Optimizing steelhead smolt production from natural-origin broodstock

NOAA FISHERIES
Northwest Fisheries Science Center

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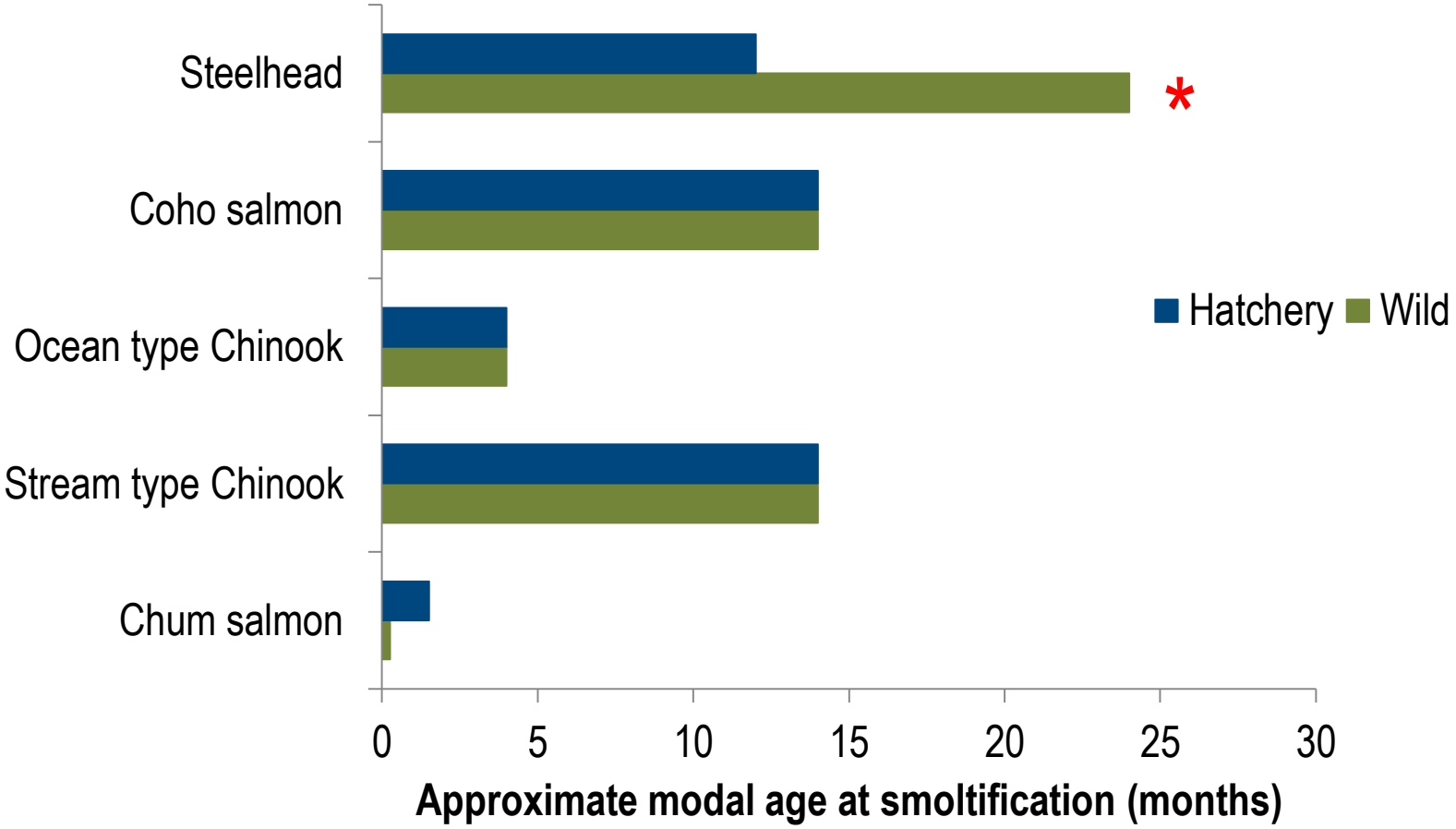
Why use natural-origin broodstock?

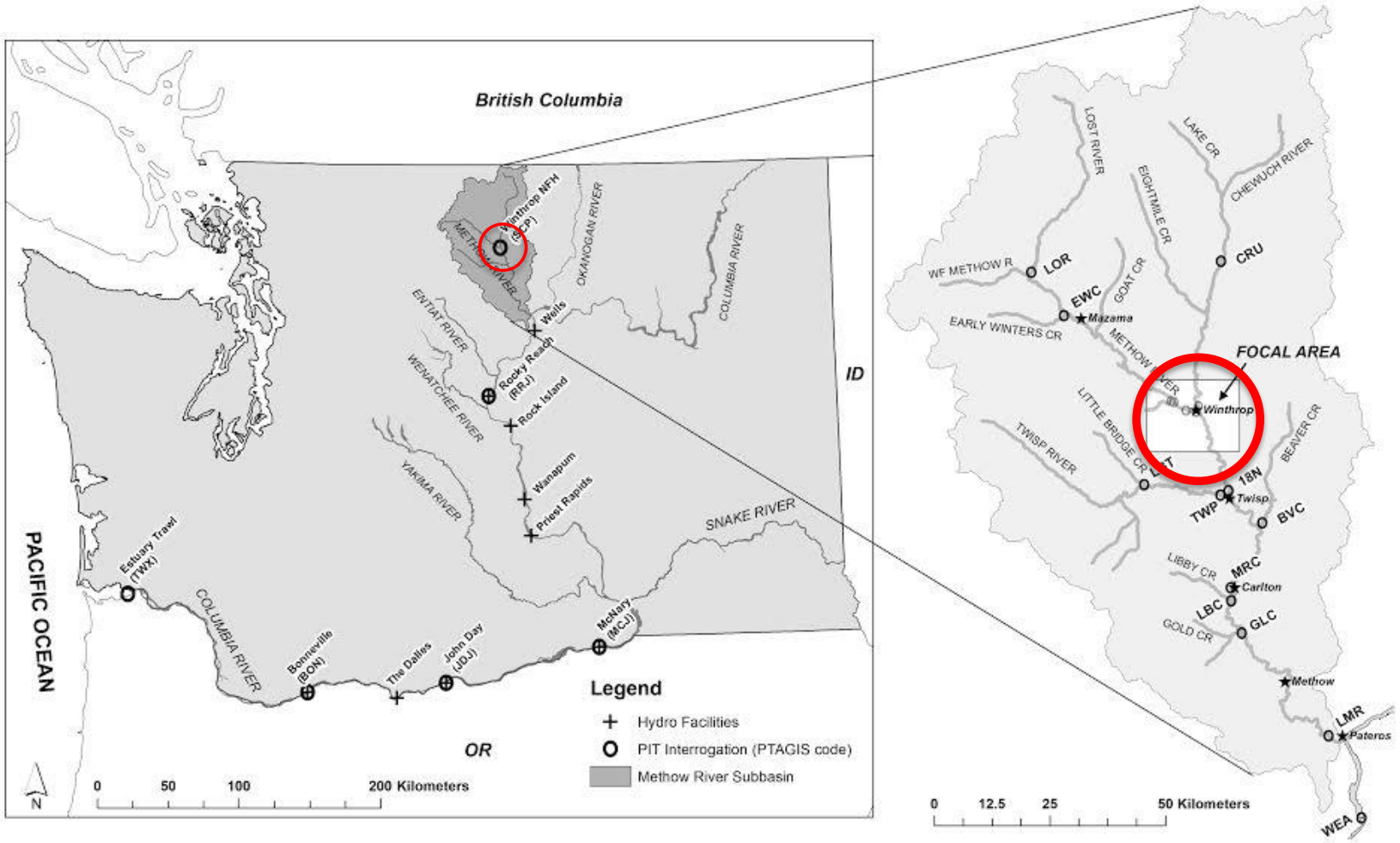
- Conserve and recover natural populations
- Maintain natural spawn timing
- Minimize fitness loss
- Reduce genetic risk/impact of domesticated broodstock

Photo: Wild Salmon Center

Hatchery & wild age at smoltification/release



Winthrop NFH, Methow & Columbia Rivers

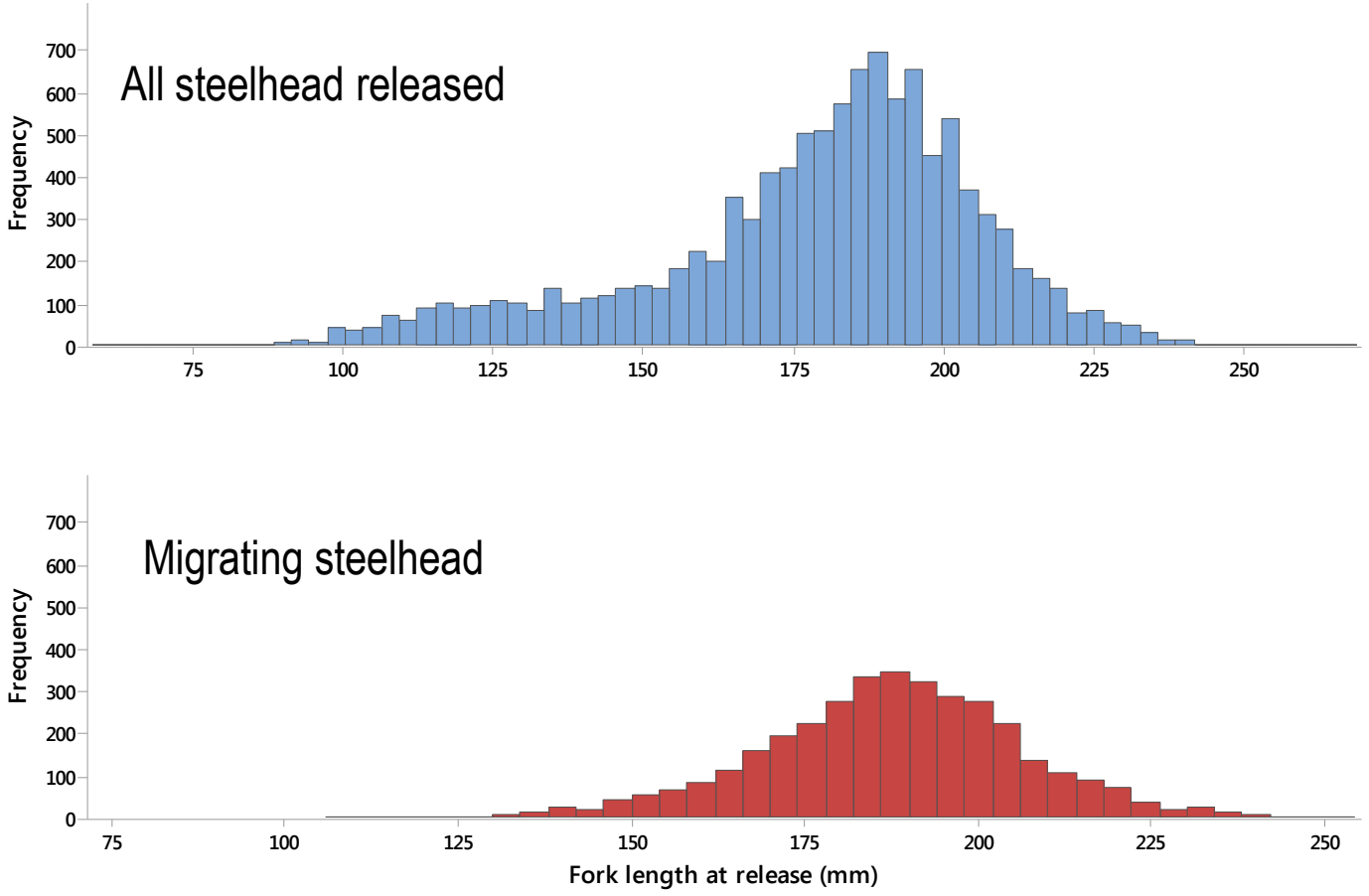


Map credit: Michael Humling, USFWS

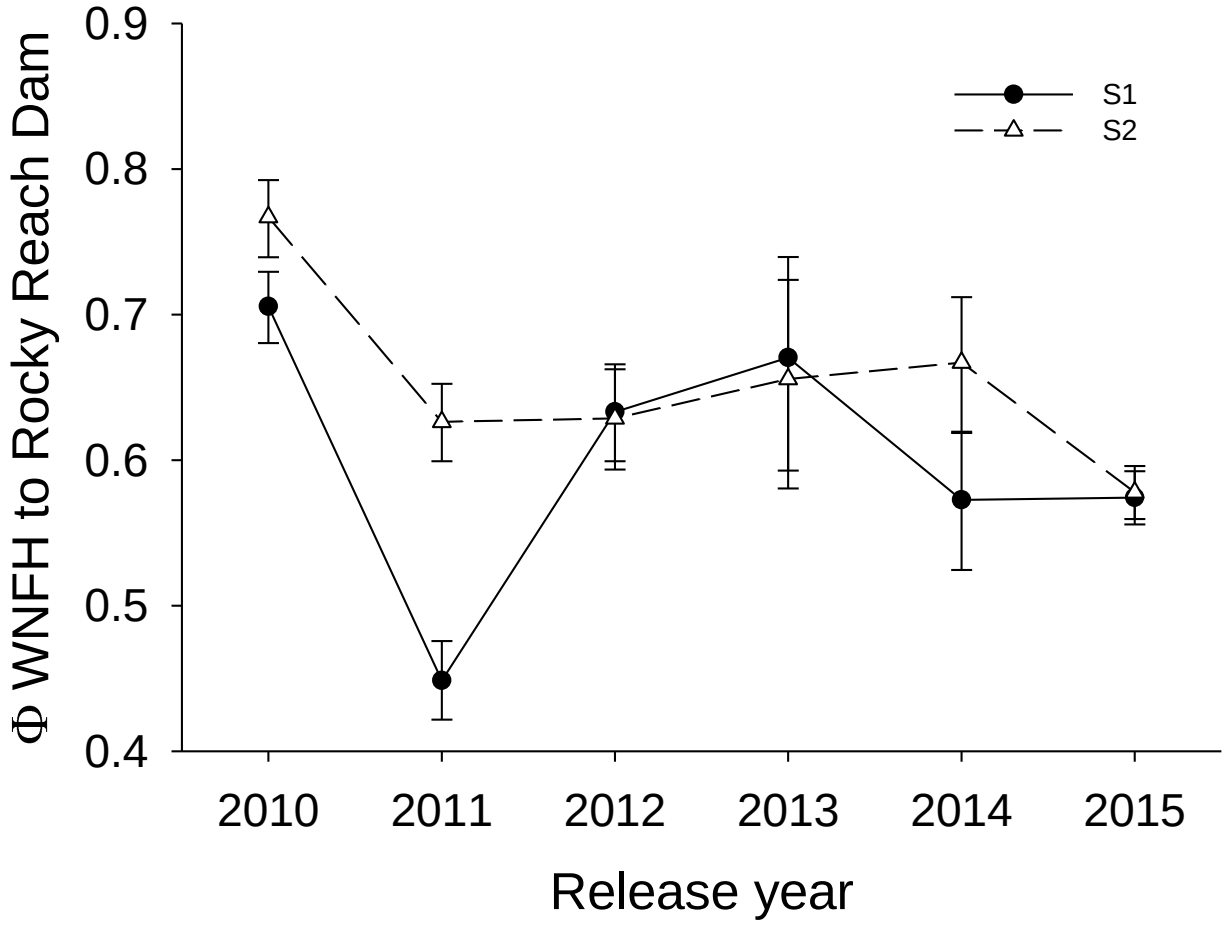
Hatchery scale research at Winthrop NFH

- Paired releases
  - Yearling (S1)
  - age-2 smolts (S2)
- Six release years 2010-2015
- 15,000 PIT tagged S1 & S2
- Pre-release sample 3,000 S1 & S2
  - Weight, Fork Length, Smolt Index, Maturation
- Estimate survival during migration

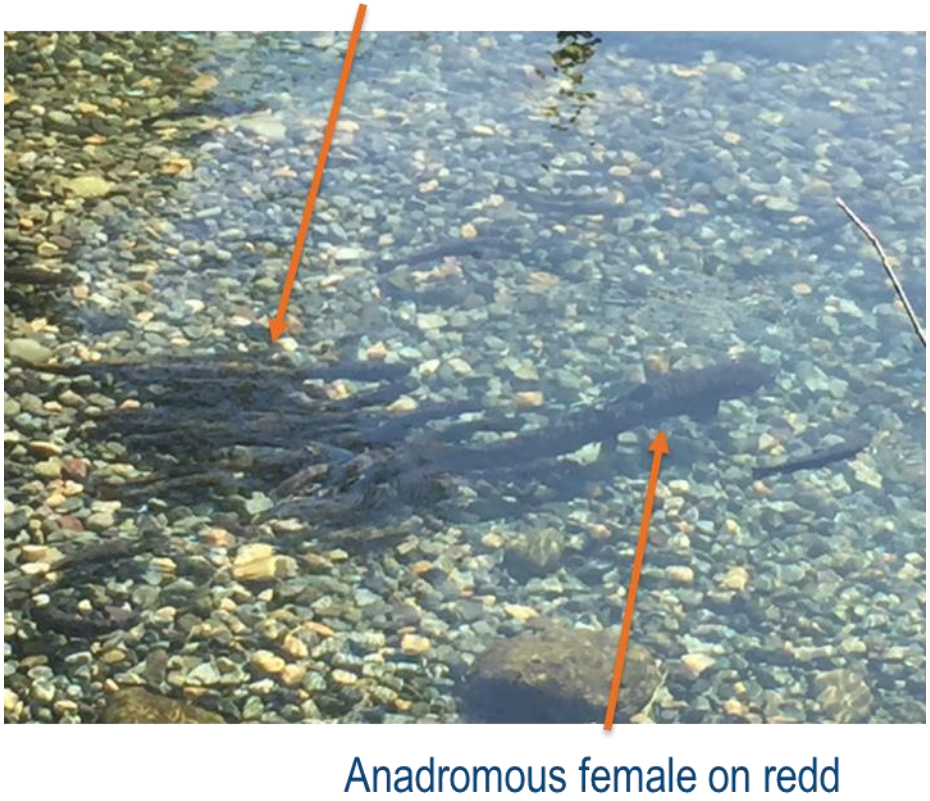
Size selection against small steelhead



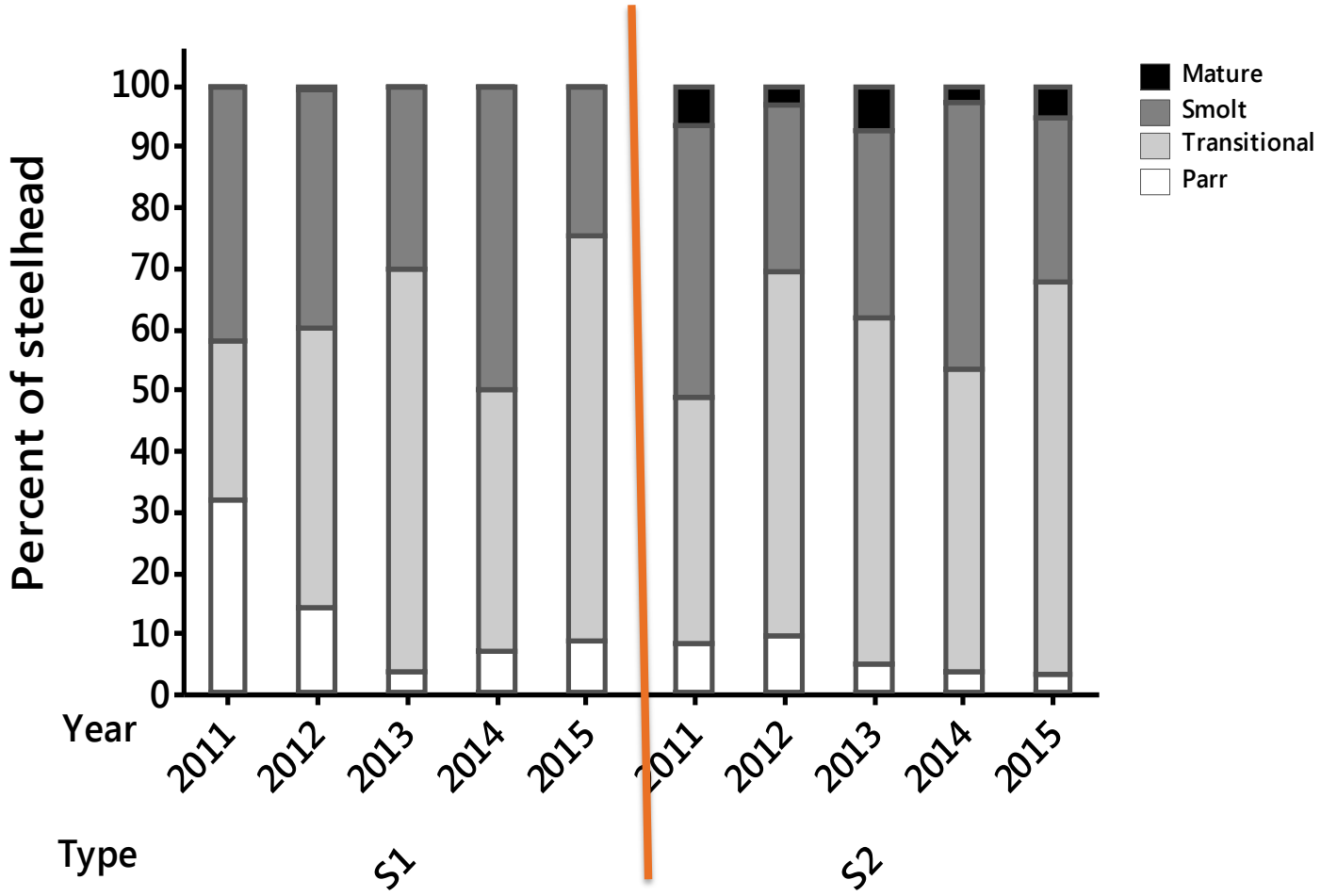
Migration and survival to the Columbia River



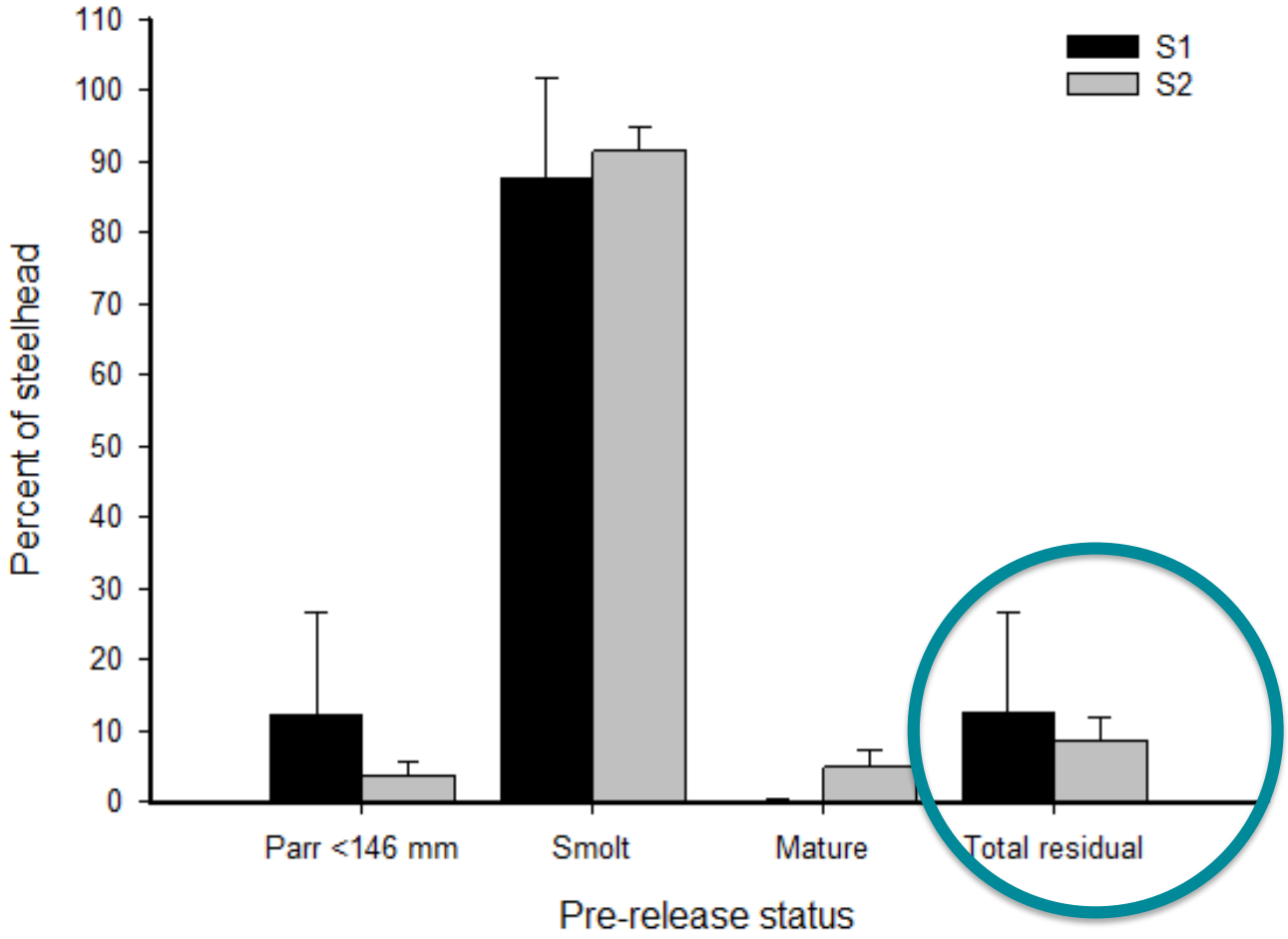
Precocious maturation in steelhead



Pre-release smoltification and maturation



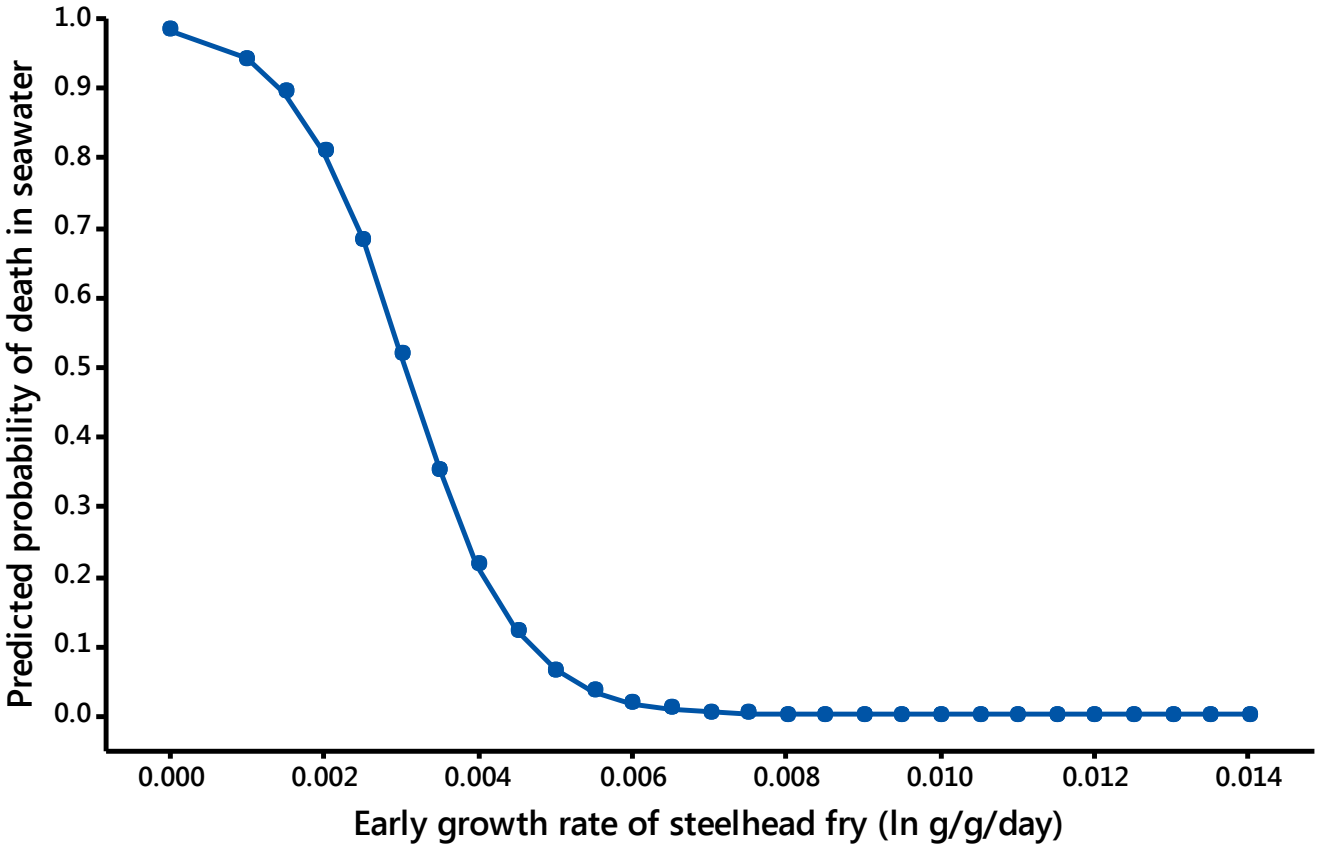
Predicted residuals



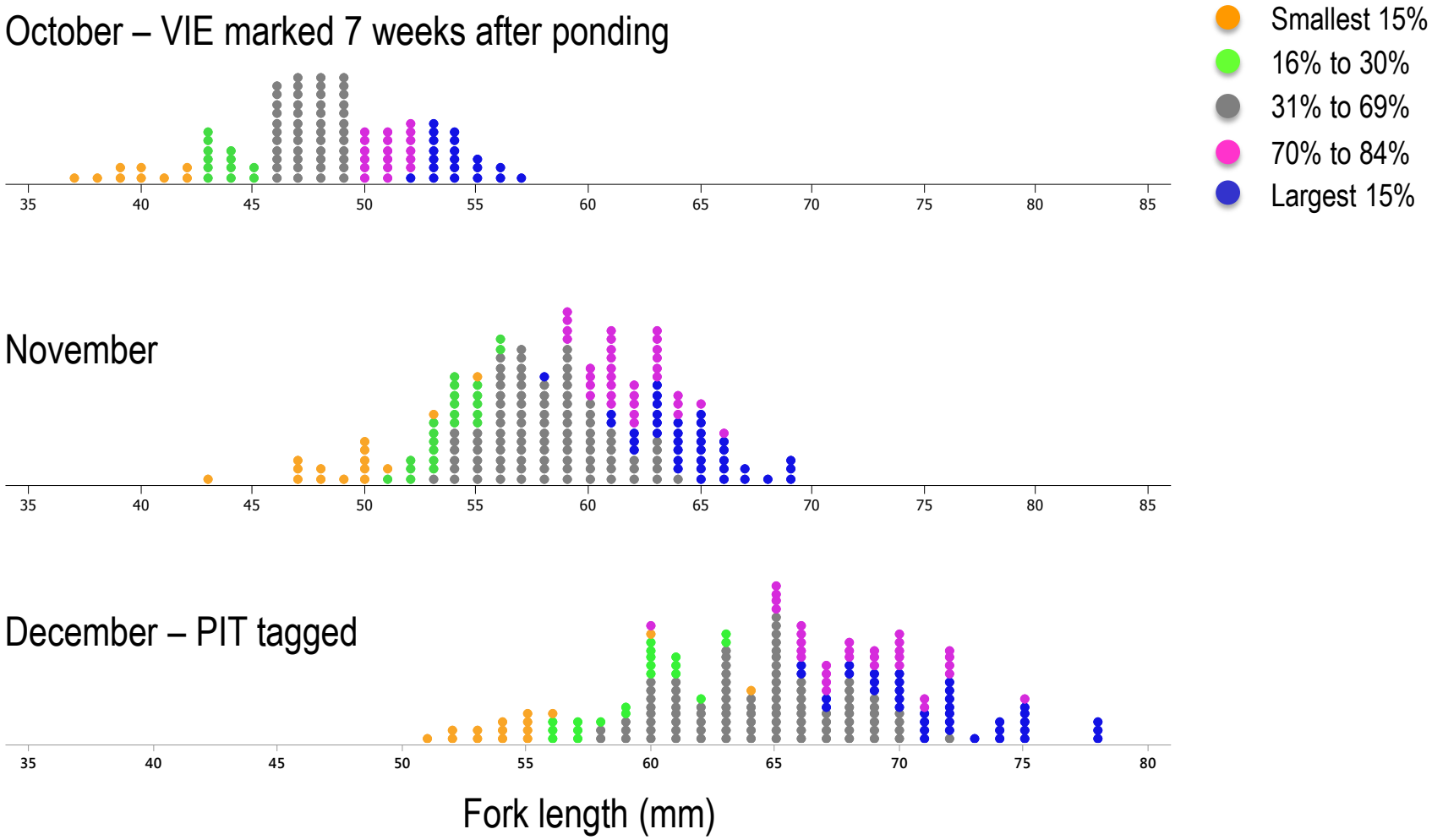
Laboratory experiments at Manchester

- Five different experiments
  - Mechanisms of domestication
  - Minimize fitness loss
- All conducted in tanks in recirculating system
- All fry produced from natural origin broodstock spawned at WNFH

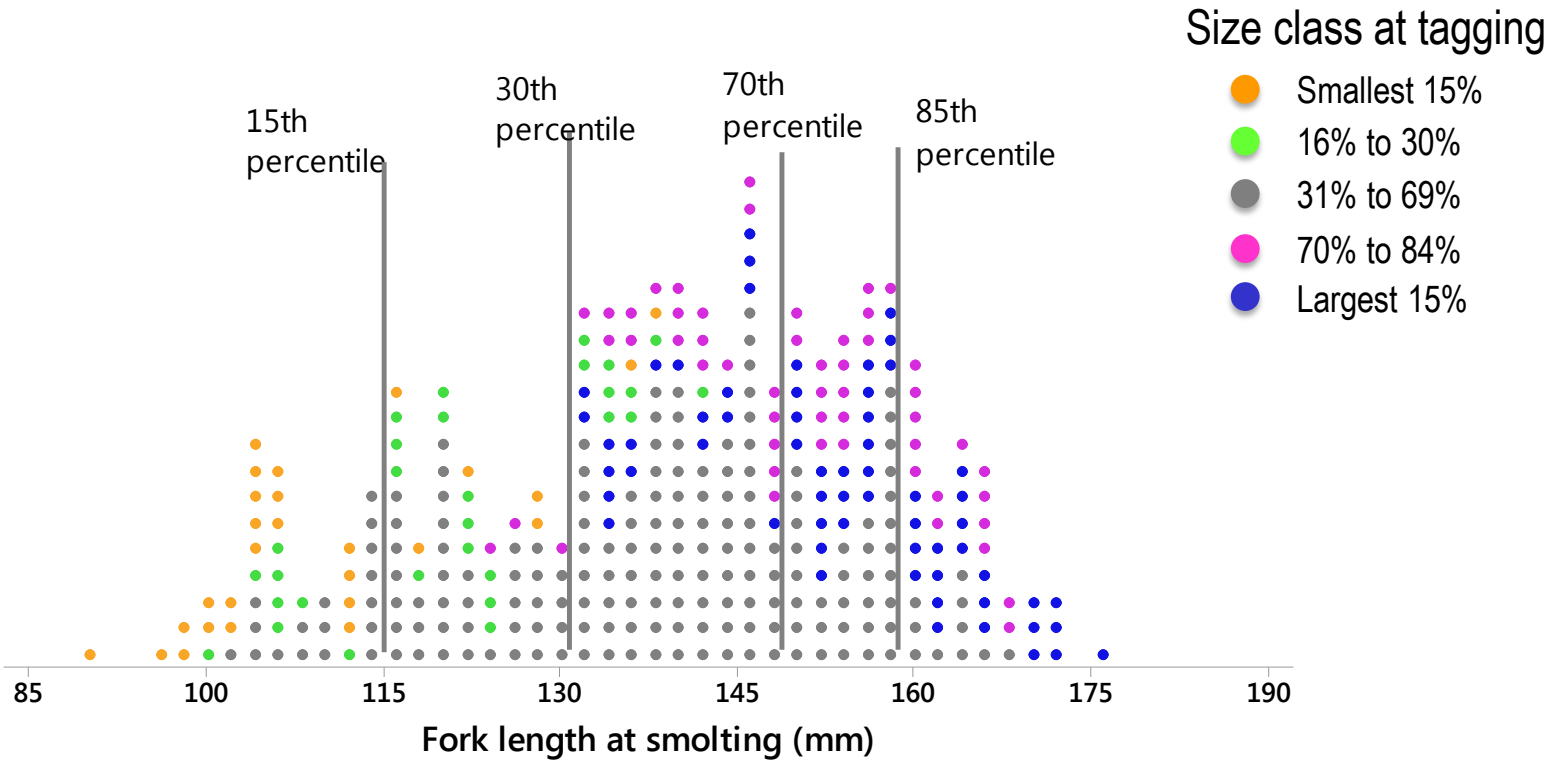
Growth & probability of death for S1 steelhead



When is the critical growth period for S1s?



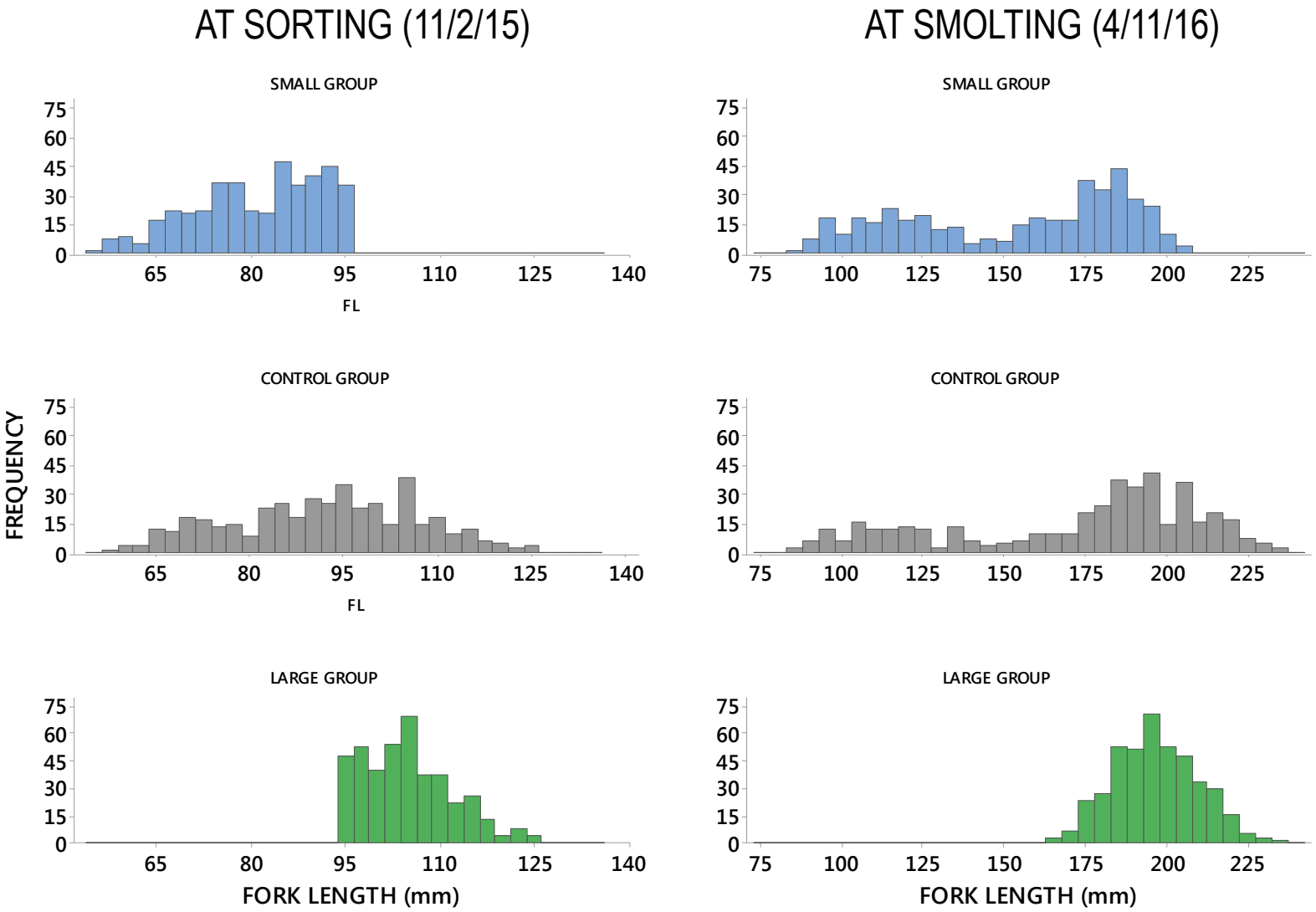
Early growth rate correlates with size at smolting



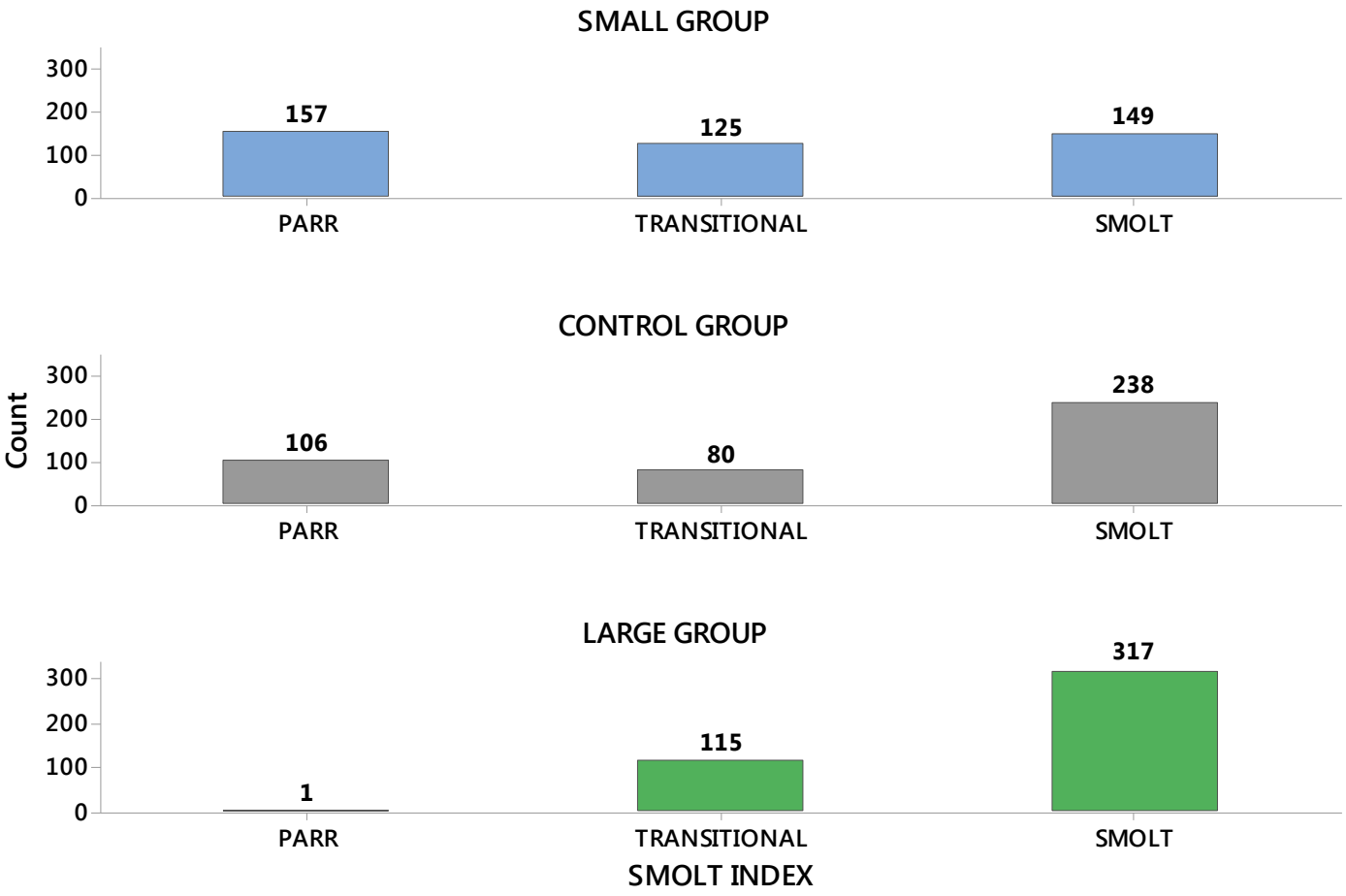
Is early growth affected by behavior in culture?

- Mechanism
  - Dominance and competition from larger faster growing fish reduces/suppresses growth of smaller fish
- Size sorting experiment
  - Three treatments – three tanks per treatment.
    - Small – Below median fork length at tagging
    - Large – Above median fork length at tagging
    - Control – Not sorted by size

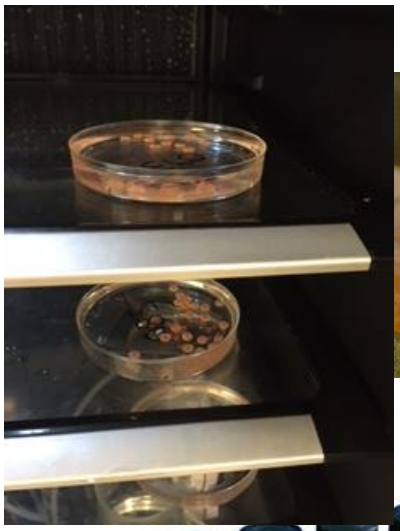
Does size sorting improve growth of small fish?

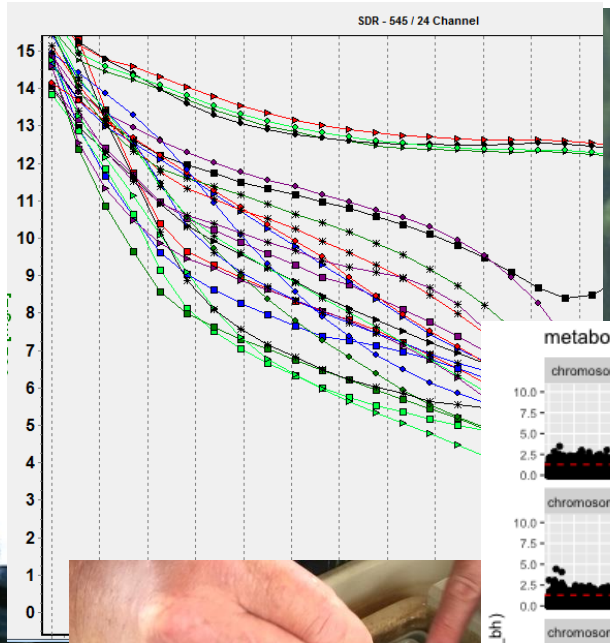


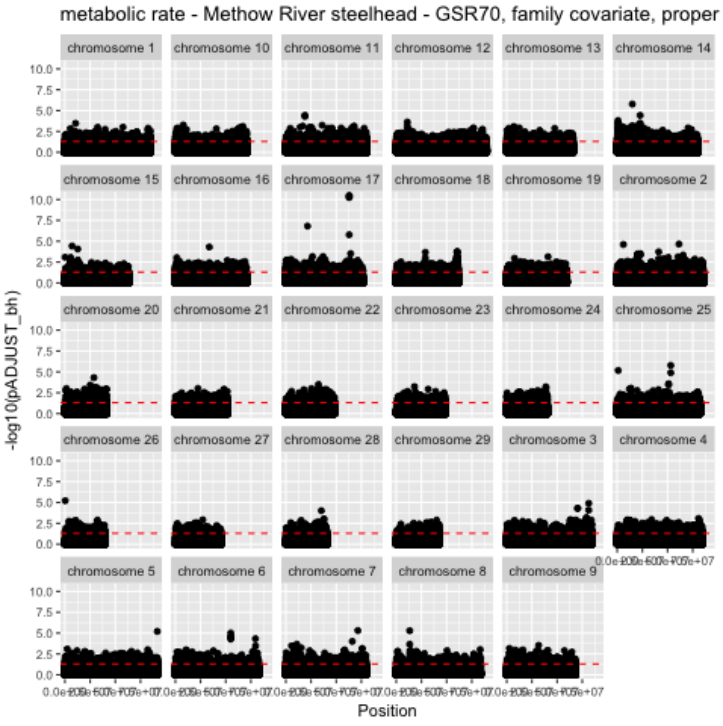
Does size sorting improve smoltification rate?



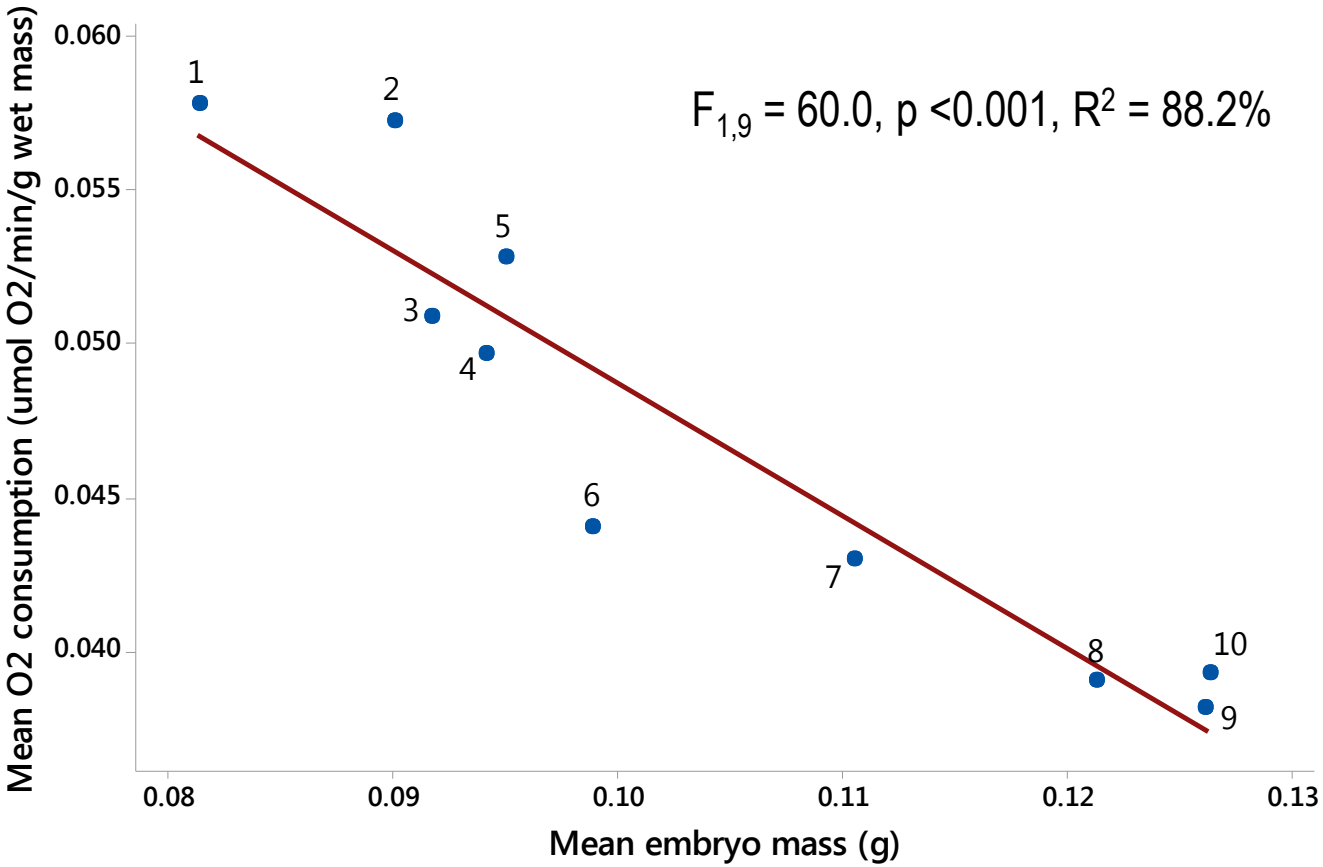
Genetic basis of metabolism, growth and survival in natural and hatchery environments



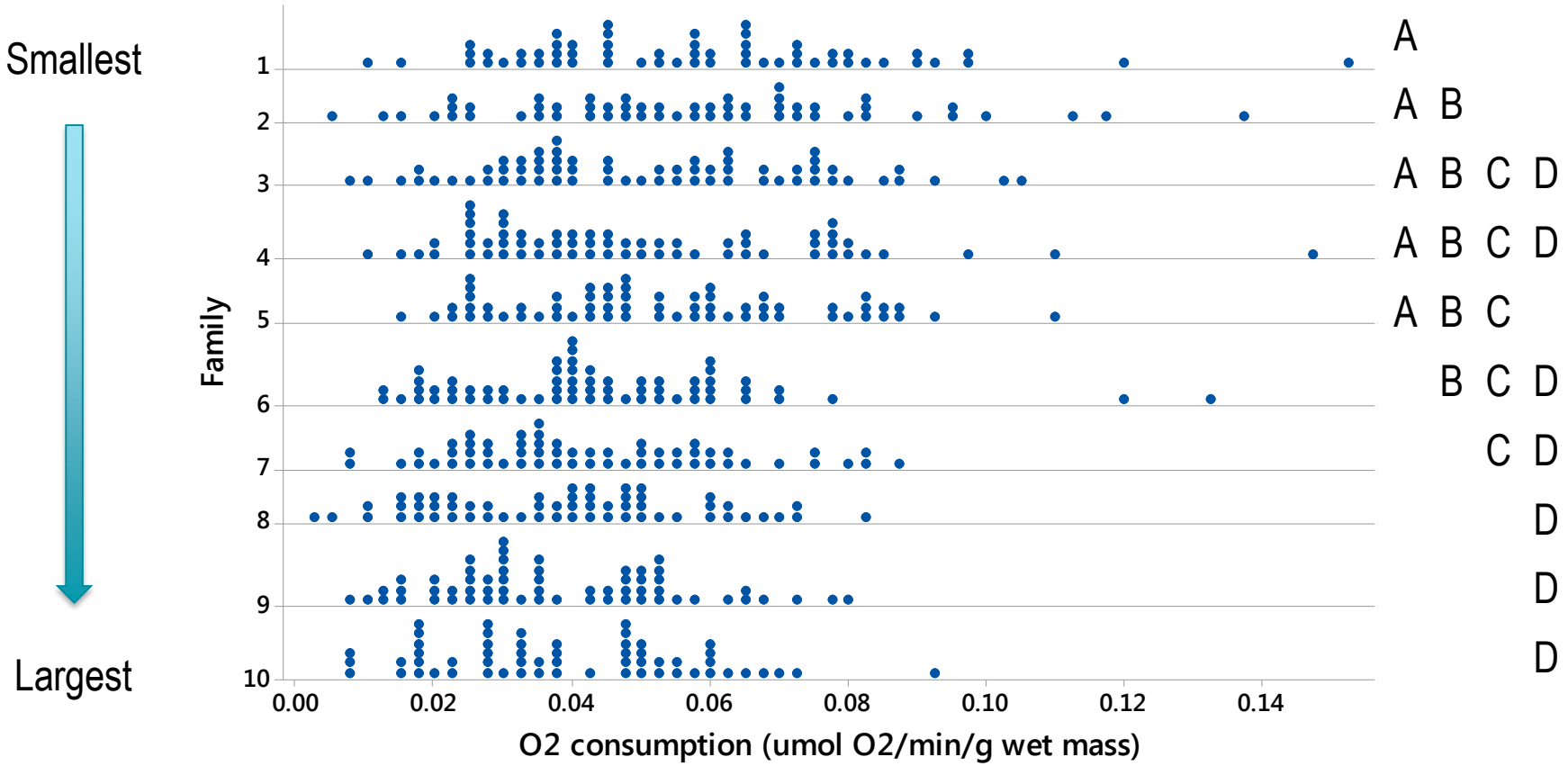




O_2 consumption inversely related to embryo mass

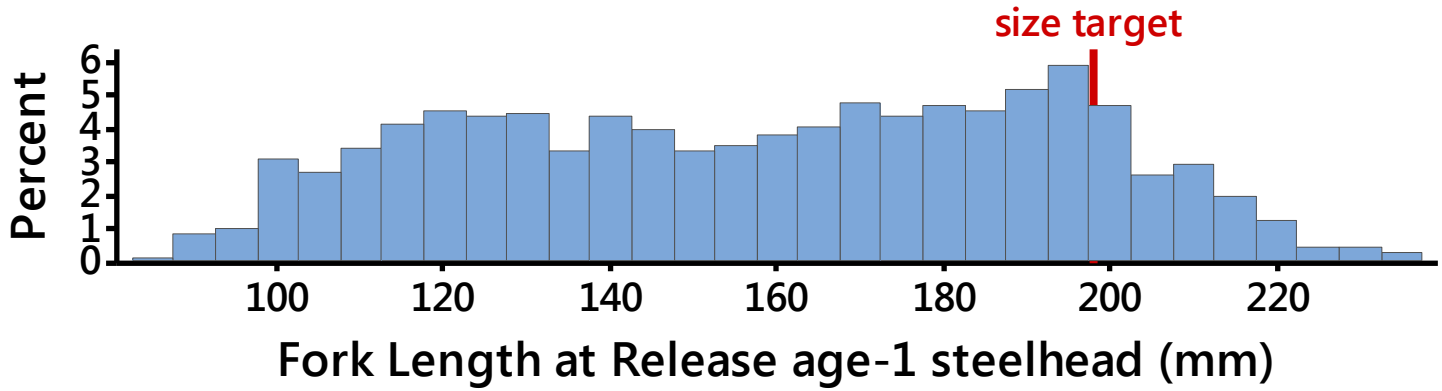


O_2 consumption rate within & among families



$F_{9,601} = 6.67$, $p < 0.001$, $R^2 = 9.20\%$

Variation in size-at-age is common

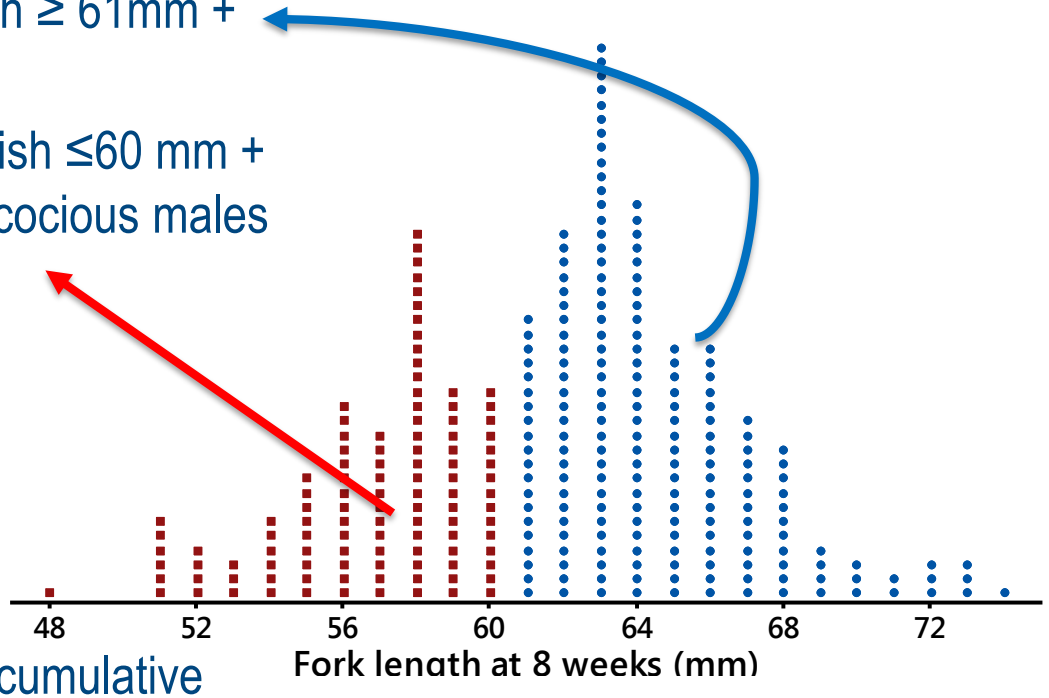


Optimizing smolt production with NOR broodstock

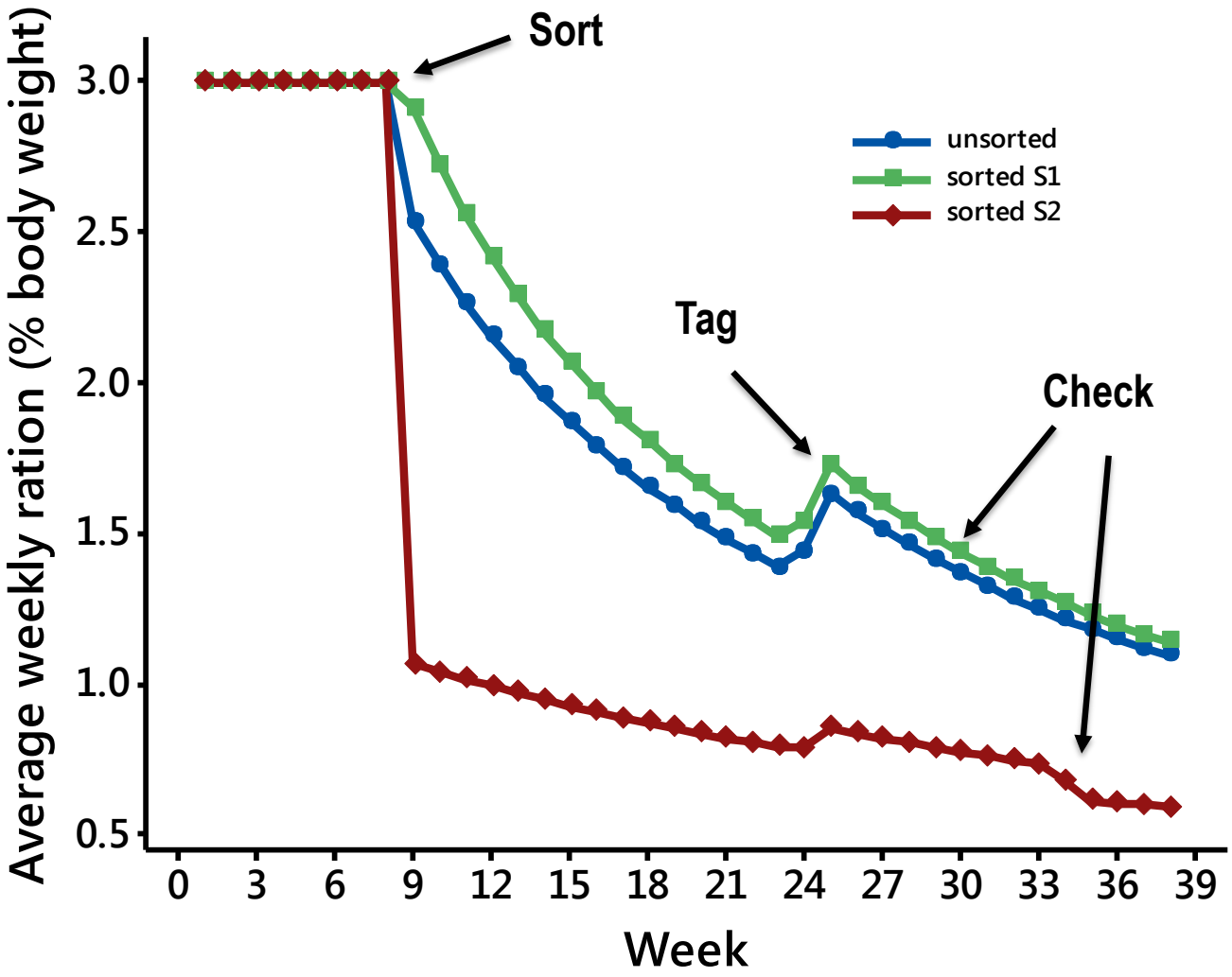
- Not all steelhead will grow rapidly enough to smolt at age-1, resulting in size selective mortality and residualism (~24%)
- Growing all steelhead as age-2 smolts relieves selection for rapid growth, but increases rate of precocious male maturation (~10% of males)
- Growth rate (and age at smoltification) is an individual characteristic established soon after emergence.
- Sort fish @ 8 weeks post-ponding, raise 2 groups: S1 & S2.

Optimizing smolt production with NOR broodstock

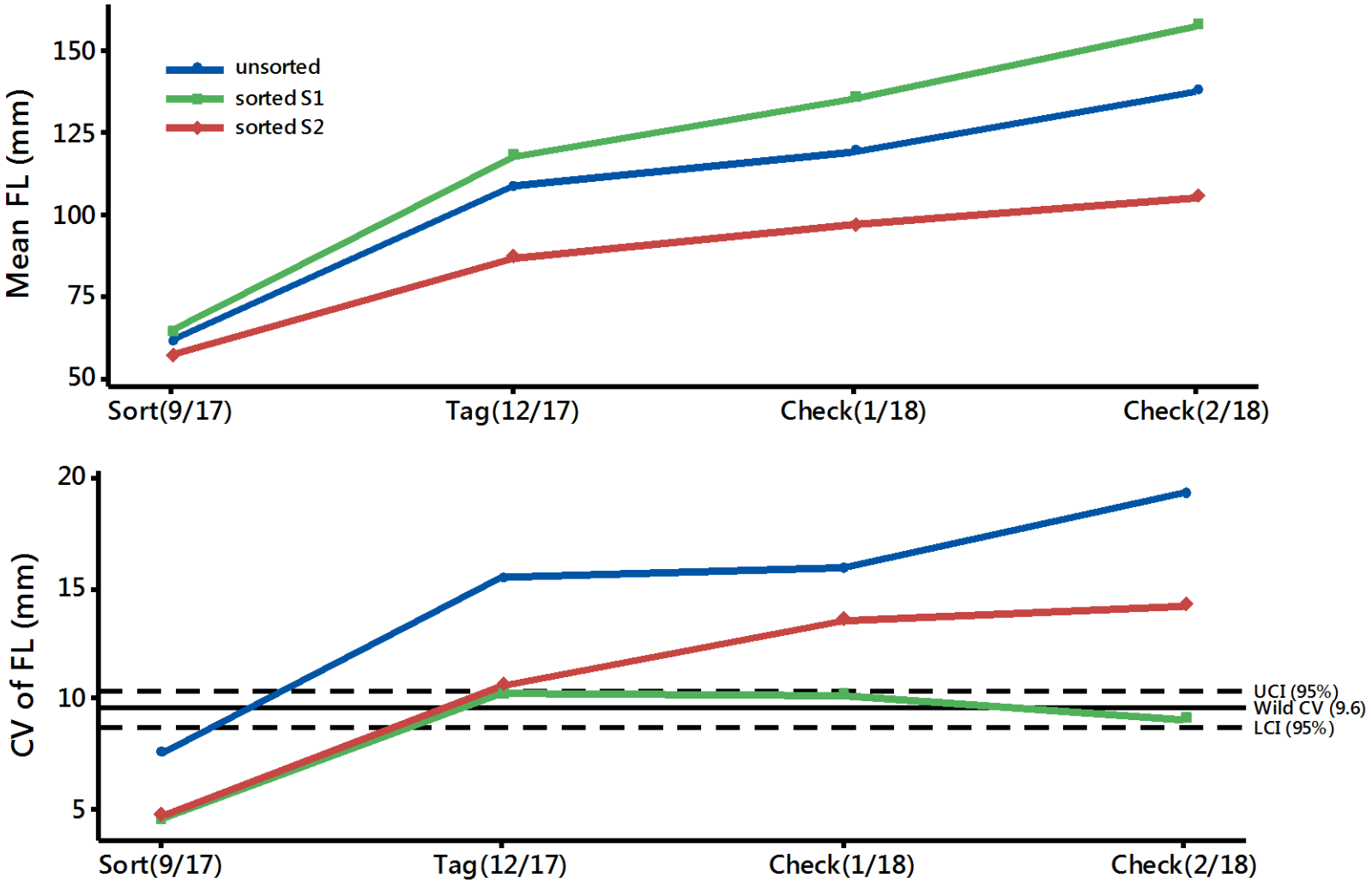
- Three treatments established 8 weeks post ponding after determining size distribution:
  - **Control**: unsorted + high ration raised S1
  - **Sorted S1**: largest 67% of fish ≥ 61mm + high ration
  - **Sorted S2**: smallest 33% of fish ≤60 mm + modulate growth, reduce precocious males
- Three replicate 6' circular tanks
  - 250 fry per tank
  - Target smolt size = 90 g
  - SWC at smoltification
- Percentage of S2 is a function of cumulative TUs of broodstock and juveniles.



Rations by treatment



Growth and Coefficient of Variation



Next steps…..

- SWC April/May 2018 for Control and S1. S2 SWC in 2019.
- Repeat sorting experiment in BY18 to increase family size (to 40) for quantitative genetic analysis.
- Production scale experiment at WNFH in BY18
  - 24,000 fish = 2 raceways of 12,000 fish.
  - Sort at 8 weeks post-ponding with AutoFish trailer using median length as criteria to establish S1 and S2 groups.
  - PIT tag 6,000 fish per treatment and measure growth, smoltification and maturation rates, post-release survival & travel time.
  - Compare to unsorted S2 steelhead as controls.

Acknowledgements

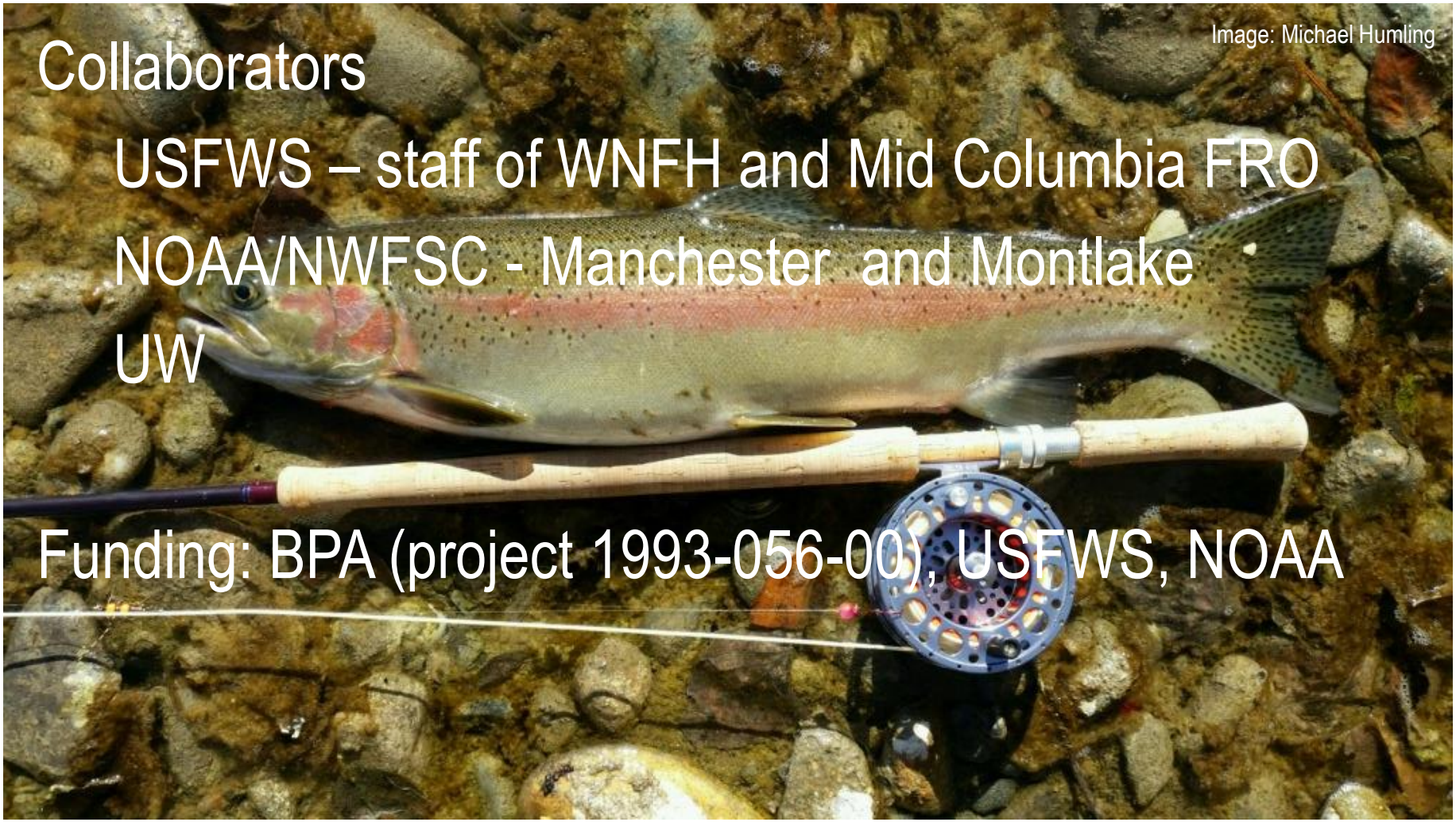


Image: Michael Humling

Collaborators

USFWS – staff of WNFH and Mid Columbia FRO

NOAA/NWFSC - Manchester and Montlake

UW

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