NOAA FISHERIES

Northwest Fisheries Science Center

Optimizing steelhead smolt production from natural-origin broodstock

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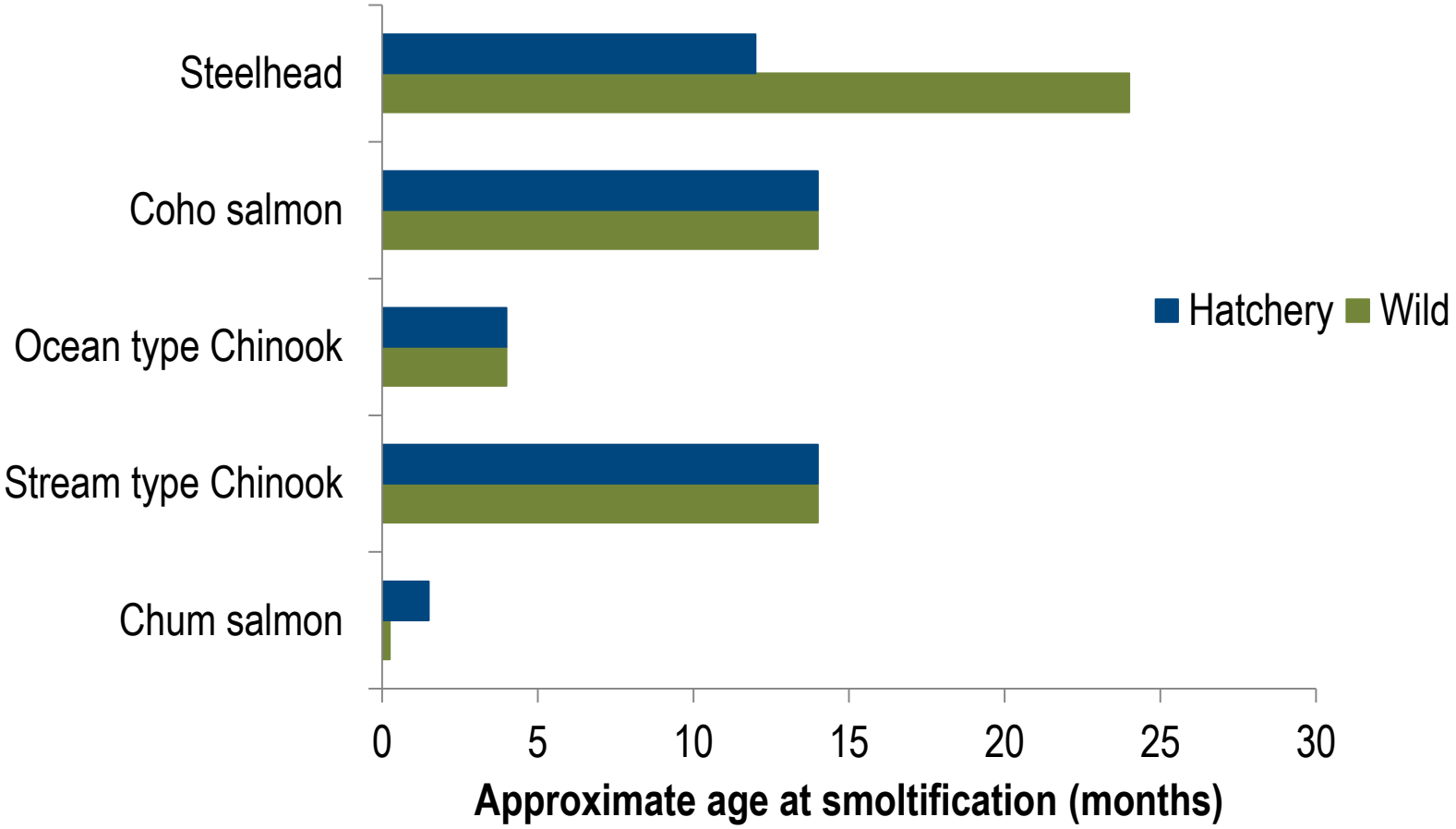
68th Annual Northwest Fish Culture Concepts Workshop
Red Lion Hotel, Redding, California: December 5-7, 2017

Why use natural-origin broodstock?

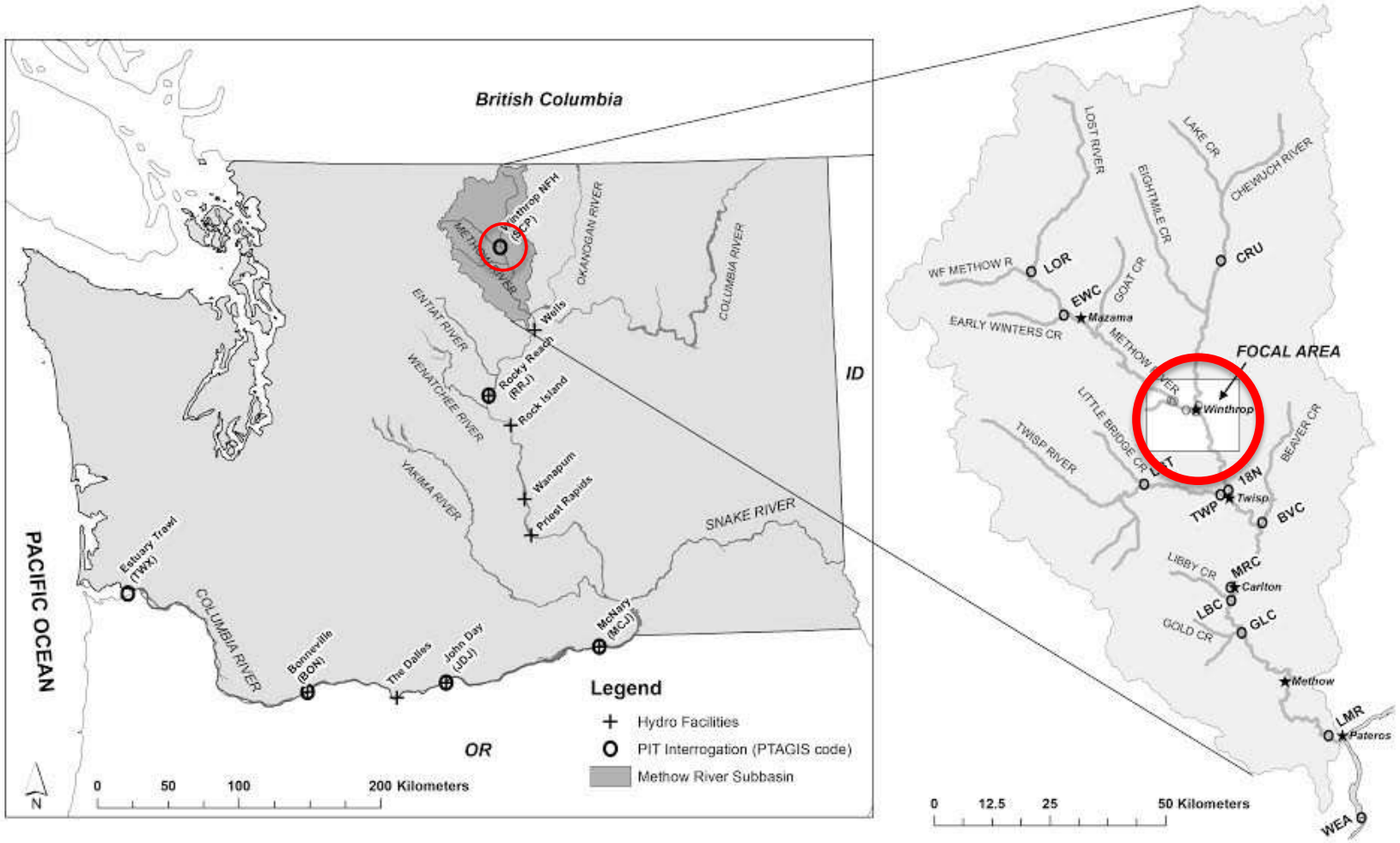
- Conserve and recover natural populations
- Maintain natural spawn timing
- Minimize fitness loss
- Reduce genetic risk/impact of domesticated broodstock

Photo: Wild Salmon Center

Hatchery & wild age at smoltification/release



Winthrop NFH, Methow & Columbia Rivers

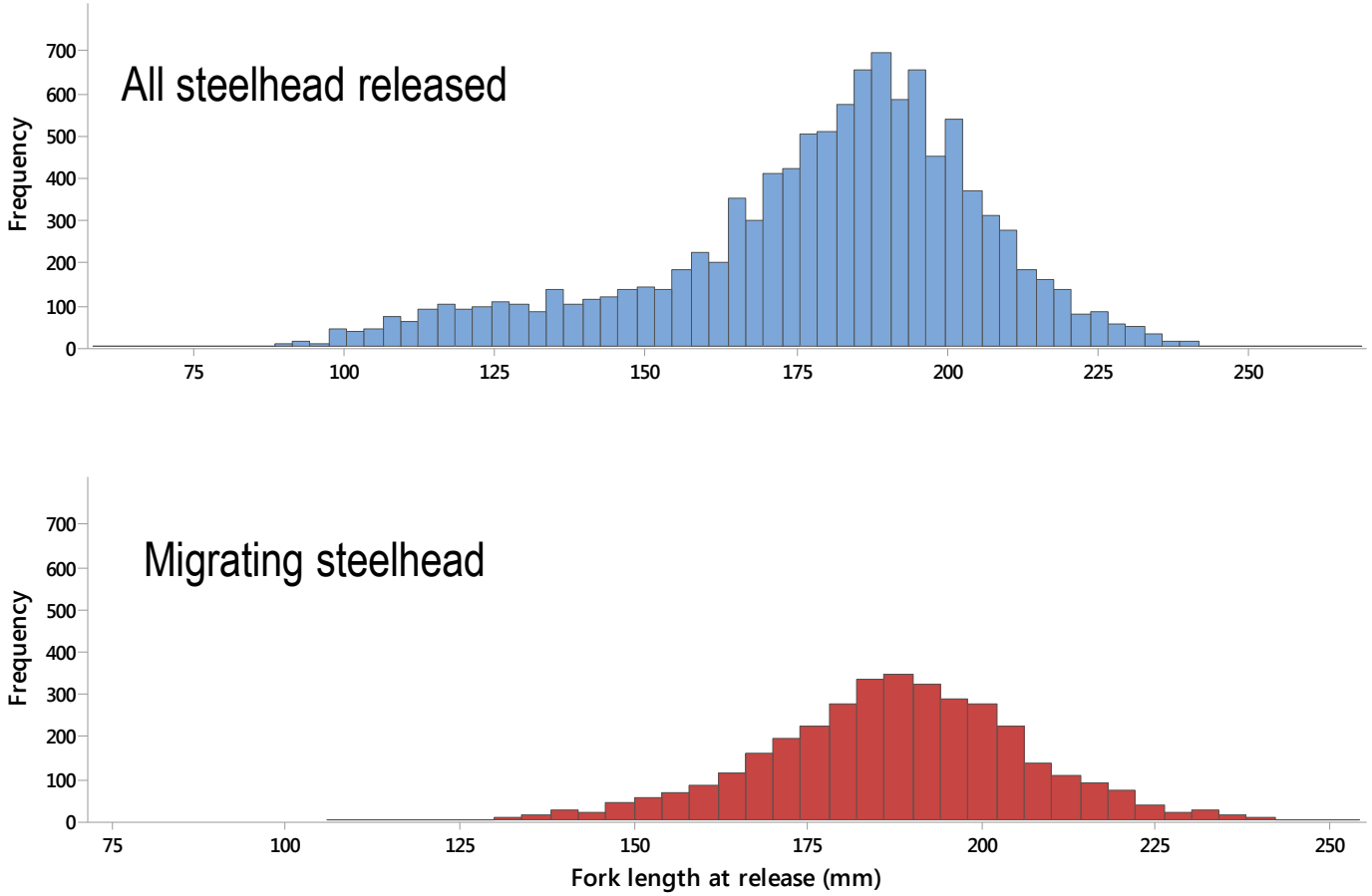


Map credit: Michael Humling, USFWS

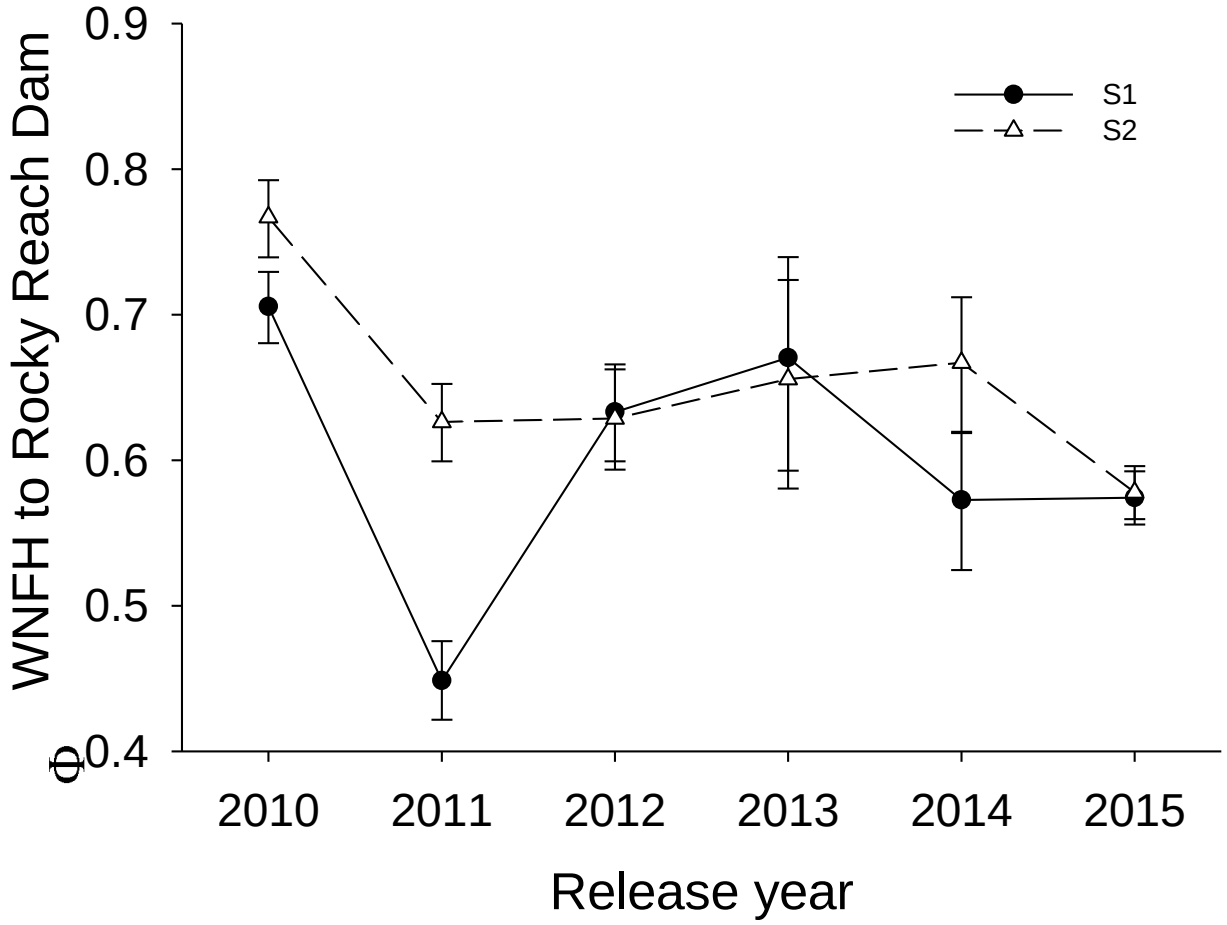
Hatchery scale research at Winthrop NFH

- 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

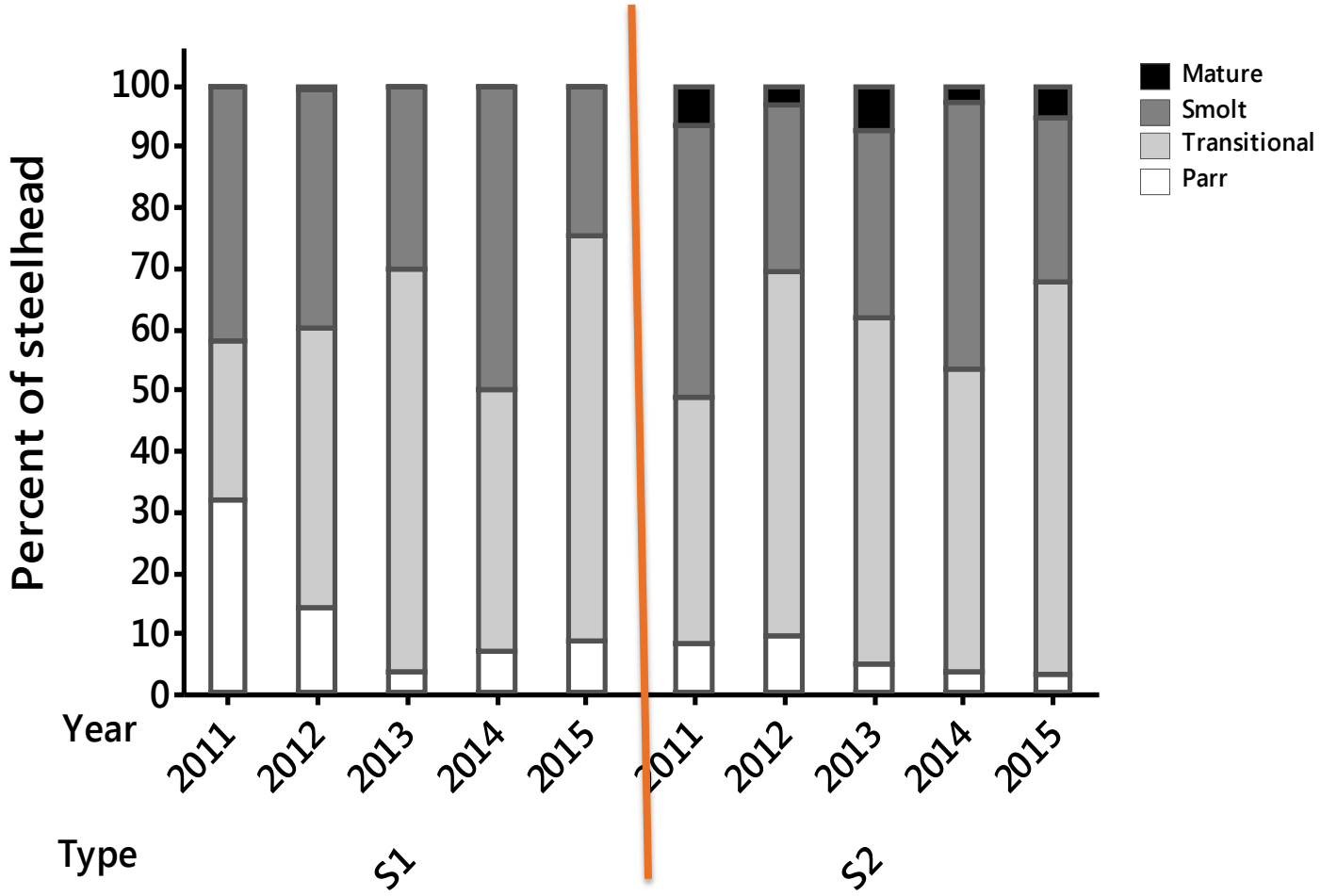


Migration and survival to the Columbia River

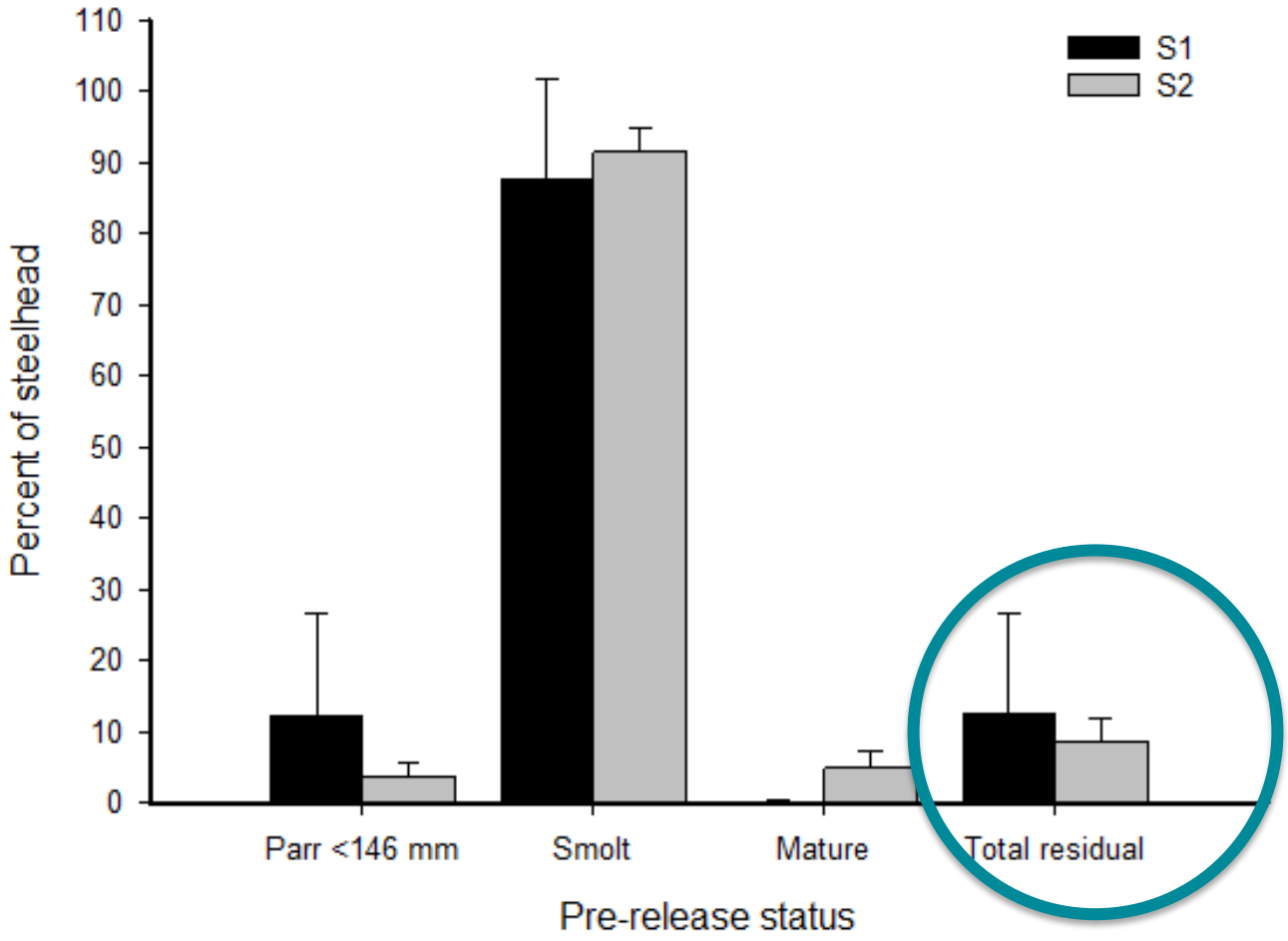


Precocious maturation in steelhead

Pre-release smoltification and maturation



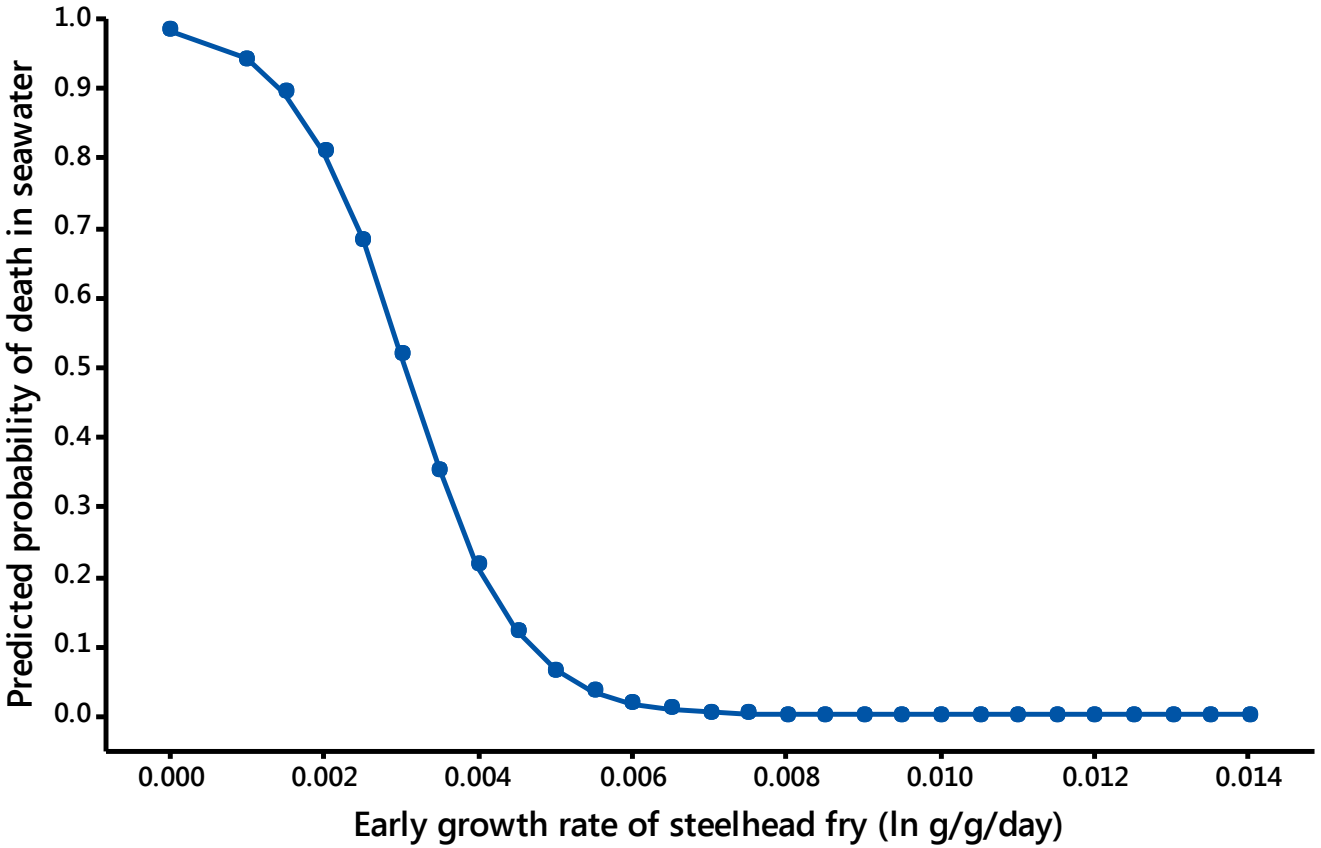
Predicted residuals



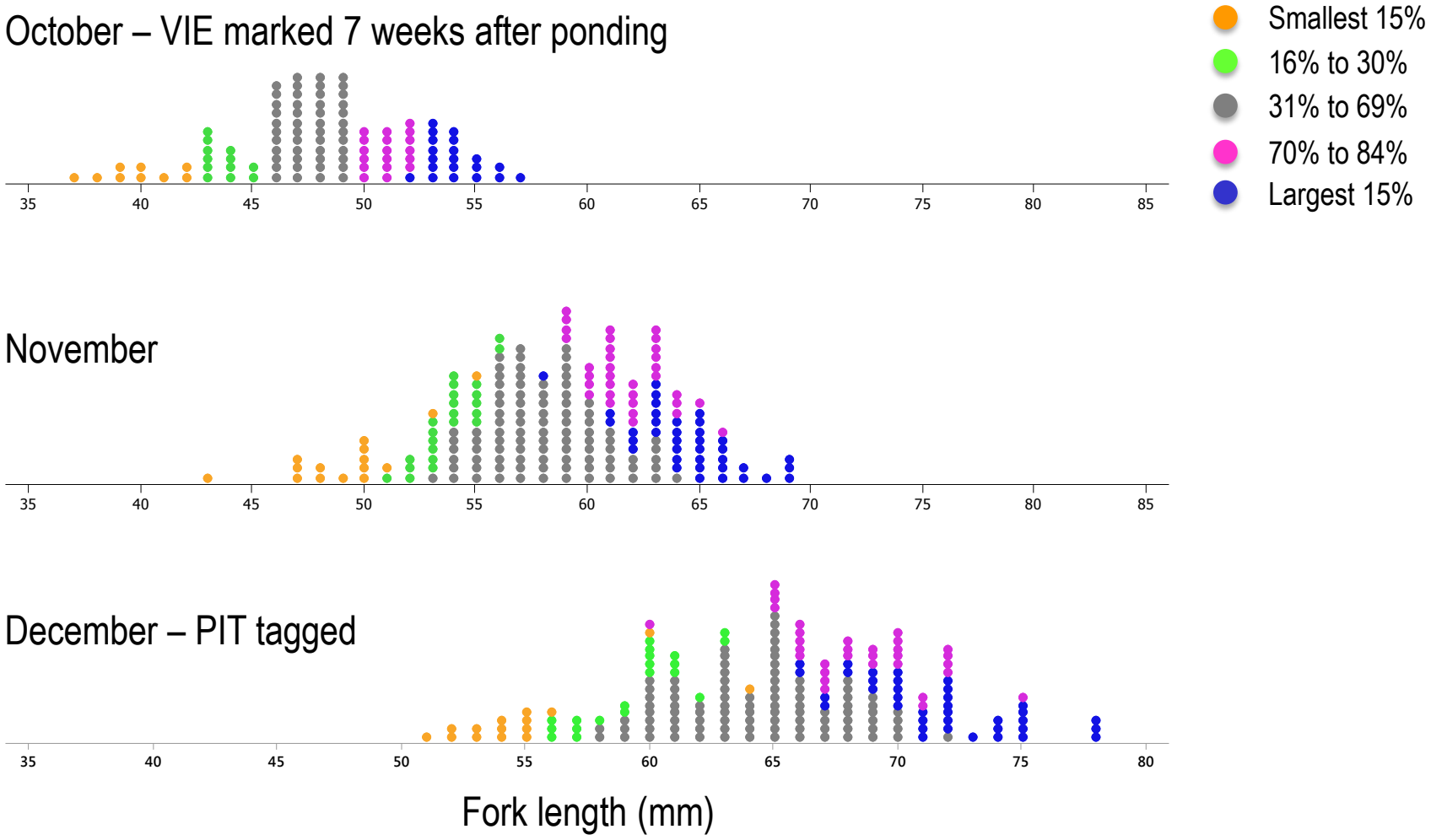
Laboratory experiments at Manchester

- 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

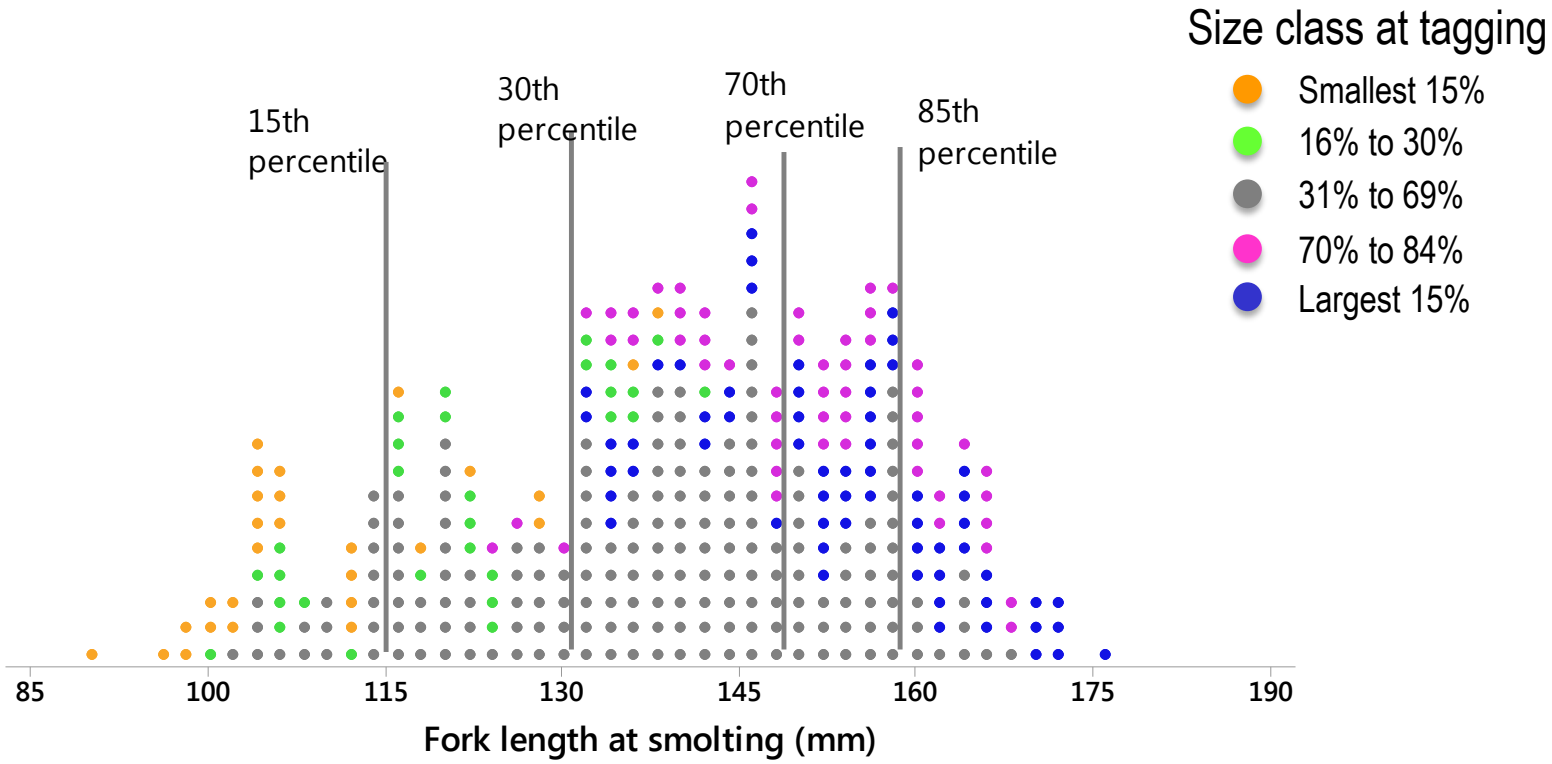
Growth & probability of death for S1 steelhead



When is the critical growth period for S1s?



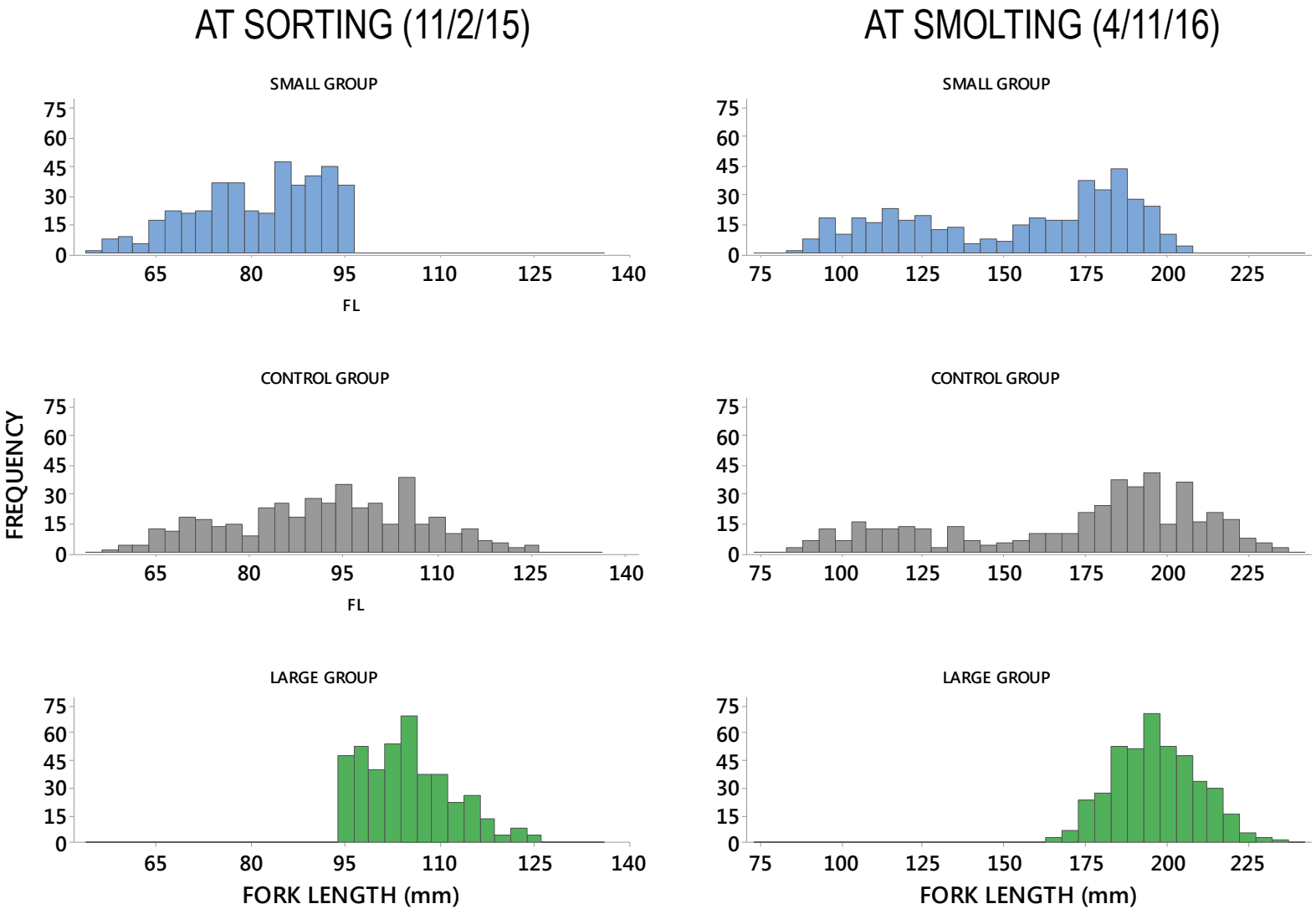
Early growth rate correlates with size at smolting



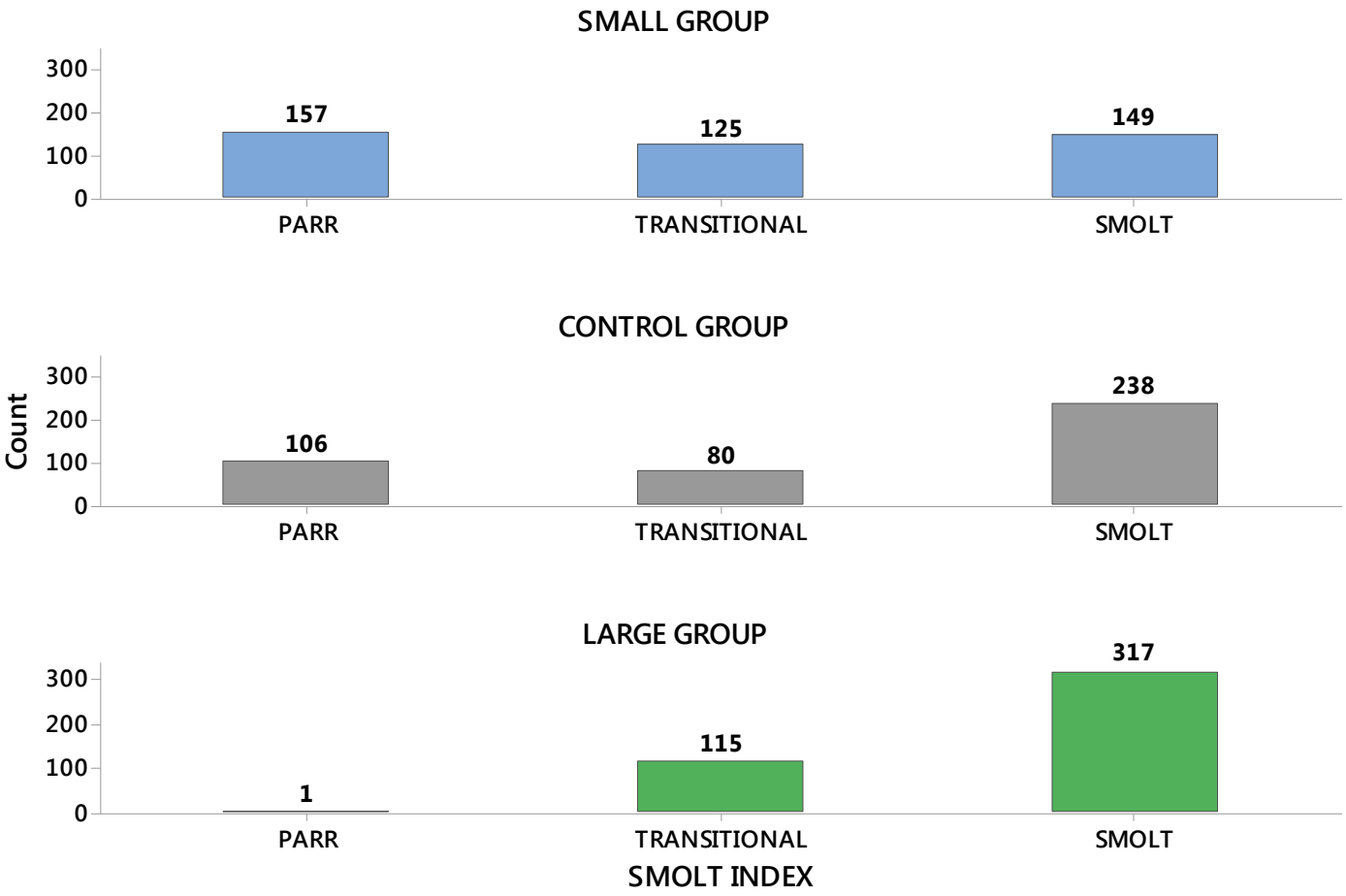
Is early growth affected by behavior in culture?

- 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?

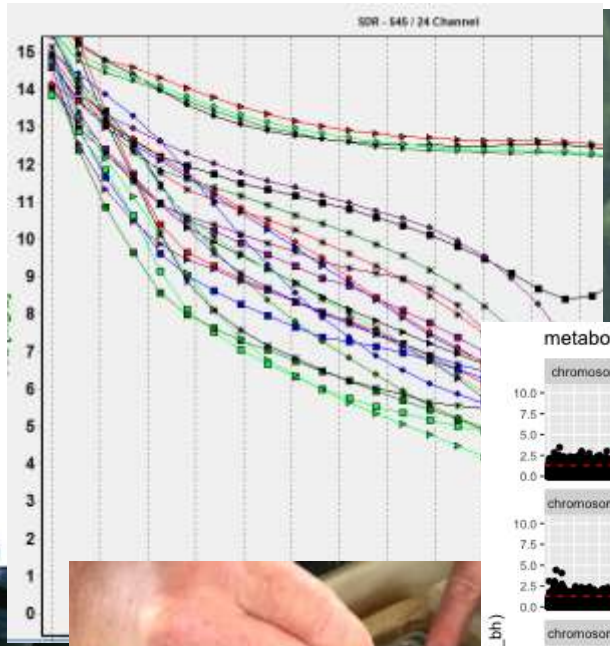


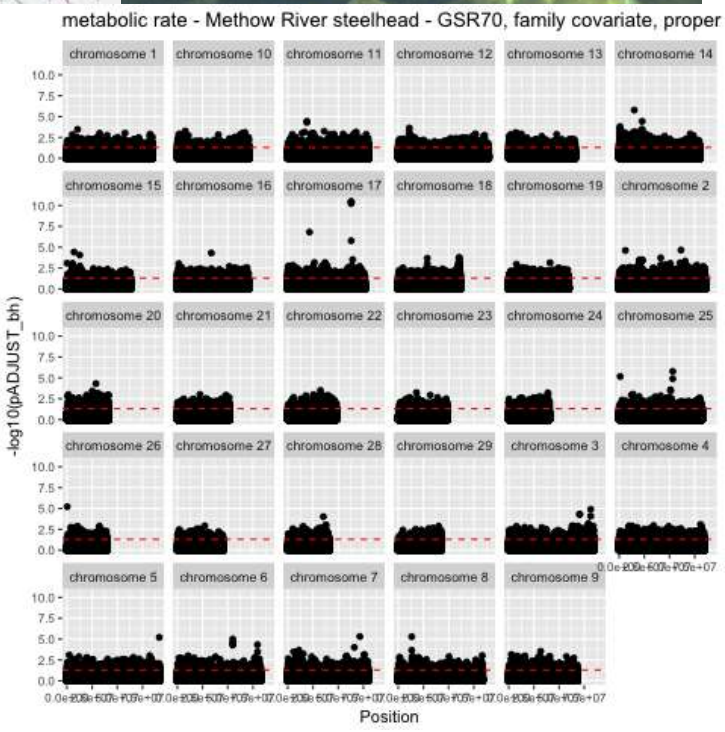
Does size sorting improve smoltification rate?



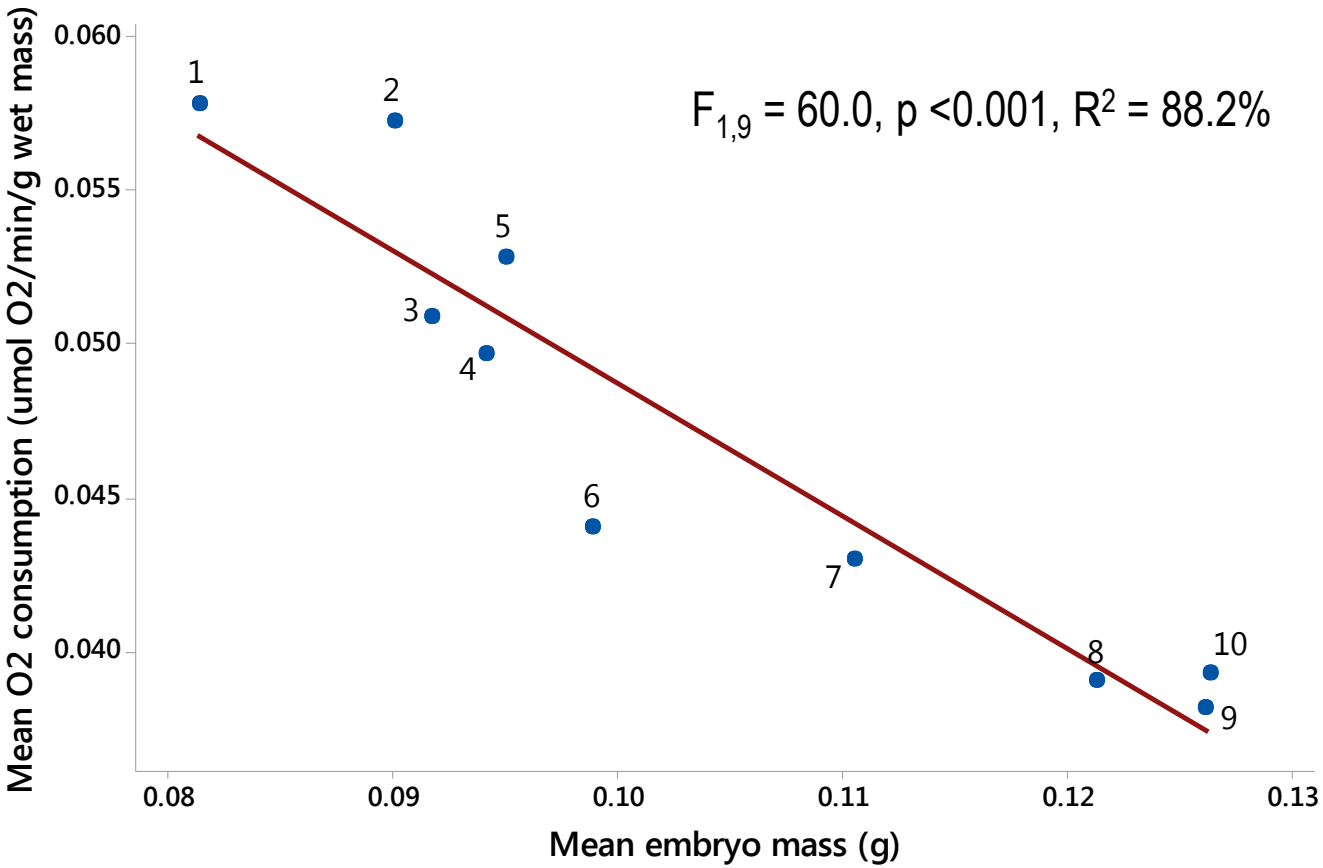
Genetic basis of metabolism, growth and survival in natural and hatchery environments

Florian Graner

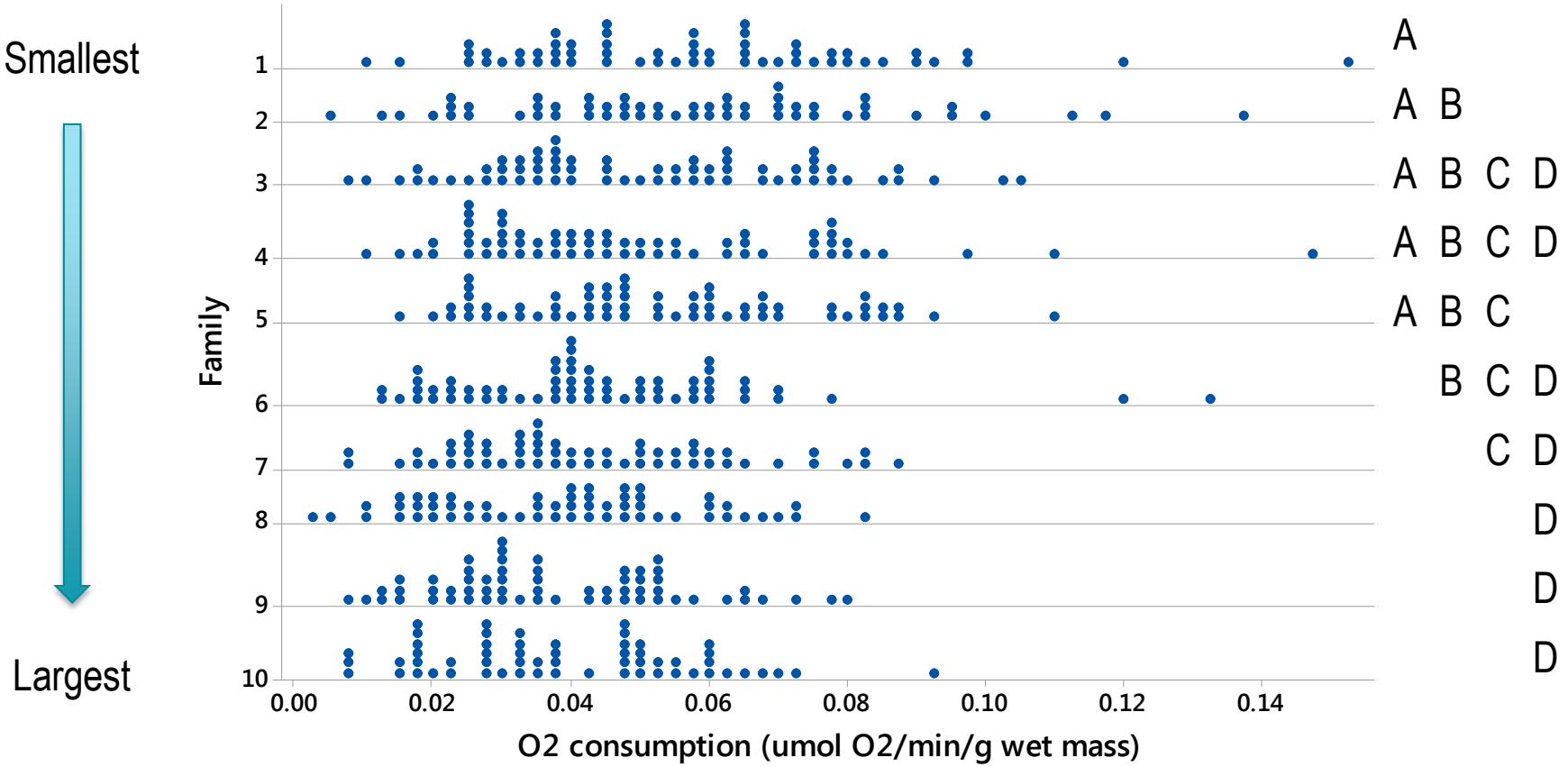




O_2 consumption inversely related to embryo mass



O_2 consumption rate within & among families



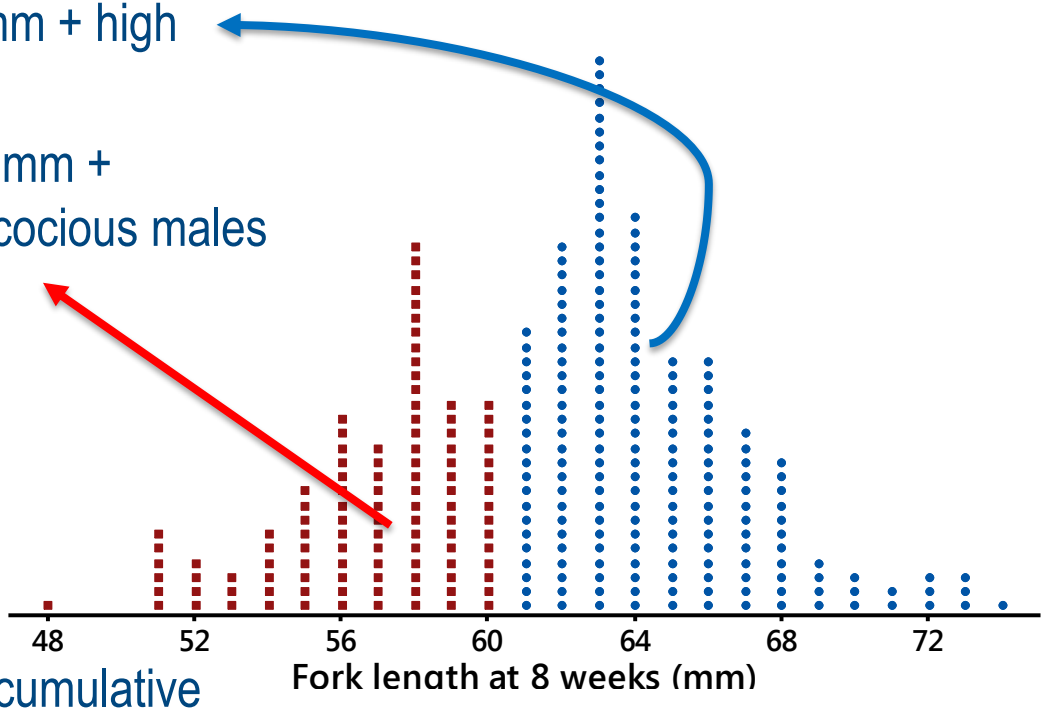
$F_{9,601} = 6.67$, $p < 0.001$, $R^2 = 9.20\%$

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 (~20%)
- 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
  - **S1**: largest 67% of fish ≥ 61mm + high ration
  - **S2**: smallest 33% of fish ≤60 mm + modulate growth, reduce precocious males
- Three replicate 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.



Acknowledgements

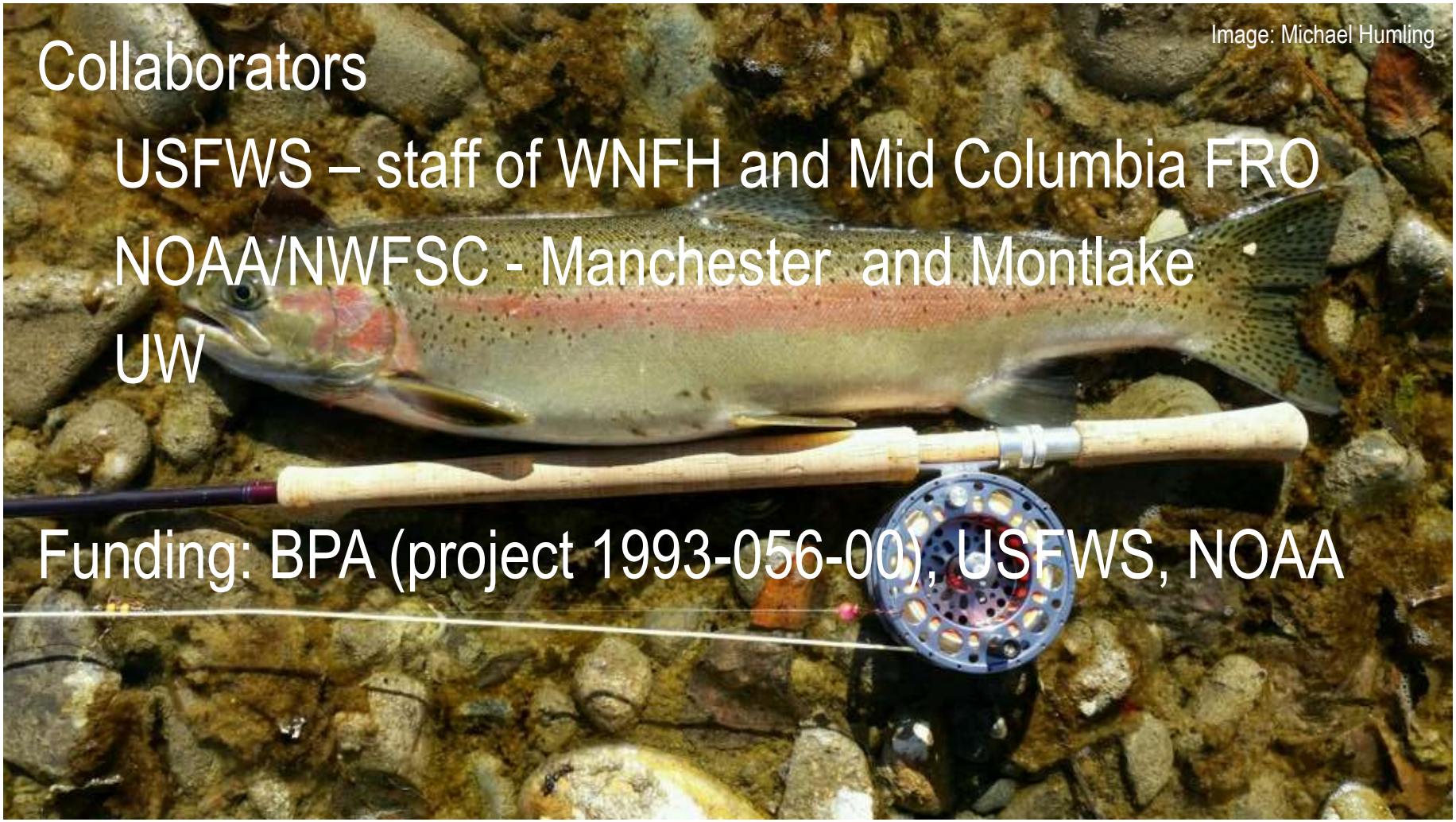


Image: Michael Humling

Collaborators

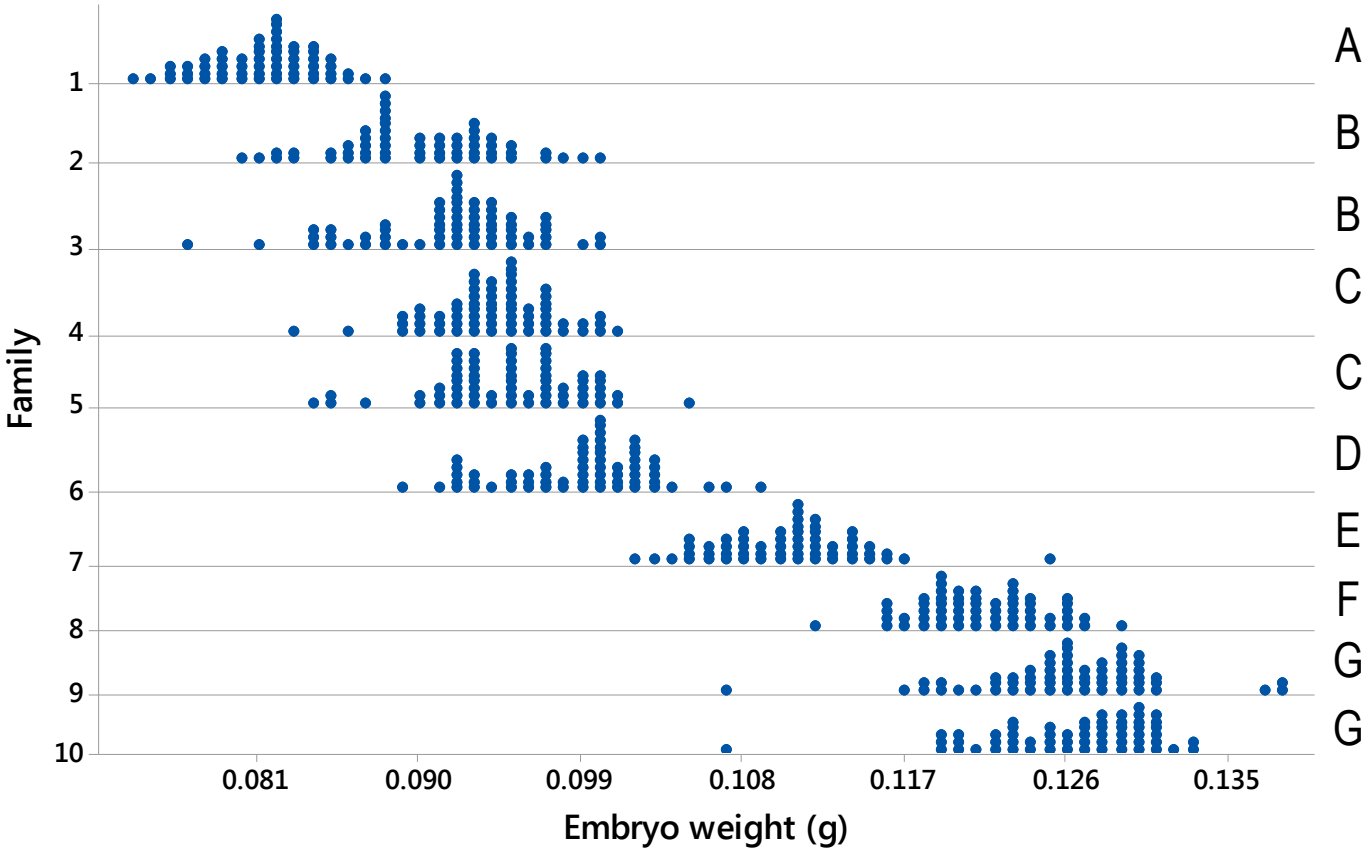
USFWS – staff of WNFH and Mid Columbia FRO

NOAA/NWFSC - Manchester and Montlake

UW

Funding: BPA (project 1993-056-00), USFWS, NOAA

Embryo mass within & among families



$F_{9,601} = 926$, $p < 0.001$, $R^2 = 93.4\%$