

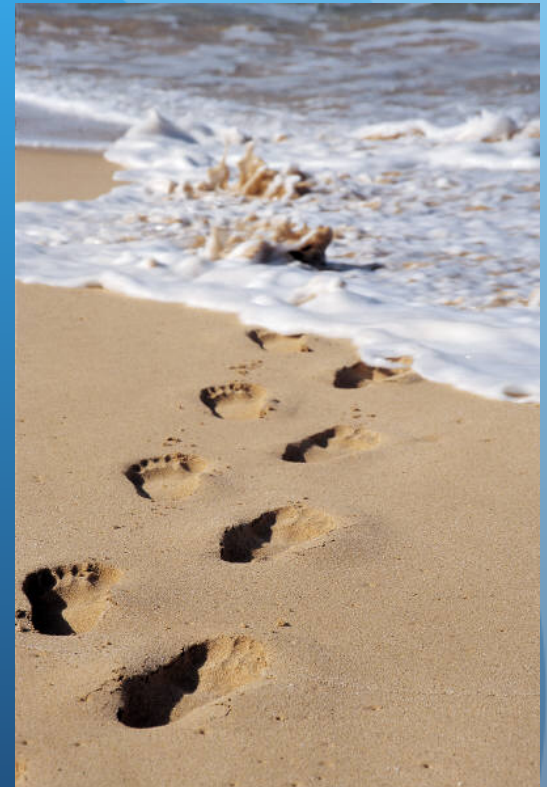
Sediment and the Sanctuary: A Coastal Processes & Climate Change Story

Douglas George, PhD
Greater Farallones National Marine Sanctuary
Advisory Council Meeting

November 14, 2016

Presentation Pathway

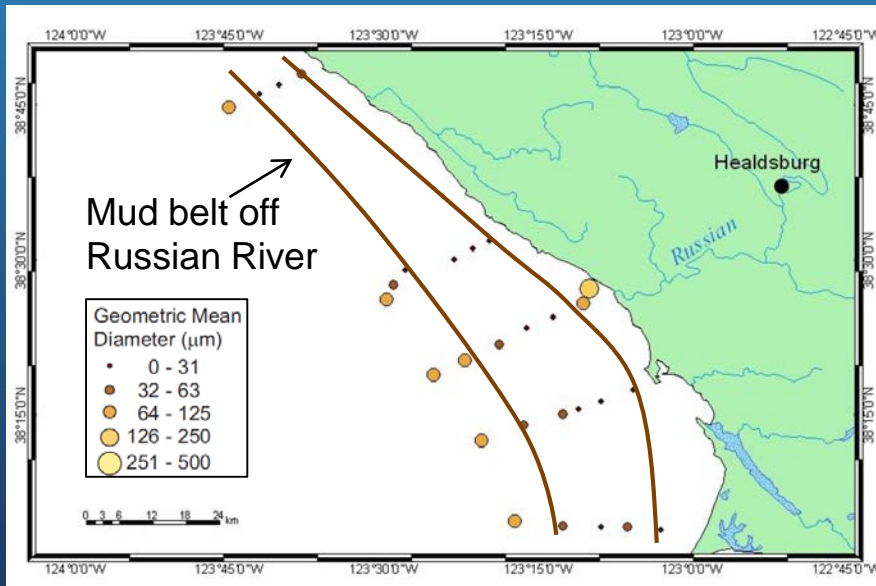
- Sediment Processes
- Managing Sediment Along the Coast
 - Local Examples
- Climate Change Plan Connection



Sediment Processes

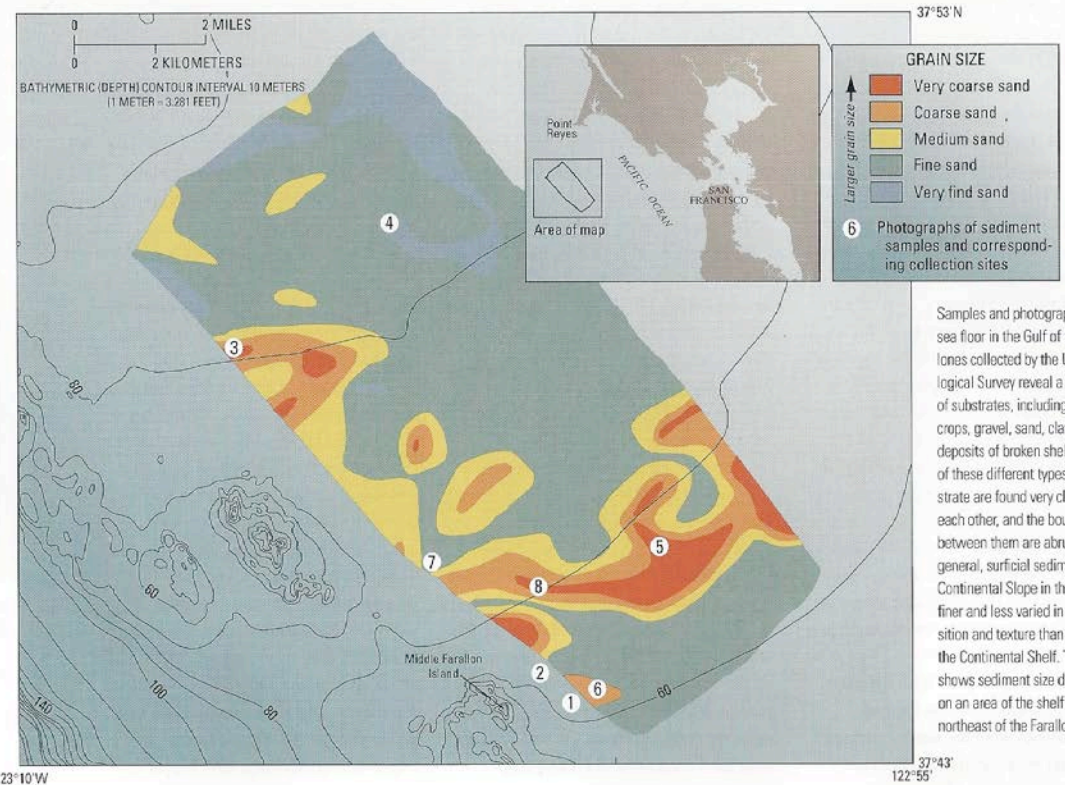
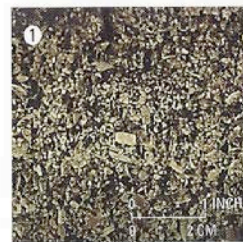
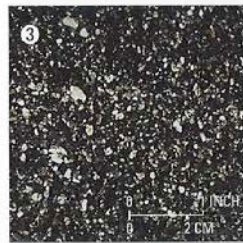
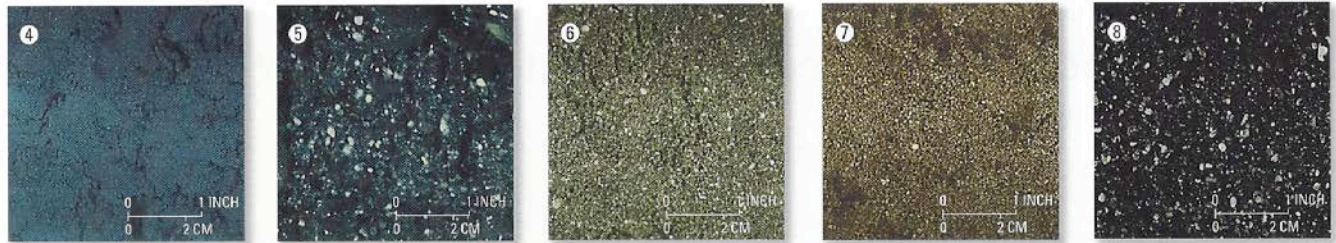
Essentials for Our Sediment Story

- Generally accepted north-south flow for sand due to currents and waves
- Mud plumes more dispersive across the shelf then reworked by waves



Essentials for Our Sediment Story

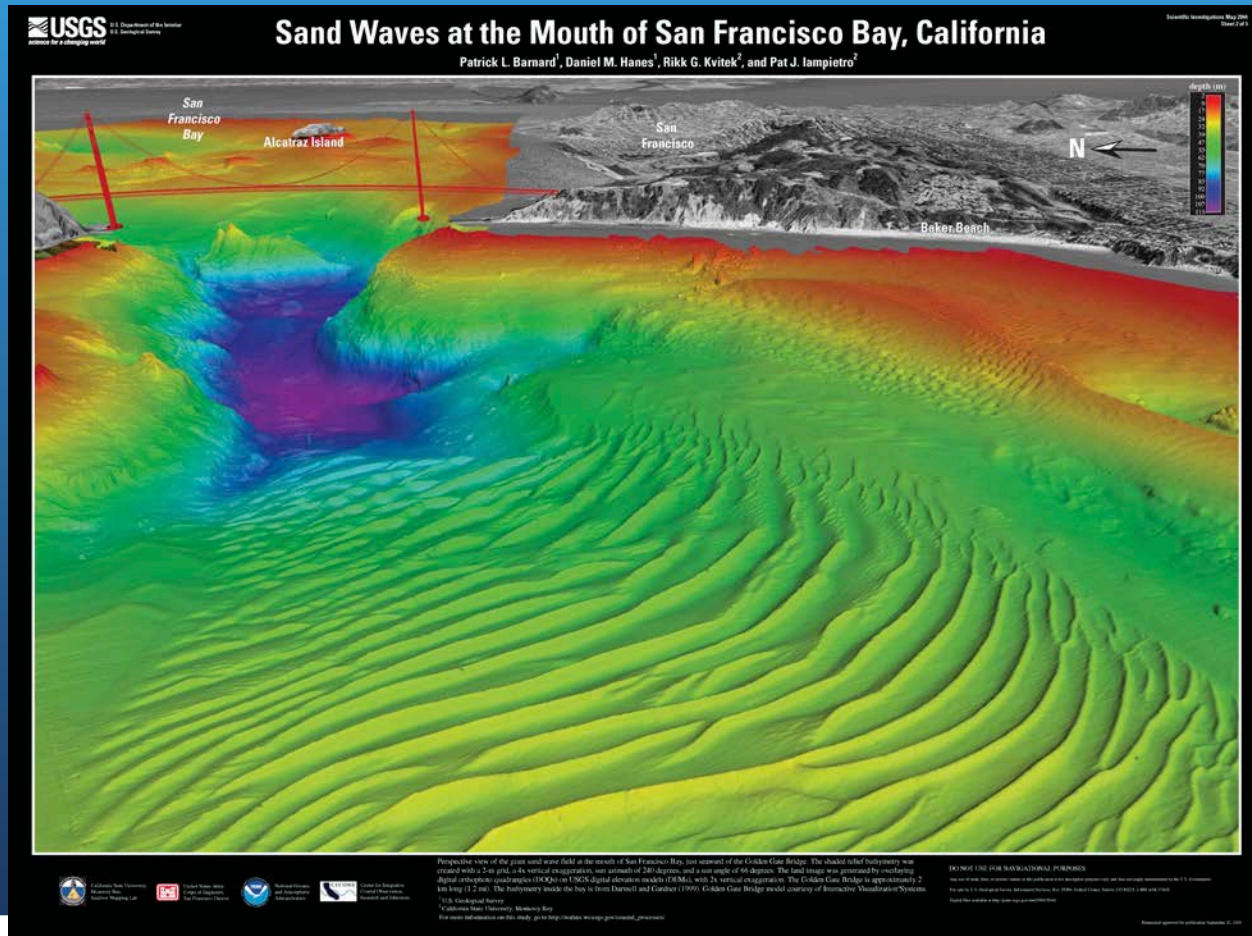
- Grain-size



Samples and photographs of the sea floor in the Gulf of the Farallones collected by the U.S. Geological Survey reveal a variety of substrates, including rock outcrops, gravel, sand, clay, and deposits of broken shells. Some of these different types of substrate are found very close to each other, and the boundaries between them are abrupt. In general, surficial sediment on the Continental Slope in the gulf is finer and less varied in composition and texture than that on the Continental Shelf. This map shows sediment size distribution on an area of the shelf to the northeast of the Farallon Islands.

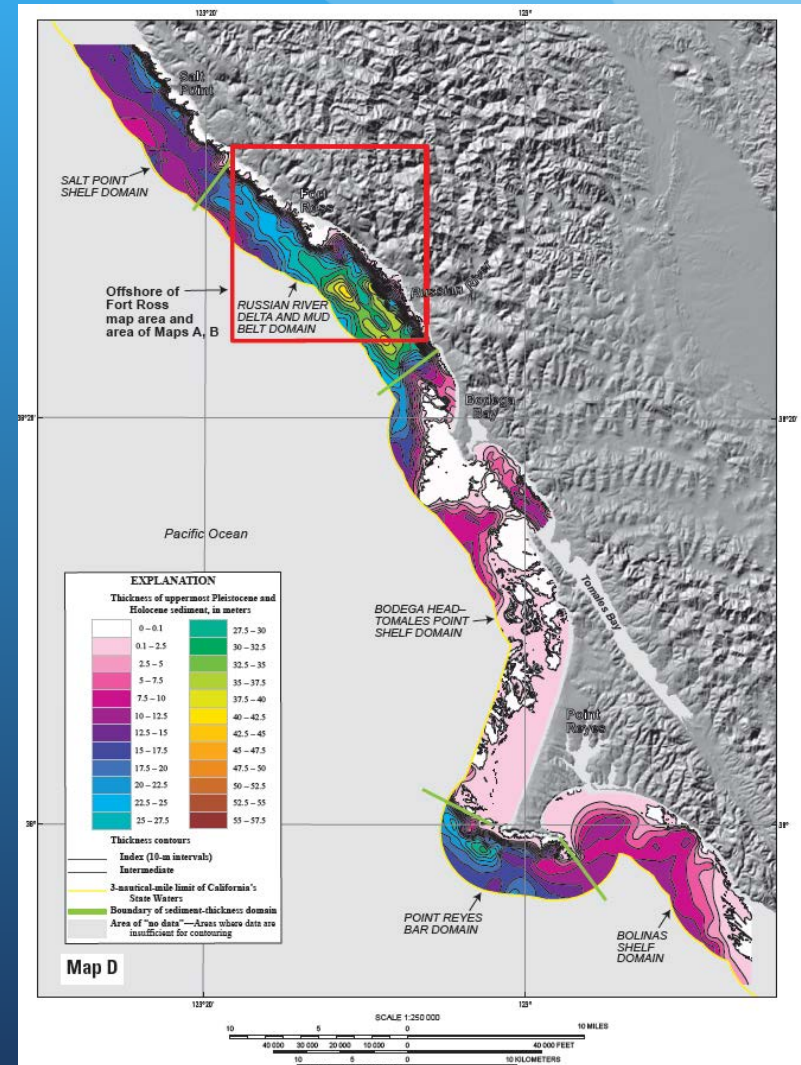
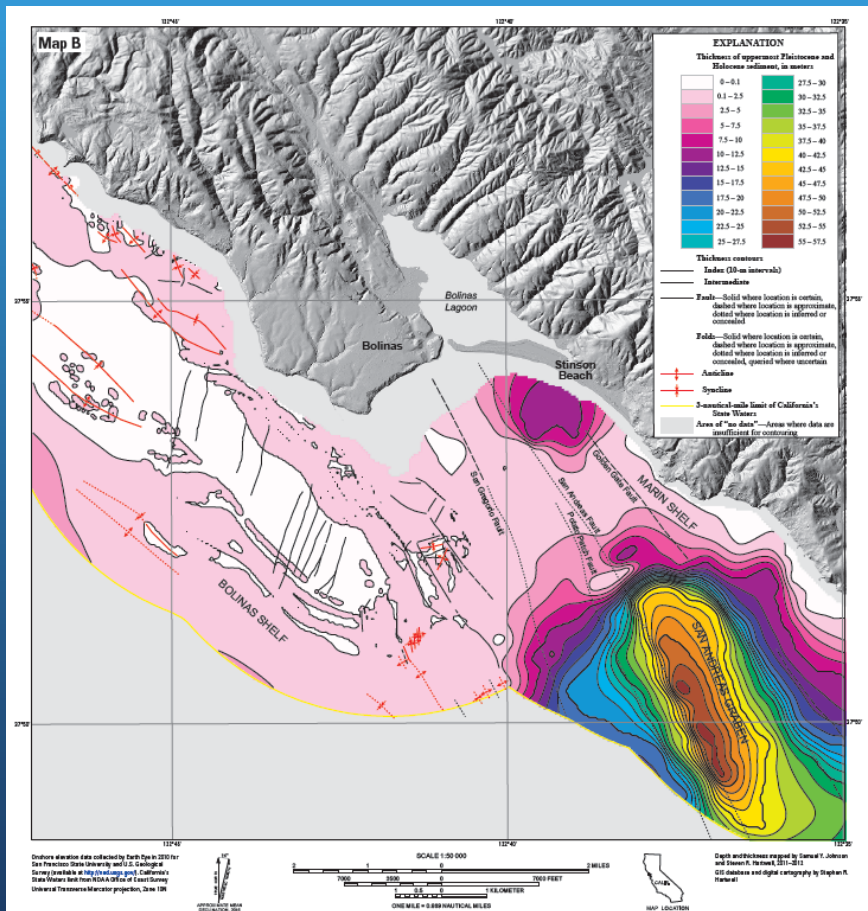
Essentials for Our Sediment Story

- Morphology



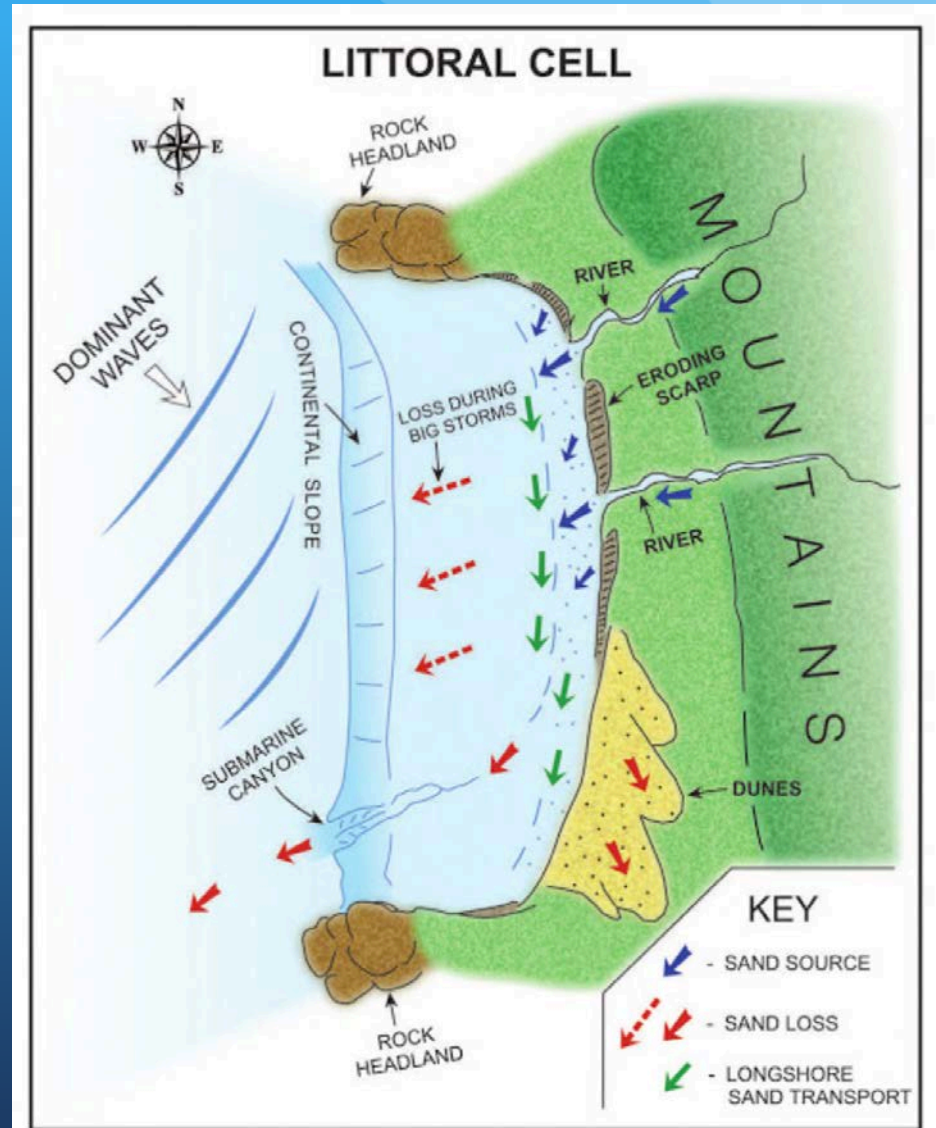
Essentials for Our Sediment Story

- Thickness on Seafloor

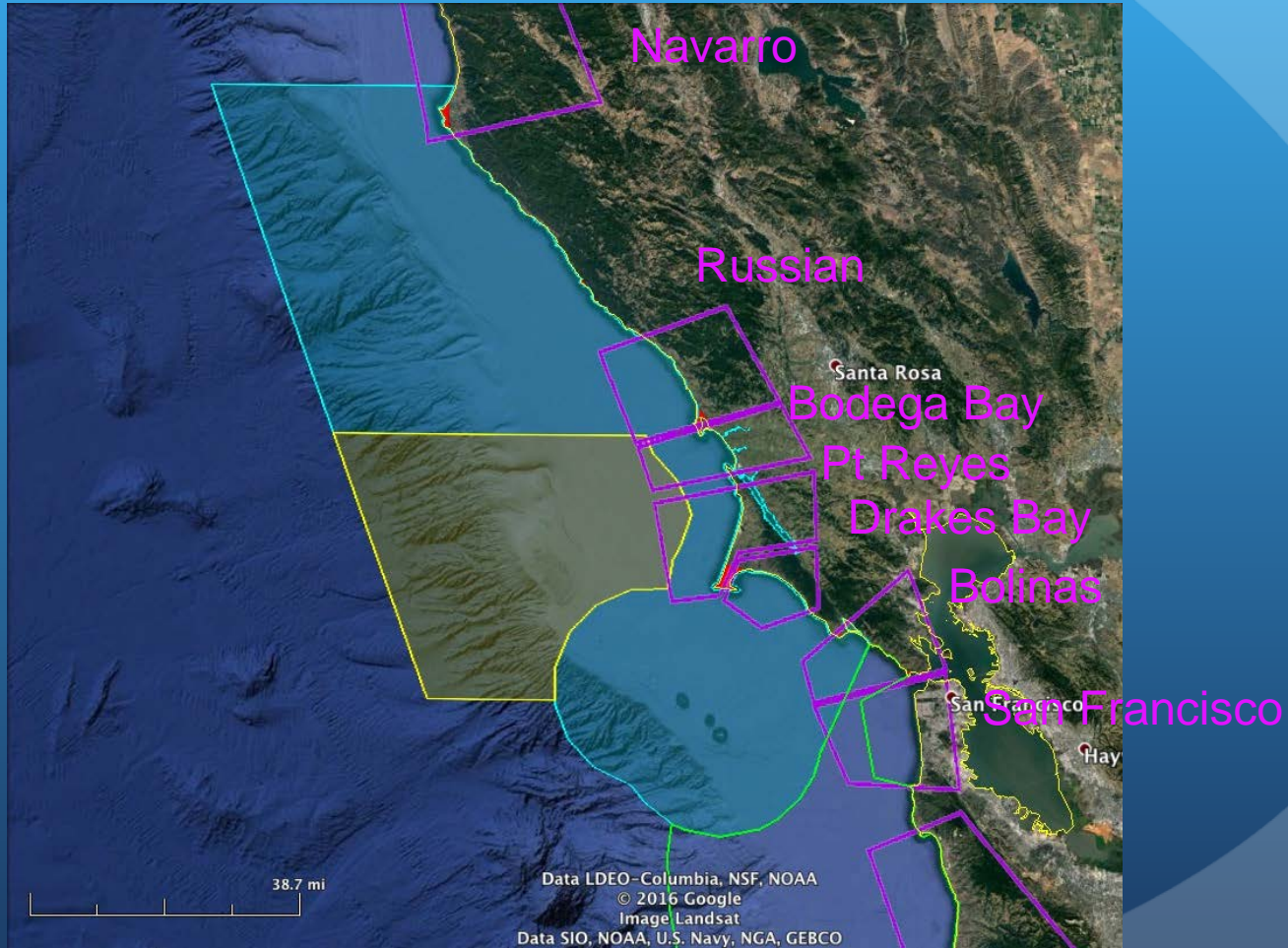


Sediment Units

- *Littoral cell* – geographic area offshore that contains a complete cycle of sedimentation including sources, transport paths, and sinks.



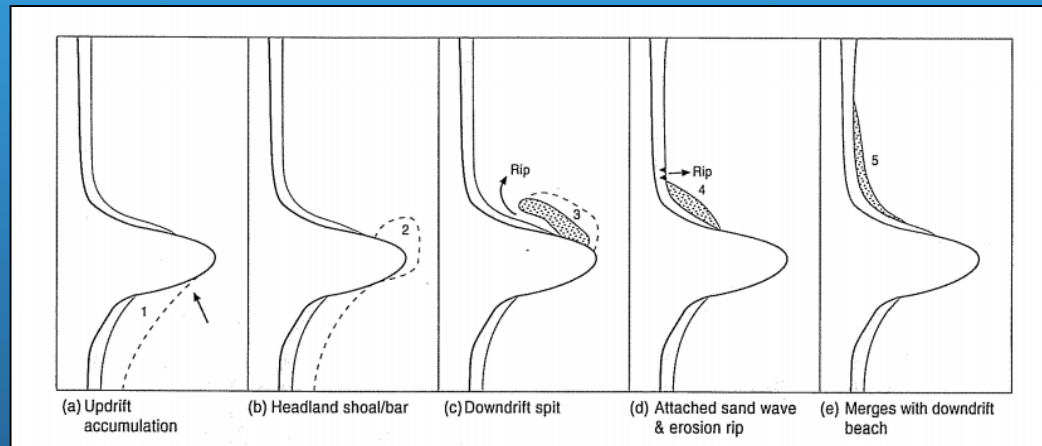
Sanctuary Littoral Cells



Headlands and Littoral Cells

- Sediment bypassing

Short, 1999



- What makes a headland a littoral cell boundary?
- Are California's littoral cells appropriately defined?

Headland study: combination of GIS and numerical modeling

Coastal Management Implications

- Local Beach Nourishments
 - More effective and appropriate placements
 - Use the right headlands as anchors, especially as a climate change strategy
- Conservation Zones
 - Incorporation into the MPAs, ASBSs, NERRS, Sanctuaries management plans for sediment, biology, water quality concerns



Carlsbad Nourishment, SANDAG



Headland Study 1: Classification of CA Headlands



Headland Study 1: Classification of CA Headlands

Motivation

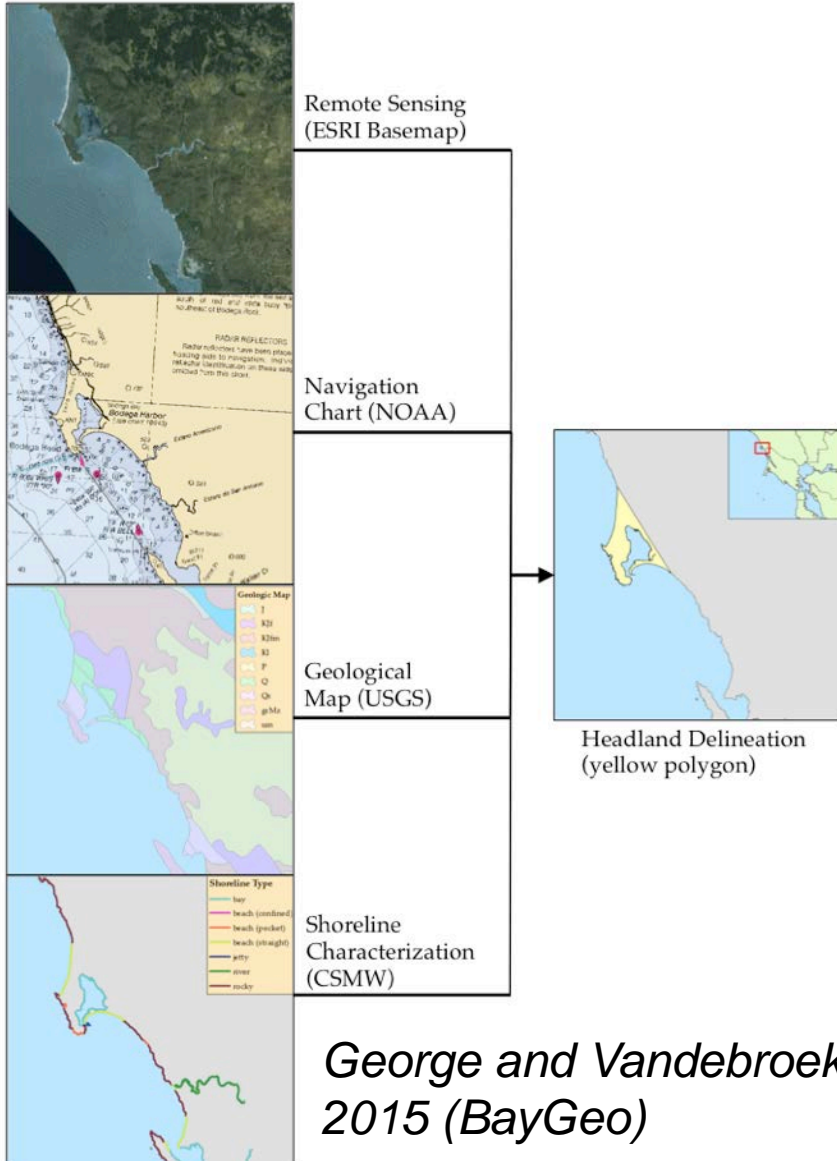
- Classifications of marine features is common
 - Beaches, coral reefs, atolls, submarine canyons, littoral cell grain size, wave climates
- No classification scheme for headlands in research community
 - No guide for 'reality'-based modeling design

Questions

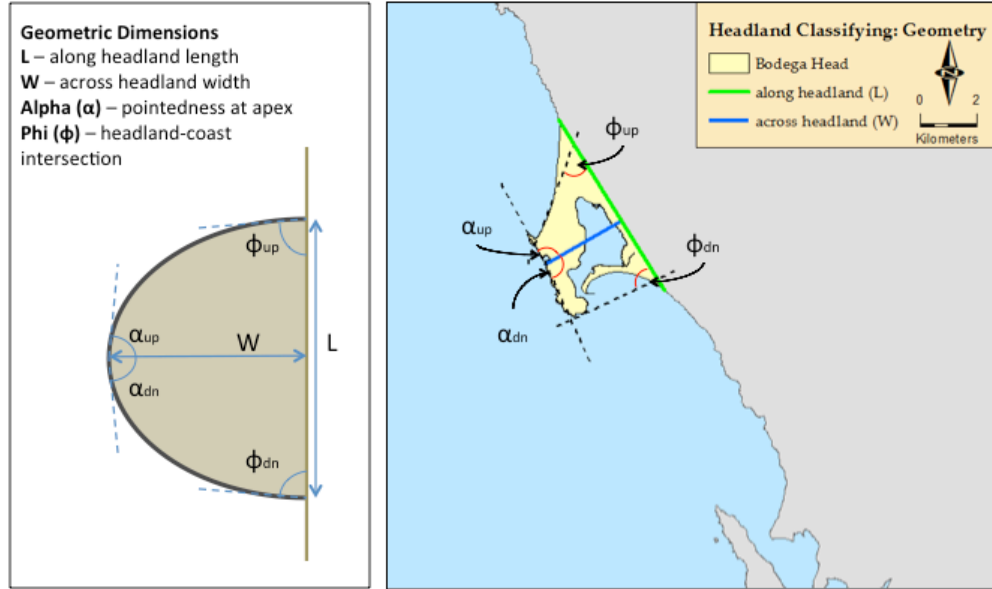
- What are the key physical and geomorphic parameters that differentiate headlands?
 - Could the results redefine littoral cell boundaries along the California coastline or other cliff-backed coastlines with littoral cell boundaries?

Bodega Head example

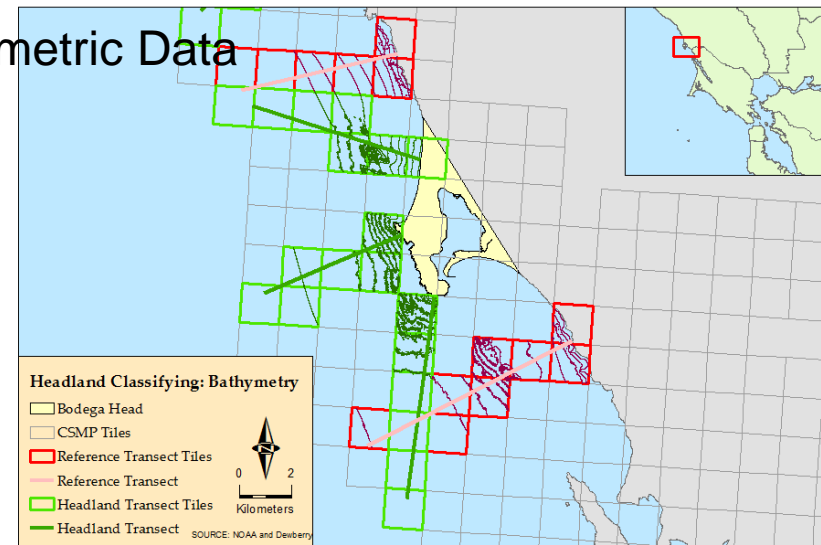
1. Selection



2. Geomorphic Data

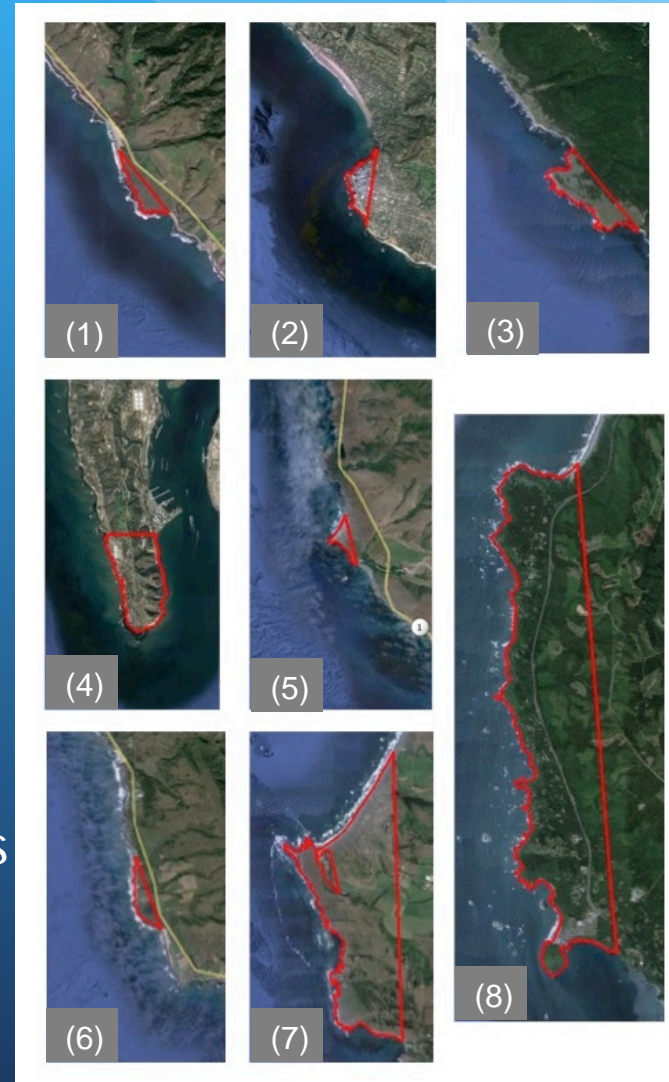


3. Bathymetric Data



Findings for California (& beyond)

- Primary parameters that define headlands (out of 54 initial ones):
 - size (perimeter)
 - sharpness (apex angle)
 - bathymetric asymmetry
- 8 groups based on those parameters
- Littoral cell boundaries along California
 - Potential to reassess some boundaries based on geomorphic elements



Headland Study 2: Modeling Sediment at Headlands

Motivation

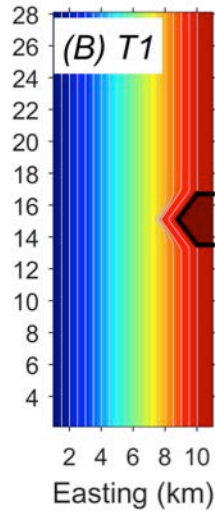
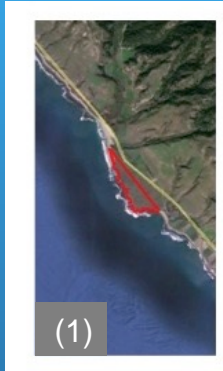
- Generalize across headland types as field observations not possible for every headland
 - Create transferability to other coastal systems
- Investigate the relative importance of variables affecting transport for future headland analyses

Questions

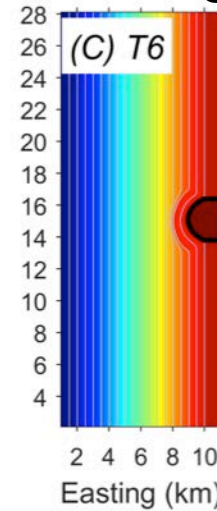
- What are controlling factors on circulation and transport patterns for idealized headlands?
- What factors create which type of littoral cell boundaries?

Input: Morphology

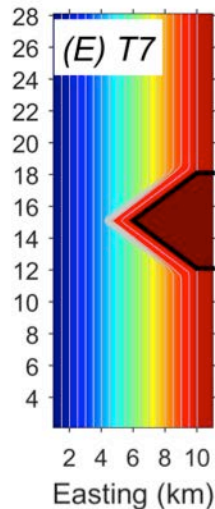
Small, Sharp



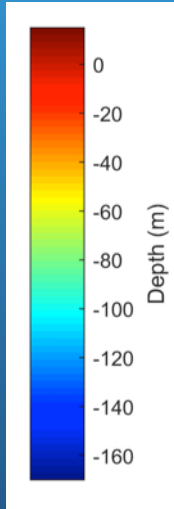
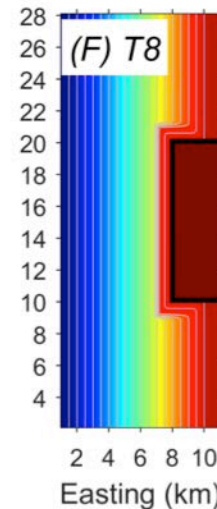
Small, Broad





Medium, Sharp

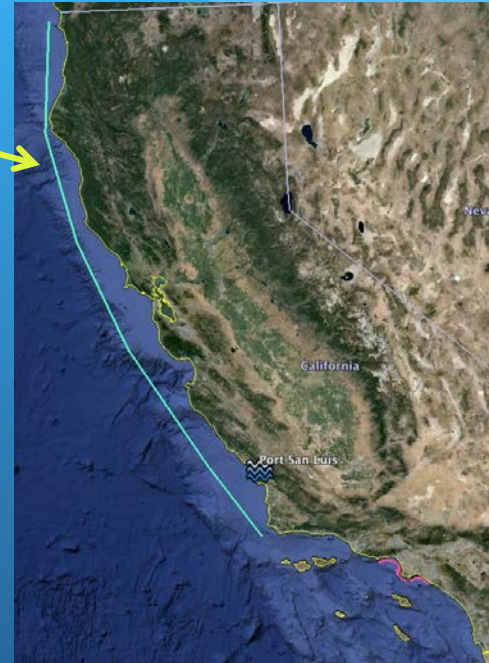


Large, Broad



Input: Processes & Sediment

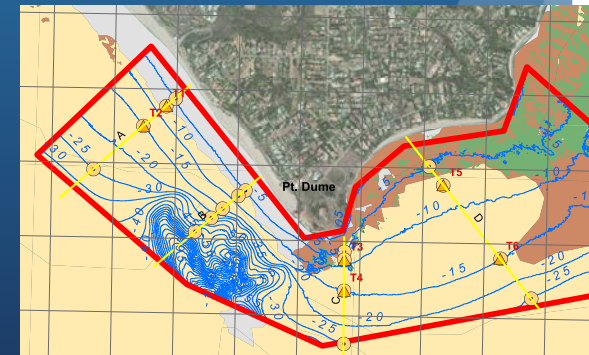
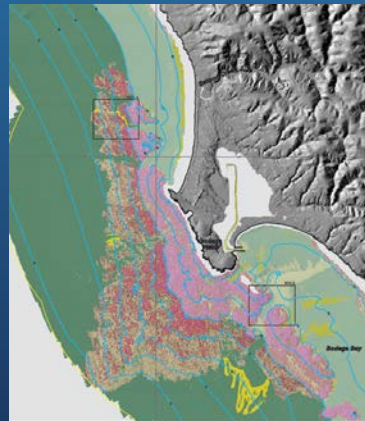
Waves	Least	Most
Direct 	$H_s = 2 \text{ m}$ $T_p = 10 \text{ s}$ $\theta_d = 270^\circ$	$H_s = 7 \text{ m}$ $T_p = 16 \text{ s}$ $\theta_d = 270^\circ$
Oblique 	$H_s = 2 \text{ m}$ $T_p = 10 \text{ s}$ $\theta_d = 345^\circ$	$H_s = 7 \text{ m}$ $T_p = 16 \text{ s}$ $\theta_d = 345^\circ$



Developed from USGS wave study (*Erikson et al., 2014*)

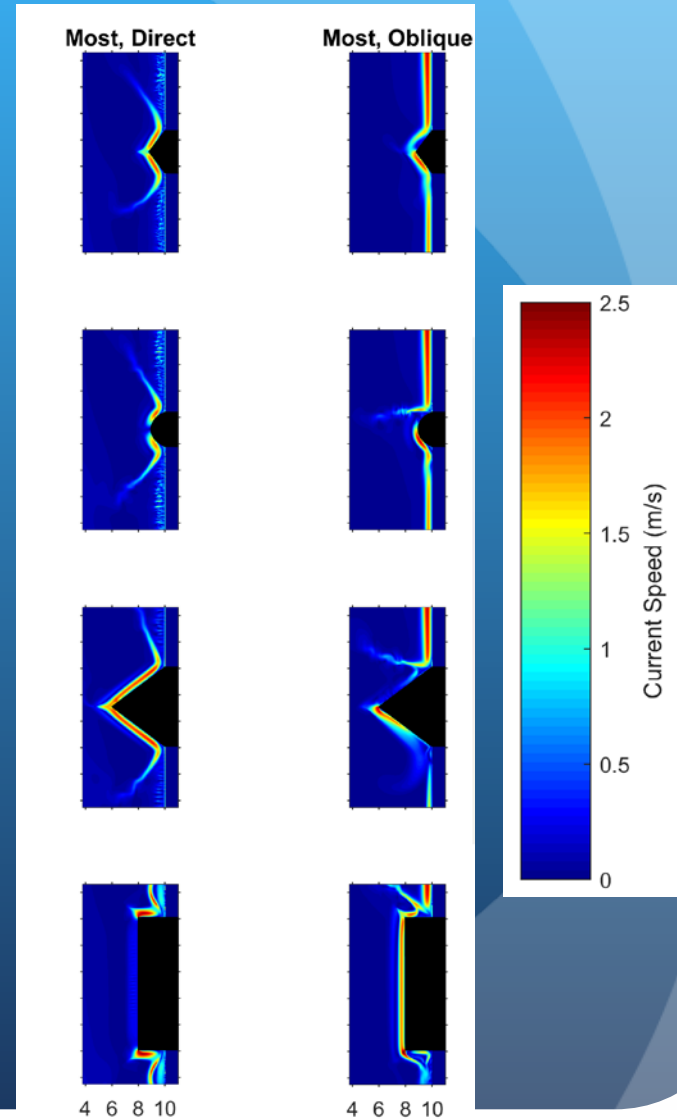
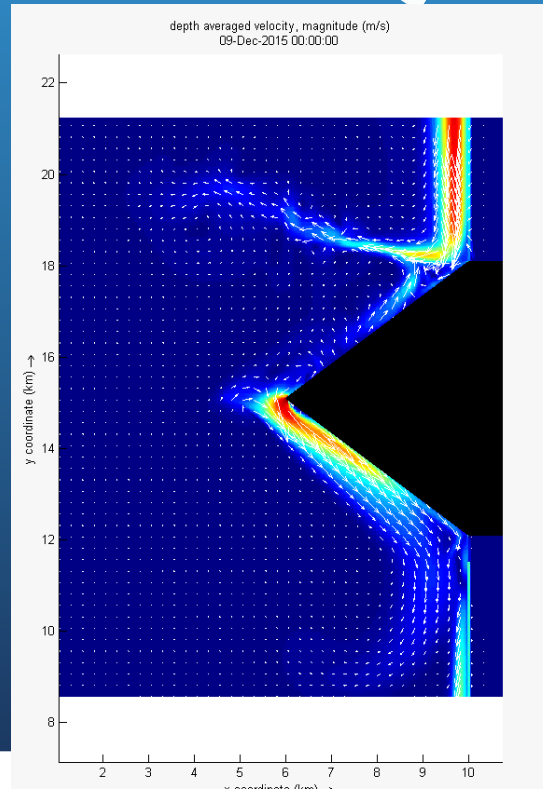
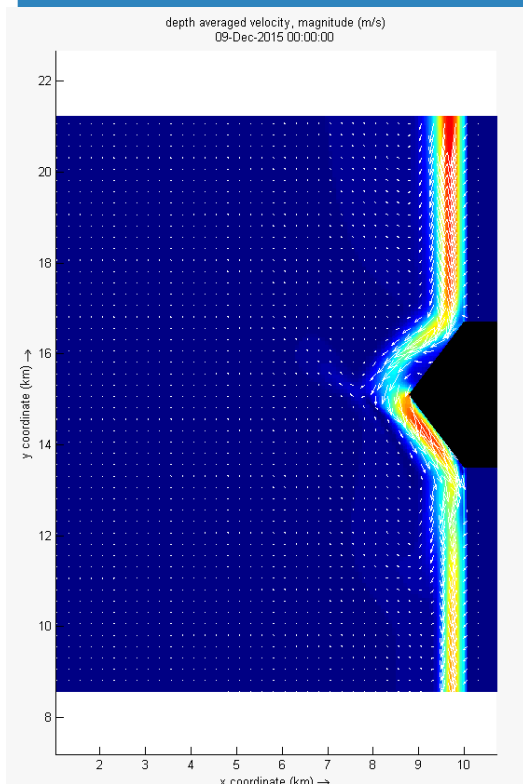
- Sediment Size
 - Fine sand (125 μm)
 - Fine-medium sand (250 μm)
 - Medium sand (500 μm)

- Bed
 - Reefed (Bodega Head)
 - Sandy (Pt. Dume, Malibu)



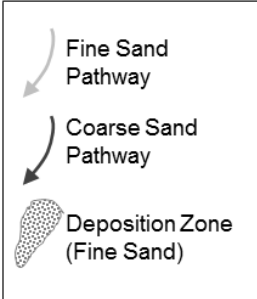
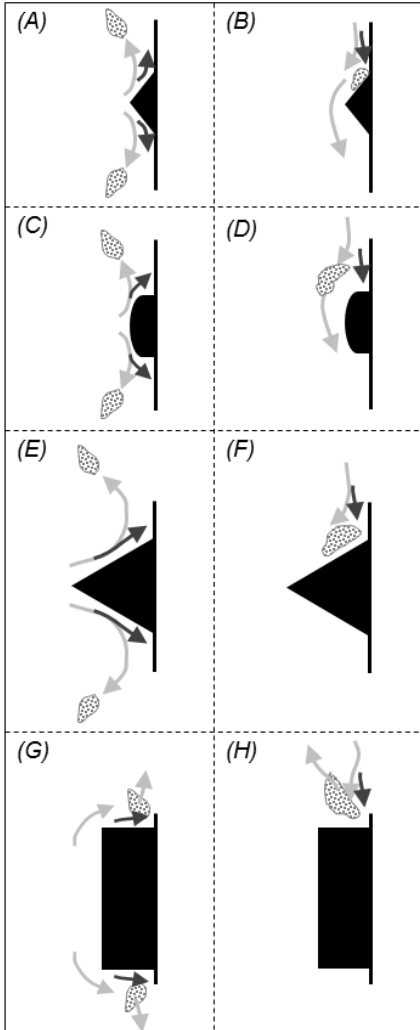
Headland Circulation Patterns

Entering the world of moustaches and jets



Littoral Cell Boundary Types

Direct Waves Oblique Waves



Likely to Be Littoral Cell Boundary?

Blocking – Partial: coarse blocked



Blocking – Partial: coarse blocked



Blocking – Full: all blocked



Blocking – Partial: divergent by grain size



Headland Study Wrap-up

1. The controlling factors on sediment transport

- Morphology: Size then shape differentiate flow and transport patterns
- Processes: Relative wave angle essential to determine transport

2. Application

- Littoral cell boundaries are more nuanced
- Beach nourishment/sediment management activities should consider influence of headlands for sustainability
 - Climate change adaptation
 - Coastal erosion

Managing Sediment Along the Coast

California Coastal Sediment Master Plan

A “Super-Regional” Approach for All of California



Port of Oakland



Ocean Beach



Pacific, 1994



South Bay Salt Ponds

CA's Coastal Regional Sediment Management Plans (CRSMPs)

Present Ideas for Local Projects

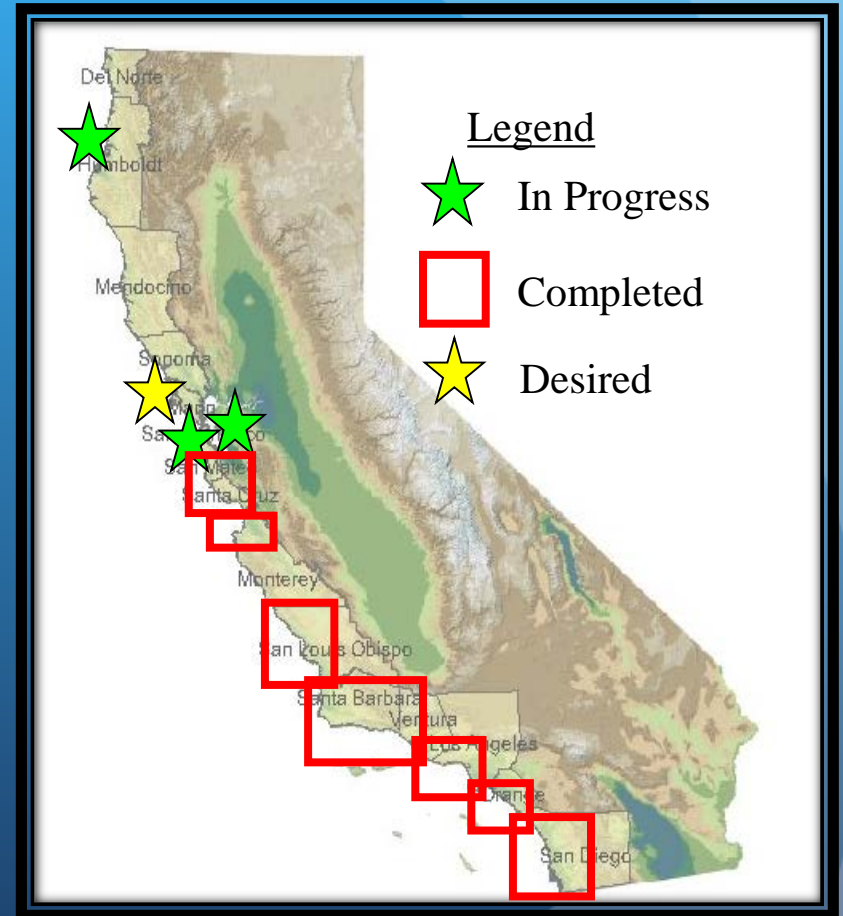
Policy & Governance

Economics Infrastructure

Ecology

Geology & Morphology

Physical Processes



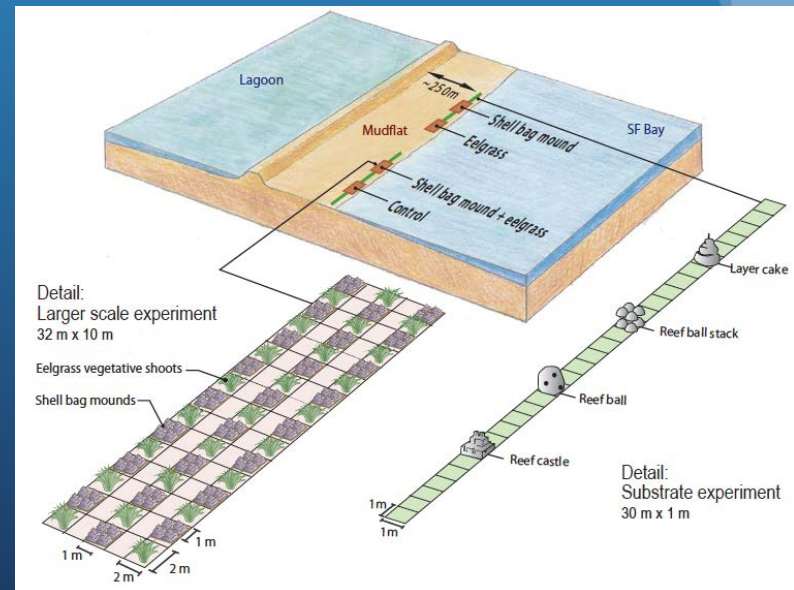
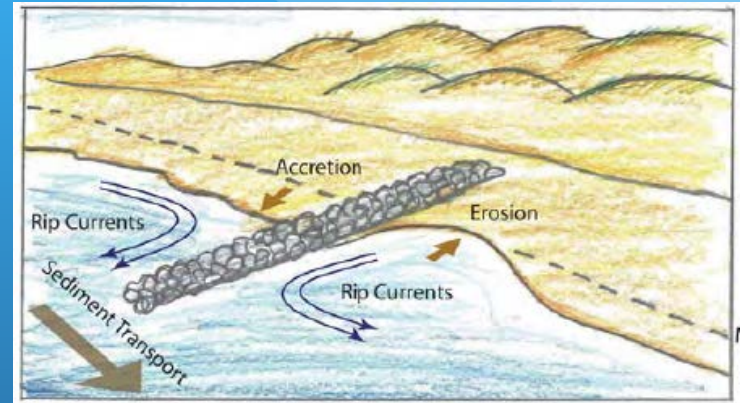
The Big Questions of a CRSMP

- Where are the sediment challenged areas?
 - Erosion (e.g., coastal highway segments)
 - Sedimentation (e.g., Bolinas Lagoon)
- What's at risk?
 - Human Needs: Infrastructure, Development
 - Nature's Needs: Habitats
 - Both: Resilience to Climate Change/SLR
- How bad is that risk?
- What can be done to minimize that risk?

Sediment Management Tools

A Short List

- Harder (Gray) Infrastructure
 - Jetties/groins
 - Seawalls
 - Breakwaters/reefs
- Softer approaches
 - Beach nourishment
 - Living shorelines
- Overarching
 - Managed retreat
 - Restoration of natural processes



Example:

Problem → Process → Solutions

Hazards



Critical Erosion Areas

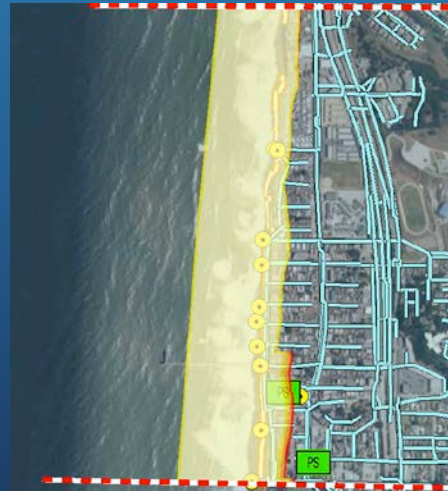
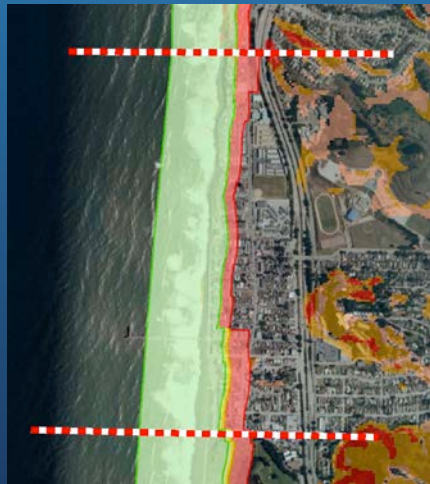


Proposed Ideas

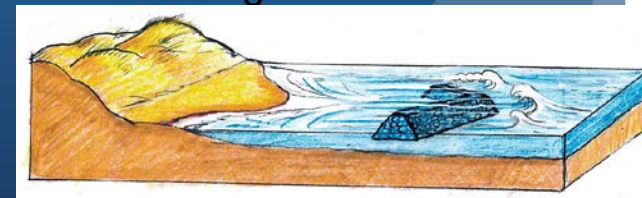
- Beach Nourishment
- Managed Retreat

South
Ocean
Beach

Beach
Blvd

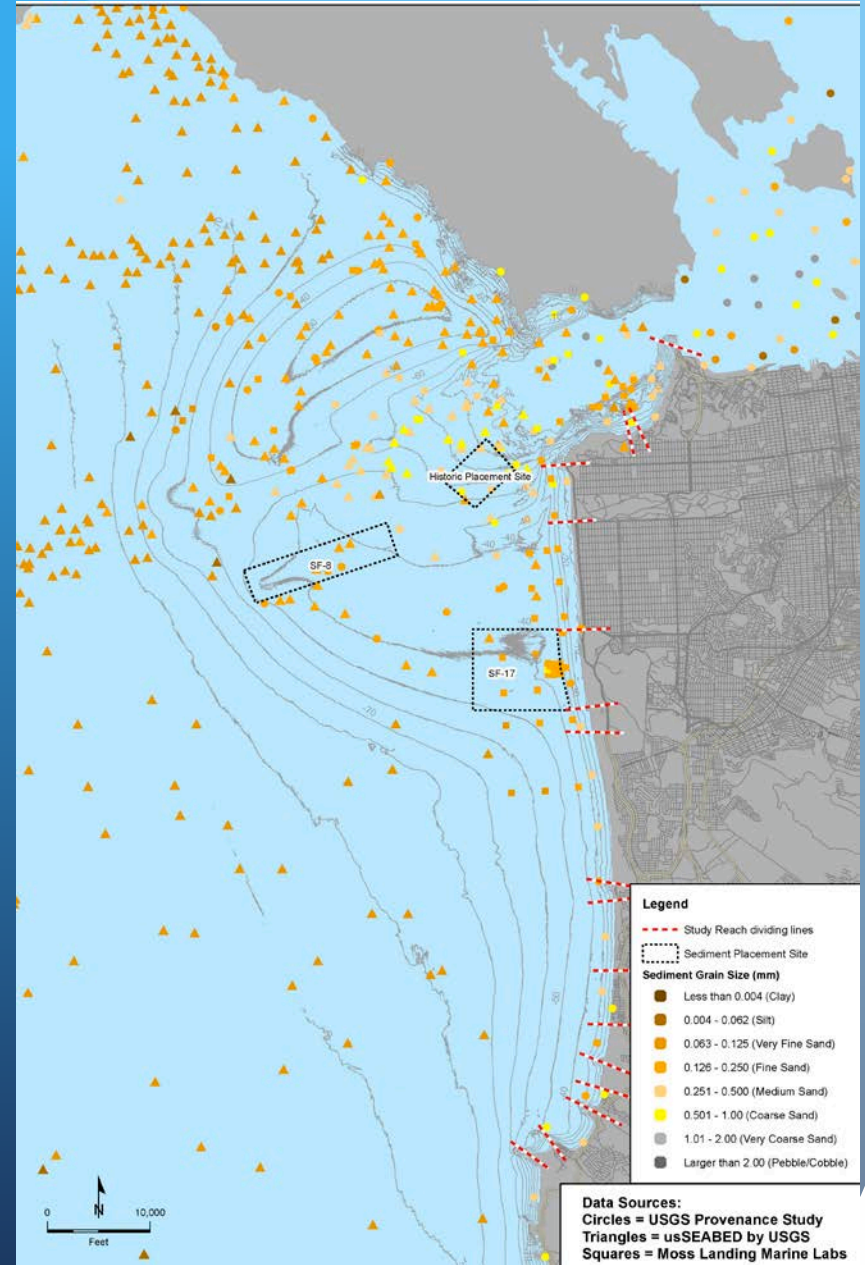


- Beach Nourishment
- Nourishment and Reefs
- Managed Retreat



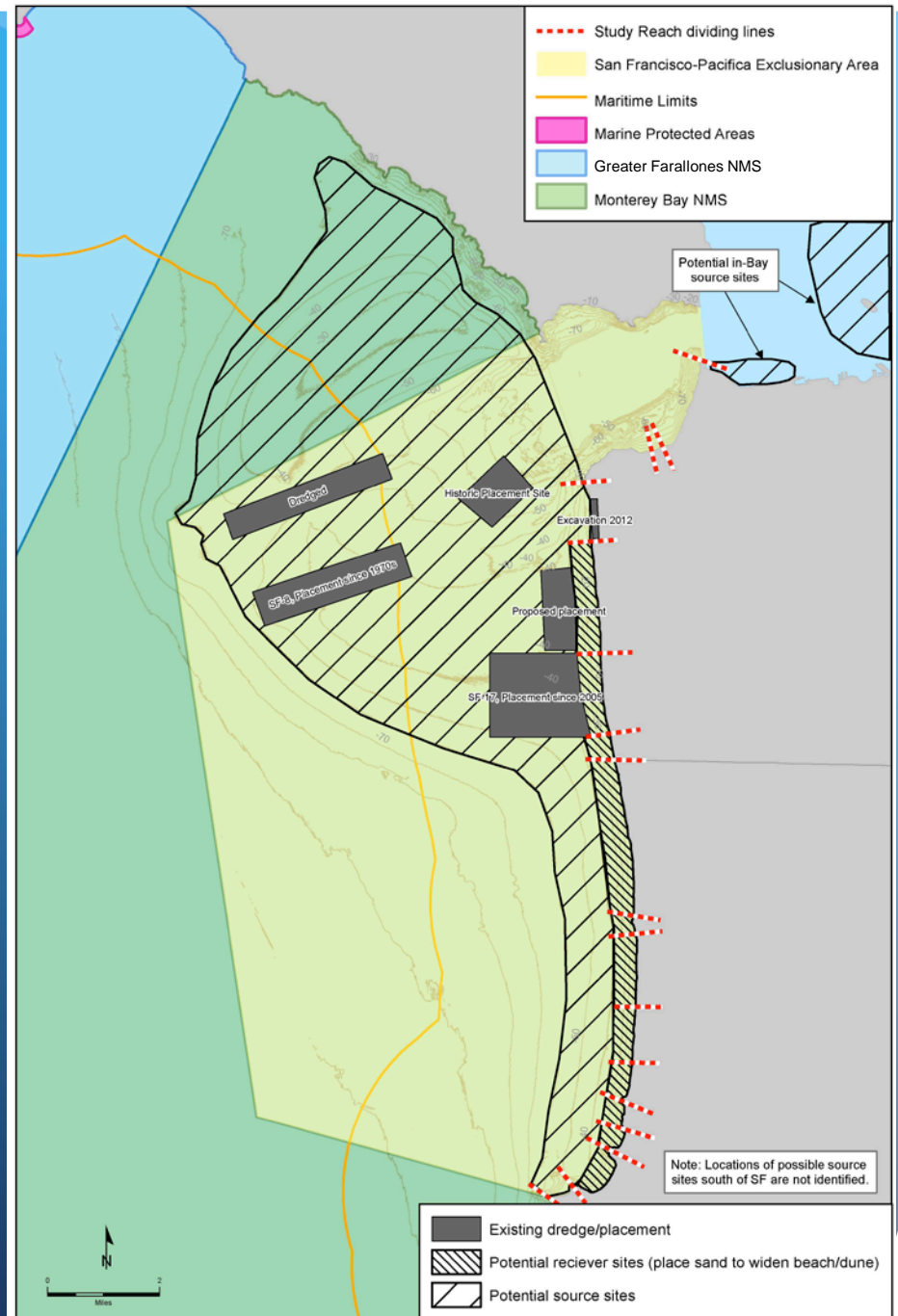
Constraints on Solutions

- Sediment sources for beach nourishment
- Nearshore dynamics
 - transport pathways?
 - reefs improbable?
- Sensitive species and habitats
- Erosion uncertainty
- Terrestrial realities



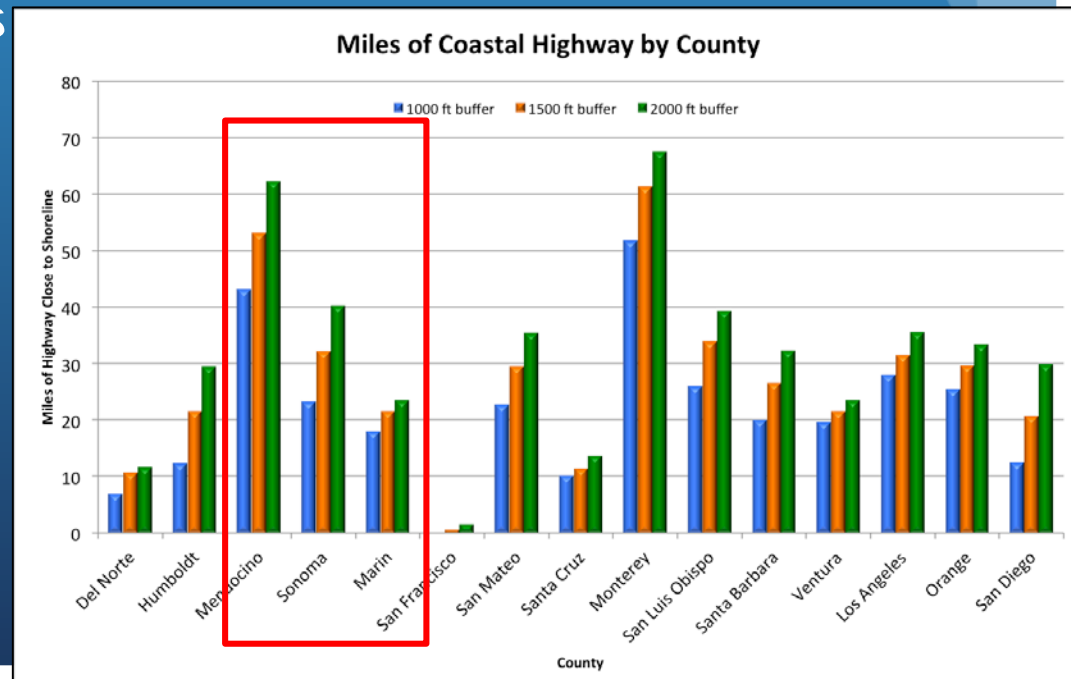
Sanctuary Challenges

- Designation of GFNMS
 - § 922.82 (a) (4):
“Discharging or depositing, from beyond the boundary of the Sanctuary, any material or other matter that subsequently enters the Sanctuary and injures a Sanctuary resource or quality...”
 - § 922.82 (a) (5):
“...drilling into, dredging, or otherwise altering the submerged lands of the Sanctuary in any way...”
- Closure of Sanctuary Exclusion Area



Propelling a Sanctuary CRSMP

- Acquisition of extensive coastline with northern expansion
- Sonoma State Beach 3rd in attendance for all state beaches
- 85-125 miles of coastal highway in Marin-Sonoma-Mendocino
- Estero and beach habitats
- Existing work groups
 - Bolinas Lagoon
 - Tomales Bay
 - Marin County
- Climate-Smart Plan (33/50 top priorities)

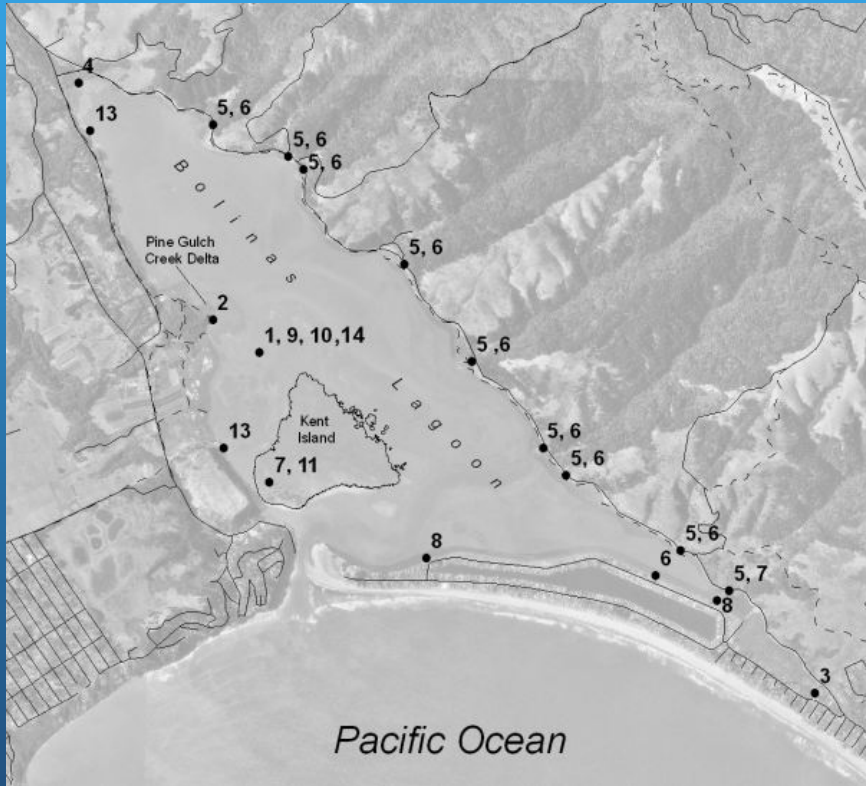


A mini-CRSMP in San Francisco

- City of SF and NPS (GGNRA)
 - Sand trucking from NOB to SOB in 2012, 2014, 2016
- USACE
 - Single placement of 300,000 cubic yards
 - Dredged sediment pumped onshore at Sloat and to 4000' south
 - Designation of OBDS as permanent site
- Ocean Beach Master Plan
 - 2 million cubic yards of sand placed every 10 years

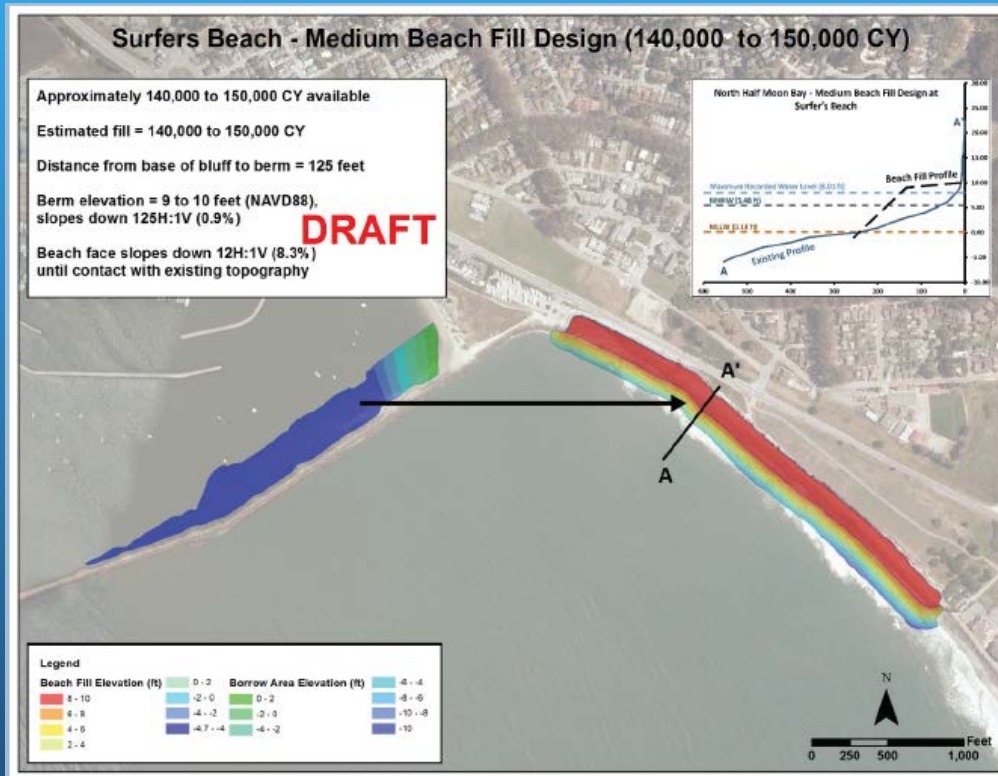


A mini-CRSMP in Bolinas Lagoon



- Sediment management objectives
 - Restore natural processes for resilience and sustainability
- Kent Island Restoration
- Bolinas “Y” at Lewis and Wilkins Gulch creeks

A mini-CRSMP in Half Moon Bay

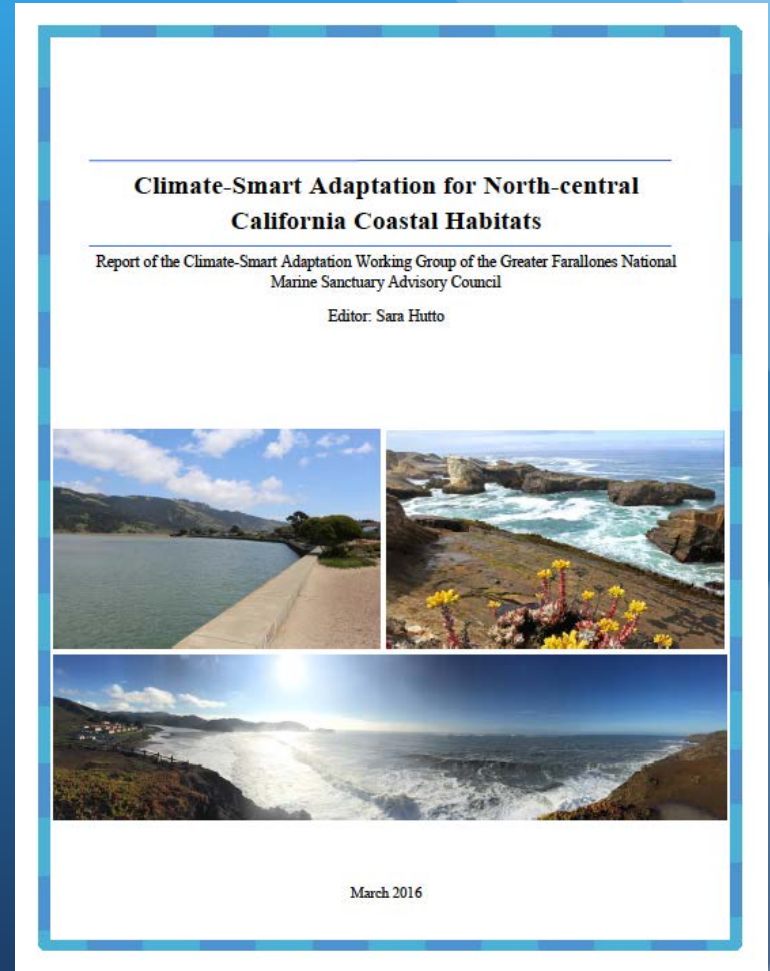


- Pilot project at Surfer's Beach
- Move 140K-150K of harbor sand to revetment along Hwy 1
- Expected to last only 6 years
- Design is meant buy time for realignment of Hwy 1

Climate Change Plan Connection

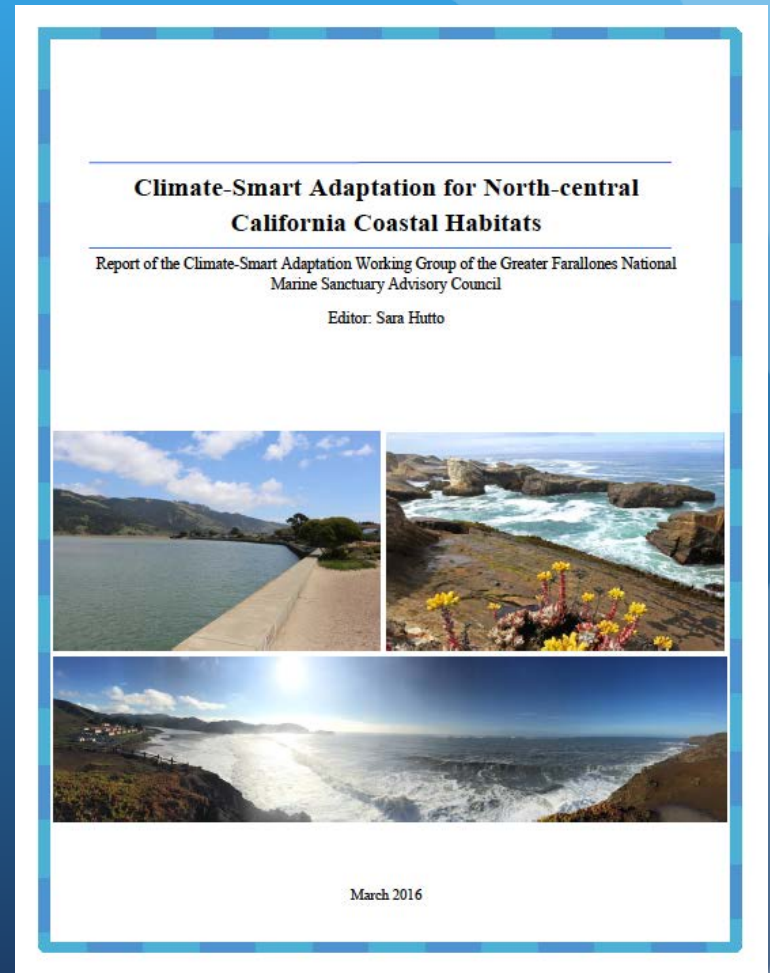
Look at all this hard work already!

- Habitats as defined:
 - Beaches and dunes
 - Cliffs
 - Rocky intertidal
 - Outer coast estuaries



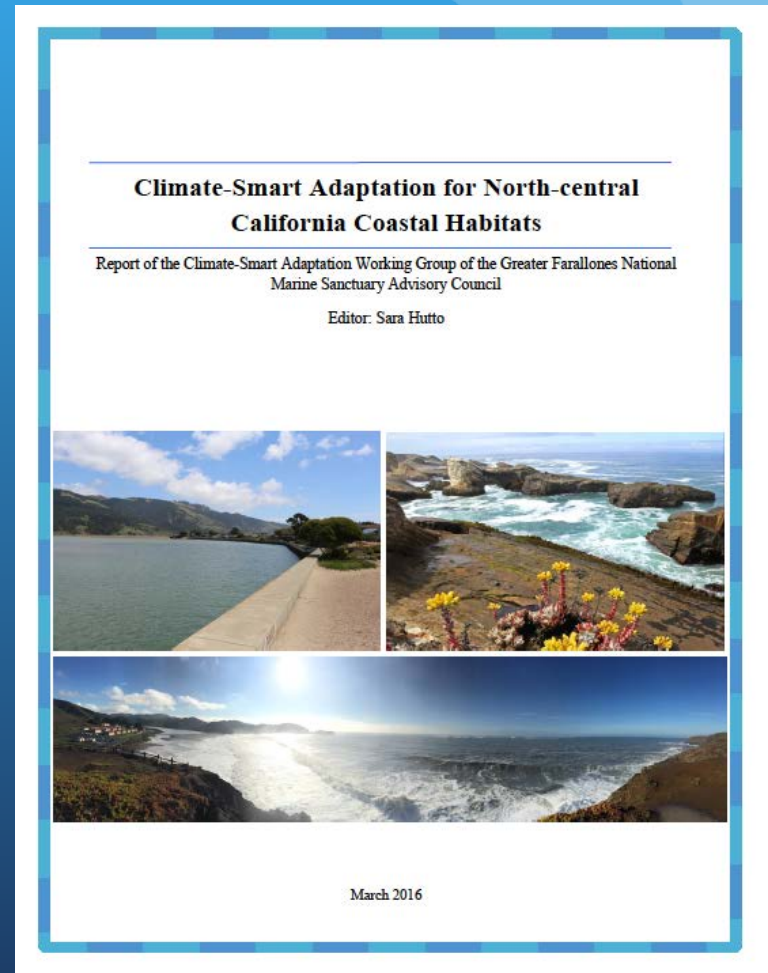
Look at all this hard work already!

- 33/50 priorities connect directly or indirectly to sediment management, including #11:
 - Create local and regional sediment management plans for full range of the sanctuary that are climate informed.



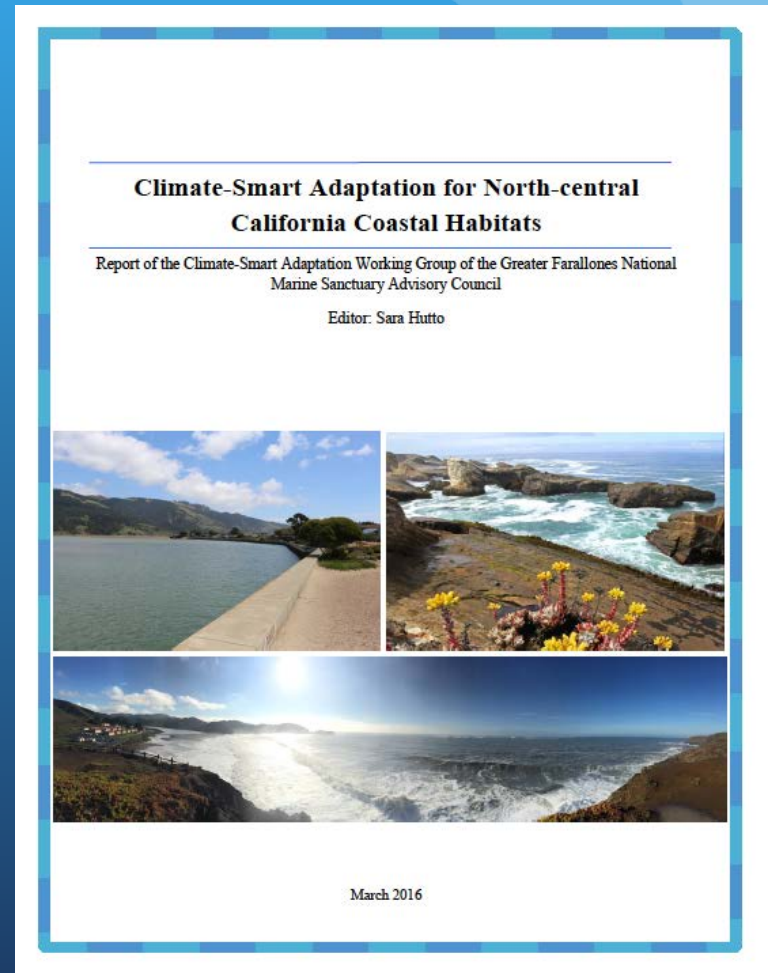
Look at all this hard work already!

- Variety of actions
 - Active sediment placement
 - Removal of armoring
 - Sacrifice of beaches
 - Watershed approach



Look at all this hard work already!

- Variety of project locations
 - Bolinas Lagoon
 - Tomales Bay
 - Drakes Estero
 - Surfer's Beach (HMB)
 - Dillon Beach



Our Story Concludes

- Headlands and Littoral Cells
 - Boundaries are in flux so best to plan around them
- Sediment Management
 - Coast of Sanctuary is ready for a regional sediment plan, or at least segments
- Climate Change Connection
 - Sanctuary has laid some essential groundwork for merging sediment management with climate change adaptation planning

IF MAD SCIENTISTS
CAN ENDANGER THE WORLD,
NICE SCIENTISTS CAN SAVE IT.

Thank you!

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