SHELLFISH AQUACULTURE-EELGRASS INTERACTIONS: EXTRAPOLATING TO THE ESTUARINE LANDSCAPE SCALE

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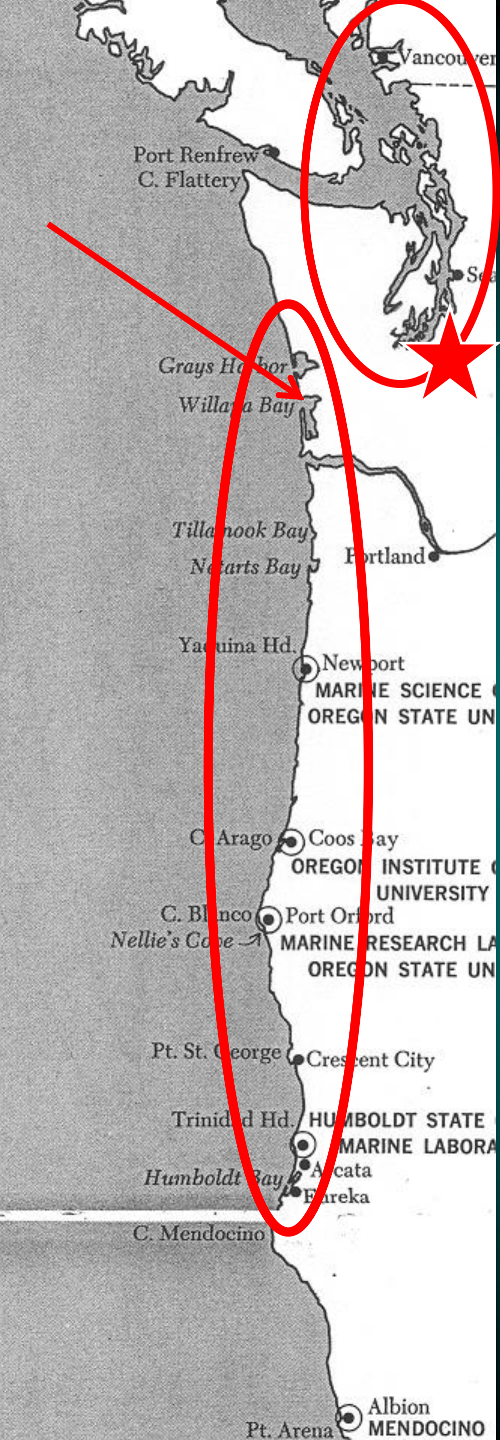


Physical and Biological Context Important

Most US West <u>Open</u> Coast estuaries have:

- Broad intertidal flats mostly consisting of soft sediments
  - Willapa Bay 58% = 63.7 km^2
  - Yaquina Bay 35% = 6 km^2
  - Coos Bay = 48% = 18 km^2
  - Humboldt Bay 45% = 28 km^2
- Small area relative to the coastline, small riverine influx, large tidal influence, strong winds can influence a shallow and therefore well mixed water column and also the substrate
  - Biology particularly 1^o production but also use by 2^o consumers is greatly influenced by nearshore coastal ocean and strong winds over shallow tidal flats

Physical "disturbances" causing change are a regular feature of these systems

Intertidal Habitats

Eelgrass density declines with oyster density in all oyster aquaculture areas and there is a threshold above which eelgrass is more dramatically affected, likely as a result of competition for space.

Eelgrass relative growth rate, plant size, and production do not change with oyster density. All of these measures are affected by oyster aquaculture, and the effect depends on aquaculture method.

Harvest method significantly affects eelgrass density. Density is lowest in mechanically harvested beds, but eelgrass growth is slightly higher and recovery is site specific ranging from 1- 4 years.

Landscape Scale Questions

1. How are oyster aquaculture and eelgrass (*Zostera marina*) spatially distributed and how much is there?

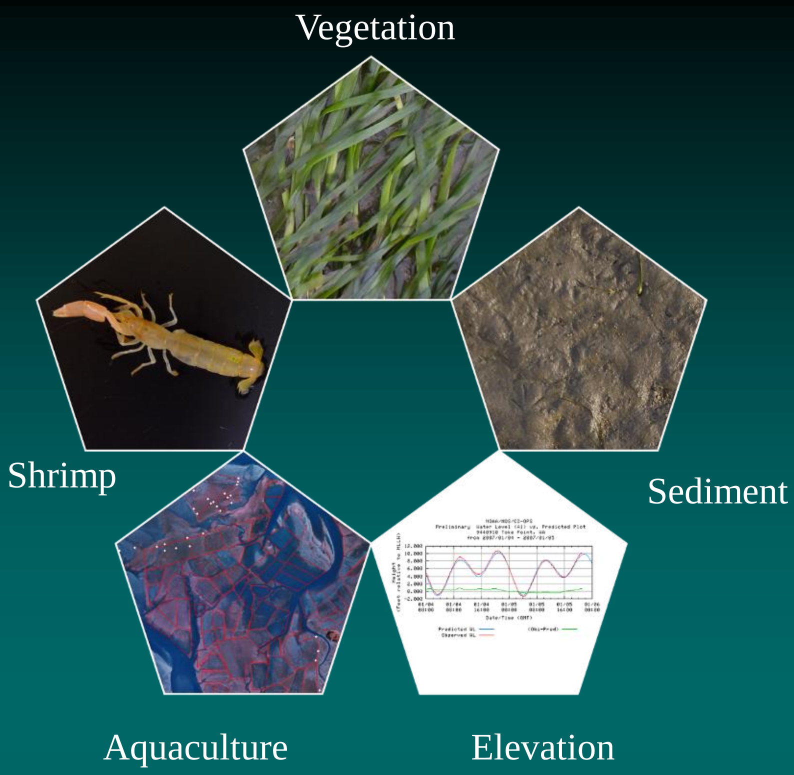
2. Does the presence of oyster aquaculture affect eelgrass?

3. Do different practices and types of oyster aquaculture affect eelgrass differently?

4. Are the effects chronic or transitory?

Methods

- Aerial color infrared photos in 2005, 2006, 2009
- Ground truthed and mapped in 2006 (4,238 stations)
- Photo rectification and GIS layer creation
- Extracted mean values for each color band in a 5 m radius buffer around survey stations
- Created a model to predict relationship between on ground density and best relationship between color bands
- Used model to predict probable density of eelgrass for each pixel in imagery



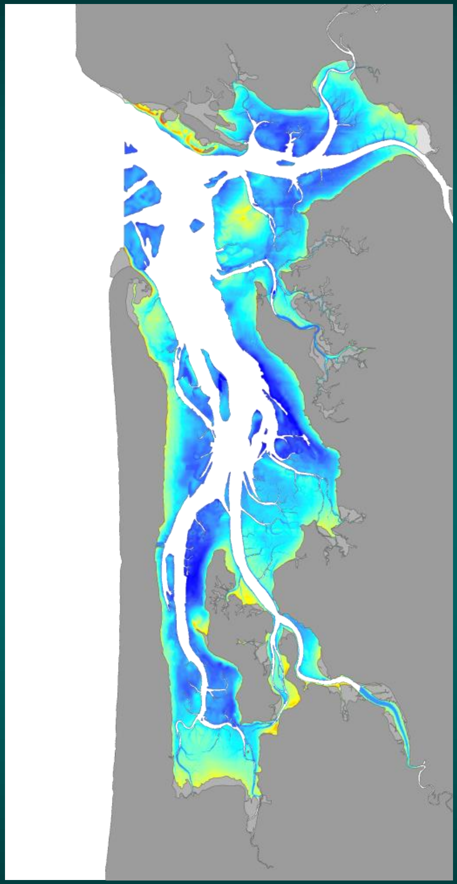
Objective 1: Quantify the spatial distribution of eelgrass and oyster aquaculture

Vegetation

Area Calculations based on 2005 photos and layers

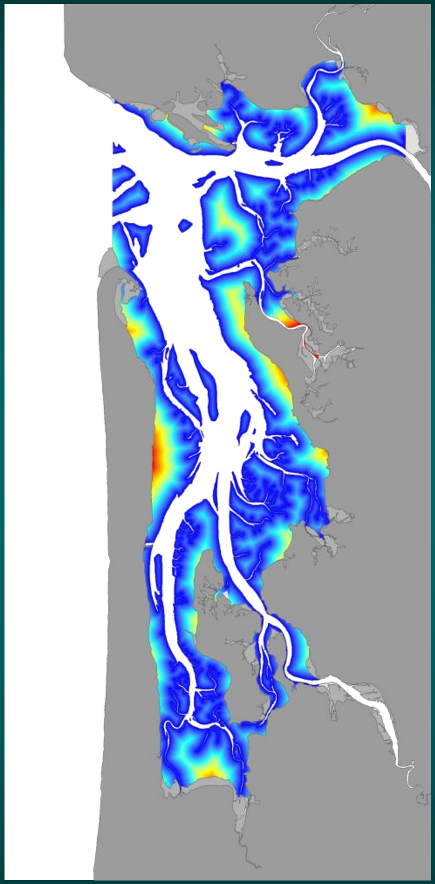
	Area (ha)	% of Category	Category
Watershed	277,387		
Entire Bay	36,864	13	Watershed
Intertidal	21,502	58	Bay
Private Ownership	12,384	58	Intertidal
All Bivalve Aquaculture	4,888	23	Intertidal
Active Intertidal Oyster Aquaculture[1]	1,764	8	Intertidal
Harvest Method			
Mechanical Dredge	876	50	Oyster Aquaculture
Hand Picked	554	31	Oyster Aquaculture
Mixed	329	19	Oyster Aquaculture
Bed Type			
Seed	1,077	61	Oyster Aquaculture
Fattening	328	18	Oyster Aquaculture
Mixed	168	10	Oyster Aquaculture
Direct	96	5	Oyster Aquaculture
Long Lines	66	4	Oyster Aquaculture
Vegetation[2]	8,722	41	Intertidal
< 4 ft MLLW	6,951	32	Intertidal

1) Create GIS layers for factors that influence the distribution of *Z. marina* and oyster aquaculture including : tidal elevation (ft relative to MLLW), distance to estuary mouth, distance to nearest channel, cumulative wave stress, and salinity



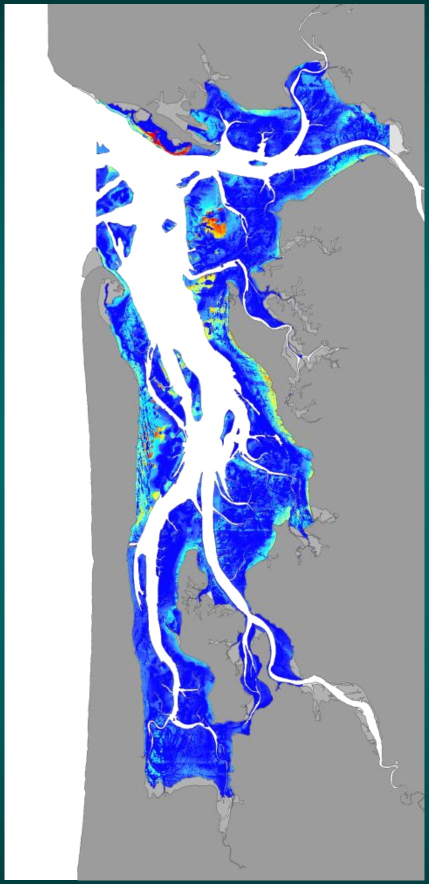
Elevation

Combined 2002 NOAA LiDAR and 2006/2007 GPS elevation data taken to fill in lower tideflat



Distance to Channel

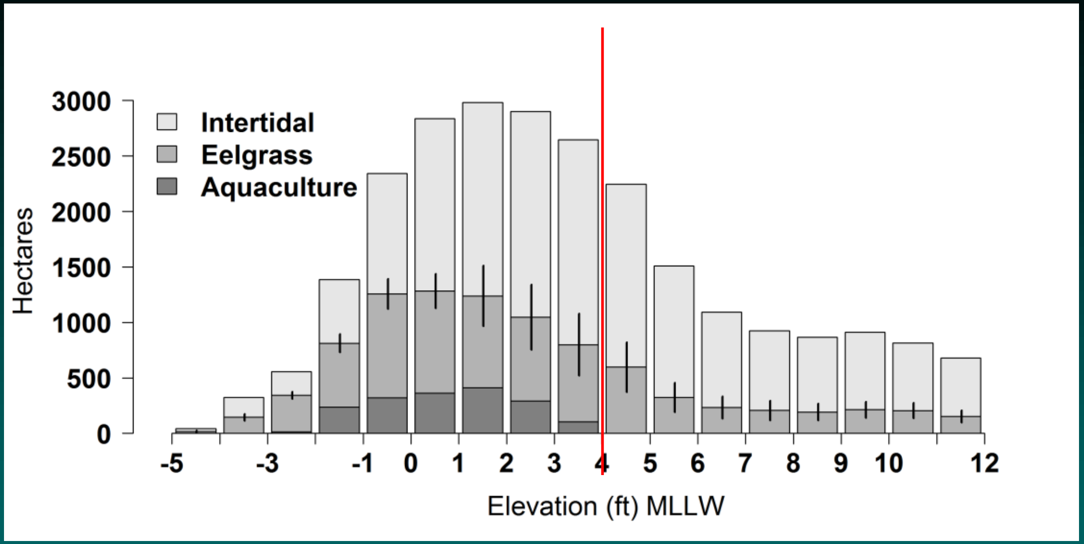
Euclidean distance to nearest channel

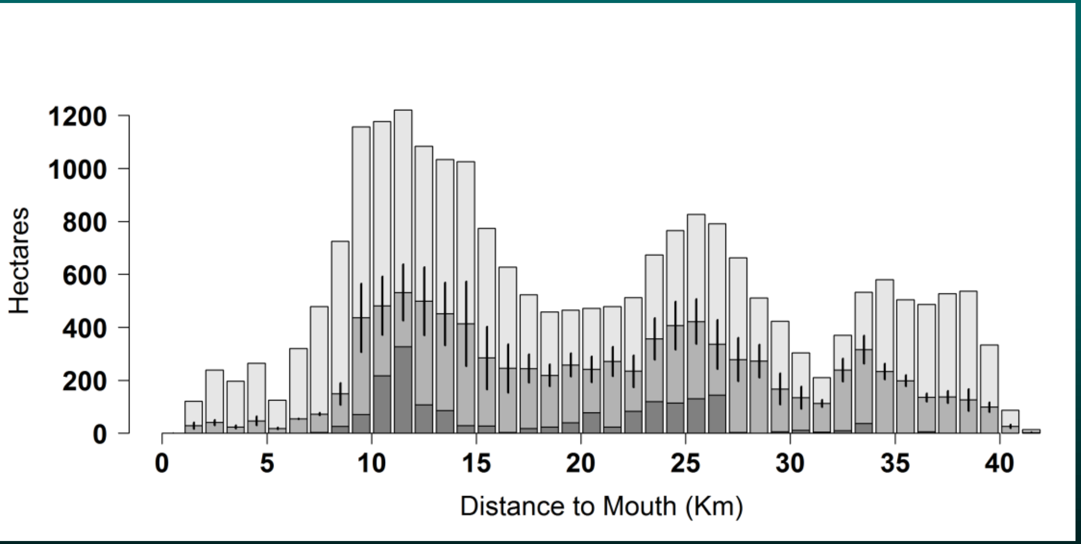


Wave Stress

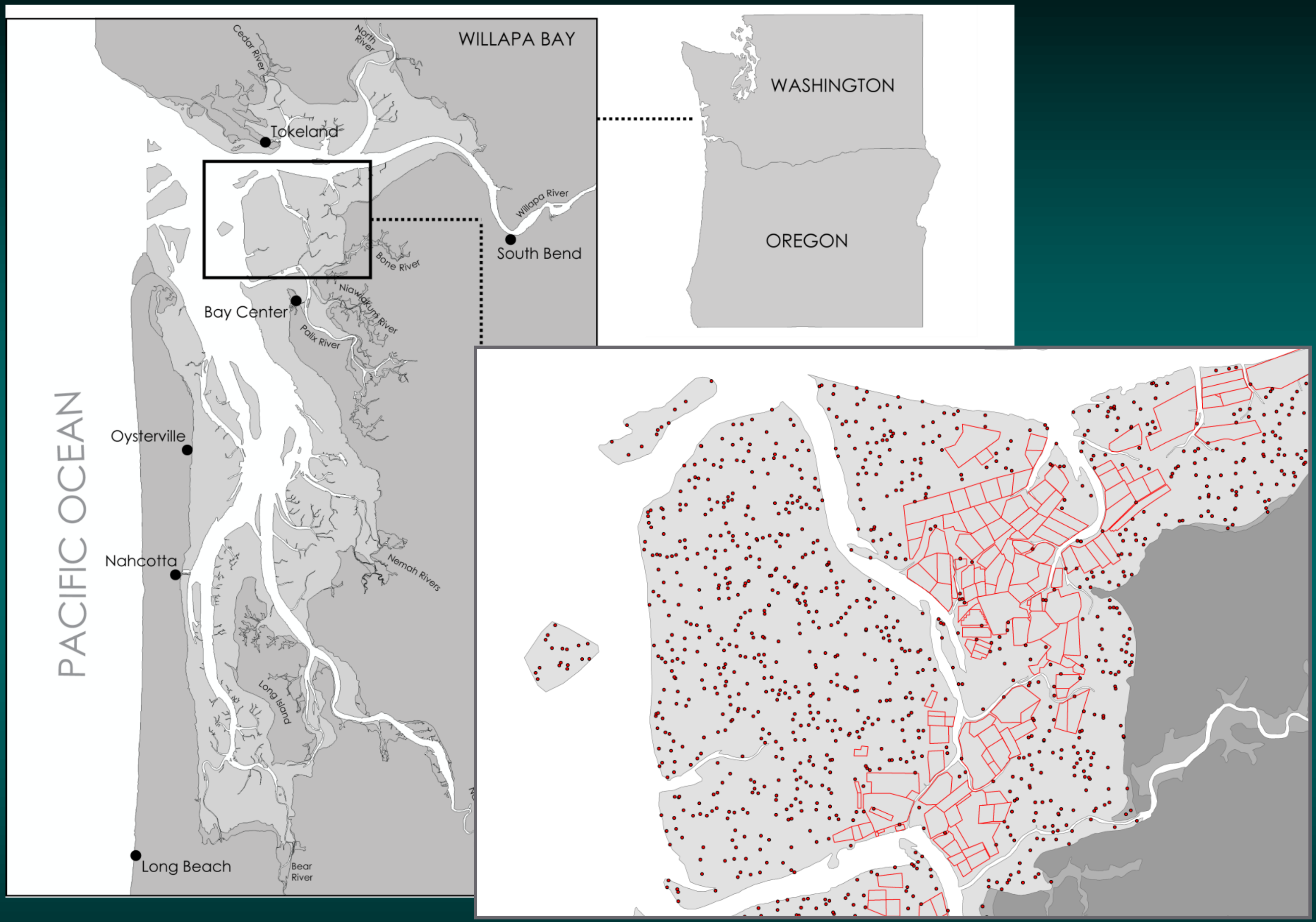
Relative cumulative wave stress calculated using elevation, tide level, wind direction and speed

2) Calculate the distribution of oyster aquaculture and eelgrass for each factor





Objective 2: Quantify the total impact of bivalve aquaculture on eelgrass



1) Randomly distribute points on tideflat outside of oyster aquaculture
2) Extract eelgrass levels at each point for each of three years
3) Extract stress, elevation, distance to mouth, distance to channel, and salinity

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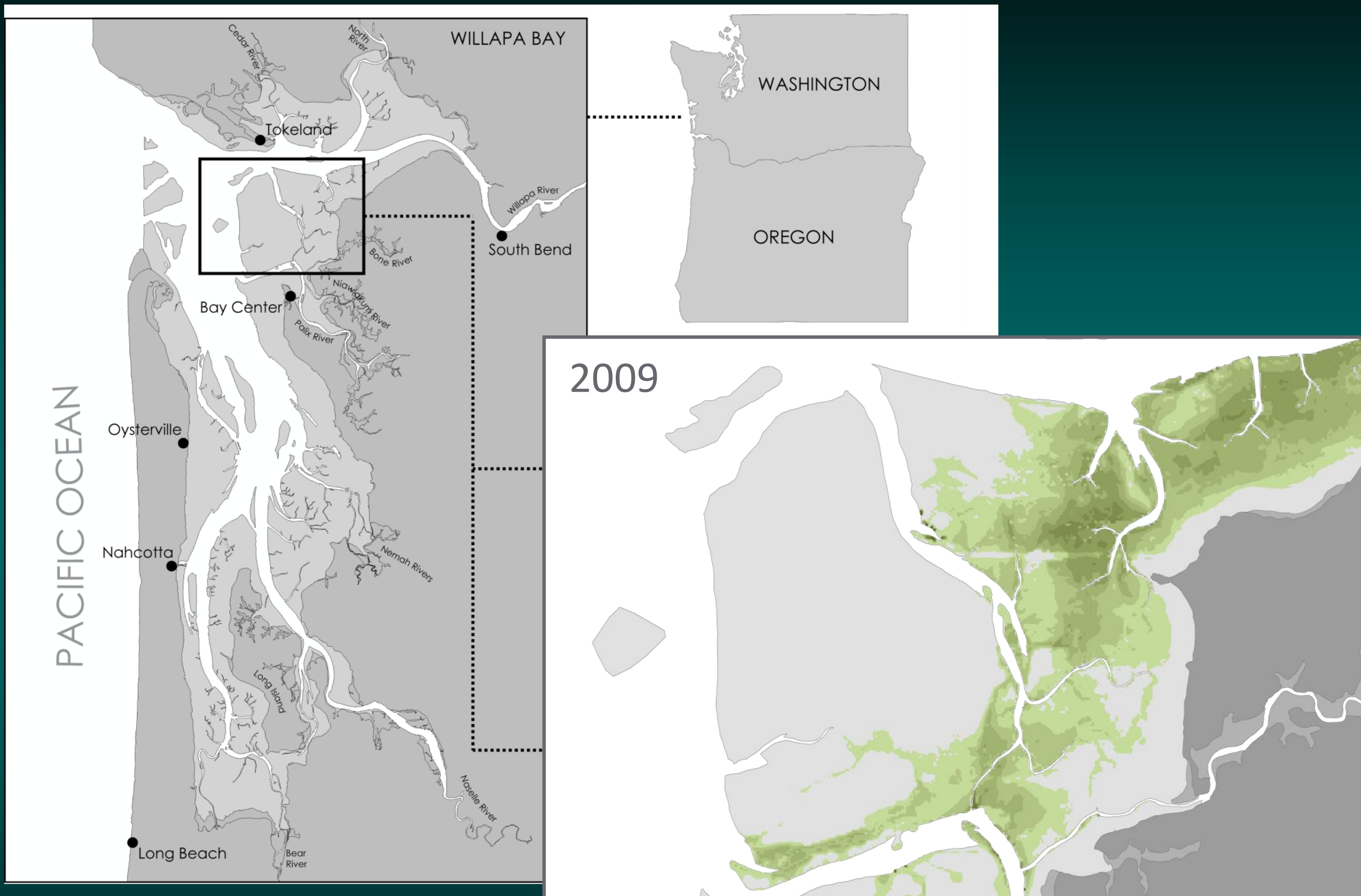

4) Create a GAM model of eelgrass outside of aquaculture for each year

Z. marina probability ~ te(Xdem, Xsalinity, Xd2mouth) + s(Xstress) + s(Xd2channel)

5) Predict eelgrass density across entire tideflat for each year

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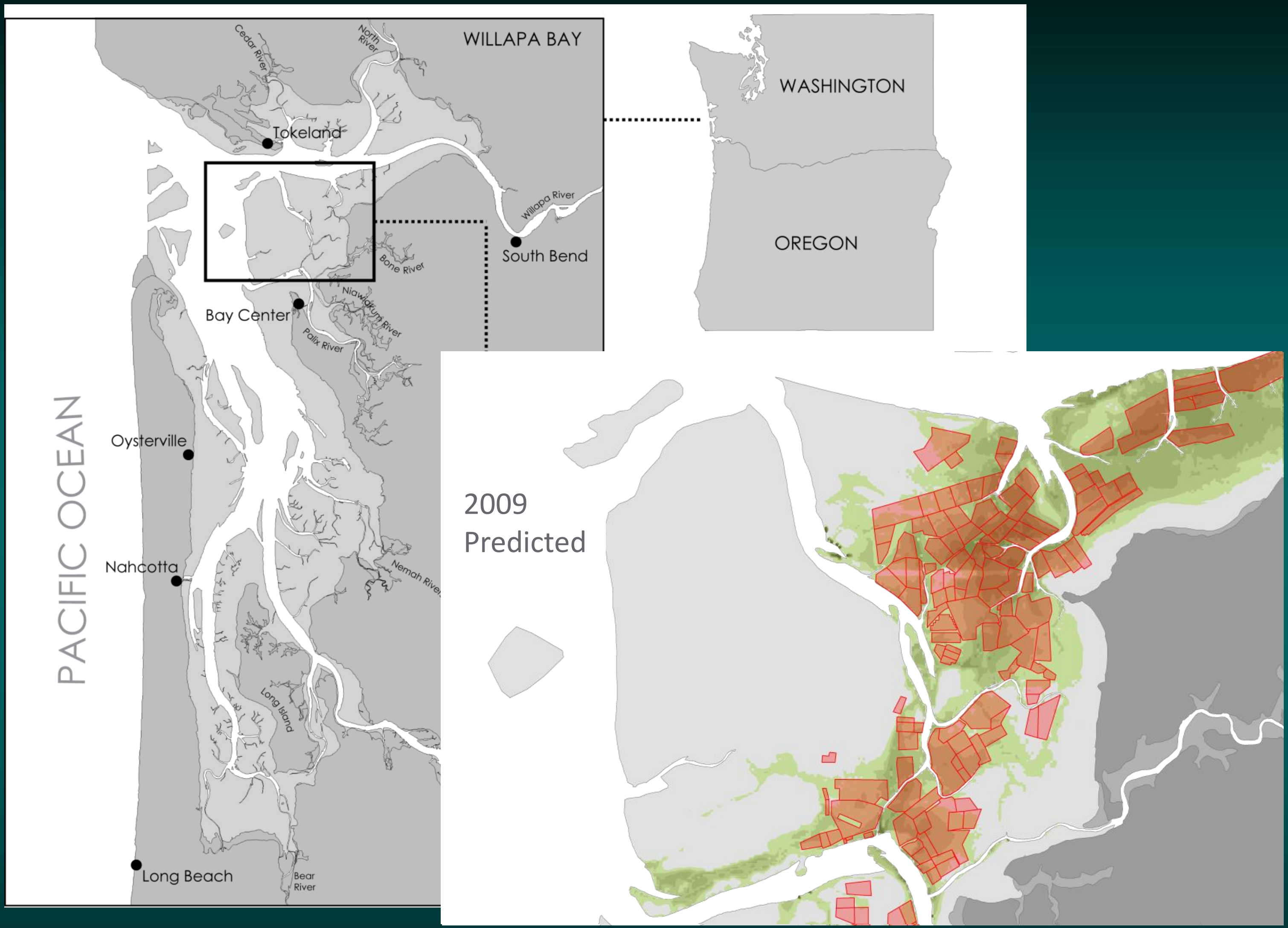


7) Overlay beds on actual and predicted layers and extract amounts of eelgrass

Objective 2: Quantify the total impact of bivalve aquaculture on eelgrass

Year	Total *Z. marina* (ha)	Total Intertidal (ha)	Percent *Z. marina* (of intertidal, %)	Proportion Missing *Z. marina* (predicted – observed, ha)	Proportion Missing *Z. marina* (predicted, %)
2005	8, 343	22,700	36.8%	-21.9	-0.26
2006	6,567	22,700	28.9%	-7.91	-0.12
2009	5,938	22,700	26.2%	0.44	0.01

8) Sum the total predicted and observed amounts of eelgrass

Objective 3: Determine the relative impact of different oyster aquaculture harvest methods and bed types

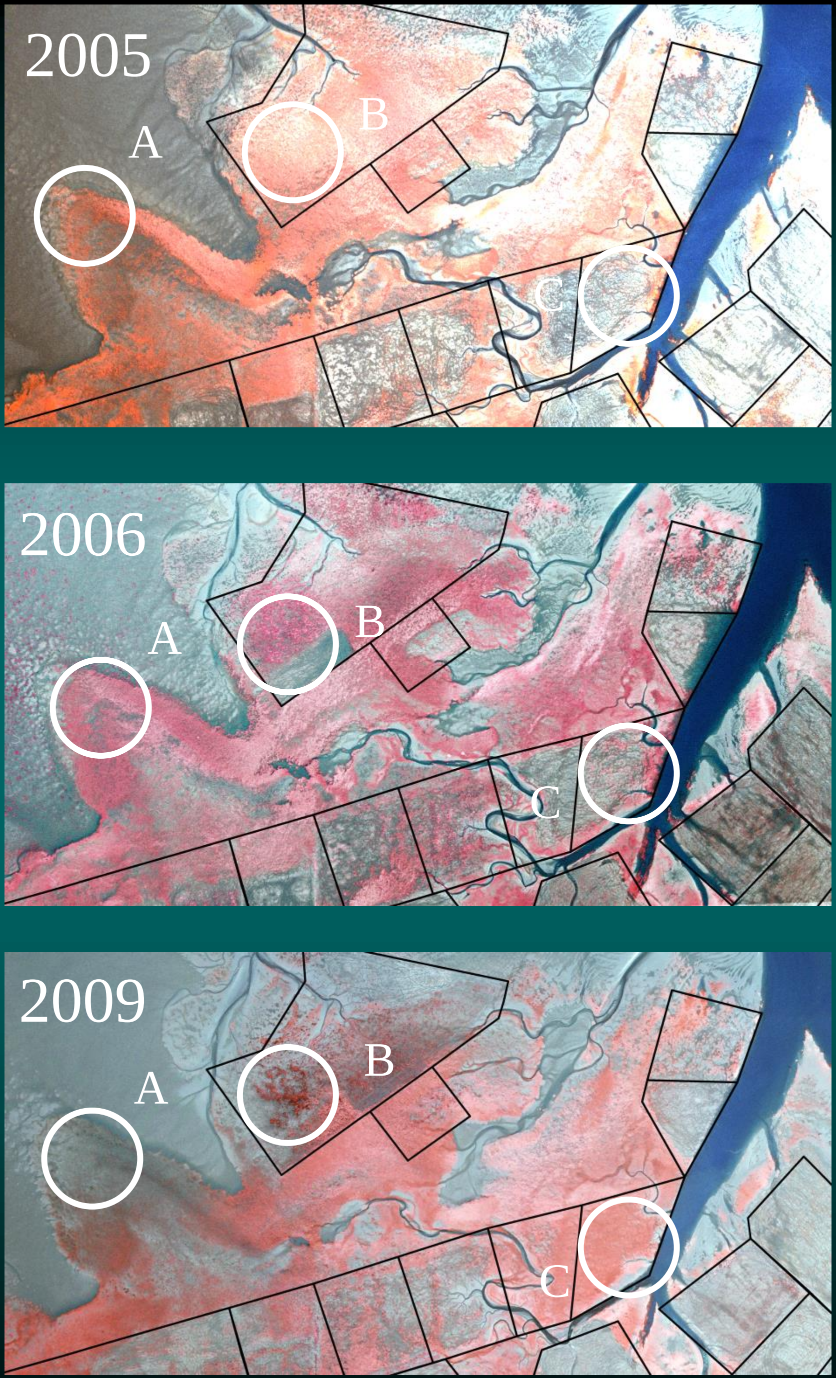
proportion actual observed / model predicted = 99.94 + (1 * Mechanical) +(19.71 * Hand)+ (16.71 * Mixed)

Mixed effect model (with bed and year as random effects)

Bed type (direct, fattening, long line, seed, and mixed) was not significant
Harvest method (hand, dredge, mixed) was a significant factor (ANOVA, $p=0.0003$)
Mechanical harvest was significant relative to others (Tukey post-hoc test).

Mechanical harvested beds had 100% of the predicted *Z. marina*
Hand harvested beds had 120% of the predicted *Z. marina*
Mixed harvest beds had 117% of the predicted *Z. marina*

Objective 4: Determine if observed impacts of oyster aquaculture on *Z. marina* are chronic or transitory



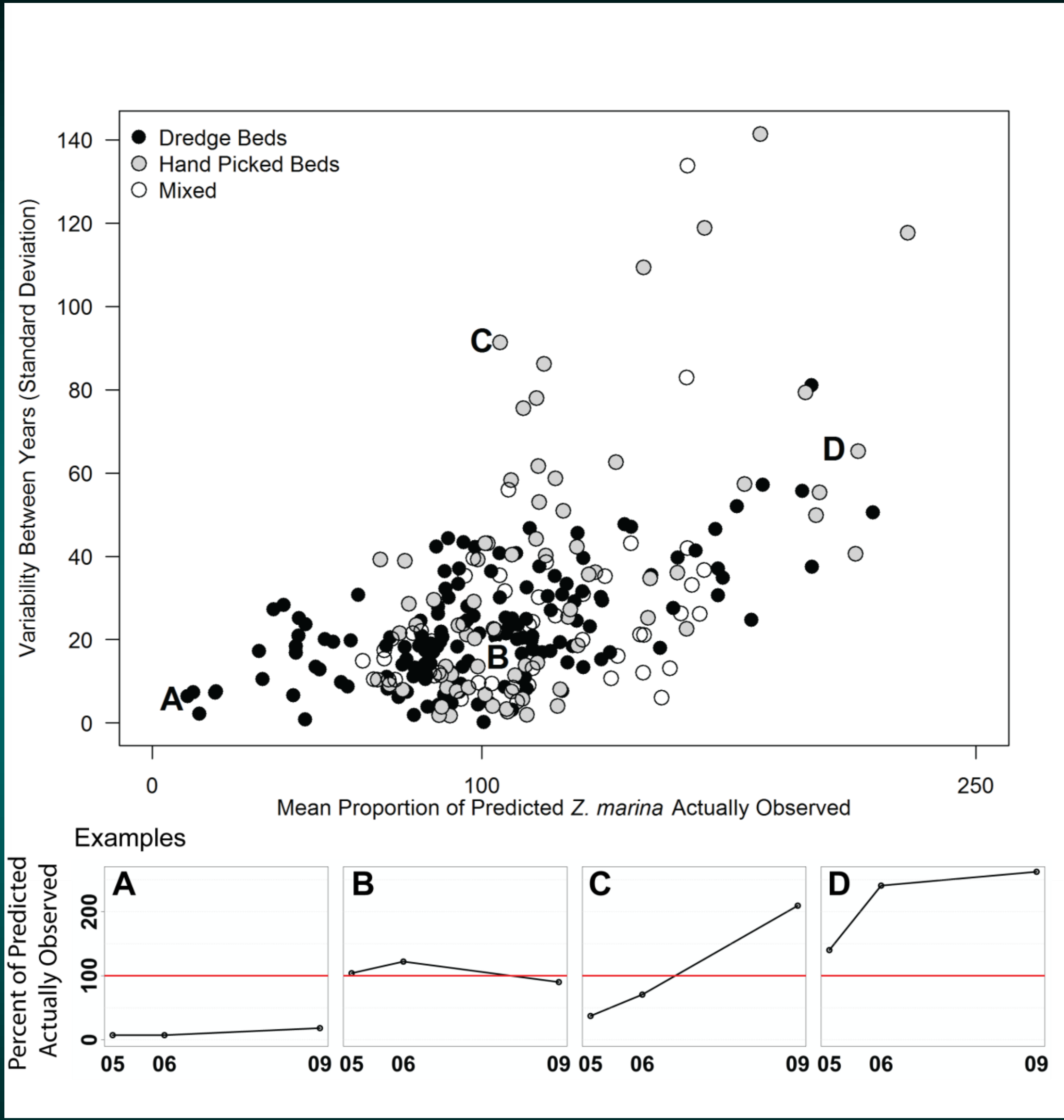
Objective 4: Determine if observed impacts of oyster aquaculture on *Z. marina* are chronic or transitory

A) beds with chronically low *Z. marina* and low variation across years

B) beds with the expected levels of *Z. marina* and low variation across years

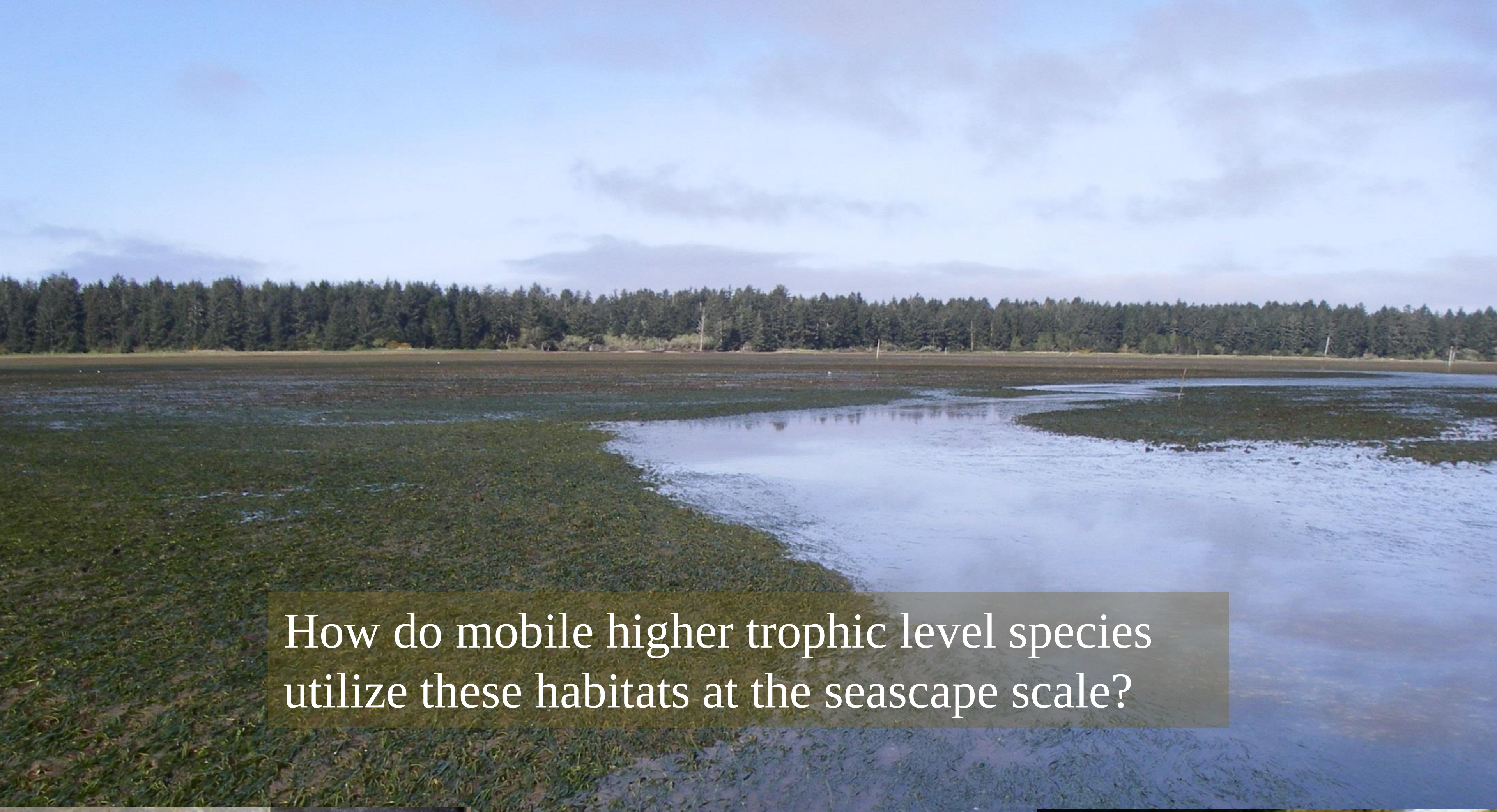
C) beds with highly variable levels of *Z. marina* across years

D) beds with high levels of *Z. marina* and high variation across years.



Conclusions

- Oyster aquaculuture reduces eelgrass presence athe landscape scale in Willapa Bay , but not by very much (less than 1%) and many areas had more than predicted amounts.
- Bed type (seed, fattening, mixed) was not a significant factor , but harvest method (mechanical, hand) was significant.
- Most beds had about the predicted amount of eelgrass present on them with low variation between years. Beds with chronically low eelgrass present were mechanically harvested, but mixed and hand harvested beds were most variable and all harvest methods had areas with consistently high levels of eelgrass present.


How do mobile higher trophic level species utilize these habitats at the seascape scale?

Thanks:

Willapa Bay Oystergrowers

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