Using GPS Enabled Smartphones for Seasonal Shoreline Change Monitoring: Ocean Shores, Washington

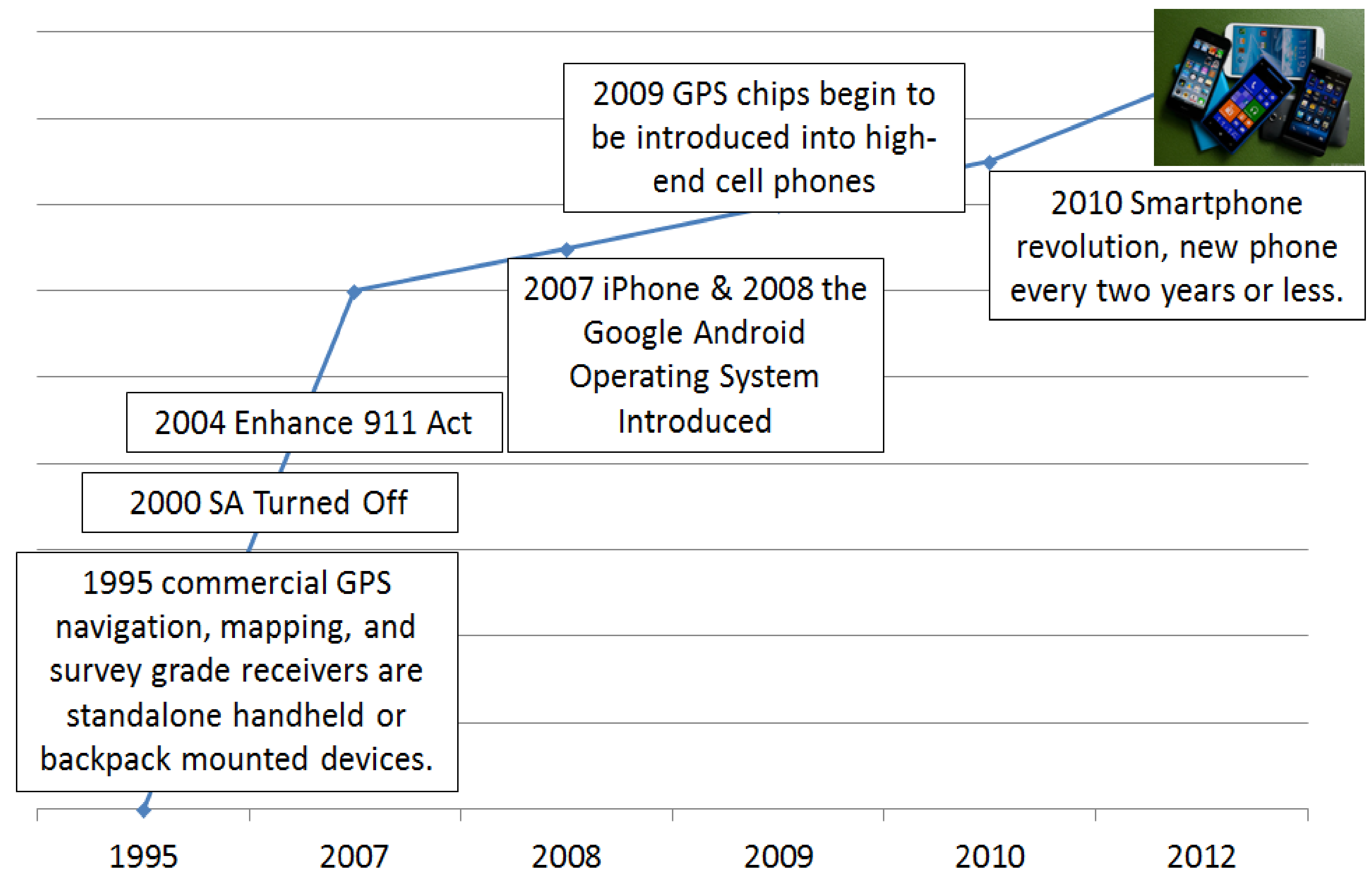
Richard C. Daniels, danielri@wsdot.wa.gov
Washington State Department of Transportation, Olympia, WA

Project Goals

This project was designed to

1. Test the feasibility of using smartphones as GPS data collectors for beach monitoring,
2. Develop accuracy estimates for the data collected using these devices, and
3. Determine the "normal" seasonal variability in shoreline position for Ocean Shores, Washington using the USGS Digital Shoreline Analysis System (DSAS).

Smartphones as GPS Data Collectors



Abstract

With the advent of GPS enabled smartphones is now possible to design and implement many environmental monitoring projects without expensive survey equipment. The rapid replacement cycle for these phones is leaving us with millions of functional GPS enabled devices that can be reconfigured as data collectors. Phones such as the LG Escape, released in 2012, contain GPS chips that track over 20 satellites, collect positions with accuracies of 3-5 meters, have built in camera/video capability with GeoTagging, and have CPU speeds and memory sizes that equate to high-end desktop systems of just 10 years ago. Once these devices are reconverted into handheld GPS data collectors they can be used for many of the data and position collection projects that previously required mapping grade GPS surveying equipment such as the Trimble Juno S and 3 Series (TM).

In this study the shoreline [i.e., the average high-water line (AHWL)], was collected for the 2 km long cell located north of the Grays Harbor North Jetty in Ocean Shores, Washington. Shorelines were collected on six different dates from fall 2013 to spring 2014 winter season and the natural shoreline variability of the area calculated and the areas annual erosion/accretion cycle monitored. During each visit positions were collected at a known location to verified the positional accuracy of the data. When the uncertainty in interpreting the physical location of the AHWL on the ground is considered, it can be stated that the results shown here are the same as would have been obtained if higher-end mapping grade GPS collectors had been used.

The location of the AHWL on a beach will change throughout the year in response to tide height, wave size, and wind strength and duration. During winter periods the higher average tides, stronger winds, and larger waves result in beach steepening as sand sized sediments are transport offshore and finer sediments are lost on-shore as they are transported by wind over the dune. The sand that moves off-shore is stored in submerged sand bars. In spring and summer months, periods of moderate waves and lower tides allow the sandbar to migrate on-shore and eventually weld to the beach, resulting in a flattening of the beach. This annual process will result in the beach recovering to its former "summertime" width and position. When the AHWL is monitored over a full year we can determine the "natural variability" of the AHWL position in a given area. Knowing the natural variability of your beach will (1) help you select safety setbacks that are realistic for your local, (2) determine if observed erosion events are within the expected range, and (3) help identify pending emergencies –e.g., the potential for larger than expected erosion events driven by El Nino.

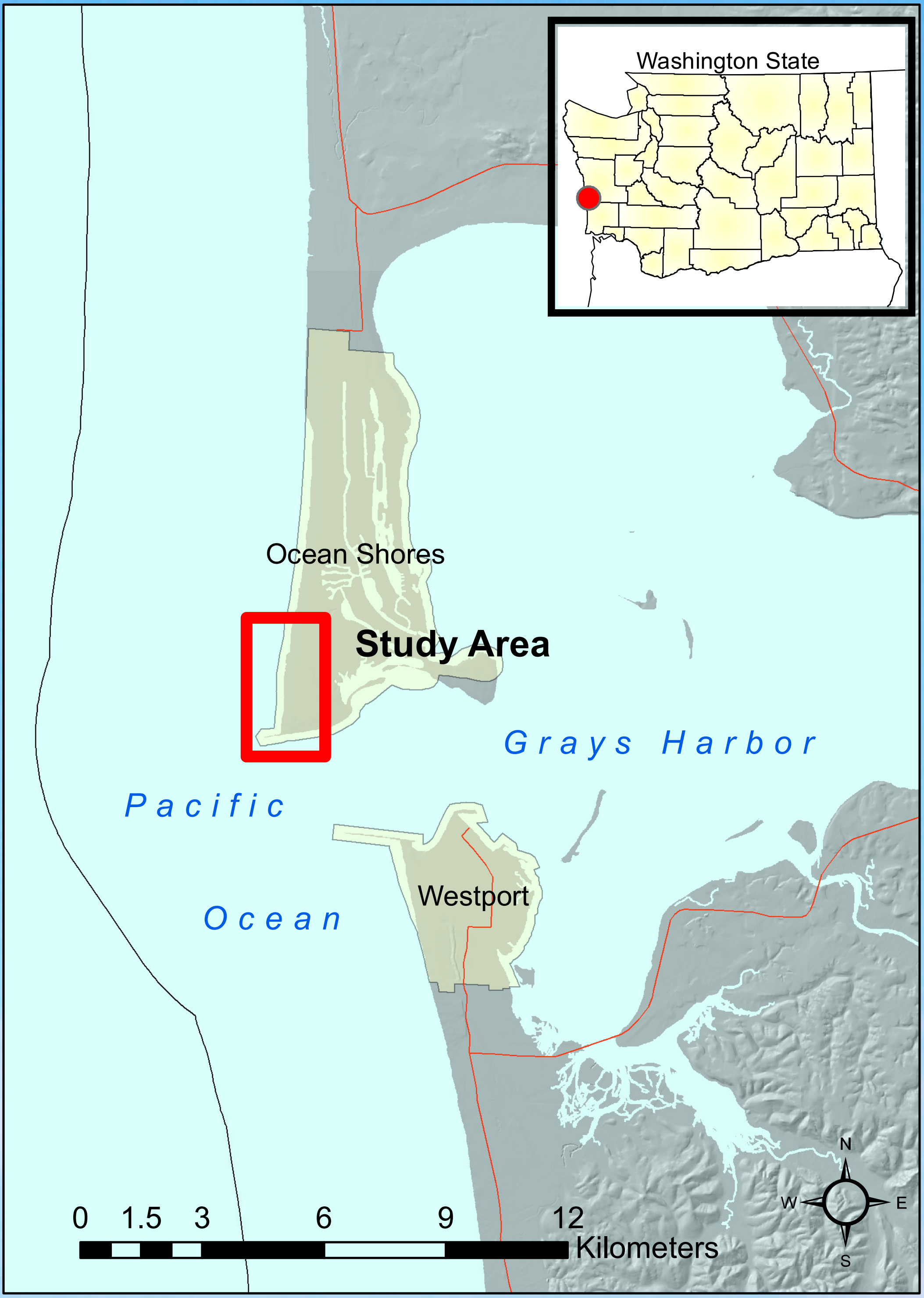
References

Brown, T.A., Gering, L.R., and T.K. Straka. 2013. A Comparison of Recreational and Intermediate Survey-Grade GPS Units for Importing Data into GIS Software Packages. Journal of Extension [On-line], Vol 51(4) Article #4RIB3.

Himmelstoss, E.A. 2009. "DSAS 4.0 Installation Instructions and User Guide" in: Thieler, E.R., Himmelstoss, E.A., Zichichi, J.L., and Ergul, Ayhan. 2009 Digital Shoreline Analysis System (DSAS) version 4.0 — An ArcGIS extension for calculating shoreline change: U.S. Geological Survey Open-File Report 2008-1278. *updated for version 4.3.

Weih, Jr., R.C., Giblert, M., Cross, J. and D. Freeman. 2009. Accuracy Assessment of Recreational and Mapping Grade GPS Receivers. Journal of Arkansas Academy of Science, Vol. 63: 163-168.

North Grays Harbor Jetty Shoreline Study Area
Ocean Shores, Washington

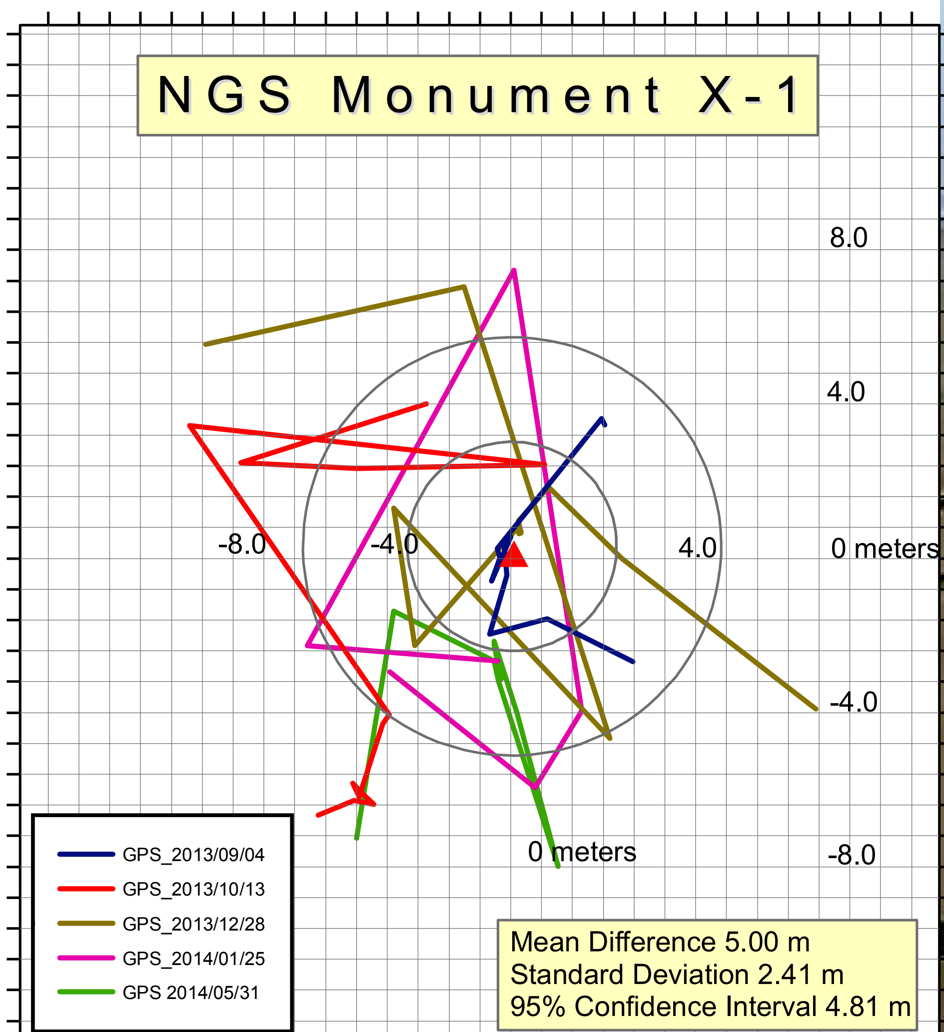


Hardware: LG Escape
4G Network, Android 4.1.2
Wi-FI 892.11 b/g/n
5 MP Camera, 1080p HD
A-GPS, S-GPS
Original $202, Now $1.99 on eBay

GPS and Shoreline Accuracy Assesment

One of the primary challenges with using GPS enabled smartphones for data collection is determining its accuracy. The simplest way to determine accuracy is to collect coordinates at a known location near the study area at the start and end of each mission. In this study we collected about 10 points during each mission at a National Geodetic Survey monument (Figure 1) located adjacent to the study area and calculated the mean, standard deviation, and 95% confidence interval for this set of points.

Figure 1. GPS points collected during each mission at NGS Survey Station X-1.

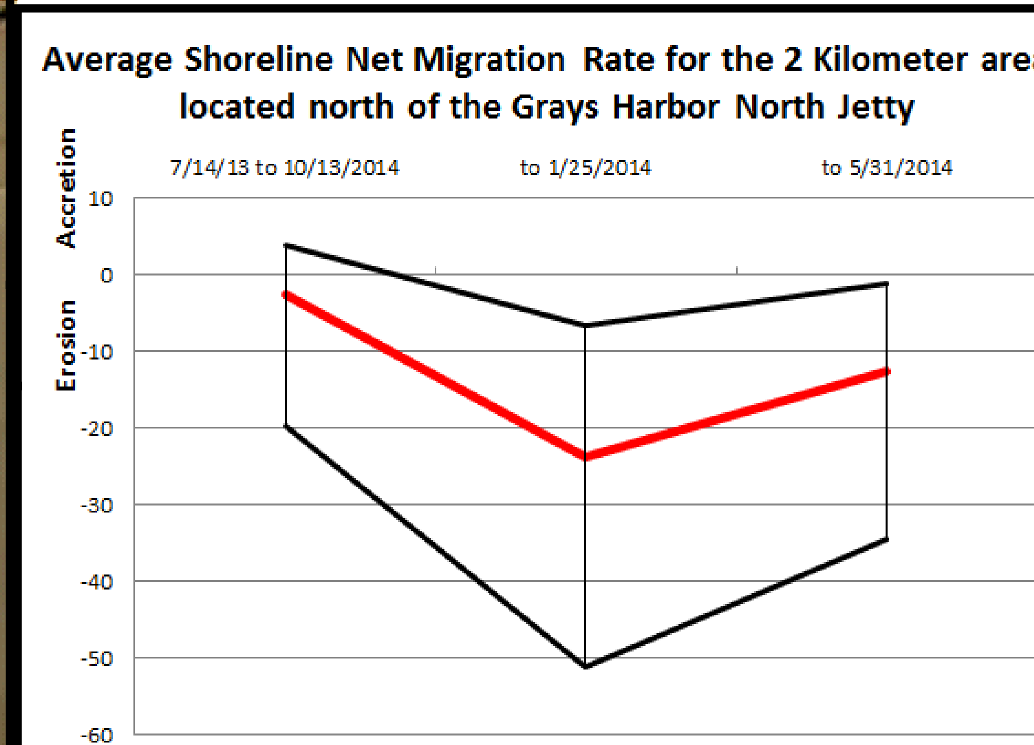


This data was then used to calculate the GPS accuracy of the device for each mission. The calculated Mean accuracy was then taken as the accuracy of the shoreline. Table 1 shows the accuracies obtained with the LG smartphone used by this study.

Table 1. Estimated GPS Accuracy of the LG Smartphone Used in this Study

Station X-1 Date	Mean Difference Easting	Mean Difference Northing	Mean Difference Z	Mean Difference XY
9/4/2013	0.41	-0.01	2.78	2.30
10/13/2013	-5.28	-3.27	8.79	8.18
12/28/2013	-1.01	1.09	-5.13	3.05
1/25/2014	-2.05	-2.50	-2.85	6.41
5/31/2014	-1.32	-4.61	-3.41	5.07
Mean	-1.85	-1.86	0.04	5.00
Std Dev	2.11	2.35	5.72	2.41
95% Confidence	4.23	4.70	11.45	4.81

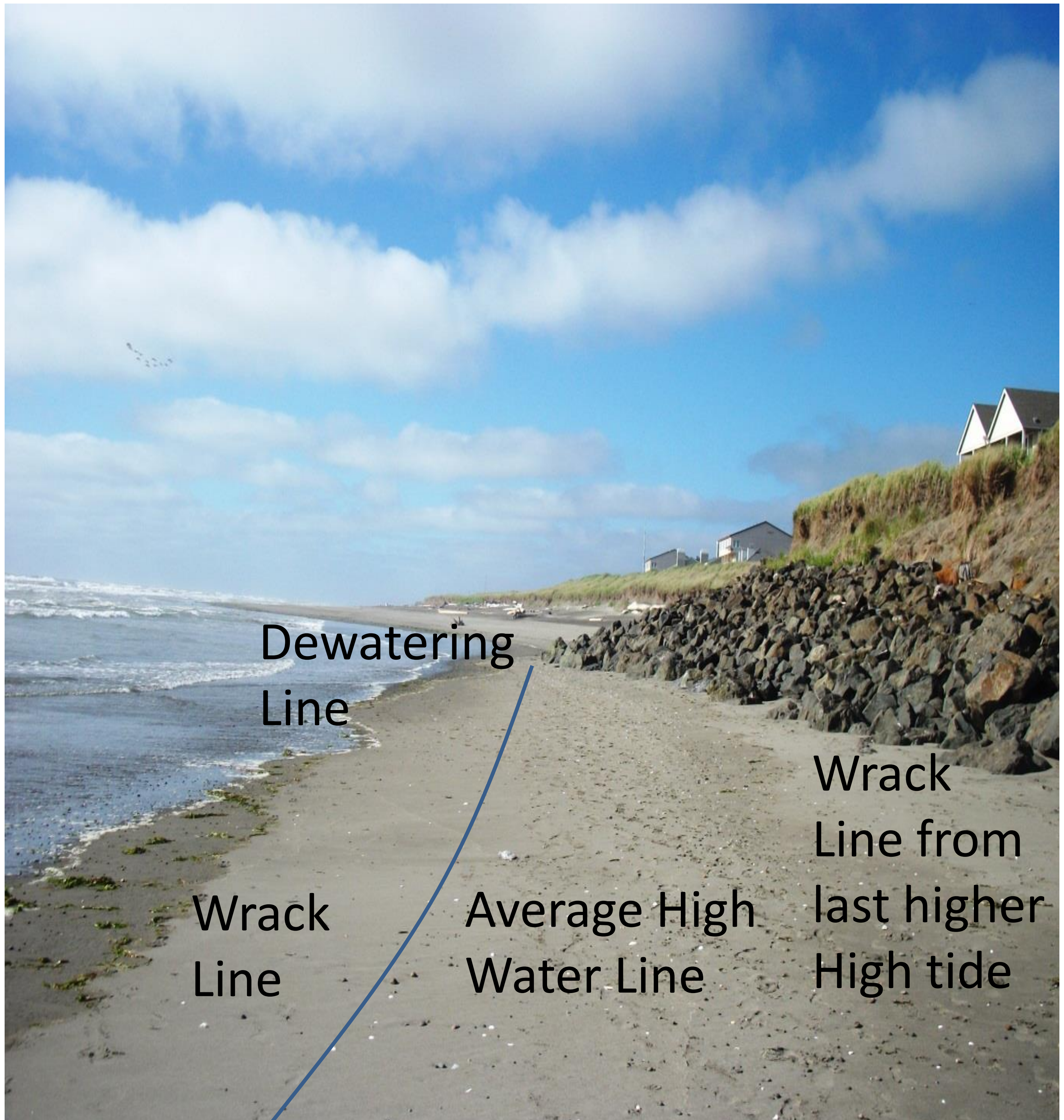
Figure 2. Average meters of shoreline erosion or accretion and the uncertainity of the measurement for each period of record.



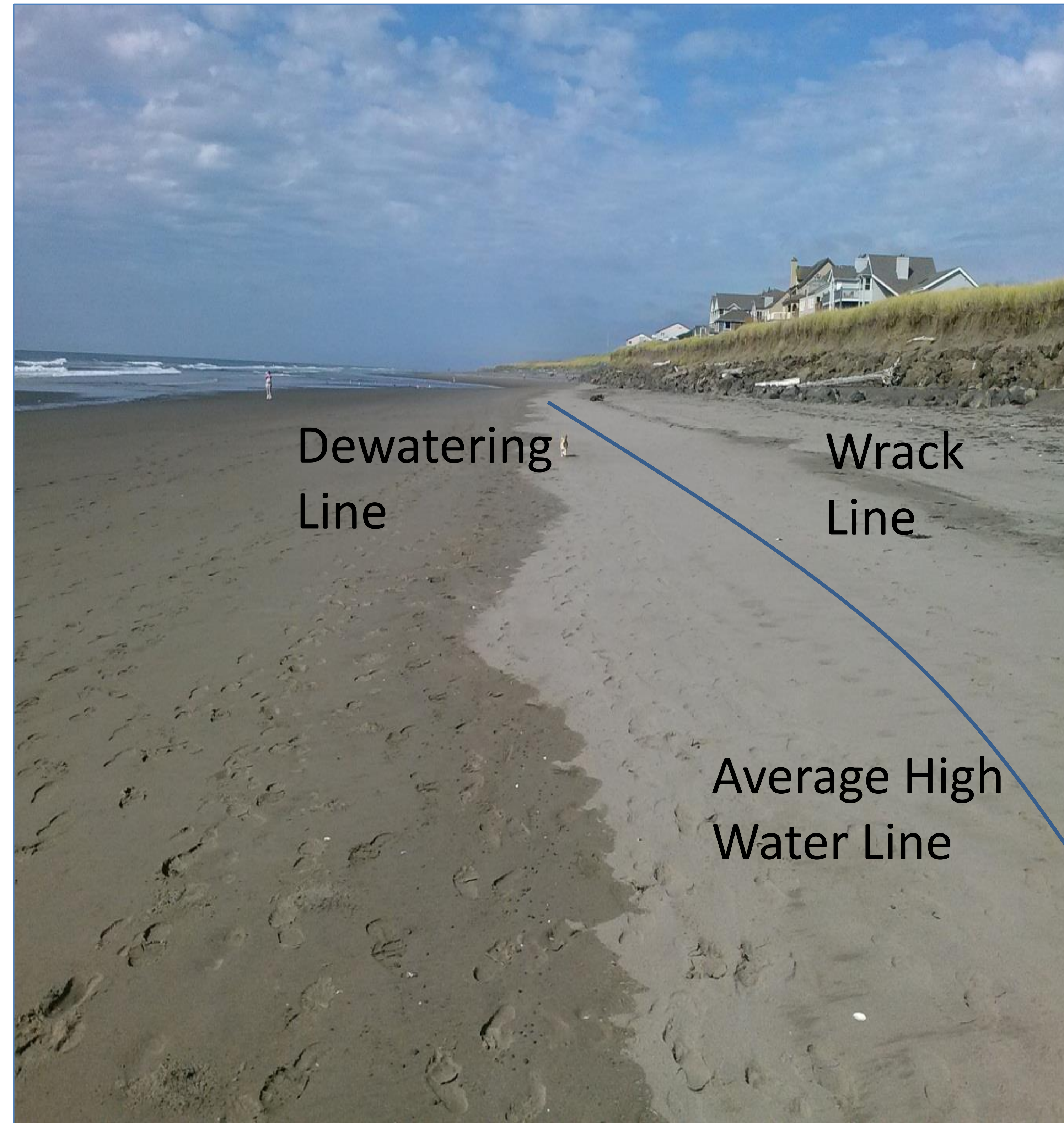
The Digital Shoreline Analysis System, from the U.S. Geological Survey, was used to calculate the shoreline change values shown here. These values were calculated for 20 transects spaced 50 meters apart extending 2 Kilometers north of the Grays Harbor North Jetty. The Net Migration Rate (NMS) was calculated for each transect for three seasons. The NMS values were then averaged for the 2 Kilometer cell to obtain a NET seasonal change rate for the cell (Figure 2). When the uncertainty bounds of the data are considered it can be seen that the shoreline started to erode by October 2013, with erosion accelerating into the Winter. As expected the shoreline began to accrete by May 31, 2014; but it had not yet fully recovered to its Summer size by the time of the 2014 ESRI User Conference.

Interpreting Average High Water Line Position

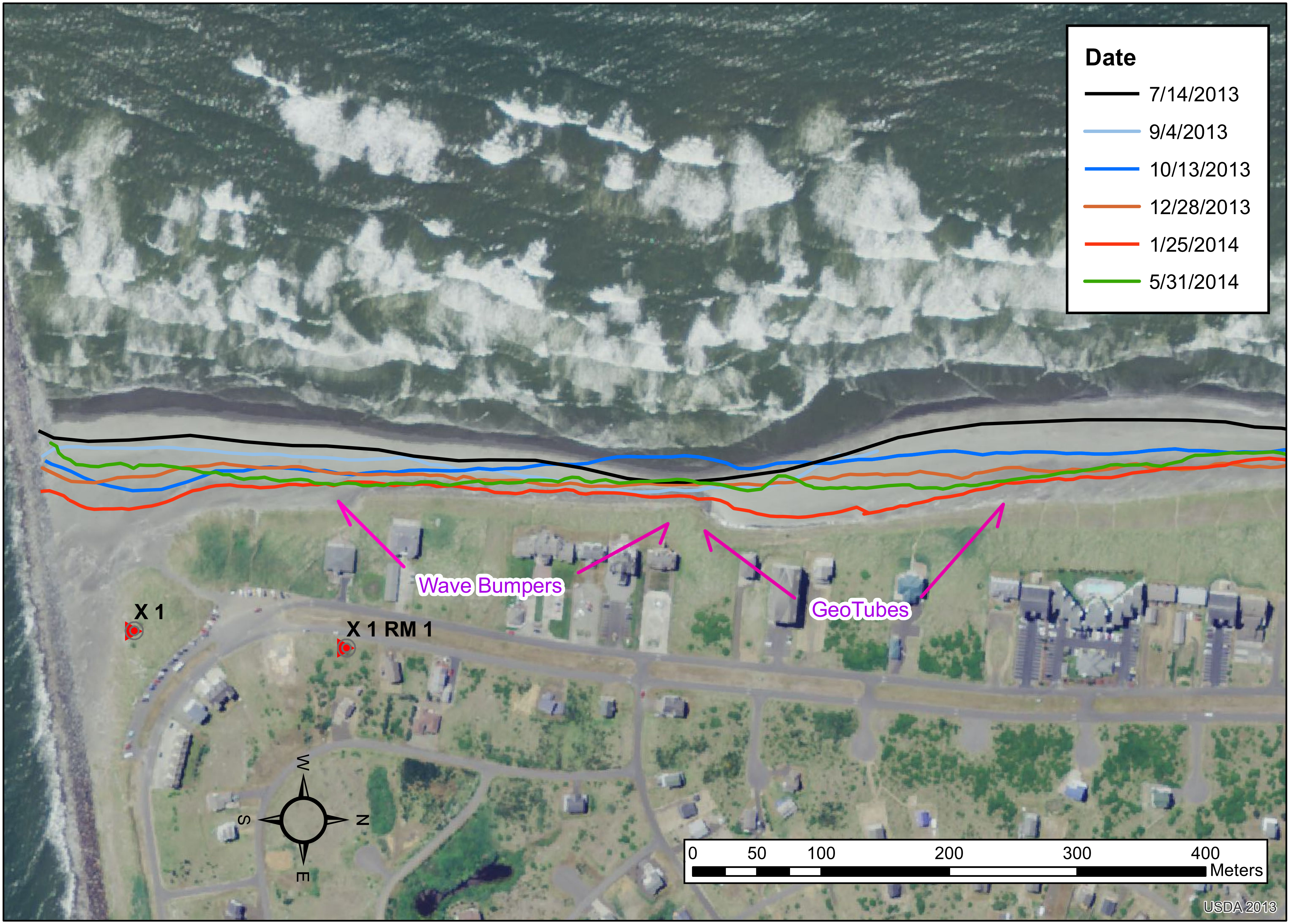
AHWL at High Tide



AHWL at Low or falling tide



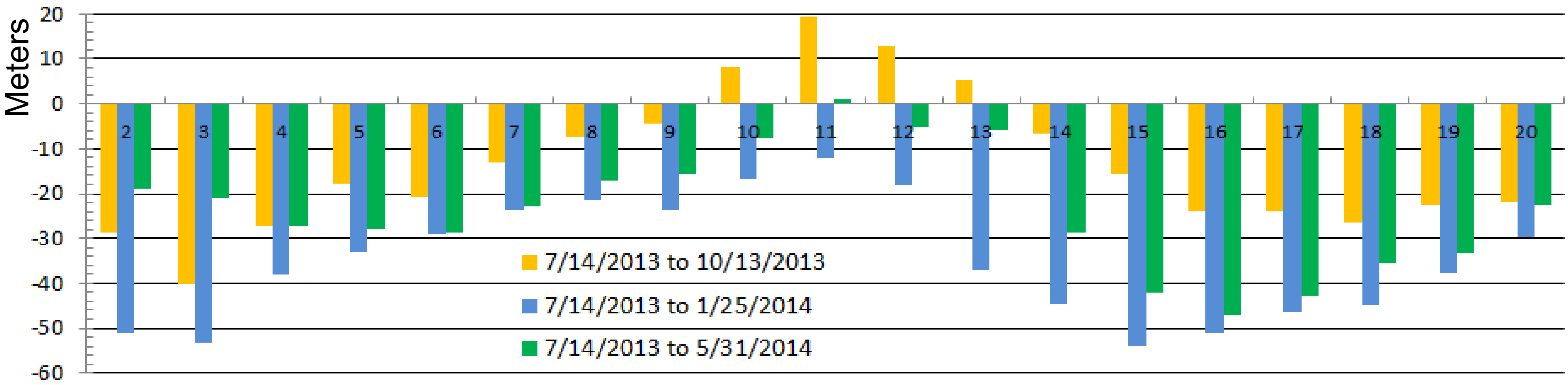
Seasonal Change in the Location of the Average High Water Line or Shoreline



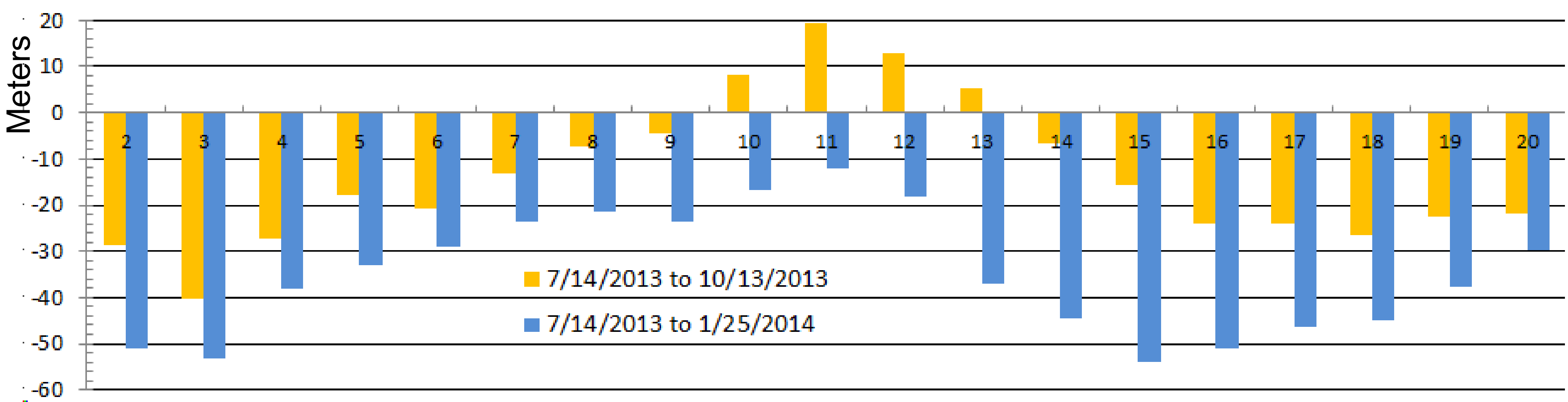
Ocean Shores, Washington - Erosion Control Structures

Fall, Winter, Spring Net Shoreline Movement Comparison
Transects at 50 Meter Spacing

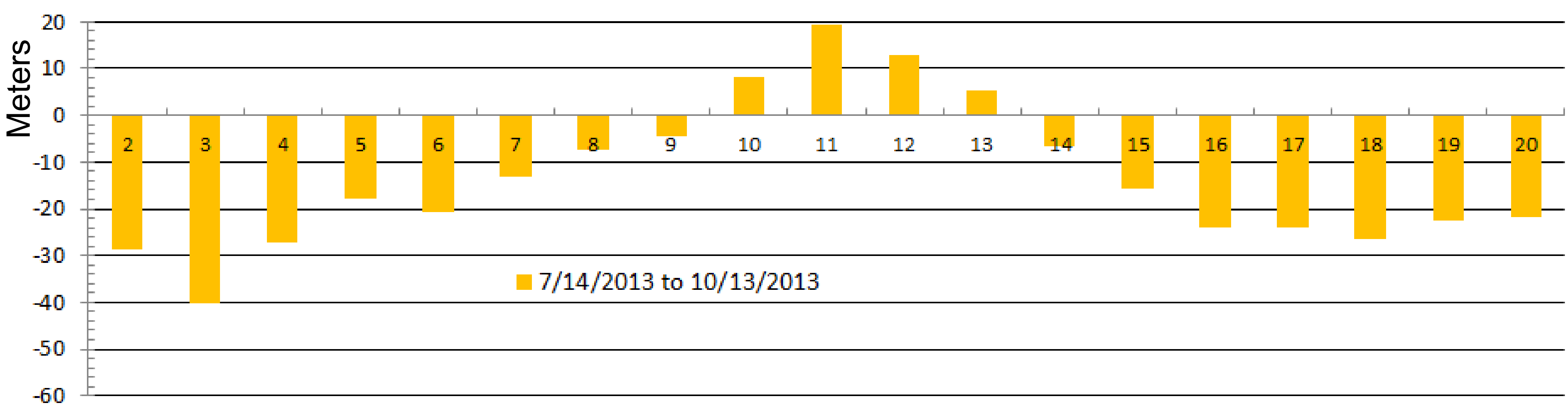
Spring 2014

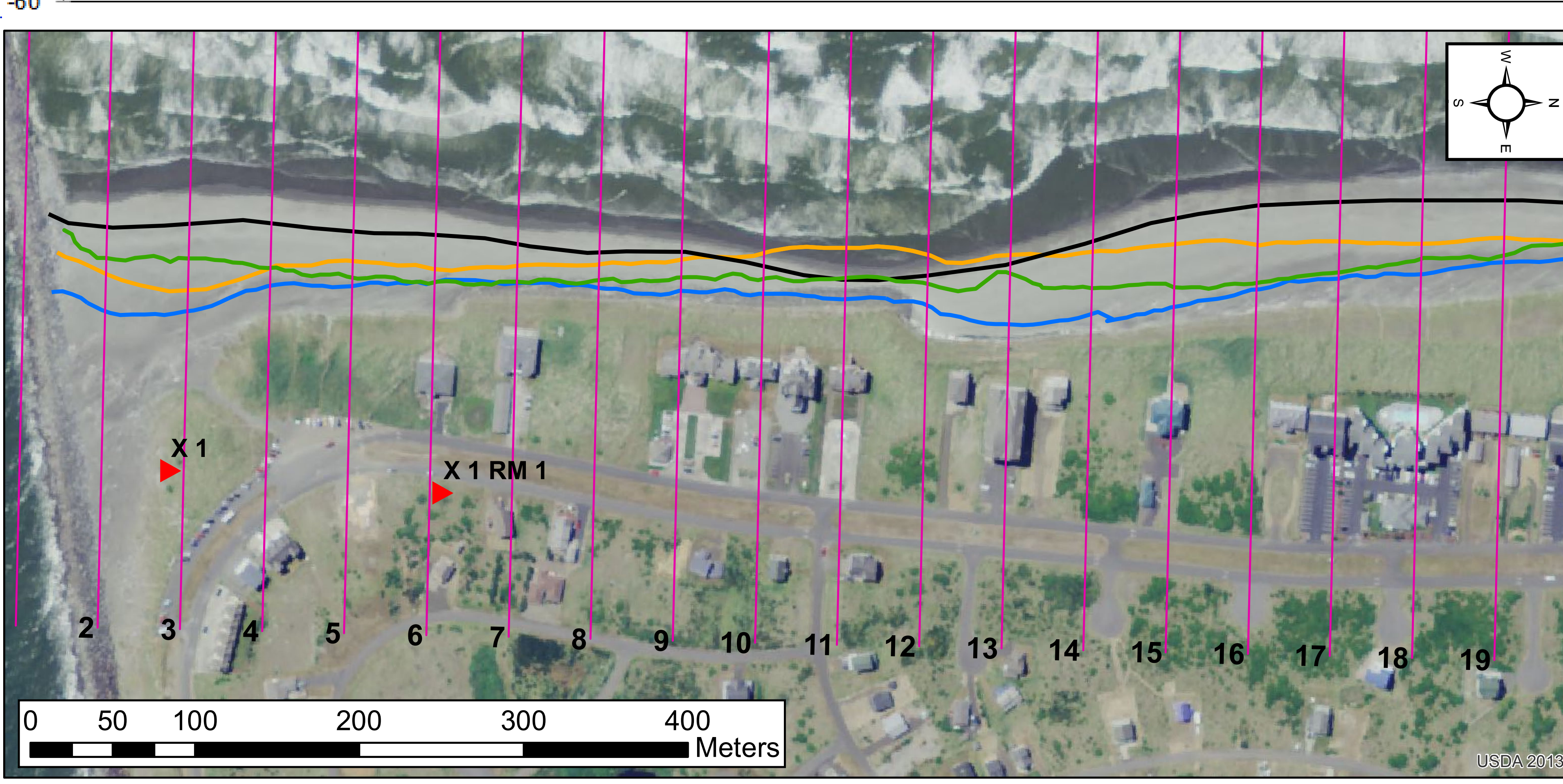


Winter 2013

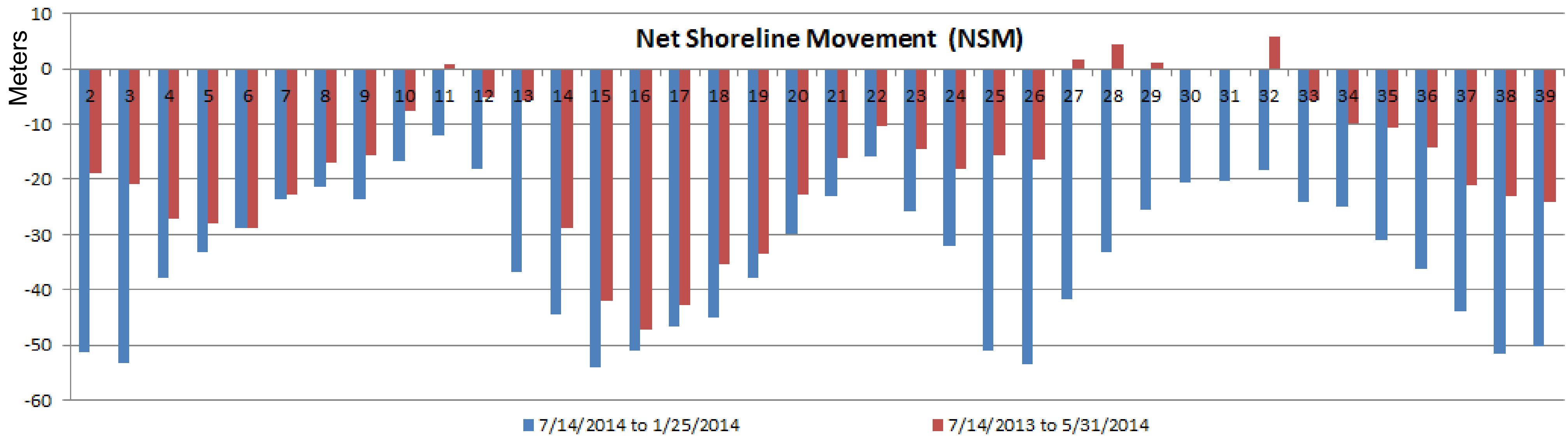


Fall 2013





Ocean Shores, Washington - Grays Harbor Jetty to Winlock Street



- AHWL Variation 7/14/2013 to 5/31/2014

0 0.2 0.4 0.8 Kilometers

Other Smartphone Uses

- Photos and Video taken while the GPS is “on” are tagged with a location. Thus you are collecting both a position and documentation of what has been seen. These coordinates will be of the same accuracy as the underlying GPS capabilities of your receiver.

- The Video capability may be used to capture real-time geophysical phenomena when we observe it in the field