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Mitigating the Effects of Bulkheads on Estuarine Shores: An Example from Fire Island National Seashore, USA

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Perceived advantages of bulkheads

Affordable, provide protection in limited space, need not alter the bay bottom.

Disadvantages

Contribute to sand starvation by preventing erosion of upland

Truncate/eliminate beach habitat.

Create exotic habitat in a soft-shore environment.

Increase wave reflection, turbulence, scour, erosion*

*Many arguments based on ocean structures

*Few process studies

The NPS Management Problem

Developed and armored enclaves exist within natural areas managed by the park

Need to identify how bulkheads contribute to erosion of adjacent environments and determine appropriate mitigating measures.

Bay Shore Characteristics

Locally generated bay waves dominant

Narrow, shallow bay limits wave energy

Low tidal range (0.2 m) & wave heights limit beach dimensions

Irregular shoreline may isolate sand transport compartments

Management of Backbarrier Beaches Affected by Management of Adjacent Environments

Sediment from ocean via inlets, overwash, dune migration now prevented by dune stabilization and inlet closures.

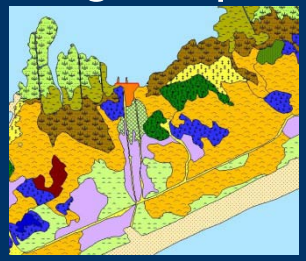
State regulations for bay bottoms (low tide terrace) restrict beach management actions.

Components of Our Study

Identify relationship of natural shoreline to bulkheads

Air photos 2003

Veg. maps



Quantify short term effects at a representative bulkhead

Instrumented study

Document beach characteristics and shoreline change

Annual topog. surveys

Identify best protection strategies

NPS mission, F&WS
State regs., Local needs

Relationship of Natural Shoreline to Bulkheads

Methods of determining length of direct bulkhead effect

Based on breaks in shoreline orientation and change from topographic profiles.

Bulkhead characteristics

18% of the 67.3 km shore protected by 43 bulkhead segments.

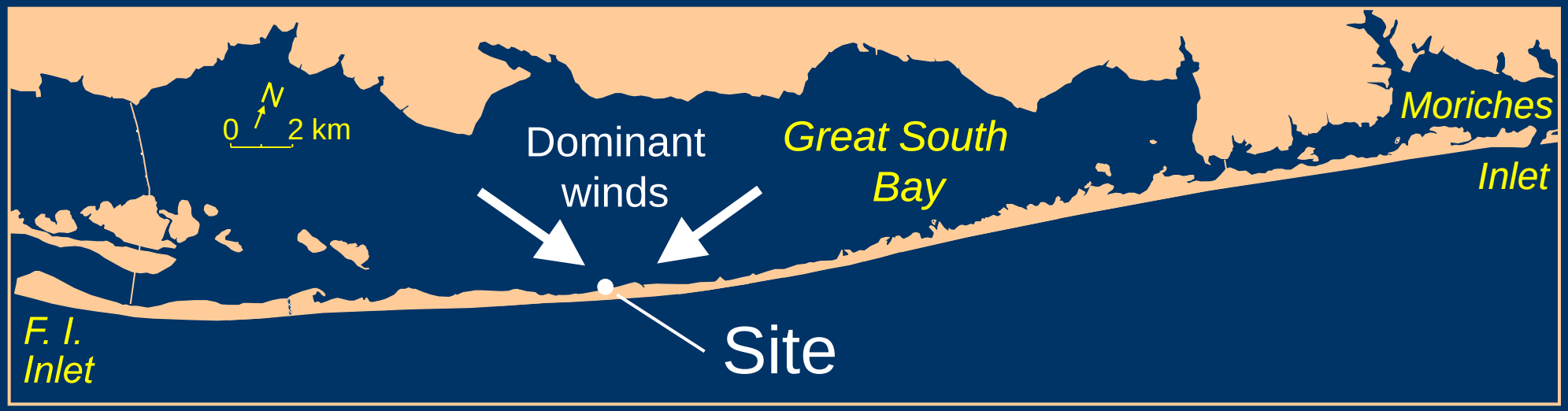
Most bulkheads are sheet-pile; longest is 1.85 km.

Critical resources affected

Half of the maritime deciduous scrub forest.

Holly forest in the Sunken Forest near Sailors Haven Marina is globally rare and is threatened by erosion.

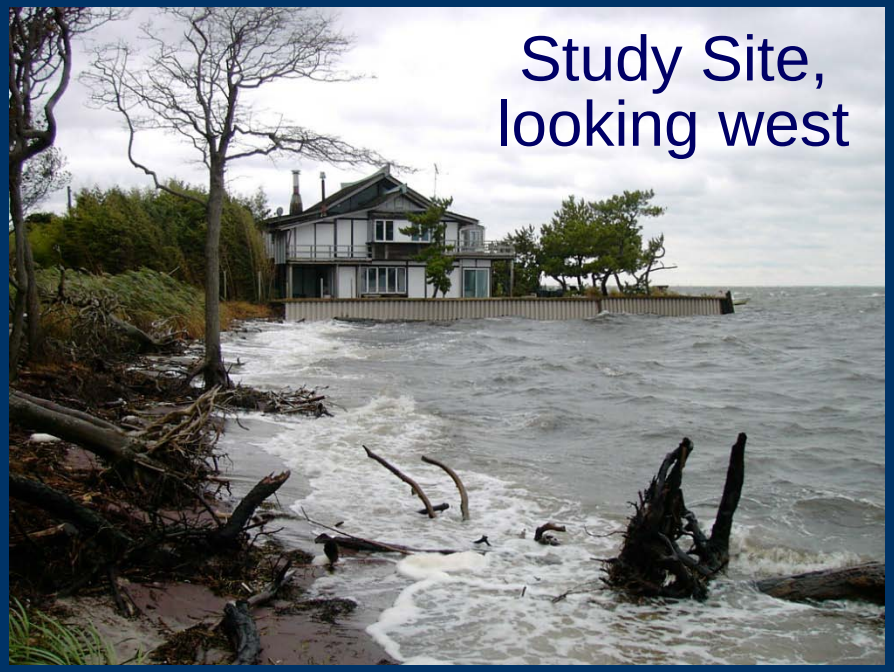
Instrumented Field Study at Cherry Grove



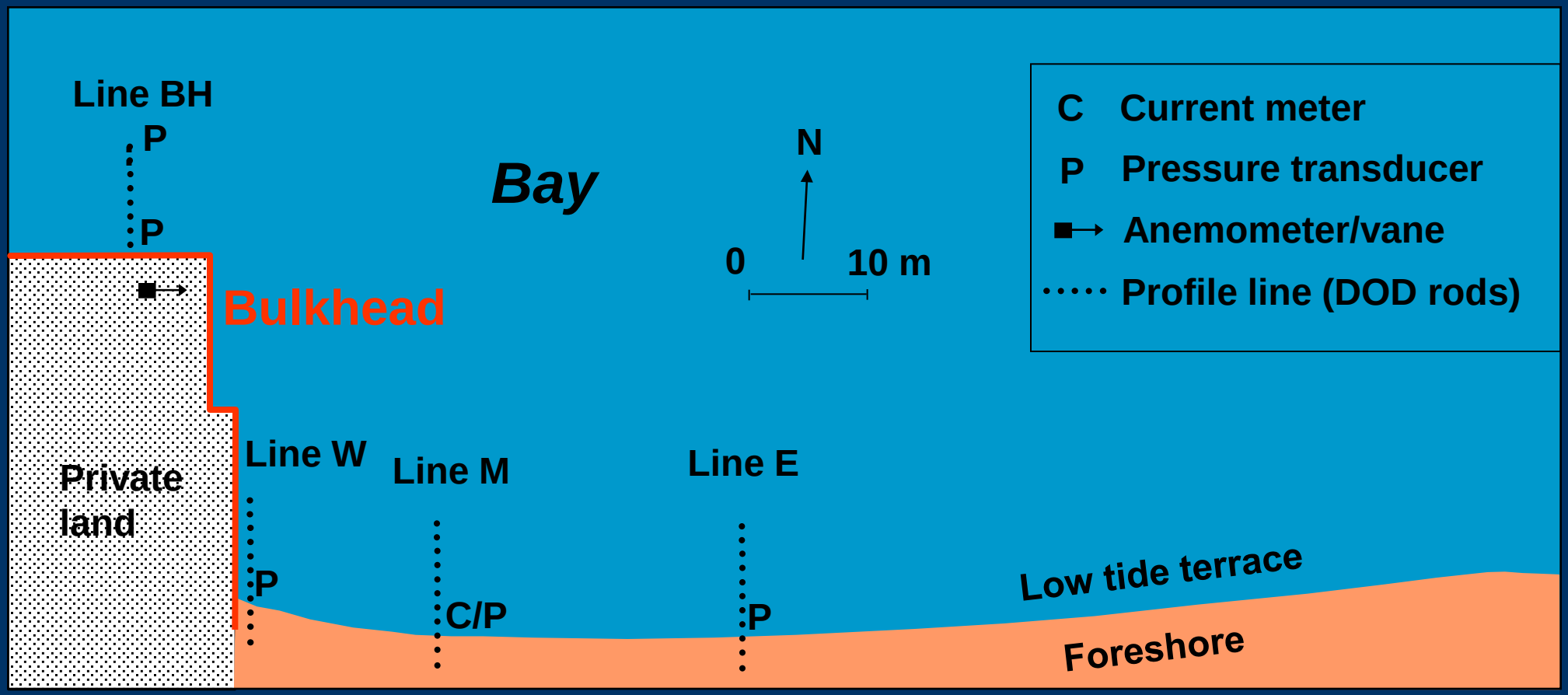
East side of 930 m long bulkhead

Frequent strong winds from NW

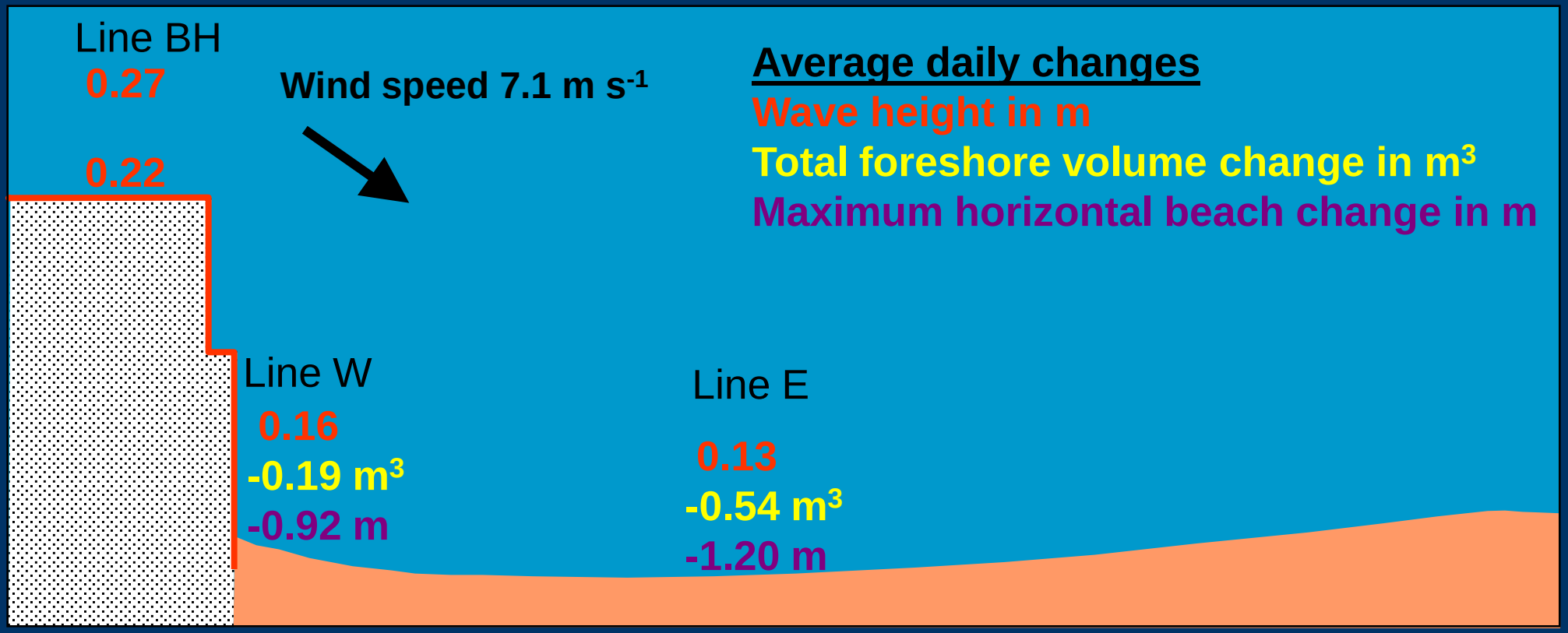
Strong NE winds during storms



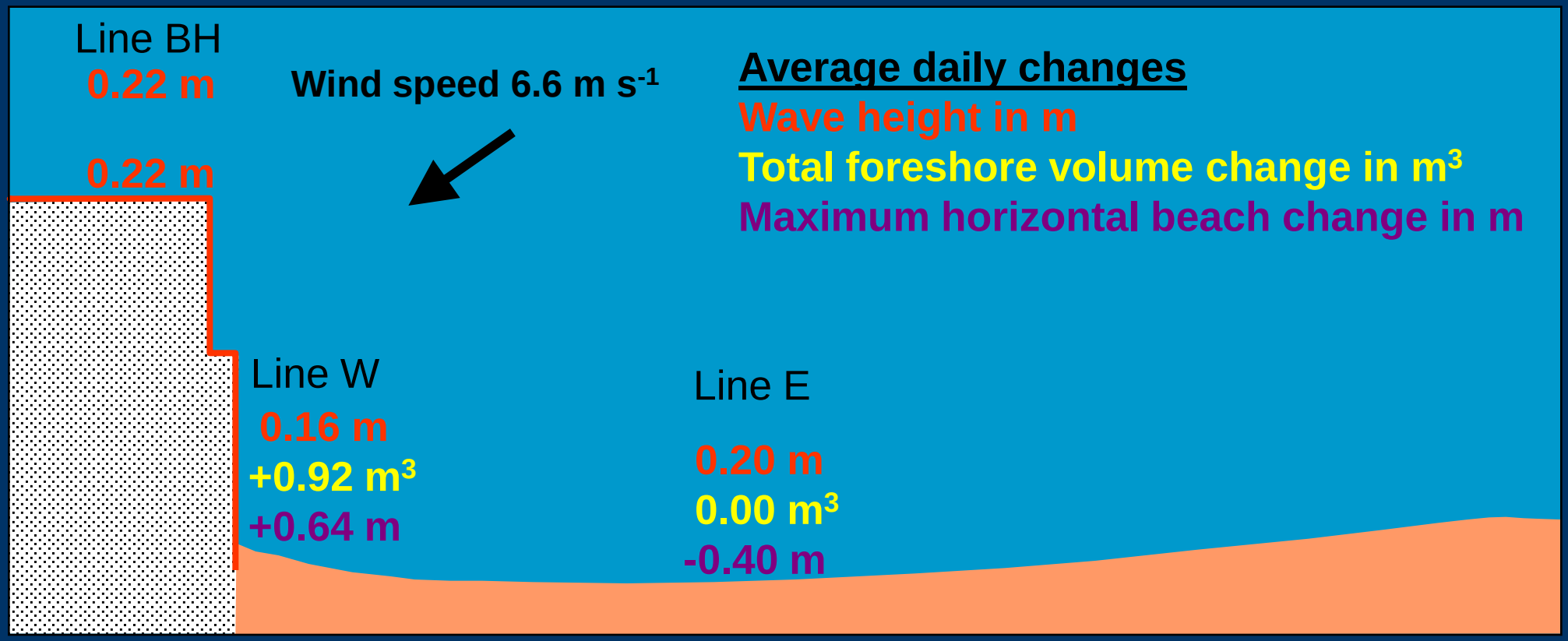
Field Setup


Line BH
P
P
Bay
N
0
10 m
C Current meter
P Pressure transducer
Anemometer/vane
Profile line (DOD rods)
Bulkhead
Private land
Line W
Line M
Line E
P
C/P
P
Low tide terrace
Foreshore

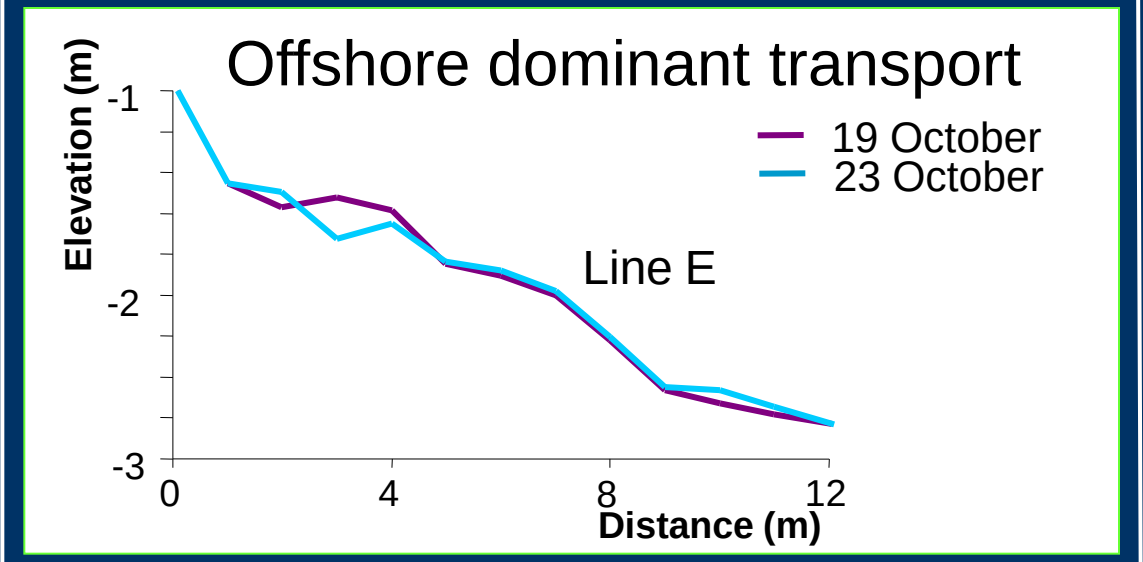
Northwest Winds (17 October 2004)

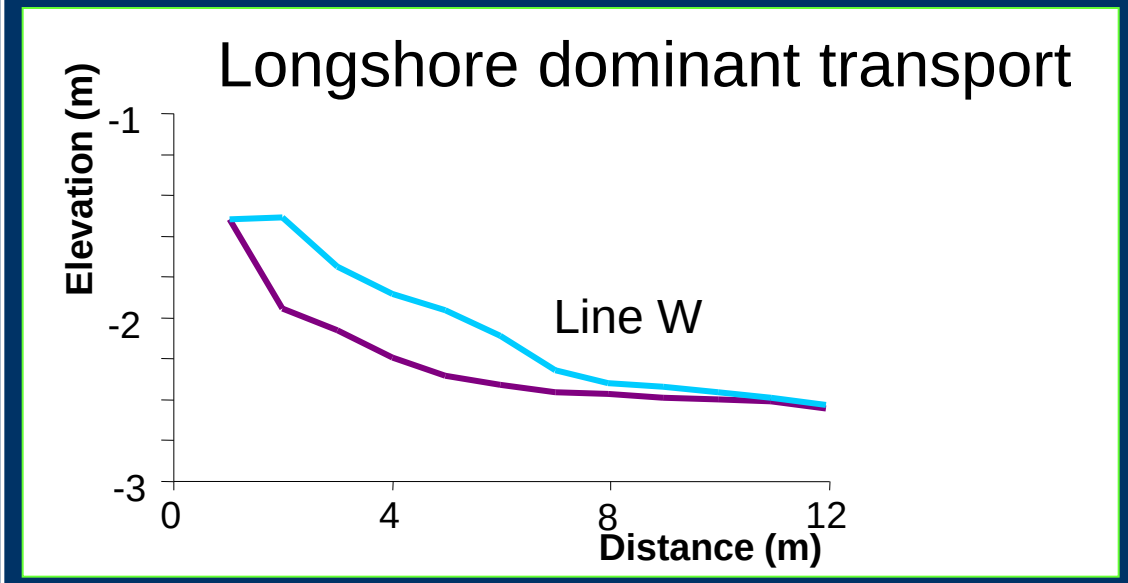


Northeast Winds (19-23 October 2004)

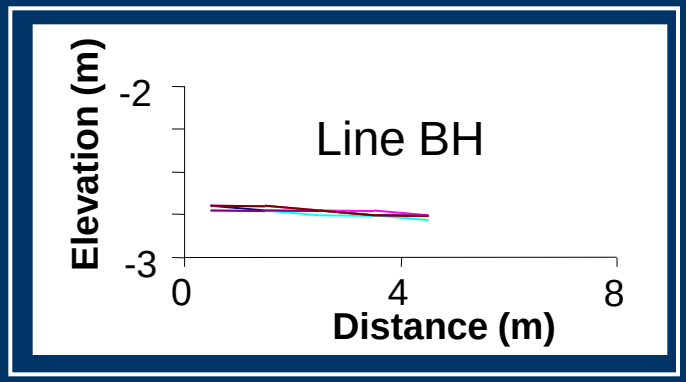


Profile Changes During Several Days of Strong NE Winds

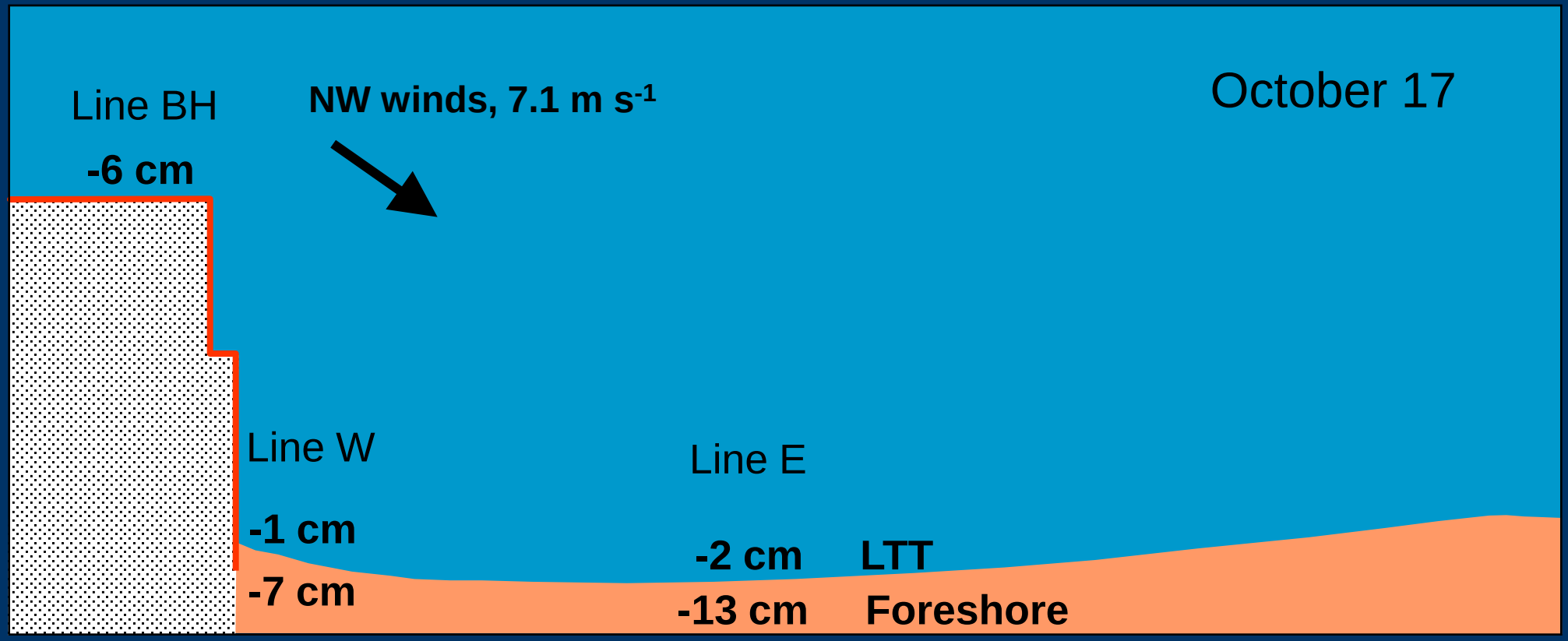




Total change at bulkhead
16-23 October



Depth of Sediment Activation (Scour)



Results of Beach Process-Response Study

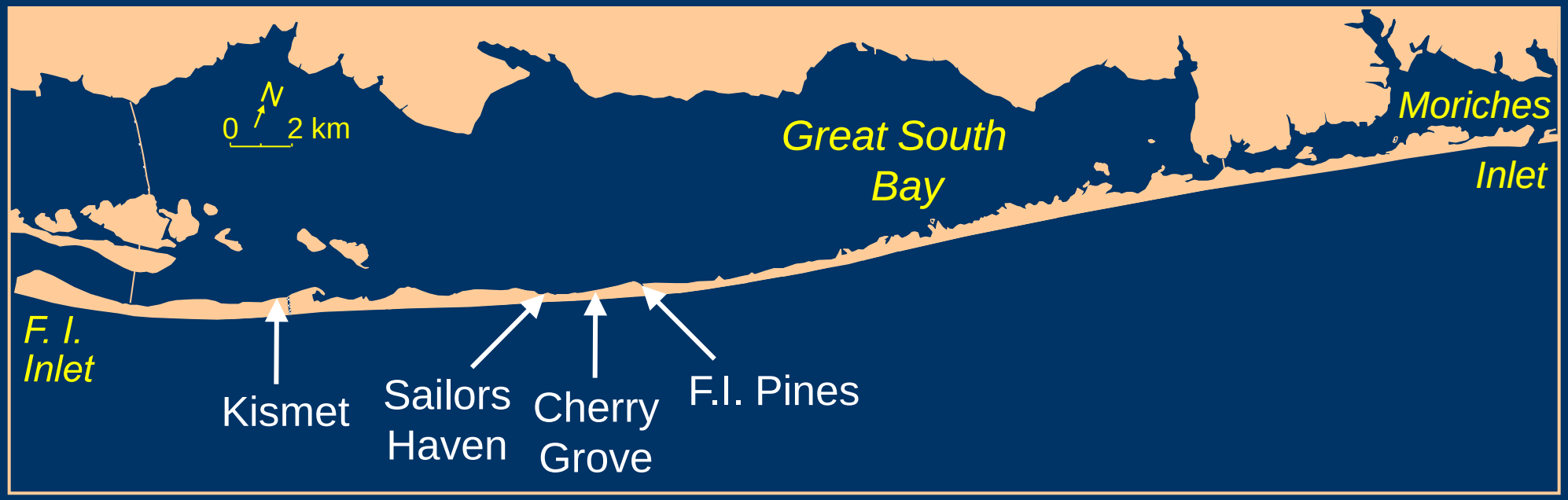
Small volume changes cause considerable horizontal shoreline displacement due to little sand in beach (1.3 m height).

A groin effect (updrift deposition, downdrift erosion) occurs with reversals in wind direction if the beach is set back from the structure (can change nature of profile response).

Activation depths on low tide terrace seaward of bulkhead are greater than at unprotected foreshore, but

Accretion and scour seaward of bulkhead are minimal where structure is on low tide terrace

Annual Changes at Representative Profiles



Profiles at east and west sides of 4 bulkhead segments

On undeveloped shore 8 m to 325 m from bulkhead

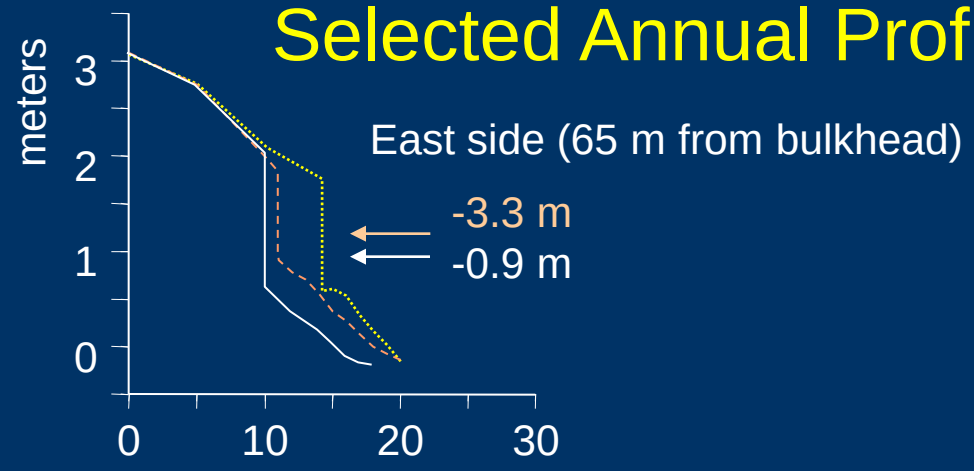
Surveys in fall 2004-2008

Selected Annual Profile Changes

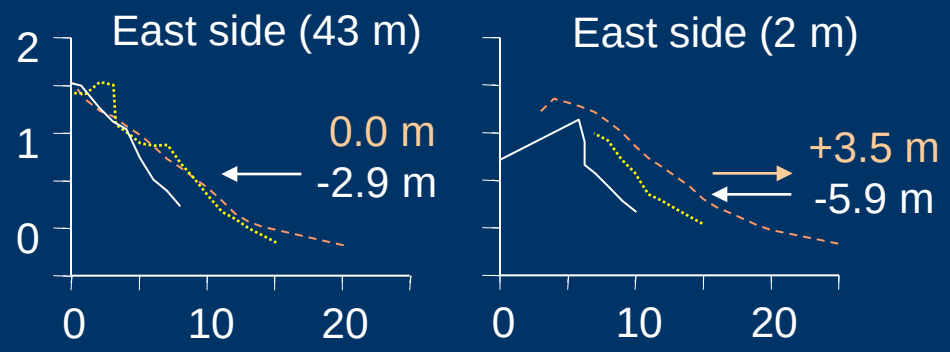
2004-2005 Drift to west
2005-2006 Drift to east

2004
2005
2006

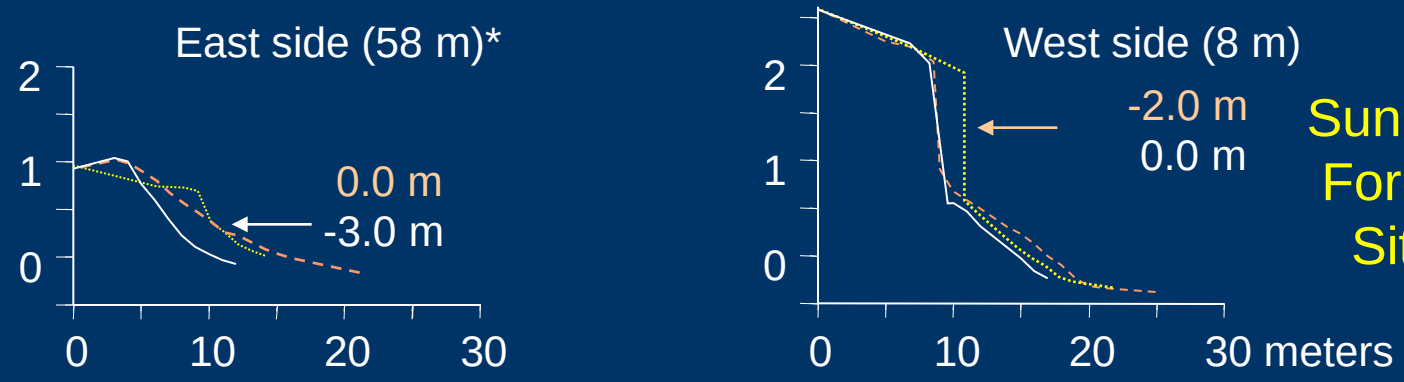
Fl Pines



Cherry Grove



Sailors Haven



Sunken Forest Site

Results From Annual Profiles

Annual upland retreat can be as great as 3.3 m.

Foreshores reveal alternating erosion and accretion, even where uplands only erode through time.

Bulkhead-influenced sand deficit may extend about 70 m alongshore.

Greater rates of upland erosion can occur far from bulkheads.

Sand starvation at bulkheads is only one aspect of the problem of overall bay shore erosion.

65 m from bulkhead (0.7 m yr^{-1})

325 m from bulkhead (1.3 m yr^{-1})

Solution: The Focus on Beach Nourishment

Considerations

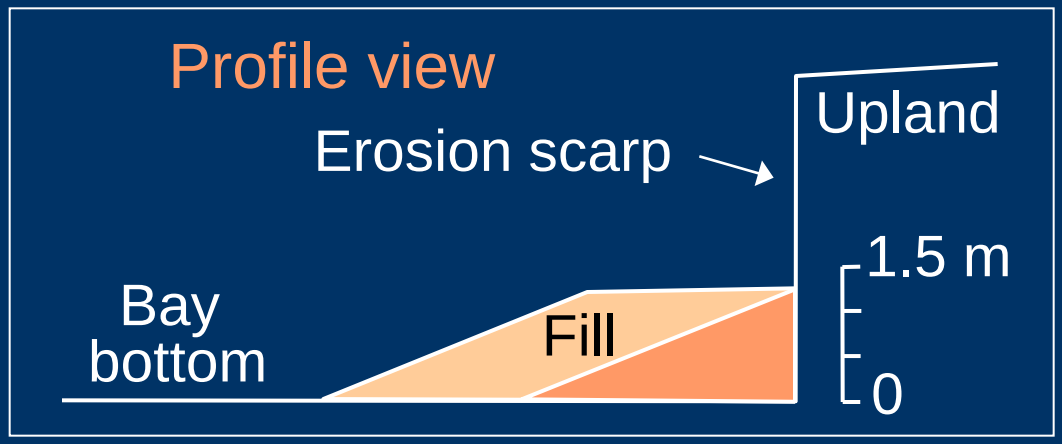
Bulkhead removal impractical; new structures incompatible with NPS mission

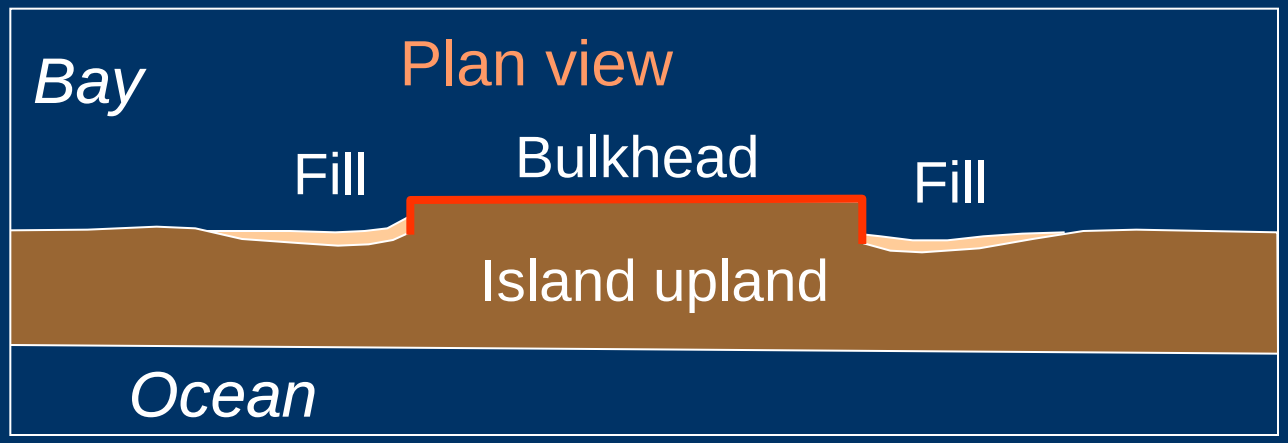
Severe state regulations on altering bay bottom

State requires permanent solution (pro bulkheads)

Need to restore sediment budget (compensate for passive erosion)

Narrow (4 m max), frequent (~2 yr), low (1.3 m) fills to retain natural interactions





Sediment available from channel dredging

Next Step: Pilot Project Assessing Fate of Beach Fill

Topographic profiles to determine sediment loss through time.

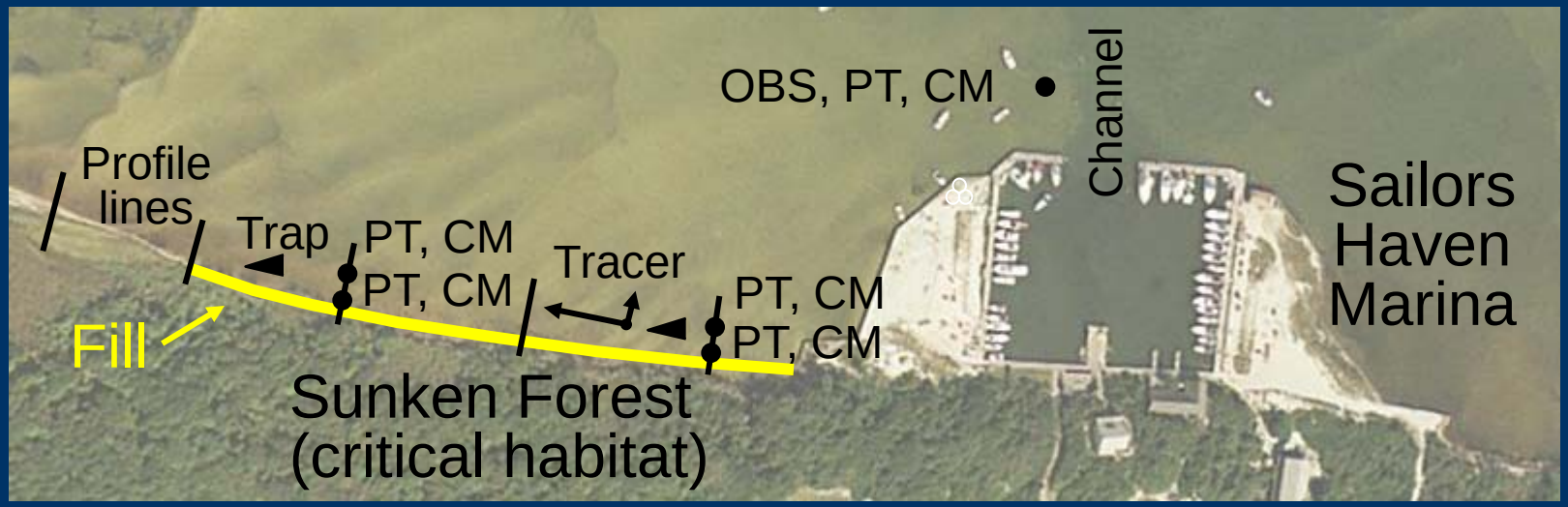
Dyed sand tracer to compare offshore to longshore transport.

Sand traps to quantify rates of transport.

Current meters (CM) and pressure transducers (PT) for process data.

Optical backscatter (OBS) instrument and current meter offshore to determine sediment delivery to the navigation channel.

Sediment samples from fill, foreshore, low tide terrace & channel.



Conclusions

Guiding principles

The need is to restore the sediment budget, not an environment.

Actions are targeted at human-induced sand starvation.

Address bulkheads now; deficit due to oceanside stabilization later.

Concerns

Will sand bypass the “headlands” (true feeder beach)?

Will much sand go offshore, back to the navigation channel?

Is the nourished beach too wide?

Potential payoff

Solution appears compatible with state regulations and local needs