Linking Wetlands Hydrology to Estuarine Salinity in the Everglades: Integrated Solutions to Establish Restoration Targets

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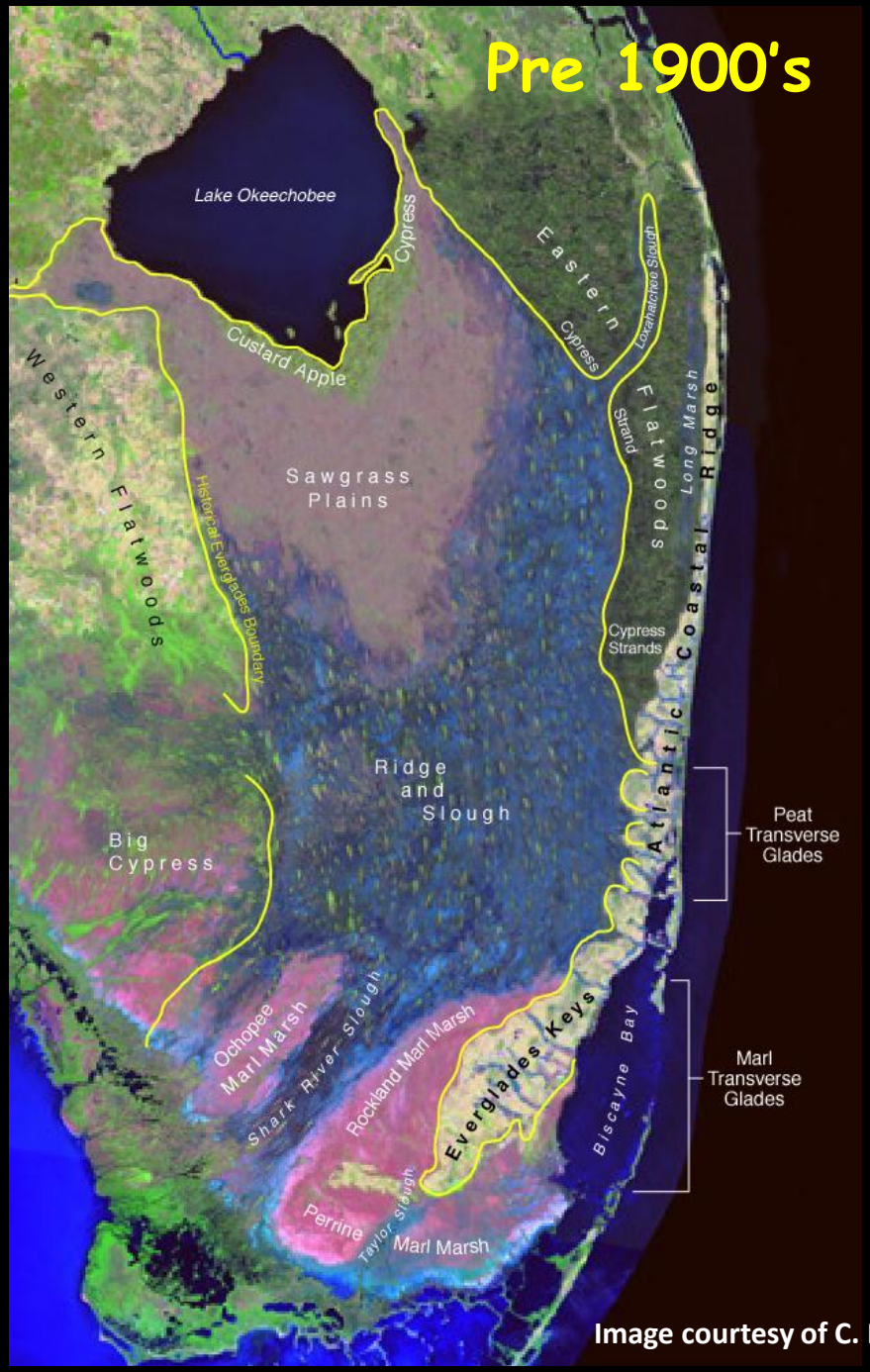


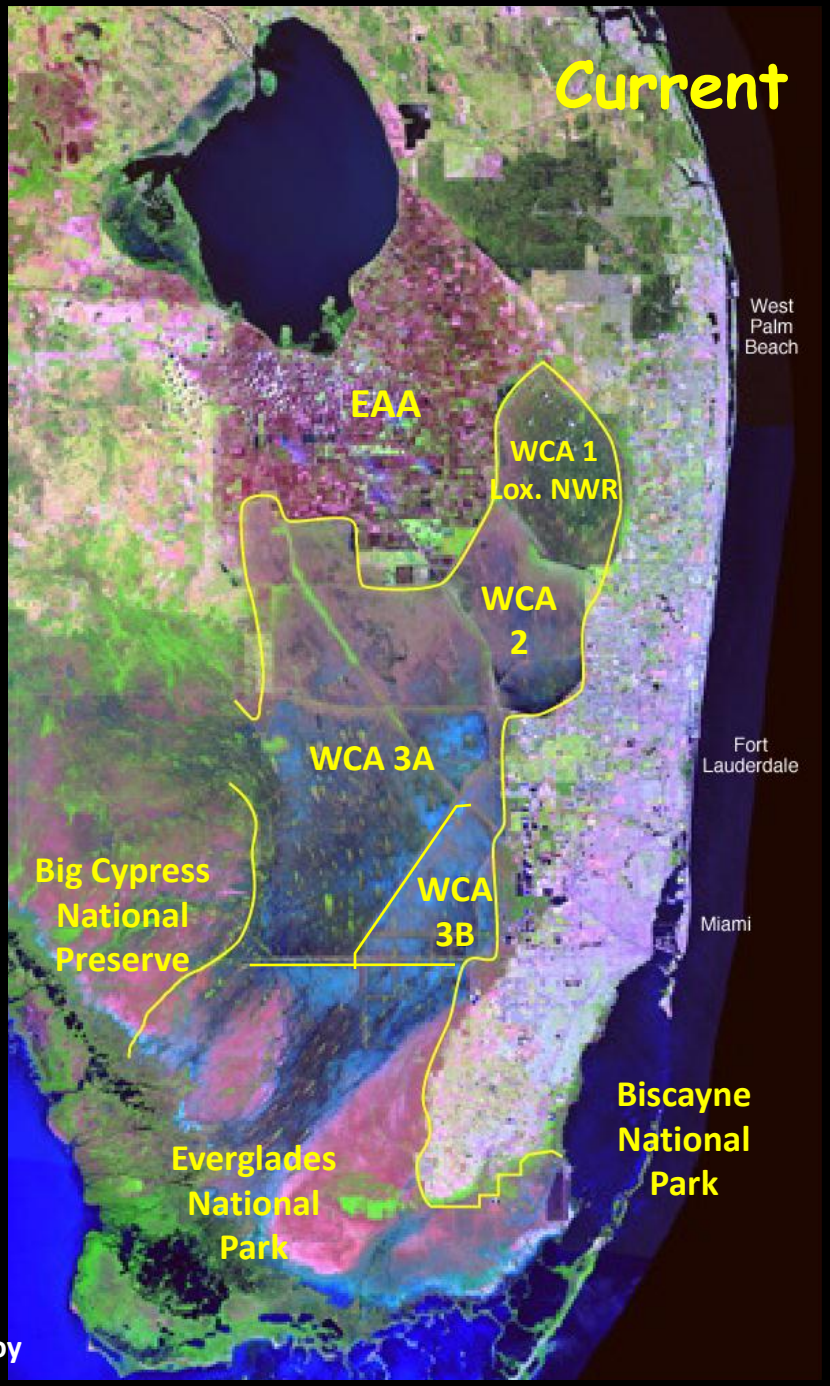


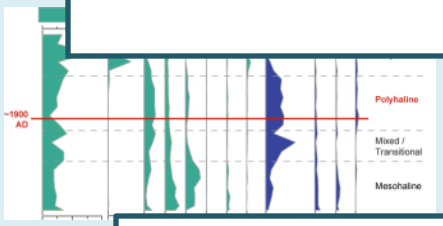
Image courtesy of C. McVoy

The Problem

- Restoration of the Greater Everglades Ecosystem is dependent on re-establishing historical hydrologic conditions
  - Freshwater flow through the wetlands
  - Salinity in the southern estuaries
- Theoretically-based mechanistic models of hydrology have not produced low salinities in the estuaries but . . .
  - Paleoecologic and anecdotal data indicate low salinities existed around 1900 CE
- RECOVER teams need estimates of historical flow and stage in the wetlands and salinity in the estuaries
  - Used to set empirically based targets and performance measures for restoration.

The Solution

Phase I: Paleoecology



Phase II: Linear Regression Models (LRMs) developed based on observed instrumental data from stations in the wetlands and the estuaries

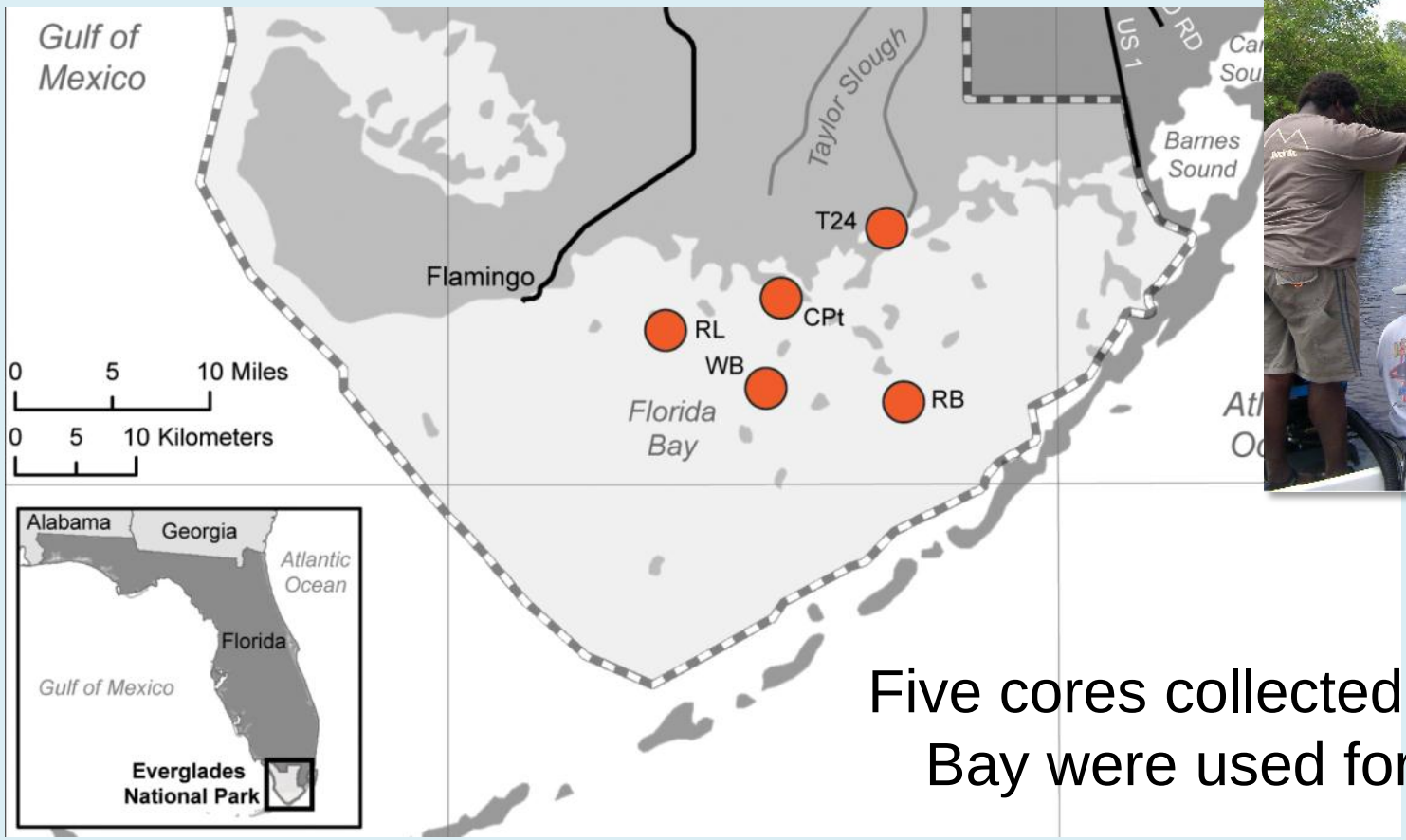
Phase III:
Couples the simulated paleosalinity regime with the LRMs to produce estimates of flow, stage, and salinity

USGS

See Marshall et al. 2009, Est. & Coasts, v. 32, p. 37-53

Phase I: Paleoecology

Cores are collected in estuaries and radiometrically dated

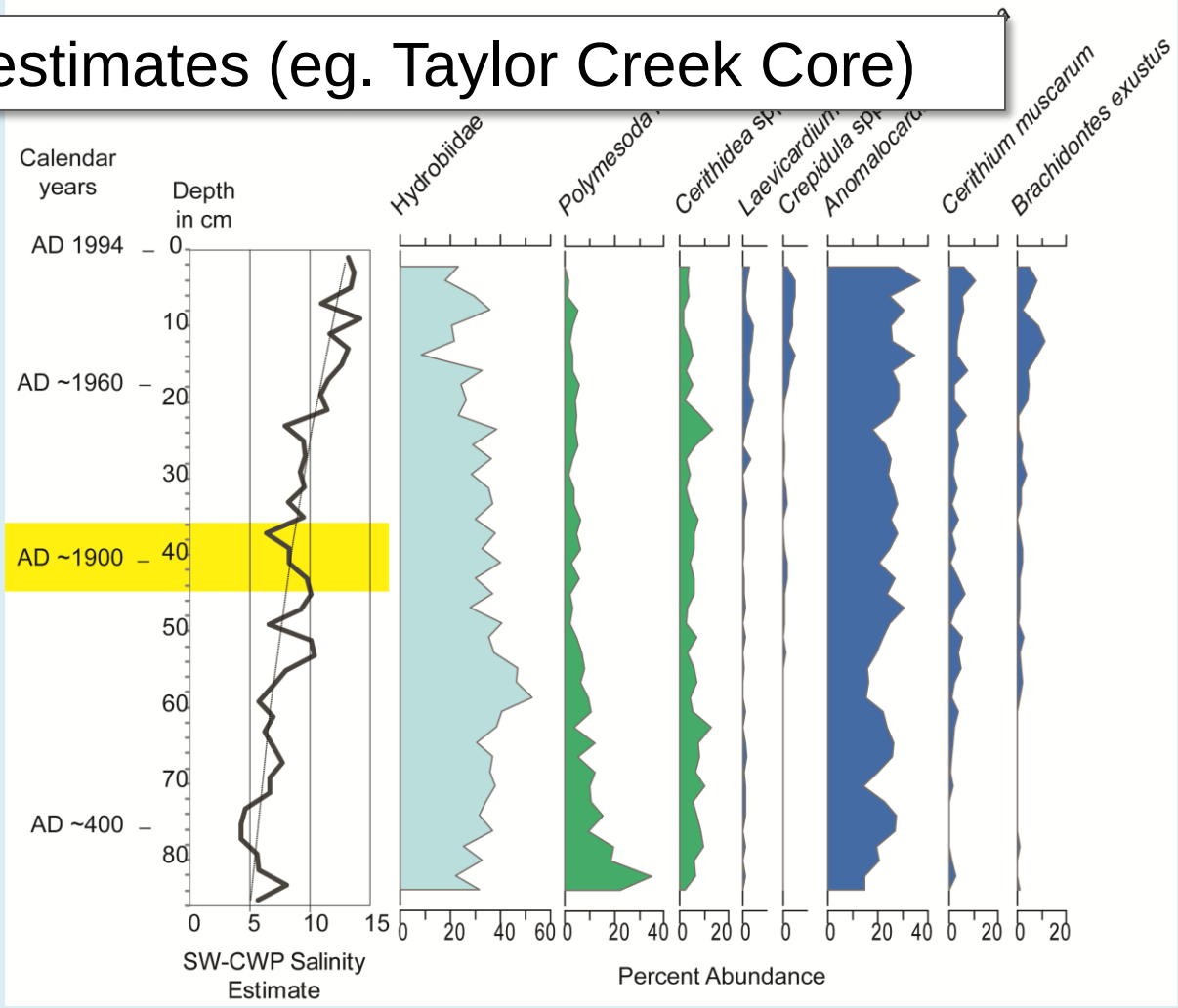


Five cores collected in Florida Bay were used for analyses

Phase I: Paleoecology

Step 1: Paleosalinity estimates (eg. Taylor Creek Core)

- Molluscan assemblages are compared to a modern analog dataset
- Average salinity values from modern dataset are weighted by the abundance of species in each sample



USGS

See Wingard & Hudley, 2012, Est. & Coasts, v. 35, p. 262-280

Phase I: Paleoecology

Step 1: Paleosalinity estimates (eg. Taylor Creek Core)

CWP = Σ (**% Abundance each species** X Modern Analog Mean psu)/100

Modern Analog Mean Salinity Data			Taxonomic	Anomalocardia	Bittiolum	Brachidontes	Bulla striata	Cerithidea	Freshwater (G)	CWP Mean Salinity CONFID
			Dataset	CONFID	CONFID	CONFID	CONFID	CONFID	CONFID	
			Mean salinity	22.94	25.61	26.48	28.76	18.43	6.42	
	Taylor Core	Depth in cm								
Percent Abundance	FB594 24/ 36	36		28.70	4.35	0.00	0.00	8.70	33.91	16.31
	FB594 24/ 38	38		30.16	1.59	1.06	0.00	6.35	40.74	14.71
	FB594 24/ 40	40		28.57	2.20	2.75	0.55	6.59	37.91	15.73
	FB594 24/ 42	42		23.60	9.55	2.25	0.56	5.06	46.07	14.41
	FB594 24/ 44	44		30.49	6.71	1.22	0.00	6.71	34.15	16.70
	FB594 24/ 46	46		27.61	3.07	1.23	2.45	6.75	42.33	15.85
	FB594 24/ 48	48		38.10	6.12	1.36	1.36	4.08	34.69	16.92

USGS

See Wingard & Hudley, 2012, Est. & Coasts, v. 35, p. 262-280

Phase I: Paleoecology

Step 1: Paleosalinity estimates (eg. Taylor Creek Core)

Analog Mean Salinity Data	Taxonomic Group	Anomalocardia auberiana	Bittiolum varium					
		CONFID	CONFID					
		22.94	25.61					
	6	28.70	4.35	0.00	0.00	8.70	33.91	16.31
	8	30.16	1.59	1.06	0.00	6.35	40.74	14.71
	0	28.57	2.20	2.75	0.55	6.59	37.91	15.73
	2	23.60	9.55	2.25	0.56	5.06	46.07	14.41
	4	30.49	6.71	1.22	0.00	6.71	34.15	16.70
	6	27.61	3.07	1.23	2.45	6.75	42.33	15.85
	48	38.10	6.12	1.36	1.36	4.08	34.69	16.92

***Anomalocardia auberiana* data**	
Mean	22.94
Median	25.43
Standard Deviation	10.82
Range	41.28
Minimum	0.94
Maximum	42.22
Count	61.00
Confidence Level (95.0%)	2.71

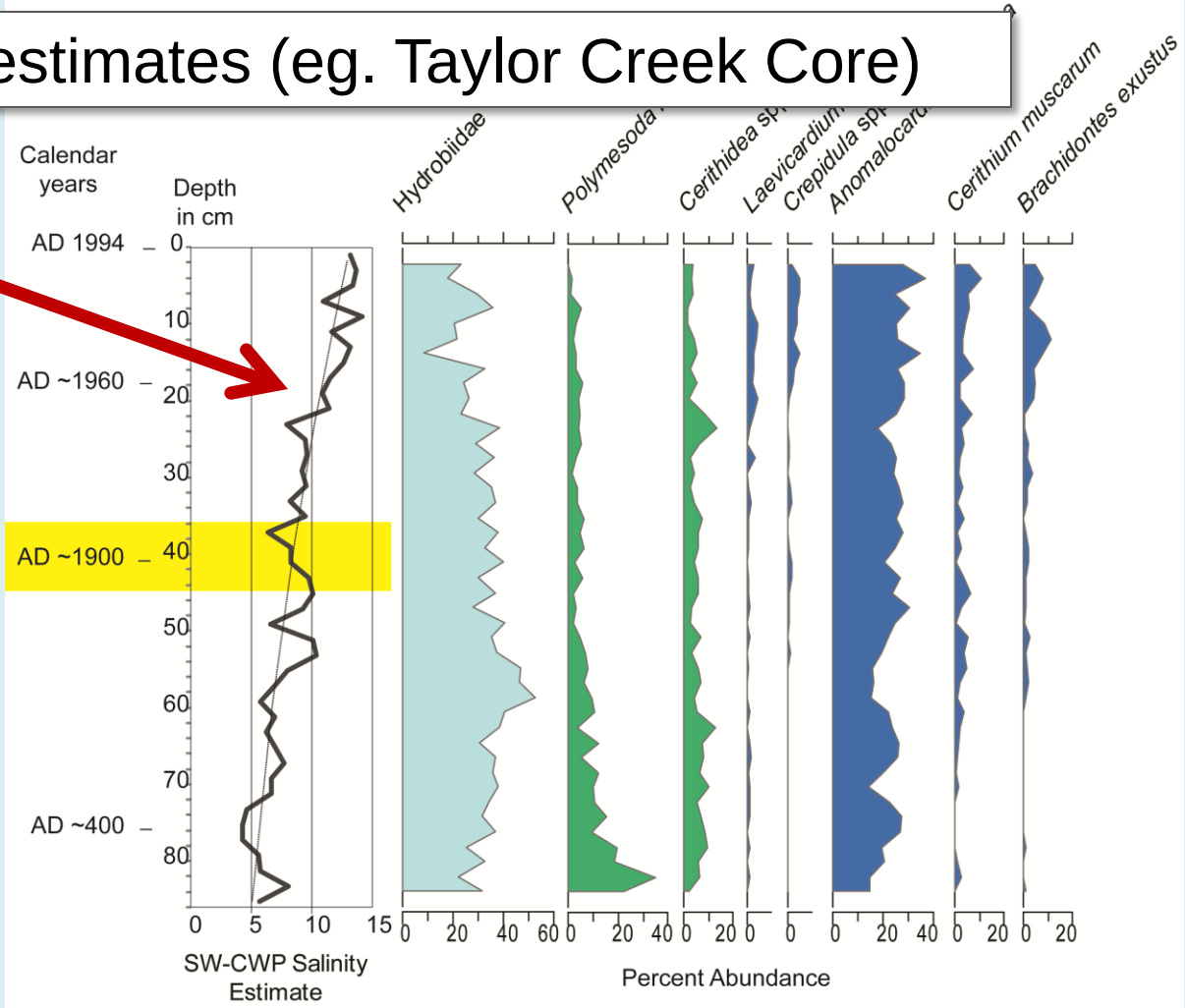
USGS

See Wingard & Hudley, 2012, Est. & Coasts, v. 35, p. 262-280

Phase I: Paleoecology

Step 1: Paleosalinity estimates (eg. Taylor Creek Core)

- Cumulative weighted average salinity is produced for each 2-cm core segment
- Paleosalinity estimates from about 1900 CE are the Phase I Step 1 output.



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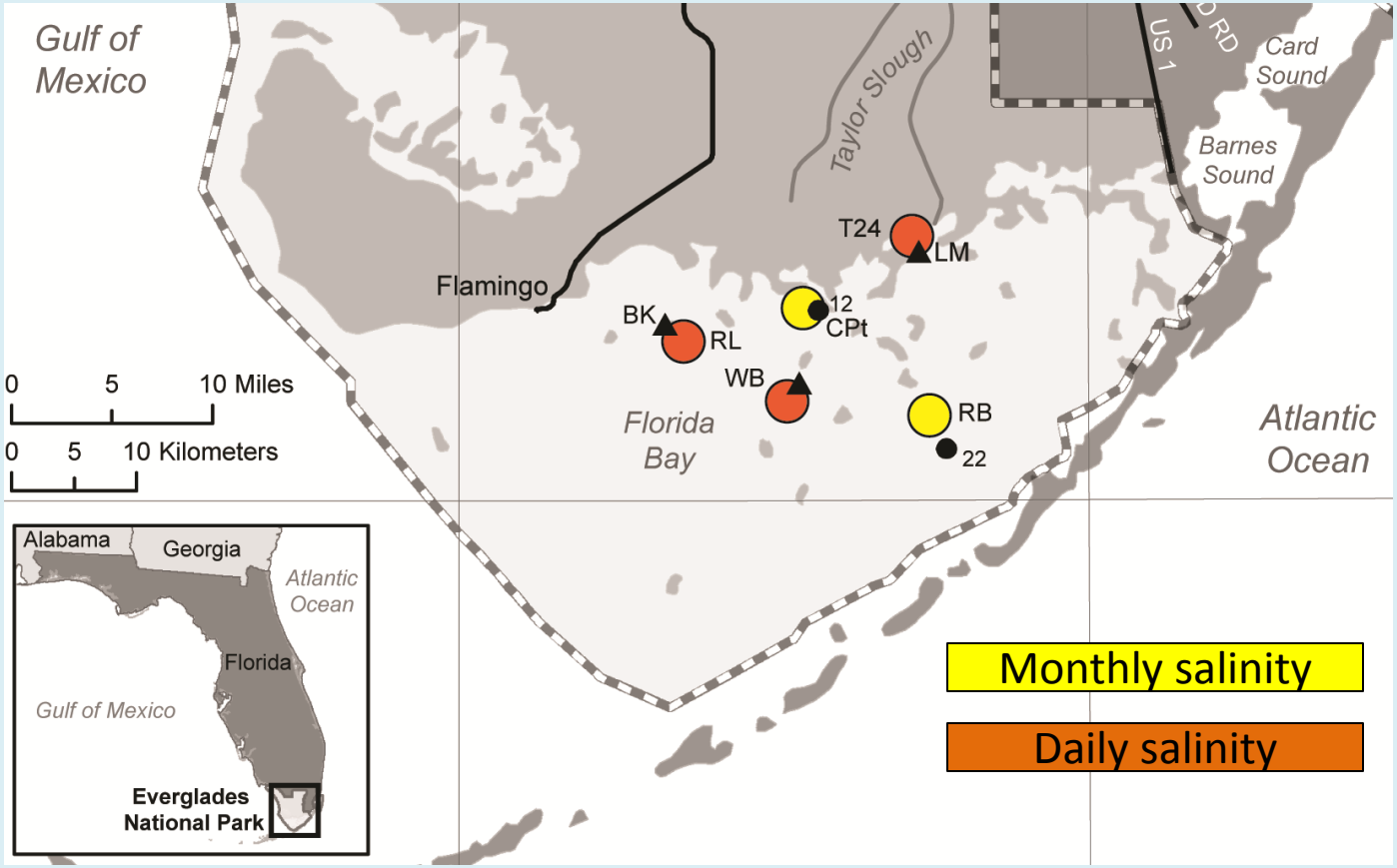
See Wingard & Hudley, 2012, Est. & Coasts, v. 35, p. 262-280

Phase I: Paleo-adjusted NSM

Step 2: Develop paleosalinity time series at each core location

Time series derived from multiple LRMs, using the SFWMD Natural System Model for each core location.



See Marshall & Wingard, 2012, USGS OFR 2012-1054

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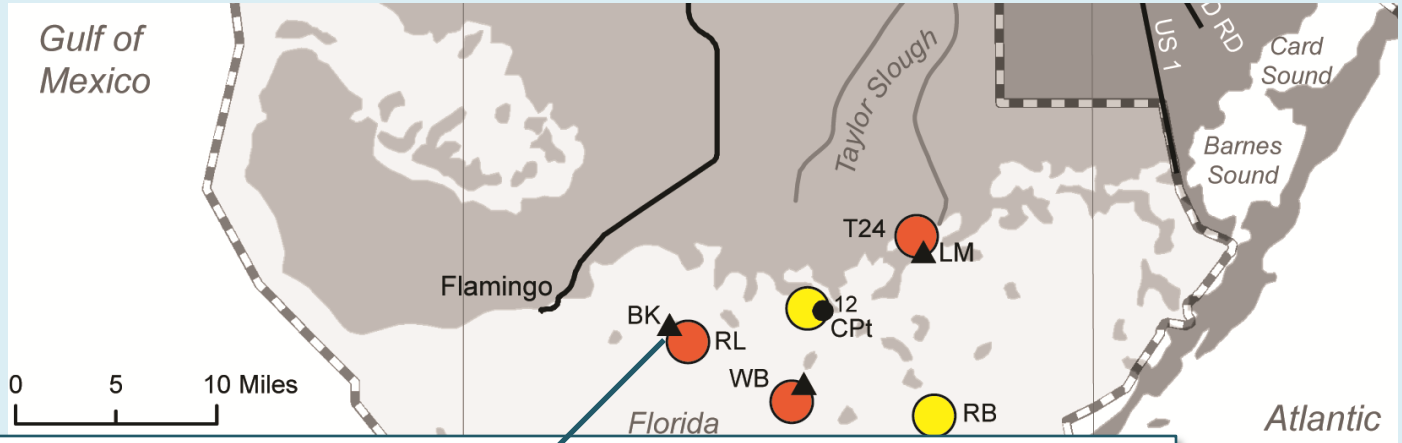

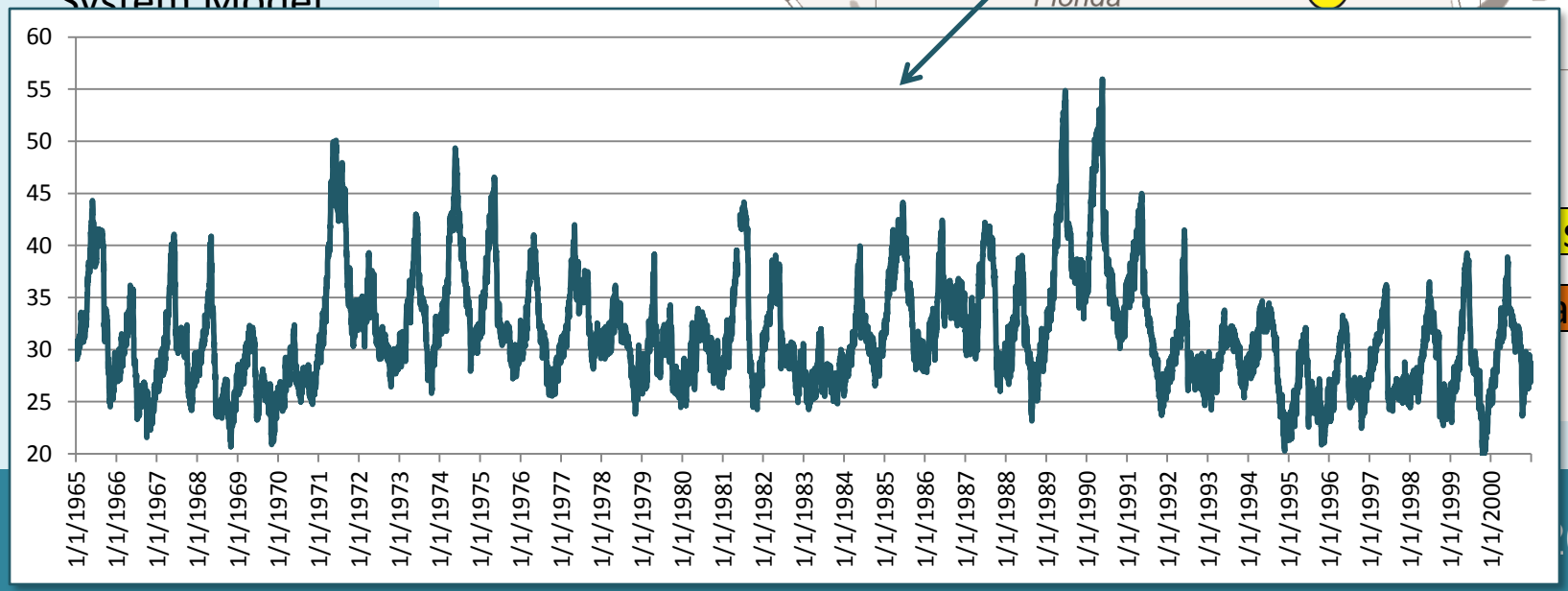

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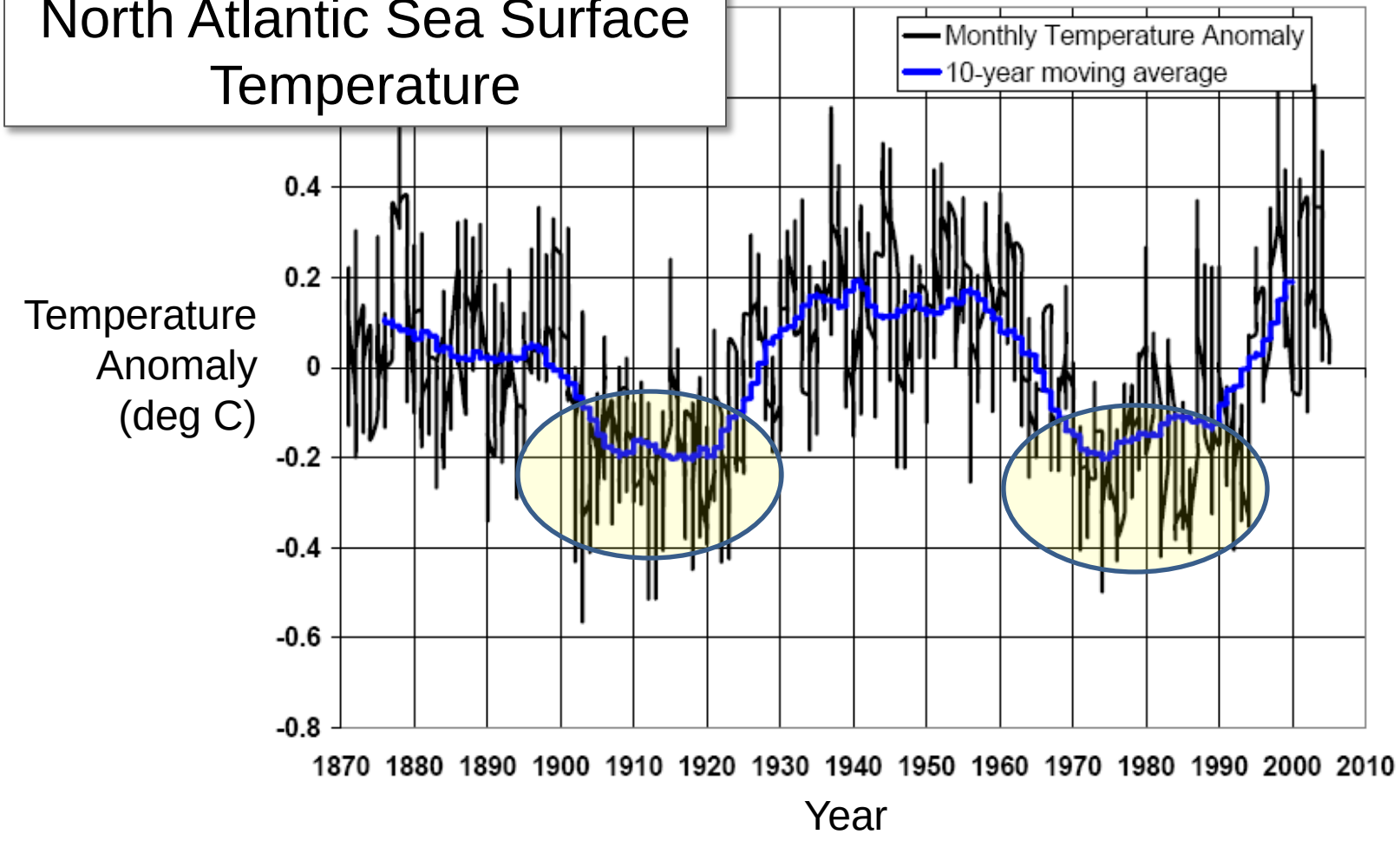
Phase I: Paleo-adjusted NSM

North Atlantic Sea Surface Temperature



See Obeysekera et al., 2006, SFWMD Report

Phase I: Paleo-adjusted NSM

Step 2: Develop paleosalinity time series at each core location

Time series derived from multiple LRMs, using the SFWMD Natural System Model for each core location.

Core Name	NSM/MLR Mean Salinity (1965-2000)	Paleosalinity Estimate (CWP CONFID)	NSM Salinity Adjustment for Paleosalinity Time Series
Crocodile Point	27.6	26.5	-1.1
Rankin Lake	30.4	28.3	-2.1
Russell Bank	28.1	26.4	-1.7
Taylor T24	17.7	16.5	-1.5
Whipray Basin	31.8	29.5	-2.3

See Marshall & Wingard, 2012, USGS OFR 2012-1054

Phase I: Paleo-adjusted NSM

Step 2: Develop pale

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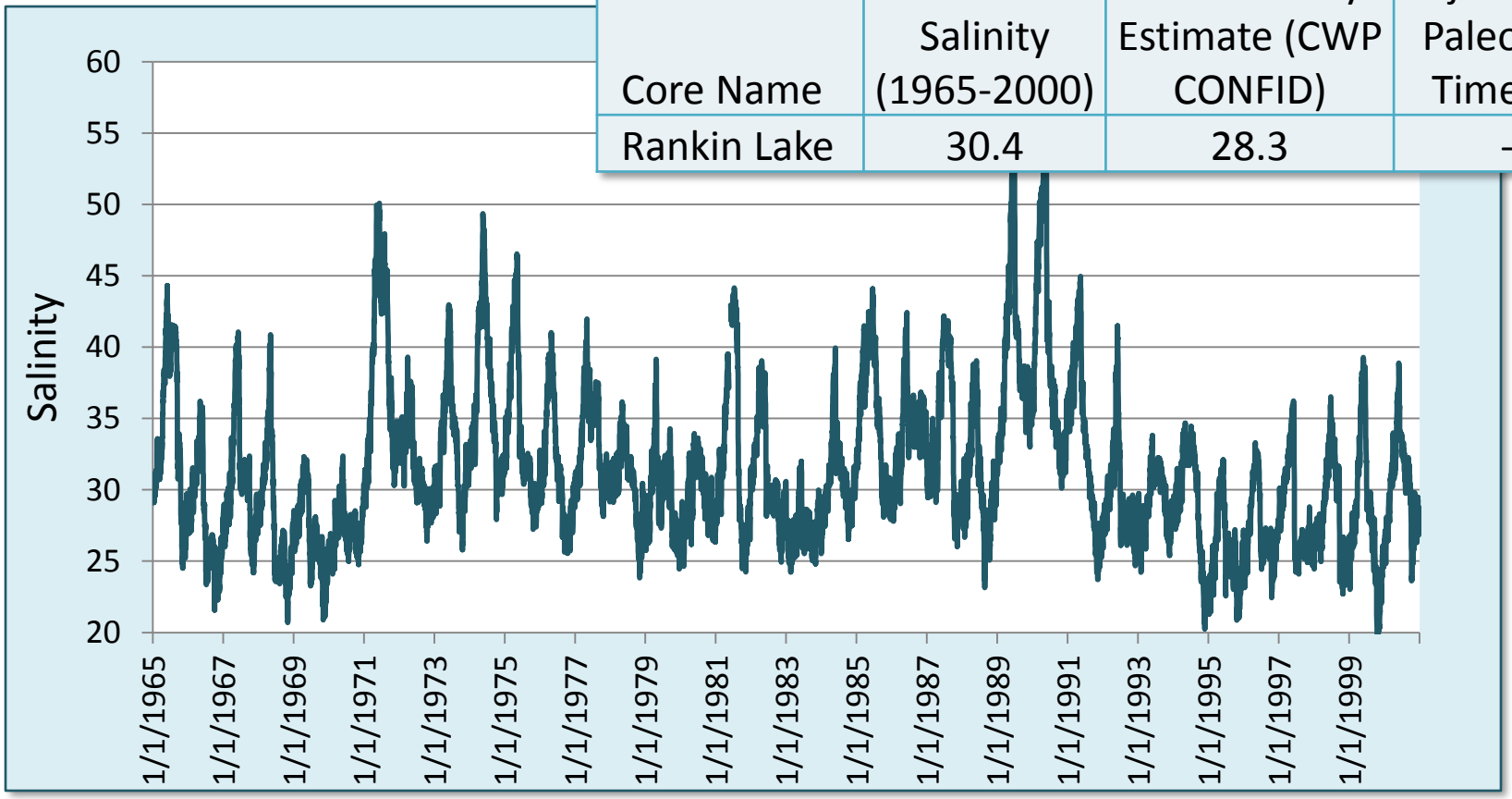

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See Marshall & Wingard, 2012, USGS OFR 2012-1054

Phase I: Paleo-adjusted NSM

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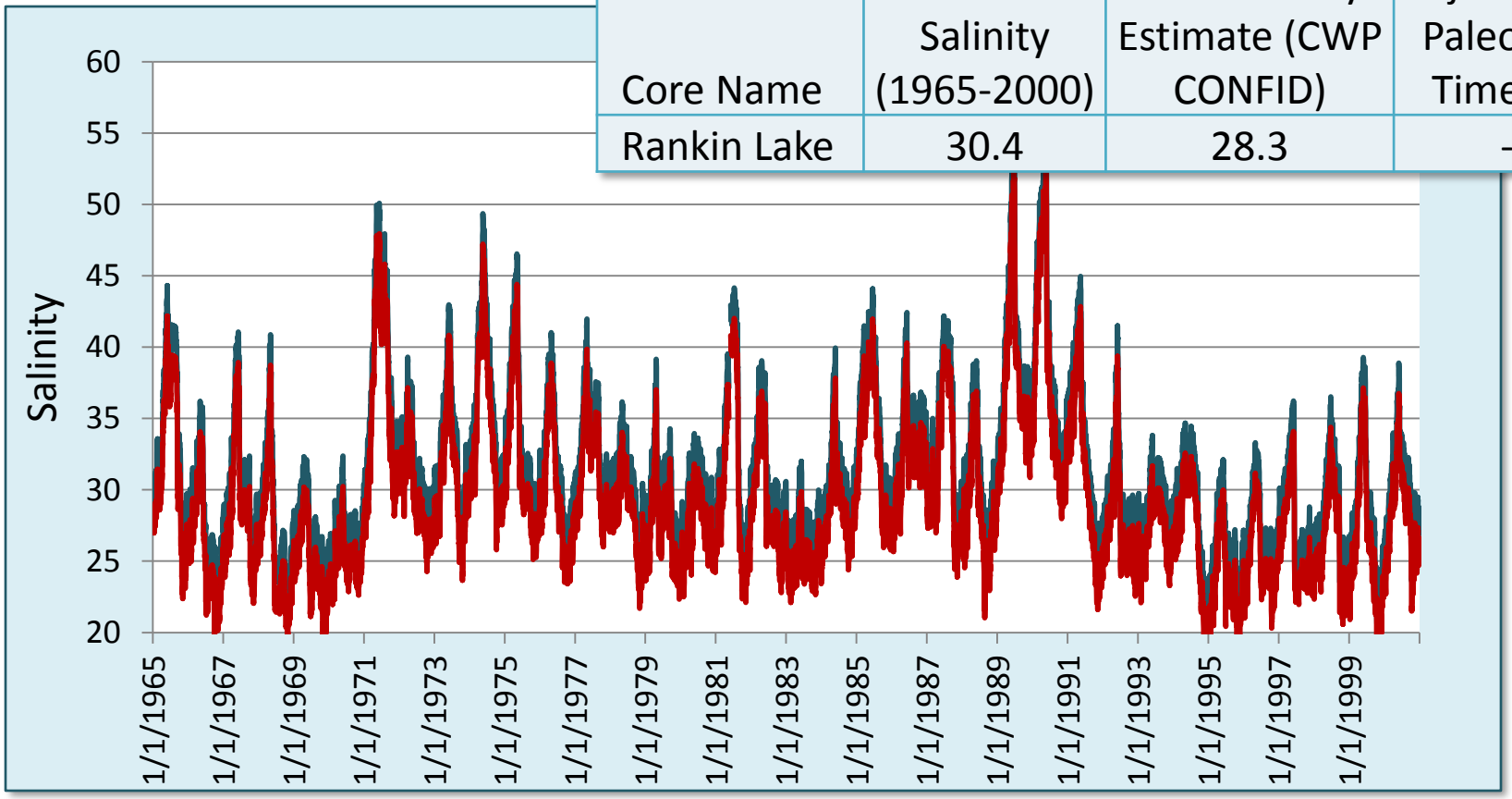

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Phase I: Paleo-adjusted NSM

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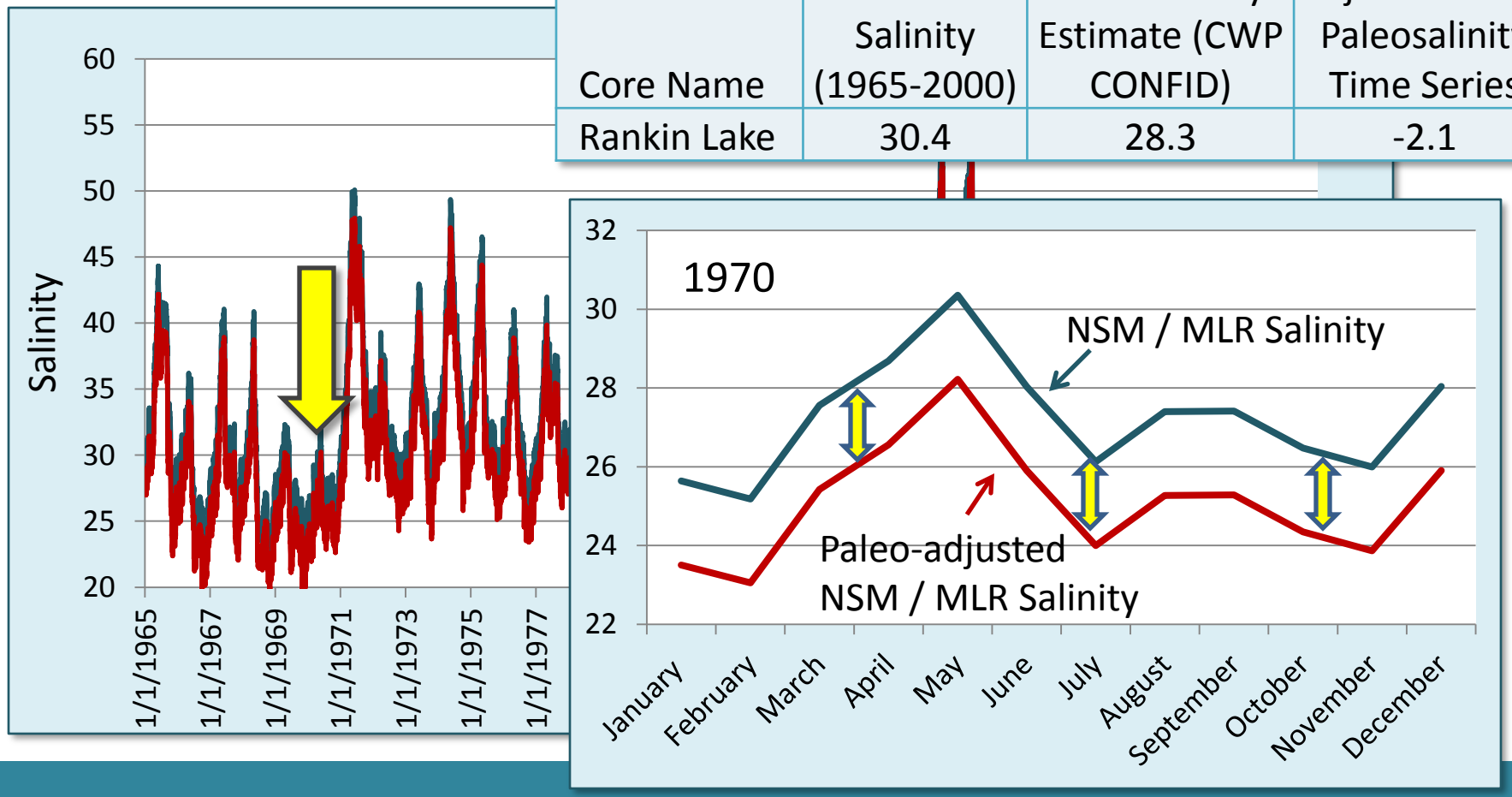

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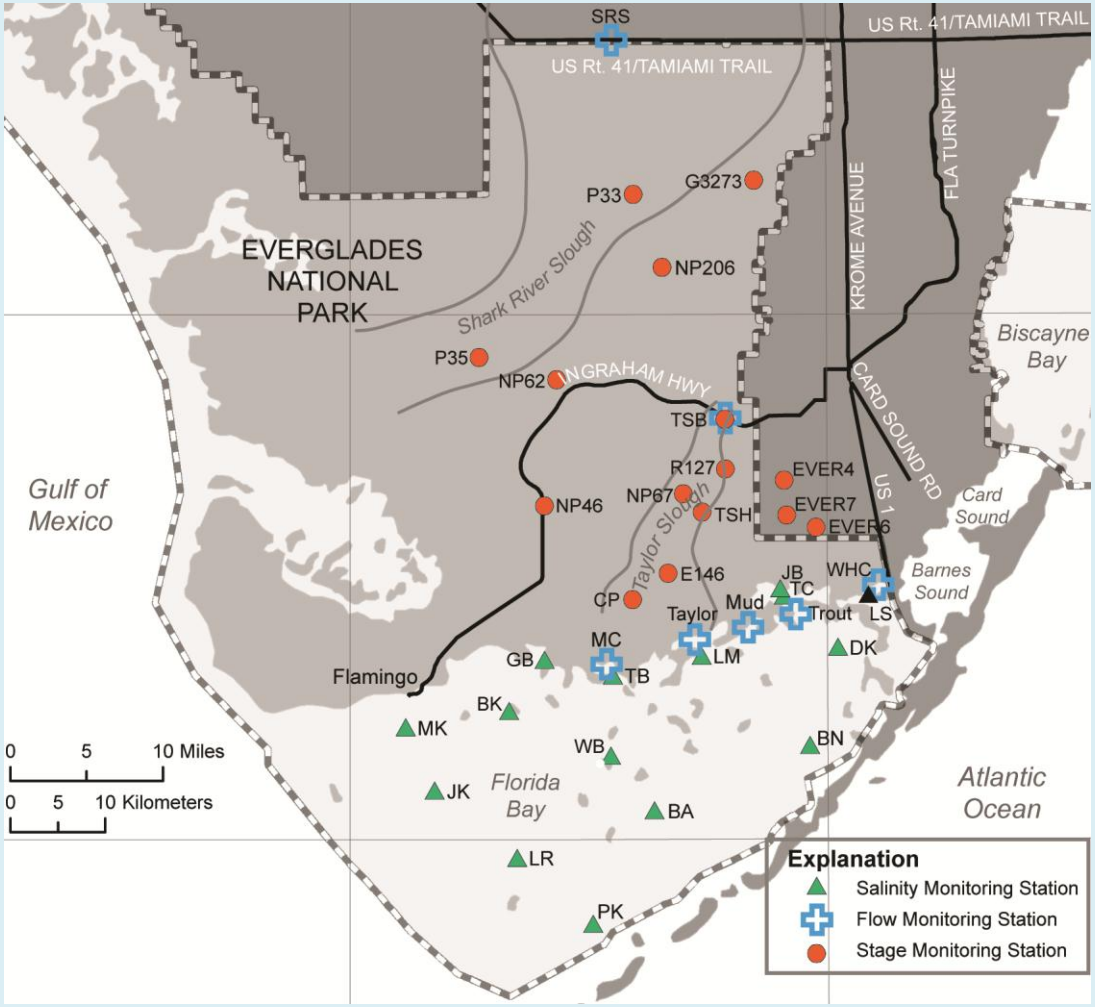
See Marshall & Wingard, 2012, USGS OFR 2012-1054

Phase II: Linear Regression Models

4 sets of Linear Regression Models (LRMs) developed based on modern hydrologic station data

- Stage to salinity
- Stage to flow
- Stage to stage
- Salinity to salinity

These models link freshwater stage and flow at locations in the Everglades wetlands to salinity in Florida Bay.



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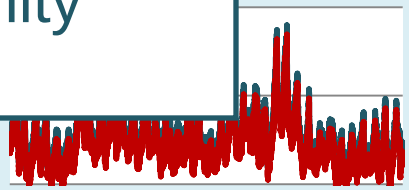
See Marshall & Wingard, 2012, USGS OFR 2012-1054

Phase III: Linking Paleo & LRMs

Phase I: NSM / MLR adjusted paleosalinity time series



Phase II: LRMs for

- Stage to salinity
- Stage to flow
- Stage to stage
- Salinity to salinity

Phase III:
Couples the simulated paleosalinity regime with the LRMs to produce estimates of flow, stage, and salinity

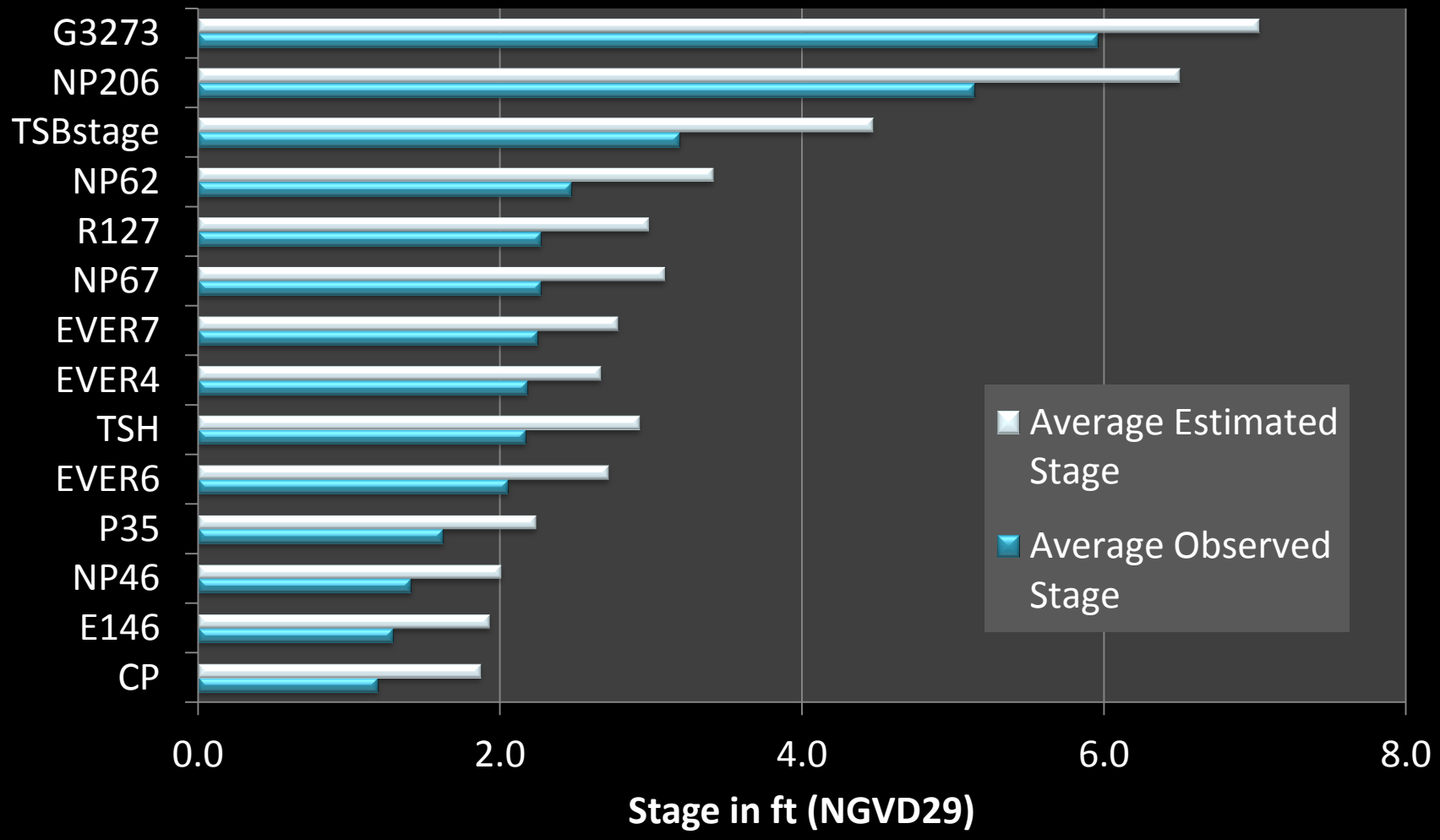
See Marshall & Wingard, 2012, USGS OFR 2012-1054

Results – Output from Phase III

Phase III Output

- Stage: Paleo-based stage throughout freshwater marshes and mangrove transition zone (14 stations)
- Flow: Upstream paleo-based flow (Shark River, Taylor River systems)
- Flow: Downstream paleo-based creek discharges (5 creeks)
- Salinity: Paleo-based salinity throughout Florida Bay (17 stations)

Paleo-based Estimate vs. Observed



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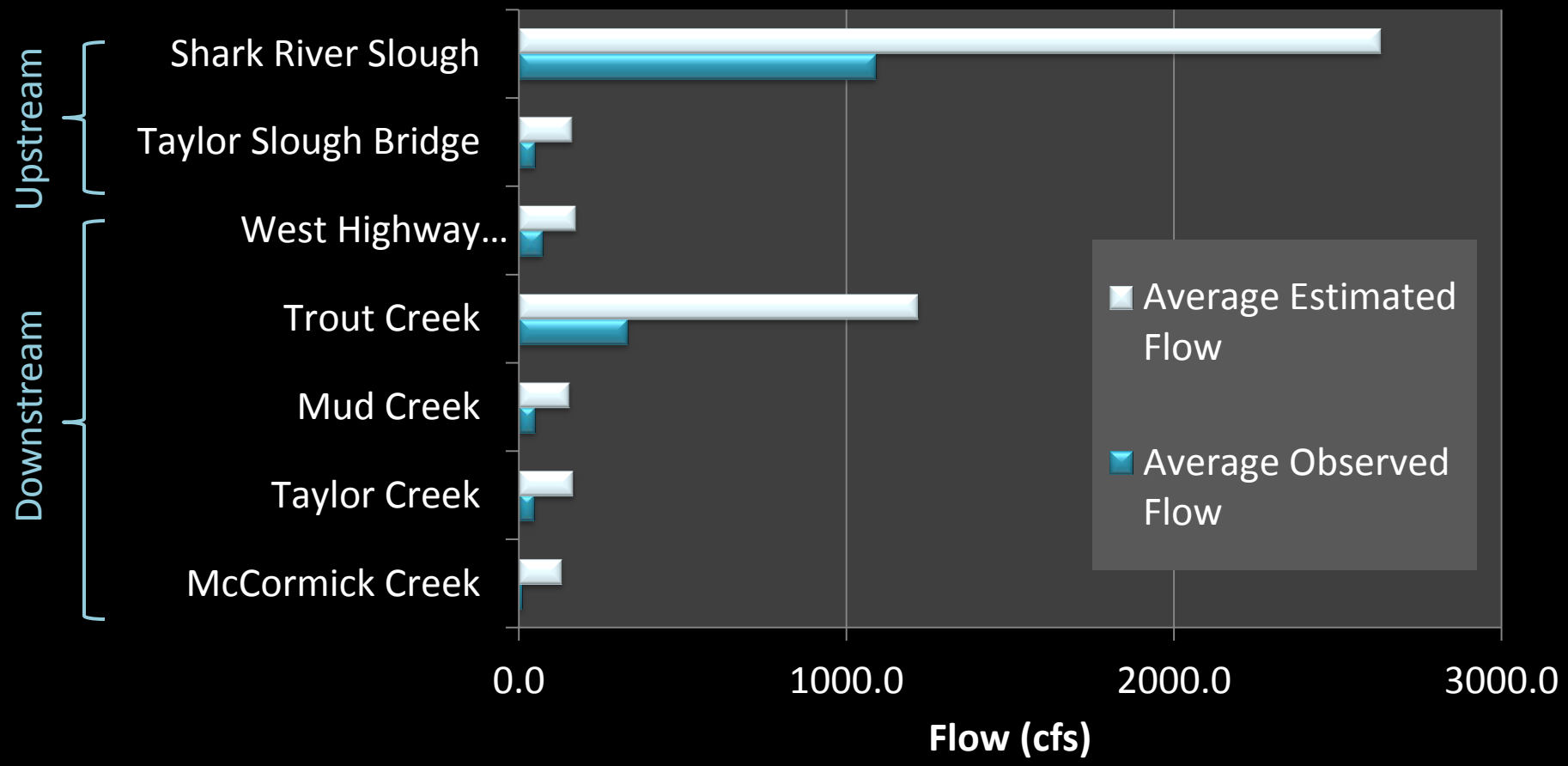
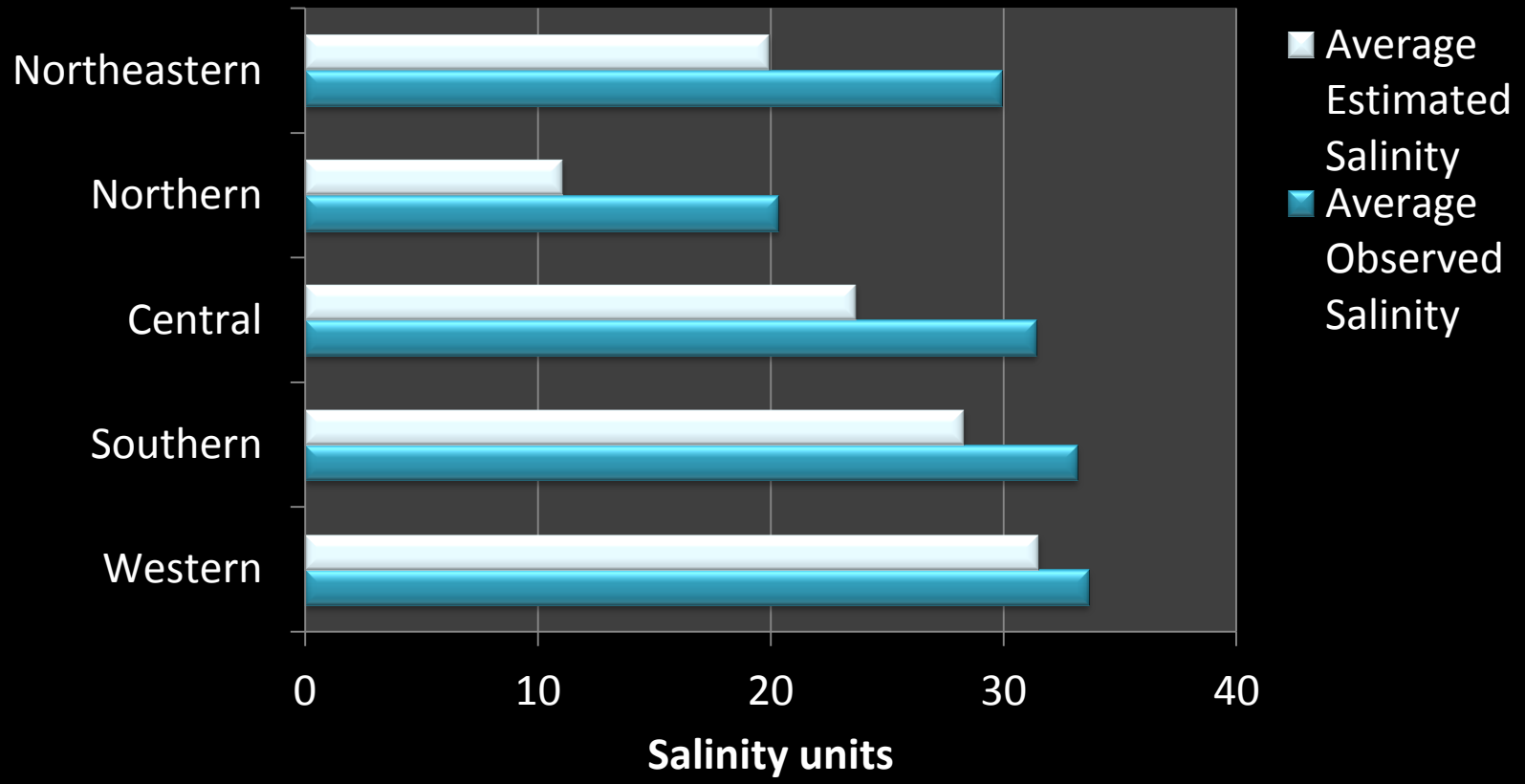
Paleo-based Estimate vs. Observed



Paleo-based Estimate vs. Observed

Results aggregated by FATHOM Basin



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Summary

Three phase integrated approach applied to 5 cores has indicated the following:

- A “wetter Everglades” prior to 20th century drainage projects. Paleo-based estimates:
  - Stage in the Everglades is 0.6 to 1.2 feet higher
  - Flow at Shark River Slough at Tamiami Trail ~1500 cfs higher
  - Flow at Taylor Slough Bridge ~120 cfs higher

Summary

- Less saline estuaries prior to 20th century drainage projects. Paleo-based estimates:
  - Salinity in nearshore transition zones ~12 psu lower
  - Salinity along western margin of Florida Bay ~3 psu lower

These results are being used by the Southern Coastal Systems Sub-team of RECOVER to develop PMs and targets for salinity in the estuaries to guide restoration of the GEE.


For more information on research visit:
http://sofia.usgs.gov/
Thank you!