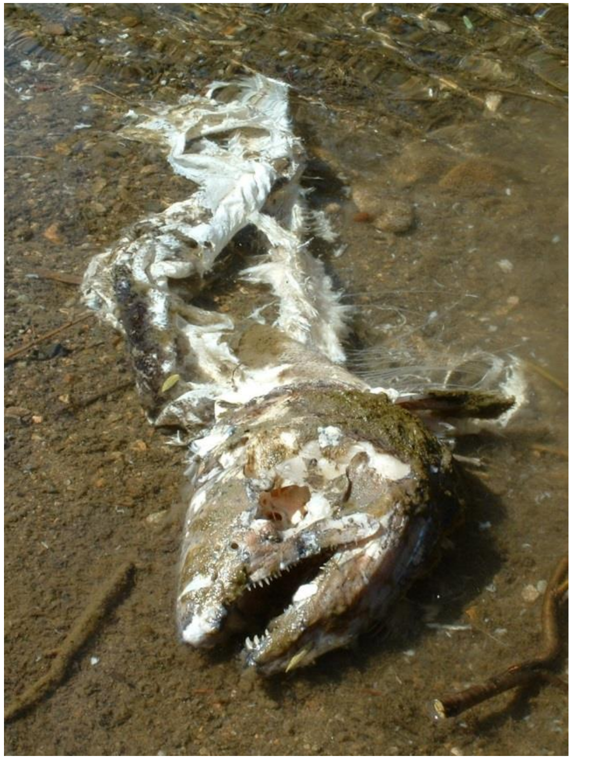
Hatchery Review and Reform Processes in the Columbia Basin

Governor's Salmon Workgroup Meeting
Video Meeting
April 28, 2020

Paul Kline
Idaho Department of Fish and Game

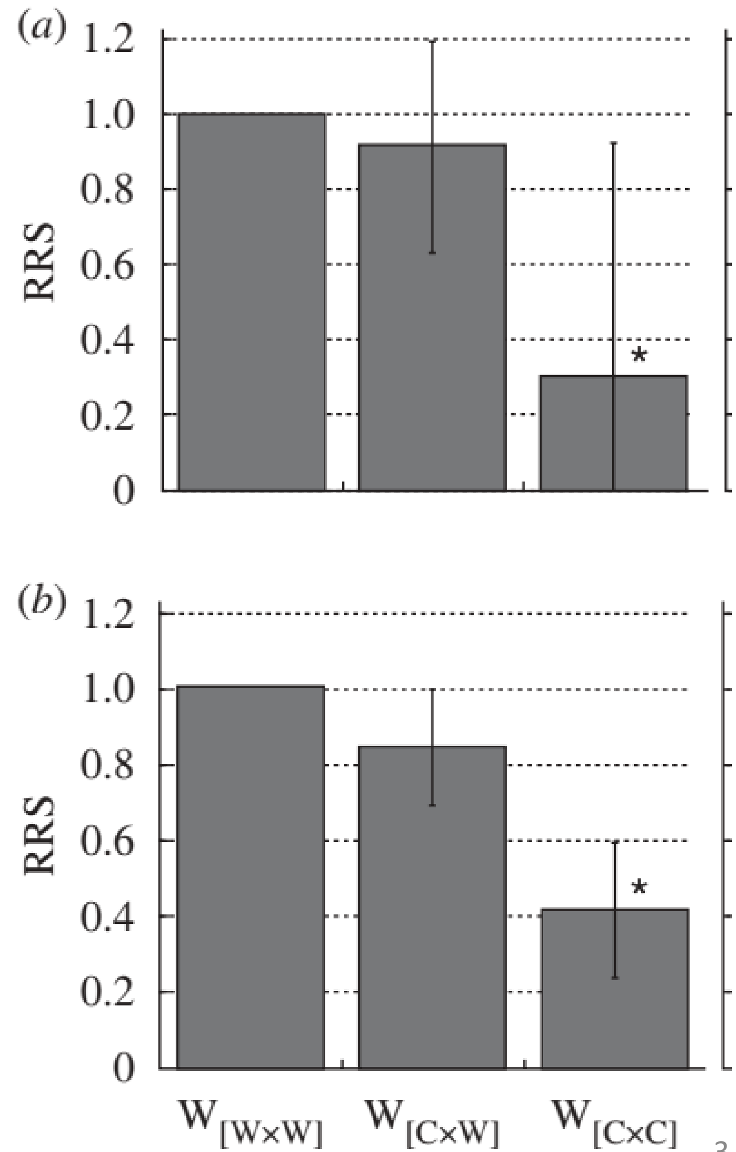
Presentation Outline

- Hatchery reform in the Columbia Basin
- Driven by the hatchery/natural fish debate
- Current gene flow-theory and adopted practices (HSRG)



Relative Fitness

Fitness or relative fitness means the survival of hatchery fish (either lifetime or some component) relative to that of wild fish spawning in the same habitat



Hatchery/Natural Debate

Chilcote, M. W., Leider, S. A., and J. J. Loch. 1986. Differential reproductive success of hatchery and wild summer-run steelhead under natural conditions, Transactions of the American Fisheries Society 115:5 726-735

Ryman, N. and L. Laikre. 1991. Effects of supportive breeding on the genetically effective population size, Conservation Biology 5:3 1523-1739

Busack, C. A., and K. P. Currens. 1995. Genetic risks and hazards in hatchery operations: Fundamental concepts and issues. American Fisheries Society Symposium 15:71-80.

Fleming, I. A., and M. R. Gross. 1993. Breeding success of hatchery and wild coho salmon (*Oncorhynchus kisutch*): measures of natural and sexual selection, Evolution 48: 637-657

Waples, R. S., and C. Do. 1994. Genetic risk associated with supplementation of Pacific Salmonids: Captive broodstock programs. Canadian Journal of Fisheries and Aquatic Sciences 51:310-329

Hatchery/Natural Debate

Ford, M. 2002. Selection in captivity during supportive breeding may reduce fitness in the wild, Conservation Biology 16:3 815-825

Lynch, M., and H. O'Hely. 2001. Captive breeding and the genetic fitness of natural populations, Conservation Genetics 2(4):363-378.

Brannon, E. and 11 other authors. 2004. The controversy about salmon hatcheries, Fisheries 29:9 12-31.

Araki, H., Cooper, B., and M. S. Blouin. 2007. Genetic effects of captive breeding cause a rapid, cumulative fitness decline in the wild. Science: 318(5847):100-103

Berntson, E.A., Carmichael R.W., Flesher M.W., Ward E.J. & Moran P. 2011. Diminished reproductive success of steelhead from a hatchery supplementation program (little sheep creek, Imnaha Basin, Oregon). Transactions of the American Fisheries Society, 140: 685- 698.

Summary of Risks

1. Genetic – loss of genetic variation within populations, increase inbreeding risk, inbreeding depression, domestication selection, loss of adaptive potential.

2. Ecological – Competition, predation, disease.

3. Demographic – reduction in productivity, SARs and relative reproductive success.

4. Facility effects – hatchery system fail, collection weirs negatively impacting migration of wild fish.

4. Management masking effects – if fish not adequately marked, accounting for the composition of fish on spawning grounds cannot be accurately estimated.

Hatcheries Modernize

Harvest Augmentation: The use of hatcheries to produce fish to increase fishing and harvest opportunities where there is no mitigation program in place.

Mitigation: The use of hatcheries pursuant to an agreement to provide fishing and harvest opportunities lost as a result of habitat deterioration, destruction or migration blockage.

Supplementation: The use of hatcheries to maintain or increase natural production, while maintaining the long-term fitness of the target population and keeping the ecological and genetic impacts on non-target populations within specified biological limits (RASP 1992).

Conservation: The use of hatcheries to maintain genetic resources, using the amplification potential of the hatchery, and restoring natural populations that face demographic, genetic, or ecological risks. The expectation is to maintain equivalent genetic resources of the native stock, and to return fish to the habitat to reproduce naturally. Captive broodstocking and captive rearing are examples. Time in culture should be minimized.

Hatchery Reform

Hatchery reform is the scientific and systematic redesign of hatchery programs to help recover wild salmon and steelhead and support sustainable fisheries. The intent of hatchery reform is to improve hatchery effectiveness, ensure compatibility between hatchery production and salmon recovery plans and rebuilding programs, and support sustainable fisheries.
https://wdfw.wa.gov/about/commission/policies/hatchery-and-fishery-reform

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We define hatchery reform as widespread, institutionalized changes to hatchery Programs intended to reduce risk to natural populations.
A review of hatchery reform science in Washington State, WDFW 2020

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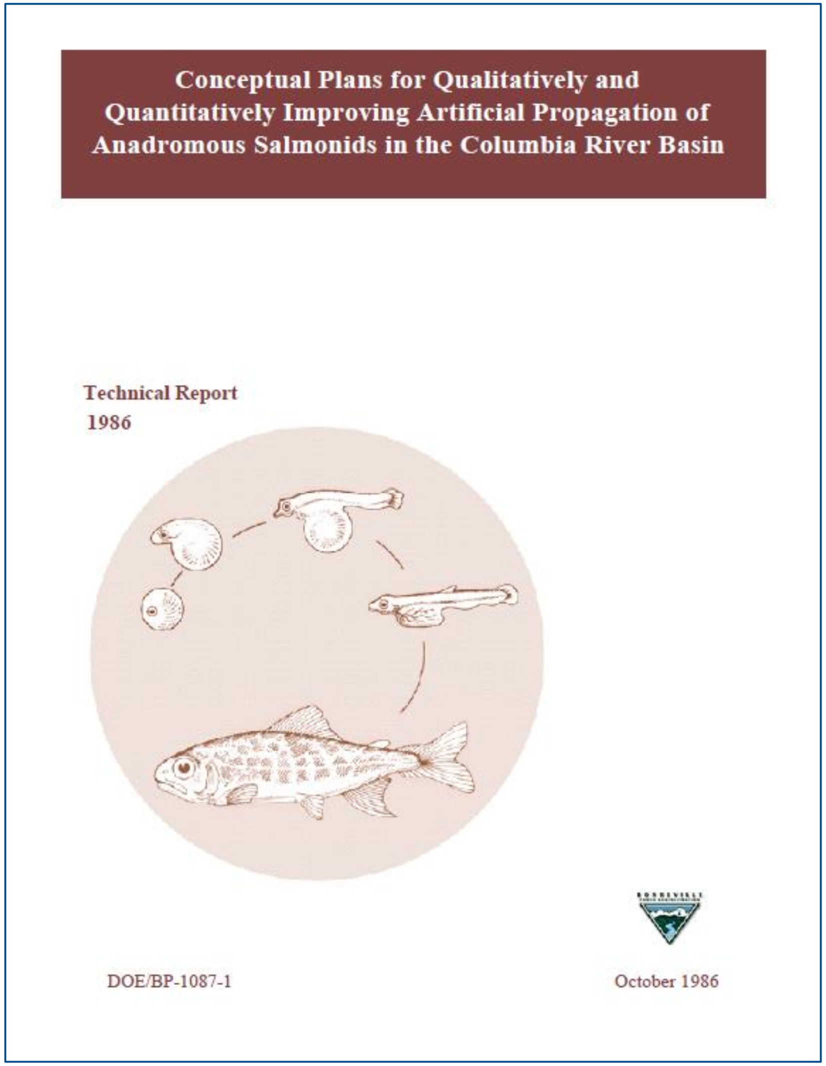
Hatchery reform is applying the same scientific principles to managing hatchery fish that we use for managing wild fish.
Don Campton, USFWS personal communication

Hatchery Reform

1. Best management practices and protocols:
    A. Improving hatchery biosecurity
    B. Improving diets
    C. Adjusting rearing and transportation densities
    D. Adjusting release strategies
        I. Acclimated or not
        II. Volitional or forced
        III. Timing of release
    E. Managing broodstock composition
        I. Local better than out-of-basin
        II. Spawning designs
    F. Improving weir management (tight better than leaky)
    G. Managing escapement management (upstream of weir)
    H. Managing size of program
    I. Marking all hatchery fish
    J. Implementing a strong monitoring and evaluation program
    K. And applying adaptive management

Hatchery Reform

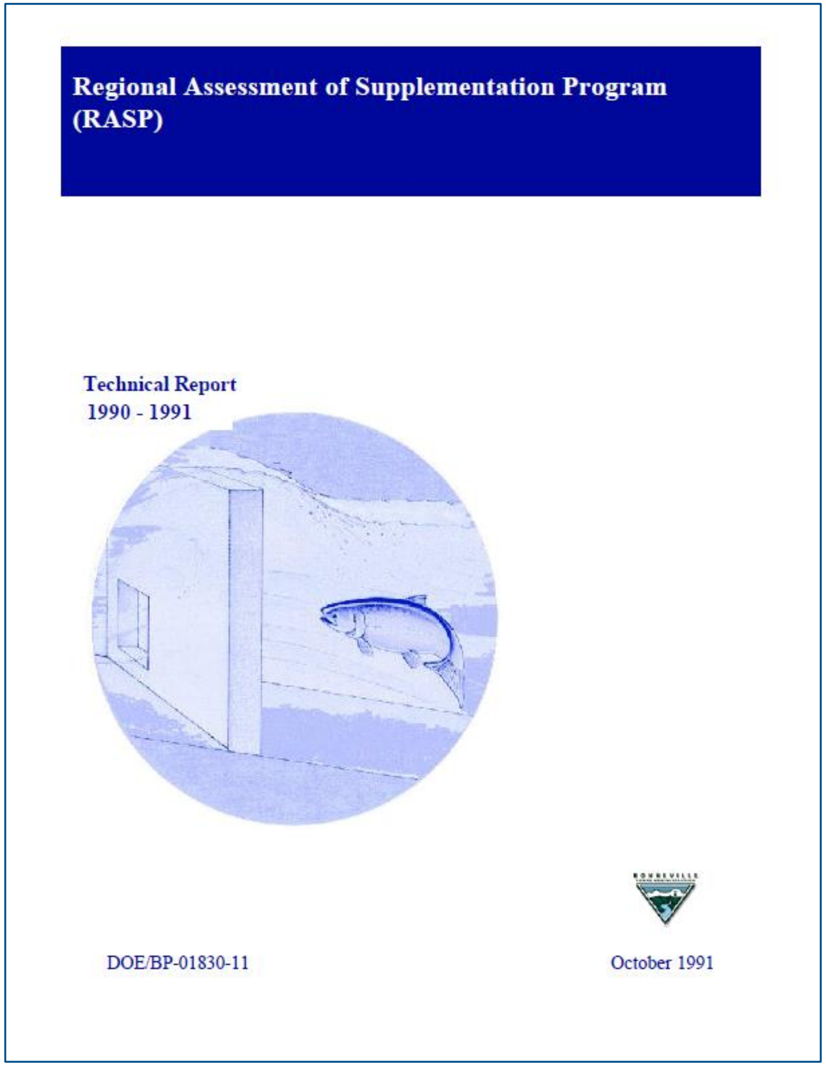


Conceptual Plans for Qualitatively and Quantitatively Improving Artificial Propagation of Anadromous Salmonids in the Columbia River Basin

Technical Report
1986

DOE/BP-1087-1

October 1986



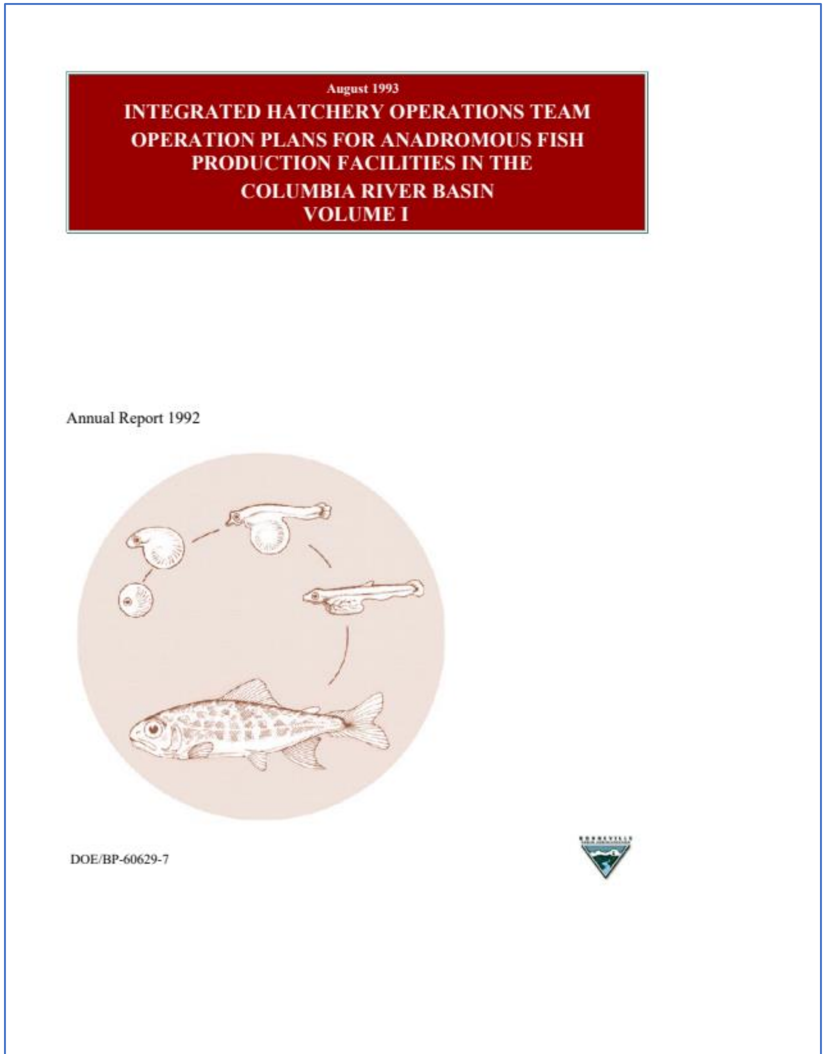
Regional Assessment of Supplementation Program (RASP)

Technical Report
1990 - 1991

DOE/BP-01830-11

October 1991

Hatchery Reform

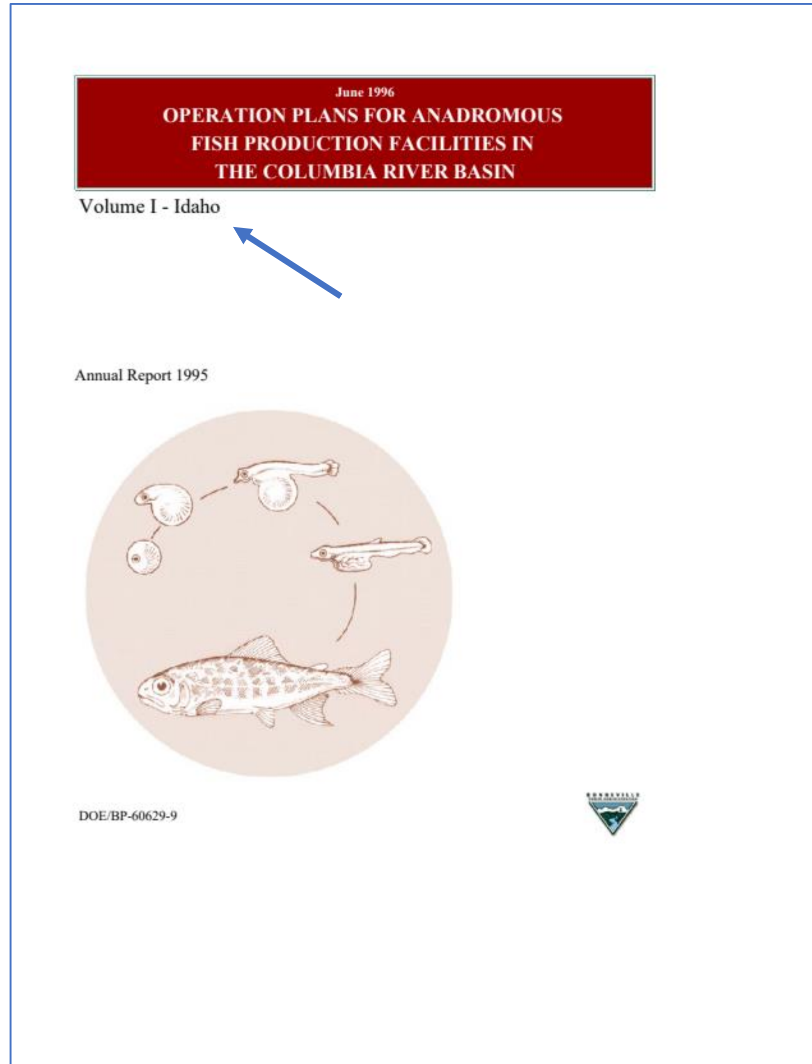


August 1993

INTEGRATED HATCHERY OPERATIONS TEAM
OPERATION PLANS FOR ANADROMOUS FISH
PRODUCTION FACILITIES IN THE
COLUMBIA RIVER BASIN
VOLUME I

Annual Report 1992

DOE/BP-60629-7



June 1996

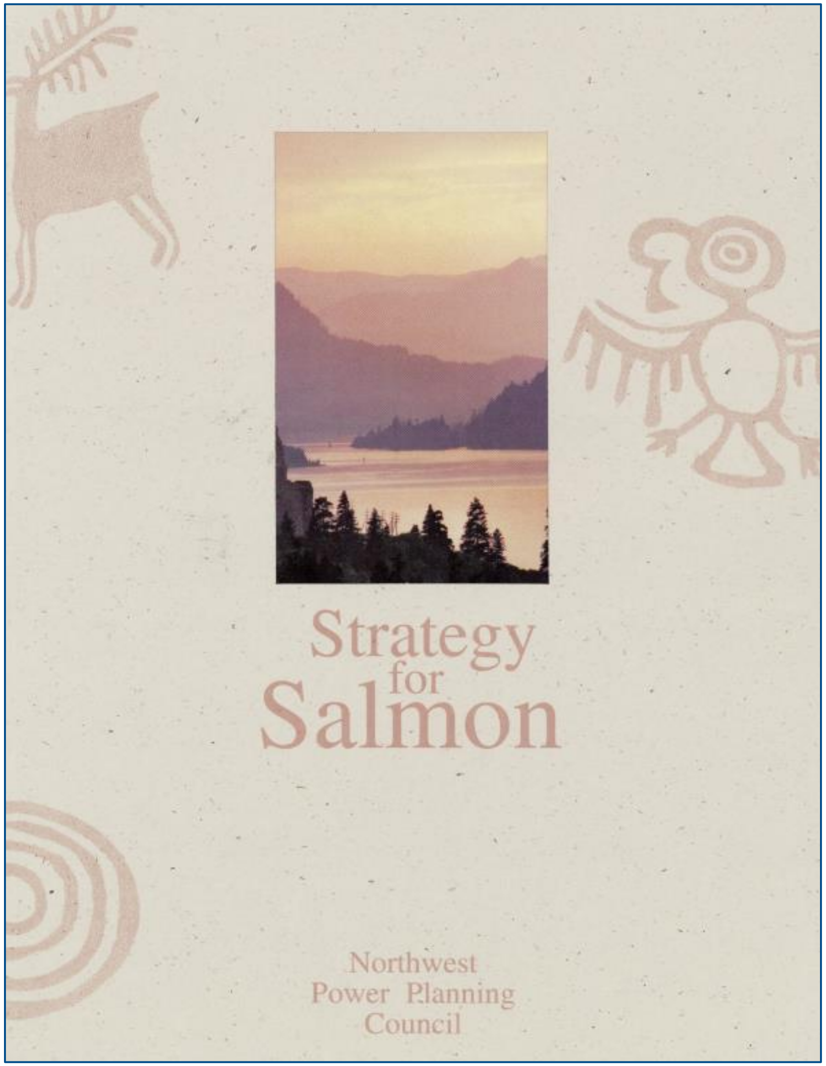
OPERATION PLANS FOR ANADROMOUS
FISH PRODUCTION FACILITIES IN
THE COLUMBIA RIVER BASIN

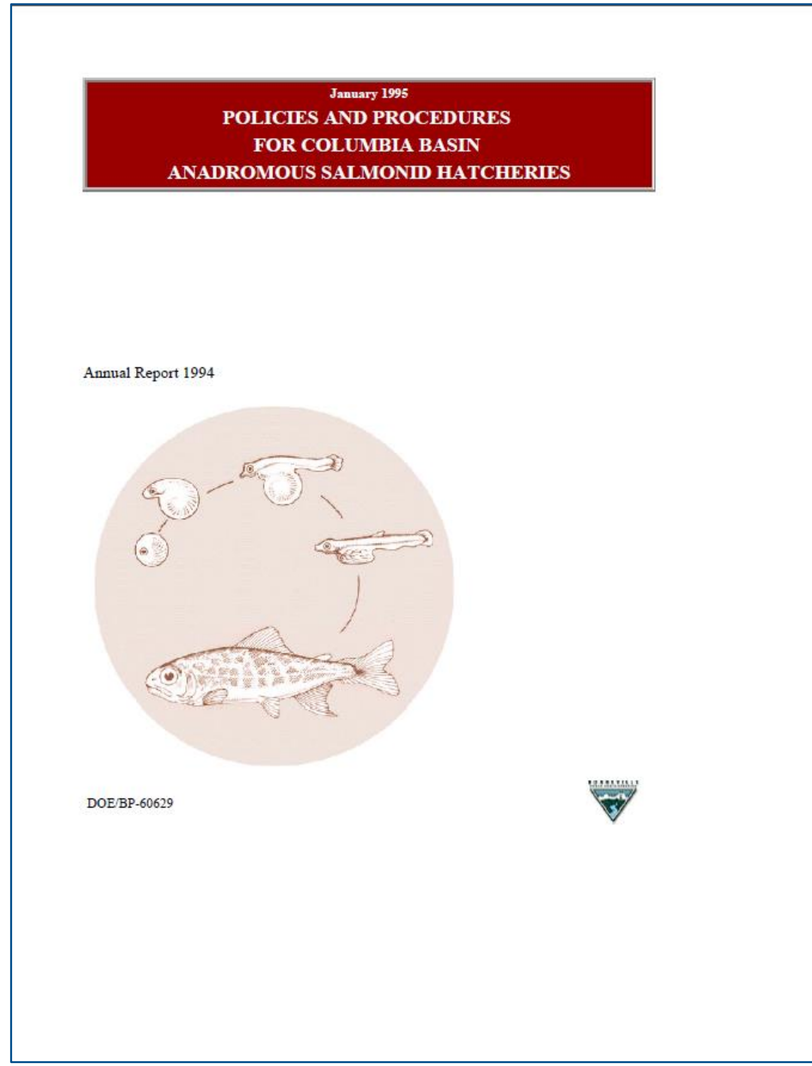
Volume I - Idaho

Annual Report 1995

DOE/BP-60629-9

Hatchery Reform





Hatchery Reform

Review of Artificial Production

of Anadromous and Resident Fish

in the Columbia River Basin

Part I:
A Scientific Basis
for Columbia River Production Programs

April 1999

Scientific Review Team
Independent Scientific Advisory Board

Ernest L. Brannon
Kenneth P. Currens
Daniel Goodman
James A. Lichatowich
Brian E. Riddell
Richard N. Williams

Willis E. McConnaha, Chair

Program Evaluation and Analysis Section
Northwest Power Planning Council
851 SW 6th Avenue, Suite 1100
Portland, Oregon 97204

Council Document 99-4

Hatchery Reform

Artificial Production Review

Report and Recommendations of the
Northwest Power Planning Council

Council document 99-15

October 13, 1999

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APRE

Artificial Production Review and Evaluation

DRAFT
Basin-Level Report

Northwest Power and Conservation Council

Document 2003-17

October 7, 2003

Hatchery Reform

Art. Prop. Performance Standards and Indicators; January 17, 2001

Performance Standards and Indicators for the Use of Artificial Production for Anadromous and Resident Fish Populations in the Pacific Northwest

January 17, 2001

HATCHERY AND GENETIC MANAGEMENT PLAN (HGMP)

Hatchery Program:	Salmon River Basin Summer Chinook Salmon. McCall Fish Hatchery.
Species or Hatchery Stock:	Summer Chinook Salmon *Oncorhynchus tshawytscha.*
Agency/Operator:	Idaho Department of Fish and Game
Watershed and Region:	South Fork Salmon River, Idaho.
Date Submitted:	September 30, 2002
Date Last Updated:	September 30, 2002

Hatchery Reform

Independent Scientific Advisory Board

Review of Salmon and Steelhead Supplementation

ISAB 2003-03
June 4, 2003

Independent Scientific Review Panel
for the Northwest Power and Conservation Council; 851 SW 6th Avenue, Suite 1100; Portland, Oregon 97204

Independent Scientific Advisory Board
for the Council, Columbia River Basin Indian Tribes, and the National Marine Fisheries Service

Monitoring and Evaluation of Supplementation Projects

October 14, 2005
ISRP & ISAB 2005-15

Hatchery Reform

1. Managers should use supplementation sparingly,
2. Only implementing supplementation in a subset of the locations where unharvested natural populations were not replacing themselves,
3. Using supplementation only where habitat capacity is believed to be able to accommodate additional production,
4. Using natural-origin adults from the target population as parents in hatchery spawning,
5. Establishing and monitoring performance standards for each project for natural-origin and hatchery-origin adult abundance and per capita production rates,
6. Requiring explicit experimental designs for all supplementation projects, and
7. Stressing the importance that managers ensure that individual projects were collecting the data necessary to test their effectiveness and ensure regional coordination of the multiple experiments.

Hatchery Reform

Recommendations for Broad Scale Monitoring to Evaluate the Effects of Hatchery Supplementation on the Fitness of Natural Salmon and Steelhead Populations

Final Report of the Ad Hoc Supplementation Monitoring and Evaluation Workgroup*

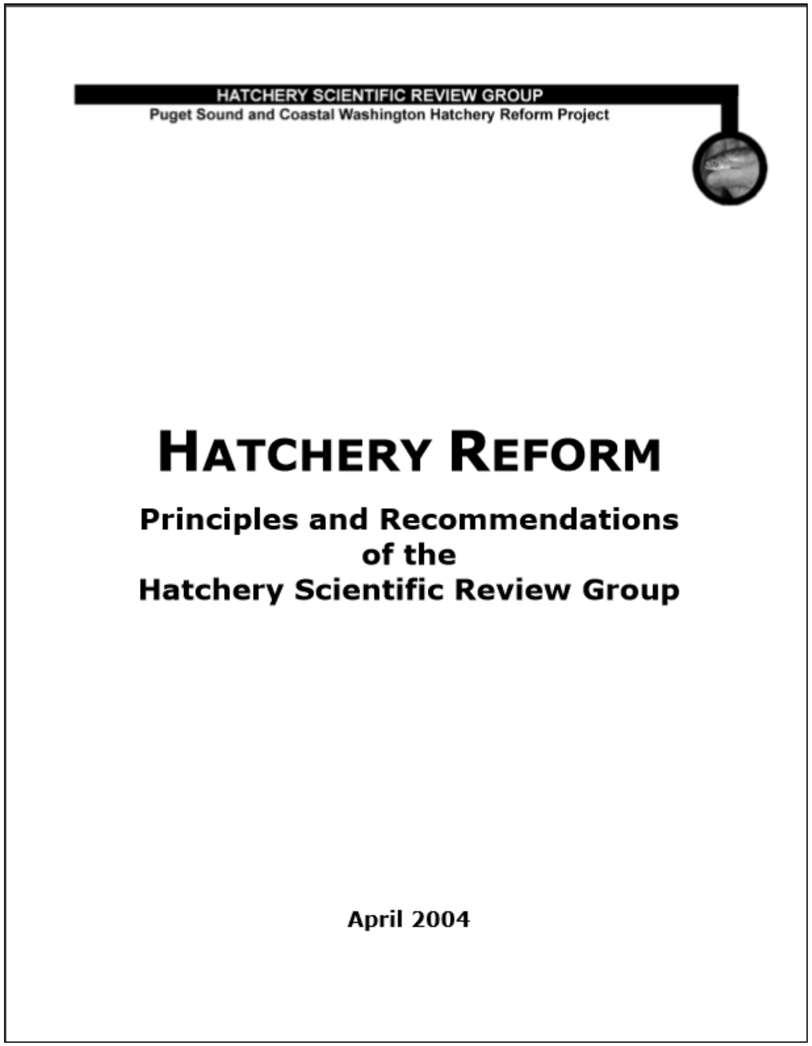
Peter F. Galbreath[1], Chris A. Beasley[2],
Barry A. Berejikian[3], Richard W. Carmichael[4],
David E. Fast[5], Michael J. Ford[3], Jay A. Hesse[6],
Lyman L. McDonald[7], Andrew R. Murdoch[8],
Charles M. Peven[9], David A. Venditti[10]

[1] Columbia River Inter-Tribal Fish Commission, Fish Science Department
[2] Quantitative Consultants, Inc.
[3] NOAA-Fisheries, Northwest Fisheries Science Center
[4] Oregon Department of Fish and Wildlife
[5] Yakama Nation, Yakima Klickitat Fisheries Project
[6] Nez Perce Tribe, Department of Fisheries Resources Management
[7] Western EcoSystems Technology, Inc.
[8] Washington Department of Fish and Wildlife
[9] Peven Consulting, Inc.
[10] Idaho Depart of Fish and Game

October 9, 2008

* Workgroup members participated as individuals, not as agency representatives. The report's content, conclusions and recommendations are solely those of the workgroup.

Hatchery Reform - HSRG



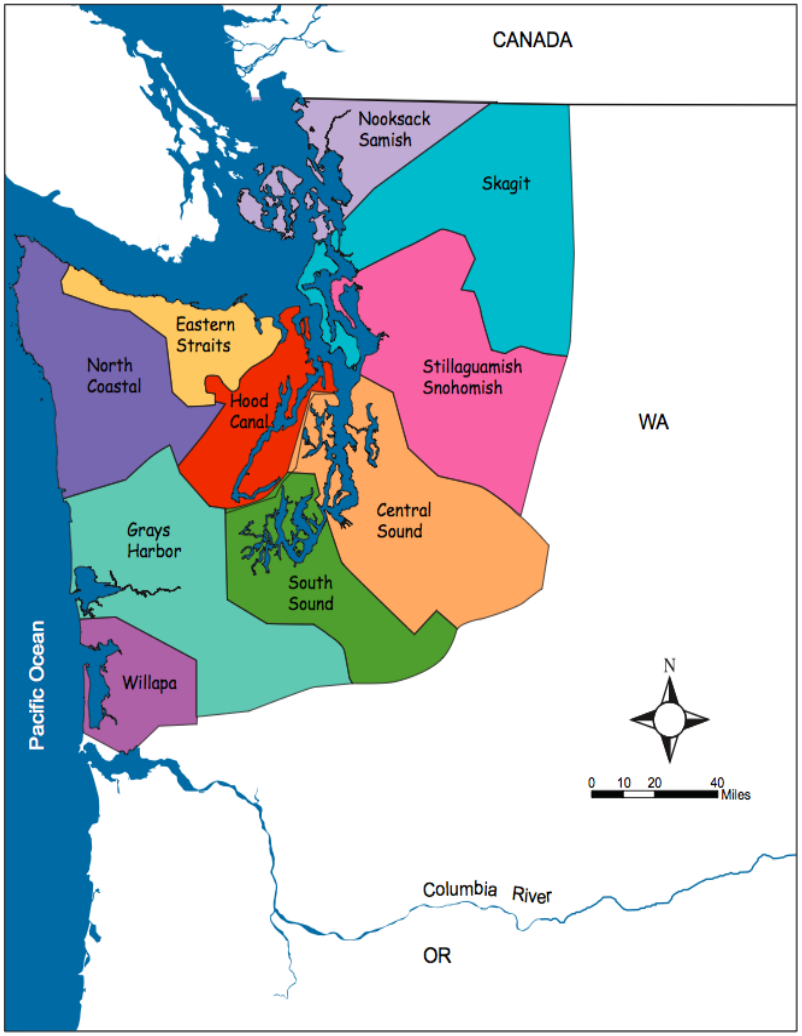
HATCHERY SCIENTIFIC REVIEW GROUP

Puget Sound and Coastal Washington Hatchery Reform Project

HATCHERY REFORM

Principles and Recommendations of the Hatchery Scientific Review Group

April 2004



Hatchery Reform - HSRG

1. Scientific framework for artificial propagation of Salmon and steelhead
2. Emerging issues in hatchery reform
3. M&E criteria
4. Operational guidelines
5. Program-specific recommendations

Hatchery Reform - HSRG

Hatchery Reform in Washington State: Principles and Emerging Issues

fisheries management

feature

ABSTRACT

Hatcheries support nearly all major fisheries for Pacific salmon (*Oncorhynchus* spp.) and steelhead (anadromous *O. mykiss*) in the Pacific Northwest. However, hatcheries have been a major source of controversy for over 30 years. The Hatchery Scientific Review Group (HSRG) was tasked by Congress to identify solutions to well-known problems so hatcheries could better meet their goals of supporting sustainable fisheries and assisting with the conservation of natural populations. We reviewed over 100 facilities and 200 programs and identified three principles of hatchery reform: (1) goals for each program must be explicitly stated in terms of desired benefits and purposes; (2) programs must be scientifically defensible; and (3) hatchery programs must respond adaptively to new information. We also identified several emerging issues critical to the success of hatcheries. We concluded that hatcheries must operate in new modes with increased scientific oversight and that they cannot meet their goals without healthy habitats and self-sustaining, naturally-spawning populations.

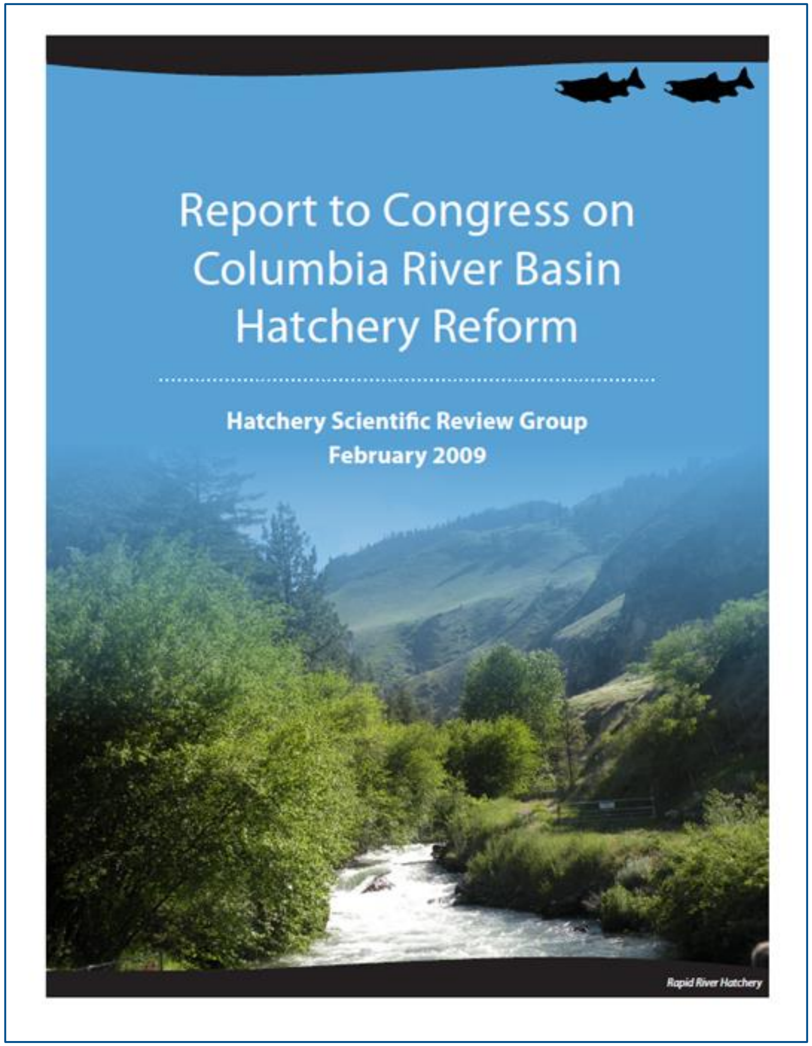
Hatchery Scientific Review Group:
Lars E. Mobrand, Chair

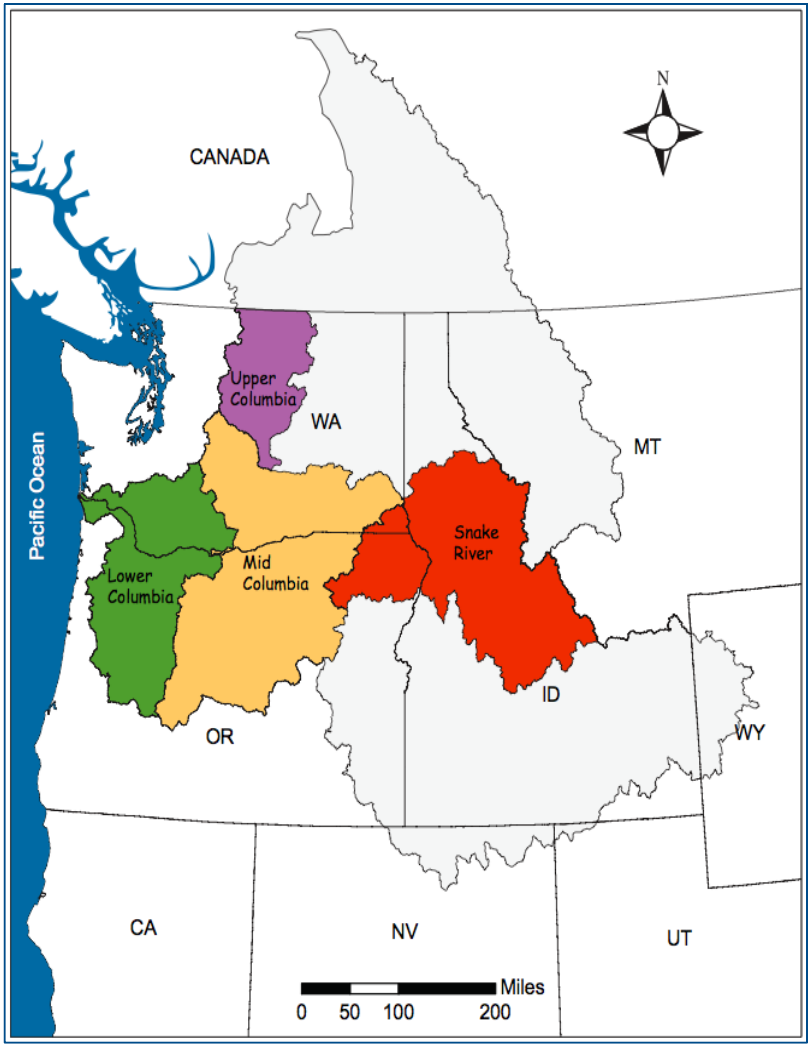
Introduction

An extensive hatchery system for Pacific salmon (*Oncorhynchus* spp.) and steelhead (*O. mykiss*) has developed over the past 100 years in the Pacific Northwest to mitigate for the effects of overfishing, logging, agriculture,

Fisheries – vol 30 no 6 – June 2005 - www.fisheries.org

Hatchery Reform

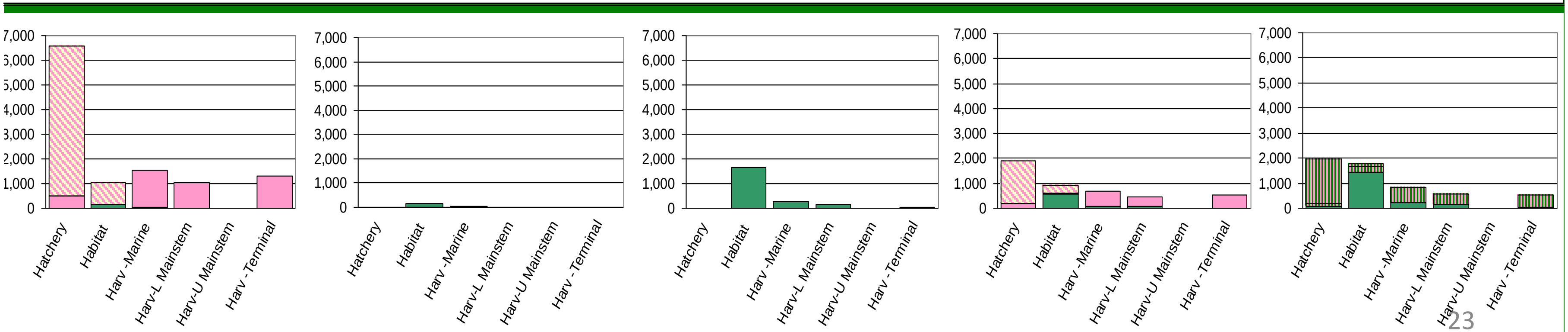




AHA Model

Example: Eagle Creek NFH coho salmon (Clackamas River, OR)

Current Hatchery Program		Current without hatchery		25% Habitat Recovery only		25% Hab. Rec. + Curr. Hatch.		25% Hab. Rec. + Int. Hatch	
1.80	704	1.80	704	4.70	2,594	4.70	2,594	4.70	2,594
1		1		1		1		1	
33.33	13,037	33.33	13,037	87.04	48,037	87.04	48,037	87.04	48,037
0.054 0.054	y	0.054 0.054	y	0.054 0.054	y	0.054 0.054	y	0.054 0.054	y
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.80	704	1.80	704	4.70	2,594	4.70	2,594	4.70	2,594
0.120	0.120	0.120		0.120		0.120	0.120	0.120	0.120
0.092	0.092	0.092		0.092		0.092	0.092	0.092	0.092
0.015	0.130	0.015		0.015		0.015	0.130	0.015	0.130
0.213	0.305	0.213		0.213		0.213	0.305	0.213	0.305
pNOB	pHOS	pNOB	pHOS	pNOB	pHOS	pNOB	pHOS	pNOB	pHOS
	5%						5%	30%	15%
	81%						33%	30%	16%
Harvest	Segregated		None	Both	Integrated	Harvest	Integrated		None
496	500,432		-		-	200	201,787	200	201,787
1250 1250						1250 1250		1250 1250	
90%	10%		100%		100%	90%	10%	90%	10%
22.3	y		y	22.3	y	22.3	y	22.3	



Ford, M. 2002. *Cons. Biol.* 16:815-825.

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

MICHAEL 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

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Abstract: *I used a quantitative genetic model to explore the effects of selection on the fitness of a wild population subject to supportive breeding. Supportive breeding is the boosting of a wild population's size by breeding part of the population in captivity and releasing the captive progeny back into the wild. The model assumes that a single trait is under selection with different optimum trait values in the captive and wild environments. The model shows that when the captive population is closed to gene flow from the wild population, even low levels of gene flow from the captive population to the wild population will shift the wild population's mean phenotype so that it approaches the optimal phenotype in captivity. If the captive population receives gene flow from the wild, the shift in the wild population's mean phenotype becomes less pronounced but can still be substantial. The approach to the new mean phenotype can occur in less than 50 generations. The fitness consequences of the phenotypic shift depend on the details of the model, but a >30% decline in fitness can occur over a broad range of parameter values. The rate of gene flow between the two environments, and hence the outcome of the model, is sensitive to the wild environment's carrying capacity and the population growth rate it can support. The results have two important implications for conservation efforts. First, they show that selection in captivity may significantly reduce a wild population's fitness during supportive breeding and that even continually introducing wild individuals into the captive population will not elimi-*

Hatchery Reform - HSRG

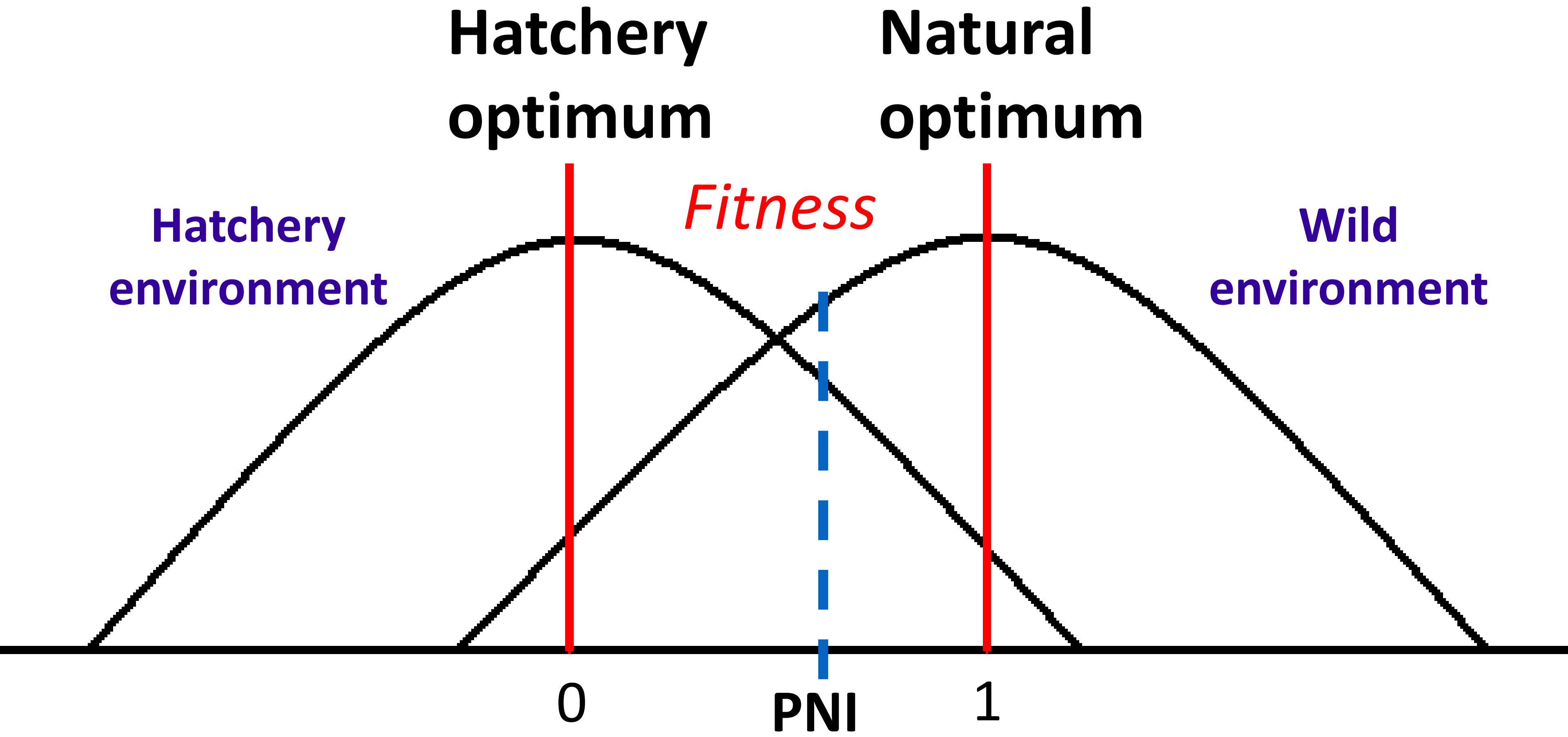
Proportionate Natural Influence –

an estimator of the selection pressure equilibrium point

$$PNI = \frac{pNOB}{pNOB + pHOS}$$

- pHOS = proportion of hatchery fish spawning
- pNOB = proportion of natural fish in broodstock
- PNI values > 0.5 indicates dominant selection pressure from the natural environment

Hatchery Reform: Controlling two-way gene flow



$$PNI = \frac{pNOB}{pNOB + pHOS}$$

PNI concept developed by Craig Busack, Wash. Dept. Fish & Wildlife

AHA **Model**

Example: Eagle Creek NFH coho salmon
Clackamas River, Oregon

Current

pNOB=0
pHOS=81%

Option 1

No Hatchery

Option 2

25% Habitat <u>Increase</u>
No Hatchery

Option 3

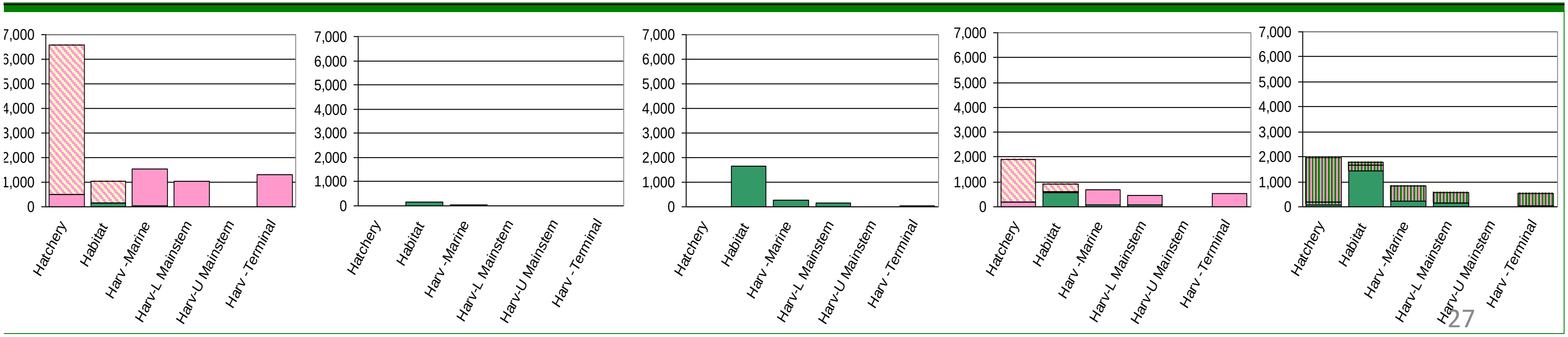
25% Habitat <u>Increase</u>

Segregated. Hatchery
<u>200K smolts</u>
pNOB=0
pHOS=33%

Option 4

25% Habitat <u>Increase</u>

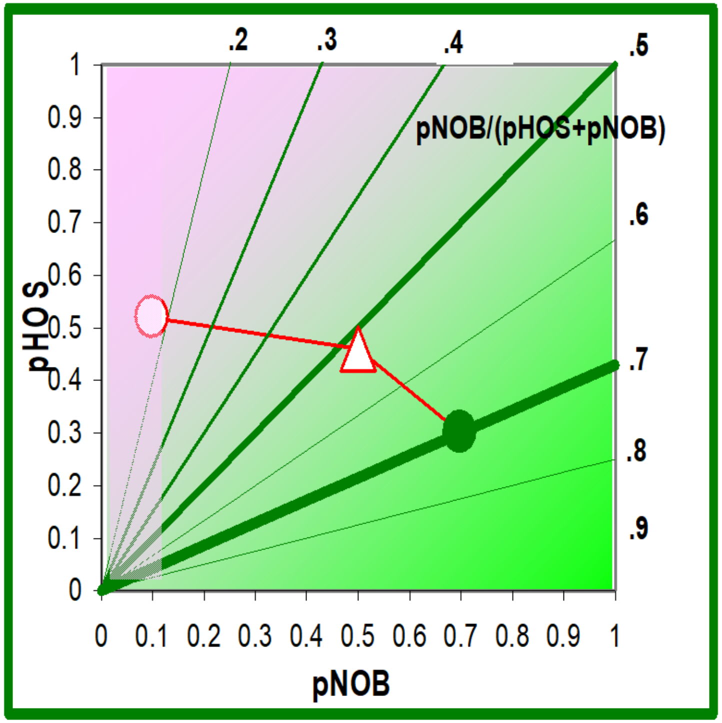
Integrated Hatchery
<u>200K smolts</u>
pNOB=30%
pHOS=16%
PNI=0.65



Controlling gene flow to achieve goals

[INPUTS in YELLOW CELLS]

	pHOS	pNOB	"PNI"
Current Condition: ○	52%	10%	0.16
Near Term Target: △	46%	50%	0.52
Long Term Target: ●	30%	70%	0.70

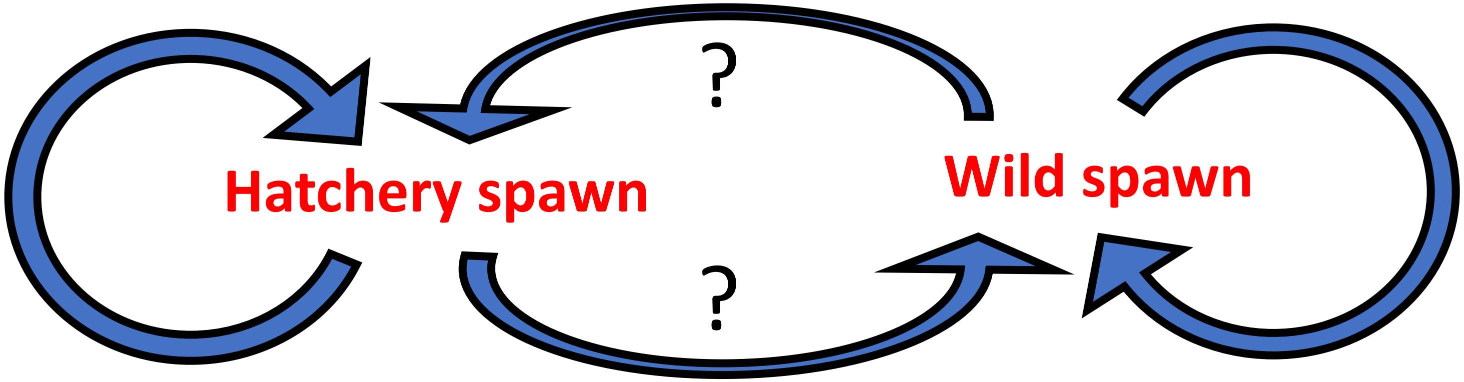


PNI = pNOB / (pNOB + pHOS)

= proportional natural influence = mean fitness of integrated population relative to natural population.

= % time genes spend in natural environment.

Historical Hatchery Problem: Unknown gene flow between two environments



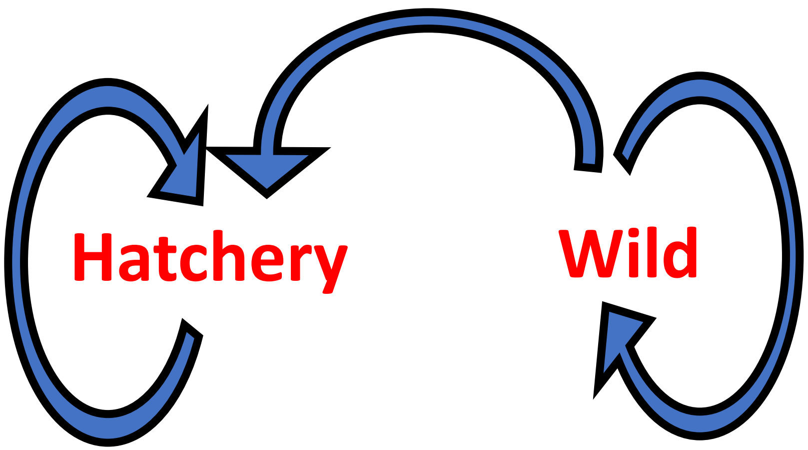
Unknown gene flow

Solution:
Genetically *Integrated* or *Segregated* broodstocks

***Integrated* Goal:**

1 population,

2 environments

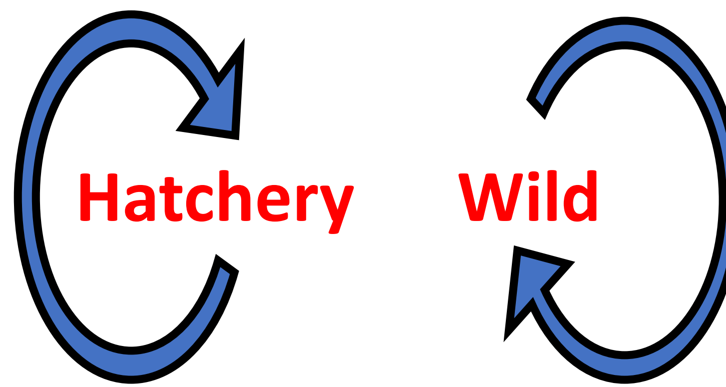


Integrated

***Segregated* Goal:**

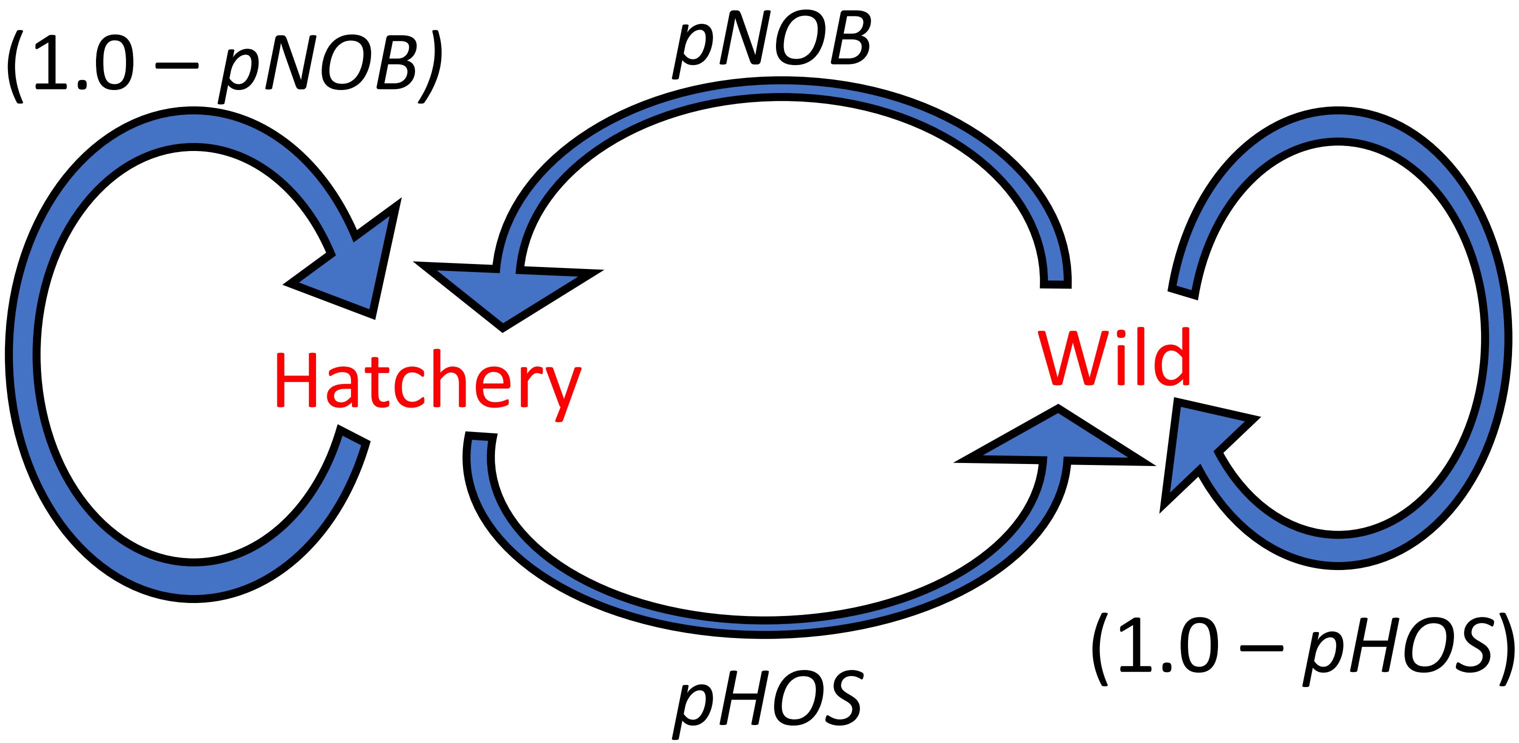
2 populations,

2 environments



Segregated

Hatchery Reform: Controlling two-way gene flow - Integrated Programs



pNOB **>** *pHOS*: wild environment dominates

pNOB **<** *pHOS*: hatchery environment dominates

HSRG guidelines for hatchery programs

Integrated broodstocks ($pNOB > 0$):

- $pNOB > 0.1$ (at a minimum)
- $pNOB > pHOS$ ($PNI > 0.5$)
- For biologically significant populations:
  $pNOB > 2 \cdot pHOS$ ($PNI > 0.67$)

Segregated broodstocks ($pNOB = 0$):

- $pHOS < 0.05$

Hatchery Reform - HSRG

1. Develop clear, specific, quantifiable harvest and conservation goals for natural and hatchery populations within an “all H” context.

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

3. Monitor, evaluate and adaptively manage hatchery programs.

4. Program-specific recommendations for each hatchery program (> 350 programs).

Hatchery Reform - HSRG

Fisheries Magazine

Feature: Conservation Management

Hatcheries, Conservation, and Sustainable Fisheries—Achieving Multiple Goals: Results of the Hatchery Scientific Review Group's Columbia River Basin Review

Criaderos, conservación y pesquerías sustentables-cumplimiento de objetivos múltiples: resultado del Grupo de Revisión Científica de Criaderos de la cuenca del Río Columbia

P. J. Paquet, T. Flagg, A. Appleby, J. Barr, L. Blankenship, D. Campton, M. Delarm, T. Evelyn, D. Fast, J. Gislason, P. Kline, D. Maynard, L. Mobrand, G. Nandor, P. Seidel, S. Smith

First published:07 November 2011 | https://doi.org/10.1080/03632415.2011.626661 | Citations: 45

All authors were members of the Columbia River Hatchery Scientifc Review Group (HSRG) at the time of this study.

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Hatchery Reform

US Fish and Wildlife Service

U.S. Fish & Wildlife Service

Columbia River Basin Hatchery Review

- U.S. Fish and Wildlife Service (Service) proactively initiated a series of hatchery reviews in May 2005 to assure that its 21 hatchery programs are part of a holistic and integrated strategy—consistent with State, Tribal, and Federal strategies—for conserving wild stocks and managing fisheries in watersheds within the Columbia River Basin.
- These reviews were tailored after a successful process recently implemented by the HSRG

Conclusions

1. A substantial investment of resources and effort has gone into hatchery reform over the last 35 years,

2. Modern hatcheries play an important role,

3. The gene-flow theory described by Ford and incorporated in modeling by the HSRG is still guiding program implementation today (HGMPs, Recovery Plans),

4. Supplementation is still experimental – but valuable to continue.