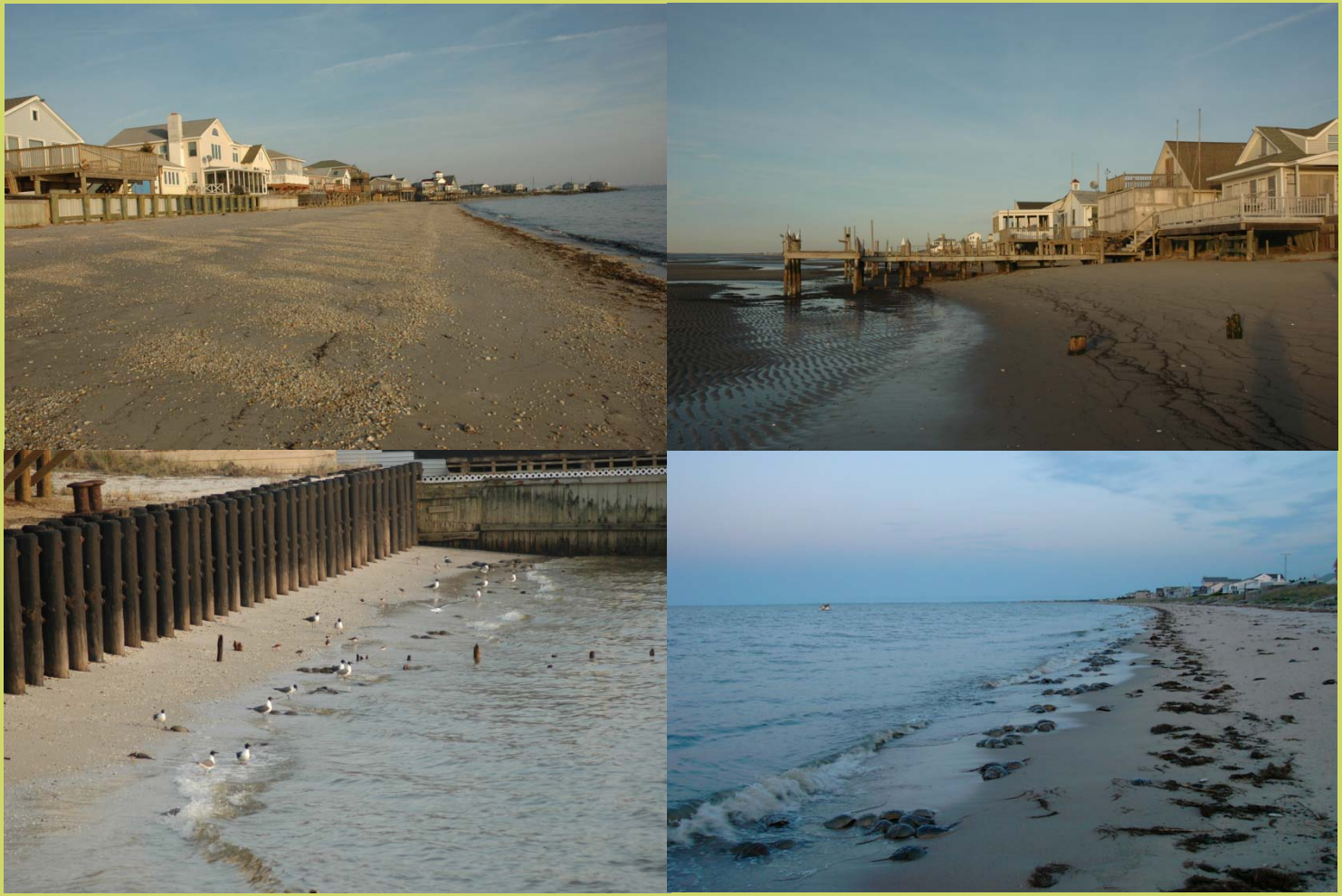
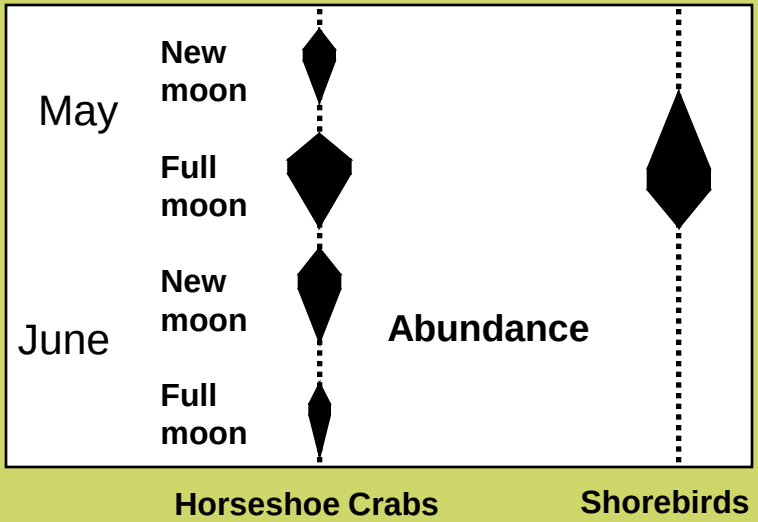
Presented at Puget Sound Shorelines and the Impacts of Armoring Workshop,
May 12-14 2009.
This presentation not peer reviewed.

Shoreline Armoring and Habitat in Delaware Bay

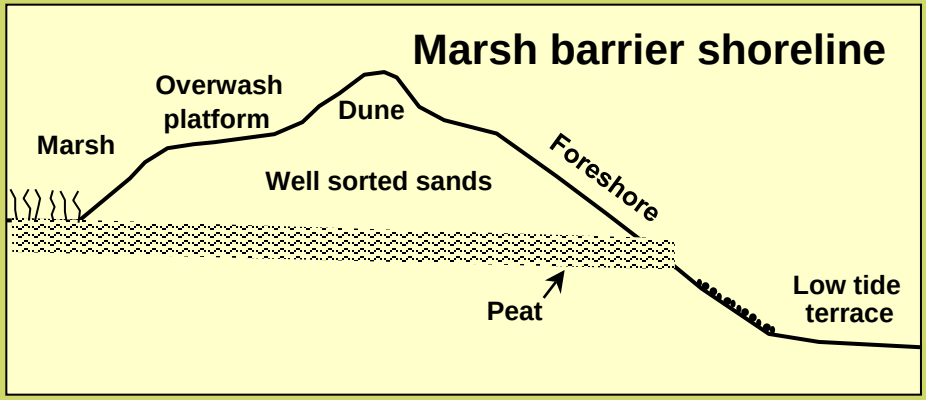


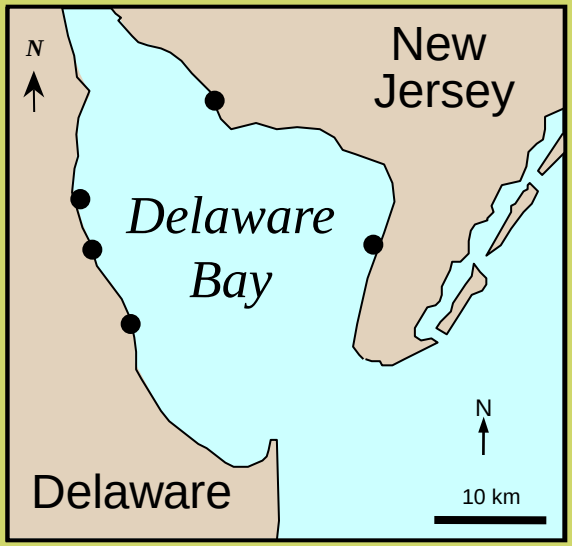
Nancy L. Jackson Dept. of Chemistry and Environmental Science, New Jersey Institute of Technology
Karl F. Nordstrom Institute of Marine and Coastal Sciences, Rutgers University
David R. Smith Leetown Science Center, United States Geological Survey

Horseshoe Crab-Shorebird Connection



Sandy Shorelines in Delaware Bay





Mean tidal range

1.6 m

Slope

Foreshore: 6.0º

Low tide terrace: <0.5º

Sediment

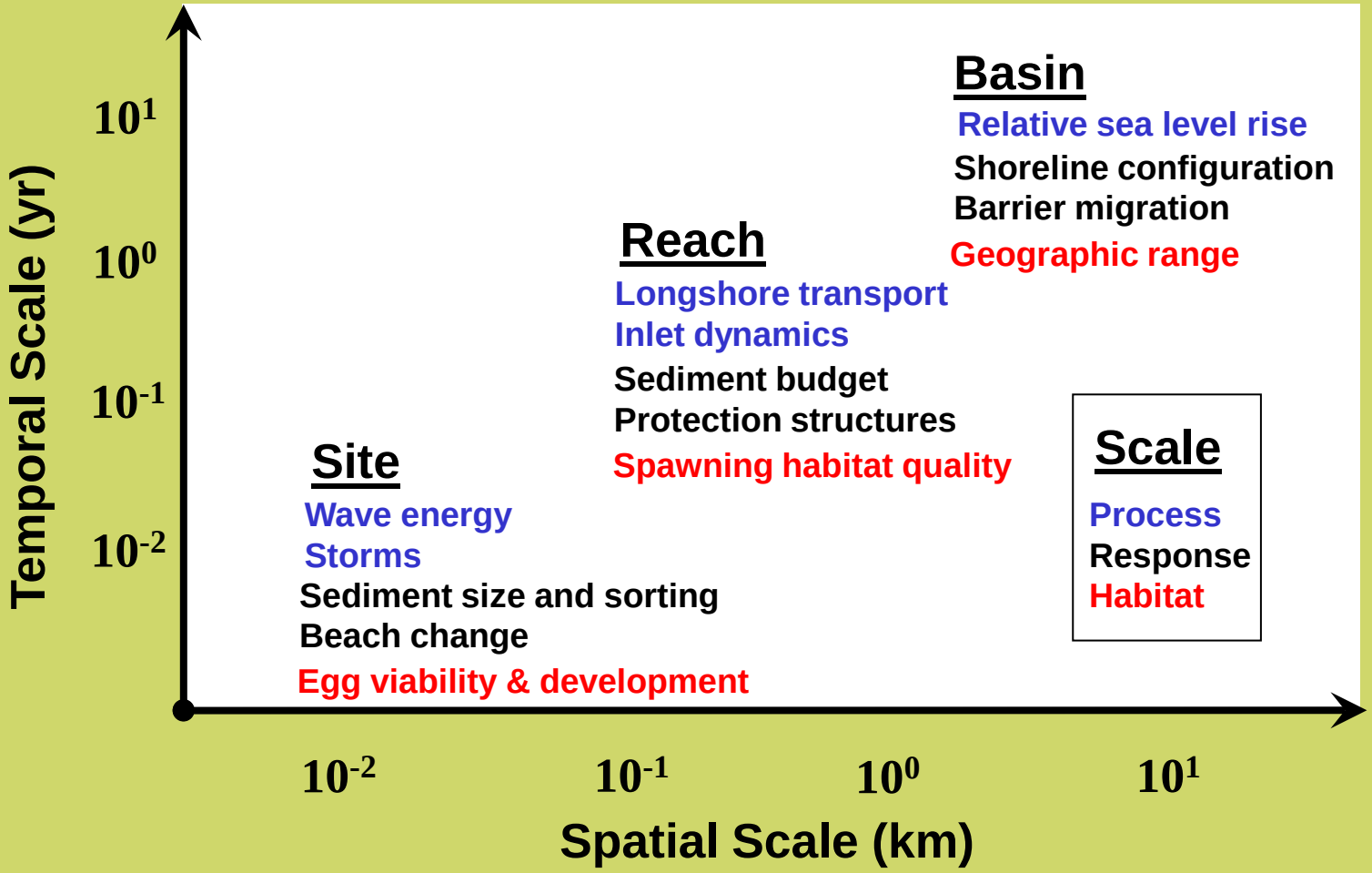
Medium Sands

Gravel on lower foreshore

“Optimal spawning beaches may be a limiting reproductive factor …”
(Atlantic States Marine Fisheries Commission, 1998)

“Beach decline is due to high erosion rates and presence of hard structures”
(US Army Corps Of Engineers, 1991)

Geomorphology – Horseshoe Crabs



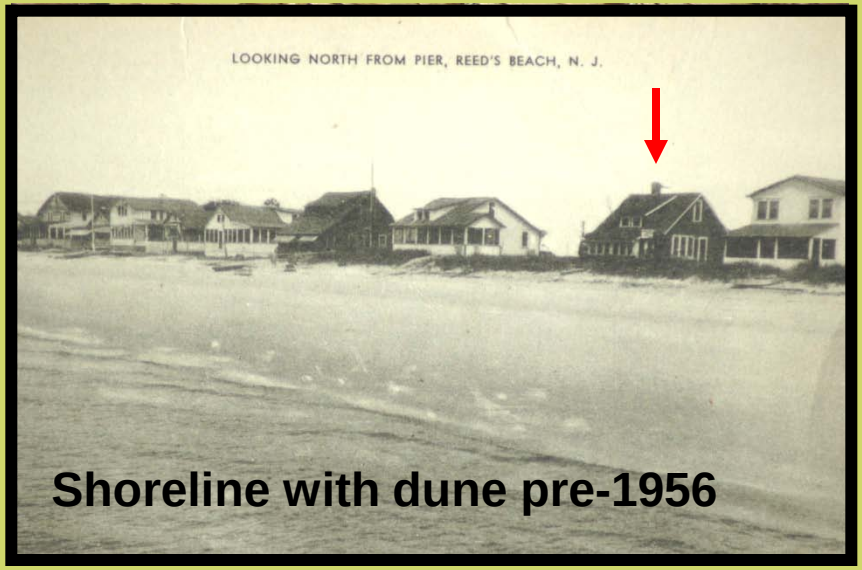
Jackson, N.L. and K.F. Nordstrom. “Strategies to conserve and enhance sandy barrier habitat for horseshoe crabs (*Limulus polyphemus*) on developed shorelines in Delaware Bay, USA”. In: J. Tanacredi, M. Botton, and D. Smith (eds.) *Biology and Conservation of Horseshoe Crabs*. Springer Publishers (in press)

New Generation of Sandy Deposits

Sediments are finer and better sorted on nourished versus un-nourished sites

Source: Jackson, N.L., D.R. Smith, and K.F. Nordstrom. 2005. Comparison of sediment characteristics on nourished and un-nourished estuarine beaches in Delaware Bay, New Jersey. *Zeitschrift fur Geomorphologie* 141: 31- 45.

Bulkheads in Delaware Bay

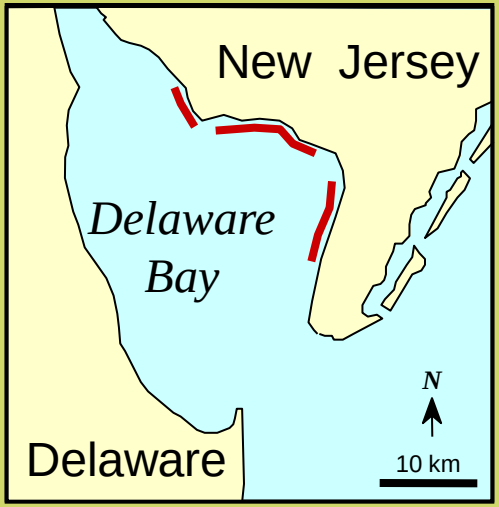


Bulkheads on high spawning foreshores in New Jersey:

Twenty two percent of the bulkheads are landward of the upper swash limit at spring tides and do not interfere with horseshoe crab spawning

Seventy eight percent are below the spring tide elevation.

Thirty percent are below mean tide elevation.



Beach – Bulkhead Interaction

Low on Foreshore

Sediment activation depths are greater at bulkheads located low on the profile relative to adjacent unbulkheaded sites

Sediment activation depths are minimal at bulkheads located on low tide terrace

Higher on Foreshore

Many statements supported only by data from seawalls in high energy environments.

Increased wave reflection, turbulence, nearshore current velocities

Increased sediment activation depths and erosion

Need for testing assumptions on estuarine beaches.

Wind Direction (mode) – Northeast
Wind Speed (mean) - 8.6 m s^{-1}

Significant wave height (m)

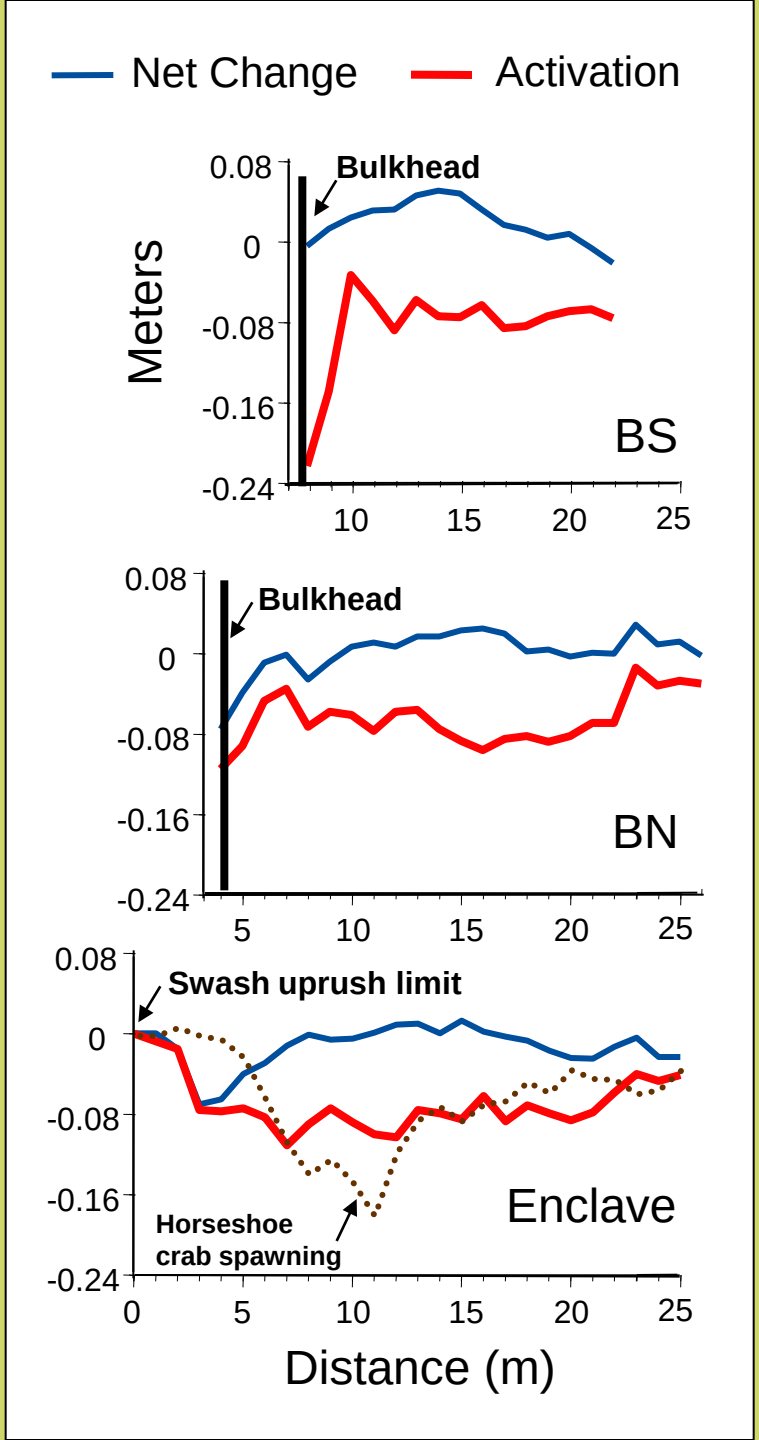
BS – 0.30 m (3.1 s)

BN – 0.26 m

Net change is similar across the profiles

Sediment activation depth is greatest at the bulkhead at BS

Sediment activation depth at the bulkhead at BN is slightly greater compared to the activation depth at the same elevation in the Enclave



Bulkhead Effect Through Time

Cross shore

Longshore

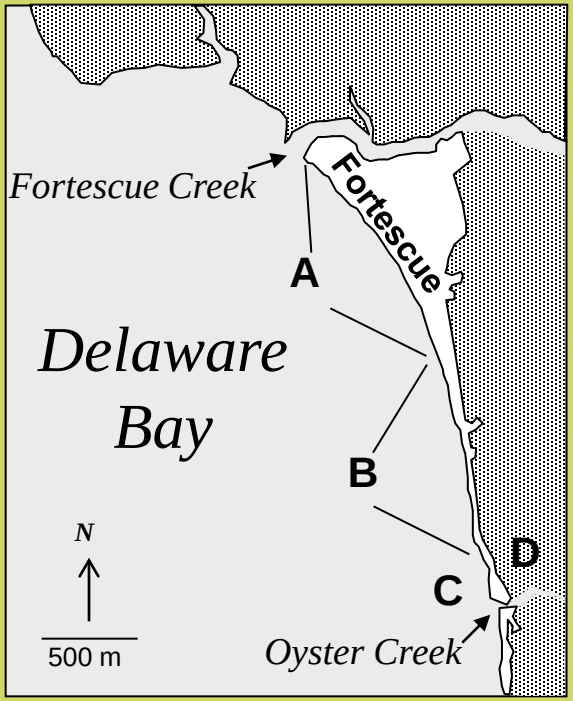
Bulkhead Enclaves as Refuge

Counts of horseshoe crab spawning

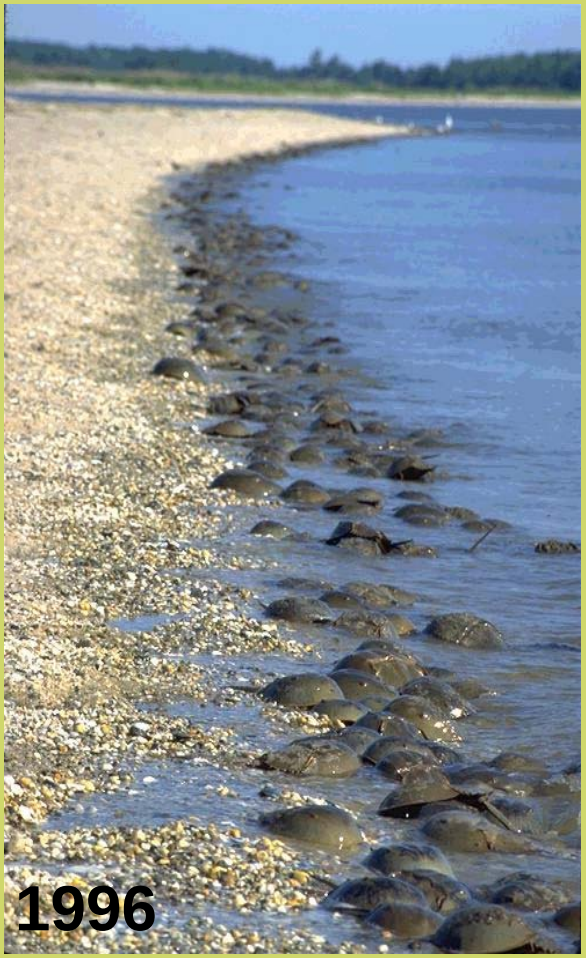
At high tide and one hour before and after high tide, within enclaves and along a segment of unarmored shoreline.

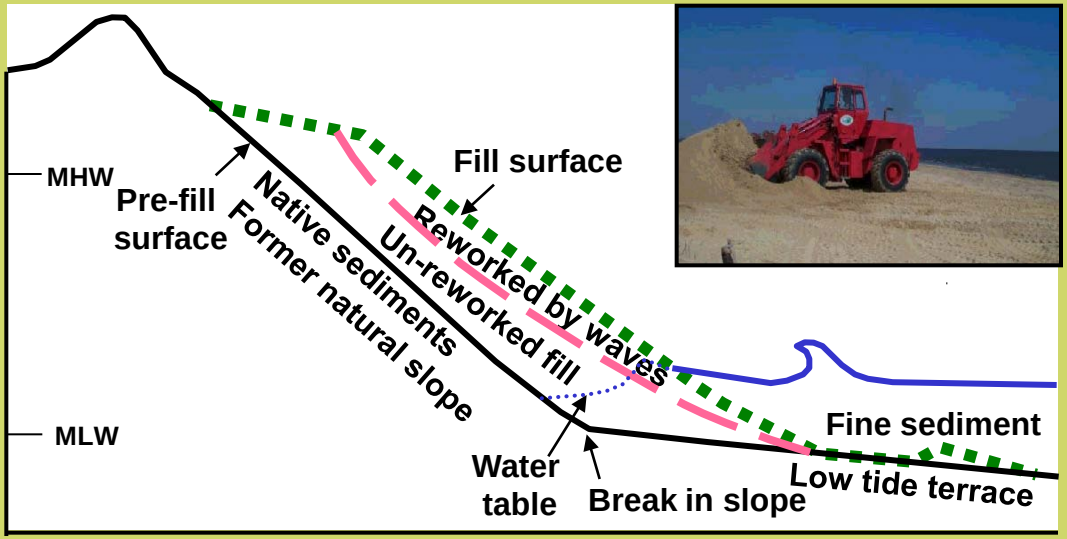
Relatively high waves revealed greater densities of horseshoe crabs in the enclaves, with more horseshoe crabs clustered in the shadow zones relative to wind direction.

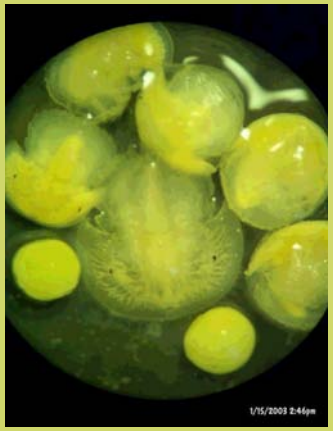
Regional Habitat Availability



Beach Nourishment

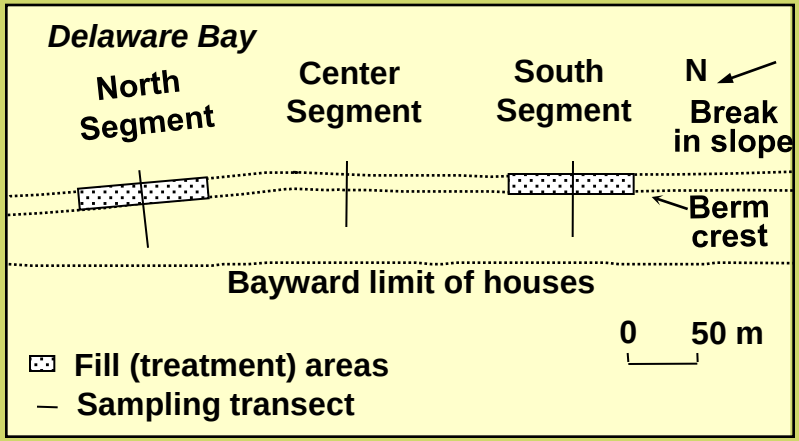




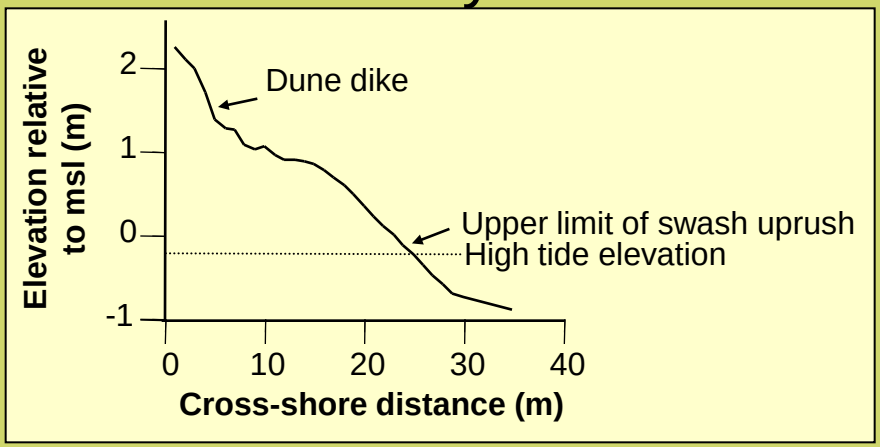


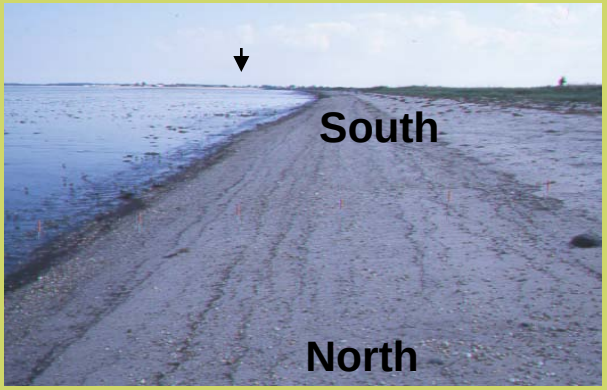
Beach Nourishment

Bowers Beach



Ted Harvey Beach



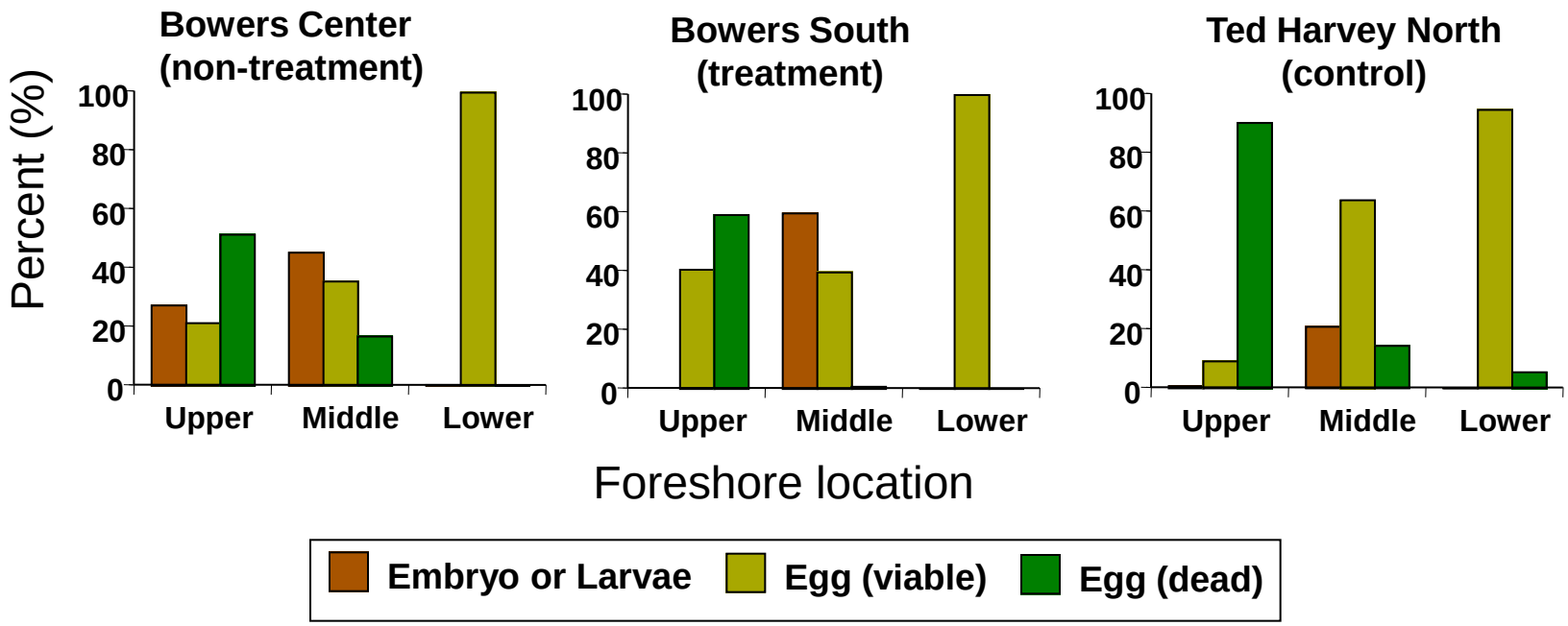


467 cubic meters of coarse sand between storm wrack and break in slope

97 cubic meters of gravel placed between high water line and the break in slope

Spawning count
Egg density
Egg development
Sediment texture
Sediment moisture
Beach water table elevation

Egg Viability and Development



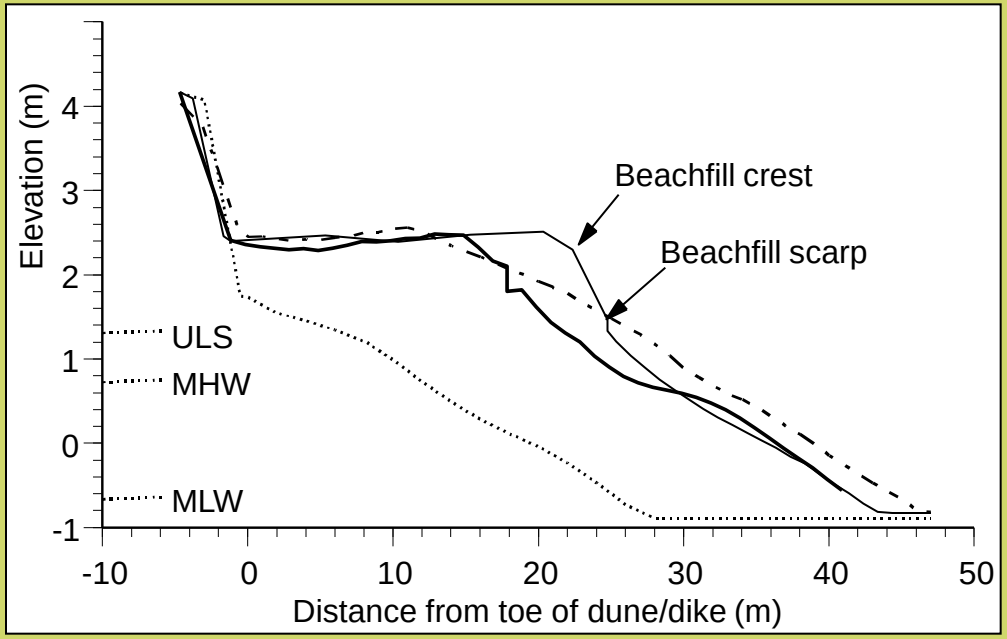
Spawning and initial egg density was higher at Ted Harvey Beach than Bowers Beach

Dessication important threat to egg survival and development.

Rates of egg development to larvae are higher and rates of egg death are less at Bowers

Greater moisture retention and lower rates of hydraulic conductivity at Bowers Beach where grain size is finer and better sorted.

Jackson, N.L., D.R. Smith, R. Tiyarattanachi, and K.F. Nordstrom. 2007. “Use of a small beach nourishment project to enhance habitat suitability for horseshoe crabs”. *Geomorphology* 89: 172-185.

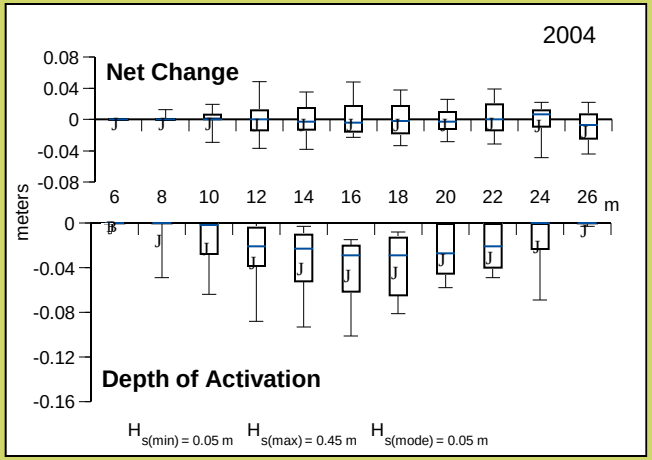


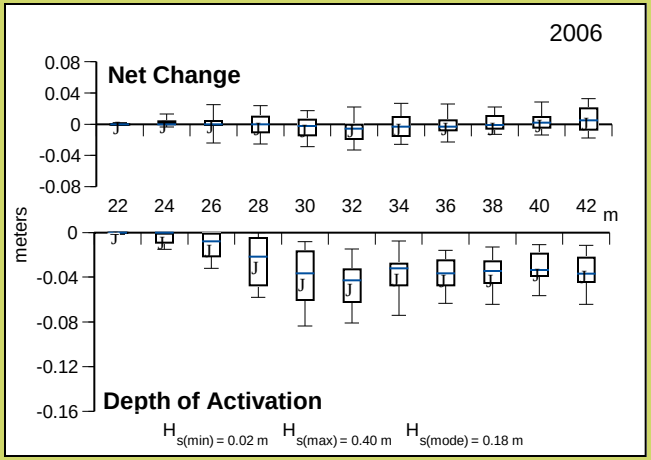
Pre Nourishment (2004)

Post Nourishment (2005)

Post Storm Season (2006)

Post Grading (2007)





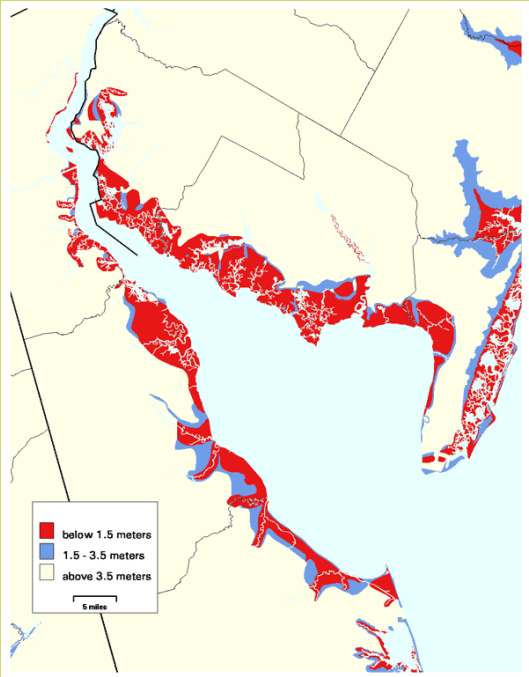
Future Habitat Change?

Some Speculation……

Relative sea level rise will increase dimensions of the bay (fetch lengths and depths) and increase wave energies, shoreline erosion and overwash.

Limited sediment in sand barriers suggests that many will not remain intact as they transgress over the marsh.

Sediments released from uplands with increases in relative sea level rise, may create sandy deposits in existing creek channels and upstream in the Delaware River.



The 1.5 meter contour represents area inundated during spring high water with a 70 cm rise in sea level (likely to occur over next 120 years). Source: http://www.epa.gov

Some Questions…

Contemporary Questions

Will habitat pose a physical limit on near-term horseshoe crab population growth?

Is there a relationship between beach type and habitat function (spawning and/or egg development)?

Anticipatory Questions

What are the physical thresholds for habitat suitability with future sea level rise?

How can adaptive management strategies in response to sea level rise incorporate habitat?