EOS Positioning Systems

CASE STUDY | STUDYING BEACH AND DUNE ECOLOGY

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Dr. Kyle Emery surveys a foredune crest at Wall Beach, Santa Barbara County, California — one of 14 sites that he and his team will repeatedly survey over the course of a three-year project to hopefully enable researchers to improve their predictions of the impact of sea level rise on beach and dune ecologies.

User
Dr. Kyle Emery, Assistant Researcher, Marine Science Institute, UCSB

Industries
Ecology, Research

Challenge
Sea level rise threatens beach and dune ecologies. But measuring these dynamic sites as they change with seasons and after major water events has always proved difficult. Historically this has made SLR impact predictions challenging.

Solution
Arrow Gold+™, CRTN Network, DJI Drone, ArcGIS® Field Maps, iPhone®, Planet Imagery

Results
Emery and his team will measure 14 California coastal sites over two years with survey-grade geospatial data; then they hope to pilot a method to extract observations to larger areas using satellite imagery.

BEYOND THE TIDE: TRACKING CALIFORNIA'S COASTAL CHANGE WITH HIGH-ACCURACY MAPS

Beaches play a crucial role as habitats. They provide refuge, nesting sites, and foraging grounds for shorebirds and invertebrates. Their "geomorphic and ecological" features — including dunes, vegetation, and drift lines — contribute significantly to stabilizing the shoreline and expanding the area of dry beach accessible to animals, vegetation, and humans. They're places to relax, recreate, and reconnect with nature. Beaches are also dynamic. Anyone who built a sandcastle has seen how wind or tides can change their canvas.

Growing up in New Jersey, Dr. Kyle Emery the coastline changing. Today, he and others have identified beaches and nearby dunes as some of the ecological systems most vulnerable to sea level rise (SLR). This is why Emery, an Assistant Researcher at the Marine Science Institute of the University of California, Santa Barbara (UCSB), is leading a three-year research project — funded by the California Ocean Protection Council — to develop methods to measure and monitor how beaches change seasonally and after strong events. His goal is to help other researchers predict how future SLR might affect these ecosystems.

HOW DO YOU MEASURE SANDY BEACHES AND DUNES?

Emery's project combines cutting-edge technologies in innovative ways to develop what hopefully becomes a best-practice and scalable methodology to measure and predict beach changes due to SLR. The first two years of the project emphasizes data collection. Emery chose 14 locations all along the California coast, each of which contains sandy beach and dune features. Site visits will take place quarterly, after an annual high ("king") tide event, and after storms. Emery will measure and map various physical and ecological features: Vegetation limit (most seaward extent of vegetation); foredunes (dune closest to the water); wrack (items washed ashore like kelp); high tide strandline (furthest inland point high tide reaches); and more. Quarterly data collection help expose patterns in seasonal growth and erosion, while post-king-tide and post-storm surveys could serve as "proxy events" for SLR (helping researchers to predict the impact of SLR).

CAPTURING DRONE IMAGERY

Each site visit starts with a DJI Mavic 3 Multispectral drone flight, used to produce high-resolution orthomosaic imagery and digital elevation models, as well as vegetation indices. Flying the drones requires first setting about 15 ground control points (GCPs) — bright markers that show up in the imagery, which software can use to stitch together and geo-reference the imagery. To ensure accurate geo-referencing, GCPs are surveyed using an Arrow Gold+™ GNSS receiver connected to the free California Real Time Network (CRTN), to achieve an average estimated location accuracy of 1-2 cm. The GNSS receiver is Bluetooth® paired to Emery's iPhone®, running the Esri ArcGIS® Field Maps mobile mapping app. Emery flies the drone in a lawnmower pattern, capturing thousands of images at an 80% overlap. Then he uses Agisoft Metashape software to process the data and output raster files including orthomosaic imagery, a digital elevation model, and vegetation indices.

"Every pixel within the drone image has its own XYZ value, based on the Arrow telling the software exactly where the GCPs are," Emery said. "This lets us get highly accurate positions and, importantly, elevation data."

Once output, the orthomosaic can be used to extract features such as high tide strandline, wet/dry line, vegetation limit, and foredune. Over time, horizontal movement of these positions can be ascertained. Meanwhile, the digital elevation models provide extremely accurate vertical measurements to help researchers understand beach growth and erosion — either seasonal or caused by extreme events. The digital elevation models also help identify further features, such as berm boundary, embryonic dune formations (spot points where wrack could be causing sand buildup eventually leading to more dunes, a feature that adds stability to the beach), and finally the vegetation indices, which help map and identify dune vegetation species.

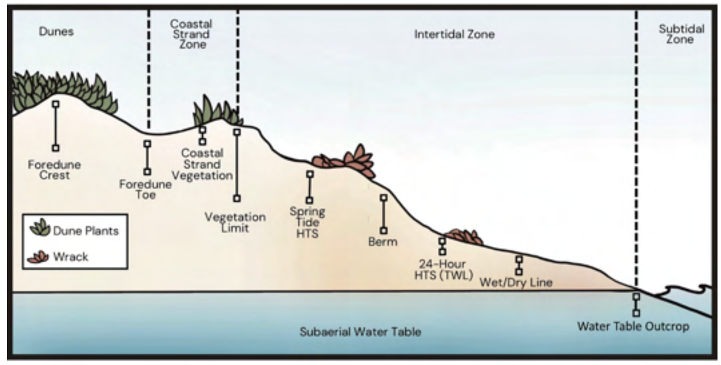
"We can track where these habitat features are over time, how their positions and elevations might or might not have changed, and how certain features move around horizontally and vertically while others don't," Emery said. "If there's a storm, we can track the impacts to any of the features or zones we've been monitoring."

BOOTS-ON-THE-GROUND BEACH SURVEYING

Emery also completes a traditional ground survey to identify additional features. He and his team map and measure the positions and elevations of each beach's foredune, for instance, as this feature denotes an important barrier between the land and sea. They measure the foredune's highest elevation point ("crest") and lowest elevation points toward both sea and land.

"Ideally, we're going to try to tease apart the seasonal changes," Emery said. "Maybe dunes will grow a lot in the spring when it's the windiest here, or we'll be able to attribute erosion and the most negative change during our winter storms."

They also set up transects from the foredune to the sea and capture the positions and elevations of "wrack" deposits (i.e., kelp, seagrass, driftwood, other vegetation); the beach water table; the dune vegetation limit; and more. This survey typically yields another 40-45 data points for the site visit. All data are captured with the Arrow Gold+ in ArcGIS Field Maps. In the office, Emery and his team can layer the data onto a single map to create a 3D picture of each site captured both in time and changing over time. Changes in these features over time can indicate huge implications for beach and dune ecology.



Beach features (geomorphic and ecological) are in a constant state of horizontal and vertical movement, having potentially significant impacts on things like beach stability and support for organisms. (Graphic Courtesy of Dr. Kyle Emery)

"Invertebrates eat the wrack that washes up, shorebirds nest around the wrack, use it as a wind-break and shelter, and eat the invertebrates, and the wrack can also facilitate dune formation," Emery explained.

SCALING THE WORKFLOW

Once data is captured on the ground, researchers hope to develop a method that could be used to extrapolate their measurements — as accurately as possible — along the entire California coast. To do this without undertaking the resource-heavy task of surveying the entire coast, the researchers will rely on slightly coarser yet high-resolution satellite imagery from imagery company Planet. Available commercially, Planet's imagery has about a three-meter-per-pixel resolution. Though the accuracy is less than surveying, the frequency of this imagery is near daily (excluding days when cloud cover and similar circumstances interfere). This makes the imagery a potential source of scaling their boots-on-the-ground observations.

To see if this is possible, Emery's assistant Max Callahan is leading a workflow that centers around extrapolating observations from the Planet imagery by using the survey-grade site data they captured as a reference. By doing this, they hope to be able to develop a method for extending their findings to monitoring changes to beaches along the entire California coastline.

"The real benefit here is that we can develop a process for extracting some of this data from satellites," Emery said. "We could in theory scale up to statewide methodology and researchers or managers in different locations could use this methodology."

BEYOND THE TIDES

Emery and his team will use the third and final year of the project to refine their data analysis, report and publicize their findings, and perform community outreach. For each of the 14 sites surveyed, Emery will conduct an educational workshop, so communities can understand the changes at their local beaches. Many of these sites are near disadvantaged communities. Emery hopes his work will help them find ways to protect their ecological and economic marine resources into the future.

Overall, Emery hopes other researchers worldwide benefit from his work. By having a method to monitor beach ecology over time at scale, the theory is that others can better predict their own local changes due to SLR.