

THE PETTAQUAMSCUTT ESTUARY: CLIMATE CHANGE

NARROW RIVER PRESERVATION ASSOCIATION ANNUAL MEETING

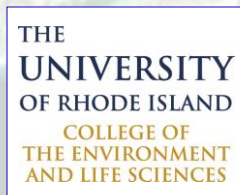
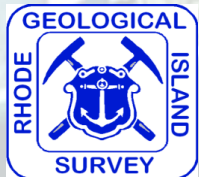
3 October 2013

***Jon C. Boothroyd^{1,2}, Bryan A. Oakley^{1,3}
and Scott Rasmussen^{1,2}***

(1) Rhode Island Geological Survey

(2) Department of Geosciences, University of Rhode Island, Kingston RI 02881

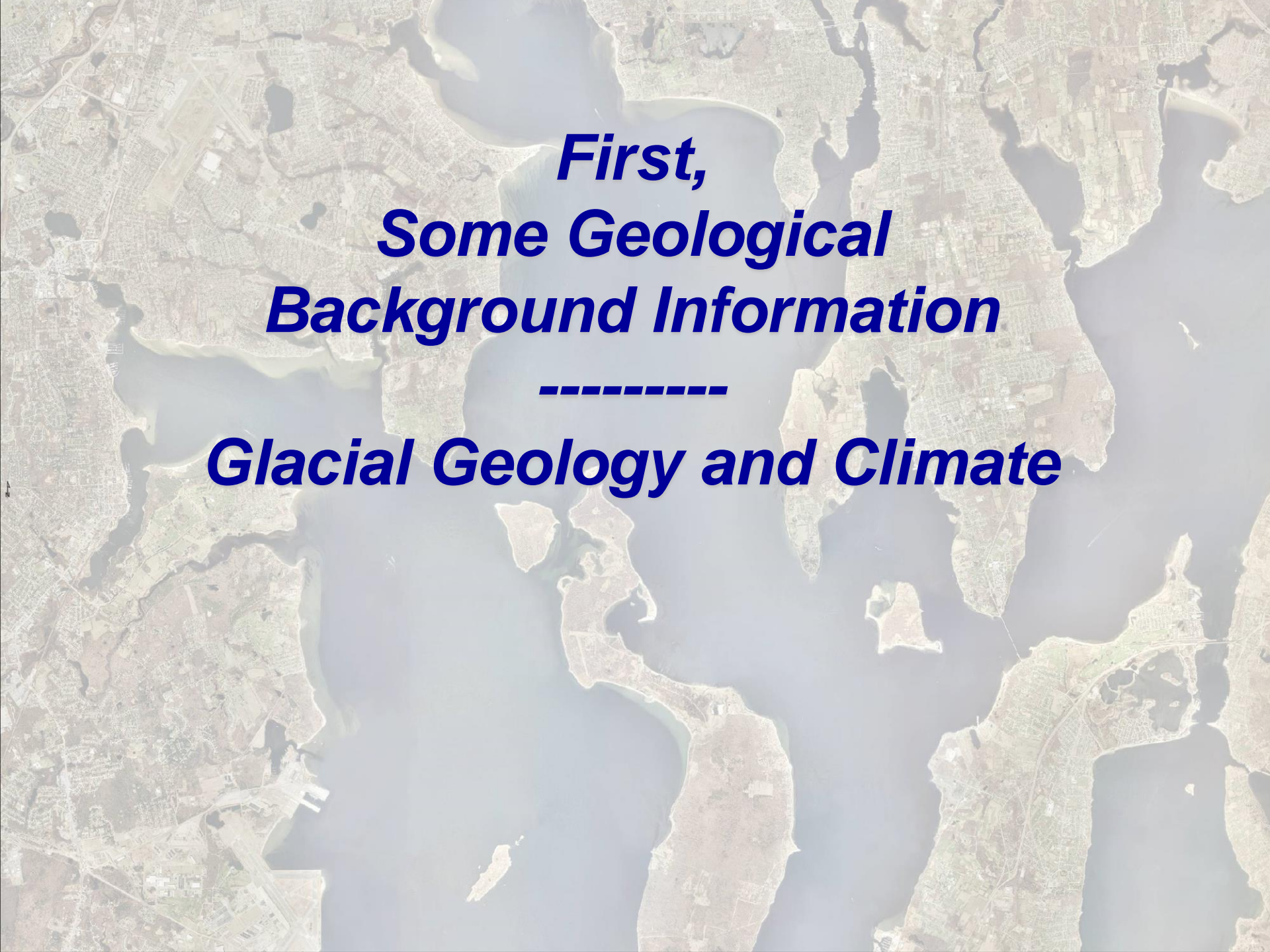
***(3) Environmental Earth Science Department, Eastern Connecticut State
University, Willimantic, CT 06226***



Summary for Rhode Island:

- **Glacial Geology, Past and Present, the Underlying Key to Understanding Processes and Products**
- **Storms the Most Important Driver in Coastal Change Sea-Level Rise a Secondary Effect**
- **Washover Fan Deposition is Key to Barrier Migration**
- **Future Major Storms Combined With Sea-Level Rise a Very Large Problem**
- **Accelerated Sea-Level Rise also a Very Large Potential Problem**
- **RI CRMC Planning for a 3-5 foot Rise by 2100 and a 1-1.5 foot Rise by 2050**

EROSION, INUNDATION, MIGRATION

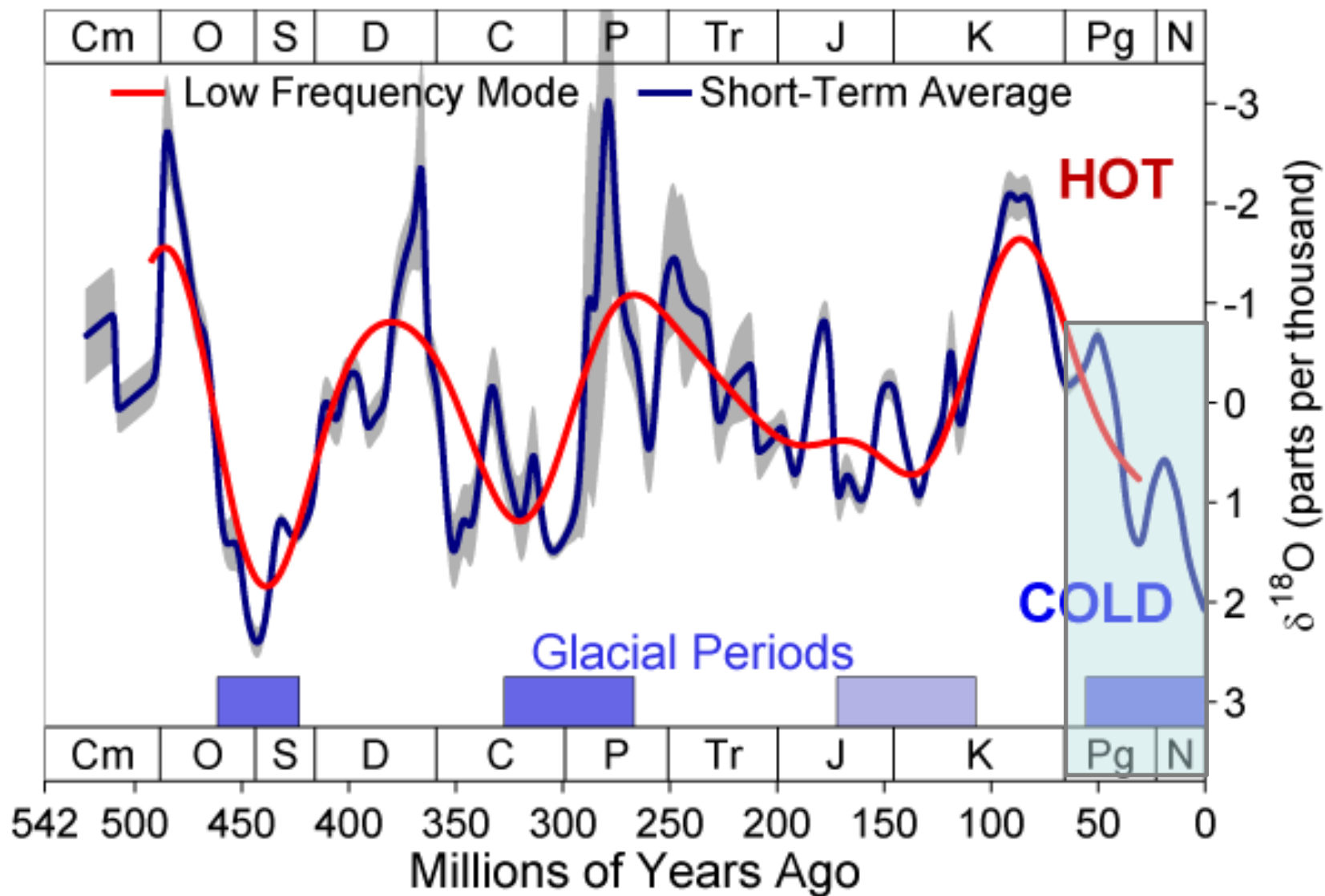
An aerial photograph of a coastal region, likely the Chesapeake Bay area, showing a large body of water in the center surrounded by land with various urban and natural features. The text is overlaid on the water and land.

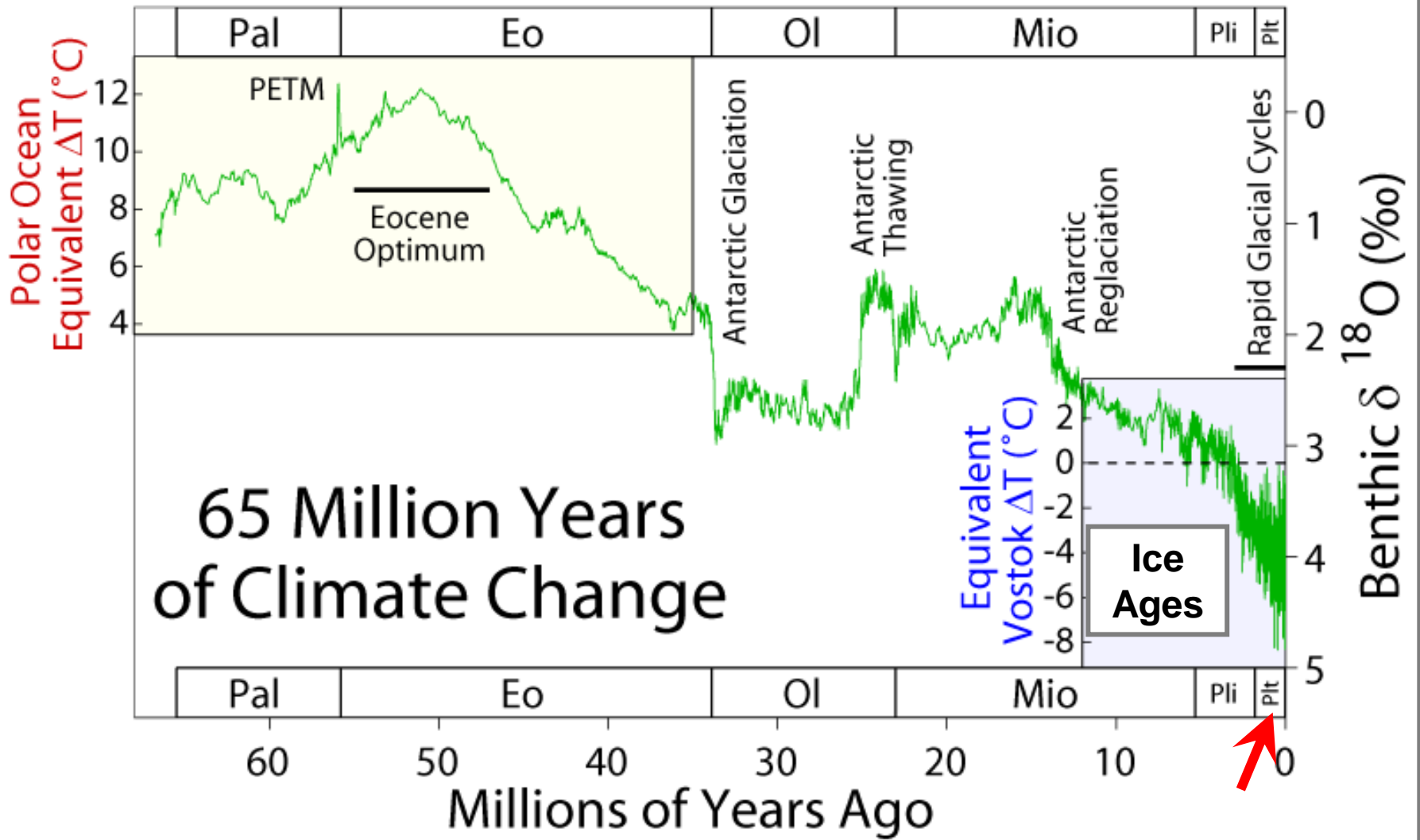
***First,
Some Geological
Background Information***



Glacial Geology and Climate

Phanerozoic Climate Change





Geologic Time Scale

Cenozoic – Last 65.5 my

Quaternary -
Last 2.6 my

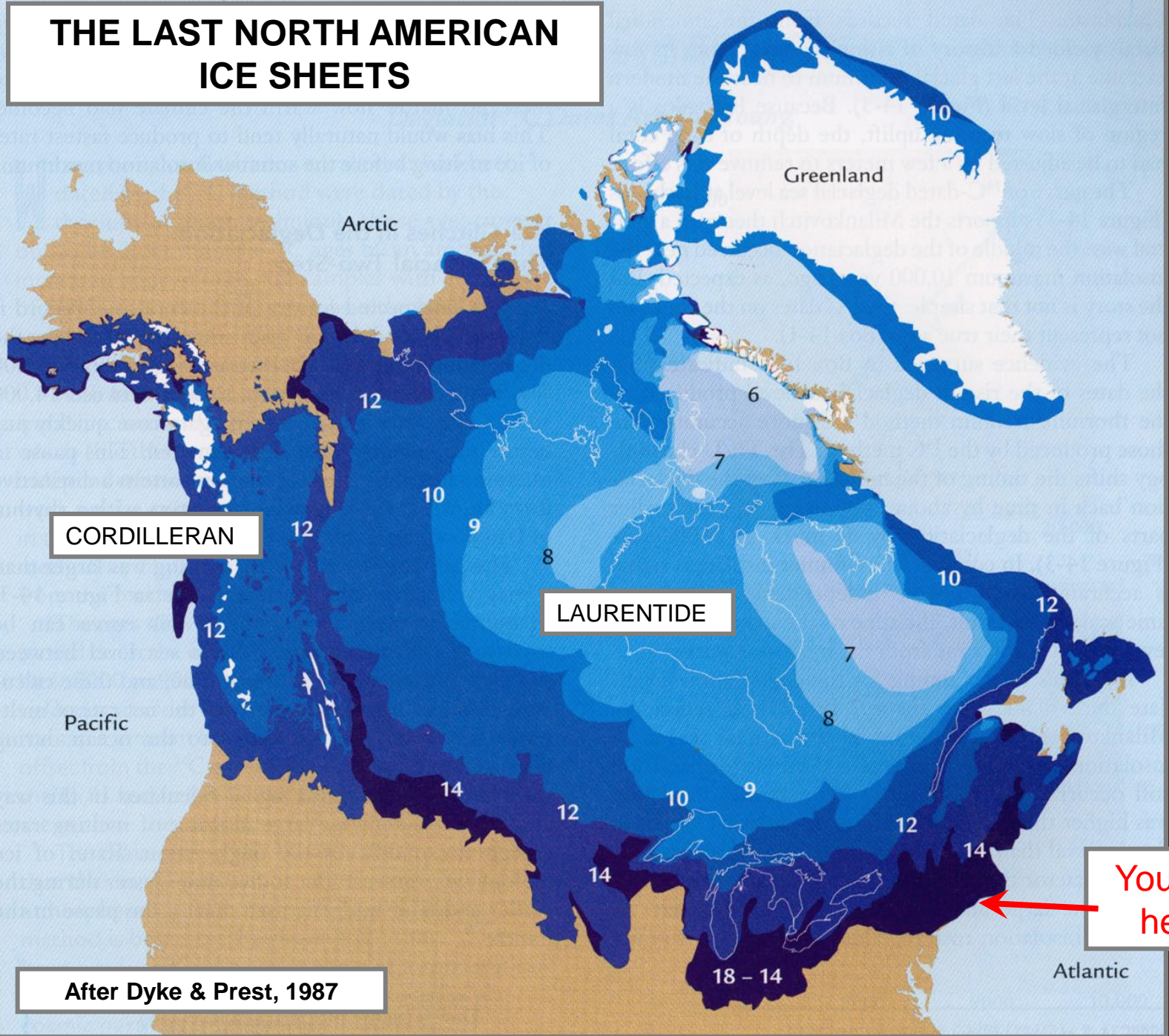


EONOTHEM / EON	ERATHEM / ERA	SYSTEM, SUBSYSTEM / PERIOD, SUBPERIOD	SERIES / EPOCH	Age estimates of boundaries in mega-annum (Ma) unless otherwise noted	
Cenozoic (Cz)	Tertiary (T)	Quaternary (Q)	Holocene	11,700 ±99 yr*	
			Pleistocene	2.588*	
		Neogene (N)	Pliocene	5.332 ±0.005	
			Miocene	23.03 ±0.05	
				Oligocene	33.9 ±0.1
			Eocene	55.8 ±0.2	
				Paleocene	65.5 ±0.3
			Paleogene (R)		

Quaternary Geology Time Scales

- **QUATERNARY PERIOD** - **Last 2.6 million years** of geologic time
- **PLEISTOCENE EPOCH** – **All of Quaternary Period except last 11,700 years**
- **WISCONSINAN STAGE** – Last glacial age of the Pleistocene (**~70,000 years BP to 11,700 yrs BP**)
- **HOLOCENE EPOCH** – **Last 11,700 years** (including now)
- **ANTHROPOCENE EPOCH** – **1850 AD onward** (some would say)

THE LAST NORTH AMERICAN ICE SHEETS



CORDILLERAN

LAURENTIDE

You are here

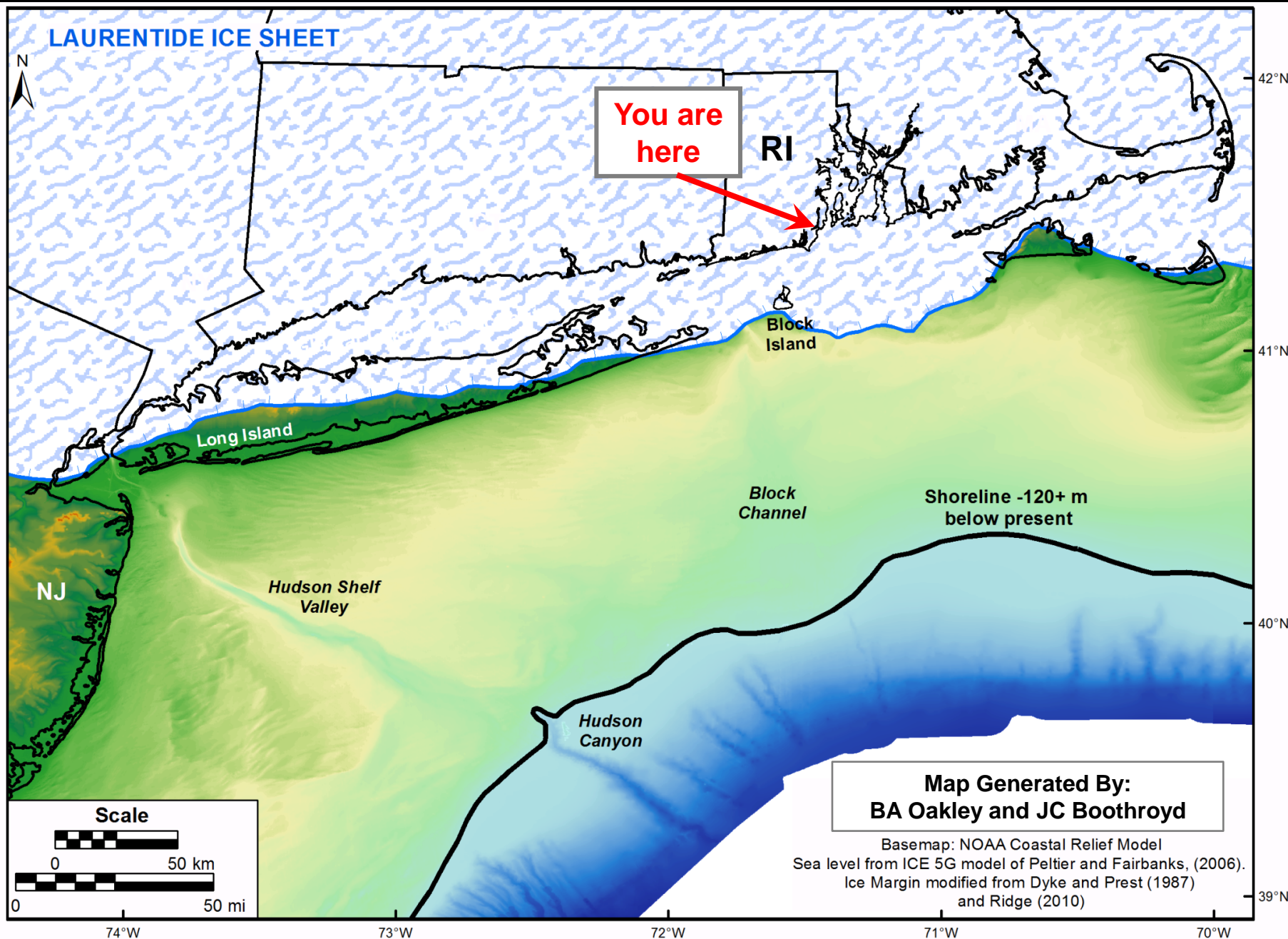
After Dyke & Prest, 1987

MALASPINA GLACIER – Northeast Gulf of Alaska

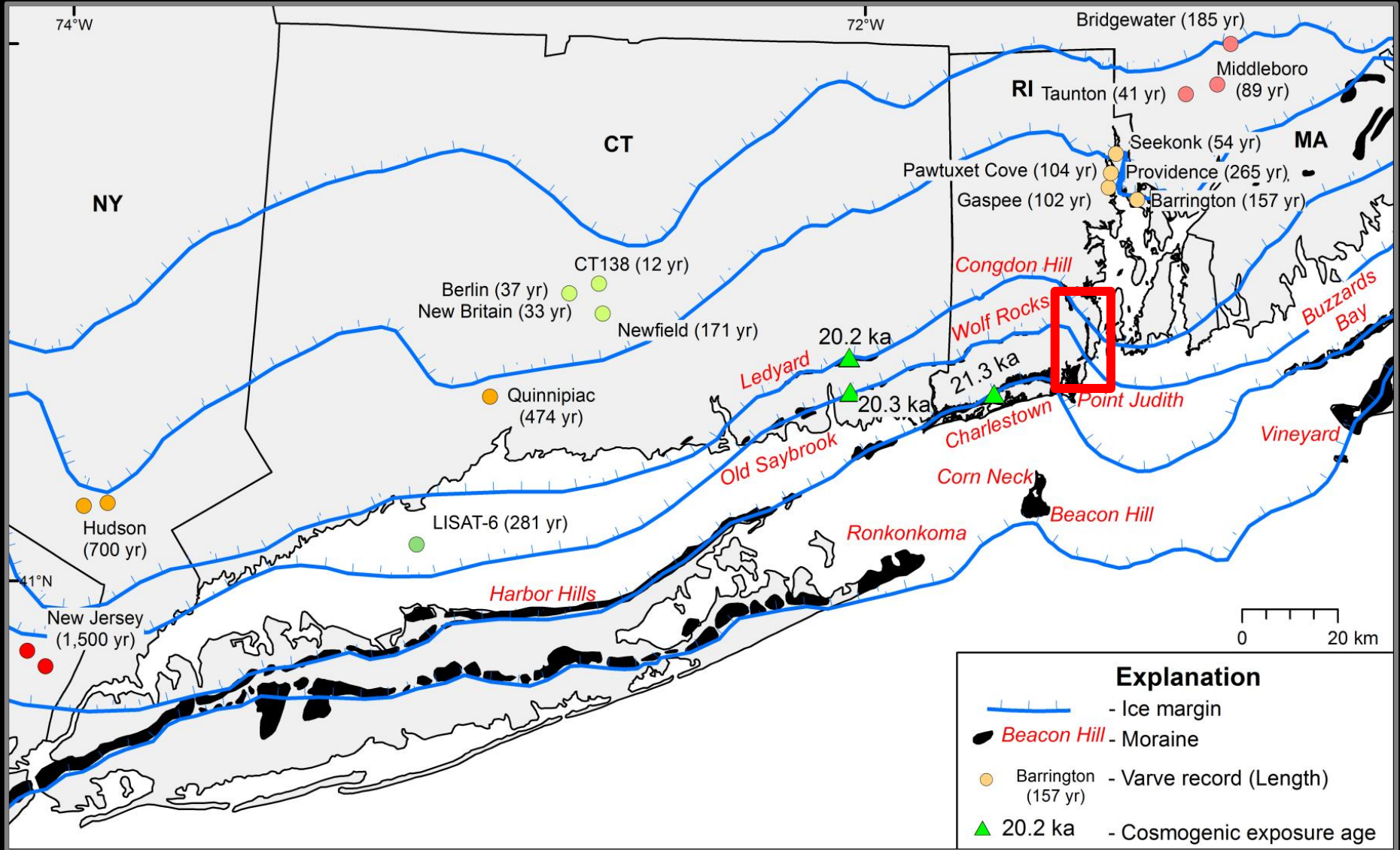


An Analog “The size of Rhode Island”

S New England, E New York, Continental Shelf at LGM ~ 26,000 yBP



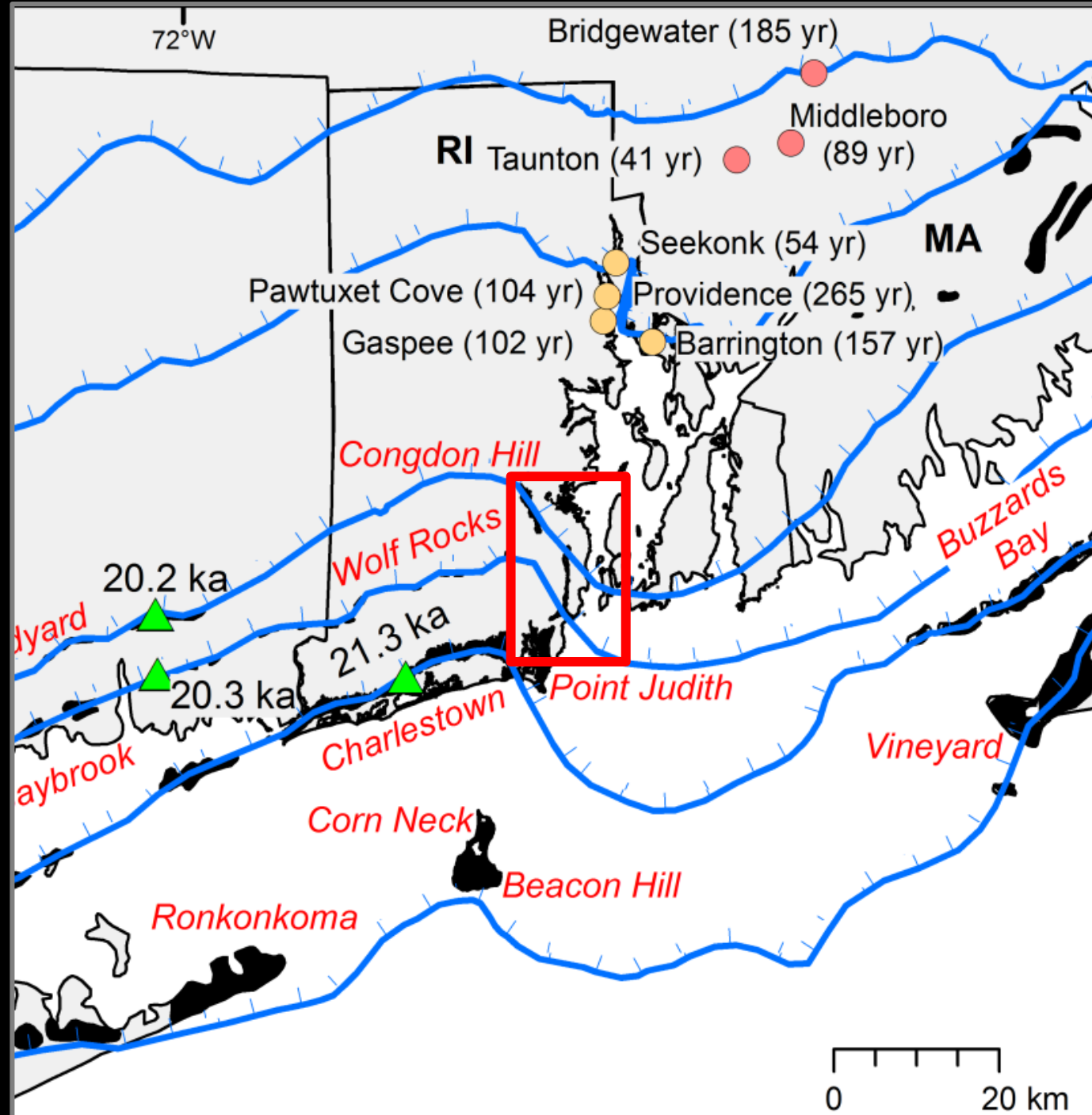
Laurentide Ice Sheet Retreat – Southern New England



Explanation	
	- Ice margin
	<i>Beacon Hill</i> - Moraine
	Barrington - Varve record (Length) (157 yr)
	20.2 ka - Cosmogenic exposure age

Laurentide Ice Retreat – Southern New England

Oakley and Boothroyd, 2013



Glacial Lakes

Block Island and Rhode Island

~ 21,300 yBP

Oakley, 2012

Charlestown
Moraine

Laurentide Ice Sheet

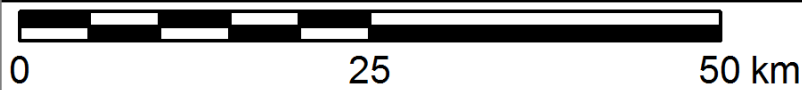
Glacial Lake
Block Island

Glacial Lake
Rhode Island

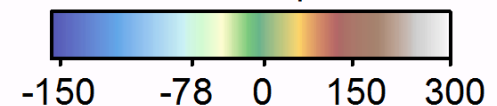
Block
Channel

The
Mud Hole

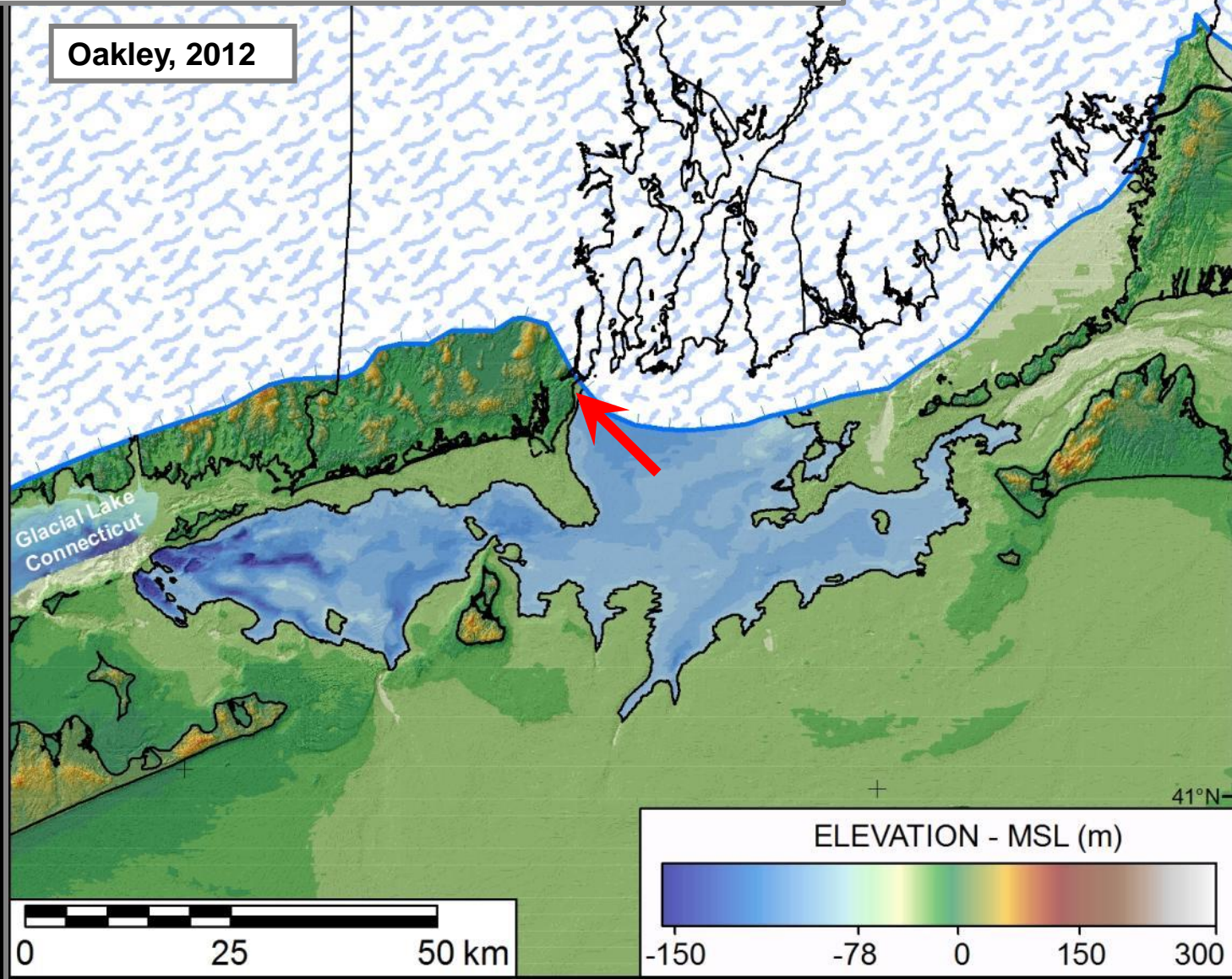
Ice margins modified from:
Dyke and Prest, 1987
Ridge, 2010; Goss, 1993
Smith, 2010



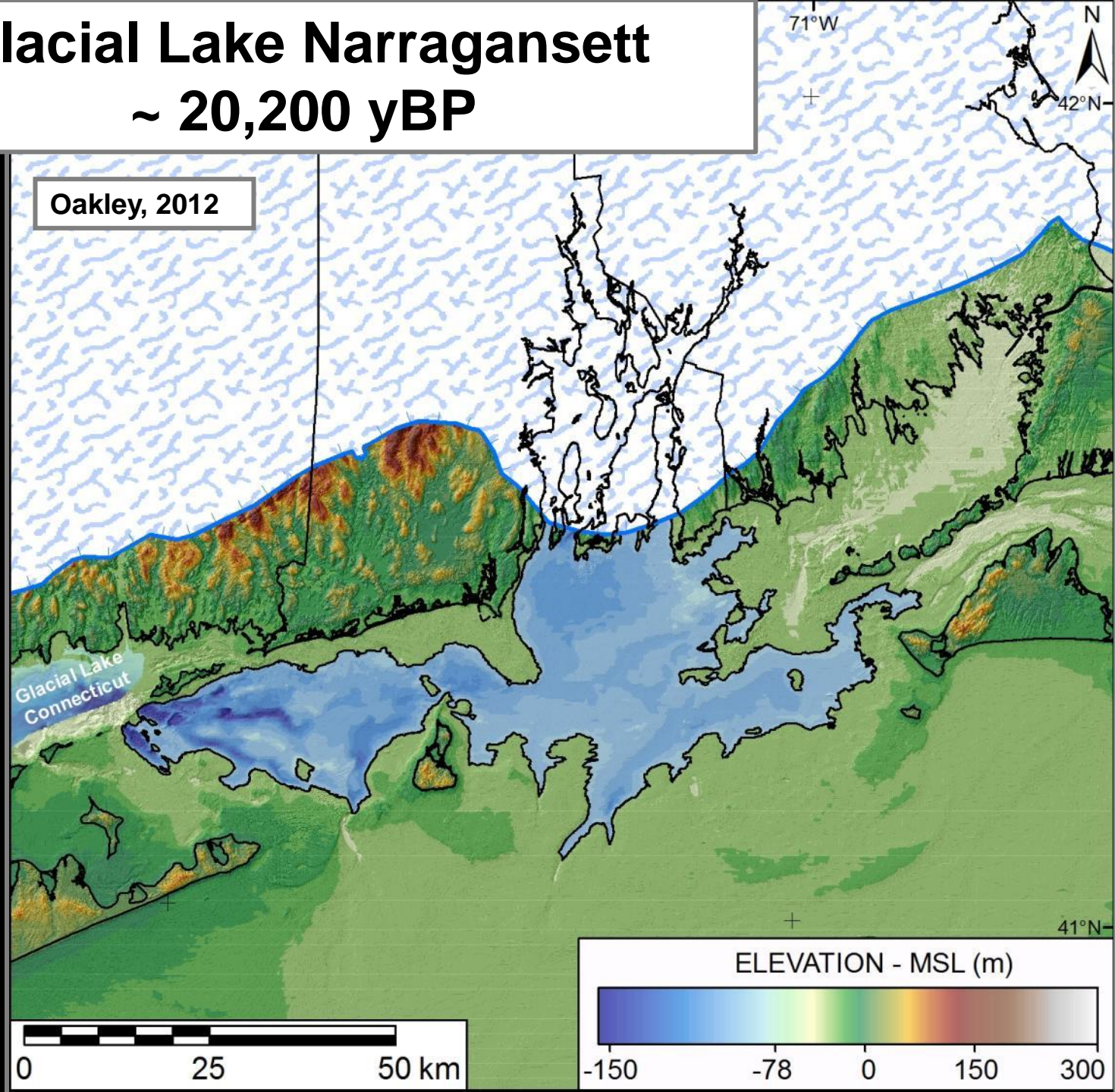
ELEVATION - m - present MSL



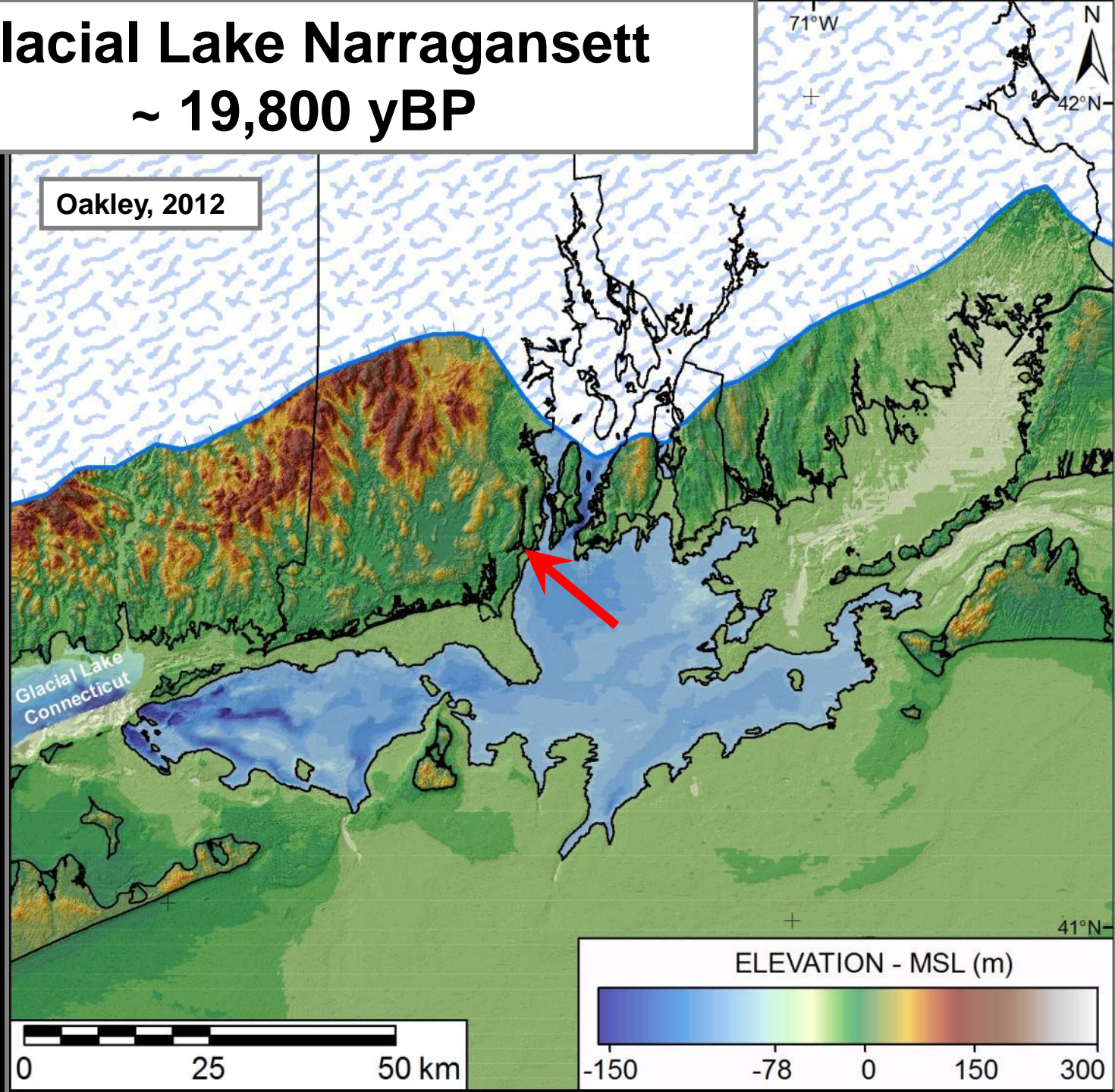
Glacial Lakes Block Island and Rhode Island ~ 20,300 yBP



Glacial Lake Narragansett ~ 20,200 yBP



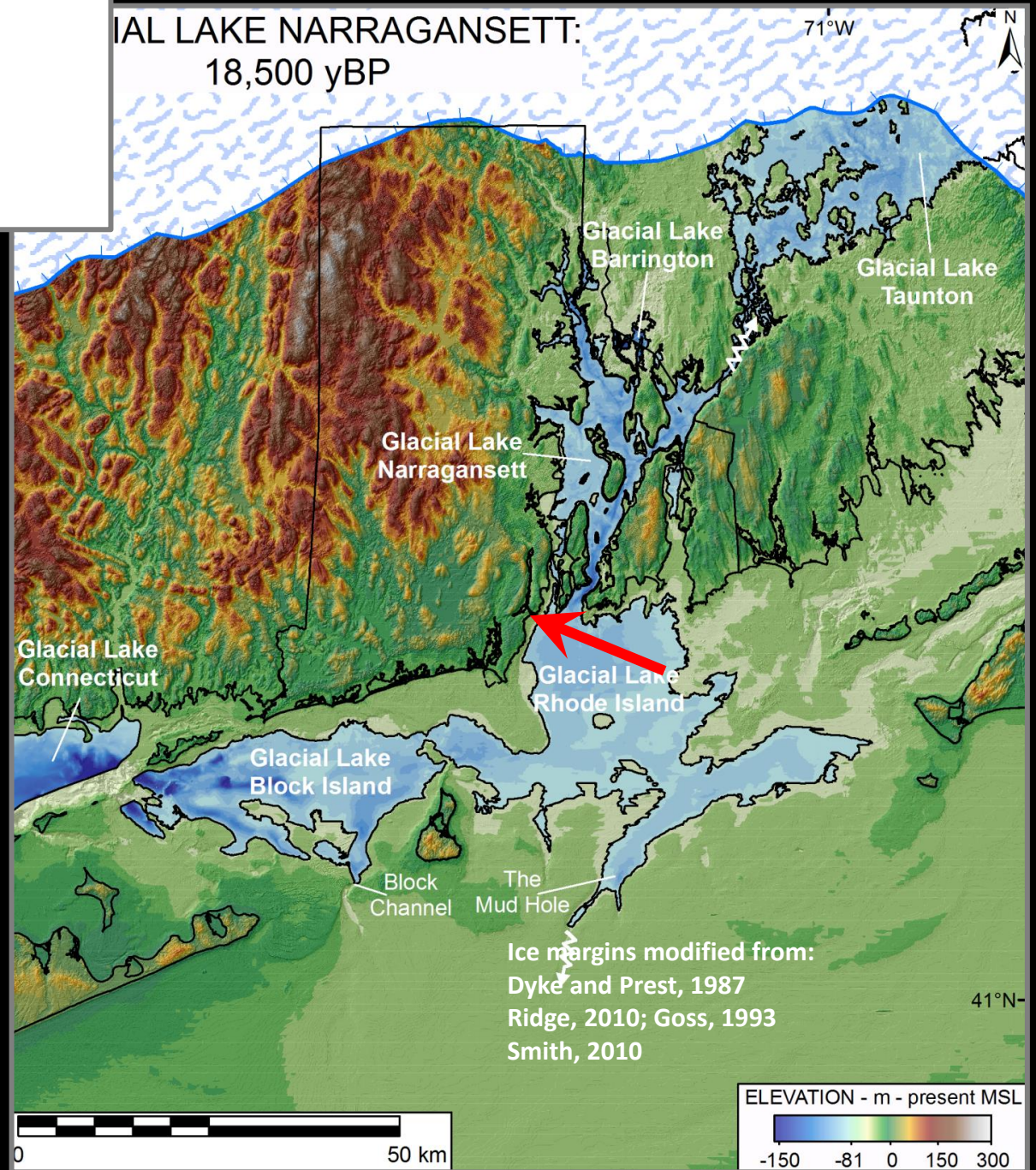
Glacial Lake Narragansett ~ 19,800 yBP



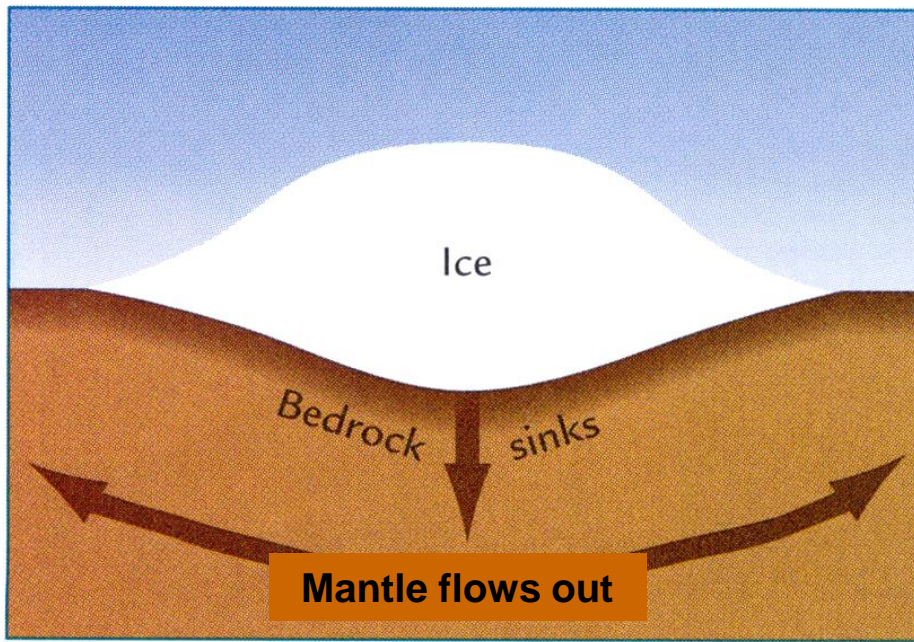
Glacial Lake Narragansett ~ 18,500 yBP

Oakley, 2012

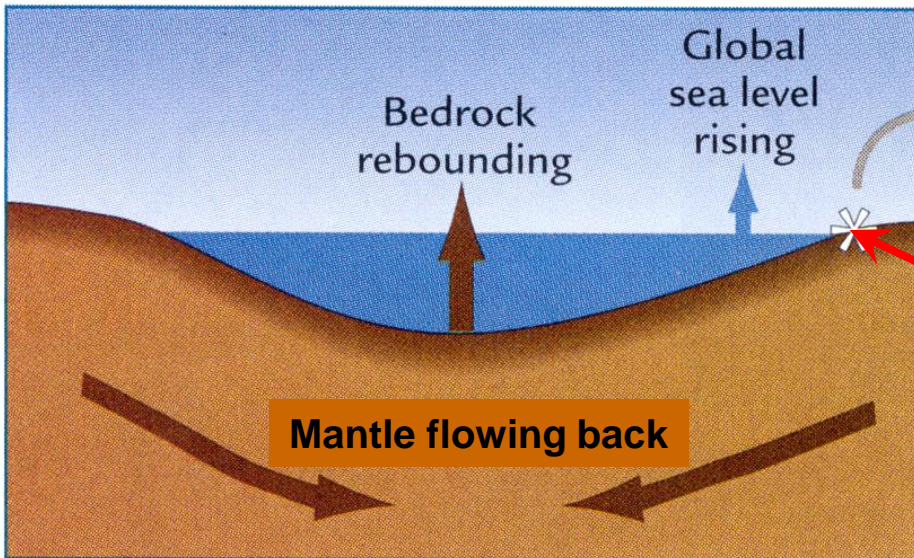
Glacier Retreat From RI



Isostatic Rebound

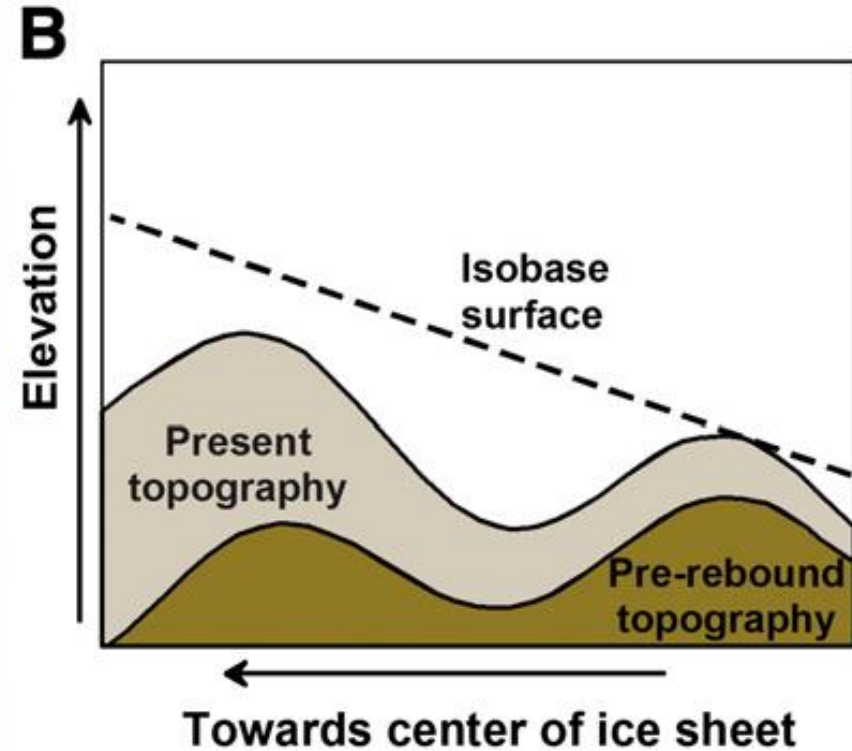
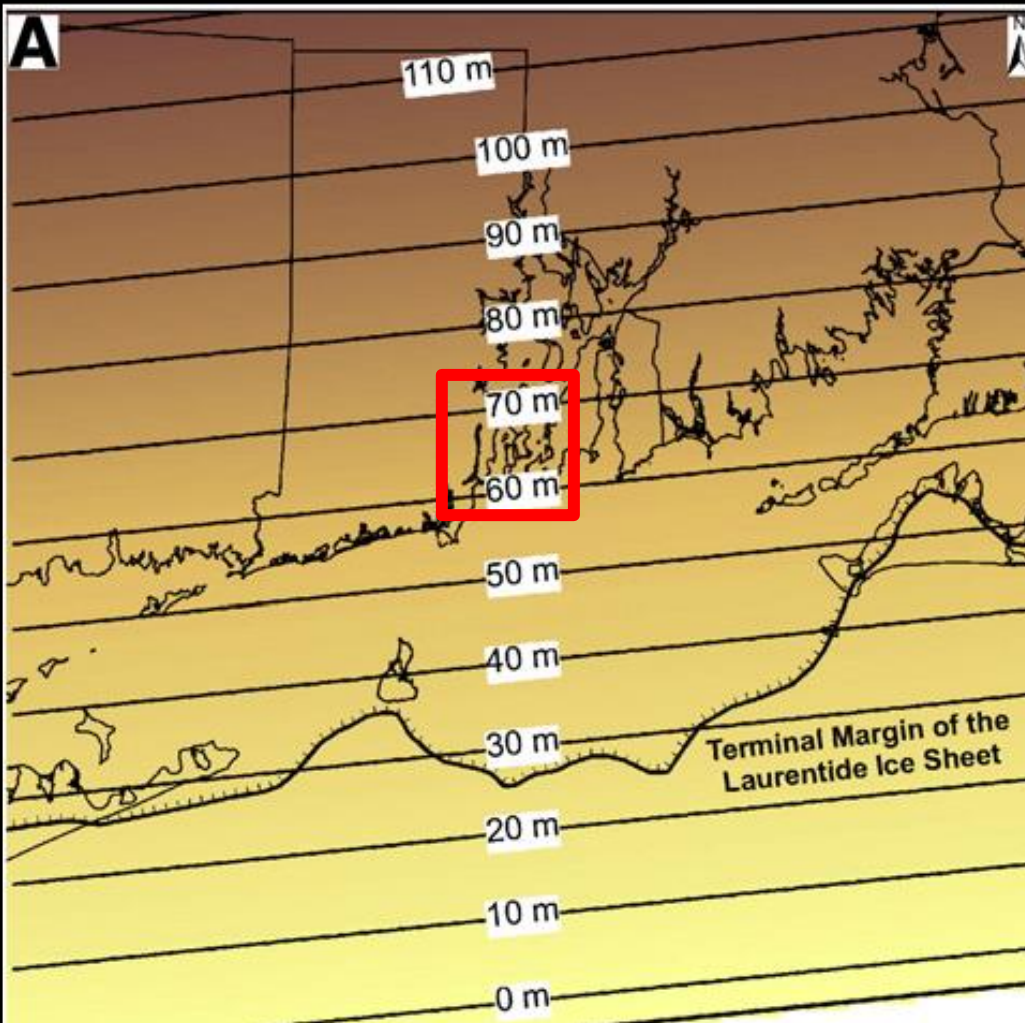


A Last glaciation (21,000 years ago)

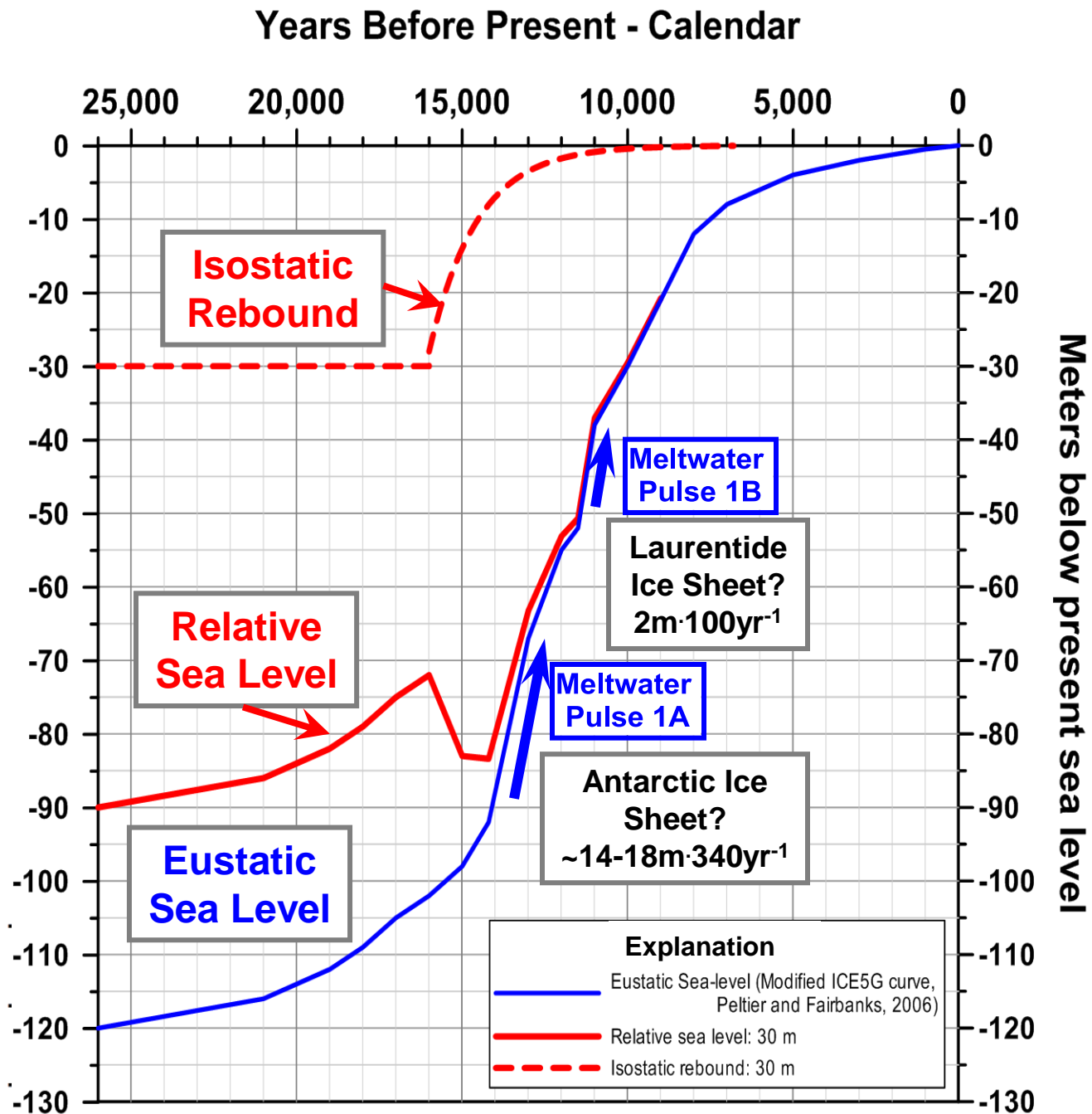


B Today

Isostatic Rebound for Rhode Island



Eustatic Sea-Level Rise + Isostatic Rebound at Block Island RI



Adapted from:
Oakley and Boothroyd,
July 2012

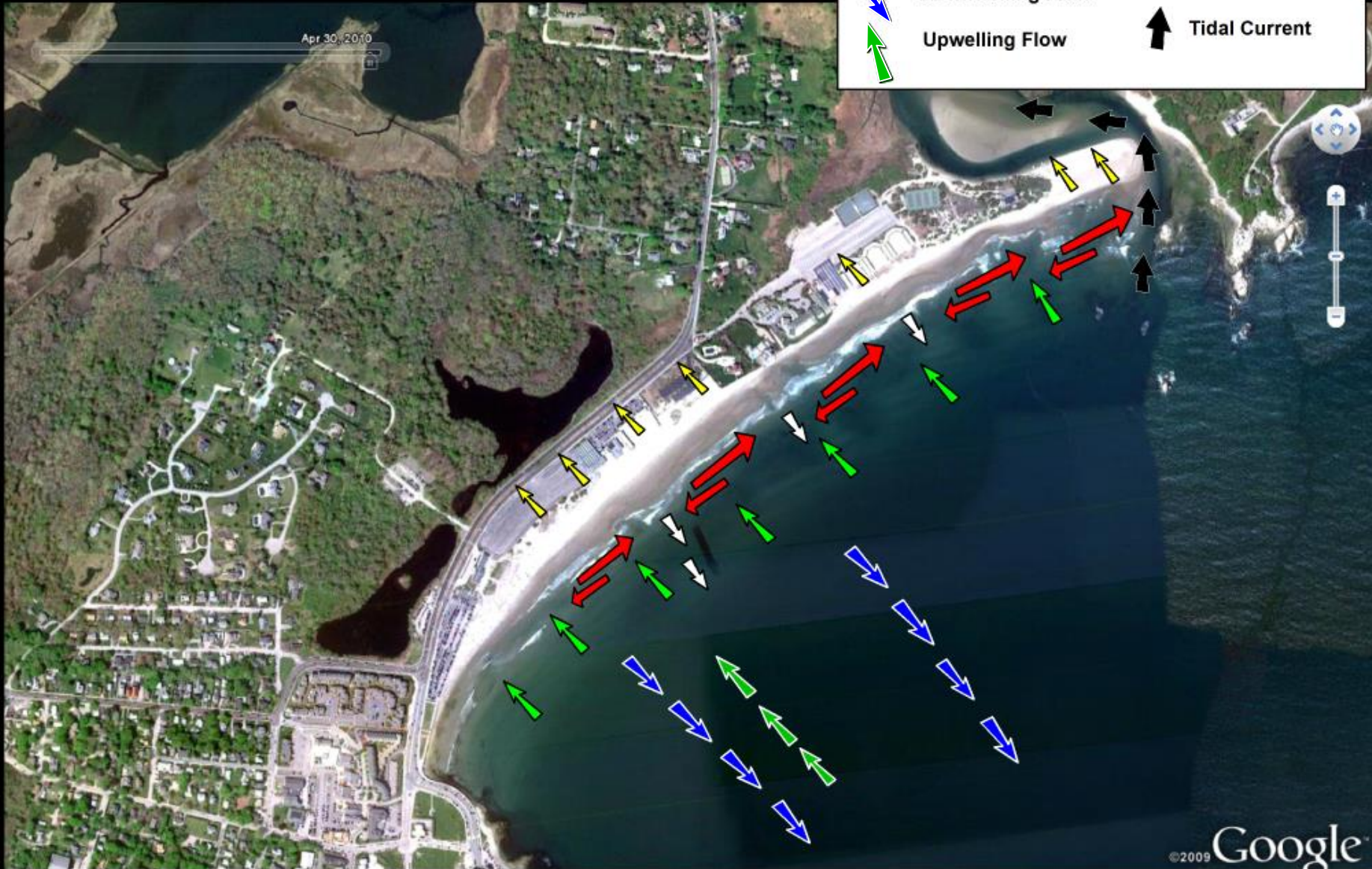
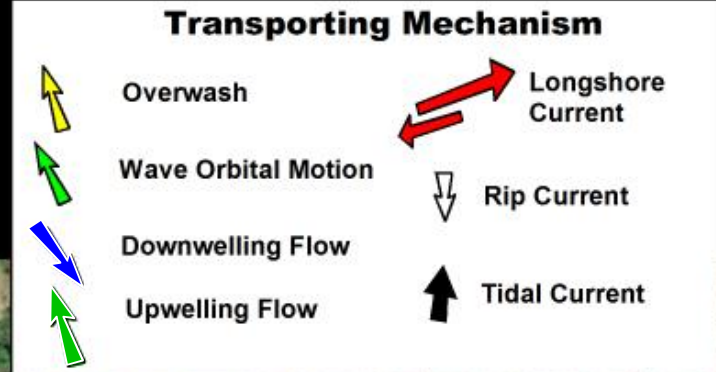
**The Sea May Be Rising Long Term – But.....
Instantaneous Storm Surges
Elevate Sea Level Now**

Narragansett Pier – Superstorm Sandy 2012



J Peabody via Facebook

SEDIMENT TRANSPORT PATHWAYS NARRAGANSETT COASTAL BARRIER



Narragansett Town Beach

Overwash Transport and Deposition – Patriot's Day Extratropical



17 apr 2007

M Salvatore

Washover Fan Deposition Boston Neck Rd - Narragansett

Washover Fan

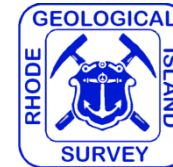


RI DOT

30 Oct 2012

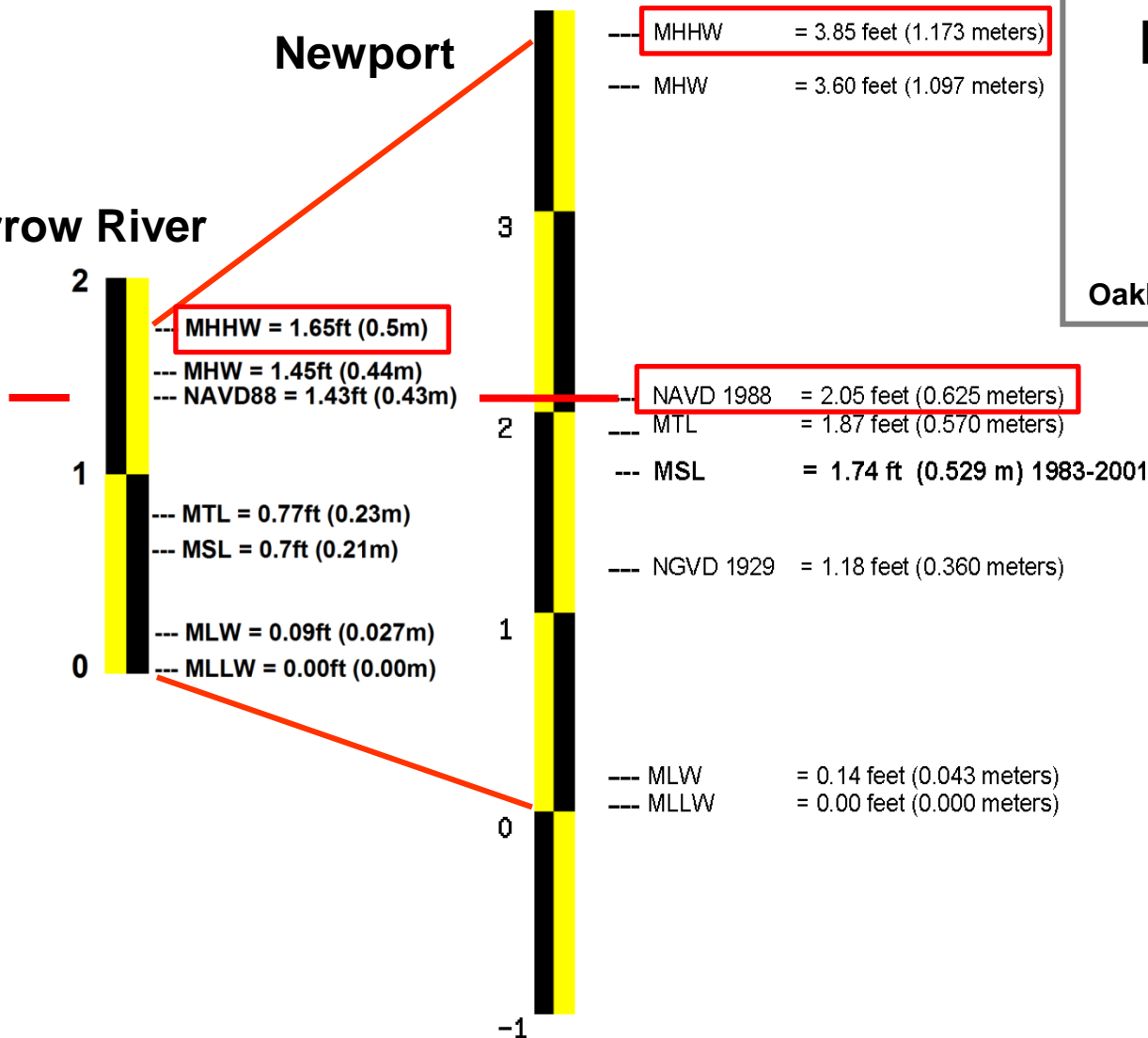
Narrow River – Newport Tidal Datums

Oakley, Alvarez and Boothroyd, 2008



Narrow River

Newport

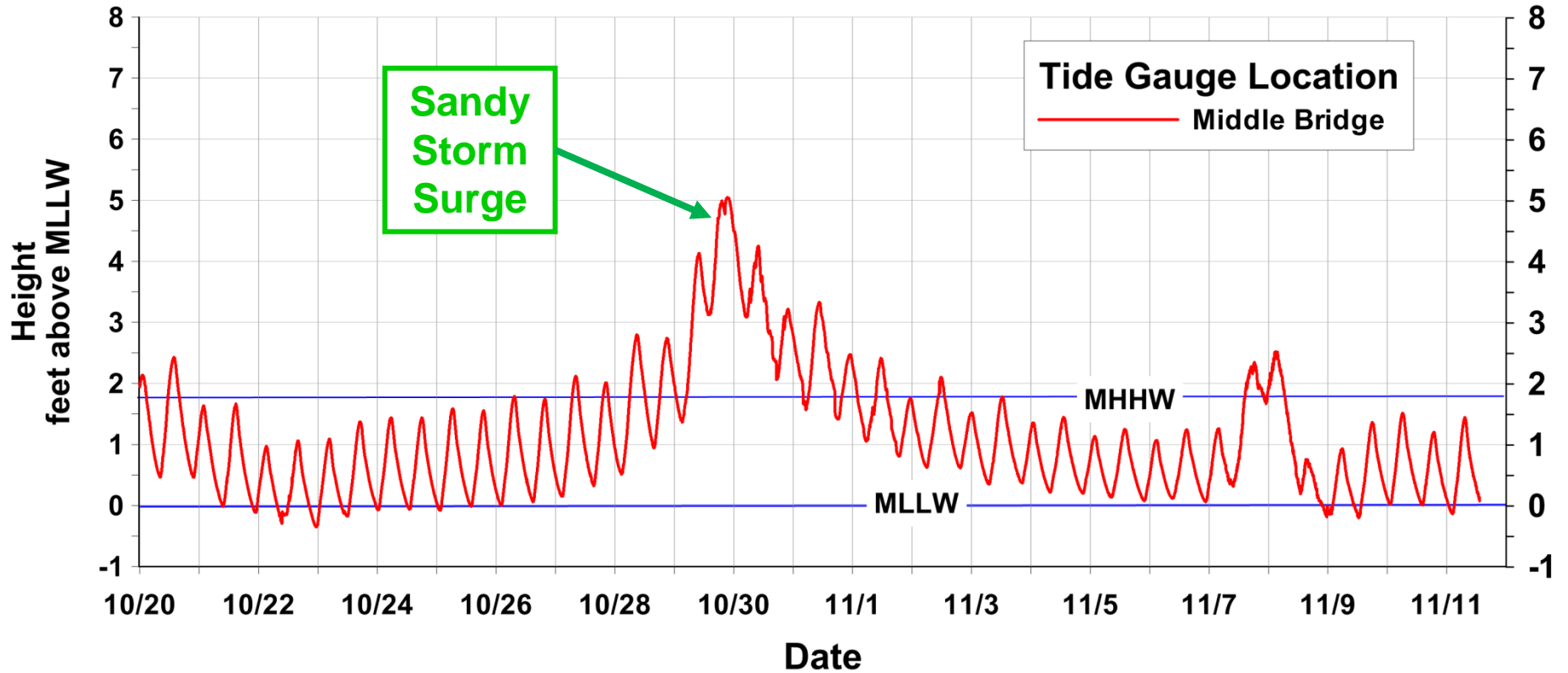


The NAVD 1988 and NGVD 1929 elevations related to MLLW were computed from Bench Mark, 845 2660 TIDAL 6, at the station.

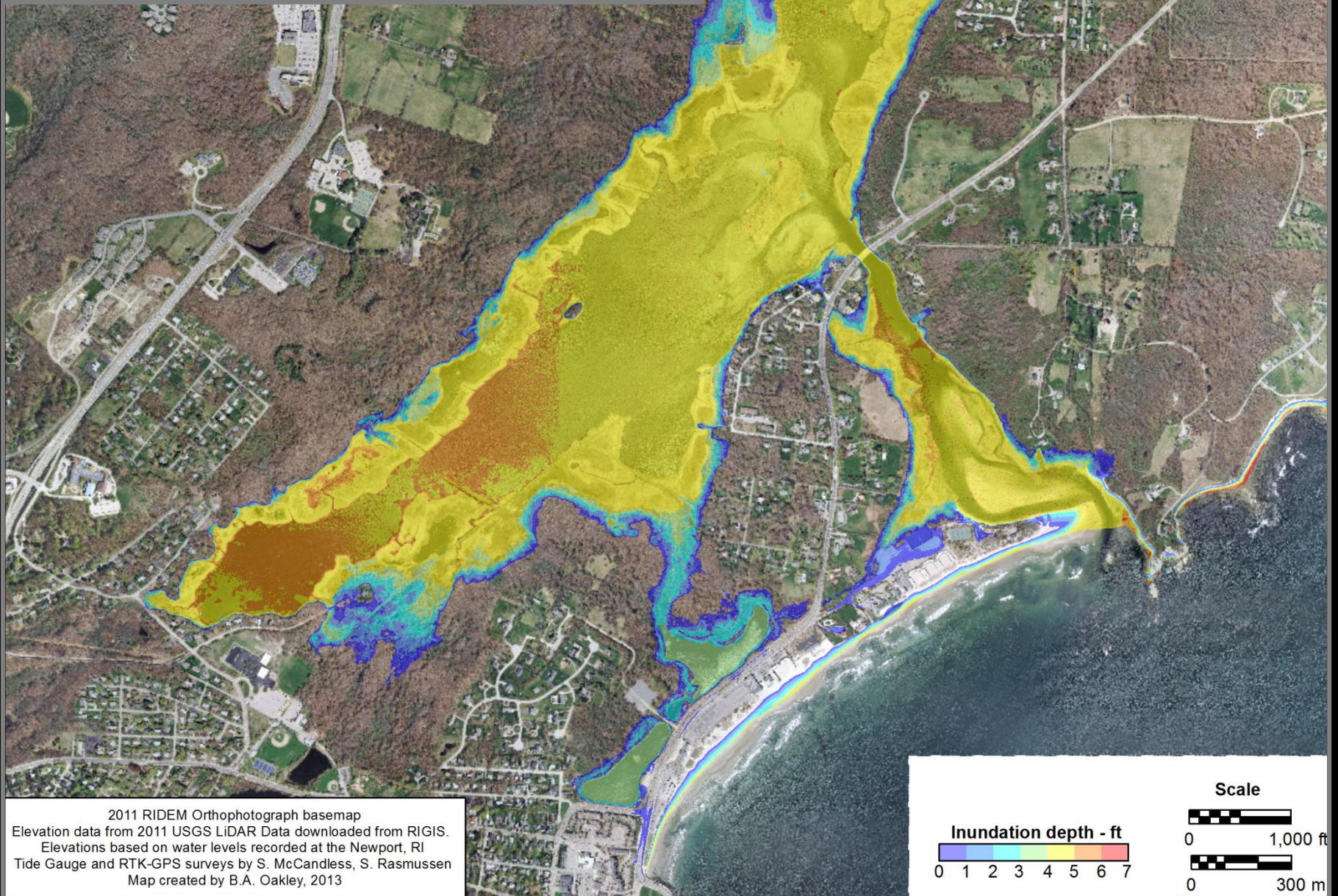
Displayed tidal datums are MEAN HIGHER HIGH WATER (MHHW), MEAN HIGH WATER (MHW), MEAN TIDE LEVEL (MTL), MEAN LOW WATER (MLW), AND MEAN LOWER LOW WATER (MLLW) referenced on 1983-2001 Epoch.

Newport datum adapted from www.ngs.noaa.gov/cgi-bin/ngs_opsd?PID=LW0493

Narrow River Tidal Range

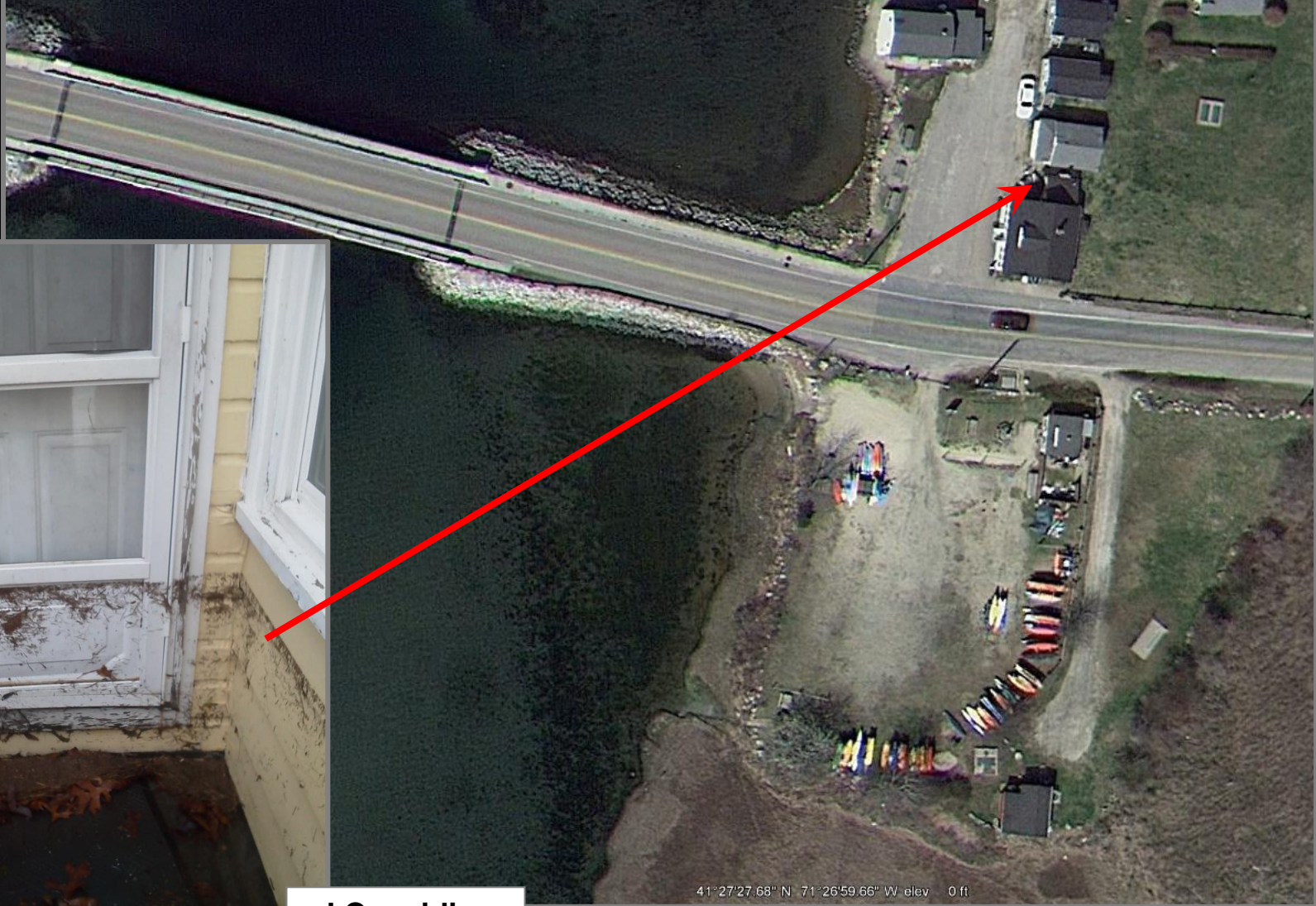


Superstorm Sandy Surge - Narragansett



2011 RIDEM Orthophotograph basemap
Elevation data from 2011 USGS LiDAR Data downloaded from RIGIS.
Elevations based on water levels recorded at the Newport, RI
Tide Gauge and RTK-GPS surveys by S. McCandless, S. Rasmussen
Map created by B.A. Oakley, 2013

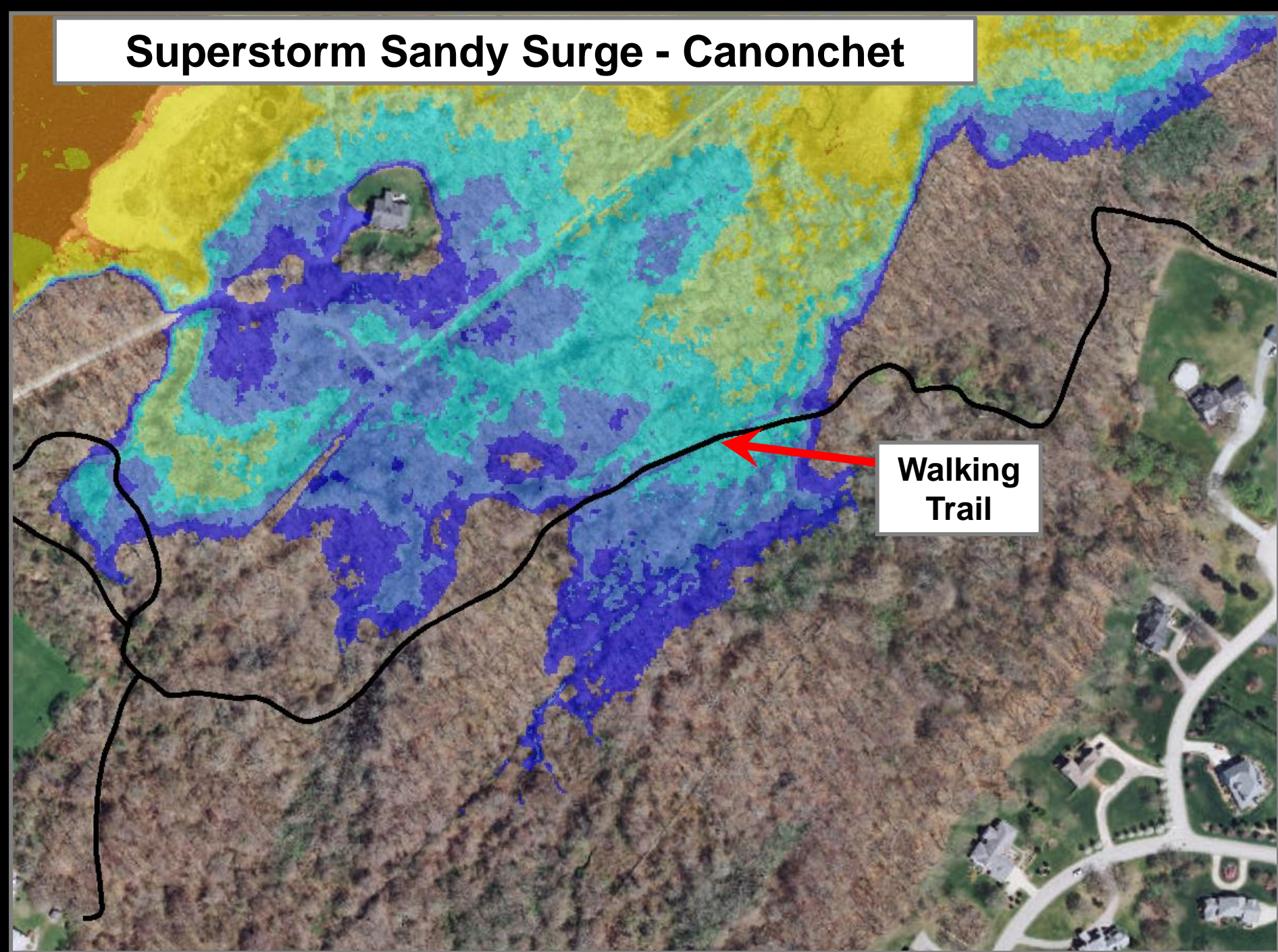
Narrow River Kayaks – Middlebridge Sandy Storm Surge



J Considine
30 Oct 2012

41°27'27.68" N 71°26'59.66" W elev 0 ft

Superstorm Sandy Surge - Canonchet



Walking
Trail

Pre-Sandy – Quonochontaug Barrier Conservation Land

**Washover Fan
Deposition**



Bousquet and Son – Aerial Views

**Post-Sandy –
Quonochontaug Barrier
Conservation Land**

**Barrier Island
Migration**



**Washover Fan
Deposition**

Washover Fan Deposition Misquamicut Barrier - Westerly



Atlantic Ave

Washover Fan

RI DOT

30 Oct 2012

Charlestown Beach, RI – Hurricane Bob 1991 Washover Fan Deposition



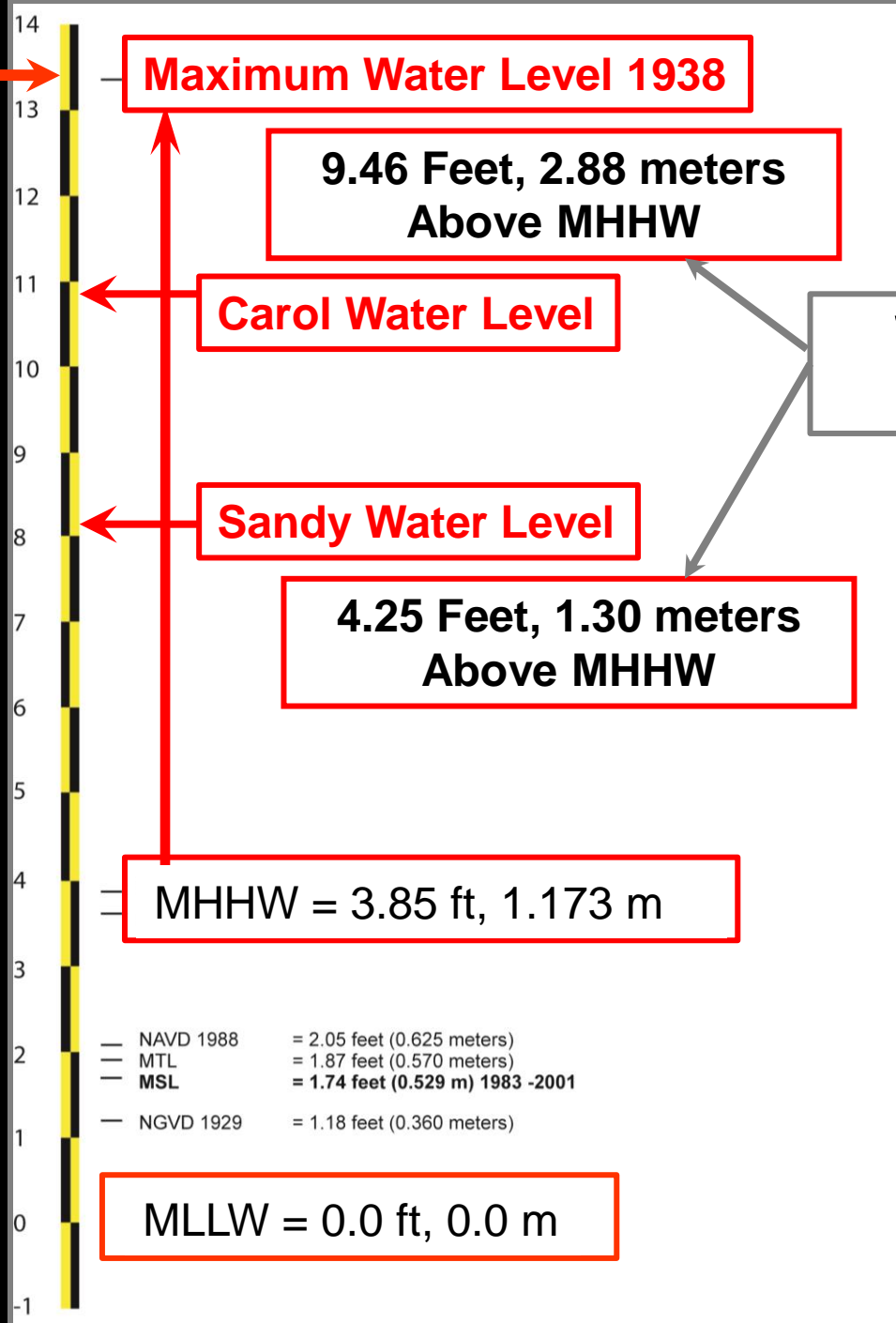
Removal is a Bad Idea
Barriers Naturally Retreat
Landward and Upward

Aug 1991

JC Boothroyd

**How High
was the
Water ?**

**Water
Levels
Newport, RI**

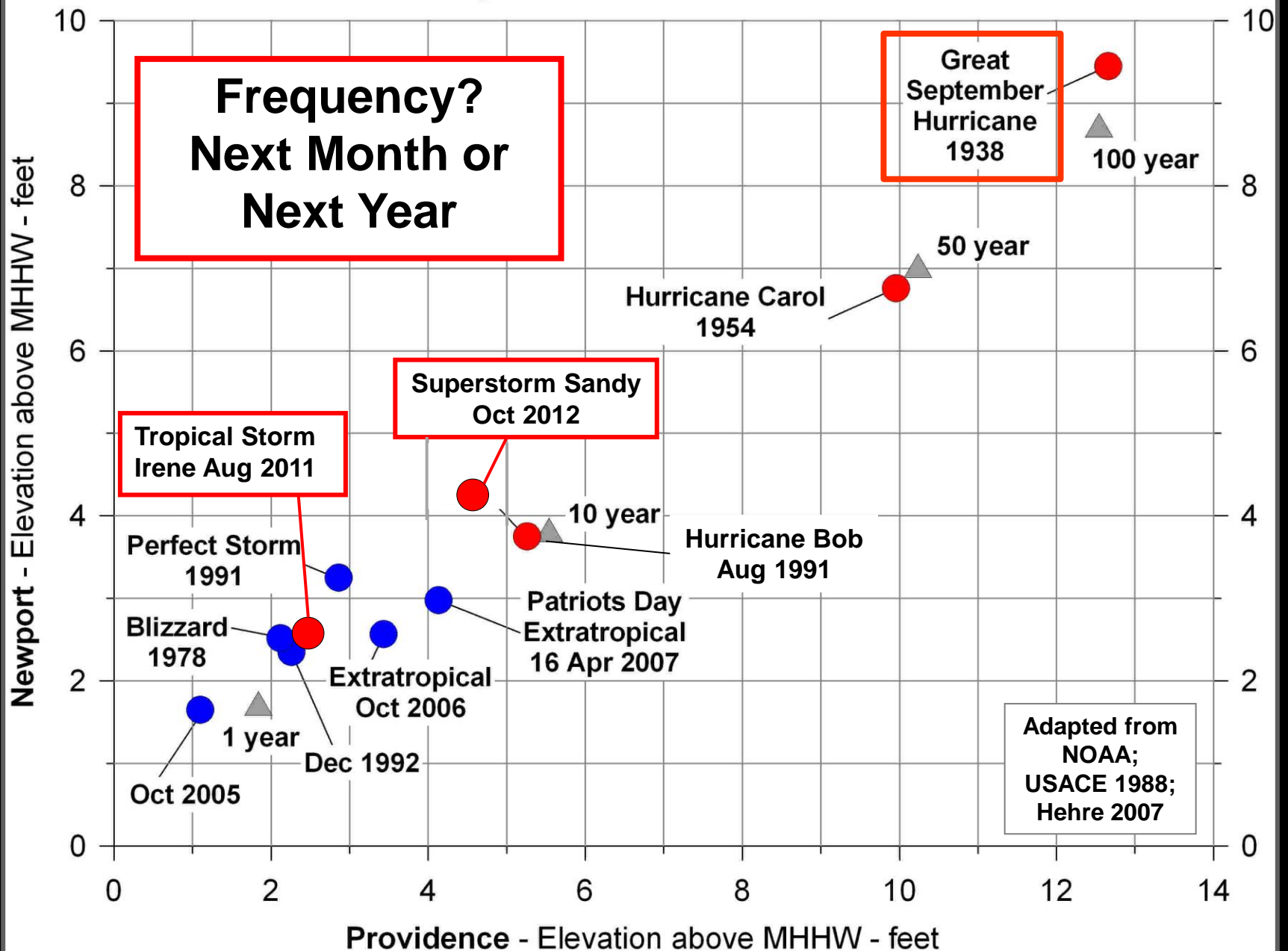


**Why above
MHHW?**

Adapted from:
www.ngs.noaa.gov/newsys-cgi-bin/ngs_opsd.pr1?PID=LW0493&EPOCH=1983-2001

STORM-SURGE ELEVATION

Newport - Providence, RI



Dauphin Island, Alabama – Hurricane Katrina Barrier Island Migration

An Analog for
Rhode Island

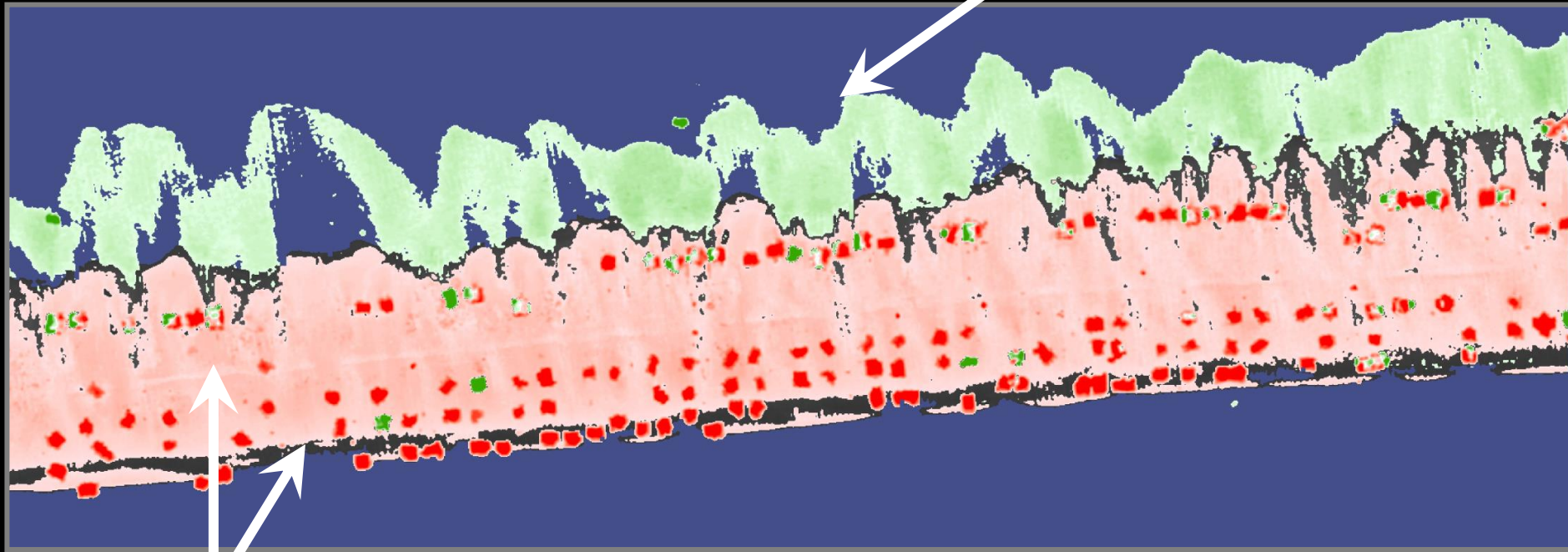
Katrina
Storm-Surge Channels

Backbarrier Marsh
Exposed on the Beach



Dauphin Island, Alabama - After Hurricane Katrina Barrier Island Migration

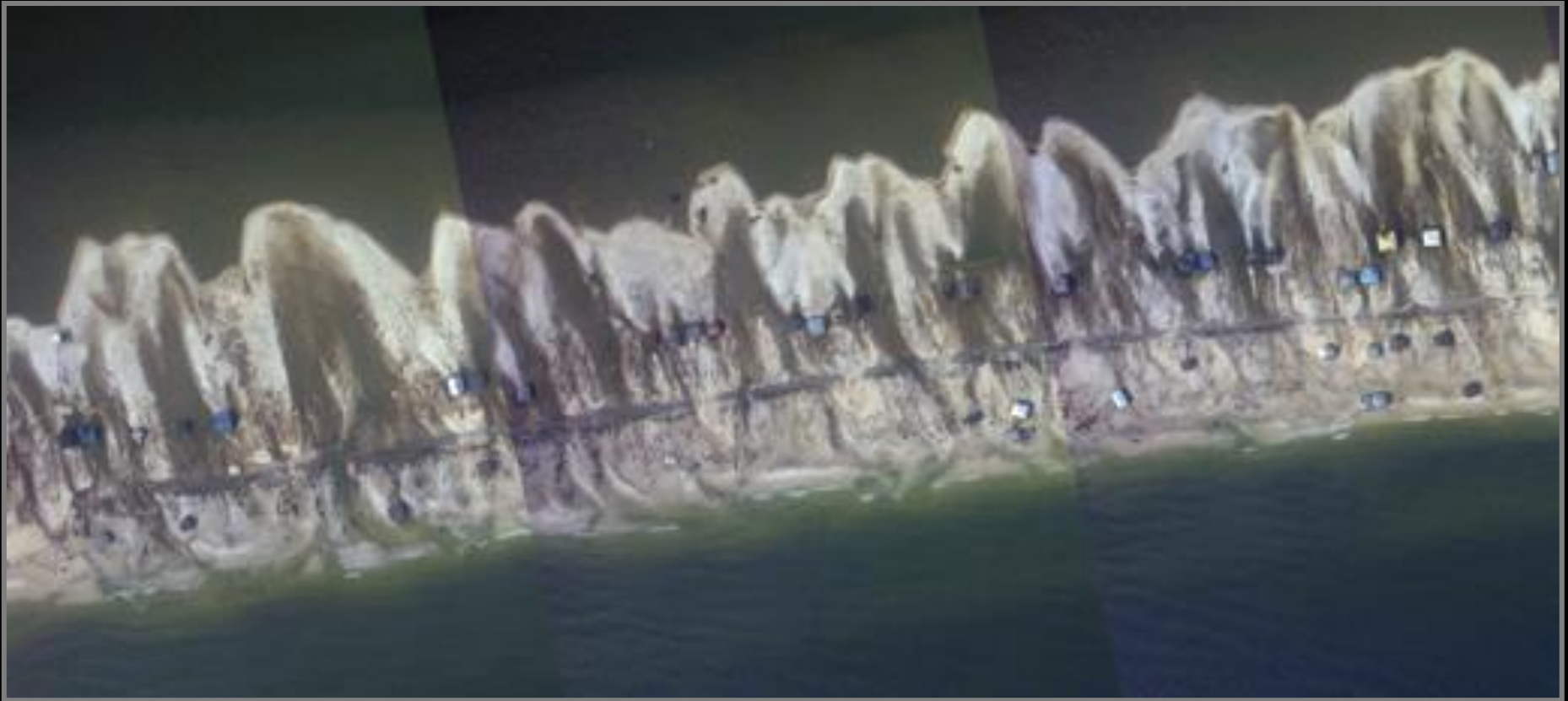
Washover Fan
Deposition



Beach,
Foredune and
Backbarrier
Erosion

http://www.nasa.gov/vision/earth/lookingatearth/katrina_poststorm.html

Dauphin Island, Alabama - After Hurricane Katrina Barrier Island Migration



http://www.nasa.gov/vision/earth/lookingatearth/katrina_poststorm.html

East Beach Barrier – Barrier Migration

EAST BEACH BARRIER
September 1938 Hurricane
3 Days After

View East

**NINIGRET
POND**

**Washover
Fan**

Surge Channel

Chimney

Swash Bar

Road

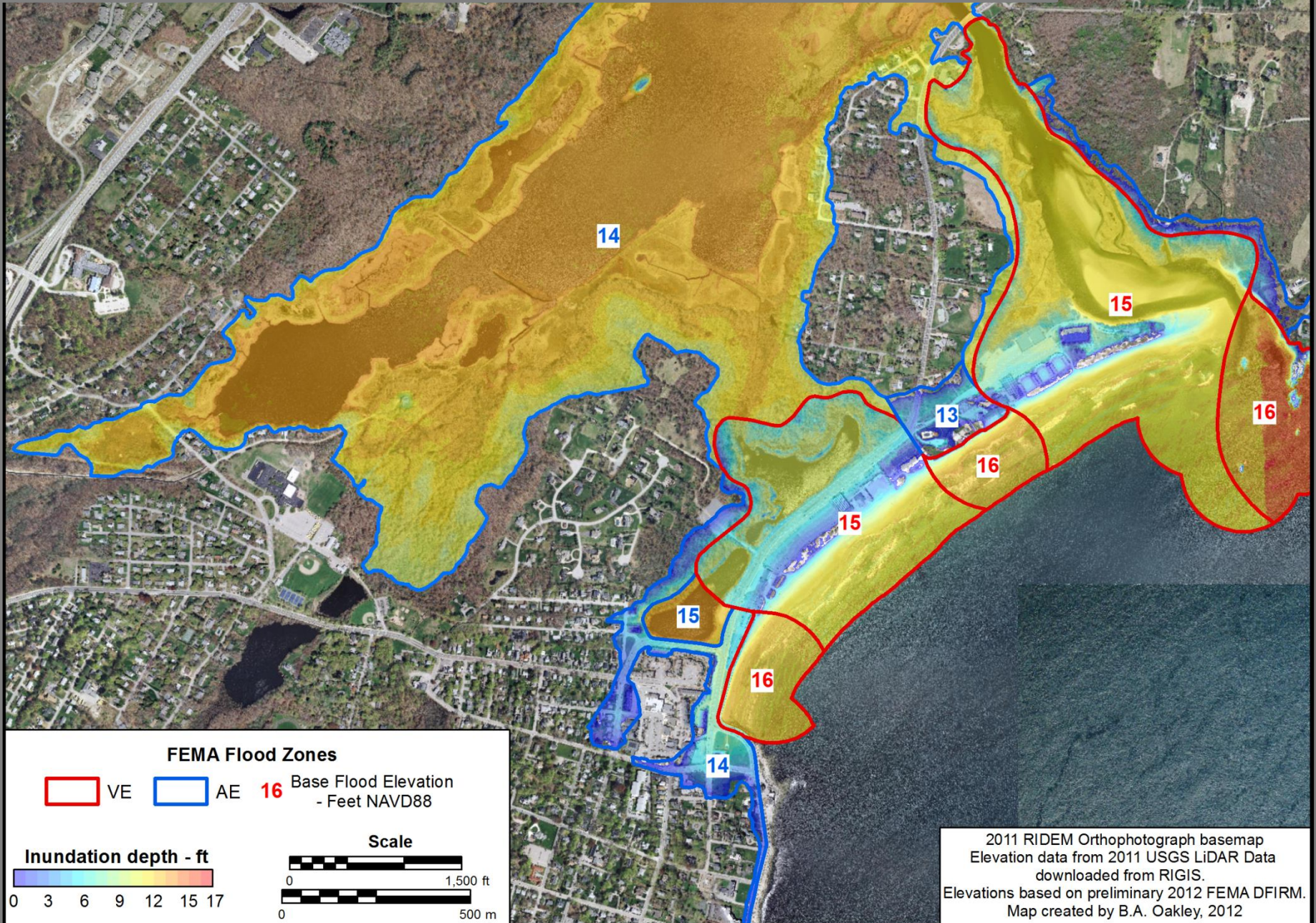
Seawall

886G-118)(9-24-38-37021508

QUONOCHEMONTAUG R. I.



Narrow River and Narragansett Barrier Area

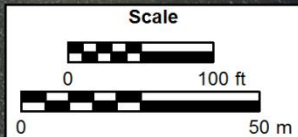
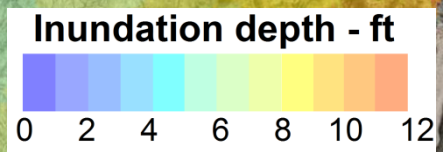


Middlebridge Area Narrow River South Kingstown

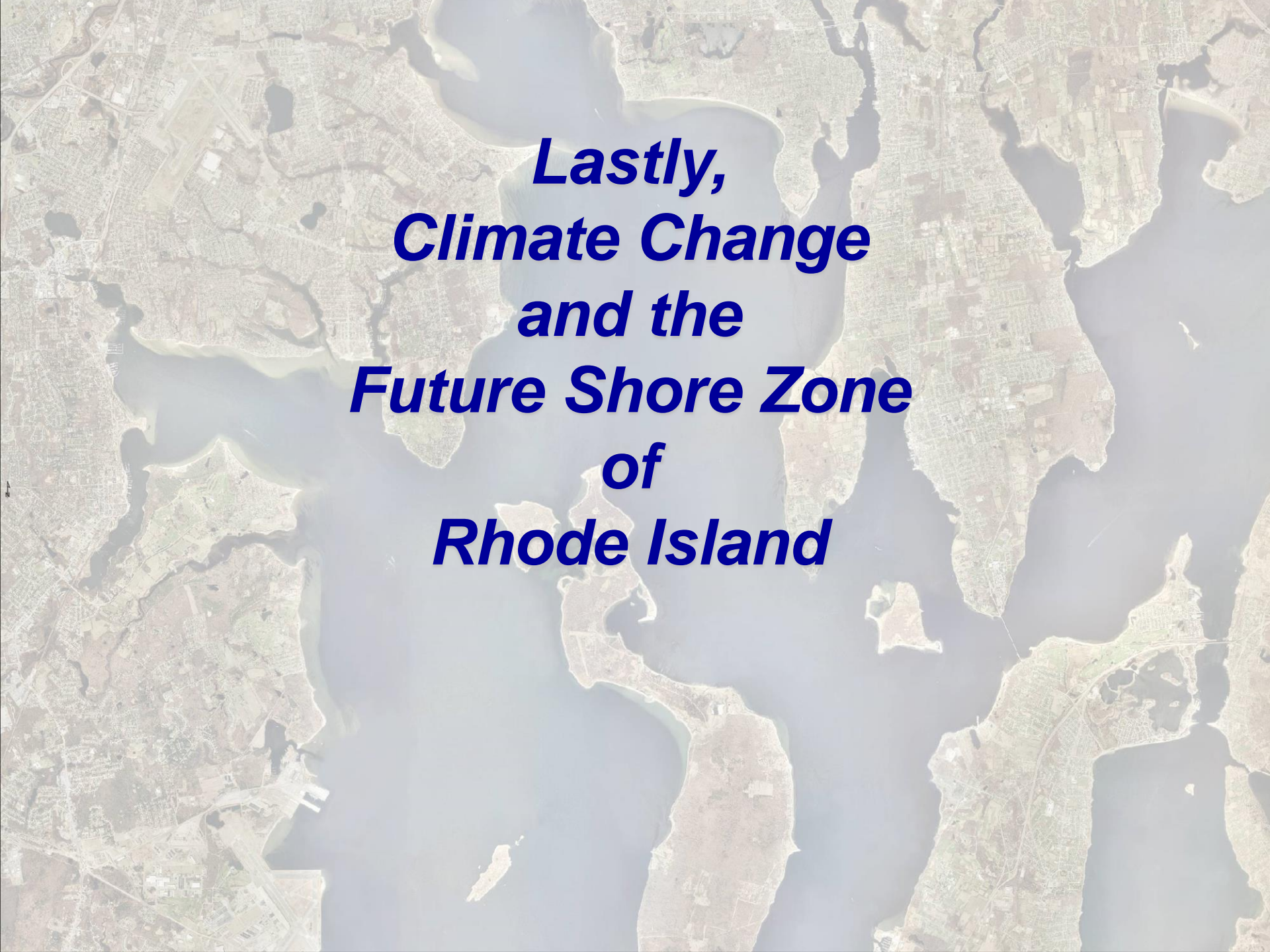
Inundation Depths
based on
2012 DFIRMs

Colors
cropped

Wastewater
Pump
Station



2011 RIDEM Orthophotograph basemap
Elevation data from 2011 USGS LiDAR Data downloaded from RIGIS.
Elevations based on preliminary 2012 FEMA DFIRM.
Map created by B.A. Oakley, 2012



***Lastly,
Climate Change
and the
Future Shore Zone
of
Rhode Island***

Carbon Dioxide - CO₂ Levels

A Cause for Concern

Now 395+ ppm

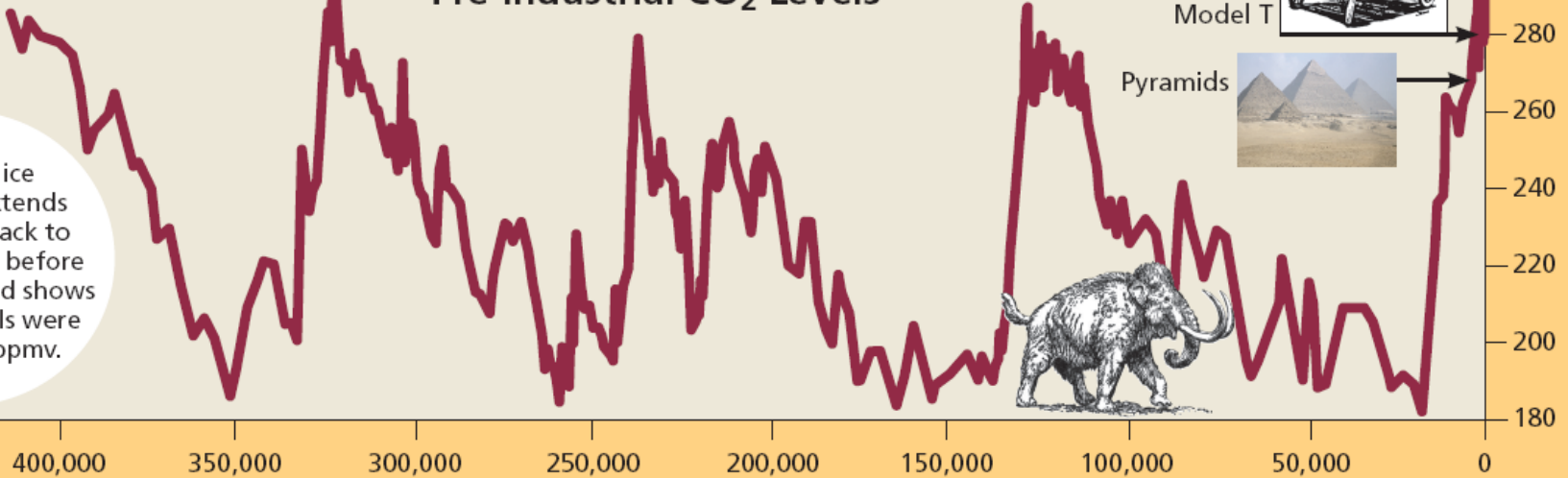
Carbon Dioxide Levels Today are Higher than over the Past 650,000 Years

Atmospheric carbon dioxide record data sources: Keeling and Whorf (2004), Petit et al. (1999), IPCC (2001), Ahn et al. (2004).

Industrial CO₂ Levels

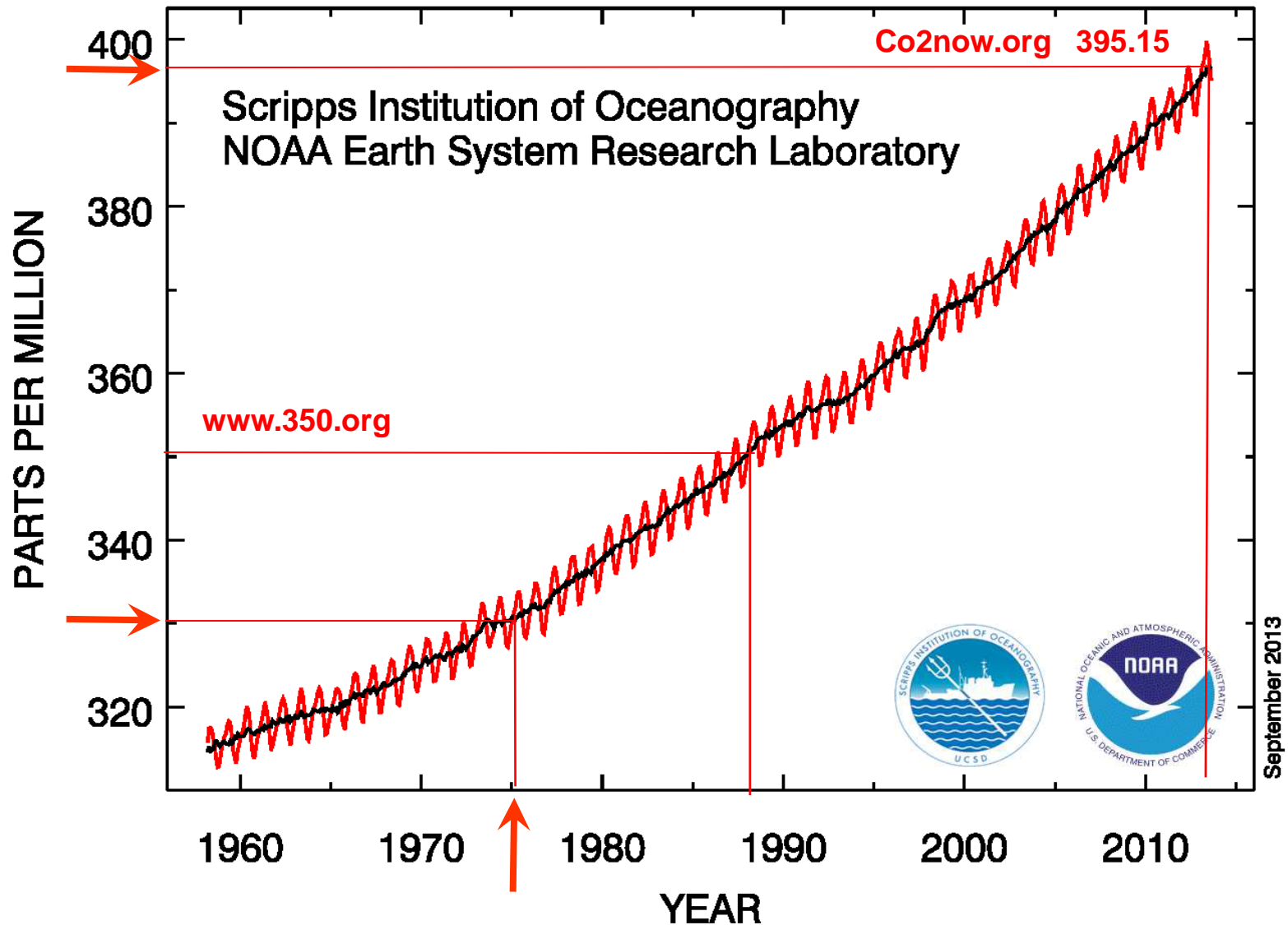
Pre-industrial CO₂ Levels

New Antarctic ice core data extends the record back to 650,000 years before the present and shows that CO₂ levels were below 300 ppmv.



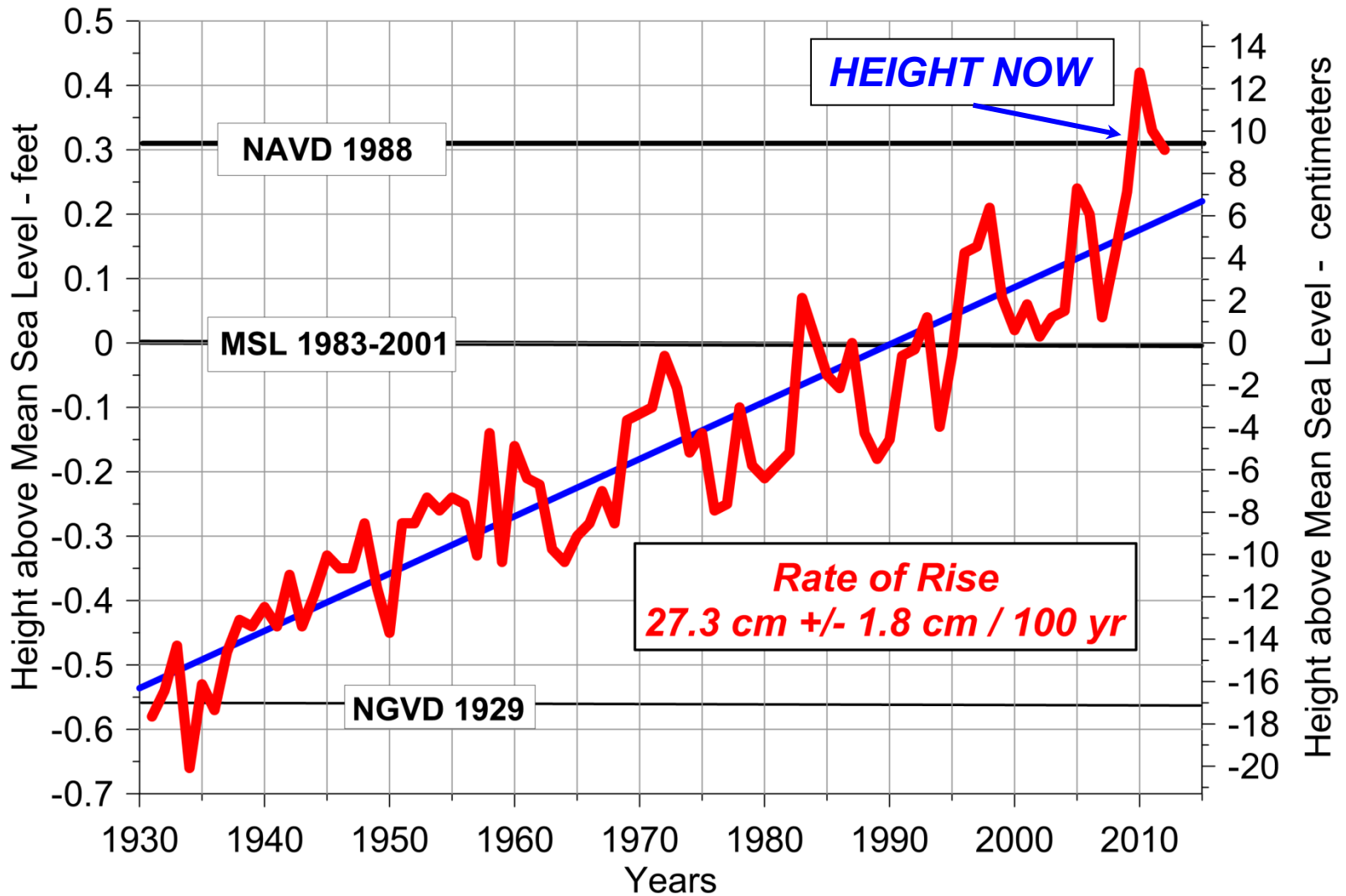
Years Before the Present

Atmospheric CO₂ at Mauna Loa Observatory

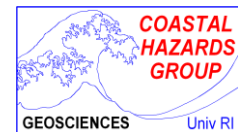
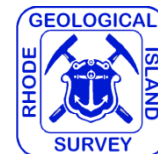


http://www.esrl.noaa.gov/gmd/ccgg/trends/co2_data_mlo.html

HISTORIC SEA-LEVEL RISE - Newport, RI



Adapted from:
http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8452660%20Newport,%20RI



Boothroyd 2013

6.0 ft

VR Max

184 cm

4.5 ft

VR A1F1

136 cm

ACCELERATED SEA-LEVEL RISE Newport RI

VR B1

IPCC 2013
Model Avg

82 cm

Height above NOW

IPCC 2007
Model Avg

60

1.3 ft

40

HEIGHT NOW

NAVD 1988

HISTORIC TREND

MSL 1983-2001

2012

NGVD 1929

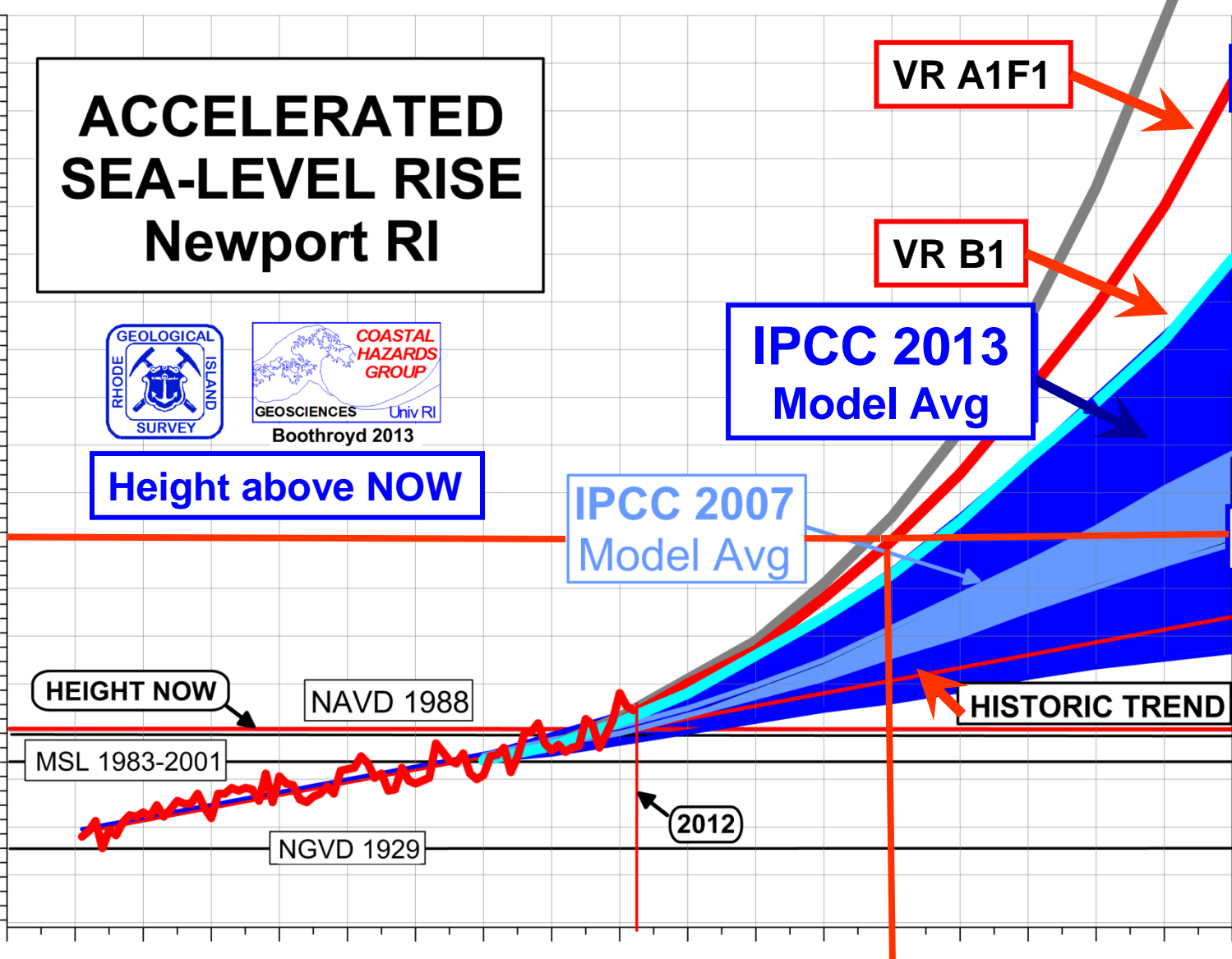
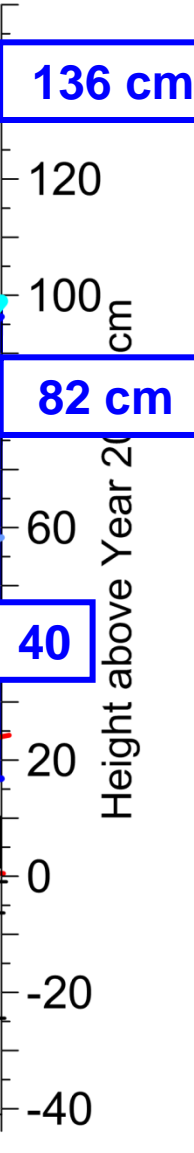
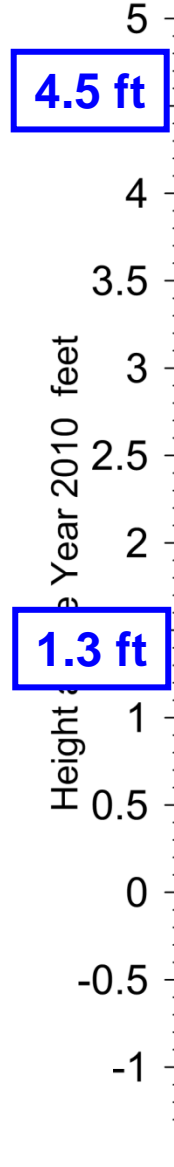
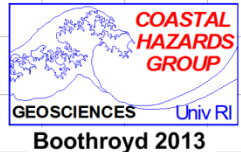
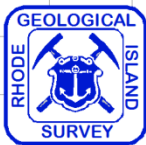
Height above Year 2010

Height above Year 2010 feet

1920 1940 1960 1980 2000 2020 2040 2060 2080 2100

Years

2050



ACCELERATED SEA-LEVEL RISE
Newport RI

Height above NOW

IPCC 2013
Model Avg

IPCC 2007
Model Avg

HEIGHT NOW

NAVD 1988

HISTORIC TREND

MSL 1983-2001

2012

NGVD 1929

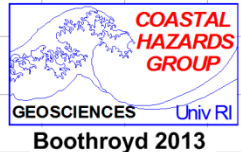
Height above Year 2010

Height above Year 2010 feet

1920 1940 1960 1980 2000 2020 2040 2060 2080 2100

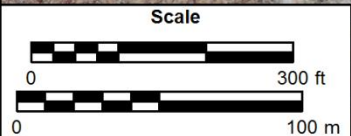
Years

2050



Narragansett Circuit Drive Detention Pond System

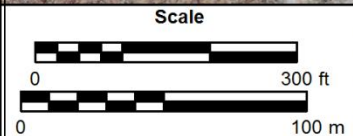
1.4 Feet
Sea Level
Rise



2011 RIDEM Orthophotograph. Elevation data from
2011 USGS LiDAR Data downloaded from RIGIS.
41 cm of sea level rise shown, based on MHHW at Sedge Island
Map created by B.A. Oakley, 2012

Narragansett Circuit Drive Detention Pond System

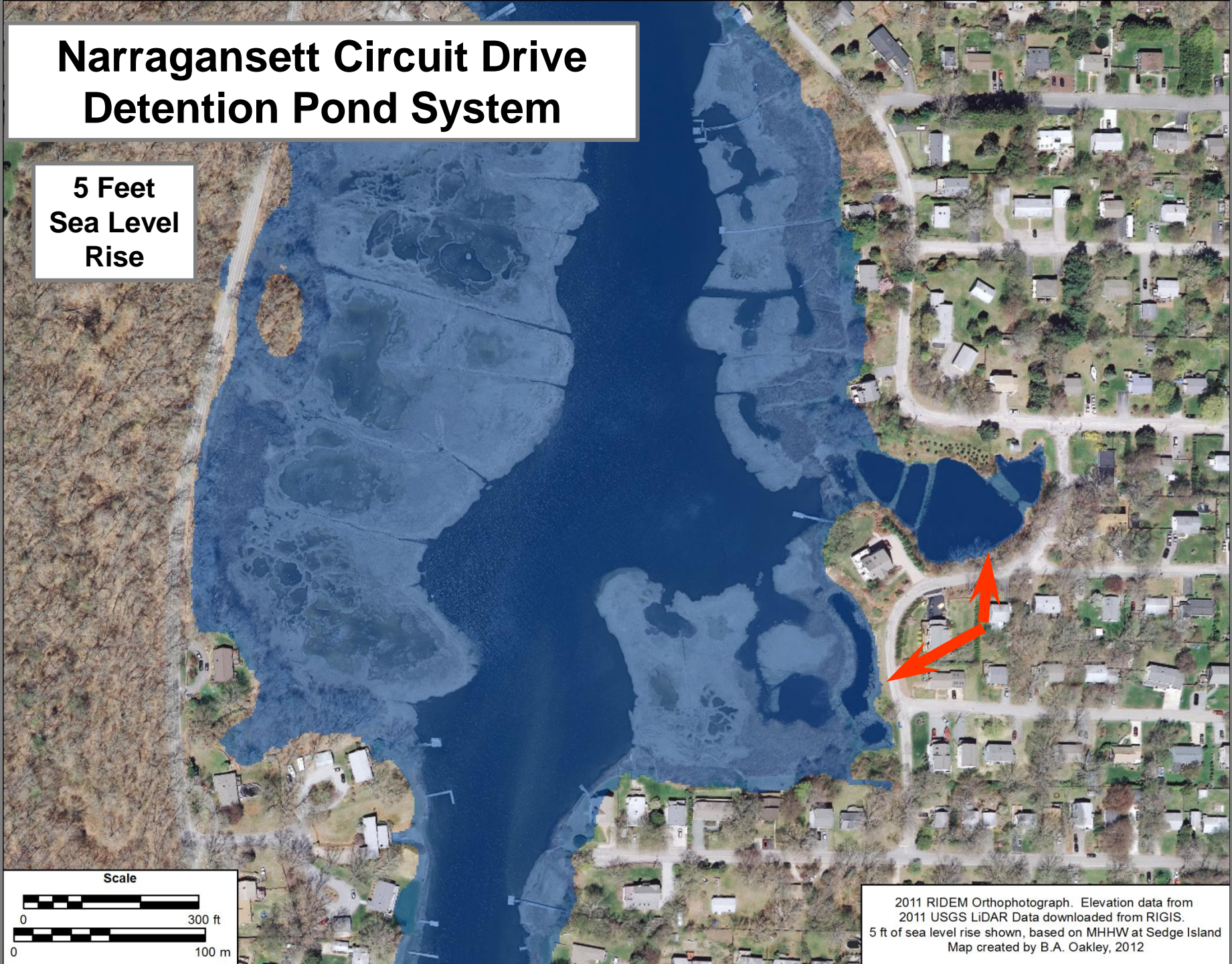
3 Feet
Sea Level
Rise



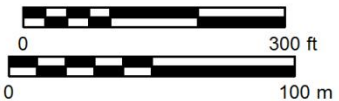
2011 RIDEM Orthophotograph. Elevation data from
2011 USGS LiDAR Data downloaded from RIGIS.
3 ft of sea level rise shown, based on MHHW at Sedge Island
Map created by B.A. Oakley, 2012

Narragansett Circuit Drive Detention Pond System

5 Feet
Sea Level
Rise



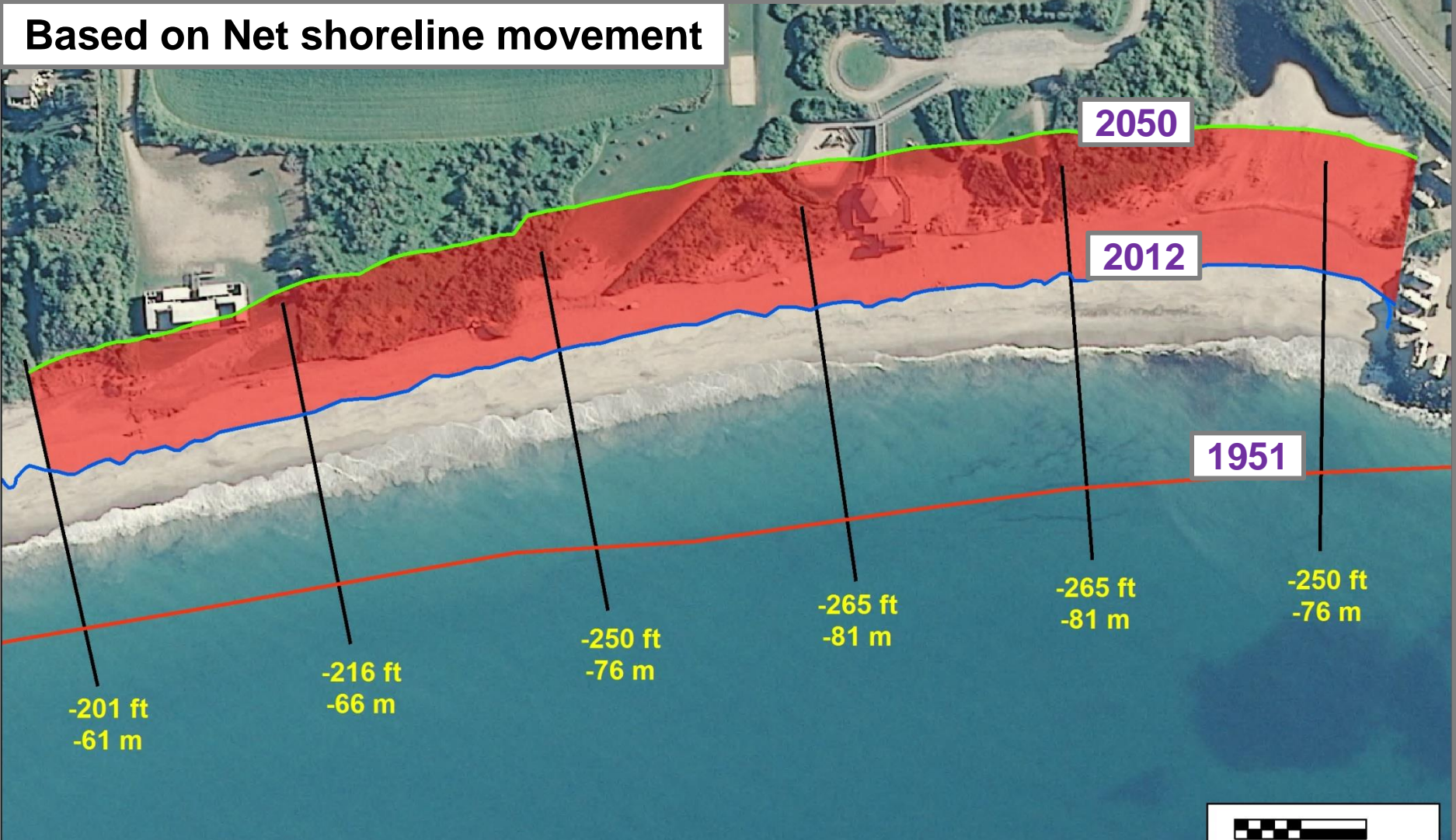
Scale



2011 RIDEM Orthophotograph. Elevation data from
2011 USGS LiDAR Data downloaded from RIGIS.
5 ft of sea level rise shown, based on MHHW at Sedge Island
Map created by B.A. Oakley, 2012

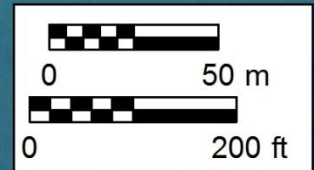
Matunuck Shoreline Change South Kingstown Town Beach

Based on Net shoreline movement



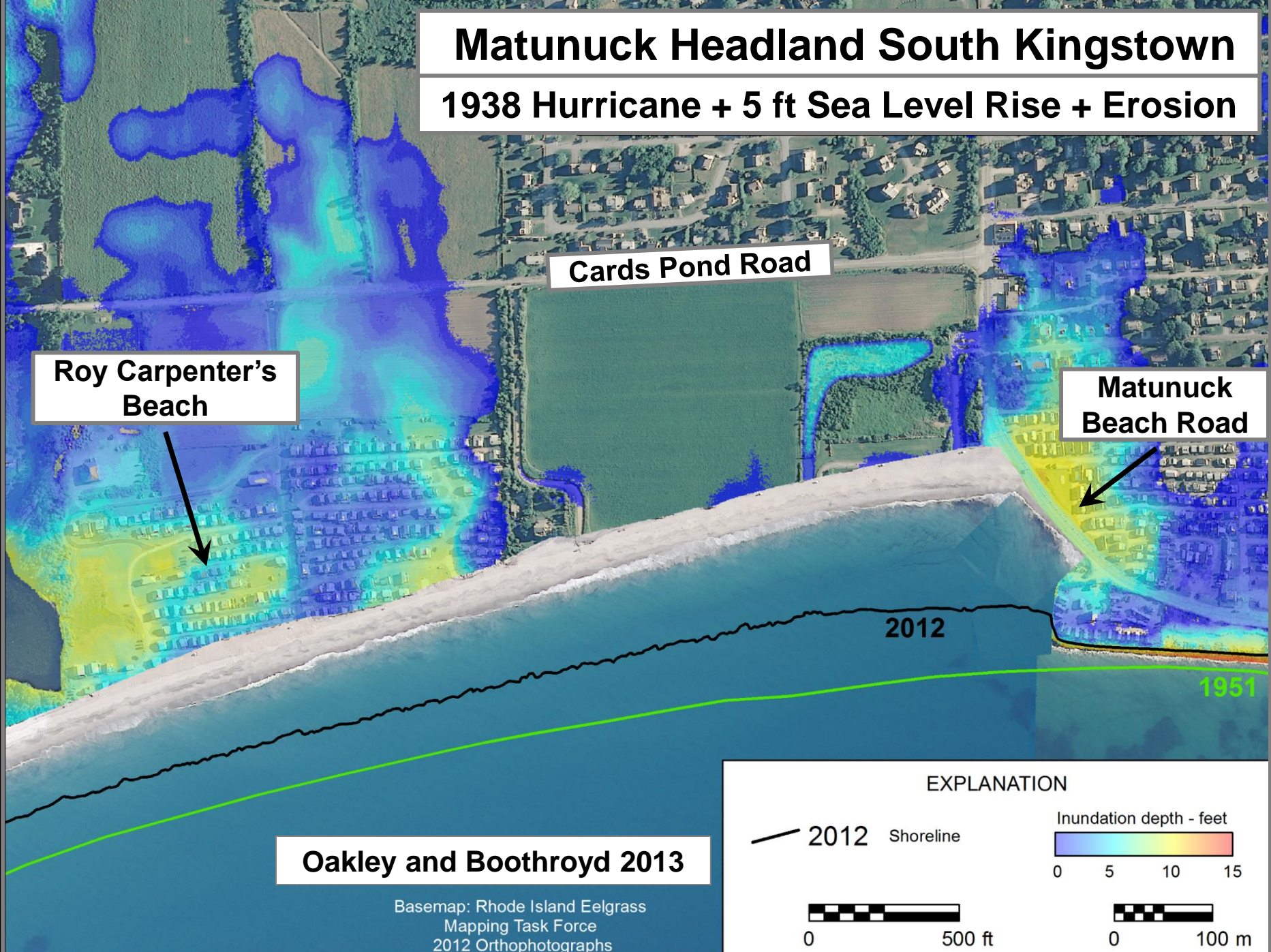
Oakley and Boothroyd 2013

Basemap: Rhode Island Eelgrass Mapping Task Force - 2012 Orthophotographs



Matunuck Headland South Kingstown

1938 Hurricane + 5 ft Sea Level Rise + Erosion



Cards Pond Road

Roy Carpenter's Beach

Matunuck Beach Road

2012

1951

Oakley and Boothroyd 2013

Basemap: Rhode Island Eelgrass Mapping Task Force 2012 Orthophotographs

EXPLANATION

— 2012 Shoreline

Inundation depth - feet

0 5 10 15

0 500 ft

0 100 m

Middlebridge, South Kingstown RI 2.5' Storm Surge from Extratropical Storm

A Common View of the Future

Today



JC Boothroyd

OCT 28 2006

End of Presentation