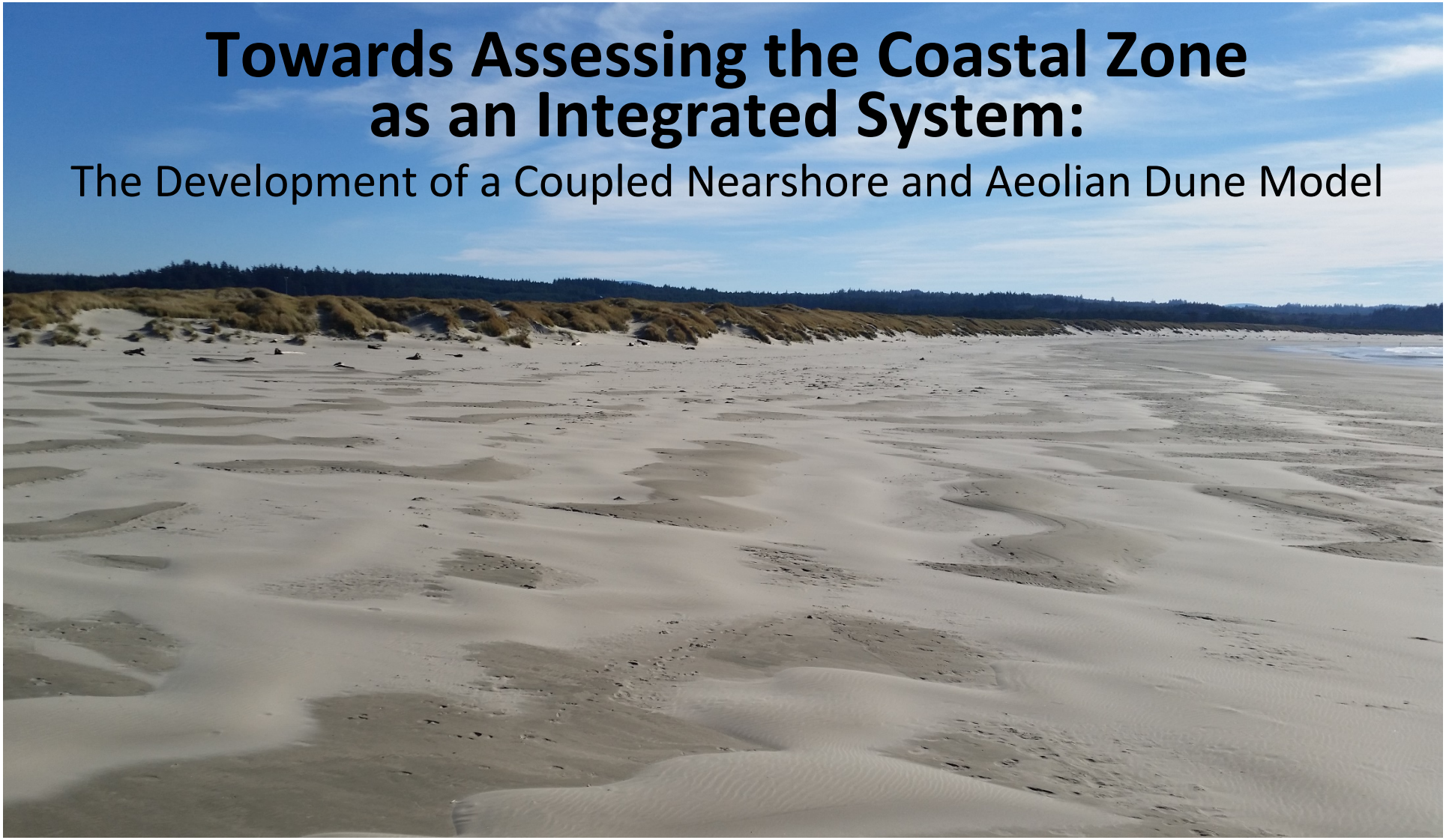
Towards Assessing the Coastal Zone as an Integrated System:

The Development of a Coupled Nearshore and Aeolian Dune Model



Nick Cohn[1], Evan Goldstein[2], Peter Ruggiero[1], Laura Moore[2], Orencio Durán[3], Dano Roelvink[4, 5] and Bas Hoonhout[5, 6]

1. Oregon State University **2.** University of North Carolina-Chapel Hill **3.** University of Bremen
4. UNESCO-IHE **5.** Deltares **6.** Delft University of Technology

Resisted for Blocking the View, Dunes Prove They Blunt Storms

Todd Heisler/The New York Times

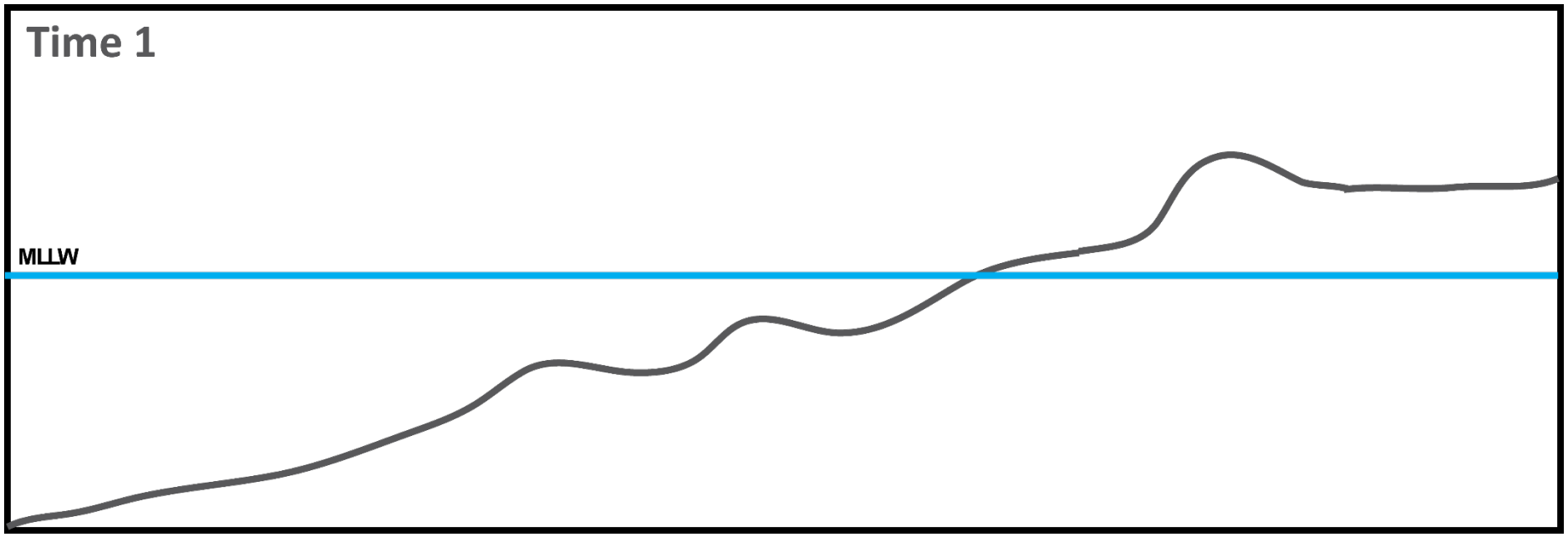
Long Beach, N.Y., which decided not to build protective sand dunes along its beach, experienced at least $200 million in losses.

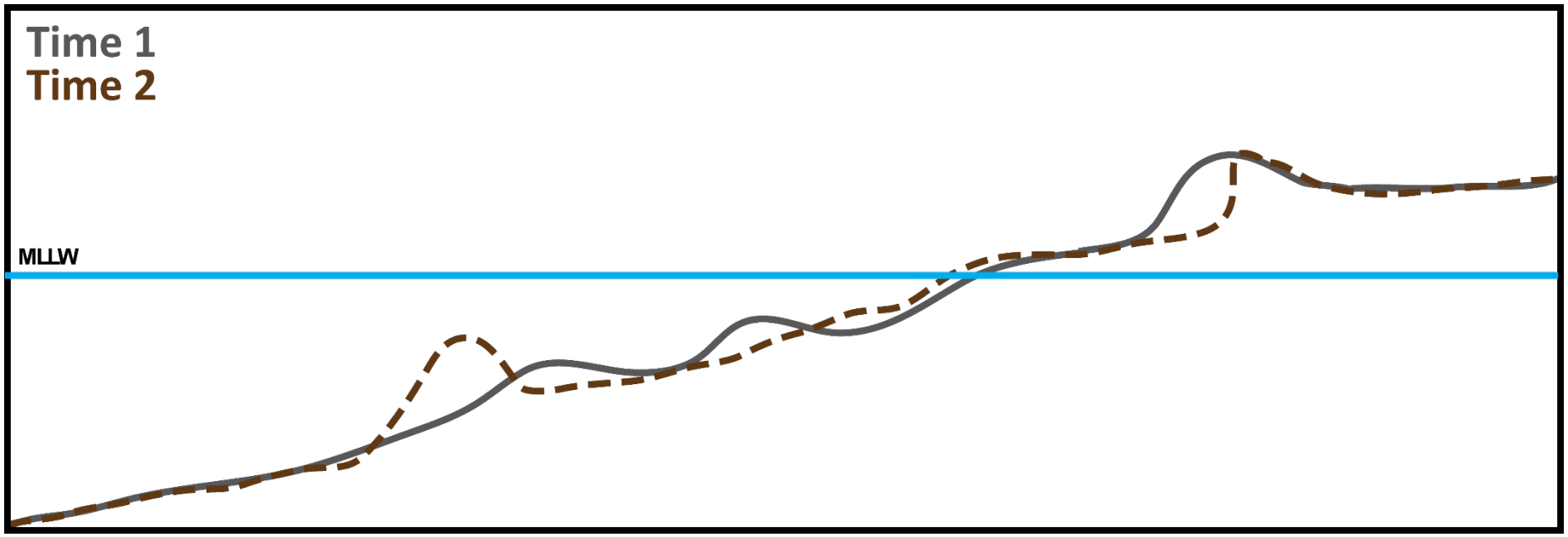
Environmental Conditions

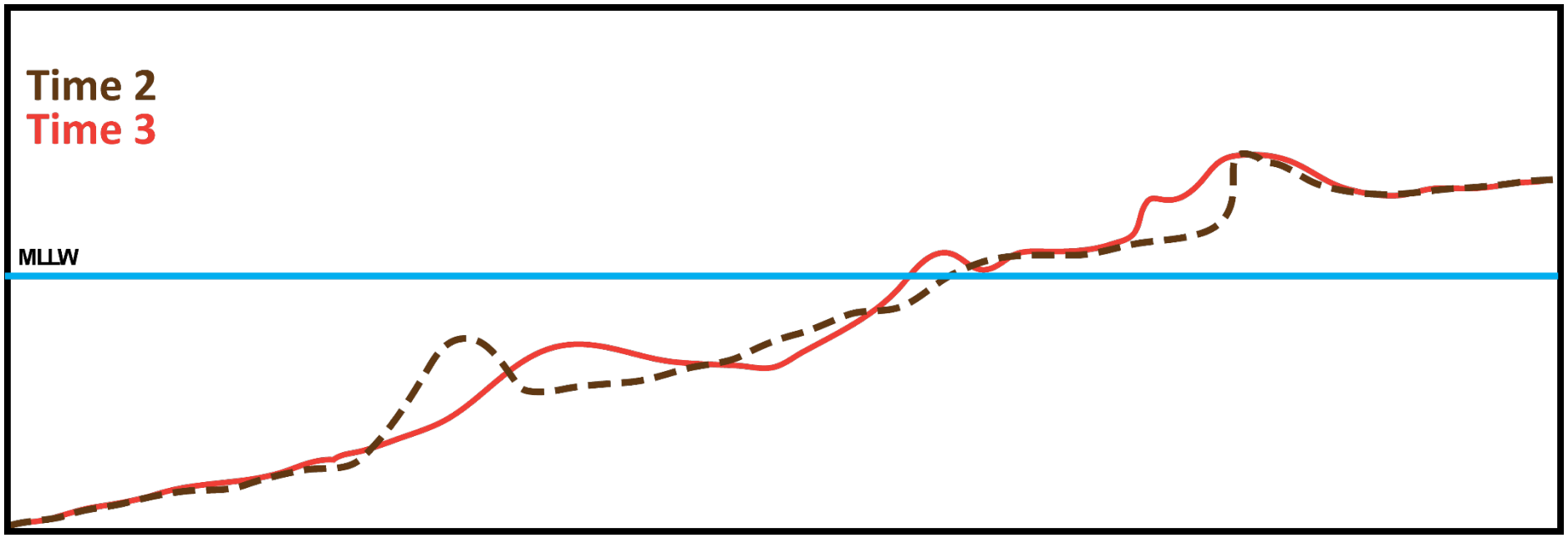
- Wind
- Water levels
  - tides
  - storm surge
  - runup
- Waves/storm frequency
- Groundwater table

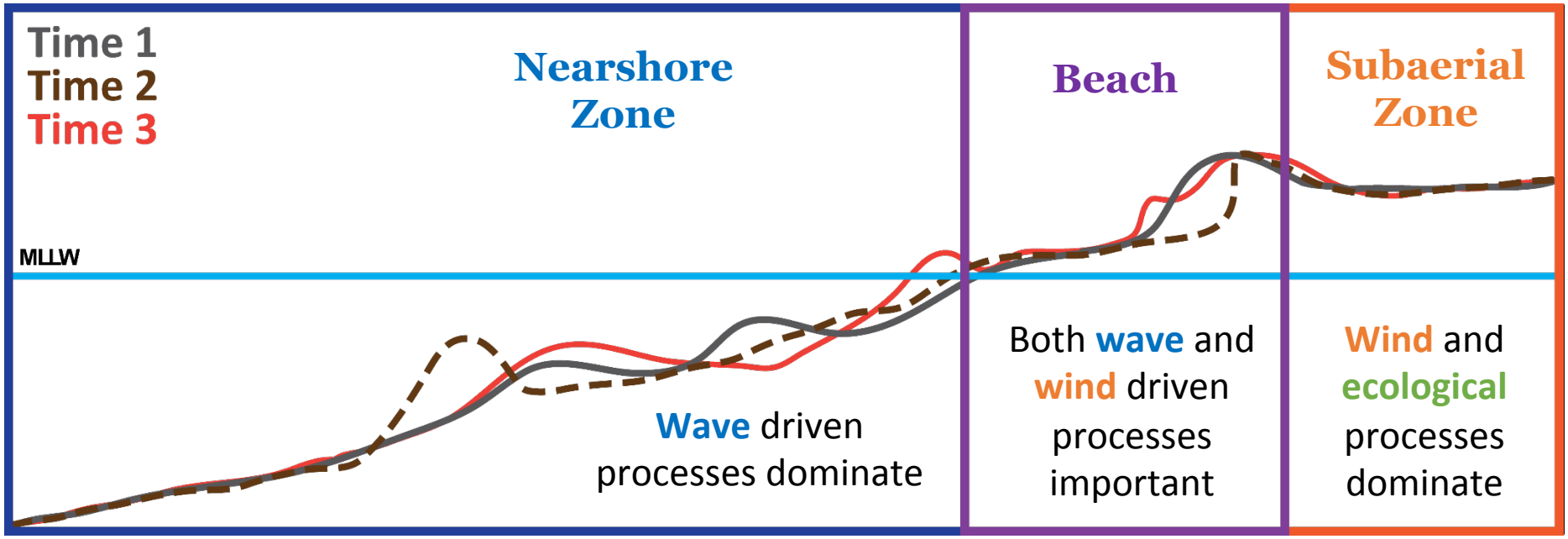
Physical Factors

- Sediment Supply and Type
- Vegetation
- Climate
- Tectonics
- Structures and anthropogenic influence

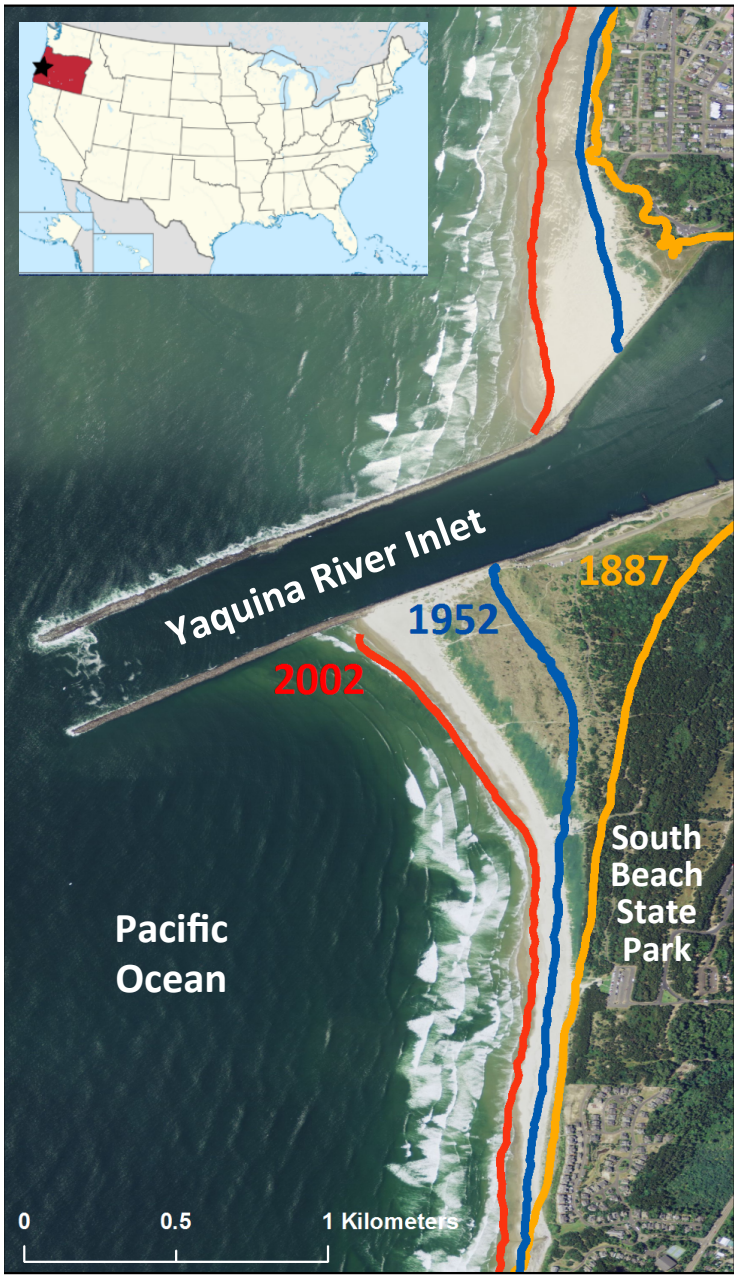

Time 1
MLLW


Time 1
Time 2
MLLW


Time 2
Time 3
MLLW

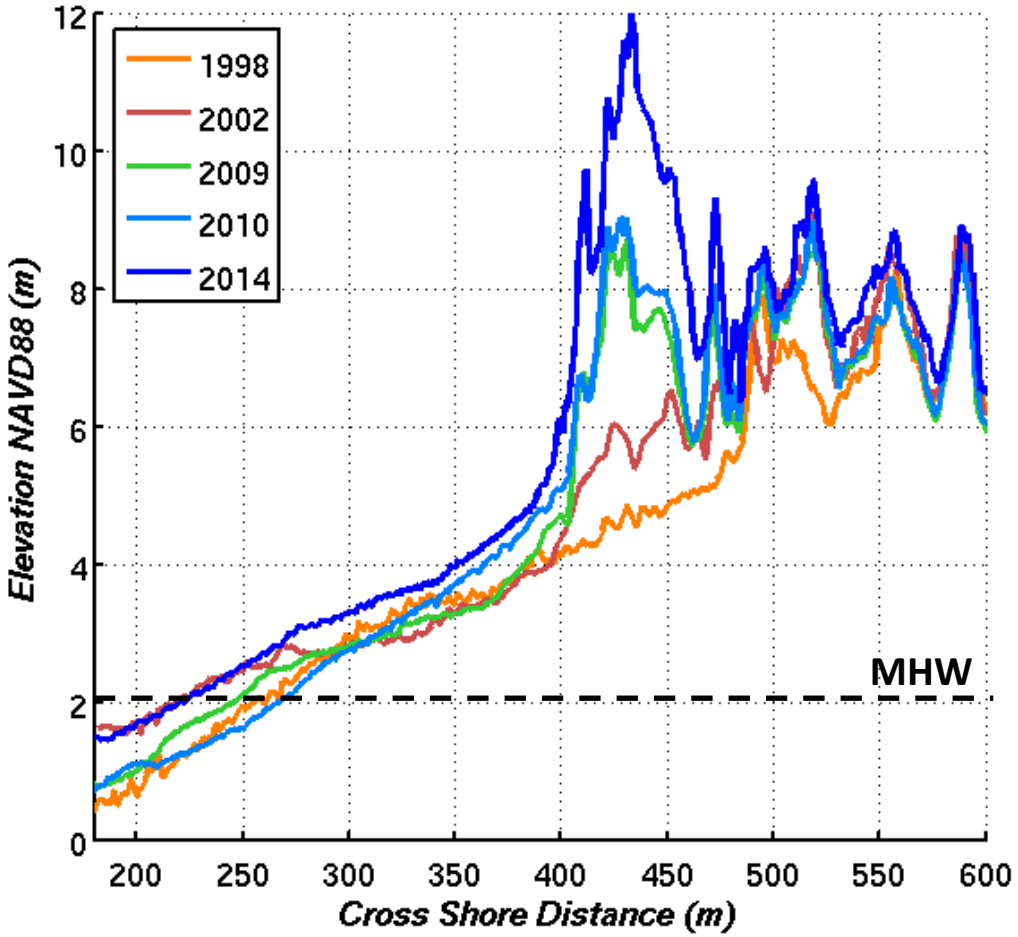

Time 1
Time 2
Time 3
Nearshore Zone
Beach
Subaerial Zone
MLLW
Wave driven processes dominate
Both wave and wind driven processes important
Wind and ecological processes dominate

Historical Shoreline Change

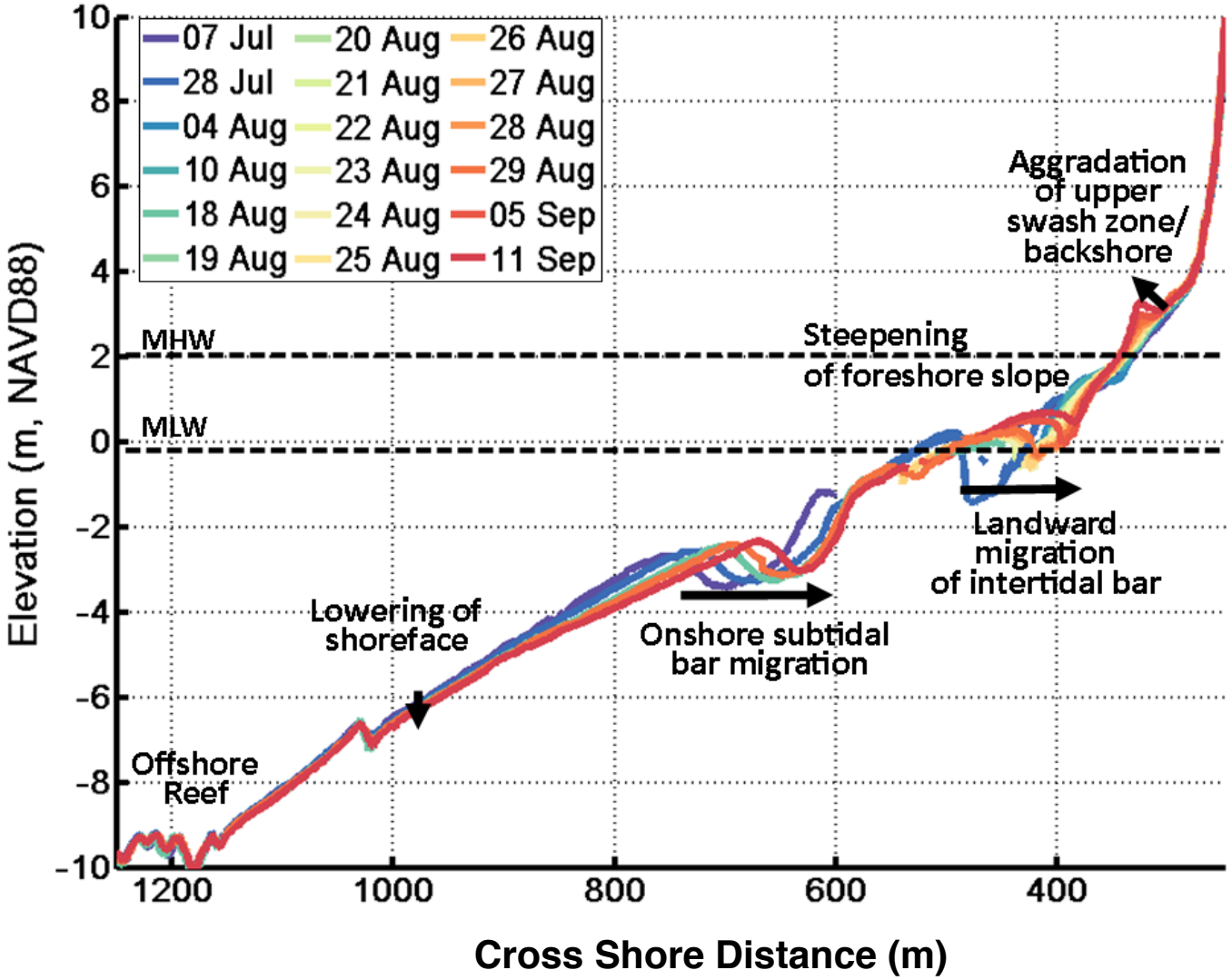


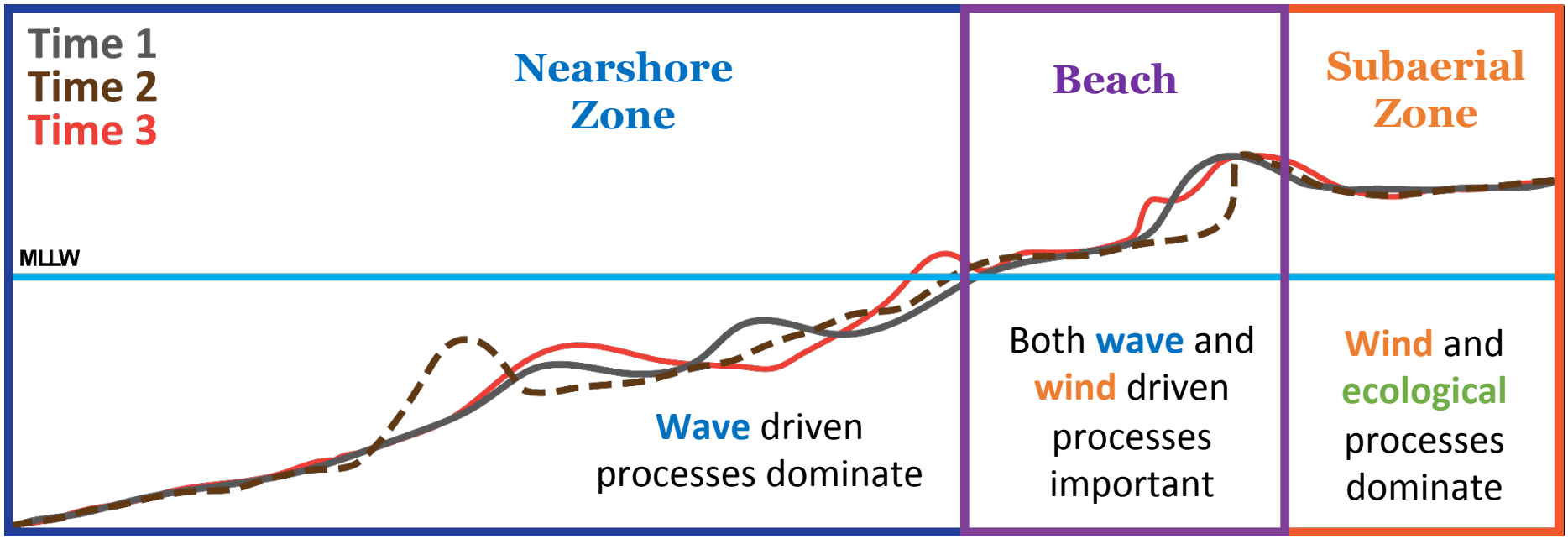
South Beach State Park
Newport, OR, USA

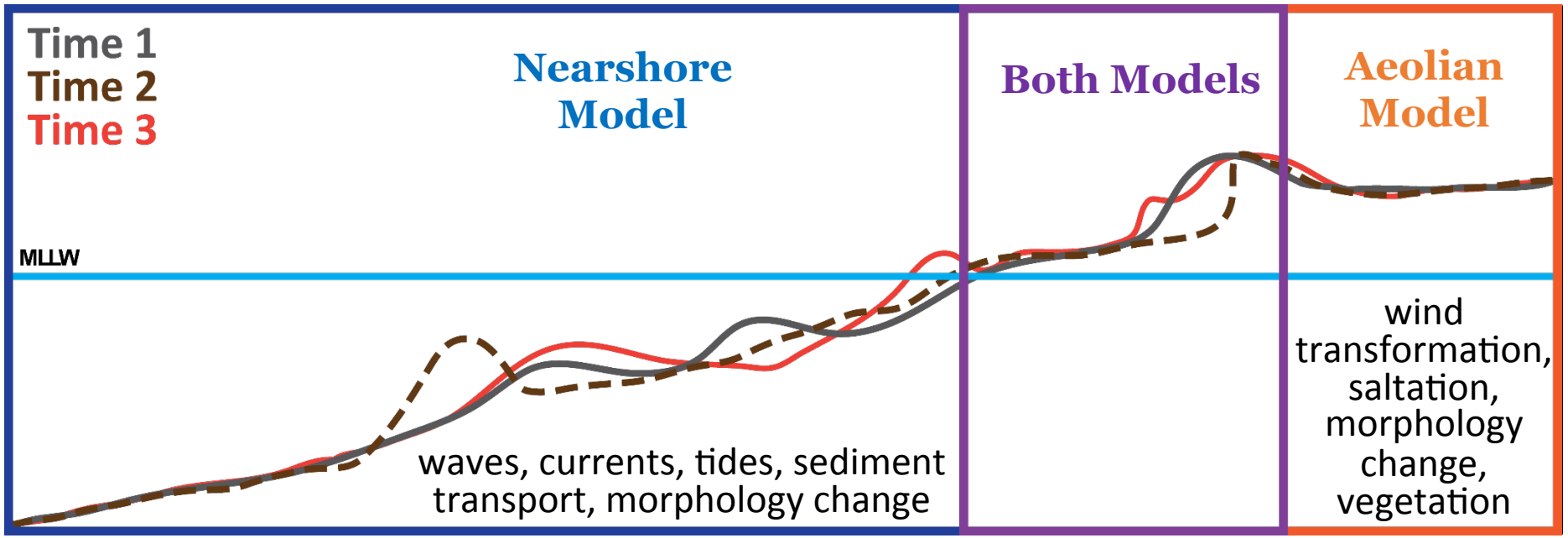
Decadal Foredune Evolution

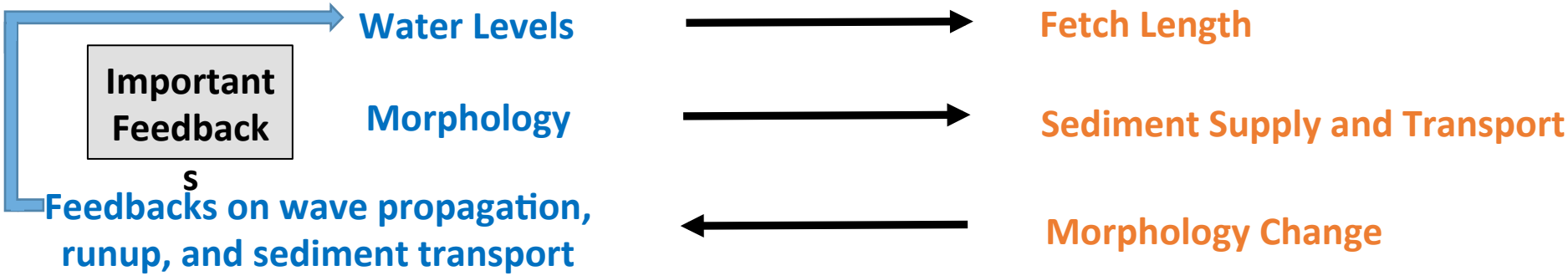


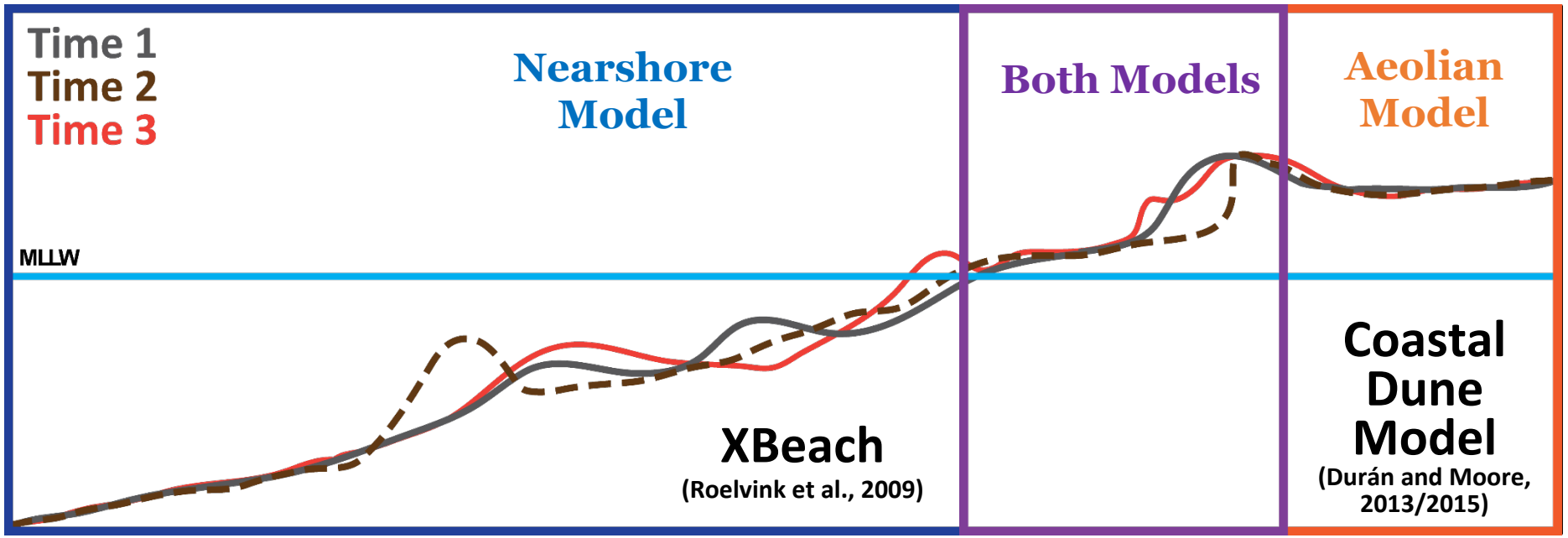
South Beach: Seasonal Morphology Observations




Time 1
Time 2
Time 3
Nearshore Zone
Beach
Subaerial Zone
MLLW
Wave driven processes dominate
Both wave and wind driven processes important
Wind and ecological processes dominate


Time 1
Time 2
Time 3
Nearshore Model
Both Models
Aeolian Model
MLLW
waves, currents, tides, sediment transport, morphology change
wind transformation, saltation, morphology change, vegetation


Water Levels
Fetch Length
Important Feedback
Morphology
Sediment Supply and Transport
s
Feedbacks on wave propagation, runup, and sediment transport
Morphology Change



Water Levels → Fetch Length

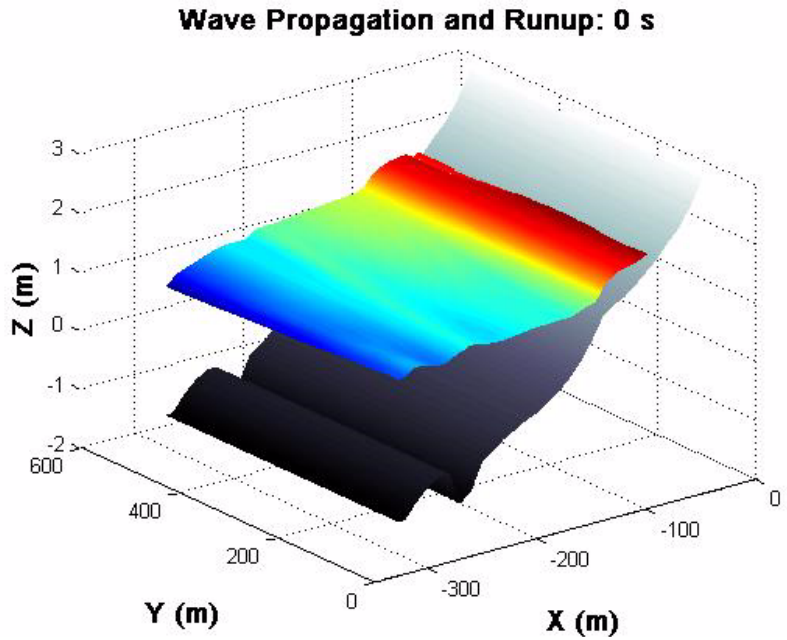
Important Feedback

Morphology → Sediment Supply and Transport

Feedbacks on wave propagation, runup, and sediment transport ← Morphology Change

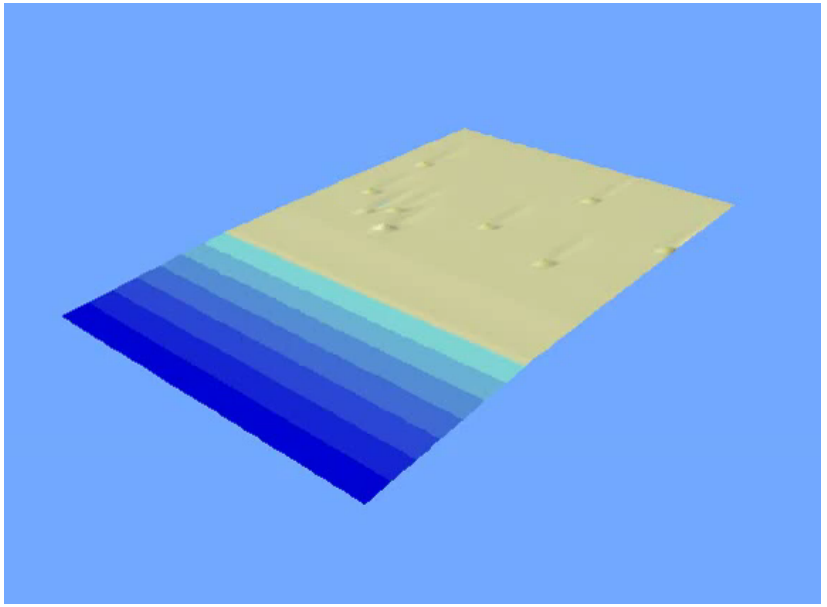
XBeach

- Phase-averaged, infragravity resolving wave model
- Predicts sediment transport/ morphology change
- Validated for wave runup, dune erosion, and storm impacts
- Open-source and under active development (xbeach.org; Deltares)

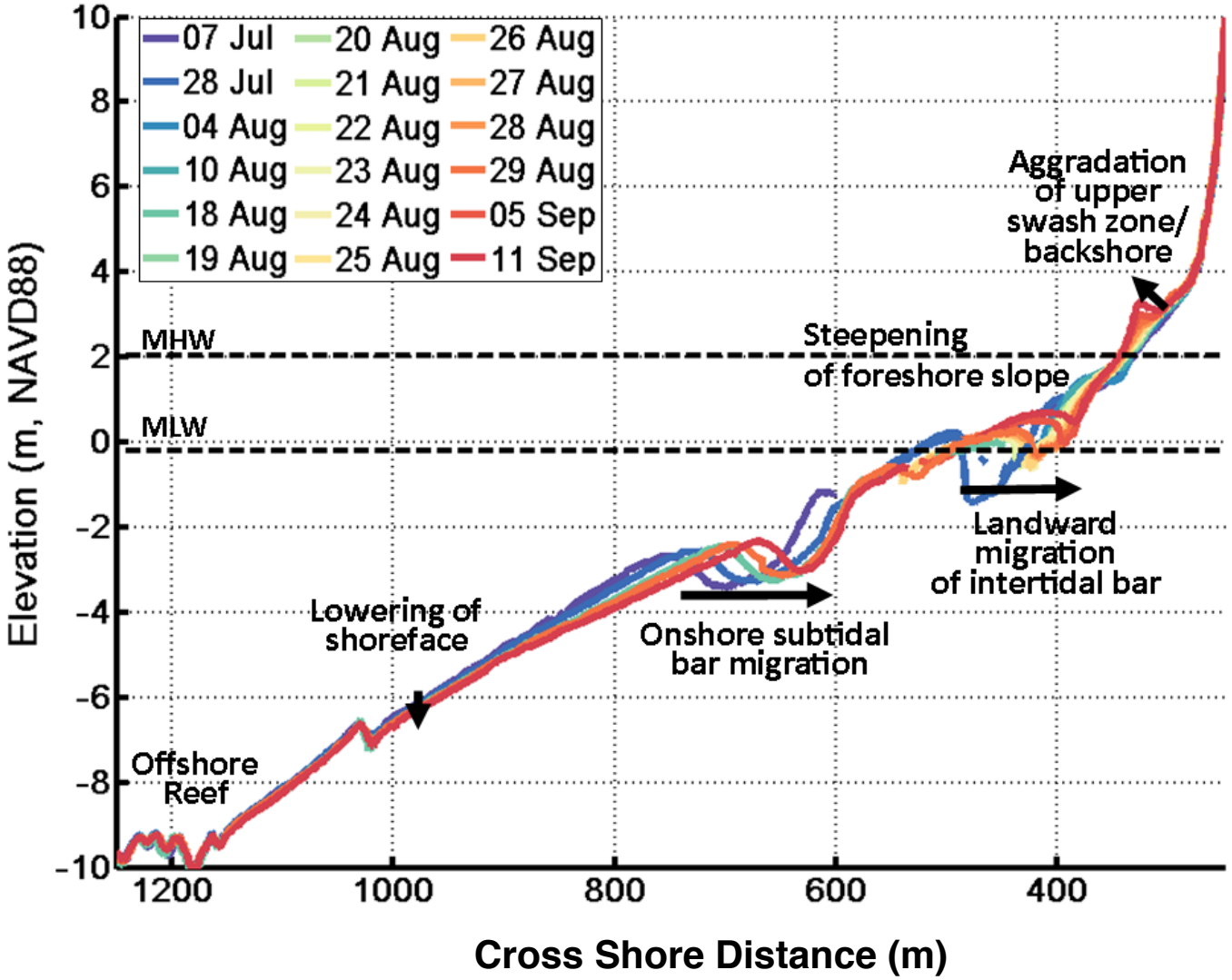


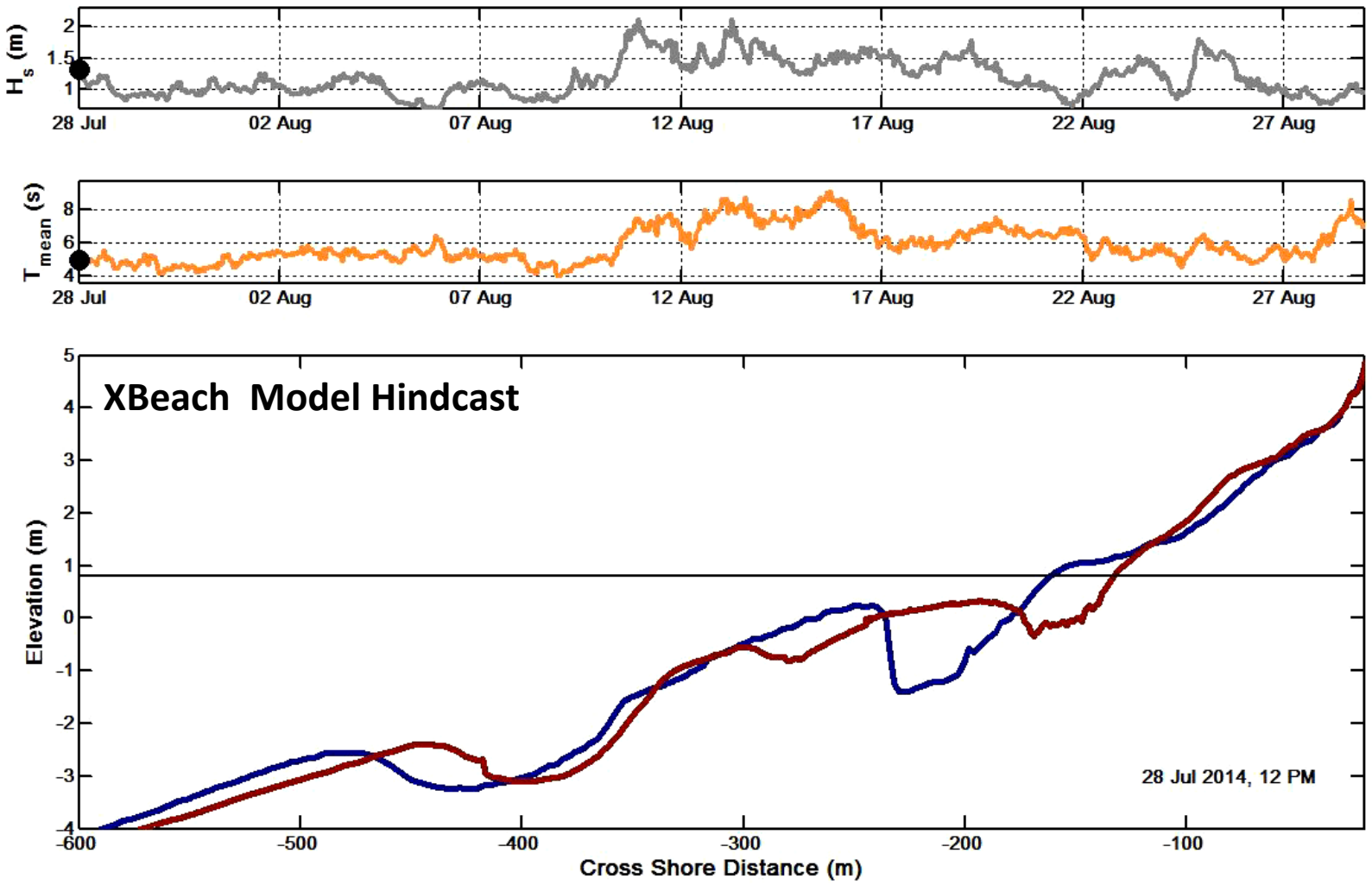
Coastal Dune Model

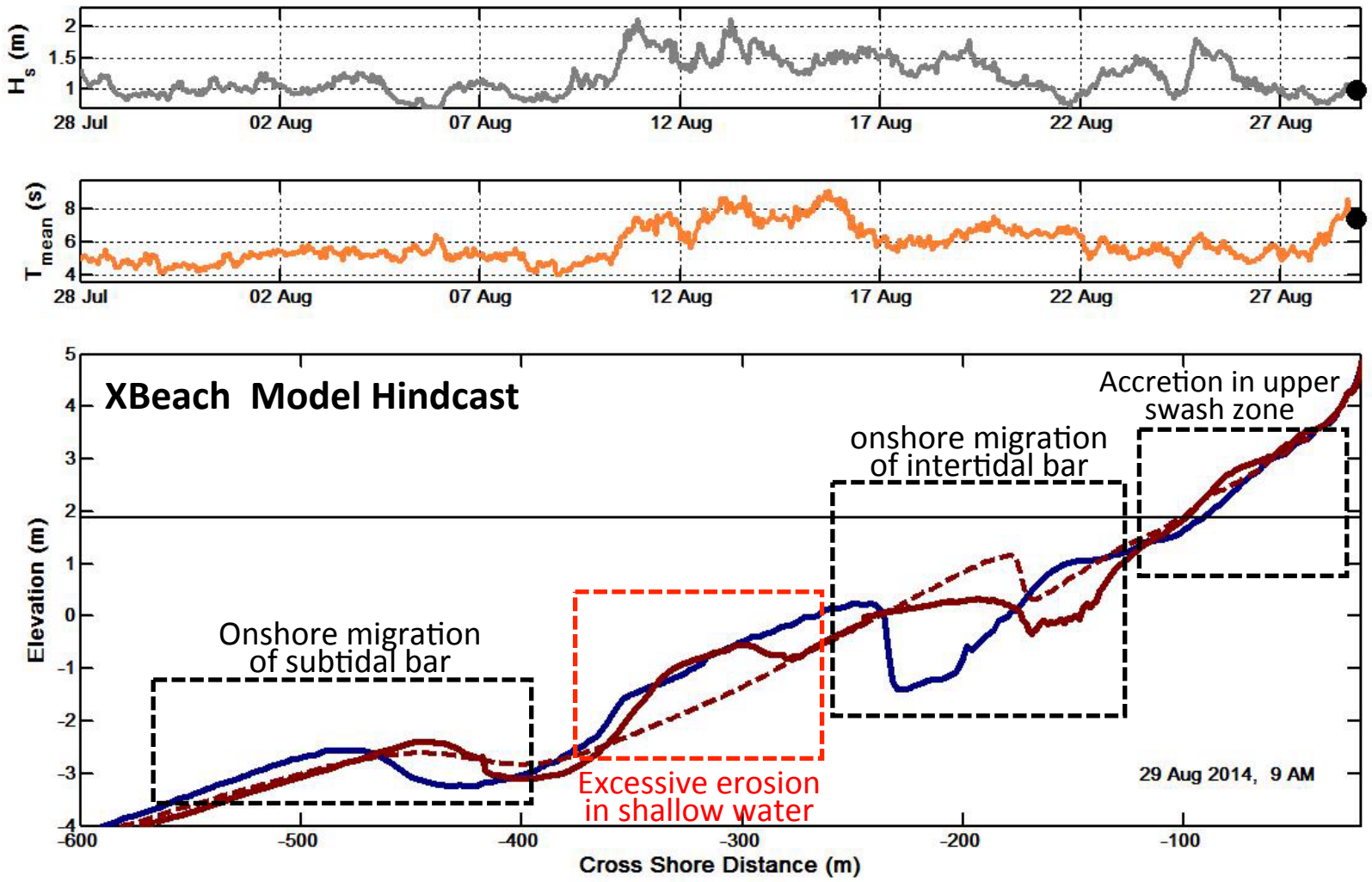
- Saltation, transport, and deposition model
- Modules for coastal vegetation
- Validated for general dune behavior
- Open-source and under active development (UNC-Chapel Hill and University of Bremen)



South Beach: Seasonal Morphology Observations




H_s (m)
2
1.5
1
28 Jul
02 Aug
07 Aug
12 Aug
17 Aug
22 Aug
27 Aug
T_{mean} (s)
8
6
4
28 Jul
02 Aug
07 Aug
12 Aug
17 Aug
22 Aug
27 Aug
XBeach Model Hindcast
Elevation (m)
5
4
3
2
1
0
-1
-2
-3
-4
-600
-500
-400
-300
-200
-100
Cross Shore Distance (m)
28 Jul 2014, 12 PM
Actual Profile 28 July
Actual Profile 29 Aug
Model Result
Tide Level



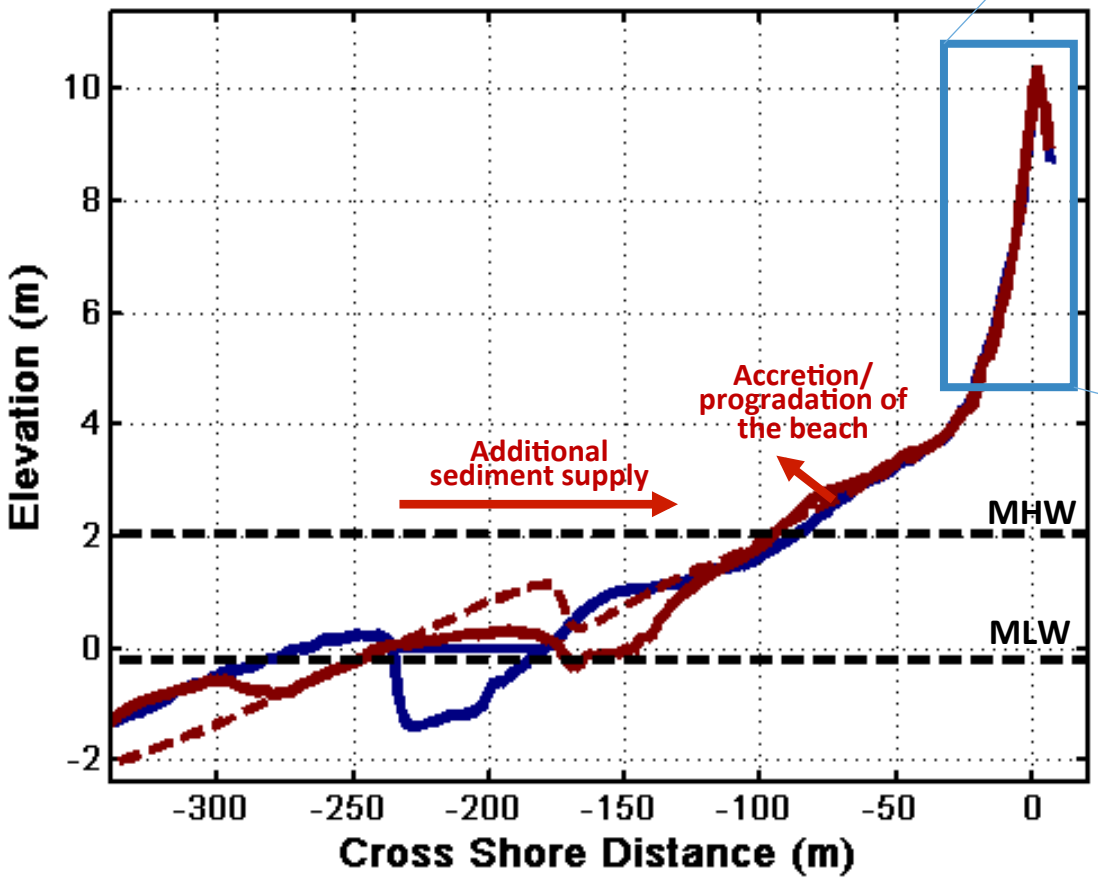
Actual Profile 28 July

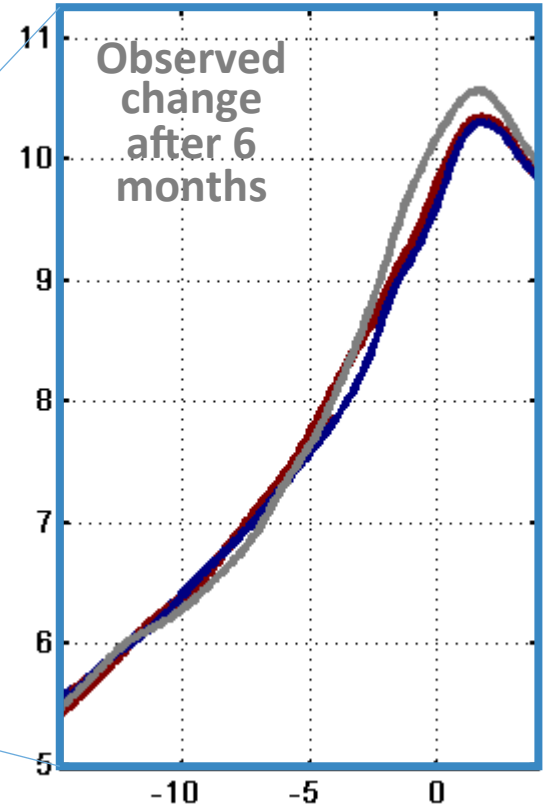
Actual Profile 29 Aug

Model Result

Tide Level

Next Steps: Can we model the synchronization between sandbar welding and dune growth?





Average shoreline/ dune progradation rate of ~2 m/yr in South Beach

Actual Profile 28 July

Actual Profile 29 Aug

Model Result

Conclusions

- Complex feedbacks necessitate considering the coastal zone as a **integrated system** driven by both wave and wind driven processes
- Working on implementing **XBeach** and **CDM** into the CSDMS framework
    - Research tool for useful for wide range of spatial (~100 m → 10+ km) and temporal (days → decades) scales
- Informal international collaboration with numerous research questions/interests
    - **SHORE**face-**BE**ach-**DU**ne **In**teraction **(SHORE-BEDUIN)**

Funding/Support Acknowledgements:

Deltares
Enabling Delta Life
NortekUSA
US Army Corps of Engineers
NANOOS
NSF