National Center for Sustainable Transportation

POLICY BRIEF

Monitoring Sea Level Rise at the Local and Regional Scale

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Issue

Shoreline habitats and infrastructure are currently being affected by sea level rise (SLR) and impacts will only worsen as global temperatures continue to rise. Decisions made by governments and individuals to adapt to SLR will have profound consequences for coastal ecosystems, transportation systems, and urban settings.

Federal guidance for adaptation relies on predictive models to guide planning[1,2]. This includes planning for the recovery of endangered species in the face of SLR, which is mandated by the federal Endangered Species Act[3,4]. FHWA and other federal organizations have recognized that new monitoring methods will be needed in order to collect new kinds of data and at a finer scale and wider extent[5]. California[6,7] among other states, provides extensive step-by-step guidance on how to plan for SLR, including the use of predictive models, and identifies the need for monitoring[8] as well. Despite the recognized need for monitoring methods, no detailed guidance is given at the state level in California[9,10] or federal level[11] for how to do this.

Measurement of sea level has historically been achieved by using tide gauges and global satellite altimetry. There is no consistent method or system for measuring and recording shoreline change over large areas and at fine resolution other than infrequent and expensive LiDAR overflights that do not capture seasonal fluctuations. The most recent coastal LiDAR data (2010) that has been used to inform Federal Highways Administration (FHWA) and other studies have known sensitivity to vegetation height on coastal floodplains and marshes.

Research Approach and Purpose

SLR at fine spatial and temmporal scales is a subtle process only detectable using instrumentation such as time-lapse, ground-based cameras that capture shoreline conditions at both high and low tides and through all tidal and storm-event conditions. To test this approach, we have deployed and networked cameras at 40 coastal sites in California (the San Francisco Bay) and Georgia (Jekyll Island), Figure 1. Collecting images and data in this

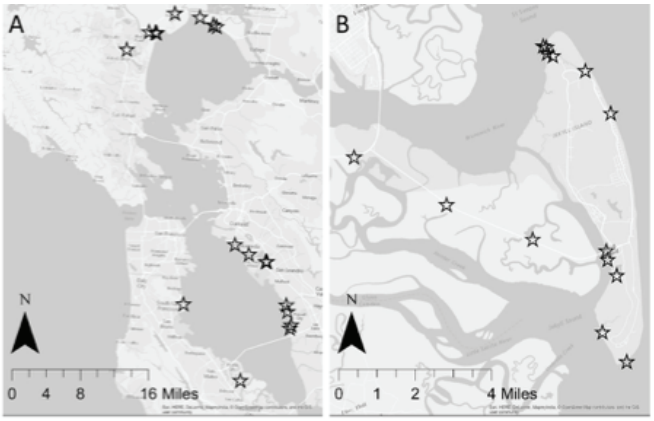

Figure 1. Locations (stars) of time-lapse cameras in San Francisco Bay Area in California (left) and Jekyll Island in Georgia (right).

manner provides multiple benefits, such as: 1) measuring actual shoreline changes; 2) validating regional change (e.g., inundation) models using local, high-resolution (spatial and temporal) image analyses; and 3) demonstrating rate and magnitude of SLR impacts to better understand the urgency of adaptation and to inform local, regional, and state level planning efforts.

For this project, a technical advisory group in both states advised the setup and deployment of the camera networks. Sites were carefully selected to represent a broad range of coastal sites, such as shoreline levees, berms, or riprap providing flooding/inundation protection; developed areas (e.g., residential, commercial); transportation structures (e.g., local roads and state highways); critical shoreline infrastructure (e.g., power station); natural or restored marshes, beaches and mudflats; and other actively-managed areas. The system is designed to be in place for years, if not decades.

The cameras collect fine-resolution images (i.e., 14 mega-pixel and 8 mega-pixel images) at 5 to 15 minute intervals. Each image receives an automatic time stamp embedded in the image file. We also developed an image analysis method that automatically processes thousands of images to detect and measure change.

Key Research Findings

Insights from over 24 months of deployment of this system include:

It is possible to monitor SLR on an annual to decadal time frame. The method tested in this project demonstrated sensitivity to vertical changes in sea level less than 1 cm, roughly equivalent to 1-2 years of SLR. Images were corrected for distortion due to camera angle and reflection from water (inundation) isolated and quantified. Tidal cycles were used to demonstrate detection of changes in inundated area due to 1 cm in sea level rise.

The development of novel and customized web-informatics tools were necessary to store, sort, summarize and share data with partners. Novel web-services were created to carry out the following functions: 1) accept image files as data-points and store them according to pre-set protocols; 2) add metadata to the image file data-points using automated (e.g., time, date, location) and manual approaches (e.g., site identity); 3) store image files in a searchable/queryable database to support quality control and visualization and data use by oceanographers, coastal planners, community organizations, ecologists, and others (e.g., local agencies); and 4) develop simple automated summaries of image data for each camera-monitoring location, which could be composed of several cameras.

Next Steps

Next steps for this project include: 1) maintaining and expanding the camera networks to monitor more built and natural system elements (e.g., coastal bluffs); 2) including additional partner agencies (e.g., local/municipal governments); 3) exploring potential to reduce image resolution in order to reduce database management requirements, while retaining enough information to track sea level change; 4) incorporating satellite image analysis to complement our approach; 5) using drone-based LiDAR and/or image analysis to periodically measure low-tide surface elevations and confirm estimates of inundation from our land-based cameras; and 6) continuing to share information about the system and data with interested parties.

Further Reading

This policy brief is drawn from the "Using Time Lapse Cameras to Track Shoreline Change Due to Sea Level Rise" research report prepared by Fraser Shilling, David Waetjen, Kevin Taniguchi, Ted Grosholz, Erik Grijalva, and Christine Sur with the University of California, Davis, and Kimberly Andrews and Alison Ballard with Georgia University. The final report can be found here: https://ncst.ucdavis.edu/project/using-time-lapse-cameras-to-track-shoreline-change-due-to-sea-level-rise/

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[5]Gopalakrishna, D., J. Schroeder, A. Huff, A. Thomas, and A. Leibrand. Planning For Systems Management and Operations As Part Of Climate Change Adaptation. FHWA-HOP-13-030. http://ops.fhwa.dot.gov/publications/fhwahop13030/index.htm - toc. 2013.

[6]California Coastal Commission (CCC) Draft Sea-Level Rise Policy Guidance. Pp. 178. 2013.

[7]Caltrans Guidance On Incorporating Sea Level Rise: For Use In The Planning And Development Of Project Initiation Documents. Pp. 13. 2011.

[8]California Coastal Commission (CCC) Draft Sea-Level Rise Policy Guidance.

[9]California Coastal Commission (CCC) Draft Sea-Level Rise Policy Guidance.

[10]Caltrans Guidance On Incorporating Sea Level Rise: For Use In The Planning And Development Of Project Initiation Documents.

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