Characterizing Drivers of Macroinvertebrate and Biofilm Food Resources for Waterbirds using the South Bay Salt Pond Restoration Project

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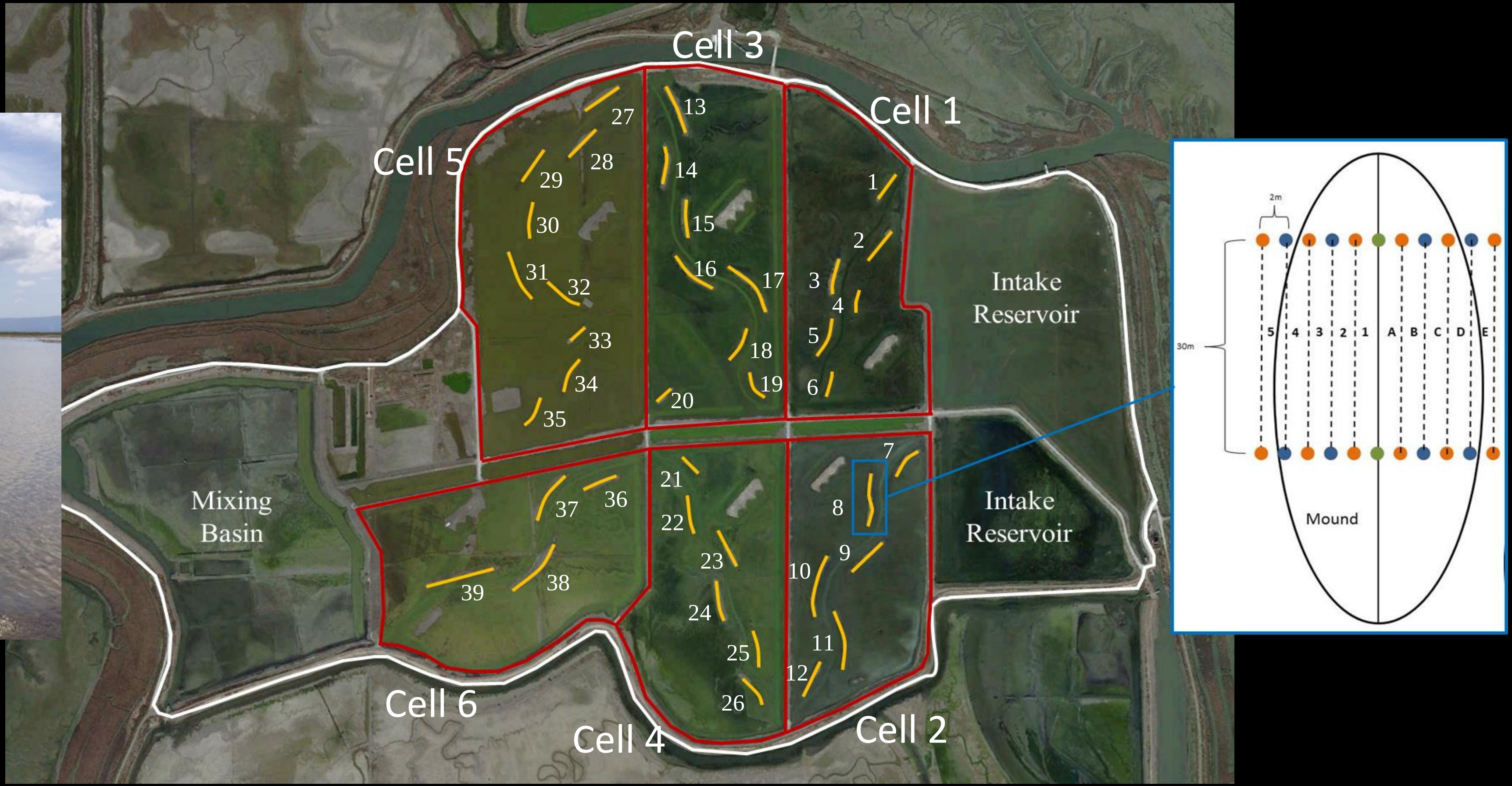
California State University MONTEREY BAY

South SFB: Critical for Migratory Waterbirds

- San Francisco Bay is a major wintering and migratory stopover site for waterfowl and shorebirds
- Recognized as one of the key Pacific Flyway stopover areas for spring migrating Calidrid sandpipers (Bishop and Warnock 1998, Page et al. 1999, Williams et al. 2009)
- South Bay supports more than 50% of Calidrid and all other shorebirds in the Bay (Wood et al. 2010)
- Waterbirds rely on the shallow water ponds and broad mudflats of the South Bay to provide critical invertebrate and biofilm food resources that fuel migration (Rowan 2012, Hall et al 2021)

Experimental ponds to enhance prey production and foraging accessibility

Ponds E12/13 at Eden Landing Ecological Reserve, Hayward, CA



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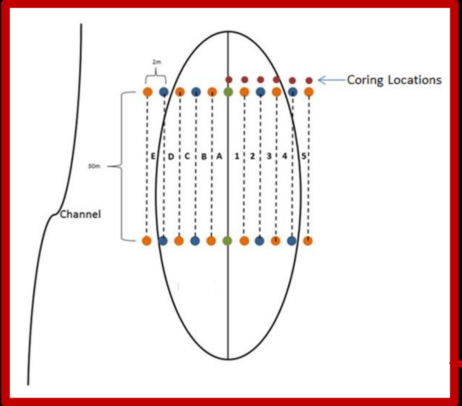
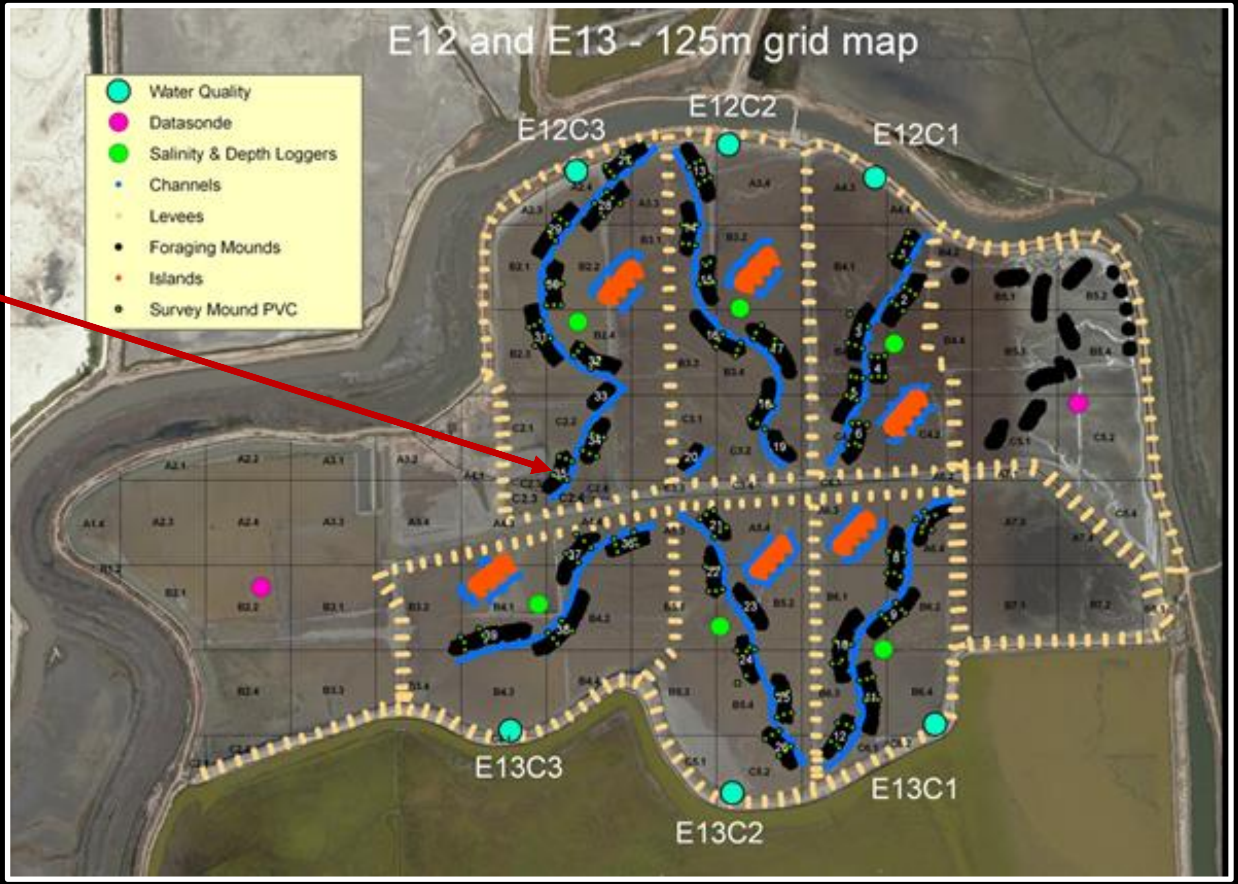
Research Questions

- How do water and sediment conditions influence macroinvertebrate biomass and community composition?
- How do water conditions, habitat features, and prey resources influence shorebird abundance?
- Which macroinvertebrate taxa are consumed by shorebirds in ponds with different salinities?

Methods





Habitat Characteristics

Elevation

Water Quality

Benthic Invertebrates

Monthly core samples

Sampled 6 elevation zones/mound

24 mounds

Waterbird Counts

Monthly pond counts

- Birds assigned to 125 x 125 m grids

Weekly foraging mound counts

- Birds assigned to elevation zones

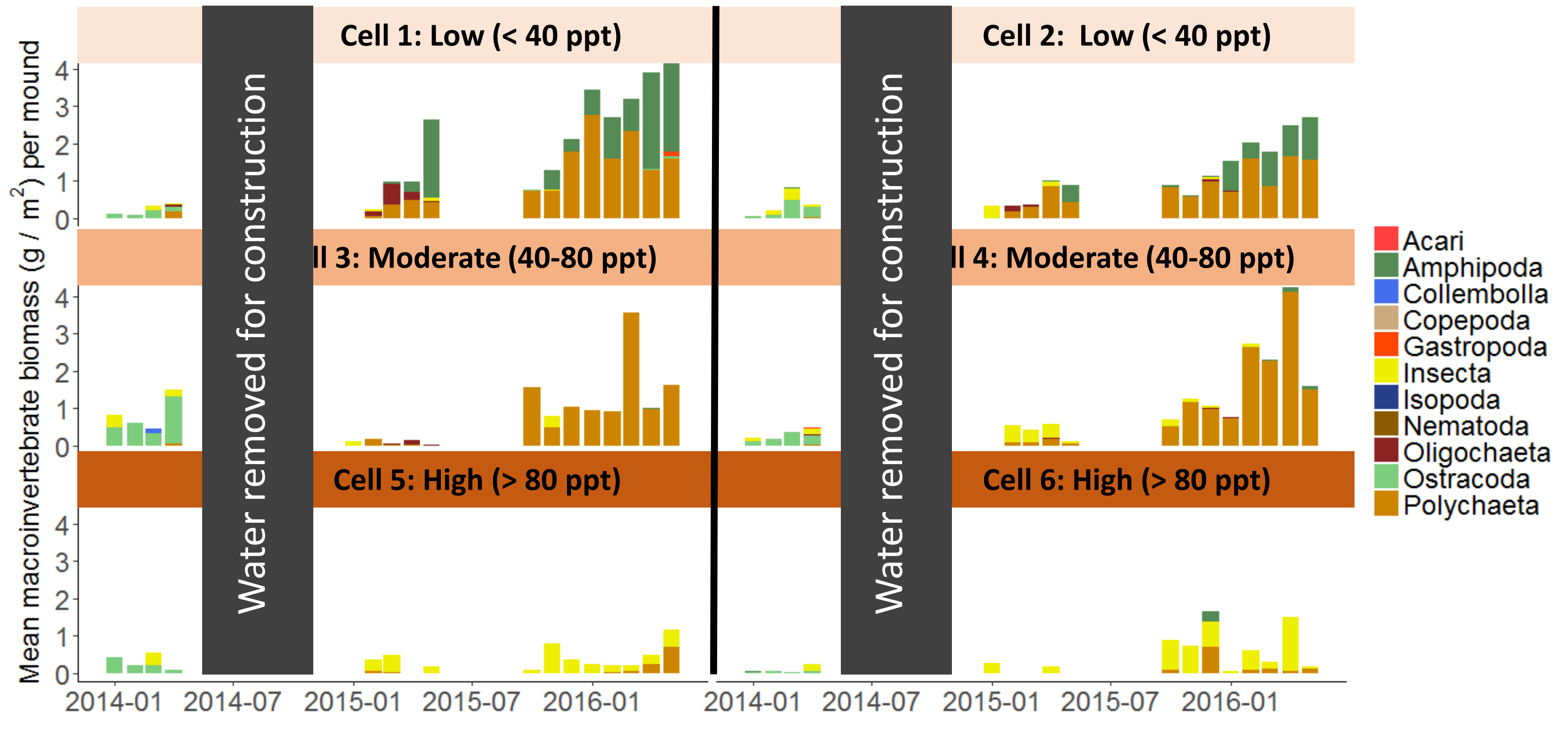
Shorebird Diets

Collected actively foraging small shorebirds and associated macroinvertebrate cores in all cells

Results: Benthic macrofauna




Macroinvertebrate community succession and biomass differed among salinity treatments



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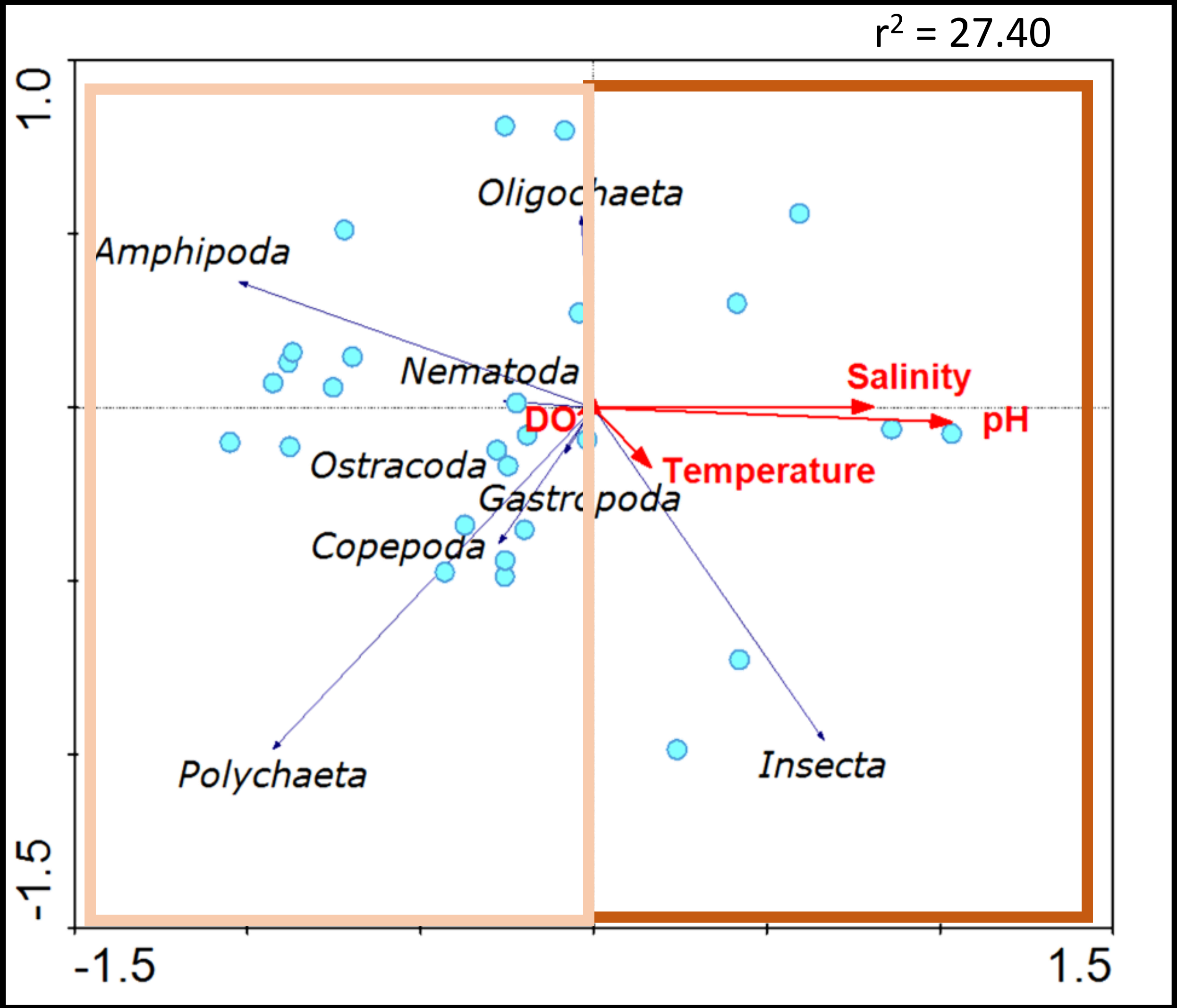
Greater taxonomic diversity was observed at low salinity and pH



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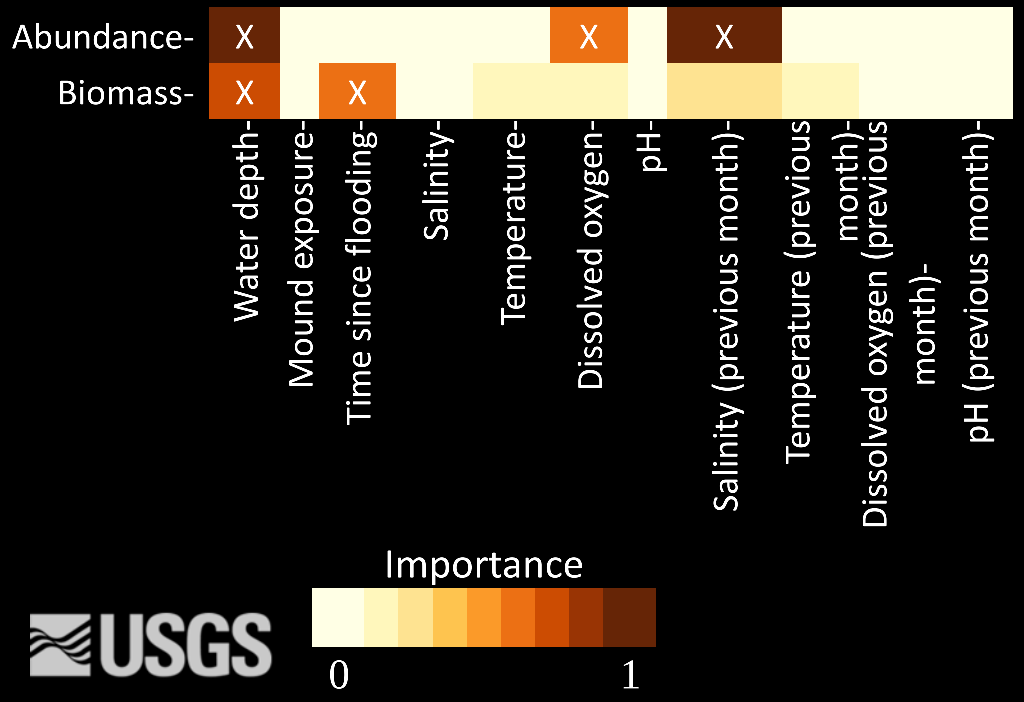
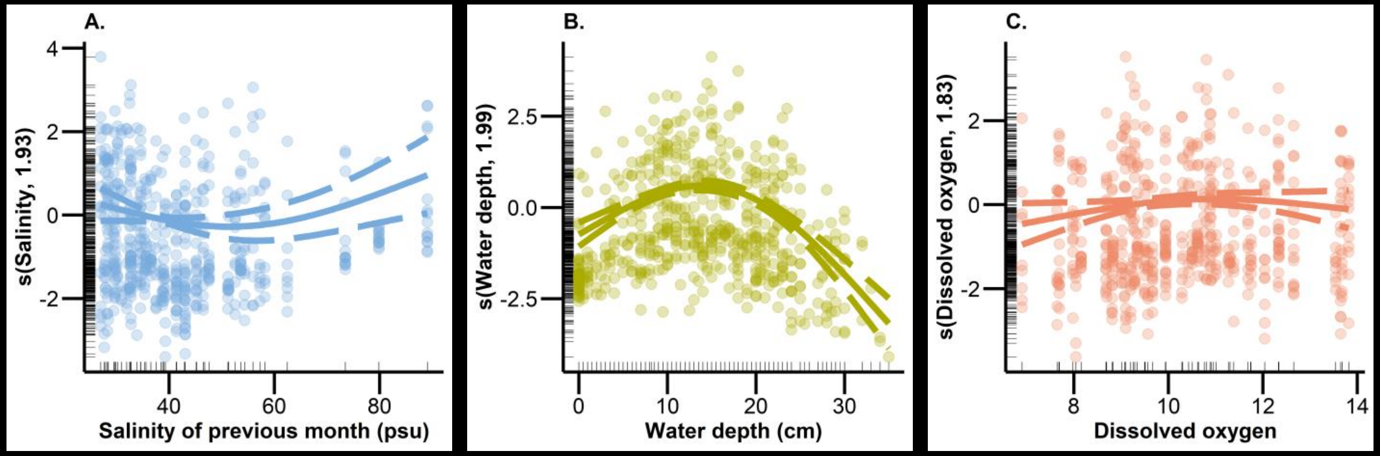
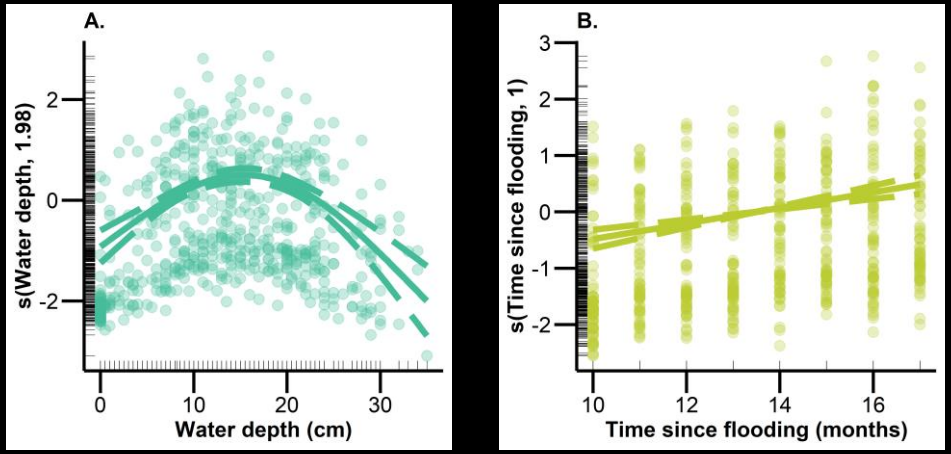
Drivers of invertebrate abundance and biomass



Abundance

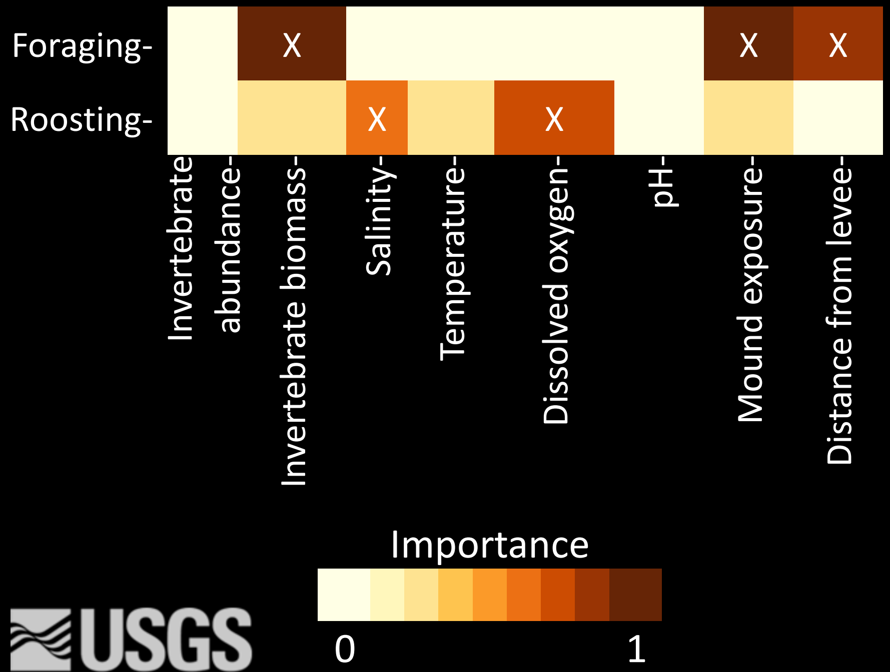


Biomass

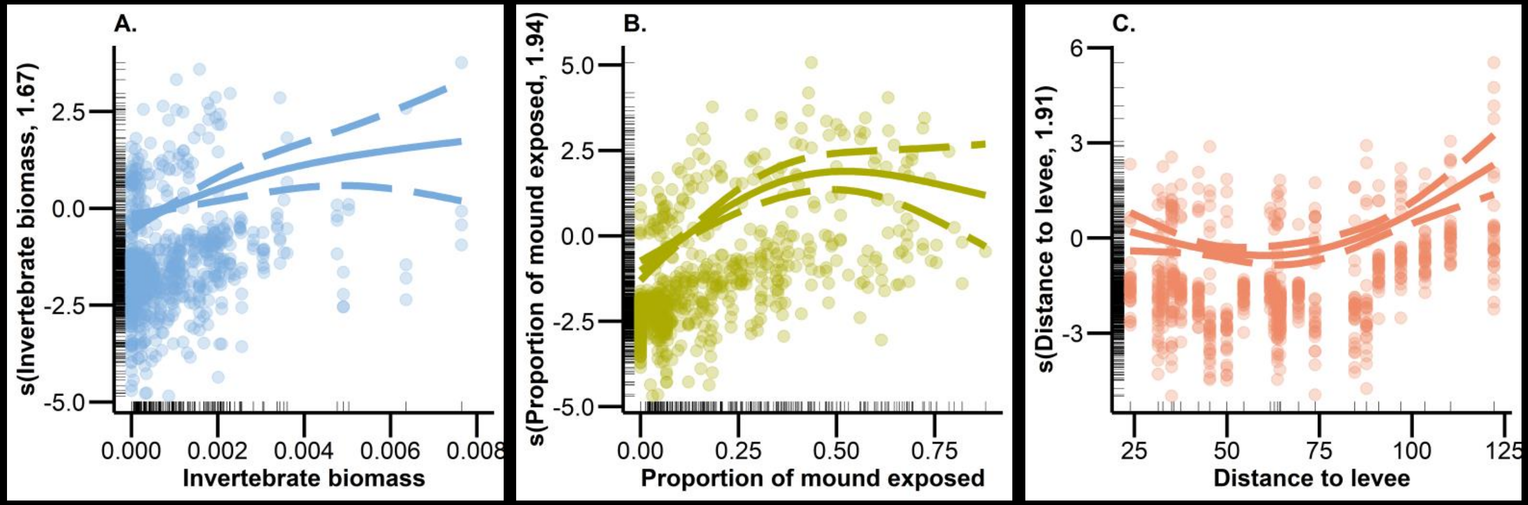


Results: Avian response

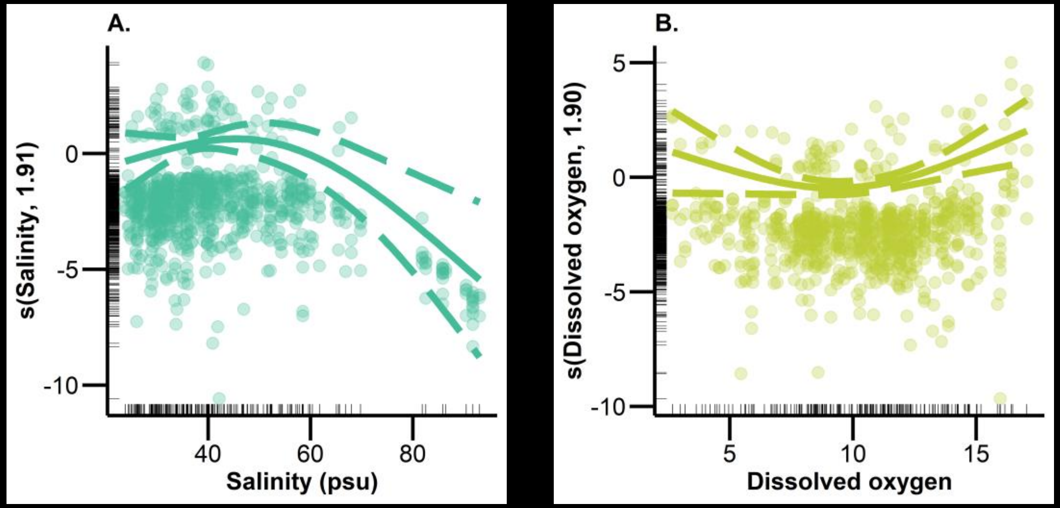
Drivers of shorebird abundance



Foraging



Roosting



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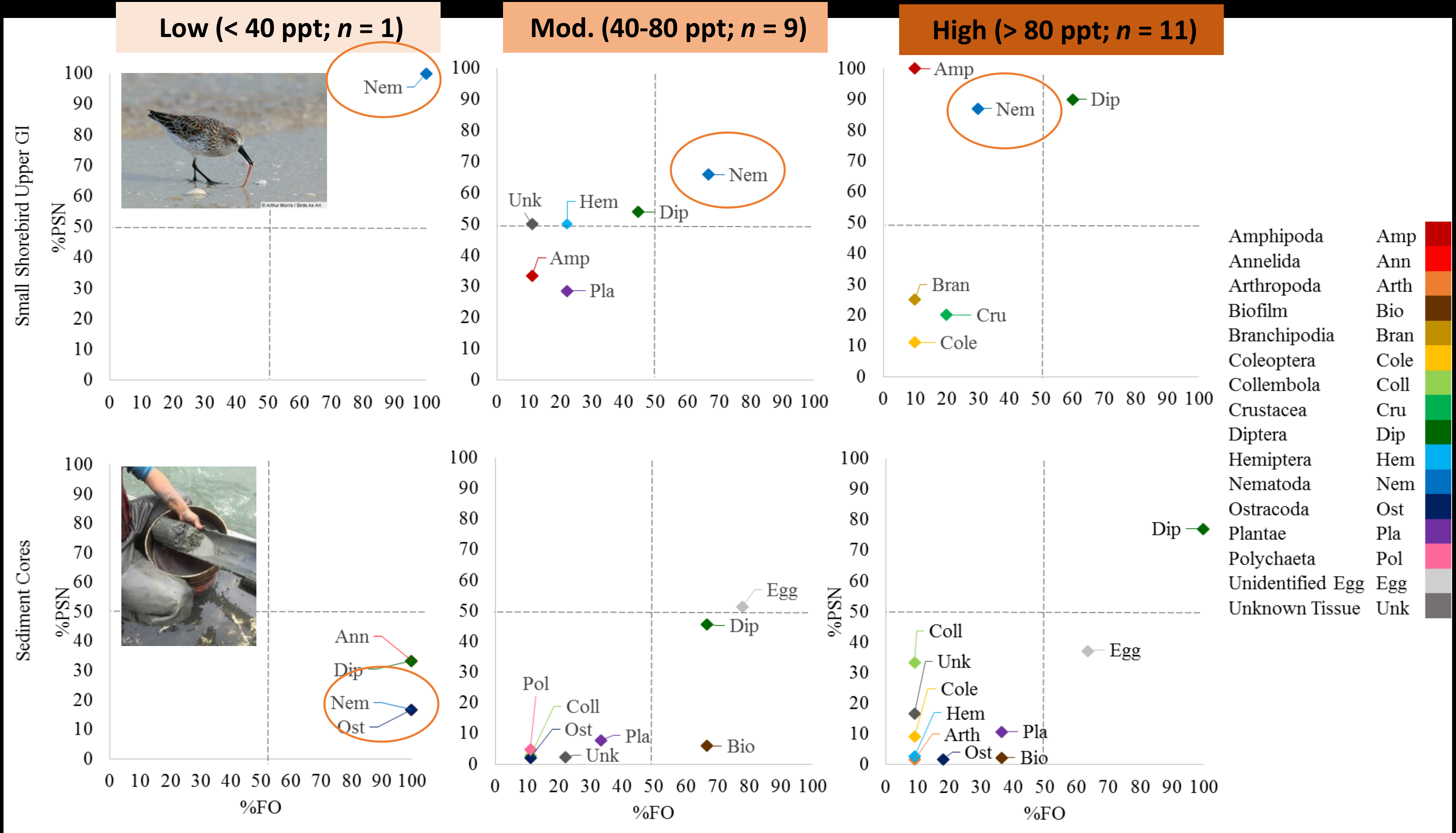
Small shorebirds consumed nematodes in all salinity treatments



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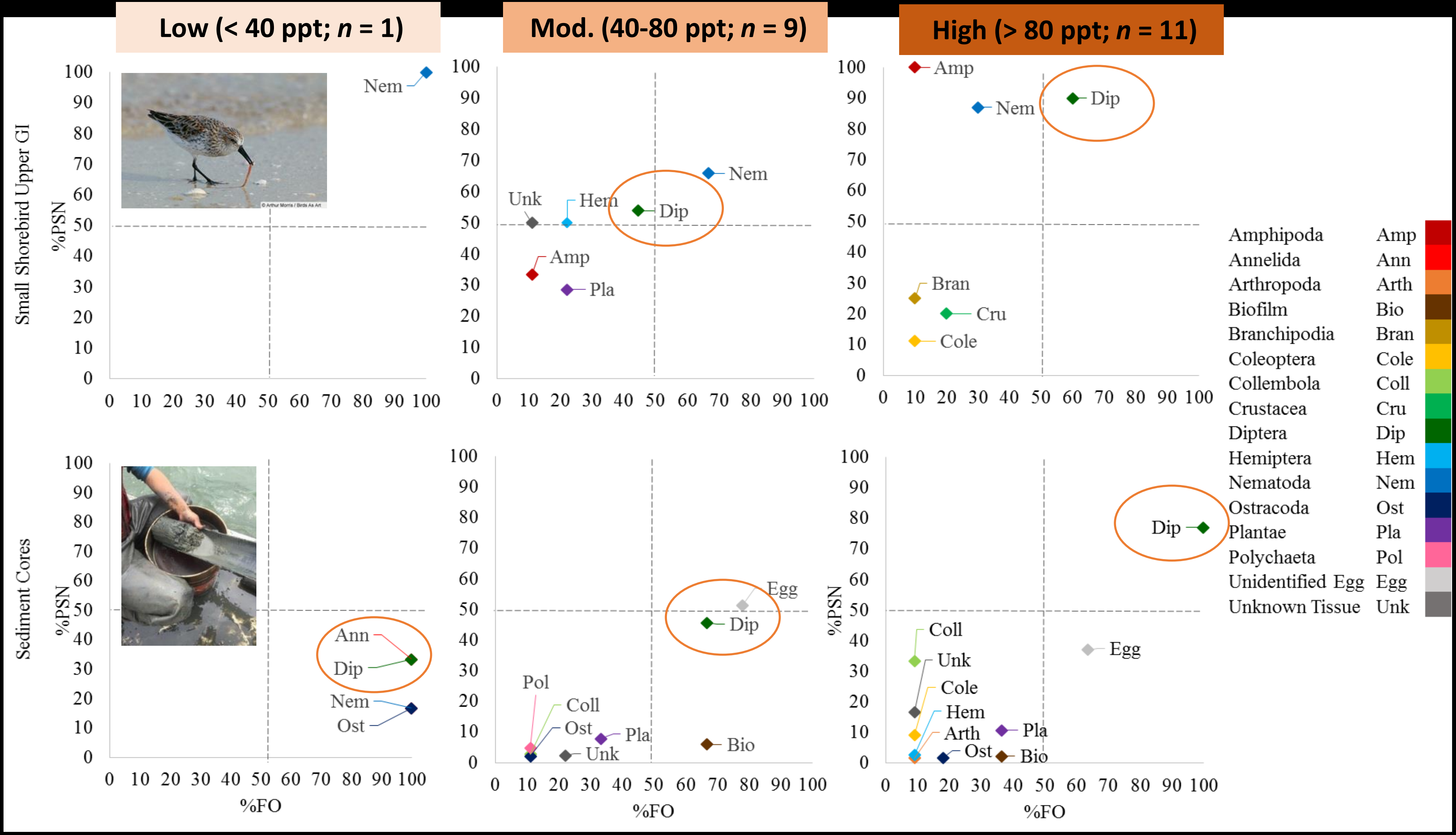
Small shorebirds consumed dipterans in moderate and high salinity treatments



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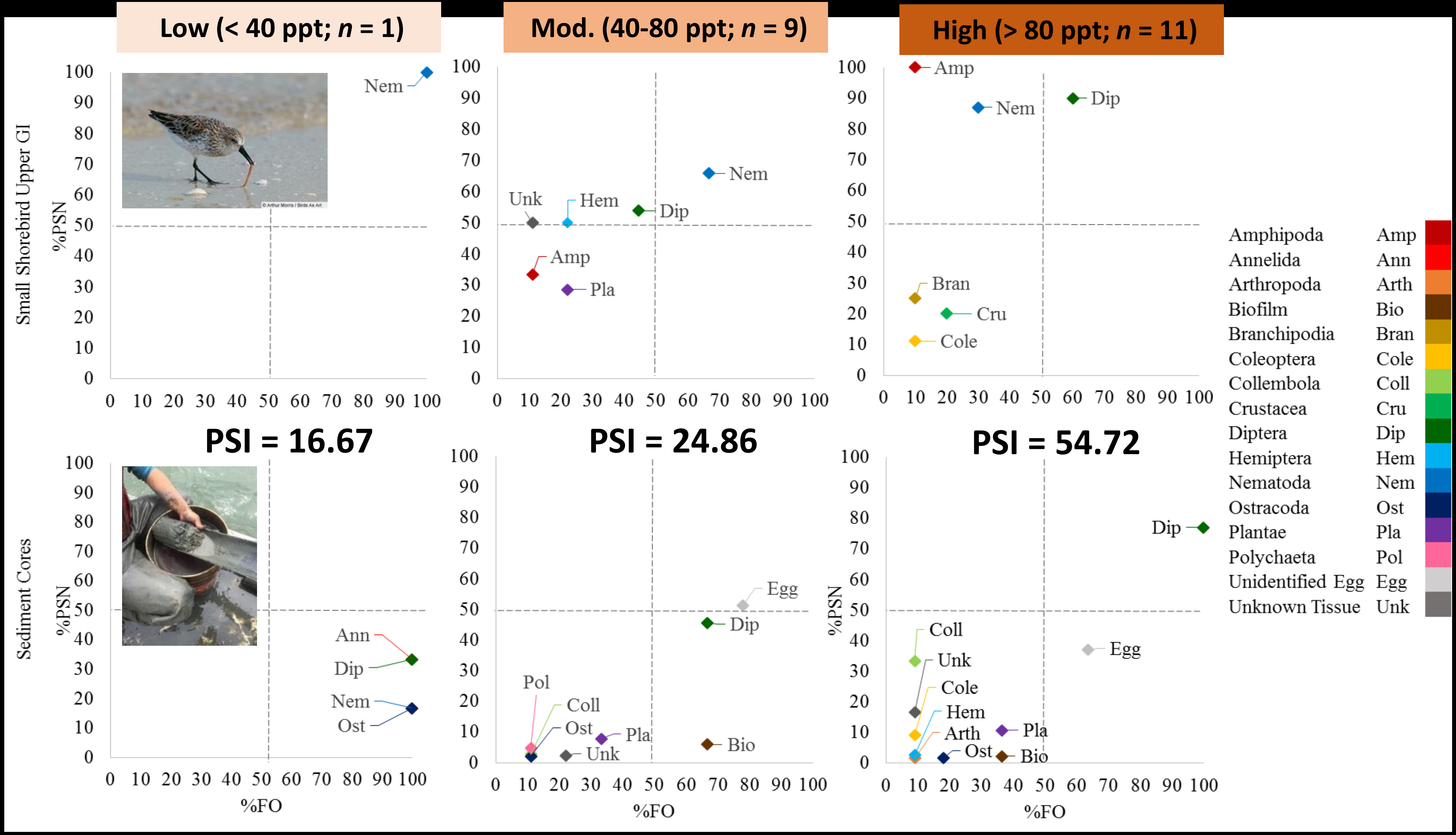
Shorebird diets differed from prey availability



Summary and Conclusions

- Macroinvertebrate diversity and biomass increased over time and were greatest in low salinity cells

- Water depth, salinity, dissolved oxygen were important predictors of macroinvertebrate abundance that can be managed to optimize prey resources for shorebirds

- Predation may play a role in limiting macroinvertebrate abundance and biomass at shallower depths (<10cm)

- Foraging shorebird abundance increased with invertebrate biomass and was maximized on mounds that were 50% exposed and farther than 75 m from levees

- Nematodes and dipterans were among the most abundant and most frequently consumed prey items in all cells. These taxa were also important for shorebirds in North Bay ponds (Takekawa et al., 2009), and efforts to maintain them could benefit shorebirds

- Proportions of prey consumed by small shorebirds differed from availability in sediment cores suggesting preference, particularly in low and medium salinity cells

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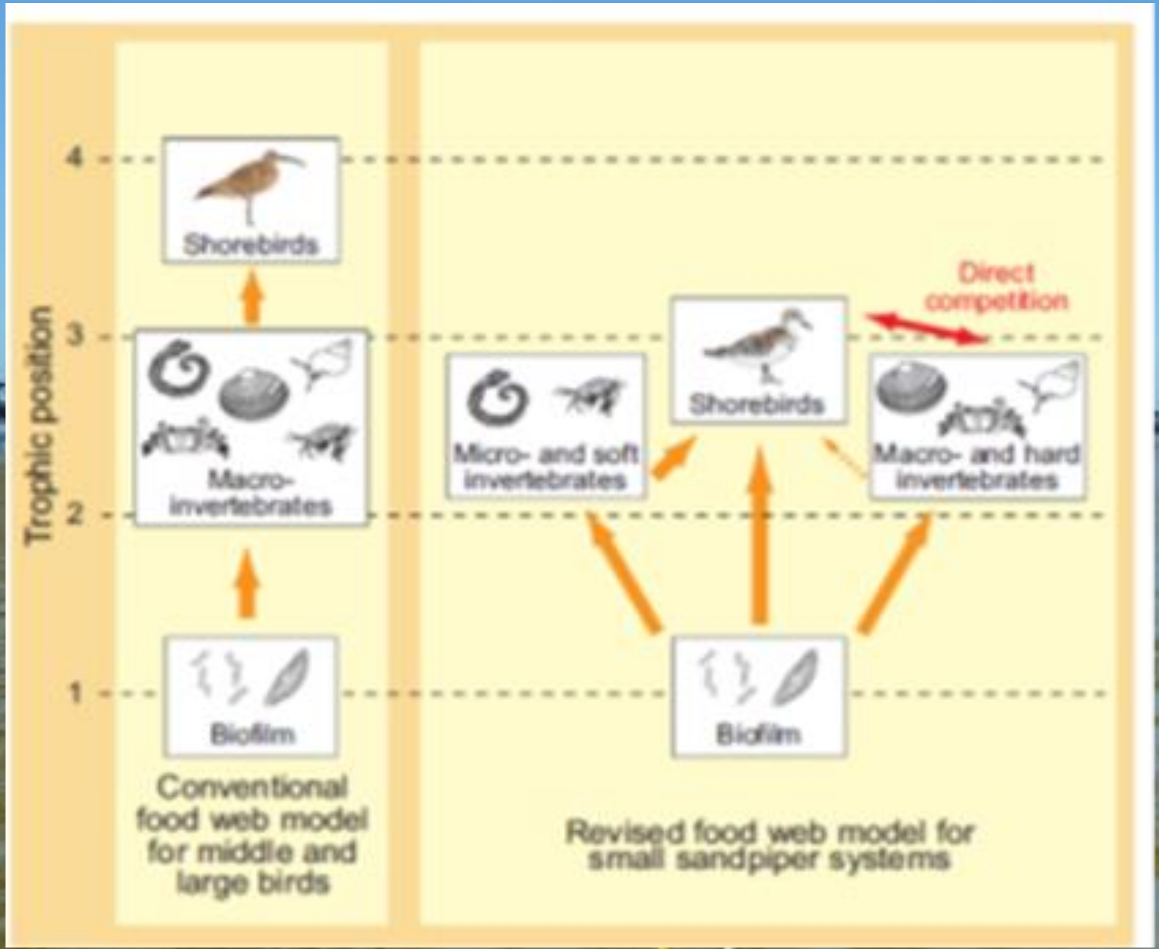
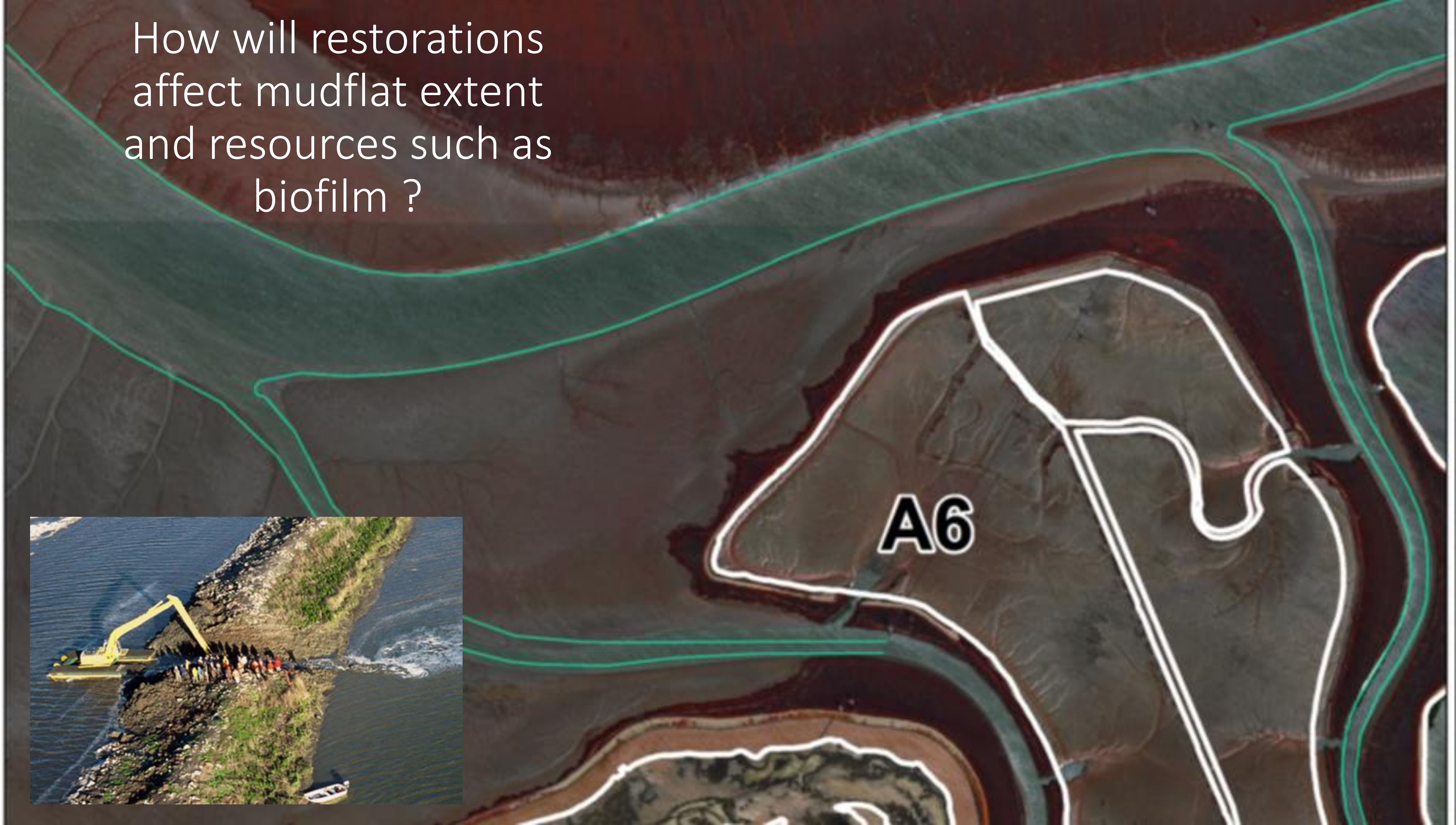
Quantifying Drivers and Stressors of Intertidal Biofilm Resources at the Largest Tidal Wetland Restoration on the U.S. West Coast



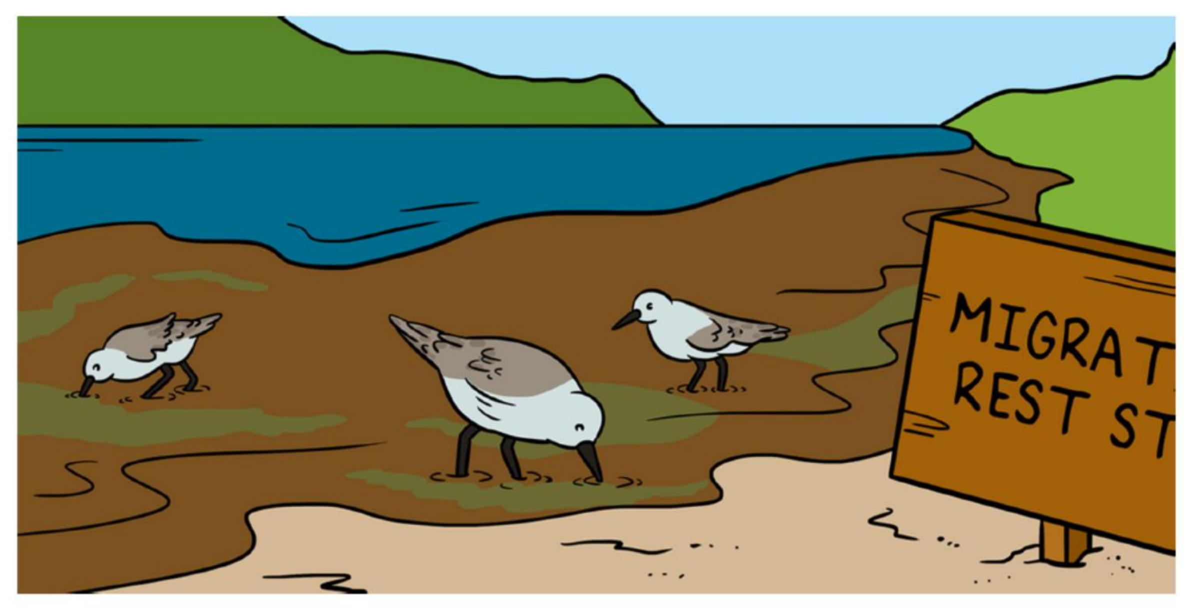
Video: T. Kuwae

How will restorations affect mudflat extent and resources such as biofilm ?



Research Questions

- How do relationships among biofilm biomass, community composition, nutritional quality and mercury concentration vary seasonally and spatially?
- What role do mudflat physical and biological features (including proximity to restoration, sediment properties, elevation/inundation, temperature, salinity, macroinvertebrates, and others) play in driving these changes?
- Can we build remote sensing models to map biofilm abundance, diversity, and nutritional quality across the Bay?



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Multi-scalar approach

"**Quadrat**" scale (1 x 1 m)

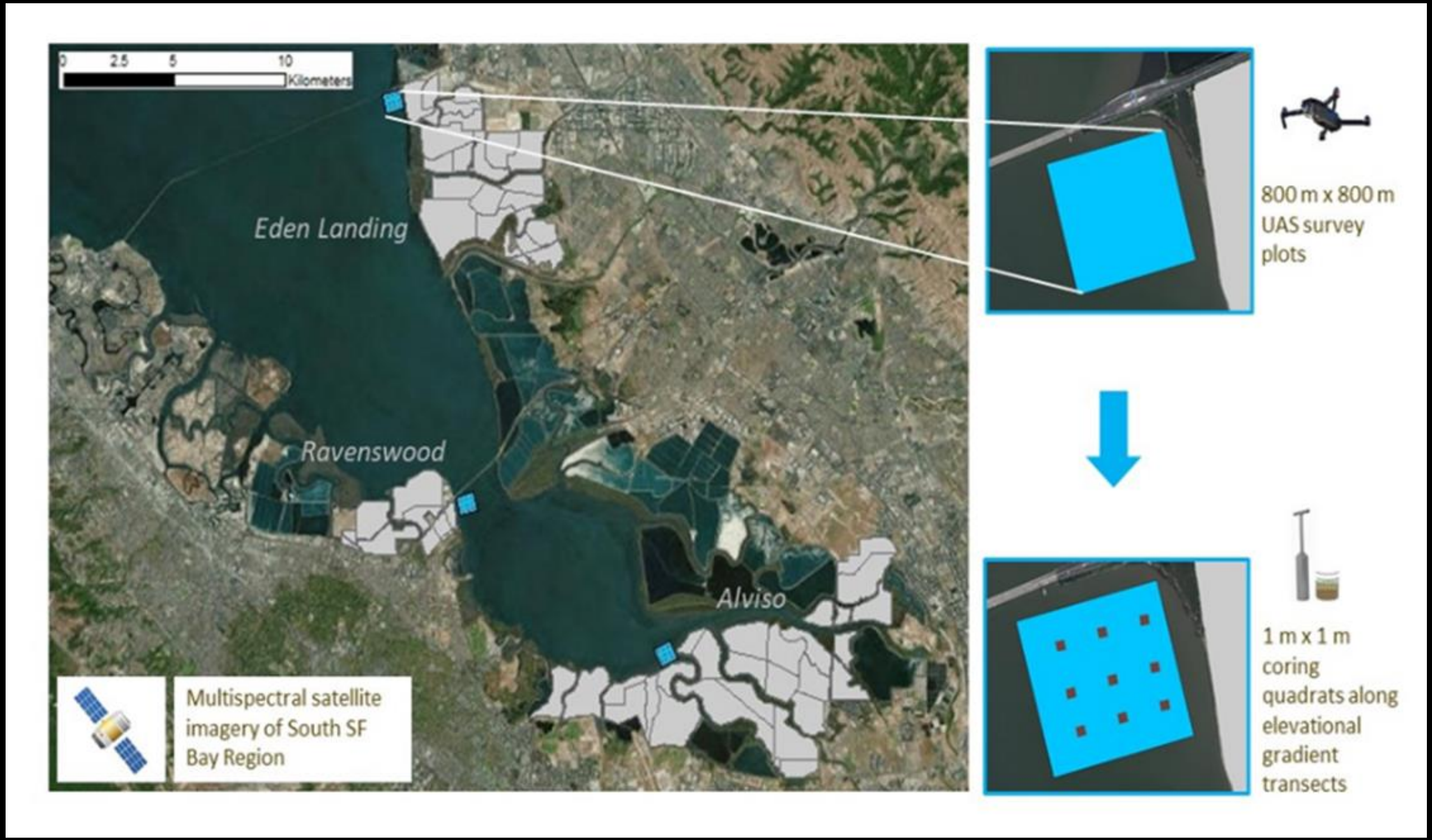
- *in situ* field measurements and field spectroscopy

"**Plot**" scale (800 x 800 m)

- field areas adjacent to existing and planned tidal marsh restoration sites

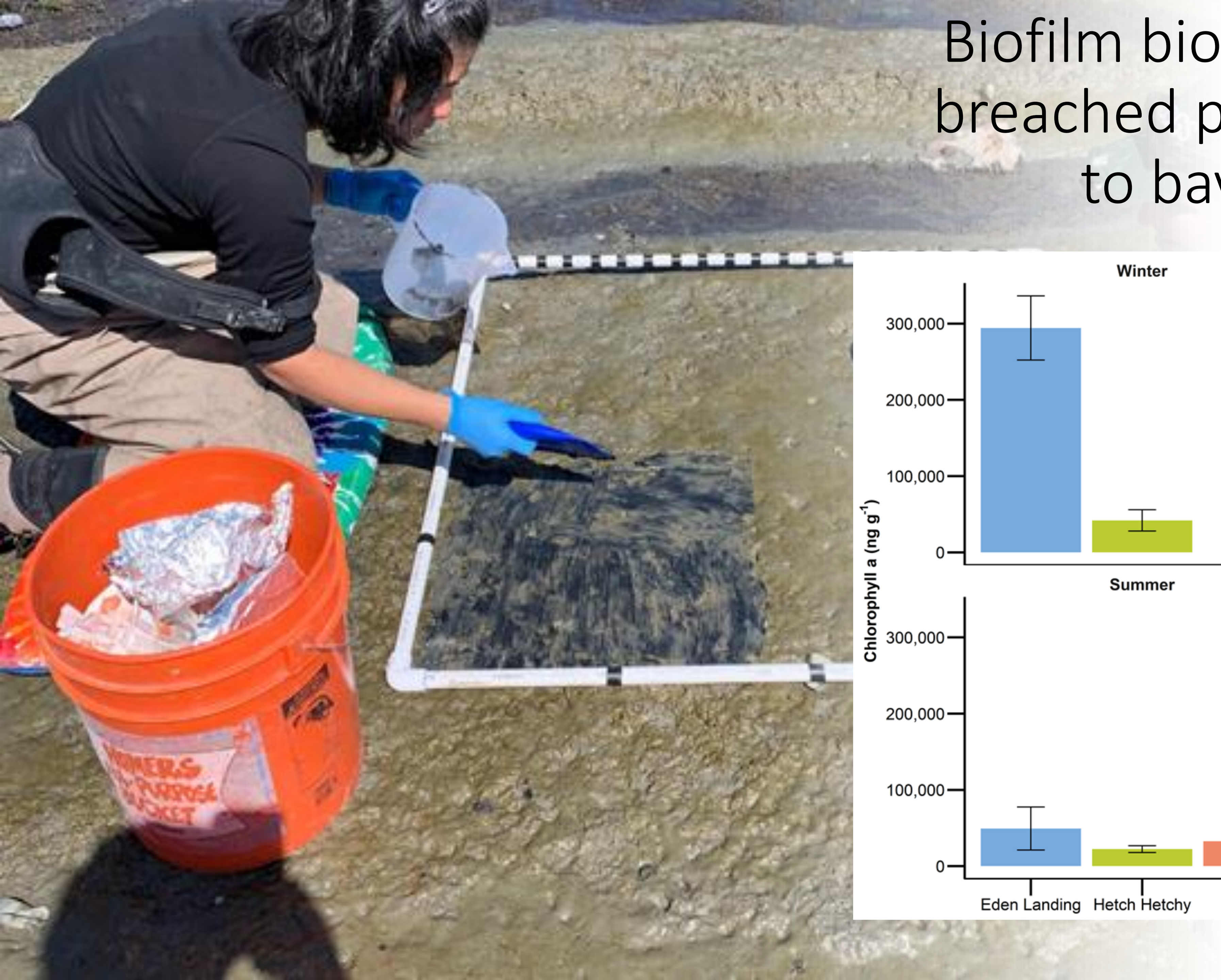
"**Regional**" scale encompassing the mudflats of the South Bay

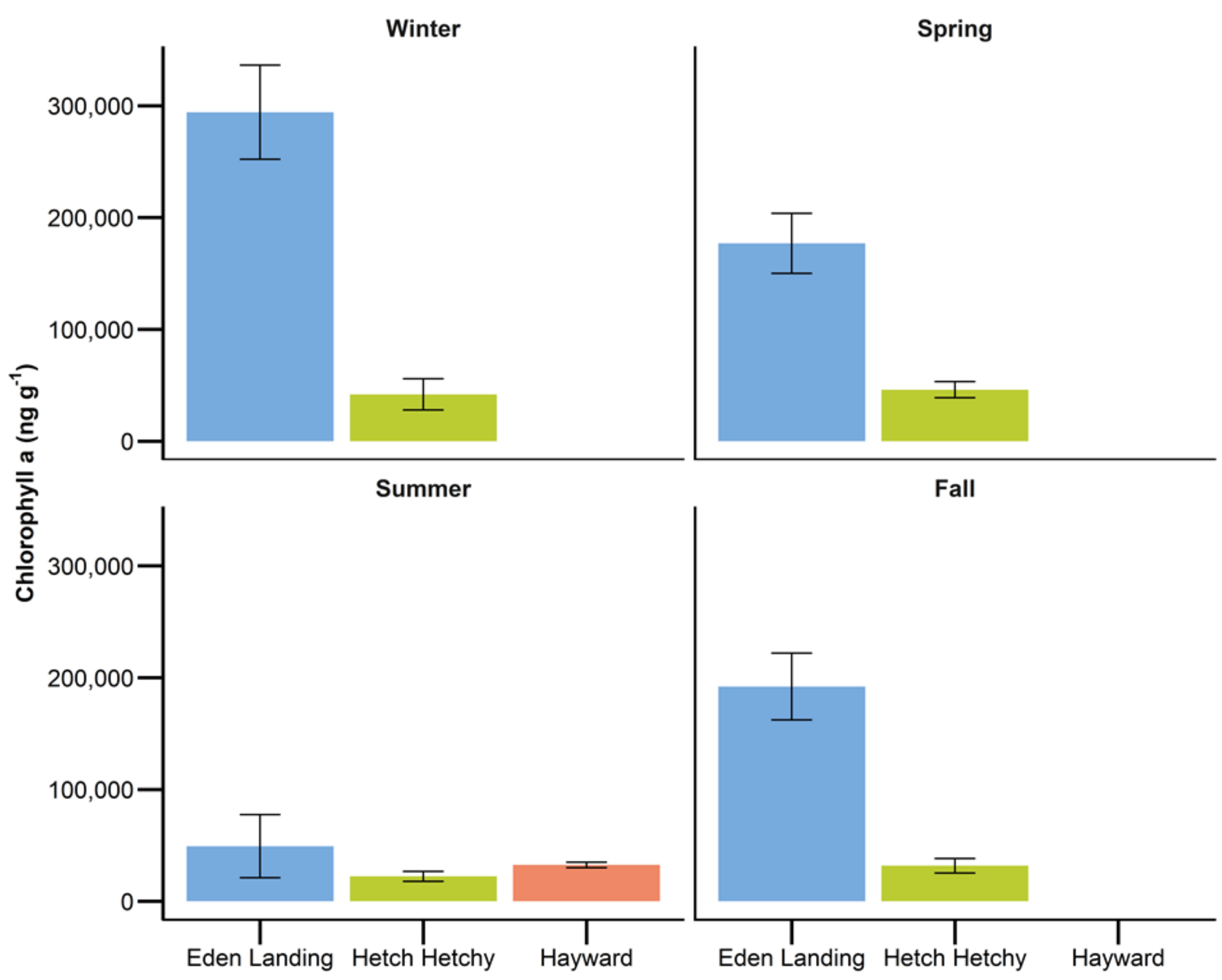
- relationships identified at the quadrat and plot scales used to develop remote sensing algorithms for multispectral satellite imagery



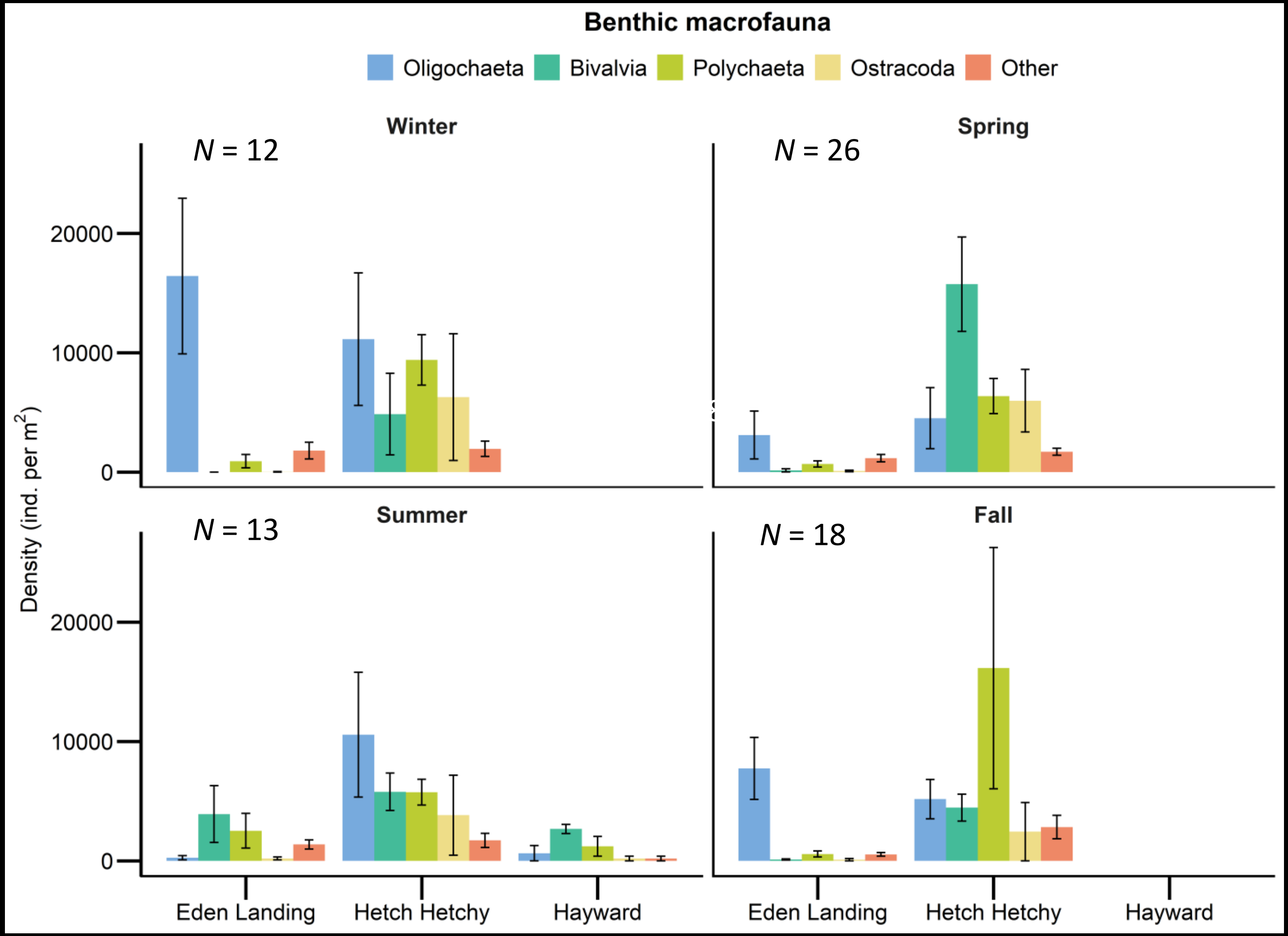
Ecological processes on intertidal mudflats act at very small (mm to cm) to large (tens of km) spatial scales to influence biofilm distribution, quantity and quality therefore, it is important to develop appropriate methods that capture and integrate the range of these processes

Biofilm biomass higher in breached pond compared to bay mudflat





Total invertebrate density was higher at bay mudflat compared to breached pond site



Winter	Feb-Mar
Spring	Apr-May
Summer	Jun-Jul
Fall	Aug-Sep

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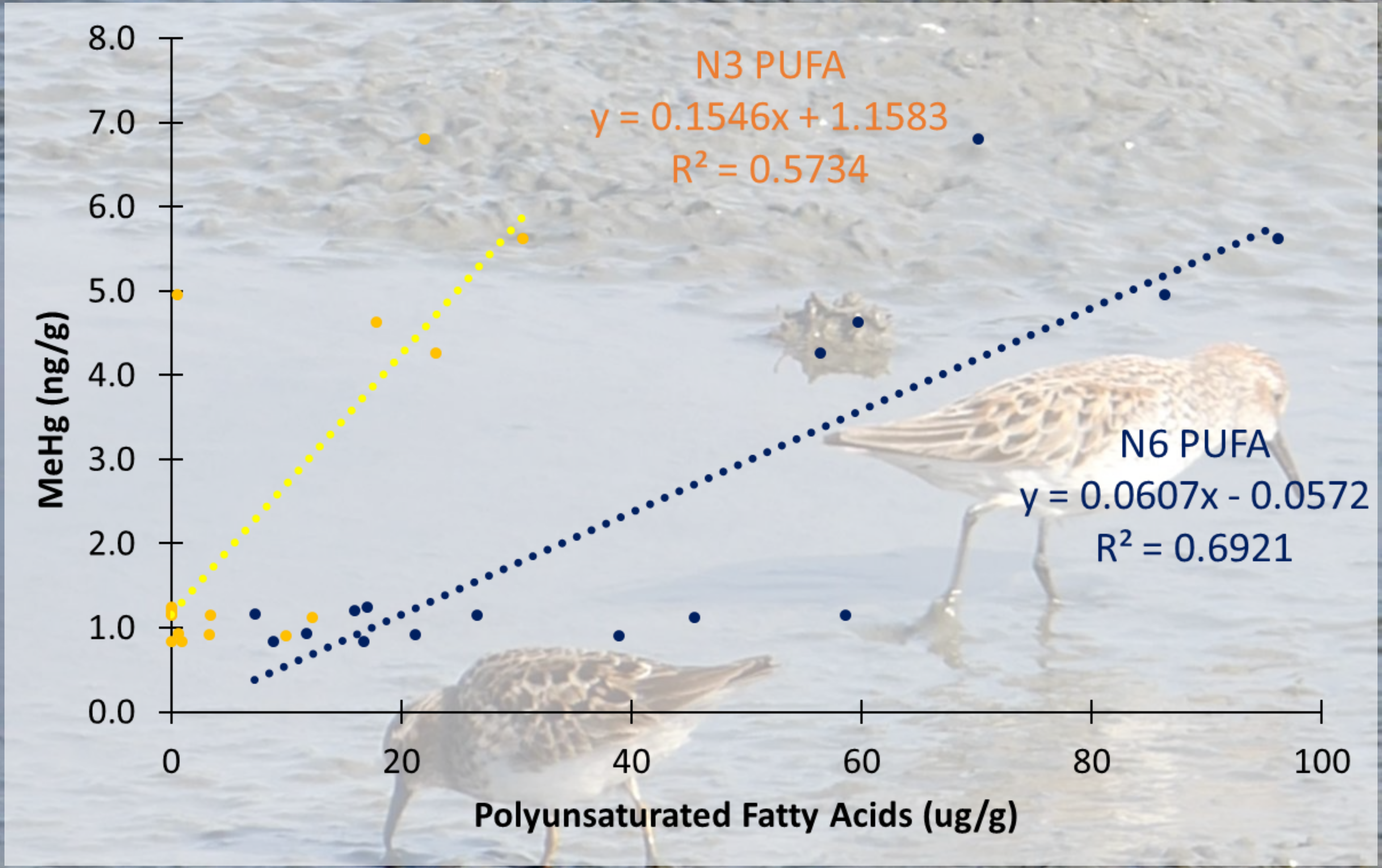
Mercury concentrations increased with fatty acids



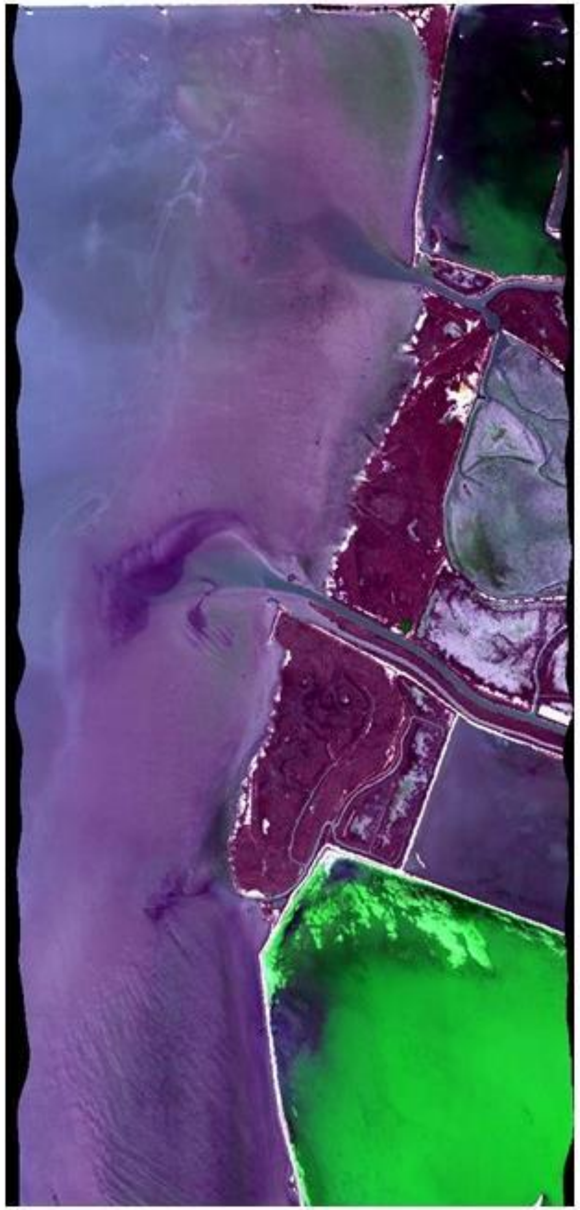
Mapping biofilm abundance, diversity, and nutritional quality

In progress:

Hyperspectral remote sensing algorithm for biodiversity of biofilm for South San Francisco Bay mudflats

Spatial variability analysis for mudflat biofilm - Sentinel - UAS – Ground sampling

Resonon Pika L VNIR UAS camera (4 cm)



AVIRIS-NG VNIR/SWIR (4 m)

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Next Steps

- Currently analyzing data to understand effects of various physical drivers across sites and seasons
- Mercury seasonal relationships with fatty acids, primary consumers and implications for shorebirds
- Remote sensing to map spatial distribution and nutritional quality so managers can visualize biofilm resources on the landscape
- Evaluate restoration and management regimes on biofilm production, carbon storage and co-benefits for avian and fish food webs
  - Collaborate with efforts to measure carbon flux at Eden Landing….?

Thank you!

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