QUANTIFYING COASTAL CHANGE AND MANAGING CULTURAL RESOURCES AT KING RANGE NATIONAL CONSERVATION AREA

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The King Range National Conservation Area (King Range) along the northern California coastline is comprised of coastal peaks and ridges, marine terraces, and ocean beaches with a topographic elevation that varies from Kings Peak at 4,091 feet above sea level to the Pacific Ocean. Despite the ruggedness of the landform, this area has appealed to humans over the centuries for its marine, riverine, and terrestrial resources. Cultural resources along the approximately 25-mile King Range coastline are threatened by high levels of precipitation, ocean wave winter storm surges, sea level rise, and tectonic activity. This study uses geospatial techniques to provide a better understanding of King Range coastline change and terrace retreat and will be useful in future conversations about resources management with the tribes, State Historic Preservation Office (SHPO), and stakeholders.

The Bureau of Land Management (BLM) has been gathering and evaluating data to assess the rate and extent of coastline change to inform a management strategy for vulnerable archaeological sites. At the beginning of the project, data available to the team included historic images in the California Coastline Records database and Lidar from 2010, 2016, 2018, and 2020 (Figure 1, left). In 2020, the BLM contracted with the U.S. Fish and Wildlife Service to collect high-resolution stereo imagery. The resulting photogrammetric surface was compared with existing Lidar data. Sampling subsets of these data showed that a feature of interest was visible (Figure 1, right).

Year	Type	Project	QL	Avg Pnt Spacing (m)
2010	Lidar	CA Coastal Conservancy	3	0.5
2016	Lidar	West Coast El Nino	1	0.2
2018	Lidar	No Cal Wildfires	2	0.3
2020	Photogrammetry	FWS PhaseOne*	NA	0.09

*iXU-RS1000 4-band (RGB & NIR) with 70mm lens.

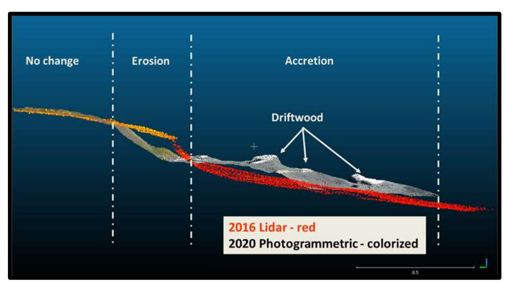

Figure 1. Available lidar and photogrammetric data for the King Range NCA (left) and an example cross-section profile of 2016 (red) and 2020 (colorized) data showing the coastal terrace (right).

MANUALLY ASSESSING RATES

We quantified the rate of terrace retreat using a photointerpretation approach. We delineated monitoring zones and drew a transect perpendicular to the terrace every 50 m within these monitoring zones. The location of the terrace along the transect was marked for each year using Digital Elevation Model (DEM) derivatives

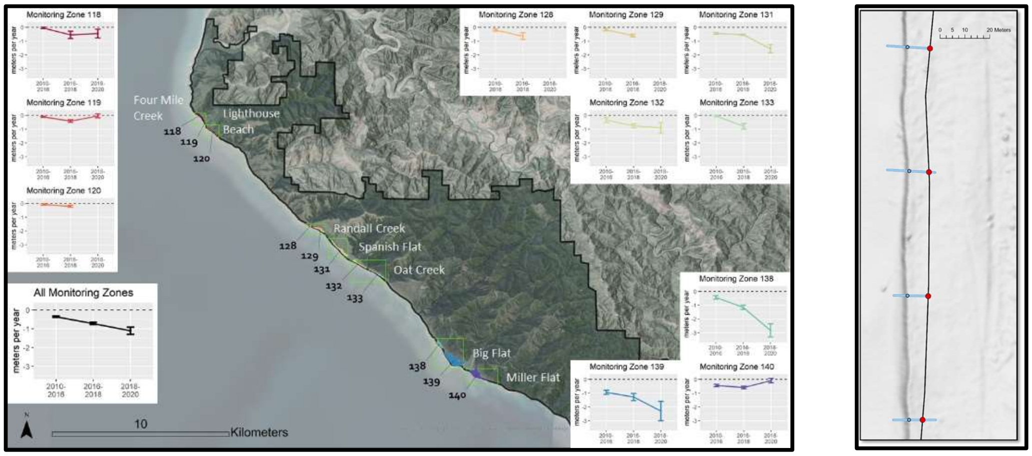

Figure 2. Map of the 11 monitoring zones with inset plots showing the rate of terrace retreat based on a manual delineation approach at each site (left). An example of the manual comparison of surfaces between years along four transects (right).

(e.g., hillshade rasters). We converted these distances to rates using the number of days between data collection flights. In Figure 2, plots show a summary of all transects measured within each monitoring zone. An overall trend of faster retreat is noted, especially towards the southern end of the coastline. Given the difficulty and spatial constraints of manually assessing coastal change, we used the CloudCompare software to directly compare surfaces between years to generate continuous maps of coastal change over larger areas.

VISUALIZING "HOT-SPOTS" OF HORIZONTAL CHANGE

In CloudCompare, we can find the distance to the nearest point in a second cloud using the cloud-to-cloud distance tool. By isolating the "difference" between the point clouds in the X-axis and Y-axis, we can create a vector. We calculated rasters representing the direction and magnitude of difference with the Raster Calculator in ArcGIS, stacked these, and displayed them using the vector field symbology (Figure 3).

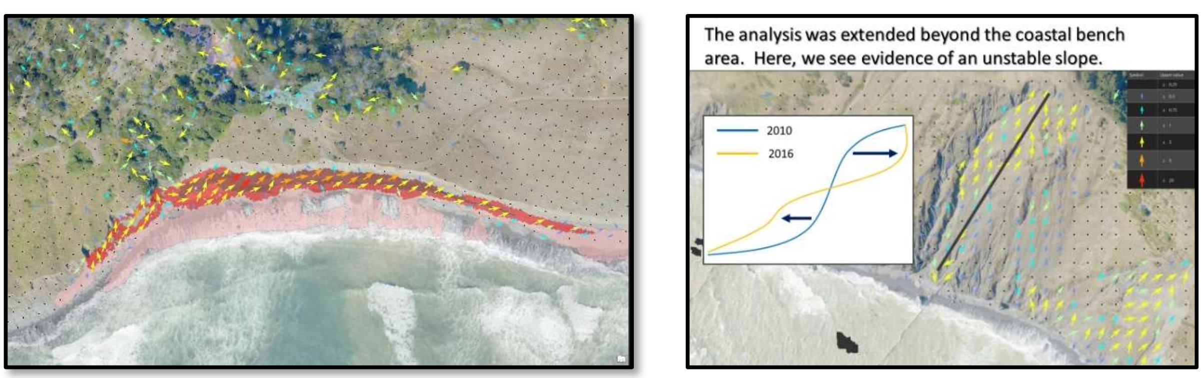

Figure 3. An example image of the direction and magnitude of difference between two dates. The arrows point in the direction of the change and the size of the arrow shows the magnitude of the change.

ESTIMATING 3D CLOUD-TO-CLOUD CHANGE

The 3-dimensional change between clouds from subsequent years was estimated using the M3C2 plugin in CloudCompare. This tool measures the distance between two surfaces (point clouds) according to the local surface normal and employs a statistical test to identify areas of statistically significant change. The result is a spatially continuous map of 3D change at the resolution of the input lidar point cloud.

In Figure 4, each plot shows the distribution of measured rates of change along the coastal bench for multiple time periods at each monitoring zone. We can see significant variability in erosion rates between the different zones, but generally more erosion in the south, consistent with the results from the manual approach.

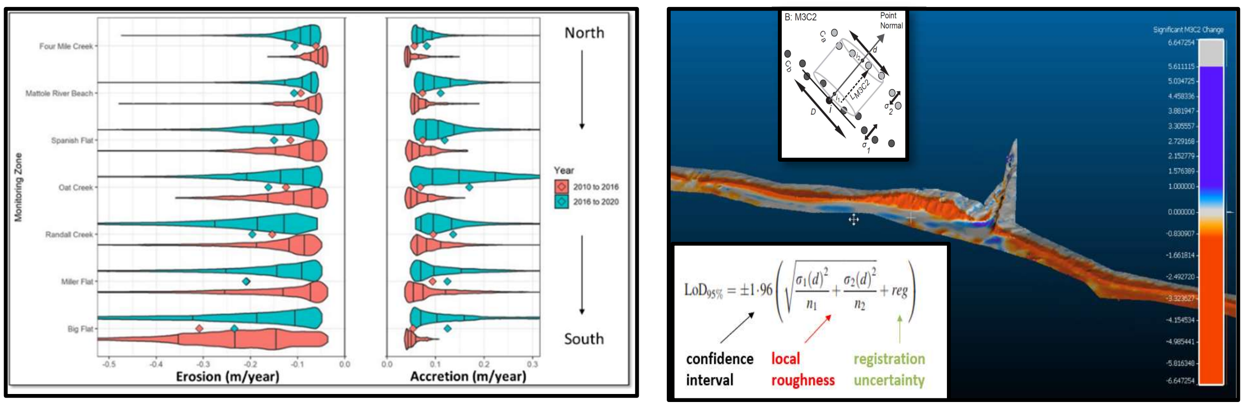

Figure 4. Distributions of measured cloud-to-cloud rates of change (2010 to 2016 and 2016 to 2020) along the coastal bench at each zone, ordered from north to south; diamonds indicate the mean erosion and accretion rates (left). CloudCompare view of the change (cloud-to-cloud) from 2016 to 2020 at the Big Flat monitoring zone; view is at an oblique angle where north is towards the upper left corner (right).

Each method assesses change in a different, but correlated, way. Moreover, photogrammetry products require additional preprocessing for comparison to Lidar surfaces. We plan to use the existing data as a baseline and continue collecting data, perhaps with hand-held laser scanner. The resulting GIS products provide a better understanding of King Range coastline change and terrace retreat, and will be useful in future conversations about resources management with the tribes, SHPO, and stakeholders.