Determination of Shoreline Erosion Rates of Double Bluff

Suzanne Cruchon
Advisor: Dr. Terry Swanson
Dept. of Earth and Space Science, University of Washington.

Introduction

The Puget Sound and southern Georgia Strait form inland seas that contain over 3400 of Washington State's 4000 kilometers of marine shoreline (Shipman, 2004). Shorelines within this inland sea are either composed of unconsolidated sediment, largely glacial and interglacial alluvial deposits or bedrock. Unconsolidated sediment bluffs dominate much of the central and southern Puget lowland (Fig. 1), where most of the population lives, while bedrock shorelines occur more frequently in the northerly inland waters.

Shoreline erosion rates are much higher for coastlines composed of unconsolidated sediment because bluff slopes are more easily eroded by wave processes and susceptible to saturation and cohesion-loss during heavy or long duration precipitation events. As exposed bluff slopes become over-steepened by wave processes, mass wasting events such as landslides and/or debris flows transport sediment down slope, where it is subsequently redistributed by shoreline processes (Fig. 2).

Quantitative assessment of the shoreline erosion rate becomes increasingly important as the population continues to grow and places more developmental pressures on these areas of prime view property. Many homes have been, or will be constructed in bluff locations that are susceptible to future mass wasting events related to shoreline erosion. Potential loss of property and human life is a likely consequence of this growth in the absence of realistic estimates of bluff retreat (Fig. 3). It is therefore imperative that shoreline planners and geotechnical personnel have a quantitative basis to assess recent and future shoreline retreat in order to best adapt long-term shoreline management policies. Declassified 1944 U.S. military air photos flown over extensive shoreline areas of Snohomish and Island Counties provide a high-resolution data set that can be used to accurately determine shoreline retreat for many coastal areas in the central and northern Puget Lowland. 57% of the shoreline of Island County is considered unstable, the second highest percentage in the Puget sound (Swanson). Because of the risk that the bluffs pose it is important that they be studied.

Method

To complete my research objectives I had to learn how to utilize computer software, including Arc Map and Endos.
I originally attempted to overlay recent Lidar imagery with the 1944 photo orthoquads using geo-referencing. By superposition of the shoreline position in 1944 versus that of today, I tried to quantify the magnitude of erosion over a sixty-year time interval. This method did not work because the 1944 images are not individual photos but a composite of many photo segments cut and pasted together. This created a large spatial error because the two sets of photos did not match up due to seams on the 1944 images and varying scale.
I then tried to overlay the photos and trace the respective shoreline and roads to create polygoal areas of space. I then compared the two sets of polygons to find the difference in area. This method created too great an error due to the seams in the 1944 images and variable scale between the photo segments.
I am now attempting is the make individual shoreline measurements using specific geo-reference points within individual photo segments to reduce the error.

Research Objectives

I had two major objectives at the start of this research project:
1. To develop a computer method where I could efficiently overlay the photo orthoquad maps directly over the 2005 LIDAR imagery in order to assess shoreline erosion over a large study area.
2. To quantify the short-term erosion rate of the Double Bluff region of Whidbey Island utilizing geo-referencing.

Fig. 2: An exposed bluff slope at Double Bluff Point has become over-steepened by wave and mass wasting processes.

Fig. 3: A recent landslide near on south Whidbey Island, near the Clinton ferry terminal. Quantitative assessment of shoreline retreat is very important for areas, such as this location, where shoreline development is occurring.

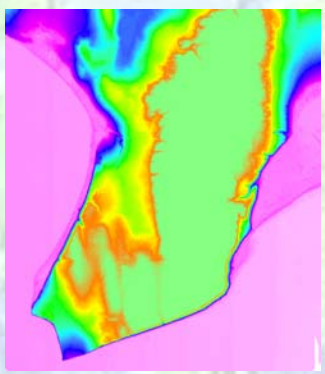

Fig. 4: High-resoluton LIDAR image of the Double Bluff area used to define the modern shoreline position.

Fig. 5: Quantitative assessment of shoreline retreat can be determined by measuring difference in shoreline positiions on the two images with known geo-referenced structures that have been present over past 60 years. Note that the erosion values given here are not adjusted to account for the angle of incidence between the transect line and the shoreline. Only those transect lines that intersect the shoreline perpendicularly will provide accurate estimates of the erosion magnitude.

Results and Conclusions

My original goal when I started this project was to use geo-referencing of identifiable roads and structures that have remained in their present location prior to 1944 in order to set up a program on the computer that could directly overlap the 1944 shoreline onto the 2005 shoreline as conveyed in LIDAR Data (Fig. 4). Because the 1944 images were comprised of composite aerial photographs, with variable scales, geo-referencing over large distances had too much error. During my initial data analysis of the complete Double Bluff photo orthoquad it became apparent that I would not be able to use geo-referencing methods calibrate over large area. Instead, I had to utilize individual geo-reference points within individual photo segments to determine differential shoreline positions over the 60 year time interval. Much of this work requires individual measurements between the geo-reference point and shoreline positions appearing on the LIDAR imagery and the 1944 photo orthoquad (shown as red lines on Fig. 5).

Educational Experience

Through my research experience I have learned that projects evolve. It is necessary to adapt your goals and methodology as potential problems that arise. I learned how to rethink the task at hand to still achieve my results despite setbacks. Because my research utilized aerial photography, I acquired important remote sensing skills necessary to study landform evolution. I also utilized computer programs, such as ArcMap and Erdas, which I needed to interpret my data.

Future Work

I plan to continue the shoreline erosion rates of Whidbey Island. My overall goal is quantify the short-term erosion rate (past 60 years) for all shorelines of Island County that have photo coverage.

Acknowledgments:

I would like to thank Charles Kiplinger and Harvey Greenberg for their assistance with the LIDAR imagery and using the ArcMap.
I would also like to thank the NASA SURP program for providing funding and guidance.

References

Haugerud, R. 2003. High-Resolution Lidar Topography of the Puget Lowland Washington- A Bonanza for Earth Science, GSA Today, Vol. 13, 4-12.

Shipman, H. 2004, Coastal Bluffs and Sea Cliffs on Puget Sound, Washington. *U.S. Geological Survey Professional Paper* 1693, p81-94.

Shipman, H., 1995, The rate and character of shoreline erosion on Puget Sound: Olympia, Washington, Puget Sound Water Quality Action Team, Puget Sound Research '95, 77-83.