

Catch Me If You Can

Steelhead Trap Effectiveness & Behavioral Insights

Derrek Faber, Lindsay Powell & Jason Seals

Oregon Department of Fish and Wildlife

The Dalles, OR

Understanding escape behavior to improve population estimates



The Initial Question – Operation of Hood River Rotary Screw Traps

When do fish arrive at the trap?

How can we optimize our release time?

Should we randomize release?

Deploy automated release devices?

Methods: Trap Setup

Location & Period

Rotary screw traps on mainstem Hood River near old Powerdale Dam site

Spring season (March-June)

PIT Tag Technology

FS2001 racket antenna in trap live box

Continuous 24/7 detection of tagged fish

Daily Operations

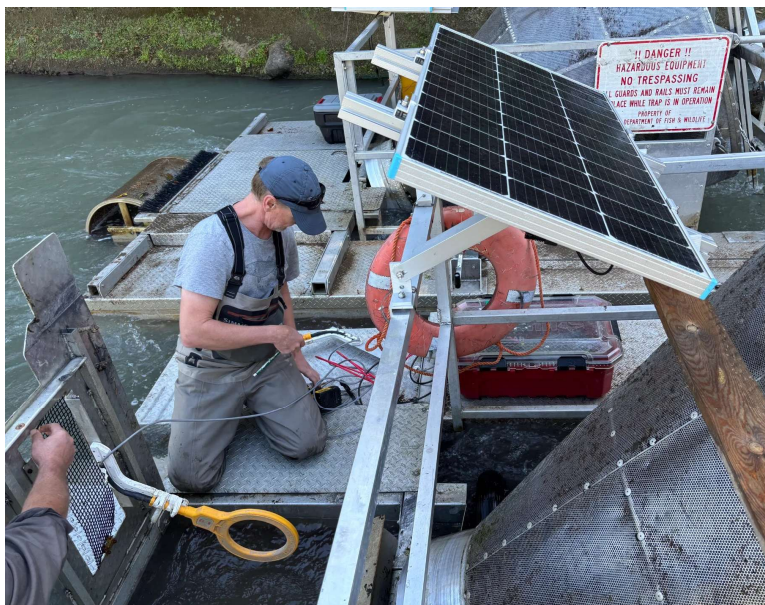
Standard check time: 8:30 – 9:30 AM

Release Time: 9:30 – 10:30 AM

Setup

Raspberry Pi with solar power and data logging enables continuous monitoring
Captures exact arrival and departure times for every tagged fish

- First detection timestamp
- Residence duration
- Last detection timestamp
- PTAGIS Recapture status (caught/escaped)



Antenna detection range: 1 ft on each side of antenna, immediately behind entrance

Methods: Trap Rotation on Mainstem Hood River

Spring:

8 to 12 rpm

Fall:

5 to 8 rpm

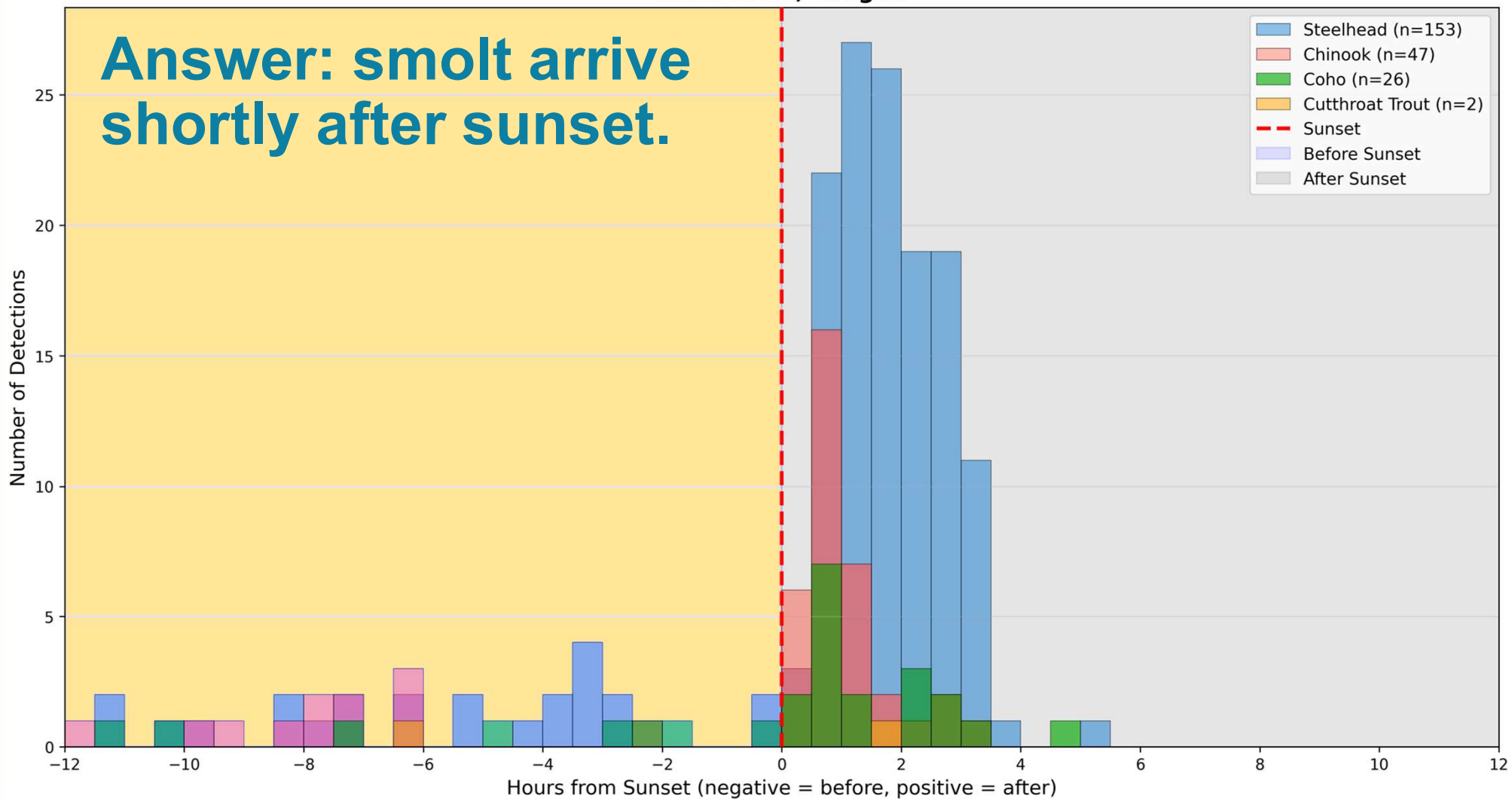
**Detection
Efficiency:
97.6%**

120 steelhead detected vs
123 collected while both
detectors/traps operating.



All Species - First Detection Time Relative to Sunset Hood River, Oregon

Answer: smolt arrive shortly after sunset.



The Discovery

The Problem

Not all fish that enter a trap are captured at morning check

Some fish escape before detection, possibly biasing population estimates

The Question

When do fish arrive and leave the trap?

Can we optimize check timing to improve trap efficiency?



Fish escaping before check = underestimated population

Trap Comparison

STEELHEAD

37.6%

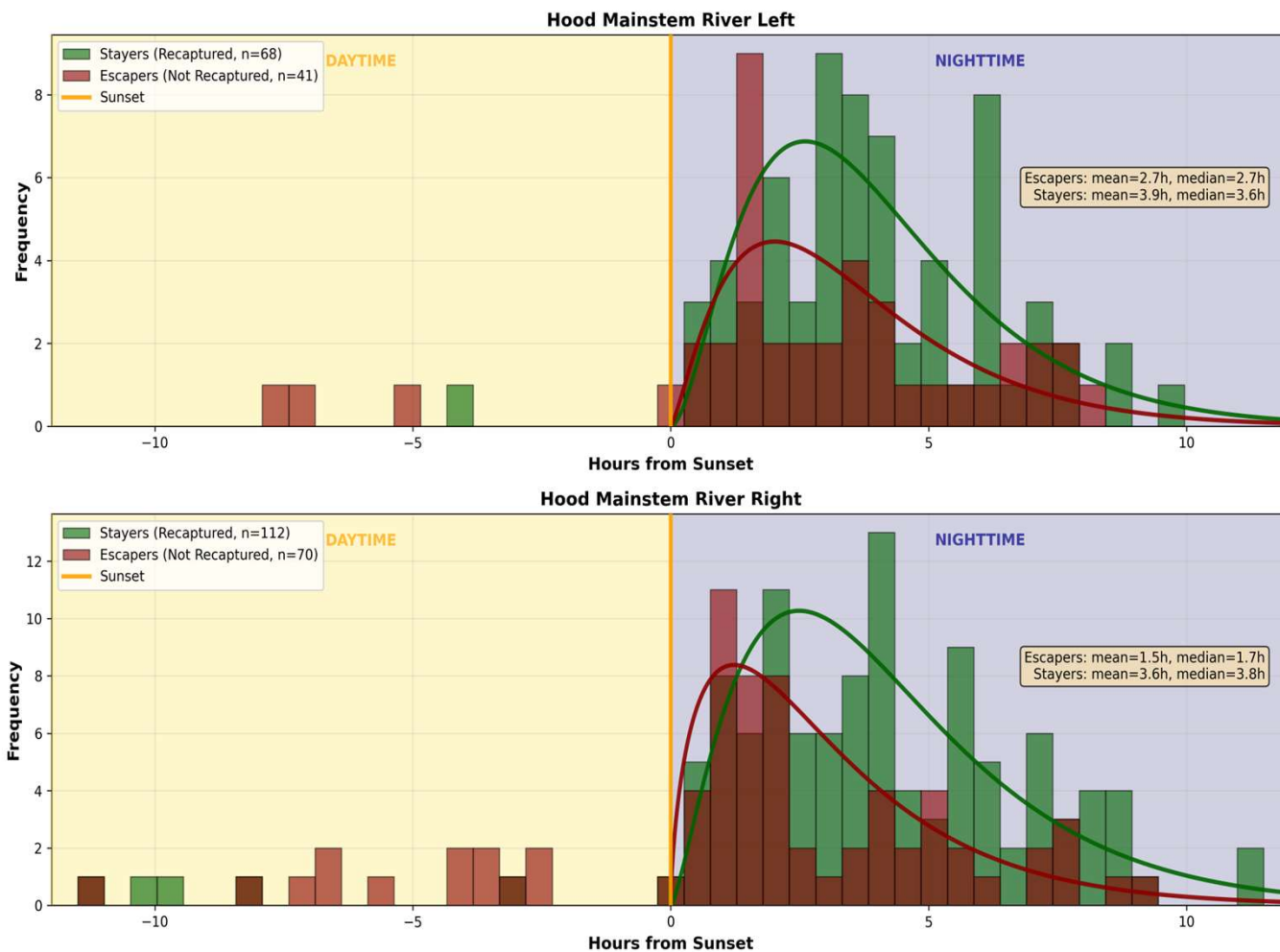
escape rate – River Left Trap

STEELHEAD

38.5%

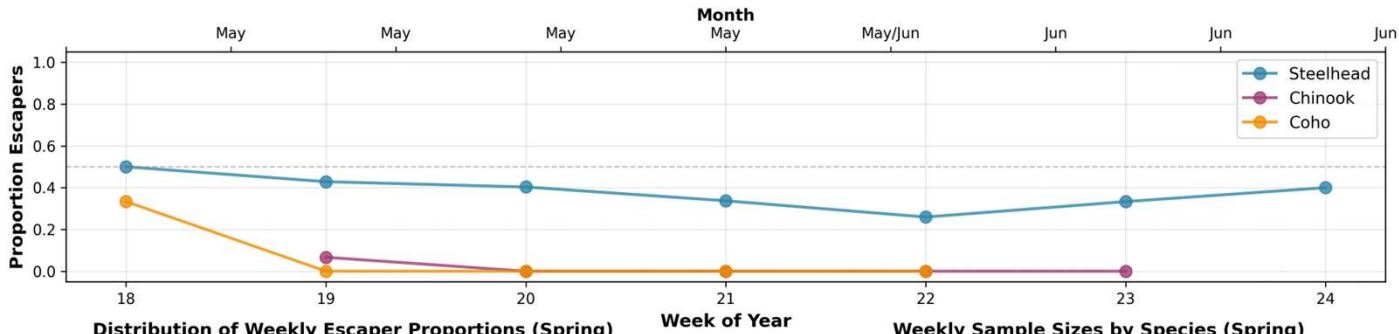
escape rate – River Right Trap

Steelhead Arrival Times Relative to Sunset Mainstem Hood River Traps

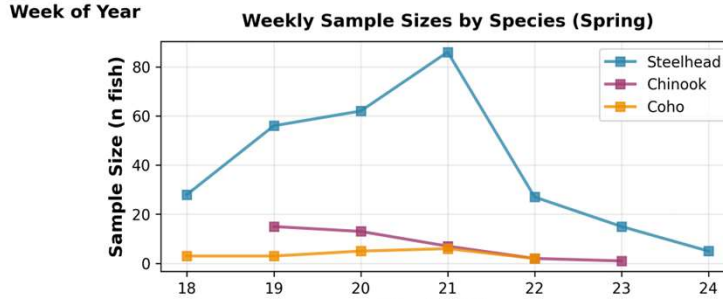
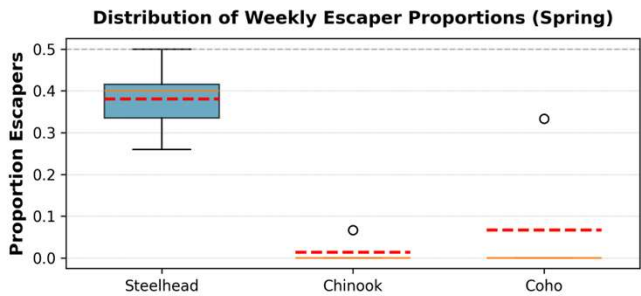


Species Differences

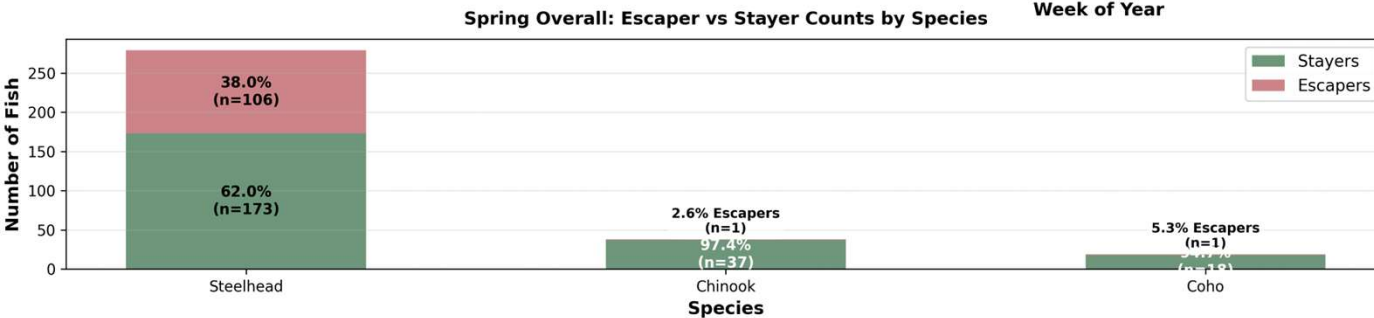
Spring Period (March-June): Escaper Proportion by Week and Species



STEELHEAD
38%
escape rate



CHINOOK
2.6%
escape rate

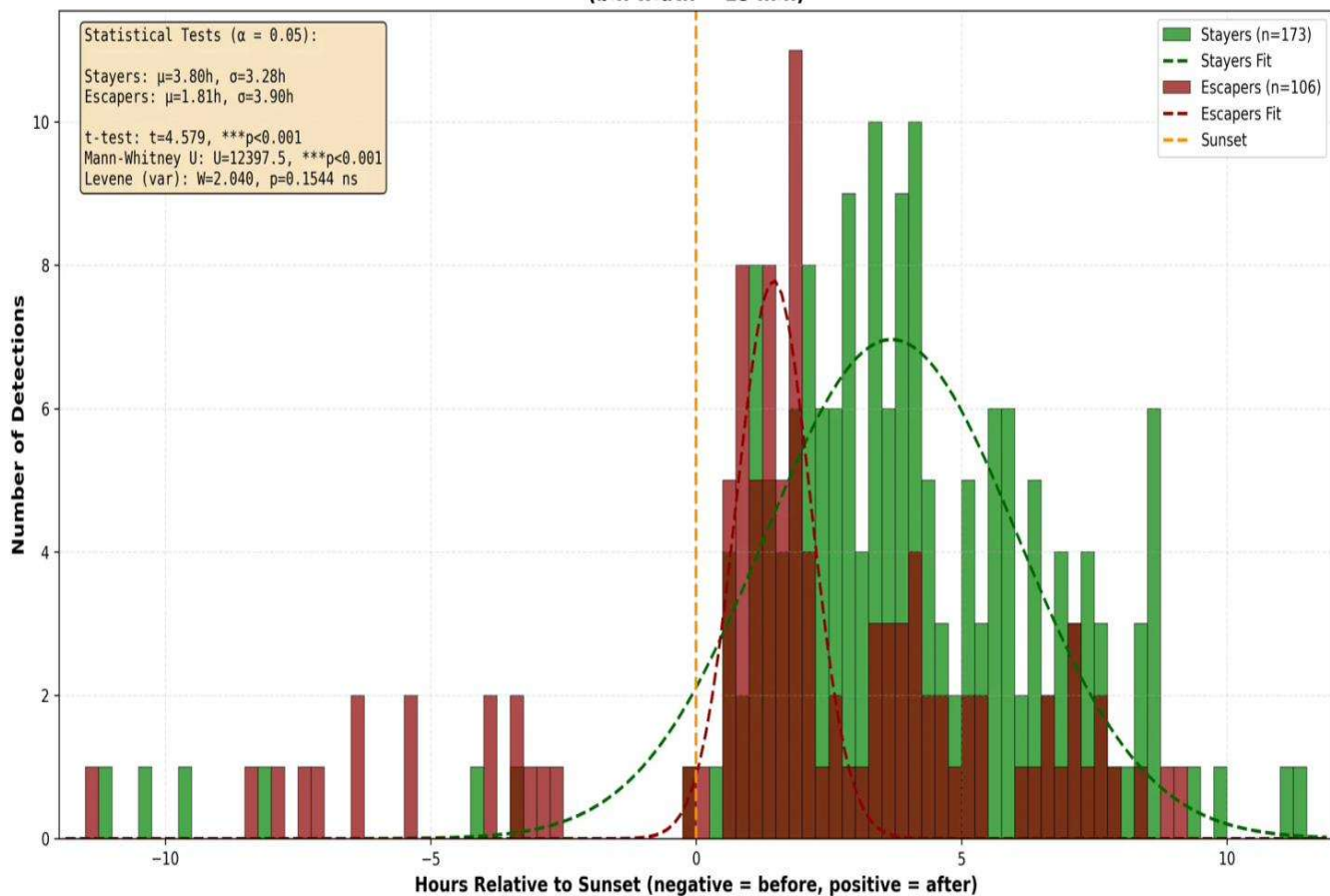


COHO
5.3%
escape rate

Total marked fish across all species during spring season

When Do Steelhead Enter the Trap?

Steelhead - Stayers vs Escapers
Spring Season - First Detection Times
(bin width = 15 min)



STAYERS

3.8 h

after sunset

ESCAPERS

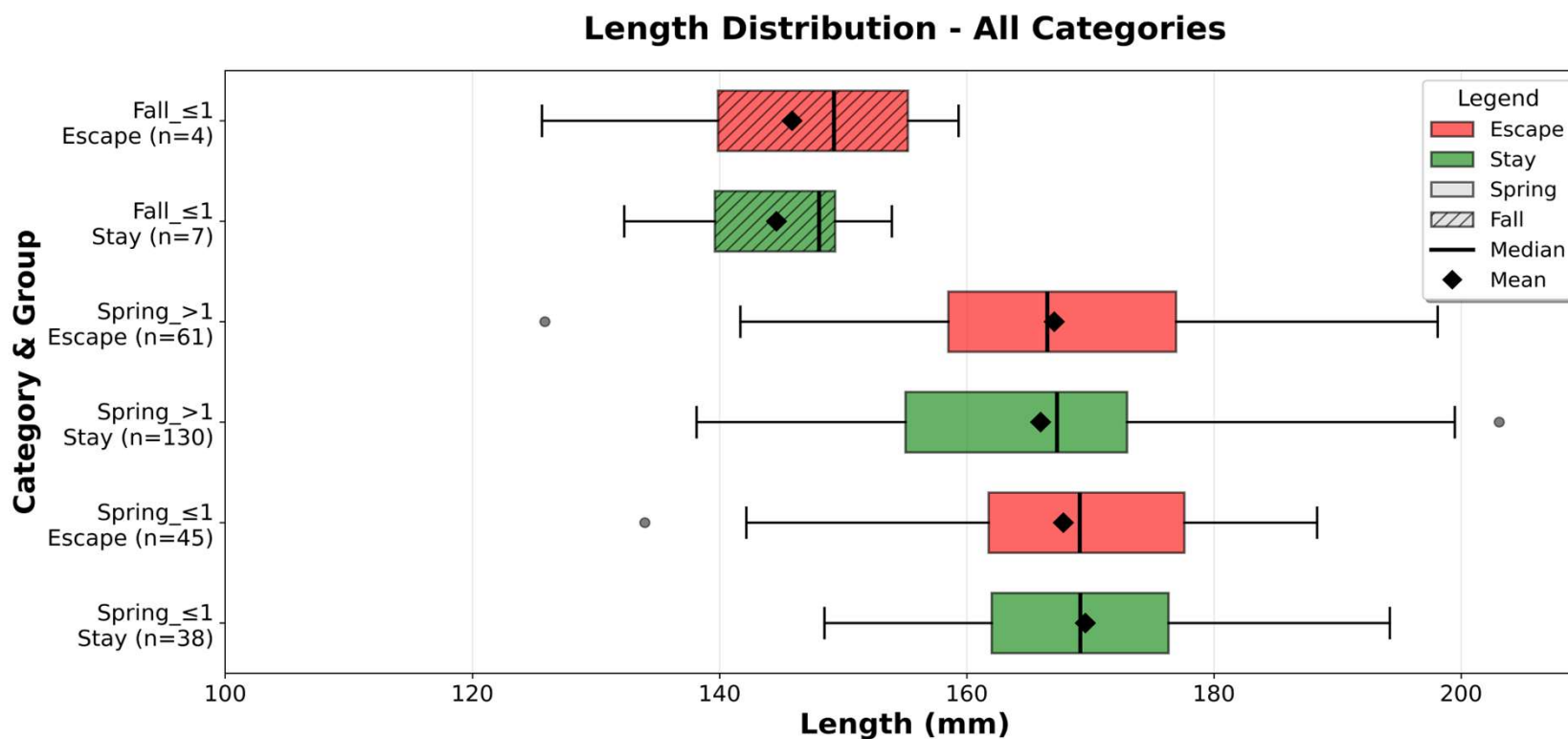
1.8 h

after sunset

Peak entry: Strong concentration around sunset for both groups, significantly different.

Escapers vs Stayers: Size Matters?

Steelhead - Comprehensive Morphology Comparison All Seasons and Release Timings Combined



Escapers show significantly larger fork length (172mm vs 167mm, $p < 0.01$)

Residence Time: A Critical Difference



STAYERS

6.6 hrs

mean residence

ESCAPERS

2.5 hrs

mean residence

DIFFERENCE

2.66x

longer

Critical threshold around 5 hours

Four Trap Efficiency Models

Model 1: Mean Entry Time

Assumes all fish are escapers; uses distribution to bootstrap mean arrival time to estimate decay

Model 2: Mixture Model

Two behavioral groups with different residence distributions

Model 3: Kaplan-Meier

Survival analysis approach accounting for censored observations

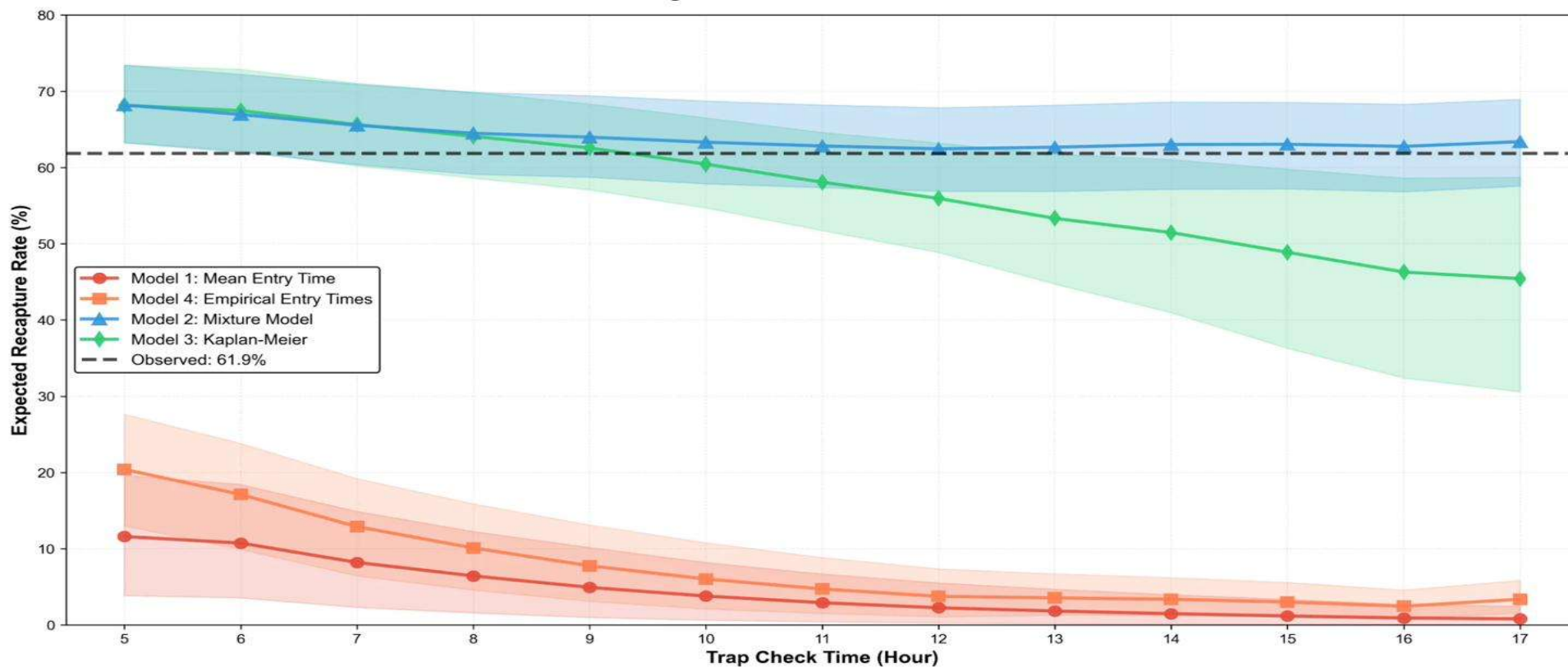
Model 4: Empirical Entry Times

Uses actual observed entry time distribution for escapers

Each model makes different assumptions about fish behavior and residence patterns

Model Performance Comparison

Steelhead Trap Efficiency: Model Comparison
Shaded regions show 95% confidence intervals



Mixture model (Model 2) best captures observed trap efficiency of 61.9%

The Behavioral Heterogeneity Story

Why Mixture Model Wins

Mixture model matches observed efficiency because it explicitly recognizes TWO distinct behavioral phenotypes

The Two Groups

STAYERS

Long residence (6.6 hrs)
Likely captured

ESCAPERS

Short residence (2.5 hrs)
Likely escape

Key Insight

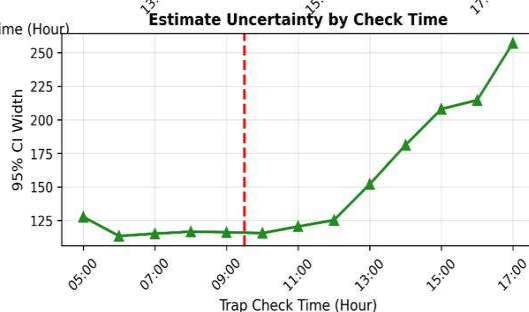
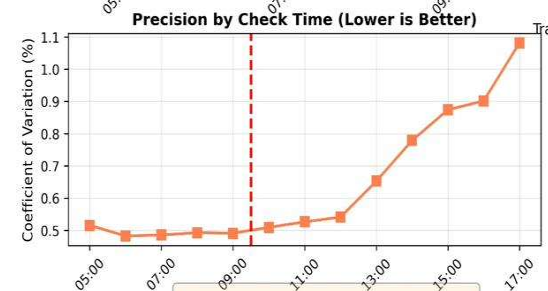
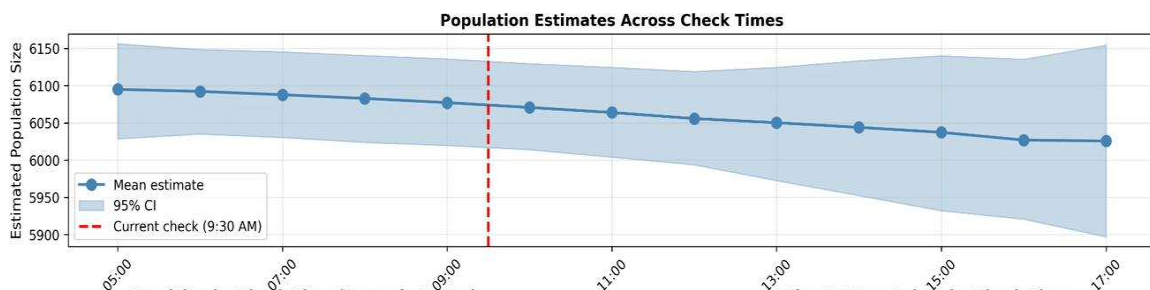
These are NOT random variations - they represent fundamentally different behavioral strategies

Understanding this heterogeneity is crucial for accurate population estimates

Single-group models (1, 3, 4) fail to capture this complexity

Optimal Check Times

Steelhead - Chapman Population Estimates by Trap Check Time



SUMMARY STATISTICS

Current Check Time (9:30 AM):
 Population Estimate: 6077.2
 95% CI: (6019.7 - 6135.9)
 CV: 0.5%

Optimal Check Time (06:00):
 Population Estimate: 6092.2
 95% CI: (6035.1 - 6148.5)
 CV: 0.5%

Improvement: 1.7% reduction in CV

Earlier checks capture more fish before escapement, improving precision

CURRENT CHECK

9:30 AM

0.5% CV precision

OPTIMAL CHECK

6:00 AM - Noon

0.5% CV precision

Don't check after noon

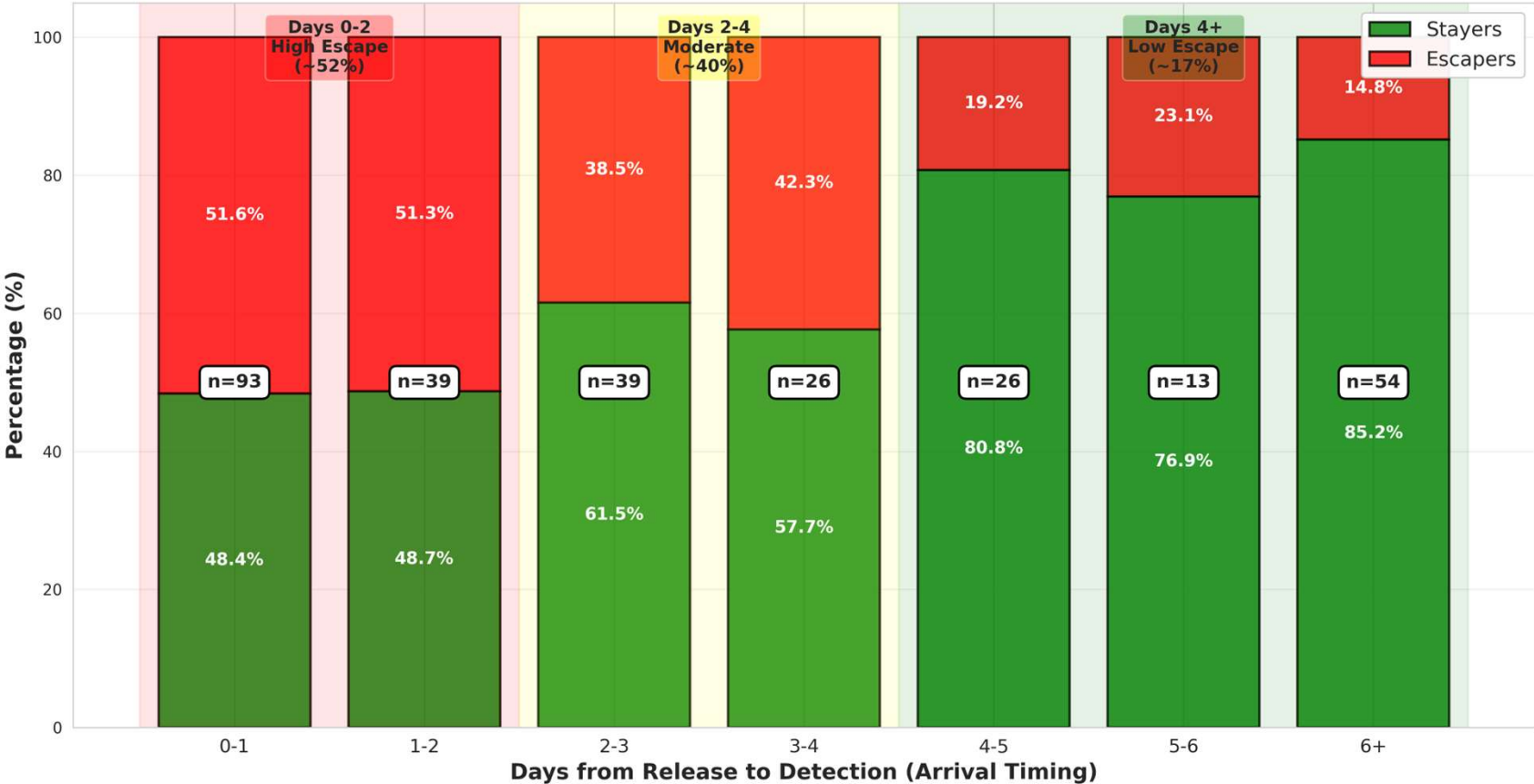
Precision falls

River Residence vs. Recapture Rate (Trap Avoidance?)

Distribution of Escapers vs Stayers by Arrival Timing
Does migration speed predict trap behavior?

Escapers

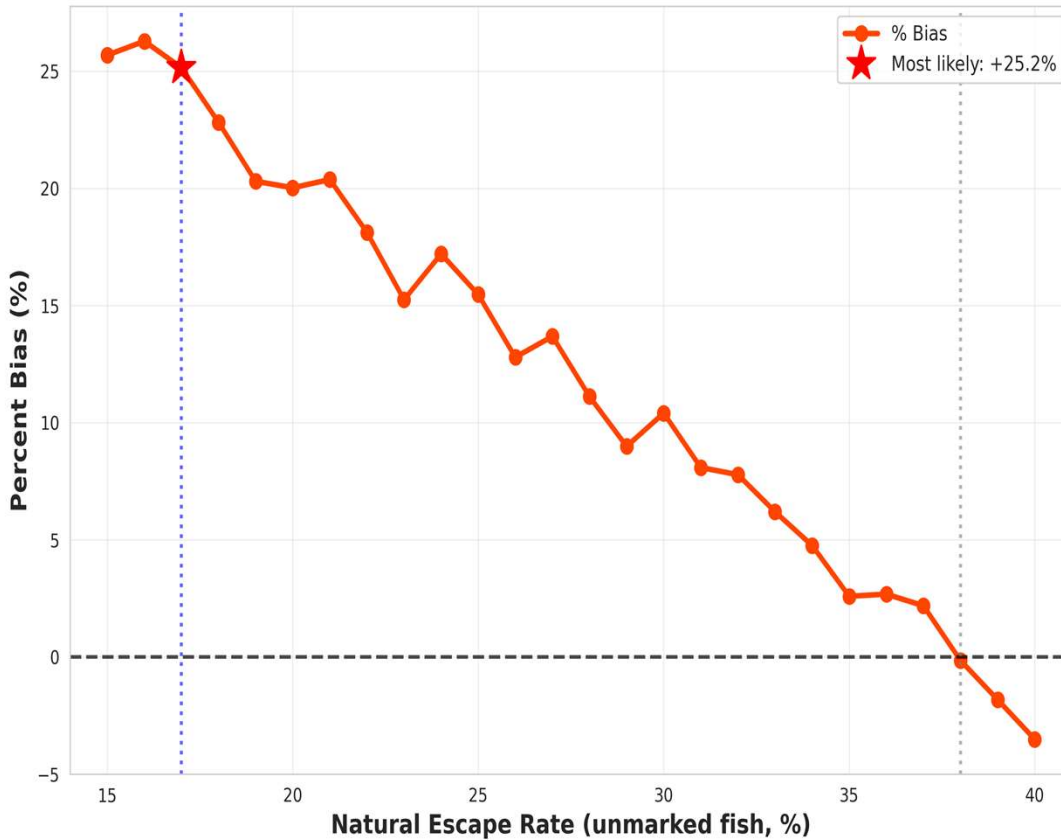
Stayers



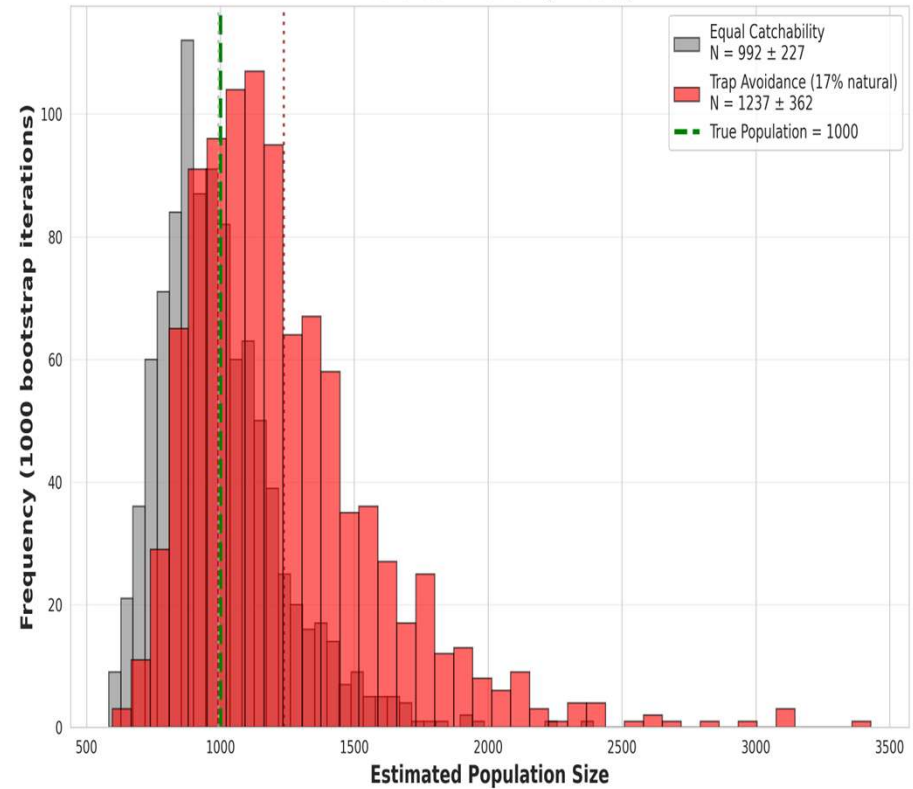
Population Estimate Bias?

(unmarked steelhead follow residence distribution)

Relative Population Estimate Bias
At 17% Natural Rate: +25.2% Overestimate



Population Estimate Distributions
Difference: 245 fish (+24.5%)



What Drives the Difference?

Potential Factors

- ****Tag status:** Previously tagged fish + time, may reduce trap avoidance (escape) behavior
- **Size effects:** Larger fish (escapers) appear to be more escape-prone
- **Sex differences:** Males vs females may show different residence patterns???
- **Smolt readiness:** Physiological preparation for ocean entry (smoltiness)

Run-of-River Fish (1-2 days river residence)

Shorter trap residence
48% recapture rate

Established Fish (>4 days)

Longer trap residence
83% recapture rate

Fish that traveled >1 day show more "stayer" behavior

Key Takeaways

1. Steelhead show 38% escape rate - highest among salmonids, precision of population estimates impacted by check-time as it stands

2. Two distinct behavioral phenotypes: stayers (6.6 hrs) vs escapers (2.5 hrs). Is this different between steelhead populations?

3. River residence influences escape behavior in our Hood River population, pointing to Trap Avoidance as most likely escape driver.

4. Earlier check times (6:00 AM - noon) could keep precision high, but also need to assess unmarked steelhead behavior (e.g., bias in capture frequency between marked/unmarked fish)

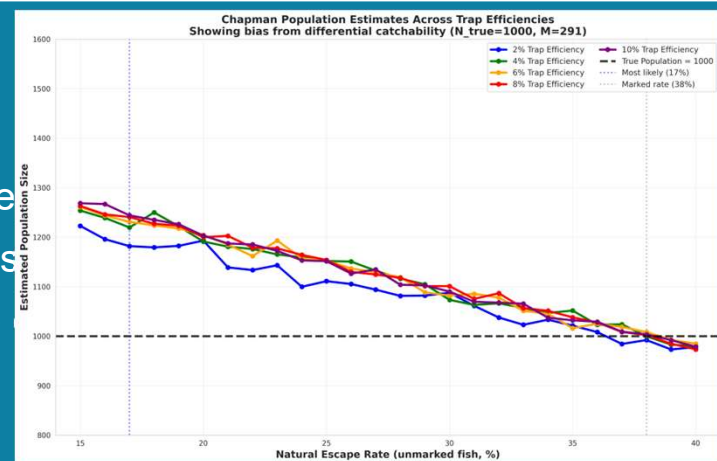
Acknowledgements

- **Field Operations & Data Collection:**
 - Calley Freedom - ODFW
 - Cort Colby - ODFW
 - Bob Edwards - ODFW
- **Watershed Coordination:**
 - Cindy Thieman, Hood River Watershed Coordinator
- **Project Support:**
 - OWEB

Future Directions

Tracking Behavioral Drivers

- Investigate sex at recapture to test male/female differences (gender)
- Track tag history (new vs previously tagged), fish from previous years
- Monitor environmental conditions (flow, temperature), and trap efficiency
- Calculate migration speed metrics systematically



Operational Changes

- Consider earlier check times
- Apply mixture models for estimates

Research Questions

- What predicts escape phenotype?
- Are these behaviors heritable?

Understanding behavioral drivers improves monitoring strategies