Emma Petersen, Laguna Beach High School

COASTAL EROSION IN SOUTH LAGUNA BEACH

4.5 km LiDAR comparison shows that South Laguna was close to volumetric balance from 2009 to 2018, with erosion concentrated at bluff-backed pocket beaches, and peaking about 90 ft inland at the bluff zone. Trend is further reinforced when only transects with net erosion of at least 100.0 m3 are isolated.

124,503 m³ gross gain

127,741 m³ gross loss

−3,238 m³ net change

Research Question

Where did South Laguna's coastal zone lose or gain material between the 2009 and 2018 LiDAR surveys, and what do those patterns mean for bluff-backed areas and coastal planning?

Why This Matters

South Laguna is a rocky pocket-beach coastline where bluffs, coves, and headlands create highly uneven erosion patterns. The 2009–2018 window also captures the 2015–2016 El Niño, helping distinguish longer-term change from short-term storm impacts.

Study Area and Data

The study spans ~4.5 km from Christmas Cove to Three Arch Bay using 1 m LiDAR DEMs from 2009 and 2018. The older DEM was aligned to the newer grid, a 0.32 ft vertical correction was applied using Pacific Coast Highway as a stable reference, and buildings were masked to avoid non-coastal changes.

Methodology

Elevation change was calculated as adjusted 2018 minus 2009 elevation. The analysis generated 900 coast-normal transects (5 m spacing, 600 ft length), sampled at 200 points, and integrated loss, gain, and net change. Outputs include a referenced difference map, hotspot map, and smoothed change map for GIS use.

Outlier Handling

Map products remove values beyond ±2.0 m to improve readability, while hotspot and transect calculations retain those values. This keeps visual maps clean without altering the underlying analysis.

Formulas

Adjusted elevation change: $\Delta Z = Z_{2018,adj} - Z_{2009}, \quad Z_{2018,adj} = Z_{2018} - 0.32\ ft$

Erosion: $V_{loss} = \Sigma\, \Delta Z_i\, ds\, w \quad for\ \Delta Z_i < 0$

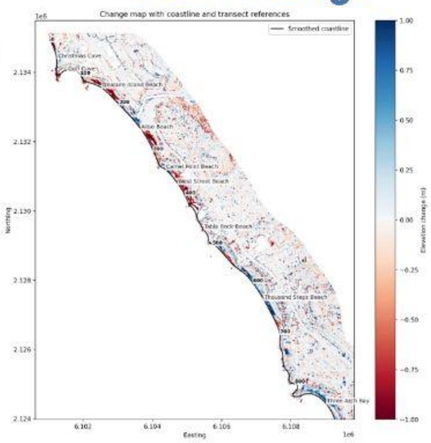
Deposition: $V_{gain} = \Sigma\, \Delta Z_i\, ds|w \quad for\ \Delta Z_i > 0$

Net gain: $V_{net} = V_{gain} - |V_{loss}|$

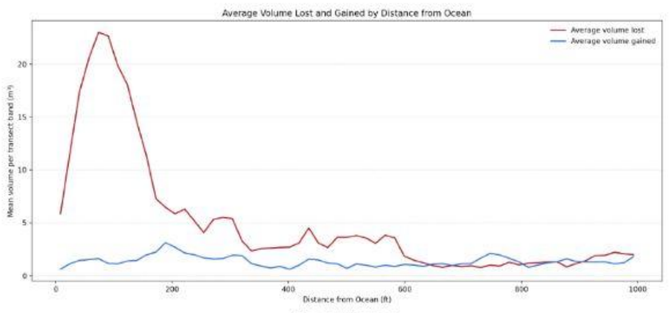
Positive ΔZ indicates deposition and negative ΔZ indicates erosion. Here ds is the along-transect sample spacing (about 0.93 m for a 182.88 m transect sampled at 200 points) and w = 5 m is the alongshore slice width represented by each transect.

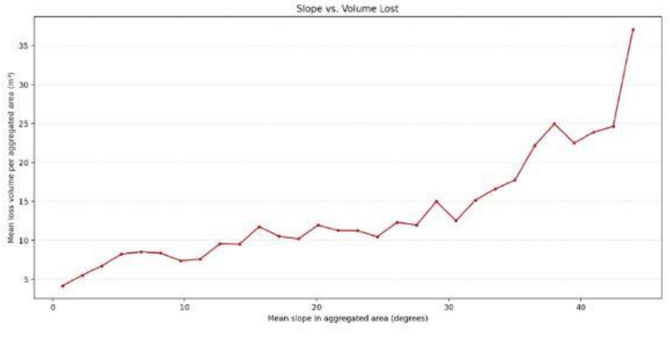
~50% of transects net-erosional; peak loss ~90 ft inland; 256 transects in the significant-erosion subset.

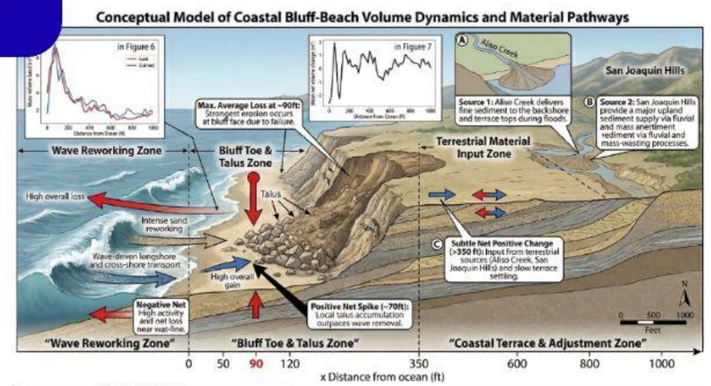
Main Findings

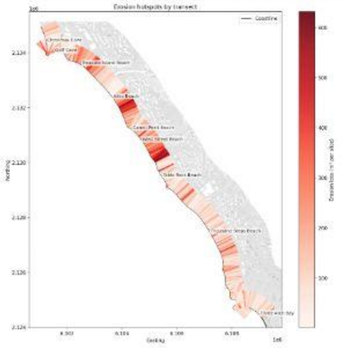


Gross loss and gain nearly balance, indicating strong internal redistribution despite slight net erosion. Peak loss occurs ~90 ft inland at bluff face, not shoreline. Hotspots cluster at Thousand Steps, Table Rock, Treasure Island, Aliso, West Street. Loss increases sharply @~30° slope, consistent with bluff failure. Farther inland, change becomes smaller and slightly positive, likely reflecting input from San Joaquin Hills and Aliso Creek.









Beach / Cove	Gross Loss (m³)	Gross Gain (m³)	Net (m³)
Thousand Steps Beach	28,400	29,100	+700
Table Rock Beach	26,800	28,600	+1,800
Treasure Island Beach	18,200	17,500	-700
Aliso Beach	17,600	15,900	-1,700
West Street Beach	14,300	12,700	-1,600
Camel Point Beach	9,400	9,200	-200
Christmas Cove	5,100	4,800	-300
Three Arch Bay	4,900	4,900	0
Goff Cove	3,000	2,800	-200

Community Implications

Two GIS layers are available to the public (~15 m Gaussian smoothing). Together, they allow users to compare detailed hotspots with a simpler neighborhood-scale view in Laguna Beach's public GIS viewer.

City Implications

Focus monitoring on Thousand Steps, Table Rock, Treasure Island, Aliso, West Street. Use repeat LiDAR surveys after major winters, El Niño events. Treat data as screening tools, not substitutes for site-specific analysis.

Acknowledgements, Sources, Findings

Special thanks to Laguna Beach High School, mentors Dr. Michelle Harper and Ms. Carissa Rice, and Mr. Jun Shen

QR Code to Full Paper

AER