# The Impact of Tides, Wave-Related Erosion, and Millennial Scale Sea Level Change on Coastal and Nearshore Archaeological Sites


by
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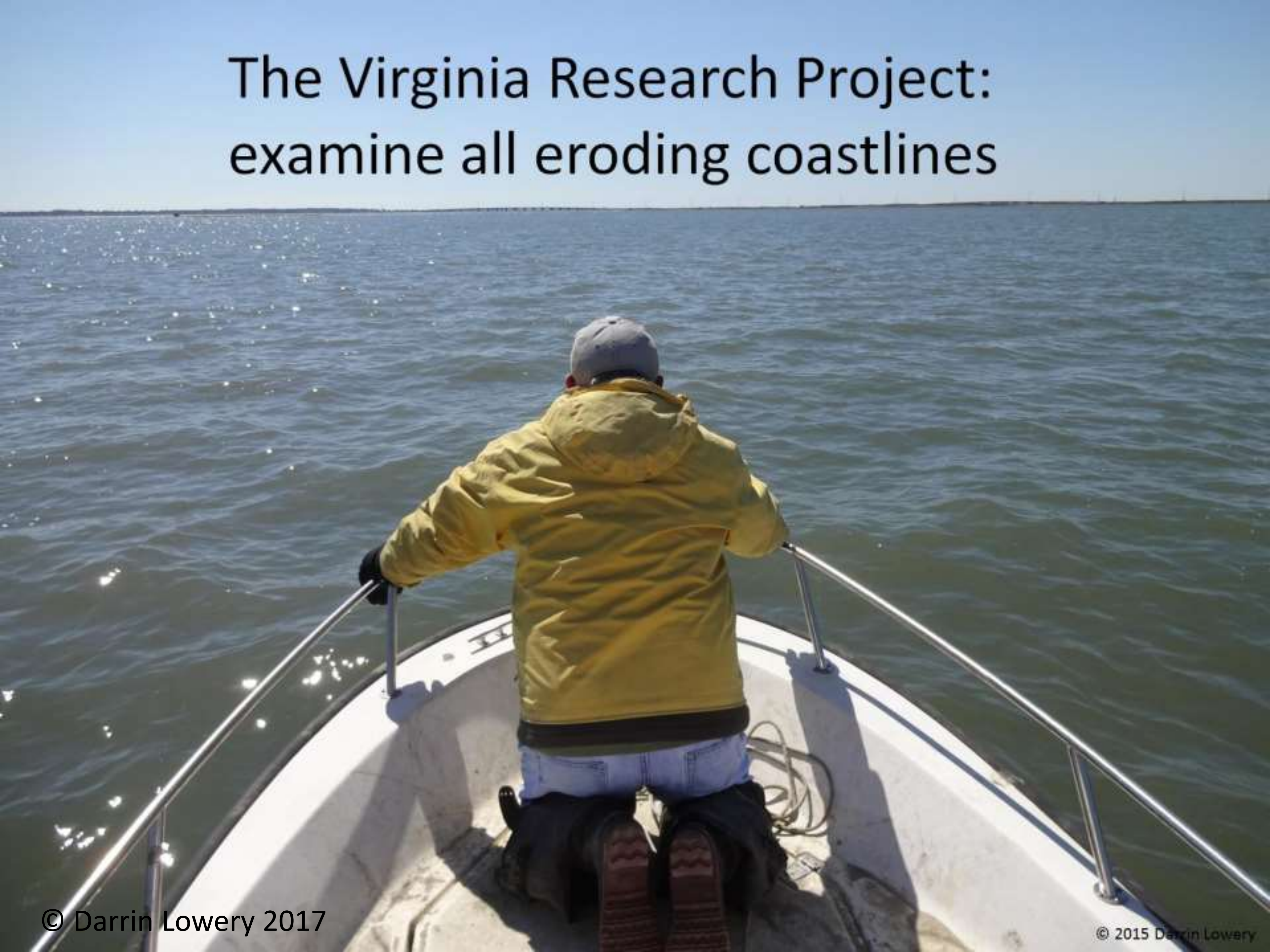
Smithsonian Institution
Department of Anthropology
National Museum of Natural History

University of Delaware


The Virginia Research Project:
examine all eroding coastlines
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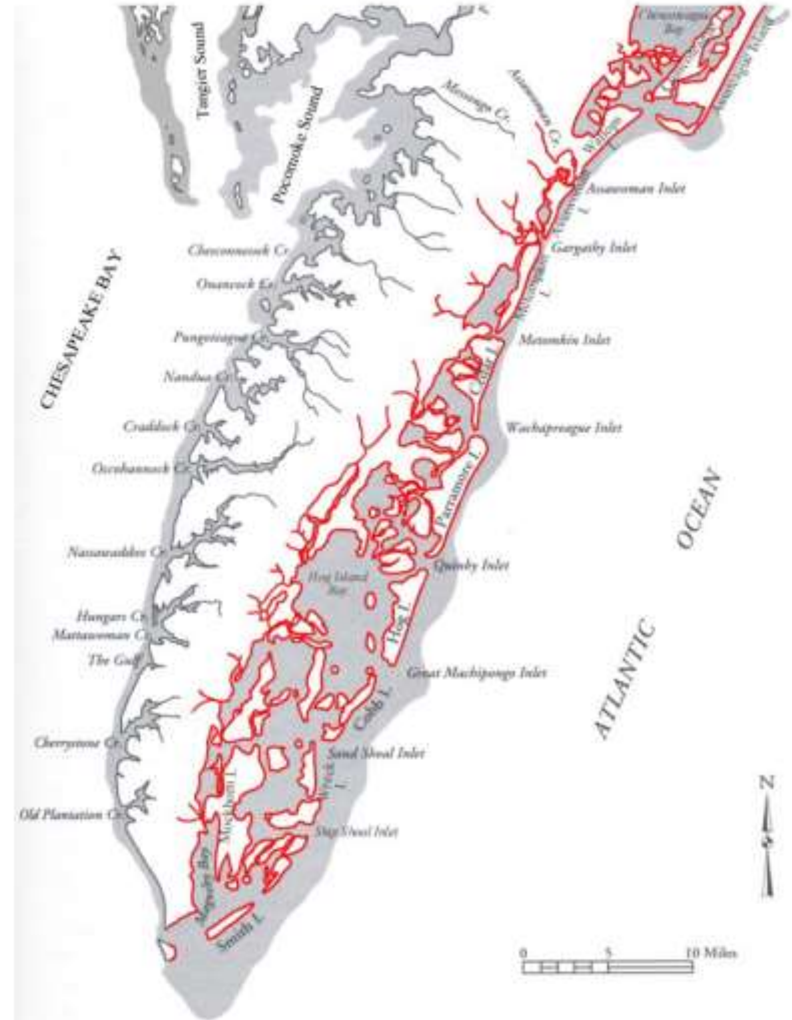
In 1999....


In 2001....




From 2014 to 2017, I had the privilege of re-examining over 1200 linear miles of Virginia's coastline after a 15-year hiatus!
However, the fieldwork has a diverse set of hazards!
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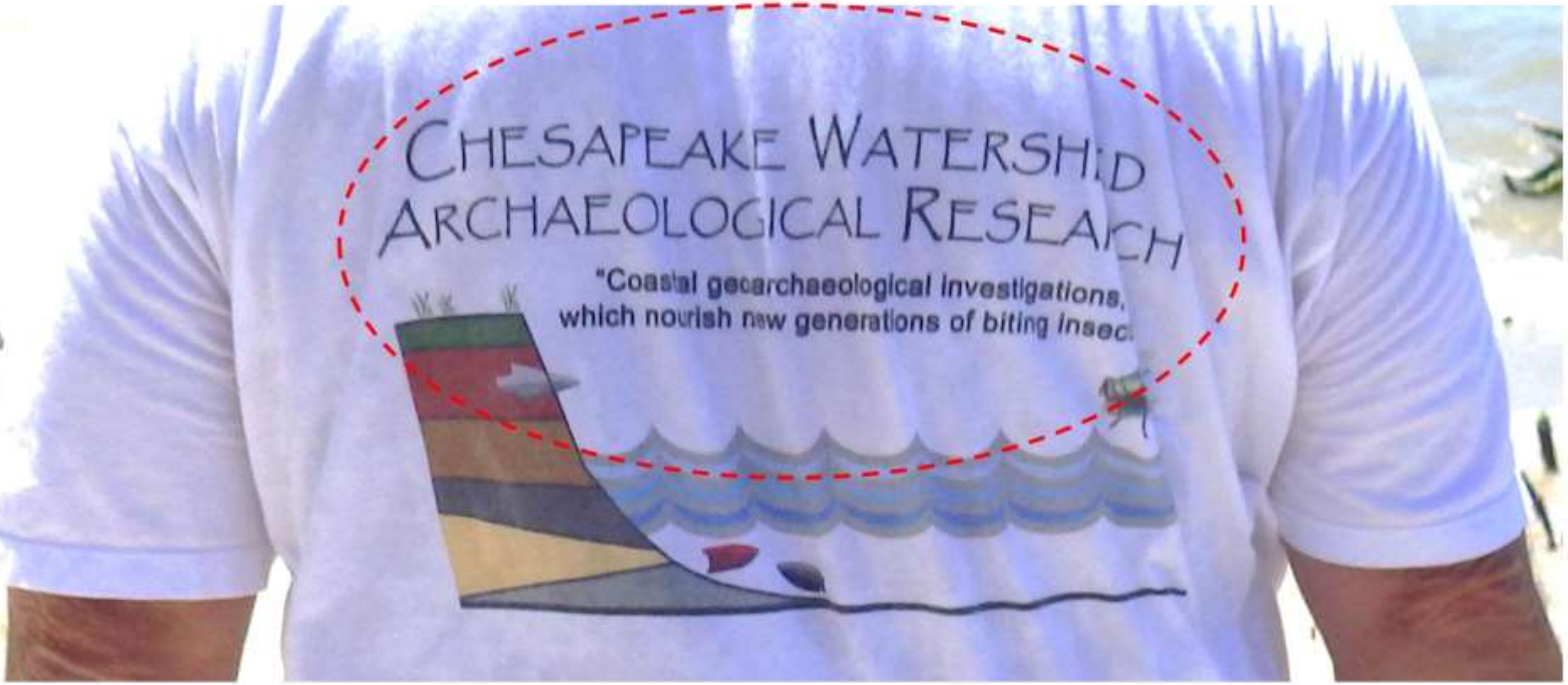
# FIELDWORK HAZARDS #1

Sharks in Magothy Bay, Virginia

# FIELDWORK HAZARDS #2

Sting Rays in Chesconessex Creek, Virginia

# FIELDWORK HAZARDS #3

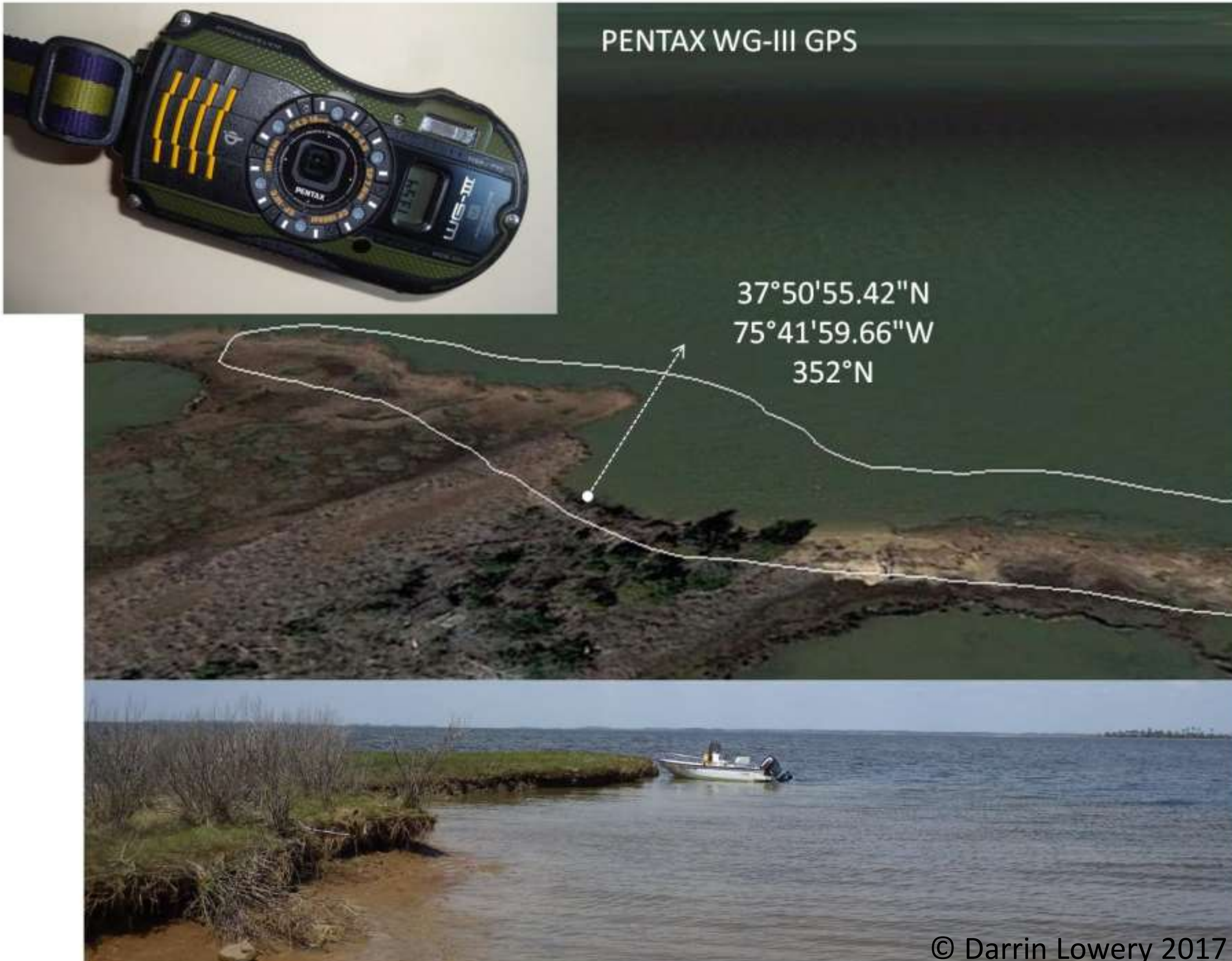


# Methodology:

- Equipment


15' BOSTON WHALER DAUNTLESS

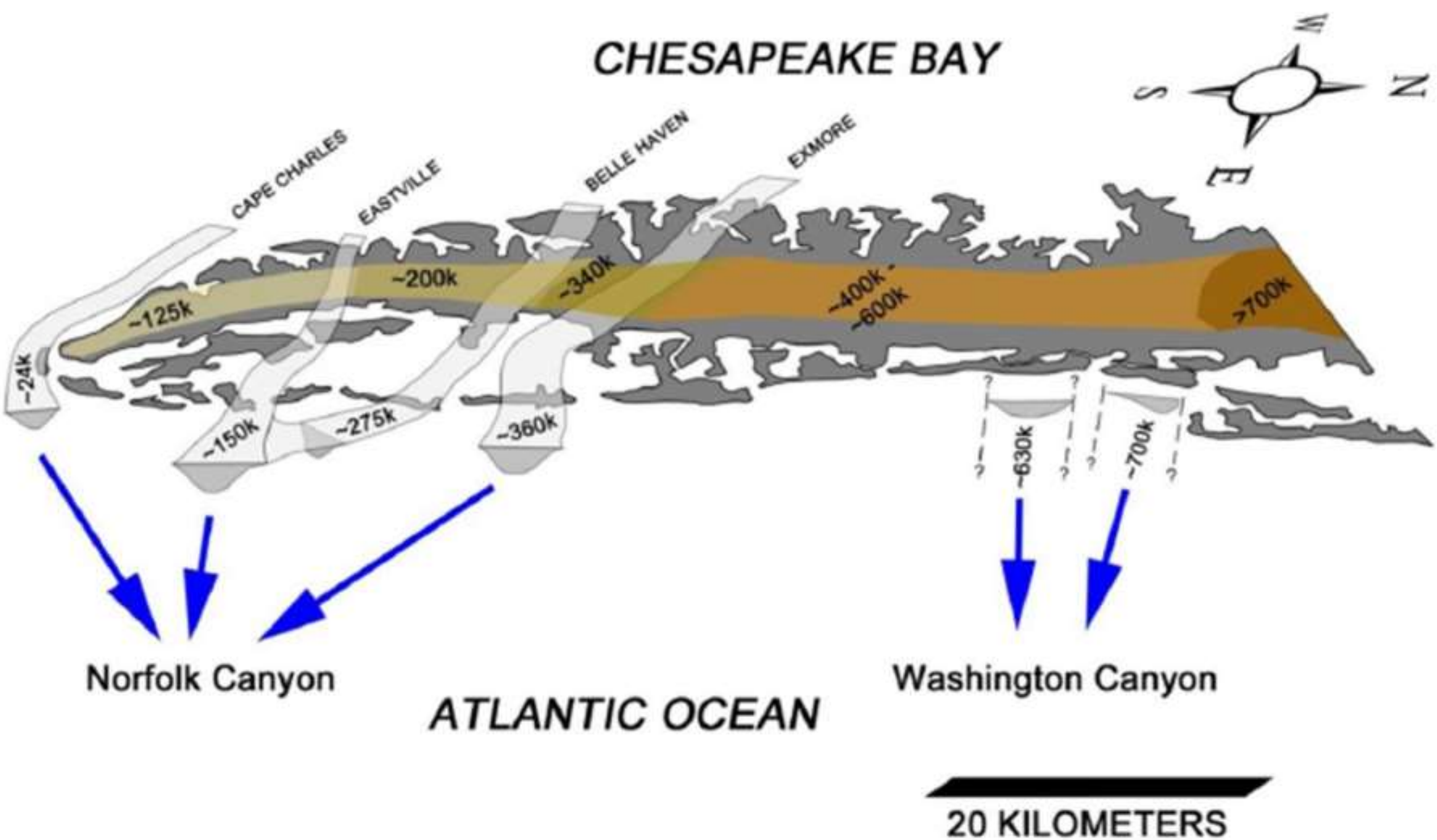

17' CAROLINA SKIFF
© Darrin Lowery 2017


PENTAX WG-III GPS
37°50'55.42"N
75°41'59.66"W
352°N
© Darrin Lowery 2017

# Methodology:

- Assess the geology of the region

# MACRO-GEOLOOGY

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MICRO-GEOLOGY

# Methodology:

- Assess the soil data along the coastline of the region
- Date the archaeological features and associated diagnostic artifacts

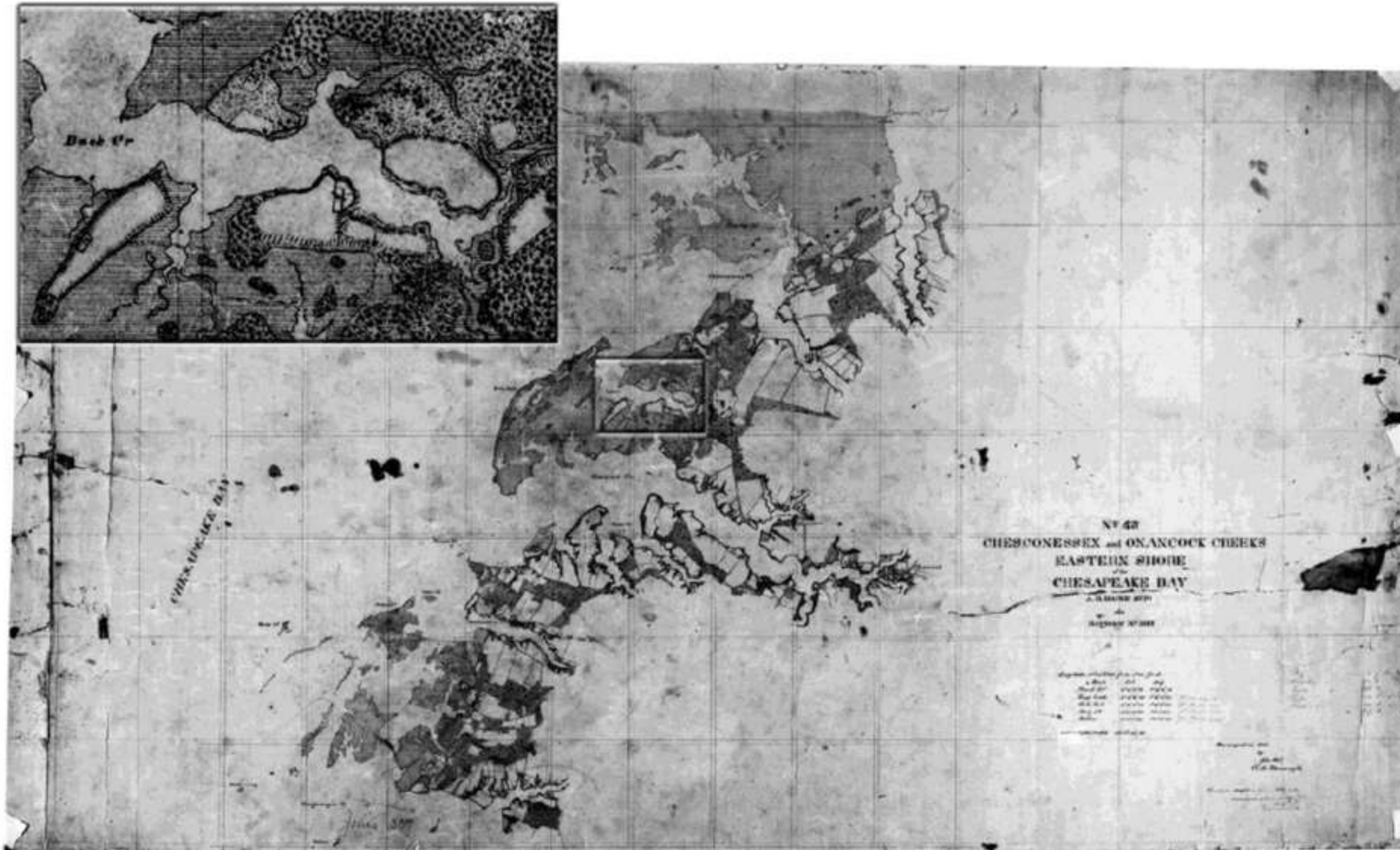
Accomack Soil
44AC404
© Darrin Lowery 2017

# 44AC404


A
484 ± 40 calAD
Oi-horizon (0 to 42 cm)
AC-horizon (42 to 63 cm)
A-horizon (63 to 70 cm)
Btg-horizon (70 to >100 cm)
© Darrin Lowery 2017

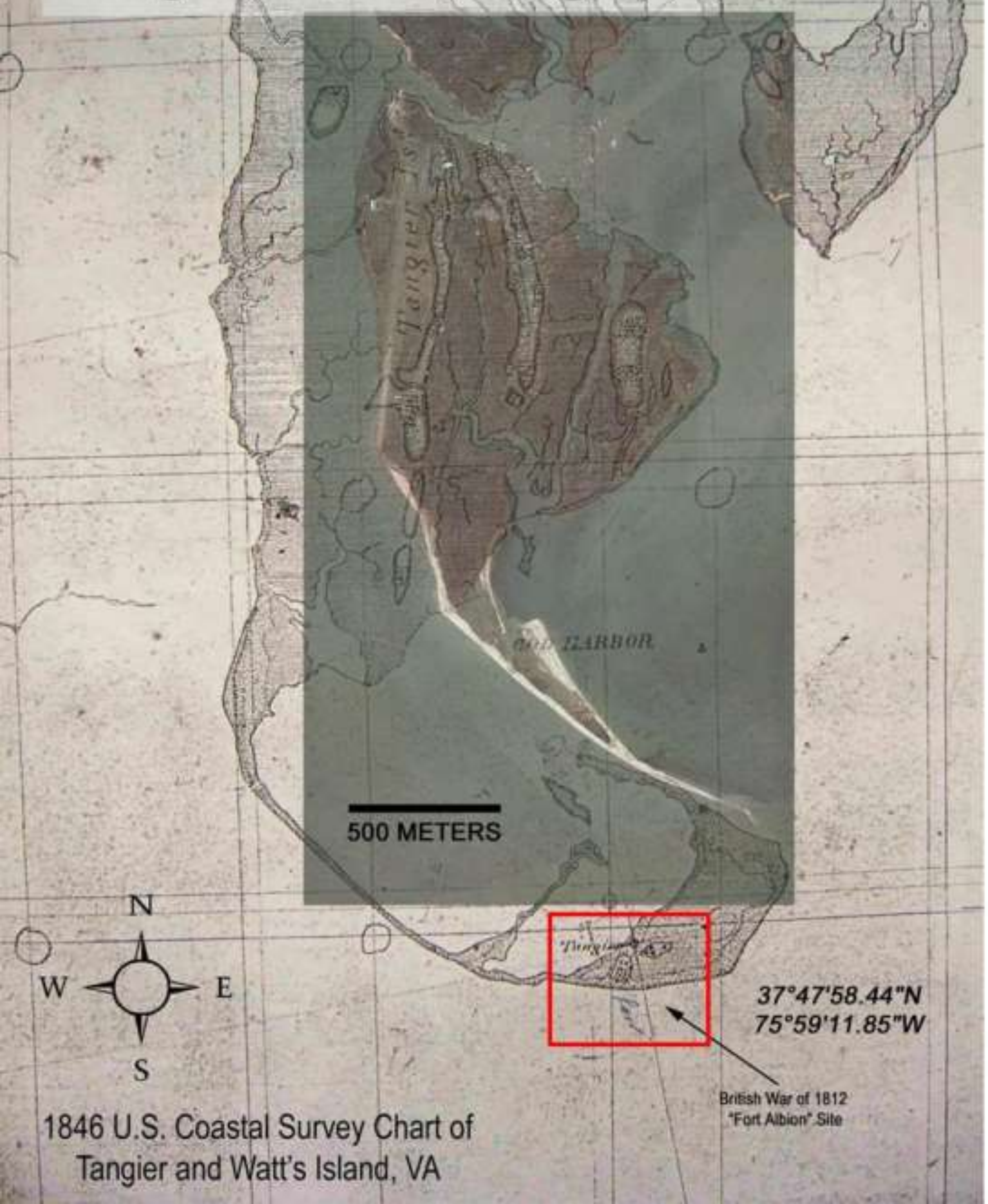
# Methodology:

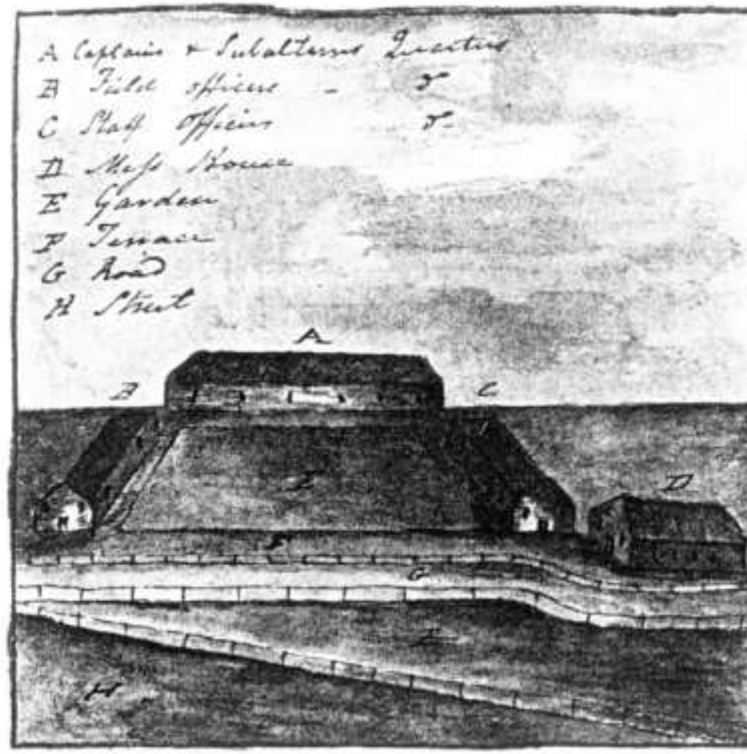
- Assess historic maps to gauge the changes that have occurred in the region


Bush Cr
CHESAPEAKE BAY
CHESCONESSEX and ONANCOCK CREEKS
EASTERN SHORE
of the
CHESAPEAKE BAY

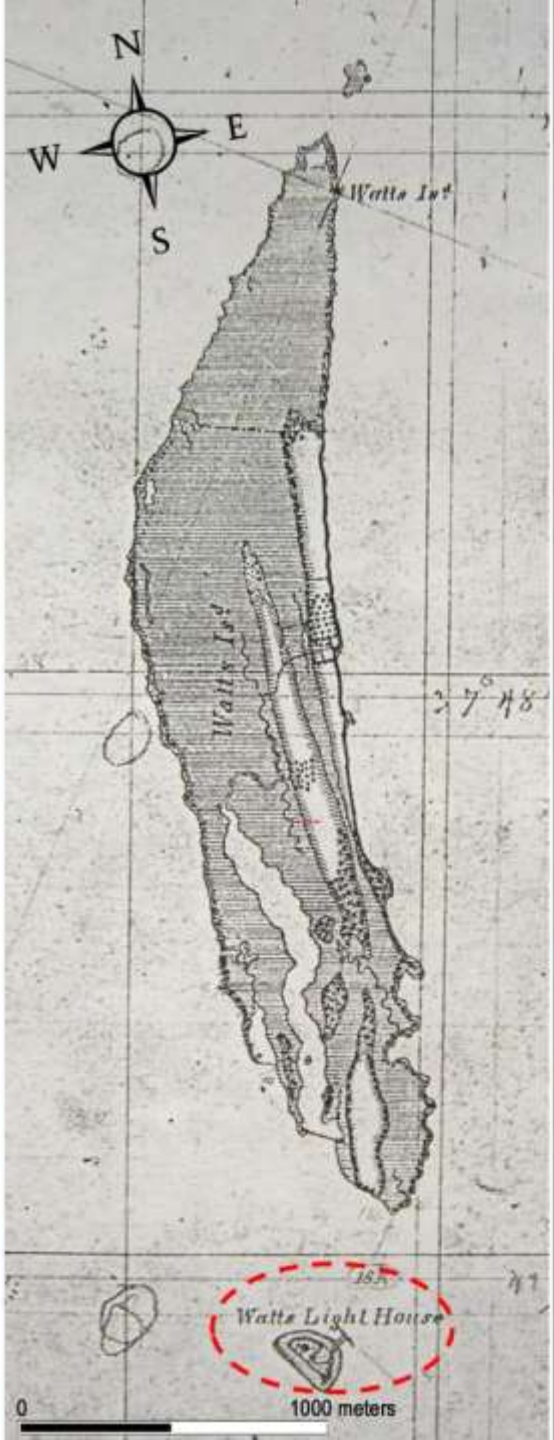
T 308

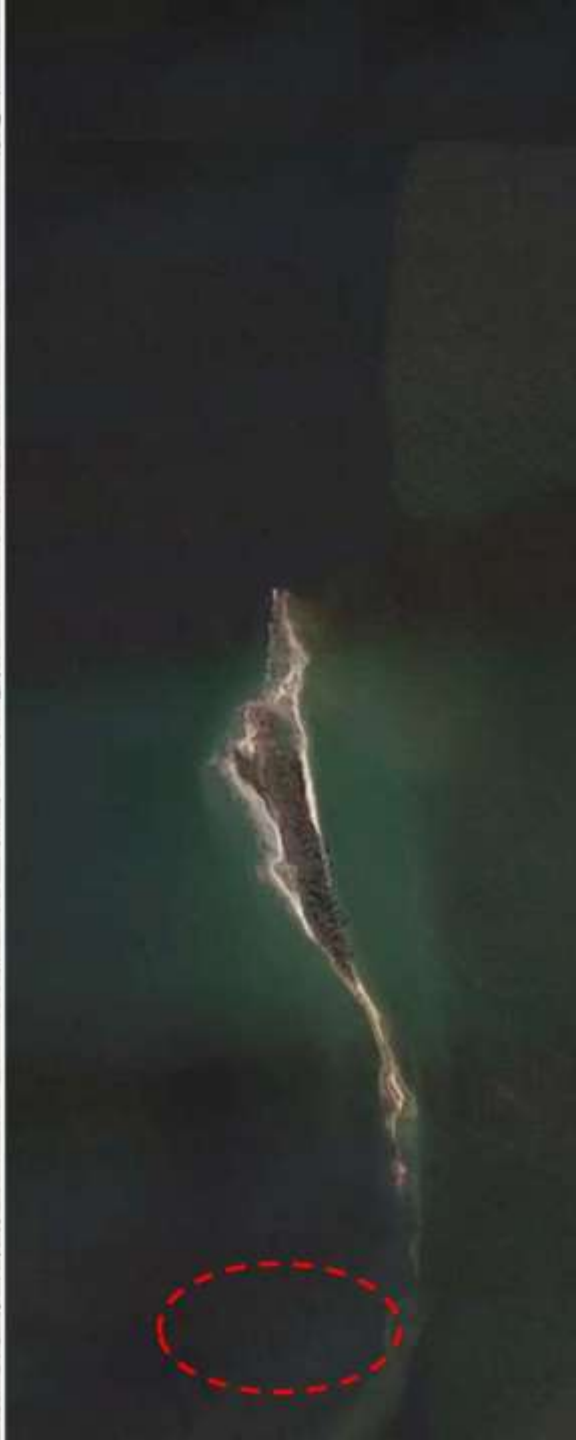
# Tangier Island, Virginia




# Watts Island, Virginia

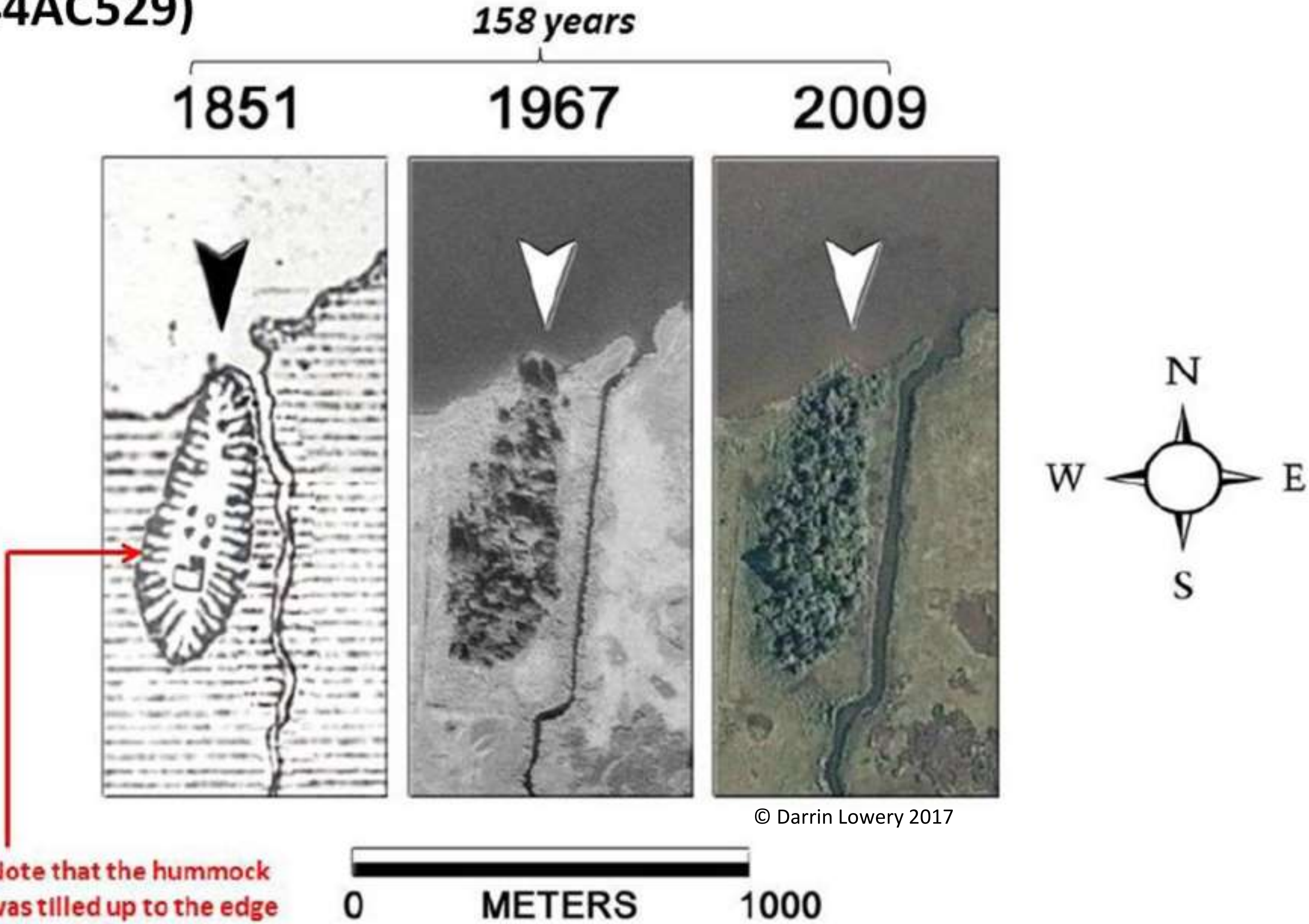


# Methodology:

- Combine the historic map data with historic aerial photographs to understand the changes associated with archaeological sites.

# Messongo Creek, Virginia
# (44AC529)



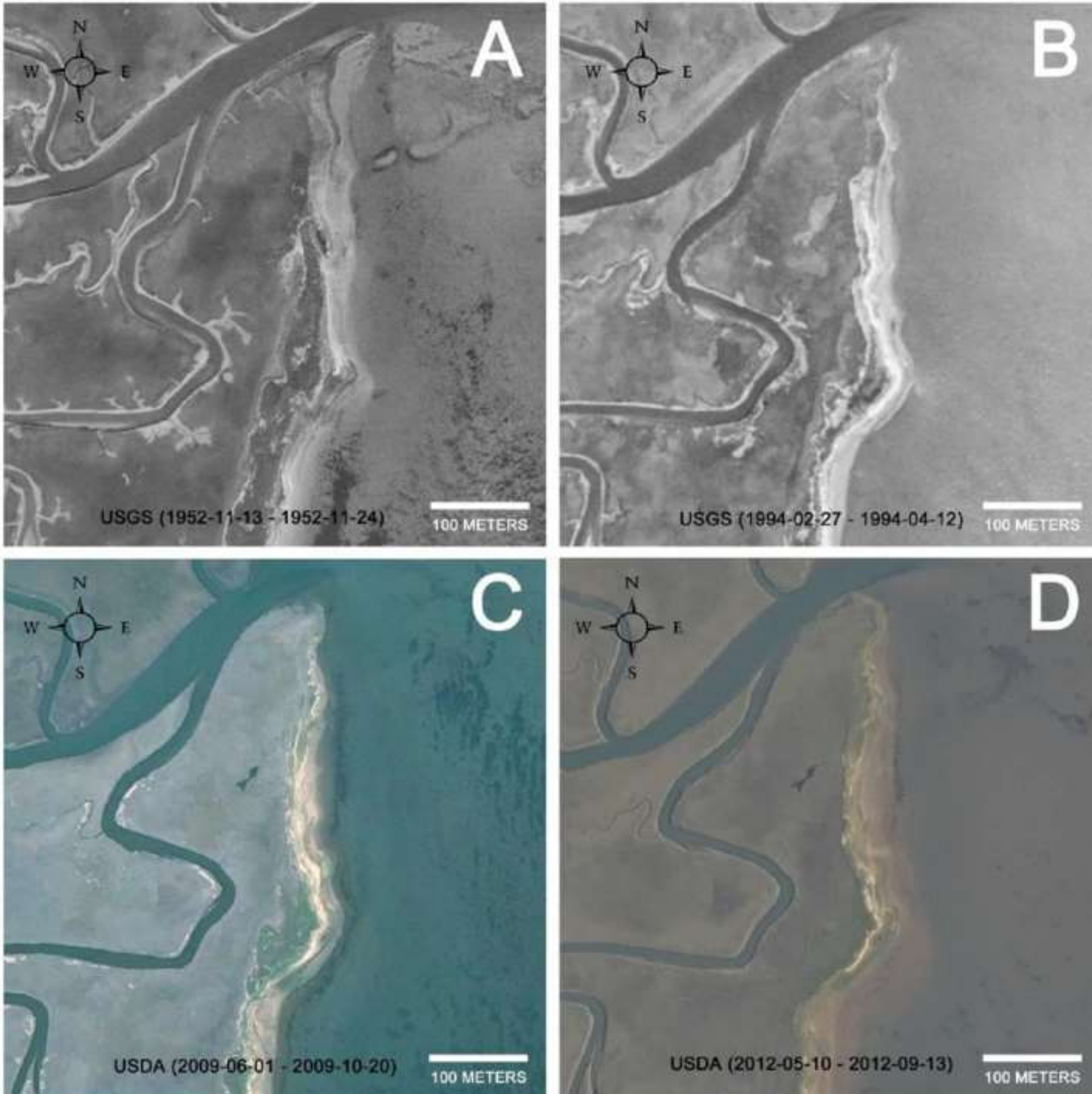


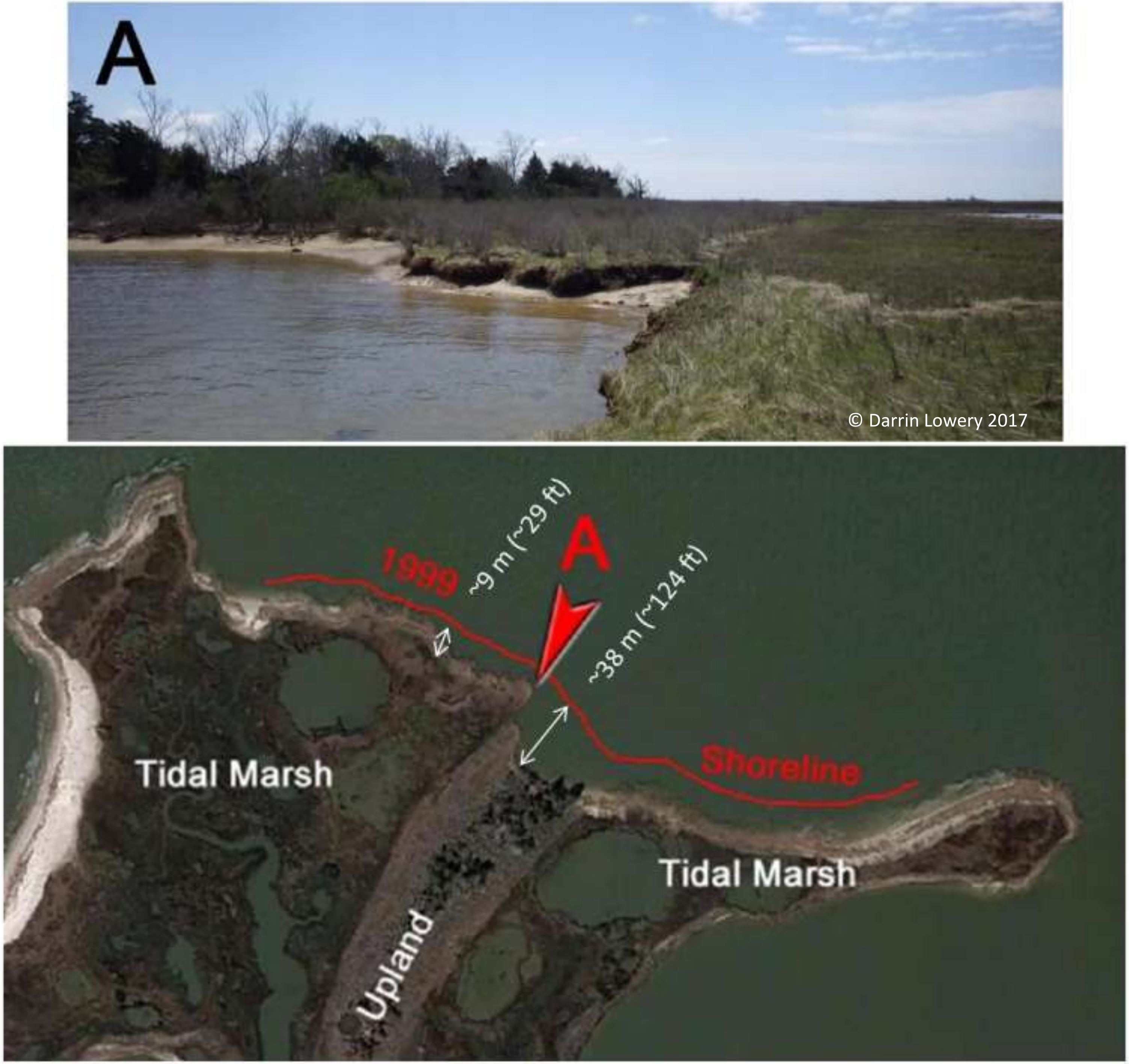

Note that the hummock was tilled up to the edge of the tidal marsh!

# Methodology:

- Overlay historic photos to gauge the amount of shoreline erosion at all archaeological sites

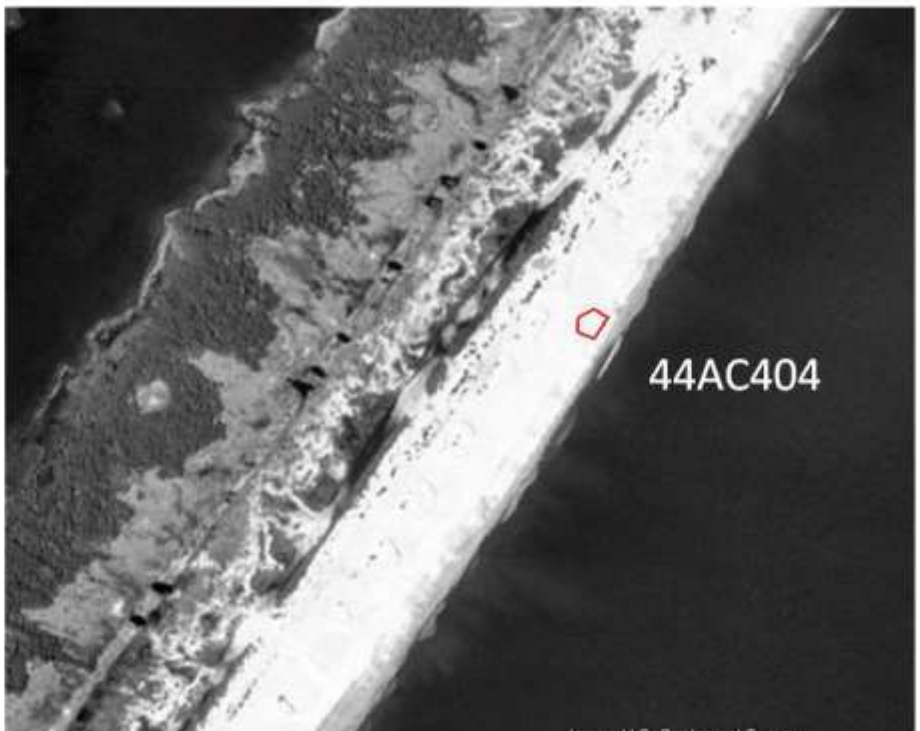
44NH440


A
B
C
D
N
S
W
E
USGS (1952-11-13 - 1952-11-24)
USGS (1994-02-27 - 1994-04-12)
USDA (2009-06-01 - 2009-10-20)
USDA (2012-05-10 - 2012-09-13)
100 METERS

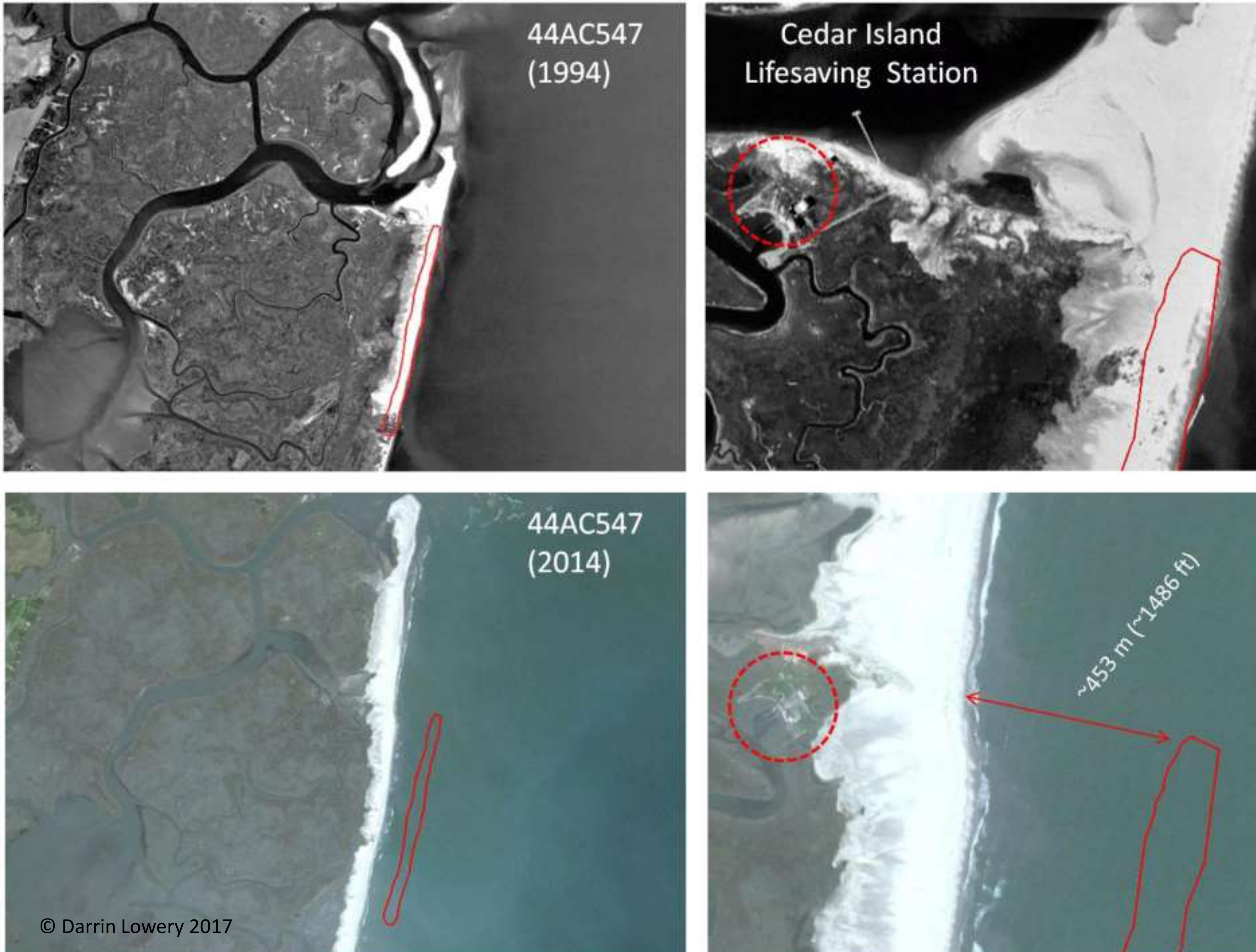

A
© Darrin Lowery 2017
1999
~9 m (~29 ft)
A
~38 m (~124 ft)
Shoreline
Tidal Marsh
Tidal Marsh
Upland

| #: | NAME and STATE NUMBER: | MAX. 15-Year EROSION: | | | MIN. 15-Year EROSION: | | | ERO. TYPE T | F | B |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Hog Neck - 44AC653* | ≤ | 282 | m | ≥ | 146 | m | | X | |
| 2 | South Smith Island - 44AC651* | ~ | 402 | m | ~ | 402 | m | | X | |
| 3 | Goose Harbor - 44AC652* | ≤ | 66 | m | ≥ | 24 | m | | X | |
| 4 | NW Tangier Island – 44AC524 | ≤ | 143 | m | ≥ | 43 | m | | X | |
| 5 | Tangier Uppers Cemetery – 44AC571 | ≤ | 135 | m | ≥ | 108 | m | | X | |
| 6 | Fort Albion – 44AC574** | ~ | 113 | m | ~ | 113 | m | | X | |
| 7 | Horse Hammock – 44AC6** | ≤ | 139 | m | ≥ | 73 | m | | X | |

1994



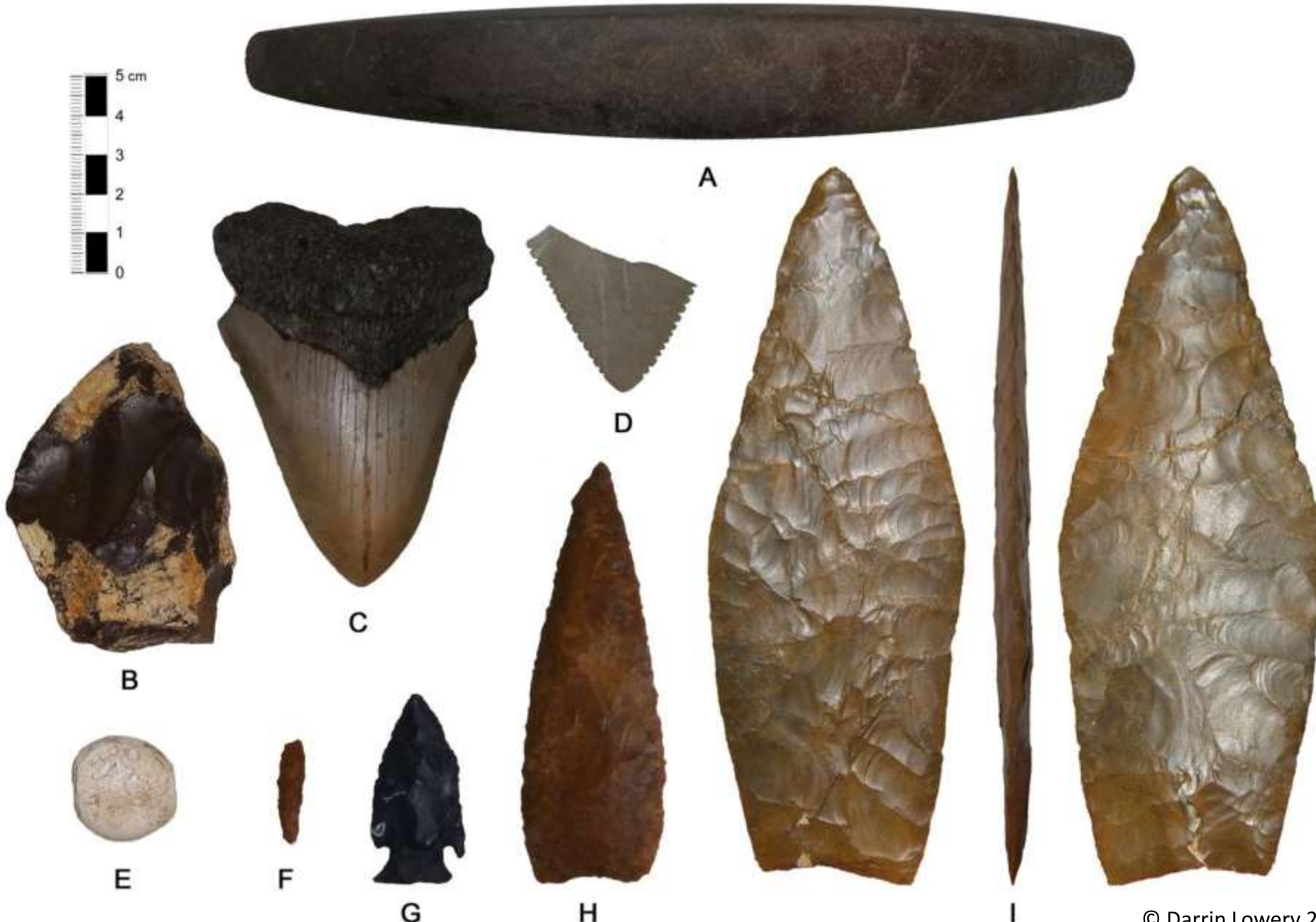

2016


44AC547
(1994)
Cedar Island
Lifesaving Station
44AC547
(2014)
~453 m (~1486 ft)
© Darrin Lowery 2017

# Methodology:

- Document avocational artifact collections from specific site locations

# 44NH431




44NH431
© Darrin Lowery 2017


© Darrin Lowery 2017


Obverse


Reverse

Obverse

Reverse

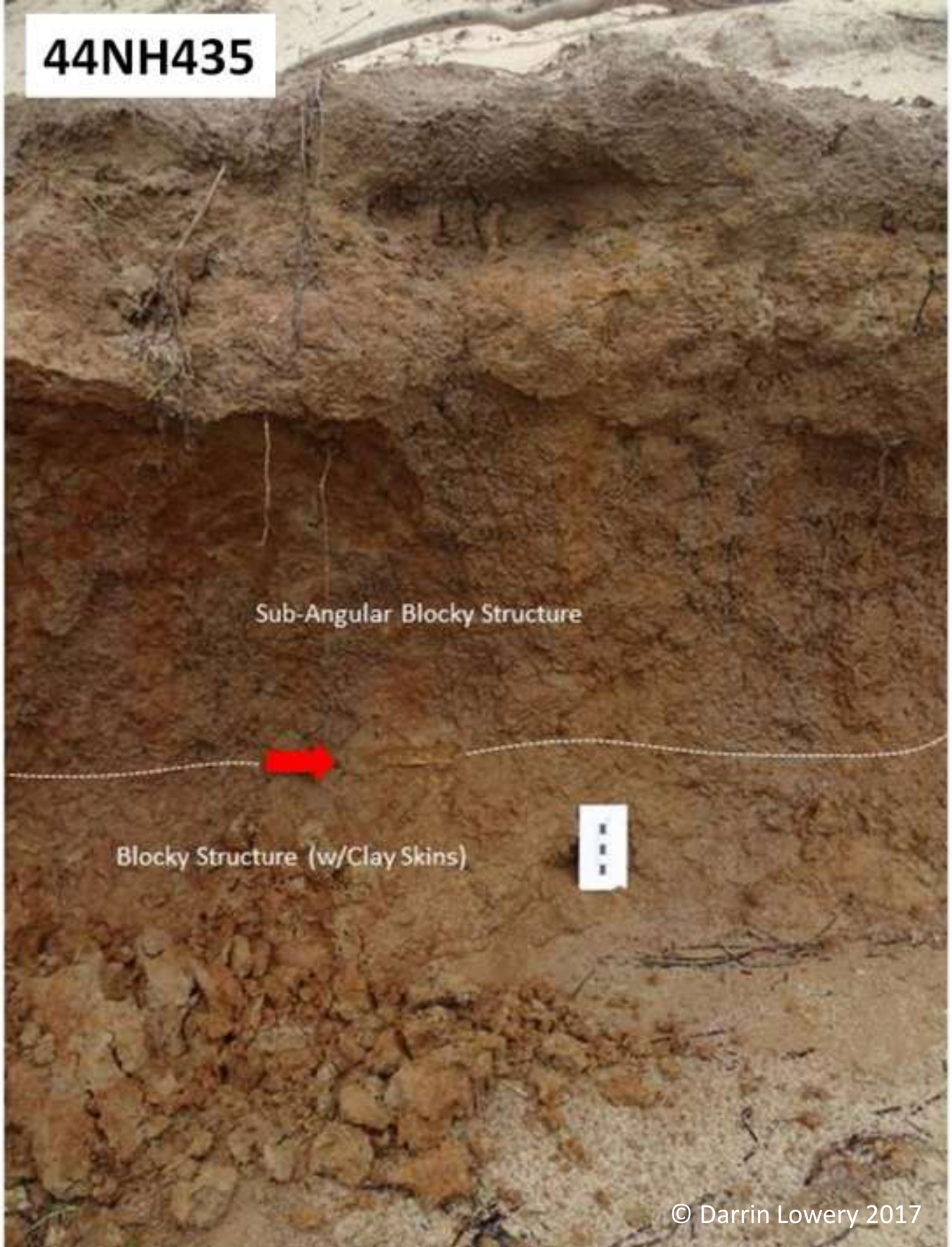
Obverse

Reverse

# 44NH435

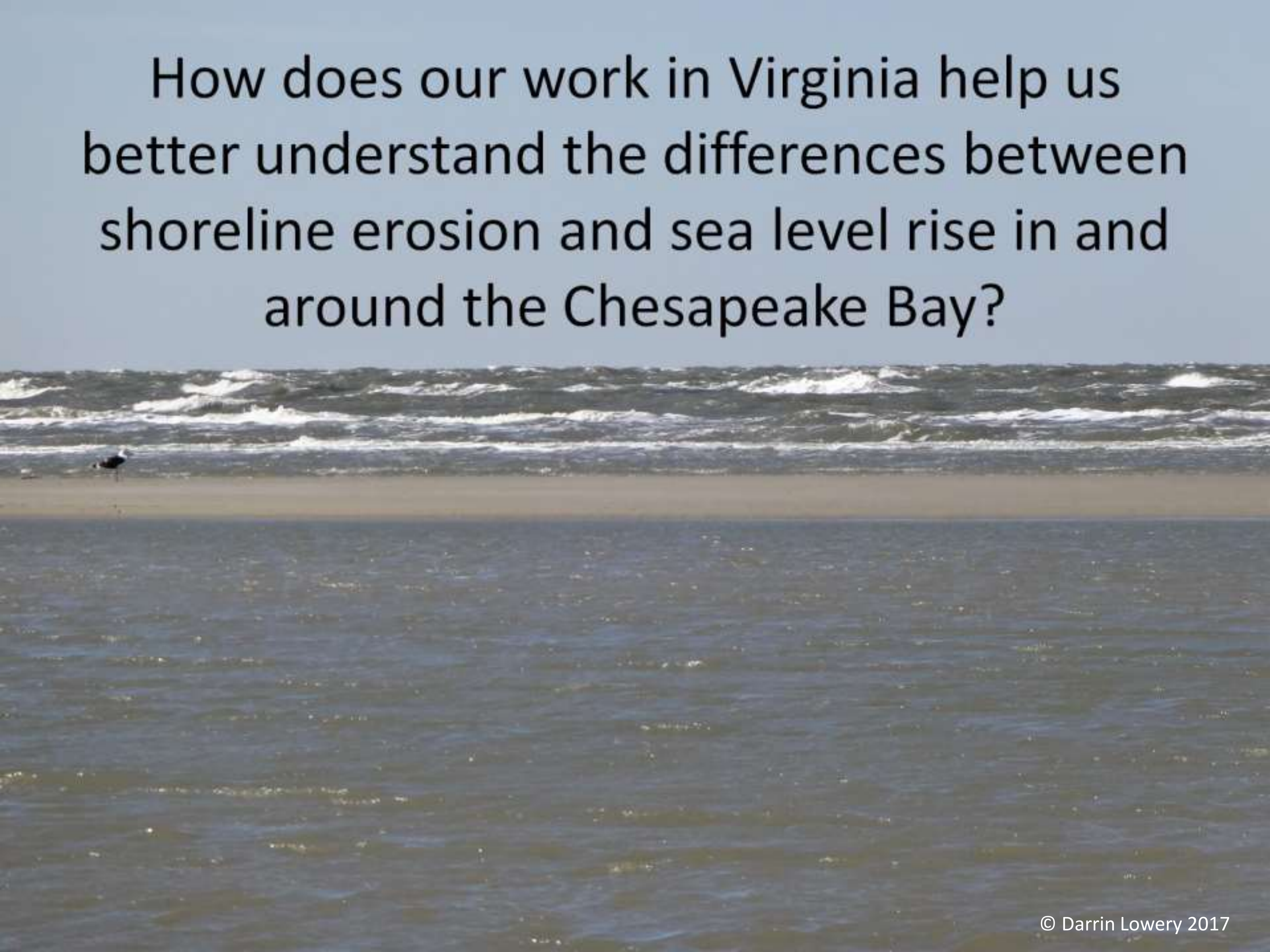
Obverse

Reverse




Loess
~80 cm
thick


How does our work in Virginia help us better understand the differences between shoreline erosion and sea level rise in and around the Chesapeake Bay?
© Darrin Lowery 2017

# Parson's Island, Maryland

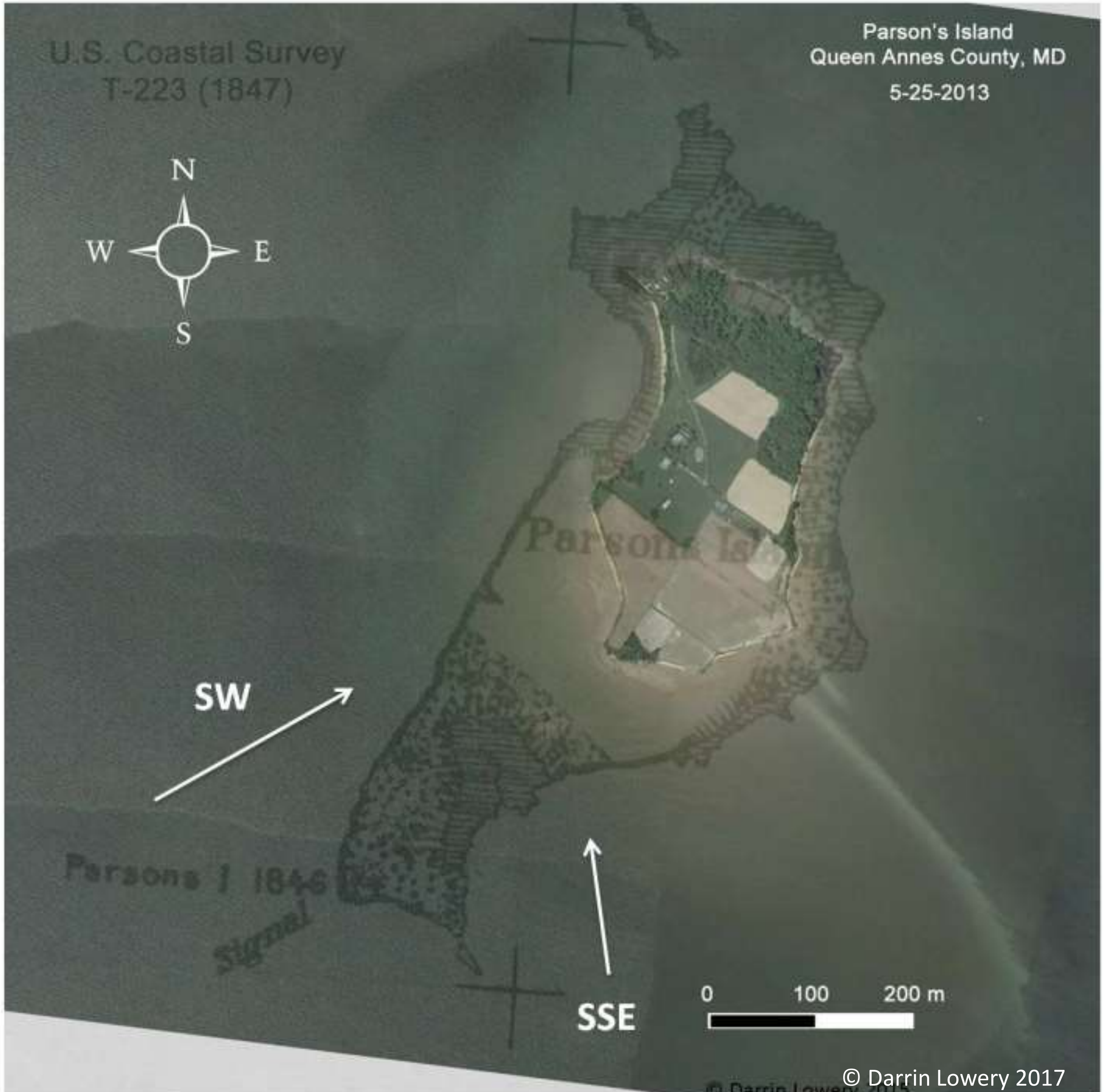

**Like many landscapes adjacent to the Chesapeake Bay, Parson's Island has been heavily eroded over the past 160+ years.**

1847= 198 acres

1997= 96.4 acres

2013= 78.2 acres






4-5-1992


5-25-2013

May 20, 2013 | August 8, 2013 | September 25, 2013 | October 16, 2013 | March 2, 2014

# ~2.5 meters of landward shoreface erosion/retreat in ~270 days.


March 2, 2014
© Darrin Lowery 2017


June 21, 2014
© Darrin Lowery 2014

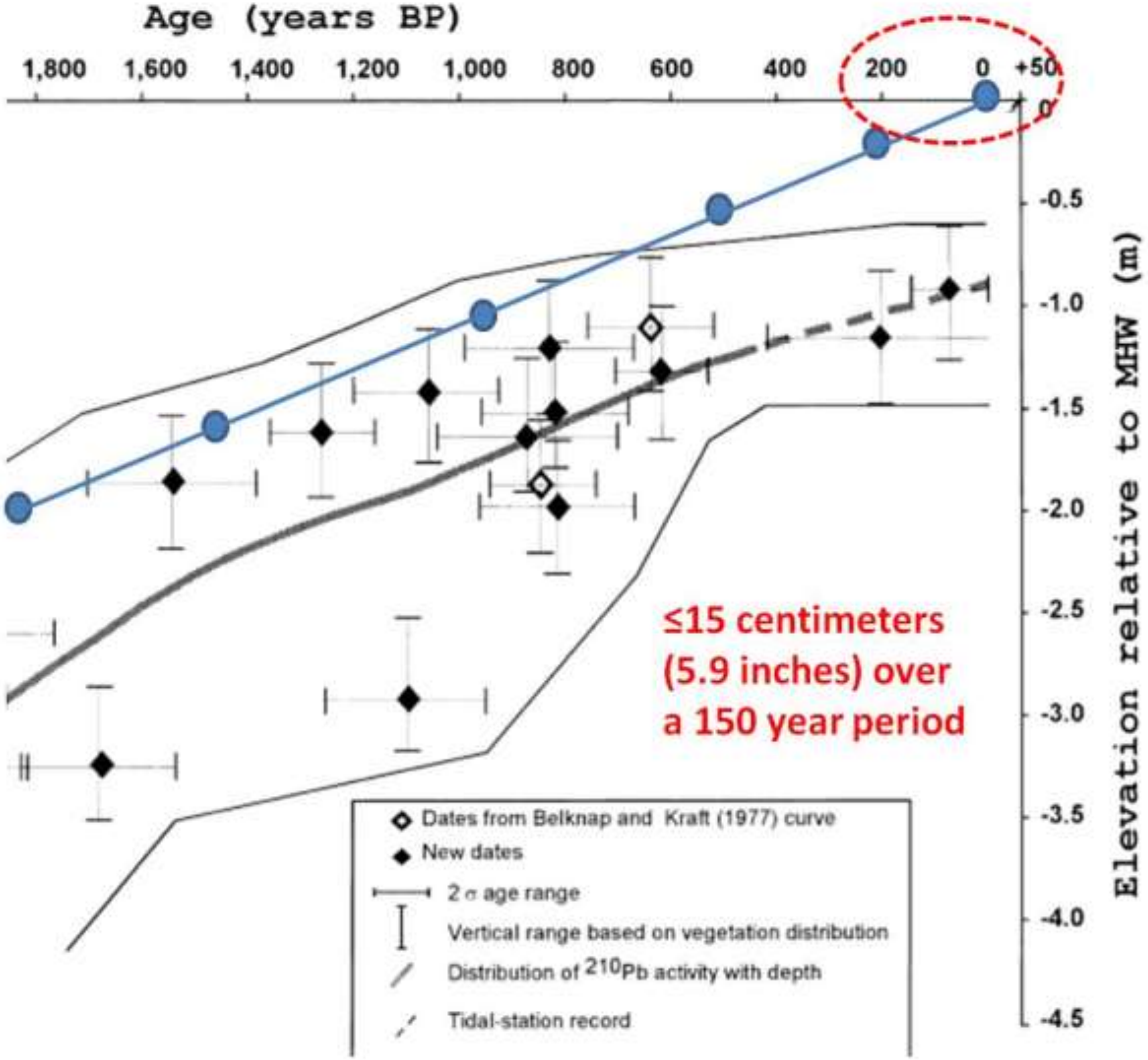

September 26, 2014

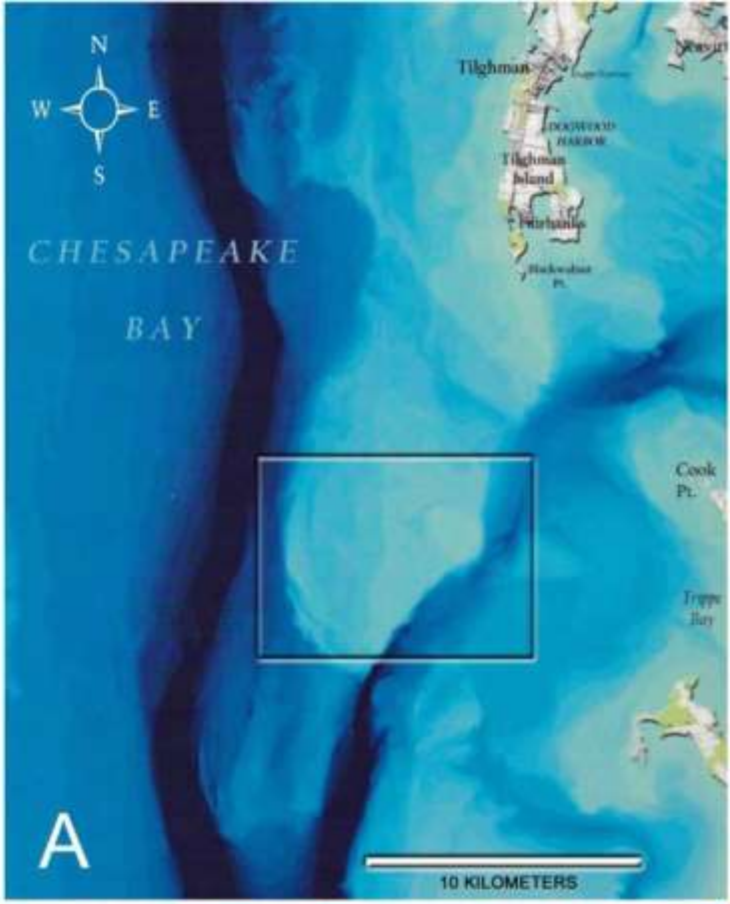
November 2, 2016

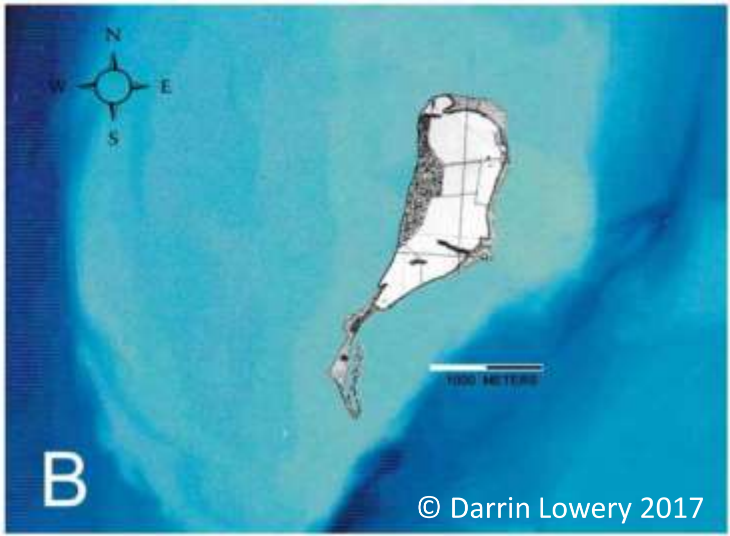
Inundation occurs during periods with high rates of sea level rise!

Erosion occurs during periods with slow rates of sea level rise.

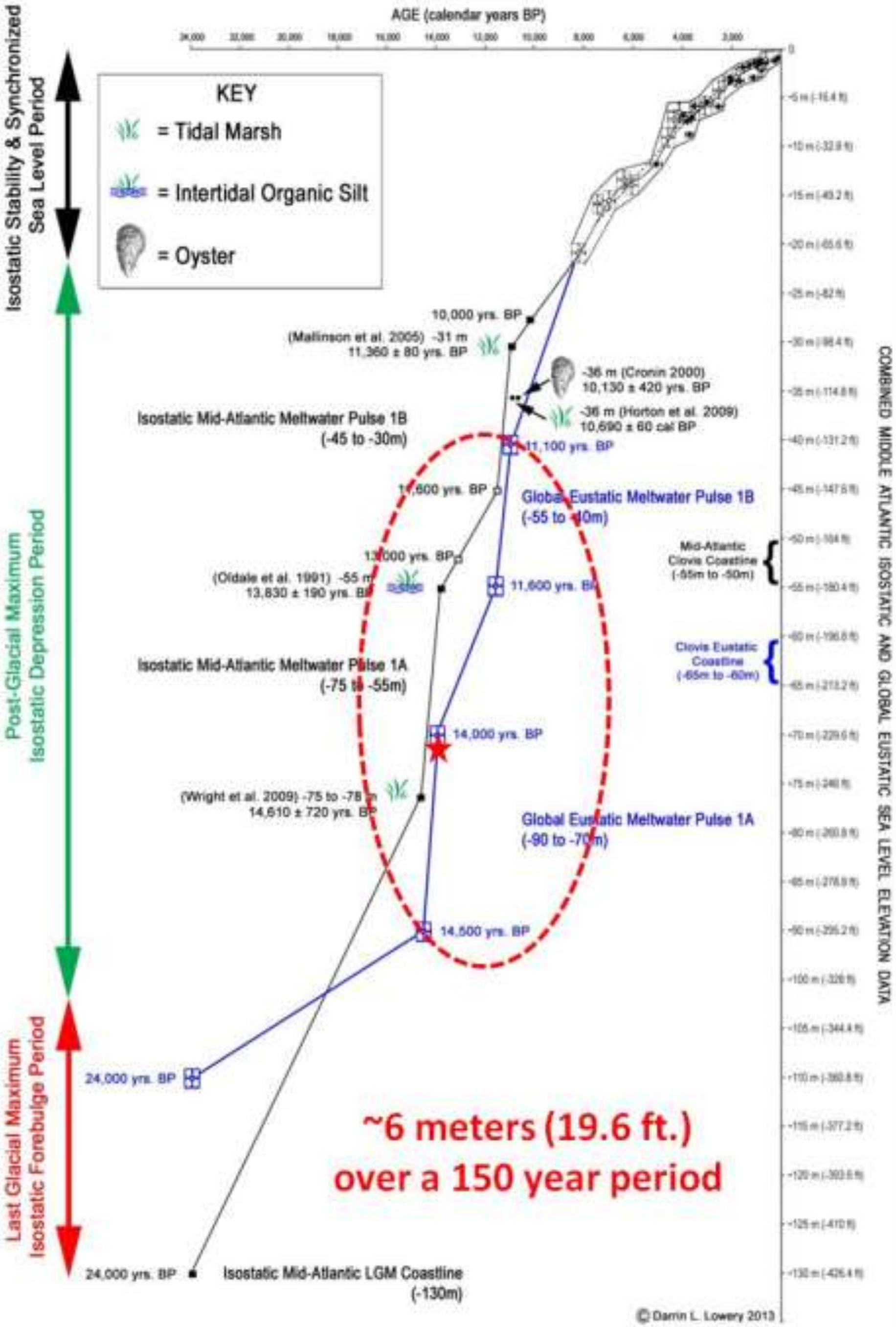
# Rates of Sea Level Rise: Impact on Former Upland Landscape Preservation

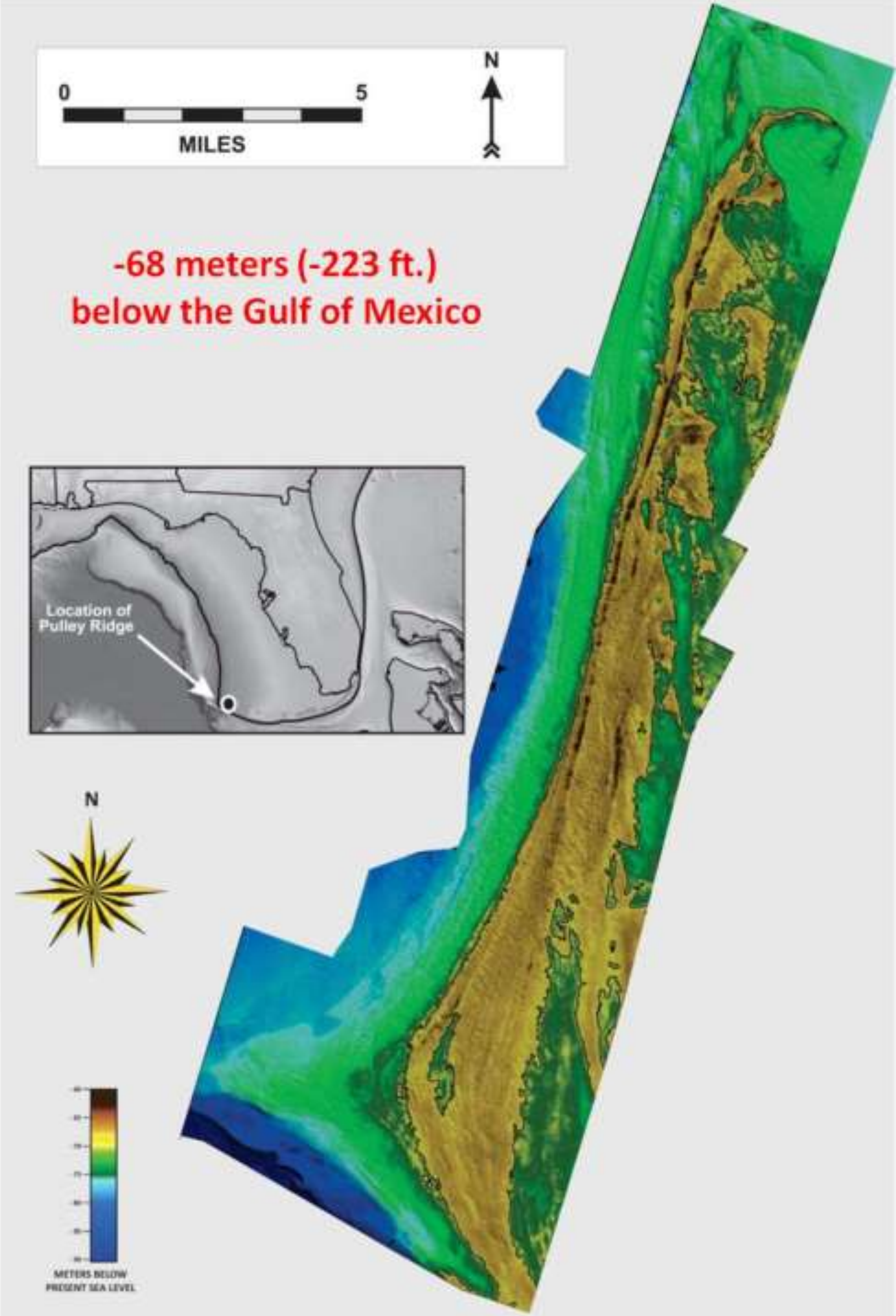


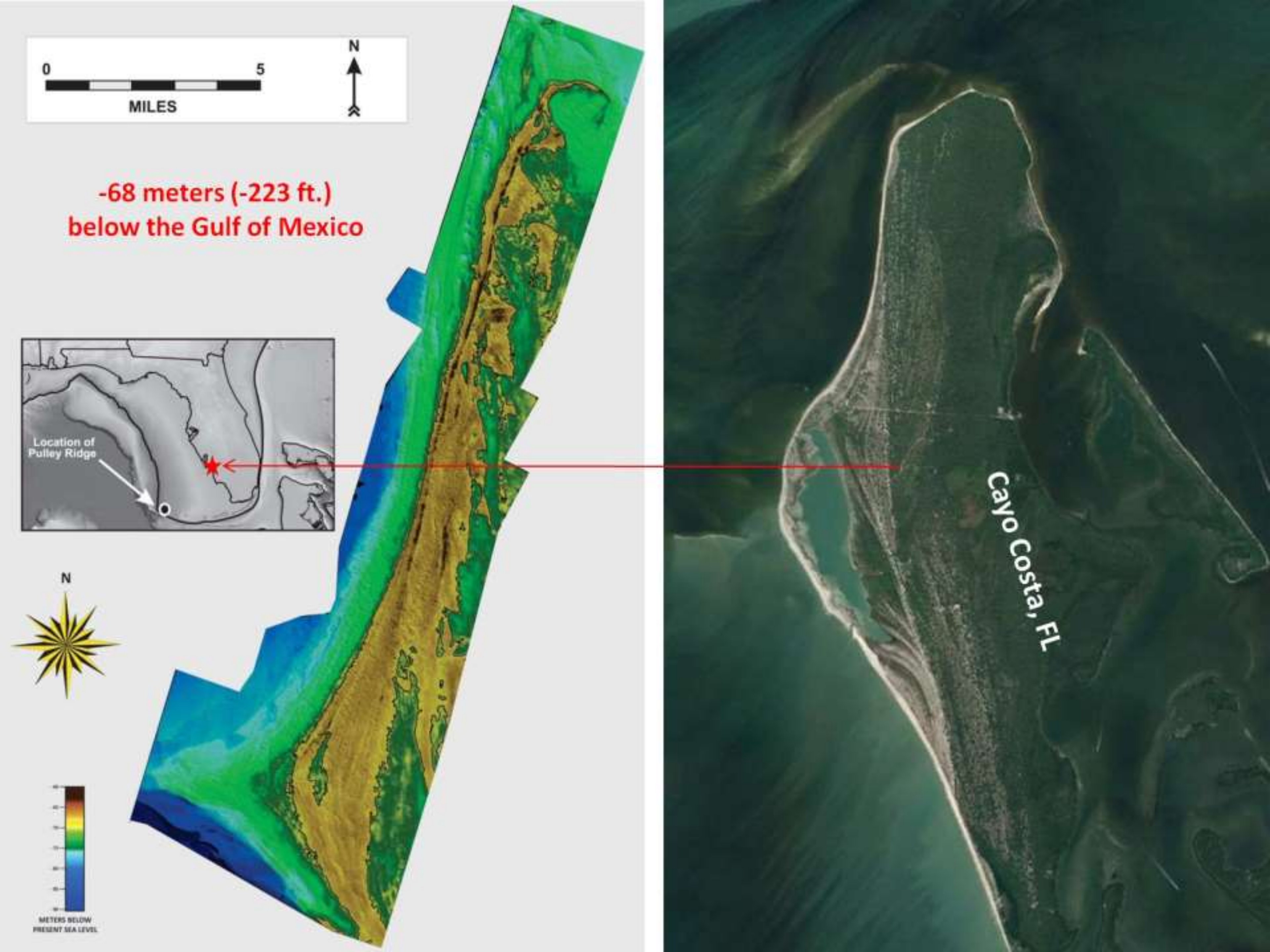



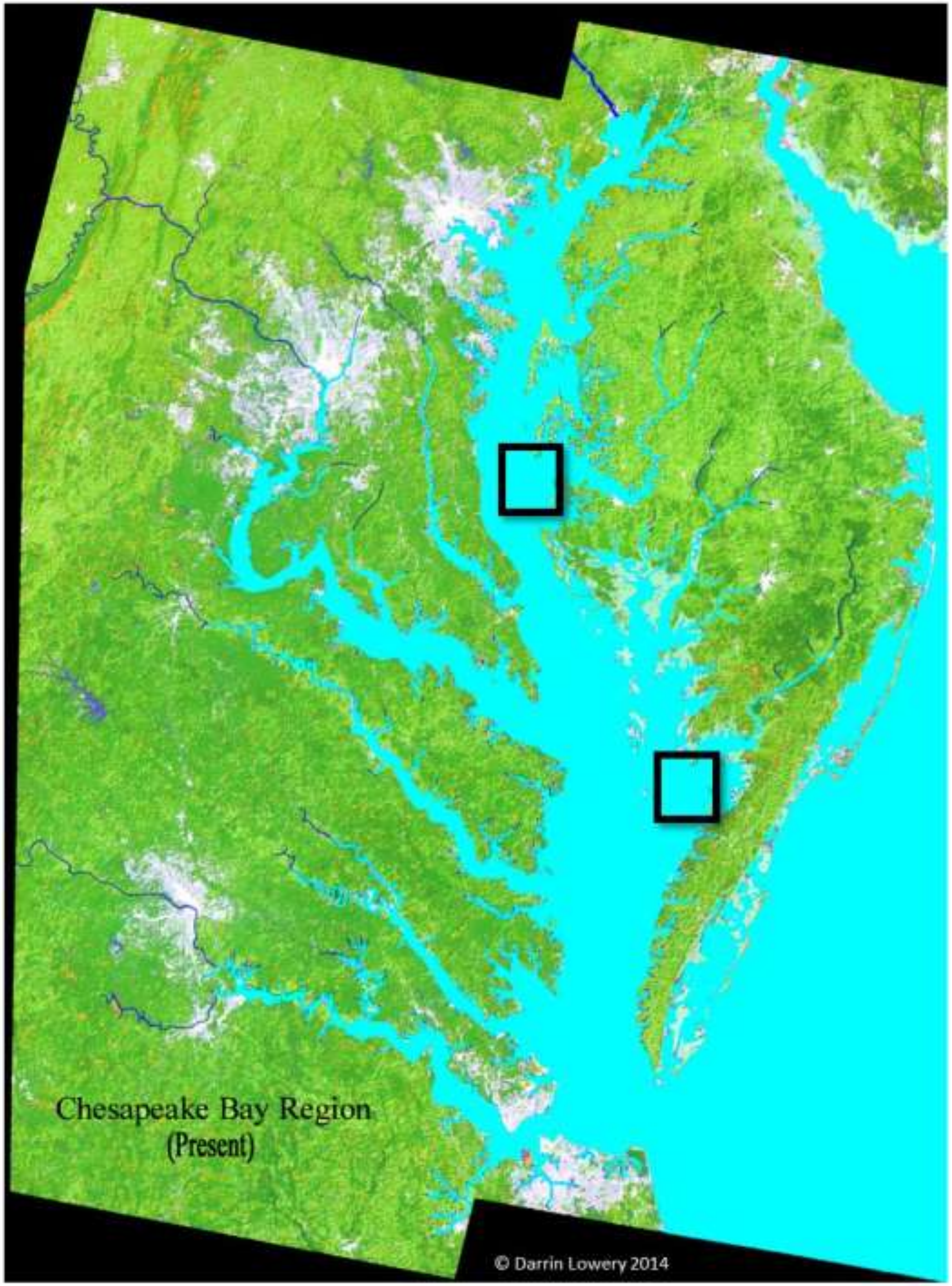




The northern part of
Sharps Island is made
up of (silt) material
of the Talbot formation
and rises out of the
water as much as
7 feet. (Hunter 1914:11)
© Darrin Lowery 2017
Poplar
Sharps' Ile


AGE (calendar years BP)
KEY
= Tidal Marsh
= Intertidal Organic Silt
= Oyster
Isostatic Stability & Synchronized Sea Level Period
Post-Glacial Maximum Isostatic Depression Period
Last Glacial Maximum Isostatic Forebulge Period
10,000 yrs. BP
(Mallinson et al. 2005) -31 m 11,360 ± 80 yrs. BP
-36 m (Cronin 2000) 10,130 ± 420 yrs. BP
-36 m (Horton et al. 2009) 10,690 ± 60 cal BP
Isostatic Mid-Atlantic Meltwater Pulse 1B (-45 to -30m)
11,100 yrs. BP
Global Eustatic Meltwater Pulse 1B (-55 to -40m)
13,000 yrs. BP
(Oldale et al. 1991) -55 m 13,830 ± 190 yrs. BP
11,600 yrs. BP
Mid-Atlantic Clovis Coastline (-55m to -50m)
Clovis Eustatic Coastline (-65m to -60m)
Isostatic Mid-Atlantic Meltwater Pulse 1A (-75 to -55m)
14,000 yrs. BP
(Wright et al. 2009) -75 to -78 m 14,610 ± 720 yrs. BP
Global Eustatic Meltwater Pulse 1A (-90 to -70m)
14,500 yrs. BP
24,000 yrs. BP
~6 meters (19.6 ft.) over a 150 year period
24,000 yrs. BP
Isostatic Mid-Atlantic LGM Coastline (-130m)
© Darrin L. Lowery 2013
COMBINED MIDDLE ATLANTIC ISOSTATIC AND GLOBAL EUSTATIC SEA LEVEL ELEVATION DATA


0
5
MILES
N
-68 meters (-223 ft.)
below the Gulf of Mexico
Location of Pulley Ridge
N
METERS BELOW PRESENT SEA LEVEL

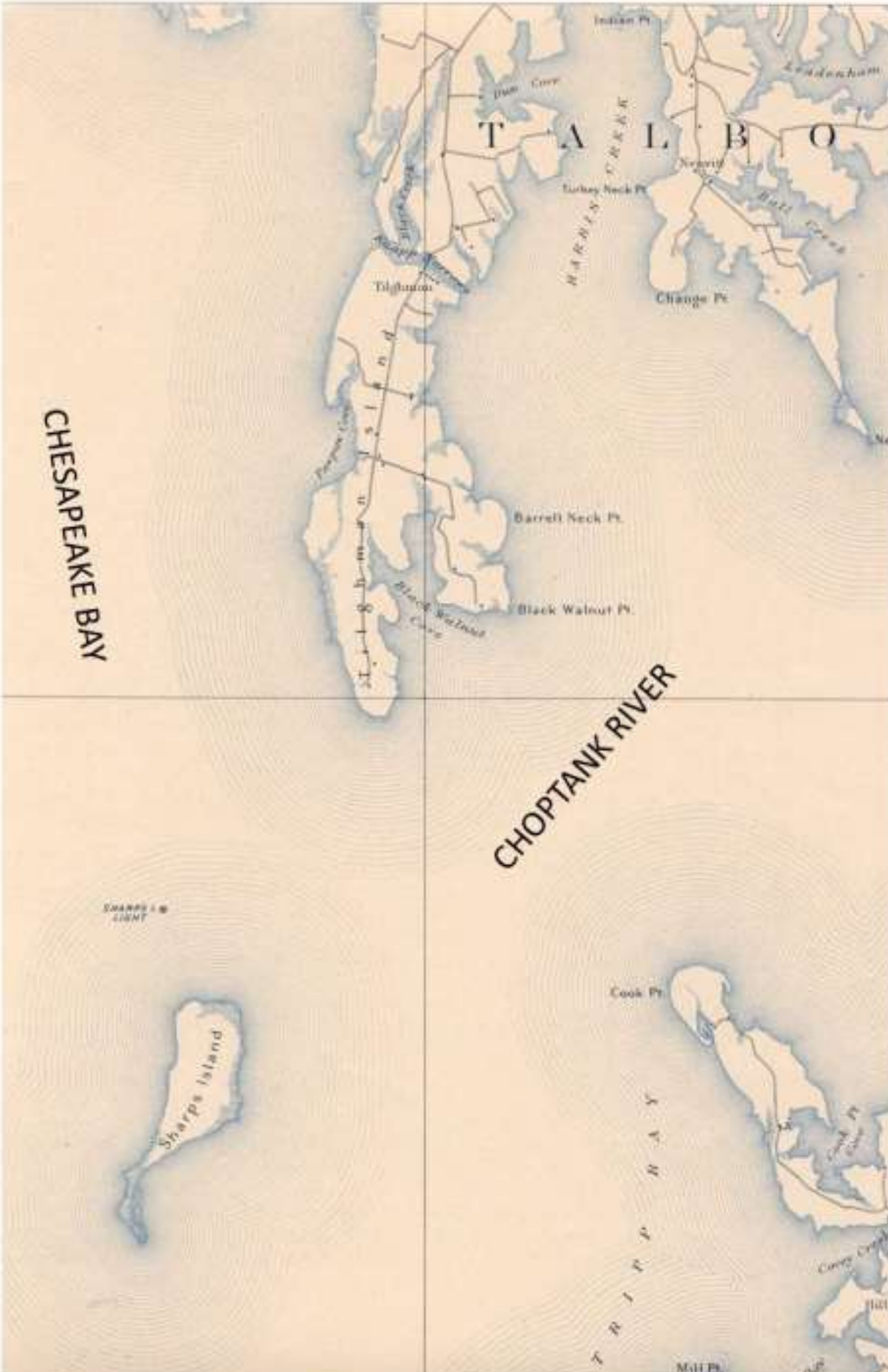

0
5
MILES
N
-68 meters (-223 ft.)
below the Gulf of Mexico
Location of
Pulley Ridge
N
METERS BELOW
PRESENT SEA LEVEL
Cayo Costa, FL



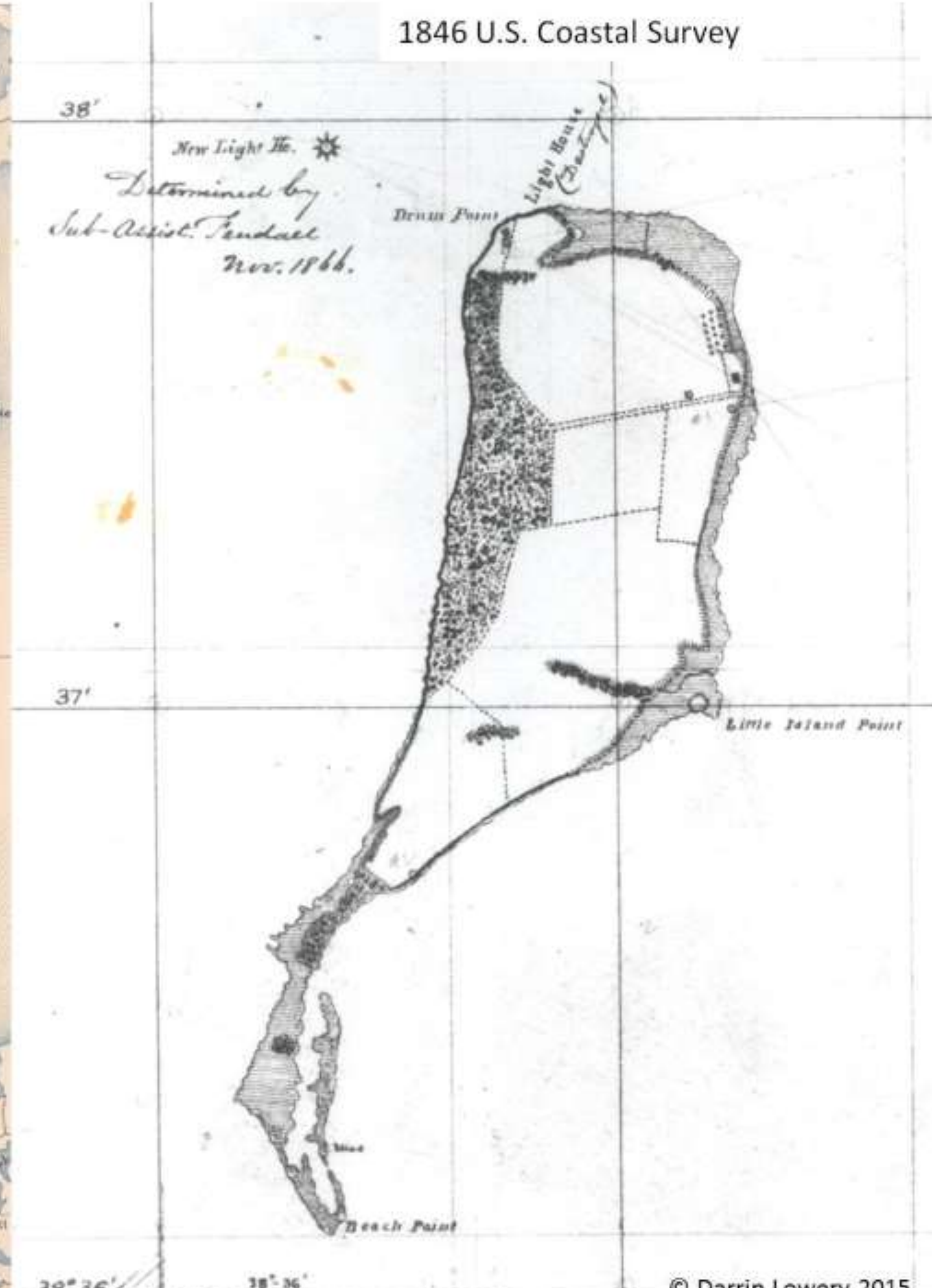

## COMPARATIVE EROSION IN THE BAY REGION

Sharps Island, Maryland
&
Watts Island, Virginia

***Erosion does not equate as evidence of climatically driven "sea level" change!***

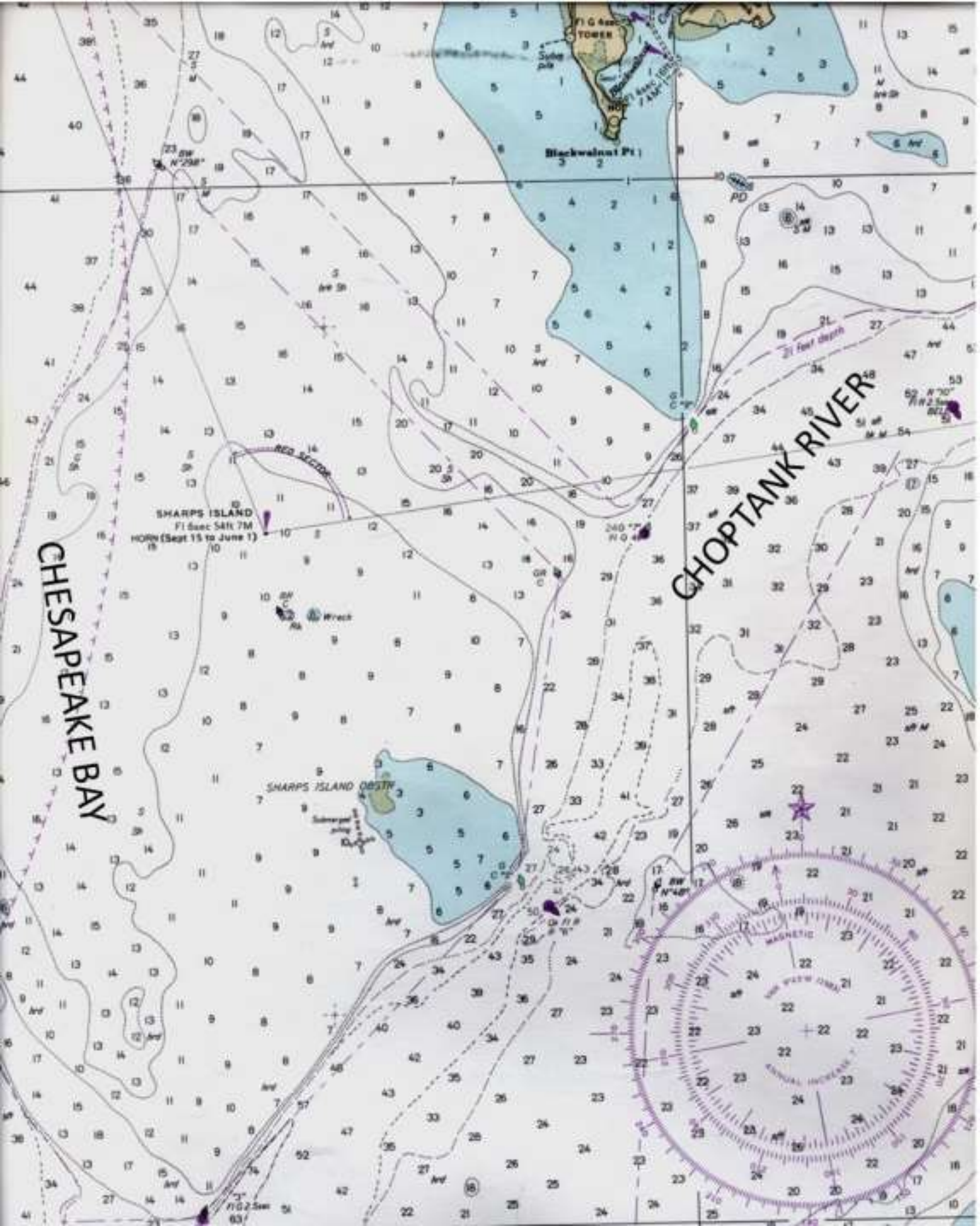


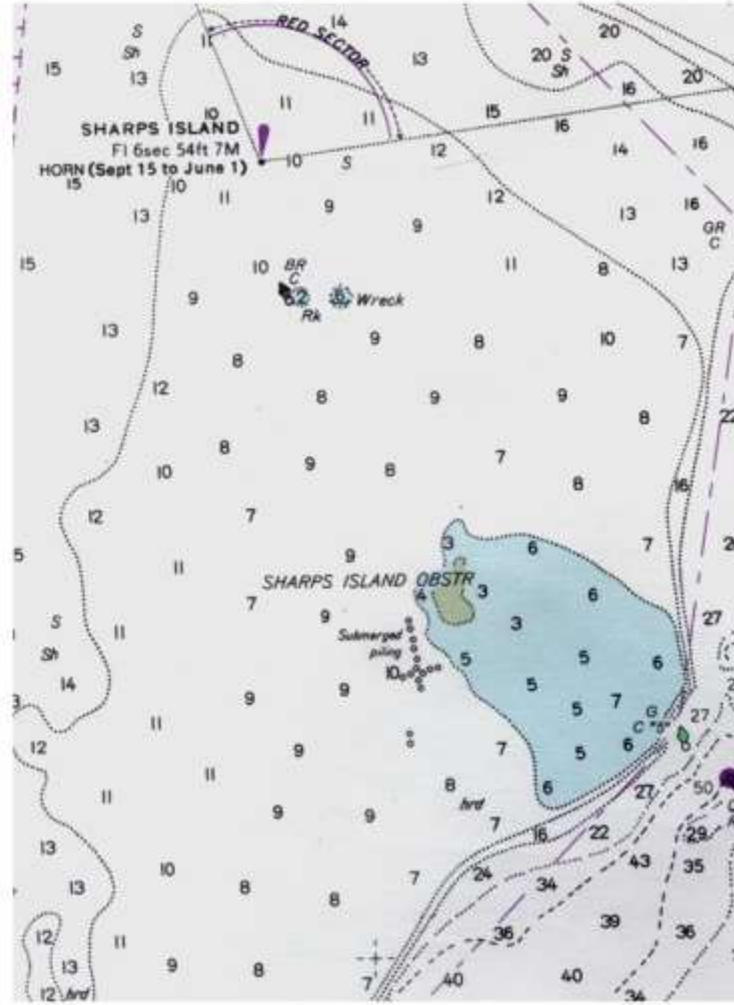
Indian Pt.
Dun Cove
T A L B O
Leadenham
Neavitt
Turkey Neck Pt.
HARRIS CREEK
Tilghman
Change Pt.
Tilghman Island
Barrett Neck Pt.
Black Walnut Pt.
Black Walnut Cove
CHESAPEAKE BAY
CHOPTANK RIVER
Cook Pt.
Sharps Island
TRIPP BAY
Mill Pt.

1846 U.S. Coastal Survey
38'
New Light Ho.
Determined by
Sub-Assist. Fendall
Nov. 1866.
Drum Point
Light House
37'
Little Island Point
Beach Point
38°36'
© Darrin Lowery 2015

# 1970 Navigation Chart



1900 U.S. Coastal Survey

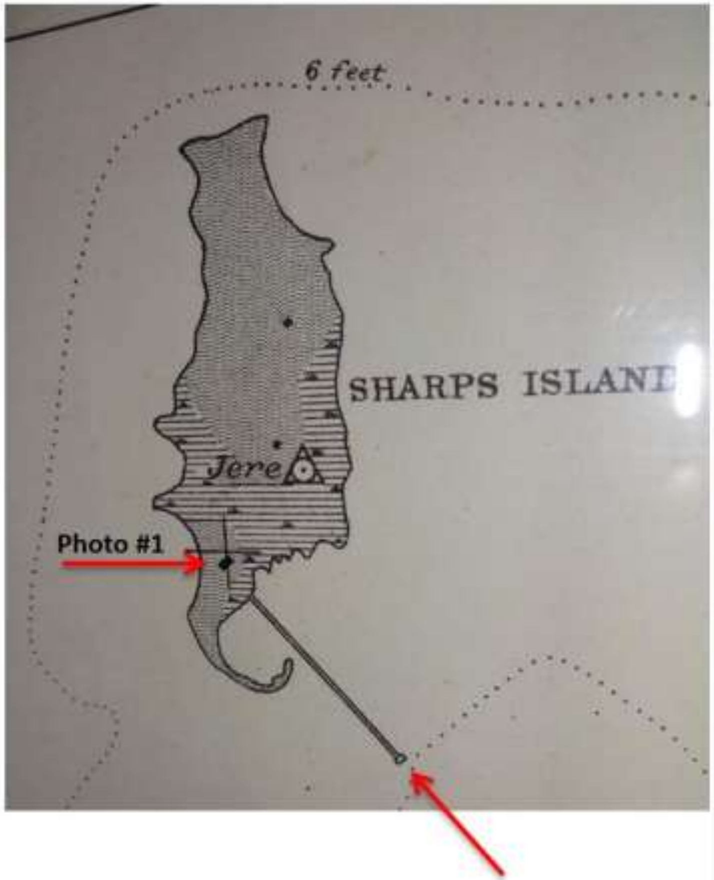



Photo #2

Note steamboat wharf (photo #2)

Photo #1
(Sept. 1905)

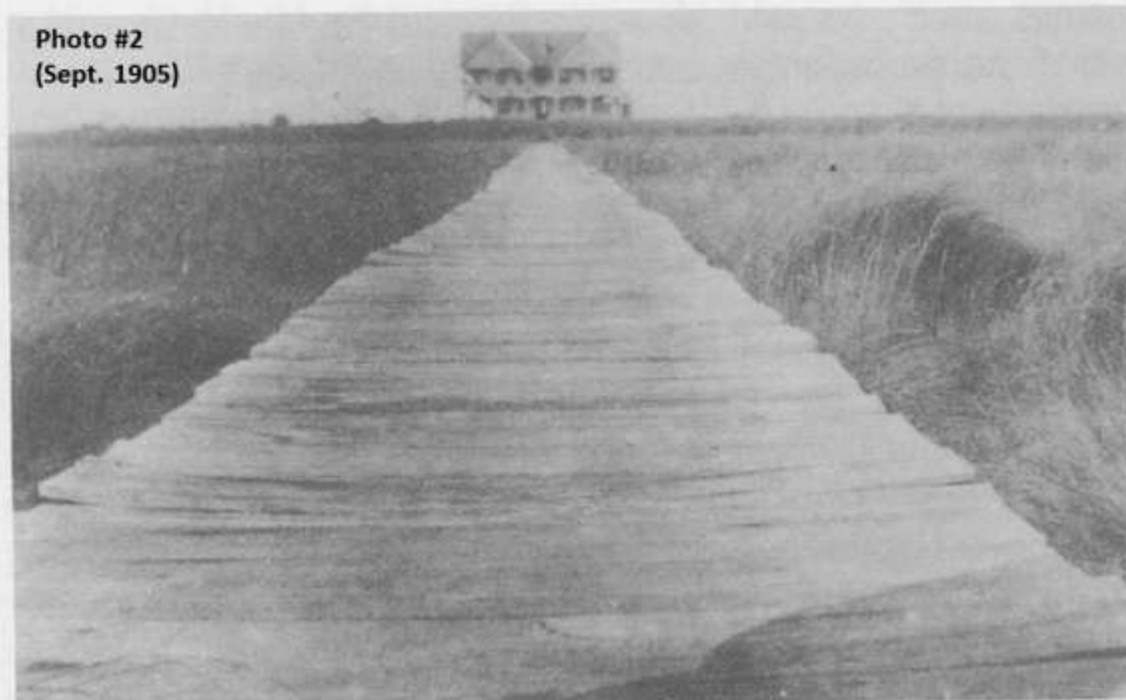
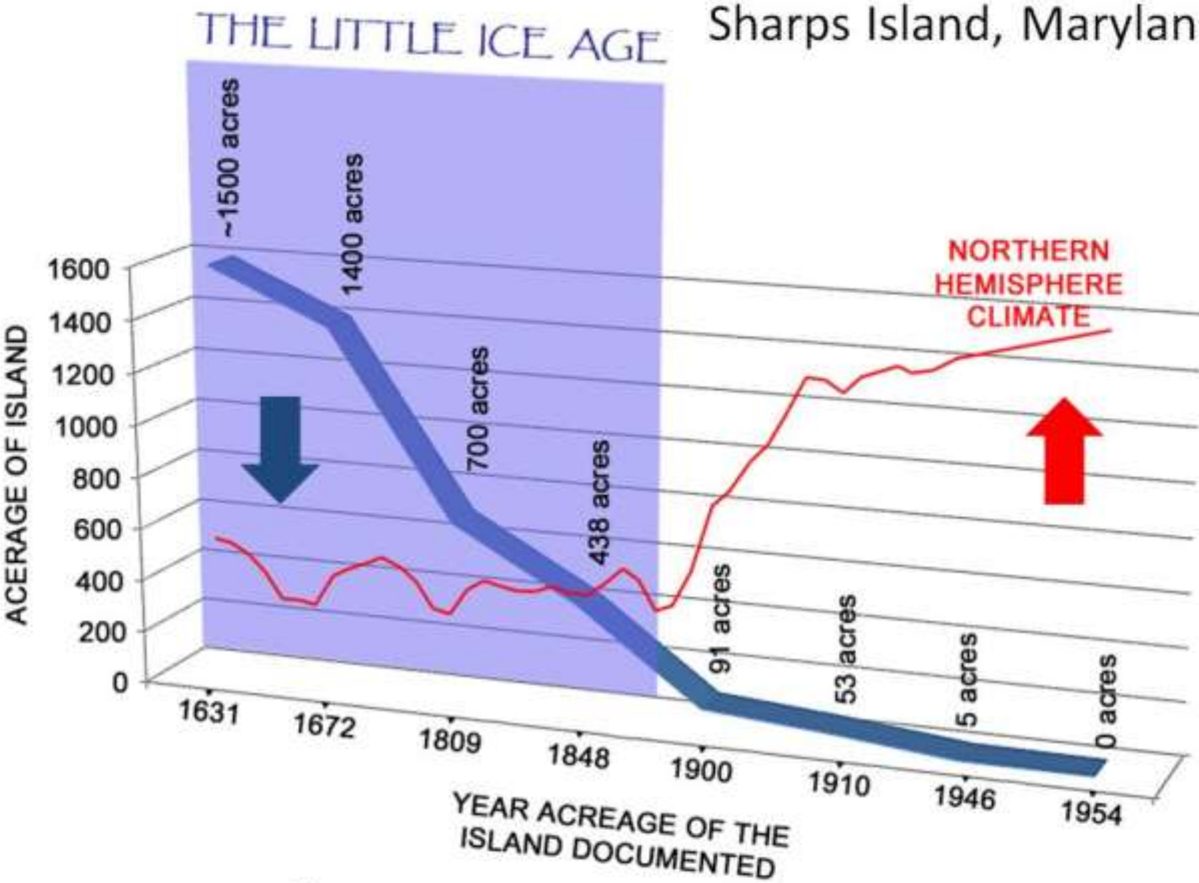


Photo #2
(Sept. 1905)

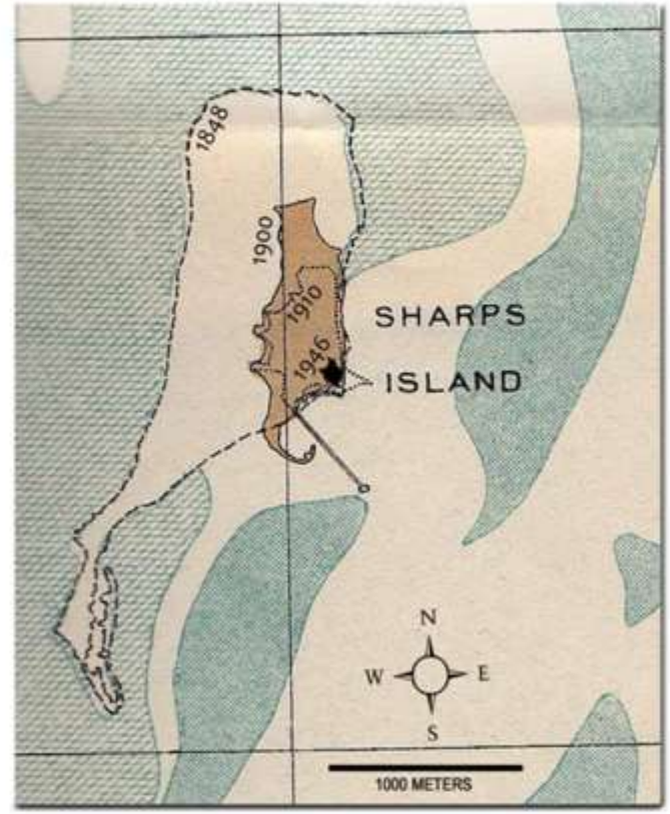

(1914)

Only known aerial photo of Sharps Island, MD taken Sept. 22, 1946

# Sharps Island, Maryland




A

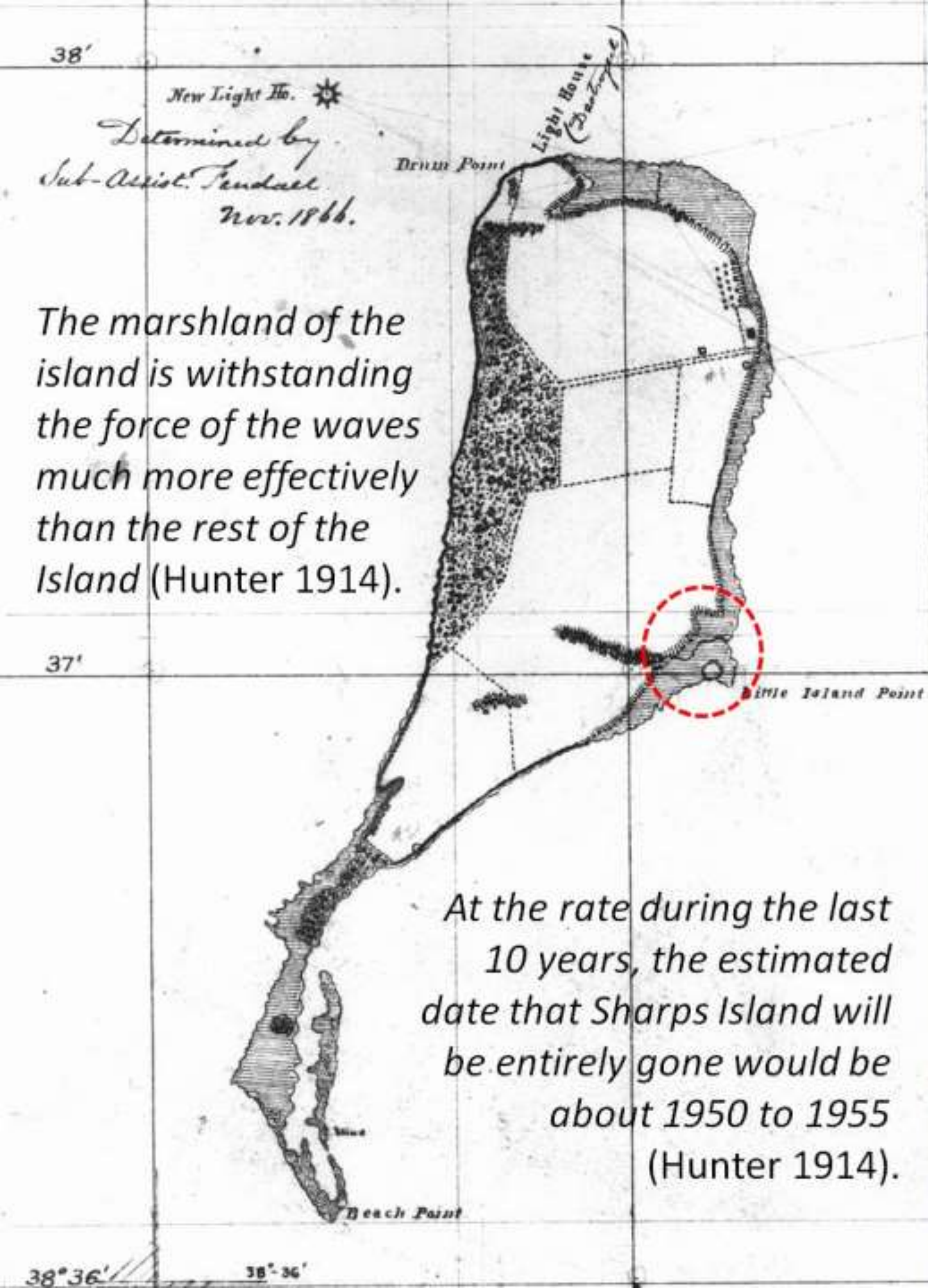



B

Between 1672 and 1848, Sharps Island was eroding at ~5.4-acres per year!

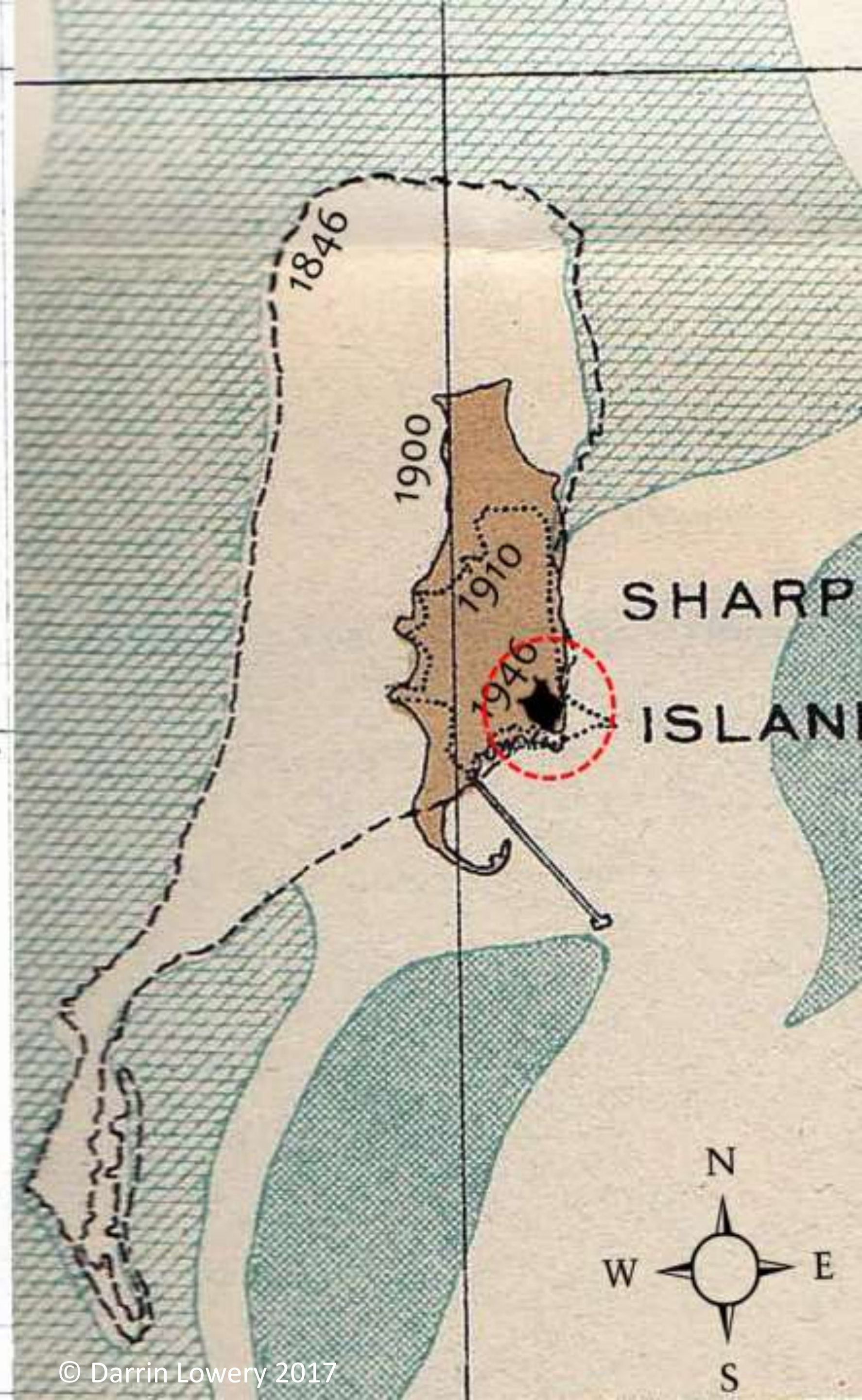
The rate of erosion slowed to ~1.7-acres per year between 1900 and 1954.

*WHY DID THE RATE SLOW?*




*The marshland of the island is withstanding the force of the waves much more effectively than the rest of the Island* (Hunter 1914).

*At the rate during the last 10 years, the estimated date that Sharps Island will be entirely gone would be about 1950 to 1955* (Hunter 1914).



Tidal marsh is more resistant to shoreline erosion!

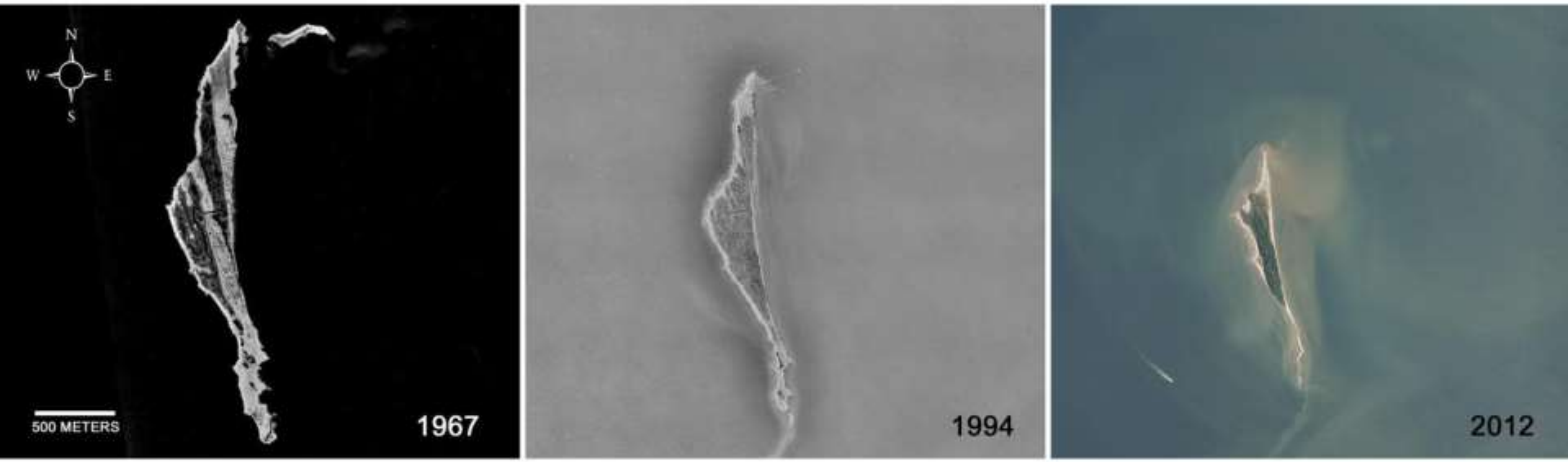
Watts Island, Virginia

**1662: 400 acres**
(< 1/3rd the size of Sharps Island at the same time)


160 years

45 years

1.6 acres per year



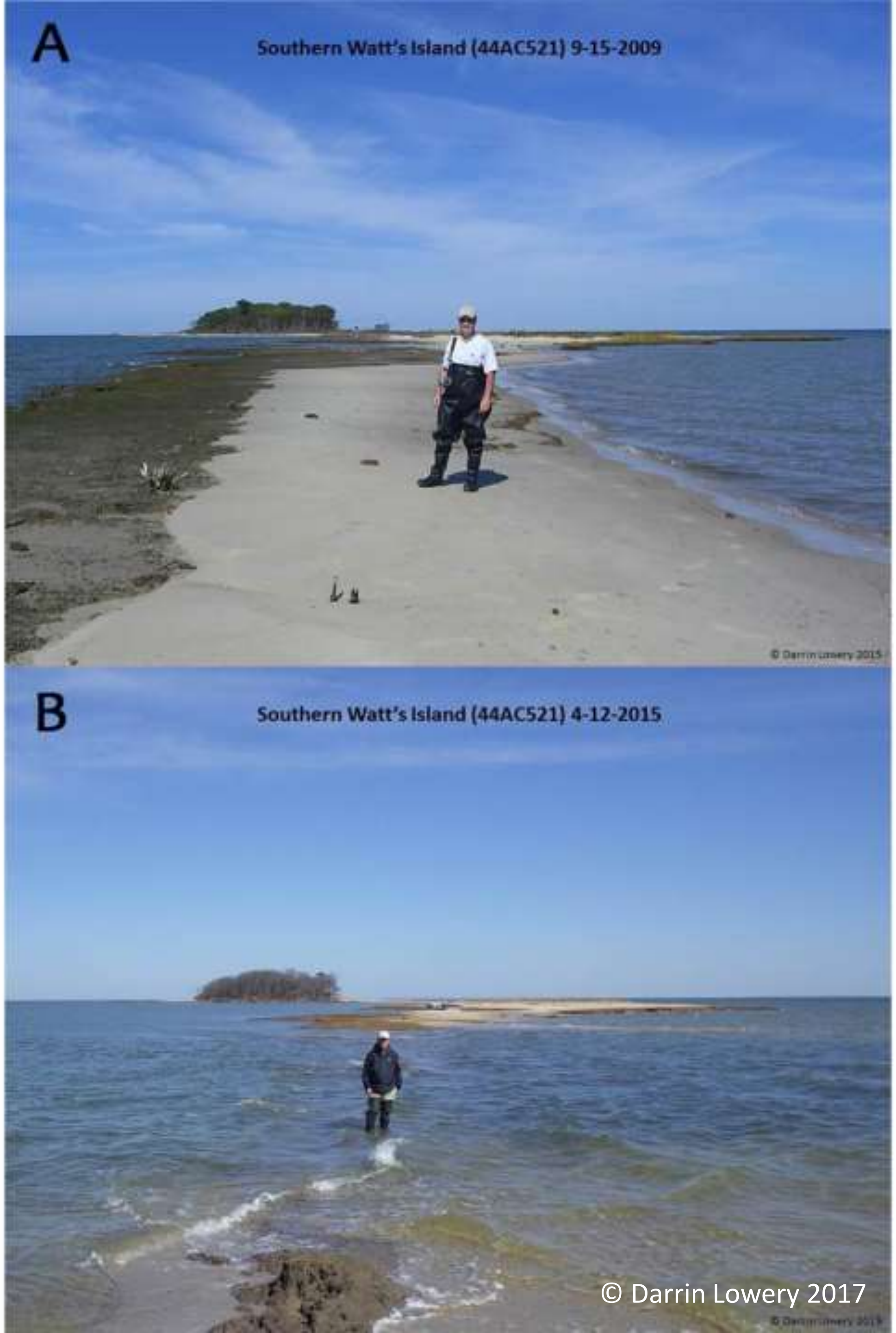

102 acres

86 acres

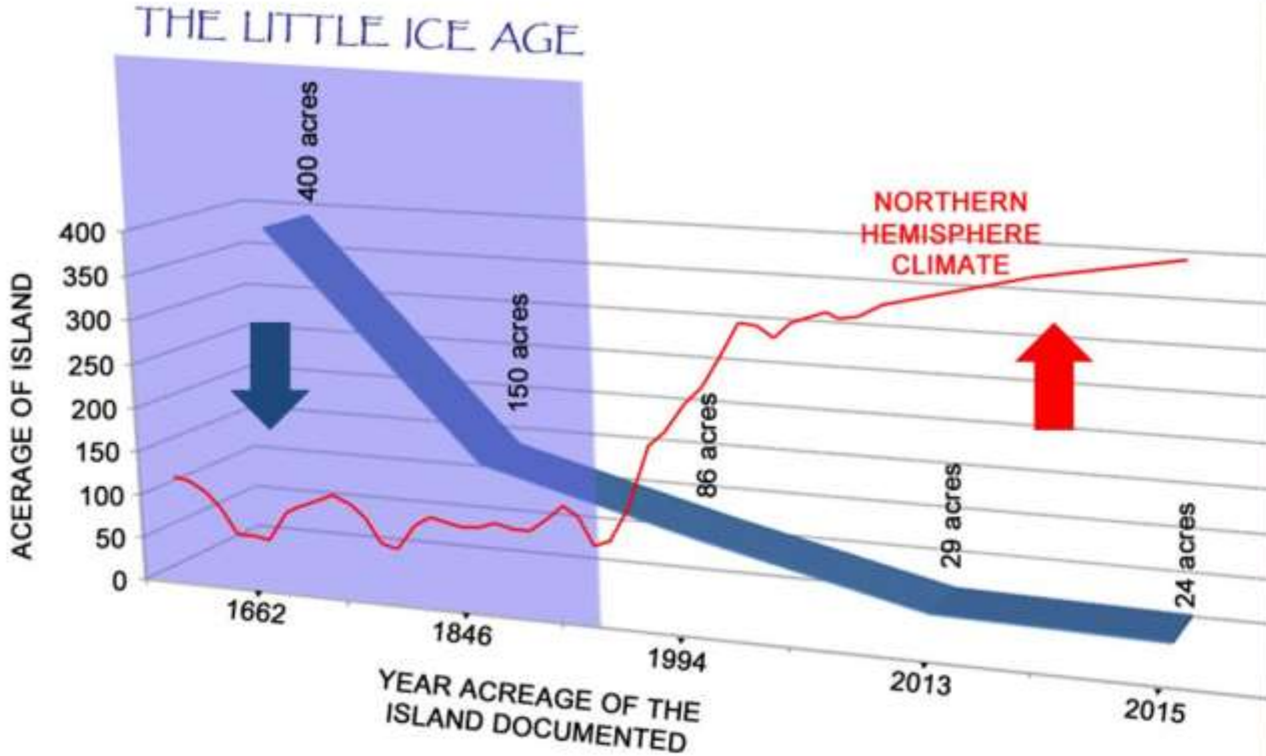
~31 acres

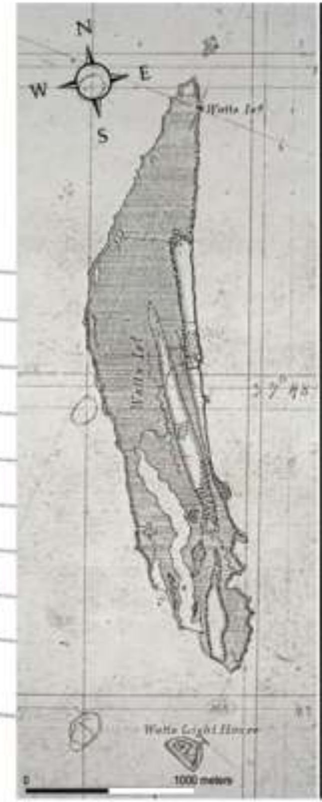
18 years

3.0 acres per year


A
Southern Watt's Island (44AC521) 9-15-2009
© Darrin Lowery 2015
B
Southern Watt's Island (44AC521) 4-12-2015
© Darrin Lowery 2017

# Watts Island, Virginia



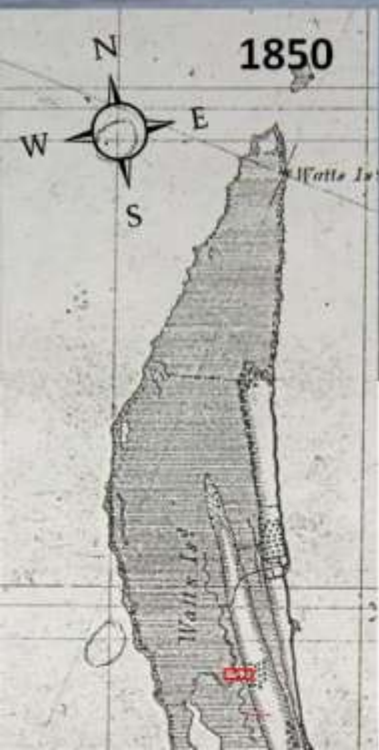




The erosion rate at Watt's Island was ~1.3 acres per year between 1662 and 1846!

The erosion rate increased to ~3 acres per year between 1994 and 2015.

*WHY DID THE RATE INCREASE?*

The answer can be seen in this photo of Watt's Island

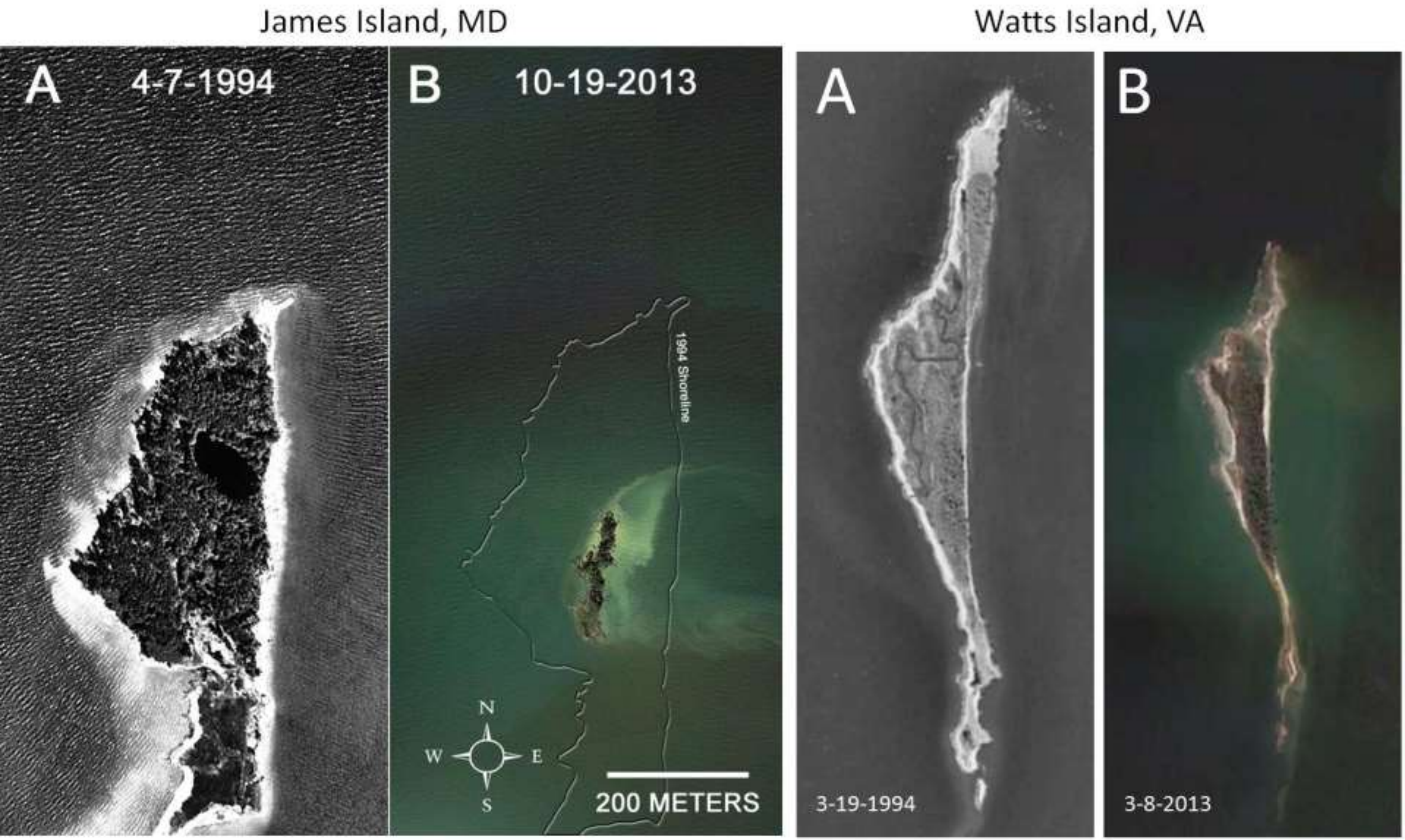



As the protective veneer of tidal marsh is eroded away from Watts, the exposed upland erodes at a markedly faster rate!

# Tidal marsh is more resistant to erosion than exposed upland sub-soil



**Northern Remnant of James Island, Maryland**

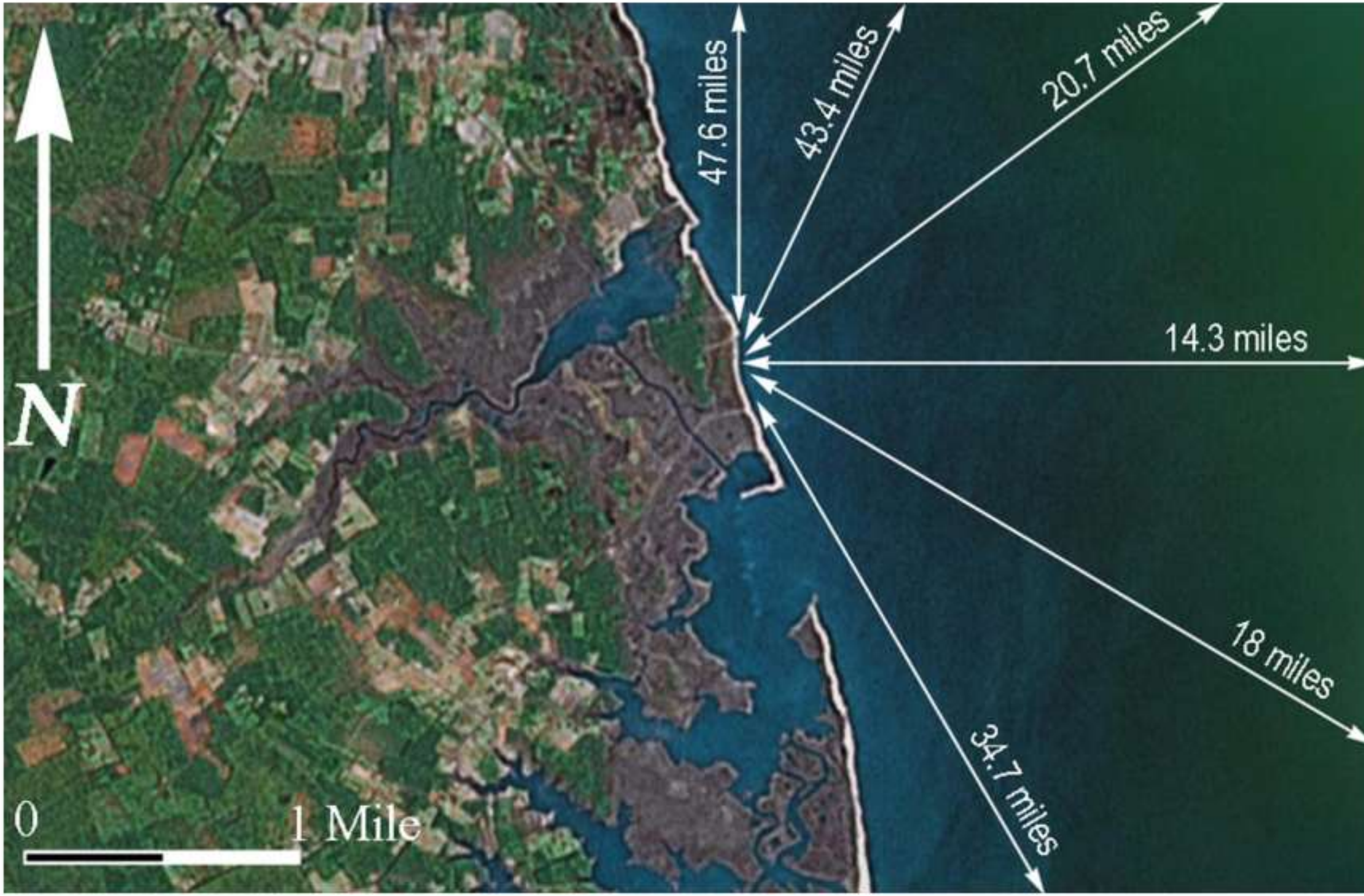





Exposed upland erodes quicker than tidal marsh

# Other factors impacting shoreline erosion

**The fetch (i.e., distance that wind travels across water) influences the rates of shoreline erosion!**



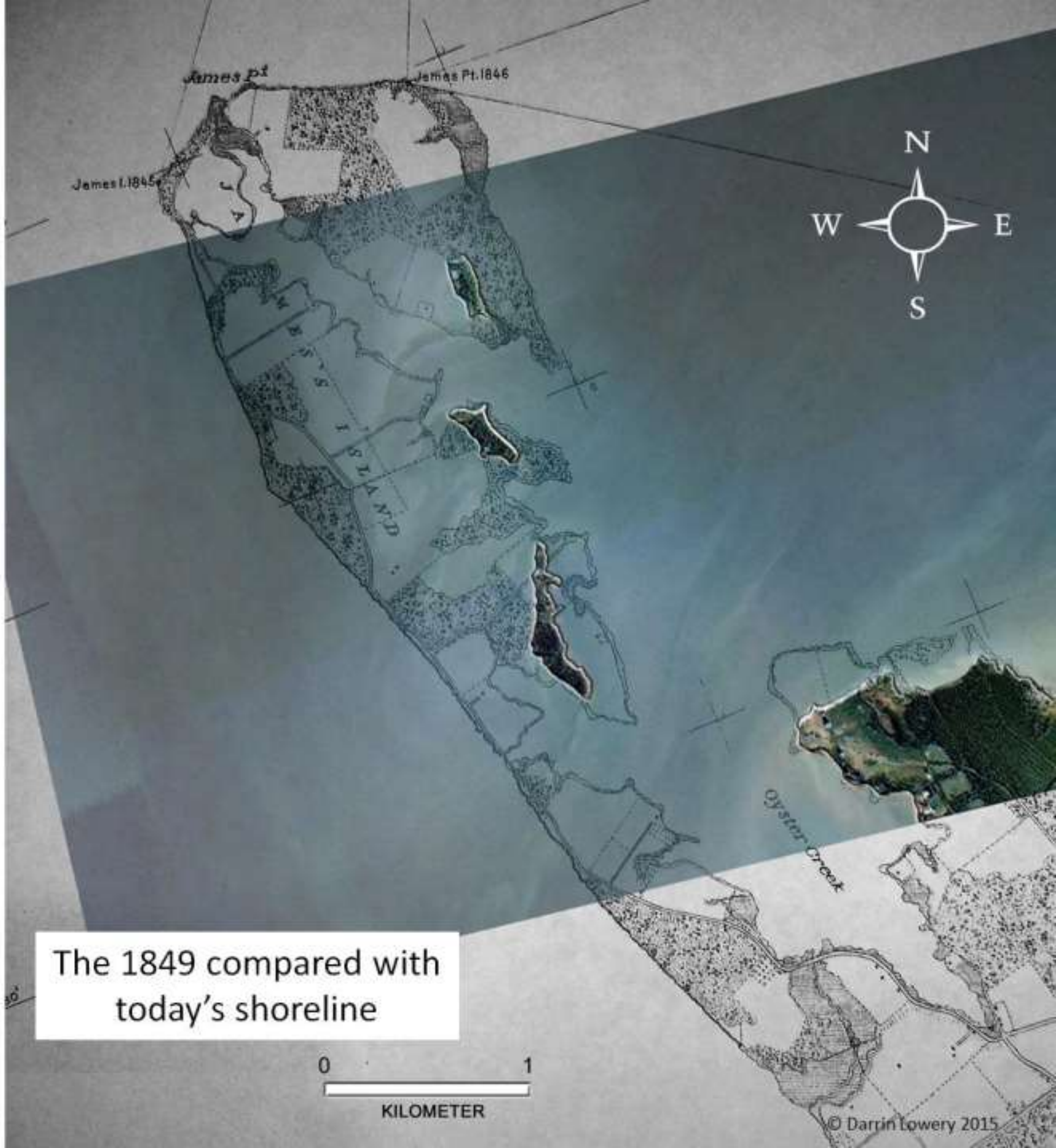
**The geology (i.e., parent sediment size) influences the observed rates of shoreline erosion!**

*"James Island, MD verses Savage Neck, VA"*

# James Island, Maryland

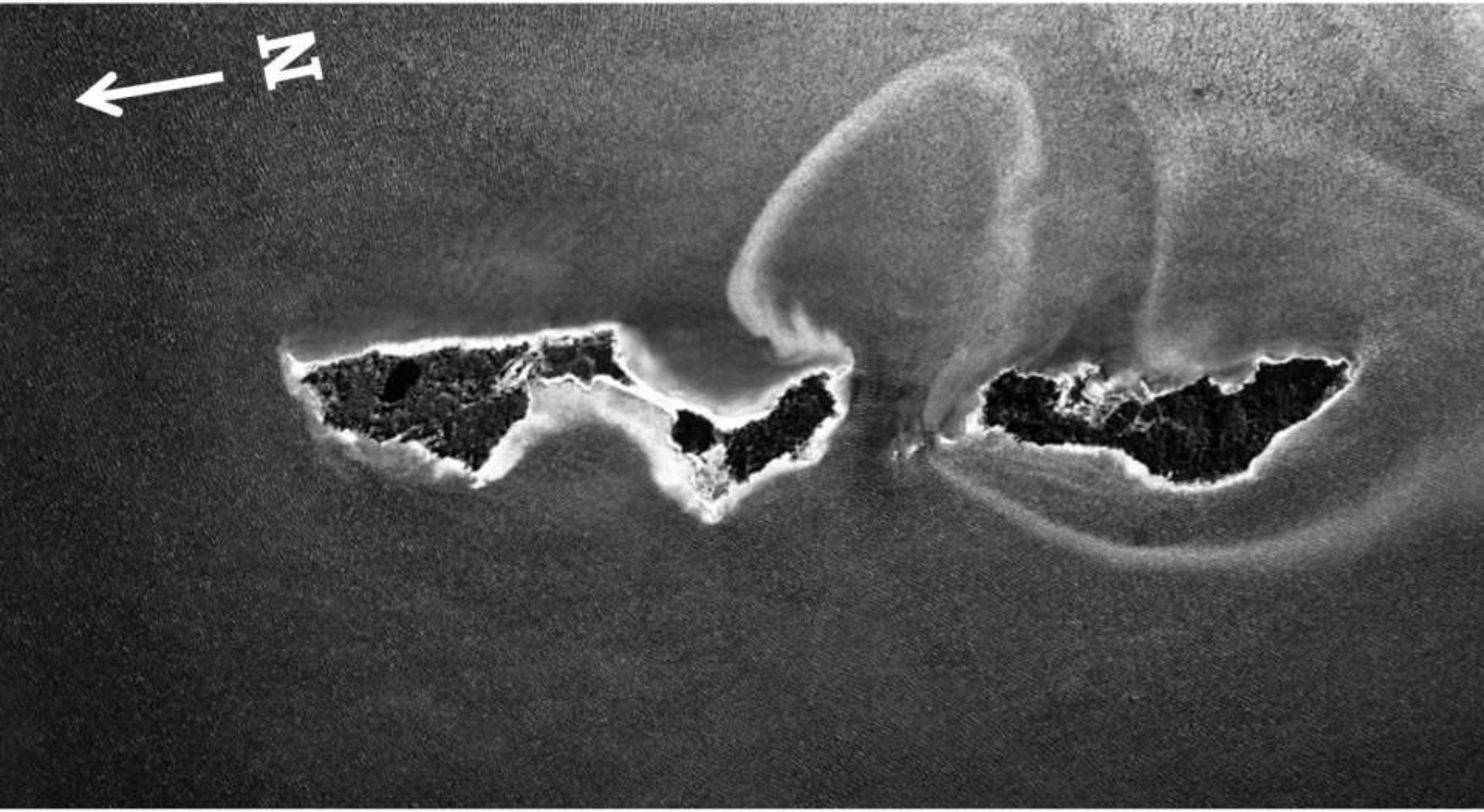
Over the past 166 years 1000 acres of upland land loss as a result of fetch-related shoreline erosion.

-NW fetch: 28 miles
W fetch: 9 miles
SW fetch: 14 miles


The 1849 compared with today's shoreline

4/7/1994




1 kilometer (.62 miles)

9/20/2005


1 kilometer (.62 miles)

10/19/2009 (Ebb Tide)

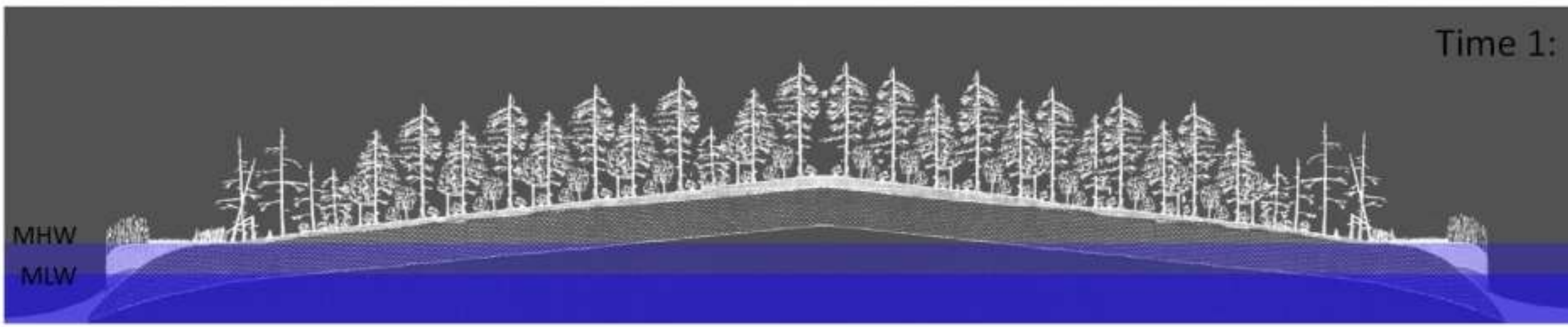

1 kilometer (.62 miles)

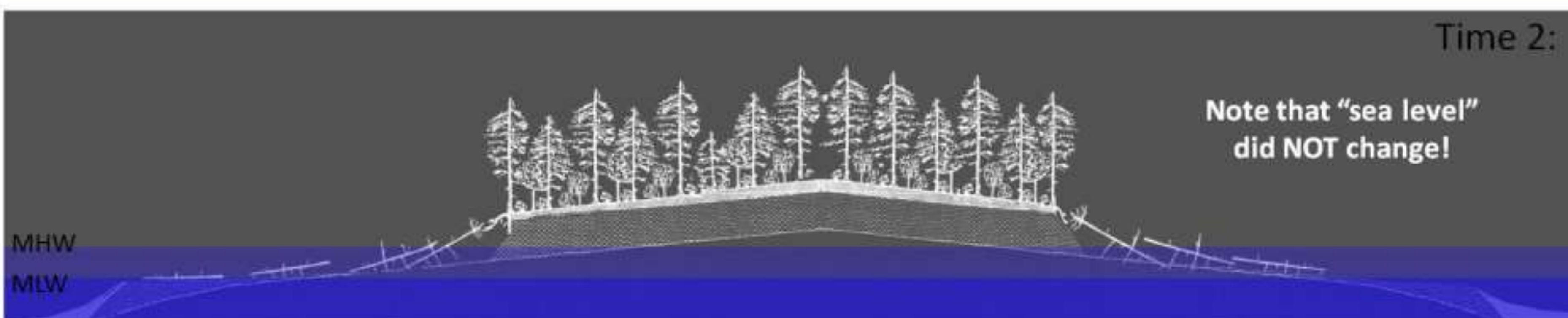
10/19/2013 (Flood Tide)


1 kilometer (.62 miles)

# James Island, Dorchester Co., Maryland

-The erosion “curse” to James Island is its parent geology (i.e., silt and silt-loam)



Time 1:
MHW
MLW


Time 2:
Note that "sea level" did NOT change!
MHW
MLW


Savage Neck,
Virginia
N Fetch: 64 miles
NW Fetch: 112 miles
W Fetch: 13 miles
SW Fetch: 29.8 miles
S Fetch: 26.4 miles
© Darrin Lowery 2017
© Darrin Lowery 2015


Interior Savage Neck
Dune Area
Parent Geology: Sand
© Darrin Lowery 2017
© Darrin Lowery 2014

9-27-2011


N
W
E
S
44NH478
0
METERS
1000

44NH478
N
W
E
S
0
METERS
1000

44NH478
SAVAGES NECK
CREEK
YSTONE
N
W
E
S
0
METERS
1000

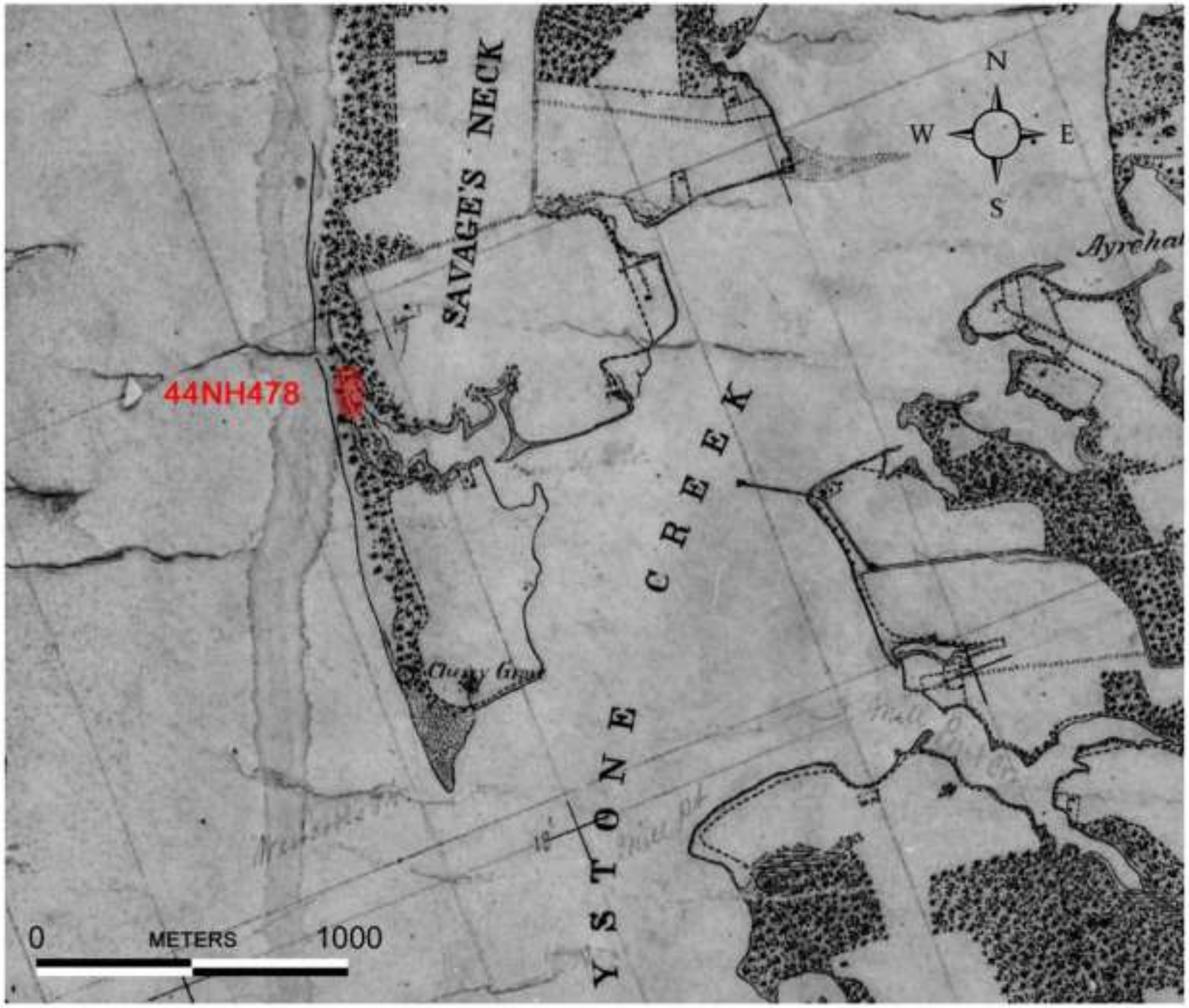

N
W
E
S
SAVAGE'S NECK
44NH478
CREEK
YSTONE
0
METERS
1000

SAVAGE'S NECK
44NH478
CREEK
YSTONE
N
W
E
S
0
METERS
1000


SAVAGE'S NECK
44NH478
CREEK
YSTONE
N
W
E
S
0
METERS
1000

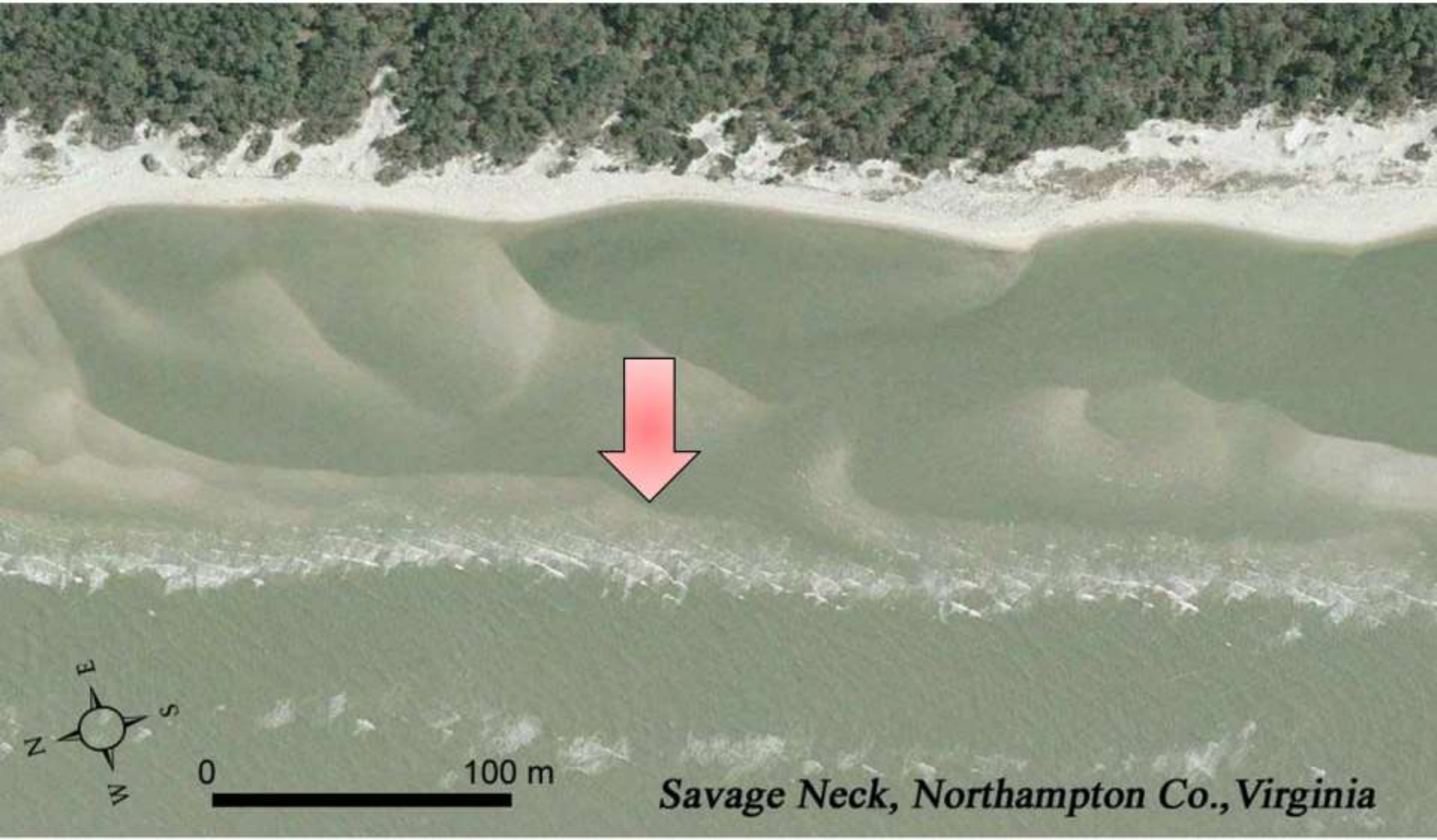

SAVAGE'S NECK
N
W
E
S
Ayreha
44NH478
CREEK
YSTONE
0
METERS
1000

# 1850 Coastal Survey




Net Loss: 0% and Net Gain: 0%

Stable shoreline over the past 160 years! Why?




Maximum NW Fetch= 112 miles


Unlike silt or silt-loam….sand does not “float away” via the ebb and flood of tides…so….
Offshore sand bars form and create natural “groins” or breakwaters!
Nearshore Low Energy Environment
© Darrin Lowery 2015
© Darrin Lowery 2017

**PROOF:** May 2-9, 2012 (44NH478: looking south)

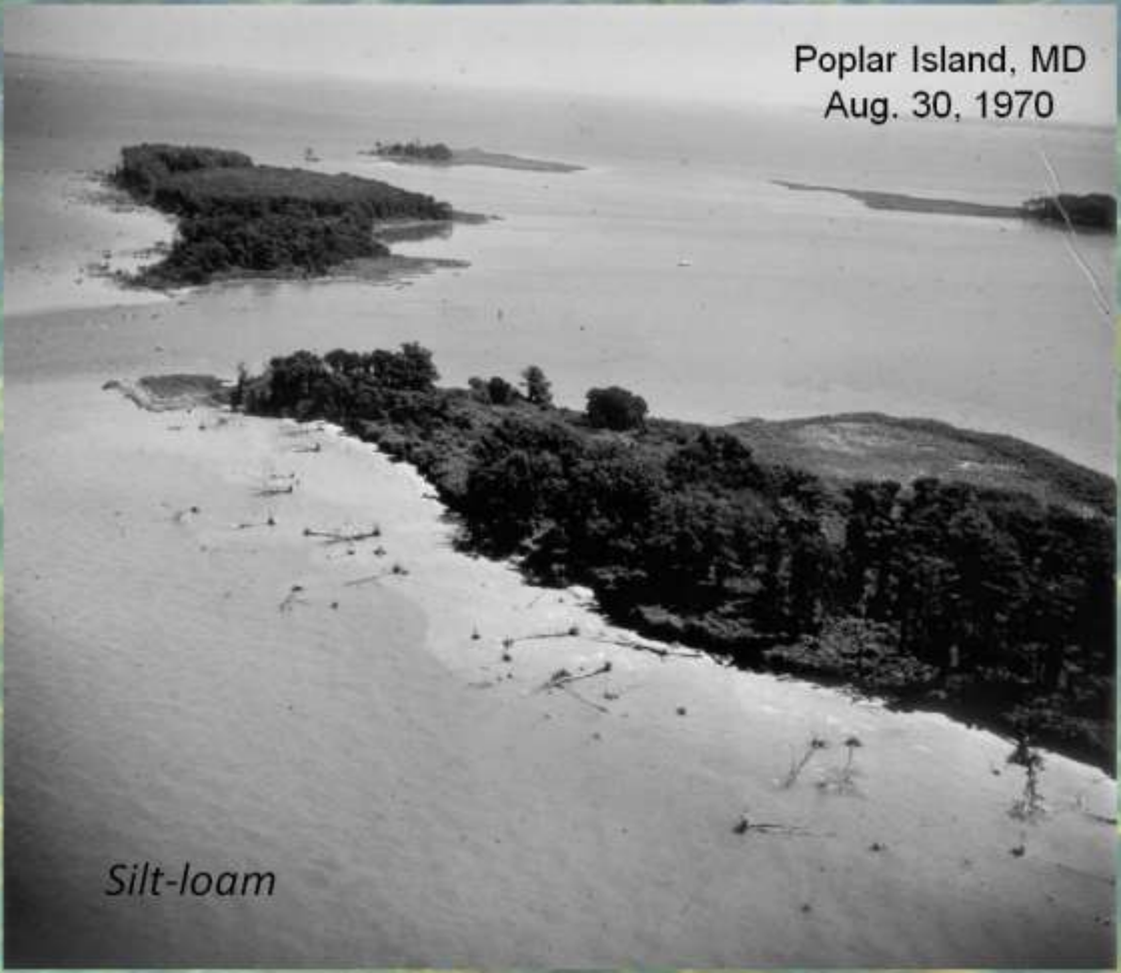

+521 days later
10/11/2013 (44NH478: looking north)
© Darrin Lowery 2015

+998 days later

1/31/2015

(44NH478: looking east)

**The bathymetry (i.e., depth) adjacent to the shoreline is a byproduct of the parent sediment type (i.e., sand or silt)!**

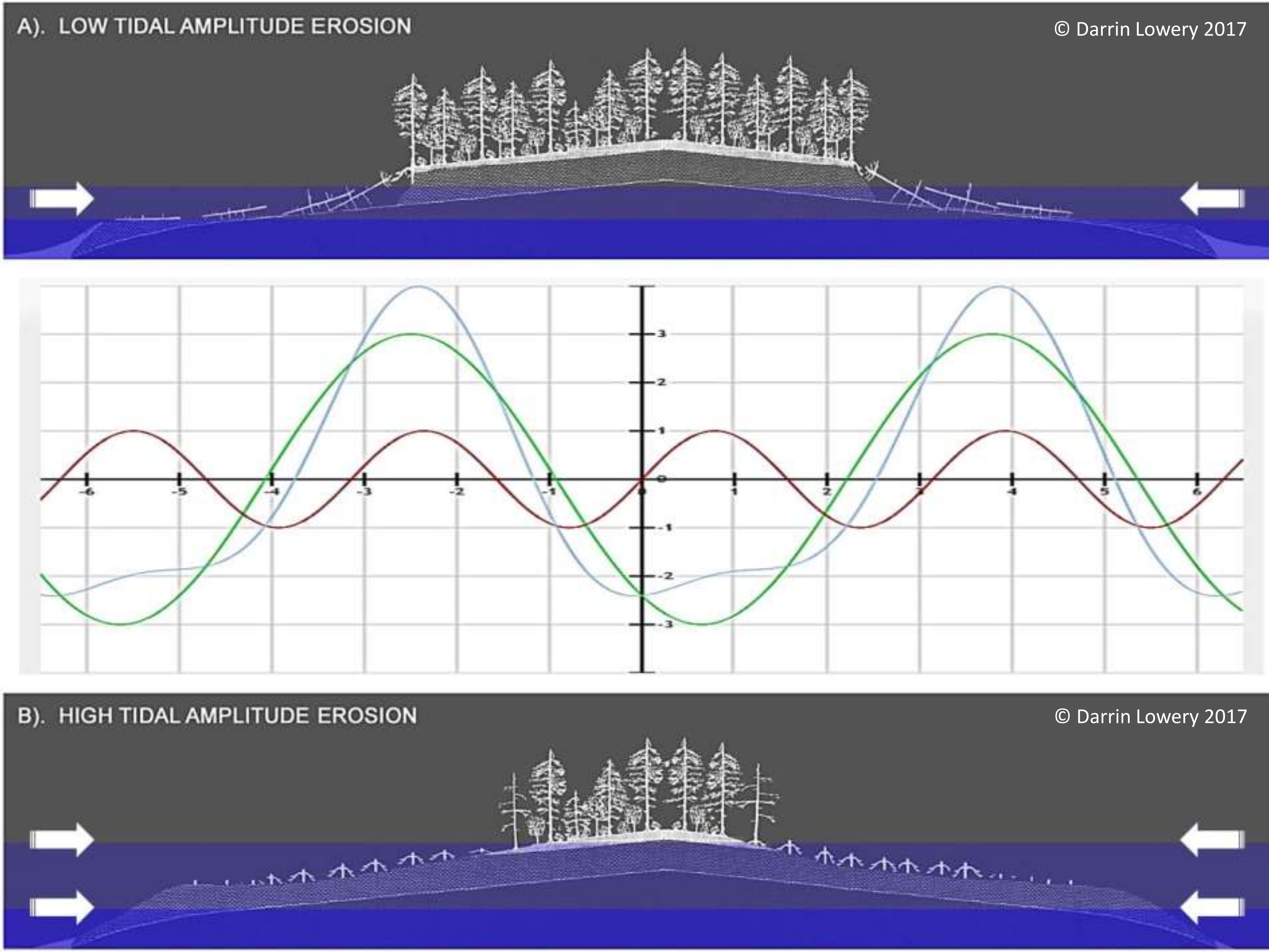

**and the bathymetry (i.e., depth) adjacent to the shoreline greatly influences the rates of shoreline erosion!**

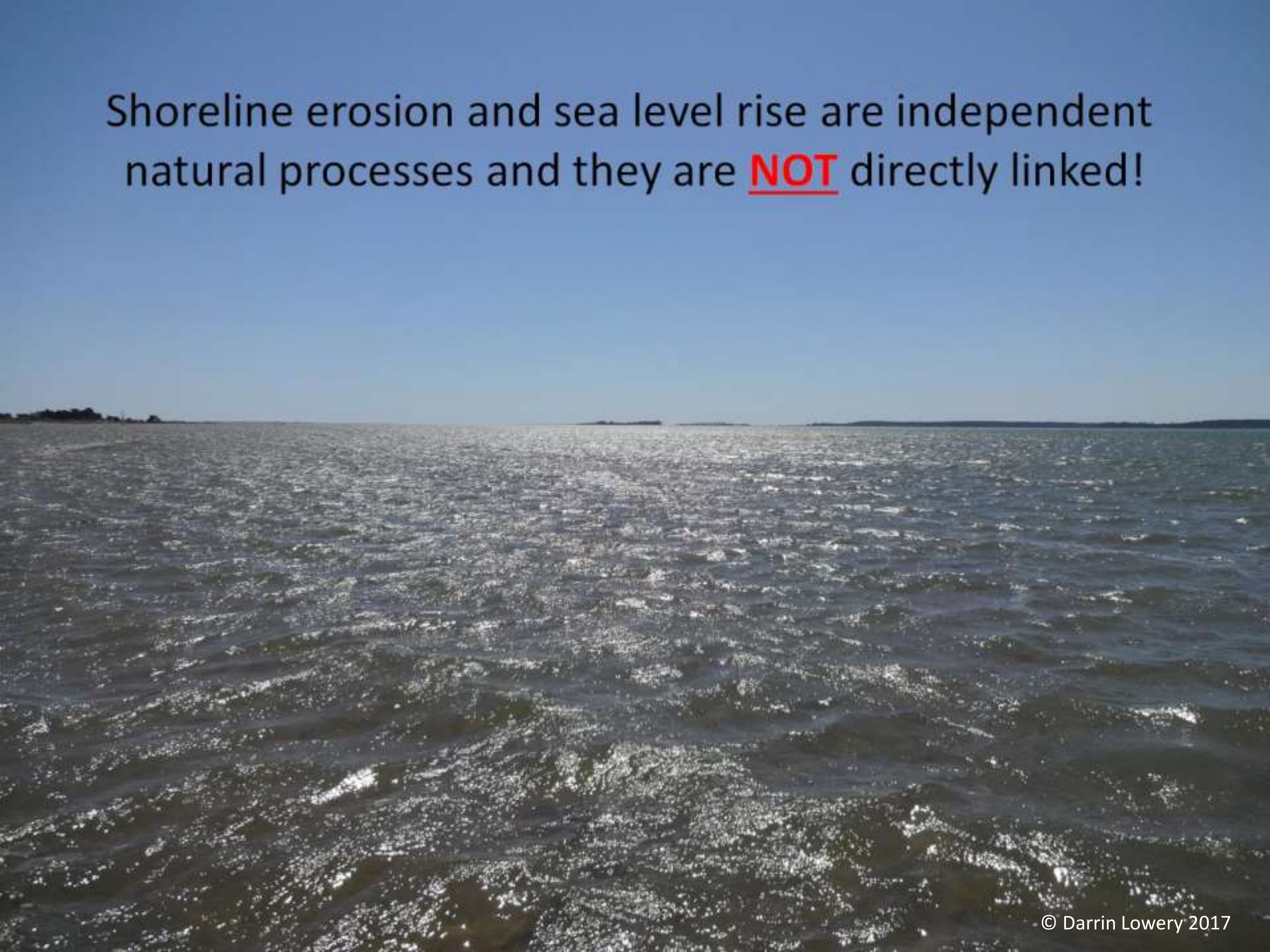

Taylors Island, MD
Oct. 31, 2011
*Silt-loam*


Savage Neck, VA
Jan. 31, 2015
Sand
© Darrin Lowery 2017


The tidal amplitude
(i.e., difference between
high and low diurnal tides)
influences the rate and
the geometry of shoreline
erosion!

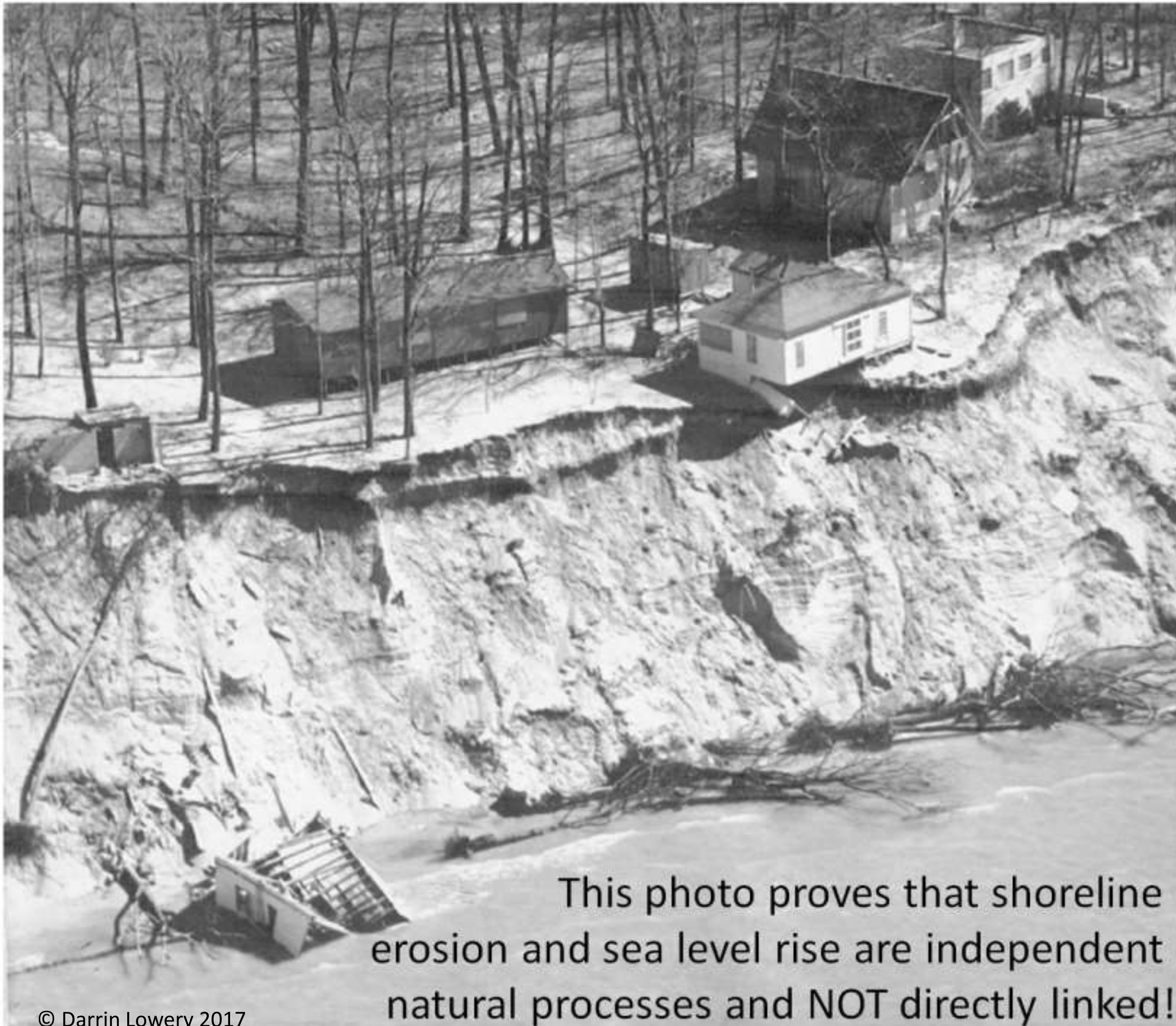

© Darrin Lowery 2017

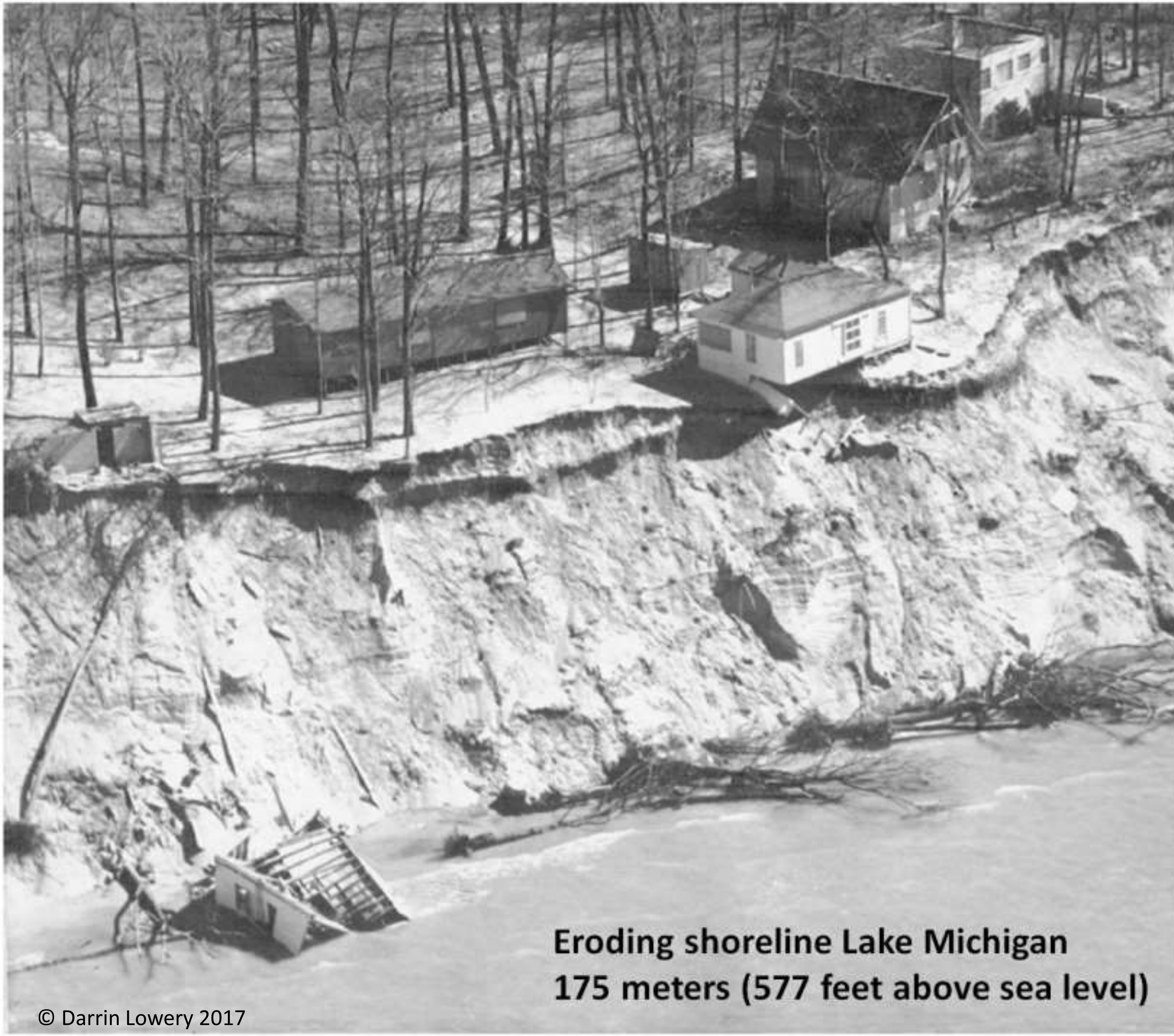

A). LOW TIDAL AMPLITUDE EROSION
© Darrin Lowery 2017
-6
-5
-4
-3
-2
-1
0
1
2
3
4
5
6
3
2
1
-1
-2
-3
B). HIGH TIDAL AMPLITUDE EROSION
© Darrin Lowery 2017


Shoreline erosion and sea level rise are independent natural processes and they are **NOT** directly linked!
© Darrin Lowery 2017

The loss of the last house at Hollands Island has served as the media's "poster child" of "sea level rise" in the Chesapeake Bay.

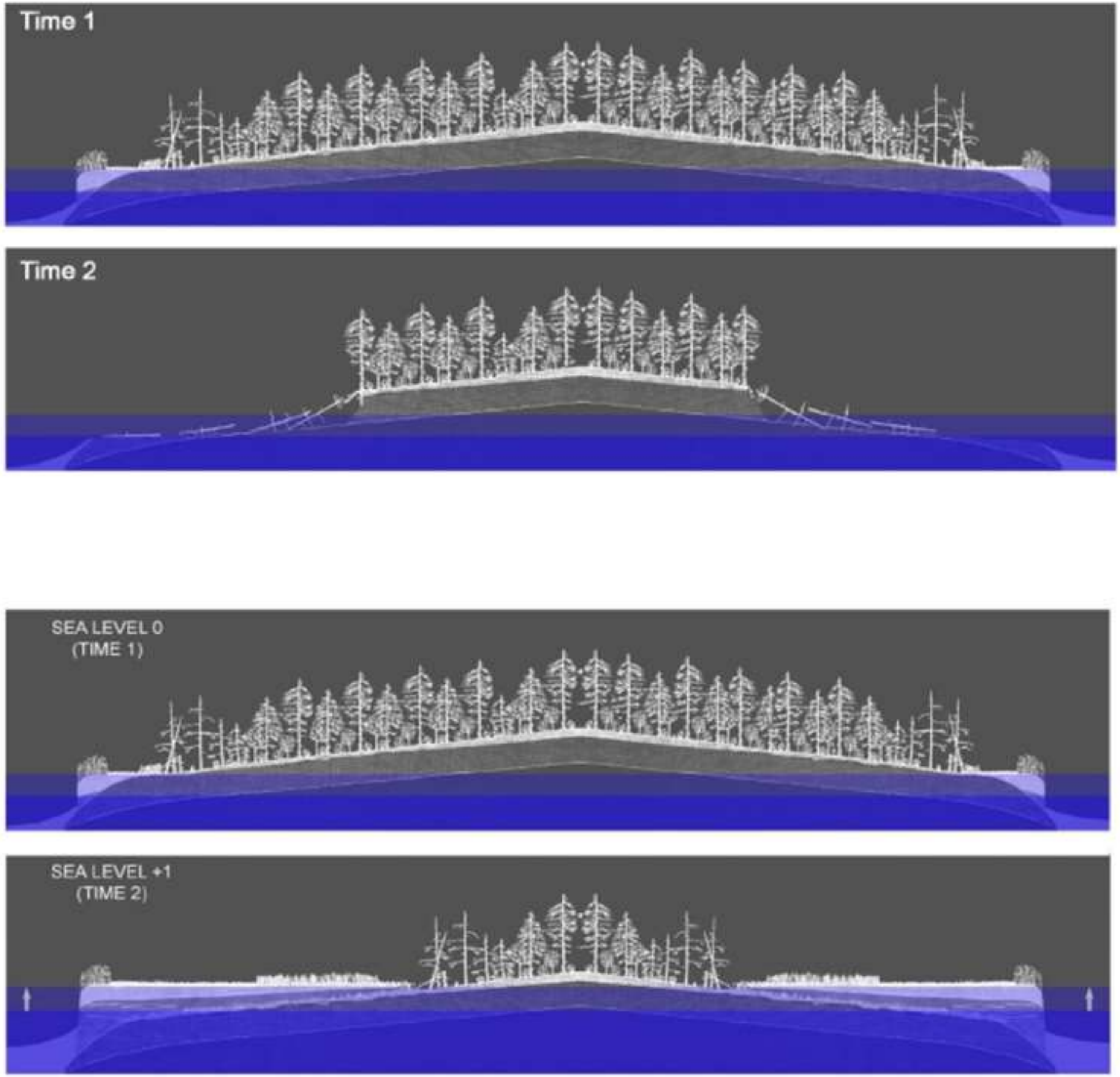
However, it is not evidence of sea level rise!


This photo proves that shoreline erosion and sea level rise are independent natural processes and NOT directly linked!
© Darrin Lowery 2017


Eroding shoreline Lake Michigan
175 meters (577 feet above sea level)

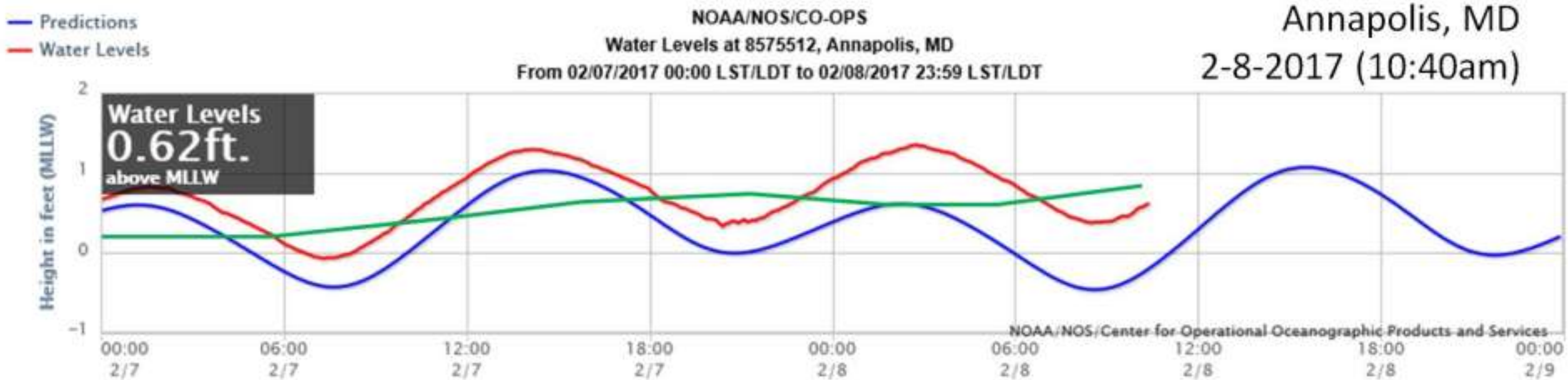
Shoreline Erosion

Sea Level Rise



# Are Tides a Measure of Sea Level?

Annapolis, MD
2-8-2017 (10:40am)




Chesapeake Bay Bridge Tunnel, VA
2-8-2017 (10:40am)

| Journal of Coastal Research | 28 | 6 | 1437–1445 | Coconut Creek, Florida | November 2012 |
|---|---|---|---|---|---|

# Evidence of Sea Level Acceleration at U.S. and Canadian Tide Stations, Atlantic Coast, North America

**John D. Boon**

Virginia Institute of Marine Science
College of William and Mary
P.O. Box 1346
Gloucester Point, VA 23062, U.S.A.
boon@vims.edu

Baltimore = 30cm (1ft.) past 100 yrs.
Sewells Pt. = 49 cm (1.6ft.) past 100 yrs.

| Station Name | Station ID | Continuous Year Series | Linear ($b_1$) (mm/y) | Quadratic ($b_2/2$) (mm/y$^2$) | Rise by 2050 Projection (m) |
|---|---|---|---|---|---|
| Baltimore, MD | 8574680 | 1903–2011 | 3.286 ** | 0.083 ** | 0.48 ± 0.19 |
| Sewells Point, VA | 8638610 | 1928–2011 | 4.996 ** | 0.093 ** | 0.62 ± 0.22 |

$$Y = b_0 + b_1 X + \varepsilon$$

$$\hat{Y} = b_0 + b_1 X$$

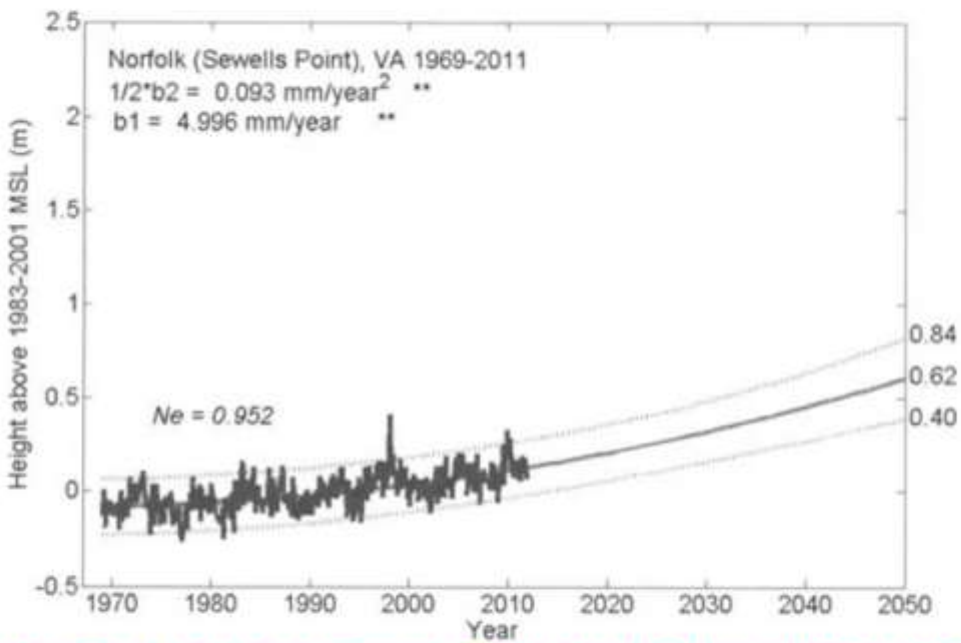
$$\varepsilon_i = Y_i - \hat{Y}_i$$

$$y_i = Y_i - \bar{Y}, \quad x_i = X_i - \bar{X}$$

$$b_1 = \sum_{i=1}^{n} x_i y_i \Big/ \sum_{i=1}^{n} x_i^2$$

$$s_e = s_{y\cdot x} \Big/ \sqrt{\sum x_i^2}$$

$$s_Y = s_{y\cdot x}\sqrt{1 + \frac{1}{n} + \frac{(X_0 - \bar{X})^2}{\sum (X_i - \bar{X})^2}}$$

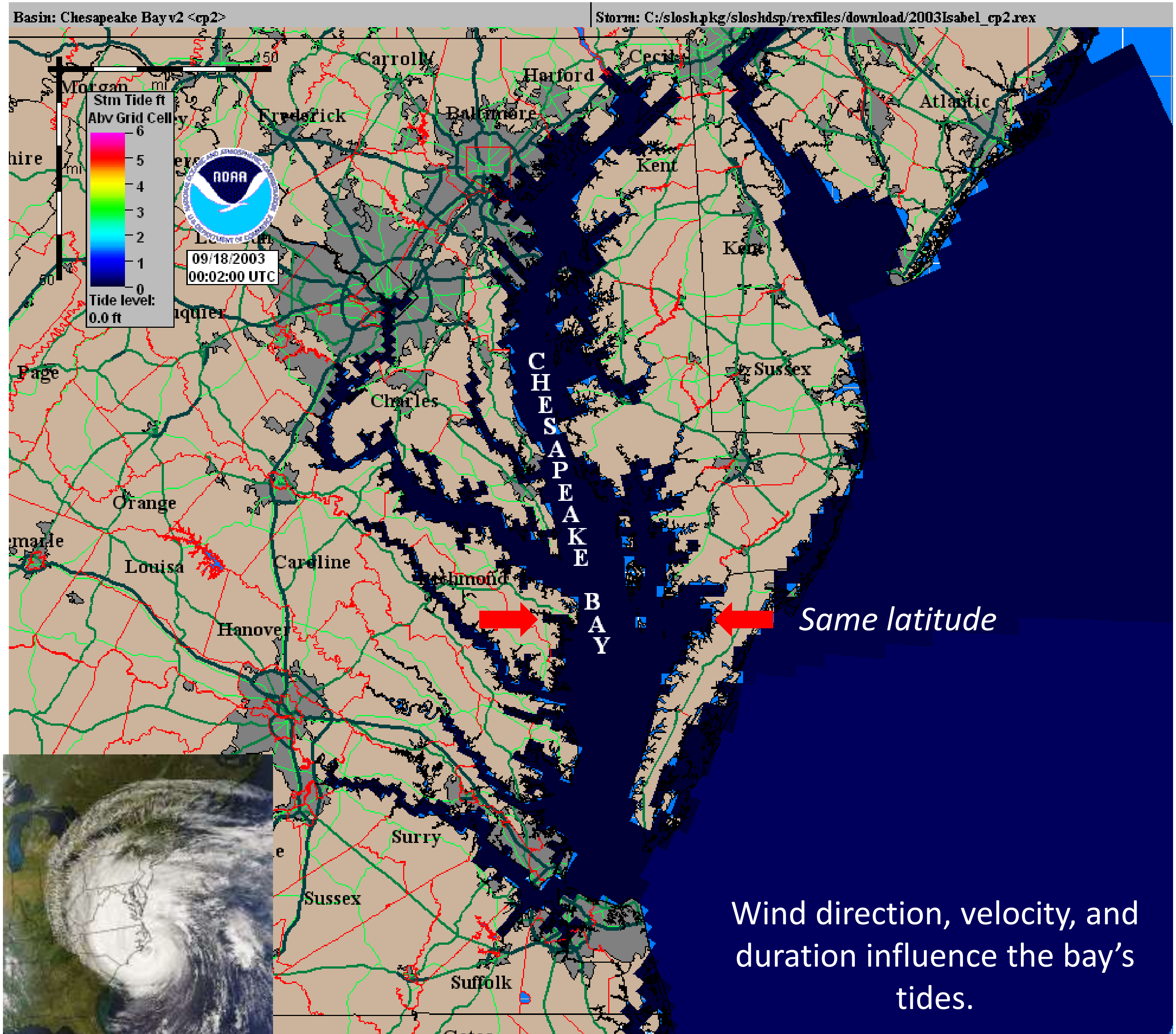



**Untested <u>models</u> that have not been field or ground truth tested are <u>NOT</u> scientific facts!**

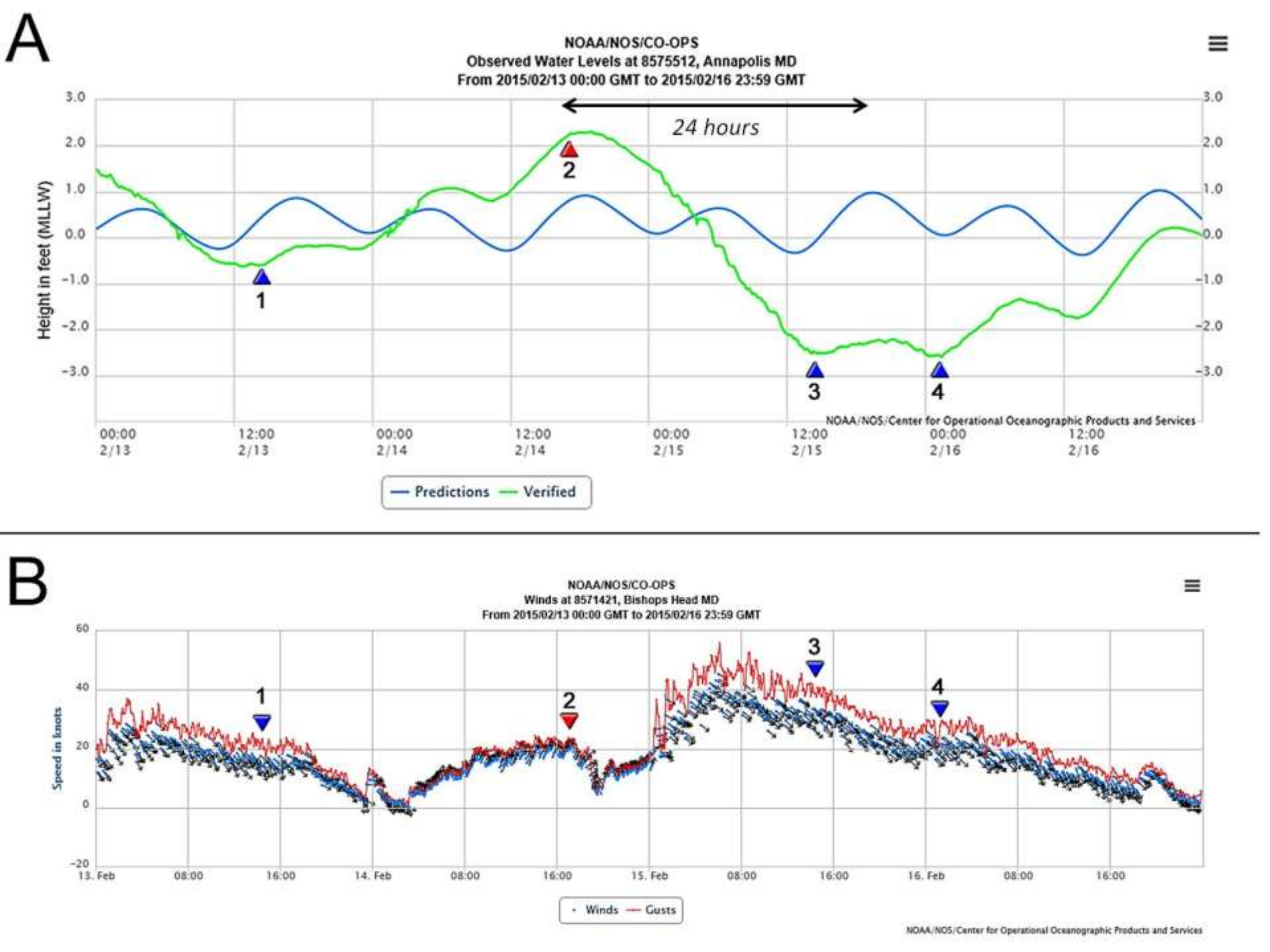
# Are tides within a partially closed basin or "bath tub" (like the Chesapeake Bay) a measure of sea level?

Note photographers are usually out taking photos during these events!

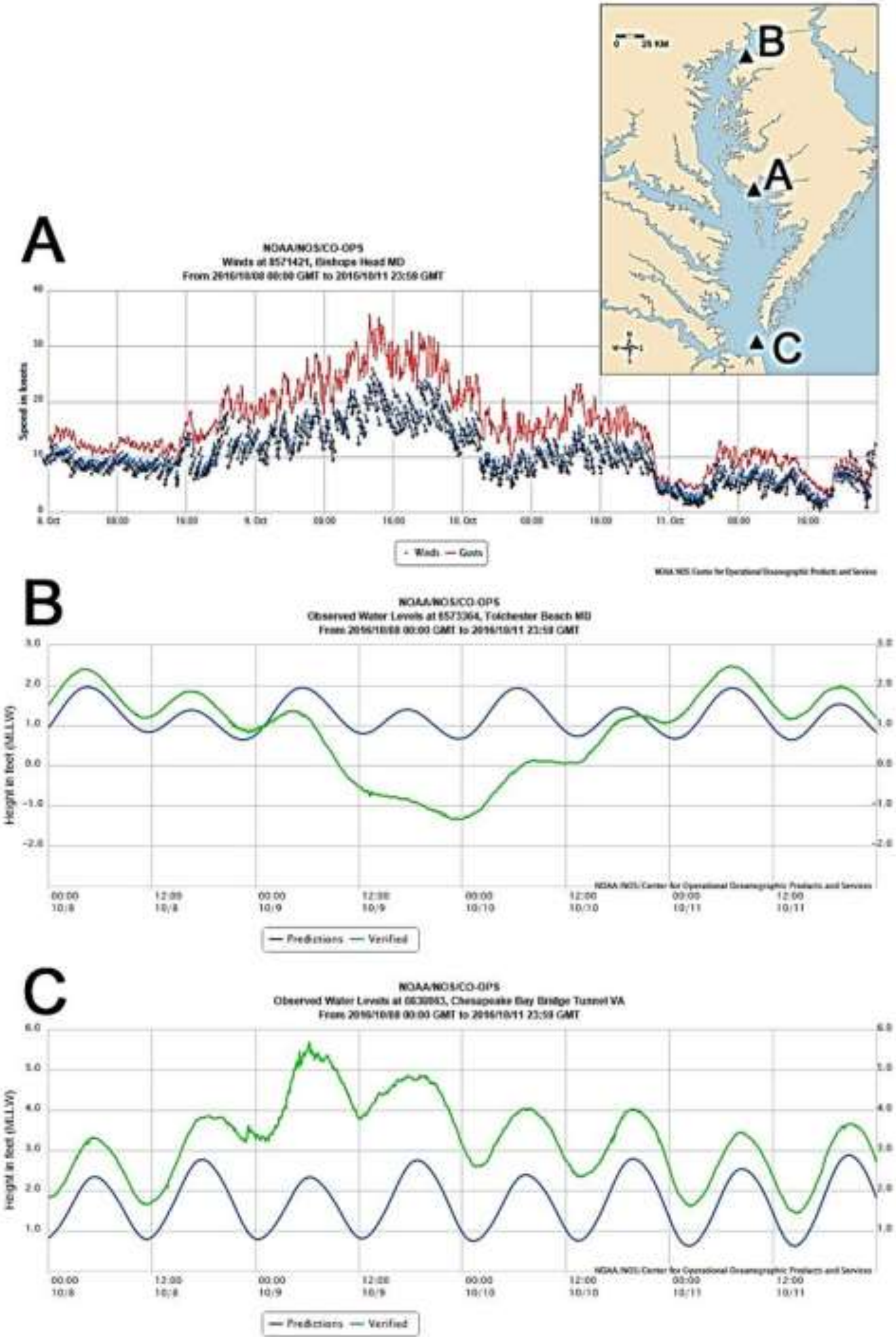

Hurricane Isabel Sept. 18 to 19 2003




Wind direction, velocity, and duration influence the bay's tides.


A
NOAA/NOS/CO-OPS
Observed Water Levels at 8575512, Annapolis MD
From 2015/02/13 00:00 GMT to 2015/02/16 23:59 GMT
24 hours
Height in feet (MLLW)
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
1
2
3
4
00:00 2/13
12:00 2/13
00:00 2/14
12:00 2/14
00:00 2/15
12:00 2/15
00:00 2/16
12:00 2/16
NOAA/NOS/Center for Operational Oceanographic Products and Services
Predictions
Verified
B
NOAA/NOS/CO-OPS
Winds at 8571421, Bishops Head MD
From 2015/02/13 00:00 GMT to 2015/02/16 23:59 GMT
Speed in knots
60
40
20
0
-20
1
2
3
4
13. Feb
08:00
16:00
14. Feb
08:00
16:00
15. Feb
08:00
16:00
16. Feb
08:00
16:00
Winds
Gusts
NOAA/NOS/Center for Operational Oceanographic Products and Services

# Hurricane Matthew
# 10-8-2016 to 10-11-2016



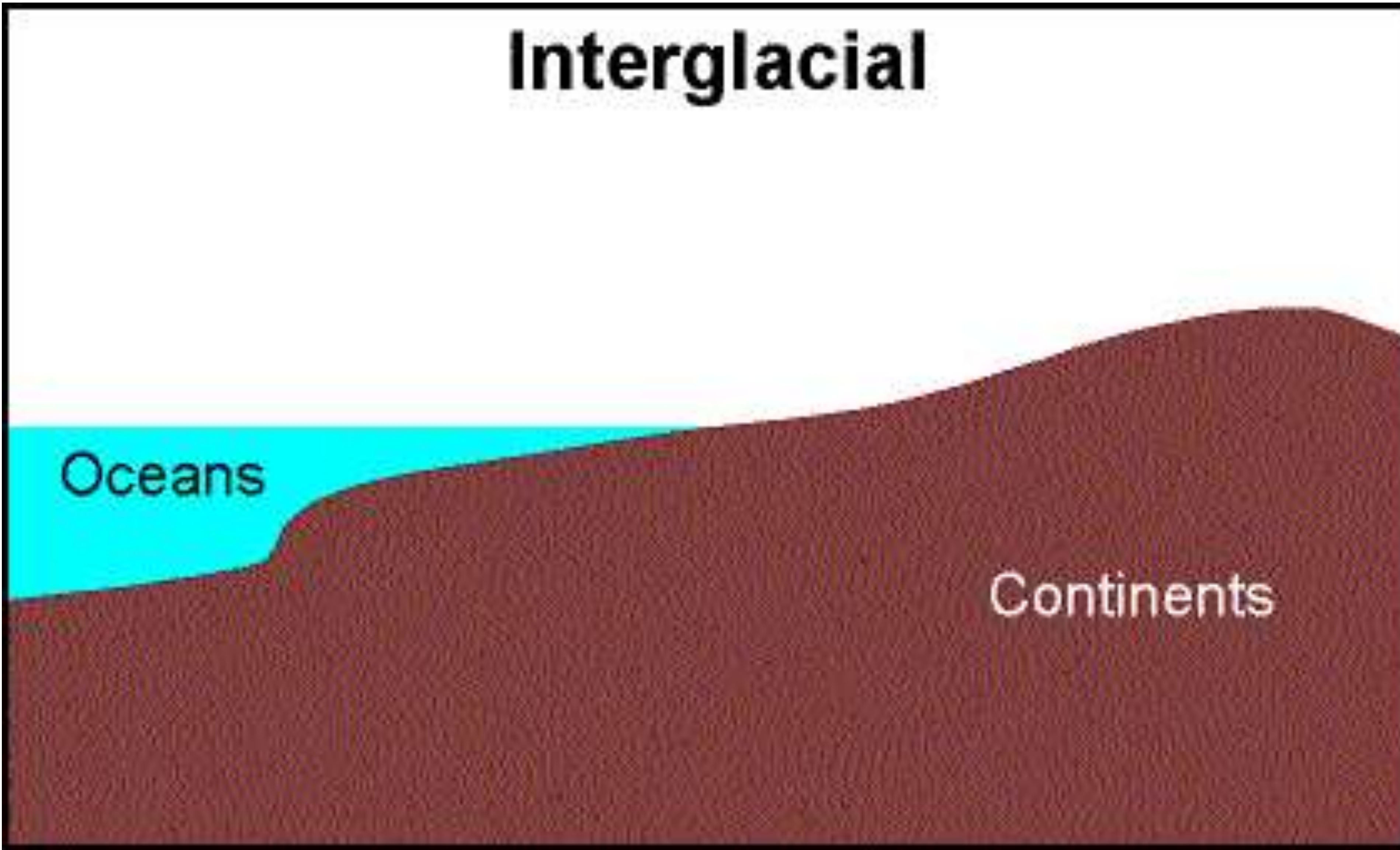


The Chesapeake Bay is a large "bath tub".
The wind direction, velocity, and duration
will impact the tides at any given location
based on the geometry of the region.


Tides are NOT a good measure
of sea level.

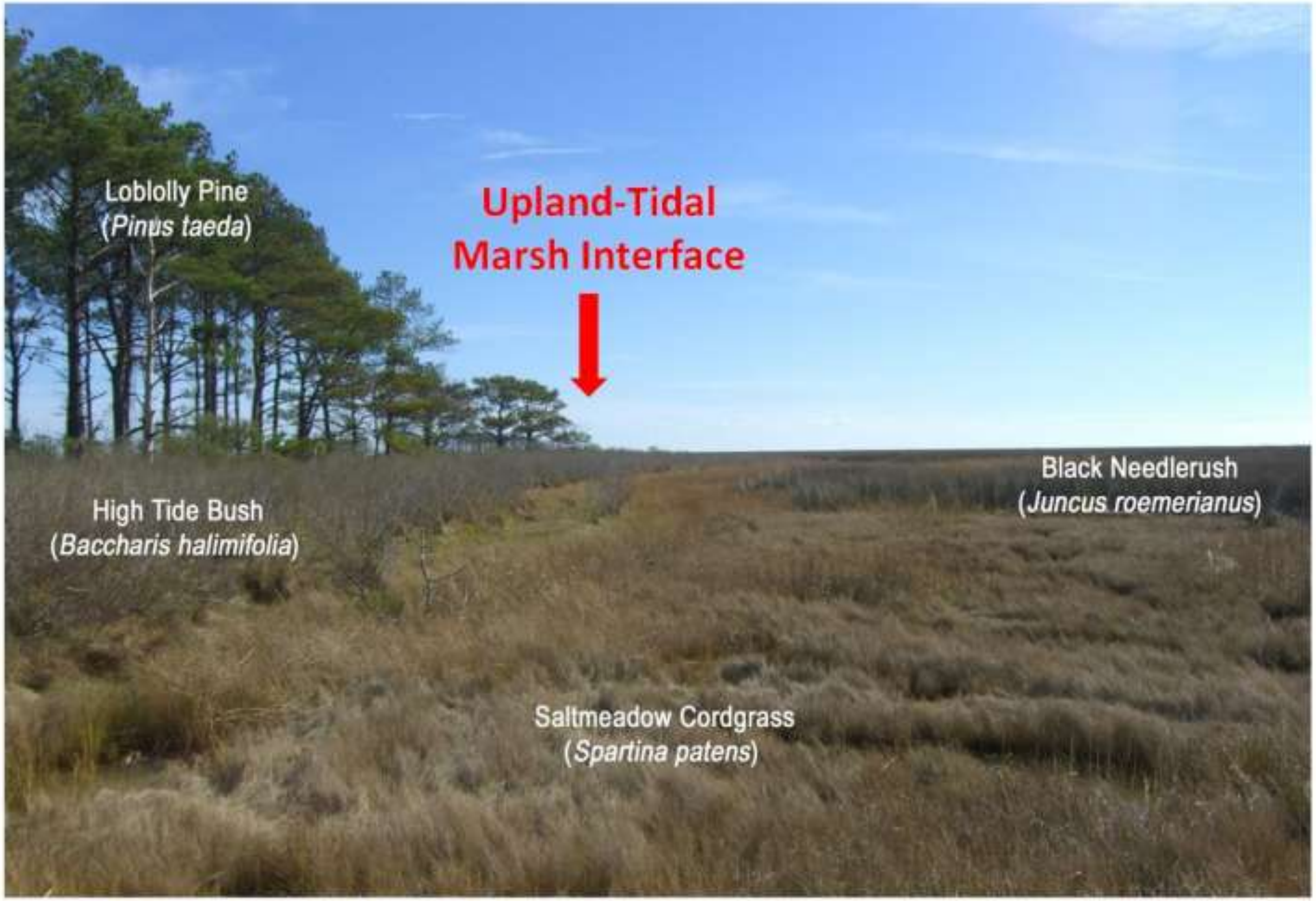

© Darrin Lowery 2017

## *What is sea level change?*
## *Type #1: Eustatic Sea Level Change*



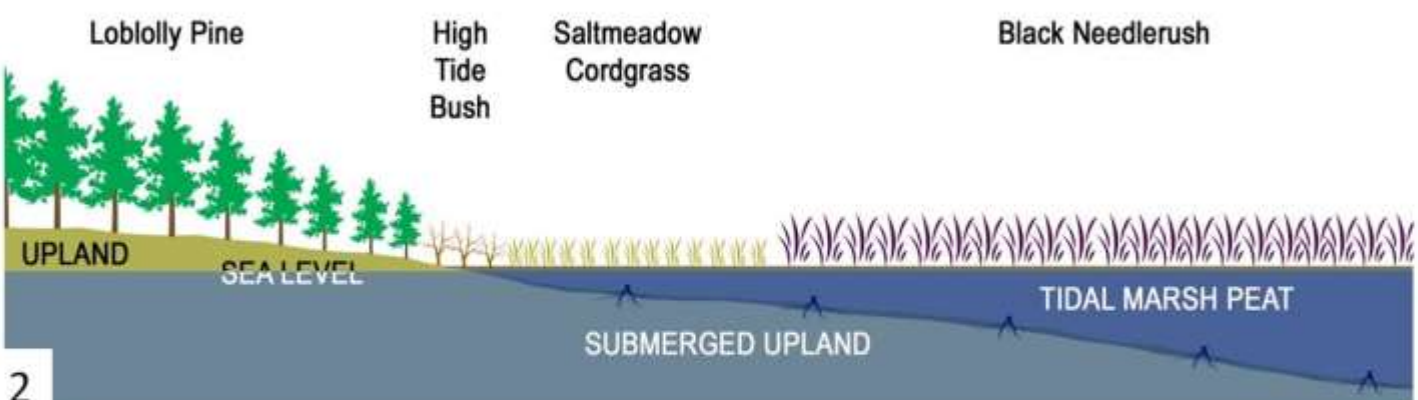
# Type #2: Isostatic Sea Level Change

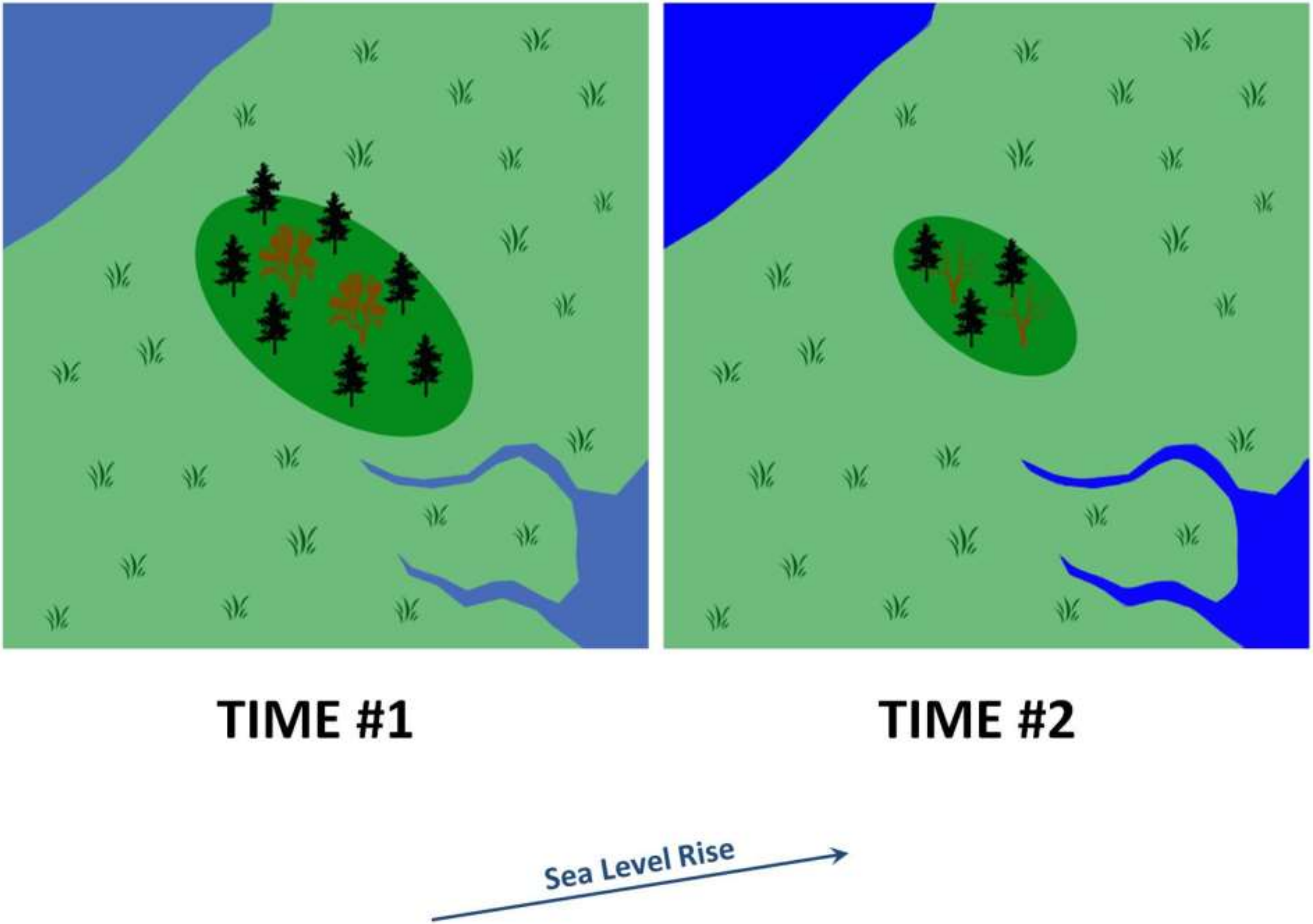
The best measure of sea level in the Chesapeake Bay is the *upland / tidal marsh interface*!

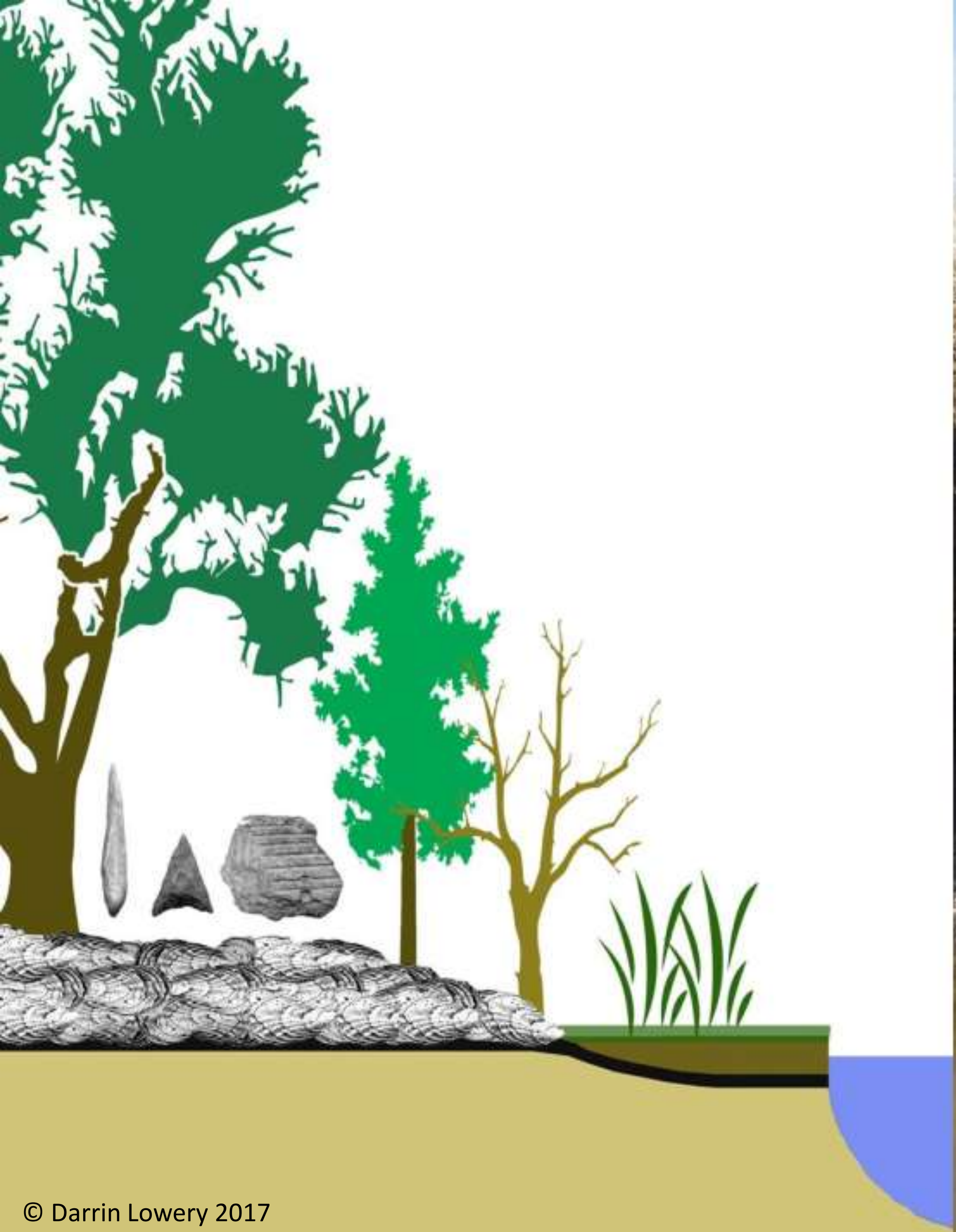



It is impossible for tidal salt marsh to form or develop above "sea level".

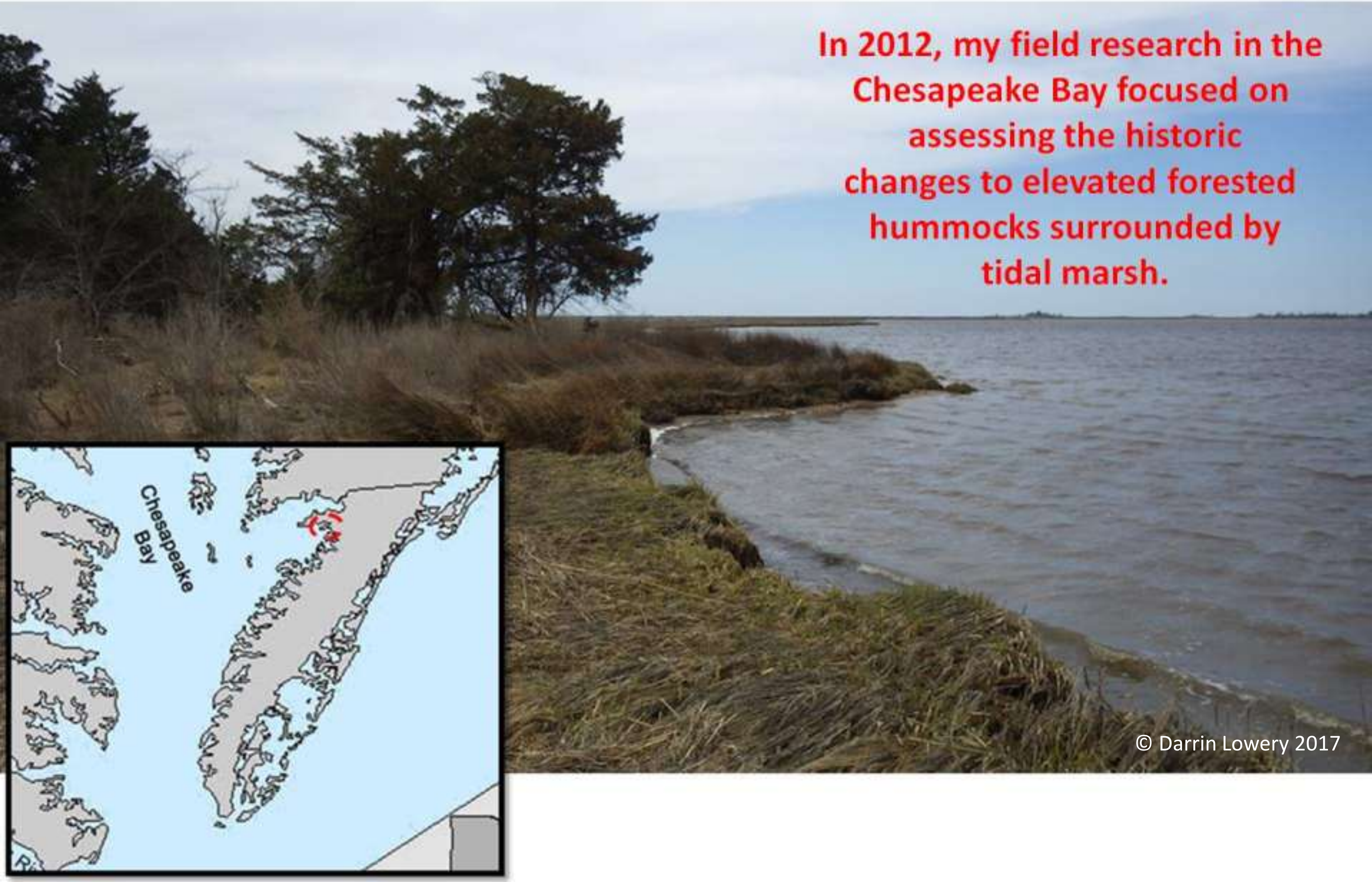
As such, changes in the upland-tidal marsh interface represent the best proxy for changes in relative sea level over time.




TIME #1
TIME #2
Sea Level Rise

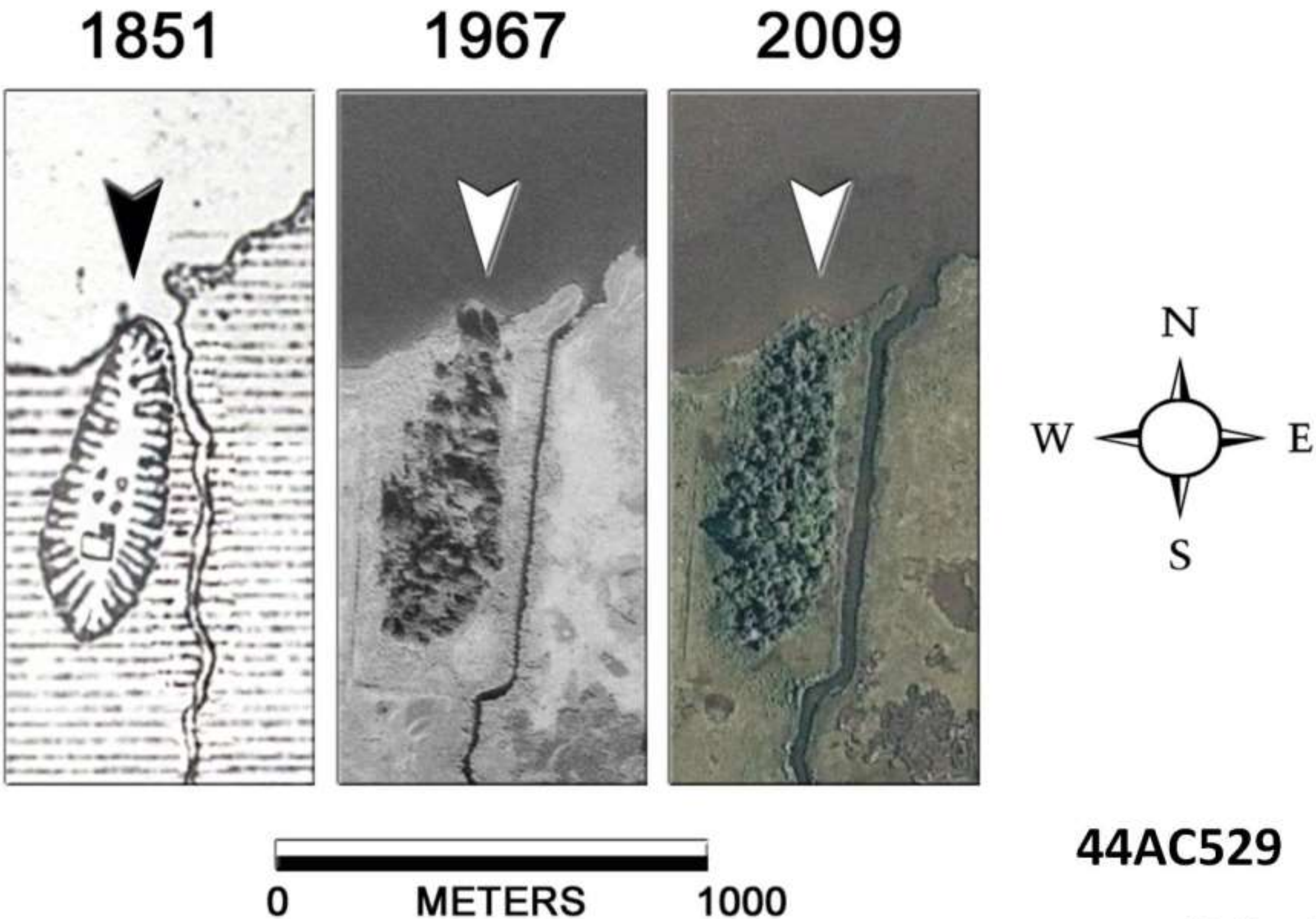
# 44AC529 Northern Accomack County, Virginia



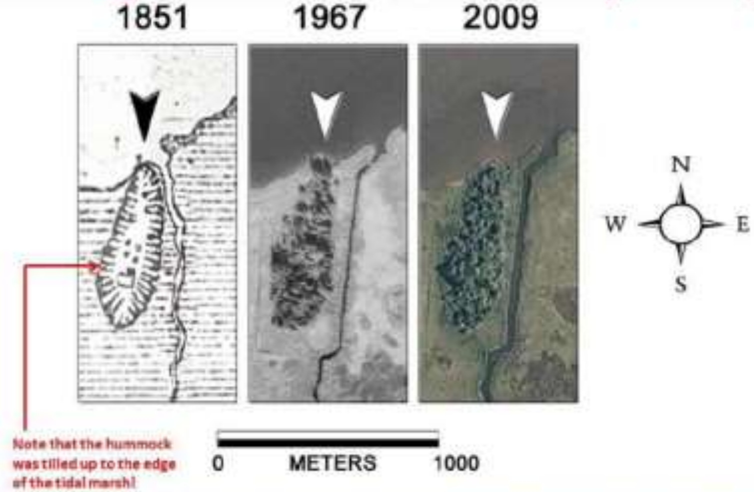

**44AC529 (1967)** **44AC529 (2009)**

***42 years***

# 158 years



## No perceptible change in relative sea level over the past 160 years!



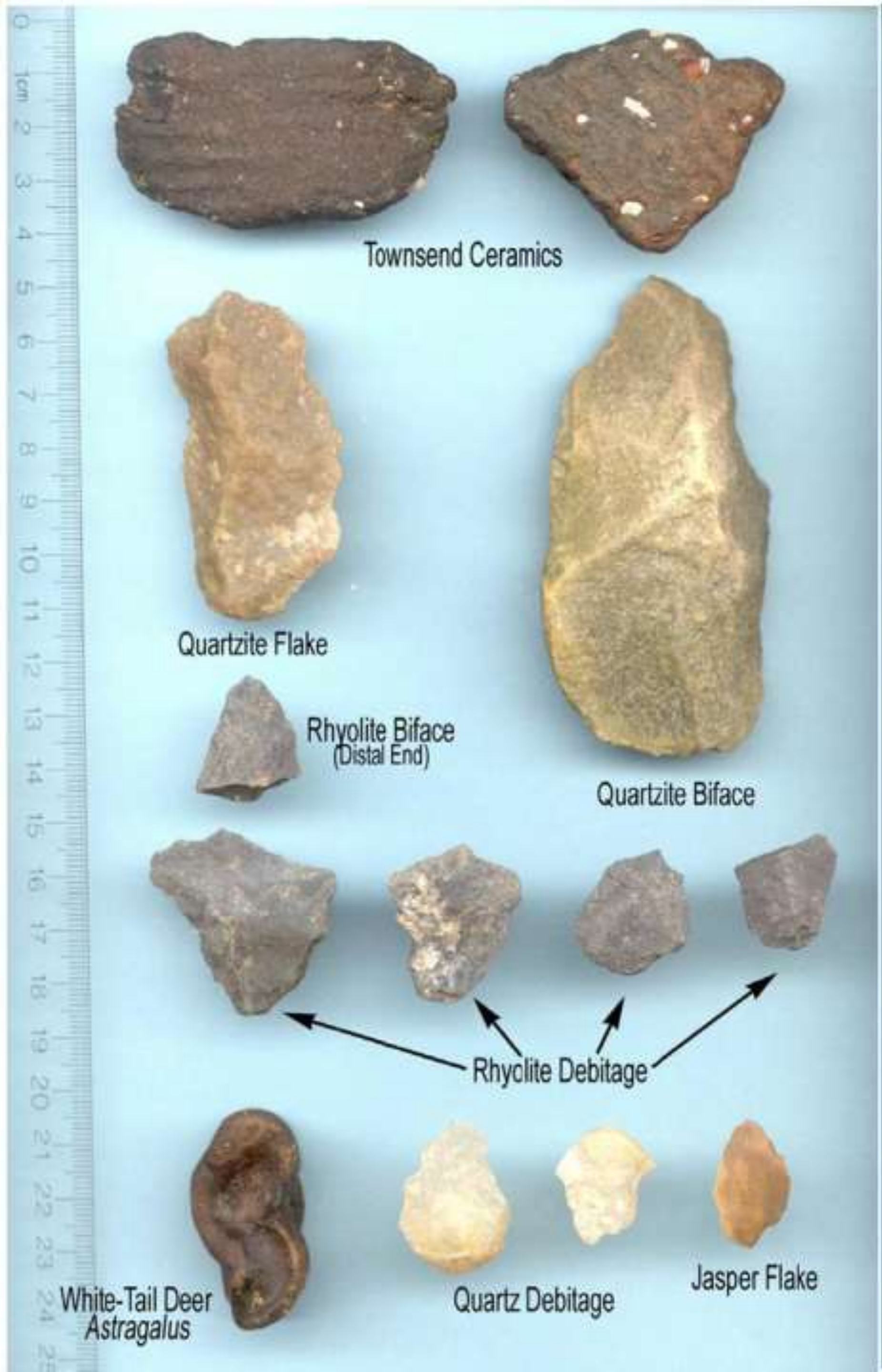


Trees >80 years in age


Upland was plowed (Ap-horizon)

Margins were untilled and contained an intact shell midden

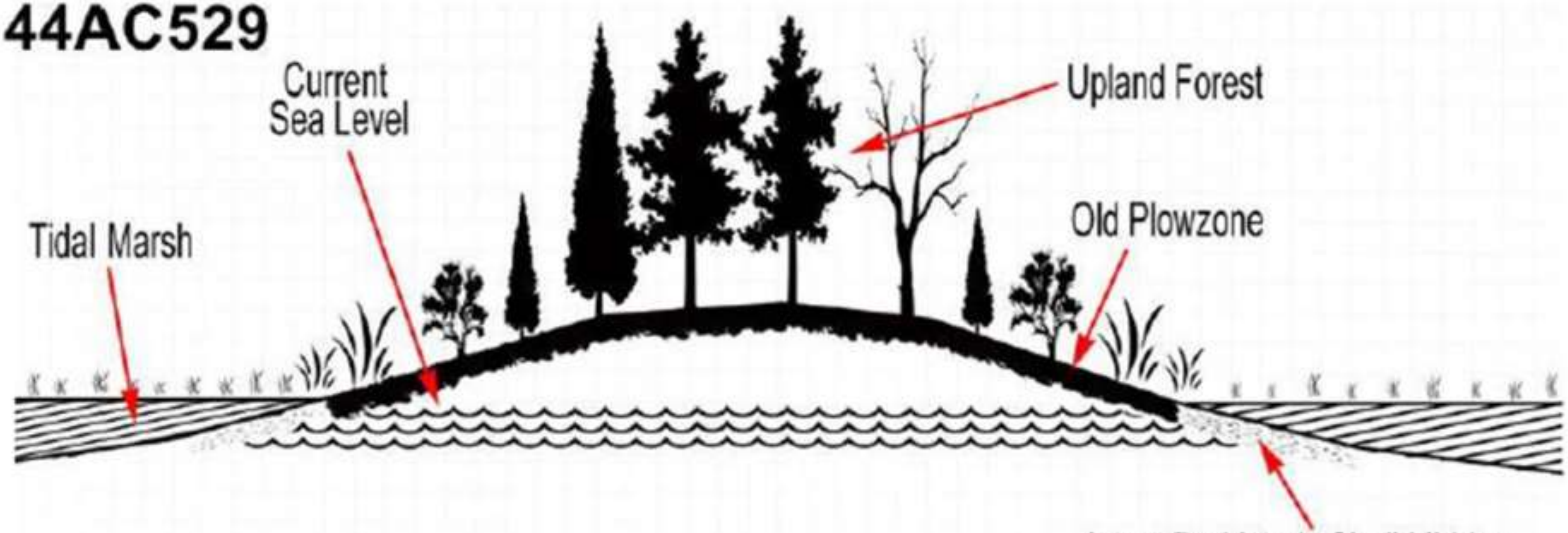
4


Townsend Ceramics
Quartzite Flake
Rhyolite Biface
(Distal End)
Quartzite Biface
Rhyolite Debitage
White-Tail Deer
Astragalus
Quartz Debitage
Jasper Flake


Oyster
(Crassostrea virginica)
Hard Clam Fragments
(Mercenaria mercenaria)
Periwinkle
(Littorina sp.)
© Darrin Lowery 2017


1521 ± 68 calAD
(beneath 22cm of tidal marsh peat)

# 44AC529

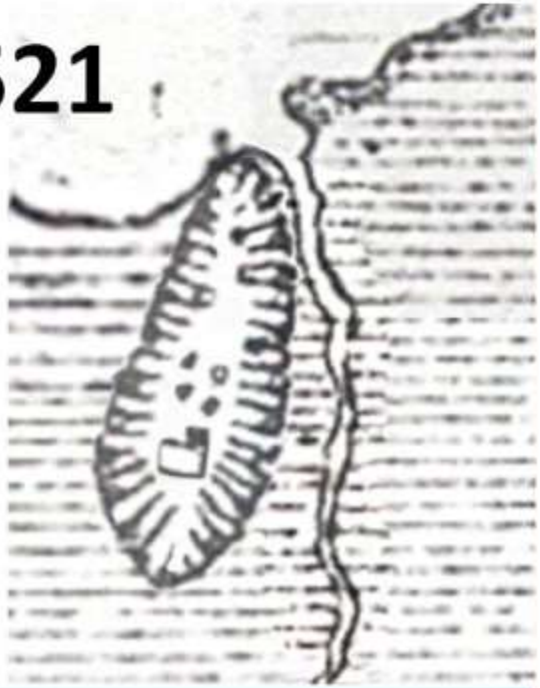




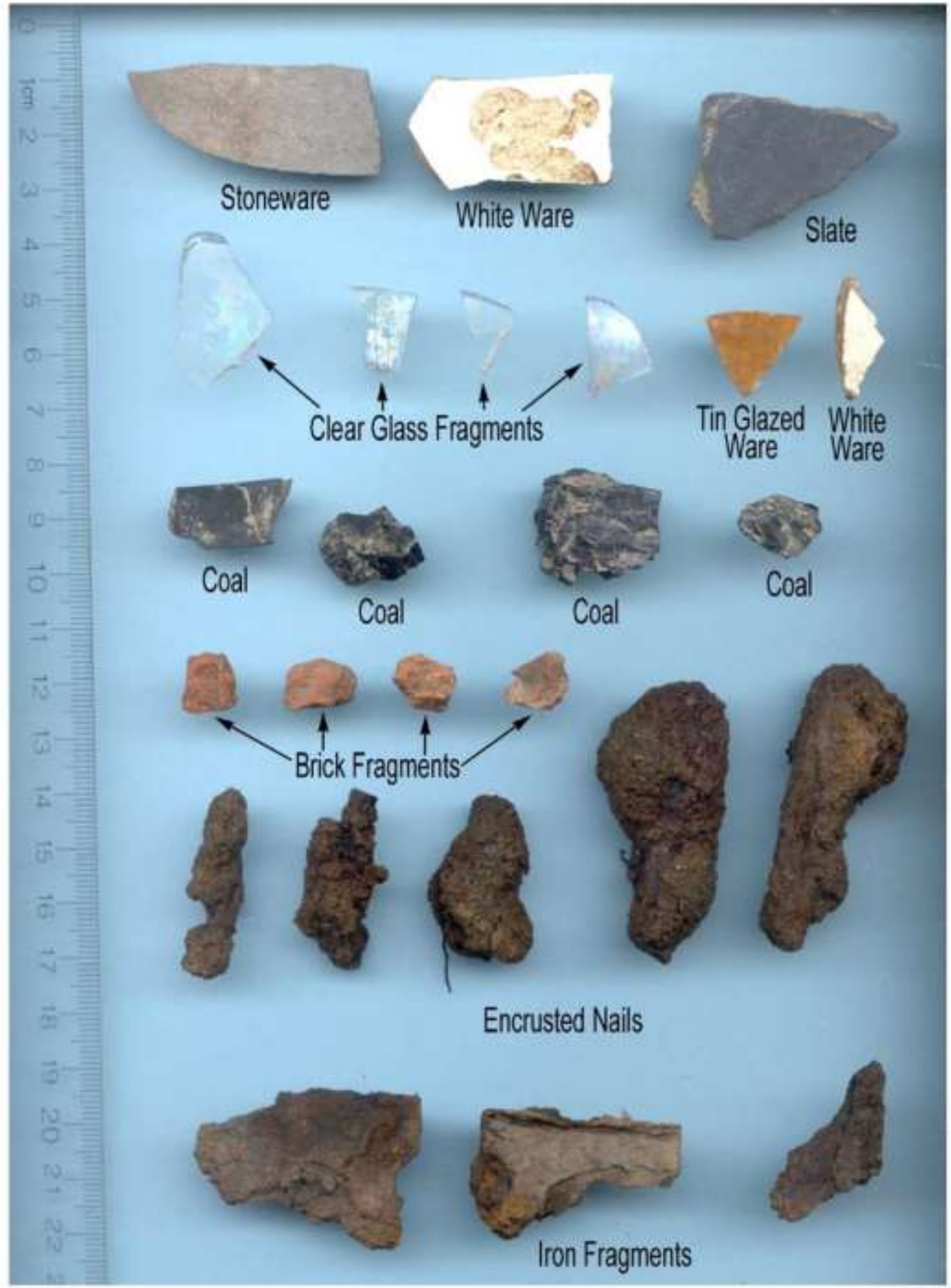

Plowed prehistoric shell midden (hummock)

Unplowed prehistoric shell midden (beneath marsh)

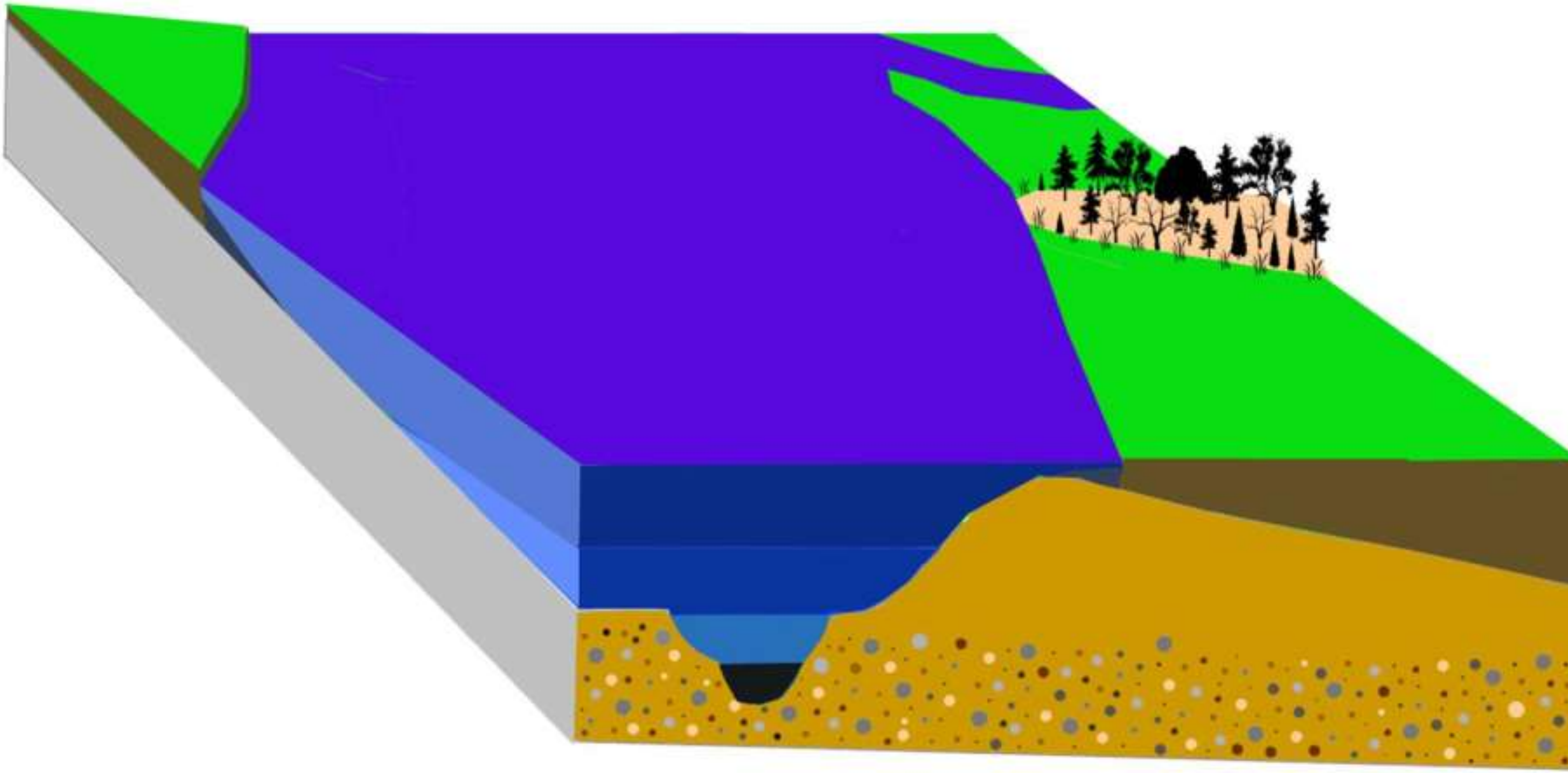
# 44AC521



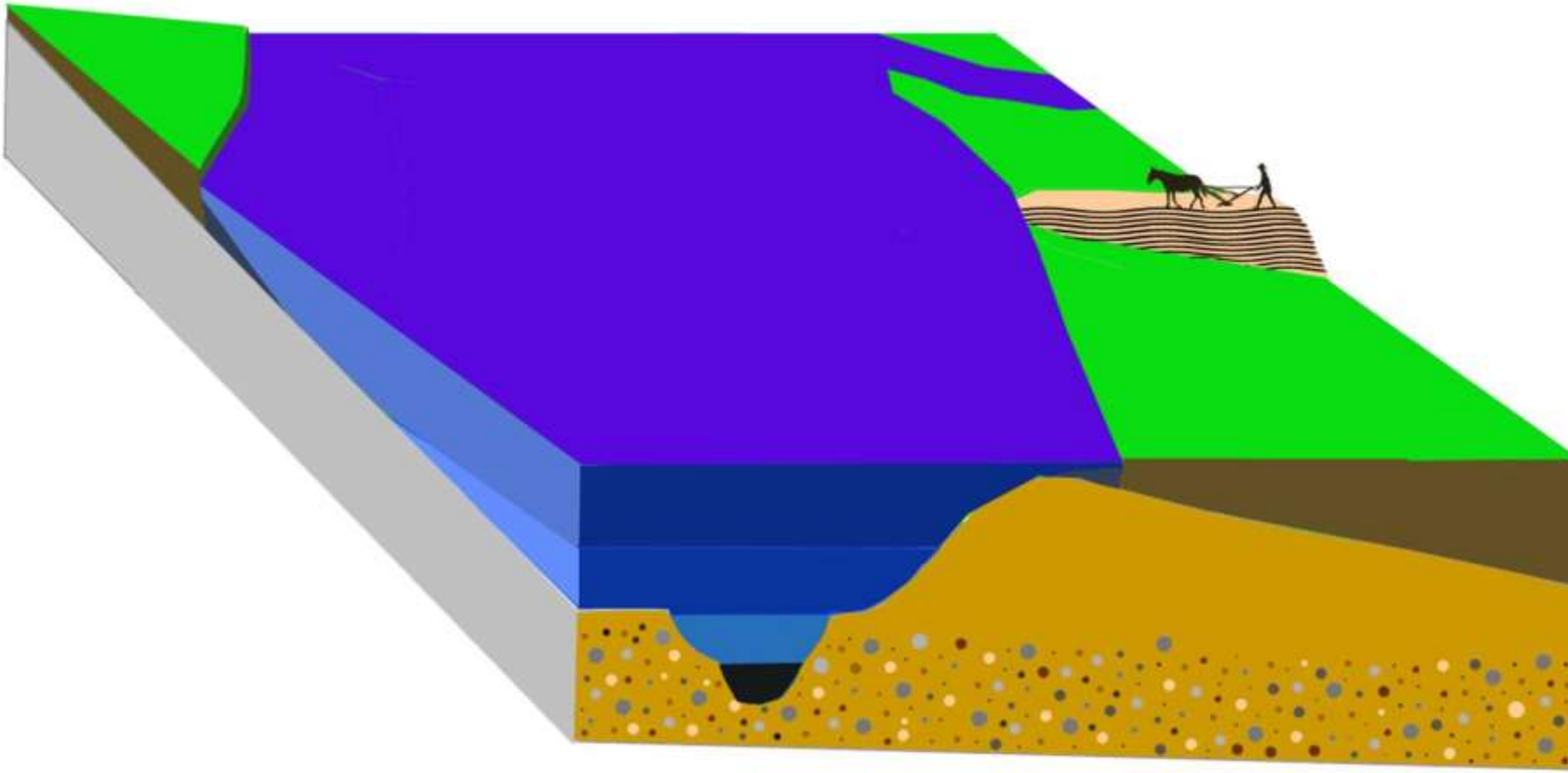

Iron Nails
Brick Fragments
Coal
White Ware
Rusted Iron



Stoneware
White Ware
Slate
Clear Glass Fragments
Tin Glazed Ware
White Ware
Coal
Coal
Coal
Coal
Brick Fragments
Encrusted Nails
Iron Fragments

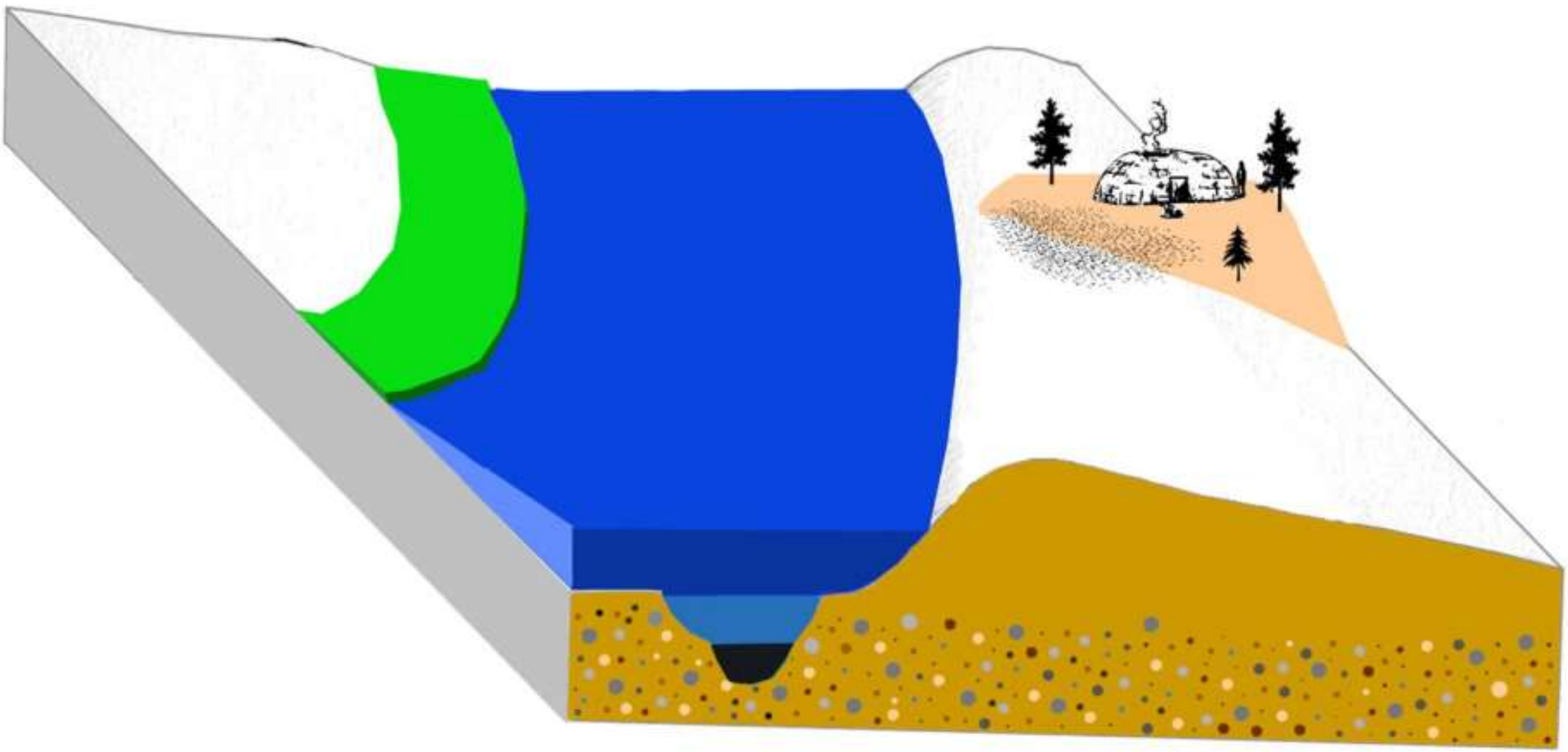
# TODAY

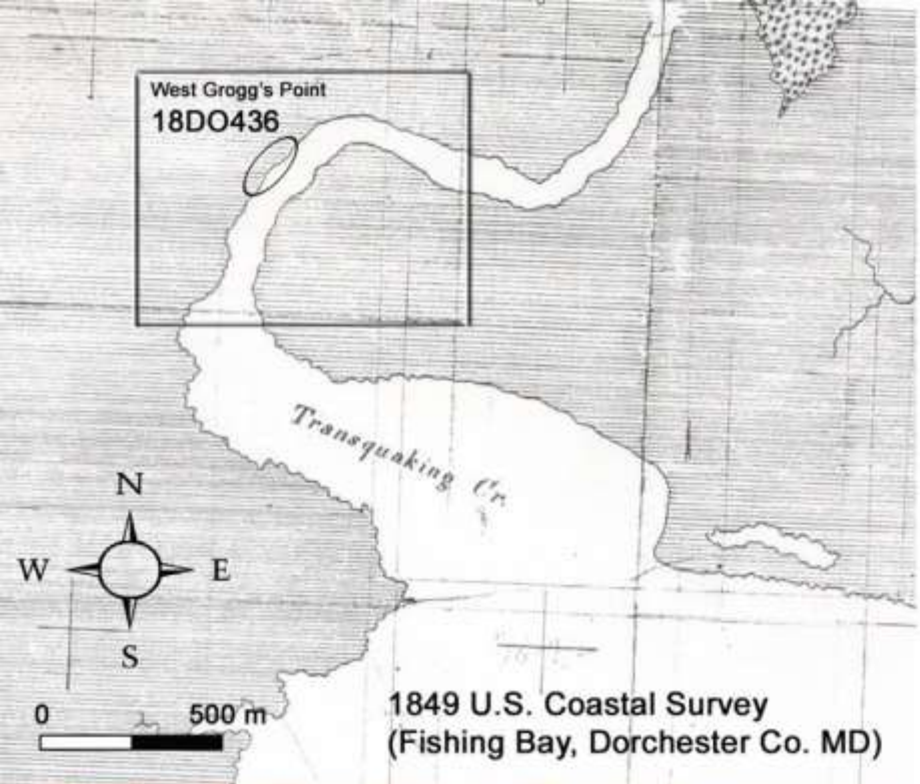


# ~1750 to ~1890



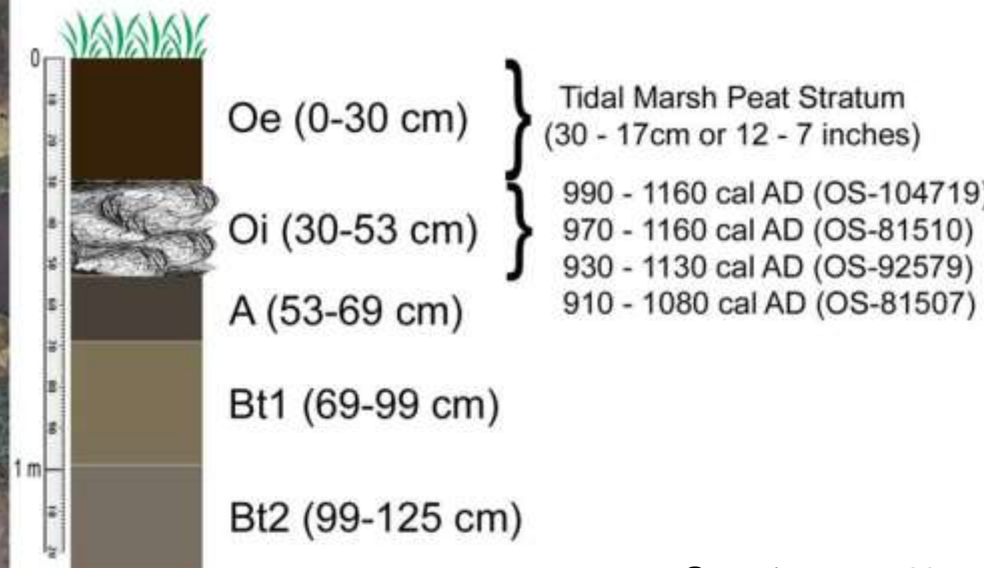
# ~1590 to ~1450




West Grogg's Point
18DO436
Transquaking Cr.
N
W
E
S
0
500 m
1849 U.S. Coastal Survey
(Fishing Bay, Dorchester Co. MD)


Chesapeake Bay Region
(Present)

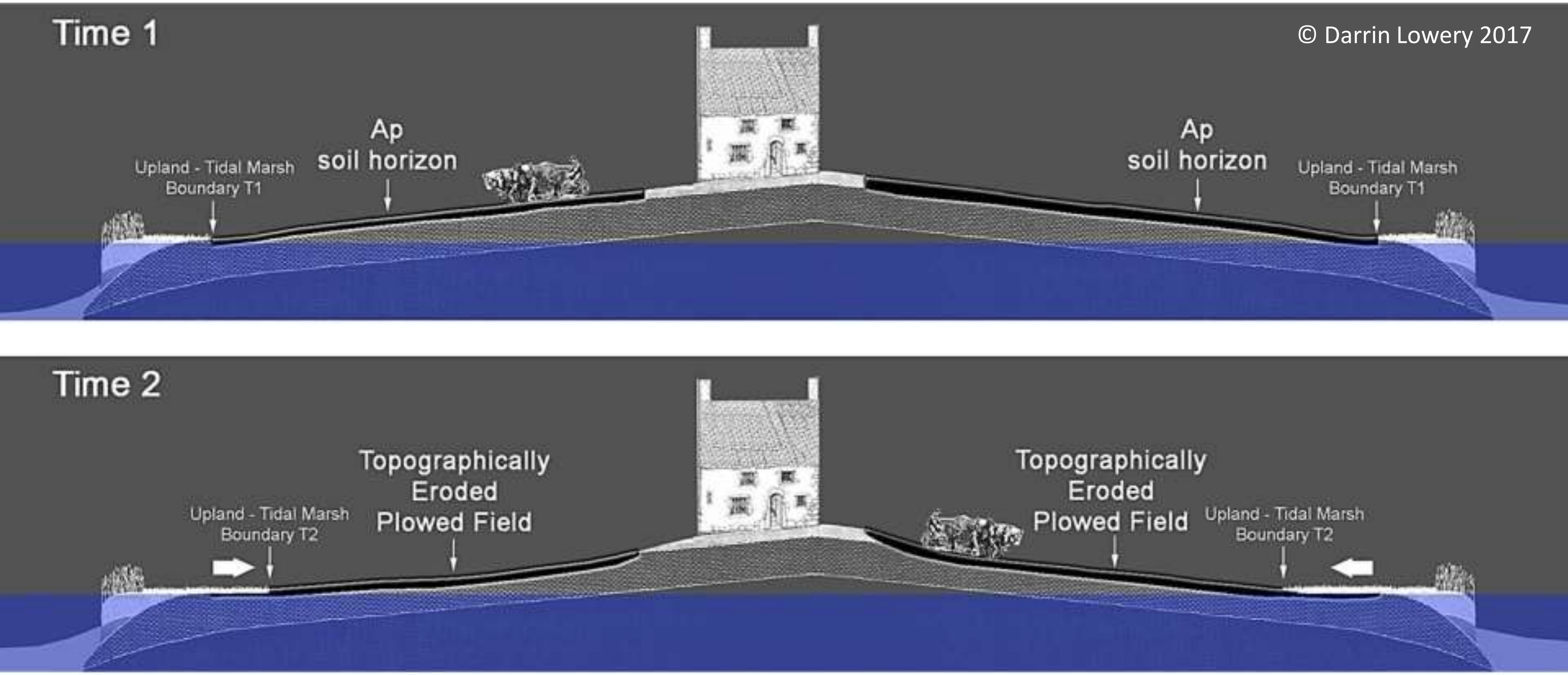

U.S.D.A. Farm Service Agency
(Imagery Date: 5-30-2009)
West Grogg's Point
18DO436
Transquaking Creek
N
W
E
S
0
200 m


0
1 m
Oe (0-30 cm)
Oi (30-53 cm)
A (53-69 cm)
Bt1 (69-99 cm)
Bt2 (99-125 cm)
Tidal Marsh Peat Stratum
(30 - 17cm or 12 - 7 inches)
990 - 1160 cal AD (OS-104719)
970 - 1160 cal AD (OS-81510)
930 - 1130 cal AD (OS-92579)
910 - 1080 cal AD (OS-81507)

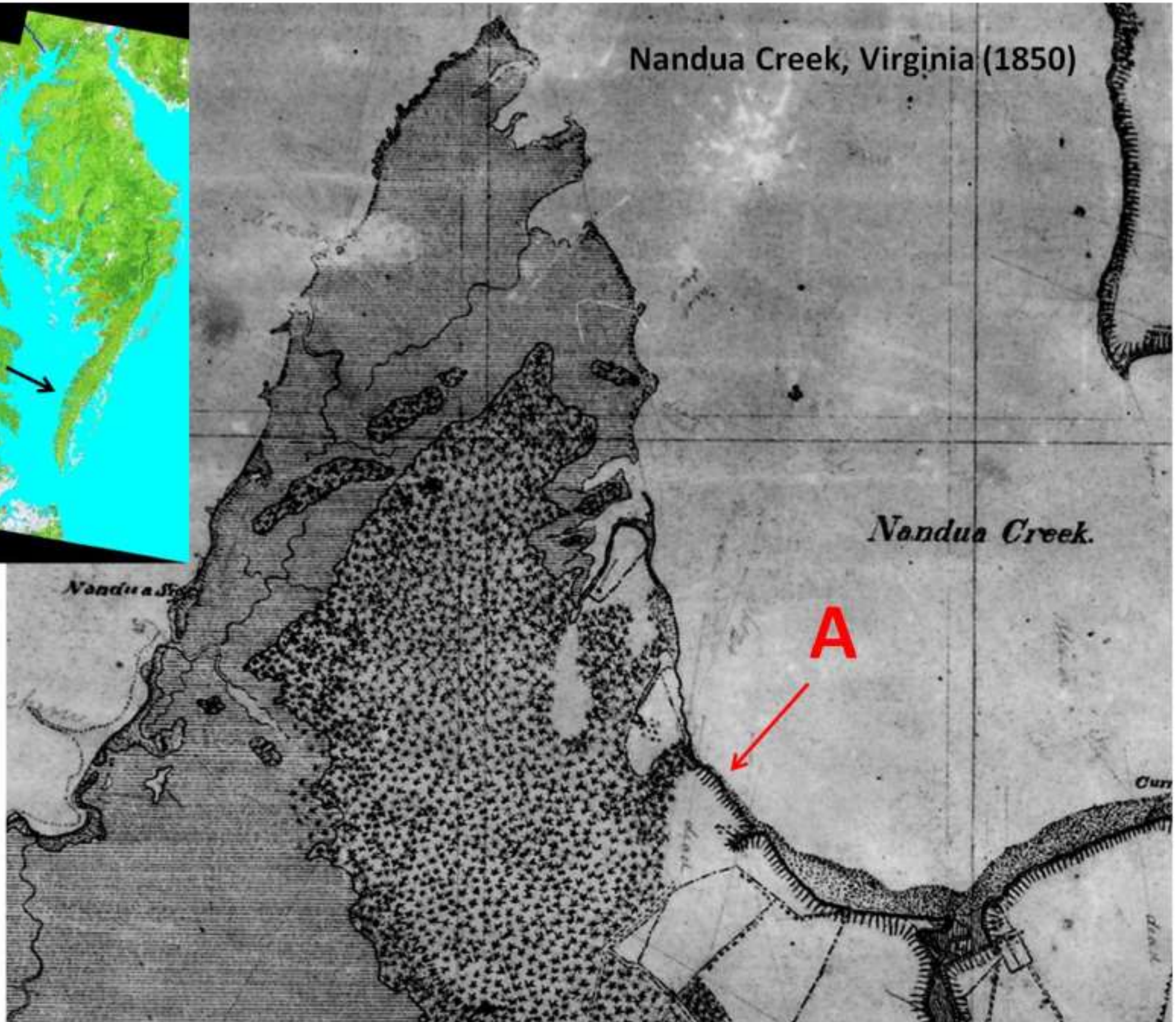
What does plowing do to landscapes adjacent to the coastline?

It erodes the topographic elevation of the landsurface!


It also leaves a distinctive signature in the soil!

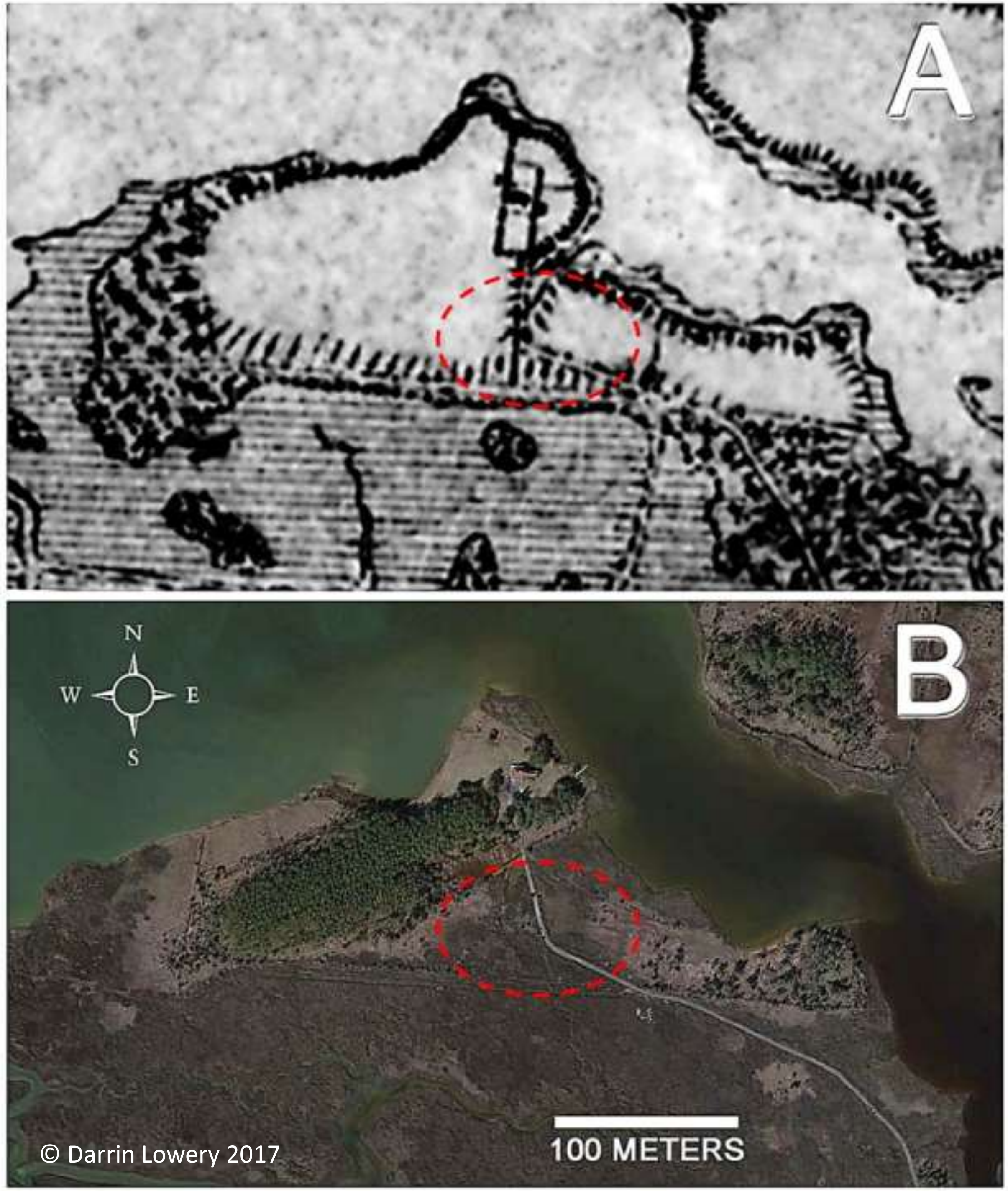

Time 1
© Darrin Lowery 2017
Ap
soil horizon
Upland - Tidal Marsh
Boundary T1
Ap
soil horizon
Upland - Tidal Marsh
Boundary T1
Time 2
Topographically
Eroded
Plowed Field
Upland - Tidal Marsh
Boundary T2
Topographically
Eroded
Plowed Field
Upland - Tidal Marsh
Boundary T2


Chesapeake Bay Region
(Present)


Nandua Creek, Virginia (1850)
Nandua Creek.
A

Oi
Ap
Bt
© Darrin Lowery 2017

# Back Creek, Virginia

Given the most extreme situation, the amount of relative sea level change would be ≤ 15 centimeters over the past 160 years.

My results are consistent with recent updates to the 20th century sea level rise record!

NATURE (January 2015)

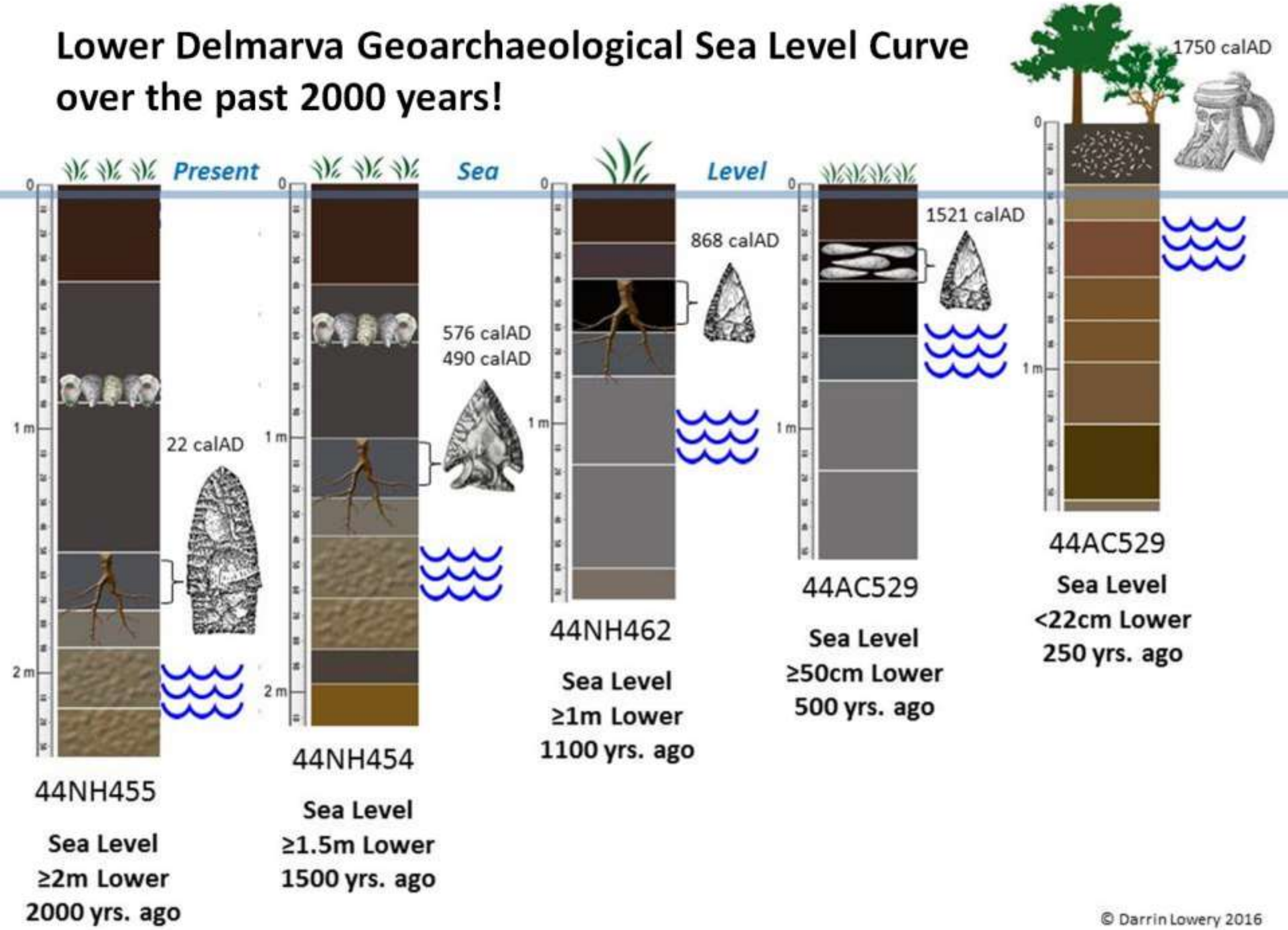
## Probabilistic reanalysis of twentieth-century sea-level rise

Carling C. Hay[1,2], Eric Morrow[1,2], Robert E. Kopp[2,3] & Jerry X. Mitrovica[1]

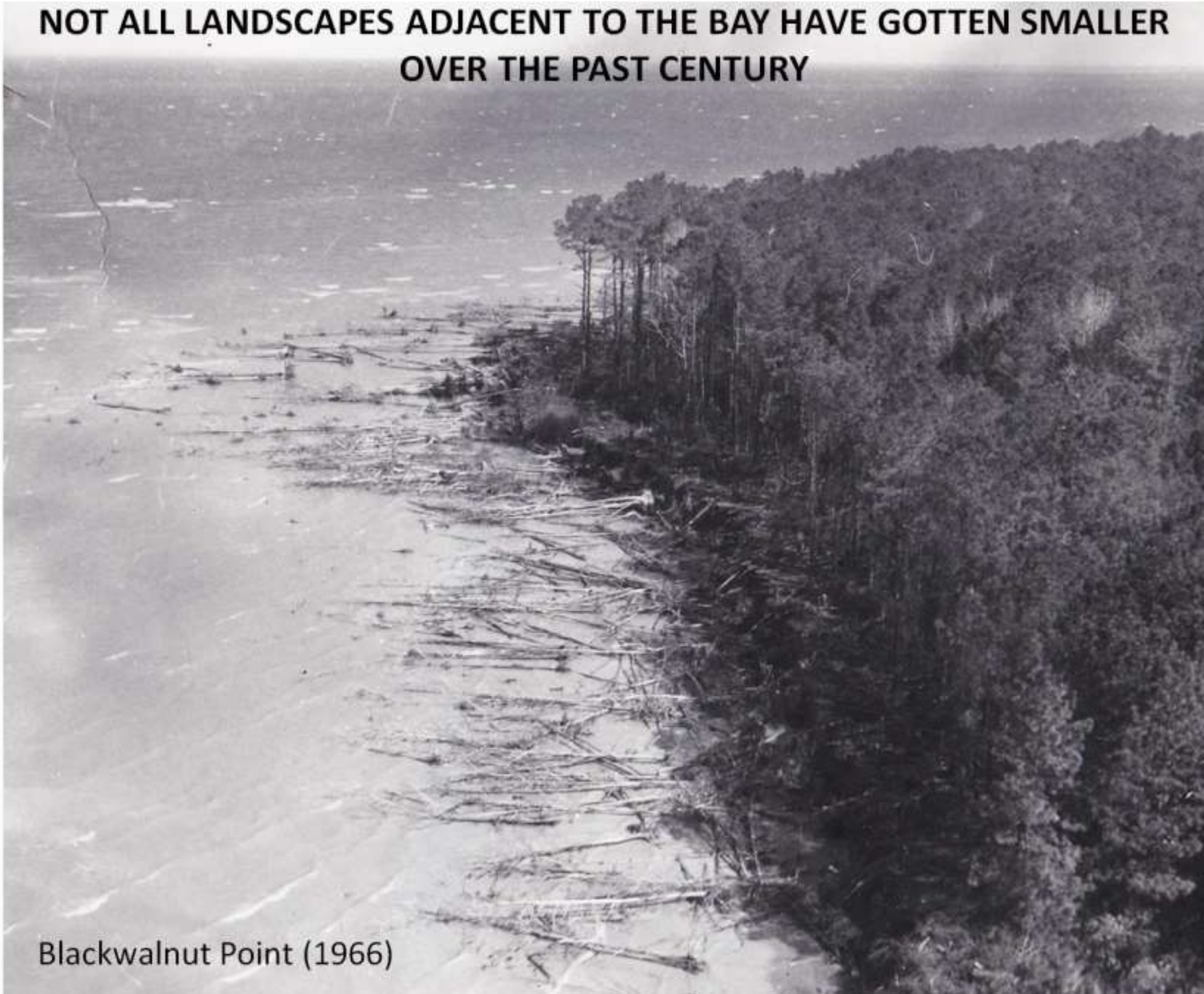
**GMSL rise from 1901 to 1990 (89 years) of 1.0 ± .2 millimeters per year: 8.9 cm ± 1.78 cm**

**GMSL rise from 1993 to 2010 (17 years) of 3.0 ± .7 millimeters per year: 5.1 cm ± 1.19 cm**

**GLOBAL MEAN SEA LEVEL RISE: ~14 cm ± 2.97 cm over 110 years**
**GMSL rise over 110 years is ≤16.97 cm and/or ≥11.03 cm**

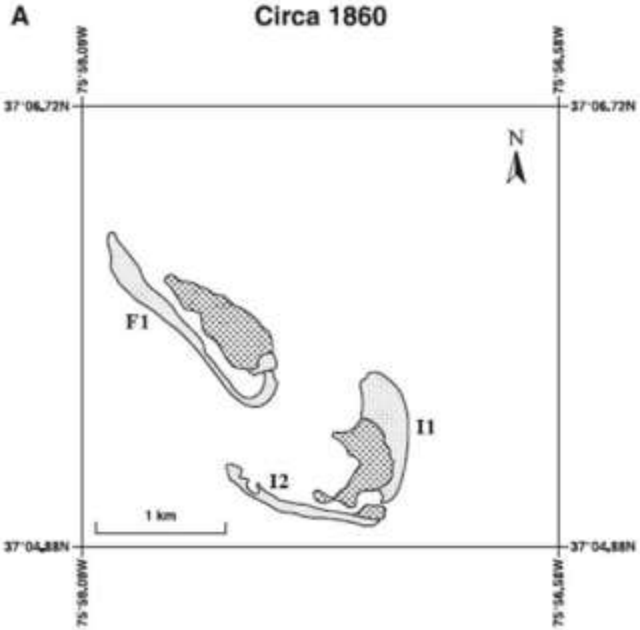

Lower Delmarva Geoarchaeological Sea Level Curve over the past 2000 years!
Present
Sea
Level
0
1 m
2 m
22 calAD
44NH455
Sea Level
≥2m Lower
2000 yrs. ago
576 calAD
490 calAD
44NH454
Sea Level
≥1.5m Lower
1500 yrs. ago
868 calAD
44NH462
Sea Level
≥1m Lower
1100 yrs. ago
1521 calAD
44AC529
Sea Level
≥50cm Lower
500 yrs. ago
1750 calAD
44AC529
Sea Level
<22cm Lower
250 yrs. ago
© Darrin Lowery 2016

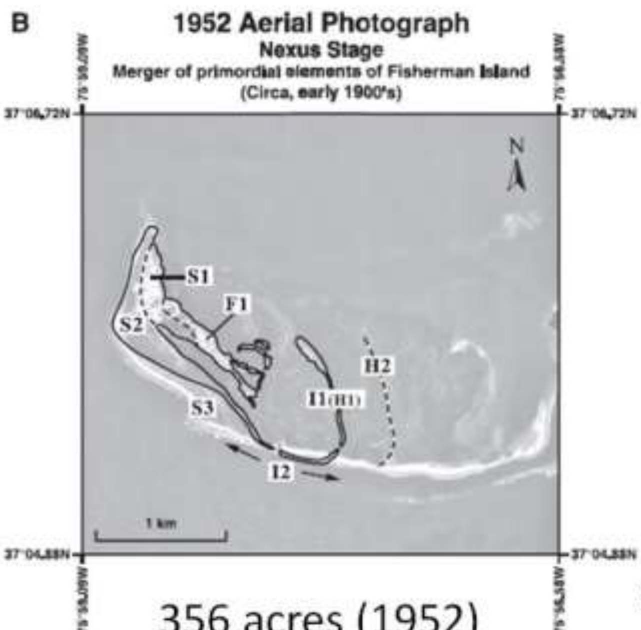
# NOT ALL LANDSCAPES ADJACENT TO THE BAY HAVE GOTTEN SMALLER OVER THE PAST CENTURY



Blackwalnut Point (1966)


SOME COASTAL LANDSCAPES HAVE GOTTEN MUCH LARGER OVER THE PAST CENTURY
© Darrin Lowery 2017

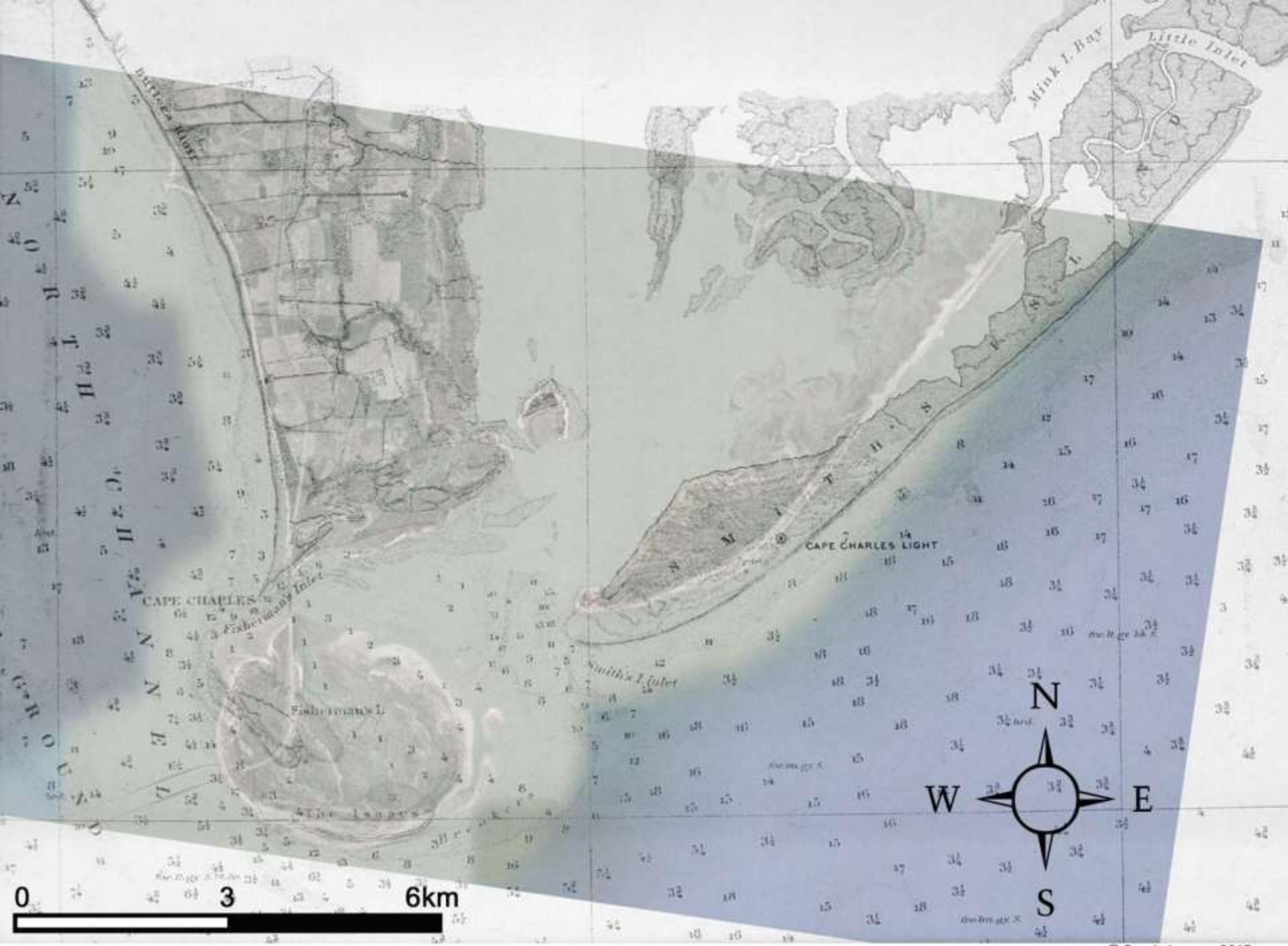


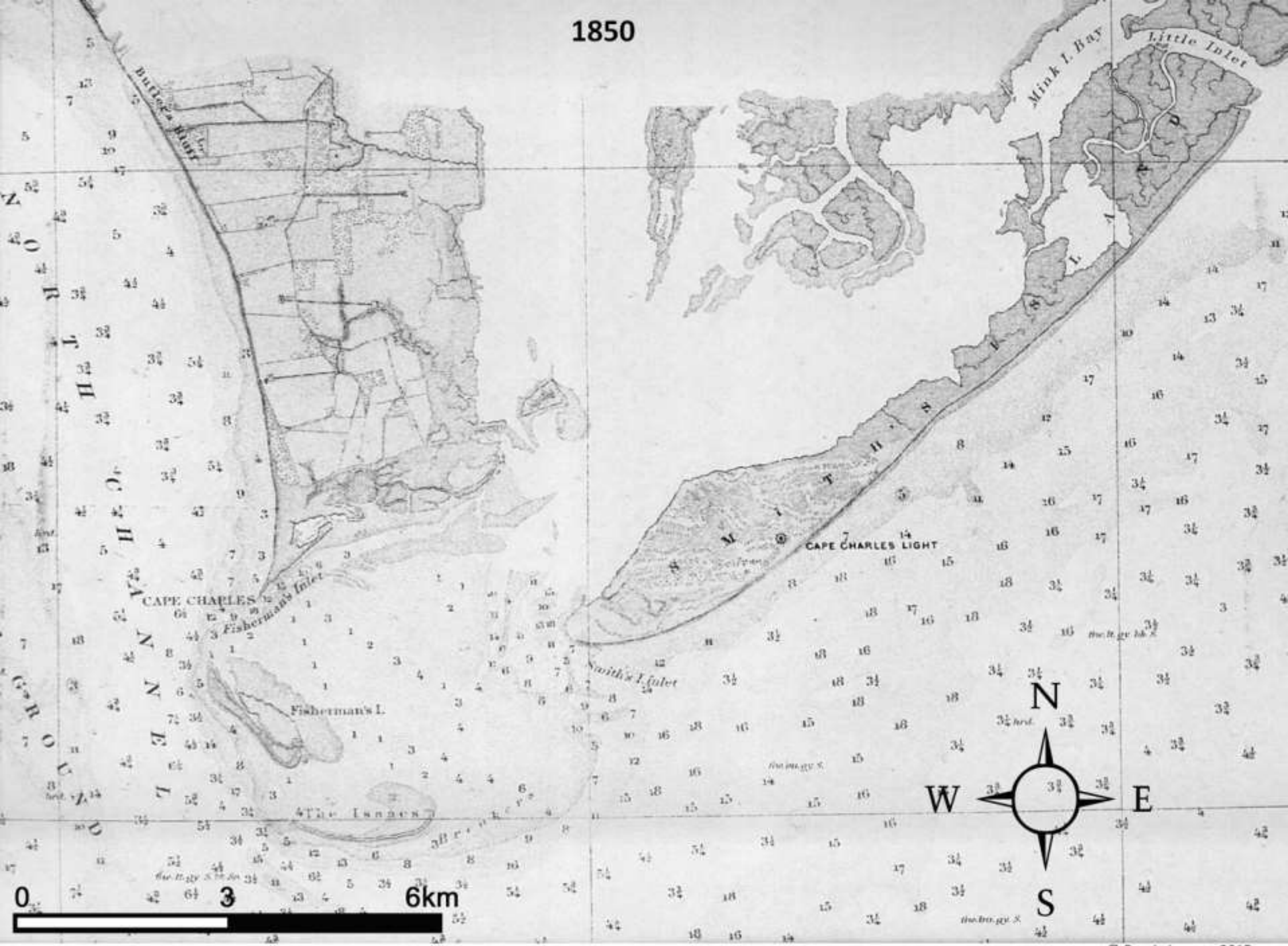




356 acres (1952)

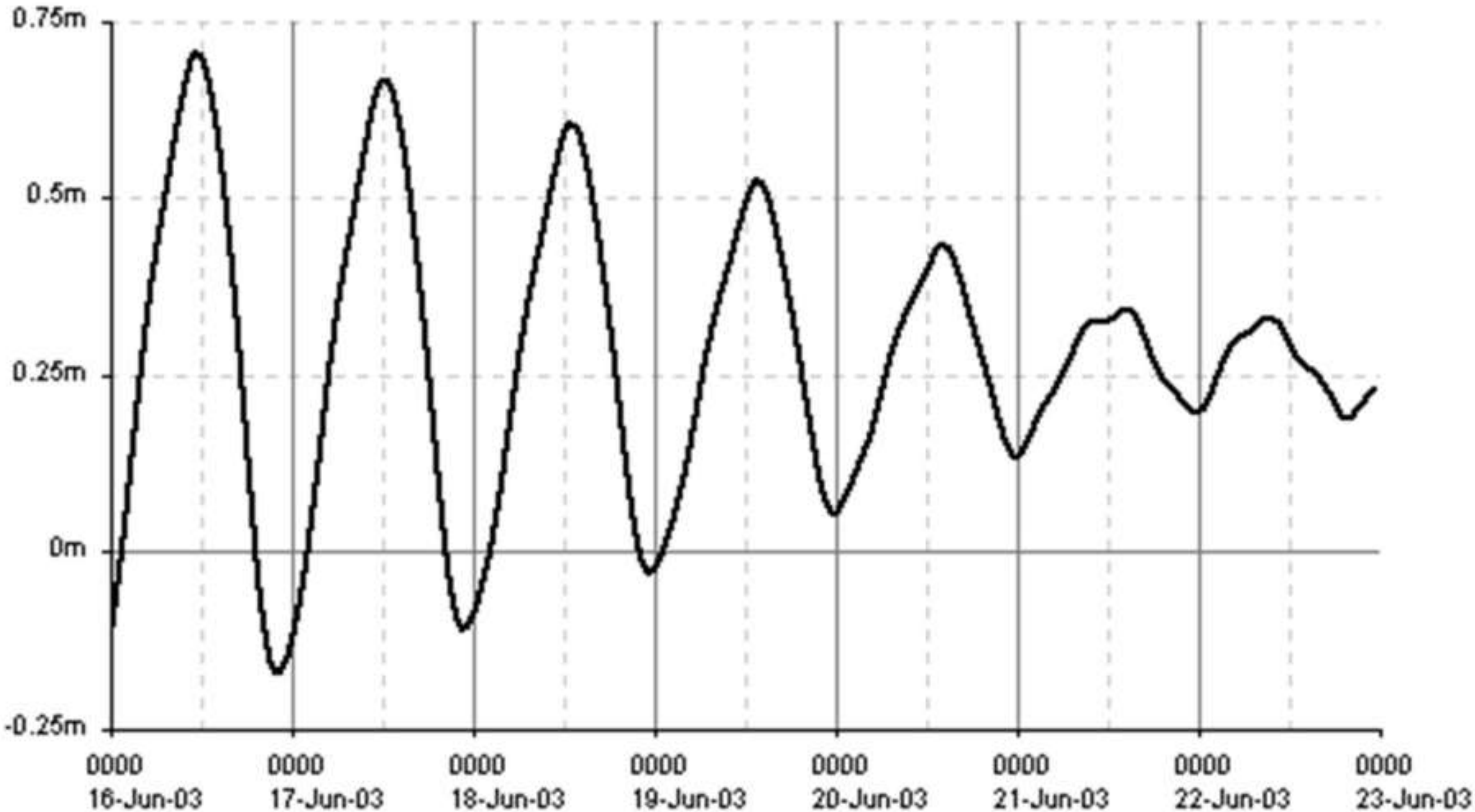

**1,850 acre Fisherman's Island did not exist 200 years ago and most of Fisherman's Island accreted over the past 60 years!**

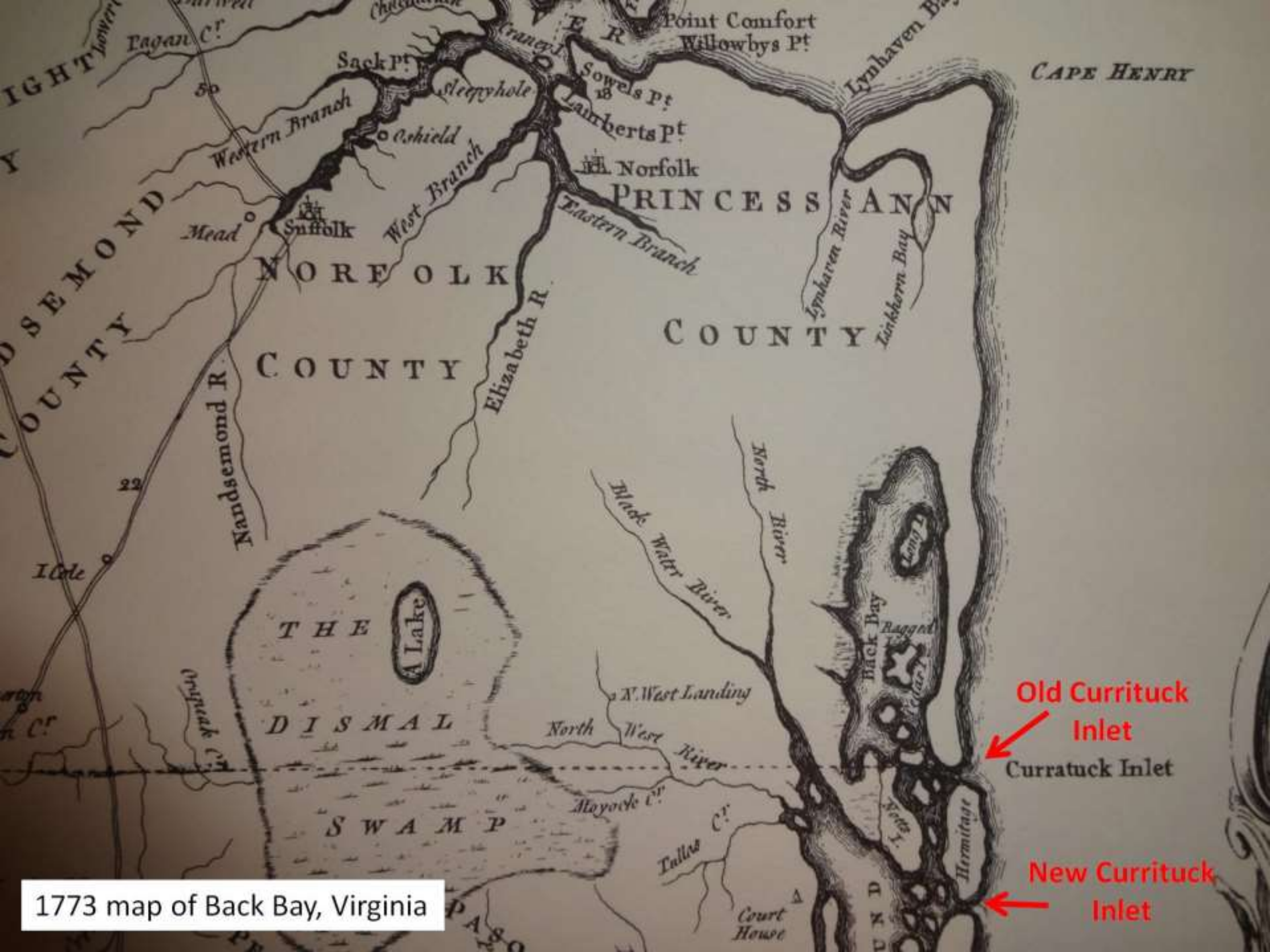
2-1-2007 (overlay with 1850 coastal survey)


Mink I. Bay
Little Inlet
CAPE CHARLES LIGHT
CAPE CHARLES
Fisherman's Inlet
Smith's Inlet
Fisherman's I.
N
W
E
S
0
3
6km

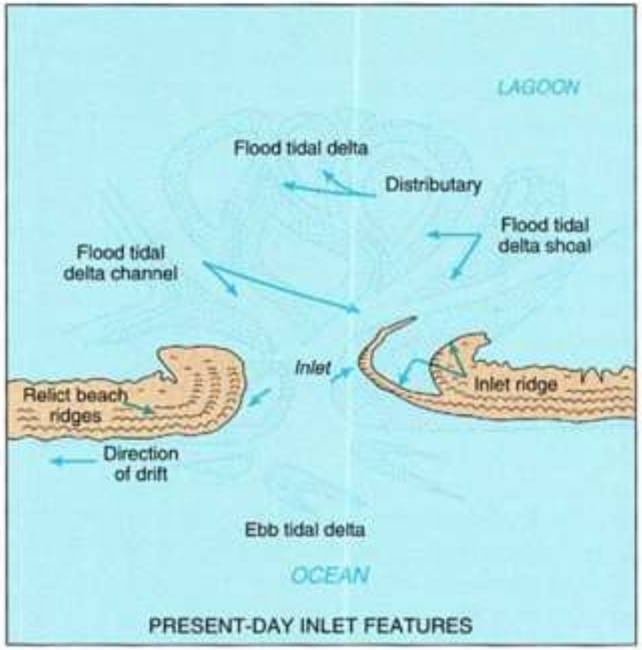

1850
Mink I. Bay
Little Inlet
Butler's Bluff
SMITHS ISLAND
CAPE CHARLES LIGHT
CAPE CHARLES
Fisherman's Inlet
Fisherman's I.
Smith's Inlet
NORTH CHANNEL
N
W
E
S
0
3
6km

# Tidal Amplitude can change over time!



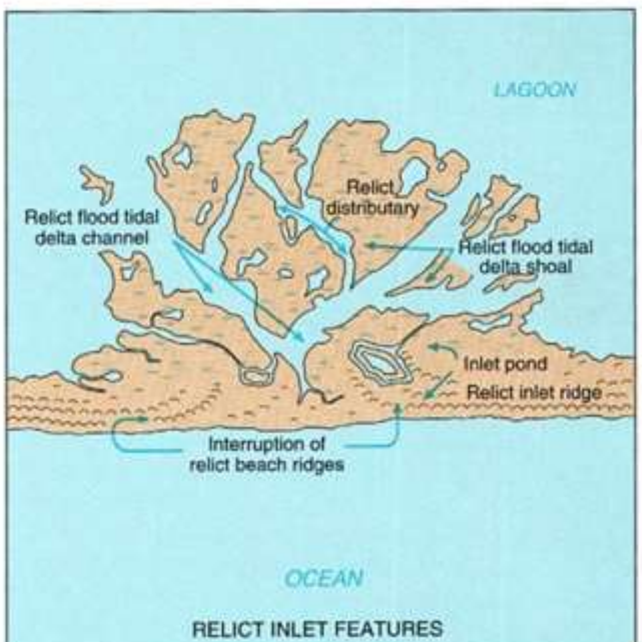


1773 map of Back Bay, Virginia



PRESENT-DAY INLET FEATURES

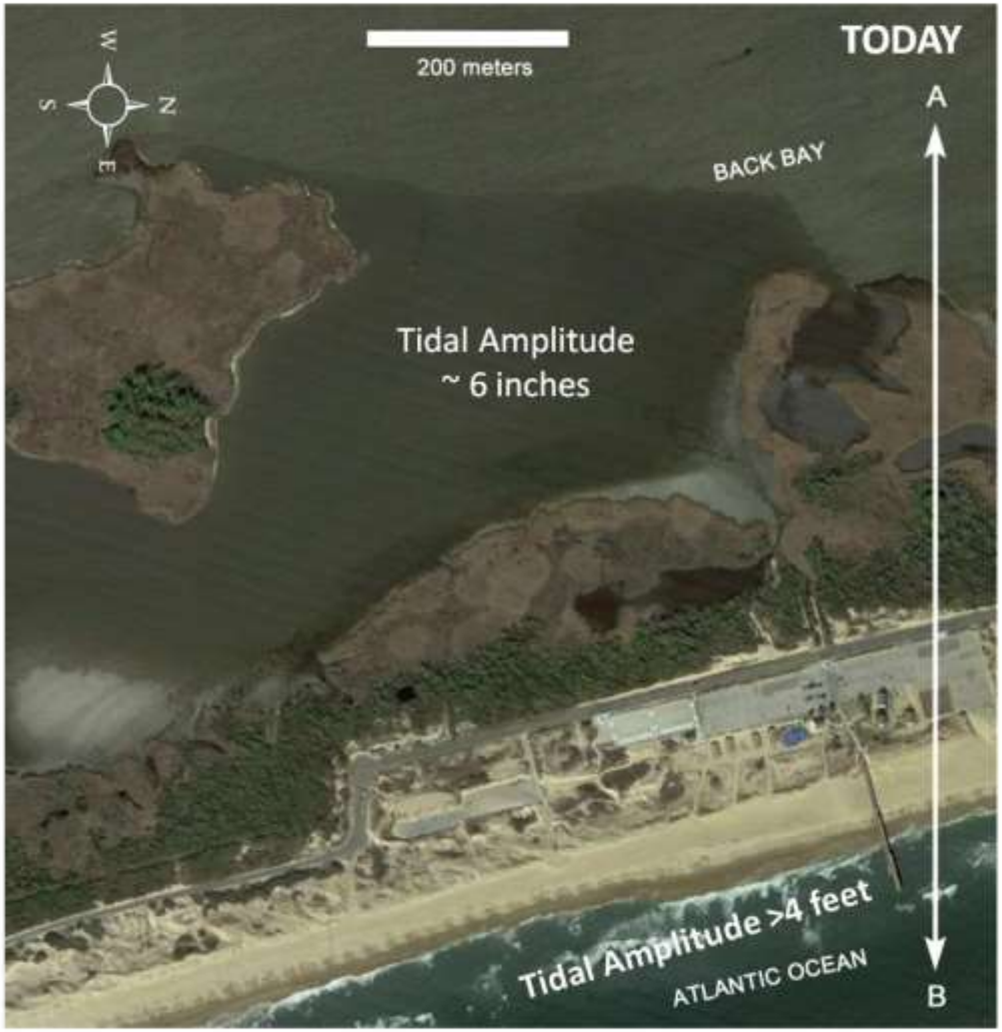
The geologic evidence of Currituck Inlet, which is now closed!

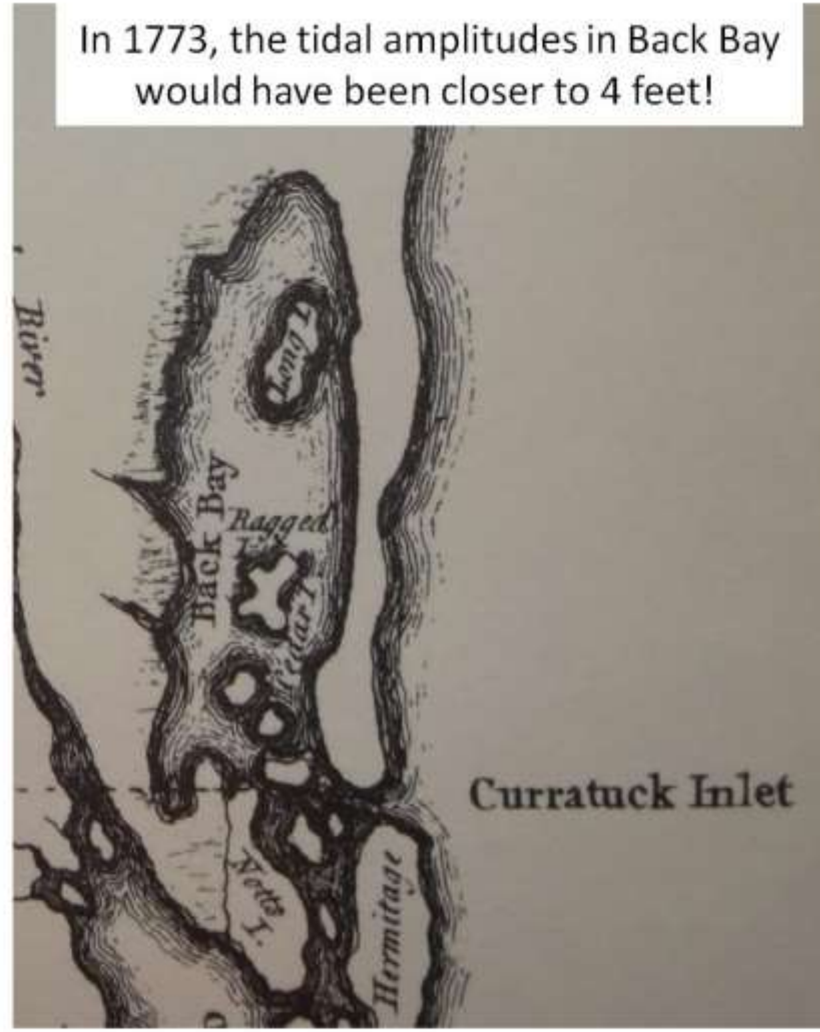


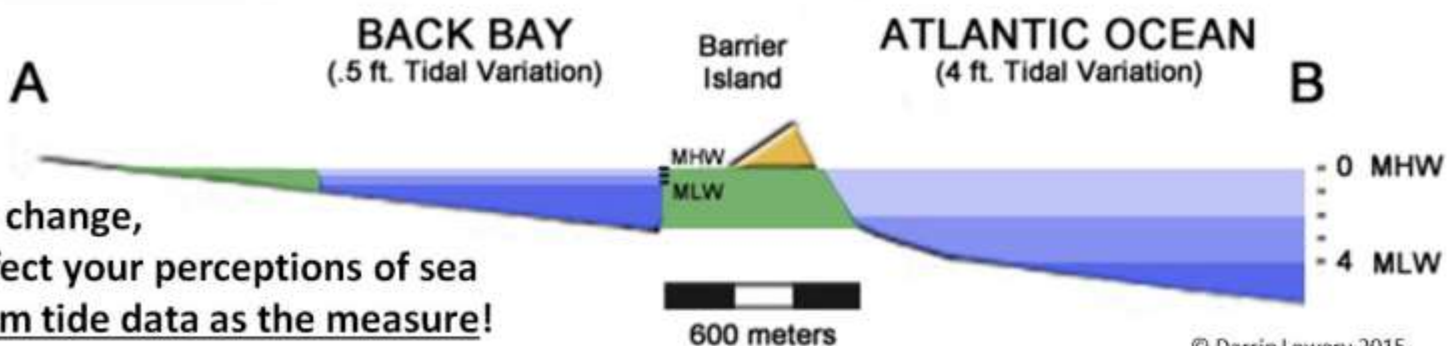
RELICT INLET FEATURES



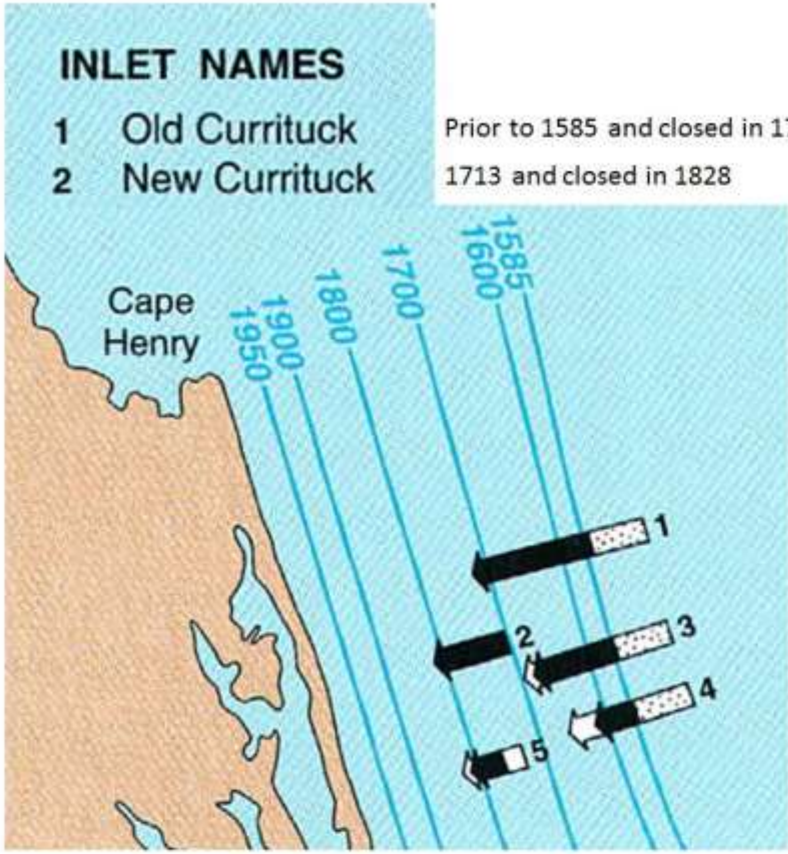
Today water in Back Bay drains south at low tide ~60 miles to Oregon Inlet, North Carolina




**So tidal amplitudes can change, which would greatly effect your perceptions of sea level <u>if you use long-term tide data as the measure</u>!**



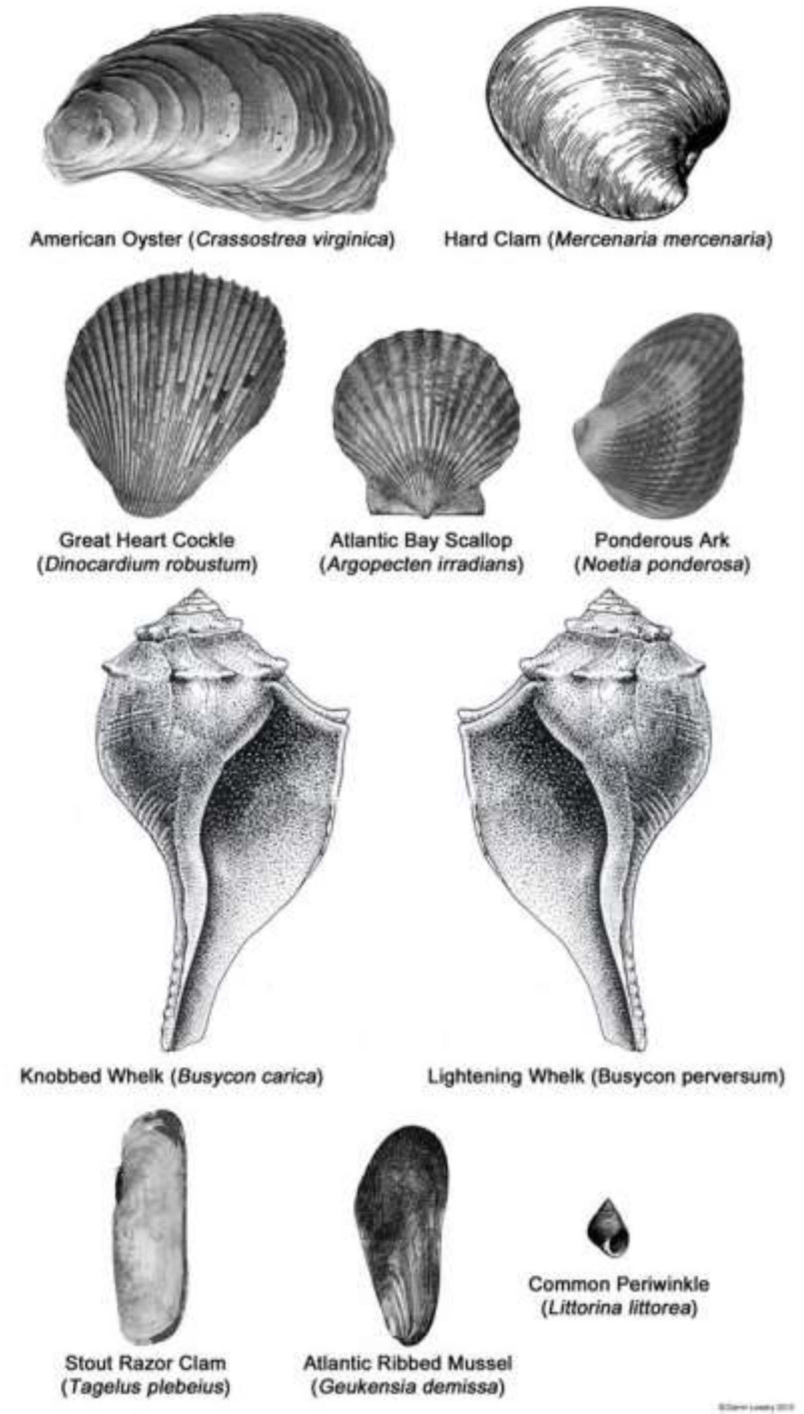

Prior to 1585 and closed in 1731

1713 and closed in 1828

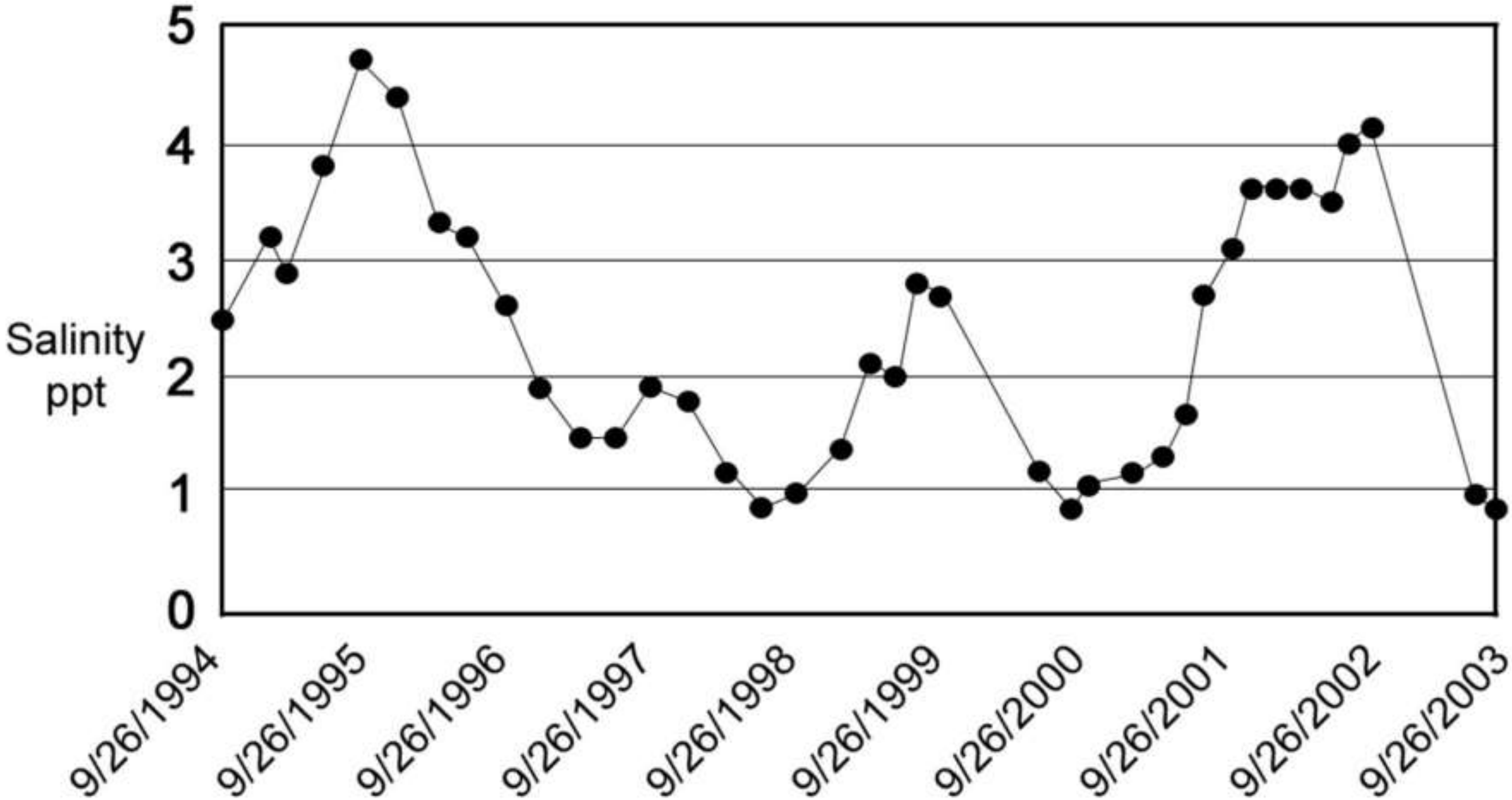

When these inlets were open, Back Bay would have had greater tidal amplitudes and would have supported marine species. But when New Currituck Inlet closed in 1828 the entire ecosystem collapsed.

# LITTLE CEDAR ISLAND PREHISTORIC MIDDEN
Back Bay, Virginia





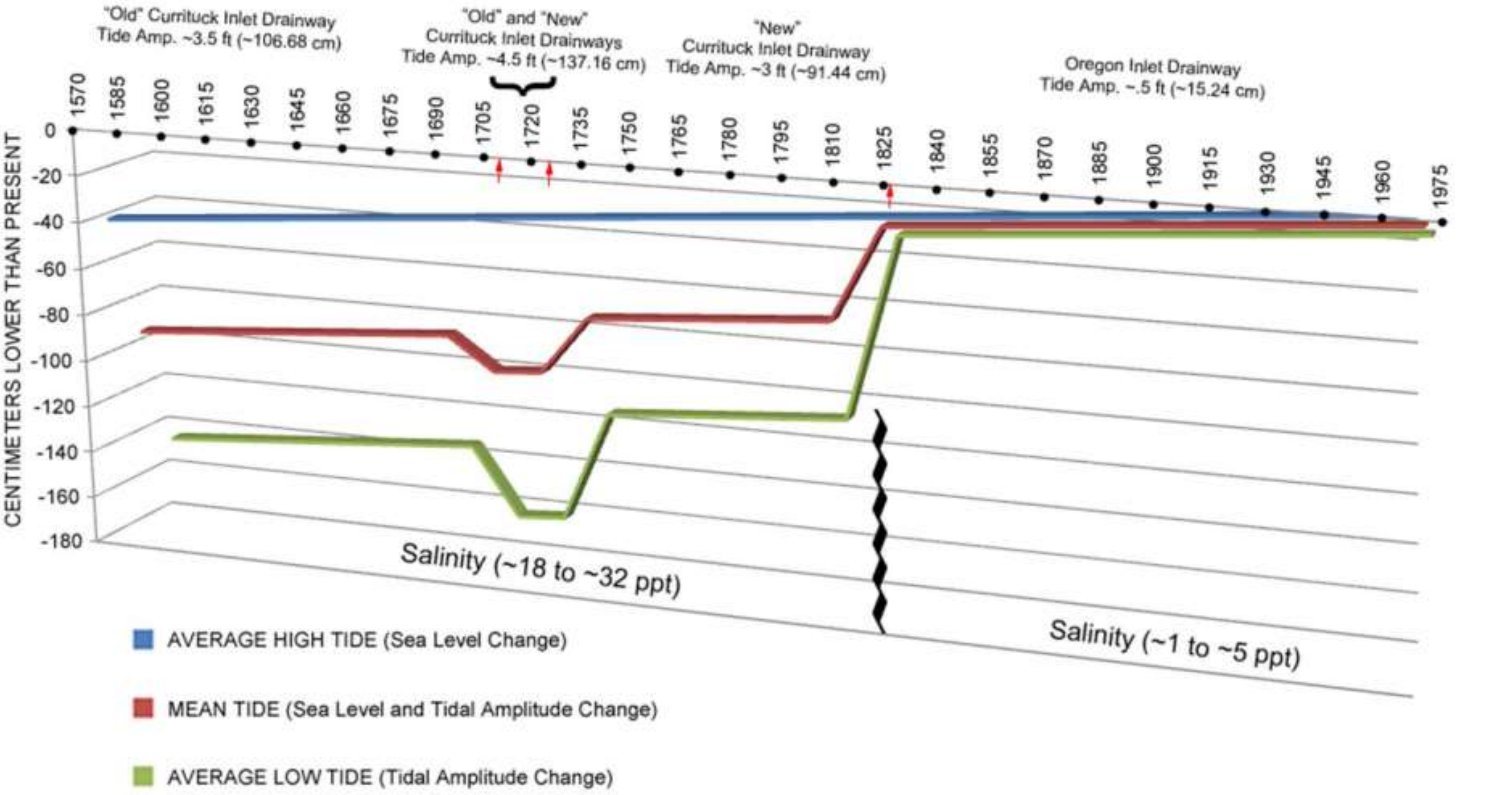
Current salinity of Back Bay would not support these species!



1). Let's assume we had a tide buoy in Back Bay over the past 440 years.

2). Let's also assume that we believe mean tide (tidal amplitude average) represents "sea level" over this period of time.

# Back Bay, Virginia:
# Sea Level, Tidal Amplitude, and Salinity Changes 1570-1975



## Tidal Ranges

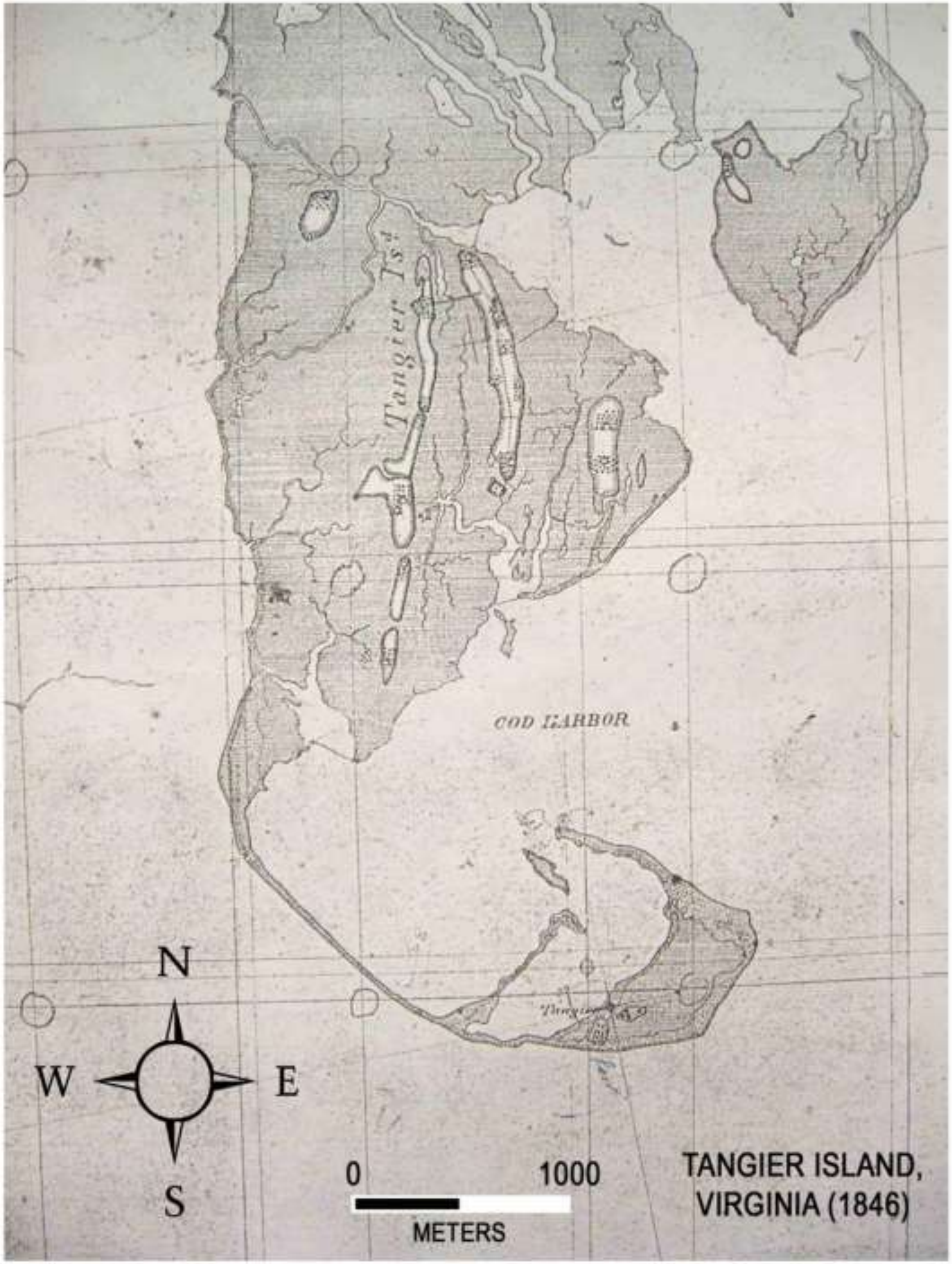
| | Mean Tidal Range | Great Diurnal Change* |
|---|---|---|
| Seaside | | |
| Chincoteague (Harbor) | 2.43 | 2.81 |
| Cobb Island | 4.00 | 4.49 |
| Fisherman's Island | 2.93 | 3.32 |
| Oyster | 4.52 | 5.04 |
| Wachapreague | 4.02 | 4.51 |
| | | |
| Bayside | | |
| Deep Creek | 2.92 | 3.28 |
| Jamestown | 1.81 | 2.15 |
| Kiptopeke | 2.60 | 2.94 |
| Occohannock Creek | 1.72 | 2.03 |
| Onancock | | |
| Pungoteague Creek | 1.76 | 2.04 |
| Saxis | 2.24 | 2.54 |
| Schooner Bay | 1.94 | 2.26 |
| Tangier | 1.59 | 1.84 |

*difference between highest and lowest tides of the day

*Source: NOAA Tides and Currents*

**Most Extreme Tidal Amplitude**
(on the coast near the mouth of the bay)

**Least Tidal Amplitude**
(within the middle Chesapeake Bay)




**HAVE TIDAL AMPLITUDES CHANGED IN THE CHESAPEAKE BAY?**

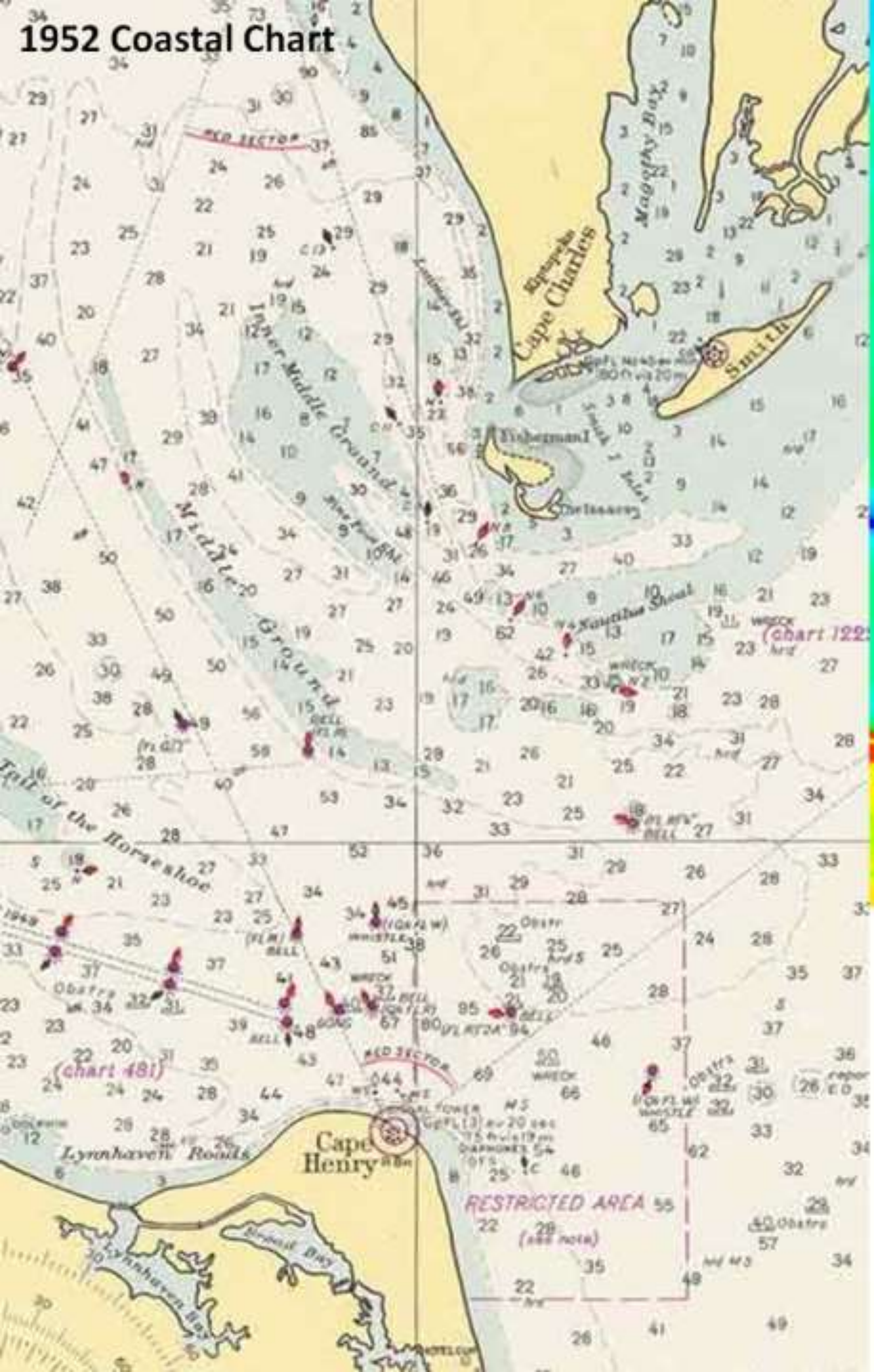
Mean Tidal Range: **1.98 feet (1904)**

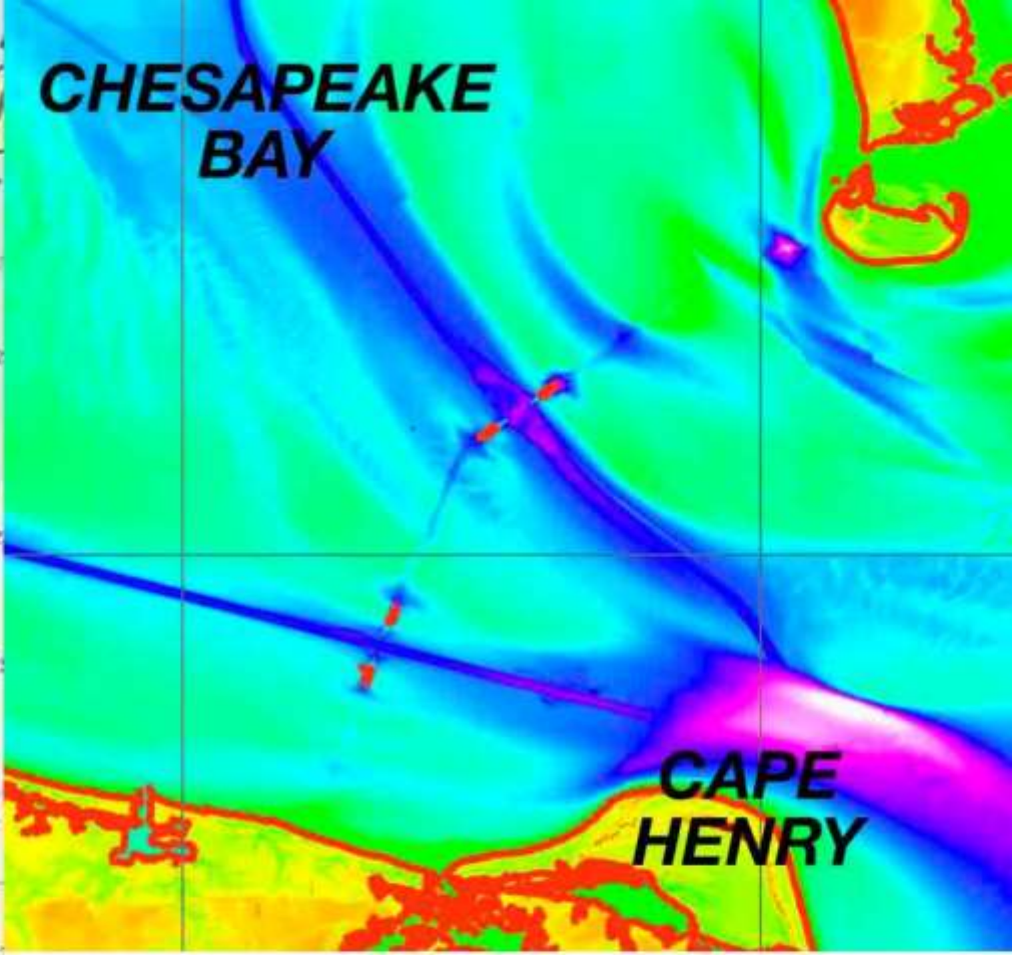
Mean Tidal Range: **1.59 feet (2015)**

Amount of Change: <u>**4.68 inches**</u>

For every acre of open water,
**~180,000 fewer gallons of water**
at the same latitude as Tangier Island
are currently being drained out of the
Chesapeake Bay (compared to 1904)!

# WHY????

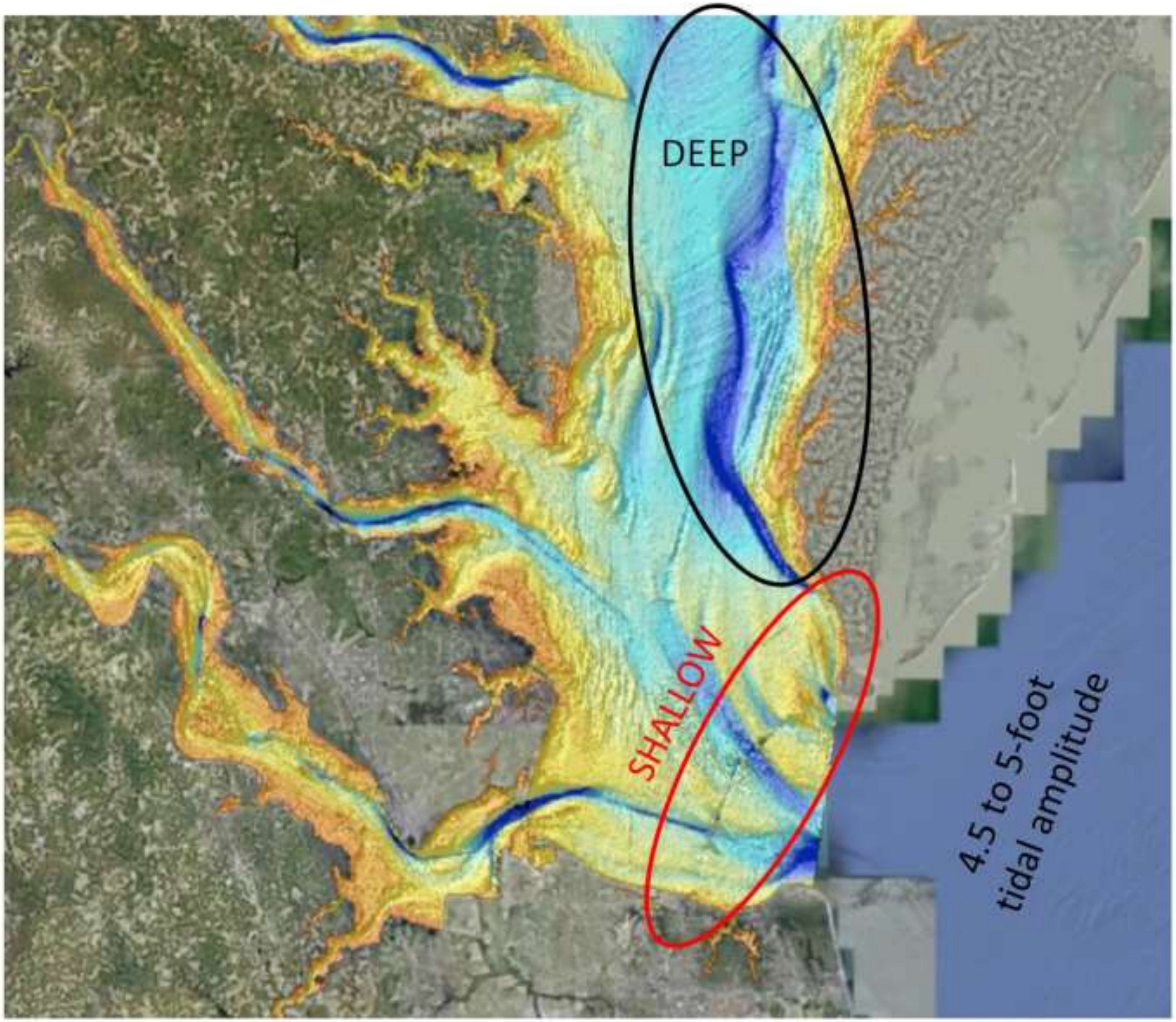



Over the past century and a half, the mouth of the Chesapeake Bay has gotten shallower because of littoral drift and increased sediment influx into the bay. The mouth of the bay has gotten markedly shallower since 1960!

# WHY????


Here's the man-made "sediment collector"!
The bridge-tunnel also explains why Fisherman's Island has gotten much larger over the past 50+ years!
The bridge is collecting sediment!
In 1952, Fisherman's Island encompassed ~350 acres!
Today, the island encompasses 1,850 acres of land!
(Net gain of 1,500 acres of land in 63 years)




Like a "giant clogged drain" the flow of water out of the deeper upper and middle bay (at low tide) is being slowly impeded! Ultimately (like Back Bay, VA) this process will reduce the tidal amplitudes along the middle and upper stretches of the bay (i.e., Tangier Island)!

# SUMMARY:

- Shoreline erosion and sea level change are complicated issues.
- Erosion occurs on an hourly or daily time scale.
- Sea level change occurs on a century or millennial time scale.
- The geoarchaeological record of the region offers a way to better understand these processes.

# SUMMARY:

Images without geologic contexts can be very misleading!


SUMMARY:
A human burial eroding from the shoreline on 10/31/2014
By 12/11/2014, it had eroded away!
42 days
The single greatest threat to the archaeological resources around the Chesapeake Bay is the Chesapeake Bay!


Thank you for your time!
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