Shifting Sands and the Shorelines of Nantucket

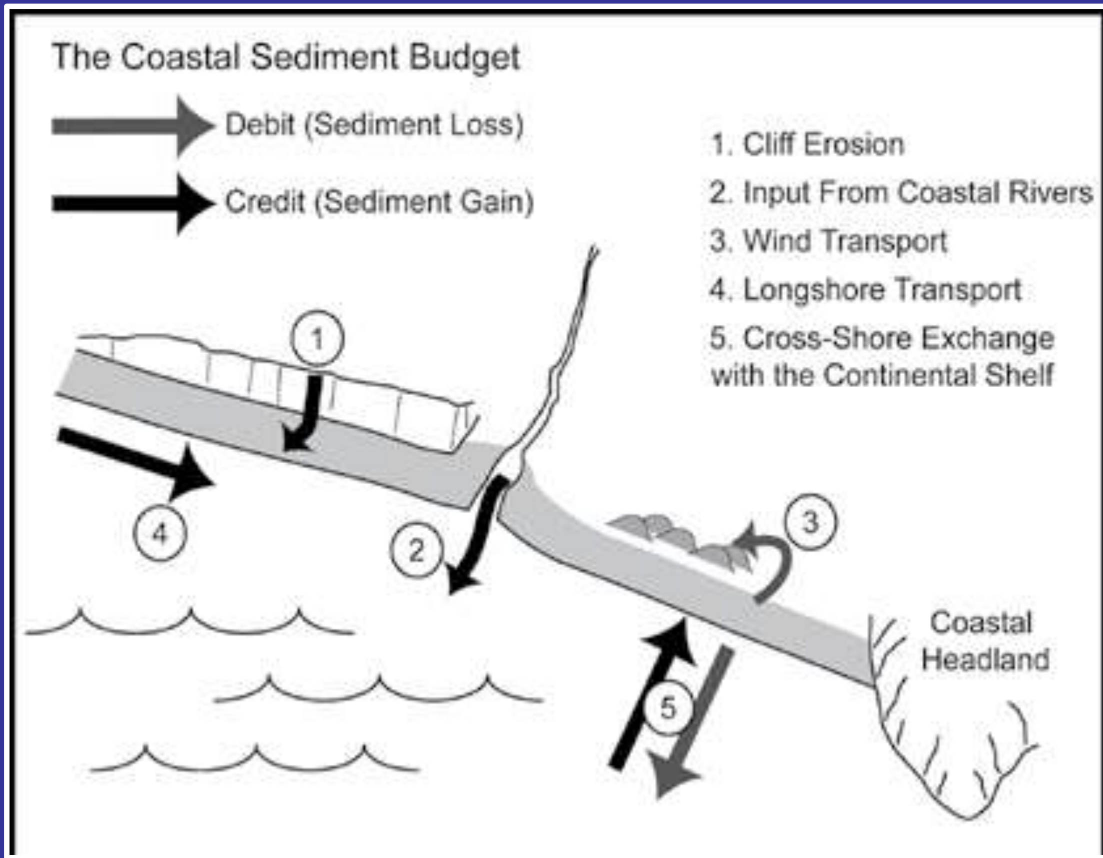
Andrew Ashton

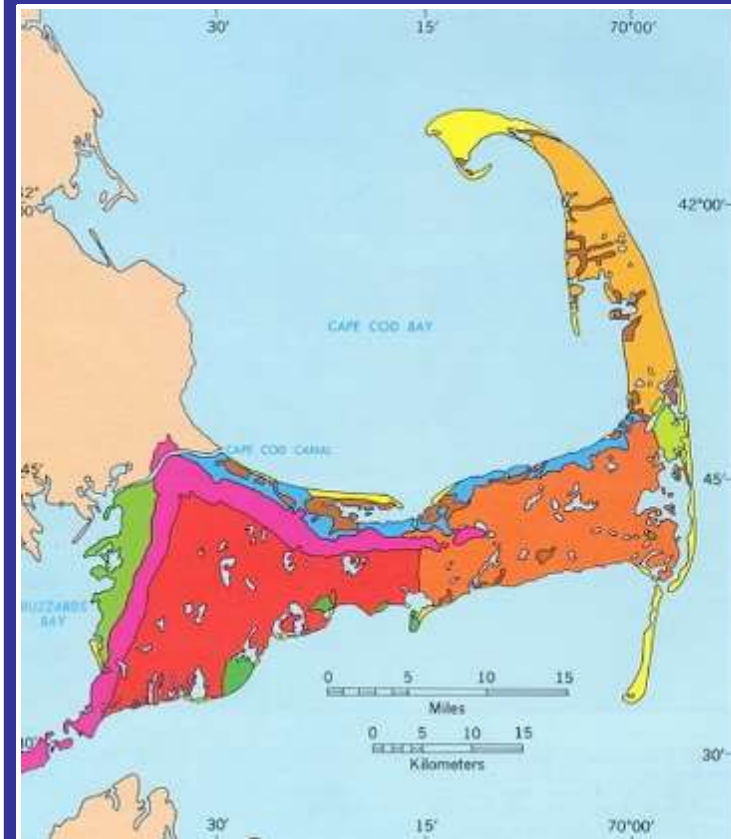
WOODS HOLE OCEANOGRAPHIC INSTITUTION
1930

perspectives

- Change is the constant along the coast
- The coastline is interconnected, from source to sink
- Current management problems are in most cases are not (yet!) related to human-induced climate change
- Sea-level rise and climate change effects will be superimposed on ongoing coastal change
- So wherever there are management problems now, they will get much worse.

coastal sediment budget





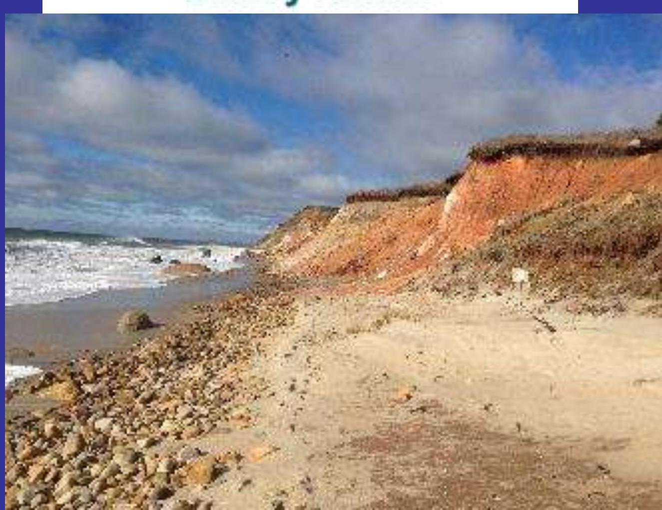
from Titus et al, 2009

Oldale, 2001

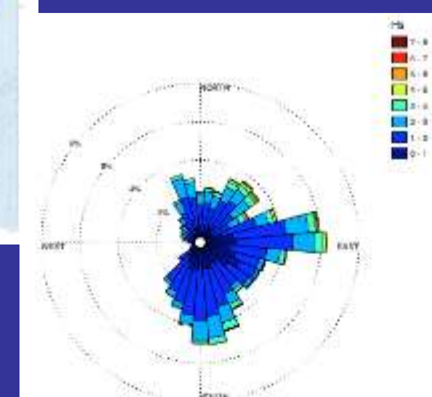
Erosional vs.Depositional Environments

sandy bluffs

- Cliffs and Bluffs
  - Loss is permanent
- Barriers and Dunes
  - Always changing
  - Accreting or being reworked

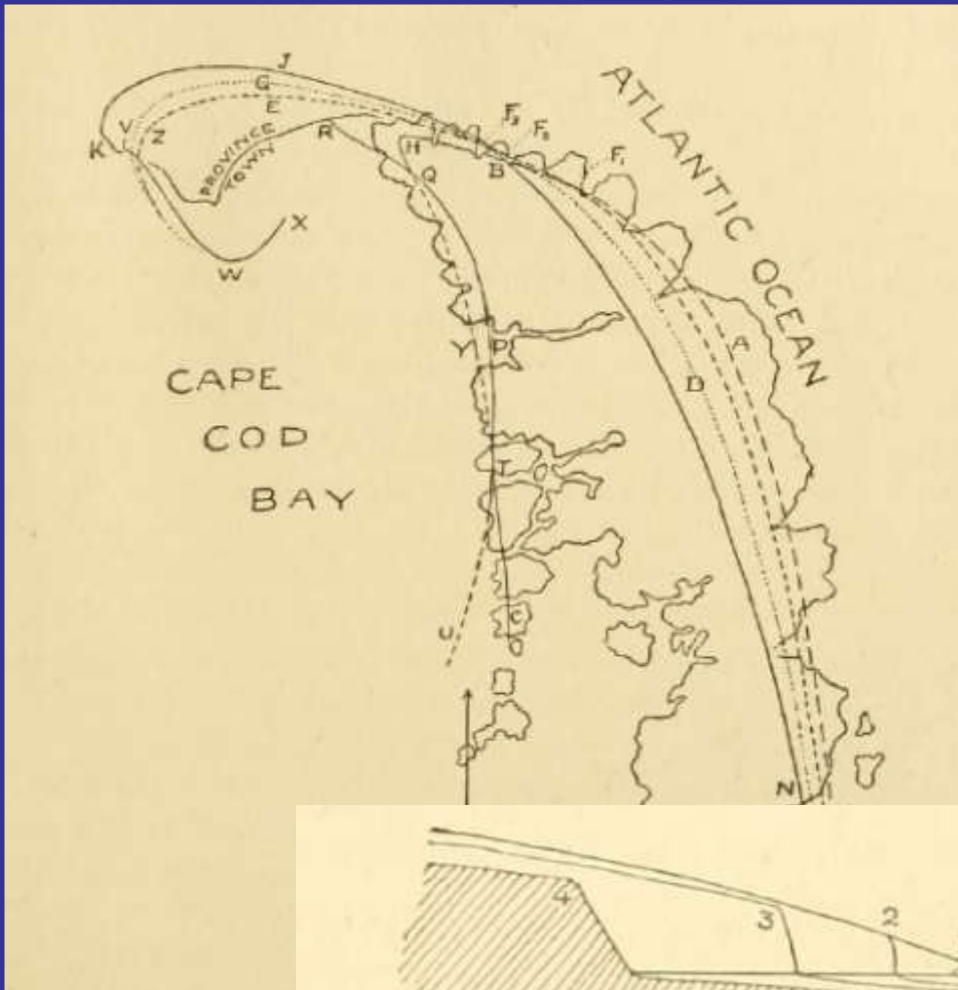


Geology of Nantucket



Oldale USGS, 1985

Processes Long Studied



The Outline of Cape Cod

by W.M. Davis, 1896

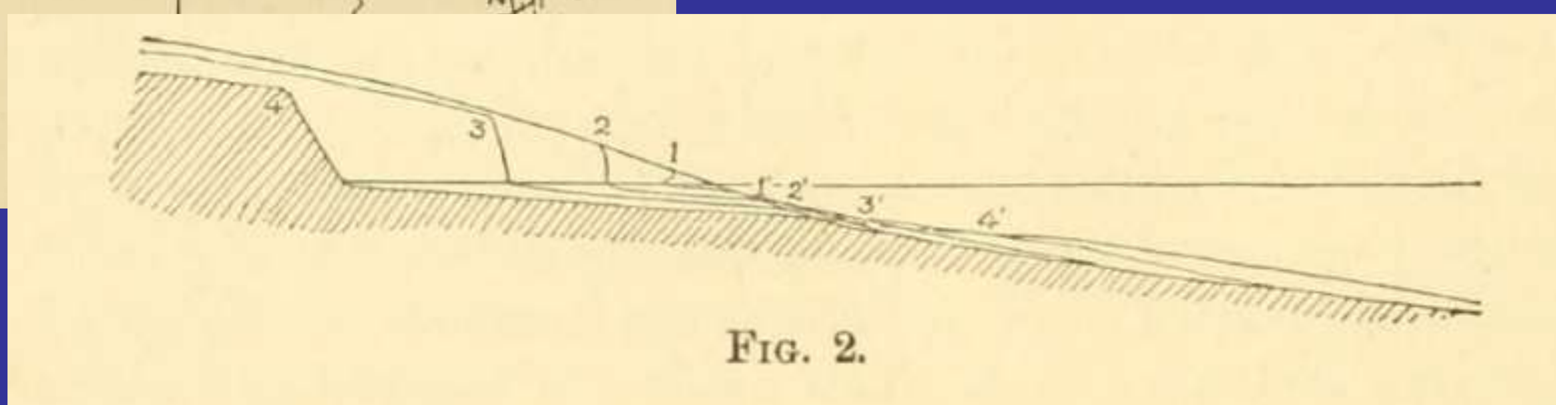
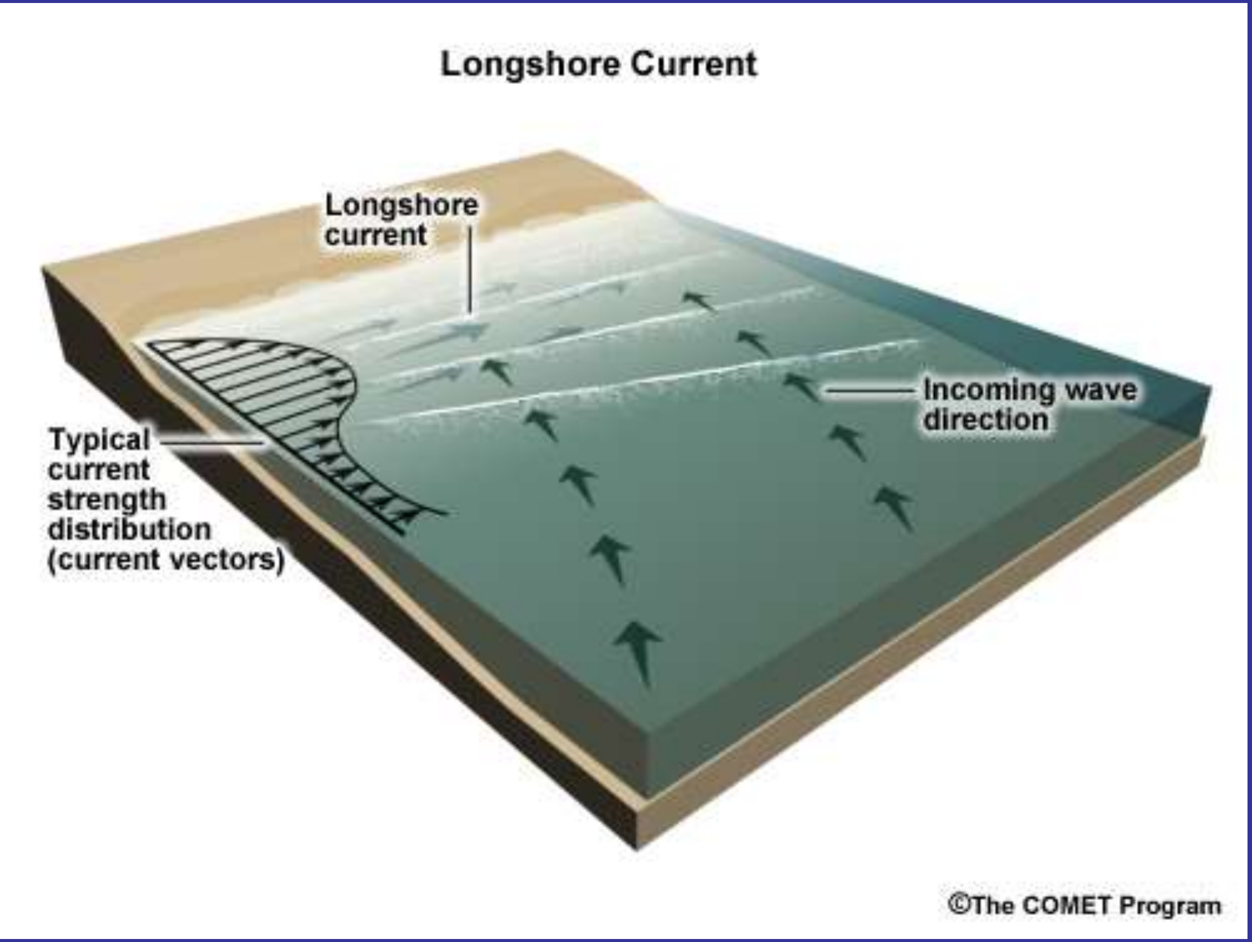


FIG. 2.

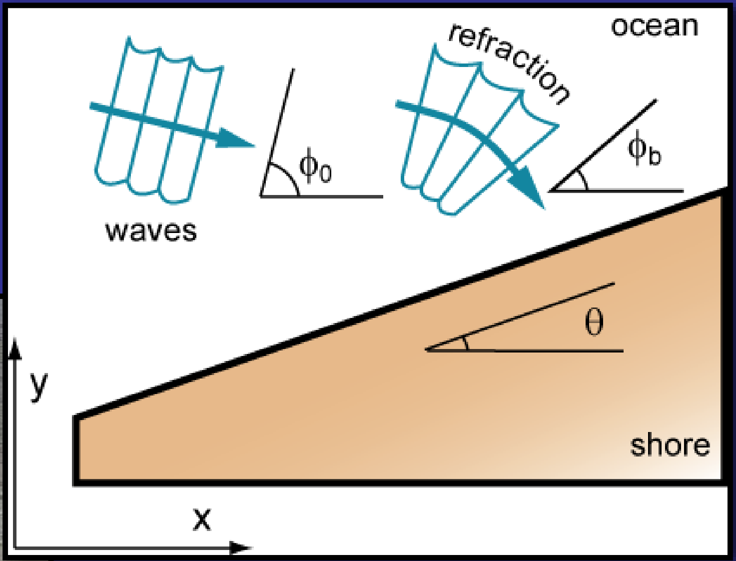
alongshore sediment transport

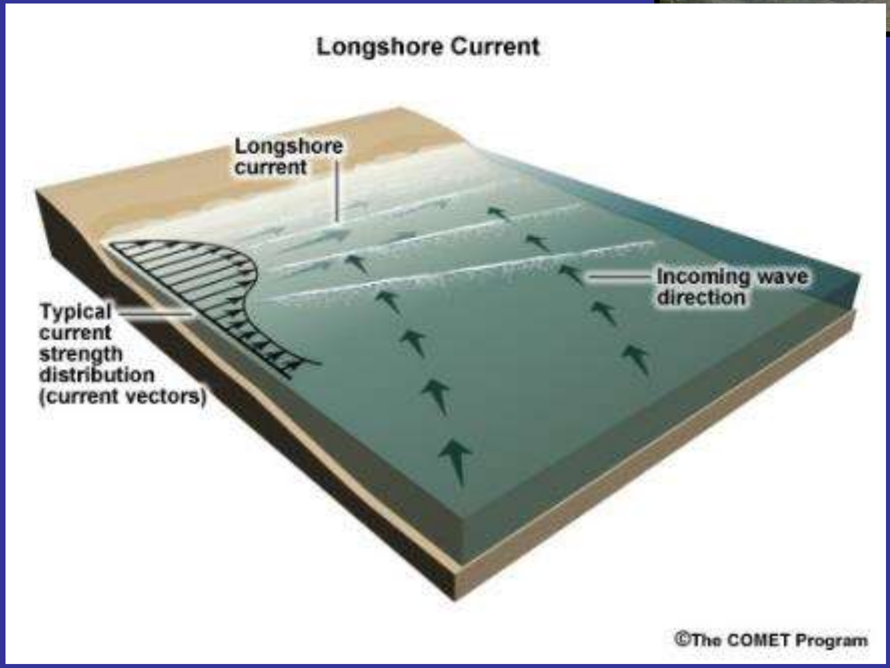
- Also known as “littoral transport”
- sediment moved along the coast by breaking waves

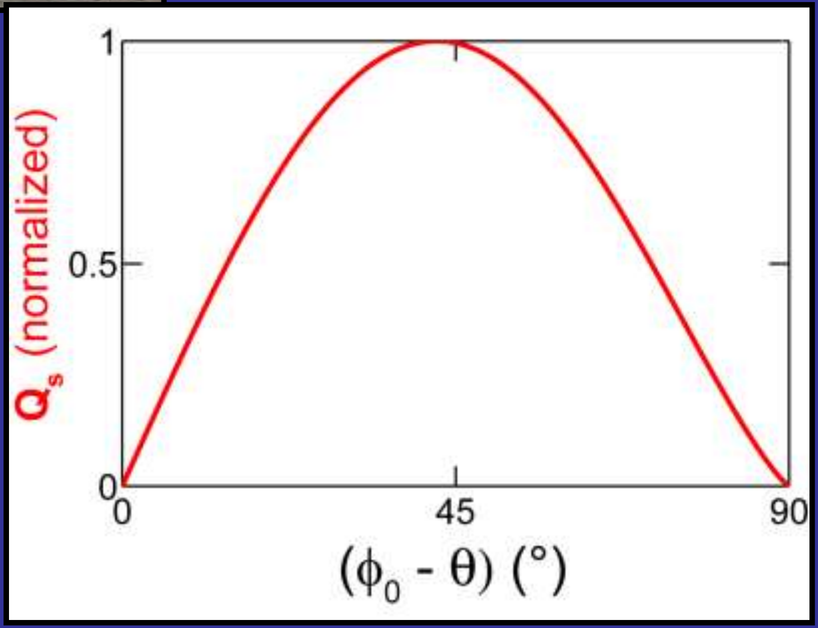


alongshore sediment transport

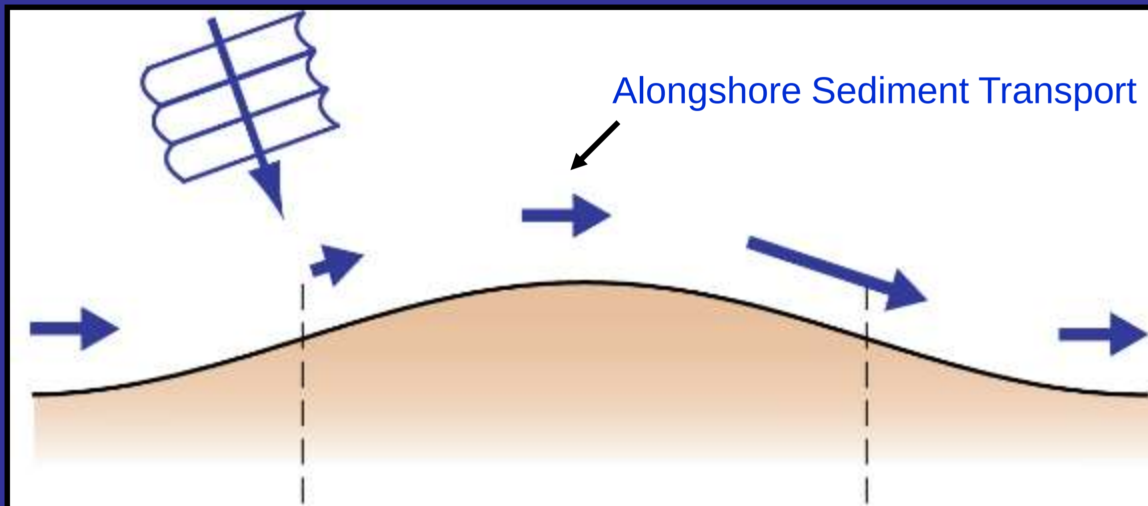
- breaking-wave-driven alongshore sediment transport (within the surf zone) is highly dependent on deep-water wave-angle

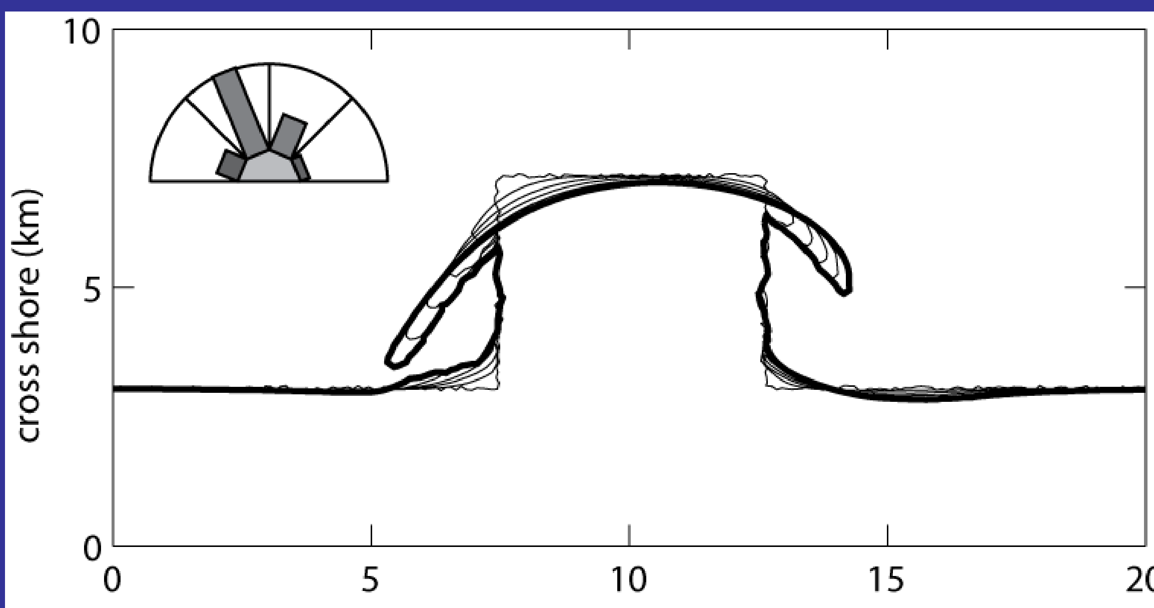


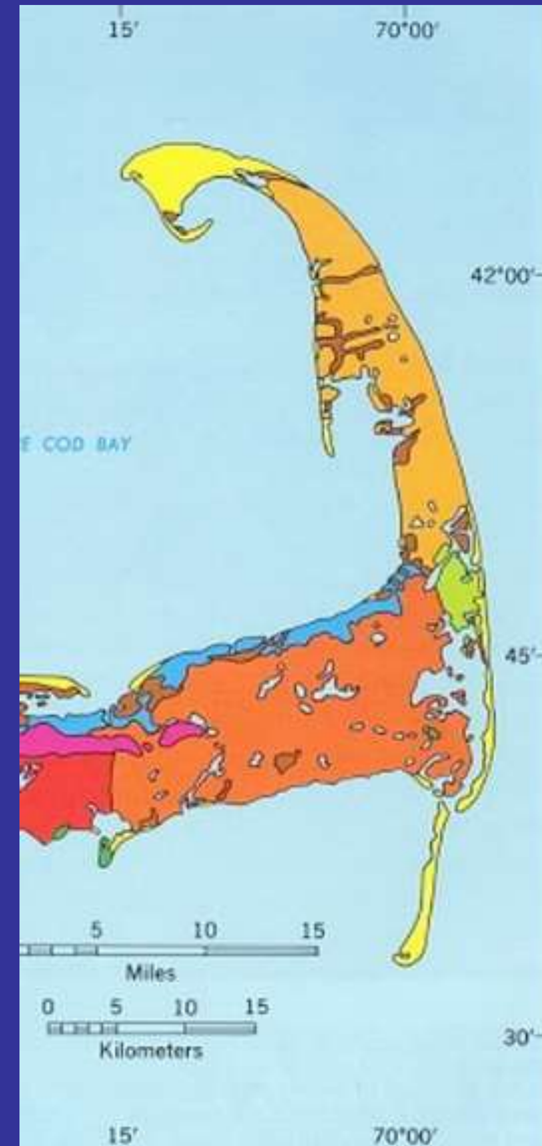




coastline change

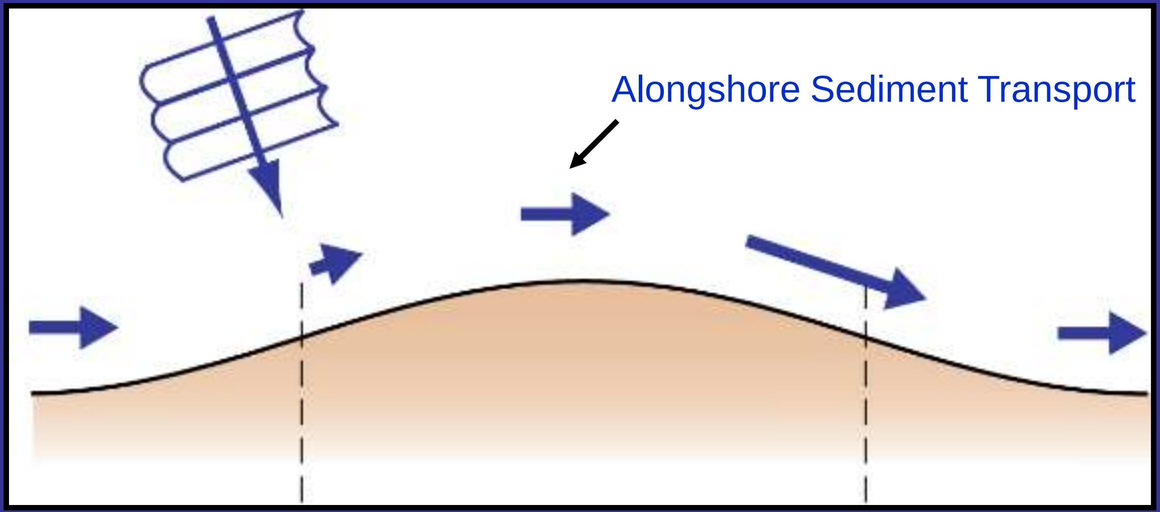


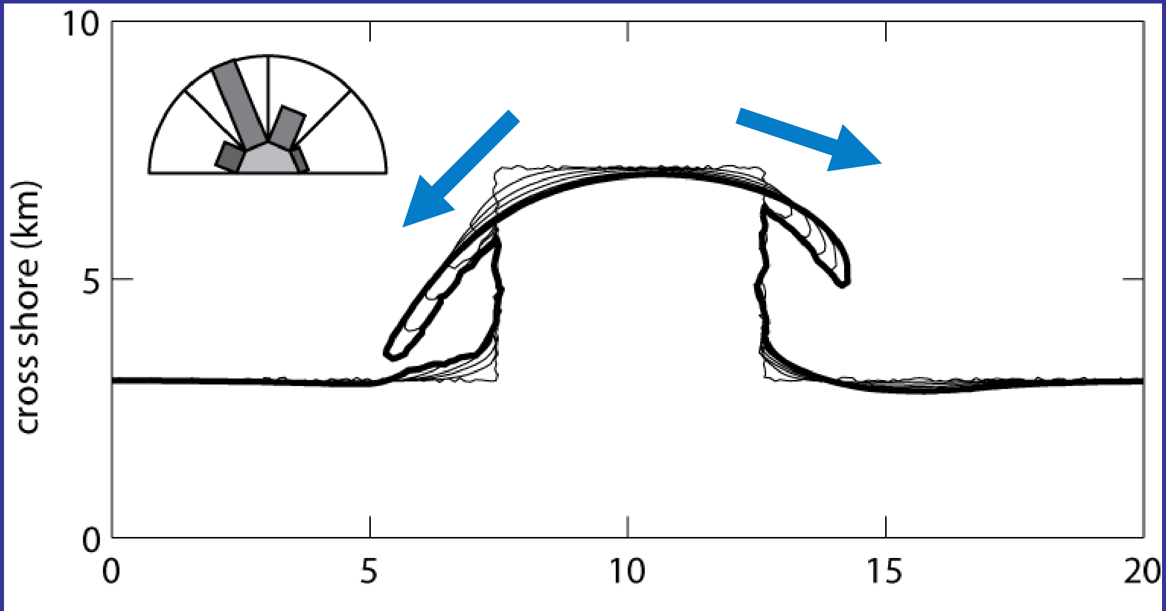


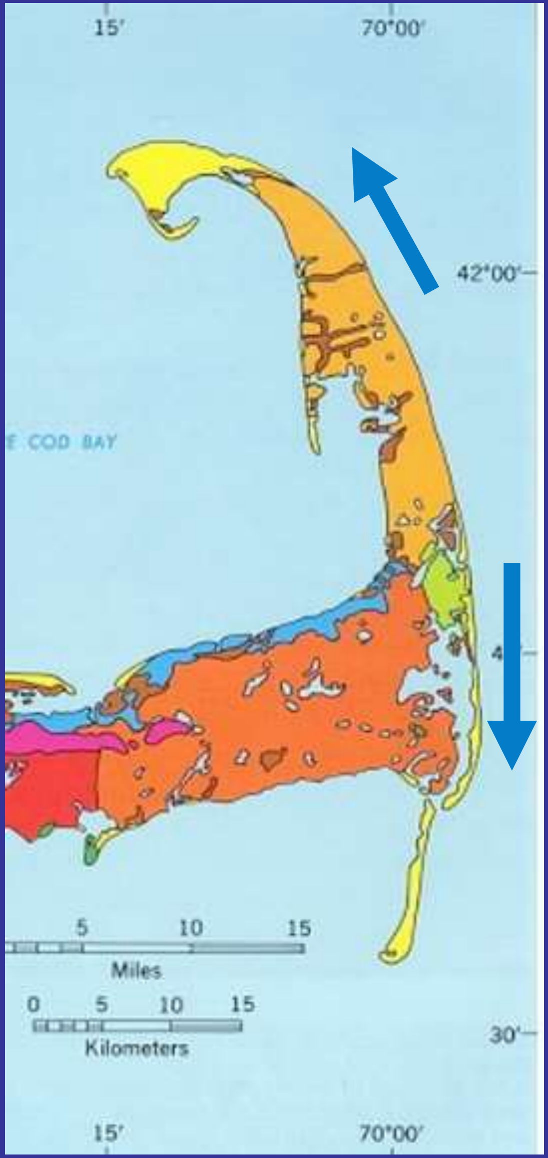


Oldale, 2001

coastline change







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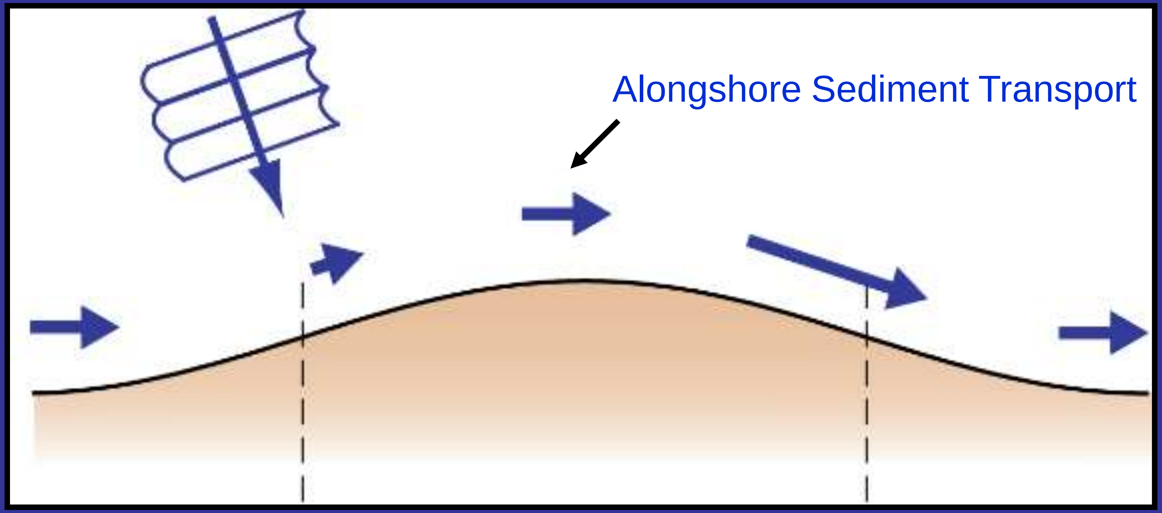
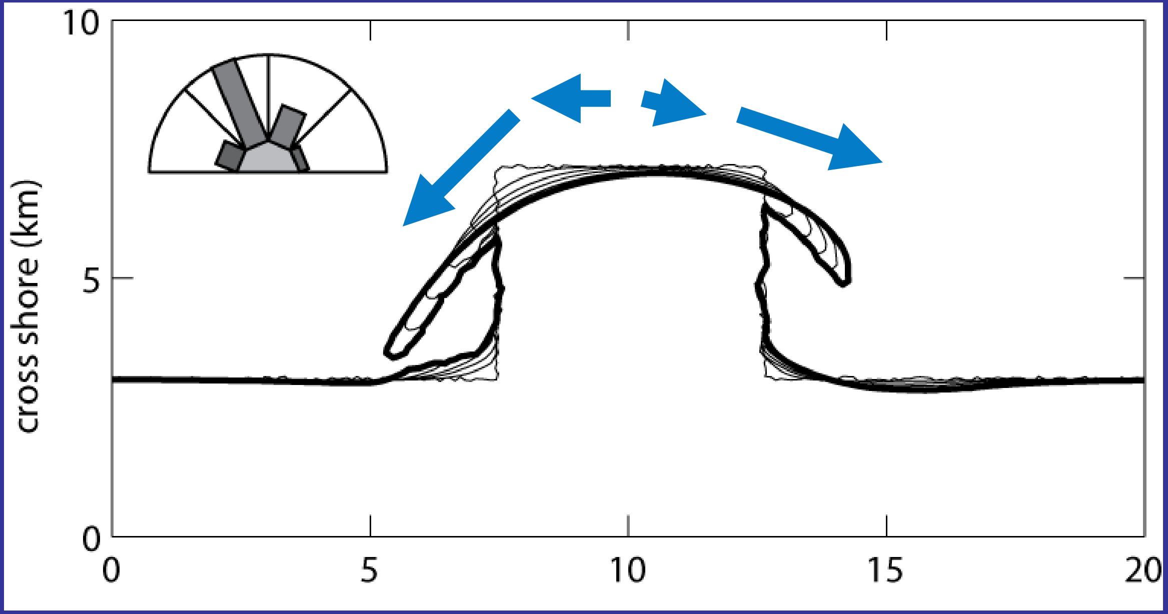
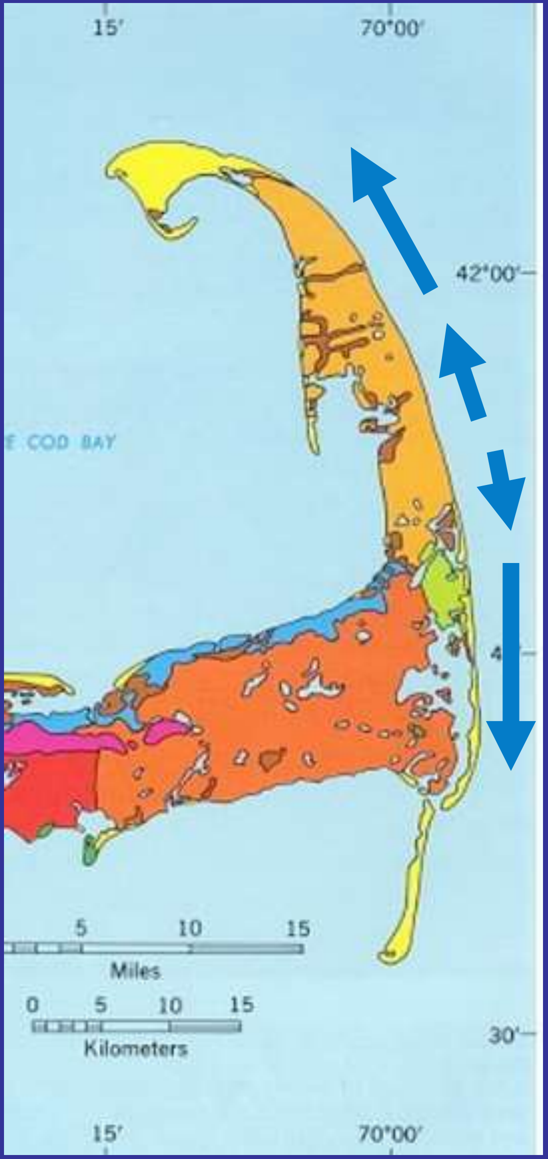
coastline change

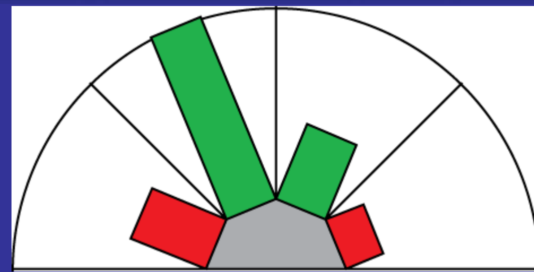


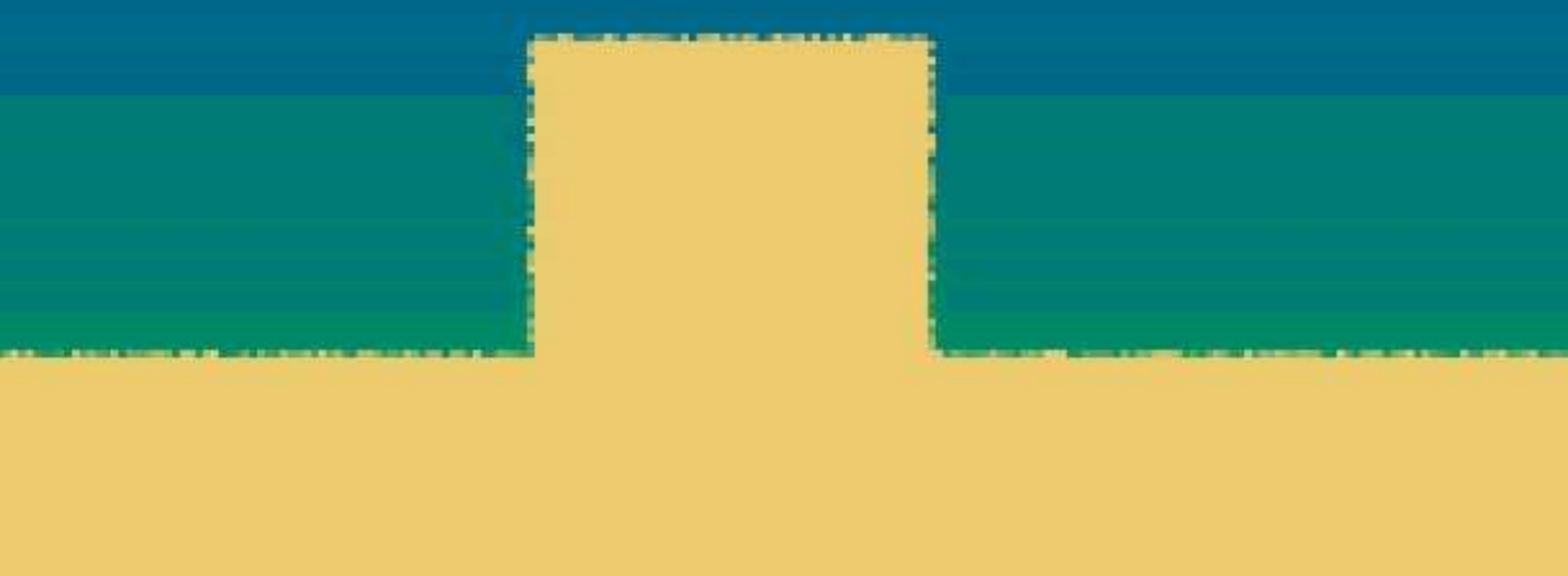




Oldale, 2001

simulated low-angle spits





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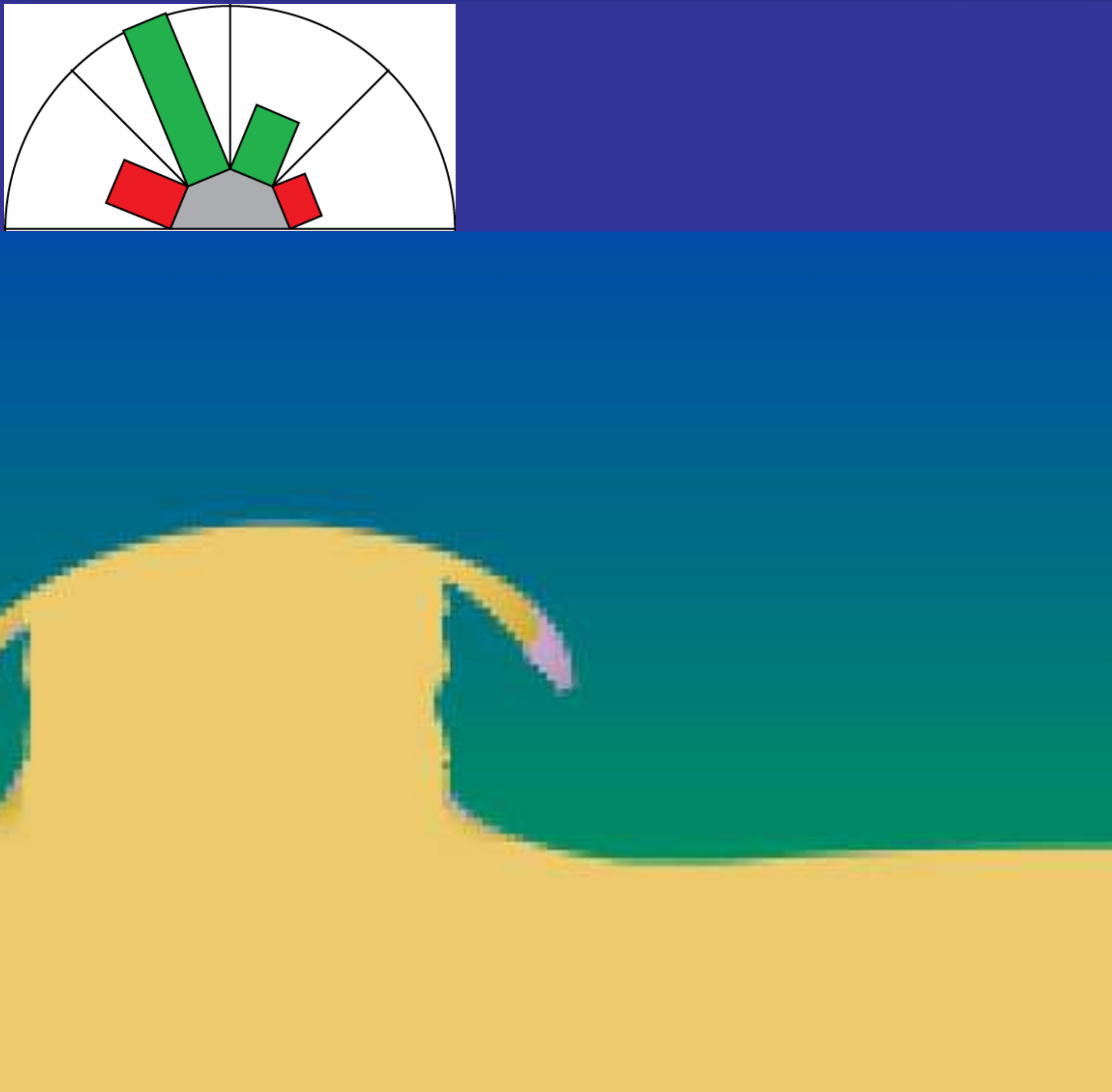
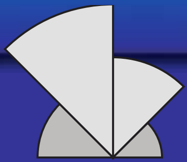
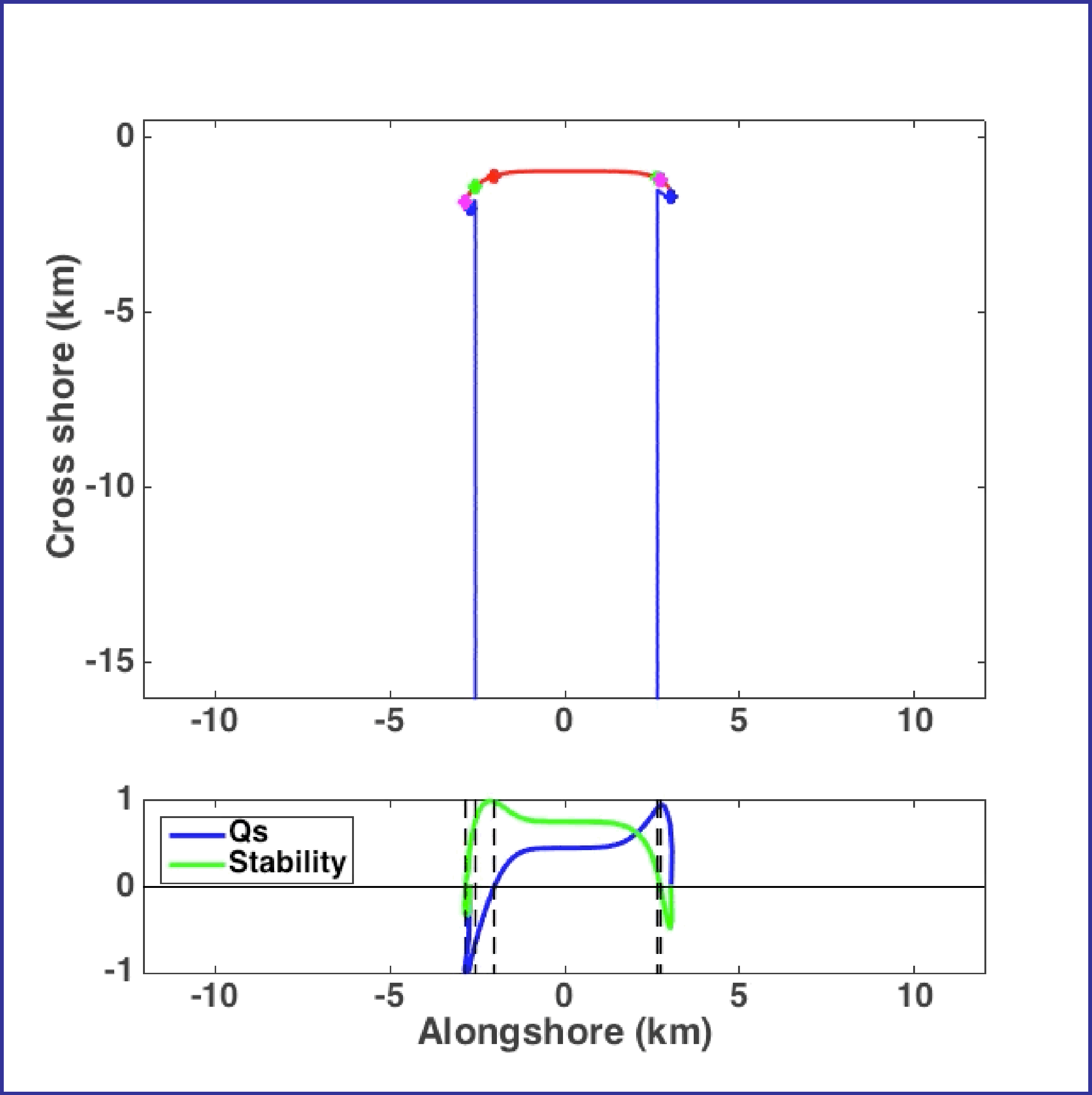


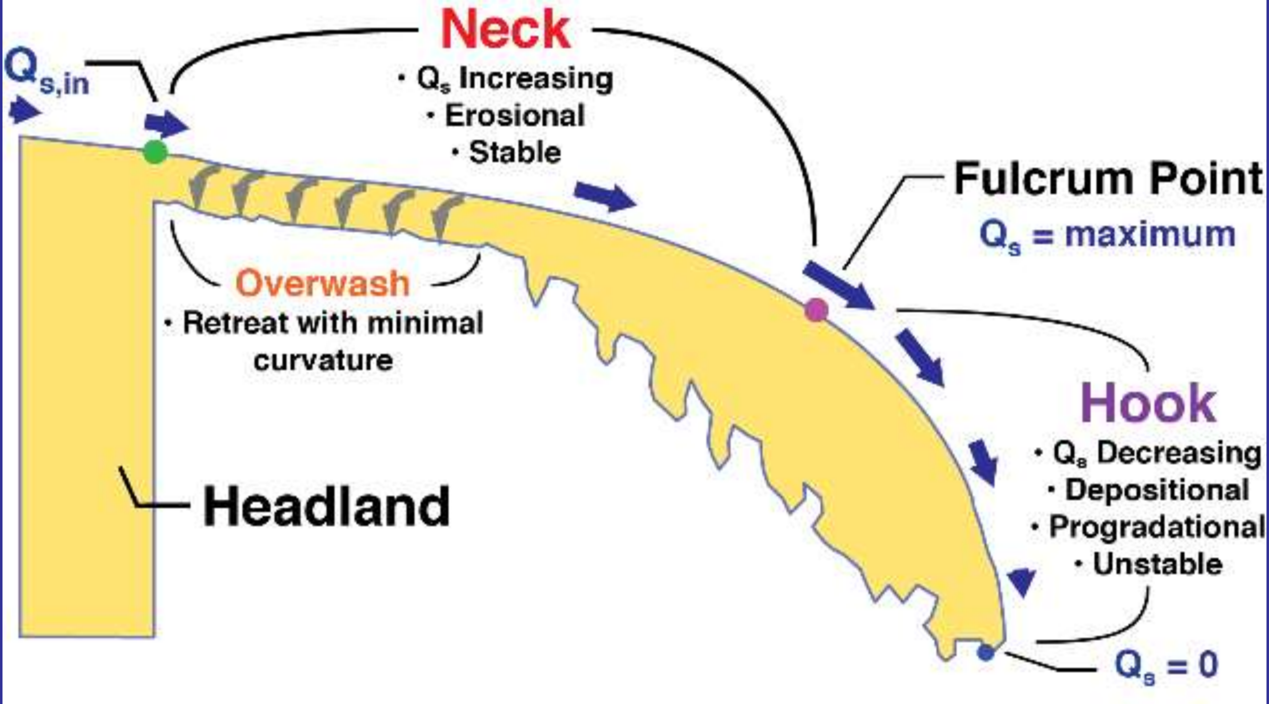
spits

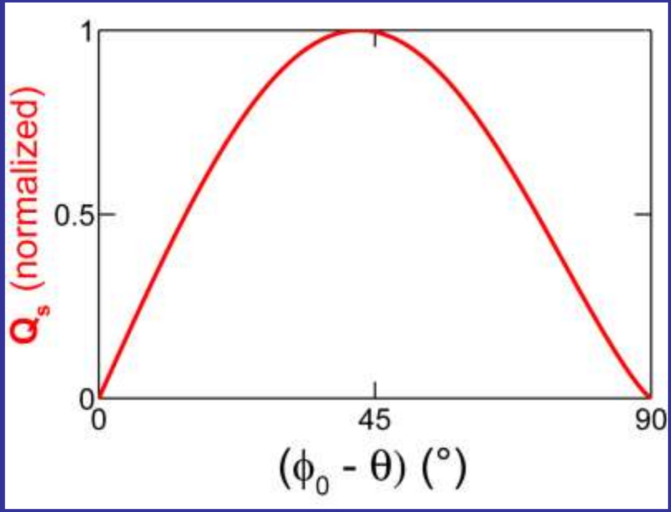
modeled spit formation

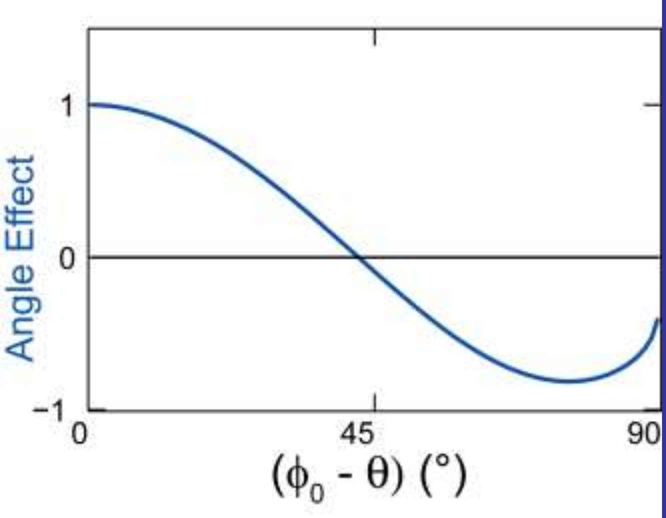




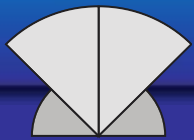
process-based spit characterization

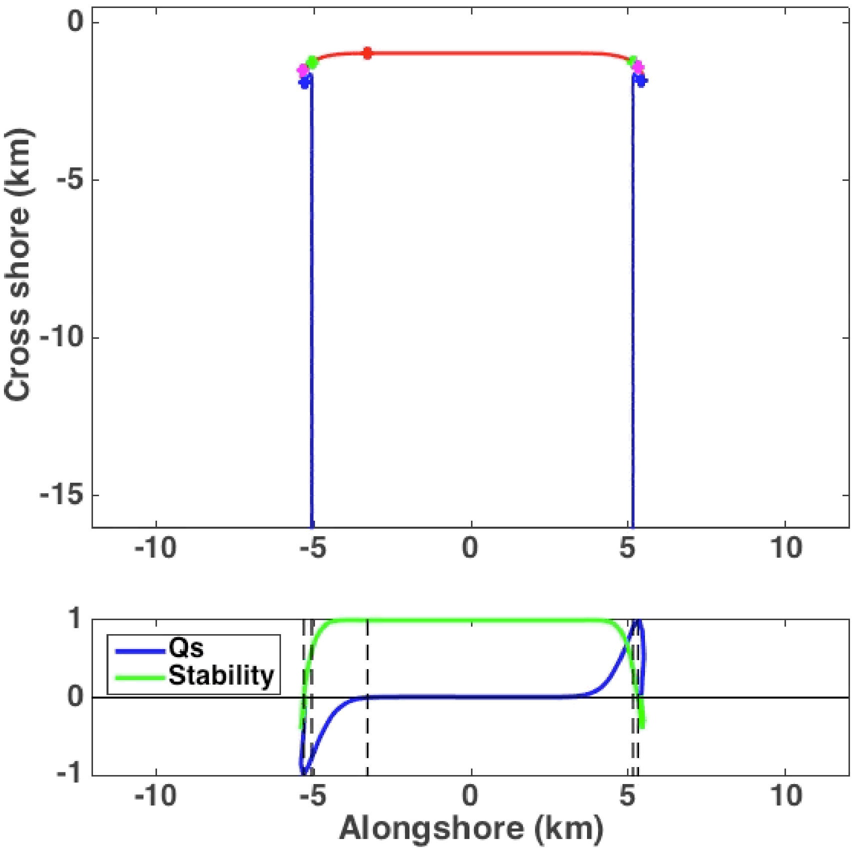


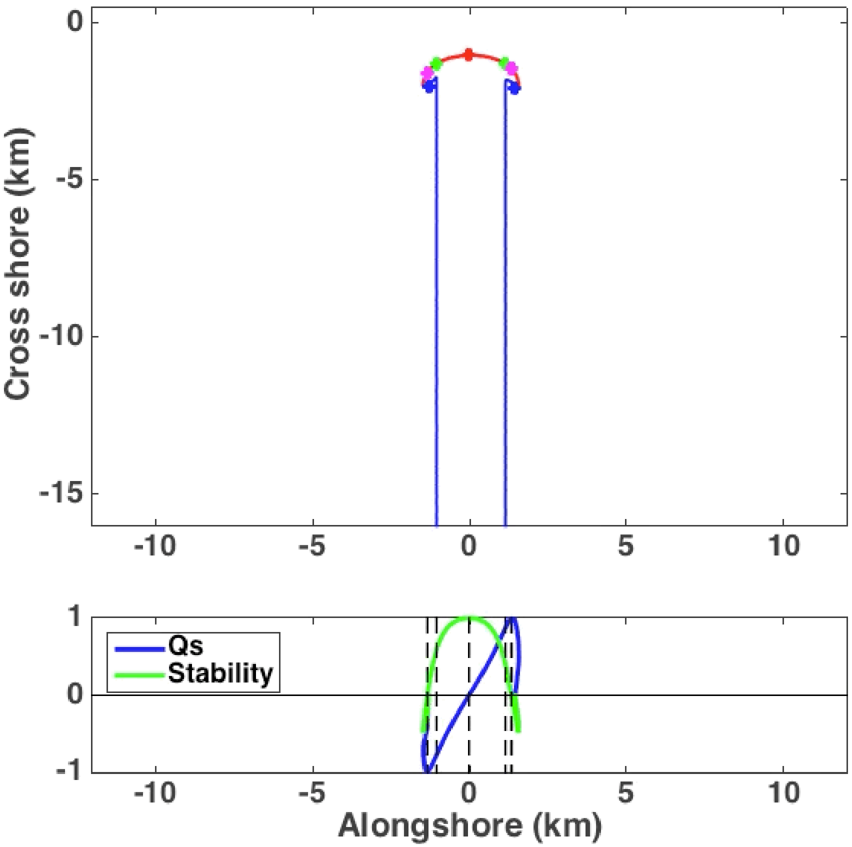




different headland widths







Ashton et al., ESD 2016

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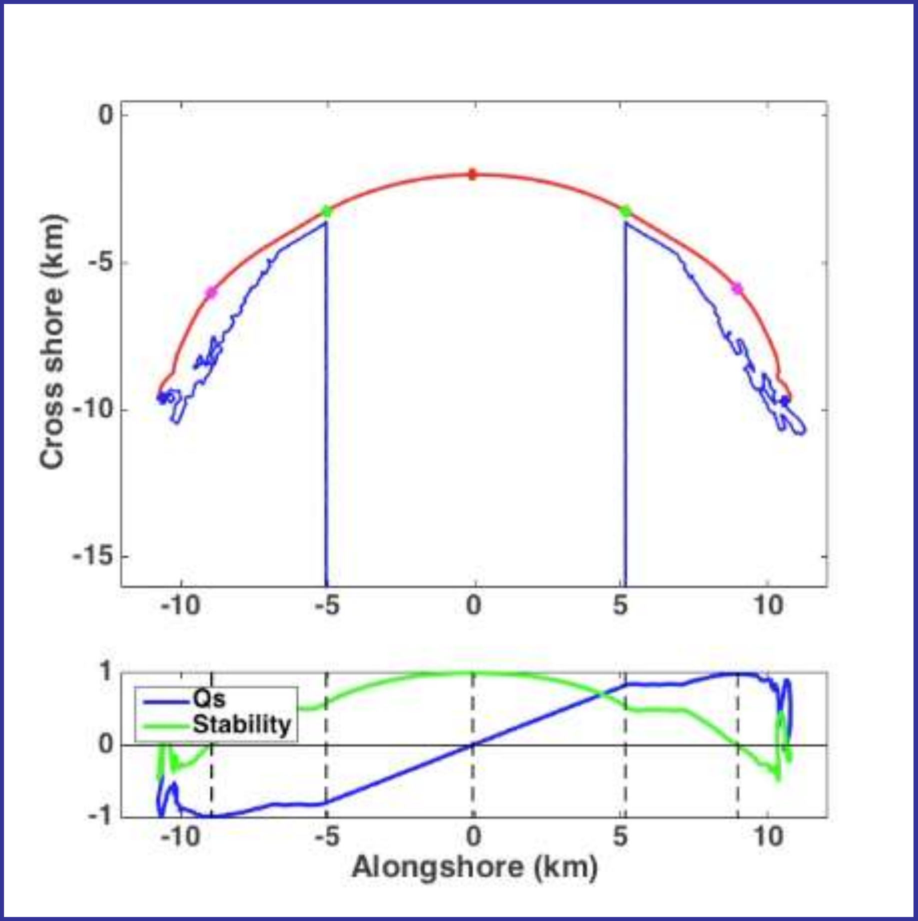
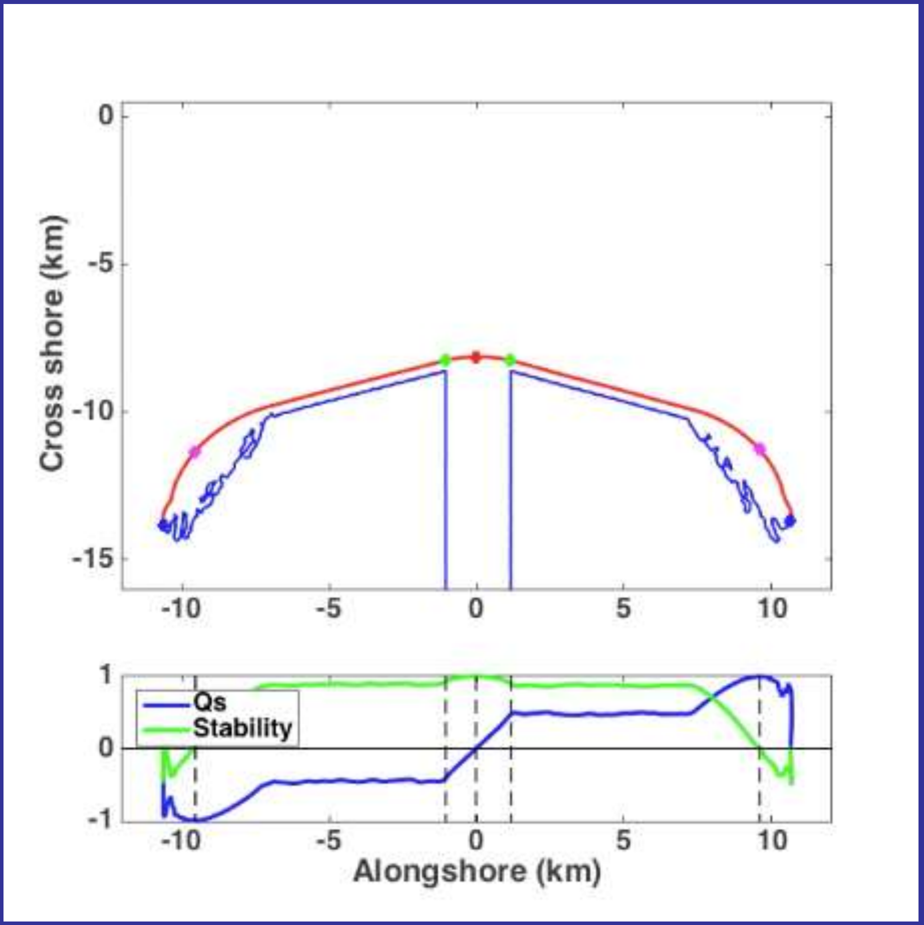
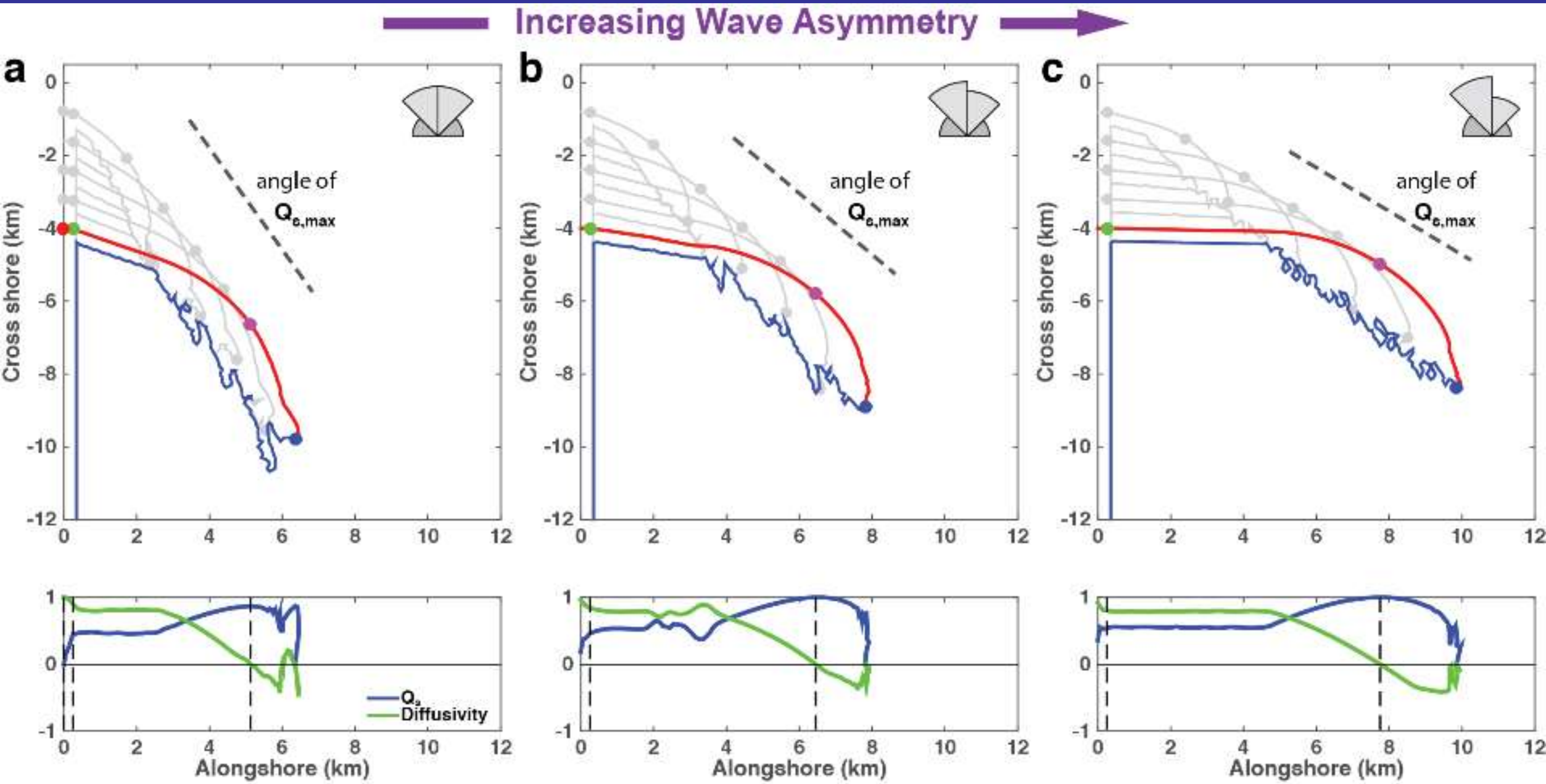


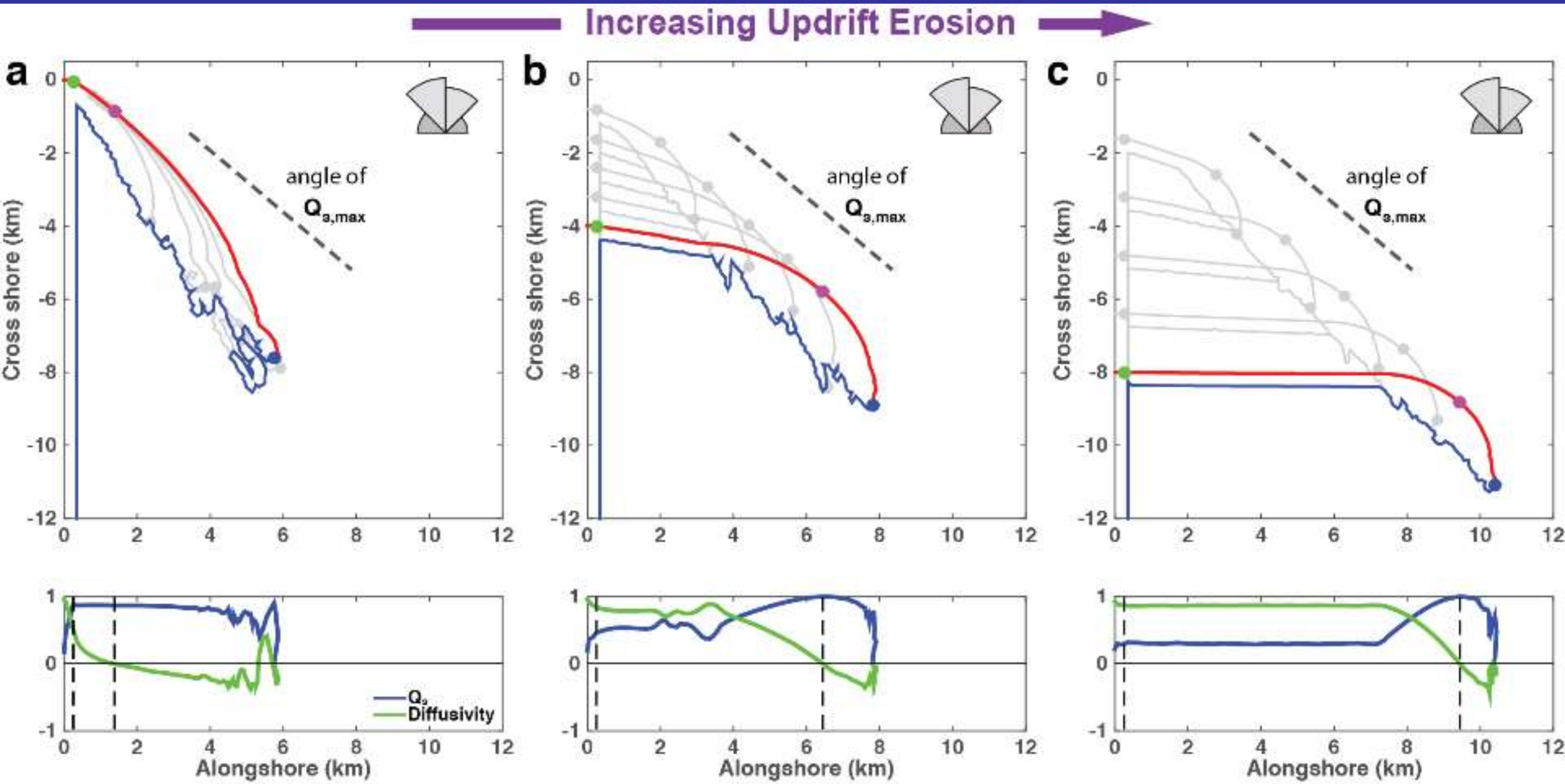


Ashton et al., ESD 2016

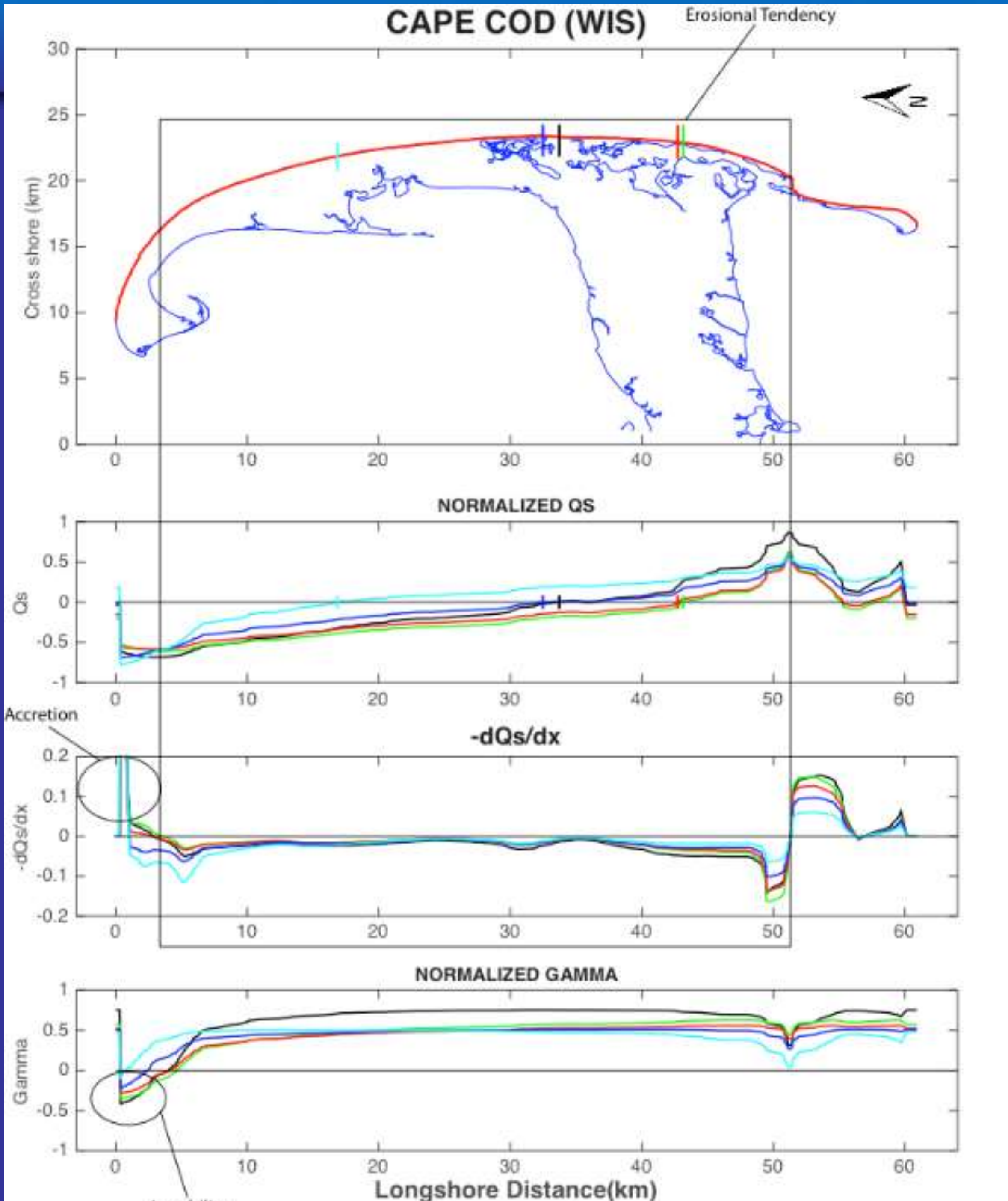
different wave angles



different headland erosion rate

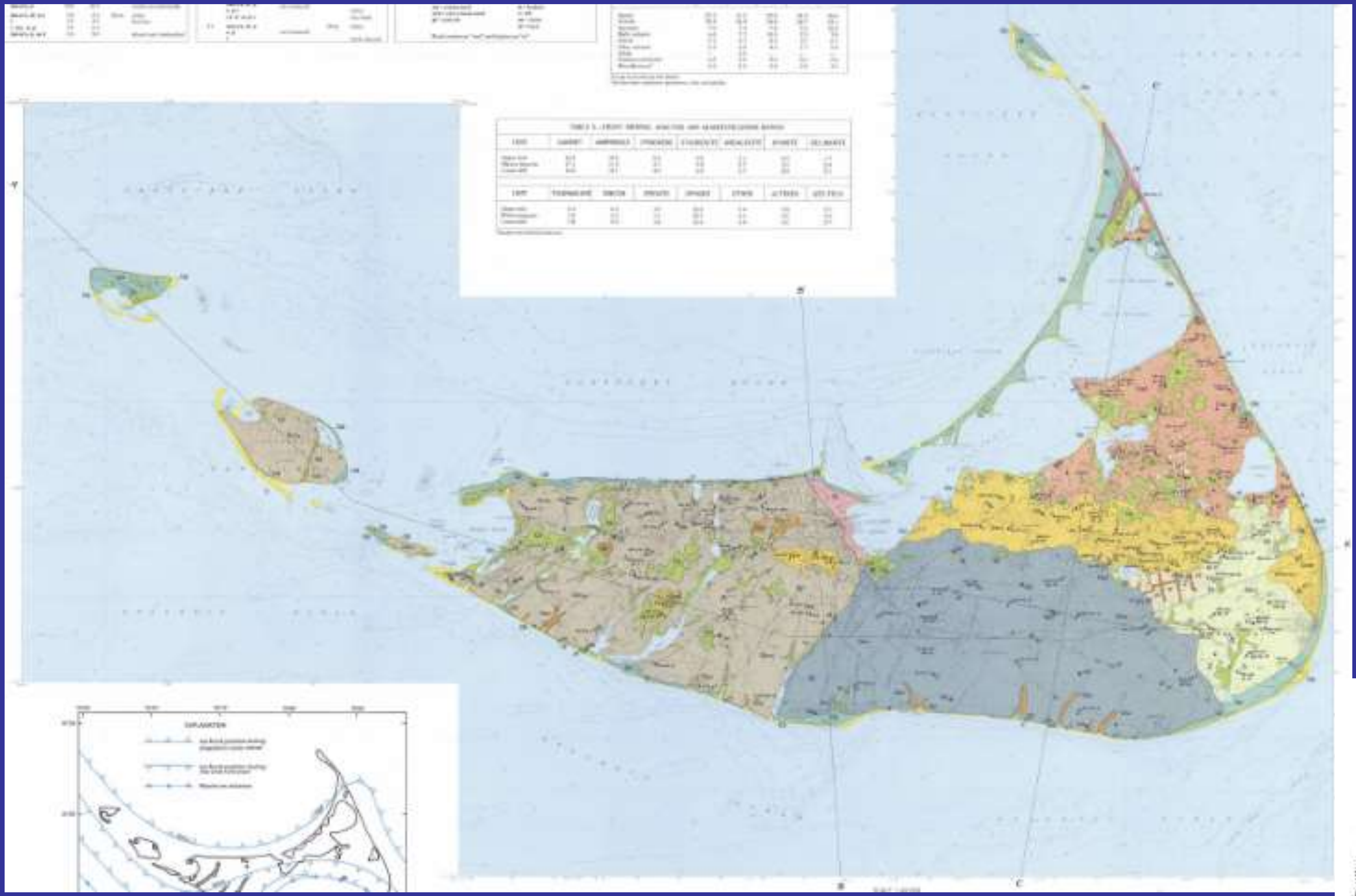


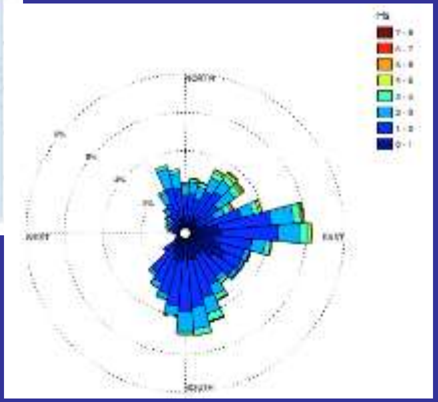
Cape Cod



CAPE COD (WIS)
Erosional Tendency
Cross shore (km)
NORMALIZED QS
Qs
Accretion
-dQs/dx
NORMALIZED GAMMA
Gamma
Longshore Distance(km)

Geology of Nantucket





Oldale USGS, 1985

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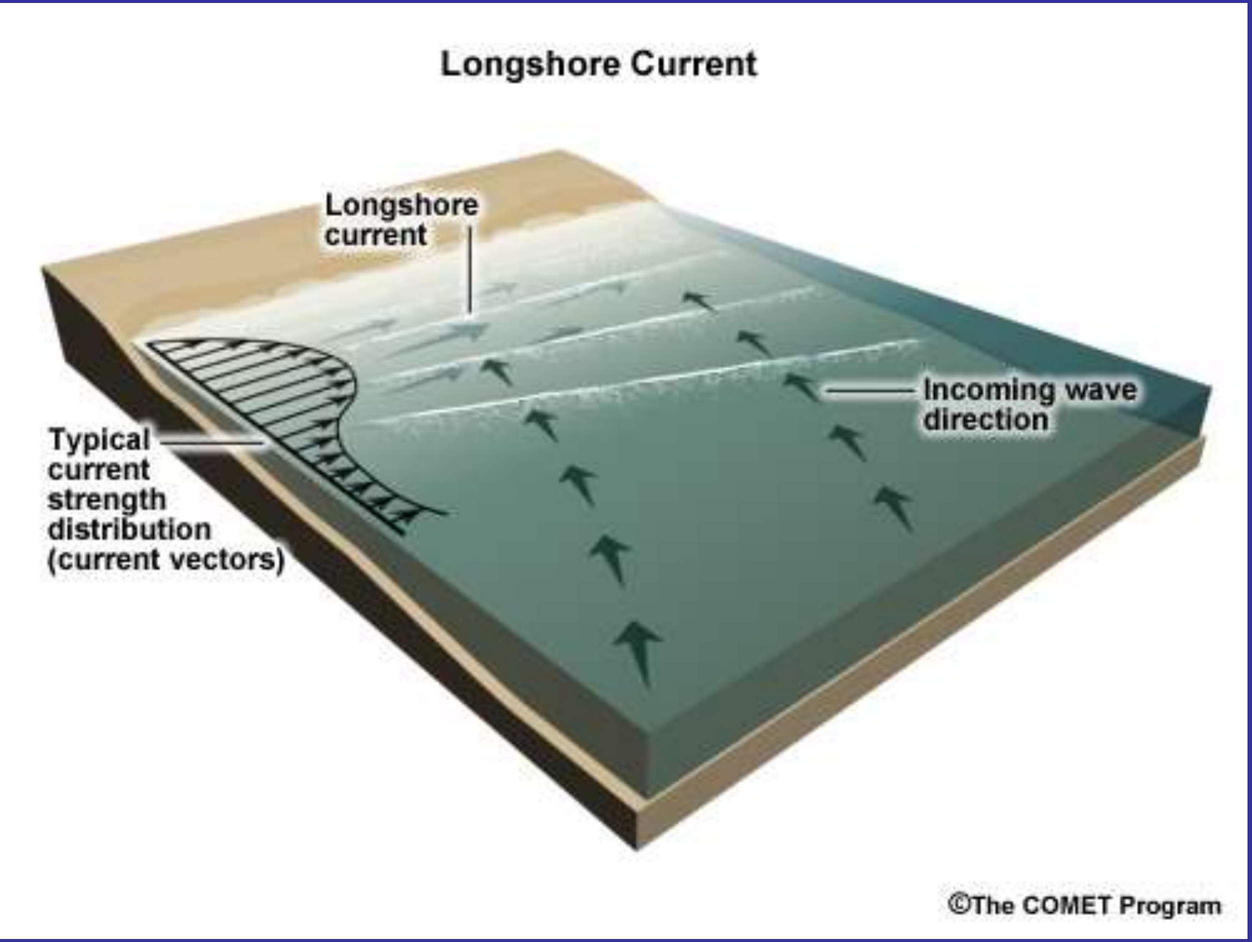
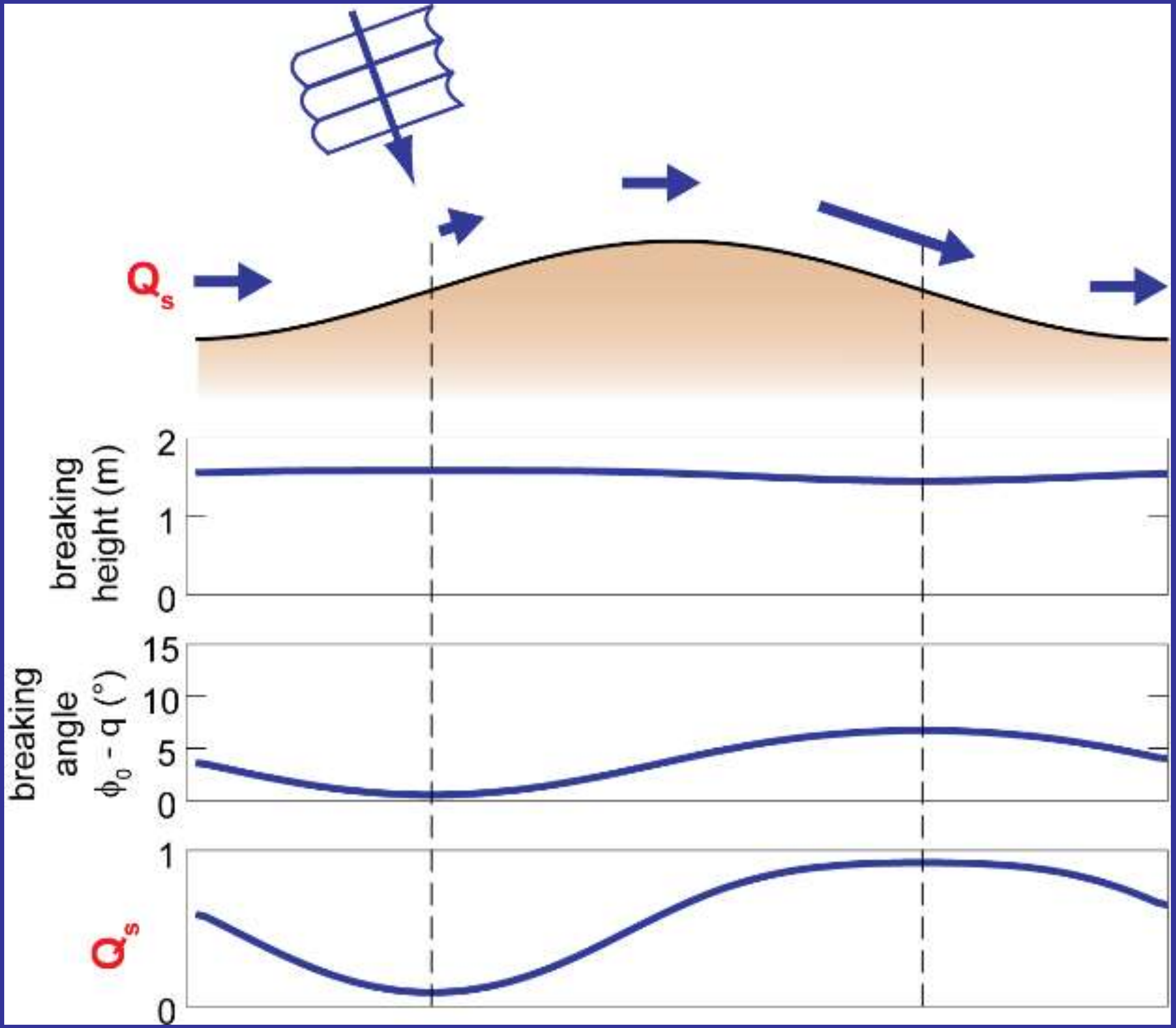


smoothing of coast?



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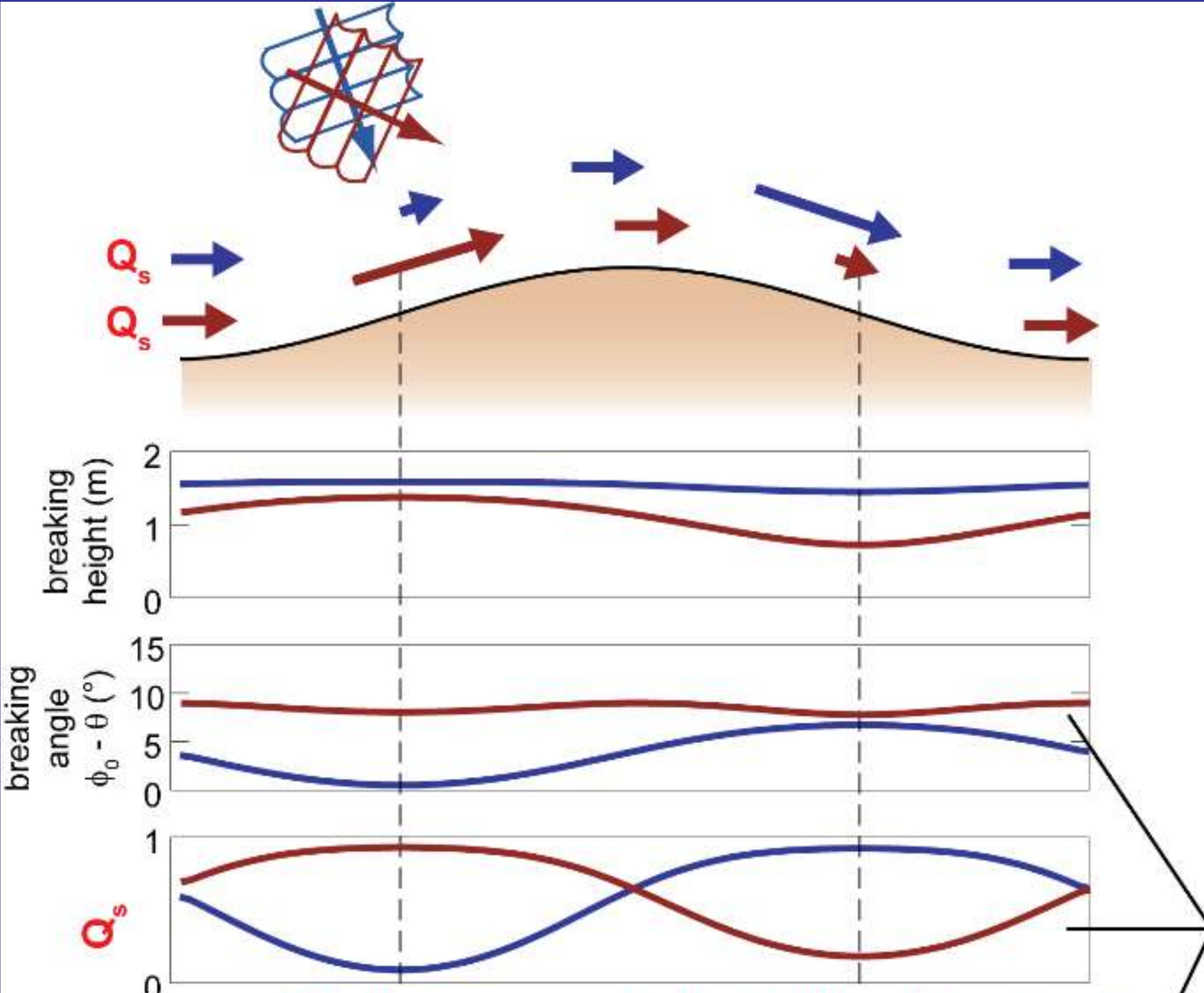
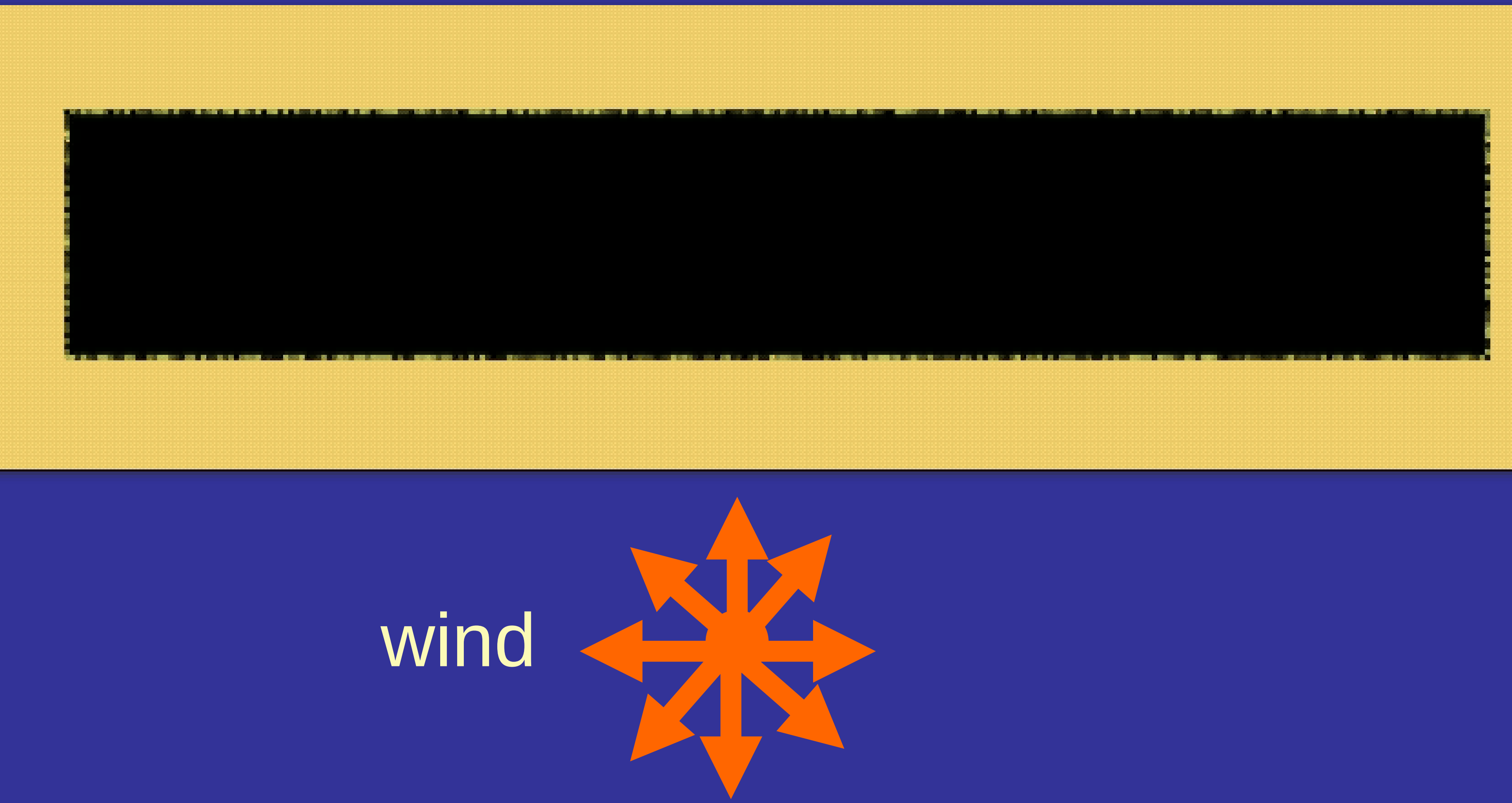
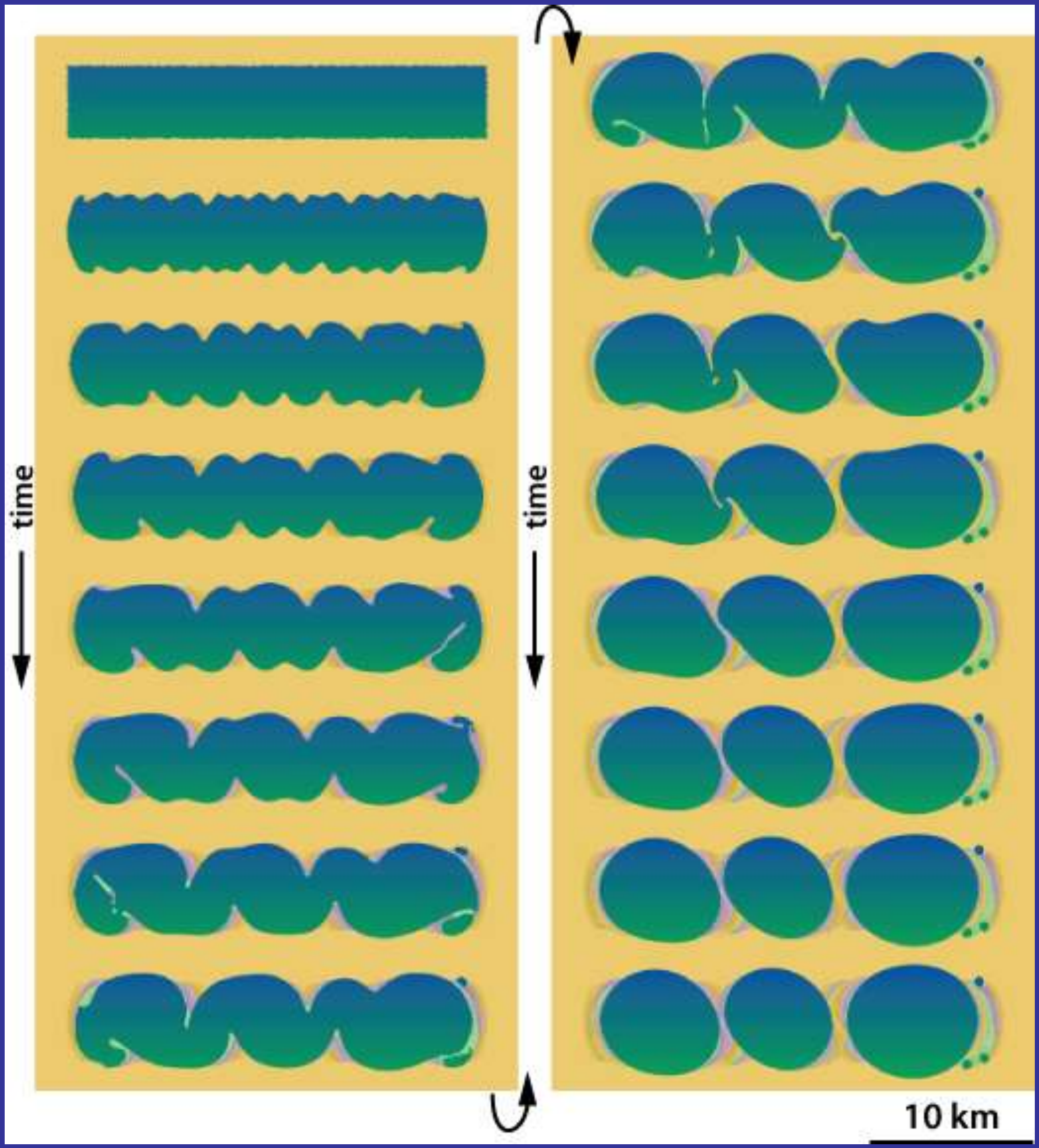


Q_s changes substantially while $\phi_0 - \theta$ remains relatively constant

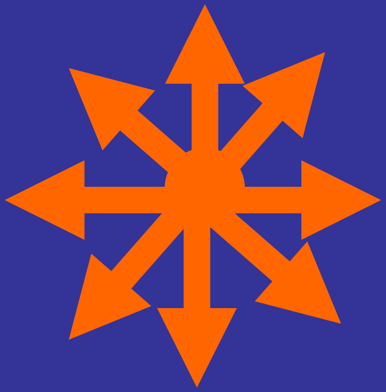
simulated evolution



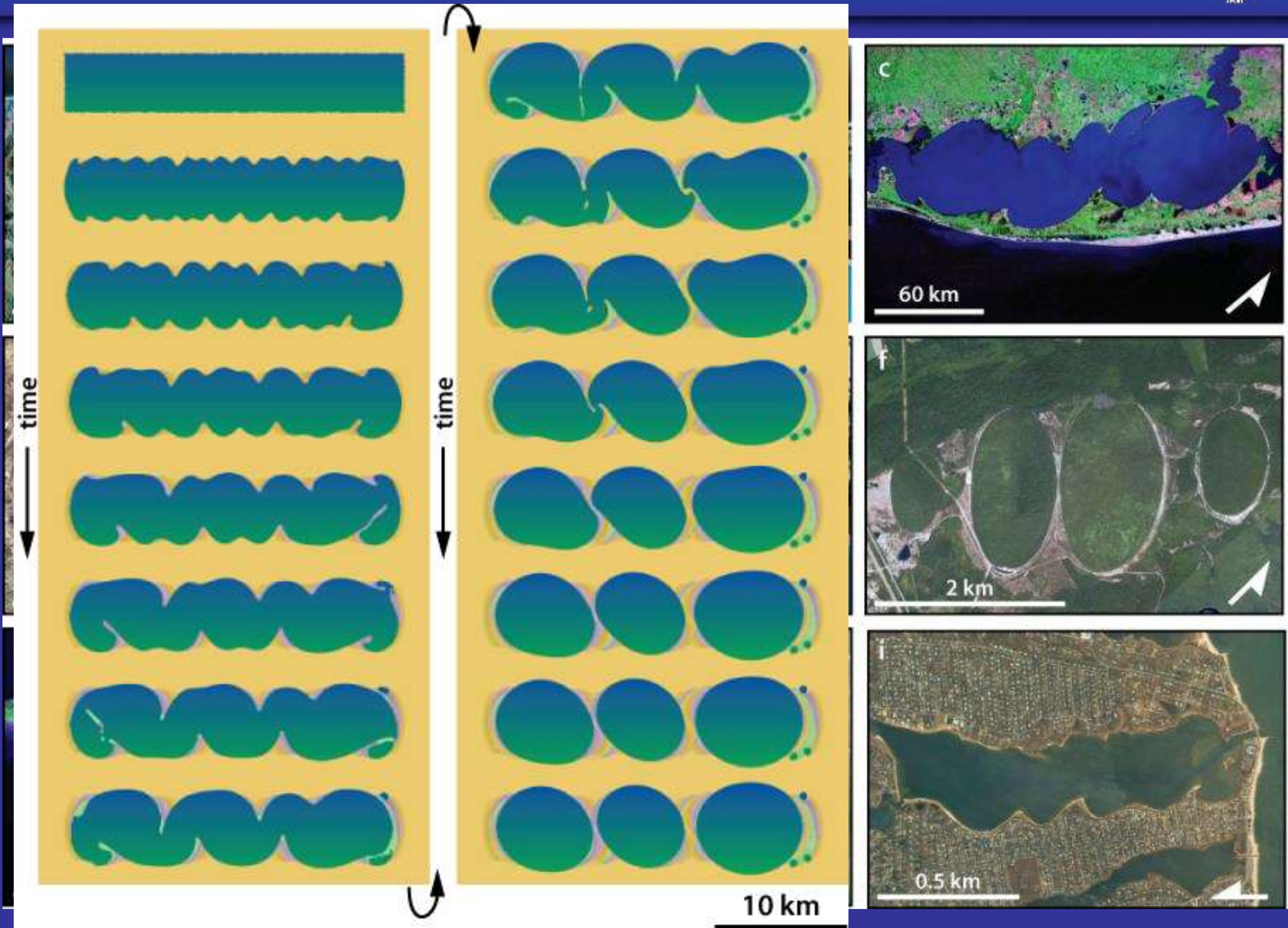
evolution



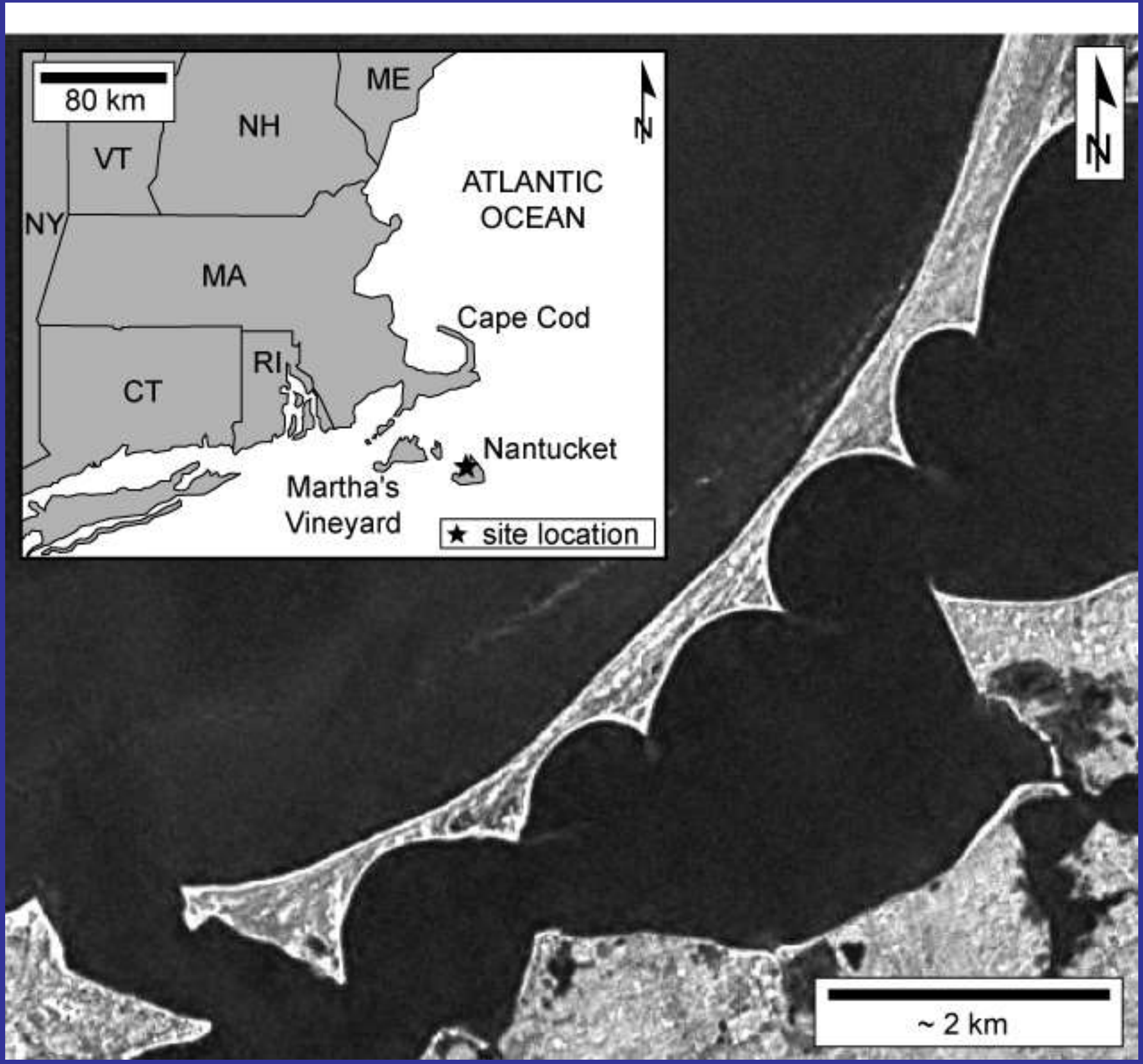
wind



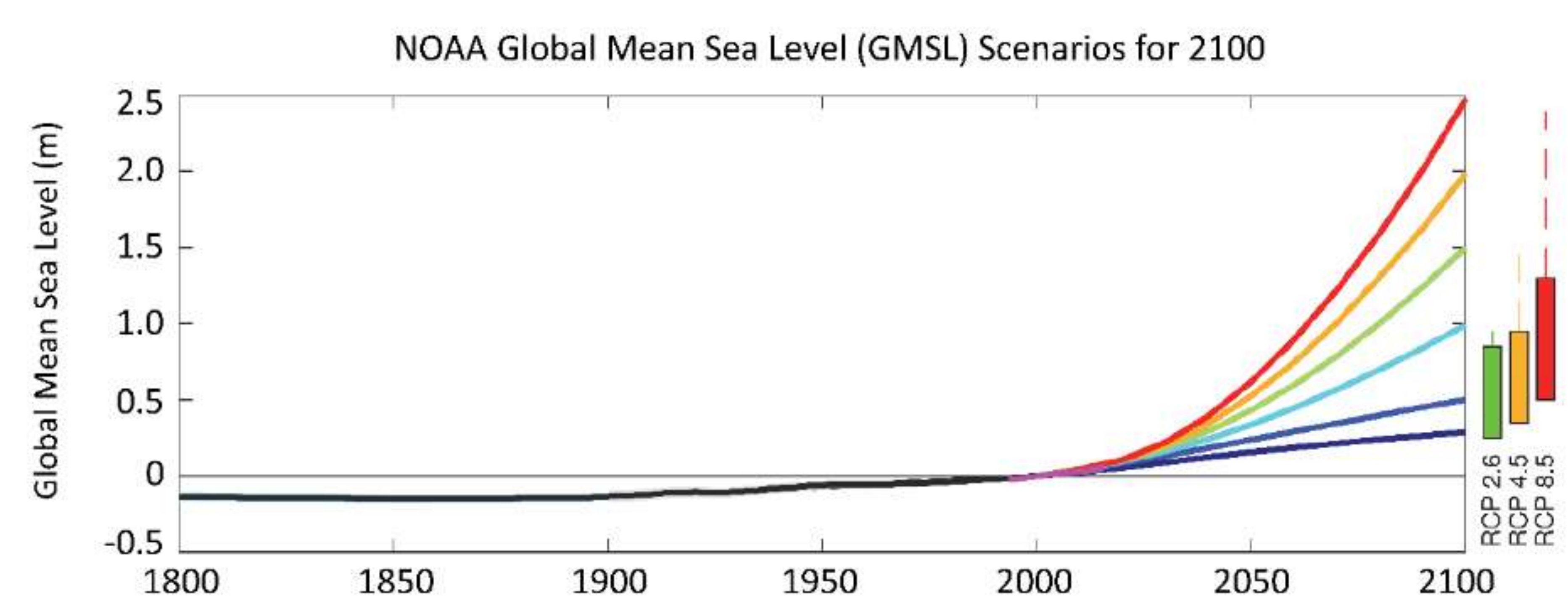
examples



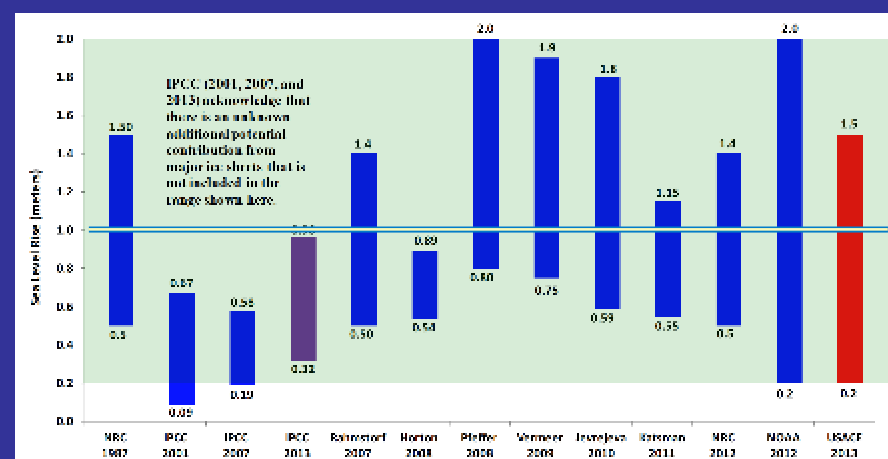
Nantucket Harbor



Sea-level Rise Projections



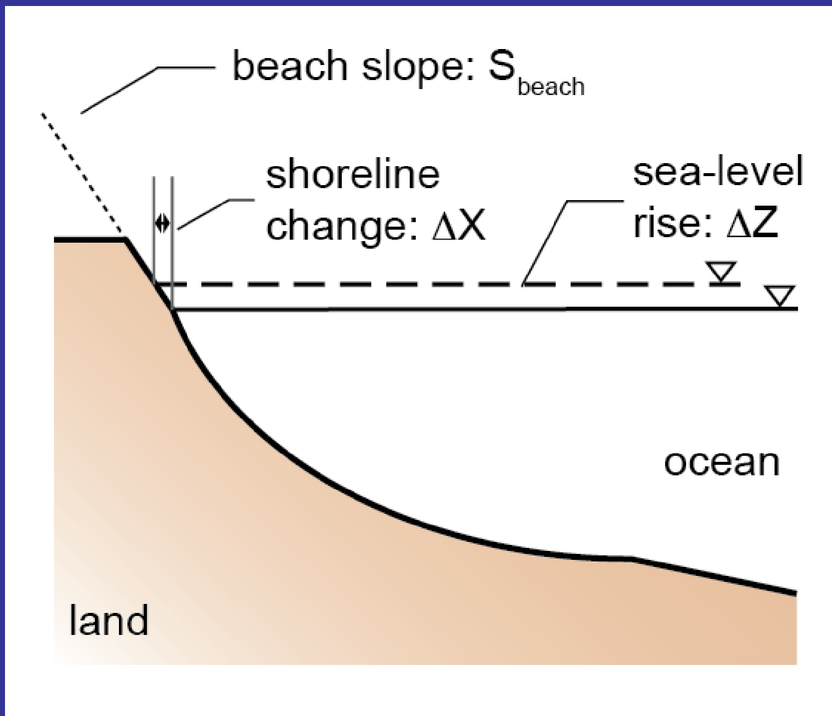
(Sweet et al., 2017)



USACE, ETL 1100-2-xx, 2014; prepublication draft)

shoreline flooding

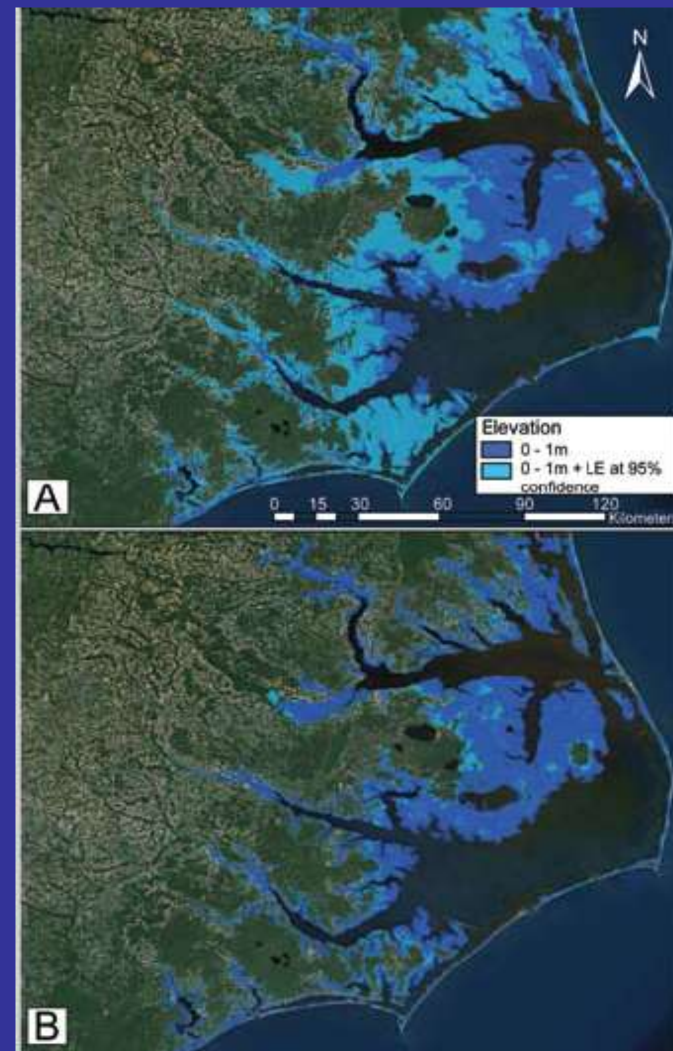
Sea-level Flooding



$$\mathrm{D}x = \frac{1}{S_{beach}}\mathrm{D}z$$

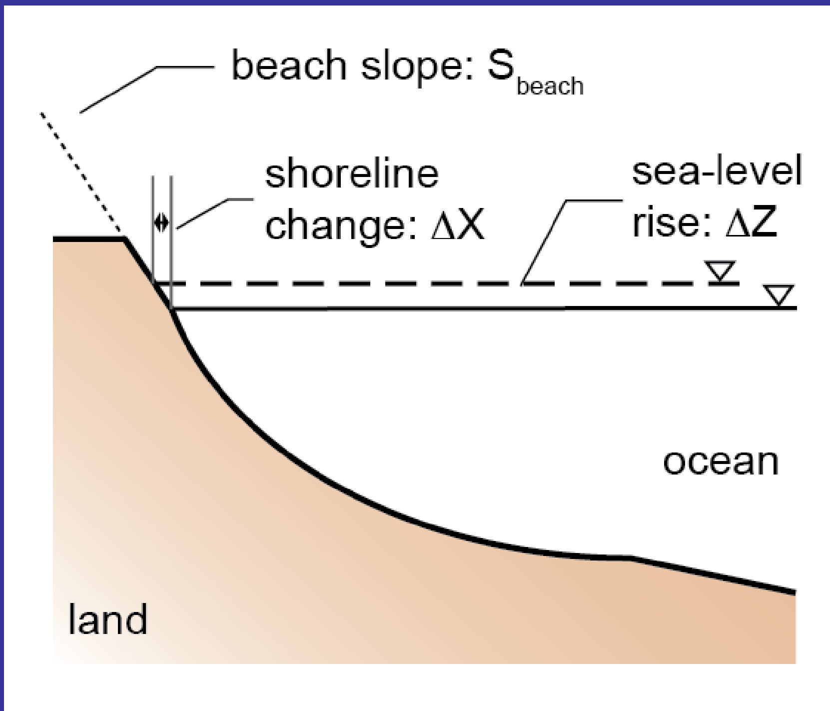
- Flooding Predictions

  (Titus et al., 2009)



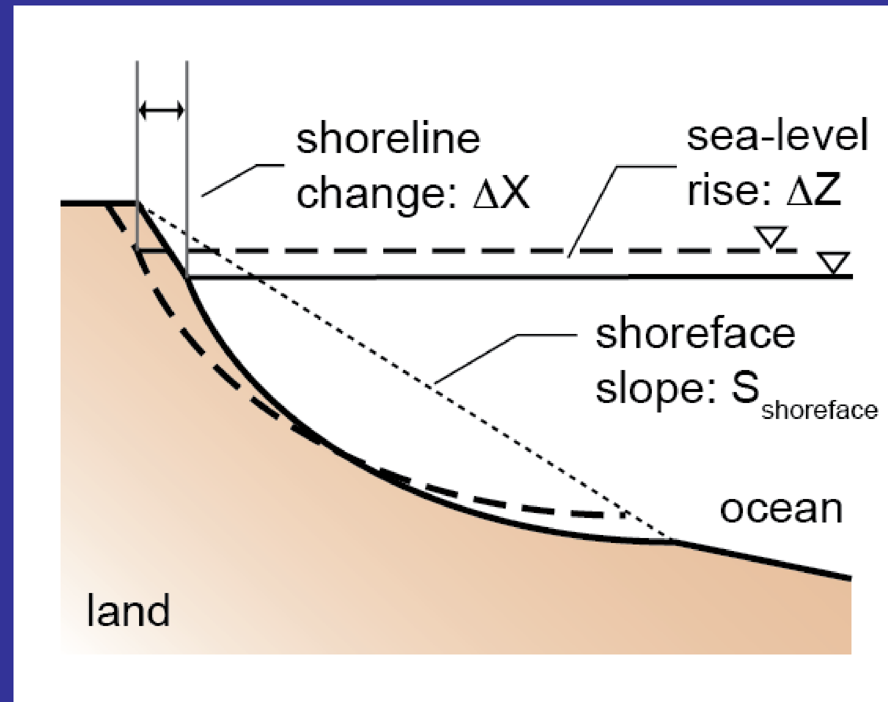
shoreline change

Sea-level Flooding



$$\mathrm{D}x = \frac{1}{S_{beach}}\mathrm{D}z$$

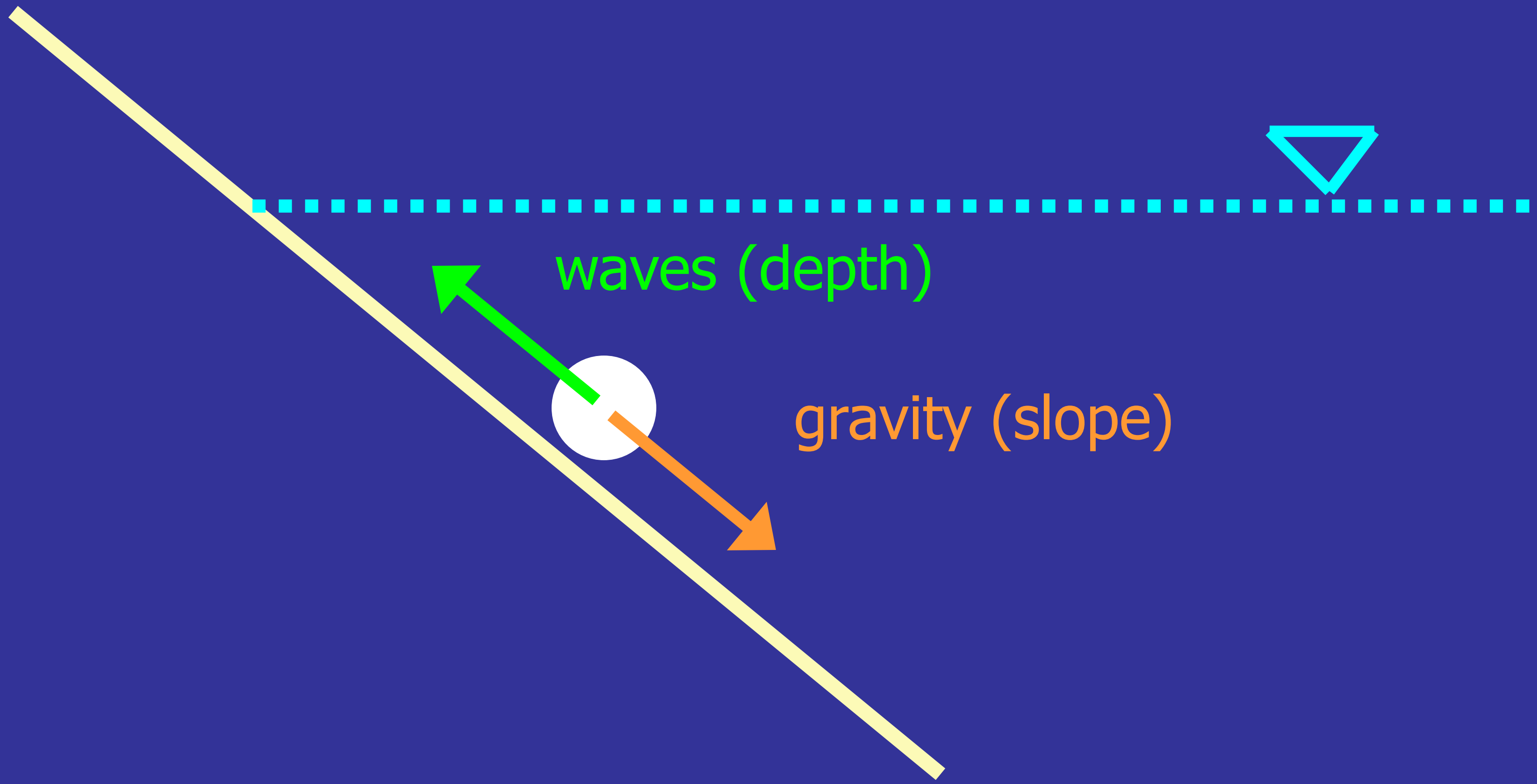
With Waves: the ‘Bruun Rule’



$$\mathrm{D}x = \frac{1}{S_{shoreface}}\mathrm{D}z$$

equilibrium slope

- balance of components
  - waves send sediment shoreward
  - gravity component offshore



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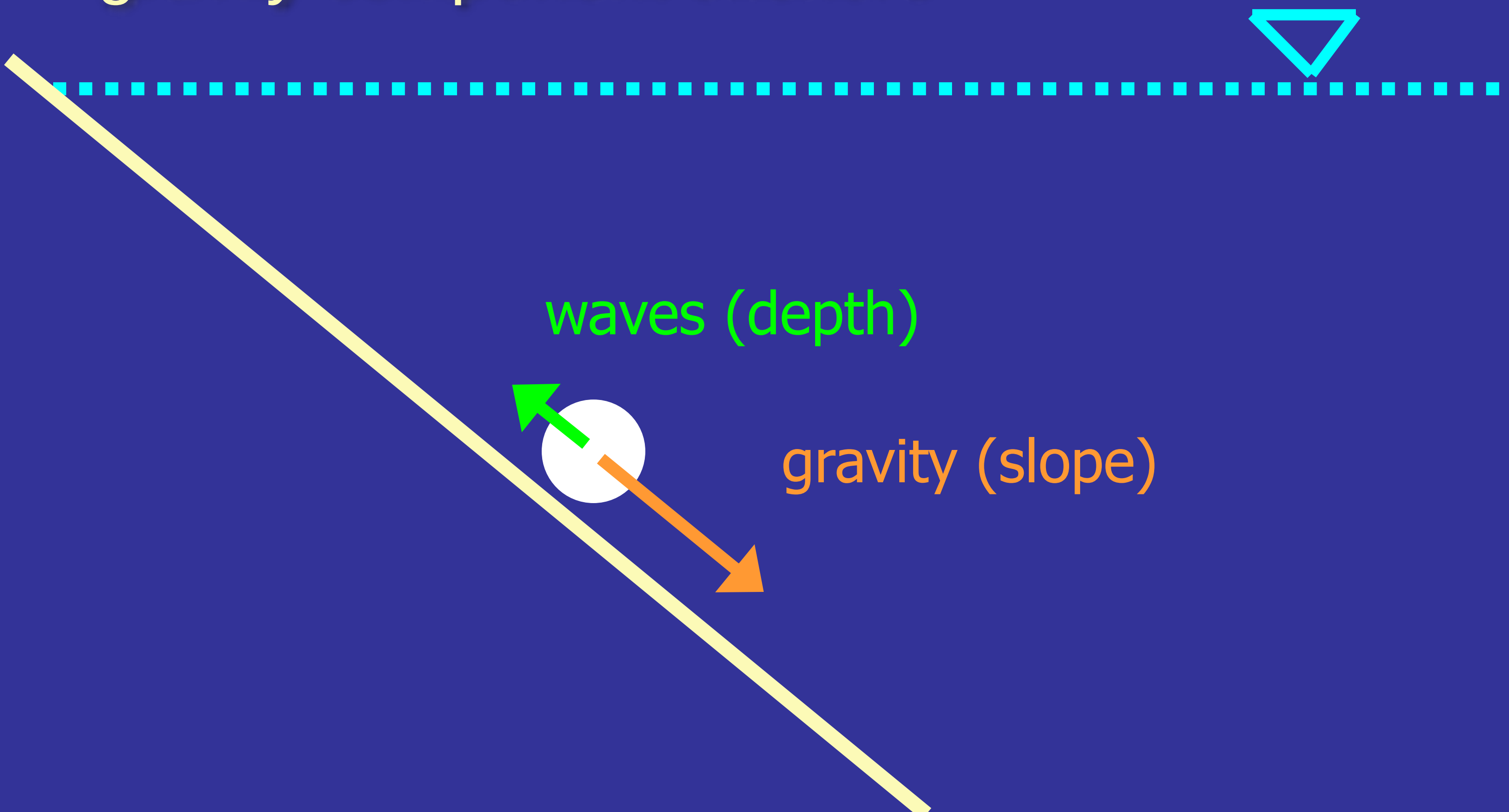

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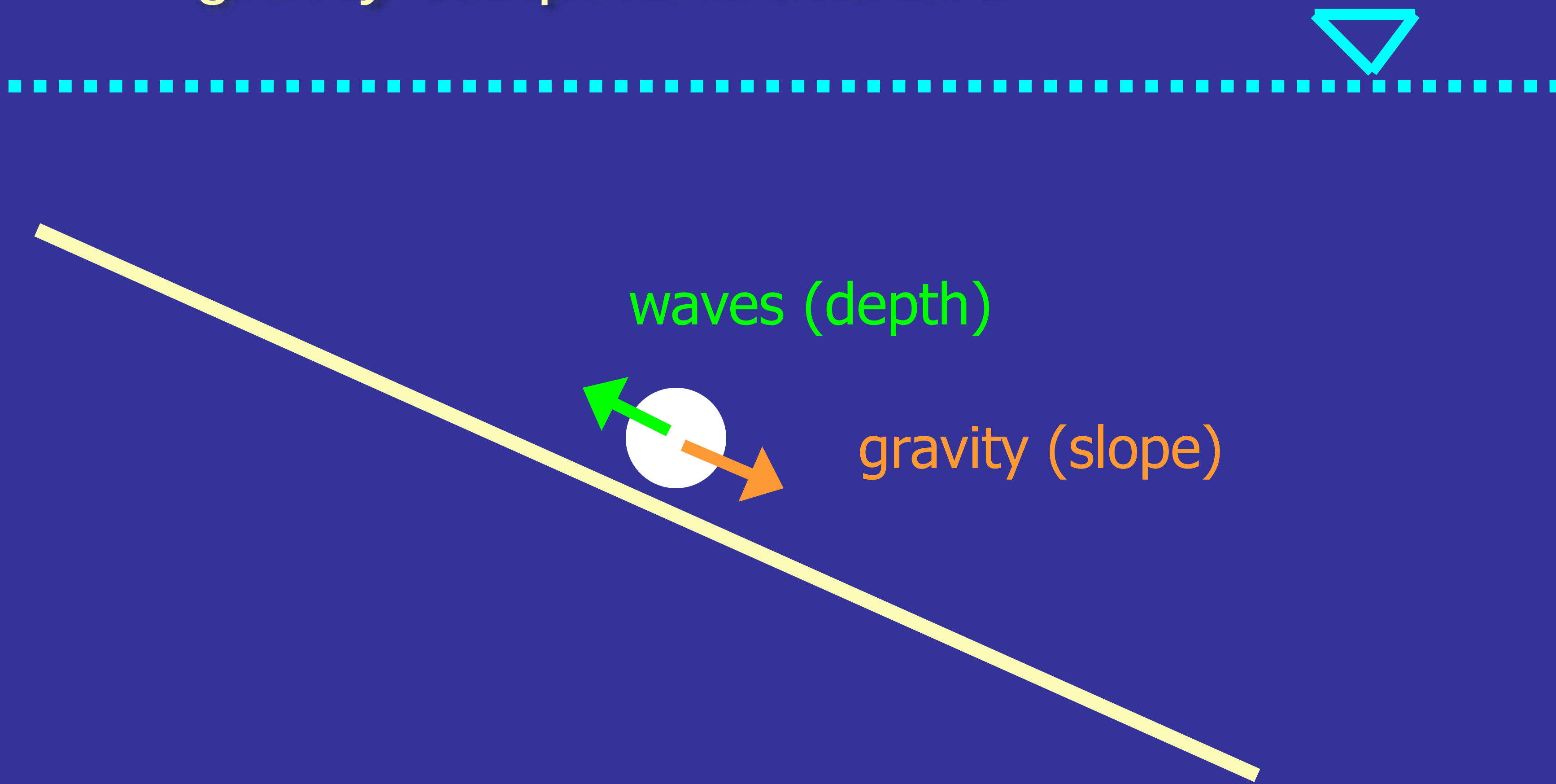

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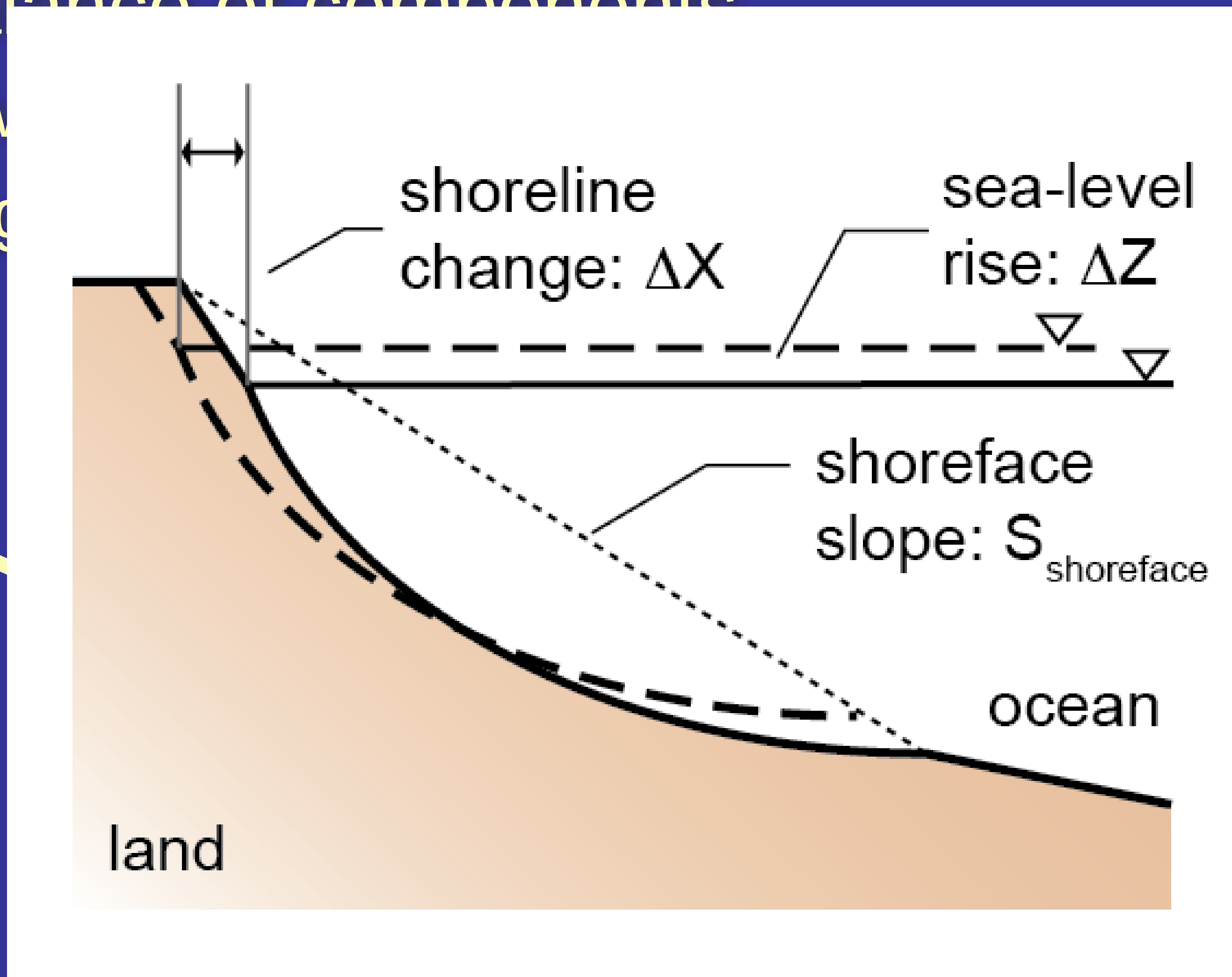

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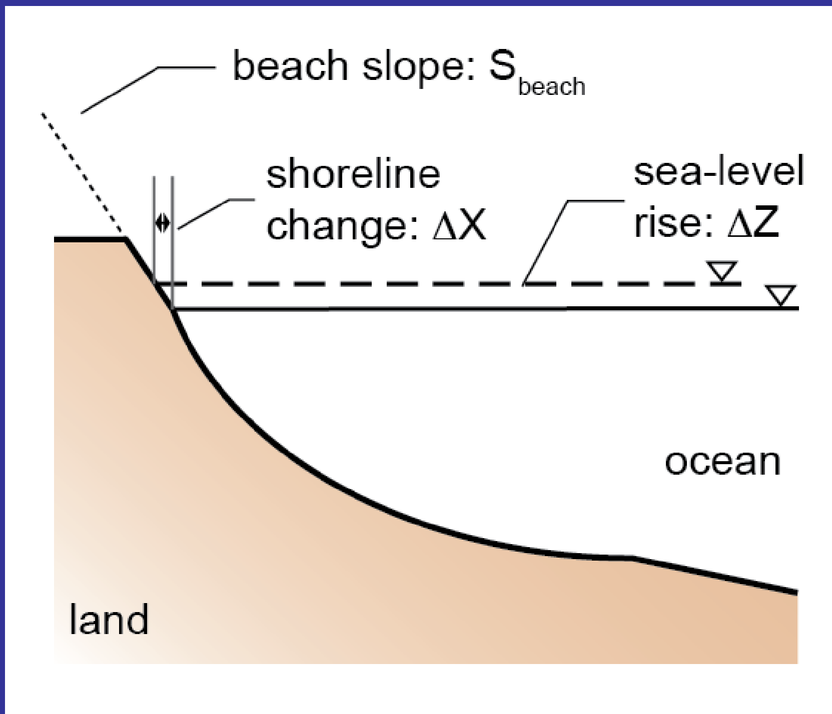
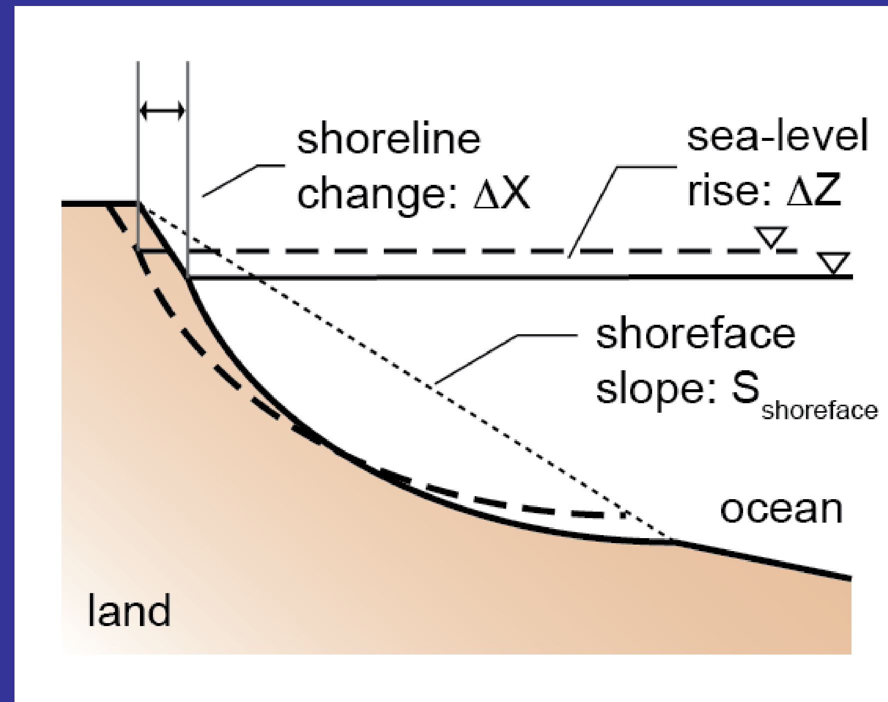


$$Dx = \frac{1}{S_{beach}} Dz$$

With Waves: the ‘Bruun Rule’



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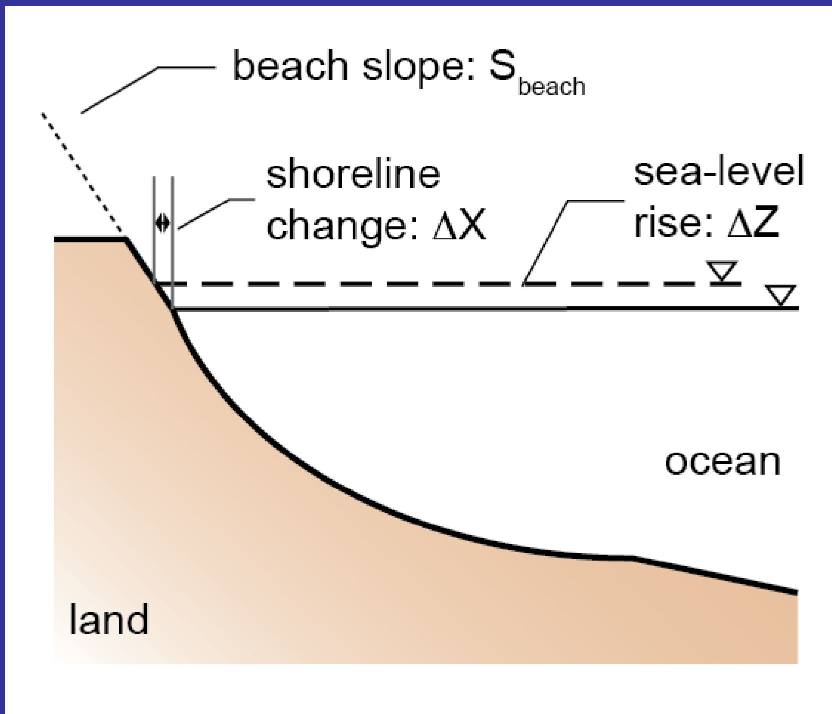
shoreline change

Sea-level Flooding

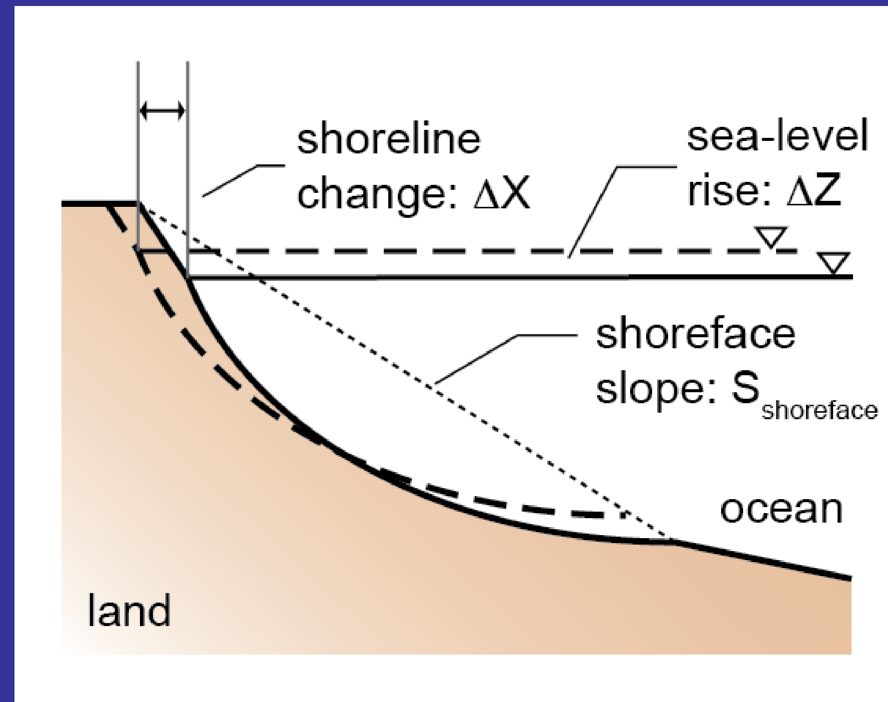


$$Dx = \frac{1}{S_{beach}} Dz$$

$S_{beach} \sim 0.1$

$\Delta x = 10 \times \Delta z$

With Waves: the 'Bruun Rule'



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shoreline change

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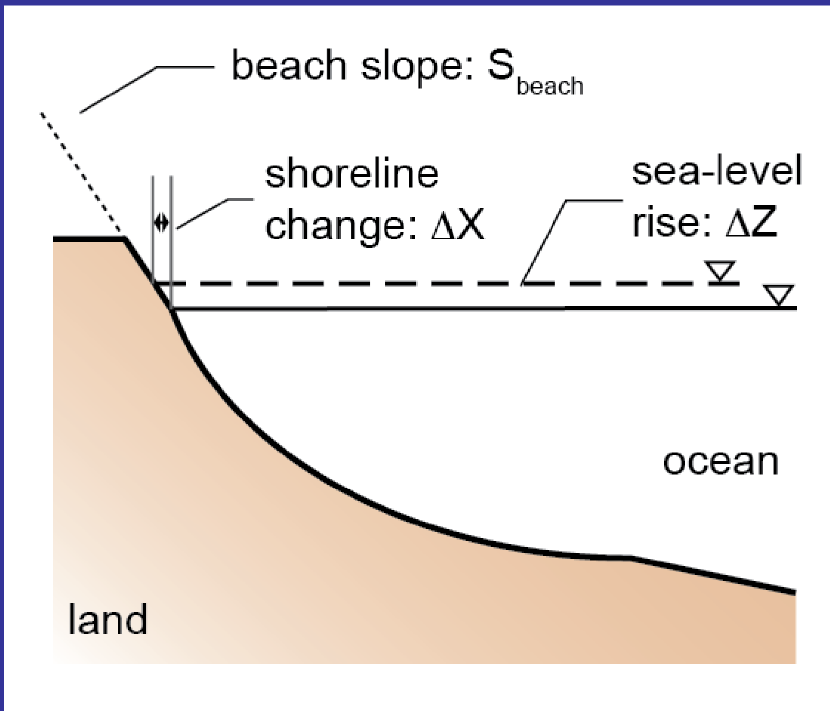

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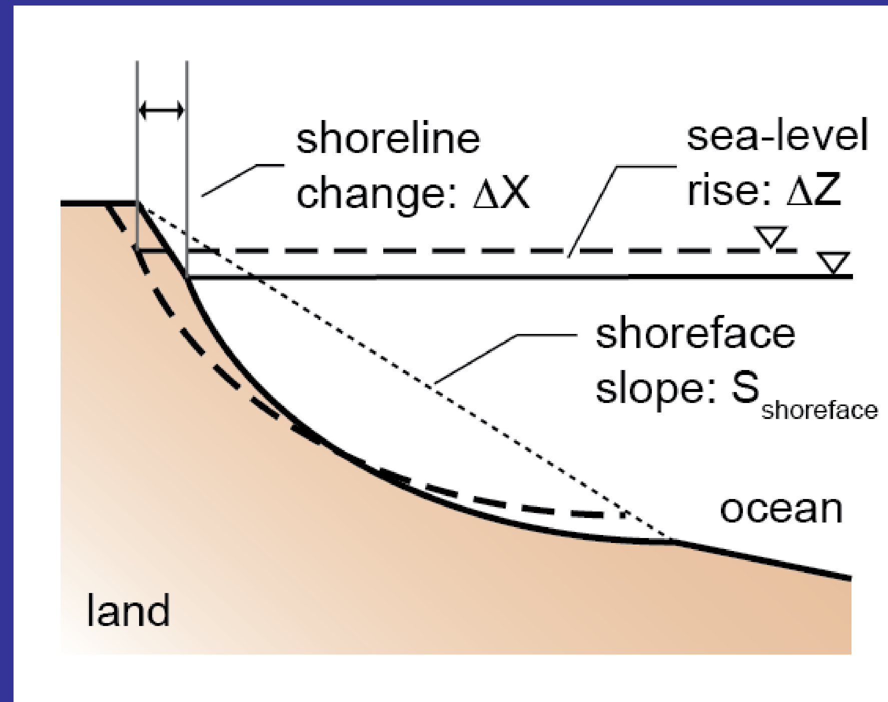
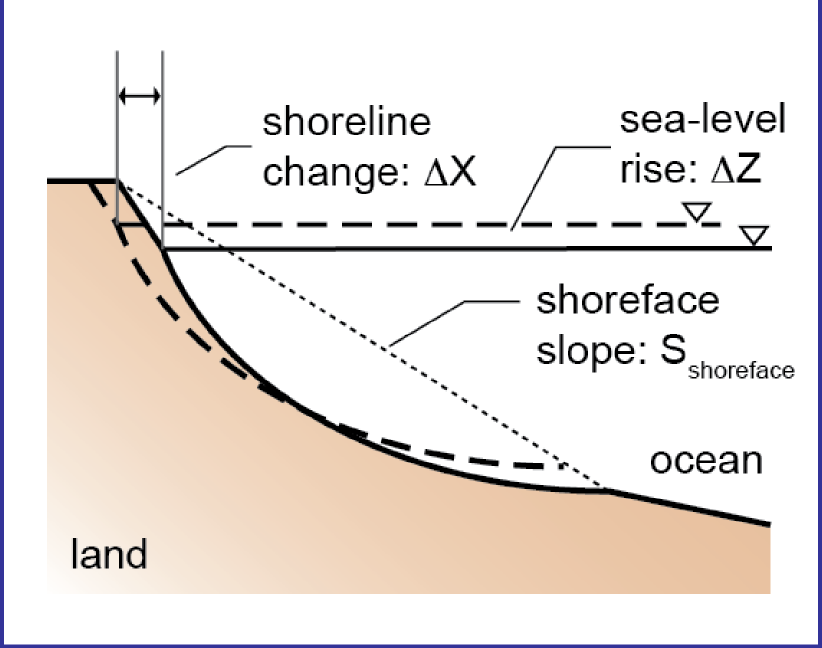


$$Dx = \frac{1}{S_{shoreface}} Dz$$

$S_{shoreface} \sim 0.01$

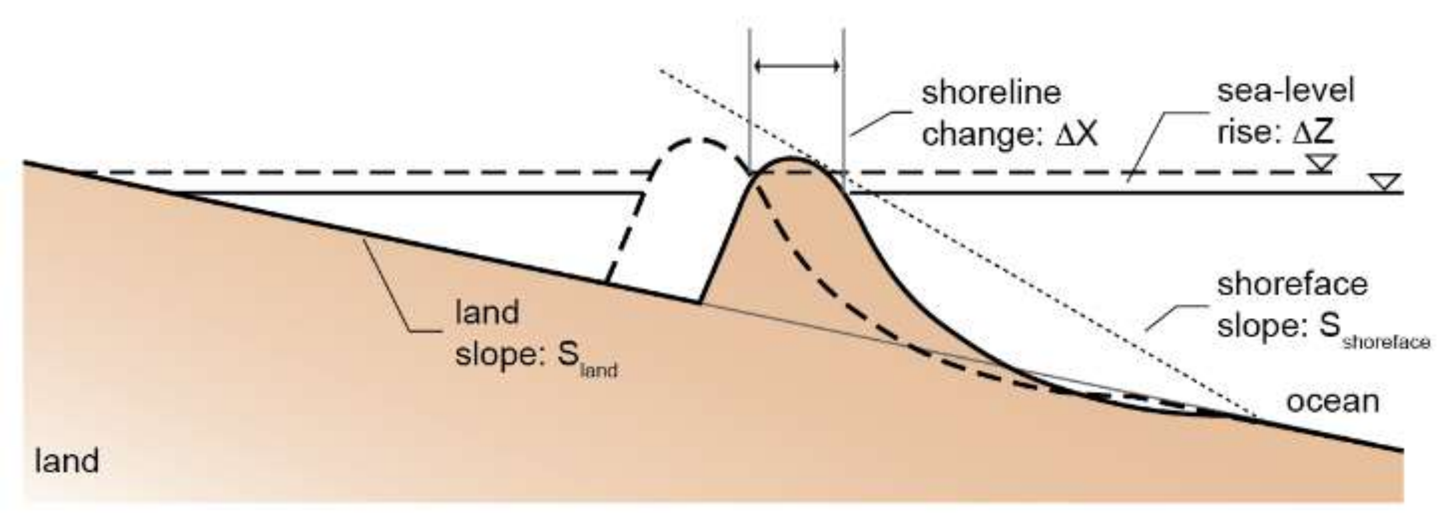
$\Delta x = 100 \times \Delta z$

barrier coasts



$S_{shoreface} \sim 0.01$
$\Delta x = 100 \times \Delta z$

$S_{land} \sim 0.001$
$\Delta x = 1{,}000 \times \Delta z$



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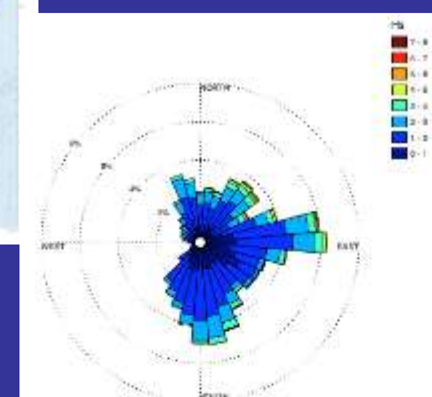

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