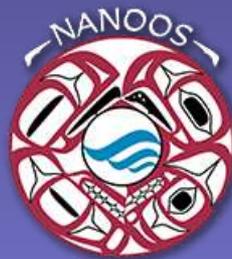
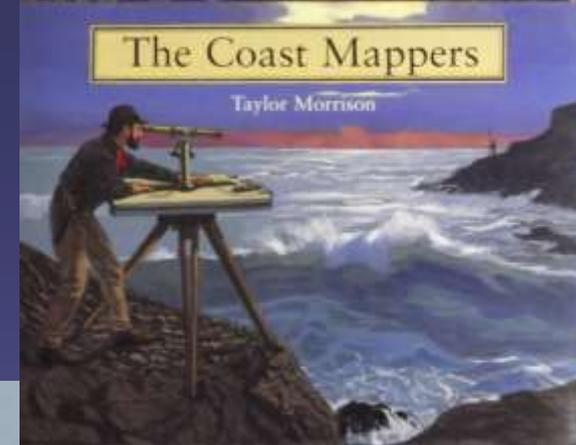
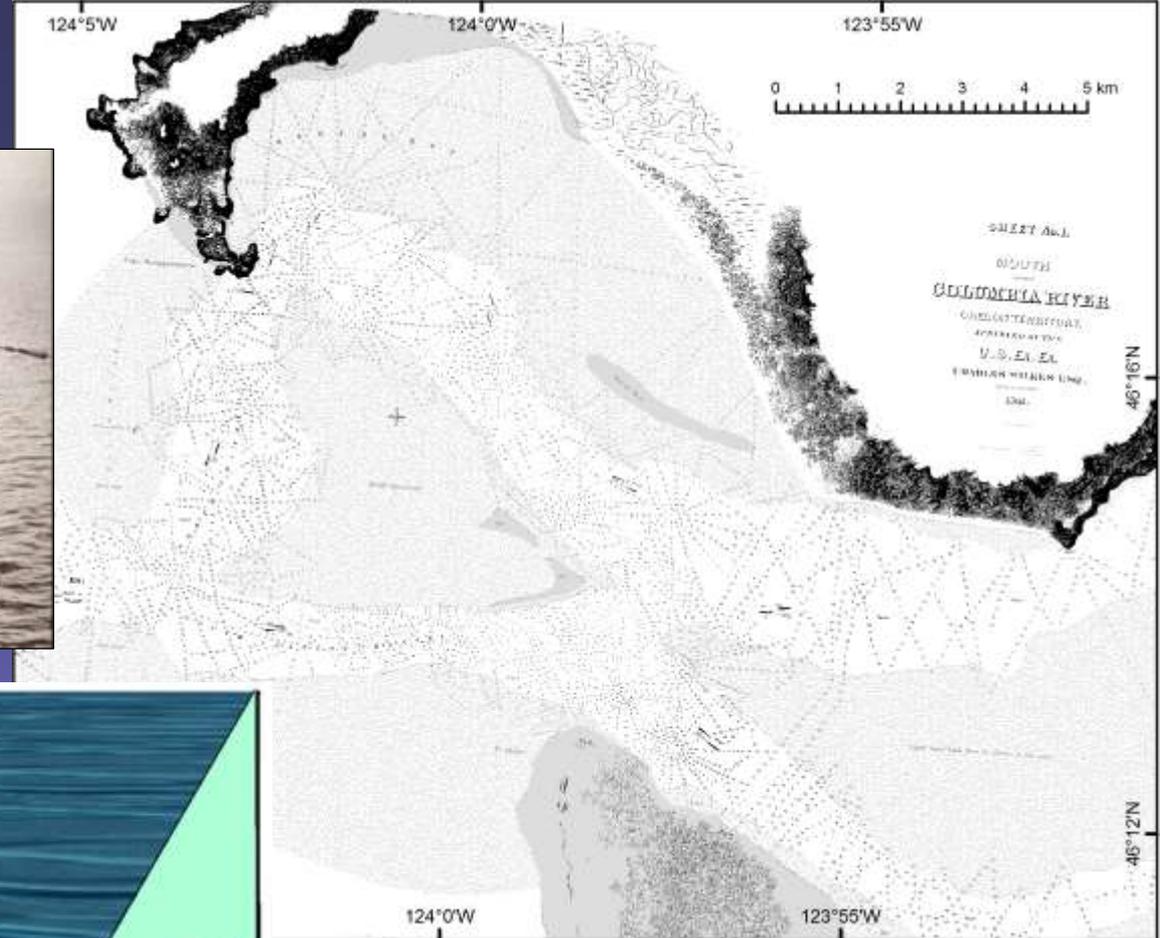


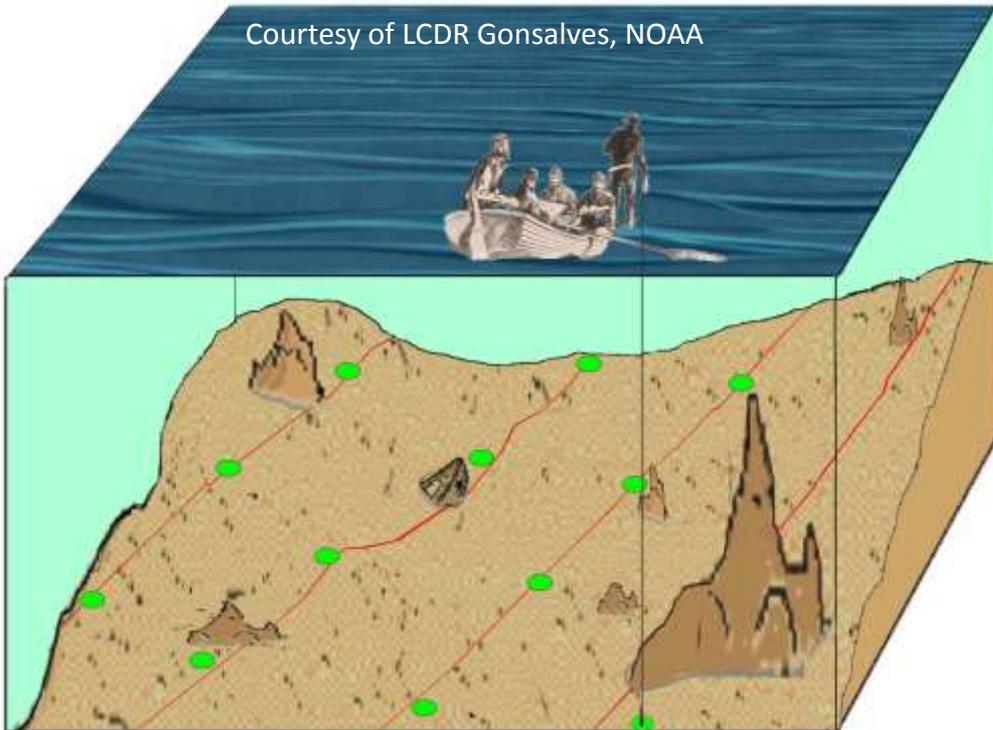
# Coastal and Nearshore Mapping



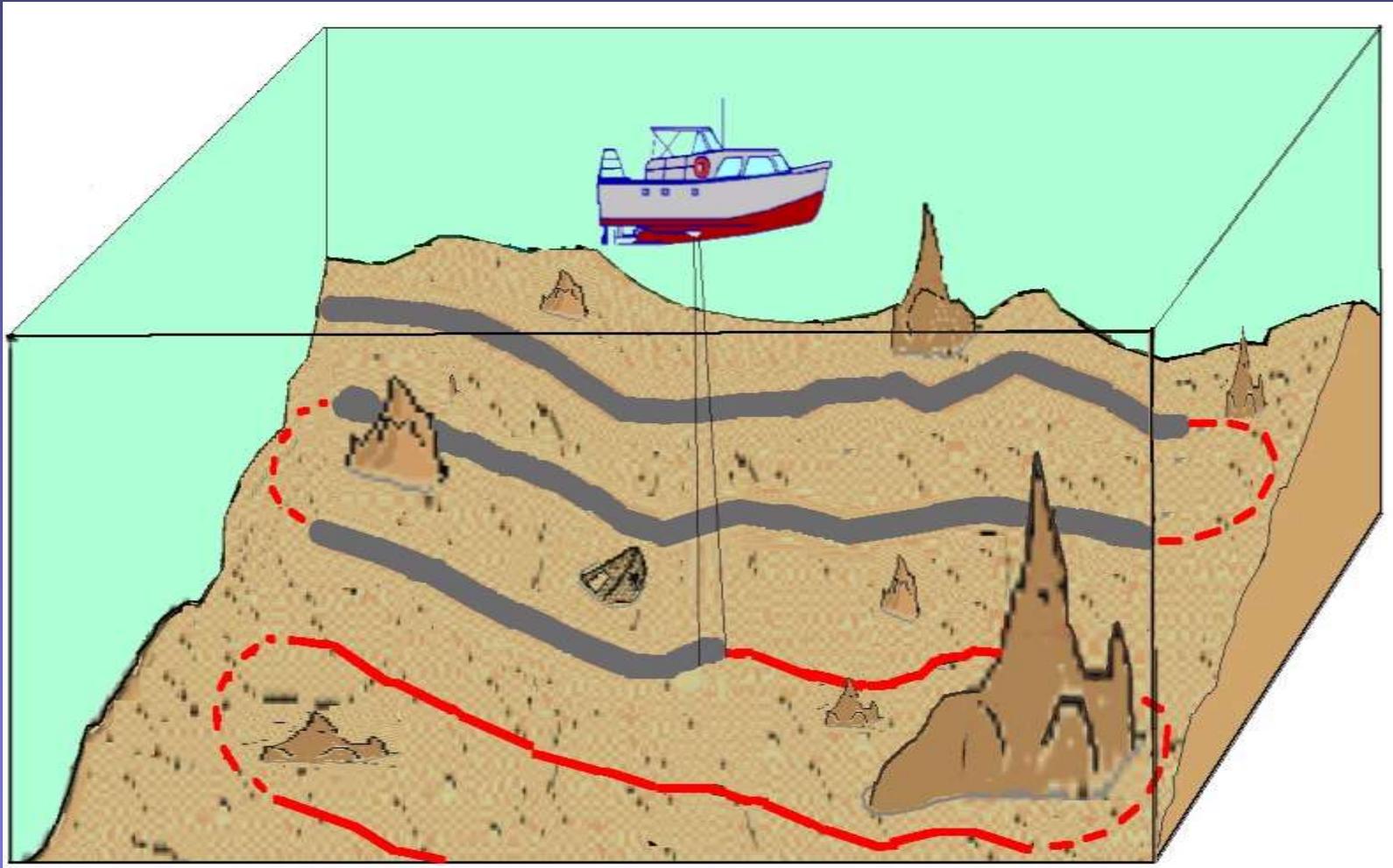
# Leadline Surveys



Courtesy of LCDR Gonsalves, NOAA

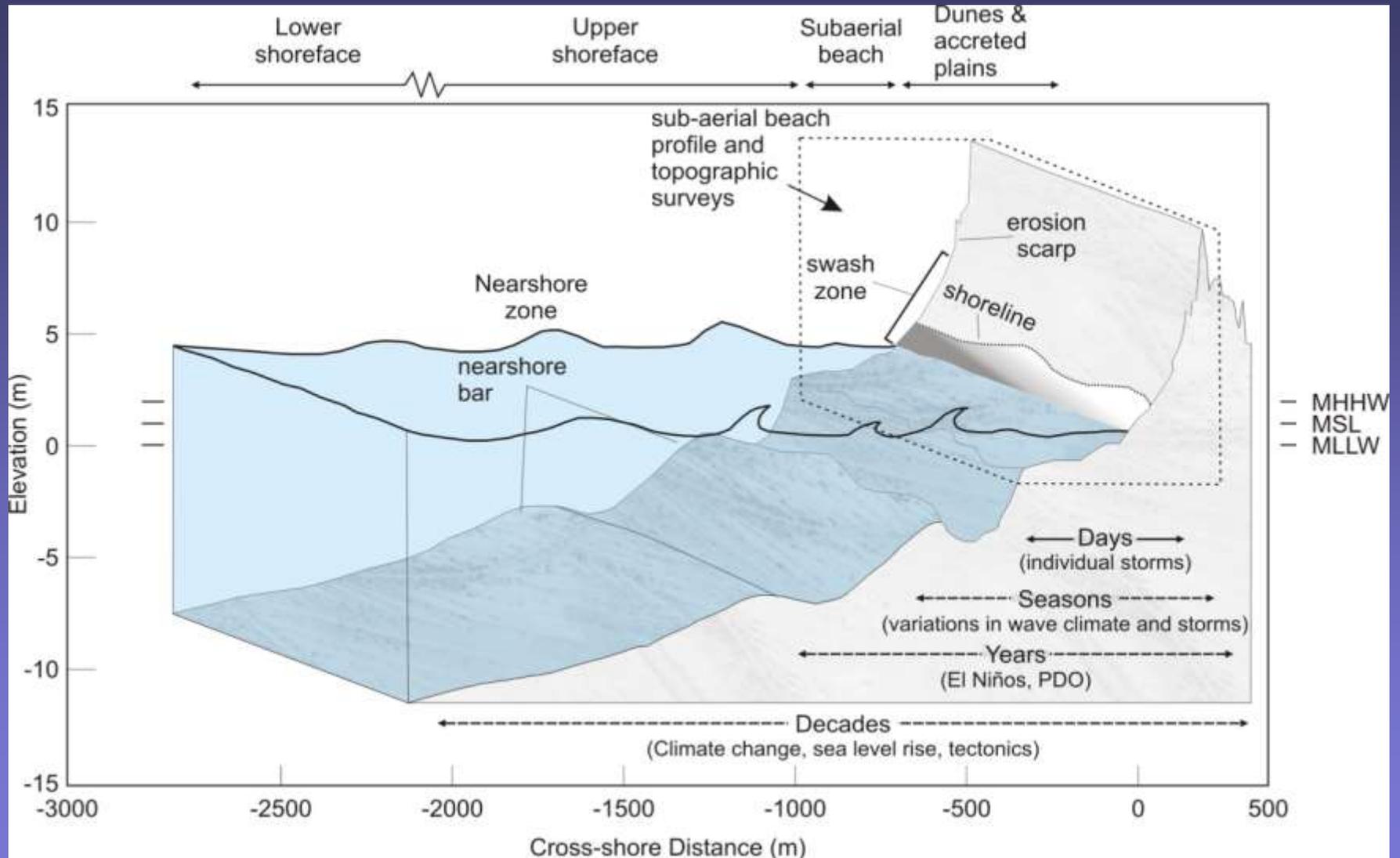


# Single Beam Echosounders (since 1950s)



Courtesy of LCDR Gonsalves, NOAA

# Temporal and Spatial Scales of Coastal Change

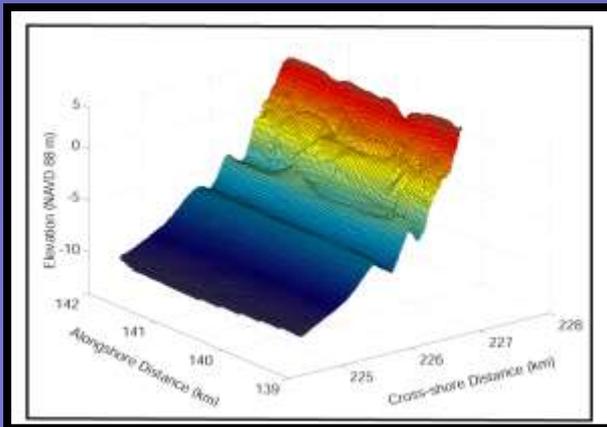


# Objectives

- Collect elevation, geologic, and benthic habitat data across the coastal zone, spanning from the top of coastal bluffs to nearshore waters up to at least 15 m deep.
- Assess the viability of performing repetitive surveys to enable change detection including bluff erosion, spit formation, and a quantification of sediment supply to the beach and nearshore.
- Develop methods, technology, survey platforms, tools, analysis, and applications for collecting and processing modern data sets needed for coastal and marine resource management.
- Assess the present condition of the nearshore zone and establish an inventory of key indicators such as beach morphology (e.g., elevation, slope and width), grain size, and habitat characteristics.
- Understand role of bluff sediment supply to nearshore physical and ecological processes:  $\Delta$  Volume;  $\Delta$  Slope;  $\Delta$  grain size;  $\Delta$  upland and aquatic vegetation

# Coastal Morphology Mapping

RTK-GPS ATV surface maps, beach profiles (to wading depth), and CPS nearshore bathymetry.



Quarterly beach profiles since summer 1997 in the CRLC

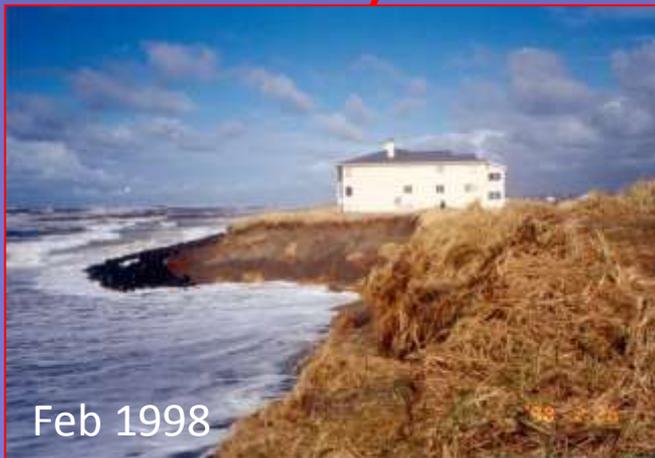
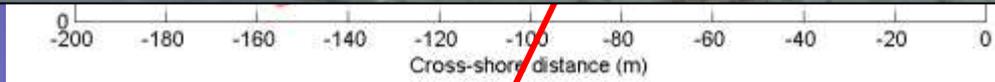
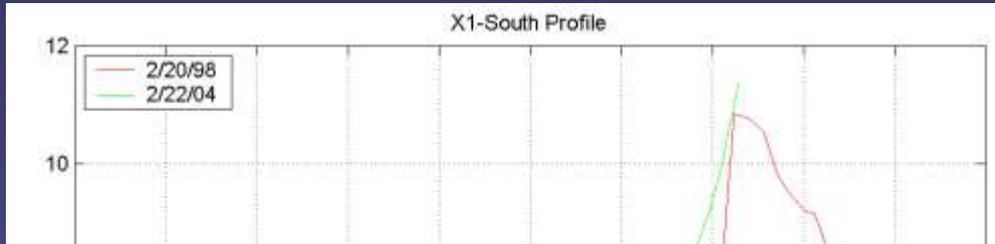
# Coastal Monitoring Techniques

## Cross-Shore Profiles

- Low tide when max amount of beach exposed
- Walk from the dune, across the beach, out to wading depth (swash zone) typically 0.5 to 1 m below MLLW depending on conditions
- Data points collected using a GPS mounted on a backpack with a measured antenna height
- Data depicts seasonal changes as well as dune elevation, beach width, and sand volume



# Cross-shore profiles



# Coastal Monitoring Techniques

## Alongshore Surface Maps

- Survey at low tide when max amount of beach exposed
- Drive ATV along beach, back and forth throughout a 3-4 km section (between dune toe and water's edge)
- Data points collected using a GPS mounted on ATV with a measured antenna height
- Data interpolated in the cross-shore to generate beach elevation maps used for volume change analysis



**CLARIS**  
Coastal LiDAR and  
Radar Imaging  
System



# Coastal Monitoring Techniques

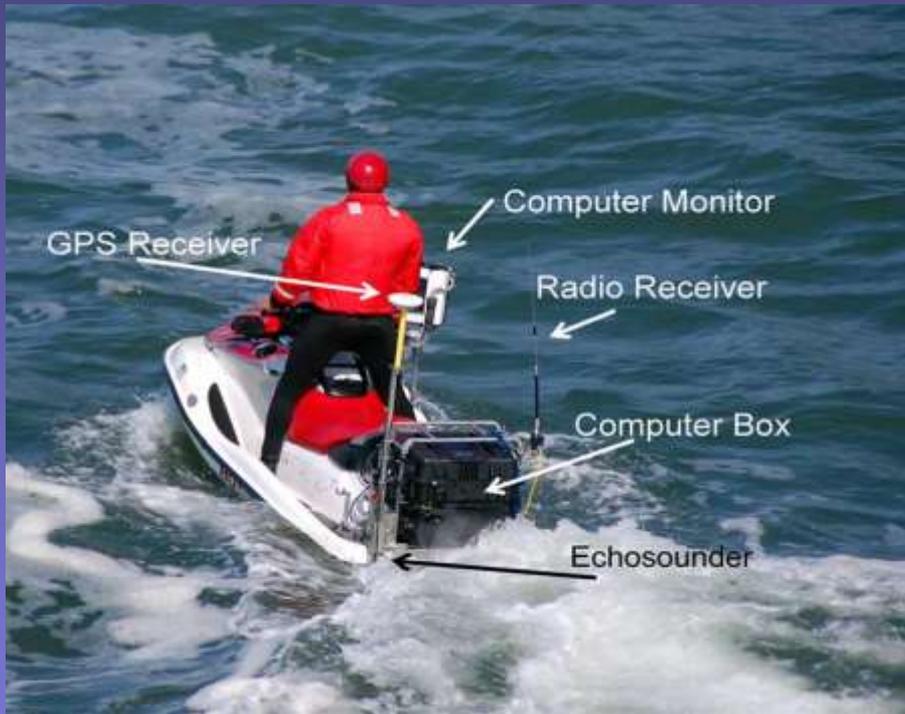
## Nearshore bathymetry

- Survey at high tide when lower beach face is submerged
- Drive PWC along transect from 1-2 km offshore through surf zone
- Data points collected using a GPS and single beam echosounder mounted on PWC with a measured antenna height
- Combine data with beach transects to generate continuous profile of beach and nearshore



# USGS/OSU Survey Vessels

## Coastal Profiling System



2007 Honda Aquatrax F-12

4-stroke Personal Water Craft (PWC)

Length 3.20 m

Beam 1.25 m

Vessel Speed ~6 knots

Maximum personnel 1

Single beam echo-sounding

RTK DGPS positioning

Operational depths to ~20 m and < 2.5 km  
from shore

Details of equipment, operational techniques, and accuracy: Ruggiero et al., 2007, USGS DS260

# Alternative Shallow Water Systems

**Ross Laboratories**



**Seafloor Systems**



**RLDA Surveying & Mapping**

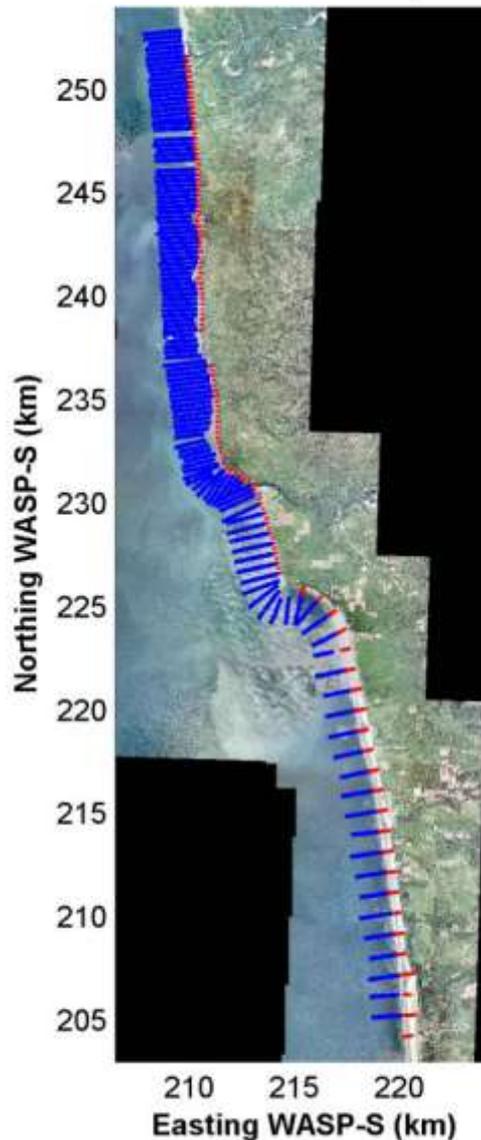


**Oceanscience**

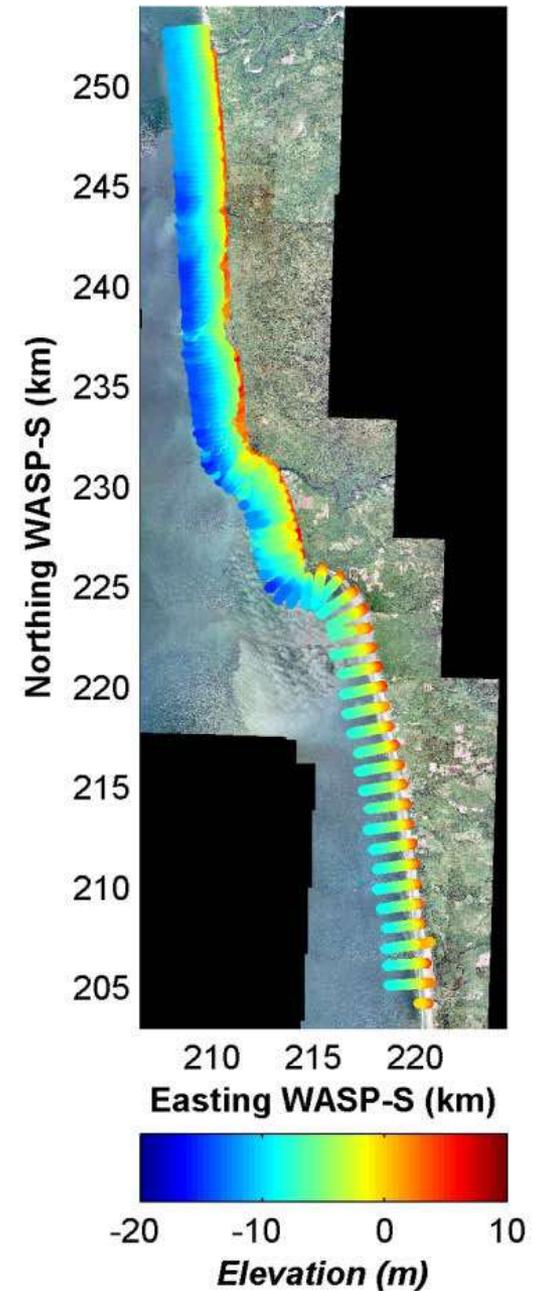


# Beach Profiles and Nearshore Bathymetry Northern WA Coast

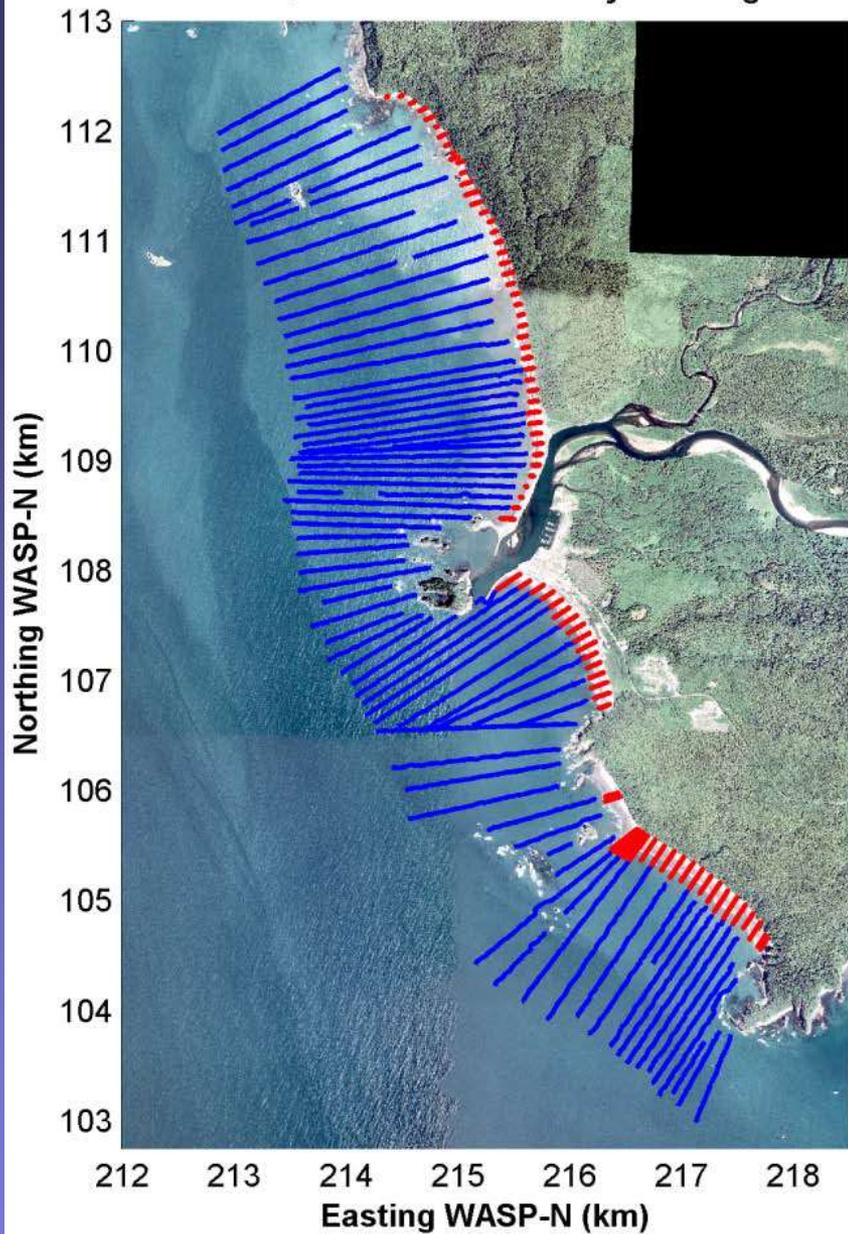
2012 Quinault Nation Survey Coverage



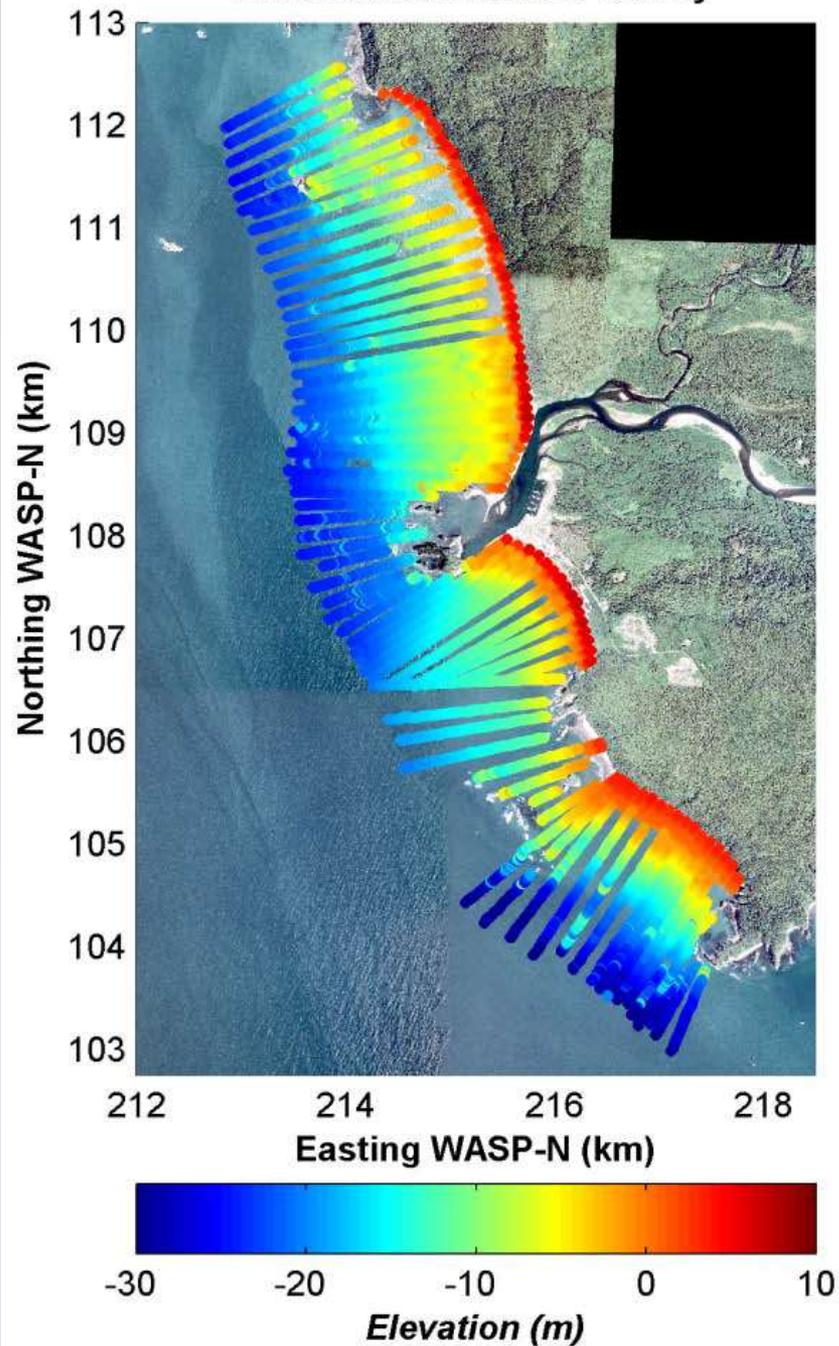
2012 Quinault Nation Survey



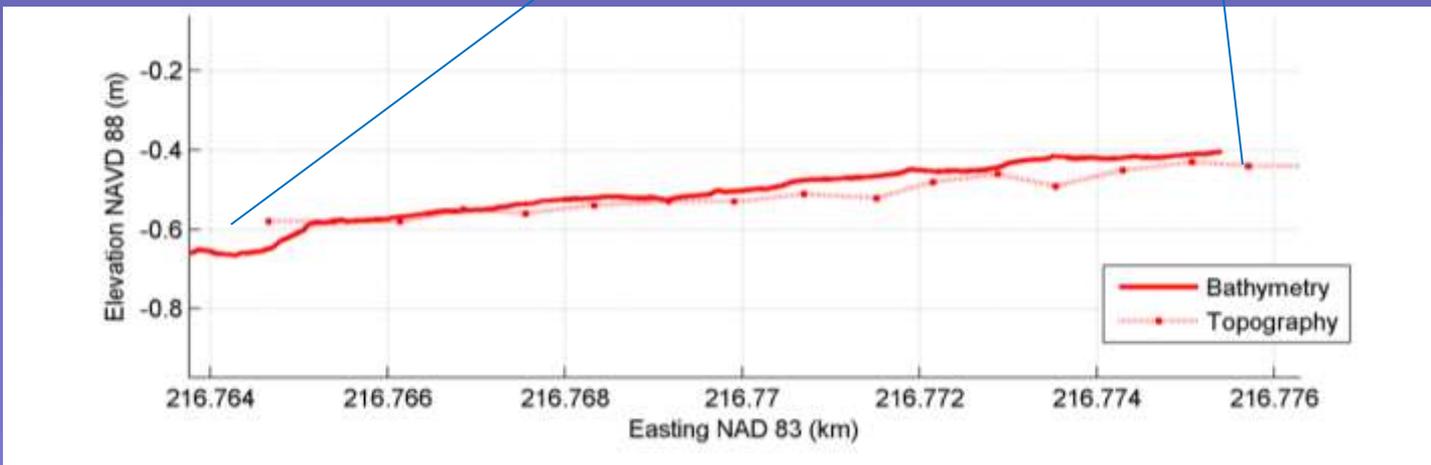
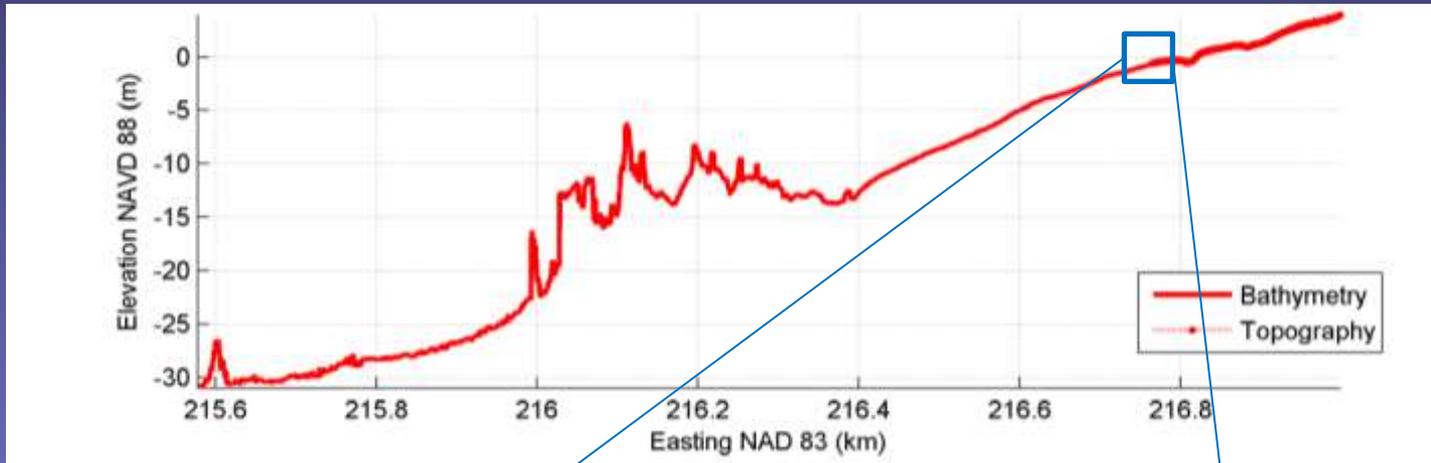
2013 Quileute Nation Survey Coverage



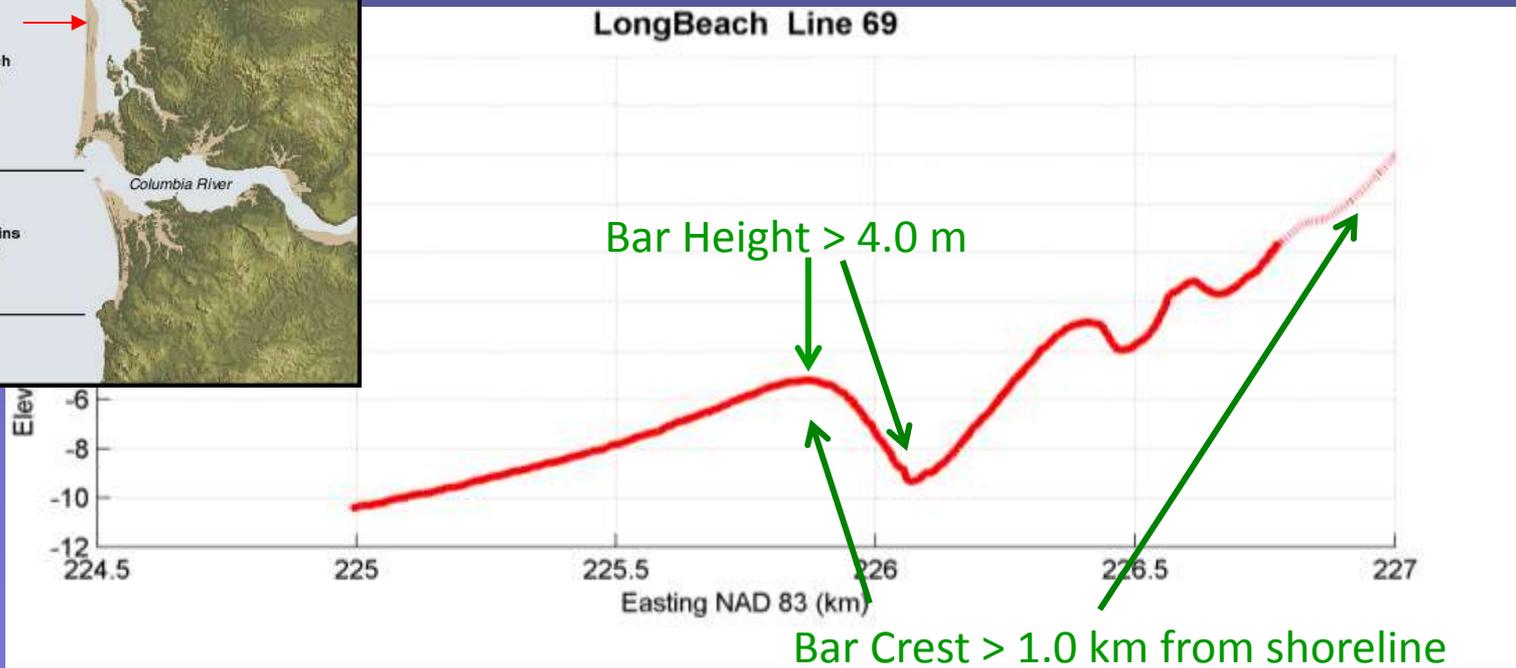
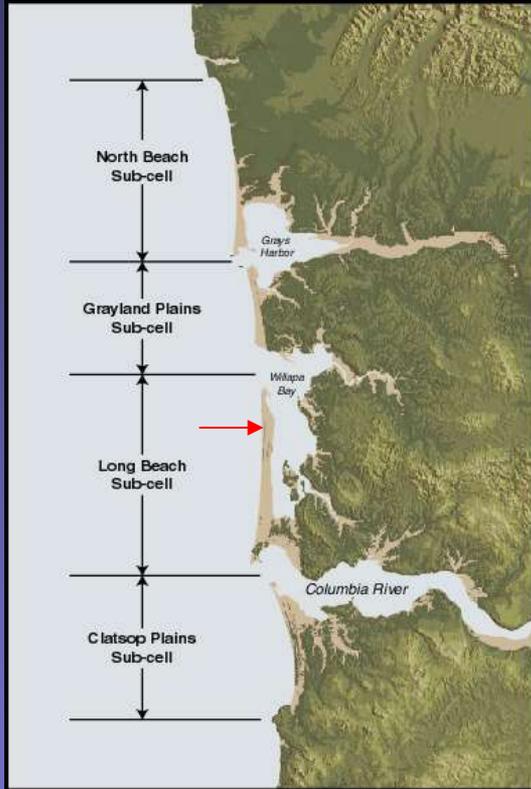
2013 Quileute Nation Survey



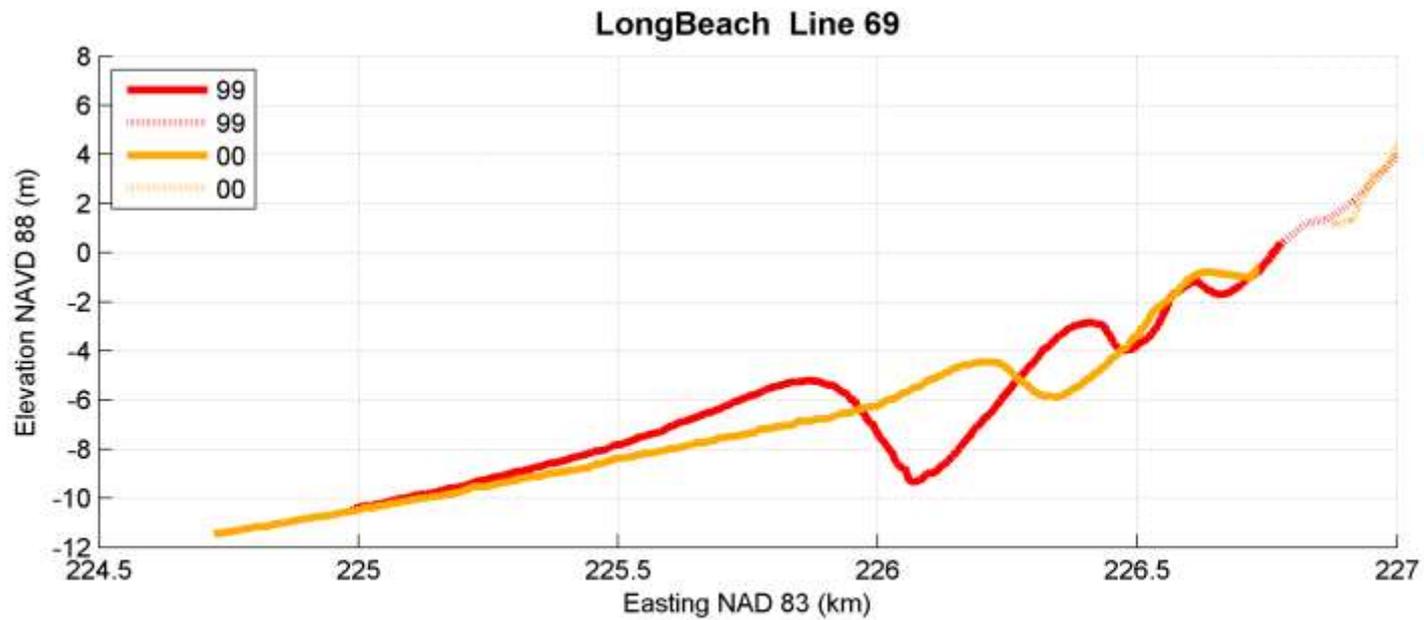
# Quileute Coast Nearshore Profile



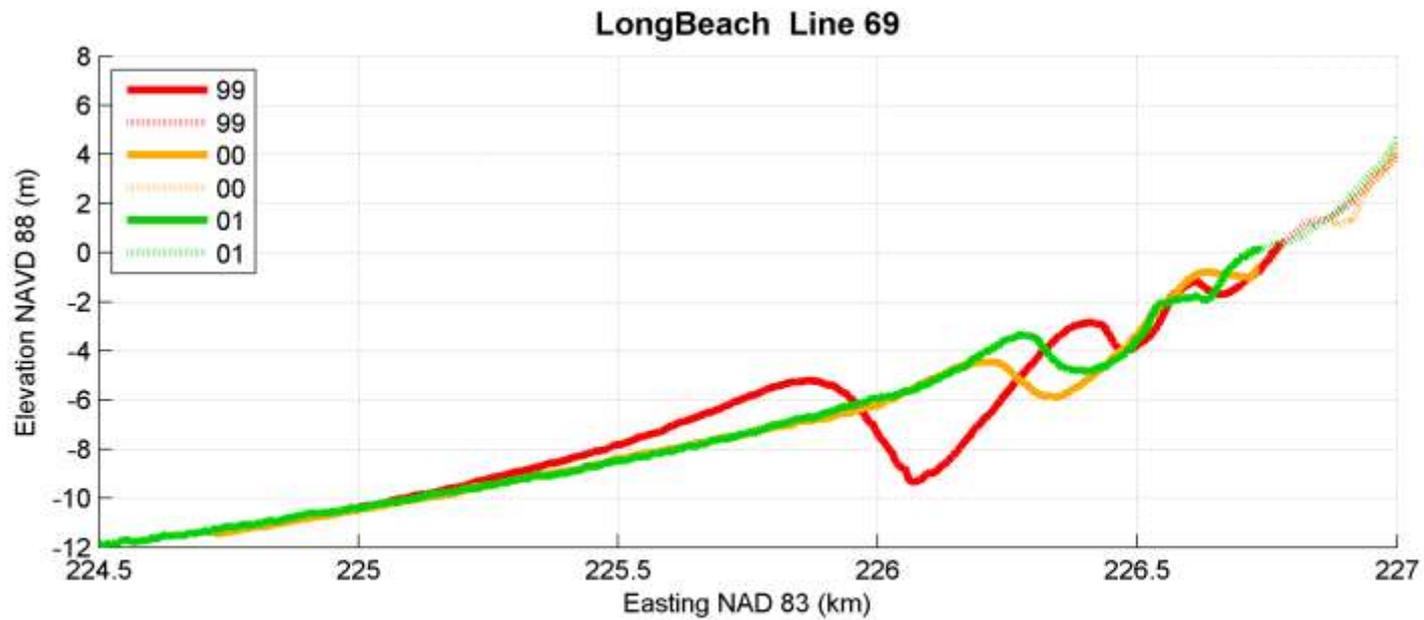
# 'Typical' Nearshore CRLC Profile



# Nearshore Profile Change



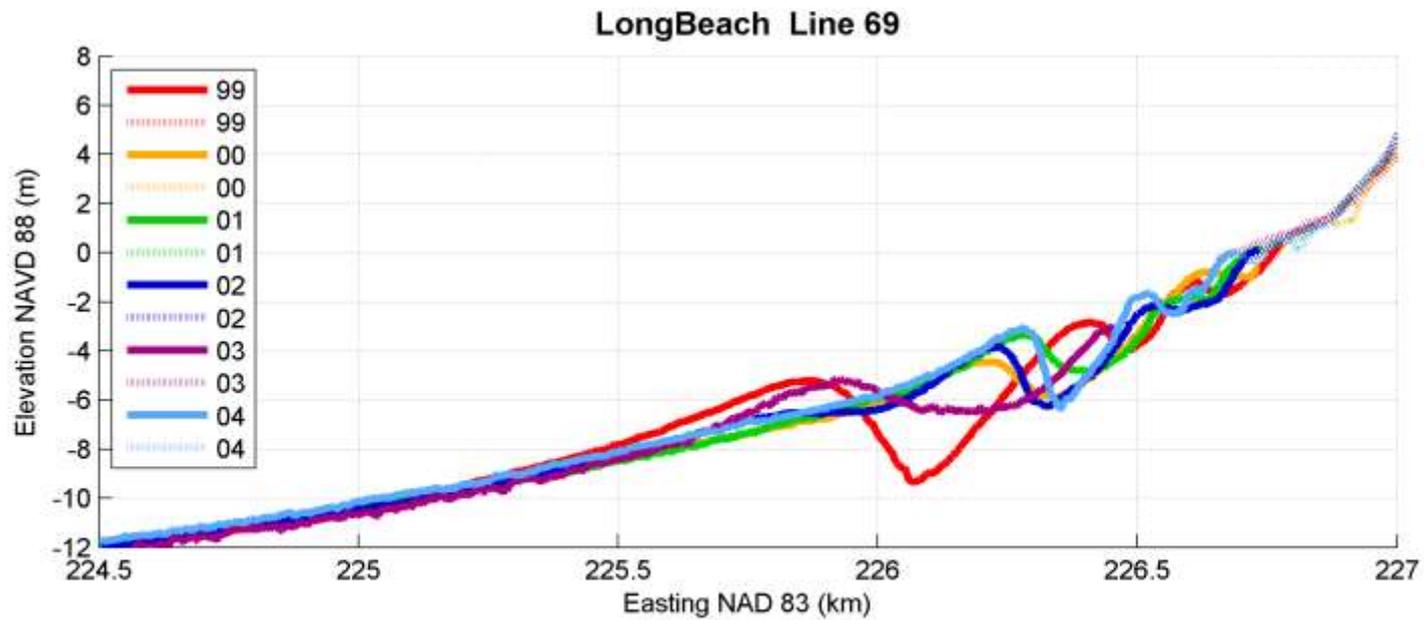
# Nearshore Profile Change



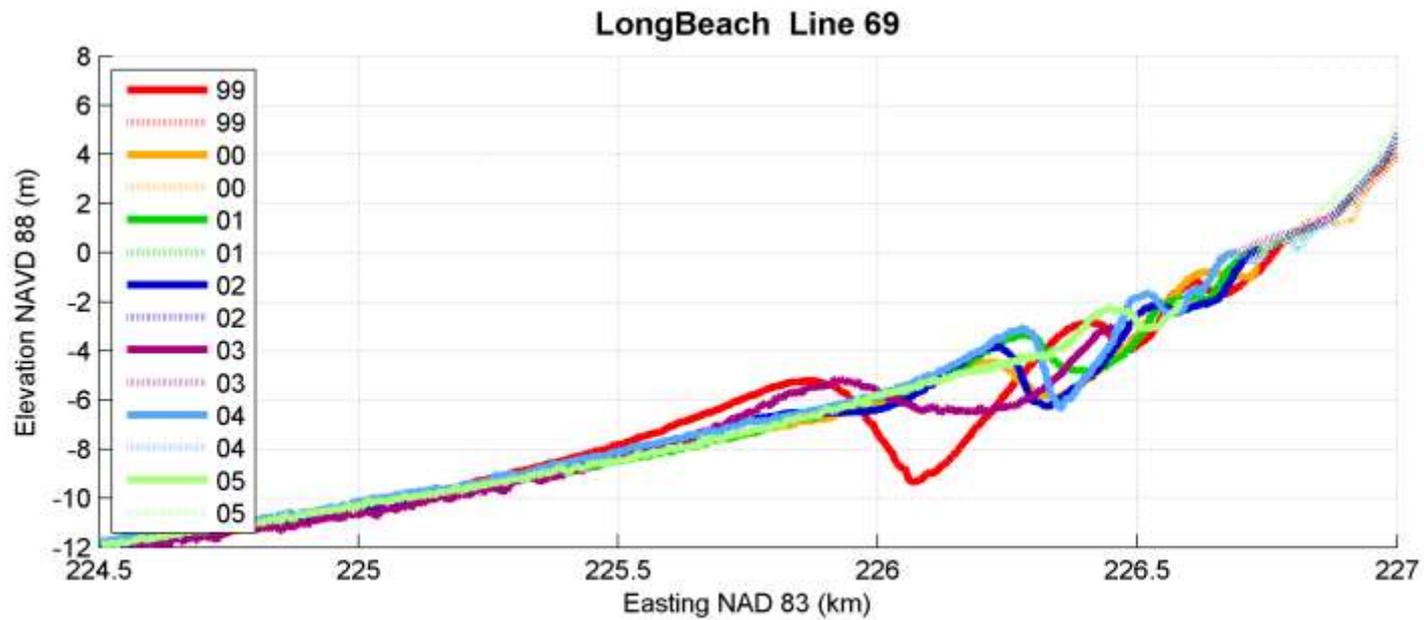




# Nearshore Profile Change

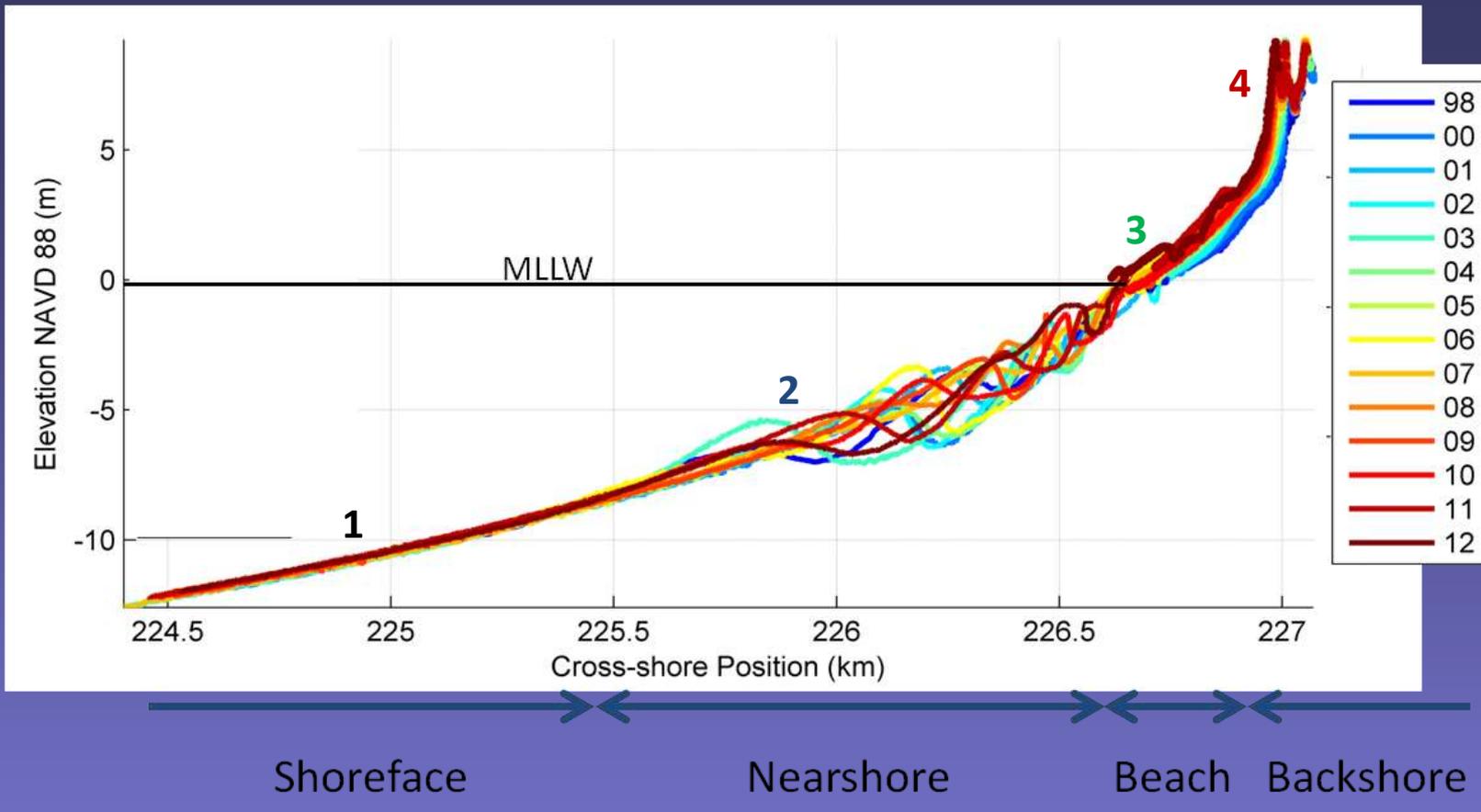


# Nearshore Profile Change



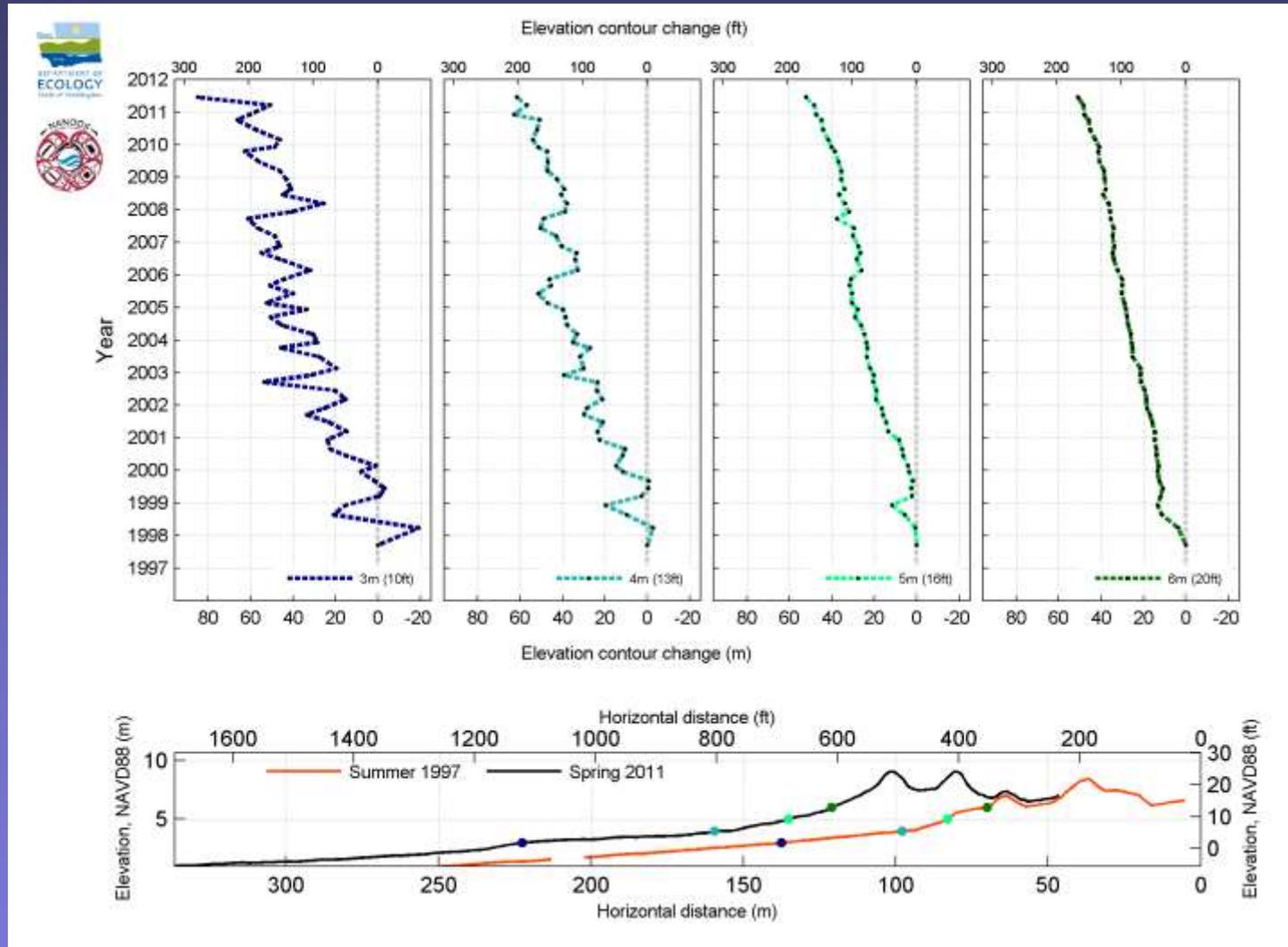
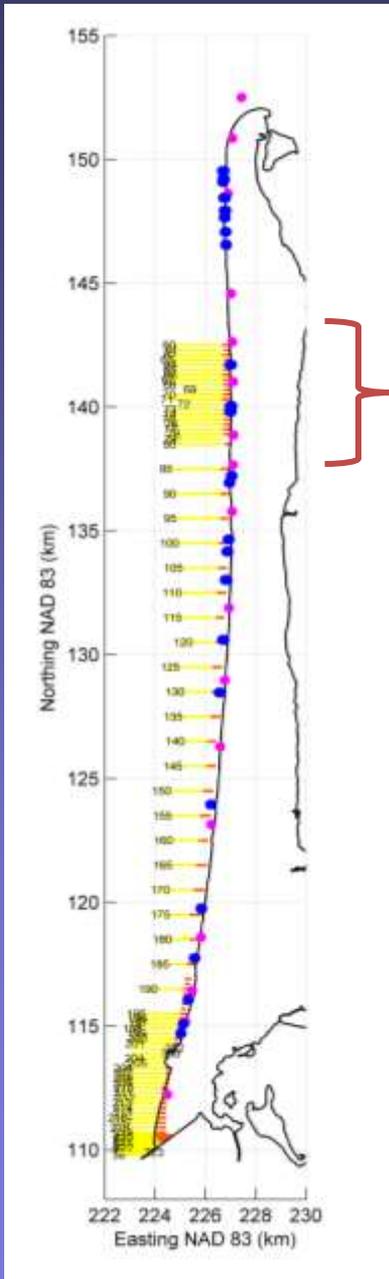






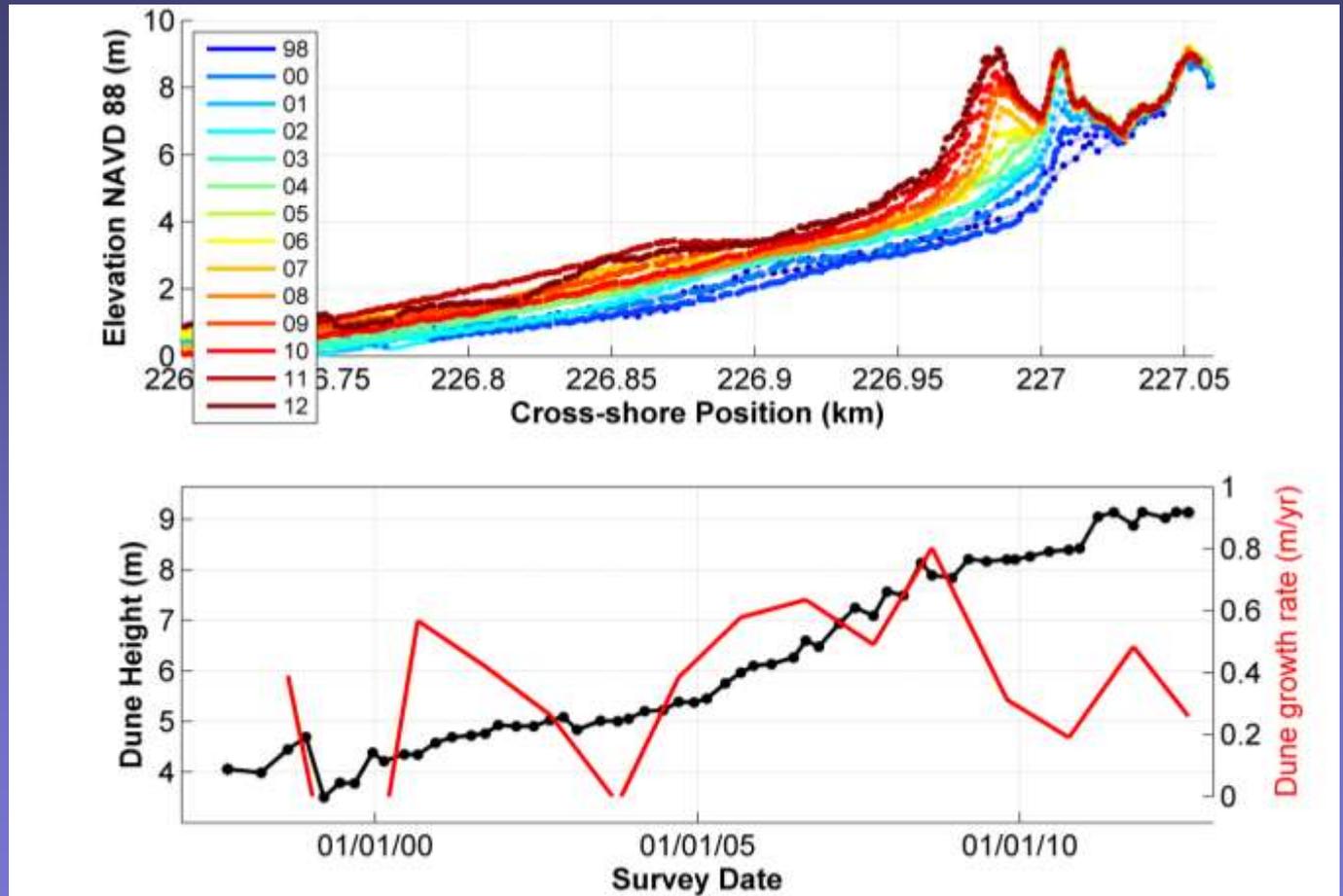
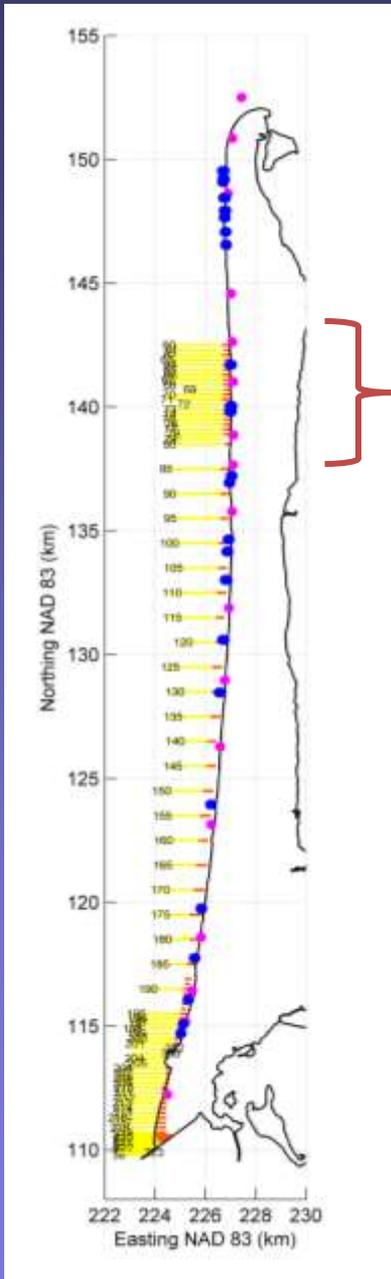
1. **Shoreface: Cross-shore feeding to upper shoreface and barriers**
2. **Nearshore: Net offshore bar migration; gradients in longshore transport; seasonal – interannual coastal change.**
3. **Beach: Rapid progradation and aggradation**
4. **Backshore: Species-specific ecomorphodynamic feedbacks between vegetation and dune geomorphology**

# Prograding beach and foredunes



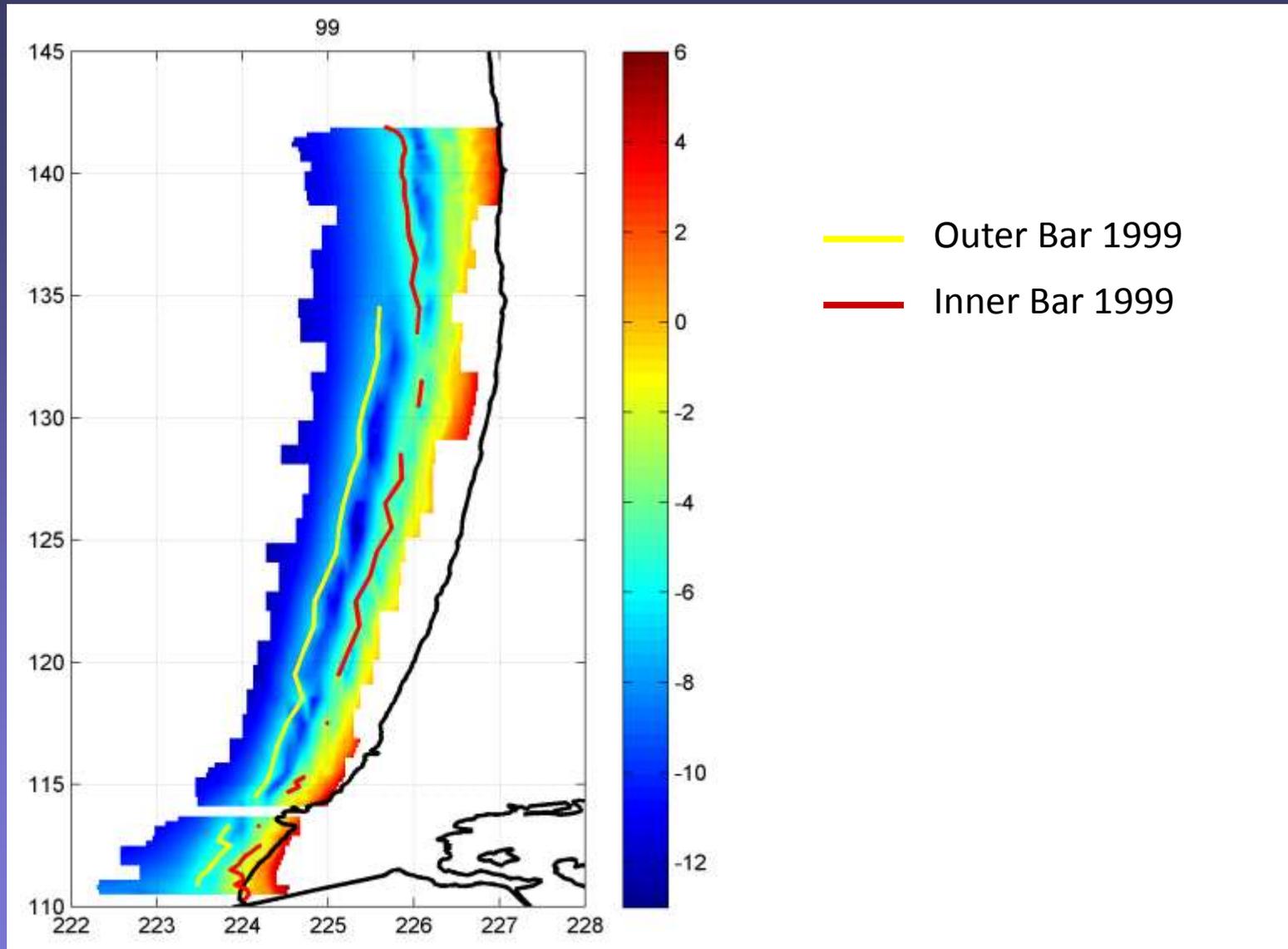
2 new foredunes since 1999;  
Coastal change rate = ~4.5 – 7.5 m/yr

# Prograding foredunes

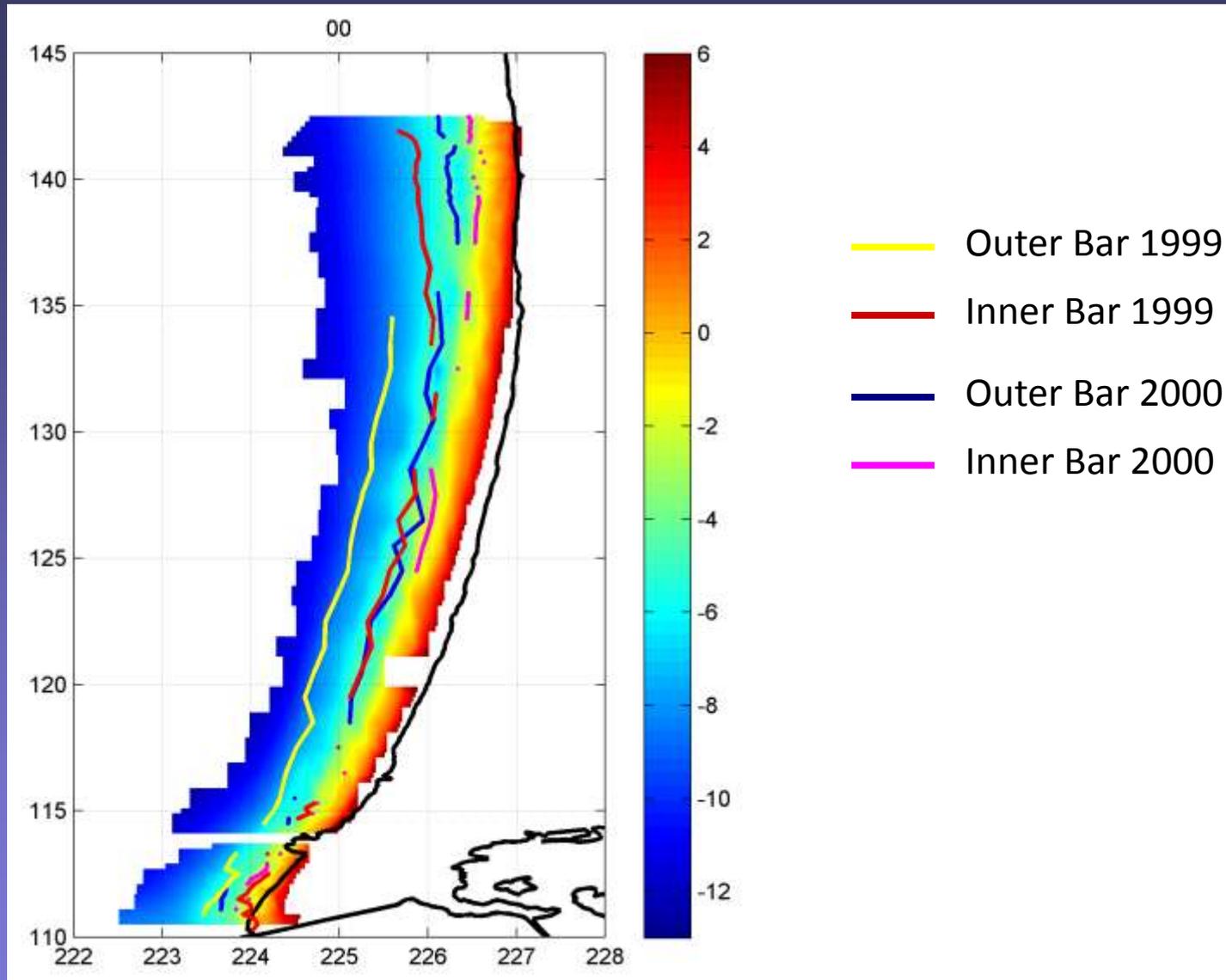


**~10 m<sup>3</sup>/m/yr of observed accumulation in foredunes;  
~.3 Mm<sup>3</sup> in 3km surface map area between 2000 and 2011.**

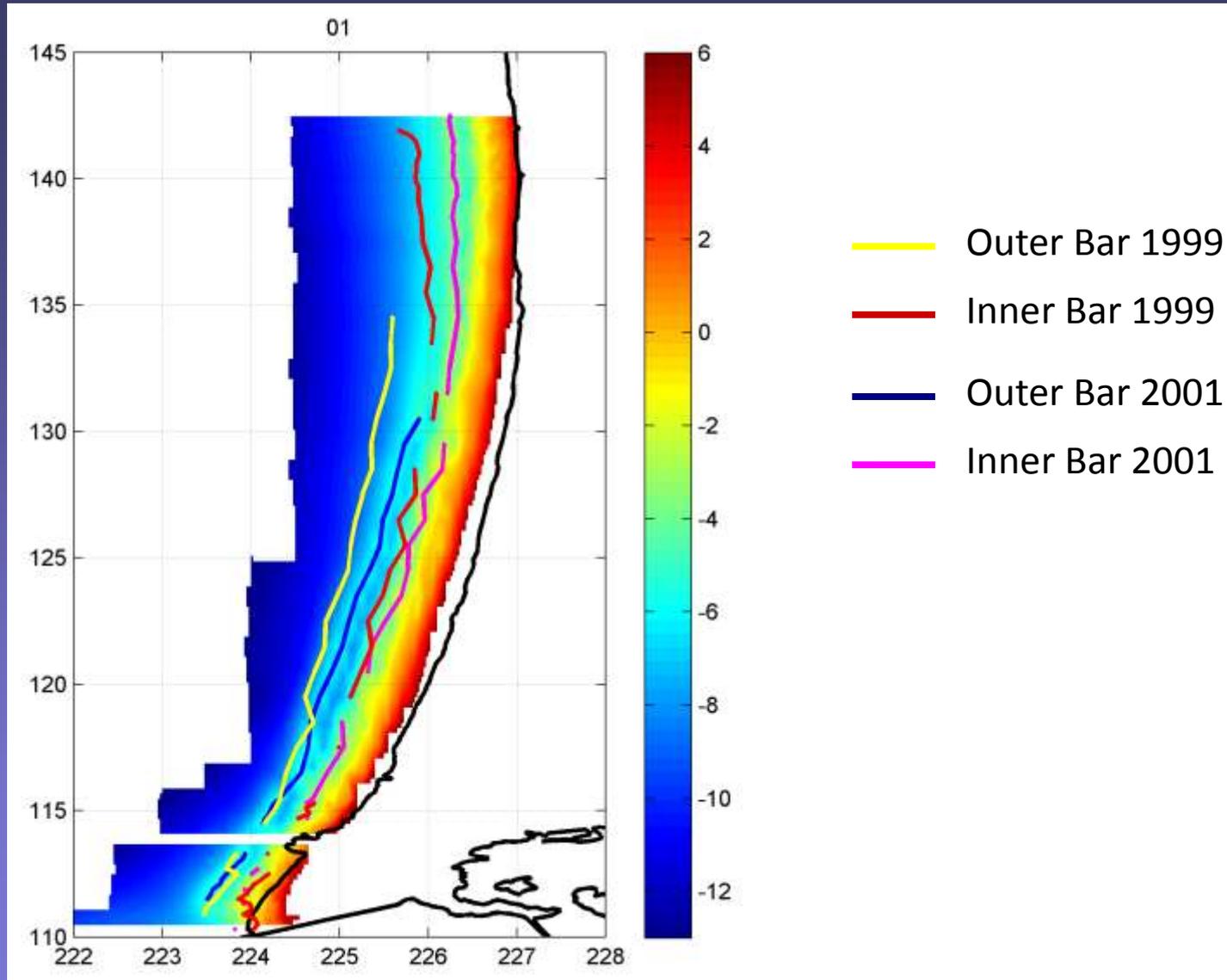
# Alongshore Varying Morphology



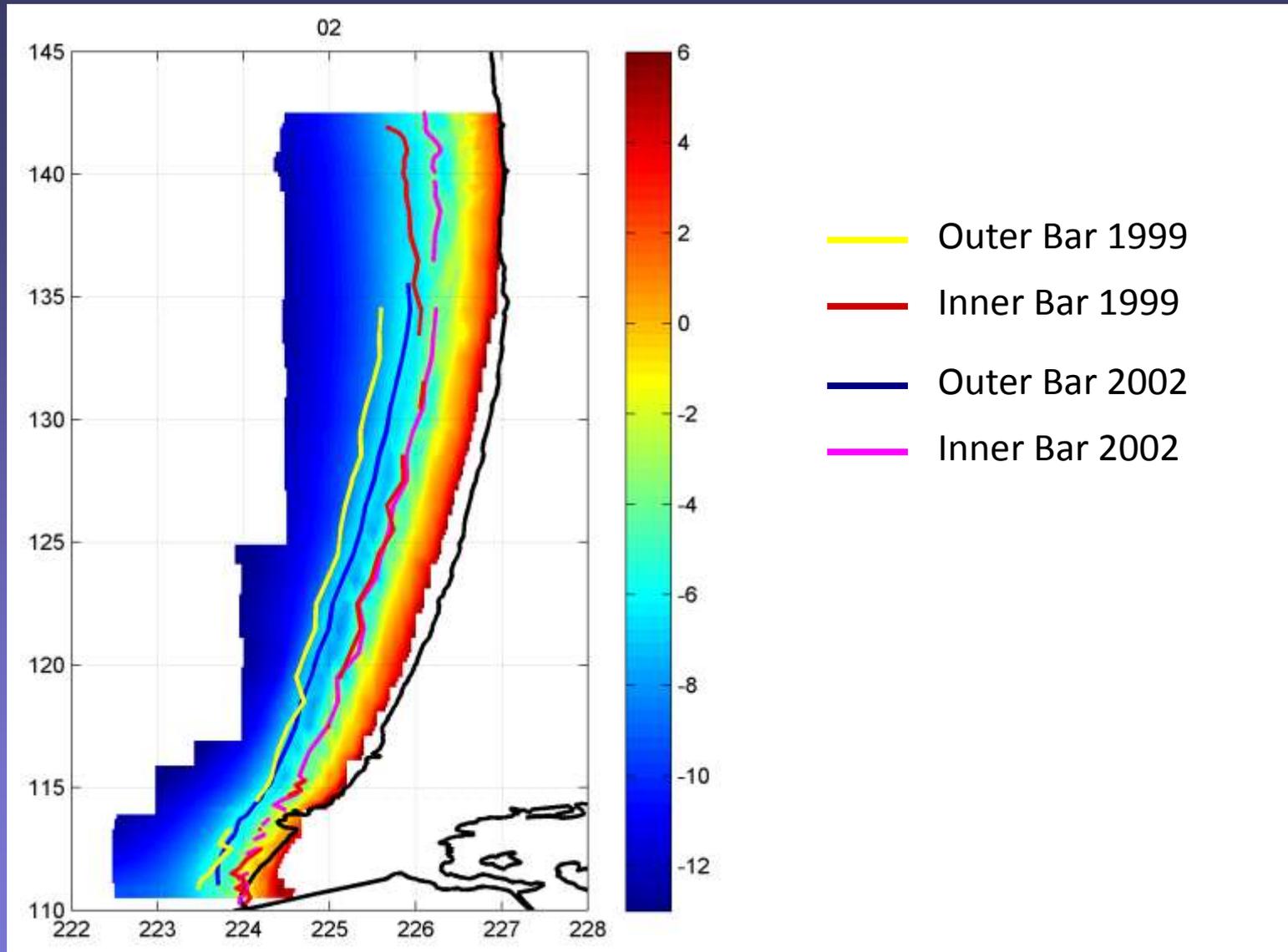
# Alongshore Varying Morphology



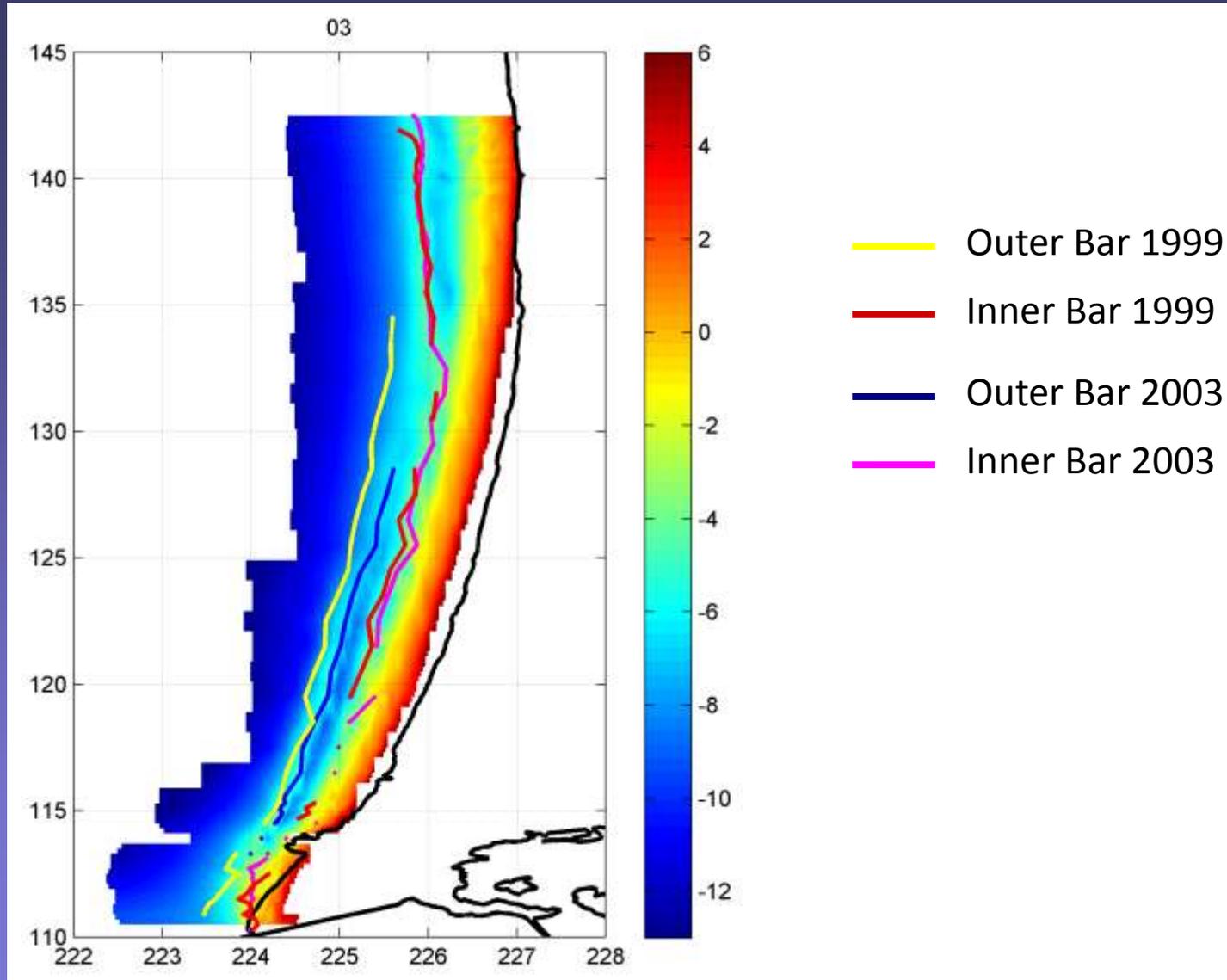
# Alongshore Varying Morphology



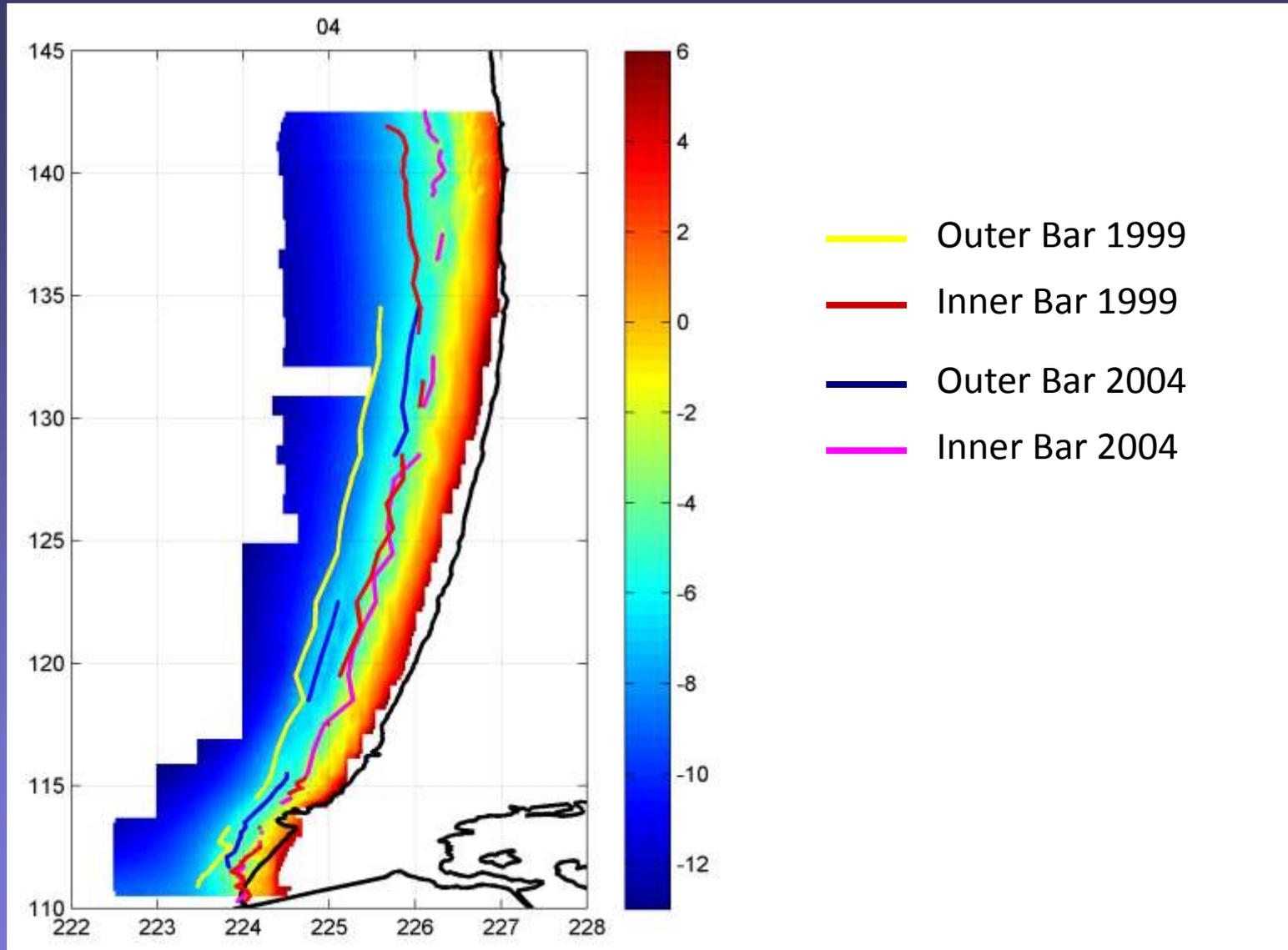
# Alongshore Varying Morphology



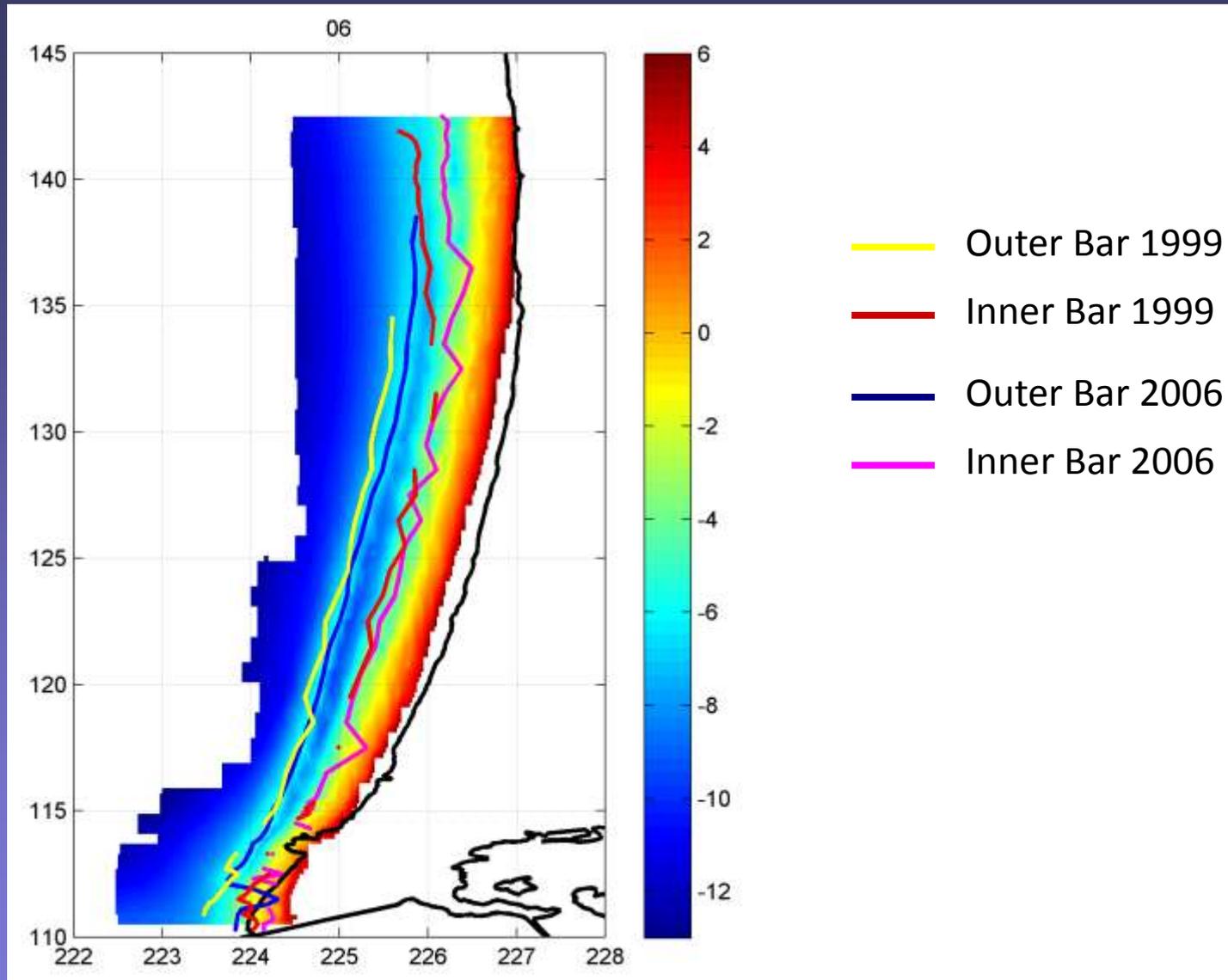
# Alongshore Varying Morphology



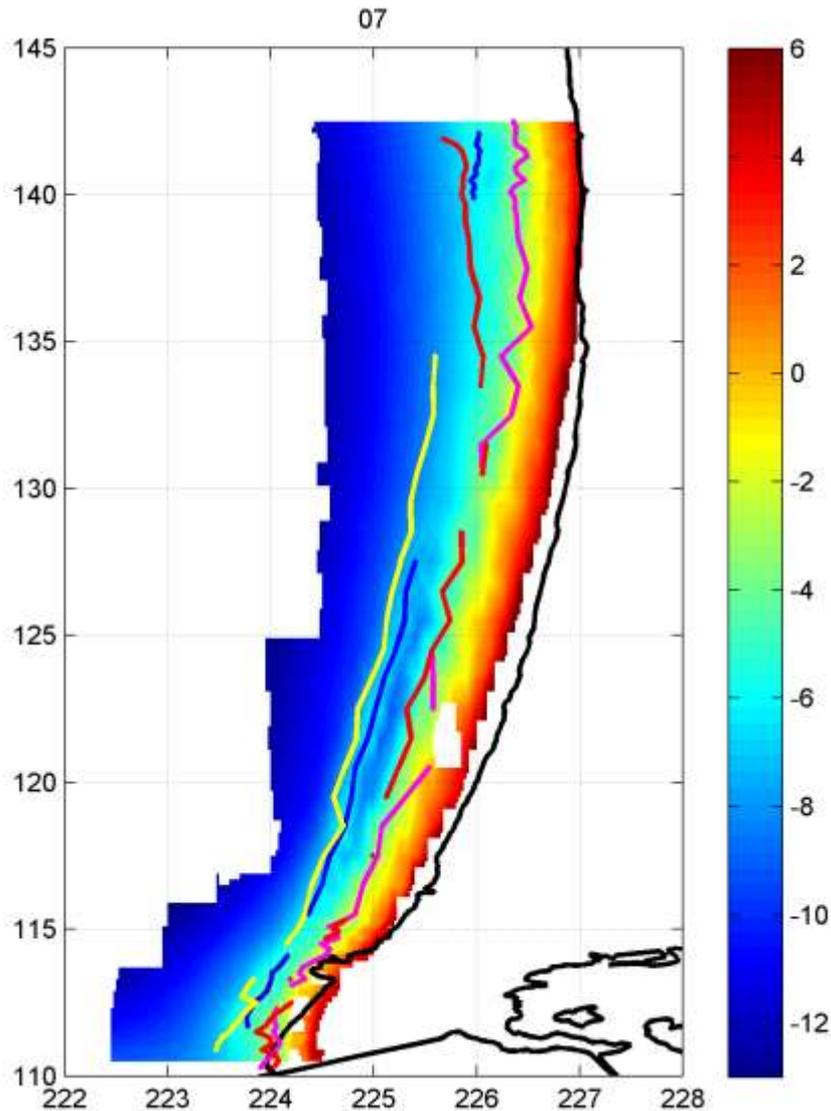
# Alongshore Varying Morphology



# Alongshore Varying Morphology



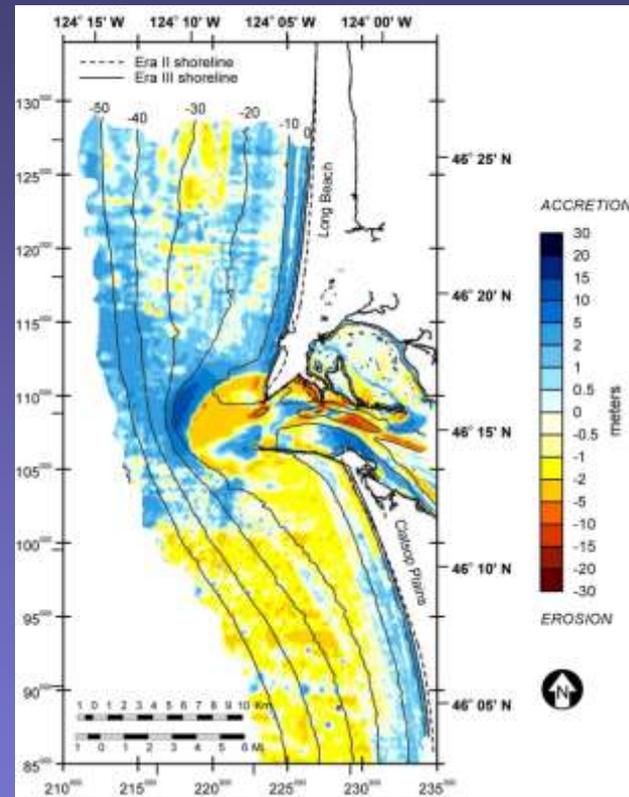
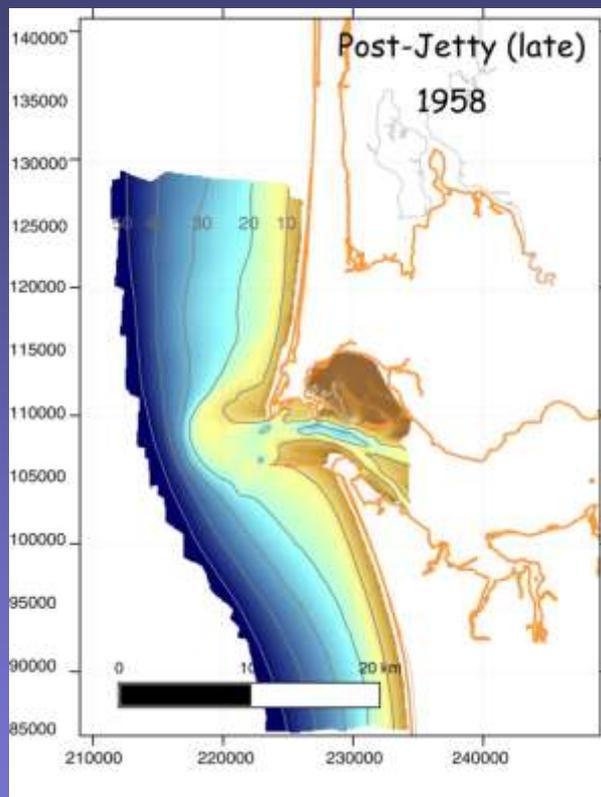
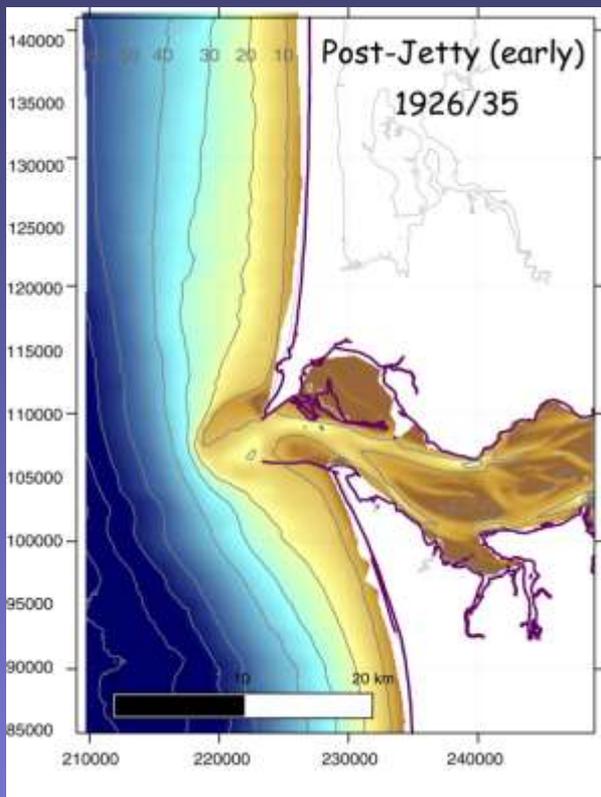
# Alongshore Varying Morphology



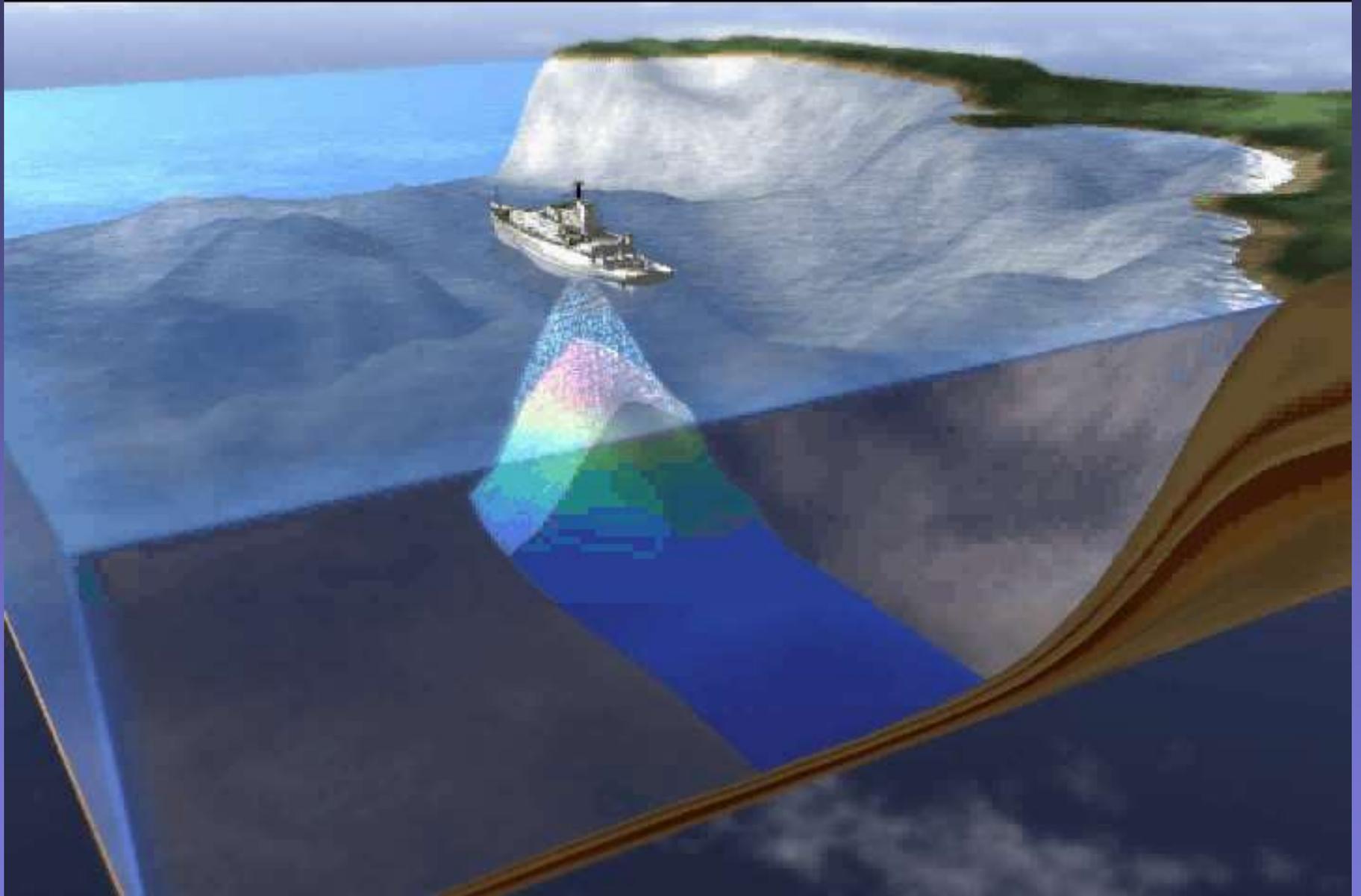
- Outer Bar 1999
- Inner Bar 1999
- Outer Bar 2007
- Inner Bar 2007

**Net Offshore Bar Migration  
~3 – 7 year cycles?**

# Shoreface Bathymetry Change: 1926-1958



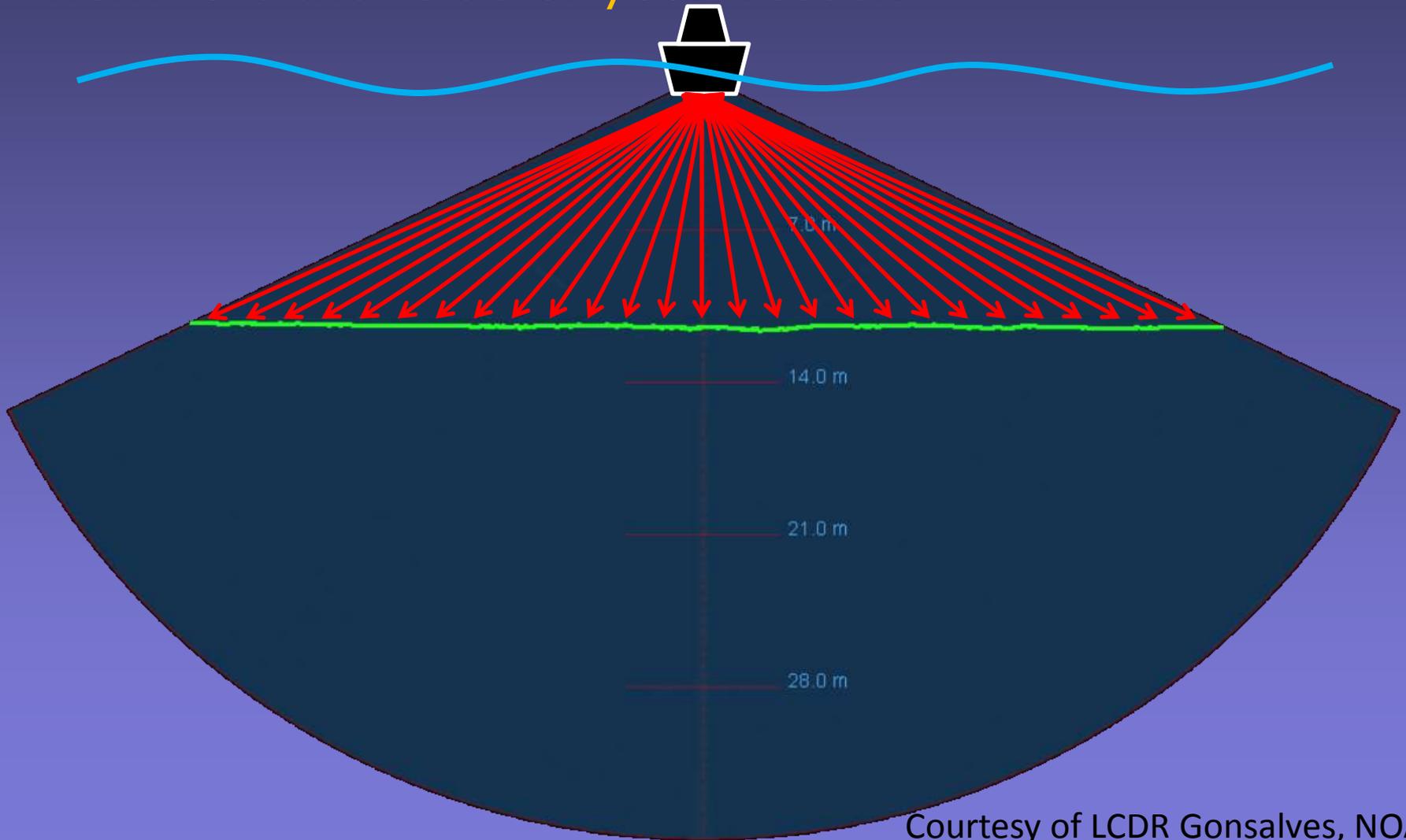
# Enter the Multibeam



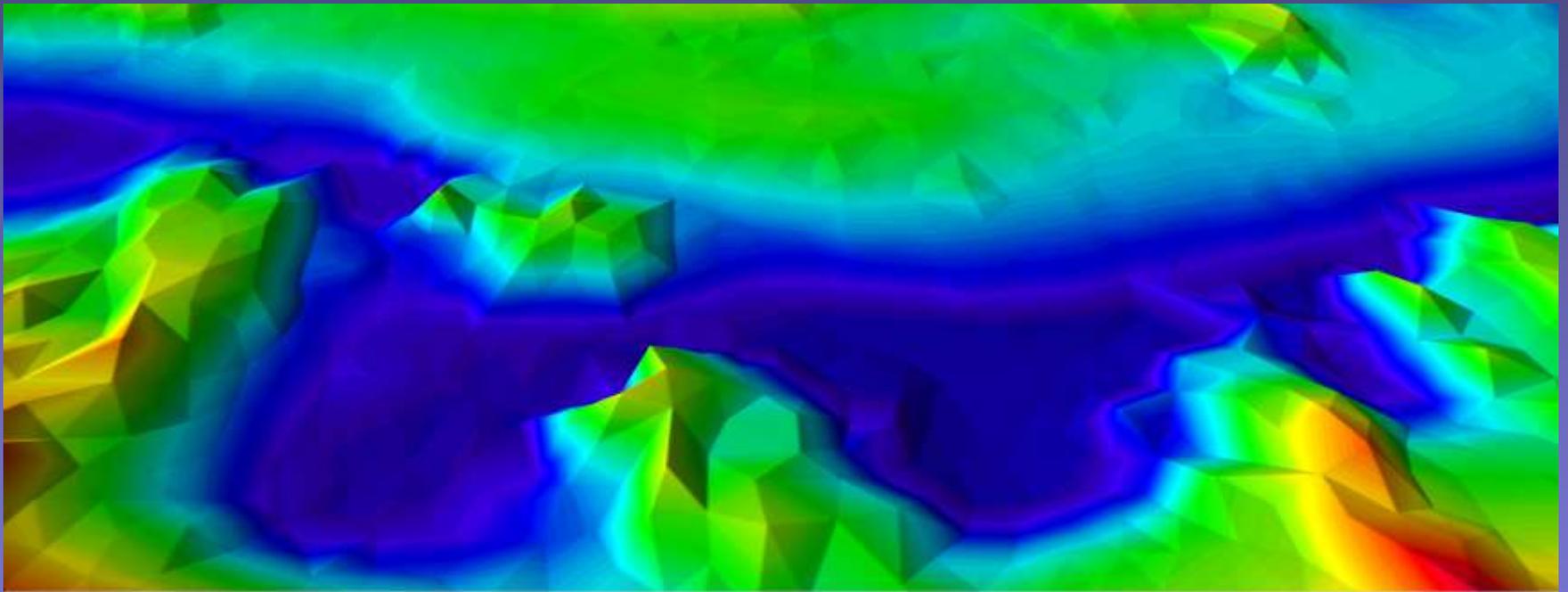
Courtesy of LCDR Gonsalves, NOAA

# Hydrography – Enter the Multibeam

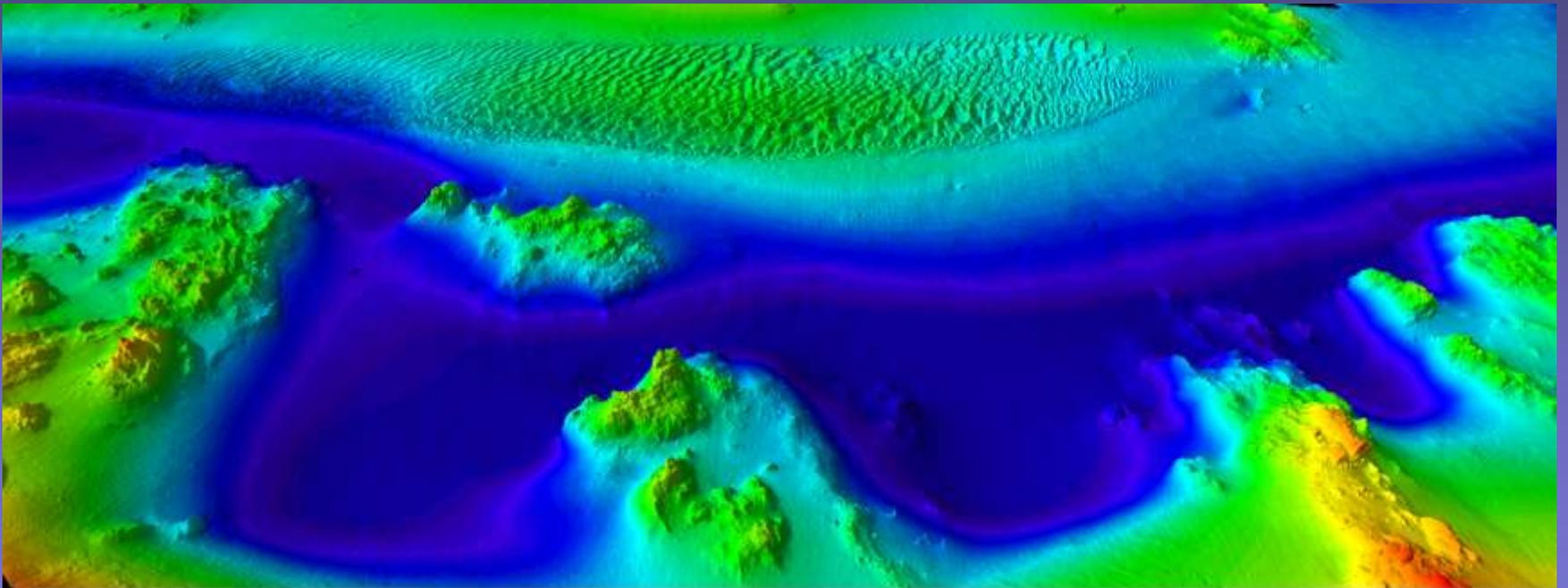
- Rather than sending a single pulse of energy straight down; imagine forming multiple beams and directing them to either side of your vessel.



# Single Beam Density Selected Soundings



# Multibeam Navigation Surface Depth Model



Courtesy of LCDR Gonsalves, NOAA

# *R/V George Davidson*



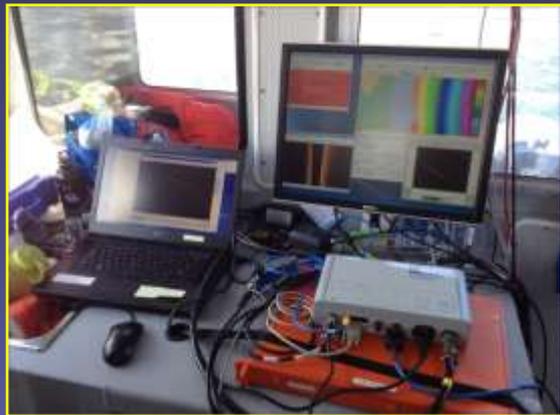
1825-1911

- Beach-landing craft specifically designed for shallow-water hydrographic and topographic surveying
- Trailerable 28' x 10' vessel for local launch and recovery
- 18" shallow draft
- Twin hull for stability and limited roll; straight line tracking; maneuverability



- Drop-down bow door for land-based surveying (RTK base, scanner targets)
- Moon-pool sonar deployment for repeatability and rigidity

# R/V George Davidson: Equipment



Survey station



Mobile laser scanner  
Inertial Measurement Unit (IMU)  
2 GNSS antennas



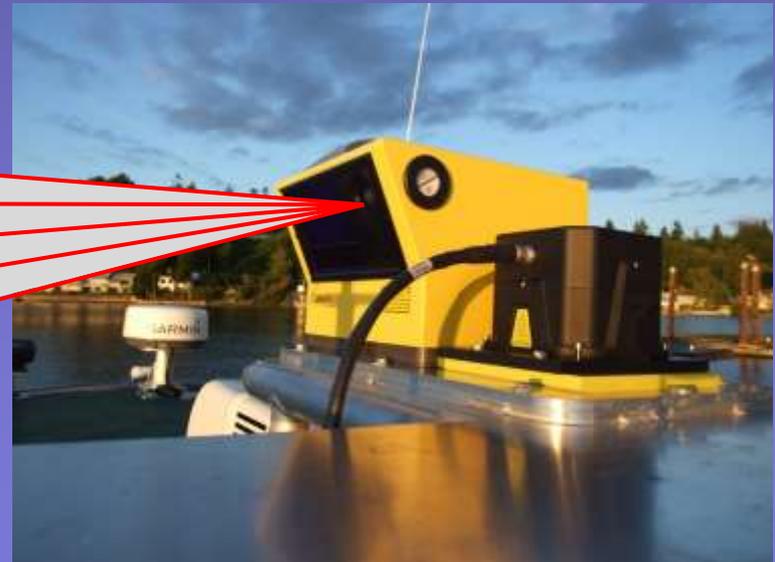
Multibeam echosounder  
w/ sound velocity probe



Forward-looking sonar

# Boat-based lidar: Optech Iris HD-ER

- Vertical swath up to  $80^\circ$
- Images landscape as vessel moves
- Range of up to 1800 m
- Up to 10,000 Hz ping rate
- Beam diameter = 19 mm at 100 m

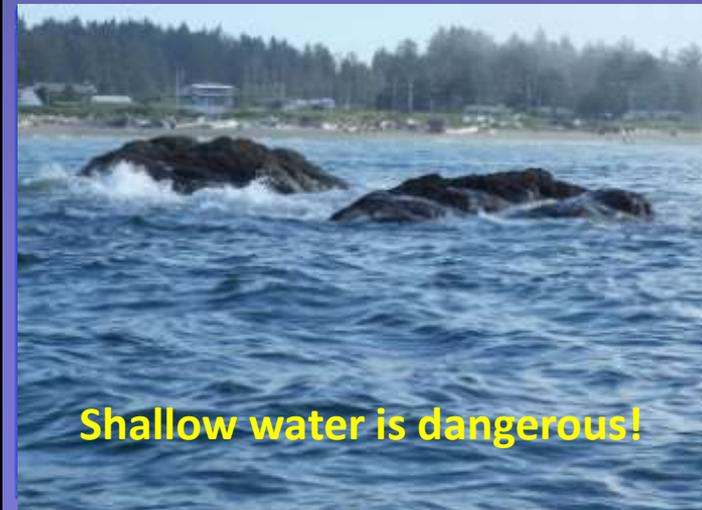
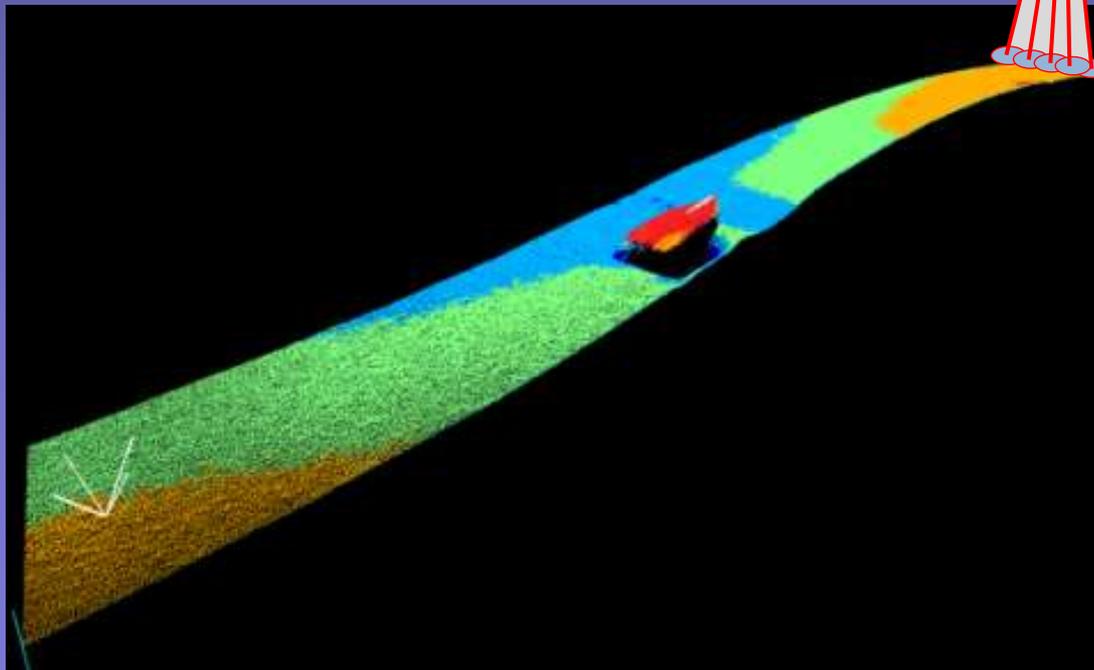


# Alternative Remote Sensing Platforms



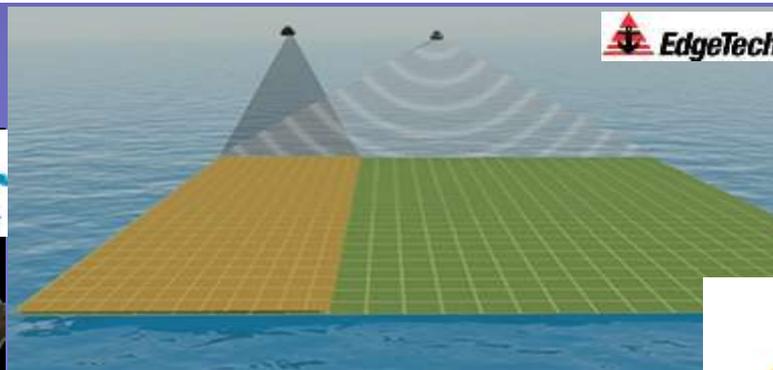
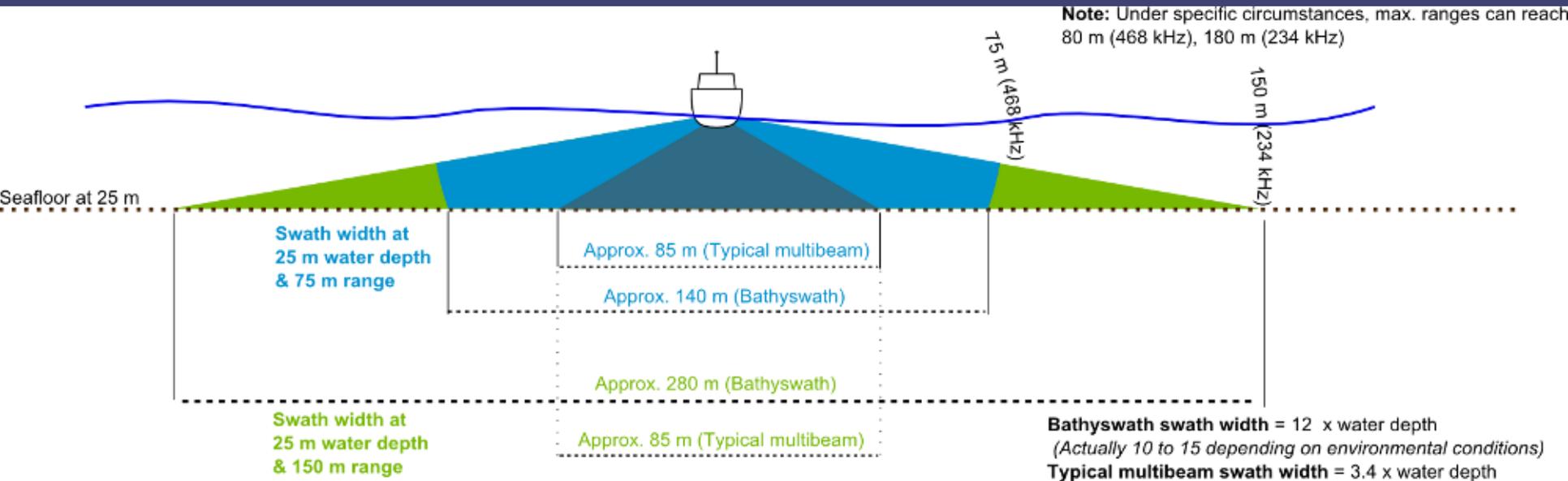
# Multibeam echosounder: R2Sonic 2022

- 256 beams ping simultaneously
- Up to 160° swath or focused for higher resolution
- 4 x water depth
- Up to 60 Hz ping rate
- Beam steering (e.g., tilt the swath towards shoreline)



# Alternative Sonar Systems

## Interferometric swath bathymetry and side scan sonar for shallow water



# Clallam County: Bluff erosion

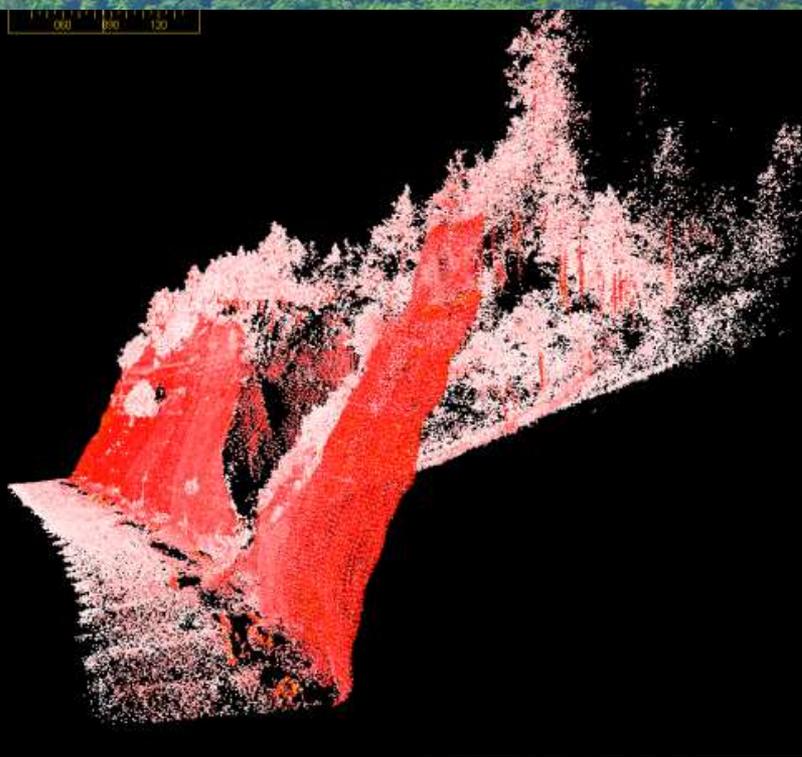
Survey 1: 21-22 Jun 2012

Survey 2: 1-4 Mar 2013

Survey 3: 19-21 Aug 2013



0.00 0.50 1.00



Washington State Co

### Oblique perspective of bluffs

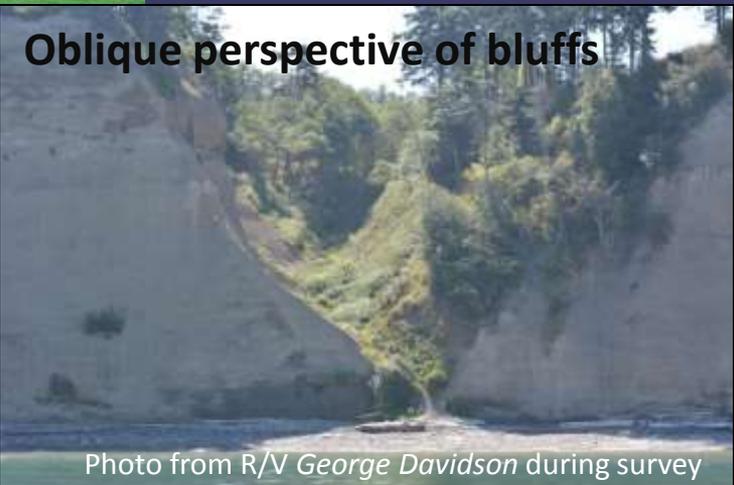
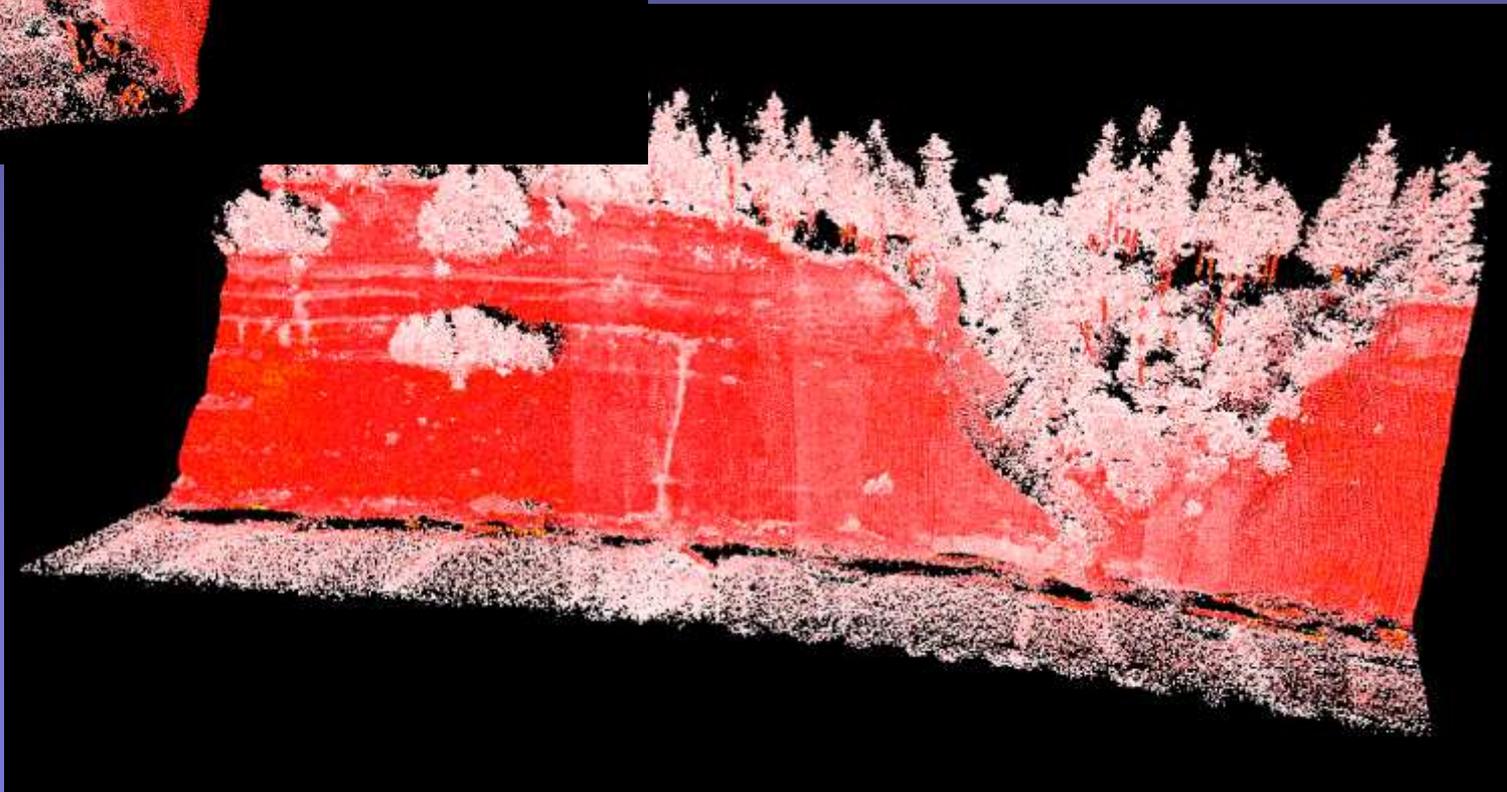


Photo from R/V *George Davidson* during survey

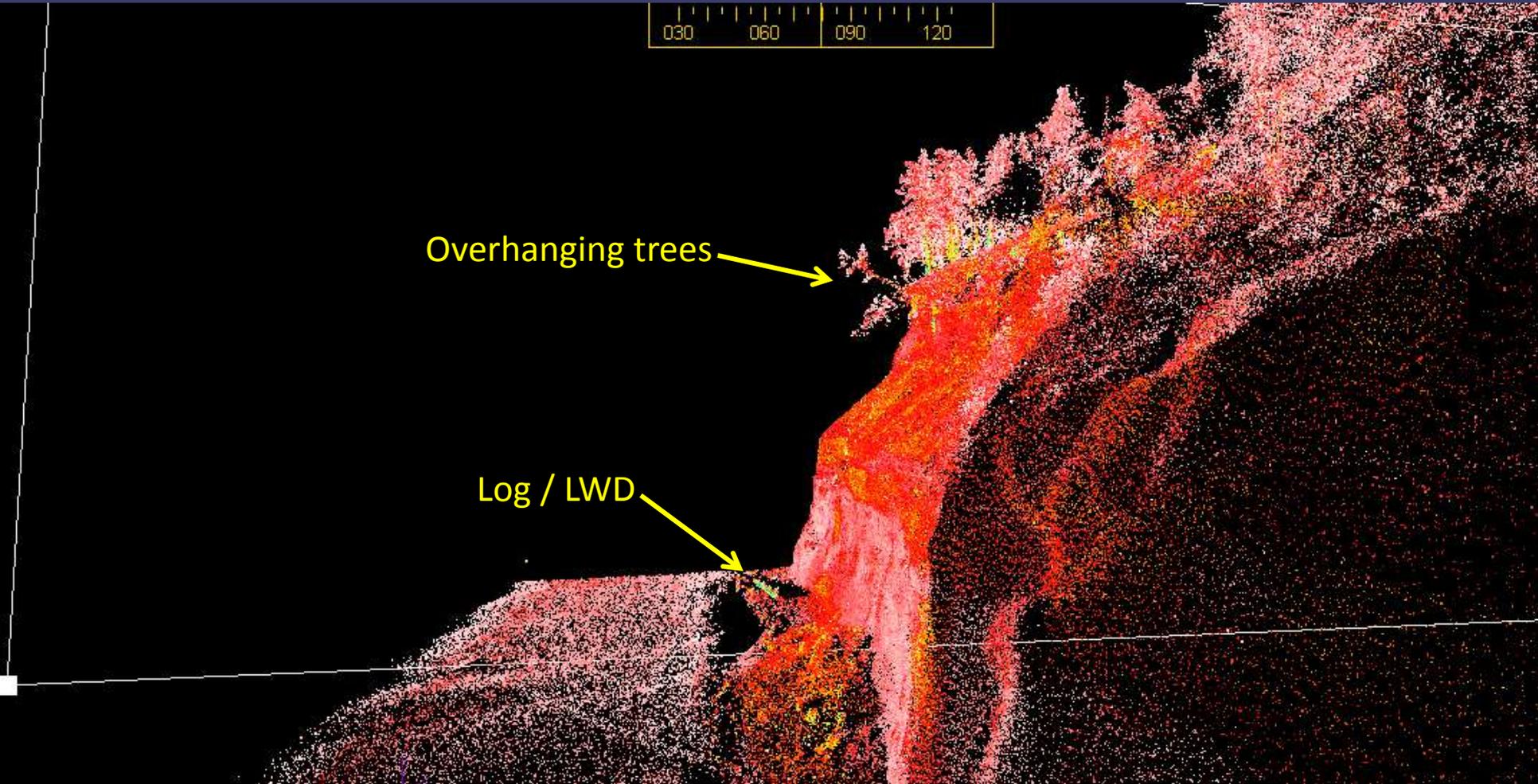


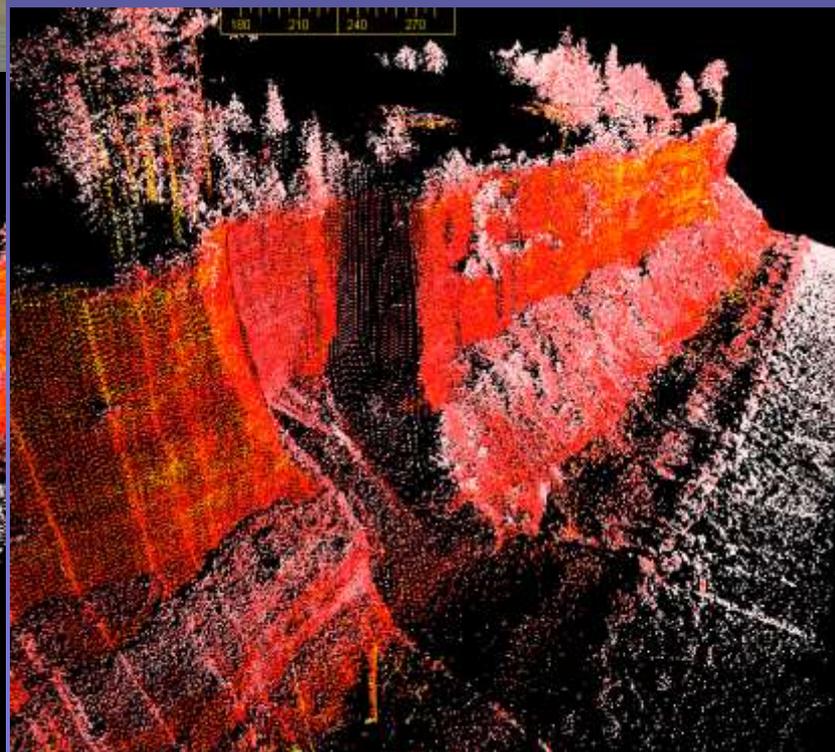
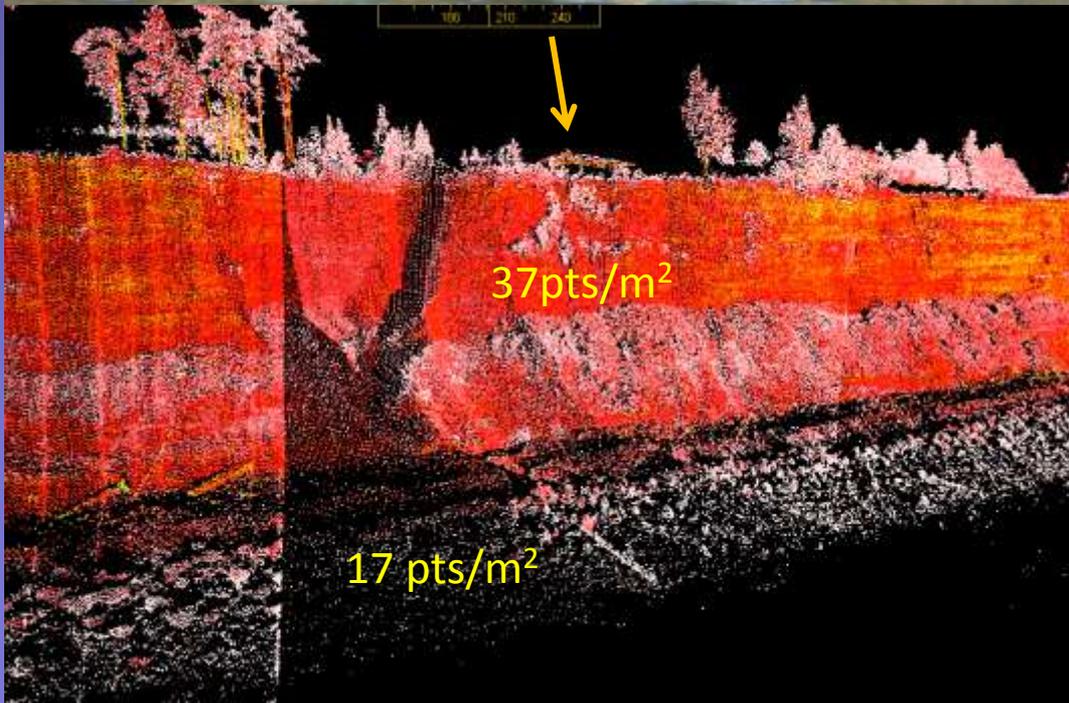


Overhanging trees



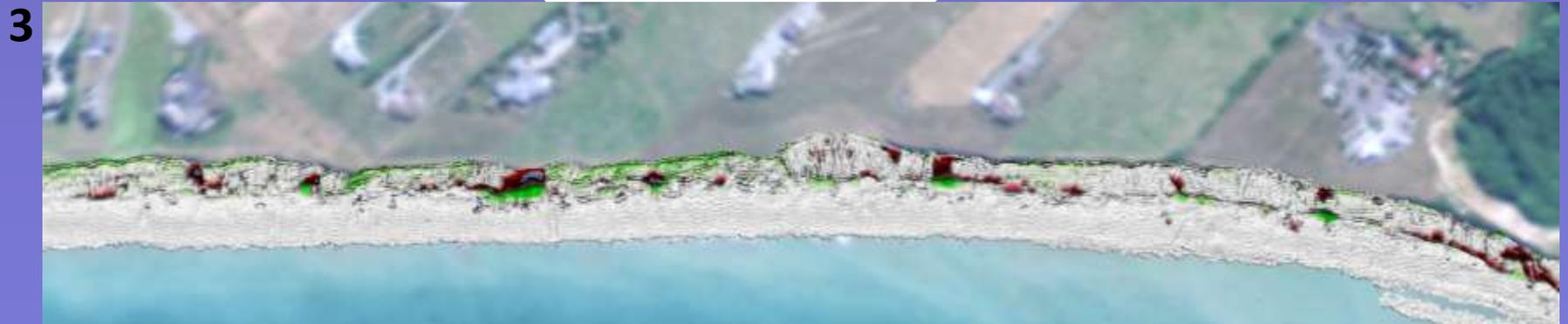
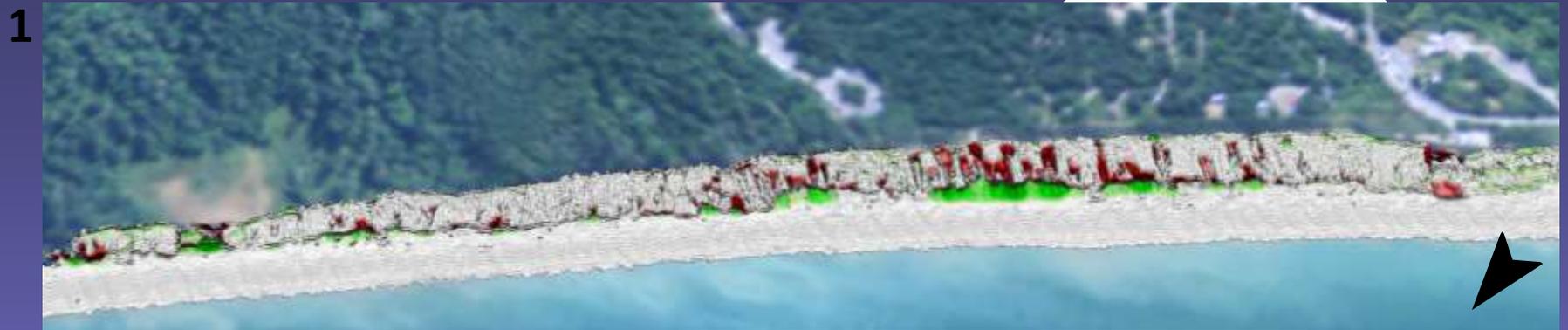
Log / LWD



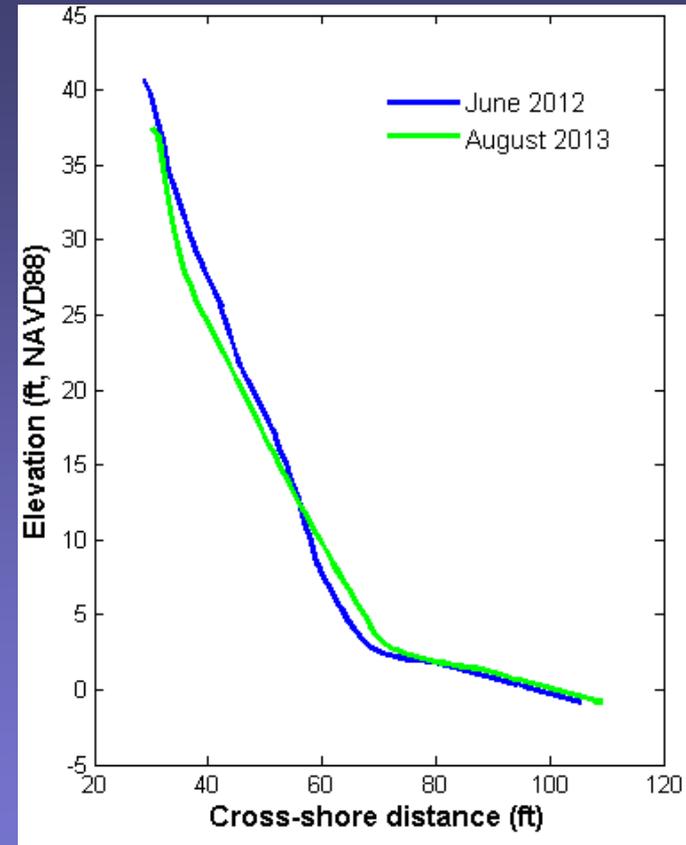
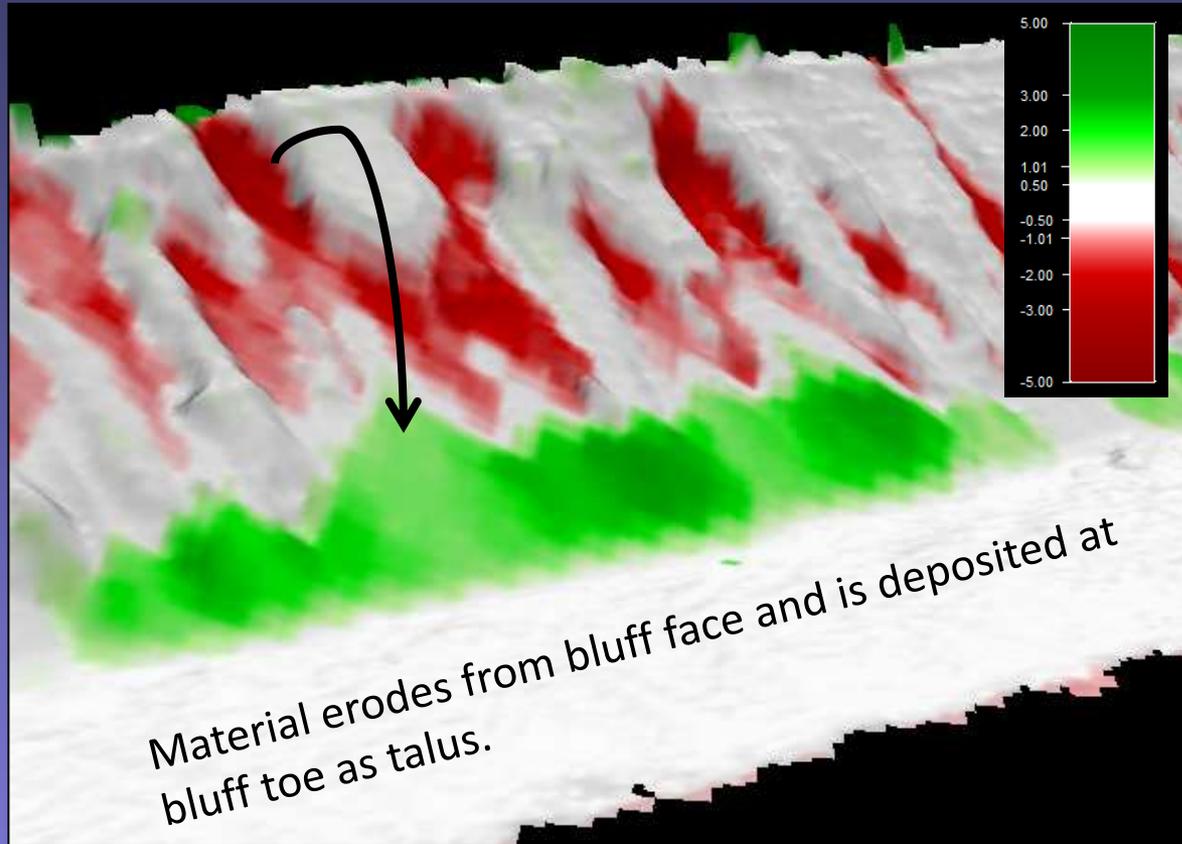


# Spatial Variability in Bluff Recession for the eastern Dungeness drift cell

June 2012-August 2013



# Boat-based LiDAR Example of Bluff Recession

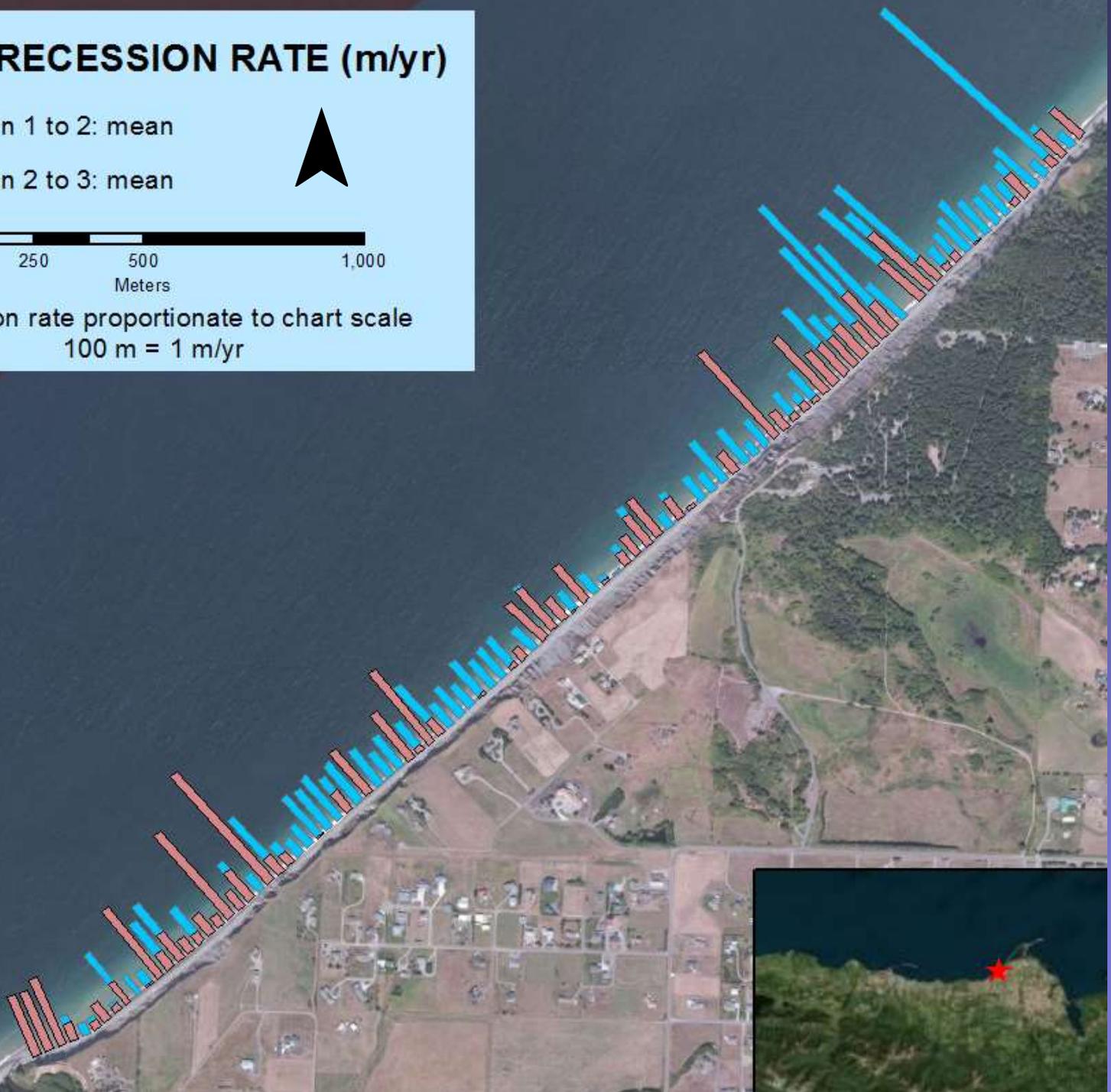


# BLUFF RECESSION RATE (m/yr)

- Scan 1 to 2: mean
- Scan 2 to 3: mean



Recession rate proportionate to chart scale  
100 m = 1 m/yr



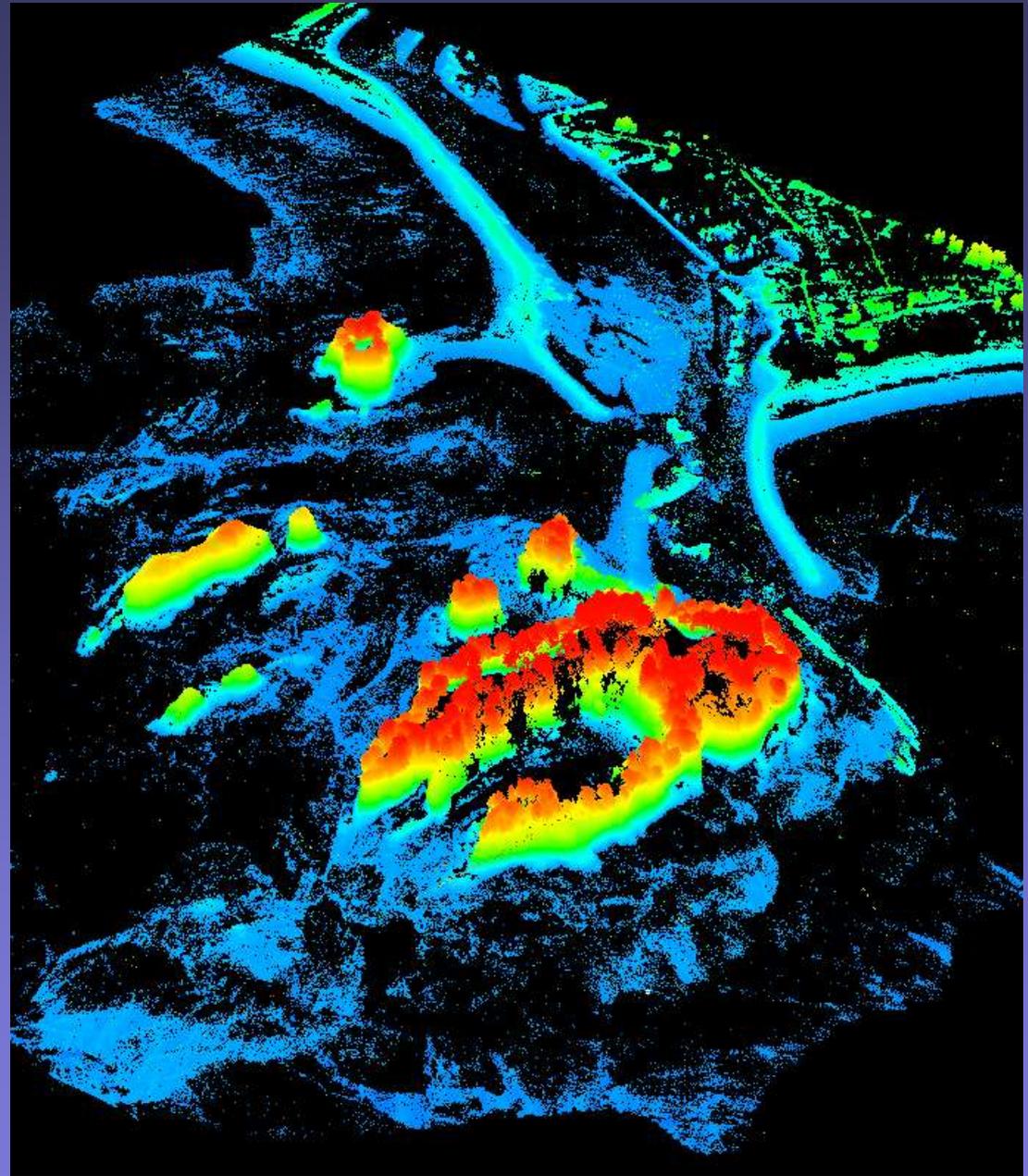
# Coastal Mapping at La Push for Marine Spatial Planning

14-16 Sept 2012



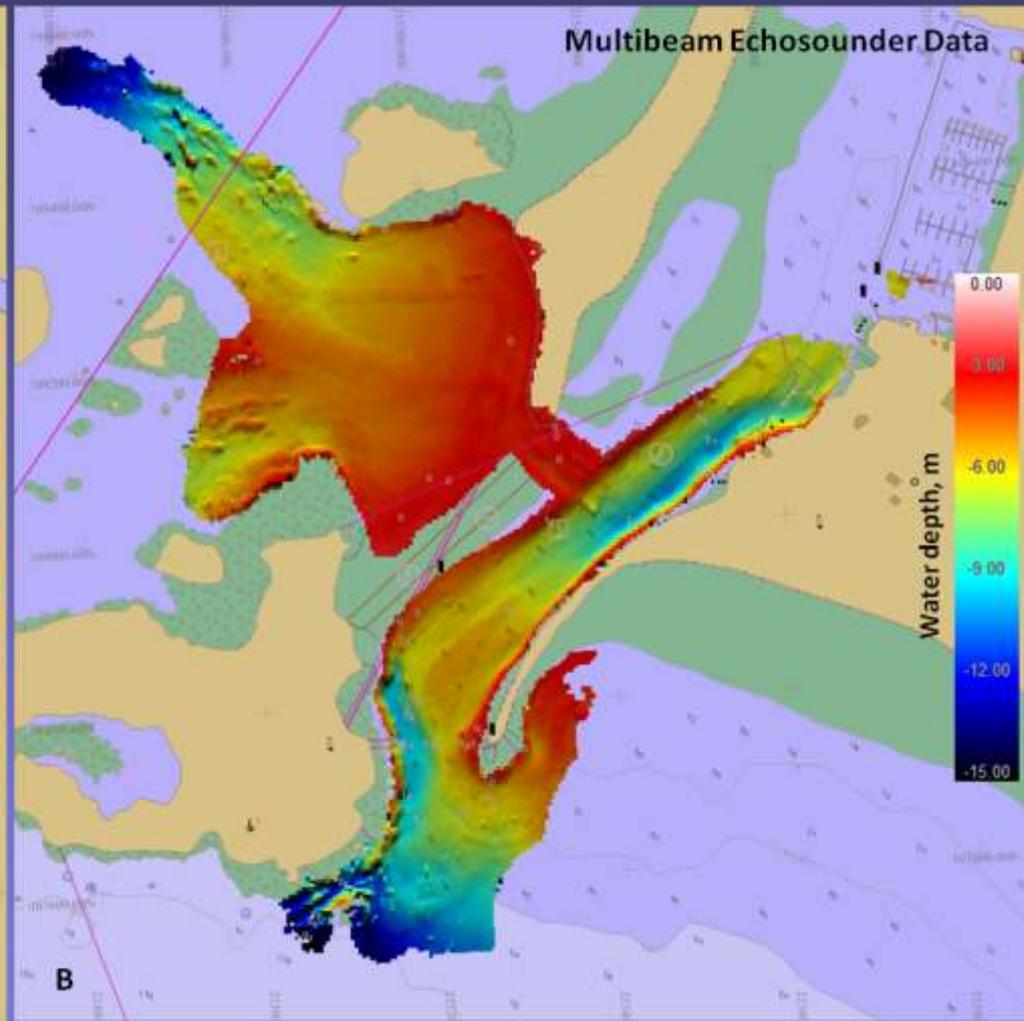
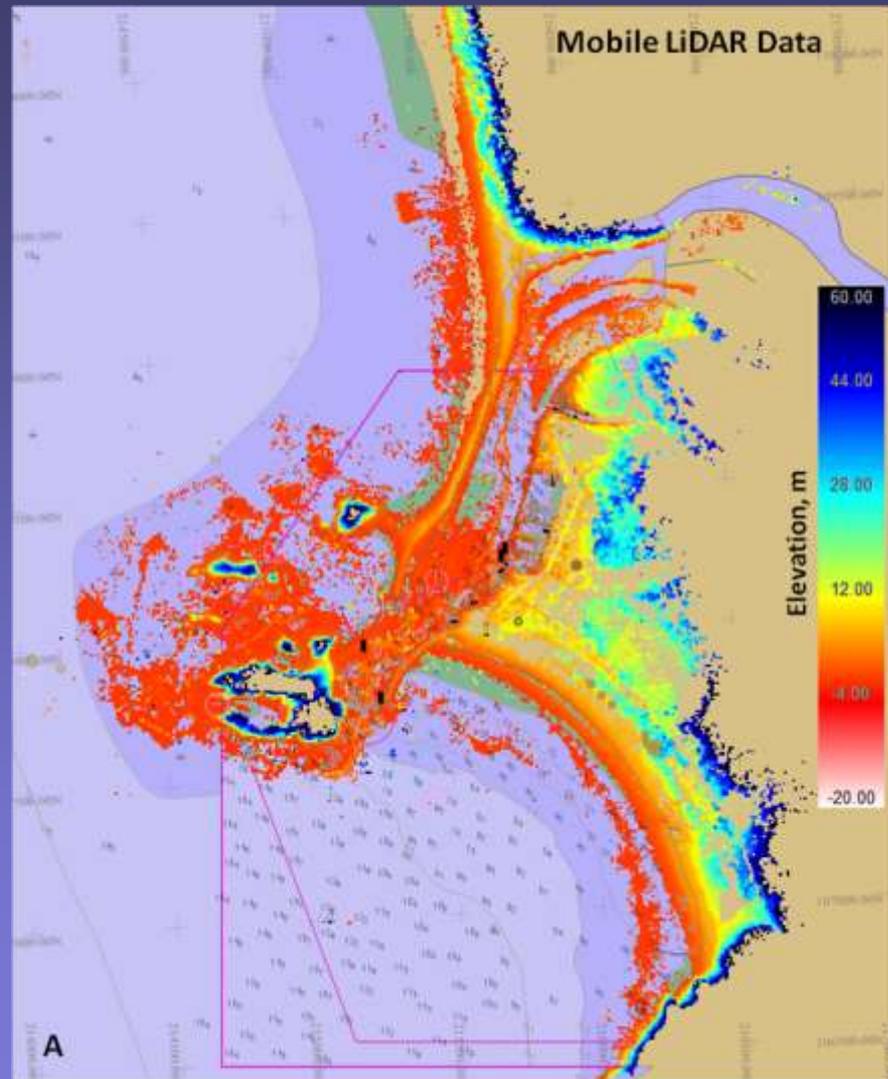
Washington State Coastal Atlas

James Island and Quillayute River



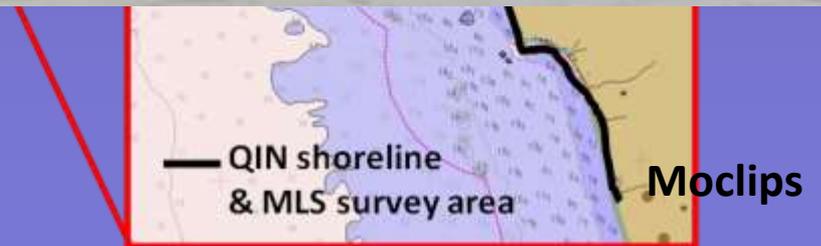
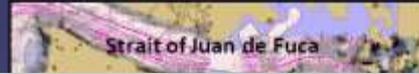
# Coastal Mapping at La Push for Marine Spatial Planning

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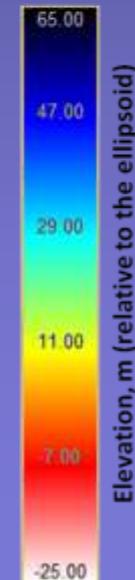
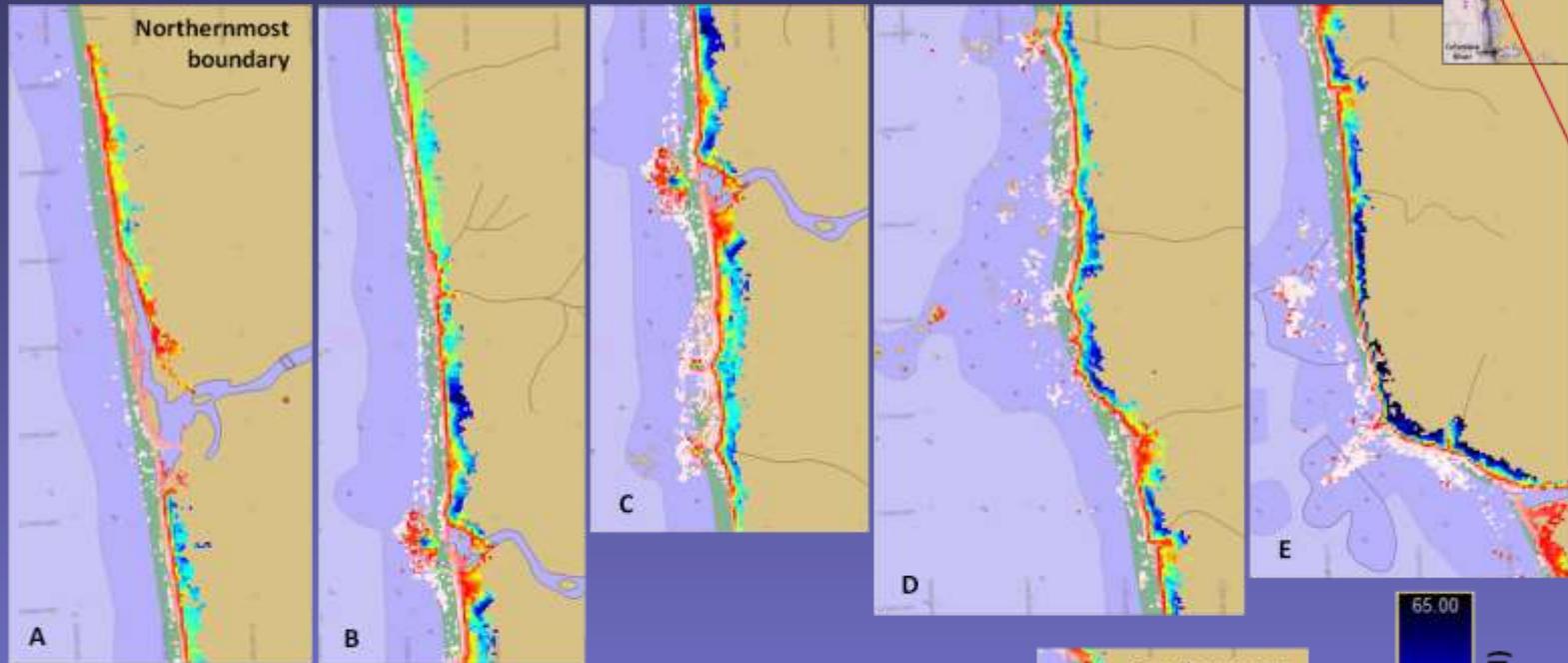
# Coastal LiDAR at Quinault Indian Nation for Marine Spatial Planning

24-25 Jun 2013



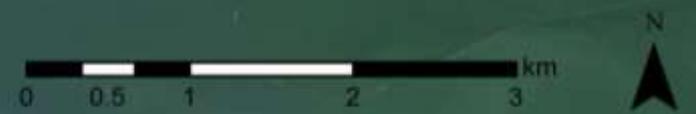
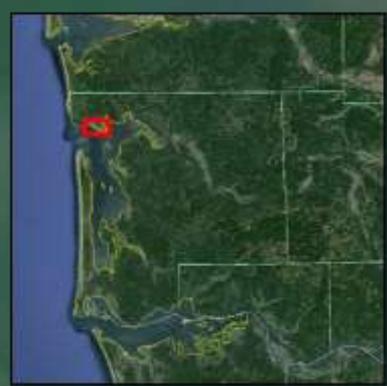
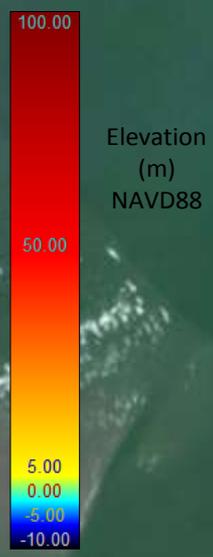
# Coastal LiDAR at Quinault Indian Nation for Marine Spatial Planning

24-25 Jun 2013

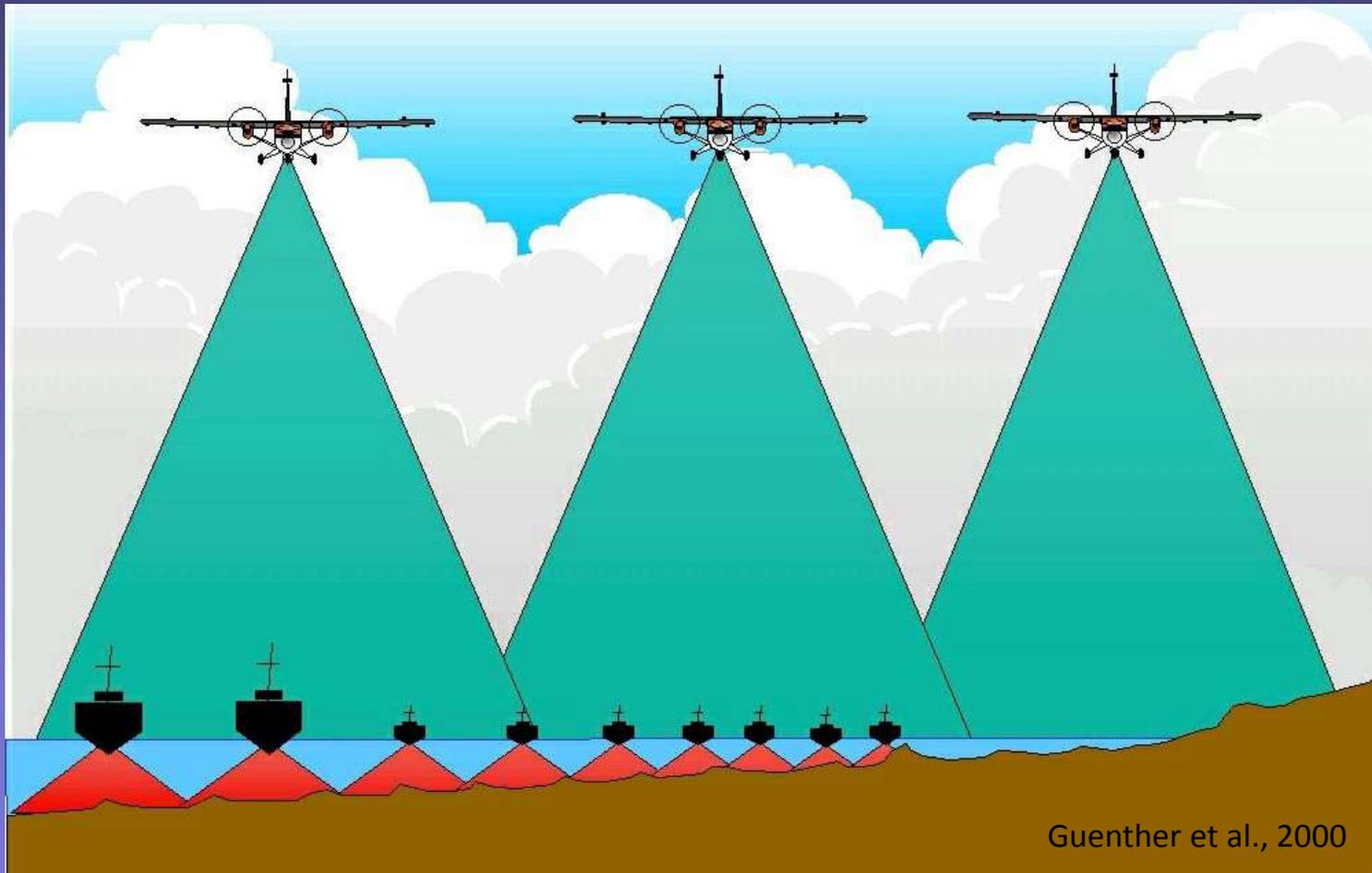


# Multibeam and Coastal LiDAR at Empire Spit/Tokeland for Shoalwater Bay Flood and Coastal Storm Damage Reduction Project

9-16 Sept 2014

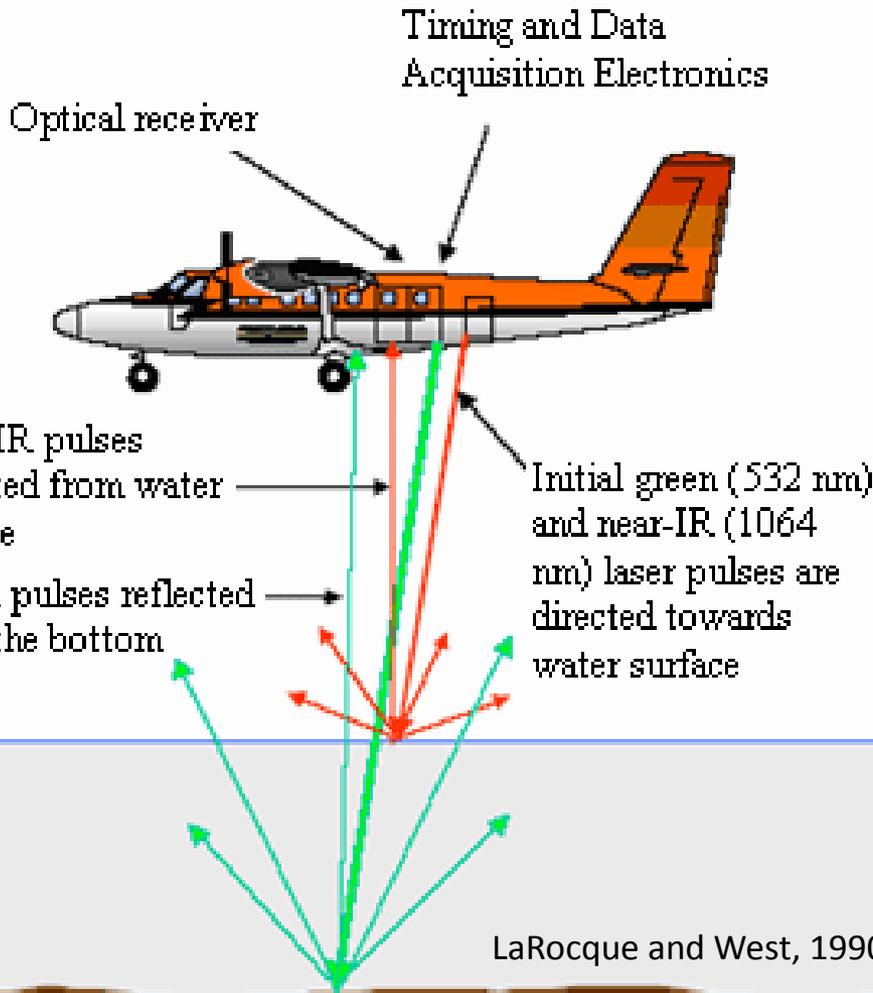


# Topobathy LiDAR



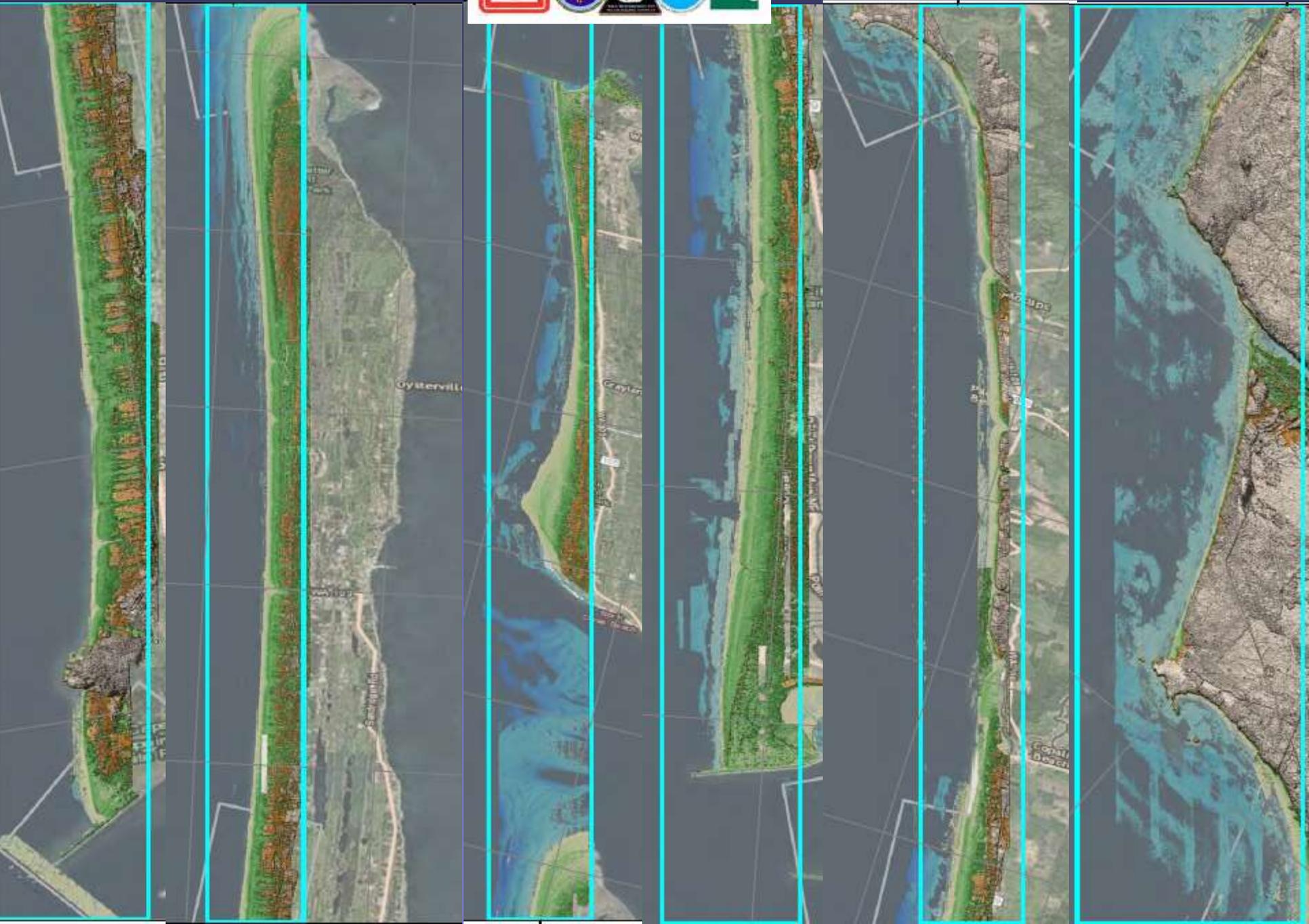
# Topobathy LiDAR

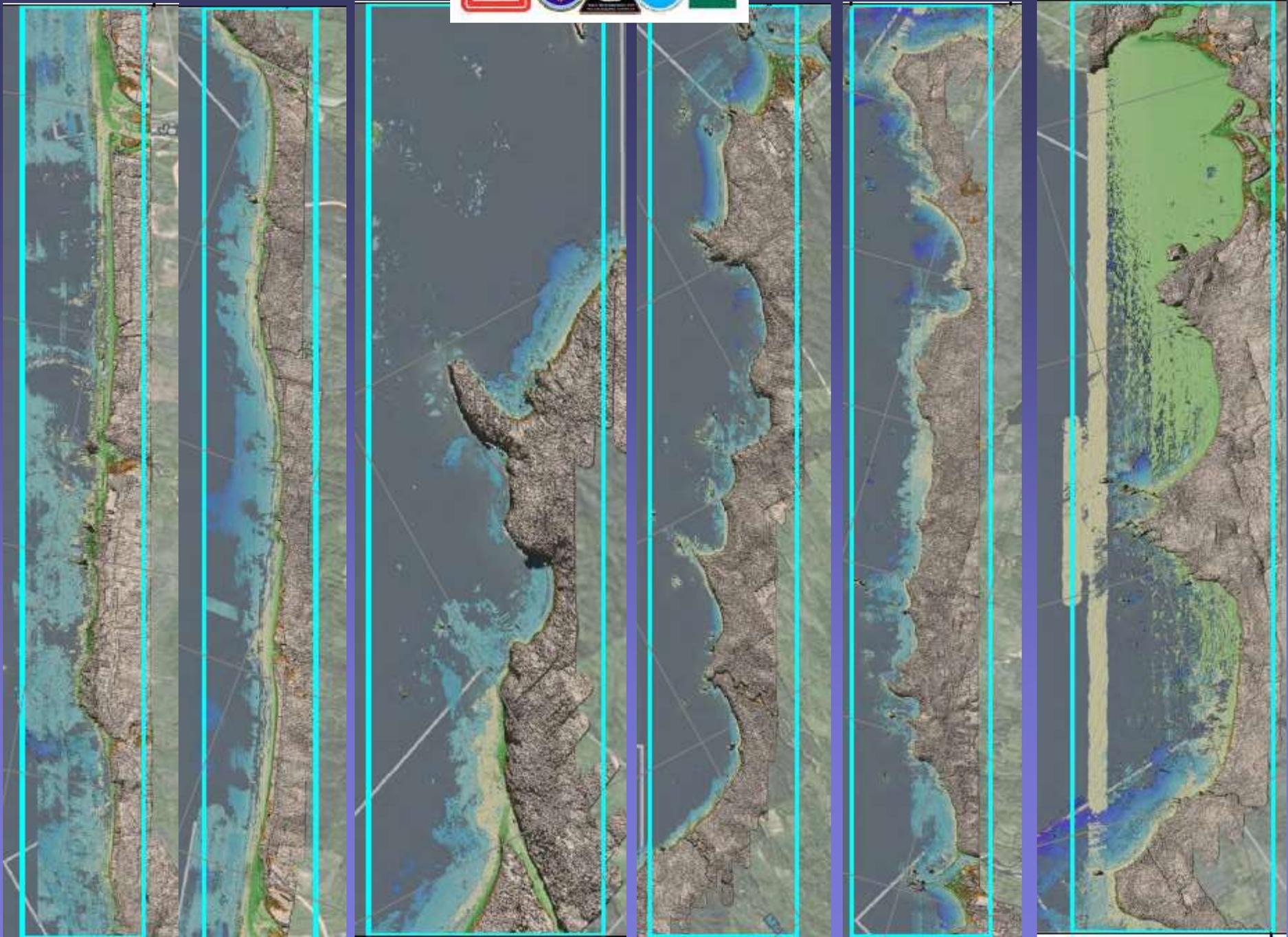
Offers efficient surveys of nearshore bathymetry where water clarity is sufficient.



Optech  
CZMIL







# Conclusions

- The coastal zone is dynamic and changes over a range of time and space scales.
- Nearshore bathymetry data is very challenging to collect.
- Determining coastal change requires repetitive surveys at sufficiently high resolution.
- A variety of complementary systems, platforms, and methods are needed to collect elevation, geologic, and benthic habitat data across the coastal zone.
- Both contemporary and historical topo-bathy data are needed for a wide range of applications.