

Port of Anchorage Deepening and Expansion

Numerical Modeling of Hydrodynamics and Sedimentation

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(and host of others)

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Alaska District

US Army Corps of Engineers
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Physical Setting & Issues



Physical Setting



Image IBCAO

Image © 2009 TerraMetrics

c2009

Google

Data SIO, NOAA, U.S. Navy, NGA, GEBCO

62°49'37.63"N 148°49'52.26"W

Eye alt 2355.39 km

Physical Setting

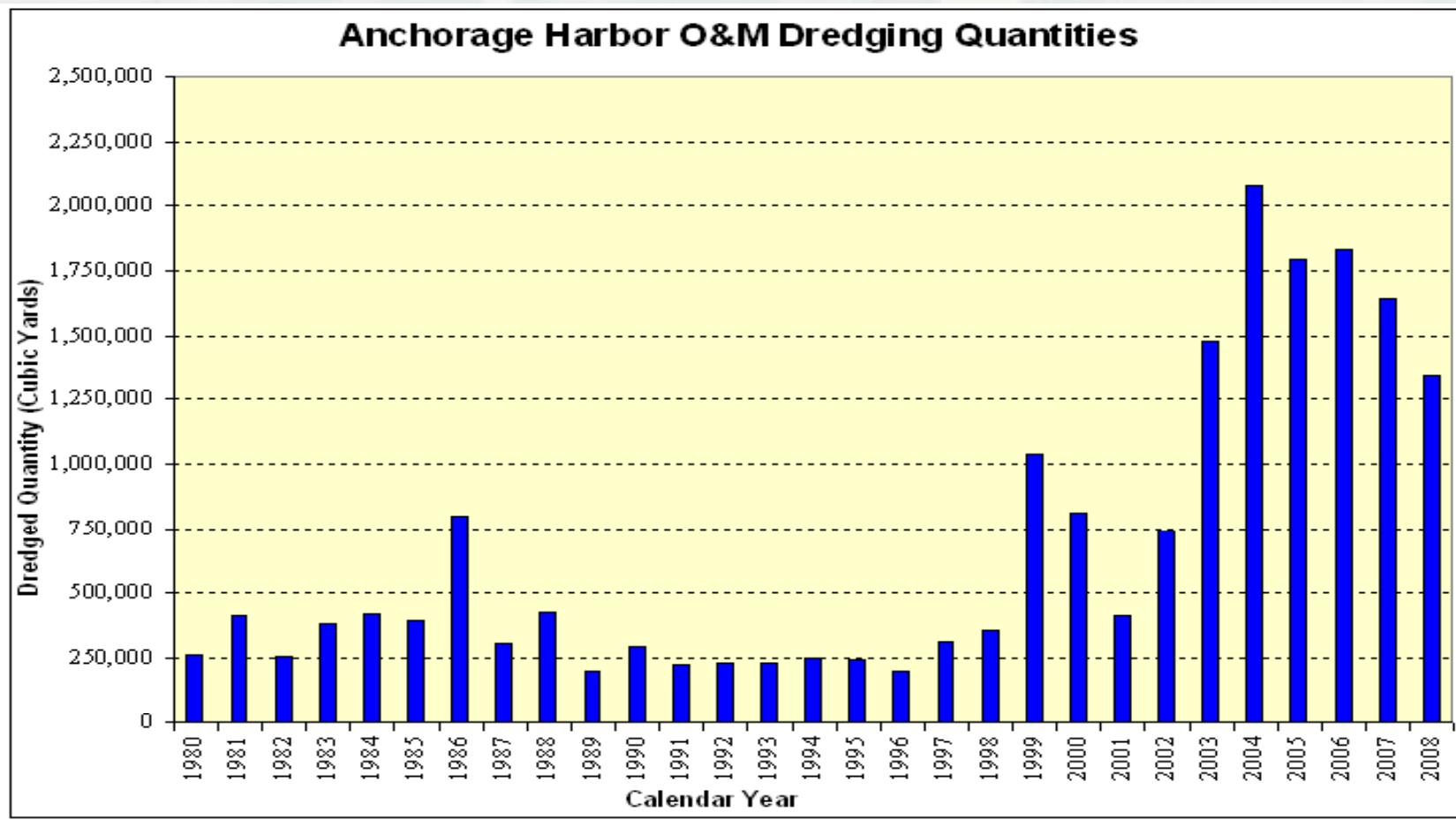


Physical Setting at POA

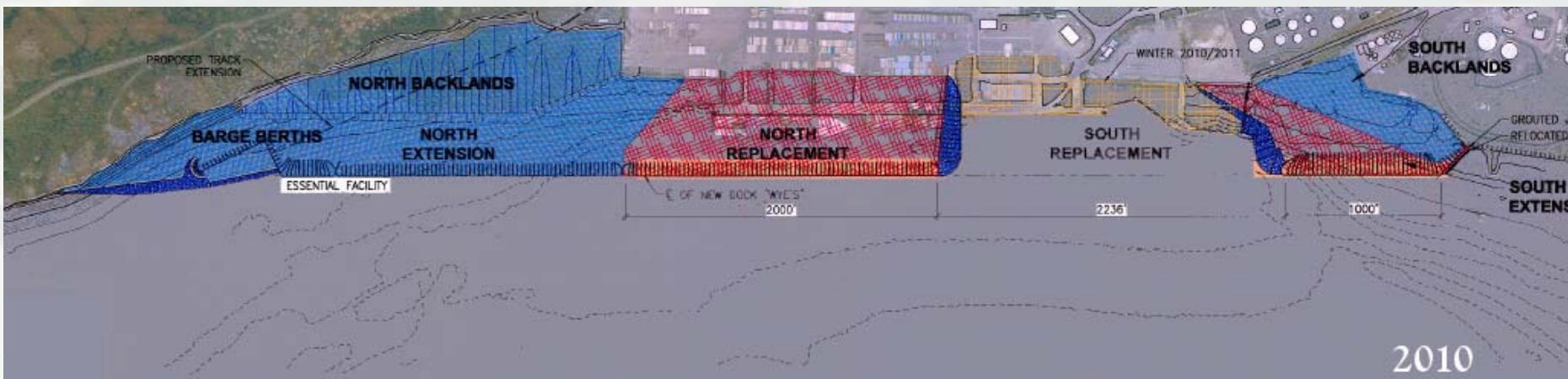
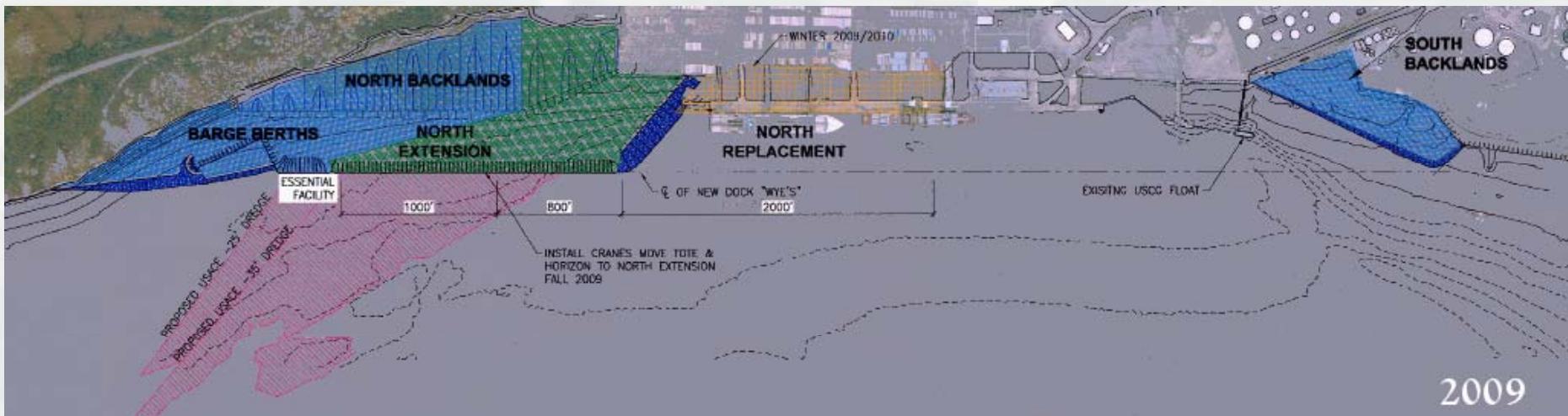
- Tide Range
 - ▶ 9 m mean, 12 m Spring
- Currents
 - ▶ Max: 1 m/s
 - ▶ ~0.10-0.20 m/s eddy
 - ▶ 70-80% flood-directed
- Suspended Sediment
 - ▶ ~ 2000 mg/L (summer)
 - ▶ ~500 mg/L (winter)
 - ▶ Predominantly silt



Dredging History

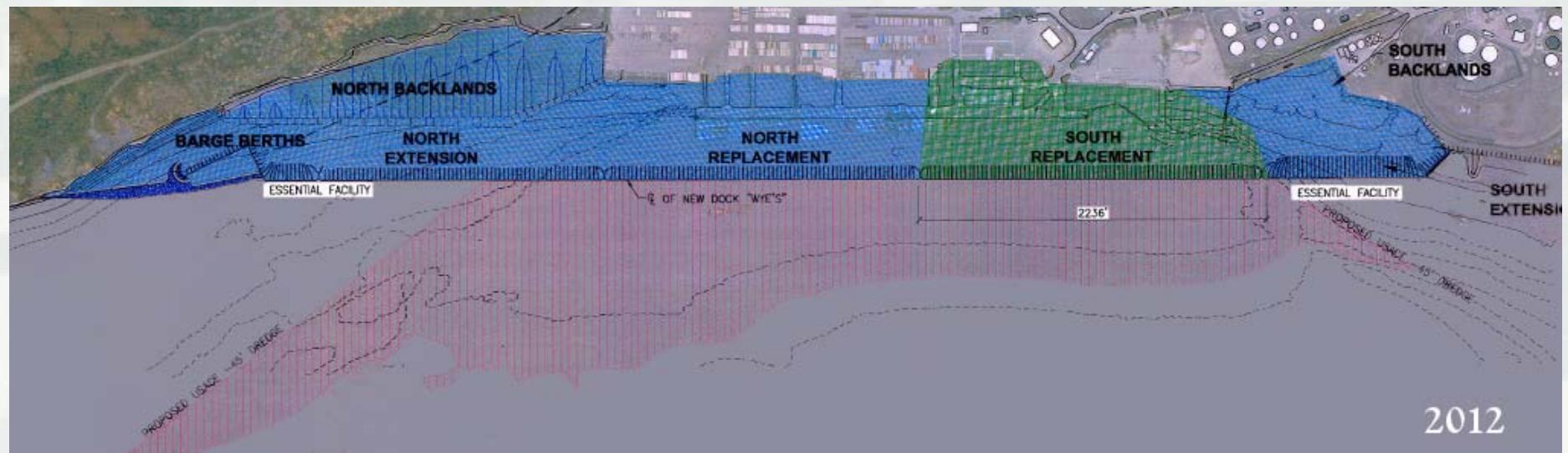
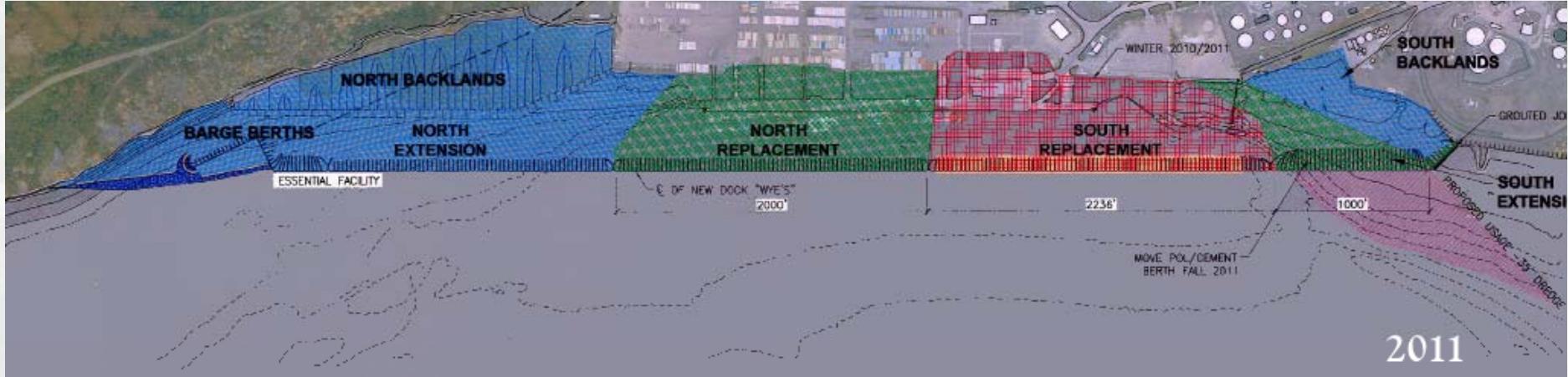


Port Expansion and Deepening



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Port Expansion and Deepening

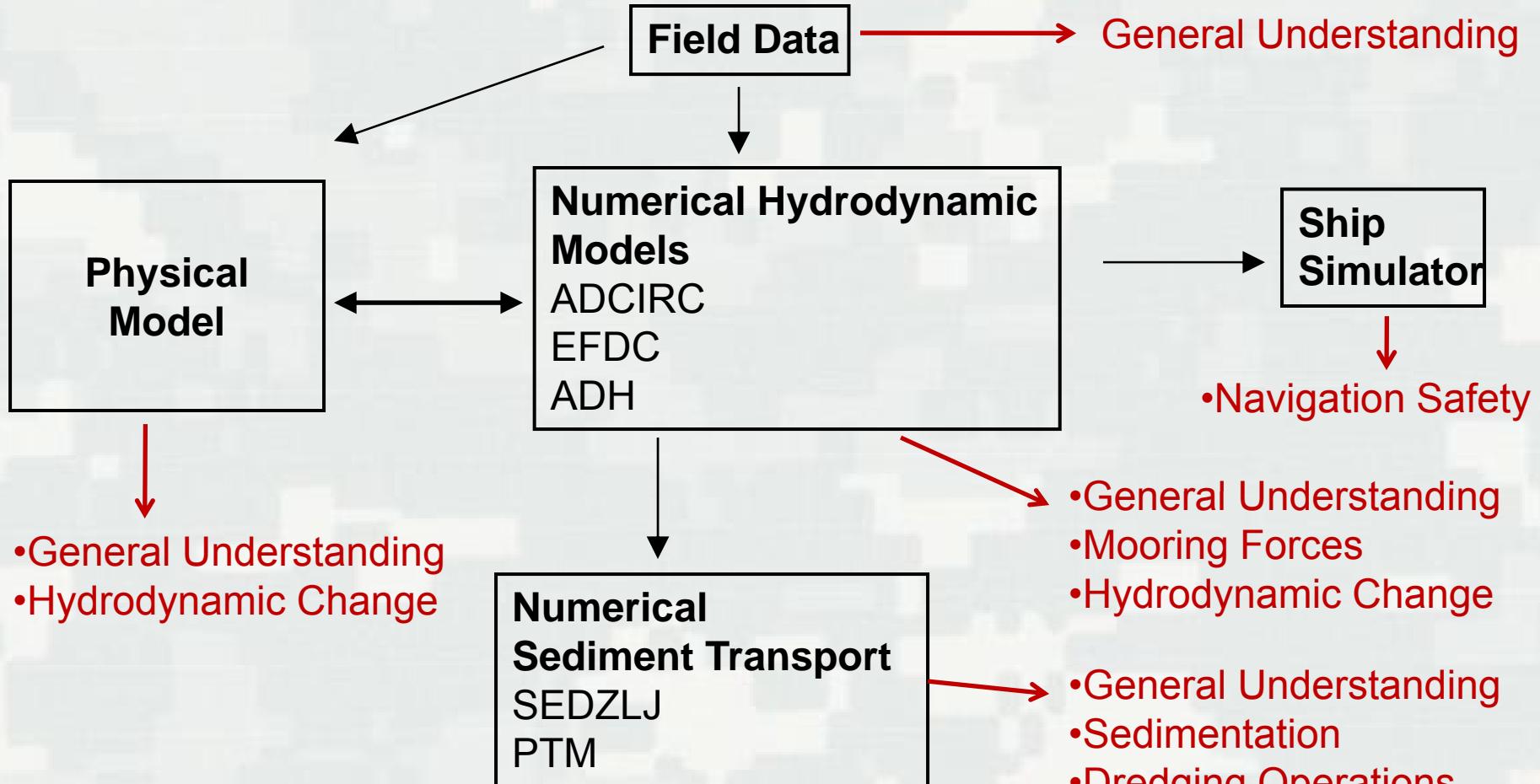


Issues

- How will expanded port influence hydrodynamics?
 - ▶ Navigation safety
 - ▶ Mooring forces
- Projected Dredging Quantities
 - ▶ During phased construction
 - ▶ Following expansion and deepening
- Evaluate dredging practices & dredged material management



Study Components



Field Experiments

- Hydrodynamics
 - ▶ ADCP transects and anchor stations
 - ▶ Tidal exchange
- Sediment Transport
 - ▶ Settling velocity
 - ▶ Concentration
 - ▶ Cohesive sediment erosion
 - ▶ Size distributions

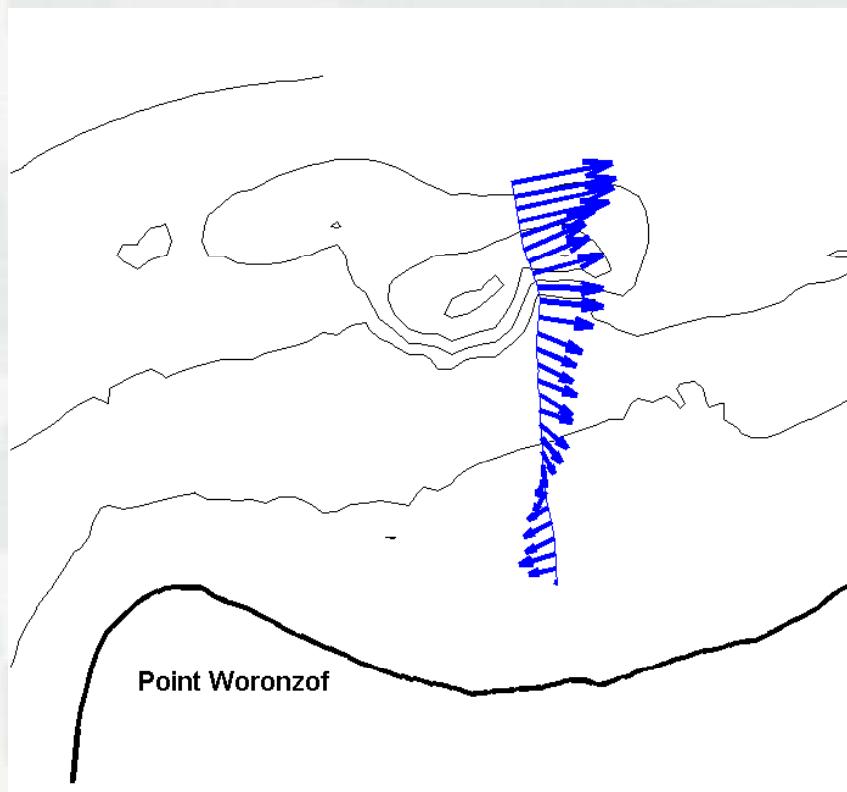


ADCP Transects

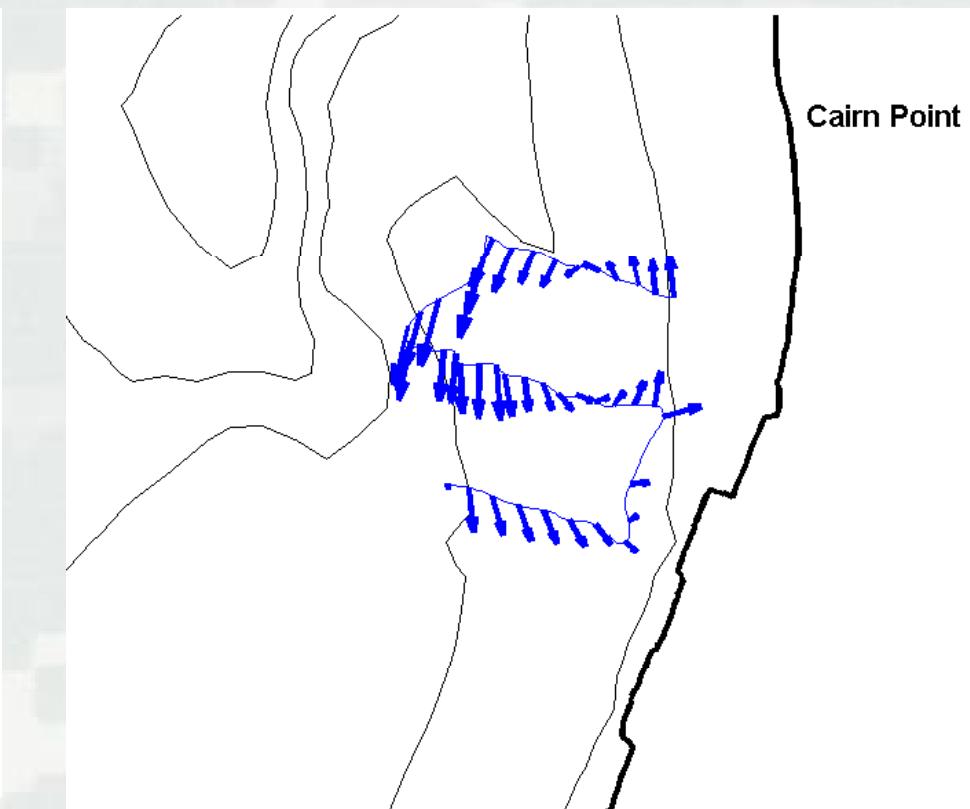


Eddies

Point Woronzof -- Flood



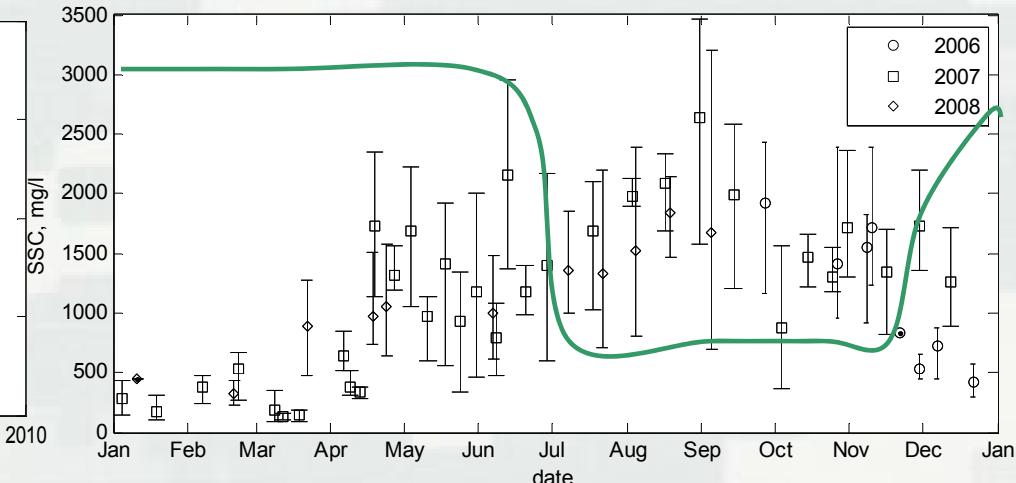
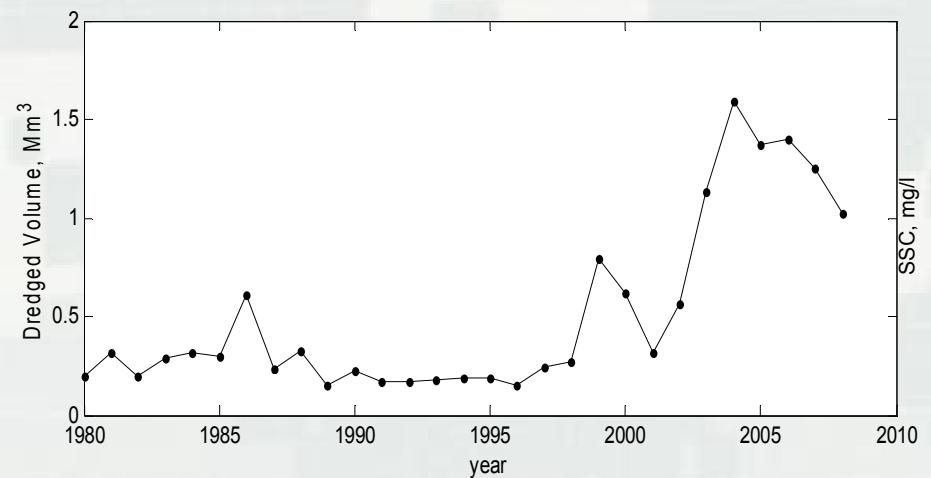
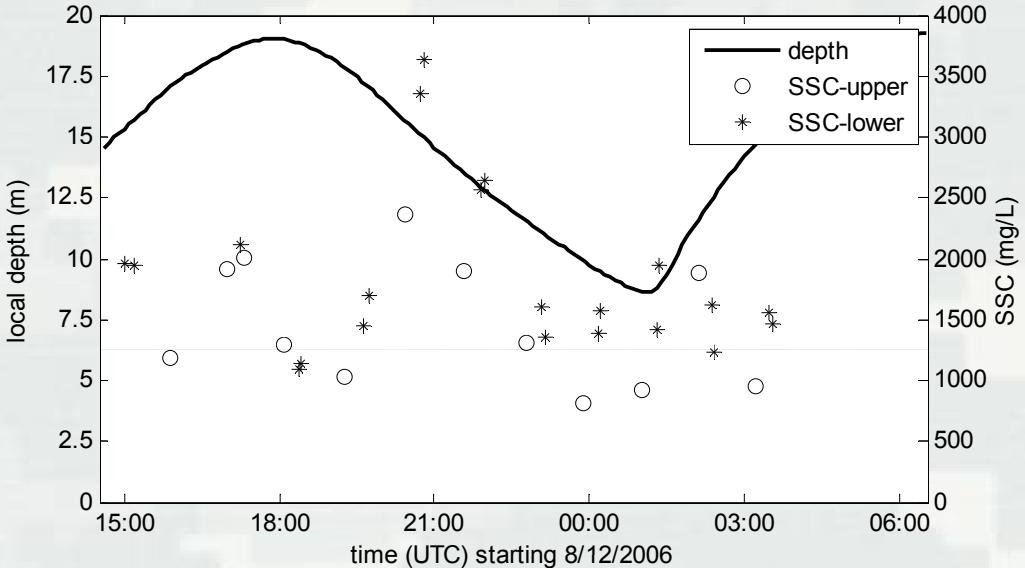
Cairn Point – Ebb



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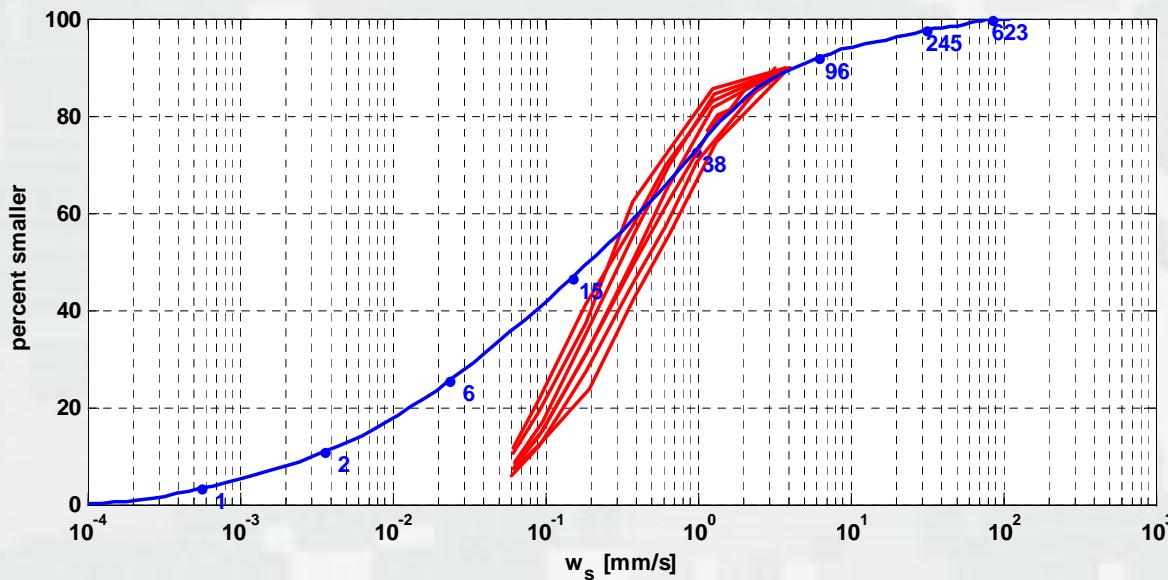
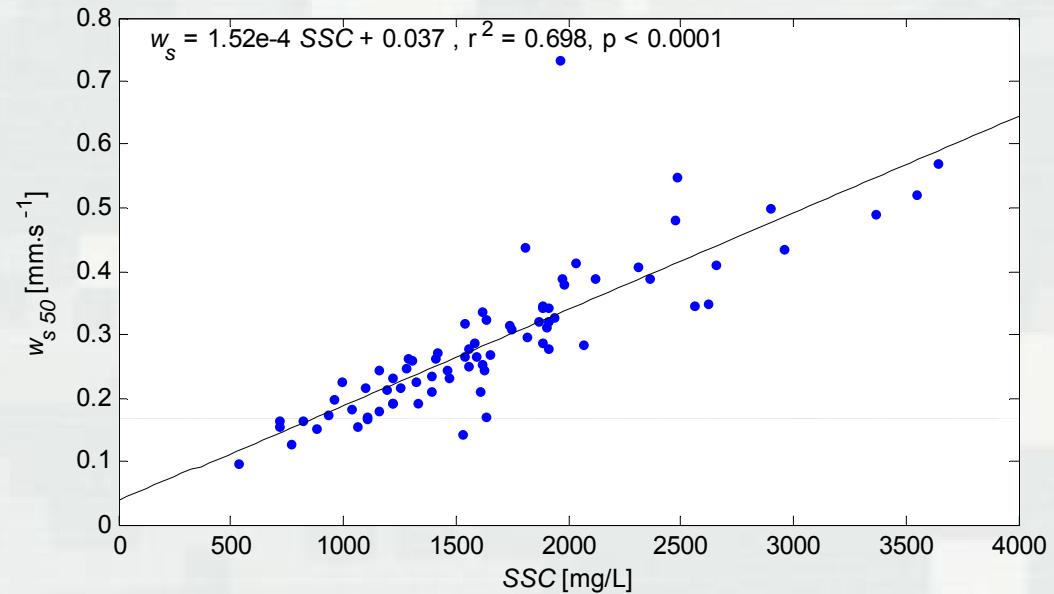
Suspended Sediment Concentration

- Variations evident at multiple time scales
 - ▶ Tidal
 - ▶ Seasonal
 - ▶ Decadal



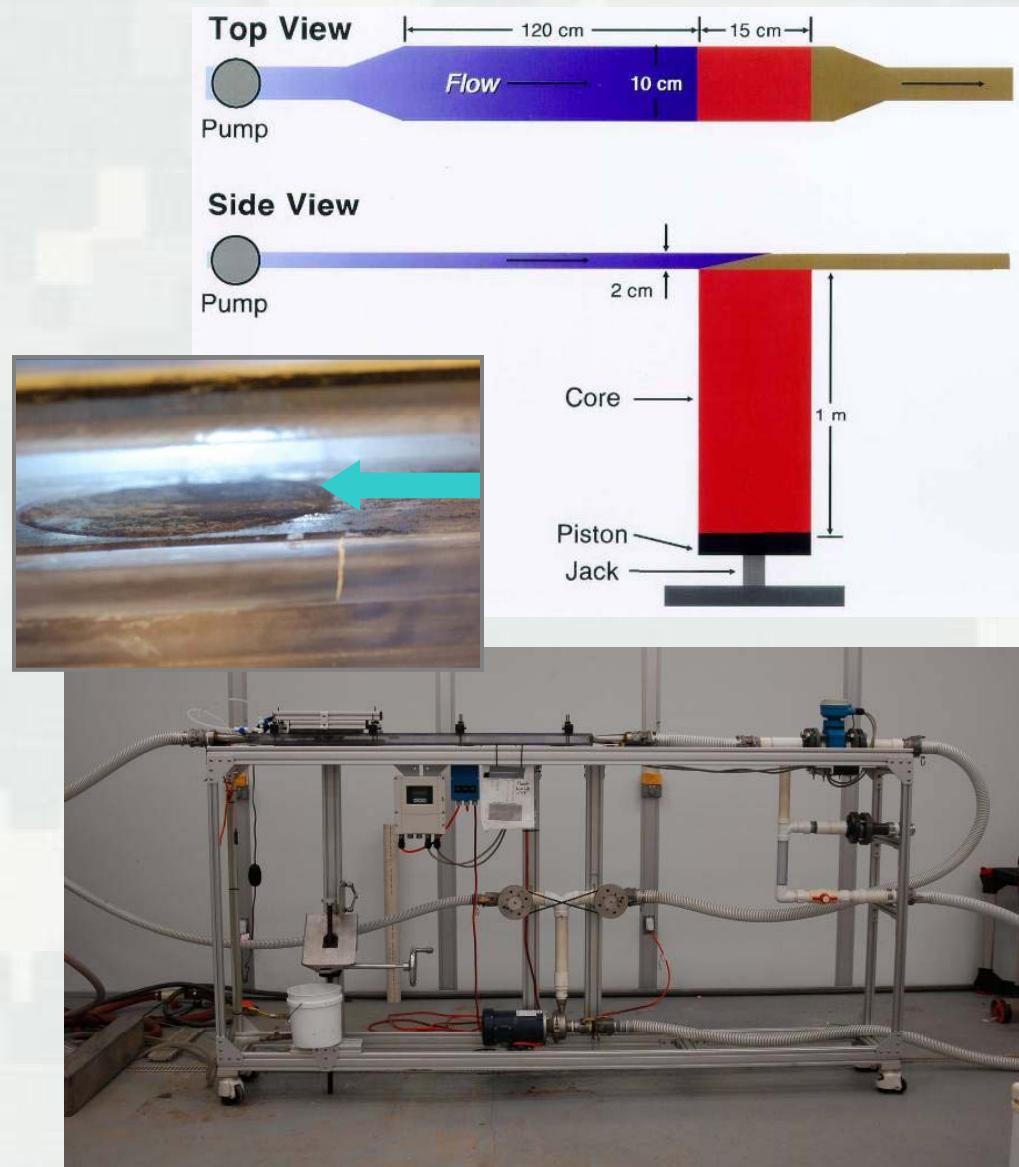
Settling Velocity

- 88 field pipette withdrawal experiments
- Flocculation / aggregation



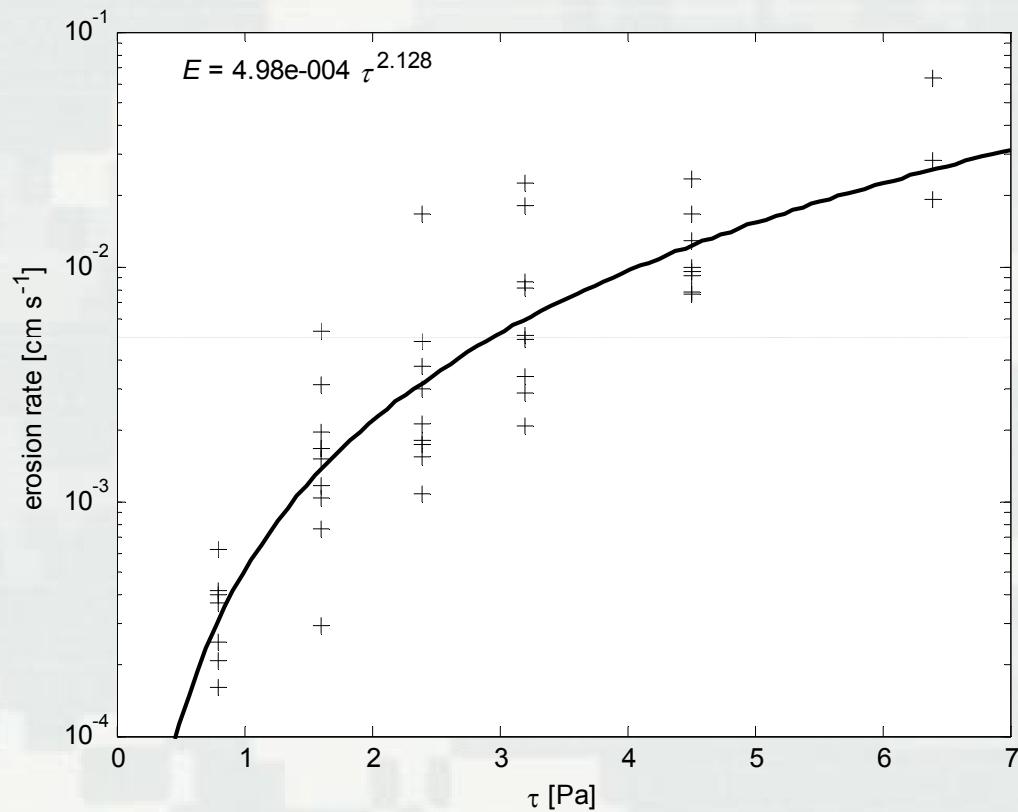
Cohesive Sediment Erosion

- Sedflume
- Samples taken from dredged basin and adjacent mudflats
- Sediment cores prepared in laboratory by slurring at gelling concentration
- Consolidation for 2-hr to 40 days



Cohesive Sediment Erosion

- Erosion not dependent on bed density.
- Weak cohesion
- Data representative of recently deposited sediment.



Numerical Hydrodynamic Modeling

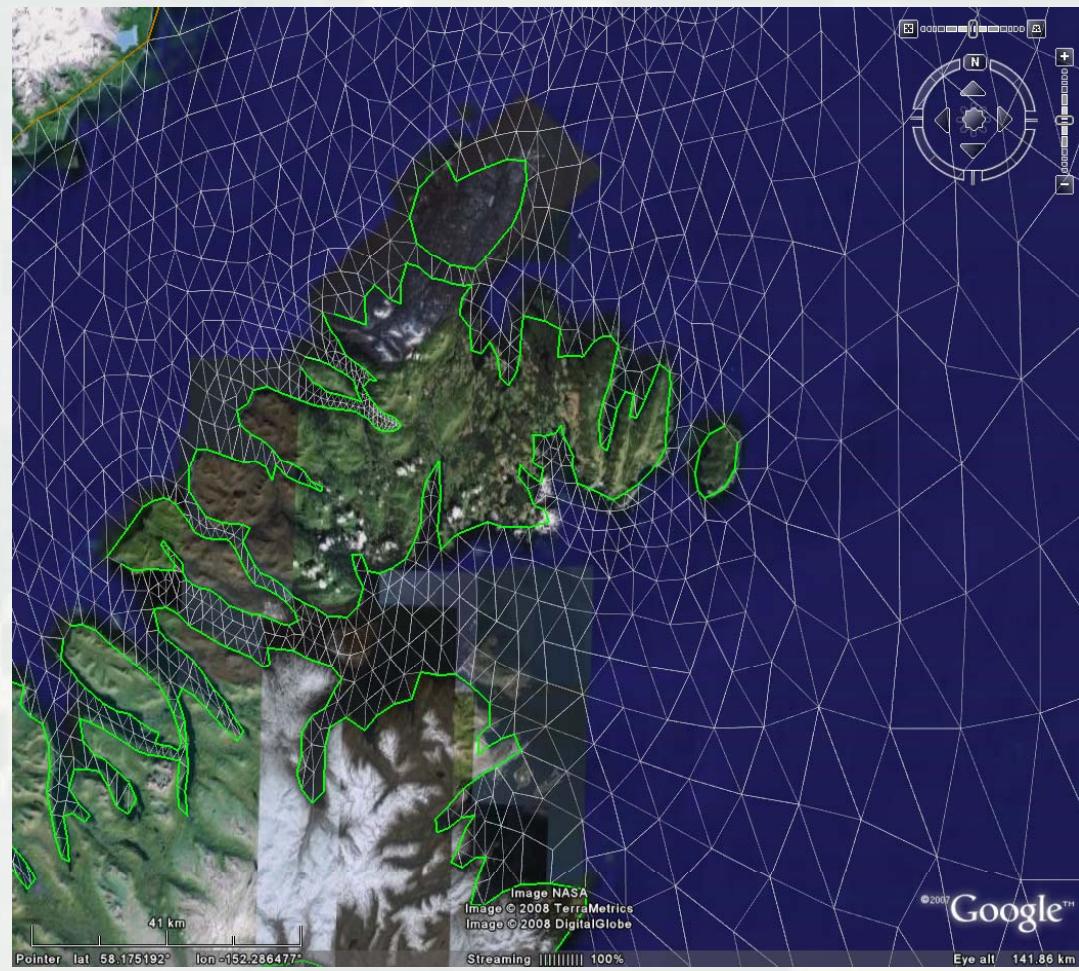


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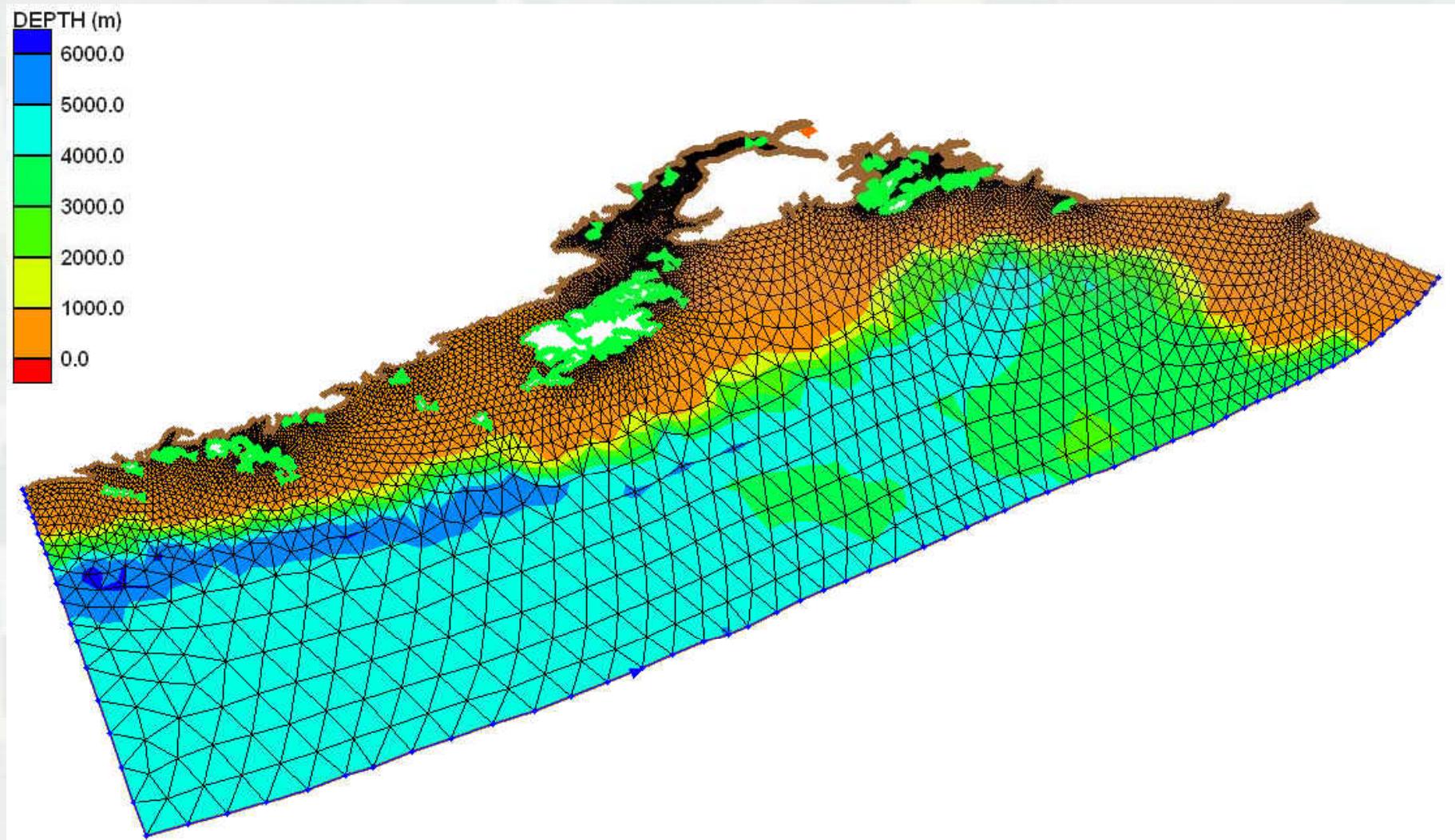
ADCIRC

ADvanced CIRCulation Model for Ocean, Coastal, and Estuarine Waters

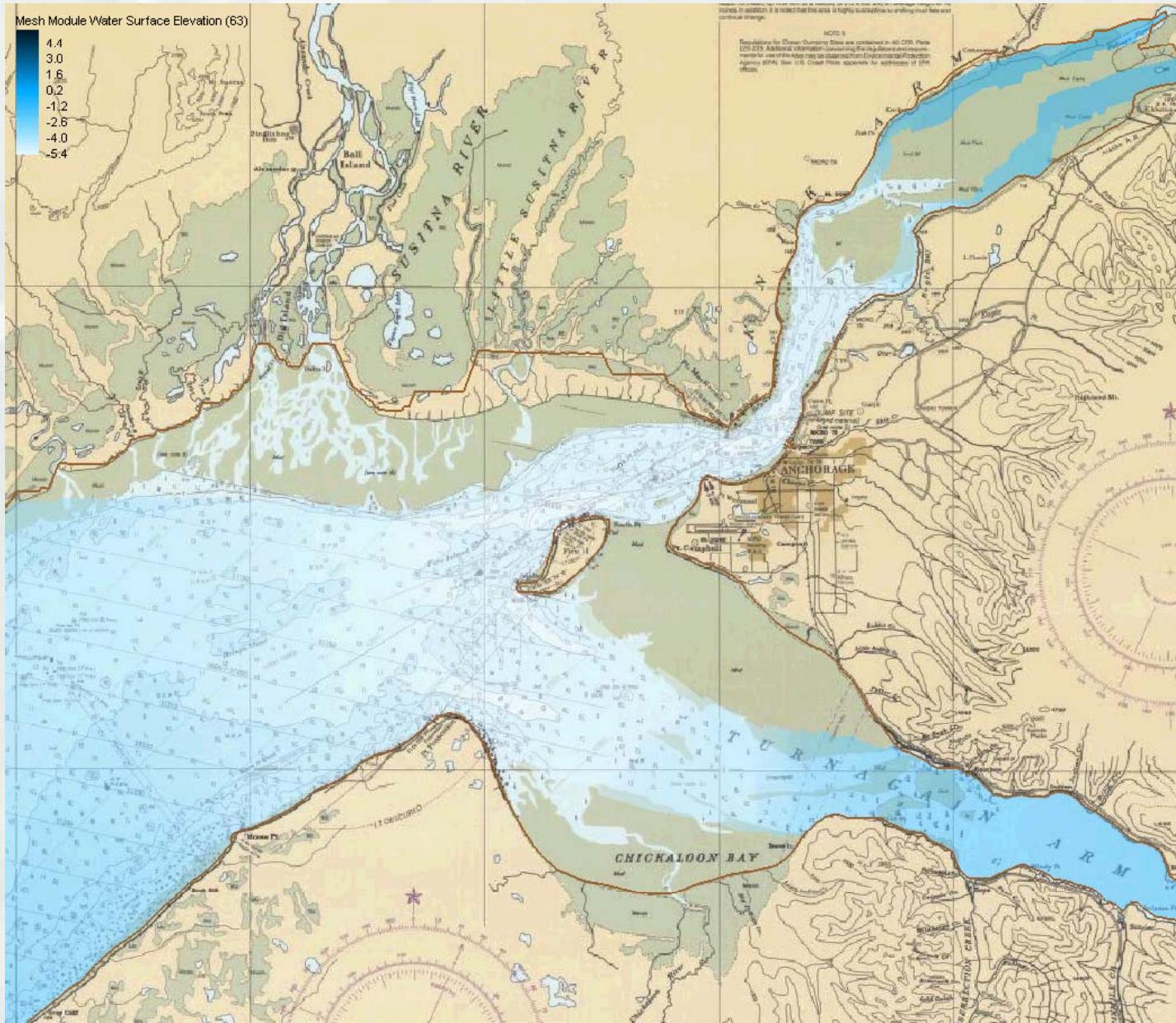
- Depth-averaged,
Unstructured, Finite
Element
- Forcing
 - ▶ Tide
 - ▶ Wind
 - ▶ River
- Other factors
 - ▶ Bathymetry
 - ▶ Friction
 - ▶ Shear/eddy formation
 - ▶ Coriolis acceleration
- Output
 - ▶ Tides and currents



ADCIRC Cook Inlet Mesh

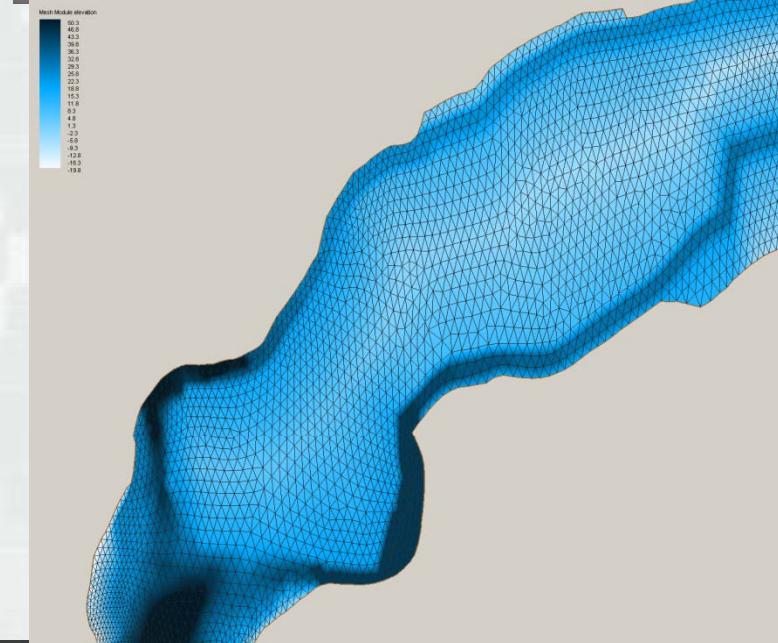


Tidal Simulation

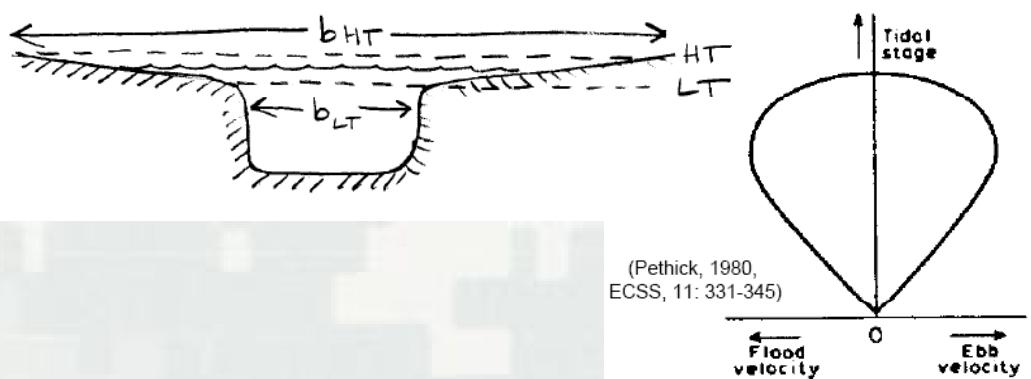
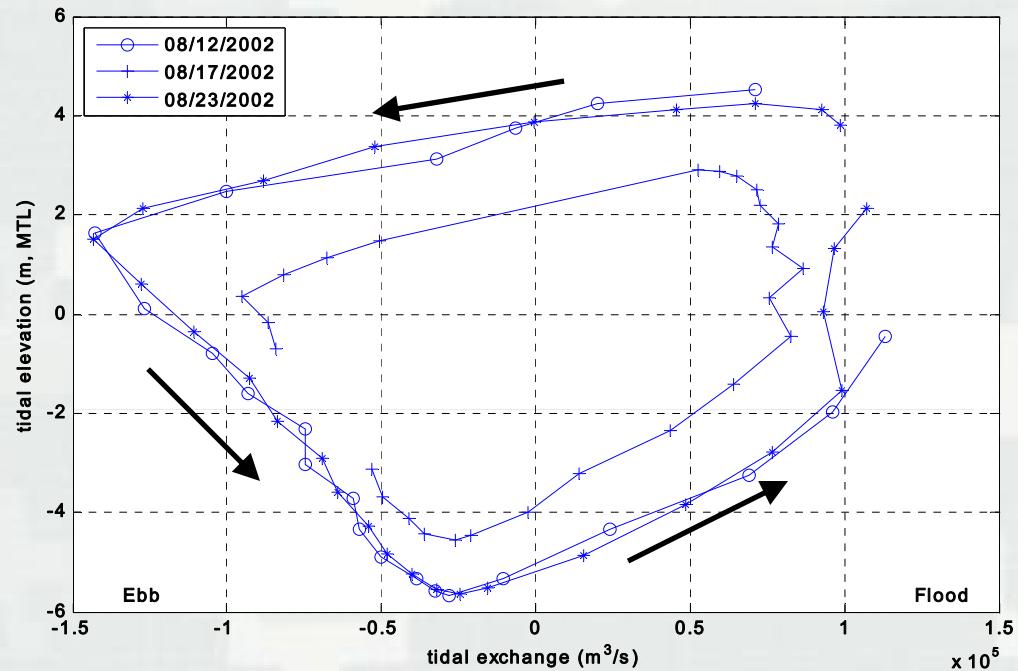


Intertidal Flooding/Drying

- Sparse/dated bathymetry
- Dynamic
- Strongly influences hydrodynamics in Knik Arm
- Approach:
 - ▶ Idealize tide flat geometry based on:
 - Alaska District survey data
 - Aerial photos
 - Navigation charts
 - Measured water exchange

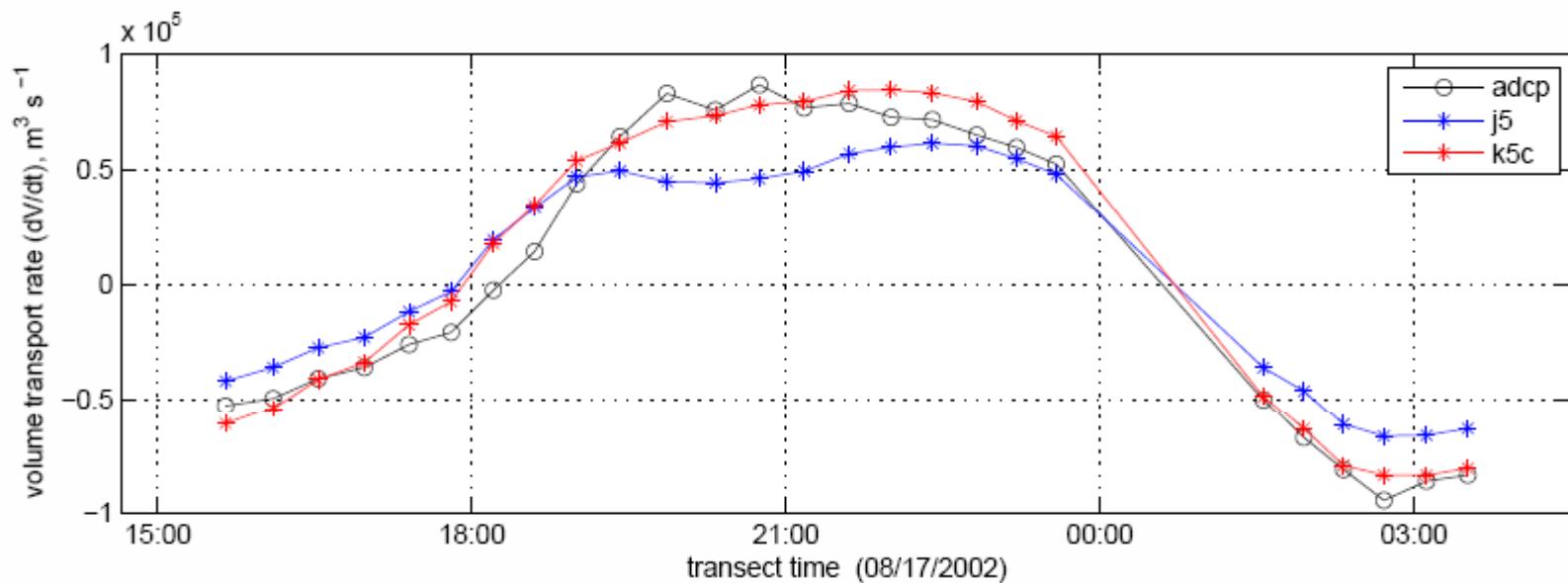
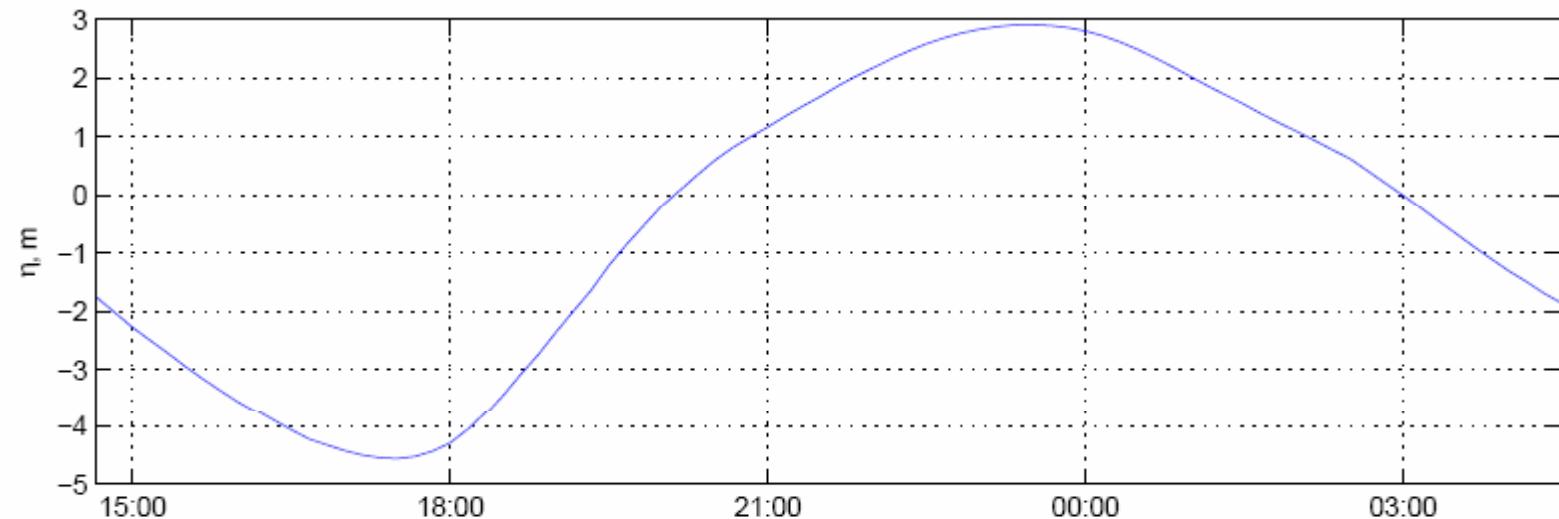


Tidal Exchange

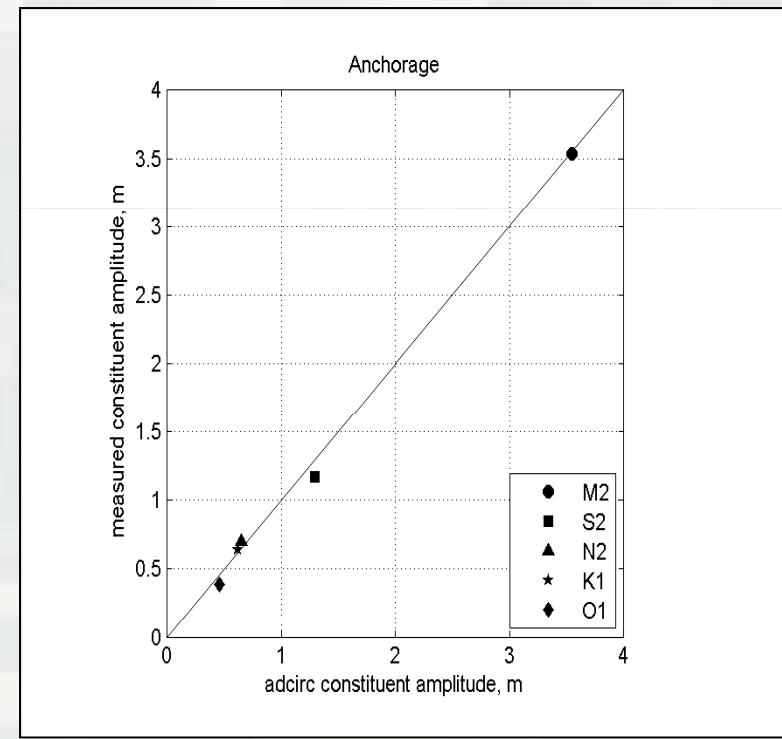
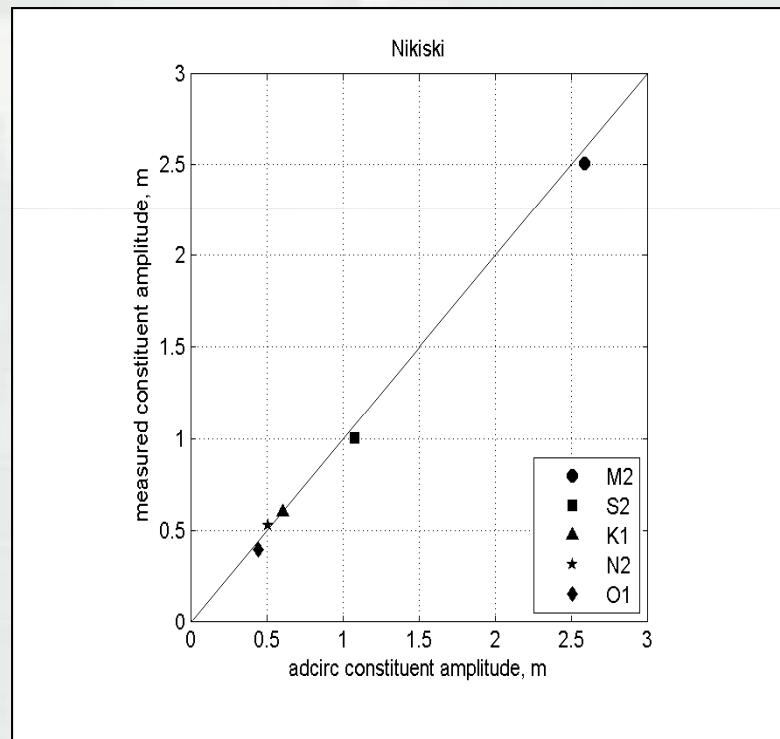


Measured and Predicted Flood Volume Flux

TRANSECT: T4 FILE: raw0817.mat



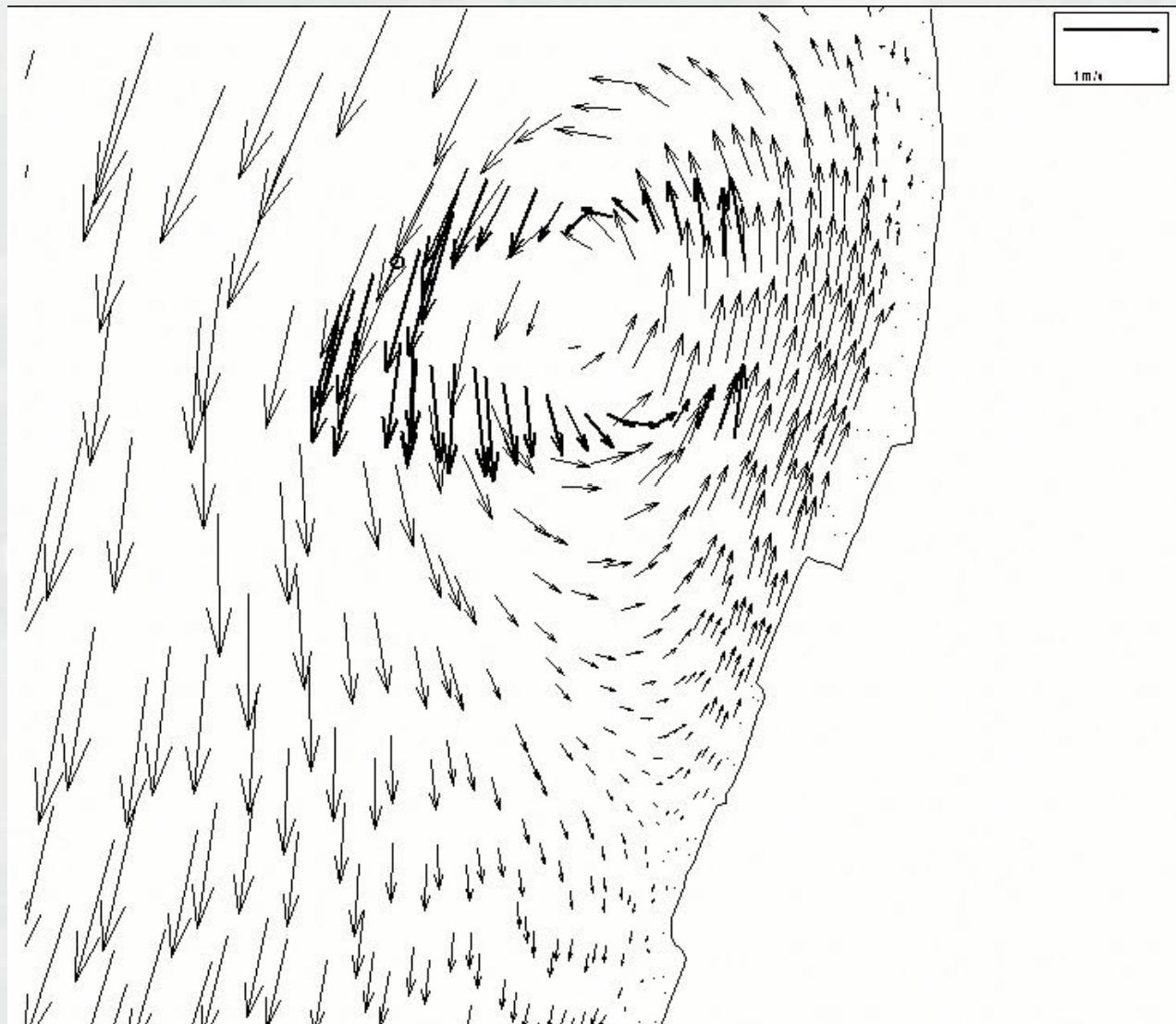
2006 Harmonic Constituent Comparison Nikiski and Anchorage



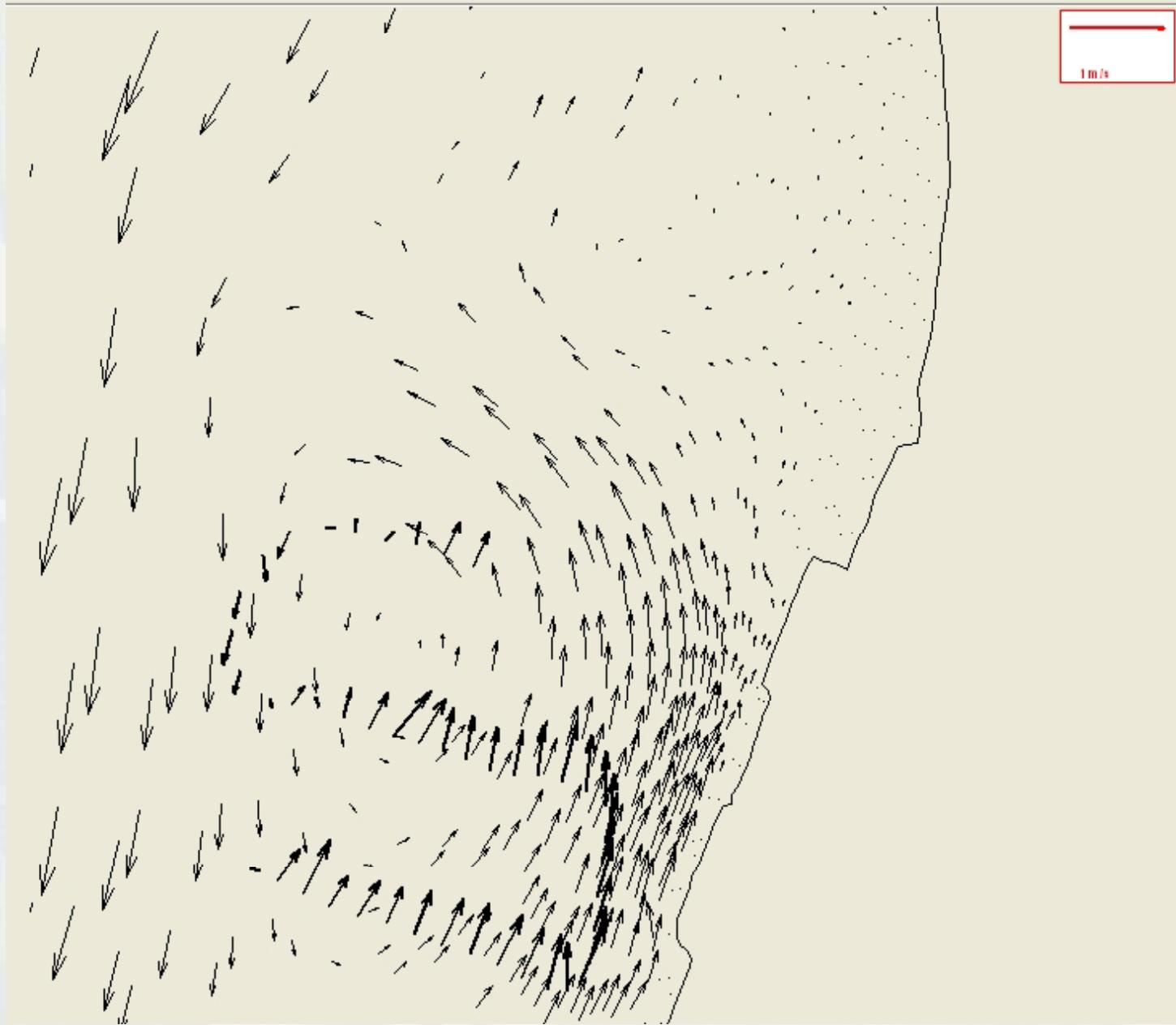
2006 Cairn Point Ebb Gyre Location



Model - NOAA 2006 Data Comparison of the Cairn Point Gyre



Cairn Point Gyre + 3Hr



Cairn Point Gyre + 5Hr

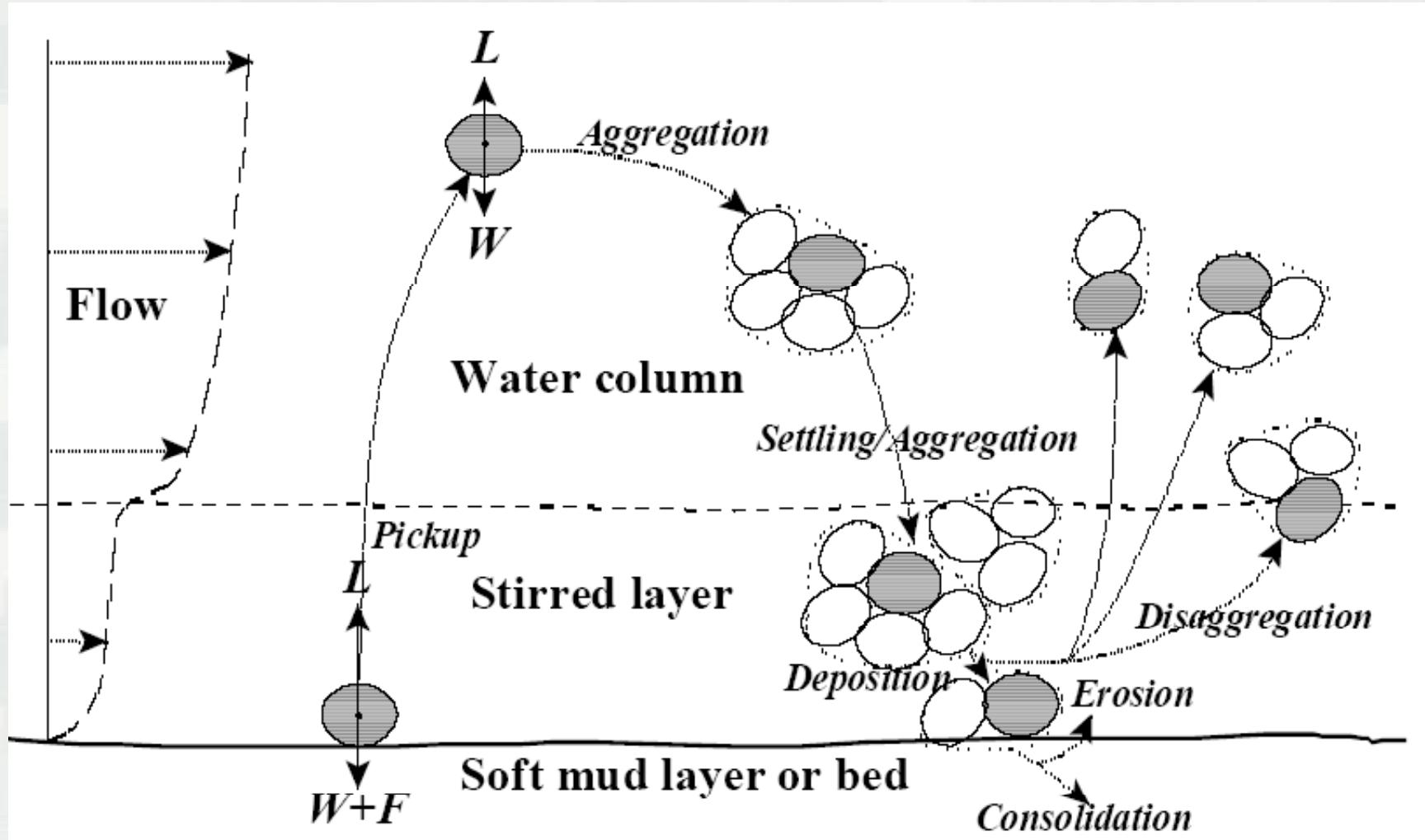


Numerical Sedimentation Modeling



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SEDZLJ Sediment Dynamics



McAnally (1999)

A satellite map showing a coastal region. A large, irregular blue polygon is overlaid on the landmass, which is covered in a grid pattern. The polygon covers approximately one-third of the visible land area. The surrounding terrain includes green fields, brownish areas, and a winding river. The water body to the right has a white stippled area. A scale bar in the bottom left corner indicates a distance of 26.7 mi. The map includes coordinate information at the bottom: 61°06'53.10" N, 150°22'42.70" W. A copyright notice for TerraMetrics and DigitalGlobe from 2009 is in the center. A Google logo with a 2009 copyright is in the bottom right. A north arrow is in the top right corner.

N

26.7 mi

Image © 2009 TerraMetrics
Image © 2009 DigitalGlobe

Image IBCAO

61°06'53.10" N 150°22'42.70" W

2009 Google

Eye alt 91.53 m

N

Image U.S. Geological Survey
Image © 2009 DigitalGlobe

2.16 mi

Image Municipality of Anchorage

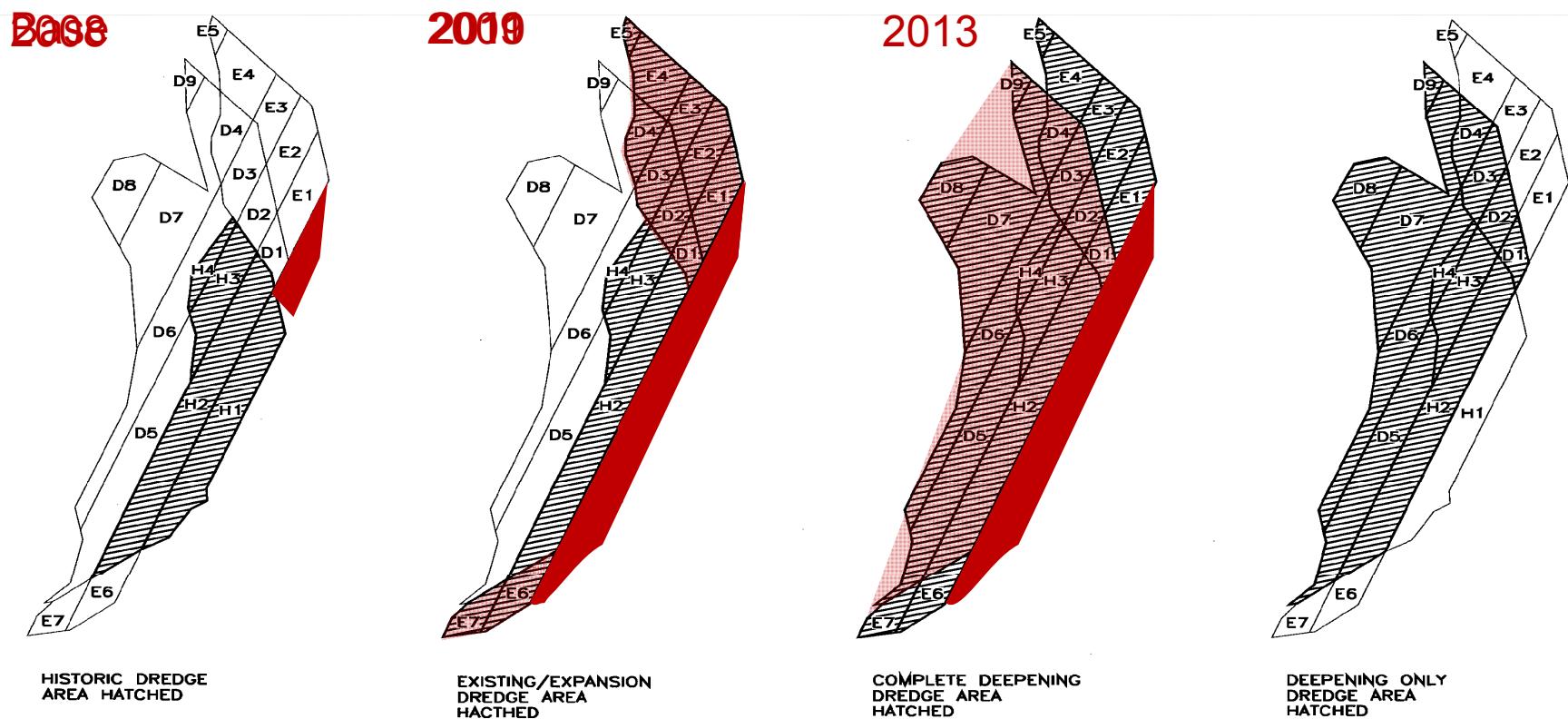
61°13'47.69" N 149°54'17.64" W elev 0 ft

2009 Google

Eye alt 39358 ft

Sedimentation Increase (compared to pre-expansion dredge basin)

Sedimentation Ratio for each Simulated Port Configuration							
Region	Area Ratio	Base	2008	2009	2010	2011	2013
Historic	1.0	1.00	1.03	1.03	0.71	0.35	0.36
Existing + Expansion	1.91	1.48	1.51	1.61	1.28	0.84	0.85
Complete Deepen	3.18	2.20	2.21	2.27	1.87	1.38	1.38
Deepen Only	2.57	1.89	1.90	1.87	1.48	1.04	1.04



Conclusions

- Port expansion and deepening results in approximately 40% increase in dredging.
- During phased expansion, dredging requirements may increase by up to 60% above historical levels.

