Port of Anchorage Deepening and Expansion
Numerical Modeling of Hydrodynamics and Sedimentation

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(and host of others)

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US Army Corps of Engineers
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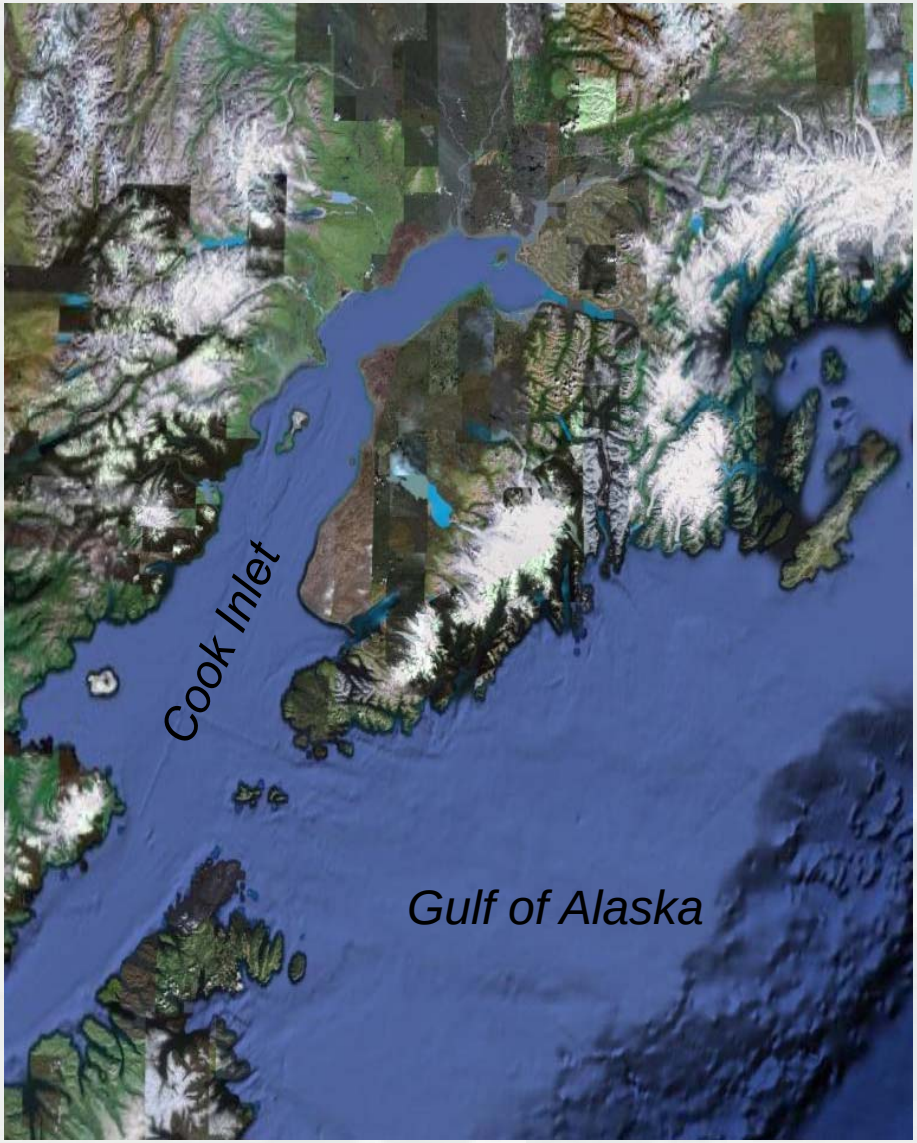
Physical Setting & Issues

Physical Setting

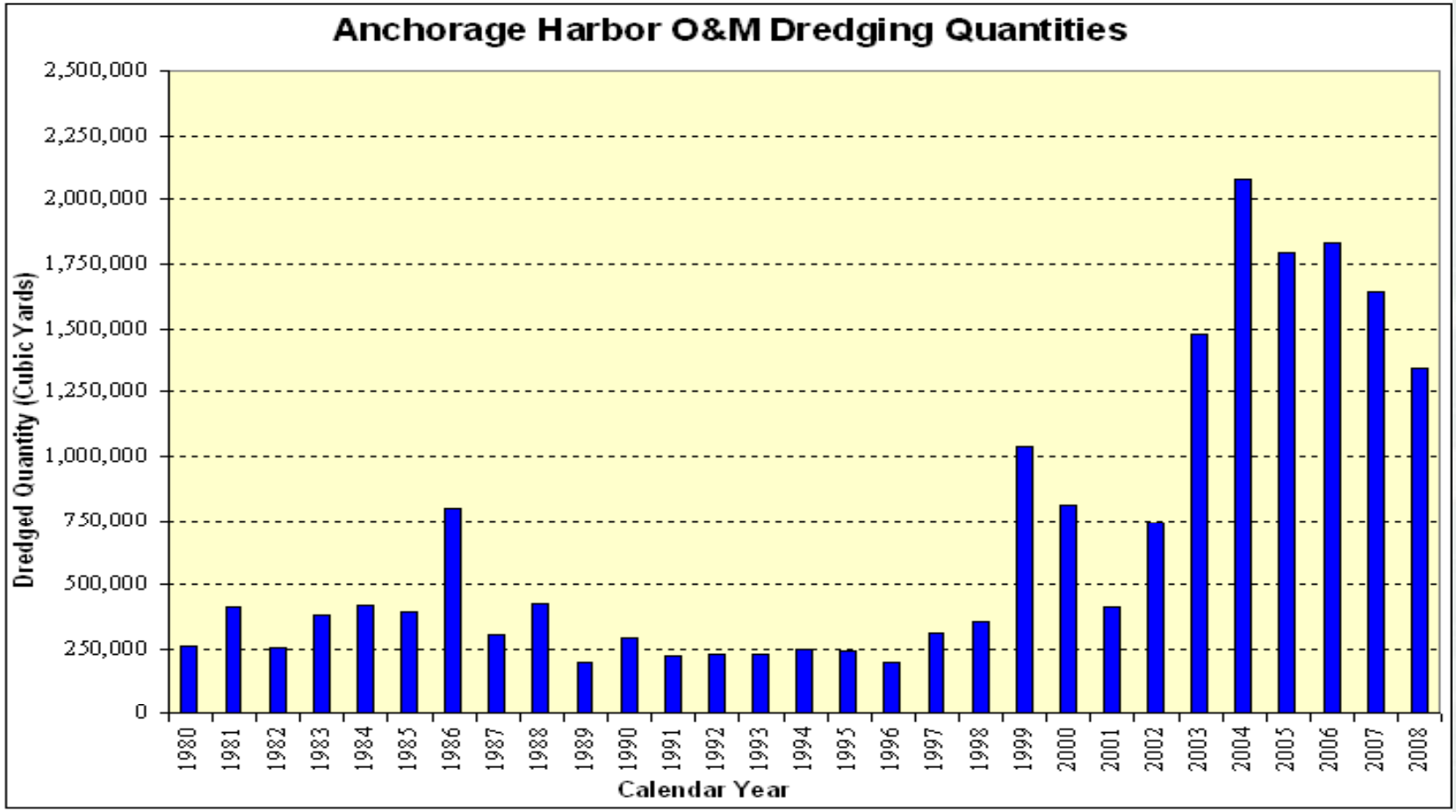
Physical Setting



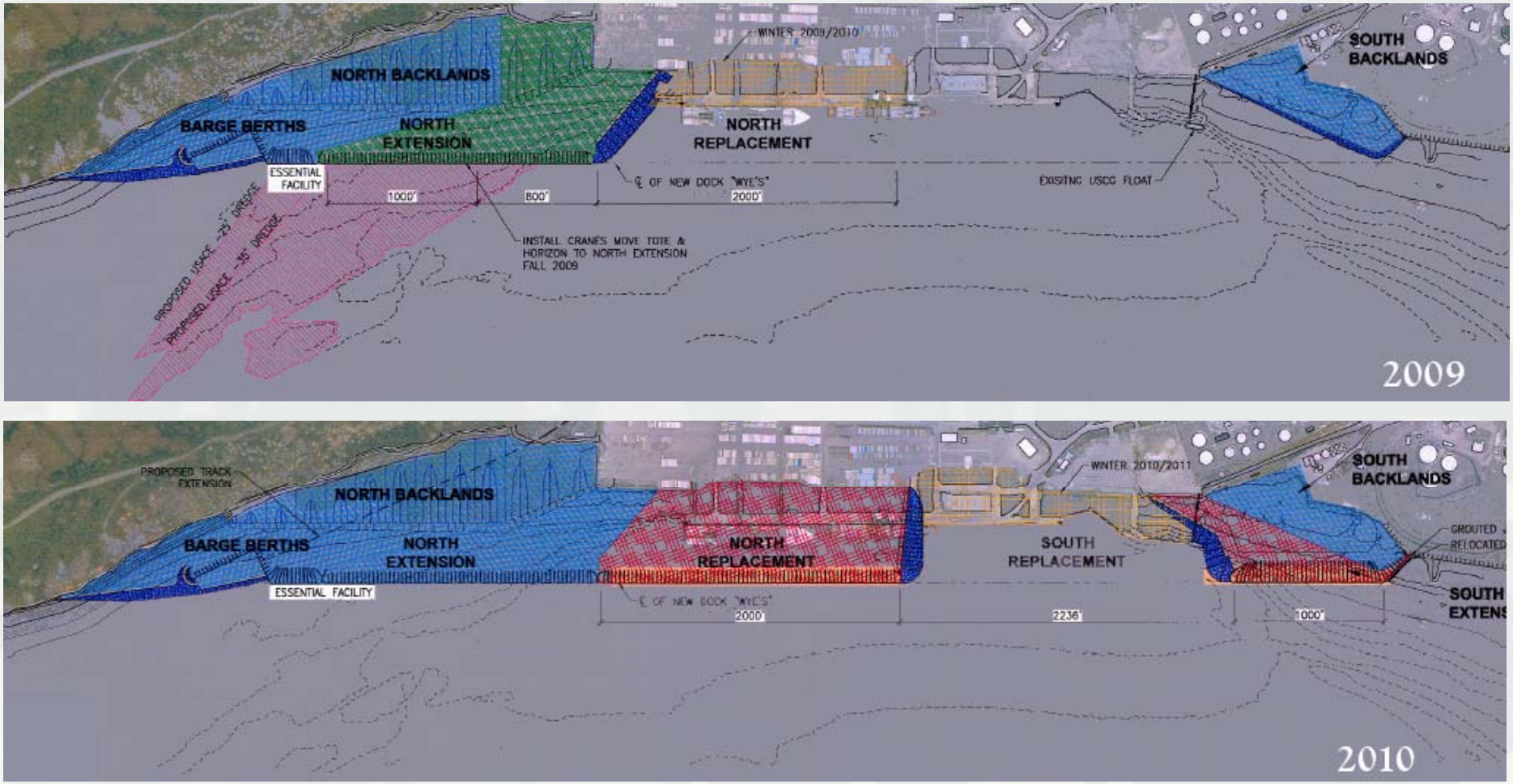
Physical Setting at POA

- 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

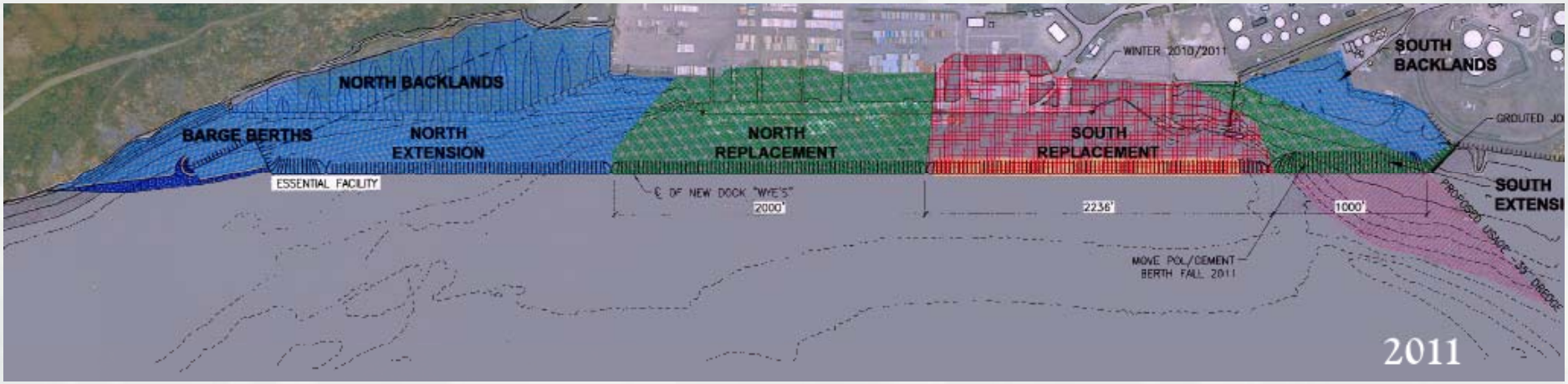
Dredging History

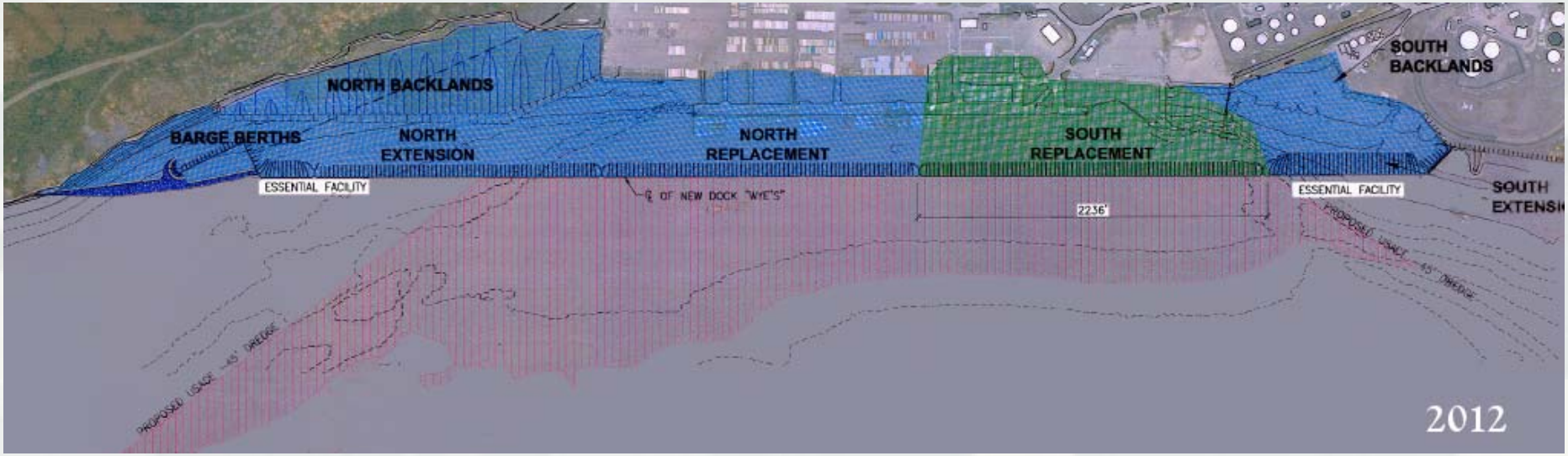


Port Expansion and Deepening



Port Expansion and Deepening

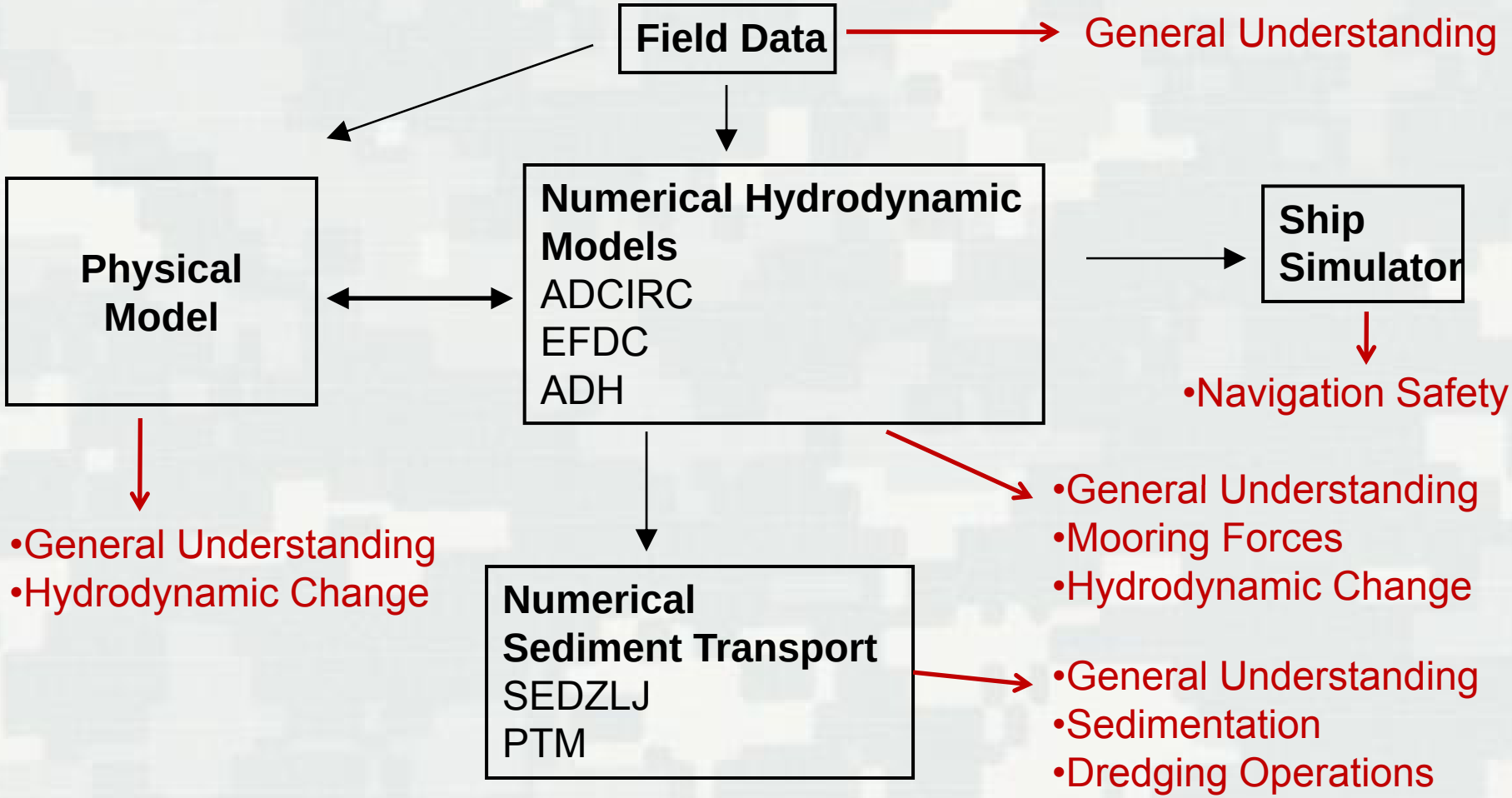




Issues

- 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



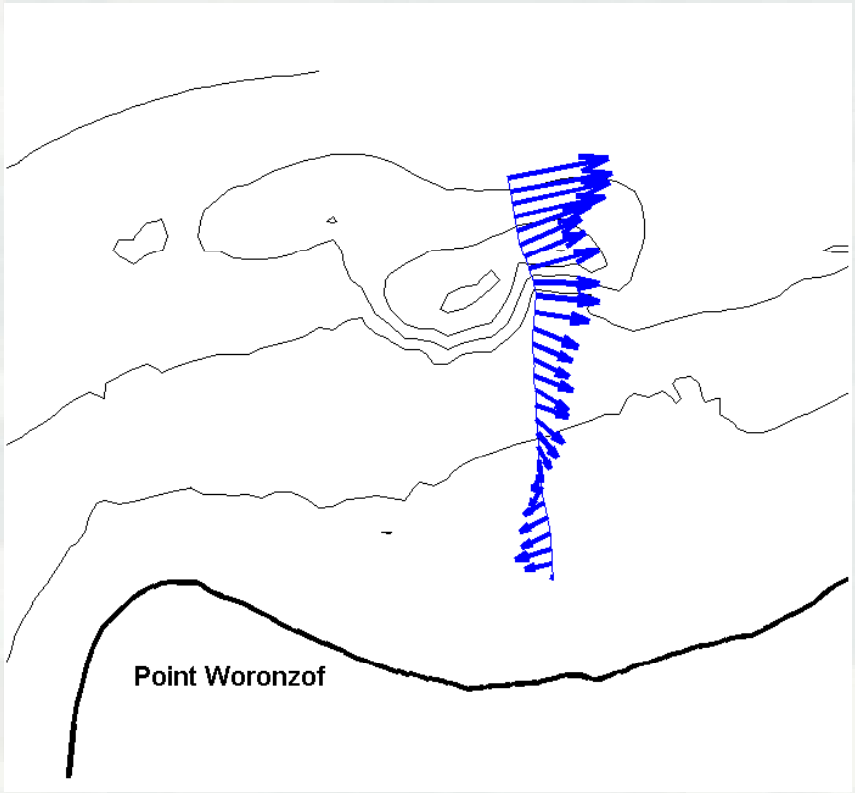
Field Experiments

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

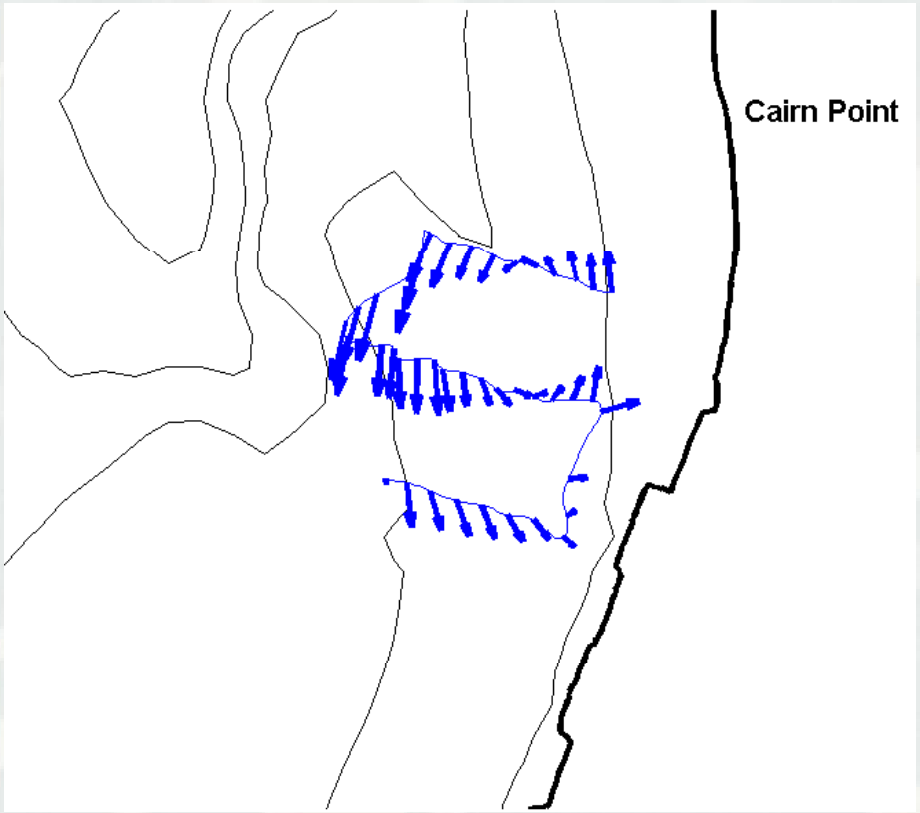
ADCP Transects

Eddies

Point Woronzof -- Flood

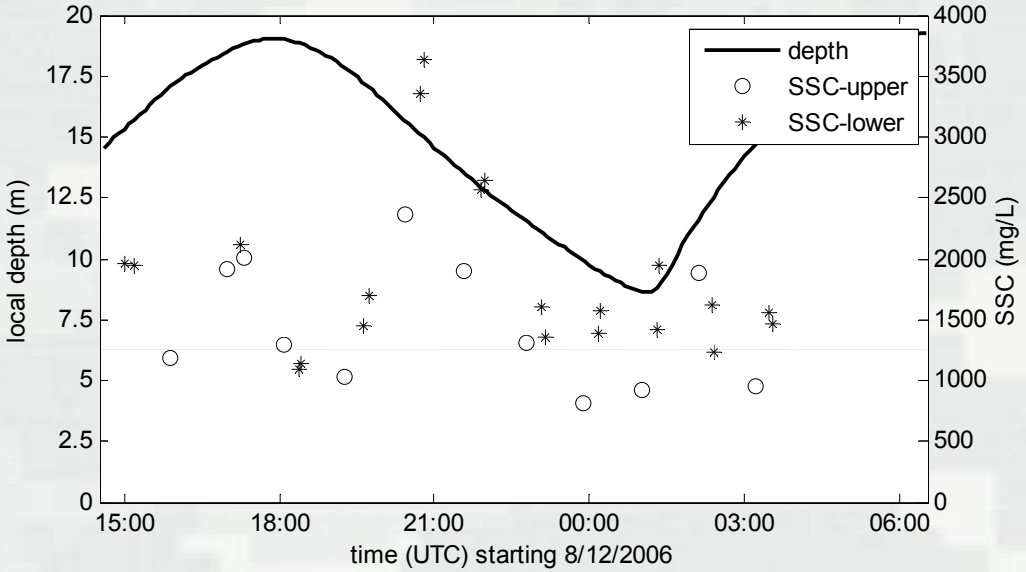


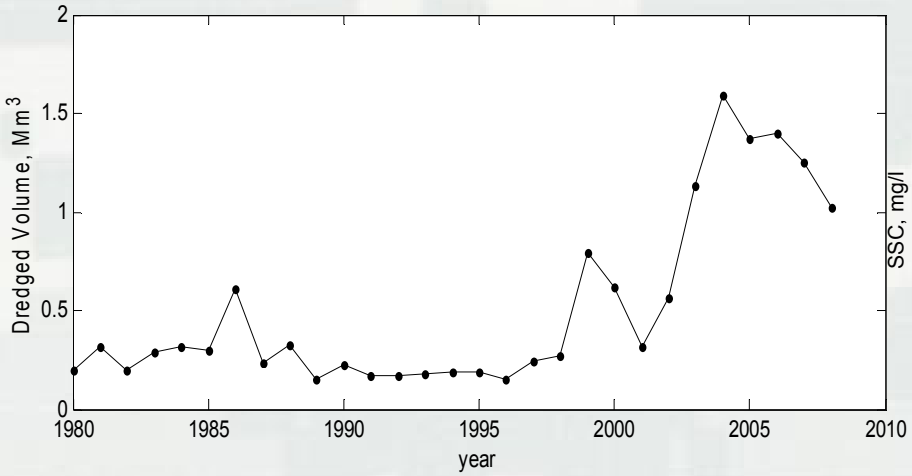
Cairn Point – Ebb

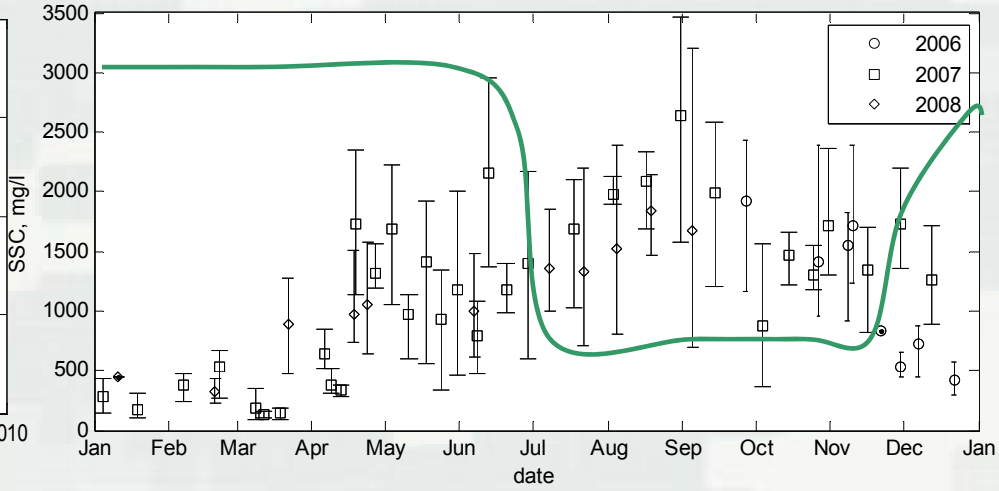


Suspended Sediment Concentration

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

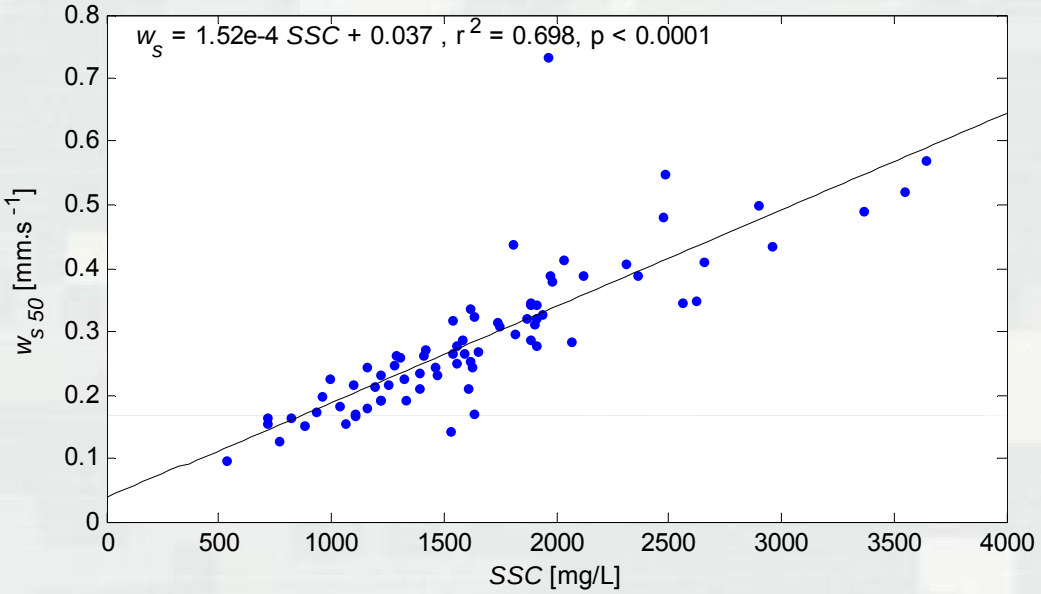


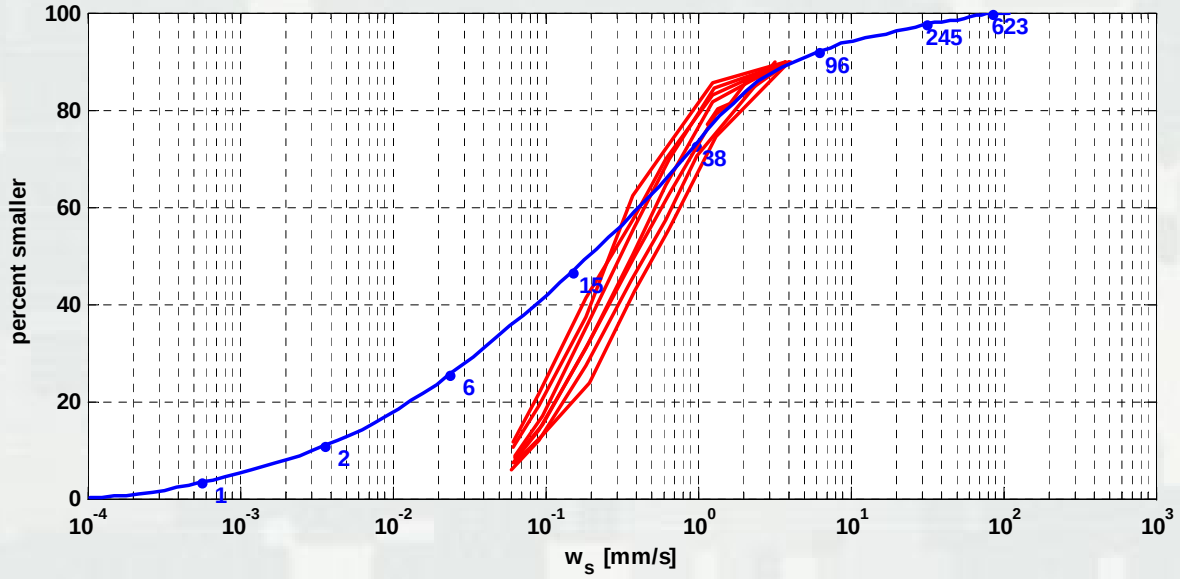




Settling Velocity

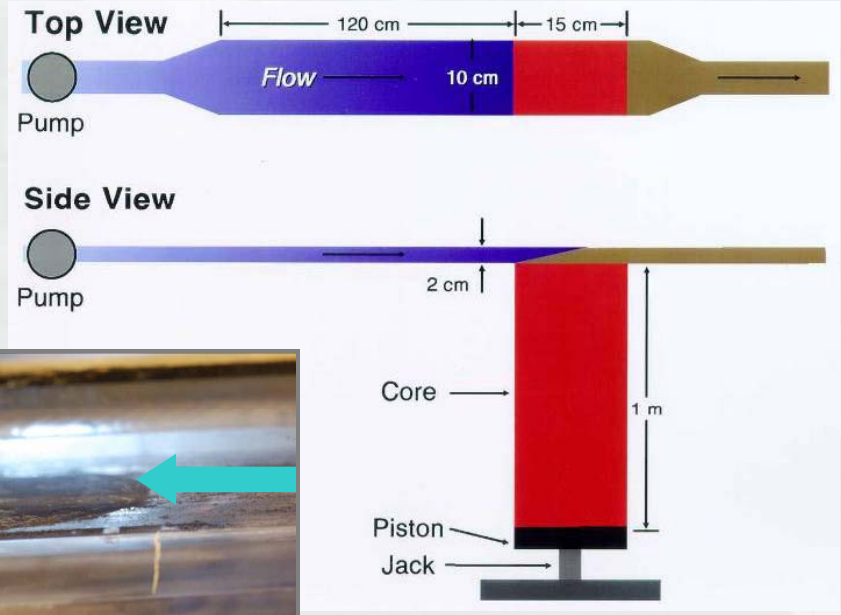
- 88 field pipette withdrawal experiments
- Flocculation / aggregation





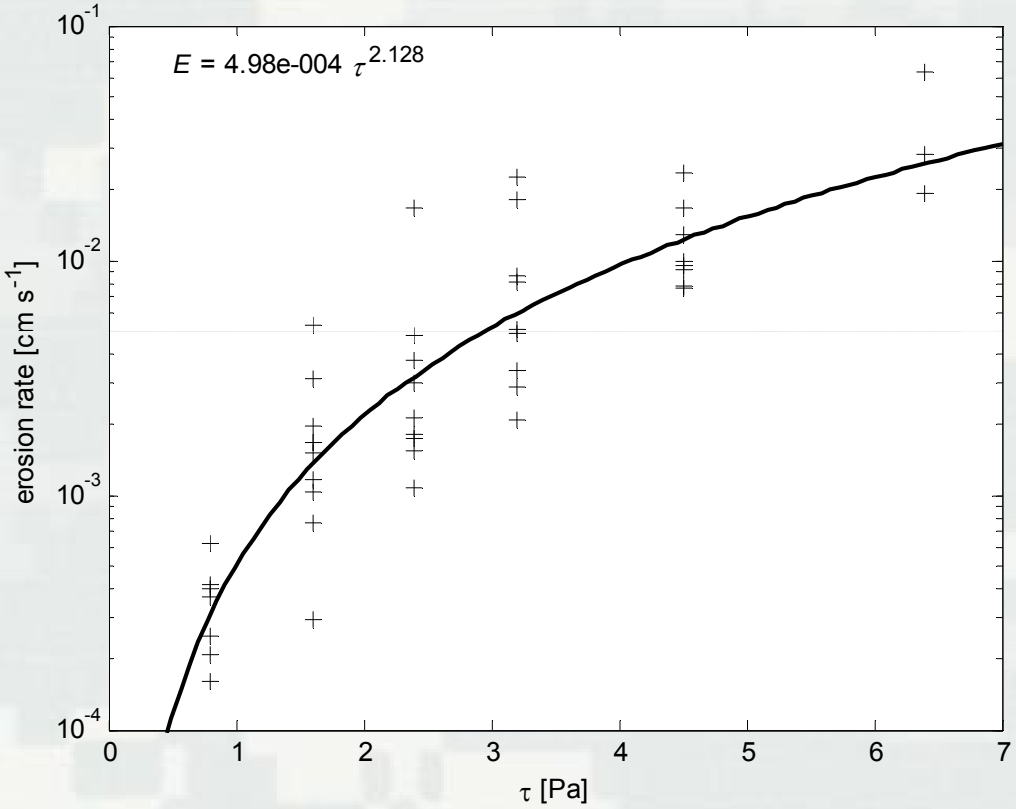
Cohesive Sediment Erosion

- Sedflume
- Samples taken from dredged basin and adjacent mudflats
- Sediment cores prepared in laboratory by slurrying 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.

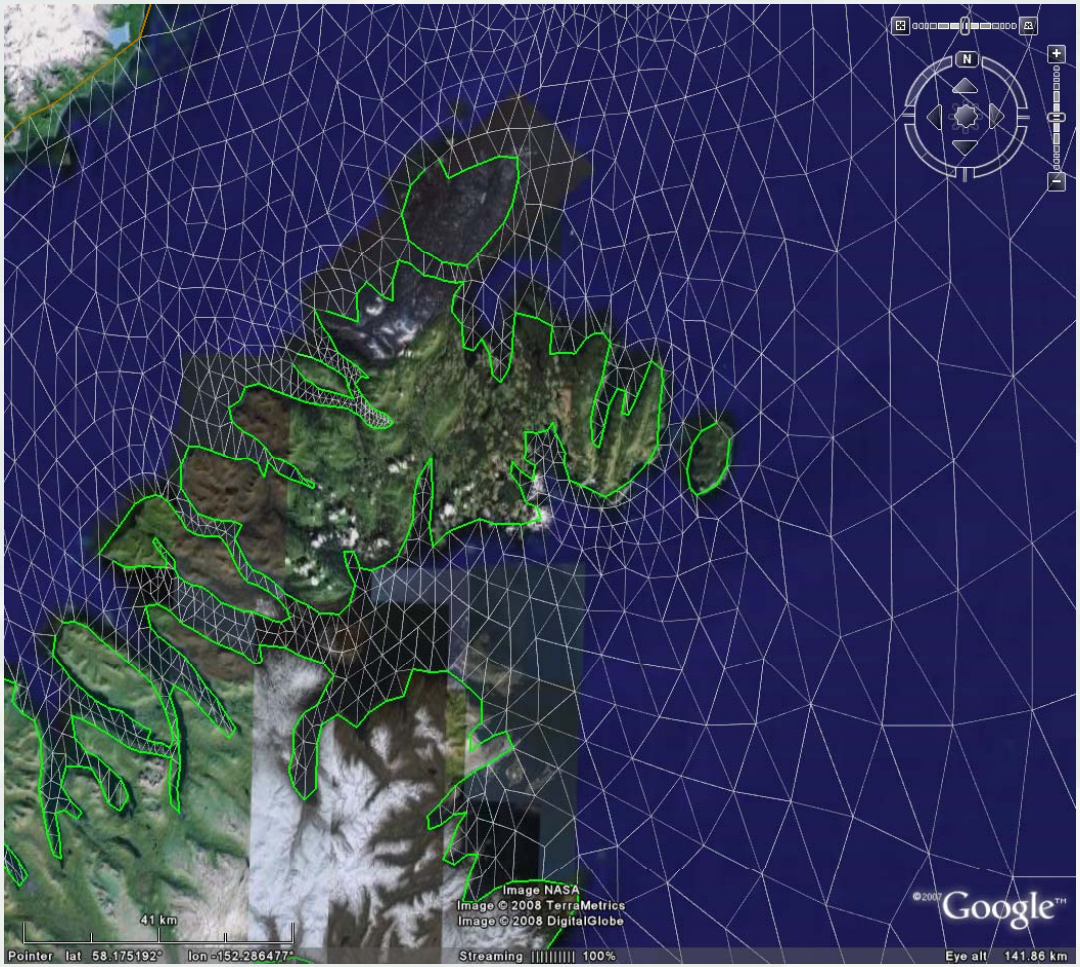


Numerical Hydrodynamic Modeling

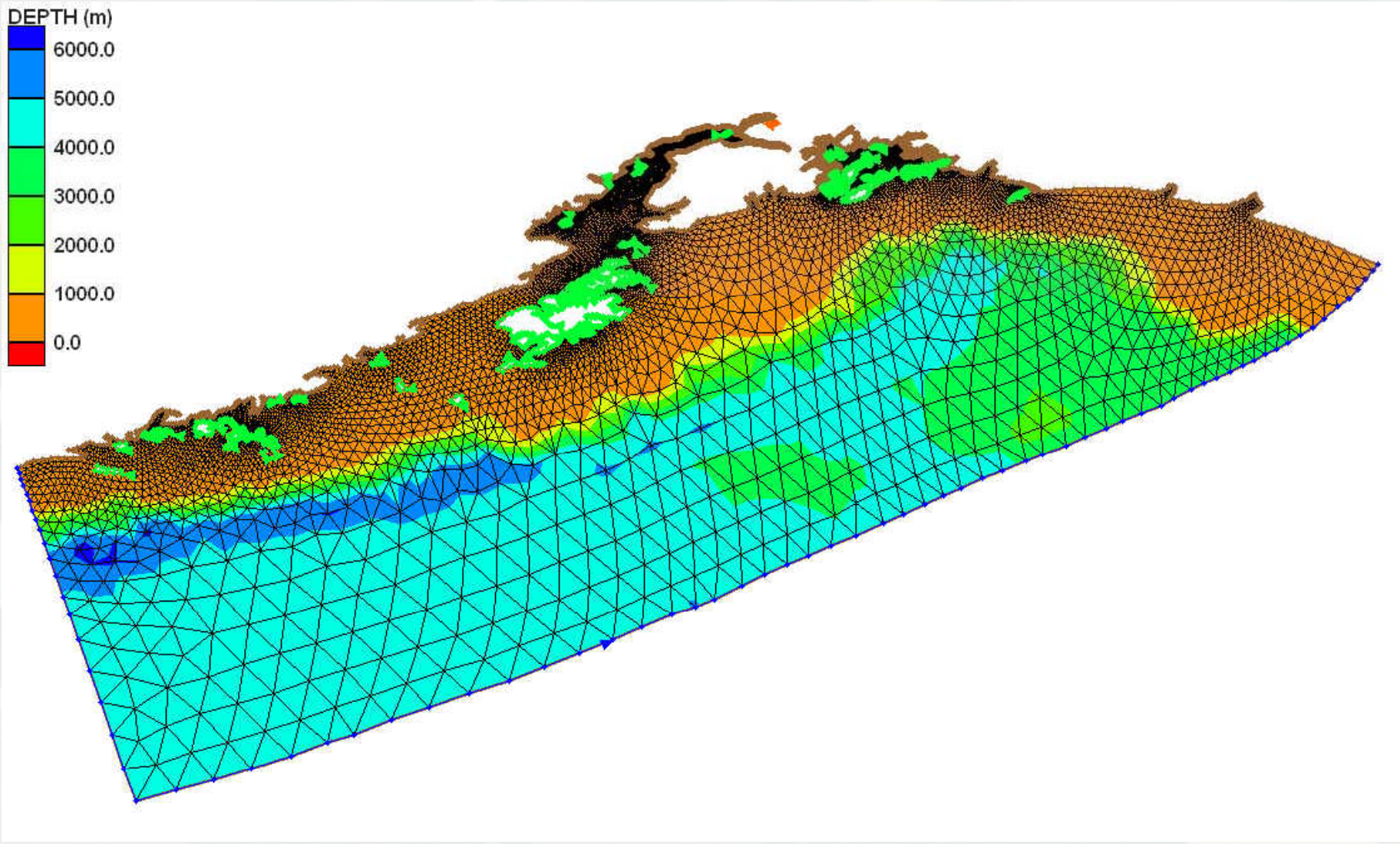
ADCIRC

ADvanced CIRCulation Model for Ocean, Coastal, and Estuarine Waters

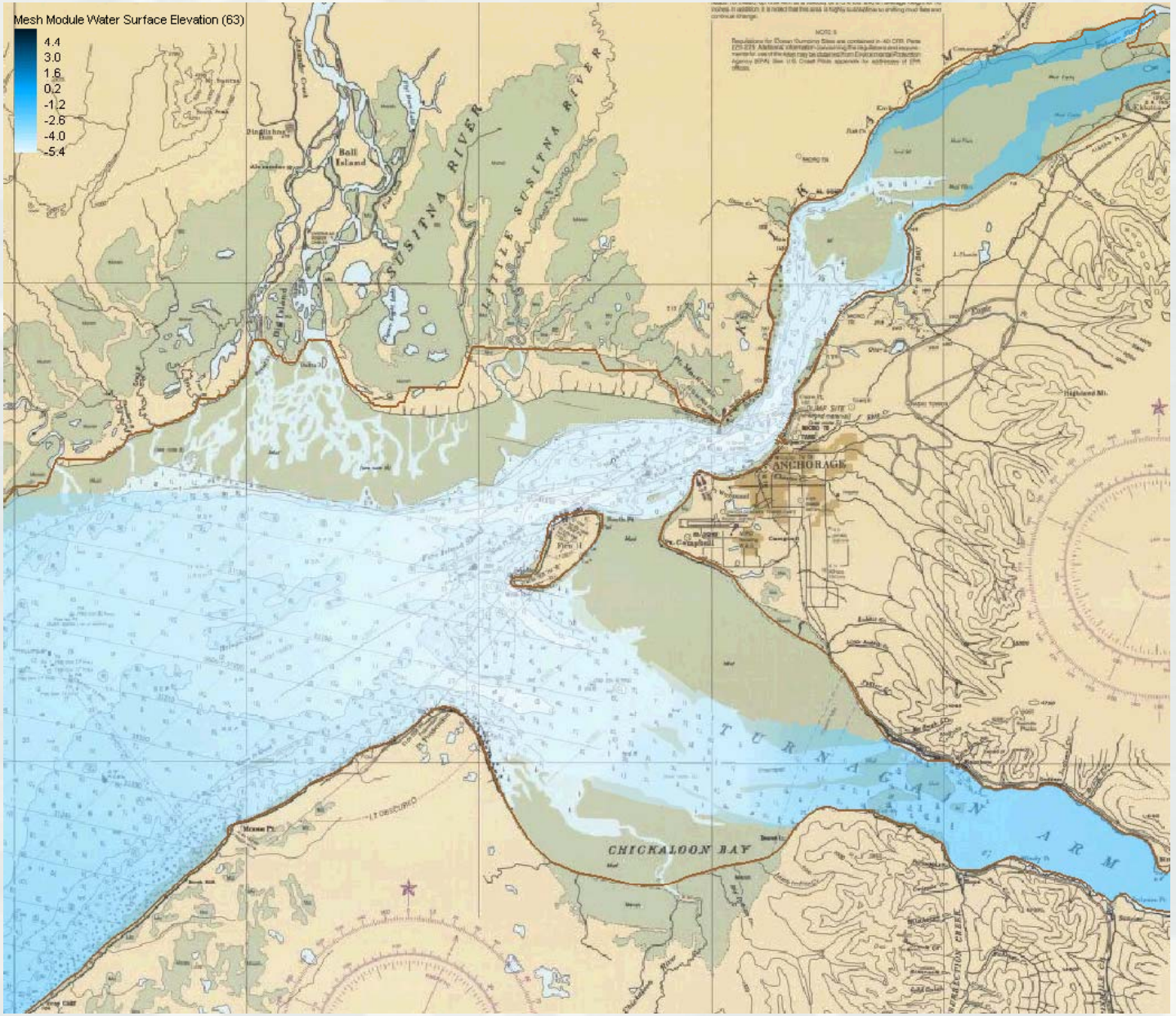
- Depth-averaged, Unstructured, Finite Element
- Forcing
  - Tide
  - Wind
  - River
- Other factors
  - Bathymetry
  - Friction
  - Shear/eddy formation
  - Coriolis acceleration
- Output
  - Tides and currents



ADCIRC Cook Inlet Mesh

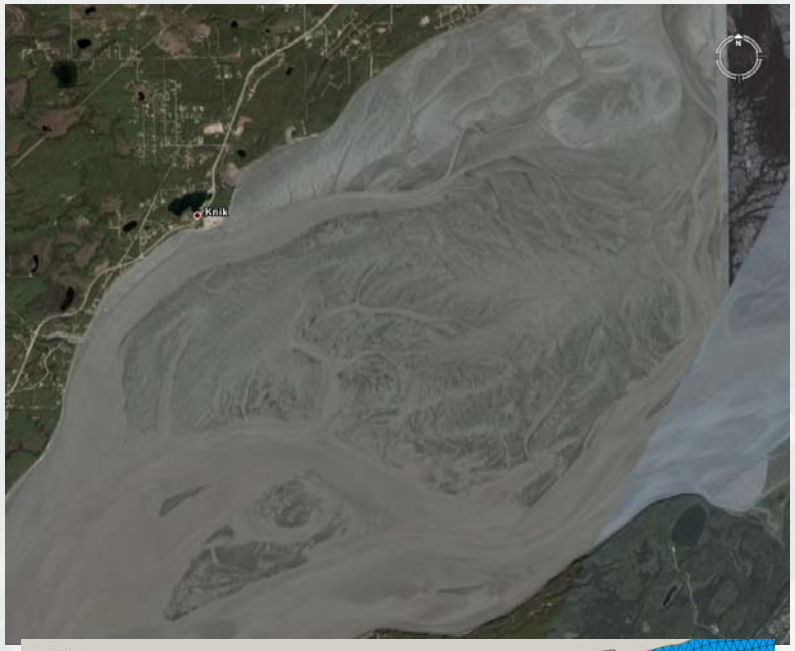


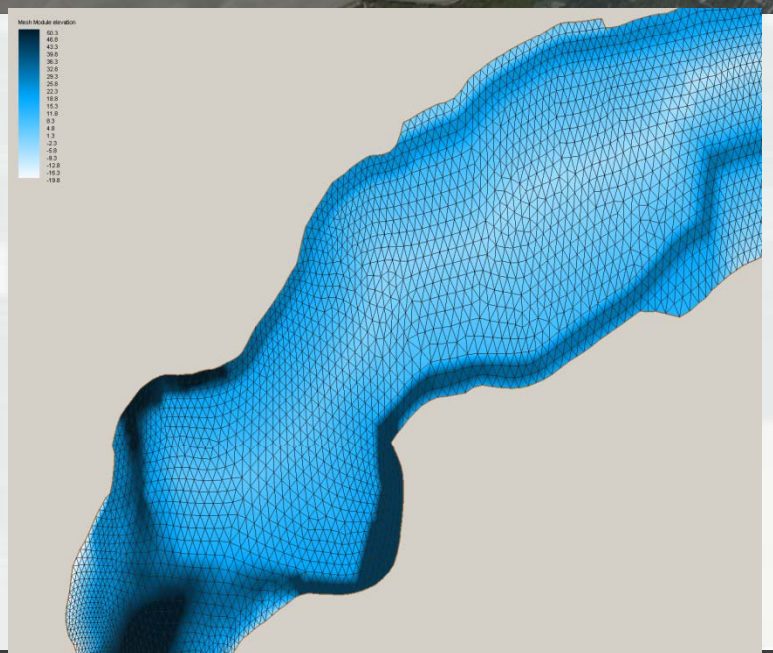
Tidal Simulation



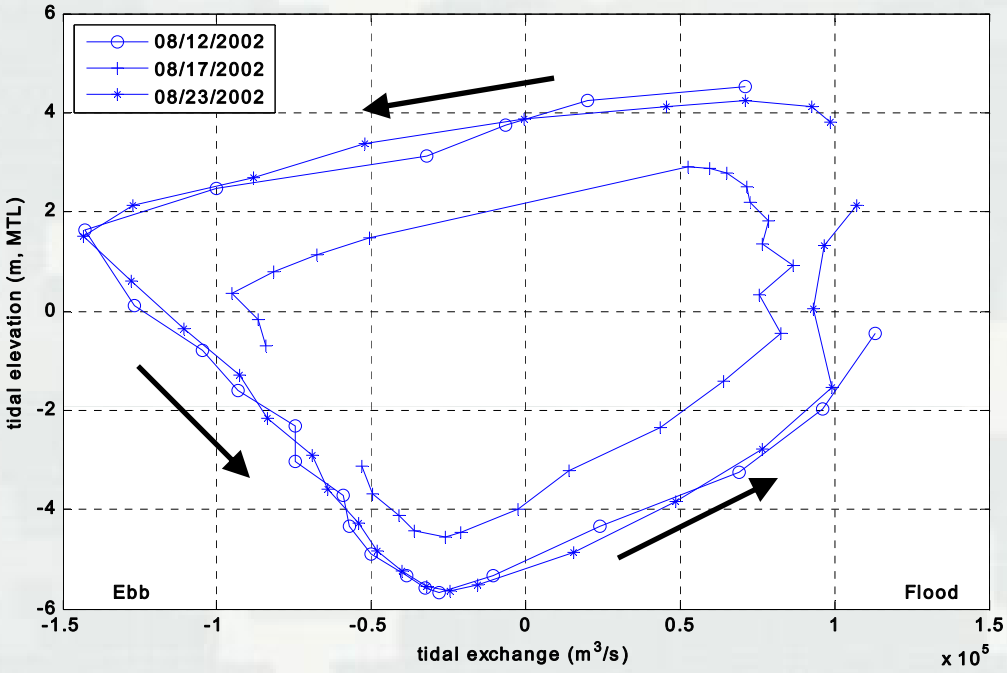
Intertidal Flooding/Drying

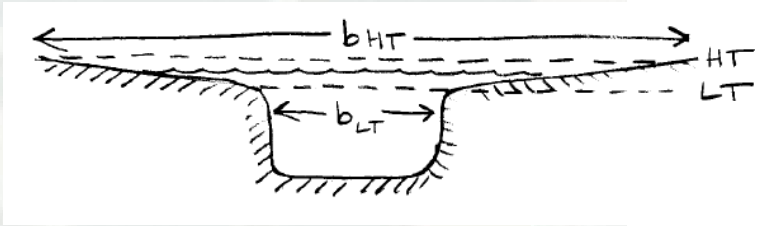
- Sparse/dated bathymetry
- Dynamic
- Strongly influences hydrodynamics in Knik Arm
- Approach:
  - Idealize tide flat geometry based on:
    - Alaska District survey data
    - Aerial photos
    - Navigation charts
    - Measured water exchange

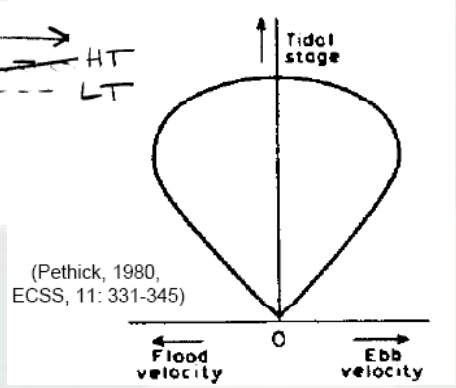




Tidal Exchange

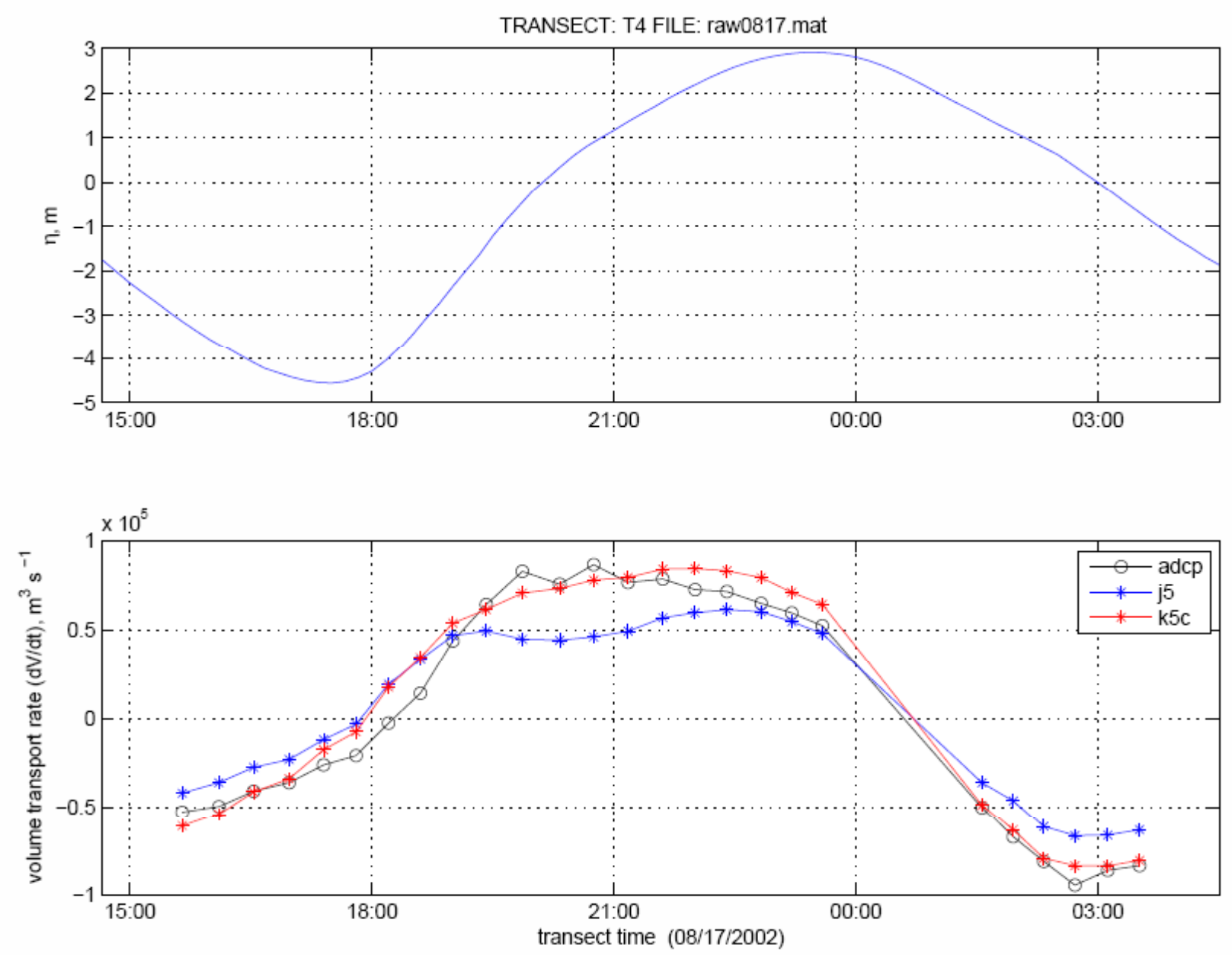




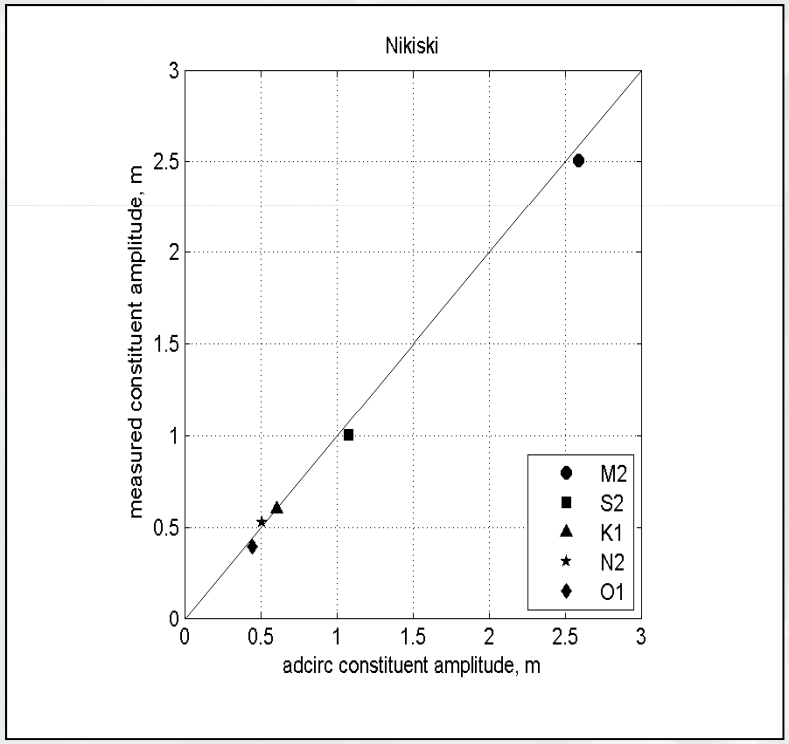


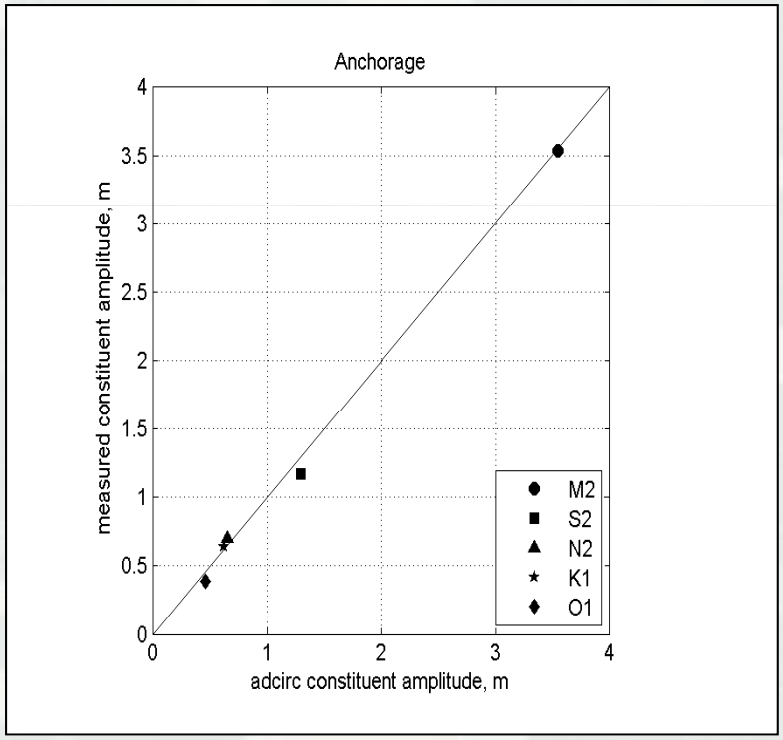
(Pethick, 1980, ECSS, 11: 331-345)

Measured and Predicted Flood Volume Flux



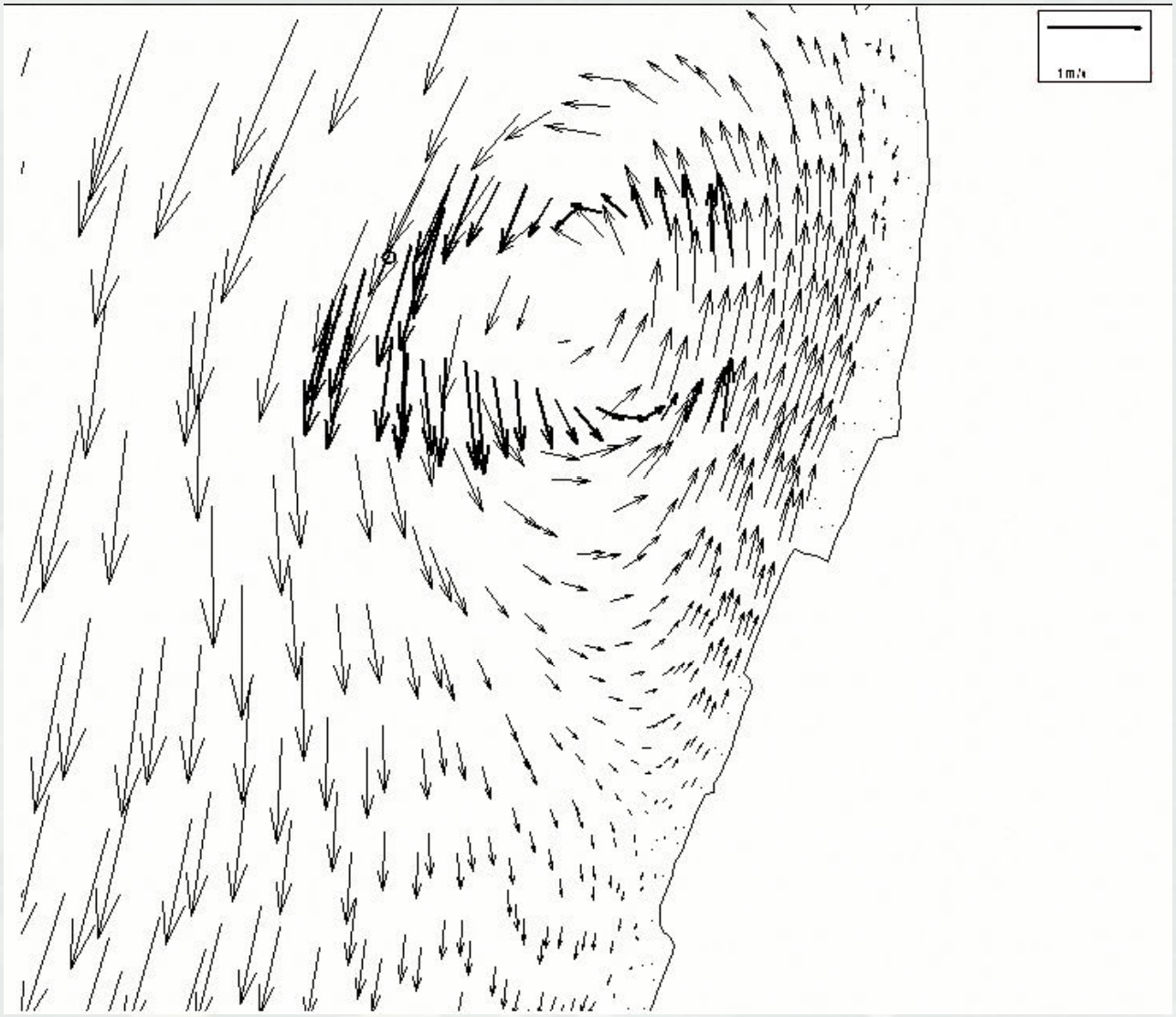
2006 Harmonic Constituent Comparison Nikiski and Anchorage



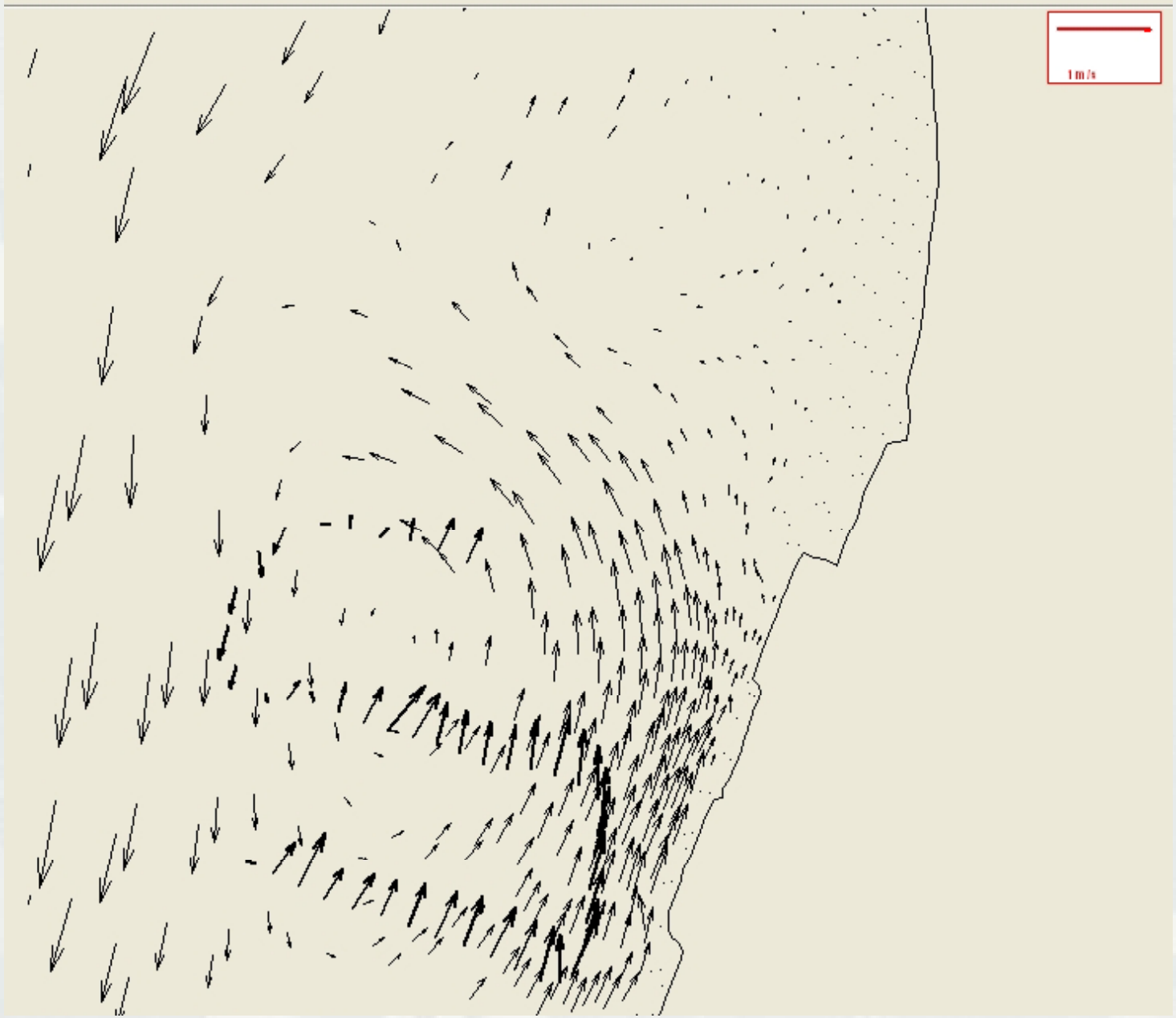


2006 Cairn Point Ebb Gyre Location

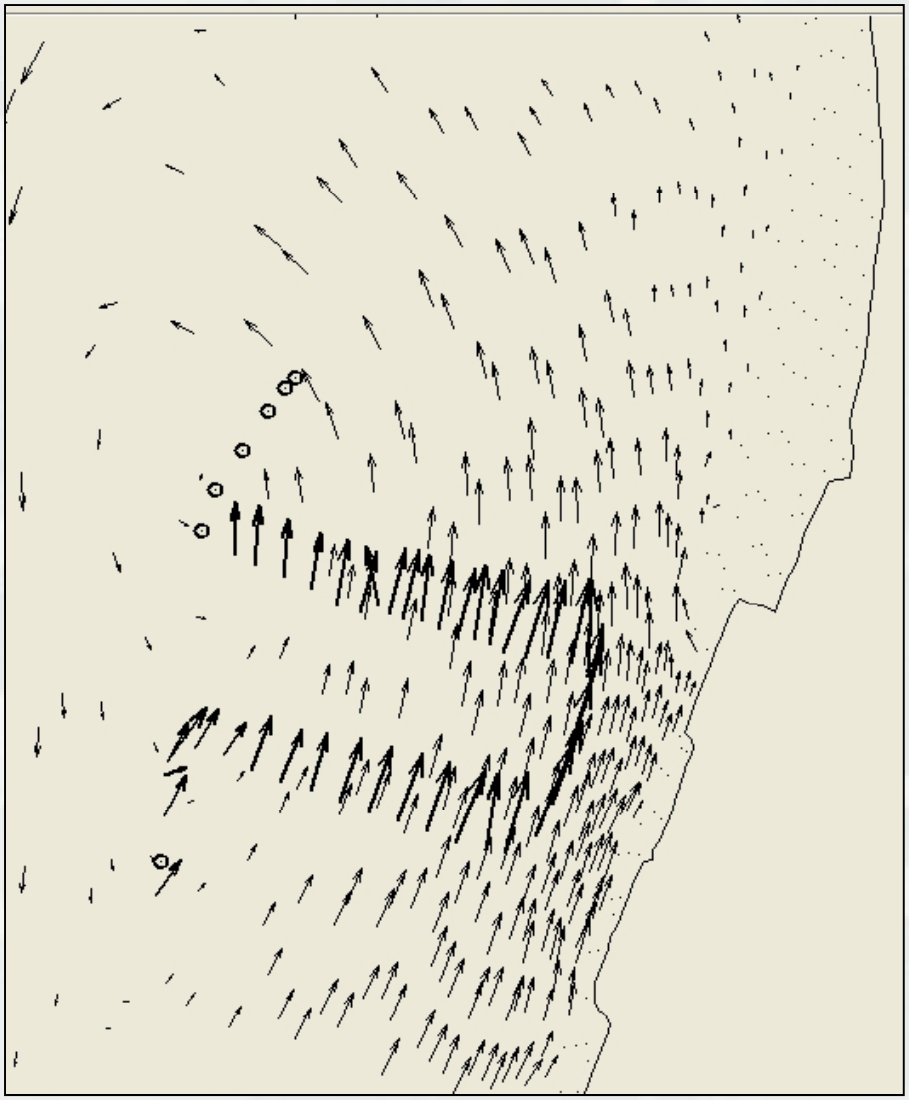
Model - NOAA 2006 Data Comparison of the Cairn Point Gyre



Cairn Point Gyre + 3Hr

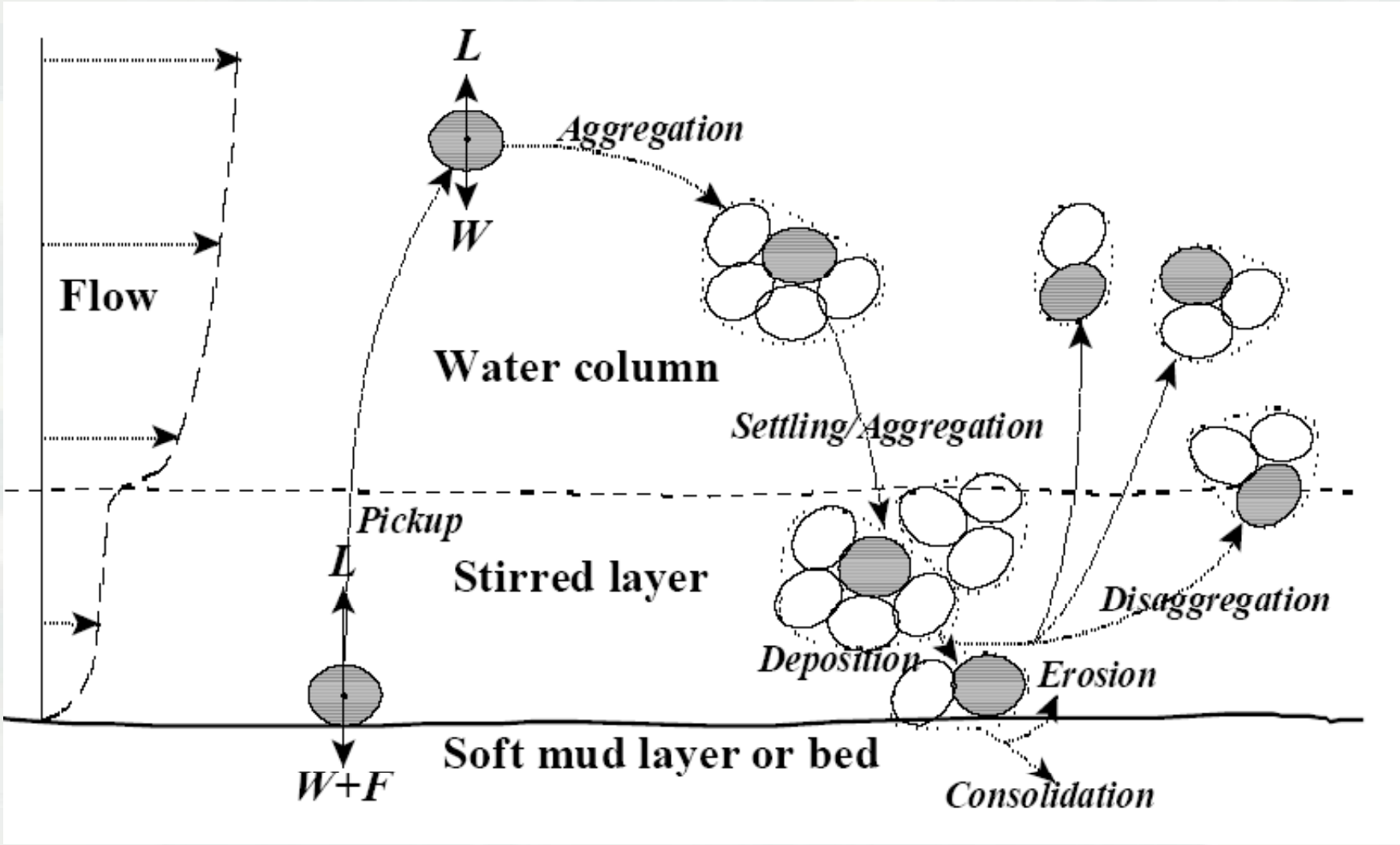


Cairn Point Gyre + 5Hr



Numerical Sedimentation Modeling

SEDZLJ Sediment Dynamics



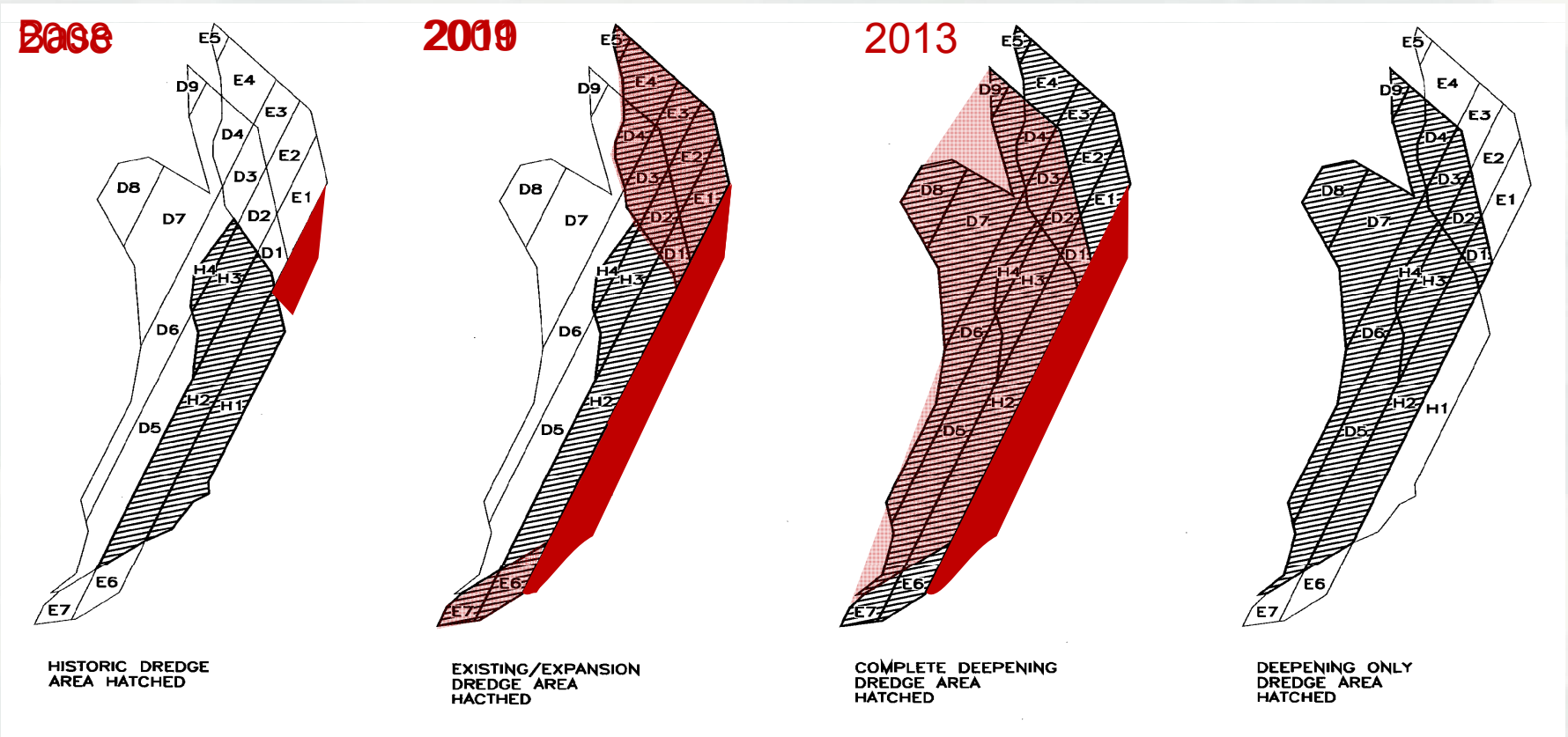
McAnally (1999)


N
Image © 2009 TerraMetrics
Image © 2009 DigitalGlobe
26.7 mi
Image IBCAO
61°06'53.10" N 150°22'42.70" W
2009 Google
Eye alt 91.53 mi


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.