Numerical Modeling of Alternatives to Reduce Channel Shoaling at Lynnhaven Inlet, Virginia Beach, USA

ERDC
Engineer Research & Development Center

Lihwa Lin, ERDC, JSU
Zeki Demirbilek, ERDC

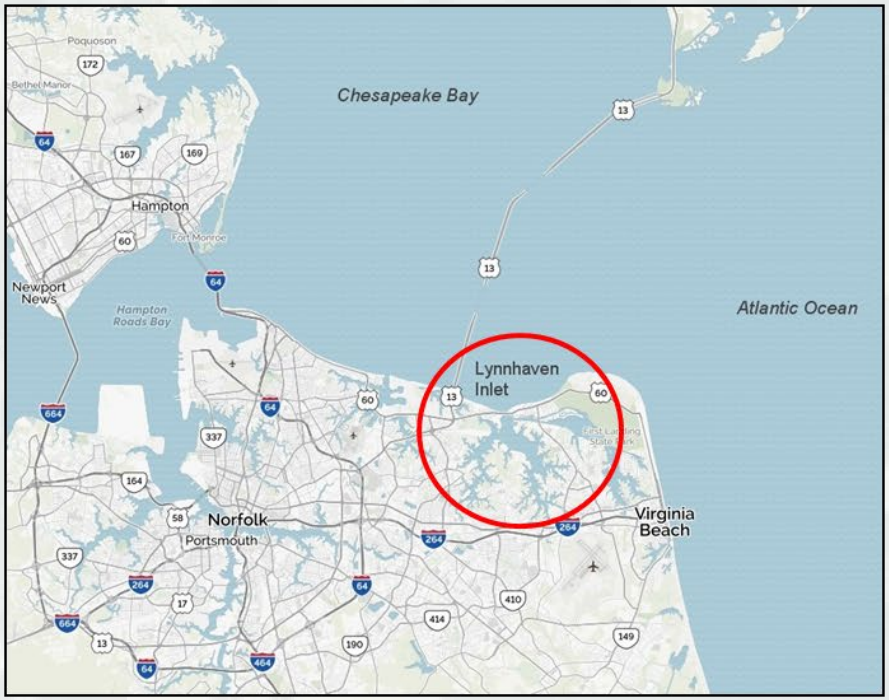
ICSE 2018, Taipei, Taiwan

5-8 November 2018

US Army Corps of Engineers®

Outline

- Background & Objectives
- Coastal Models & Input forcing
- Wave & Hydro Simulations
- Modeling Alternatives
- Summary & Conclusions



Background

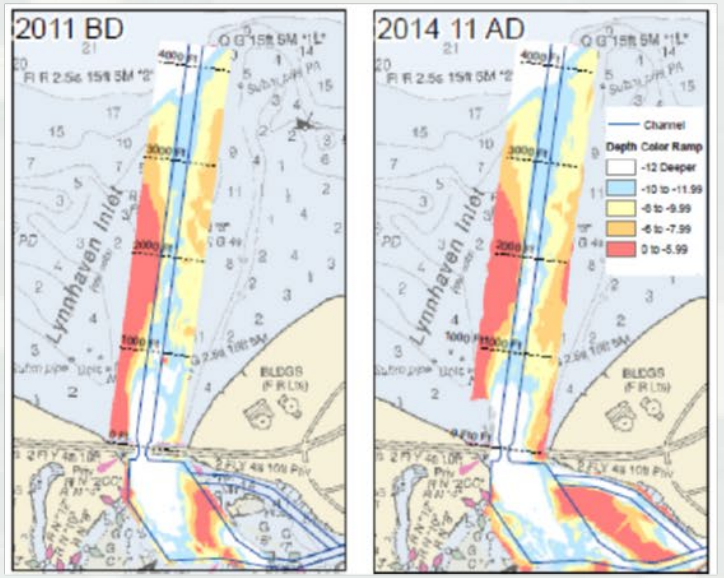
- Lynnhaven Inlet is located on the south shore of Chesapeake Bay entrance, approximately 3.5 km east of the CB Bridge-Tunnel and 12 km west of town center of Virginia Beach.

- The inlet is a 1.3-km long, federally authorized shallow-draft channel cuts though a large ebb shoal. The inlet channel is maintained at 46-m wide and 4-m deep (Mean Sea Level). The inlet throat is narrow ~ 5-m deep & 200-m wide.

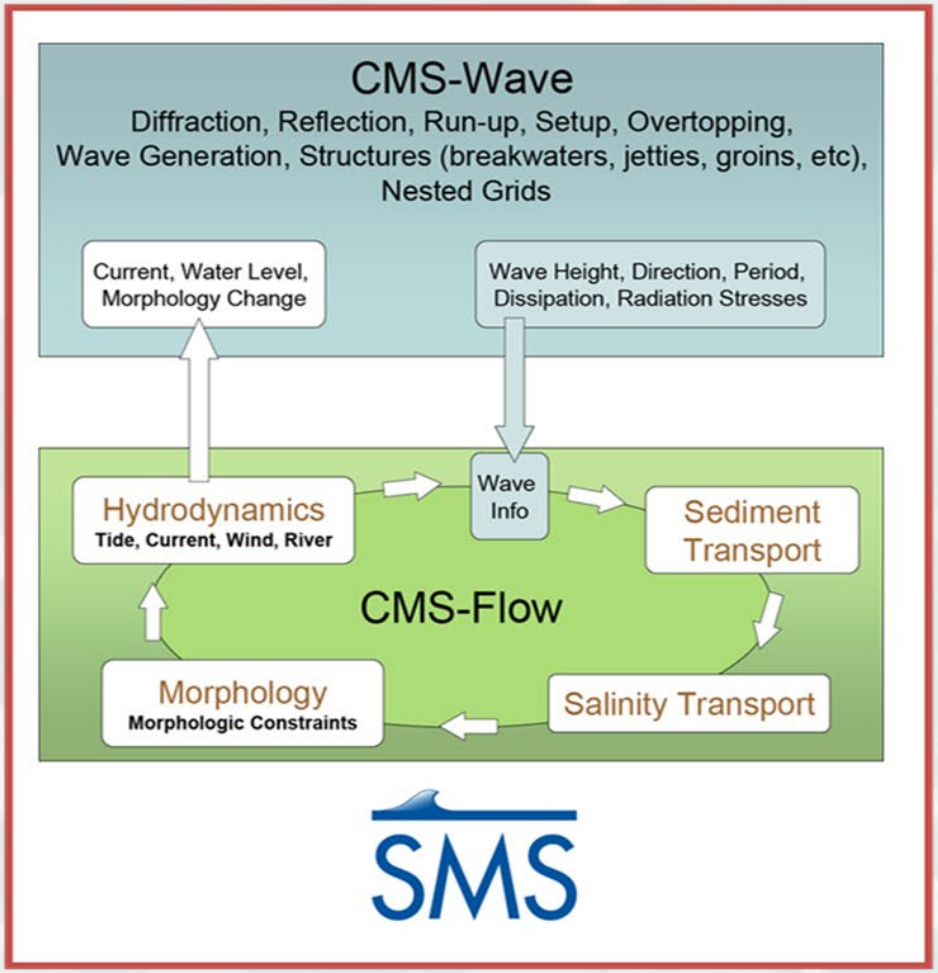
- Without any jetty protection, the inlet channel requires frequent dredging, typically once or twice a year. Average annual dredging volume is ~ 30,000 CY. The post-Sandy dredging removed ~ 110,000 CY from the channel.

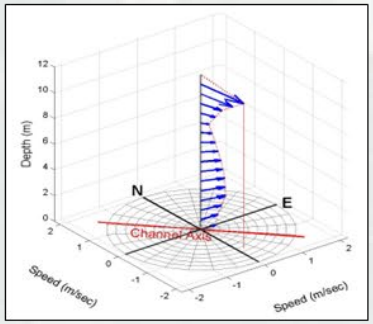
Objectives

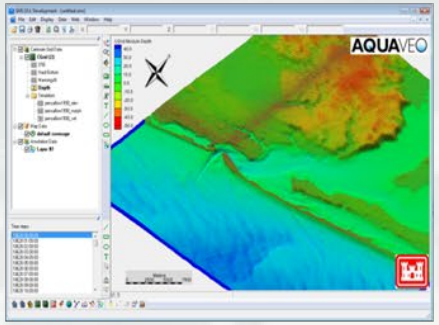
- Analyze regional meteorological and oceanographic condition in the study area. Select design wave and water level conditions for the numerical modeling.
- Apply a Coastal Modeling System (CMS) consisting of wave, hydrodynamic and sedimentation models in the present study.
- Conduct modeling and analysis to evaluate non-structural and structural alternatives including a single long jetty, dual short jetties, and dual long jetties (low-crest jetty elevation ~ 1.8 m above Mean Lower Low Water, MLLW)



Coastal Modeling System (CMS)

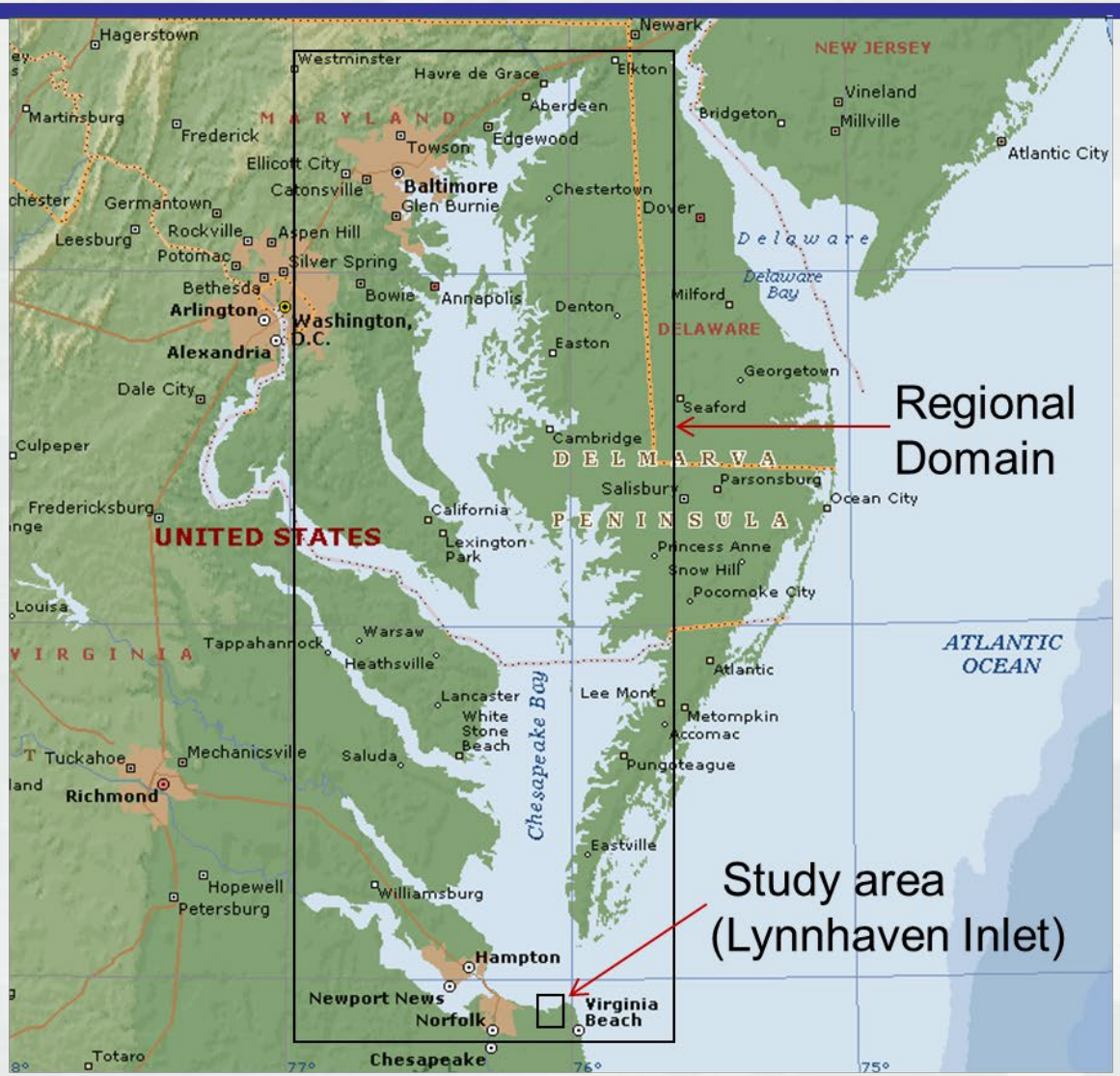




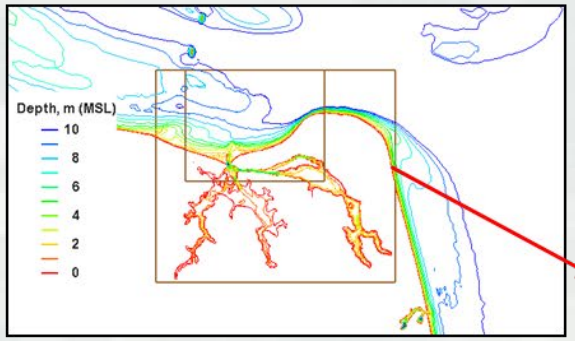


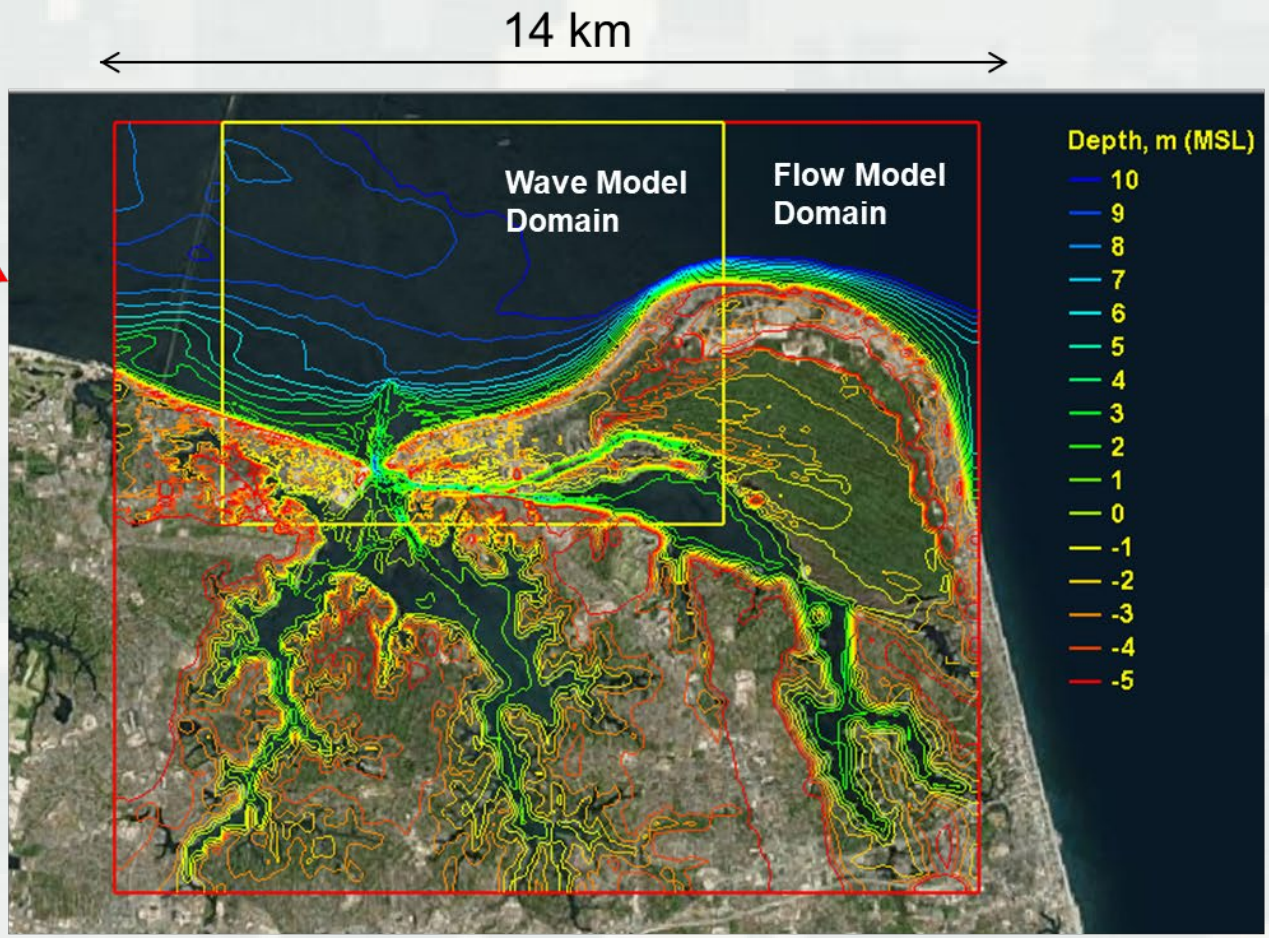
- A suit of time-dependent flow, salinity, wave, & mixed sediment transport models
- Physics-based to simulate complete coastal processes
- Integrated with visual interface thru Surface-water Modeling System (SMS)

Regional Modeling Domain



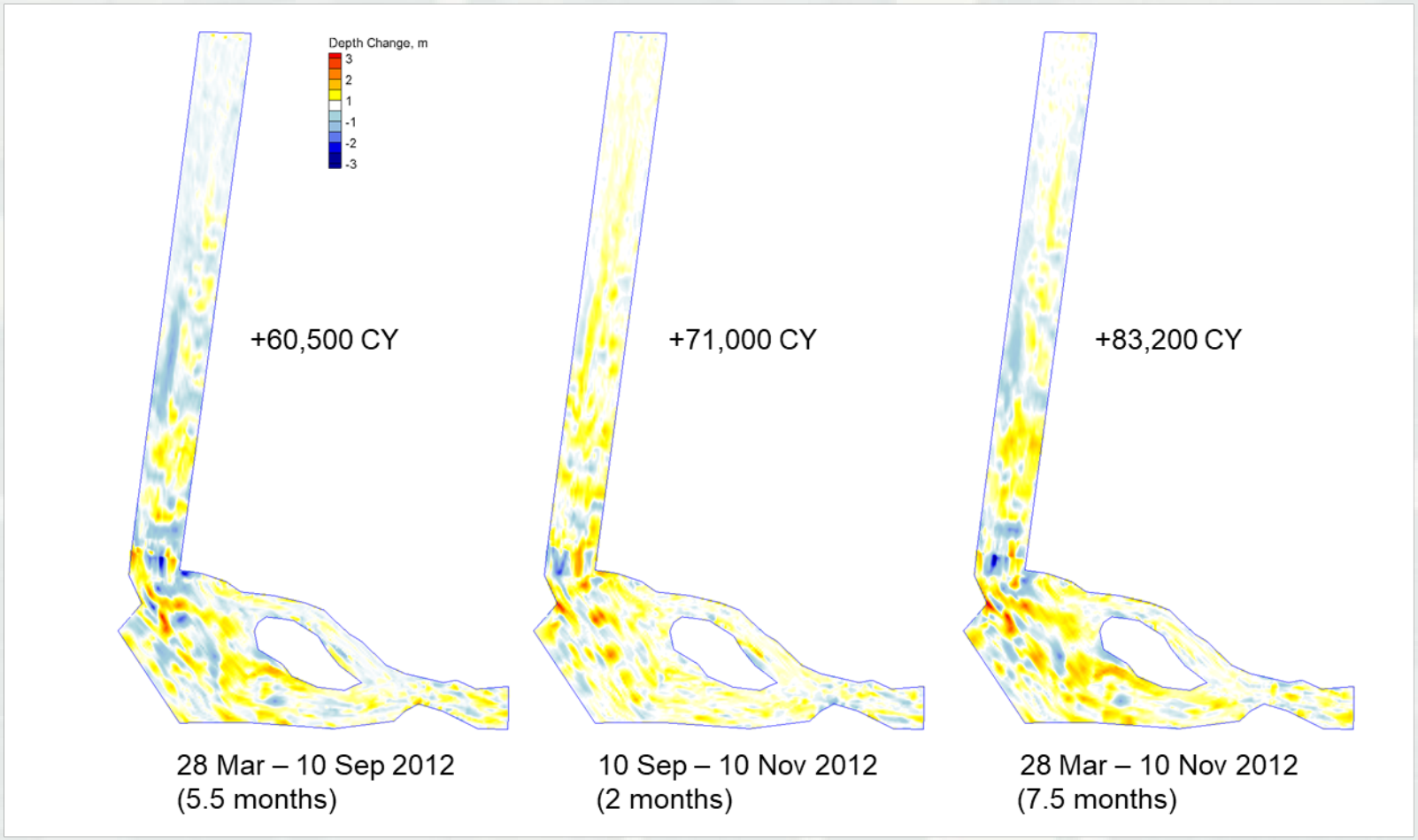
Local Flow and Wave Model Domains



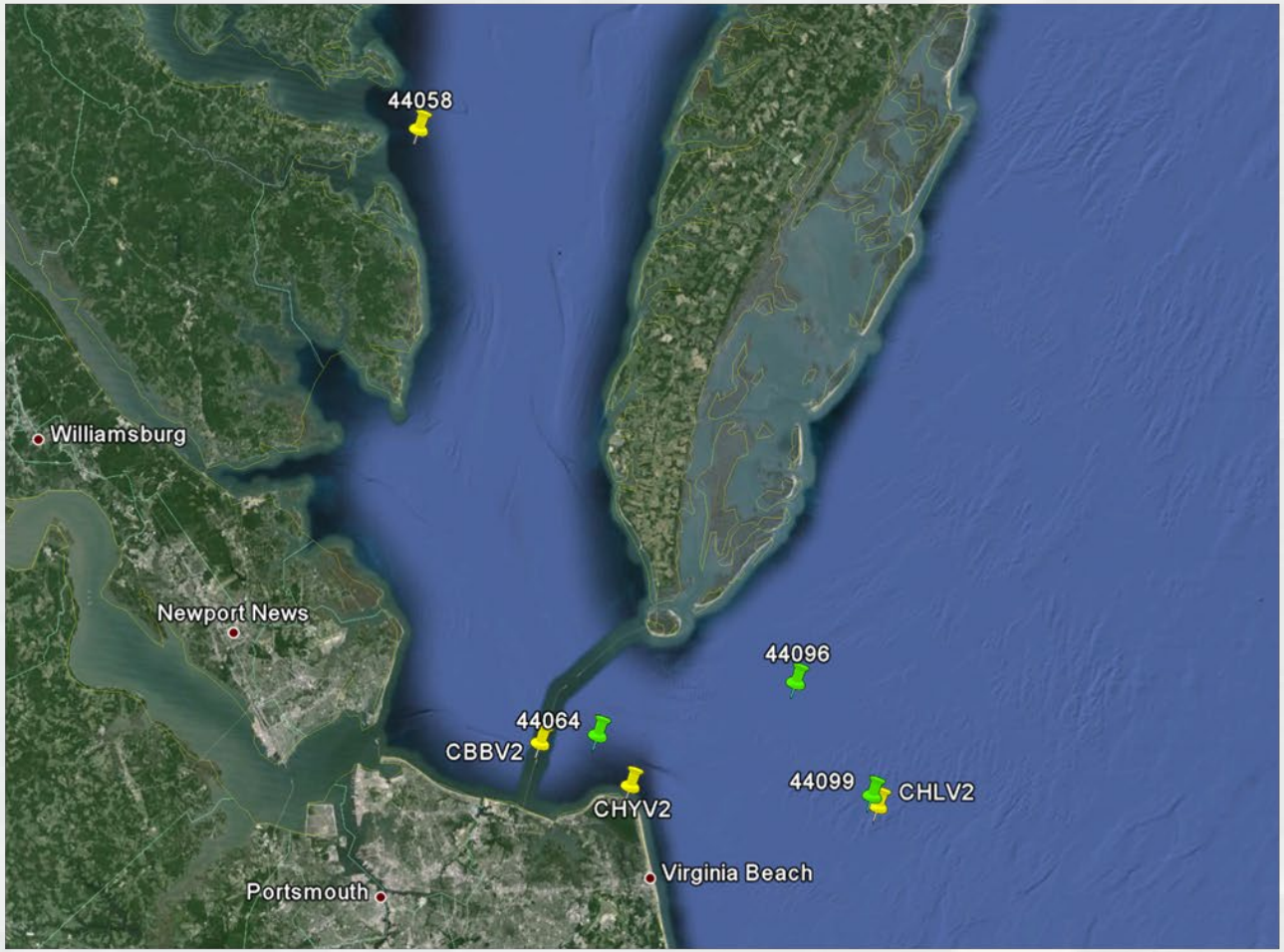


Model grid cell size
~ 5 m around inlet channel and bays
~ 150 to 200 m in offshore areas

Channel Shoaling Volume (Mar-Nov 2012)



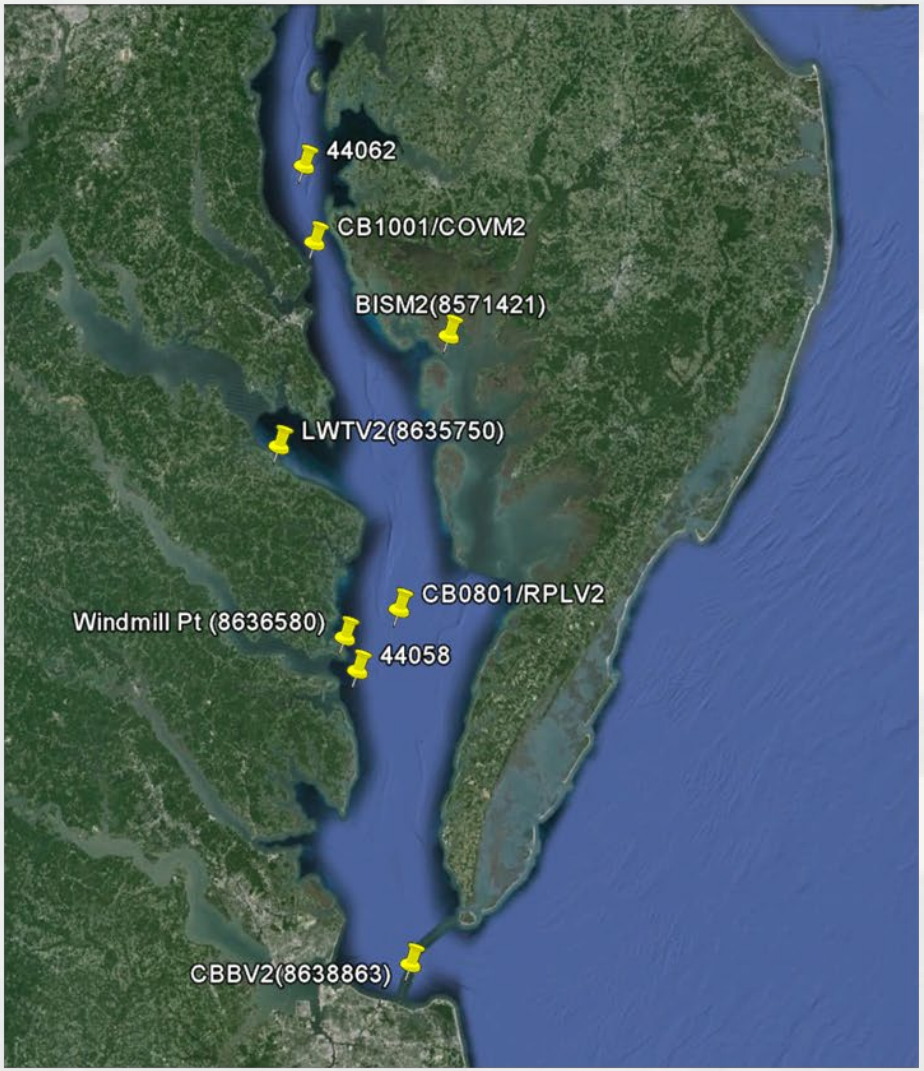
NOAA Buoys and Coastal Stations (wind, wave, water level measurements)



Buoys:
44058, 44064, 44096, 44099

Coastal Stations:
CBBV2, CHLV2, CHYV2

More Water Level and Wind Stations



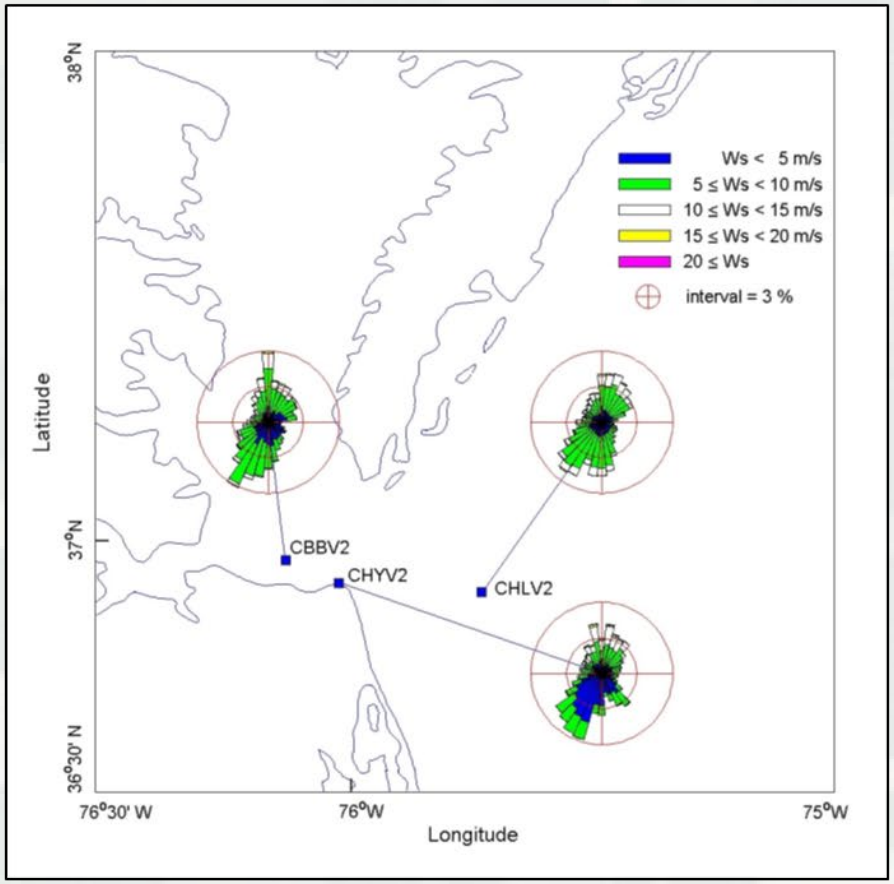
CBIBS/NDBC

- 44058 - Stingray Pt, VA
- 44062 - Gooses Reef, MD

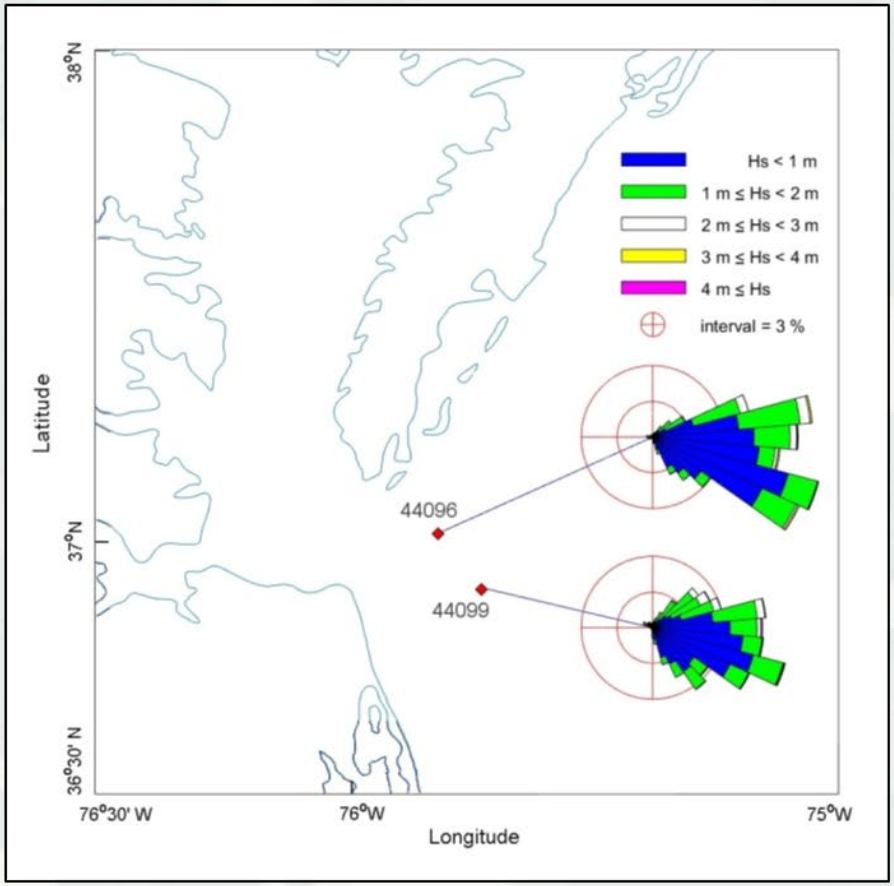
NOAA Coastal Stations

- CB0801/RPLV2 - Rappahannock Light, VA
- CB1001/COVM2 - Cove Point LNG Pier, MD
- BISM2 (8571421) - Bishops Head, MD
- LWTV2 (8635750) - Lewisetta, VA
- CBBV2 (8638863) – Chesapeake Bay Bridge Tunnel, VA
- Windmill Pt, VA (8636580)

Wind and Wave Roses, 2012

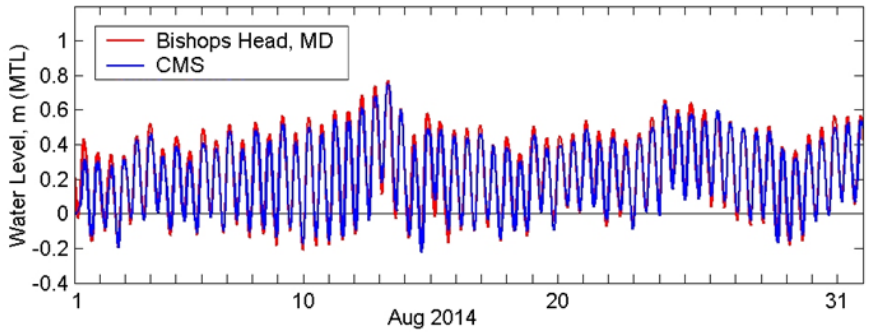


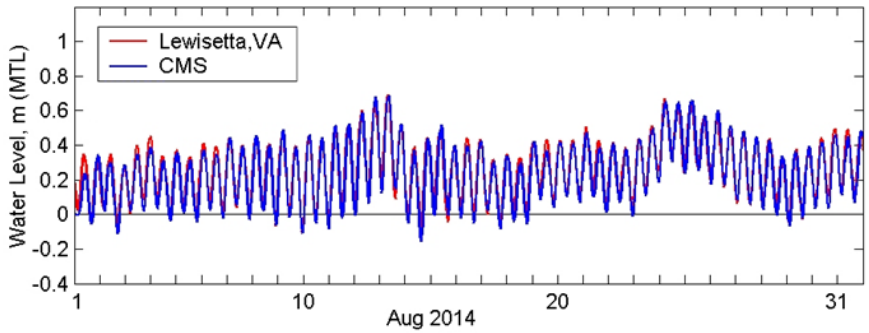
Wind Roses

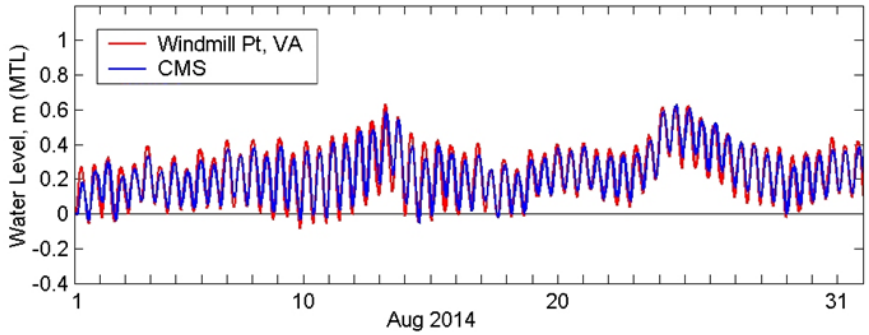


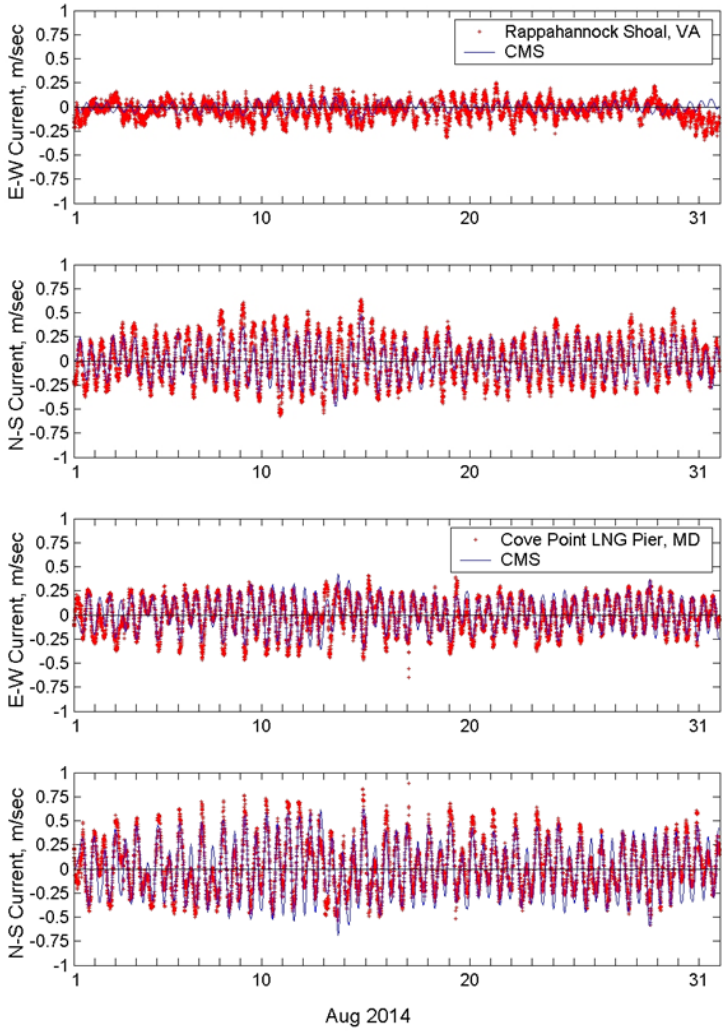
Wave Roses

Model Hydro Calibration – August 2014



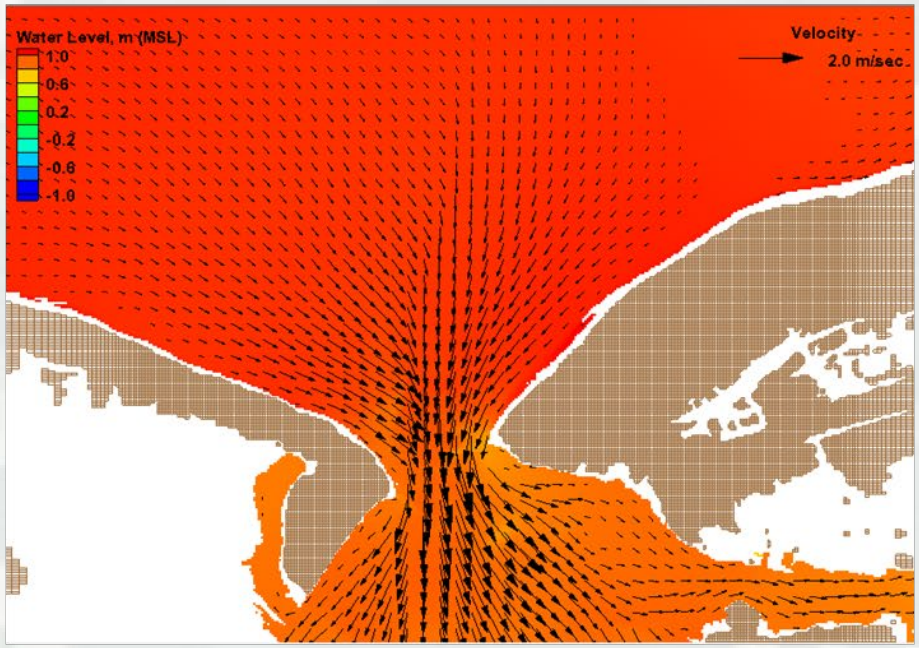




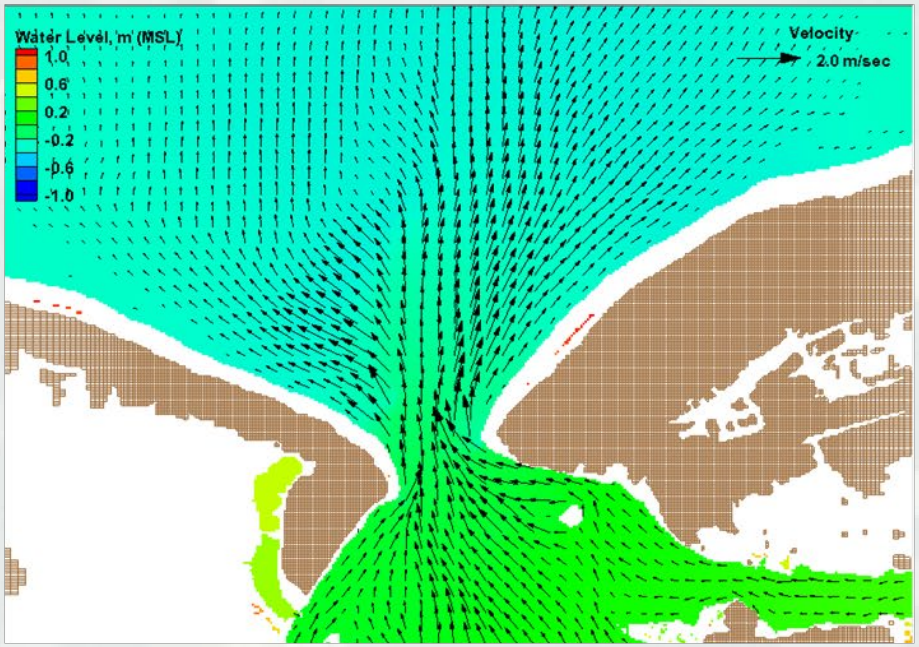


Calculated Flood and Ebb Flow Fields

00:00 GMT, 3 May 2012



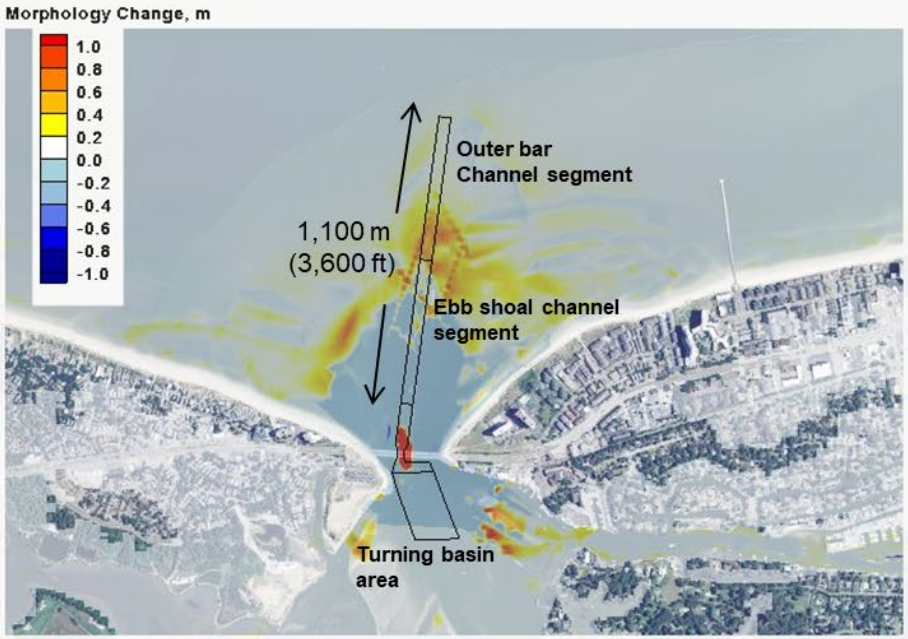
22:00 GMT, 9 April 2012



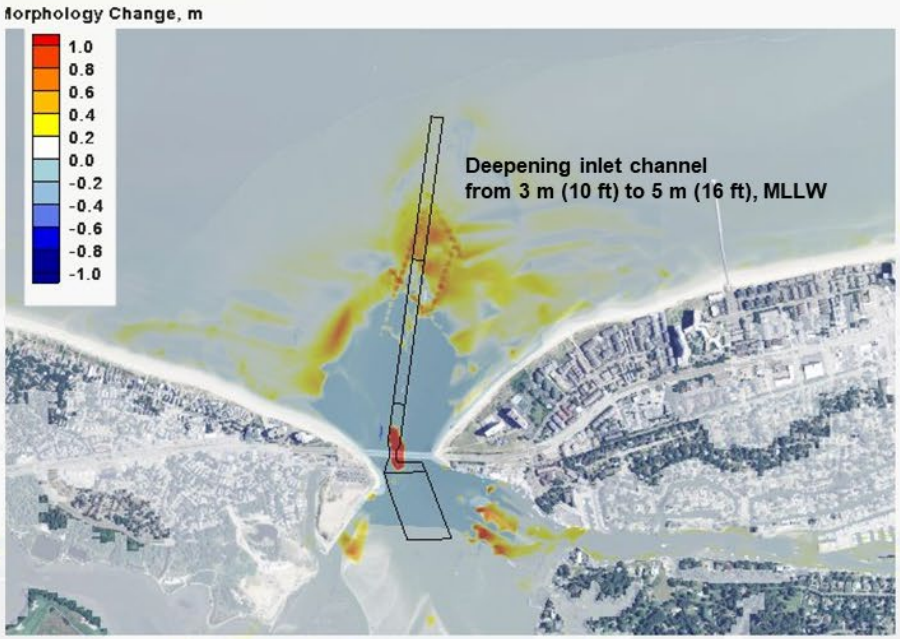
(Tidal prism ~ 23,000,000 m^3)

Max current ~ 1.1 m/sec at inlet throat

Model Morphology Change for 2014
Alt 0 and Alt 1

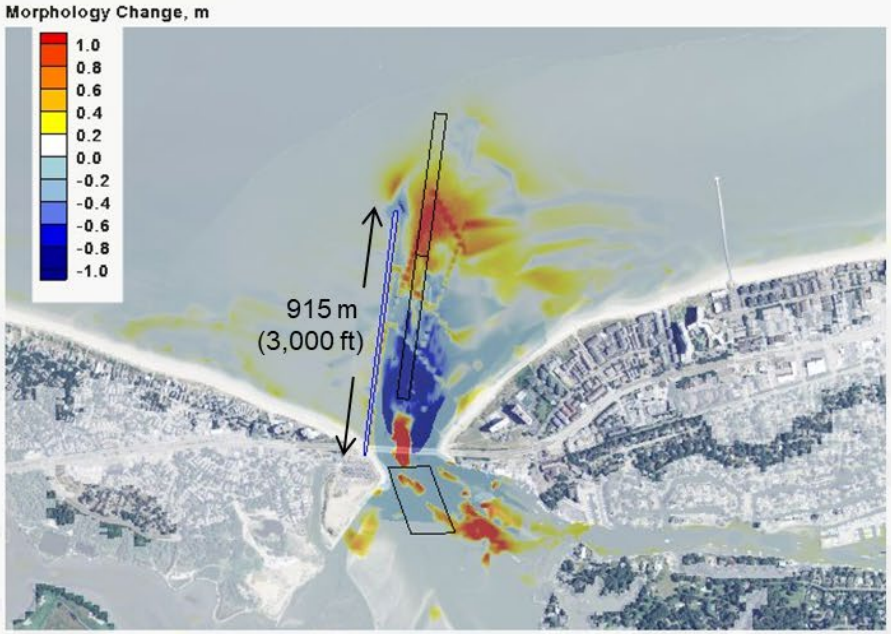


Alt 0
(No Action)

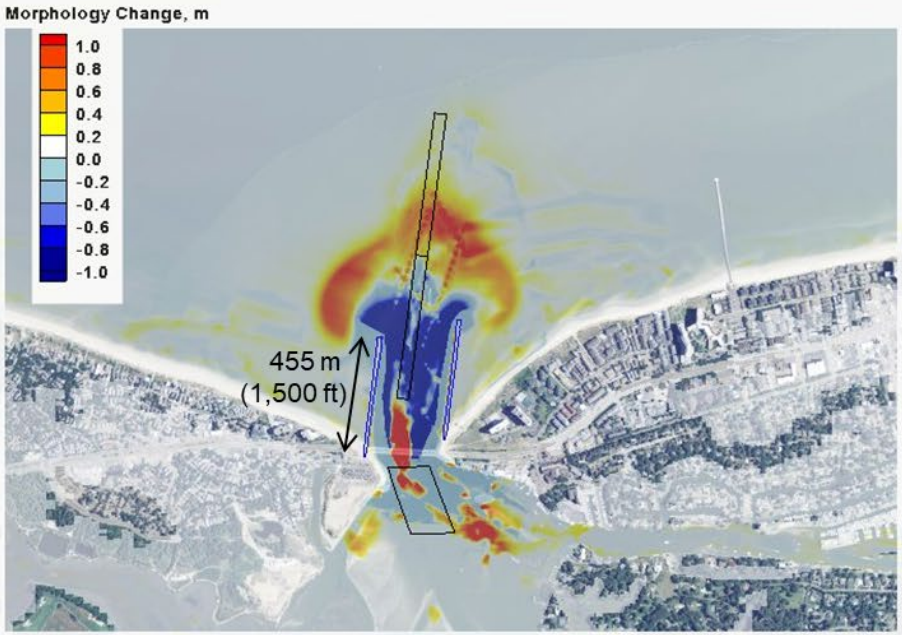


Alt 1
(Deepening Channel,
total volume removal ~ 200,000 CY)

Model Morphology Change for 2014
Alt 2 and Alt 3

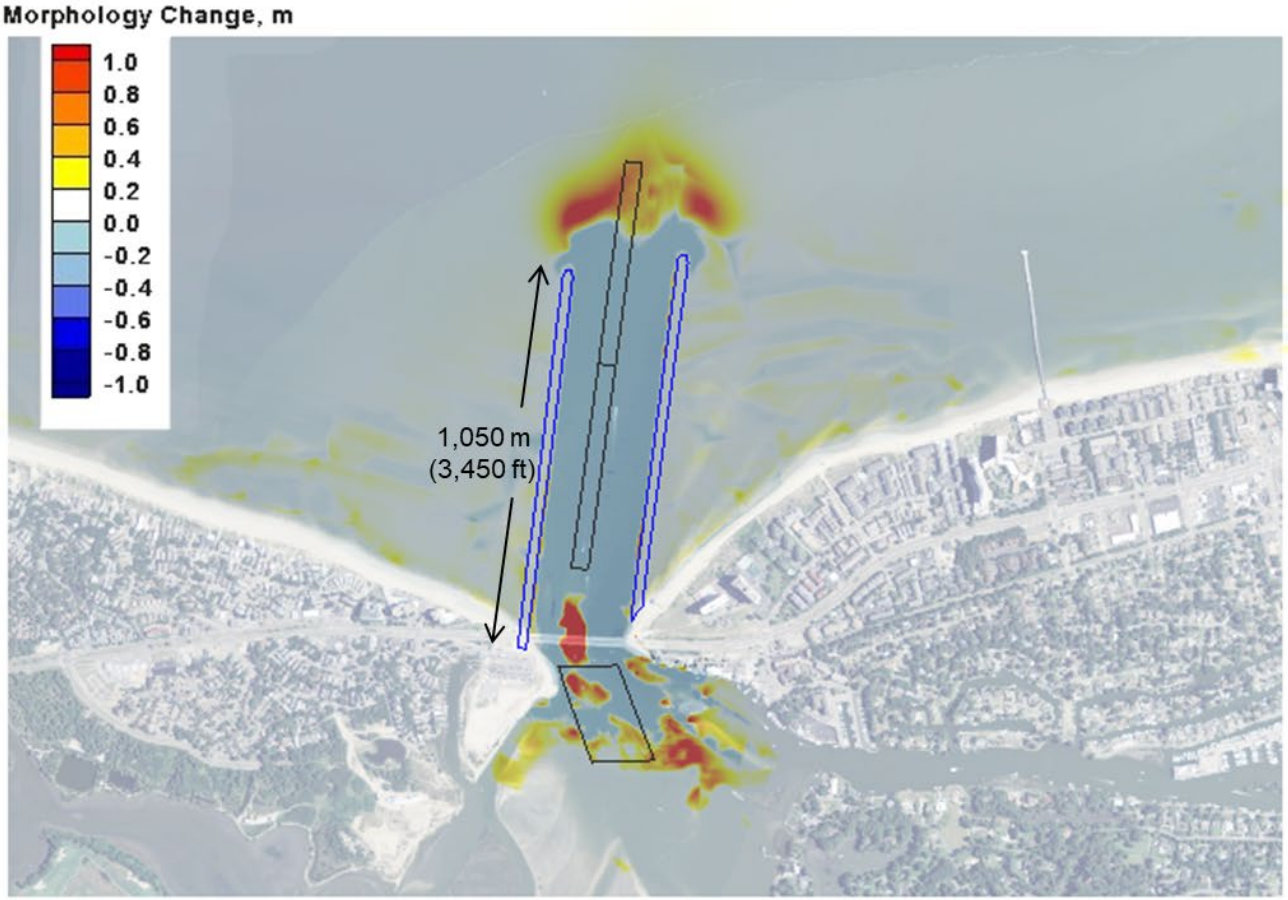


Alt 2 (West Jetty only, 915 m long)



Alt 3 (Dual Jetties, each 455 m long)

Model Morphology Change for 2014 Alt 4 (Long Dual Jetties)



Alt 4 (Dual Jetties, each 3,400' long and extends baywards to 12' contour, MLLW)

Model Channel Shoaling (CY) for 2014

Channel Segment	Alt 0 No Action	Alt 1 Deepening Channel+	Alt 2 West Jetty only, 3,000' long	Alt 3 Dual Jetties, each 1,500' long	Alt 4 Dual Jetties, each 3,400' long
Outer Bar Channel	6,800	6,200*	16,900	10,900	5,900
Ebb Shoal Channel	1,900	12,400*	3,700	400	0
Turning Basin	50	0	4,800	7,900	8,100
Total	8,750	18,600	25,400	19,200	14,000

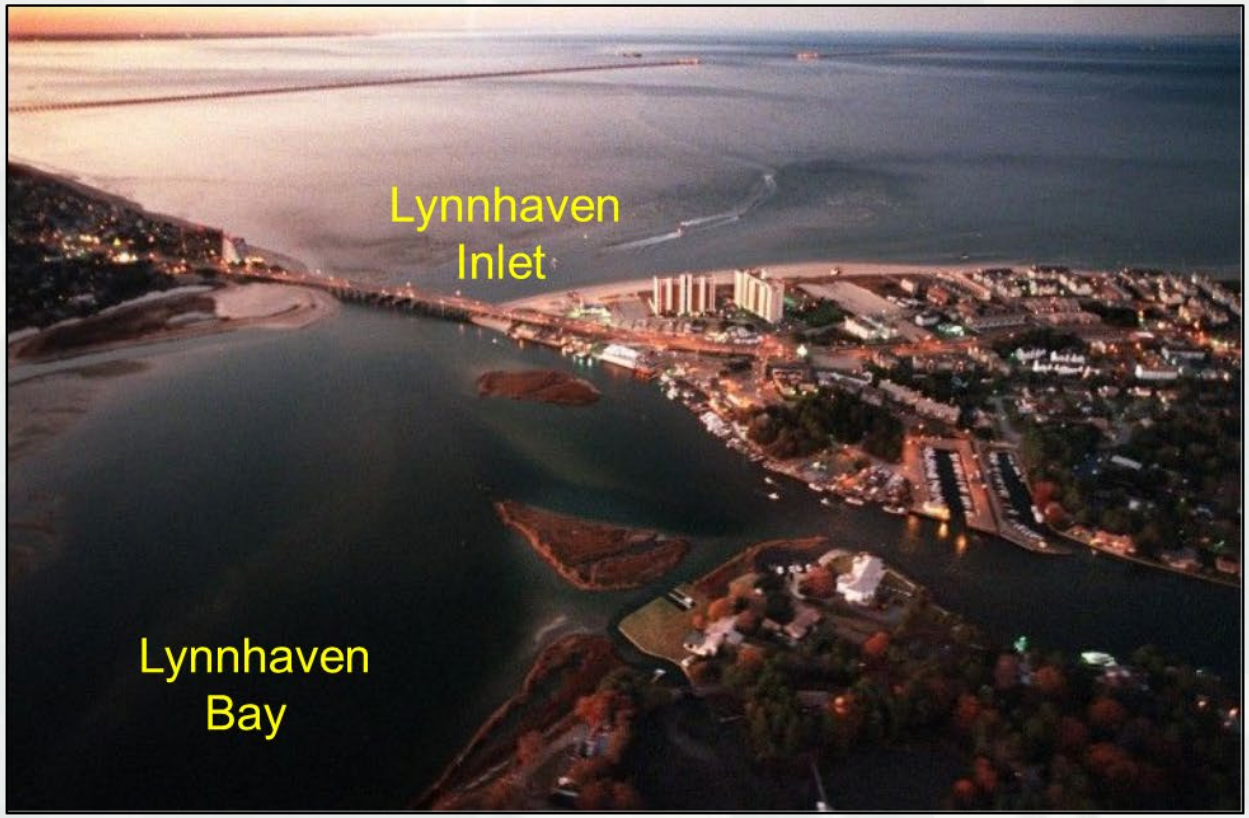
+ Alt 1 is deepening 46 m wide channel from 3 to 5 m, MLLW (total volume removal ~ 200,000 CY)

* Average and max sediment accretions in the channel are 0.33 and 0.6 m, respectively

Summary & Conclusions

- US Army Engineer CIRP is teamed with Norfolk District to investigate the impacts of structural and non-structural alternatives to reduce shoaling rate at Lynnhaven Inlet, Virginia Beach, USA.
- The ERDC Coastal Modeling System models are used to simulate the existing inlet and four other alternatives including over-dredging channel and construction of inlet jetty structure(s).
- Model results show the over-dredging alternative (Alt 1) could have the advantage to reduce dredging cycles over the existing condition (Alt 0). Alt 4 with dual long jetties will reduce dredging cycles but appears not a feasible option due to low benefit-cost ratio.
- The modeling of alternatives was conducted for a typical average year without major tropical storms. Future modeling study should be conducted for severe tropical events which may promote excessive shoaling rates.

Thank you!



Questions?

Lihwa Lin, Email: Lihwa.Lin@usace.army.mil
Zeki Demirbilek, Email: Zeki.Demirbilek@usace.army.mil