Can angler-assisted broodstock programs improve the catch rate of hatchery steelhead

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#### **ODFW** hatcheries

- In 2019, ODFW operated 32 hatcheries
- Produce fish for harvest and conservation
- Broodstock collection of salmon & steelhead:
  - Trapping
  - Seining
  - Angling
    - Involves public outreach and engagement
    - Collects broodstock from larger population diversity
    - Collects in rivers where trapping is inadequate to meet goals







#### Do angler-caught broodstock improve catch rates in fisher

Conclusions

#### Genetics of behavior





Response to two generations of selection on horizontal position (time near observer) in zebrafish.



Steelhead spawn timing. Abadia-Cardosa et al. (2013) Molecular Ecology 22:4733-4746



## a) Schooling behavior in sticklebacks

Greenwood et al. (2015) Genes, genomics, genetics 5:761-769

#### b) Boldness and surface orientation of zebrafish

Oswald et al. (2013) PLoS ONE

c) Spawn timing in steelhead

Abadia-Cardosa et al. (2013) Molecular Ecology 22:4733-4746

## d) Migration timing in Chinook salmon and steelhead

Prince et al. (2017) Science Advances 3: e1603198 Hess et al. (2016) Royal Society Proc. B Bio Sci 283: 20153064

O'Malley et al. (2007) Molecular Ecology 16:4930-4941 Thompson et al. (2020) Science 370:609-613 Introduction Methods Results Conclusions

# Genetic basis for vulnerability to anglers

 Heritable propensity to strike a lure demonstrated in







FIGURE 2.—Total catch rates of high-vulnerability and lowvulnerability largemouth bass, showing the divergence across three generations of selection from the parental  $(P_1)$ generation.

Philipp et al. (2009) *Transactions Am. Fish Soc.* 138:189-199

### Alsea River steelhead

Steelhead that don't bite a hook escape the fishery and are spawned at the



Steelhead that bite a hook are harvested in the fishery and don't contribute to the



So, spawning only trap-caught broodstock could "breed out the bite" of hatchery steelhead

#### General Question (Q1)

Are offspring of AC broodstock over-represented in the creel, relative to the proportion of the cohort produced with AC broodstock?



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Mechanistic Question (Q2) Are the offspring of AC broodstock overrepresented in the creel, relative to collections in the trap? AC broodstock

<u>Mechanistic Question (Q3)</u> Do AC broodstock produce more offspring than TC broodstock?



Introduction Methods Results Conclusions

# Steelhead collection, spawn & smolt release

|                       | 2015<br>Spawn | 2016<br>Spawn |
|-----------------------|---------------|---------------|
| Brood from traps      | 22 pairs      | 27 pairs      |
| Brood from<br>anglers | 17 pairs      | 23 pairs      |

#### 

- Unique pair 1F:1M mating
- Tissue collected from all brood
- Juvenile steelhead
  - reared together
  - marked same (ADRM)
  - released in April of 2016 (cohort 1) and 2017 (cohort 2)





### Sampling the ADRM adult returns

- Genetically "tagged" offspring returned in winters of 2018 and 2019
  - Collected samples at hatchery trap
  - Collected samples through creel surveys



### Genotyping, parentage & analysis

- All samples genotyped (15  $\mu$ sats) brood and ADRM returns
- Parentage of ADRMs with CERVUS v3.0.7 (Kalinowski et al. 2007)
- Tested for parent-offspring relationships using only full triad data

| Question 1   |   | Question 2   |                                      |                       |  | Question 3  |  |
|--|---|--|--------------------------------------|-----------------------|--|---|--|
| Are offspring of AC k<br>represented in the c<br>proportion of the co<br>AC broodstock?                        | proodstock over-<br>reel, relative to the<br>hort produced with | Are the offspring<br>over-represented<br>to collections in | of AC br<br>d in the ci<br>the trap? | oodstoc<br>reel, rela | k<br>ative                                 | Do AC broodstock<br>produce more offspring<br>than TC broodstock? |  |
| Estimated the likelihood<br>of observed AC<br>offspring catch<br>through a probability<br>density<br>function. | Chi square test   | <b>□</b> <sup>2</sup> =                                    |                                      |                       | Median number of<br>offspring compared for |   |  |
|  | Brood   | Trappe<br>d  | Angle<br>d                           | Total                 | Mann-Whitney U Test                        |   |  |
| N = total number of smolts released<br>K = total number of smolts released from angler-                        | Offspring of AC<br>parents                                      | а  | b                                    | a+b                   |  |   |  |
| caught brood<br>n = total number of fish sampled in creel  |   | Offspring of TC parents                                    | С                                    | d                     | c+d  | Wedla   |  |

#### Data summary for adult returns

| Winter 2018                                  | Hatchery Trap             | Creel               |
|--|---------------------------|---------------------|
| Sampled                                      | 369                       | 167                 |
| Genotyped >10 loci                           | 369                       | 167                 |
| Assigned to both parents                     | 300                       | 137                 |
|  |                           |                     |
| Winter 2019                                  | Hatchery Trap             | Creel               |
| Winter 2019<br>Sampled                       | Hatchery Trap<br>474      | <b>Creel</b><br>302 |
| Winter 2019<br>Sampled<br>Genotyped >10 loci | Hatchery Trap   474   473 | Creel<br>302<br>302 |

- 93% of parents and adult returns genotyped at all 15 loci
- 87% of 2018 & 2019 adult returns confidently assigned\* to both parents
- 4.6% of cohort 1 returned as "3-salt" steelhead in 2019

\*Based on simulated distribution of delta LOD scores; > 95% confidence of assignment

## Q1: Were offspring of AC broodstock over-represented in the creel, relative to the proportion of the cohort produced with AC broodstock?



For the 2015 and 2016 experimental cohorts, the percent of broodstock collected by anglers, the percent of all creel samples assigned as offspring of these angler-caught broodstock.

Q1: Were offspring of AC broodstock over-represented in the creel, relative to the proportion of the cohort produced with AC broodstock?



The likelihood (*y*-axis) that *x* number of steelhead produced with angler-caught broodstock would be observed among creel samples, given cohort size, composition and sampling effort. Actual observed numbers for each cohort are indicated by red lines.

# **No**, in fact, offspring of AC broodstock were consistently **under-represented** ( $P \le 0.005$ ) in the creel

# Q2: Were the offspring of AC broodstock over-represented in the creel, relative to collections from the trap?



# Q3: Do AC broodstock produce more offspring than TC hrondstock?



Median number of adult offspring was greater for trap-caught parents (12/pair) than for angler-caught parents (4/pair) (U = 99.5; df = 1; P = 0.014) Median number of adult offspring was greater for trap-caught parents (15/pair) than for angler-caught parents (8/pair) (U = 167.0; df = 1; P = 0.005)

#### **No.** AC broodstock consistently produced significantly fewer

Conclusions

#### Take home messages

- 1. Offspring of AC broodstock were under-represented in the creel.
- 2. Proportion of AC offspring in the creel exceeded that of trap in one of two years.
- 3. AC broodstock consistently produced fewer adult returns to *both* the creel and the trap than TC broodstock.



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Anglers of the Alsea River

Results

Collection method

Conclusions

#### *Research*: Does parental stress affect performance and offspring survival?



Angler-caught steelhead in temporary holding tube