

Mapping Shoreline Change to Inform Coastal Restoration Projects

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Purpose: Identify eroding shorelines in order to target coastal restoration efforts.

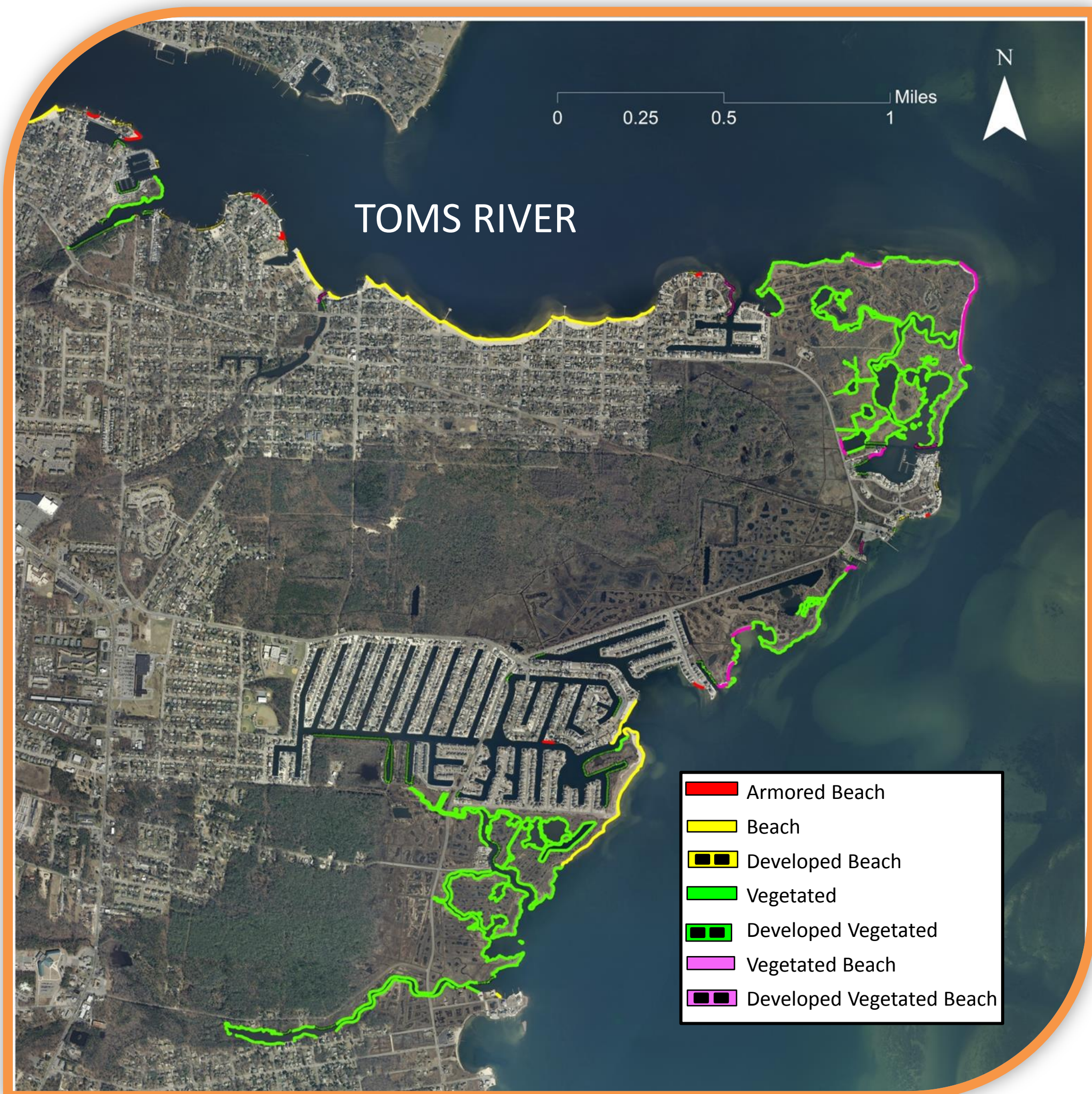
Introduction:

In the wake of Hurricane Sandy the importance of estuarine systems as storm surge buffers was made evident. Efforts to restore degraded wetlands and improve their resiliency capabilities by replanting lost vegetation and using natural materials like rocks and oyster reefs to dampen wave energy are underway, not just in New Jersey, but all over the USA. These tactics, collectively known as "Living Shorelines", also provide wildlife habitat, improved water quality and a host of other ecosystem services.

This study, piloted in Good Luck Point, Berkeley Township, NJ, identified those shorelines that were quickly eroding and may require restoration efforts. This study also broke the shoreline into distinct shoreline types to determine if a particular shoreline type experienced different rates of change compared to the others. This study marks the first attempt by NJDEP to measure estuarine shoreline loss in detail.

Step 1: Shoreline Inventory

To map the shoreline types along the study area NOAA's Environmental Sensitivity Index (ESI) layer was used. ESI provides shoreline type descriptions for the entire coast of the USA. ESI is used for prioritizing oil spill clean up response. The New Jersey ESI layer was added to GIS and edited, resulting in nine distinct shoreline types.

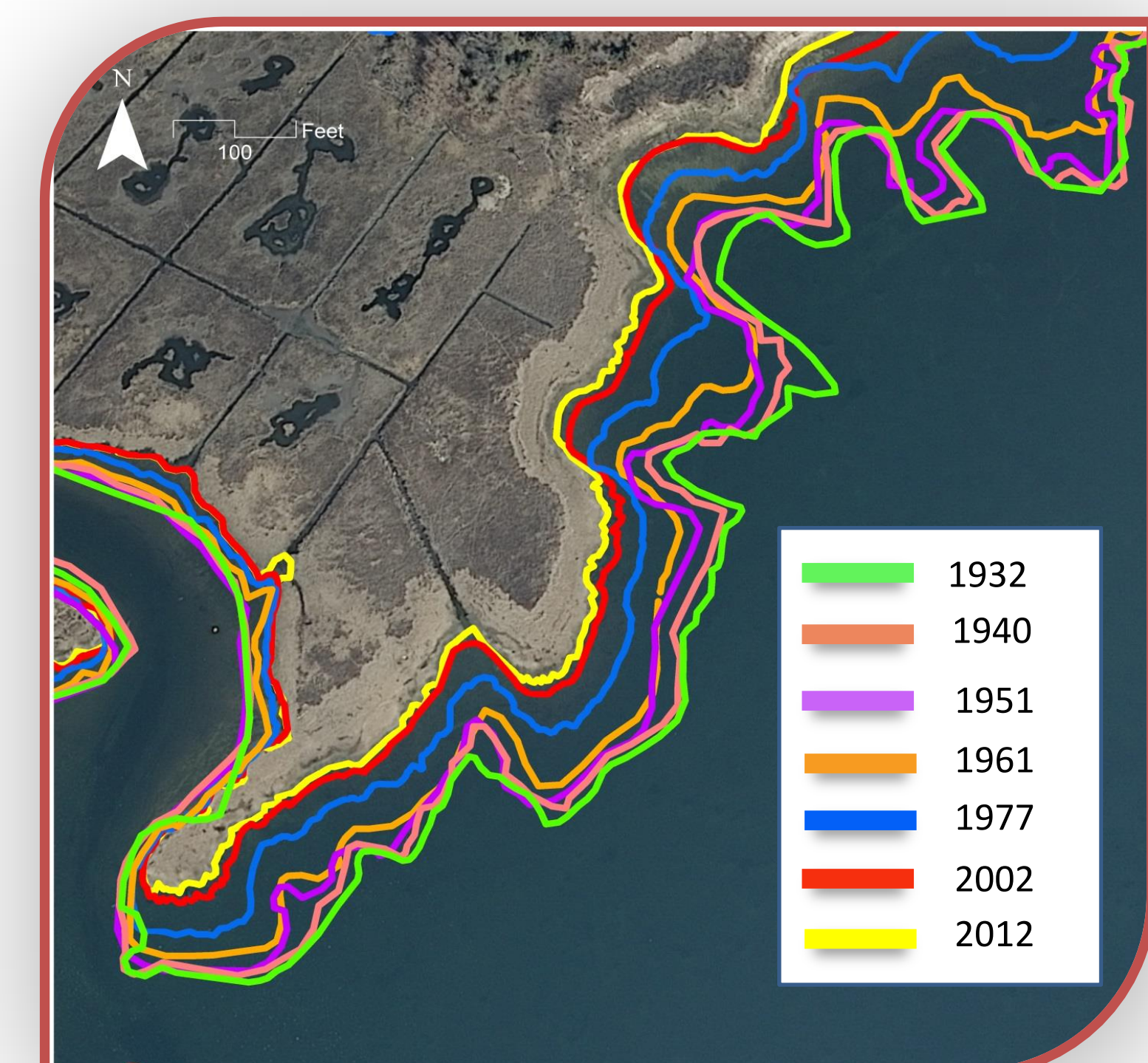


Shoreline inventory of the Good Luck Point, using NOAA's ESI data. "Developed" shoreline types are natural shorelines that are adjacent to hardened shorelines. Developed shorelines may receive higher erosional forces from wave energy being redirected off of adjacent hardened shorelines. Hardened shorelines were mapped as well, but were not included in the shoreline change rate analysis. Vegetated shorelines accounted for over two-thirds of the study area.

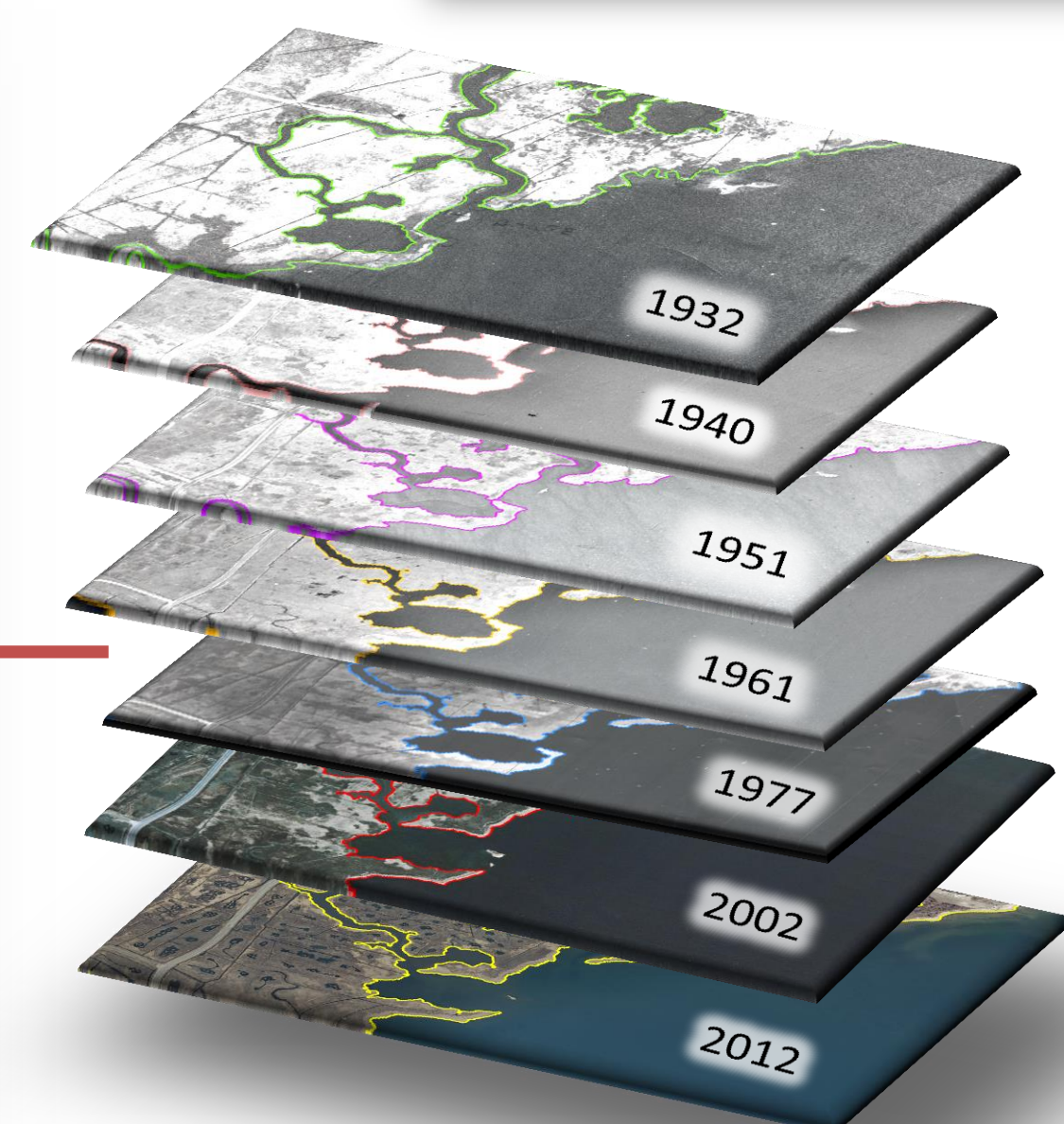
Step 2: Historic Shorelines

Seven historic shoreline vectors were created from georeferenced aerial photos (1932 – 1961) and existing NJDEP data layers (1977-2012). Shorelines were digitized to the "wet/dry line", characterized by a change in tone along the shore from dark to light. The shorelines were then compiled together onto a single map (shown to the right).

Baselines were created in preparation for Step 3. All of the shorelines for a particular shoreline type were buffered and dissolved together. The buffer was then turned to a polyline and cut so that only the most landward or seaward line remained.



Seven historic shorelines were digitized from aerial photography and existing GIS imagery. This map gives a close up view of the shorelines used in the study area



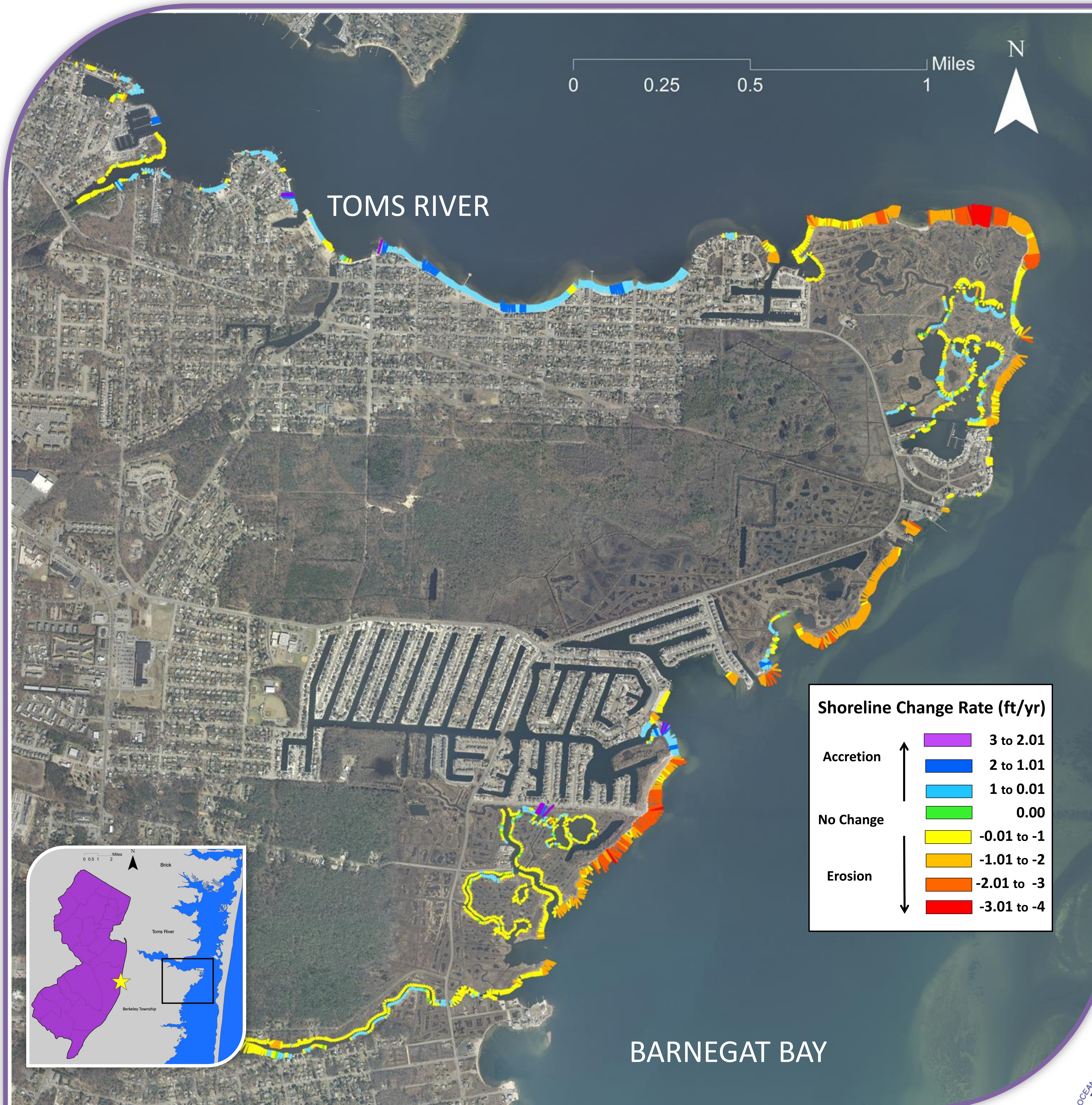
The colored lines along the shoreline are the transects cast by DSAS to calculate shoreline change (The Linear Regression Rate, LRR). The warmer colors indicate erosion and the cooler colors indicate accretion. The length of the transects were clipped to show the difference between the furthest and closest shorelines. Longer transects indicate more shoreline change than shorter transects.

Step 3: Digital Shoreline Analysis System

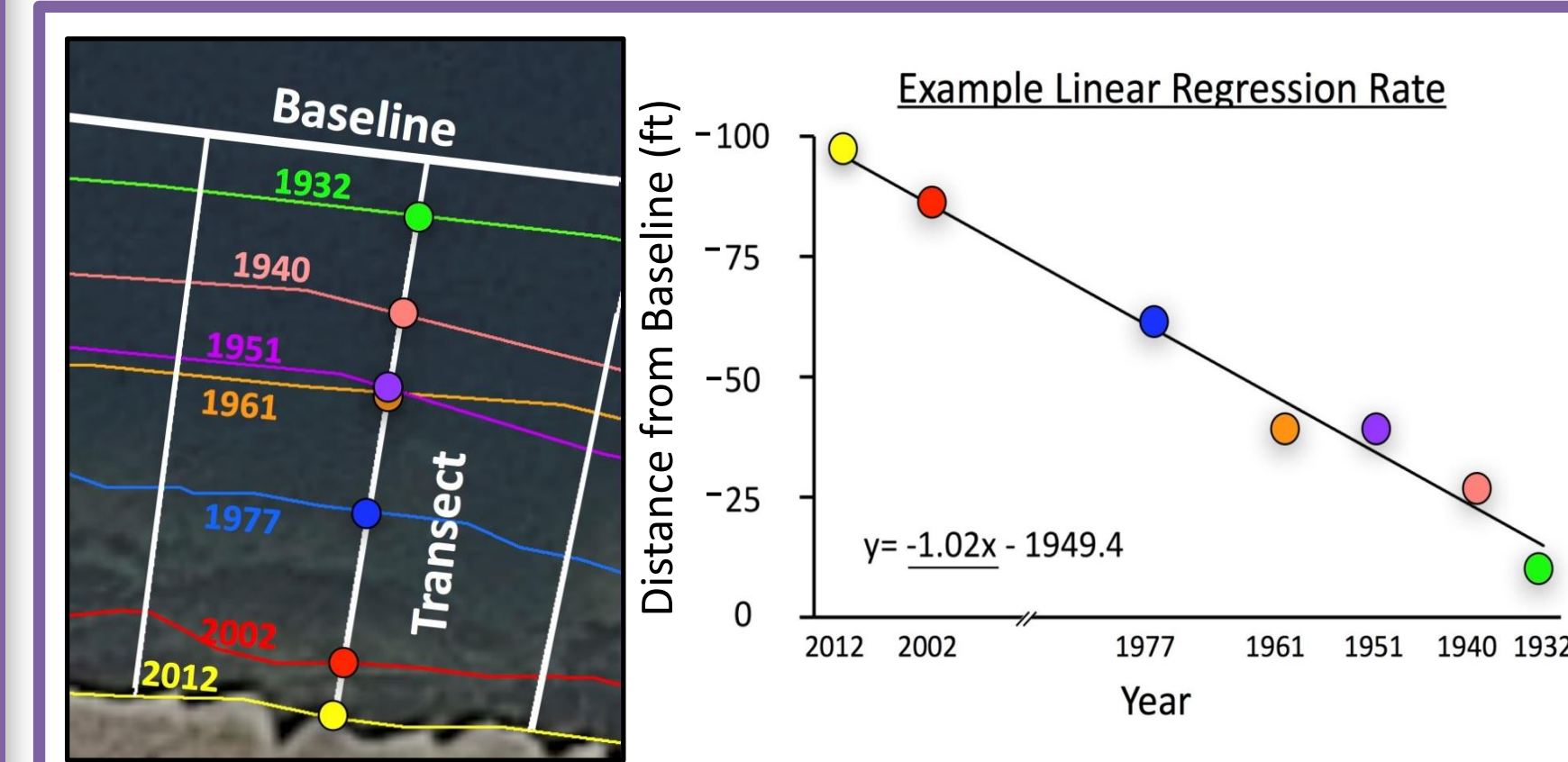
The historic shoreline vectors were analyzed using the Digital Shoreline Analysis System (DSAS) program developed by USGS. DSAS casts transects at user defined intervals from the baselines created in Step 2. DSAS allows a number of statistics to be calculated. This map shows the Linear Regression Rate (LRR), calculated by taking the distance between the baseline and the point where the historic shorelines cross a transect. The residuals are plotted and a best fit line is placed that minimizes the sum of squares of the residuals. The LRR at that transect is equivalent to the slope of the best fit line. Armored shorelines and areas that eroded to allow inland ponds to open up to become shoreline were not included in this study as they would have given inaccurate shoreline change rates.

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Step 3, cont



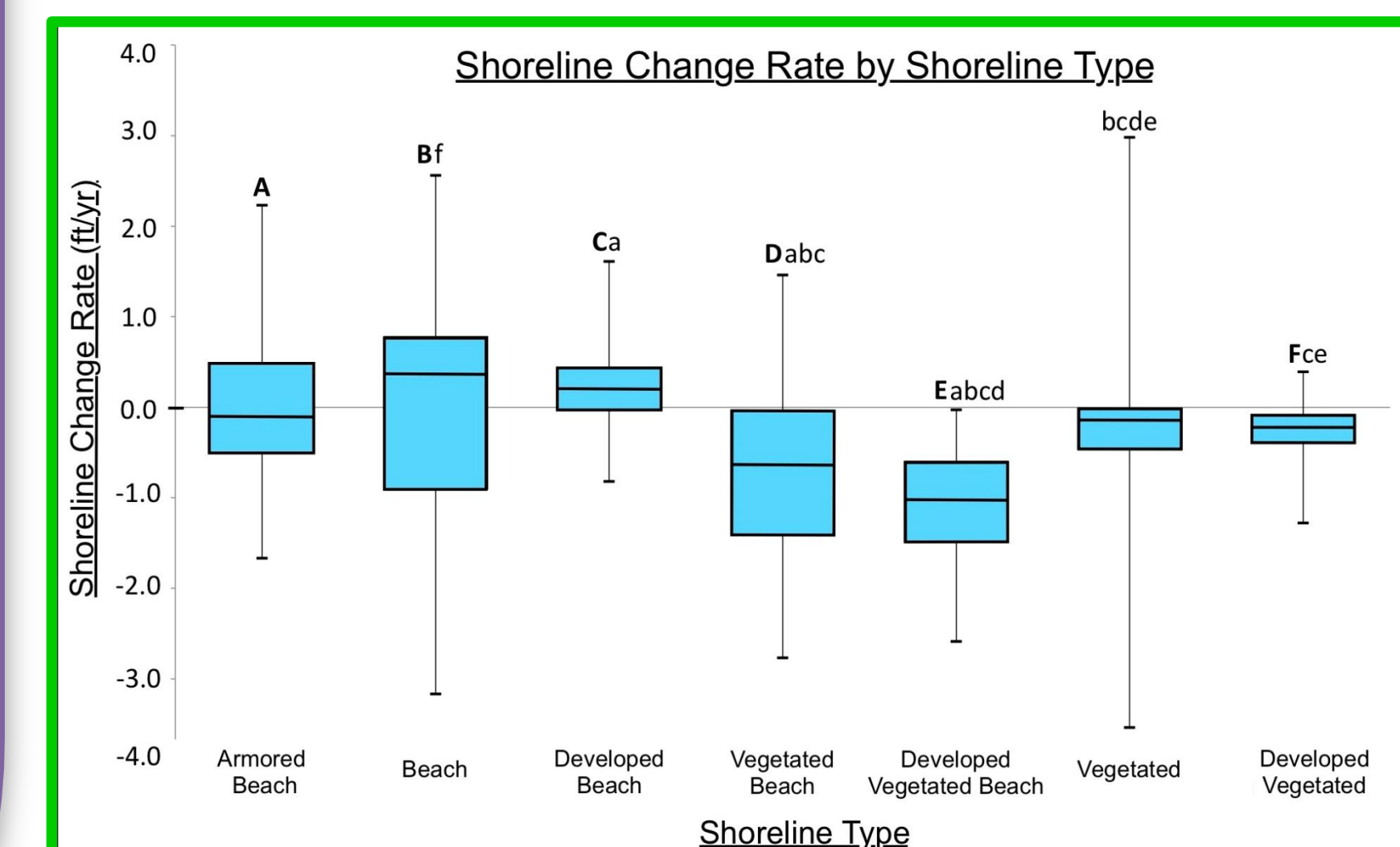
The rate of shoreline change is equal to the slope of the best fit line, -1.02. The shoreline is eroding 1.02 ft/yr. Hardened shoreline and areas where inland ponds opened up as a result of erosion were not included in the results as they would have given inaccurate rates.

Step 4: Results

All statistics were performed using R statistical software (version 3.2.3). The shoreline change rate (LRR) for each shoreline type were compared using a Kruskal-Wallis test, followed by a Dunn's test for multiple comparisons (using the Holm method to adjust p-values).

The results suggest that Developed Vegetated Beaches experience the most consistent erosion at Good Luck Point with all transects having negative rates. Vegetated Beaches also show high erosion with 75% of the transects having negative rates. Vegetated shorelines account for the highest rates of shoreline change, both eroding and accreting (this is most likely aided by the fact that vegetated shorelines account for over two-thirds of the study area). Coastal restoration efforts should be focused on these shoreline types.

Eroding shorelines seem to appear on more exposed areas with longer fetches. Future studies will incorporate wave energy analysis to determine the relationship between wave energy, shoreline type and shoreline change rate.



This plot depicts the shoreline change rates by shoreline type. The area within each blue box represents the interquartile range (middle 50% of the data). The line in the middle of each box is the median and the ends of the whiskers represent the maximum and minimum shoreline change rates for each shoreline type. Shoreline types with a lowercase letter have a shoreline change rate that is significantly different than shoreline types with a corresponding uppercase letter.



Citations:

Dinno, A. (2016). *Dunn's Test of Multiple Comparisons Using Rank Sums*. R package version 1.3.2. <https://CRAN.R-project.org/package=dunn.test>

National Oceanic and Atmospheric Administration (NOAA), National Ocean Service, Office of Response and Restoration, Hazardous Materials Response Division, Seattle, Washington. (2014). *Environmental Sensitivity Index (ESI)*. Delaware, New Jersey and Pennsylvania. <http://response.restoration.noaa.gov/maps-and-spatial-data/download-esi-maps-and-gis-data.html#NewJersey>

R Core Team (2015). *R: A Language and Environment for Statistical Computing*. Vienna, Austria. <https://www.R-project.org>

Thieler, E.R., Himmelstoss, E.A., Zichichi, J.L., and Ergul, A. (2009). *Digital Shoreline Analysis System (DSAS)*. An ArcGIS Extension for Calculating Shoreline Change. Version 4.3.4730. U.S. Geological Survey Open-File Report 2008-1278. <http://woodshole.er.usgs.gov/project-pages/DSAS/version4/index.html>