Making the case for nature-based solutions to coastal erosion in Virginia's coastal bays

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Background

Sea level rise, increased storminess, and human population growth amplify coastal erosion problems, pressuring landowners to implement shoreline protection measures. Growing concern over the negative impacts of traditional shoreline protection methods (seawalls or bulkheads) has increased interest in nature-based solutions, called "living shorelines". Studies offer encouraging findings that living shorelines that use natural marsh vegetation and constructed oyster reefs can control erosion while maintaining ecosystem functions.

This project explores the factors influencing erosion along salt marshes and the suitability of individual shorelines for nature-based protection techniques. Field study in Virginia's coastal bays investigated the effects of marsh vegetation and constructed oyster reefs on dampening waves, the main driver of shoreline erosion. Using geospatial information, a Marsh Vulnerability Index (MVI) was developed that relates disparate factors related to shoreline erosion and serves as the foundation for living shoreline design and placement recommendations.

Figure 1. Typical constructed oyster reef design used in Virginia's coastal bays composed of interlocking bio-concrete blocks.

Objectives

- **Measure** the ability of marsh vegetation and artificial oyster reefs to dampen waves in order to provide evidence-based mitigation metrics.
- **Develop** a Marsh Vulnerability Index (MVI) in order to characterize variables that contribute to marsh erosion potential.
- **Design** a site suitability model in order to determine appropriate nature-based shoreline protection techniques given site-specific characteristics.
- **Share** data with the public through a free, online mapping portal – coastalresilience.org.

Study area

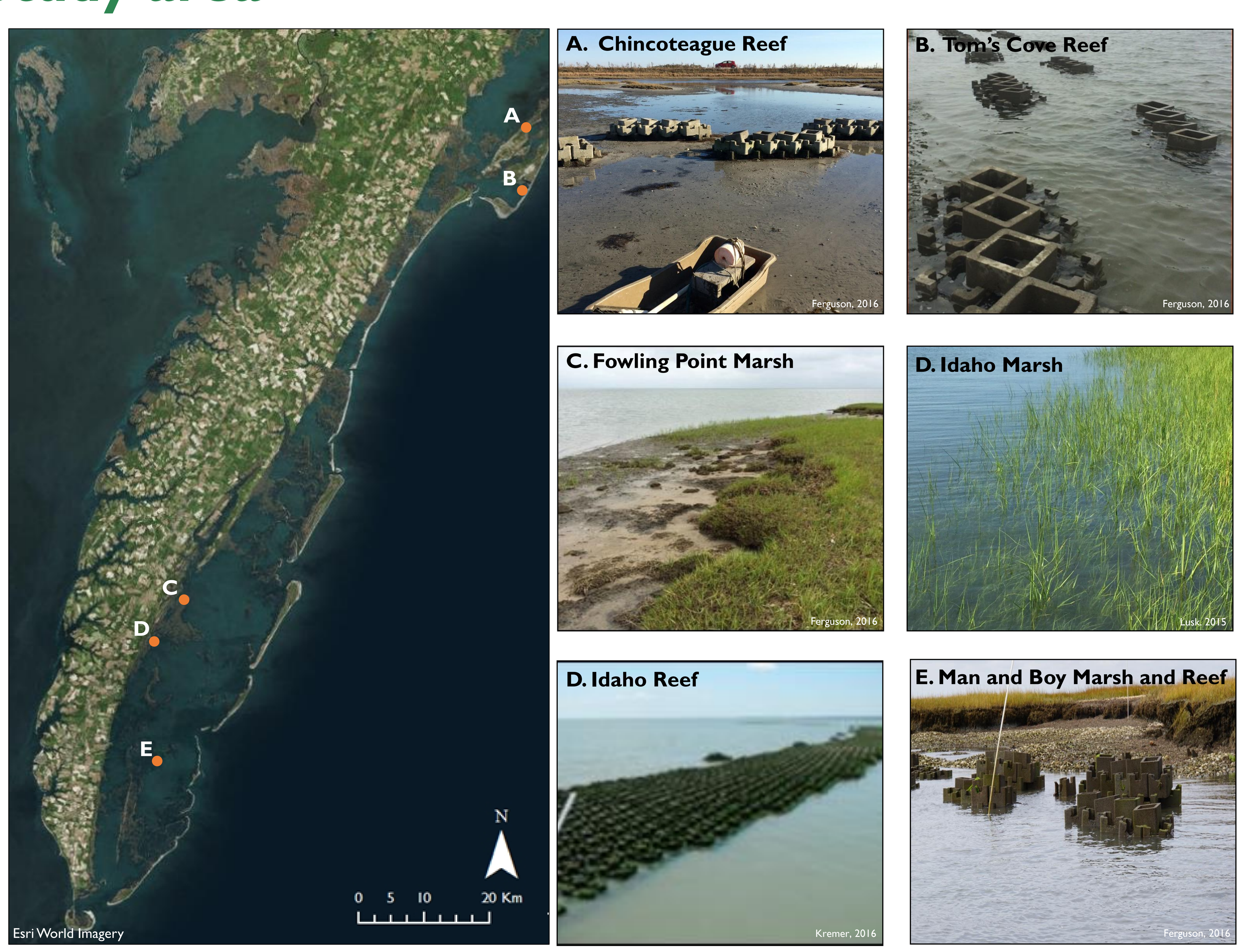


Figure 2. Five representative sites were selected for varying marsh shape and structure and the presence or absence of oyster reefs.

Field methods

The wave-dampening effects of marsh vegetation and oyster reefs were investigated through field study in Virginia's coastal bays. Wave measurements were collected at all five sites.

Figure 3. Wave gauges were placed along a transect on either side of the reef at Chincoteague Reef (A, B). The sensors measure changes in pressure to determine water depth; water depth fluctuations about the mean water level are used to resolve wave height.

Field results

Results suggest that combining marsh vegetation with constructed oyster reefs may offer effective and sustainable long-term coastal protection.

- Constructed oyster reefs are effective at dampening waves at low to moderate water levels.

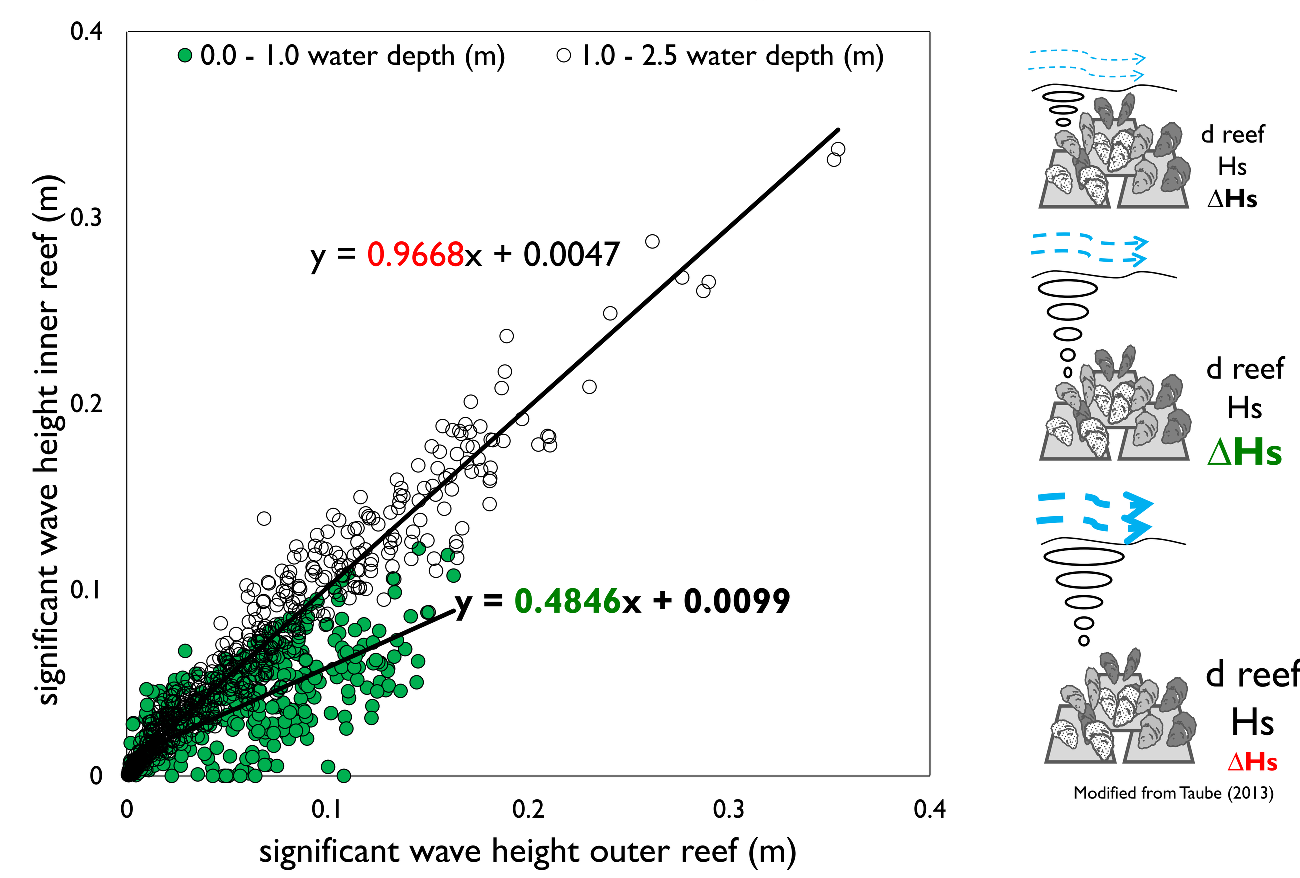


Figure 4. Wave height comparison between outer and inner wave gauge sites at Idaho Reef. A slope less than 1 suggests a decrease in wave height as waves move landward from the outer to inner stations. Data were collected during July - August 2016.

- Marsh vegetation dampened waves by 91% over a 20-meter transect at high water levels.

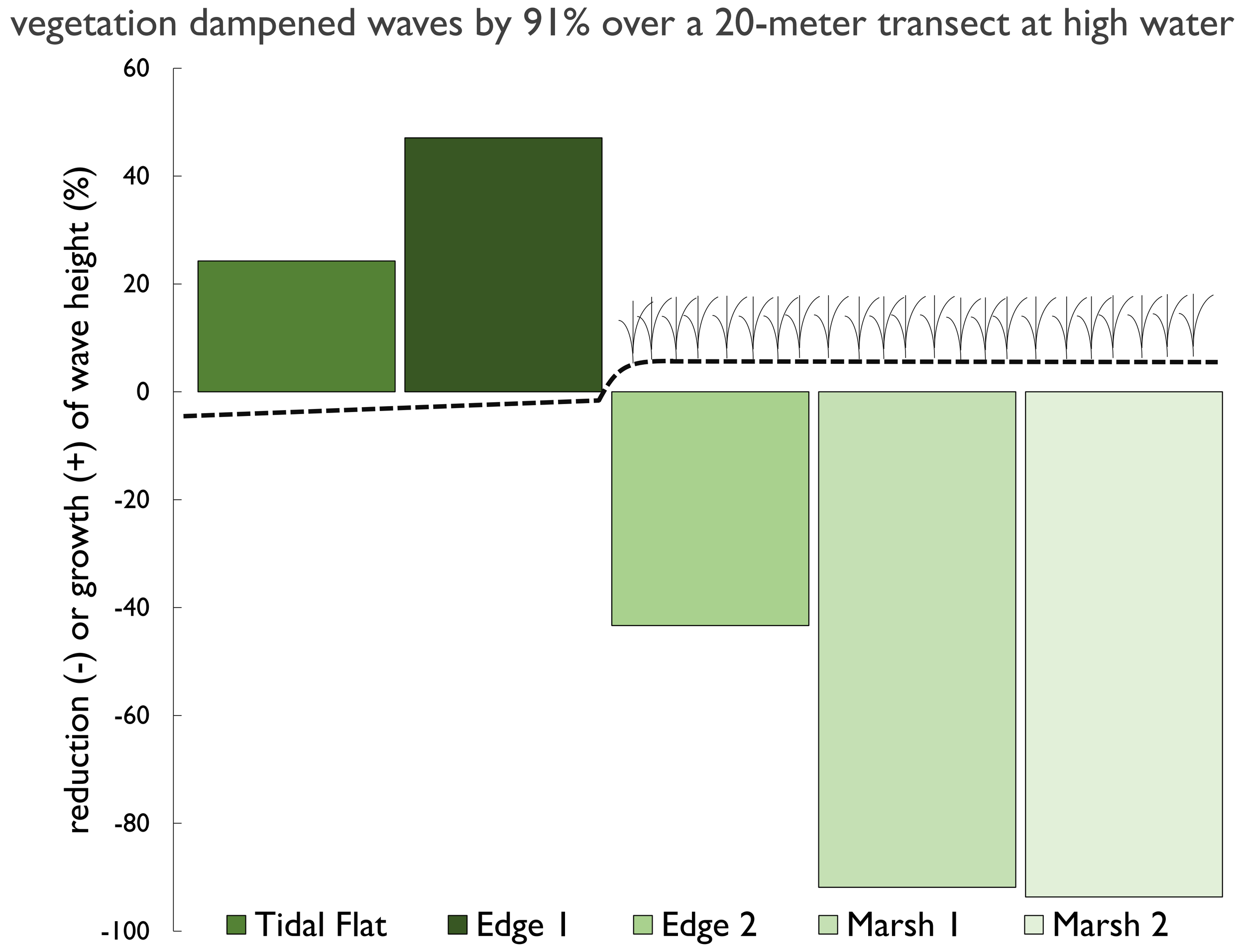


Figure 5. Average growth or reduction of wave height as waves move landward, shown as a percentage of initial height recorded at the most bayward station (lagoon) at Fowling Point Marsh (~100 m). Data were recorded during June - July 2016.

Geospatial methods

A Geographic Information System (GIS) was used to relate and manipulate spatial data collected at different scales and units to develop a Marsh Vulnerability Index (MVI).

- The MVI incorporates high resolution spatial datasets on eight salt marsh erosion variables.
- Erosion variables are assigned a risk value in the range of 1 to 5 in order of increasing vulnerability and combined via a simple geospatial computation to reveal erosion potential.

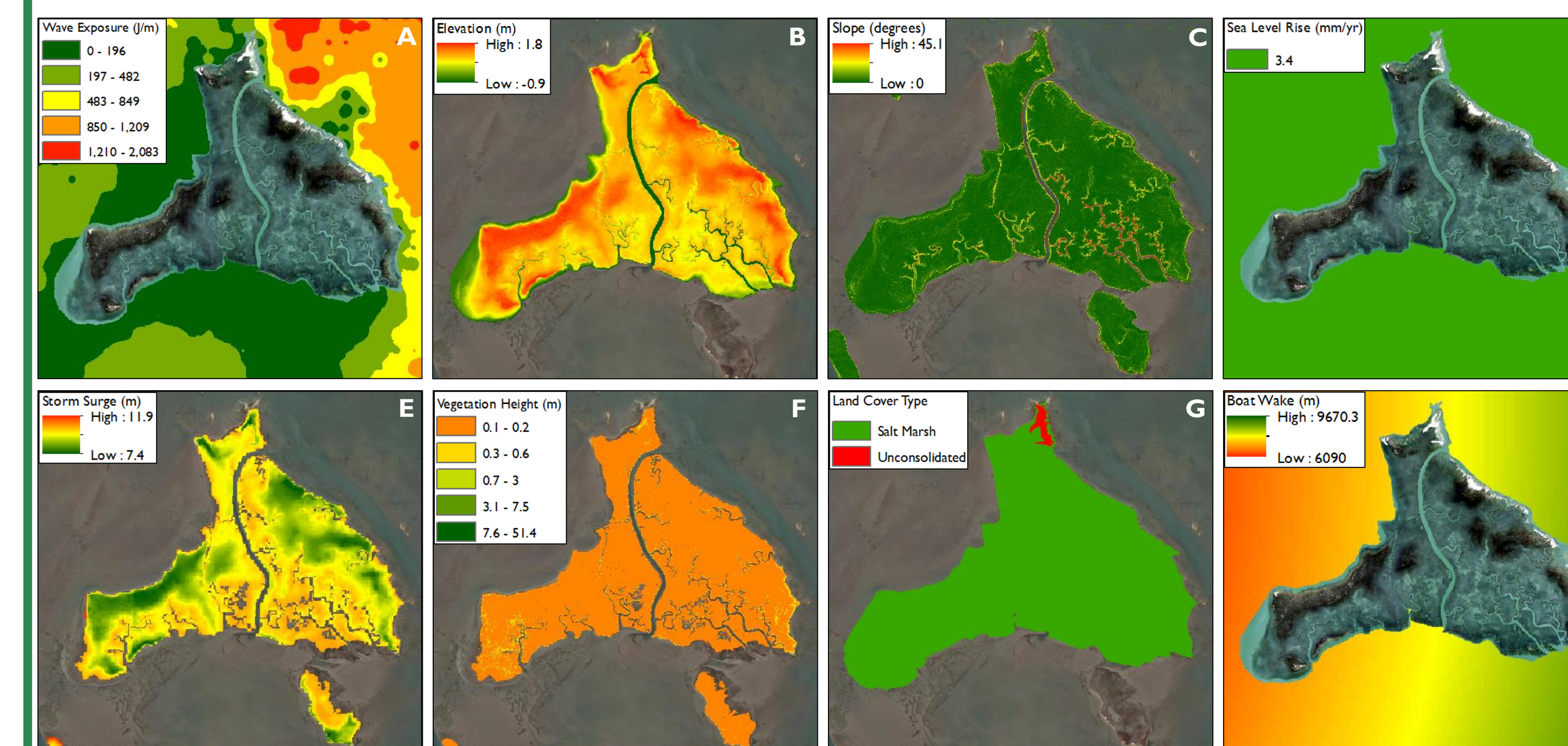


Figure 6. Factors that influence salt marsh erosion include wave exposure (A), marsh elevation (B), marsh slope (C), sea level rise (D), storm surge (E), vegetation height (F), vegetation buffer width (G), and boat wake (H). A vulnerable shoreline is characterized by high elevation, steep marsh slope, short vegetation height, narrow vegetation buffer; and, is exposed to high levels of wave energy, sea level rise, storm surge, and boat wake activity. The panels above illustrate these variables for Man and Boy Marsh.

Geospatial results

- MVI output shows generally good agreement with historical shoreline erosion rates.

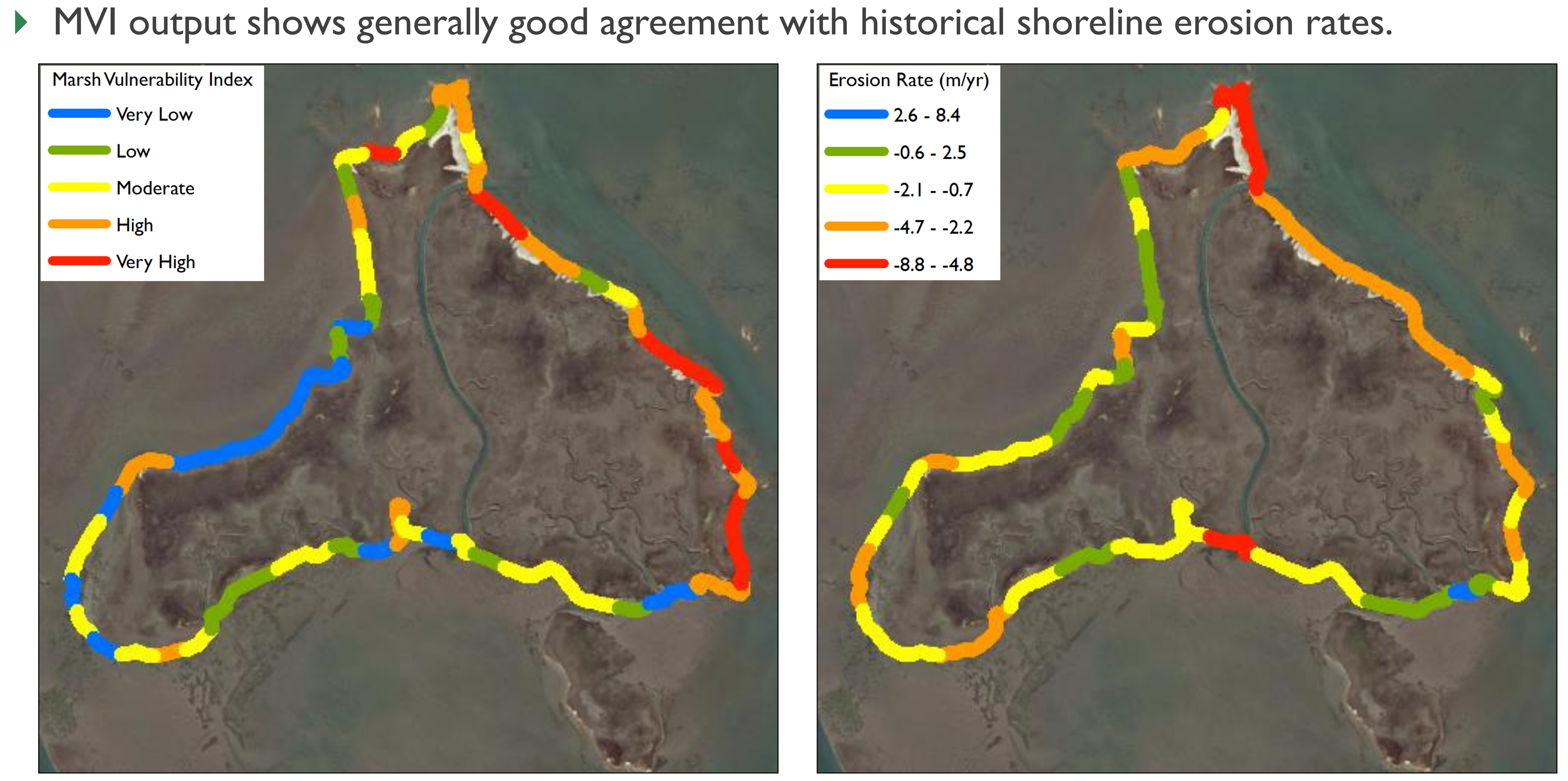
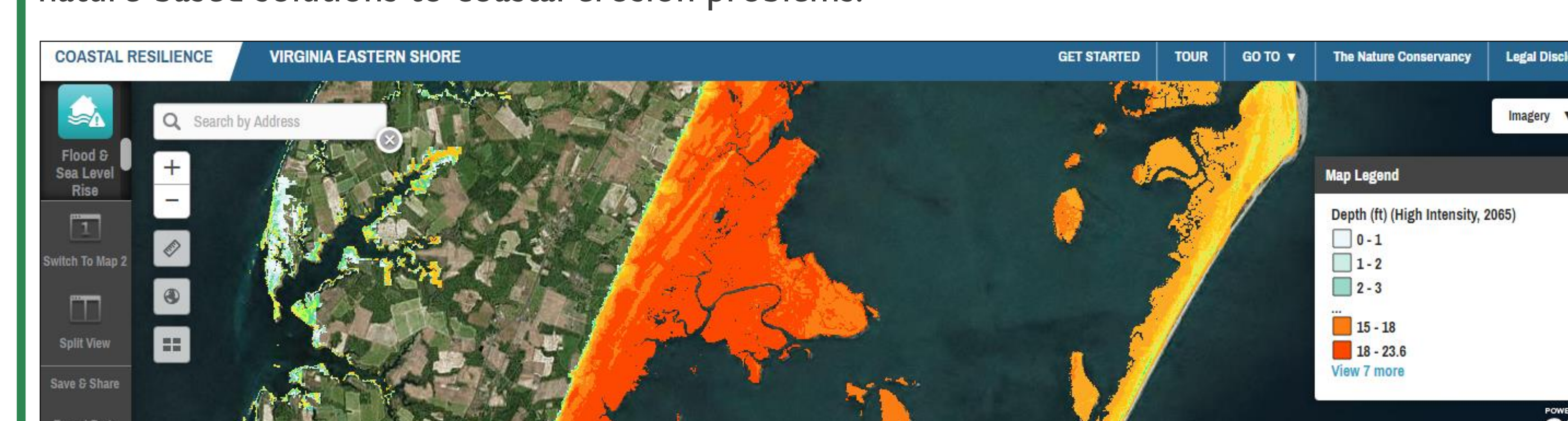


Figure 7. Comparison between MVI output (*left*) and shoreline erosion rates (*right*) (2009 – 2014) at Man and Boy Marsh. Areas of high (low) risk generally correspond with areas of higher (lower) shoreline erosion.

Future work

Resultant data will be available to the public through The Nature Conservancy's Coastal Resilience online decision-support tool, where it can be used with other spatial data to find cost-effective, nature-based solutions to coastal erosion problems.



References

Coastal Resilience mapping portal. Virginia. http://maps.coastalresilience.org/virginia.
Droter, S. 2016. People behind a stronger coast: Kevin Holcomb and Amy Ferguson. U.S. Fish and Wildlife Service NE.
Emery, K. 2015. Man and Boy Shoreline Change 2009-2014. A report for The Nature Conservancy. University of Virginia.
Lusk, B. 2015. Man and Boy Marsh Oyster Reef Restoration Site Project Pictures.
Kremer, M. 2016. Wave dissipation over constructed oyster reefs in the Virginia Coast Reserve. Undergraduate thesis. UVA.
Taube, SR. 2013. Impacts of fringing oyster reefs on wave attenuation and marsh erosion rates. Master's thesis. UVA.

Funding sources