Public Draft

BEACON REGIONAL COASTAL ADAPTATION MONITORING PROGRAM (RCAMP)

Monitoring Plan

Prepared for
BEACON
with funding from
California Coastal Commission

August 2025

B.E.A.C.O.N.
Beach Erosion Authority for Clean Oceans and Nourishment

ESA

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CALIFORNIA COASTAL COMMISSION

Image Credit: MODIS Land Rapid Response Team, NASA GSFC; Date: January 1, 2024

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EXECUTIVE SUMMARY

The purpose of the Regional Coastal Adaptation Monitoring Program (RCAMP) is to provide consistent data and analysis to support local government agencies and resource managers conducting coastal resilience planning and implementation in the BEACON (Beach Erosion Authority for Clean Oceans and Nourishment) region, which encompasses Santa Barbara and Ventura Counties. BEACON, a California Joint Powers Agency (JPA), provides regional coordination for coastal sediment management and coastal planning and adaptation within the Santa Barbara Littoral Cell (SBLC), spanning from the mouth of the Santa Maria River north of Point Conception to Point Mugu in the south, and the Mugu Submarine Canyon. The member agencies of BEACON include the Counties of Santa Barbara and Ventura as well as the coastal cities of Santa Barbara, Goleta, Carpinteria, Ventura, Oxnard, and Port Hueneme.

The SBLC and the BEACON coastal region, including the Santa Barbara Channel (SBC), are home to world-renowned and locally cherished sandy beaches, as well as numerous threatened natural coastal resources, importantly including several Marine Protected Areas. In addition, a large portion of the Chumash Heritage National Marine Sanctuary (established 2024), the newest federally designated sanctuary, lies within the SBLC, covering extensive areas along the central coast in San Luis Bay and the SBC. The sanctuary's eastern boundary extends just west of the City of Goleta near Naples.

Key RCAMP objectives are to provide local management agencies with the information needed to:

- Assess whether changed conditions within the coastal zone require new adaptation planning approaches;
- Evaluate the effectiveness of implementation projects; and
- Promote regional collaboration.

The Monitoring Plan provides a roadmap for BEACON, its members and agency representatives, other interested agency representatives, stakeholders, and members of the public to implement the RCAMP by establishing recommended monitoring strategies and pilot studies. The Monitoring Plan considered a wide range of monitoring options that could improve the understanding of local physical, ecological, social, and Chumash cultural resources conditions within the coastal zone. These options were evaluated and prioritized by key RCAMP objectives. The Monitoring Plan was informed by robust collaboration between BEACON members, the BEACON Science Advisory Committee (SAC), and stakeholders.

Monitoring Plan Recommendations Summary

The Monitoring Plan outlines a strategic framework with two parallel paths for the RCAMP to pursue:

1. **Utilize existing data:** Use existing available data to develop new data analyses, syntheses, and products useful to BEACON members for adaptation planning, and
2. **Collect new data:** Collect new data to fill identified data gaps and provide important information for adaptation planning.

All recommended Monitoring Plan components are critical to advance scientific understanding of local sea level rise and climate change impacts such as coastal storms and extreme climate events. However, resource constraints necessitate prioritizing Monitoring Plan components, and each has been assigned one of the following rankings:

1. **Critical Priority.** Critical for decision-making, high alignment with RCAMP goals, and required to complete other monitoring topics.
2. **High Priority.** High need for decision-making and alignment with RCAMP goals.
3. **Priority.** Advances priority scientific need or requires another component to be completed.

A complete list of potential Monitoring Plan components is provided in Chapter 5, and detailed information about how those were evaluated and recommended is found in Chapter 6. A summary of recommended Critical Priority and High Priority components is found in Table ES-1 and Table ES-2.

TABLE ES-1. RECOMMENDED CRITICAL PRIORITY MONITORING COMPONENTS

Topic	Recommended Analysis	Recommended Monitoring Approach
Sea Level Rise	Every three to five years: • Determine sea level rise amount and rate of change. • Compare change in sea level to sea level rise projections using a baseline year of 2000 for both. • Indicate any coincidence with El Niño-Southern Oscillation events.	Continuously: • Monitor sea levels. Approach: • Use the existing Santa Barbara Tide Gage. • Partner with National Oceanic and Atmospheric Administration (NOAA) to determine when additional sea level rise analysis will be available and if the Ventura Tide Gage can be re-established.
Sandy Beach Shoreline Change	Annually: • Map spring shoreline position (Mean High Water). Every three to five years: • Assess recovery from storm erosion. • Determine Spring beach width, change, and rate of change analysis.	Annually (spring) or biannually (fall and spring): • Monitor seasonal shoreline positions and beach width using surveys and/or satellite imagery. Approach: • Support continued USGS data collection using best practices to be identified in the pilot study. • Partner with USGS to release information and analysis on a standardized and regular interval.
Bluff Erosion	Annually: • Determine position of bluff top edge and base. Every three to five years: • Determine rate of change of position of bluff top edge and base.	Annually: • Monitor bluff top edge and base position. Approach: • Support continued USGS data collection using best practices to be identified in the pilot study. • Partner with USGS to release information and analysis on a standardized and regular interval.

TABLE ES-2. RECOMMENDED HIGH PRIORITY MONITORING COMPONENT

Topic	Recommended Analysis	Recommended Monitoring Approach
Sandy Beach Shoreline Change	Annually: • Determine maximum winter erosion extent.	Annually and after storm events: • Monitor shoreline position and beach width. Approach: • Coordinate with USGS on regular satellite imagery analysis and products. • Consider on-call arrangements or contracts with universities, surveyors, or consultants.
Storm Events	Annually: • Determine storm event intensities (rainfall, flood levels, wave heights). • Estimate storm recurrence frequency based on comparison with historical frequencies and climate model projections.	Annually and after storm events: • Monitor and analyze rainfall, stream flow rates, wave heights and periods, water levels in lagoons. Approach: • Coordinate with county flood control districts and BEACON member cities, USGS, and/or California Department of Water Resources (DWR) to develop and plan for new stream flow and estuary water level gages (e.g., Gaviota Creek, Carneros Creek and Tecolotito Creek tributaries of Goleta Slough, Arroyo Burro Creek, Laguna Channel, Sycamore Creek, multiple creeks from Montecito to Carpinteria, Franklin Creek, Santa Monica Creek, and multiple creeks between Carpinteria and Ventura). • Consider on-call arrangements or contracts with universities or consultants. • Continue to support and coordinate with Coastal Data information Program (CDIP) and Southern California Coastal Ocean Observing System (SCCOOS) to deploy a roving CDIP buoy in the Santa Barbara Channel to improve the CDIP Monitoring and Prediction (MOP) system and wave runup modeling.
	Annually: • Summarize standardized documentation of storm event extents and impacts. • Estimate the extent and duration of flooding and erosion.	Annually during storms and after the storm season: • Document the physical extent of storm events, costs to resource managers, and a storm event narrative. Approach: • Consider video cameras at flood- and erosion-prone sites, PlaneCam, CoastSnap at high public use sites, coordination with Surfline. • Consult and coordinate with County Office of Emergency Services (which serves the cities of Ventura, Oxnard, and Port Hueneme), Santa Barbara County Office of Emergency Management, and emergency service and other relevant departments for the cities of Goleta, Santa Barbara, and Carpinteria to confirm and detail what and how storm reports, damage assessments, Federal Emergency Management Agency (FEMA) claims, asset management, and Customer Relations Management (CRM) is being collected and could be used or modified.
Combined Flooding	Every three to five or more years: • Update vulnerability modeling and mapping of combined coastal and fluvial flooding, including lower-level and more frequent storm events (aka 10- and 20-year events).	Continuously: • Monitor and analyze rainfall, stream flow rates, lagoon water levels, wave heights and periods, information on flooding extents and duration. • See Storm Events above.

Topic	Recommended Analysis	Recommended Monitoring Approach
Sediment Movement	Every three to five or more years: • Determine sediment movement through the littoral cell. • Project future sediment movement patterns.	In conjunction with sediment management actions: • Gather or monitor dredging and sediment/debris basin removal volumes and grain size data and shoreline topography, bathymetry and beach widths including at sediment placement sites in various portions of the littoral cell. Consider conducting topographic/bathymetric surveys of sediment placements (before and after placement). Annually: • Gather/collect the above sediment management data within the littoral cell. Approach: • Explore data repository options.
	Every three to five or more years: • Evaluate effectiveness of nourishment placement.	Biannually (fall and spring): • Survey beach topography and width before and after placement. Annually: • Gather/collect the above sediment management data within the littoral cell. Approach: • Consider supplemental surveys at placement sites within USGS shoreline change data collection.
Chumash Cultural Resources	Every three to five or more years: • Compare cultural resource locations with existing hazard maps to identify potential future impacts.	Approach: • Collaborate with Chumash tribal representatives to develop and implement a cultural resource sites erosion monitoring plan • Consider utilizing current hazard maps and confidential cultural site locations to identify potential erosion impacts.
Social Vulnerability	Every three to five or more years: • Determine which communities, including Disadvantaged Communities, are being impacted by storms, flooding, and erosion events.	Approach: • Leverage available data, studies, and Storm Damage Analysis (see above). • Utilize current hazard maps, census data, and storm damage documentation. • Prioritize new Storm Damage monitoring and updated flood hazard mapping in disadvantaged communities

Recommended Pilot Studies Summary

The recommended pilot studies are:

1. **Develop a demonstration RCAMP Monitoring Report.** This demonstration report will serve as a template and prototype for what will become the regularly updated monitoring report that is expected to be updated every three to five years. This demonstration report will be a proof-of-concept that maximizes the use of available grant funding to summarize and document available data, document shoreline position data provided by the pilot study below, establish a baseline to compare future changes against (as possible based on available data), and create a document outline that implements the RCAMP Monitoring Plan recommendations and priorities discussed above. At a minimum, the demonstration report will include:
   - A framework, example, and template for future RCAMP Monitoring Reports to build from.
   - Baseline data and priority monitoring components identified in the RCAMP, intended to establish a foundation to support future analysis, comparison, and decision-making.
   - Recommendations of additional data and analysis to include in future Monitoring Reports.
   - An assessment of RCAMP Monitoring Plan needs, priorities, and utility.
2. **Develop a new shoreline data analysis and monitoring framework in partnership with the United States Geological Survey (USGS).** In this pilot study, USGS will finalize and analyze USGS shore profile surveys, PlaneCam topography data, CoastSat data, and other relevant data sources. USGS will use this information to provide shoreline data and make recommendations on how best to leverage new monitoring techniques to conduct future shoreline monitoring.

Process and Next Steps

Figure ES-1 summarizes the RCAMP development process and next steps. The process has included multiple technical, stakeholder and public outreach opportunities in the development of this Public Draft Monitoring Plan. The next step in the process is for the BEACON Science Advisory Committee and stakeholders to review the Public Draft Monitoring Plan and the recommended pilot studies. A final Monitoring Plan will then be developed to incorporate feedback.

Pilot studies will begin in fall 2025 and conclude in winter 2026/2027, with pilot study reports completed by spring 2027. A pilot study results report will be prepared and presented to the BEACON Science Advisory Committee and stakeholders in the first quarter of 2027 to share lessons learned and identify needed Monitoring Plan revisions. The City of Santa Barbara will then prepare an amendment to the City's fully certified Local Coastal Program (LCP) to incorporate the Final Monitoring Plan into the City's Coastal Land Use Plan.

SOURCE: ESA, BEACON, City of Santa Barbara, 2025

Figure ES-1. RCAMP Planning Process

After completion of the Final Monitoring Plan and dependent on future funding, the RCAMP anticipates preparing an RCAMP monitoring results report every three to five years.

1. INTRODUCTION

With rising sea levels and changing weather patterns in California and along the coast, there is a growing need for local governments and resource managers to monitor changes to the shoreline and plan for current and future conditions. Across Santa Barbara and Ventura counties, the impacts of sea level rise and extreme storm events have already been observed and experienced. Several monitoring efforts across the BEACON region have been completed or are ongoing but are not specifically intended nor directly useful for coastal adaptation planning. Similarly, while several efforts to monitor and plan for sea level rise across the BEACON region have already been implemented, the monitoring approaches are not consistent across the region, and regional collaboration is needed. The Regional Coastal Adaptation Monitoring Program (RCAMP) is intended to address these needs in the BEACON region.

The BEACON region spans the Santa Barbara Littoral Cell (SBLC) and its member agencies include the Counties of Santa Barbara and Ventura as well as the coastal cities of Santa Barbara, Goleta, Carpinteria, Ventura, Oxnard, and Port Hueneme. Designated in 2024, the Chumash Heritage National Marine Sanctuary spans 4,543 square miles along 116 miles of Central California's coastline, protecting ecologically and culturally significant marine and coastal resources; notably, a large portion of this sanctuary lies within the SBLC, with its boundary extending to just west of the City of Goleta, underscoring the importance of coordinated monitoring and planning across shared jurisdictions.

Although various separate jurisdictions exist within the BEACON region, the regional coastline of the SBLC crosses these boundaries. Actions in one area, whether natural or anthropogenic, can impact another. With a shared coastline, there is a need for cohesive planning across the region. BEACON, working cooperatively with member agencies and stakeholders, seeks to address this need by developing a framework to provide consistent data, analysis, planning, and decision-making across the region.

BEACON has initiated the RCAMP to provide consistent data and analyses to support local government agencies and resource managers conducting coastal resilience planning and implementation in the BEACON region. As the first step in developing the program, BEACON has prepared this Regional Coastal Adaptation Monitoring Plan (Monitoring Plan) with funding from the California Coastal Commission. The process to develop the Monitoring Plan included review and inventory of existing monitoring and available data; obtaining input from BEACON's members, Science Advisory Committee (SAC), and stakeholders; identifying, assessing, prioritizing, and recommending monitoring plan components to meet physical, ecological, social, and Chumash cultural purposes; and recommending pilot studies. The Monitoring Plan sets monitoring priorities and provides a framework that BEACON, its members, and stakeholders can use to pursue funding, establish, and perform an ongoing regional monitoring program to support adaptation planning.

1.1 Integration of Physical, Ecological, Social, and Chumash Cultural Resource Monitoring

The RCAMP and Monitoring Plan seeks to provide physical, ecological, social, and Chumash cultural resource monitoring to inform integrated and holistic regional adaptation planning. The Monitoring Plan identifies approaches that provide integrated multi-objective data where possible. BEACON member adaptation plans generally focus on physical adaptation thresholds and triggers related to flooding and erosion. Physical monitoring is therefore critically important to adaptation planning and a focus of RCAMP and the Monitoring Plan.

Ecological monitoring is closely linked to physical monitoring and crucial to understanding ecological and biological changes relevant to adaptation planning. Ecological monitoring can provide information about status and distribution of species and natural communities (vegetation cover or habitats), response to environmental change, signals of future ecological change, and effectiveness of management actions. Certain biotic elements may be selected for monitoring because of their protected status (sensitive species and their critical habitat) or as indicators of ecosystem function and response. Adaptation plans should consider ecological requirements of sensitive species indicators, especially to meet environmental compliance requirements for adaptation projects. For example, sea level rise will likely impact birds such as the western snowy plover and California least tern due to alteration and loss of beach breeding habitat, fishes such as steelhead and tidewater goby due to alteration of lagoon dynamics, and plants such as salt marsh bird's beak due to altered hydrology and salinity of coastal dunes and marsh. Assessing the habitats of special status species can be more efficient and cost-effective than surveys for the species themselves.

Social data is a fundamental, yet often overlooked, component of current coastal adaptation decisions and models. Without accurate, current, social data, it is impossible to understand how changes to the coastal environment will impact local populations and visitors. Social data allows researchers to understand who uses coastal resources, how they get there, what amenities they prefer or require, and how their use impacts local communities and economies. This is particularly important when considering climate change adaptation because without up-to-date data, climate change models can become rapidly outdated. Most accurate, up-to-date data allows decision makers to better understand the current conditions and projected effects of climate change to support a range of adaptation and management objectives

Chumash cultural resource monitoring is necessary for a comprehensive and inclusive understanding of the impacts of coastal degradation and change, including the potential vulnerability of Chumash resources and cultural sites. Integrating indigenous perspectives in coastal adaptation monitoring also preserves Chumash heritage and supports the Chumash community.

1.2 Monitoring Plan Process and Organization

The Monitoring Plan was developed via the following process:

1. Collaboratively develop goals and objectives with BEACON members, Science Advisory Committee, and stakeholders (Section 2).
2. Review relevant plans, review existing local, regional, state, and federal coastal monitoring, and assess coastal monitoring needs in consultation with BEACON members Science advisory Committee and stakeholders (Section 3).
3. Identify current data gaps (Section 4).
4. Develop Monitoring Plan components (Section 5).
5. Establish priorities, recommendations, and pilot studies in coordination with stakeholders (Section 6).
6. Determine next steps (Section 7).

To inform the Monitoring Plan, the RCAMP team held several workshops and meetings with BEACON members, the BEACON Science Advisory Committee (SAC), interested stakeholders, and Chumash tribal representatives. Their input guided the identification of monitoring needs and purposes, which in turn shaped the development of Monitoring Plan components to address each purpose. Each component includes:

- A background summary of relevant prior monitoring and studies.
- Monitoring and data collection activities, covering existing efforts and potential new initiatives.
- Potential data analyses to meet the identified monitoring purposes.
- Products for use by BEACON members and the region in adaptation planning.
- Potential priority pilot studies.

Following stakeholder and public review of this Public Draft Monitoring Plan, selected pilot studies will be conducted. At the conclusion of the monitoring period, a monitoring results report will be prepared. BEACON will coordinate ESA staff, City of Santa Barbara staff, and the SAC, agency staff, and stakeholders to examine the lessons learned from the monitoring and prepare revisions to the Monitoring Plan accordingly. The City of Santa Barbara will then prepare an amendment to the City's fully certified LCP to incorporate the final monitoring protocols into the City's Coastal Land Use Plan.

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2. GOAL AND OBJECTIVES

The Monitoring Plan goal and objectives are discussed below. The goal and objectives are intended to guide the RCAMP and inform criteria for prioritizing monitoring (see Section 6).

Goal: The overarching goal of the Monitoring Plan is to provide consistent data and analysis to inform the implementation of sea level rise adaptation plans in the Santa Barbara Littoral Cell, including BEACON member agencies (the Counties of Santa Barbara and Ventura as well as the coastal cities of Santa Barbara, Goleta, Carpinteria, Ventura, Oxnard and Port Hueneme).

Objectives:

1. **Inform adaptation planning:** provide local management agencies with the information needed to assess if changed conditions warrant new adaptation approaches.
    a. Establish a baseline to assess sea level rise impacts over time (e.g., how ecology will adapt over time) and support planning, analyses, environmental compliance/regulatory requirements, and design development.
    b. Focus on metrics that quantify progress towards adaptation triggers, thresholds, and decision-points.
2. **Inform assessment of adaptation actions:** provide information to assess adaptation action effectiveness.
    a. Establish a baseline to assess adaptation action effectiveness (e.g., comparison of reference sites to adaptation projects).
    b. Inform assessments of the effectiveness of adaptation projects by regularly providing regionally consistent data to compare to baseline data and assess change over time for adaptation projects and reference sites.
    c. Provide data and information for use in ongoing adaptation projects in the BEACON region.
3. **Support regional adaptation planning:** have a regional and coordinated adaptation approach (e.g., understanding of the littoral and ecological system, identification of project and mitigation sites, Regional Sediment Management).
4. **Create a "model" program:** design a transferable program that could be adopted and replicated in other coastal communities.
5. **Leverage and synthesize existing efforts:** utilize existing monitoring efforts and datasets (e.g., USGS and NOAA monitoring data) and present that data in a manner that efficiently and effectively informs decision making.
    a. Provide distilled and user-friendly data products for scientific and public users (e.g., extract key attributes from large data sets and provide "how to" documents).

   b. Reduce data collection and analysis costs by using available data, supporting regional-scale analyses, and providing data products that BEACON members and stakeholders can use.

6. **Focus efforts:** concentrate resources on monitoring efforts that provide the physical, social, and ecological parameters required for adaptation decision making.
7. **Collaborate with stakeholders:** develop programs with a stakeholder process that includes representatives from multiple jurisdictions within Santa Barbara and Ventura Counties, Chumash tribal representatives, a science advisory team led by members of the BEACON Science Advisory Committee, and outside technical advisors.
8. **Provide emergency/disaster data:** provide information needed for FEMA damage assessments, other processes (e.g., before and after information, characterize people affected), and repetitive loss.
9. **Provide accessible data:** provide information that is readily available to BEACON member agencies, stakeholders, and the public.
10. **Promote equitable adaptation planning:** provide data related to equity to inform just adaptation decisions.
11. **Include Chumash tribes:** meaningfully involve Chumash tribes. Based on input from Chumash tribal representatives (see Section 5.2.4), the Monitoring Plan identifies several specific objectives below:
    a. Involve indigenous people and knowledge in the monitoring planning processes.
    b. Include monitors who spend time on the coast through the seasons.
    c. Recognize natural resources as significant for indigenous people.
    d. Propose a Chumash youth monitoring program location on the coast.
    e. Formally consult with Chumash tribes following State guidelines.
12. **Inform Local Coastal Programs (LCPs):** support a City of Santa Barbara LCP Amendment and integrate with BEACON member agency's LCPs.

3. BACKGROUND

The following sections briefly summarize relevant plans.

3.1 Relevant Plans

3.1.1 State Agency Sea Level Rise Action Plan for California

The 2024 Ocean Protection Council *State Agency Sea-Level Rise Action Plan for California* prescribes ways for state agencies to support sea level rise planning through trackable actions centered around seven principles: best available science, partnerships, alignment, communications, local support, coastal resilience projects, and equity. While this document focuses on state-agency level actions, it also reflects important principles relevant to the goals of BEACON and of this Monitoring Plan, including developing data on the vulnerability of coastal communities and natural resources to sea level rise, providing local and regional adaptation and planning guidance, building interagency partnerships, supporting local leadership and regional collaboration, addressing social vulnerabilities to climate change and sea level rise, and social and environmental justice and equity objectives.

3.1.2 BEACON Plans

BEACON Strategic Planning Goals, Objectives, and Work Action Plans 2021–2026

The 2021 BEACON *Strategic Planning Goals, Objectives, and Work Action Plans 2021–2026* provides a set of eight goals, objectives, and actions to preserve and enhance coastal resources from 2021 to 2026. The Monitoring Plan aligns with Goal 3, Objective 3.2 of the Strategic Plan, which is to investigate establishing a regional shoreline monitoring program. The Monitoring Plan will strengthen the regional monitoring program, Objective 2.3, by providing information on existing projects and recommendations for future monitoring efforts. Objective 2.4 is addressed in this Monitoring Plan through the promotion and emphasis on interdisciplinary science efforts.

BEACON Research Agenda

The 2021 BEACON *Research Agenda* identifies "key research and scientific actions that would advance BEACON's primary objectives of coordinated regional coastal resource management." The Research Agenda summarizes research topics and actions that helped to inform the monitoring programs and adaptation described in this Monitoring Plan. These topics include management and decision science, regional monitoring programs including physical shoreline, ecology, and human use and economics, and interdisciplinary approaches that address combined social and ecological systems. The research agenda also identifies gaps in science, data, knowledge, and policy. A table of relevant research and science initiatives provided in the Research Agenda was expanded upon as part of this Monitoring Plan and is provided in Section 4.

BEACON Coastal Regional Sediment Management Plan

The 2009 BEACON *Coastal Regional Sediment Management Plan (CRSMP)* provides a regional planning approach to address coastal sediment processes within the BEACON region. This plan was written as a component of a State-wide initiative to identify “coastal erosion hotspots" and delineate zones of concern for future erosion. While the CRSMP acknowledged the potential exacerbation of erosion processes by sea level rise, it did not include an in-depth analysis of its future implications for the BEACON region. The CRSMP identifies challenges and opportunities for sediment management and provides key objectives related to beach preservation and maintenance, beneficial sediment use, and use of technology to maximize longevity of sand on the beach. Table 3 and Figure 9 of the CRSMP provide recommended activities, divided into study, management, and policy activities and identified as region-wide or specific to a sediment management reach.

The 2009 CSRMP included a comprehensive review of socioeconomics pertaining to beaches within the BEACON region. The economic analysis involved original data collection efforts, including data on beach attendance, as well as survey information from beach visitors. In the past five years, BEACON has been collecting more recent and contemporary information on beach visitation and beach use patterns, preferences, and behaviors.

Since 2020, BEACON has partnered with academic and governmental scientists and beach management agency staff to develop a coastal and beach access data research project. The project has employed traditional beach attendance and visitation methods, including beach counts and beach surveys, combined with mobile device location-derived beach origin and destination data (BEACON 2025). These efforts are continuing with research to be conducted, including beach observational studies, additional beach count and survey initiatives combing data sources and methods in the next two years.

3.1.3 BEACON Member Agency Sea Level Rise Adaptation Plans

Several member agencies have developed sea level rise adaptation plans, including the Cities of Santa Barbara, Goleta, Carpinteria, Oxnard, and Ventura; the Counties of Santa Barbara and Ventura; Naval Base Mugu; and UC Santa Barbara. **Table 1** lists the sea level rise planning documents to date and includes weblinks to the reports.

TABLE 1. SEA LEVEL RISE PLANNING DOCUMENTS

Planning Document	Weblink
Final 2021 City of Santa Barbara Sea Level Rise Adaptation Plan	https://santabarbaraca.gov/sea-level-rise-adaptation-plan-and-vulnerability-assessment
Draft 2015 City of Goleta Coastal Hazards Vulnerability Assessment and Fiscal Impact Report	https://www.cityofgoleta.org/home/showpublisheddocument/11317/635908658293030000
Final 2019 City of Carpinteria Sea Level Rise Vulnerability Assessment and Adaptation Project	https://carpinteriaca.gov/wp-content/uploads/2020/03/cd_General-Plan-Sea-Level-Rise-A_Cover-Table-of-Contents-Definitions.pdf
Final 2017 County of Santa Barbara Coastal Resiliency Project: Sea Level Rise and Coastal Hazards Vulnerability Assessment	https://cosantabarbara.app.box.com/s/uon3kzbfsviq8xoevcxeeke64c2tk87f
Draft May 2019 City of Oxnard Local Coastal Program Update Sea Level Rise Adaptation Strategy Report	https://www.oxnard.org/wp-content/uploads/2023/07/Copy-of-Oxnard-Adaptation-Strategy-Report_5.21.2019.pdf
Public Review Draft Oct 2022 City of Ventura Climate Action and Resilience Plan	https://static1.squarespace.com/static/5f34bf7ddc1cd21c88c0c407/t/6360533d3e58ef4f4ffcc9a0/1667257170182/VenturaCARP_PUBDRAFT_2022_1031_Reduced2.pdf
2019 Ventura County Resilient Coastal Adaptation Project	https://www.researchgate.net/publication/370426469_Ventura_County_Resilient_Coastal_Adaptation_Project_Sea_Level_Rise_Adaptations_Strategies_Report?enrichId=rgreq-6e60bfabfe43233c265da49c84a0d495-XXX&enrichSource=Y292ZXJQYWdlOzM3MDQyNjQ2OTtBUzoxMTQzMTI4MTE1NDY3NDExNEAxNjgyOTUyOTgzNDcy&el=1_x_3&_esc=publicationCoverPdf
Draft 2022 UC Santa Barbara Sea Level Rise Adaptation Strategy	
2021 Naval Base Ventura County Point Mugu Sea Level Rise Adaptation Vision	https://www.scienceforconservation.org/assets/downloads/TNC_NBVC_Report_Aug21_FINAL.pdf

A review of member agency SLR adaptation plans reveals that the plans have several overlapping adaptation themes, which are summarized in **Table 2**.

TABLE 2. SUMMARY OF BEACON MEMBER AGENCY SEA LEVEL RISE ADAPTATION PLANS

Shoreline Typology/ Sub-areas	Current Coastal Management Measures	Hazards	Thresholds/Triggers	Monitoring
Bluff-backed beach	• Bluff setbacks for development	• Bluff erosion	• Distance to asset • Erosion exposure	• Bluff top, offset & slope • Pre- and post-storm monitoring
Low-lying beach	• Harbor dredging & beach nourishment • Winter berming • Living shoreline pilot projects	• Beach erosion • Storm flooding • Tidal inundation	• Sea level rise amount • Beach width • Wave overtopping events frequency • Flood insurance claims total number	• Sea level rise elevation data • Install local tide gage • Beach width • Shoreline transect profiles • Storm/flood damage/ frequency • Biological monitoring
Creeks/ inland areas	• Creek mouth management • Levees • Debris basin management	• Creek/storm drain flooding • Groundwater seepage	• Lagoon berm elevation • Creek flood level/ frequency • Groundwater level	• Creek water levels • Storm/flood damage/ frequency • Extent/duration of inland flooding • Groundwater elevation

3.2 Existing Coastal Monitoring

The BEACON region is fortunate to have a solid foundation of existing coastal monitoring efforts to build from. These efforts were recently summarized in the 2022 BEACON Science Advisory Committee (SAC) *Summary of Science Initiatives in the BEACON Region*. UC Sea Grant/UC Santa Barbara also maintain the Coastal Monitoring Web Application and Coastal Monitoring Map, which provide an overview of current physical, ecological, or social coastal monitoring efforts within the BEACON region to identify analysis gaps and opportunities for inter-agency collaboration. **Table 3** summarizes and bolsters the information found in these resources.

TABLE 3. INVENTORY OF ONGOING COASTAL MONITORING INITIATIVES IN THE BEACON REGION

Research Topic	Research Initiative	Lead Organization	Geographic Extent	Time Period	Research Focus
Physical Monitoring	King Tides	California Coastal Commission	California		Community science – coastal storms and flooding
Physical Monitoring	Dunes as nature-based solutions	California Coastal Dune Science Network	California		Compile existing data from pilot dune projects and extend monitoring to assess performance across a range of scales and types
Physical and Ecological Monitoring	Nature-Based Adaptation Evaluation	UCSB	Southern California	2022–2024	Evaluating ecological and physical trajectories of beach restoration to inform nature-based adaptation approaches that enhance coastal resilience
Physical Monitoring	Community Alliance for Surveying the Topography of Sandy Beaches (CoAST SB)	CASG	Santa Barbara (various beaches)	2018–present	Community science – shoreline monitoring
Physical Monitoring	Wave Buoys	CDIP	Point Conception, Topanga Beach (nearshore)	1998–present (Harvest), 2020-present (Topanga)	Wave energy, wave direction, sea temperature, current, wind, air temperature, barometer
Physical Monitoring	Wave Buoys	NOAA	Santa Barbara (offshore)	1994–present	Wind direction & speed, wave height & period, sea level pressure, temperature, water level
Physical Monitoring	Carpinteria City Beachcam	City of Carpinteria	Carpinteria City Beach	2014–present	Shoreline monitoring
Physical Monitoring	Rainfall and Streamflow Monitoring	County of Santa Barbara	Santa Barbara County	1868–present	Rainfall, river-stream, and reservoir data
Physical Monitoring	Streamflow Monitoring	County of Ventura	Ventura County	1928–present	Streamflow (discharge)
Physical Monitoring	Streamflow Monitoring	USGS	US-wide	late 1800s–present	Stream levels, streamflow (discharge), reservoir and lake levels, surface-water quality, and rainfall
Physical Monitoring	Coastal Armoring Database	CSU CI	California	1971–2018	Location and amount of coastal armoring
Physical Monitoring	Impact of Sea Level Rise on Groundwater Pollution Vulnerability in Shallow Coastal Aquifers	CSU COAST/ CA Sea Grant with CSU Long Beach and Northridge	Oxnard	2021–Present	Sea level rise flooding and groundwater flooding impacts on toxic sites

Research Topic	Research Initiative	Lead Organization	Geographic Extent	Time Period	Research Focus
Physical Monitoring	Surface Water and Ocean Topography (SWOT)	NASA	Worldwide	2022–present	Surface water elevation
Physical Monitoring	Shore Profile Surveys	Santa Barbara County Parks	Goleta Beach		Spring and fall surveys and annual reports
Physical Monitoring	Shore Profile Surveys	Navy	Naval Base Point Mugu		
Physical Monitoring	Shoreline Profile Surveys	USGS	Santa Barbara Littoral Cell (Elwood Beach to Pt. Mugu)	1995–present	Annual (fall)
Physical Monitoring	Beach Water Quality	SB Channel Keeper	Santa Barbara and Ventura		Community science – water quality
Physical Monitoring	Surfrider BWTF-Ventura	Surfrider	Ventura and Santa Barbara	2018–present	Community science – water quality
Physical Monitoring	Kelpwatch		Alaska to Baja	1984–present	Presence and size of kelp forests, changes over time
Physical Monitoring	CoastSat	USGS, UNSW Sydney	US (excludes Alaska), Peru, Chile, Portion of Australia	1984-2021	Shoreline position
Physical Monitoring	CoastSnap		Planning for 12 locations in Santa Barbara		Shoreline change
Physical and Ecological Monitoring	Performance Monitoring	City of Ventura	Surfers' Point	2010–present	Performance of project – Shore profile surveys, drone LiDAR survey, photos, vegetation mapping, community science cell phone monitoring
Physical and Ecological Monitoring	SONGS wetland mitigation monitoring	Southern California Edison	Carpinteria Salt Marsh, Mugu Lagoon	2011–present	Evaluation of physical and biological performance standards (water quality, fish and invertebrates, birds)
Physical and Ecological Monitoring	Restoration Design Conceptual Model	TNC	Ormond Beach Wetlands	2020-present	Correlate soil and hydrology properties with vegetation for a conceptual model to inform restoration design
Ecological Monitoring	Multi-Agency Rocky Intertidal Network (MARINe)	BOEM, NPS, OPC, PISCO, US Navy	Alaska to Baja	1997–present	Rocky intertidal habitats
Ecological Monitoring	SBC LTER	NSF	Santa Barbara Channel (local focus)	2000–present	Kelp and sandy beach ecosystem monitoring
Ecological Monitoring	Grunion Greeters	Pepperdine	Southern California Bight	~2010–present	Community science – grunion spawning
Ecological Monitoring	California Estuary Marine Protected Area (EMPA) Monitoring Program	SCCWRP	Goleta Slough, Ventura River Estuary	2021–present	vegetation cover, algae cover, fish (abundance, length, diversity, and richness, epifauna diversity and richness), sediment grain size, crab (biomass and length), invertebrate abundance, water quality

Research Topic	Research Initiative	Lead Organization	Geographic Extent	Time Period	Research Focus
Ecological Monitoring	Southern California Bight Regional Monitoring Program	SCCWRP	Point Conception to Punto Colonet, Mexico	1990s–present	sediment and water quality, harmful algal blooms, trash and microplastics, microbial water quality on beaches, ecological functioning of estuaries, ecological assessments of submerged aquatic vegetation
Ecological Monitoring	California MPA Network: Baseline, Monitoring and Evaluation	UCSB	Santa Barbara and Ventura	2019 to 2022	Sandy beach and surf zone baseline and monitoring studies
Ecological Monitoring	COPE Ecological Monitoring Network	UCSB	Central Coast	2021–present	Subtidal ecological monitoring
Ecological Monitoring	SBC Kelp Monitoring	UCSB	Coal Oil Point Reserve	2012–present	Kelp monitoring
Ecological Monitoring	Western Snowy Plover Monitoring	UCSB	Sand's Beach, Coal Oil Point Reserve	2001–present	Snowy plover monitoring
Ecological Monitoring	Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO)	UCSB, UCSC, OSU	Oregon and California	1999–present	Long term ecosystem monitoring
Ecological Monitoring	Waterfowl Monitoring	Ventura Joint Venture			Waterfowl monitoring
Social Monitoring	Coastal User Assessment	BEACON/MRCA/ CA Sea Grant	Santa Barbara-Malibu	2021–Present	Coastal user identification and assessment
Social Monitoring	Beach Sustainability Assessment (BSA)	BEACON/CSU Channel Islands	Santa Barbara and Ventura	2013–present	Interdisciplinary coastal assessment: ecology, geomorphology, social utility
Social Monitoring	Coal Oil Point Reserve Beach Use Monitoring	UC Santa Barbara	Coal Oil Point Reserve	2001–present	Daily snapshot counts every 2 hours of people on the beach or surfing, leashed and unleashed dogs, compliance after request by docents, trespassing events, and interactions with docents

3.3 Identified Monitoring Needs

The following sections present outcomes from discussions with BEACON members, focusing on monitoring needs for their agency. The section also summarizes the monitoring needs identified in BEACON member agency sea level rise adaptation plans.

3.3.1 BEACON Member Agency Sea Level Rise Adaptation Plans

A review of member agency sea level rise adaptation plans reveals that the plans have several overlapping themes, which are summarized in Section 3.1.3. The plans identify overlapping monitoring needs regarding beaches, bluffs, and creeks/inland areas. Monitoring needs identified for beaches include sea level rise elevation data, installation of a local tide gage, beach width monitoring, shoreline transect profiles, storm/flood damage/frequency monitoring, and biological monitoring. Bluff monitoring needs include bluff top, offset & slope monitoring and pre- and post-storm monitoring. For creeks and inland areas, creek water level monitoring, storm/flood damage/frequency monitoring, extent/duration of inland flooding measurements, and groundwater elevation monitoring were identified as needs.

3.3.2 BEACON Member Needs

The RCAMP team obtained input from BEACON members and stakeholders to gather input to the RCAMP, including identifying monitoring needs and establish evaluation criteria for prioritizing monitoring within the Monitoring Plan, which are included in Section 6.

BEACON Science Advisory Committee (SAC)

A BEACON Science Advisory Committee meeting was held February 27, 2023, on Zoom to discuss the RCAMP and specific monitoring needs in the BEACON region. The event included breakout groups. The key takeaways include considering and monitoring seasonal variations, recovery from storm incidents, and long-term changes. Additionally, the significance of interpreting data and educating the public through a widely accessible platform was emphasized.

BEACON Member Agencies

A BEACON member workshop was held on May 15, 2023, to provide input to the RCAMP and specifically identify monitoring needs. BEACON Science Advisory Committee (SAC) members and other stakeholders also attended this event. Individual meetings with BEACON member agencies were held throughout 2023 to provide input to the RCAMP and identify monitoring needs. Summaries of input from each of these agencies are discussed below.

The SAC and BEACON members emphasized the importance of monitoring seasonal variability and recovery, or lack thereof. They proposed monitoring that could answer the question of whether beaches are recovering from erosion or not. Monitoring that indicates a lack of recovery would trigger adaptation strategies.

The County of Santa Barbara proposed tracking beach profiles over time at key locations in online databases with visualization. They also emphasized the importance of monitoring sediment delivery from key watersheds.

The County of Ventura suggested establishing a baseline for a map of beach erosion/accretion rates, accounting for and removing seasonal fluctuations. This would help to track and predict the loss of dry beach, lateral access, and towel space.

The City of Santa Barbara proposed several measures, including post-event monitoring, damage monitoring, repetitive damage monitoring, and using more/better stream gages. They also suggested compiling and synthesizing existing data to establish a baseline and track changes, including the analysis of recent local sea level rise rate and comparison to projections.

The State Coastal Conservancy suggested monitoring the sediment budget and the watershed fire/flood regime.

Naval Base Point Mugu highlighted the need to monitor sediment erosion in the Mugu submarine canyon and suggested installing a water level gage in Mugu Lagoon.

The City of Carpinteria proposed monitoring beach width/depth, sediment deposition, and beach composition.

The United States Geological Survey (USGS) suggested shoreline monitoring with timelapse cameras and event response monitoring. They also proposed the use of more frequent satellite imagery and grainsize and substrate monitoring.

BEACON Summit

The annual BEACON Manager-Scientist Summit was held November 28, 2023, in Ventura to discuss research and science needs to implement regional sediment management. The event included multiple small group discussions. Relevant discussion summaries are below.

Several groups recognized the importance of incorporating bacteria and turbidity into water quality monitoring parameters. There was a shared focus on the significance of comprehending the regional interconnections within sediment, as well as understanding the sources of pollution and vulnerable communities in the region. One group suggested a greater focus on opportunities that enable natural sediment redistribution within estuarine systems, as opposed to offshore deposition. They also proposed increased monitoring by BEACON during the off-season.

Several suggestions were made to enhance regional adaptation strategies, actions, and tactics through expanded research. These included developing state guidelines for managed retreat evaluations and augmenting social data collection. The importance of maximizing natural sediment movement and establishing reference sites and baselines for coastal impact identification were also noted as valuable research updates. Baseline sets of regional beach profiles should be implemented, perhaps using CoastSat or another satellite data source Additionally, BEACON's proposals for post-emergency monitoring, managed retreat, and offshore reefs were highlighted.

It is crucial to address existing data gaps to enhance monitoring capabilities. The gaps in fines and the variability of fine sediments in nearshore environments were particularly emphasized. BEACON could potentially fill some data gaps and contribute to the regional monitoring program. Several groups suggested that regional monitoring could be improved by better utilizing existing efforts, including further collaboration with universities, state, federal, and local agencies. The groups also recognized the advantages of expanding data monitoring technology, such as drones, satellites, and LiDAR.

Oxnard Elected Officials

Elected officials from Oxnard convened a meeting on January 4, 2024, to discuss the significant rainfall event that occurred on December 21 and the coastal flooding event that followed on December 28. The Ventura County Sheriff's Emergency Services and the Ventura County Fire Department presented internal documentation of the storm damage, which was recorded on mapping platforms. The presentations and discussion from this meeting reinforced the need for systematic gathering and interpreting of storm incident data for the BEACON region.

Coastal Band of Chumash

The RCAMP team met separately with two representatives of the Coastal Band of Chumash. The Coastal Band of Chumash highlighted the importance of observation, not only monitoring for a short period of time. They recommended spending more time in the field on our coastline to get a better perspective and understanding of the coastal systems. They also suggested that monitoring plans should not be one-time events and instead encompass multiple seasons and different aspects of the shoreline. They propose including the tribal communities in monitoring efforts.

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4. DATA GAPS

In the BEACON region, there is a significant need for enhanced data synthesis and visualization. A public data platform for a range of information and monitoring data would improve data access and usability. This organization of data facilitated by a public data portal could better inform management strategies, contributing to regional resilience. Additionally, advanced visualization tools can translate complex data into intuitive formats, making it more accessible to decision-makers, researchers, and the public. The following is a summary of data gaps based on the RCAMP team's evaluation, input from BEACON member agencies and stakeholders, and relevant plans.

4.1 Physical Monitoring

The recurring physical monitoring data gaps that are recognized through relevant plans, existing monitoring efforts, and input from BEACON's members, SAC, and stakeholders are summarized in **Table 4**.

TABLE 4. PHYSICAL MONITORING GAPS

Monitoring Gap	Description
Shoreline change	Studies by USGS and others are available of past or historic erosion rates. USGS leads an ongoing shore profile and topography survey program in the BEACON region and is progressing the processing and analysis of these data to update and expand the USGS shore profile survey data available through 2005 and related studies. Funding and further coordinating with USGS to complete these efforts and incorporate more recently available satellite-derived shoreline change data could support a more informed and coordinated monitoring approach.
Seasonal Variability and Post/Pre-Storm Events	Lack of monitoring for sediment budget/delivery and tracking of sand accretion/erosion and deposition locations.
Storm event damage and emergency response documentation	Systematic documentation and data collection on flooding and erosion resulting from storm events and agency response to these events is not being performed.
Wave Event Prediction Tools	Region lacks reliable tools to predict when wave events may damage specific areas; existing tools need validation.
Comprehensive Monitoring of Combined Flooding Events	Inadequate tracking of combined flooding events (precipitation, swell, and combined events) due to lack of a categorized database.
Wave Gages in Santa Barbara Channel	Need for one or two wave gages inside the Santa Barbara Channel; current local gage (Harvest CDIP buoy) doesn't capture swell from different directions.
Improved Stream Gage Array	Fewer monitoring programs for stream gages; enhancing the array will enhance the region's ability to monitor environmental changes and threats.
Regional Sediment Data	Current up-to-date regional sediment source, transport, and fate data is not available.

4.2 Ecological Monitoring

The recurring physical monitoring data gaps that are recognized through relevant plans, existing monitoring efforts, and input from BEACON's members, SAC, and stakeholders are summarized in **Table 5**.

TABLE 5. ECOLOGICAL MONITORING GAPS

Monitoring Gap	Description
Baseline monitoring of natural communities (vegetation or habitat mapping)	While baseline monitoring has occurred at a variety of locations, large portions of the coastal region remain unmonitored including sites where changes in habitat due to sea level rise may influence adaptation decisions, adaptation projects may need to occur, and understanding reference conditions is important for evaluating adaptation actions. Existing coastal habitat data for most of the region is either missing, out of date, or of low spatial resolution in the BEACON region. Filling this gap will provide the necessary data to document ecological impacts and benefits of sea level rise and adaptation projects. Example applications include: • Developing a baseline map of coastal and nearshore habitat zones similar to products available for coastal wetlands • Establishing reference site conditions • Evaluating and comparing the ecological benefits and ecosystem services of different nature-based approaches • Evaluating regional-scale effects of large potential projects such as the Matilija dam removal.
Defining habitat parameters for mapping and assessing existing and potential habitat	Parameters on habitat requirements for key habitats and species have not been regionally or consistently established to guide mapping and assessment of existing and potential habitats. Monitoring habitat parameters is more important than monitoring specific species because use of habitats by specific species can be highly variable. Species typically require certain physical habitat conditions, which could be defined and used in habitat assessments. Example parameters include minimum beach widths, grooming activity, and level of pedestrian use.

4.3 Social Monitoring

Social estimates are necessary for robust coastal planning, but the data to support these estimates should be significantly improved. An estimate of the economic value of beach recreation relies on understanding (1) beach attendance, (2) how much attendance the beach can support, and (3) what the beach offers visitors. **Table 6** outlines the major gaps in relevant data.

TABLE 6. SOCIAL MONITORING GAPS

Data Type	Monitoring Gap
Beach Use and Attendance	• Improved attendance data would not rely on observations or counts. It would indicate a visitor's place of origin (residence) and how long they stay at a particular site. This would help refine estimates of (1) travel cost (non-market value of a beach trip) and (2) patterns of use (e.g., turnover) for a site. • Attendance data including a visitor's residence can indicate which beaches serve underserved communities with less ready access to the coast and allows beach attendance to be connected to measures of vulnerability, such as the CalEnviroScreen or the Justice40 initiative. • Attendance data that indicates visitor "avidity" (repeated or regular visitors) would help refine estimates of beach value.
Beach Access Barriers and Constraints Data, Disadvantaged Communities	• Improved access monitoring would indicate the popularity of an access point and who it serves (demographic information). • This would enable planners to understand the demand for access at sites, and if there are barriers to access—such as lack of parking, unsafe crossings, or illegal prohibitions (such as "No Trespassing" signs).

Data Type	Monitoring Gap
Post-storm impacts	• Improved monitoring of flooding/storm impacts to property, especially who is impacted. Demographic and equity analysis of expected property loss and damages. • Improved monitoring of how a significant coastal event—such as a severe storm—impacts beach attendance, access, and amenities including parking would aid climate adaptation planning. • These data would refine estimates of the economic losses associated with flooding and storm events.
Beach Amenities	• Improved monitoring of what amenities beachgoers use, and if they visit a particular site to access those amenities, would help determine beach value and indicate which neighboring sites can serve as substitutes in the event of beach loss or overcrowding.
Recreation Specific Activities such as Surfing and Fishing	• Improved monitoring of specific recreational activities (e.g., surfing, fishing) would include more accurate counts of recreation specific visitation over the course of a day and how long they use the sites. • This would allow researchers to determine the capacity of a recreation specific location and peak times for users. • Data which indicates regular users—those that repeatedly visit a site—would help refine estimates of surfing (and other activity) value, as many surfers are regular visitors (high avidity). • Improved data may also include similar information to beach attendance data, indicating where surfers come from to use the spot. • Pier Fishing Surveys: Important social coastal resource.
Flood and Storm Impacts – Demographics	• While Census data and parcel tax data are available, data on property damage is not readily available to analyze demographics of impacts.
Changes to Transportation	• Improved monitoring of how beachgoers get to the beach and how they are willing to change their behaviors and practices, which would aid in access planning.

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5. POTENTIAL MONITORING PLAN COMPONENTS

The Monitoring Plan provides a roadmap for BEACON, its members, and stakeholders to implement the Regional Coastal Adaptation Monitoring Program with potential monitoring plans and pilot studies to inform decision making on adaptation. The Monitoring Plan was developed in collaboration with BEACON members, a Science Advisory Committee, and stakeholders. Several types of monitoring parameters have been investigated including physical processes, ecological processes, social topics, and cultural resources. The following sections present how monitoring evaluations could be accomplished.

5.1 Potential Monitoring Topics

Monitoring the following topics will close critical analysis gaps, provide missing data required for coastal resiliency efforts, and address monitoring needs for BEACON members, SAC, and stakeholders.

Potential Physical Coastal Processes Topics

- Sea level rise
- Sandy beach shoreline change
- Bluff erosion
- Sediment budget tracking, including littoral processes, emergency sediment placement and fate/transport, and watershed inputs
- Storm events, damage, emergency response, and recovery, including flood and erosion extents
- Wave runup and coastal flooding, including coastal flood forecasting
- Combined coastal and fluvial flooding, including combined flood forecasting
- Shallow groundwater rise
- Effectiveness of nature-based adaptation, focused on evaluation and "proof of concept" at the Surfers' Point Living Shoreline and Managed Retreat Project in Ventura.

Potential Ecological Resource Topics

- Baseline habitat mapping, including distribution and status of natural communities (interchangeably called vegetation types or habitats) in the coastal zone.
- Sensitive species, including status and occurrence of special-status species depending on coastal habitats
- Coastal wetland change with sea level rise, including estuary water level, sediment dynamics & habitat change

Potential Social Topics

- Beach attendance including beach use and beach user information
- Beach access, including barriers and constraints to coastal access, focused on disadvantaged communities
- Flooding and storm impacts, focused on demographics and equity

Potential Chumash Tribal Cultural Resources Topics

- Chumash cultural resource sites erosion

5.2 Potential Monitoring Plan Components

Potential Monitoring Plan components include physical, ecological, and social monitoring. The Cultural Resources and Chumash Monitoring Plan applies to all coastal adaptation monitoring included in the Monitoring Plan.

For each plan component, specific data collection, analyses, and products are identified to support evaluation and implementation. For data products, the intent is that various products could be organized within an integrated regional data management system (see Section 7.1.1 for additional discussion). To advance transparency and accessibility across all subject areas, and to facilitate access while minimizing redundancy, any portal, dashboard, library, web-mapper, or similar tool related to a specific topic should be developed as a component of a broader integrated regional data management system.

Where possible within the scope of this Monitoring Plan, the RCAMP team estimated preliminary rough order of magnitude or “ballpark” cost ranges for specific data collection and analyses. Cost ranges are intended to bracket potential costs given a range of uncertainties. For other data collection and analyses efforts, it is beyond the scope of the Monitoring Plan to estimate cost ranges. Cost estimates will need to be obtained from the parties performing data collection and analyses to confirm actual costs.

5.2.1 Potential Physical Monitoring

The suggested monitoring plans described in the following sections encompass each of the monitoring topics. Certain types of data and monitoring reflect multiple topics. Therefore, subsequent plans refer back to data and monitoring descriptions and discussions in preceding plans. **Table 7** summarizes which topics are reflected in each monitoring method.

TABLE 7. MONITORING METHODS AND TOPICS ADDRESSED

Monitoring Method	Availability	Monitoring Topics									
		Sea Level Rise	Sandy Beach Shoreline Change	Bluff Erosion	Sediment Budget Tracking	Storm Events, Damage, Emergency Response & Recovery	Wave Runup and Coastal Flooding	Combined Coastal and Fluvial Flooding	Shallow Groundwater Rise	Effectiveness of Nature-Based Adaptation	# of Topics Addressed
NOAA water level gage	Available, site specific	●					●	●			3
Additional water level gages	New, site specific	●					●	●		●	4
Satellite imagery	Available, regional	●	●		●					●	4
USGS shore profile surveys	Ongoing, regional, annual	●	●	●	●		●	●		●	7
BEACON member shore profile surveys (e.g., Goleta Beach)	Ongoing, site specific	●	●	●	●		●	●		●	7
Supplemental shoreline profiles (temporal and spatial)	New, regional + site specific	●	●	●	●		●	●		●	7
Available aerial LiDAR topography	Available, regional	●	●	●	●			●		●	6
USGS aerial imagery-based topography	Ongoing, regional	●	●	●	●					●	5
New regular LiDAR and/or imagery-based topography	New, regional + site specific	●	●	●	●						4
Cameras	New, site specific	●	●		●	●	●	●		●	7
CoastSnap	New, site specific	●	●		●					●	4
Beach habitat zonation and change	New, site specific	●	●								2
Detailed bluff geology	New, site specific			●							1
Harbor bypass volumes	Available, site specific				●						1

Monitoring Method	Availability	Monitoring Topics									
		Sea Level Rise	**Sandy Beach Shoreline Change**	**Bluff Erosion**	**Sediment Budget Tracking**	**Storm Events, Damage, Emergency Response & Recovery**	**Wave Runup and Coastal Flooding**	**Combined Coastal and Fluvial Flooding**	**Shallow Groundwater Rise**	**Effectiveness of Nature-Based Adaptation**	**# of Topics Addressed**
Sediment basin clean out and beach placement documentation	Available, inconsistent, site-specific				●						1
Creek sediment loads	Available, regional				●						1
Bathymetric surveys of littoral cell boundaries	New, site specific				●						1
SandSnap beach grain size	New, site specific				●						1
Turbidity monitoring	New, site specific				●						1
Nearshore biological monitoring	New, site specific				●						1
Storm damage documentation	Available, inconsistent, regional	●				●		●		●	4
"Flood Snap" app	New, regional	●				●		●			3
FEMA flood insurance claims	Available, regional but specific to properties with FEMA flood insurance					●		●			3
Pre- and post-storm surveys of erosion	New, site specific	●				●		●		●	4
CDIP and NOAA wave buoys	Regional, available						●	●			2
New wave buoys (e.g., CDIP roving wave buoy in Santa Barbara Channel)	Planned + new, regional						●	●		●	3
Wave monitoring and prediction (MOP) system	Available, regional						●	●			2

Monitoring Method	Availability	Monitoring Topics									
		Sea Level Rise	Sandy Beach Shoreline Change	Bluff Erosion	Sediment Budget Tracking	Storm Events, Damage, Emergency Response & Recovery	Wave Runup and Coastal Flooding	Combined Coastal and Fluvial Flooding	Shallow Groundwater Rise	Effectiveness of Nature-Based Adaptation	# of Topics Addressed
Wave runup	New, site specific	●					●	●		●	4
Stream channel geometry	New, site specific							●			1
Storm drain system mapping	New, site specific							●			1
Precipitation	Available, regional + site specific							●			1
Stream gages	Available, inconsistent, site specific							●			1
Lagoon dynamics	Available, inconsistent, site specific	●						●			2
Existing groundwater wells	Available periodically, site specific	●							●		2
New groundwater wells	New, site specific	●							●		2
Available aerial topography	Ongoing, site specific									●	1
Plant community surveys	New, site specific									●	1
Cobble PIT or RFID tag tracking	New, site specific									●	1

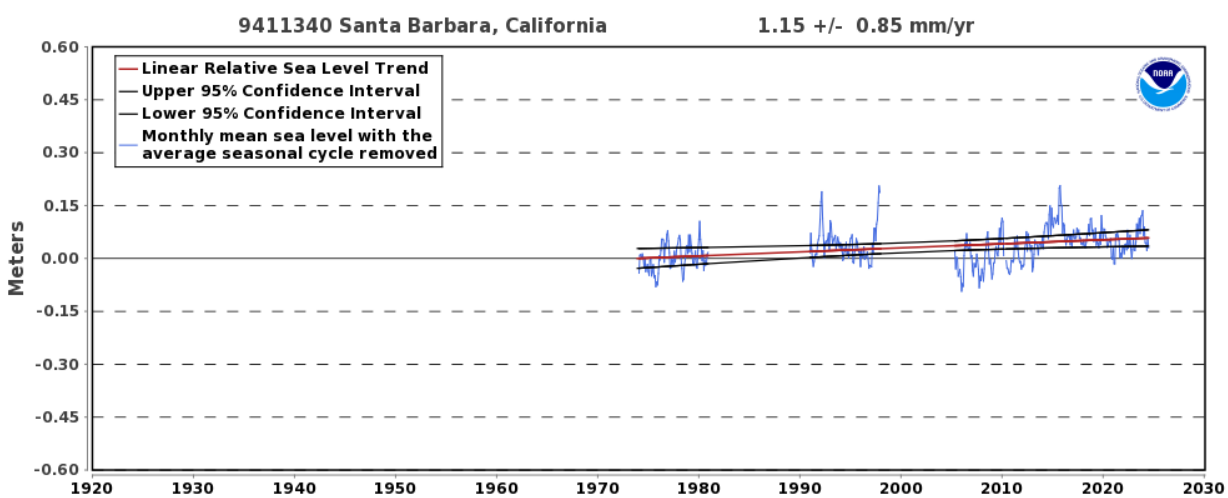
Sea Level Rise

Background

Sea level rise in California is documented by the California Ocean Protection Council (OPC) in the State of California Sea Level Rise Guidance 2024 Science and Policy Update (OPC 2024) and NOAA. Increasing sea levels can cause an increase in coastal flooding due to high tides, large storm and wave events, and El Niño events. During the last 30 years, El Niño and decadal variability caused a shift in the rates of sea level rise. However, the rates have since evened out, and longer-term records indicate that sea level rise in California should resemble the global average (OPC 2024).

The rate of relative sea level rise, or the rise of seas relative to land, is impacted by vertical land motion. Vertical land motion is a combination of tectonics, sediment compaction, groundwater and hydrocarbon withdrawal and is the primary driver of local variation in sea level rise across the state. OPC (2024) calculated vertical land motion in California or each tide gage and on 1-degree grids using a statistical model that divides tide gage data into three components: (1) a global sea level rise signal, (2) a long-term linear—but regionally varying—rate, and (3) local effects that vary in time and by region. These rates of past vertical land motion are assumed to persist into the future. OPC calculated an uplift rate of 0.4 inches per decade at the Santa Barbara tide gage (OPC 2024).

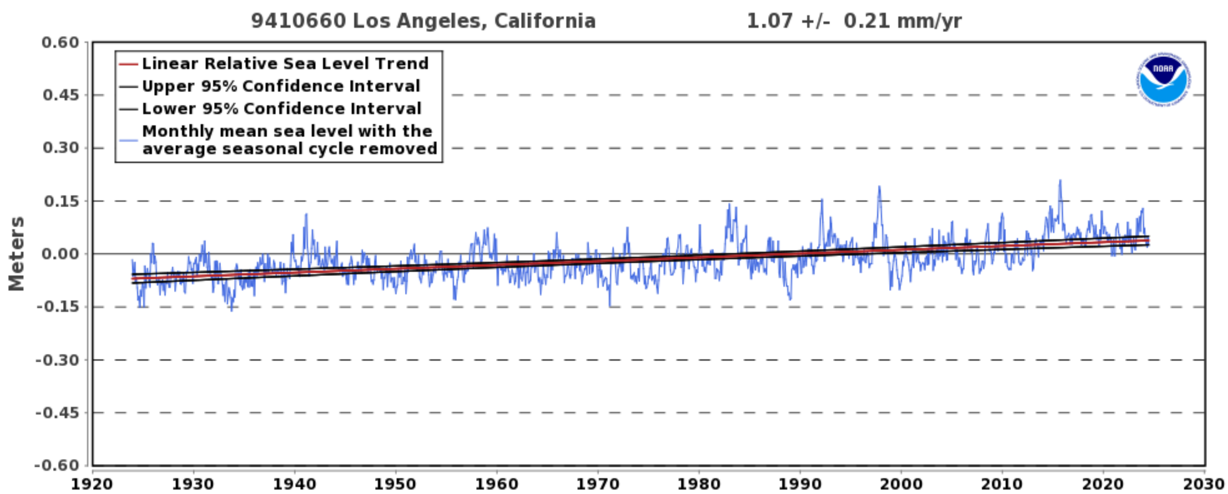
NOAA Tides and Currents has measured and recorded water levels in Santa Barbara since 1973. Using these data, NOAA calculated a relative sea level trend, shown in **Figure 1** (NOAA 2024). NOAA also provides a list of tidal datums, which are calculated within a specific range of time, or epoch, that captures an 18-year astronomical tide cycle. The present epoch is for the years 1983–2001. The epoch is currently undergoing revision, to be replaced with updated tidal datums that use measurements spanning the years 2002–2020. The new tidal datums are proposed to be released after 2026 (NOAA 2024). Comparison of tidal datums from the current 1983-2001 epoch and the soon-to-be-released updated 2002–2020 epoch will provide one measurement of sea level rise that has occurred. NOAA has updated tidal datums about once every 20 years. The RCAMP could analyze, assess, and track measured sea level rise amounts on a more frequent regular interval.



SOURCE: NOAA 2024

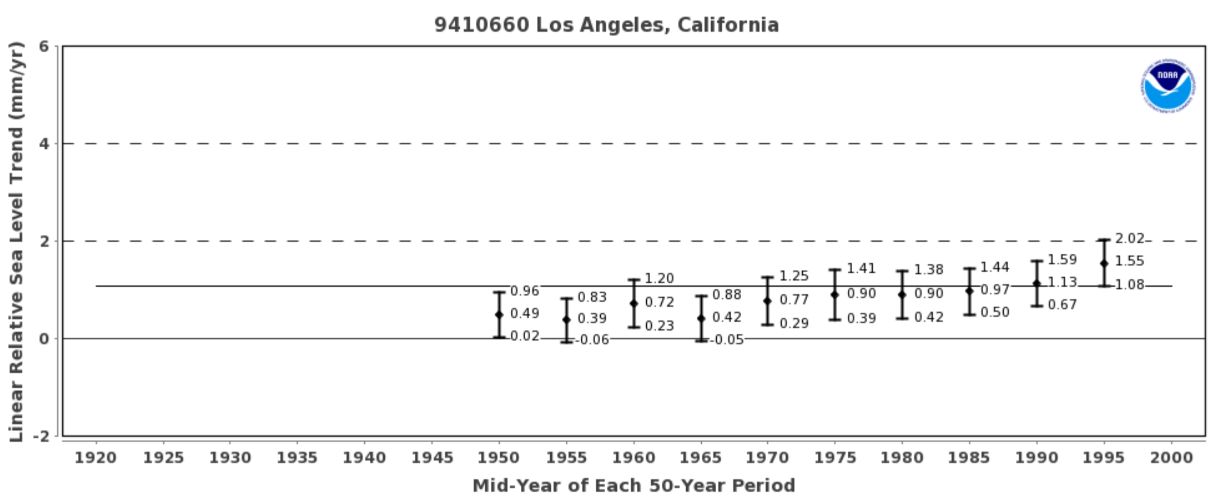
Figure 1. Relative Sea Level Trend in Santa Barbara, CA

While NOAA provides a long-term sea level rise trend for Santa Barbara, the length of the record is relatively short and there are several gaps in the data. As the length of the record increases, more analyses can be performed on the data. An example of the additional analyses can be seen in the data from the NOAA tide gage in Los Angeles, CA, which provides water level data from 1923 to the present (**Figure 2**). For the Los Angeles tide gage located in the Port of Los Angeles harbor, NOAA provides the variation of 50-year relative sea level rise trends, which were calculated in overlapping 50-year increments and plotted against the mid-year of each 50-year period (**Figure 3**, NOAA 2024). The 50-year relative sea level rise trends at Los Angeles tide gage show an increase or acceleration in the rate of sea level rise; however, note that the Santa Monica tide gage does not clearly show a similar trend. NOAA has not performed this analysis for the Santa Barbara tide gage because the gage does not have a long enough continuous dataset.



SOURCE: NOAA 2024

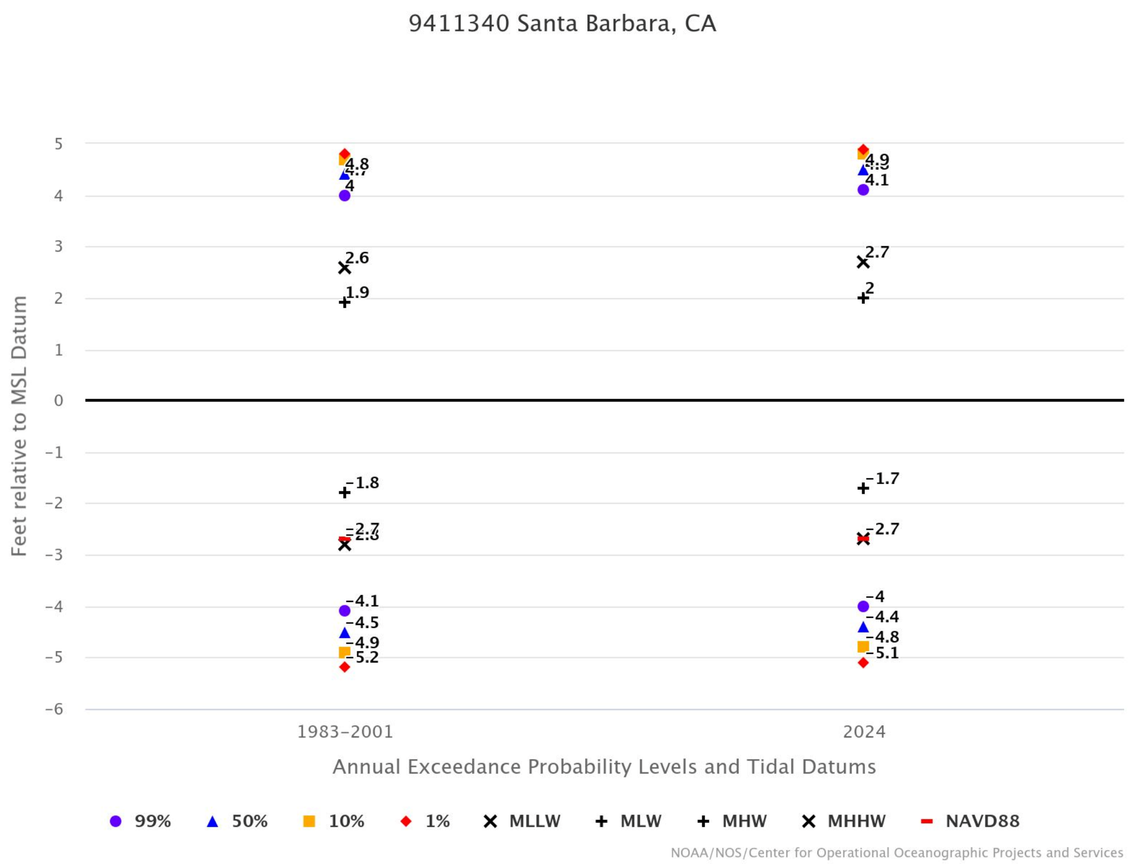
Figure 2. Relative Sea Level Trend in Los Angeles, CA



SOURCE: NOAA 2024

Figure 3. Variation of 50-Year Relative Sea Level Trends in Los Angeles, CA

In addition to mean sea level rise trends, NOAA provides annual exceedance probabilities of extreme still water levels relative to tidal datums. The annual exceedance probability still water levels for the Santa Barbara tide gage are shown in **Figure 4**. On the left, exceedance probability still water levels for the current epoch (1983-2001) are displayed in Mean Sea Level (MSL) datum. The values on the right are projected exceedance probability levels and tidal datums, assuming continuation of the long-term historical linear trend. The results show a projected 0.1-foot increase in still water levels at present relative to 1983-2001 levels based on a corresponding long-term historical rate of sea level rise. The RCAMP could build upon these data by estimating the annual exceedance probability still water levels on a regular interval based on collected data, instead of using a projection.



SOURCE: NOAA 2024

Figure 4. Exceedance Probability Levels and Tidal Datums in Santa Barbara, CA

Note that these still water level data and projections do not account for wave runup heights above still water levels or the resulting total water level including wave runup. See **Wave Runup and Coastal Flooding** for further discussion of wave runup. Also, note that the NOAA Ventura Harbor water level station is inactive and, while predicted astronomical tide levels are available, no measured water level is readily available.

Data and Monitoring

Data could be collected from existing and potential new tide gages to inform rates of relative sea level rise in the BEACON region. Existing and potential new tide gages are described below.

NOAA water level gage	*Available, site specific.*
Spatial scale: Santa Barbara Harbor, applicable to nearby areas	*Frequency:* every six minutes, continuous
Cost: Currently funded by NOAA	
NOAA Tides & Currents provides observed water level data in Santa Barbara Harbor and data analysis products on tidal datums, rate of sea level rise, and extreme still water levels (see Background discussion above). Other parameters measured by NOAA include wind speed, direction, gust, atmospheric pressure, and air temperature. Data collected from water level gage can be used to inform modeling and forecasting of waves, wave runup, coastal storm flooding, and erosion. *Other purposes:* coastal storm flooding, erosion	

Additional water level gages	*New potential monitoring, site specific.*
Spatial scale: point data, applicable to nearby areas	*Frequency:* every six minutes, continuous
Cost: For one permanent water level gage attached to a pier or similar: • Installation and telemetry system: \$50,000–\$100,000 depending on location, type of gage, and level of permitting required • Annual maintenance: \$30,000–\$40,000 for one year of maintenance	
Additional water level gages could be installed in other harbors and on piers to monitor local water levels for use in wave runup and coastal flood analyses. This could include re-establishing the inactive water level gage at Ventura Harbor, either separate from or in coordination with NOAA. The cost ranges above are for a water level gage similar to a NOAA gage, such as a radar gage installed at the top of a very long stilling well, with a telemetered Campbell Scientific CR1000x data logger (or similar). The cost ranges include data architecture buildout that would be publicly accessible and hosted on a website. At the lower end of the cost range, a simple pressure transducer that is hosted on a proprietary telemetry data hosting system could be used but would be less reliable. *Considerations:* Specialist maintenance staff are required. Requires surveying of water levels at gage by a licensed surveyor or engineer or scientist experienced in land surveying.	

Analysis

- **Regularly updated sea level rise analysis.** This analysis would use available water level data from the NOAA Santa Barbara water level station to analyze, assess, and track measured sea level rise amounts on a regular interval. This would include a more frequent calculation of tidal datums and annual exceedance probabilities than those updated by NOAA about once every 20 years. With additional data, the variation of sea level trends could be calculated to determine how the amount and rate of sea level rise has been changing over time in the BEACON region.

Products

- **Regular sea level rise report.** A regular report could be prepared to document and summarize sea level rise and relevant processes. Recent weather patterns, including storm or El Niño events, would be included to inform the results.
- **Interactive web tool.** An interactive web tool could be developed to display sea level rise trends, including changes to tidal datums and annual exceedance probabilities and graphics showing how the rate of sea level rise is changing over time. This tool would supplement the data provided by NOAA Tides and Currents (https://tidesandcurrents.noaa.gov/).

Plan execution options: partner with academic institution, consultant contract.

Pilot studies (prioritized list):

1. Pilot sea level rise analysis and report
2. Pilot interactive web tool

Sandy Beach Shoreline Change

Background

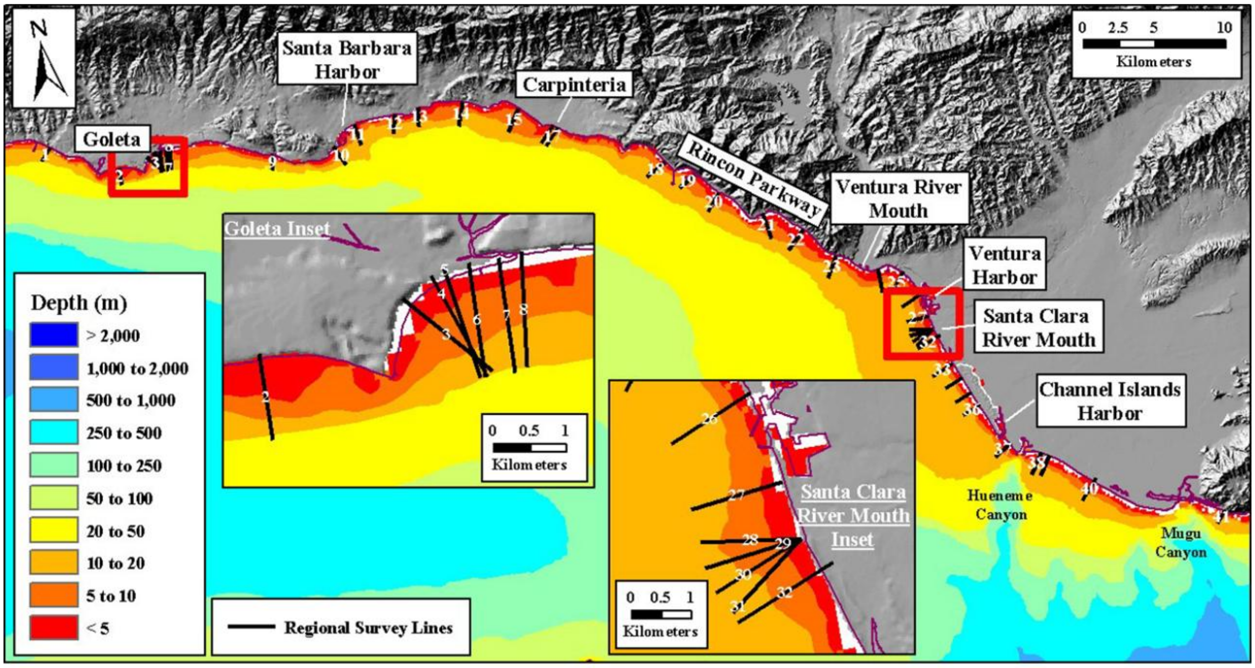
Several studies have analyzed past and historic patterns and rates of shoreline change, including:

- USGS National Assessment of Shoreline Change Part 3: Historical Shoreline Change and Coastal Land Loss Along Sandy Shorelines of the California Coast (Hapke and others 2006, https://pubs.usgs.gov/of/2006/1219/), using historic maps and recent LiDAR topography
- Studies by Revell, Griggs, and Orme (Revel and Griggs 2006 and 2007, Revell 2007, Orme and others 2011), using aerial photographs and LiDAR
- BEACON (2009) Coastal Regional Sediment Management Plan, using aerial photographs from 1929 to 2003 (PWA 2008)
- USGS Coastal Processes Study of Santa Barbara and Ventura Counties (Barnard and others 2009, http://pubs.usgs.gov/of/2009/1029/), using historic maps from the 1870s and 1933; aerial photographs from 1929 to 2003; and comparison of USGS and BEACON shore profile surveys from 1987, 2003, and 2007.
- USGS National Shoreline Change: Summary Statistics of Shoreline Change From the 1800s To the 2010s for the Coast of California (Kratzmann 2024), using historic shorelines digitized from maps and recent shorelines derived from lidar.

The Coastal Resilience program[1] funded by the State of California and The Nature Conservancy Coastal projected erosion and flooding for future sea levels for Ventura County (ESA PWA 2013, https://maps.coastalresilience.org/california/methods/SLR_Ventura.pdf) and Santa Barbara County (ESA 2015; ESA 2016; Revell Coastal and others 2016, https://maps.coastalresilience.org/california/methods/SLR_SantaBarbara.pdf). These studies organized available historical shorelines, erosion, and other data within a Geographic Information System (GIS) interface to establish a baseline from which to predict accelerated erosion (and increased flooding) resulting from sea level rise.

USGS surveys annual (fall) ground and nearshore bathymetry transects or shore profiles at the locations shown in **Figure 5**. USGS has also occasionally surveyed spring profiles in addition to fall. As noted above, USGS analyzed changes from profiles surveyed in 2003 and 2007 for the Coastal Processes Study of Santa Barbara and Ventura Counties (Barnard and others 2009). While more recent surveys have not yet been formally analyzed or published, the data could be shared by USGS through a potential partnership with BEACON. USGS is currently progressing the processing and analysis of data collected since 2005. Note that BEACON members also separately survey shore profiles at specific sites, such as the County of Santa Barbara Parks at Goleta Beach (spring and fall surveys and annual reports), the Navy at Naval Base Point Mugu, and others.

1 Coastal Resilience Mapping Portal, https://maps.coastalresilience.org/california/.



SOURCE: Correspondence with Patrick Barnard at the USGS, April 19, 2019.

Figure 5. USGS Biannual Shore Profile Survey Locations

Fall surveys, which reflect post-winter shoreline recovery, are commonly used for scientific assessments. This is partly because fall conditions tend to show less year-to-year variability than spring, which can be more influenced by the timing of winter storms and other factors. However, spring shoreline measurements are also important for adaptation planning, as they capture shoreline conditions immediately following winter, before natural recovery occurs. Spring surveys are particularly valuable for identifying storm-related erosion and damage, informing management triggers and thresholds, and guiding adaptation efforts. Conducting spring surveys in addition to fall surveys would improve seasonal coverage and data continuity, ultimately supporting more informed decision-making across the region.

The USGS has also collected several sets of oblique aerial photogrammetric imagery of the coastline from 2016 to 2023 (**Table 8**). This imagery can be used to delineate the shoreline and develop topographic data of beaches and bluffs using structure from motion (SfM) methods (similar to photogrammetric methods). USGS has published SfM instructions for developing topographic data from imagery (Processing Coastal Imagery with Agisoft Metashape Professional Edition, Version 1.6—Structure From Motion, Over and others 2021). USGS plans to use the imagery to provide topographic data and map products in the future. The high-resolution images can be viewed through the USGS Remote Sensing Coastal Change Simple Data Distribution Service website (usgs.gov) (Ritchie and others 2023), which includes directories, GIS, and Google Earth files of the image sets. As an example, **Figure 6** and **Figure 7** show a 2018 image set in Google Earth and one of the images at Shoreline Park in Santa Barbara.

The California Coastal Records Project produced another set of surveys of oblique aerial photogrammetric imagery of the California coastline. Datasets range from 1972 to 2013. The imagery can be accessed via https://www.californiacoastline.org.

TABLE 8. AVAILABILITY AND EXTENTS OF USGS OBLIQUE AERIAL IMAGERY FOR THE BEACON REGION

Year Taken	Date Taken	Extent of Flight and Available Photos
2016	28-Sep	Point Conception to Point Mugu
2017	1-Mar	Point Conception to Point Mugu
2017	27-Dec	Point Conception to Point Mugu
2018	29-Mar	Shoreline Park to Oxnard Shores
2018	13-Sep	Point Conception to Port Hueneme
2020	6-May	Point Conception to Ormond Beach
2020	18-Sep	Point Conception to Port Hueneme
2022	2-Mar	Point Conception to Ormond Beach
2022	28-Sep	Point Conception to Ormond Beach
2022	2-Oct	Santa Rosa Island
2023	8-Mar	Point Conception to Ormond Beach
2023	19-Apr	Montecito
2023	12-Oct	Point Conception to Point Hueneme
2024	5-Jan	Point Conception to Point Mugu
2024	12-Feb	Point Conception to Point Mugu
2024	23-Feb	Point Conception to Point Mugu
2024	18-Mar	Point Conception to Point Mugu
2024	30-Oct	Point Conception to Point Mugu

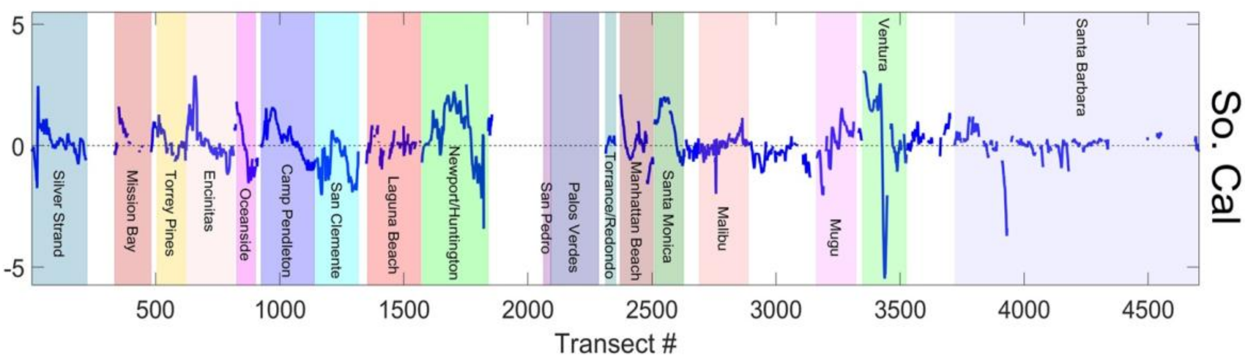
SOURCE: USGS, Google Earth, 2024

Figure 6. Example of USGS Oblique Aerial Imagery from 2018 in Google Earth Viewing Platform

SOURCE: USGS (usgs.gov), 2023

Figure 7. USGS Aerial Photograph – Isla Vista, March 8, 2023

Satellite imagery is now being used as a newer data source for shore change analysis. CoastSat (https://www.wrl.unsw.edu.au/research/coastsat) provides a web-based sandy beach shoreline change map and data developed using satellite imagery from 1984 to 2020 (**Figure 8**).



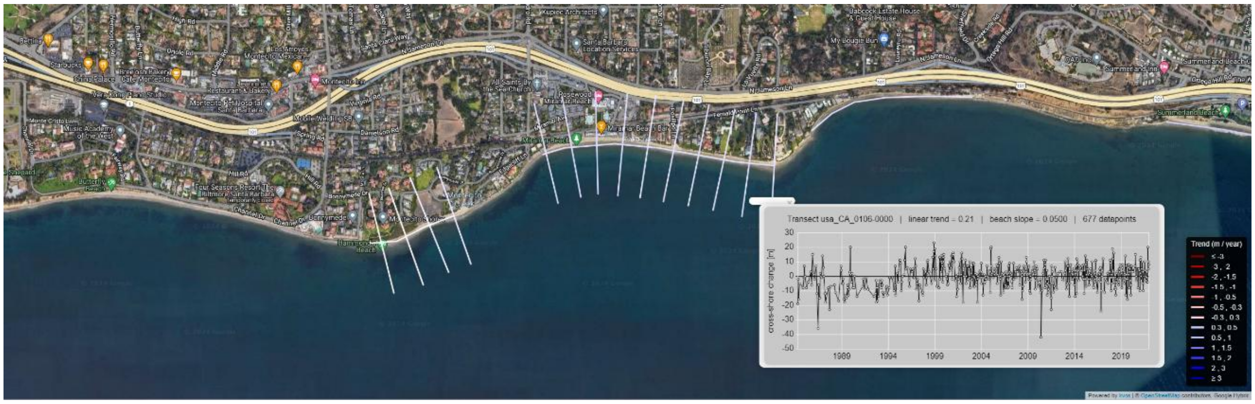
SOURCE: CoastSat, 2024

Figure 8. CoastSat Website Sandy Beach Shoreline Change Analysis Areas (polygons) in the BEACON and Shoreline Change Trends in the BEACON Region

The CoastSat web-site provides shoreline change data and rates based on the shoreline position (i.e., water line) from satellite imagery at transects defined for the analysis (**Figure 9**) (Vos and others 2019). Note that the CoastSat transects are not ground survey transects; rather, the CoastSat transects are locations defined for the analysis where shoreline position is determined from satellite imagery.[2] The

2 This approach is similar to the USGS Digital Shoreline Analysis System (DSAS) used by most practitioners: https://www.usgs.gov/centers/whcmsc/science/digital-shoreline-analysis-system-dsas.

accuracy of satellite-derived shoreline position data is limited by the spatial resolution (i.e., pixel size) of satellite imagery and uncertainty and noise due to wave runup at the time the imagery is taken; however, imagery is available about weekly and averaging over these frequent images addresses some of these limitations. Also, as discussed below, ground surveys can be used to confirm satellite-derived data.



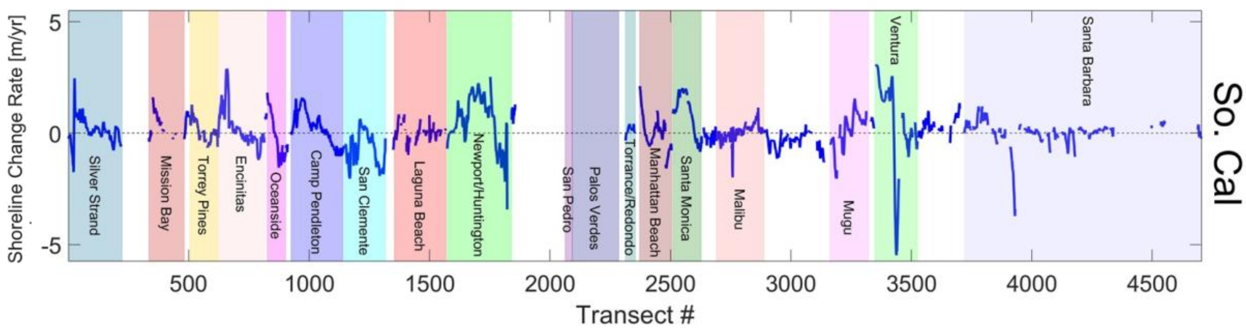
SOURCE: CoastSat, 2024

Figure 9. Example of CoastSat Website Sandy Beach Shoreline Change Transects, Data, and Trends at Hammonds and Miramar Beach, Montecito

USGS analyzed 22 years (2000–2021) of satellite-derived shoreline positions using the CoastSat methodology to characterize seasonal shoreline change across 7,777 beach transects along California's coast including the BEACON region (Warrick et al. 2025). The study applied time-series decomposition and spectral analysis to identify statistically significant seasonal cycles in shoreline position. The data set includes monthly median shoreline positions, seasonal excursion distances, and timing of minimum and maximum shoreline positions for each transect. The full data set, including shoreline seasonality metrics and environmental variables for each transect, is available through a USGS data release (Warrick and Buscombe 2024, https://doi.org/10.5066/P14WWHOJ), and can be used to support regional shoreline management, erosion forecasting, and coastal resilience planning.

USGS' Coastal Storm Modeling System (CoSMoS)[3] has modeled and projected future shoreline erosion with sea level rise for California based on historic erosion rates from CoastSat (Vitousek et al. 2023). For CoSMoS, USGS used CoastSat tools and satellite imagery to obtain shoreline position data, applied corrections to the satellite-derived data to match ground and bathymetric surveys at Ocean Beach (San Francisco), and calculated shoreline change from 1995 to 2020 (**Figure 10**). The downloadable GIS and Google Earth data for CoSMoS (https://doi.org/10.5066/P9CJMB2H) includes model transect locations with the satellite-derived historic erosion rates at each model transect, which may differ from the CoastSat website's erosion rates due to differences in the averaging time period and methods.

3 https://www.usgs.gov/centers/pcmsc/science/coastal-storm-modeling-system-cosmos.



SOURCE: Vitousek et al., 2023.

Figure 10. Satellite-Based Shoreline Change Rates (meters/year) from 1995 to 2020 Developed and Used for CoSMoS

Note that in order to calculate and monitor beach width, the backshore position is needed in addition to shoreline position. While the developed backshore is generally fixed, bluff-backed shores have backshores that move with bluff erosion, and dune-backed shores fluctuate, and can erode and accrete. CoSMoS has defined a developed backshore line, which could be confirmed or refined in the BEACON region. Bluff toe backshore position can be monitored using a combination of aerial topography and shore profile surveys as discussed below and in the following Bluff Erosion section. Dune geometry could also be monitored to assess dune erosion rates in addition to beach width and erosion rates.

In summary and as listed in the section below, a significant amount of sandy beach shoreline and topographic data has been collected. While CoSMoS has analyzed shoreline change for the California coast through 2020 using satellite imagery, an analysis specific to the BEACON region that incorporates the various types of available data has not been performed since 2007. *The Monitoring Plan therefore identifies an updated shoreline change analysis as a priority need. In addition, continued monitoring of current and future erosion and regular analysis and reporting on shoreline change are needed to track actual progress towards adaptation triggers such as minimum beach widths.*

Note that this **Sandy Beach Shoreline Change** monitoring section is focused on shoreline and beach width change monitoring and tracking. Additional monitoring and more in-depth analysis and interpretation of coastal processes driving shore change are discussed below for **Sediment Budget Tracking: Littoral Processes, Emergency Sediment Placement and Fate/Transport, and Watershed Inputs**.

Data and Monitoring

Shoreline position varies seasonally and in response to and recovery from storms. Different data and monitoring methods provide different temporal frequencies, spatial scales, and accuracy. The Monitoring Plan recommends using a combination of monitoring methods and data sources to improve data accuracy and temporal and spatial coverage and resolution.

Satellite imagery	*Available, regional*
Spatial scale: 10 to 15-meter resolution	*Frequency:* Weekly (approximately every 5 days)
Cost: Free from various publicly available sources. Other private services provide imagery for a fee; however, publicly available imagery may be sufficient for the purposes of the Monitoring Plan.	
Satellite imagery is a newer method being used to monitor wet/dry shoreline position and shoreline change (but not topography). Images are captured by satellites including NASA's Landsat 5, Landsat 7, Landsat 8, Landsat 9, Sentinel-2, Sentinel-3, and others. USGS and others have used satellite imagery and the publicly available CoastSat tools to perform shoreline change analyses in California (see Background section above). In addition, satellite-derived shoreline seasonality data from USGS (Warrick and others 2025) provides 22 years of monthly shoreline positions and seasonal erosion patterns across 7,777 California beach transects, offering a robust dataset to inform long-term coastal change trends and adaptation planning. Note that the precision and certainty of shoreline positions derived from satellite imagery is limited by the spatial resolution; however, averaging shoreline positions over the frequent images addresses some of these limitations. The CoastSat website provides ongoing shoreline change data from 1984 to the present using satellite imagery. CoastSat also offers open-source code that allows users to run analyses for specific geographic areas and time periods. *Other purposes:* Sediment Budget Tracking	

USGS shore profile surveys	*Ongoing, regional, annual*
Spatial scale: profiles approximately 100 to 200 meters apart	*Frequency:* annual (fall)
Cost: Currently funded by USGS. USGS costs are not available at this time. Estimated cost range: $100,000–$200,000	
USGS surveys annual (spring) ground and bathymetric profiles (see Background section above). Shore profile surveys or beach transects involve measuring elevations at intervals and breaks of slope along a cross-shore transect (perpendicular to the shoreline) across the beach and typically extending into the water (near shore). This method is used to monitor beach elevation and slope, and change in sand volume over time. Effort involves ground survey of elevation points on beach, and bathymetric survey typically collected using a boat or jet ski. Data collected in the BEACON region by USGS since 2007 is not yet published or available due to an internal review process required by USGS. USGS plans to make these data available in 2025. The data can be shared by USGS through a partnership with BEACON. When available, profile surveys will be useful for confirming satellite-based shoreline change data and providing backshore position. Profile surveys will also provide additional information such as the change in beach elevation and sand volume including in the nearshore subtidal zone. USGS has funded surveys to date. *Other purposes:* Bluff Erosion (for bluff toe), Sediment Budget Tracking, Wave Runup and Coastal Flooding	

Goleta Beach shore profile surveys	*Ongoing, site specific*
Spatial scale: Goleta Beach	*Frequency:* semi-annual (spring and fall)
Cost: Currently funded by County of Santa Barbara Parks. Costs not available at this time.	
Shore profile surveys are collected by the County of Santa Barbara Parks at Goleta Beach (spring and fall surveys and annual reports). In addition to monitoring shoreline change at Goleta Beach, these profile surveys would be useful for calibrating and validating satellite-based shoreline change data for the region. *Other purposes:* Bluff Erosion (for bluff toe), Sediment Budget Tracking, Wave Runup and Coastal Flooding	

Supplemental shore profile surveys (temporal and spatial)	*Potential new monitoring, regional or site specific*
Spatial scale: USGS shore profile survey locations, potentially new locations interspersed in between USGS profiles.	*Frequency:* annual (fall) at USGS survey locations, semi-annual (fall, spring) at new locations, potentially more frequently
Cost: $100,000 to $200,000 per year including annual report assuming spring surveys at all USGS profile locations to supplement USGS fall surveys.	
Shoreline profiles could be surveyed more frequently, for example by surveying spring profiles (as assumed for cost) or up to monthly profiles. USGS usually conducts shoreline surveys in fall when conditions are less variable; spring surveys are also important for capturing post-winter shoreline positions and beach width. Spring surveys in addition to fall surveys help identify erosion and damages related to winter storms and better informing adaptation planning. Additional shoreline profiles could also be surveyed to fill spatial gaps in the USGS shoreline profiles; however, the Monitoring Plan recommends first analyzing USGS profiles to identify the need and location of additional profiles, if any. *Considerations:* Consistent profile locations based on location points/landmarks and vertical and horizontal survey control are critical for consistent data quality. While citizen scientists and others have collected ground survey profiles, professional surveyors or scientists/engineers experienced in surveying are needed to perform quality-controlled surveys. *Other purposes:* Bluff Erosion (for bluff toe), Sediment Budget Tracking, Wave Runup and Coastal Flooding	

Available aerial LiDAR topography	*Intermittently available, regional*
Spatial scale: high-resolution (5–15 cm vertical accuracy, 100 cm or less horizontal accuracy, 1 m or less point spacing)	*Frequency:* intermittent, approximately every 5 years over the last decade (2011, 2016, 2018, 2021)
Cost: Funded by state and federal agencies and others (State Coastal Conservancy, USGS, NOAA)	
Light detection and ranging (LiDAR) is a method of remote sensing, typically from a small aircraft, in which a pulsed laser measures distances to the ground surface at specific points. The data collected is high-resolution information about the topography and characteristics of the surfaces. LiDAR data processing includes data cleaning, point cloud creation, and feature identification and classification. LiDAR datasets are provided by USGS throughout the BEACON region, and by others such as CSUCI for specific sites (Surfers' Point and Carpinteria). LiDAR datasets of the coastline are available for 2011, 2016, and 2018 from NOAA's Coastal Services Center's Digital Coast website (https://coast.noaa.gov/dataviewer/#/). National Coastal Mapping Program (NCMP) 2021 LiDAR for the coast is likely to become available on the USGS LiDAR Explorer Map (nationalmap.gov) in 2024. *Considerations:* Collecting and processing data requires a team of specialists. Ground control surveys, data processing, and QA/QC review are necessary to improve data accuracy. *Other purposes:* Bluff Erosion, Sediment Budget Tracking. Combined Coastal and Fluvial Flooding, Habitat Monitoring	

USGS aerial imagery-based topography	*Ongoing, regional*
Spatial scale: BEACON region	*Frequency:* Every one to two years (USGS)
Cost: Imagery collection currently funded by USGS once every one to two years. USGS has not processed imagery into topography. USGS costs not available at this time.	
Aerial imagery-based topography utilizes aerial photographs to capture the physical features of an area. The visual information from these photographs is used to create topographic maps and 3D models of the landscape. This method relies on the use of satellite, drone, or aircraft photography. USGS has flown aerial imagery of the coastline every year or two since 2016 (see Background section above). USGS' Structure from Motion (SfM) instructions or other photogrammetric methods could be used to develop shorelines and beach topography data from the USGS imagery data sets. USGS plans to do this in the future for BEACON region imagery. Others could perform this analysis as well using USGS instructions or other methods. CSU Channel Islands also collects drone imagery approximately once per year on beaches that can be processed into topography using SfM when needed. *Considerations:* High image quality is critical for data. Quality control includes validating derived data to ground control points or reference data. *Other purposes:* Bluff Erosion, Sediment Budget Tracking, Habitat Monitoring	

New regular LiDAR and/or aerial imagery-based topography	*Regional or site specific*
Spatial scale: BEACON region or specific sites, high-resolution (5–10 cm accuracy)	*Frequency:* regular interval (annual or twice per year) in years and seasons when LiDAR data and aerial imagery are not collected by State and federal agencies

Cost: $70,000 to $100,000 for one set of aerial imagery and 1-foot topographic map (lower end of range) or LiDAR data (higher end of range) for coastline from Point Mugu to Gaviota State Park (excluding coastline west to Point Conception, including ground control survey).

The Monitoring Plan could collect new LiDAR and/or aerial imagery-based topography data of beaches and coastal bluffs during years and seasons when LiDAR data and aerial imagery are not collected by State and federal agencies. New data could also be collected pre- and post-sediment management activities, including harbor dredging/bypassing and nourishment and emergency sediment placement at Goleta Beach and Carpinteria.

LiDAR data collection is typically higher-cost and can take longer to process than aerial imagery-based topography; however, LiDAR data can capture ground elevations in vegetated areas, whereas aerial imagery cannot. LiDAR may therefore be preferable for densely vegetated areas, including certain coastal bluffs, whereas aerial imagery may be preferable for unvegetated areas, including sandy shorelines.

Other purposes: Bluff Erosion; Sediment Budget Tracking; Storm Events, Damage, Emergency Response & Recovery.

Cameras	*Potential new monitoring, site specific*
Spatial scale: 100–500 feet distance and area within field of view depending on location/direction	*Frequency:* continuous

Cost: For installation and maintenance of one camera:

- Installation: $15,000 (on existing building or pole) to $40,000 (with new pole) (includes ground topography survey for calibrating runup elevation)
- Annual upkeep, maintenance, data management, and QA/QC: $30,000 to $50,000

Cameras could be installed at specific sites to provide visual monitoring of shore change. Imagery includes video or time lapse photos, which can be downloaded via telemetry or manually. Camera imagery could be analyzed to quantify shoreline change and nearshore wave conditions driving change. Video image analysis could be performed using available “off-the-shelf” or custom tools. As an example, the City of Carpinteria maintains a Beachcam (https://video-monitoring.com/beachcams/carpinteria/), which could be used shoreline change analysis.

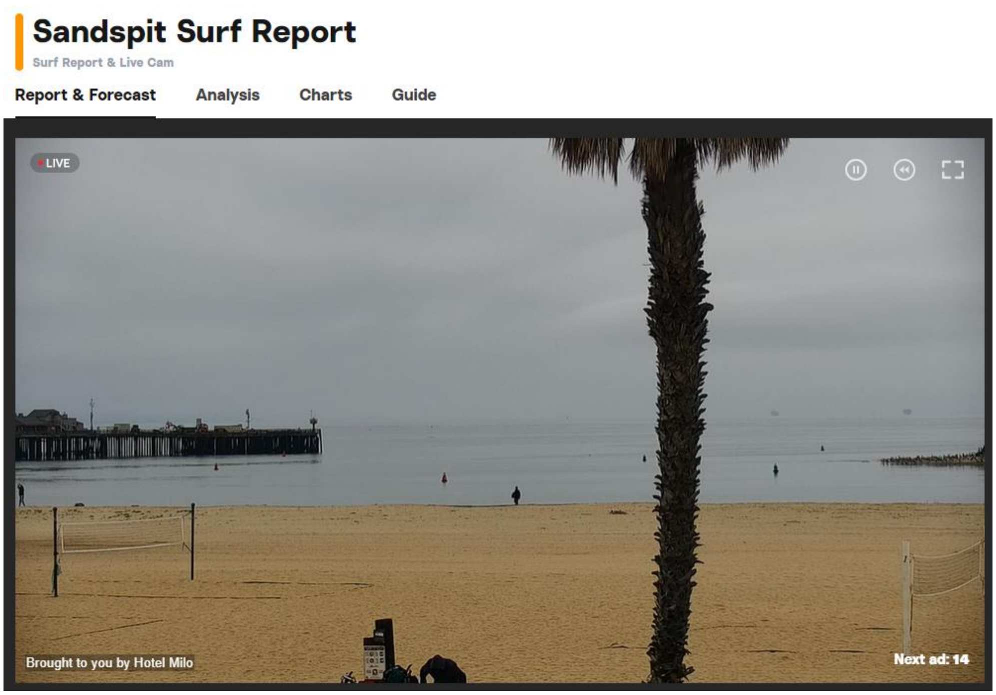
Surfline maintains a network of cameras (**Figure 11**); however, the viewable area of shoreline and surfzone varies camera to camera as these existing cameras focus on surf breaks. Four days of historic footage from Surfline cameras is available online to Surfline members in 10-minute video increments. An example of this footage is shown in **Figure 12**. Surfline video can be analyzed to provide nearshore wave height and period data (e.g., Egan, no date), indicating potential usefulness for analysis of shoreline change and storm conditions. SurfZone AI is a new service available from Surfline/Wavetrak that uses Surfline cameras to measure wave and Surfzone data, as well as surfer tracking and beach attendance (https://www.surfzone.ai/, SurferToday, 2024). Surfzone AI sources, installs and maintains monitoring cameras that connect to cloud servers and deliver processed data via Application Programming Interface (API) in near real-time.

Considerations: Cameras require maintenance. Installation on an elevated pole or building improve view and decrease vandalism.

Other purposes: Sediment Budget Tracking; Storm Events, Damage, Emergency Response & Recovery; Wave Runup and Coastal Flooding; Visitor counts and recreational activities.

SOURCE: ESRI, Surfline, 2024

Figure 11. Surfline Camera Locations in the BEACON Region



SOURCE: Surfline, 2023

Figure 12. Example Surfline Footage from Sandspit Beach (aka West Beach)

CoastSnap	*Potential new monitoring, site specific*
Spatial scale: Field of view of phone camera from one location per site, dependent on resolution and field of view of participants' phone cameras.	*Frequency:* Dependent on public uptake. For reference, there were 684 images uploaded to the CoastSnap website in 2023 at Scripps Pier in La Jolla, CA.
Cost: For installation and maintenance of one CoastSnap cradle: • Installation: $15,000 to $20,000 • Annual upkeep, maintenance, data management, and QA/QC: $5,000 to $10,000 • Data analysis to develop shoreline positions: $10,000 to $20,000 (excludes ground-based shore profile surveys for calibration/validation)	
CoastSnap is a crowdsourced citizen science network that utilizes repeat photos from the same location to track changes to beaches and coastlines. Members of the public use their phones to take pictures from CoastSnap camera cradles at monitoring sites and upload them via QR code or the CoastSnap app to survey123 or spotteron. Images are then bulk registered with photoshop or other techniques, and the CoastSnap MATLAB toolbox is used to rectify images, map shorelines, and create movies. Example data products include beach width, beach cusp, cobble, rip current, and river plume tracking. There is also an option to upload "free roaming" images, that are not at official CoastSnap stations. There are currently CoastSnap stations in the BEACON region located at UCSB East Campus Beach, Stearns Wharf, and Surfers' Point. Additionally, dozens of "free roaming" images have been taken at coastal locations throughout the region. CoastSnap cradles could be installed at specific locations to crowd source cell phone photo data that could be analyzed to provide shoreline and backshore positions and people counts. CoastSnap also provides the opportunity for community outreach and engagement in monitoring, for example at Goleta Beach and the beach at Ash Avenue in Carpinteria given community interest and concerns with County of Santa Barbara's emergency sediment placements. *Considerations:* Stations should ideally be installed in high traffic areas that are open year-round to avoid seasonal gaps, and elevated and facing along the coast to maximize field of view. Snapshots measure instantaneous shoreline position which does not account for water-level oscillations (Conery and others 2023). There is also the potential for vandalism. CoastSnap also provides a service to create and maintain a Microsoft Excel database for each station to populate with entries for each image uploaded from the site. CoastSnap also performs data processing using the MATLAB CoastSnap GUI. In addition to services offered by CoastSnap, the Monitoring Plan recommends using shore profile surveys to calibrate and validate accurate shoreline positions from CoastSnap photo data. Survey and calibration/validation tasks may not be offered by CoastSnap. Professional surveyors and/or scientists/engineers experienced in surveying and shoreline analysis are recommended to perform quality-controlled surveys and calibration/validation. *Other purposes:* Sediment Budget Tracking, changes in ecology, potentially estimate number of vehicles and beachgoers	

Beach habitat characteristics	*Potential new monitoring, regional and site specific*
Spatial scale: BEACON region or representative sites	*Frequency:* annual to twice per year
Cost: TBD	
Sandy beach shoreline habitat characteristics could be monitored in conjunction with shoreline change to map and assess habitat changes over time. Beach width, grain size and substrate including the nearshore zone, backshore type, and dune characteristics are important physical parameters that influence beach habitat and ecology, in addition to other factors including beach grooming activities and public uses. Shore profile data, camera data, aerial imagery and topography, and potentially satellite imagery gathered for physical monitoring could also be used as a basis for mapping beach habitat zones and change. Camera and aerial data would be useful for regional mapping but would require focused ecology ground-truthing surveys. Vegetation and other habitat parameters such as wrack could be surveyed at representative shore profiles. Repeat photos can also be taken from fixed point locations to document changes to the beach.	

Analysis

- **Annual analysis of shoreline change and beach width using a combination of satellite imagery, ground-based shore profile surveys, aerial topography, and camera data.** *Cost: $100,000–$200,000 for first year, $60,000 to $120,000 per year for subsequent years.* This analysis would provide an annual update and report on shoreline change patterns and rates. At a minimum, the analysis would use existing/available satellite imagery, LiDAR, USGS aerial imagery, shore profile surveys by USGS and at Goleta Beach (by County of Santa Barbara), and cameras (i.e., Carpinteria Beachcam and UC Santa Barbara CoastSnap photos). The accuracy of the results would be improved by incorporating any new aerial topography and shore profile surveys and camera data collected (e.g., new aerial topography data collected in years that LiDAR and USGS aerial imagery are not collected to check and improve the accuracy of satellite imagery). An annual analysis would serve to document shoreline changes and observations after each winter storm season and subsequent recovery and inform refinement of data collection in subsequent years. The first year's analysis would also analyze past available data using the same methodology and summarize and compare to prior studies.

- CoastSat provides tools to analyze shoreline change from satellite imagery, which CoastSat and CoSMoS used to provide shoreline change rates through 2020. Shoreline positions can be derived using publicly available CoastSat tools and averaged to yield seasonal and annual shoreline change rates. Ground and bathymetric survey profiles from USGS (if available) or RCAMP (if collected) could be used to correct and improve the accuracy of satellite-derived data following methods used by Vitousek et al. (2023). Available and new potential LiDAR and aerial imagery topography data could also be incorporated into the analysis. CoastSnap data could be similarly used in conjunction with ground/bathymetric surveys. CoastSnap data can be improved by incorporating wave runup or using smoothing interpolation to account for instantaneous imagery effects (Conery and others 2023).
- Beach width change would be analyzed using shoreline results and backshore position and typology (e.g., developed, armored, and/or constrained backshore and natural and unconstrained backshore). The backshore position and typology could be refined using available topography, imagery, shore profile data, and coastal armoring databases. Note that the movement of the natural backshore location at bluff toes would need to be updated over time. Ground and aerial topography data could also be used to monitor and track dune geometry and change rates.

- **Coastal processes assessment.** *Cost: $20,000 to $60,000 per year depending on level of detail.* As an add-on to the above analysis, coastal processes including storm and wave conditions and sediment management activities could be assessed and documented each year to interpret and understand observed shoreline and beach width changes. The assessment could also consider the effects and differences in shoreline and beach width change patterns due to backshore development (including coastal armoring).
- **Beach habitat mapping and change assessment.** *Cost: TBD.* As a complement to the physical analyses above, beach habitat could be mapped in conjunction with shoreline change analyses and habitat changes over time could be assessed, documented, and tracked annually. As discussed further in Potential Ecological Monitoring (Section 6.2.2), habitat types or categories would need to be defined and parameters or requirements for each habitat type would need to be established. Habitat parameters would include physical characteristics such as beach width. Other data and information such as beach grooming and public use would also be needed. Habitat types or zones could then be mapped using the established habitat parameters.

Products

- **Shoreline change and beach width GIS web map.** *Cost: $20,000 to $60,000 to build and launch depending on complexity of interface, $10,000 to $20,000 to update annually.* The shoreline change analysis and beach width results could be provided in an interactive GIS web map. The web map could provide long-term, annual, and seasonal shoreline change rates and beach widths for specific locations and averaged by beach. In addition to physical changes, map products could include beach habitat and zonation change data and shore typology data (e.g., developed, armor type and data, constrained, unconstrained, natural, bluff backed, dune backed). Coastal processes data could also potentially be incorporated (e.g., time series or annual summaries of storm events and/or wave conditions).

- **Annual shoreline change report.** *Cost: $20,000 to $40,000.* An annual report could be prepared to summarize shoreline change and document any coastal processes assessment. An example is the SANDAG Regional Shoreline Monitoring Program Annual Reports (https://www.sandag.org/projects-and-programs/environment/shoreline-management/monitoring-program).
- **Beach habitat GIS web map and annual change report.** *Cost: TBD.* Beach habitat mapping and change analysis results could be provided as shoreline change GIS web map layers and in annual reporting.

Plan execution options: partner with USGS or academic institution, consultant contract.

Pilot studies (prioritized list):

- Continue annual USGS shore profile surveys by USGS.
- Partner with USGS to make shore profile survey data since 2007 available to BEACON, BEACON members, and the public.
- Perform and report shoreline change and beach width analysis using a combination of available data. Upon release of USGS shore profiles, perform analysis for the entire BEACON region (for efficiency of scale). This could include collaboration with USGS, analysis from the present back to 2020 (end date of USGS CoSMoS website analysis), 2007 (end date of USGS's last analysis of profile data), or earlier.
- GIS web map of results.
- Coastal processes assessment, which could include assessment of 2022 – 2024 storm events (e.g., waves, wave runup and total water levels, creek flows and sediment load estimates) to inform understanding of the shore change analysis results.
- Beach habitat and zonation change baseline monitoring of natural communities (vegetation or habitat mapping), which could be for select areas of interest for efficiency (e.g., Goleta Beach, East Beach, Carpinteria, Surfers' Point, Pierpont Beach, Ormond Beach, and/or Naval Base Point Mugu).

Bluff Erosion

Background

From Point Conception to Rincon Point, much of the BEACON region's shoreline is backed by coastal bluffs or sea cliffs, which are subject to coastal and terrestrial erosion. The USGS National Assessment of Shoreline Change Part 4, Historical Coastal Cliff Retreat along the California Coast (Hapke and Reid 2007, https://pubs.usgs.gov/of/2007/1133/), provided an analysis of past and historic rates of bluff erosion based on historic maps and LiDAR topography data. CoSMoS and Coastal Resilience Santa Barbara County used these data, supplemented with additional available LiDAR data, to update historic erosion rates as the basis for modeling projected future erosion rates with sea level rise. Site specific data and studies on bluff erosion are also available (e.g., Alessio 2021). USGS also prepared New Techniques to Measure Cliff Change from Historical Oblique Aerials (Warrick 2017, https://pubs.usgs.gov/publication/70179824), a recommendation on how software could be used to assess cliff erosion. For this paper, USGS used oblique aerial photography from the California Coastal Records Project as introduced in the Sandy Beach Shoreline Change plan.

Mapping of bluff top edge and analysis of bluff erosion for the BEACON region has not been performed since completion of Coastal Resilience Santa Barbara County and CoSMoS. As discussed for **Sandy Beach Shoreline Change** above and listed in the section below, more recent LiDAR and USGS aerial imagery are available to provide topographic data for bluff mapping and bluff erosion analysis. *The Monitoring Plan therefore identifies updated bluff top mapping and erosion analysis as a priority need. Continued collection and regular analysis and reporting of bluff erosion data is needed to assess progress towards bluff erosion thresholds and triggers. In addition, updated bluff erosion rates have a role in updating the sediment budget and understanding the contribution of the bluff sediment in the littoral cell.*

Data and Monitoring

The following topographic data sources discussed for **Sandy Beach Shoreline Change** above can also be used for bluff top mapping and bluff erosion analysis (see prior discussions for more information):

- **Available aerial LiDAR topography:** Collected approximately every 5 years by State and federal agencies.
- **USGS aerial imagery-based topography:** Imagery collected every one to two years by USGS, photogrammetric analysis (i.e., Structure from Motion or SfM) is needed to develop topography data.
- **New regular LiDAR topography:** New data collection at regular interval (annual or twice per year) in years and seasons when LiDAR data and aerial imagery are not collected by State and federal agencies. LiDAR can capture ground elevations in vegetated bluff areas and is therefore preferred over aerial imagery.
- **Shore profile surveys for bluff toe position:** Ground-based topographic surveys of bluff toe are useful for confirming LiDAR and aerial imagery-based bluff toe mapping.

In addition to the above, detailed bluff geology data could be collected as described below.

Detailed bluff geology	*Potential new monitoring, site specific*
Spatial scale: bluffs from Rincon Point to Gaviota State Park (for adaptation purposes) or Point Conception (for informing sediment budget)	*Frequency:* one time study
Cost: $100,000 to $300,000 depending on level of detail.	
More detailed bluff geology data could be collected to support refined analysis, modeling, and projection of bluff erosion with sea level rise. This could include bluff base position and elevation at the marine platform and bluff intersection, measure maximum compressive strength of each lithologic unit along the coastline, a detailed geology map of lithologic units and formations.	

Analysis

- **Regularly updated bluff top edge and toe mapping and bluff erosion analysis.** *Cost: $80,000 to $200,000 for first year, $50,000 to $100,000 per year for subsequent years.* Bluff topography data would be used to map bluff top edge every year or few years. Topography data could also be used to track bluff face erosion, slope, toe position, and bluff erosion rate. This could be accomplished using available and new LiDAR and processing of available USGS aerial imagery, supplemented with bluff toe positions from USGS shore profile surveys for confirmation.
- **Geotechnical study.** *Cost: TBD.* A detailed geotechnical study of bluffs in the BEACON region could be performed to establish slope stability and threshold distances between the top and toe of bluffs and bluff-top assets (i.e., the distance which is required to provide enough bluff width to laterally support the asset combined with a safety factor). Detailed geology and geotechnical data would be required to support this analysis.

Products

- **Bluff top edge and erosion rate GIS web map.** *Cost: $20,000 to $60,000 to build and launch depending on complexity of interface, $10,000 to $20,000 to update annually, less if integrated with Sandy Beach Shoreline Change GIS web map.* The bluff edge mapping and erosion analysis results could be provided in an interactive GIS web map. The web map could provide bluff top edge location, long-term bluff erosion rates, and other data such as bluff toe location at specific locations and averaged over bluff areas. Any detailed bluff geology data collected could also be incorporated.
- **Regular bluff erosion change report.** *Cost: $20,000 to $40,000 per report.* A report could be prepared every one to two years to document and summarize bluff erosion and relevant processes. Any detailed bluff geology data collected could be used to interpret results.
- **Bluff erosion thresholds.** *Cost: TBD.* As discussed above, a geotechnical study could provide bluff erosion adaptation thresholds and trigger distances and slopes for different bluff areas within the BEACON region.

Plan execution options: partner with USGS or academic institutions, consultant contract.

Pilot studies (prioritized list):

For the entire BEACON region (for efficiency of scale):

- Current bluff top edge and toe mapping using most recent available LiDAR and USGS aerial imagery, web map, and report.
- Updated bluff erosion analysis, web map, and report.

Sediment Budget Tracking

Background

A littoral or coastal sediment budget provides a quantified understanding and accounting of sediment sources, sinks, transport, and storage within a littoral cell. Per the CSRMP, the Santa Barbara Littoral Cell starts at the headland north of the Santa Maria River and terminates at the Mugu Submarine Canyon with a net sand transport in the southerly direction; however, the amounts of sand transported around Point Conception and past the Mugu Submarine Canyon are variously estimated, with BEACON estimating that only third of the total volume is transported to the south Coast. (Patsch and Griggs, 2006; Patsch, 2024). More precise and up to date estimates and conditions are needed. Sediment budget tracking would include littoral processes, emergency sediment placement and fate/transport, and watershed inputs.

Several studies on coastal sediment processes have been completed for specific sites and portions of the BEACON region, such as studies at Goleta Beach and Naval Base Ventura County Point Mugu; however, sediment movement in the BEACON region is not currently monitored in an ongoing systematic manner. Regionally-consistent data from the **Sandy Beach Shoreline Change** and **Bluff Erosion** monitoring plans described above and additional data gathered on sediment budget components and sediment management actions could be used to track sediment movement and analyzed to develop an improved sediment budget for the BEACON region.

The BEACON (2009) Coastal Regional Sediment Management Plan (CRSMP) included a sediment budget based on available studies and research that describes and accounts for sediment delivery from creeks, rivers, and bluffs; sand bypassing at harbors; and wind-blown sand loss. The CRSMP sediment budget also maps stable, erosive, and accreting reaches of the BEACON coast. Per the CSRMP, "a reasonable understanding of the average shoreline processes is known, but more monitoring, research, and study is needed to better understand the variability of sand delivery and movement along the coast and how different reaches respond to each change."

Partnering with BEACON, the USGS Coastal Processes Study of Santa Barbara and Ventura Counties (Barnard and others, 2009) collected a range of data from 2005 to 2008 and analyzed historic shore change, morphological changes during the 2005 to 2008 study period, the impacts of debris basins on sediment delivery to the littoral cell, and littoral sediment transport rates using numerical modeling sediment budget analysis. Data collection included shore profiles (see Figure 1 and discussion in **Sandy Beach Shoreline Change** above), LiDAR topography, grain size, bathymetry, and physical characterization of offshore shallow sediment deposits.

Regarding sediment management actions, Patsch and Griggs (2021) gathered and analyzed harbor dredging volumes in the BEACON region. While harbor dredging and nourishment volumes are available, subsequent movement of sediment placed for nourishment is not systematically monitored. The County of Santa Barbara Flood Control District performs emergency operations to remove sediment from debris basins, creeks, and flood control channels and places suitable sediment at Goleta Beach and the beach at Ash Avenue in Carpinteria to nourish and widen the beaches.

As part of a Proposition 68 Coastal Resilience Grant-funded project, BEACON, CSU Channel Islands, UCSB, and Santa Barbara County Flood Control (SBCFC), in partnership with USGS, and supported by

OPC, developed the report titled *Framework for Integrating Regional Sediment Management and Coastal Adaptation in the Santa Barbara Littoral Cell* (Beyeler and others 2025). This comprehensive study focuses on tracking sediment placements, assessing their ecological and geomorphological effects, and evaluating the feasibility of using sediment with a higher proportion of finer grain sizes than previously permitted.

This study also includes modeling sediment transport dynamics, monitoring sediment plume behavior, and testing placement strategies that minimize ecological disruption. A key focus of the study is the development of a regional monitoring protocol and centralized data repository to track sediment placement, movement, and ecological impacts. The study emphasizes the importance of long-term monitoring and explores the use of finer-grained and mixed sediments, including cobbles, to increase beach resilience. In addition to this study, continued and expanded monitoring is needed to better understand the fate, transport, and long-term effects of placed sediment, including cobbles, which are known to have an important role in stabilizing the shoreline and enhancing beach resilience.

Improved and continued monitoring and understanding of the BEACON littoral cell and watershed (or "sandshed") sediment budget would benefit adaptation planning and decision making. Data and analyses for **Sandy Beach Shoreline Change** and **Bluff Erosion** could be augmented with the data and analyses discussed below to better understand and predict patterns of erosion, accretion, and storm recovery and the coastal processes driving change. For example, nearshore sand deposits (e.g., from creeks and rivers in major storms, beach nourishment) tend to spread and move downcoast in accretion "waves," as do areas of erosion. A sediment budget tool or conceptual model (e.g., Warrick and others 2022a) could be developed to relate shore change patterns and longshore progression of changes to wave conditions and sediment budget "terms" including longshore sediment transport rates, sandshed inputs, and sediment management actions. Continued monitoring and tracking of shore change and the sediment budget could aid in predicting recovery from erosion events, thereby informing management and adaptation actions. An improved understanding of the sediment budget would also inform the effects and effectiveness of beach nourishment adaptation measures in the BEACON region.

Data and Monitoring

Sediment Budget Tracking data and monitoring would build on the data, monitoring, and analyses for **Sandy Beach Shoreline Change** and **Bluff Erosion** discussed in the sections above, including satellite imagery, beach and bluff topography data, and camera data (see sections and discussion above for more information). In addition, sediment budget data could be collected as described below.

Harbor sand dredging, bypass, and nourishment	*Available/ongoing, site specific*
Spatial scale: Santa Barbara, Ventura, and Channel Islands Harbors	*Frequency:* dredge events
Cost: Currently funded as part of dredging operations.	
Harbor dredging and placement/nourishment volumes are available and have been analyzed previously. Grain size data collection should also be collected. Placed material quantities and data should be submitted and documented in the following repositories for beach nourishment and placement: • National Beach Nourishment Database: https://gim2.aptim.com/ASBPANationwideRenourishment/ • Beach Nourishment Viewer: https://beachnourishment.wcu.edu/	

Sediment basins clean out and beach placement	*Available/ongoing, regional*
Spatial scale: sediment basins and beach placement sites	*Frequency:* clean out and placement events
Cost: Currently funded by the County of Ventura and County of Santa Barbara.	
Ventura County Watershed Protection District's (2005 and 2019 Draft) Debris and Detention Basin Manual documents debris basin removal volumes, which are possibly useful for understanding reductions in sandshed inputs to the sediment budget and other purposes. The County of Santa Barbara Flood District also likely has volumes and grain size of sediment removed from debris basin and emergency placement at Goleta Beach and Carpinteria. Placed material quantities should be submitted and documented in the two repositories listed above. Grain size data collection should also be collected.	

River/creek sediment loads	*Available, regional*
Spatial scale: individual rivers and creeks	*Frequency:* infrequent storm events
Cost: TBD for monitoring to improve sediment load estimates, if the need for any is identified through review of previous studies and available data sources. Developing new creek sediment load rating curves typically involves one or more years of sediment load monitoring during storm events.	
The CSRMP summarized previous studies on creek and river sediment loads (i.e., watershed or sandshed loads) to the BEACON coast. USGS and others have performed more recent studies (Barnard and Warrick, 2010; Warrick and Barnard, 2012; Warrick, 2020; Warrick and others, 2015, 2022b, and 2023). Continued monitoring and assessment of creek sediment loads could be performed to quantify annual loads to improve sediment budget tracking and understanding. Improvements in sediment load monitoring could be made. For example, additional creek suspended and bed load monitoring at stream gages could be performed. Additional review and assessment of previous studies and available data sources is needed to identify potential improvements.	

Bathymetric surveys of littoral cell boundaries	*New potential monitoring, site specific*
Spatial scale: Mugu Submarine Canyon and Point Mugu	*Frequency:* annual or every few years
Cost: TBD	
To address uncertainties in the amounts of sand transported around Point Conception and past the Mugu Submarine Canyon, repeated bathymetric surveys could be performed at these locations. Multi-beam bathymetric surveys would characterize bathymetry as well as sand and hard substrates. Comparison of successive surveys could be used to assess patterns and volumes of sand transport (USGS 2017, 2018, 2020). Existing seafloor bathymetry and geology data could be incorporated (e.g., Johnson and Cochran, 2018; Cochrane and others, 2017). Note that it may be possible to develop sediment budgets for littoral sub-cells before performing bathymetric surveys of the littoral cell boundaries.	

SandSnap beach grain size	*Potential new monitoring, site specific*
Spatial scale: point locations uploaded by public users.	*Frequency:* Dependent on public uptake.
Cost: Currently funded by U.S. Army Corps of Engineers	
SandSnap is a crowdsourced citizen science network that utilizes photos of the sand at beaches to collect and analyze grain size. Members of the public use their phones to take photos of the sand with a US coin. SandSnap measures the sand's grain size using a deep learning neural network (Buscombe 2020; McFall and others 2023). The photos are uploaded onto the SandSnap app and added to a database https://sandsnap-erdcchl.hub.arcgis.com/.	

Turbidity monitoring	*Potential new monitoring, site specific*
Spatial scale: regional satellite imagery data calibrated with	*Frequency:* during significant storm events and following sediment management actions, and regular monitoring of non-storm background levels.
Cost: TBD	

Turbidity, or the clarity of near-shore ocean water, is an indicator of sediment loading and transport and water quality. Turbidity can affect coastal recreation and near-shore habitat and ecology. Ocean turbidity can be high following storms with significant rainfall and streamflow and sediment load discharge events. Ocean turbidity can also be elevated due to coastal sediment management actions such as sediment placement on beaches or in the nearshore zone. Turbidity and/or suspended sediment monitoring could be performed to quantify and compare conditions both during significant storm events and following sediment management actions, such as emergency placements at Goleta Beach and Carpinteria. These data would be useful for assessing effects of sediment management, its environmental impacts, the potential for beneficial reuse of finer sediment for nourishment, and could also possibly be used for refining the sediment budget.

Turbidity could potentially be monitored using satellite imagery in conjunction with turbidity sensors to measure water turbidity and calibrate turbidity measurements derived from satellite imagery. Turbidity sensors can be trawled by boat or installed on piers or similar. Satellite imagery can be used to monitor ocean turbidity by measuring the penetration of blue-green visual light through the water (Diffuse Attenuation Coefficient at 490 nm or Kd490) (Shi and Wang 2010). Kd490 data are publicly available through the Level 3 Browser of NASA's OceanColor page, using measurements taken by sensors aboard Landsat-8, Landsat-9, Sentinel-2, and Sentinel-3 satellites. Data from Sentinel-2 has been confirmed to estimate turbidity with good performance in the San Francisco Estuary and Sacramento-San Joaquin Delta when compared to measurements from 69 fixed water quality stations in the area (Lee and others 2021). A combination of in-situ turbidity sensors, water sampling, and remote sensing (e.g., UAV/drone imagery) can be used to capture both immediate and broader-scale turbidity changes, supplemented with visual observations and photographic documentation during and after sediment management actions.

Considerations: Turbidity sensors require regular maintenance.

Nearshore macroinvertebrate monitoring	*Potential new monitoring, site specific*
Spatial scale: Sediment management action locations	*Frequency:* Before and after sediment management actions
Cost: TBD	

Sediment management and placement in nearshore environments can affect macroinvertebrate populations. The Southern California Coastal Water Research Project (SCCWRP, 2022) has previously monitored benthic macrofauna in the Southern California Bight for the Southern California Bight Regional Monitoring Program from Pt. Conception to the Mexican Border.

Using methods similar to SCCWRP, nearshore macroinvertebrate monitoring could be performed before and after sediment placement to assess biological effects of sediment management actions, possibly relative to effects of significant storm events. Post management action monitoring could occur over a period of time to assess macroinvertebrate recovery.

Analysis

- **Sediment fate and transport analysis.** Data described above could be used to analyze and improve the understanding of sediment placement actions and subsequent sediment fate and transport, building off the recent study by BEACON and CSU Channel Islands (Beyeler and others 2025). Note this study includes a study, *Development and Completion of Sediment Transport and Fate Analysis of Fine Sediments at Select Locations within the Santa Barbara Littoral Cell* prepared by the USGS, which modelled and identified specific conditions that affect sediment dispersal (Beyeler and others 2025, Appendix IV).
- **Sediment budget refinement.** Data described above and results of **Sandy Beach Shoreline Change** and **Bluff Erosion** analyses (discussed in those monitoring plans above) could be integrated into a refined sediment budget analysis for the BEACON region, which would include improved tracking of sediment management actions and understanding of their effects. This analysis could also survey the boundaries of the littoral cell.
- **Effects of placement.** Physical shoreline change monitoring of pre- and post- sediment placements and turbidity and biological monitoring could be used to analyze the effects of placements.

- **Effectiveness of placement as nourishment.** A refined sediment budget and data on the physical effects of placements could be used to assess and improve the effectiveness of placements for beach nourishment.

Costs for the above analyses and the products below depend on the scope, which can be developed further following data collection. Each analysis above is likely on the order of a few to several hundred thousand dollars.

Products

- **Sediment placement information repository and GIS web map.** Harbor dredging and sediment placement information could be provided in an interactive GIS web map. The GIS web map could have a form for entering data where placements could automatically show up on a map and be easily queried by the user. Creating the GIS web map could include an updated process for documenting sediment placement locations, quantities, timing, methods, etc. Use of and integration with the existing beach nourishment repositories discussed in **Harbor sand dredging, bypass, and nourishment** above would be assessed.
- **Sediment budget tool.** A refined sediment budget could be developed as a tool to assess potential future sediment management and adaptation measures.
- **Findings and recommendations on effects and effectiveness of sediment placement.** Recommendations could support refinement of sediment management plans, influence regulations and policies, and inform adaptation decision making.

Execution options: partner with county staff, USGS, and academic institutions; consultant contract.

Pilot study options (prioritized list):

1. Pilot studies listed for **Sandy Beach Shoreline Change**, which are critical data for sediment budget tracking and precursors to sediment budget analyses.
2. Sediment budget assessment and update building off prior studies, available data, and new data from pilot studies to progress a refined sediment budget. This assessment would likely be the first step in refining a sediment budget over time based on future data collected through the RCAMP.
3. Studies of sediment placements, which could include surveys (e.g., shore profiles and/or aerial imagery-based topography) of pre- and post-sediment placement at Goleta Beach and Ash Avenue in Carpinteria, cameras, real-time plume monitoring (e.g., wave, wind, and tidal conditions to adjust placement activities as needed), turbidity monitoring, additional surveys after major storm events, and indicator species surveys (e.g., sand crabs, clams, shorebirds) before and after placement.

Storm Events, Damage, Emergency Response & Recovery

Background

Data and information on storm events, damage, emergency response and recovery are being collected by various municipal departments. While some departments may have some systems in place to gather and store these data and information, much of it is either anecdotal or collected on an ad hoc basis and only available internally. This information could be collected in a more systematic way and gathered into a database that would allow for retrieval and analysis to assess when the frequency and extent of storm damage exceed thresholds for adaptation.

Data and Monitoring

In addition to the data and monitoring specific to Storm Events, Damage, and Emergency Response & Recovery below, see discussion of cameras in **Sandy Beach Shoreline Change**. Cameras could be installed at specific sites prone to flooding and erosion to provide visual monitoring of storm events and shoreline change. Camera imagery could be analyzed to quantify wave heights, wave runup elevations and extents, and erosion extents. Other data and monitoring include the following.

Storm damage documentation	*Partially available, ongoing, municipality-specific*
Spatial scale: flood prone coastal and inland areas within each city and county jurisdiction	*Frequency:* during/after significant storm flooding and damage
Cost: TBD based on further coordination with municipal departments	
Municipal departments such as Ventura County Emergency Services and Fire Department are currently collecting internal information on storm damage. For example, these departments presented information on the December 20 and 22, 2023 flooding in Oxnard in a January 2024 workshop. The Ventura County Fire Department, the City of Oxnard, and the Ventura County Emergency Services presented storm incident maps with data points showing significant flooding impacts and rescues. Additional outreach and coordination to counties and cities are needed to confirm and detail what and how information is being collected. Most municipal governments have Customer Relationship Management (CRM) systems, like the City of Santa Barbara's SB Connect (https://santabarbaraca.citysourced.com/), through which service requests can be made by the public and tracked by municipal departments. CRM systems are already used to share, integrate, and analyze data and could be used or modified to collect flooding and storm damage data from the public in conjunction with a promotional campaign. Municipalities also use GIS-based asset management systems, which could be used to track and map flooding (e.g., when public works closes streets) and storm clean up and damage incidents and costs.	

"FloodSnap" app to crowd source flooding pictures and videos	*Potential new monitoring, regional*
Spatial scale: Field of view of phone camera from one location per site, dependent on resolution and field of view of participants' phone cameras	*Frequency:* Dependent on public uptake
Cost: TBD	
A new app platform (coined by the Monitoring Plan as FloodSnap) could be developed for the general public to use to take and upload cell phone photos and videos of flooding throughout the BEACON region (rather than using separate municipal CRM systems as described above). The app would need to be promoted and advertised, for example by local news outlets when reporting storm forecasts. Municipal departments could potentially also use this type of app. Alternatively, an existing social media platform could possibly be used.	

FEMA flood insurance claims	*Available, regional*
Spatial scale: properties in FEMA flood zones (i.e., mapped in Flood Insurance Rate Maps)	*Frequency:* Flood damage events
Cost: Already being collected by municipal floodplain management departments	
Municipal floodplain management departments that administer the FEMA National Flood Insurance Program (NFIP) prepare and process FEMA NFIP claims, which contain standardized and detailed information on storm damage to structures. The Monitoring Plan could gather FEMA claims from the region into a regional storm damage database. This information is only available for properties that are within the FEMA floodplain and required to carry FEMA flood insurance, not for areas or properties that may be outside of a FEMA flood zone but still subject to flooding (e.g., due to storm drainage).	

Pre- and post-storm surveys of erosion	*Potential new monitoring, site specific*
Spatial scale: specific locations of interest	*Frequency:* before and after major storms
Cost: $40,000 to $60,000 for approximately 1 mile of shoreline including ground-based shore profile surveys and drone aerial imagery topography collected once before a storm and once after a storm (excludes analysis and reporting of data)	
At specific erosion and storm damage "hot spots," surveys could be performed by a ground survey before and after major storm events to document and quantify erosion. Subsequent post-storm surveys could also be performed to document any shore accretion and recovery. Survey methods could include shore profiles and ground- and/or drone-based LiDAR or imagery. Shore profile locations could be aligned with USGS shore profile surveys, where possible, thereby providing supplemental profile data. Surveys could be used to confirm erosion extents derived from cameras and supplement shore change data and analyses described above.	

Analysis

- **Storm conditions and damage quantification.** Data from cameras and flooding pictures and videos could be analyzed using available or customized automated tools to quantity storm conditions (e.g., flood extents, water levels, wave heights, wave runup extents). Comparison of pre- and post-storm surveys would quantify erosion. Storm damage documentation data would need to be processed into flood extent and water level data.
- **Standardizing and collecting information for the region.** The RCAMP could gather, standardize, and enter storm flooding, erosion, damage, and response data and information discussed above from agencies and the public into a regional database, ideally via a storm damage reporting and data management platform, for example using existing CRM systems.
- **Storm flooding and damage frequency analysis.** As the database is added to over time, field results could be analyzed and mapped to assess storm flooding and damage frequency by area. This will also aid in verifying and calibrating numerical models of flooding.

Products

- **Storm flooding, damage, and response information and frequency GIS web map.** The web map could contain flood extents, reported damage, response activities, and emergency projects organized by storm event. The storm flood, damage, and response information history and frequency analysis results could be provided in an interactive GIS web map. The web map could provide viewing of the database and analysis results by storm event for the region and as a history for specific areas. Example databases include national platforms like the National Centers for Environmental Information Storm Events Database (https://www.ncdc.noaa.gov/stormevents/) and the Flood Event Viewer (https://www.usgs.gov/tools/usgs-flood-event-viewer), which provide real-time data and support research on various coastal processes and hazards.
- **Regular storm flooding, damage, and response report.** A report could be prepared to document and summarize storm flooding after years with significant storm events and damage. The report could summarize rainfall, wave, and flooding intensities and frequencies (e.g., rainfall for a particular storm was a 10-year event, wave runup was a 20-year event, etc.).
- **Storm erosion thresholds.** Analysis of storm conditions and damage quantification could be used to further define storm flooding and erosion adaptation thresholds such as minimum beach widths needed to reduce flood impacts.

Execution options: partnering with municipalities would be necessary to gather storm damage documentation, with support from an academic institution and/or consultant contract.

Pilot study options (prioritized list):

With one or more volunteer BEACON member city/county:

- Outreach and coordination with municipal departments to gather information on current data collection and CRM systems that may function to track flooding, and preferred methods and system for storm event, damage, and emergency response data collection. This effort could also include:
- Trial gathering of available municipal CRM, FEMA claim, and other data into data collection system.
- Development of detailed storm event, damage, and emergency response monitoring plan with standardized protocols for municipal data collection, camera installation and analysis, pre- and post-storm surveys, etc.
- Pre- and post-storm surveys of erosion and/or camera installation at one or more erosion and/or flood "hot spot" (e.g., Goleta Beach, East Beach or flood-prone area in Santa Barbara, and/or Pierpont Beach).
- Use an existing social media platform (e.g., Instagram) to establish and promote a repository for crowd sourced geo-located photos of flooding. This could potentially be accomplished by creating a dedicated RCAMP page for users to upload photos or GeoTags of each monitoring location that would automatically collect all user-posted photos tagged to that location.

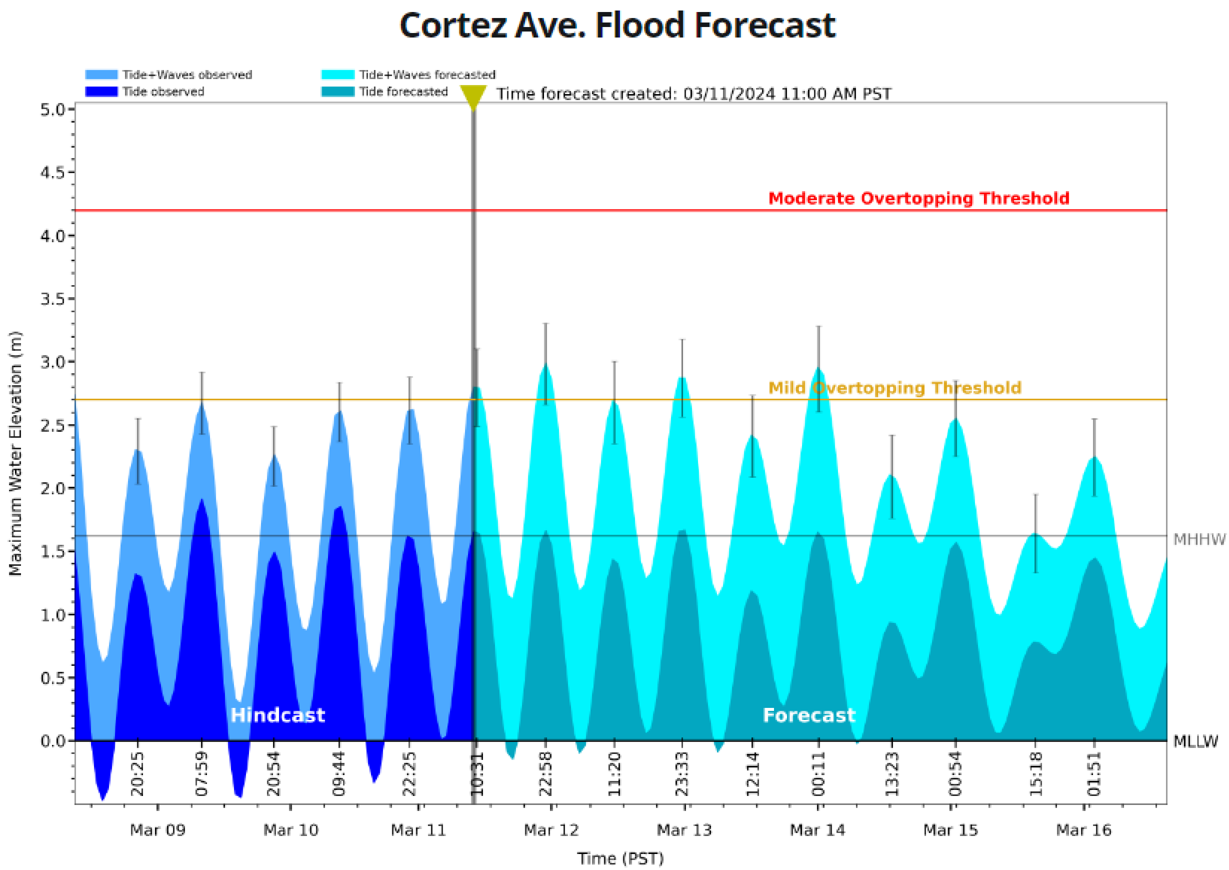
Wave Runup and Coastal Flooding

Background

Coastal storms, wave runup, and coastal flooding have been analyzed for FEMA Flood Insurance Studies and Flood Insurance Rate Maps, CoSMoS, and Coastal Resilience Santa Barbara County and Ventura County. These analyses are based on wave data records, storm scenarios, and wave and wave runup modeling. Monitoring of actual wave runup and coastal flooding is not available, but would be useful for confirming and refining wave runup and coastal flood modeling, including projections with future sea level rise.

Wave runup and coastal flood monitoring could also be used to develop coastal flood forecast systems for flood prone areas. As an example, the Southern California Coastal Ocean Observing System (SCCOOS) has developed and provides flood forecasting systems for Imperial Beach and Cardiff State Beach in San Diego County (**Figure 13**, https://sccoos.org/beach-erosion-inundation/). SCCOOS systems are based on repeated shore profile surveys, wave runup monitoring using water level sensors installed in beaches, wave forecasting based on offshore wave buoy data and nearshore wave transformation models, and a wave runup forecasting model validated with wave runup monitoring. SCCOOS is developing forecasting systems for sites in Orange County and Los Angeles County, but previously delayed developing systems for Santa Barbara County due to the need for field validation data. SCCOOS is currently planning to deploy a roving offshore wave buoy in the Santa Barbara Channel to improve wave transformation models and forecasts as a step towards developing forecast systems for the region. Certain coastal flood-prone areas in the BEACON region could benefit from a coastal flood forecasting system (e.g., Oxnard Shores, Pierpont in Ventura, and the Santa Barbara Harbor commercial area and Leadbetter Beach).

In addition to wave runup and coastal flooding, coastal storm erosion and damage will also be important to monitor and potentially forecast for the BEACON region (see Storm Events, Damage, Emergency Response, and Recovery Monitoring Plan).



SOURCE: SCCOOS (sccoos.org), 2024

Figure 13. SCCOOS Flood Forecasting at Cortez Ave. in Imperial Beach, CA

Data and Monitoring

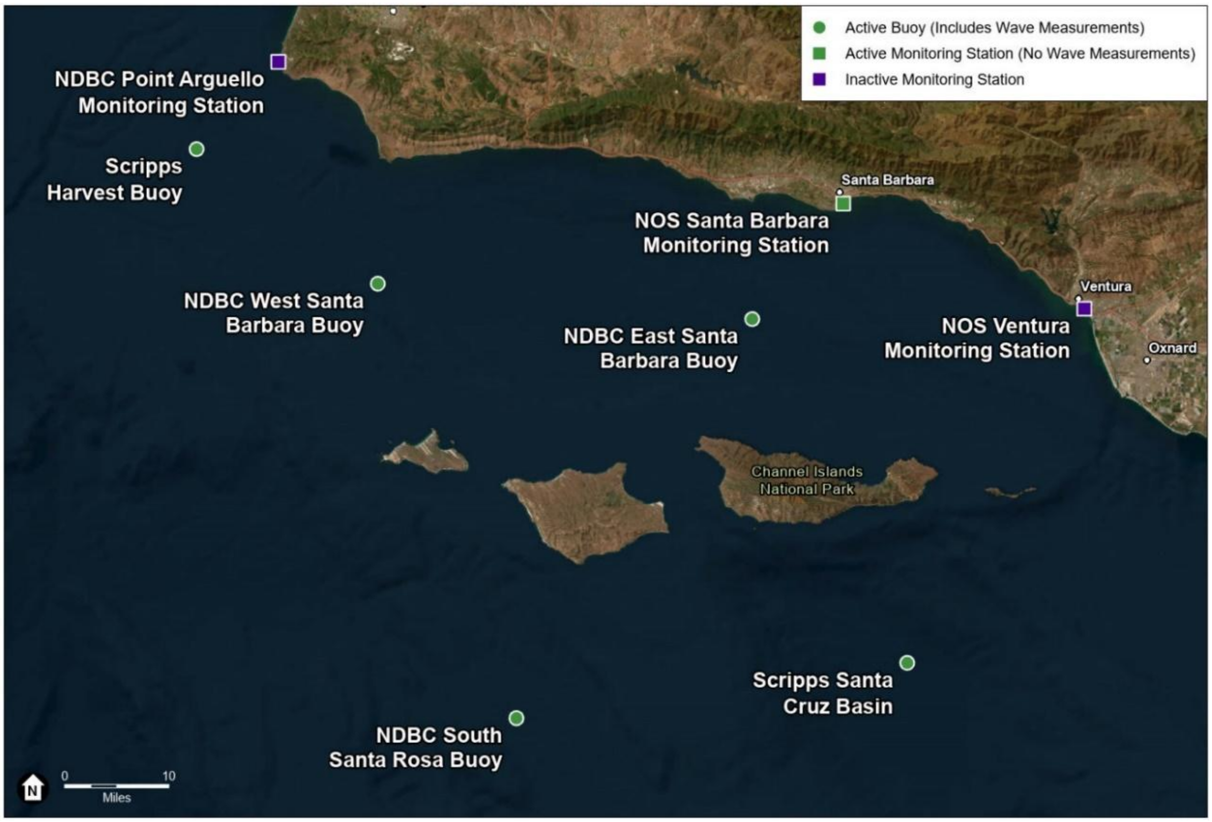
In addition to wave runup monitoring described below, water level and shore profile surveys would be required to understand shore conditions concurrent with wave runup monitoring in order to model wave runup and compare to monitoring. Supplemental shoreline profiles are likely necessary to support wave runup analysis (e.g., monthly surveys during the winter); however, USGS shore profile surveys collected at the location and time of wave runup monitoring could also be used. Cameras could be installed at specific sites and imagery could be analyzed to quantify wave heights and wave runup elevations and extents. See **Sea Level Rise** and USGS, Goleta Beach, and supplemental shore profile surveys and cameras descriptions in **Sandy Beach Shoreline Change**.

CDIP and NOAA wave buoys	*Available, regional*
Spatial scale: greater than 10 miles offshore, 20–60 miles between buoys	*Frequency:* hourly, continuous
Cost: Currently funded by CDIP and NOAA	

Wave buoys measure wave height, period, and direction. Buoys are deployed offshore with mooring to the ocean floor. Data is transmitted via telemetry and processed by an oceanographic data collection specialist. Wave buoys within the region are shown in the **Figure 14**. NOAA's National Data Buoy Center (NDBC) maintains two buoys in the Santa Barbara Channel. Scripps Institute of Oceanography maintains three offshore buoys: one off Point Arguello and two off the Channel Islands. Note that this existing network of wave buoys does not include a buoy in the eastern Santa Barbara Channel off of Oxnard/Ventura. Wave buoy data is critical for supporting nearshore wave transformation modeling and wave runup and coastal flood modeling, analysis, and forecasting.

Considerations: Buoys require regular servicing.

Other purposes:



SOURCE: ESRI, NOAA, CDIP, NBDC, ESA, 2024

Figure 14. Wave Buoys and Tide Gage/Water Level and Meteorological Monitoring Stations in the BEACON Region

New wave buoys (CDIP roving wave buoy planned in Santa Barbara Channel)	*Planned, regional*
Spatial scale: One or more location in the Santa Barbara Channel, likely on the east end	*Frequency:* hourly or continuous
Cost: Funded planned by SCCOOS and CDIP, TBD	

SCCOOS is planning to deploy an additional roving CDIP wave buoy in the Santa Barbara Channel. SCCOOS and CDIP will use the buoy to improve the existing CDIP Monitoring and Prediction (MOP) System for swell and nearshore wave transformation modeling and predictions. Deploying a wave buoy in the eastern Santa Barbara Channel could improve monitoring and prediction of nearshore waves in this area.

RCAMP could also consider deploying a new wave buoy separate from SCCOOS if SCCOOS plans change or for other reasons. Note that a significant level of permitting is required for permanent wave buoy installation.

Wave Monitoring and Prediction (MOP) System	*Available, regional.*
Spatial scale: Regional	*Frequency:* Hourly
Cost: Currently funded by CDIP	
The offshore wave buoys CDIP maintains in the BEACON region are used to initialize a high spatial resolution wave propagation model that provides hourly hindcasts and nowcasts of CA coastal wave conditions at Monitoring and Prediction (MOP) nearshore wave prediction points (CDIP MOP Introduction [ucsd.edu]).	

Wave runup	*New potential monitoring, site specific.*
Spatial scale: 100–500 ft distance and area within field of view depending on location/direction	*Frequency:* video for five minutes every half hour
Cost: For one timelapse video camera: • Installation: $15,000 to $40,000 (includes ground topography survey for calibrating runup elevation) • Annual maintenance, data management, and analysis/processing video into runup elevation data: $60,000 to $80,000	
Wave runup monitoring could be performed using one or more of the following methods and installations: radar-based water level gages installed on piers or other elevated areas, cameras, and/or arrays of pressure sensors installed in beaches. Video cameras may be the preferred approach and are therefore used as the basis for the cost ranges above. SCCOOS is interested in potentially partnering on wave runup monitoring as part of developing a flood forecasting system.	

Analysis

In addition to the **Storm Events, Damage, and Emergency Response** analyses discussed above, analyses of wave runup and coastal flooding could include:

- **Wave runup and coastal hazard modeling.** *Cost: $100,000 to $200,000 or more.* The above monitoring data could be used to calibrate/validate and improve site-specific or regional wave runup and coastal hazard modeling and projections with sea level rise.
- **Wave runup, coastal storm flooding, and erosion forecasting.** *Cost: TBD.* Forecasting models could be developed for coastal flood- and erosion-prone areas.

Products

- **Improved wave runup and coastal flood projection maps.** *Cost: $50,000 to 100,000 in addition to the modeling analysis described above.* Maps of results from calibrated/validated wave runup and coastal flood projections with future sea level rise could be prepared to improve upon available projections from CoSMoS and Coastal Resilience Santa Barbara County and Ventura County.
- **Coastal flood and erosion forecasting systems for vulnerable coastal communities.** *Cost: TBD.* Similar to existing SCCOOS coastal flood forecast systems in San Diego County, flood forecast systems could be developed for specific flood-prone areas to predict and notify BEACON members of likely coastal flooding to assist with flood preparedness. A similar type of system could possibly be developed to forecast potential coastal storm erosion and damage.

Plan execution options: partnership with SCCOOS and/or other academic institutions, consultant contract.

Pilot studies (prioritized list): the following pilot studies assume SCCOOS will deploy a roving wave buoy in the Santa Barbara Channel. If SCCOOS does not implement this plan, the RCAMP should consider deploying a wave buoy.

- Wave runup monitoring and shore profile surveys at one or more coastal flood-prone area(s), such as Goleta Beach, City of Santa Barbara waterfront, Pierpont Beach (e.g., Seaward Ave) in Ventura.
- Wave runup and coastal hazard modeling analysis using the above data for calibration/validation and improving projections with sea level rise.

Combined Coastal and Fluvial Flooding

Background

Coastal areas subject to creek/river flooding (i.e., fluvial flooding), as well as pluvial flooding due to insufficient storm drainage, are at risk of combined coastal and fluvial flooding currently and with climate change. Combined flood events occur when coastal storm flooding occurs in conjunction with extreme precipitation, and due to coastal storm surge and waves inhibiting or "backing up" creek and river mouth discharge. Creek mouth opening and closure dynamics and lagoon conditions are also factors. In addition to future sea level rise, the projected increase in extreme precipitation is a hazard for coastal areas experiencing combined flooding. Areas within the BEACON region at risk of combined flooding include Goleta Slough and the Santa Barbara Airport, "downtown" Santa Barbara north and south of Highway 101, the area around Carpinteria Salt Marsh, and the Ventura and Santa Clara River mouths.

Hazards analyses and mapping are regionally available for both coastal and fluvial flooding, but not necessarily for combined flood risks. FEMA analyzes extreme coastal and fluvial flooding separately for Flood Insurance Studies and maps the higher of the two as the 1% annual chance flood in Flood Insurance Rate Maps. CoSMoS models and projects coastal flooding with sea level rise and includes estimated coincident discharge for larger creeks and rivers; however, CoSMoS does not analyze extreme (e.g., 1% chance) fluvial flooding with sea level rise. In coastal areas subject to fluvial flooding, extreme fluvial flooding with sea level rise may present a higher risk than coastal flooding with sea level rise. To address this, Coastal Resilience Santa Barbara County modeled and mapped extreme fluvial flooding for Carpinteria Creek with sea level rise and increased precipitation.

A similar approach could be taken for the BEACON region, with additional monitoring data collection and analysis to calibrate and validate analyses and track actual combined flooding. A plan for monitoring combined flooding can help identify and assess areas at high risk of coastal and fluvial flooding, which could help prioritize updated stormwater infrastructure and adaptation projects.

The critical data for monitoring and analyzing combined flood risks are topography including creek/river geometry, precipitation, streamflow, lagoon dynamics, coastal flood parameters, and – for pluvial flooding – storm drain systems. Stream gages and extreme streamflow data are critical for understanding combined flood risks.

Data and Monitoring

The data and monitoring discussed for **Storm Events, Damage, and Emergency Response** and **Wave Runup and Coastal Flooding** above are also important for monitoring combined flooding. Available aerial LIDAR data, discussed for **Sandy Beach Shoreline Change**, would also be used for combined flood analyses; however, the LIDAR data would need to extend further inland. Further review would be needed to confirm the availability and coverage of recent data for areas of combined flood risk and the need for any new LiDAR data collection. The additional data and monitoring below would be needed to assess and analyze combined flood risks.

Stream channel geometry	*Potential new monitoring, site specific.*
Spatial scale: Areas of combined flood risk, depends on stream channel.	*Frequency:* Once to characterize current stream conditions.
Cost: Depends on creek/bridge/other feature to be surveyed. May range from $10,000 for one stream channel that can be surveyed in one day to $150,000 for a stream channel that requires three weeks to survey.	
While LiDAR data may be adequate for regional-scale study, supplemental topography and bathymetry surveys of river/creek channels, bridges, and other structures (e.g., channel cross-sections) are often needed to support site-specific flood risk assessments or confirm and refine LiDAR topography. Stream channel geometry surveys to support a detailed analysis of combined flooding could potentially involve an extensive effort to gather available data including bridge and structure as-built plans and perform supplemental surveys.	

Storm drain system mapping	*Potential new monitoring, site specific.*
Spatial scale: Areas of combined flood risk	*Frequency:* Once to characterize current storm drain conditions.
Cost: TBD	
Municipalities typically have some level of storm drain system information and mapping; however, this information is often incomplete or out of date. A storm drain system mapping effort would likely involve gathering available information and potentially an extensive effort to prepare, confirm, and detail storm drain mapping for analysis of combined flooding.	

Precipitation	*Available, regional and site specific.*
Spatial scale: Network of rain gages throughout region	*Frequency:* Continuous to daily
Cost: Funded by various public agencies	
Networks of precipitation gages are already in place, with gages and data maintained and provided by various public agencies and BEACON members.	

Stream gages	*Available (only for certain streams, see below), potential new monitoring*
Spatial scale: see below for available locations	*Frequency:* every 15 minutes to daily
Cost: Available gages currently funded by USGS and counties. Cost of new gages depends on stream.	
Stream gages are used to measure discharge or flow rate and water level, which are crucial for combined flood monitoring. Collected data is downloaded via telemetry or manually. Stream gages can provide information on changes to baseflow and storm event streamflow over time. If appropriate information is available, discharge can be calculated from water level data using a calibrated water level-discharge curve. USGS and the Counties of Santa Barbara and Ventura maintain publicly available stream and reservoir gage data at locations throughout the region, as shown in **Figure 15**. Certain gages on flood-prone streams, such as Mission Creek in Santa Barbara, may not capture extreme discharge data. Further review would be needed to assess potential improvements to existing stream gages and the need for additional stream gages. **Table 9** summarizes coastal rivers and creeks with permanent gages that provide ongoing monitoring data. Currently, the ungaged coastal creeks in the region are multiple creeks between Point Conception and Goleta including Gaviota Creek, Carneros Creek and Tecolotito Creek (tributaries of Goleta Slough), Arroyo Burro Creek, Laguna Channel, Sycamore Creek, multiple creeks from Montecito to Carpinteria, Franklin Creek, Santa Monica Creek, and multiple creeks between Carpinteria and Ventura. Additional stream gages are needed to assess combined flood risks for many of these creeks. *Considerations:* Stream gages are currently maintained by USGS and the counties. Gages may not accurately measure discharge for out-of-bank flood events, such as for the Mission Creek gage. Also, gages may be damaged in flood events. *Other purposes:* Sediment Budget Tracking; Storm Events, Damage, Emergency Response & Recovery	

TABLE 9. COASTAL RIVERS AND CREEKS WITH PERMANENT STREAM GAGES IN THE BEACON REGION

Location	Gage Owner	Status
San Pedro Creek	USGS	Permanent, ongoing
Atascadero Creek	SBCPWD	Permanent, ongoing
San Jose Creek	SBCPWD	Permanent, ongoing
Maria Ygnacio Creek	USGS	Permanent, ongoing
Mission Creek	USGS	Permanent, ongoing
Montecito Creek	SBCPWD	Permanent, ongoing
Carpinteria Creek	USGS	Permanent, ongoing
Ventura River	USGS	Permanent, ongoing
Santa Clara River	USGS	Permanent, ongoing

SOURCE: ESRI, USGS, NHD, SBCPWD, VCPWD, ESA, 2024

Figure 15. Stream Gages in the BEACON Region

Lagoon water level gages and mouth dynamics	*Potential new monitoring, site specific.*
Spatial scale: at specific lagoons	*Frequency:* continuous to hourly

Cost: For one water level gage and one camera at one lagoon:

- Installation: $15,000 (temporary installation) to $40,000 (permanent installation)
- Annual maintenance, data management, and analysis: $50,000 to $70,000

Coastal lagoon water level gages and cameras to monitor lagoon mouth opening and closure dynamics could be installed to monitor and improve understanding of lagoon effects on combined flooding. These methods have been effectively used for several coastal lagoon studies in the BEACON region (**Table 10**); however, no ongoing regional lagoon water level and mouth dynamics monitoring program is in place other than the County of Santa Barbara's water level gage in Goleta Slough.

TABLE 10. COASTAL LAGOON WATER LEVEL GAGES IN THE BEACON REGION.

Location	Gage Status
Devereux Slough	Previous
UC Santa Barbara Campus Lagoon	None
Goleta Slough	Permanent, ongoing
Mission Creek Lagoon	Previous, May-December 2012
Andrée Clark Bird Refuge	None
Carpinteria Salt Marsh	Possible UC NRS measurements
Santa Clara River Estuary	Ongoing, planned through 2024 by City of Ventura
Mugu Lagoon	None

Analysis and Products

In addition to the **Storm Events, Damage, and Emergency Response** analyses discussed above, analyses of combined flooding could include:

- **Combined flooding hazard modeling and mapping.** *Cost: $200,000 to $400,000.* The above monitoring data could be used to model and map combined flood hazards for current conditions and with projected future sea level rise and increased precipitation with climate change. Calibrated/validated combined flood hazard projections and mapping with future sea level rise and increased precipitation for a range of combined event frequencies could be prepared to fill the current combined flooding gap in available coastal hazard mapping products and climate change projections.
- **Combined flood forecasting.** *Cost: TBD.* Forecasting models could be developed for areas prone to combined flooding. Combined flooding forecast systems could be developed for specific flood-prone areas to predict and notify BEACON members of likely combined flooding to assist with flood preparedness.

Plan execution options: partnership with municipalities and academic institutions, consultant contract.

Pilot studies (prioritized list):

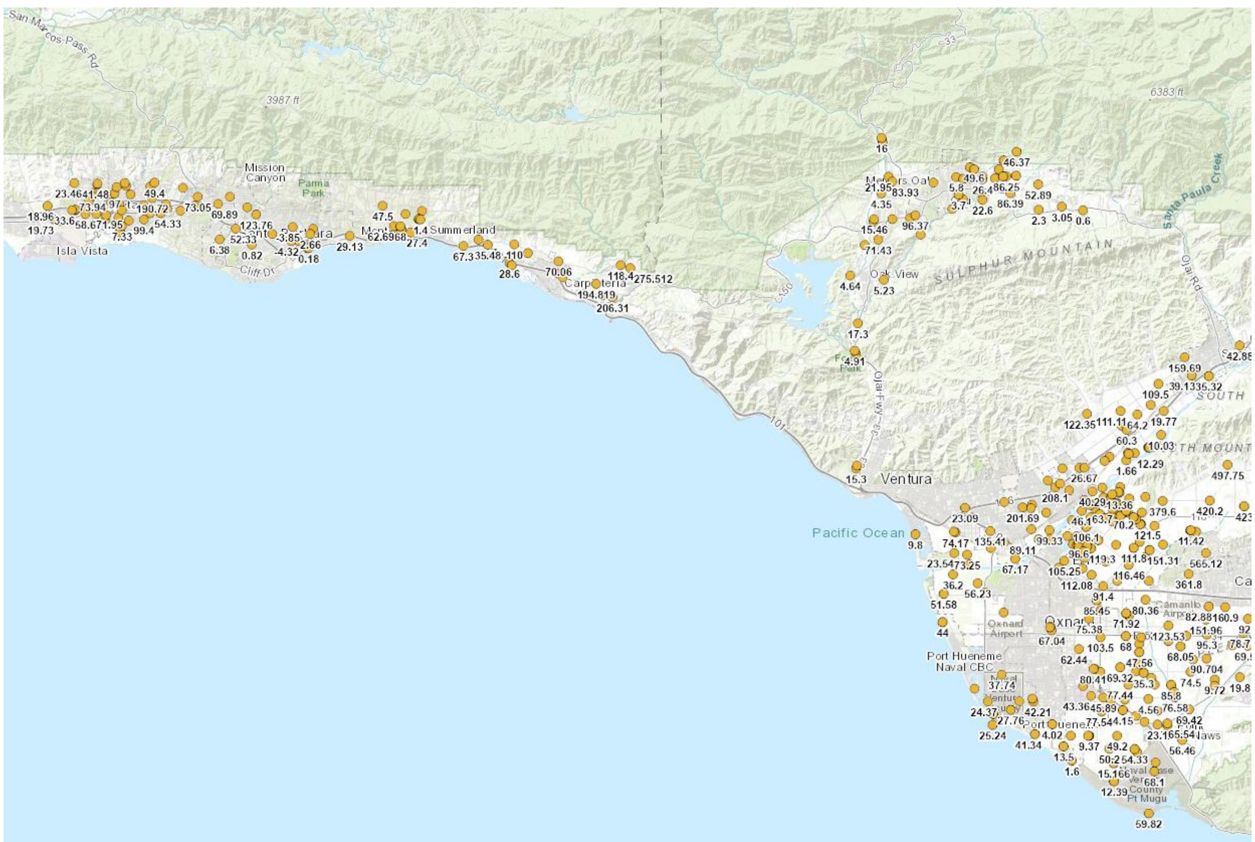
- Install stream gages and lagoon water level gages in one or more combined flood-prone area(s), such as Mission Creek Lagoon, Laguna Channel, and Sycamore Creek in Santa Barbara; Carpinteria Salt Marsh, Franklin Creek and/or Santa Monica Creek; Ventura River mouth; and Mugu Lagoon.
- Analysis for one or more combined flood-prone area(s), including data collection (e.g., topography, stream geometry, storm drain system mapping) and combined flood modeling and projections.

Shallow Groundwater Rise

Background

Coastal areas where groundwater levels are currently shallow are at risk of groundwater level rise, emergence and inundation with sea level rise and increased extreme precipitation with climate change. Areas at risk to groundwater rise overlap with areas at risk of combined flooding. The Monitoring Plan includes tracking changes in shallow coastal groundwater levels to inform adaptation planning for strategies related to groundwater rise management.

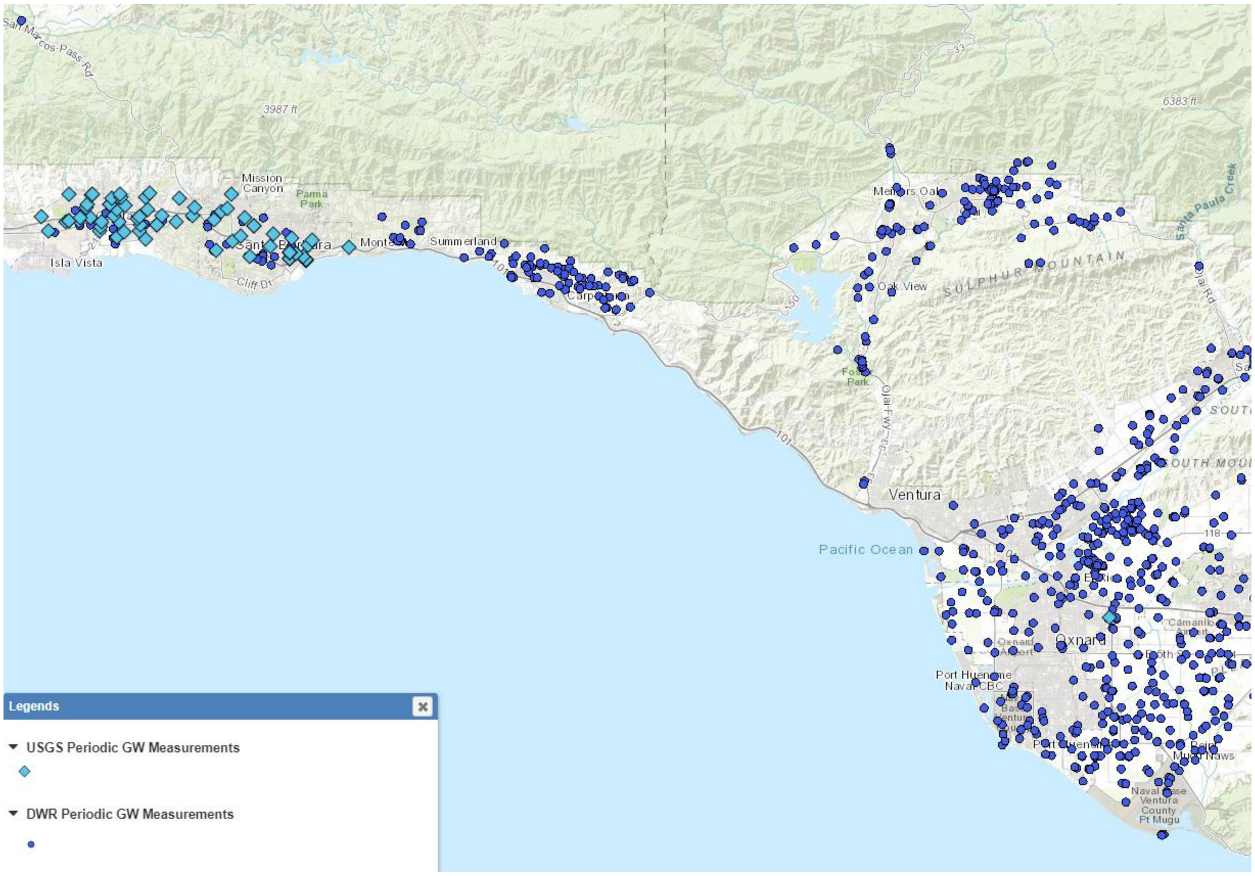
Groundwater depth data in the region is available on a seasonal and periodic basis. The Department of Water Resources (DWR) has numerous groundwater gages in the BEACON region that provide seasonal groundwater depth values with depths reported twice a year, once in spring and once in fall. **Figure 16** is a screenshot of the SGMA web map that shows the DWR sites in the region with groundwater depth reported for spring 2023.



SOURCE: SGMA Data Viewer (sgma.water.ca.gov) 2024

Figure 16. DWR Seasonal Groundwater Depth Measurement Well Locations and Spring 2023 Depths in Feet

Additionally, there are both DWR and USGS wells where groundwater depth is periodically measured. The frequency of these measurements varies by site but is typically between once and five times per year. **Figure 17** is a screenshot of the web map that displays DWR and USGS wells where at least one groundwater depth measurement has been taken.



SOURCE: SGMA Data Viewer (sgma.water.ca.gov) 2024

Figure 17. DWR and USGS Periodic Seasonal Groundwater Depth Measurement Well Locations

USGS used the groundwater wells shown in Figure 17, which have at least one measurement reported, for the CoSMoS groundwater rise modeling. CoSMoS modeled and projected groundwater depths and emergence with sea level rise for California (https://ourcoastourfuture.org/hazard-map/).

As required by the Sustainable Groundwater Management Act (SGMA), Groundwater Sustainability Agencies (GSAs) are also monitoring and assessing groundwater in the BEACON region, including changes due to sea water intrusion. SGMA is a set of laws passed in 2014 to regulate groundwater use with the goal of sustainably managing groundwater resources to prevent negative outcomes such as lowering of groundwater levels, degradation of groundwater quality, reduction of groundwater storage, and saltwater intrusion in coastal areas. California's 515 groundwater basins were classified into high, medium, low, and very low priority categories based on population, irrigated acreage, number of wells, and other factors. High and medium priority basins are required to create a Groundwater Sustainability Agency (GSA) that are tasked with developing a Groundwater Sustainability Plan (GSP) for the basin that includes current and historic groundwater conditions, a water budget, monitoring program, and objectives to achieve groundwater sustainability by 2040.

In the BEACON region, there are four coastal groundwater basins with GSPs: Santa Clara River Valley – Oxnard, Santa Clara River Valley – Mound, Carpinteria, and Montecito groundwater basins. **Figure 18** presents a screenshot of the SGMA web map delineating these basins. The monitoring plans for these basins are summarized in **Table 11**. The Goleta, Foothill, Santa Barbara, and Lower Ventura River groundwater basins are not subject to SGMA as they are all low or very low priority basins. Non-coastal groundwater basins are not addressed in this report.

SOURCE: SGMA (sgma.gov), 2024

Figure 18. BEACON Region SGMA Groundwater Basins

TABLE 11. GROUNDWATER SUSTAINABILITY PLAN MONITORING SUMMARY FOR COASTAL GROUNDWATER BASINS IN THE BEACON REGION

County	Groundwater Basin	Metric	Method	Additions to Monitoring Network	Status
Ventura	Santa Clara River Valley – Oxnard Groundwater Subbasin	Groundwater level	Use existing groundwater monitoring well network (150 wells)	Recommended to add more (~6) monitoring wells, take more frequent measurements, and add pressure transducers to existing wells	Active, additions recommended in GSP
		Groundwater quality	Use existing groundwater monitoring well network (the majority of the 150 wells can be used)	Add full general minerals to analyte list	Active, additions recommended in GSP
		Seawater intrusion	Use measurements from existing groundwater monitoring well network to map	See groundwater level additions	Active, additions recommended in GSP
		Surface water conditions	Use existing surface water gages (four daily stream gages, plus others measuring peak flows during storm events only)	Recommended to add a gage to the "tile drains" drainage system	Active, additions recommended in GSP
	Santa Clara River Valley – Mound	Groundwater level	Use existing groundwater monitoring well network (23 wells) and add two monitoring well clusters	Two monitoring well clusters	Active, additions planned in GSP
		Groundwater quality	Use existing groundwater quality monitoring network (10 wells) and additional monitoring well clusters	Two monitoring well clusters	Active, additions planned in GSP
		Seawater intrusion	Use a subset of groundwater quality monitoring wells to measure for chloride and other markers	Two monitoring well clusters	Active, additions planned in GSP

County	Groundwater Basin	Metric	Method	Additions to Monitoring Network	Status
		Surface water conditions	N/A – no interconnected surface water systems identified in the basin		
Santa Barbara	Carpinteria	Groundwater level	Use existing groundwater well monitoring network	See seawater intrusion	Active
		Groundwater quality	Use existing groundwater well monitoring network	Add water quality to well measurements where appropriate	Active
		Seawater intrusion	Use existing network	Plans are in place to expand the seawater intrusion network to new coastal locations (7 new wells)	Active, additions planned
		Surface water conditions	N/A – no interconnected surface water systems identified in the basin		
	Montecito	Groundwater level	Use existing groundwater monitoring network (63 wells) plus additions	Drill and monitor several new wells within the Basin	Active, some wells currently under construction as of April 2023
		Groundwater quality	Use existing groundwater quality network (13 wells) plus additions	Take groundwater quality measurements more frequently (semiannually)	Active
		Seawater intrusion	Use pre-existing coastal wells to measure iodide, bromide, silica, and others, plus additions	Construction of new wells planned	Active, construction of new wells scheduled as of April 2023
		Surface water conditions	Install 4-6 new streamflow gages in 3 creeks	4-6 streamflow gages	Active

Additionally, sites that potentially impact groundwater quality are reported in GeoTracker (https://geotracker.waterboards.ca.gov/), a data management system used by the Water Boards of California. Information is collected there from sites that require cleanup, which are typically privately-owned shallow groundwater sites such as leaky underground storage tanks or irrigated lands. Each of these sites is required to include an electronic submission of all reports and data related to the site, including data, boring logs, and depth to well data.

In summary, monitoring of coastal groundwater levels and sea water intrusion is ongoing by GSAs in the Oxnard, Carpinteria, and Montecito groundwater basins. *The Monitoring Plan recommends coordination with GSAs to confirm that GSPs will provide monitoring data and assessments of coastal groundwater changes that are useful for purposes of adaptation planning by BEACON members. GSA monitoring programs do not exist for the Goleta, Foothill, and Santa Barbara basins and additional coastal groundwater monitoring wells may be required to adequately monitor and assess groundwater changes in these basins.*

Data and Monitoring

Groundwater monitoring data could be collected from existing groundwater monitoring networks and/or new monitoring wells, as described below.

Existing groundwater monitoring wells	*Available periodically, site specific*
Spatial scale: throughout the BEACON region	*Frequency:* currently about one to five measurements per year, can be collected more frequently.
Cost: currently funded by USGS, DWR, GSAs, and others.	
Groundwater wells measuring shallow groundwater levels provide critical information on the freshwater-saltwater transition zone and the potential threat posed by sea level rise to underground structures. Data collected from groundwater wells include depth, elevation, and salinity. Groundwater depths for the existing wells discussed in the Background section above are typically reported twice a year, once in spring and once in fall. More frequent measurements (e.g., monthly) during winters with extreme precipitation may be useful to monitor and track peak groundwater levels. *Considerations:* Some of the existing groundwater monitoring wells may be intended to monitor deeper aquifers and may therefore not be useful for the purposes of the RCAMP. Many current shallow groundwater wells reported on the GeoTracker may be operated by private parties that are required to report data to the RWQCB and to track and archive sites that impact, or have the potential to impact, water quality. Data available on the GeoTracker may be limited to one or a few groundwater level readings per year and salinity data is typically not available. Review of the utility of individual wells is beyond the current scope of the Monitoring Plan. It is assumed that GSA monitoring of groundwater levels and sea water intrusion in the Oxnard, Carpinteria, and Montecito Basins is adequate for the purposes of the RCAMP, but that additional groundwater wells may be required in the Goleta and Santa Barbara Basins.	

New groundwater monitoring wells	*New potential monitoring, site specific*
Spatial scale: Goleta and Santa Barbara Groundwater Basins	*Frequency:* seasonal or monthly
Cost: For one new groundwater well: • Installation: $5,000 to $10,000 (excludes permitting) • Annual data collection and management: $5,000 to $15,000	
Pending further review of existing groundwater wells per above, the Monitoring Plan assumes that new groundwater monitoring wells are required to monitor shallow groundwater levels in the Goleta and Santa Barbara Groundwater Basins, particularly in areas at risk to rising groundwater levels. New wells should be installed to the depth needed to capture an adequate range of shallow groundwater levels. Data will be collected through an automatic groundwater level logger and/or manual groundwater depth and salinity readings. Surveying ground elevation at the well and top of well (well head) elevation is required to convert depths to elevations with surveys by licensed or experienced survey professionals.	

Analysis and Products

- **Groundwater level trends analysis.** *Cost: $100,000 to $200,000.* Groundwater level data from existing and new wells can be analyzed to identify and track trends and extremes. Results could be provided in an online groundwater level tracking tool.
- **CoSMoS groundwater hazard projections validation and guidance.** *Cost: $100,000 to $200,000.* CoSMoS provides state-wide groundwater hazard projections results for a range of possible soil hydraulic conductivities. Groundwater data analysis can be used in conjunction with an assessment of soil hydraulic conductivity to validate projections. This analysis could inform the selection of CoSMoS results with the hydraulic conductivities that best represent groundwater basins in the BEACON region and provide guidance on application of results.
- **Refined groundwater projections with sea level rise.** *Cost: $100,000 to $300,000.* Groundwater data collected over time could be used to refine groundwater predictions specific to the BEACON region.

Execution options: partner with USGS DWR, and GSAs; consultant contract.

Pilot study options (prioritized list):

- Review of existing groundwater monitoring wells and develop detailed plan for installing new groundwater wells, including outreach and coordination with regional entities that can perform or assist with data collection (e.g., USGS, DWR, GSAs).
- Shallow groundwater well installation in one or more areas at risk to shallow groundwater rise where existing monitoring wells are not available, such as downtown Santa Barbara and Goleta Slough.

Effectiveness of Nature-based Adaptation at the Surfers' Point Living Shoreline and Managed Retreat Project

Background

Monitoring the effectiveness of nature-based adaptation projects is crucial for planning nature-based adaptation projects throughout coastal California. BEACON members are planning and adopting adaptation plans that include nature-based adaptation as potential strategies. Currently, BEACON members are pursuing multiple nature-based adaptation projects such as the Carpinteria Living Shoreline Project. Monitoring built nature-based adaptation projects to better understand their effectiveness, benefits, and limitations is important to inform and refine future nature-based project planning, design, and implementation both in the BEACON region and throughout California.

The Surfers' Point Living Shoreline and Managed Retreat Project (https://beacon.ca.gov/current-events/surfers-point-project/) in the City of Ventura is a primary implemented nature-based adaptation project in the BEACON region. Phase 1 of the project included realigned development, managed retreat, and a restored dune system constructed over a buried cobble berm. Following the Phase 1 construction in 2011, permit required monitoring efforts have been undertaken, including beach transects, drone-based topography surveys, and plant community surveys. The City of Ventura was required by permit to perform limited ongoing monitoring for a five-year period from 2012 to 2017. Surfers' Point serves as a successful and innovative example of managed retreat and a nature-based "living shoreline" beach restoration, emphasizing the importance of long-term regional monitoring and adaptive management. The monitoring results inform best practices and guide future coastal resilience efforts across the region.

The project's Phase 1 included initial monitoring, but funding constraints limited long-term assessments. BEACON has funded the continuation and expansion of the project monitoring as part of a long-term monitoring program from 2020 to 2024 (Beyler and others 2025, ESA 2024). More comprehensive monitoring of the Surfers' Point project and its effectiveness would benefit nature-based adaptation project planning, design, and implementation in the BEACON region and throughout California. Comprehensive monitoring would include continued monitoring at the adjacent Emma Wood reference site, Ventura River, and Phase 2 of the project. Note that Phase 2 project implementation is planned for 2024–2025.

Data and Monitoring

The following data and monitoring described above for other purposes could be used to supplement ongoing monitoring at Surfers' Point:

- Sandy Beach Shoreline Change: satellite imagery, USGS shore profile surveys (one transect at Surfers' Point) and aerial imagery, available regional LiDAR, cameras, CoastSnap, and beach habitat zonation and change.
- Sediment Budget Tracking: refinement of Ventura River sediment loading, including cobble.
- Storm Events, Damage, Emergency Response & Recovery: pre- and post-storm surveys of erosion
- Wave Runup and Coastal Flooding: new wave buoy, additional water level gate at Ventura Pier or Ventura Harbor, wave runup
- Other data and monitoring specific to Surfers' Point include the following:

BEACON member shore profiles	*Ongoing, site specific*
Spatial scale: Surfers' Point and vicinity	*Frequency:* Semiannual to annual
Cost: $10,000 for each survey.	
Seven shore profile surveys of the Surfers' Point project beach as well as the adjacent Emma Wood State Park reference site have been conducted on an annual or semiannual basis (fall and spring) since 2011 by the City of Ventura and BEACON. The City will continue to perform surveys as required by permits and BEACON will continue to perform supplemental surveys as available funding allows.	

Available aerial topography	*Ongoing, site specific*
Spatial scale: Surfers' Point and vicinity	*Frequency:* Annual or seasonal (ongoing)
Cost: $5,000 to $10,000 for each survey.	
CSUCI has performed drone-based surveys of Surfers' Point in partnership with BEACON, which they may continue as available funding allows. Surveys were performed in 2016, two times in 2017, two times in 2018, 2019, 2021, four times in 2023 (January, September, and December), and 2024.	

Supplemental shore surveys	*Potential new monitoring, site specific*
Spatial scale: Surfers' Point	*Frequency:* Quarterly to monthly
Cost: TBD	
Supplemental surveys could be performed to provide additional spatial and temporal data. This could include biannual drone-based photo surveys (utilizing structure from motion photogrammetry to create 2D and 3D data products), quarterly or monthly ground-based shoreline profile surveys, and/or ground-based shoreline profiles before and after major storm events to document and quantify changes and effectiveness of the project. Surveys could be used to confirm topographic changes derived from cameras and supplemental Sandy Beach Shoreline Change data discussed above.	

Plant community surveys	*Ongoing, site specific*
Spatial scale: Surfers' Point	*Frequency:* Annual or semiannual (ongoing)
Cost: TBD	
Usually coordinated with CSUCI, City of Ventura, and BEACON, plant community surveys are conducted to evaluate the growth and health of the dune habitats, which may continue as available funding allows. Surveys could continue twice per year.	

Cobble PIT or RFID tag tracking	*Potential new monitoring, site specific*
Spatial scale: Surfers' Point and vicinity	*Frequency:* Annual or semiannual
Cost: TBD	
Methods used by researchers at UC San Diego's Scripps Institute of Oceanography could be used to tag cobble stones with small radio-frequency identification (RFID) tags that allow the movement and transport of individual cobbles to be tracked and mapped with an antenna. This method has been successfully used at Torrey Pines State Beach in San Diego (https://siocpg.ucsd.edu/projects/cobble-tracking/,Young, 2023).	

Analysis and Products

- **Annual shore change analysis and project performance reporting.** *Cost: $50,000 to $200,000.* The current monitoring and analysis by the City, BEACON, and CSUCI could be continued and expanded to include supplemental surveys and monitoring described above in addition to the ongoing profile, LiDAR, and plant community surveys. The RCAMP could perform an expanded and integrated analysis of seasonal and interannual shore change, storm response and recovery, cobble movement, and dune processes and vegetation. Annual or regular reporting on shore change and project performance would provide information on long-term project performance as an ongoing nature-based project case study.
- **Wave runup, erosion, and coastal processes analysis.** *Cost: $40,000 to $80,000.* With additional data on shore change, water levels, waves, and wave runup, a mechanistic analysis of coastal processes, shore change, and project effectiveness could be performed to develop refined analysis tools and guidance for similar nature-based projects.
- **Nature-based project analysis tools and guidance for BEACON and other regions.** *Cost: $60,000 to $80,000.* More comprehensive data collection and analysis could yield validated nature-based project analysis tools, proof of project performance and effectiveness, and guidance and lessons learned to inform similar projects in the BEACON region and throughout California.

Plan execution options: Partnership with BEACON, CSUCI, and possibly other academic institutions; consultant contract.

Pilot study: Fund the continuation and possible expansion of the ongoing monitoring for a season or year.

5.2.2 Potential Ecological Monitoring

Overview

The potential ecological monitoring plans are intended to document existing biological resources and to support assessment of ecological changes to beach, coastal strand, dune, near-shore habitats, and coastal wetlands. Habitat changes can be due to natural variation (e.g., differences in natural sediment delivery to the coast between years), stochastic events (e.g., large swells), coastal structures (e.g., groins, sea walls), coastal management (e.g., beach nourishment and grooming), and longer-term stressors (e.g., sea level rise).

Ecological monitoring should follow a tiered approach that progresses from coarse-scale to fine-grained monitoring. Coarse-scale monitoring focuses on large-scale patterns and processes to detect landscape-wide changes. Mapping natural land cover will quantify extent, fragmentation and connectivity of habitats used by various species.[4] Another parameter is distribution and range of certain species that rely on coastal habitats or have protected status (special-status species). This scale is useful to establish a baseline at the regional scale.

Fine-grained monitoring focuses on specific habitats (more precise spatial distribution, composition, quality), species (abundance, population dynamics) or localized environmental factors at smaller spatial and/or temporal scales. Targeted species can include special-status species or sensitive species that serve as indicators of ecosystem health and function (Clark-Wolf and others 2024). Selection of indicators depends on an understanding of species life history and habitat needs, the type and variability of physical conditions and processes, and the sensitivity and response time of natural communities and species.

Coarse-scale monitoring is a logical first step to understand biological resources at a regional scale. Fine-grained monitoring can then be added for priority locations and/or species. More intensive ecological monitoring will be necessary for the design phase of coastal projects and for permit compliance of implemented projects. In addition, post-project monitoring will be important to assess the effectiveness of projects implemented for the purpose of increasing coastal resilience. Integrated monitoring of physical and ecological resources can provide more clarity on the dynamics of the system.

Natural Communities (Vegetation or Habitat Mapping) Baseline and Change

Background

Documenting the current distribution and status of biological resources on the coast is fundamental to establishing a baseline from which to measure changes and responses in ecosystem condition and function. Baseline spatial data for beaches, coastal sand, dune, and near-shore habitats are generally lacking from much of the BEACON coast. The California Aquatic Resource Inventory (CARI) (https://www.sfei.org/cari) provides approximate mapping of surface waters and related habitat types, including estuarine, beach, dune, rocky shore, and wetlands.

Purposes of establishing a regional framework and program to regularly collect ecological data (e.g., on an annual to multiyear cycle) include:

- Assessing and tracking changes over time due to interannual cycles, ongoing coastal management regimes, sea level rise, and climate change so that ecological thresholds and triggers can be included and considered in adaptation decision making.
- Focus areas where adaptation projects are planned or likely where baseline ecological data is likely to be needed to support adaptation project permitting and before and after (i.e., post-project) performance assessments.

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[4] Although the terms habitat type and natural community are frequently used interchangeably, they differ slightly in meaning and purpose. A habitat is the specific environment that provide the resources, conditions and space necessary to support a species. A natural community is a broader concept, encompassing all species living together in a shared environment and interacting within an ecosystem. Natural communities are classified based on land cover vegetation types. Some natural communities have special status because of limited distribution or because they contain wetlands and other waters protected under federal and state laws.

- Support Chumash tribal monitoring objectives related to culturally-significant species and habitats, preservation and protection of culturally significant ecosystems, and undeveloped and preserved lands.

To fully develop a baseline ecological monitoring plan, a more detailed process would be required as a next step to:

- Identify, collect, and review available ecological monitoring data compiled from a variety of sources in the region.
- Determine data gaps, such as locations where baseline monitoring of natural communities (vegetation or habitat mapping) has not occurred, missing data on habitat zones/types and parameters and missing data on presence/absence of listed species throughout the Santa Barbara Littoral Cell.
- Develop consistent and replicable ecological data collection protocols and analyses that document how biological resources and ecological processes are impacted by sea level rise and adaptation projects.
- Provide consistent data reporting standards that are easily interpreted by local management agencies.

Example applications of baseline ecological monitoring include:

- Understanding effects of current coastal management practices, including existing coastal structures.
- Serving as a regional baseline for adaptation projects with large-scale effects. For example, the planned Matilija Dam Removal project could have effects within a large portion of the littoral cell. The project has modeled and predicted change in conditions for Emma Wood state beach to Ventura Harbor via increased sedimentation. The Matilija Dam Removal project should include a monitoring plan to assess the project's relevant physical and ecological effects on coastal areas. The RCAMP could provide a framework and protocols for regional monitoring that the Matilija Dam Removal project could follow and build upon.
- Evaluating the benefits and effects of nature-based adaptation projects in a regional context. In addition to the Effectiveness of Nature Based Adaptation Monitoring Plan discussed in Section 6.2.1 above, which is focused on site-specific long-term physical and ecological monitoring at Surfers' Point, regional-scale baseline ecological monitoring is needed to evaluate the effectiveness of adaptation projects relative to baseline conditions, reference sites, and between different types of nature-based projects. A regional ecological monitoring framework and protocols would provide a consistent basis for assessing a range of adaptation projects.

In addition to physical monitoring that provides ecological information discussed in Section 6.2.1 above, on the ground surveys of site ecology will be necessary to further document habitats and their respective cover, species composition and cover, presence of special status species, their associated habitats, and co-occurring species.

Data and Monitoring

- **Available project data – *available/ongoing, site specific*.** Review and catalog historical and current projects in the BEACON region that have collected baseline biological data.

- **Aerial imagery – *potential new monitoring, regional, annual*.** Use to define unique ecosystems and habitats, vegetation communities, percent cover, and how these change over time.
- **Site-specific surveys – *potential new monitoring, site specific, annual or semi-annual*.** Provide a more detailed resolution of vegetation communities to validate aerial imagery, presence or absence of species, including host species or indicator species, and accurate estimates of population size of these species.

Analysis and Products

- **Define habitat parameters for habitat mapping and criteria.** As a precursor to baseline ecological monitoring and mapping baseline habitat and change over time, biological and abiotic parameters for specific habitat types could be defined. These parameters could also be used to inform adaptation project planning and performance evaluations. A collaborative stakeholder process involving a range of local experts is recommended to define habitat parameters. The process could start with a review of existing prior relevant studies and frameworks and defining habitat types or categories for the region, such as intertidal beach, beach (groomed and ungroomed), foredune, dune, rocky intertidal, and so on.
- **Habitat mapping.** The habitat parameters could be applied to collected data to map baseline habitats and change over time. Products could include GIS web maps of baseline habitats and, over time, changes in habitat.
- **Habitat quality and coverage trends analysis.** Data collected over time could be analyzed to determine changes in the coverage and quality of habitats regionally. Data from site specific surveys such as population size of indicator species and other plant species could be used to determine habitat health and resilience to stressors. Data for listed species could also be informative. Products could include an analysis report that is updated every few years.

Plan execution options: Partnership with academic institutions and non-profits; consultant contract.

Pilot study: fully develop a baseline ecology monitoring plan.

Sensitive Species

Background

Sensitive species as used here include those protected by federal and state law (special-status species), indicators of a key ecological process, and managed species such as fisheries. Monitoring status and trends in sensitive species could also inform adaptation planning. While BEACON member agencies are not required to plan adaptation to specifically to benefit and sustain sensitive species, permitting for adaptation projects often requires consideration of sensitive species. Collecting sensitive species data and considering sensitive species in adaptation planning has the potential to streamline permitting for adaptation projects. The Monitoring Plan also considers sensitive species monitoring to support regional management and recovery of sensitive species.

Changes in sensitive species use of beach, dune, and estuarine habitats can be due to sensitive species behavior and population dynamics as much as changes in habitat quality and area. Populations of these species naturally vary over time due in part to the dynamic nature of the habitats they inhabit. Longer-term monitoring is useful for assessing potential trends (versus natural variability) that may indicate increases or decreases in habitat quality and/or area. Non-listed species may also be useful indicators of change, however existing monitoring and future funding for continued/expanded monitoring is more likely to occur for listed species. The following state and federally listed and/or managed species are potential indicators of ecosystem health and are all being monitored to some extent in the BEACON region:

- Western snowy plover that nest and over-winter in beach and dune habitats.
- California least tern that nest in beach and dune habitats.
- Southern California steelhead that migrate through and occasionally rear in estuarine habitats.
- Tidewater goby that are restricted to bar-built estuarine habitats.
- Salt marsh bird’s beak, an annual plant that grows in a narrow elevation zone in some estuaries.
- California grunion that spawn on sandy beaches.

sea level rise will likely impact beach nesting areas for western snowy plover and least terns and upper beach breeding habitat for California grunion. sea level rise may also affect salt marsh bird’s beak habitat, since currently occupied habitat may become inundated in the future. Tidewater goby that are found almost exclusively in bar-built estuaries (lagoons) and surrounding brackish marshes and channels may suffer from reduced habitat availability and quality as sea level rise could result in more frequent breaching, changes in wetted area, increases in salinity and ultimately inundation of these lagoons. Steelhead may be impacted by rising water temperatures due to climate change, especially in upstream spawning habitat. sea level rise may also inundate and degrade estuarine and lagoon habitats used by juvenile steelhead.

Adaptation plans could take into account the different habitat/ecological requirements of the sensitive species, including bird’s (western snowy plover, least tern), fish (steelhead and tidewater goby) and plants (salt marsh bird’s beak). The different taxonomic groups have very different requirements and therefore may react differently to changing conditions over time.

1. Chumash monitoring objectives (see Section 5.2.4) include monitoring specific species, like leopard sharks, certain species of mollusk, and general kelp density, for preservation of culturally significant ecosystems.

Data and Monitoring

The California Natural Diversity Database (CNDDB) provides a general inventory of known status and potential locations of rare plants and animals. More accurate, site-specific, and ground-truthed baseline ecological data could be collected to support adaptation planning. A first step would be to assess habitat suitability for target species Ecological monitoring could include documentation of terrestrial and aquatic vegetation communities, species composition, and area coverage paired with observations of animal species that use and/or occupy areas.

The following are monitoring efforts and methods focused on specific species. These are provided as examples. The decision to implement any new monitoring would need to be evaluated based on project priorities.

- **Western snowy plovers and California least terns – *available, site specific*.** Annual nest monitoring of snowy plovers and least terns is currently performed by Ventura Audubon (Ormond Beach and Hollywood Beach), UCSB at Coal Oil Point Reserve, and by California State Parks at State beaches where the species occurs.
- **Salt marsh bird's beak – *available, site specific*.** Monitoring is currently performed at Mugu Lagoon and Ormond Beach. Salt marsh bird's beak monitoring at Navy Base Ventura County Mugu Lagoon is performed by the Navy. Ormond Beach monitoring was done in 2017 by Coastal Restoration Consultants and ESA (2017) and monitoring has also been performed at Carpinteria Salt Marsh.
- **Southern California steelhead – *potential new monitoring, site specific*.** Per the Southern California Steelhead Recovery Plan (NMFS 2012), there is no current comprehensive assessment of the condition and distribution of steelhead populations and habitats in southern California that use standard population and habitat assessment protocols. Monitoring for steelhead can follow the steelhead recovery plan and can include reconnaissance surveys and assessments of steelhead populations and riverine and estuarine habitat conditions, as well as counting and life cycle stations. However, direct monitoring of steelhead requires special permits and is difficult, time-intensive, costly because of their scarcity and movement patterns (with migration on high outflows).
- **Tidewater goby – *potential new monitoring, regional*.** The USFWS identified occupied localities for the tidewater goby in their 2014 proposed downlisting (79 FR 14340). Periodic presence-absence surveys have been conducted along the coast by individual researchers from UCLA and CSU Channel Islands, but no systematic monitoring occurs regularly. First steps are to review historic distribution and occurrence data, then assess habitat suitability (bar-built estuary dynamics, presence of submerged aquatic vegetation) of target sites. Direct monitoring methods for tidewater goby include seine netting, dip netting, trapping and snorkeling/direct observation, but this requires permits from USFWS and CDFW. USGS and others are also developing and using environmental DNA detection methods.
- **Additional sensitive species surveys – *potential new monitoring, regional*.** In addition to the species monitoring discussed above, further assessment of data gaps and monitoring strategies for sensitive species could be performed to fully develop a monitoring plan for sensitive species. This should include specific species like leopard sharks, certain species of mollusk, and general kelp density that are relevant for preservation of culturally significant ecosystems for Chumash tribes monitoring objectives.

Analysis

- **Western snowy plover and California least tern nesting assessment.** Nesting data could be analyzed regionally to assess whether nesting at current nesting sites is stable, increasing, or declining and whether new nesting areas are being established.

- **Salt marsh bird's beak zonation assessment.** Salt marsh bird's beak survey data and elevation zonation data could be analyzed regionally to assess whether salt marsh bird's beak is moving up-slope in marshes in response to sea level rise.
- **Additional sensitive species assessments.** If and when adequate regional data is available for Southern California steelhead, tidewater goby, and other sensitive species, data could be analyzed to assess baseline population status and trends over time.

Products

- Regular regional reporting on sensitive species populations and trends.
- Web map and data tool for sensitive species data.

Plan execution options: Partnership with Audubon and other non-profits, regulatory agencies, and academic institutions; consultant contract.

Pilot study options:

1. Assess the current monitoring efforts and locations and seek funding to add new monitoring locations where additional data are needed
2. Fund the continuation and possible expansion of an ongoing monitoring effort for a season or year.
3. Pilot system for compiling, tracking, and viewing existing ongoing indicator species monitoring data.

Coastal Wetland Change

Background

Coastal wetlands are a high priority natural community that supports a range of species and ecological services. Sea level rise is expected to cause the conversion and loss of vegetated coastal salt marsh habitat to lower elevation mudflat and subtidal habitat. Marsh habitat could potentially migrate upslope into low-lying open space areas adjacent to marshes; however, adjacent areas are typically developed or have other land uses. Coastal lagoon mouth conditions and dynamics are also likely to change with sea level rise and beach shore change. Potential adaptation to improve coastal wetland resiliency may be linked with flood and sediment management adaptation. Monitoring of coastal wetland change with sea level rise would provide a more comprehensive understanding of environmental change to inform integrated adaptation planning that achieves multiple benefits.

The Southern California Wetland Recovery Project (WRP) Regional Strategy (WRP 2018) assessed potential marsh habitat loss with sea level rise for the Southern California Bight, from Point Conception to the southern border. Results show the potential for significant habitat loss. The Regional Strategy also recommended a comprehensive monitoring program for coastal wetlands and the WRP has initiated a Regional Monitoring Program that builds from the California Estuary Marine Protected Area (EMPA) Monitoring Program. Per the WRP (2024) draft report, *Assessing Wetland Recovery: Building Capacity* *for Assessing Wetland Recovery Efforts in Supporting Regional Wetland Health and Resiliency – Development of a Coastal Wetland Sentinel Site Network*:

> *… there is currently no monitoring program that tracks the collective health and resiliency of wetlands in the region and how they are responding to stressors brought on by climate change and anthropogenic impacts… The goal of the WRP Regional Monitoring Program is to develop comparable approaches for coastal wetland monitoring and assist interested agencies in incorporating these into permit- and funding-required monitoring programs.*

The RCAMP could support monitoring to track and improve understanding of coastal wetland change with sea level rise, for example by supporting the development and implementation of the WRP Regional Monitoring Program.

Data and Monitoring

- **California Estuary Marine Protected Area (EMPA) Monitoring Program (https://empa.sccwrp.org/) – *available/ongoing, regional*.** This monitoring program was designed primarily to (1) assess the effectiveness of EMPA designations, (2) track ecological and socioeconomic changes over time in EMPAs, and (3) to inform adaptive management needs. The monitoring program was designed to assess biotic and abiotic factors in a consistent way throughout the state in EMPA's and reference sites. Goleta Slough (EMPA) and the Ventura River Estuary (reference site) are the only two sites within the BEACON region. A report on the 2021 monitoring is available and mostly reports results as indexed condition scores from CRAM[5] analyses relative to other estuaries in the program. Raw data from this monitoring is expected to be available to the public (at least some currently is). The monitoring categories where data may be available for some sites include vegetation cover, algae cover, fish abundance, length, diversity and richness, epifauna diversity and richness, sediment grain size, crab biomass and length, invertebrate abundance, and water quality.
- **Southern California Wetland Recovery Project (WRP) Regional Monitoring Program – *in progress, regional*.** Per the WRP (2024) draft report, *Assessing Wetland Recovery: Building Capacity for Assessing Wetland Recovery Efforts in Supporting Regional Wetland Health and Resiliency – Development of a Coastal Wetland Sentinel Site Network*, the WRP has proposed the sentinel coastal wetland sites listed in **Table 12** in the BEACON region. Once the sentinel sites are selected, the WRP plans to develop and establish a monitoring plan.

5 https://www.sfei.org/projects/california-rapid-assessment-method-cram.

TABLE 12. SENTINEL COASTAL WETLAND SITES IN THE BEACON REGION

Site	Subregion	Archetype	Category
Mugu Lagoon	Ventura	Intermediate Estuary	Reference
Ventura River Estuary	Ventura	Intermediate Estuary	Other Site of Interest
McGrath Lake	Ventura	River Valley Estuary	Other Site of Interest
Santa Clara River	Ventura	River Valley Estuary	Other Site of Interest
Ormond Beach	Ventura	River Valley Estuary	Other Site of Interest
Arroyo de las Aguas	Santa Barbara	Small Creek	Reference
El Capitan	Santa Barbara	Small Creek	Reference
Damsite Canyon	Santa Barbara	Small Creek	Reference
Carpinteria Salt Marsh	Santa Barbara	Intermediate Estuary	Reference
Canada de la Gaviota Creek	Santa Barbara	Intermediate Estuary	Reference
Devereux Lagoon	Santa Barbara	Large Lagoon	Restoration
Goleta Slough	Santa Barbara	River Valley Estuary	Other Site of Interest
Mission Creek Lagoon	Santa Barbara	Small Creek	Other Site of Interest

- **Southern California Bight Regional Monitoring Program (https://www.sccwrp.org/about/research-areas/regional-monitoring/southern-california-bight-regional-monitoring-program/) –** ***available/ongoing, regional.*** This marine monitoring program, started in the mid 1990's, focuses on assessing how human activities effect marine habitats in the coastal zone from Point Conception to Punto Colonet, Mexico. It is made up of dozens of governmental, non-governmental, and academic agencies and groups. The primary areas of focus in the programs current iteration include monitoring related to sediment and water quality, harmful algal blooms, trash and microplastics, microbial water quality on beaches, ecological functioning of estuaries, and ecological assessments of submerged aquatic vegetation. The Southern California Coastal Water Research Project (SCCWRP) has a data portal with limited data available, all from 2013 or earlier.
- **SONGS Wetland Mitigation Monitoring (https://marinemitigation.msi.ucsb.edu/) –** ***available/ongoing, Carpinteria Salt Marsh and Mugu Lagoon.*** The SONGS wetland mitigation monitoring program is managed by UC Santa Barbara and is designed to assess the performance of a large wetland mitigation site at San Dieguito Lagoon (in San Diego) by comparing physical and biological conditions at the mitigation site to three reference wetlands, two of which are in the BEACON region (Carpinteria Salt Marsh and Mugu Lagoon). Physical monitoring includes topography, water quality, tidal prism, and acreages of different habitat types. Biological monitoring includes fish, bird, and macroinvertebrate communities, vegetation cover, cordgrass canopy architecture, plant reproductive success, bird feeding activity, and exotic species. Data is available via the UCSB web portal.
- **Santa Clara River Estuary Monitoring (https://www.cityofventura.ca.gov/2196/Santa-Clara-River-Estuary-Monitoring) –** ***available/ongoing, site specific.*** The City of Ventura is overseeing long-term monitoring of the Santa Clara River Estuary as part of its VenturaWaterPure project. This includes the Pre-Construction Assessment Plan (PCAP) and a subsequent Monitoring and Adaptive Management Plan (MAAMP). The PCAP will collect data during a 3-year baseline period prior to reductions in the VWRF discharge to the estuary (2022 through 2025). The project tracks changes in

lagoon morphology, hydrology and ecology. Morphologic and hydrologic parameters include water quality data (continuous in-situ sensors and boat-based vertical profiling), bathymetry and beach berm height, berm status and lagoon mouth breach morphology, continuous surface and groundwater levels, Santa Clara River flow and connectivity, and water discharge rates from the reclamation facility. Biological parameters include levels of nutrients, Chlorophyll-a, macroalgae, and harmful algal blooms, fish surveys, shorebird populations, estuary edge habitat, and vegetation habitat mapping and transects. The subsequent MAAMP will include similar data collection efforts during Phase 1a of the VenturaWaterPure project (approximately 2025 through 2030), but with an additional focus on habitat triggers and thresholds.

- **Sedimentation monitoring –** ***ongoing partially available, at coastal wetland sites in the region.*** Sedimentation monitoring is important to understand the rate of wetland accretion, how accretion keeps pace or lags sea level rise, and resulting changes in habitats. Sedimentation is monitoring using feldspar horizon placement and coring, sedimentation plates or pins, and/or repeat ground-based topography surveys. WRP Regional Monitoring Program has installed feldspar plates at Goleta Slough and potentially other locations.
- **Supplemental topography surveys –** ***potential new monitoring, at coastal wetland sites in the region.*** As discussed in the Bluff Erosion Monitoring Plan, LiDAR topography data has been collected approximately every 5 years (i.e., 2010, 2016, 2021). This frequency is likely adequate for assessing large-scale topographic changes to intertidal portions of estuary wetlands. Focused supplemental ground-based surveys are important to ground-truth LiDAR in vegetated areas and confirm topographic changes.
- **Estuary and lagoon water level gages and stream gages –** ***potential new monitoring, at coastal wetland sites in the region.*** As discussed in the Combined Coastal and Fluvial Flooding Monitoring Plan (see Table 10), permanent gages as exist at Goleta Slough could be installed to monitor water levels in the BEACON region's main estuary and lagoon water levels, which would allow tracking of estuary water level response to storms and, over the long-term, sea level rise. Similarly, stream gages are needed to monitor and track fluvial influence.
- **Plant community and habitat mapping –** ***potential new monitoring, at coastal wetland sites in the region.*** Coastal wetland plant community monitoring and habitat mapping could be performed at sites throughout the region to assess and track changes over time. The WRP Regional Monitoring Program may facilitate data collection at the sentinel sites identified above.

Analysis and Products

- **Physical and ecological habitat change.** Data collected could be analyzed to assess changes over time in coastal wetland elevation, inundation frequency, geomorphology, plant communities, and habitat. Habitat change results could be provided in GIS web maps.
- **Modeling of habitat change with sea level rise.** Data collection and analysis could inform modeling and projection of future habitat change with sea level rise. Projections of habitat change could be provided in a GIS web map tool.

Plan execution options: Partnership with wetland managers, WRP Regional Monitoring Program, and academic institutions; consultant contract.

Pilot study options:

1. Partner with WRP Regional Monitoring Program to perform pilot studies.
2. Install coastal wetland water level gages in one more vulnerable site, such as Carpinteria Salt Marsh or Mugu Lagoon.

5.2.3 Potential Social Monitoring

Overview

The collection and analysis of accurate, current social data is crucial for informed decision-making and effective public policy, especially in the context of climate change adaptation. Social data enables coastal managers to understand who uses the beach, and what value they gain from it. Such data underpin the understanding of how human activities interact with environmental changes, enabling decision-makers to anticipate and mitigate the impacts of climate change on coastal areas. Social data, including beach attendance, usage patterns, and coastal access metrics, informs the allocation of limited public resources, ensuring that adaptations to changing coastal conditions are both effective and equitable. Data can be incorporated into benefit-cost analyses to quantify public benefits in adaptation decisions.

Building off of the importance of social monitoring presented in the introduction, social data can also allow social scientists and policymakers to see how humans respond to the geophysical changes that will occur with climate change. For example, if a beach's size is reduced by half, how will that change attendance patterns?

Social data measures *human use*. The policy and research that builds on this data is vital to understanding how our coast is currently used and how we might use it in the future. From an adaptation planning perspective, social research allows us to better identify public priorities and determine which adaptations will preserve, protect, and enhance those priorities. This ability is particularly important given that the California coast is a public resource protected under the California Constitution and mandated under the California Coastal Act of 1976.

Climate change adaptation is informed by a better understanding of the public's use of coastal resources; a vital component of public use is public access. One of the main goals of the California Coastal Act is to "maximize public access to and along the coast". However, social research is vital to understanding the extent to which this access is provided, and to whom. Coastal access has important implications for environmental justice and coastal resource management. Social data, including both cultural and economic data, can inform planning to preserve, and improve, coastal access for underserved and vulnerable communities.

Continued social research and better, more accurate, beach visitation data are vital to modeling the expected impacts of climate change. Climate change preparedness includes emergency preparedness—how the State, region, and local community respond in the wake of a disaster. Understanding public use of the coast can help communities determine how to respond after a severe storm or flooding event. As we face a future of climate-induced sea level rise and an increase in storm damage and flooding, having accurate, up-to-date information on the social utility of the coast, more specifically beaches, will facilitate the development of decision support tools to assess the trade-offs involved.

There are a range of social data improvements necessary to improve analyses, planning, and adaptation. Estimates of the value of coastal resources and understanding of their use rely on *accurate beach use and attendance data*.[6] Therefore, the top data monitoring priorities listed in **Table 13** are focused on attendance.

TABLE 13. TOP SOCIAL DATA MONITORING PRIORITIES

Priority Data	Key Questions Answered	Data Source	Frequency
Priority 1: Attendance Data	Who goes to the beach? Where do they come from? How long do they stay? How far will people drive to go to a preferred beach?	Cellphone Data for delineated beach areas On the ground visitor counts at targeted beaches (hourly and daily) Combined to provide full data outputs	Daily Counts. (purchased annually) Annually
Priority 2: Access, Amenities, and Parking Data	Which access points, amenities, and parking spaces are vulnerable to sea level rise? Which access points serve the most people and how are these spatially distributed? Which access points have desirable amenities? How will a change in parking affect access equity?	GIS database of access points (marked consistently), amenities, and parking associated with beaches	Database updated regularly
Priority 3: Flood and Storm Damage Impacts to Disadvantaged Populations	Who is adversely impacts by coastal flooding events? Are these primary residences? How severe are expected property damages? Are disadvantaged populations impacted?	Census data City and county parcel tax data	Database updated biannually (census update)
Priority 4: Barriers to Access	Why do people choose the beaches they do? Why don't people use coastal resources? What are barriers to access that result in equity issues?	Attendance data (derived from cell-phone locations information) Focus group interview panels Intercept surveys Latent demand surveys	Every 5 to 10 years
Priority 5: Beach Recreational Activities	Where are the home locations for recreation specific users? (Cell Phone data does not provide this) When and where is peak demand? What are the most used locations for surfing, fishing, and other recreational activities?	Cellphone data (Points of interest delineated around known surf locations)	Daily Counts (purchased annually)
Beach Management Governance and Finance	Who Manages the Beach? How are they funded? How are beaches currently managed for extreme storms and sea level rise	GIS Database of beach management agencies, beach management operations and costs, management for sea level rise	Part of a continuous integrated annual coastal access data program; Updated Annually
Beach Use and Beach User Coastal Access Datasets	Integration of data Data compatibility and comparability Data Accessibility Data Usability	GIS Dashboard Information Station • Data Assembly • Data Sources and • Data Management Data Availability and Usability	Part of a continuous integrated annual coastal access data program; Updated Continuously

6 King and McGregor (2012) found that official lifeguard attendance counts in the BEACON study area were inaccurate and inconsistent from beach to beach; many smaller beaches systematically overestimate attendance.

A recent study conducted for the Natural Resources Defense Council (NRDC) and co-authored by two members of the RCAMP team (Colgan and others, 2021), concluded that:

> *Because there is no systematic, regular assessment of coastal recreation in California it is difficult to make decisions about current and future uses of the coast. These decisions include addressing such questions of how much of the coast to set aside for conservation purposes. California has an extensive network of Marine Protected Areas in addition to federal and local conserved lands and waters. Perhaps even more critically, climate change will alter the physical dimensions of the California coast in ways that may dramatically alter future human uses. Without a baseline, the impact of these changes on visitation can never be known.*

As State and local stakeholders decide how to use their coast, we must have accurate data on who goes, why they go, and what are the key barriers to access for those who cannot go. The best available science informs us that California will lose up to two-thirds of its beaches by 2100 without intervention (Vitousek et al. 2023), but California's economy and population will continue to grow, and the hotter summers predicted by climate change models will increase the demand for beach recreation year-round.

Determining the value of coastal resources for planning purposes requires understanding their human use, or social utility, value from a range of ecosystem services, from cultural services such as recreation to storm protection), including their ecological value as critical species habitat. Estimating the associated value of these functions requires drawing on multiple types of data and data sources, including social information and data.

Valuing beach use in California involves a combination of traditional and emerging data sources and methods. BEACON has been coordinating a Coastal Access Data Working Group for the past three years developing additional social data sources, methods, and preparing a regional beach use and beach user regional monitoring program, integrating traditional on-the-ground data methods, with new sources of georeferenced, mobile device origin and destination data.

BEACON currently seeks to collect social data from its human beach use and human beach user data collection efforts, including both quantitative and qualitative information to improve management, including a focus on underrepresented communities. BEACON has looked to traditional methods of beach use data collection, and more recently, to more novel and new sources of beach use and beach user information focused on geo-referenced mass data from mobile device locations to fill in gaps in our knowledge base, as well as opportunities to utilize new technology, complementing more traditional sources of beach use information.

BEACON staff have been examining opportunities to develop new sources and methods of collecting human use data analyzing the use and applicability of new geo-located cell-phone location-derived data. BEACON has utilized traditional on-the-ground data collection efforts in the past, but many limitations make these efforts expensive, labor intensive and time consuming. However, each source has limits and constraints and requires that the sources be combined in an integrated program of data collection, data management, data analysis and development of decision-support frameworks and tools.

One missing part of the monitoring program is the lack of a transparent and accessible data 'dashboard' and the identification of a management agency to house such a data access portal. BEACON has proposed these various sources and methods of human beach use and human beach user be combined into a continuous program of integrated data collection, storage, development, and management organized under collaborative efforts by multiple partners.

Some of the most common data sources include:

- **Observational Studies:** These involve direct observation of beach areas to record visitor numbers, activities, and demographic information. Lifeguard counts are examples of observational studies used to gather data on visitor use dimensions and transportation patterns.
- **Intercept Surveys:** Intercept surveys are conducted by engaging directly with beachgoers to gather information about their motivations, experiences, spending behaviors, and preferences regarding amenities. These surveys provide insights into visitor demographics, origins, and amenity preferences.
- **Transportation, Traffic, and Parking Data:** Traffic and parking counts provide information on transportation patterns and visitor origins. They help understand how visitors access beach areas and can inform decisions regarding transportation infrastructure and management.
- **Latent Demand Studies:** These studies aim to understand the potential demand for beach access by examining visitor origins, demographics, spending behaviors, and amenity preferences. By analyzing latent demand, policymakers can anticipate future beach visitation trends and plan accordingly.
- **Social Media Analysis:** Analyzing social media platforms like Instagram and X (formerly known as Twitter) can provide insights into visitor sentiment, preferences, and behaviors regarding beach visits. Social media data can complement traditional methods by offering real-time information on visitor experiences and trends.
- **Cellphone/Mobility Data:** Cellphone data tracking involves using data derived from cellular phone locations to estimate visitation. This method can provide information on visitor counts, origins, duration of stay, demographics, and behaviors, offering a more passive and comprehensive approach to data collection.
- **Satellite and Aerial Imagery:** Satellite and aerial imagery can be used to assess beach attendance and visitor counts from a broader geographic perspective. These methods offer a bird's-eye view of beach areas and can help identify popular locations and trends over time.

By leveraging these diverse data sources, researchers and policymakers can develop a comprehensive valuation of beach use in California, informing coastal management strategies, infrastructure planning, and policy decisions. While these data sources provide valuable insights into beach visitation patterns, they also come with certain limitations:

- **Observer Bias:** Observational studies may suffer from observer bias, where the presence of researchers or lifeguards may influence visitor behavior, leading to inaccurate counts or representations of activities.

- **Sampling Bias:** Intercept surveys and observational studies may suffer from sampling bias if they do not adequately represent the diversity of beach visitors. Certain demographic groups or visitor types may be underrepresented, leading to skewed results.
- **Limited Coverage:** Traditional data collection methods like intercept surveys and traffic counts may have limited coverage, focusing on specific beach areas or times of the year. This limited coverage may not capture the full range of visitor behaviors and preferences across different regions and seasons.
- **Resource Intensive:** Traditional data collection methods can be resource-intensive, requiring significant time, effort, and funding to conduct surveys, observations, traffic counts, or data purchasing. This can make it challenging to sustain long-term or large-scale monitoring efforts.
- **Privacy Concerns:** Cellphone data tracking raises privacy concerns as it involves tracking individuals' movements and activities. While this data is typically purchased aggregated from a third-party vendor with all identifying personal information removed, the perceived privacy concerns are still an issue.
- **Data Interpretation Challenges:** Social media analysis and satellite imagery may present challenges in data interpretation, such as distinguishing between genuine visitor posts and promotional content on social media or accurately identifying visitor counts from satellite images amidst other environmental features.
- **Technical Limitations:** Emerging methods like cellphone data tracking and satellite imagery may have technical limitations, such as inaccuracies in location tracking or resolution limitations in satellite images, which can affect the reliability and accuracy of the data collected.

By acknowledging these limitations and considering them when interpreting findings, researchers and policymakers can better utilize these data sources to inform beach management strategies and policies effectively. Every method will have limitations. It's important to understand those limitations, while still using the best available science to inform decisions. Ideally, a standard monitoring protocol will rely on a set of monitoring parameters that is consistent spatially and temporally throughout the study regions, so data is comparable across sites.

Table 14 outlines the most common data sources, how they are monitored, and their limitations.

Plan execution options: Partnership with BEACON, CSUCI, and possibly other academic institutions, public agencies, and non-governmental agencies (NGOs), such as community non-profits.

Pilot studies: Some amount of the social data needs, including cultural and economic data needs, are currently incorporated in data collection efforts by BEACON and its partner agencies, and in the ongoing Beach Sustainability Assessment Project. These efforts need to be expanded and enlarged to fully address the full range of data needs, including the development and use of new sources of mass data. Given this situation, all the following priorities are necessary.

1. Obtain accurate cellphone data to analyze beach use patterns over time including an analysis of visitor origins, including underrepresented and underserved communities.
2. Regular periodic (1-2 years) surveys of beach visitors, including both observations and intercept surveys. As part of an annual program of data collection.

3. Regular periodic focused data collection of underserved communities, including surveys and focus group interviews. As part of an annual program of data collection
4. Develop necessary elements of integrated coastal access data program

TABLE 14. COMMON DATA SOURCES, MONITORING APPROACHES, AND ASSOCIATED LIMITATIONS

Data Type	Most Common Monitoring Approach	Limitations
Beach attendance counts	Observational Studies: Lifeguard counts	• Counts significantly overestimate • Don't include duration of visit
Beach attendance information (demographics, travel distance etc.)	Intercept surveys	• Time consuming • Costly • High potential for error
Beach access points	GIS analysis & mapping	• Location data does not include information on visitation/visitors
Recreational use (e.g., surfing and fishing)	Observations or expert opinion analysis	• Counts are often inaccurate • Expert opinions on surf spot use often differs greatly from observed counts • Peak times for surfing and fishing are different from other activities

Beach Attendance

Background

BEACON's most recent Coastal Access Data initiatives include partnerships with multiple public agencies and university and agency researchers, including researchers at California State University Channel Islands, who have been collecting and analyzing beach use data as part of the Beach Sustainability Assessment (BSA), developed by California State University Channel Islands (CSUCI) in partnership with San Francisco State University. While BEACON and CSUCI have partnered on additional beach use data efforts, the BSA is a larger rapid assessment tool and classification model designed to quickly capture the geomorphological, ecological, and socioeconomic health of a beach. BEACON may choose the partner further with the BSA researchers on developing elements of an integrated Coastal Access Data Monitoring Plan and on the development of a public data portal.

BEACON's potential to invest in enhanced data infrastructure presents an opportunity to assist local communities in bolstering their monitoring capabilities concerning coastal access and recreational activities, leveraging innovative methodologies (refer to Section 7.1) and standardized data collection protocols.

Researchers at CSUCI, UCSB, and San Francisco State are currently in the final phase of a project funded by the State Science Information Needs Program, funded by the CSU Council on Ocean Affairs, Science & Technology (COAST), and Sea Grant, aimed at enhancing the Social Utility Grade of the BSA. This refined metric aims to address environmental justice concerns, including barriers to beach access and equity in access, through a multifaceted approach. This approach encompasses on-site intercept surveys, focus groups in underserved areas within Santa Barbara and Ventura counties, and Latent Demand, or "telephone" surveys.

BEACON is pioneering the feasibility and applicability of using geo-referenced mobile phone location-derived data for analyzing public beach use with a Dr. Patsch at CSUCI and other partners. This data source is an important additional source of beach visitor data.

Mobility, or cellphone, derived location data are multifaceted, rapidly evolving, and come in various formats and styles with varying attributes. Fundamentally, these data are rooted in the collection of smartphone location information by various applications installed on these devices. Once collected, this information is sold to data companies, which aggregate and process it, ensuring the removal of any personally identifiable information, to derive valuable insights such as foot traffic patterns and visitor origins at the census block group level.

To ensure precision in beach visitation data, BEACON is implementing a range of alternative sources and methodologies, such as expanded periodic 'continuous' counts, use of cellphone-derived visitation data, or other innovative sources and methods.

Data and Monitoring

- **Cell phone data calibrated with on the ground beach use and attendance data – *available, regional*.** cellphone location-derived visitation datasets and information include both visitor origin and beach destination data, identifying hourly and daily unique visitor counts to identified beach access sites. There remain many limitations in the use of this geo-referenced data. Even with the limitations, cellphone location-derived beach use data is the best available data for this type of analysis both temporally and spatially. The Monitoring Plan recommends that mobile device data be paired with on-the-ground beach use and attendance data to calibrate visitation estimates.

Analysis

The use of cellphone derived beach use data can be used for many complementary analyses, including:

- Further develop and improve evaluation methods and expand data collection and analysis of market and non-market values for social ecosystem services, focused on beach access and recreation, and visitation.
- Improve methods and sources for estimating the full range of beach visitation costs, building on current analysis models, for example, employing ecosystem services framework and data into Cost-Benefit Analysis.
- Deepen insights into beach visitor demographics and origins to better grasp coastal access dynamics, inequities, and nuances in recreation demand.
- Identify beaches offering recreational opportunities to communities with the highest needs, leveraging tools in California, including OEHAA's CalEnviroScreen and DWR's DAC Mapping Tool.
- Provide more detailed information regarding visitation use patterns (days of the week, time of day, time of year) at beaches to inform management and planning.

Products

- **Annual Beach Use Estimate Reports:** Using cell phone data, annual reports could be generated, comparing annual beach use. Local management agency counts could corroborate the cell phone data where available. BEACON is also currently developing additional beach use and attendance data through continuous counts and intercept surveys to complement cell phone data.

- **Plan execution options and pilot studies – see Overview section**

Beach Access

Background

Beaches provide a wide array of amenities and recreational opportunities from general beach recreation to picnicking. Beach goers have varying preferences for these and other opportunities and amenities, such as lifeguards and snack bars. Ease of access to California beaches varies greatly. Some beaches provide parking, although in many cases parking is limited and paid. At others, there is no public parking and access points may be difficult to find between private homes. Regular geospatial analysis of these access points and any changes to accessibility factors into better understanding of beach use.

A complete social analysis would incorporate these amenities and how they factor into visitors' decisions. Currently the Beach Sustainability (BSA) Assessment Project (Patsch, et al. 2024) is analyzing this data as part of a grant. Patsch and Reinemann (2024) examine the impacts of sea level rise on California's beaches and access.

Access for All—ensuring that all communities can participate in coastal recreation, is also a high priority for the State of California. Christensen et. al. (2017) and Patsch and Reinemann (in press) examine how access is unevenly distributed along southern California's Coast. The use of cell phone data allows for not only pinpointing when and where people go to the beach and other coastal access spots, but also where they reside. The CalEnviro screen allows planners to identify visitors from underserved communities and this identify which beaches and management strategies increase access for the underserved.

Looking ahead, as beaches within the BEACON region face threats that could decrease their number and size, planners will face the challenge of understanding the crucial factors for preserving a range of ecosystem services, including recreational and ecological values. Monitoring and analyzing cell phone beach use data will significantly improve the ability to assess and quantity the social benefits and tradeoffs of adaptation, including more accurate benefit-cost analyses in adaptation planning.

Data and Monitoring

- **Intercept surveys – *new potential monitoring, site specific*.** Conduct intercept surveys every on a regular schedule to gather additional data on beach use and beach users to validate and complement cellphone-derived data.
- **Focus groups – *new potential monitoring, site specific*.** Conduct periodic focus groups with local residents from underserved communities to monitor barriers to access and communication pathways.
- **Beach access and amenities – *new potential monitoring, site specific*.** Maintain an inventory of data related to beach access locations and amenities, including parking (official beach parking and available local parking). This database should be updated annually to incorporate changes due to climate events, closures, or development. (Patsch and Reineman, 2024)

- **Latent demand surveys – *new potential monitoring, regional*.** Conduct latent demand or “telephone” surveys on a regular schedule starting in 2024 and thereafter every 24-36 months to identify barriers to access and changing visitation patterns.

Analysis

- **Travel costs and economic impacts.** Revise travel cost and economic impact (spending) estimates for specific beaches using survey and cellphone data on visitor origins.
- **Travel distance.** Determine visitor travel distance to access specific beaches using geospatial analysis of access point data and parking data.
- **Demand for different types of recreation and beach amenities.** Analyze what types of recreation visitors engage in and recreational facilities they use.

Products

- Provide revised travel cost estimates for regional beaches to identify disparities and inequities in beach access costs between regional beach users.
- Develop an interactive website (managed by a regional entity such as BEACON to ensure data availability and transparency) with drop-down menus for each beach, including:
  - Total number of visitors (monthly) for each beach (Generate annual beach use and attendance reports)
  - Demographic information of visitors
  - Average duration of stay
  - Estimate capacity for each beach, including beaches and recreation specific areas, such as surfing.
- Updated inventory of impacts to access points and amenities including parking due to sea level rise and coastal storm events building on the database created by Patsch and Reineman (2024).
- Identification of the “beach use market area” for each beach, analyzing who goes. BEACON is completing initial identification of beach use ‘market areas’ using cell phone data. The data can tell the origin of beach user disaggregated to the census block group level across time. The identification of a ‘market area’ or ‘visitor-shed’ would not by itself tell us the why.
- Identification of barriers to access, identifying those who do not go to the beach. Detailed description of each beach's current management plan with appropriate links.
- Detailed description of each beach’s current management plan with appropriate links
- **Plan execution options and pilot studies – see Overview section**

Flooding and Storm Impacts – Demographics

Background

With rising sea levels and increasing inundation risk throughout California, coastal property is increasingly at risk of severe flooding. Understanding who is impacted by these events, and how severely, is fundamental to climate adaptation, and to emergency response and management after a flood. There are at-risk populations—those who cannot easily absorb the costs of lost or damaged property or retreat from at-risk areas. Regular geospatial analysis of the at-risk properties and populations will inform planning and mitigation.

All the demographic data necessary to understand who is impacted by flooding is readily available from public agencies and routinely updated. Flood and storm surge monitoring would need to be updated regularly based on the physical data collected and the latest science to accurately capture expected damage.

Data and Monitoring

- **Affected populations – *available, regional*.** Using up to date Census data and parcel tax data, determine the demographics of residents of at-risk properties (e.g., median income, primary vs secondary home, age, race, ethnicity).
- **Affected properties – *new potential monitoring, regional*.** Based on the best available science and as modeling and monitoring evolve, maintain a geospatial database of at-risk properties. Determine loss or damage and expected cost.

Analysis and Products

- Assessment of impacts to private residences and who is impacted by flooding.
- **Plan execution options and pilot studies – see Overview section**

5.2.4 Potential Cultural Resources and Chumash Monitoring

Overview

The Chumash people have inhabited their ancestral lands for centuries, encompassing all of the BEACON counties of Ventura and Santa Barbara, and extending from Los Angeles County to San Luis Obispo County, including portions of inland regions. The Santa Ynez Band of Chumash Indians, a sovereign nation located in Santa Barbara County, is currently the only federally recognized Chumash band among a total of 14 distinct bands.

In 2020, the Santa Ynez Band led a coordinated effort involving 11 of the 14 Chumash bands to document the impacts of climate change across traditional Chumash territory (SYBCI 2019, 2020a, 2020b, and 2020c).

Sea level rise and coastal erosion are already affecting culturally significant Chumash sites along the California coast (PBMI and SYBMI 2021). As sea levels continue to rise, traditional gathering areas are becoming inaccessible, and erosion is damaging sacred and historical locations. (SYBCI 2022) The loss of access to these sites disrupts the transmission of cultural knowledge and traditions, a loss deeply felt across generations of tribal members (PBMI and SYBMI 2021; SYCEO 2021).

For example, the California Climate Change Report notes that Olivella shells, which are traditionally gathered by the Chumash for use in shell money, jewelry, and regalia, are becoming increasingly scarce (SciNews 2021). Many of the customary gathering areas for these shells are now inaccessible due to environmental changes (PBMI and SYBMI 2021; OEHHA 2022).

The Chumash have long relied on both terrestrial and marine ecosystems for sustenance and cultural practices. According to the State of California's 2022 report, climate change, through ocean warming and acidification, has already impacted species vital to Chumash lifeways (PBMI and SYBMI 2021; OEHHA 2022).

Numerous species important to the Chumash are now threatened, including Belding's Savannah Sparrow, tidewater goby, steelhead, snowy plover, willow flycatcher, white-tailed kite, monarch butterfly, Coastal Range newt, Western Pond Turtle, and brown pelican.

The Santa Ynez Chumash have already observed reductions or local extinctions of species such as steelhead, red-legged frogs, kelp, seagrass, and Olivella.

Additionally, plant communities and animal habitats are expected to face further disruption due to both primary climate drivers (e.g., temperature shifts, precipitation changes, sea level rise) and secondary climate impacts (e.g., drought, wildfire, flooding, cliff erosion, and debris flows) (SYBCI 2020a).

The Monitoring Plan seeks to incorporate indigenous knowledge and associated purposes into monitoring and coastal adaptation efforts. The RCAMP team met with tribal leaders from the Northern Chumash Tribal Council and the Coastal Band of Chumash. Through meeting with these tribal representatives, suggestions and insight that came up were not necessarily specific to cultural monitoring components. However, the suggestions were identified as important goals and objectives to be considered as monitoring priorities. The tribal representatives shared their suggestions and thoughts about coastal adaptation monitoring. The information shared by tribal leaders is summarized and included in the Monitoring Plan as overarching input that could apply coastal adaptation monitoring.

A distinction was made between the act of monitoring and the act of observation. The act of observation involves spending time in each season on a site, experiencing the elements and seasonal changes to the vegetation, shoreline, streams, and wildlife. Tribal leaders recommended that including indigenous people and/or other participants in monitoring efforts who spend time on the sites and have deeper understanding of the sites would be beneficial to the monitoring methods outlined in this plan. A way to provide this could be to invite tribal members to the planning meetings for the monitoring projects, and to make sure that those involved in the process are knowledgeable of the sites.

In regulatory settings, cultural resources may be defined to only include cultural sites that have historical tribal importance and artifacts. However, there are also natural resources important to the Chumash that can be monitored as triggers for coastal adaptation. Sites with important natural resources may not have Chumash artifacts, but still hold significant importance to the Chumash and other indigenous groups. The following are two general examples of natural resources that should be considered as cultural resources in the Monitoring Plan:

- *Culturally significant species and habitats* – Culturally-significant species, such as leopard sharks and certain species of mollusk, and habitat features such as general kelp density can be monitored for preservation of culturally significant ecosystems.

- *Landscapes* – Undeveloped and preserved lands are significant to indigenous people and should be conserved and protected as cultural resources. Monitoring these lands for degradation is especially important to indigenous people.

To expand the Chumash presence in the BEACON region, a location could be chosen for Chumash members to meet and lead a monitoring program to encourage Chumash youth and Chumash presence on the coast. Supporting the establishment of a Chumash community-led science program would provide an opportunity for Chumash youth to experience the outdoors and grow their own attachment to the land. This program would include ecological and physical observation and visiting different coastal areas year-round.

In summary, Chumash tribal leaders provided overarching input and recommendations that apply to *all coastal adaptation monitoring* included in the Monitoring Plan, which include:

- Involve indigenous people and knowledge in the monitoring planning processes,
- Include monitors who spend time on the coast through the seasons,
- Recognize natural resources as significant for indigenous people, and
- Propose a Chumash youth monitoring program location on the coast.

Implementation of the physical, ecological, and social monitoring plans described in the above sections should incorporate the above recommendations.

In addition, a partnership with the Tribal Marine Stewards Network should be considered, as the network represents an alliance of Tribal Nations working to steward, protect, and restore ocean and coastal resources within their ancestral territories. This network includes the Santa Ynez Band of Chumash Indians, offering an opportunity to share knowledge and build Tribal capacity for monitoring coastal resources while integrating Traditional Knowledge and Tribal Science into long-term coastal management practices. Through such collaboration, culturally informed monitoring and planning efforts could be strengthened across the BEACON region.

Over the past year, BEACON has actively engaged with representatives from Chumash tribes and will continue this outreach as it advances the RCAMP, including for the CEQA review of this Monitoring Plan. This commitment aligns with the consultation policies and practices adopted by the State of California, including the Tribal Consultation Policy of the California Native American Heritage Commission (NAHC). Adopted on July 15, 2016, the NAHC defines consultation as:

> *The meaningful and timely process of seeking, discussing, and carefully considering the views of others for the purposes, where feasible, of seeking agreement. Consultation between government agencies and Native American Tribes shall be conducted in a way that is mutually respectful of each party's cultural point-of-view. Consultation shall also recognize the tribes' potential needs for confidentiality with respect to places that have traditional tribal cultural significance.*

Chumash Cultural Resources Sites Erosion

The Monitoring Plan team identified monitoring Chumash cultural resource sites erosion as a potential Monitoring Plan component. There are several notable cultural sites along the BEACON coastline and riverbanks that have become exposed and are at risk of exposure with storm events and sea level rise. These cultural sites should be monitored for risk of exposure from erosion, predominantly on bluffs and streambanks. Post-storm event monitoring should also be performed as reconnaissance for artifacts in stream corridors following significant events. Coordination with the tribal organizations and groups in the BEACON region is necessary to identify and monitor these culturally sensitive locations. Cultural resource data for these sites is partially available, though information on extents and locations of cultural resource sites is widely unknown. Additional outreach and coordination to tribal members and BEACON partners is needed to confirm sites and extents and understand what information is currently available and in use. It is important to note that this material is highly sensitive and should remain confidential. Physical monitoring methods discussed in Section 5.2.1 could be used to monitor potential erosion of cultural resources sites; however, Chumash tribal representatives should be consulted further to develop a detailed cultural resource sites erosion monitoring plan.

Plan execution options: partnering with the tribal organizations, consultant contract for coordination and support.

Pilot study option (study and prioritization to be confirmed by Chumash tribal representatives):

- Collaboration with Chumash tribal representatives to develop a detailed cultural resource sites erosion monitoring plan.

Intentionally Blank

6. MONITORING PLAN PRIORITIZATION AND RECOMMENDATIONS

All monitoring elements are important to advancing scientific understanding of local sea level rise impacts. However, current resource constraints and funding availability necessitate identifying highest priority actions. Recommended Monitoring Plan elements and pilot projects are prioritized below. The prioritization considers stakeholder input and informs the selection of the pilot study based on how best to use the currently available $200,000 grant during the pilot period.

6.1 Criteria

The following criteria were developed with input from BEACON members and stakeholders to evaluate the monitoring elements against the Monitoring Plan goal and objectives (see Section 2). Each of these criteria are intended to guide the prioritization of monitoring elements that are effective, relevant, and sustainable. They provide a comprehensive framework for evaluating the monitoring elements and guiding their implementation in the BEACON region.

- *Degree needed to protect loss of life:* This criterion assesses the extent to which the monitoring elements help mitigate risks and prevent loss of life.
- *Supports adaptation plan implementation and adaptation pathway decision making:* This criterion assesses whether the monitoring elements contribute to the execution of the adaptation plan and facilitate decision-making processes for adaptation pathways. It's crucial that monitoring elements align with the overall strategy and aid in making informed decisions.
- *Supports specific adaptation project needs:* The monitoring efforts are directly relevant and beneficial to adaptation projects.
- *Promotes equitable adaptation planning:* The monitoring should provide data related to equity to inform just adaptation decisions as stated as an objective.
- *Applicable throughout BEACON region:* The monitoring elements should be applicable across the entire BEACON region. This ensures that the data collected is representative and useful for the entire region, not just specific areas.
- *Includes Chumash tribes:* The monitoring elements should ideally support Chumash tribes' objectives and/or include Chumash tribal representatives.
- *Related to specific permitting needs:* This criterion assesses whether monitoring efforts could support compliance with relevant regulations and permits.
- *Leverages ongoing monitoring efforts:* The monitoring elements should ideally build upon existing monitoring efforts. This can lead to synergies and efficiencies, avoiding unnecessary duplication of work.

- *Reasonable to implement:* The feasibility of implementing the monitoring elements is a key consideration. This includes factors such as technical feasibility, resource availability, and the practicality of monitoring methods.
- *Cost-effectiveness:* This criterion evaluates whether the benefits derived from the monitoring elements justify the costs incurred in their implementation.
- *Ability for other entity to eventually take over monitoring:* The monitoring elements should be designed in a way that allows for the possibility of another entity taking over the monitoring efforts in the future. This ensures the sustainability and continuity of monitoring efforts.
- *Transferability to other jurisdictions in the state:* The monitoring elements should be transferable to other jurisdictions within the State. This promotes consistency and standardization across different regions and allows for shared learning and best practices.

6.2 Priorities and Recommendations

The RCAMP team identified data collection and analysis priorities based on the criteria above and stakeholder input. The evaluation process first prioritized analyses to support regional coastal adaptation decision-making needs and then identified data gathering priorities necessary to support those analyses.

For analyses, the prioritization process defined the analysis need, frequency of analyses and reporting, overall evaluation and priority, and—where available—initial “ballpark” cost estimates. Based on each analysis’s evaluation, priority, and frequency, the team grouped analyses into the following phases:

- **Pilot study phase** (next 1 to 2 years)
- **Phase 1 monitoring** (within 3 to 5 years)
- **Phase 2 monitoring** (5 to 7 years)

To guide implementation and resource allocation, each Monitoring Plan component was assigned a priority level based on its importance to decision-making, alignment with RCAMP goals and objectives, and its ability—or need—to support other components:

- **Critical Priority:** Essential for decision-making, strongly aligned with RCAMP goals, and foundational to completing other Monitoring Plan components.
- **High Priority:** Highly important for decision-making and well-aligned with RCAMP goals.
- **Priority:** Advances significant scientific understanding and/or depends on the completion of other components to be fully effective.

Table 15 presents the analysis evaluations, priorities, and phasing, organized by phase and priority. Some cost estimates in the table are marked as “to be determined” (TBD) for monitoring activities that require additional detailed assessment and planning before accurate costs can be established. For example, costs for stream gauges can vary substantially based on location and technical specifications.

Table 15. Monitoring Plan Priorities, Analysis and Data Needs, and Cost Estimates by Monitoring Phase

Phase	Need Category	Needed Analysis	Analysis Frequency	Reporting Frequency	Data Needed for Analysis	Data Collection Frequency	Priority Level Evaluation	Priority	Initial Cost (Estimated Range)	Repeat Analysis Cost (Estimated Range)
Pilot study phase (next 1 to 2 years)	Sea Level Rise	Determine sea level rise amount and rate of change. Compare change in sea level to sea level rise projections using a baseline year of 2000. Indicate any coincidence with El Niño-Southern Oscillation events.	3 to 5 years	3 to 5 years	Sea levels	Continuous	Required for making many decisions and other second-order analysis.	Critical Priority	$20,000–$40,000	$15,000–$30,000
	Sandy Beach Shoreline Change	Regularly mapped spring shoreline position (MHW)	Annual	1 to 5 years	Annual (spring) or biannual (fall and spring): shoreline positions and beach width	Annually (spring) or biannually (fall and spring):	Required for making many decisions and other second-order analysis. Spring information shows end of winter exposure. Triggers for adaptation are not likely tied to maximum erosion during storms (see Sandy Beach Shoreline Change).	Critical Priority	$200,000–$360,000	$60,000–$240,000
		Regularly updated Spring beach width, change, and rate of change analysis	3 to 5 years	3 to 5 years	Annual shoreline positions and beach widths	Annual, Spring	Required for making many decisions and other second-order analysis	Critical Priority	Included above	Included above
		Storm erosion and recovery	3 to 5 years	3 to 5 years	Biannual seasonal shoreline positions and beach widths for at least a couple of beaches	Biannual, Fall and Spring	Useful to understand seasonal vs long-term changes for resource management and planning.	Critical Priority	Included above	Included above
		Post-storm erosion extent in winter	Annual	1 to 5 years	Post-storm shoreline position and beach width	Ad-hoc annually	Would help to inform post-storm erosion and storm damage. However, adaptation triggers likely based on seasonal erosion (Sandy Beach Shoreline Change).	High Priority	$20,000–$30,000	$10,000–$30,000
	Bluff Erosion	Top and base of bluff position	Annual	1 to 5 years	Bluff top edge position and base of bluff position	Annual	Required for making many decisions and other second-order analysis	Critical Priority	$80,000–$200,000	$50,000–$100,000
		Rate of change of position of bluff top edge and base of bluff	3 to 5 years	3 to 5 years	Bluff top edge position and base of bluff position	Annual	Required for making many decisions and other second-order analysis	Critical Priority	Included above	Included above
Phase 1 monitoring phase (3 to 5 years)	Storm Events	Monitor storm intensity (rainfall, flood levels, and wave heights) and estimate storm recurrence frequency based on comparison with historical frequencies and climate model projections.	Annual	1 to 5 years	Rainfall totals and intensity, stream flow rates, wave heights and periods, water levels in lagoons	Continuous	Post-storm analyses of storm frequency (e.g., 20-year, 50-year) are typically lacking. Would be very useful to communicate risks, assess increases in frequency, and inform management and decision making. Relevant to environmental justice.	High Priority	TBD	TBD
		Standardized event documentation of storm event extents and impacts. Estimation of extent and duration of flooding and erosion during storms.	Annual	1 to 5 years	Documenting physical extent of event, costs to resource managers, and storm event narrative (what happened, where, when, and response)	Annually during storms and after storm season.	Post-storm analyses of storm frequency (e.g., 20-year, 50-year) are typically lacking. Would be very useful to communicate risks; assess increases in frequency, extent, damages, and costs; and inform management and decision making. Could be time consuming. If reporting was standardized, though, it could be efficient when needed to obtain funding and communicate impacts. Relevant to environmental justice. Related to federal funding.	High Priority	TBD	TBD
	Combined Flooding	Refined vulnerability modeling of combined coastal and fluvial flooding and mapping, in particular lower-level and more frequent storm events (aka 10- and 20- year events as opposed to 100-year)	3 to 5 or more years	3 to 5 or more years	Monitor and analyze rainfall, stream flow rates, lagoon water levels, wave heights and periods, information on flooding extents and duration	Continuous	Needed to understand more frequent flooding events. Could be done jurisdiction by jurisdiction but would be more costly and fragmented. Related to environmental justice.	High Priority	$300,000–$800,000	TBD
	Chumash Cultural Resources	Comparison of cultural resource locations with existing hazard maps to identify potential future impacts	3 to 5 or more years	3 to 5 or more years	Cultural site locations. Hazard maps	N/A	Important cultural resources that are not currently being monitored. Results will not be able to be public and only select entities can view. Consultation a priority. Needed for project permitting.	High Priority	TBD	TBD
		Erosion impacts to cultural sites	5 years	5 years	Surveys of impacted areas	Annual post storm (spring)	Important cultural resources that are not currently being monitored. Requires specialized and resource-intensive monitoring if conducted after each event. Results will not be able to be public and only select entities can view. Second-order analysis that requires physical monitoring.	Priority	TBD	TBD
		Changes and impacts to culturally significant species, habitats, and landscapes	5 years	5 years	Surveys of species and habitats	Every 2 years	Analysis would require a lot of physical and ecological monitoring.	Priority	TBD	TBD

Phase	Need Category	Needed Analysis	Analysis Frequency	Reporting Frequency	Data Needed for Analysis	Data Collection Frequency	Priority Level Evaluation	Priority	Initial Cost (Estimated Range)	Repeat Analysis Cost (Estimated Range)
	Social Vulnerability	Changes and disruption of visitation, and beach use	5 years	5 years	Beach use numbers, beach width, facilities impacts, including parking	Annual	Useful information for resource managers. Second order analysis that requires information on storm events and physical changes.	Priority	TBD	TBD
		Which communities, including Disadvantaged Communities, are being impacted by storms, flooding, and erosion events	3 to 5 or more years	3 to 5 or more years	Hazard maps; census data, new storm damage reporting system	Annual	Useful information for resource managers to integrate equity into planning and decision making. Second order analysis that requires information on storm events and physical changes. Also needed for grant funding.	High Priority	TBD	TBD
		Economic impacts	3 to 5 or more years	3 to 5 or more years	TOT; sales tax	Annual	Useful information for resource managers for long-term planning and decision making. Second order analysis requires information on storm events and physical changes.	Priority	TBD	TBD
Phase 2 monitoring phase (5 to 7 years)	Sediment Movement	Analysis of movement of sediment through littoral cell, potentially including projections for future sediment movement patterns	3 to 5 or more years	3 to 5 or more years	Shoreline change (see category above), dredging and sediment/debris basin removal volumes and grain size data and shoreline topography, bathymetry and beach widths including at sediment placement sites in various portions of the littoral cell. Consider conducting topographic/bathymetric surveys of sediment placements (before and after placement)	Annual	Would be useful for assessing effectiveness of adaptation actions.	High Priority	TBD	TBD
		Effectiveness of placement and nourishment	3 to 5 or more years	3 to 5 or more years	Shoreline change (see category above), sediment placement volumes and grain size data, shoreline topography, bathymetry, and beach widths before and after placement,	Biannual (fall and spring)	Would be useful, but if in limited locations may not be very predictive region wide given different characteristics of beaches throughout region.	High Priority	TBD	TBD
	Shallow Groundwater Rise	Analysis of change in shallow groundwater elevations	3 to 5 or more years	3 to 5 or more years	Shallow groundwater levels	Annual	Useful information. Could be done locally but would be more useful and less fragmented if done regionally.	Priority	$100,000–$200,000	TBD
	Habitat Changes	Changes in shoreline habitats	3 to 5 or more years	3 to 5 or more years	Habitat location and extent. Beach widths.	Every 2 years	Second order analysis that would be good information but not critical to infrastructure and life safety. If we believe in nature-based adaptation projects and programs (which is the state's preferred adaptation strategy, then this information will be of critical importance. Needed for project permitting	Priority	TBD	TBD
		Changes in estuary and wetland habitats	3 to 5 or more years	3 to 5 or more years	Habitat location and extent.	Every 2 years	Second order analysis that would be good information but not critical to infrastructure and life safety. Needed for project permitting	Priority	TBD	TBD
		Changes in sensitive species	3 to 5 or more years	3 to 5 or more years	Sensitive species types, locations, and numbers	Every 2 years	Second order analysis that would be good information but not critical to infrastructure and life safety. Needed for project permitting.	Priority	TBD	TBD
	Effectiveness of Nature Based Adaptation Methods	Annual shore change compared to a non-project baseline. Assets impacted.	3 to 5 or more years	3 to 5 or more years	Shoreline position	Fall	Second order analysis that would be good information if could easily be achieved at same time as higher priority items.	Priority	$50,000–$200,000	TBD
		Storm wave runup, sand deposition, and erosion compared to a non-project baseline. Assets impacted.	3 to 5 or more years	3 to 5 or more years	Shoreline position, storm wave runup, deposition of sand during storms.	Spring and Fall	Second order analysis that would be good information if could easily be achieved at same time as higher priority items.	Priority	$40,000–$80,000	TBD
		Evaluation of habitat restoration performance	3 to 5 or more years	3 to 5 or more years	Plant community location, type, and density	Annual	Good information for project decision making.	Priority	$40,000–$80,000	TBD

Following the analysis prioritization, data gathering and collection priorities were developed to support identified analysis needs. This process considered existing data sources, new data collection, various data collection methods, and qualitative discussions of costs and benefits, including (where available) initial ballpark cost estimates.

Table 16 summarizes the data assessments, priorities, and phasing—also organized by phase and priority—and presents RCAMP's concluding data collection recommendations.

Critical Priority Monitoring

- **Sea level rise:** Sea level rise is a trigger for most adaptation plans and is therefore critical to monitor. NOAA provides long-term rates of past sea level rise and additional information for the Santa Barbara water level gage. NOAA also provides more detailed information on the change in sea level rise rate over time for the Santa Monica and Los Angeles water level gages, which have longer records than Santa Barbara. These data could be analyzed to estimate the amount of sea level rise and increase in extreme high water levels that have occurred since a baseline date, such as 2000. In coordination with NOAA, this analysis could be performed or planned as a pilot study.
- **Sandy beach shoreline change:** This effort provides beach width data to assess erosion and flood risk triggers for adaptation. Critical priority recommendations related to sandy beach shoreline change for the Monitoring Plan are:
  - **LiDAR and Aerial imagery-based topography.** Analyze and synthesize a combination of available satellite imagery, ground-based shore profile surveys by USGS and BEACON members, aerial topography (LiDAR data from USGS, NOAA, and others; derived from USGS aerial imagery), and camera data (Carpinteria beach camera, CoastSnap, and possibly Surfline cameras and/or new cameras) to provide shoreline position and beach width data and metrics for adaptation planning.
  - **Satellite imagery.** This could include deriving shorelines from available aerial topography, partnering with USGS to develop viewers for shore profile surveys and satellite data analyzed previously for CoSMoS, and analyzing more recent satellite data using available tools (e.g., USGS methodology, CoastSeg, CoastSat). Data could be provided through a public interactive digital "library" of shoreline data with tools or methodologies for visualizing data and metrics (e.g., shoreline positions and beach width over time).
  - **Continue USGS shore profile surveys.** While satellite and aerial survey data are available, ground and bathymetric profile surveys provide additional and more accurate data that are useful for monitoring shore change and ground-truthing aerial data. USGS conducts annual fall shore profile surveys throughout the BEACON region. USGS is progressing the processing of data collected since 2007 through an internal review process required by USGS. USGS plans to make these data available in 2025.
- **Bluff erosion:** Regional LiDAR topography data have been collected by USGS and NOAA approximately every five years over the last decade. USGS collects oblique aerial imagery every one to two years, which can be analyzed to develop topography data. USGS plans to do this analysis in the future for the BEACON region, and data may be adequate to monitor, analyze, and track bluff erosion.

High Priority Monitoring

- **Sandy beach shoreline change:** This effort provides beach width data to assess erosion and flood risk triggers for adaptation. High priority recommendations related to sandy beach shoreline change for the Monitoring Plan are:
  - **Perform supplemental spring profile surveys at USGS shore profile locations.** Spring profile surveys are important for monitoring post-winter beach conditions and width as triggers for adaptation. A potential pilot study is to perform spring profile surveys for at least two “erosion hot spot” beaches.
  - **Utilize cameras.** Cameras are a potentially efficient method to monitor storms and shoreline response for specific sites but require ground-truthing elevation surveys. Camera data from the existing Carpinteria City Beachcam and CoastSnap stations at UCSB East Campus Beach, Stearns Wharf, and Surfers’ Point are available. Options for expanding a camera network should be investigated including potentially public, university, private, and private non-profit partnerships, such as CoastSnap, USGS’s CoastCam program, or Surfline services.
  - **Drone-based topography.** Drone-based data can be used for supplemental monitoring of seasonal and storm changes and sediment management events at select sites in between regional collection events by airplane, where it may provide higher resolution.
- **Storm events, damage, emergency response & recovery:** Information on storm damage frequency and repetitive damages would be used to assess related thresholds for adaptation.
  - **Wave and water level data.** Storm parameter data is available (i.e., rainfall, creek discharge, Santa Barbara water level gage, and waves), but could be supplemented with additional stream gages, a new permanent water level gage in Ventura Harbor, a new wave buoy (in partnership with CDIP and/or SCCOOS) or separately in the eastern Santa Barbara channel), and wave runup calculations.
  - **Documenting physical extent of events.** Useable data on actual storm event flood extents and damages are largely lacking. BEACON members could potentially use existing and Customer Relations Management (CRM) systems as storm flooding and damage reporting systems. The utility of existing Surfline camera data and the Carpinteria City Beachcam could be assessed, and new cameras could also be installed to monitor flood-prone areas.
  - **Pre- and post-storm surveys of erosion hotspots.** These could be performed to characterize shoreline erosion extents. As a potential pilot study, a web dashboard and data viewer could be developed that compiles available storm parameter data to allow BEACON members to assess storm conditions (see Summary of Recommended Pilot Study section below for details). Pre- and post-storm erosion surveys could also be performed as part of pilot studies.
  - **Beach habitat characteristics.** Shore profile surveys of wrack line and other habitat parameters, along with repeat photography, can support beach habitat monitoring. These measurements may be taken in conjunction with existing shore profile surveys at low incremental cost. BEACON should coordinate with USGS to integrate habitat data into their shore profile monitoring program.

TABLE 16. MONITORING DATA GATHERING AND COLLECTION ASSESSMENT, PRIORITIES, RECOMMENDATIONS, AND COST ESTIMATES BY MONITORING PHASE

Phase	Category	Data Need	Methods	Other Data Needs Addressed	Existing	Potential New	Cost/Benefit	Recommendation/Roles	Priority	Initial New Data Collection Cost Estimate	Subsequent Data Collection Cost Estimate	Cost Note
Pilot study phase (next 1 to 2 years)	Sea Level Rise	Water levels	Tide gage	Storm Events, Combined Flooding	Santa Barbara tide gage	Ventura Harbor tide gage	Currently performed by NOAA.	(1) inquire when additional sea level rise analyses results will be available for Santa Barbara gage; (2) inquire with NOAA on feasibility of re-establishing Ventura tide gage (optional)	Critical Priority	$50,000–$100,000	$30,000–$40,000	For one permanent gage with annual maintenance, data management, and analysis
	Sandy Beach Shoreline Change	Shoreline positions	Aerial imagery-based topography (by airplane camera, topography above water line only)	Bluff Erosion, Sediment Movement, Habitat Changes, Effectiveness of NBS	Collected by USGS twice per year every 2 years (and occasionally every year)	Collection during years when not collected by USGS	Currently performed by USGS. Cost for new additional collection TBD (~$100-200k/collection for region for one flight and data processing)	Support continuation of USGS data collection using best practices to be identified in the pilot study. Once USGS data products are available in ~summer 2025, assess if new/additional collection is needed based on data analysis.	Critical Priority	Previously funded by USGS. Cost TBD.	$70,000 or more	One set of aerial imagery and topo map (Mugu to Gaviota)
	Sandy Beach Shoreline Change	Shoreline positions	LiDAR-based topography (by airplane)	Bluff Erosion, Sediment Movement, Habitat Changes, Effectiveness of NBS	Collected by NOAA/USGS once every ~5 years and by BEACON members locally (e.g., SB County & City collecting every few years)	Collection for SB & Ventura Counties every 2+ years	Currently performed by NOAA/USGS. Higher cost and can take longer to process than airplane imagery.	Prioritize airplane imagery topography (continuing existing and collecting new data per above)	Critical Priority	Previously funded by NOAA/USGS/State	$100,000 or more	One set of LiDAR and topo map (Mugu to Gaviota)
	Sandy Beach Shoreline Change	Shoreline positions	Satellite imagery (image and shore/water line only)	Sediment Movement, Habitat Changes, Effectiveness of NBS, Storm Events	NASA and others. Available from CoastSat (through 2021) and others.	Standardized annual datasets	Free public sources and paid private services. Weekly frequency, low resolution	Requires analysis to ground-truth and average/smooth. Coordinate with USGS on regular future data analysis and products.	Critical Priority	Free from various publicly available sources	TBD	
	Sandy Beach Shoreline Change	Shoreline positions	Shore profile surveys	Sediment Movement, Habitat Changes, Storm Events and Damage, Effectiveness of NBS	Fall survey every 1 to 2 years (USGS), Goleta Beach annual spring and fall surveys, Surfers' Point surveys	Spring surveys	Collected by USGS, but data has not been released on a regular basis. Accurate and provides nearshore bathymetry. Higher cost, limited spatial scale. Useful for specific analyses and ground-truthing other data above.	Ideally partner with USGS to release information and analysis on a standardized and regular interval. [Need strategy if not]	Critical Priority	$100,000–$200,000	TBD	One set of surveys for region.
Phase 1 monitoring phase (3 to 5 years)	Sandy Beach Shoreline Change	Shoreline positions	Drone-based topography (using aerial imagery or LiDAR)	Bluff Erosion, Sediment Movement, Habitat Changes, Effectiveness of NBS, Storm Events	Collected by CSUCI ~annually at select beaches; annual and seasonal flights collected with City Aerial flights on an irregular timeline	Seasonal, pre-/post-storm and pre-/post-sediment management events at select sites; standardized annual datasets	Cost-effective for site scale (and not necessarily for regional scale). Requires qualified surveyor or other staff, similar to other methods above.	Can be used for supplemental monitoring of seasonal and storm changes and sediment management events at select sites in between regional collection events by airplane. May provide higher resolution than airplanes.	High	Currently funded by CSUCI and some cities	TBD	
	Sandy Beach Shoreline Change	Post-storm shoreline positions, maximum erosion extent in winter	Shore topo surveys	Sediment Movement, Habitat Changes, Storm Events and Damage, Effectiveness of NBS	Ad-hoc photos	Post-storm surveys (aerial and/or ground), or drone imagery	Requires "on-call" effort/capabilities.	Consider on-call arrangements with universities and/or contracts with surveyors/consultants.	High	$40,000–$60,000	TBD	For 1 mile of shoreline with profiles and drone topo before and after storm (excluded analysis and reporting)

Phase	Category	Data Need	Methods	Other Data Needs Addressed	Existing	Potential New	Cost/Benefit	Recommendation/Roles	Priority	Initial New Data Collection Cost Estimate	Subsequent Data Collection Cost Estimate	Cost Note
	Storm Events and Damage	Estuary water levels	Estuary water level gages, stream flow rates	Combined Flooding	Goleta Slough (SB Co), Andree Clark Bird Refuge, Santa Clara River (City of Ventura Water, through 2024 only)	Mugu Lagoon, Ventura River, Carpinteria Salt Marsh, Andree Clark Bird Refuge, Mission Creek, UCSB Campus Lagoon, Devereux Slough	Gages are lacking and needed for documenting and analyzing combined flooding. Potential priority gages for larger and flood-prone estuaries: Mugu Lagoon, Santa Clara River, Ventura River, Carpinteria Salt Marsh, Mission Creek	Coordinate with county flood control districts and BEACON member cities, USGS, and/or California Department of Water Resources (DWR) to develop and prioritize plan for new estuary water level gages. Consider on-call arrangements with universities and/or contracts with consultants.	High	$65,000–$110,000	$50,000–$70,000	For one gage with annual maintenance, data management, and analysis
	Storm Events and Damage	Wave height, period, direction, rainfall	Wave buoys, precipitation gages	Combined Flooding, Sediment Movement	Scripps Harvest Buoy, NDBC buoys at Point Arguello, West SB channel, East SB channel, Santa Barbara Airport	Roving and/or further East SB Channel buoy ("Anacapa Passage buoy")	High cost for permanent buoy including permitting. New buoys can improve CDIP Monitoring and Prediction System.	Continue to support and coordinate with Coastal Data information Program (CDIP) and Southern California Coastal Ocean Observing System (SCCOOS) to deploy a roving CDIP buoy in the Santa Barbara Channel to improve the CDIP Monitoring and Prediction (MOP) system and wave runup modeling.	High	Currently funded by CDIP and NOAA, TBD for new buoy	TBD	
Phase 1 monitoring phase (3 to 5 years)	Storm Events and Damage	Documenting physical extent of event	Videos and photos	Sandy Beach Shoreline Change, Sediment Movement, Habitat Changes, Effectiveness of NBS	Carp, CoastSnap (UCSB, Stearns Wharf, Surfers' Point), ad-hoc collected by local agencies	Surfline, additional cameras and CoastSnap	Site-scale only. Cameras: more useful for storm events. CoastSnap: low-cost installation, engage public, supplemental data only. Surfline: limited shoreline view, cost TBD	Consider video cameras at flood- and erosion-prone sites, CoastSnap at high public use sites, coordination with Surfline	High	$15,000–$40,000	$15,000–$50,000	For one new camera or cradle with annual maintenance, data management and analysis, and QA/QC
	Storm Events and Damage	Documenting physical extent of event	Geo-referenced and timestamped photos and video	Combined Flooding	Ad-hoc collected by local agencies, FEMA claims	Use/modify Customer Relationship Management (CRM) and asset management systems, crowd-sourcing app or similar	Existing and new information could be collected in a more systematic way and gathered into a database that would allow for retrieval and analysis to assess when the frequency and extent of storm damage exceed thresholds for adaptation	Consult and coordinate with County Office of Emergency Services (which serves the cities of Ventura, Oxnard, and Port Hueneme), Santa Barbara County Office of Emergency Management, and emergency service and other relevant departments for the cities of Goleta, Santa Barbara, and Carpinteria to confirm and detail what and how storm reports, damage assessments, Federal Emergency Management Agency (FEMA) claims, asset management, and Customer Relations Management (CRM) is being collected and could be used or modified.	High		TBD	
	Storm Events and Damage	Documenting costs to resource managers	Standardized reporting	Combined Flooding	Repair costs. FEMA claims. Possibly information from county and city offices of emergency services/management	Damage assessments	New information could be collected and analyzed to assess when damage costs warrant adaptation investments	See above. Develop standardized reporting guidance for BEACON members to follow so that reporting can be more easily and regionally synthesized	Medium		TBD	
	Storm Events and Damage	Storm event narrative (what happened, where, when, and response)	Standardized reporting	Combined Flooding		Annual documentation, regular reporting	New information could be analyzed to assess adaptation need and used in adaptation project planning	Develop standardized reporting guidance for BEACON members to follow so that reporting can be more easily and regionally synthesized	Medium		TBD	

Phase	Category	Data Need	Methods	Other Data Needs Addressed	Existing	Potential New	Cost/Benefit	Recommendation/Roles	Priority	Initial New Data Collection Cost Estimate	Subsequent Data Collection Cost Estimate	Cost Note
	Sediment Movement	Harbor dredging and placement/ nourishment	Volume and grain size measurements		Dredging and placement volumes from local agencies and in national database repositories, grain size data (regional collection TBD)	Grain size and topography/bathymetry of placement	Grain size data is low cost and may be available. Pre-/post-placement topo/bathy is higher cost and only necessary for detailed analyses (e.g., sediment budget development, model calibration).	Confirm/collect grain size data. Explore data repository options. Consider topo/bathy surveys of placement.	High	Currently funded as part of dredging operations	TBD	
	Sediment Movement	Sediment basins clean out and placement	Volume and grain size measurements		Ventura Co. Basin Manuals, SB Co. data for clean out and placement	Grain size. Data repository. Extent and topo/bathy of placement	Using existing data repositories is low cost. Pre-/post-placement topo/bathy is higher cost and only necessary for detailed analyses.	Explore grain size data collection and data repository options. Consider topo/bathy surveys of placement.	High	Currently funded by County of Ventura and County of SB	TBD	
	Chumash	Cultural site locations and extents	Records search, tribal consultation, field survey		Records, tribal knowledge of sites along coast and rivers/creeks	Gathering/preparation of information appropriate to inform erosion monitoring with tribal participation	Involved effort including tribal participation required	Collaborate with Chumash tribal representatives to develop a cultural resource sites erosion monitoring plan	High		TBD	
	Chumash	Cultural site erosion	Tribal consultation, baseline and post-storm field reconnaissance, physical data (see above)		Tribal knowledge	Baseline and post-storm field reconnaissance with tribal participation	Initial involved effort including tribal participation required. Possibility to streamline once vulnerable sites are identified.	Collaborate with Chumash tribal representatives to develop a cultural resource sites erosion monitoring plan	High		TBD	
Phase 1 monitoring phase (3 to 5 years)	Social Vulnerability	Demographic data	Census		Regularly-updated Public agency data	None required	Data is available	None	High	Publicly available	TBD	
	Social Vulnerability	Flood hazards and damage	Regularly updated monitoring and mapping	Effectiveness of NBS; Surfers' Point long-term monitoring	See Storm Damage above	See Storm Damage above	See Storm Damage above	Prioritize new Storm Damage monitoring and updated flood hazard mapping in disadvantaged communities	High		TBD	
Phase 2 monitoring phase (5 to 7 years)	Sandy Beach Shoreline Change	Beach habitat characteristics	Shore profile surveys of wrack line and other habitat parameters, repeat photography with shore profile surveys	Effectiveness of NBS	Physical data above	Shore profile surveys of wrack line and other habitat parameters, repeat photography with shore profile surveys	Potential to collect habitat characteristics in conjunction with shore profile surveys and with repeat photography at low incremental cost	Coordinate with USGS regarding adding habitat characteristics to shore profile surveys	High		TBD	
	Storm Events and Damage	Stream flow rates	Stream gages	Combined Flooding, Sediment Movement	USGS and SBCPWD gages: San Pedro Creek Atascadero Creek San Jose Creek Maria Ygnacio Creek Mission Creek Montecito Creek Carpinteria Creek Ventura River Santa Clara River	Subset of multiple creeks between Point Conception and Goleta including Gaviota Creek, Carneros Creek and Tecolotito Creek (tributaries of Goleta Slough), Arroyo Burro Creek, Laguna Channel, Sycamore Creek, multiple creeks from Montecito to Carpinteria, Franklin Creek, Santa Monica Creek, and multiple creeks between Carpinteria and Ventura	Potential priority gages for larger and flood-prone creeks: Gaviota Creek, Laguna Channel, Sycamore Creek, Franklin Creek, Santa Monica Creek, Calleguas Creek, others in Ventura TBD.	Consult with county flood control districts to identify priorities. Coordination with USGS and/or DWR to further assess need and develop plan for new gages. Explore funding opportunity for new stream gages through Climate Bond/DWR.	High	Current gages funded by USGS and counties. Cost of new gage depends on stream	TBD	
	Sediment Movement	River/creek sediment loads	Suspended sediment and bed load monitoring at stream gages		Data analysis and estimates by USGS and others	Continued/improved monitoring	Higher cost: requires 1 year or more of storm monitoring. Only necessary for detailed analyses.	Review and assessment of previous studies and available data sources to identify potential improvements, such as grain size data and estimates.	Priority		TBD	

Phase	Category	Data Need	Methods	Other Data Needs Addressed	Existing	Potential New	Cost/Benefit	Recommendation/Roles	Priority	Initial New Data Collection Cost Estimate	Subsequent Data Collection Cost Estimate	Cost Note
	Sediment Movement	Bathymetric surveys of littoral cell boundaries	Repeated bathy surveys at Mugu Submarine Canyon and Point Mugu		Prior NOAA bathy data	Repeated surveys every few years	Higher cost and only necessary for the specific areas and complete analysis of the littoral cell	Coordinate with Naval Base Ventura County, Point Mugu.	Priority		TBD	
	Sediment Movement	Beach grain size	Grain size sampling		SandSnap	Promotion/adoption of SandSnap and/or field sample collection and sieve analyses	SandSnap crowdsourcing is low cost collection if it can be promoted/scaled. May benefit from calibration with field samples. Only necessary for detailed analyses.	Further assess SandSnap utility, accuracy, and options to promote/scale. Consider field sample calibration.	Priority		TBD	
	Sediment Movement	Ocean turbidity	Satellite imagery with calibration by turbidity sensors		Satellite imagery	Turbidity sensor boat trawls and/or moorings (e.g., on piers)	May be possible to limit turbidity sensors to calibration period so that satellite imagery can be used at low cost	Explore options to perform pilot study and establish program/protocol.	Priority		TBD	
Existing/ ongoing	Storm Events and Damage	Rainfall totals and intensity	Rain gages	Combined Flooding, Sediment Movement	NOAA and local rain gages	None proposed	Gages and data already maintained and provided by various public agencies and BEACON members	None	Critical	Currently funded by various public agencies	TBD	

- **Wave runup and coastal flooding:** Directly monitoring wave runup and coastal flooding is important for refining projections of flooding with sea level rise and developing coastal flood and erosion forecasting systems. BEACON member adaptation plans do not directly identify these needs; however, forecasting systems could greatly enhance efforts to prepare for and manage flood events. The Monitoring Plan recommends partnering with CDIP and SCCOOS towards expanding their flood forecast system to the BEACON region. CDIP and SCCOOS plan to deploy a roving wave buoy in the Santa Barbara Channel as part of this effort. If CDIP and SCCOOS do not deploy a wave buoy, the Monitoring Plan recommends a new wave buoy in the eastern portion of the channel to supplement the existing wave buoy network.
- **Combined coastal and fluvial flooding:** Hazard mapping and projections of combined flooding with sea level rise and increased precipitation due to climate change are a critical gap in adaptation planning for low-lying flood-prone areas adjacent to the coast, such as lower downtown Santa Barbara and areas near Goleta Slough and Carpinteria Salt Marsh and within the Oxnard plain. The Monitoring Plan recommends installing new permanent stream gages in un-gaged creeks with high combined flood risks, such as Laguna Channel and Sycamore Creek in Santa Barbara and Franklin Creek and/or Santa Monica Creek in Carpinteria, as well as improving stream gaging for creeks where flooding inhibits peak discharge data collection such as for Mission Creek in Santa Barbara. The Monitoring Plan also recommends installing new lagoon water level gages in the following un-gaged flood-prone lagoons: Mission Creek Lagoon, Andrée Clark Bird Refuge, Carpinteria Salt Marsh, and Mugu Lagoon. Note that Mugu Lagoon and Carpinteria Salt Marsh do not have previous water level gage monitoring and therefore are priorities (pending confirmation that the UC Natural Reserve System does not have a continuous gage at Carpinteria Salt Marsh). Naval Base Point Mugu has expressed interest in partnering with the RCAMP to install a water level gage at Mugu Lagoon.
- **Sediment movement – dredging:** Data on dredging and placement volumes may be available from local agencies and in national database repositories. Grain size data collection should be explored and may already exist. Topography and bathymetry surveys before and after dredging operations should be considered for detailed analyses such as sediment budget development or model calibration. These efforts are currently funded as part of dredging operations. These efforts are currently funded as part of dredging operations.
- **Monitor Chumash cultural sites for risk of exposure from erosion:** Several notable cultural sites exist along the BEACON coastline and riverbanks that have become exposed and are at risk of exposure with storm events and sea level rise. Physical monitoring methods discussed in the following section could be used to monitor potential erosion of cultural resources sites; however, Chumash tribal representatives should be consulted further to develop a detailed cultural resource sites erosion monitoring plan. Monitoring could include post-storm event monitoring as reconnaissance for artifacts in stream corridors following significant events. Coordination with tribal organizations and groups is necessary to identify and monitor these culturally sensitive locations.
- **Flooding and storm impacts – demographics:** Parcel and census data are available and could be used in conjunction with data on **Storm events, damage, emergency response & recovery** to analyze storm impacts based on demographics. This analysis could identify the highest need communities and inform and support equitable adaptation planning.

Priority Monitoring

- **Sediment movement and physical parameters analysis:** Regional sediment source, transport, and fate monitoring data should be collected across the Santa Barbara Littoral Cell along with beach shoreline change and bluff erosion (Critical Priority) to support sediment budget tracking and inform adaptation planning. Regional sediment monitoring would document the volumes, dynamics, trends, and changes of sediment systems within the littoral cell and sub-cells. Suspended sediment and bed load monitoring at stream gages and measurement of beach grain size and ocean turbidity are options to contribute to the understanding of sediment transport and inform adaptation planning as well as triggers and thresholds. BEACON should review existing studies and bathymetric data sources, such as those from USGS and NOAA, and coordinating with Naval Base Ventura County for repeated bathymetric surveys at key locations like Mugu Submarine Canyon and Point Mugu. BEACON should also evaluate the use of low-cost tools such as SandSnap (potentially in coordination with UCSB) for beach grain size monitoring, with calibration using field samples as needed, and explore monitoring ocean turbidity through satellite imagery calibrated with turbidity sensors.
- **Natural Communities (Vegetation or Habitat Mapping) Baseline and Change:** Natural communities baseline and change data is lacking for much of the BEACON coast, and data that is available is not regionally consistent. Ecological data and analysis are a priority as they inform ecological vulnerability and ecosystem services in adaptation planning, support adaptation project permitting, and support post-project performance assessments. The recommended next step is to create a more detailed process to fully develop a baseline ecology monitoring plan for the region.
- **Beach attendance and access:** BEACON and CSUCI are already using cell phone-derived beach attendance and travel origin data to assess attendance for the Beach Sustainability Assessment (BSA). Additional data including intercept surveys, focus groups, and latent demand surveys would be useful to supplement cell phone data. Data could be analyzed to estimate travel costs and no-market values, demographics of attendees including high need communities, visitation use patterns, and demand for recreation and amenities. A regular GIS inventory of beach access and amenities would also be useful.
- **Shallow groundwater rise:** While shallow groundwater rise due to sea level rise and increased precipitation extremes contributes to combined flooding and is important to monitor for adaptation planning, monitoring groundwater rise is less critical than monitoring storm flooding. Pending further review of existing groundwater wells, the Monitoring Plan assumes that new groundwater monitoring wells are required to monitor shallow groundwater levels in the Goleta and Santa Barbara Groundwater Basins, particularly in areas at risk to rising groundwater levels. These basins do not require monitoring and assessment under the Sustainable Groundwater Management Act (SGMA). In contrast, Oxnard, Carpinteria, and Montecito Basins have Groundwater Sustainability Agencies (GSAs) and Groundwater Sustainability Plans (GSP) for monitoring of groundwater levels and sea water intrusion, which are likely adequate for the RCAMP's purposes.
- **Effectiveness of nature-based adaptation at the Surfers' Point Living Shoreline and Managed Retreat Project:** Continue and expand BEACON's supplemental monitoring at Surfers' Point. This is a cost-effective approach to provide continued proof of concept and refinement of nature-based adaptation approaches that are programmed and planned in adaptation plans and projects, both in the BEACON region and Statewide.

- **Sensitive species:** Collecting sensitive species data and considering sensitive species in adaptation planning has the potential to streamline permitting for adaptation projects and support regional management and recovery of sensitive species. The recommended next steps are to further assess current monitoring efforts and locations and to seek funding to add new monitoring locations where additional data are needed.
- **Coastal wetland change:** Coastal wetland habitat resiliency is important to support a range of species and ecological services. The Southern California Wetland Recovery Project (WRP) is developing a Regional Monitoring Program to track coastal wetland response to climate change, which the RCAMP should coordinate and partner with.

In addition to the priorities above, monitoring could incorporate the following recommendations provided by Chumash tribal representatives, which apply to all coastal adaptation monitoring included in the Monitoring Plan:

- Involve indigenous people and knowledge in the monitoring planning process,
- Include monitors who spend time on the coast through the seasons,
- Recognize natural resources as significant for indigenous people, and
- Propose a Chumash youth monitoring program location on the coast

6.3 Recommended Pilot Studies

BEACON and the RCAMP identified the two recommended pilot studies listed in **Table 17** and described further below. These recommended studies meet critical priorities identified above and can be accomplished within the pilot study phase and currently available $200,000 grant funding from the CCC, and align with BEACON member and stakeholder input.

TABLE 17. SUMMARY OF RECOMMENDED PILOT STUDIES

Pilot Study
Pilot demonstration and framework RCAMP Monitoring Report and web map and data access tool
Provide shoreline data in partnership with USGS

Develop demonstration RCAMP Monitoring Report framework. This pilot demonstration report (Report) will be a framework and partial draft of a regularly updated monitoring report (e.g., every two to five years). Available data will be documented and summarized.

The Report will provide a framework and partially complete draft of the following:

a. A framework, example, and template for future RCAMP Monitoring Reports to build from.
b. Baseline information of RCAMP Monitoring Plan priority data and analysis.
c. Recommendations of additional data and analysis to include in future Monitoring Reports.
d. An assessment of RCAMP Monitoring Plan needs, priorities, and utility.

The report will document available data, focusing on the high priority Monitoring Plan components. Recommended new data collection and additional studies will be documented as next steps. The data presented in the report will have a range of topics at different levels of completion based on priorities and available data. The report will ideally process and present available data for the highest priority monitoring processes in a format that can be easily used by BEACON members and stakeholders. This process will support the development of a practical and adaptable reporting structure that can be refined over time.

The framework will also incorporate a review of tide gage data from the Santa Barbara and Los Angeles tide gages in coordination with NOAA to assist in performing or planning analysis of long-term sea level trends and short-term water level fluctuations related to storm events.

Develop shoreline data and monitoring framework in partnership with USGS. This pilot study will involve USGS finalizing previously collected shore profile surveys and PlaneCam topography data and developing new refined satellite-derived shoreline data for the Santa Barbara Littoral Cell. The goal is to produce shoreline and topography data and provide recommendations for future shoreline monitoring strategies.

The pilot study will include the development of new, refined satellite-derived shoreline data using the full archive of available satellite imagery from 1984 to 2025, with 50 m transect spacing. This would address existing gaps in the publicly available CoastSat dataset (e.g., at Goleta Beach Park) and improve transect resolution from 100 m to 50 m. The refined shoreline dataset would cover the entire extent of the littoral cell along the BEACON region from Point Mugu to Pismo Beach (Shell Beach).

USGS will then provide a synthesis and summary of coastal data by comparing the data generated above with other available data (e.g., Lidar, USGS historic shorelines). The summary will focus on uncertainty and completeness of each data set, with the goal of informing BEACON about the potential for application of these data sets for understanding and planning for coastal change. Results will be communicated in a presentation and memo to BEACON.

Other pilot studies considered and deferred. Other pilot studies were considered, but deferred for further consideration in subsequent phases of collection and studies. These studies are critical and high priority, however the recommended pilot studies are higher priority and/or precursors to these studies. To maintain focus and feasibility in the pilot study, the deferred studies were not selected due to current resource limitations and sequencing needs within the broader monitoring strategy, but remain important for future implementation as resources and sequencing allow. Other pilot studies considered and deferred include:

- Analyze shoreline data and provide shoreline data products that synthesize multiple data sources and provide results in a web-based map and tool. This study is being pursued as a Phase 1 study in partnership with USGS.
- Perform supplemental spring profile surveys for a subset of USGS shore profile locations including at least two “erosion hot spot” beaches. Estimated cost range: $100,000–$200,000 depending on scope and extent.
- Initiate post-storm erosion or spring shore profile surveys. Post-storm erosion shore profile surveys could be conducted at USGS shore profiles. If significant erosion does not occur,

supplemental spring beach profile surveys could be performed for at least two “erosion hot spot” beaches. Estimated cost range: $25,000–$40,000 including annual report.

- Install a new permanent water level gage in Ventura Harbor. Estimated cost range: $50,000–$100,000 depending on type of gage and level of permitting required, plus $30,000–$40,000 for one year of maintenance.
- Develop automated storm event data web dashboard and tool. This effort would focus on producing a web viewer and dashboard that compiles storm event data from available rain and stream gages, the Santa Barbara water level station, wave buoys, and nearshore wave conditions from the CDIP MOP system. Rainfall and stream discharge data could be organized by watershed. The dashboard could be automated to update using available data feed services. Santa Barbara County maintains a similar web application for its gages. The RCAMP tool would seek to provide storm data as synthesis that is useful for BEACON member coastal managers and stakeholders. Potential features could possibly include estimated recurrence intervals of storm conditions (e.g., 10-year wave event). Estimated cost range: $100,000 to $200,000 depending on scope.
- If SCCOOS does not deploy a wave buoy, deploy a new wave buoy in the eastern portion of the channel to supplement the existing wave buoy network. Estimated cost range: TBD.
- Install lagoon water level gage at Mugu Lagoon and Carpinteria Salt Marsh (pending confirmation that the UC Natural Reserve System does not have a continuous gage at Carpinteria Salt Marsh). Estimated cost range for one water level gage at one lagoon: $10,000 (temporary installation) to $30,000 (permanent installation) for installation; $30,000 to $50,000 for annual maintenance, data management, and analysis. Naval Base Point Mugu has expressed interest in partnering with the RCAMP to install a water level gage at Mugu Lagoon.

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7. NEXT STEPS

The following sections outline the process and next steps for the RCAMP, starting with stakeholder and public review and comment on the Monitoring Plan and the recommended pilot studies. After public review and comment, the RCAMP team will perform pilot studies and finalize the Monitoring Plan. BEACON is also pursuing Phase 1 (Year 3 to 5) monitoring studies performing and seeks to establish a plan for RCAMP data and information management, and long-term funding.

7.1 Final Monitoring Plan and Pilot Studies

The RCAMP team is providing a Public Draft Monitoring Plan for review by the SAC and stakeholders, including recommended pilot studies. The Team will revise the Monitoring Plan and refine pilot studies based on SAC and stakeholder comments and input.

Following preparation of a revised Final Draft Monitoring Plan, select pilot studies will be conducted. At the conclusion of the monitoring period, a monitoring results report will be prepared. The science advisory team and agency stakeholder group will then reconvene to examine the lessons learned from the monitoring and prepare revisions to the Monitoring Plan accordingly. The City of Santa Barbara will then prepare an amendment to the City's fully certified LCP to incorporate the final monitoring protocols into the City's Coastal Land Use Plan.

7.2 Phase 1 (Year 3 to 5) Monitoring Studies

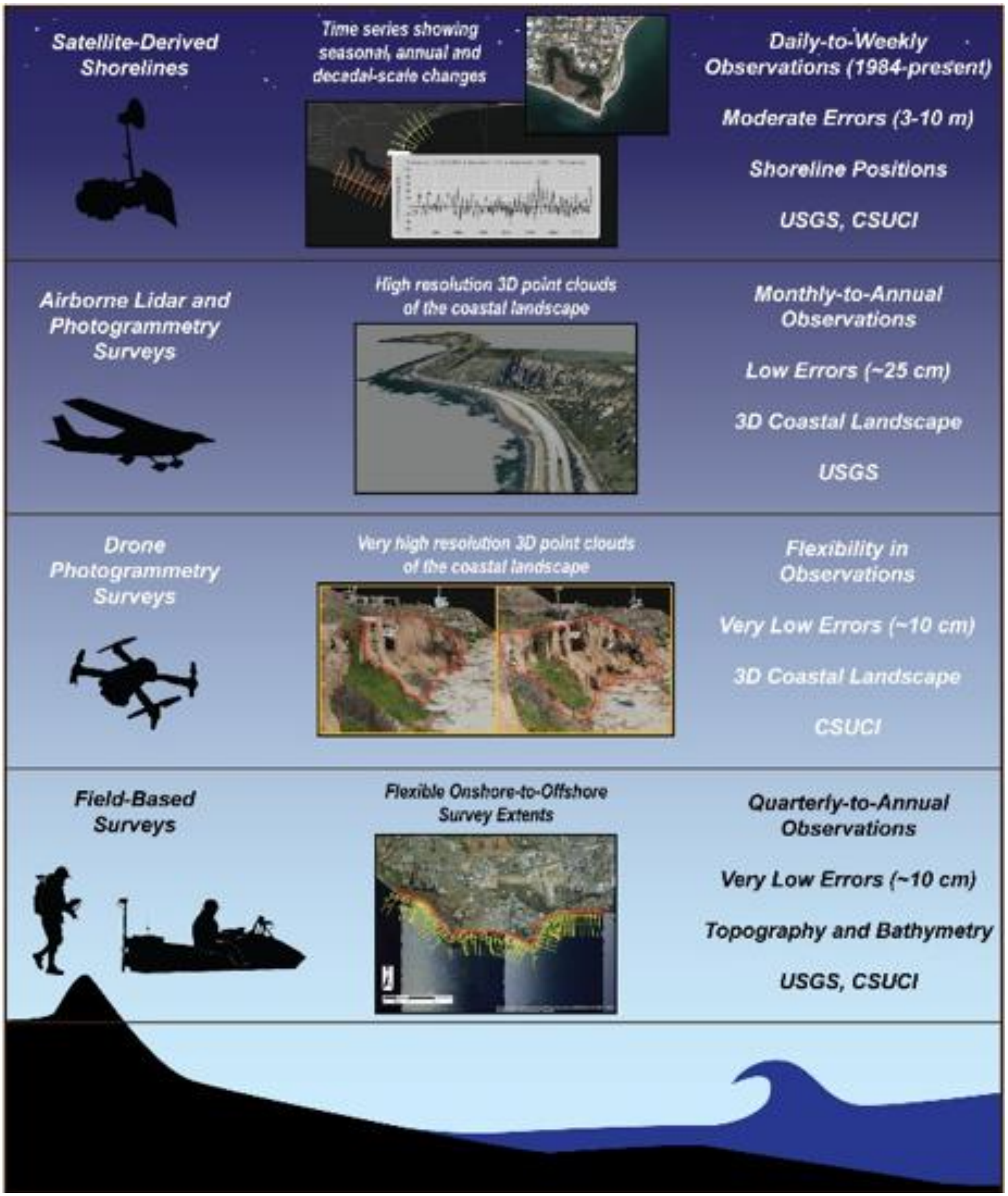
BEACON is pursuing funding for a subset of recommended Phase 1 (Year 3 to 5) monitoring studies in coordination with USGS and CSUSI. This Phase 1 monitoring study proposal is to develop the Coastal Shoreline Hazards Tool (aka ShoreCHaT) focused on Coastal Shoreline Adaptation (**Figure 19**). ShoreCHaT would be a map-based tool that would provide accessibility to state-of-the-art coastal change measurements and forecasts, and illustrated in the mock-up below (**Figure 20**).

7.3 Plan Management and Implementation

The next step is to establish a plan for data and information management. The RCAMP provides guidance that could support funding opportunities. BEACON plans to prepare a more detailed Implementation Plan as part of the pilot study phase.

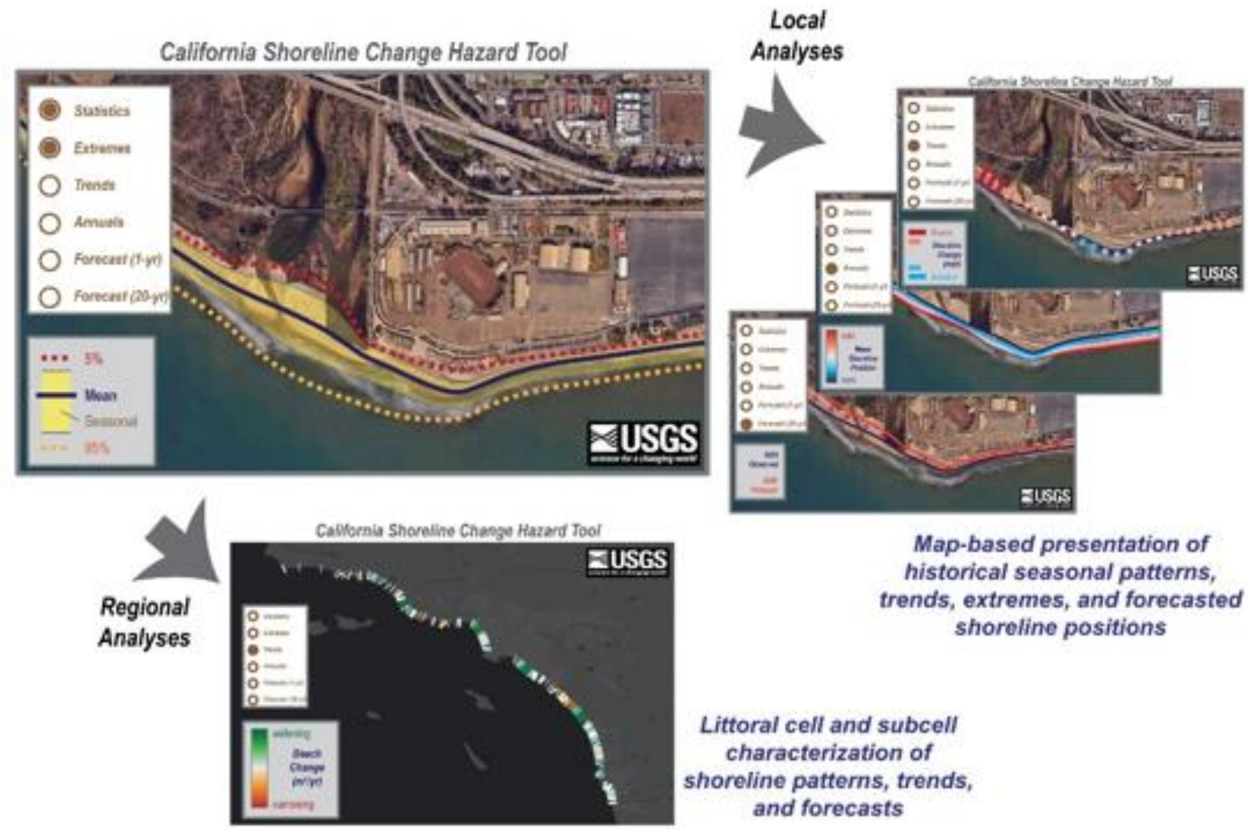
7.3.1 Data and Information Management

The RCAMP intends to provide integrated data collection, storage, development, and management through collaborative efforts with partners. The RCAMP seeks to support the creation of a publicly accessible data portal or library and data dashboard. A management agency will need to be identified to host these data services. Alternatively, consultants or other private services could be used.



SOURCE: USGS

Figure 19. New Data Collection Techniques Available for Evaluating Shoreline Responses to Sea level rise in the Santa Barbara Littoral Cell



SOURCE: USGS

Figure 20. Functionality of the Proposed Shoreline Change Hazard Tool (ShoreCHaT) for Both Local- and Regional-Scale Analyses

7.3.2 Long-Term Funding

The Monitoring Plan provides guidance to BEACON members and on regional-scale efforts. BEACON members may choose to fund and share monitoring data collection within their jurisdictions using approaches and methods recommended in the Monitoring Plan for regional consistency. The Monitoring Plan also provides information that can be used to pursue partnerships with public agencies (e.g., USGS), academic institutions, and others. The Monitoring Plan can also be used to support grant applications to fund data collection, analyses, and products subsequent to the pilot study.

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Note: Resources with links provided in the report are not included in the references section

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Appendix A
Social Science Applications

APPENDIX A. SOCIAL SCIENCE APPLICATIONS

Current, accurate social science data is the foundation of high-quality research and well-informed public policy. This is particularly important when considering climate change adaptation because without up-to-date data, climate change models can become rapidly outdated. Most accurate, up-to-date data allows decision makers to better understand the current conditions and projected effects of climate change to support a range of adaptation and management objectives and maximize the impact of investments.

Social science data, including social cultural and socioeconomic data, can inform planning to preserve, and improve, coastal access for underserved and vulnerable communities and allow social scientists and policymakers to see how humans respond to the geophysical changes that will occur with climate change. For example, if a beach's size is reduced by half, how will that change attendance patterns?

Despite its importance, social science data is often overlooked in climate-related decision-making and models. Without accurate, current, social science data, it is impossible to understand how changes to the coastal environment will impact local populations and visitors. Social science data allows researchers to understand who uses coastal resources, how they get there, what amenities they prefer or require, and how their use impacts local communities and economies.

In many coastal communities, beach visitation is a vital component of fiscal health–beachgoers generate significant tax revenue through spending and lodging. In addition, coastal access and views substantially impact property values, and, therefore, property tax revenues.

Furthermore, social science data measures *human use*. The policy and research that builds on this data is vital to understanding how our coast is currently used and how we might use it in the future. Human use data, particularly attendance estimates, determines how limited public resources are allocated by informing beach assessments (King and McGregor 2012).

From an adaptation planning perspective, social science research allows us to better identify public priorities and determine which adaptations will preserve, protect, and enhance those priorities. Additionally, it allows us to better balance conflicting priorities and devise solutions that maximize potential benefits for all stakeholders. This ability is particularly important given that the California coast is a public resource protected under the California Constitution and mandated under the California Coastal Act of 1976.

A key aspect of public use is access, and climate change adaptation is informed by a better understanding of the public's use of coastal resources. One of the main goals of the California Coastal Act is to "maximize public access to and along the coast". However, social science research is vital to understanding the extent to which this access is provided, and to whom. Coastal access has important implications for environmental justice and coastal resource management.

Continued social science research and better, more accurate, beach visitation data, are vital to modeling the expected impacts of climate change. Climate change preparedness includes emergency preparedness—how the State, region, and local community respond in the wake of a disaster. Understanding public use of the coast can help communities determine how to respond after a severe storm or flooding event.

As we face a future of climate-induced sea level rise and an increase in storm damage and flooding, having accurate, up-to-date information on the social utility of the coast, more specifically beaches, will facilitate the development of decision support tools to assess the trade-offs and guide adaptation strategies that reflect both environmental and human needs.

A.1 Benefit-Cost Analysis: Valuing Public vs. Private Property

High-quality social science data which allows for accurate estimates of the value of public space—in particular the recreational and ecological value of beaches—helps local communities and regulatory agencies accurately consider the impacts to coastal resources and weigh those impacts against the value of private coastal property. Without reliable data and estimates, one cannot adequately compare public space with private property.

The impact of sea level rise on private homes and coastal public property is significant and will be a vital concern for California soon. However, these private, beachfront homes tend to be worth millions to tens of millions of dollars. The high value of these homes, especially those in the most affluent areas, can distort the perceived impact of sea level rise and coastal storms, making private losses appear disproportionately important.

Robust social science data and the ability to estimate the value of the coast is necessary to protect and preserve environmental and recreational resources that may be overlooked otherwise. Unless one values public resources and ecosystem services properly, private homes will appear, or “pencil out” to be more valuable than the ecosystem goods and services, and social utility of public land and amenities related to public beaches and open space. This disparity arises from the fact that developed land typically holds higher market value than undeveloped or public land.

This imbalance can skew adaptation decisions in favor of protecting private property, since, in a conventional benefit cost analysis, the “benefits” of saving private property and structures will outweigh the benefits of other resources (e.g., public beaches). Consequently, prioritizing the protection of private, developed properties may inhibit other forms of adaptation.

Assigning a high value to private development discourages managed retreat or relocation; however, retreat may be the only way to preserve certain areas of California's coastline, especially in areas with critical habitat and high social utility. Without assigning a significant value to critical habitat and public use, private properties may appear unduly important in the coastal planning process and skew the focus in assessing coastal adaptation strategies. Going forward, State and local agencies in California may wish to develop an alternate method for valuing coastal property.

In practice, both the California Coastal Commission and the State Lands Commission have used private property values for mitigation purposes. Private land values depend upon several factors that are completely independent of the social utility or ecological value to the State. If one uses a private assessment, most “valuable” land is typically land zoned for expensive single-family dwellings.

For example, at Malibu Lagoon 72 parcels, valued at $735 million, are inundated by a sea level rise of 100 cm (according to the Coastal Storm Modeling System (CoSMoS). At San Buenaventura, 367 parcels are inundated with the same sea level rise scenario, yet the value of the damage is estimated at $482 million. Based on the dollar value alone, Malibu Lagoon’s homes (the “Malibu Colony”) appear more important, and yet a far greater number of Californians are impacted by the flooding in Ventura and far more people visit San Buenaventura Beach.

For the same reasons, a market-based valuation does not place significant weight on public lands since these lands typically cannot be developed into expensive single-family dwellings. This, once again, could influence coastal planning efforts in favor of privately developed property rather than important publicly accessible open spaces.

To weigh the value of the public coastline against the high value of private, developed property, one must estimate the “total economic value” (TEV) of the ecosystem. As California’s coastline is a non-market good, the total economic value (TEV) model provides a framework for valuing the full suite of economic values associated with a resource, incorporating direct use (e.g., recreation), indirect use (e.g., habitat), and non-use values.

A.2 Climate Change Impacts

Our best scientific modeling indicates that up to two-thirds of California’s beaches will be lost by 2100 without intervention. Statewide, approximately 100 beach access points will be lost for every foot of sea level rise (Patsch and Reineman, in press). Specifically, Santa Barbara County will lose close to four beach access points, out of a total of 69 for the county, for every foot of sea level rise. In the Santa Barbara littoral cell, many smaller beaches may disappear while larger beaches such as Santa Barbara’s East Beach, will require human interference to maintain beach width.

The demand for beach visitation in the Santa Barbara littoral cell is likely to grow, both due to small increases in local population (around 0.3 to 0.5% per year) and likely increased demand due to hotter summers associated with climate change. As we lose beach width due to sea level rise and increase the demand, the beaches will inherently become more “valuable” resources.

As beaches narrow, they lose capacity–they can support fewer visitors on a given day. The non-market value of a beach is determined in part by the carrying capacity; beaches with lower carrying capacity will see a reduction in non-market value either from fewer visitors, less value per-visit due to excessive crowding, or some combination of the two.

Past social science research indicates that each visitor requires 100 square feet of “towel space” (open sand) and that visitors typically do not stay a full day. Thus, the carrying capacity of a beach is determined by its dry sand area (towel space) divided by 100 square feet and adjusted to account for expected turnover.

Better social science data can help refine both the estimate of necessary towel space, and the estimated turnover rate by providing more accurate estimates of visit duration. Many beaches in California are already over capacity on busy summer days – that is to say, they are overcrowded with visitors and exceed the available sandy beach area. On these crowded days, visitors will either choose not to visit a particular beach and try to find another location or activity or they settle for what little space they can find.

That smaller space has less value than on a less crowded day because it is less desirable. The narrowing beaches expected with climate induced sea level rise is expected to increase crowding, pushing many beaches past capacity for most of the summer high season. Continued social science research, and better methods of monitoring beach attendance and social utility, help determine how to adapt to these changing conditions. Monitoring and modeling beach attendance can indicate which beaches are most vulnerable to the adverse impacts of narrowing–those that are expected to see the worst increases in crowding.

Monitoring the social utility of beaches can also indicate vulnerable beaches that may be less popular (fewer visitors per day) but offer unique opportunities for recreational use such as fishing, surfing, or hiking. For surfing, fishing, hiking, and other activities, other methods of carrying capacity, such as the capacity of the waves, may be an appropriate addition to the social utility monitoring protocols. Continued social science research and better, more accurate, beach visitation data, are vital to modeling the expected impacts of climate change to these niche resources and to determining appropriate mitigation and implementation timing.

Parking is also a key consideration in carrying capacity since most visitors drive to the beach. If parking is impeded by flooding/erosion due to climate change, then carrying capacity is diminished. Future planning needs to account for potential impacts to parking as a consideration in carrying capacity as well as from the prospective of protecting infrastructure. It should be noted, however, that most coastal storms occur in the winter, when attendance at beaches is typically lower.

Climate change preparedness includes emergency preparedness—how the State, region, and local community respond in the wake of a disaster. Understanding public use of the coast can help communities determine how to respond after a severe storm or flooding event. For example, knowledge of which beaches are most visited and how they're accessed can inform which access points and amenities to repair, which parking lots to clear of sand and debris, and which beaches to prioritize reopening to the public.

As we face a future of climate-induced sea level rise and an increase in storm damage and flooding, having accurate, up-to-date information on the social utility of the coast, more specifically beaches, will facilitate the development of decision support tools to assess the trade-off that will be inevitable.

Information can be used to determine appropriate mitigation fees or in-kind mitigation (e.g., a beach nourishment project at a comparable site). Without current, accurate, social science data, impacts of management scenarios on the public use and benefit of coastal resources will be overlooked, unvalued, and left unaddressed. Social utility "monitoring" for the value of these mitigation efforts is essential.

One further element to consider in mitigation is the "replacement cost" of the property. A study for the California Coastal Commission funded by NOAA recommended that any loss of the coast created by a seawall or other structure should be mitigated using a "replacement cost" approach. The "replacement cost" theory essentially says that mitigation should require applicants to pay the full damages to

California's coast. This approach avoids the use of private property valuations, which, as discussed in section 3.5.1 above, skews heavily in favor of wealthy property zoned for single family dwellings (e.g., Malibu). Developing mitigation banks would be a useful alternative.

A.3 Coastal Access

Both climate change adaptation and mitigation requirements are informed by a better understanding of the public's use of coastal resources; a vital component of public use is public access. California has a long and distinguished history promoting and protecting public access to the coast, beginning in 1849 and culminating with the 1976 California Coastal Act (Christensen and others 2016). One of the main goals of the California Coastal Act is to "maximize public access to and along the coast," which extends to limiting and regulating development along the shoreline.

However, social science research is vital to understanding the extent to which this access is provided, and to whom. Several recent studies, including Reineman (2016) and Christensen (2017) indicate that access to California's coast is unequal. Mapping different demographic groups' access to beaches revealed that "wealthy, white, senior residents" have the easiest access to the coast while minority groups are "significantly underrepresented" in proximity to coastal access (Reineman 2016).

Sixty-two percent of voters indicate that they face coastal access issues, with 78 percent citing limited affordable parking as a barrier to access, and 75 percent indicating the lack of affordable accommodation, (Christensen and others 2017). Helping alleviate these inequalities requires continued examination of who goes to the beach, how they get there, and what amenities they look for, especially as beach and population conditions change with time.

Coastal access has important implications for environmental justice and coastal resource management. Low-income communities "rely on beaches for low-cost recreation" and as an economic resource (Reineman 2016). Not all beaches, however, serve this purpose. Continued monitoring, and site-specific human use data are vital to understanding which sites are most important to these communities. This can inform planning to preserve, and improve, coastal access for underserved and vulnerable communities.

These considerations should be factored into Local Coastal Programs (LCPs) to address and mitigate access disparities (Reineman 2016). Accurate data can help local governments engage in informed adaptation planning, especially in the face of the projected impacts of climate change on coastal resources.

By determining who visits the beach and what they do there, social scientists can estimate the value of that beach to the public. As California beaches are ostensibly free to the public (parking costs aside), the beach has a non-market value–meaning its value to a visitor or user is not captured by an entry cost. Economists use the data on beachgoers to determine "willingness to pay" as an approximate for the non-market value. Willingness to pay (WTP) estimates rely on standard econometric methods such as the travel cost method (revealed preference) or contingent valuation (stated preference). Although estimates vary, the current average day use value, in 2024 dollars, is over $60 a day.

Further research with improved monitoring methods could allow researchers to refine this estimate to a value per hour, for specific sites and regions, and to determine the WTP for different types of recreation and different populations based on their place of origin. Improved monitoring could show researchers which beaches have the highest non-market value per visit by indicating which beaches visitors will invest significant time and expense to experience. These methods, and research utilizing them, will be discussed in more detail in the coming sections.

Social science research not only indicates the value of visiting the beach, but also how sensitive beachgoers are to perceived losses in value, which can further inform adaptation decisions, tradeoffs, and investment in beaches. A loss in value refers to the cost of visiting the beach increasing, the perceived benefits of that visit decreasing, or some combination of the too. The difference between the value of a beach trip–the maximum WTP for that trip–and the actual cost of that trip is referred to as “surplus value” by economists. This essentially represents the remaining funds a visitor must expend on shopping, parking, or other expenses on the trip before that trip becomes too costly.

When those additional costs outweigh the surplus value, visitors will choose not to come, resulting in lost attendance. Similarly, if the value of the beach decreases, say due to overcrowding or lost recreational opportunities, it may no longer be worth it, and attendance will fall.

Current social science research and monitoring enables modeling of these changes and can inform an understanding of the tipping point in costs/benefits, at which point visitation will fall. This can factor into planning, project prioritization, and adapting to changing coastal conditions. It can enable a regional or statewide consideration of how we allocate resources to minimize loss.

A.4 Local Coastal Communities

Changes in beach attendance and recreational opportunities can have significant impacts on coastal economies. Many beach communities rely on tourism to generate revenue in the form of transient occupancy taxes, sales taxes, parking fees, and other use fees related to coastal recreation. Social science data and research enables fiscal impact modeling and analysis for these communities. This factors into their Local Coastal Programs (LCPs) and into project design and implementation decisions where there may be an opportunity to positively impact coastal access, recreation opportunities, and general social utility.

Social scientists can estimate how specific changes may impact coastal access and visitation, and the expected impact on a community's finances. This, in turn, can justify investment in the California coast, be that recreational amenities, improved lodging opportunities, or climate adaptation.

Traditionally, social science data required labor- and time-intensive intercept surveys. In an intercept survey, researchers at specific locations (most often a beach or beach parking lot) ask beachgoers a series of questions related to their visit such as group size, days or hours in their visit, trip origin, and how much they’ve spent in different categories (lodging, food, alcohol etc.).

These responses are aggregated and used to analyze beach use, access, and economic value. Another key data point for this analysis is beach attendance, which typically comes from lifeguard counts. As California beaches are a public trust resource and therefore open to the public for their free use, an exact count cannot be obtained from entry fees or tickets sold. Until recently, observational counts provided the most accurate source of data. These counts often have a large margin of error, as shown in King and Macgregor (2012).