Fish and Wildlife Commission Hatchery Workshop #2: Risks and Benefits

June 9, 2023

Kenneth Warheit, Joe Anderson, Alf Haukenes, Eric Kinne, Todd Seamons, Bethany Craig, Andrew Murdoch, Philip Sandstrom, and Laurie Peterson (Fish Program)
Hannah Anderson (Wildlife Program), Julie Watson (Director's Office)

Washington Department of FISH and WILDLIFE

Workshop Agenda

- “Major reviews” of hatchery effects on wild salmon populations
- Hazards and Risks
- Genetics
  - Broodstock Management

  Break – 5 minutes
  - Relative Reproductive Success (RRS) and Fitness

  Break – 5 Minutes
  - RRS – Hazards and Risks

  Break – 15 minutes
- Disease
  - Hazards and Risks
  - Disease Ecology and Theory
- Ecological
  - Competition
  - Predation
- Hatchery Benefits

  Break – 5 minutes
- SRKW Prey Initiative – Intro
- C-3624 and Co-Manager Hatchery Policy Discussion

Major Reviews

Terms of Reference mentions two reviews

National Research Council. 1996. *Upstream: Salmon and Society in the Pacific Northwes*t. Washington, DC: The National Academies Press. 452 + xx pp. https://doi.org/10.17226/4976

Hatchery Scientific Review Group (HSRG). 2014*. On the science of hatcheries: an updated perspective on the role of hatcheries in salmon and steelhead management in the Pacific Northwest*. Available from www.hatcheryreform.us

Other reviews

Naish, K.A., J.E. Taylor III, P.S. Levin, T.P. Quinn, J.R. Winton, D. Huppert, and R. Hilborn. 2008. *An evaluation of the effects of conservation and fishery enhancement hatcheries on wild populations of salmon.* Advances in Marine Biology 53:61-194. https://doi.org/10.1016/S0065-2881(07)53002-6

Anderson, J.H., K.I. Warheit, B.E. Craig, T.R. Seamons, and A.H. Haukenes. 2020. A review of hatchery reform science in Washington State. Final Report to the Washington Fish and Wildlife Commission. Available from https://wdfw.wa.gov/sites/default/files/publications/02121/wdfw02121_0.pdf

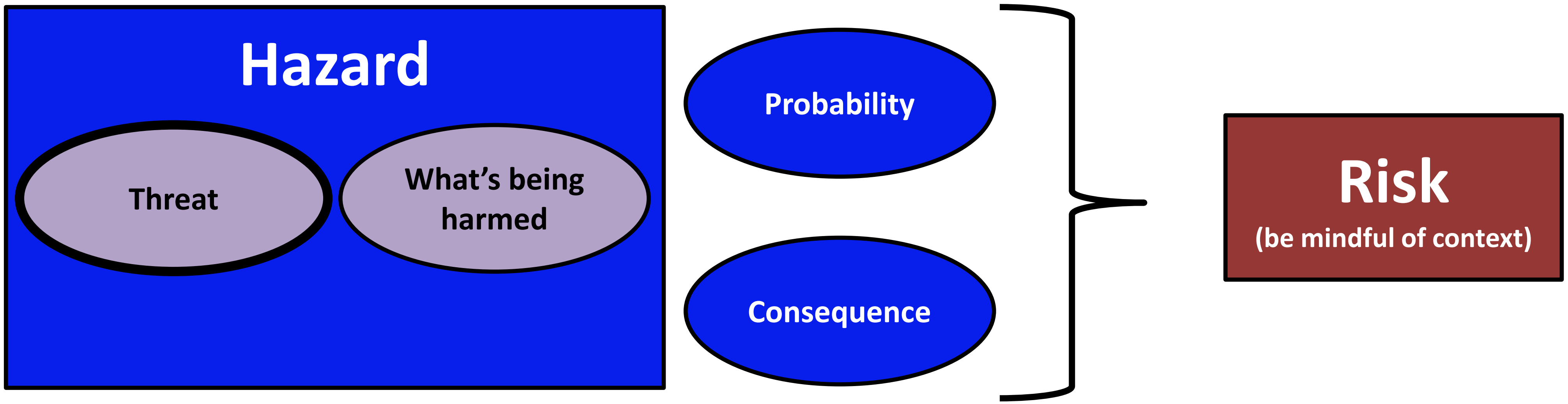
Hazards and Risks

Hazards and Risks

Hazard: threat, danger, stressor . . . anything that causes harm
(What's being harmed)

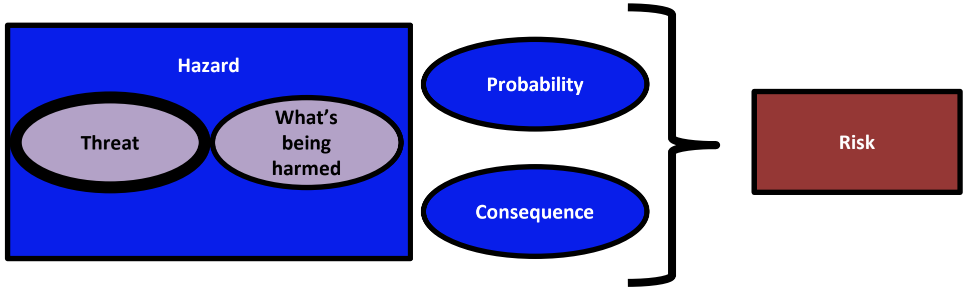
Risk: the chance (probability) of a hazard with a specific consequence[1]
(context is important)

A risk in one basin may not be a risk in another basin



[1] Modified from Burgman, M.K. 2007. Risks and Decisions for Conservation and Environmental Management. Cambridge University Press xii + 488 pages.

Managing based on hazards or risks?



A silly (but heuristic) example:

Version 1

Threat: Planet-killing (5-10 km) asteroid hitting earth this year

What's being harmed: Everything on earth

Probability: 0.000001% (1 in 100 million)[1]

Consequence: Extinction

Hazard: Space rocks hitting earth affecting people

Version 2

Threat: Small meteorites hitting earth today

What's being harmed: Depends . . . . Most meteorites hit earth as dust particles

Probability: 17,000 per year (1 in 31 minutes today)[2]

Consequence: Practically nothing

[1] https://interestingengineering.com/science/what-is-the-probability-of-a-huge-civilization-ending-asteroid-impact

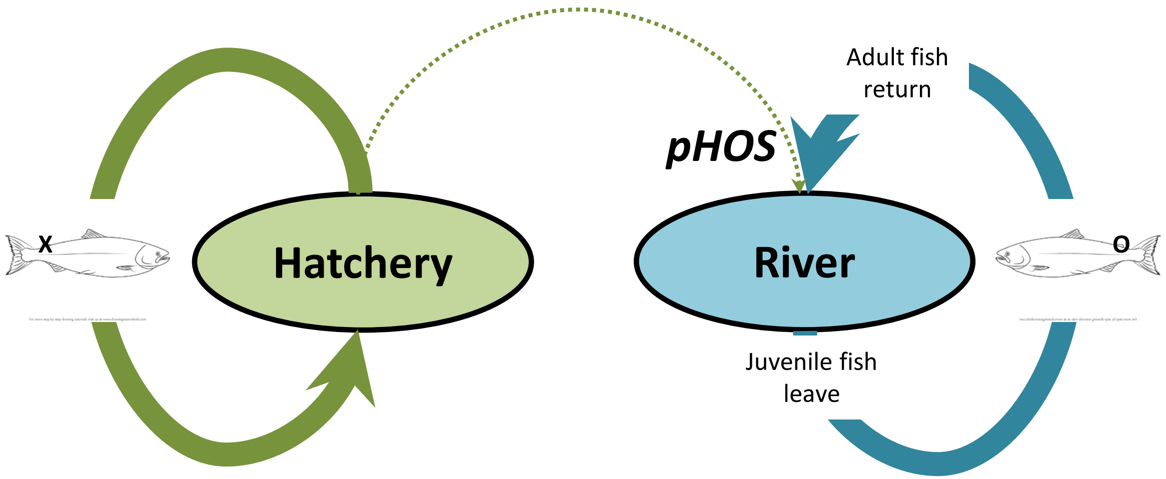
[2] https://www.iberdrola.com/innovation/meteorites-earth#:~:text=You%20may%20never%20have%20actually,17%2C000%20of%20them%20a%20year.

Broodstock Management

Broodstock Management – Two ways to reduce hatchery influence on natural-origin populations

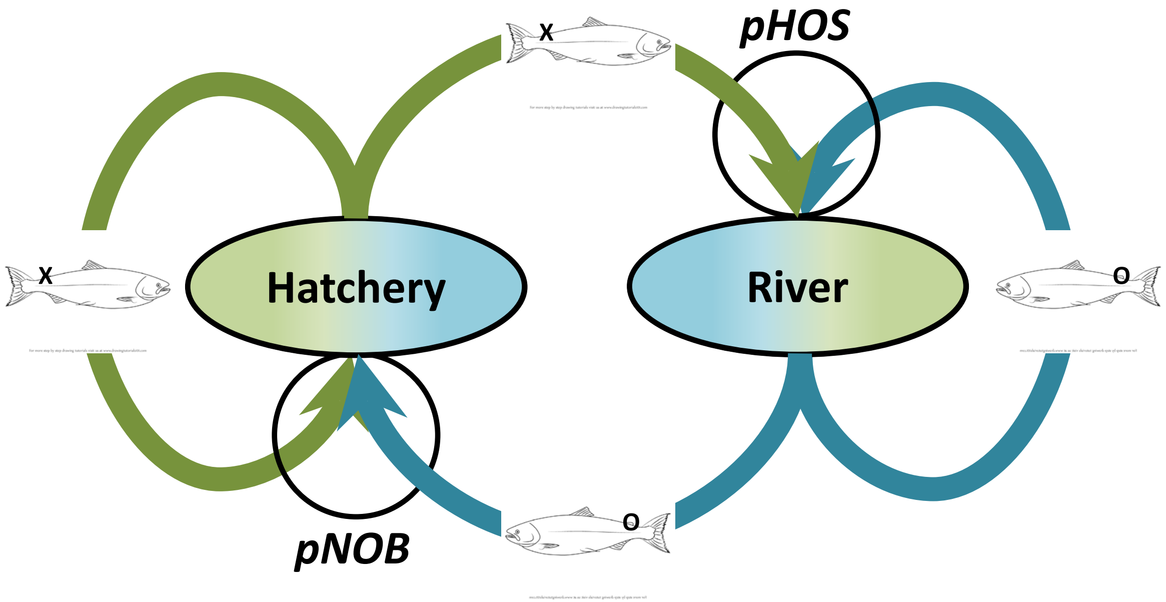
Managed as two populations

Segregated Hatchery



Managed as a single population

Integrated Hatchery



PNI (proportionate natural influence)
Proportion of total genetic "influence" from natural-origin population

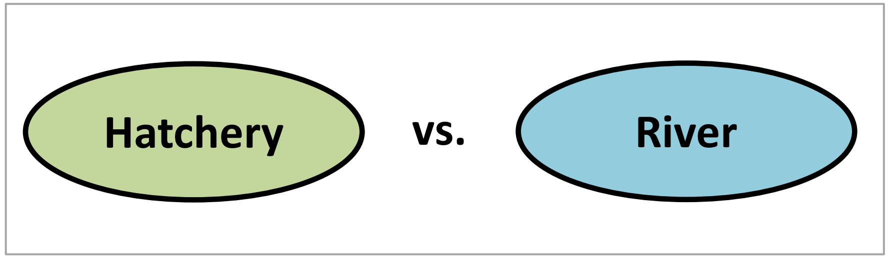
PNI = pNOB / (pHOS + pNOB)

pHOS (proportion hatchery-origin spawners)
proportion of natural (in-river) spawners that are hatchery-origin

pNOB (proportion natural-origin broodstock)
proportion of broodstock (in-hatchery) that are natural-origin

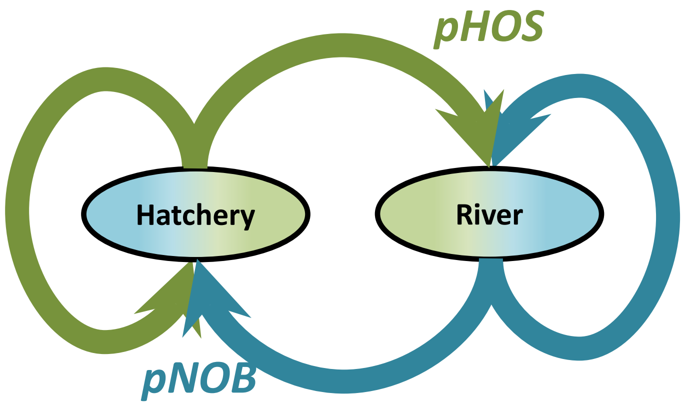
PNI and Fitness

- *PNI = pNOB / (pHOS + pNOB)*

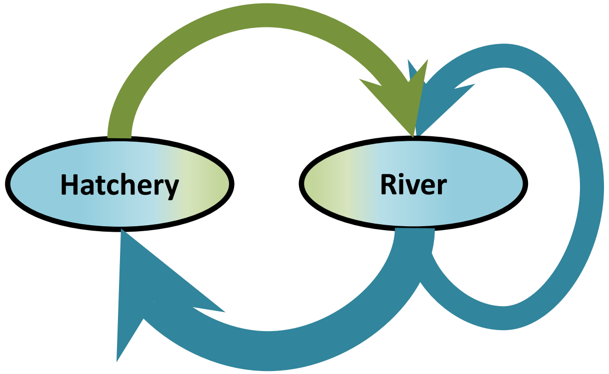


- Fitness (in a particular environment):
  - Survival
  - ✓ Reproduction
    - Average reproductive success (RS) of a population
    - A reduction in RS of a population is a loss of fitness
- Hatchery Scientific Review Group (HSRG) used PNI as a measure of "risk" associated with integrated hatcheries
- Hazard: loss of fitness of a population resulting from particular broodstock management strategies (mix of pHOS and pNOB)
- PNI = a measure of the likelihood of that loss in the natural environment

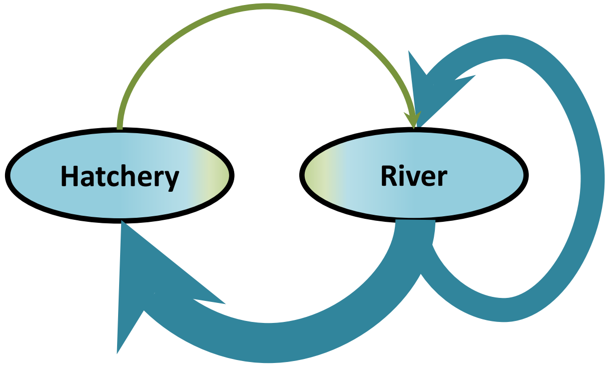
Broodstock Management – Integrated Programs



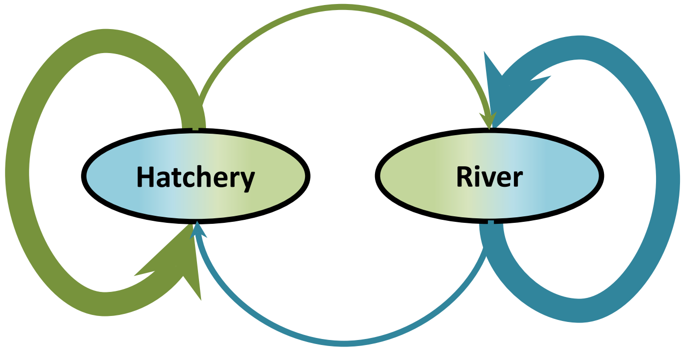
pHOS = 0.50 ***pNOB*** = 0.50
PNI = 0.50 / (0.50 + 0.50) = 0.50



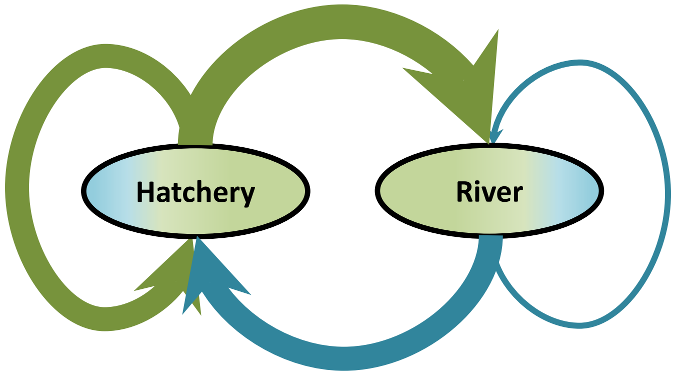
pHOS = 0.50 ***pNOB*** = 1.00
PNI = 0.67



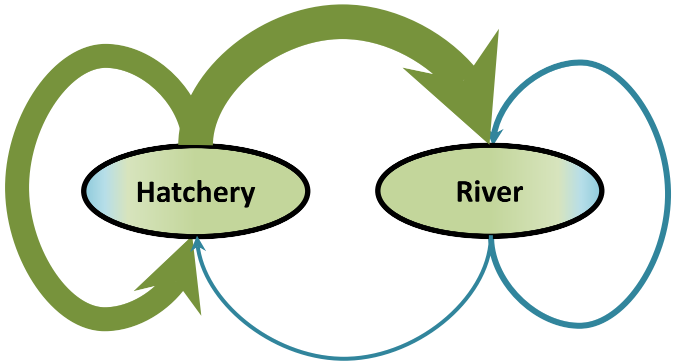
pHOS = 0.10 ***pNOB*** = 1.00
PNI = 0.91



pHOS = 0.10 ***pNOB*** = 0.10
PNI = 0.10 / (0.10 + 0.10) = 0.50

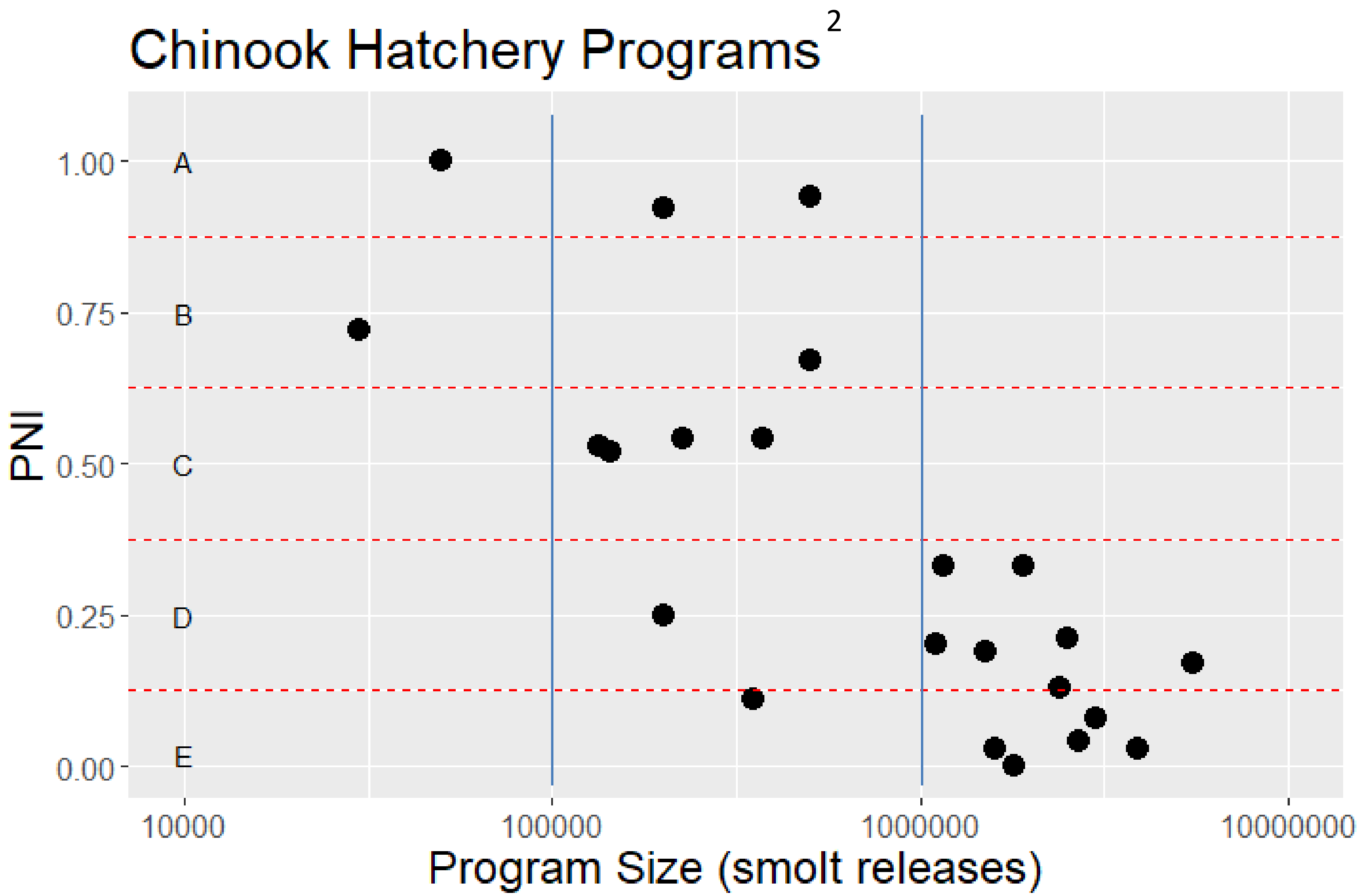


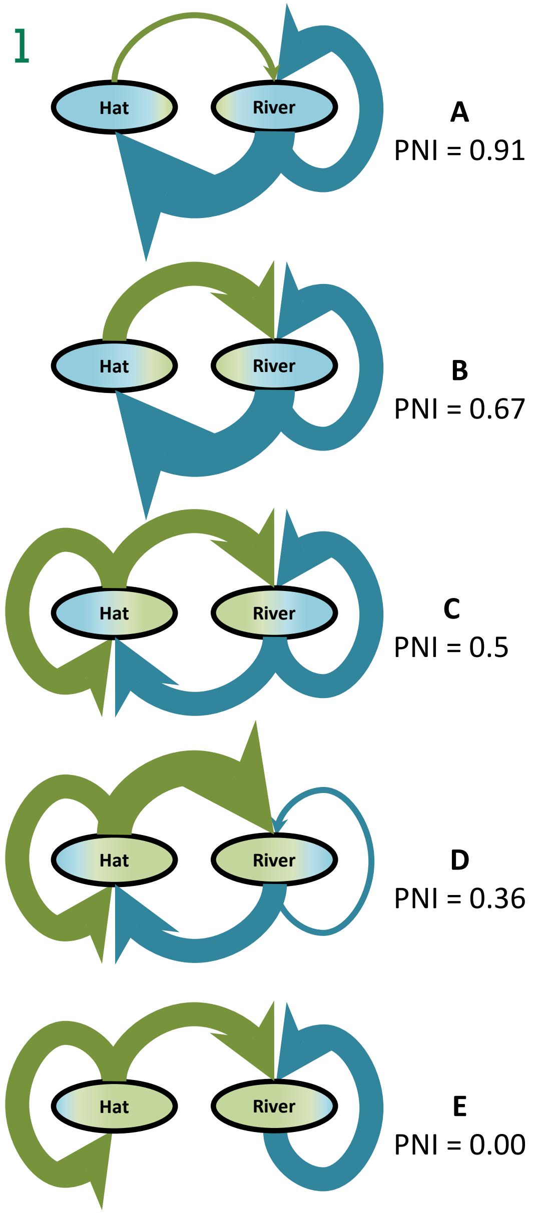
pHOS = 0.90 ***pNOB*** = 0.50
PNI = 0.36



pHOS = 0.90 ***pNOB*** = 0.05
PNI = 0.05

Small programs have high PNI, large programs small PNI [1]



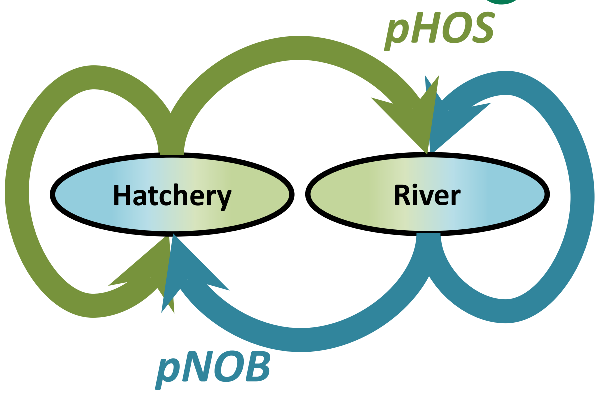


PNI = pNOB / (pHOS + pNOB)

[1] Many factors may affect PNI

[2] Data from Anderson et al. (2020, Table 4)

Broodstock Management - Summary



PNI = pNOB / (pHOS + pNOB)

- **Hazard**: Hatchery-origin fish spawning naturally lowers RS, and therefore fitness of natural-spawning population
- **PNI** estimates the likelihood of the hazard (low PNI, high likelihood . . .)
- How we **manage our hatcheries** can affect overall fitness of the integrated population
  - Controlling pHOS and to a lesser extent pNOB is difficult
- Relationships between PNI, pHOS, pNOB, and fitness is based on **models**
- **Risk uncertain**, because relative consequences of the hazard are also uncertain – does low PNI and high pHOS affect the abundance and viability of natural spawning populations?

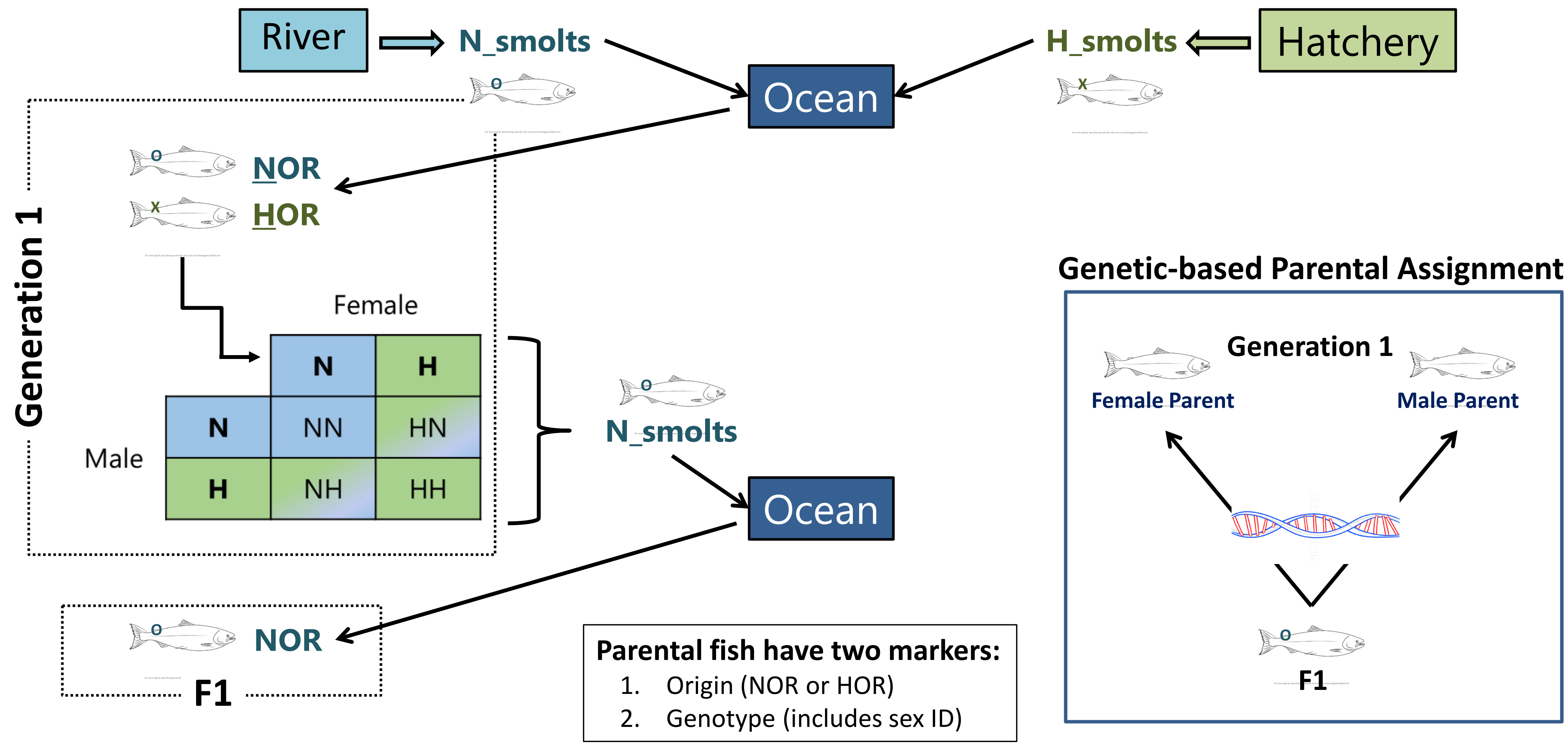
Break – Five Minutes

Relative Reproductive Success (RRS)

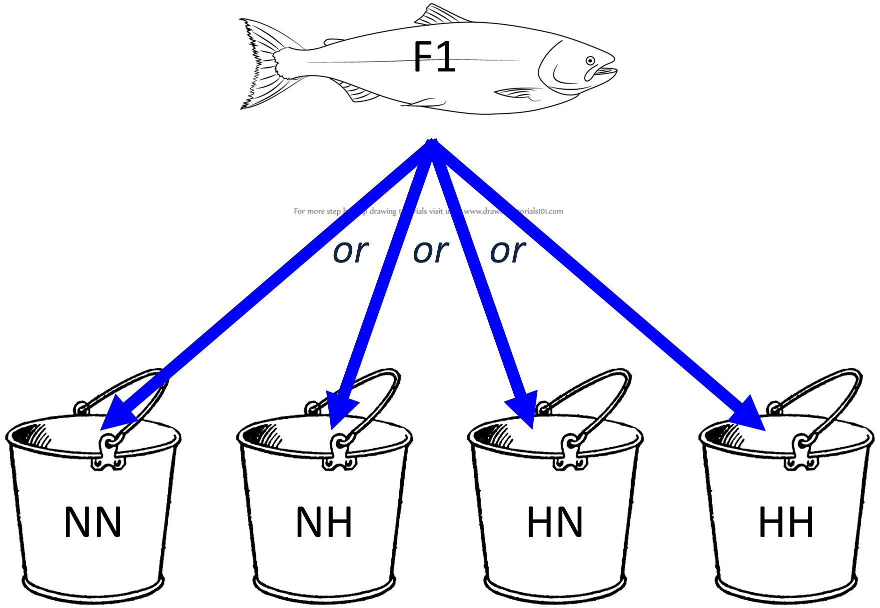
Summary

- The average hatchery-origin spawner (HOS) has lower reproductive success (RS) than the average natural-origin spawner (NOS)
  - Across all species where there are data
  - For the most-part, males more so than females
- Most studies include only the first-generation HOS spawners, so uncertain if lower relative RS is genetic (heritable)

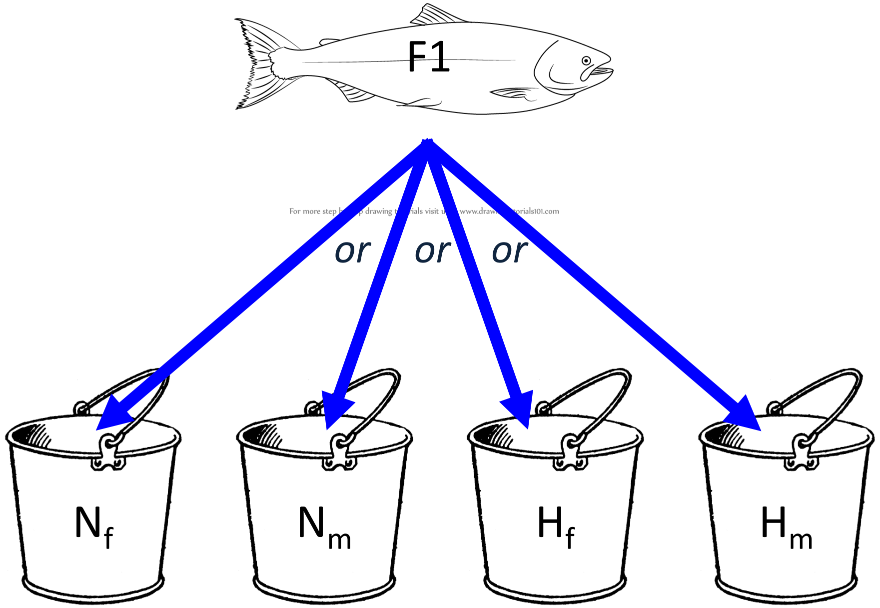
- What is the hazard? And what is being harmed?


River
N_smolts
Ocean
H_smolts
Hatchery
o
x
Generation 1
NOR
HOR
Female
N
H
Male
N
H
NN
HN
NH
HH
N_smolts
Ocean
NOR
F1
Parental fish have two markers:
1. Origin (NOR or HOR)
2. Genotype (includes sex ID)
Genetic-based Parental Assignment
Generation 1
Female Parent
Male Parent
F1

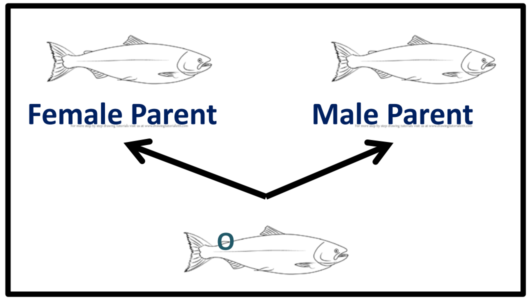
Placing fish into parental buckets – based on parental assignments

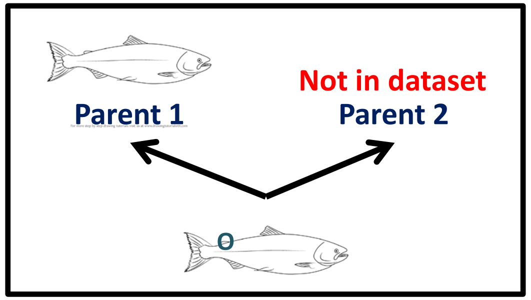


Generation 1: Parents
Two Parent Assignments



Generation 1: Parents
One Parent Assignments





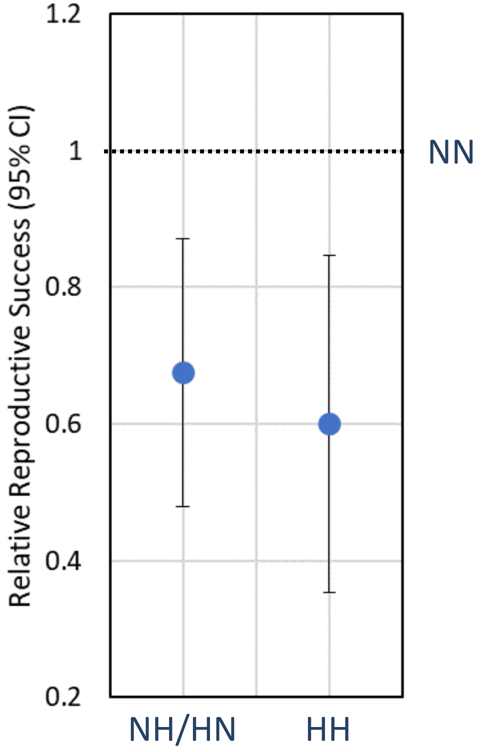
		Female	
		N	**H**
Male	**N**	NN	HN
	H	NH	HH

Calculating RRS – Easy as counting fish in buckets

Parental Pairs (2-parent)

NN	NH	HN	HH
#1 2	#11 1	#21 3	#31 2
#2 2	#12 2	#22 2	#32 1
#3 3	#13 1	#23 1	#33 3
#4 1	#14 2	#24 3	#34 1
#5 4	#15 4	#25 1	#35 1
#6 5		#26 1	#36 3
			#37 1

	NN	NH/HN	HH
Mean:	2.83	1.91	1.71
Standardized	1	0.67 (0.46,0.89)	0.60 (0.36,0.85)



Parental Pool (1-Parent)

N_f	H_f	N_m	H_m
#1 2	#11 0	#21 3	#31 0
#2 0	#12 1	#22 0	#32 1
#3 4	#13 1	#23 0	#33 2
#4 0	#14 2	#24 3	#34 0
#5 2	#15 3	#25 2	#35 1
#6 3	#16 0	#26 3	#36 2
#7 2			#37 1

	N_f	H_f	N_m	H_m
Mean:	1.86	1.17	1.83	1.00
Standardized	1	0.63 (0.12,1.14)	1	0.55 (0.22,0.87)

Yakima Spring Chinook – RRS Study

Transactions of the American Fisheries Society 151:373–388, 2022

ISSN: 0002-8487 print / 1548-8659 online
DOI: 10.1002/tafs.10354

ARTICLE

Effects of Supplementation in Upper Yakima River Chinook Salmon

Ilana J. Koch
Columbia River Inter-Tribal Fish Commission, Hagerman Genetics Lab, 3059-F National Fish Hatchery Road, Hagerman, Idaho 83332, USA

Todd R. Seamons
Washington Department of Fish and Wildlife, Molecular Genetics Laboratory, 1111 Washington Street Southeast, Olympia, Washington 98501, USA

Peter F. Galbreath and Hayley M. Nuetzel
Columbia River Inter-Tribal Fish Commission, Fish Science Department, 700 Northeast Multnomah Street Suite 1200, Portland, Oregon 97232, USA

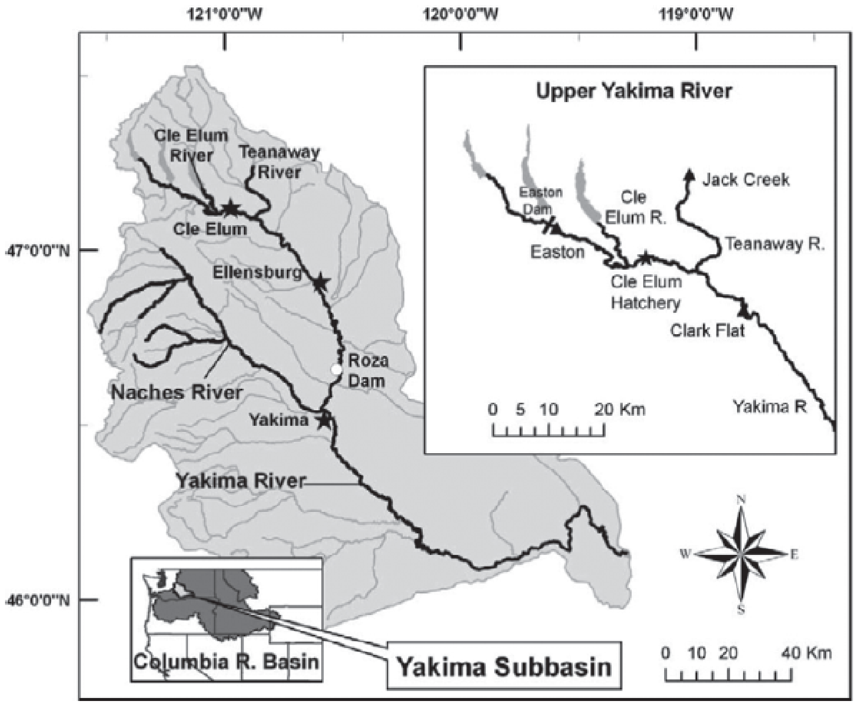
Andrew P. Matala
Yakama Nation Fisheries, Post Office Box 151, Toppenish, Washington 98948, USA

Kenneth I. Warheit
Washington Department of Fish and Wildlife, Molecular Genetics Laboratory, 1111 Washington Street Southeast, Olympia, Washington 98501, USA

David E. Fast, Mark V. Johnston, and Charles R. Strom
Yakama Nation Fisheries, Post Office Box 151, Toppenish, Washington 98948, USA

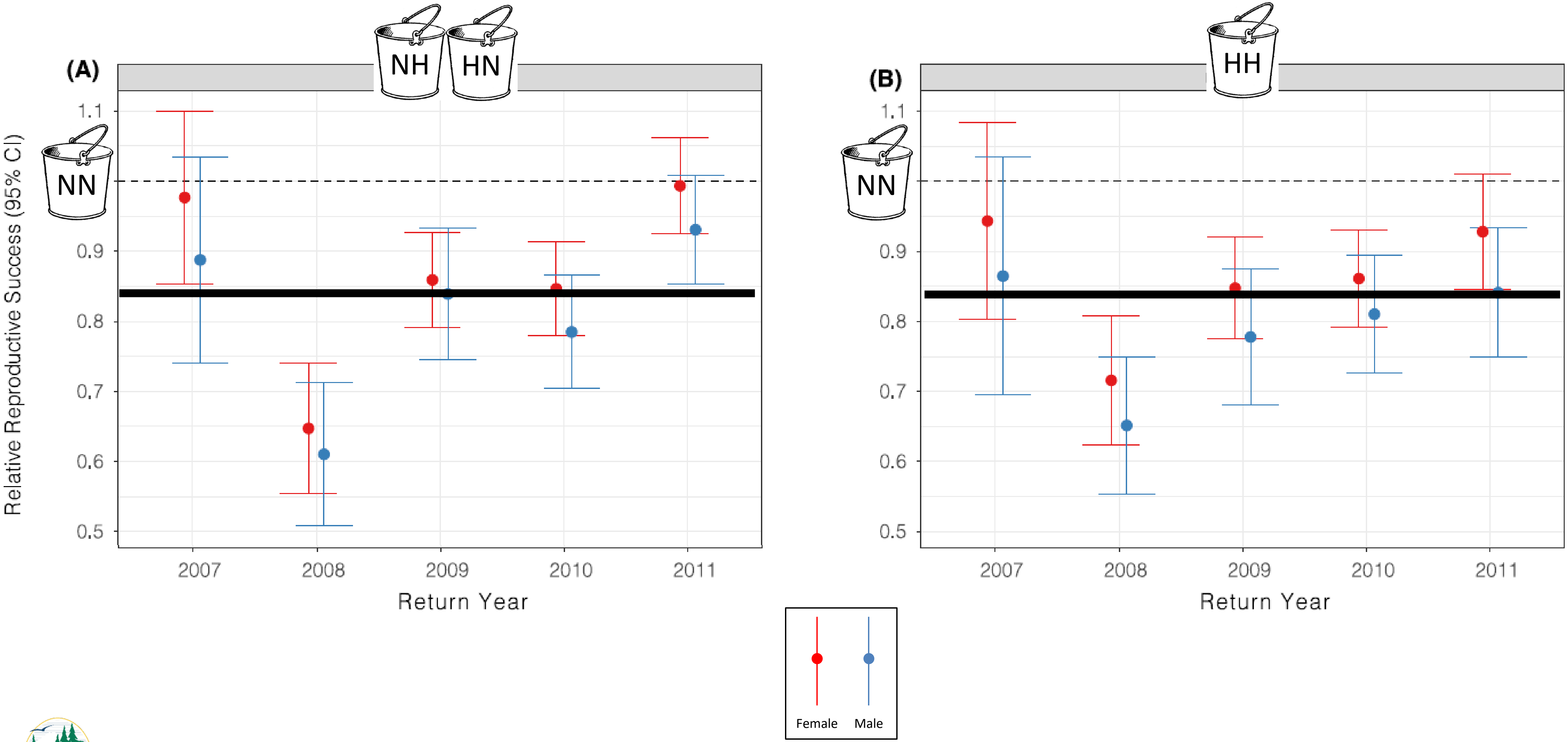
Shawn R. Narum
Columbia River Inter-Tribal Fish Commission, Hagerman Genetics Lab, 3059-F National Fish Hatchery Road, Hagerman, Idaho 83332, USA

William J. Bosch
Yakama Nation Fisheries, Post Office Box 151, Toppenish, Washington 98948, USA



- Parental return years: 2007 – 2011
  - Total # of potential Parents: 31,965
    NOR = 12,956 | HOR = 19,009
- Offspring return years: 2009 – 2016
  - Total # of potential offspring: 54,351

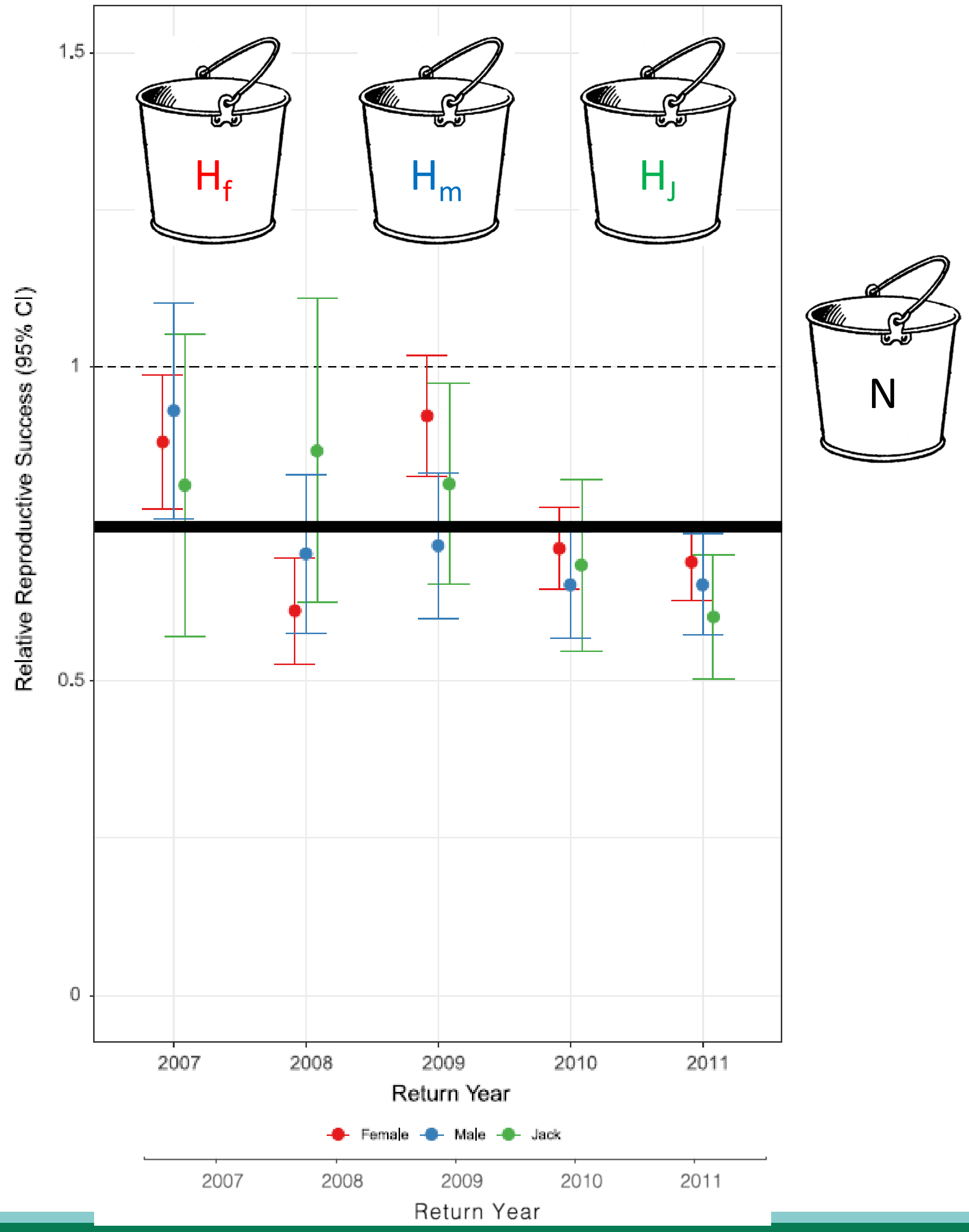
Yakima Spring Chinook – RRS Study (*Parental Pairs*)



Yakima Spring Chinook – RRS Study Parental Pool (*1-parent assignments*)

Some Overall Conclusions

- The average hatchery-origin fish spawning naturally (HOR) has **lower RRS** than the average natural-origin fish (NOR)
- **No difference** in NOR x HOR and HOR x HOR RRS
- **RS is variable**
  - Among individuals
  - Between sexes
  - Among years
- 1-Parent assignments – Lower RRS than Parental Pair assignments. Includes the "**zeros**"



Six Case Studies - RRS

Evolutionary Applications Open Access
Evolutionary Applications ISSN 1752-4571
2014. doi: 10.1111/eva.12183

REVIEWS AND SYNTHESIS

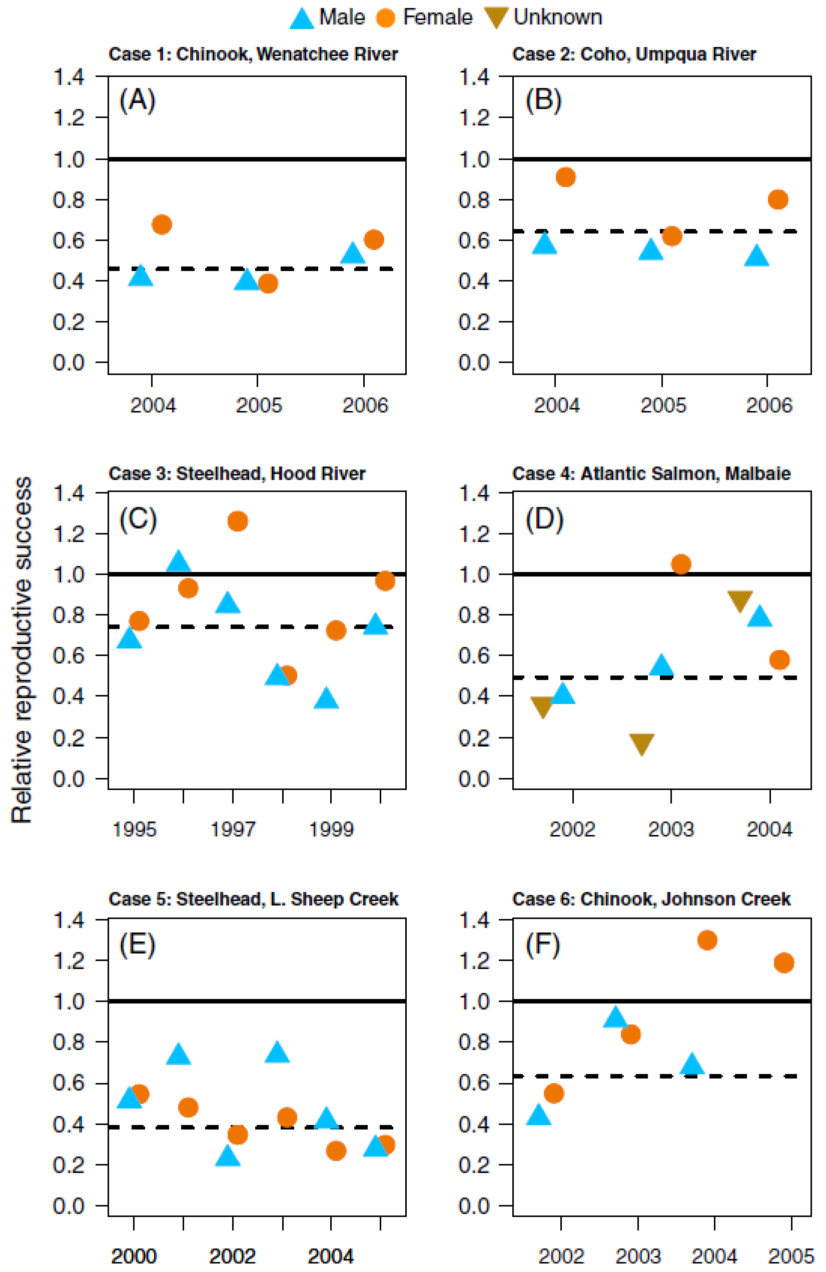
On the reproductive success of early-generation hatchery fish in the wild

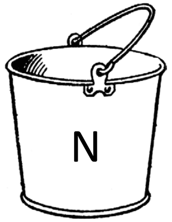
Mark R. Christie,[1,2] Michael J. Ford[3] and Michael S. Blouin[1]

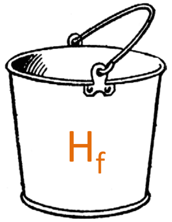
1 Department of Integrative Biology, Oregon State University, Corvallis, OR, USA
2 Department of Biological Sciences and Department of Forestry and Natural Resources, Purdue University, West Lafayette, IN, USA
3 Conservation Biology Division, National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, WA, USA

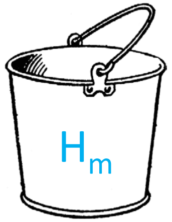
- HORs averaged only **½ the RS** of NORs
- Male RRS was **lower** than female RRS
- For all species HORs had **lower** RRS than NORs

- **RS is variable**
  - Between sexes
  - Among years
  - Among species and location



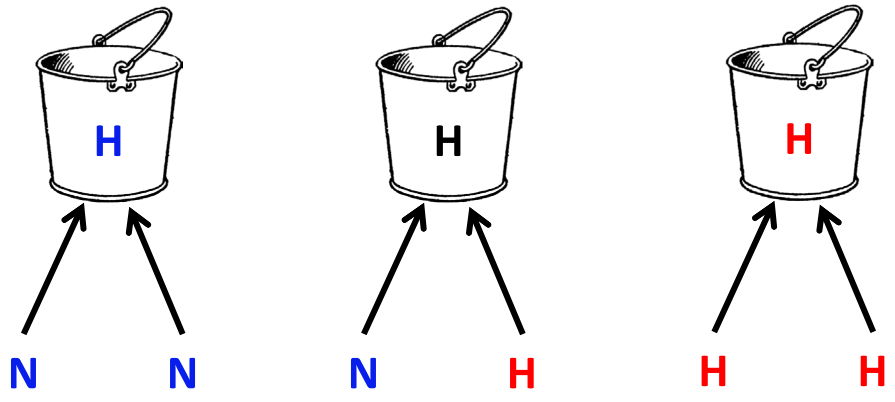


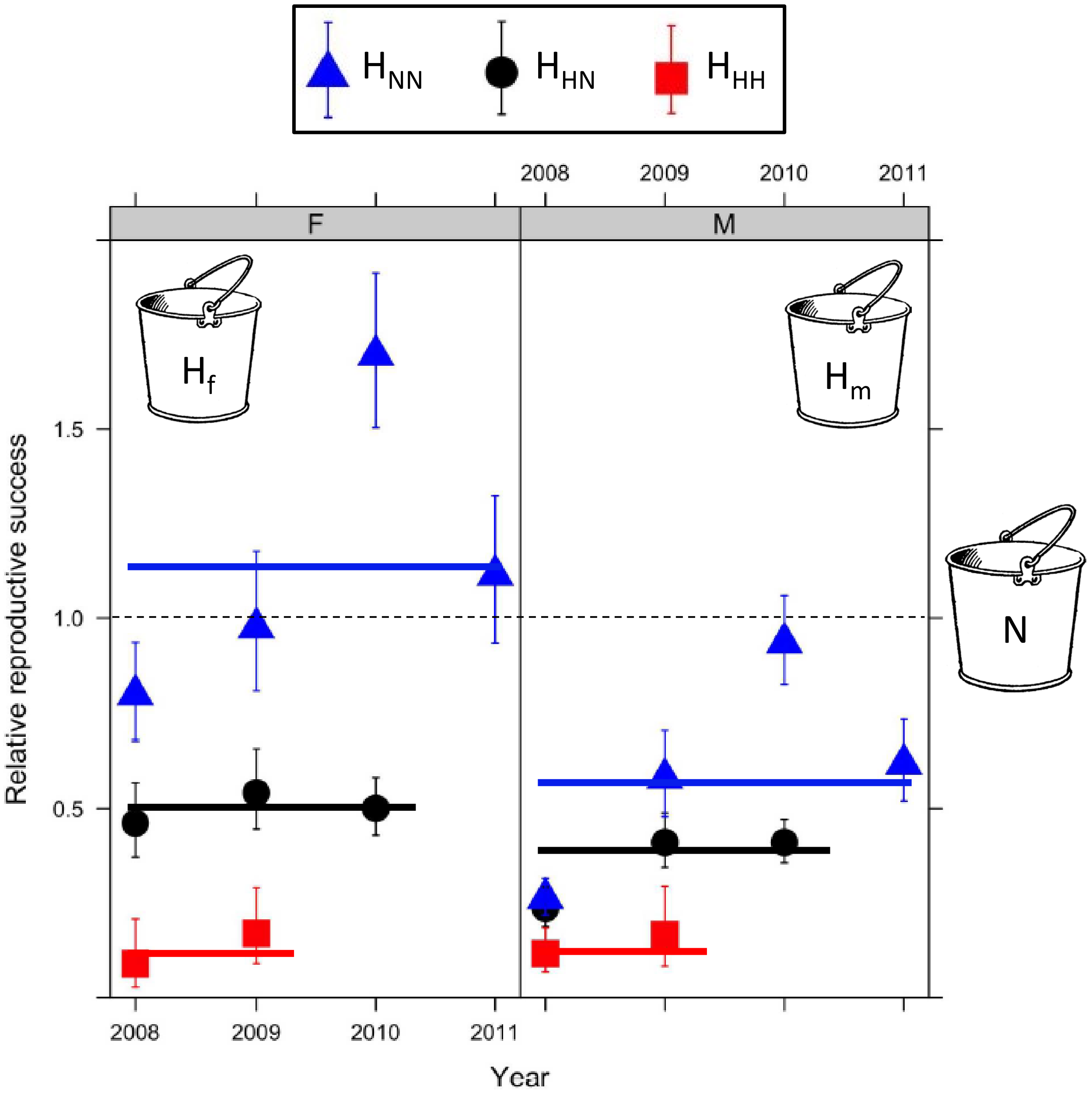




Wenatchee Steelhead – RRS 2-generation analysis

- Except H_{NN} females, HOR RRS **lower** than NORs RRS
- **H_{NN} females** RRS > NOR RRS
- **H_{NN} RRS > H_{HN} RRS > H_{HH} RRS**
- Male RRS was **lower** than female RRS
- Results nearly identical to Hood River steelhead
- **RS is variable**
  - Between sexes
  - Among years
  - Among Individuals





Break – Five Minutes

RRS – Hazards and Risks

1. What is the hazard associated with lower RRS of hatchery-origin fish spawning naturally?
2. What is being harmed?

- Hatchery-origin fish spawning naturally lower RS, and therefore fitness of natural-spawning population
- Hatchery-origin fish spawning naturally decrease size and productivity of natural-spawning population

RRS studies inform us more about hazards than risks

Risk: the chance (probability) of a hazard with a specific consequence

Hazard	Probability	Consequence (If the hazard occurs what is its effect?)
Hatchery-origin fish spawning naturally **lower RS, and therefore fitness** of natural-spawning population	**High** – but variable	**Decrease productivity?** Steady decline to extinction? Reaches equilibrium, suggested by models? **Uncertain**
Hatchery-origin fish spawning naturally **decrease size and productivity** of natural-spawning population	**Uncertain**	Decrease abundance? Decrease productivity? Local extinction? **Uncertain**

Does the loss in fitness result in lower productivity?

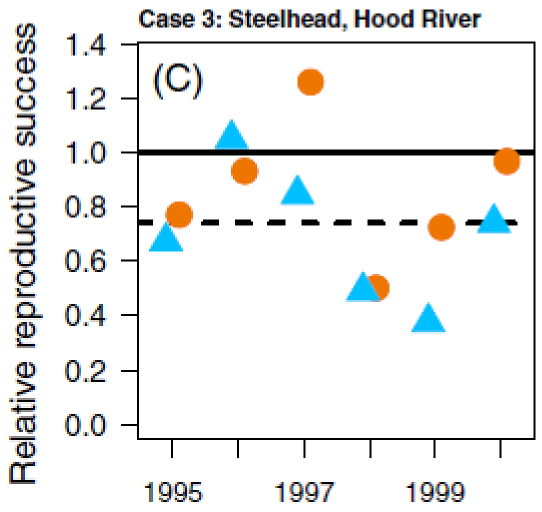
Canadian Journal of Fisheries and Aquatic Sciences
2022

OPEN ACCESS | Article

Hatchery propagation did not reduce natural steelhead productivity relative to habitat conditions and predation in a mid-Columbia River subbasin

Ian I. Courter[a], Tom Chance[b], Ryan Gerstenberger[c], Mark Roes[a], Sean Gibbs[a], and Adrian Spidle[d]

[a]Mount Hood Environmental, PO Box 744, Boring, OR 97009, USA; [b]Lummi Nation, 2665 Kwina Road, Bellingham, WA 98226, USA; [c]Confederated Tribes of Warm Springs, 6030 Dee Hwy , Parkdale, OR 97041, USA; [d]Northwest Indian Fisheries Commission, 6730 Martin Way E, Olympia, WA 98516, USA



- **27-year** period
- Effect of **pHOS and PNI** (and other variables) on natural productivity

Concept: lower HOS RRS – natural-spawning population would become less productive

Hazard: Hatchery-origin fish spawning naturally lowers productivity of population

PNI: likelihood of loss of fitness

Results: Adult natural winter steelhead productivity:

- No association with pHOS
- No association with PNI

Possible Conclusions

- PNI not a good measure of likelihood of fitness loss
- Loss of fitness did not result in lower productivity

Genetics – Conclusion

- On average hatchery-origin spawners (HOS) have lower relative reproductive success (RRS) and therefore lower fitness than natural-origin spawners (NOS)
- The degree of fitness-loss can depend on year, species, sex, population (geographic location), and lineage of HOS
- Only a few RRS studies have sufficient data to test if RRS has a genetic basis (heritable)
  - More hatchery influence of HOS (Parental HH > HN > NN) the lower the RS
  - Broodstock management strategies (PNI, pNOB, and pHOS) can mitigate, in part, lower RRS
- Uncertainty – several sources
  - Individual variation
  - Environmental stochasticity (year effect)
  - Parental assignments
  - Consequences of lower RS and fitness – effects on population viability
    - *Problem with reducing this uncertainty is that there are many factors that affect population viability*
  - Hatchery operations should be adaptively managed
- **<u>Hazard</u> of HOS spawning naturally decreasing RS and fitness of natural-spawning population exists. The <u>risk</u> to population viability of hatchery-origin fish spawning naturally is uncertain.**

Break – 15 Minutes

Disease Hazard and Risk

Disease – Hazard and Risk

- Disease causing organisms occur in both hatchery and natural populations

- Disease is more readily observed at hatchery facilities
  - Most pathogens observed are native to the watershed

- Disease dynamics in natural aquatic and marine systems is more difficult to characterize than terrestrial systems

Disease – Hazard and Risk

Risk: the chance (probability) of a hazard with a specific consequence

Hazard	Probability	Consequence (If the hazard occurs what is its effect?)
Infected hatchery origin fish transmit pathogen to natural origin fish reducing population size and productivity of the wild population	**Uncertain/Moderate–** pathogens can move among fish from different origins but pathogens to not equal disease **Uncertain/Low that disease is initiated** – the wide variety of host pathogen relationships create a difficulty in generalizing. While rare, prior occurrence illustrates it as a possibility	**Uncertain/Rare -** Decrease abundance

Disease – Hazard and Risk

- Relationships between susceptible and infected individuals population vary, creating a great deal of uncertainty.
- How we operate our hatcheries reduces the likelihood of a hazard having impact
  - Biosecurity
  - Disease surveillance, Transport restrictions, Hatchery practices
- Generalizations (testable hypotheses) can be applied based upon principles of disease ecology and disease theory.

Disease Ecology and Disease Theory

- Disease Ecology: Characterization of the growth in frequency of a disease in a population. (Epidemiology -- Epizootiology)
  - Initially used in public health but increasingly used in fisheries and wildlife science
  - Aquatic/Marine applications present some unique challenges
- Disease Theory: Introduces concepts that include evolutionary selection to explaining how a host/pathogen relationship can develop over time
- Both are relevant in characterizing hazards and as a means of illustrating potential risk.

Generalizations Surrounding Fish Pathogens

More Easily Observed

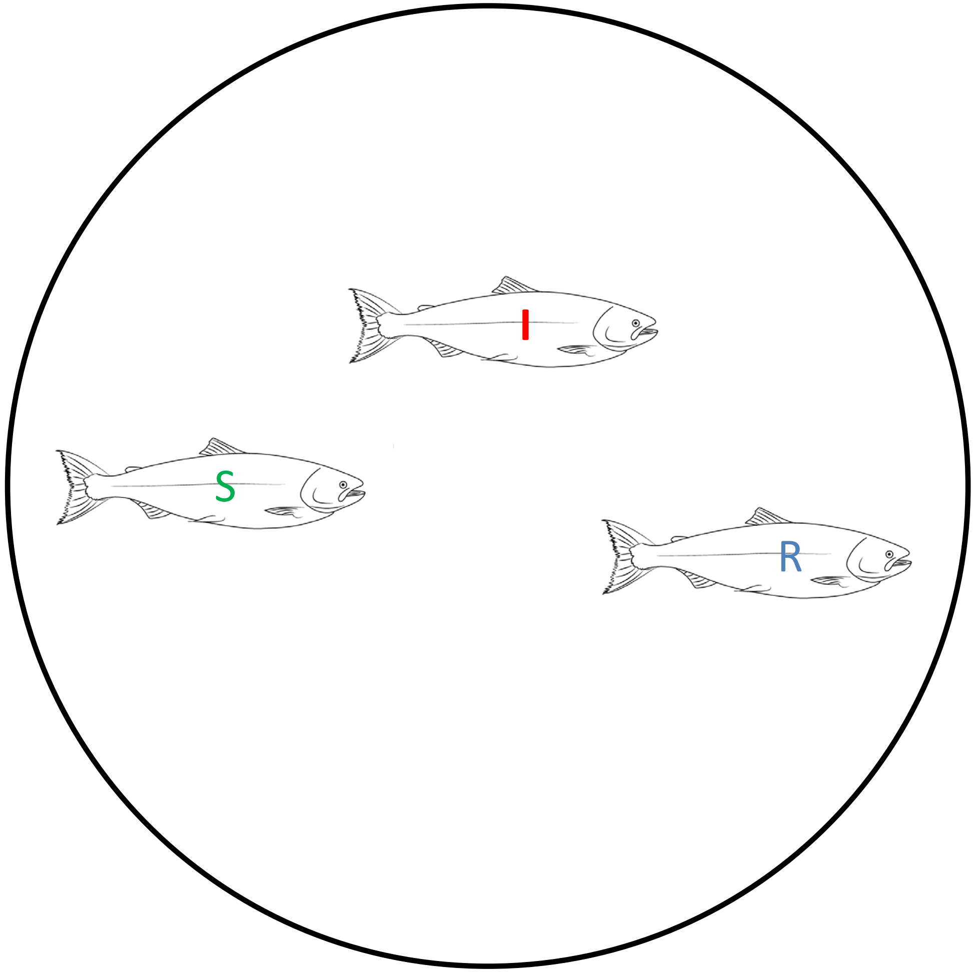
Conditions may favor expansion of transmission

Population response is cryptic

Tools recently developed to understand transmission pathways

The impact of hatchery populations on wild populations is a provocative topic

Disease Models

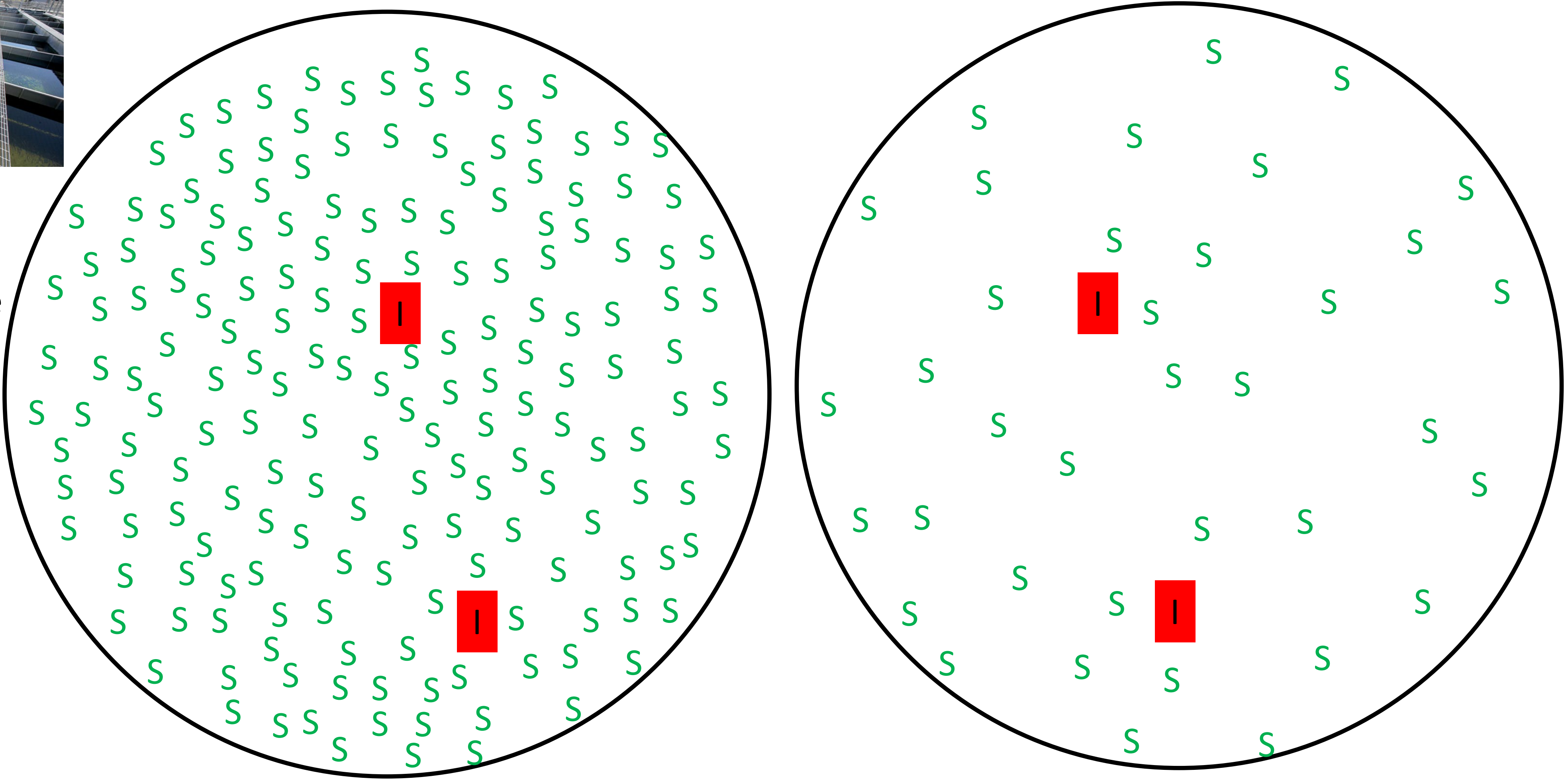


- S = Susceptible
- I = Infected
- R = Resistant
- Transmission coefficient
- S% + I% + R% = 100%

Disease Models – Susceptible Host Density

Legend

- S = Susceptible
- I = Infected



Hi Density

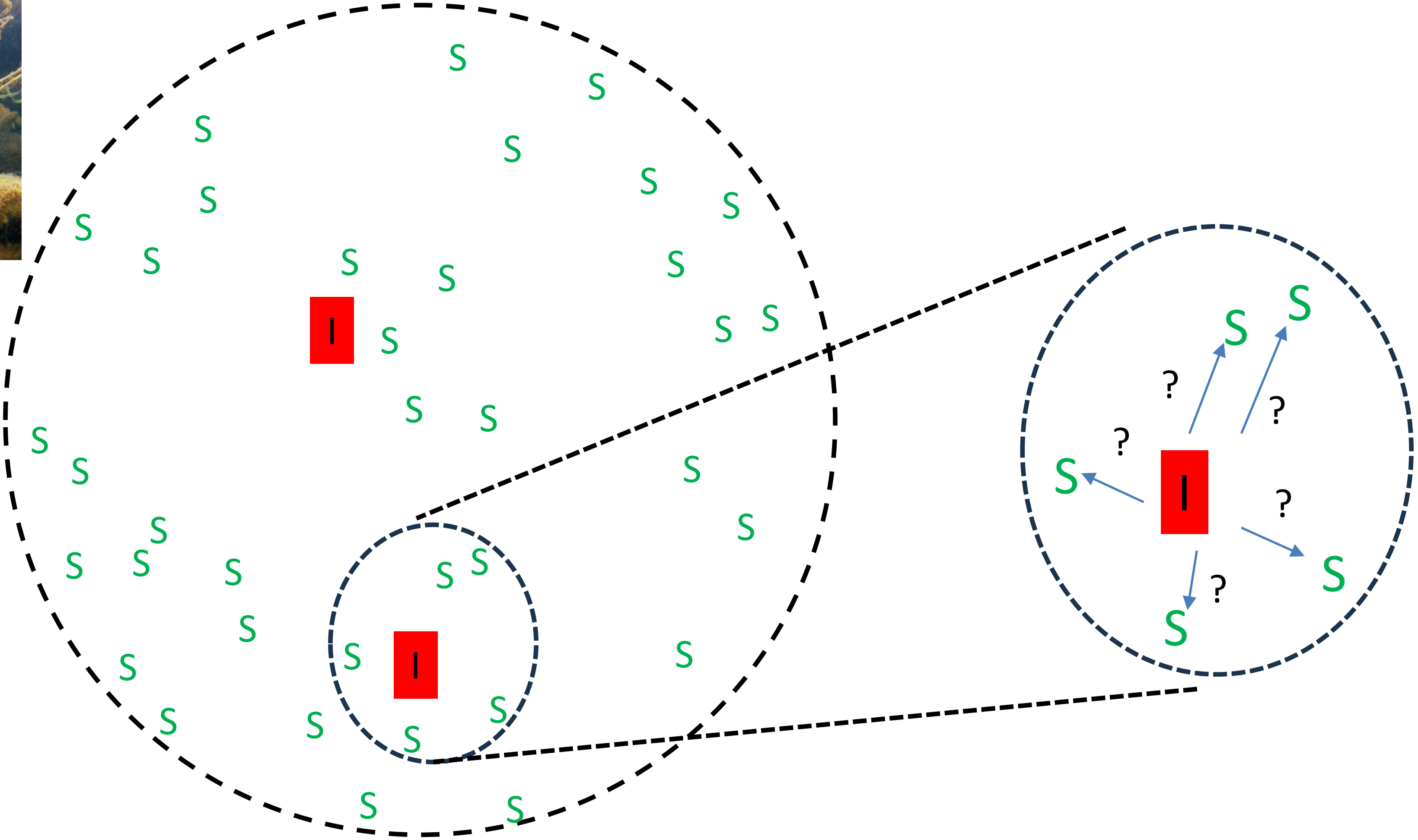
Low Density

Disease Models – Uncertainties in Application

Legend

- S = Susceptible

- I = Infected



Natural Population:
Lower Density
Non-random patchy distribution

Greatest Hazards – Introduction of Novel Pathogens

Whirling Disease and Wild Trout:

The Montana Experience

By E. Richard Vincent

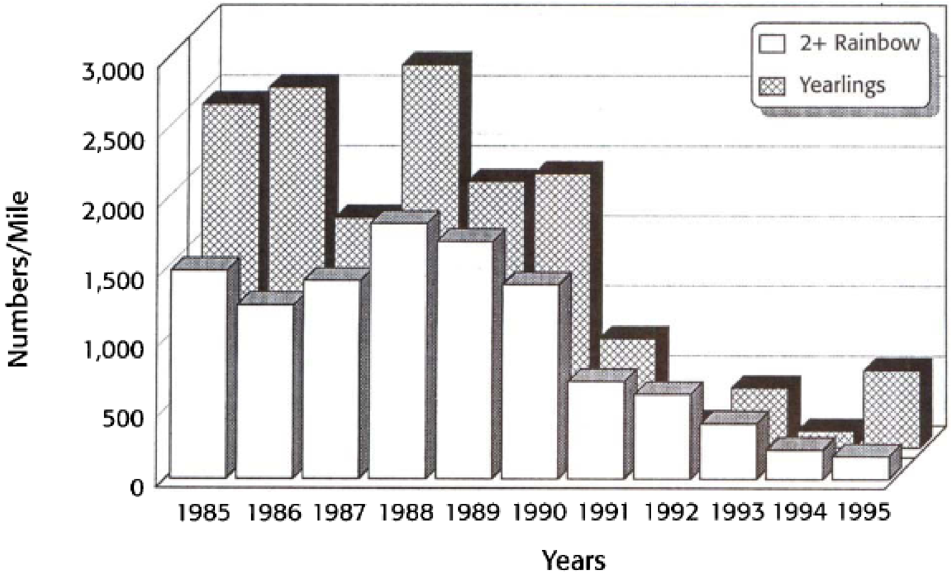


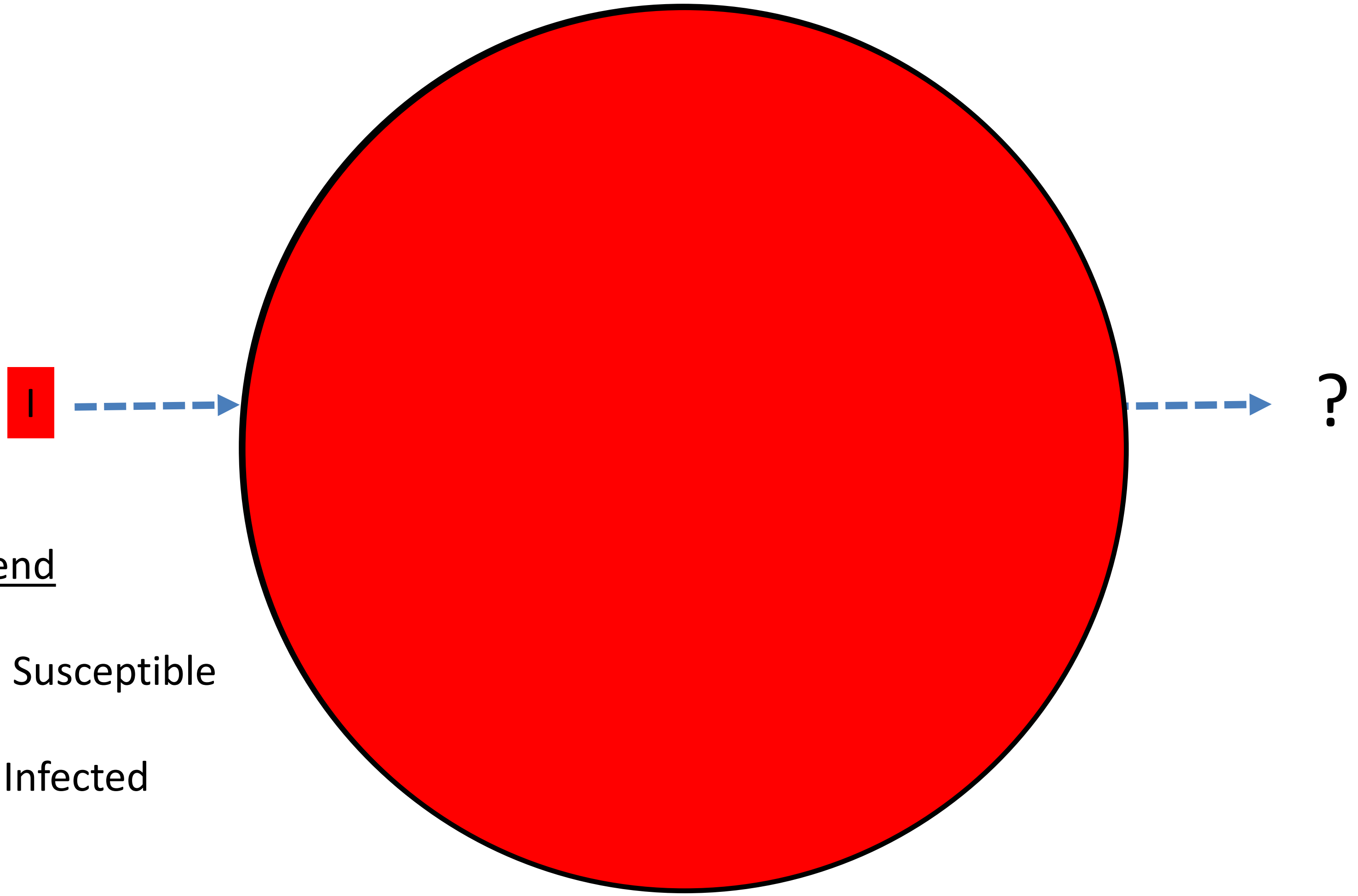
Figure 2 displays wild rainbow trout population estimates for the Pine Butte study section for 1985–1995. Population estimates are shown as numbers per mile.

Montana wild trout fishery

Source of introduction is speculative

The pathogen continues to be present but may be reaching a new equilibrium with less impact (Miller and Vincent 2008)

Greatest Hazards – Amplification of Pathogen Number



Legend

- S = Susceptible

- I = Infected

Pathogens can be detected at times from hatchery effluent (Watanabe et al 1988)

The impact on natural populations is uncertain

Sentinel fish studies attempted are difficult to interpret

Environmental DNA approaches have been used to characterize dispersal pathogen dispersal (Shea et al. 2022)

Greatest Hazards – Examples From Commercial Aquaculture

- Resistant carriers reared in proximity with more vulnerable individuals
- Changes in virulence (selection) of a pathogen in commercial settings

Disease Risk Summary

Disease has an impact in both hatchery and wild populations

It is not surprising that we have better disease understanding in a hatchery environment

Greatest hazards include the introduction of a new pathogens and pathogen amplification

- WDFW fish health policy and practice reduce the likelihood of impacts

Disease Mitigation at WDFW Hatcheries

Fish Health Unit Staffing

- 4 veterinarians
- 4 pathologists
- 3 microbiologists
- 1 Fish Transport Permit application coordinator
- 1 PhD-level Supervisor

Biosecurity

- Operate biosecurity at WDFW hatcheries facilities under explicit policies
  - The Salmonid Disease Control Policy of the Fisheries Co-Managers of Washington State
  - WDFW Policy 5104: Executing Fish Health Standards for Washington State
- Regulate transport or planting of finfish under explicit RCWs and WACs
  - Examples: RCWs 15.85, 77.12.455, 77.115, 77.125, and WACs 220-353-130, 220-370, 220-450-010
- Receive and evaluate 250-300 Finfish Transport Permits per year

Maintaining Fish Health at WDFW hatchery facilities

- Routine fish health visits and inspections by aquatic veterinarians and pathologists
- Judicious use of therapeutants
- WDFW Policy 5304: Using Drugs on Finfish at WDFW Hatchery Facilities and Natural Environment

Ecological Interactions

Two mechanisms for hatchery-natural ecological interactions

1. *Competition*, due to limitations in food or space in habitats shared by hatchery and natural-origin fish
2. *Predation*, direct consumption and indirect alterations in the behavior and/or abundance of predators

Overall theme (spoiler alert!)

High likelihood that ecological interactions resulting from hatchery releases present hazards to wild populations, but…

High uncertainty regarding the ultimate consequence or magnitude of the impact on wild populations

Factors affecting degree of hatchery-natural competition

1. *Number of hatchery fish released*
   - frequency of hatchery-natural interactions
   - aggregate abundance relative to carrying capacity

Photo: Clayton Kinsel

2. *Duration of co-habitation*
   - length of exposure to competition

3. *Individual traits*
   - degree of niche overlap, size, behavior differences

Following Tatara & Berejikian 2012
Environmental Biology of Fishes

What do we know about competition and capacity limitations?

- At the scale of the Pacific Ocean, there is evidence for competition but sockeye, chum and pink salmon dominate numerically

  Ruggerone 2018 *Marine & Coastal Fisheries*

- Some *but not all* retrospective survival studies
  - Find evidence for competition in coastal or Salish Sea marine habitats
  - Indicate hatchery releases, among other factors, can contribute to marine capacity limitations

  Beamish 1997 *ICES J Mar Sci*, Kendall 2020 *Ecosphere*, Levin 2001 *Proc Roy Soc London*, Ruggerone 2004 *Can J Fish Aquat Sci*, Nelson 2019 *Can J Fish Aquat Sci*

- In some Puget Sound estuaries, the addition of hatchery-origin fish can push rearing densities past predicted rearing capacities

  Greene 2021. Report to Estuary Salmon Restoration Program.

Competition - summary

- Salmon habitats – including marine habitats – have some carrying capacity limitations and hence there is potential for competition
- Numerical magnitude of hatchery production suggests competition likely but consequences uncertain
- Difficult to predict capacity limits or competition outcomes in larger, open marine habitats that support multiple populations
  - Changing climate conditions likely affect carrying capacity
  - Movements of fish among habitats that are difficult to sample
- Species that use estuary and nearshore habitats extensively for juvenile rearing (Chinook, chum) probably have highest likelihood for hatchery-induced competition

Hatchery Risk Mitigation Strategies for Competition Effects

- Hold smolts at hatchery to increase proportion of natural populations that have migrated out of the river system
- Release smolting fish to increase rate of hatchery outmigration
- Volitional releases to increase rate of hatchery outmigration
- Ongoing studies to assess migration and survival patterns of alternative release times

Risk-risk trade-offs

- Reducing one hatchery risk will necessarily increase a different hatchery risk
- Example: holding fish to reduce competition risk may increase risk of domestication selection

Predation

Direct impacts of hatchery-released fish on natural-origin salmonids

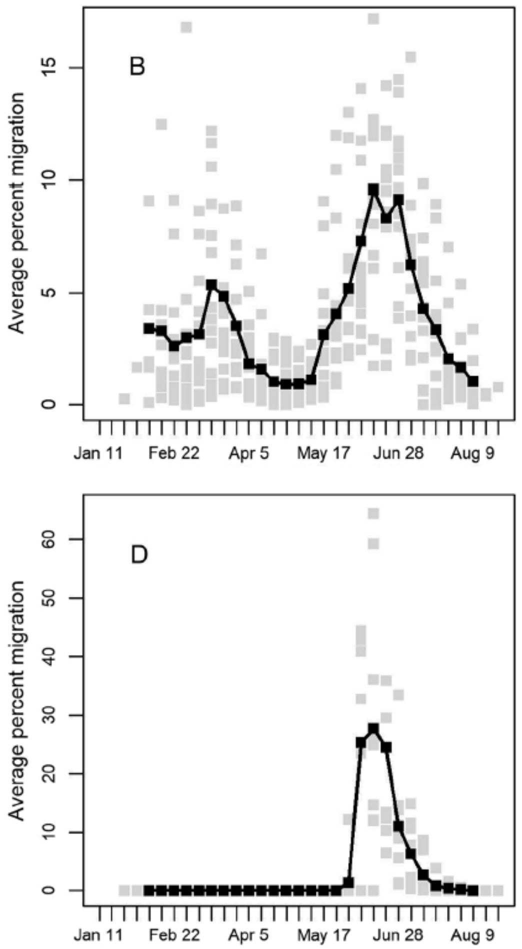
- Typically concerned with releases of age-1 (yearling) salmon and steelhead preying upon smaller, age-0 natural origin fish
- Large potential range of predation impacts
- In most cases, predation by hatchery-origin fish was low
- Localized examples of high predation when hatcheries release age-1 fish before age-0 fish have migrated

Naman & Sharpe 2012
Environmental Biology of Fishes

Predation

Indirect - alter behavior, distribution or abundance of mammals, birds and fish predators

- Hatcheries alter patterns of life history diversity
- Predators known to aggregate following hatchery releases
- Long term population increases in some predators
- Potential for higher impacts to natural populations
  Malick 2022 *Marine and Coastal Fisheries*
- Also potential for predator swamping (lower impacts to natural populations)
  Wood 1987 *Can J Fish Aquat Sci*



Dungeness River

Natural-origin Chinook salmon

Hatchery-origin Chinook salmon

Nelson et al. 2019 *Ecosphere*

Hatchery Risk Mitigation Strategies for Predation Effects

- Hatchery managers typically time releases (wait) to reduce predation risk
- Volitional releases to increase rate of migration
- Release strategies include nighttime releases, releases when water has higher turbidity, and releases during high water etc.
- Predator hazing
- Maintain hatchery infrastructure to reduce the attraction of predators

Ecological interactions – final thoughts

- Significantly less research and understanding of ecological hazards than genetic hazards of hatcheries

- Issues of scaling
  - Difficult to predict how lessons from smaller scale experiments apply to populations or entire regions
  - Difficult to measure ecological impacts at larger population or regional scales due to multitude of confounding factors

- Bottom line
  - *High likelihood* of hatchery-natural ecological interaction
  - *High uncertainty* of context-dependent consequences for natural populations

Benefits

Tribal Treaty Rights and Tribal Culture

Fishing rights "were not much less necessary to the existence of the Indians than the atmosphere they breathed."

- US Supreme Court 1905 opinion (U.S. vs. Winans, 198 U.S. 371) quoted in Anderson et al., 2020

"[H]atchery programs are essential components of regional salmonid management plans that support natural resource management responsibilities in sustaining Treaty Rights."

- Draft Co-Manager Hatchery Policy

Until the time when salmonid populations have recovered "to levels that support healthy ecosystem functions and services, including robust harvest" (Draft Co-Manager Hatchery Policy), hatcheries are not a benefit to tribes but rather are a necessity that sustains Tribal culture.

Benefits of Hatchery Production

Mitigation

- Discussed during Workshop #1
- Generally, for lost habitat from construction of dams and destruction of habitat

Economics

- Discussed during Workshop #1
- Combined recreational and commercial fisheries account for over $8 billion in sales and over 65,000 jobs in Washington State

Social

- Connected to economics and harvest
- "[P]ersonal identity, emotional satisfaction, and psychological well-being derived from opportunities to catch fish." Anderson et al. 2020

Enhancing ecosystem services

- Nutrient enhancement from carcasses of hatchery broodstock
- Prey for Southern Resident Killer Whales (see below and Workshop #3)

Conservation

Conservation Benefits of Hatchery Production

Preventing extirpation

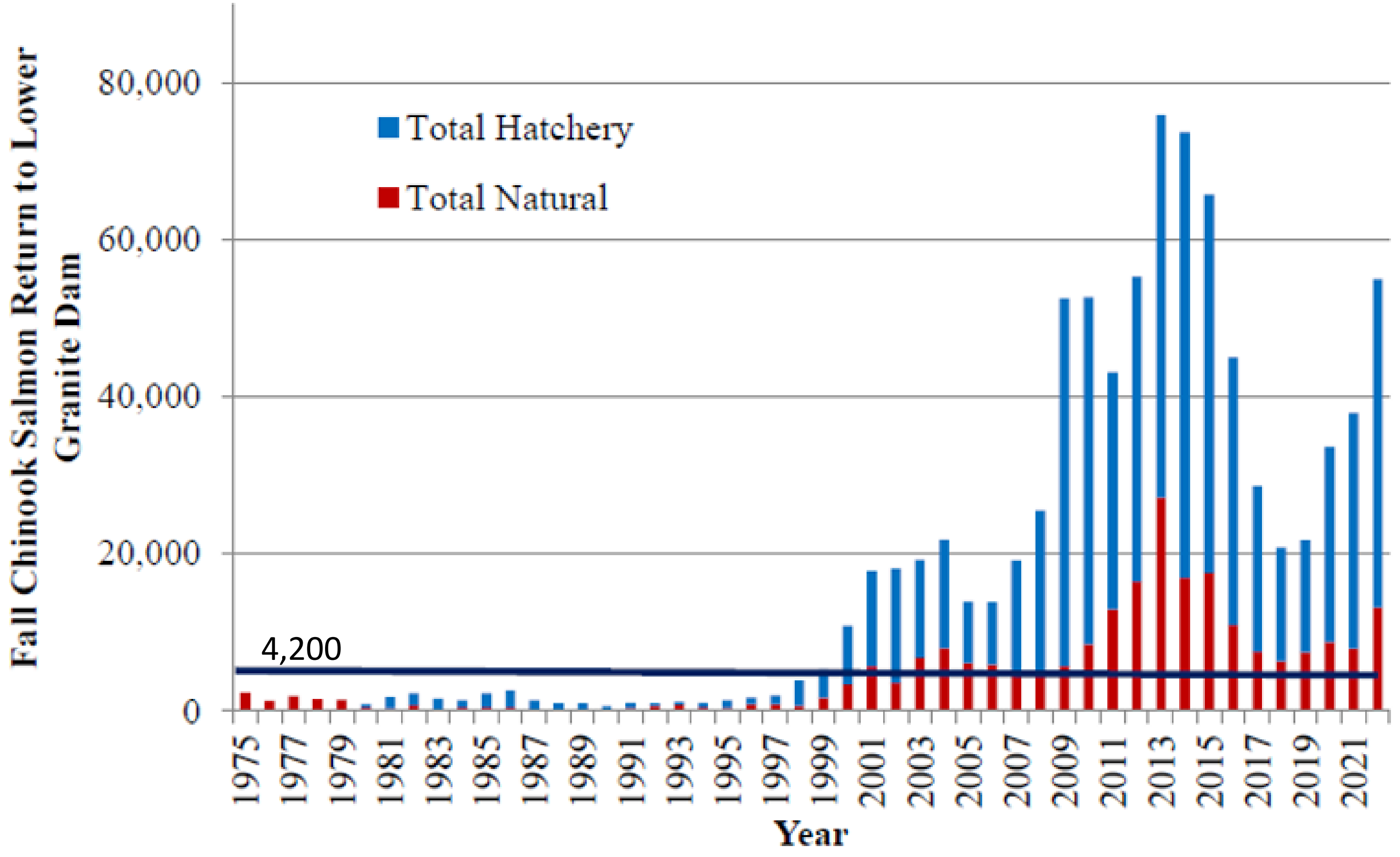
- Sockeye Redfish Lake (Kalinowski et al. 2012, Kline and Flagg 2014)
- Summer Chum Hood Canal (Kostow 2012, Small et al. 2013)
- Chinook NF Stillaguamish (Eldridge and Killebrew 2007)
- Snake River Fall Chinook

Snake River Fall Chinook – Hatchery success story

- In the early 1990s only 78 natural origin Snake River fall Chinook crossed Lower Granite Dam.
- Hatchery program was started in 1997 (first releases) above Lower Granite Dam.
- Successful in preventing extirpation and rebuilding the natural population. The ESA minimum abundance threshold to warrant delisting is 4,200 natural origin adults. The 10-year geometric mean of natural-origin fish is 9,778 adults.
- Successful in supporting a robust harvest – 40-60% harvest rate from Alaska along the coast back up the Columbia and Snake rivers.
- Redd counts have expanded from just a couple hundred to thousands.

Snake River Fall Chinook – Hatchery success story

The 2022 fall Chinook salmon return to the Snake River was approximately 55,000 fish (Figure 1).



Conservation Benefits of Hatchery Production

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- Chinook NF Stillaguamish (Eldridge and Killebrew 2007)
- Snake River Fall Chinook
- Maintaining gene pools

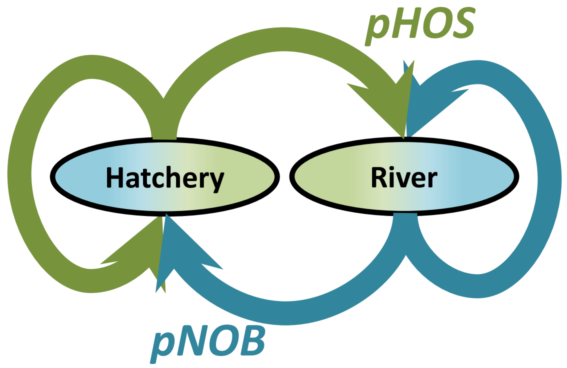
Reintroducing extirpated populations

- Few examples of hatchery releases establishing self-sustaining natural production, but may require several decades (Anderson et al. 2014)
- Promising results, but more time needed
  - Chum reintroduced to Chimacum Creek (Kostow 2012)
  - Coho in Elwha River after dam removal (Liermann et al. 2017)
  - Coho in Columbia Basin (Galbreath et al. 2014, Campbell et al. 2017)

Augmenting size of extant populations

Conservation Benefits:

Augmenting size of extant populations



Integrated hatchery programs with a conservation goals

Attempt to achieve a demographic benefit while mitigating or avoiding fitness loss

ORIGINAL ARTICLE

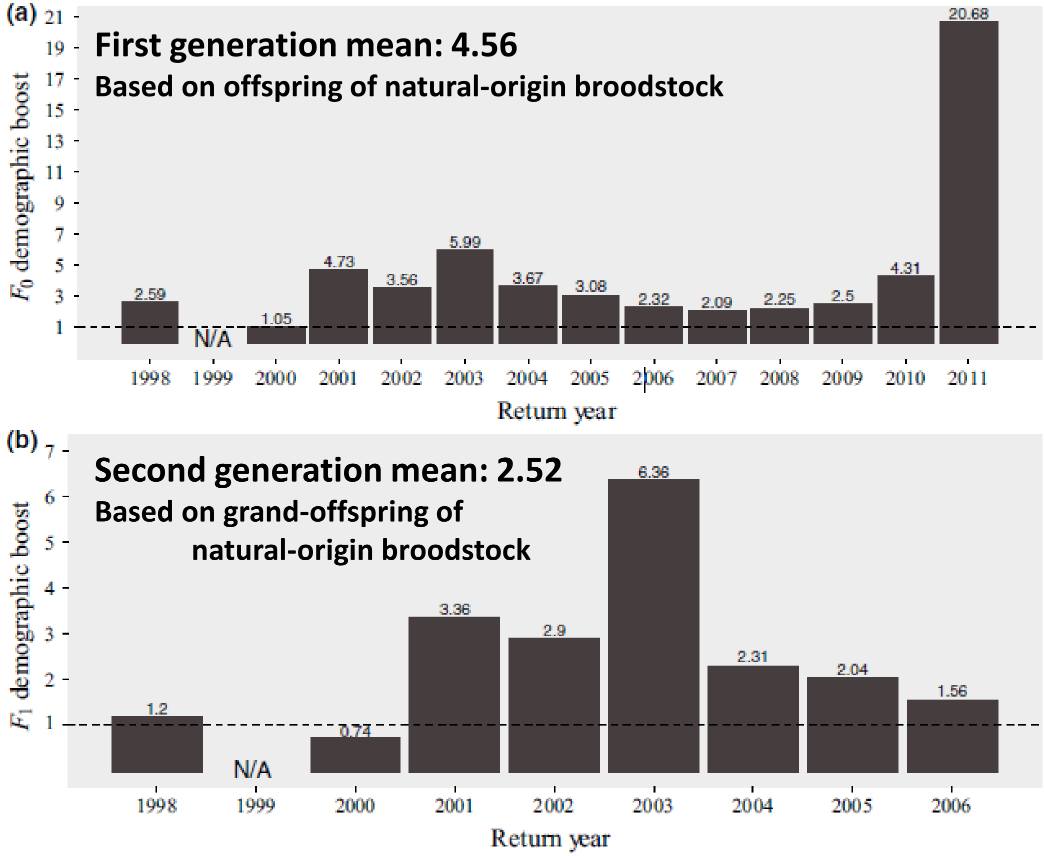
WILEY Evolutionary Applications 2019

Long-term evaluation of fitness and demographic effects of a Chinook Salmon supplementation program

Ilana Janowitz-Koch[1] | Craig Rabe[2] | Ryan Kinzer[2] | Doug Nelson[2] | Maureen A. Hess[1] | Shawn R. Narum[1]

- RRS study Johnson Creek, Idaho
- Two generations
- Program size: small
- pNOB = 1.00
- Average RRS females: 0.89
- Average RRS males: 0.95
- Average RRS jacks: 1.30

Demographic Boost:
Ratio of
RS-wild fish as broodstock
RS-wild fish spawning naturally



Conservation Benefits:
Augmenting size of extant populations

Integrated hatchery programs with a conservation goals

Attempt to achieve a demographic benefit while mitigating or avoiding fitness loss

Ecology and Evolution 2015

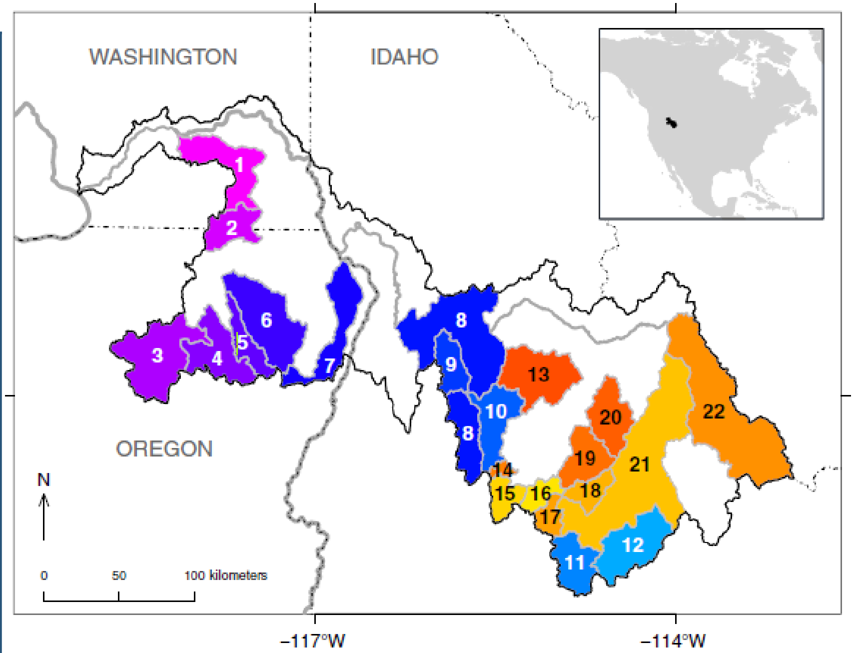
Open Access

Analyzing large-scale conservation interventions with Bayesian hierarchical models: a case study of supplementing threatened Pacific salmon

Mark D. Scheuerell[1], Eric R. Buhle[1], Brice X. Semmens[2], Michael J. Ford[3], Tom Cooney[3] & Richard W. Carmichael[4]

Study

- Retrospective study: Chinook salmon Snake River Basin
- Only natural-origin (unmarked) returns
- Evaluate the effects of supplementation
  - 12 supplemented, 10 nonsupplemented



Results

- Over 25 years period average abundance at supplement populations increased 0 – 8% over nonsupplemented populations
- Supplementation effect smaller that effects from climate, habitat alterations, and hydroelectric
- Study did not include harvest

Break – Five Minutes

Southern Resident Killer Whales 2018 Prey Initiative and Risk Assessment – In Brief . . . . More to Come Workshop #3

FW Commission 2018 SKRW Prey Initiative

Friday, September 07, 2018

B. Salmon Hatcheries: Conservation, Fishery Enhancement, and Prey Availability - Decision

Commissioner McIsaac made the following motion and it was seconded by Commissioner Holzmiller:

I move that the Commission adopt the following general policy intent and guidance for the primary purpose of proposing enhanced Chinook salmon abundance for the benefit of SRKW recovery, acknowledging that there will also be secondary fishery benefits. This general policy intent is provided to Commission and Director representatives on the Southern Resident Killer Whale Task Force for guidance as they comply with the Governor requests under the Executive Order, and to the Director to include as a separate funding proposal for consideration in the Governor's proposed budget, at this point in those processes.

1. At a high policy level, the Commission proposes a significant enhancement in Chinook salmon abundance, via increases in releases from hatchery programs, approximating 50 million smolts beyond 2018 status quo releases. This is to include approximately 30 million from Puget Sound locations and approximately 20 million from Columbia River locations.

Commissioner Thorburn made a motion to amend the motion by removing items 2, 4, 5 Commissioner Kehoe seconded the motion, the motion passed.

The main motion, as amended, was then voted on and passed as well.

Question#1 from Terms of Reference: "What risks does the Commission's 2018 Prey Initiative identify and what protections does it propose or provide from adverse effects on wild Chinook salmon populations?"

Governor Jay Inslee
Excerpts from
March 14, 2018

EXECUTIVE ORDER 18-02

SOUTHERN RESIDENT KILLER WHALE RECOVERY AND TASK FORCE

Implement Immediate Actions to Benefit Southern Resident Killer Whales

- Washington Department of Fish and Wildlife (WDFW) with review from the Governor's Salmon Recovery Office (GSRO) and the Puget Sound Partnership (PSP)—By July 31, 2018, identify the highest priority areas and watersheds for Southern Resident prey in order to focus or adjust, as needed, restoration, protection, incentives, hatcheries, harvest levels, and passage policies and programs.

Establishment of the Southern Resident Killer Whale Task Force

From 2018 – 2021 there were seven directives for WDFW to increase prey for SRKW

1. Governor Inslee Executive Order 18-02
2. FWC 09/07/2018 Motion (“2018 Prey Initiative”)
3. 2018 Orca Task Force Report
4. 2019 Final Orca Task Force Recommendations (Recommendation #6)
5. Legislative Proviso FY 2019
6. Legislative Proviso FY 2020 and FY 2021
7. FWC Anadromous Salmon and Steelhead Hatchery Policy (C-3624) – Guideline #6

The directives also included other tasks:

- Sustainable fisheries and stock management
- Habitat protection, restoration efforts, and recovery plans
- Prey increases should consider
  - Best available science
  - Available habitat
  - HSRG hatchery standards
  - Adaptive management

Question #2 from Terms of reference: What other reviews have been done on the proposed increase in hatchery production? What did they find?

Hatchery Scientific Review Groups (HSRG)*

* 32 Programs proposed and reviewed
* 19 supported
* 7 not supported
* 6 recommended additional analysis

In June 2018 FWC suspended HSRG recommendations (Guidelines 1, 2, & 3) in C-3619 (Original Hatchery Policy)

Co-managers reviewed proposals

* HGMPs revised, submitted to NOAA for consultation where applicable
* 24 programs moved forward

Received support letter from NOAA Fisheries

* NOAA supported increasing hatchery production to benefit SRKW
* Held judgement pending review and approval of revised HGMPs

Prey Initiative – Adaptive Management

- Initiated or expanded coded wire tag (CWT) programs.
- Implement robust monitoring and evaluation (M&E) program for Puget Sound, Lower Columbia, and Coast, based on on-going funding from the legislature.

- Better estimates of straying and pHOS from prey initiative increases.
- Robust estimates of smolt to adult return rates.
- Compare survival estimates among different release size groups.
- Compare different hatchery program contributions to fisheries.
- Improved estimates of age structure hatchery returns

C-3624 and Co-Manager Hatchery Policy

At the April 8 FWC meeting in Anacortes FWC requested that as part of Workshop #2:

- Continue discussion of the draft Co-Manager Hatchery Policy
- Provide examples of situations where the draft policy and C-3624 will result in different decisions concerning hatchery management
  - Both policies require a collective decision-making process. Therefore, we cannot anticipate specific decisions – examples are not possible
  - We will highlight where the two policies differ

Foundation for decision-making may be different among WDFW and Tribal Co-Managers

WAC 77.04.012 (Mandate of department and commission): "The commission, director, and the department shall preserve, protect, perpetuate, and manage the wildlife and food fish, game fish, and shellfish in state waters and offshore waters."

WDFW Mission: "To preserve, protect and perpetuate fish, wildlife and ecosystems while providing sustainable fish and wildlife recreational and commercial opportunities."

Tribes: "Tribal hatcheries continue to play a vital role in supporting tribal fisheries and are now essential for maintaining the tribal right to harvest fish. Tribal hatcheries are also increasingly important in rebuilding depressed wild stocks." https://nwifc.org/about-us/enhancement/

Policy Development: Co-Managers worked through these differences, but there are futures decisions (e.g., new hatchery management plans, adaptive management, monitoring and evaluation)

C-3624 & Co-Manager Policy are Different Policies

C-3624

- Purpose: Hatcheries advance conservation and recovery, mitigation, and sustainable fisheries
- Balance risks and benefits achieved through a transparent structured decision-making process, making use of a science-based risk management framework
- Details included in technical procedures document – not yet written
    - Consultation with Tribal Co-Managers

Co-Manager Policy

- Purpose: Hatcheries are needed for recovery and legal requirements. They preserve, reintroduce, or supplement natural production contributing to natural spawning and harvest.
- Optimal balance of risks and benefits (undefined process)
- WDFW and Tribes reaffirm Co-Management and shared decision-making authority

C-3624 & Co-Manager Policy - Summary

- C-3624 focuses on process and decision-making, emphasizing both risks and benefits of hatchery production
- Co-Manager Policy focuses on Co-Manager relationships, Tribal Treaty Rights, decline in habitat, and need for hatchery production
- This Workshop provided an understanding of hatchery hazards (risks), benefits, and uncertainties associated with the effects of hatchery production

Questions and Discussion