Long Island Sound: Relative Sea level Rise over the last Millennium

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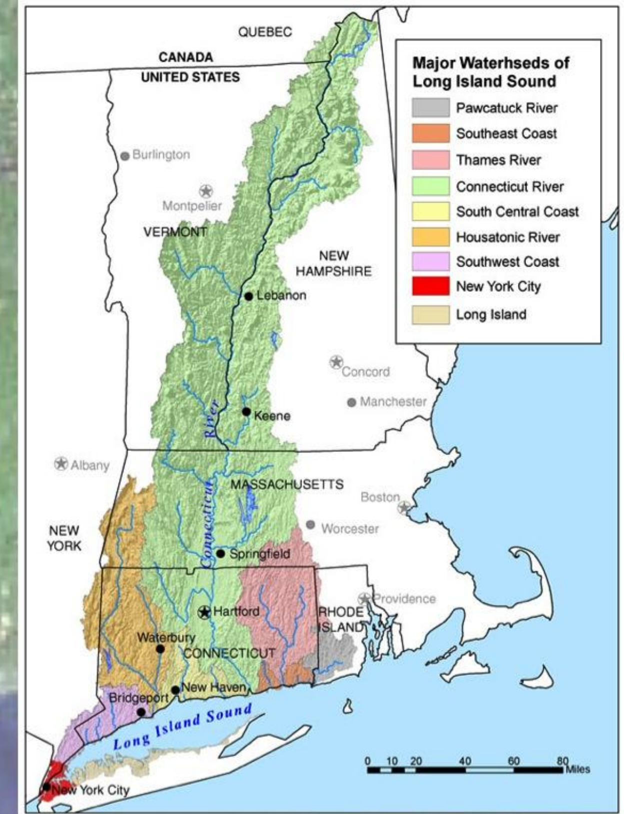
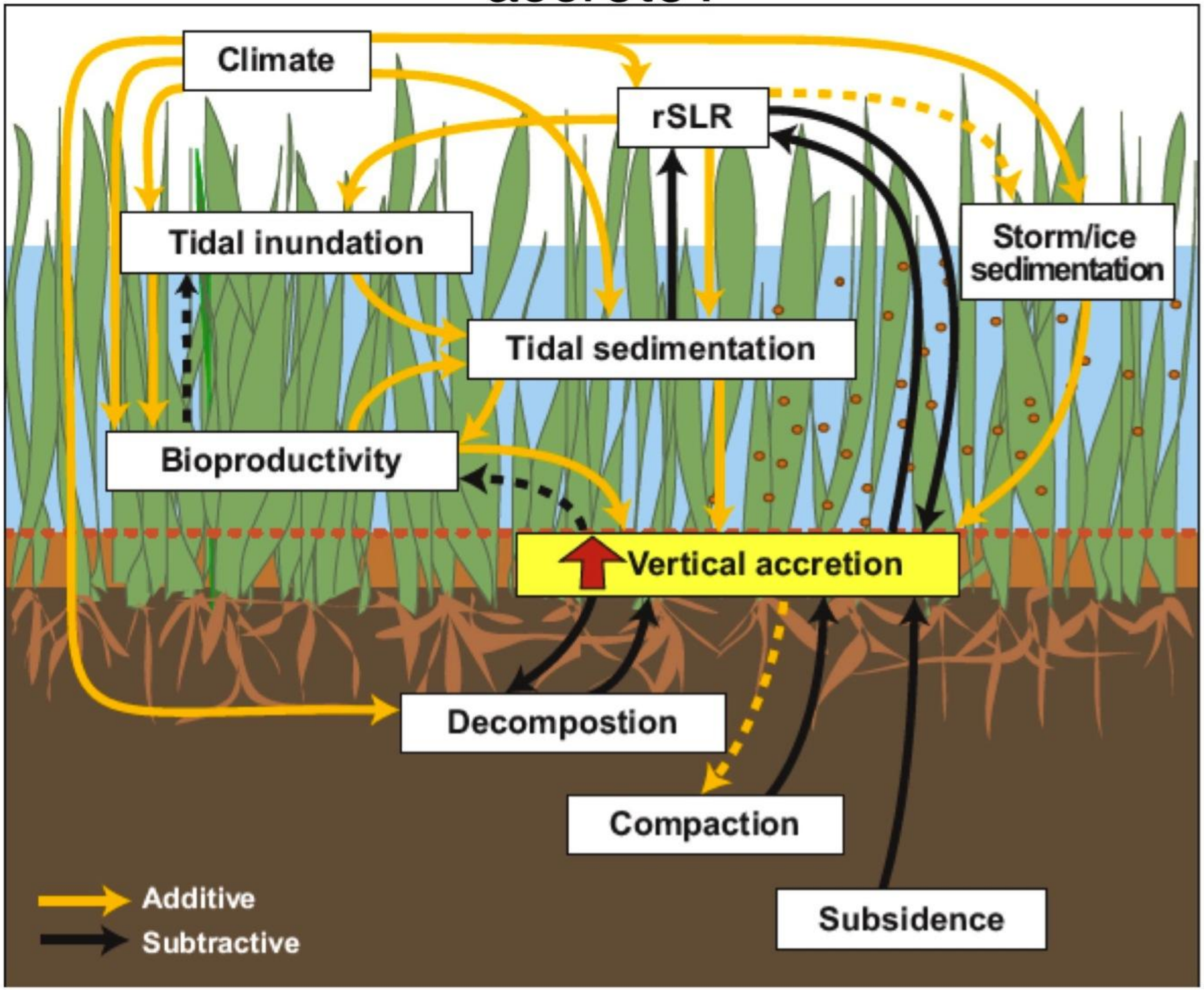
LUX ET VERITAS

Long Island Sound

- **Great American Waters**
- **Coastal salt marshes**: what will happen with increased rates of sea level rise?
- **Pre-historical records**:
  - What was variability in rates of sea level rise?
  - Did marshes ‘keep up’, i.e. did the marsh surface accrete upwards as fast as the rate of relative sea level rise?

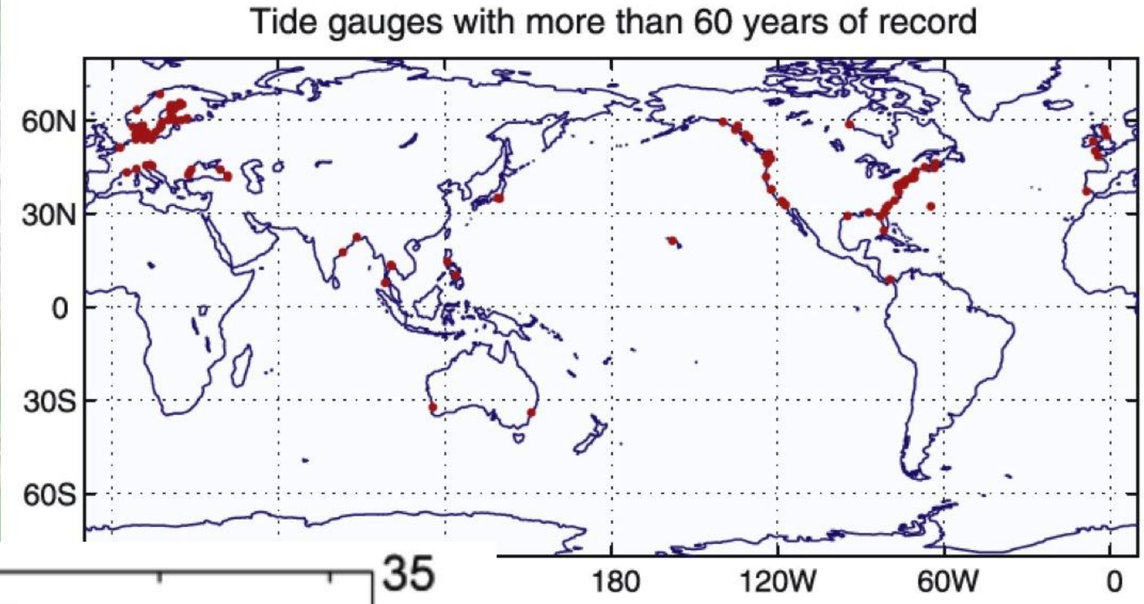


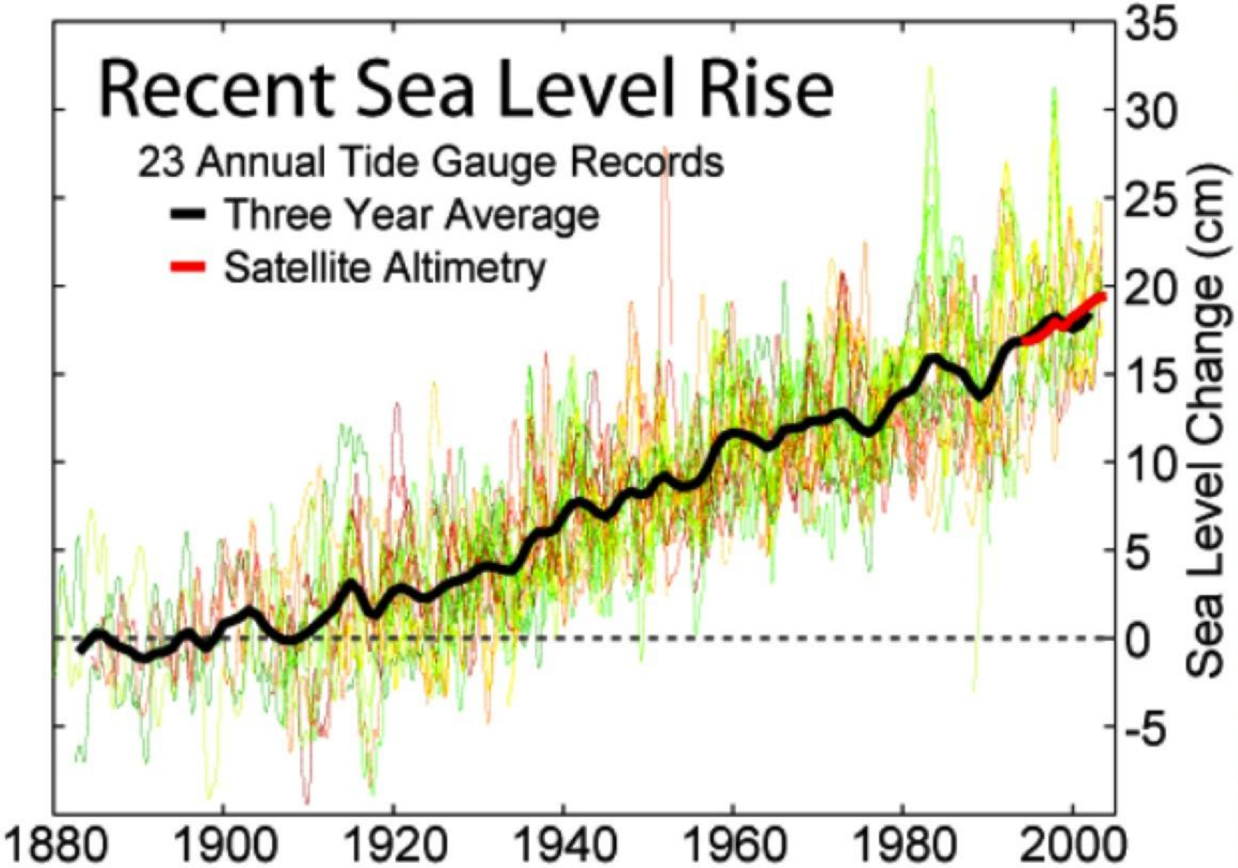
What determines how fast salt marsh sediments accrete?



Fitzgerald et al., 2008

- **Satellite data: ~ 2.8 mm/yr + 0.4**
- **Tide gauges (few stations: ~ 100 yrs)**
- **1880-2000 (120 yrs - ~ 18 cm): ~ 1.5 mm/yr**

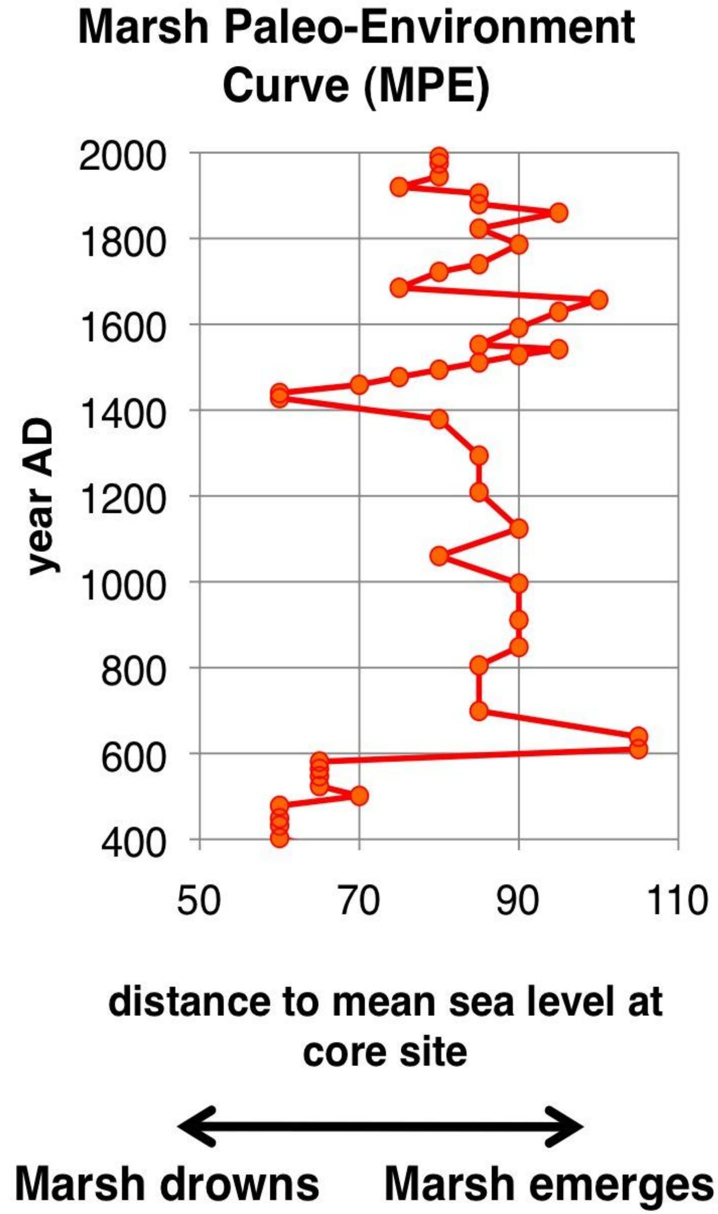


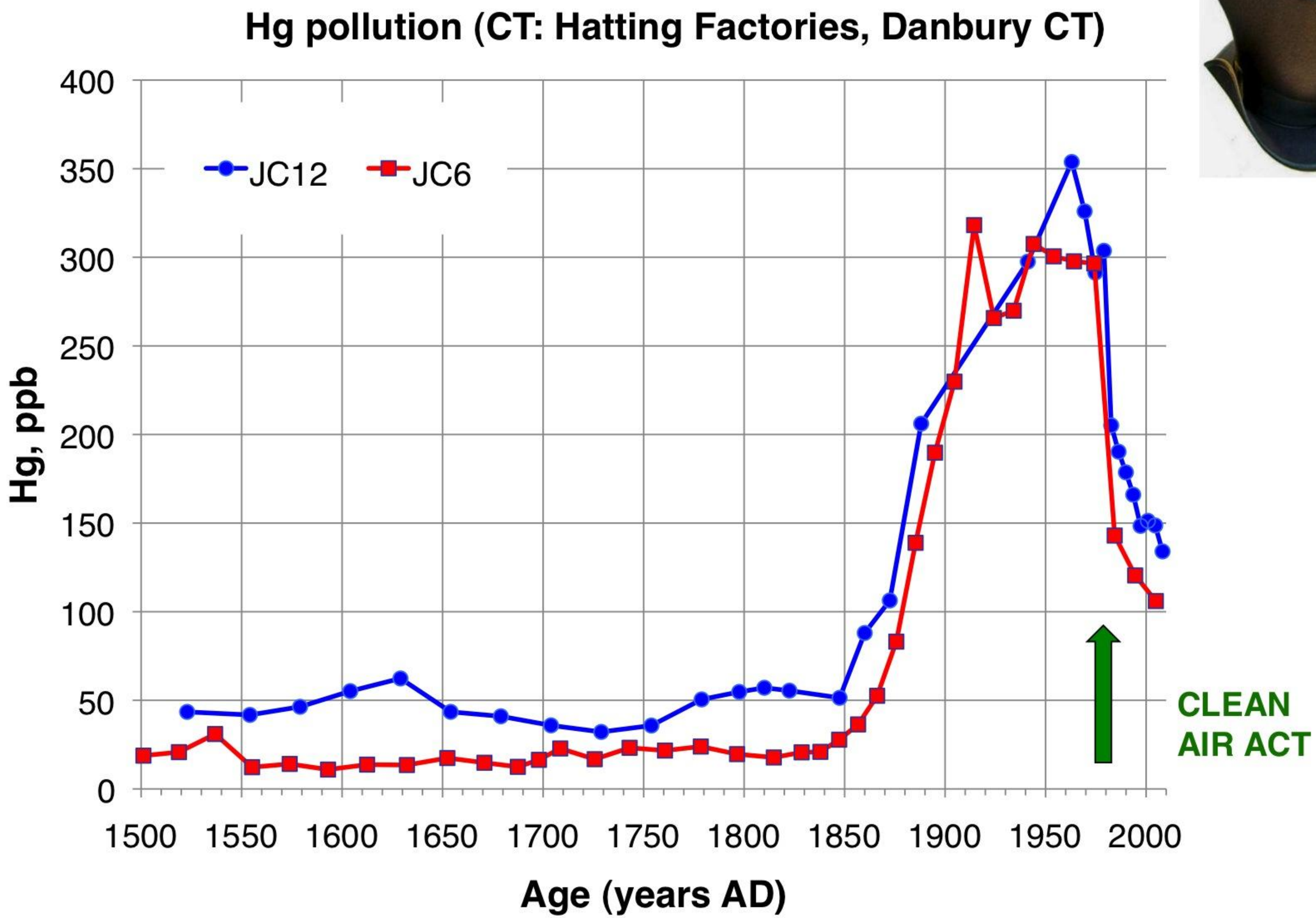


Rates of sea level rise - last century:
Tide gauges
How to go back in time to before tide gauges?
USE SALT MARSH DEPOSITS

Salt marsh deposits

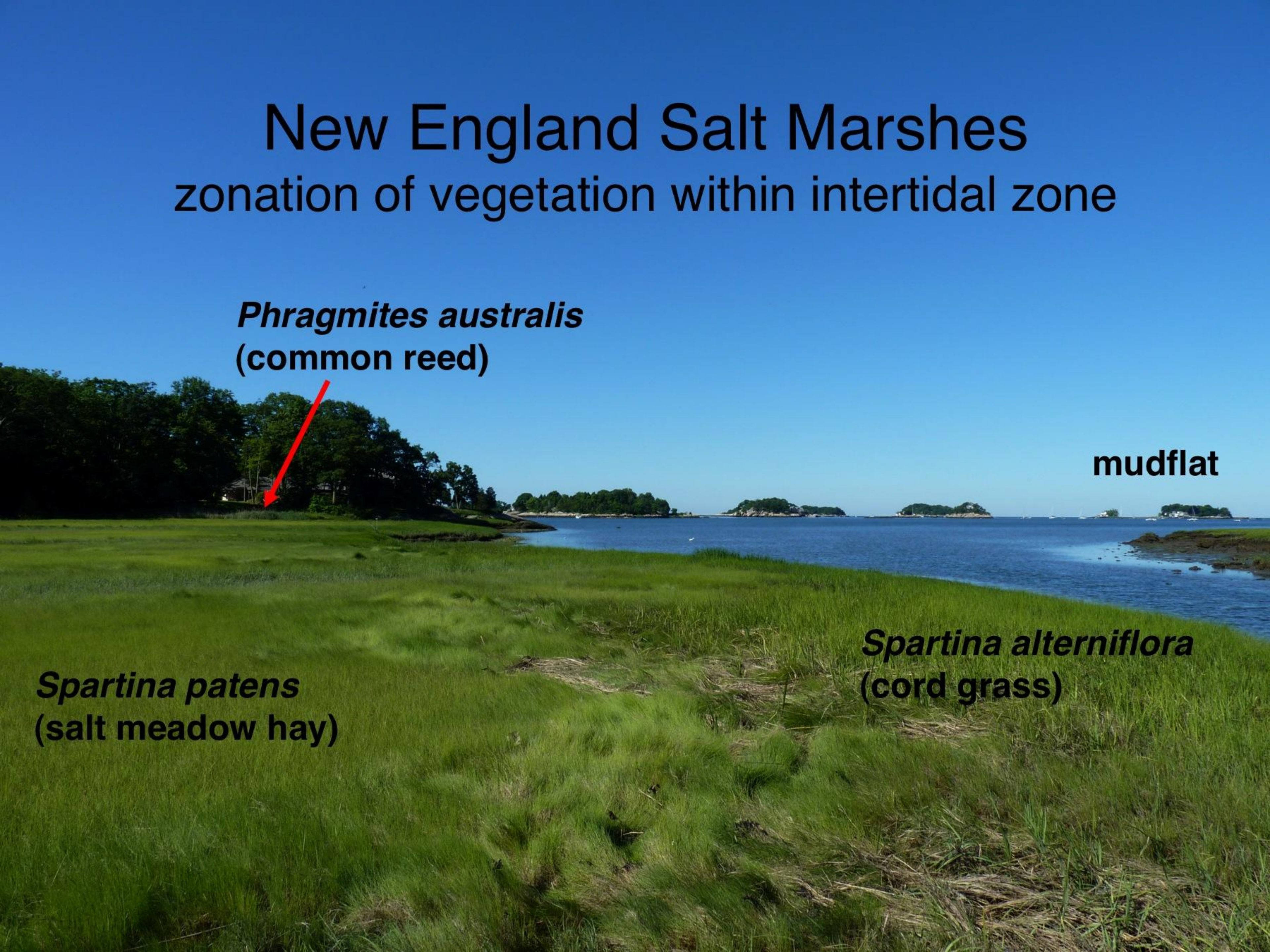
- **Use sediments and/or microfossils in these deposits to reconstruct environments of the past**
- **<u>Importance for ecosystem reconstruction</u>: Reconstruct to what? How variable were past environments? On what time scales?**



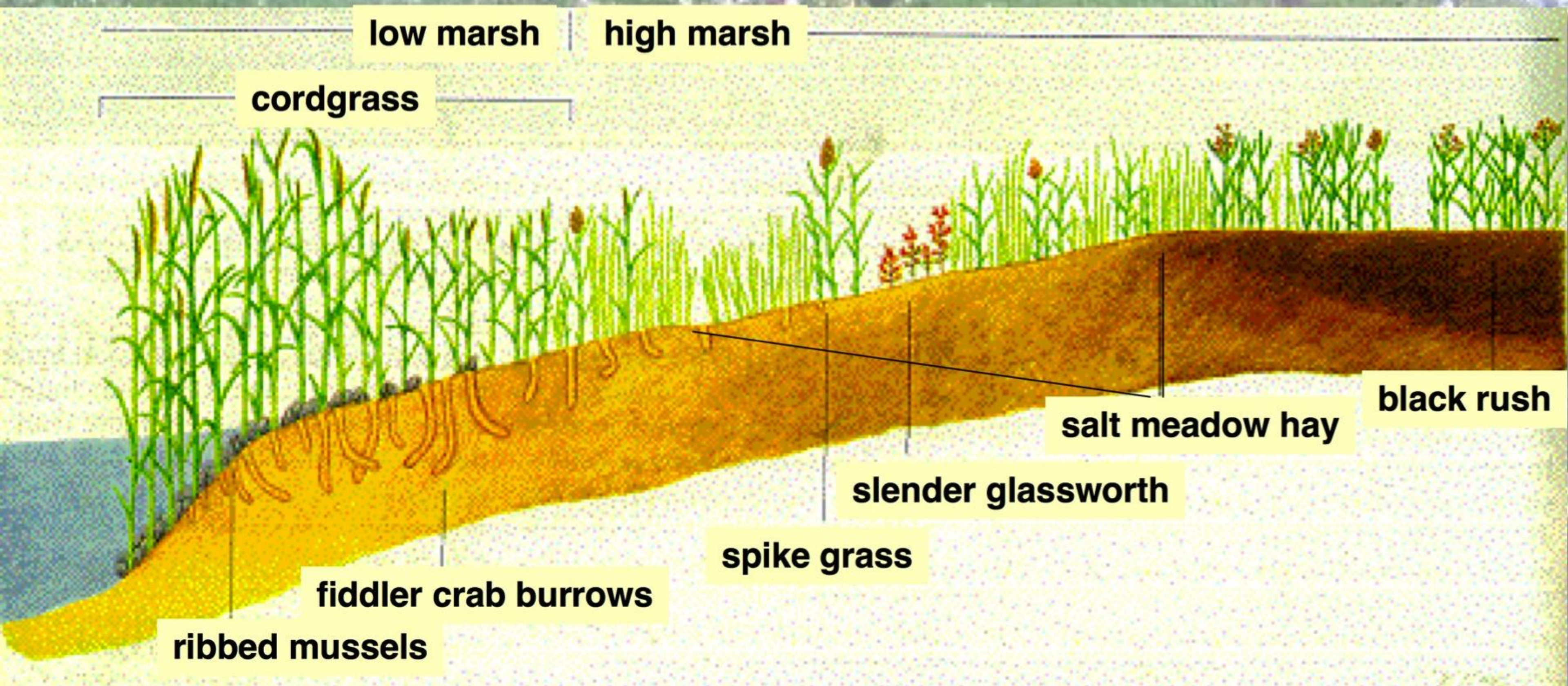

Hg pollution (CT: Hatting Factories, Danbury CT)
JC12
JC6
Hg, ppb
400
350
300
250
200
150
100
50
0
1500
1550
1600
1650
1700
1750
1800
1850
1900
1950
2000
Age (years AD)
CLEAN
AIR ACT

RATES of RELATIVE SEA LEVEL RISE

- **Question**: how to extract detailed records of relative sea level rise (RSLR) from salt marshes?
- **Answer**: through paleo-environmental analyses of dated salt marsh sediment sequences (peat)


New England Salt Marshes
zonation of vegetation within intertidal zone
Phragmites australis
(common reed)
mudflat
Spartina alterniflora
(cord grass)
Spartina patens
(salt meadow hay)

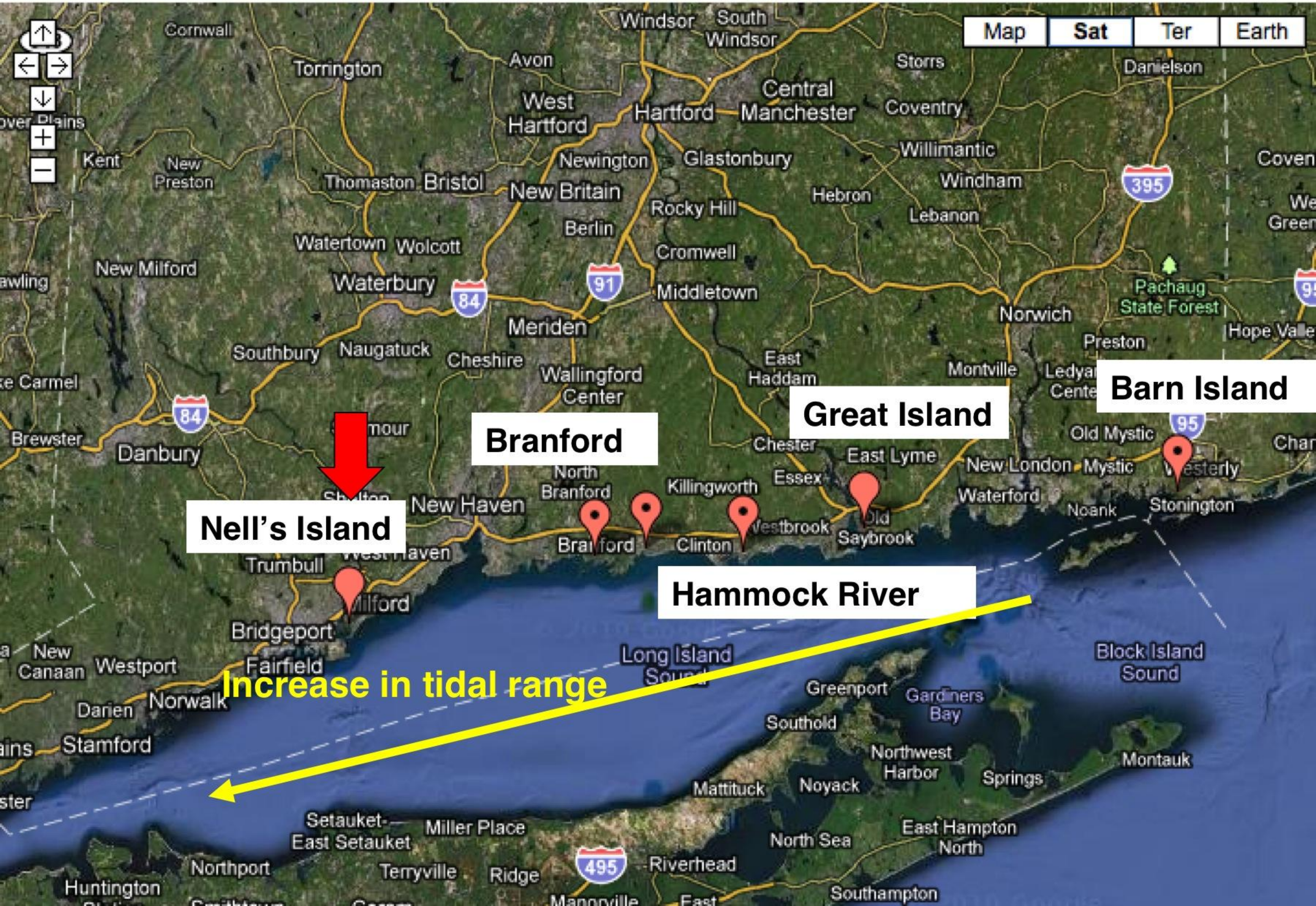
Marshes: zoned parallel to Mean Sea Level
(vegetation)
* Benthic foraminifera (unicellular, eukaryotes)
* Derive environment of deposition of peat.



METHODS

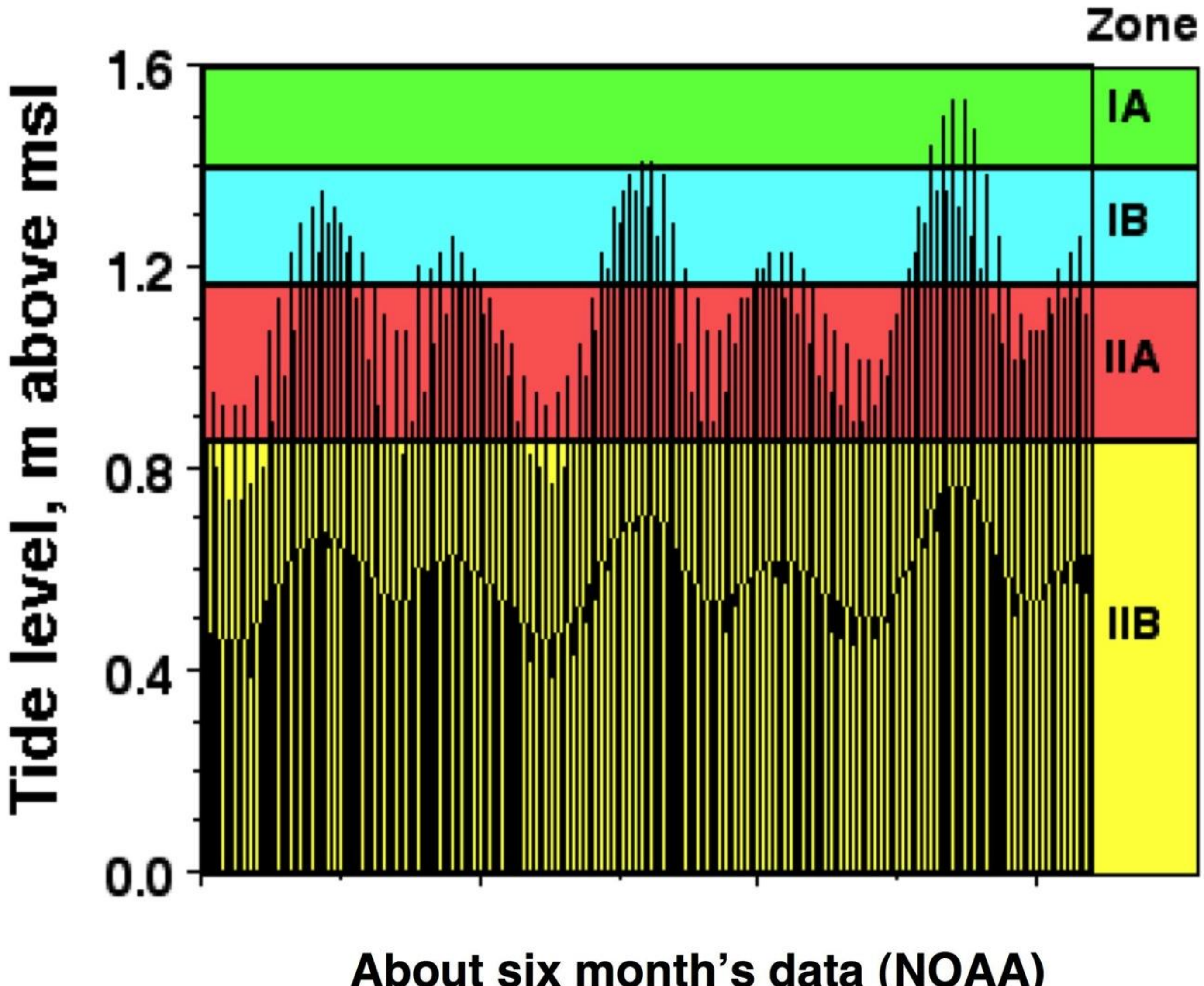
1. Take core, slice into samples (few cm)
2. Foraminifera: distance to mean high water
3. Plot in **M**arsh **P**aleo**E**nvironment (MPE) curve
4. Derive age using ^{210}Pb and ^{14}C data.
5. Derive curve that shows how the position of Mean High Water (MHW) relative to modern MHW changed over time

Connecticut Marshes



Nell's Island (Housatonic River): foraminiferal zonation and flooding frequency

Tidal framework: mean sea level, mean high water, mean high water at spring tide, etc..

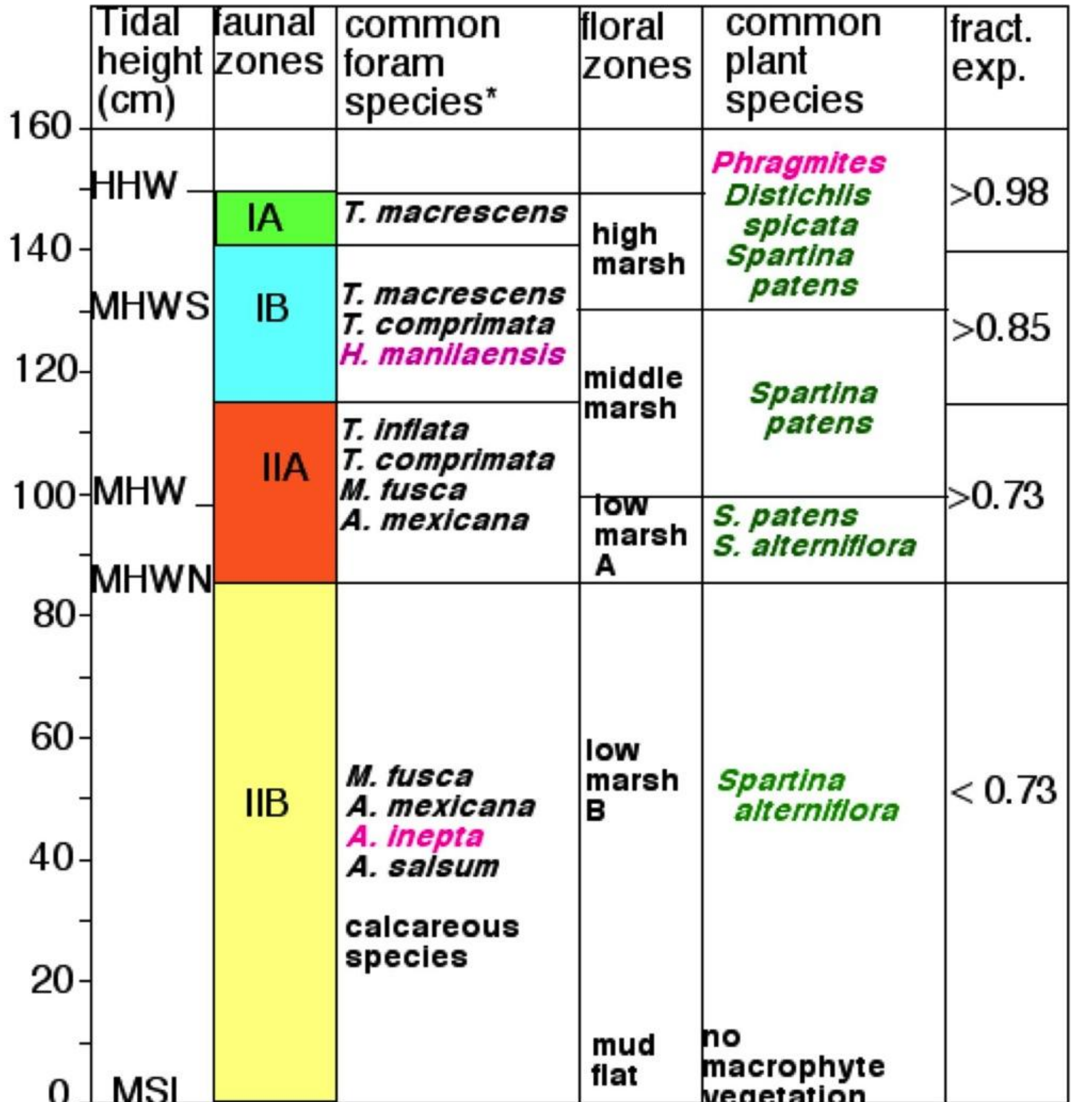


Zones: different 'fractional exposure time', different foraminiferal assemblages

(Scott & Medioli, 1980, Nova Scotia, California)

Nell's Island Foraminiferal Zonation: observations on marsh surface (modern analog method).

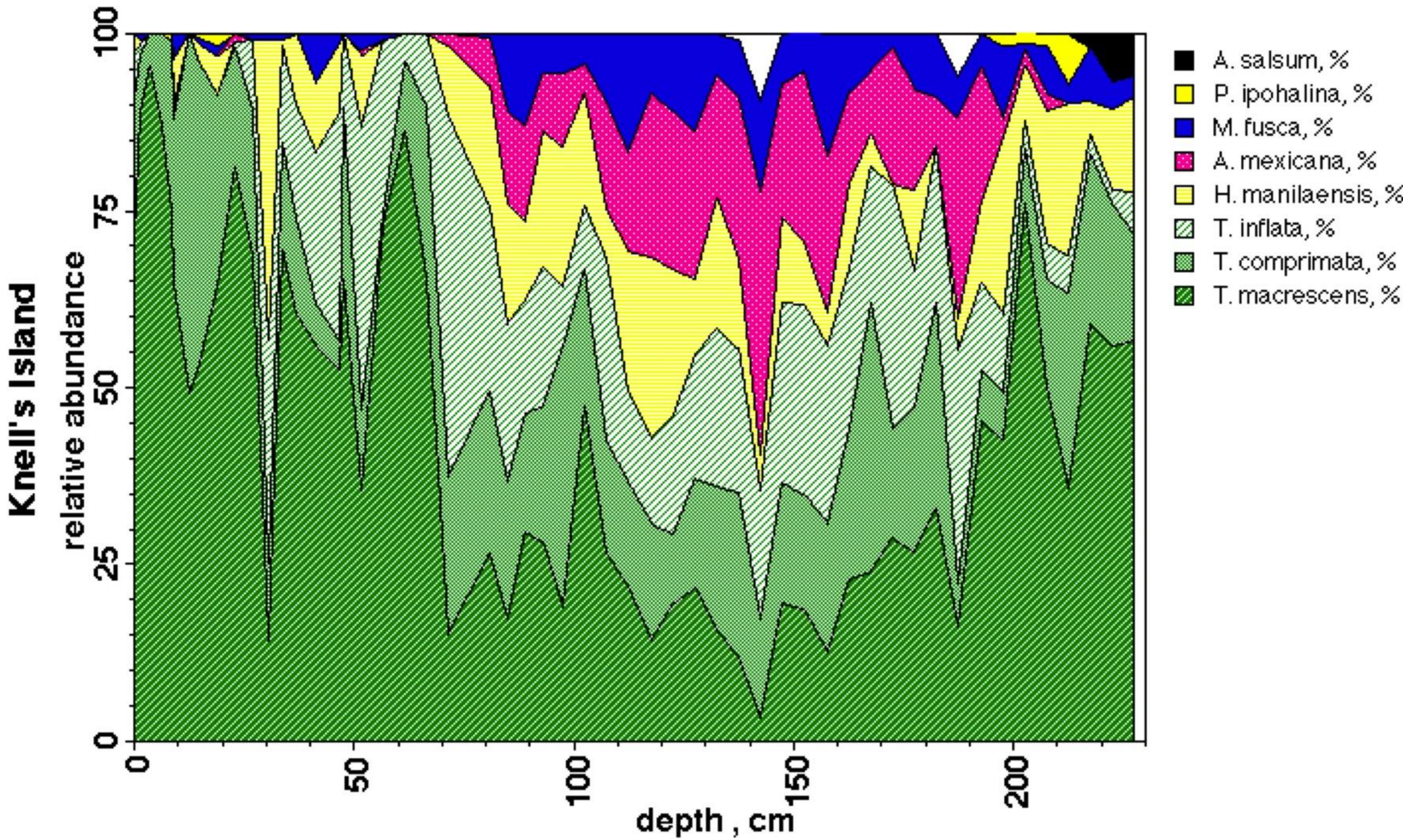
Transfer functions



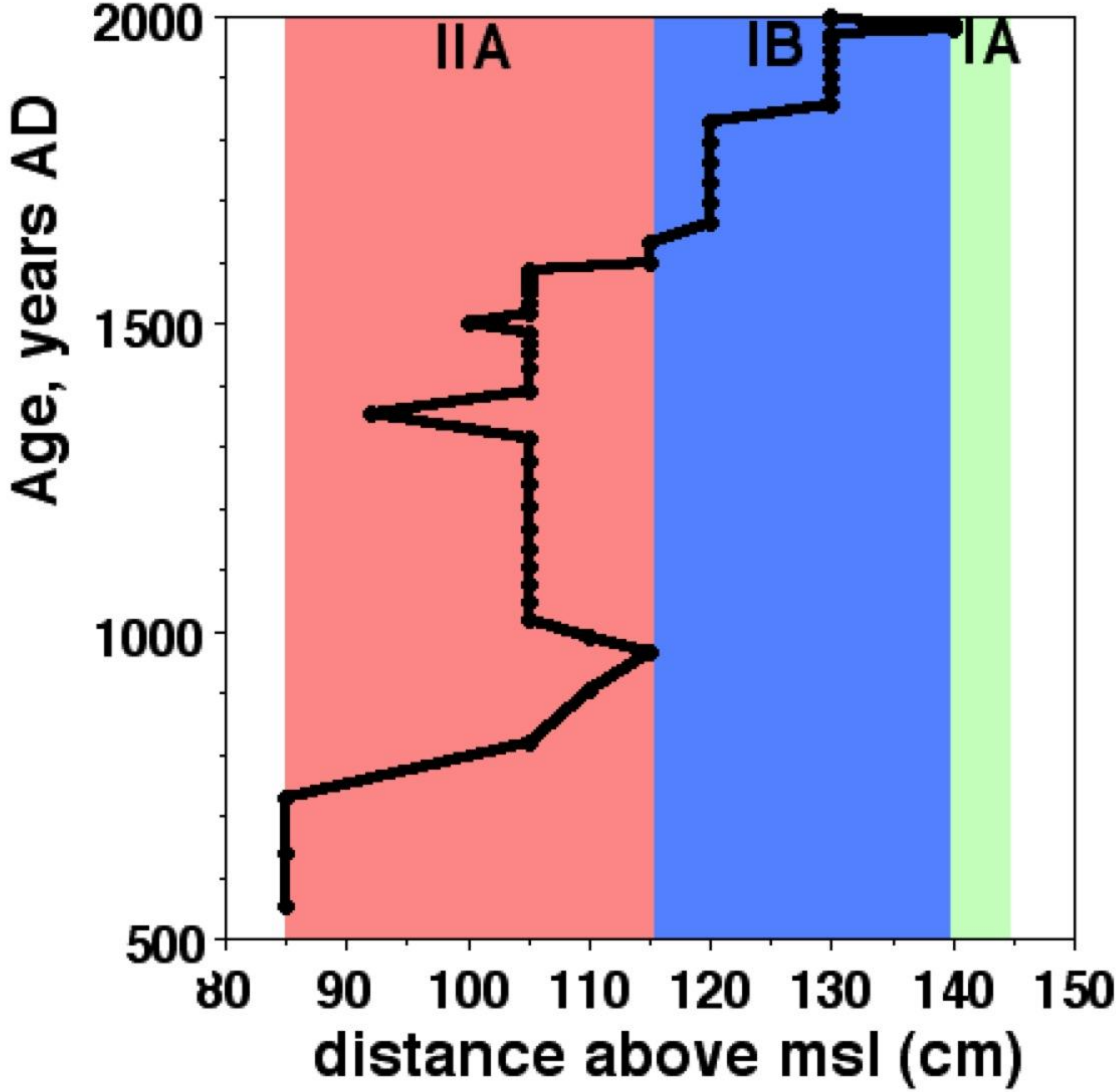
MSL: mean sea level
MHW: mean high water
MHWN: mean high water at neap tide
MHWS: mean high water at spring tide

* name in pink: low salinity
fract. exp.: fractional exposure

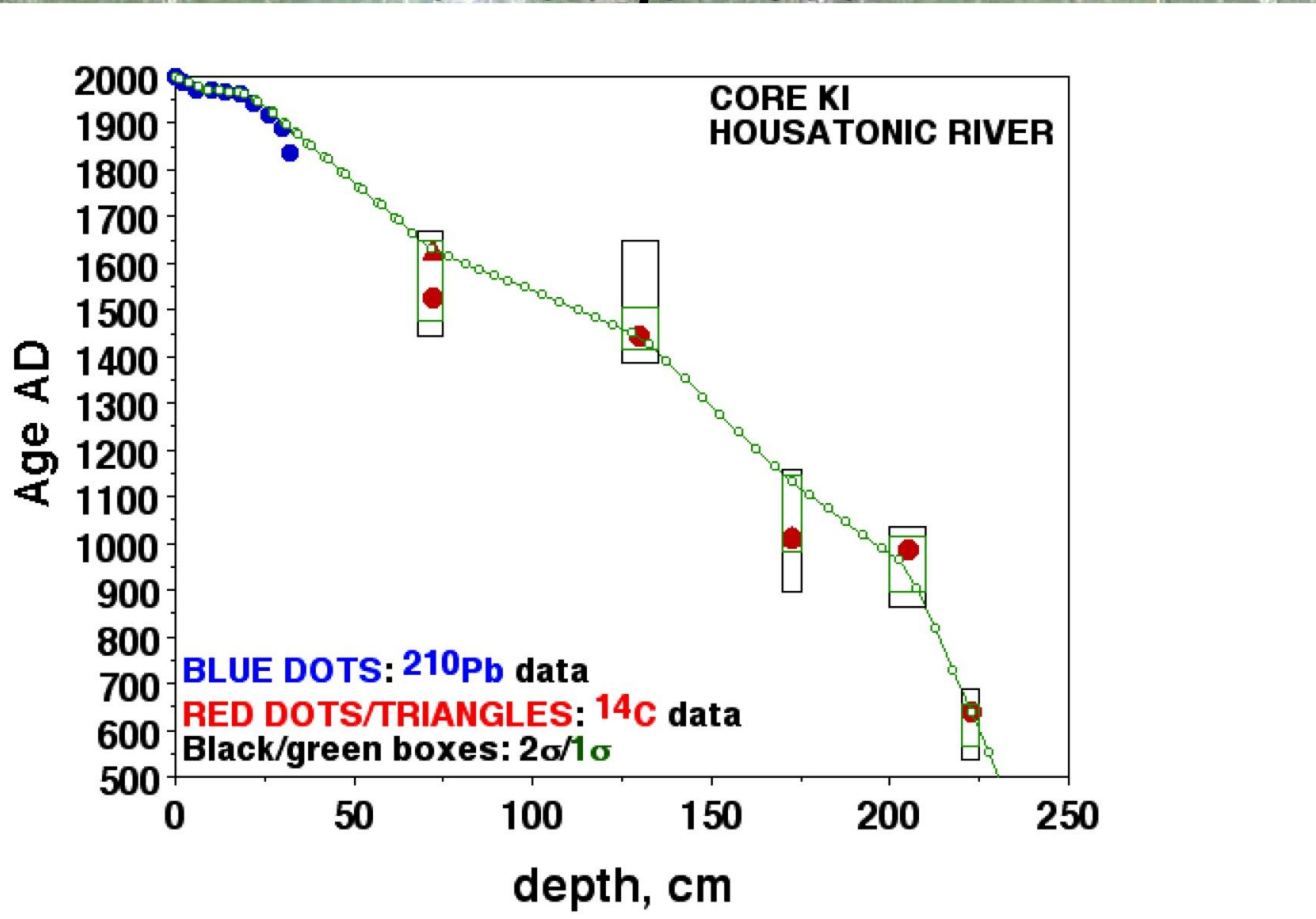
Example: Housatonic river, Nell's Island



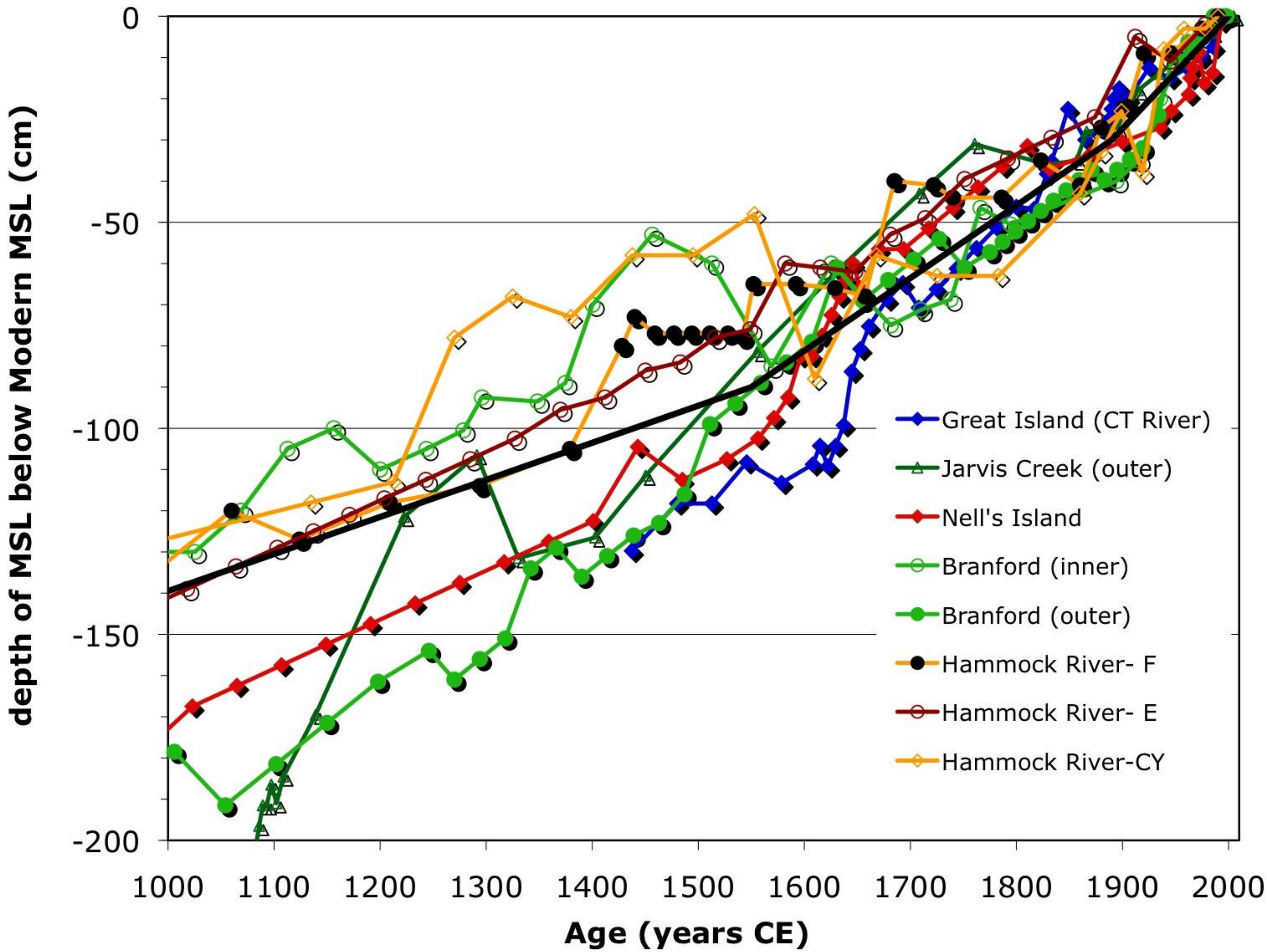
KNELL's ISLAND (Housatonic River)
Marsh PaleoEnvironment Curve



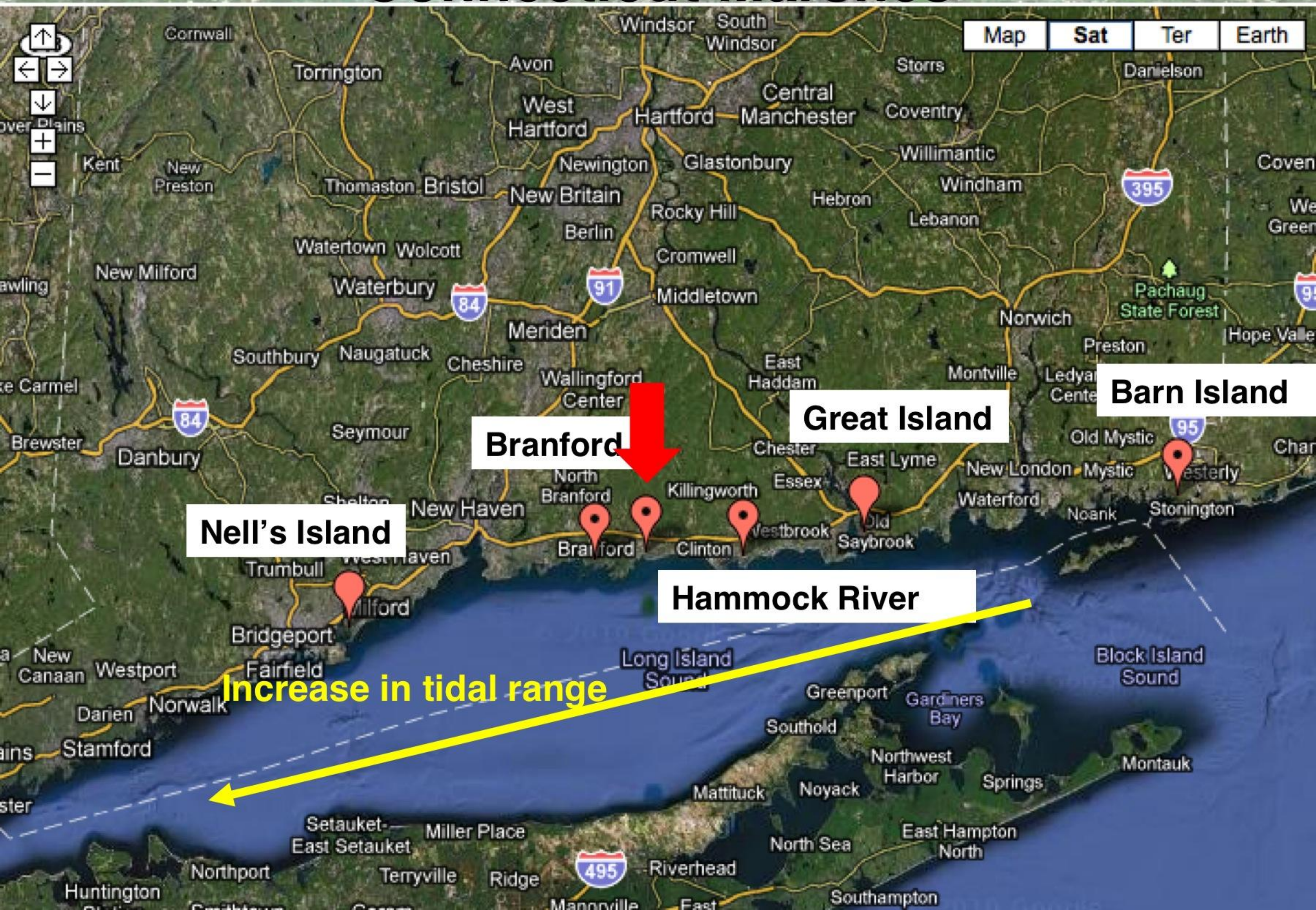
Derive age model:

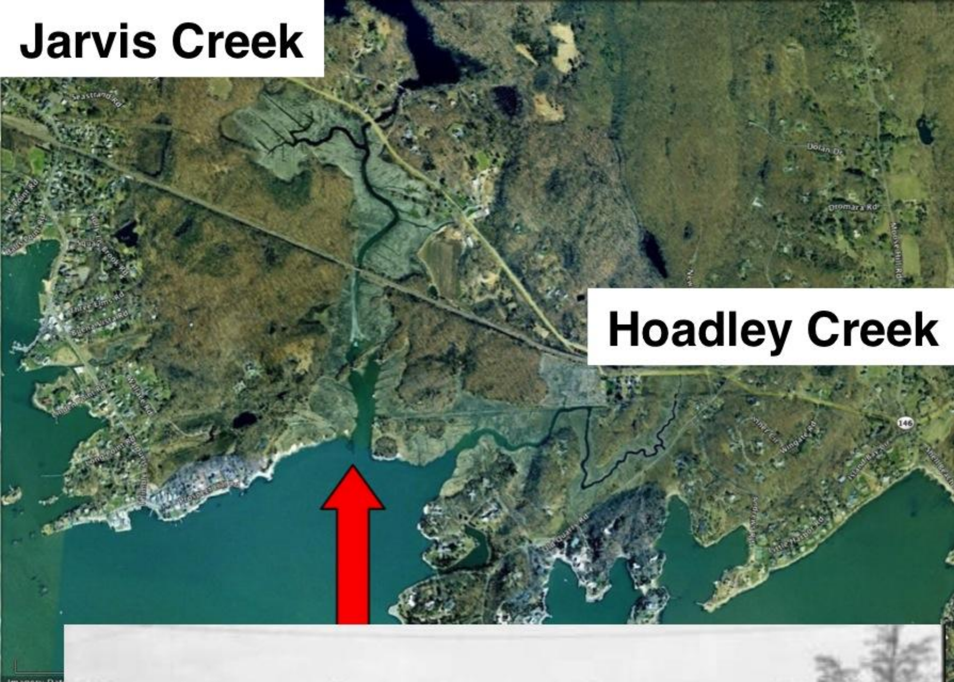


Black line: 0.9 mm/yr; 1.7 mm/yr, 3.0 mm/yr



Connecticut Marshes



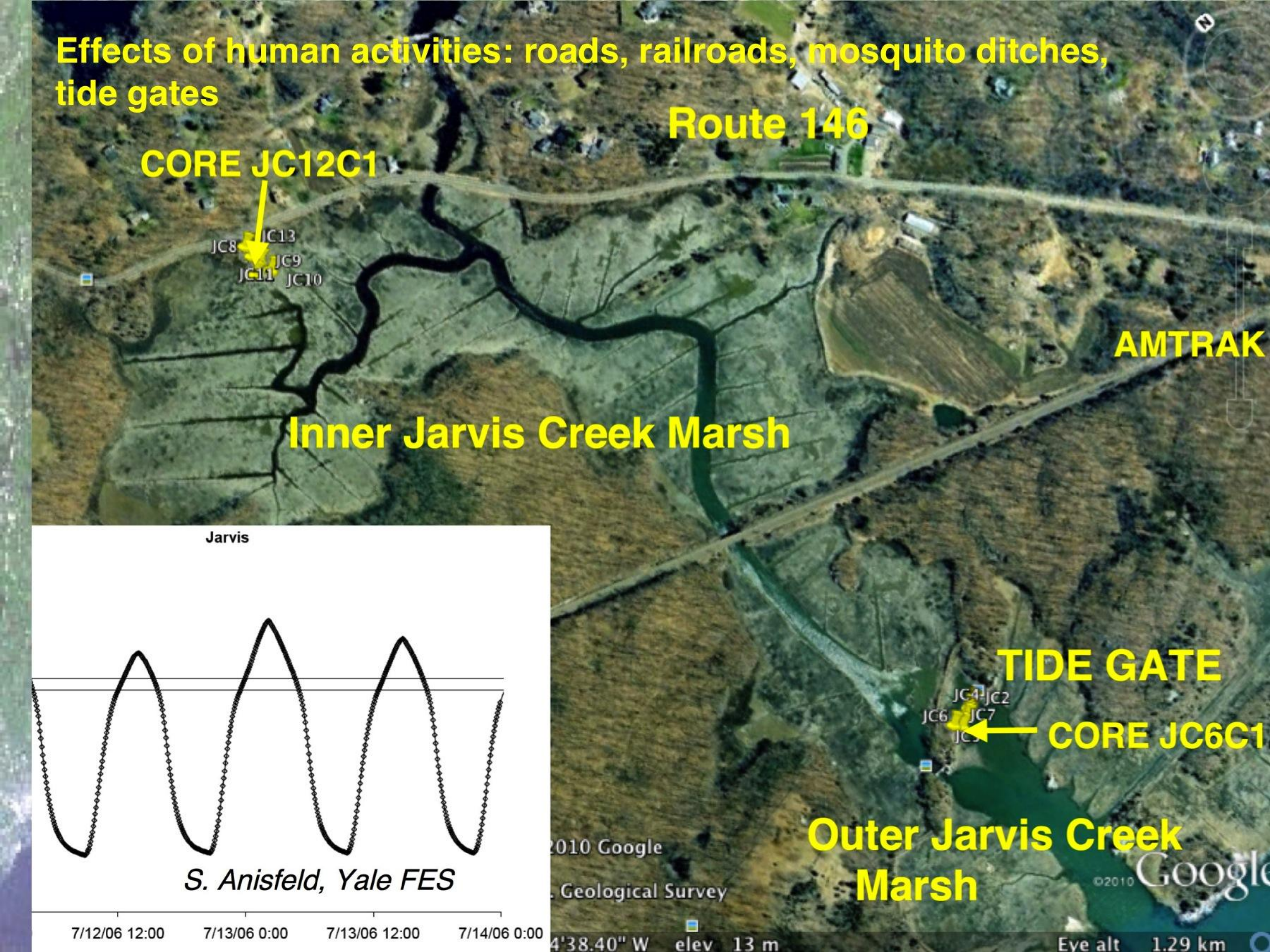


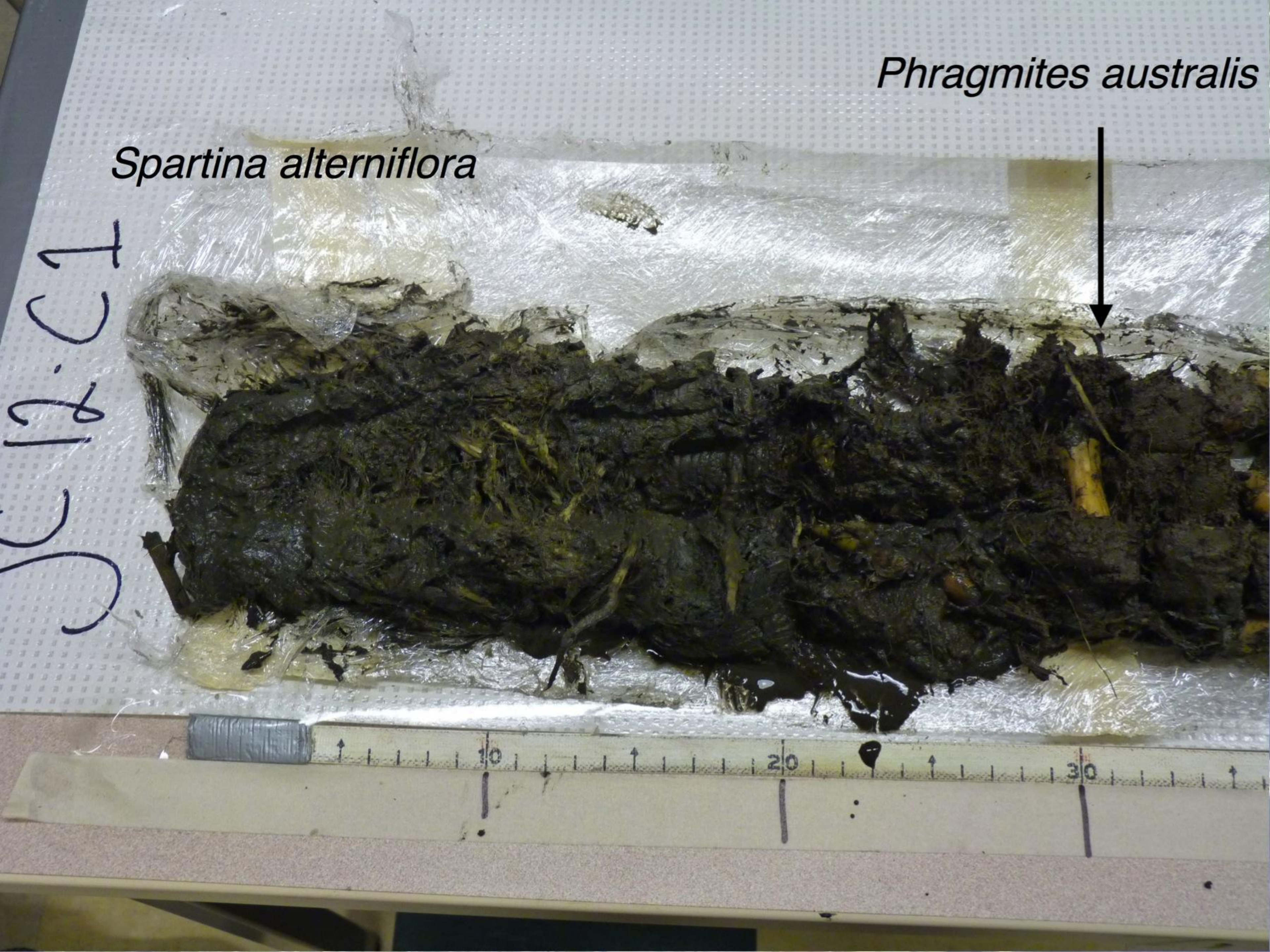
Jarvis Creek Marsh (Branford, CT): Tidegate closed off marsh - *Phragmites* replaced *Spartina* Tidegate partially removed 1979

Connecticut River

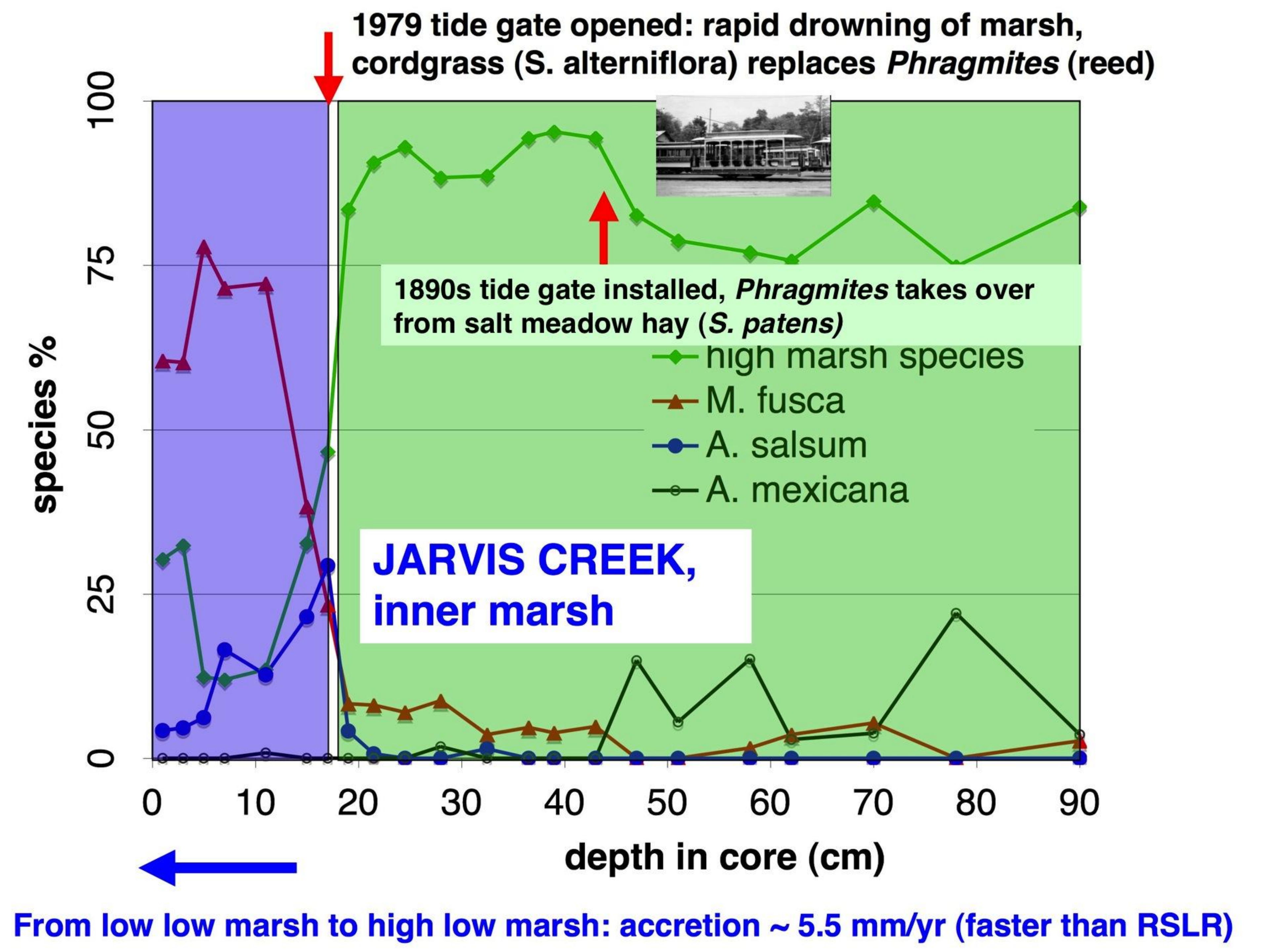
Thimble Islands

Inner Jarvis Creek Marsh now: dominated by *Spartina alterniflora* (low marsh)
Outer Jarvis Creek Marsh: low to high marsh


Effects of human activities: roads, railroads, mosquito ditches, tide gates
Route 146
CORE JC12C1
JC8
JC13
JC9
JC11
JC10
AMTRAK
Inner Jarvis Creek Marsh
TIDE GATE
JC4
JC2
JC6
JC7
CORE JC6C1
Outer Jarvis Creek Marsh
Jarvis
S. Anisfeld, Yale FES
7/12/06 12:00
7/13/06 0:00
7/13/06 12:00
7/14/06 0:00
2010 Google
Geological Survey
4'38.40" W
elev 13 m
Eye alt 1.29 km


Spartina alterniflora
Phragmites australis
10
20
30


Phragmites australis
Spartina patens, mud, Juncus gerardii
30
40
50
60


1979 tide gate opened: rapid drowning of marsh, cordgrass (S. alterniflora) replaces *Phragmites* (reed)
1890s tide gate installed, *Phragmites* takes over from salt meadow hay (*S. patens)*
high marsh species
M. fusca
A. salsum
A. mexicana
JARVIS CREEK, inner marsh
species %
0
25
50
75
100
0
10
20
30
40
50
60
70
80
90
depth in core (cm)
From low low marsh to high low marsh: accretion ~ 5.5 mm/yr (faster than RSLR)

- **When marsh was closed off from tidal flow, *Phragmites* became established, accretion rate decreased (< 2 mm/year)**
- **Marsh surface was ‘left behind’ sea level rise (1880-1979, ~ 100 years)**
- **When tidal flow was restored, the marsh surface ‘drowned’ and low marsh vegetation became established**
- **High accretion rates in the low marsh setting (~ 5.5 mm/year) let the marsh accrete faster than sea level rise**

CONCLUSIONS

- **Rates of Relative Sea Level Rise along Long Island Sound averaged ~1 mm/yr before ~1600 CE, ~1.7 mm/yr until 1900 AD, ~3.0 mm/yr until 2010.**
- **High-middle marsh (*Spartina patens*) probably will not be able to keep up with these rates (surface marsh foraminifera indicate lower elevation than vegetation)**
- **Low marsh (*Spartina alterniflora*) is able to keep up and more, IF sediment supply sufficient and tidal flushing not constrained**
- **High marsh regions are expected to shrink, whereas we see increased relative area of low marsh**

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