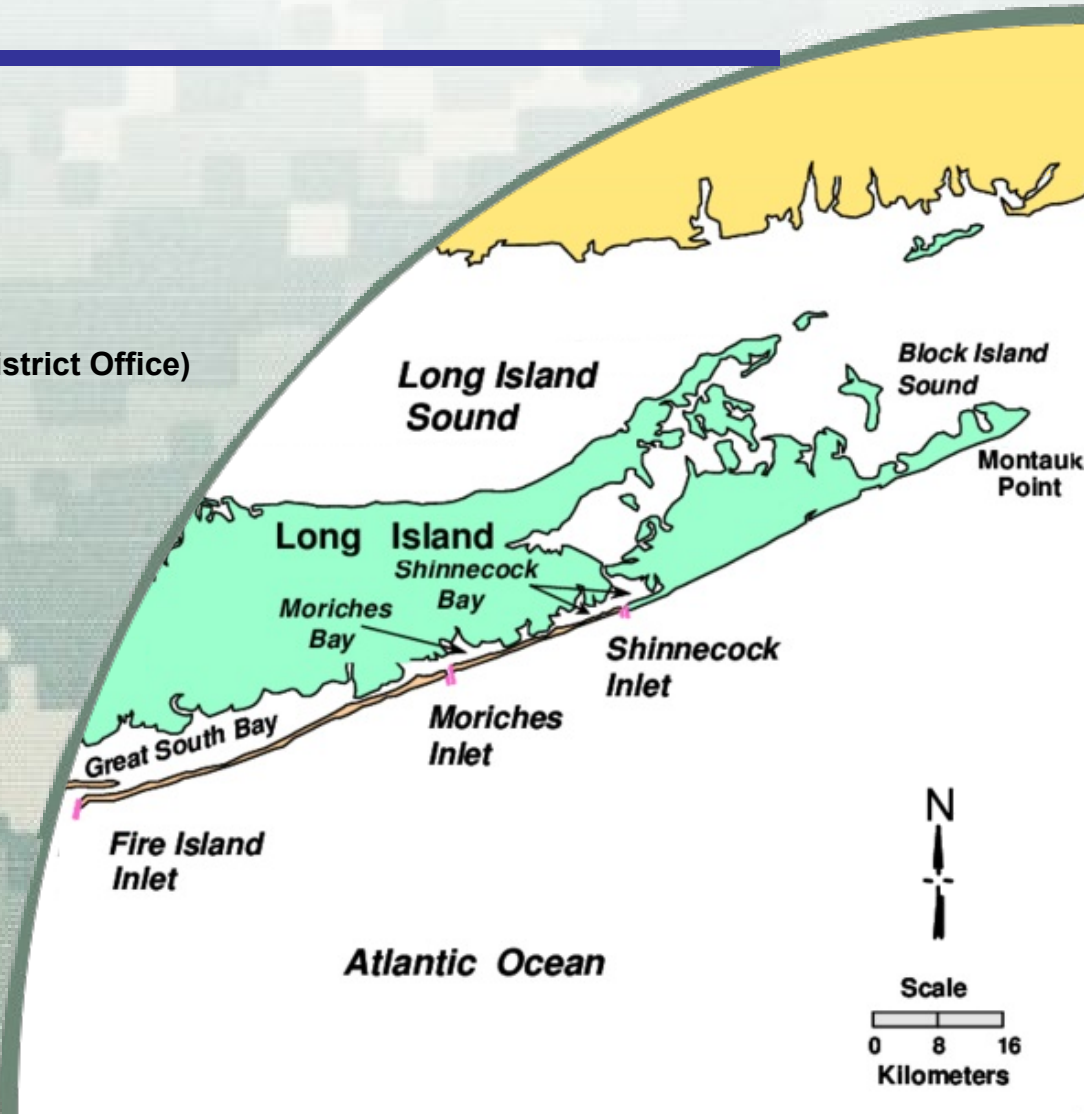
Numerical Modeling of Fire Island Inlet to Montauk Point, New York, for Coastal Erosion Control and Design Support

ERDC
Engineer Research & Development Center

Lihwa Lin and Zeki Demirbilek,
USACE ERDC

Elisheva Greenblatt and Suzana Rice
USACE NAN (North Atlantic Division, New York District Office)

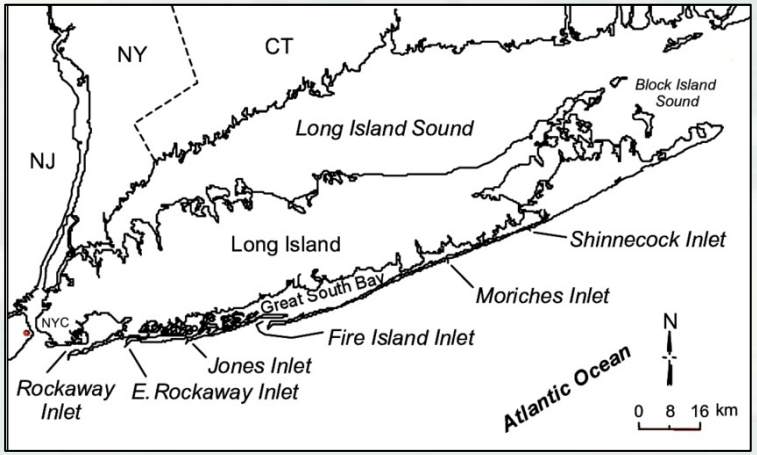


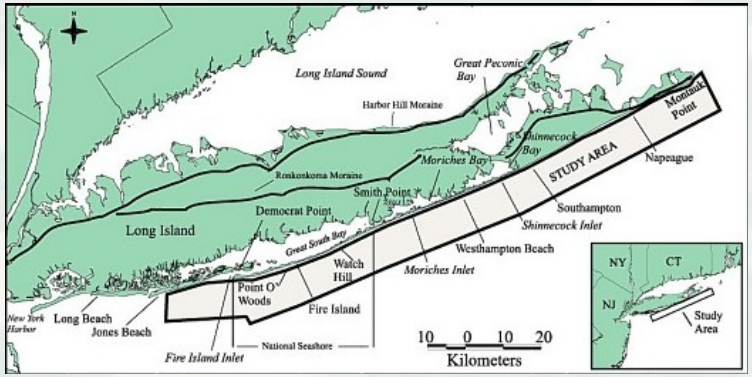
CIRP Technical Discussion
24 May 2022

US Army Corps of Engineers®

Background

- The Fire Island Inlet to Montauk Point (FIMP), New York, (a distance of about 83 miles) combined beach erosion control and hurricane protection project was authorized by the River and Harbor Act of 1960.
- Super storm Hurricane Sandy (2012) has made substantial damage and coastal erosion in the FIMP. Post-Sandy measurements of beach and dune volume loss on Fire Island indicated that the local beach lost ~ 4.5 million cubic yards of sand or 55 percent of its pre-storm volume.
- The net longshore transport, approximately 120k to 250k cubic yards (yd) per year, is directed westward along the south shore of Long Island.
- Local beaches have faced persistent erosion and required periodic nourishment projects.



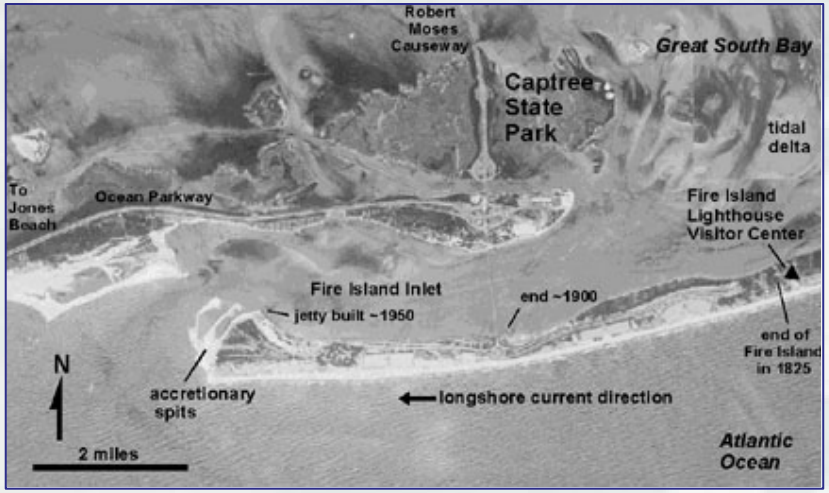


BUILDING STRONG®

Innovative solutions for a safer, better world

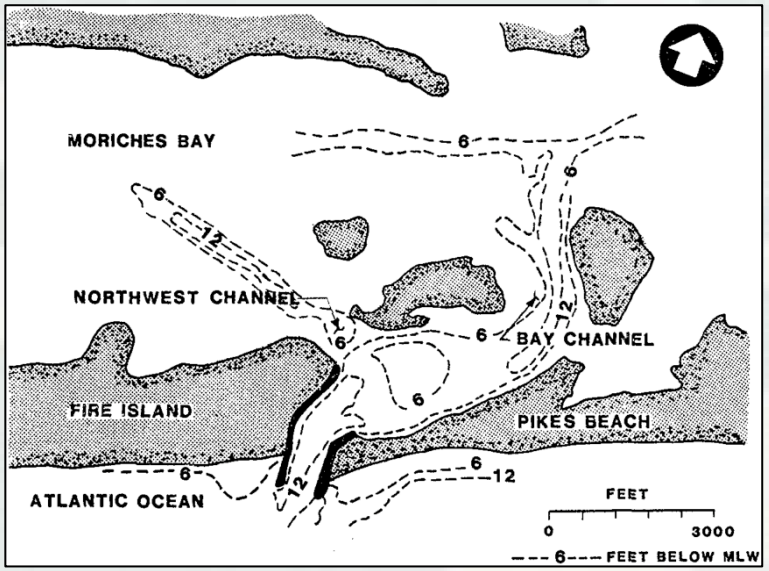
Three Major Inlets in FIMP

- Fire Island Inlet is the primary outlet for the Great South Bay connecting to the Atlantic Ocean. Fire Island was extended westward at ~200 ft per year prior to the Federal Jetty completed in 1941 (the northern segment was quickly damaged and rebuilt in 1950).
- Moriches Inlet is a narrow pass, created in 1931 by a strong Nor'easter, connecting Moriches Bay and Atlantic Ocean. It was stabilized and protected by a pair of rocky jetties built in 1952-1953.
- Shinnecock Inlet, opened during a great hurricane in 1938, cuts through Long Island outer barrier and connects Shinnecock Bay and Atlantic Ocean. It was protected by a pair of jetties constructed in 1953.



Modeling Challenges

- Model domain(s) – dealing with a multi-bay (three large bays) and multi-inlet (three main inlets) system.
- High-energy coast – a long stretch of open-coast shoreline with year-round high-wave energy from the Atlantic Ocean. Often large wind waves generated in the bay.
- Large tidal prisms with strong flow currents through inlets. Varying sediment size and characteristics along the coast and in bays.
- Natural sand bypass at inlets creating flood and ebb shoals with inlets.
- Shoreline and bathymetry data for modeling.
- Available field data (wind, wave, current, and water level measurements) for modeling.



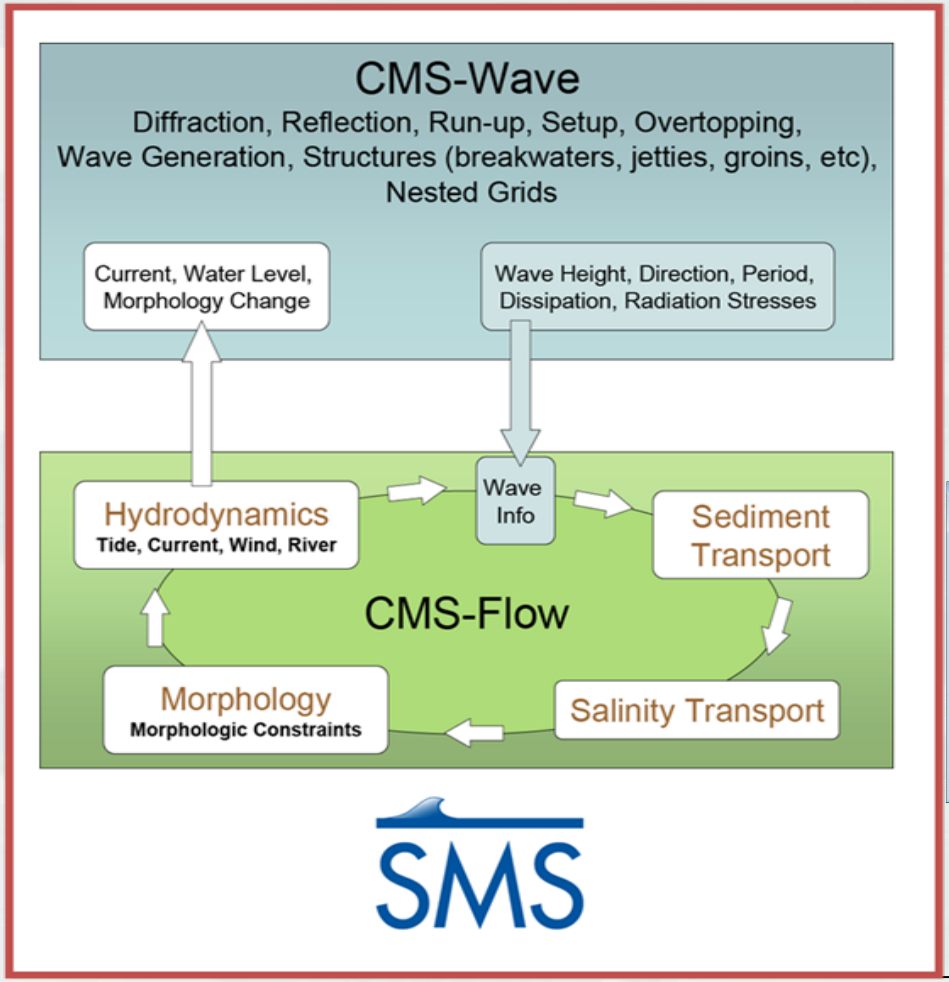
Available Field Data for the Study

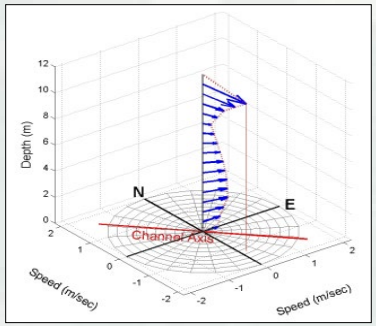
- NOAA coastal stations SDHN4 and MTKN6 (long-term wind, air pressure & water level data).
- NDBC coastal buoys 44069 (wind data), 44017, 44025 and 44065 (wind, air pressure & wave data).
- USGS coastal stations 01310521, 01309225, 01306402, 01305575, 01304920, 01304746 (wind & water level data)
- NOAA Coastal Relief Models (DEM) and 2020 Lidar data, USACE recent channel surveys (2011 - 2022).

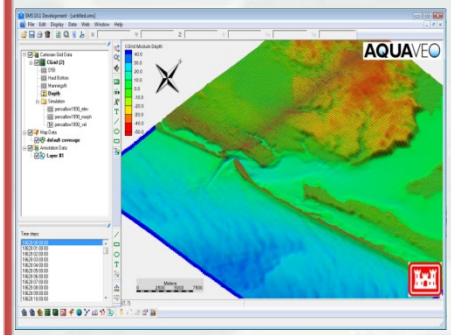
Field data collection program (2021-2023)

Numerical Models

Coastal Modeling System (CMS)

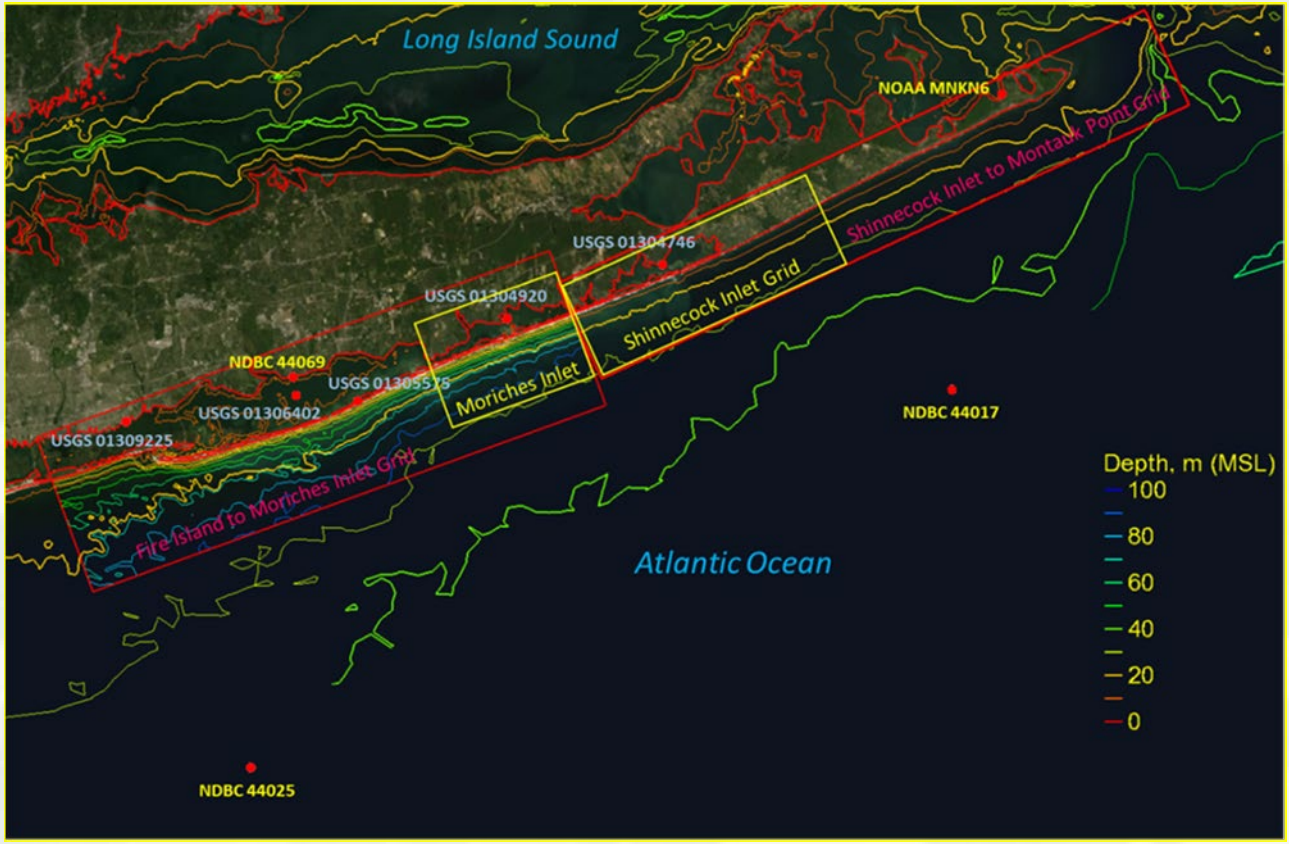






- A suite of time-dependent flow, salinity, wave, & mixed sediment transport models
- Physics-based to simulate complete coastal processes
- Integrated with visual interface thru Surface-water Modeling System (SMS)

CMS-Wave Model Grid Domain



CMS Fire Island Inlet to Montauk Point CMS Grid system

Variable spacing

~ 15 m around inlet

~ 180 m to offshore

Manning's coefficient

n (bottom friction)

~ 0.014 in the bay

~ 0.025 in the ocean

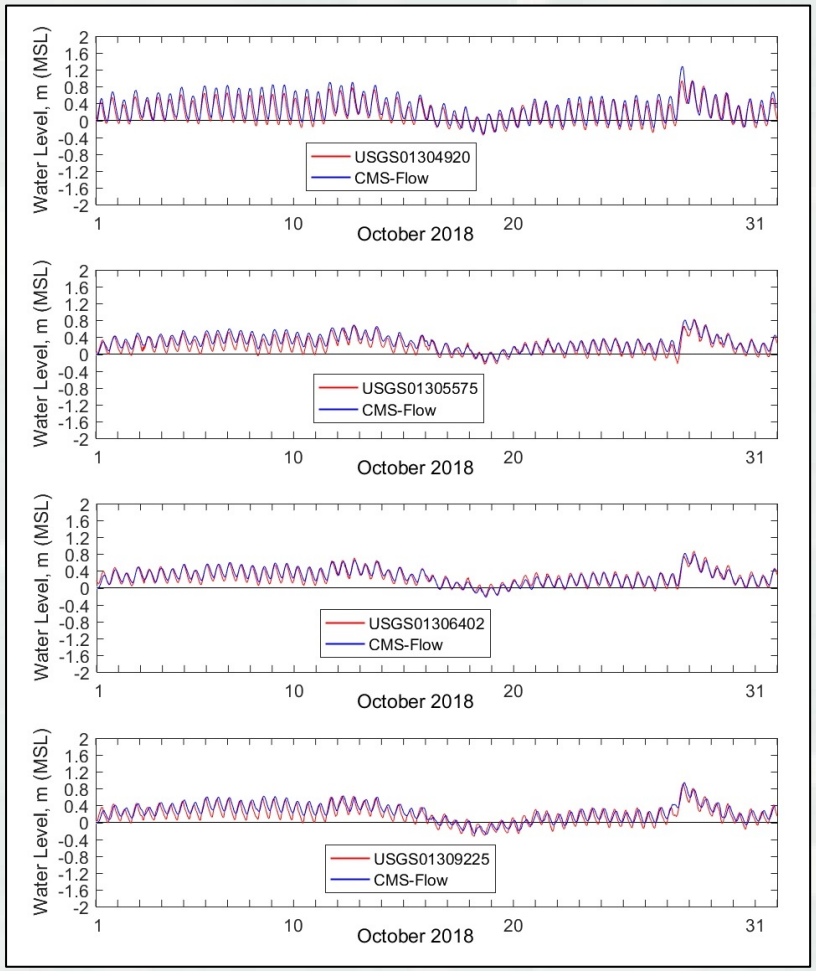
Sand size D50 (mm)

~ 0.25 Fire Island Inlet

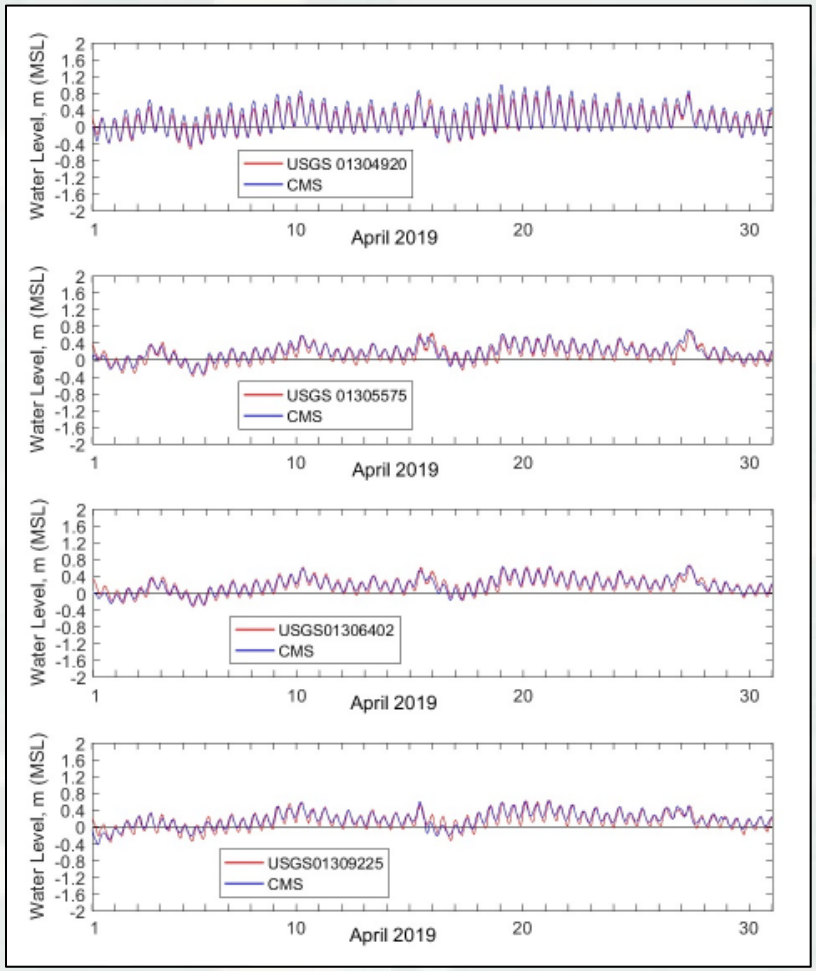
~ 0.4 Moriches Inlet

~ 0.35 Shinnecock Inlet

Model Water Levels and Data Comparison

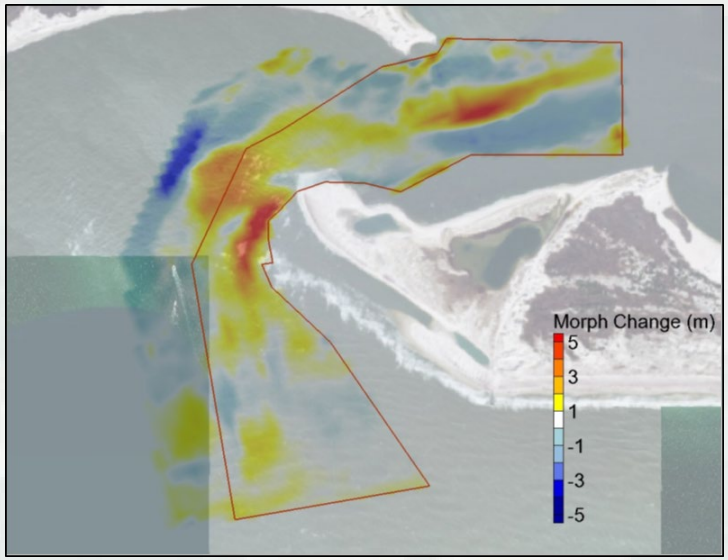


Model Calibration

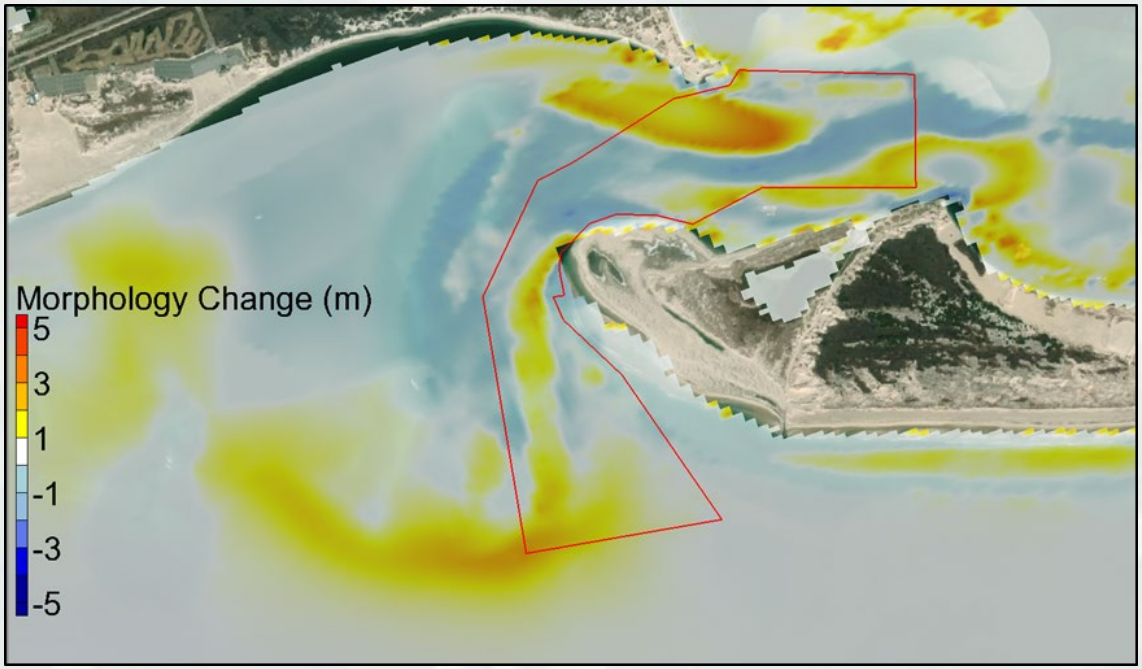


Model Validation

Model Morphology Change versus Data
April 2019 - March 2020



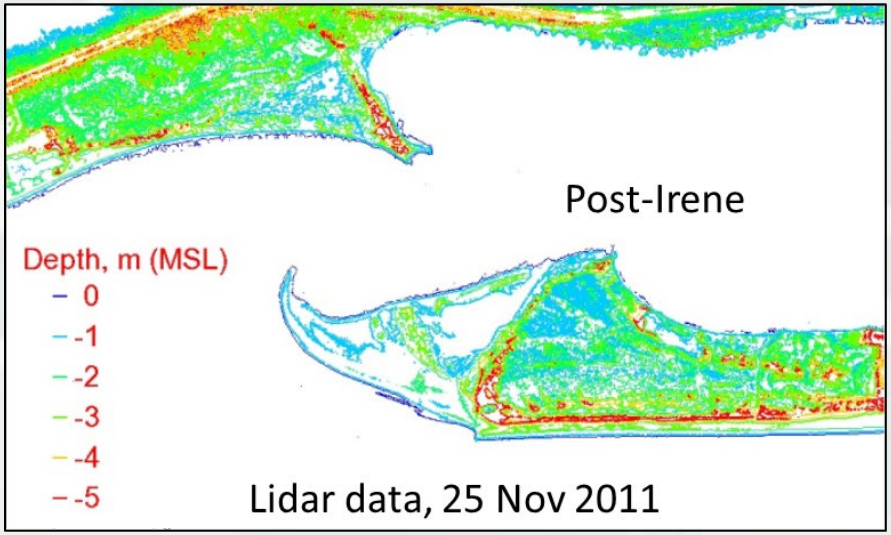
Local bathymetric changes based on NAN April 2019 & March 2020 surveys



Model (12-month) morphology change - bedload dominated according to modeling

(Red polygon covers inlet channel and deposition basin survey area in March 2020)

Aerial Photos (26 May 2011, 3 Nov 2012) Lidar Data (Nov 2011)



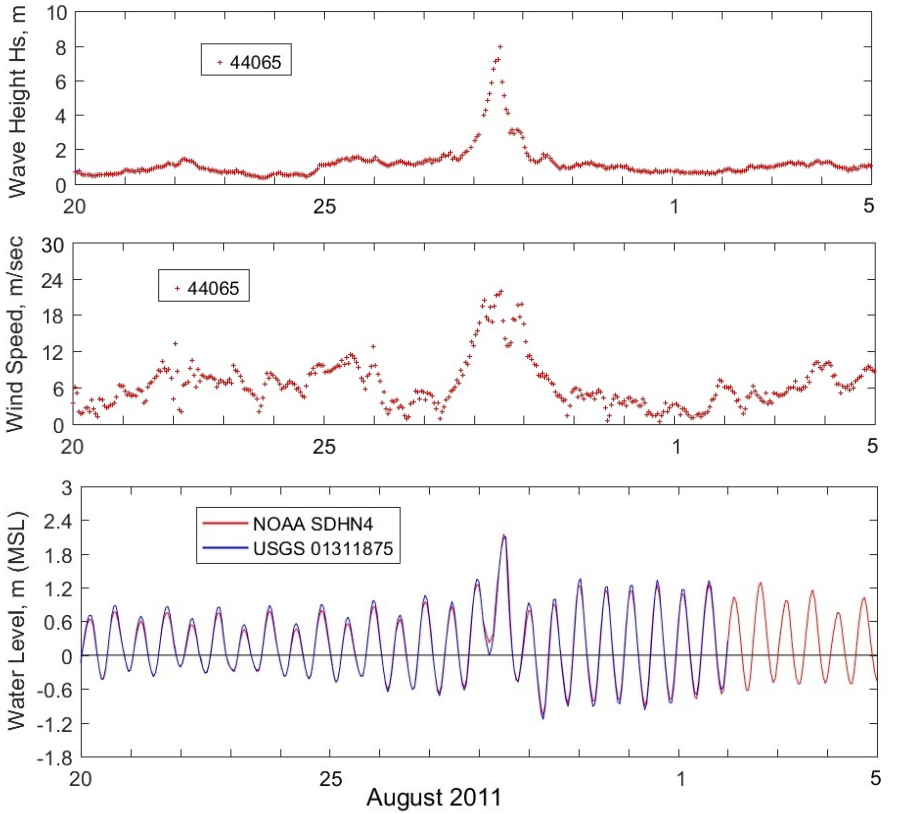
Hurricane Irene (22 Aug - 1 Sep 2011)

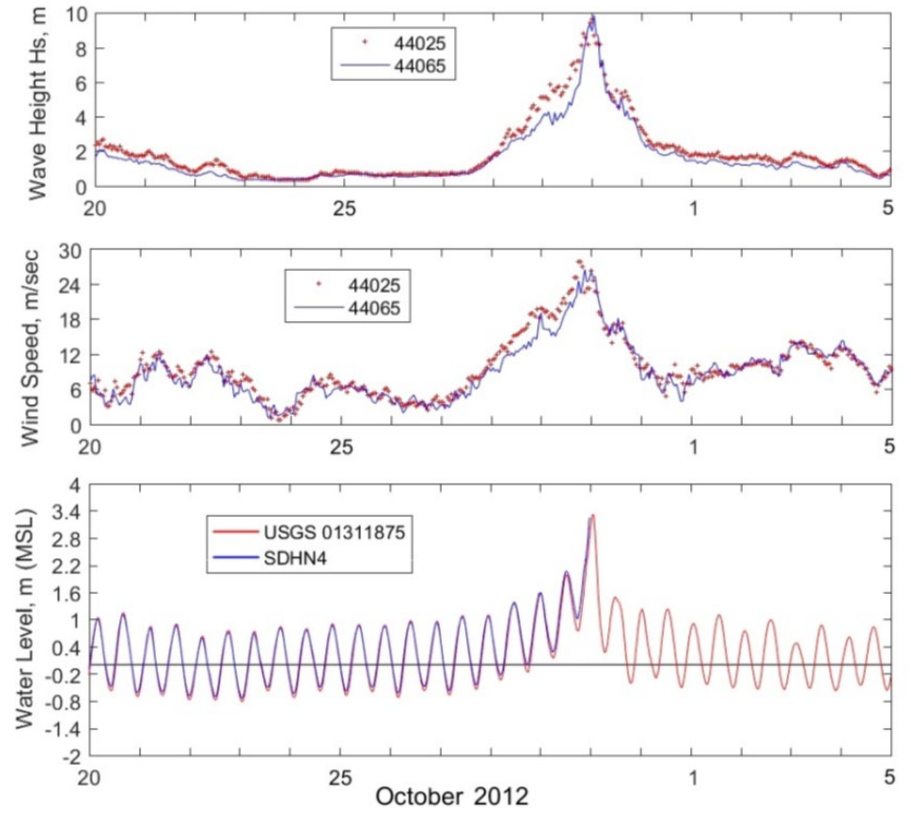
Hurricane Sandy (23 Oct - 2 Nov 2012)

Additional pre-Irene & pre-Sandy Lidar data

- Aug 2010
- Dec 2011 - Feb 2012

Model Input Data for Irene & Sandy



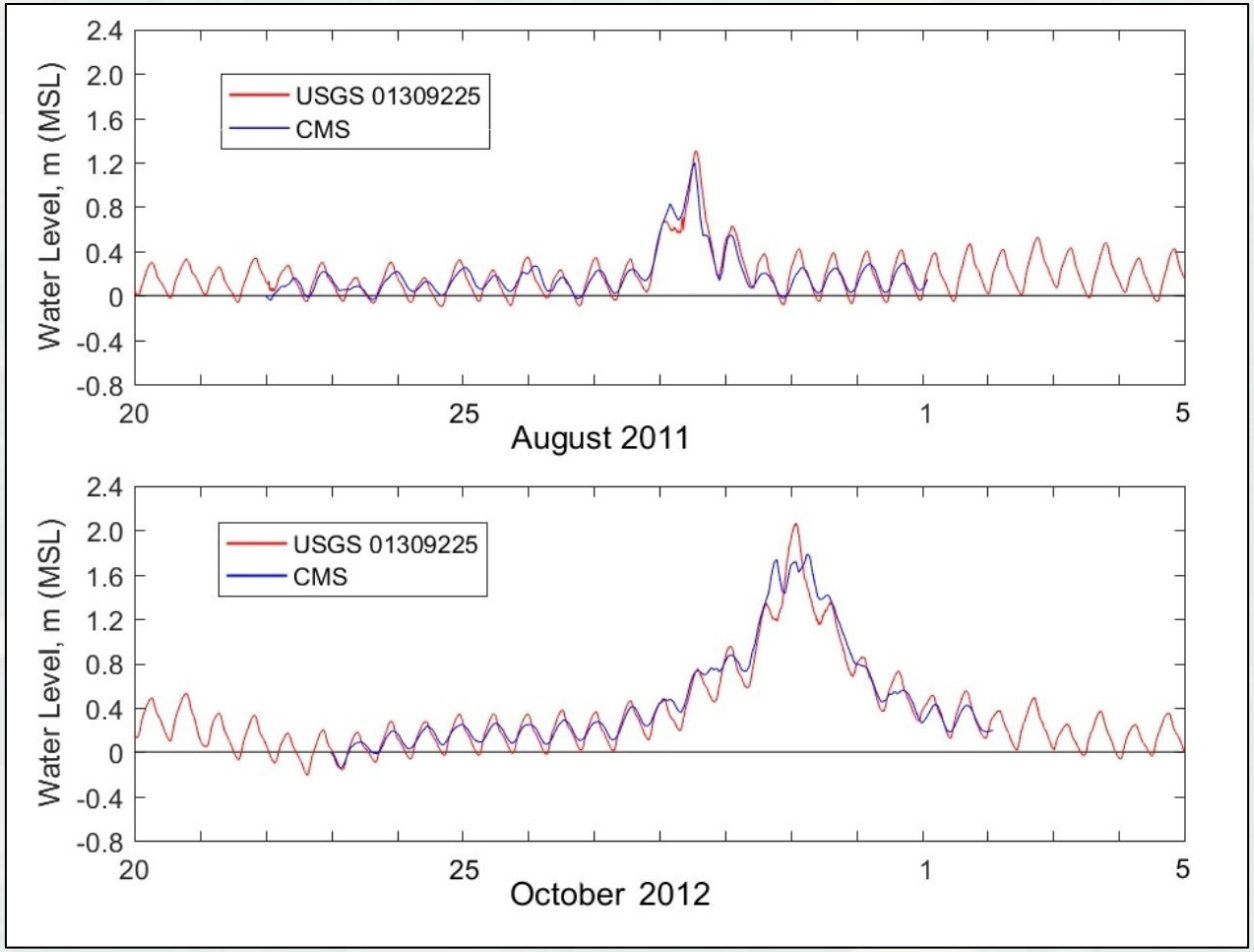


Wind, wave, and Water Level forcing for Irene

Wind, wave, and water level forcing for Sandy

(USGS 01311875 is located at the Rockaway Inlet to Jamaica Bay, NY)

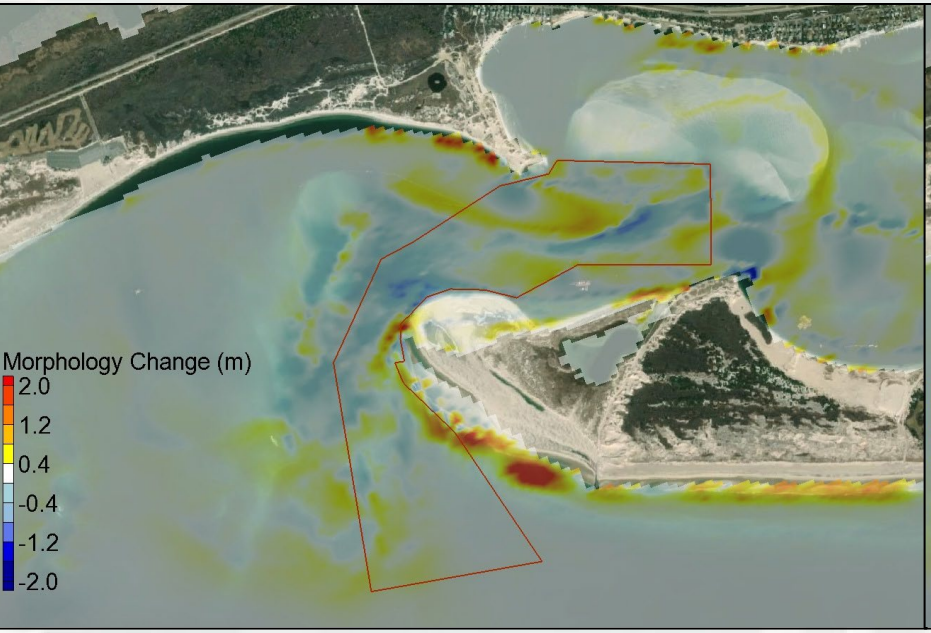
Model Water Level and Data Comparison for Irene and Sandy



(USGS 01309225 is located at the northwest shore of Great South Bay)

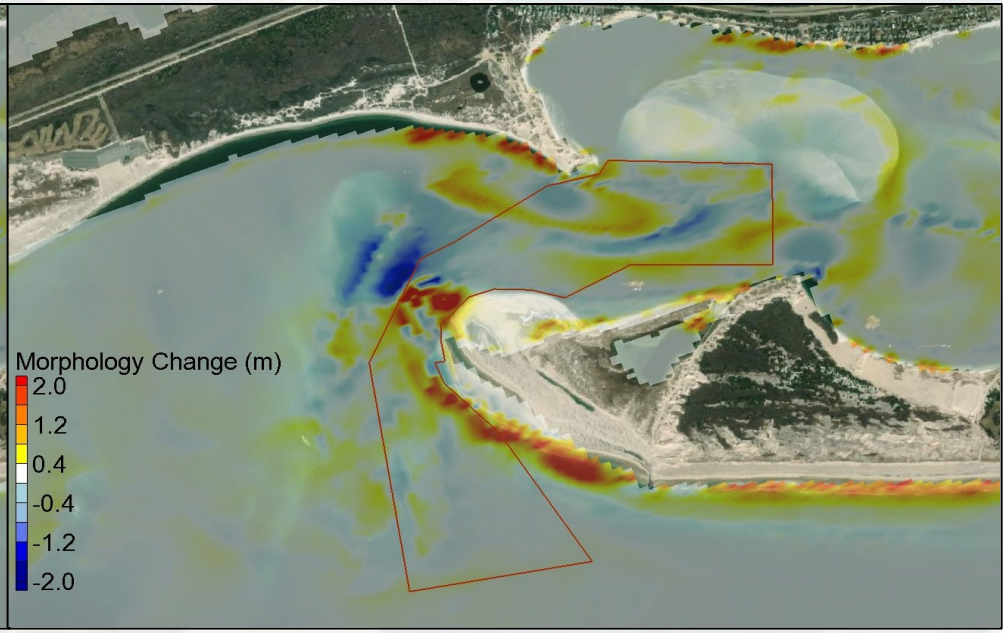
Model Morphology Change for Irene and Sandy

Model Irene (22 Aug - 1 Sep 2011)



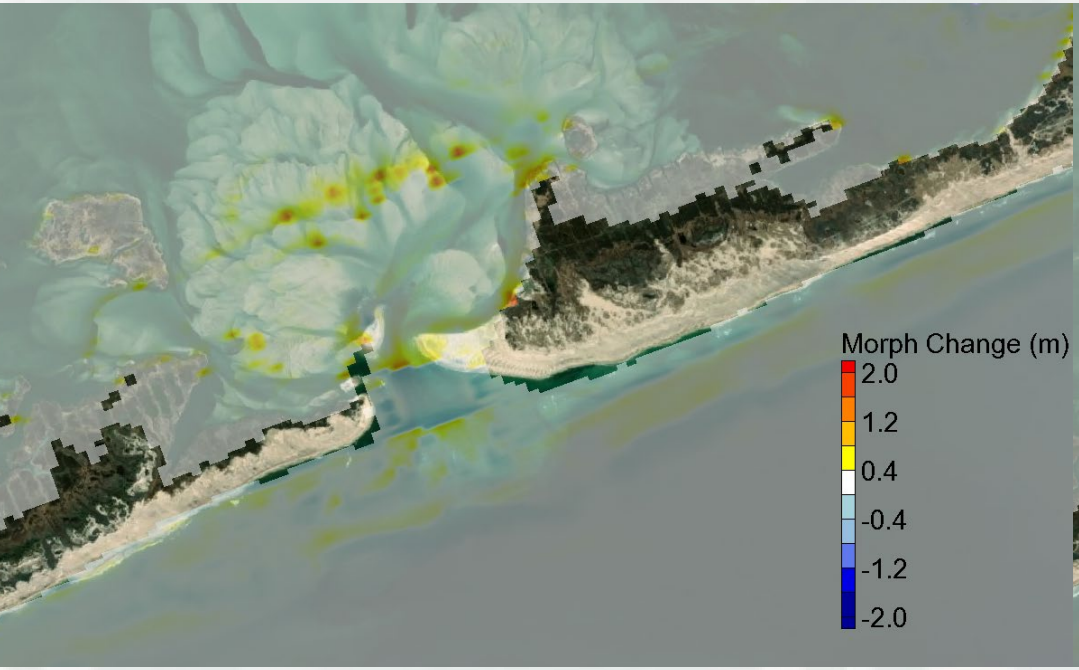
Total volume accretion in the inlet
And deposition basin (red polygon)
~ 148,000 m^3 (10-day simulation)

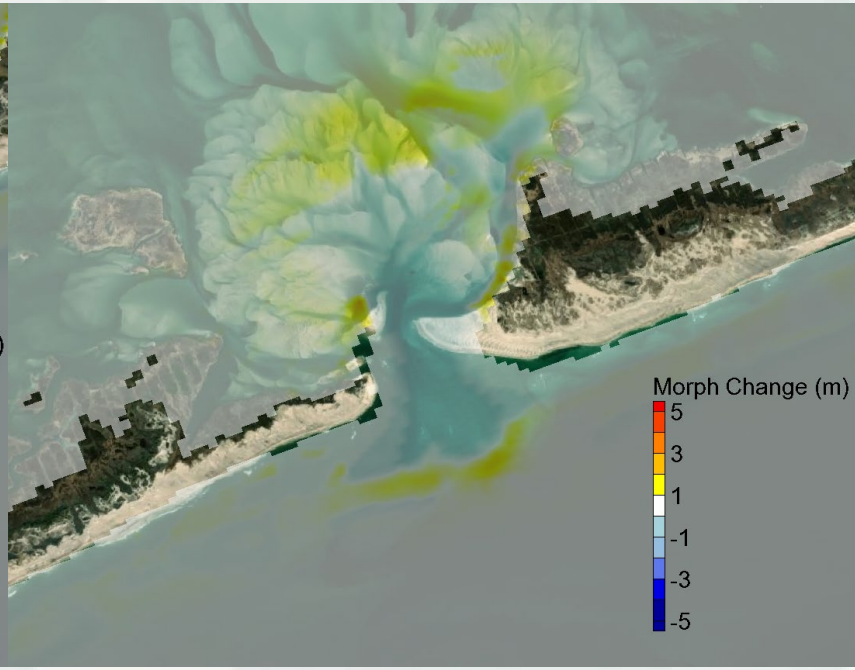
Model Sandy (23 Oct - 2 Nov 2012)



Total volume accretion in the inlet
And deposition basin (red polygon)
~ 256,000 m^3 (10-day simulation)

Model Morphology Change at the Old Inlet (Breaching during Sandy)



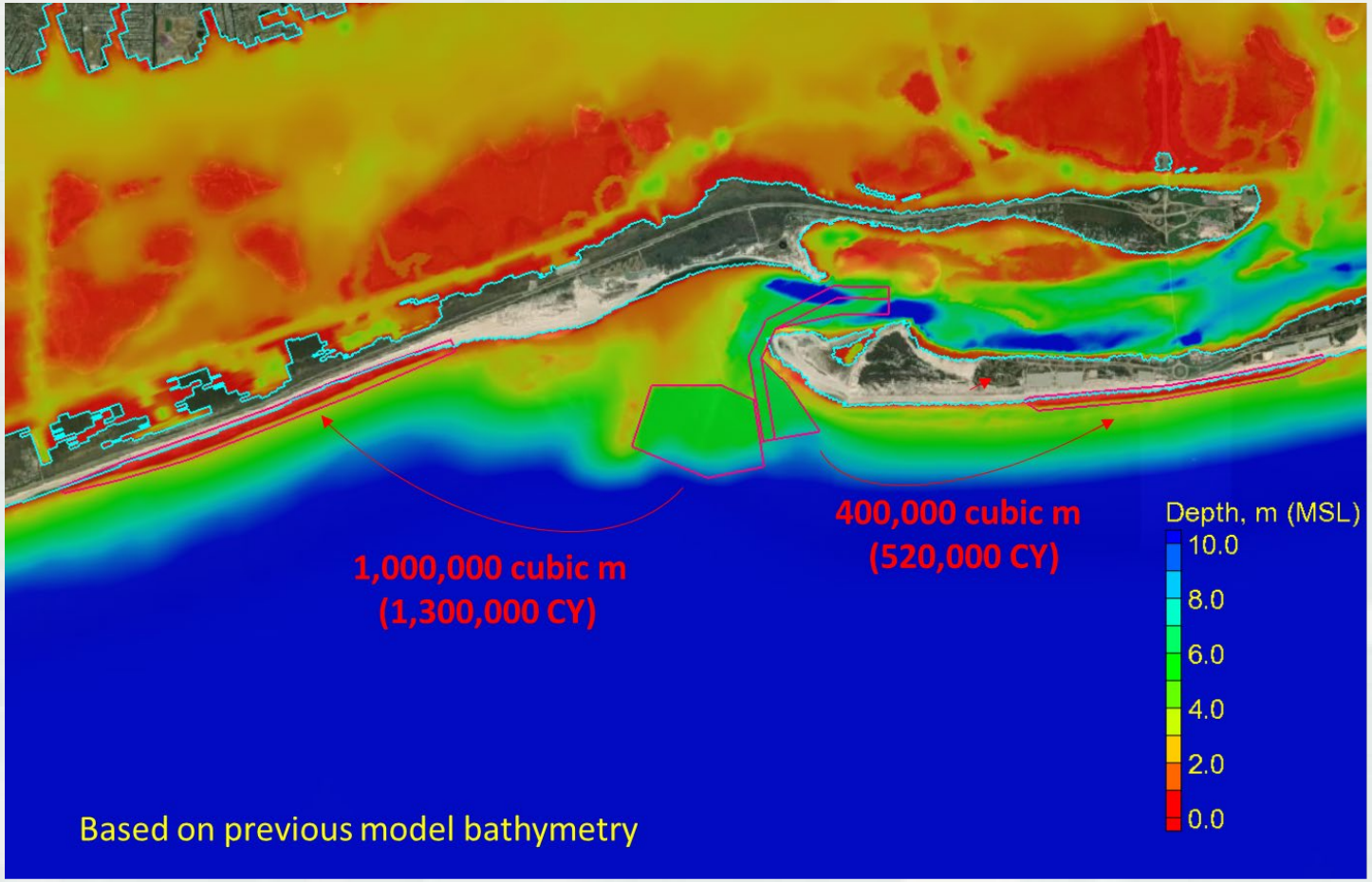


Model 10-day simulation for Sandy

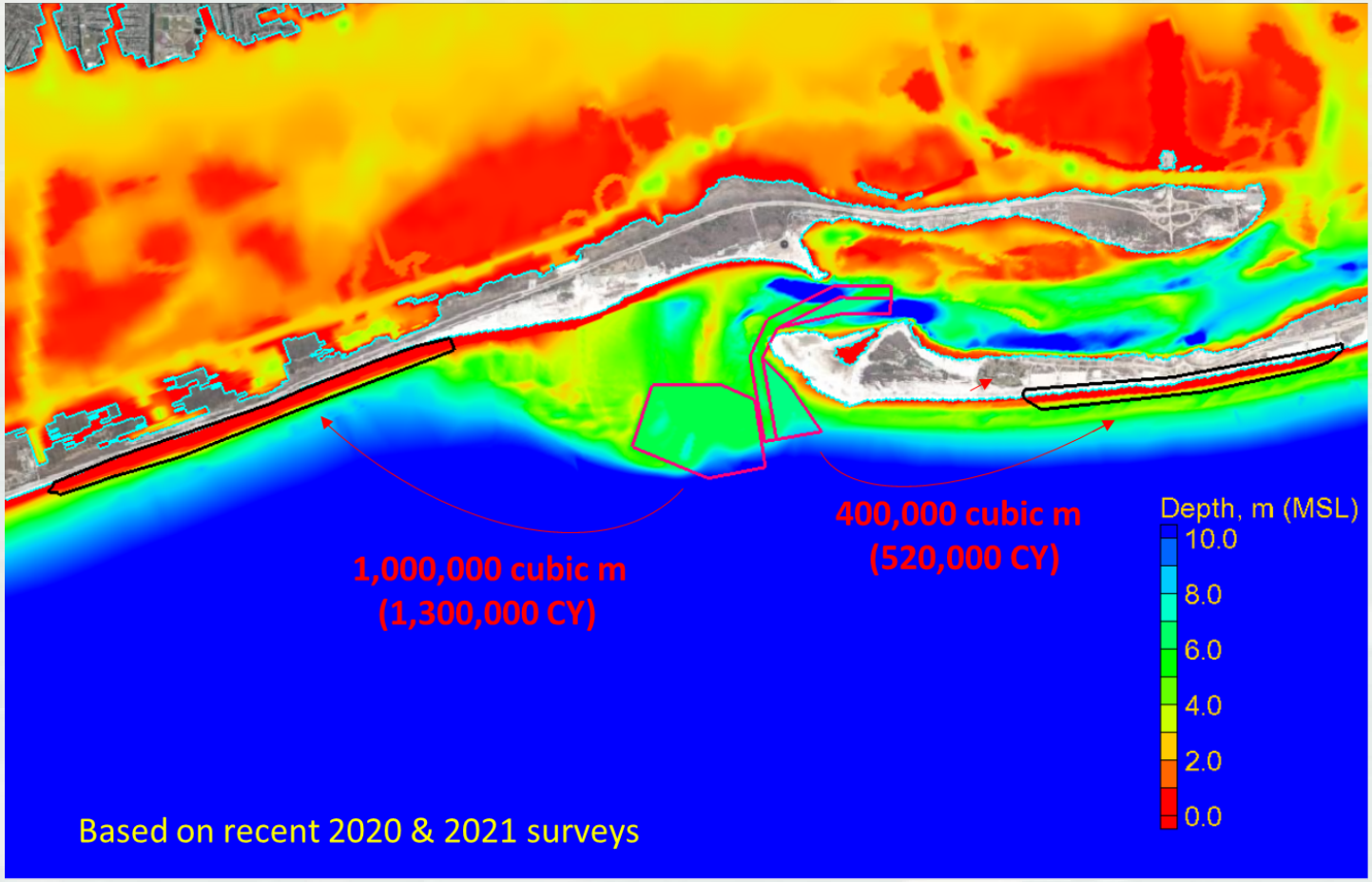
6-month simulation for Apr - Sep 2019

(the Old Inlet is approx. 23 miles east of Fire Island Inlet)

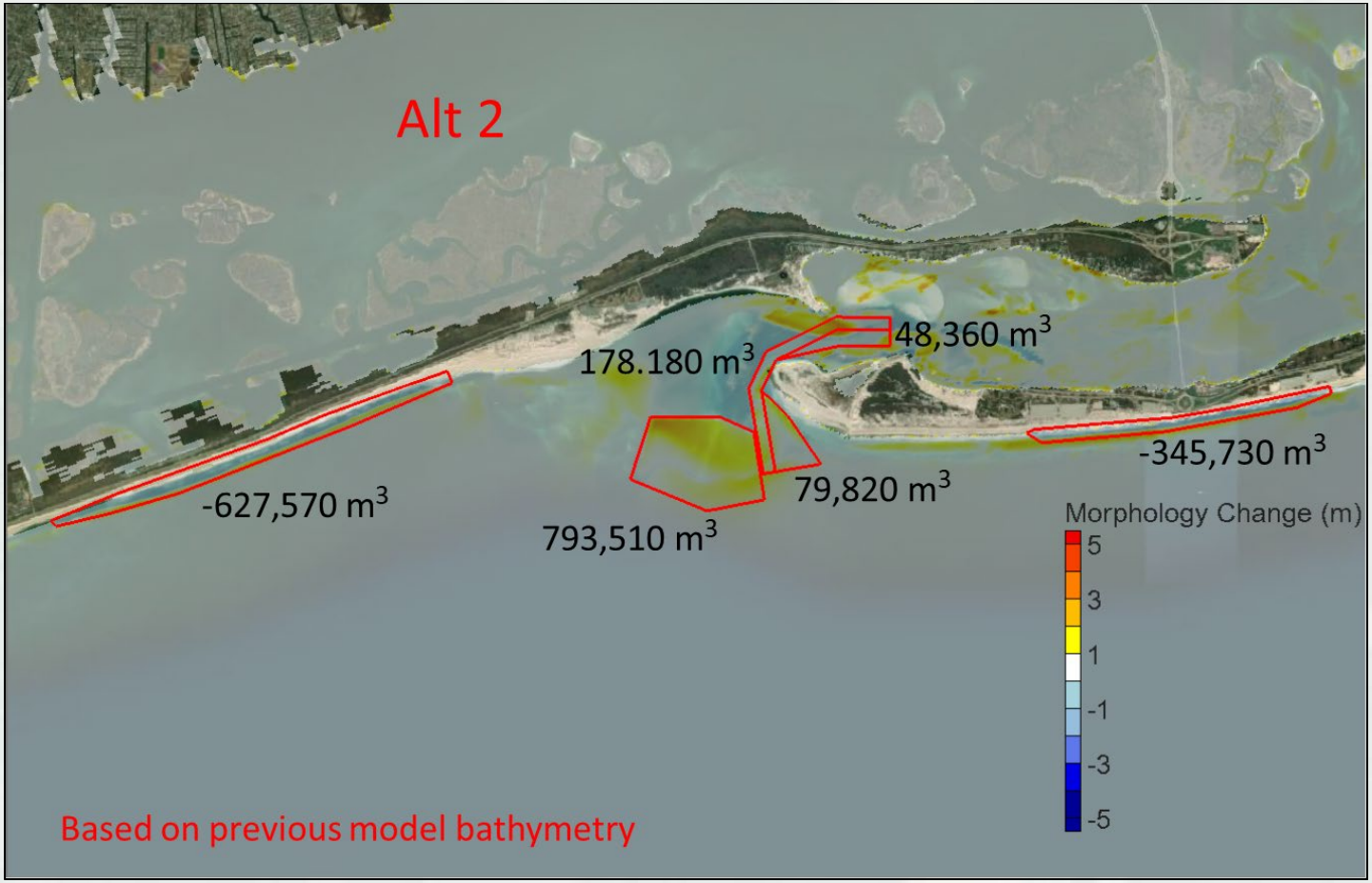
Fire Island Inlet Model Initial Bathymetry Alt 2 (Previous Model Bathy)



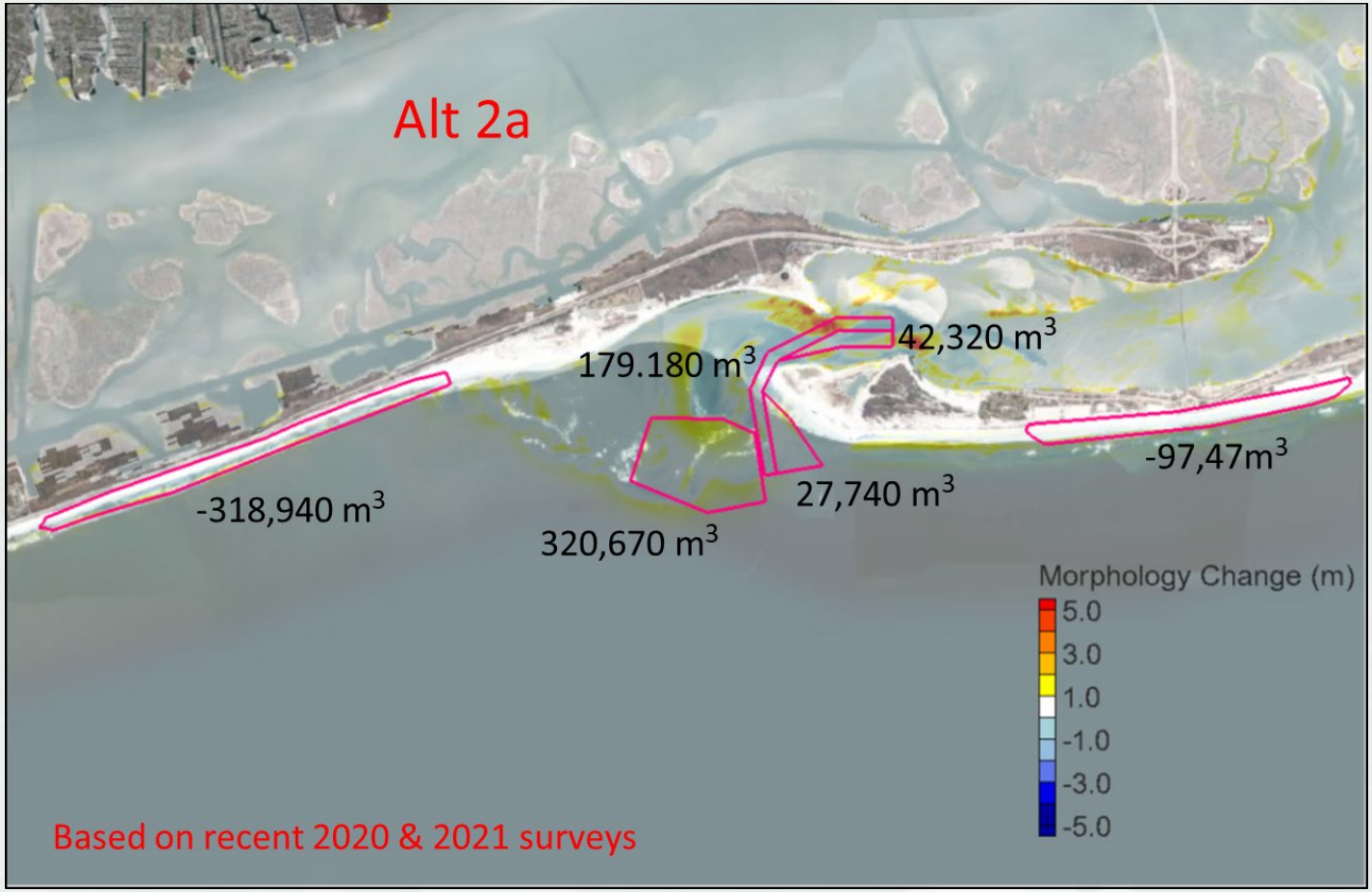
Fire Island Inlet Model Initial Bathymetry Alt 2a (New Model Bathy)



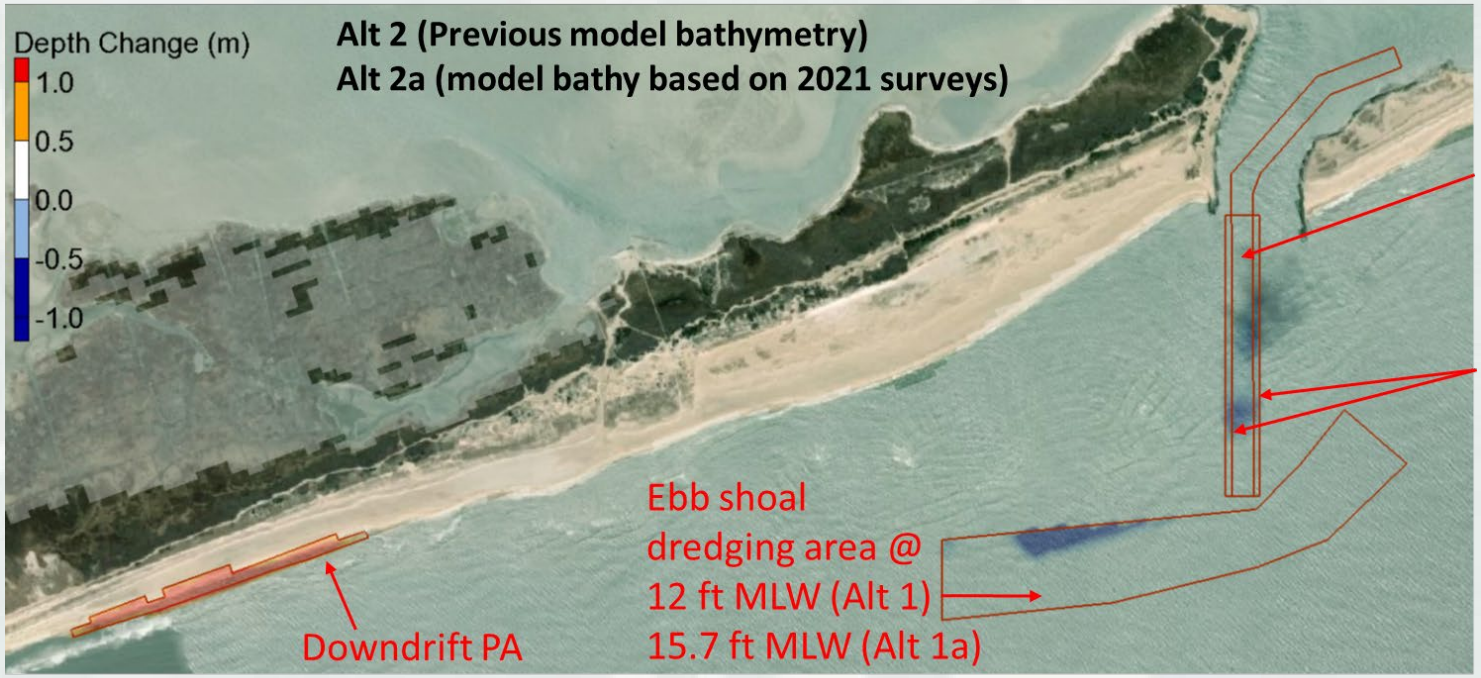
Fire Island Inlet Alt 2 Model 1-Yr Morphology Change (Apr 2019 – Mar 2020)



Fire Island Inlet Alt 2a Model 1-Yr Morphology Change (Apr 2019 – Mar 2020)



Moriches Inlet Alt 2 (Previous Model Bathy) and Alt 2a (New Bathy)

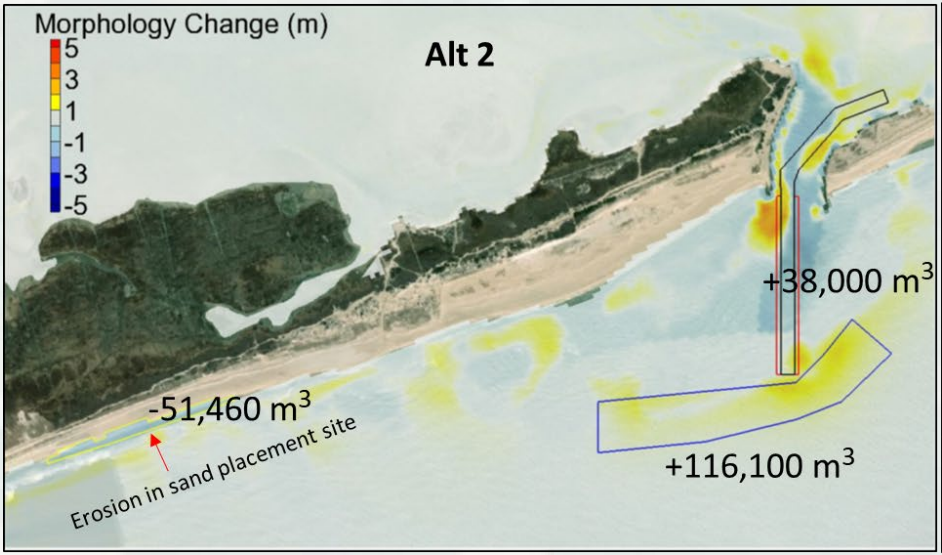


Removal of 17,000 cubic m from channel and deposition basins

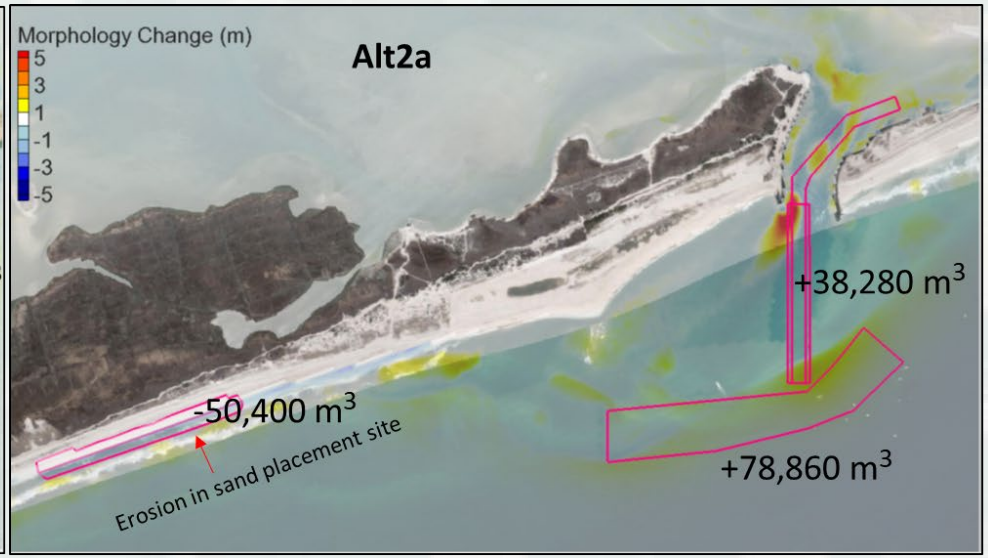
Removal of 27,000 cubic m from ebb shoal sand borrow area

Placement of 44,000 cubic m along downdrift beach west of Smith Point County Park

Moriches Inlet Alts 2 & 2a Model Morphology Change for April 2019 – March 2020 (Sensitivity Test)



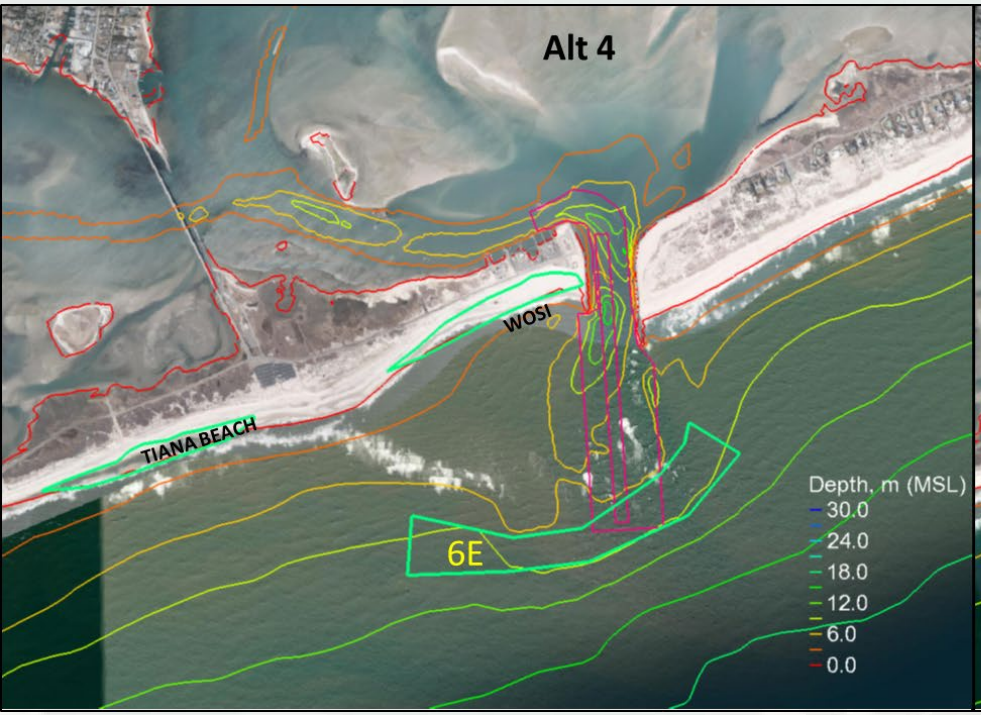
(Previous model bathymetry)

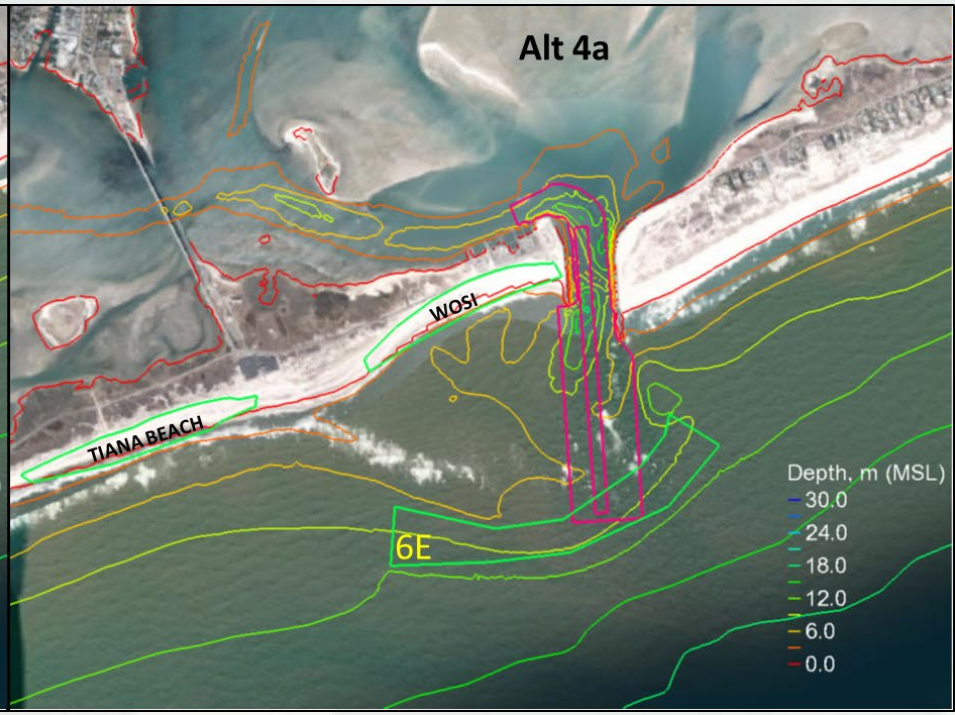


(New model bathy based on 2021 surveys)

Model results show similar inlet channel shoaling and downdrift beach eroding volumes between Alt 2 and Alt2a. The sediment accumulation at the ebbshoal borrow area is much less in Alt 2a than Alt 2 (as the ebbshoal volume in Alt2a is much less than in Alt 2 based on 2021 survey data).

Shinnecock Inlet Alt 4 (Previous Model Bathy) and Alt 4a (New Bathy)





(Previous model bathymetry)

Dredged to depth = 8 m, MSL (~ 213,000 m^3)

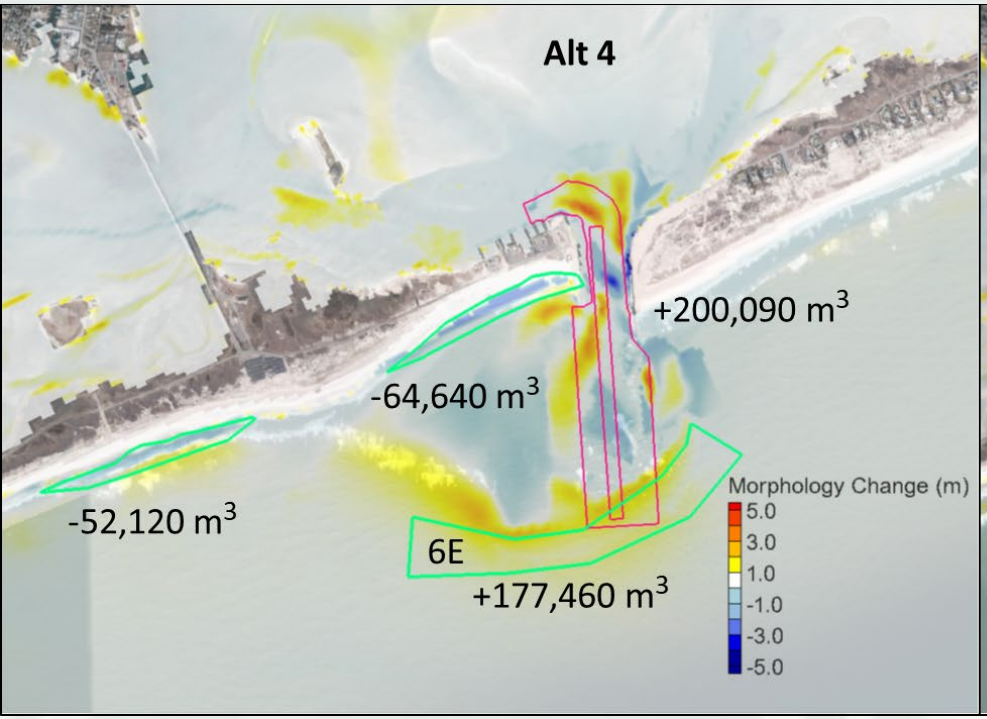
Downdrift beach fill volume ~ 205,000 m^3

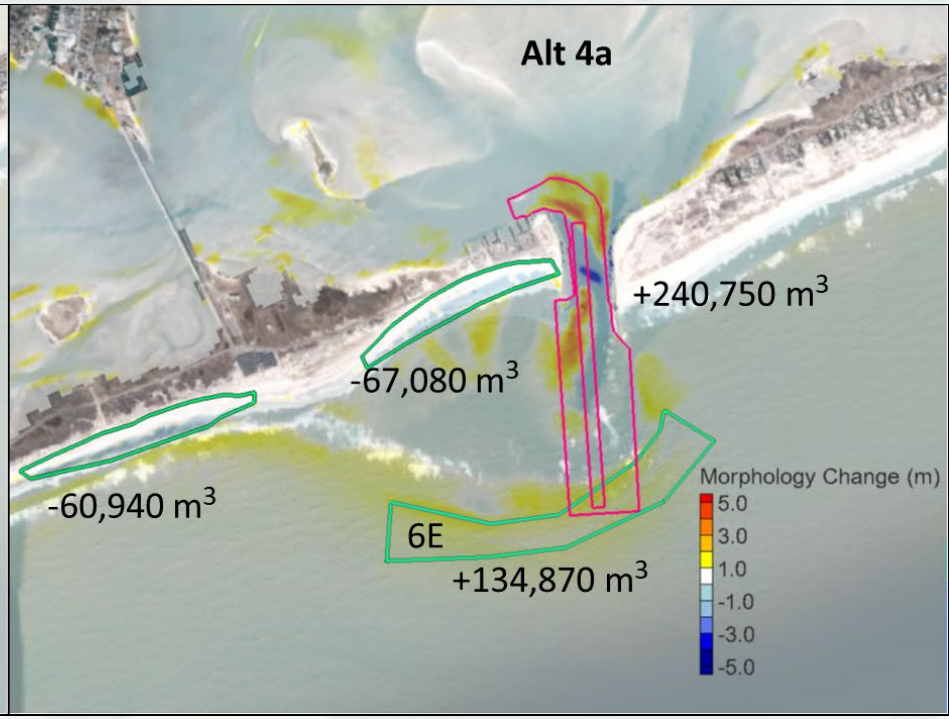
(New model bathy based on 2021 surveys)

Dredged to depth = 8.2 m, MSL (~ 205,000 m^3)

Downdrift beach fill volume ~ 205,000 m^3

Shinnecock Inlet Alts 4 & 4a Model Morphology Change for May 2019 – March 2020 (Sensitivity Test)

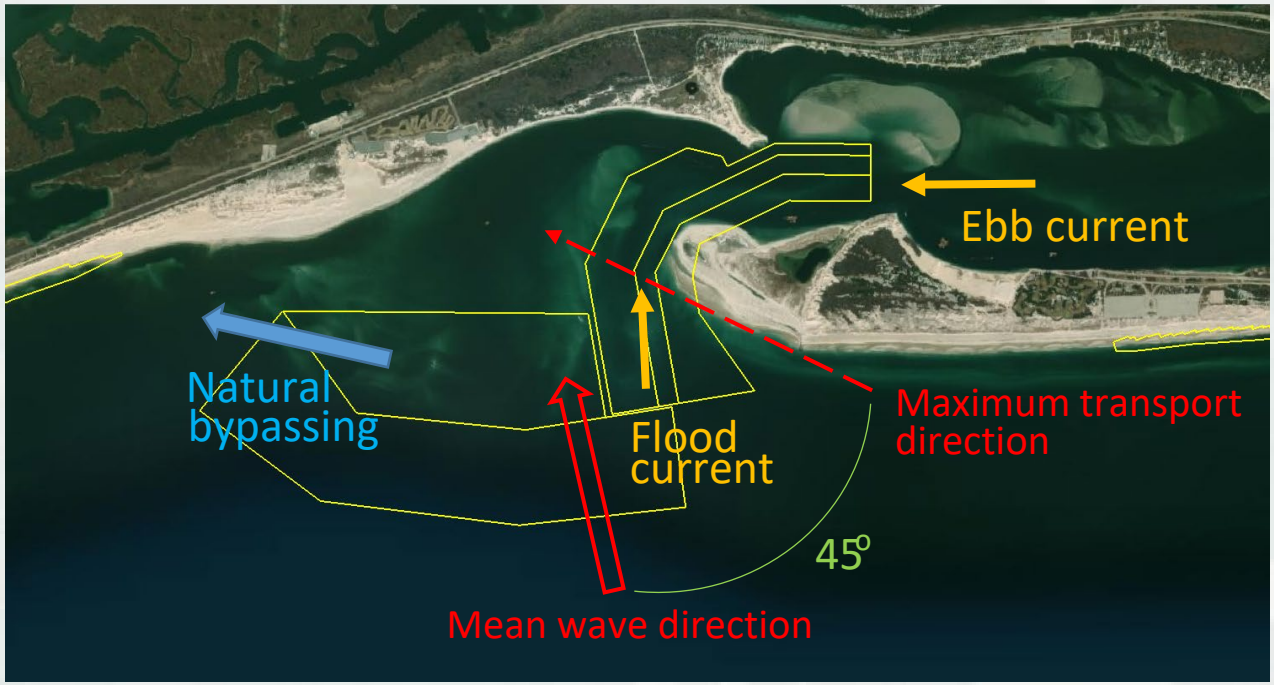




Alt 4 - Outer bar borrow site (6E) with downdrift beach fill
Dredged to depth of 8 m, MSL (~ 213,000 m^3)

Alt 4a – Ebb shoal borrow area (6E) with downdrift beach fill
Dredged to depth of 8.2 m, MSL (~ 205,000 m^3)

Thank you!



Questions?

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