So many ways of measuring shoreline change ...which one do I choose?

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Paper #: 229
Session Title: Unique Mapping Applications of GIS
Date: Wednesday, July 16, 2014
Time: 3:15 PM - 4:30 PM
Room: Room 27 B

So many ways of measuring shoreline change ...which one do I choose?

Outline:

- ~15min talk & time for questions
- Methods
- Pros & Cons
- Local Examples

The Massachusetts Shoreline

Shoreline: "The water's edge…where the sea meets the land

"Encyclopedia of Coastal Science." Encyclopedia of Earth Sciences Series, M.L. Schwartz (ed.). 2005.

The Massachusetts Shoreline: Sinking and Rebounding of Crust

The Massachusetts Shoreline: World-wide Change in Sea Level

Global Avg. Sea Level Observations:

20th century rate: 1.7 ± 0.5 mm/yr

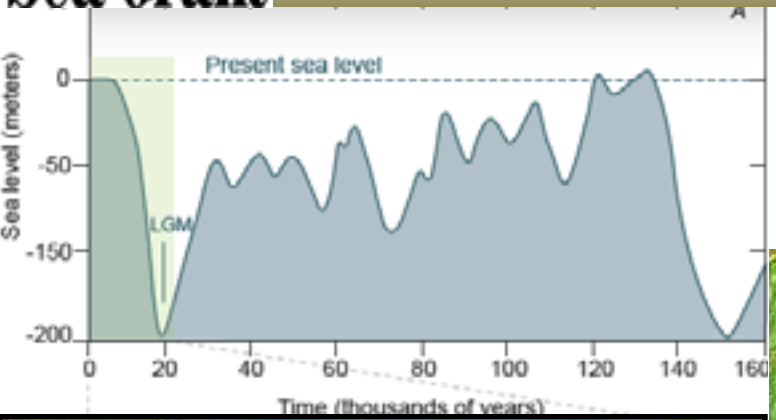
1993 to 2003 rate: 3.1 ± 0.7 mm/yr

thermal expansion 1.6 ± 0.5 mm/yr

changes in land ice 1.2 ± 0.4 mm/yr

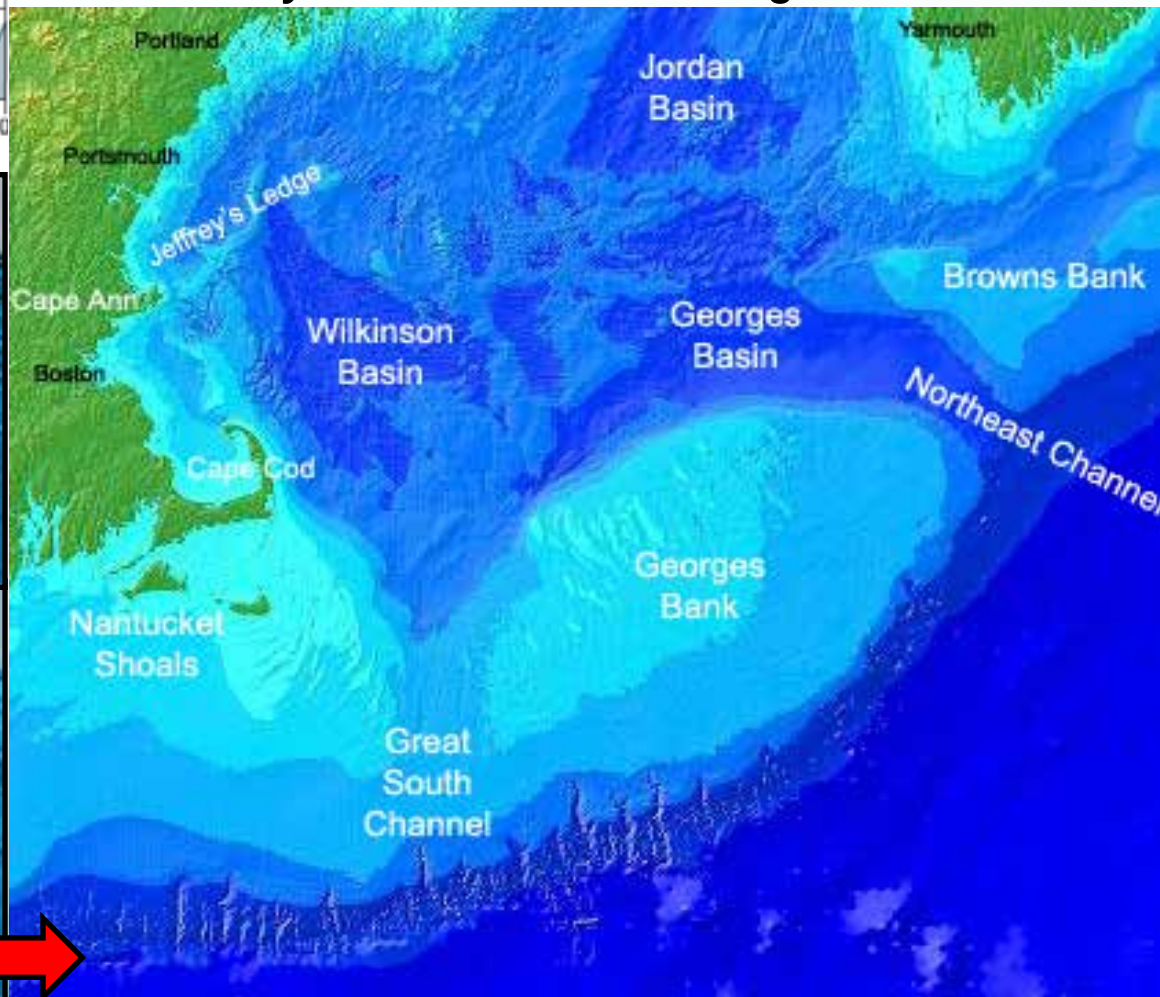
The Massachusetts Shoreline: COMBINED, but still too simple

Glacial History



25,000 yr ago
400’ below SL, ~1 mile thick
By ~ 15,000 ice was gone.

(Shaw et al., 2002)



What is a datum?, at a tide station

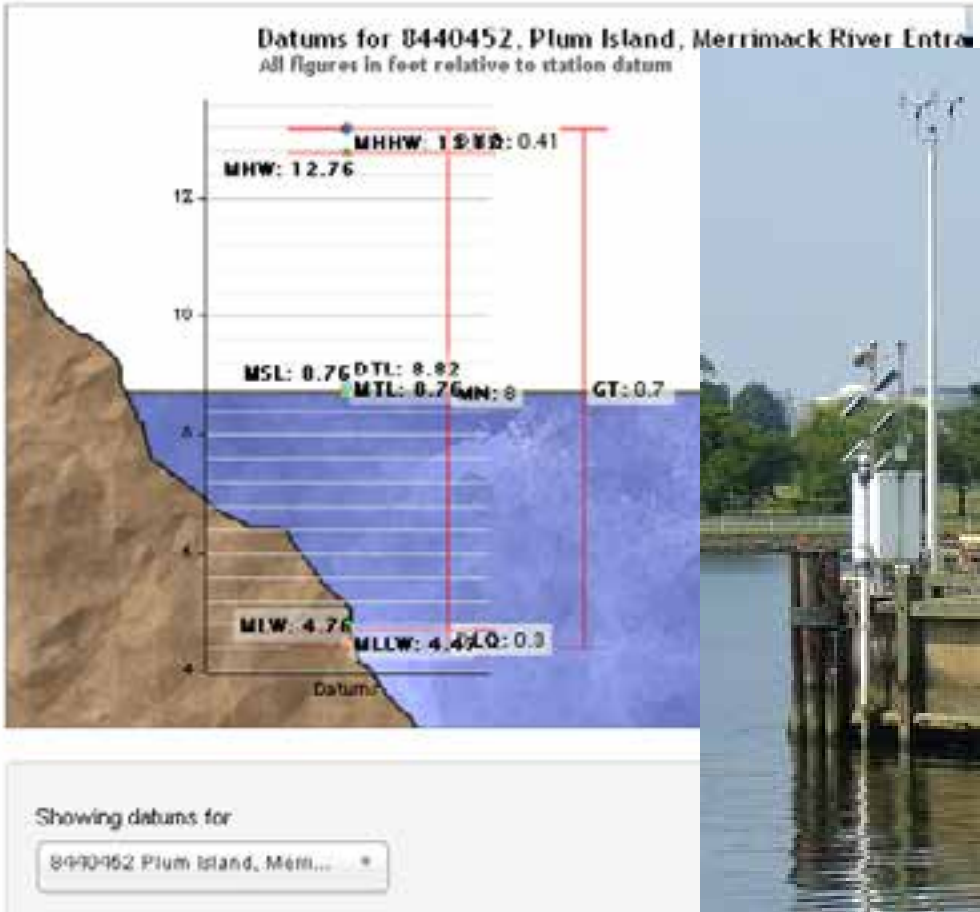
The high water line was the most common shoreline reference feature

MHW: The average of all the high water heights observed over the National Tidal Datum Epoch. The specific 19-year period over which tide observations are taken and reduced to obtain mean values for tidal datums, present NTDE is 1983 through 2001 and is considered for revision every 20-25 years.

Elevations on Station Datum

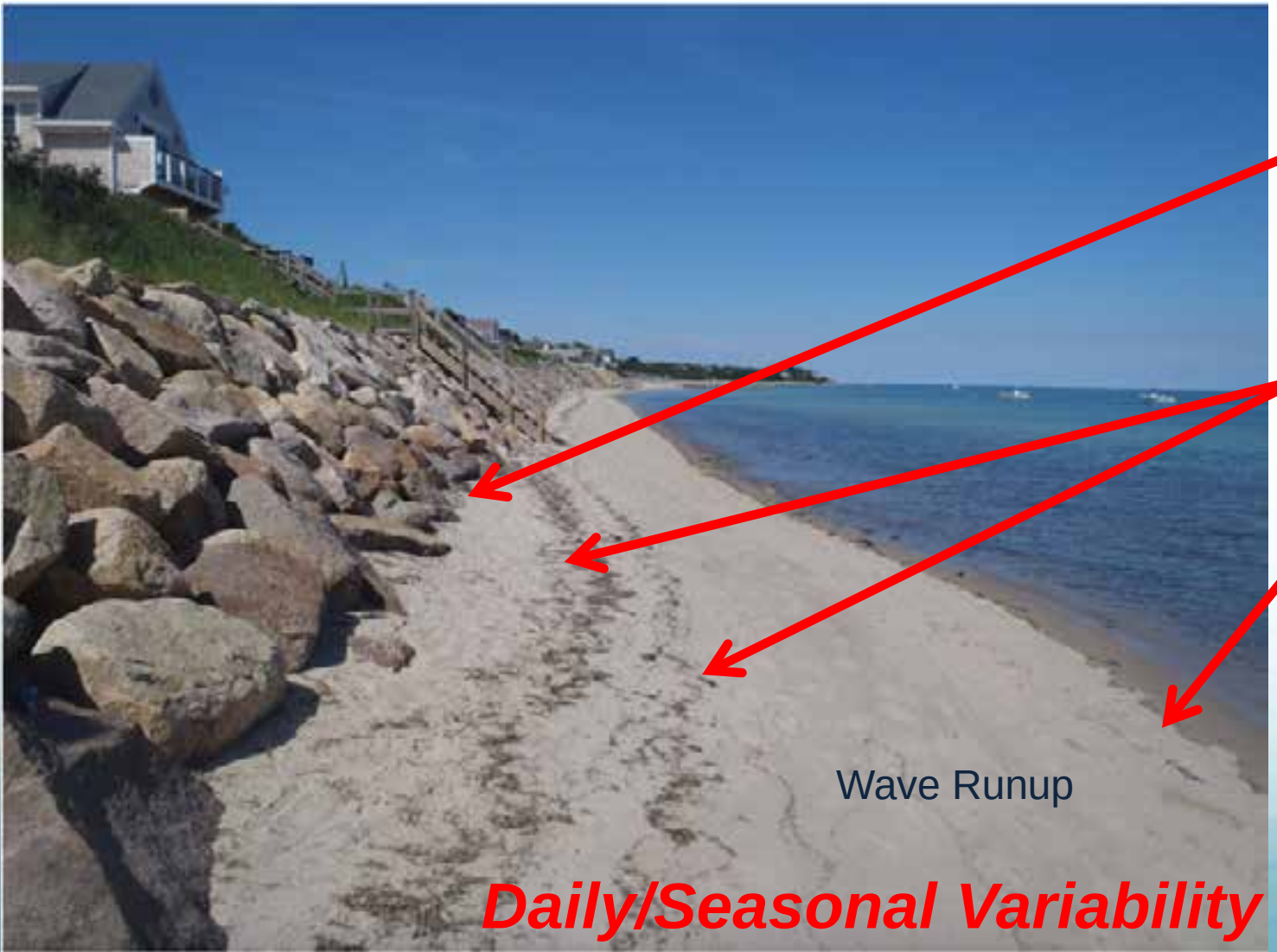
Station: 8440452, Plum Island, Merrimack River Entrance, MA
Status: Accepted (Aug 27 2003)
Units: Feet
T.M.: 75 W
Epoch: 1983-2001
Datum: STND

Datum	Value	Description
MHHW	13.17	Mean Higher-High Water
MHW	12.76	Mean High Water
MTL	8.76	Mean Tide Level
MSL	8.76	Mean Sea Level
DTL	0.02	Mean Diurnal Tide Level
MLW	4.76	Mean Low Water
MLLW	4.47	Mean Lower-Low Water
NAVD88		North American Vertical Datum of 1988
STND	0.00	Station Datum
GT	8.70	Great Diurnal Range
MN	8.00	Mean Range of Tide
DHQ	0.41	Mean Diurnal High Water Inequality
DLQ	0.30	Mean Diurnal Low Water Inequality
HWI	4.01	Greenwich High Water Interval (in hours)
LWI	10.23	Greenwich Low Water Interval (in hours)



Where is the datum?

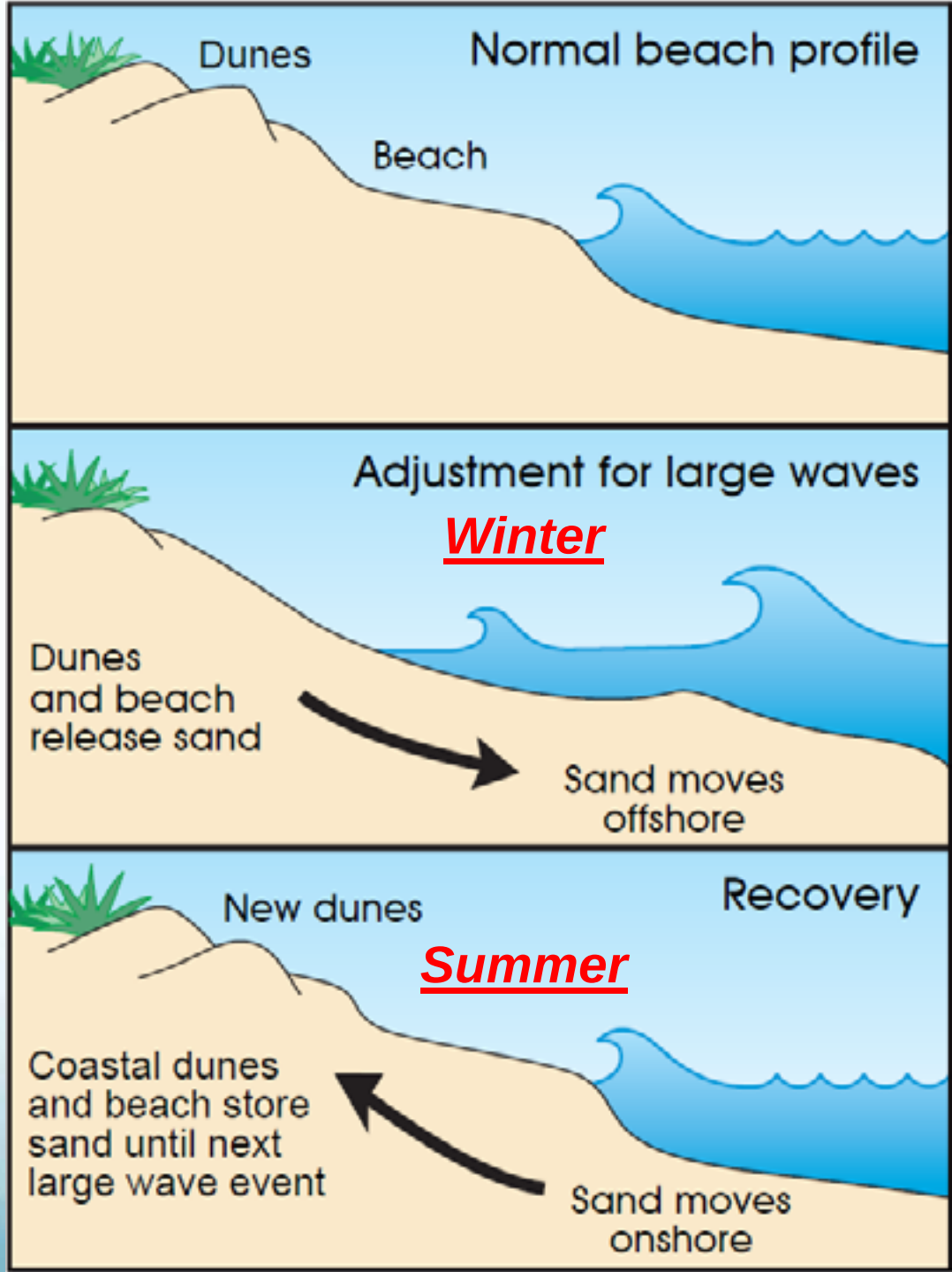
Which beach reference feature (PROXY) is best for MHW?



Daily/Seasonal Variability

Daily/Seasonal Variability

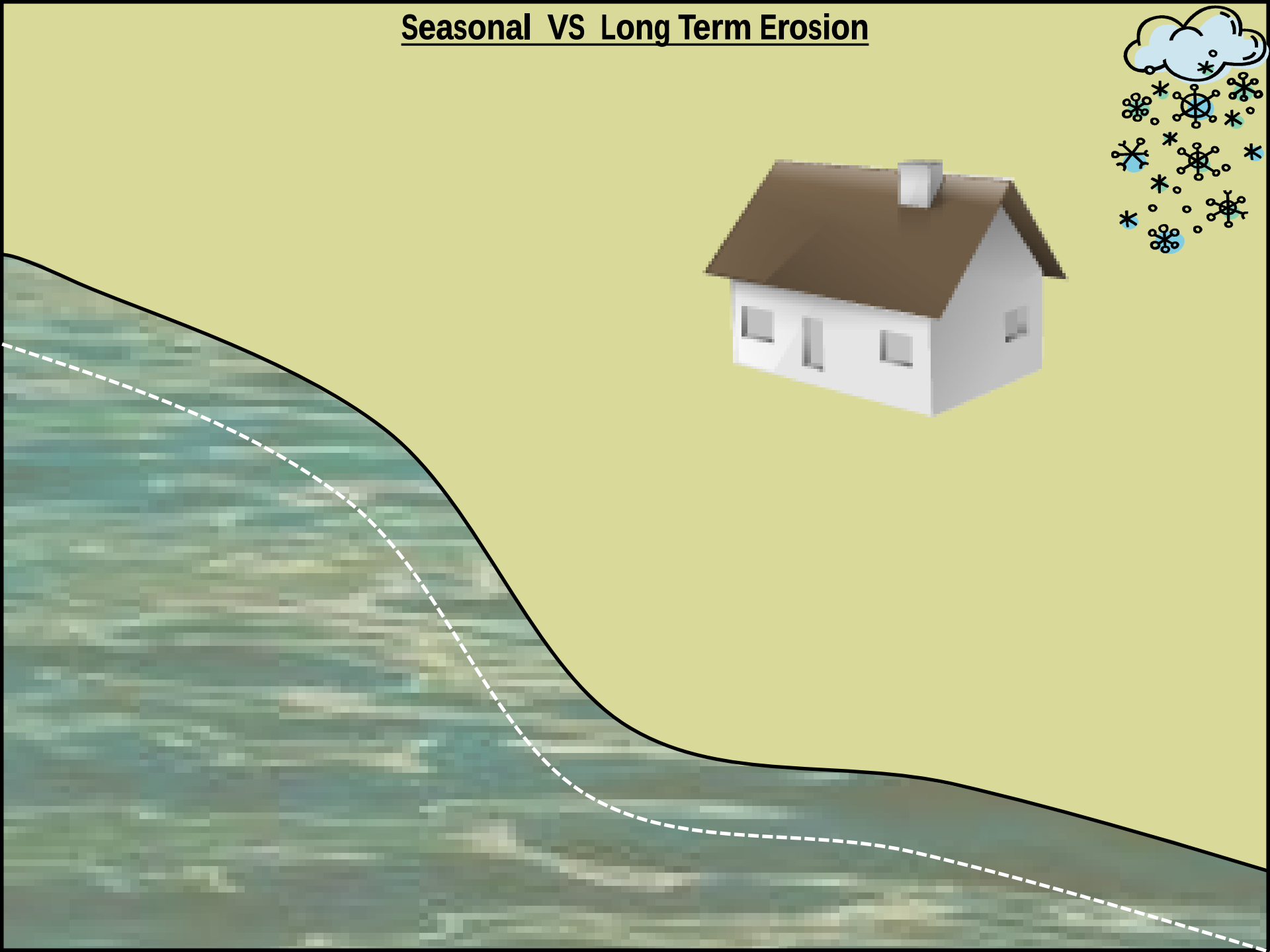
Beach Profile Adjustments
Large waves, which tend to occur in the winter in Massachusetts, cause the beach to temporarily change its profile.



Images adapted from ***Natural Hazard Considerations for Purchasing Coastal Real Estate in Hawaii - A Practical Guide of Common Questions and Answers,*** by University of Hawaii Sea Grant College Program, 2006.

Seasonal VS Long Term Erosion

Seasonal VS Long Term Erosion



Seasonal VS Long Term Erosion

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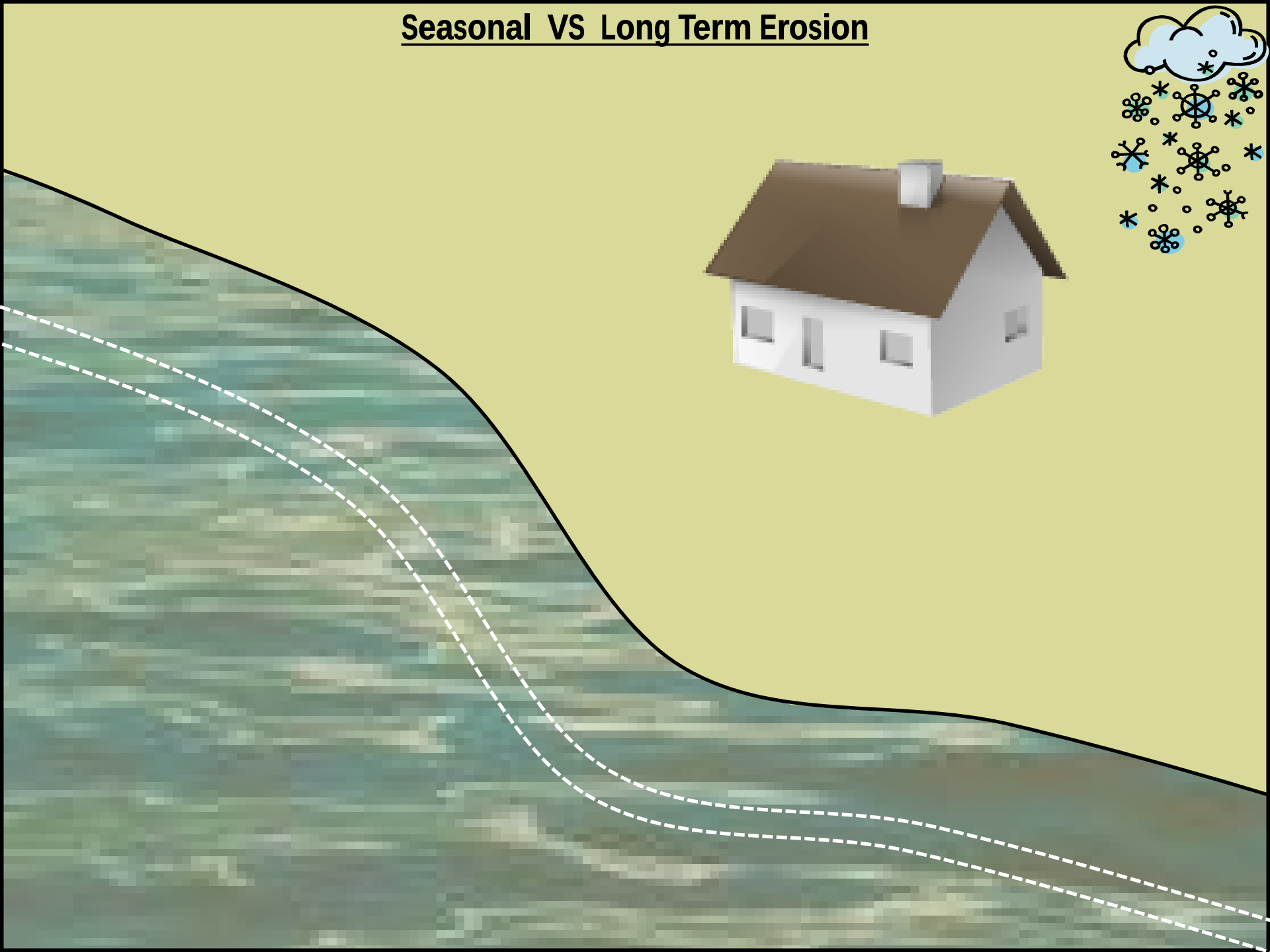

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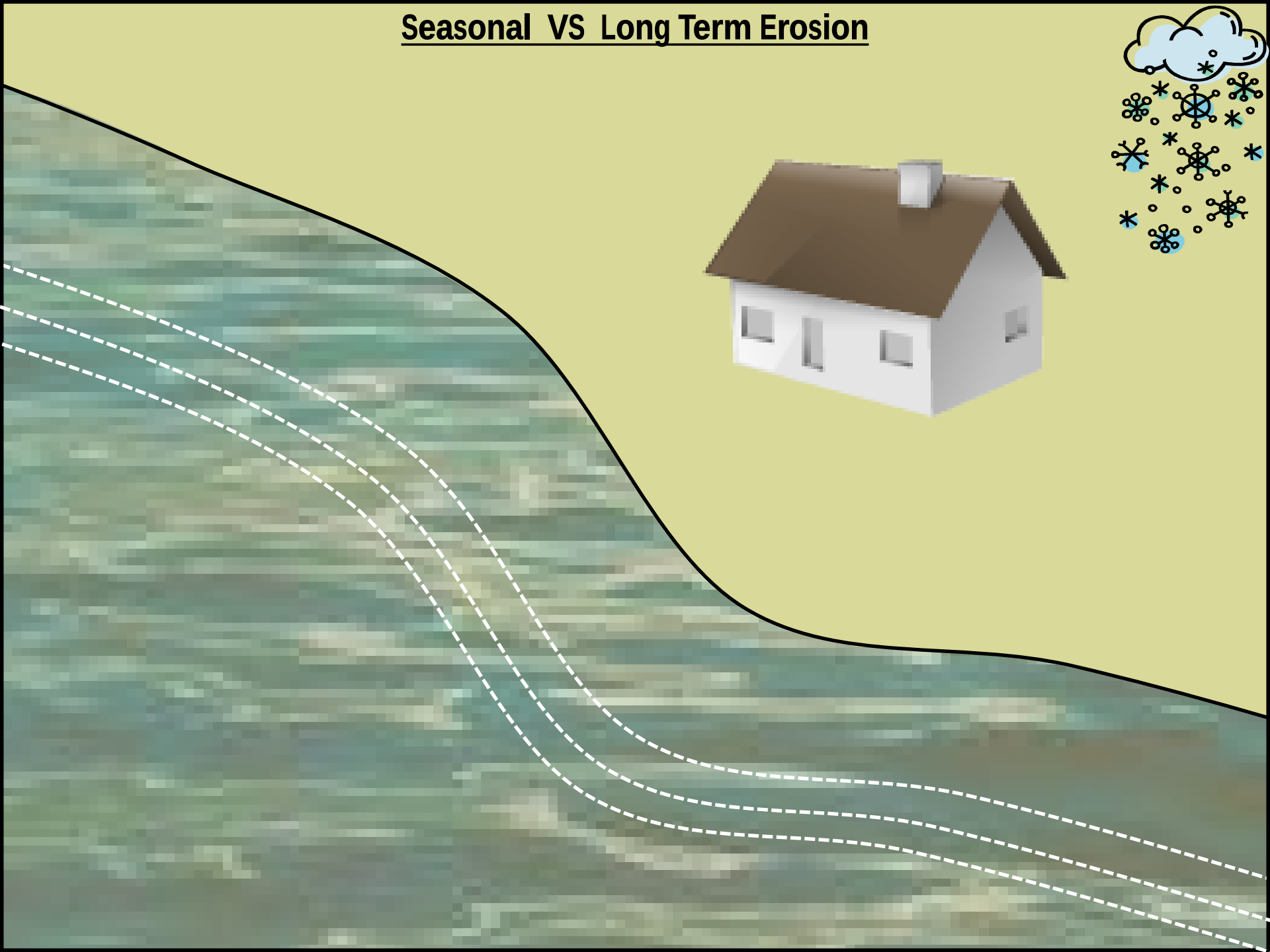
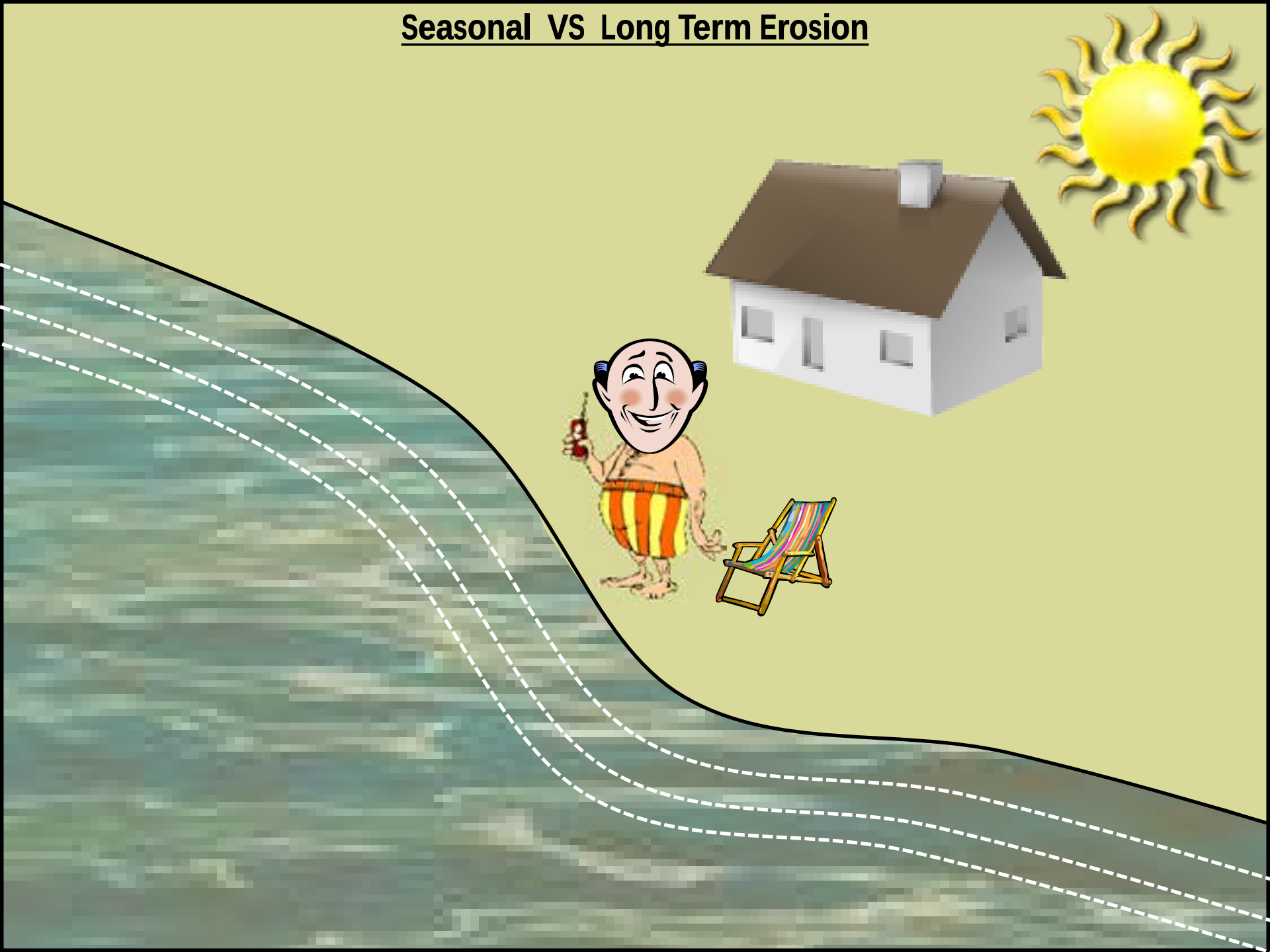
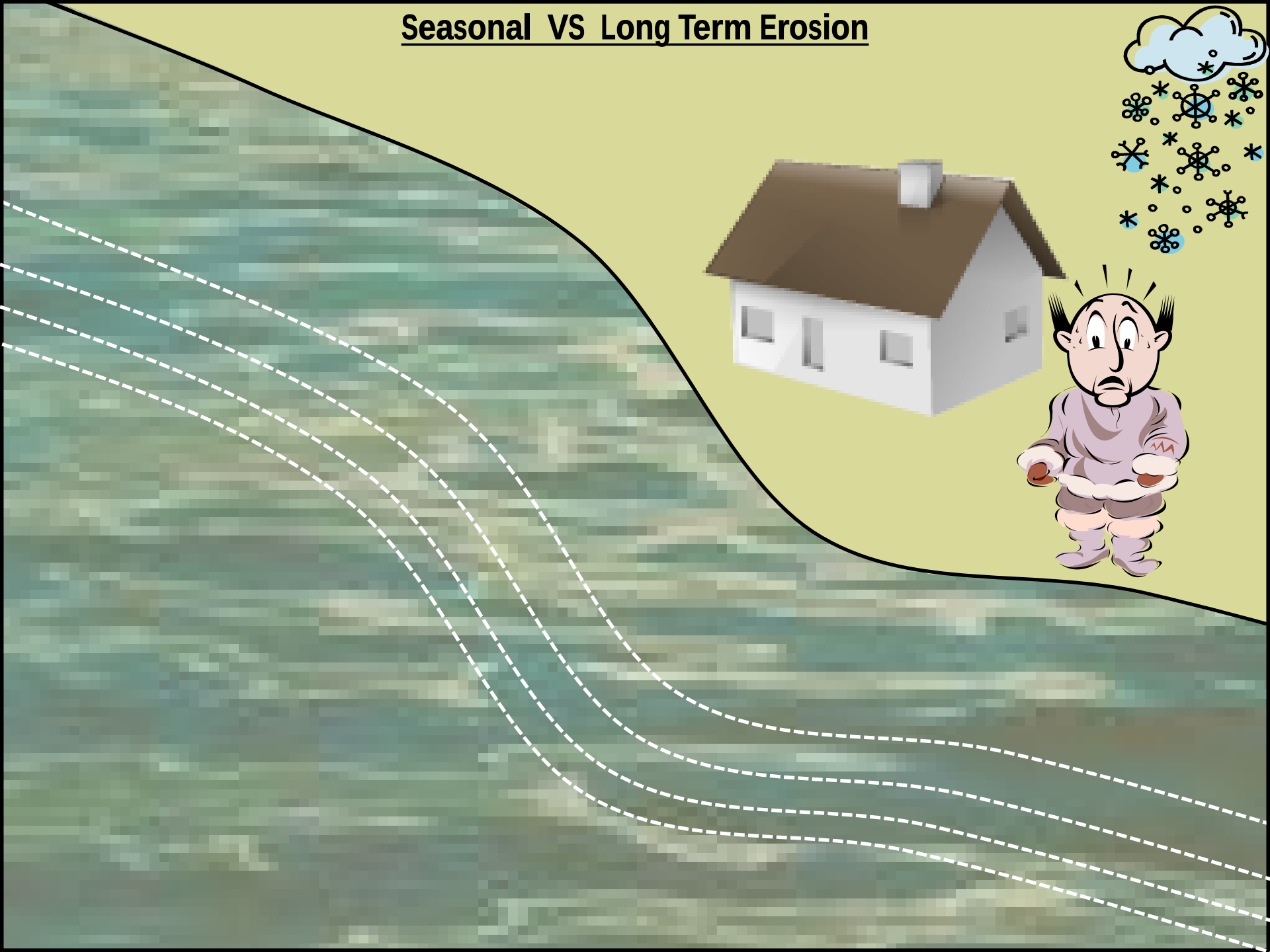


Seasonal VS Long Term Erosion



Seasonal VS Long Term Erosion



Eastham – Coast Guard Beach

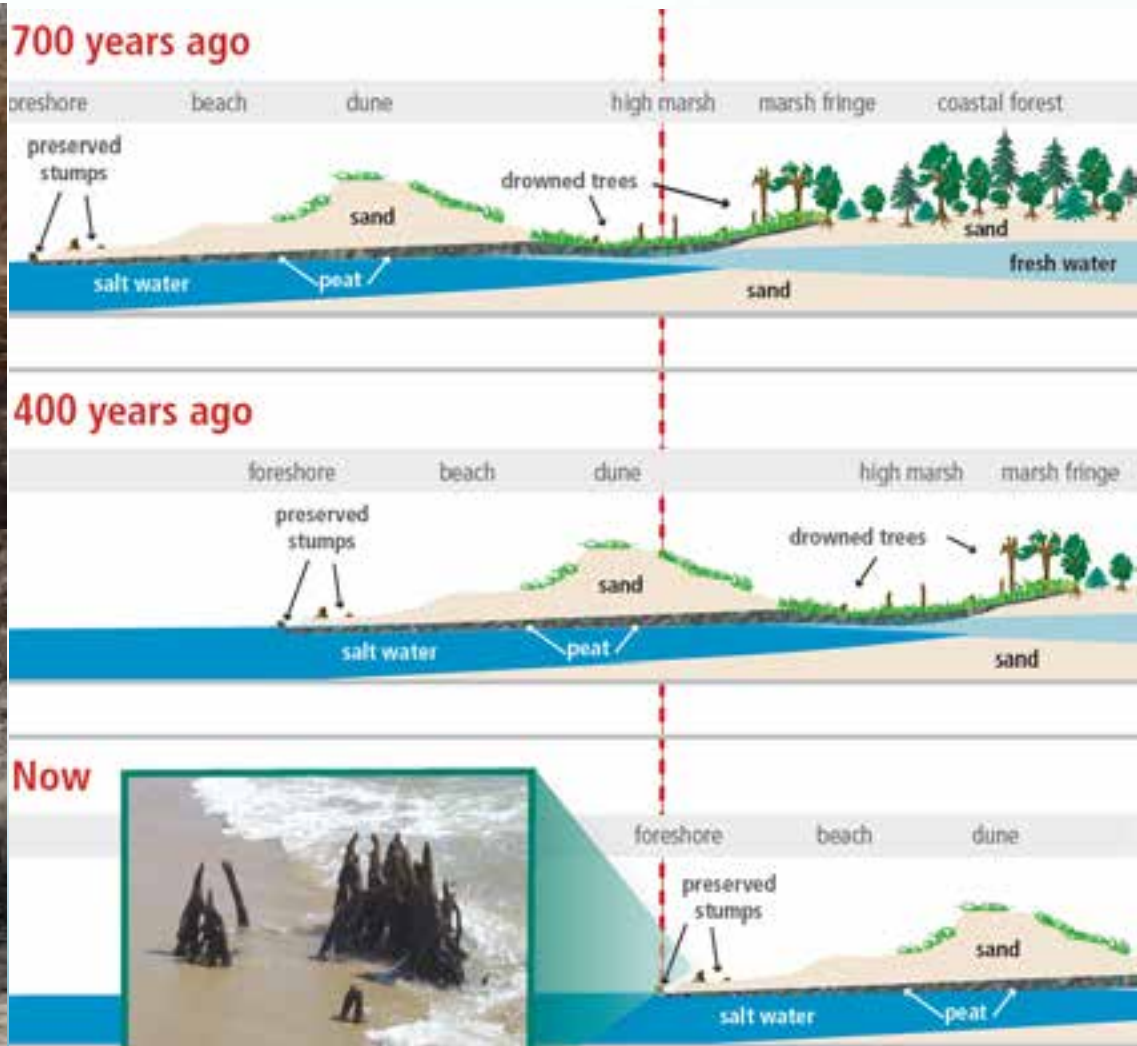
The exposed features are typically short-lived on our shoreline.

over 5’ of sand

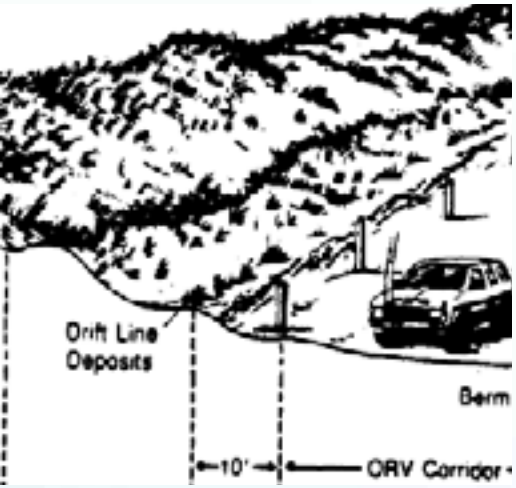
March 2013

Photo Credit: Ann McNichol

May 2013

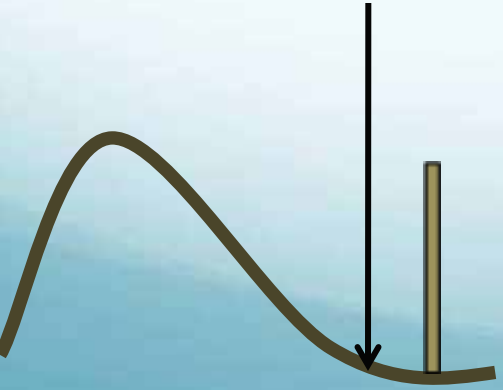


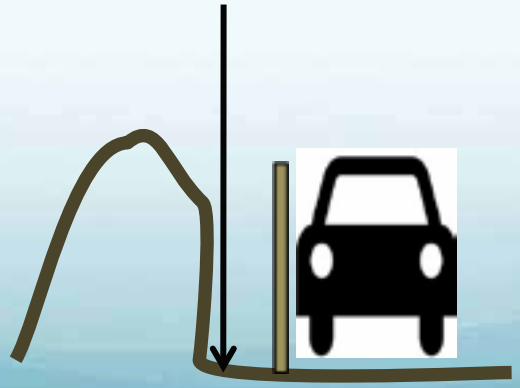
Dennis/Yarmouth – Chapin Beach

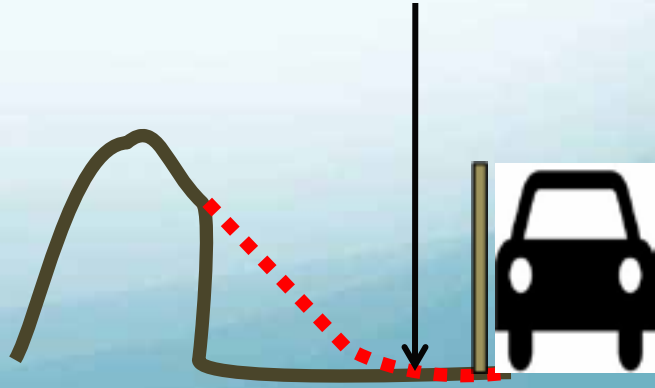


Triggers for 10' buffer (posts)

- Spring High Tide / Spring Wrack
- Vegetation
- Toe of dune
- Theoretical toe of dune







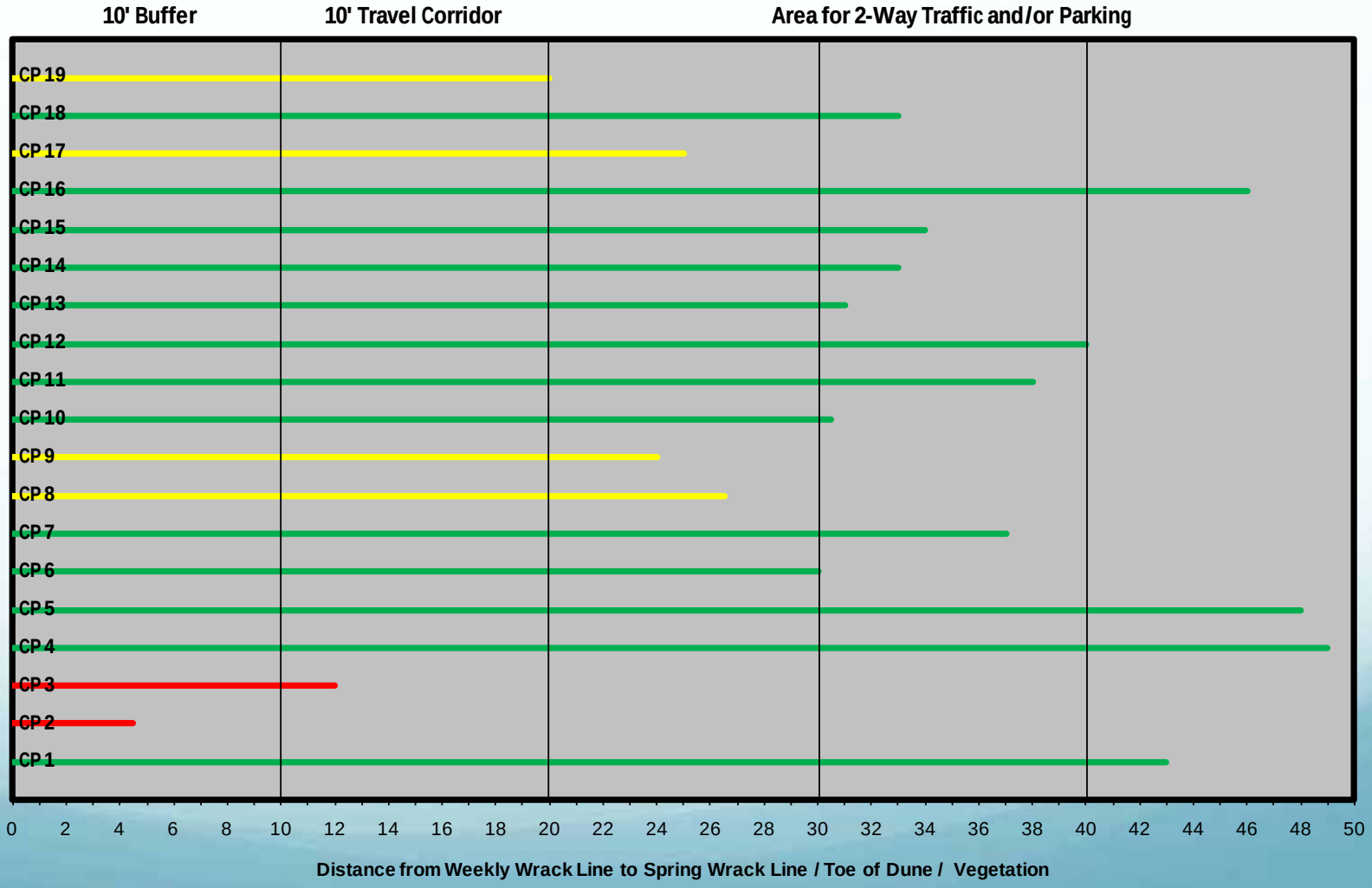
Crowes Pasture, Dennis, MA - April 16, 2010

Results:

Corridor < CP03 - Most = two-way traffic and/or parking

CP19= one-way traffic (turn or park?), Yellow = one-way traffic

Go North, Not South!



Crowes Pasture, Dennis, MA - April 16, 2010

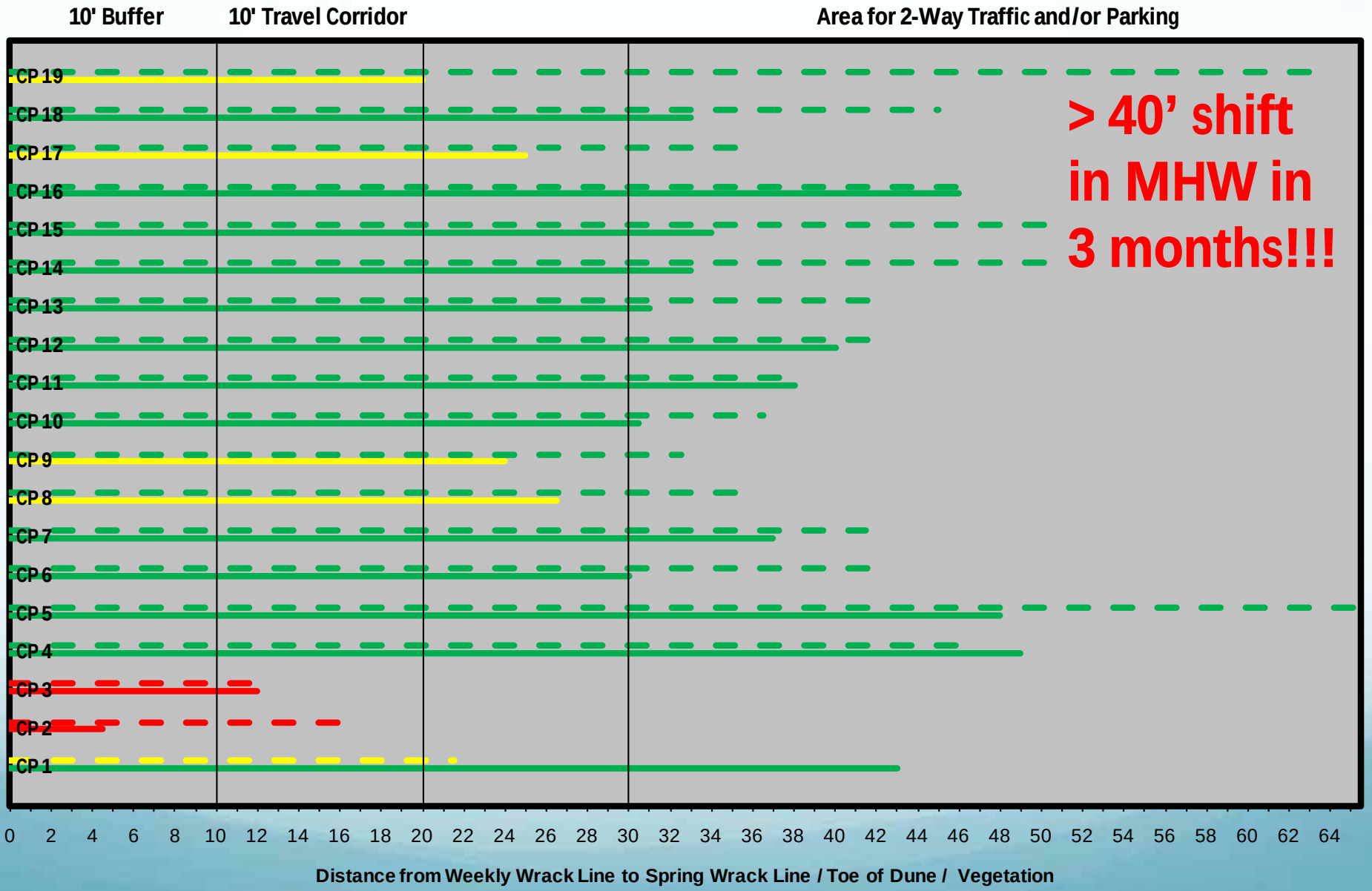
Results:

Corridor < CP03 - Most = two-way traffic and/or parking

CP19= one-way traffic (turn or park?) - CP8/CP9/CP17/CP19 = one-way traffic

Go North, Not South!

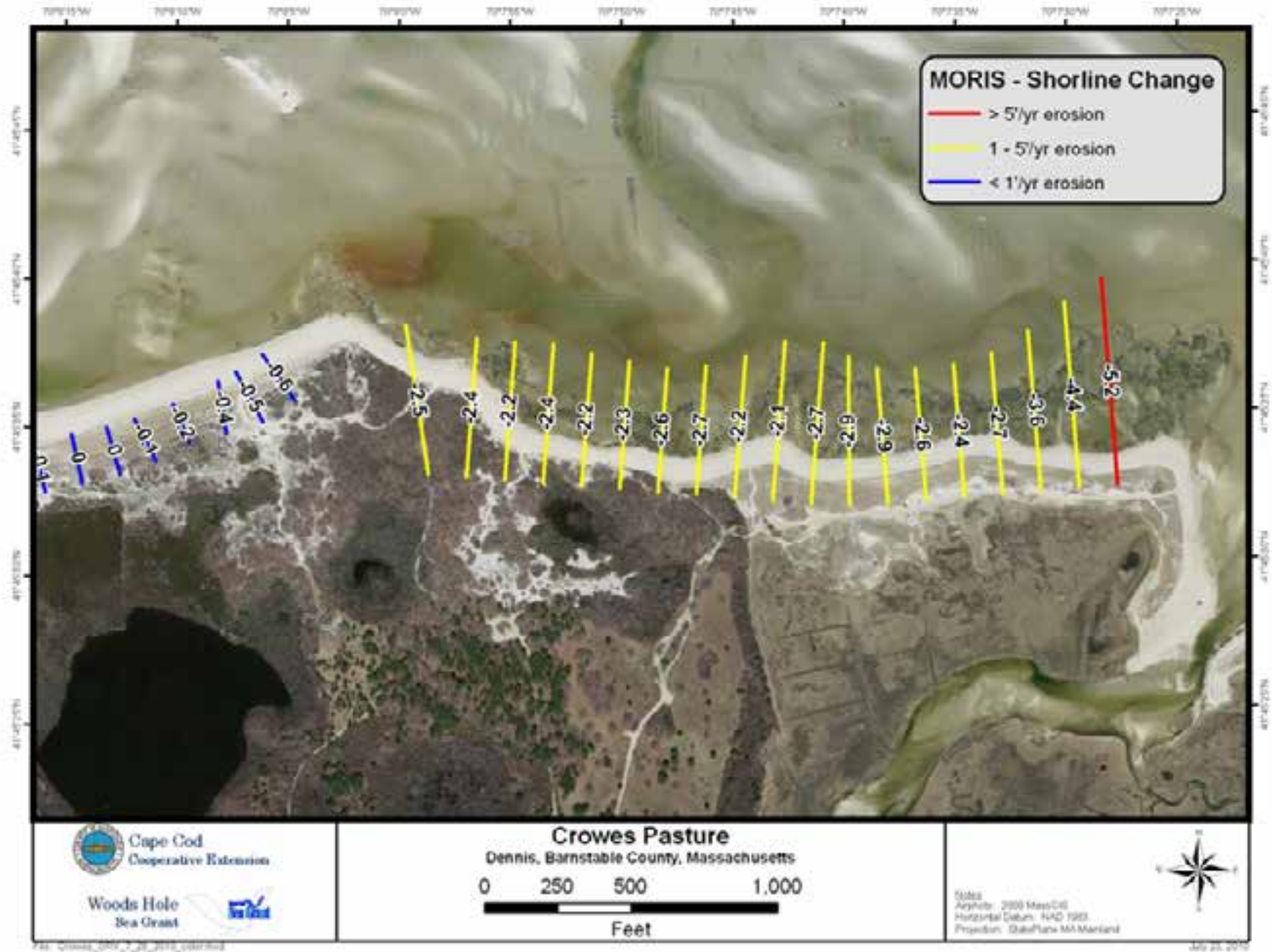
Crowes Pasture, Dennis, MA - April 16 - July 28, 2010



April 16 & July 28, 2010

Coastal Bank / Coastal Dune:

Crowes Pasture, Dennis, MA



Crowes Pasture, Dennis, MA

Recommendations / Thoughts:

(1868 – 1994) Shoreline retreat rates around 2-3’ per year

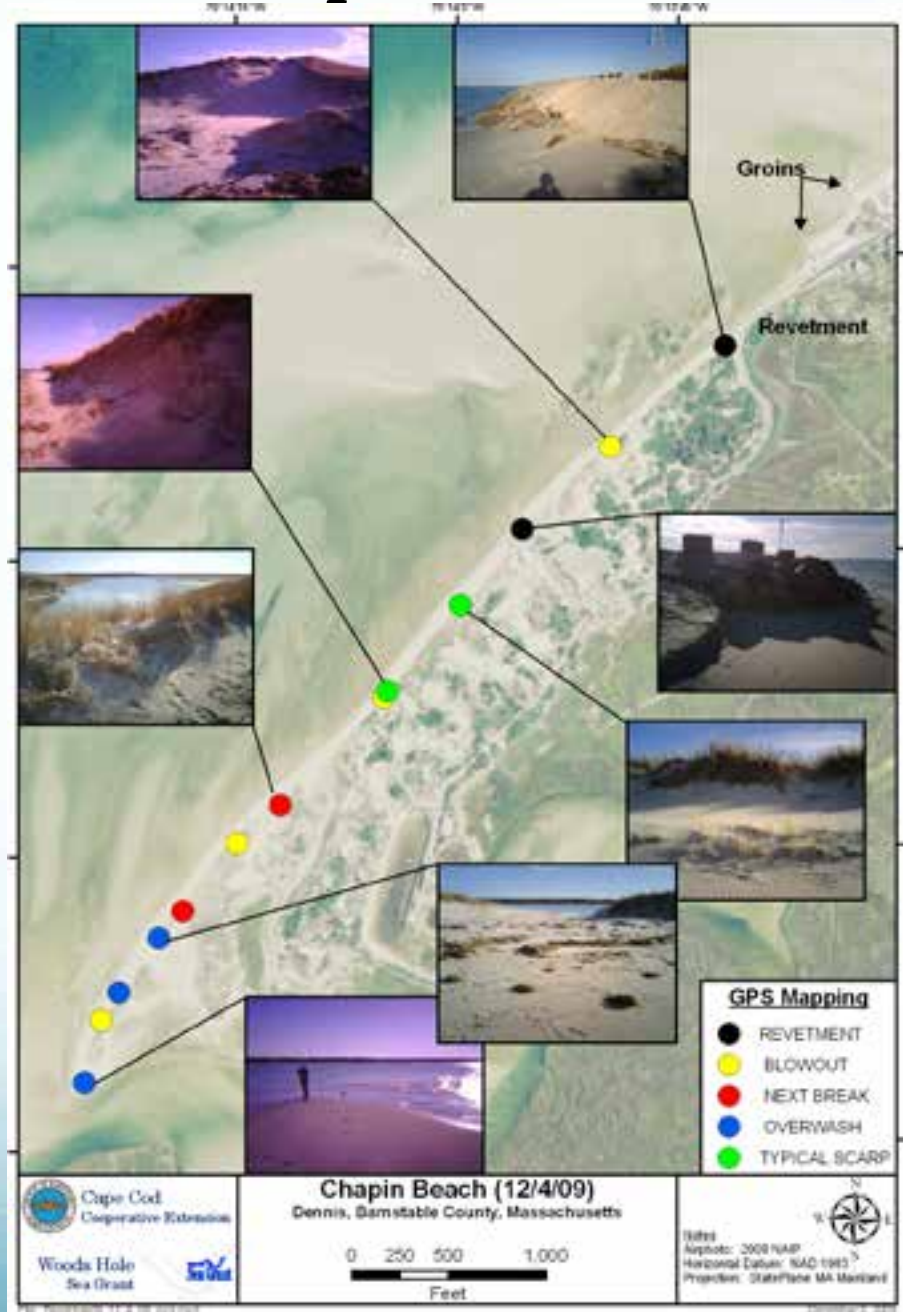
(1994–2009) Change (erosion + accretion) rates around 1-2’ per year

Chapin Beach, Dennis, MA - April 8, 2010

Recommendations / Thoughts:

Overwash and blow-out areas are concerning.

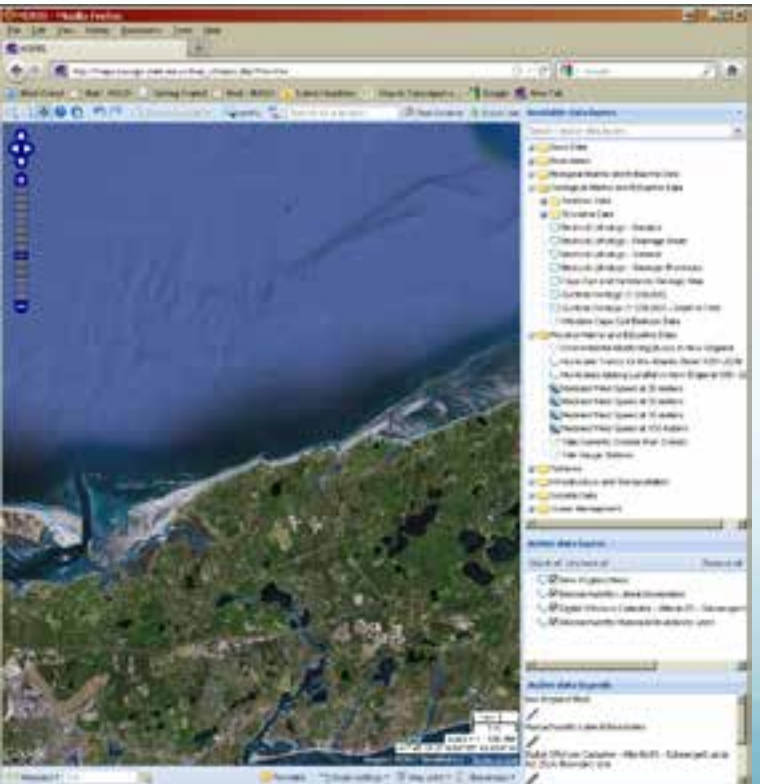
Indicate a beach experiencing relatively rapid erosion.



Chapin Beach, Dennis, MA

Massachusetts
Ocean
Resource
Information
System:

CZM's Online Mapping Tool

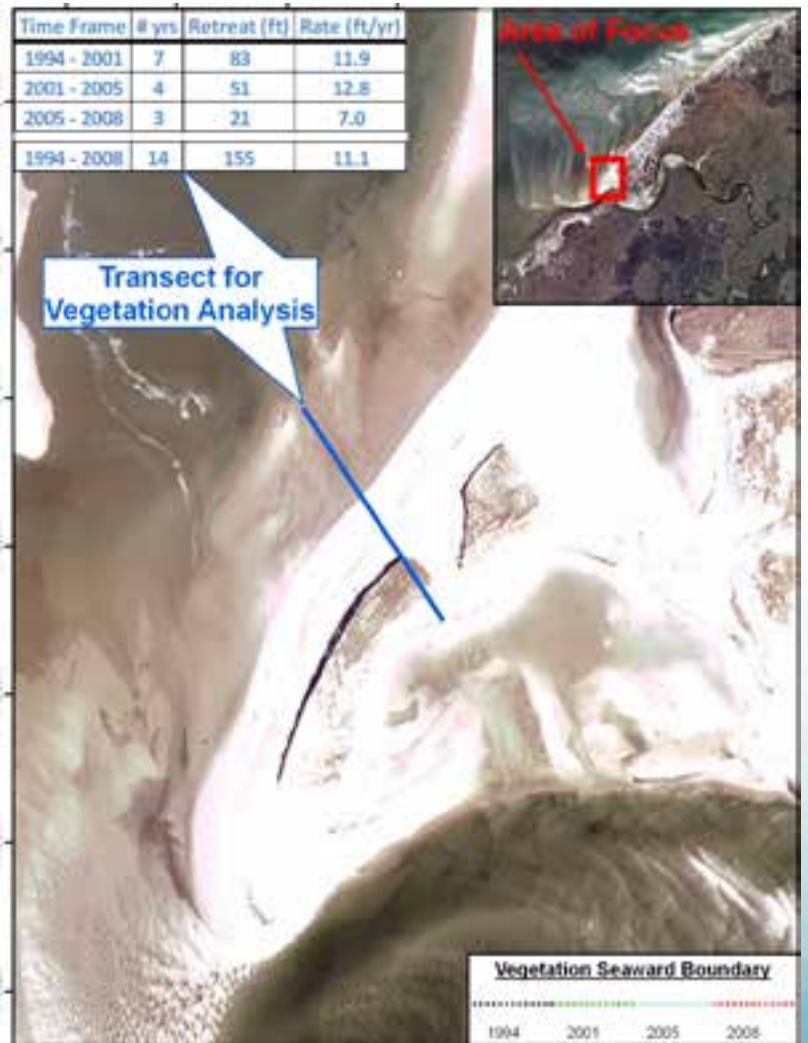


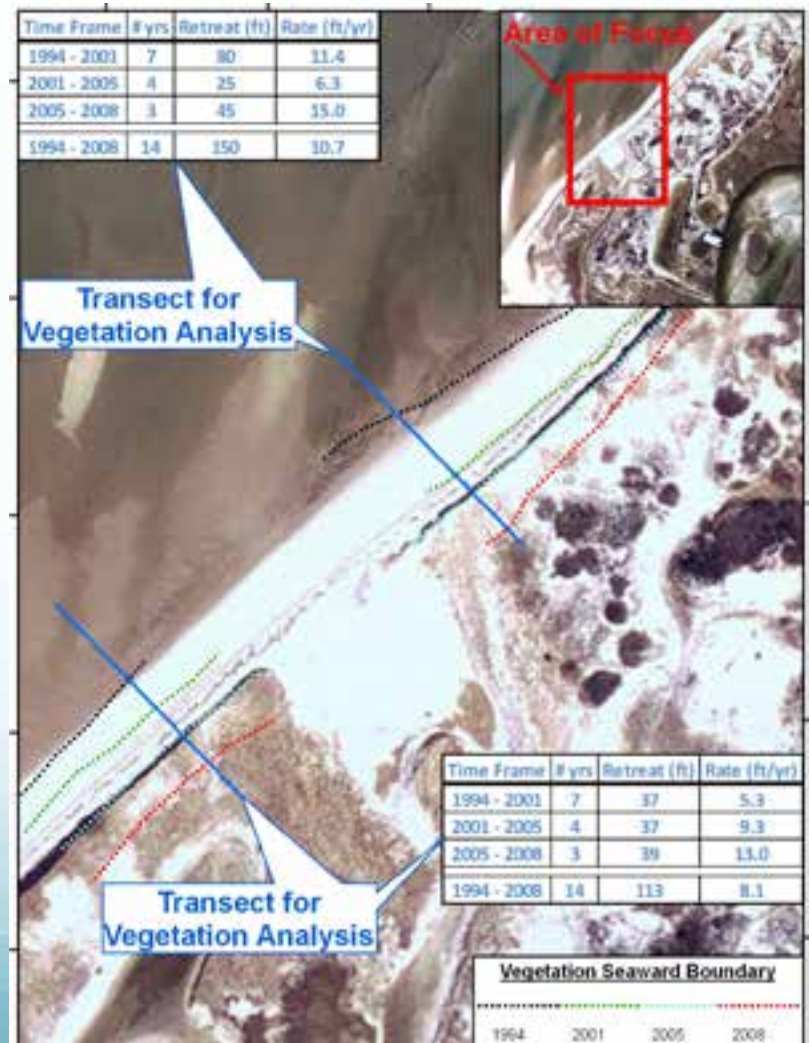
Chapin Beach, Dennis, MA

Recommendations / Thoughts:

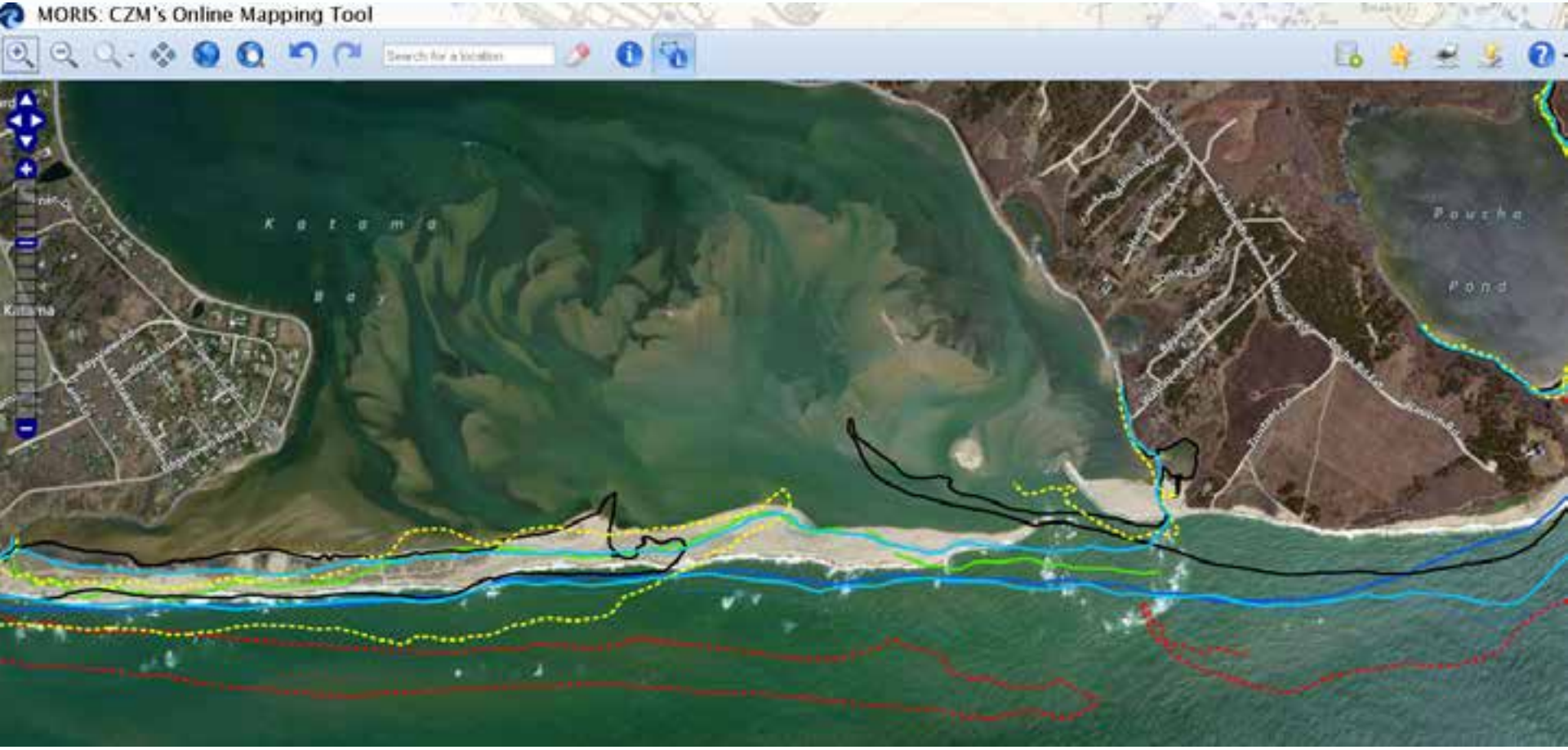
(1934 – 1994) Shoreline retreat rates up to 20' per year and average around 6-12' per year

(1994–2009) Dune retreat rate up to 15' per year and average around 11' per year

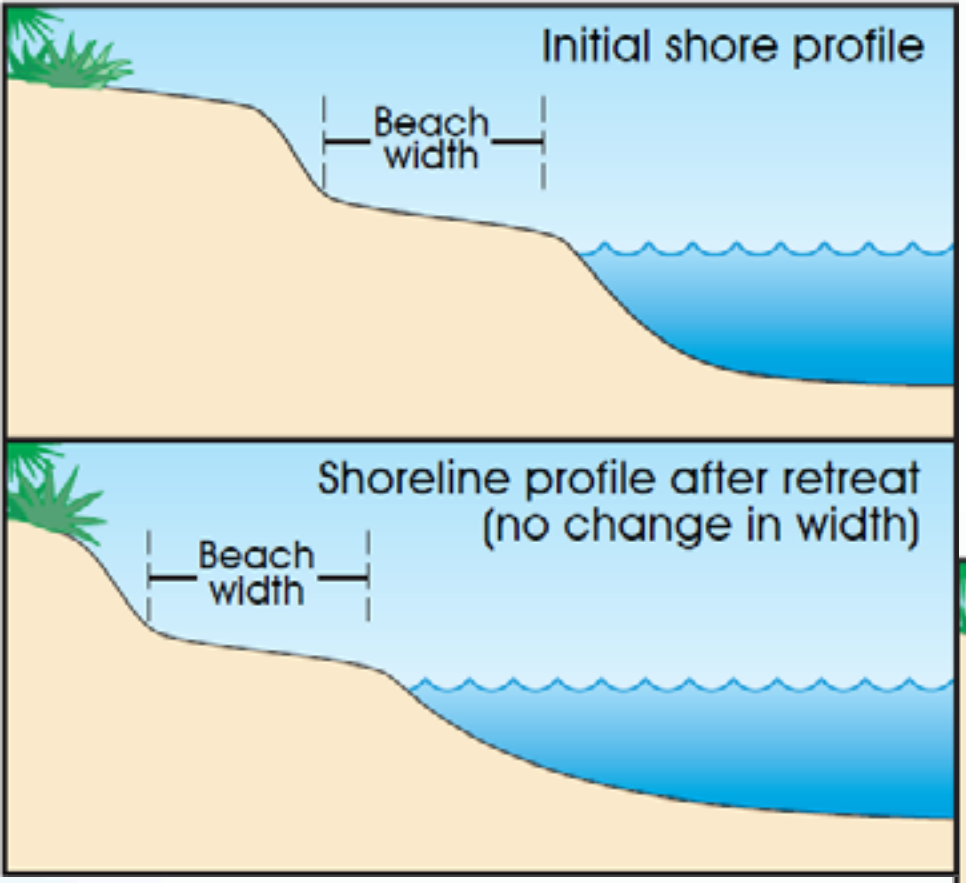




Even Long-Term erosion rates can be of limited use in some areas

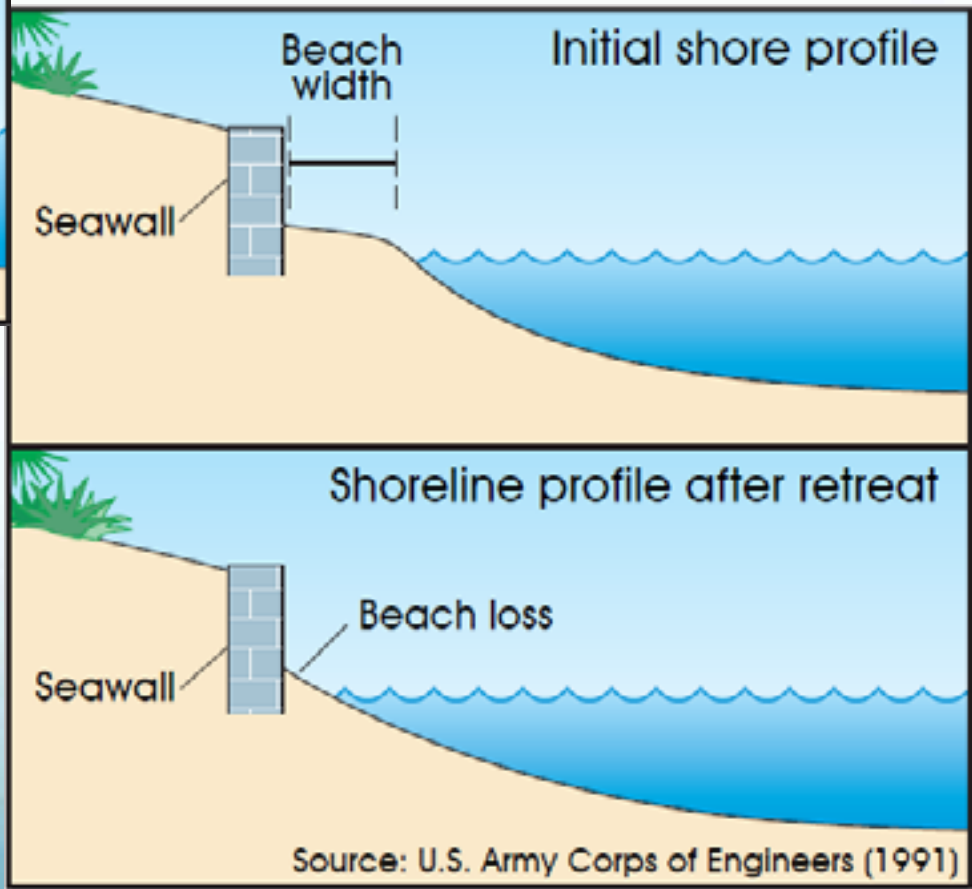


Other Shoreline Reference Marks



A beach undergoing net longterm retreat will maintain its natural width.

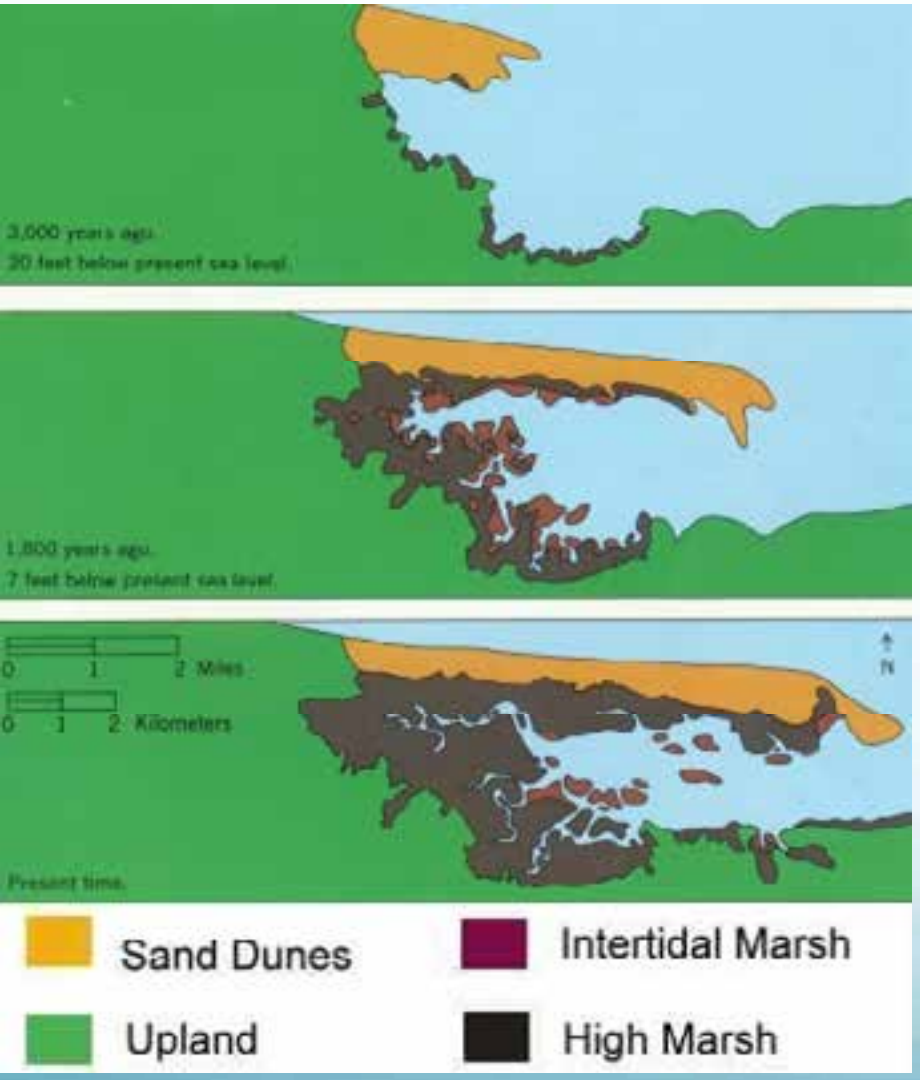
Beach loss eventually occurs in front of a seawall for a beach experiencing net longterm retreat.



Images adapted from ***Natural Hazard Considerations for Purchasing Coastal Real Estate in Hawaii - A Practical Guide of Common Questions and Answers,*** by University of Hawaii Sea Grant College Program, 2006.

2 Ways for Beaches to Move

Parallel to Shore



Perpendicular to Shore

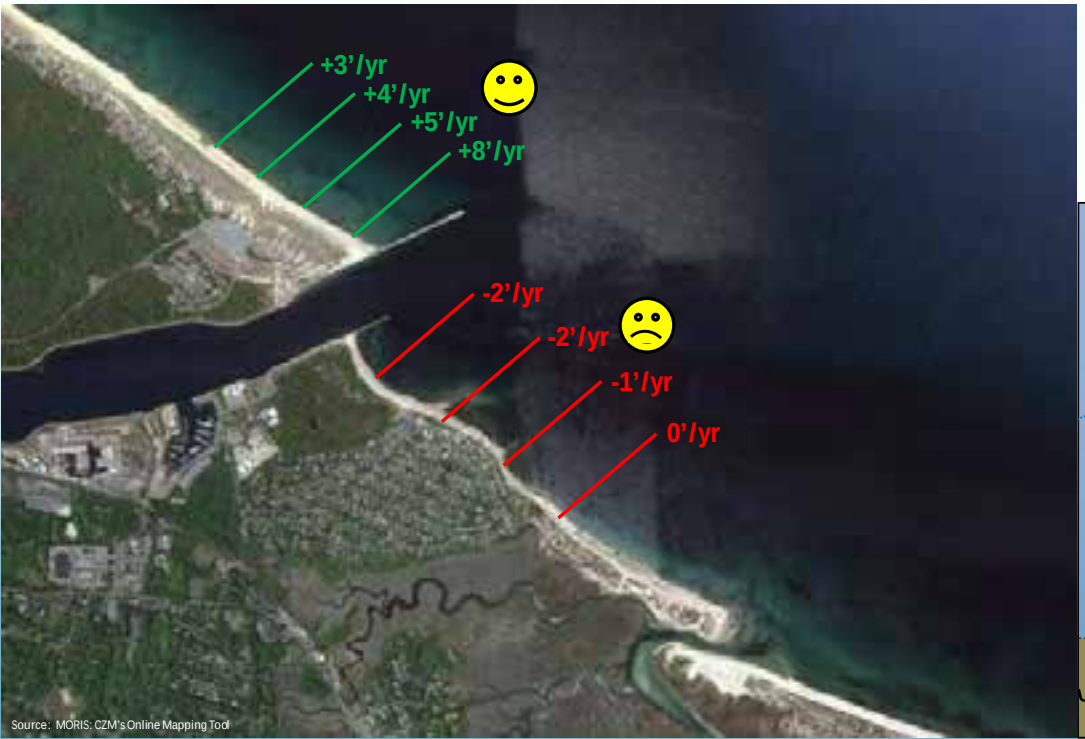
1st appeared as ridges (far out on continental shelf) flooded by SLR

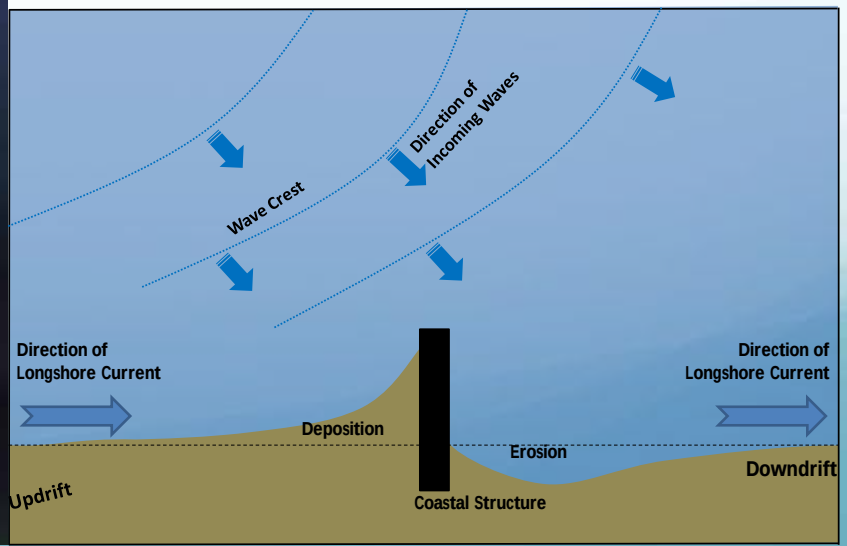
Rising SL breaches the beach ridge and floods behind creating a bay.

System migrates landward across the shelf and SL as rises.

General Coastal Processes

Transects on Scusset Beach in Bourne show long-term accretion rates of more than seven feet per year. However, the short-term accretion rates of approximately five feet per year are more reflective of the current shoreline trend. The north jetty of the Cape Cod Canal was constructed in the early 1900s and resulted in an initial rapid growth of Scusset Beach, contributing to the higher long-term rates that have since leveled off.





Estuaries can change quickly

Chatham - Andrew Harding's Beach

The only constant is change:

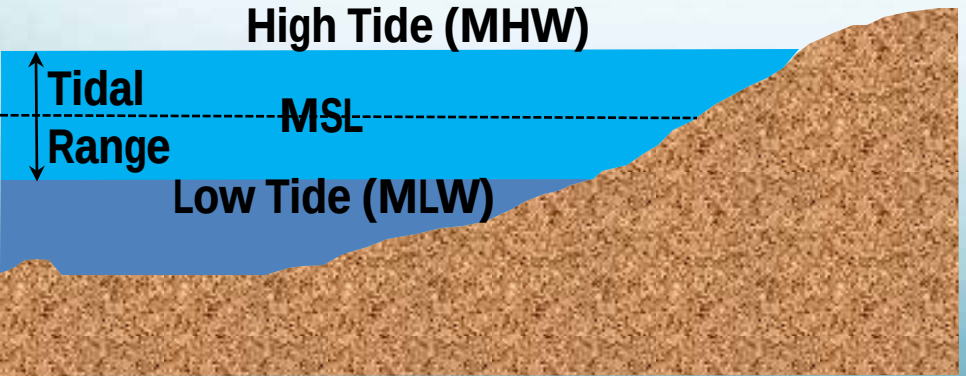
2007 inlet = bad for Scatteree,
good for Andrew Harding

April 2011

Photo Credit: Ted Keon

Changing Tides

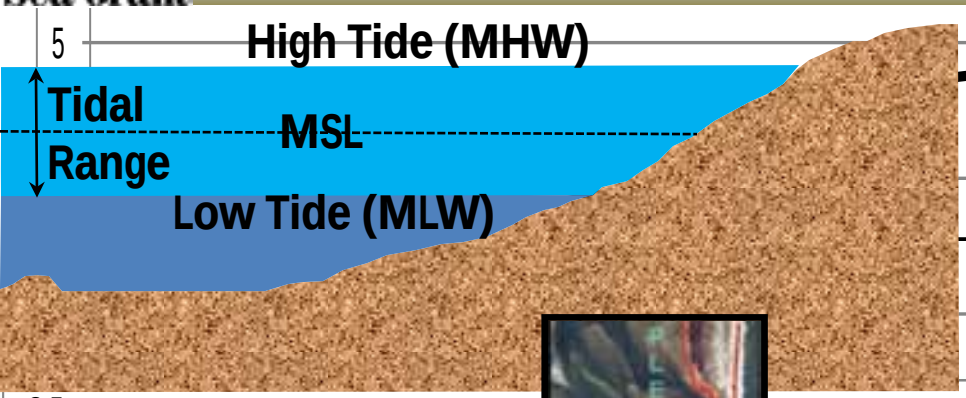
"The formation of the 2007 inlet resulted in bigger tides in Pleasant Bay. However, over the past two years that trend has reversed."



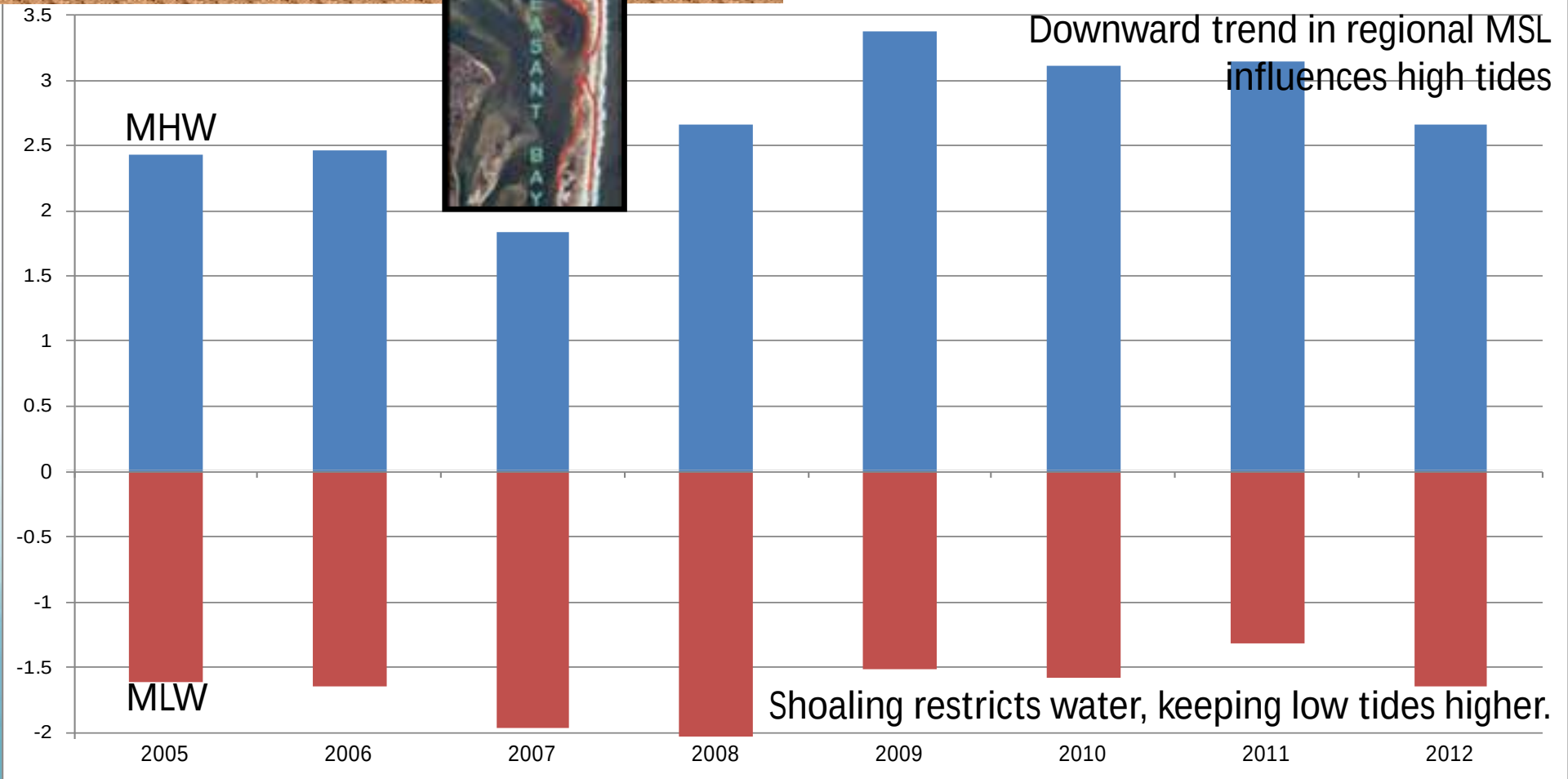
More "flushing" can improve WQ

Higher tide can erode more

Changing Tides – Meetinghouse Pond



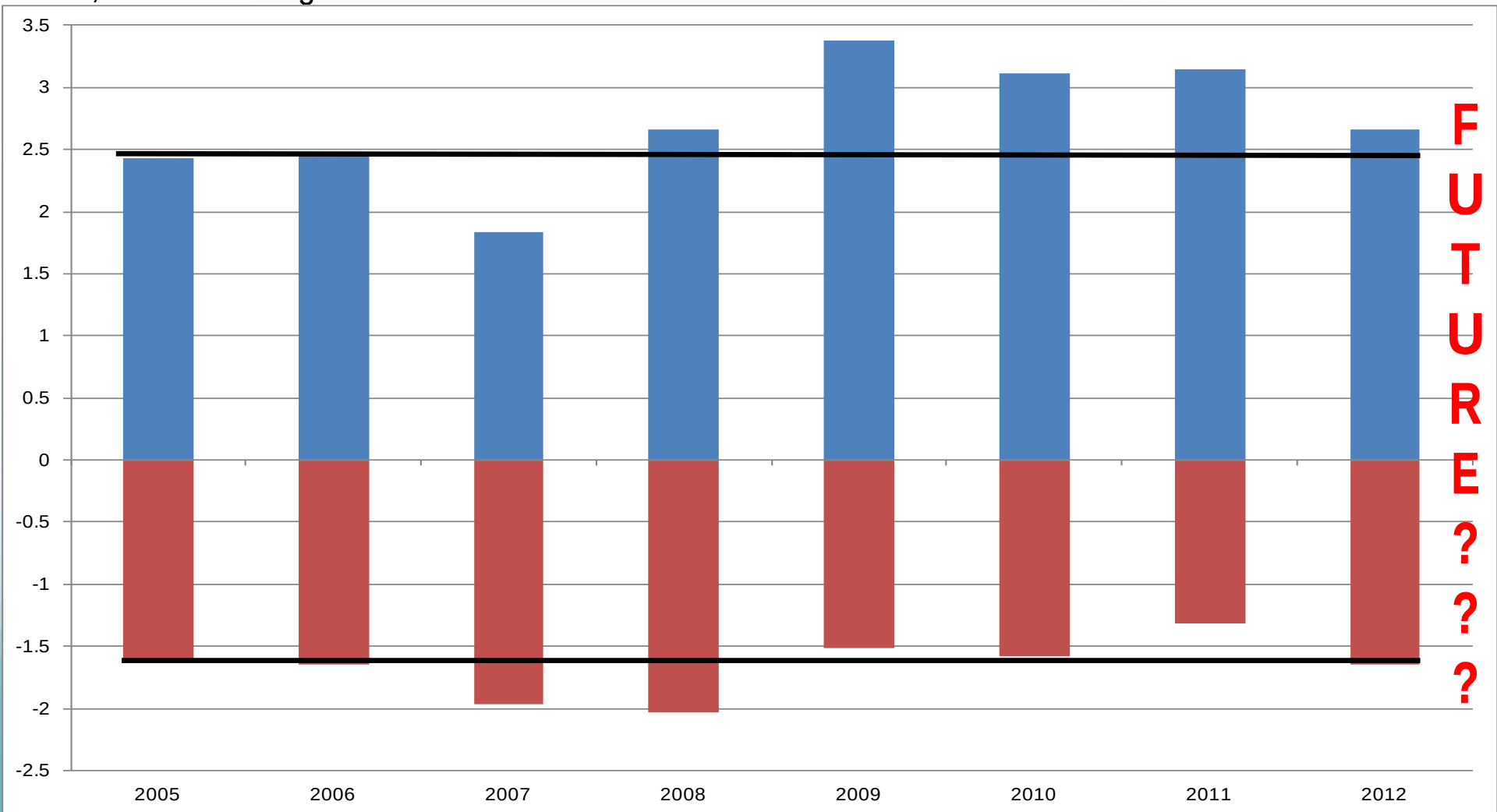
HW + MLW = Tide Range



Changing Tides - Summary

Volume of water flowing in and out of Pleasant Bay in 2012 is about the same as it was right after the 2007 inlet formed

Tidal range is now less than at any time since soon after the formation of the second inlet in 2007, and mean high water is lower than it has been since 2009.

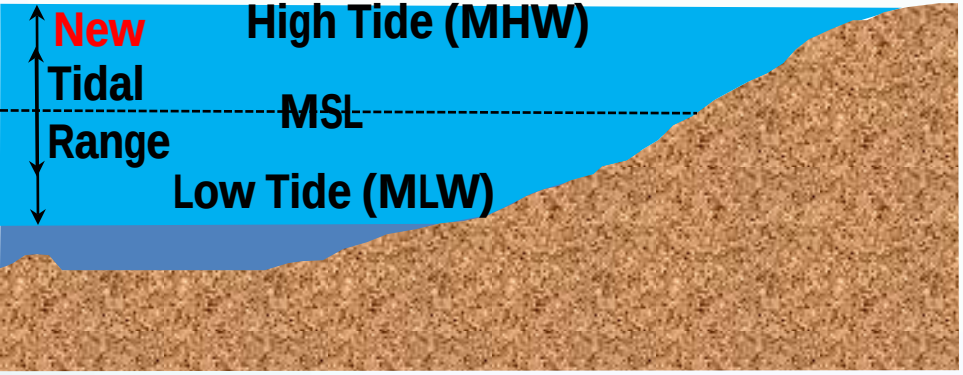


What causes shoreline change?

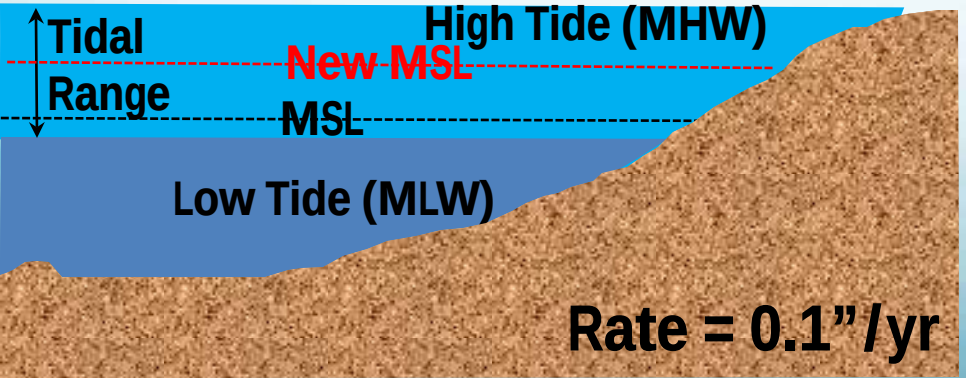
Natural

Change in Wind/Waves/Storms

Change in Tidal Range



Change in Sea Level



Human Induced

Seawall / Revetment

Bulkhead

Gabbion

Breakwater

Jetty

Groin

Summary – Site Specific !!!

Try to figure out the best shoreline reference mark for you project, and short-term vs long-term

More MHW = more space for your towel.

More concerned about top of bank than MHW!

Questions?

Moving away from proxy data and into land-based datums (NAVD88), but all our historic data for comparisons will still be proxy based.

http://oceanservice.noaa.gov/education/seafloor-mapping/lidar.html