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Recovery of Ecological Function of Salt Marsh Fauna Following Habitat Restoration *Implications for Restoration Scaling in the Northern Gulf of Mexico*

Restore America's Estuaries Summit 2016
New Orleans, Louisiana
December 10-15, 2016

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Objective

Improve understanding of the development of salt marsh function following habitat restoration or creation in the Northern Gulf of Mexico

Analytical Approach

Use meta-analysis to investigate the temporal recovery of two marsh resident invertebrates developed from a literature review:

1. Periwinkle snail (*Littorina irrorata*)
2. Broad grouping of amphipod crustaceans (Amphipoda)

Ecological Importance of Marsh Grazers

Marsh Periwinkle



NOAA Photo Library

- Small, epifaunal and conspicuous
- Long-lived (<10 years) and multiple life-stages

Gammarid Amphipod



http://www.usgs.gov/newsroom/images/2013_04_01/gammarus.jpg

- Small and inconspicuous
- Short-lived (<1 year)
- Many different families inhabit GOM salt marshes

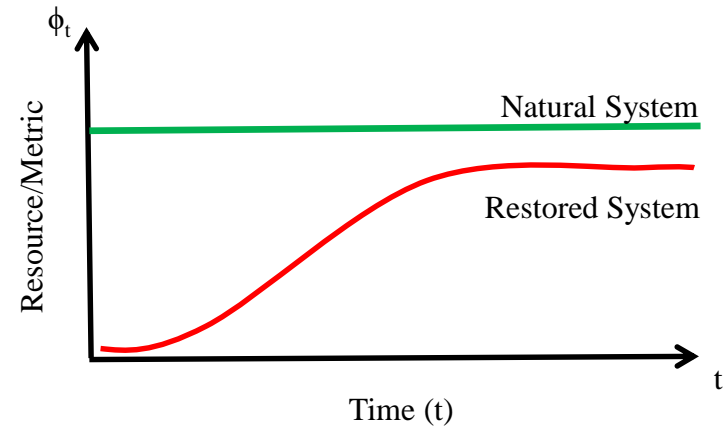
Ecological Roles

- Grazers of senescing organic matter and vegetation
- Facilitate nutrient cycling within the system
- Represent important prey items for larger species

Recovery Trajectory Framework

- Recovery trajectory describes repopulation through time
- Metric: *Response Ratio* of paired observations of fauna density (no./m²)

$$RR_i = \left(\frac{\text{Restored Mean} + 0.01}{\text{Reference Mean} + 0.01} \right)_i$$

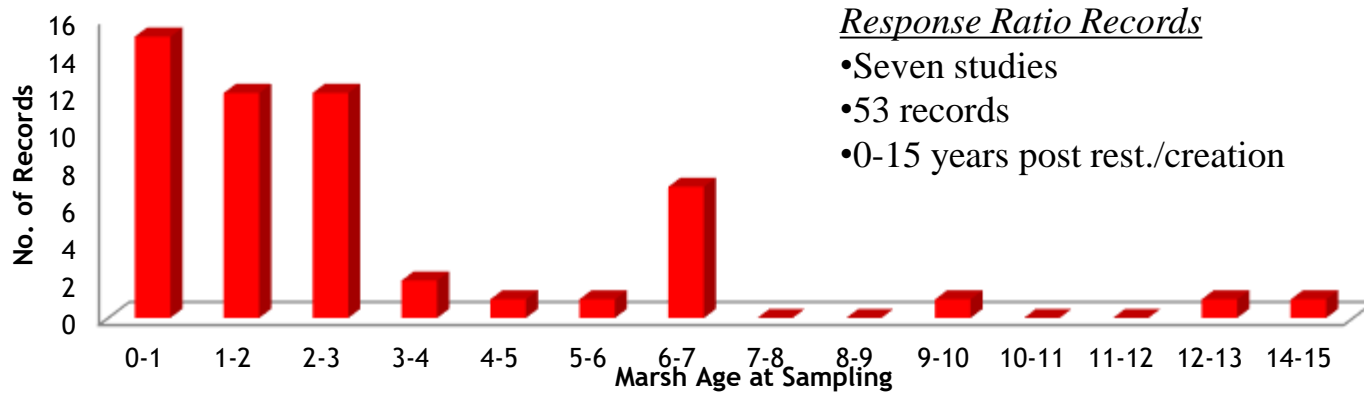


Literature Review

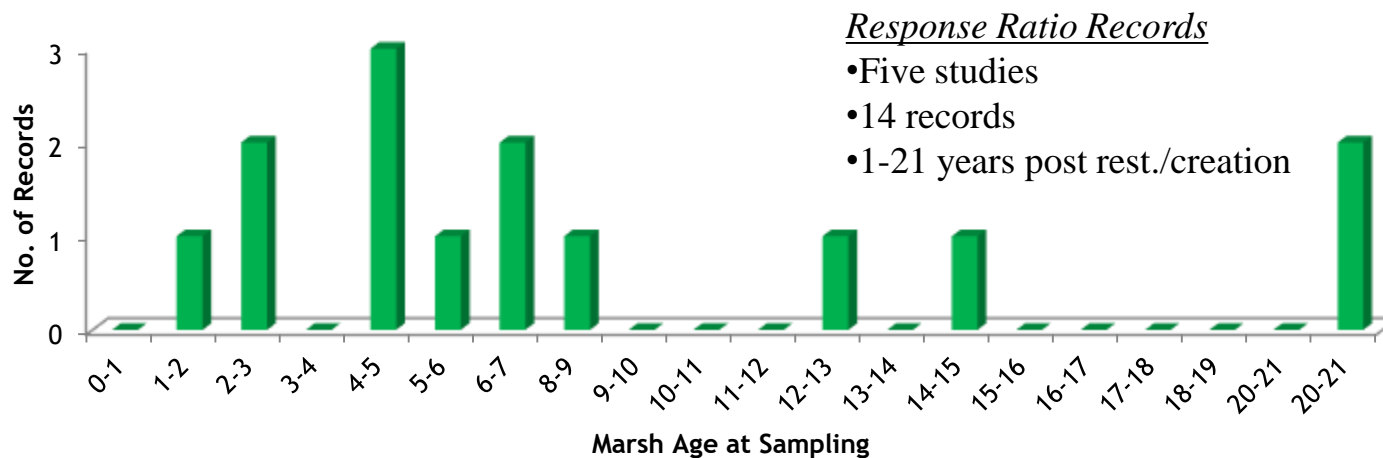
1. Report densities in restored or created marshes with corresponding reference values
 - Must have a defined age at sampling since restoration/creation
 - Located in U.S. Mid-Atlantic to GOM
2. Report densities in reference marshes
 - Periwinkles: Louisiana
 - Amphipods: Northern GOM

Literature Review Results - *Response Ratio* Data

Periwinkles



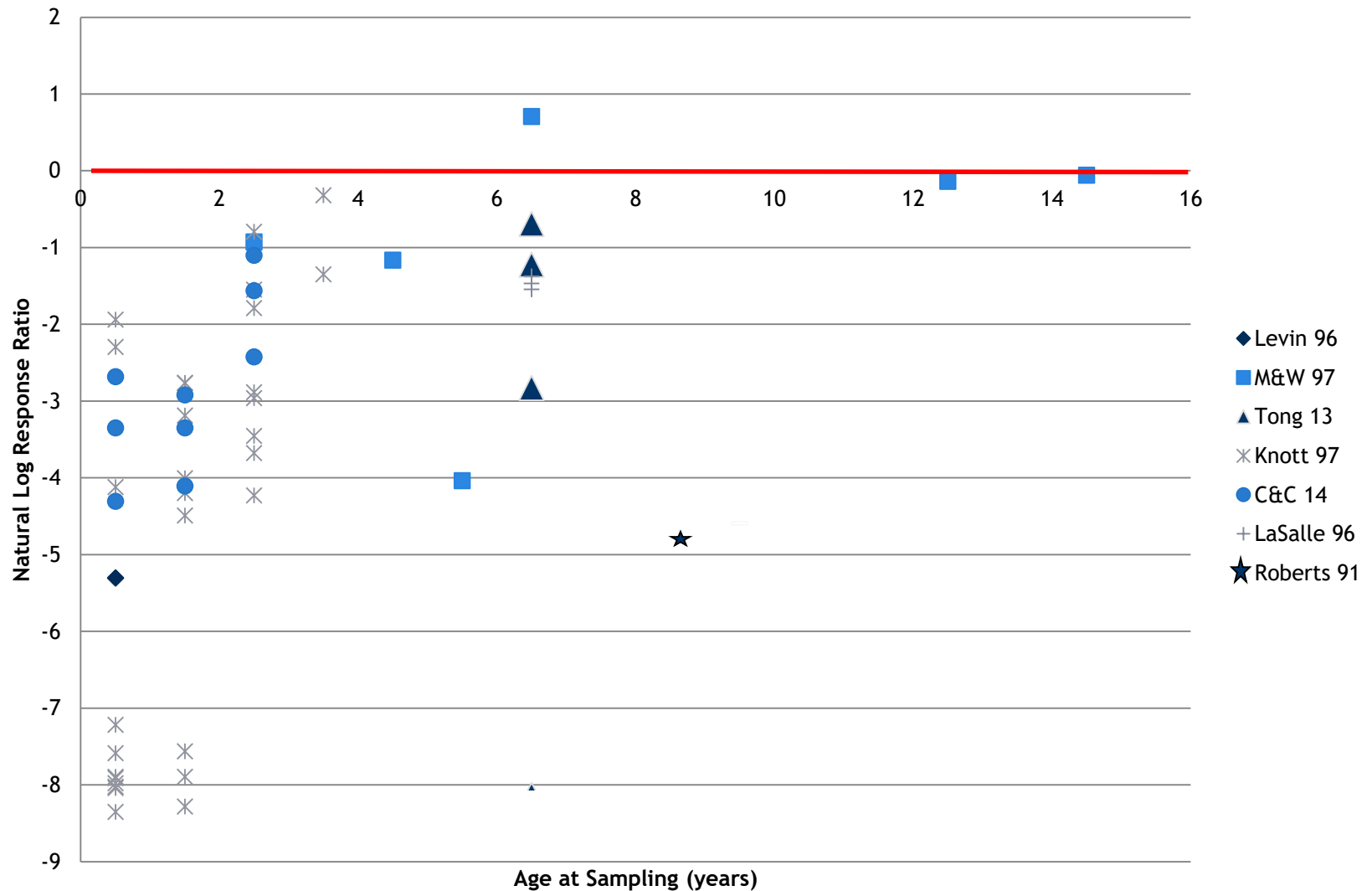
Amphipods



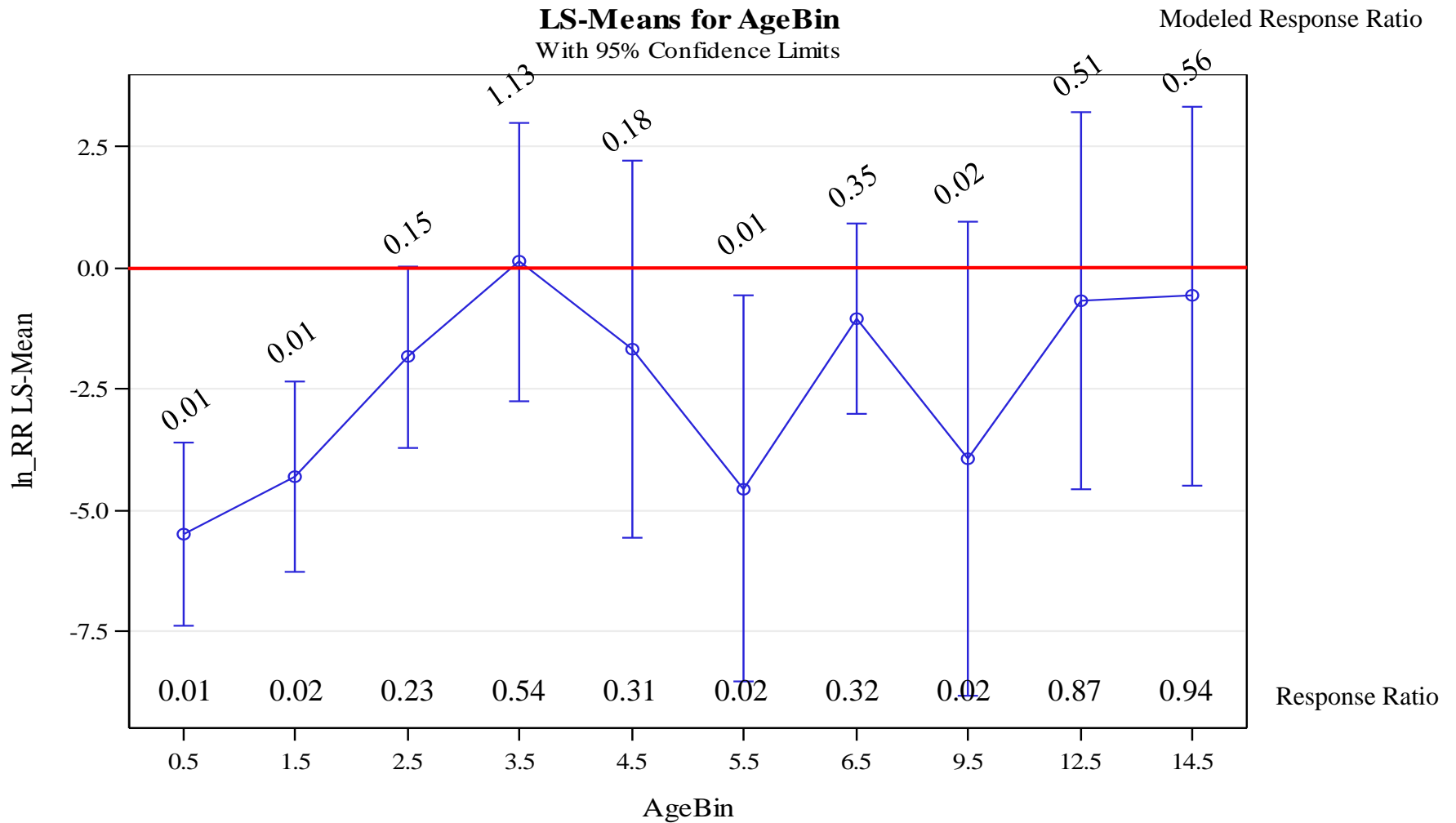
Recovery Trajectory - Meta-analysis of *Response Ratios*

- Aggregate information across multiple heterogeneous studies
 - Higher statistical power
- Analysis performed using a weighted random effects model
 - Natural log transform the *Response Ratio* data
 - Data binned by age at sampling (1 year bins)
 - Age category is a fixed effect
 - Analysis weighted by the inverse of *Response Ratio* variance
 - Justification:
 - Have an estimate of variance associated with most paired observations
 - Impute variance for few values missing uncertainty

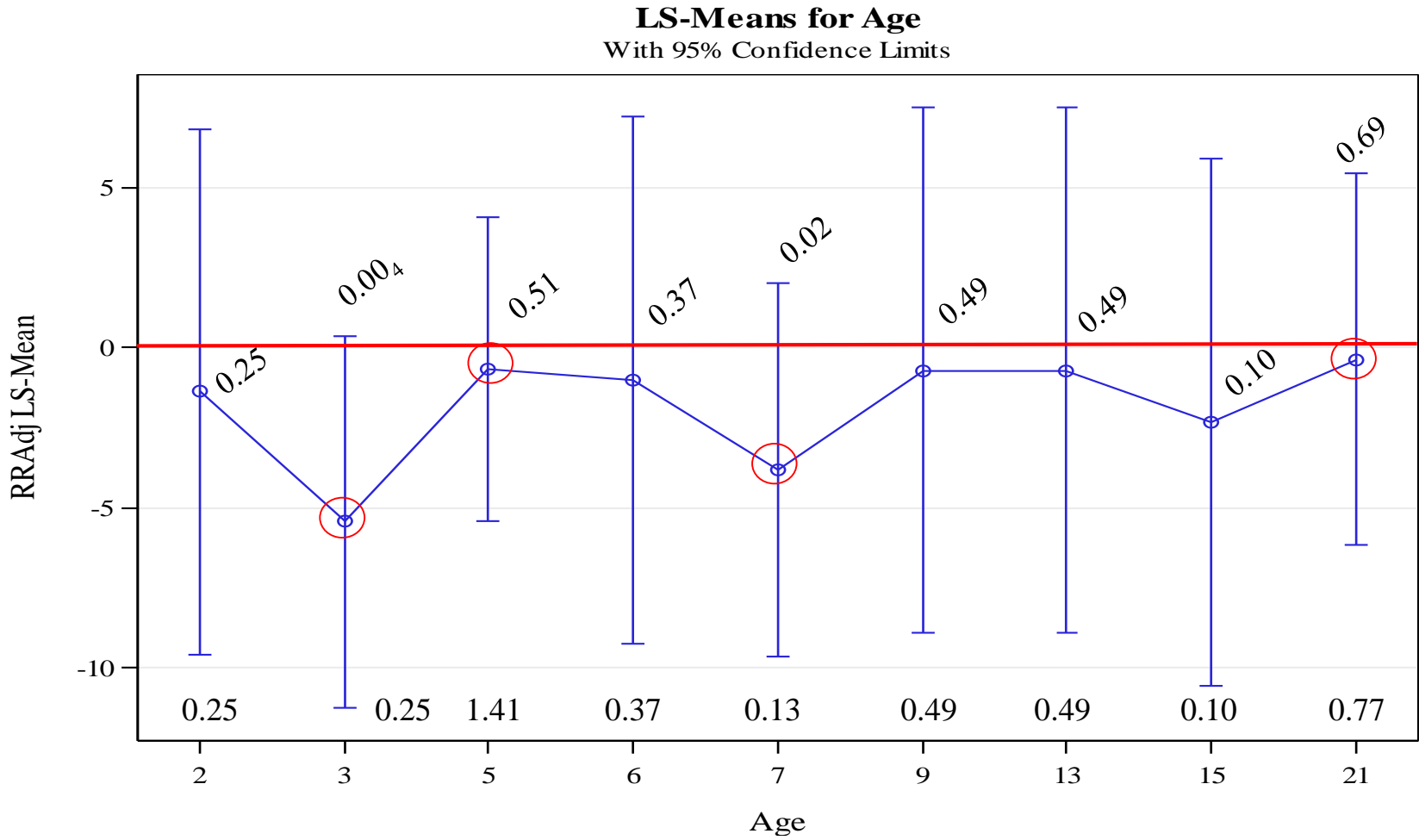
Periwinkles - Observed Data - Ln (Response Ratios)



Periwinkles - Weighted Random Effects Model



Amphipods - Weighted Random Effects Model



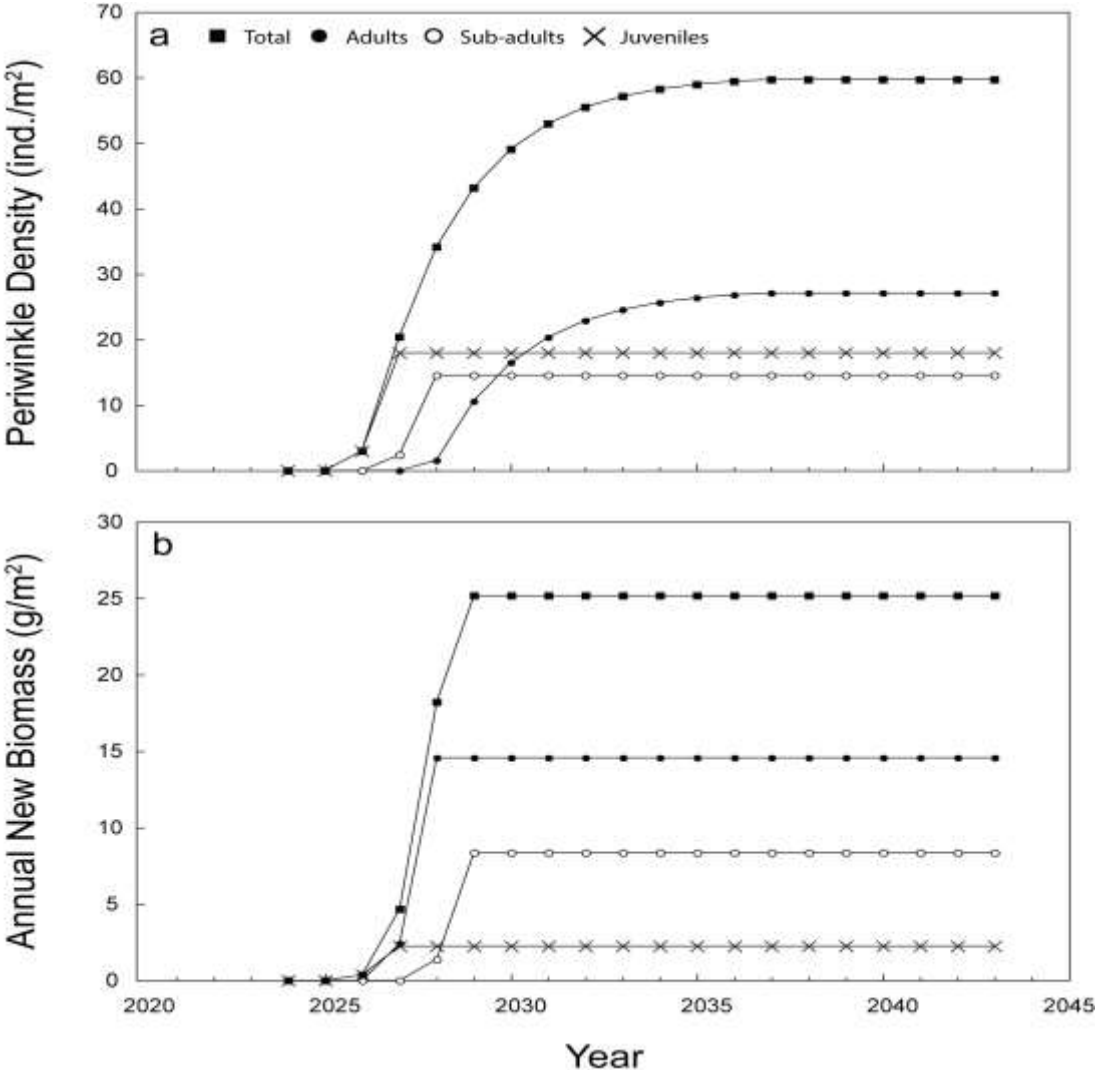
Recovery Trajectory Conclusions

- Periwinkles - Statistical recovery of restored/created sites with reference densities by years three or four
 - How long until potential steady-state population structure and biomass?
- Amphipods - Insufficient data to determine how amphipods recover following restoration using weighted random effects model
 - Possible solutions when faced with limited data:
 1. Remove age category as a fixed effect
 1. Lose progressive temporal recovery component
 2. Opt to use a simple weighted mean over the more complex weighted random effects model

Recovery of Periwinkle Total Biomass

- Most reported densities include the sub-adult and adult age classes (Zengel et al., 2015)
- Assumptions:
 - Recovery of restored sites to reference in year four
 - Biomass for each age class (von Bertalanffy):
 - Juveniles: 0.125g
 - Sub-adults: 1.125g
 - Adults 2.000g
 - Reference Density: 41 ± 34 sub-adult and adults m^{-2}
 - Population ratio of 1.9:1:1.2 (juvenile:sub-adult:adult)
 - Annual mortality rate of 0.422 (Hoenig, 1983)
- Use recovery trajectory, age class ratio, and mortality rate to back-calculate juvenile recruitment

Periwinkle Repopulation and Annual Biomass Addition



Conclusions

- Meta-analysis is a powerful tool to assimilate data from a range of studies
 - More data → higher statistical power
- Call for monitoring data beyond vegetation parameters in created or restored salt marshes
- Data can be used in a restoration scaling application
 - REA in a natural resource damage assessment
 - Gail Fricano's presentation



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Questions?

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