Development of a Consensus Reconstruction of the Pre-drainage Everglades Hydrology and Florida Bay Salinity

GEER 2008

Frank Marshall

CLF

Lynn Wingard, USGS

Patrick Pitts, USFWS

Evelyn Gaiser, FIU

Ania Wachnicka, FIU

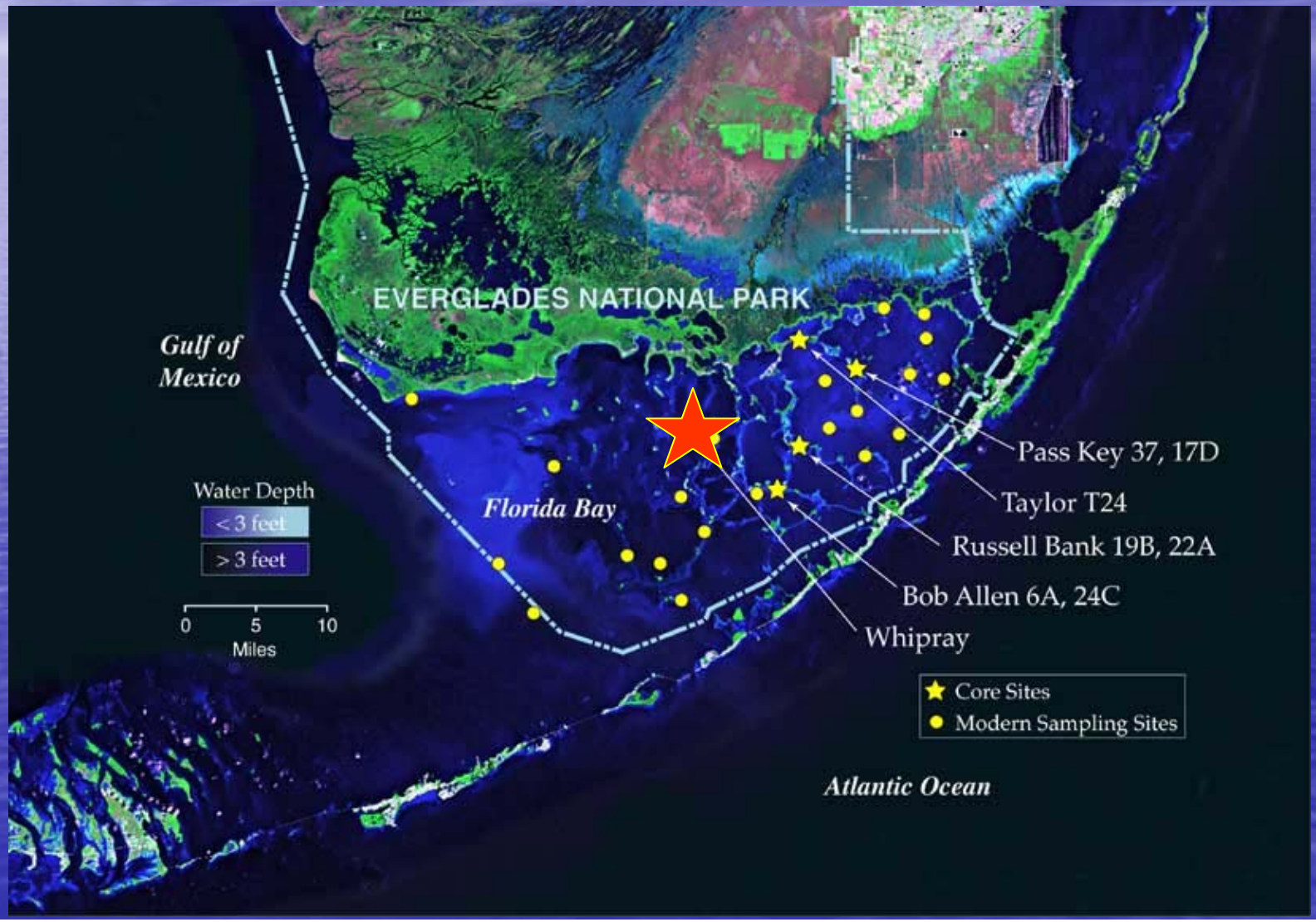
OBJECTIVES OF ON-GOING PALEOSALINITY PROJECTS

- Use paleoecological information from multiple sediment cores in Florida Bay coupled with statistical models to develop independent estimates of pre-drainage hydrology in the Everglades and salinity in the Bay

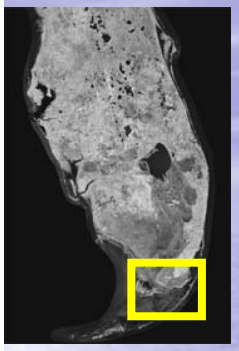
AVAILABLE DATA

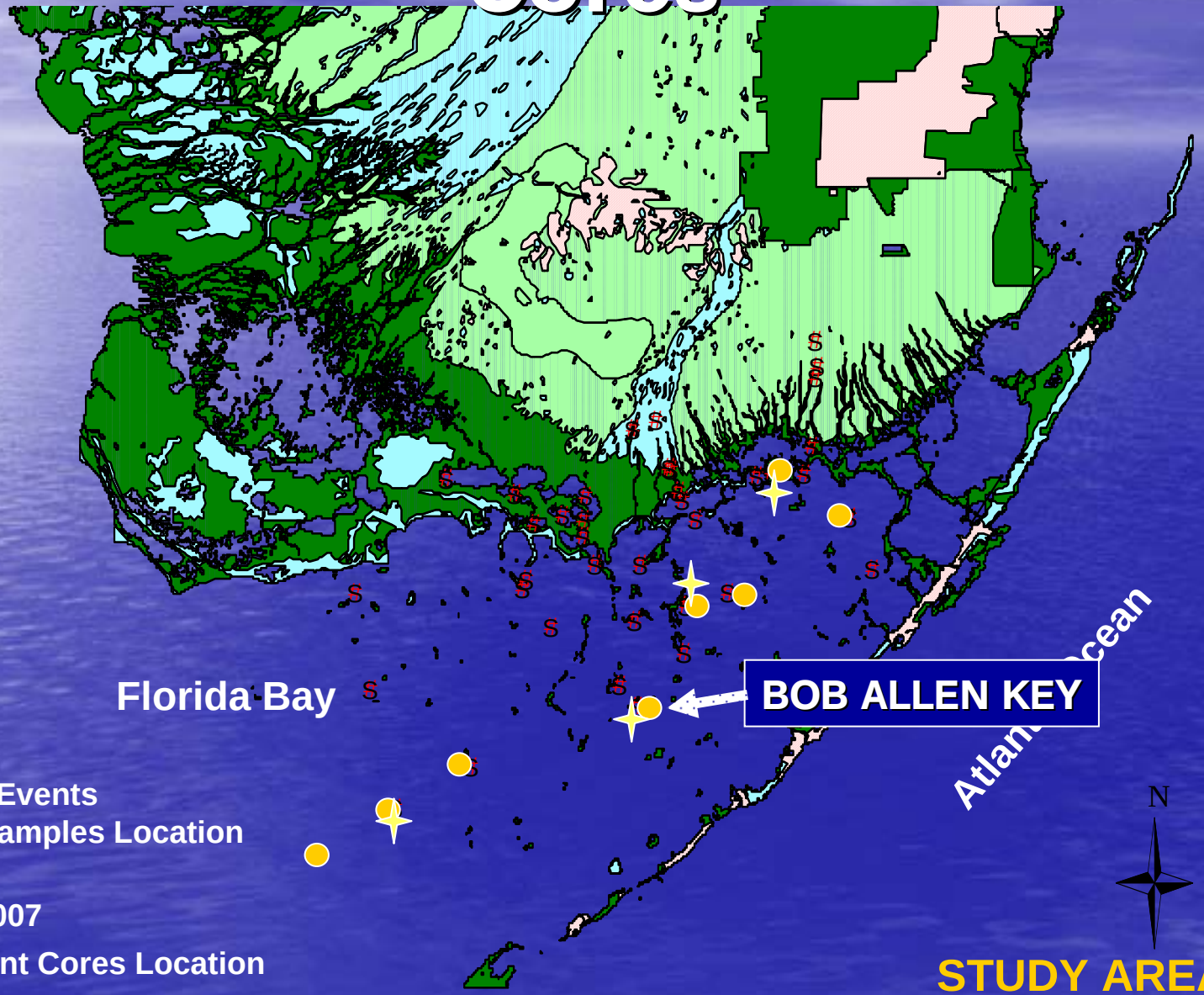
- Paleoecology
- Stage in Everglades
- Flow in Shark Slough and Taylor Slough
- Salinity in Florida Bay

Paleoecological Data: USGS Sediment Cores

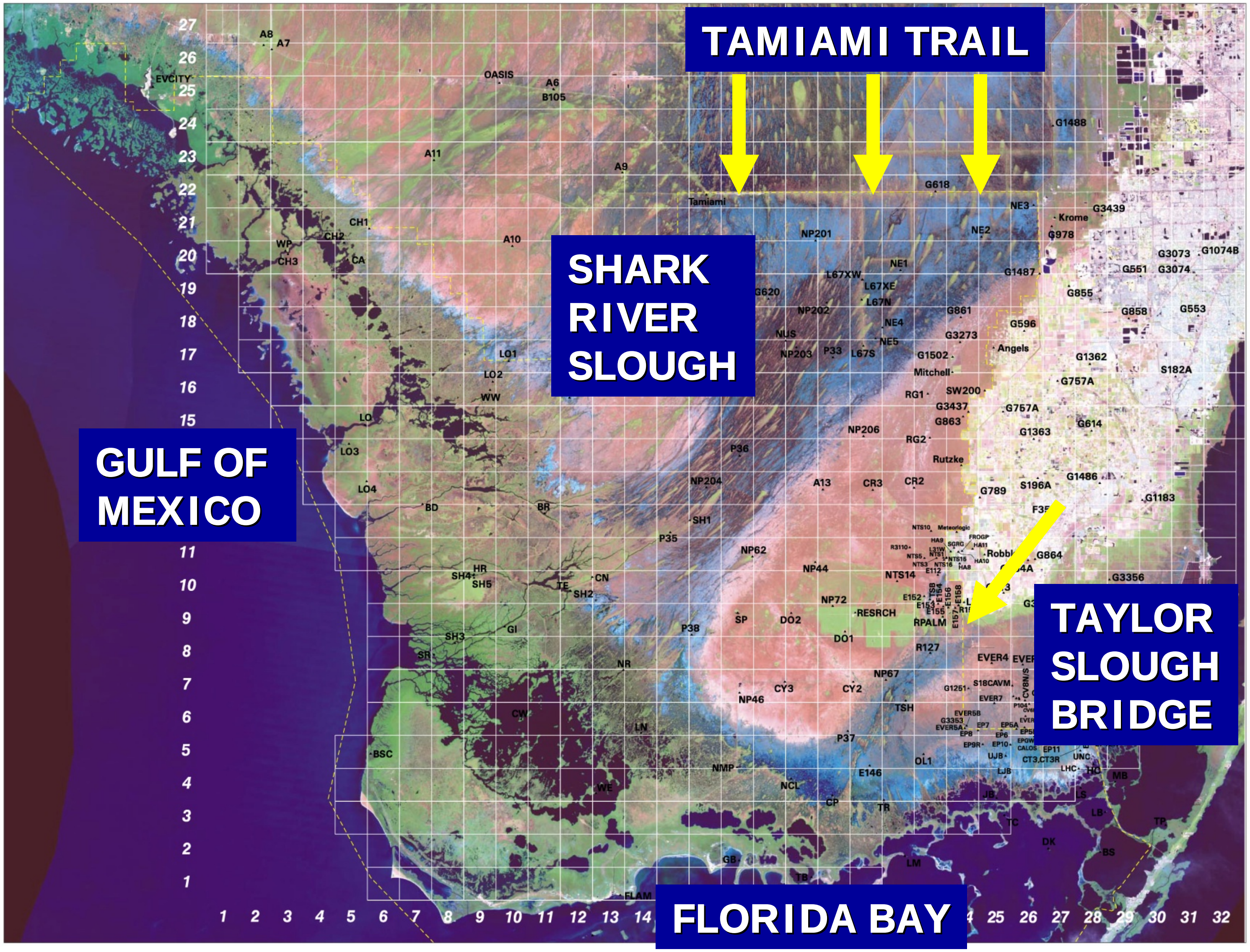


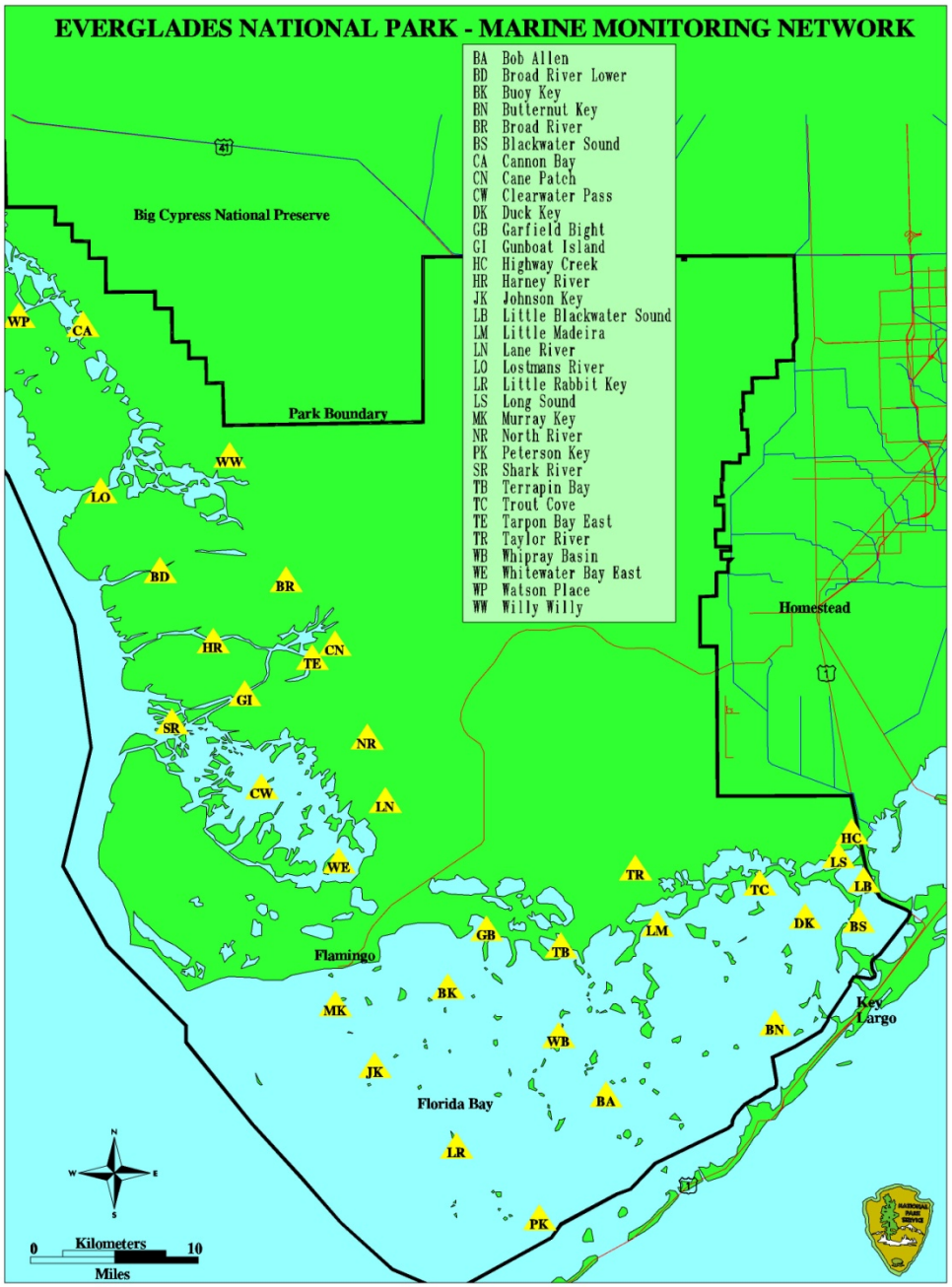
Paleoecological Data: FIU Sediment Cores





Available Data: Stage and Flow





Available Data: Salinity

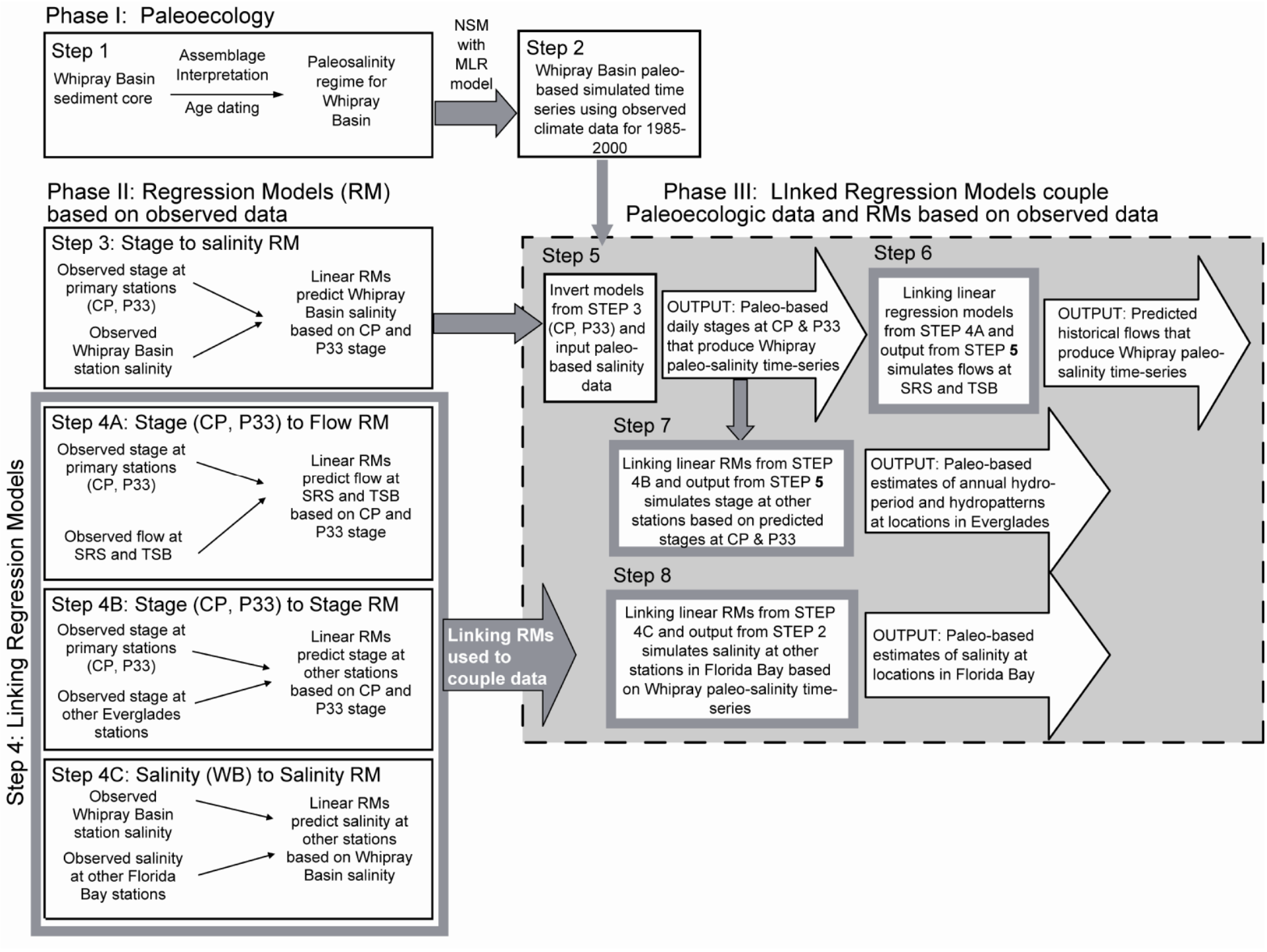
Everglades National Park Marine Monitoring Network Stations

NOTE: MLR Salinity models exist for all 31 stations

1ST STUDY – WHIPRAY BASIN PALEOSALINITY ANALYSIS WITH USGS & FWS

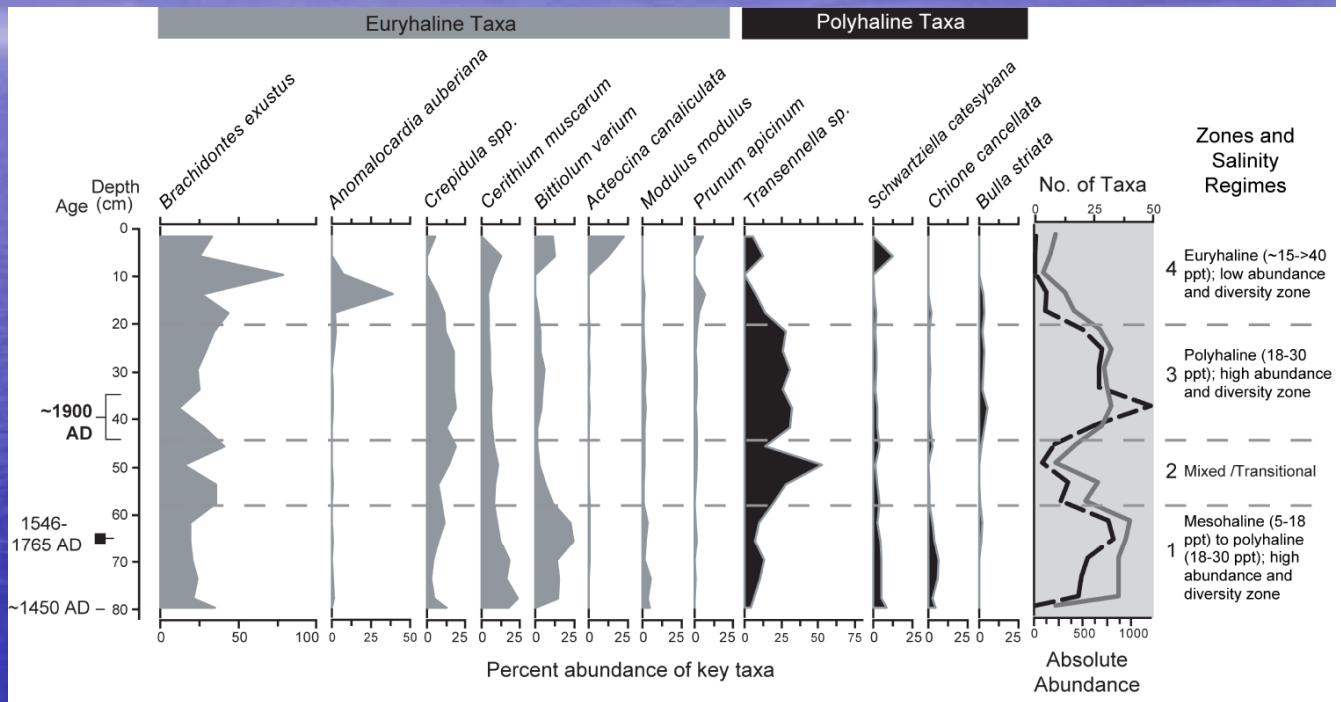
DEVELOPED METHODOLOGY:

- 3 PHASES
  - Develop paleosalinity regime
  - Develop regression models
  - Link paleo salinity regime and regression models to estimate pre-drainage stage, flow, and salinity
- 8 Steps

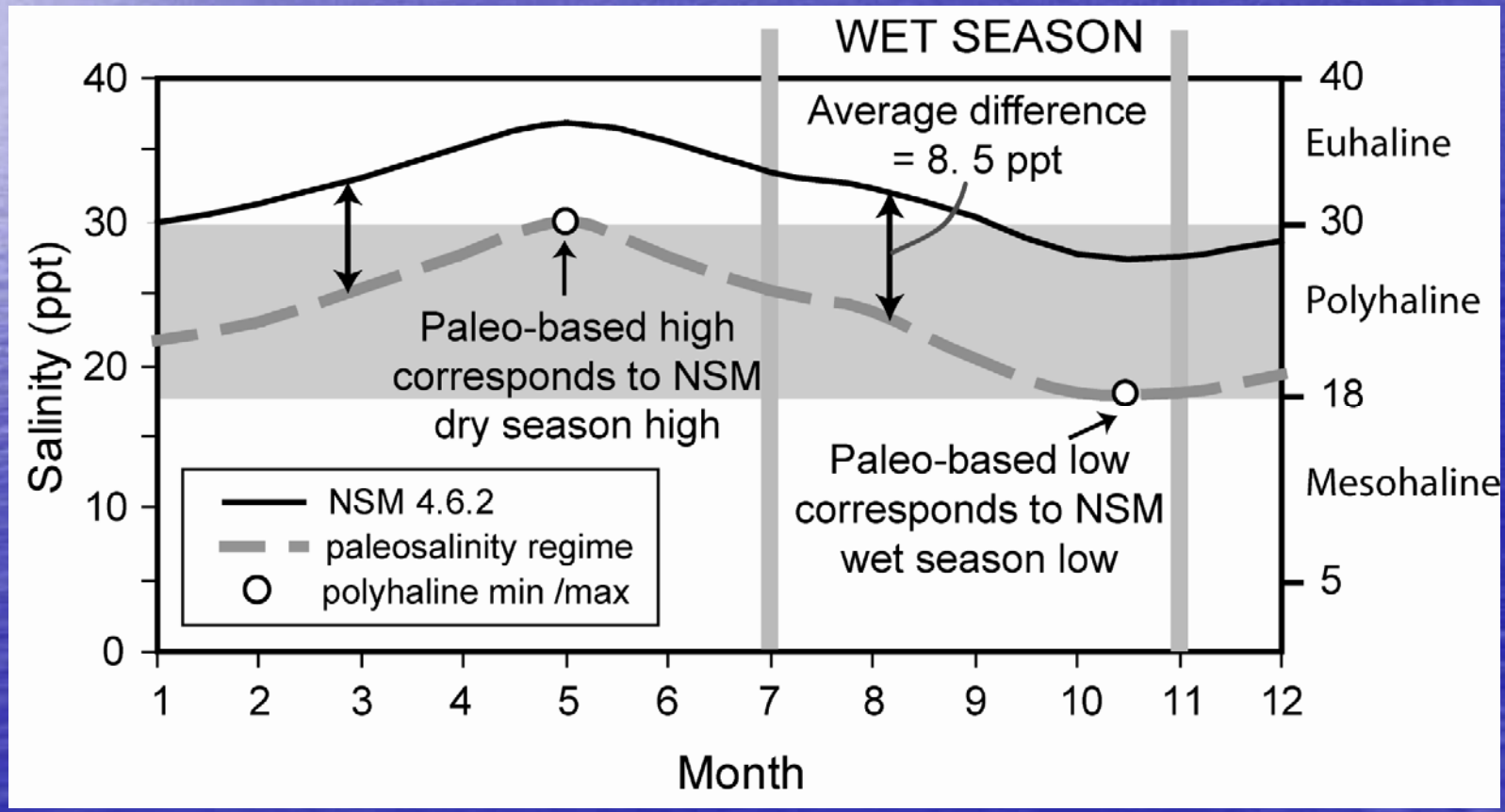

Phase I: Paleoecology
Step 1
Whipray Basin sediment core
Assemblage Interpretation
Age dating
Paleosalinity regime for Whipray Basin
NSM with MLR model
Step 2
Whipray Basin paleo-based simulated time series using observed climate data for 1985-2000
Phase II: Regression Models (RM) based on observed data
Step 3: Stage to salinity RM
Observed stage at primary stations (CP, P33)
Observed Whipray Basin station salinity
Linear RMs predict Whipray Basin salinity based on CP and P33 stage
Phase III: LInked Regression Models couple Paleoecologic data and RMs based on observed data
Step 5
Invert models from STEP 3 (CP, P33) and input paleo-based salinity data
OUTPUT: Paleo-based daily stages at CP & P33 that produce Whipray paleo-salinity time-series
Step 6
Linking linear regression models from STEP 4A and output from STEP 5 simulates flows at SRS and TSB
OUTPUT: Predicted historical flows that produce Whipray paleo-salinity time-series
Step 7
Linking linear RMs from STEP 4B and output from STEP 5 simulates stage at other stations based on predicted stages at CP & P33
OUTPUT: Paleo-based estimates of annual hydro-period and hydropatterns at locations in Everglades
Step 8
Linking linear RMs from STEP 4C and output from STEP 2 simulates salinity at other stations in Florida Bay based on Whipray paleo-salinity time-series
OUTPUT: Paleo-based estimates of salinity at locations in Florida Bay
Step 4: Linking Regression Models
Step 4A: Stage (CP, P33) to Flow RM
Observed stage at primary stations (CP, P33)
Observed flow at SRS and TSB
Linear RMs predict flow at SRS and TSB based on CP and P33 stage
Step 4B: Stage (CP, P33) to Stage RM
Observed stage at primary stations (CP, P33)
Observed stage at other Everglades stations
Linear RMs predict stage at other stations based on CP and P33 stage
Step 4C: Salinity (WB) to Salinity RM
Observed Whipray Basin station salinity
Observed salinity at other Florida Bay stations
Linear RMs predict salinity at other stations based on Whipray Basin salinity
Linking RMs used to couple data

Whipray Basin Paleoecological Information

WHIPRAY BASIN CORE, USGS ANALYSIS, BASED ON MOLLUSKS & FORAMS



Whipray Basin Paleosalinity Regime



LINKING REGRESSION MODELS – STAGE AND FLOW

Dependent Variable	Independent Variable	N	Coefficient	Intercept	Adj-R^2
Whipray Basin	P33	3368	-7.91	86.31	0.53
Whipray Basin	CP	3354	-6.75	43.82	0.33
TSB	CP	2707	14.25	-3.5	0.46
SRS	P33	3254	184.95	-325.69	0.58
G3273	P33	3788	1.36	-0.75	0.75
NP206	P33	8382	1.48	-1.19	0.61
TSH	CP	2260	0.93	0.26	0.71

LINKING REGRESSION MODELS – SALINITY

Dependent Variable	Independent Variable	N	Coeff.	Intercept	Adj-R^2
Bob Allen	Whipray Basin	1506	0.84	4.23	0.83
Buoy Key	Whipray Basin	1424	0.8	5.99	0.73
Butternut Key	Whipray Basin	3757	1	-5.01	0.73
Duck Key	Whipray Basin	3498	0.91	-3.9	0.71
Garfield Bight	Whipray Basin	1971	1.4	-18.1	0.61
Joe Bay	Whipray Basin	3697	1.1	-24.54	0.45
Johnson Key	Whipray Basin	1573	0.62	13.18	0.69
Little Madeira Bay	Whipray Basin	3879	1.13	-17.13	0.73
Little Rabbit	Whipray Basin	1596	0.54	16.46	0.68
Murray Key	Whipray Basin	1438	0.6	12.58	0.75
Peterson Key	Whipray Basin	3700	0.36	22.42	0.63
Terrapin Bay	Whipray Basin	3419	1.58	-30.1	0.72

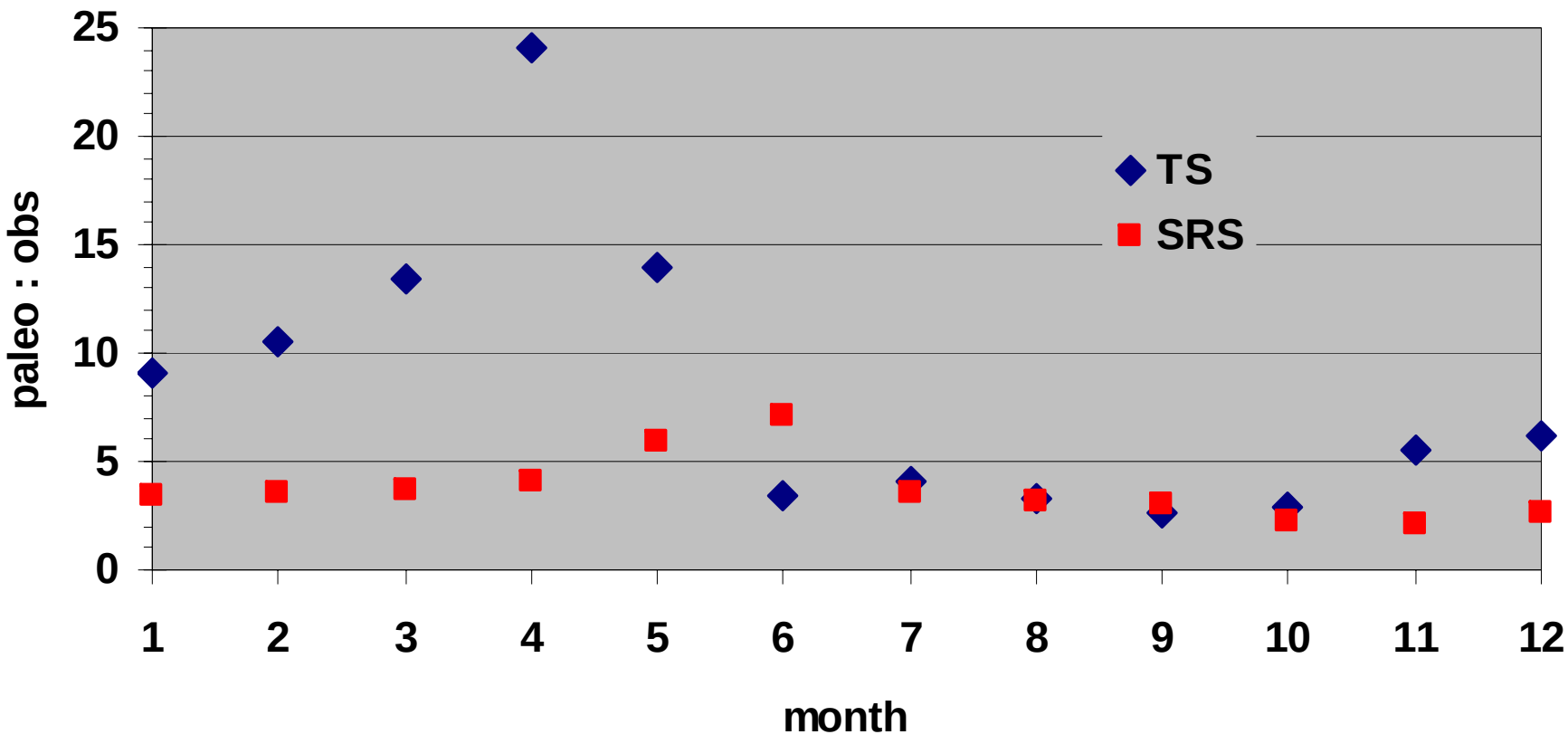
Mean Stage – Paleo-based vs Observed

Stage Station		N	mean	paleo:observed
P33	observed	4581	1.93	1.28
	paleo	3920	2.48	
CP	observed	4477	0.39	2.54
	paleo	3922	0.99	

Mean Flow – Paleo-based vs Observed

Flow Station		N	Mean flow	paleo: observed
SRS	observed	4052	42.4	2.73
	paleo	4036	115.8	
TSB	observed	3627	2.23	3.99
	paleo	4760	8.9	

Monthly Average Flow Comparison



DRY

WET

Paleo-based Salinity Regime in Florida Bay

Station	Observed Average	Paleo Average	Difference: Observed-Paleo
Bob Allen	33.20	21.10	12.10
Buoy Key	32.80	22.20	10.60
Butternut Key	31.30	17.70	13.60
Duck Key	29.00	16.80	12.20
Garfield Bight	28.90	10.30	18.60
Joe Bay	15.36	2.73	12.63
Johnson Key	35.30	27.00	8.30
Little Madeira Bay	23.83	8.20	15.63
Little Rabbit	34.40	27.30	7.10
Murray Key	33.00	24.80	8.20
Peterson Key	35.80	30.50	5.30
Terrapin Bay	23.60	3.50	20.10

Paleo-based Salinity Regime

PALEO-BASED

EXIST

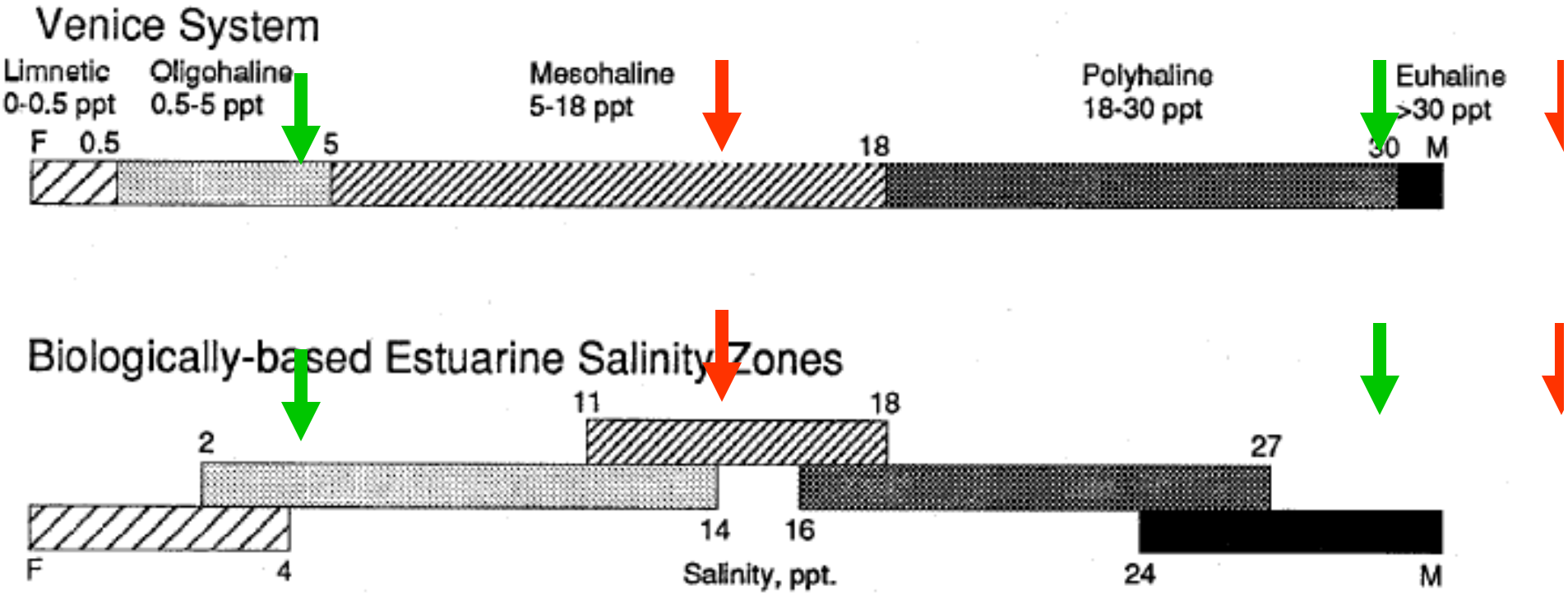
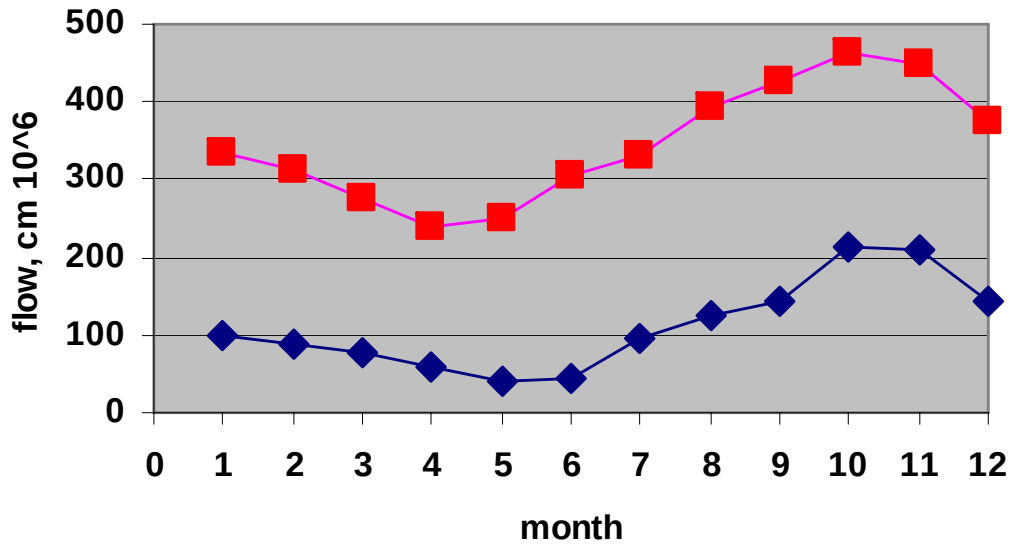


Fig. 1. Comparison of Venice System and estuarine salinity zones derived from multivariate analysis.

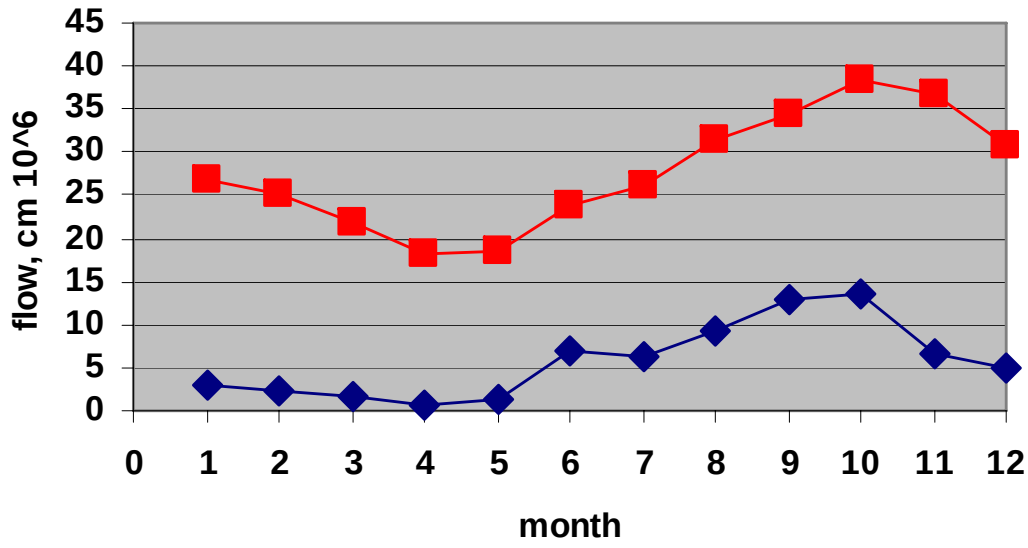
SOURCE: Bulger, Hayden, Monaco, Nelson, McCormack-Ray;
Estuaries Vol. 16, No. 2, p. 311-322 June 1993



Target: Shark River Slough Flow

DRY SEASON

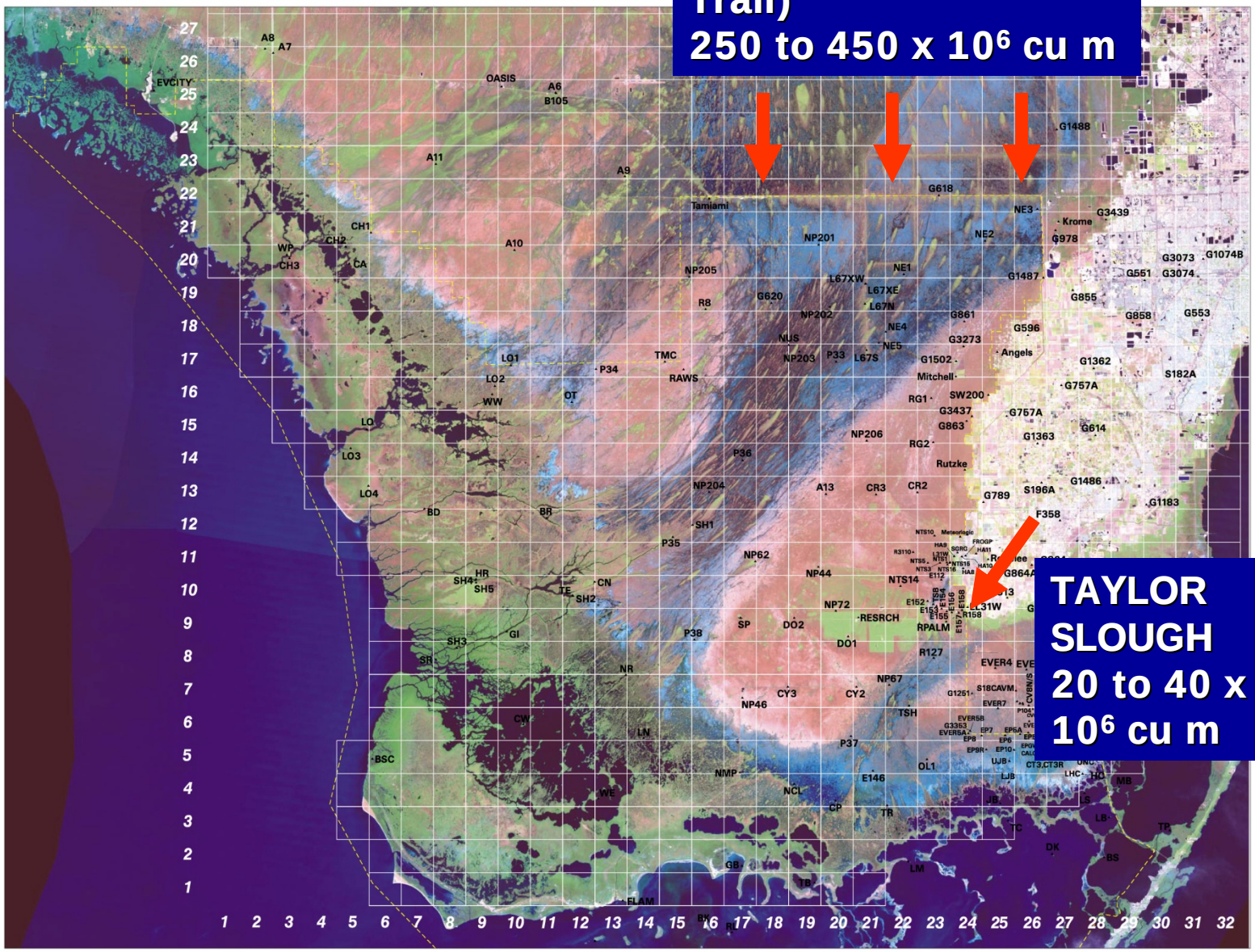
WET SEASON



Target: Taylor Slough Flow

Targets

SHARK RIVER SLOUGH (Tamiami Trail)
250 to 450 x 10^6 cu m



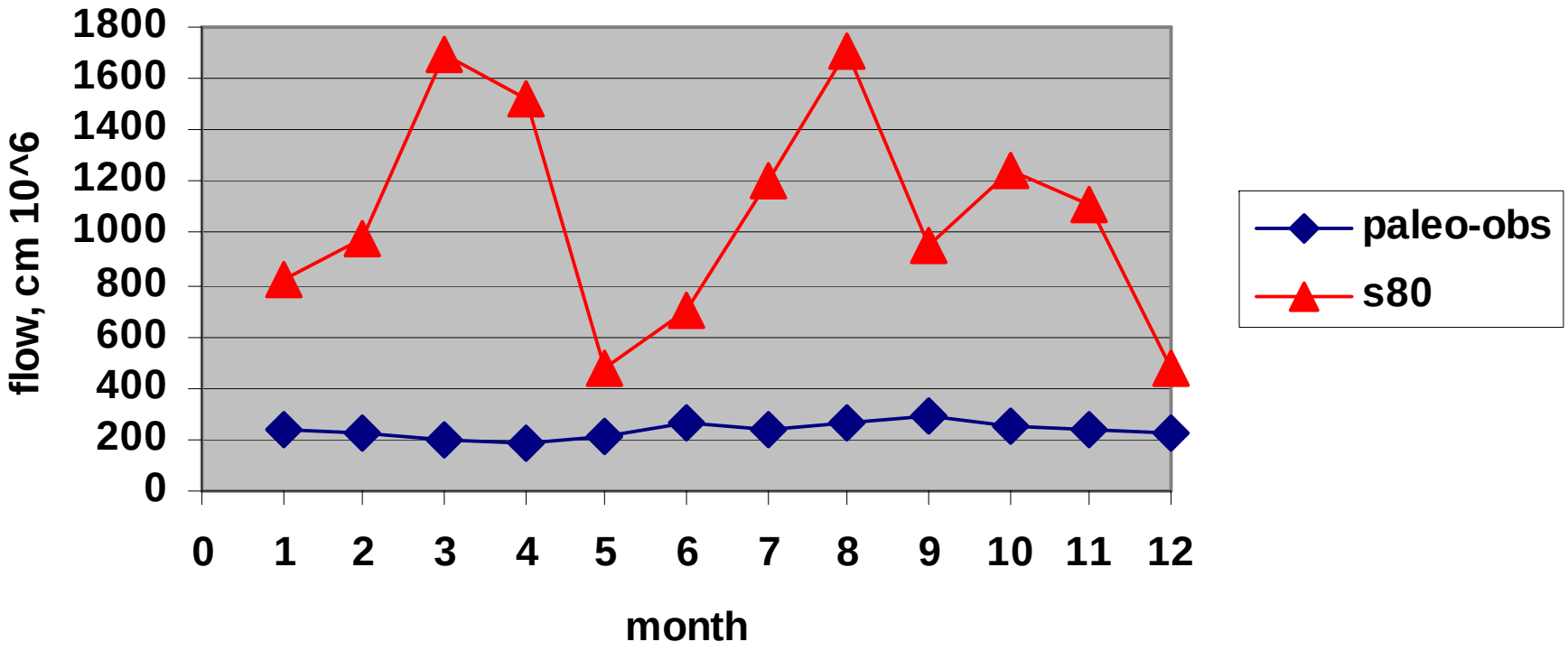
WHIPRAY BASIN PALEOSALINITY ANALYSIS SUMMARY

- A methodology was developed to link paleosalinity data to upstream hydrology in the Everglades.
- Pre-drainage salinity regime requires about 2-2.5 times more freshwater than the current flow regime.
- Florida Bay pre-drainage salinity was oligohaline to polyhaline

SUMMARY – CURRENT CONDITIONS COMPARED TO PALEO CONDITIONS

- Currently:
  - Taylor Slough flow deficit is >>> than the deficit in Shark River Slough during the dry season.
  - Average Everglades stage is about 0.5 m lower.
  - Florida Bay salinity is about 10 – 15 psu higher.

WHERE WILL THE WATER COME FROM?

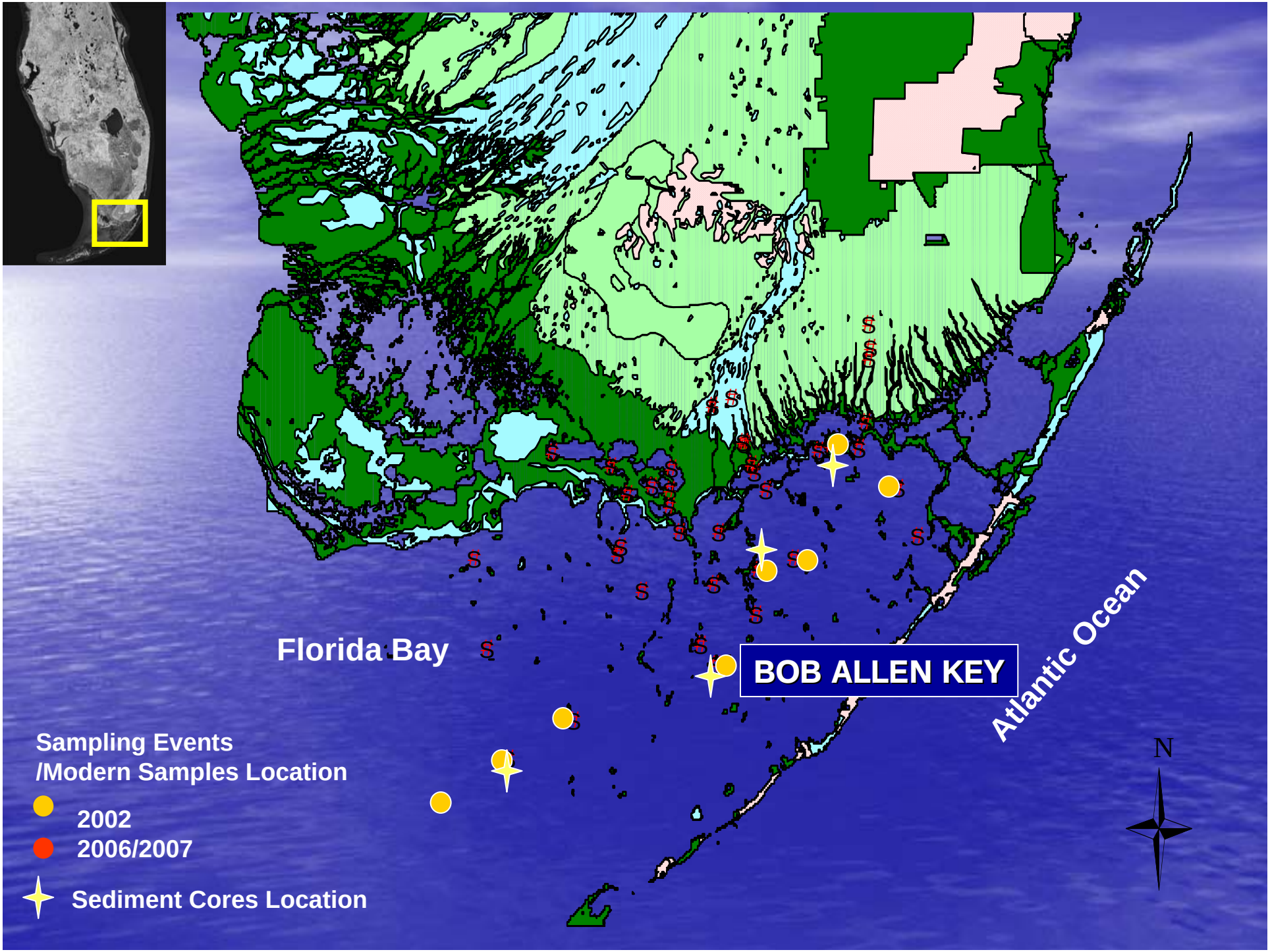


Deficit of SRS Flow vs S-80 Discharge

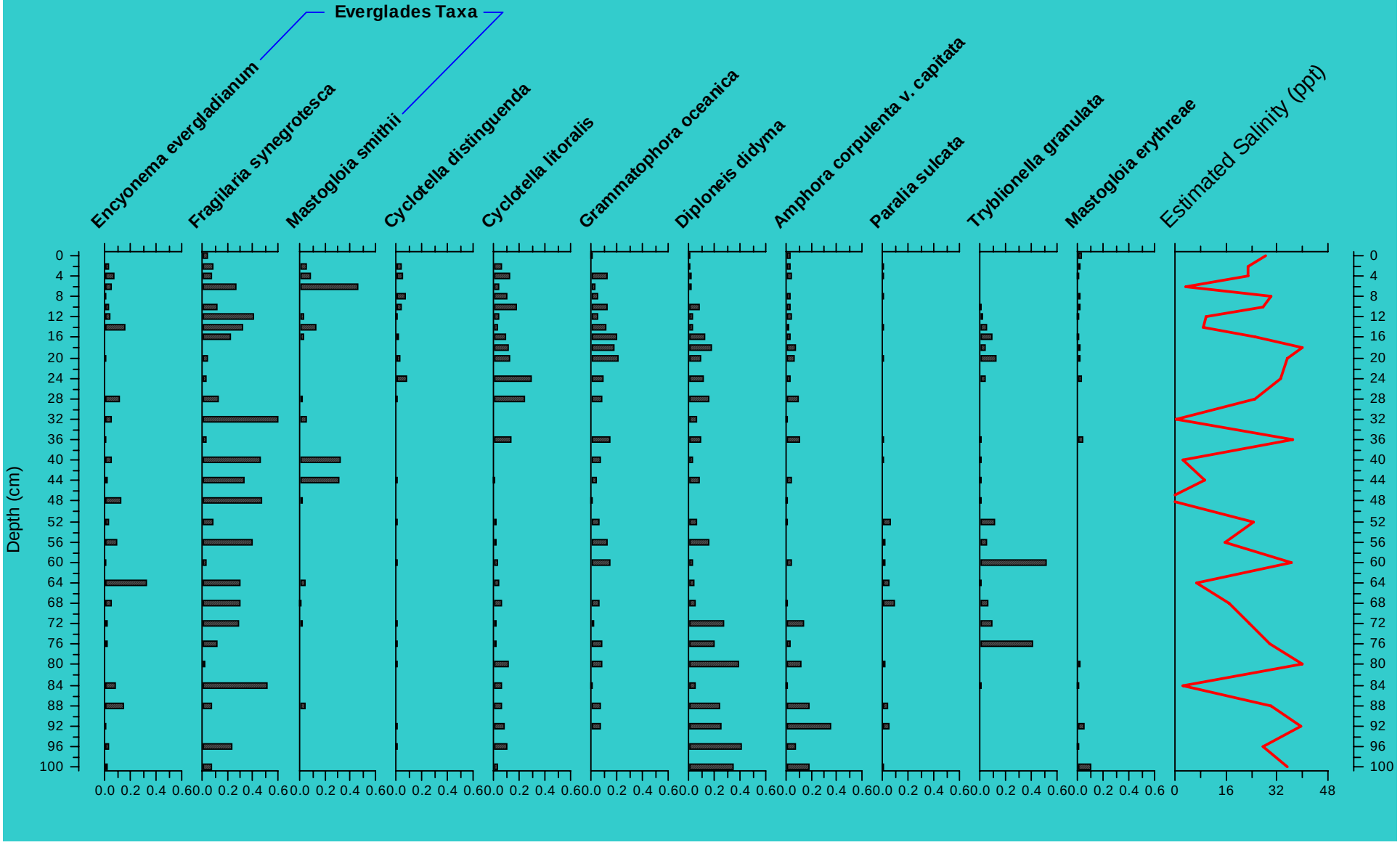
2nd Study: Use of Diatom-Inferred Salinity From FIU Sediment Core Information at Bob Allen Key in Florida Bay

INITIAL INVESTIGATION – RECOVER Southern Estuaries Sub-team - Completed

FINAL ANALYSIS – ENP CESI – On-going


Florida Bay
BOB ALLEN KEY
Atlantic Ocean
N
Sampling Events
/Modern Samples Location
2002
2006/2007
Sediment Cores Location

RELATIVE ABUNDANCE OF TAXA AND DIATOM-INFERRED SALINITY



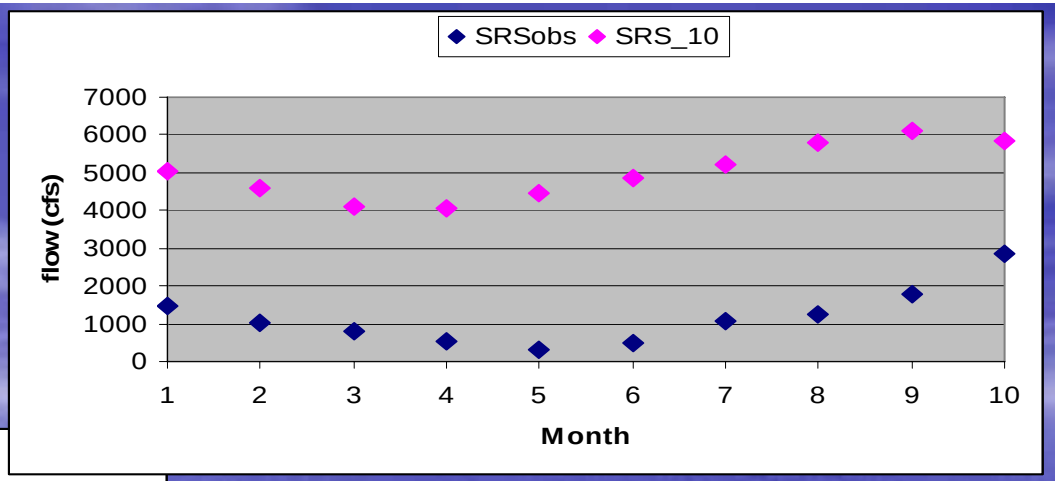
BOB ALLEN KEY CORE-BASED PALEOSALINITY

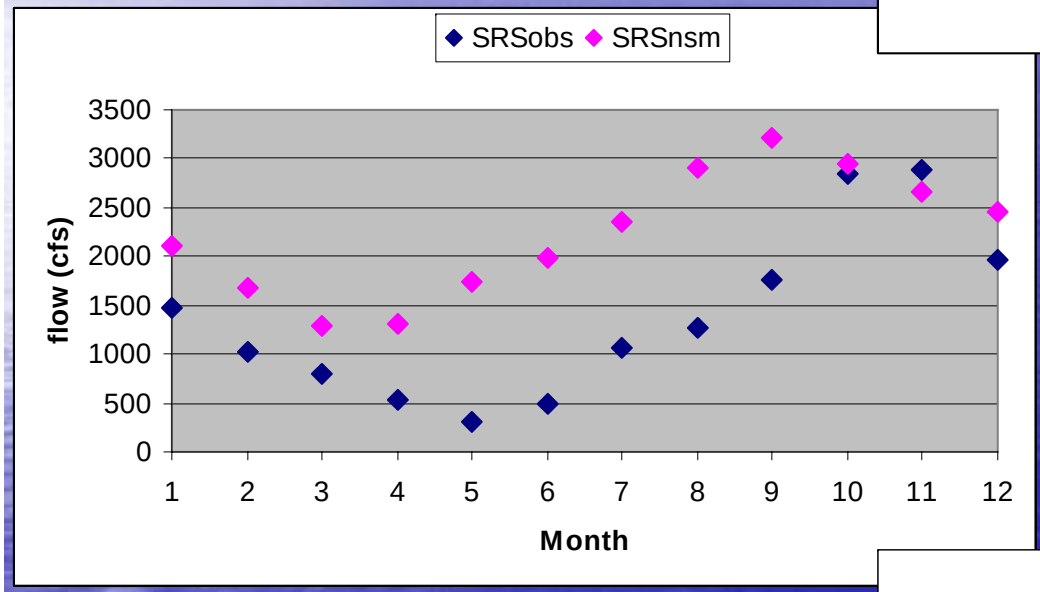
- 16 – 100 cm: average salinity = 19.9 psu
- 32 – 100 cm: average salinity = 17.3 psu
- 16 - 24 cm: average salinity = 31.5 psu
- 28 -36 cm: average salinity = 18.6 psu
- NSM-based salinity (daily, 1965-2000) = 30.06 psu

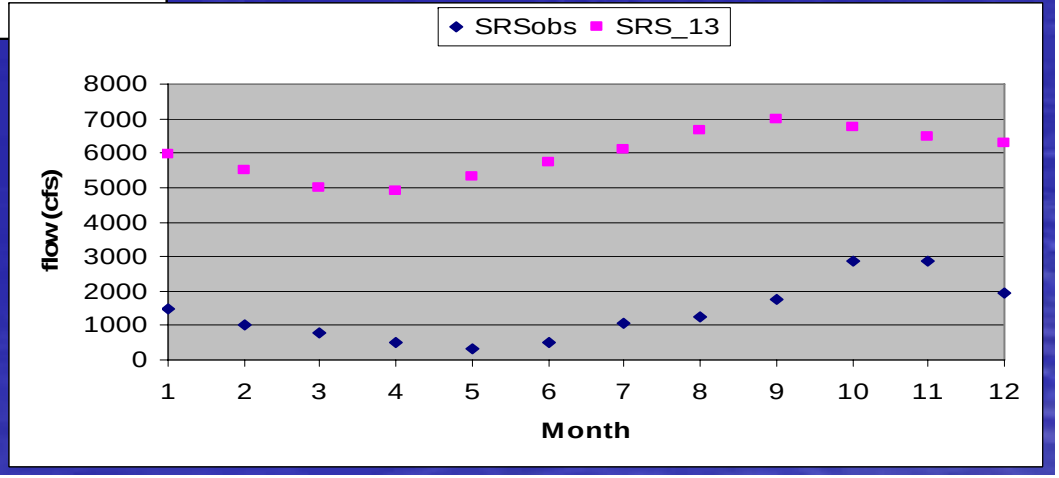
MLR SALINITY MODELS SENSITIVITY RUNS

- NSM (average 30 psu)
- NSM minus 13 psu (30 – 13 = 17 psu)
- NSM minus 10 psu (30 – 10 = 20 psu)

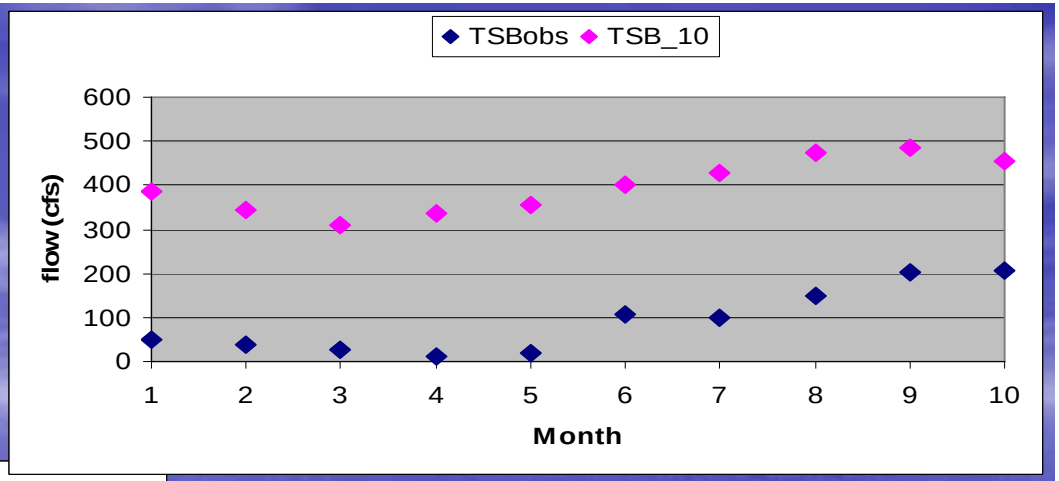
TAMIAMI TRAIL (SRS) FLOW

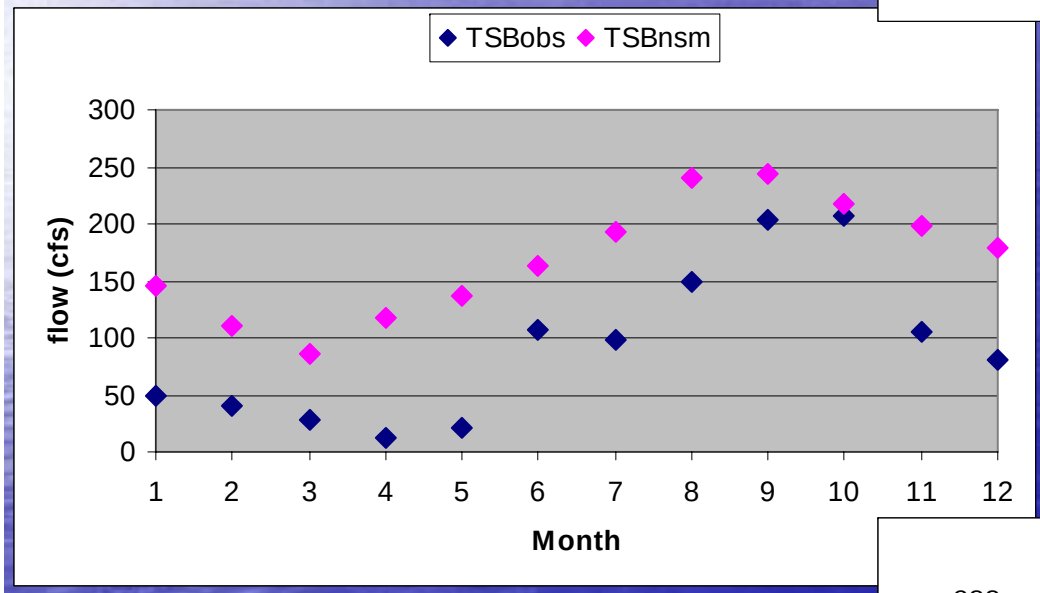


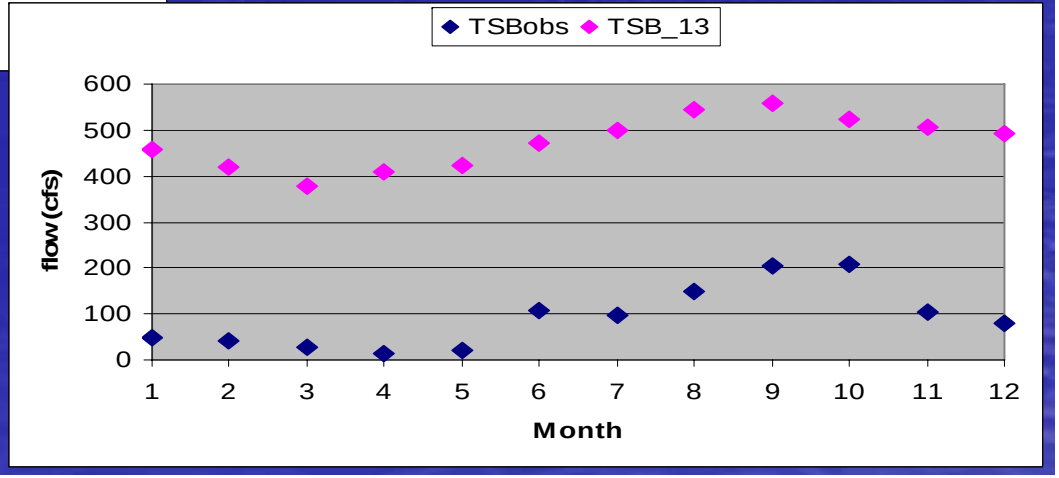




TAYLOR SLOUGH BRIDGE FLOW







SENSITIVITY RUNS COMPARISON – AVERAGE MONTHLY FLOW RATIOS

Location	NSM / Observed	NSM Minus 10 psu / Observed	NSM Minus 13 psu / Observed	Whipray Basin Paleo / Observed
SRS	2.2	5.4	7	3.7
TSB	3	8.1	10.5	8.3

BOB ALLEN KEY PALEOSALINITY – INITIAL INVESTIGATION FINDINGS

- Diatom-inferred salinity estimates from Bob Allen Key sediment cores are quite variable for segments
- From this analysis: best estimate of pre-drainage salinity is average of 32 cm – 100 cm segments = 17.3 psu average over segments (NSM – 13 psu)

ADDITIONAL PALEO PROJECTS UNDERWAY

- CESI Bob Allen Key Final Analysis w/FIU - Underway
  - Finalize paleosalinity regime using upgraded model for diatom-inferred salinity
  - Develop final estimates of pre-drainage hydrology and salinity using the developed methodology
- USGS Additional Florida Bay Analysis – Just Starting
  - Choose 2 more sites for analysis
  - Develop paleosalinity regime for each
  - Estimate pre-drainage hydrology and salinity using the developed methodology for each

FINAL DESTINATION

- Combined analysis of all pre-drainage estimates of stage and flow in Everglades and salinity in Florida Bay
- Interpret together, including uncertainty
- Develop consensus estimates of pre-drainage conditions (stage, flow, salinity)
- Use results for SLR interpretations
- Missing piece from paleosalinity puzzle – Shark River paleo analysis – Next year??


THANK
YOU!