Sea Level Rise in Delaware

Presented by

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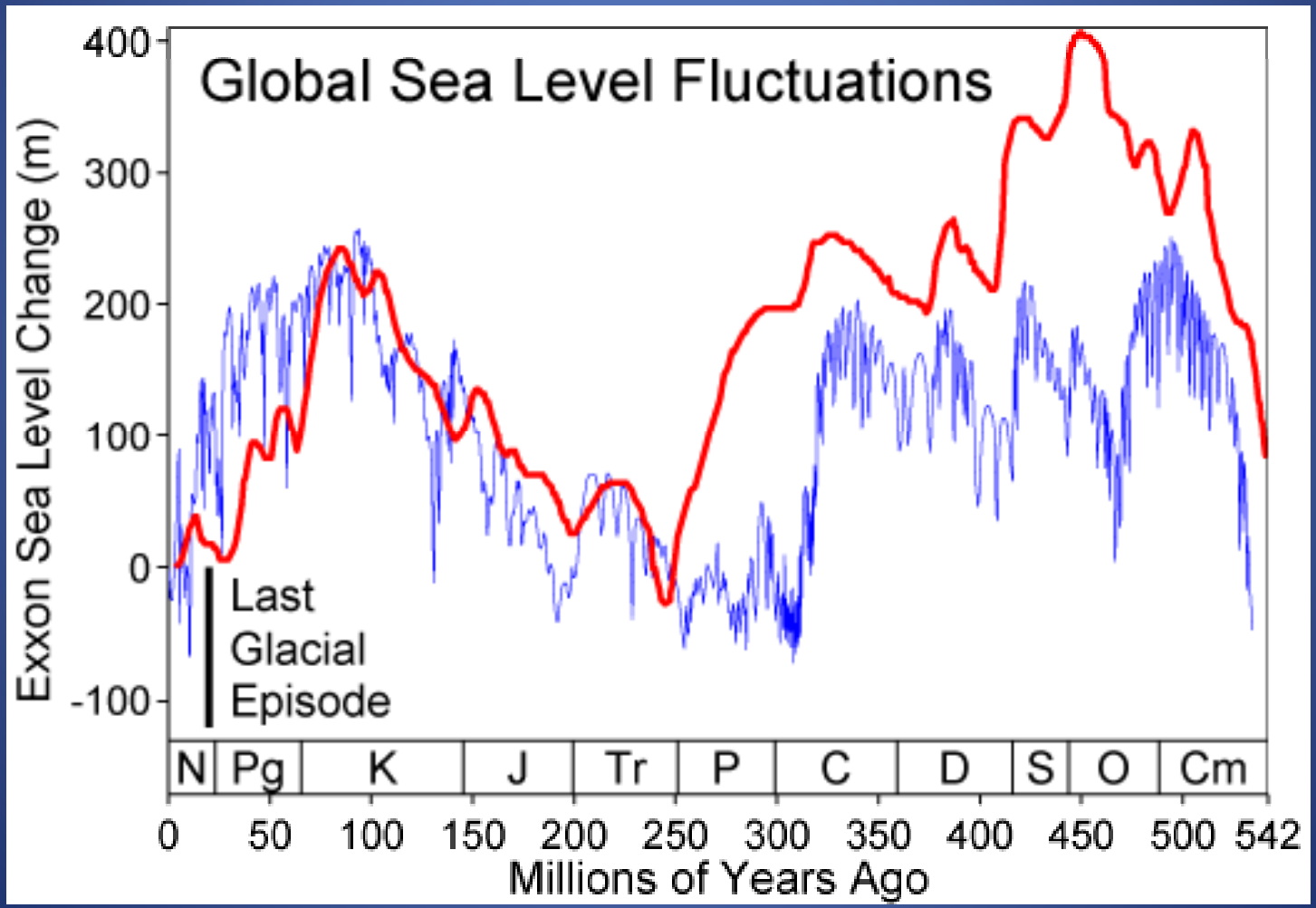
to

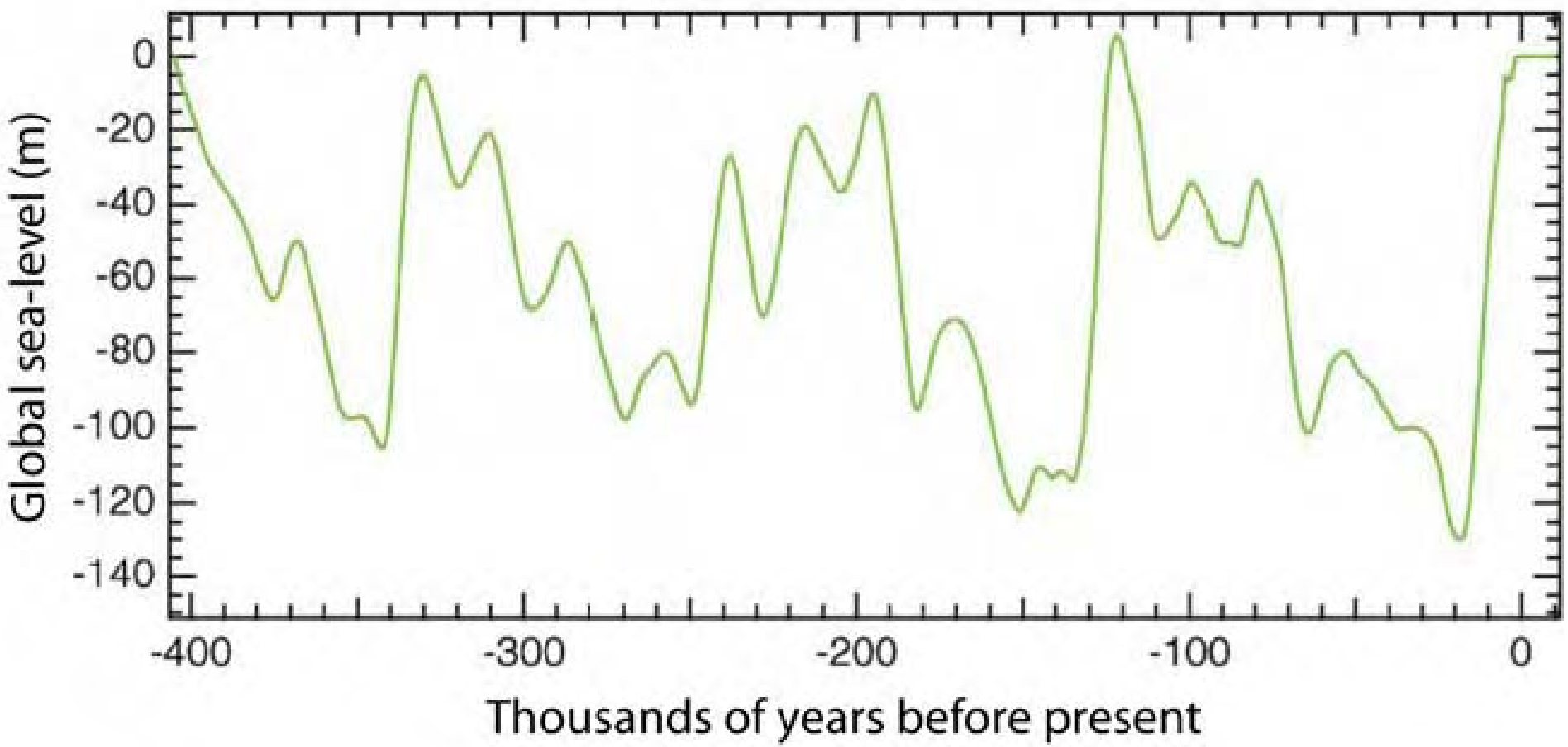
The Center for the Inland Bays

Scientific and Technical Advisory Committee

August 21, 2009

Sea level has been fluctuating ever since there have been seas




Global sea-level (m)
0
-20
-40
-60
-80
-100
-120
-140
-400
-300
-200
-100
0
Thousands of years before present

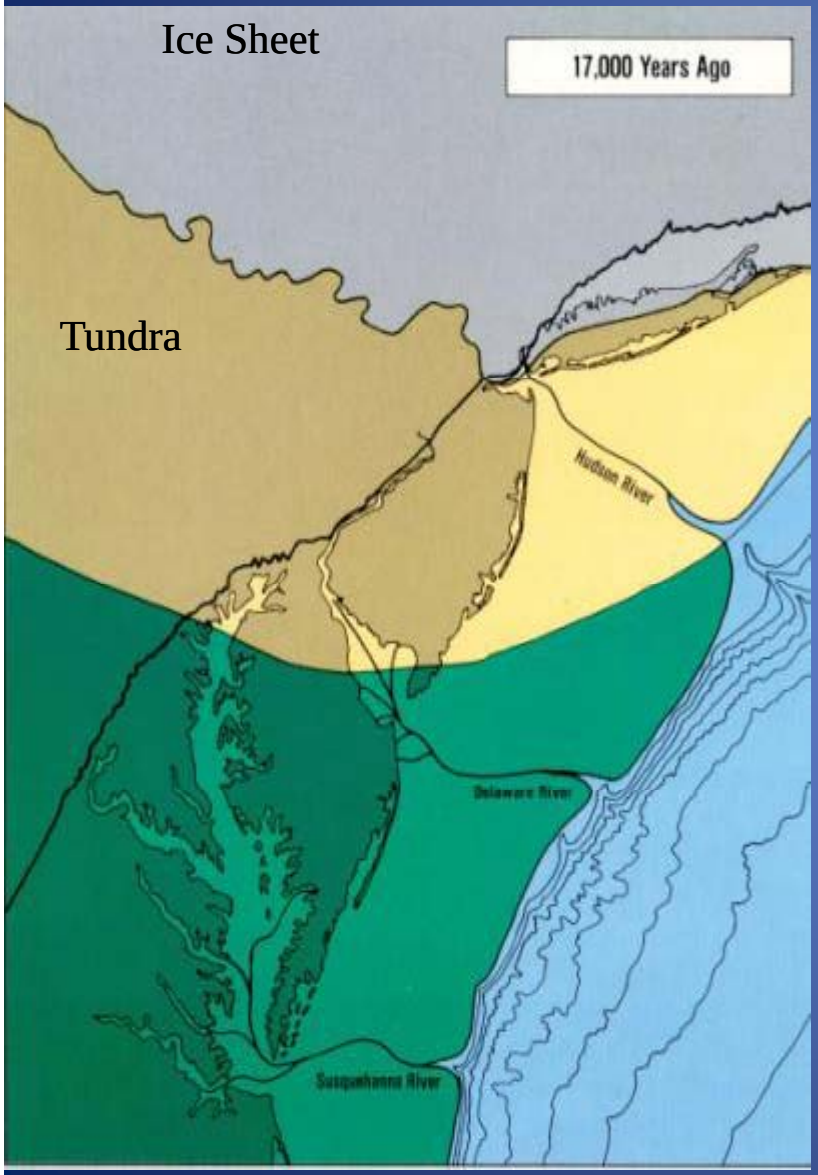
Late Cretaceous 75 million yrs ago

Greenhouse Earth

Last 2.6 million yrs

Huge ice sheets advance/retreat

Icehouse Earth



During the last glacial episode, massive glacial ice sheets, up to two miles thick, covered the northern half of North America and Greenland. In North America, ice sheets extended southward to Long Island and Cape Cod.

Delaware - 17,000 ybp: sea level -425 feet;

Ancestral Delaware River flowed to edge of continental shelf where shoreline was located;

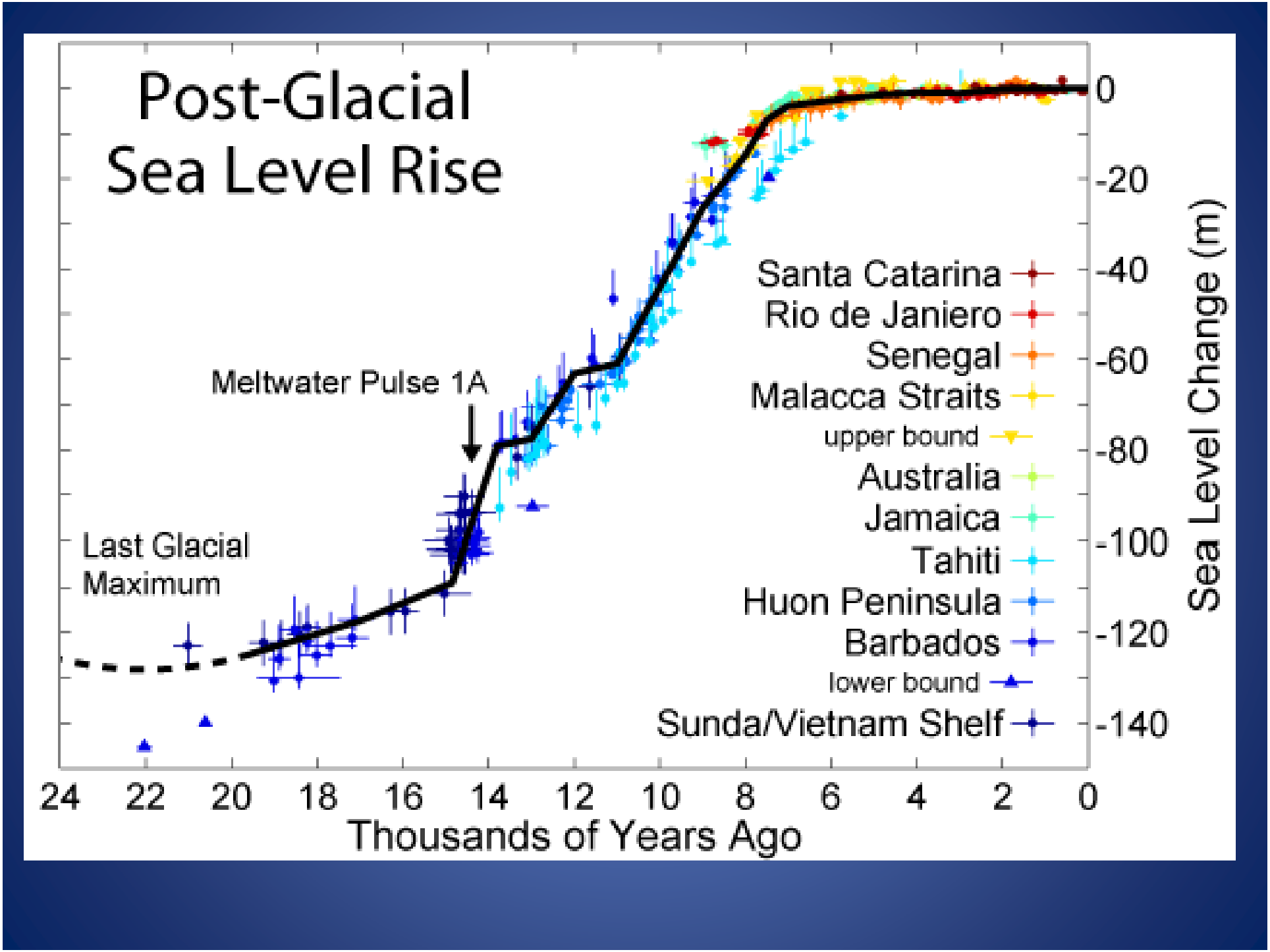
Similar climate to arctic northern Canada - tundra, boreal forest.

Graphic courtesy Delaware Estuary Atlas and J.C. Kraft

11,000 ybp: glaciers melting, sea level rising; climate similar to Maine

2007: shoreline has migrated to present position

Graphics courtesy Delaware Estuary Atlas and J.C. Kraft


Post-Glacial
Sea Level Rise
Meltwater Pulse 1A
Last Glacial
Maximum
Santa Catarina
Rio de Janiero
Senegal
Malacca Straits
upper bound
Australia
Jamaica
Tahiti
Huon Peninsula
Barbados
lower bound
Sunda/Vietnam Shelf
0
-20
-40
-60
-80
-100
-120
-140
Sea Level Change (m)
24
22
20
18
16
14
12
10
8
6
4
2
0
Thousands of Years Ago

Eustatic vs. Relative Sea Level Rise

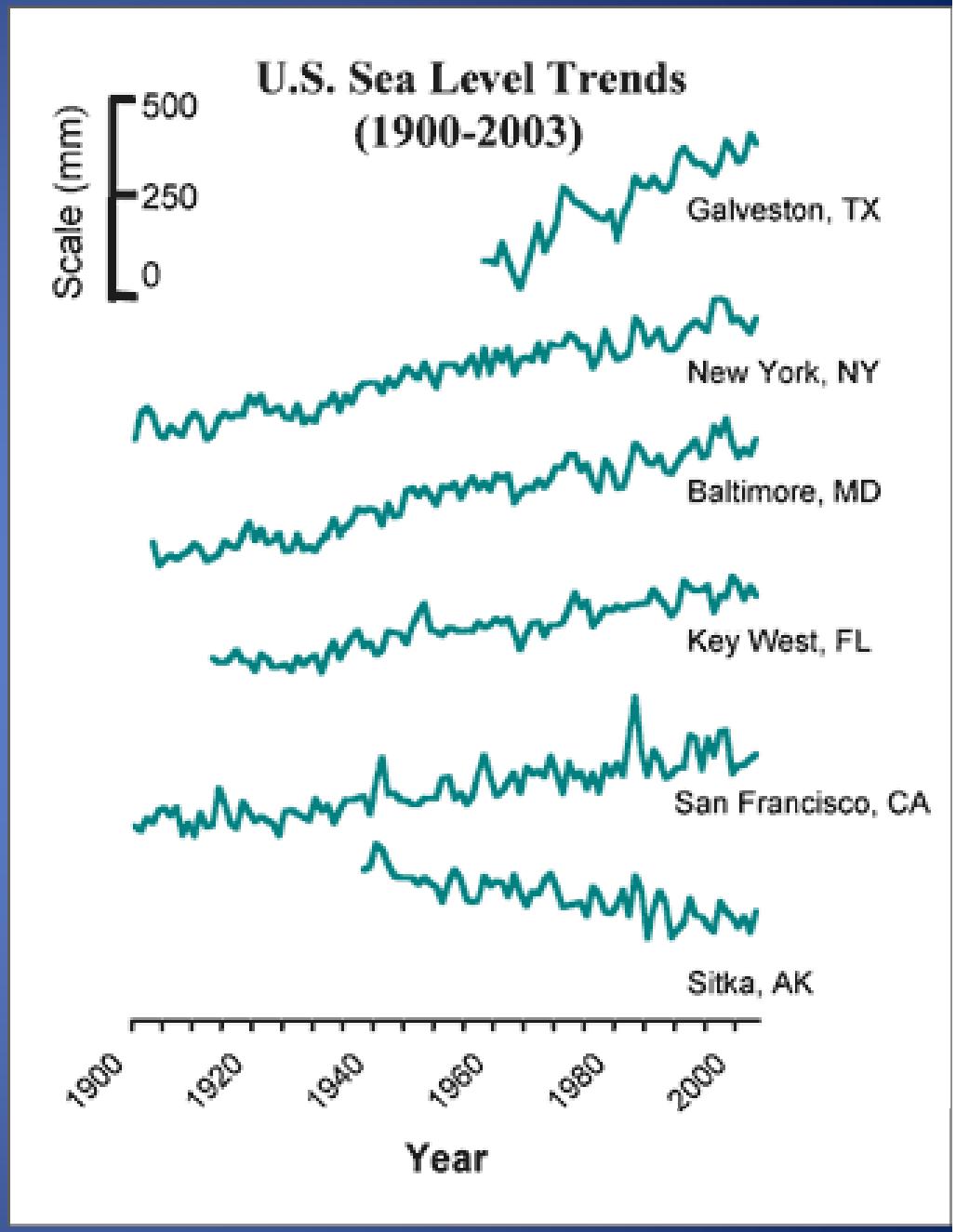
- Eustatic sea level rise refers to the change of the volume of the global ocean.

- Relative Sea-Level Rise refers to the change at a particular location.
  - Varies depending on tectonic uplift or subsidence.
  - commonly exceeds the global rate of sea-level rise.
  - Important factor when determining coastal vulnerability and management plans.

100 yr tide gauge record

Short-term cycles in relative sea level

Geologic perspective:
Sea level has always been dynamic



An updated Holocene Sea-Level Curve for the Delaware Coast

Daria L. Nikitina, James E. Pizzuto, Reed A. Schwimmer, Kelvin W. Ramsey

June 1999

The updated curve documents a rate of sea-level rise of 0.9 mm/yr from 1250 yr BP to present (based on 11 dates), in good agreement with other recent sealevel curves from the northern and central U.S. Atlantic coast, while the previous curve documents rates of about 1.3 mm/yr(based on 4 dates). The precision of both estimates, however, is very low, so the significance of these differences is uncertain.

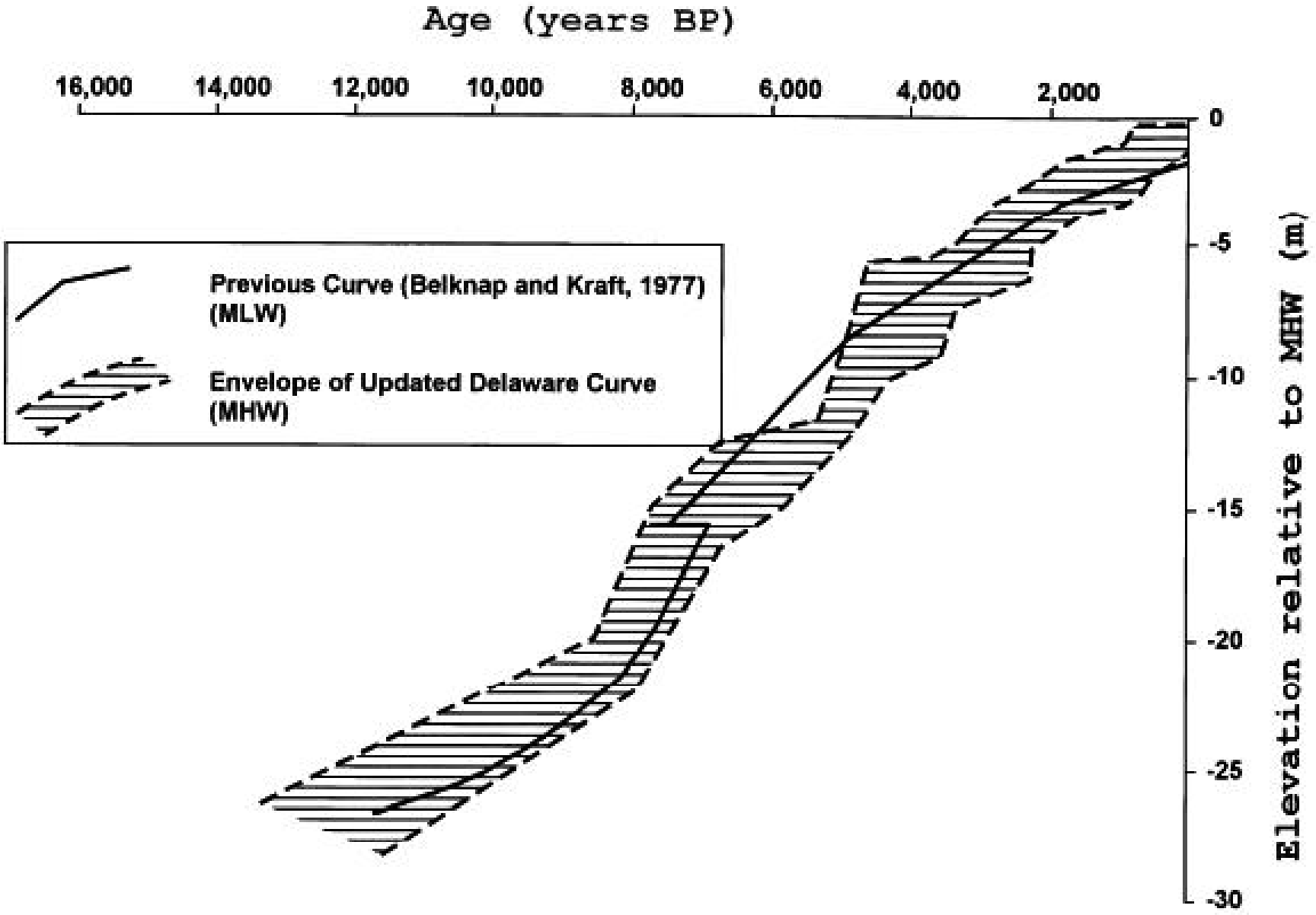


Fig. 7. Comparison of the envelope of the updated sea-level curve with Belknap and Kraft's (1977) curve.

IPCC 2007 Report

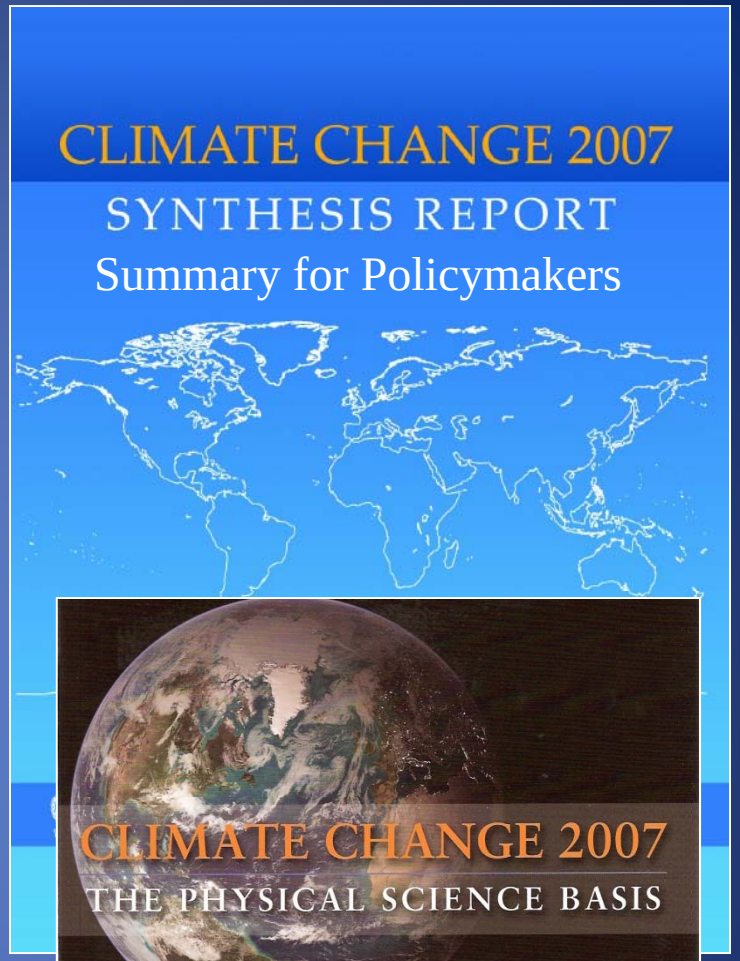
- 3 volumes & synthesis
- Nearly 3,000 pages
- www.ipcc.ch

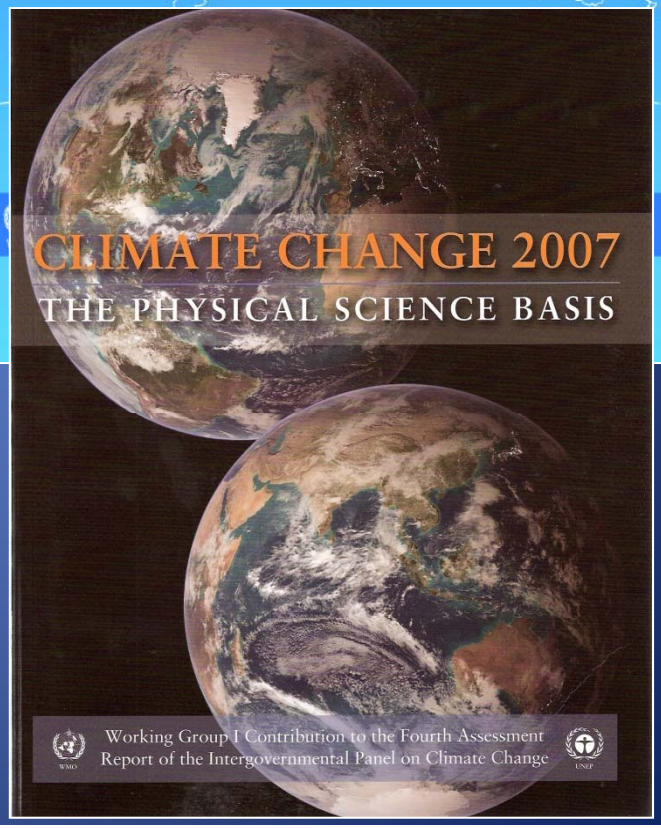
2500+ SCIENTIFIC EXPERT REVIEWERS
800+ CONTRIBUTING AUTHORS AND
450+ LEAD AUTHORS FROM
130+ COUNTRIES
6 YEARS WORK
1 REPORT

2007

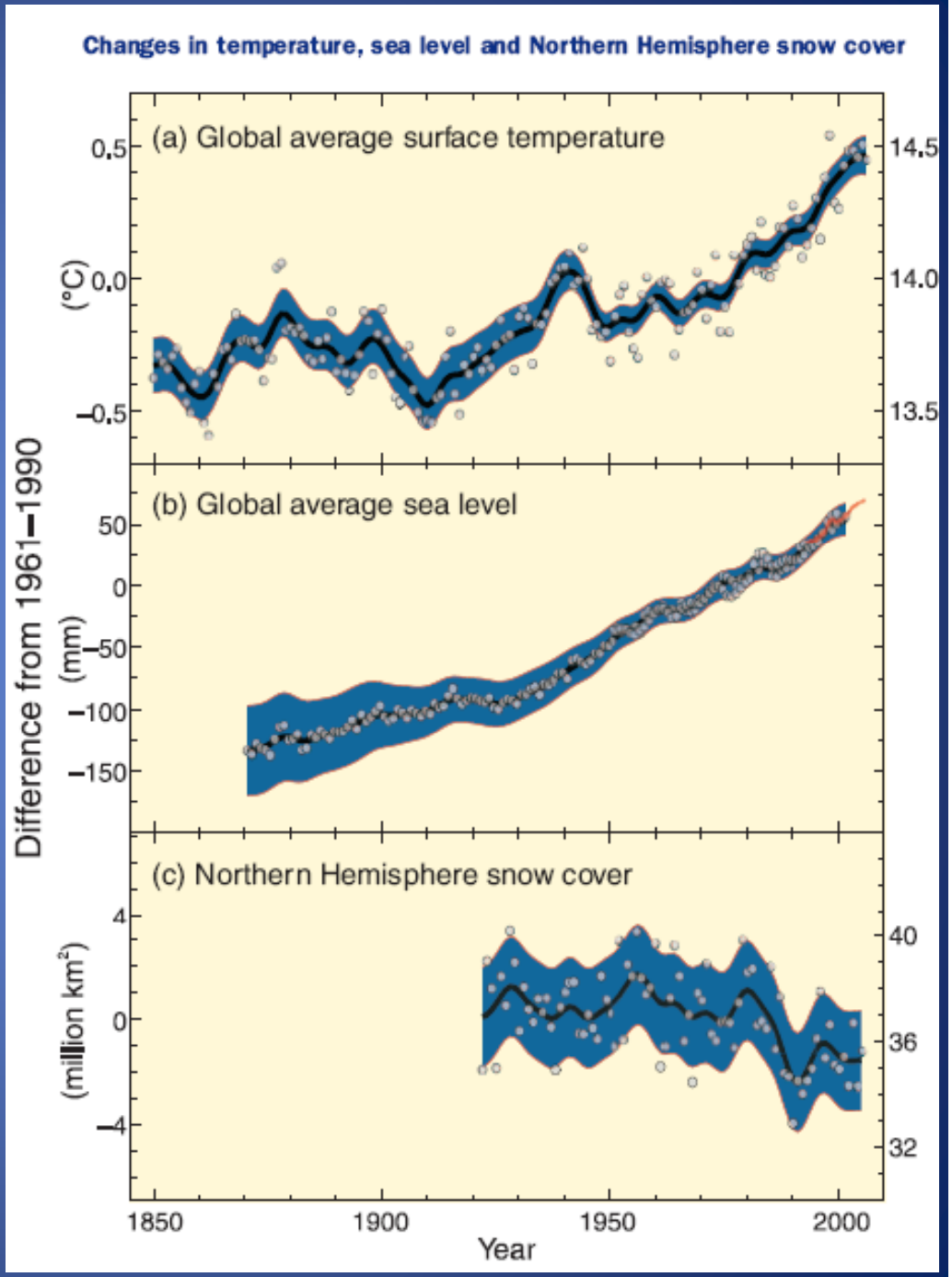
The IPCC 4th Assessment Report is coming out
A picture of climate change
the current state of understanding

WMO INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE UNEP





The rate of sea level rise is accelerating



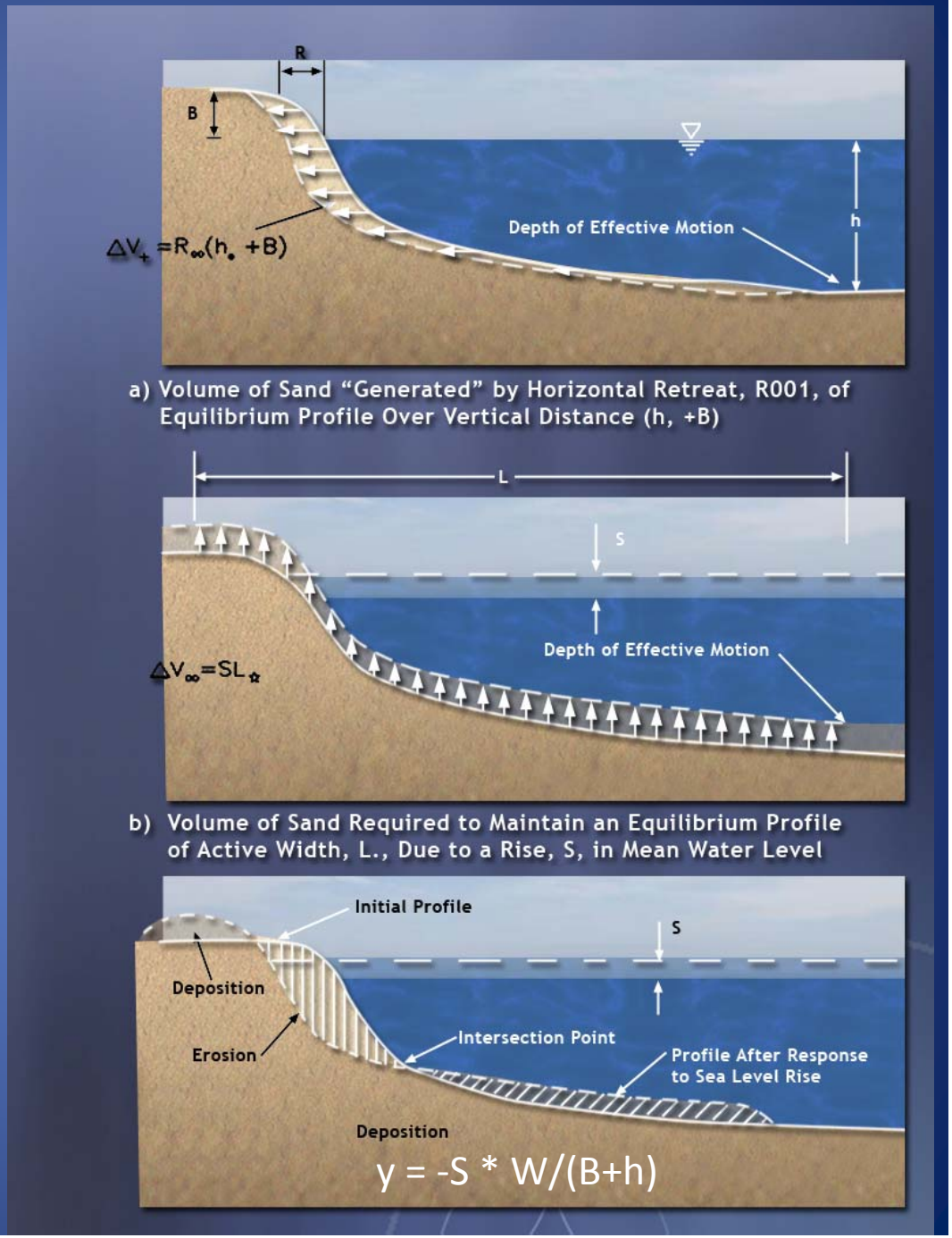
What might happen?

- Sea level rise
  - Land loss: coastal erosion
    - Wetlands (< 2’ above MHW)
    - Beaches (5-10’ above MHW)
- Migration of coastal landforms and changes to coastal environments
  - Potentially adverse affect on coastal species
- Storms & Flooding
  - Storm surge and waves impact farther inland
  - Potential to increase intensity of tropical storms
  - Reduce drainage rate of low-lying areas
- Coastal Water Supplies
    - Encroachment of saltwater wedge into estuaries & shallow coastal aquifers

How to calculate what might happen

Beach Response to Sea Level Rise

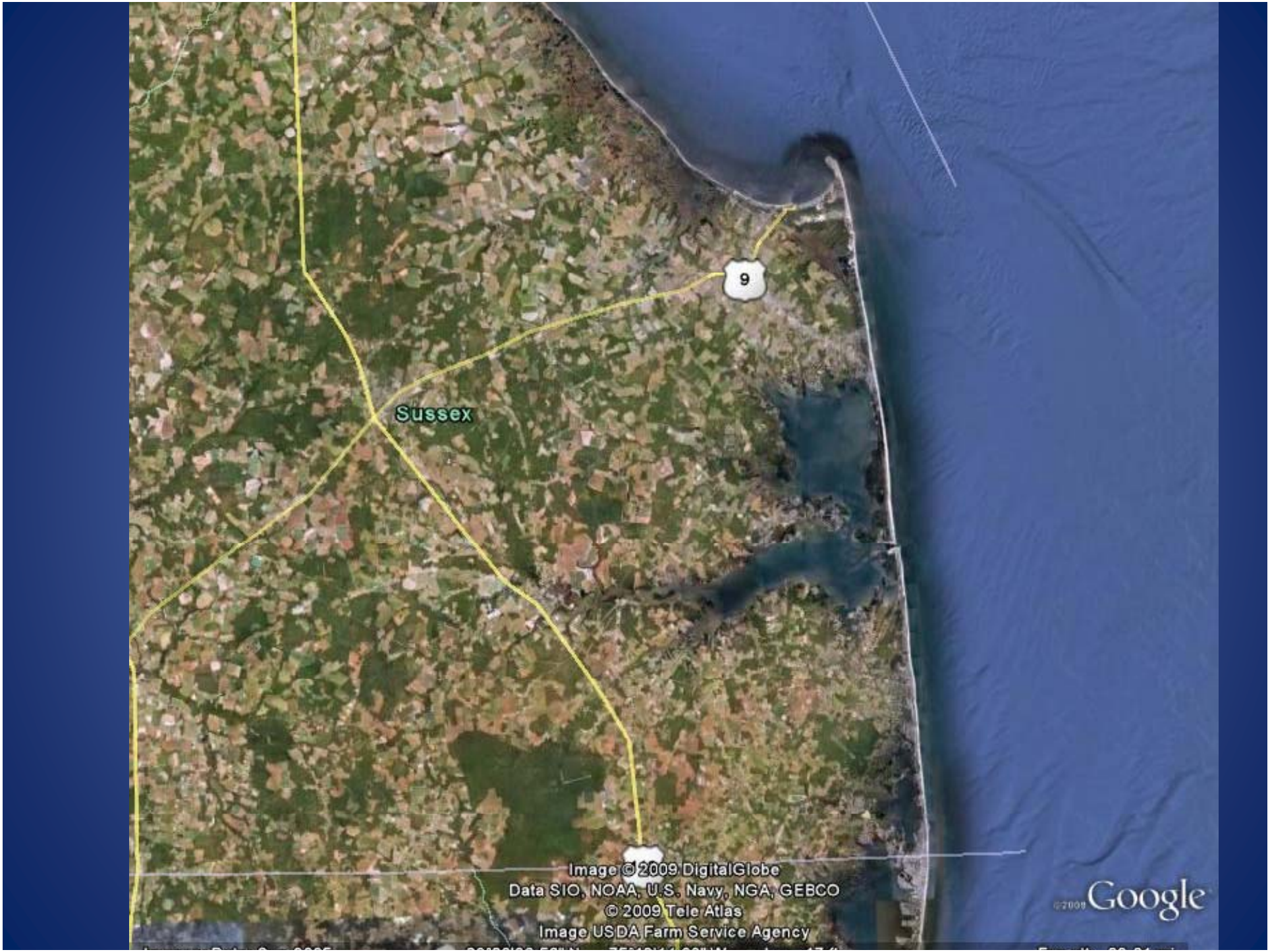
Brunn Rule



How NOT to calculate what might happen

Inundation Maps do not represent reality

Projection for 2100: 1m SLR


9
Sussex
Image © 2009 DigitalGlobe
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2009 Tele Atlas
Image USDA Farm Service Agency
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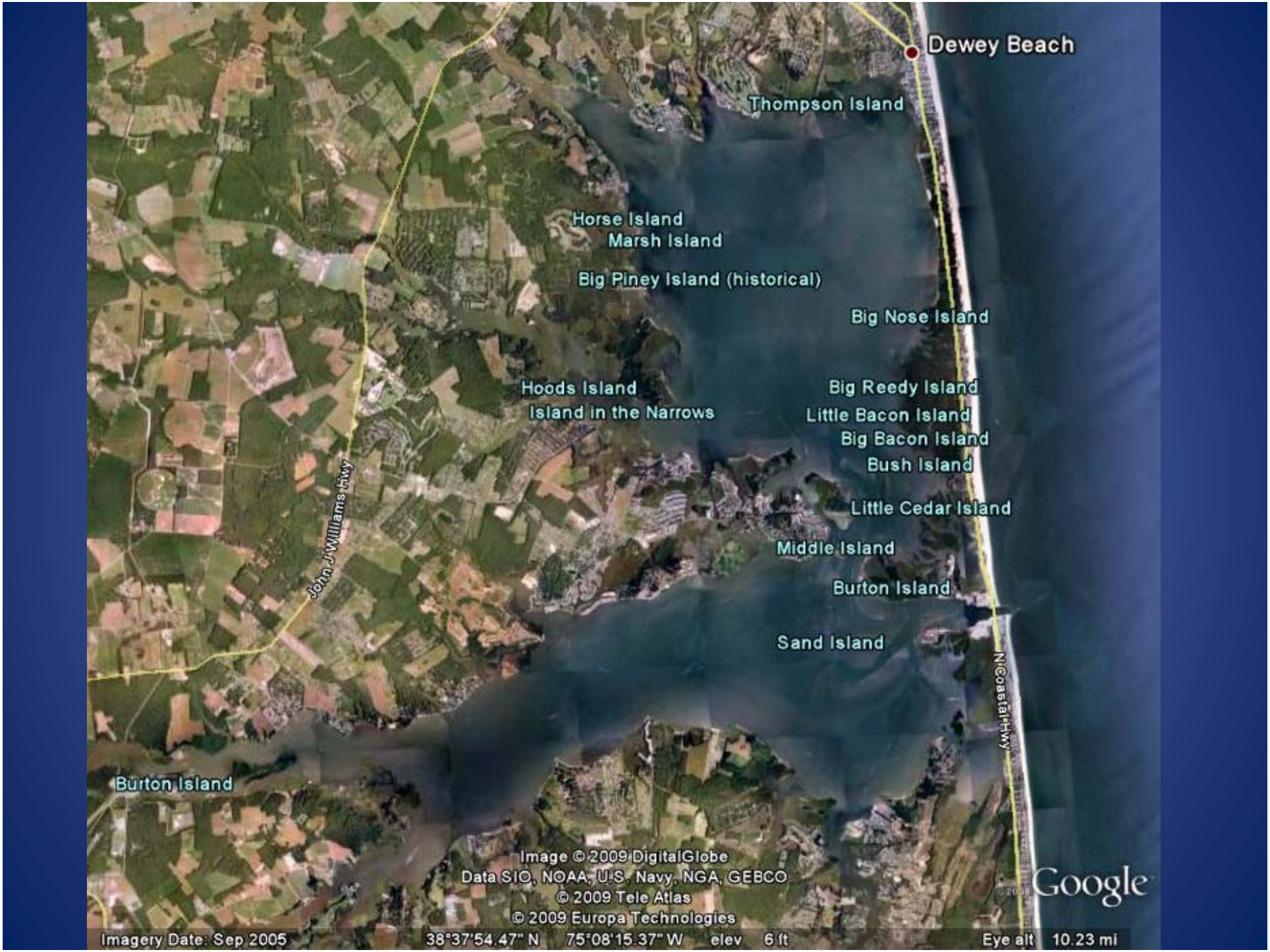
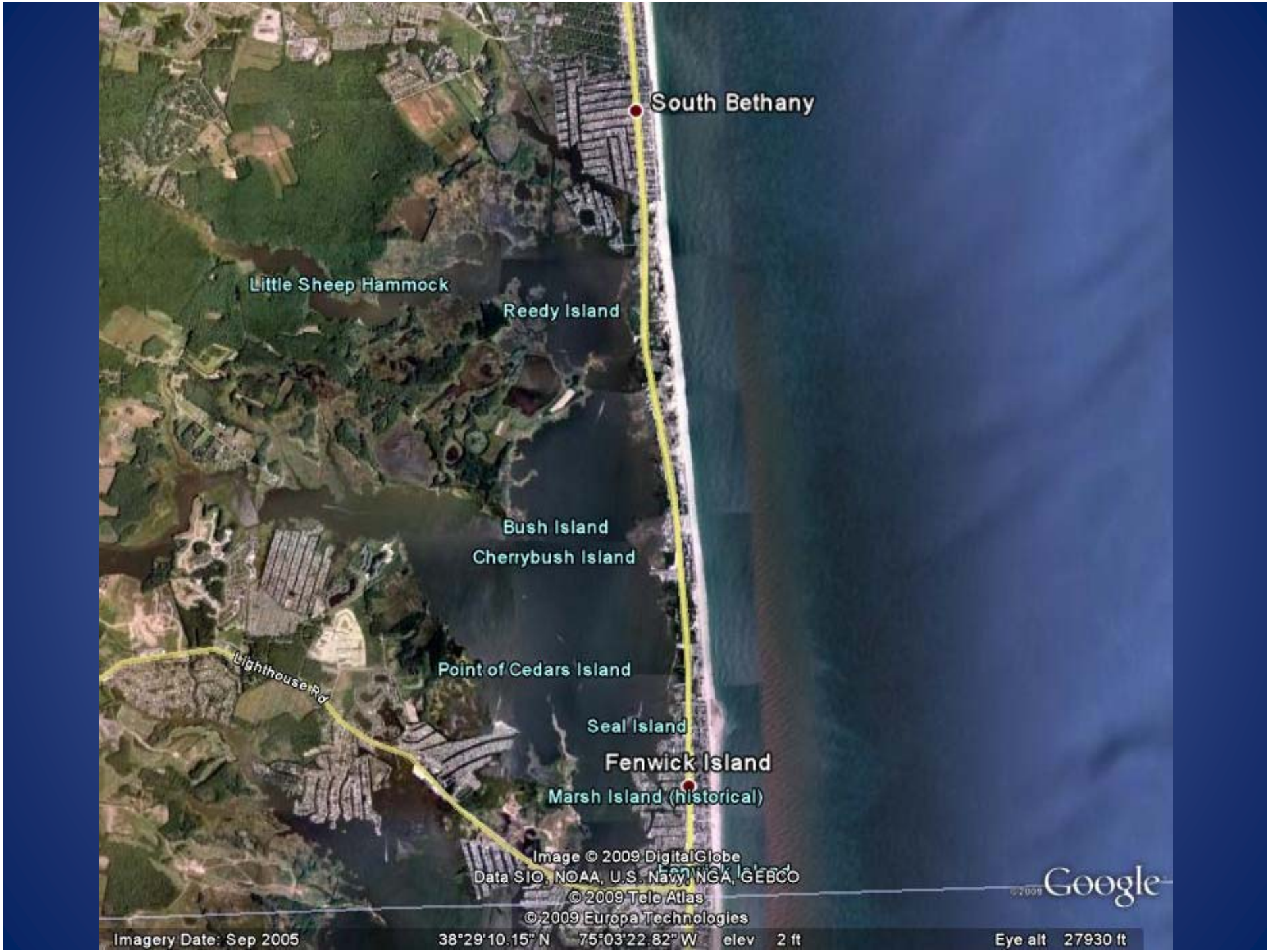

Dewey Beach
Thompson Island
Horse Island
Marsh Island
Big Piney Island (historical)
Big Nose Island
Hoods Island
Island in the Narrows
Big Reedy Island
Little Bacon Island
Big Bacon Island
Bush Island
Little Cedar Island
Middle Island
Burton Island
Sand Island
John J Williams Hwy
N Coastal Hwy
Burton Island
Image © 2009 DigitalGlobe
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2009 Tele Atlas
© 2009 Europa Technologies
Google
Imagery Date: Sep 2005
38°37'54.47" N 75°08'15.37" W elev 6 ft
Eye alt 10.23 mi


South Bethany
Little Sheep Hammock
Reedy Island
Bush Island
Cherrybush Island
Lighthouse Rd
Point of Cedars Island
Seal Island
Fenwick Island
Marsh Island (historical)
Image © 2009 DigitalGlobe
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2009 Tele Atlas
© 2009 Europa Technologies
Google
Imagery Date: Sep 2005
38°29'10.15" N 75°03'22.82" W elev 2 ft
Eye alt 27930 ft

U.S. Climate Change Science Program

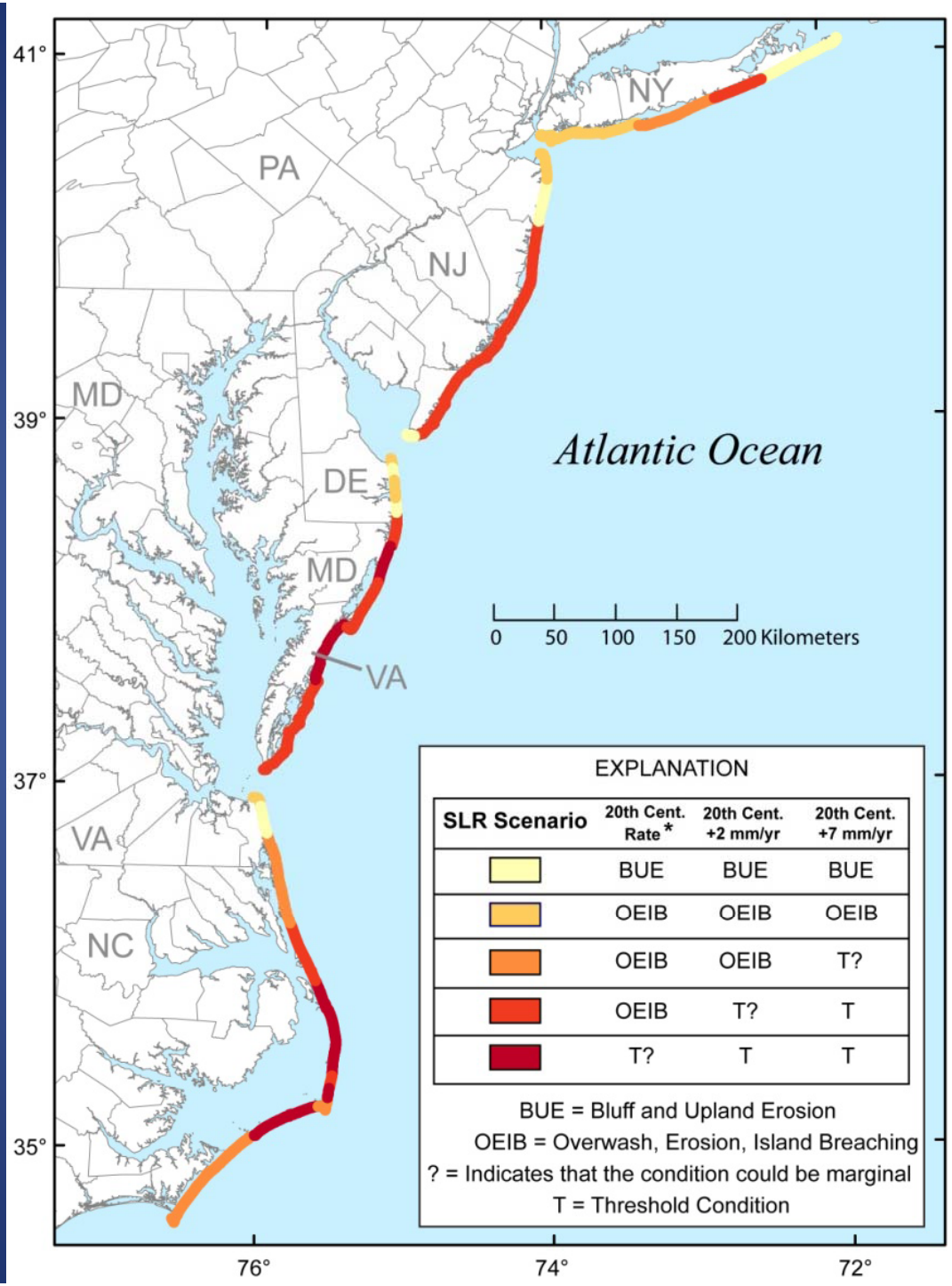
Synthesis and Assessment Product 4.1

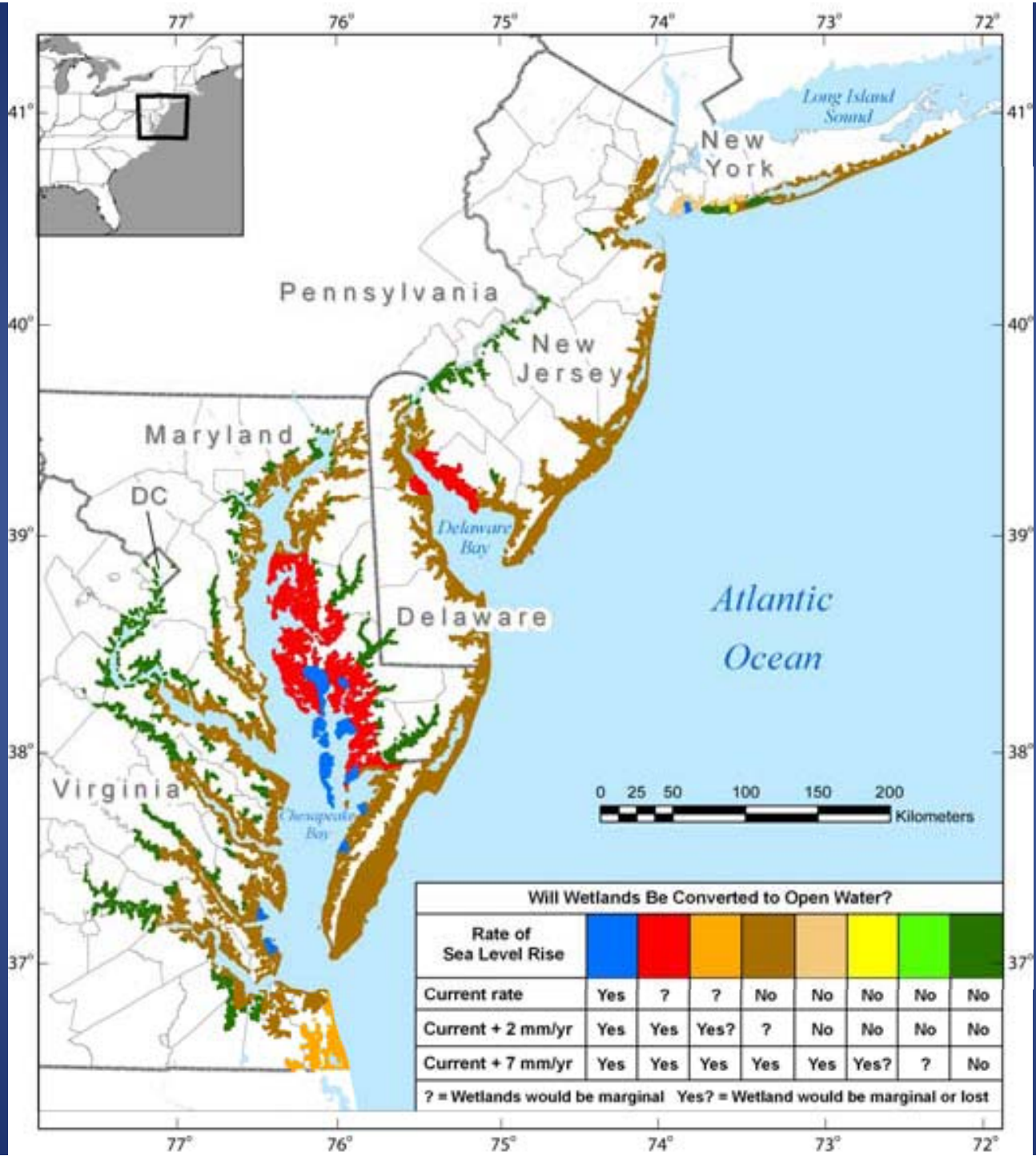
January 2009

Coastal Sensitivity to Sea-Level Rise:

A Focus on the Mid-Atlantic Region

http://www.climatescience.gov/Library/sap/sap4-1/final-report/default.htm


41°
39°
37°
35°
76°
74°
72°
NY
PA
NJ
MD
DE
MD
VA
VA
NC
Atlantic Ocean
0 50 100 150 200 Kilometers
EXPLANATION
SLR Scenario
20th Cent. Rate *
20th Cent. +2 mm/yr
20th Cent. +7 mm/yr
BUE BUE BUE
OEIB OEIB OEIB
OEIB OEIB T?
OEIB T? T
T? T T
BUE = Bluff and Upland Erosion
OEIB = Overwash, Erosion, Island Breaching
? = Indicates that the condition could be marginal
T = Threshold Condition

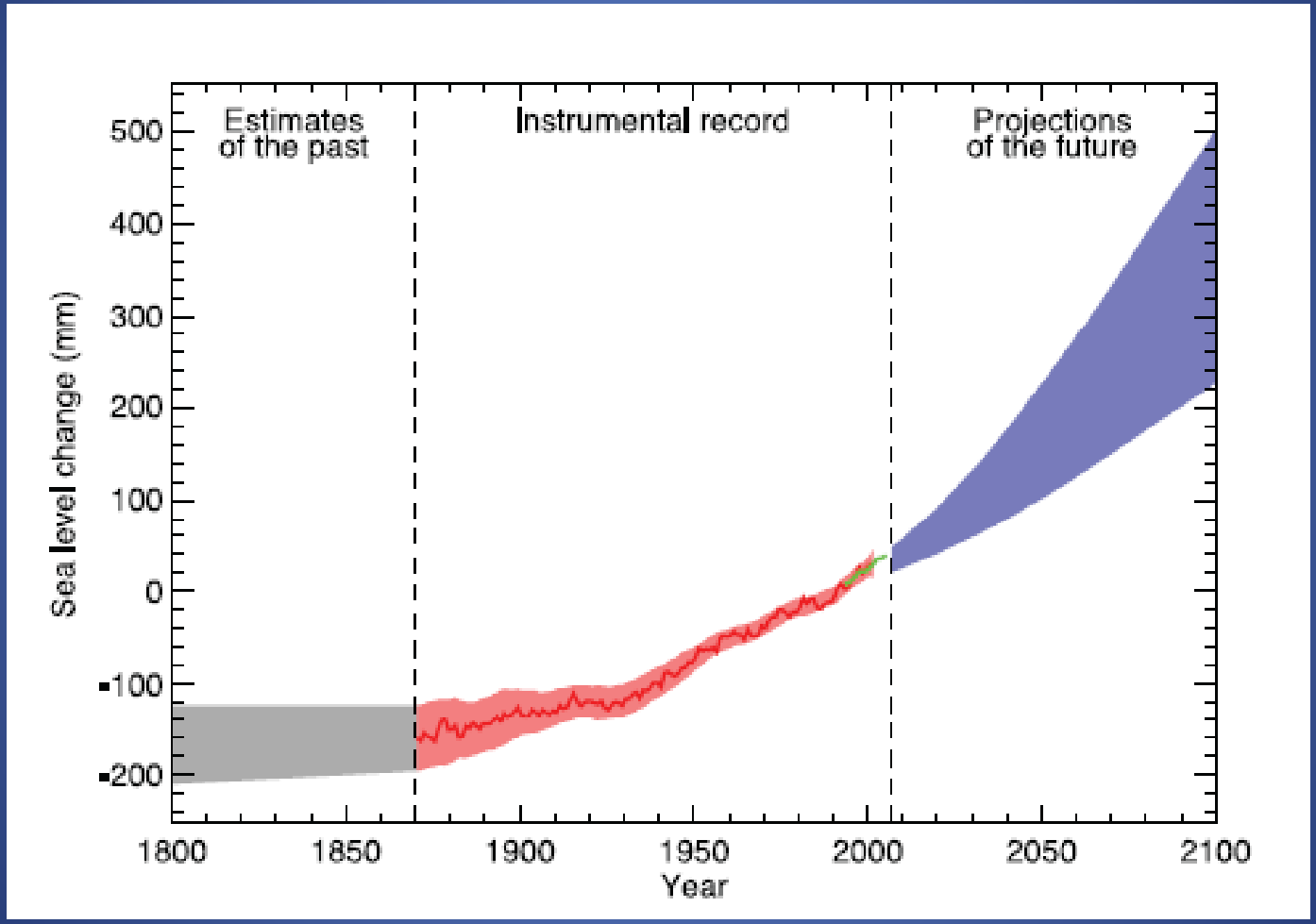

77°
76°
75°
74°
73°
72°
41°
40°
39°
38°
37°
Long Island Sound
New York
Pennsylvania
New Jersey
Maryland
DC
Delaware Bay
Delaware
Atlantic Ocean
Virginia
Chesapeake Bay
0 25 50 100 150 200
Kilometers
Will Wetlands Be Converted to Open Water?
Rate of Sea Level Rise
Current rate Yes ? ? No No No No No
Current + 2 mm/yr Yes Yes Yes? ? No No No No
Current + 7 mm/yr Yes Yes Yes Yes Yes Yes? ? No
? = Wetlands would be marginal Yes? = Wetland would be marginal or lost

Sea-Level Rise Predictions

- IPCC – 22 to 44 cm above 1990 levels by mid-2090 (8.6 to 17.3 in)
- EPA – 9 to 88 cm by 2100 (3.5 to 34.6 in)
- USGS – 15 to 95 cm by 2100 (6 to 37 in)
- NOAA – 50 cm by 2100 (19.7 in)

  – Variability in prediction due to uncertainties.

Global Mean Sea Level



(IPCC, 2007)

Effects of Sea-Level Rise

- Tidal inundation of low-lying areas
- Coastal erosion of wetlands and beaches
- Barrier island migration
- Increased coastal flooding
- Increased salinity of aquifers and estuaries

Uncertainties of Coastal Response

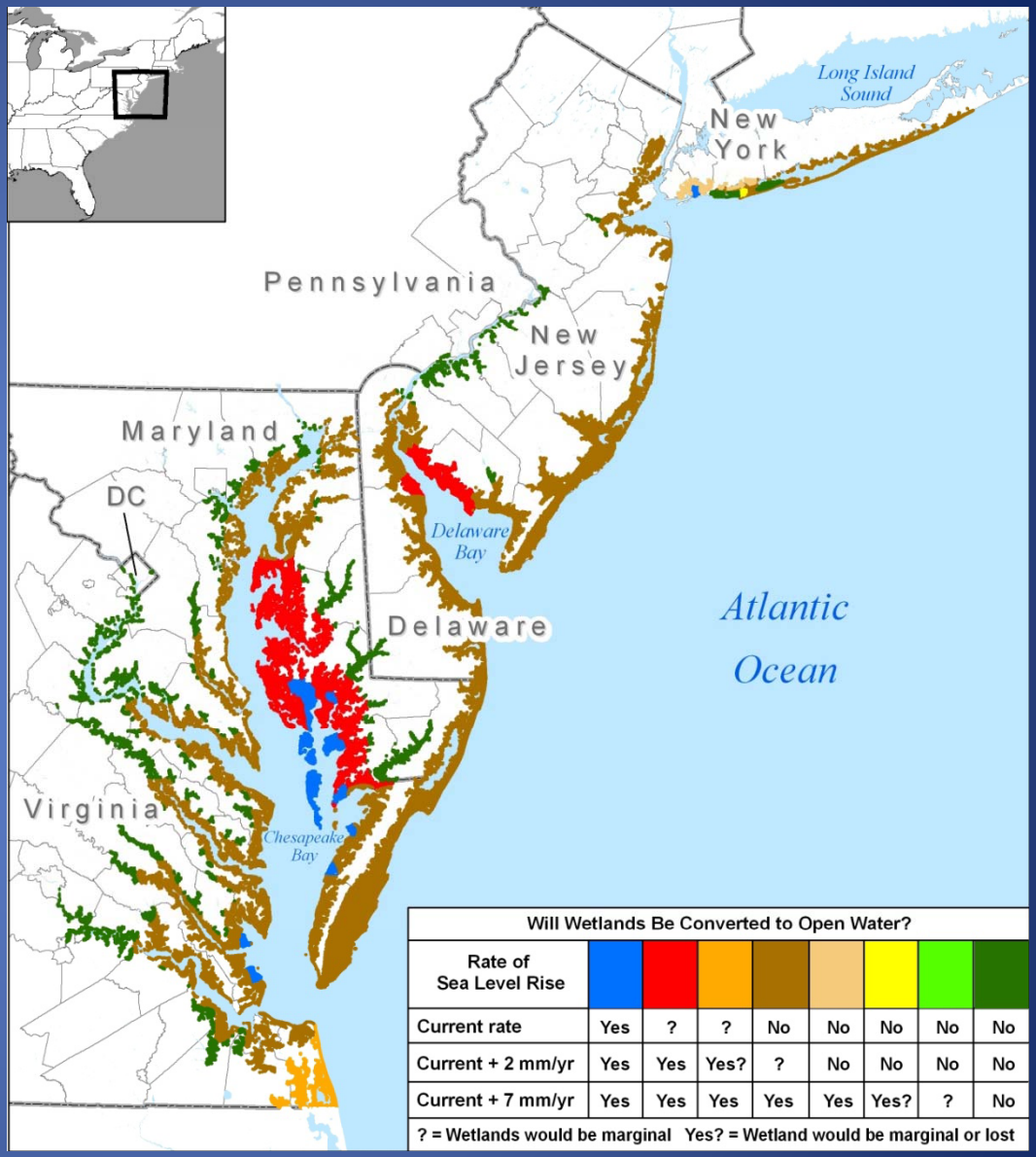
- Shorelines are in a continual state of change in response to natural processes.
- Difficult to quantify the range of factors that influence coastal change.

Assess Vulnerability

Example:

Wetland survival in response to three potential sea-level rise scenarios:

Current rate
Current rate +2 mm/yr
Current rate +7mm/yr



Will Wetlands Be Converted to Open Water?								
Rate of Sea Level Rise								
Current rate	Yes	?	?	No	No	No	No	No
Current + 2 mm/yr	Yes	Yes	Yes?	?	No	No	No	No
Current + 7 mm/yr	Yes	Yes	Yes	Yes	Yes	Yes?	?	No

? = Wetlands would be marginal Yes? = Wetland would be marginal or lost

(CCSP 4.1)

Goals and Future Plans

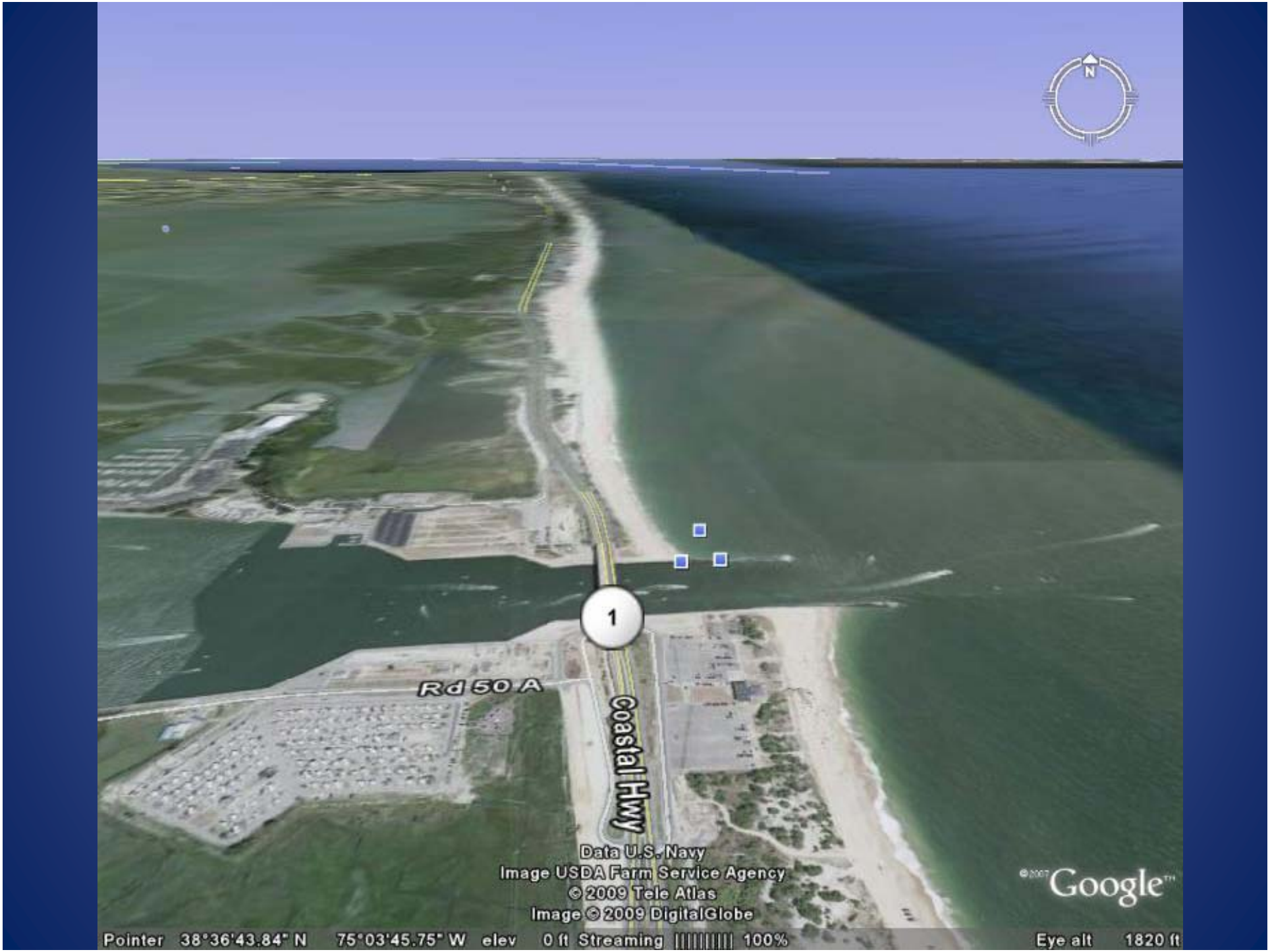
- Strike a balance between growing populations desire to use coastal areas and the coast's naturally changing shoreline
- Protect life and property from coastal hazards
- Protect coastal wetlands and habitats in harmony with economic growth.
- Continue research, data collection and planning to assess coastal vulnerability and improve coastal management actions to adapt to sea-level rise and maintain societal expectations for natural resources and land use.

(CCSP 4.1)

Beaches

Doug Inman, University of California, San Diego

- SEDIMENT SOURCES
- SEDIMENT PATHWAYS
- SEDIMENT SINKS


N
1
Rd 50 A
Coastal Hwy
Data U.S. Navy
Image USDA Farm Service Agency
© 2009 Tele Atlas
Image © 2009 DigitalGlobe
Google
Pointer 38°36'43.84" N 75°03'45.75" W elev 0 ft Streaming 100%
Eye alt 1820 ft


N
Data U.S. Navy
Image © 2009 TerraMetrics
© 2009 Tele Atlas
Image © 2009 DigitalGlobe
©2007 Google™
Pointer 38°45'55.78" N 75°05'05.61" W elev 4 ft Streaming 100%
Eye alt 11738 ft

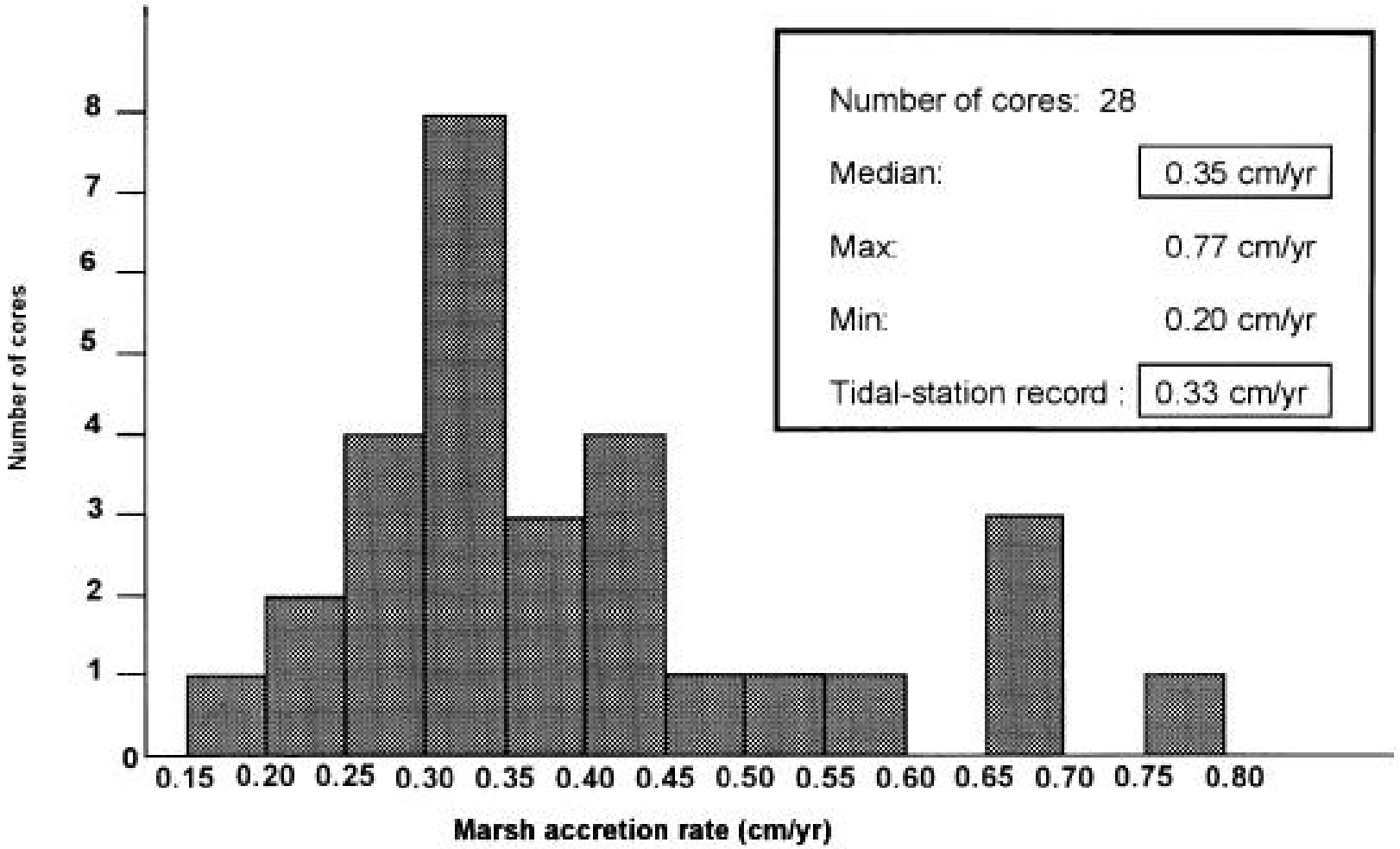


Fig. 6. Histogram showing the distribution of marsh accretion rates along the Delaware coast determined from ^{210}Pb analyses.

Photo Courtesy of Wendy Carey

Photo Courtesy of Wendy Carey

1991

Flooding impacts – permanent, ephemeral; (courtesy of Wendy Carey)

Other impacts on wetlands? - e.g. snow goose grazing, etc.

Courtesy of Wendy Carey