Use of Sediment Mapping to Simulate Transport of Dredging Placed Material at Beaufort Inlet, NC

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CIRP TD
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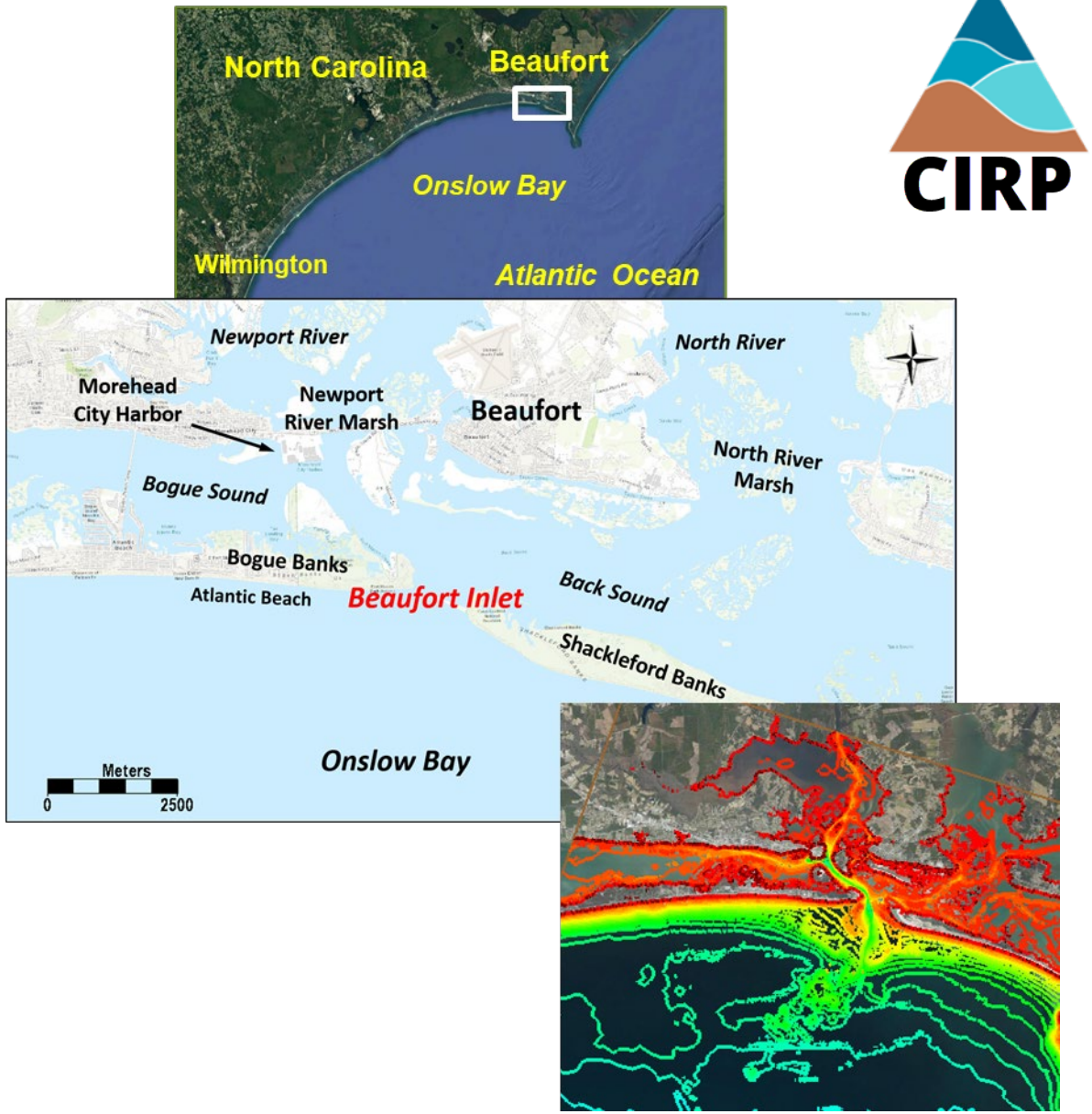
Background

- Beaufort Inlet lies approximately 1.7 miles south of Beaufort, North Carolina, between Bogue Banks and Shackleford Banks, and approximately 1.7 miles wide.
- The maintained channel has a depth of 45 ft (MLLW) and varying width ranging from 450 to 800 ft, reaching 1,350 ft at the harbor.
- The dredged channel extends seaward through inlet ebb shoals to the open ocean and connects to the Morehead City Harbor and the Atlantic Intracoastal Waterway.



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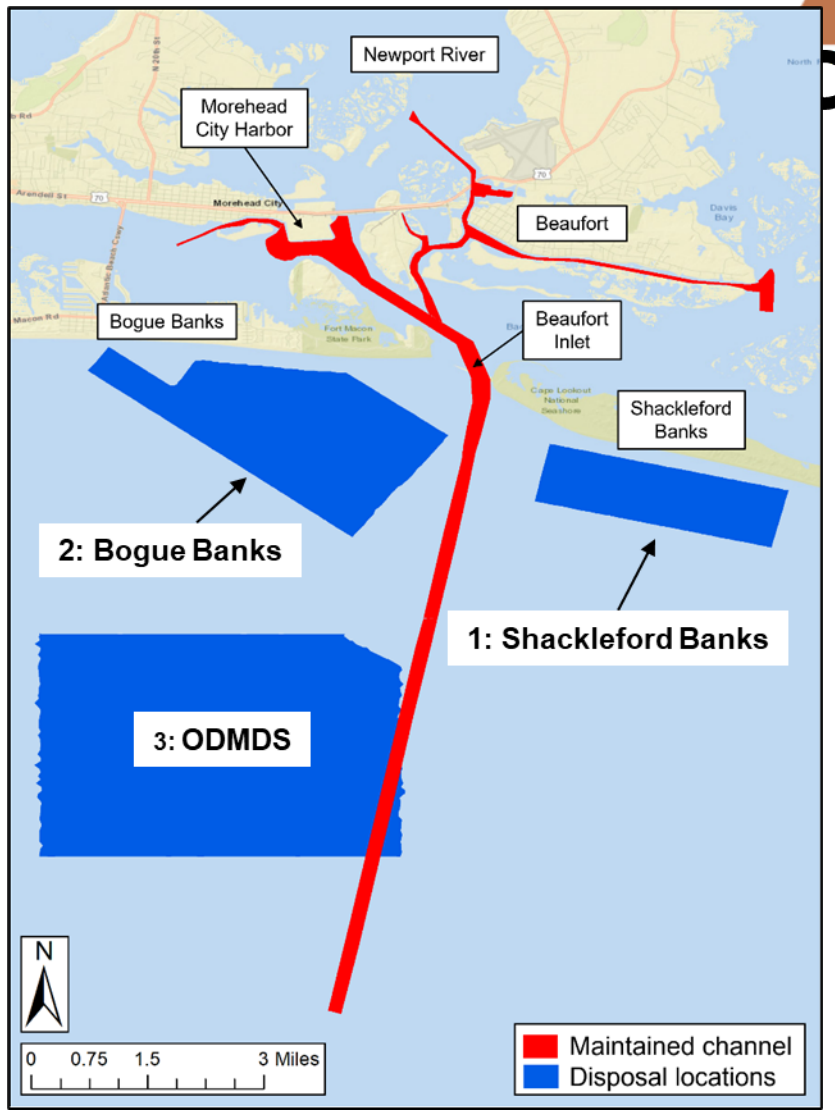
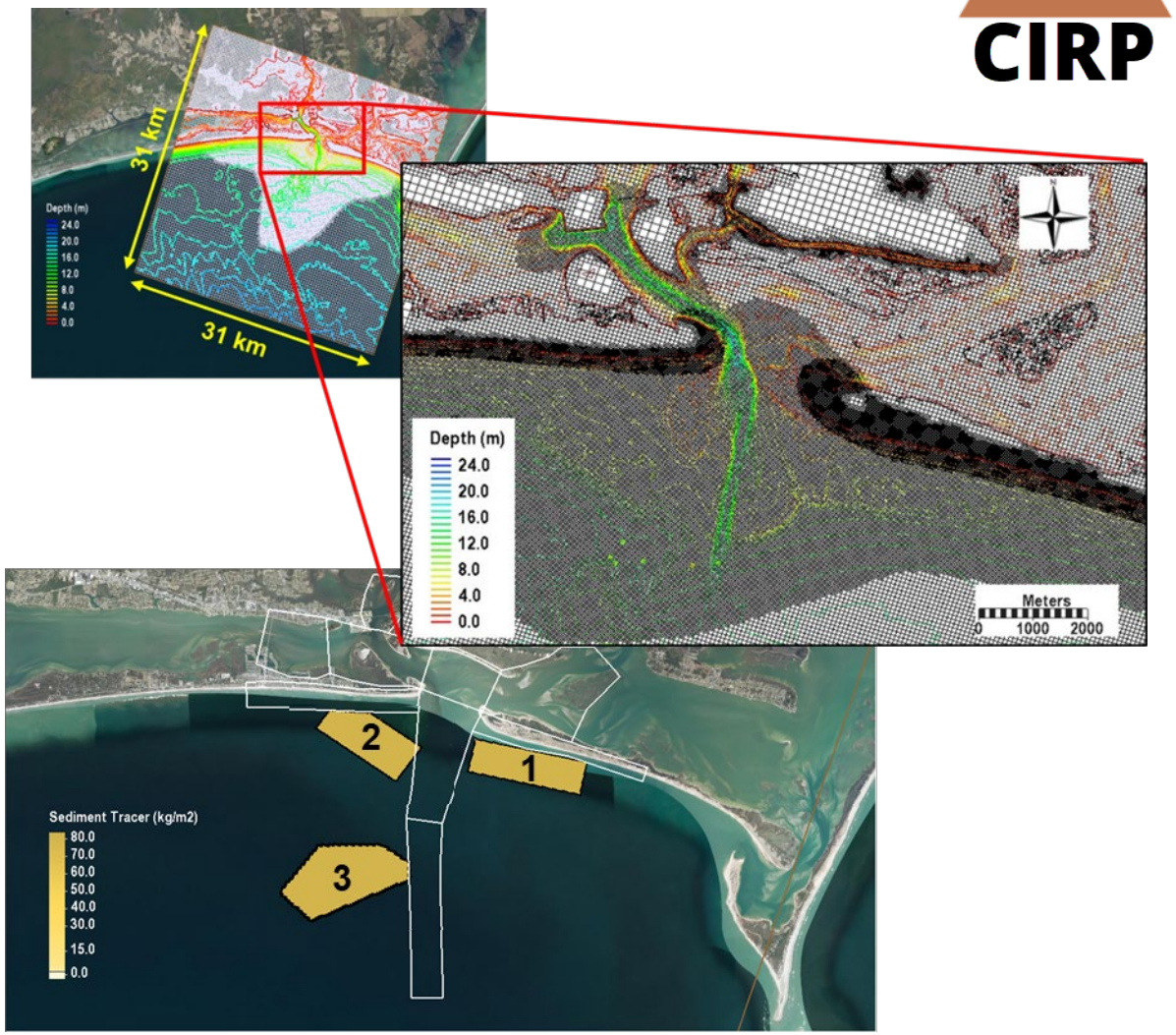
Objectives

- Eliminate dredging window and explore year-round dredging from the current dredging window, December to mid-April, based on environmental conditions.
- Material dredged from the channel is placed in two nearshore placement areas to the east and west of Beaufort Inlet along the shoreline or in an offshore site, the ocean dredged material disposal site (ODMDS).
- Evaluate the transport of sediment material placed at designated sites by modeling sediment plume originated from the placement sites outside the present dredging window.



Modeling Approach

- Coastal Modeling System (CMS) –variable-resolution telescoping and rectangular model grid
- Physical forcing - water level, wind stress, and wave spectra
- Sediment mapping to track sediment plume originated from three placement sites.
- Simulation periods – summer and winter months



Alternative	Placement Site	Area (km^2)	Average Depth (m)	Mass Tracked (10^3 kg)
1	Shackleford Banks	5.32	7.3	423,000
2	Bogue Banks	5.31	7.8	422,180
3	ODMDS	8.65	15.1	687,390

Sediment Transport equation

$$\frac{\partial}{\partial t}\left[\frac{DC_{tk}}{\beta_{tk}}\right]+\frac{\partial(DuC_{tk})}{\partial x}+\frac{\partial(DvC_{tk})}{\partial y}=\frac{\partial}{\partial x}\left[\varepsilon_s D\frac{\partial(r_{sk}C_{tk})}{\partial x}\right]+\frac{\partial}{\partial y}\left[\varepsilon_s D\frac{\partial(r_{sk}C_{tk})}{\partial y}\right]+\frac{U_c D}{L_t}(C_{t^*k}-C_{tk})$$

c_{tk}: depth-averaged sediment concentration

k: sediment size class

c_{t^*k}: depth-averaged total load concentration at the equilibrium state

β_{tk}: correction factor as the ratio of depth-averaged sediment and flow velocities

U_c: resultant velocity of current

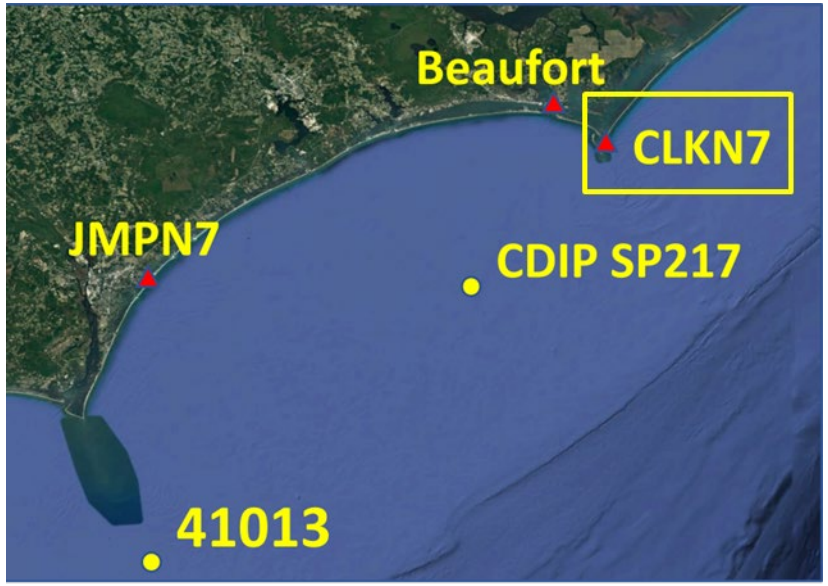
ε_s: sediment diffusion coefficient

r_{sk}: ratio of suspended load to total load

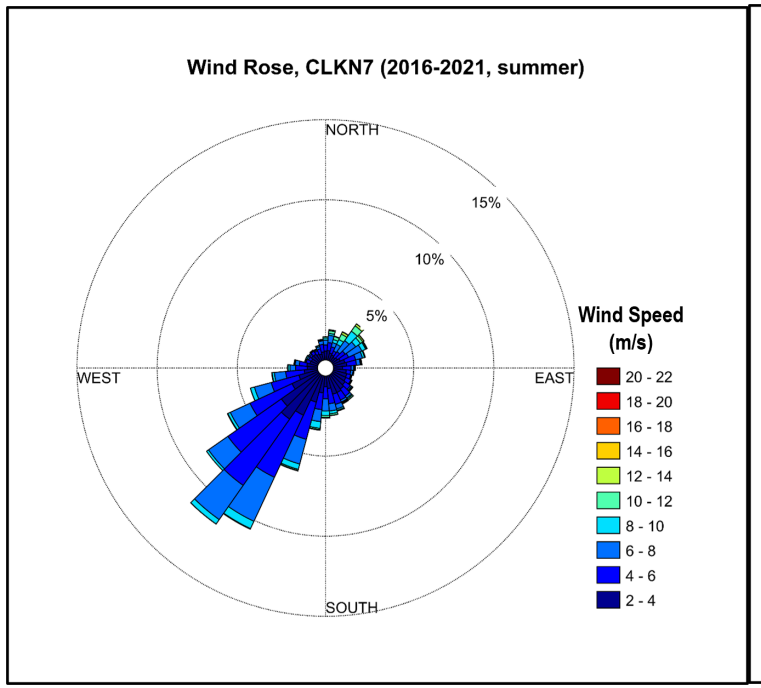
L_t: total load adaptation length

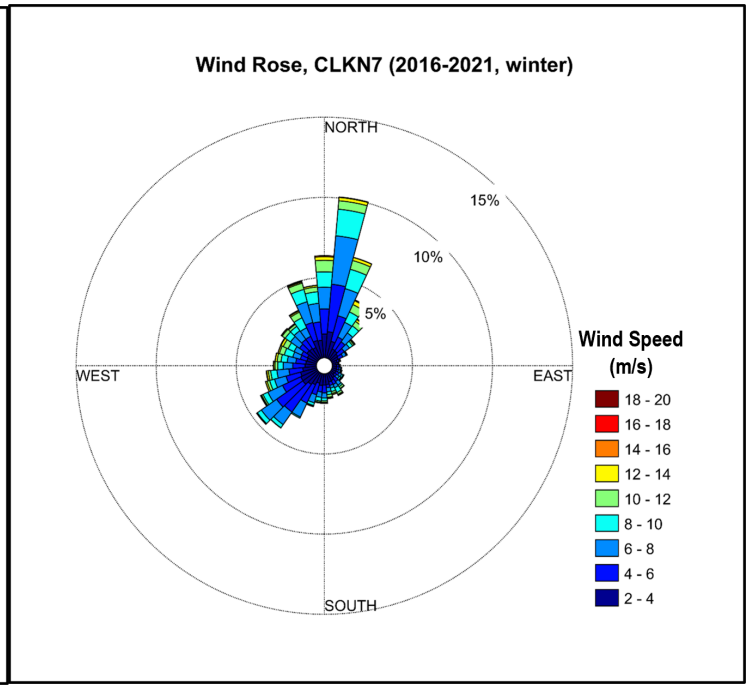
Surface Wind Data

NOAA Coastal Station CLKN7 at Cape Lookout, North Carolina



Wind Roses



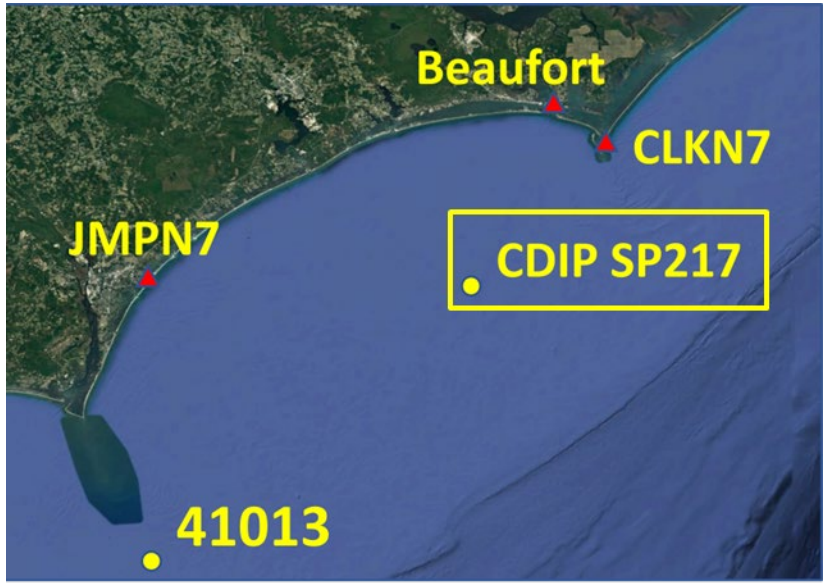


Summer Month (2016 – 2021)

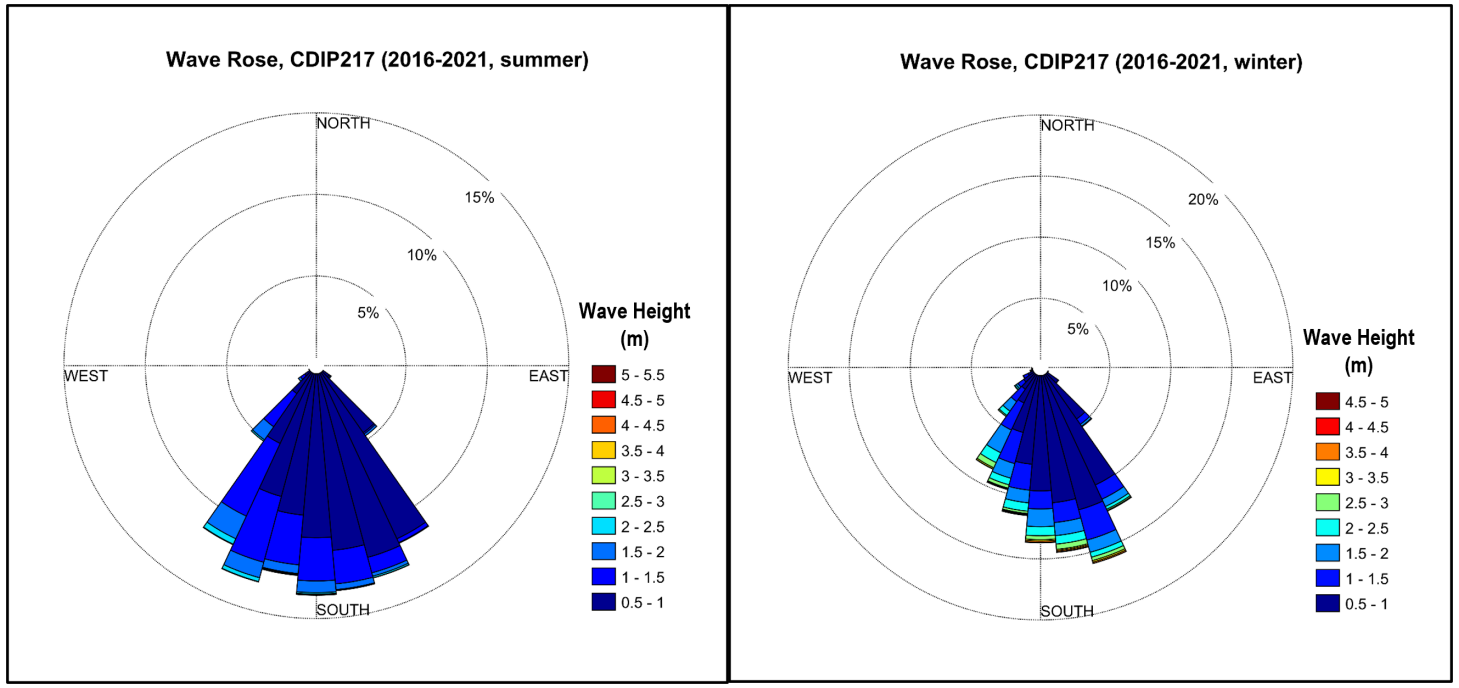
Winter Month (2016 - 2021)

Coastal Wave Data

CDIP buoy SP 217, at Onslow Bay Outer, North Carolina



Wave Roses

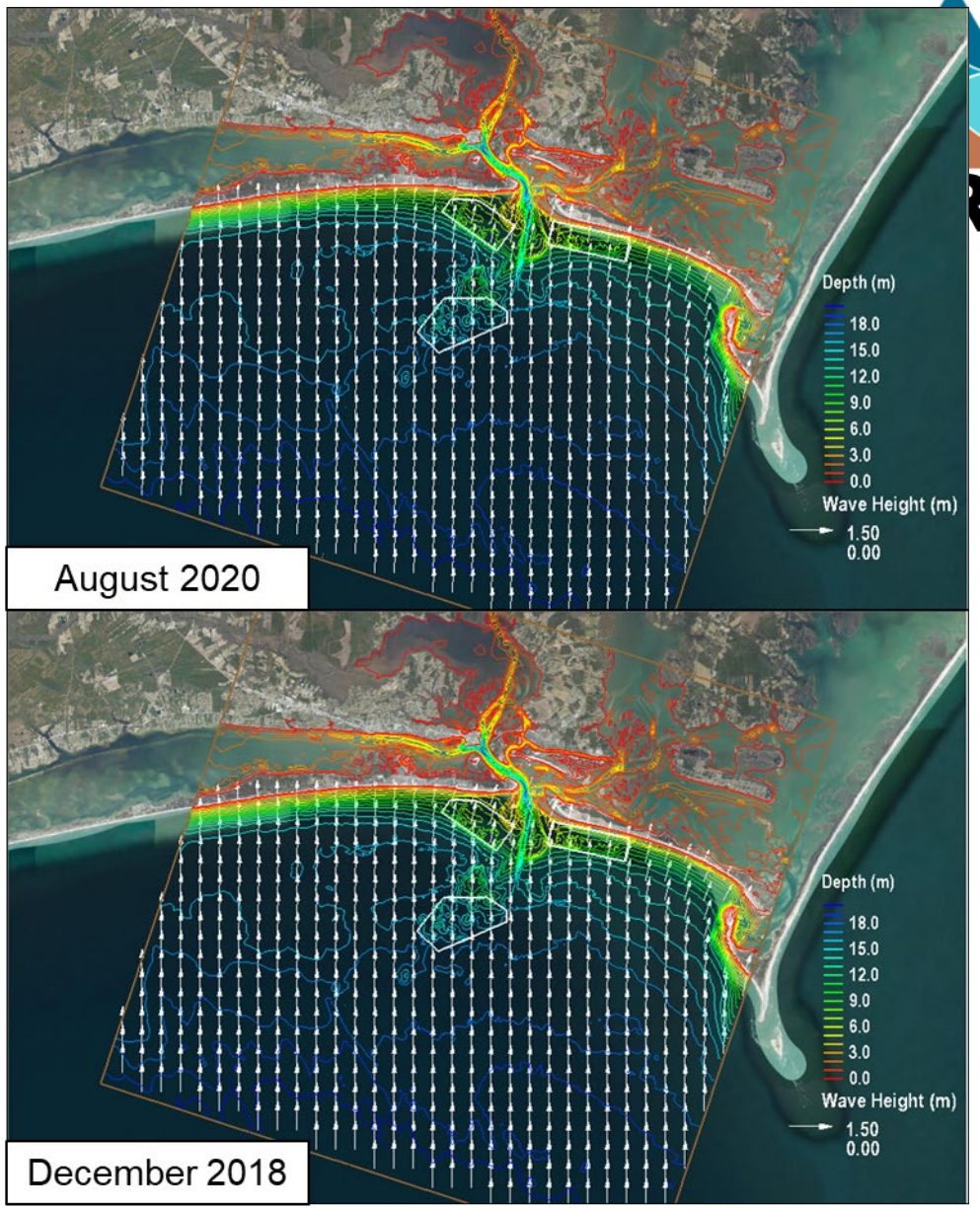


Summer Month (2016 – 2021)

Winter Month (2016 - 2021)

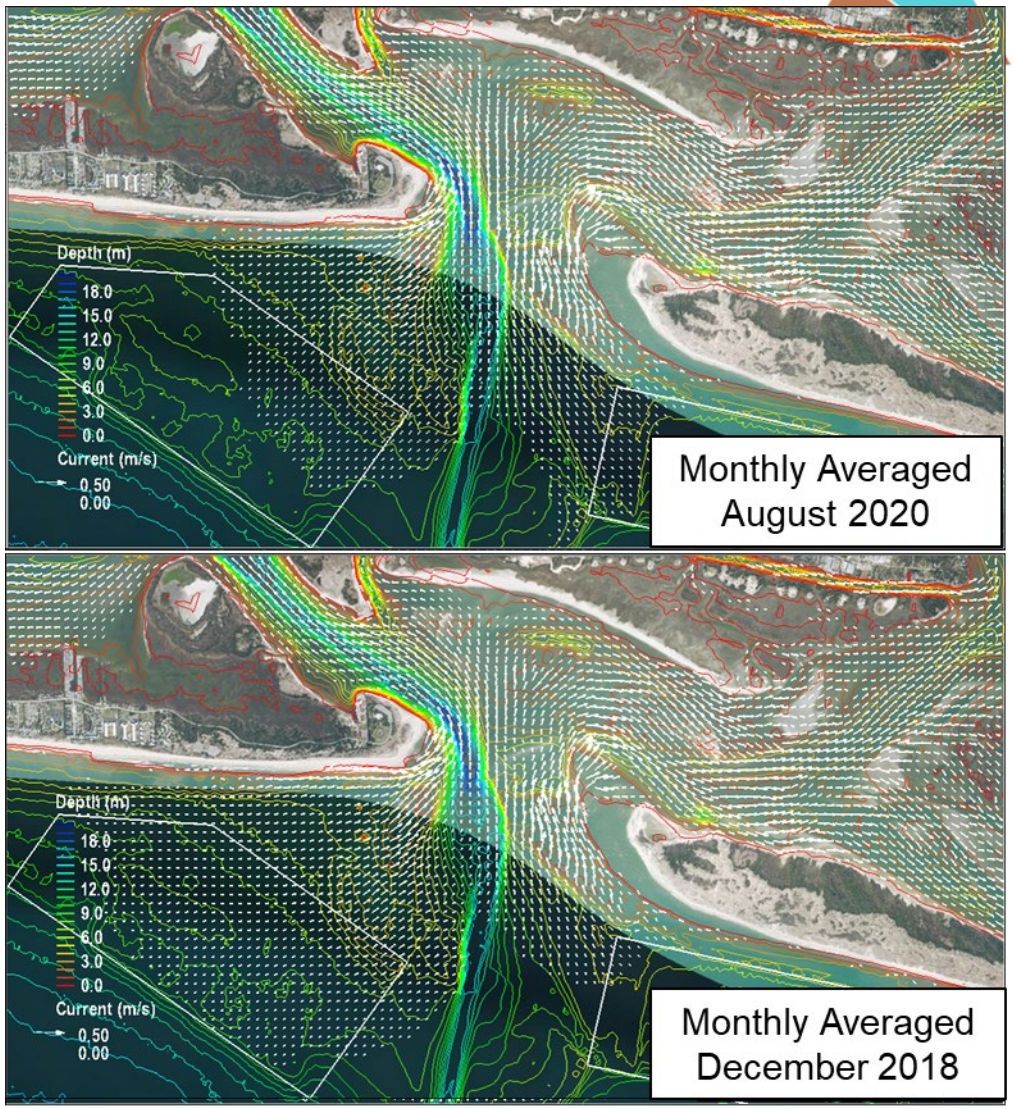
Waves

- Summer month
  - Incident wave direction: north-northwest
  - Average wave height:
    - 0.85 m offshore
    - 0.6-0.7 m nearshore
    - 0.3-0.4 m inlet entrance channel
    - <0.05 m in Bogue and Back Sound
- Winter month
  - Incident wave direction: north-northwest
  - Average wave height:
    - >1.0 m offshore
    - 0.7-0.8 m nearshore
    - 0.3-0.4 m inlet entrance channel
    - <0.05 m in Bogue and Back Sound



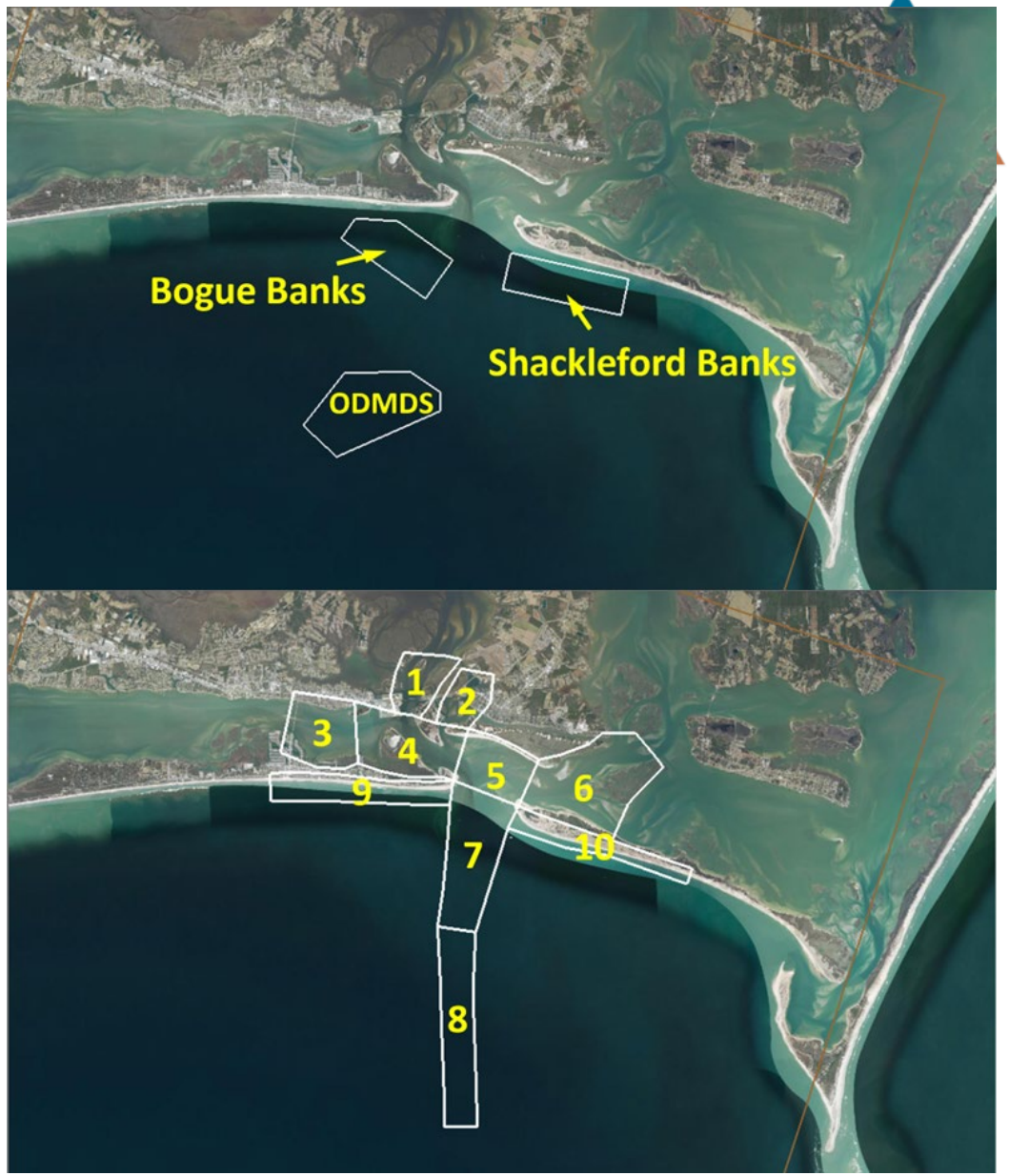
Current

- Summer month
  - Channel current:1.2-1.4 m/sec, flood current
    0.8-0.9 m/sec, ebb current
  - Longshore current: 0.4 m/sec, flood current
    0.2-0.3 m/sec, ebb current
  - Current direction: flood current splits and flows into Back and Bogue Sound. Longshore current flow towards the inlet
- Winter month
  - Channel current: 1.0-1.1 m/sec, flood current
    0.7-0.8 m/sec, ebb current
  - Longshore current: 0.3 m/sec, flood current very small, ebb current
  - Current direction: similar to the summer month

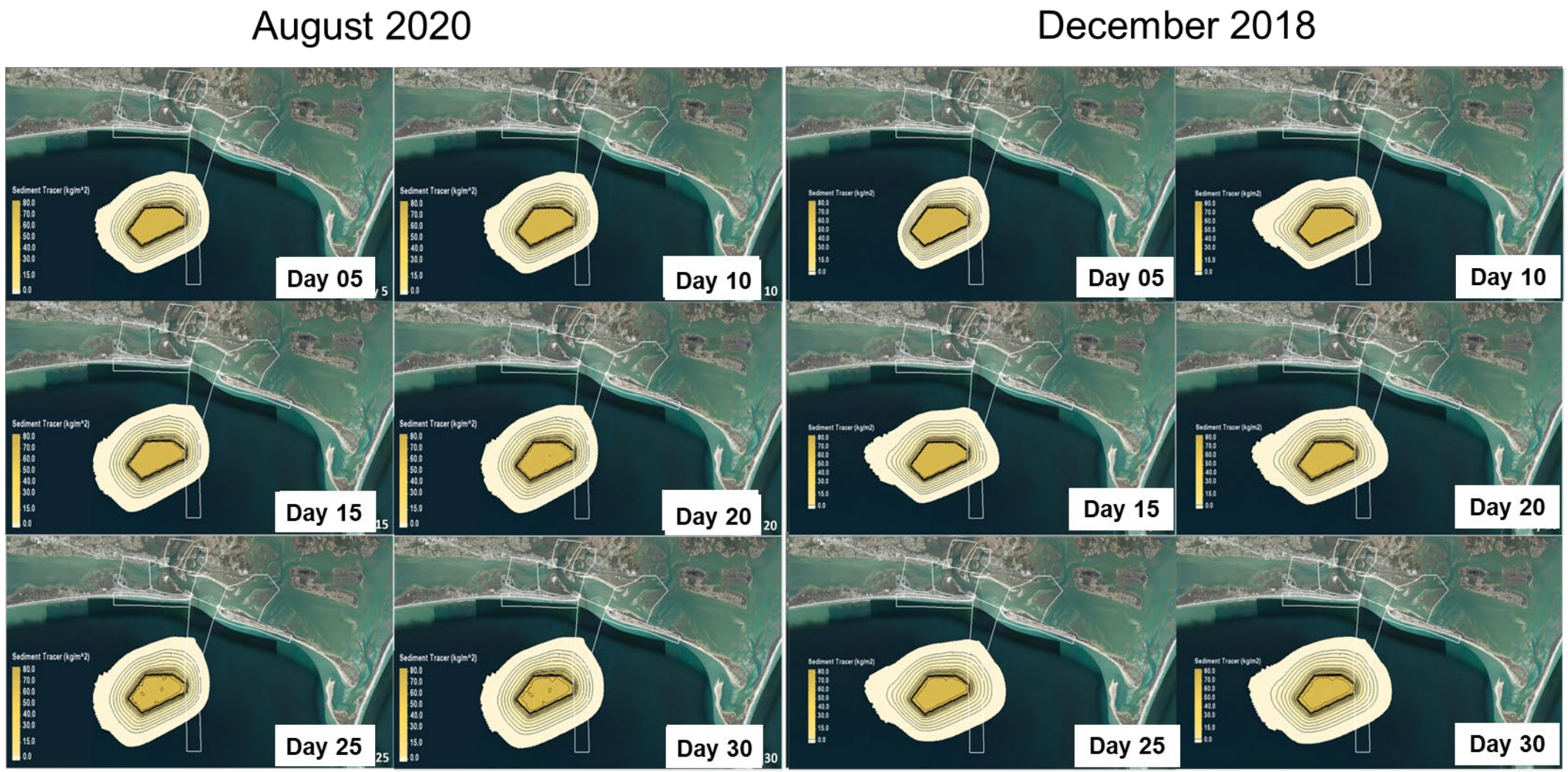


Sediment Placement and Tracking

- Placement sites as sediment sources
- Defined areas to obtain information about sediment movements and distribution of sediment plume.
- The areas include:
  - Newport River marsh - 1 and 2
  - Bogue Sound - 3 and 4
  - Back Sound and North River marsh - 6
  - Inlet and navigation channel 5, 7, and 8
  - Open nearshore zone - 9 and 10

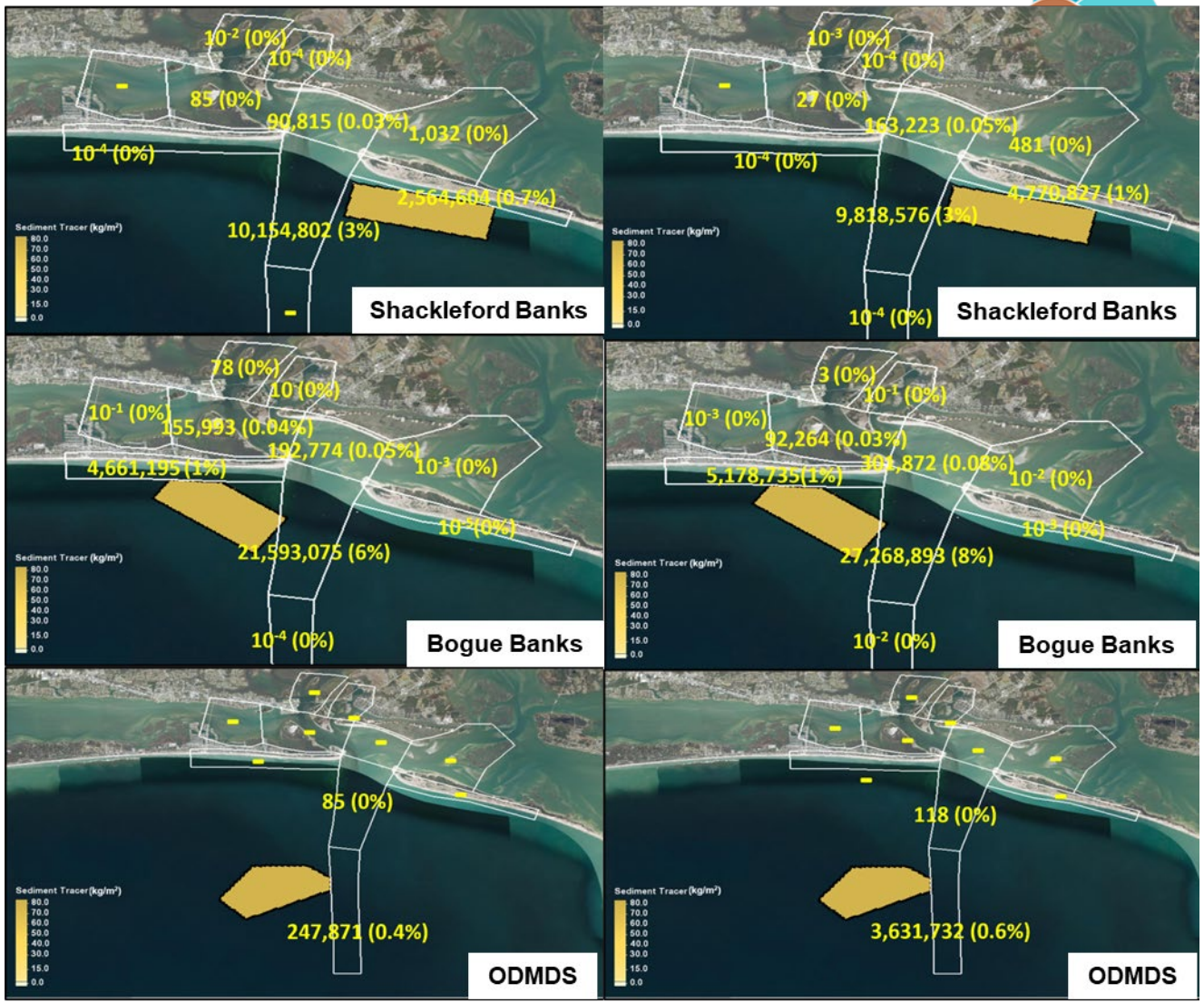


Sediment Plume



Sediment Plume results

- Shackleford Banks: Initial longshore and offshore spreading, the plume intrusion to the bay through the eastern portion of the channel. In the bay, the plume moves in both directions towards Back and Bogue Sound.
- Bogue Banks: Westward longshore plume spreading related to hurricane driven flows (winter not as strong), the plume intrusion to the bay through the western portion of the channel, and the plume primarily moves towards the west.
- ODMDS: The calculated depth-averaged flow speeds < 0.1 m/s. Sediment plume is mostly dominated by diffusion. The maximum plume expansion < 800 m. Winter month: stronger plume expansion in east-west direction.



Summary

- Sediment plumes originated from nearshore placement sites are under influence of coastal processes, wave-driven longshore and cross-shore currents. Flood dominated tidal currents carry sediments into the bay.
- Storm conditions (tropical/extratropical storms) have a major impact on spreading of sediment plumes, which is demonstrated by further westward expansion of the sediment plume in Bogue Sound during the summer month and relatively larger east-west plume growth around the ODMDS site during the winter month.
- Currents around the ODMDS site, located in deep area, are relatively weak and migration of sediment plumes is limited due to weak advection.