



# Habitat Restoration Impacts on Salmon and Water Management in California

*Principal Investigator:*  
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**Technical Completion Report**  
**Project Period: March 1, 2017 – February 28, 2019**

## Project Summary

Juvenile salmon are ecologically and economically important and encounter many predators while traveling. Scientists and managers have focused on the consumption of migrating salmon, but how those predators may affect prey behavior is unclear. Predation risk can drastically alter non-migrating prey behavior with consequences on populations and communities. The goal of this research was to examine predator effects on migrating juvenile salmon behavior and evaluate population consequences to the prey. First, we developed a conceptual framework to predict how migrating prey perceive and respond to predation risk—a direct extension of classic economic escape theory. Next, we tested this theory empirically using behavioral assays where we timed juvenile salmon swimming downstream with and without predator cues. In two experiments, juvenile salmon changed behavior (speed) in response to predator cues, but the pattern of response was context-dependent on previous predator experience and habitat. Wild salmon with more previous predator experience reacted more strongly to predation risk than hatchery salmon. Salmon also responded more strongly to predation risk in the shade compared to the sun and varied their escape strategy—slowing down in the shade and speeding up in the sun. Ongoing research will link these fine-scale decisions and responses to known ecological tradeoffs in juvenile salmon through a dynamic model. This model will explore optimal antipredator decisions for migrating salmon and relate those decisions to survival of juveniles and adults under various management scenarios. Cumulatively, this work evaluates an under-studied mechanism potentially contributing to migratory salmon declines—non-consumptive effects of predators on prey behavior.

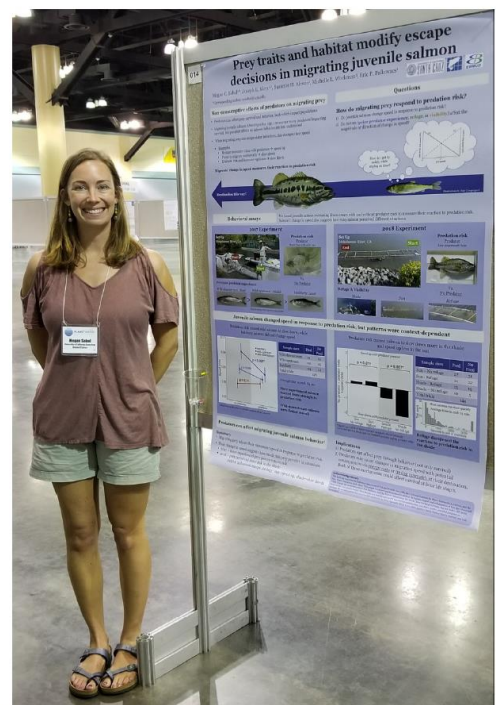
## Student Support

This award supported research activities for one PhD graduate student and funded two undergraduate students as Laboratory Assistants for 6 months to help with data synthesis.

## Outreach

### Talks

- Sabal MC, Merz JE, Palkovacs, EP. Habitat, hatcheries, and predators affect salmon migration and survival. Bay-Delta Science Conference (September 13, 2018; Sacramento, CA).
- Sabal MC, Merz JE, Palkovacs, EP. Migration decisions made under the risk of predation for wild and hatchery salmon. Cal-Neva Chapter of the American Fisheries Society Meeting (March 1, 2018; San Luis Obispo, CA). (Won best student talk)



M. Sabal presenting poster at ASLO 2019 in Puerto Rico

- Sabal MC, Merz JE, Palkovacs, EP. Wild, but not hatchery, salmon adjust migration speed under the risk of predation. Data Theory Seminar, Southwest Fisheries Science Center (February 20, 2018; Santa Cruz, CA).
- Sabal MC, Merz JE, Palkovacs, EP. Trade-offs between migration speed and predator evasion in hatchery and wild salmon. American Society of Naturalists Meeting (January 4, 2018; Pacific Grove, CA).

### Posters

- Sabal MC, Merz JE, Alonzo SH, Palkovacs, EP. Prey traits and habitat modify escape decisions in migrating juvenile salmon. Salmon Restoration Federation (April 23, 2019; Santa Rosa, CA).
- Sabal MC, Merz JE, Alonzo SH, Palkovacs, EP. Prey traits and habitat modify escape decisions in migrating juvenile salmon. Association for the Sciences of Limnology and Oceanography (March 1, 2019; San Juan, PR).

### Other

- M. Sabal participated in outreach program, Watsonville Area for Teens Conserving Habitat (WATCH)
- M. Sabal lead outreach program, Trout in the Classroom through the student subsection of the American Fisheries Society

### **Notable Achievements and Awards**

- 2019 M. Sabal, J. Frances Allen Award, AFS \$2,500
- 2019 M. Sabal, Skinner Travel Award AFS Honorable Mention \$350
- 2018-2020 M. Sabal, Delta Science Fellowship \$138,594
- 2018 M. Sabal, Best Student Oral Presentation, Cal-Neva AFS \$150
- 2018 M. Sabal, Travel Award, American Society of Naturalists \$500



M. Sabal during field experiment in 2018 measuring salmon behavior

### **Publications & Products**

#### Publications

- Sabal MC, Merz JE, Alonzo SH, Palkovacs, EP. *In Review*. An escape theory model for migrating prey and an experimental test with juvenile salmon. *Journal of Animal Ecology*.
- Sabal MC, Workman M, Merz JE, Alonzo SH, Palkovacs, EP. *In prep*. Shade and structure modify escape behavior in migrating juvenile salmon. *Behavioral Ecology*.

### Informal Communication

- [California Sea Grant Science Fellowship Spotlight: Megan Sabal](#) (May 30, 2019)
- Sabal, Megan C. 2018. [Ready, set, go! Racing salmon to learn about migration and predator avoidance](#). Coastal Sustainability Guest Blog. (January 24, 2018).
- Sabal, Megan C. 2017. [How to Scare a Salmon?](#) (November 3, 2017).