An Assessment Into Vegetation Farms as a Solution to Coastal Erosion in Southern Maine

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I. Introduction

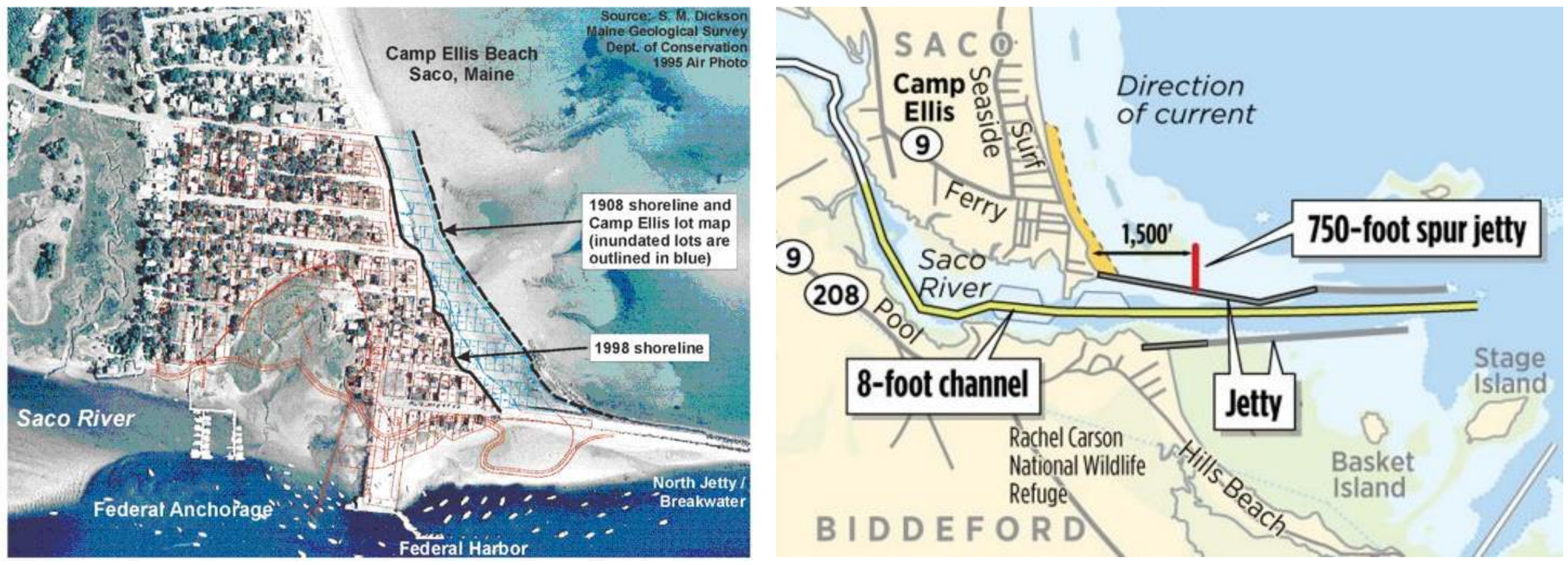

Figure 1: 1908-1998 shoreline recession map of Camp Ellis (left) (Dickson, 1995), and schematic of ACOE proposed solution to mitigate erosion rates (right) (ACOE, 2013).

- Camp Ellis of Saco Bay, suffers erosion rates of 0.5 m to 1m per year
- The installment of the 2 km north jetty in the late 19th and 20th centuries compounded the problem by hauling northward alongshore sediment transport
- To rectify the situation, the United States Army Corps of Engineers (ACOE) proposes a beach fill program coupled with a 229 m spur-structure extending off of the north jetty
- Alternatively, the establishment of a vegetation farm along the coastal zone is under consideration
- To assess engineering viability, two major questions are addressed:

1. How will the vegetation change incoming wave heights?
2. What are the primary drivers of erosion at Camp Ellis?

II. Methodology

- Analytical models were produced for sugar kelp and eelgrass
- Kelp canopy (Zhu et al. 2018):

$$H(x) = H_0\,exp(-K_D x)$$

- Seagrass canopy (Luhar et al. 2017):

$$H(x) = \frac{H_0}{1 + K_D H_0 x}$$

- Data was collected for three wave climates using ACOE and NERACOOS data
- The method of Empirical Orthogonal Functions (EOFs) was applied to beach profile data from Maine Sea Grant for two beaches in Saco Bay: Ferry Beach and Kinney Shores

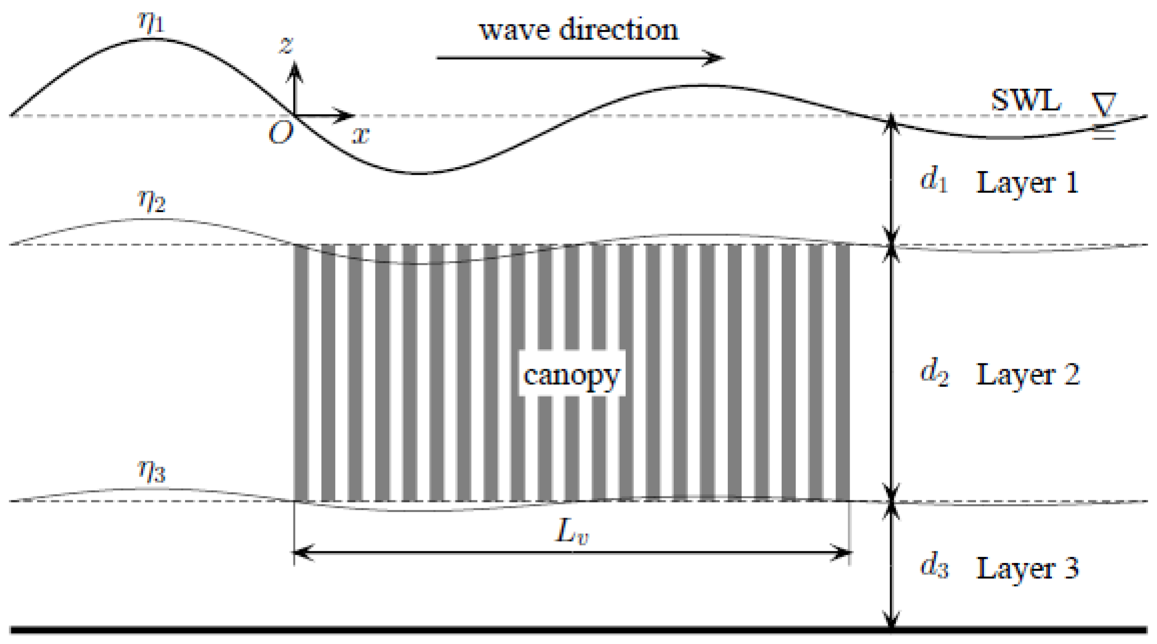

Figure 2: Sample schematic of wave attenuation for a three-layer kelp model. SWL is the still water line. The water level surface is given by and the kelp farm length by L_v (Zhu et al., 2018).

- EOFs were computed during severe storm events so that seasonal profile variability can be identified

III. Wave Attenuation Results

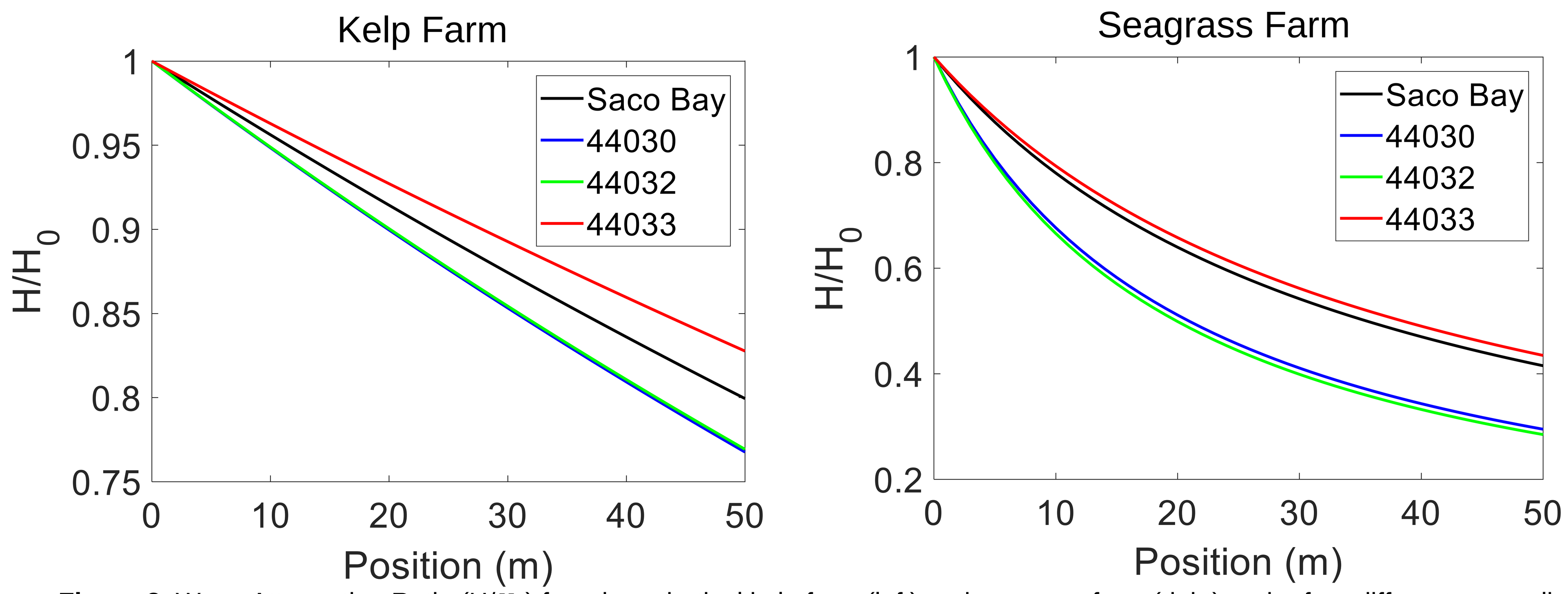

Figure 3: Wave Attenuation Ratio (H/H_0) for a hypothetical kelp farm (left) and seagrass farm (right) under four different wave climates. Numbers in the figure legend refer to the corresponding NERACOOS buoy.

- In shallower waters, seagrass is more effective than kelp at attenuating waves, however seagrass generally cannot be found in water depths greater than 5 m
- Variable hydrodynamics have a clear impact on attenuation ratio

IV. Wave Attenuation Sensitivity Study

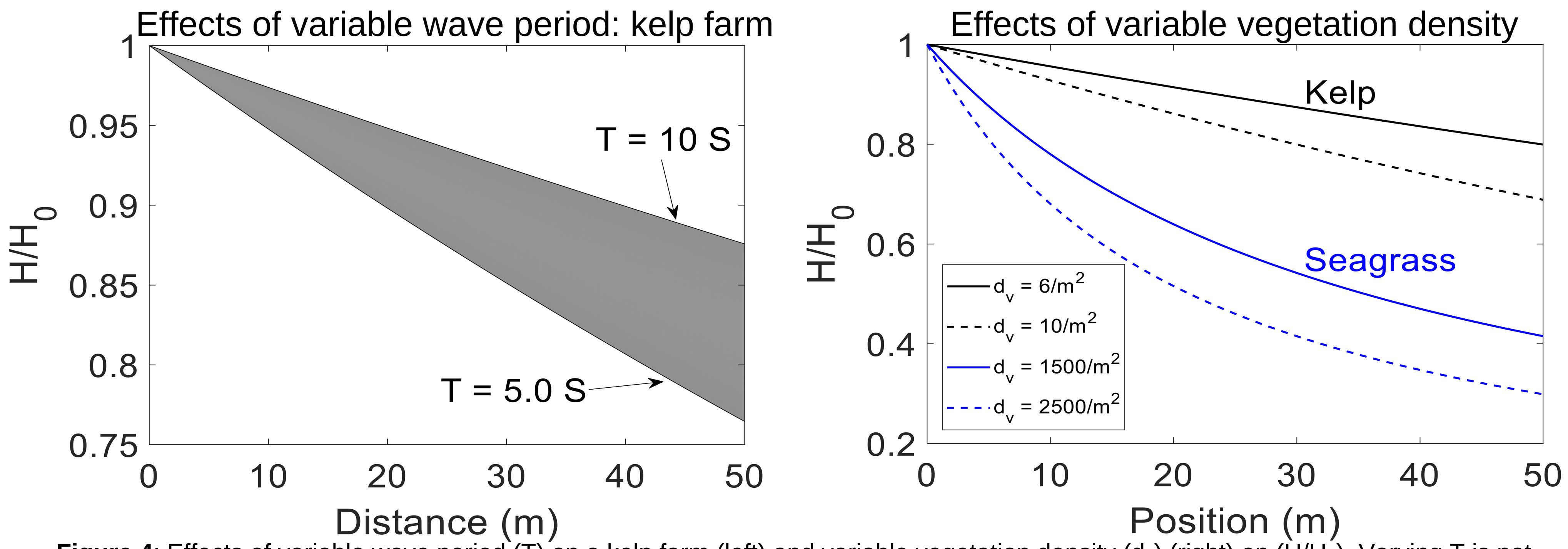

Figure 4: Effects of variable wave period (T) on a kelp farm (left) and variable vegetation density (d_v) (right) on (H/H_0). Varying T is not shown for a seagrass farm due to overlap existing with the kelp farm.

- Longer period waves can reduce H/H_0 by ~ 10%.
- Increasing vegetation density can increase H/H_0 by ~10%

V. Reconstructed Beach Profiles using EOFs

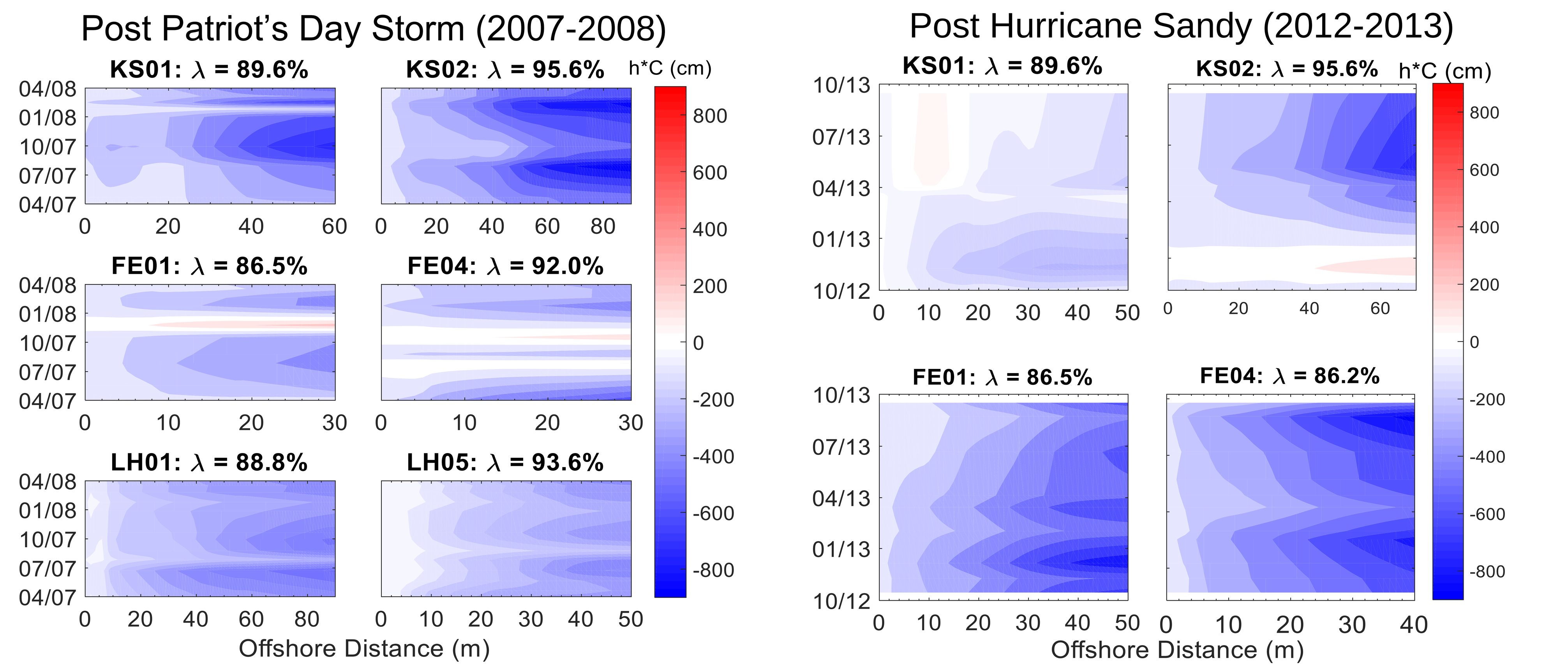

Figure 5: Reconstructed beach profile transects following the Patriots Day Storm (left) and Hurricane Sandy (right) for two profiles of Kinney Shores (KS), Ferry Beach (FE), and Laudholm Beach (LH). Red indicates accretion and blue indicates erosion. The variance explained by the first *two* eigenfunctions is represented by λ. The reconstructed profiles are obtained by multiplying the spatial (h) and temporal (C) eigenfunctions together.

- The first two spatial and temporal eigenfunctions (not individually shown here) explain the majority of variance among beach profiles
- Severe storm events do not necessarily result in the highest erosion of that year, contrary to expected results
- Multiple forcing mechanisms such as wave action, high river discharge events, storm events, and a sediment budget deficit are likely included in the first two eigenfunctions but cannot be individually identified

VI. Conclusions

- Vegetation farms will attenuate incoming wave action, however their effectiveness is influenced by wave hydrodynamics and the physical properties of the vegetation
- The EOFs indicate that morphodynamics in Saco Bay are highly complicated and physical processes cannot be identified from the EOFs alone
- To perform a comprehensive feasibility study, future research should differentiate the amount of erosion caused by wave action versus the amount caused by the presence of the north jetty

VII. References

1. Dickson, S. M. (1995). 1908-1998 shoreline recession map of camp ellis beach [photograph]. Maine Geological Survey Publications.

2. Luhar, M., Infantes, E., and Nepf, H. (2017). Seagrass blade motion under waves and its impact on wave decay. Journal of Geophysical Research: Oceans, 122(5):3736-3752.

3. United States Army Corps of Engineers (2013). Saco River and Camp Ellis Beach, Saco, Maine Section 111 Shore Damage Mitigation Project Draft Decision and Environmental Assessment and Section 404 (b) Evaluation. Technical report.

4. Zhu, L., Huguenard, K., Zou, Q., and Fredriksson, D. (2018). A theoretical approach to evaluate the wave-attenuating capacity of suspended aquaculture structures with living shorelines. In progress.