Hatchery Reform in Washington State

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WDFW Commission Meeting

June 15, 2018

Presentation Outline

- **Hatchery Reform**
  - What is it?
  - Origin & Milestones
  - Hatchery Scientific Review Group (HSRG)
  - NMFS Administration of Endangered Species Act
  - FWC Policies & Policy Statements
- **WDFW Hatchery Reform Implementation**
- **Hatchery Reform's Contributions to Recovery and Stability of Wild Populations**
- **Emerging Policy Questions**

Hatchery Reform – What is it?

"…scientific and systematic redesign of hatchery programs to help recover wild salmon and steelhead and support sustainable fisheries."

Hatchery & Fishery Reform Policy

A fundamental shift from viewing a hatchery as an isolated fish production factory to an integrated part of the environmental and ecological systems in which it operates.

Hatchery Reform Origin & Milestones

Early 1990s – Field studies raise concerns about hatchery-wild interactions

- Competition with wild fish
- Negative genetic effects result in lower productivity

1990s – Multiple ESA-listing identify hatchery practices as listing factor

2002 – Ford model provides tool for analyzing genetic effects

2014 – Synthesis of 51 field estimates concludes:

- Hatchery fish spawning in wild produce half as many progeny as wild fish
- Reduction is greater for male fish than females
- All species studied (Chinook, Coho, Steelhead, and Atlantic salmon) show reduced fitness

ESA Listings

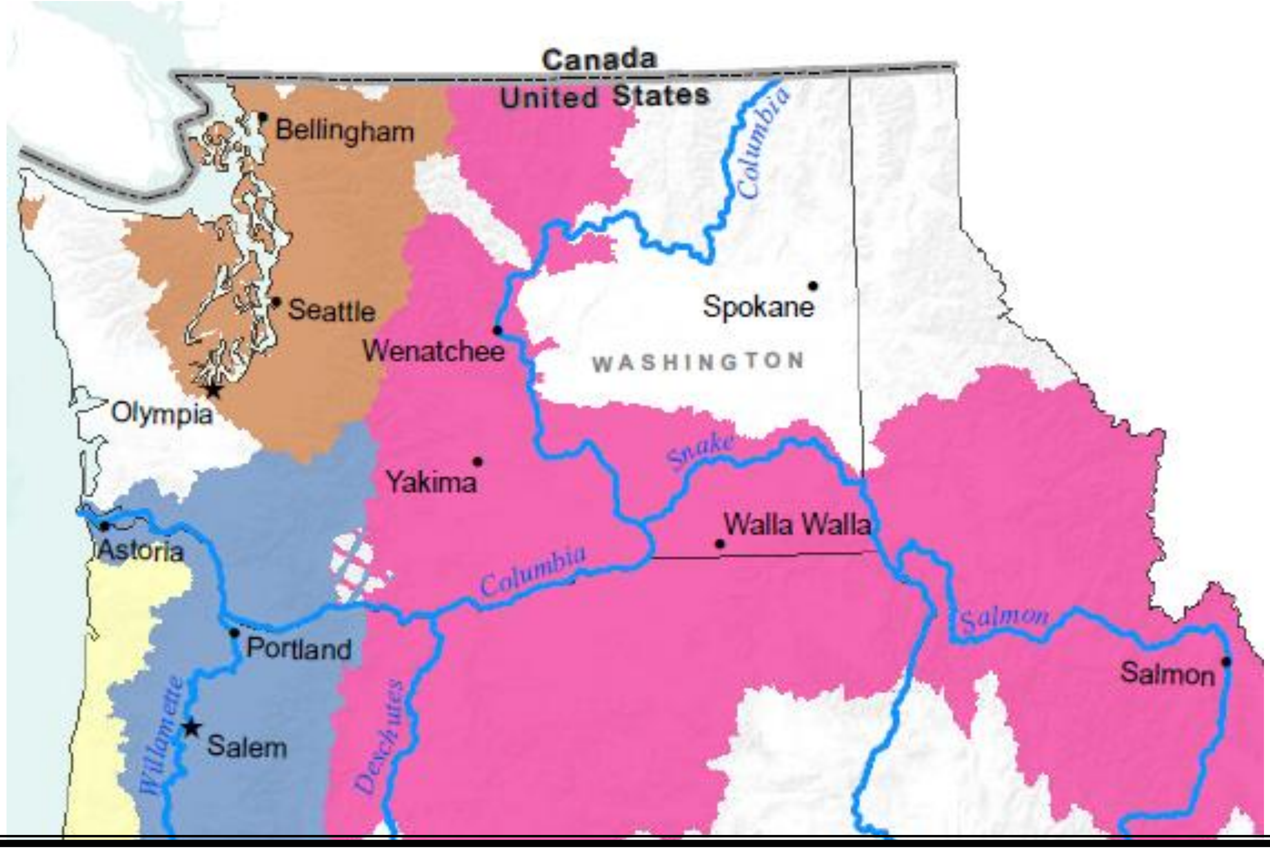
1991 - Snake Sockeye

1992 - Snake Spring/Summer Chinook, Snake Fall Chinook

1997 – Upper Columbia Steelhead, Snake Steelhead

1998 – Lower Columbia Steelhead

1999 – Hood Canal Summer Chum, Ozette Sockeye, PS Chinook, Middle Columbia Steelhead, Upper Columbia Spring Chinook, Columbia Chum, Lower Columbia Chinook



In 1999, confronted with question
"Can hatcheries continue to operate with ESA-listings?"

Hatchery Scientific Review Group (HSRG)

1999 – Gorton Science Advisory Group Proposes Hatchery Reform

- Recovery and conservation of wild salmon and steelhead
- Support sustainable fisheries

2000 – Congress Funds HSRG

2004 – Principles and Recommendations Report

2005 – All-H Analyzer (integrated hatchery, harvest, habitat analysis)

2009 – Broodstock Management Standards

2012 – Standards Linked to Recovery Phases (population status)

2015-2017 – Reports to Congress Updating Principles

NMFS Administration of ESA

4(d) Rule – Provides criteria for approving hatchery programs

- Evaluate, minimize, and account for genetic introgression caused by straying

2011 Reference Document for Hatchery Consultations

- Standard: < 5% of natural spawners originate from hatchery program of non-local stock origin

Refinement of Approach – Application Broodstock Management Guidelines

- ESA Litigation: HSRG standards have not been challenged as allowable impact

NMFS Administration of ESA

“NMFS considers the HSRG’s principles, findings and recommendations important to the advancement and implementation of measures needed to reduce the risk of adverse hatchery-related effects to natural-origin salmon and steelhead populations. Although not the sole source of information considered by NMFS to render ESA determinations regarding harvest and hatchery actions, the HSRG’s contributions to hatchery-risk related science are valuable to our evaluations.”

Puget Sound Chinook Resource Management Plan
Proposed Evaluation of and Pending Determination on a Resource Management Plan (RMP), Pursuant to the Salmon and Steelhead 4(d) Rule

FWC Policies & Policy Statements

2008 – Statewide Steelhead Management Plan

- Harvest programs "shall provide fishery benefits while allowing watershed-specific goals for the diversity, spatial structure, productivity and abundance of wild stocks to be met."

2009 - Hatchery and Fishery Reform (C-3619)

- "Advance the conservation and recovery of wild salmon and steelhead by promoting and guiding the implementation of hatchery reform."

2013 – Columbia River Basin Salmon Management (C-3620)

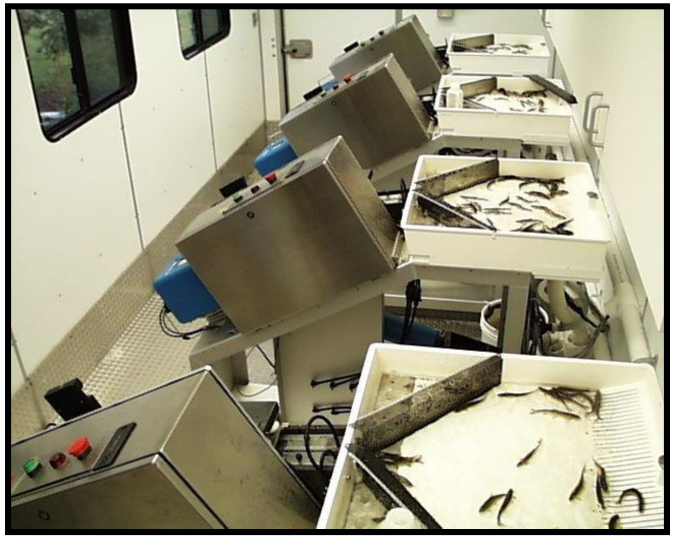
- "The Department will seek to implement mark-selective salmon and steelhead fisheries, or other management approaches that are at least as effective, in achieving spawner and broodstock management objectives."

2015 - Willapa Bay Salmon Management (C-3622)

- "Implement improved broodstock management (including selective removal of hatchery fish) to reduce the genetic and ecological impacts of hatchery fish..."

WDFW Hatchery Reform Implementation

- Key Policy Provisions
- HSRG Concepts
- Broodstock Management Implementation Status
- ESA-Approval Status
- Accomplishments



Key Policy Provisions

Fish and Wildlife Commission Hatchery and Fishery Reform Policy C-3619

"…to advance the conservation and recovery of wild salmon and steelhead by promoting and guiding the implementation of hatchery reform."

Hatchery and Fishery Reform Policy C-3619

- "…implemented as part of an all-H strategy…"
- Implemented "in a manner consistent with U.S. v. Washington and U.S. v. Oregon and other applicable state laws and agreements or federal laws and agreements"
- "Use the principles, standards, and recommendations of the Hatchery Scientific Review Group (HSRG) to guide the management of hatcheries…."
- "…working toward a goal of achieving the HSRG broodstock standards for 100% of the hatchery programs by 2015."
- "Secure necessary funding to ensure that Department-operated hatchery facilities comply with environmental regulations…"

HSRG Concepts

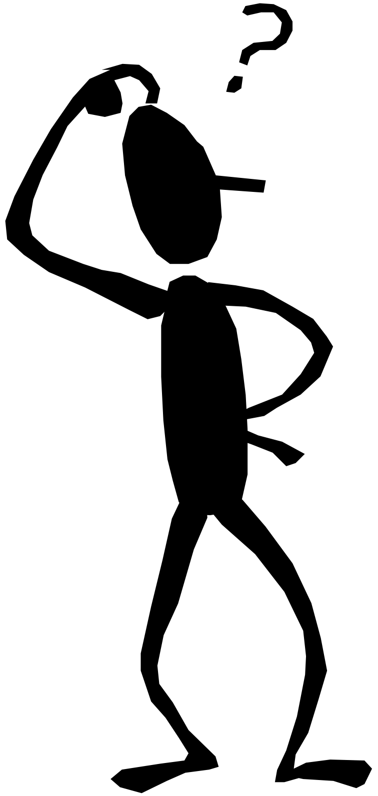
HSRG Principles

- Principle 1: Develop clear, specific, quantifiable harvest and conservation goals for natural and hatchery populations within an "All H" context.

- Principle 2: Design and operate hatchery programs in a scientifically defensible manner.

- Principle 3: Monitor, evaluate and adaptively manage hatchery programs.

Principle 2 – Scientific Defensibility



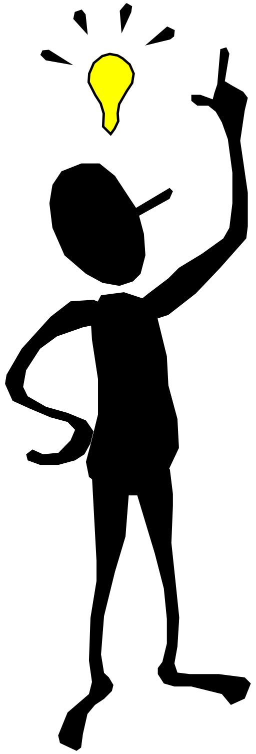
How do we manage hatcheries to contribute to the achievement of objectives for the diversity, productivity, and abundance of wild salmon and steelhead?

Broodstock Management - actions to control the number of hatchery fish spawning in rivers and the number of natural-origin fish used as broodstock in the hatchery to contribute to achieving conservation and sustainable fishery objectives.

…naturally spawning fish adapted to the natural environment….

Terminology

Proportionate Natural Influence (PNI) provides an index of the "wildness" of the fish. Larger proportions mean that the natural environment is driving selection, resulting in higher productivity for naturally spawning fish.



PNI – Proportionate Natural Influence

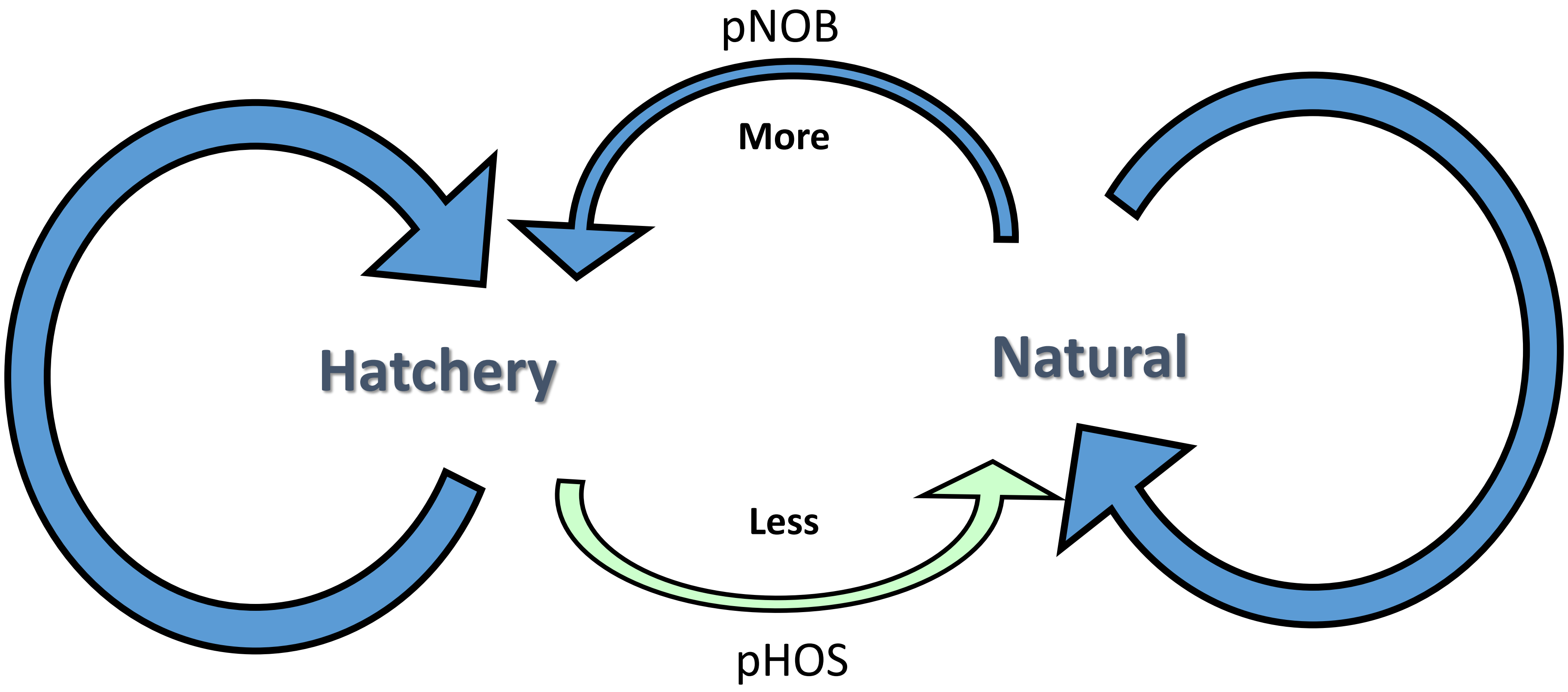
- Calculated as pNOB/(pNOB+pHOS)

pHOS – Proportion of Hatchery-Origin Spawners on the spawning grounds

pNOB – Proportion of Natural-Origin Broodstock used in a hatchery program

Integrated Hatchery Strategy

Hatchery and natural spawning populations are genetically connected

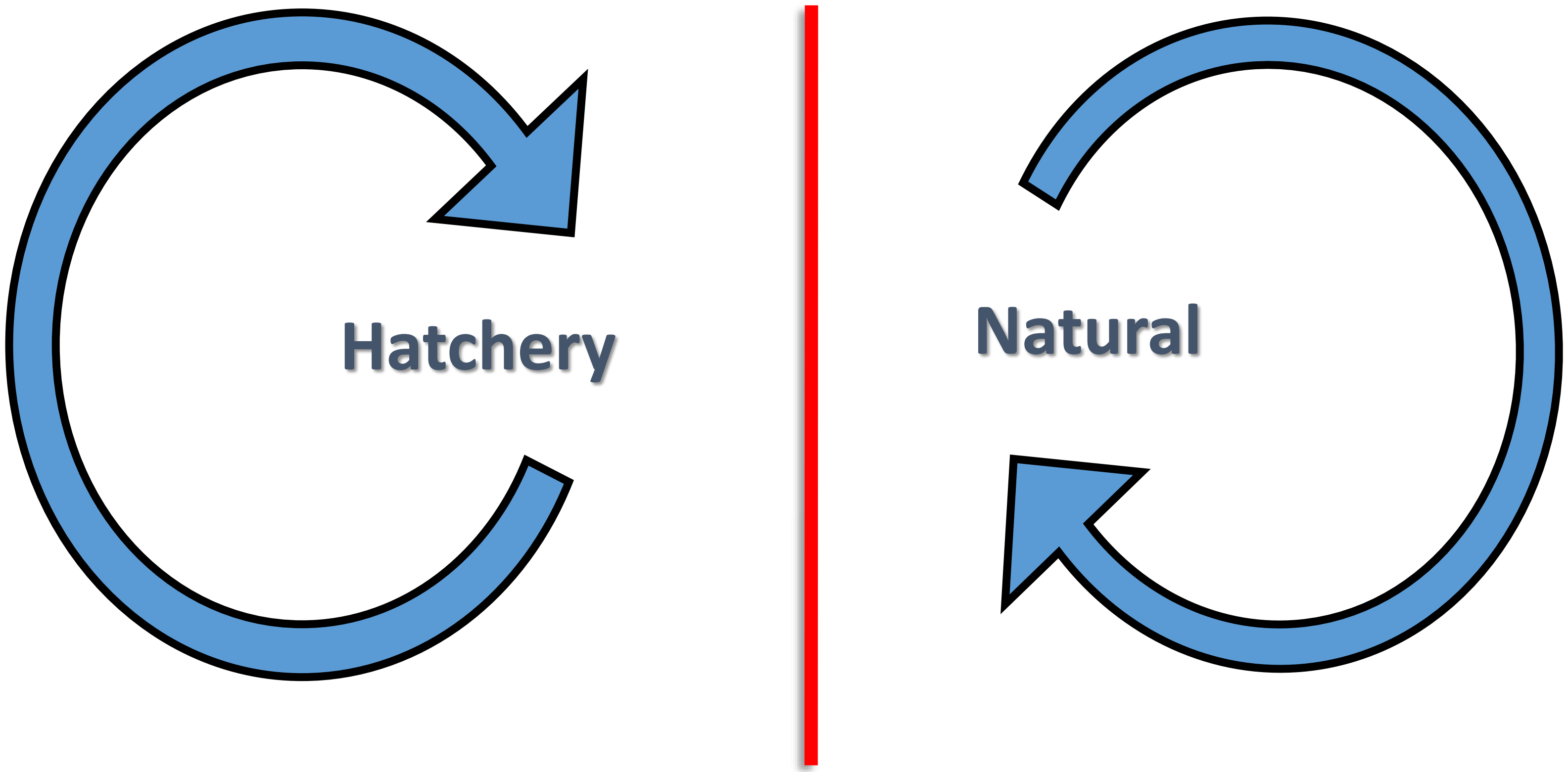


Integrated Hatchery Objectives

Associated Natural Population Role	PNI	pNOB & pHOS
Primary (highly significant for conservation & recovery)	> 67%	pNOB = Twice pHOS pHOS < 30%
Contributing (moderately significant for conservation & recovery)	> 50%	pNOB Exceed pHOS pHOS < 30%
Stabilizing (less significant for conservation & recovery)	Current	pNOB ≥ 10% pHOS = current levels

Segregated Hatchery Strategy

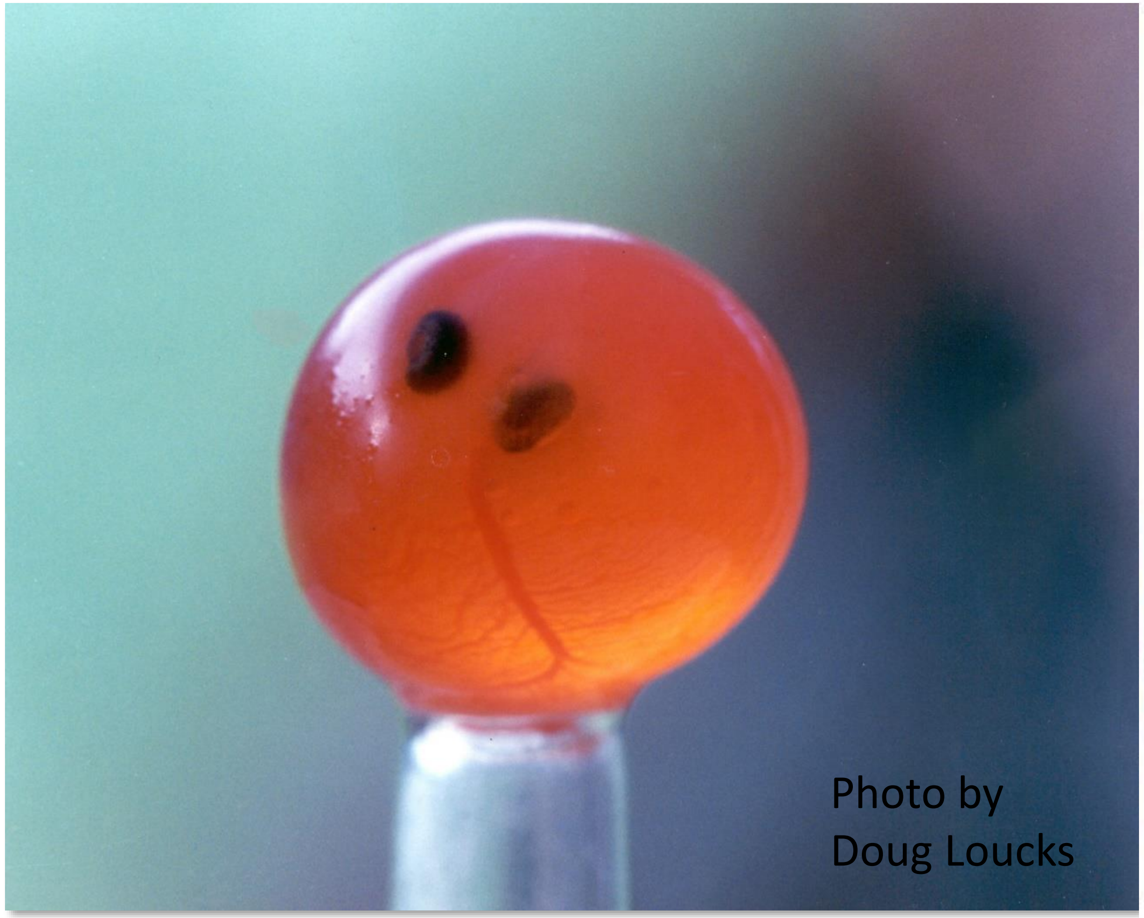
Hatchery and natural populations are genetically isolated



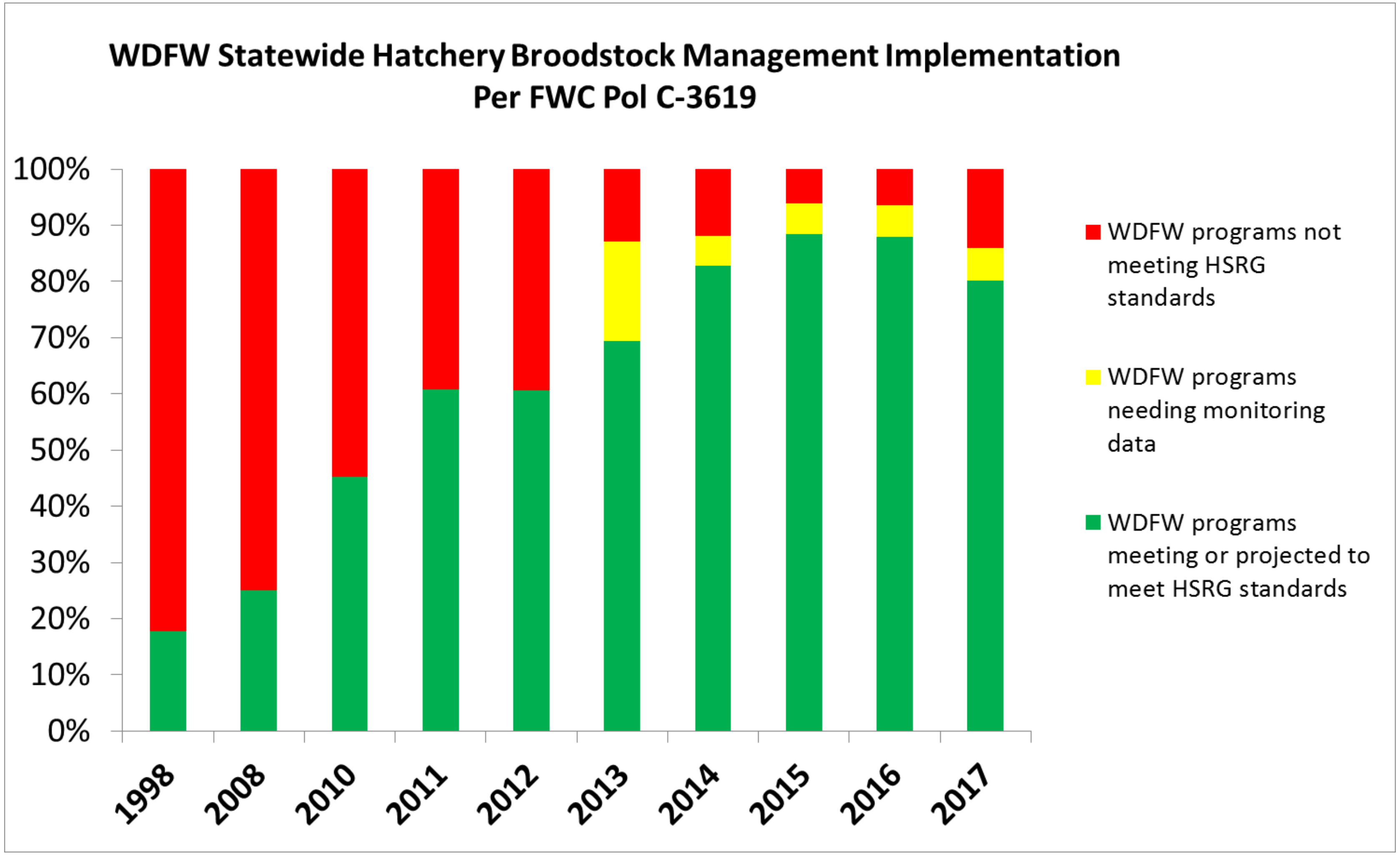
Segregated Program Objectives

Associated Natural Population Role	pHOS
Primary (highly significant for conservation & recovery)	5%
Contributing (moderately significant for conservation & recovery)	10%
Stabilizing (less significant for conservation & recovery)	Current

Current Status

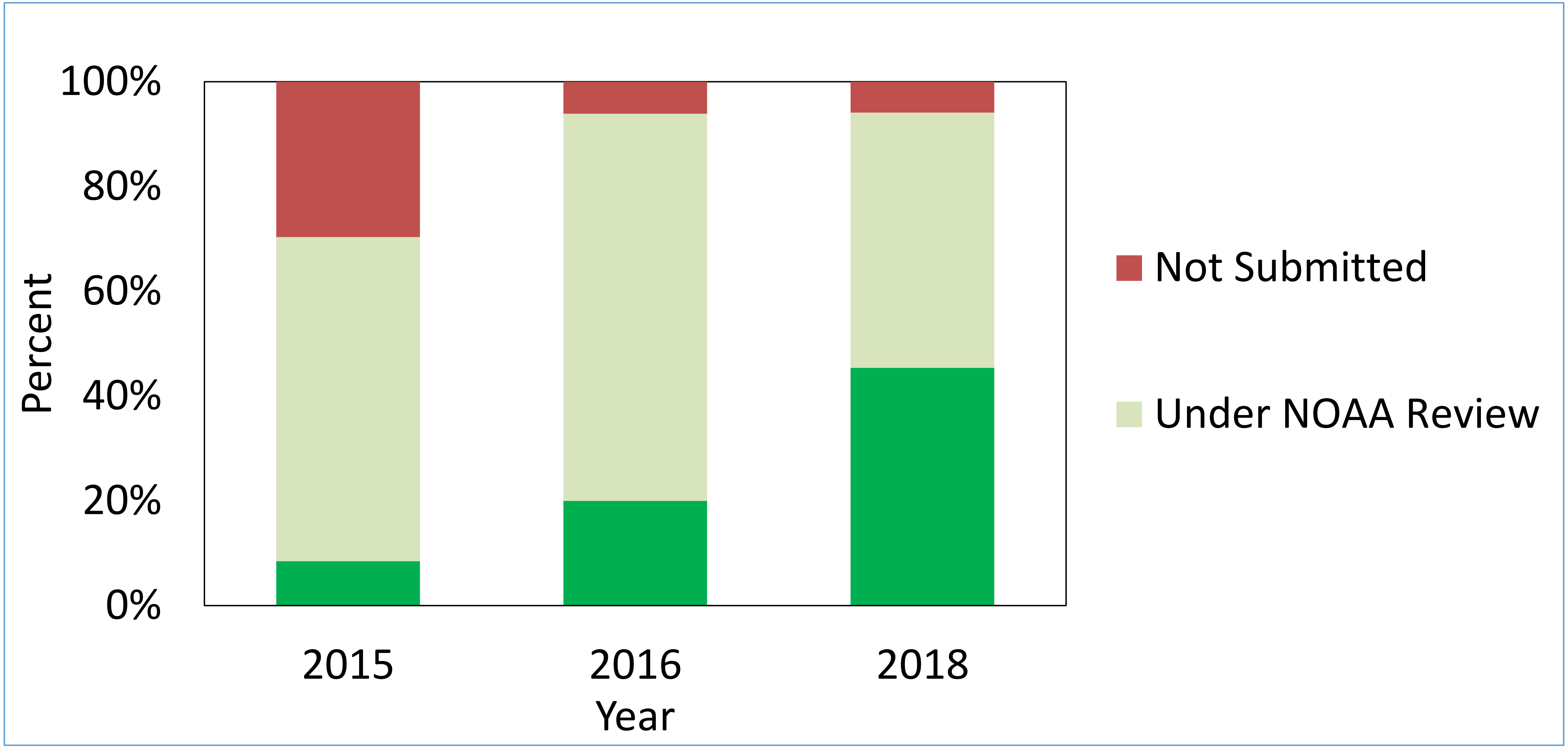


Broodstock Management Implementation Status



WA Dept. of Fish and Wildlife, Information subject to changes and amendments over time

ESA-Approval Status



Accomplishments

1999 - Can hatcheries continue to operate with ESA-listings?

- 83% programs meet broodstock management objectives
- 94% programs have hatchery plan submitted to NMFS
- 45% programs ESA-approved
- $40M secured this biennium to work toward ensuring hatcheries meet intake screening, fish passage, and pollution abatement rules.

Hatchery Reform's Contributions to Recovery and Stability of Wild Populations

Contributions of Hatchery Reform to Recovery

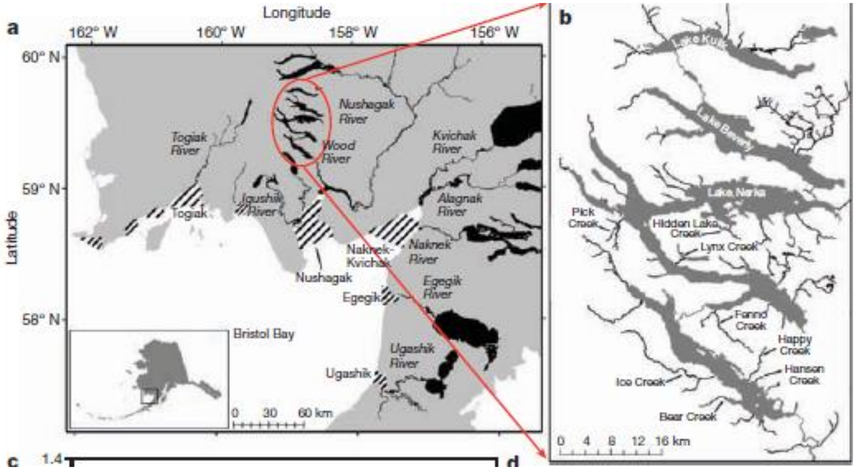
- Reduces Genetic (and related life history) effects to wild populations:

1. **Genetic diversity – facilitates resilience**
   - Within basin (e.g., off station releases)
   - Regional (e.g., Puget Sound fall Chinook)

2. **Promotes local adaptation – Fitness of wild population**

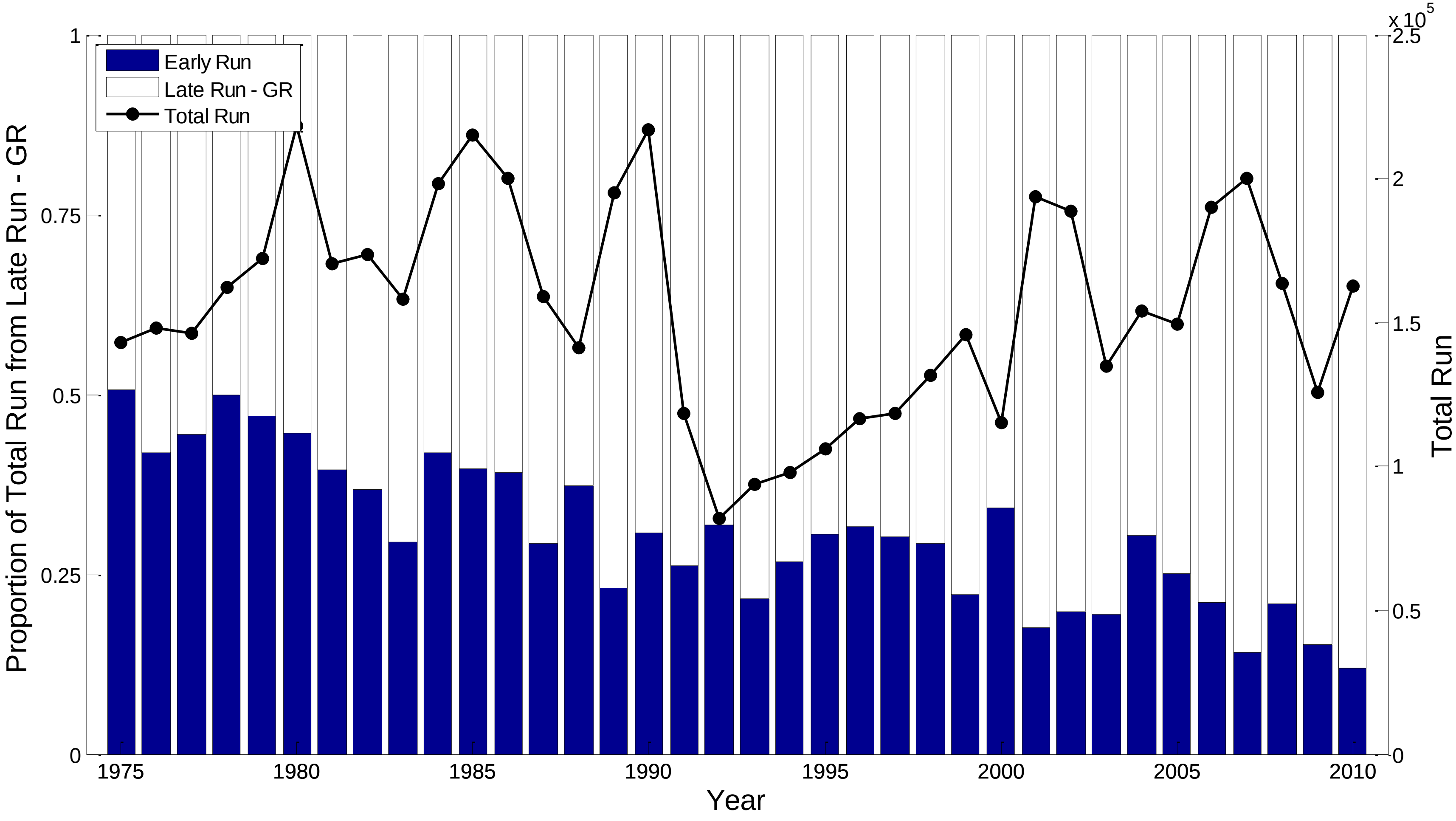
Population diversity and the portfolio effect in an exploited species

Daniel E. Schindler[1], Ray Hilborn[1], Brandon Chasco[1], Christopher P. Boatright[1], Thomas P. Quinn[1], Lauren A. Rogers[1] & Michael S. Webster[2]

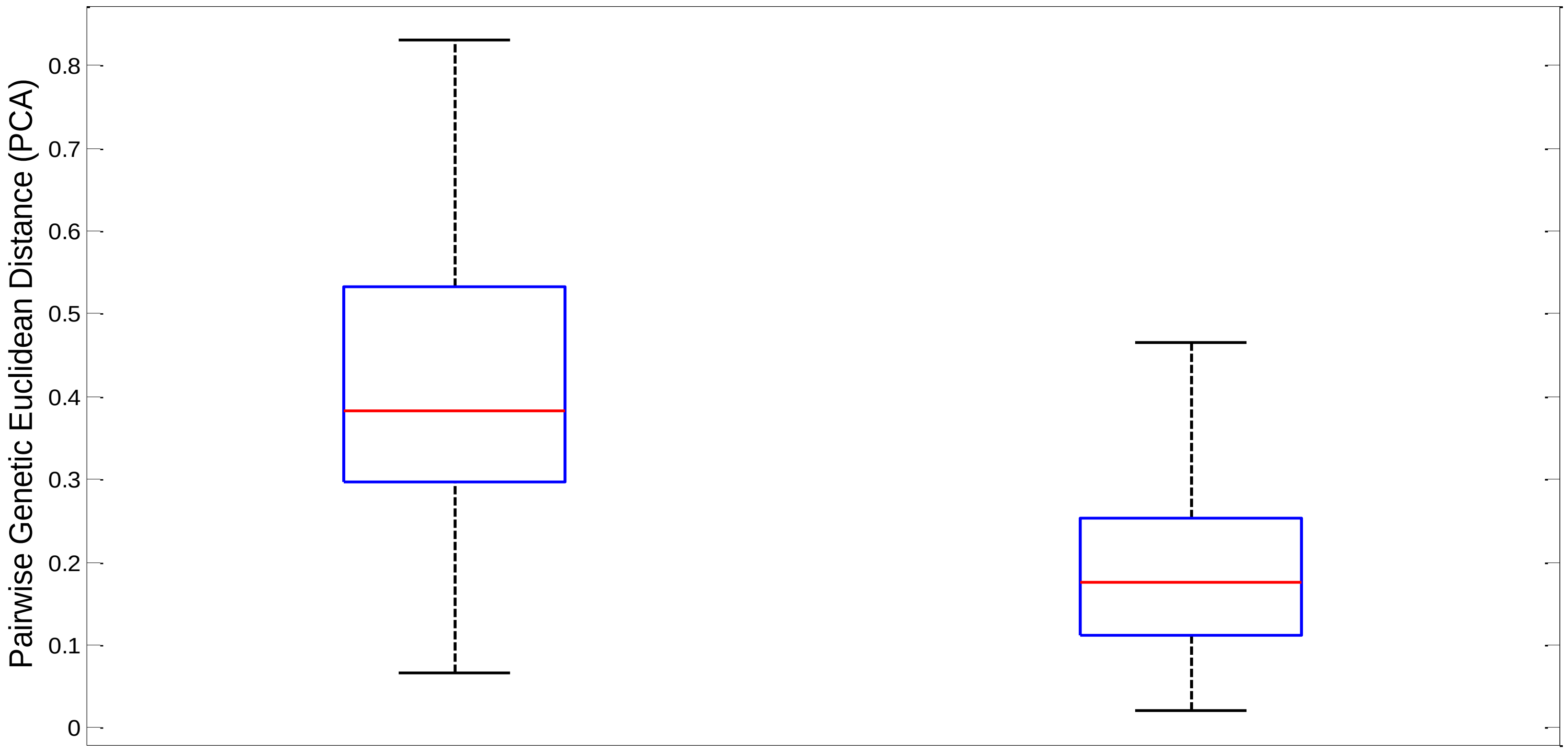


"One of the most pervasive themes in ecology is that biological diversity stabilizes ecosystem processes and the services they provide to society . . . ."

- Sockeye salmon in Bristol Bay
- System consists of hundreds of discrete populations
- Low interannual variability in returns
- Few fisheries closures



Observation 1: Roughly 90% of the total run for Puget Sound Chinook is now from late-run populations dominated by hatchery production



Skagit R. Populations
N = 10
(Max Geo Dist = 76 km)

Late Run – GR
N = 45
(Max Geo Dist = 292 km)

Observation 2: Late-run populations, dominated by a single hatchery population but now widespread throughout PS, have reduced genetic differentiation

Contributions of Hatchery Reform to Recovery

- Reduces Genetic (and related life history) effects to wild populations:

1. **Genetic diversity – facilitates resilience**
    - Within basin (e.g., off station releases)
    - Regional (e.g., Puget Sound fall Chinook)

2. **Promotes local adaptation – Fitness of wild population**

FISH AND WILDLIFE COMMISSION
POLICY DECISION

POLICY TITLE: Washington Department of Fish and Wildlife Hatchery and Fishery Reform **POLICY NUMBER: C-3619**

Effective Date: November 6, 2009

Supersedes: N/A

See Also:

Approved by: Miranda Wecker
Washington Fish and Wildlife Commission

<u>Policy Guidelines</u>

1. Use the principles, standards, and recommendations of the **<u>Hatchery Scientific Review Group (HSRG) to guide the management of hatcheries operated by the Department.</u>** In particular, promote the achievement of hatchery goals through adaptive management based on a structured monitoring, evaluation, and research program.

2. The Department will prioritize and implement improved broodstock management (including selective removal of hatchery fish) to reduce the genetic and ecological impacts of hatchery fish and improve the **<u>fitness and viability of natural production</u>** working toward a goal of achieving the HSRG broodstock standards for 100% of the hatchery programs by 2015.

HSRG modeled long-term fitness using a quantitative genetic model based on Ford (2002)

From *Section 3.1.1 The HSRG Hypothesis* (p. 37)

Selection in Captivity during Supportive Breeding May Reduce Fitness in the Wild

Conservation Biology, Pages 815–825
Volume 16, No. 3, June 2002

MICHAEL J. FORD

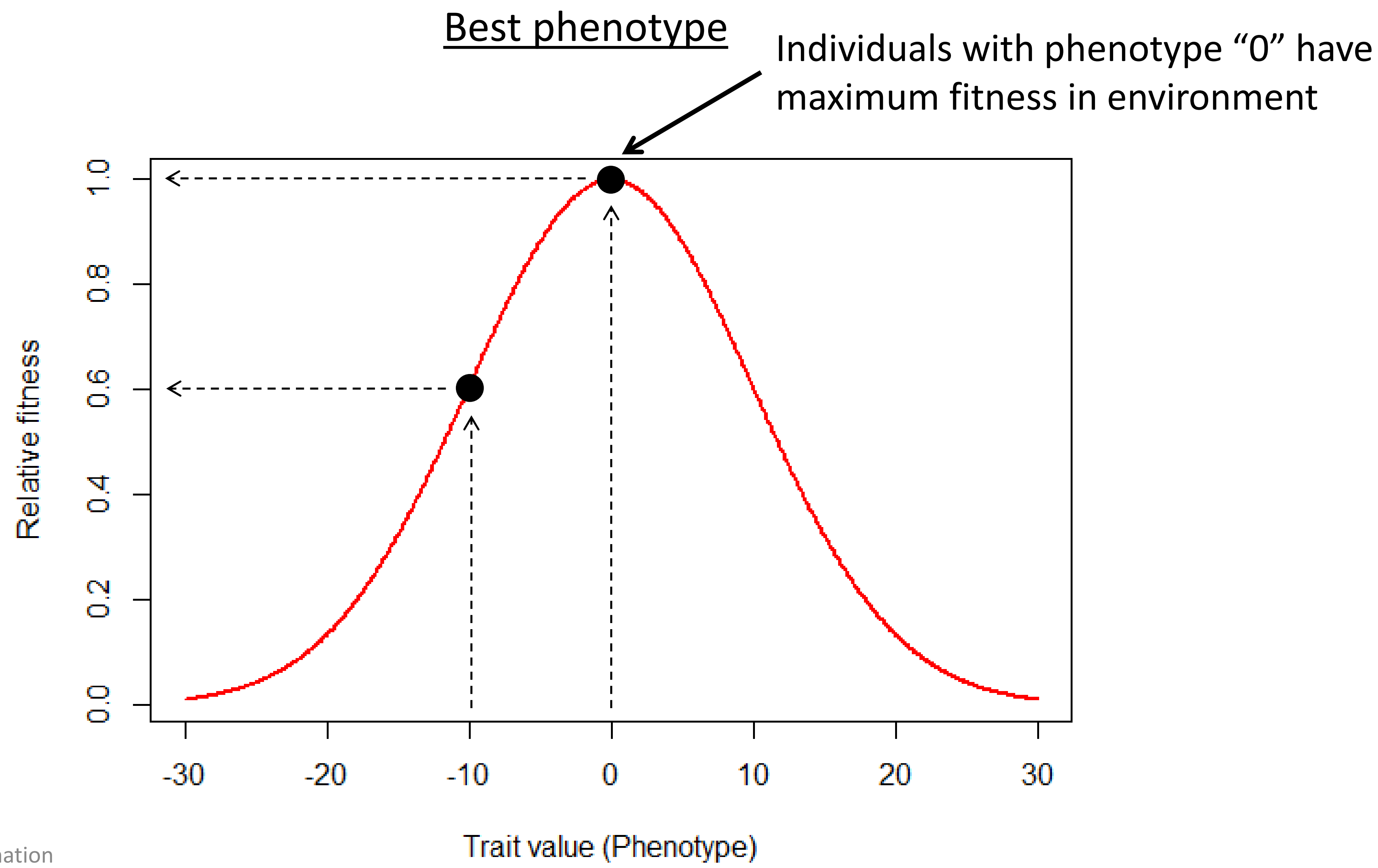
National Marine Fisheries Service, Northwest Fisheries Science Center, Conservation Biology Division, 2725 Montlake Boulevard E., Seattle, WA 98112, U.S.A., email mike.ford@noaa.gov

"... quantitative genetic model to explore how the combined effects of **selection** in two environments, captive and wild, can influence the distribution of a phenotypic trait and the **fitness** of a population." *(p. 815)*

Selection: Natural selection is the differential survival and reproduction of individuals due to differences in phenotype. *(Wikipedia)*

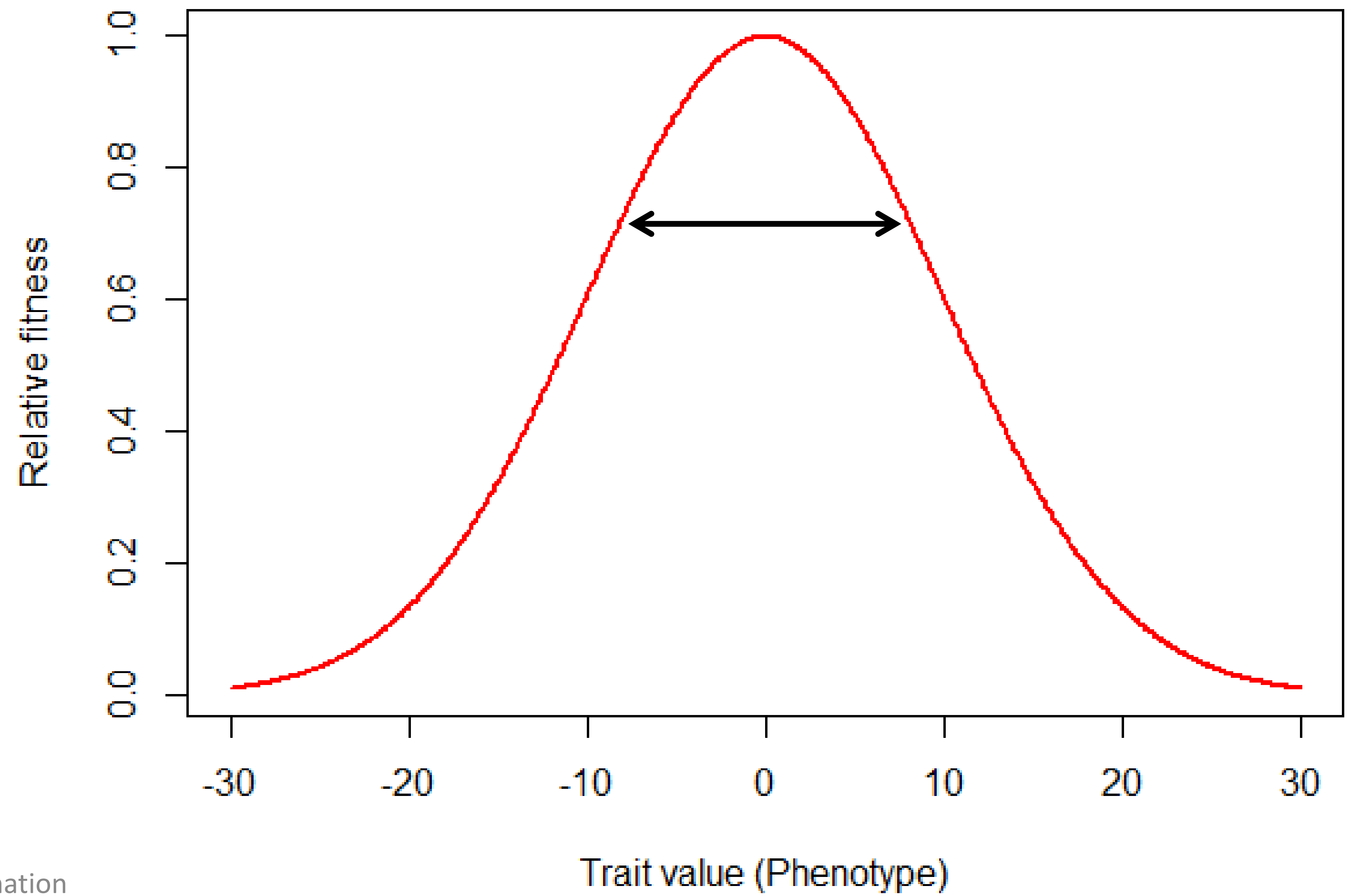
Fitness: individual's relative reproductive success based on their specified genotype or phenotype. *(Wikipedia)*

Fitness Curve



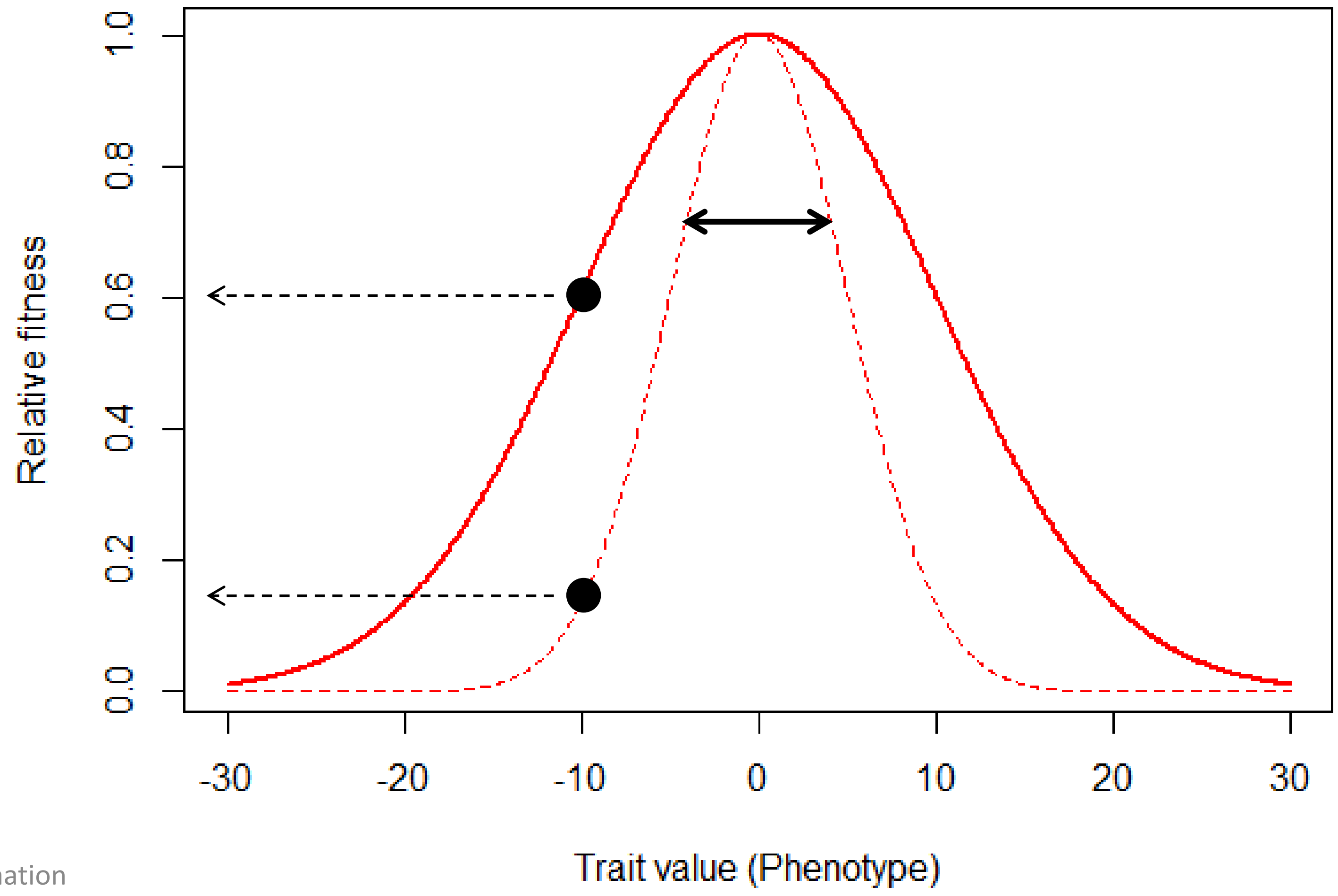
Fitness Curve

Selection strength



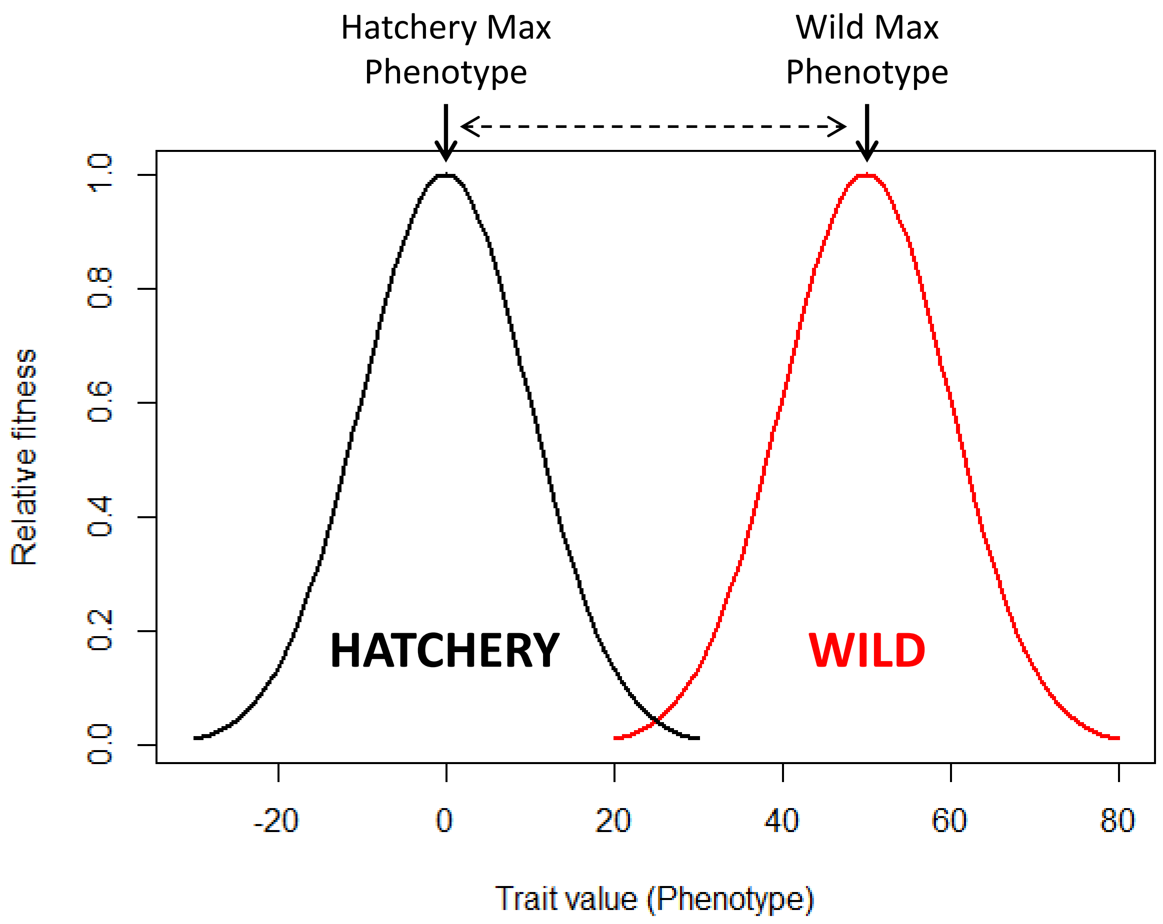
Fitness Curve

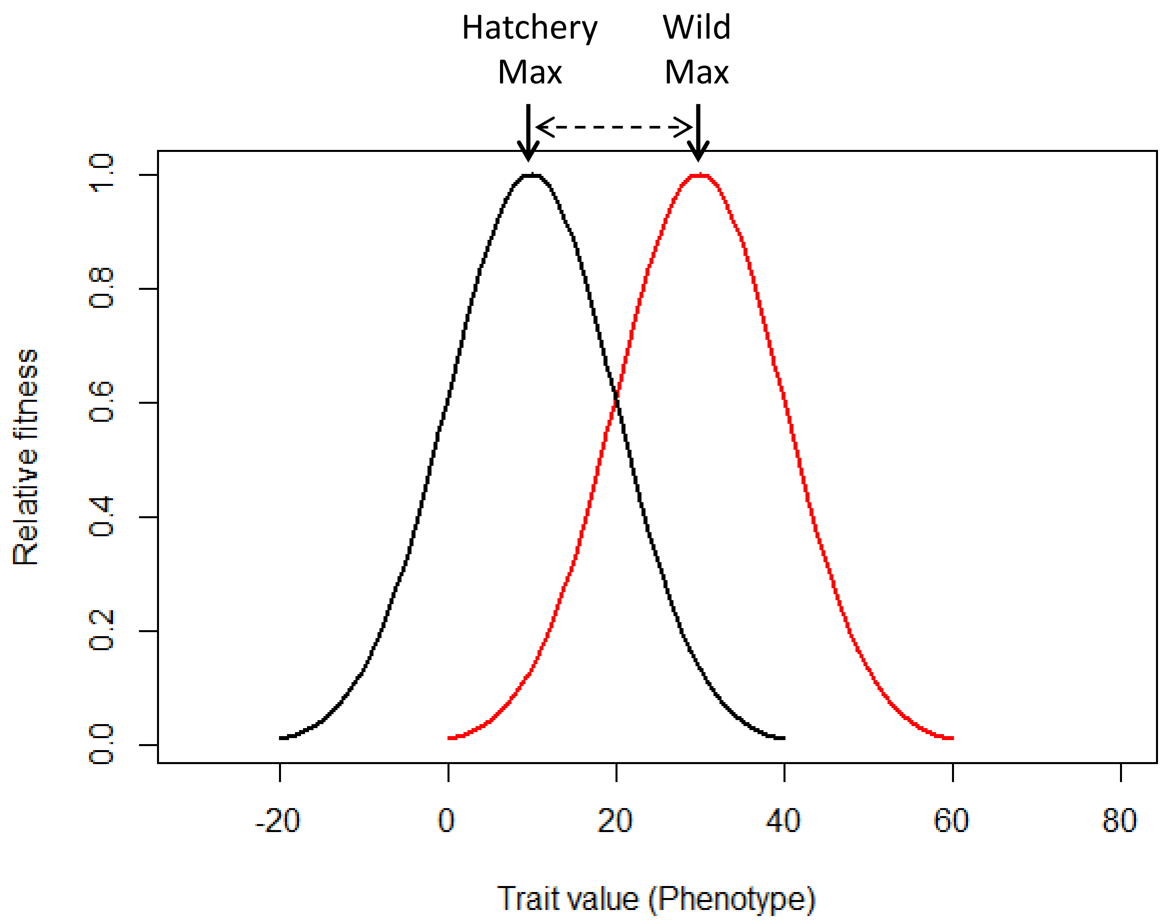
<u>Selection strength</u>



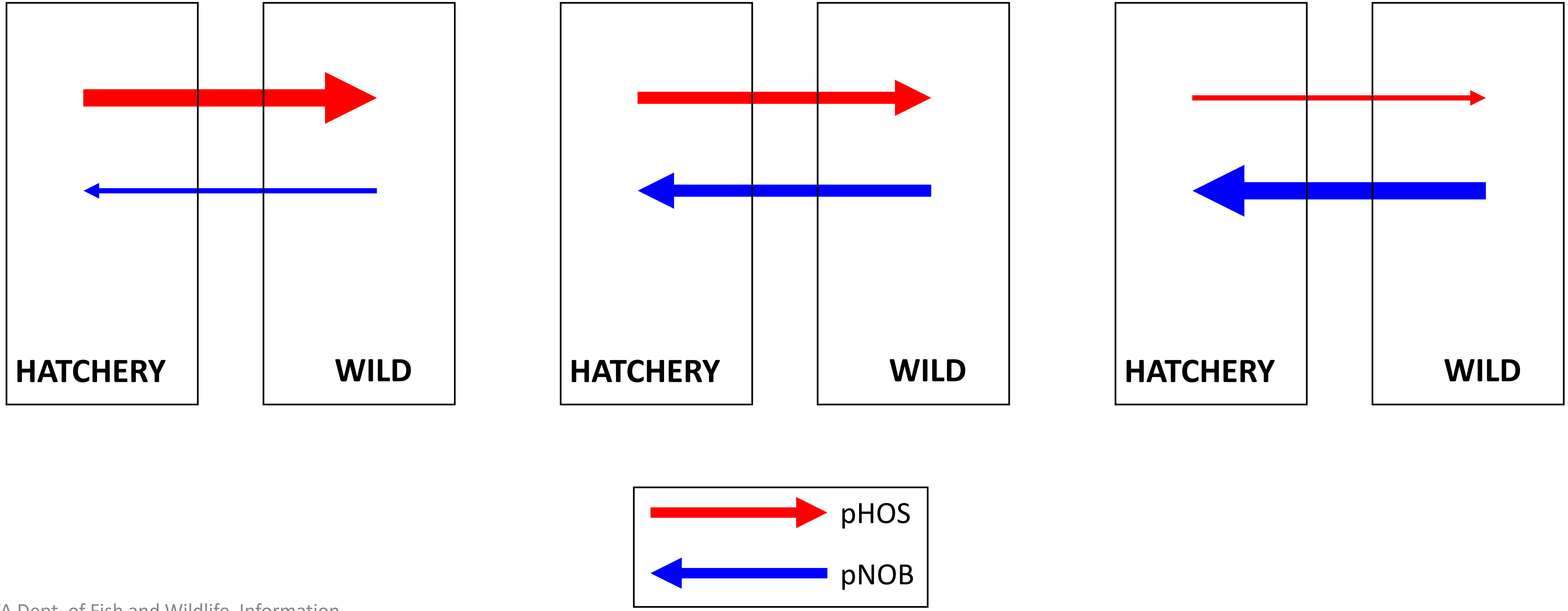
Fitness Curve

Selection in two different environments





Movement of Individuals Between Populations



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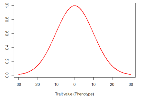
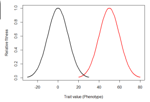
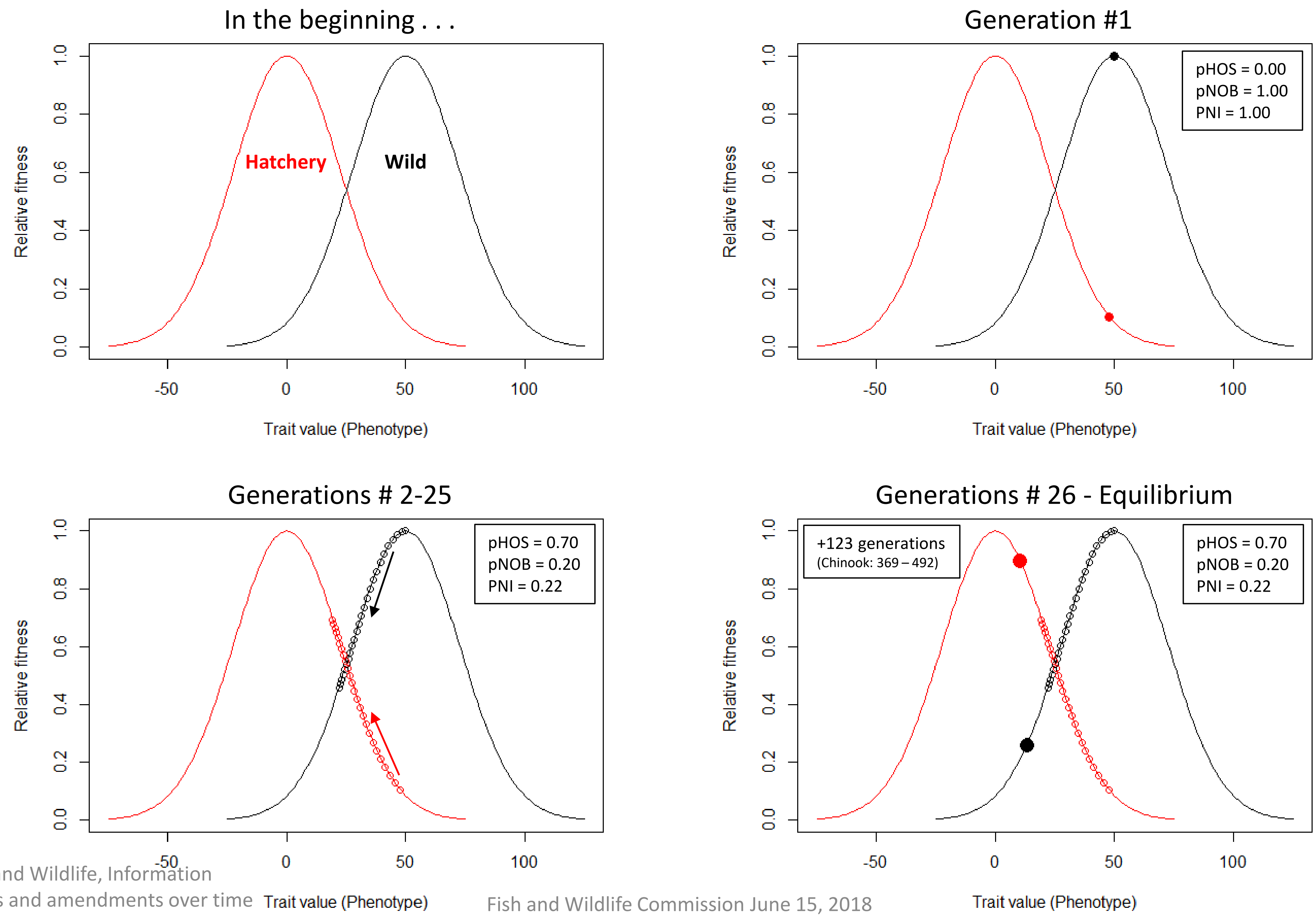
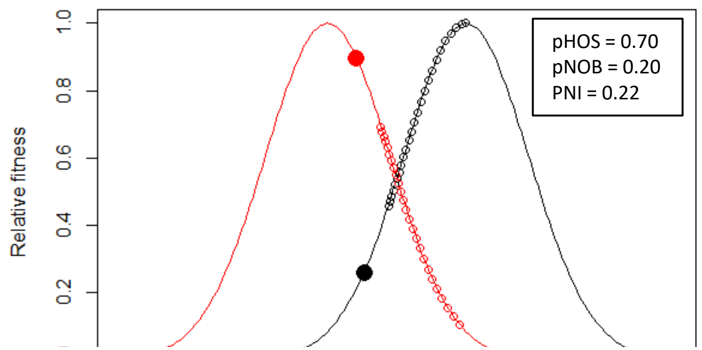
$$\bar{z}_w' = p_w\left\{\bar{z}_w + \left[\frac{\bar{z}_w\omega_w^2 + \theta_w\sigma^2}{\omega_w^2 + \sigma^2} - \bar{z}_w\right]h^2\right\} + (1-p_w)\left\{\bar{z}_c + \left[\frac{\bar{z}_c\omega_w^2 + \theta_w\sigma^2}{\omega_w^2 + \sigma^2} - \bar{z}_c\right]h^2\right\} \qquad (5)$$

and

$$\bar{z}_c' = p_c\left\{\bar{z}_c + \left[\frac{\bar{z}_c\omega_c^2 + \theta_c\sigma^2}{\omega_c^2 + \sigma^2} - \bar{z}_c\right]h^2\right\} + (1-p_c)\left\{\bar{z}_w + \left[\frac{\bar{z}_w\omega_c^2 + \theta_c\sigma^2}{\omega_c^2 + \sigma^2} - \bar{z}_w\right]h^2\right\}, \qquad (6)$$

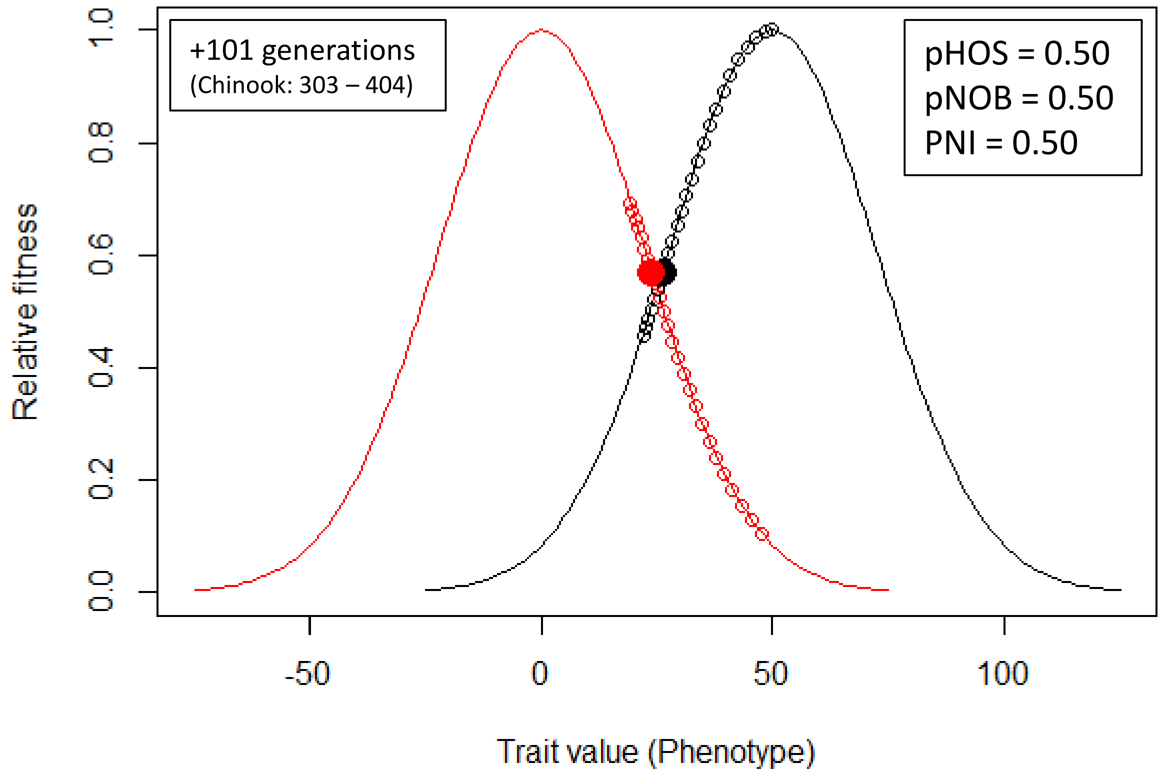
1. Gene Flow: Movement of individuals between hatchery and wild
   - pHOS and pNOB
2. Understand how selection operates in hatcheries
   - Strength of selection 
   - Distance between fitness max. in hatchery and wild 

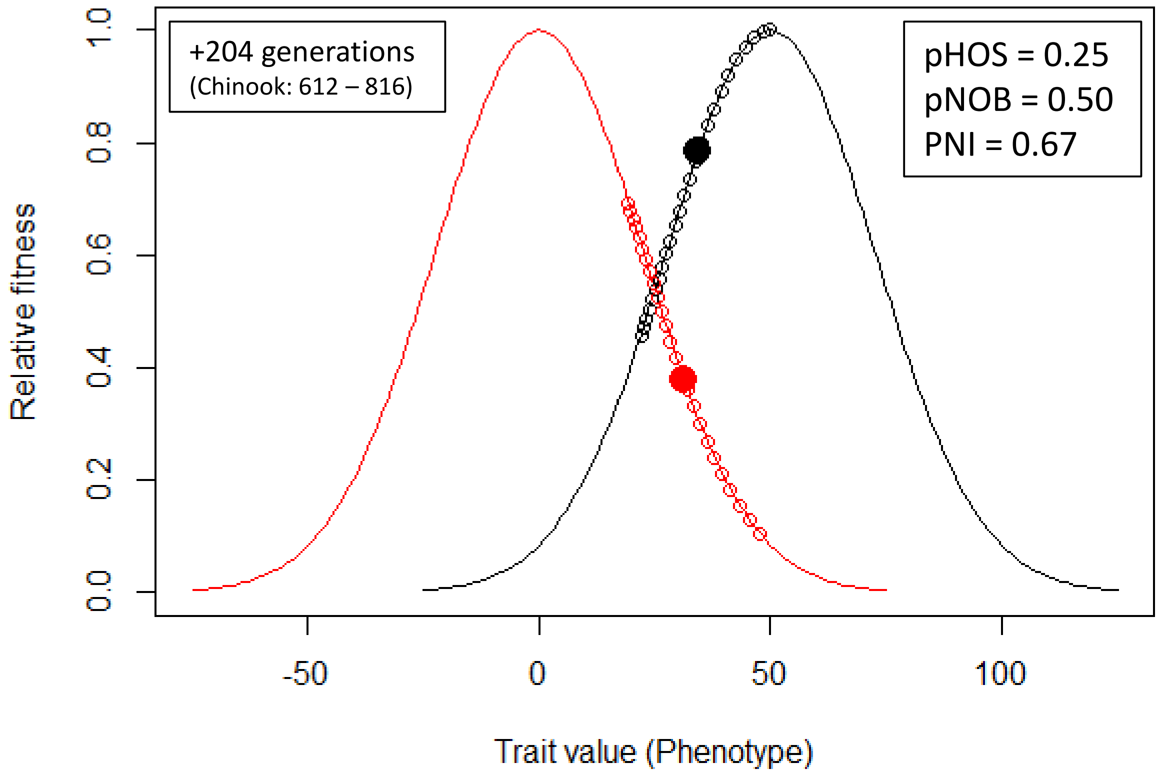

In the beginning . . .
Hatchery
Wild
Relative fitness
Trait value (Phenotype)
Generation #1
pHOS = 0.00
pNOB = 1.00
PNI = 1.00
Generations # 2-25
pHOS = 0.70
pNOB = 0.20
PNI = 0.22
Generations # 26 - Equilibrium
+123 generations
(Chinook: 369 – 492)
pHOS = 0.70
pNOB = 0.20
PNI = 0.22



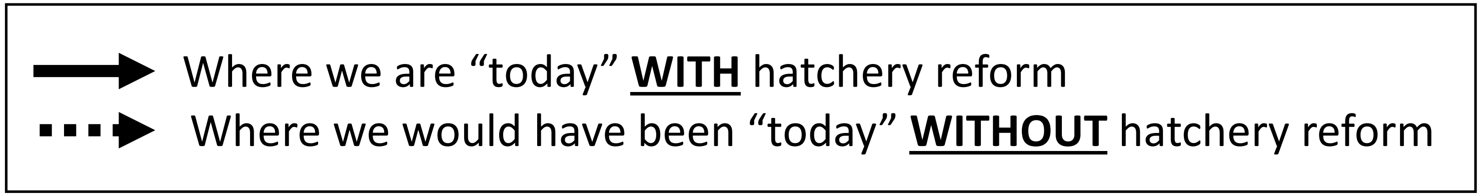
HSRG Hatchery Reform

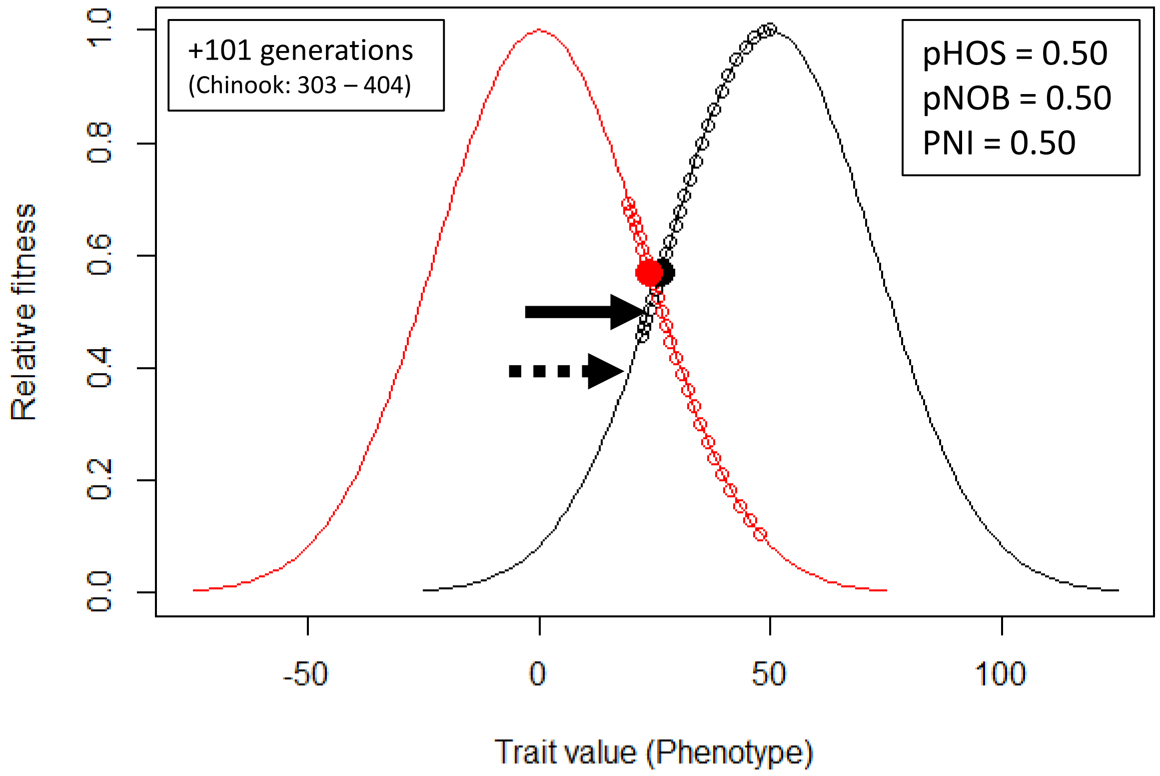
Generation # 25 -> Equilibrium

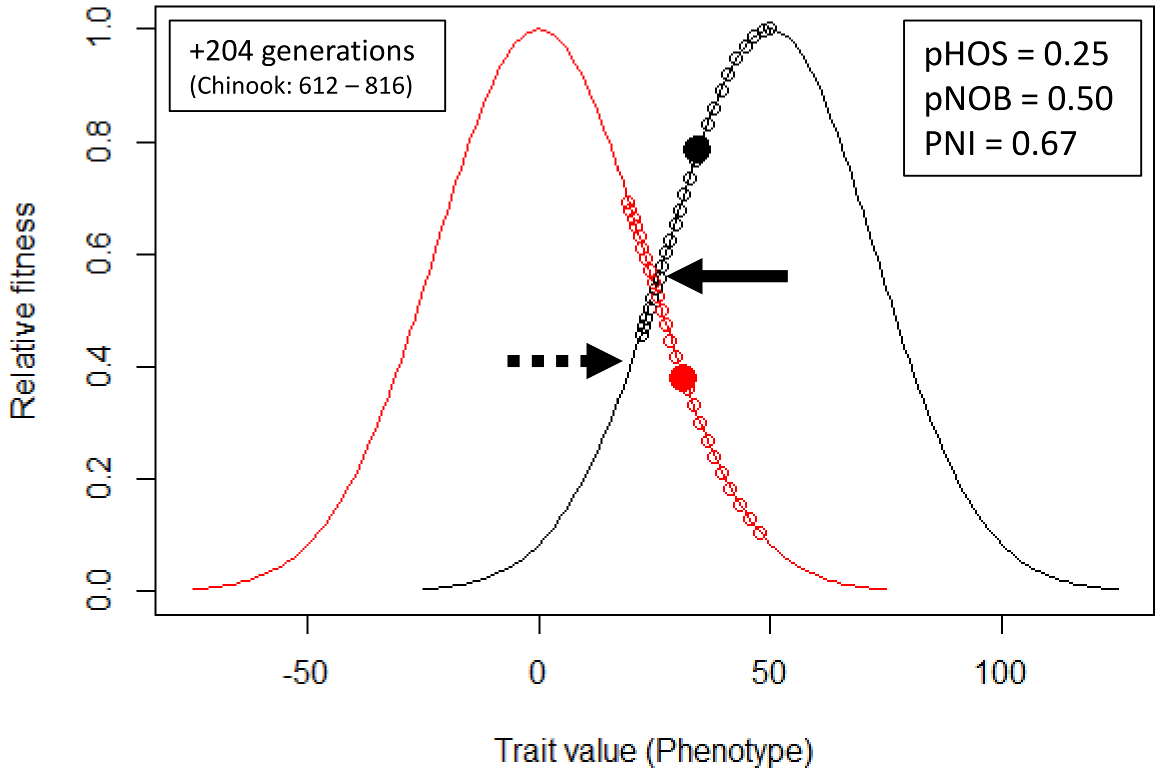




WA Dept. of Fish and Wildlife, Information subject to changes and amendments over time


Where we are "today" **WITH** hatchery reform
Where we would have been "today" **WITHOUT** hatchery reform


+101 generations
(Chinook: 303 – 404)
pHOS = 0.50
pNOB = 0.50
PNI = 0.50
Relative fitness
Trait value (Phenotype)
0.0
0.2
0.4
0.6
0.8
1.0
-50
0
50
100


+204 generations
(Chinook: 612 – 816)
pHOS = 0.25
pNOB = 0.50
PNI = 0.67
Relative fitness
Trait value (Phenotype)
0.0
0.2
0.4
0.6
0.8
1.0
-50
0
50
100

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and

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1. Gene Flow: Movement of individuals between hatchery and wild
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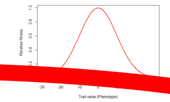
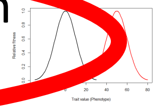
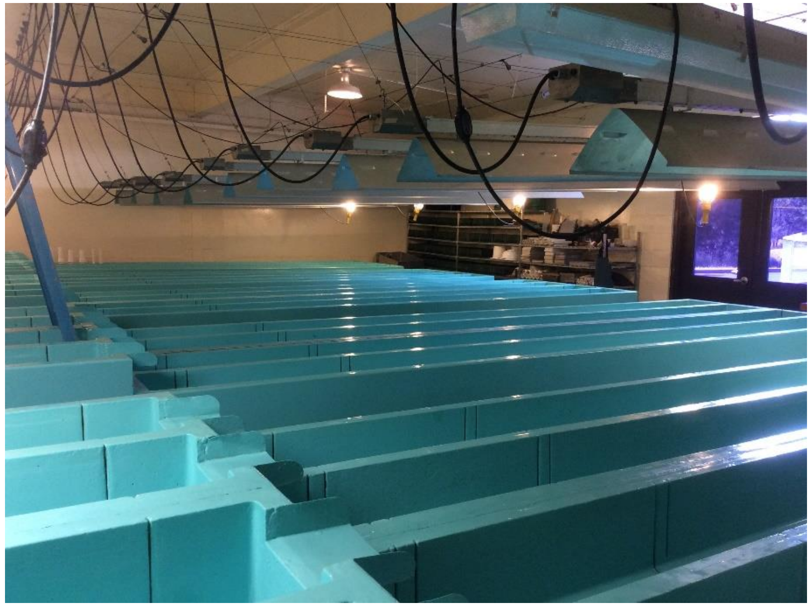
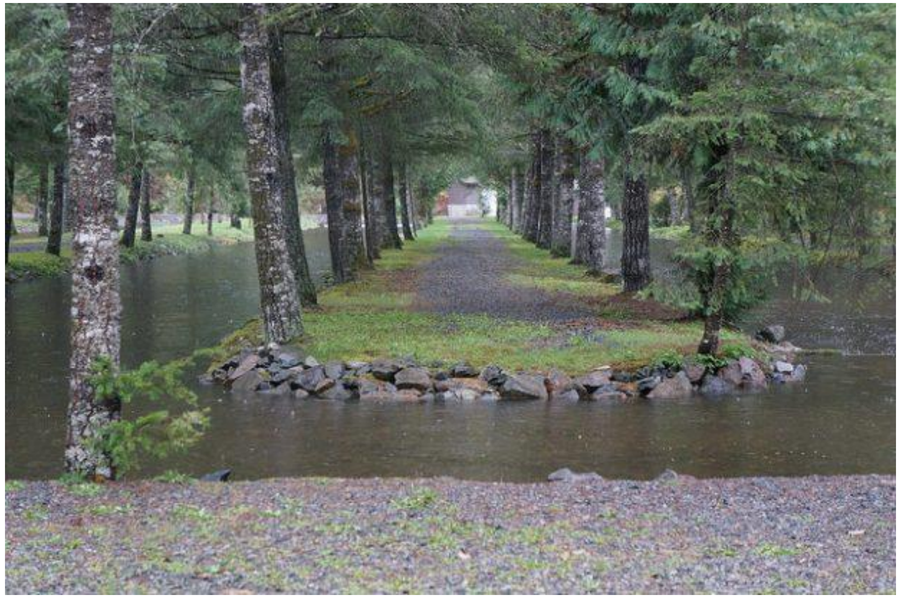




Making Hatcheries More Similar to Nature

- Move hatchery fitness curve closer to wild fitness curve
- Improvement to wild fitness without changing pHOS & pNOB
- Even more improvement when combined with increased PNI





https://blog.travel-british-columbia.com/best-places-to-see-salmon-spawning-near-vancouver-british-columbia/

Summary #1 – Science and Hatchery Reform

- WDFW policy
  - follows HSRG broodstock standards
- HSRG standards
  - based on Ford 2002 model
- Ford model
  - pHOS and pNOB, and selection to quantify average fitness
  - Model is a risk management tool
  - Model assumes constant environment and selection – over decades, and is based on a single trait whose effect is large enough to affect fitness

Summary #2 – Science and Hatchery Reform

- Diversity
  - Stabilizes ecosystem processes and services (e.g., fisheries)
  - Reduces risk of ESA listings and fishery reductions
- Local Adaptation – Risk Management
  - Prevents further decline in average fitness
  - Improves average fitness
  - Improvement takes time and may be imperceptible in first 5-10 generations

Emerging Policy Questions

Hatchery Reform – Essential Contributor to Conservation and Recovery

Southern Resident Killer Whales – Dire Status

- Toxins, vessel traffic noise, and lack of prey
- Task Force evaluating options to increase hatchery production

Hatchery Reform Policy Provides Flexibility

- Recognizes necessity of close coordination with co-managers
- Implemented as part of All-H strategy
- Broodstock management standards less restrictive for:
  - Stabilizing and Contributing populations
  - Populations at low abundance

Emerging Policy Questions

Potential Commission Actions:

- Recognize hatchery role in providing prey for Southern Resident Killer Whales
- Clarify and emphasize potential to increase production for hatchery programs primarily affecting Stabilizing populations
- Provide staff opportunity to brief Commission if additional policy guidance needed

Questions?