Restoration and Sea-Level Rise:

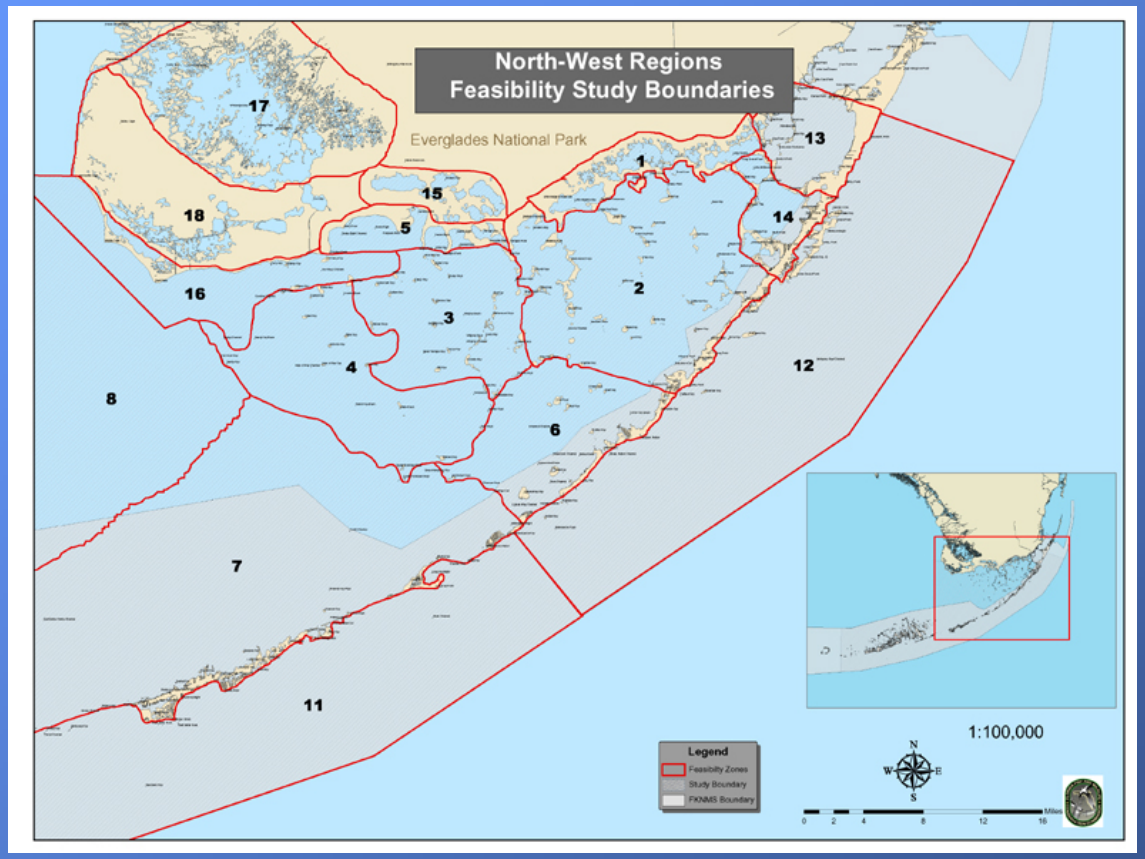
The Role of Paleoecologic Data in Incremental Adaptive Management

G. Lynn Wingard (USGS) , Frank E. Marshall (CLF),

Patrick Pitts (USF&W)

U.S. Department of the Interior
U.S. Geological Survey

Image downloaded from Google Earth



- To get the water right . . . which means . . .
- Setting attainable and sustainable performance measures and targets that reflect natural patterns in the estuaries

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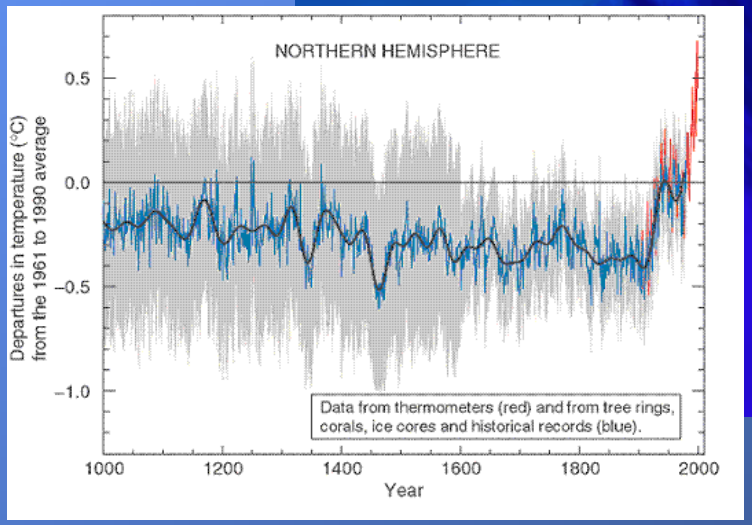
But how do we define attainable and sustainable in the face of global change?

Given the current projections of sea level rise should we reevaluate our goals?



NOAA 2 m rise

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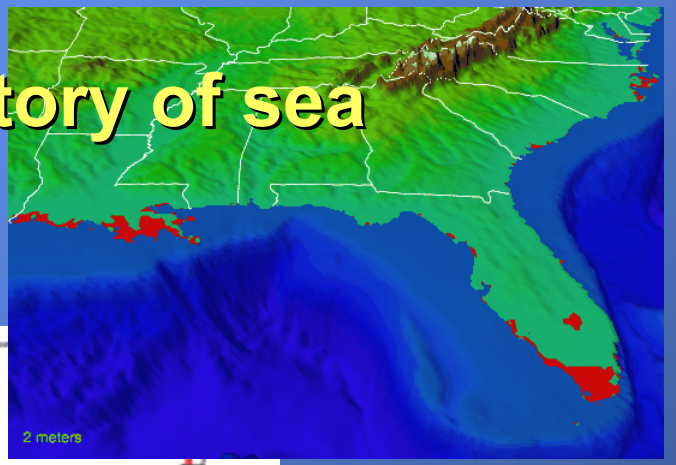
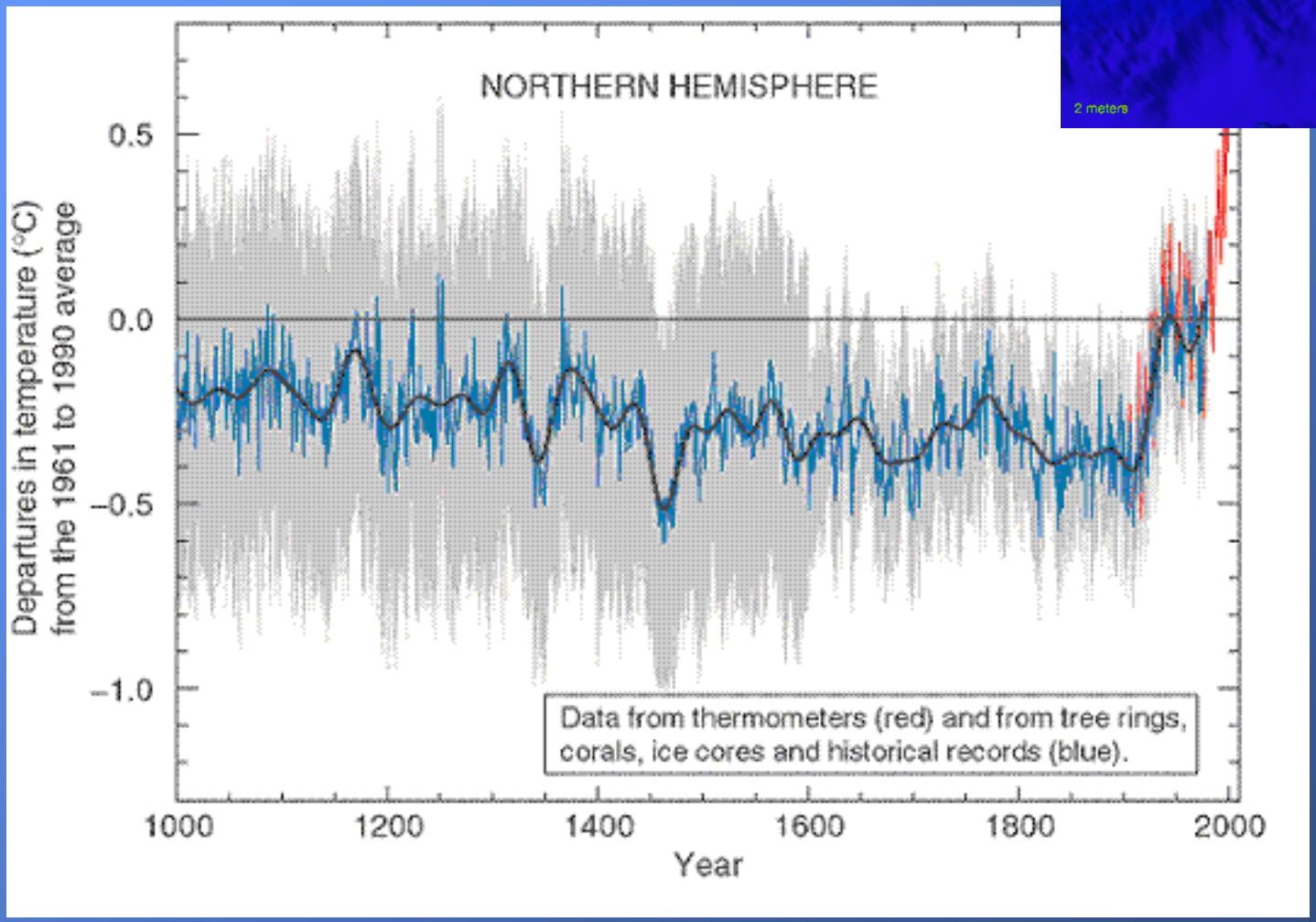
What do we know about the history of sea level rise in Florida?





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Changes in Estuarine salinities: Natural and Anthropogenic

~ 2000 yrBP
Freshwater reached past the current terrestrial margin

~ 1900 AD
Increasing estuarine salinities consistent with rising sea level

Current
Loss of typical estuarine zonations occurred in 20th century

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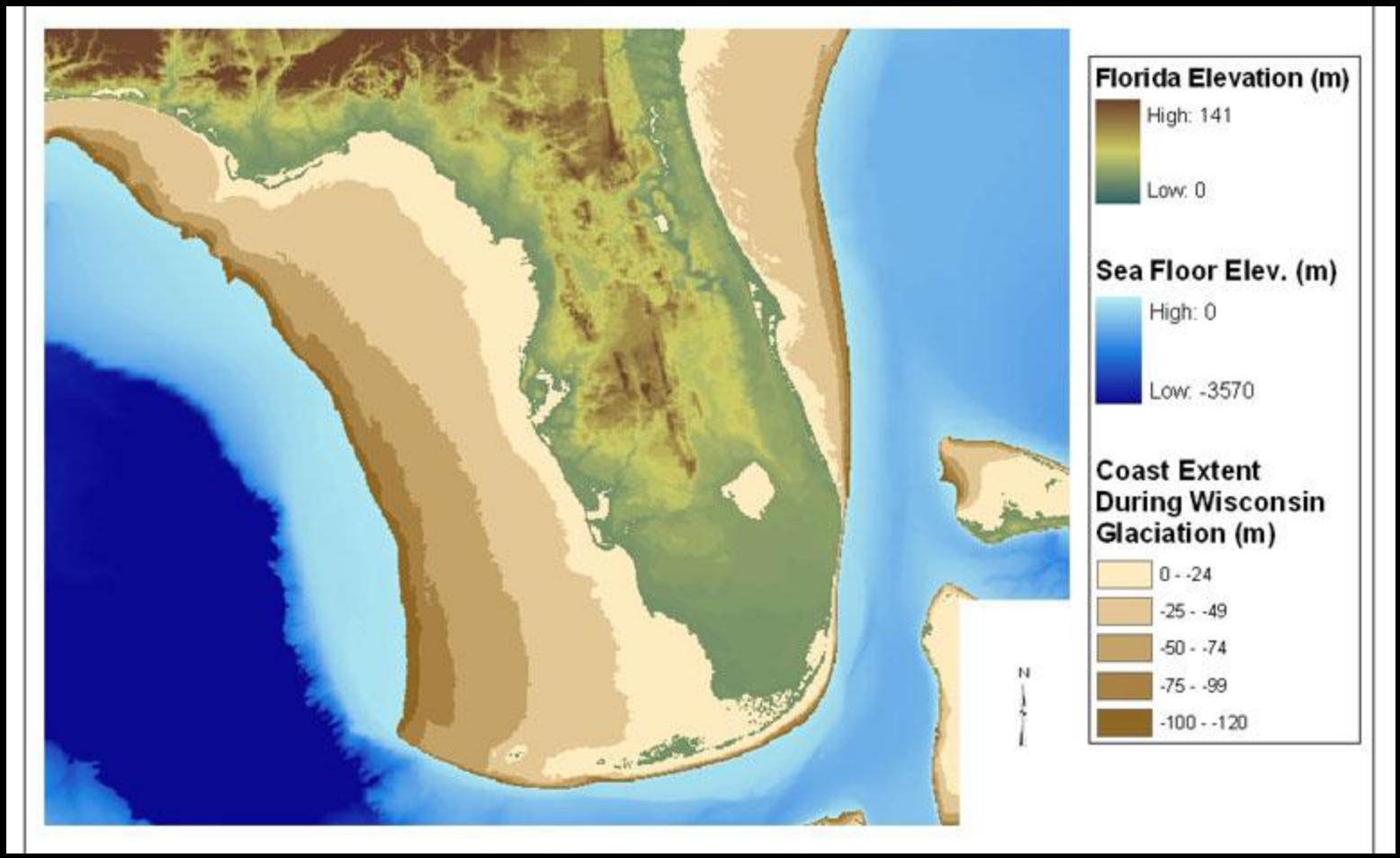
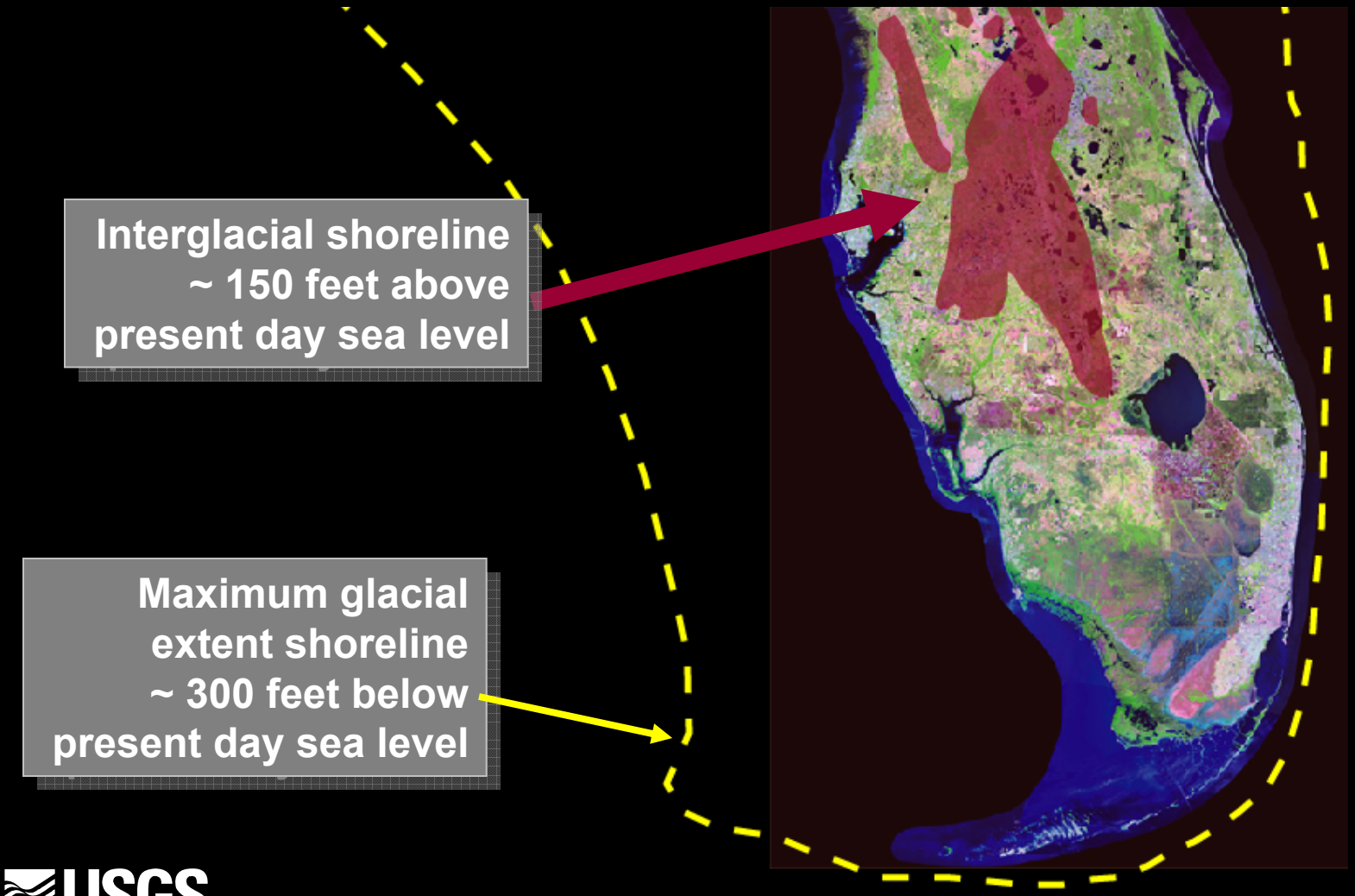
The Last Ice Age



No sedimentary record of shallow marine or estuarine environments.

http://www.emporia.edu/earthsci/student/laird1/Floact2.jpg

Pleistocene Interglacial Time Periods



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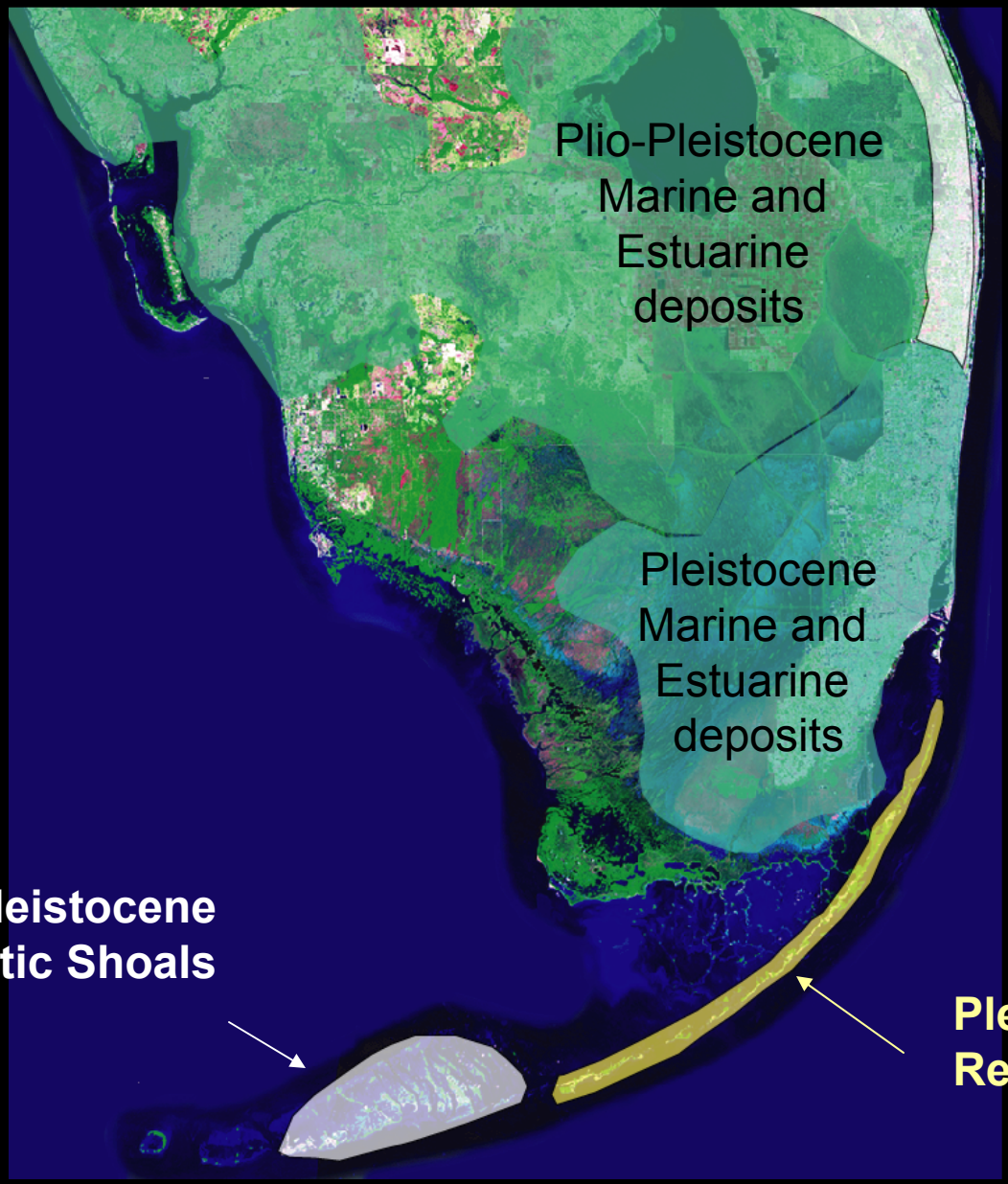
Adapted FGS SP 35

Plio-Pleistocene Time Period



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Pleistocene Reef

Pleistocene Reef exposed at Windley Key Quarry

Modern Reef

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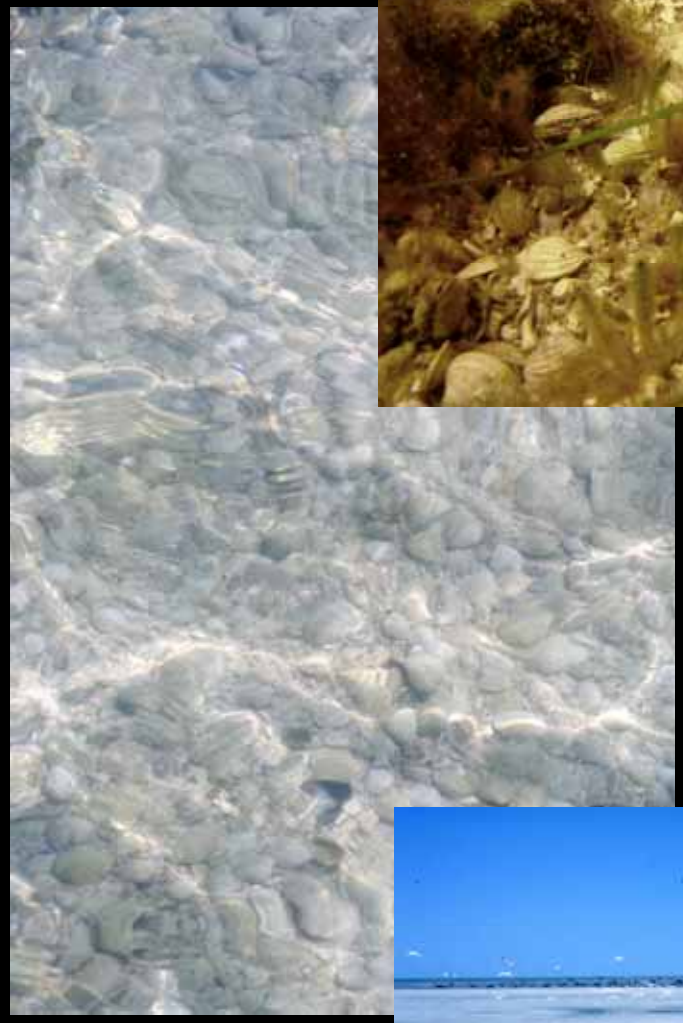
Pliocene

Modern

USGS

Pliocene

Modern



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Pliocene

Modern

USGS

Significance of longer term record of marine deposition:

- South Florida has undergone repeated episodes of submergence and emergence over geologic time as global climate has changed
- During these temporal cycles, the marine environments have shifted spatially, but the basic habitats have remained the same
- Over the last ~ 2 million years, the benthic invertebrate fauna have remained relatively stable – reoccupying the Florida platform during the warm periods

Under natural rates of sea level rise – the habitats and most of the organisms can adapt and/or migrate

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Management questions related to sea level rise:

- How do we set realistic targets and performance measures?
- Can we predict what the effects of sea level rise will be on the environments of the estuaries and the southern glades?
- Does it make sense to re-evaluate these goals on a regular basis as changes occur?

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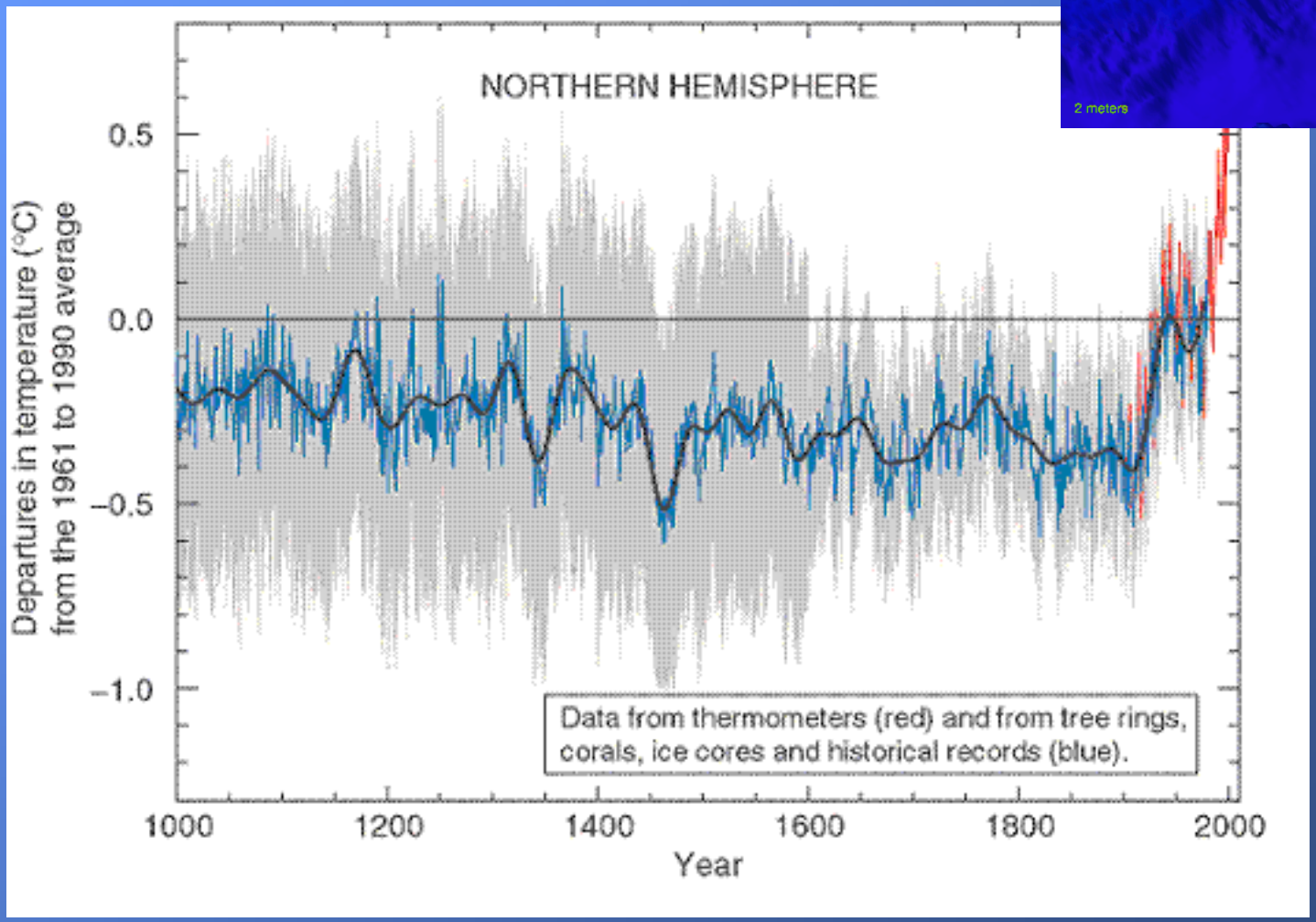
What tools do we have to help us set attainable and sustainable targets and performance measures?



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Linear Regression Model based on Paleoecology Data: 3 Phases

Phase I: Paleoecology

Phase II: Linear Regression Models based on observed instrumental data records from 2 stations in ENP (CP & P33) and from Whipray Basin

- LRMs predict flow based on ppt
- LRMs predict flow based on stage
- LRMs predict stage at other stations
- LRMs predict ppt at other stations

Phase III

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Output: Paleo-based historical estimates

- Daily stage at CP & P33
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Equations predict flow based on Whipray salinity

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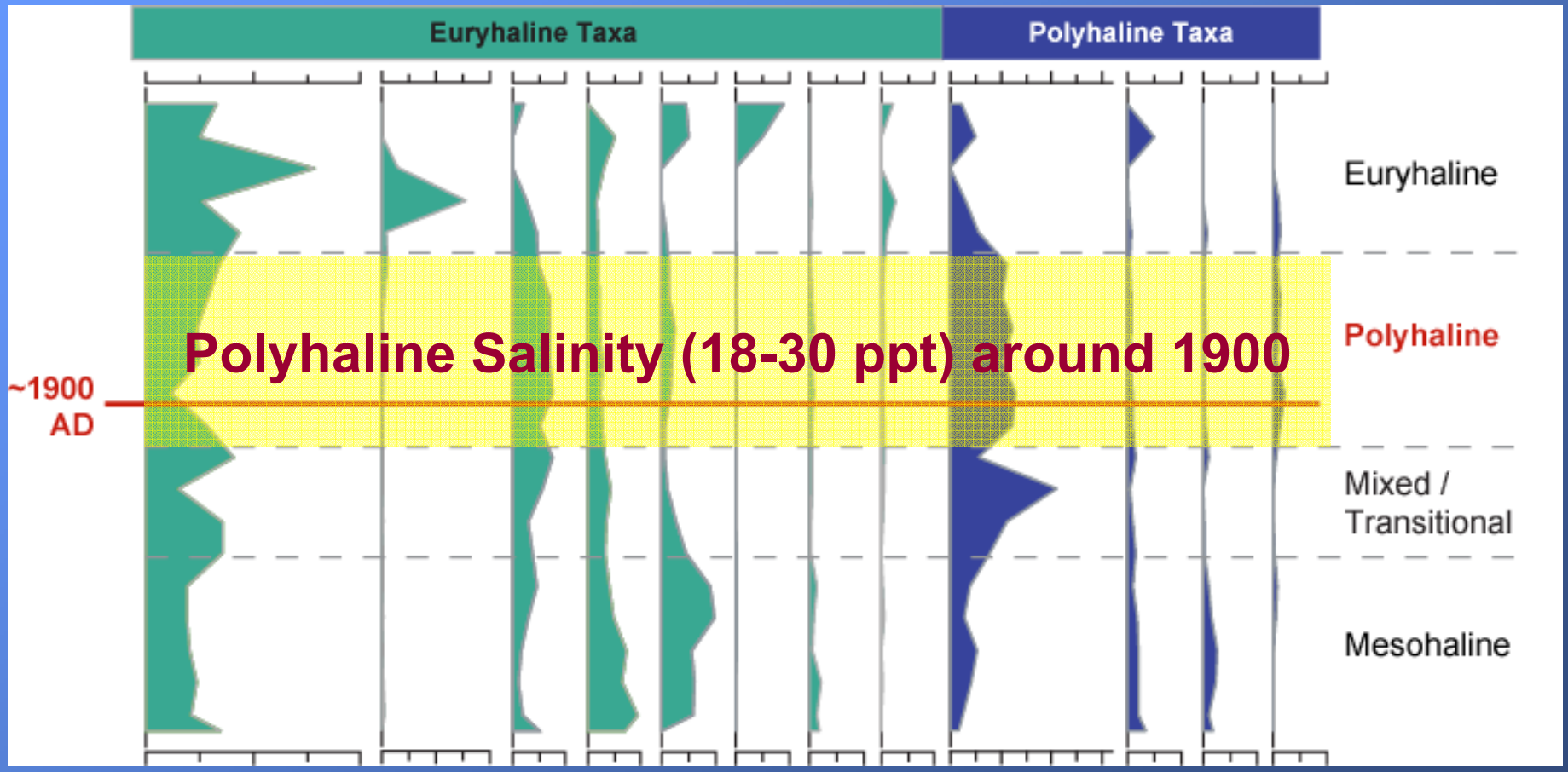
Linear Regression Model: Phase I
Develop Paleo-based Salinity Regime



Percent Abundance of Key Salinity Indicators in Whipray Basin Core

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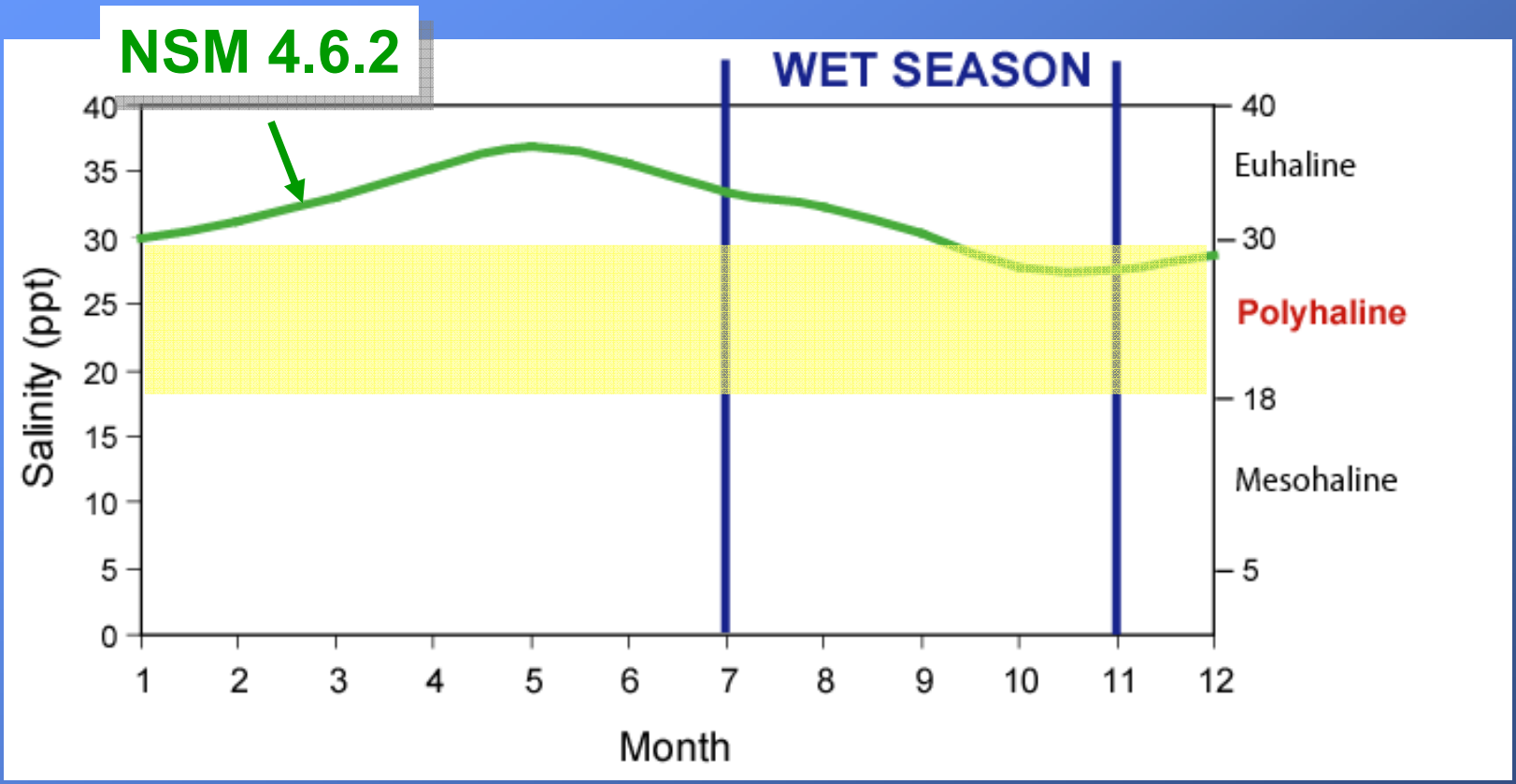
Linear Regression Model: Phase I
Develop Paleo-based Salinity Regime



Determining Offset between Paleo-salinity and NSM

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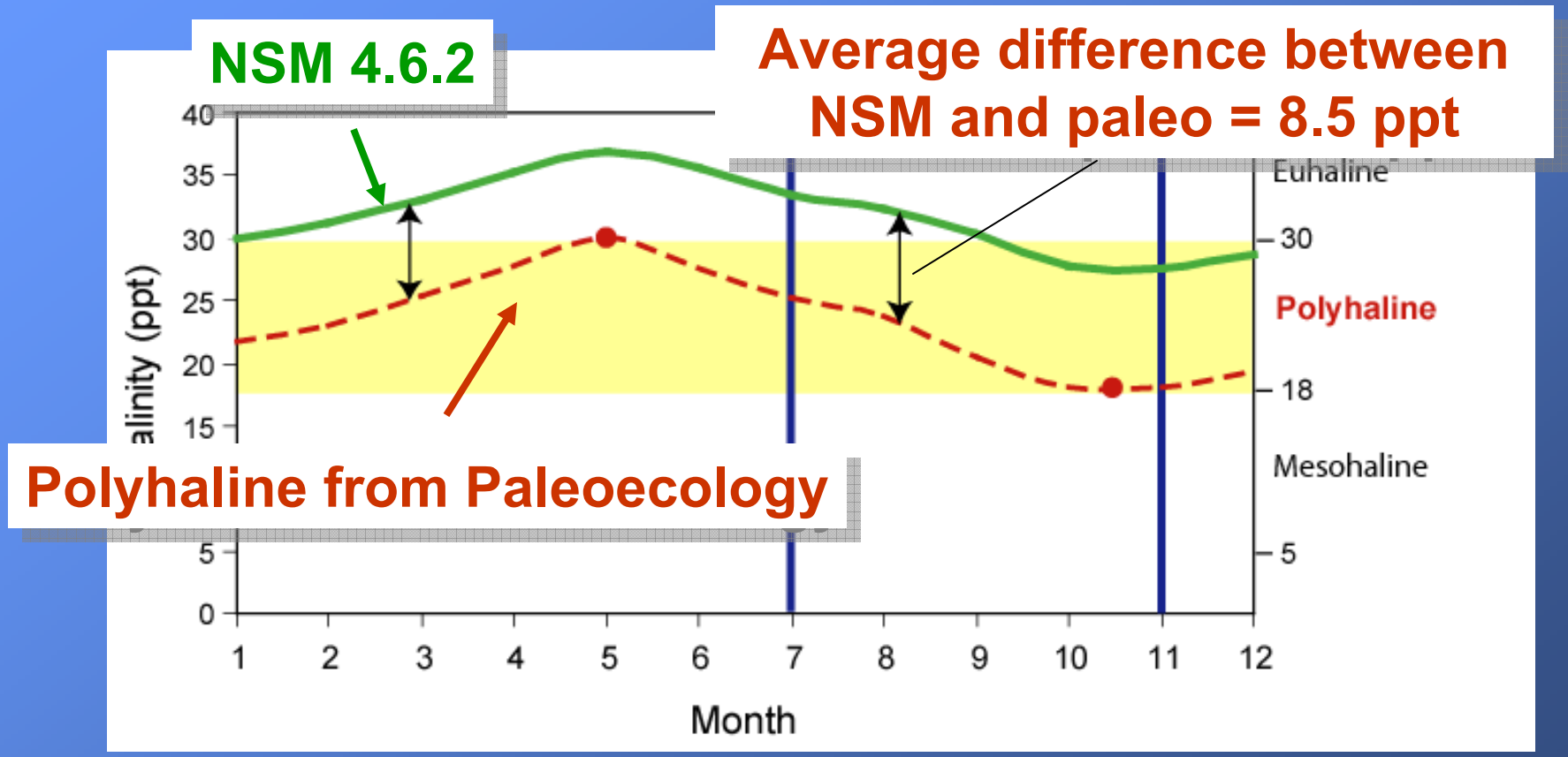
Linear Regression Model: Phase I
Develop Paleo-based Salinity Regime



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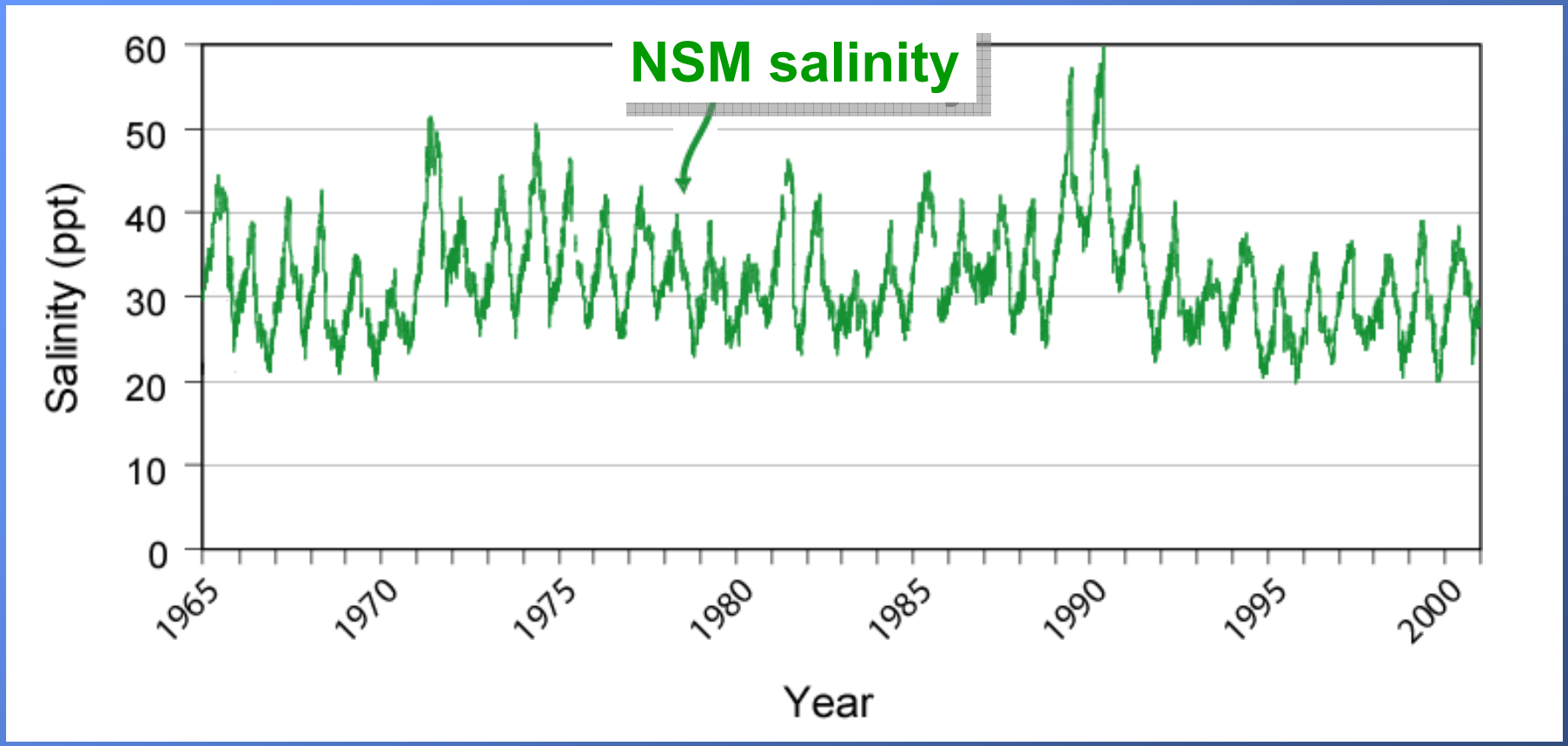

Developing Paleo-based Simulated Time Series
Using Observed Climate Data for 1965 to 2000

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Linear Regression Model: Phase I
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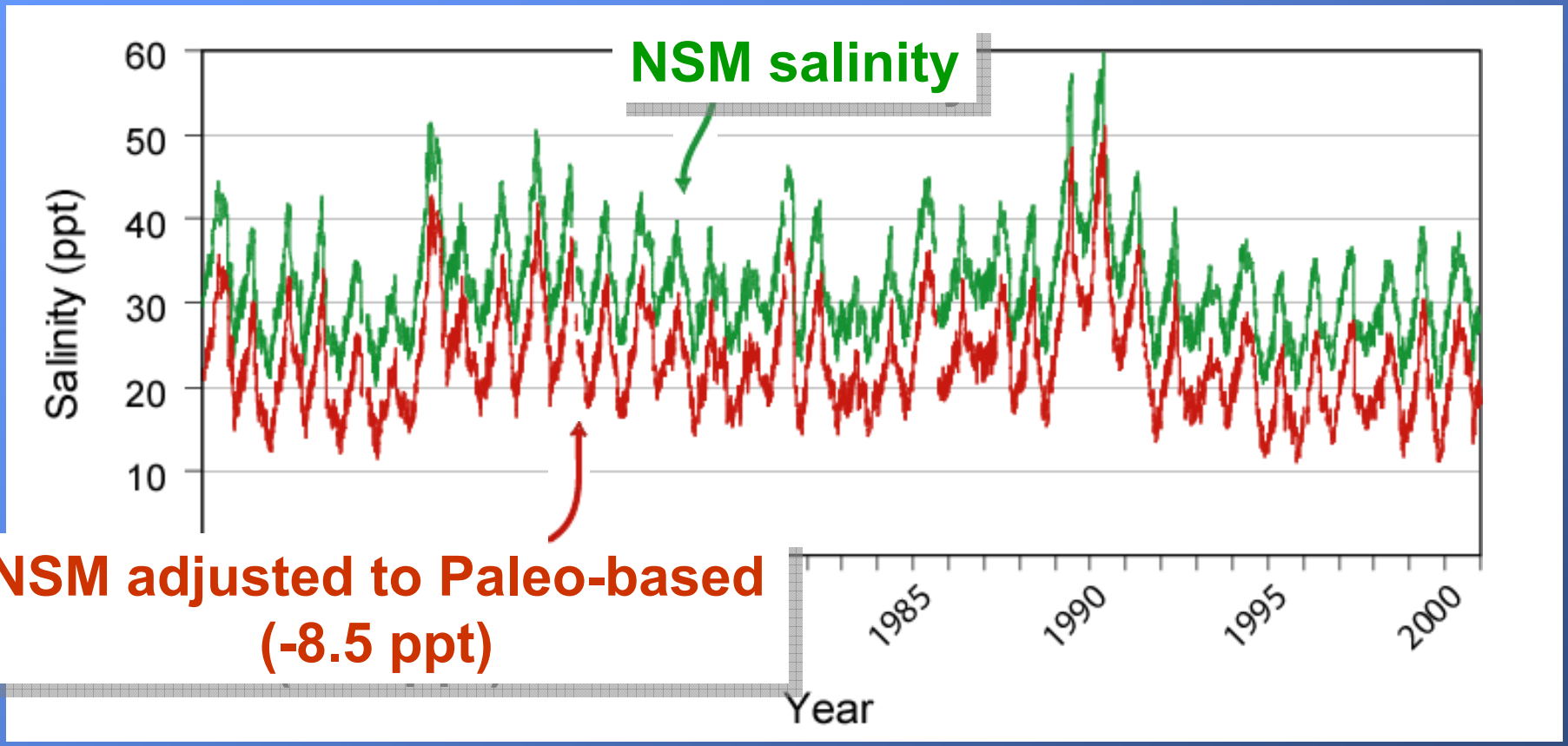

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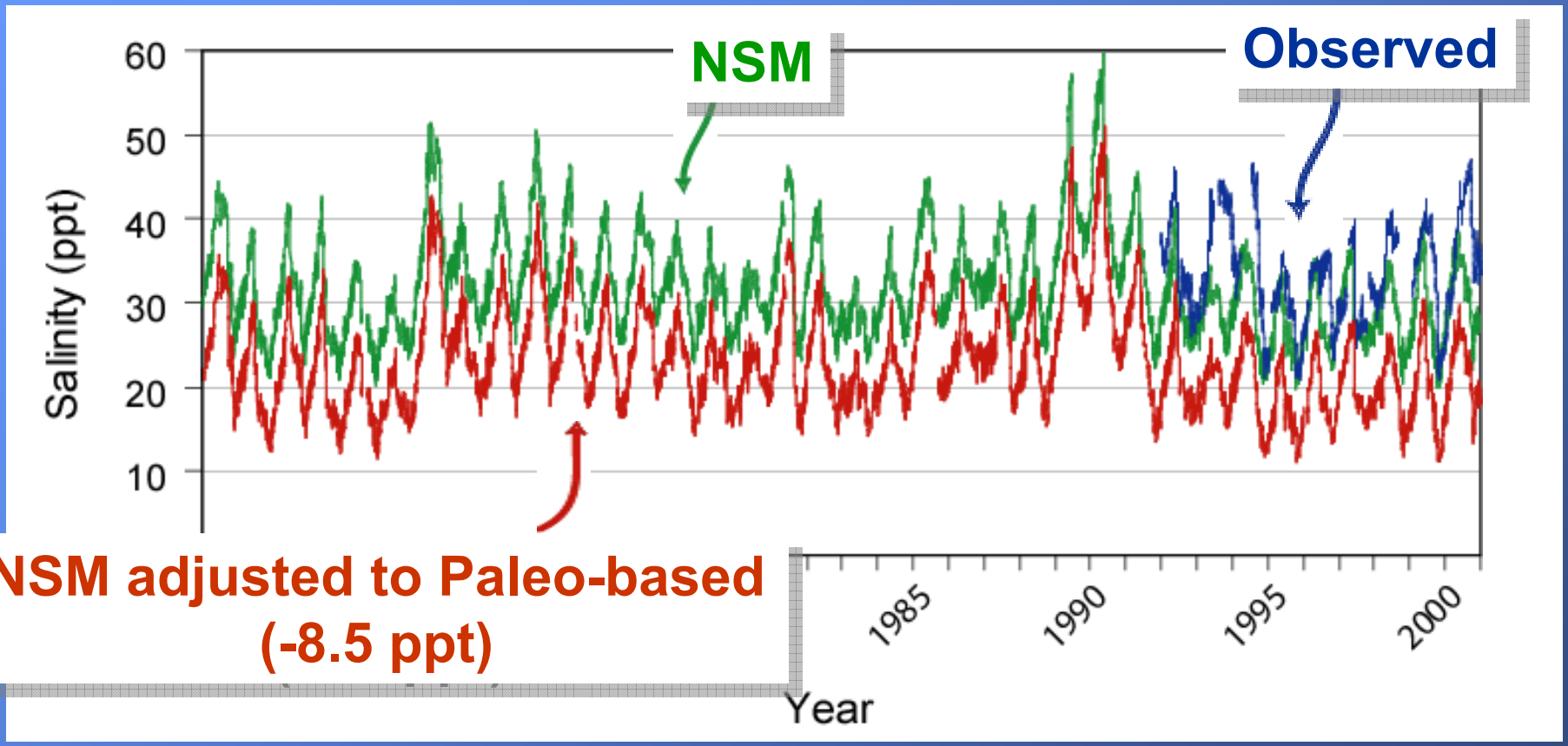

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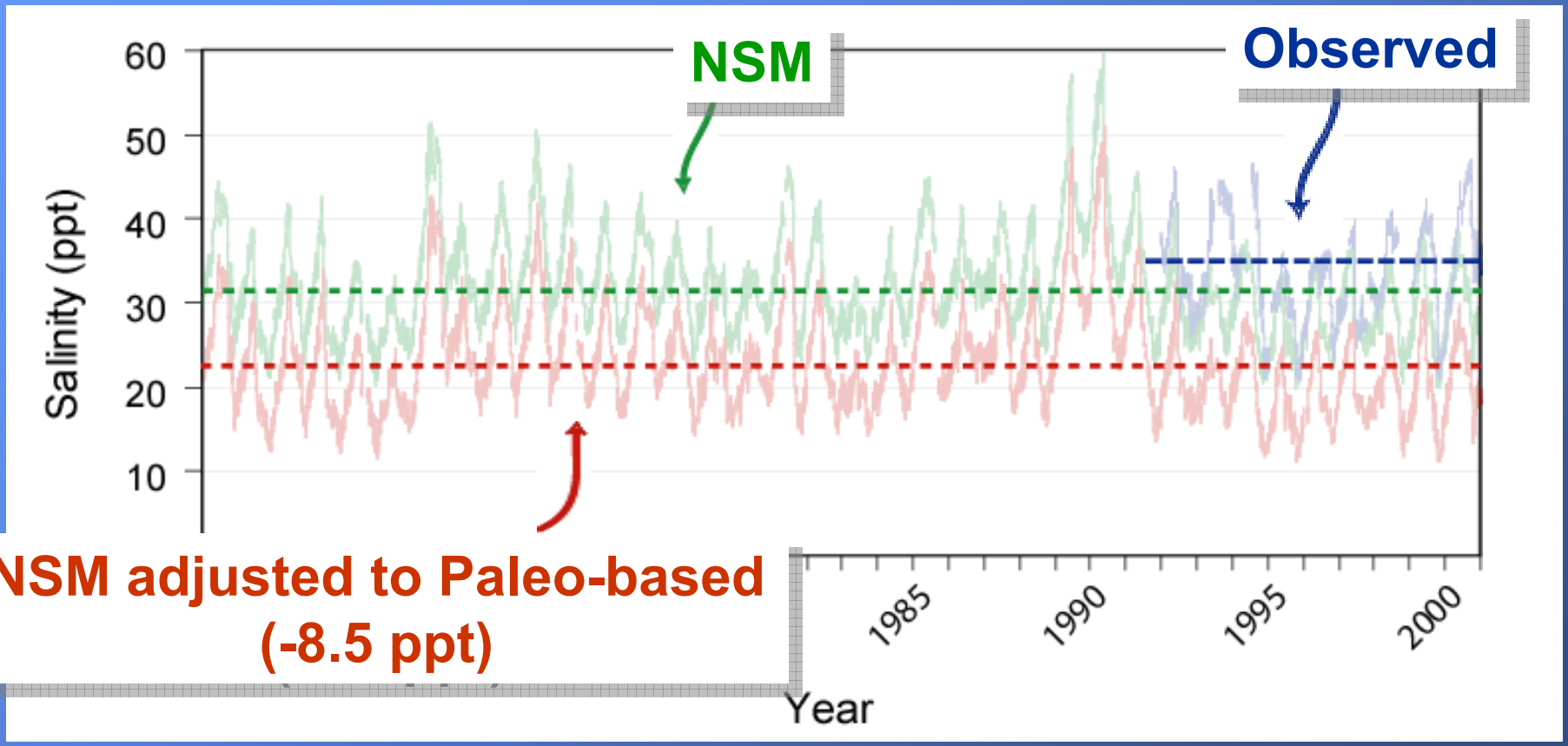

Comparison of Mean daily salinity

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Linear Regression Model: Phase I
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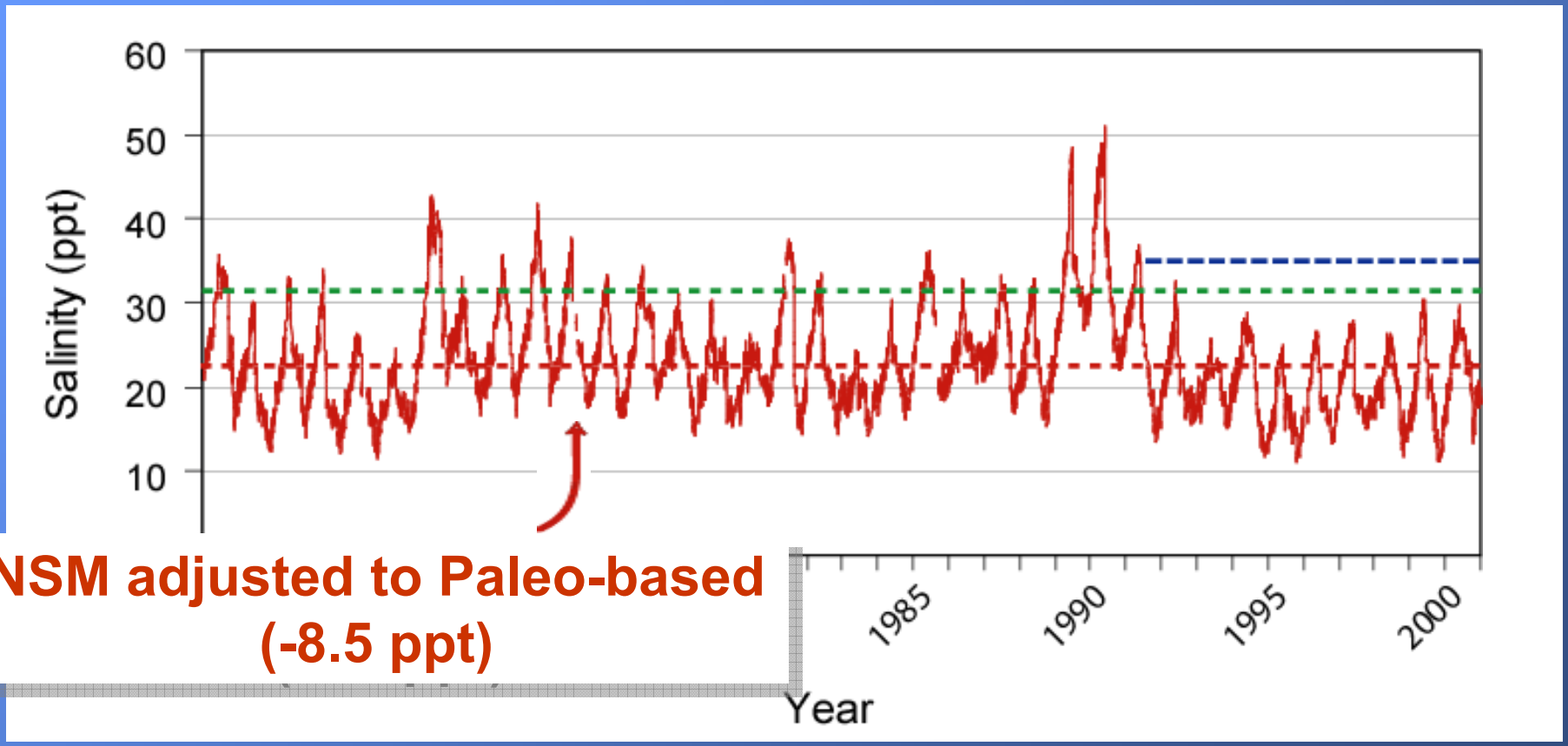

Daily paleo-based salinity regime at Whipray Basin, produced by modifying the NSM-based salinity is output to Linear Regression Models

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Linear Regression Model based on Paleoecology Data: 3 Phases

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- Daily stage at CP & P33
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Equations predict flow based on Whipray salinity

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Linear Regression Model Results: Historical paleo-based stage and flows

Station	Observed Mean	Paleo-based Mean	Difference (paleo-obs)	Paleo: obs
P33 (stage)	1.93	2.48	0.55	1.28
CP (stage)	0.39	0.99	0.6	2.54
SRS (flow)	42.4	115.8	73.4	2.73
TSB (flow)	2.23	8.9	6.67	3.99

Stage

Flows

Stage in m
Flow in m^3/sec

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Linear Regression Model Results: Historical salinity estimates in Florida Bay

Salinity

Florida Bay Station	Observed Average	Paleo Average	Difference (Obs - Paleo)
Peterson Key	35.8	30.5	5.3
Little Rabbit		7.3	7.1
Murray Key		4.8	8.2
Johnson Key		27	8.3
Buoy Key		2.2	10.6
Bob Allen	33.2	21.1	12.1
Duck Key	29	16.8	12.2
Joe Bay	15.36	2.73	12.63
Butternut Key	31.3	17.7	13.6
Little Madeira Bay	23.83	8.2	15.63
Garfield Bight	28.9	10.3	18.6
Terrapin Bay	23.6	3.5	20.1

Results show that if we are restoring to a pre-1900 condition – need to lower ppt by 12-20 ppt in nearshore areas

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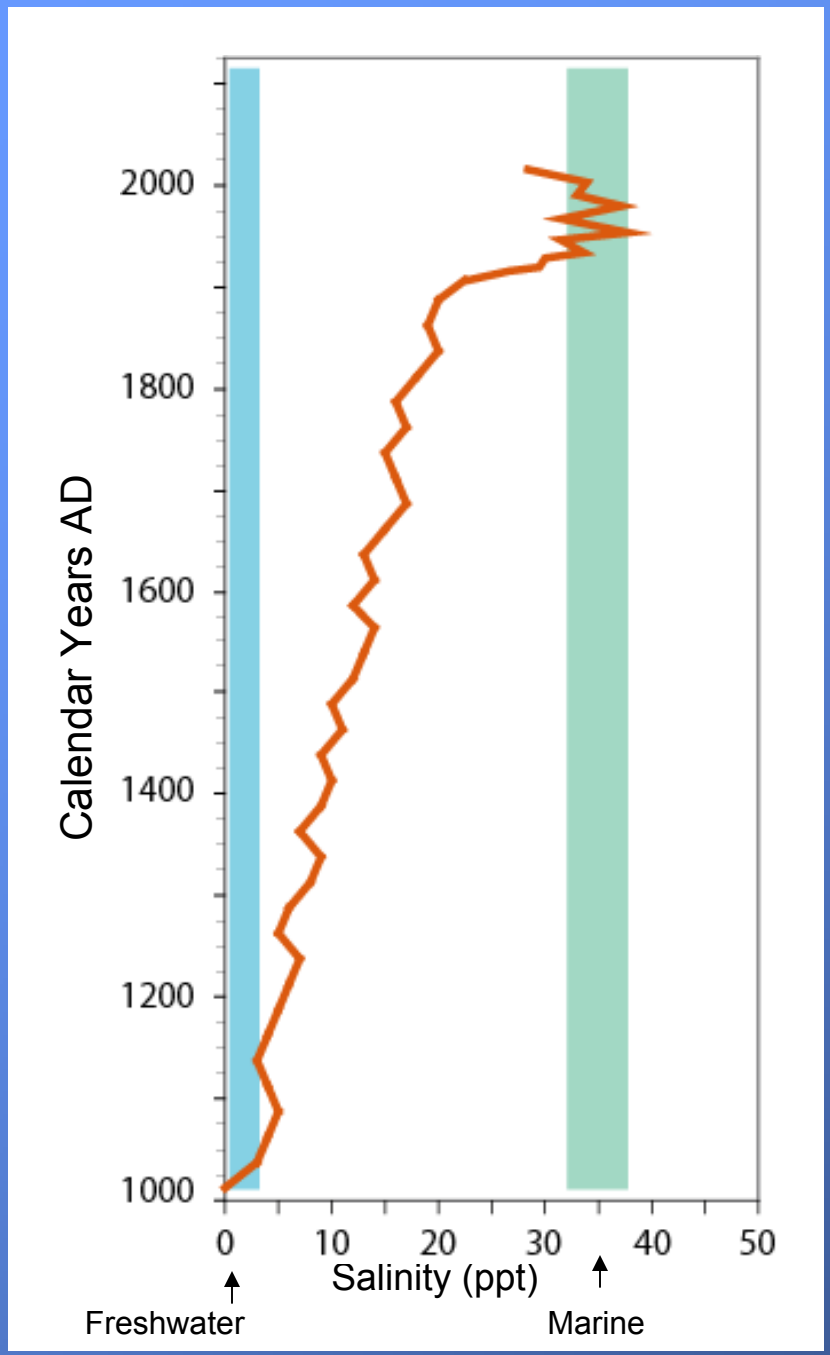

Setting Attainable Restoration Performance Measures: Accounting for Sea-Level Rise

- Orange line represents hypothetical salinity data derived from analyses of sediment cores
- From 1000 AD to approximately 1900 AD data show gradual increase in salinity that might occur during sea level rise

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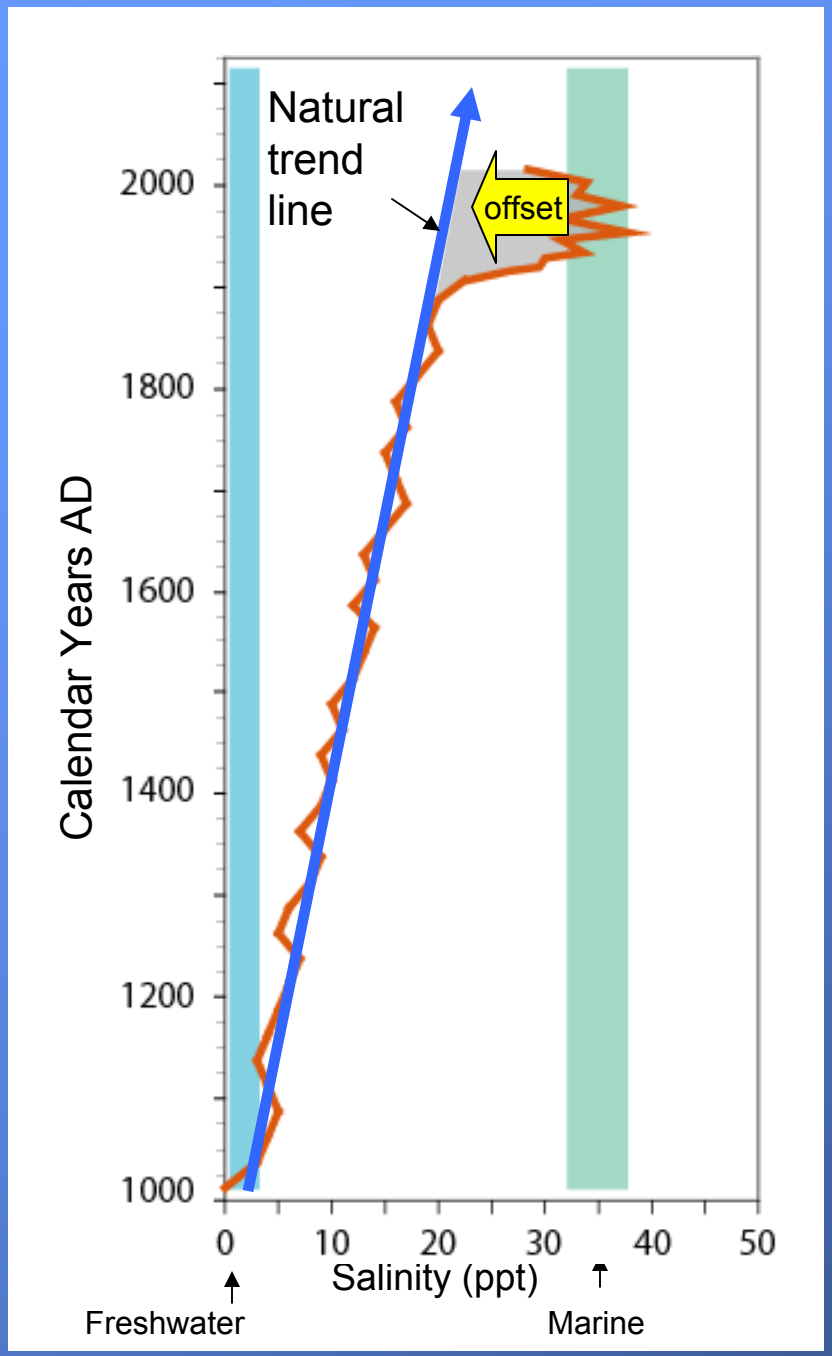

Setting Attainable Restoration Performance Measures: Accounting for Sea-Level Rise

- Blue line highlights the trend in increasing salinity due to rising sea level
- Gray area represents the offset from the natural trend – can assume this is probably an anthropogenic effect

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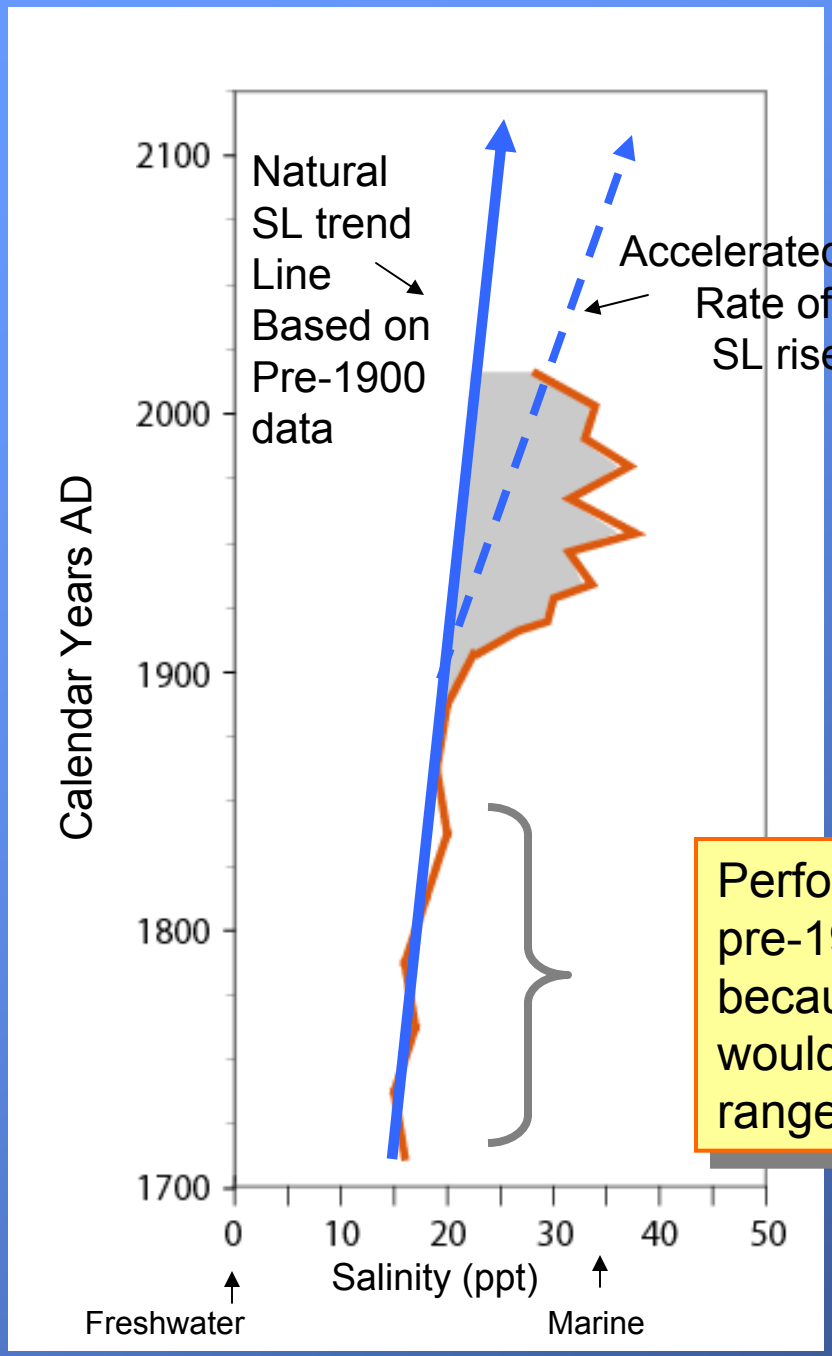
Setting Attainable Restoration Performance Measures: Accounting for Sea-Level Rise



Performance measures that set targets at pre-1900 salinities may not be attainable because sea level rise and other factors would make it difficult to return to this salinity range

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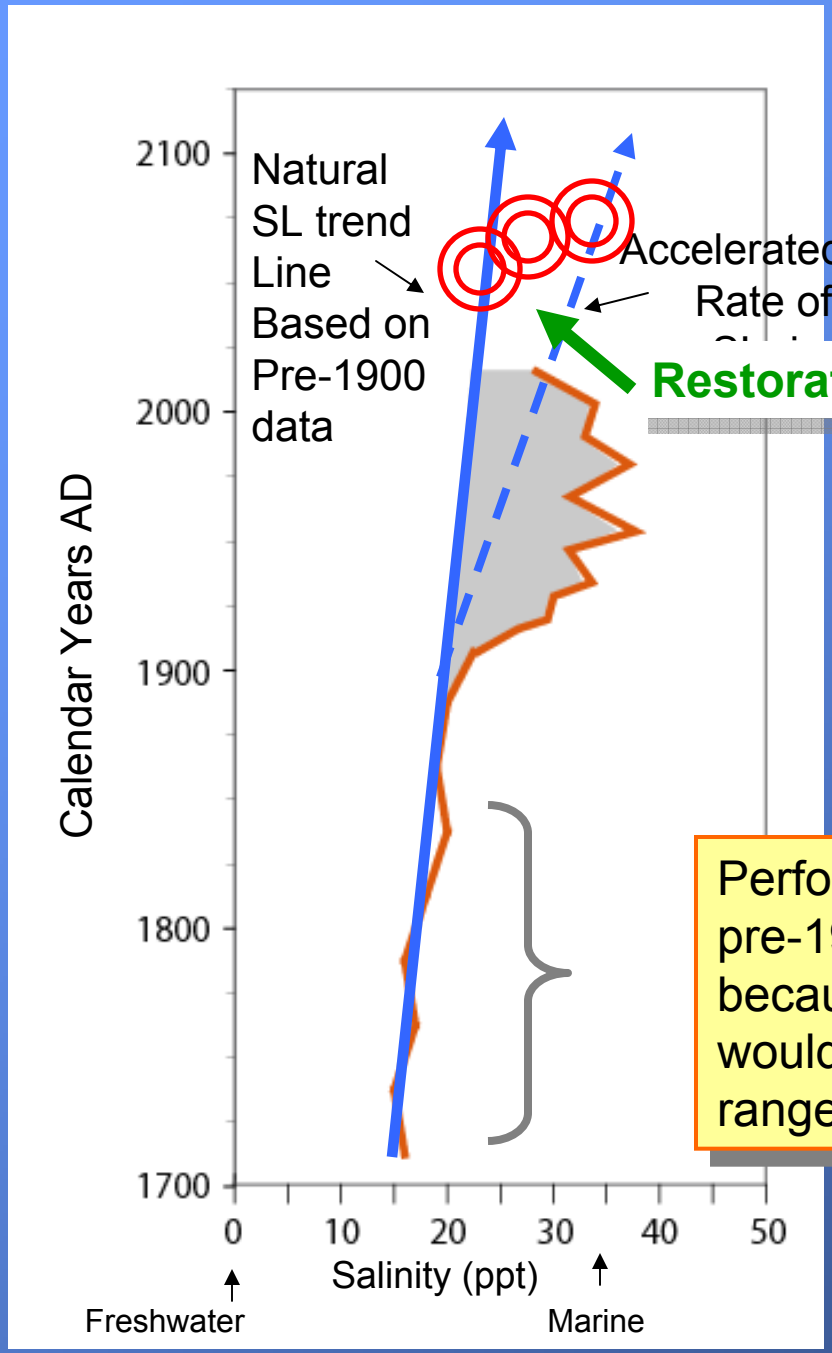
Setting Attainable Restoration Performance Measures: Accounting for Sea-Level Rise



Performance measures could set targets at intersect point along the natural trend line or adjust as SL rises

Performance measures that set targets at pre-1900 salinities may not be attainable because sea level rise and other factors would make it difficult to return to this salinity range

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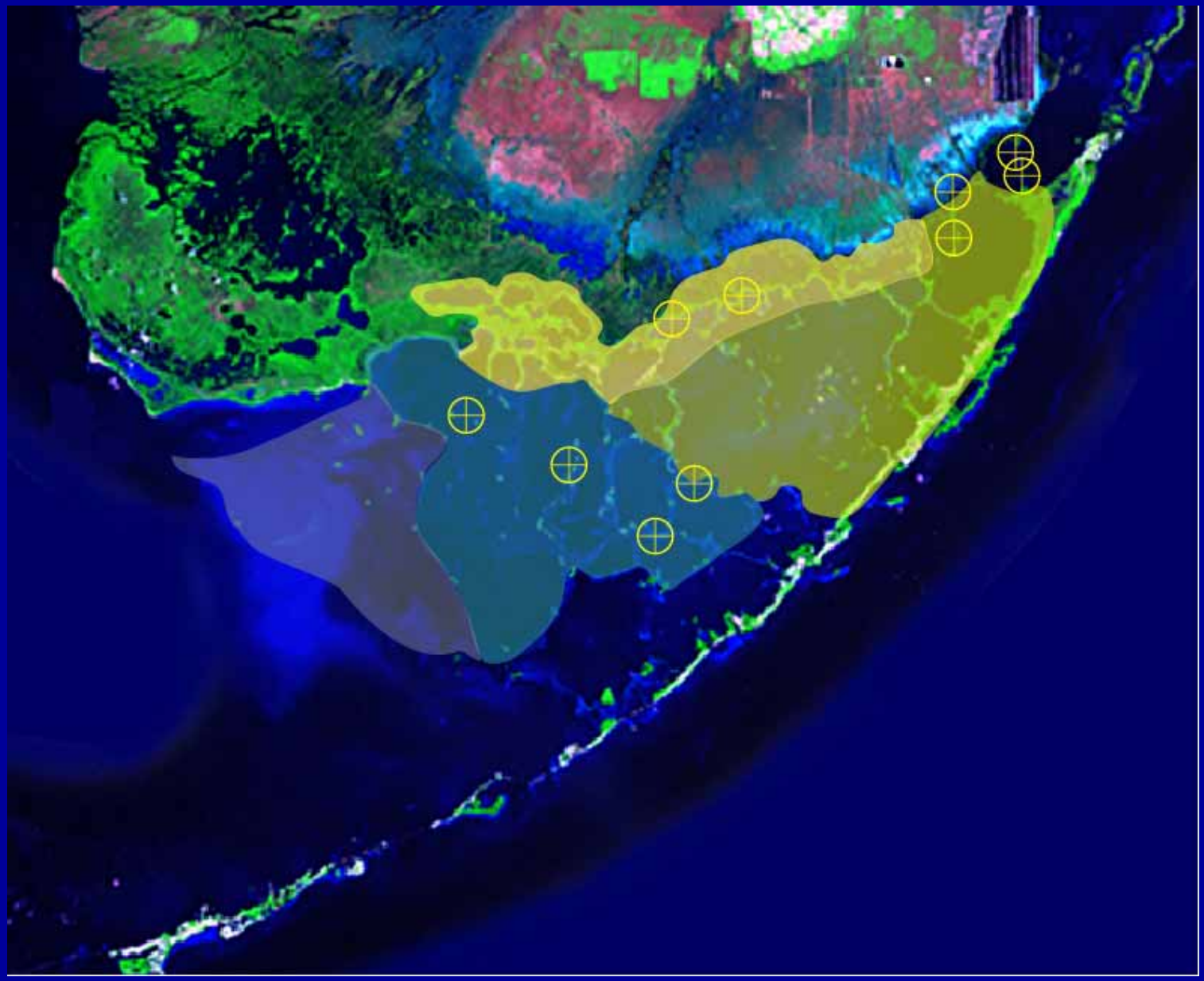

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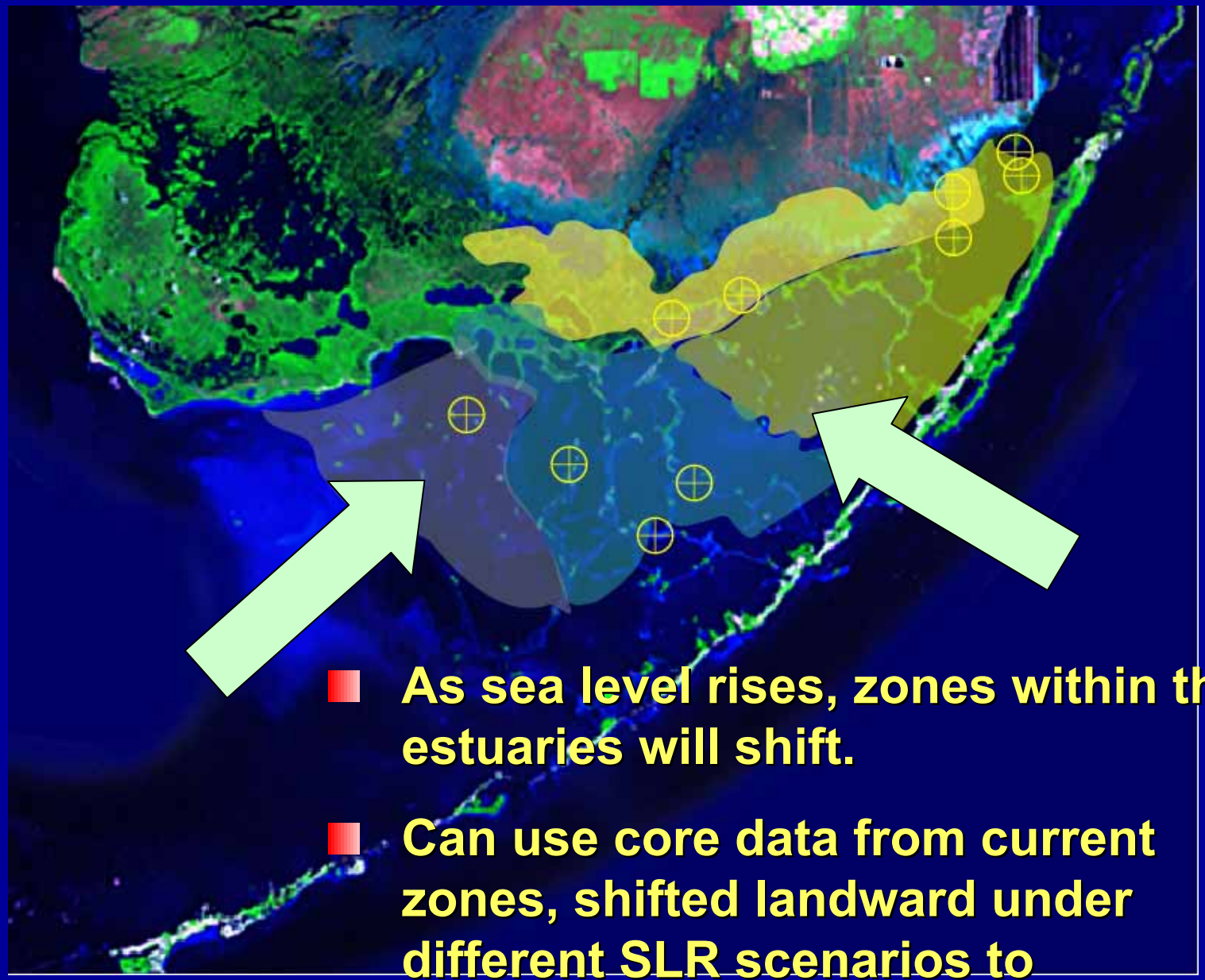

- As sea level rises, zones within the estuaries will shift.
- Can use core data from current zones, shifted landward under different SLR scenarios to determine realistic PMs and targets

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Things to Consider

- Sea level has risen and fallen many times over the past and it will continue to do so – this is natural and expected
- Under the natural conditions of change organisms migrate, adapt or go extinct – this is natural and expected

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Things to Consider

HOWEVER – Humans have altered the natural system

- **Global climate changing at an unprecedented rate – this is outside the scope of CERP**
  - **Adapt restoration goals to incorporate current trajectory of change**
  - **DO NOT consider restoration as a return to past conditions**
- **We know that given natural rates of sea level rise and climate change – the estuarine and marine systems have survived the last 2 million + years**
  - **Unknown – how will they respond to an escalated rates of sea level rise and climate change**

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Restoration of the Marine and Estuarine Systems

What we can do –

- Try to restore the natural resilience of the system
  - Restore the natural seasonality – to hopefully return to the natural zonations that existed in the pre-drainage estuaries
  - Reduce anthropogenic factors under our control – pollution, nutrients, over-harvesting, introduction of invasives

- Use LRMs linked to Paleoecologic data as adaptive management tools to periodically adjust the PMs and targets as the system changes (SL, climate, etc)

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Thank You!