Presented at Puget Sound Shorelines and the Impacts of Armoring Workshop,
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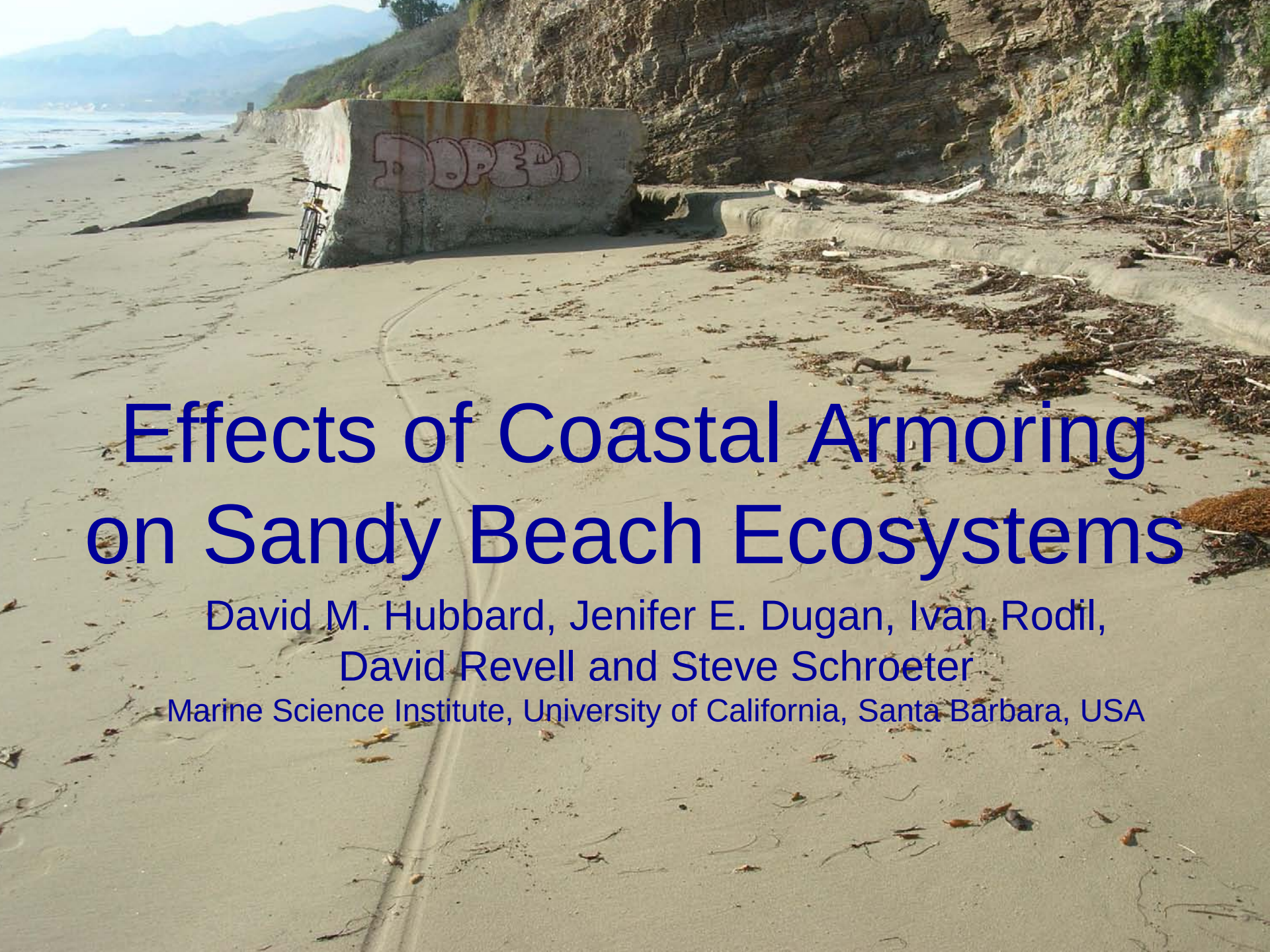

Effects of Coastal Armoring on Sandy Beach Ecosystems

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- UCSB Shoreline Preservation Fund
- Santa Barbara Coastal LTER
- National Science Foundation

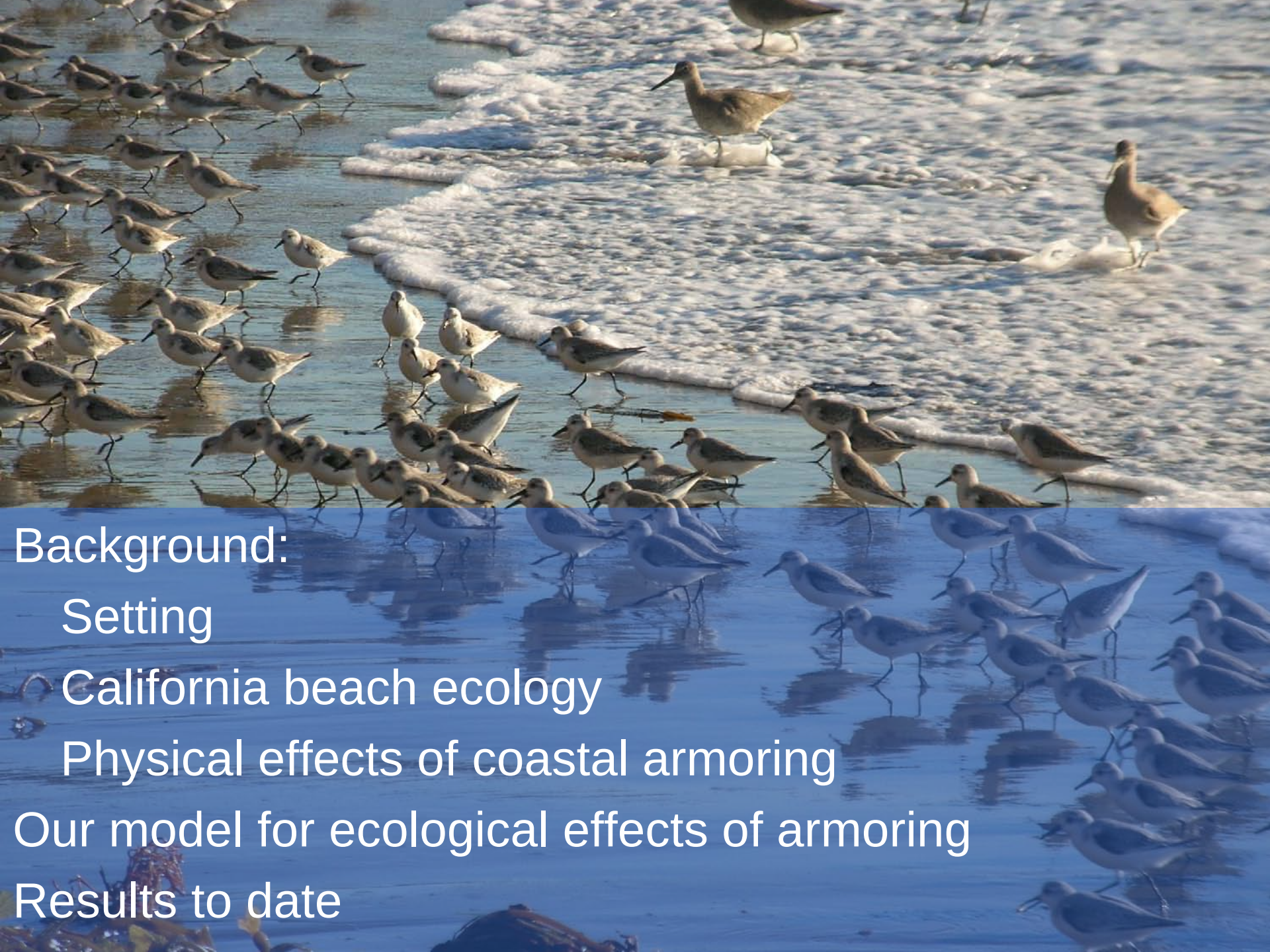
Beaches

- Recreation
- Coastal economy
- Aesthetics
- Cultural identity

Coastal Squeeze

Coastal erosion and armoring

Beaches as ecosystems



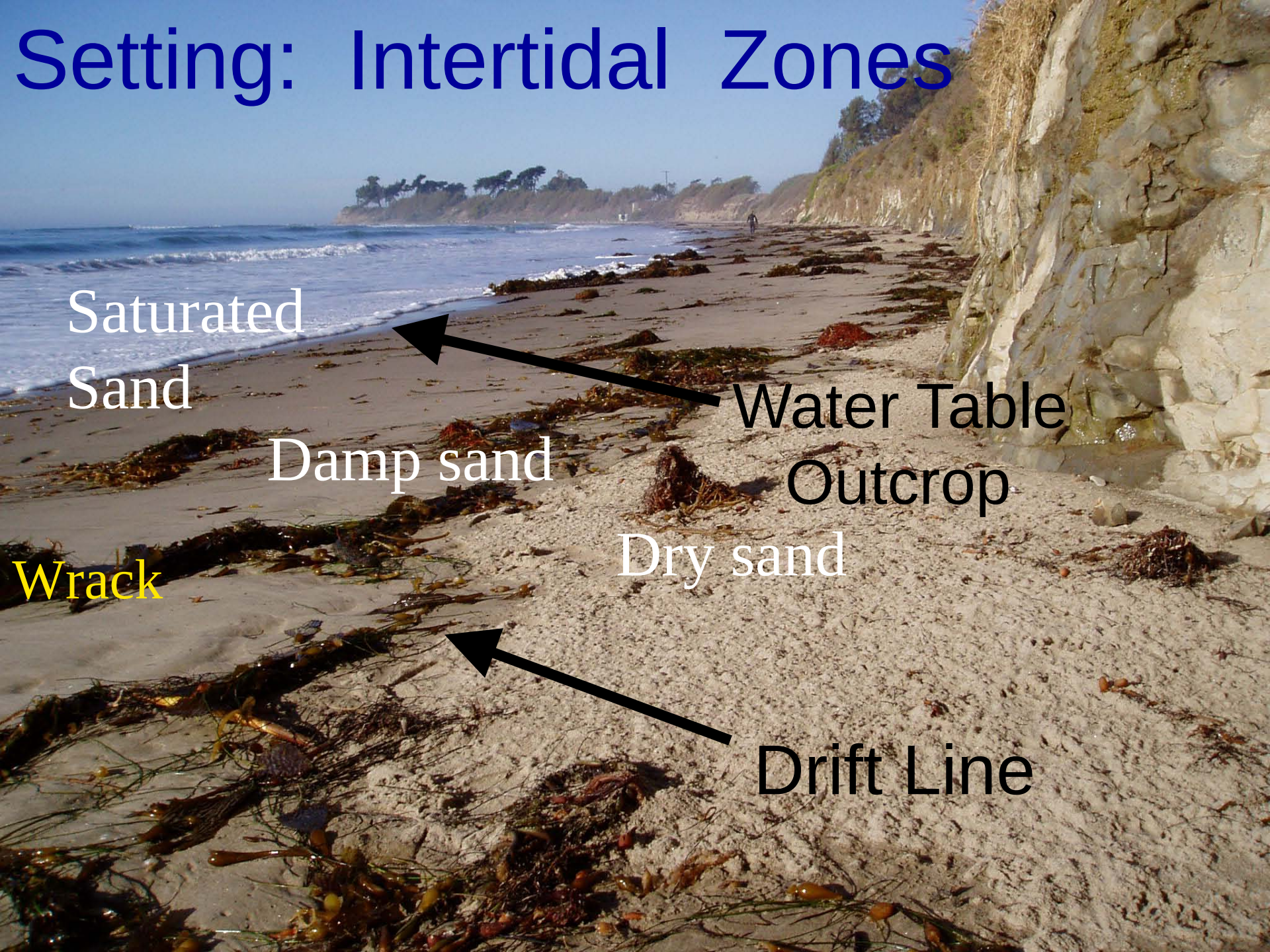
Background:

- Setting
- California beach ecology
- Physical effects of coastal armoring

Our model for ecological effects of armoring

Results to date

Setting: Intertidal Zones



Coastal Strand Vegetation

Coastal strand
vegetation

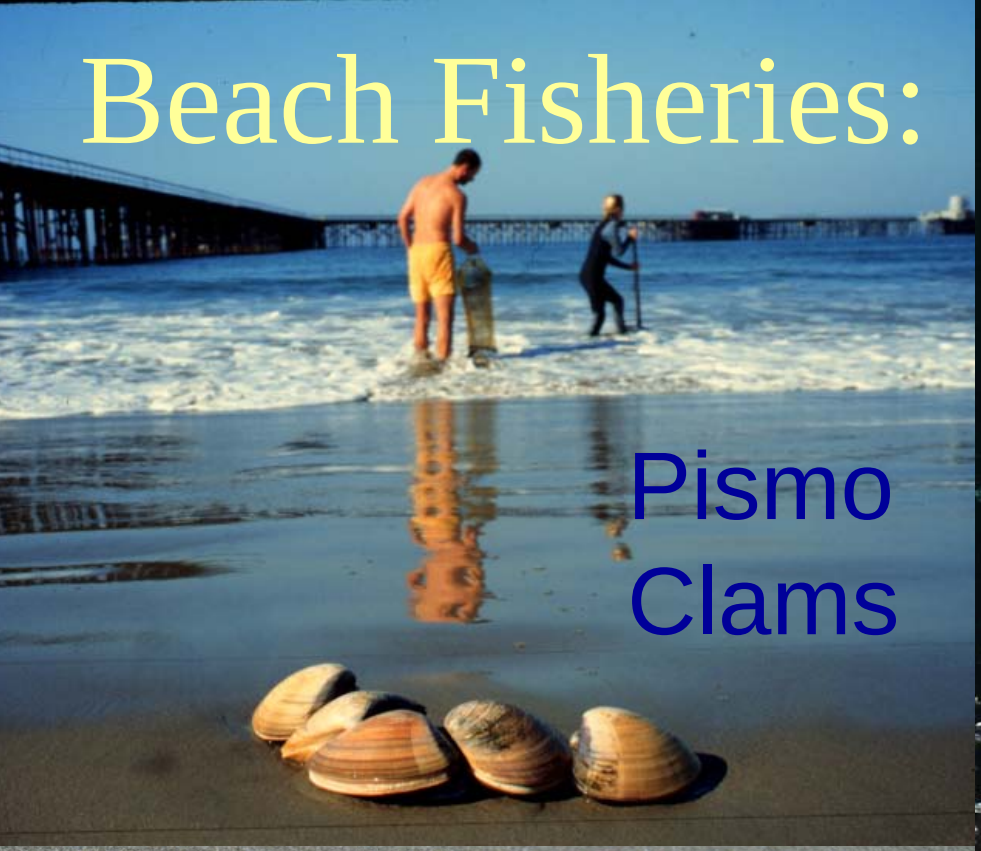
Extreme high tide zone

Coastal habitat in the study area

- Mostly bluff-backed beaches
- Bedrock platform
- Seasonal movement of sand
- Coastal strand vegetation

California beach ecology: high diversity & rich prey resources for birds & fish

Beach Fisheries:



Pismo Clams

California Grunion

Grunion.org
J. Flannery

Upper Intertidal Macroinvertebrates

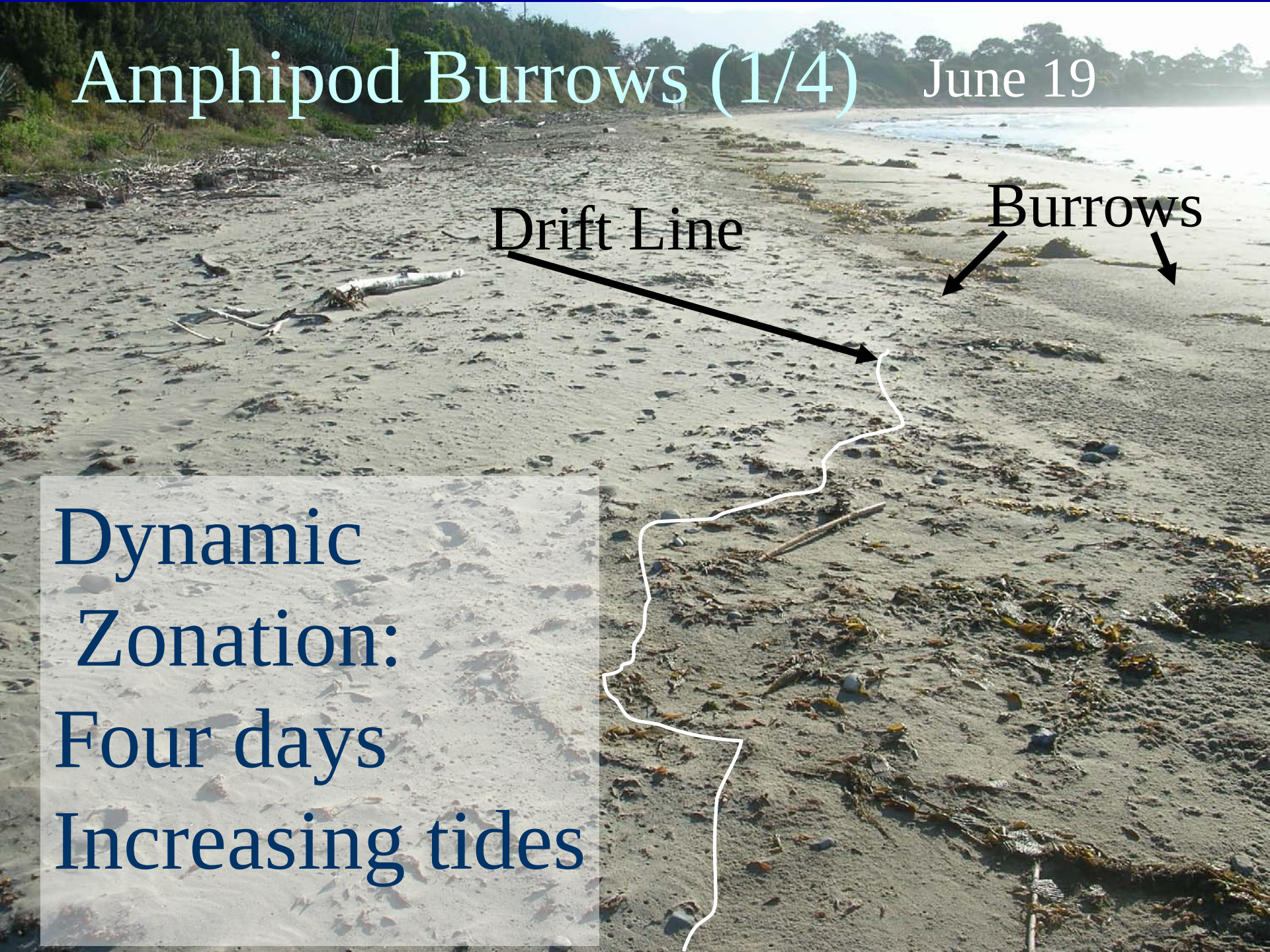
- Inhabit specific zones/ habitats
- Migrate tidally, episodically, seasonally
- Respond strongly to macrophyte wrack

Dynamic distributions

Amphipods move upshore ahead of rising tide

Amphipod Burrows (1/4)

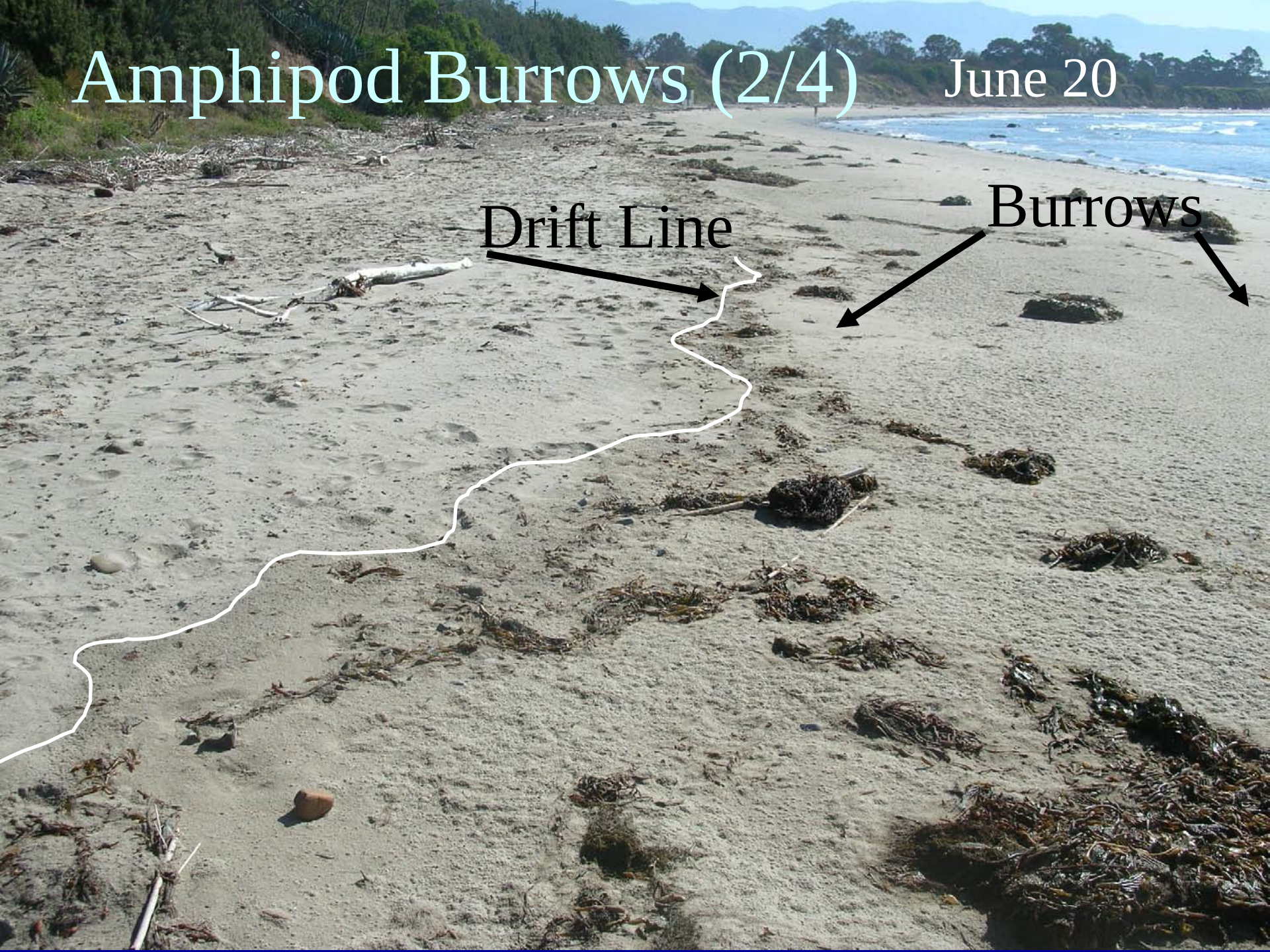
June 19



Dynamic Zonation:
Four days
Increasing tides

Amphipod Burrows (2/4)

June 20

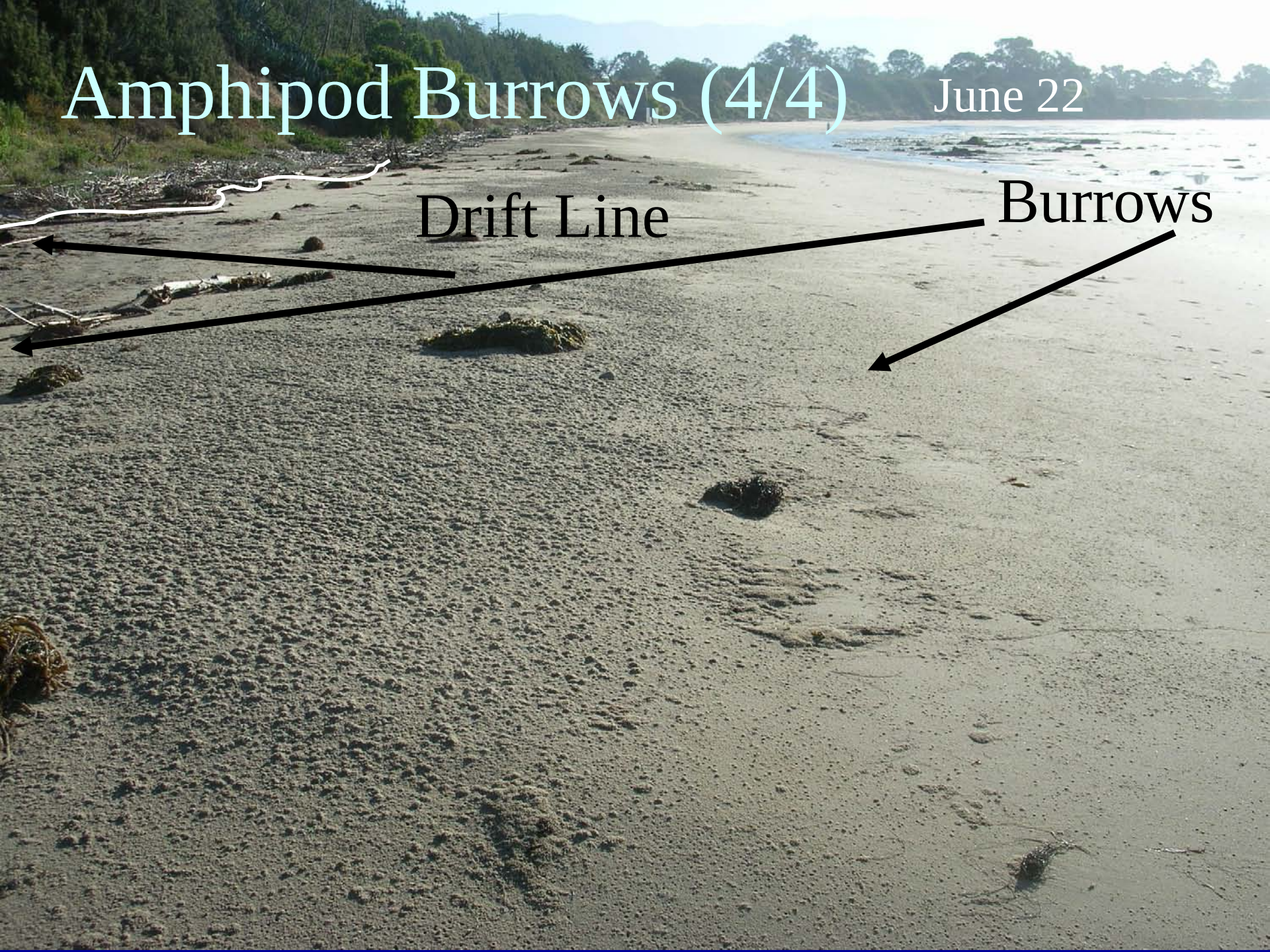


Amphipod Burrows (3/4)

June 21

Amphipod Burrows (4/4)

June 22



Seasonal Dynamics

Critical Habitat & Prey for Shorebirds

Shorebirds

- Feeding habitat
- High tide refuges
- Habitat preferences

Young Western Snowy Plover chick with prey

Factors Affecting Shorebirds on Sandy Beaches

Beach width **+**

Wrack **+**

Beach grooming **-**

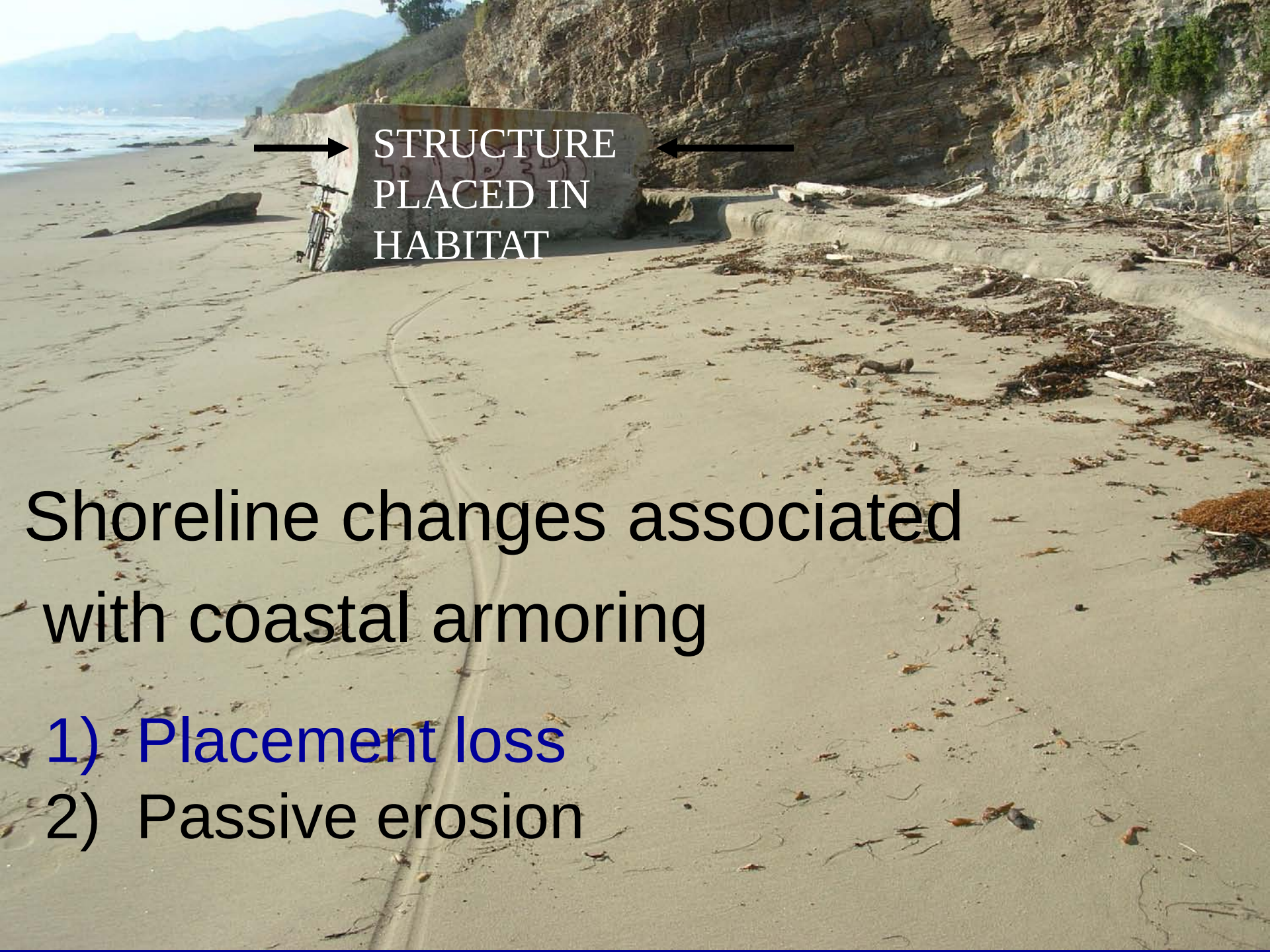
Invertebrate Prey Diversity, Abundance, Mass **+**

n California, coastal armoring:

- Extends over 200 km of shoreline (open coast)
- Has increased 4-fold since the 1970s
- Varies regionally

Predictions of Ecological Responses to Coastal Armoring

1) Physical effects of armoring
2) Beach ecology & food webs
3) Use of beaches by shorebirds



Shoreline changes associated with coastal armoring

1) Placement loss
2) Passive erosion

Shoreline changes associated with coastal armoring

1) Placement loss
2) Passive erosion
3) Active erosion?

Seawall at high tide

Coastal processes interact with coastal armoring
Wave reflection

Seawall
Adjacent
Adjacent
Surf zone

Effects of Armoring

Armored beaches lose width

<u>Prediction</u>: Strongest ecological effects in upper intertidal zones

Armoring Effects on Beach Ecology?

Our Model:

Changes in intertidal processes affect:

1) Zone widths
2) Wrack dynamics
3) Invertebrates
4) Shorebirds

Testing predictions of the model

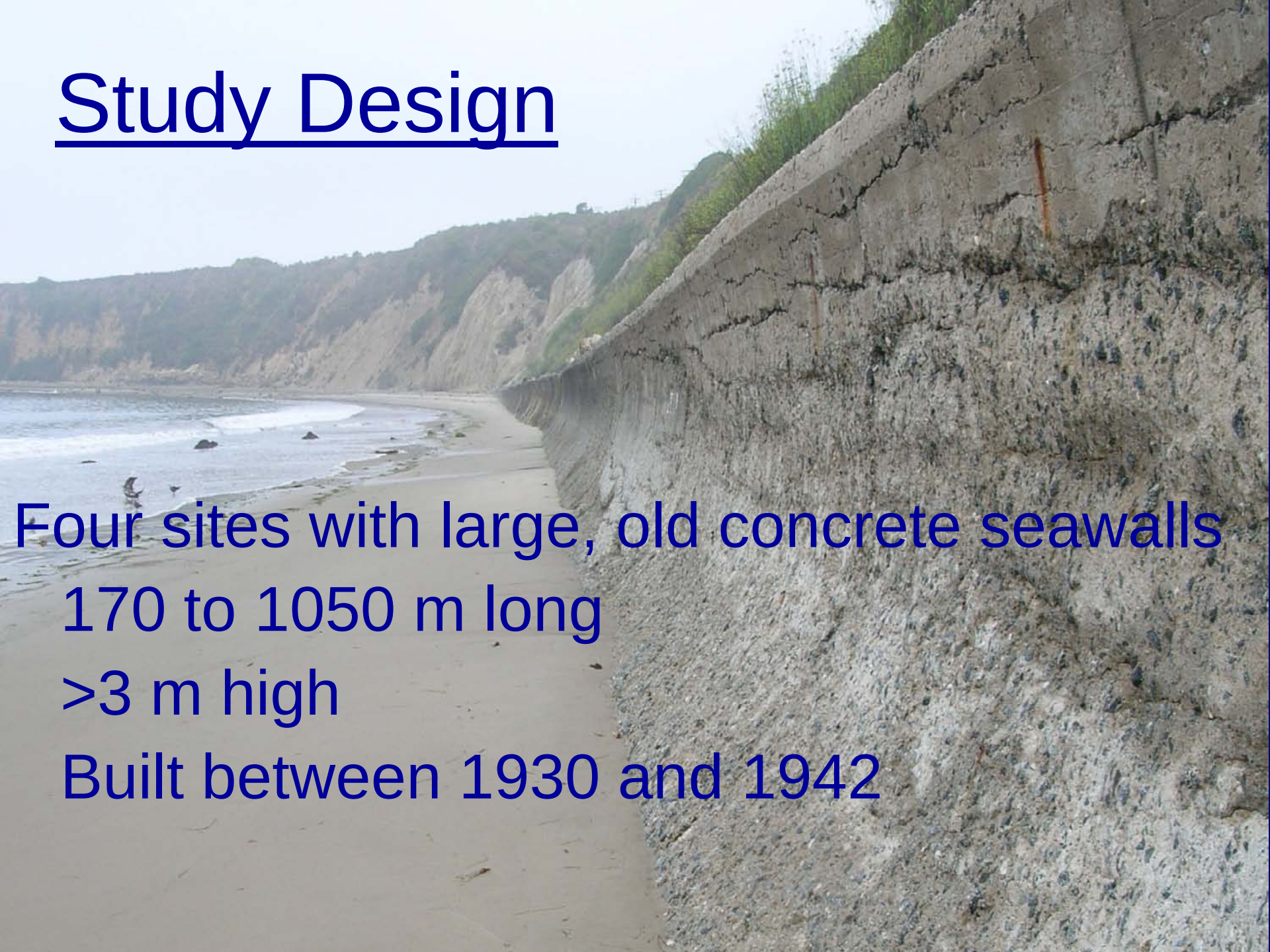
<u>Study Area</u>

Santa Barbara County, California

Narrow, bluff-backed beaches

Segments of armored & unarmored coast

Study Design



Four sites with large, old concrete seawalls

- 170 to 1050 m long
- >3 m high
- Built between 1930 and 1942

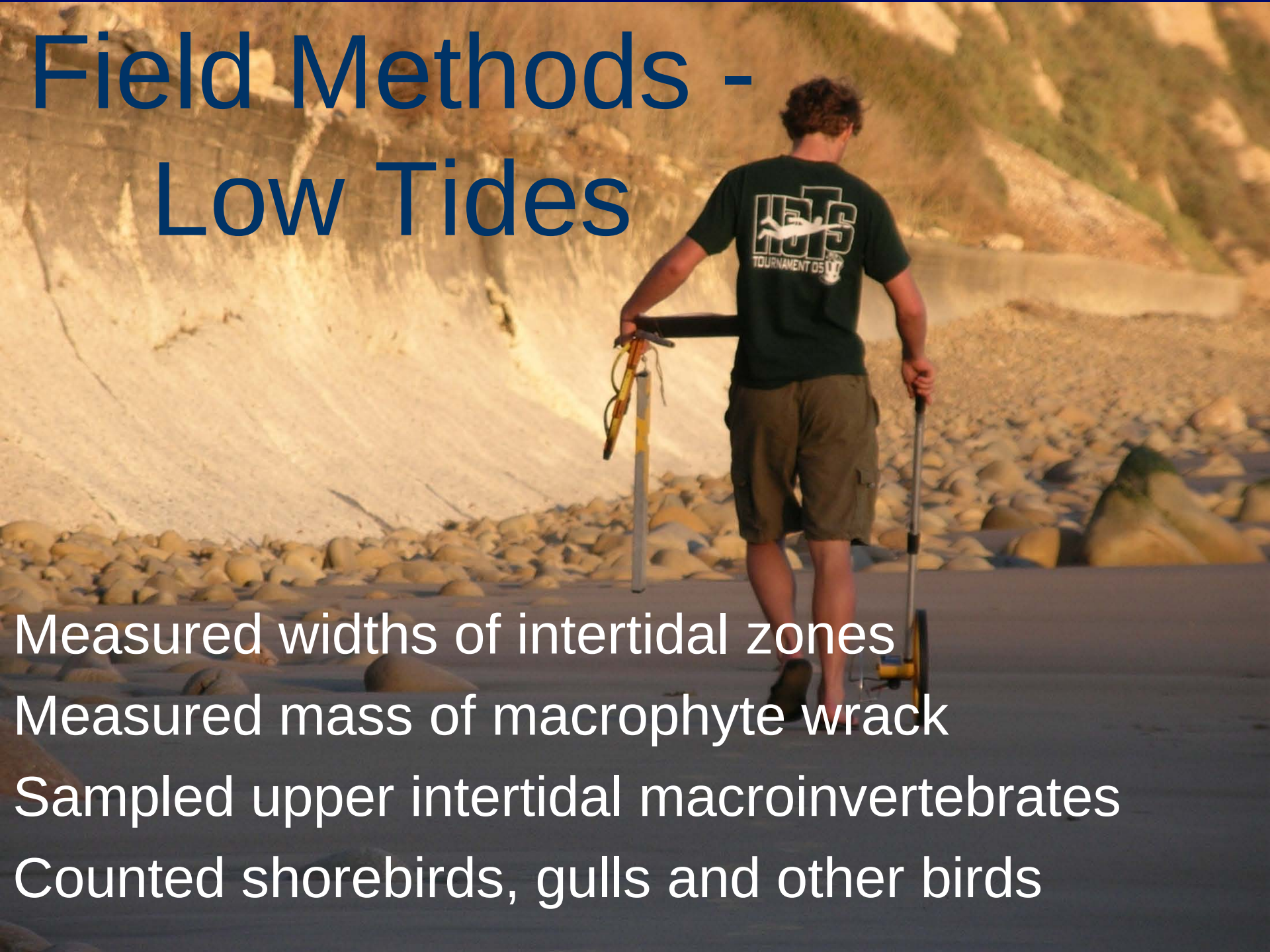
Design:

Paired segments:

1) Intertidal segment below seawall

2) Adjacent segment- same length, similar orientation

Field Methods - Low Tides

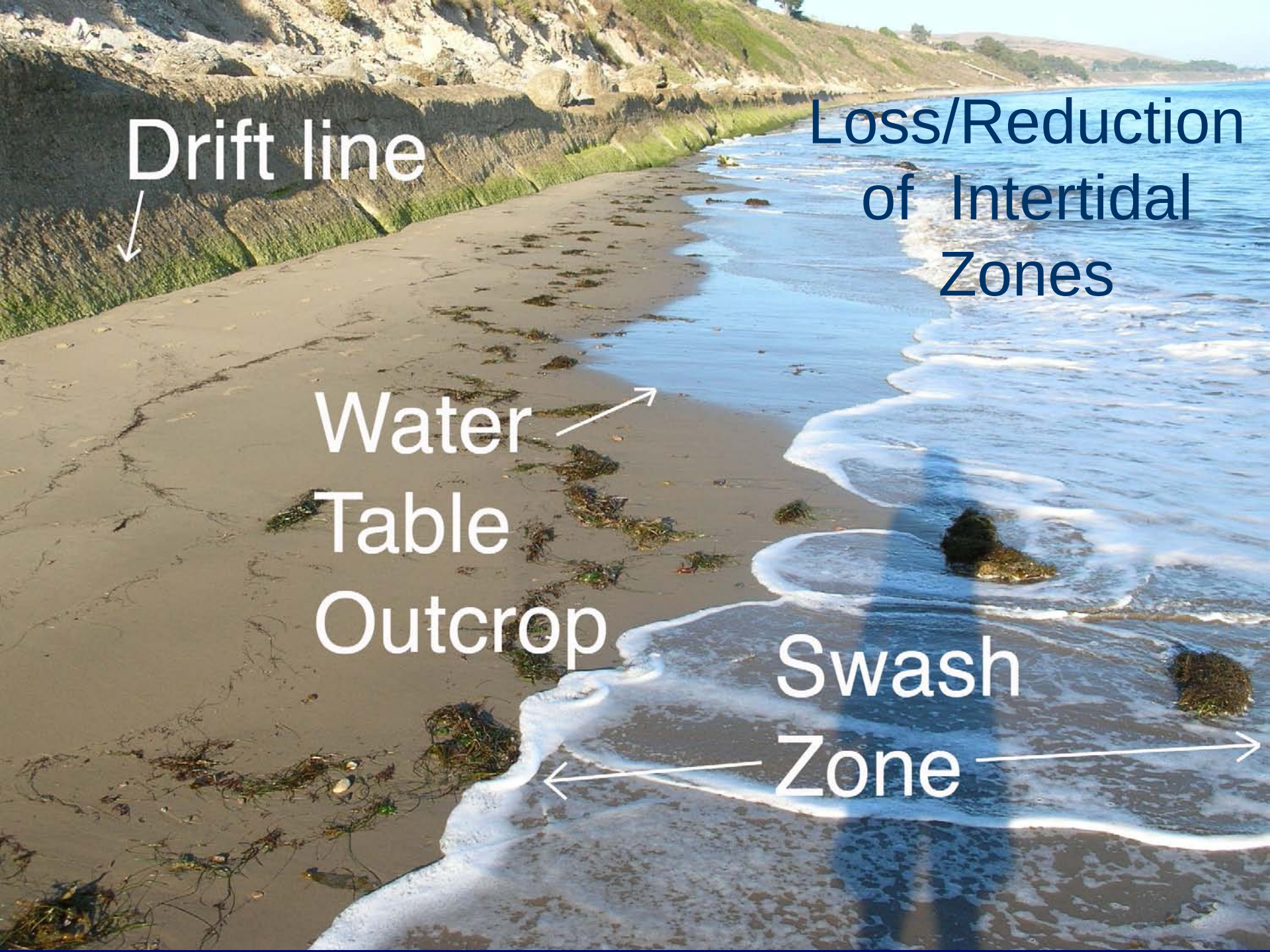


Measured widths of intertidal zones

Measured mass of macrophyte wrack

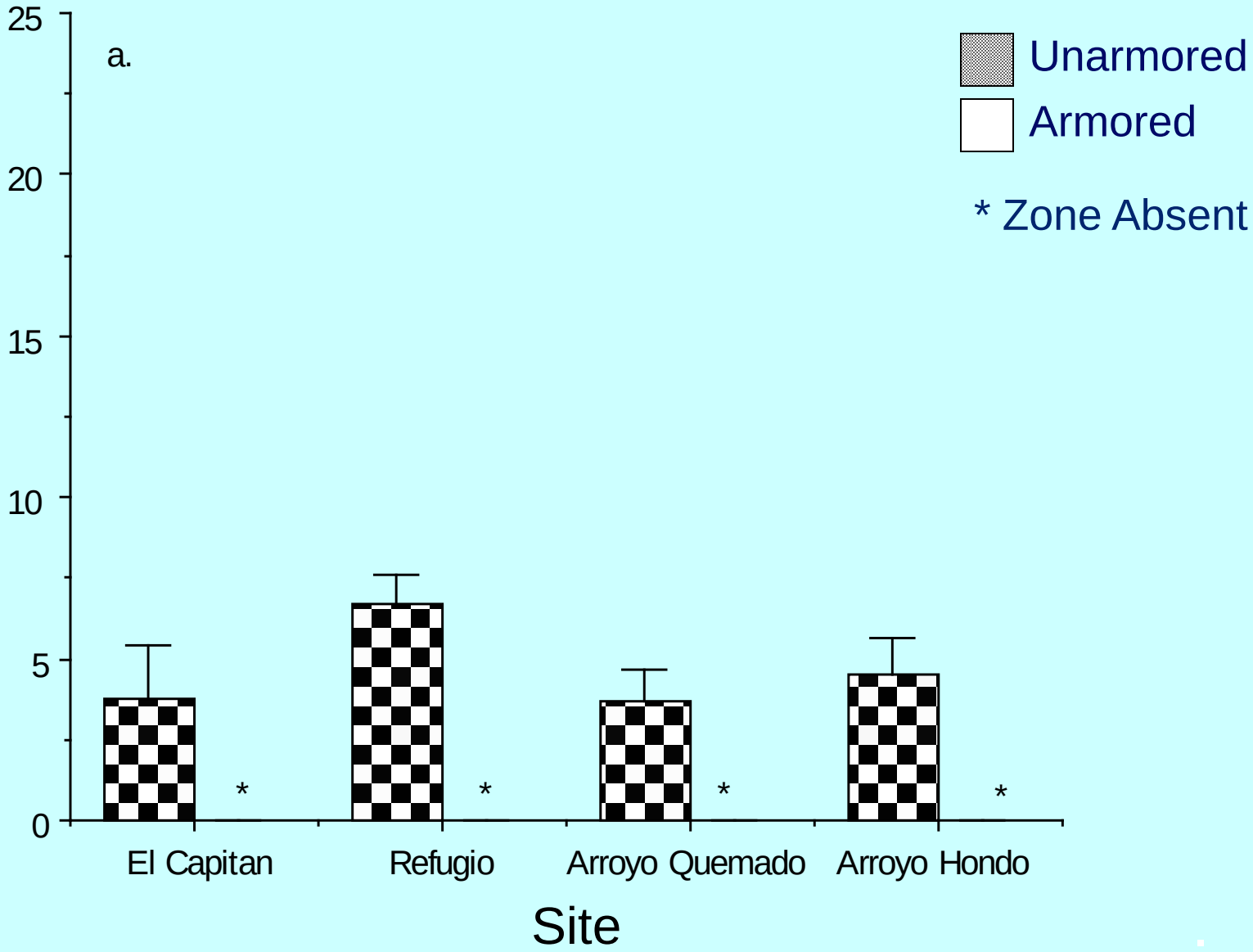
Sampled upper intertidal macroinvertebrates

Counted shorebirds, gulls and other birds


Drift line
Loss/Reduction of Intertidal Zones
Water Table Outcrop
Swash Zone

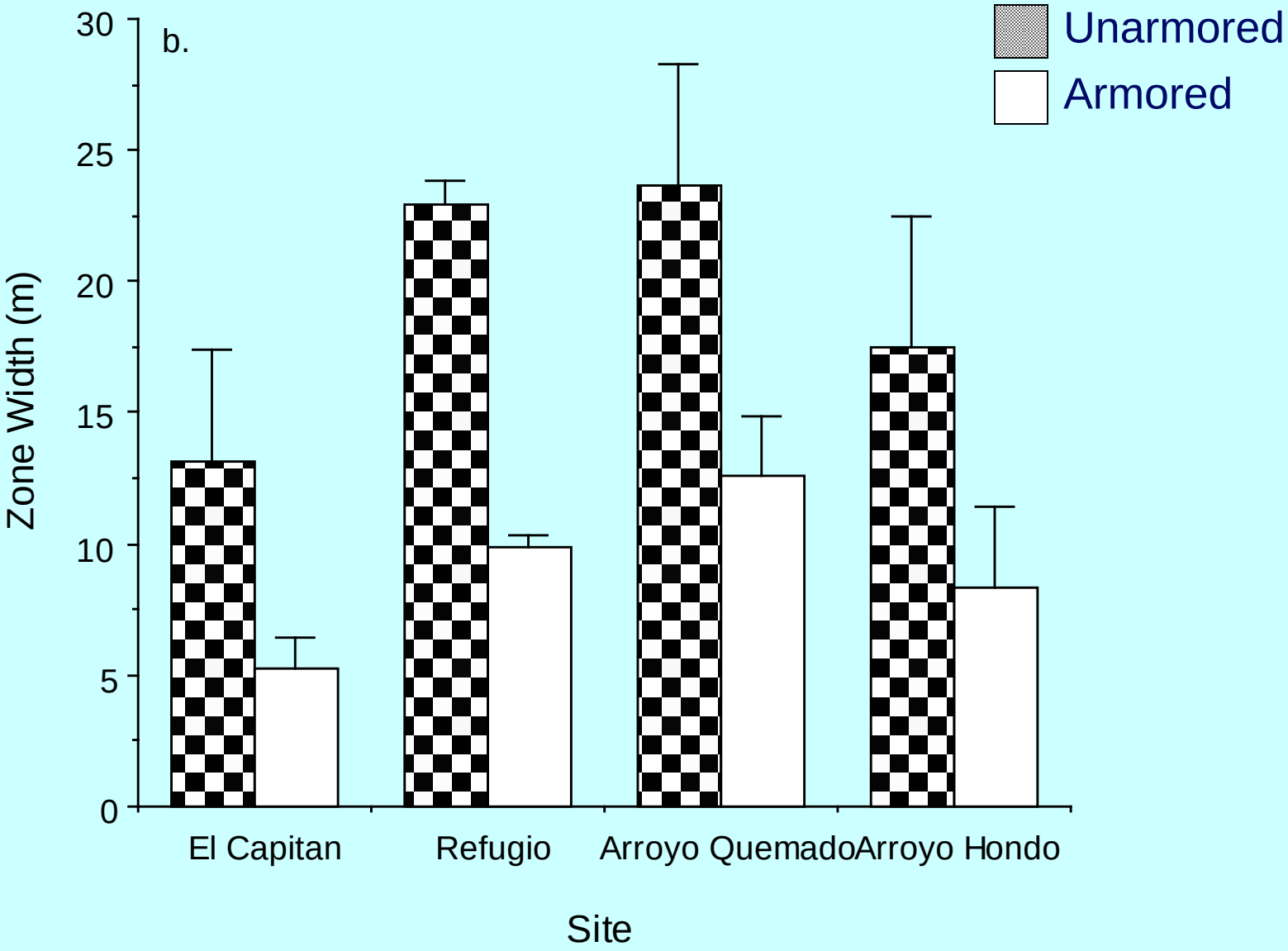
Intertidal Zones - Upper Beach

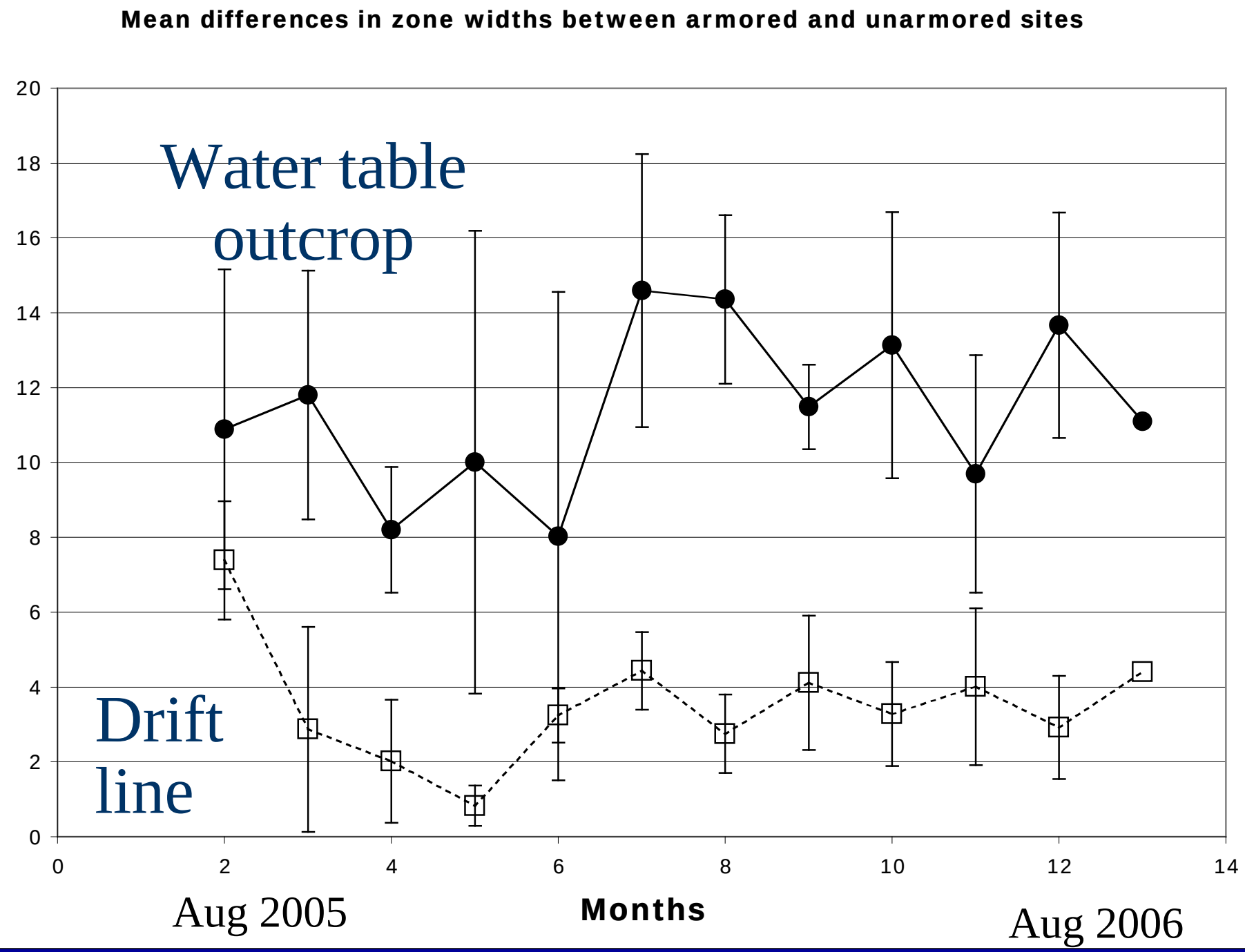
(above driftline)



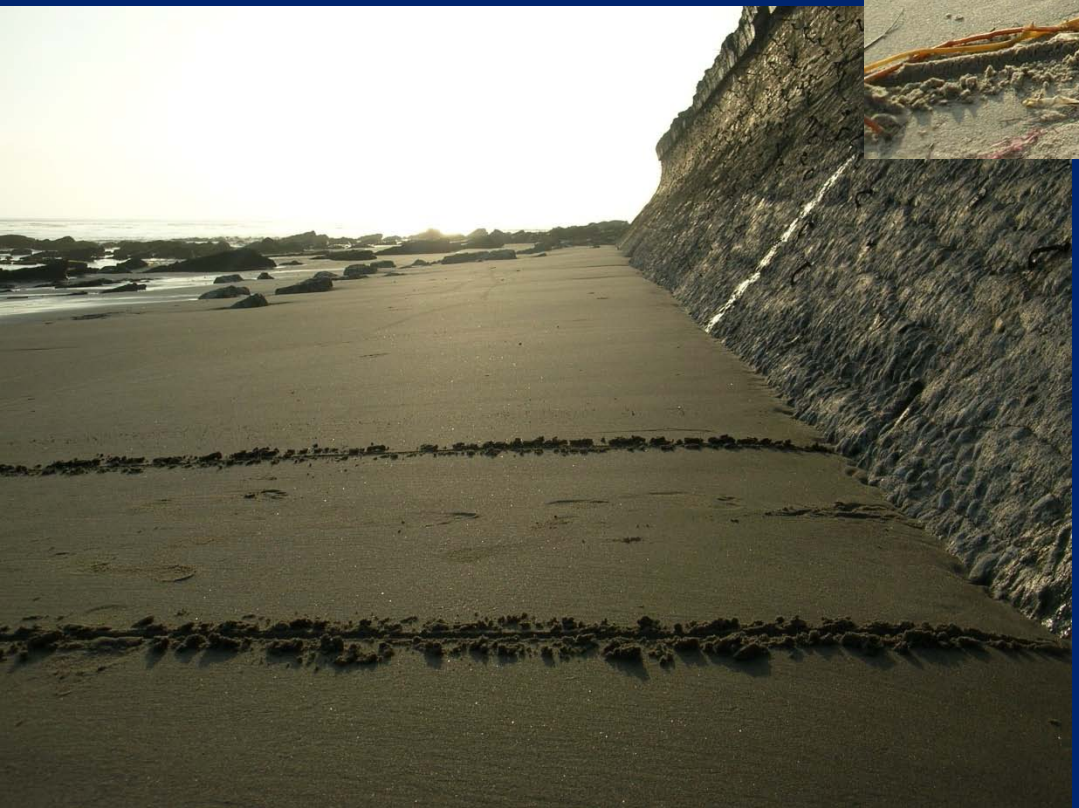
Intertidal Zones - Mid-Beach

(Above Water Table Outcrop)




Mean differences in zone widths between armored and unarmored sites
Water table outcrop
Drift line
20
18
16
14
12
10
8
6
4
2
0
0
2
4
6
8
10
12
14
Aug 2005
Months
Aug 2006

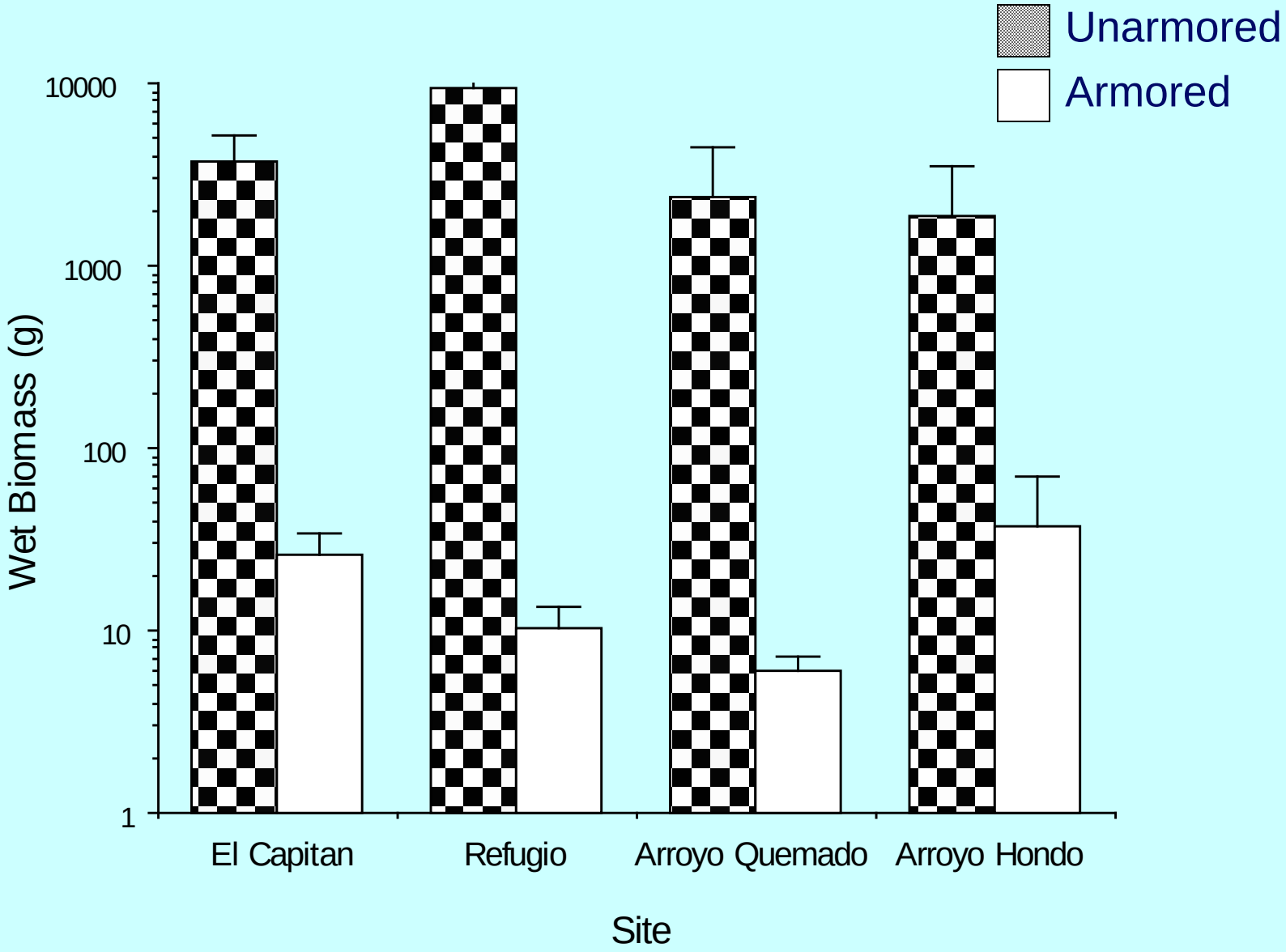
Wrack in One Meter Wide Strips



↑ Unarmored

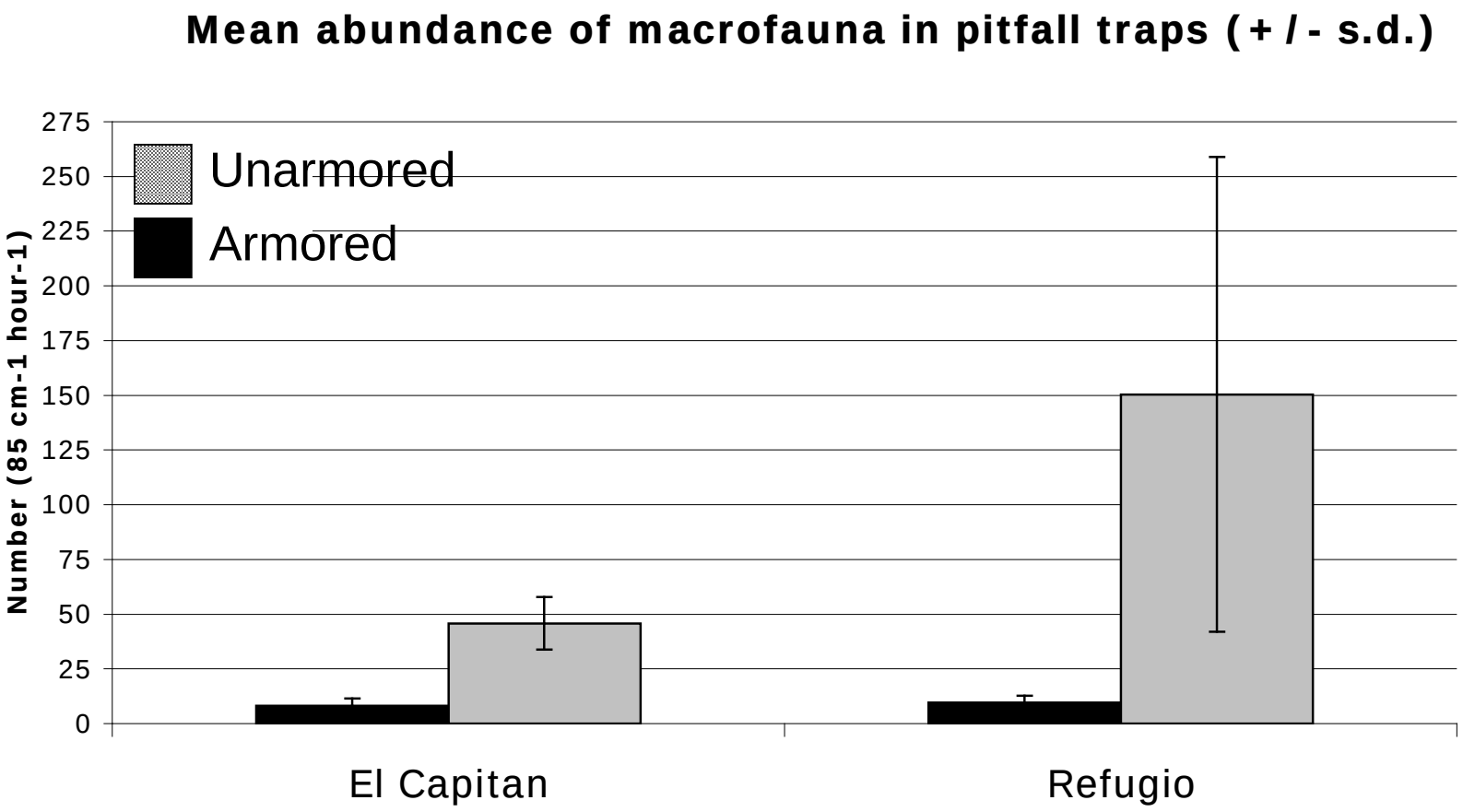
← Armored

Wrack Deposition and Retention



High Intertidal
Macroinvertebrates
Five replicates of 3 pits
One hour, before sunset
at low tide
Diameter 9 cm
Perimeter
28.3 cm
3 cm
seawater
Talitrid amphipods
Traskorchestia traskiana

Macrofaunal Abundance, n = 5

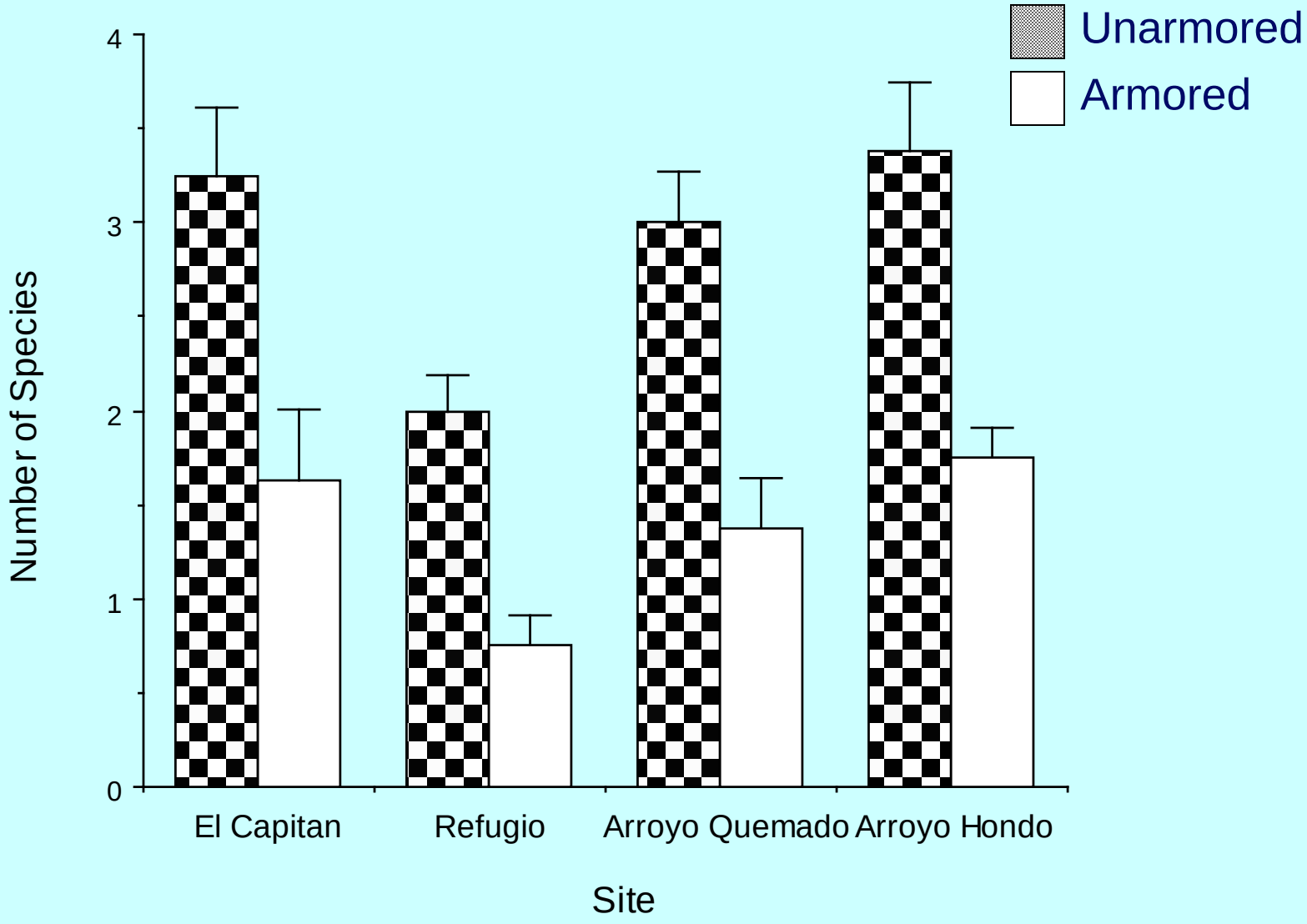


Shorebirds

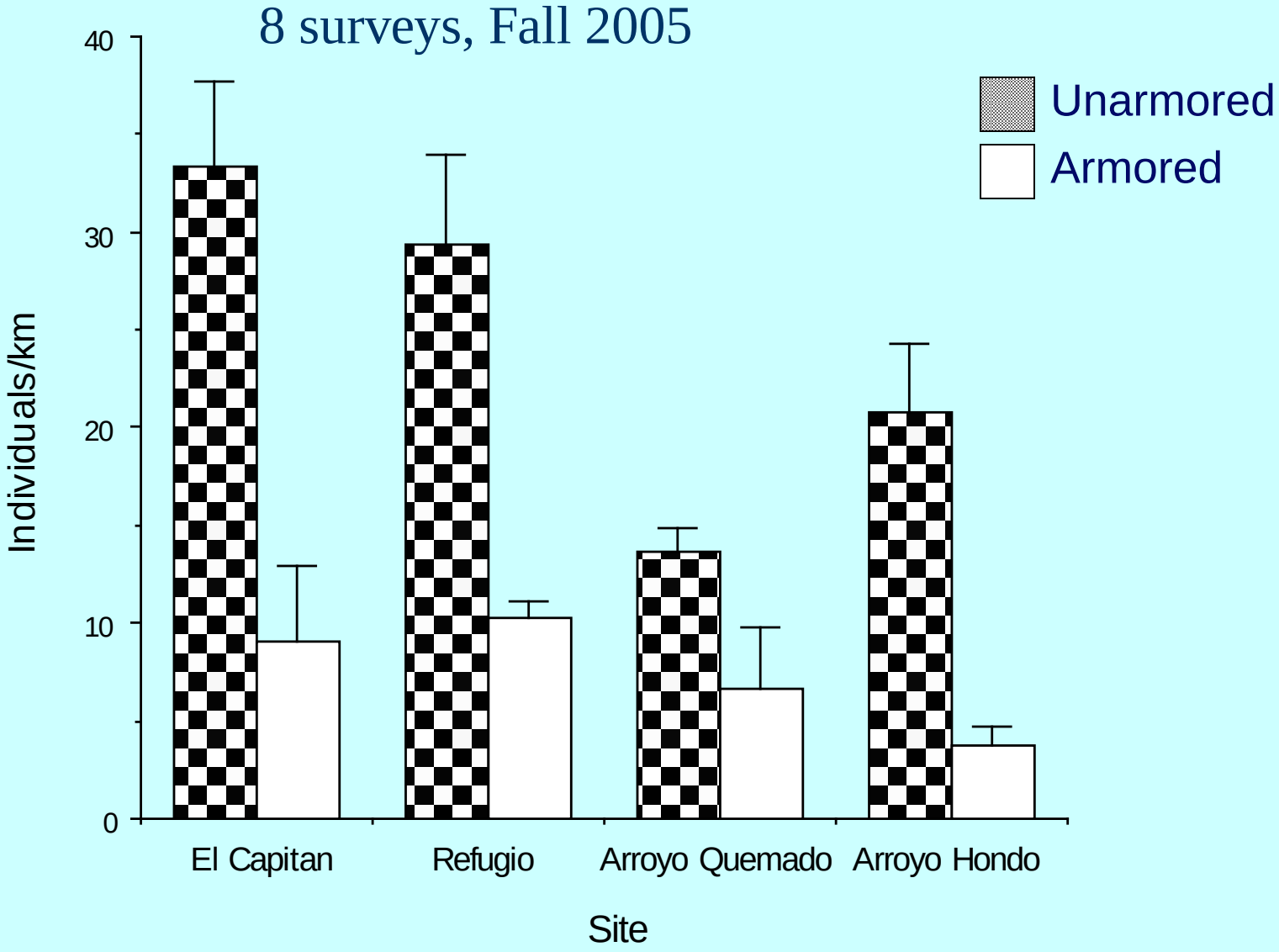
- 1285 shorebirds
- 14 species
- 12 of 14 species more abundant on unarmored segments
- Majority of birds were actively foraging

Species Richness of Shorebirds

8 surveys, Fall 2005



Abundance of Shorebirds



Spotted Sandpiper

Actitis macularia

2.5 times more abundant
on unarmored segments

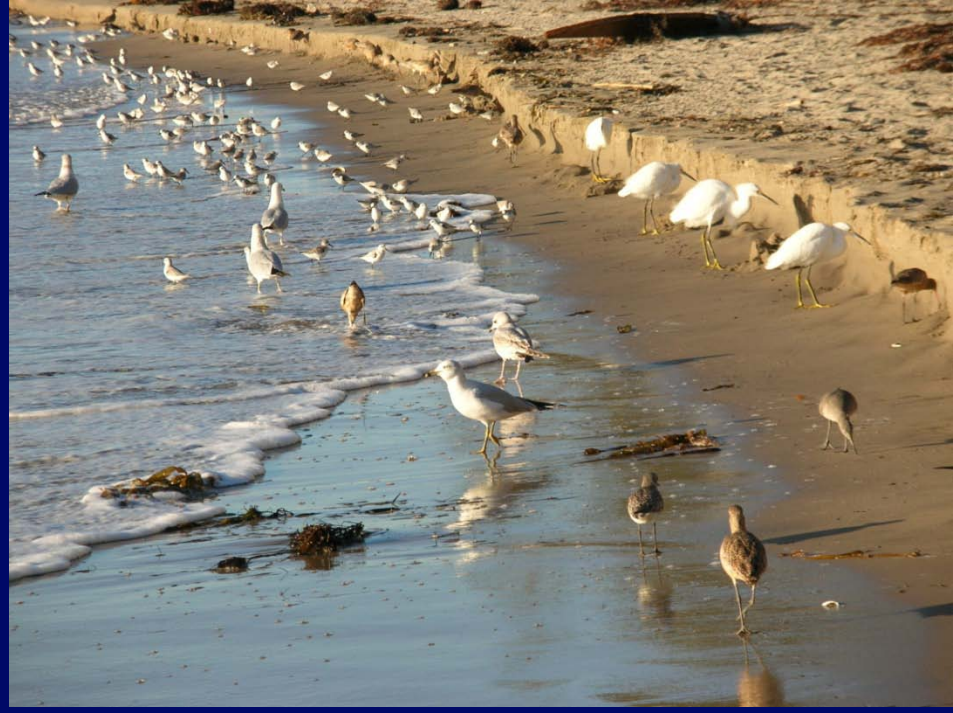
Sanderlings

Calidris alba

7.3 times more abundant on unarmored segments

Summary: Bird Abundance

	Adjacent	Seawall
SHOREBIRDS	987	298
GULLS	4006	1109
OTHER BIRDS	389	81



Results supported predictions of model

- Loss of upper beach zones
- Narrowing of middle beach zones
- Reduced wrack and biocomplexity
- Decreased macrofauna abundance
- Decreased shorebird diversity & abundance

Summary: effects of armoring

Ecological Characteristic	Scale of effect
Zone widths	
Upper beach to driftline	36x***
Upper beach to WTO	2x***
Macrophyte Wrack (standing crop)	374x*
Macroinvertebrate abundance	11x*
biomass	16x***
Shorebird species richness	2x***
abundance	4x*
Gull species richness	2x
abundance	5x***
Other bird species richness	3x***
abundance	8x***

* $p<0.05$, ** $p< 0.01$, ***$p<0.001$

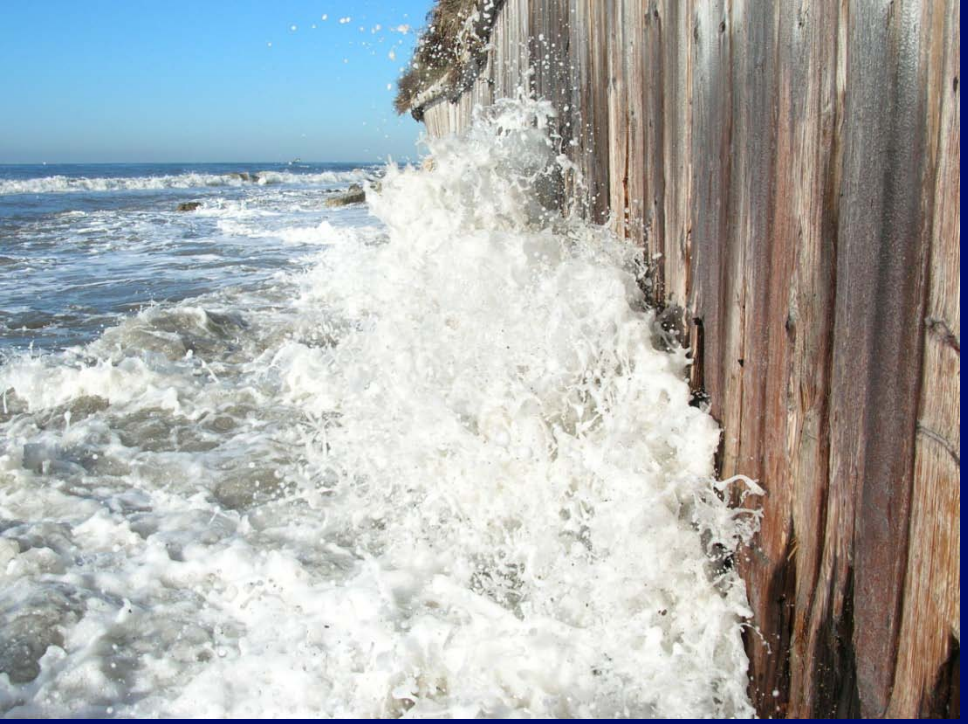
Amphipods on sandy shore

Upper intertidal habitat on seawall

Upper limit
along seawall

Upper limit
in seawall gap

Distribution of
sand crabs,
Emerita analoga



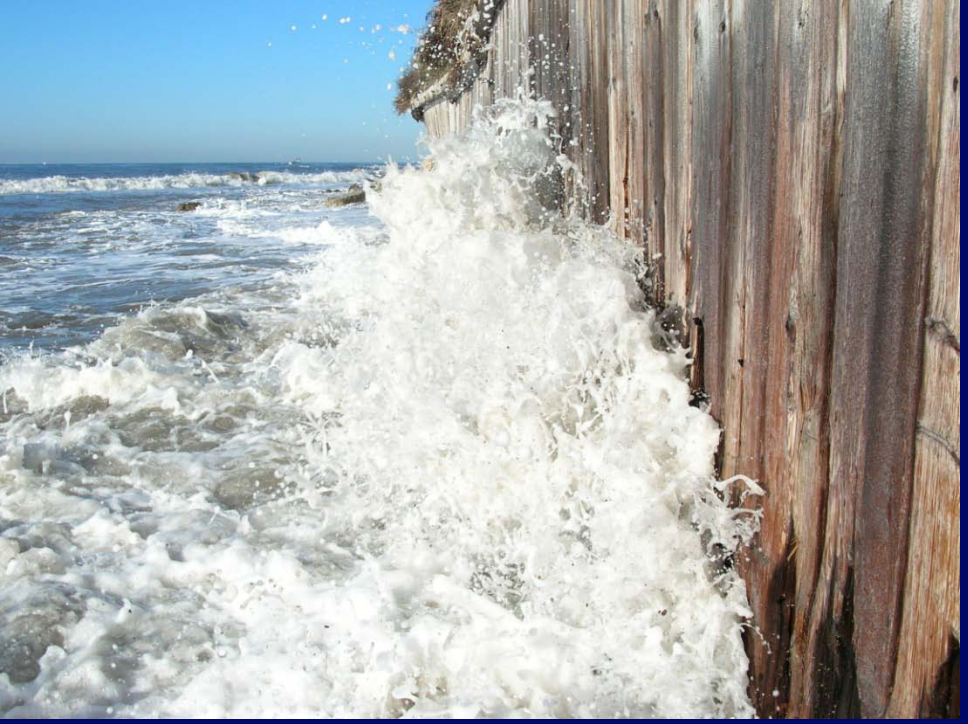
Ecological responses may depend on:

Degree of interaction with waves & tides

Structure type

Ecology of Armored Coasts

- Implications for coastal management and development
- Understanding responses of beaches to climate change – sea level rise



Conservation of beaches requires better understanding of the effects of climate change