Integrating data to monitor life history diversity in Columbia Basin salmonids

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Columbia River Inter-Tribal Fish Commission
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Overview

• Genetics Lab Conceptual Workflow
• Steelhead age-at-maturity
  • Life history variation: age-at-first return ("maturity")
  • Why it matters: portfolio effects and unequal harvest
  • Identifying genetic markers for age-at-maturity in steelhead
• Opportunities in conservation
  • Age at maturity markers
  • Run timing markers
• Products and data sharing
Hagerman Genetics Lab: Common workflows

Paradigm: Putting fish back in the rivers

- **Important Phenotypic Variation**
- **Manager Questions**
- **Traditional Ecological Knowledge**

**Whole genomic data of distinct groups** (many genetic loci, few individuals)

- What genes influence a [heritable] phenotype?
- Population structure/assignment
- How strong is a marker-trait association?

**Genotypes of neutral or candidate loci** (fewer genetic loci, many individuals)

- Predict phenotypes

**Loci (genes) contributing to a trait → candidate markers**

- Association strength & patterns
- Phenotypes across time
- Fishery Composition

**Data sharing + promotion**

**Phenotypic & Environmental Data**

- Phenotypic & Environmental Data

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**Locus** (plural: **loci**): physical location on a chromosome

**Gene**: a locus exhibiting a function or effect, often coding a protein

**Genotype**: variants an individual has at each copy of a locus (one each from mom and dad), assessed using genetic markers

**Phenotype**: the physical characteristics (incl. behavior) of an individual; a.k.a. traits
Steelhead natural history:
*one size does not fit all (age/size at migration)*

Steelhead sampled at Bonneville Adult Fish Facility (BONAFF)
Portfolio effects: *population insurance*

**Spawn year**

1.1 1.2 1.1 1.2

Stevehead: repeat spawners!

Original diagram design by Ilana Koch (Koch et al. 2018 Evolutionary Applications, 12725)
Portfolio effects: population insurance

Poor migration or spawning conditions in spawn year 4
Portfolio effects: *population insurance*

Original diagram design by Ilana Koch (Koch et al. 2018 Evolutionary Applications, 12725)
Portfolio effects: *population insurance*

**Spawn year**

**Heritability of age-at-first migration (age-at-maturity)**

Original diagram design by Ilana Koch (Koch et al. 2018 Evolutionary Applications, 12725)
Loci influencing age-at-maturity

Pool-seq: pooled [individual-barcoded] whole genomic libraries

1-ocean

2-ocean

PBT Age (parentage based tagging), i.e. spawn year of hatchery fish

Original Figure by Shawn Narum
Genetic Markers for Age-At-Maturity

Figure 4 from Waters, Narum, et al. 2021 Mol. Ecol.
Genetic Markers for AAM

BONAFF (SY 2014-19):
- Fin Clip
- PIT Tag

Image from fishbio.com
Genetic Markers for AAM

Individuals sampled at Bonneville in the right time period (H.G.L. SQL database)

PIT array recordings (PITAGIS complete records)

Complete migration histories (in R using 'allowed arrays')

Utilized PIT arrays

Bonneville Passage Day, Spawning Tributary Arrival Day, and stock (subbasin)
Genetic Markers for AAM

Marker interrogation

BONAFF (SY 2014-19):
Fin Clip
PIT tag  N=1,538
Fork Length  fish
Scale (aging)
Genetic Markers for AAM

Marker interrogation

**BONAFF (SY 2014-19):**
- Fin Clip
- PIT tag
  - N=1,538
- Fork Length
- Fish Scale (aging)

**Genotype * covariates =** fork length or ocean duration

- sex (genetic)
- migration phenology
- kinship
- population structure
Genetic Markers for Age-at-maturity

Results: SIX6 gene markers explain >10% of ocean age variation in a sex-specific manner
Portfolio effects: *population insurance*

Original diagram design by Ilana Koch (Koch et al. 2018 Evolutionary Applications, 12725)
Basin-wide variation in steelhead
Steelhead natural history: one size does not fit all

Run Timing

- April
- May
- June
- July
- August
- September
- October
- November
- December

Arrival day (ordinal)

Bonneville day (ordinal)

53%
Warm Springs Fisheries:
East Fork Hood winter-run stock:
- Fish caught at weir can be rapidly genotyped to predict stock and migration-phenotype
- Allows identification and avoidance of stray or introgressed summer-run fish in broodstock
Run-timing markers: GREB1L-ROCK1
Results

A. Interior ocean-type (iOT)

B. Interior stream-type (iST)

C. Lower Columbia (LC)

Passage Day

GA
Steelhead (*Oncorhynchus mykiss*) lineages and sexes show variable patterns of association of adult migration-timing and age-at-maturity traits with two genomic regions

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**Journal data reporting requirements:**
- Genotype/Phenotype Data
- Genomic Data

**Direct data sharing: partner agencies & collaborators**
- Cloud distribution in text/zip format for addition to non-public databases (PBT baseline)
- Courier portable hard drives (genomic data)

**Stakeholder presentation, discussion, collaboration**
- Data sharing + promotion
  - CRITFC Commission presentations
  - Tribal and agency collaborations
  - Working groups

**Variation**
- Phenyotypic & Environmental Data

**Traditional Ecological Knowledge**
- Population structure/assignment

**What genes influence a heritable phenotype?**
- Loci (genes) contributing to a trait ➔ candidate markers
- Predict phenotypes
- Association strength & patterns
- Phenotypes across time

**Fishery Constituency**
- Data sharing + promotion
- Stakeholder presentation, discussion, collaboration
Questions

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- Collaborators at CRITFC, Warm Springs Fisheries, Idaho F&G
- Labmates at the Hagerman Genetics Lab
- Funding from Bonneville Power Administration
Genetic Markers for AAM Chinook

Utilized PIT arrays
Genetic Markers for AAM

males

stream-type

ocean-type

FALL

ocean-type

SUMMER
Genetic Markers for AAM

- **females**
  - stream-type
  - ocean-type
  - FALL
  - ocean-type
  - SUMMER