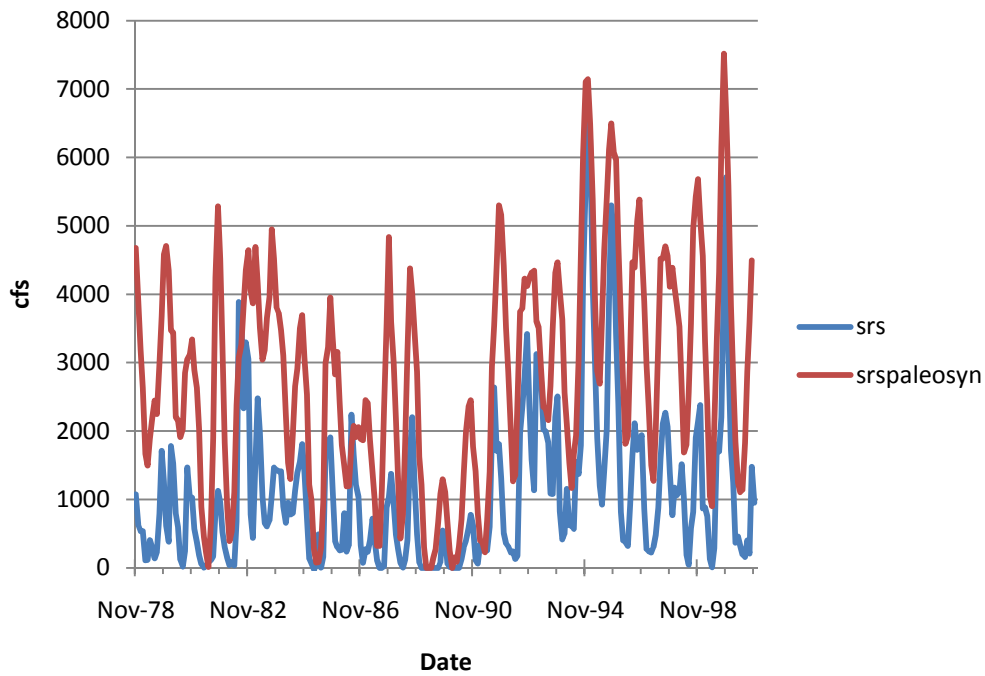


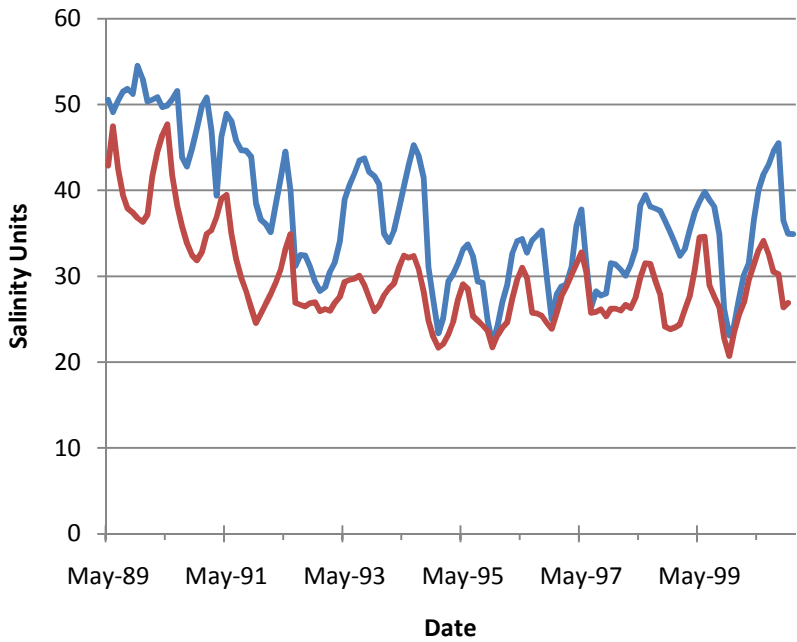
— CP
— cppaleosyn



— P33
— p33paleosyn

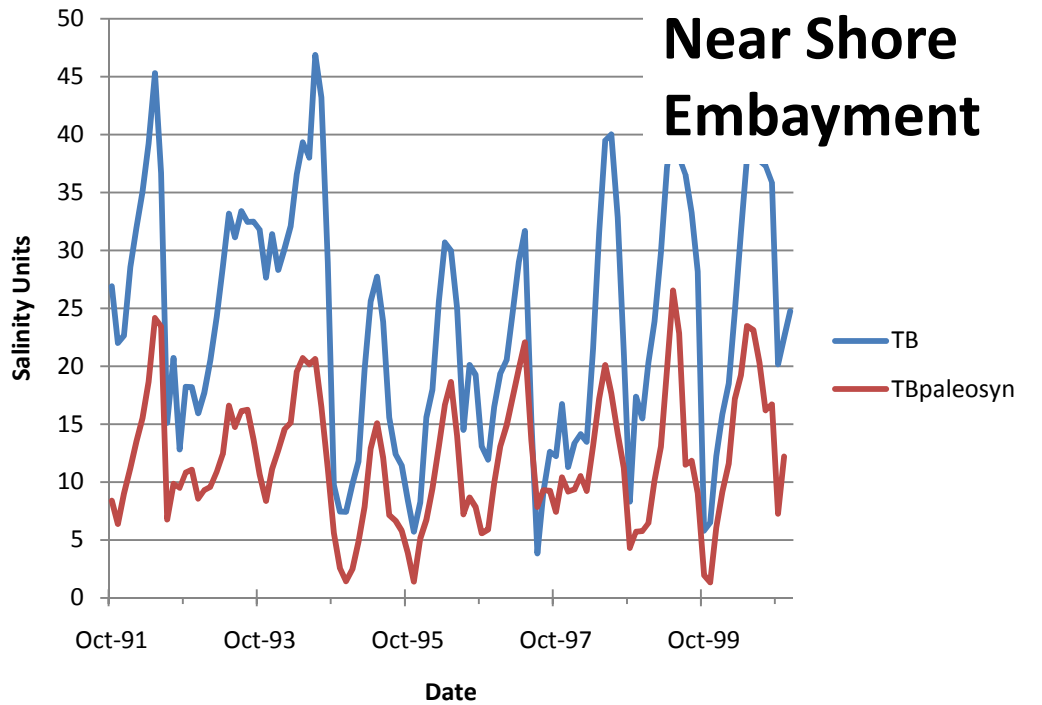
Synthesized Paleo-based Flow





Central Bay

Synthesized Paleo-based Salinity



Mean Synthesized Paleo-based Values vs Observed

Parameter	N	Obs Mean	Obs 95% CI	Paleo Syn Mean	Paleo Syn 95% CI
CP¹	265	1.2	1.1-1.3	1.9	1.8 - 2.0
P33¹	429	6	5.9-6.1	7	6.9 - 7.1
TSBstage¹	274	3.2	3.1-3.3	4.6	4.5 - 4.7
TSB²	425	47.7	41-56	167	158 - 176
SRS²	264	1090	947-1242	2814	2616 - 3012
WB³	139	37.2	35.9-38.5	29.7	28.8 - 30.6
TB³	110	23.7	21.7-25.7	11.9	10.9 - 13.0

¹ ft NGVD29

² cfs

³ salinity

Synthesized Paleo-based Salinity Regime in Terrapin Bay

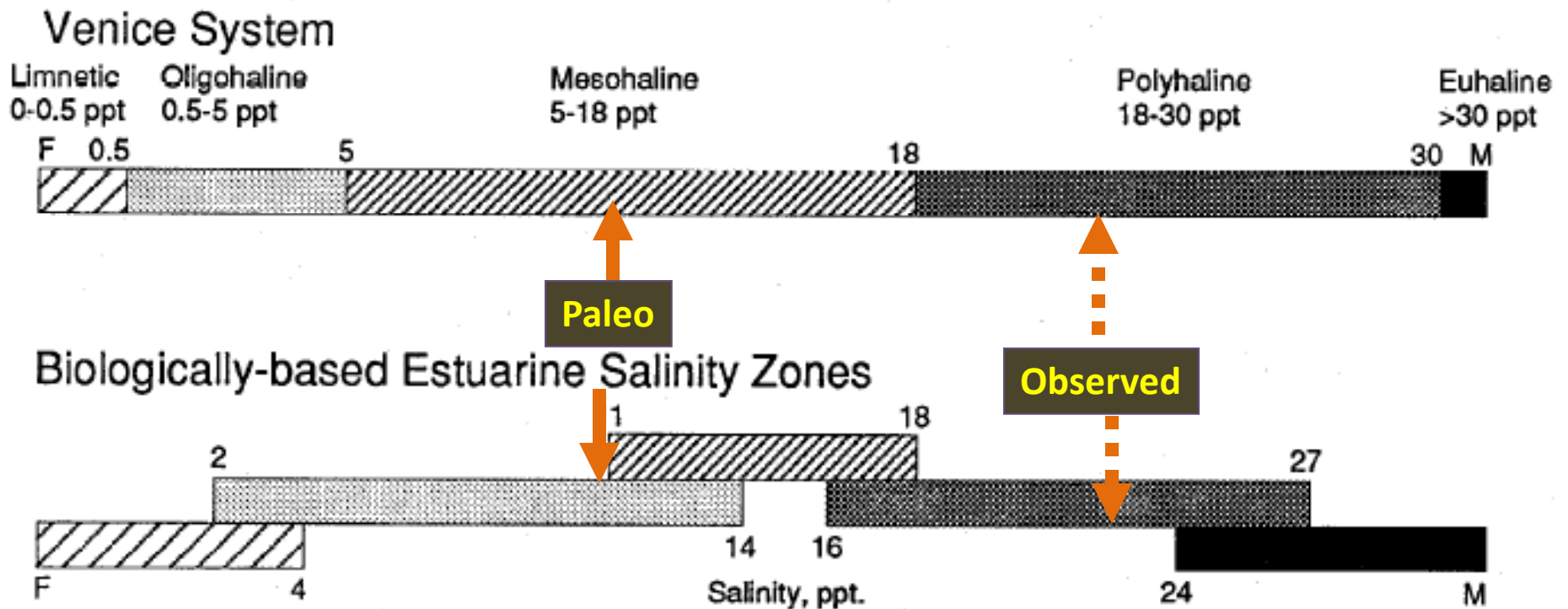


Fig. 1. Comparison of Venice System and estuarine salinity zones derived from multivariate analysis.

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

Reality Check

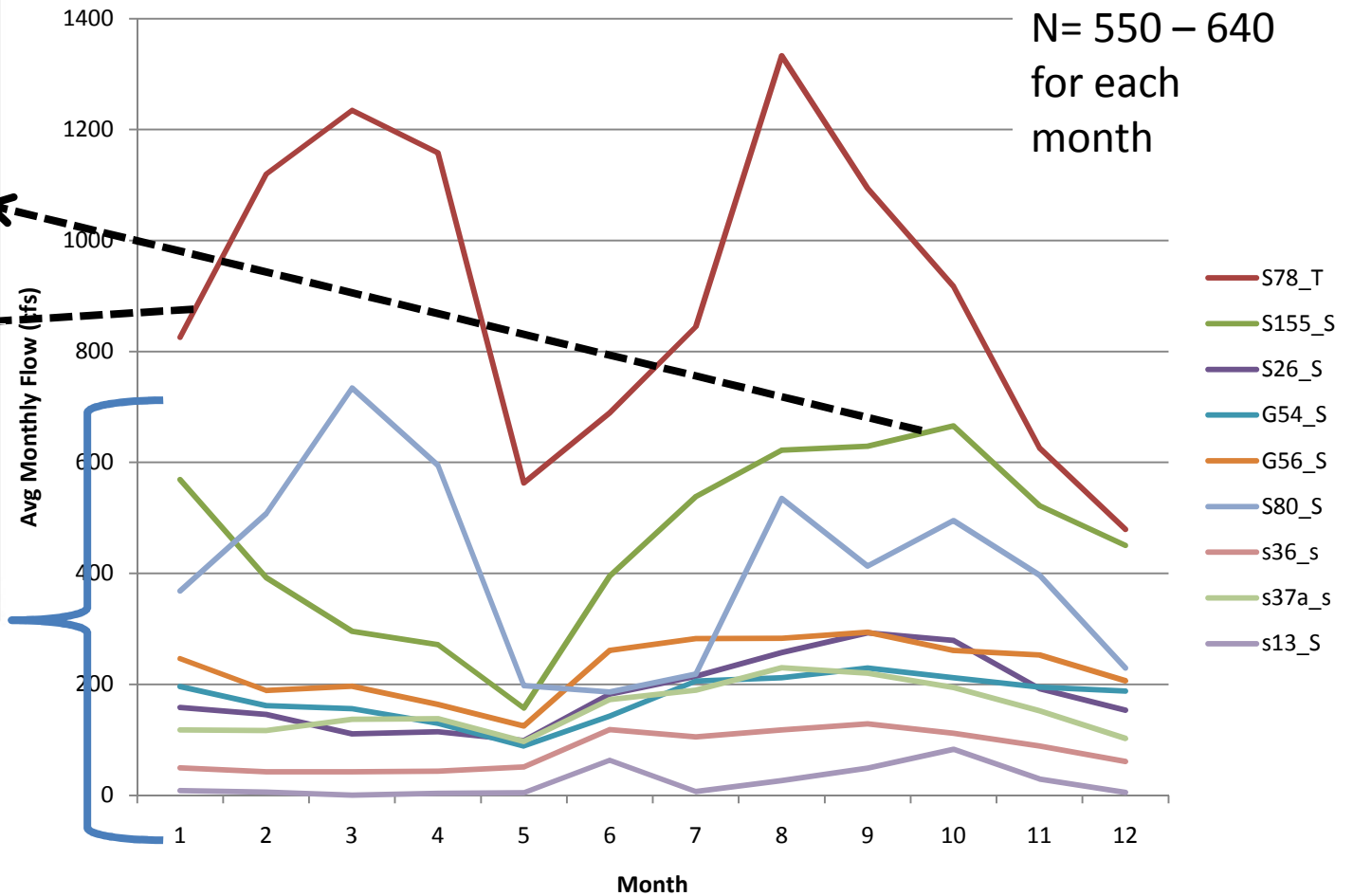
How do paleo-based river flow estimates compare to estimates of available water in the system?

POR Freshwater Discharges to Atlantic Ocean, Gulf of Mexico

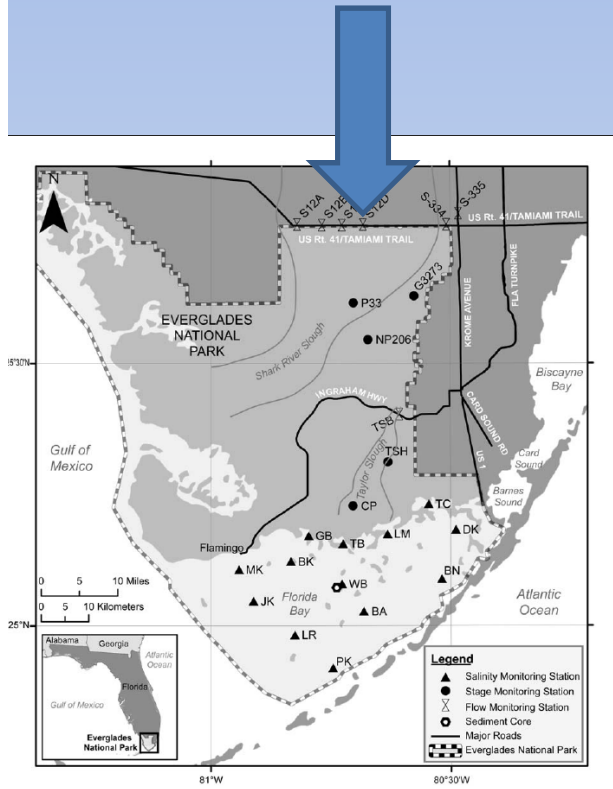


Current Flow

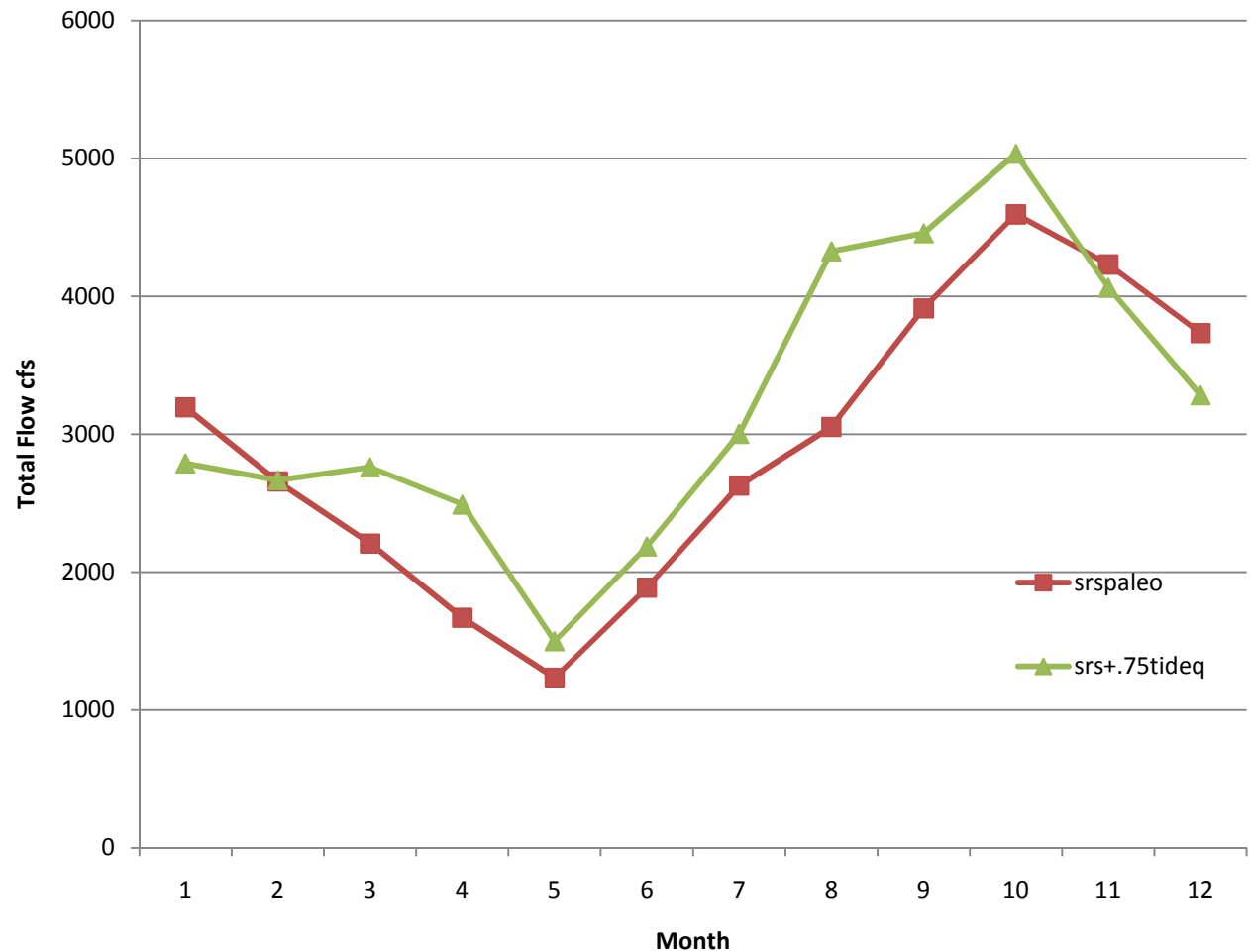
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Comparison of Synthesized Paleo-based SRS Flow and Existing SRS + Tide Discharge (75%)



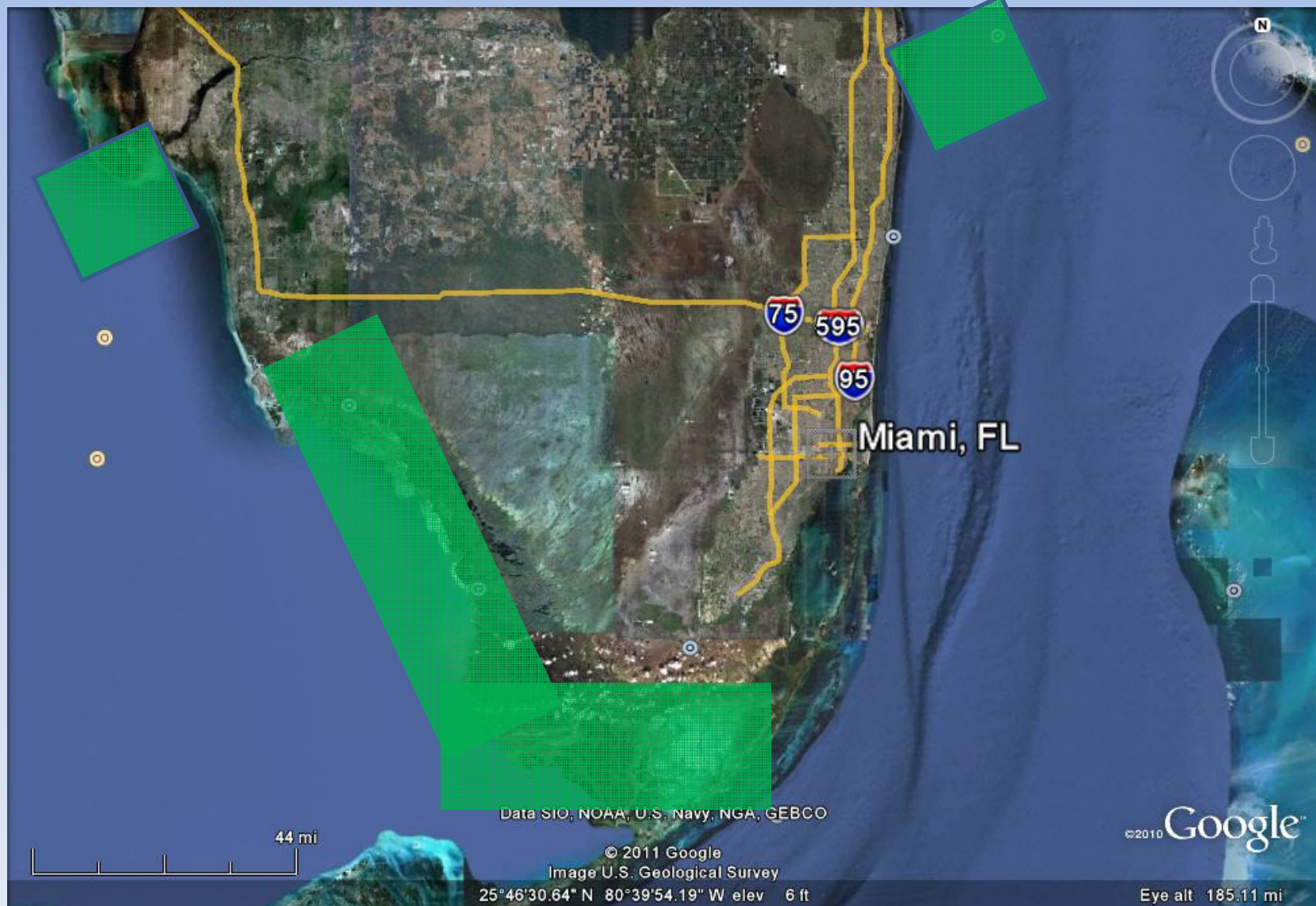
N= 550 – 640
for each
month



Reality Check Answer

- Paleo-based flow estimates agree favorably with available water
- Plenty of water discharged to tide to cover paleo-based needs
- Technical issues:
 - Storage
 - Treatment
 - Operations

Estuarine / Nearshore Coastal Shelf Benefits of Re-diversion to Park



Summary

- Coupling sediment faunal characterizations with regression models is a useful tool for linking paleosalinity data to upstream hydrology in the Everglades
- Consistent but slightly different results from all 5 paleo evaluations
- Optimal Linear Combiners allowed use of information from all cores in synthesis
- Upcoming work on west (Gulf) coast may validate or modify these findings

Summary

- Establishing pre-drainage salinity regime requires about 2.5 times more freshwater than current flow regime
- Volume of water discharged to tide is more than sufficient
- Restored result is a more estuarine Florida Bay - mesohaline to polyhaline as opposed to euryhaline current condition
- Restoring flow regime restores hydroperiod and pattern in freshwater marshes and mangroves

Greater Everglades Ecosystem Take-home Message

Restored Hydrology =

Restored Salinity =

Restored Ecosystem



Photo by A. Gelber via D. Deis



**THANK
YOU!**