CHAPTER 5: Relative Impacts of Double-crested Cormorants and Caspian Terns on Survival of Juvenile Salmonids in the Columbia River Estuary: A Retrospective Analysis

Avian Synthesis Report Meeting
April 14, 2021

REAL TIME RESEARCH

Oregon State UNIVERSITY

CHAPTER 5

Purpose: Evaluate the relative susceptibility of juvenile salmonids to predation by cormorants and terns nesting at spatially explicit locations in the marine and freshwater zones of the CRE.

Approach: Retrospective analysis of colony size (number of breeding pairs) and smolt PIT tag recoveries on cormorant and tern colonies to estimate per capita consumption rates at East Sand Island in the marine zone and Rice Island and Miller Sands Spit in the freshwater zone.

- Results used to support/refute previous studies based on the diet composition of terns (Roby et al. 2003) and to generate first-time results for cormorants

CHAPTER 5

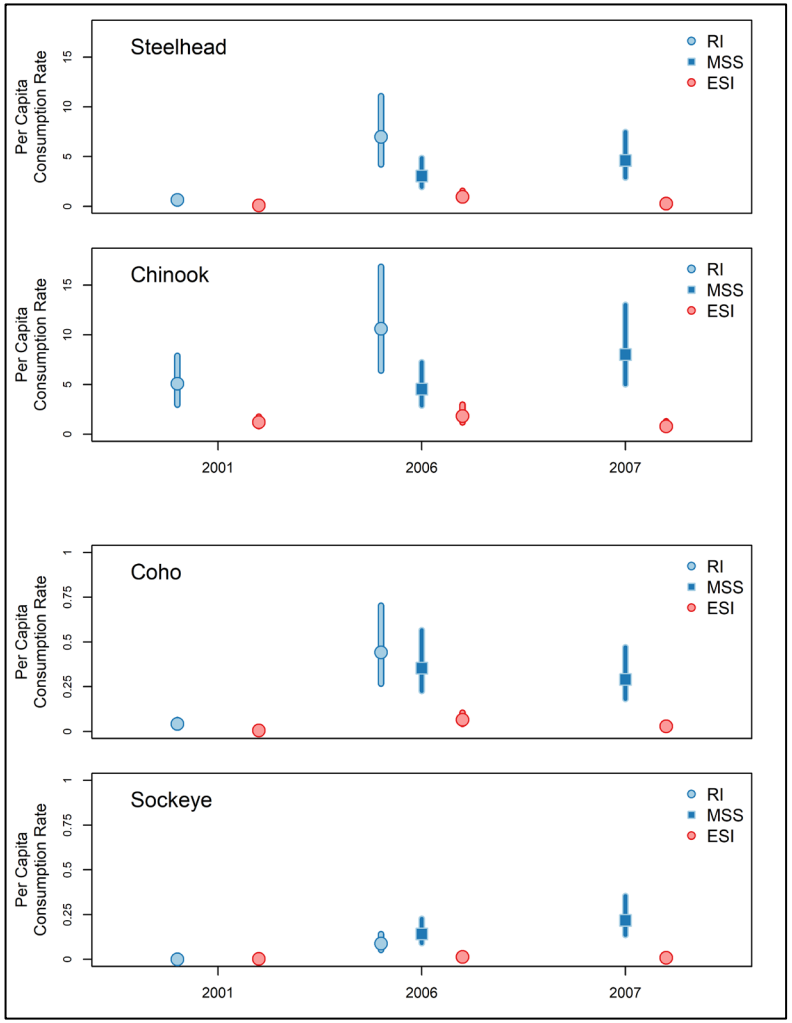
Summary of Findings

- Per capita consumption by terns and cormorants significantly higher on smolts by birds nesting at upper estuary colony sites compared with the lower estuary.

- Confirms previously published tern research by Roby et al. 2003 and indicates similar, but perhaps more dramatic, differences in cormorants.
  - Small sample sizes of tags recovered on RI and MSS cormorant colonies resulted in imprecise estimates

- Suggests that cormorants nesting on the Astoria-Megler bridge are likely to have higher per capita impacts on smolts than those on East Sand Island.

Cormorants (Figure 5.2)



Acknowledgments

Authors: Brad Cramer, Allen Evans, Quinn Payton, Ken Collis, and Daniel Roby

Funding: Oregon Department of Fish and Wildlife, Bonneville Power Administration & Grant County PUD/Priest Rapids Coordinating Committee

CHAPTER 7: Cumulative Effects of Avian Predation on Juvenile Salmonids in the Columbia River Basin

Avian Synthesis Report Meeting
April 14, 2021

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CHAPTER 7

Purpose: Estimate the cumulative and reach-specific effects of avian predation on UCR and SR smolts and determine what proportion of all sources of smolt mortality were due to avian predation.

Approach: Jointly estimate reach-specific predation and survival on groups of PIT-tagged steelhead, yearling Chinook, sub-yearling Chinook, and sockeye during 11-year study period.

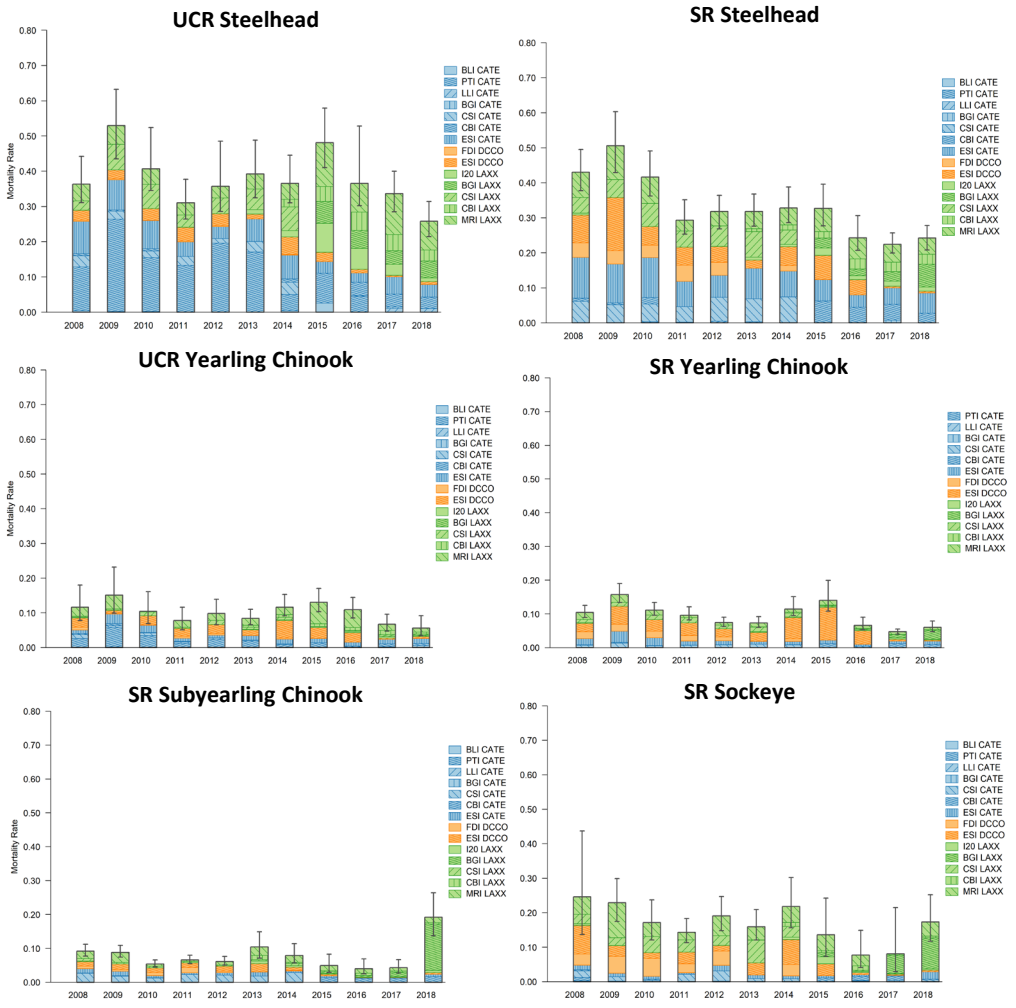
- Identify where, spatially, predation occurs
- Identify which predator species and colonies have the highest impacts
- Quantify mortality due to avian predation relative to all sources of mortality

CHAPTER 7

Summary of Findings

- Predation probabilities vary by salmonid species, avian predator species, colony, river reach, and year.
- Cumulative effects of predation often the highest on steelhead (18–53%), with predation on sockeye (8–25%), yearling Chinook (5–16%) and subyearling Chinook (4–10%) lower.

Cumulative Predation (Figure 7.1)

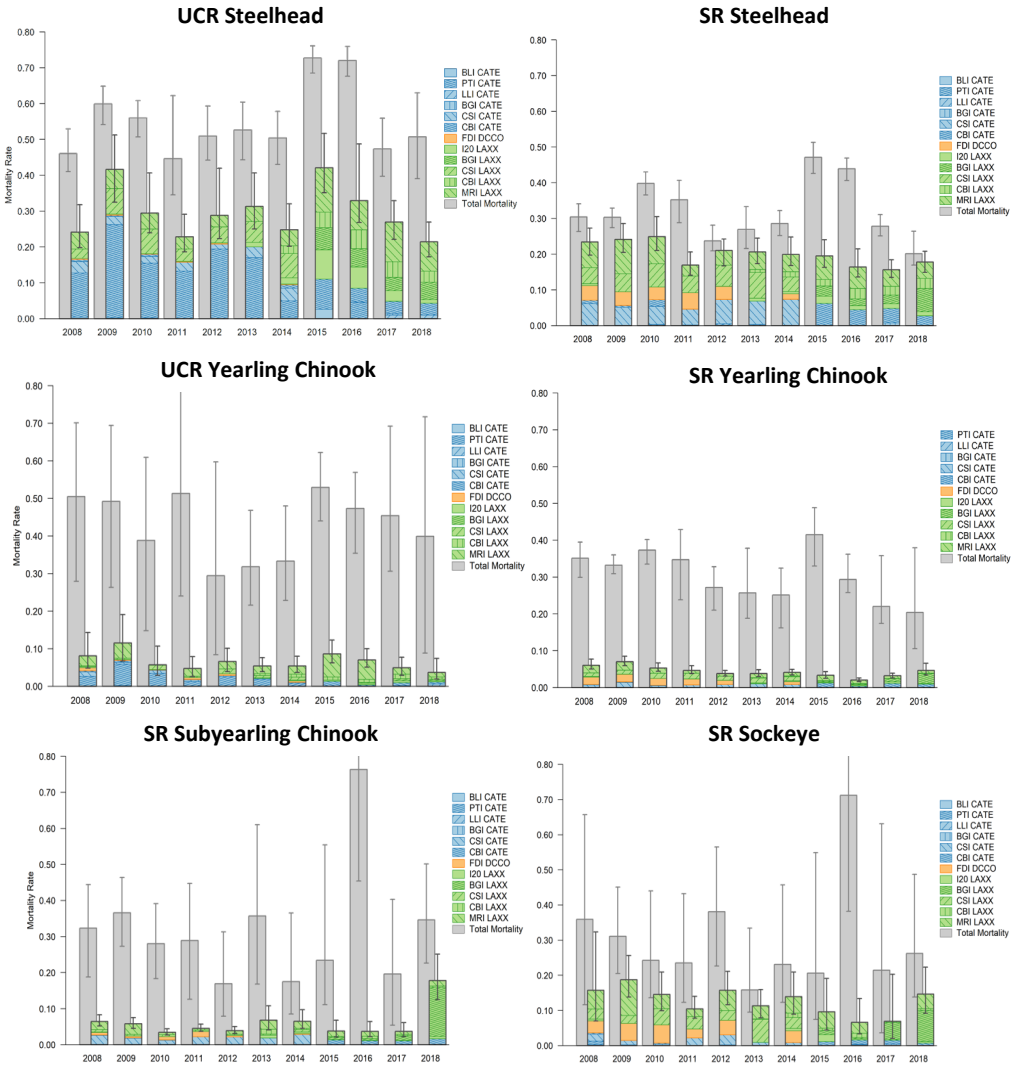


CHAPTER 7

Summary of Findings Cont.

- Avian predation was often the greatest source of steelhead mortality (>50%) upstream of BON, but a much lower source in Chinook (<20%).
  - Greater uncertainty on SR sockeye, UCR yearling Chinook, and SR sub-yearling Chinook due to small sample sizes.
  - No relative comparisons in the estuary due to a lack of smolt survival estimates.
- Results suggest that the potential benefits of managing avian predators will vary greatly depending on the species of avian predator, the location of the breeding colony, and the salmonid species and population depredated.

Predation vs Survival (Figure 7.4)

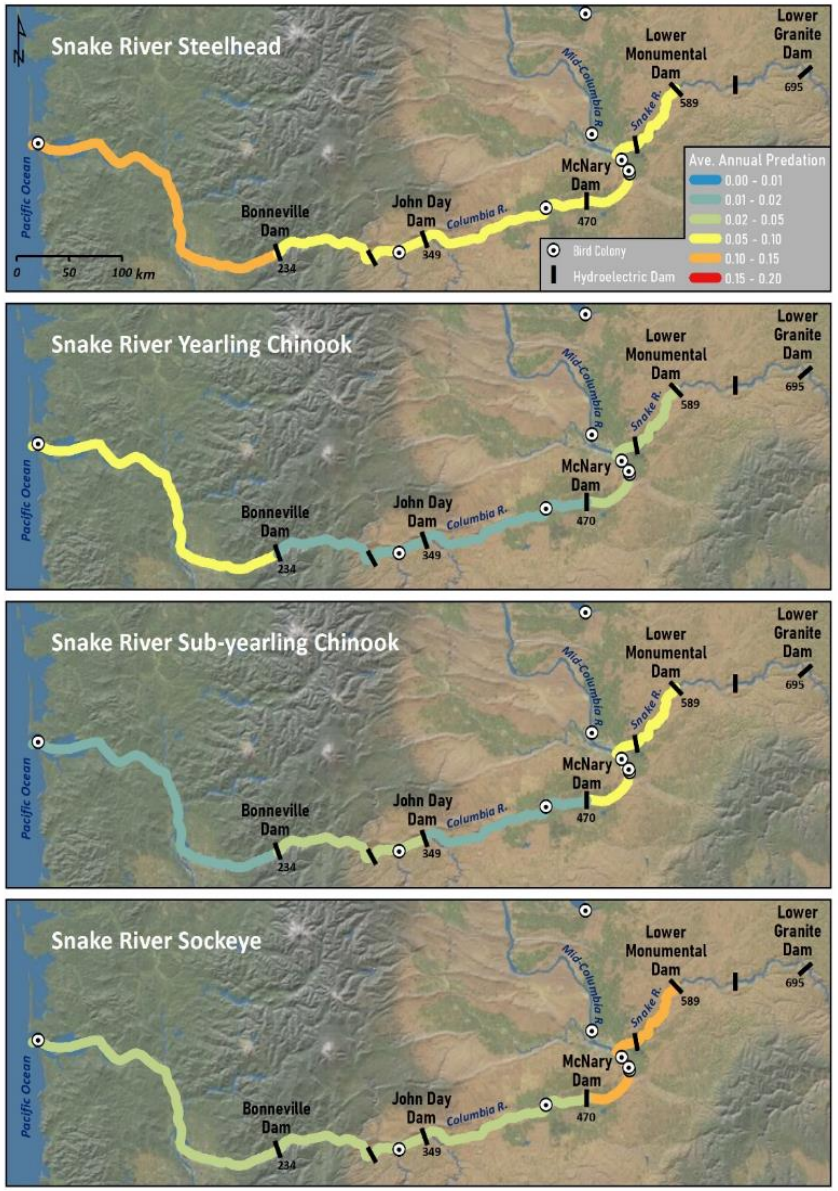


CHAPTER 7

Summary of Findings Cont.

- Predation impacts vary spatially.
- More recent (2015-2018) average annual reach-specific estimates of cumulative predation were often the highest by colonies foraging near the confluence of Snake and Columbia rivers and in the estuary.

Reach-specific Predation (Figure 7.3)



Acknowledgments

Authors: Allen Evans, Quinn Payton, Ken Collis, Brad Cramer, Aaron Turecek, Nathan Hostetter, and Daniel Roby

Funding: Bonneville Power Administration

CHAPTER 8: Additive Effects of Avian Predation on the Survival of Juvenile Salmonids in the Columbia River Basin

Avian Synthesis Report Meeting
April 14, 2021

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CHAPTER 8

Purpose: Investigate the additive effects of predation on UCR and SR smolts during outmigration through the CRPS based on smolt predation upstream of BON and SARs based on smolt predation in the estuary.

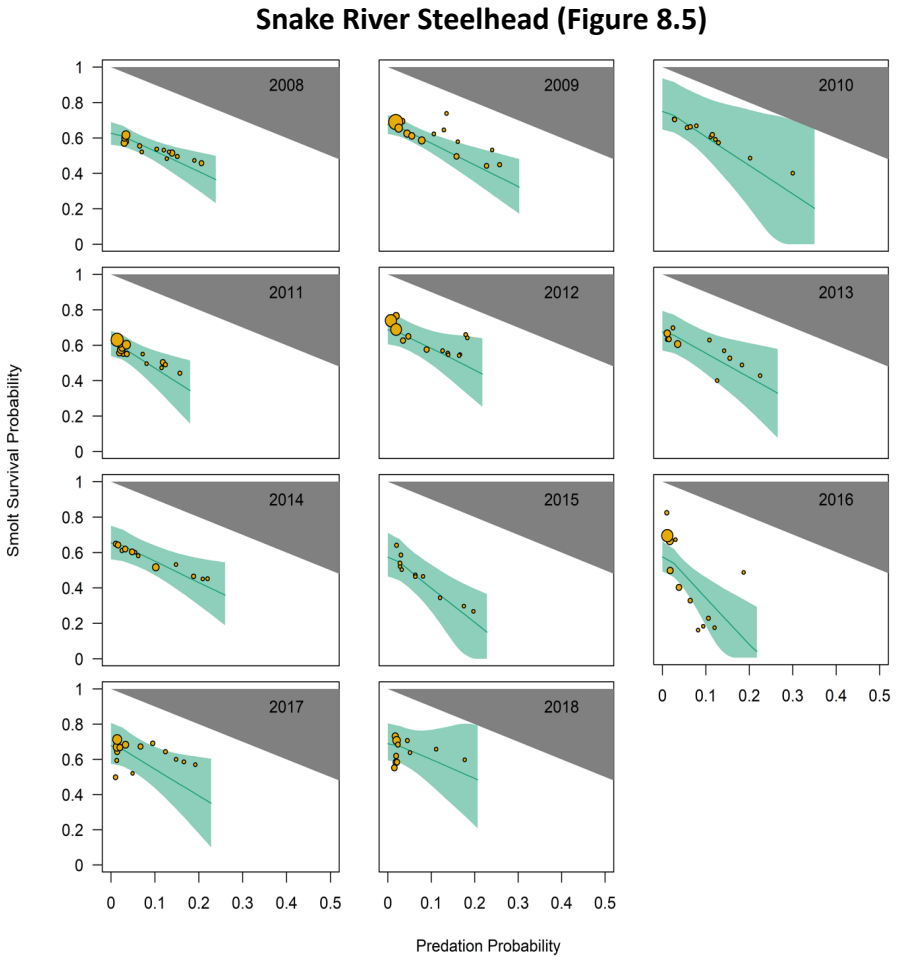
Approach: Use weekly and annual estimates of predation by terns, cormorants, and gulls on PIT-tagged smolts to investigate strength, magnitude, and direction of the relationship between predation and survival probabilities.

- Used the methods of Payton et al. (2020)

CHAPTER 8

Summary of Findings

- Statistically significant relationship between SR and UCR steelhead and SR yearling Chinook predation by terns and smolt survival to BON
  - Largely additive (super-additive); underestimating predation impacts.
  - Predation rates were low on Chinook thus little estimated benefit to management in the absence of tern predation upstream of BON.
- Statistically significant relationship between SR steelhead predation by cormorants and smolt survival to BON.

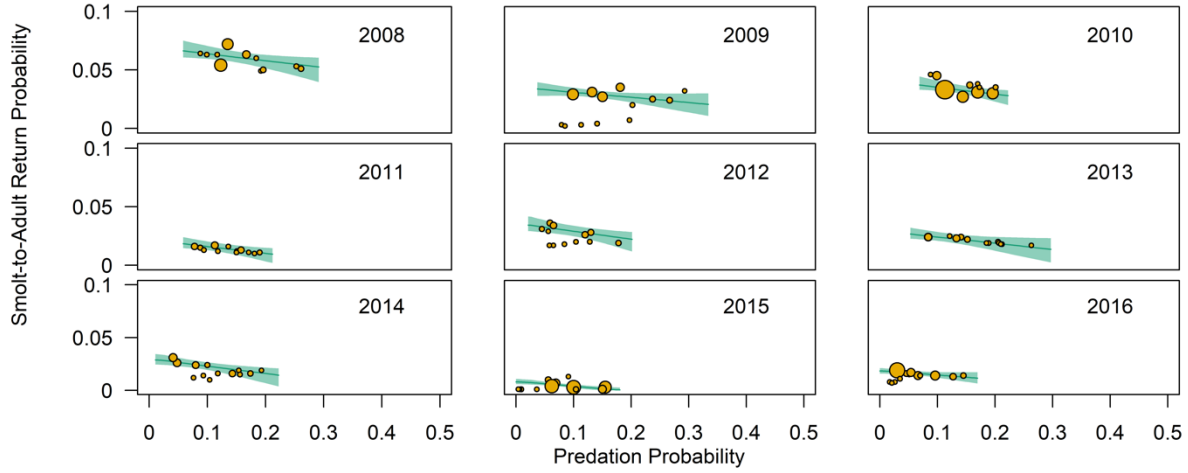


CHAPTER 8

Summary of Findings Cont.

- Statistically significant relationship between SR and UCR steelhead predation by estuary terns and SARs; suggest relationship between UCR steelhead predation by estuary cormorants and SARs.
  - Partially additive relationship
  - SR steelhead results consistent with Payton et al. (2020)

Snake River Steelhead (Figure 8.8)



CHAPTER 8

Summary of Findings Cont.

- No statistically significant relationship between gull predation on smolts and smolt survival to BON.
  - Years with high intra-annual variation were suggestive in steelhead
  - Some proportion of smolt mortality by gulls is known to be compensatory
- Multiple factors influence the ability to evaluate the additive effects of predation: (1) level or magnitude of predation, (2) variation in predation, (3) precise estimates of predation and survival, and (4) life stage / spatial scale evaluated.
- Even with high levels of uncertainty, results suggest that significantly more SR and UCR steelhead smolts would survive outmigration as smolts through FCPS and would return as adults in the absence of tern predation upstream and downstream of BON.

Acknowledgments

Authors: Quinn Payton, Allen Evans, Nathan Hostetter, Brad Cramer, Ken Collis, and Daniel Roby

Funding: Bonneville Power Administration

CHAPTER 9: Functional Responses Across Predator Species, Space, and Time: How Piscivorous Waterbirds Respond to Changes in Juvenile Steelhead Abundance

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CHAPTER 9

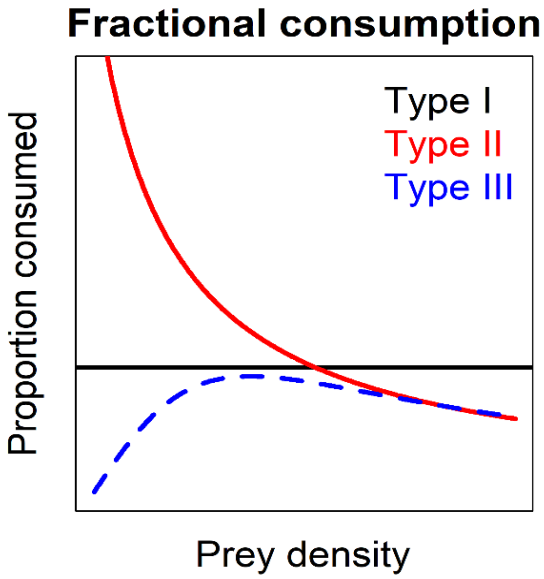
Purpose: To investigate how different avian predators respond to changes in prey availability (functional or density-dependent relationships)

Approach: Model the relationship between weekly per capita predation probabilities by tern, cormorants, and gulls, and changes in steelhead availability to determine functional responses:

Type I: Per capita predation is proportional to change in prey density

Type II: Per capita predation decrease as prey density increases (prey swamping)

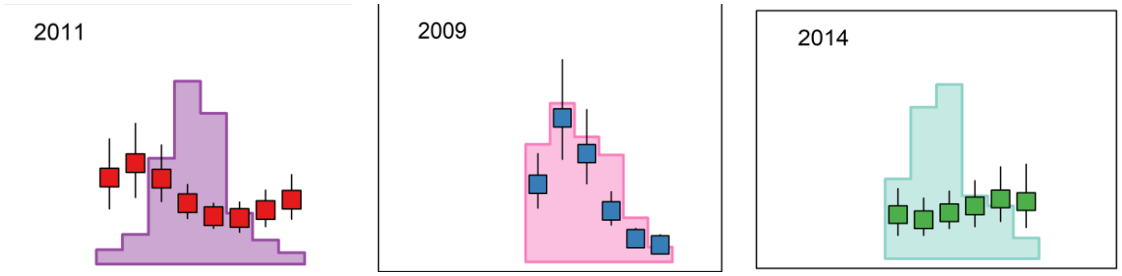
Type III: Per capita predation slow to respond when prey are scarce, then rapidly increases (prey switching)



CHAPTER 9

Summary of Findings

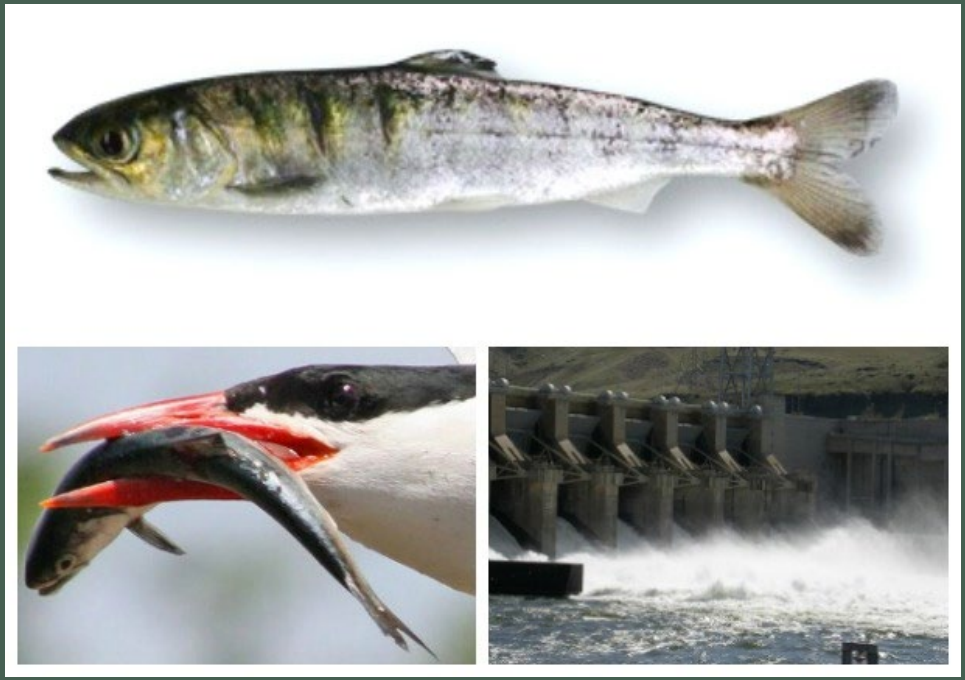
- Inland and estuary terns consistently displayed Type II
- Inland cormorants displayed Type II, but estuary Type III
- No weekly estimates of gull colony size; trends consist with Type I or III
- Colony size, foraging behavior, and diet composition are all important
- Large numbers smolts (e.g., en masse hatchery releases) or areas where smolts are concentrated may attract cormorants and gulls
- Tern predation maybe more likely to regulate population-level steelhead survival



Acknowledgments

Authors: Nathan Hostetter, Quinn Payton, Allen Evans, Daniel Roby, and Ken Collis

Funding: Oregon Department of Fish and Wildlife, Bonneville Power Administration, and Grant PUD/Priest Rapids Coordinating Committee



CHAPTER 10: Factors Affecting the Susceptibility of Juvenile Salmonids to Avian Predation

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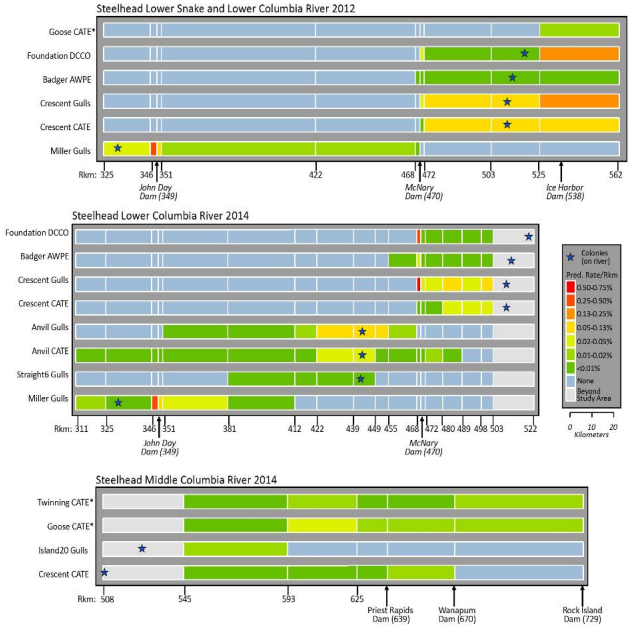
CHAPTER 10

Purpose: Synthesis the results of previous studies that investigated factors that influence fish susceptibility to predation by colonial waterbirds

Approach: Reviewed over 90 peer-reviewed and grey-literature studies on salmonid predation by piscivorous colonial waterbirds. Results groups into four categories:

- Environmental factors
- Prey/predator density and migration timing
- Prey characteristics
- Predator characteristics



CHAPTER 10

Summary of Findings

- Predator-prey interactions were complex and dynamic; varied by predator species, prey species, and across time and space.
- Multiple factors were identified including, but not limited, to:
  - River flows, water transit times, and water clarity; factors that influence prey exposure times and levels.
  - Ocean conditions and nesting locations; factors that influence the availability of prey, including alternative, non-salmonid prey.
  - Dams, hatchery release locations, or other areas where smolts may congregate; factors that can increase smolt susceptibility to avian predators.
  - Colony size, with both intra- and inter-annual changes important.
  - Smolt abundance (Type I, II, and III functional response) and run-timing (spatial and temporal over-lap).
  - Fish size; terns and gulls prefer larger-sized smolts up to a threshold, while no size-selective observed in cormorants; pelicans can consume fish > 70 cm.
  - Fish condition; degraded fish generally but not always more susceptible.
  - Fish rearing-type; no consistent trend, some evidence for hatchery smolts by some plunge-diving predators but fish size maybe more important.

Acknowledgments

Authors: Nathan J. Hostetter, Allen F. Evans, Quinn Payton, Daniel D. Roby, Donald E. Lyons, and Ken Collis

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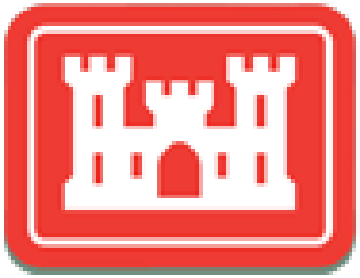

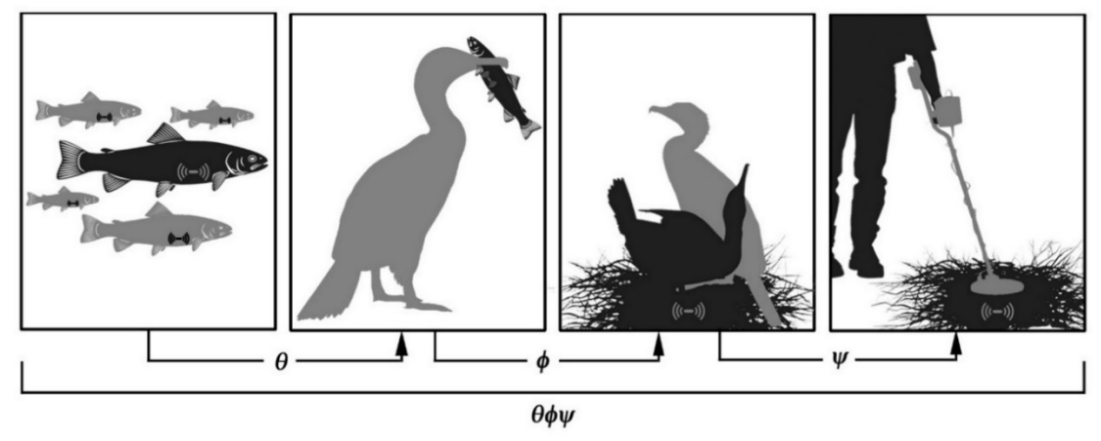

APPENDICES

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APPENDICES

APPENDIX A: Standardized Methods for Data Collection & Analysis

- Colony size and predation rate estimation techniques

APPENDIX B: Summary Data Tables

- Colony sizes and predation rates

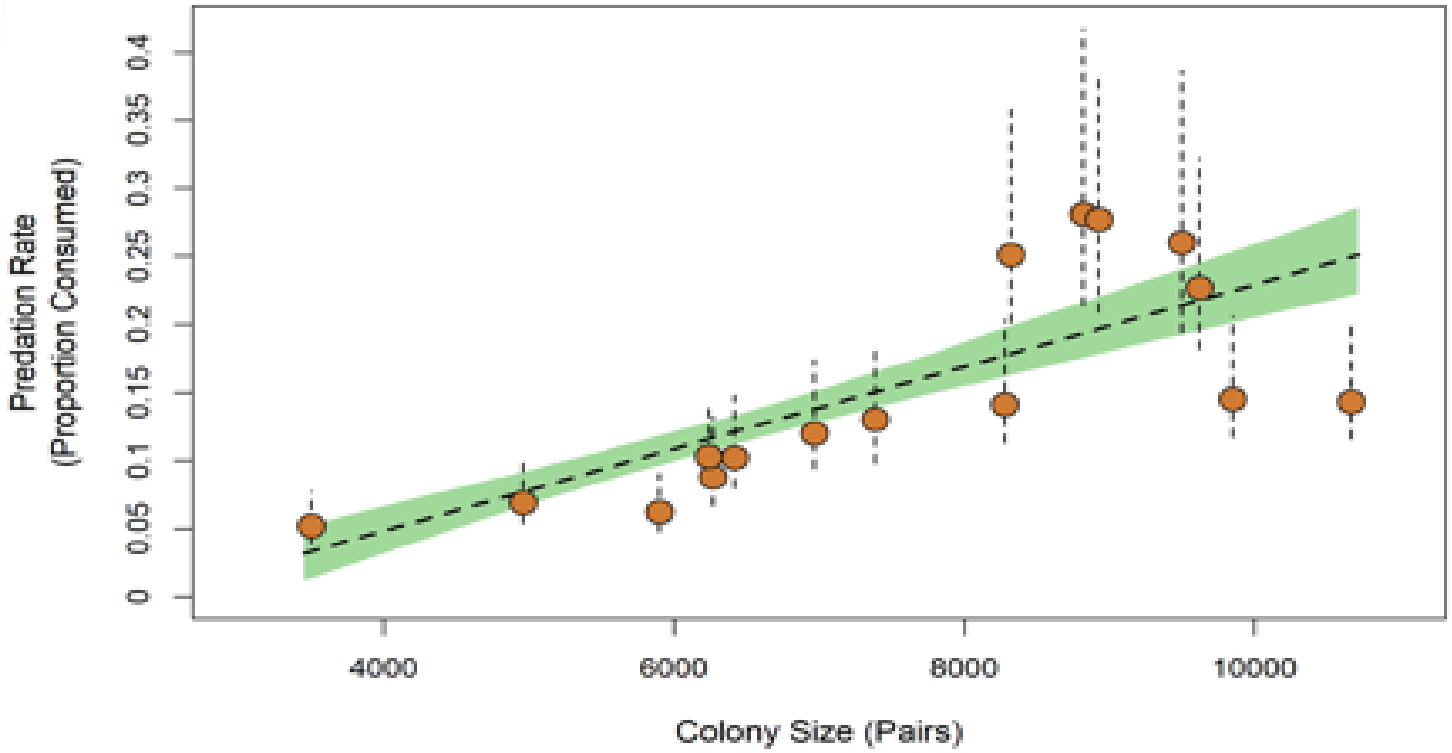
APPENDIX C: East Sand Island Caspian Tern Predictive Predation Rate Analysis

APPENDIX D: Annotated Bibliography

- Citations, key words, and abstracts
- Available Online (printed version also available)

APPENDIX C

Snake River Steelhead (Figure 1.24)



APPENDIX C

Snake River Steelhead (Figure C.1)