



## **Measuring the cumulative and additive effects of colonial waterbird predation on steelhead survival in the Columbia River Basin**

# Acknowledgments

**Authors:** Quinn Payton\*, Allen Evans, Nathan Hostetter, Brad Cramer, Ken Collis, and Dan Roby

**Funding:** Bonneville Power Administration (G. Smith, L. Sullivan)  
Priest Rapids Coordinating Committee (C. Dotson)

**Cooperators:** Corps (D. Trachtenbarg, J. Macdonald, C. Studebaker)



Bureau of Reclamation (M. Lesky, M. Mumma)

USF (L. Glass, M. McDowell)

NOAA (L. Krasnow, B. Bellerud, R. Graves),

WDFW (R. Finger, M. Monda, A. Victory)



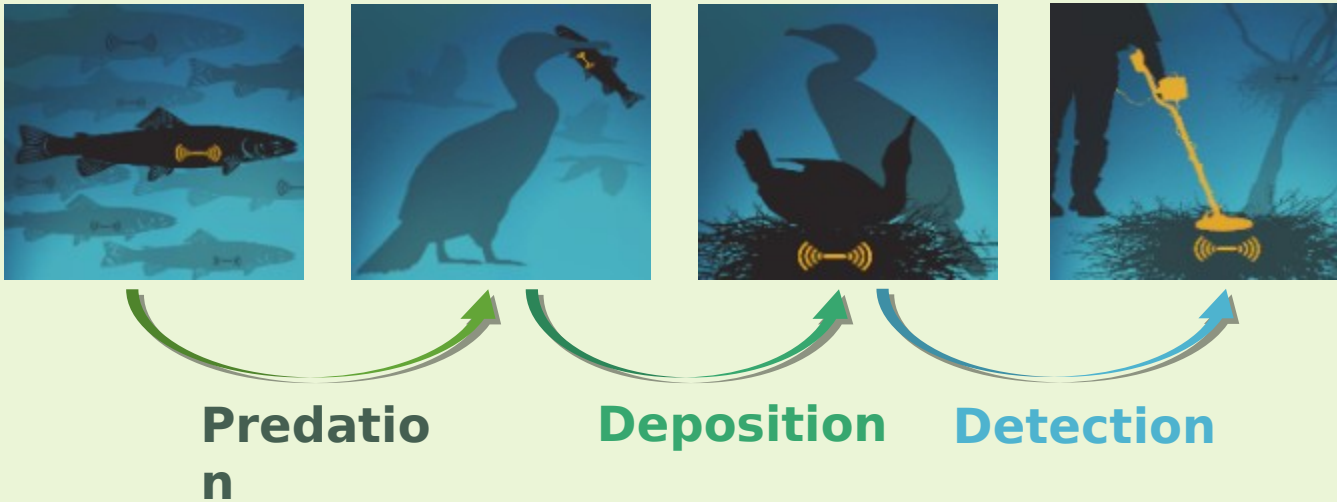
# Background -- the region

- Avian predation research in the Columbia Basin began over 20 years ago
- Colonies of piscivorous waterbirds are widespread throughout
- Nesting season largely overlaps with the smolt out-migration period
- 3 primary genera of avian predator of concern



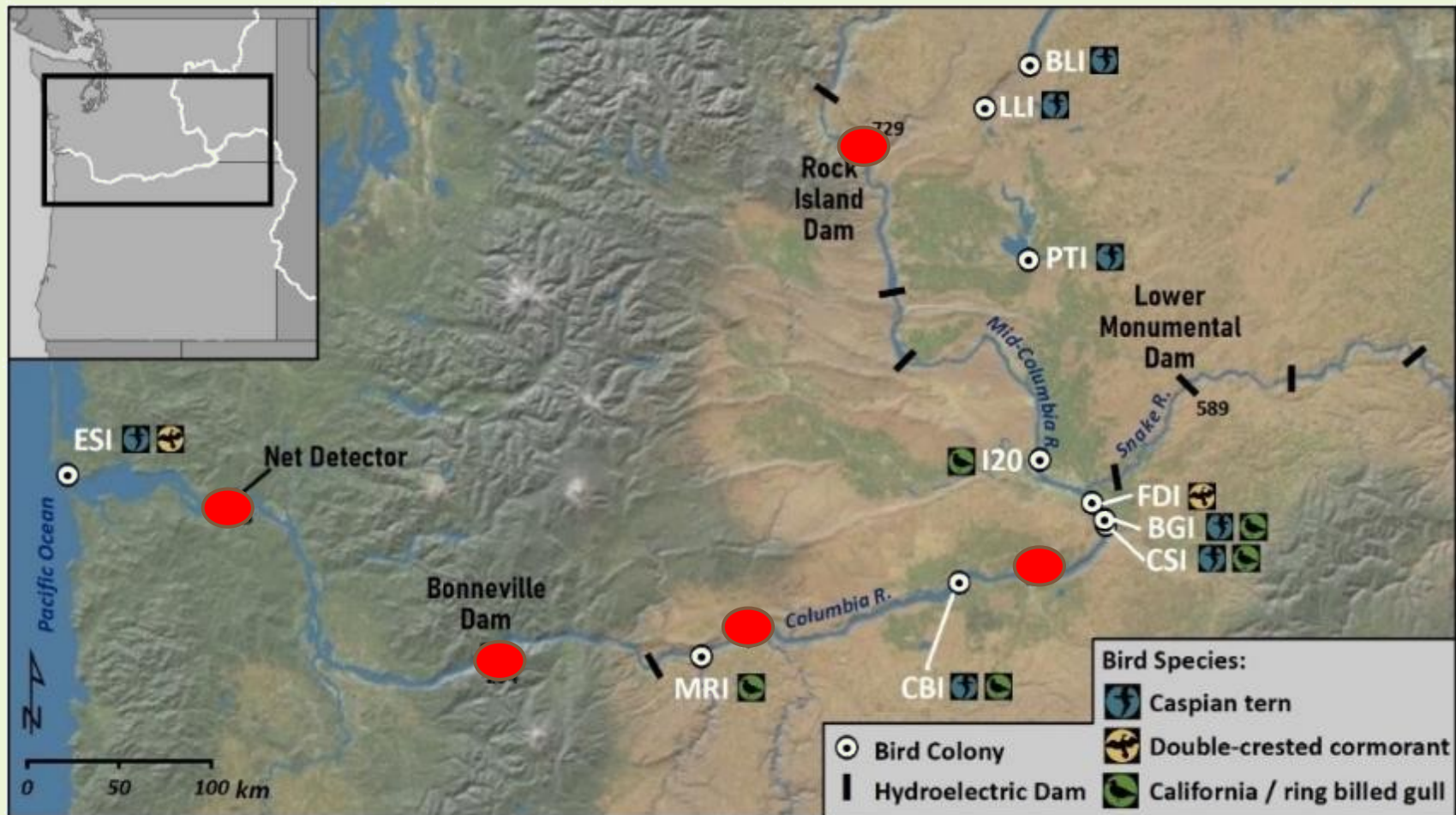
# Background -- the models

- Predation probability model
  - Estimation of uses recovered tags from bird colonies
  - Not all consumed tags are “deposited” on the colony
  - Not all deposited tags are recovered by researchers



# Background -- the models

- Joint Mortality and Survival model
  - Aggregate and accumulate predation across colonies
  - Use tag interrogations at dams to jointly inform survival



# Background -- the models

- Compensatory/Additive mortality model (Payton et al. 2020)
  - Do birds eat fish “fit” enough to survive to outmigration or even to adulthood?
  - What proportion of consumed fish would have survived in the absence of avian predation?



# Payton et al. (2020) -- the fish

- In 2008, we began tagging and releasing steelhead from Rock Island Dam
  - ~7,000 steelhead selected at random regardless of size, rear-type, or condition and tagged in proportion with the run at-large (9-to-12-weeks/yr)
- Rock Island Dam was chosen due to its location relative to avian predators



# Payton et al. (2020) - Spatial/temporal scale

Smolt outmigration -- Rock Island Dam to Bonneville Dam

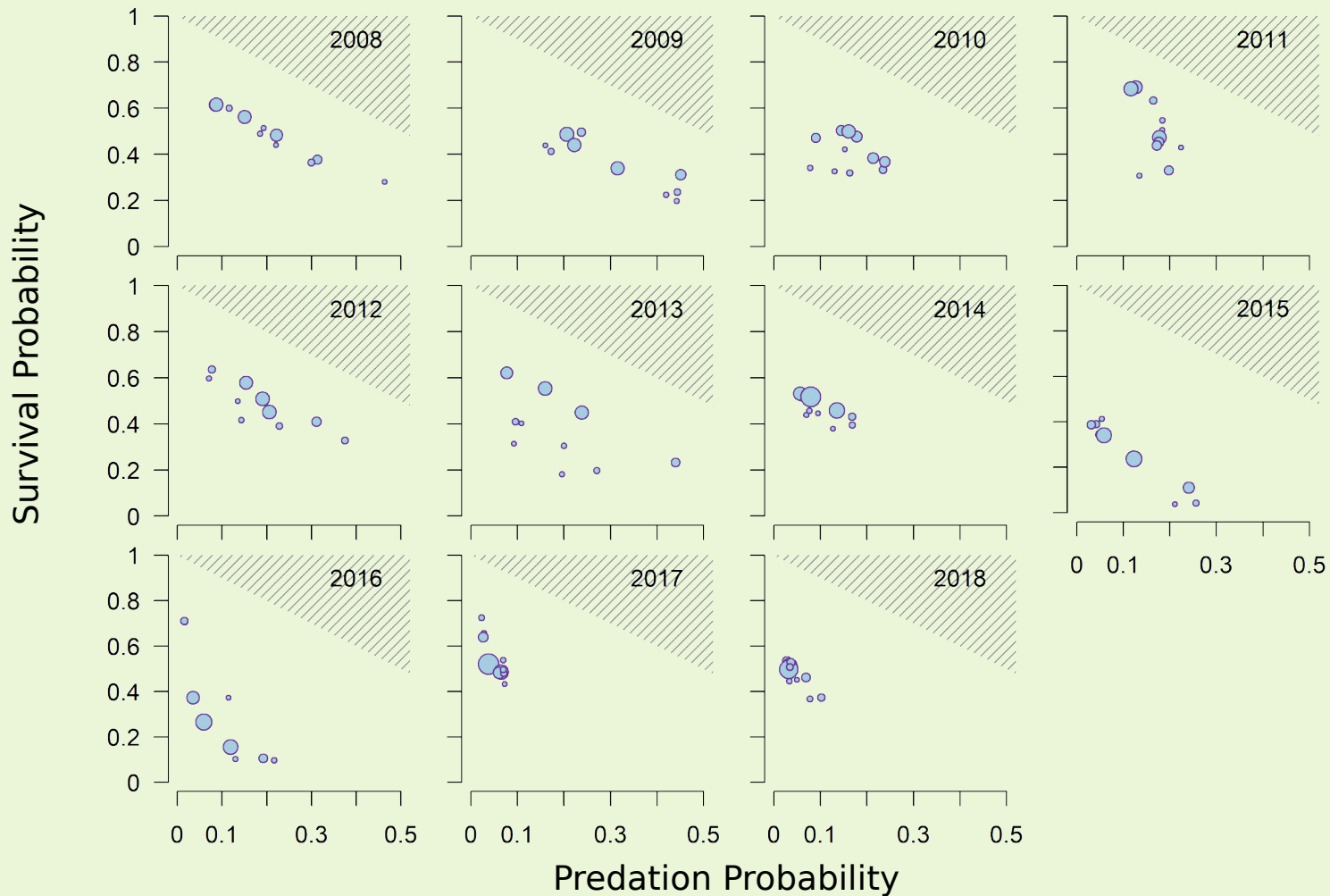
- Significant impacts by all avian predators
- We focus on predation by Caspian terns





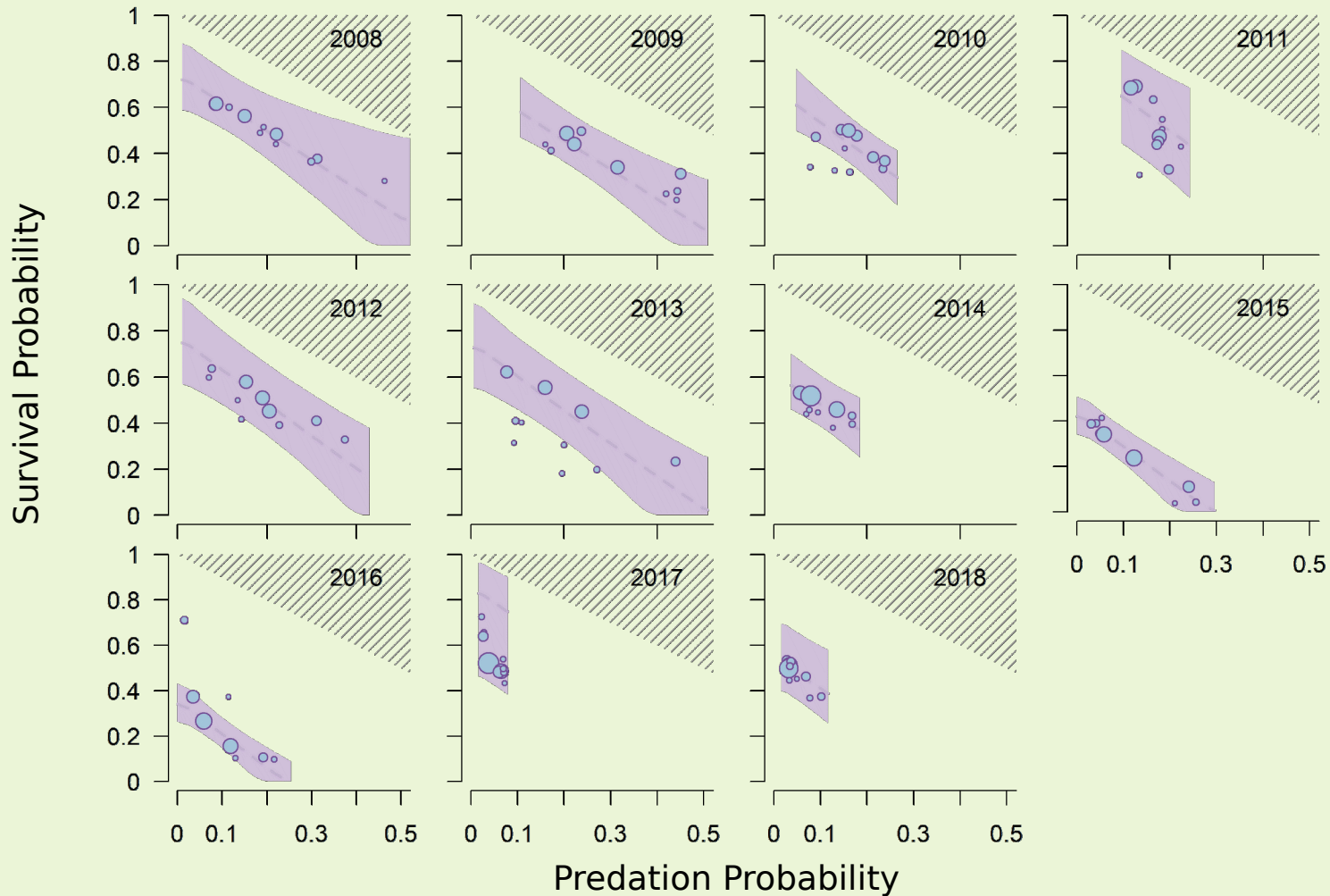
# Survival

Joint Weekly Estimates of  $p(\text{UCR Steelhead Survival})$  and  $p(\text{Tern Predation})$   
--Rock Island Dam to Bonneville Dam (2008-2018)--



# Survival

Joint Weekly Estimates of  $p(\text{UCR Steelhead Survival})$  and  $p(\text{Tern Predation})$   
--Rock Island Dam to Bonneville Dam (2008-2018)--

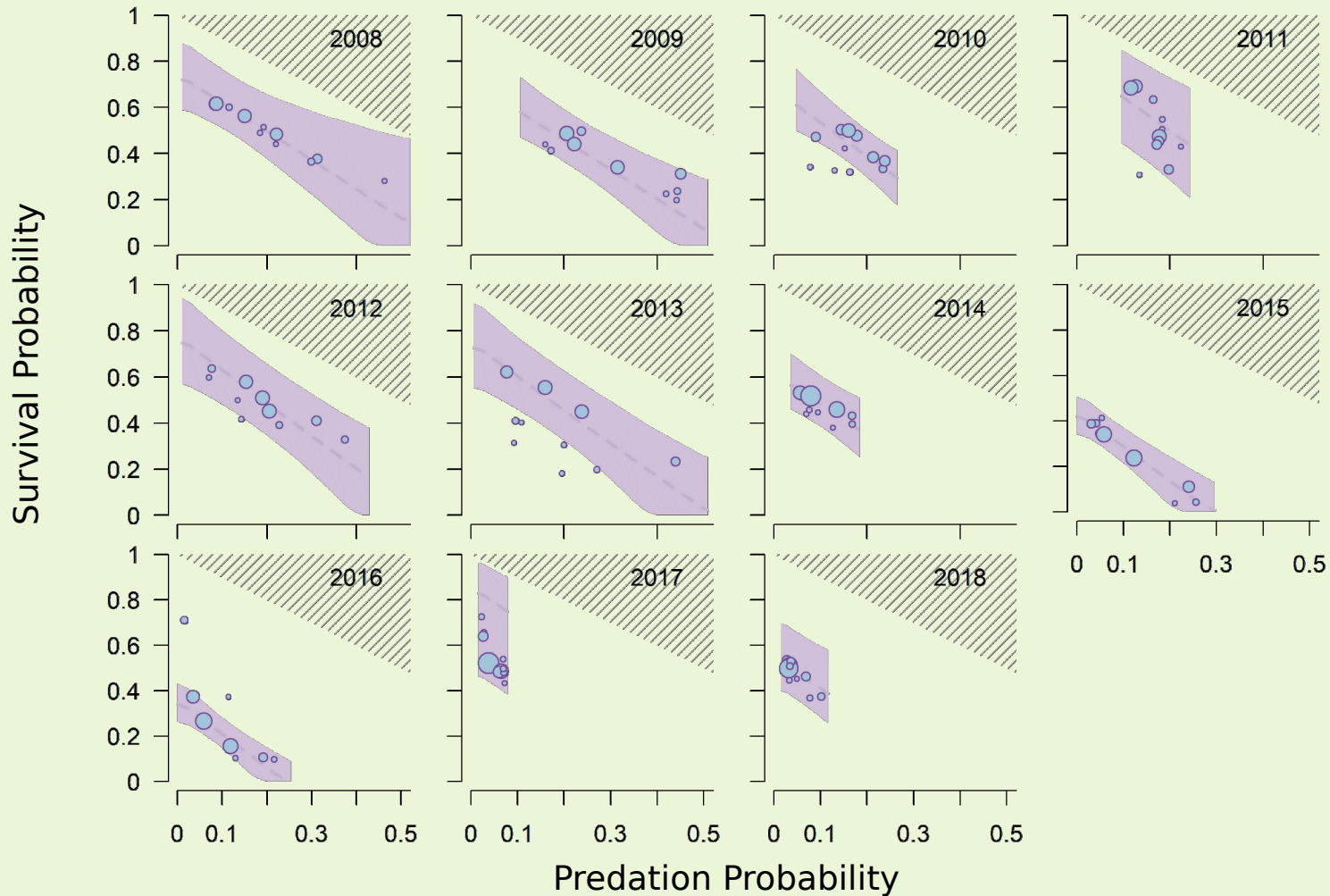


# Super Additive Impacts?

- Across all years,
  - Super-additivity
  - Implies that for every 10 steelhead that terns **consume**, 14 don't make it to Bonneville that would have otherwise
- We must infer that the full impact of tern predation isn't being measured: i.e. more steelhead are dying due to terns than just those being consumed
  - Kleptoparasitism (Adkins et al., 2011)
  - Crippling Loss (Reimchen 1988, Williams et al. 2002, Servanty et al. 2010)
  - Predation by transient birds
- How can we make a more meaningful statement about the impact of tern predation?

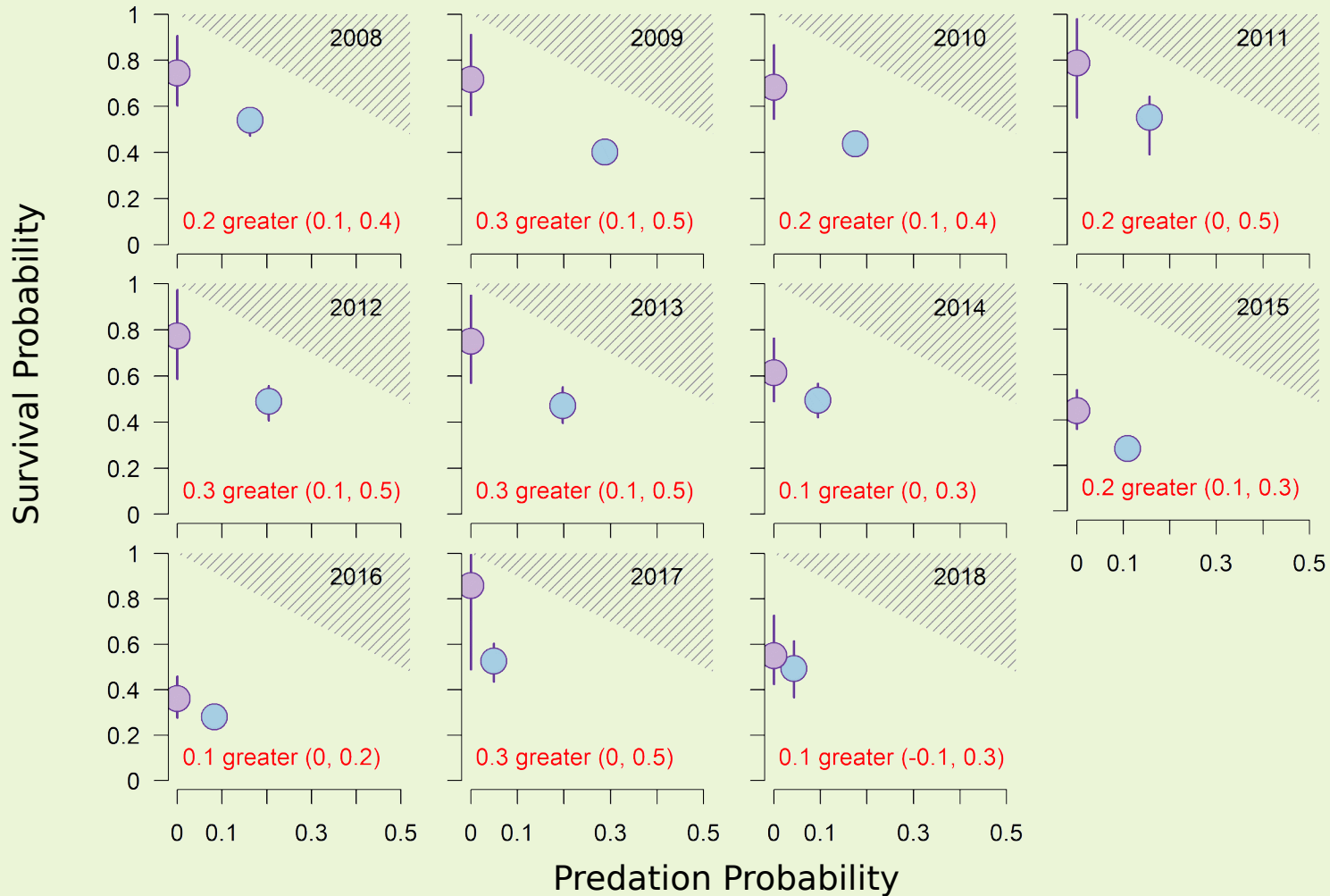
# Survival

Joint Weekly Estimates of  $p(\text{UCR Steelhead Survival})$  and  $p(\text{Tern Predation})$   
--Rock Island Dam to Bonneville Dam (2008-2018)--



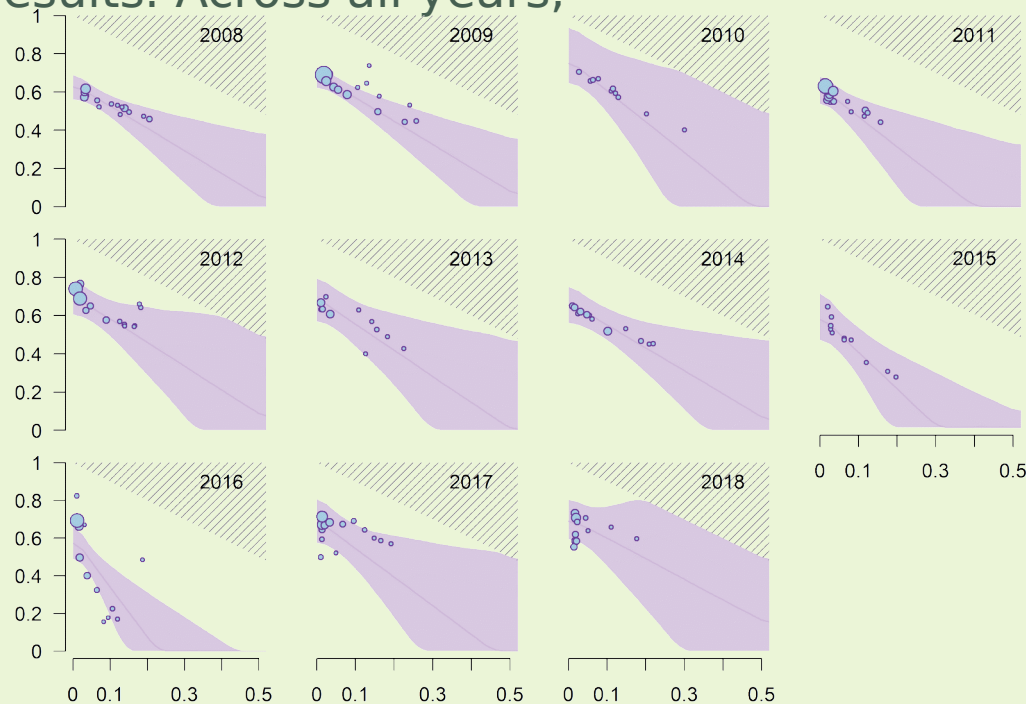
# Survival

Joint Weekly Estimates of  $p(\text{UCR Steelhead Survival})$  and  $p(\text{Tern Predation})$   
--Rock Island Dam to Bonneville Dam (2008-2018)--



# Super Additive Impacts

- This analysis has since been repeated with another group of steelhead
  - We assessed the impact of predation by Caspian terns on Snake River Steelhead
  - Smolt outmigration from Lower Monumental Dam to Bonneville Dam
  - Similar results. Across all years,



# Payton et al. (2020) - Spatial/temporal scale

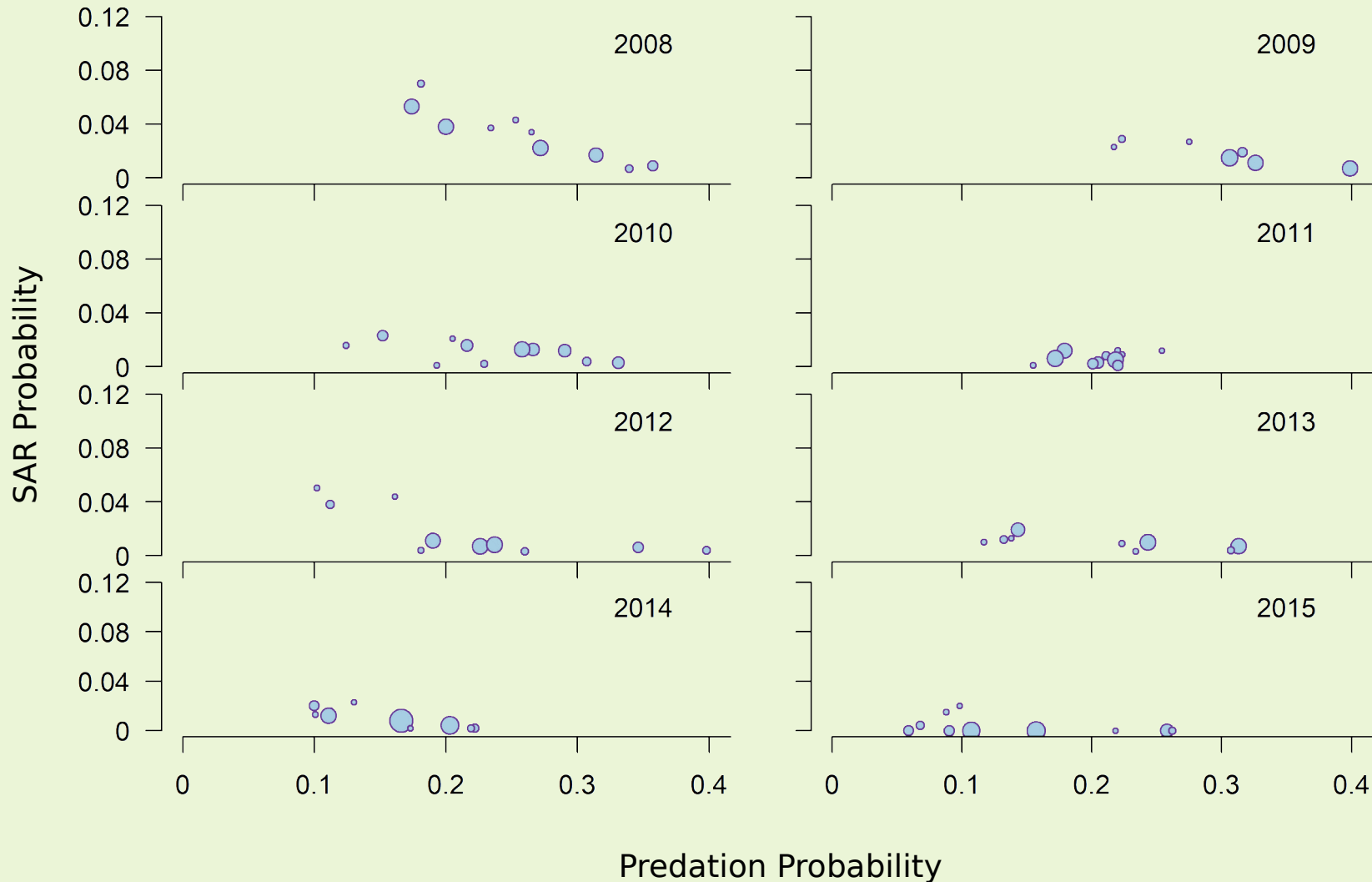
Smolt to adult return -- Rock Island Dam to adult return at Bonneville

- Larger predation impacts
- Greater uncertainty and mortality impacts from other sources



# Survival

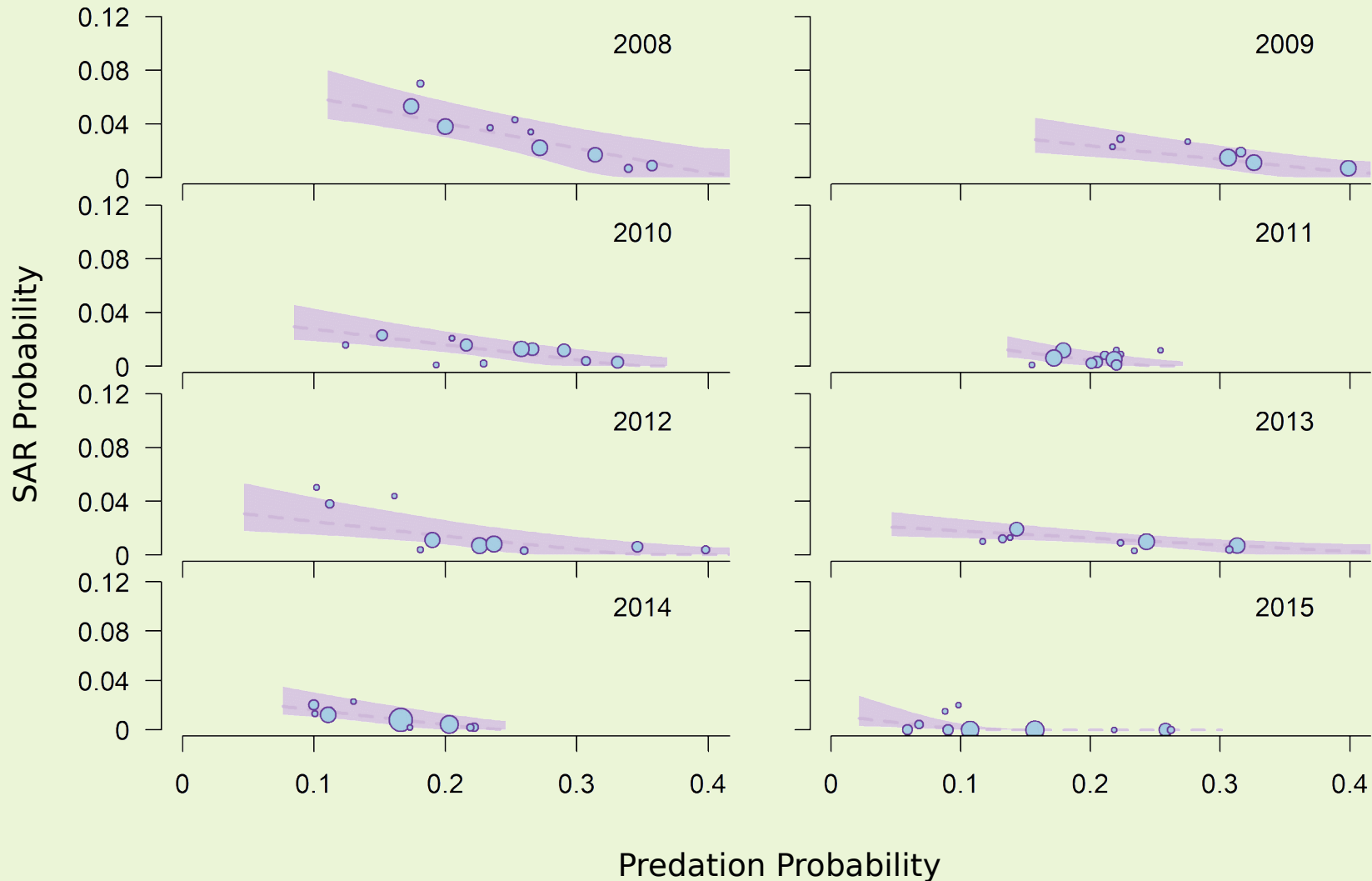
Joint Weekly Estimates of  $p(\text{UCR Steelhead Survival})$  and  $p(\text{Tern Predation})$   
--Rock Island Dam to adult return Bonneville Dam (2008-2015)--





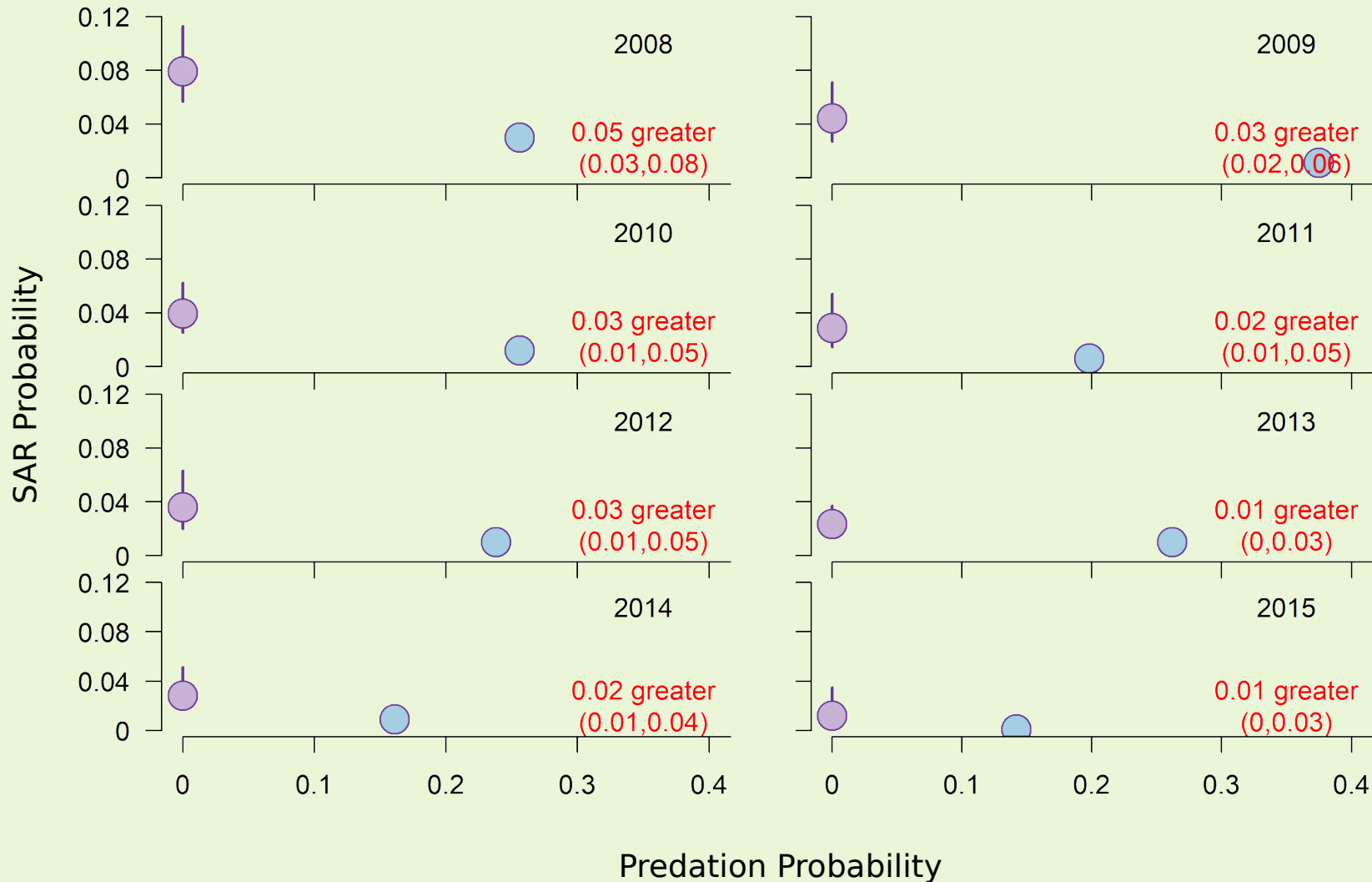
# Survival

Joint Weekly Estimates of  $p(\text{UCR Steelhead Survival})$  and  $p(\text{Tern Predation})$   
--Rock Island Dam to adult return Bonneville Dam (2008-2015)--



# Survival

Joint Weekly Estimates of p(UCR Steelhead Survival) and p(Tern Predation)  
--Rock Island Dam to adult return Bonneville Dam (2008-2015)--



# Results

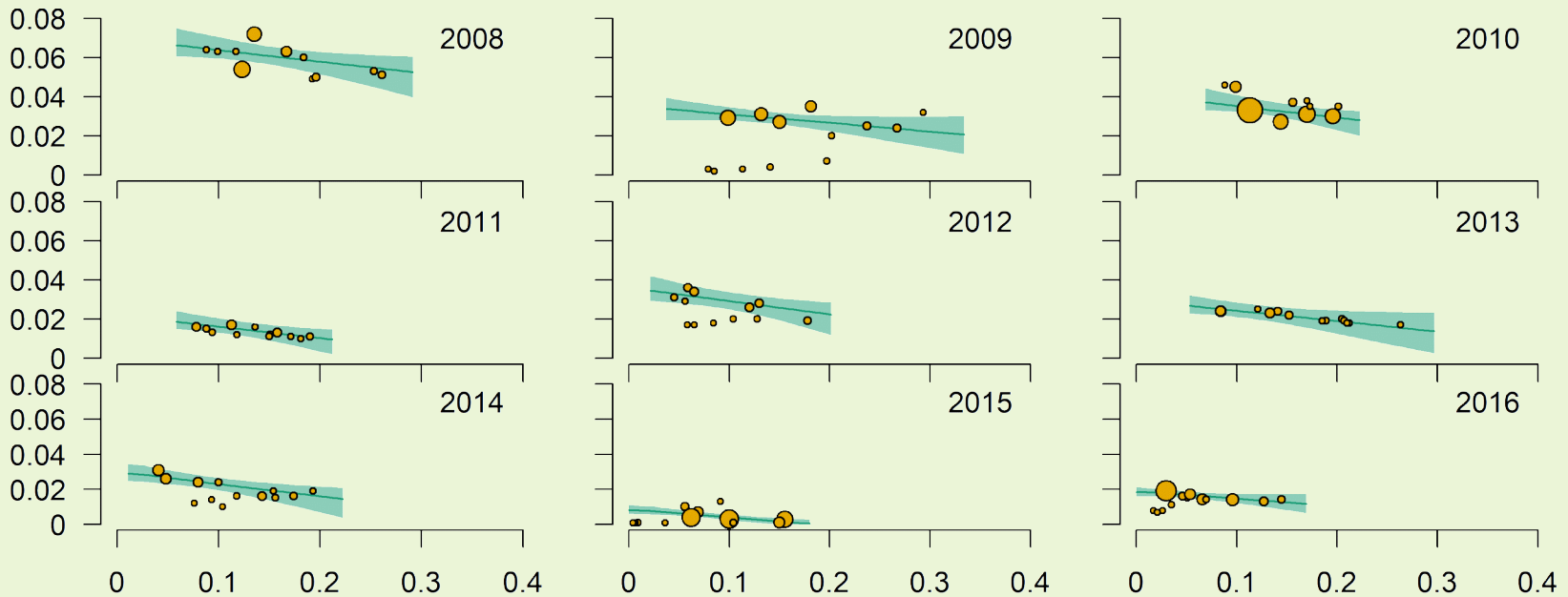
- Tern predation was largely compensatory over this time/spatial scale
  - Consistently estimated baseline survival probabilities greater than observed survival probabilities
  - Years of lower SAR probabilities and lower predation probabilities were associated smaller estimates of difference in baseline vs observed survival
- Most steelhead die somewhere/somehow in the ocean
  - A great deal of noise in which to find a signal
  - All sources of mortality are “compensatory” over a long enough time frame (*almost every living thing eventually dies “otherwise”*)



# Results

- This analysis has since been repeated with Snake River Steelhead
  - Bonneville as smolts to adult return at Bonneville
  - Greater survival rates but smaller predation rates (one single colony)

Joint Weekly Estimates of  
 $p(\text{Snake River Steelhead SAR})$  and  $p(\text{Tern Predation})$   
-- Bonneville Dam to Bonneville Dam as Adults--



# Summary

- We found evidence that Caspian tern predation was largely an additive source of mortality for steelhead smolts upstream of Bonneville Dam
- We found evidence that Caspian tern predation was a largely, but not completely, compensatory source of mortality for steelhead smolts to adult returns
- These results are very specific to Caspian tern predation on steelhead smolts
  - Other predator impacts have proven more difficult to measure
    - The ocean creates a lot of noise to signal ratio
    - Cormorant impacts can be great but more variable
    - We know gull impacts are compensatory to some extent

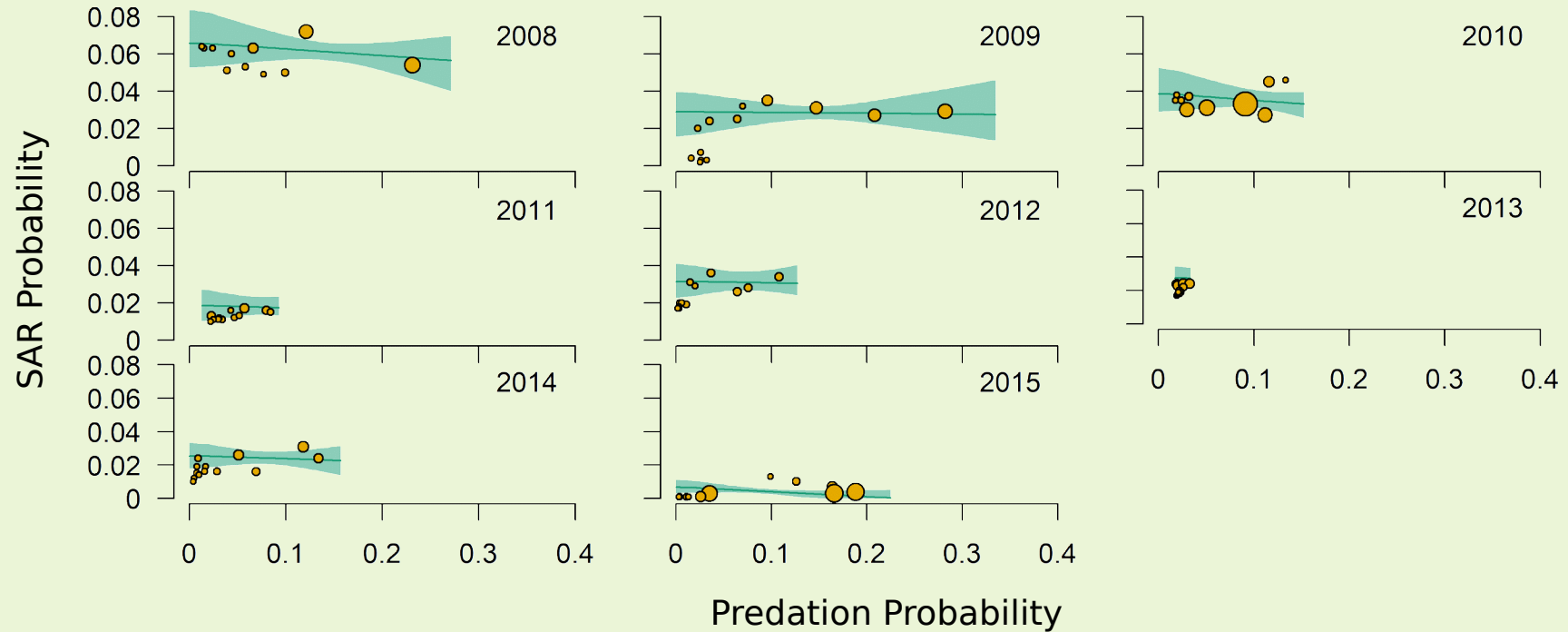
**Questions?**



# Discussion

Largely but not Completely Compensatory  
(SAR - Bonneville Dam to Return at Bonneville Dam--)

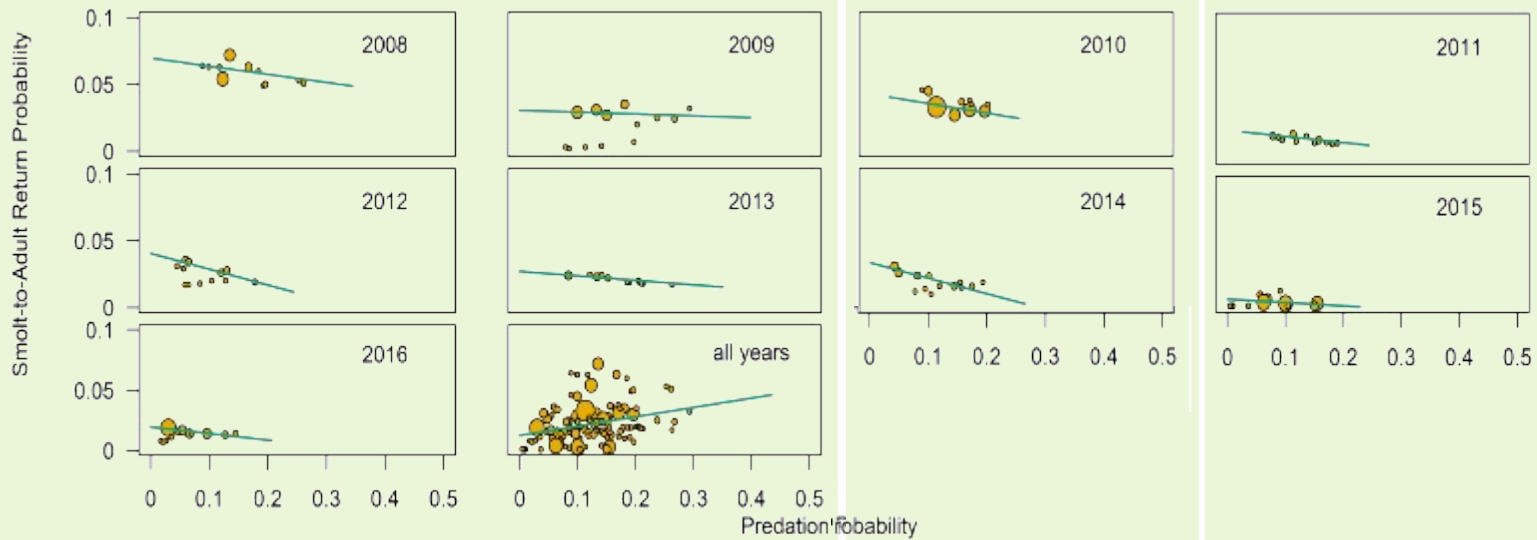
Joint Weekly Estimates of  
 $p(\text{Snake River Steelhead SAR})$  and  $p(\text{Cormorant Predation})$   
-- Bonneville Dam to Bonneville Dam as Adults--



# Discussion

Largely but not Completely Compensatory

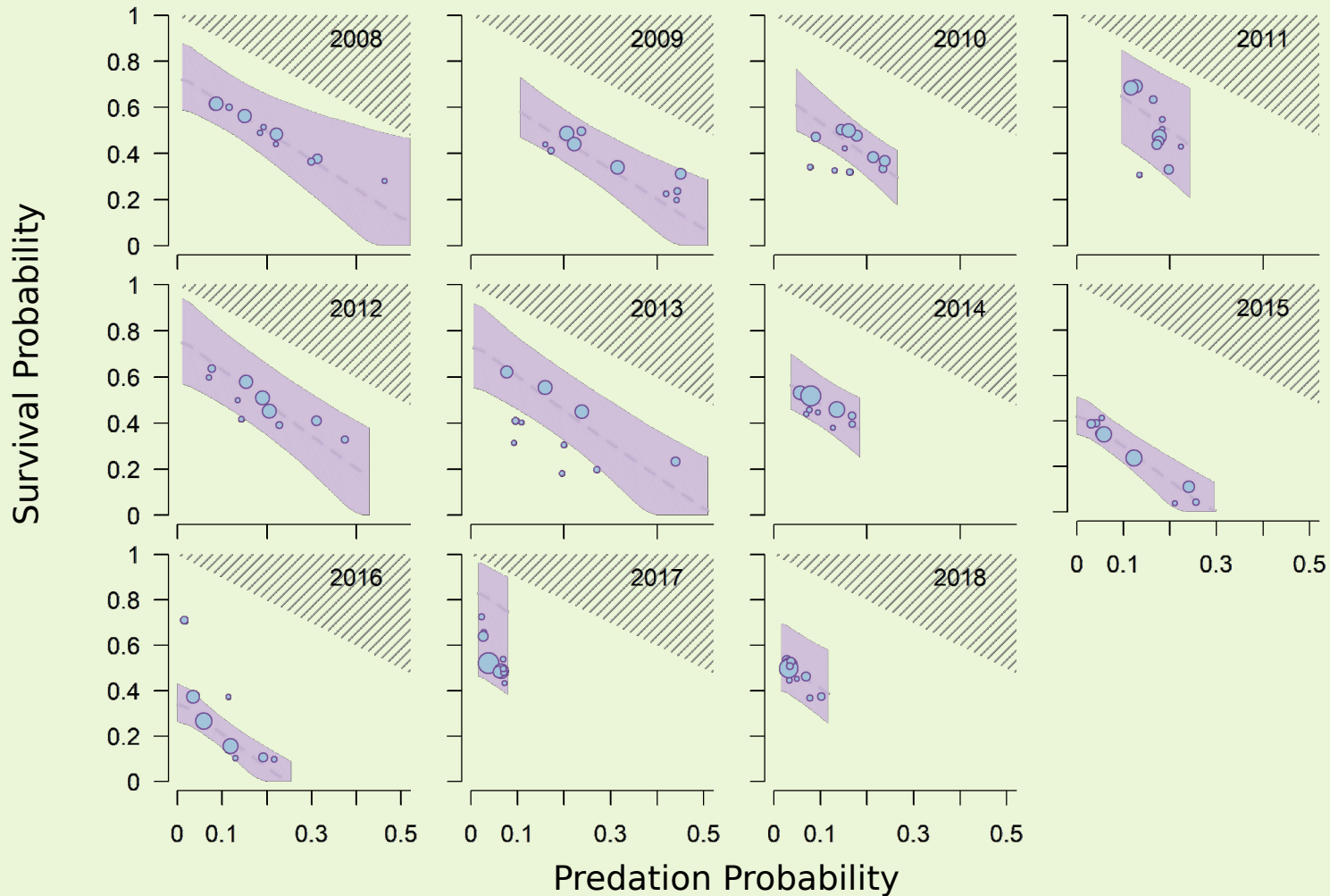
(SAR -Bonneville Dam to Return at Bonneville Dam--)





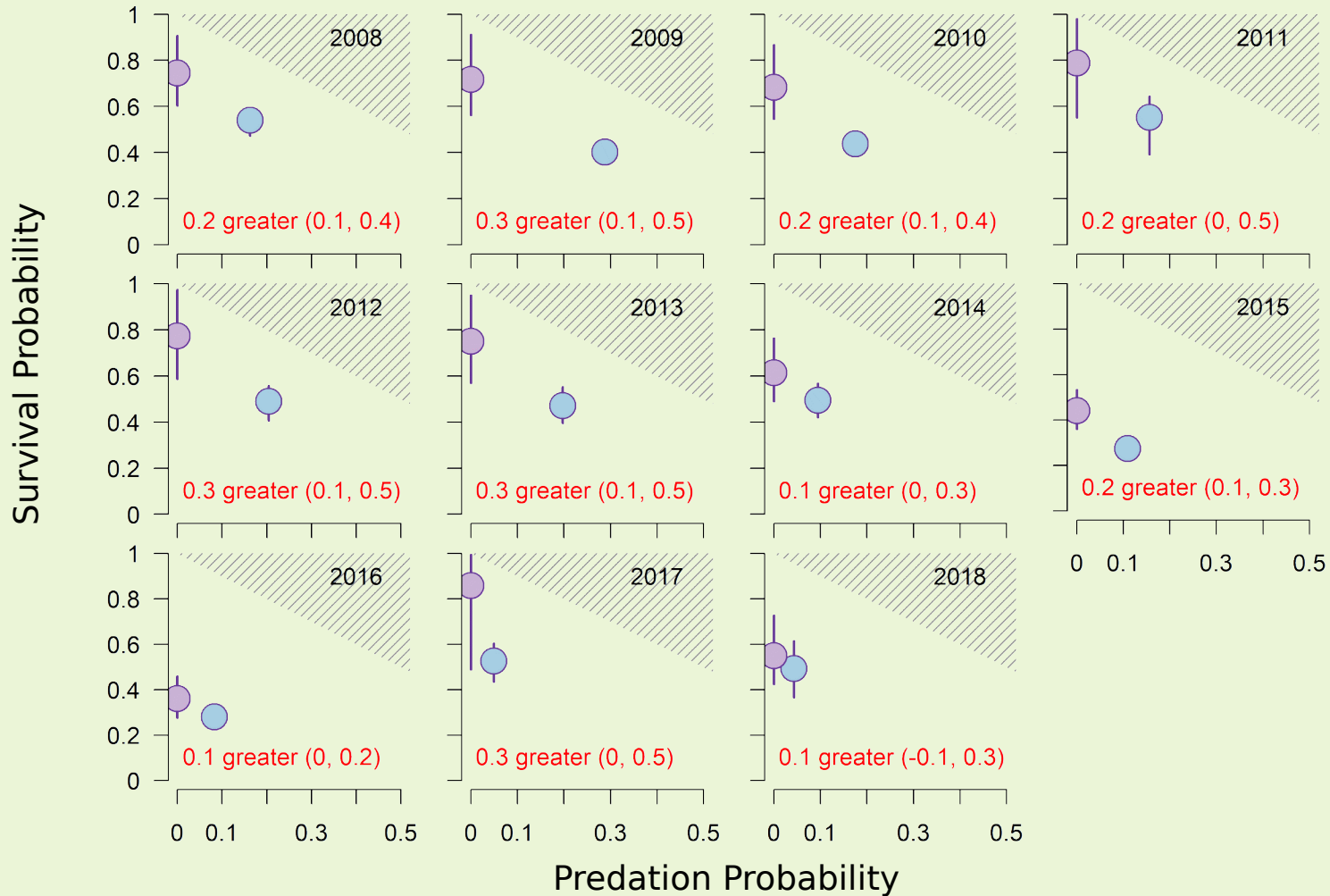
# Survival

Joint Weekly Estimates of  $p(\text{UCR Steelhead Survival})$  and  $p(\text{Tern Predation})$   
--Rock Island Dam to Bonneville Dam (2008-2018)--



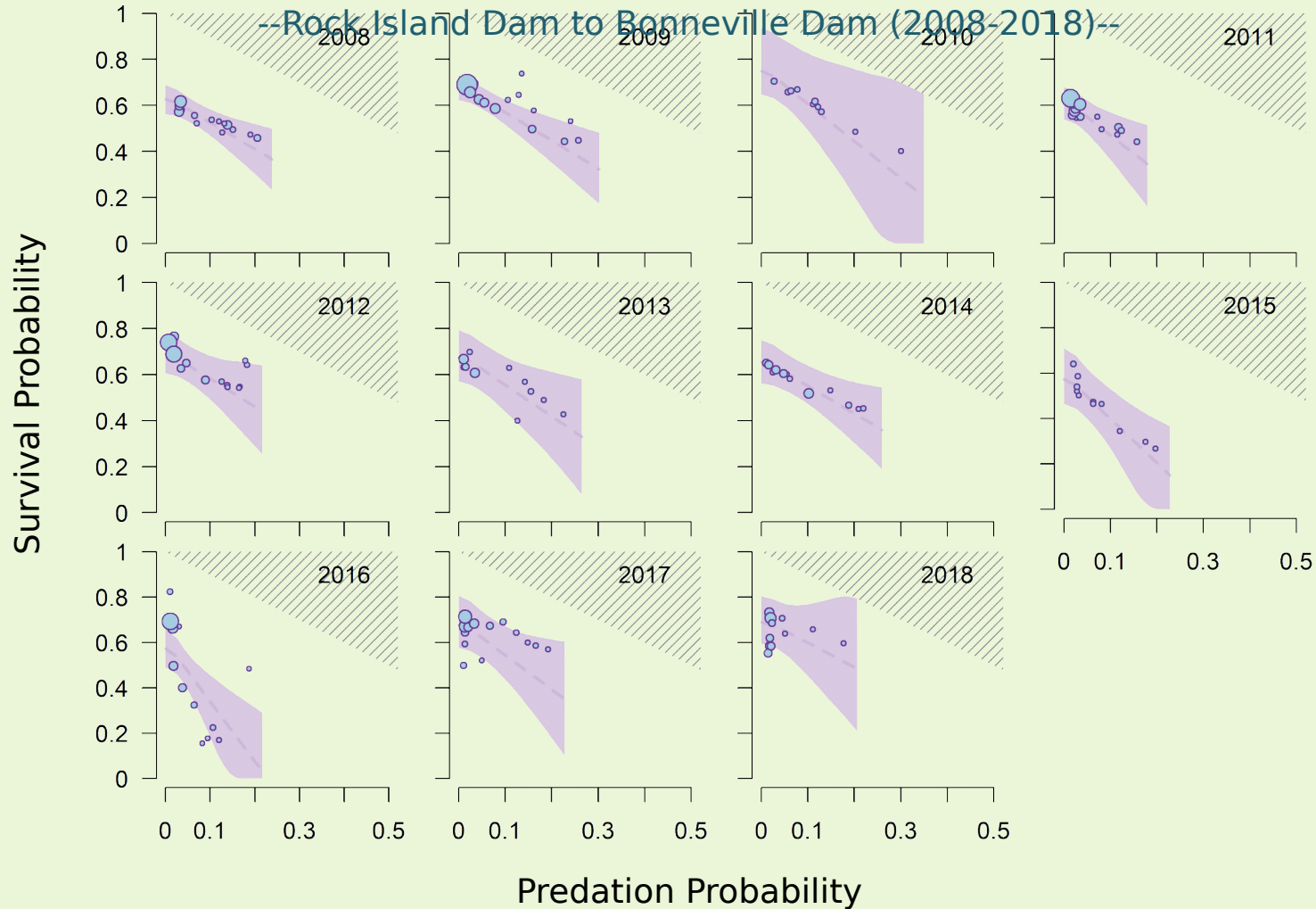
# Survival

Joint Weekly Estimates of  $p(\text{UCR Steelhead Survival})$  and  $p(\text{Tern Predation})$   
--Rock Island Dam to Bonneville Dam (2008-2018)--



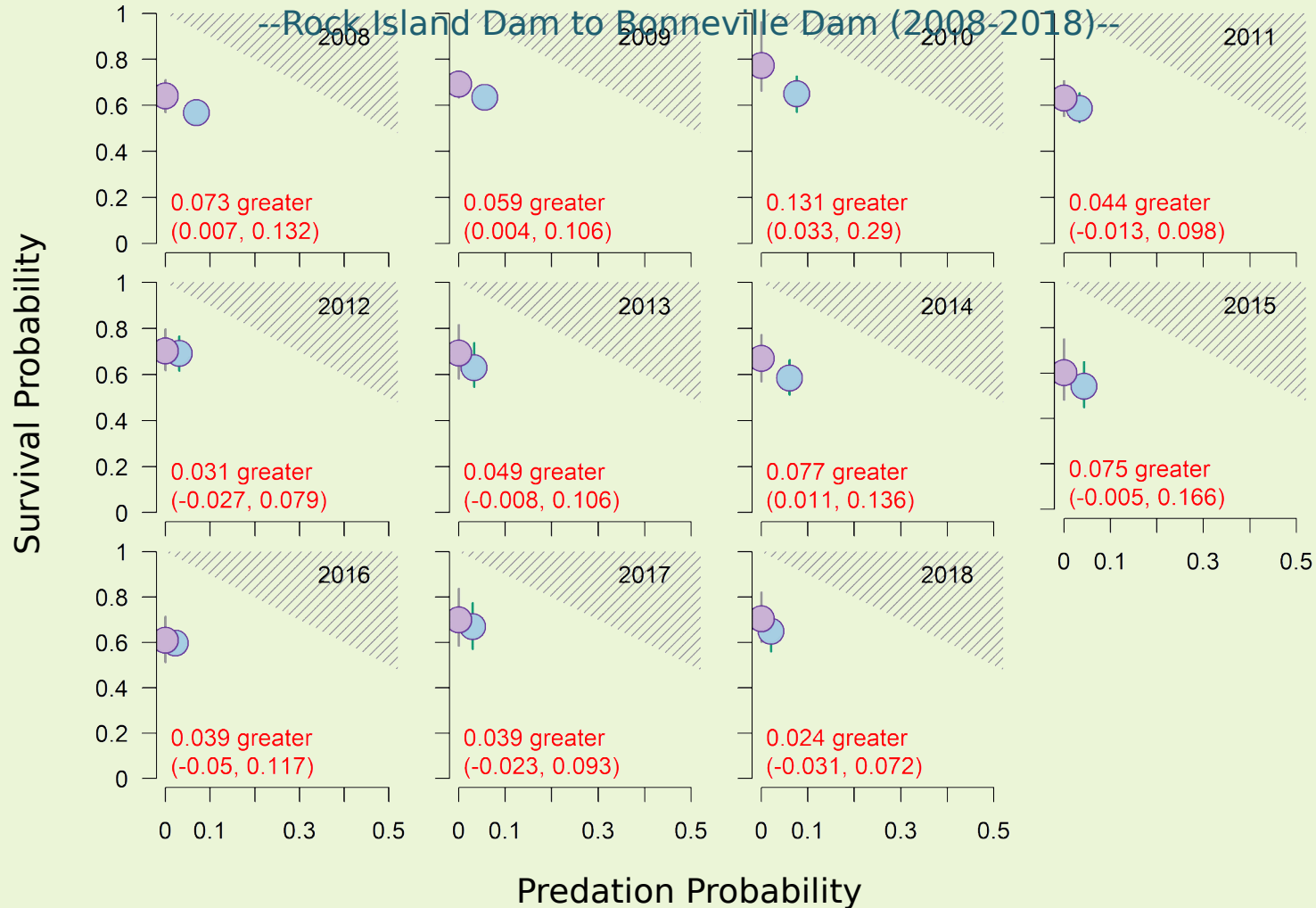
# Survival

Joint Weekly Estimates of  $p(\text{Snake River Steelhead Survival})$  and  $p(\text{Tern Predation})$



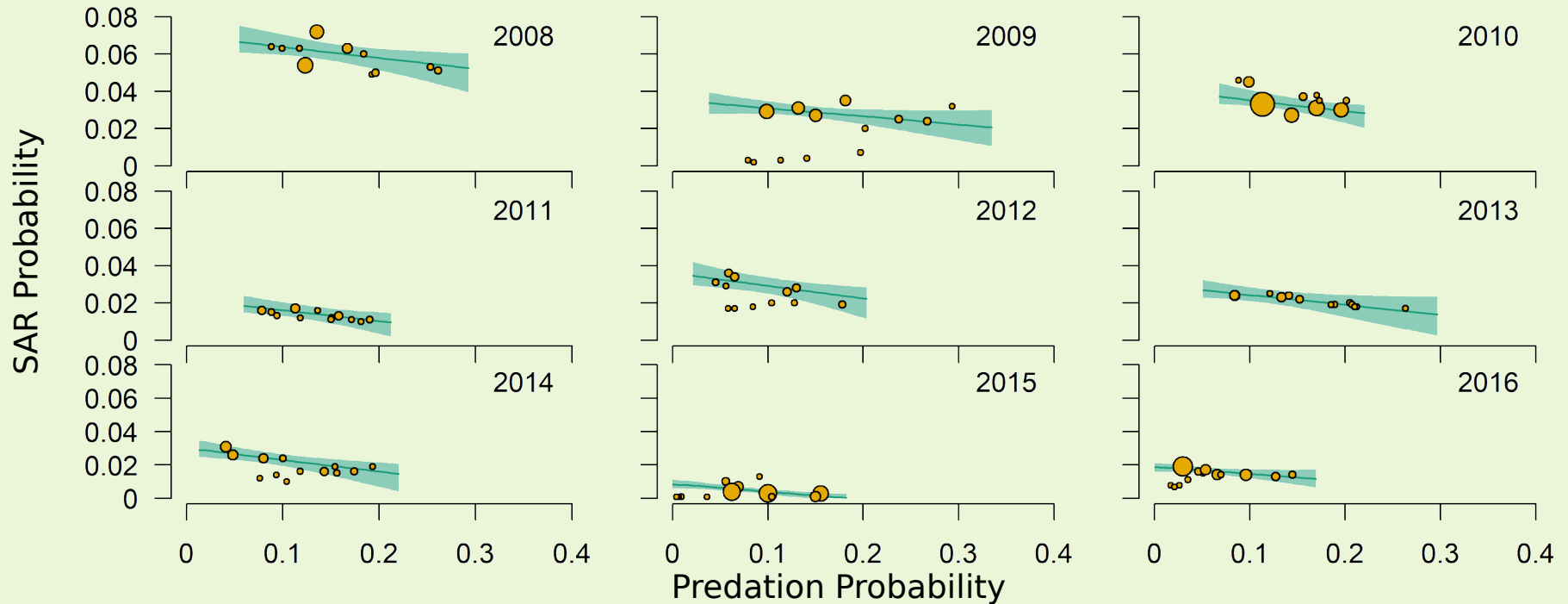
# Survival

## Joint Weekly Estimates of $p(\text{Snake River Steelhead Survival})$ and $p(\text{Tern Predation})$



# Impacts of SARs?

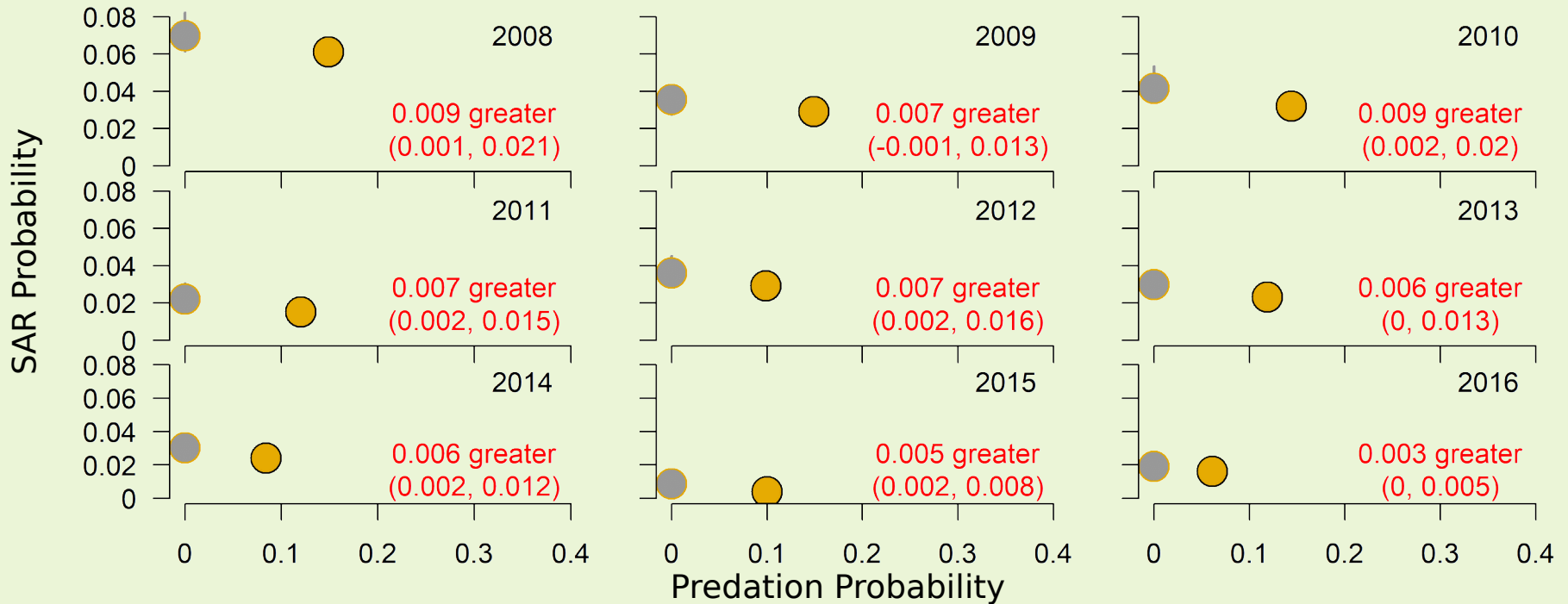
Joint Weekly Estimates of  
 $p(\text{Snake River Steelhead SAR})$  and  $p(\text{Tern Predation})$   
-- Bonneville Dam as smolts to Bonneville Dam as Adults--



- Relationship again significant in many years
- Largely but not completely compensatory

# Impacts of SARs?

Joint Weekly Estimates of  
 $p(\text{Snake River Steelhead SAR})$  and  $p(\text{Tern Predation})$   
-- Bonneville Dam as smolts to Bonneville Dam as Adults--



- Relationship again significant in many years
- Largely but not completely compensatory
- Estimates of baseline survival consistently significantly greater than observed survival even in years with greatly diminished adult returns

# Super Additive Impacts?

- Across all years,
  - Super-additivity
  - Implies that for every 10 steelhead that terns **consume**, 14 don't make it to Bonneville that would have otherwise
- We must infer that the full impact of tern predation isn't being measured: i.e., more steelhead are dying due to terns than just those being consumed

# Super Additive Impacts?

- Across all years,
  - Super-additivity
  - Implies that for every 10 steelhead that terns **consume**, 14 don't make it to Bonneville that would have otherwise
- We must infer that the full impact of tern predation isn't being measured: i.e. more steelhead are dying due to terns than just those being consumed
  - Kleptoparasitism (Adkins et al., 2011)





# Super Additive Impacts?

- Across all years,
  - Super-additivity
  - Implies that for every 10 STHD that terns **consume**, 14 don't make it to Bonneville that would have otherwise
- We must infer that the full impact of tern predation isn't being measured: i.e. more steelhead are dying due to terns than just those being consumed
  - Kleptoparasitism (Adkins et al., 2011)
  - Crippling Loss (Reimchen 1988, Williams et al. 2002, Servanty et al. 2010)

