Apr 4th, 4:30 PM - 4:45 PM

Waterbird monitoring and habitat association modeling to inform tidal marsh restoration in an urbanized estuary

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Speaker

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Monitoring Waterbird Response to Wetland Management and Restoration in Pacific Coast Estuaries

Susan E. W. De La Cruz, Isa Woo, Melanie Davis, Lacy Smith, Tanya Graham

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CALIFORNIA DEPARTMENT FISH & GAME

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SAN FRANCISCO BAY BIRD OBSERVATORY

Nisqually Indian Tribe

DUCKS UNLIMITED

Coastal Conservancy

South Bay Salt Pond Restoration Project

Connectivity among Pacific Coast Estuaries

Birds rely on networks of interconnected coastal sites to build stores during migration

(Western Sandpiper -Williams et al. 2007)

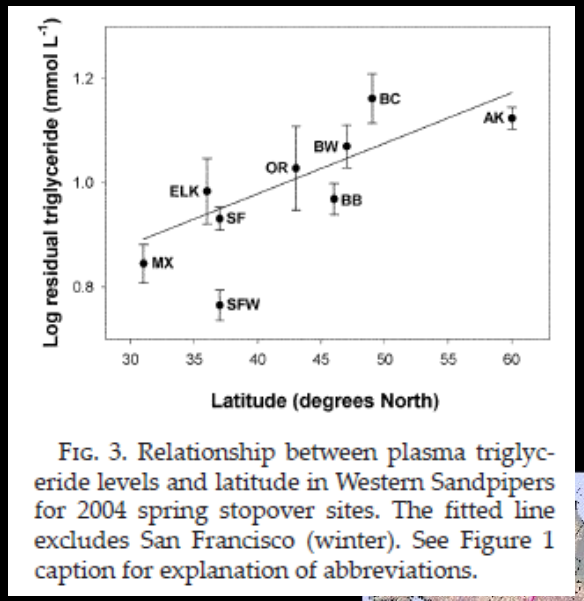
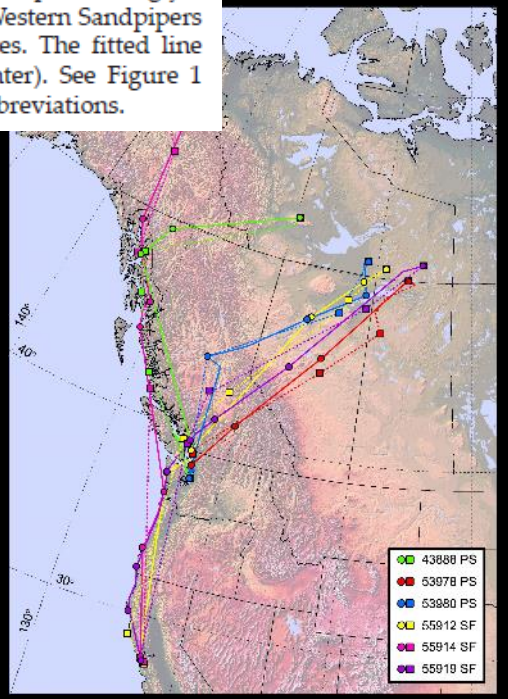


FIG. 3. Relationship between plasma triglyceride levels and latitude in Western Sandpipers for 2004 spring stopover sites. The fitted line excludes San Francisco (winter). See Figure 1 caption for explanation of abbreviations.

Species may show high site fidelity to wintering and stopover sites, reusing them year after year

(Surf Scoters - De La Cruz et al. 2009;
Red Knots – Buchanan et al. 2012)



Need a common way to evaluate habitat change and avian response among linked estuaries

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Landscape Scale Change in Coastal Estuaries

Coastal Development

- Worldwide loss of intertidal flats associated with declining waterbird populations

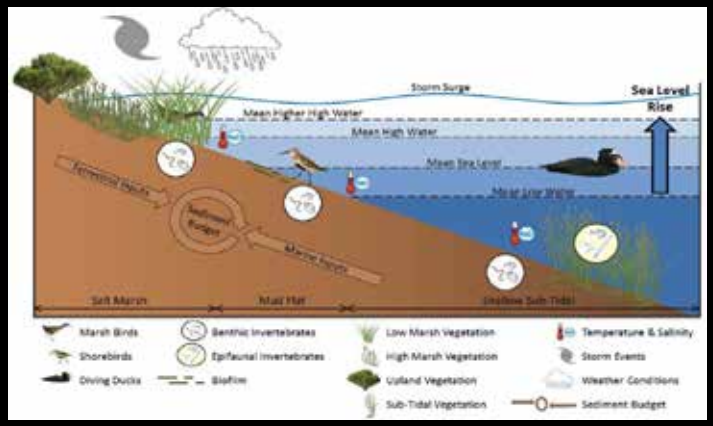
  (Zöckler et al. 2003, Boere and Piersma 2012, Iwamura et al. 2013)

N. Murray, G. Appleton

Climate Change

SLR, storm events, altered freshwater and sediment inputs may affect characteristics of intertidal areas

(e.g. Galbraith et al. 2002)



Thorne et al.

Tidal Restorations

- Opportunities to restore tidal flow to large areas to benefit native endangered species
- Balancing the needs of migratory birds

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Measuring Avian Response to Tidal Restorations

Goals

- Compare function and values of restoring and managed areas
- Inform adaptive management to optimize restoration design for waterbird habitat
- Evaluate how well restoration is meeting targets

Developing a Common Monitoring Framework

Benefits of using similar methods within a region, across estuaries

- Ask same questions among sites, regions, estuaries
- Commonalities and differences in use among sites
- Importance of key resources among sites

Challenges

- Not all restorations are created equal
  - Elevation
  - Hydrology
  - Sediment availability
  - Accessibility
- Difficult to measure in the same way across sites

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Spatially Explicit, Scalable Approach

Grid-based Area Counts

Scales

Grid

Single Site

Regional

Variables Measured and Frequency

1 X /Infrequently: Site area, Distances to key features (Bay edge, urban, creek slough), area and location of key features (islands, levees), public access

Yearly/Seasonally: Bathymetry/elevations, vegetation density and distribution, prey density and distribution

Each survey: Water depth, bird species/sex/number and behavior, predator numbers

Continuously: Water quality

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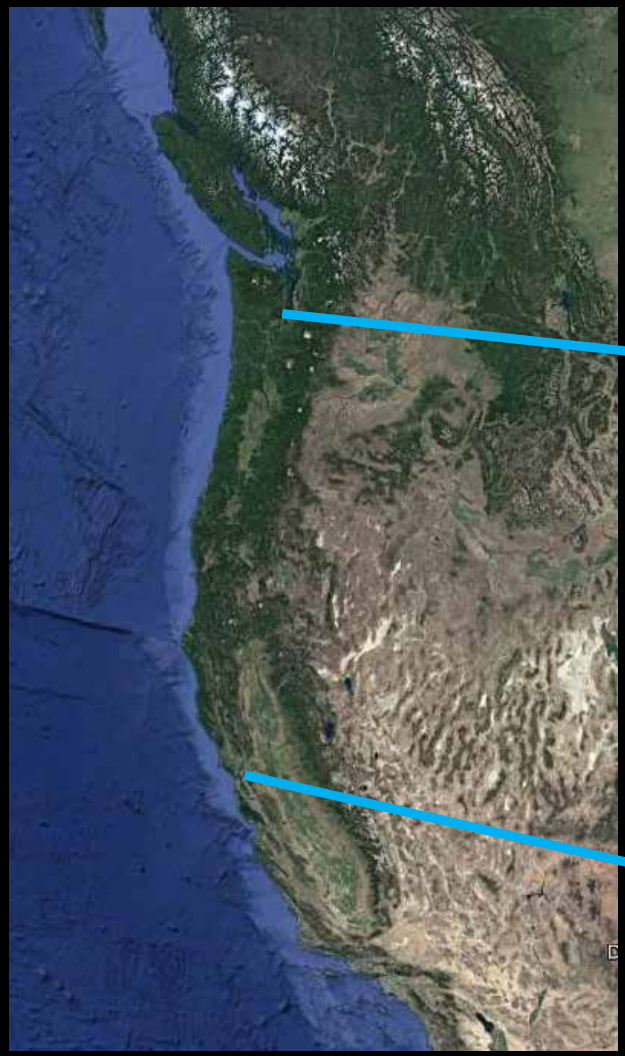
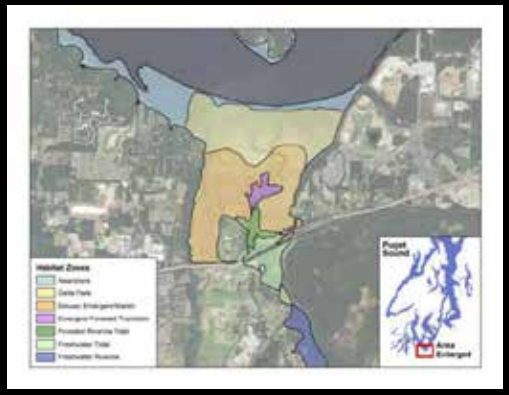
Avian Guilds

Drawing adapted from Warnock 2004

Pacific Coast Estuary Studies





Nisqually NWR
Assessing effects of restoration on capacity for salmon and waterbirds

SFB
North and South Bay Salt Pond Restoration

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North and South Bay Salt Pond Restoration

Goal: Restore a mosaic of habitats ranging from tidal marsh to open ponds that balance needs of marsh species with migratory shorebird and waterfowl populations

North Bay

- 3,828 ha, 14 impoundments
- 2006 - present: Phased Restorations
  - 61% Pond Area breached
- 1999 – Present: Avian Surveys

South Bay

- 6,110 ha, 53 impoundments
- 2004 - 2013: Phased Management and Restoration
  - 13% Pond Area Breached
- 2002 – Present: Avian Surveys

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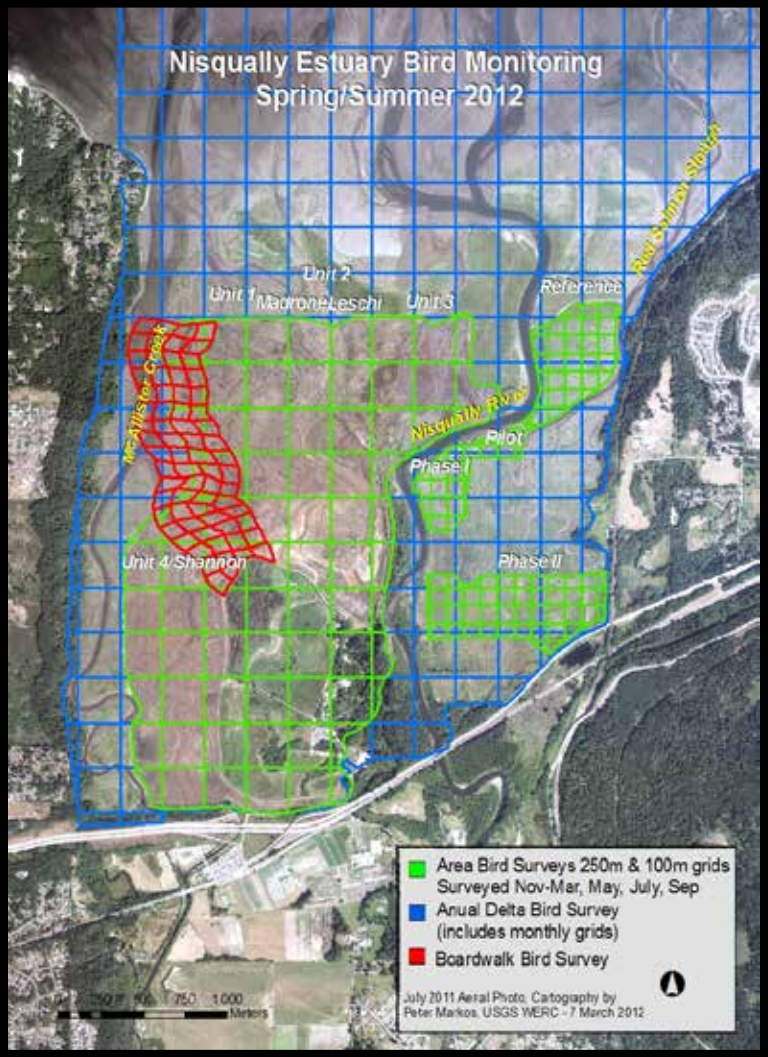
Nisqually Delta Restoration



- 360 ha
- 2006 - 2009: Phased Restorations
  - Complete tidal flow restored, freshwater unit maintained
- 2009 – 2015: Avian Surveys

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Scalable Research Questions

Across Regions

- How do waterbird abundances compare across regions?

Within Regions

- How do waterbirds use restoring vs managed wetlands?
- What meso and macro habitat features that drive waterbird densities?

Site

- How does spatial distribution of waterbirds within a site shift across tidal cycle and seasons?
- How do prey resources influence waterbird densities?

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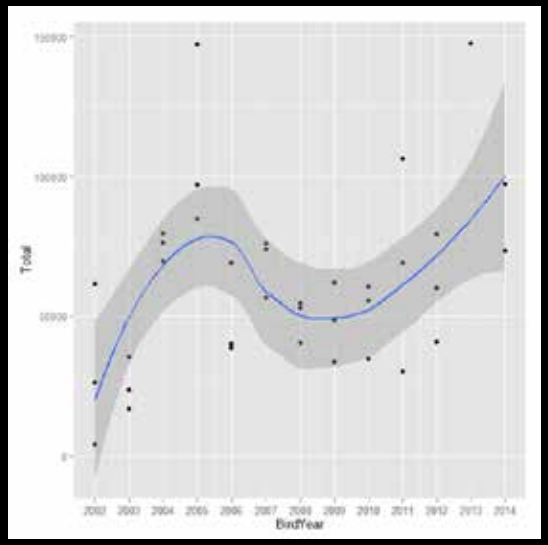
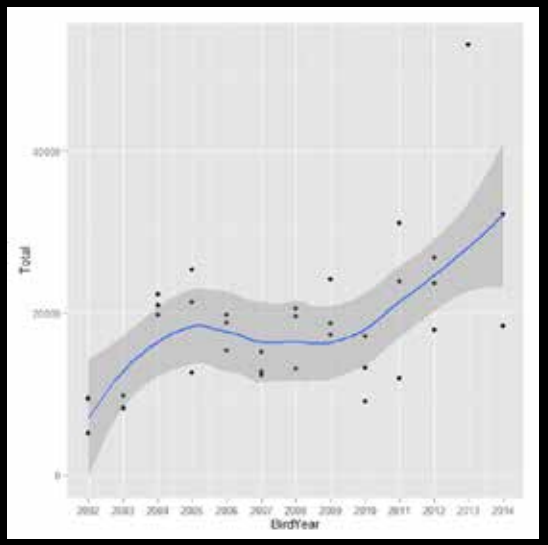
Across Regions: How Do Abundance Trends Compare?

Small Shorebirds

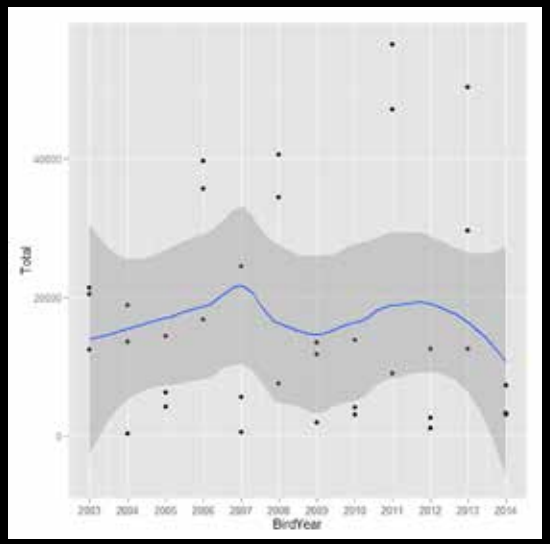
Medium Shorebirds

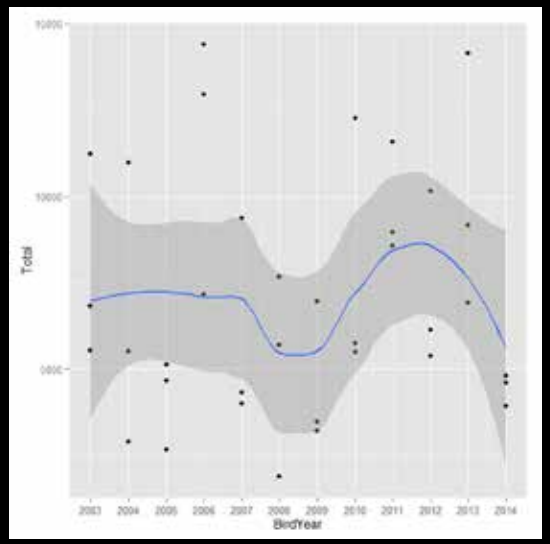
South Bay





North Bay





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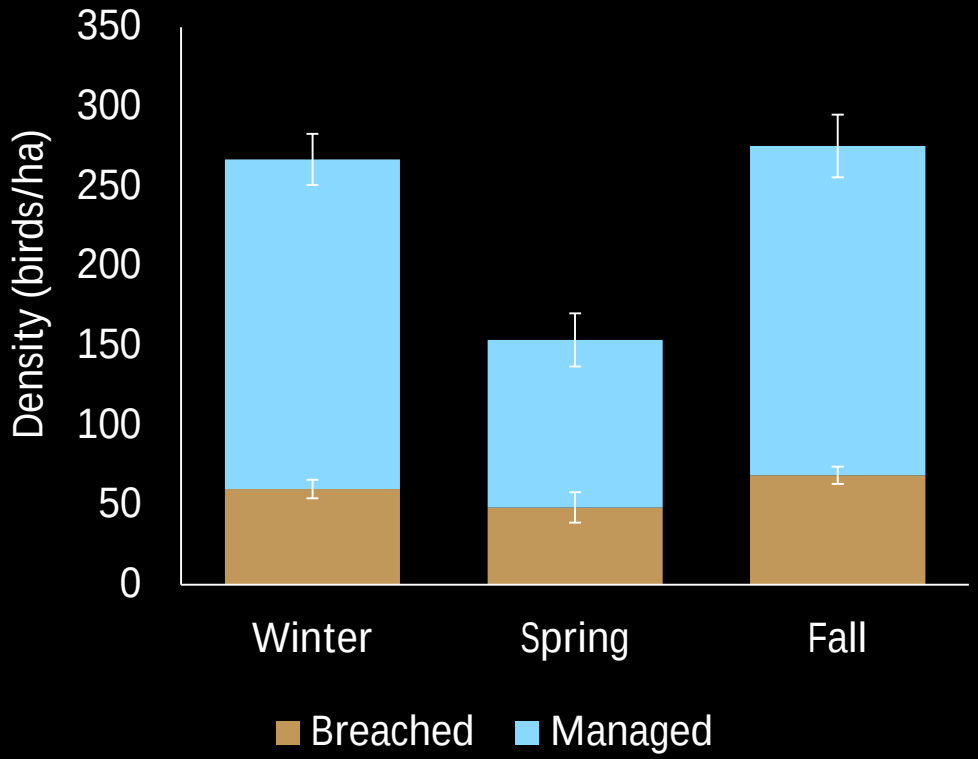
Within Region: How do Waterbirds Use Restoring vs Managed Wetland Areas?



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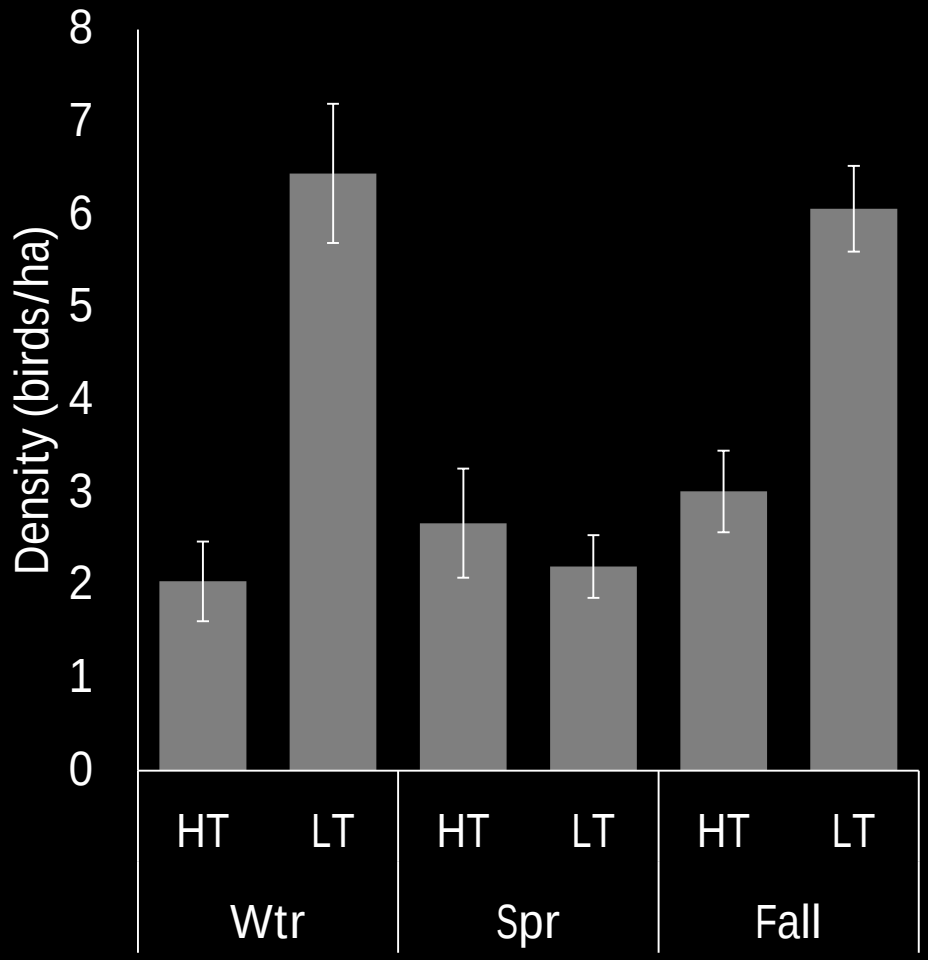
Breached at High Tide vs Low Tide

Medium Shorebirds



Fixed Effect	Foraging	Roosting
(Intercept)	+	+
Tide Category: Low	+	-
Pond Area		
Season: Spring	-	-
Season: Winter		-
Days Since Breached	+	

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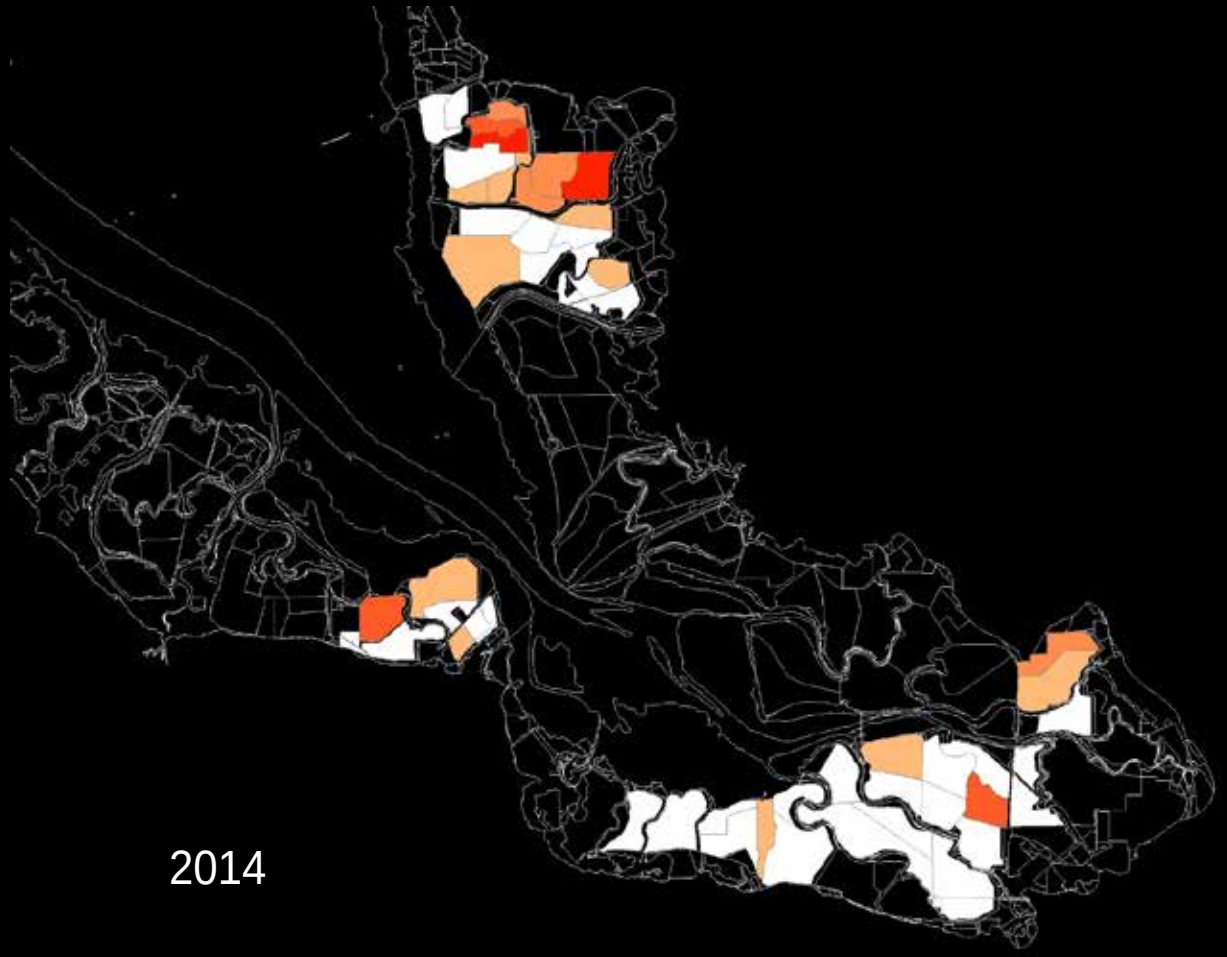
Within Region: How Do Small Shorebird Distributions Change with Restoration Actions?



2014

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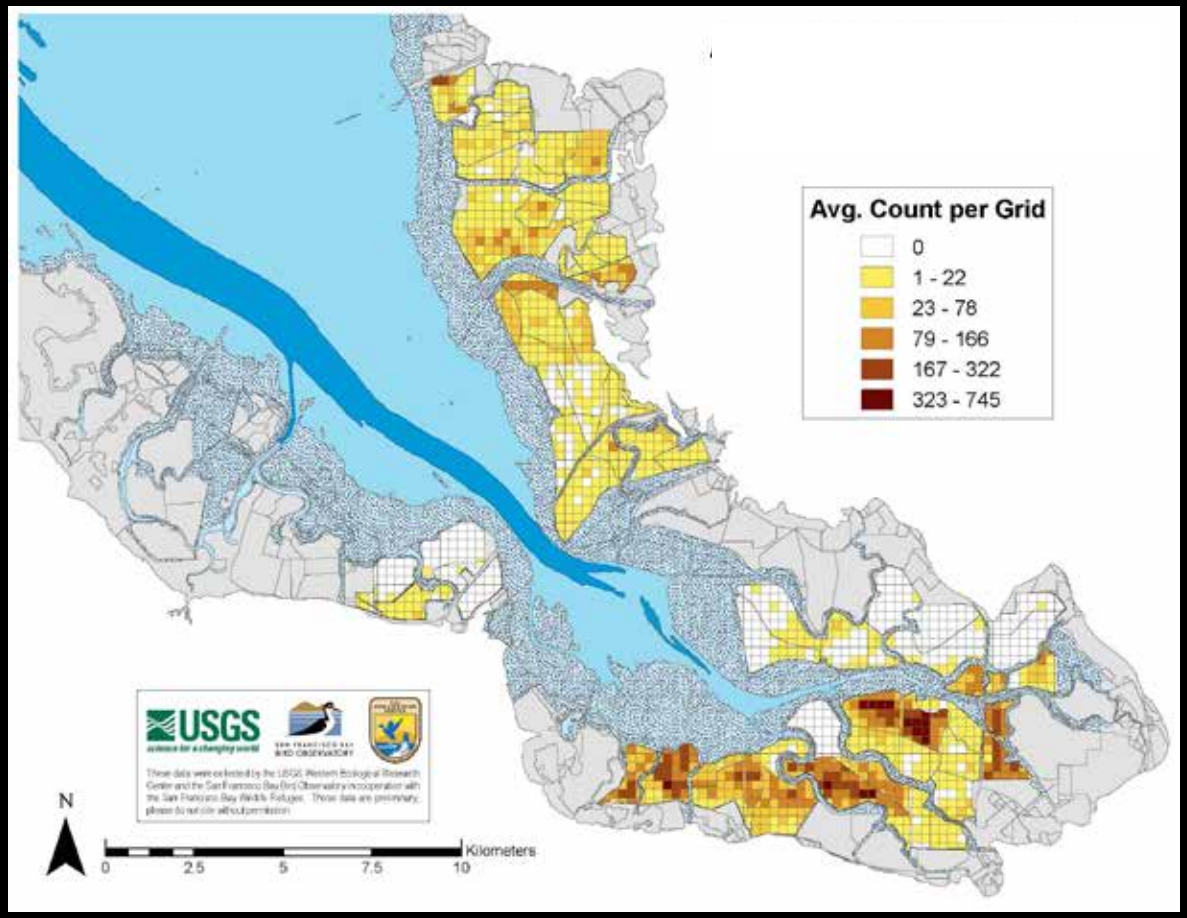
Within Region: Small Shorebird Distributions



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Within Region: What Habitat Features Drive Waterbird Densities?

Data colletion: Monthly grid-based HT counts at 53 ponds and associated habitat features data

Time period: Oct to Apr 2003-2015

Analyses:

1) Generalized Linear Mixed Models (GLMM) to identify important predictor variables
2) Generalized Additive Models (GAMs) to identify values of predictor variables where abundance was maximized

Response variables: Foraging and roosting abundance of several species and guilds

Predictor variables: Pond area, water depth, topography, mean salinity, distance to SF Bay, distance to urban area, distance to creek, pond management (breached or not), island presence, hunting access, public access

Scales:

Pond Scale

Grid Scale

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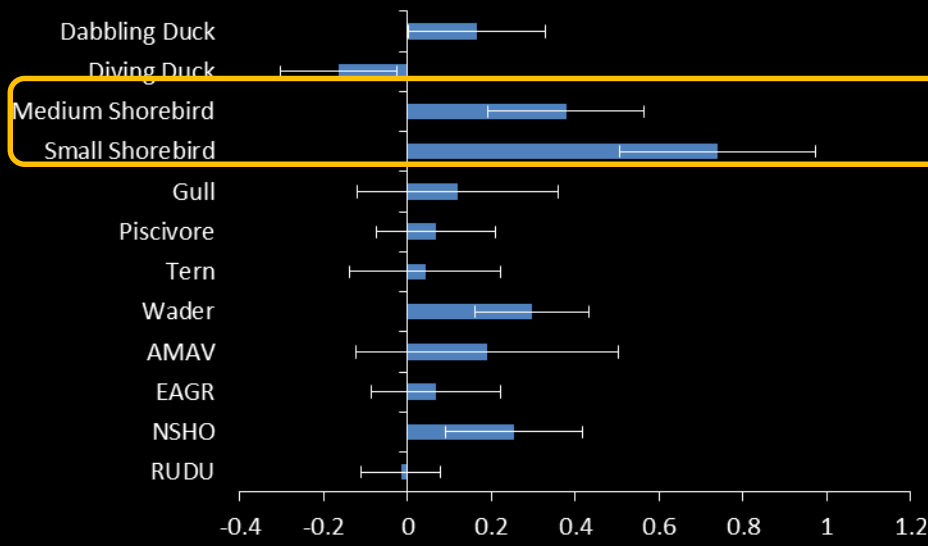
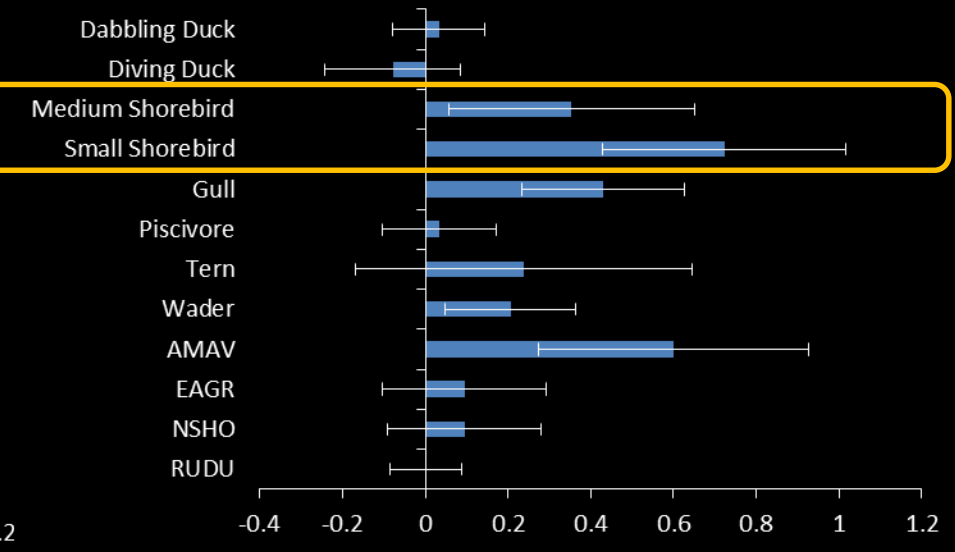
Grid Scale

Within Region: What Habitat Features Drive Waterbird Densities?

Grid Topography



Foraging



Roosting

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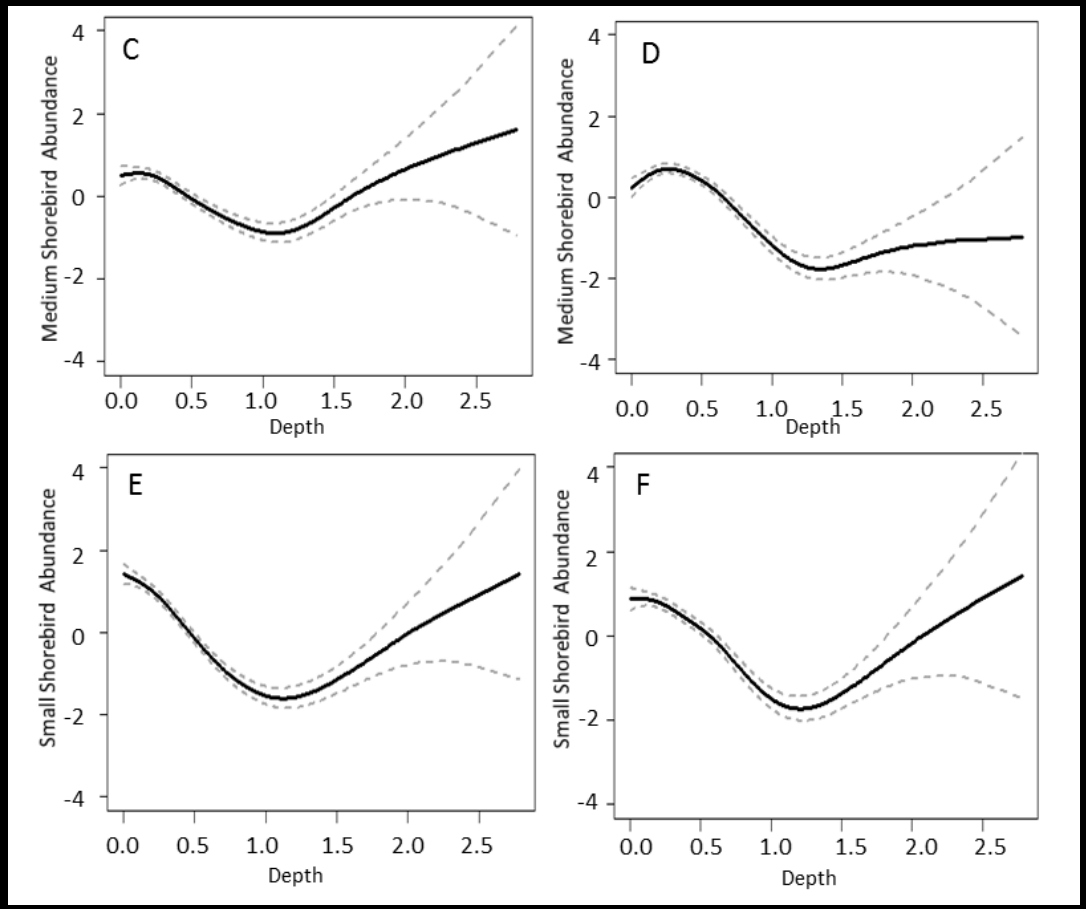
Model-averaged results from General Linear Mixed Models (GLMM) to identify important predictor variables

Within Region: What Habitat Features Drive Waterbird Densities?

Depth



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Generalized Additive Models (GAMs) to identify values of predictor variables where abundance is maximized

Pond Scale: Optimized Habitat Values

Characteristic	Dabbling Ducks	Diving Ducks	Medium Shorebirds	Small Shorebirds	Gulls	Piscivores	Terns	Waders
Foraging								
Depth (m)	--	0.75	0.13	0	1.48	≥0.4	--	0.4
Salinity (ppt)	6	<17	--	--	124	4	15	17
Pond Area (km2)	--	1.25	--	--	>0	>0	>0.75	>0
Distance to Bay (km)	--	1.1	--	--	>0.9	--	--	--
Distance to Urban (km)	--	--	--	--	--	--	--	--
Islands (Presence)			--		--			
Levee Open Hunting (%)	--	--	--	--	>78	25	--	--
Topography (m)	--	--	--	--	--	--	--	--
Breached	--		--		--		--	--
Levee Open Public (%)	--	--	--	0 & 70	--	--	--	--
Distance to Landfill (km)	N/A	N/A	N/A	N/A	--	N/A	N/A	N/A
Roosting								
Depth (m)	--	1.5	0.25	0	0.3	>1.25	--	--
Salinity (ppt)	6	<5	--	--	--	4	15	17
Pond Area (km2)	--	1.25	--	--	>1.75	>0.5	>1.5	>0
Distance to Bay (km)	--	1.1	--	--	>0	--	--	--
Distance to Urban (km)	--	--	--	--	--	--	--	--
Islands (Presence)								
Levee Open Hunting (%)	<77	--	--	--	--	--	100	77
Topography (m)	0.61	--	>0.15	--	--	--	--	--
Breached	--		--		--		--	--
Levee Open Public (%)	--	--	--	--	46	--	--	--
Distance to Landfill (km)	N/A	N/A	N/A	N/A	2.8	N/A	N/A	N/A

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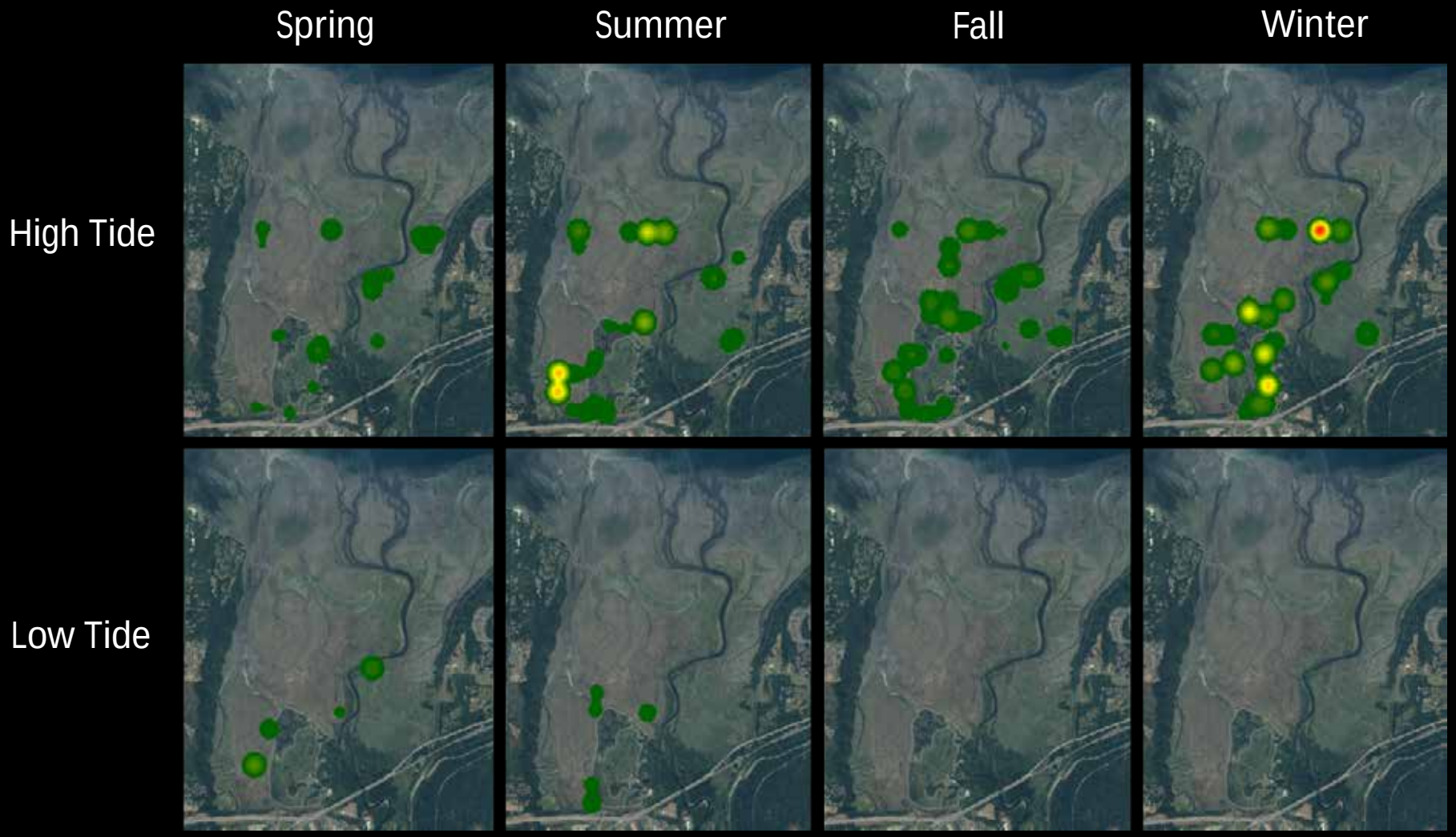
Site Scale: What is the Seasonal Density and Distribution of Nisqually Small Shorebirds?



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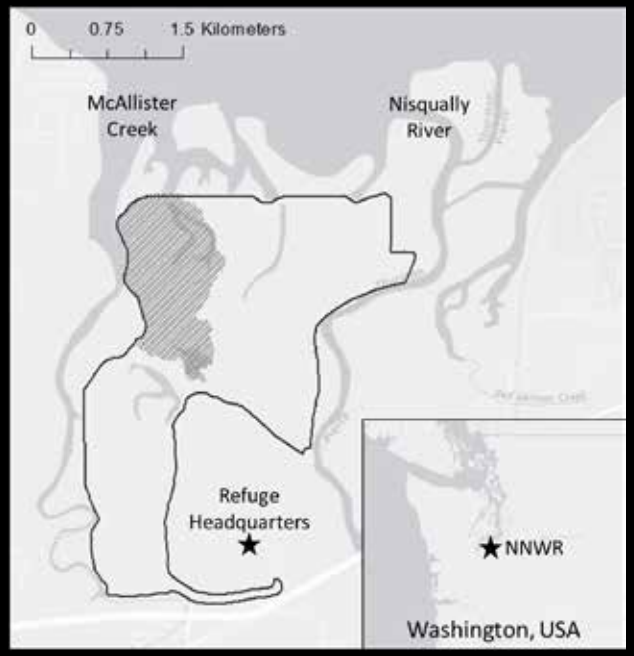
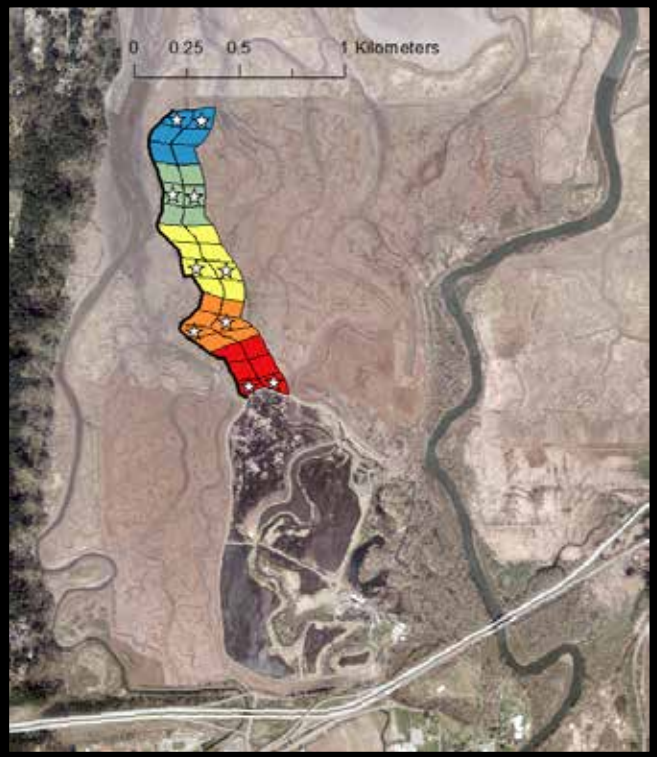
Site: How do Prey Resources Influence Waterbird Densities?

Restored Refuge





Survey Area:

- Boardwalk Transects
- Benthic Invertebrates: Spring, Summer, Fall 2012 (at starred grids)
- Birds: Weekly, March 2012 – January 2013

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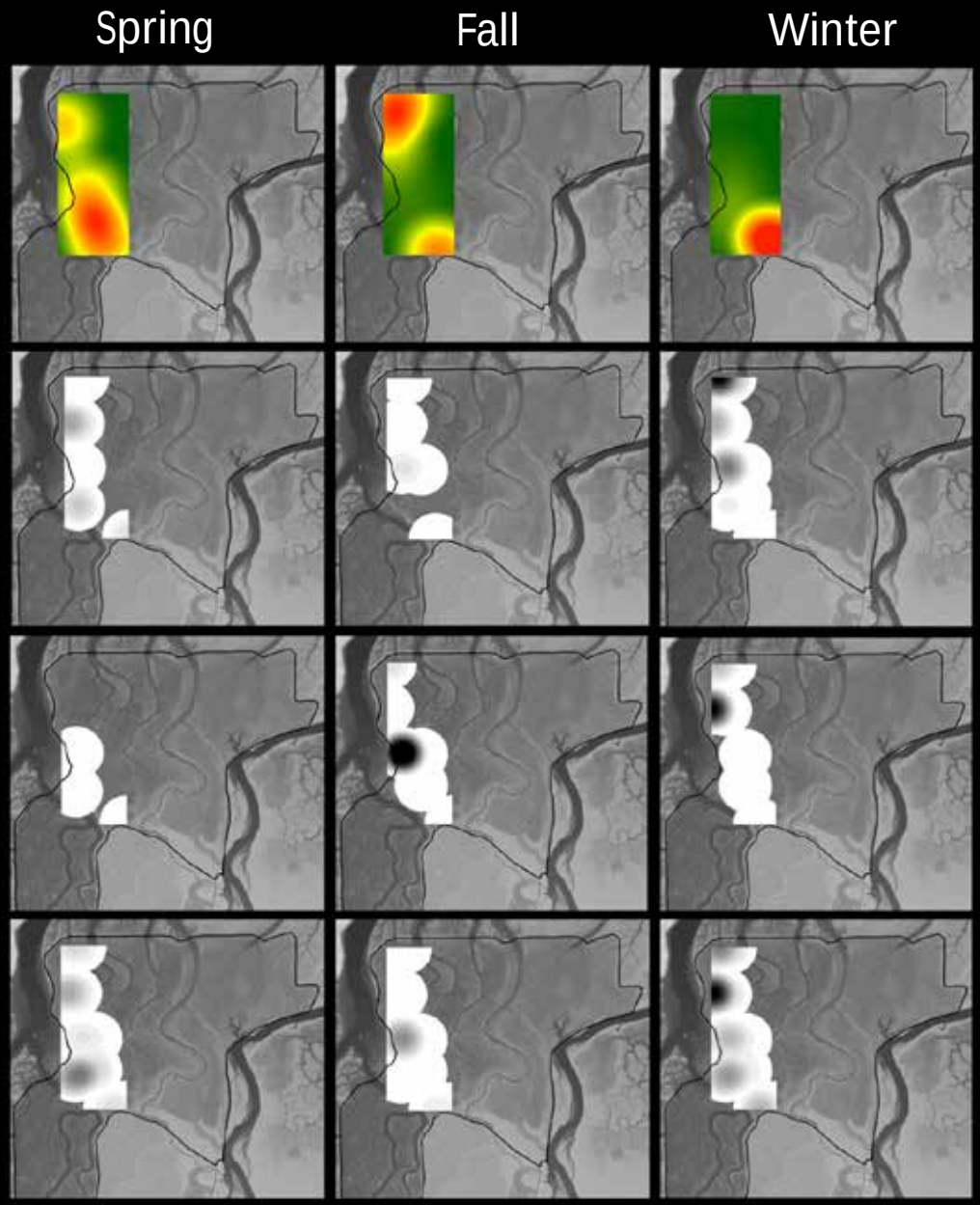
Site: Shorebird Densities and Prey Biomass

Benthic invertebrate prey densities and biomass were 79-150% greater during the fall than in spring or summer

Highest prey densities were observed at lower elevations that were more frequently inundated ($R^2 = 0.12$, $p = 0.002$)



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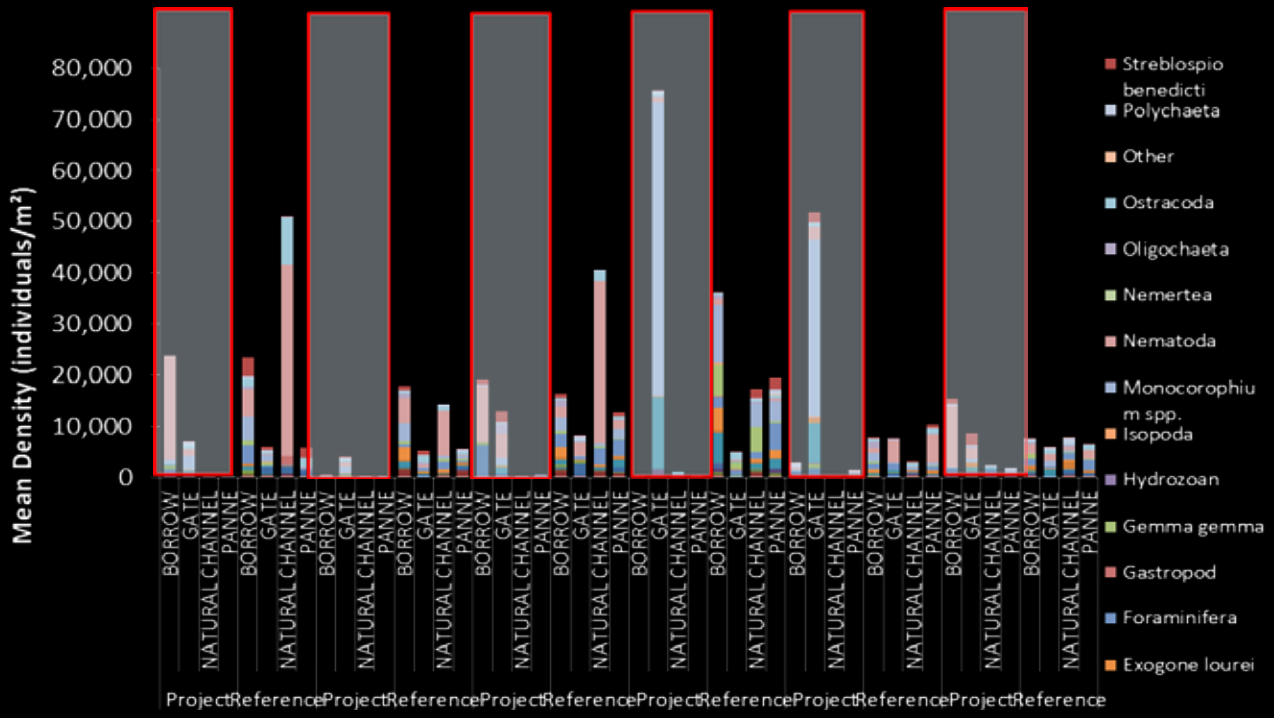
Prey Availability in Restoring Wetlands



- Prey Availability:
  - Oct, Jan, Mar
  - Sampling locations stratified random
  - Balanced number of cores each in:
    - Borrow ditches, natural channels, pannes
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Conclusion

- Grid-based area counts provide a scalable methodology to link response of waterbirds to biotic and abiotic changes at restoration site
  - Common currency enabling comparison across sites and regions
  - Enables meso and macro-scale habitat association modeling
  - Informs adaptive management and restoration design
- Pre and post breach/dike removal data ideal to capture avian response to site evolution
- Accessibility, staffing, funding may limit effort. Random sampling of grids allows for modeling, but may limit ability to evaluate fine scale spatial distributions
- Restorations may benefit multiple species at different times in their trajectories. Important to evaluate use by all waterbird species to have multiple indicators of restoration benefits
  - Co-benefits for fish and birds – shared prey resources

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Collaborators: Nisqually Tribe, SFBBO, PRBO, Ducks Unlimited, Moss Landing Marine Labs, San Jose State University, San Francisco State University

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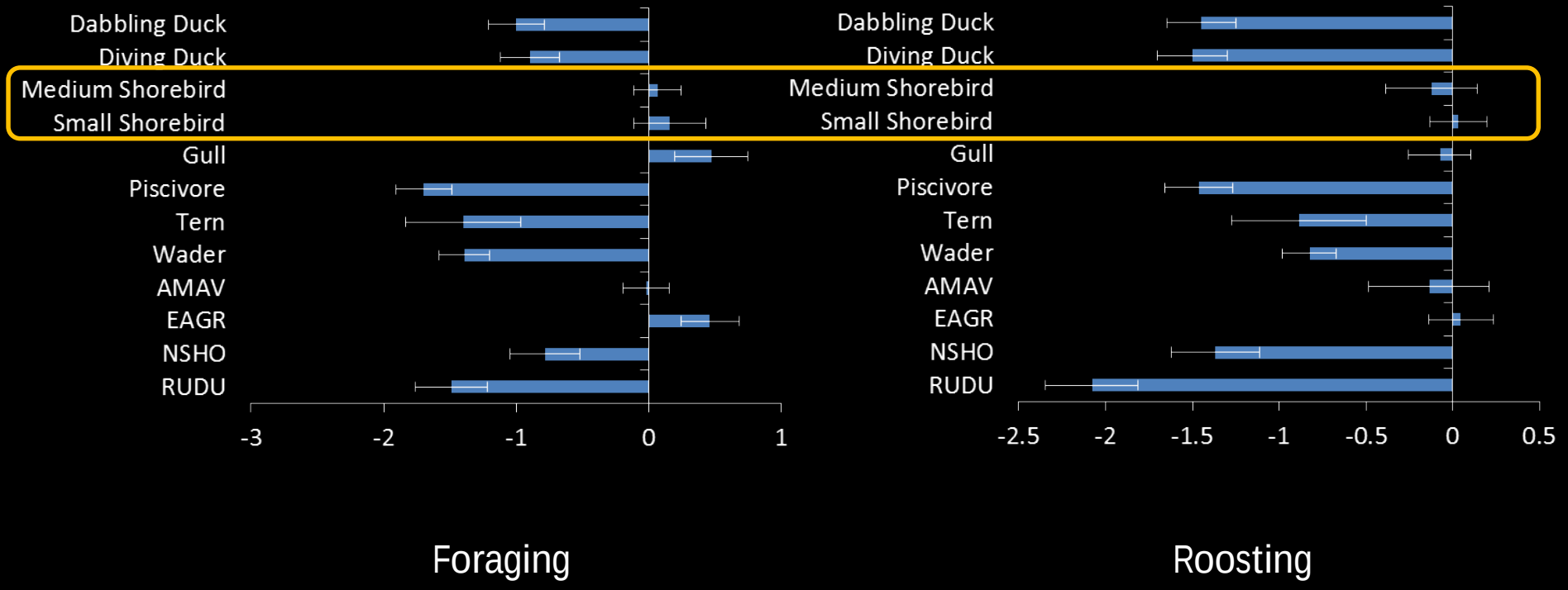
Within Region: What Habitat Features Drive Waterbird Densities?

Pond Salinity



Foraging

Roosting

Model-averaged results from General Linear Mixed Models (GLMM) to identify important predictor variables

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