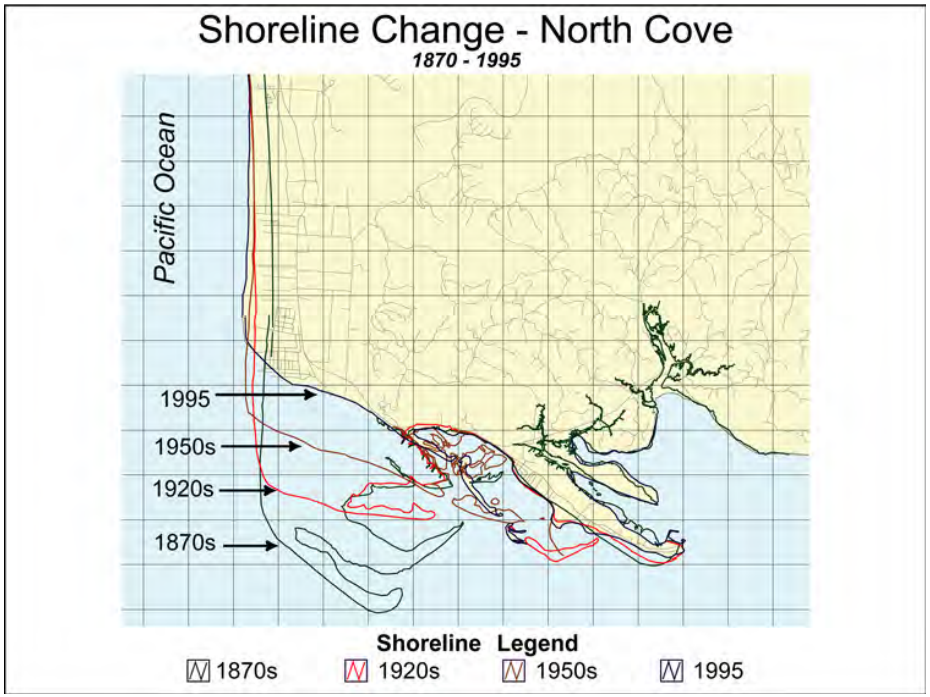
Morphological trends and flood probability of Empire Spit: Willapa Bay, WA

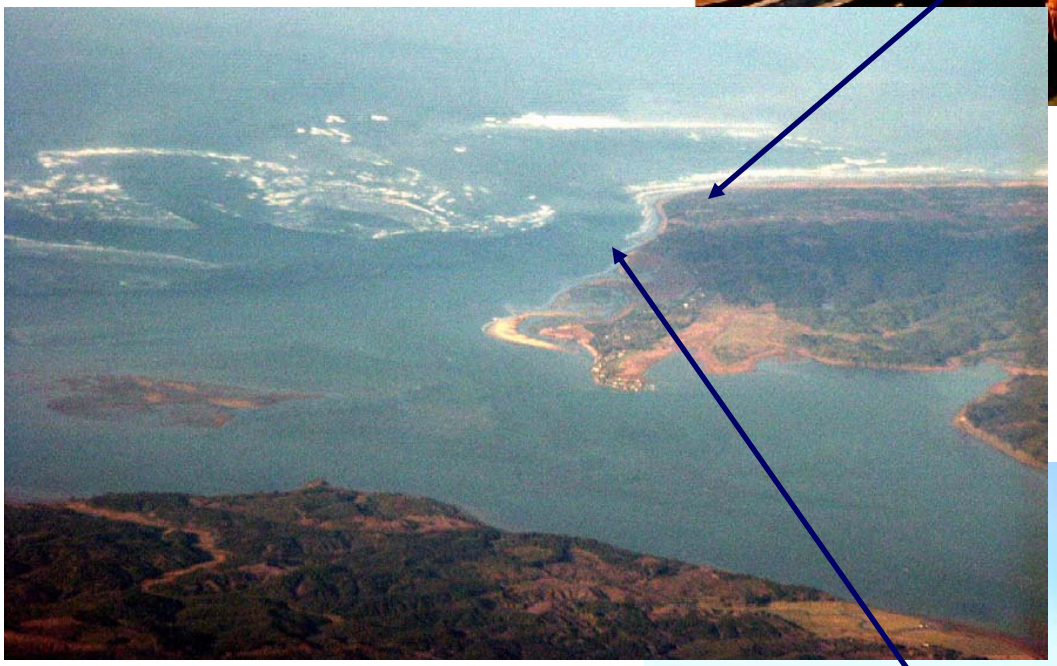


Peter Ruggiero

Department of Geosciences
College of Science
Oregon State University

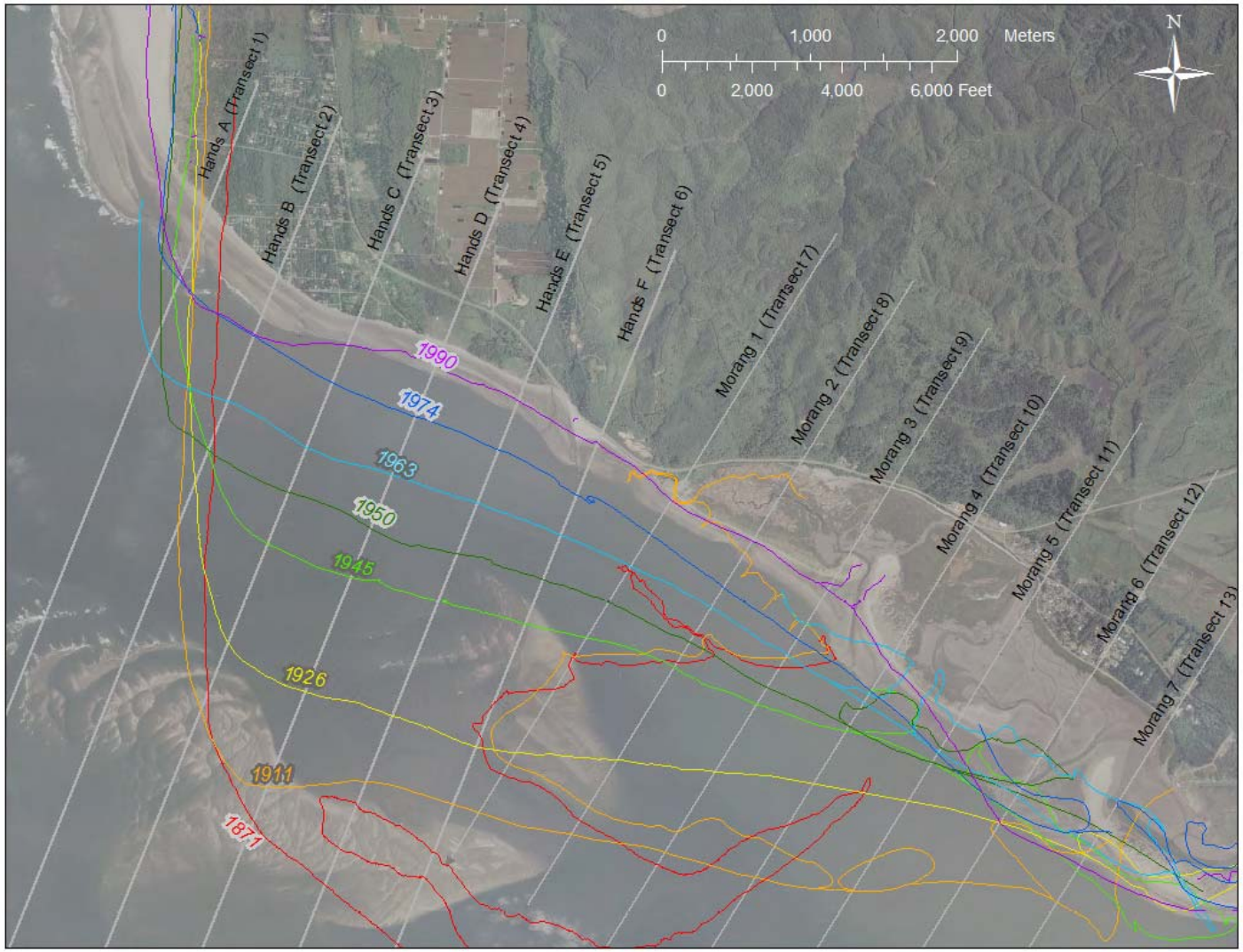
Study Area

2007 Photo

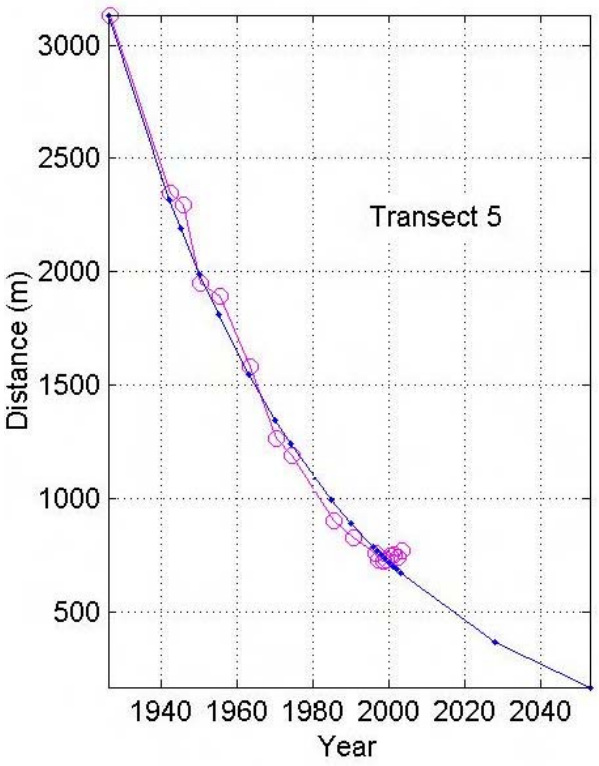


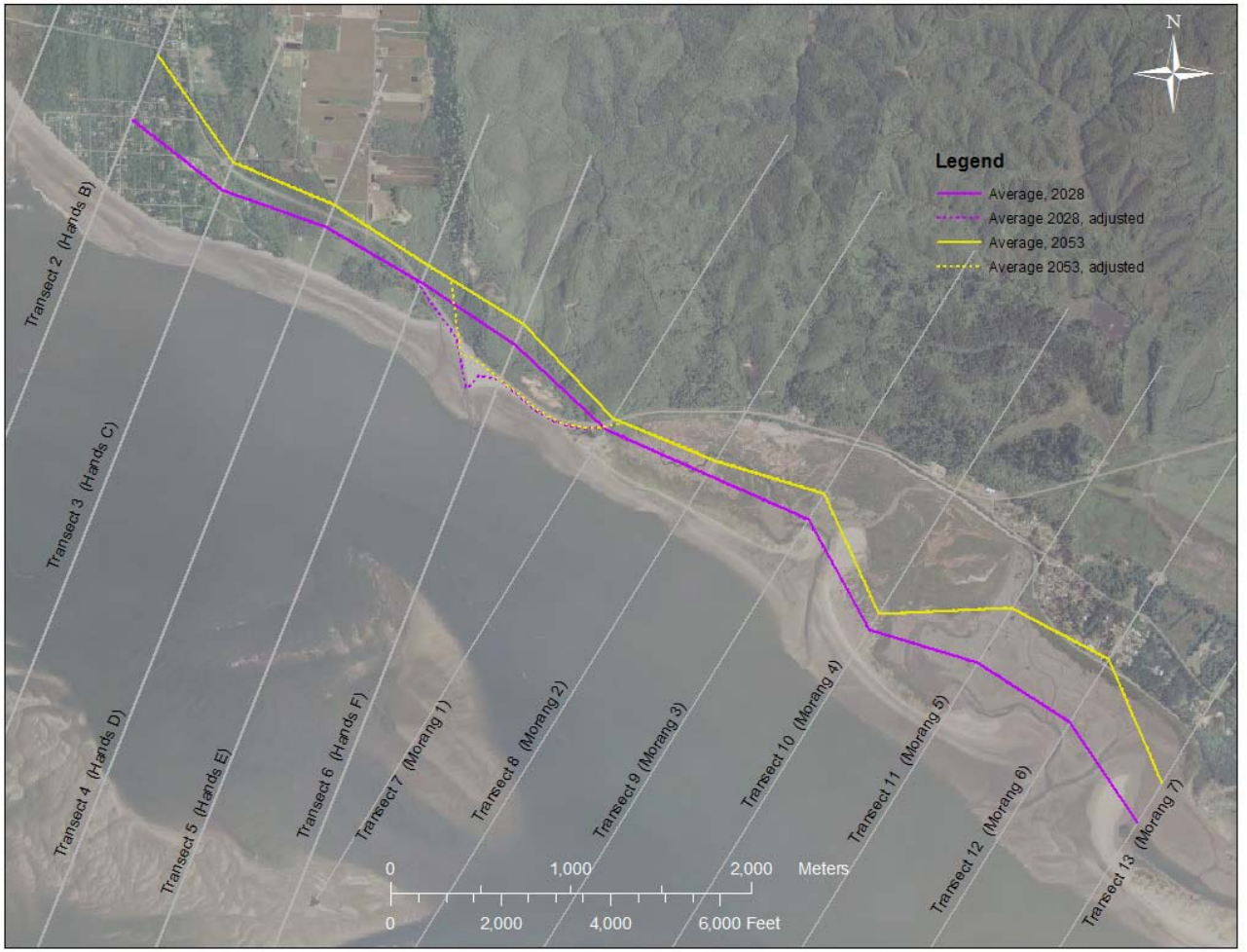
2000 Photo

Shoreline Change

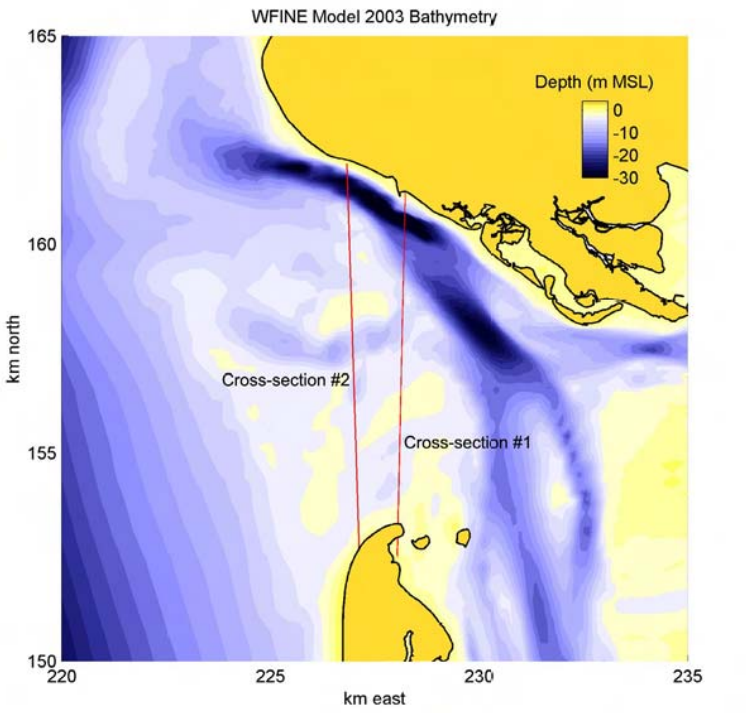


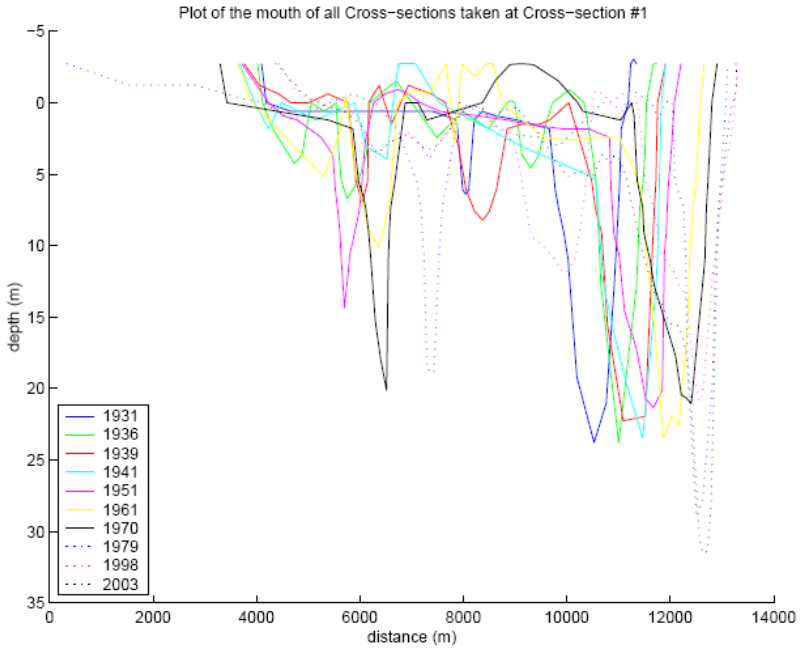
Shoreline Change (Extrapolations) Predictions

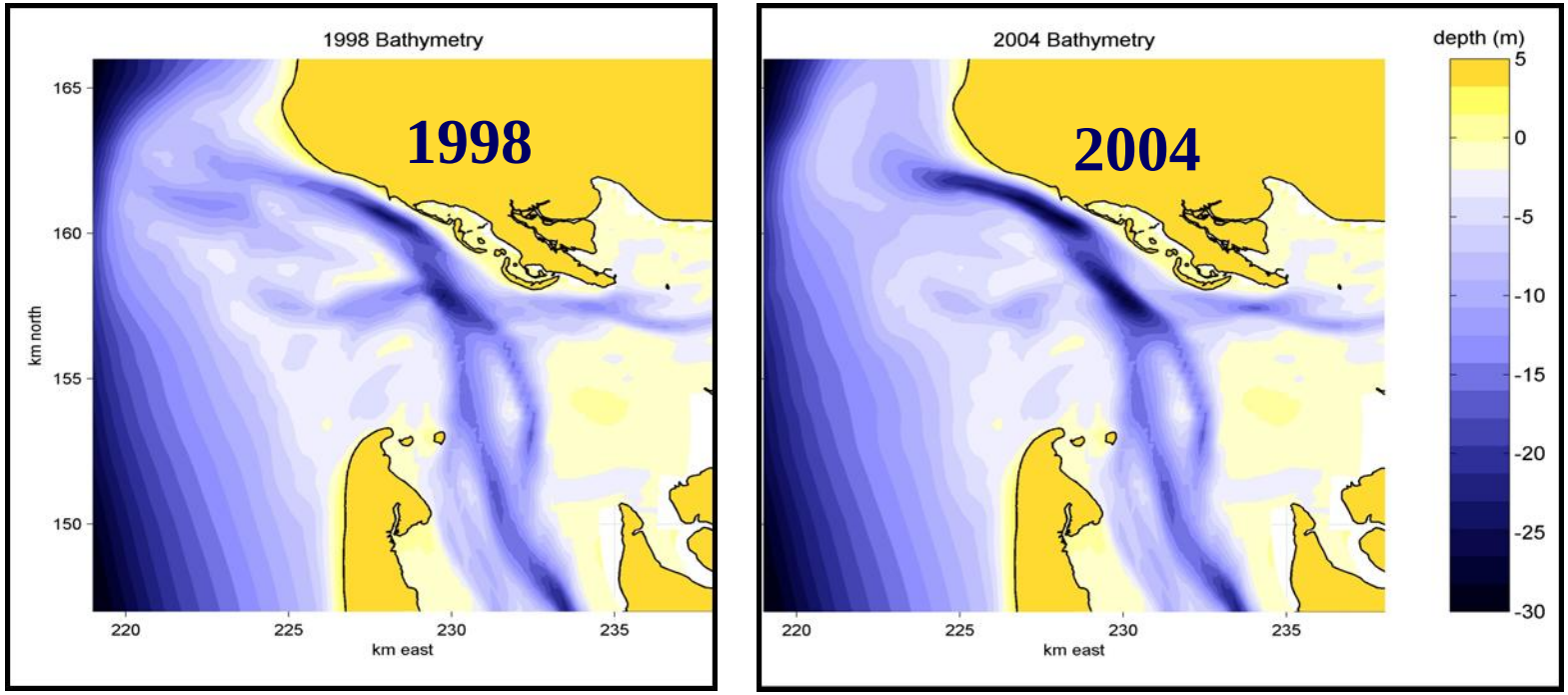




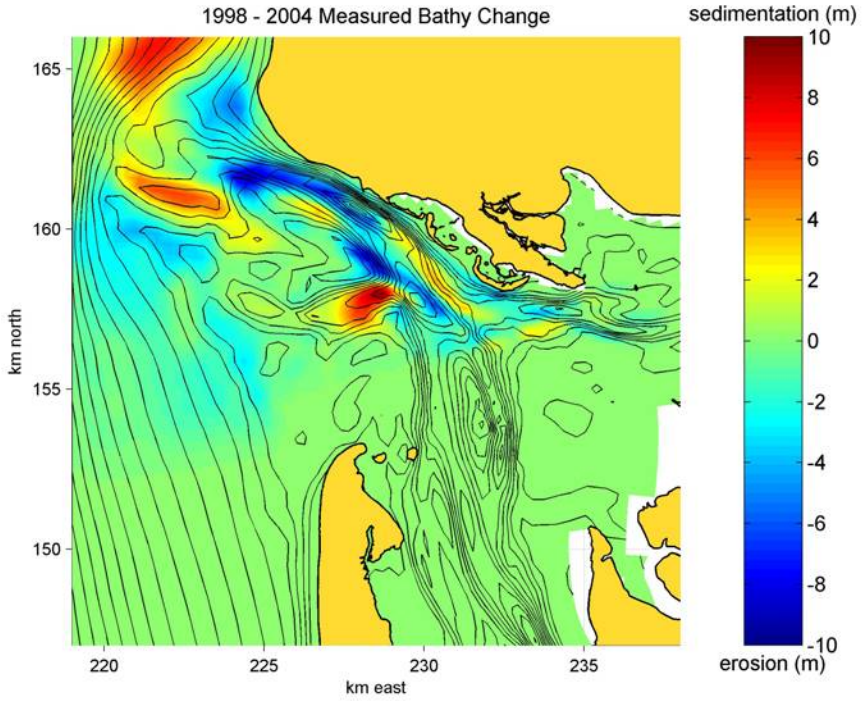
Bathymetric Change







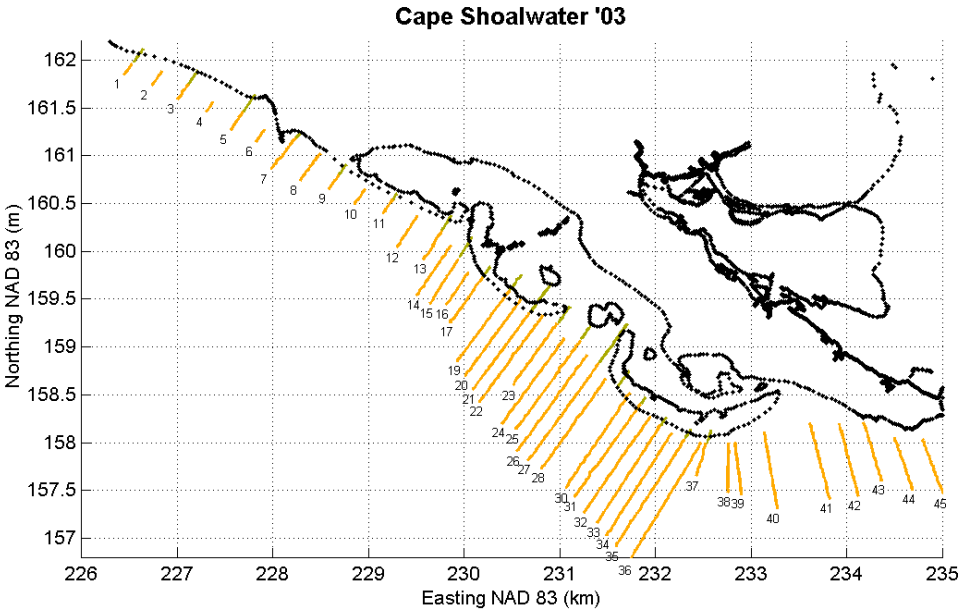
Bathymetric Change



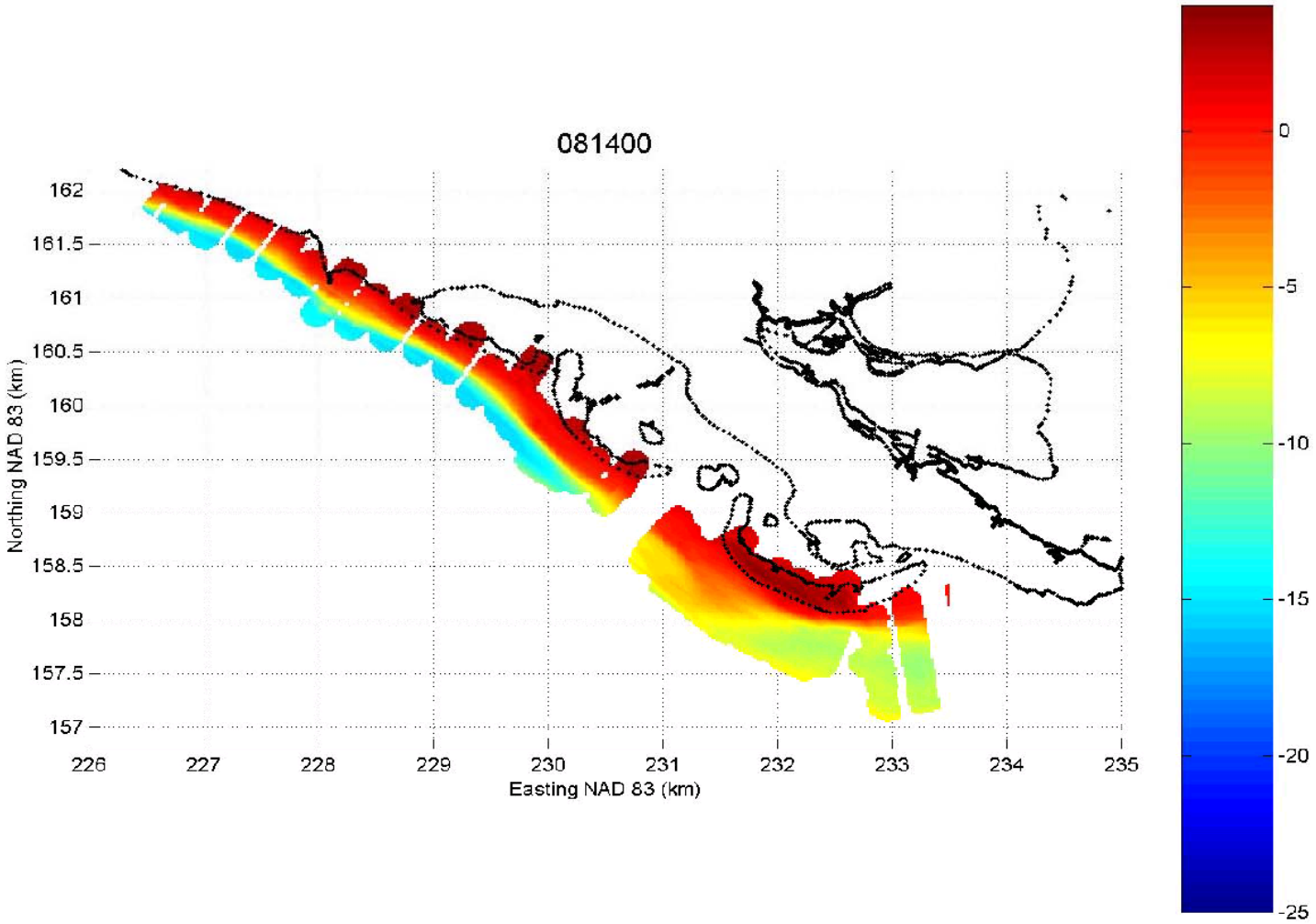
Observations from historical shoreline and bathymetric change analyses

- Erosion rates greatest in NW (near mouth)
- SE end of Empire Spit relatively stable
- Channel and shoreline tend to move together
- Primary mechanism for migrating channel is sediment supply to entrance shoal south of main channel
- Channel migration and shoreline erosion rates decreasing from mid 1980s

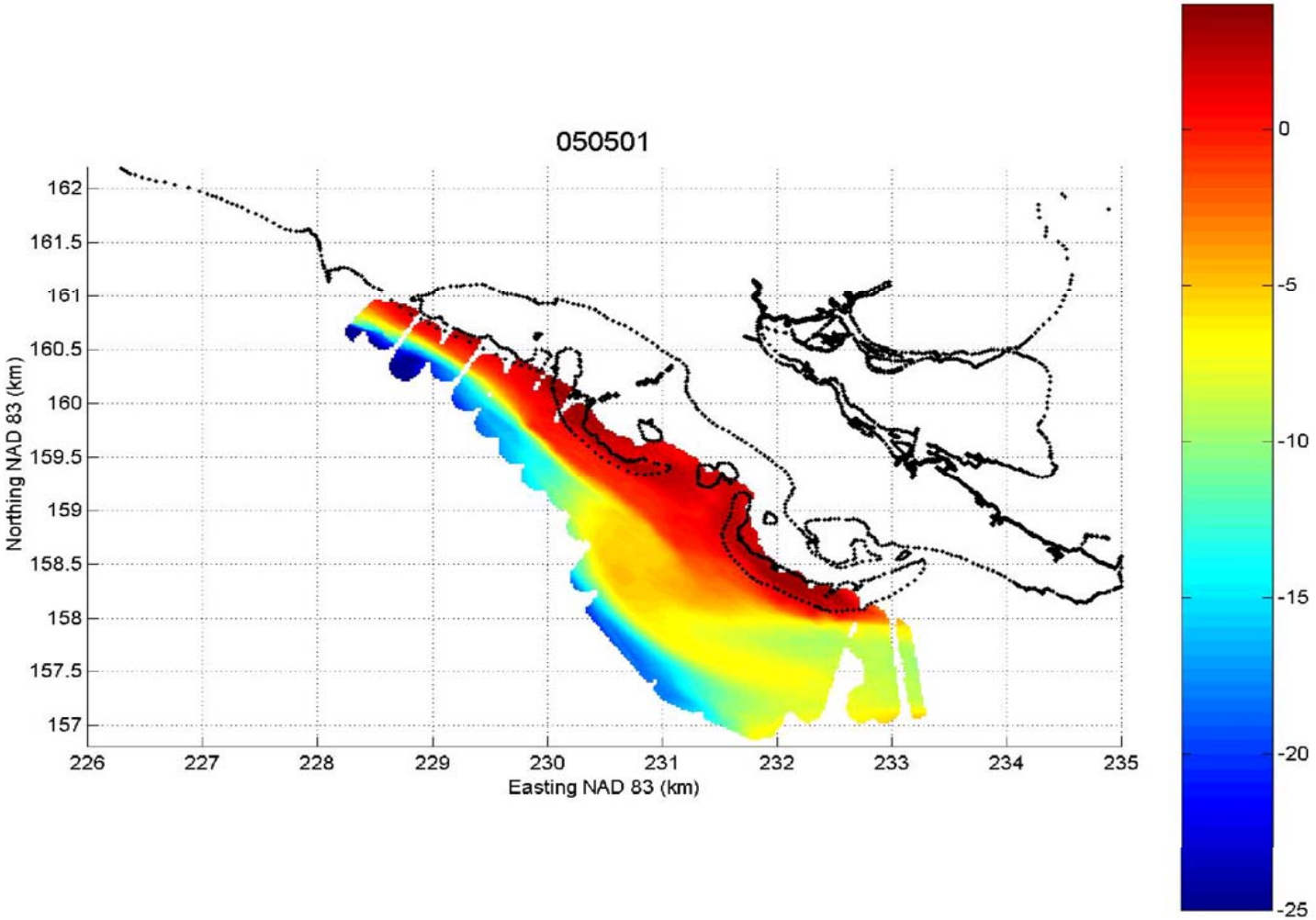
Modern shore/beach face evolution



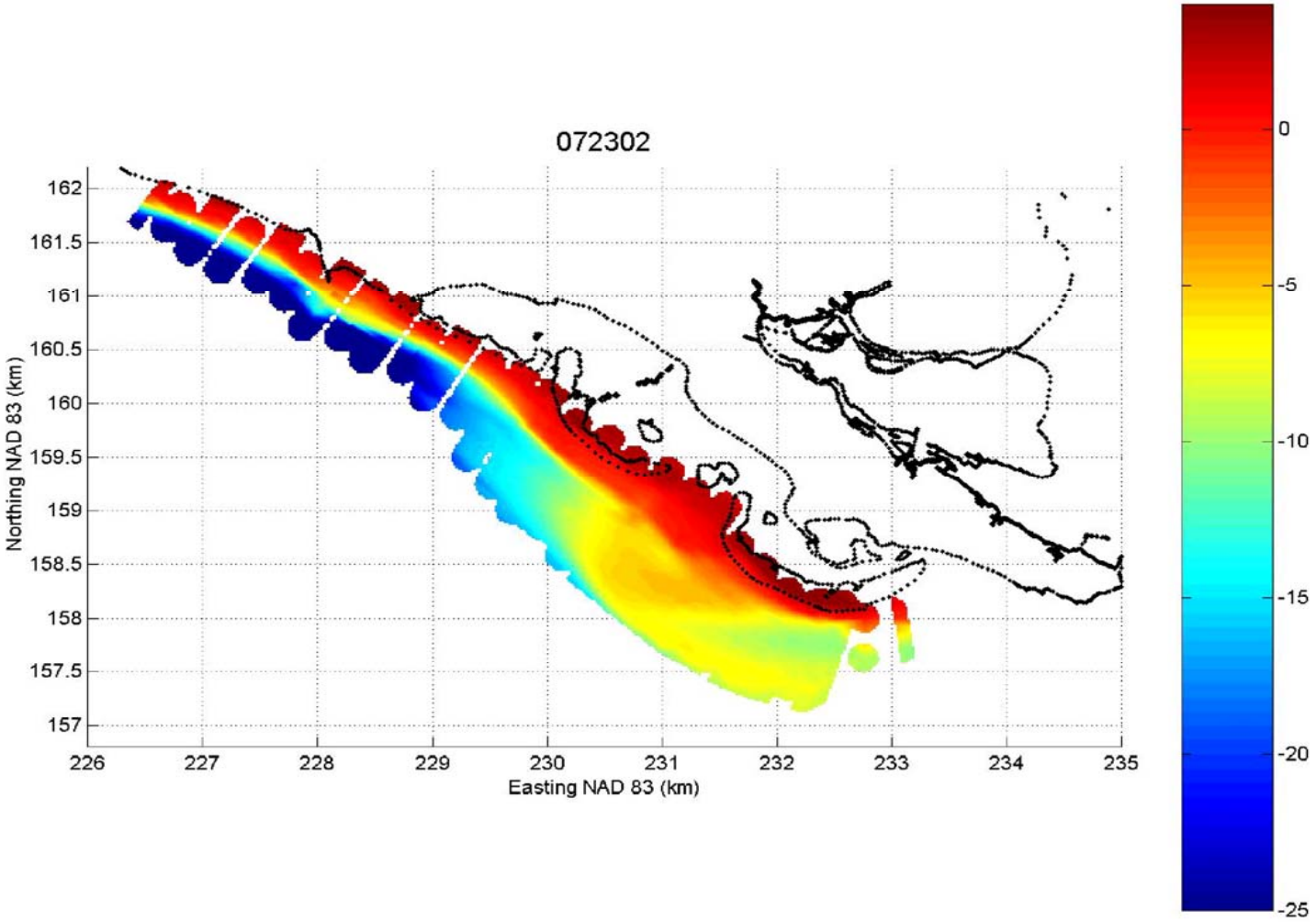
2000 Nearshore Bathymetry



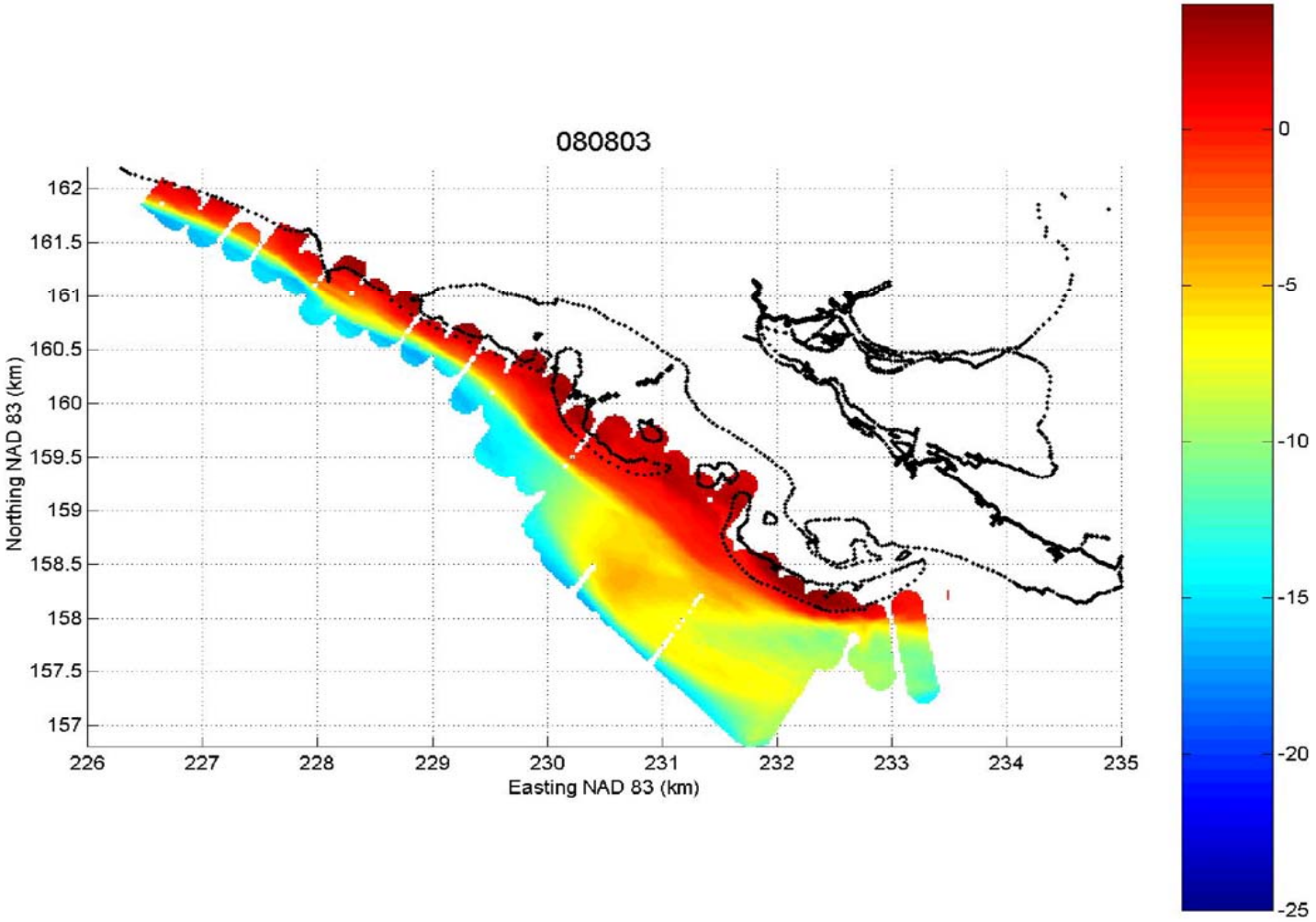
2001 Nearshore Bathymetry



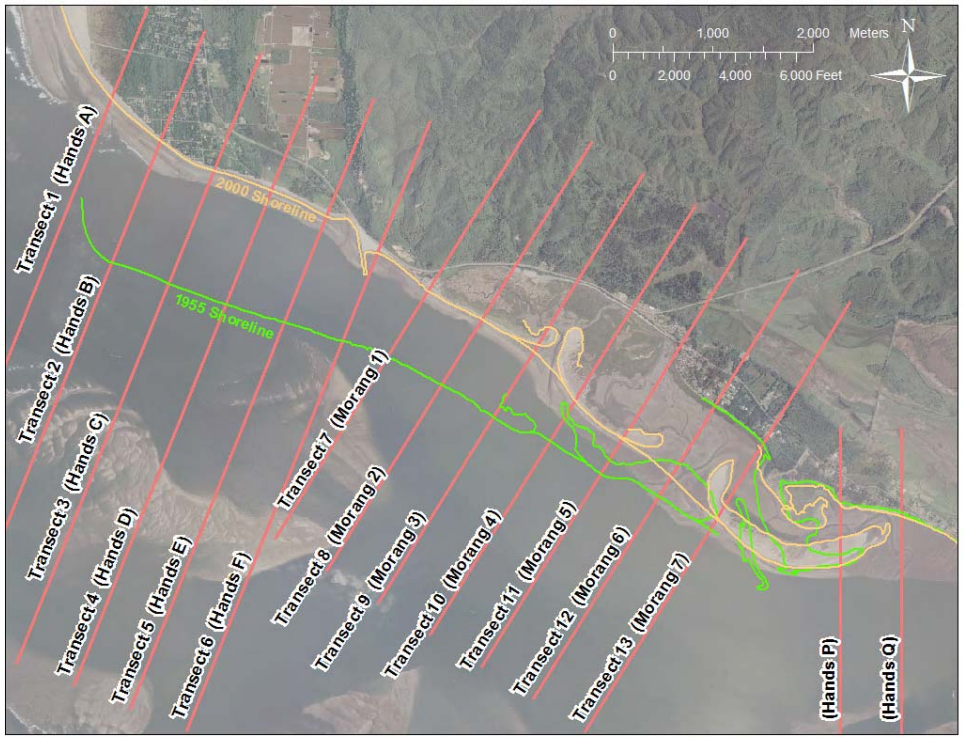
2002 Nearshore Bathymetry

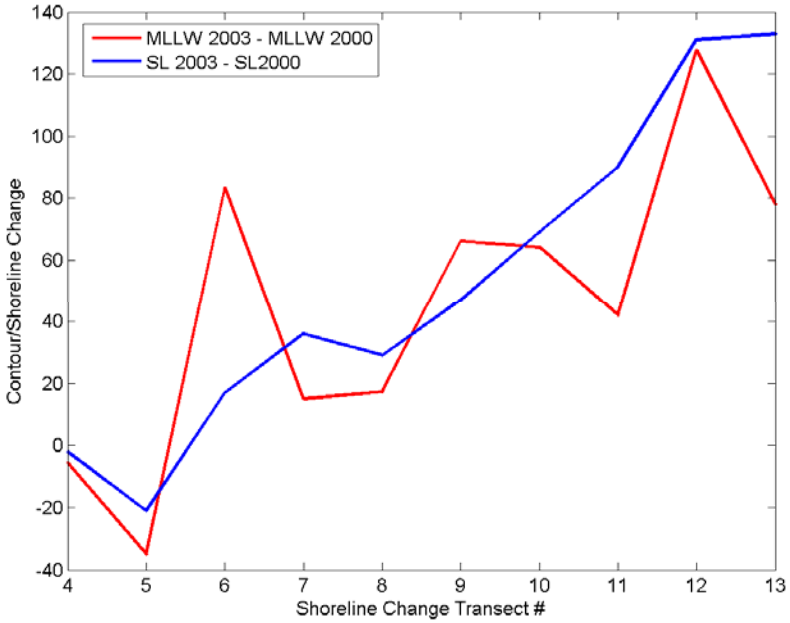


2003 Nearshore Bathymetry

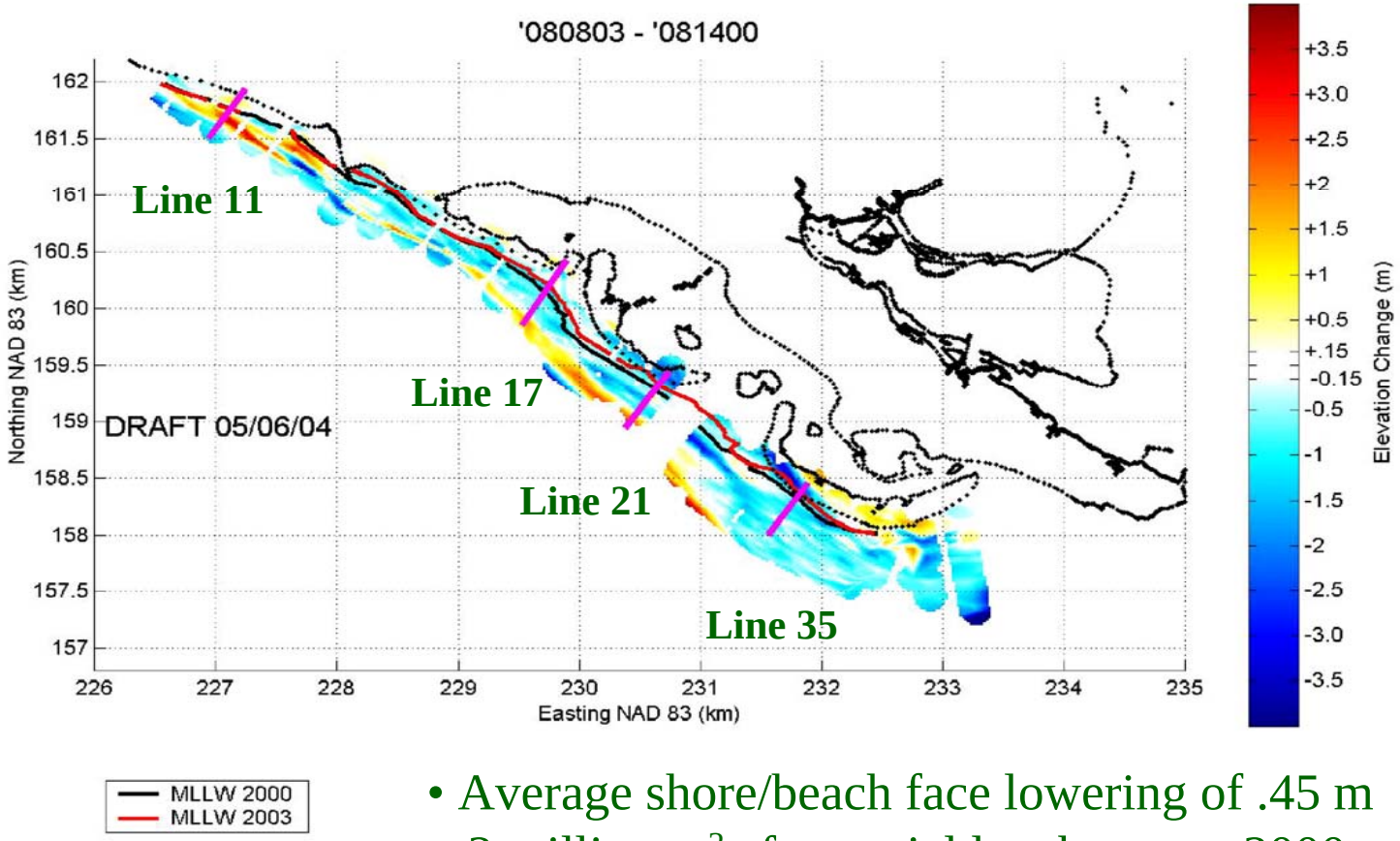


Confirming Accuracy of Shoreline Change Analyses

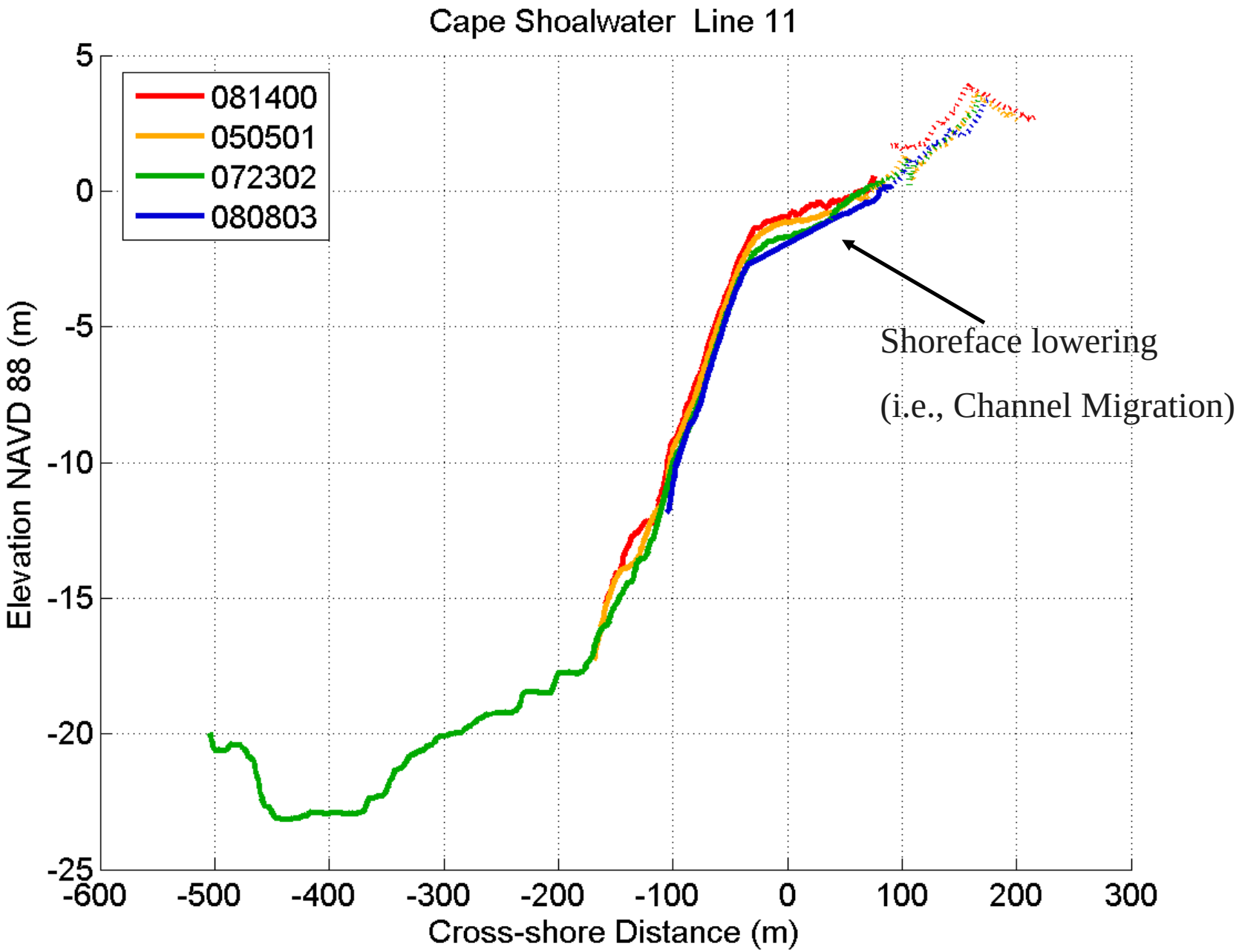


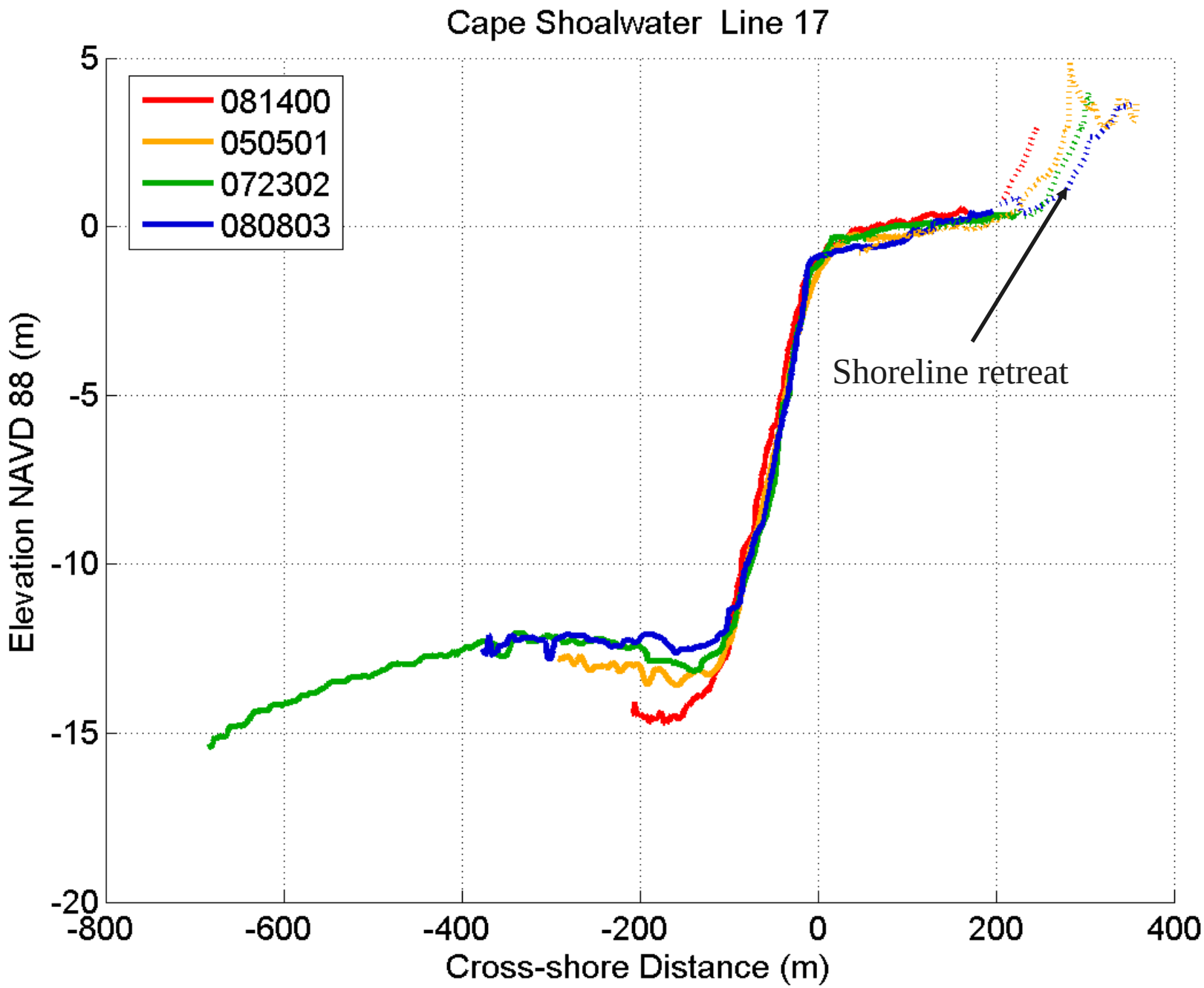


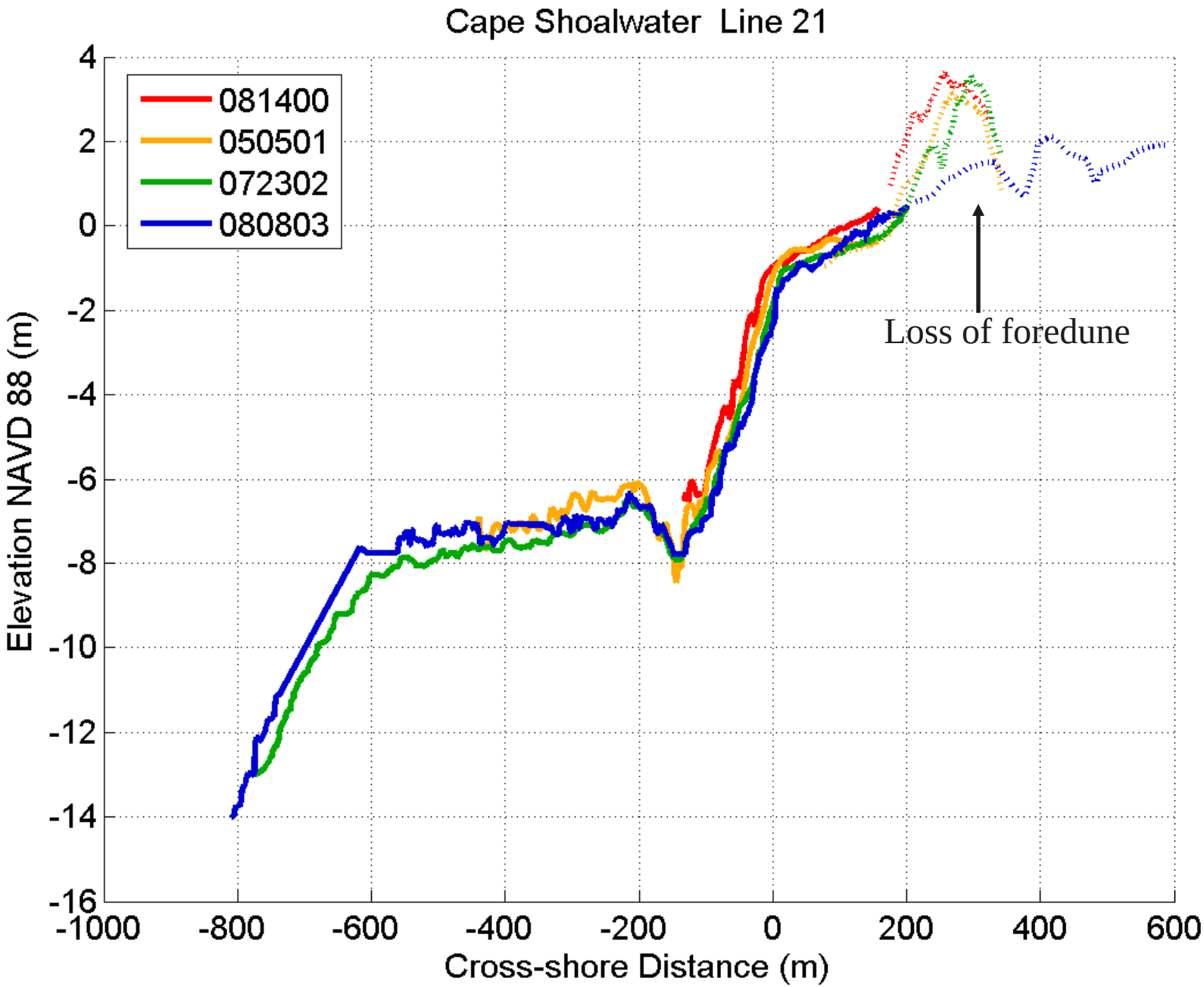
Bathymetric Difference 2000 to 2003

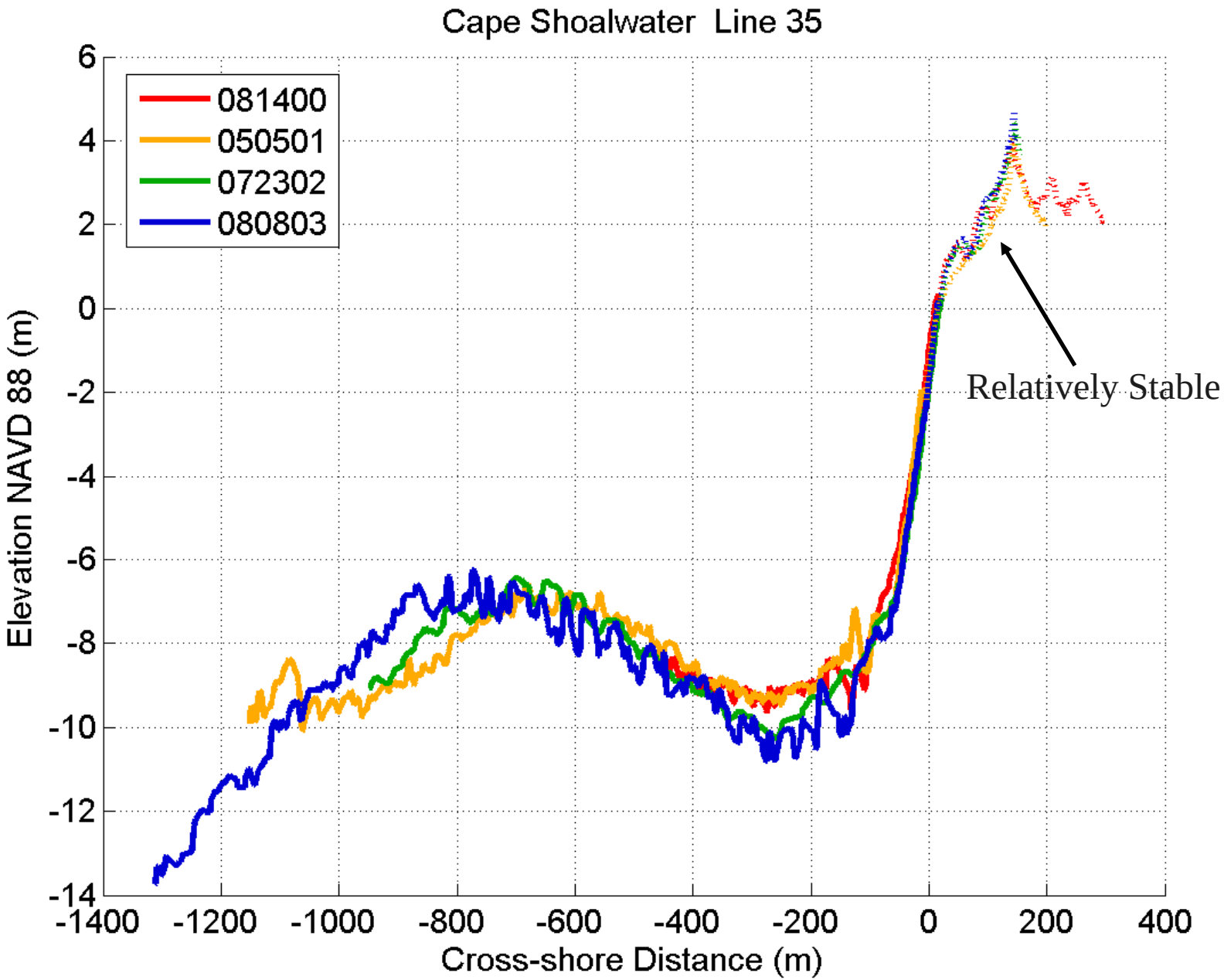


- Average shore/beach face lowering of .45 m
  ~2 million m^3 of material lost between 2000 and 2003!
  Significant alongshore variability


Cape Shoalwater Line 11
081400
050501
072302
080803
Shoreface lowering
(i.e., Channel Migration)
Elevation NAVD 88 (m)
Cross-shore Distance (m)
5
0
-5
-10
-15
-20
-25
-600
-500
-400
-300
-200
-100
0
100
200
300

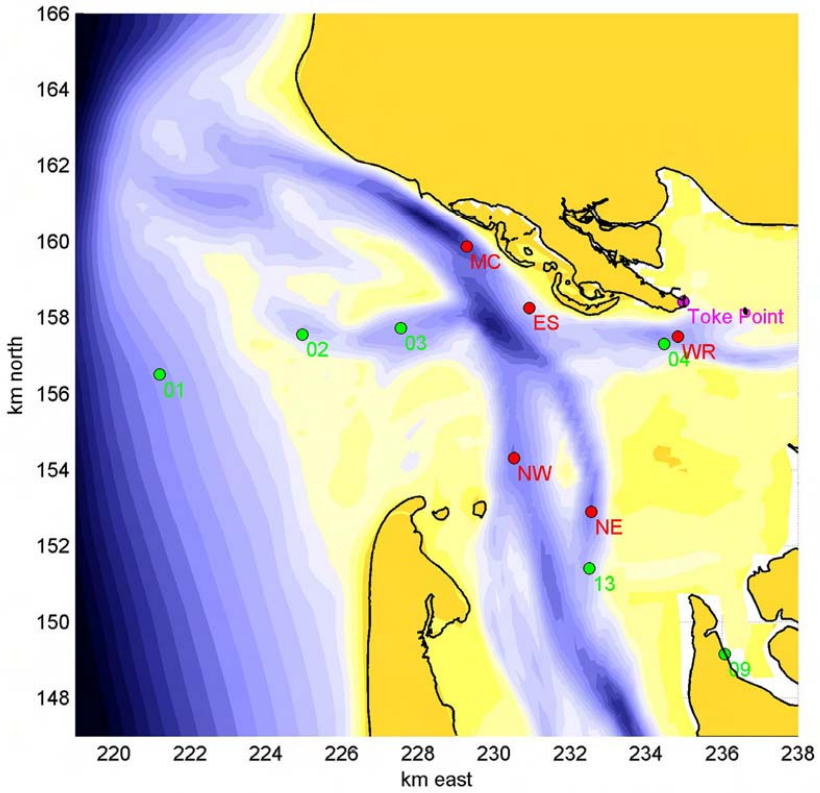

Cape Shoalwater Line 17
081400
050501
072302
080803
Shoreline retreat
Elevation NAVD 88 (m)
Cross-shore Distance (m)
5
0
-5
-10
-15
-20
-800
-600
-400
-200
0
200
400

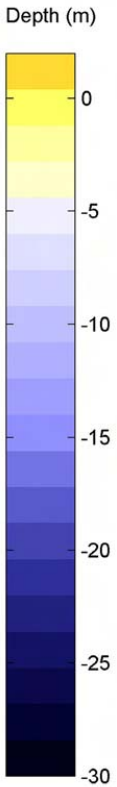

Cape Shoalwater Line 21
081400
050501
072302
080803
Loss of foredune
Elevation NAVD 88 (m)
Cross-shore Distance (m)
4
2
0
-2
-4
-6
-8
-10
-12
-14
-16
-1000
-800
-600
-400
-200
0
200
400
600

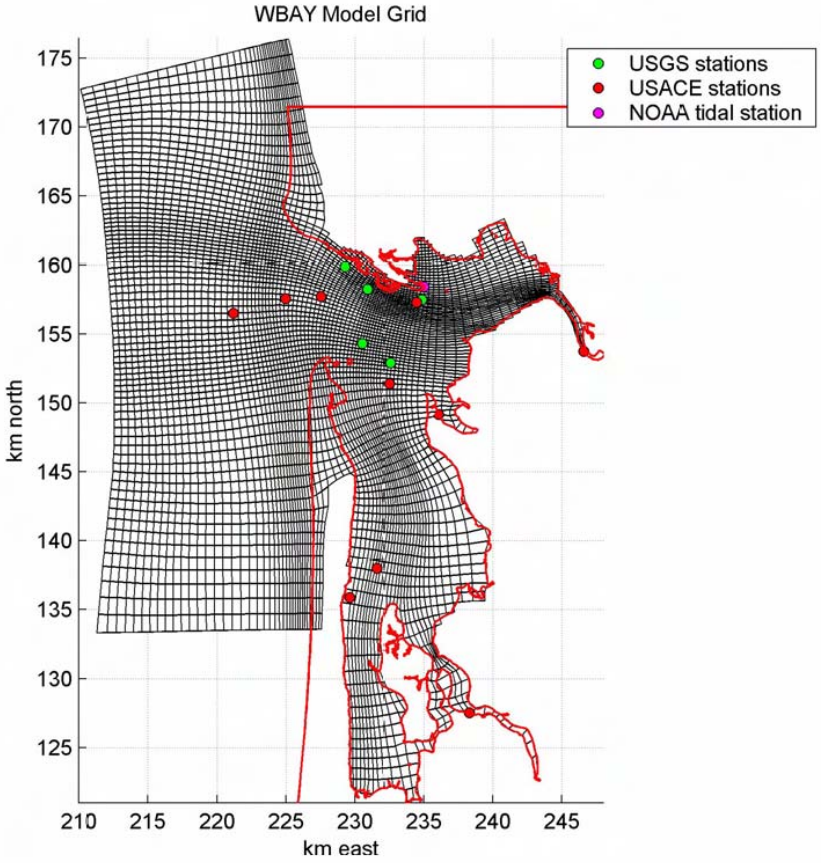

Cape Shoalwater Line 35
081400
050501
072302
080803
Relatively Stable
Elevation NAVD 88 (m)
Cross-shore Distance (m)
6
4
2
0
-2
-4
-6
-8
-10
-12
-14
-1400
-1200
-1000
-800
-600
-400
-200
0
200
400

Oceanographic Measurements

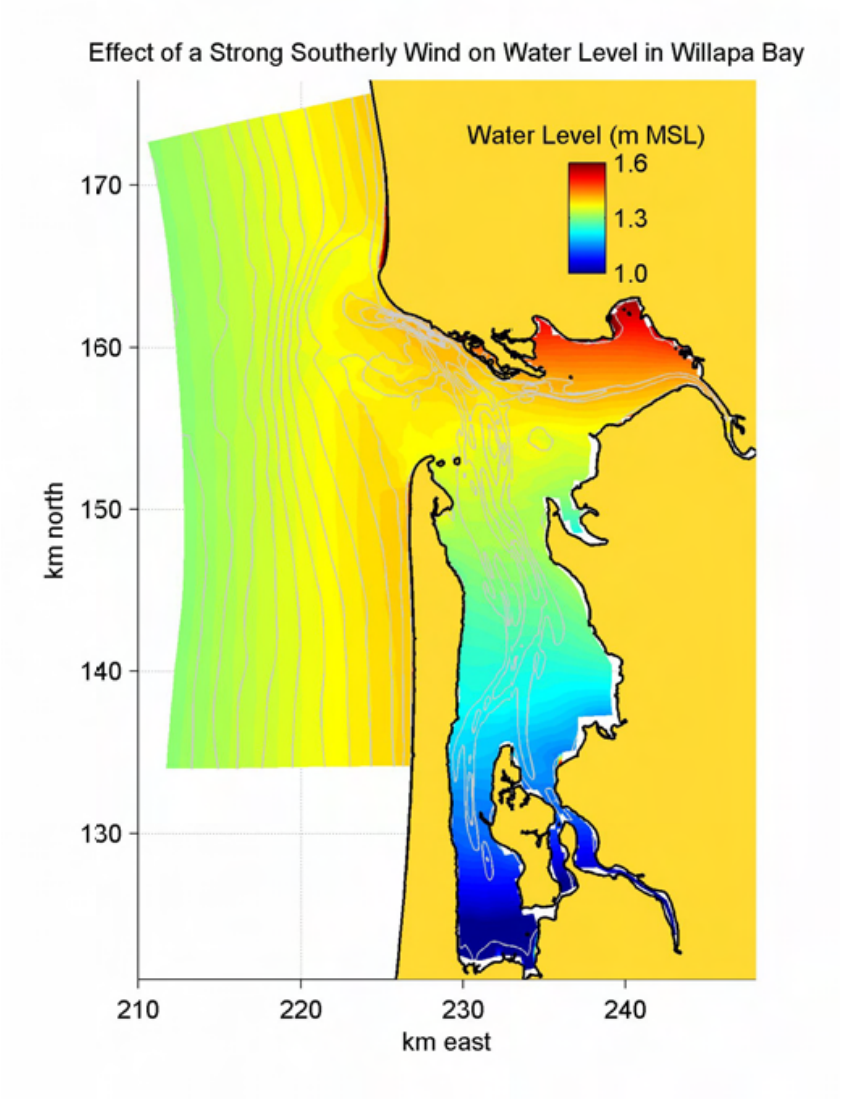
Process-based hydrodynamic, sediment transport, and morphological change modeling

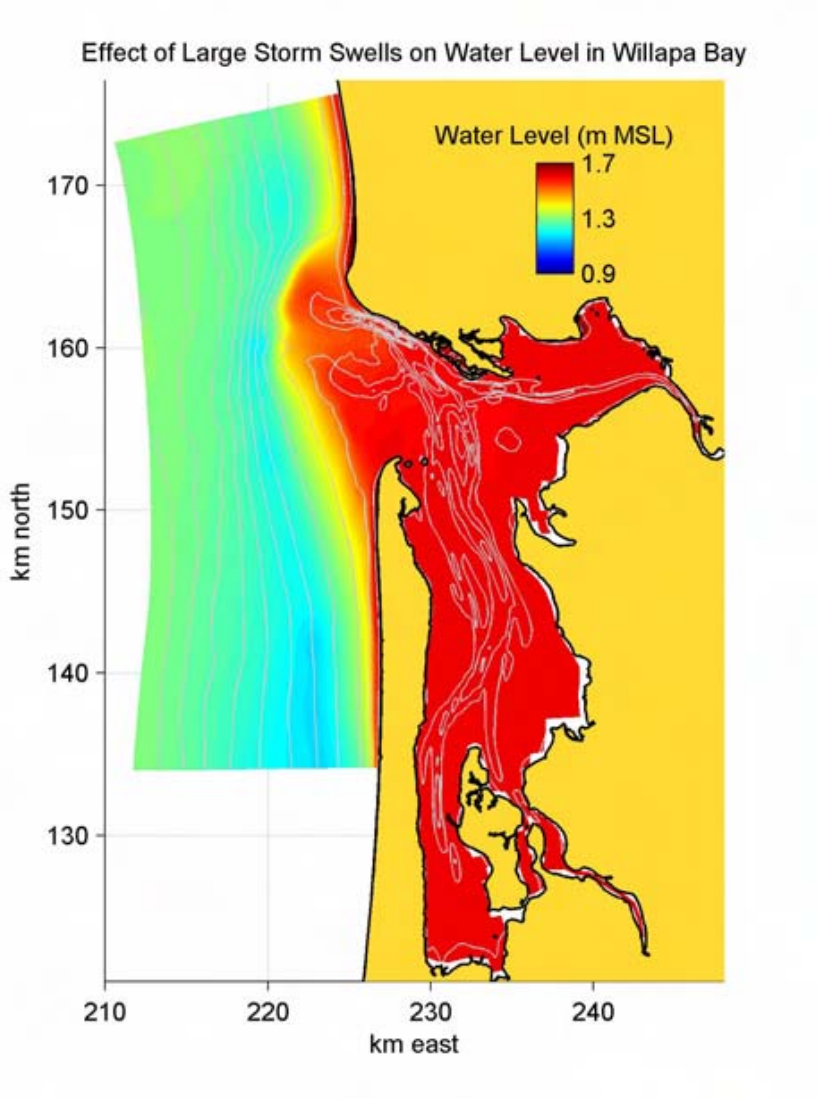






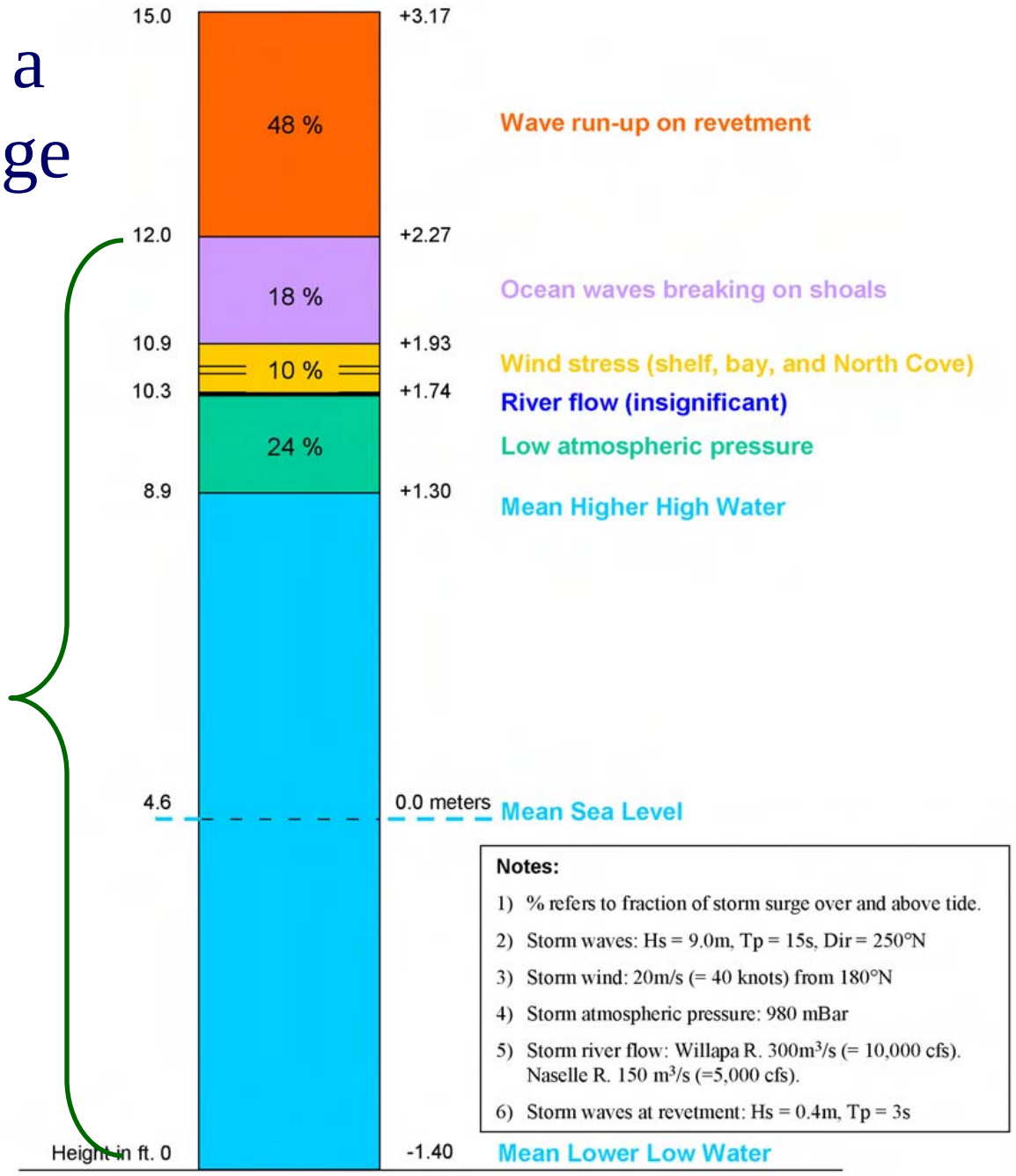
Modeled Contributions to Storm Surge



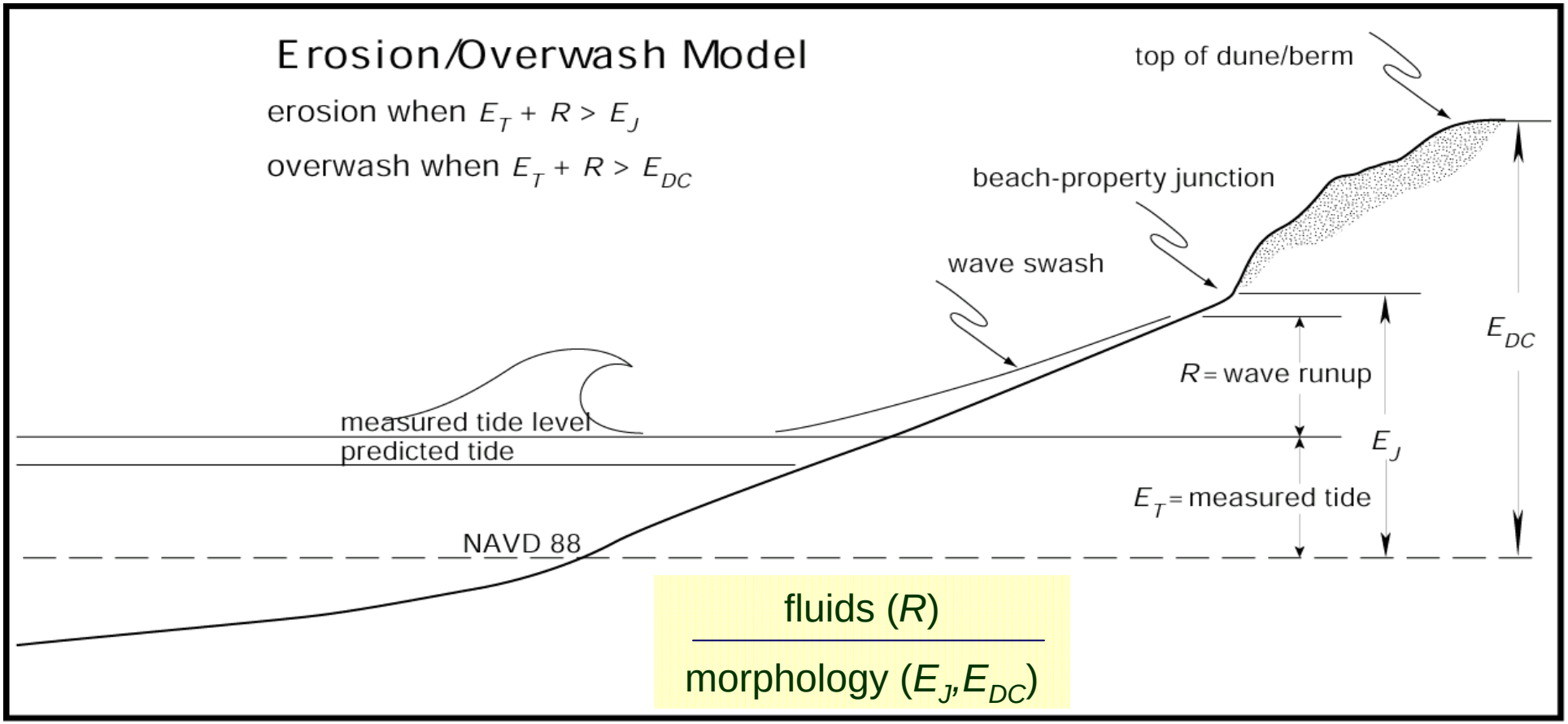


Contributions to a typical storm surge

Measured by Toke Point tide gage

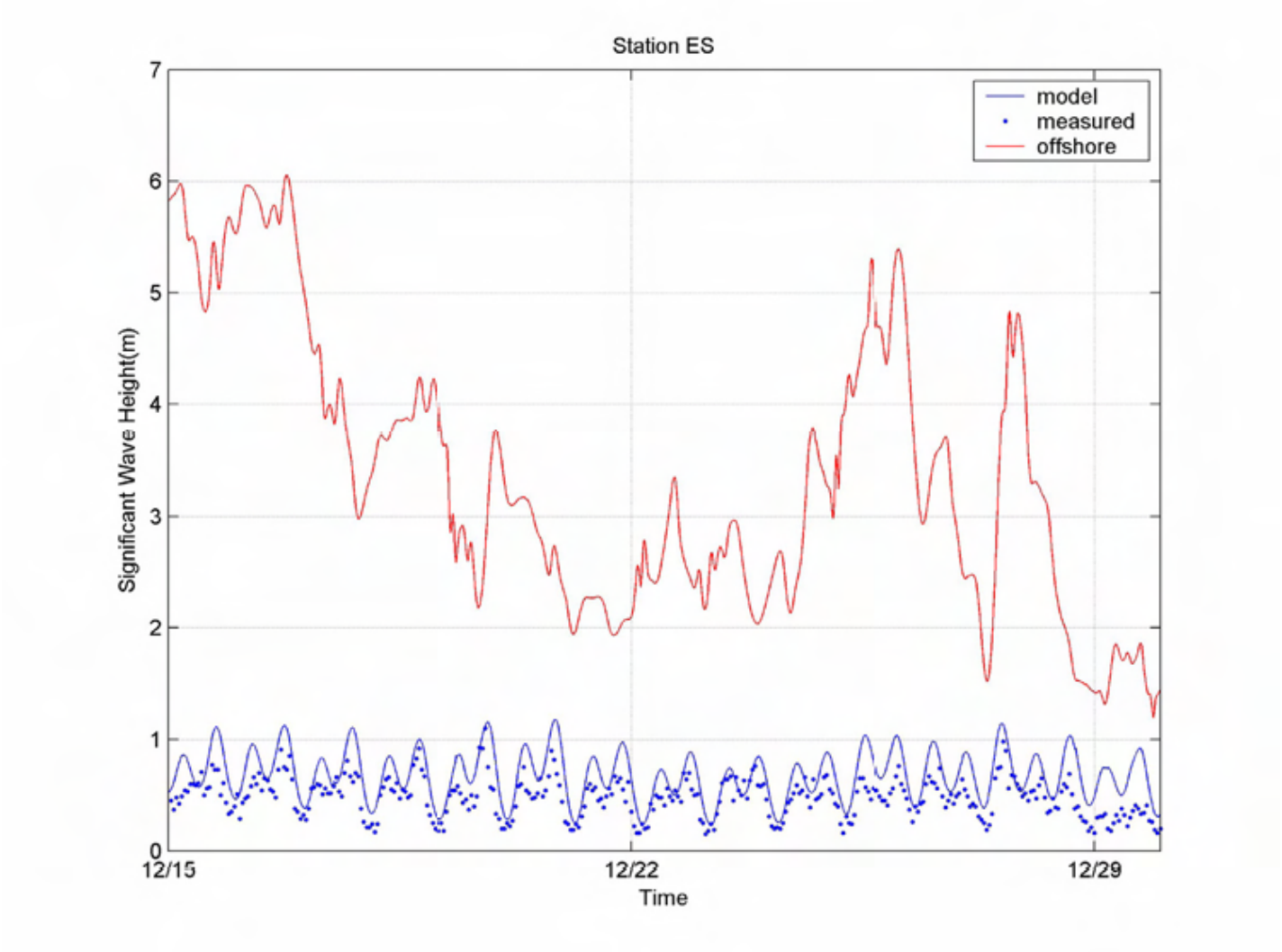


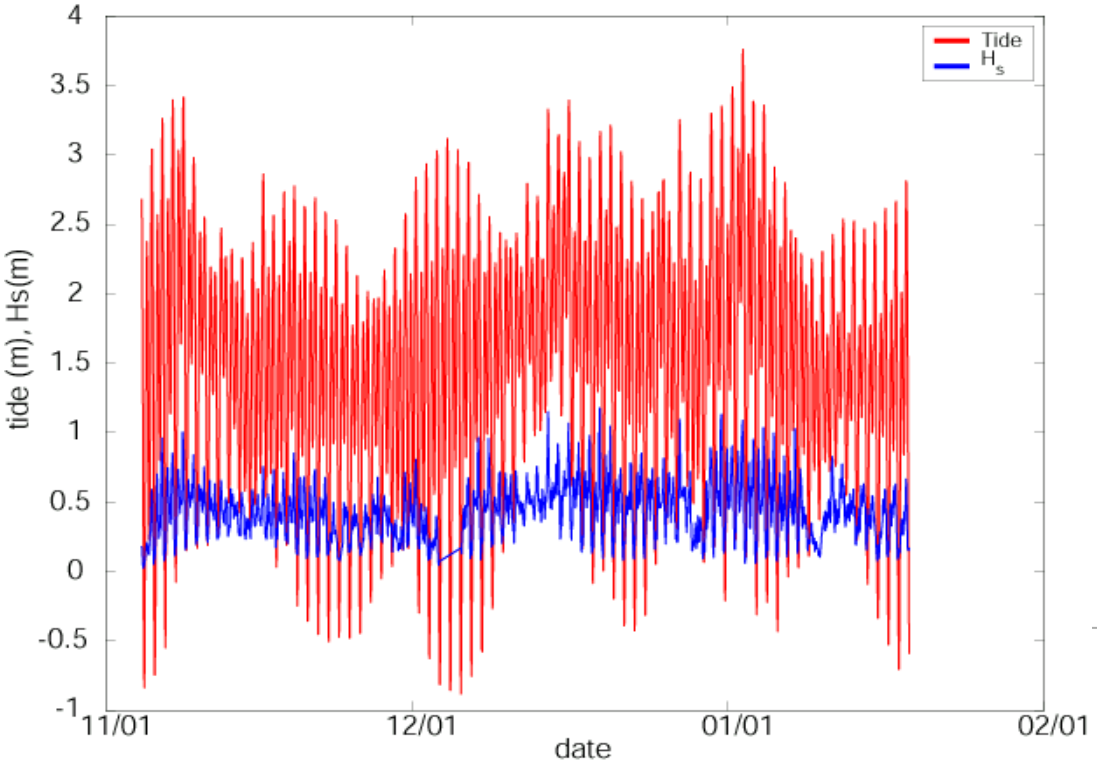
Probabilistic Assessment of Wave Overtopping on Empire Spit



after: Ruggiero et al., 1996, 2001

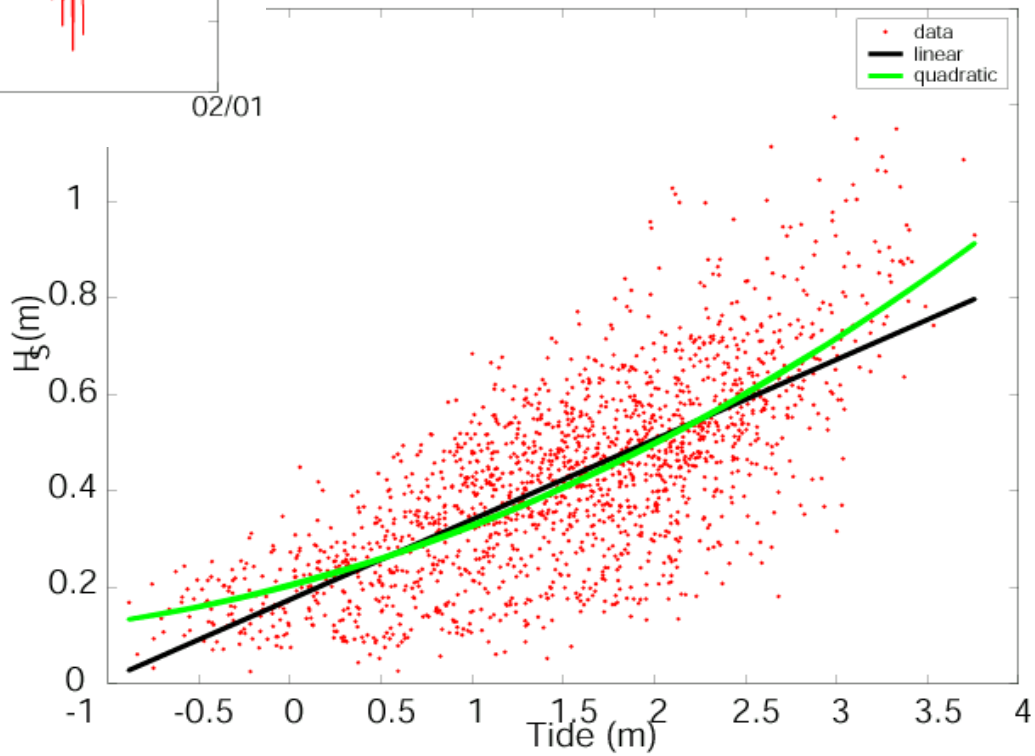
Wave heights off of Empire Spit



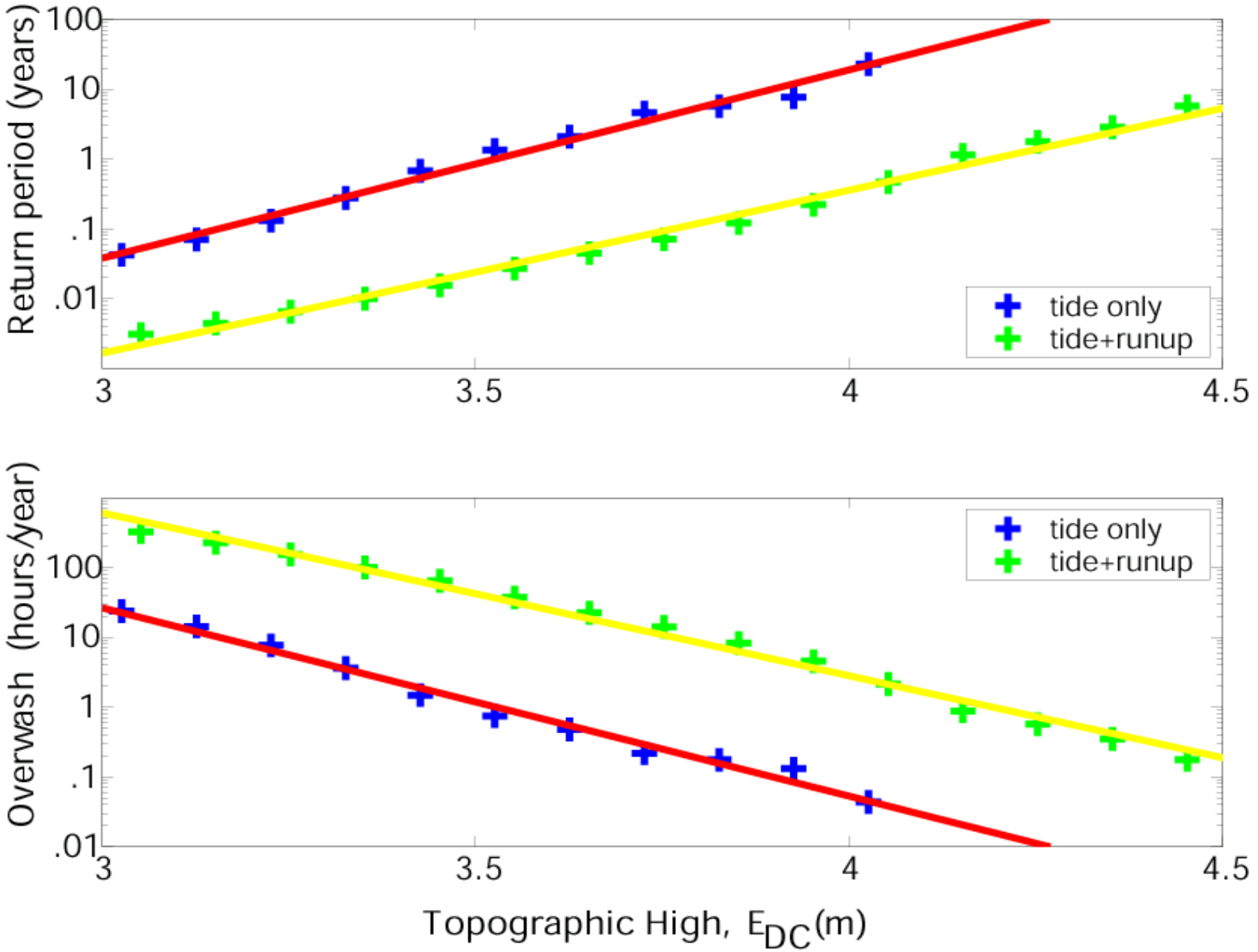


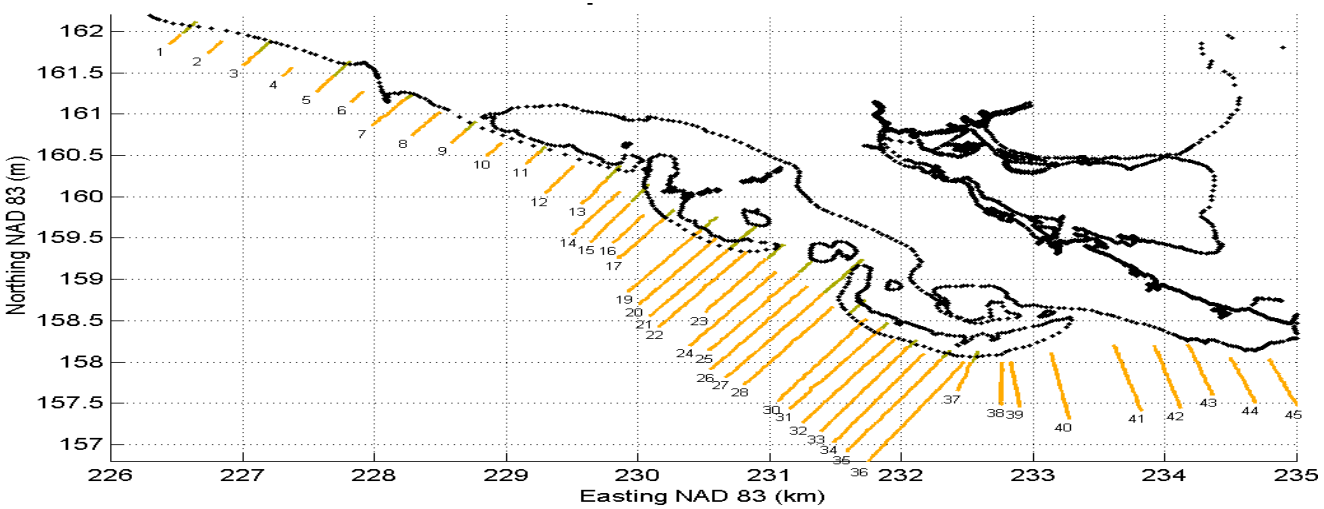
•Water level and wave height data from field experiment.

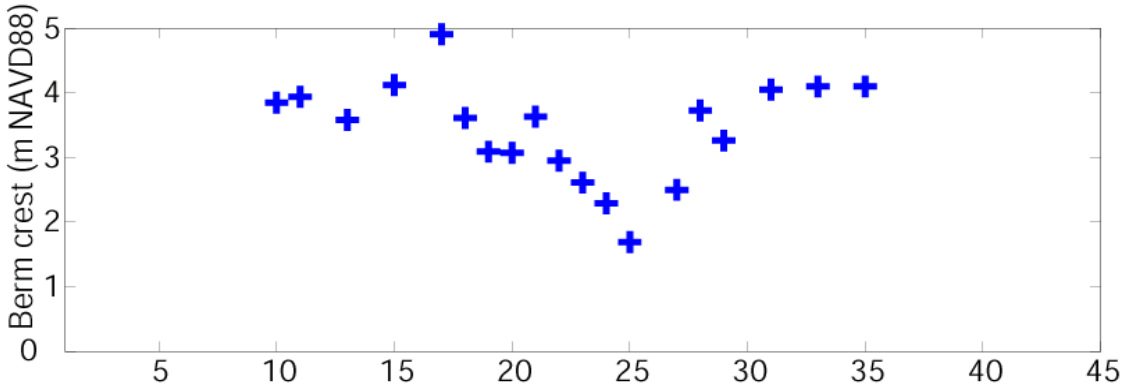
•Relationship between Toke Point tide data and significant wave height at station ES (significant at .01 confidence level) .

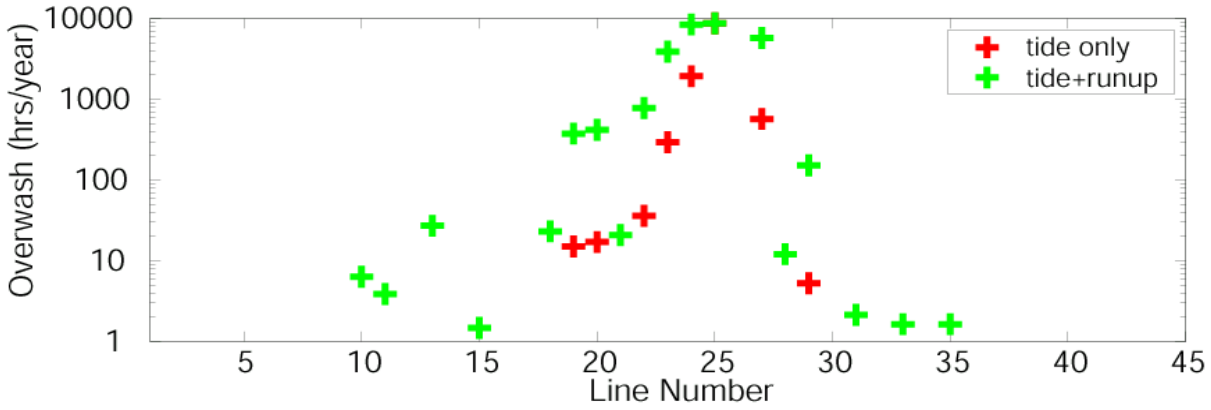


Probability of overtopping dune crest




Northing NAD 83 (m)
Easting NAD 83 (km)


Berm crest (m NAVD88)


Overwash (hrs/year)
tide only
tide+runup
Line Number

Conclusions/Discussion

- Why was the channel rotating?
  - It was pushed north by sand filling the entrance from the south
- Why has it slowed down or stopped?
  - The present shape of the entrance has blocked the supply of sand that produces northward pressure on the channel
- What will happen in the future?
  - Until the entrance reverts to previous geometry channel migration is expected to be relatively slow
  - However, morphological feedbacks may increase the frequency of spit overtopping even as channel migration rate slows

Annual Sand Movement