Contributions of natural and reconditioned repeat spawning female steelhead to spawning above Lower Granite Dam

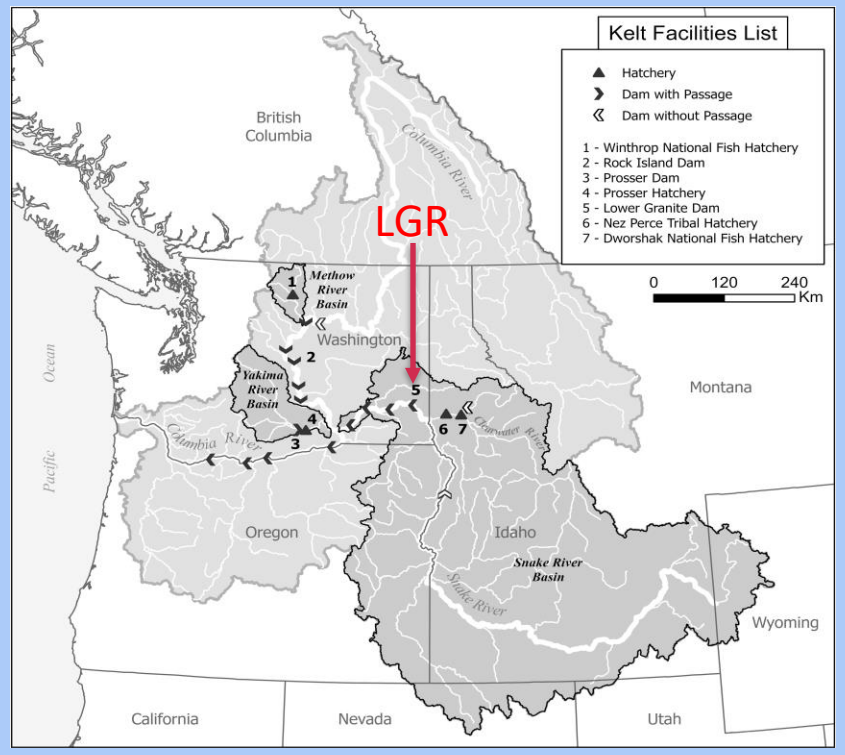
Laura Jenkins, Corey Dondero, Neil Graham, Ben Staton, Ryan Kinzer, Mike Ackerman, Lea Medeiros, James Nagler, Tim Copeland, Doug Hatch, Andrew Pierce

Columbia River Inter-Tribal Fish Commission
Idaho Department of Fish and Game
Nez Perce Tribe Department of Fisheries Resources Management
Department of Biological Sciences, University of Idaho

Steelhead and Repeat Spawning

- Natural origin steelhead stocks above LGR are in decline and may be facing extirpation
- Steelhead can repeat spawn
  - Most repeat spawners are female
  - Repeat spawning occurs 1 or 2 years after first spawning (consecutive and skip spawning)
- Benefits
  - Provide greater reproductive contributions than 1st time spawners
  - Increase population stability, particularly in poor recruitment years
- Repeat spawners successfully return to LGR at a rate of ~1.2% in natural origin steelhead
- However, despite low # of Natural repeat spawners, post-spawn, downstream migrating steelhead (kelts) are abundant

Kelt reconditioning utilizes aquaculture as a conservation tool in the Columbia R. Basin



Pierce et al. 2025 Fisheries

Collection

- Natural origin female steelhead collected post-spawn at LGR JBS

Transport

- By truck to reconditioning facilities

Reconditioning

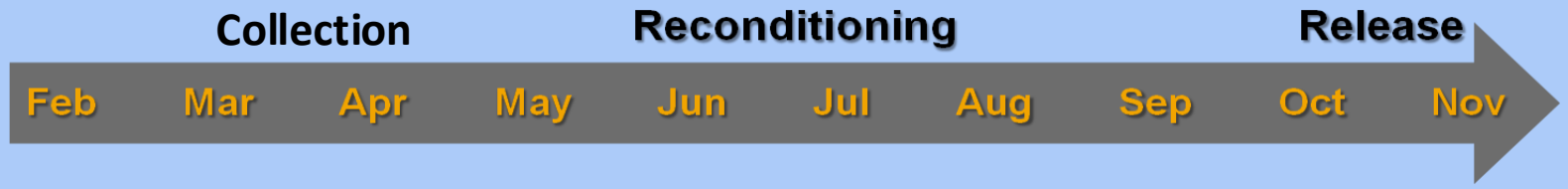
- Held in tanks on river water
- Natural photoperiod
- Satiation fed krill & pellets

Sampling

- Plasma E2 measured to determine reproductive status

Release

- In fall, below LGR, to migrate and spawn with wild run
- Skips held over winter , fed, re-evaluate the following fall



Research Objectives

1. Quantify **kelting rates** back to LGR

2. Determine rates of **repeat spawning** and **consecutive/skip spawning** in both Natural and Reconditioned repeat spawners
    1. Explore potential predictors of consecutive/skip spawning rates

3. Determine **contributions** of both Natural and Reconditioned repeat spawners to the spawning run above Lower Granite Dam (kelt reconditioning at the *research scale*)

Methods

- Combined datasets from PTAGIS, CRITFC/NPT, and IDFG
- Restricted data to:
  - natural-origin steelhead
  - female steelhead
- **Pre-spawn dataset**
  - Represents the run at large
  - Natural-origin steelhead PIT-tagged at LGR adult fish trap during upstream migration
    - ~Year-round systematic sampling, ~20% run is tagged, biological samples collected
- **Post-spawn dataset** –
  - Represents the portion of the upstream (pre-spawn) run detected during kelt migration
  - PITs placed during upstream migration were detected at LGR JBS in spring after spawning
- **Repeat spawn dataset** –
  - Represents portion of the pre-spawn run detected on a repeat spawn (upstream) migration
  - PITs placed during upstream migration were detected 1 or 2 years later at LGR adult ladder

Analysis – kelt detection efficiency

- Retrieved complete tag histories of **natural origin steelhead** that migrated up through LGR adult ladder (captured and PIT-tagged at LGR or tagged previously), analyzed using mark-recapture
- **Restricted dataset to fish detected upstream** at IPTDS, MRR sites, indicating successful migration to a spawning area (mark/release)
- **Downstream detections** (recapture) occurred at either LGR JBS and later spillway antennas and/or further downstream in Snake or Columbia River hydrosystem or estuary antennas
- Excluded kelts collected for reconditioning, and fish later ID-ed as hatchery-origin/unknown sex
- Implemented Cormack-Jolly Seber (CJS) models – mark recapture analysis
- Candidate models included fixed effects for predictors of detection and survival: spawn year, spawning population, sex, and any biologically plausible interaction terms

AIC table for survival (φ) and detection (p)

Model	Terms	Delta AIC
Phi(~year + pop * sex + time)p(~year * time)	**89**	**0**
Phi(~year + pop * sex + time)p(~year * time + sex)	90	1.549812
Phi(~year + pop + sex + time)p(~year * time)	68	27.3944
Phi(~year + pop + sex + time)p(~year * time + sex)	69	28.45477
Phi(~pop + sex + time)p(~year * time + sex)	55	68.5107
Phi(~pop + time)p(~year * time + sex)	54	74.51936
Phi(~year + pop + time)p(~year * time + sex)	68	80.44341
Phi(~pop + sex + time)p(~year * time)	54	80.87168
Phi(~pop * time)p(~year * time + sex)	75	85.04739
Phi(~year + mpg + sex + time)p(~year * time + sex)	52	110.5104
Phi(~year + mpg + sex + time)p(~year * time)	51	110.7914
Phi(~year + mpg + time)p(~year * time + sex)	51	146.1927
Phi(~mpg + time)p(~year * time + sex)	37	149.0672
Phi(~mpg * time)p(~year * time + sex)	41	149.4936
Phi(~mpg + sex + time)p(~year * time + sex)	38	150.8227
Phi(~mpg + sex + time)p(~year * time)	37	163.3362

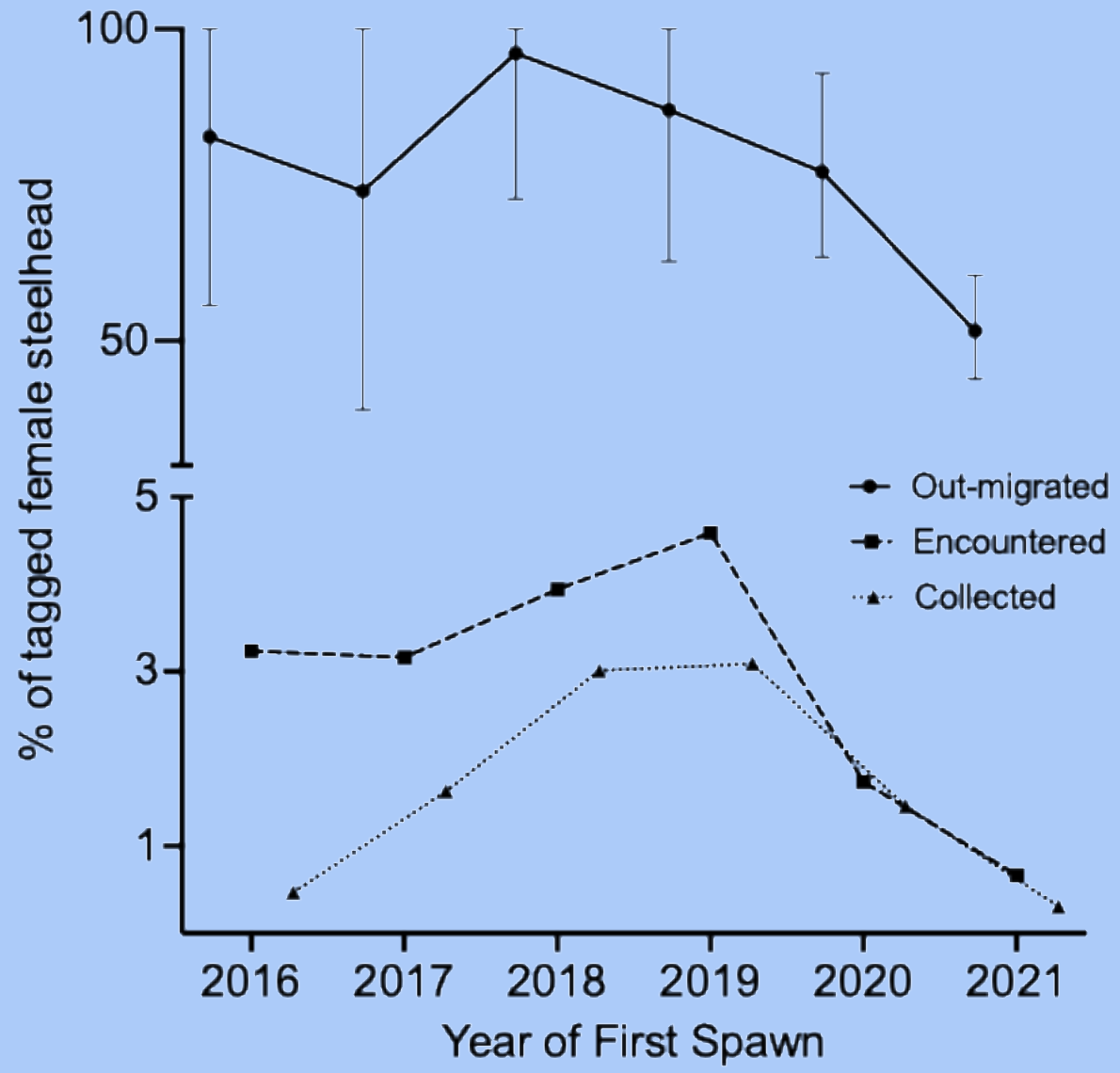
Analysis – kelting rate

- **Queried PTAGIS** with a list of **fish tagged pre-spawn at LGR**
- **Identified kelts detected** migrating downstream through LGR that next spring (March 18-June 30) at LGR JBS (2016-2021) and/or spillway antennas (2020, 2021)

$$Tags\ detected\ * \frac{1}{detection\ efficiency} * \frac{1}{total\ tags} = kelting\ rate$$

- Parametric bootstrap use to obtain bootstrap means and 95% CI

Kelting rates were high; encounter/collection rates were low



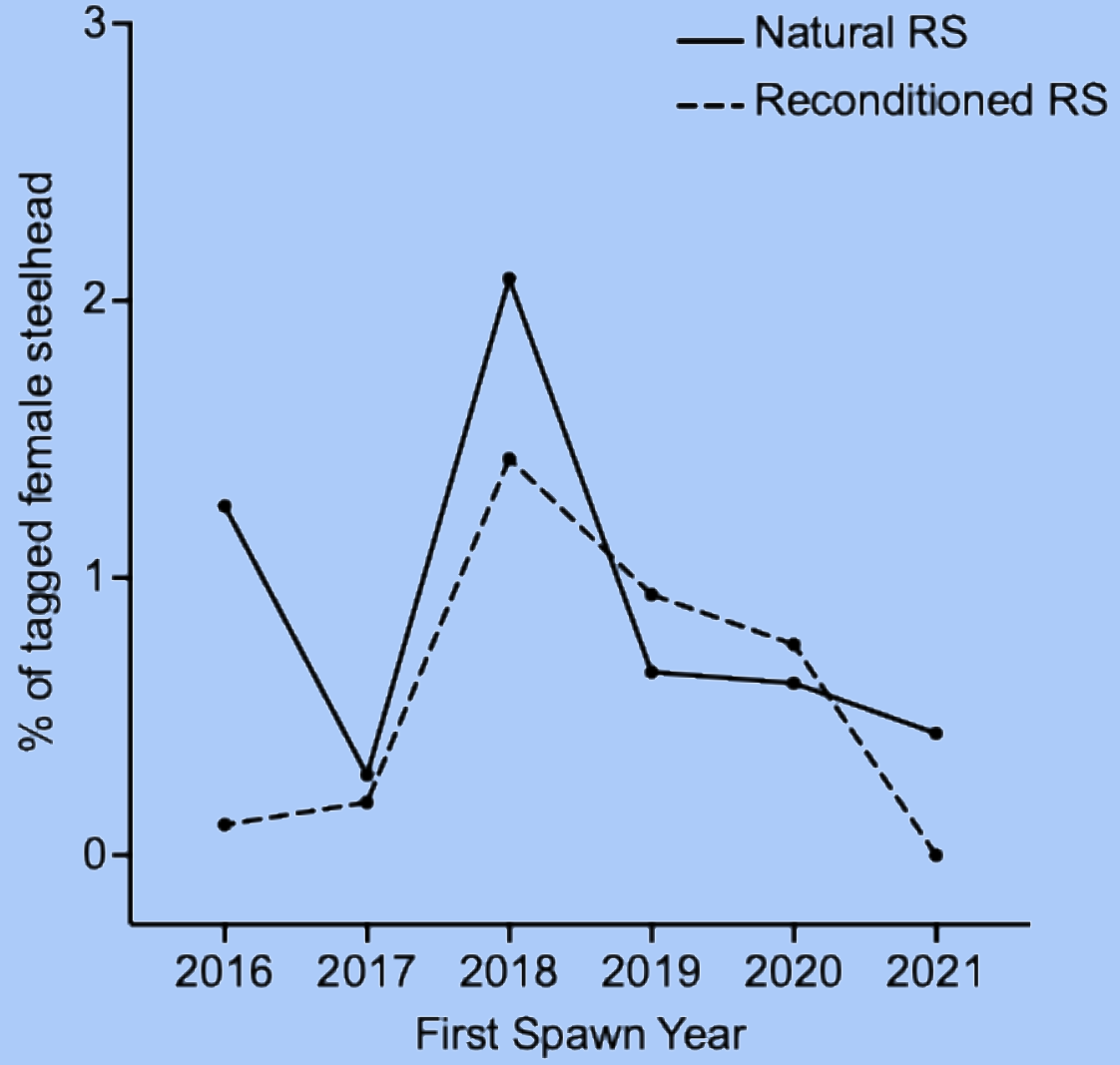
78% average kelting rate

3% average encounter rate

Most kelts encountered at the LGR JBS post-spawn were female (71%)

2% average collection rate

Repeat spawning rates



Natural average 0.88%
Reconditioned average 0.57%
Total average 1.3%

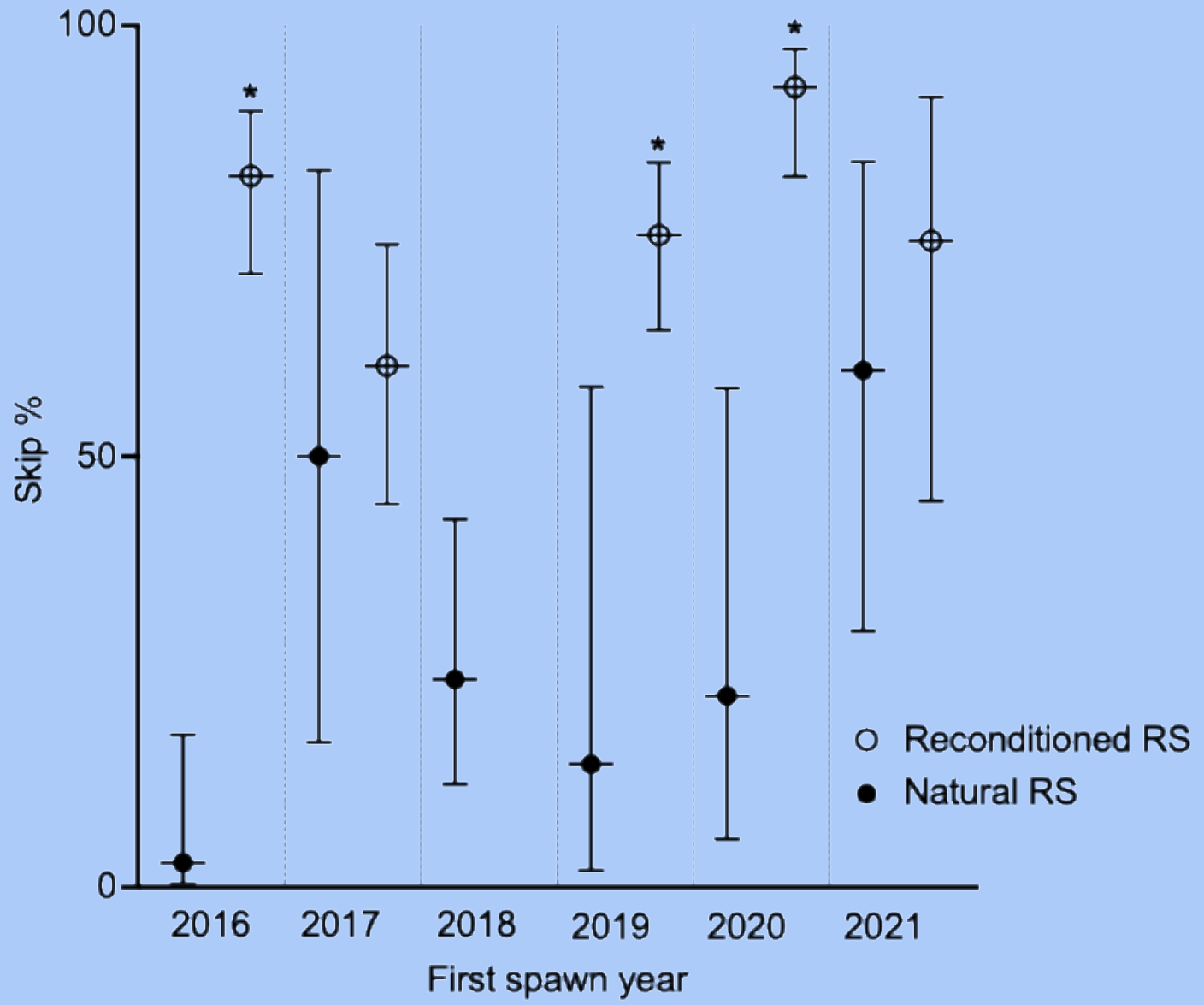
Analysis – Probability of Skip Spawning

- Assessed probability of returning as a skip spawner (p(skip)) - binary logistic regression
- Predictor variable: **RS Type (Natural or Reconditioned)**
- Binary response variables: **Consecutive, and Skip**
- Bootstrapping was used to produce 95% confidence intervals
- The entire Reconditioned dataset was used in this analysis, instead of just those that were tagged pre-spawn at LGR, in order to increase N

AIC table for p(skip)

Model	Terms	Δ AICc
Type × Year	10	0.0
Type + Year	6	11.5
Type	2	19.0
Year	5	89.4
Intercept Only	1	98.3

Probability of skip spawning was significantly greater in reconditioned fish



* = $p < 0.05$

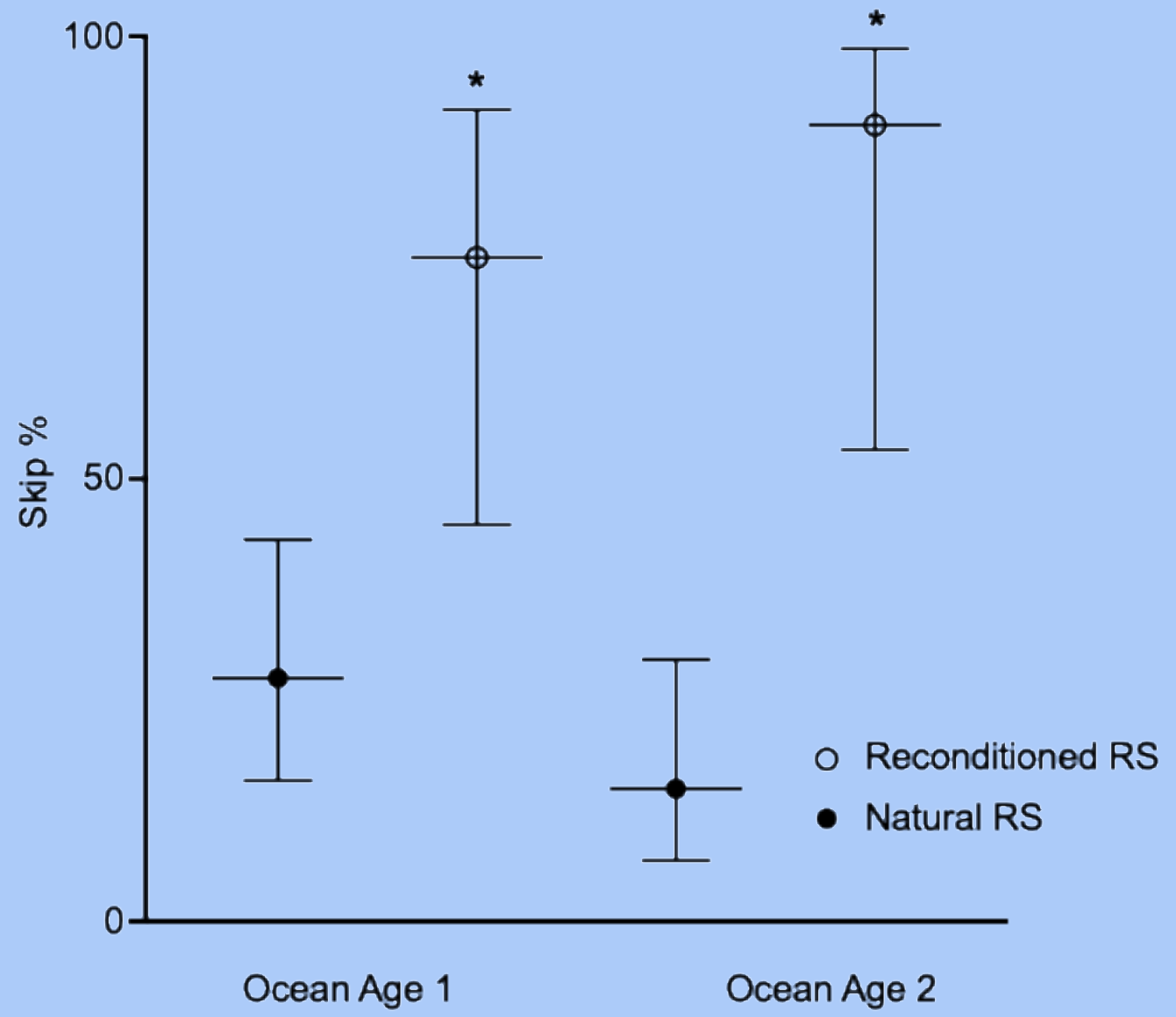
Analysis – Predictors of Skip Spawning Probability

- Assessed the effects of predictors variables on p(skip) using binary logistic regression
- Defined binary response variables: **Consecutive, and Skip.**
- Predictor variables:
  - RS type (Natural or Reconditioned), and
  - **Ocean Age at first spawn**
  - **Pre-spawn fork length** (centered and scaled separately by age)
- This analysis was restricted to fish captured and tagged at LGR prior to first spawning, predictor variables were only measured in captured fish

AIC table for p(skip) GLM 2 with covariates

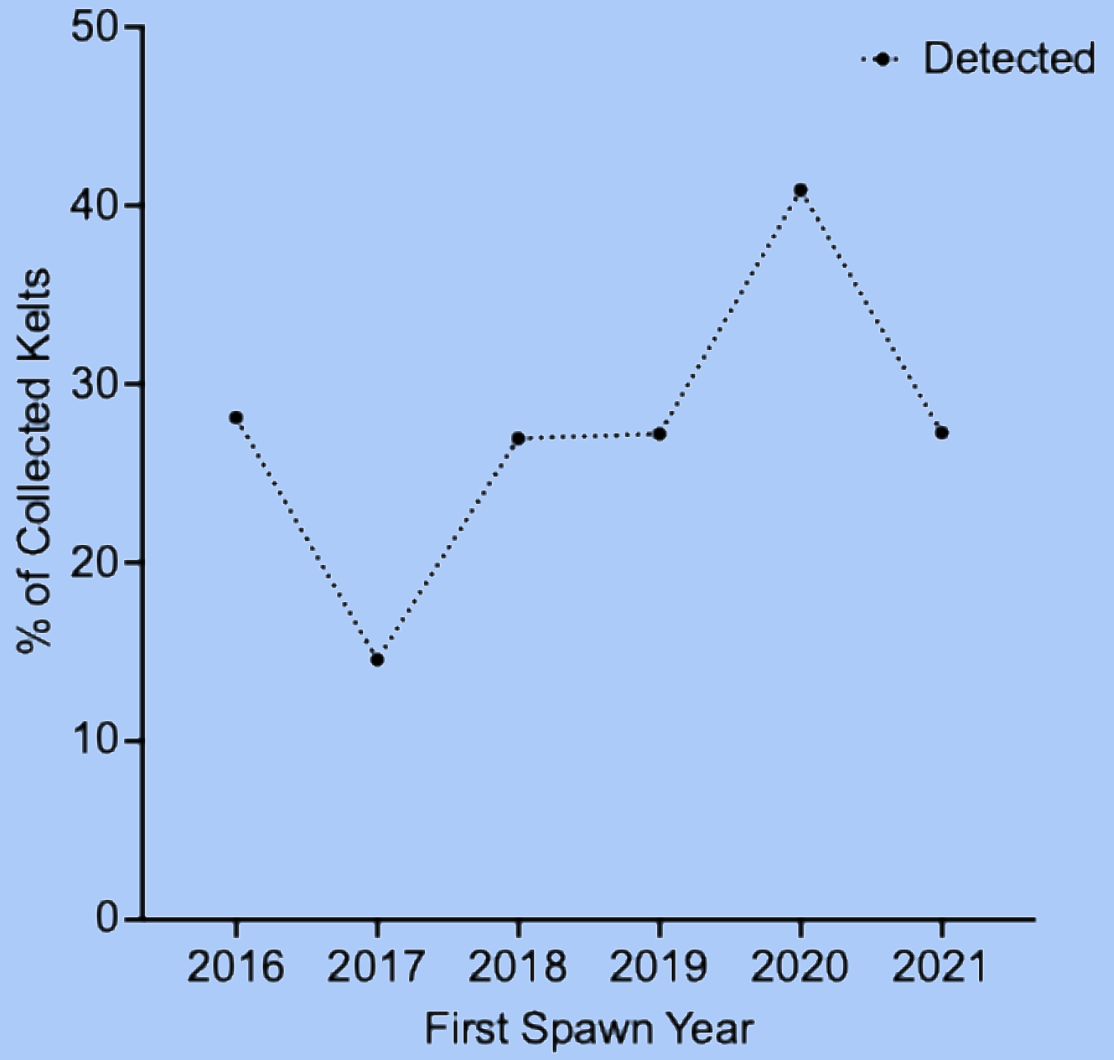
Model	Terms	Δ AICc
Age + Type + Age × Type	4	0.00
Length + Type + Length × Type	4	1.12
Length + Age + Type + Age × Type	5	1.41
Length + Age + Type + Length × Type	5	2.46
Length + Age + Type + Length × Type + Age × Type	6	2.78
Length + Age + Type + Length × Age + Age × Type	6	3.21
Length + Age + Type + Length × Age + Length × Type	6	4.34
Length + Age + Type + Length × Age + Length × Type + Age × Type	7	4.46
Length + Age + Type + Length × Age + Length × Type + Age × Type + Length × Age × Type	8	6.44

Probability of skip spawning was significantly greater in reconditioned fish



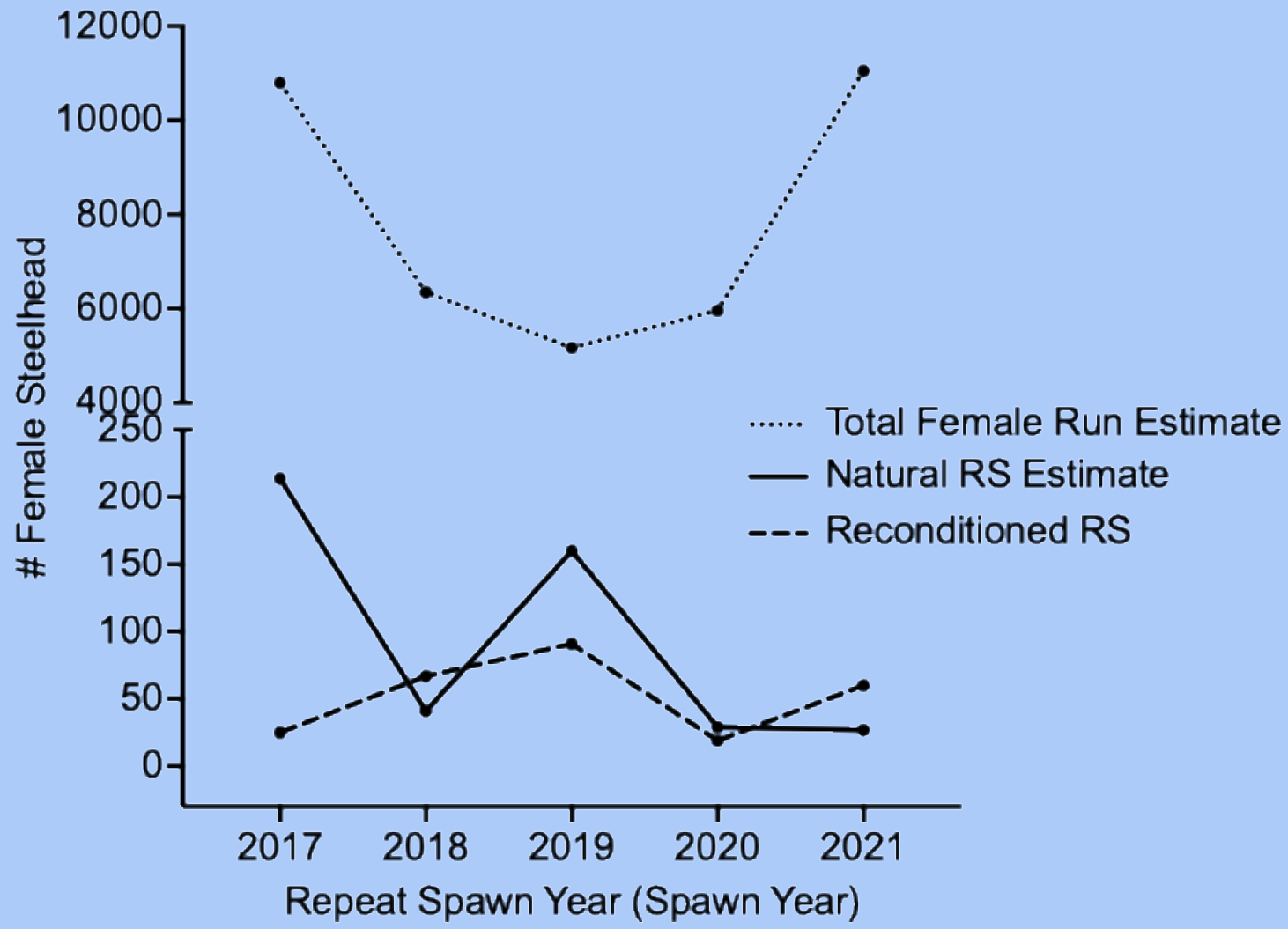
* = p < 0.05

Approximately 1/3 of kelts collected by KRP were detected migrating upstream after release



- Mortalities in reconditioning
- Detection after release

Reconditioned repeat spawners contributed to the spawning run



Upstream run averaged 65% female

Natural RS averaged 2.1%

Reconditioned RS averaged 0.78%

Summary and Conclusions

1. Kelting rates were high (78%) back to LGR
    1. Encounter (3%) and collection (2%) rates of kelts at LGR JBS are low
    - **Alternate methods of collection** may need to be developed
2. Repeat spawner rates were low but comparable in Natural (0.88%) and Reconditioned RS (0.57%)
3. Skip spawning rates were significantly higher in Reconditioned RS
    - **Reconditioning is preserving skip spawning**, historically the dominant life history trait of repeat spawners in Snake River tributaries.
4. ~1/3 kelts collected were detected migrating upstream to spawn again
    - **Can scale a reconditioning project** - collect 3x as many kelts as need to make impact
5. Reconditioned RS contribution to the spawning population was comparable to that of Natural RS
    - Even at the research scale, Reconditioned RS have made **a critical contribution** to repeat spawning, **substantially increasing the number of natural-origin repeat spawning female steelhead headed for the spawning grounds** during a period when upstream spawning numbers were disturbingly low

Thank you!

- Any questions?