Yakima River Basin
Mobile PIT-Tag Detection Surveys

2025 Yakima Basin Science and Management Conference

June 18, 2025

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Project motivation 1:
Steelhead and Chinook Salmon population status

Upper Yakima River steelhead

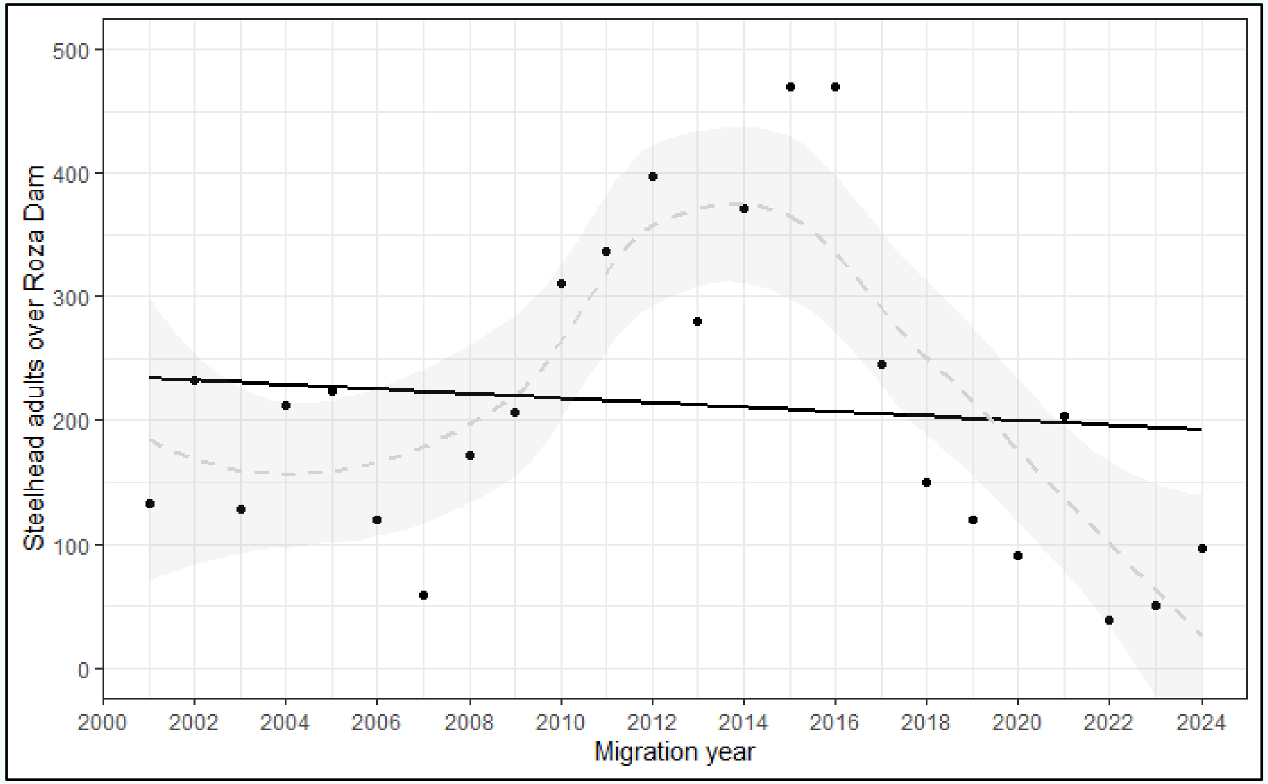


Figure 1. Yakima River adult steelhead passing Roza dam by migration year. Solid line represents linear trend and the dashed line a non-linear splined trend over time (Adapted from Temple et al. 2025)

Yakima Basin spring Chinook Salmon

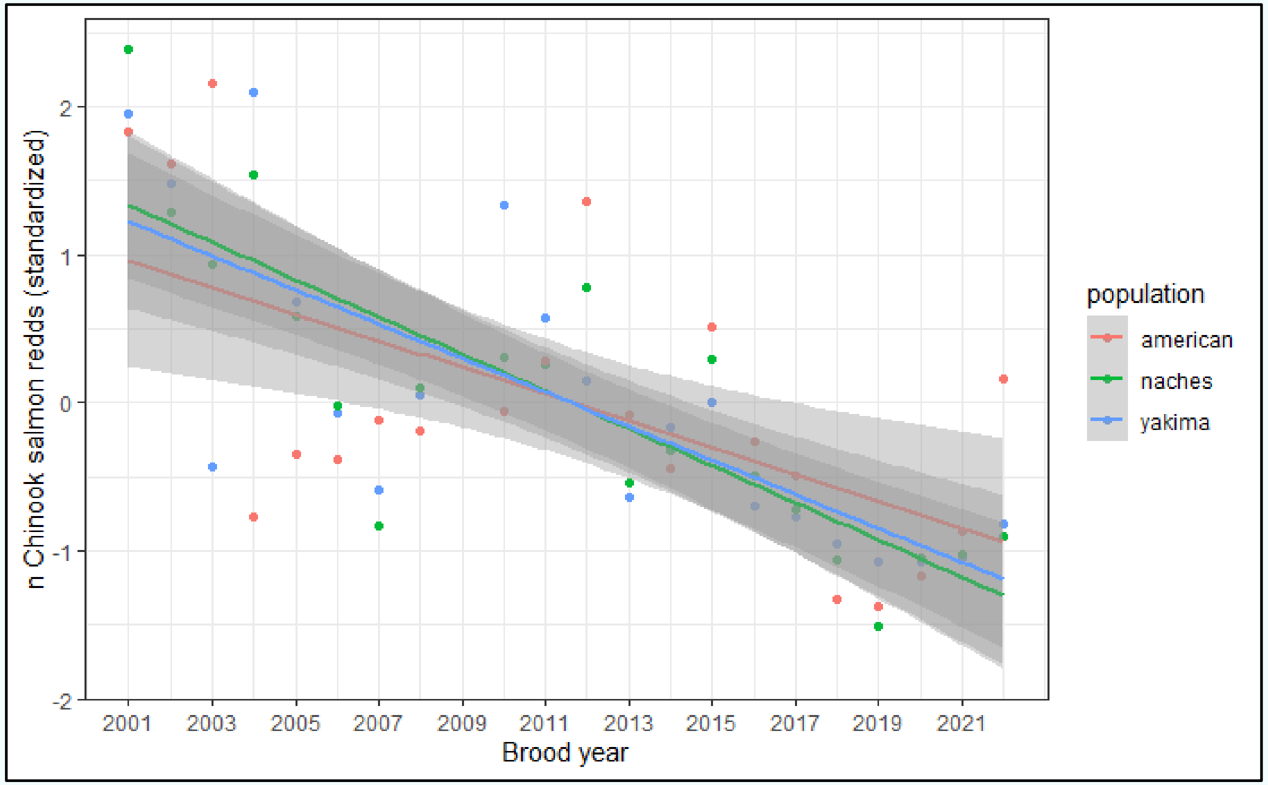


Figure 2. Yakima basin Chinook salmon redds documented in the American, Naches, and Yakima Rivers by migration year. Counts standardized for comparison among populations

Project motivation 2: leveraging of existing information

~ 88,000 salmonids are tagged annually:

- ~ 20,000 *O. mykiss*
- ~5000-10,000 spring Chinook Salmon fall parr
- ~40,000 tagged hatchery-origin spring Chinook Salmon
- ~18,000 Coho Salmon (Blodgett et al. 2024)

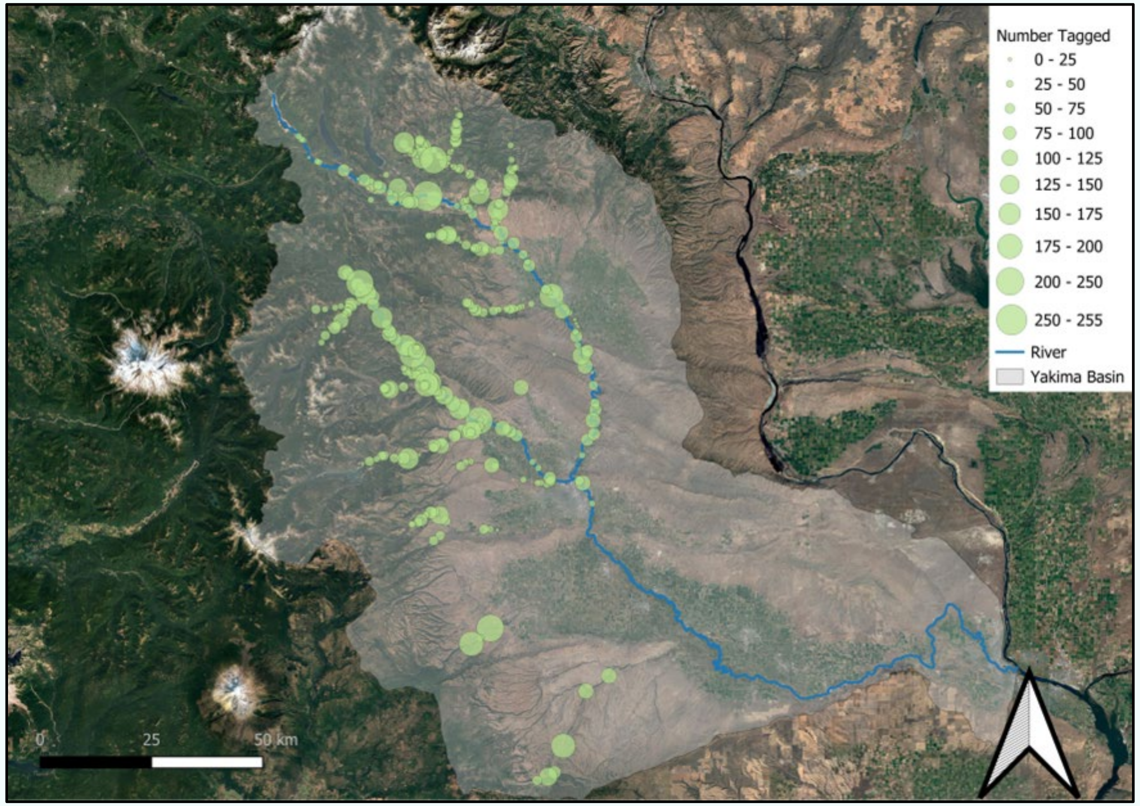


Figure 3. Number and spatial distribution of *O. mykiss* PITT tagged throughout the Yakima Basin 2024. (Figure sourced from Temple et al. 2025)

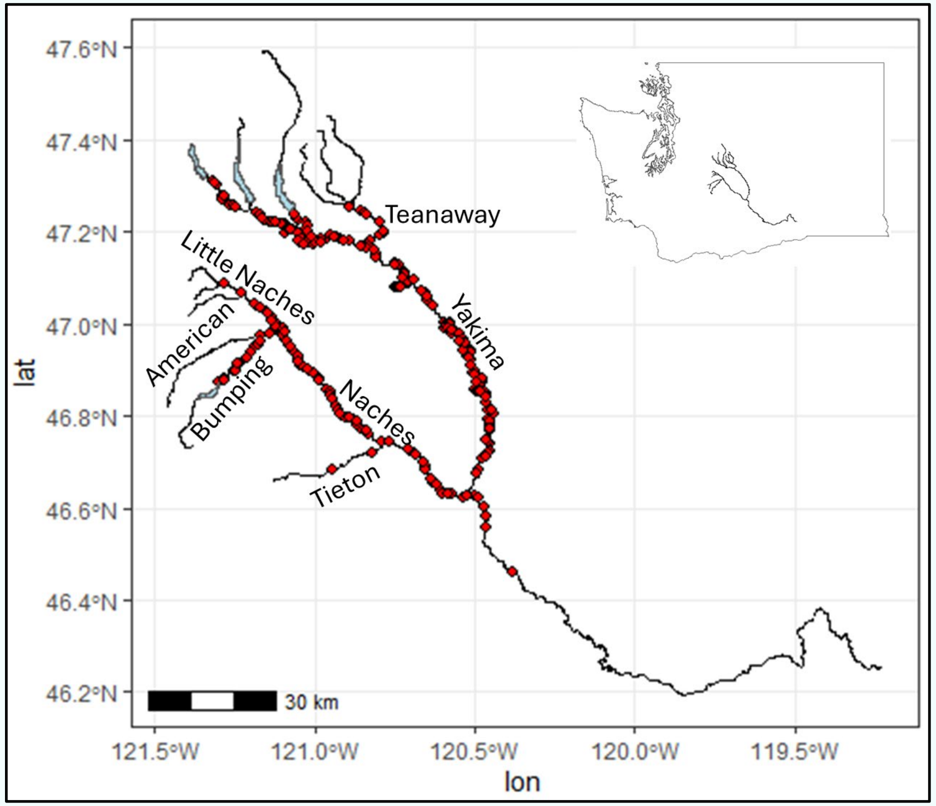
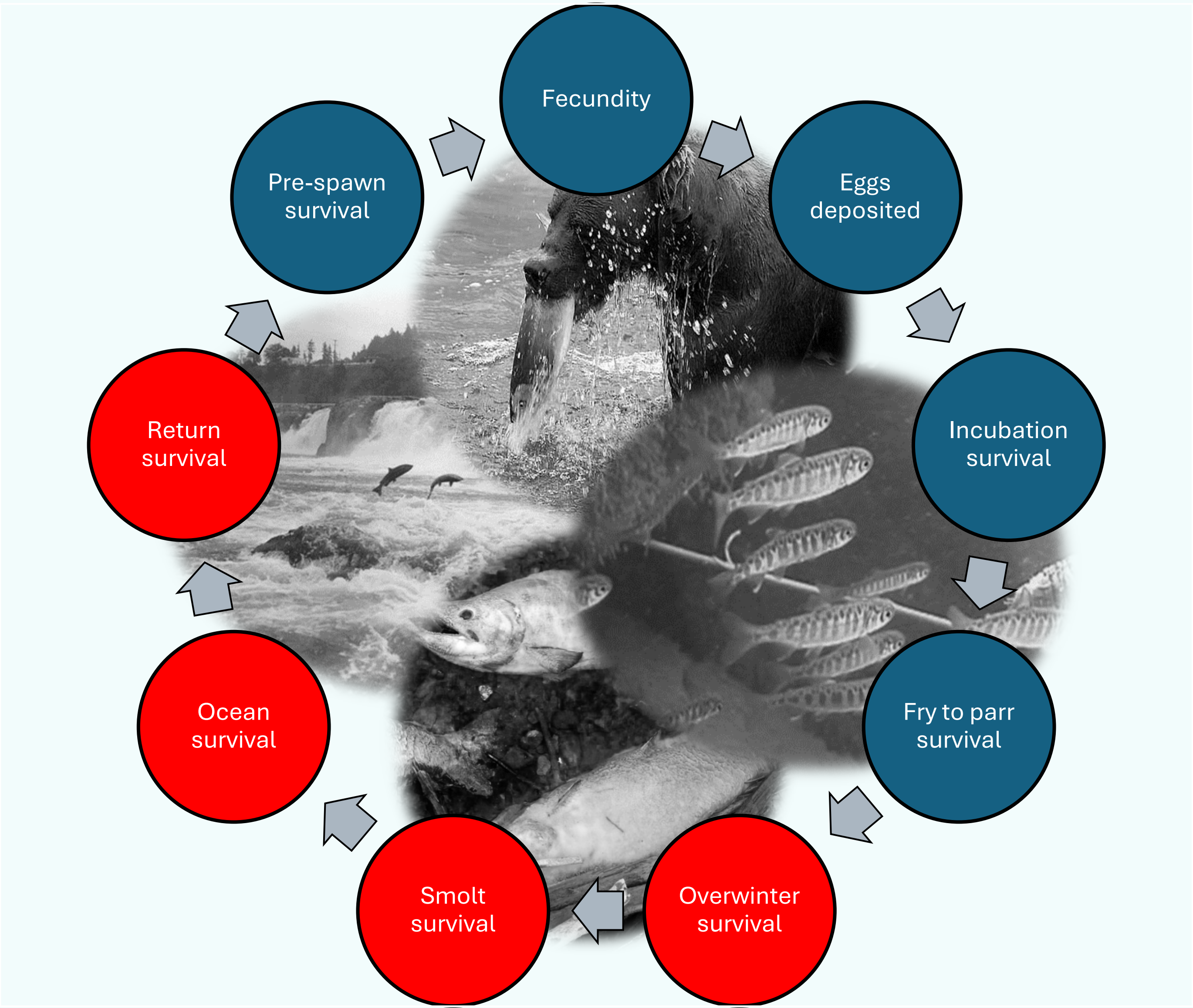
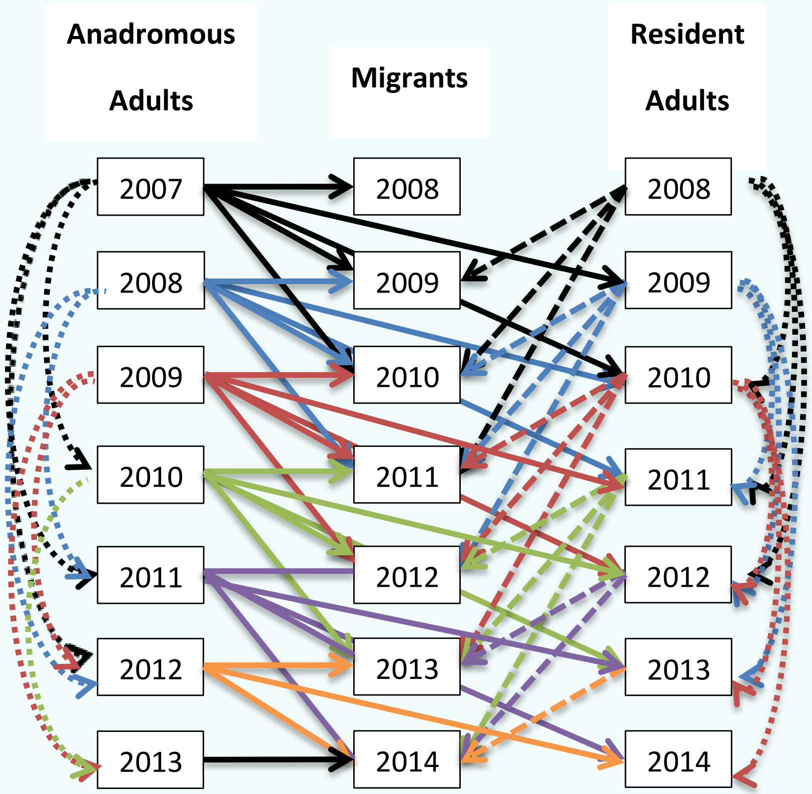


Figure 4. Yakima River Basin tagging locations for naturally produced spring Chinook salmon. 2011-25

Project motivation 3: additional data needed to inform modeling efforts



Yakima Basin Spring Chinook IPM structure



Graphic from Temple et al. (2022)

Additional complexity of *O. mykiss* life-history strategies

Uncertainty in smolt monitoring of tagged individuals

- Current modeling suggests low overall survival, particularly between tagging the first point of detection at Prosser.
- However, low detection efficiency at fixed points in combination with low survival at multiple life-history stages results in high uncertainty and the need for strong priors.

Tag group survival from tagging (i.e., cumulative survival rate)

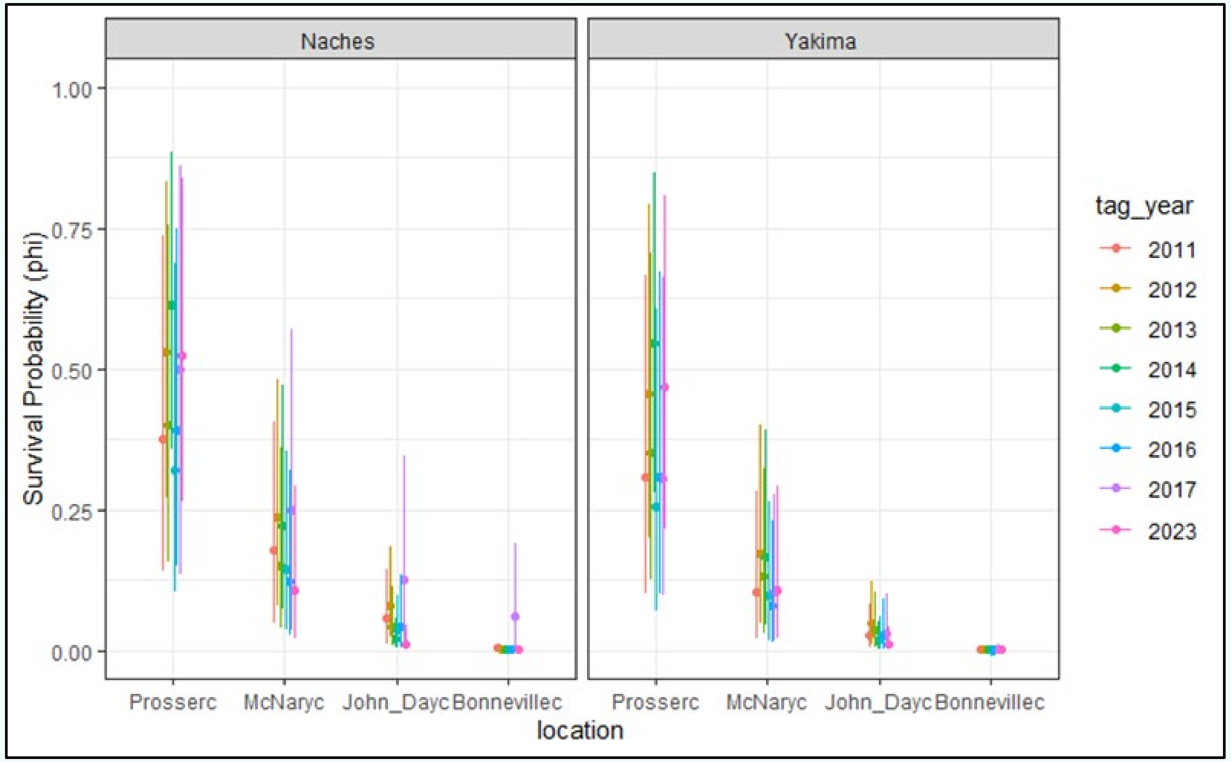


Figure 11. Preliminary estimates of downstream survival **from tagging** for Naches and Yakima River Chinook salmon populations (2011 – 2023)

Model estimated detection efficiency at fixed locations

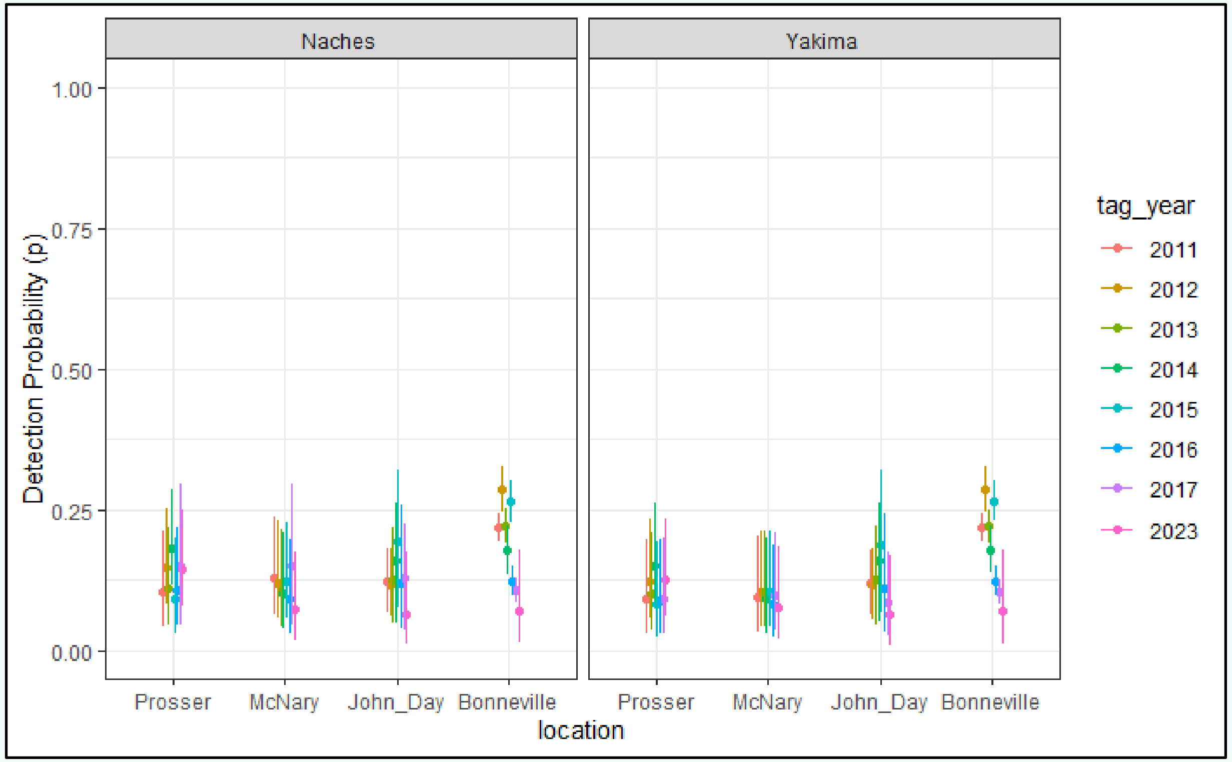
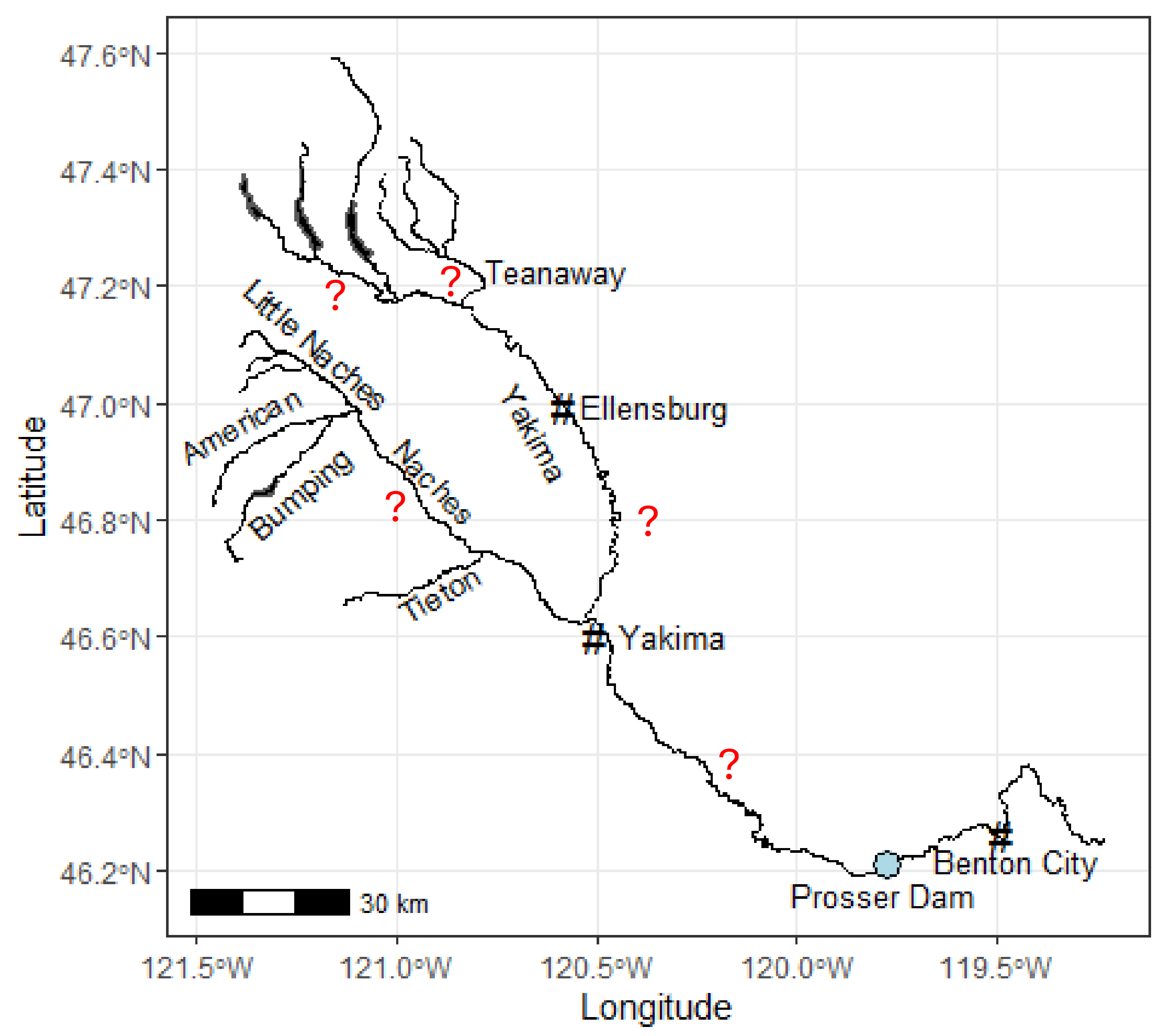


Figure 12. Preliminary estimates of downstream detection efficiency for Naches and Yakima River Chinook salmon populations (2011 – 2023)

Many unknowns with respect to overwinter and migration survival



- Respond to declining population abundance
- Leverage existing data
- Further inform efforts to understand population dynamics of multiple species

How do we do this….?

Mobile PIT tag detection

Nick Mankus and Stefan Woodruff (WDFW: Ellensburg), Zack Mays (YN), Jay Deason and Matt Stillwater (WDFW; Wenatchee)

- Advantage of benefit from **ALL** detections (independent of known detection efficiency)
- Temporal and spatial information
- Abundance estimates (given detection efficiency)
- Adjusted group size through known mortality
    - Informs estimates of both survival and detection efficiency at fix points
- Developing methodology and so opportunity to evaluate

How do we estimate detection efficiency?

Begin to

- First -Make untenable assumptions to be modified in the future:
  - *Pr(tag detection) = Pr(fish detection)* [unlikely]
  - *Pr(tag detection here) = Pr(tag detection there)* [also unlikely]
  - *Pr(placed tag detection) = Pr(ghost tag detection)* [probably not]

- Then- Ignore (preliminarily) other factors potentially affecting efficiency:
  - Turbidity
  - Antenna shape or angle
  - Electrical interference
  - Sampling speed
  - Water depth
  - Temperature
  - Habitat complexity
  - Distance from the bank
  - Substrate type
  - Tag orientation
  - Species

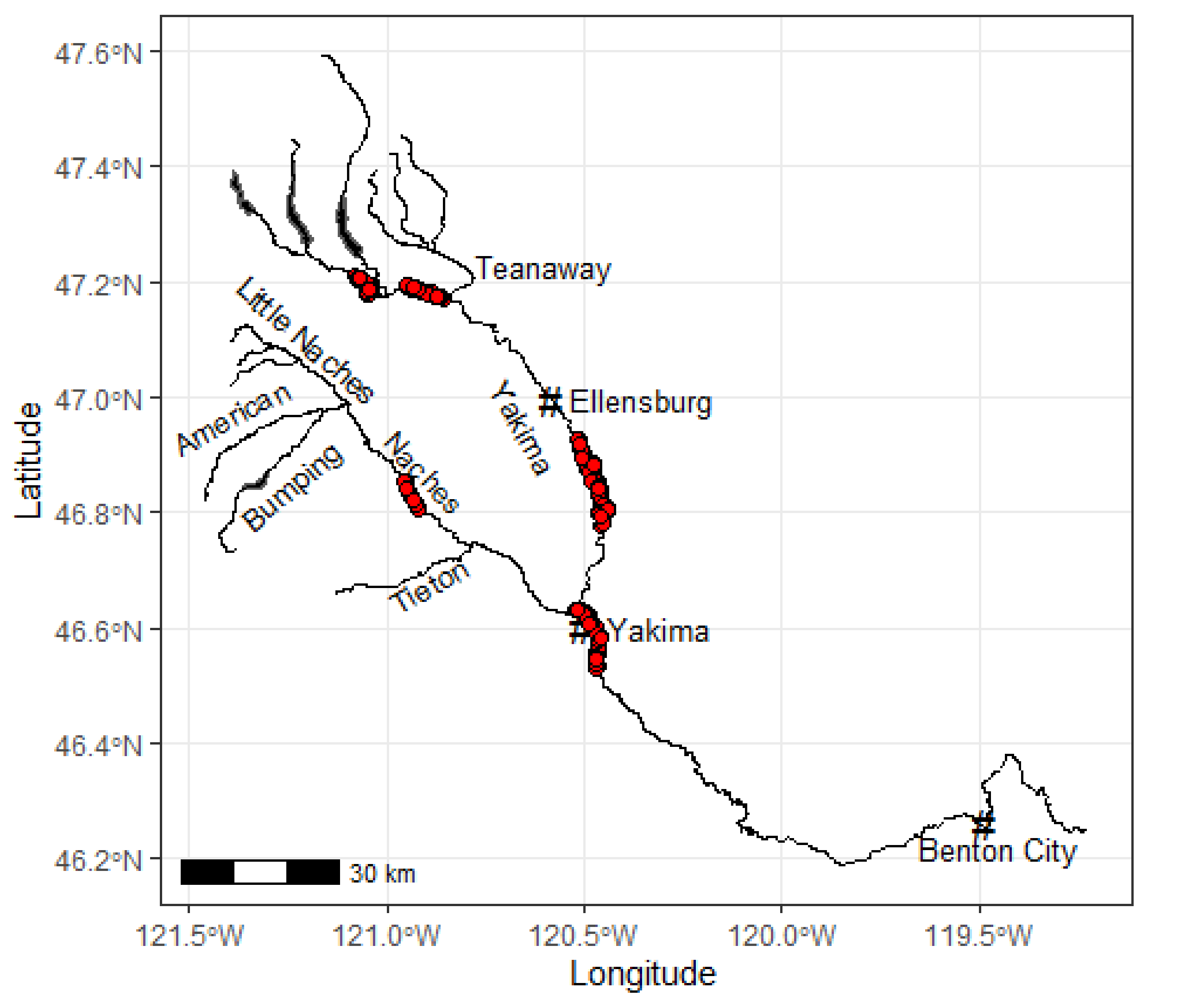
***But note: the greater tag detection efficiency, the less critical these factors become**

2024-25 Pilot Objectives

- Determine if we can detect tags
- Determine effort required to conduct sampling surveys
- Enumerate and categorize detected tags by species
- Estimate detection efficiency
- Sensitivity analysis for efficiency estimates
- Generate preliminary abundance estimates with a known sample
- View these in perspective of an existing tag group

Results

Effort and detections

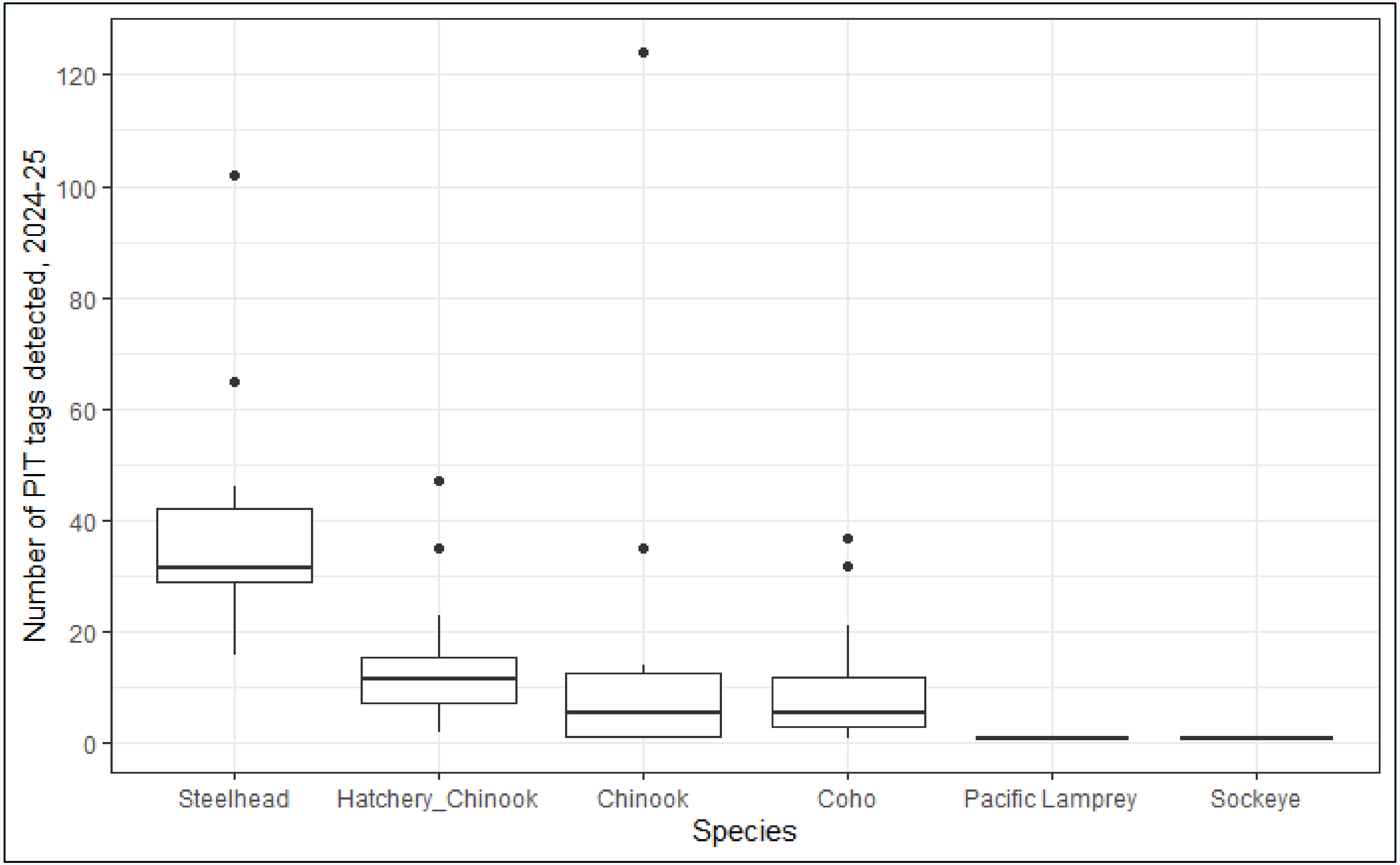


2024 single-raft surveys

- 18 bank surveys (Nov. 2024-April 2025)
- 106 river kilometers total
- 1407 tags detected
- 1284 of these (91%) on PTAGIS
- Mean: 15.5 tags/rkm, sd: also 15.5
- 21.7% from 2024-25 tag group

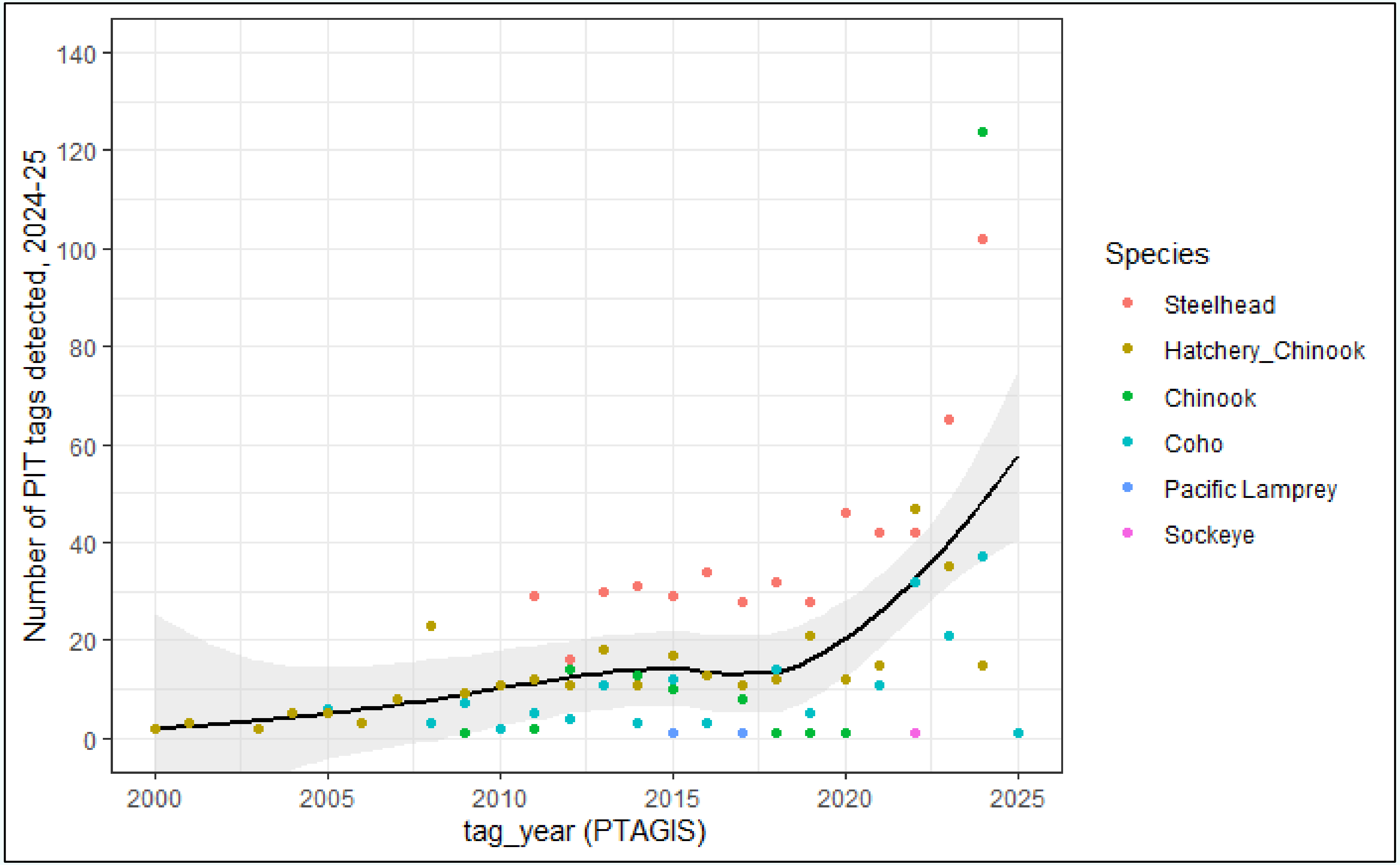
Results

Species composition of detected tags (n = 18 surveys)



Results

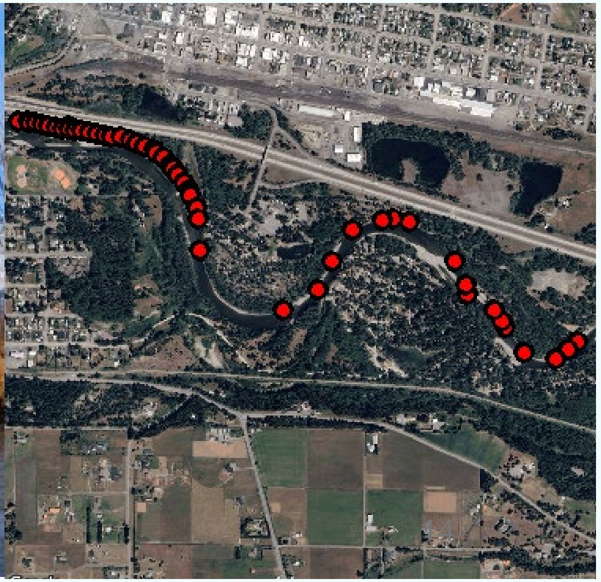
Detected tag composition by species/origin and mark year



Objective: Detection efficiency

2024 field study, Primary Investigator: Nick Mankus (WDFW)

- 50 tags placed along 3 RKM of bank habitat
- Two blind detection surveys, and two more 10d later
- Recaptures included both the placed tags and those of unknown origin ("ghost-tags")



Detection efficiency

Model Structure

1. Priors:

$$p_{\text{detect}} \sim \text{Beta}(1,5), \quad \lambda_{\text{ghost}} \sim \text{Normal}(5000, 3000)$$

2. Likelihood (Static Tags):

$$N_{\text{week1, both}} \sim \text{Binomial}(N_{\text{static}}, p_{\text{detect}}^2)$$
$$N_{\text{week1, pass1}} - N_{\text{week1, both}} \sim \text{Binomial}(N_{\text{static}} - N_{\text{week1, both}}, p_{\text{detect}} \cdot (1 - p_{\text{detect}}))$$
$$N_{\text{week1, pass2}} - N_{\text{week1, both}} \sim \text{Binomial}(N_{\text{static}} - N_{\text{week1, both}}, p_{\text{detect}} \cdot (1 - p_{\text{detect}}))$$

$$N_{\text{week2, both}} \sim \text{Binomial}(N_{\text{static}}, p_{\text{detect}}^2)$$
$$N_{\text{week2, pass1}} - N_{\text{week2, both}} \sim \text{Binomial}(N_{\text{static}} - N_{\text{week2, both}}, p_{\text{detect}} \cdot (1 - p_{\text{detect}}))$$
$$N_{\text{week2, pass2}} - N_{\text{week2, both}} \sim \text{Binomial}(N_{\text{static}} - N_{\text{week2, both}}, p_{\text{detect}} \cdot (1 - p_{\text{detect}}))$$

3. Likelihood (Ghost Tags):

$$N_{\text{week1, both}} \sim \text{Poisson}(\lambda_{\text{ghost}} \cdot p_{\text{detect}}^2)$$
$$N_{\text{week1, pass1}} - N_{\text{week1, both}} \sim \text{Poisson}(\lambda_{\text{ghost}} \cdot p_{\text{detect}} \cdot (1 - p_{\text{detect}}))$$
$$N_{\text{week1, pass2}} - N_{\text{week1, both}} \sim \text{Poisson}(\lambda_{\text{ghost}} \cdot p_{\text{detect}} \cdot (1 - p_{\text{detect}}))$$

$$N_{\text{week2, both}} \sim \text{Poisson}(\lambda_{\text{ghost}} \cdot p_{\text{detect}}^2)$$
$$N_{\text{week2, pass1}} - N_{\text{week2, both}} \sim \text{Poisson}(\lambda_{\text{ghost}} \cdot p_{\text{detect}} \cdot (1 - p_{\text{detect}}))$$
$$N_{\text{week2, pass2}} - N_{\text{week2, both}} \sim \text{Poisson}(\lambda_{\text{ghost}} \cdot p_{\text{detect}} \cdot (1 - p_{\text{detect}}))$$

4. Posterior:

$$P(p_{\text{detect}}, \lambda_{\text{ghost}} | \text{data}) \propto P(\text{data} | p_{\text{detect}}, \lambda_{\text{ghost}}) \cdot P(p_{\text{detect}}) \cdot P(\lambda_{\text{ghost}})$$

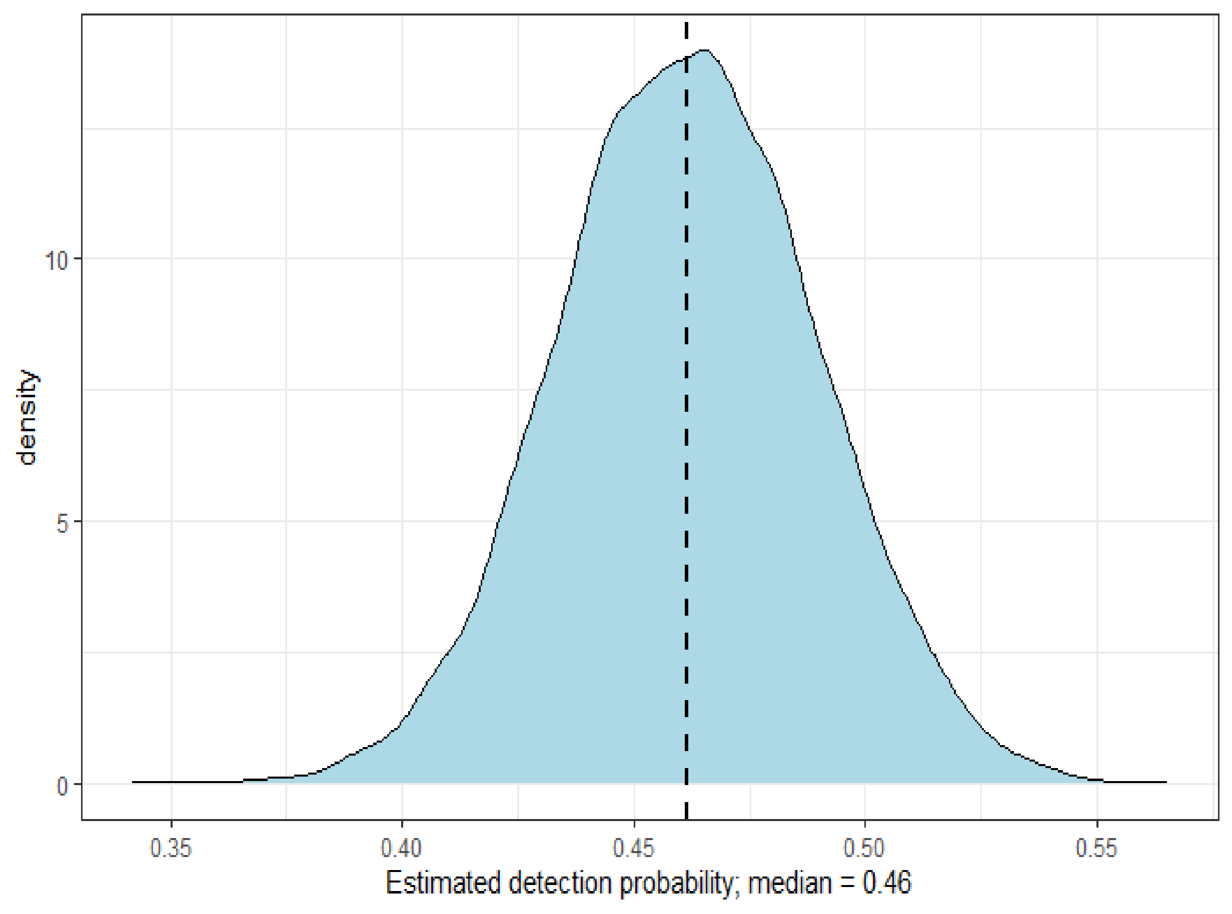
Priors lean toward lower values of detection, median ~ *Pr(0.13)*

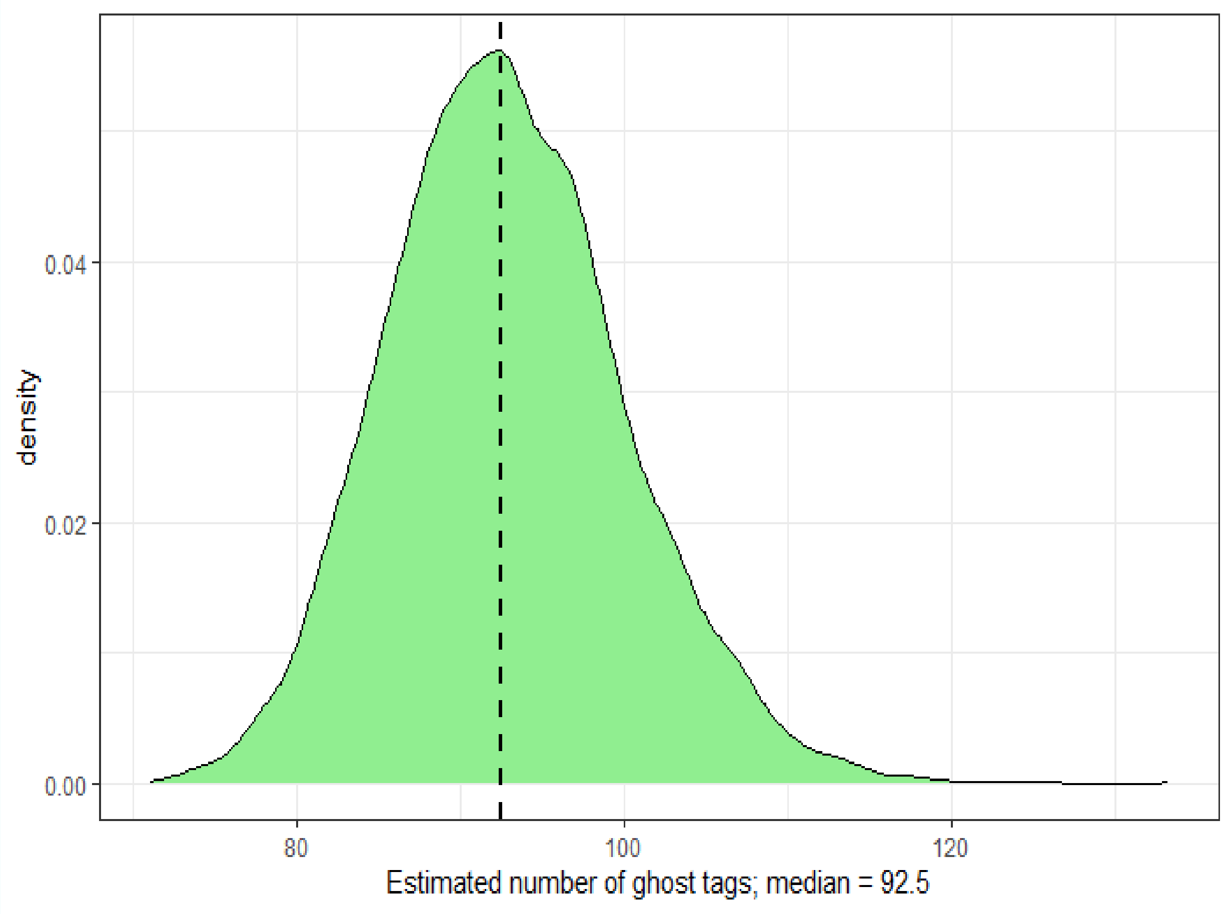
Here a binomial distribution for static tags. These are count data with a known number of placed tags

This is a marginal likelihood for the probability of ghost tag detection, where the total number of ghost tags is a latent variable

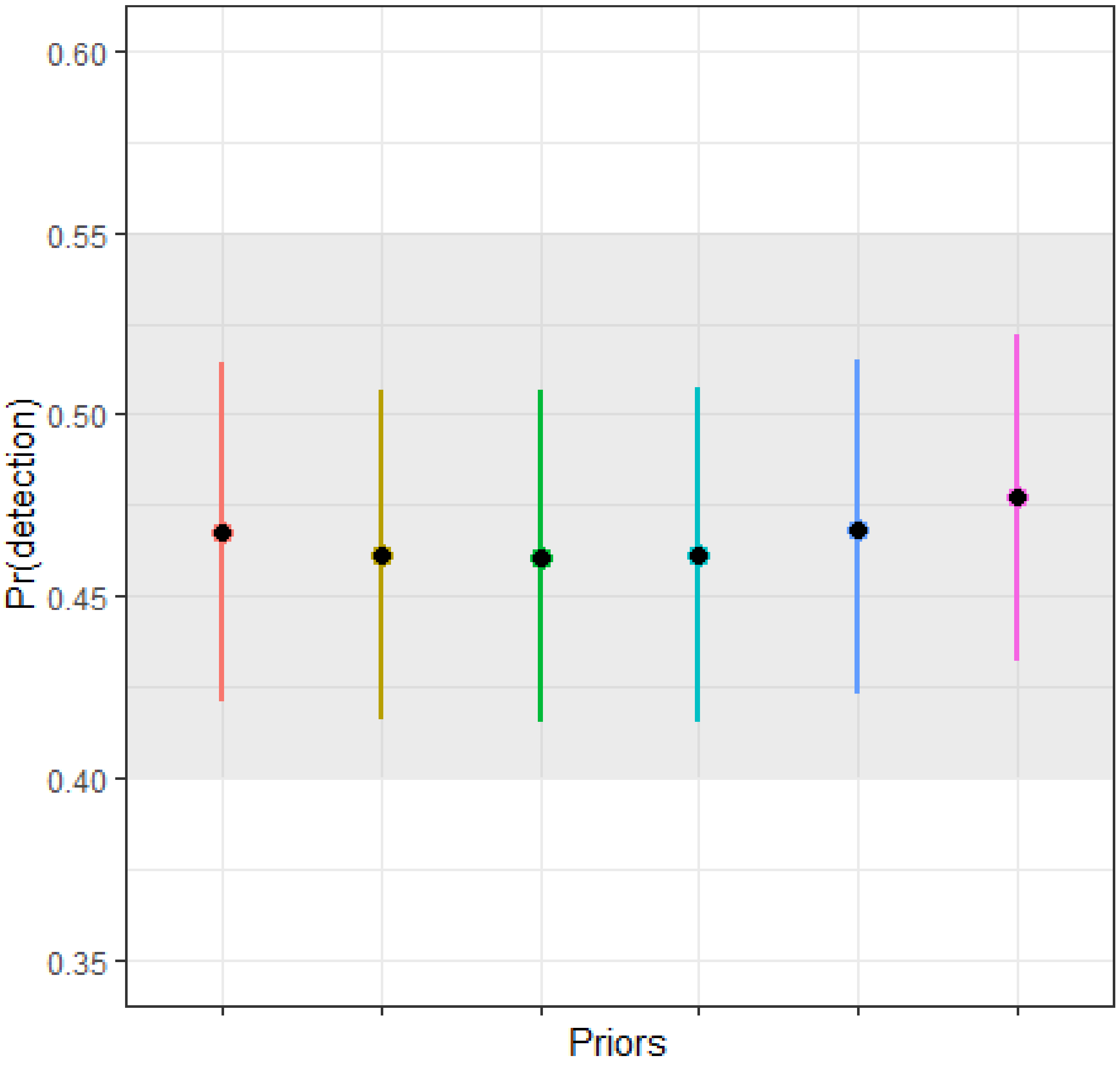
And finally, the probability of detection and n ghost tags (our latent variable) given the data

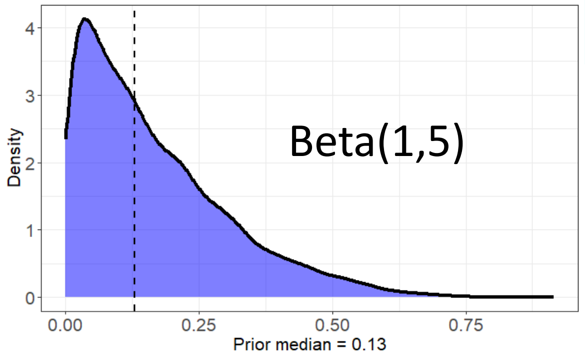
Probability of detection and n “ghost” tags

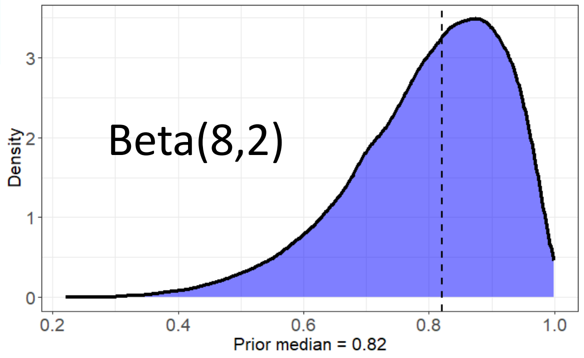




Prior sensitivity







Sensitivity analysis suggests minimal change to the response variable across a broad range of priors

Abundance estimates
Application with estimated efficiency

Model Structure

1. Priors

$$\mu_N \sim \mathcal{N}(50, 30), \quad N_{\text{cont}} \sim \mathcal{N}(\mu_N, 20), \quad p_{\text{detect}} \sim \mathcal{N}(p_{\text{detect, mean}}, p_{\text{detect, sd}})$$

2. Likelihood

$$N_{\text{detected}} \sim \text{Poisson}(N_{\text{cont}} \cdot p_{\text{detect}})$$

3. Posterior

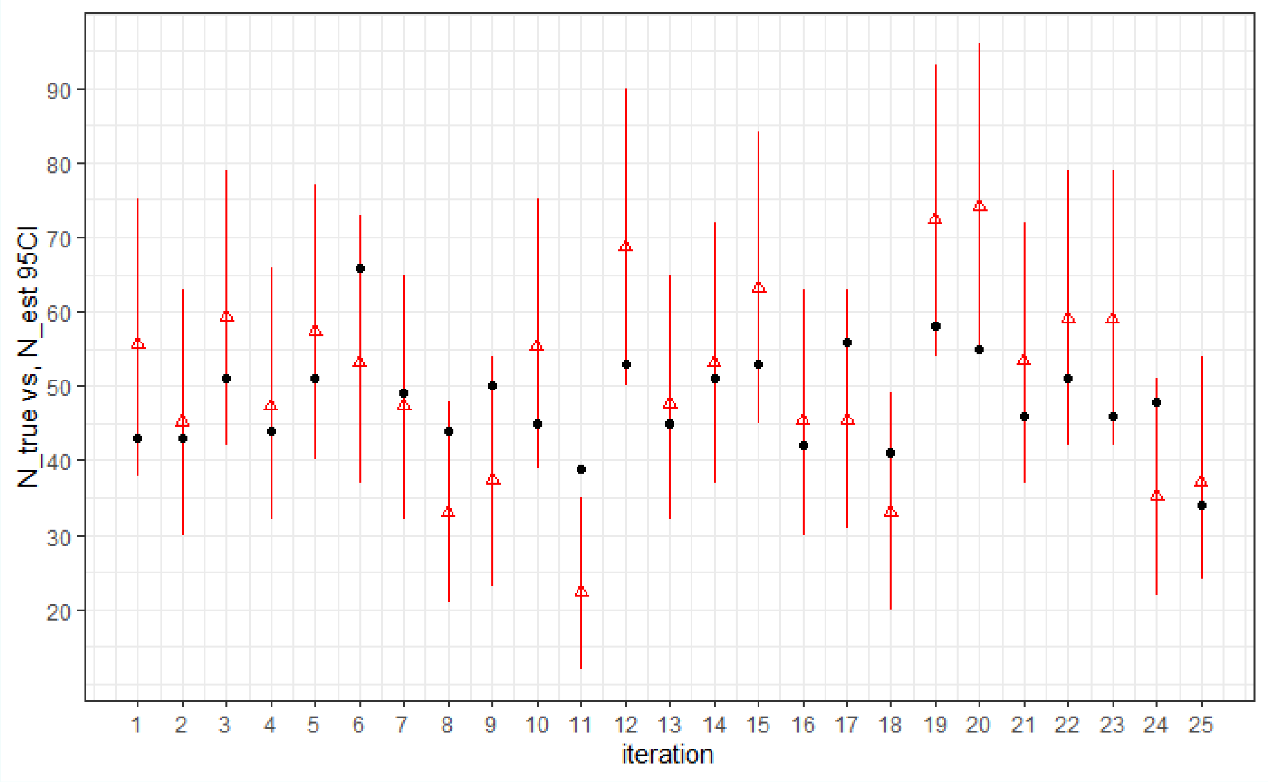
$$P(\mu_N, N_{\text{cont}}, p_{\text{detect}} \mid N_{\text{detected}}) \propto P(N_{\text{detected}} \mid N_{\text{cont}}, p_{\text{detect}}) \cdot P(N_{\text{cont}} \mid \mu_N) \cdot P(\mu_N) \cdot P(p_{\text{detect}})$$

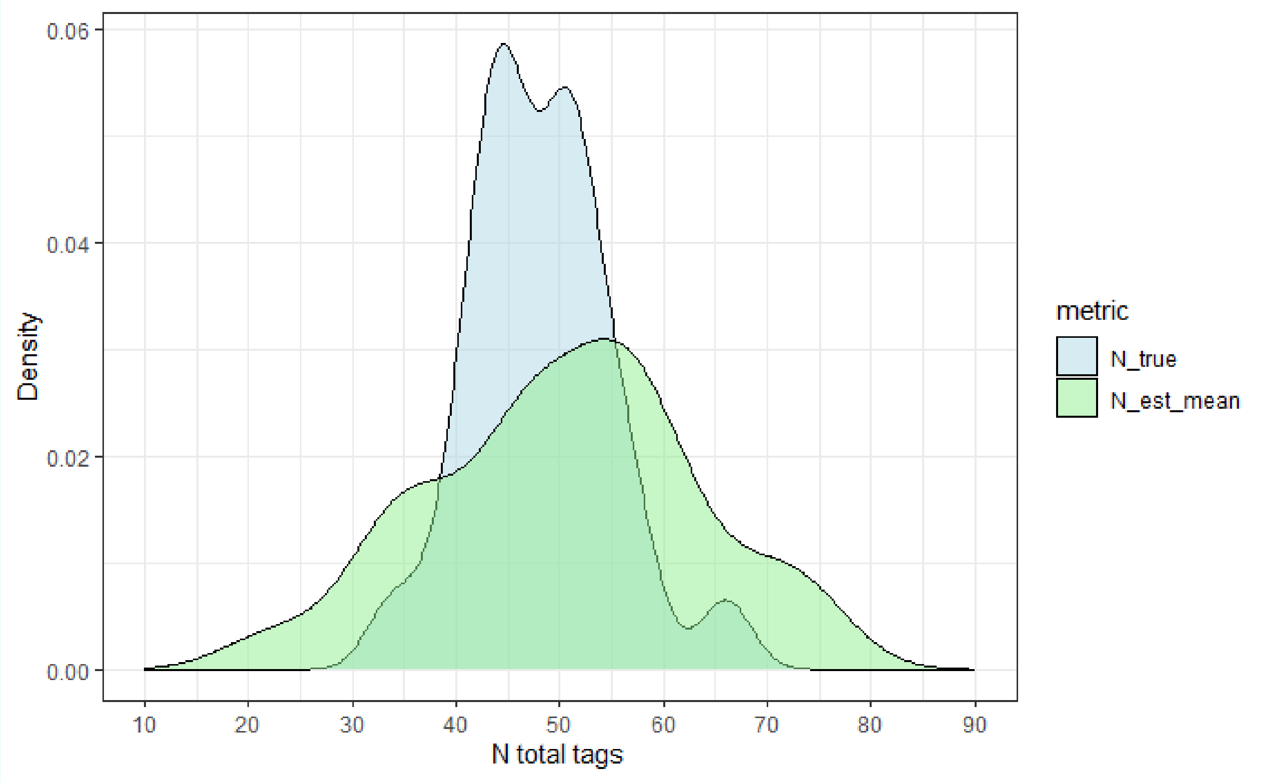
4. Generated Quantities

$$N_{\text{est}} = \text{round}(N_{\text{cont}})$$

Abundance estimates

Posterior prediction; simulated data (variable N)





Comparison of the distribution of estimates over 25 model fit iterations, when allowing true N to follow a Poisson distribution centered on N = 50

Are our abundance estimates reasonable?

Fall 2024 Spring Chinook Salmon tagging effort; Expected tag density given tag group and distance *if equally distributed*:

Yakima ~ 5000 PIT-tags / (185 RKM * 2 banks) = ~ 13.5 tags/RKM/bank

Naches ~ 5000 PIT-tags / (123 RKM * 2 banks) = ~ 20.3 tags/RKM/bank

Total ~ 10,000 PIT-tags/ 308 RKM * 2 banks) = ~ 16.2 tags/RKM/bank

Reach*	Bank	RKM	n_obs	n_est	est/rkm	q05	q95	n_expected	% of expected
Harlan to Birchfield	left	186-180	4	11	1.8	0.6	3.5	97	11.3
Harlan to Birchfield	right	186-180	2	7	1.2	0.2	2.5	97	7.2
Birchfield to Century	left	180-172	3	9	1.1	0.4	2.3	130	6.9
Birchfield to Century	right	180-172	3	9	1.1	0.4	2.3	130	6.9

*survey sections are below the lowest tag release sites

2024-25 pilot results summary

- Methodology is capable of detecting tags
- Required effort appears reasonable, ~ 100 RKM/raft/season
- Multiple species, origins, and tag years represented in the detections
- Preliminary estimates of detection efficiency appear favorable and robust
- Subsequent estimates of abundance were near known values
- Estimates of abundance were reasonable (on scale with) expectations for a known tag group.

What's next?

- Two rafts for 2025-26 surveys
  - + 2 additional rafts and associated surveys *if* SRFB funded (YBFWRB assisted, thank you)
- Live vs static
  - Possible attempt at a closed design assessment of live vs. static tag detection efficiency
- Confounds in detection probability
  - Measurement of and modeled influence of potential confounds (e.g., depth, speed, electrical interference)
- Habitat-specific differences in detection efficiency
  - Multiple pass estimates with known N tags in variable habitats
- Antenna design
  - Investigation of improved detection efficiency through antenna orientation or design

Antenna Design

- Increased access to bank habitats
- Improved detection efficiency
- Potential for dual antennas
- Adjustable mounting

Photo: Zack Mayes (YN)

End

- Questions/Comments/Discussion