THE PETTAQUAMSCUTT ESTUARY: CLIMATE CHANGE

NARROW RIVER PRESERVATION ASSOCIATION ANNUAL MEETING

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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
First,
Some Geological Background Information
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Glacial Geology and Climate
65 Million Years of Climate Change
Geologic Time Scale
Cenozoic – Last 65.5 my

Quaternary - Last 2.6 my
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

After Dyke & Prest, 1987

CORDILLERAN
LAURENTIDE

You are here
MALASPINA GLACIER – Northeast Gulf of Alaska

An Analog “The size of Rhode Island”
Laurentide Ice Retreat – Southern New England

Oakley and Boothroyd, 2013
Glacial Lakes
Block Island and Rhode Island
~ 21,300 yBP

Charlestown Moraine

Laurentide Ice Sheet

Glacial Lake Block Island

Block Channel

The Mud Hole

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

Oakley, 2012
Glacial Lakes
Block Island and Rhode Island
~ 20,300 yBP

Oakley, 2012
Glacial Lake Narragansett

~ 20,200 yBP

Oakley, 2012
Glacial Lake Narragansett
~ 18,500 yBP

Oakley, 2012

Glacier Retreat From RI

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

A Last glaciation (21,000 years ago)

Ice

Bedrock

Mantle flows out

B Today

Bedrock rebounding

Global sea level rising

Mantle flowing back

Rhode Island

W F Ruddiman, 2001
Isostatic Rebound for Rhode Island

Isostatic Rebound
Relative Sea Level
Eustatic Sea Level

Terminal Margin of the Laurentide Ice Sheet

Towards center of ice sheet

Isobase surface

Present topography

Pre-rebound topography

Oakley and Boothroyd, July 2012
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 Town Beach

Overwash Transport and Deposition – Patriot’s Day Extratropical
Newport datum adapted from www.ngs.noaa.gov/cgi-bin/ngs_opsd?PID=LW0493

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.

Oakley, Alvarez and Boothroyd, 2008
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
Pre-Sandy – Quonochontaug Barrier Conservation Land

Washover Fan Deposition
Post-Sandy – Quonochontaug Barrier Conservation Land

Barrier Island Migration

Washover Fan Deposition

Bousquet and Son – Aerial Views
Charlestown Beach, RI – Hurricane Bob 1991
Washover Fan Deposition

Removal is a Bad Idea ……
Barriers Naturally Retreat Landward and Upward

Aug 1991
JC Boothroyd
Water Levels Newport, RI

How High was the Water?

Maximum Water Level 1938
- 9.46 Feet, 2.88 meters Above MHHW

Carol Water Level

Sandy Water Level
- 4.25 Feet, 1.30 meters Above MHHW

MHHW = 3.85 ft, 1.173 m

MLLW = 0.0 ft, 0.0 m

Why above MHHW?

Adapted from:
Frequency?
Next Month or
Next Year

STORM-SURGE ELEVATION
Newport - Providence, RI

Adapted from
NOAA; USACE 1988; Hehre 2007

Superstorm
Sandy Oct 2012

Tropical Storm
Irene Aug 2011

Great September
Hurricane 1938
100 year

Hurricane Carol
1954
50 year

Hurricane Bob
Aug 1991

Extratropical
Oct 2006

Patriots Day
Extratropical
16 Apr 2007

Blizzard
1978

Perfect Storm
1991

Oct 2005
Dec 1992

1 year
10 year

Adapted from
NOAA; USACE 1988; Hehre 2007

Newport - Elevation above MHHW - feet

Providence - Elevation above MHHW - feet
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

NINIGRET POND

Washover Fan

Surge Channel

Chimney

Swash Bar

Road

Seawall

EAST BEACH BARRIER
September 1938 Hurricane
3 Days After

View East
Lastly, Climate Change and the Future Shore Zone of Rhode Island
Carbon Dioxide - CO$_2$ Levels
A Cause for Concern

Now 395+ ppm

HISTORIC SEA-LEVEL RISE - Newport, RI

Rate of Rise
27.3 cm +/- 1.8 cm / 100 yr

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

Boothroyd 2013
Narragansett Circuit Drive Detention Pond System

1.4 Feet Sea Level Rise
Narragansett Circuit Drive
Detention Pond System

3 Feet Sea Level Rise
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 Beach Road

Roy Carpenter’s Beach

Matunuck Beach Road

1938 Hurricane + 5 ft Sea Level Rise + Erosion

Matunuck Headland South Kingstown

Oakley and Boothroyd 2013

Basemap: Rhode Island Eelgrass Mapping Task Force 2012 Orthophotographs

EXPLANATION

Inundation depth - feet

2012 Shoreline

0 5 10 15

0 500 ft 0 100 m
Middlebridge, South Kingstown RI
2.5’ Storm Surge from Extratropical Storm Today

A Common View of the Future
End of Presentation