HARNESSING DRIVERS OF PHENOTYPIC VARIATION: THE MAKING OF WILD FISH SURROGATES WITH SPECIFIC MIGRATORY PHENOTYPES

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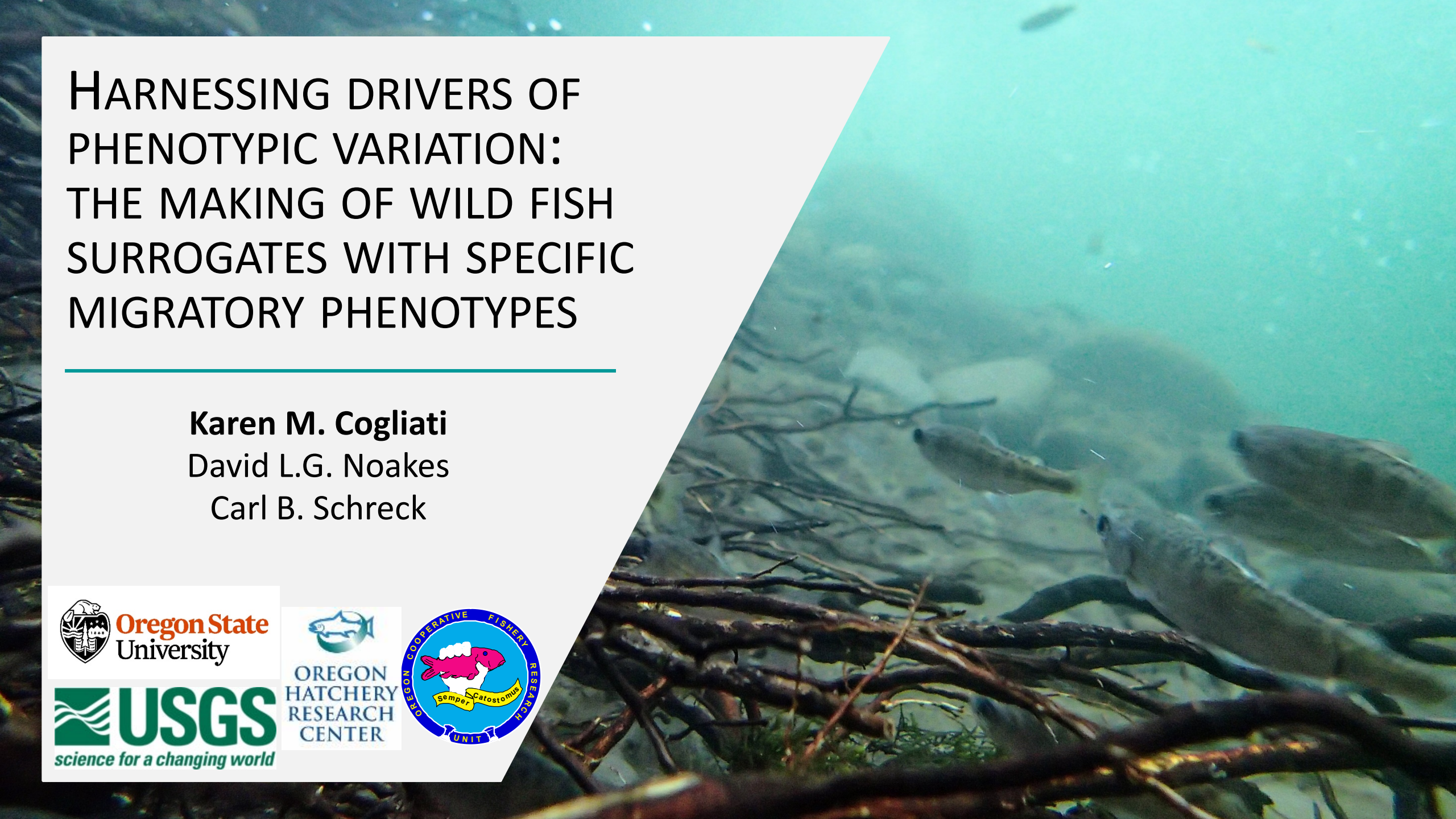


WILD FISH SURROGATE PROJECT

Produce juvenile salmonids that emulate <u>specific wild fish movement phenotypes</u>

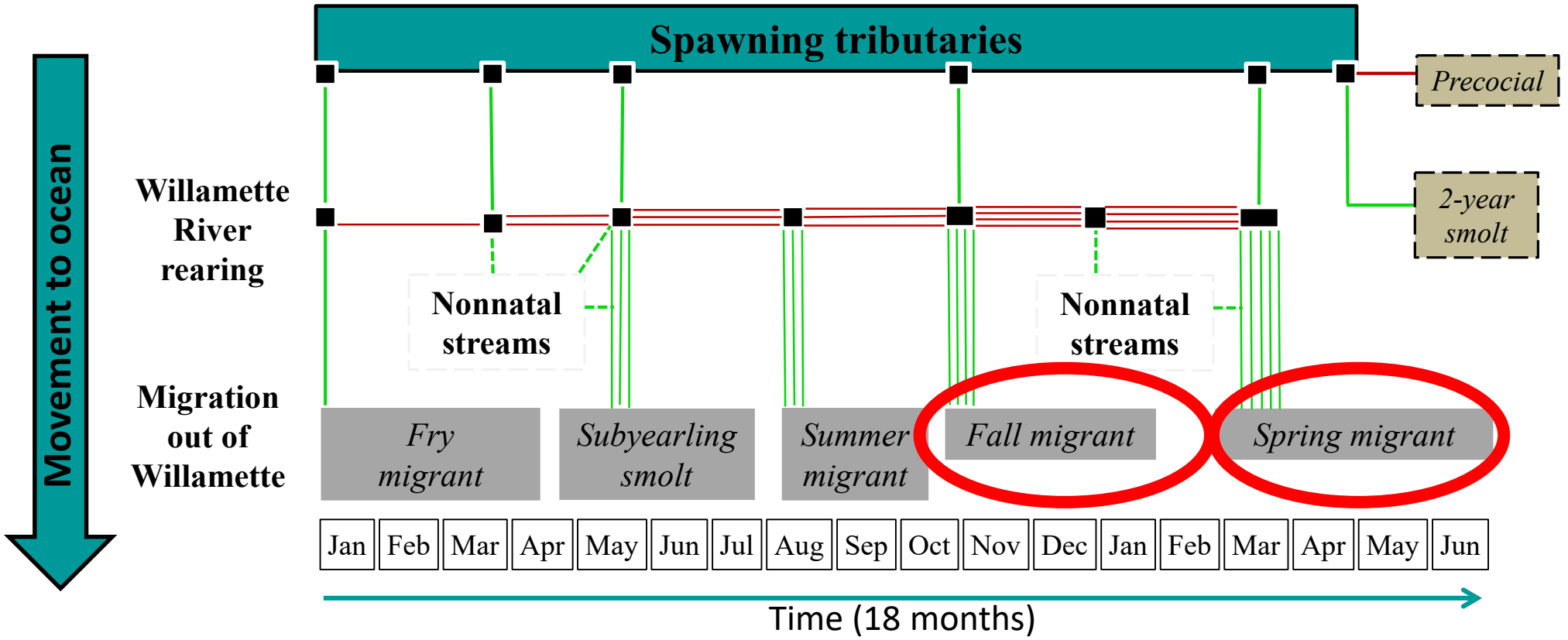
Steelhead

Chinook Salmon

Fish provided in 2018

Brood year	Project location	Developmental stage	Fish #	Tag – Purpose
Chinook salmon				
2016	Lookout Point	Yearlings	1,625	JASTS/PIT – passage rates and distribution (PNNL)
2017	Lookout Point	Fry-parr	165,000	Genetic - fry survival study (USGS)
2016	Foster	Yearlings	1,500	RT/PIT – passage rates and distribution (PNNL)
2016	Foster	Yearlings (hatchery)	2,000	Balloon – injury and survival (Normandeau)
2017	Foster	Sub-yearlings	1,500	RT/PIT – passage rates and distribution (PNNL)
2017	OSU	Sub-yearlings	2,000	Copepod project
Steelhead				
2016	Foster	2-year smolts	1,300	RT/PIT – passage rates and distribution (PNNL)
2017	Foster	1-year smolts (hatchery)	800	RT/PIT – passage rates and distribution (PNNL)
2017	Foster	1-year smolts (hatchery)	320	Balloon – injury and survival (Normandeau)

Juvenile Migration in Willamette River Basin



■ **Threshold or decision points**

Migration downstream

Rearing

Schroeder et al. 2015


Donnell Gasbarinni


Grant and Grant


Hill


Natural Environment Research Council


Shuster and Wade


Lee et al. 2015

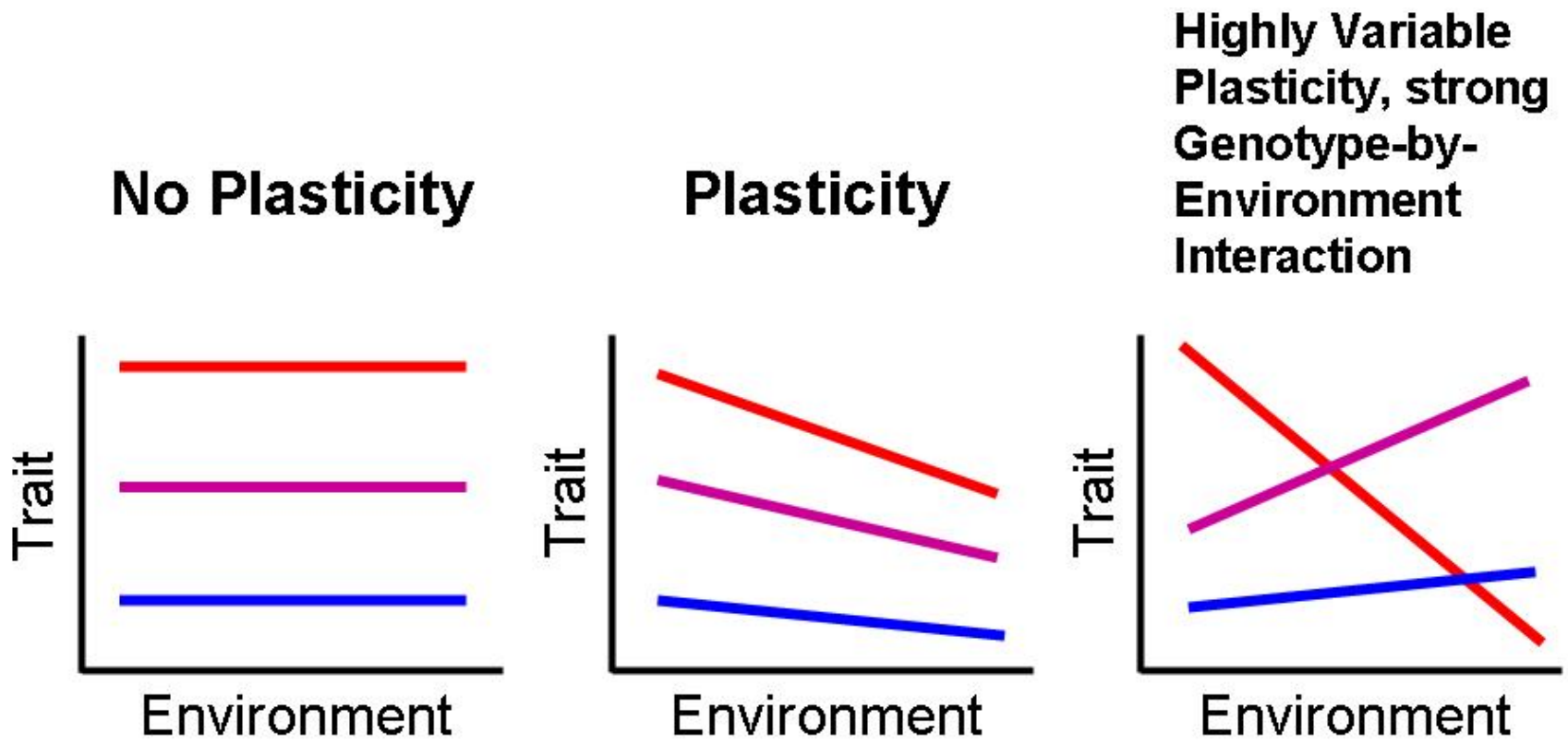
GENETIC AND ENVIRONMENTAL INFLUENCES

PHENOTYPIC TRAITS

$\times$ V_{GE}

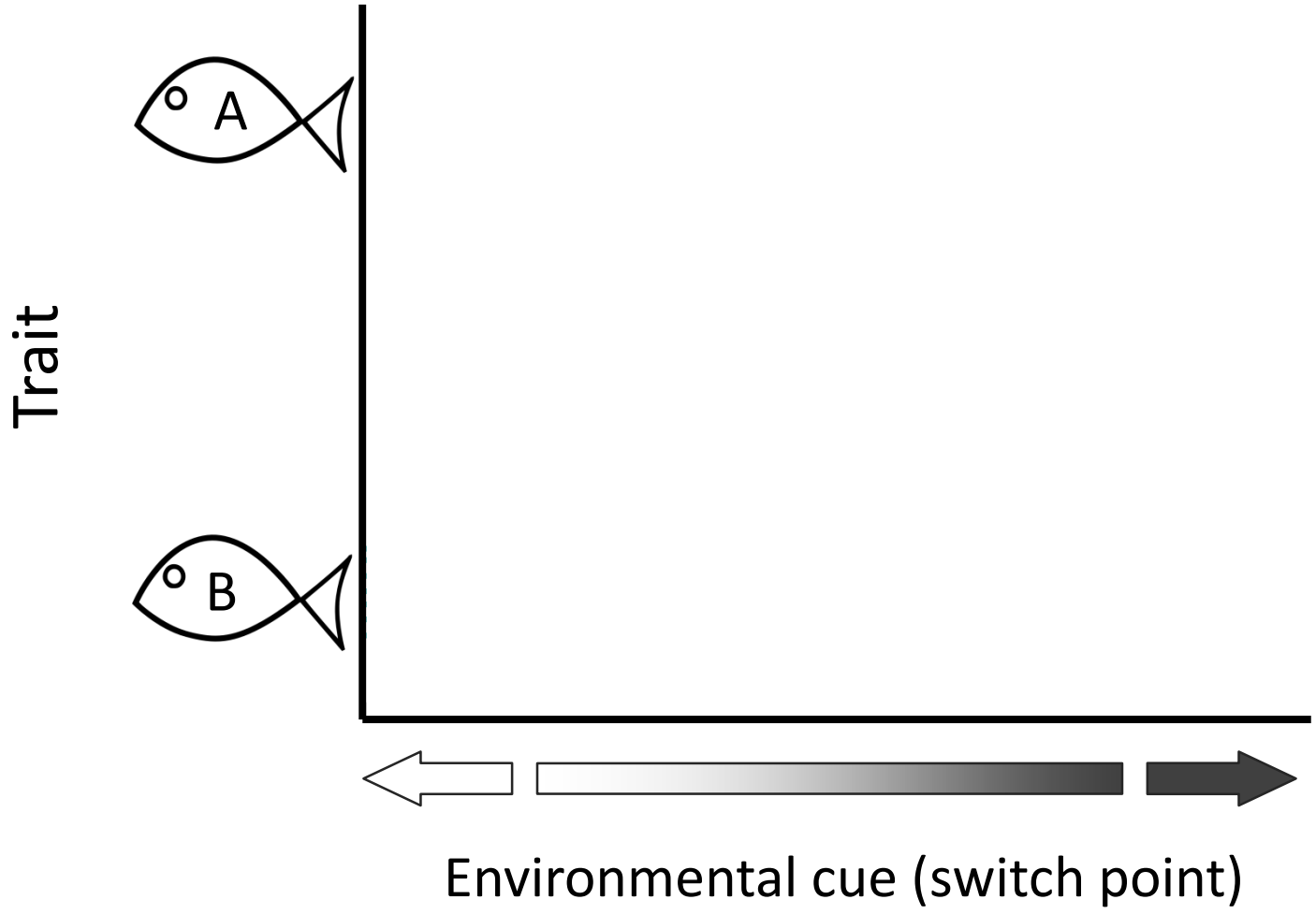
G x E = Phenotypic plasticity

The ability of one genotype to produce more than one phenotype when exposed to different environments

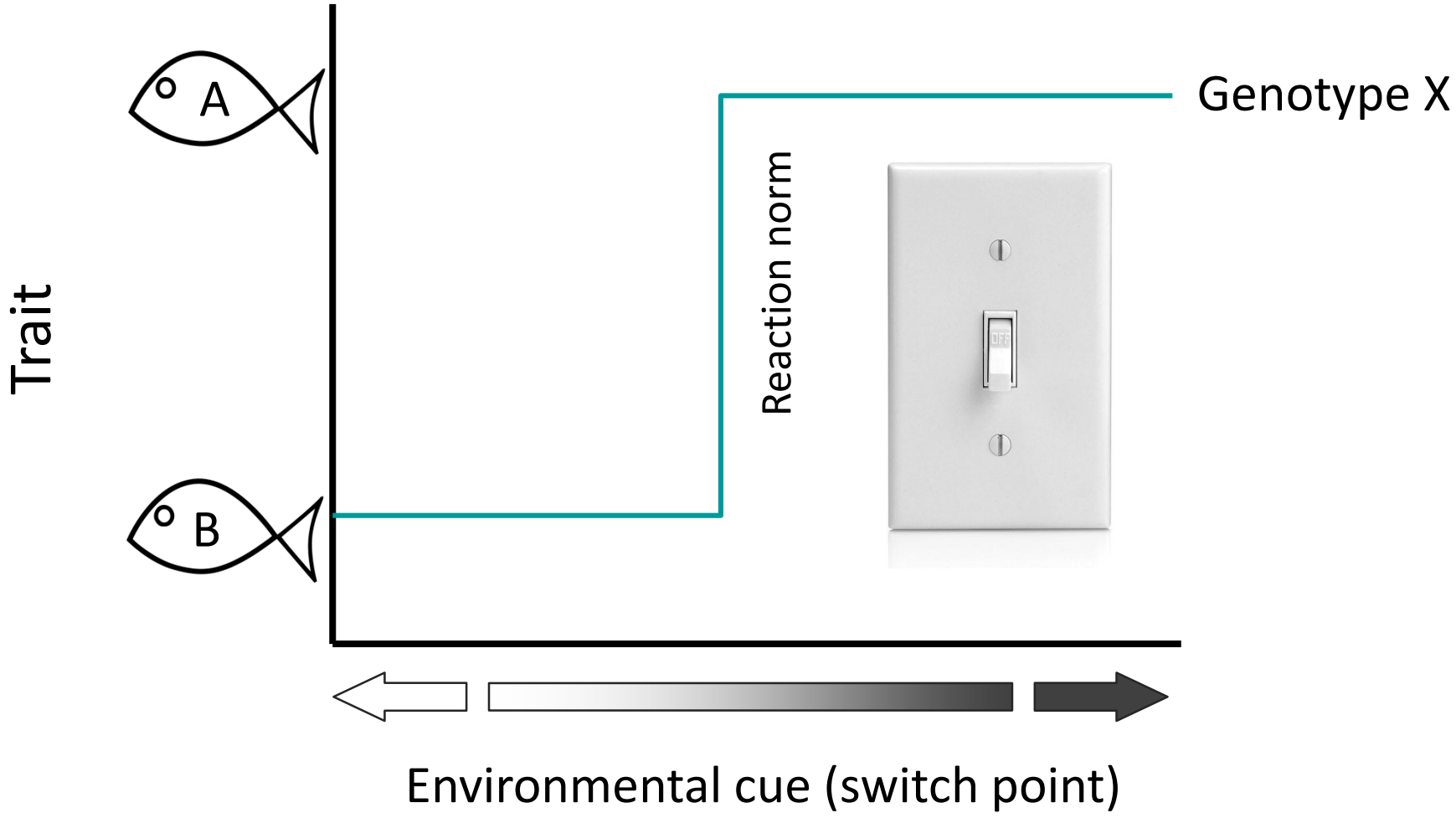


Each of these lines represent reaction norms

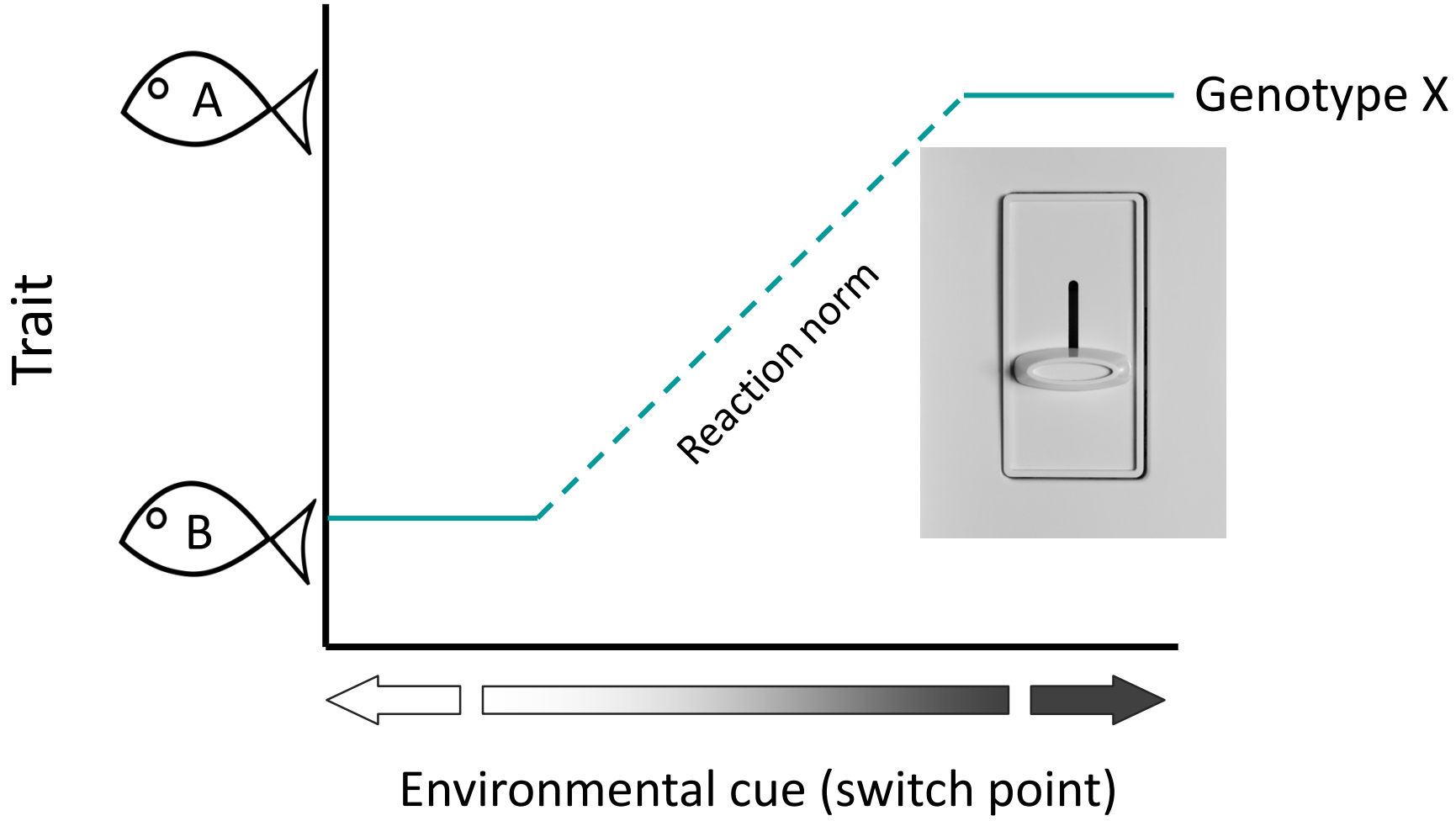
VARIATION AND REACTION NORMS



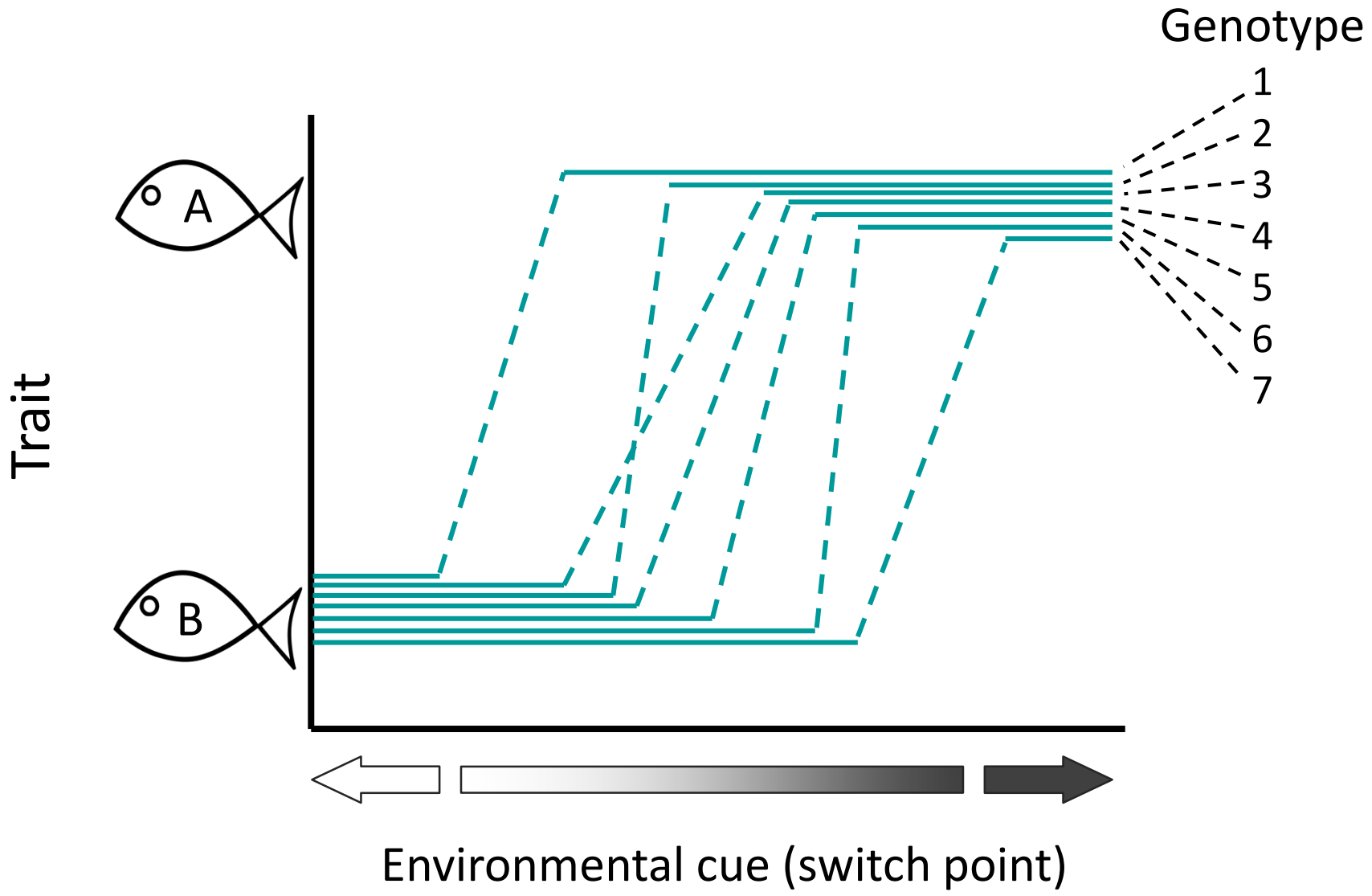
VARIATION AND REACTION NORMS



VARIATION AND REACTION NORMS

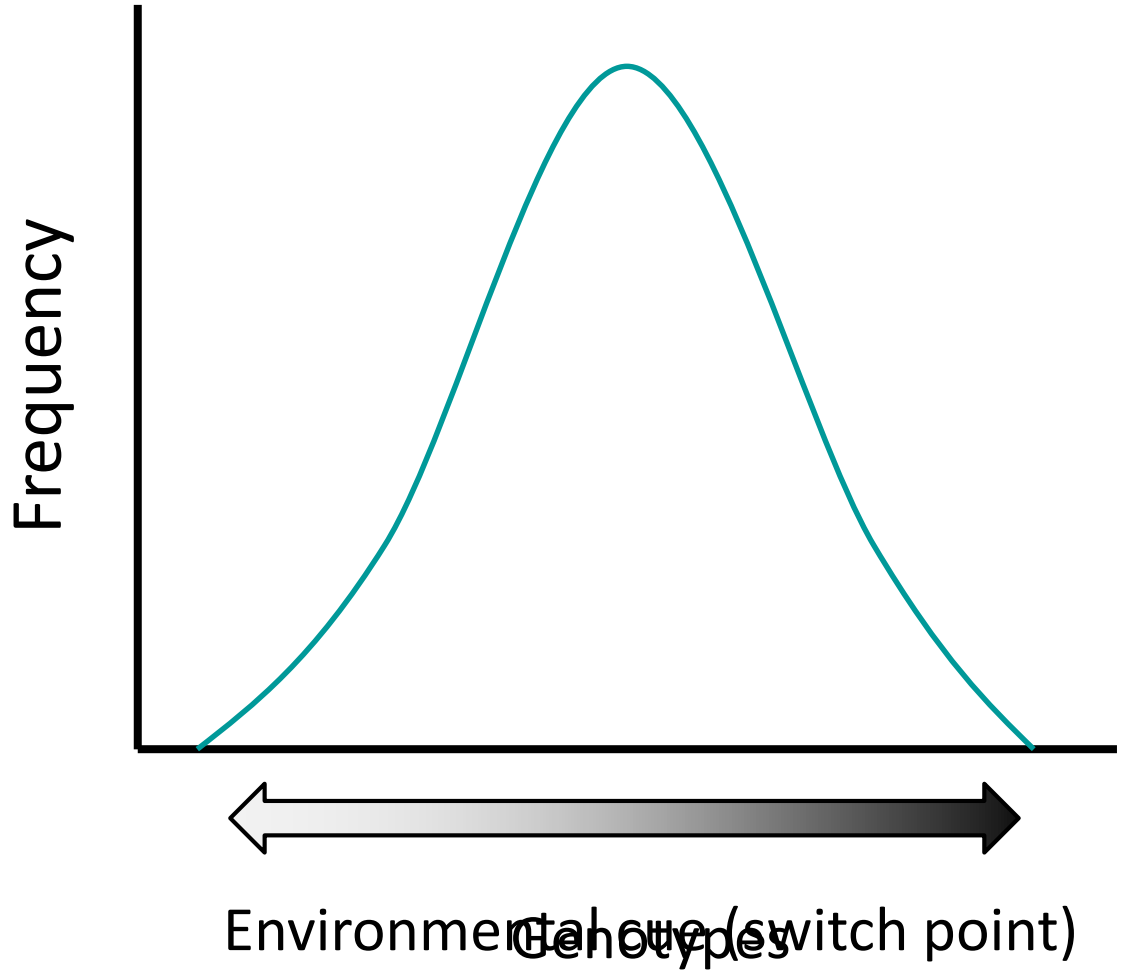


VARIATION AND REACTION NORMS

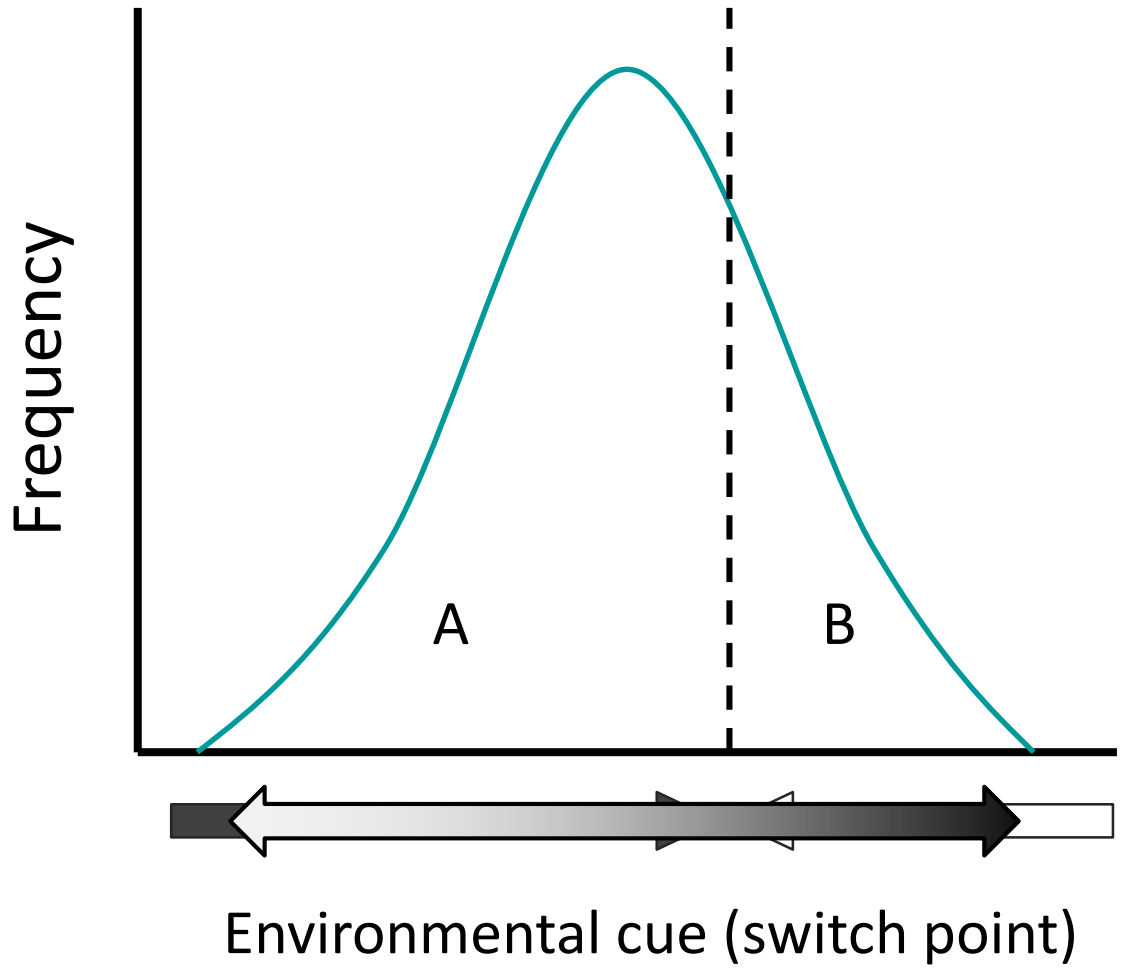


FREQUENCY OF LIFE HISTORY TRAITS

Distribution of genotypes in population



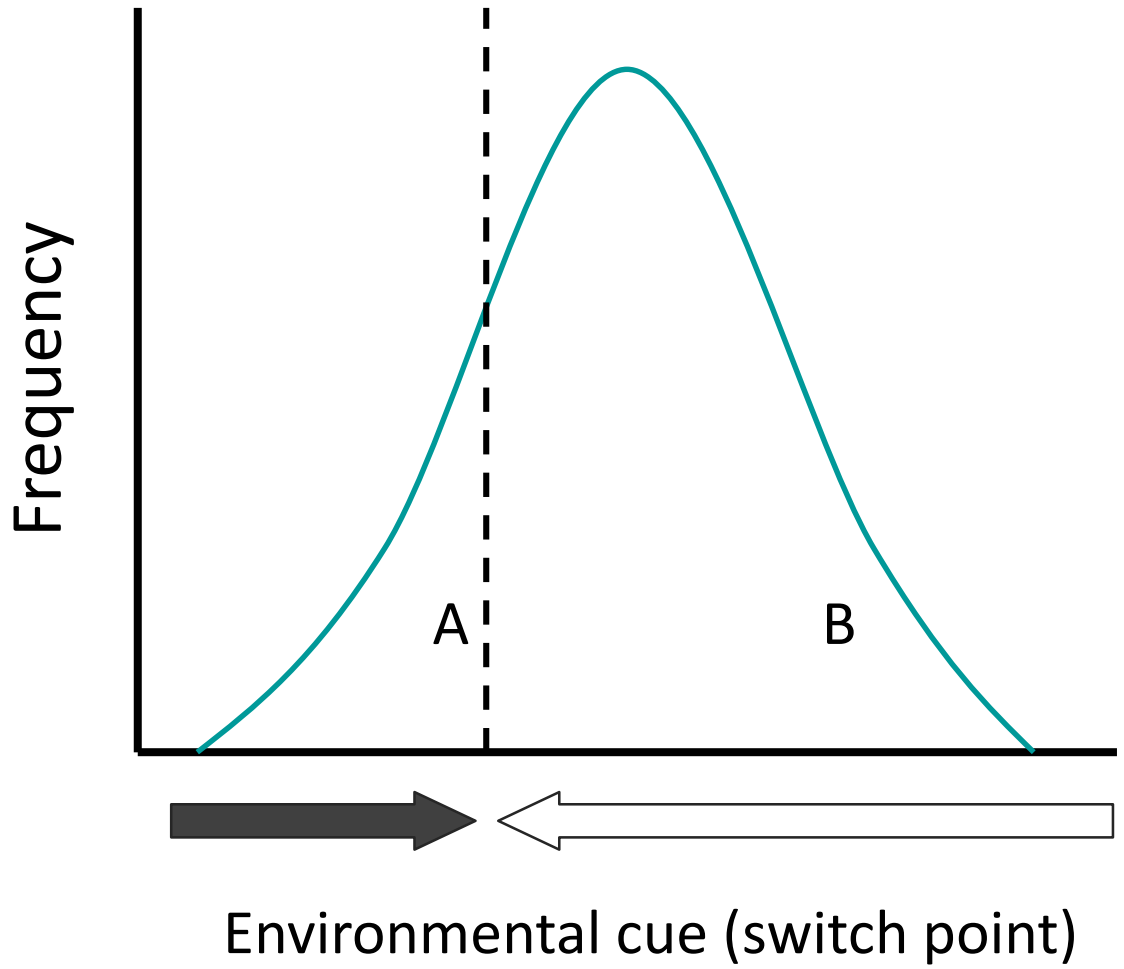
FREQUENCY OF LIFE HISTORY TRAITS



Distribution of genotypes in population

Can produce different phenotypes (e.g. A and B)

FREQUENCY OF LIFE HISTORY TRAITS

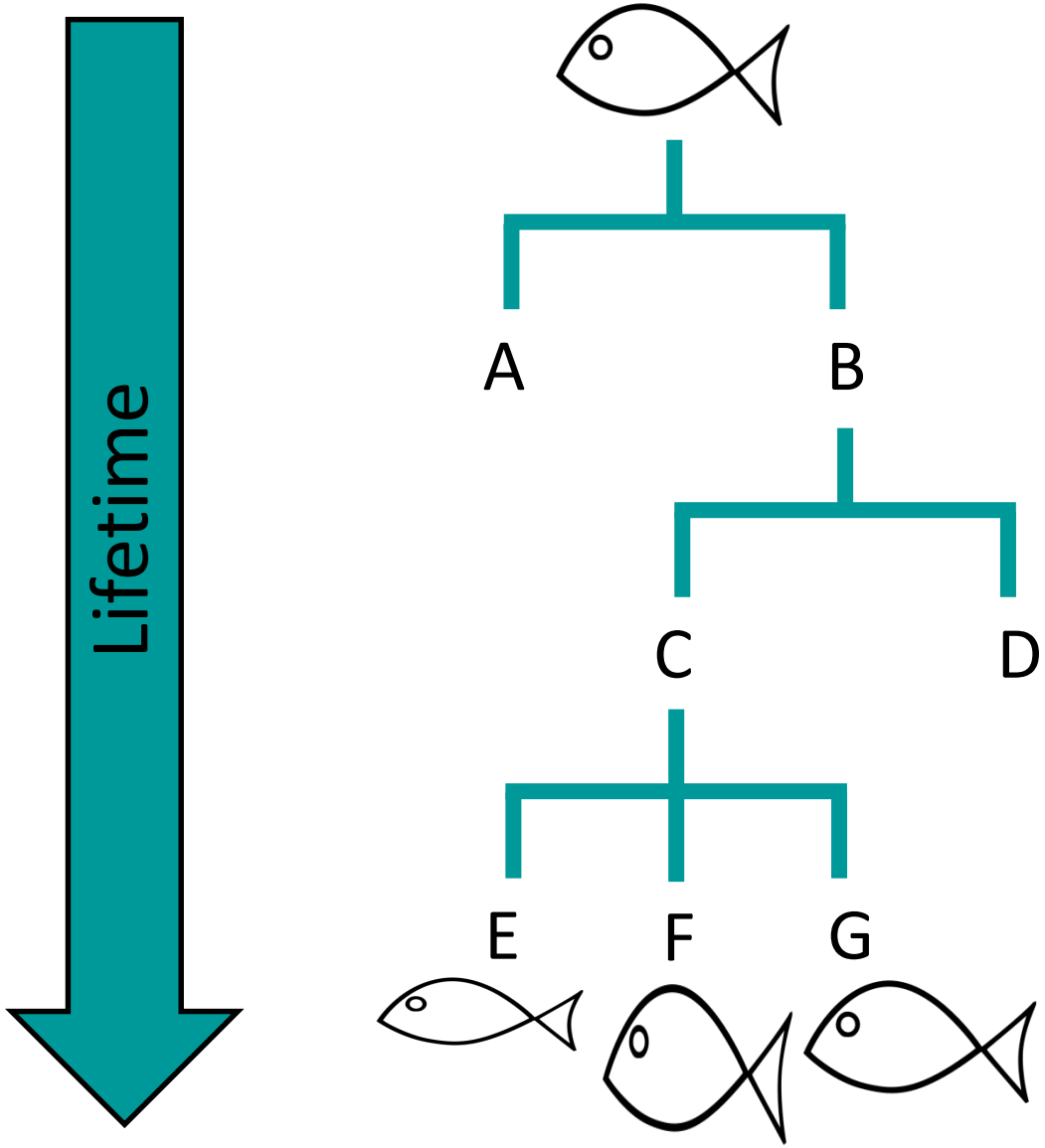


Distribution of genotypes in population

Can produce different phenotypes (e.g. A and B)

Changes depending on environmental cue

LIFE HISTORY PATHWAYS



Switch point 1

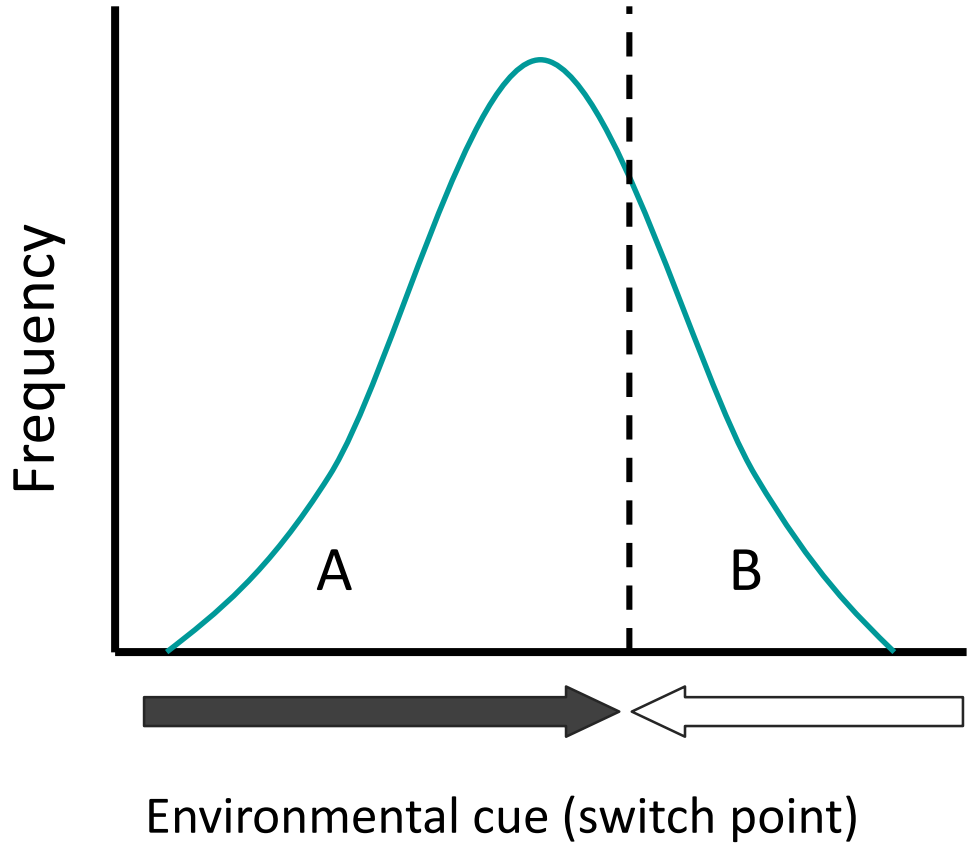
Switch point 2

Switch point 3

Phenotypic plasticity and the Wild Fish Surrogate Project

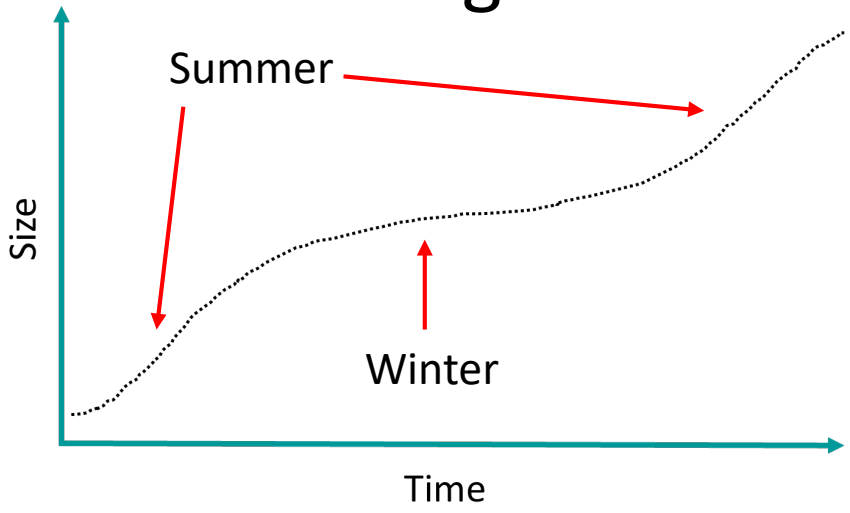
PART 1: ENVIRONMENT

Evaluate how aspects of the **early rearing environment** influences the expression of juvenile downstream movement phenotypes

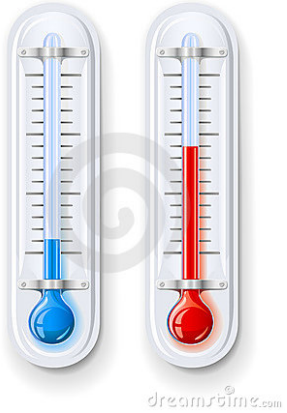


ALTERED REARING ENVIRONMENT

Wild-like growth



Temperature

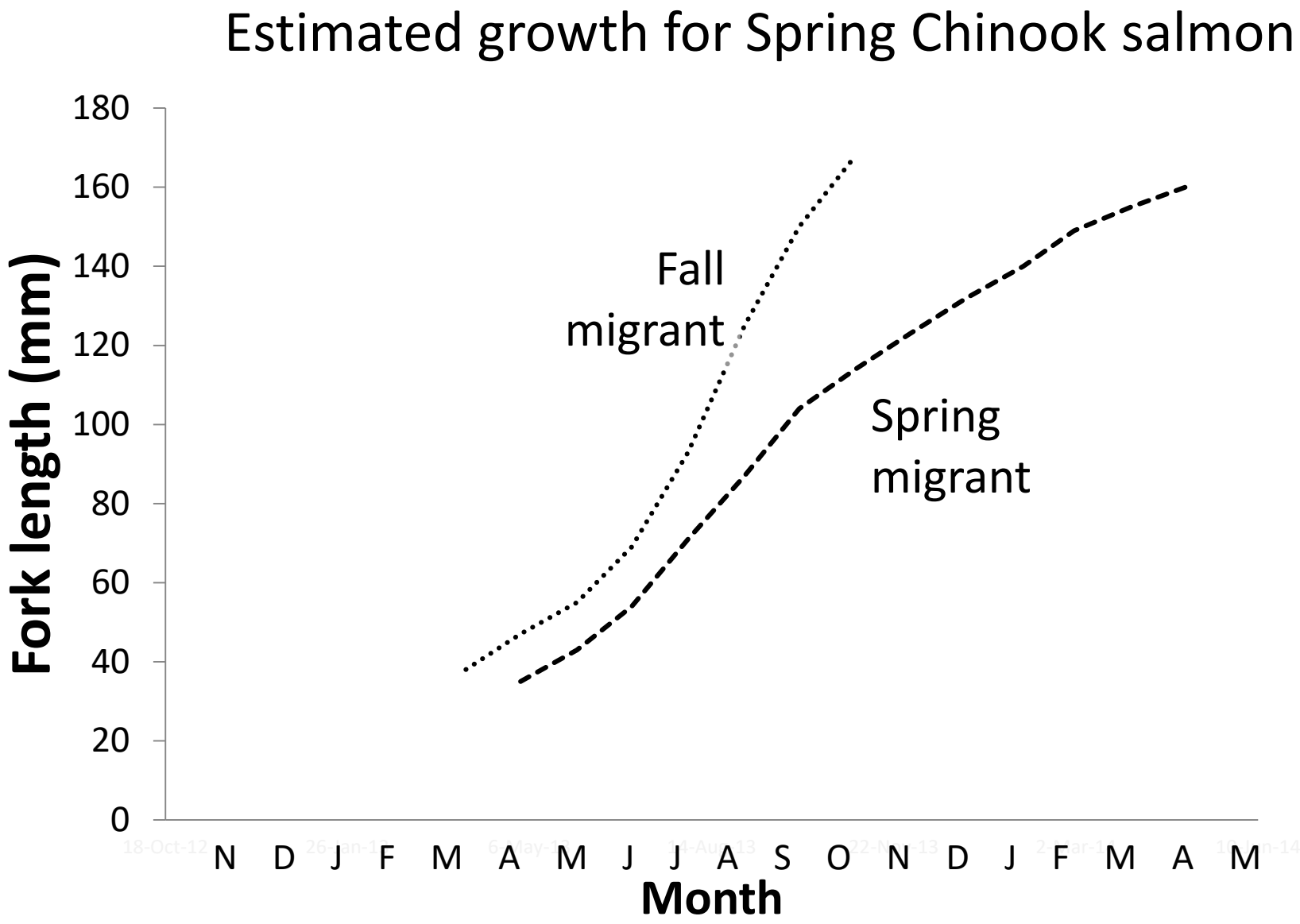


Diet quality and pattern of delivery

Density

Tank environment

WILD FISH GROWTH TRAJECTORIES



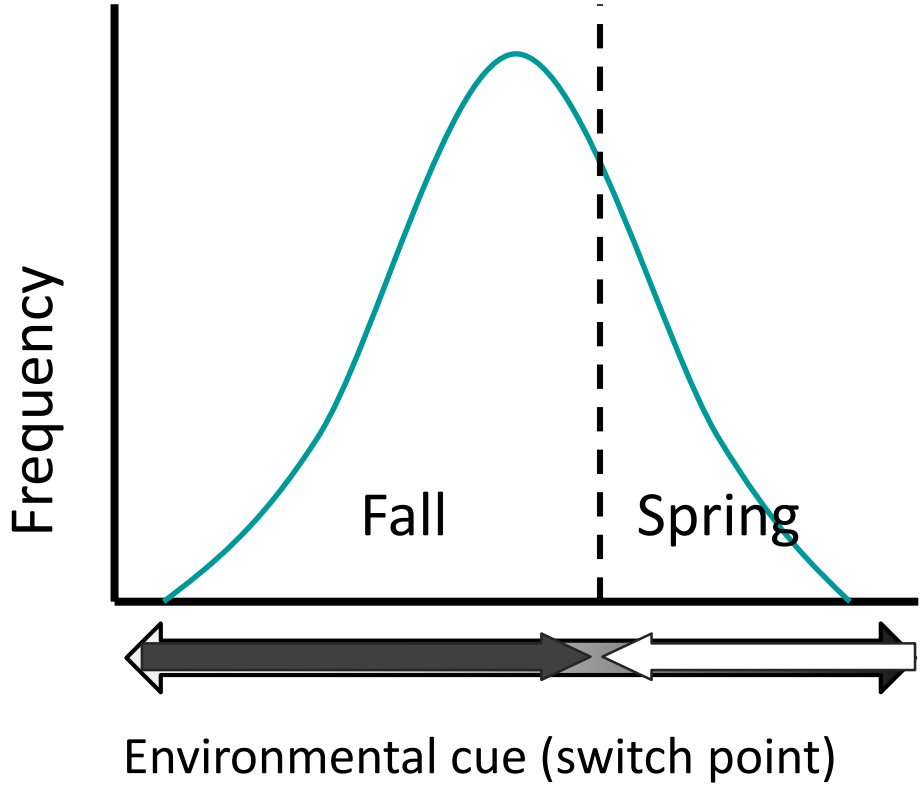
PROVIDE DIFFERENT CUES DURING REARING

Growth rate

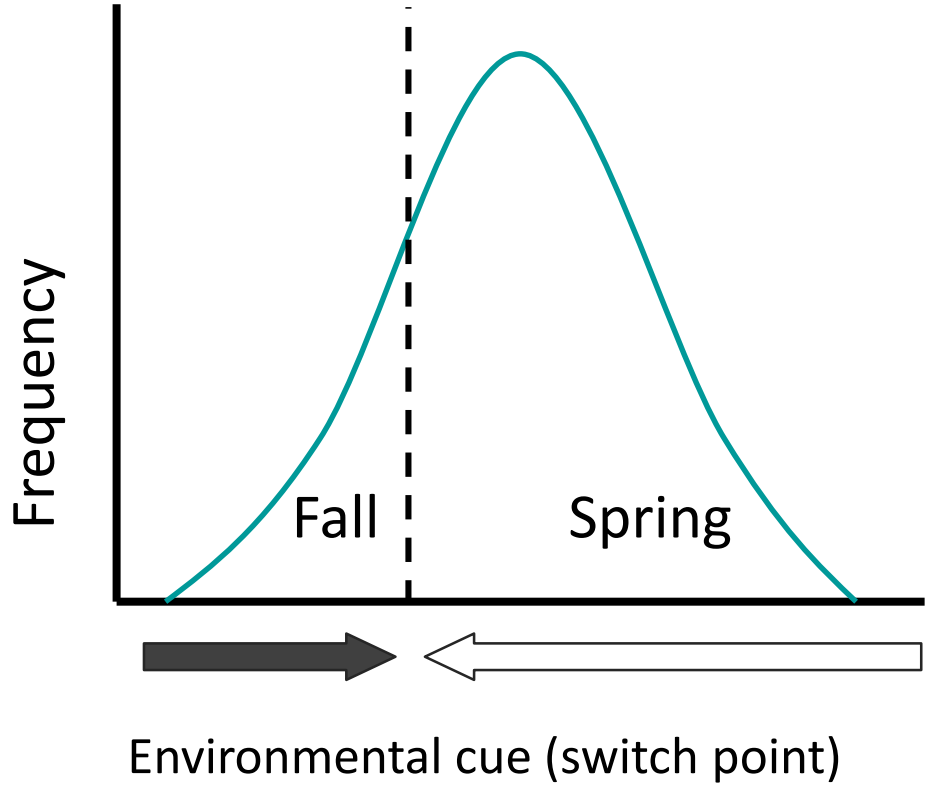
Slower growth

Faster growth

PROVIDE DIFFERENT CUES DURING REARING

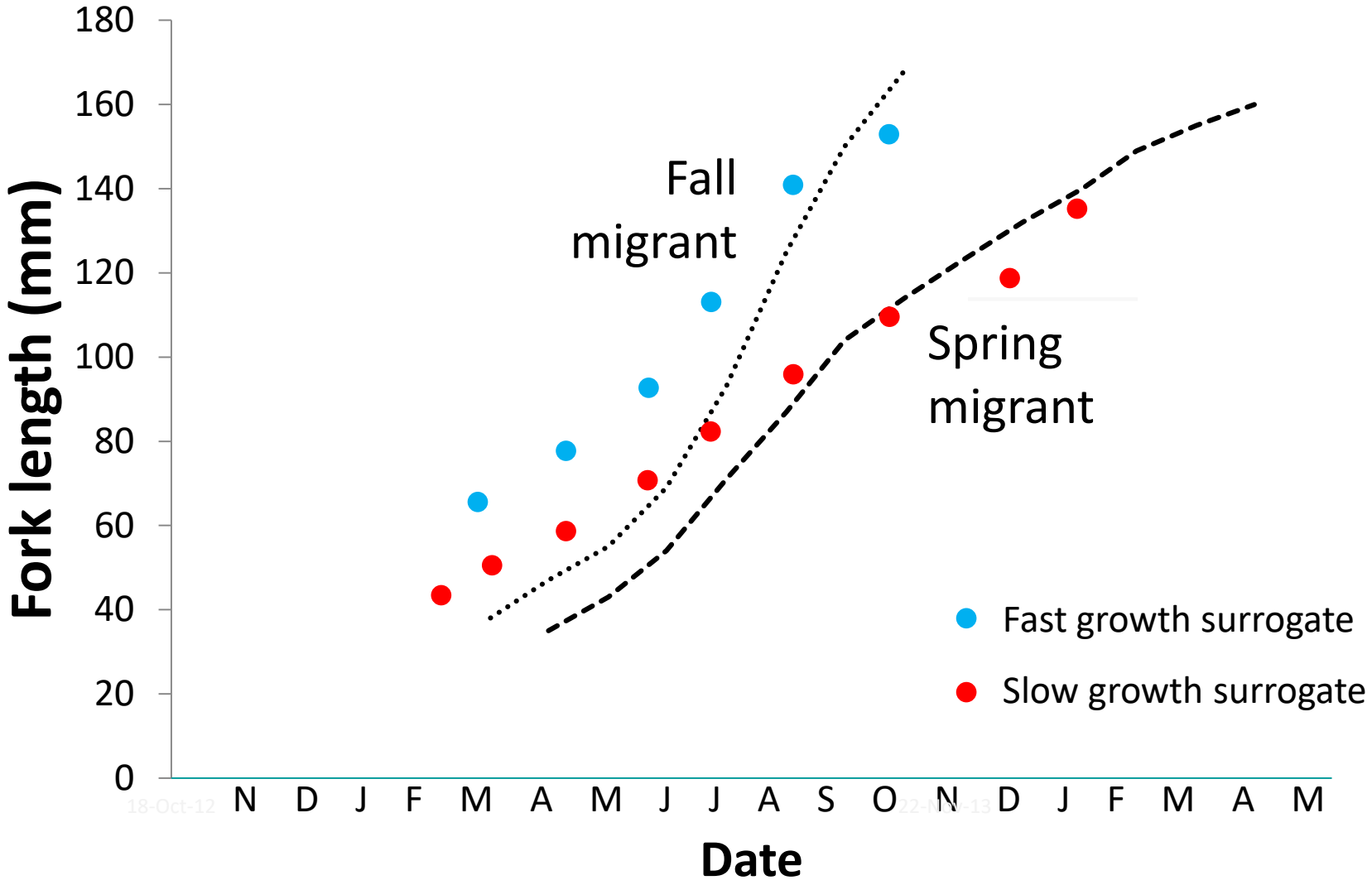


Fast growth

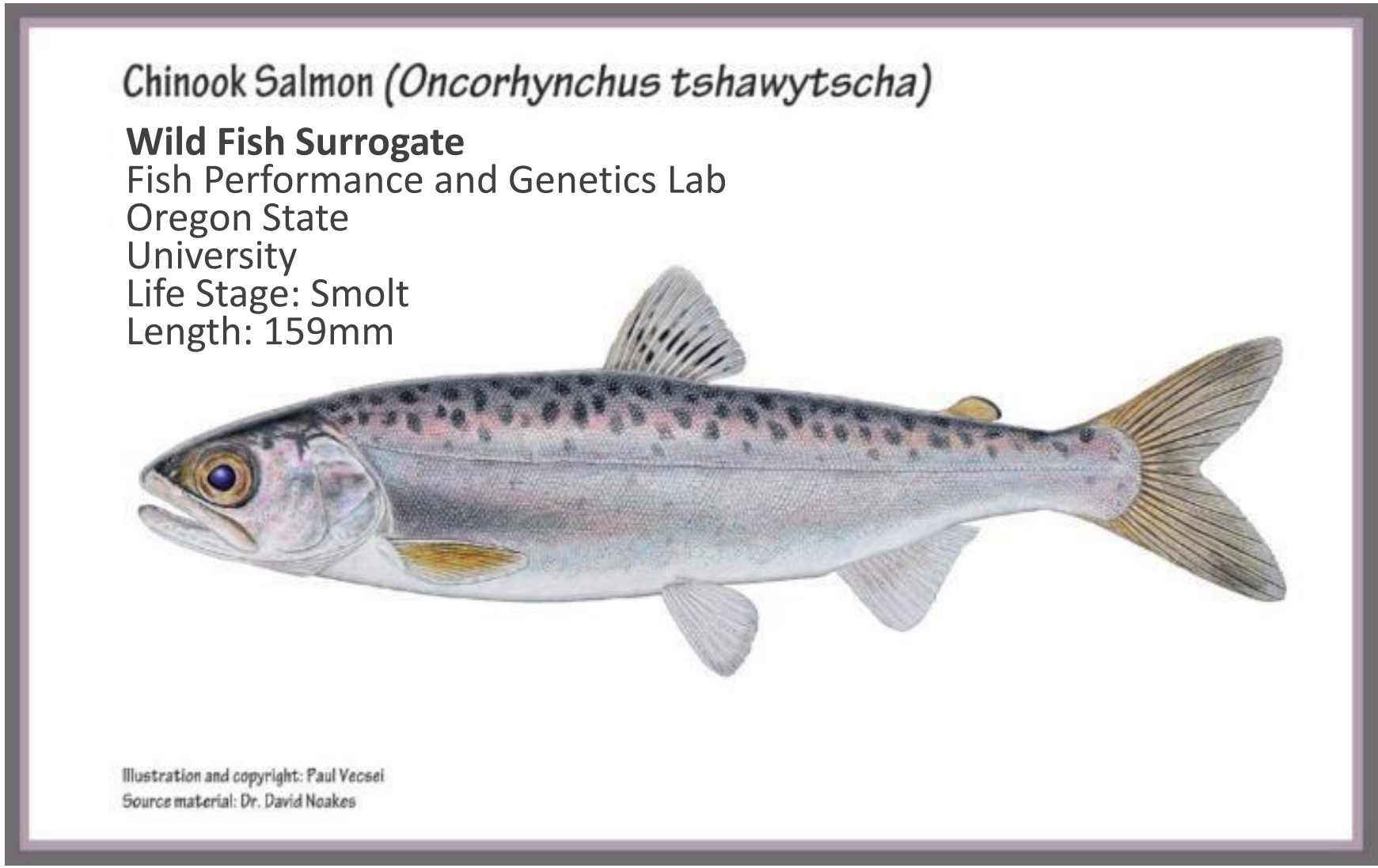


Slow growth

GROWTH TRAJECTORIES

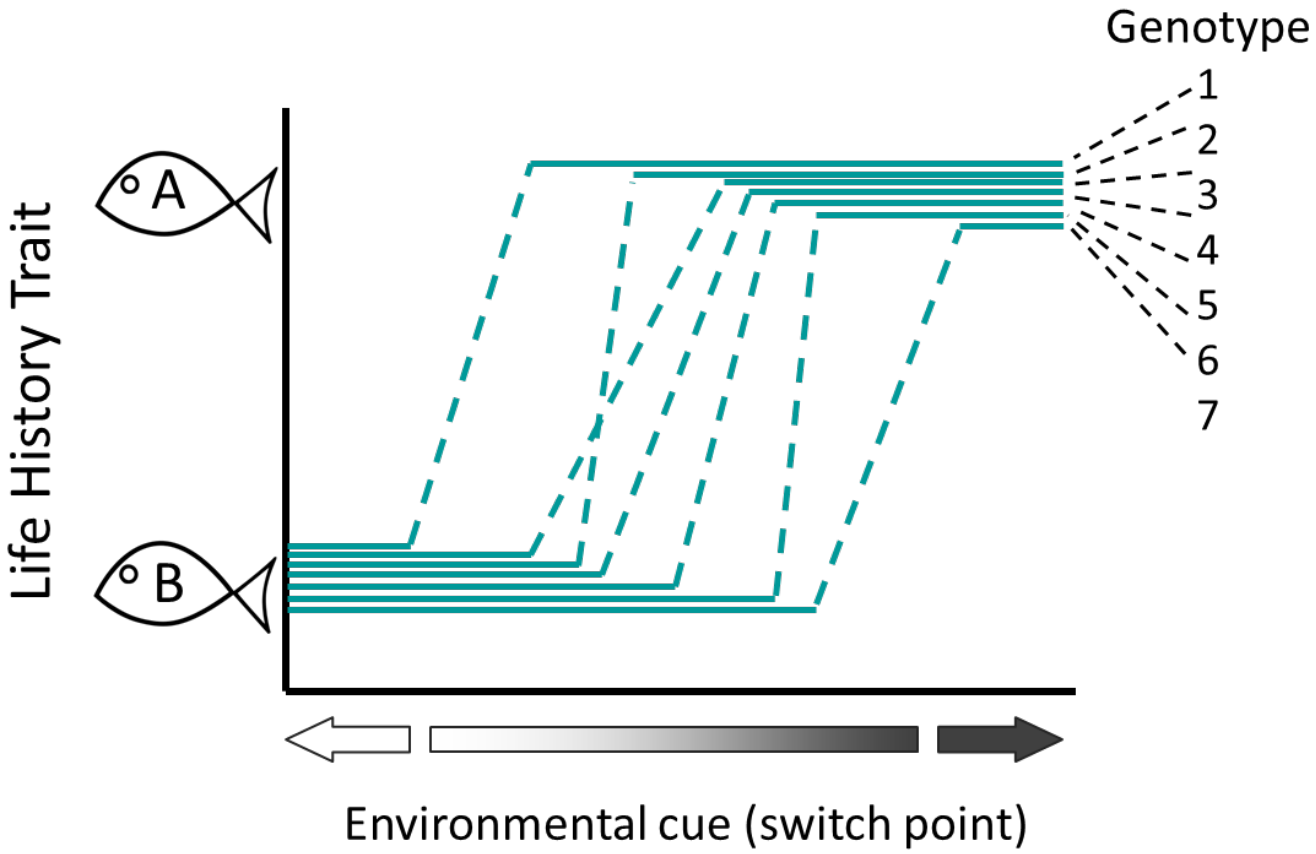


Depending on dam operations, as high as 92% of fish released above dams migrated as expected

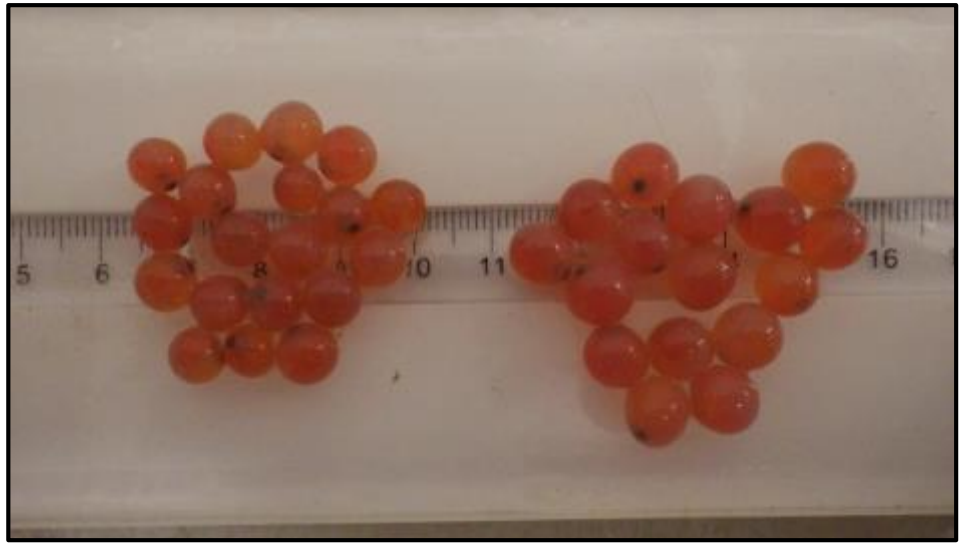


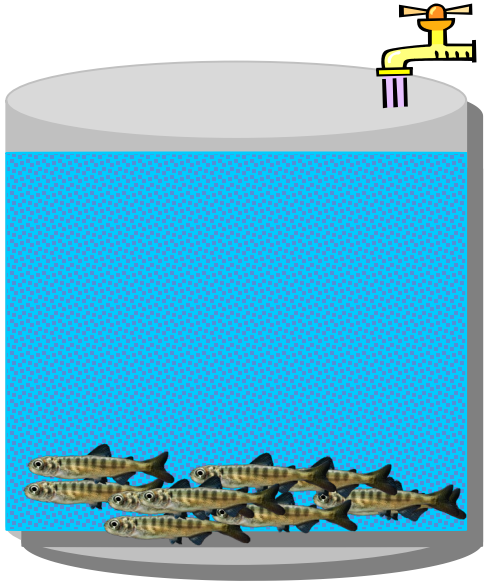
PART 2: NATURAL LIFE HISTORY

Evaluate how **natural early phenotypic differences** influence the expression of juvenile downstream migration phenotypes



NATURAL LIFE HISTORY VARIATION

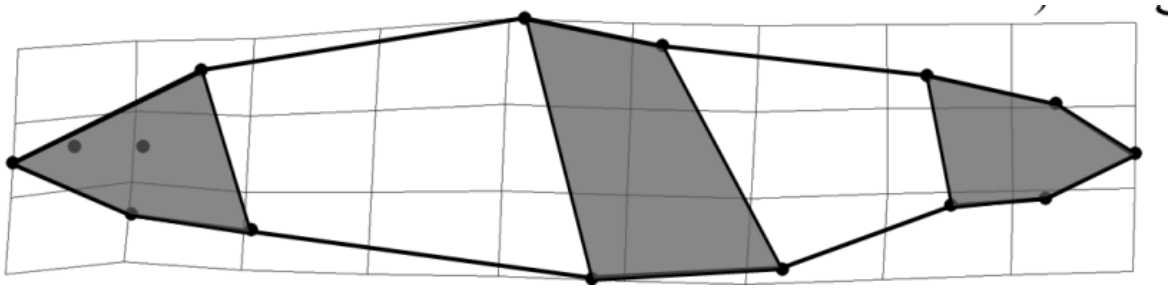




Phenotypic differences expressed early in life lead to different phenotypes expressed later

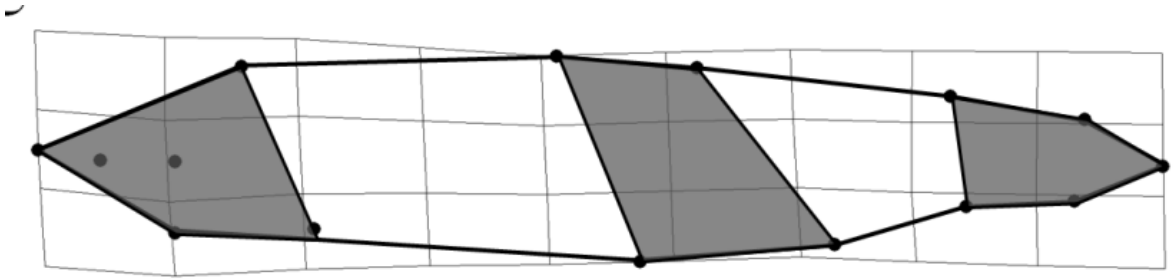
VARIATION IN JUVENILE BODY MORPHOLOGY

- Actively migrating juvenile Chinook salmon
  - Fall (subyearlings)
  - Spring (yearlings)



Fall migrant

- Deeper bodies and caudal peduncles
- Shorter heads



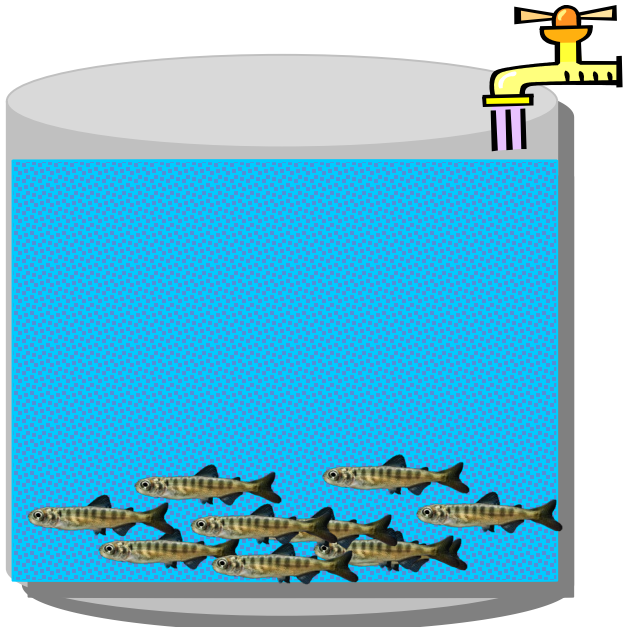
Spring migrant

Billman et al. 2014

Research Questions

1. Does variation in egg size, emergence timing, and vertical self-sorting affect future body shape?

2. Can early traits be used as predictors of migration?



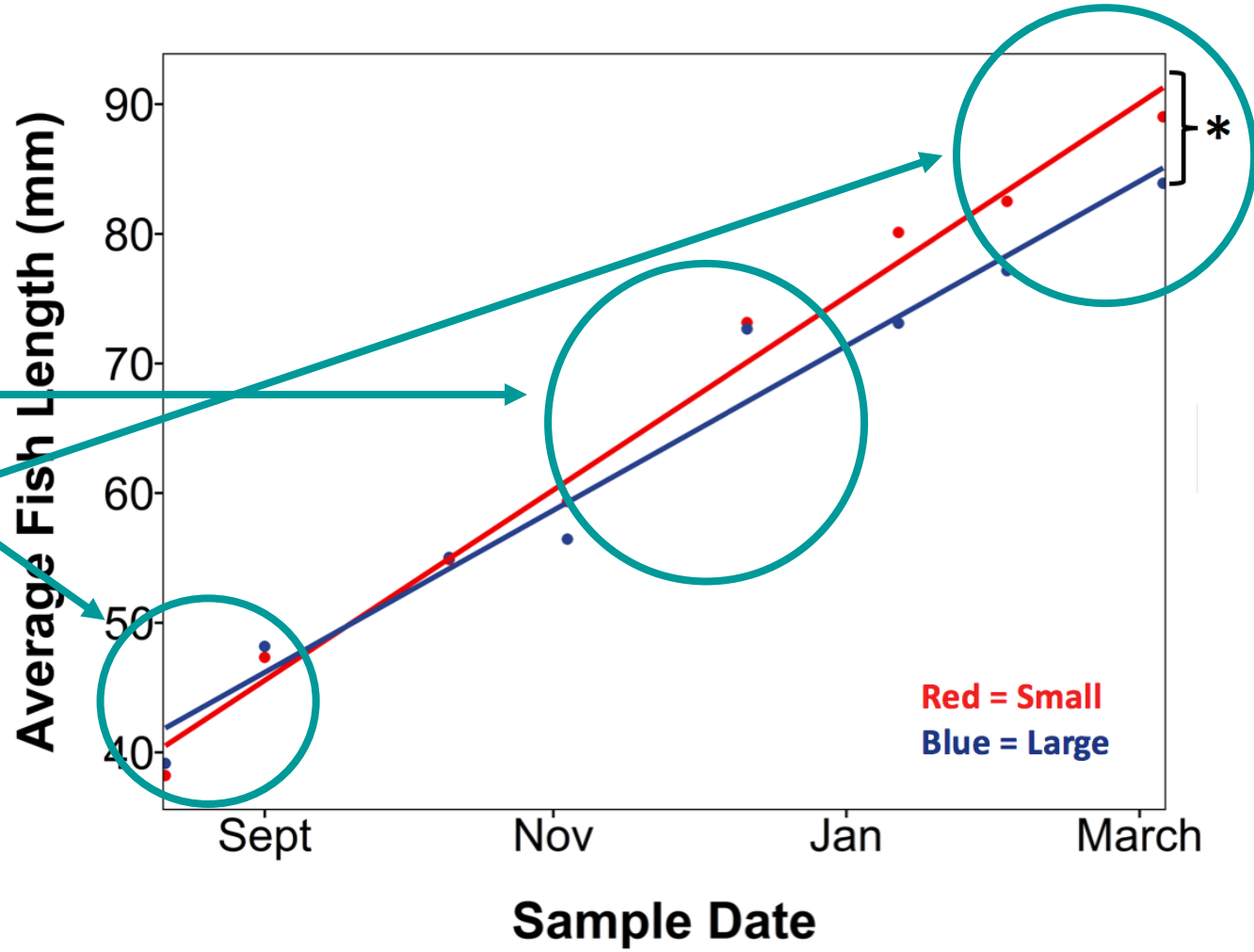
Egg size variation in fishes

- Egg size can vary within and across females
- Offspring from small eggs often grow faster than from large eggs

  (Eldridge et al. 1982; Heath et al. 1999; Valdimarsson et al. 2002; Leblanc 2011)
- Growth rate can affect future phenotypes
  - Spawn timing
  - Precocial maturation
  - Migration timing

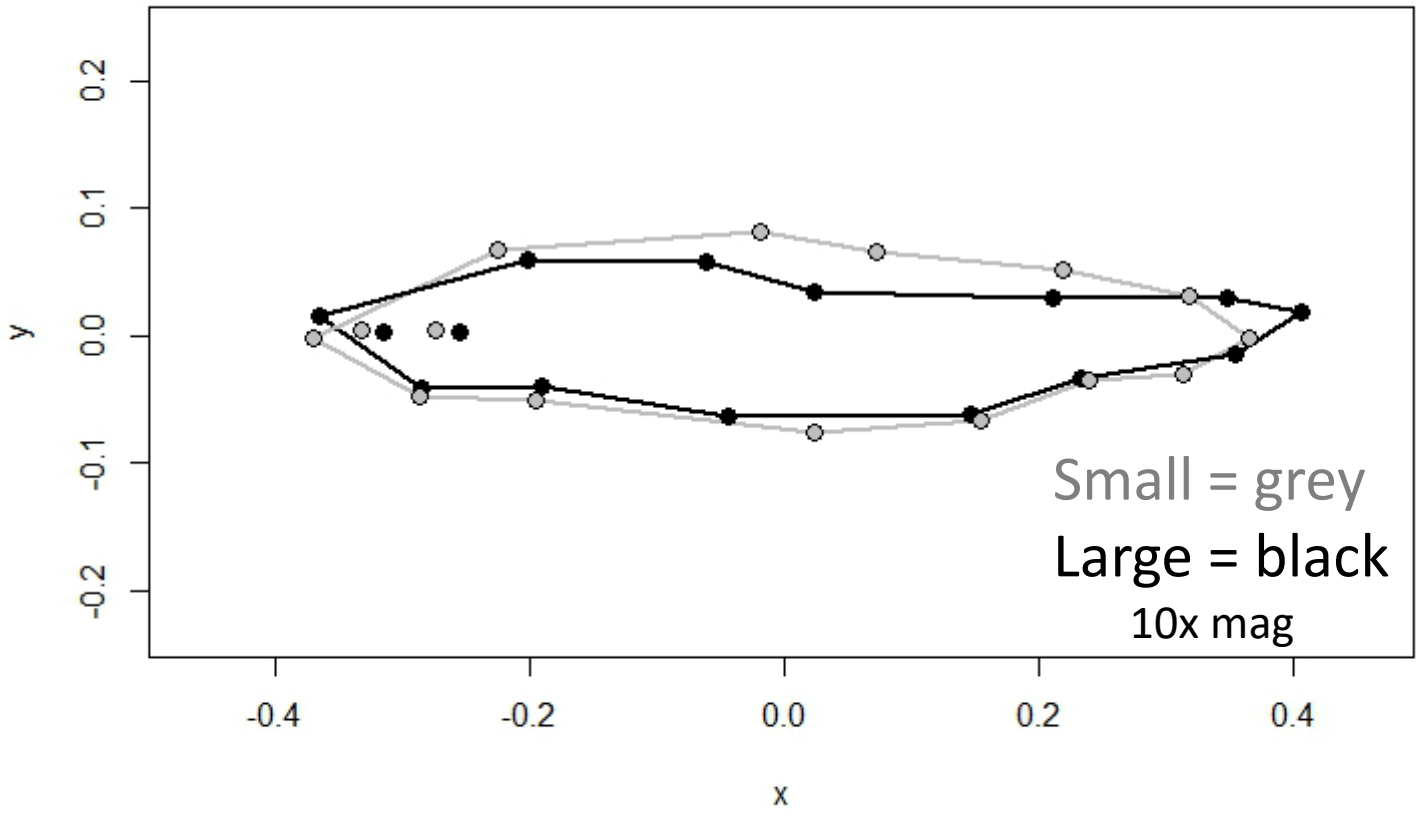
CHINOOK SALMON AND STEELHEAD GROWTH RATE

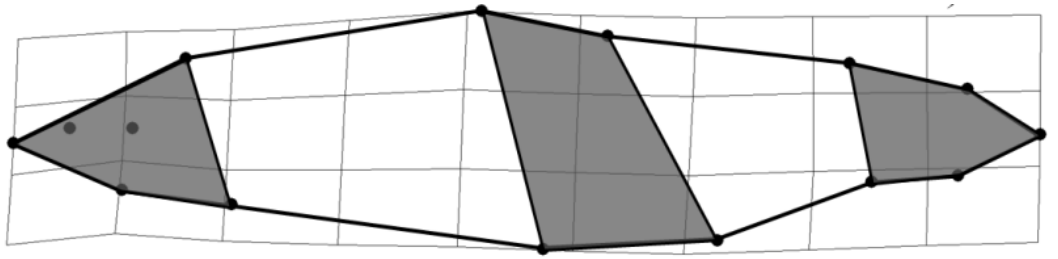
- Fish from small eggs have FASTER growth rate
  - Fish smaller initially
  - Outgrow fish from large eggs within a few months
  - Maintain size advantage



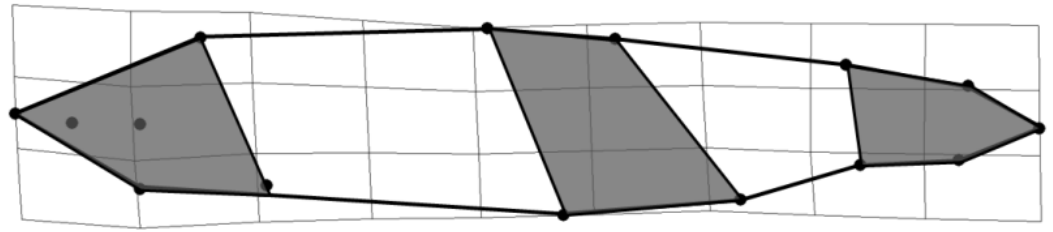
Cogliati et al. 2018, *Ecol and Evol;* Self et al. 2018, *J Fish Biol*

FISH FROM SMALL EGGS MORE SIMILAR TO FALL MIGRANTS



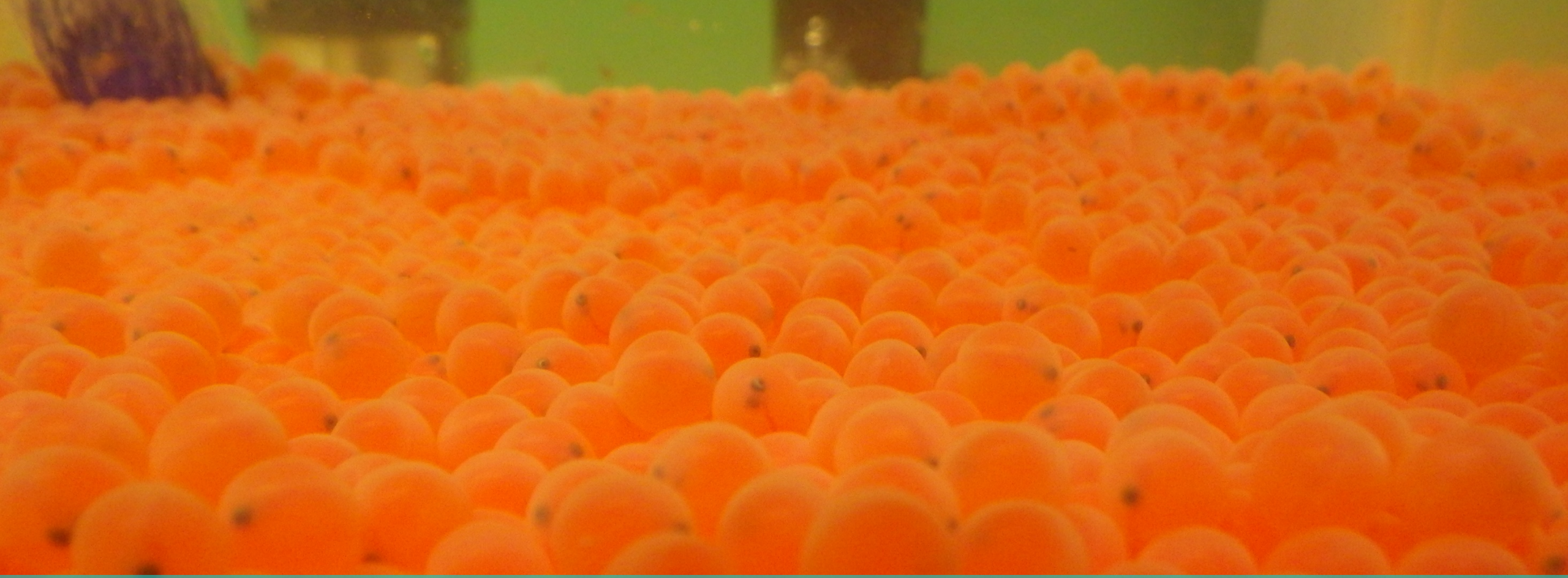


Fall migrant



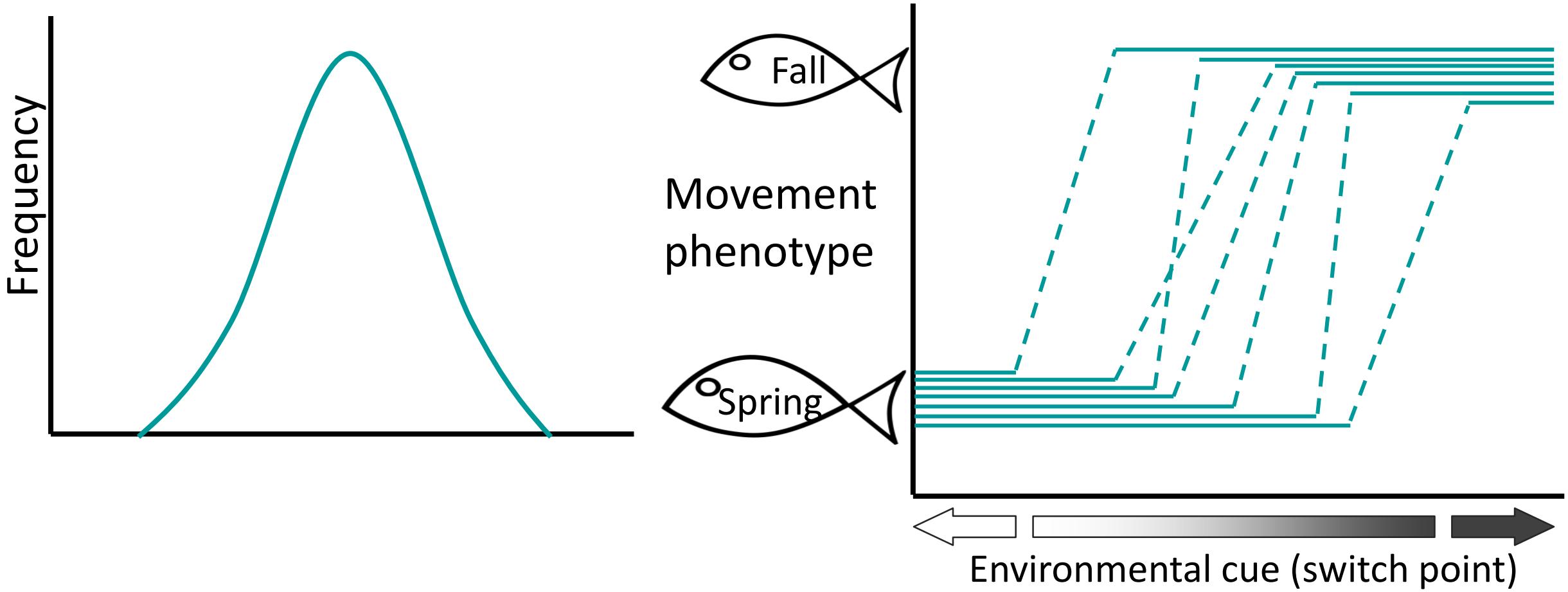
Spring migrant

Cogliati et al. 2018, *Ecol and Evol*

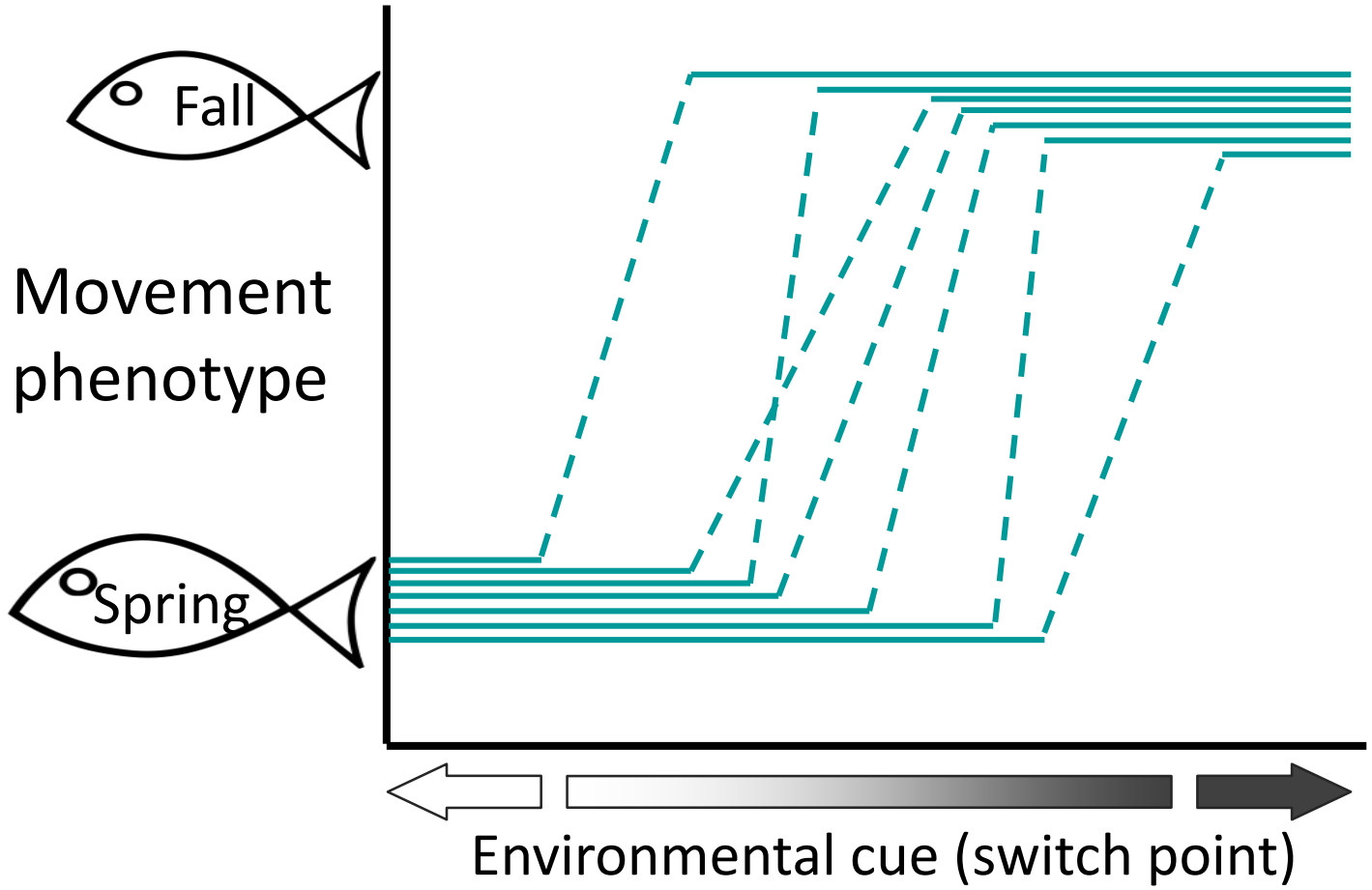


- Growth rate, body shape, and migration timing all related to traits happening early in development
- Can we harness this variation to produce more accurate movement phenotypes?

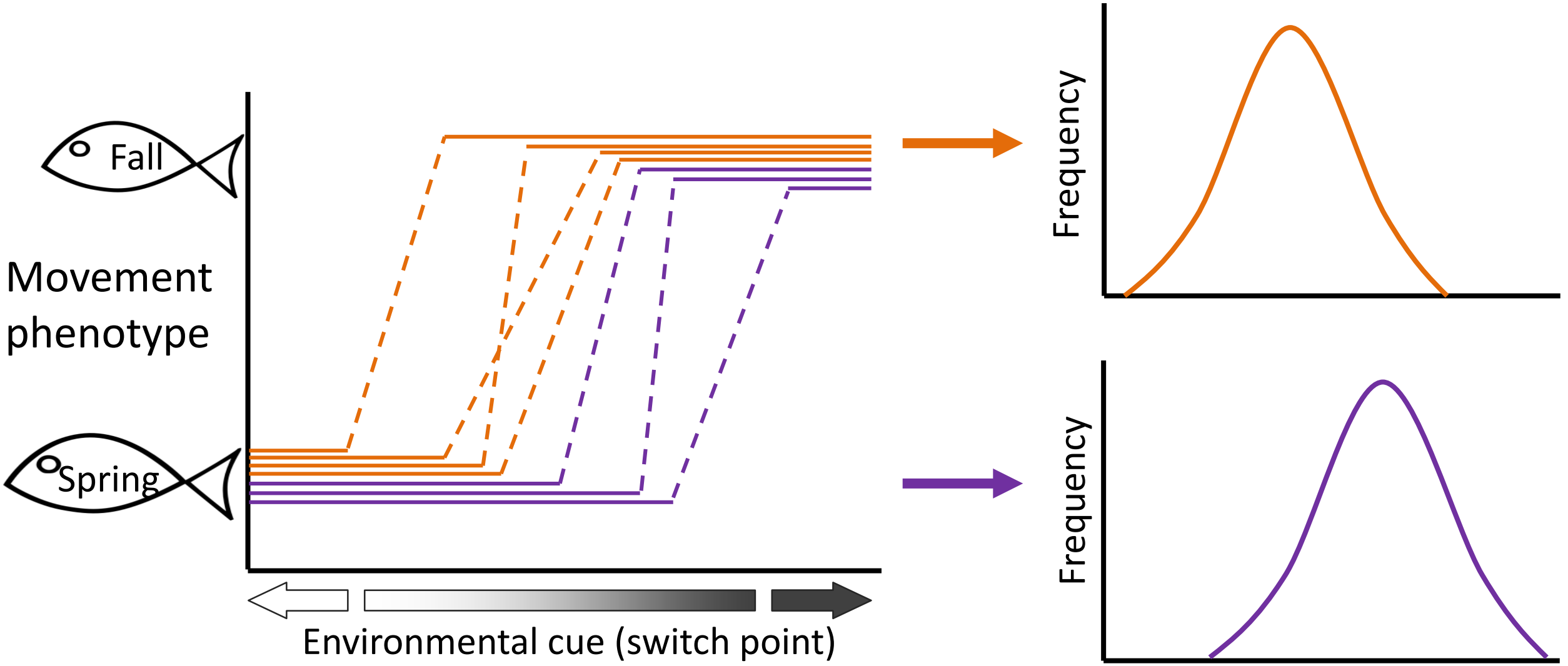
HARNESS EARLY TRAIT DIFFERENCES



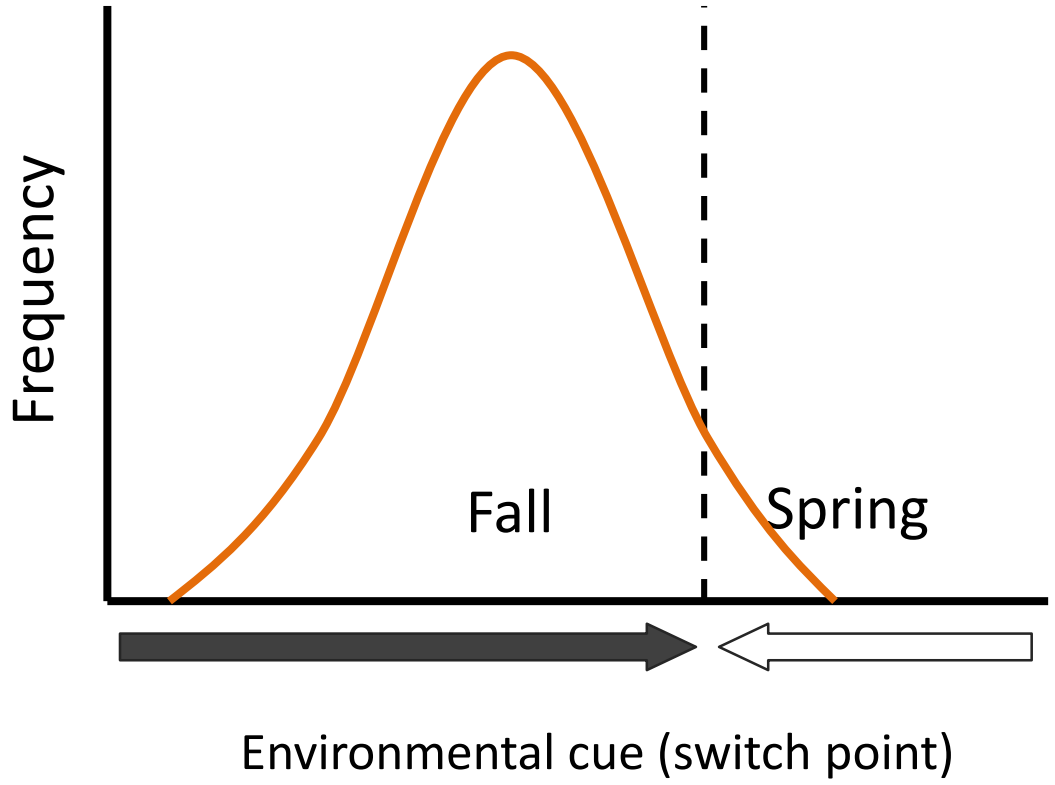
HARNESS EARLY TRAIT DIFFERENCES



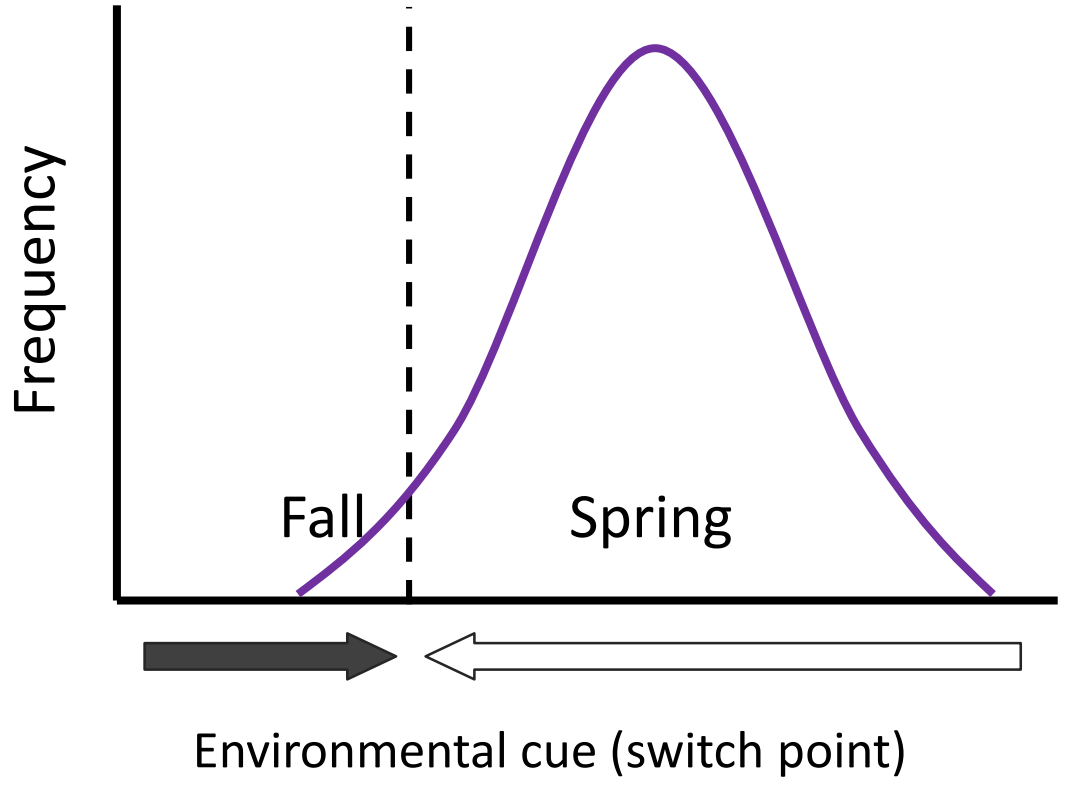
HARNESS EARLY TRAIT DIFFERENCES



PROVIDE DIFFERENT ENVIRONMENTAL CUES



Fast growth



Slow growth

HIGH QUALITY SURROGATES

Natural life history differences

+

Altered rearing environment

=

More wild-like fish with appropriate movement phenotype?

Photo by Todd Pierce

ACKNOWLEDGEMENTS

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ODFW staff & hatchery managers

ODFW Researchers

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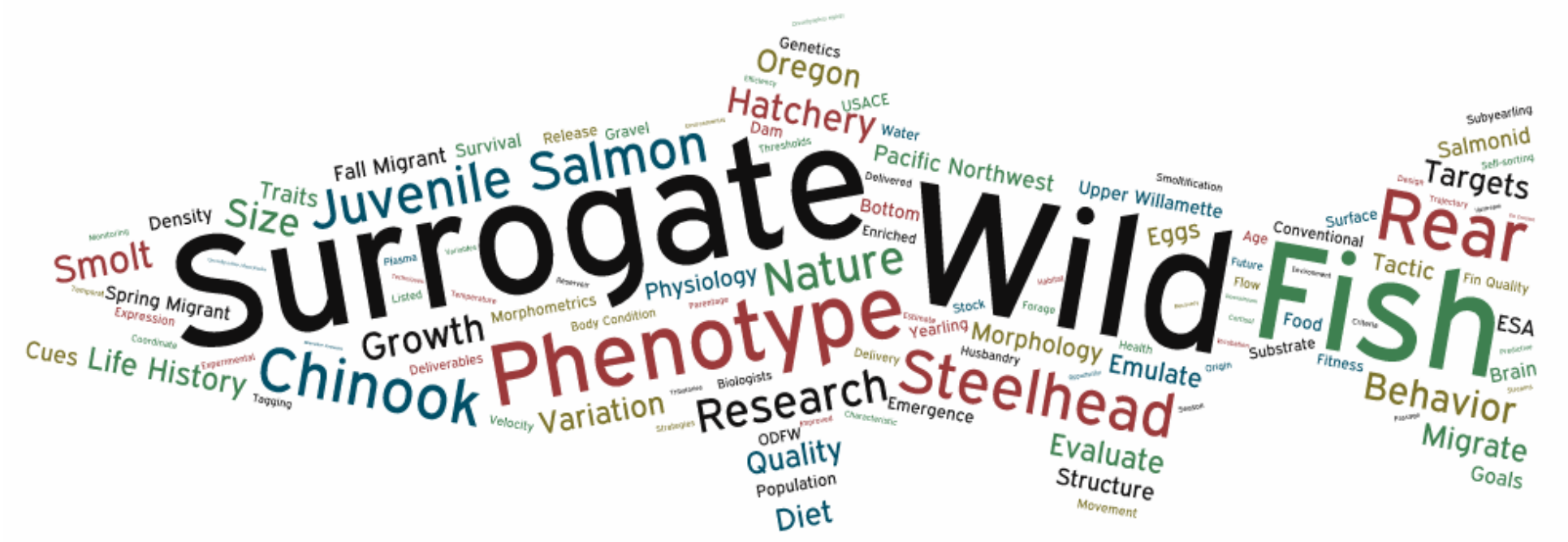
THANK YOU



QUESTIONS?