Southeastern Wisconsin Coastal Recession Between 1956 to 2015

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Executive Summary

Lake Michigan coastal bluff and shoreline recession data are provided for Kenosha, Racine, Milwaukee, and Ozaukee Counties (collectively called "southeastern Wisconsin") for a time period between 1956 to 2015 and is publicly available on the Wisconsin Shoreline Inventory and Oblique Viewer (http://floodatlas.org/asfpm/oblique_viewer/). Coastal recession is the distance that coastal bluff or shoreline features have receded, or moved landward. For areas with coastal bluffs, recession information is provided for the bluff crest, where the relatively flatter upland meets the steeper bluff face, and the bluff toe, where the bluff face meets the beach. In areas that lack a bluff, recession information is provided for the shoreline, where the beach meets the water. Recession was measured from the position of these features in historic aerial orthophotography over two analysis periods: a long-term period from 1956 to 2015 and a short-term period from 1995 to 2015. Recession is represented as both the distance coastal feature changed in position over the analysis period ("recession distance") as well as the average annual of change of the coastal feature's position ("recession rate") Each recession data point represents an average of recession measurements along a 300-foot section of coast and does not represent any specific property or municipal boundary. Approximate uncertainty in the long-term recession distances is ±4 feet (±0.07 ft/year for recession rate) and in the short-term recession distances ±2 feet (±0.1 ft/yr for recession rate). This data should be considered preliminary and are intended for informational purposes. Care should be exercised in interpreting these data based on knowledge of coastal geology, engineering and mapping.

This data was produced as a part of ongoing studies at the University of Wisconsin-Madison Coastal Sustainability Laboratory with assistance from Freshwater Engineering. This data has been made public through collaborations of the University of Wisconsin-Madison, the Wisconsin Coastal Management Program, University of Wisconsin Sea Grant, and the Association of State Floodplain Managers.

Funding
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Southeastern Wisconsin's Coast

The Lake Michigan coast of Southeastern Wisconsin (defined here as Kenosha, Racine, Milwaukee, and Ozaukee Counties) is composed of low sandy shores of less than 10 feet in elevation, low bluffs 10 feet to 50 feet high, and high bluffs up to 130 feet high (Figure 1). Bluffs in this region are principally composed of clayey soil deposited by glaciers during the last Ice Age. The coast is also composed of breakwaters and harbor infrastructure near the port and harbor cities of Port Washington, Milwaukee, Racine, and Kenosha.

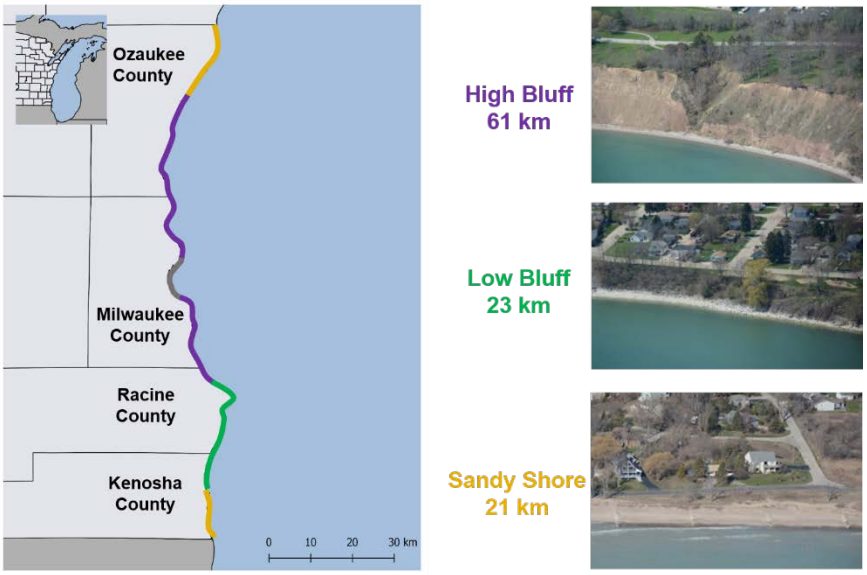

Figure 1: Southeastern Wisconsin's coast is composed of high bluffs (purple), low bluffs (green), sandy shores (tan), and harbor infrastructure (gray).

This coastline is subject to erosion and bluff slope failures which can cause the coast to recede, or move landward, and threaten upland coastal properties. Coastal recession is often referenced to key recognizable coastal features which are depicted in Figure 2 and defined as follows:

Bluff Crest: the location where the relatively flatter upland meets the steeper bluff face

Bluff Toe: the location where the bluff face meets the beach

Shoreline: the location where the beach meets the water

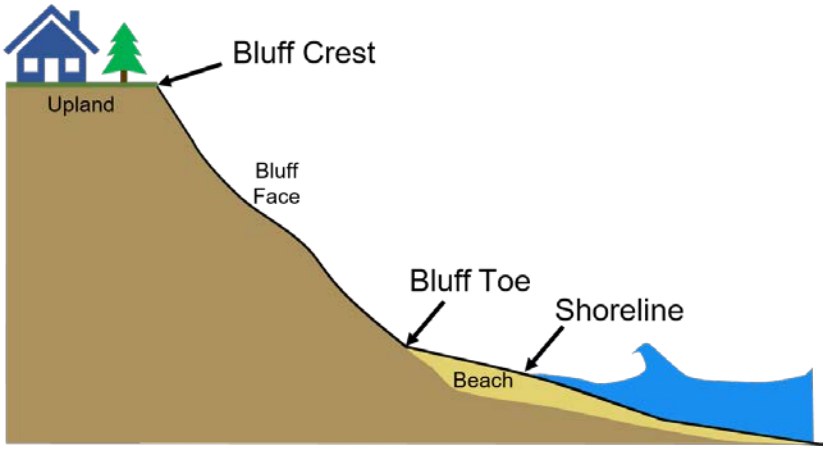

Figure 2: The bluff crest, bluff toe, and shoreline

Coastal Recession Measurements

Coastal recession is the distance the bluff or shoreline has receded, or moved landward over a given period of time. Recession was measured along bluffed coasts for the bluff crest and the bluff toe or, in areas that lack a bluff, for the shoreline (Figure 3). Coastal feature recession distances were measured from historical aerial photos in Geographic Information System (GIS) software for two analysis periods: 1956-2015 and 1995-2015.

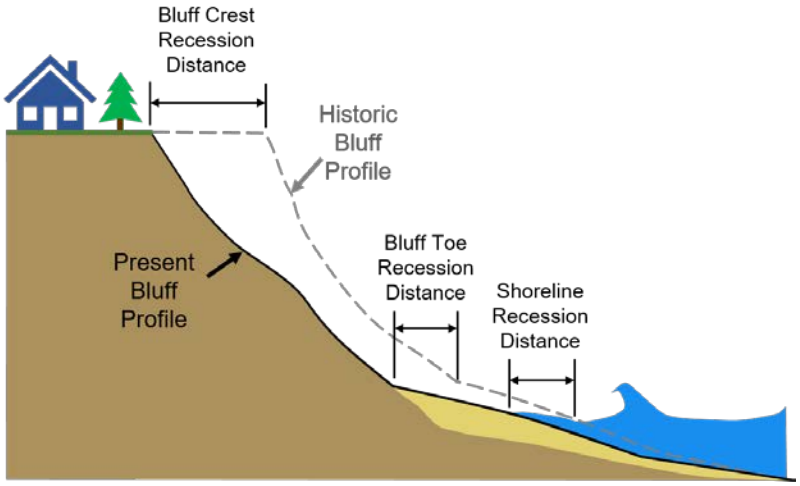

Figure 3: Coastal recession measurements which compare the positions of coastal features over time

The procedure for making coastal recession measurements explained below and summarized in Figure 4 (following page).

1) Photos from each analysis year (1956, 1995, and 2015) were orthorectified to remove vertical distortions caused by the camera lens and georeferenced to position them accurately in space. The photos used for this analysis are summarized in Table 1.

Table 1: Summary of aerial photos used in recession analysis

Year	*Month*	*Photo Source*	*Photo Description*	*Photo Scale*	*Resolution (m)*
1956	May/June	USDA	Scanned B&W Aerial Photo	1:20,000	N/A
1995	April	SEWRPC	B&W Aerial Orthophoto	1:20,000	N/A
2015	April	SEWRPC	Color Aerial Orthophoto	N/A	0.152

2) Coastal features were traced in each photo using differences in soil color, vegetation or other indicators to distinguish the features on each photo.

3) Once each feature is digitized, the United States Geological Survey (USGS) Digital Shoreline Analysis System (DSAS) software was used to measure the location of each digitized feature along transect lines spaced at 10-meter intervals (~33 feet) along the shoreline.

4) Recession distances are averaged at 100 meter intervals (~328 foot) along the coast using a spatial averaging technique. This spatial averaging serves two purposes: i) to represent recession over a distance wider than the typical scale of a single lot, and not at a specific parcel and ii) in order to removes spikes in the data which may result from localized erosion events.

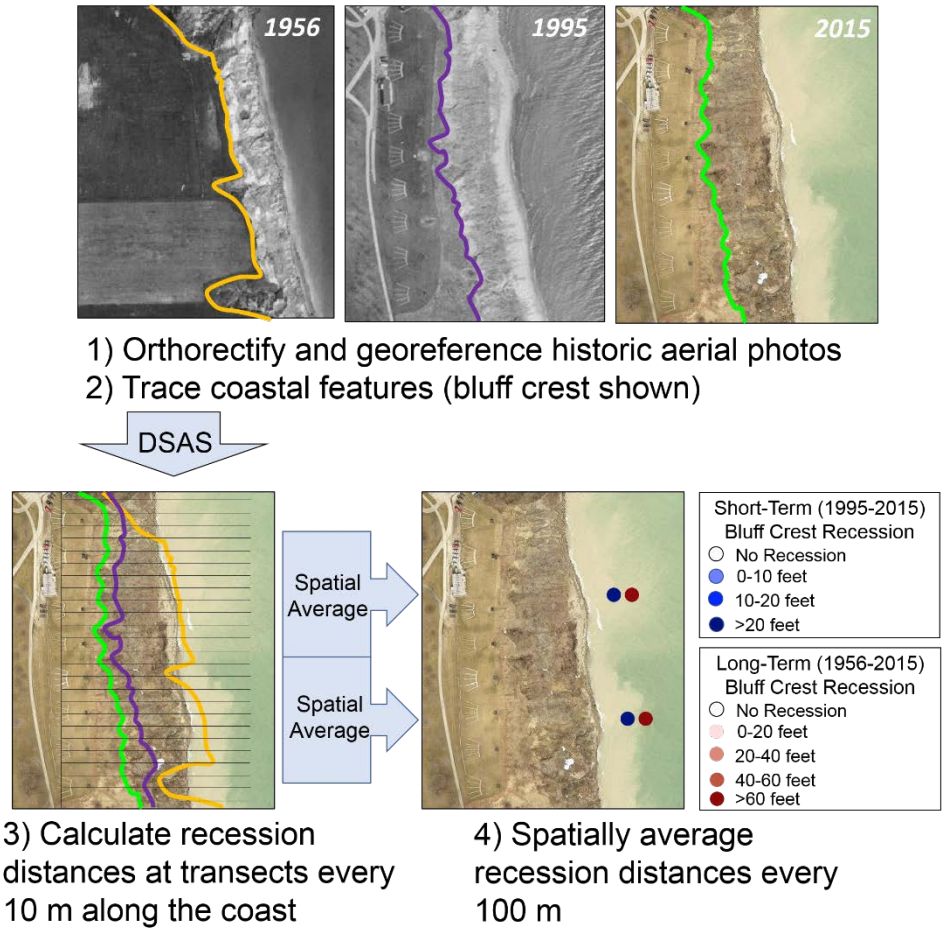

Figure 4: Coastal recession measurement procedure

The following recession measurements are available.

Layer	Description
Bluff Toe Recession – Long-term (1956 – 2015)	The distance the bluff toe has moved landward between 1956 and 2015.
Bluff Crest Recession - Long-term (1956 - 2015)	The distance the bluff crest has moved landward between 1956 and 2015.
Shoreline Recession – Long-term (1956 - 2015)	The distance the shoreline has moved landward between 1956 and 2015.
Bluff Toe Recession – Short-term (1995 – 2015)	The distance the bluff toe has moved landward between 1995 and 2015.
Bluff Crest Recession – Short-term (1995 - 2015)	The distance the bluff crest has moved landward between 1995 and 2015.
Shoreline Recession – Short-term (1995 - 2015)	The distance the shoreline has moved landward between 1995 and 2015.
Shoreline Position (2015)	The location where the beach met the water, as measured in 2015 aerial photographs

Each data point represents an average of recession measurements along a 300-foot section of coast and does not represent any specific property or municipal boundaries. By clicking on a point, the actual average measured recession distance and an average annual rate of recession can be viewed. Note that a positive recession value represents a landward movement of the feature and a negative recession value represents a lakeward movement of the feature, also known as accretion.

The recession information can provide useful insights into the historic migration of the southeastern Wisconsin coast. It should be noted that the recession distances provided here represent how the bluffs and shorelines have responded to historic environmental conditions and human actions over a specific time period in the past (1956-2015 and 1995-2015). There is always uncertainty in how bluff and shoreline recession will respond to future conditions. Bluff recession can also be sporadic. For example, a bluff crest that had remained unchanged for decades can recede many feet almost instantly due to a bluff collapse. Human actions may also change the evolution of the coast. For example, a bluff that may have been heavily eroded historically may have been recently stabilized or had shore protection added such that recession could be expected to decrease compared to historic rates.

Disclaimer

Please note that the data presented here should be considered preliminary and may not reflect current conditions along the coast. Care should be exercised in interpreting these data based on knowledge of coastal geology, engineering and mapping. Site assessments may be necessary to property interpret this data. As the Lake Michigan coast is a dynamic and constantly changing environment, one should consider consulting with local authorities and qualified professionals before building or making other land use decisions along the coast.

Methods

Bluff recession distances were measured from historical aerial photos in Geographic Information System (GIS) software for two analysis periods: 1956-2015 and 1995-2015. Using GIS software, photos from each year are georeferenced to position them accurately in space and orthorectified to remove vertical distortions caused by the camera lens. The bluff crest, bluff toe, and shoreline are carefully traced on each photo. The bluff crest is identified as the break in slope between the upland and the bluff slope, the bluff toe is identified as the break in slope between the bluff slope and beach, and the shoreline is defined as the location that appears as the interface between the water and the land at the time the photo was acquired. Differences in soil color, vegetation or other indicators are used to distinguish the features on each photo. Once each feature is digitized, the Digital Shoreline Analysis System (DSAS) software is used to measure the location of each digitized feature along transect lines spaced at 10-meter intervals along the shoreline. The data presented here shows recession data which have been spatially averaged along 300-foot sections of coast. The data shown on this data viewer therefore represents average recession over a distance wider than a typical single lot, parcel, or shoreline frontage, and not at a specific parcel or location on the coast.

Measurement Uncertainty

Uncertainty is inherent in any measurement. Errors during the digitization process of coastal features are the primary source of uncertainty for these bluff recession measurements. The most important sources of uncertainty during the digitization process are georeferencing errors of older photographs, photo resolution and/or quality, and visual obstruction of features in photos (i.e., dense forests concealing the bluff crest). Approximate uncertainty in the long-term recession distances is ±4 feet (±0.07 ft/year for recession rate) and in the short-term recession distances ±2 feet (±0.1 ft/yr for recession rate). Uncertainty values may be higher in some areas that suffer from image quality issues.

Funding
Funded by the Wisconsin Coastal Management Program and the National Oceanic and Atmospheric Administration, Office for Coastal Management under Grant # NA17NOS4730144.

Appendix: Metadata

Dataset Title	Southeastern Wisconsin 2015 Shoreline Position
Dataset Reference Date	1/4/2019
Dataset Responsible Party	UW-Madison Coastal Sustainability Lab
Geographic location of the dataset	Northernmost Latitude: 43 32’ 44” Southernmost Latitude: 42 29’ 36” Easternmost Longitude: 87 45’ 26” Westernmost Longitude: 87 51’ 44”
Dataset language	English
Dataset topic category	Shoreline Lake Michigan Great Lakes Coastal Erosion Environmental Hazard Landform Land Status
Abstract defining the dataset	This dataset contains a digitized shoreline position in 2015 in Kenosha, Racine, Milwaukee, and Ozaukee Counties on Southeastern Wisconsin’s Lake Michigan coast. The shoreline is traced in GIS software from vertical aerial photos taken in Spring 2015 by the Southeastern Wisconsin Regional Planning Commission. The position of the shoreline is defined as the wet/dry line visible in photos. Shoreline position in the Great Lakes is highly sensitive to lake level fluctuation, wave conditions, beach material, and beach slope. The shoreline position in this dataset represents one moment in time and may not reflect current shoreline positions.
Update Frequency	Not planned
Spatial representation type	ESRI Shapefile
Reference system	EPSG 3069
Metadata language	English
Metadata point of contact	Chin Wu - chinwu@engr.wisc.edu
Metadata date stamp	

Dataset Title	Southeastern Wisconsin Bluff Recession Rates
Dataset Reference Date	1/4/2019
Dataset Responsible Party	UW-Madison Coastal Sustainability Lab
Geographic location of the dataset	Northernmost Latitude: 43 32’ 44” Southernmost Latitude: 42 29’ 36” Easternmost Longitude: 87 45’ 26” Westernmost Longitude: 87 51’ 44”
Dataset language	English
Dataset topic category	Bluff Shoreline Lake Michigan Great Lakes Coastal Erosion Environmental Hazard Landform Land Status
Abstract defining the dataset	This dataset contains bluff crest, bluff toe, and shoreline change data in Kenosha, Racine, Milwaukee, and Ozaukee Counties on Wisconsin’s Lake Michigan coast. Rates of change are presented for two time periods: 1956-2015 and 1995-2015. Rates are calculated at 10 m intervals from features digitized from leaf-off vertical aerial photos in GIS software and measured using the Digital Shoreline Analysis System. A spatial averaging technique is applied to the dataset to provide data at 100 m intervals along the coast.
Update Frequency	Not planned
Spatial representation type	ESRI Shapefile
Reference system	EPSG 3069
Metadata language	English
Metadata point of contact	Chin Wu - chinwu@engr.wisc.edu
Metadata date stamp	