Hatchery Genetic Effects
A Simple Talk about a Complicated Topic

Tom Chance
Salmon Enhancement Program Manager
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LUMMI NATION
TREATY OF 1855

Presentation Outline

- Background
- Overview of genetic effects
- Counter arguments and other explanations
- Consequences and Conclusion
- Q&A

Are Hatcheries Good or Bad?

- A highly divisive and contentious debate that has been ongoing for over 20 years
  - Highly politicized
  - Heavily litigated
  - Personal motives
  - Ideology
  - Opposing scientific schools of thought (literally and figuratively)
  - Competing fishing gear type groups
  - Directly and indirectly, money has a major influence
- It is extraordinarily complicated debate that has relied more upon speculation and assumption than empirical evidence

Disclaimer: I still have bias just like everyone else

Many Criticisms of Hatcheries Exist Beyond Genetic Effects

- Disease transmission
- Various forms of competition with natural-origin fish
  - Estuary competition
  - 🔥 Marine competition (e.g., North Pacific pinks) 🔥
- Predation effects
  - Direct predation (hatchery coho eats ESA-listed chinook fry)
  - Indirect (e.g., the pinniped Pied Piper effect)

Our focus is on direct genetic effects: Maladaptation and reduction of diversity (but with various tangents)

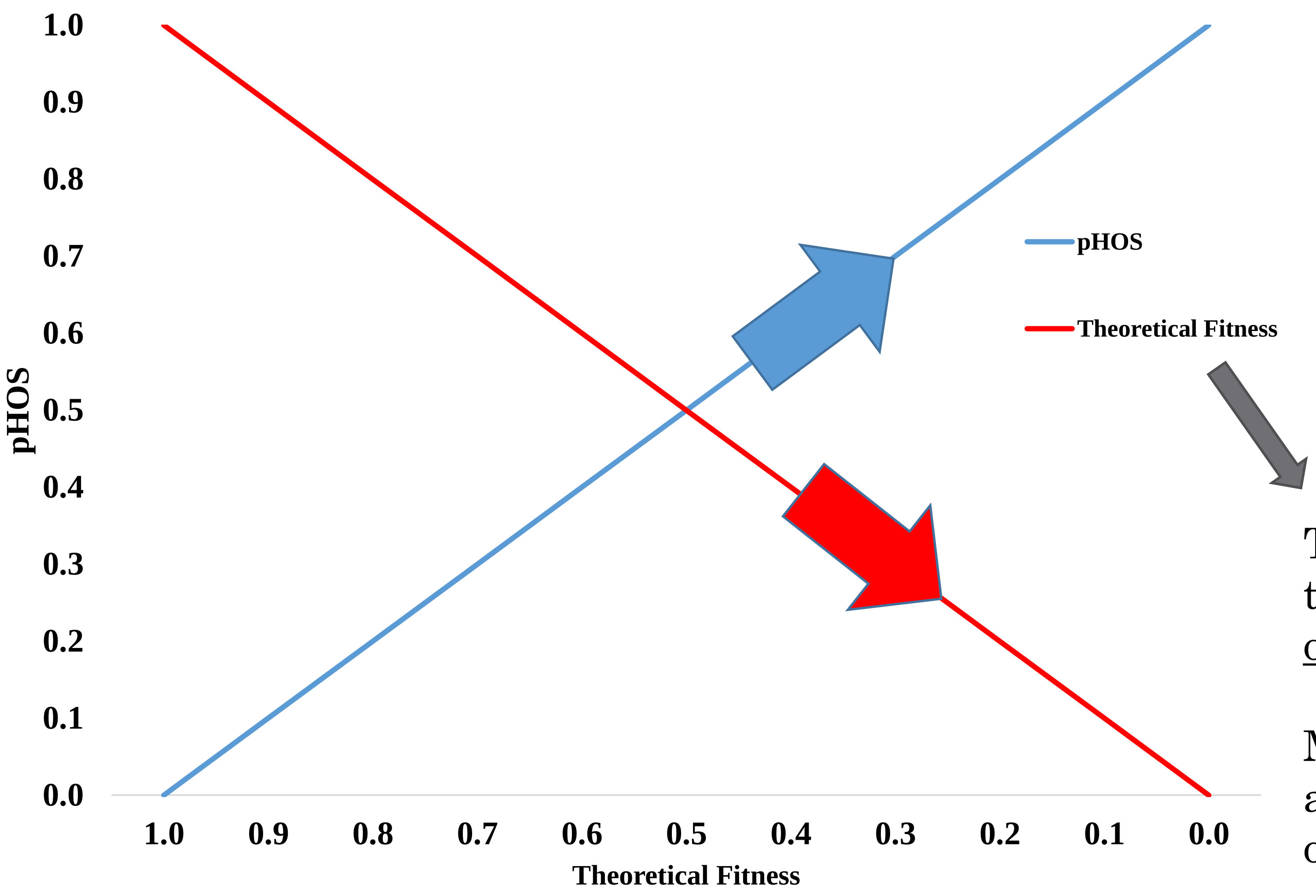
Definitions and Acronyms

- **Fitness:** Quantitative representation of individual reproductive success
  - The capability of an organism to pass genetic material onto the next generation
- **pHOS:** Proportion of Hatchery-Origin Spawners
  - The fraction of hatchery fish spawning naturally in a river
- **HOS:** Hatchery-Origin Spawners
- **NOS:** Natural-Origin Spawners
- **RRS:** Relative Reproductive Success
  - Proportion of successful natural spawners relative to total number of spawners
- **Population Component:** Hatchery and natural components; can be a highly related stock or a propagated non-native stock concurrent to a native stock

The Theory of Genetic Fitness Loss and Purported Outcomes

- Hatchery-origin salmonids have maladapted genes because a *natural* selection processes not occurring – humans make the selection
  - Results in a **domestication** effect (i.e., adaptation to captivity)
  - Claims of a "hatchery gene"
- Naturally spawning hatchery-origin fish drive down the fitness of the natural population component
  - Reduces productivity of the natural population
  - In turn causes a decline in the abundance of the natural population
  - Is heritable and therefore will persist in time even in an eventual absence of hatchery-origin fish
- A proposed explanation for the decline of once-abundant natural salmonid populations
- Considered by some as a barrier to future salmon recovery

The Overly Simplistic Fitness Loss Concept

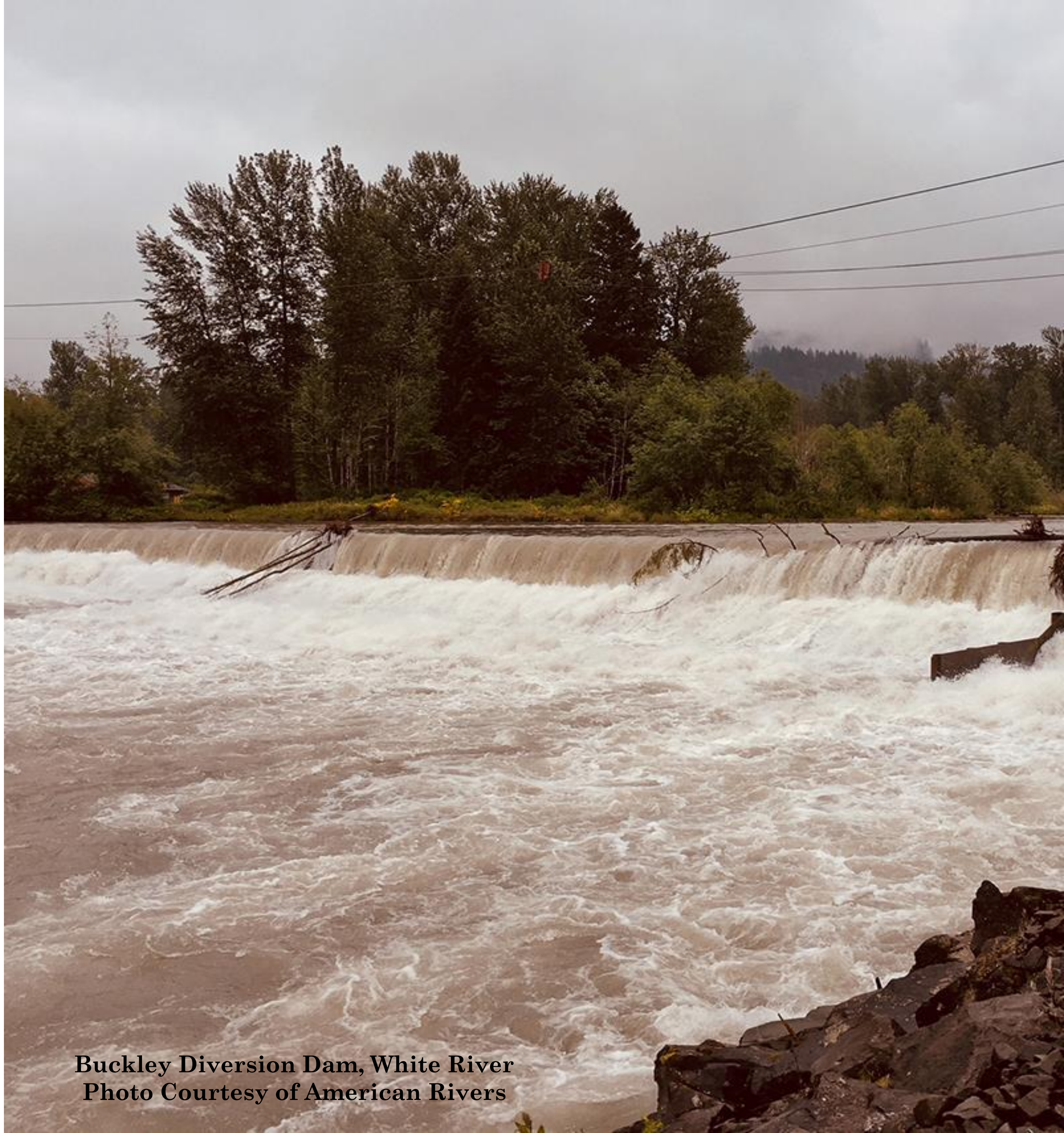


Theoretical fitness applies to the population's <u>natural-origin</u> component

May be smolts per spawner, adult-to-adult productivity, or other metrics

Comparison between Segregated and Integrated Programs

- Segregated program: Hatchery component is isolated from the natural component
  - Very low or no geneflow
  - Often shows genetic distinction with a native population
- Integrated program: Hatchery program uses a significant proportion of natural-origin broodstock
  - Many hatchery critics believe all hatchery programs should be integrated
  - Rarely possible to achieve high rate of integration without robust fish capture capability (e.g., collection facility at a dam)
- Many studies claim HOS from integrated programs have higher fitness than HOS from segregated programs
  - Greater “wildness”
  - Most frequently represented by Proportionate Natural Influence (PNI) estimates


Buckley Diversion Dam, White River
Photo Courtesy of American Rivers

The Scientific Basis

A single generation of domestication heritably alters the expression of hundreds of genes

Mark R. Christie[1,2,3], Melanie L. Marine[3], Samuel E. Fox[3,4], Rod A. French[5] & Michael S. Blouin[3]

Genetic Effects of Captive Breeding Cause a Rapid, Cumulative Fitness Decline in the Wild

Hitoshi Araki,* Becky Cooper, Michael S. Blouin

Effective population size of steelhead trout: influence of variance in reproductive success, hatchery programs, and genetic compensation between life-history forms

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Genetic adaptation to captivity can occur in a single generation

Mark R. Christie[a,1], Melanie L. Marine[a], Rod A. French[b], and Michael S. Blouin[a]

Genetic risk associated with supplementation of Pacific salmonids: Captive broodstock programs

ROBIN S. WAPLES AND CHI DO

Naturally Spawning Hatchery Steelhead Contribute to Smolt Production but Experience Low Reproductive Success

KATHRYN E. KOSTOW*
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ANNE R. MARSHALL AND STEVAN R. PHELPS[1]
Washington Department of Fish and Wildlife, 600 Capitol Way North, Olympia, Washington 98501, USA

Fitness of hatchery-reared salmonids in the wild

Hitoshi Araki,[1,2] Barry A. Berejikian,[3] Michael J. Ford[4] and Michael S. Blouin[1]

1 Department of Zoology, Oregon State University, Corvallis, OR, USA
2 Eawag, The Swiss Federal Institute of Aquatic Science and Technology, Kastanienbaum, Switzerland
3 NOAA, Northwest Fisheries Science Center, Manchester, WA, USA
4 NOAA, Northwest Fisheries Science Center, Seattle, WA, USA

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

Reproductive Success of Captive-Bred Steelhead Trout in the Wild: Evaluation of Three Hatchery Programs in the Hood River

HITOSHI ARAKI,*‡** WILLIAM R. ARDREN,*§** ERIK OLSEN,† BECKY COOPER,* AND MICHAEL S. BLOUIN*
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Carry-over effect of captive breeding reduces reproductive fitness of wild-born descendants in the wild

Hitoshi Araki, Becky Cooper and Michael S. Blouin

Biol. Lett. 2009 **5**, doi: 10.1098/rsbl.2009.0315 first published online 10 June 2009

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The “Scientific” Basis

Genetic Effects of Captive Breeding Cause a Rapid, Cumulative Fitness Decline in the Wild

Hitoshi Araki,* Becky Cooper, Michael S. Blouin

- Not a molecular study yet concluded heritable genetic effects unsupported by the methods
- Still frequently and widely cited as “The” evidence for genetic effects

A single generation of domestication heritably alters the expression of hundreds of genes

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- A former Blouin Lab post-doc conducting the DNA sequencing for this study on steelhead provided verifiable evidence of egregious scientific dishonesty:
  - Omission of confounding sequencing results
  - Intentionally selecting a certain timeframe
  - Hiding that cuttbows were spawned
- Still frequently and widely cited as evidence for genetic effects
- NOAA Fisheries staff not allowed to cite

Problems in Science

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NEWS | 12 October 2023

Reproducibility trial: 246 biologists get different results from same data sets

Wide distribution of findings shows how analytical choices drive conclusions.

Anil Oza

In a massive exercise to examine reproducibility, more than 200 biologists analysed the same sets of ecological data – and got widely divergent results. The first sweeping study[1] of its kind in ecology demonstrates how much results in the field can vary, not because of differences in

Dealing with the positive publication bias: Why you should really publish your negative results

Ana Mlinarić*[1,2], Martina Horvat[1,3], Vesna Šupak Smolčić[1,4,5]

[1]Research Integrity Editor, *Biochemia Medica*
[2]Department of Laboratory Diagnostics, University Hospital Centre Zagreb, Zagreb
[3]Department of Medical Laboratory Diagnostics, University Hospital Split, Split
[4]Clinical Institute of Laboratory Diagnostics, Clinical Hospital Center Rijeka, Rijeka
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RESEARCH

Publication bias and the canonization of false facts

Abstract Science is facing a "replication crisis" in which many experimental findings cannot be replicated and are likely to be false. Does this imply that many scientific facts are false as well? To find out, we explore the process by which a claim becomes fact. We model the community's confidence in a claim as a Markov process with successive published results shifting the degree of belief. Publication bias in favor of positive findings influences the distribution of published results. We find that unless a sufficient fraction of negative results are published, false claims frequently can become canonized as fact. Data-dredging, p-hacking, and similar behaviors exacerbate the problem. Should negative results become easier to publish as a claim approaches acceptance as a fact, however, true and false claims would be more readily distinguished. To the degree that the model reflects the real world, there may be serious concerns about the validity of purported facts in some disciplines.
DOI: 10.7554/eLife.21451.001

SILAS BOYE NISSEN, TALI MAGIDSON, KEVIN GROSS*† AND CARL T BERGSTROM*†

world. In the development of a scientific field, certain claims stand out as both significant and stable in the face of further experimentation (*Ravetz, 1971*). Once a claim reaches this stage of widespread acceptance as true, it has transitioned from claim to *fact*. This transition, which we call *canonization*, is often indicated by some or all of the following: a canonized fact can be taken for granted rather than treated as an open hypothesis in the subsequent primary literature; tests that do no more than to confirm previously canonized facts are seldom considered publication-worthy; and canonized facts begin to appear in review papers and textbooks without the company of alternative hypotheses. Of

Silas Boye Nissen, Tali Magidson, Kevin Gross, Carl T Bergstrom (2016) Research: Publication bias and the canonization of false facts eLife 5:e21451 https://doi.org/

Where are the Alternative Hypothesis Hatchery Science Publications?

Improved productivity of naturalized spring Chinook salmon following reintroduction from a hatchery stock in Lookingglass Creek, Oregon

Hayley M. Nuetzel[a], Peter F. Galbreath[a], Benjamin A. Staton[a], Carrie A. Crump[b], Leslie M. Naylor[b], and Gene E. Shippentower[c]

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]

[1]Fish Ecology Division, Northwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Seattle, Washington 98112
[2]Scripps Institute of Oceanography, University of California, San Diego, La Jolla, California 92093
[3]Conservation Biology Division, Northwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Seattle, Washington 98112
[4]Northeast-Central Oregon Research and Monitoring, Oregon Department of Fish and Wildlife, Eastern Oregon University, La Grande, Oregon 97850

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, [illegible]30 Dee Hwy, Parkdale, OR 97041, USA; [d]Northwest Indian Fisheries Commission, 6730 Martin Way E, Olympia, WA 98516, USA

Corresponding author: Ian I. Courter (email: ian.courter@mthoodenvironmental.com)

First paper to successfully dismantle Araki and Blouin Hood River Steelhead Papers

Increases in steelhead (*Oncorhynchus mykiss*) redd abundance resulting from two conservation hatchery strategies in the Hamma Hamma River, Washington

Barry A. Berejikian, Thom Johnson, Richard S. Endicott, and Joy Lee-Waltermire

Supportive breeding boosts natural population abundance with minimal negative impacts on fitness of a wild population of Chinook salmon

MAUREEN A. HESS,* CRAIG D. RABE,† JASON L. VOGEL,‡ JEFF J. STEPHENSON,* DOUG D. NELSON† and SHAWN R. NARUM*

*Columbia River Inter-Tribal Fish Commission, Hagerman Fish Culture Experiment Station, 3059F National Fish Hatchery Road, Hagerman, ID 83332, USA, †Department of Fisheries Resources Management, Nez Perce Tribe, PO Box 1942, McCall, ID 83638, USA, ‡Department of Fisheries Resources Management, Nez Perce Tribe, PO Box 365, Lapwai, ID 83540, USA

Influences of Hatchery Supplementation, Spawner Distribution, and Habitat on Genetic Structure of Chinook Salmon in the South Fork Salmon River, Idaho

Andrew P. Matala* and Shawn R. Narum
Columbia River Inter-Tribal Fish Commission, 3059-F National Fish Hatchery Road, Hagerman, Idaho 83332, USA

William Young
Nez Perce Tribe, Department of Fisheries Resources Management, McCall, Idaho 83638, USA

Jason L. Vogel
Nez Perce Tribe, Department of Fisheries Resources Management, Lapwai, Idaho 83540, USA

Impacts of supplementation: genetic diversity in supplemented and unsupplemented populations of summer chum salmon (*Oncorhynchus keta*) in Puget Sound (Washington, USA)

Maureen P. Small, Ken Currens, Thom H. Johnson, Alice E. Frye, and Jennifer F. Von Bargen

Little impact of hatchery supplementation that uses native broodstock on the genetic structure and diversity of steelhead trout revealed by a large-scale spatio-temporal microsatellite survey

Jennifer L. Gow,[1] Patrick Tamkee,[1] Jan Heggenes,[1,2] Greg A. Wilson[3] and Eric B. Taylor[1]

1 Department of Zoology, Biodiversity Research Centre and Native Fishes Research Group, University of British Columbia, Vancouver, BC, Canada
2 Laboratory of Freshwater Ecology, University of Oslo, Oslo, Norway
3 British Columbia Ministry of Environment, Surrey, BC, Canada

Extirpation and Tribal Reintroduction of Coho Salmon to the Interior Columbia River Basin

Peter F. Galbreath[a], Michael A. Bisbee Jr.[b], Douglas W. Dompier[c], Cory M. Kamphaus[d] & Todd H. Newsome[e]

[a] Columbia River Inter-Tribal Fish Commission, 700 NE Multnomah Street, Suite 1200, Portland, OR 97232. E-mail:
[b] Fisheries Department, Nez Perce Tribe, Lapwai, ID
[c] Columbia River Inter-Tribal Fish Commission, Portland, OR
[d] Yakama Nation Mid-Columbia Field Station, Peshastin, WA
[e] Yakama Nation Fisheries, Toppenish, WA
Published online: 26 Feb 2014.

Views on Genetic Maladaptation Outside of Salmonid Fisheries Science

- The scientific perception that maladapted, heritable genes affect population viability of terrestrial, avian, or non-salmonid fish species is generally absent
- On the contrary, many captive breeding programs involving near-extinct species/sub-species have been heralded for success (with no fitness loss):
  - American alligator
  - California condor
  - Green sea turtle
  - Hawksbill sea turtle
  - Whooping crane
  - Peregrine falcon
  - Channel Islands fox sub-species (3 of 4)
- Notable invasive species originating from entirely captive, small populations: Starlings, monk parakeets, Eurasian collared doves

Important Questions to Ask

- Is it possible studies purporting genetic fitness loss have been confounded with spurious data or study designs that did not (or could not) account for other concurrent variables?
- How is domestication occurring if fish are not in captivity for 50-90% of their lifetime?
- Are researchers evaluating study results in an objective, unbiased, scientifically defensible manner?
- Can results be replicated?
- Do existing data and the current understanding of genetics provide indisputable evidence for detrimental genetic effects?

The Problem with Genetic Evidence

- **No genomic or molecular mechanism has been identified or described in any study that supports or provides evidence for genetic fitness loss**
- The genetic effect arguments almost always:
    - Incorrectly use *demographics* as a proxy for unquantifiable genetic effects
    - Confuse genotypic and *phenotypic* expression
    - Ignore phenotypic plasticity
    - Disregard accepted evolutionary processes
    - Rely on a faith-based science approach:

*“Trust us, it **is** happening, but it will take more time for us to see it…”*

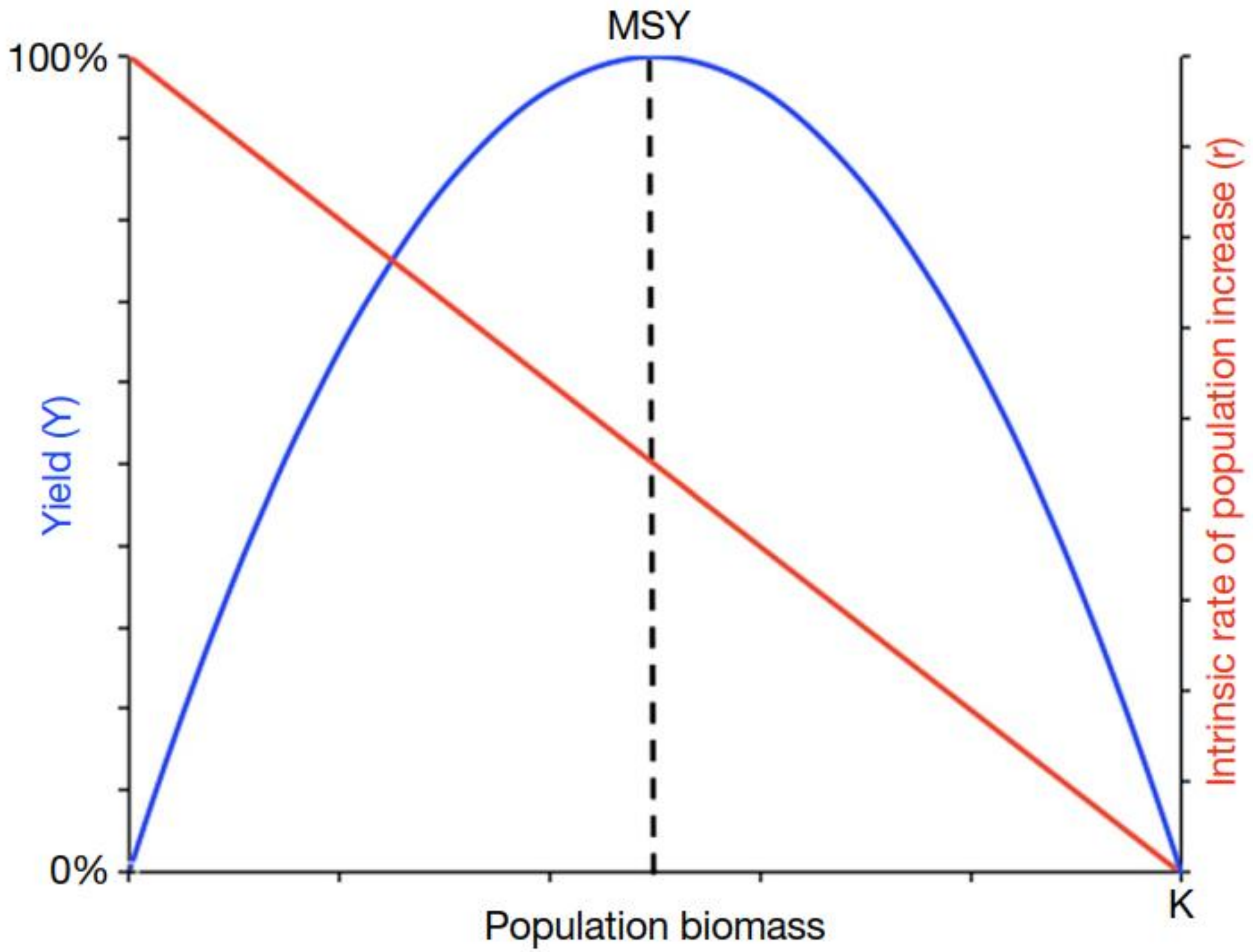
Considering the consistent support for HSRG broodstock principles, the scarcity of unequivocal, population scale empirical RRS evidence for a genetic basis to fitness loss merits further discussion. Case studies of Hood River (OR) steelhead (Araki et al. 2007) and Wenatchee River steelhead (Ford et al. 2016) found such evidence, whereas case studies of Wenatchee River Chinook salmon (Ford et al. 2012) and Umqua River (OR) coho salmon (Thériault et al. 2011) did not. Such studies require at least three generations of genetic information combined with census DNA sampling of adult salmon. Thus, the tremendous long-term investment in research and monitoring required to test for a genetic component to fitness loss has contributed to the scarcity of evidence for it. Furthermore, a history of interbreeding

A review of hatchery reform science in Washington State

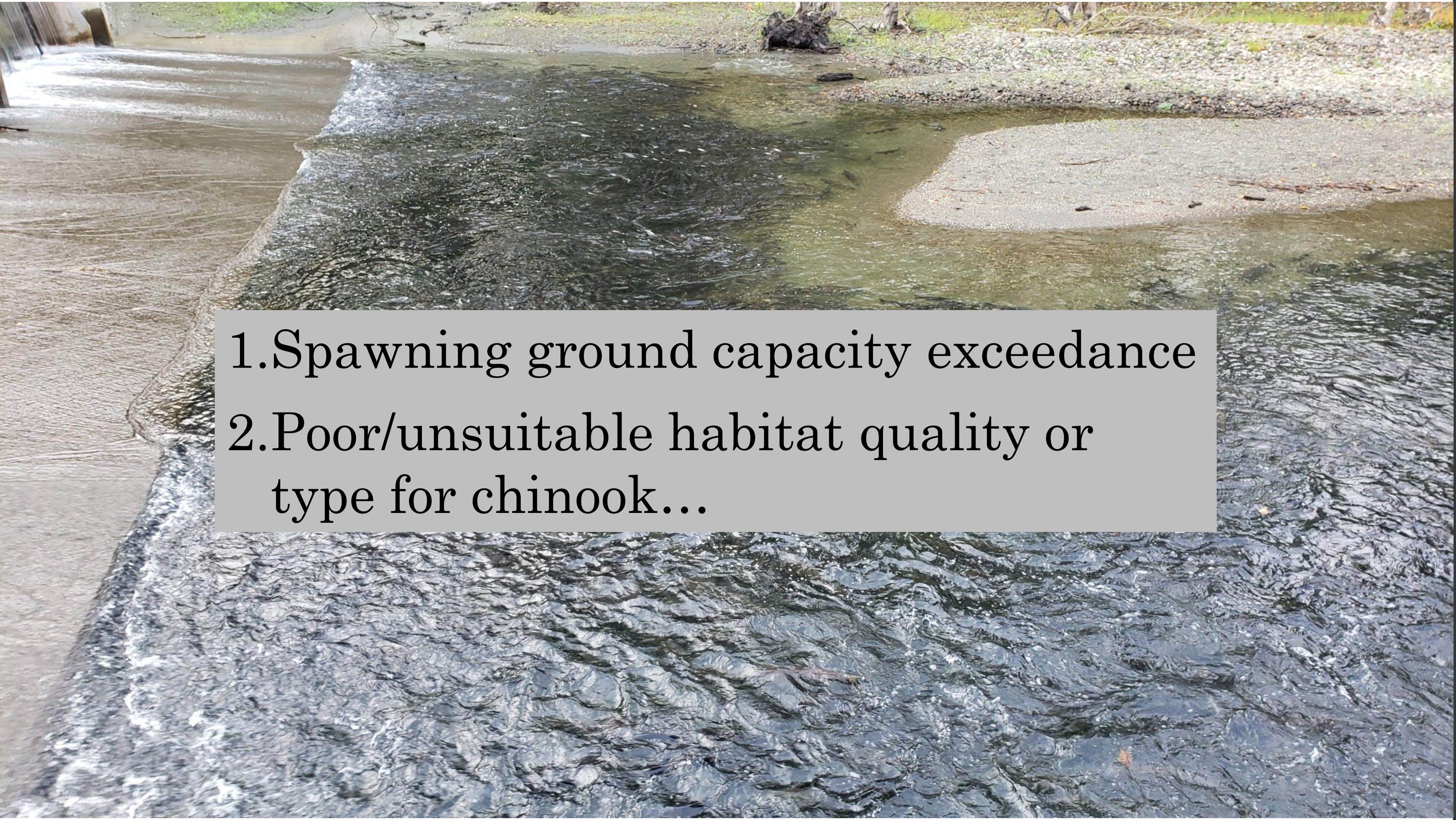
Joseph H. Anderson, Kenneth I. Warheit, Bethany E. Craig, Todd R. Seamons and Alf H. Haukenes
Washington Department of Fish and Wildlife

Alternative Explanations: Demographics

- Fitness = Productivity
- The basic, foremost principle of fisheries management is **Maximum Sustained Yield** (AKA Maximum Surplus Production, Maximum Equilibrium Catch, etc.)
  - Various models and iterations to suit different purposes
  - Too much harvest = Productivity loss
  - Too little harvest = Productivity loss
- A population that exceeds the carrying capacity will have reduced productivity



Tsikliras and Froese 2018



1. Spawning ground capacity exceedance
2. Poor/unsuitable habitat quality or type for chinook…

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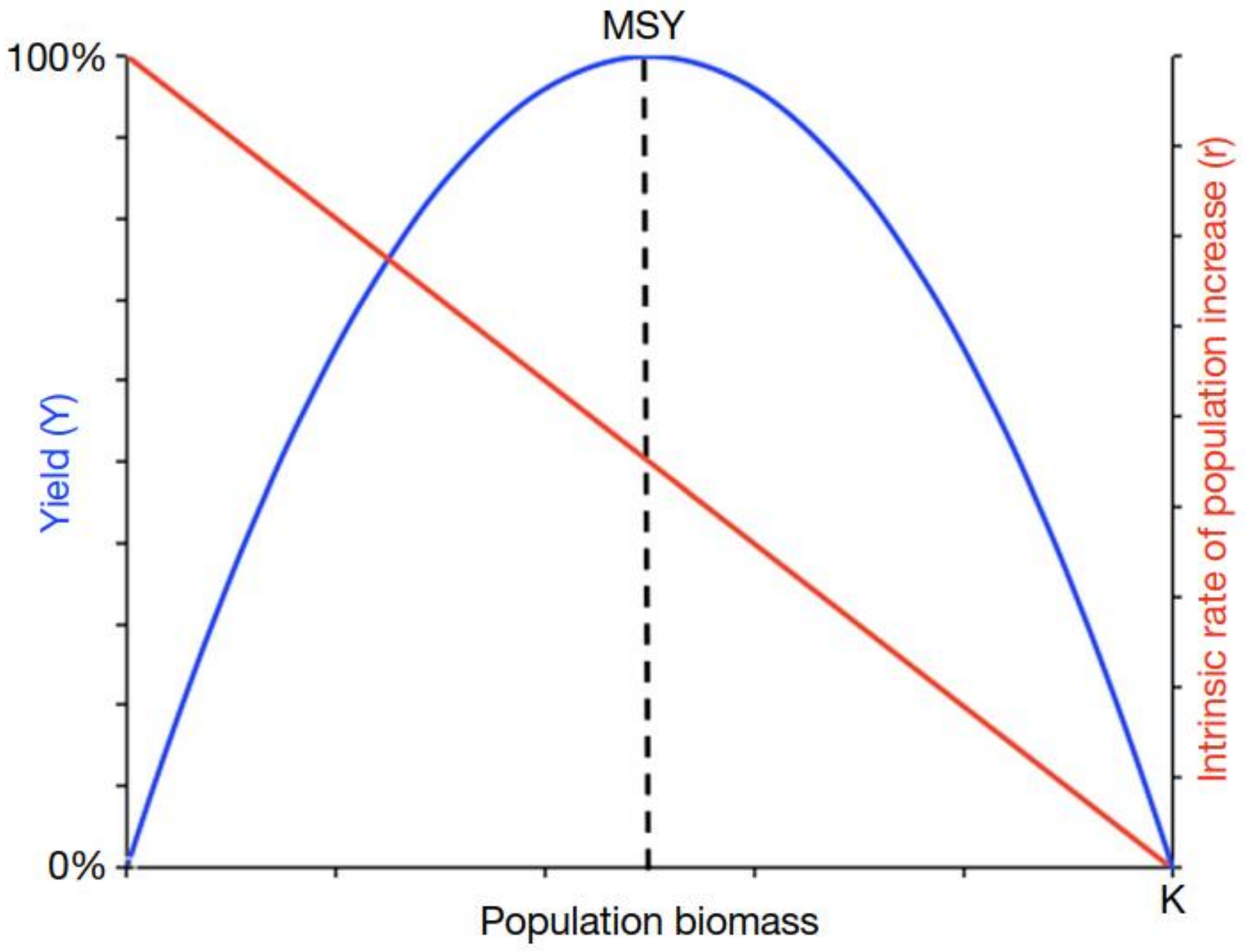
  - Various models and iterations to suit different purposes
  - Too much harvest = Productivity loss
  - Too little harvest = Productivity loss
- **<u>To reiterate:</u>** A population that exceeds the carrying capacity will have reduced productivity (depensatory effect)



Tsikliras and Froese 2018

Alternative Explanations: Habitat Function

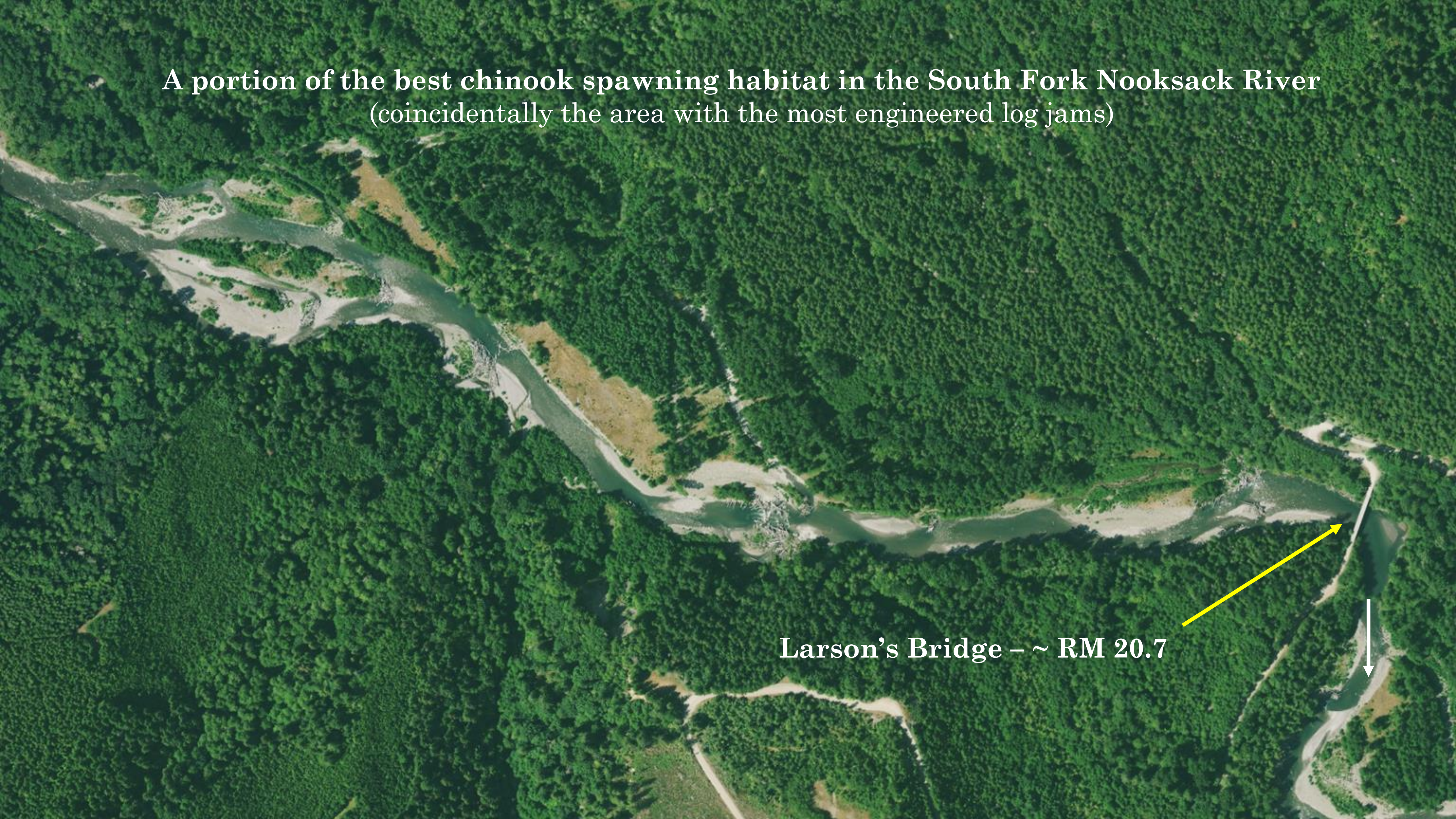
Redd scour in the North Fork Nooksack is documented to annually induce a loss of Chinook spawner productivity ranging 57.6 – 92.4% (WRIA 1 SRB 2005)

Anthropogenic habitat alteration leads to rapid loss of adaptive variation and restoration potential in wild salmon populations

Tasha Q. Thompson[a,b,1], M. Renee Bellinger[c,2], Sean M. O'Rourke[a,b,2], Daniel J. Prince[a,b,2], Alexander E. Stevenson[d], Antonia T. Rodrigues[e], Matthew R. Sloat[f], Camilla F. Speller[g,h], Dongya Y. Yang[e], Virginia L. Butler[i], Michael A. Banks[c], and Michael R. Miller[a,b,1]

Alternative Explanations: Habitat Selection

- Numerous studies have found that hatchery-origin spawners often do not seek out or encounter quality spawning habitat
  - Simple reason: Hatchery fish are often imprinted to locations (e.g., hatcheries or acclimation sites) that are not located near the highest quality spawning habitat
- **But…what happens when HOS disperse into quality habitat and spawn?**


A portion of the best chinook spawning habitat in the South Fork Nooksack River
(coincidentally the area with the most engineered log jams)
Larson's Bridge – ~ RM 20.7

Alternative Explanations: Habitat Selection

All 2018 HOS+NOS SS (LNR Reaches)

Basin Fork	SF
Successful Spawner	Yes
Sex_Code	(All)
CWT Detect Id	(All)
Ad Clip Status ID	(All)
Reach Category	(Multiple Items)
Stream	(All)
Survey Reach	Count of LNR DNA#
Bottom of Dyes Canyon - Saxon	10
Cable Crossing - Dyes Canyon	7
Larson's Bridge - Cable Crossing	38
Larson's Bridge - Cable Crossing Tribs	6
Grand Total	**61**

Most 2018 Skookum Chinook HOS SS (LNR Reaches)

Basin Fork	SF
Successful Spawner	Yes
Sex_Code	(All)
CWT Detect Id	1
Ad Clip Status ID	2
Reach Category	(Multiple Items)
Stream	(All)
Survey Reach	Count of LNR DNA#
Bottom of Dyes Canyon - Saxon	2
Cable Crossing - Dyes Canyon	4
Larson's Bridge - Cable Crossing	15
Larson's Bridge - Cable Crossing Tribs	3
Grand Total	**24**

Larson's Bridge – Cable Crossing reach is only 1.9 RM but has the best spawning habitat in the SF

Conclusion: HOS can have RRS ≥ NOS when spawning in the highest quality habitat in the South Fork Nooksack River

Alternative Explanations: RRS Factors

- **Common myth and discrete assumption:** Most or all natural-origin spawners successfully produce offspring
- This data example is empirical, but we must recognize there will always be a long list of variables and caveats that will confound interpretation unless we account for them

2018 North Fork Nooksack Surveys
All Natural Origin Spawners Only

E-Detect	WNT		
Mark	U		
Count of Sex			
Successful Spawner	**No**	**Yes**	**Total**
BOULDER CR	1		1
CANYON CR	15	1	16
KENDALL CR	1		1
KENDALL SL	12		12
LEAVITTS SC	9		9
MCDONALD SC	10		10
NF NOOKSACK	26	2	28
WICKS SL	2		2
Grand Total	76	3	79*

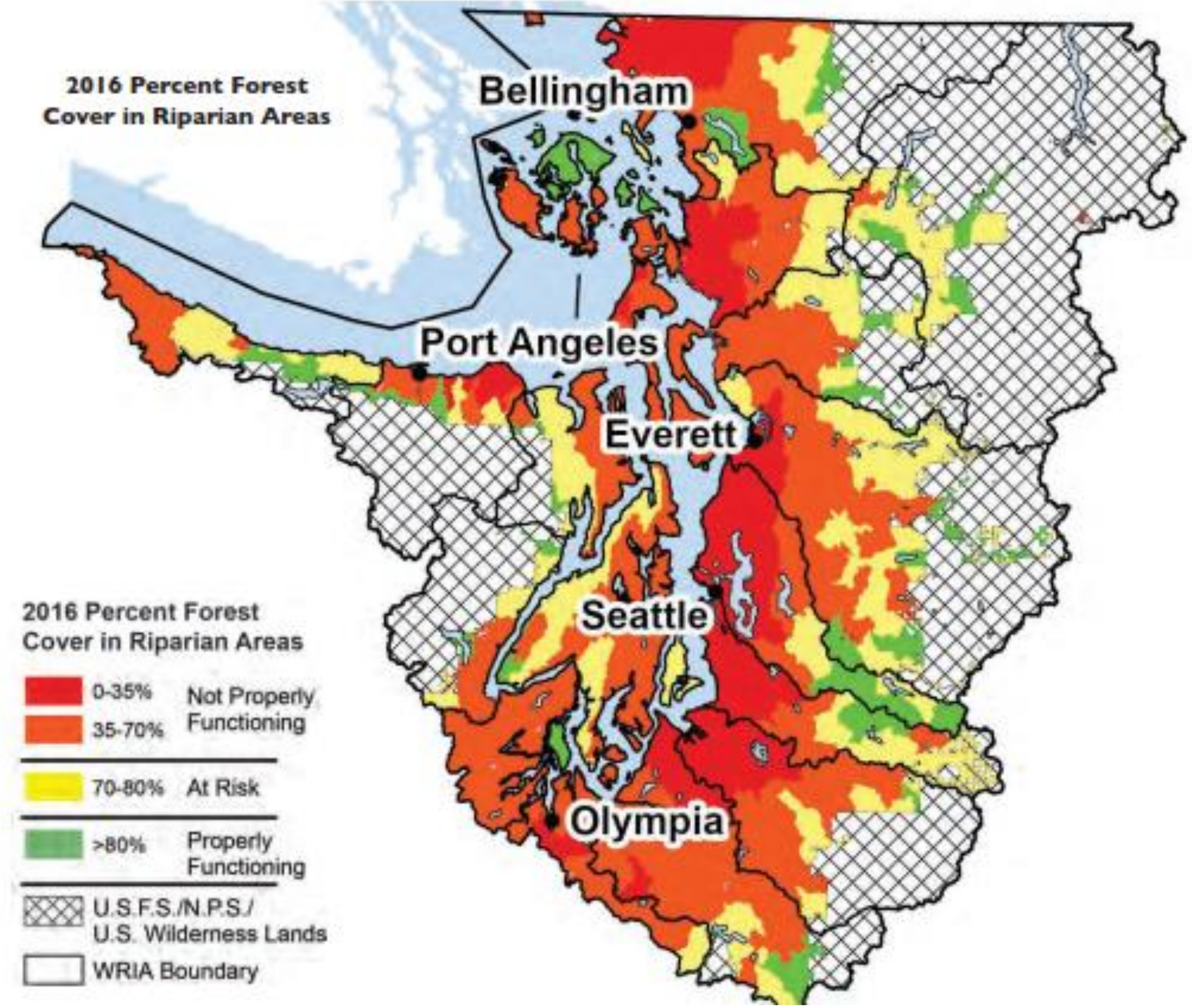
*For the same reaches + 3 others, successful HOS was 9/218

A Brief List of Habitat Impacts

- 87% of rivers and streams inventoried in 2014 were designated impaired for one or more parameters by the EPA and Washington Dept. of Ecology
- Developed land area continues to increase
- Human population growth in Washington has significantly outpaced official projections
- Water withdrawal volumes continue to increase
- Poor land use/resource extraction practices continue
- Approximately **<u>45%</u>** of the habitat historically accessible to anadromous Pacific salmonids in the contiguous United States has been blocked by human structures (McClure et al. 2007)
  - This loss of genetic diversity is <u>exponentially</u> higher than the loss of genetic diversity caused by all past, present, and future hatchery programs
- **<u>29%</u>** of the assumed 1,400 historical West Coast salmon and steelhead populations have gone extinct since Euro-American contact

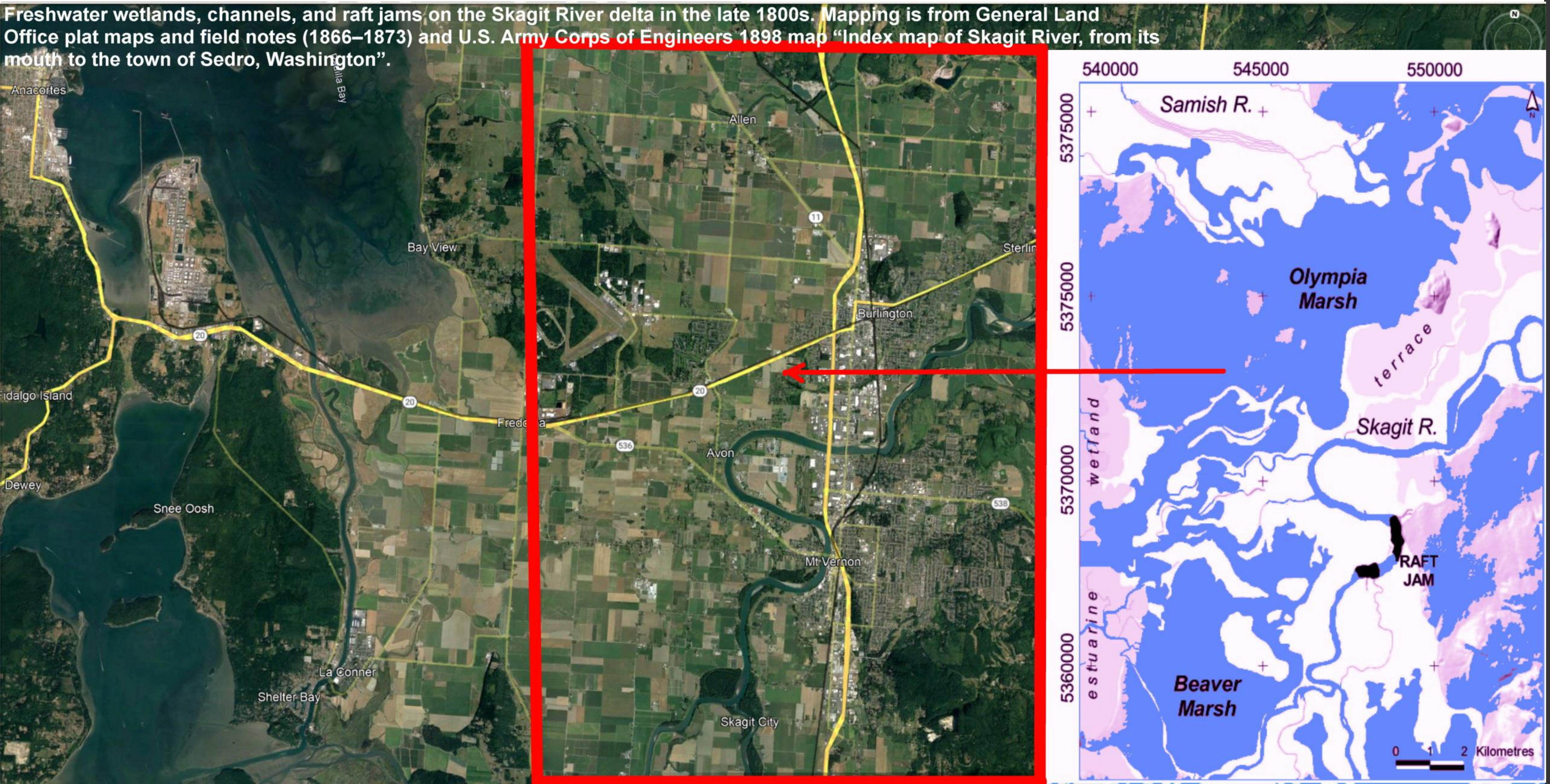
Diminished Riparian Forest Cover

Diminishing riparian forests in the lowlands of western Washington continue to impair habitats critical to the recovery of the region's anadromous salmon. The number of 6th-level HUCs rated for properly functioning riparian forest cover shrank by 37.9% between 2011 and 2016. In 2011, NMFS identified for most of Puget Sound that degraded riparian areas are a limiting factor to the recovery of chinook salmon.[1]



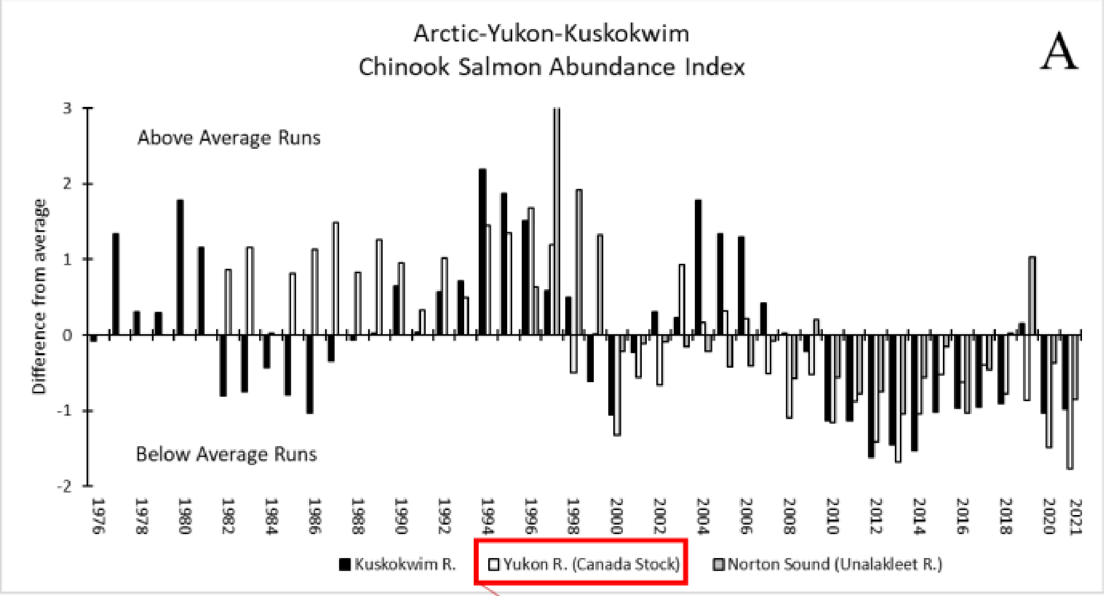
State of Our Watersheds Report (NWIFC 2020)

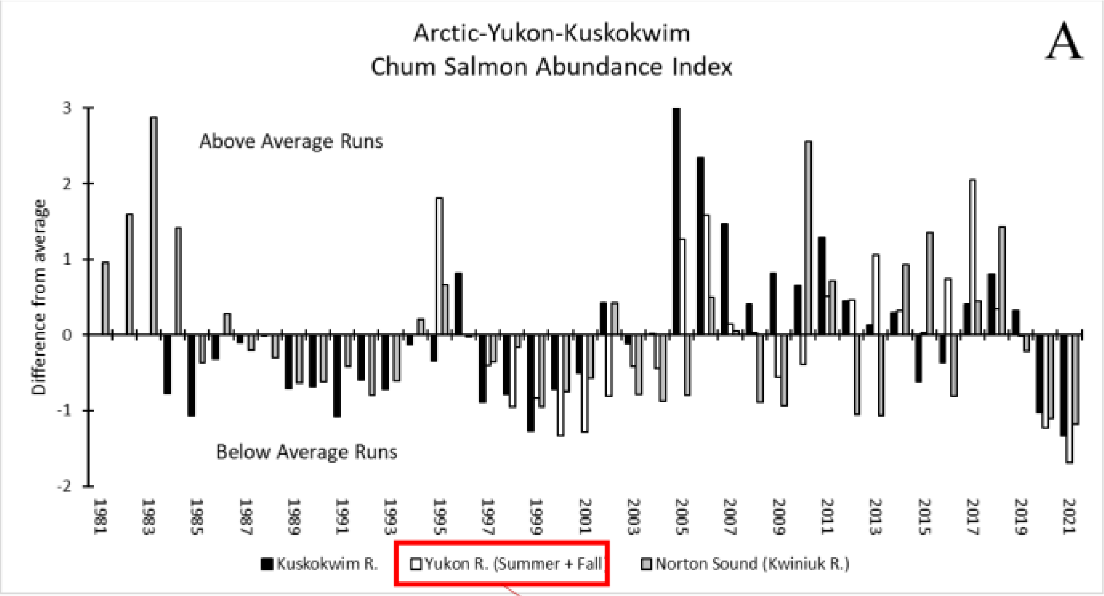
Skagit River Delta

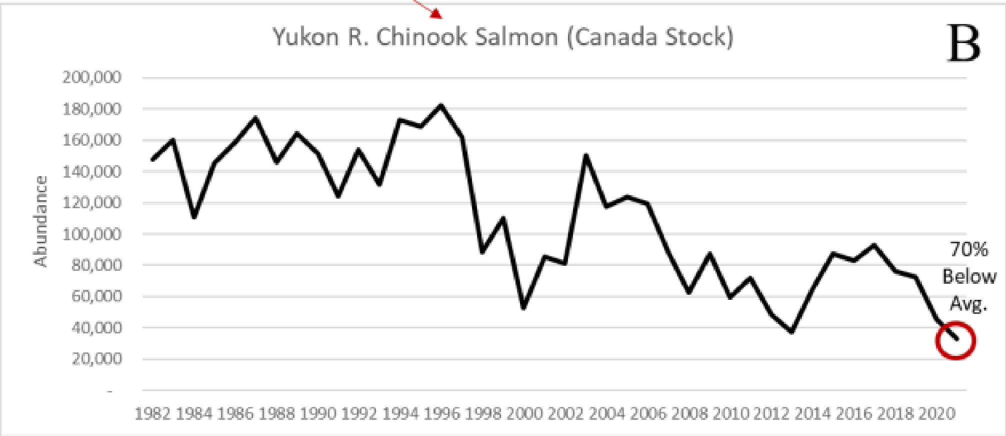


Absence of Hatcheries – Yukon River

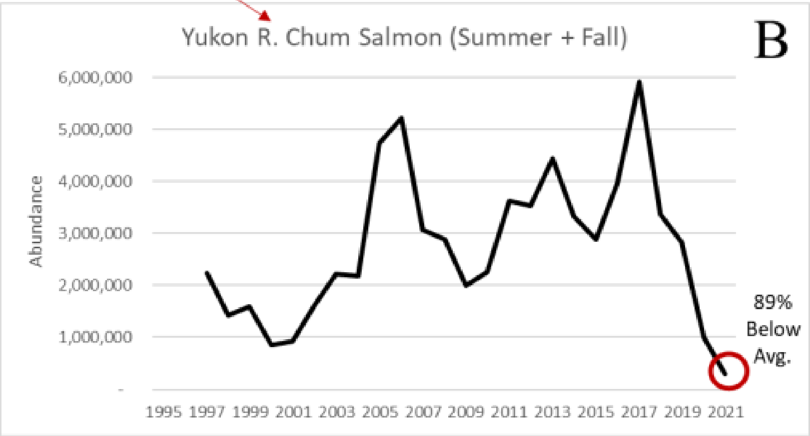
- Will a natural-origin population magically rebound if hatchery production is eliminated?*







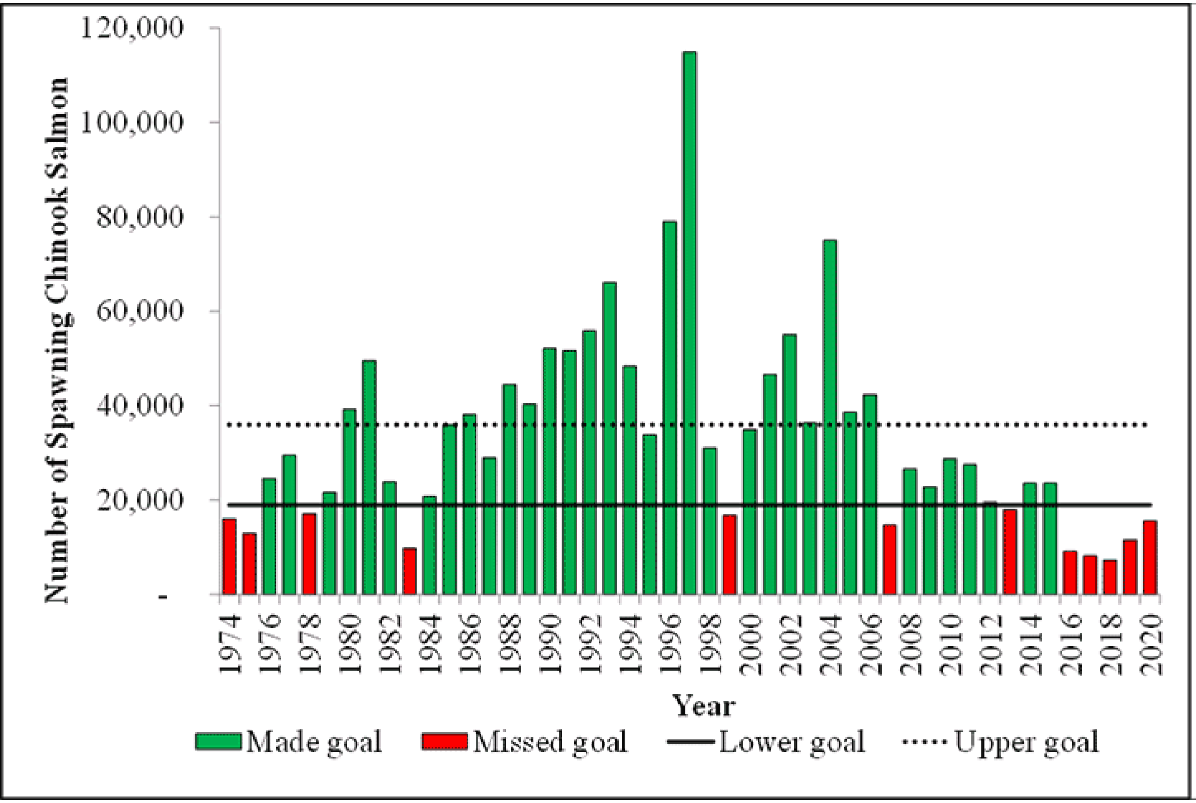
*150,000 – 400,000 chinook released from Whitehorse, Yukon since 1980s – program is not eliminated



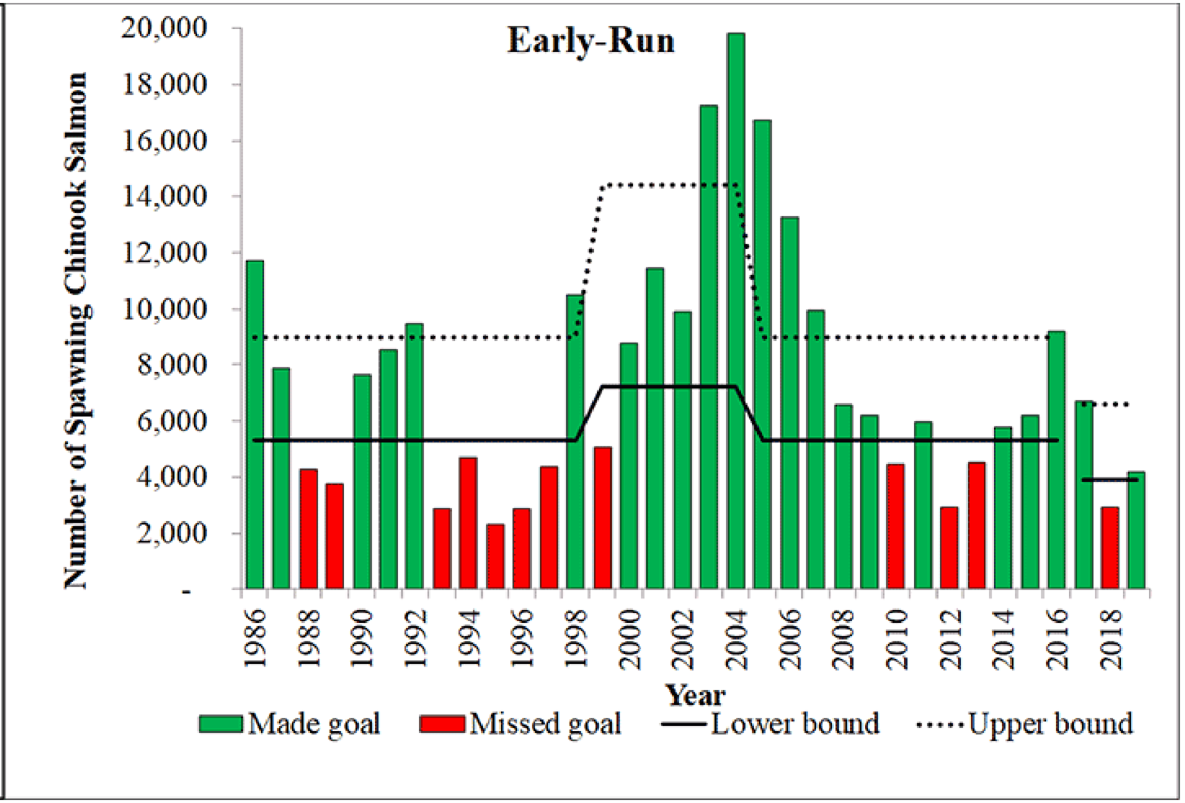
Absence of Hatcheries – Taku & Kenai

- Will a natural-origin population magically rebound if hatchery production is eliminated?

Taku River Chinook

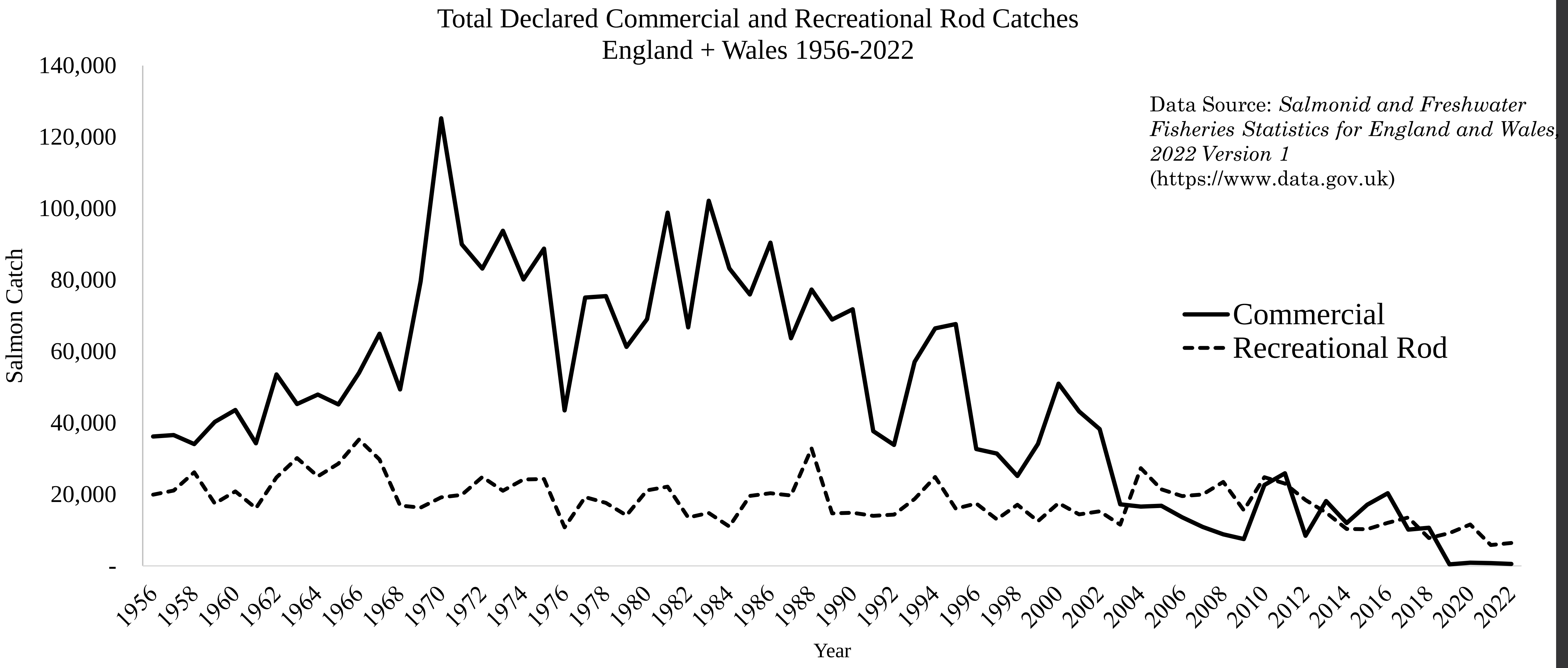


Kenai River Chinook



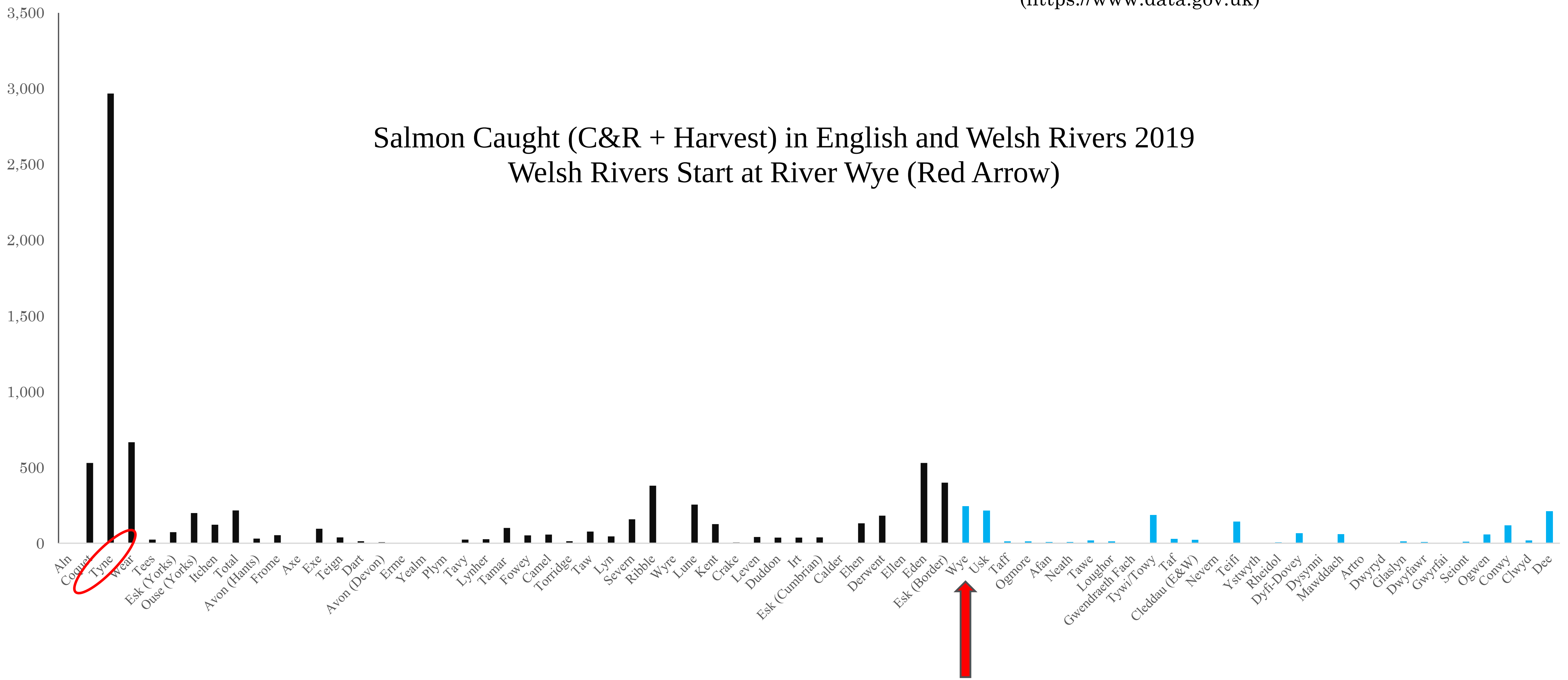
Figures from Alaska Department of Fish and Game

Long Term UK Salmon Catch Trends



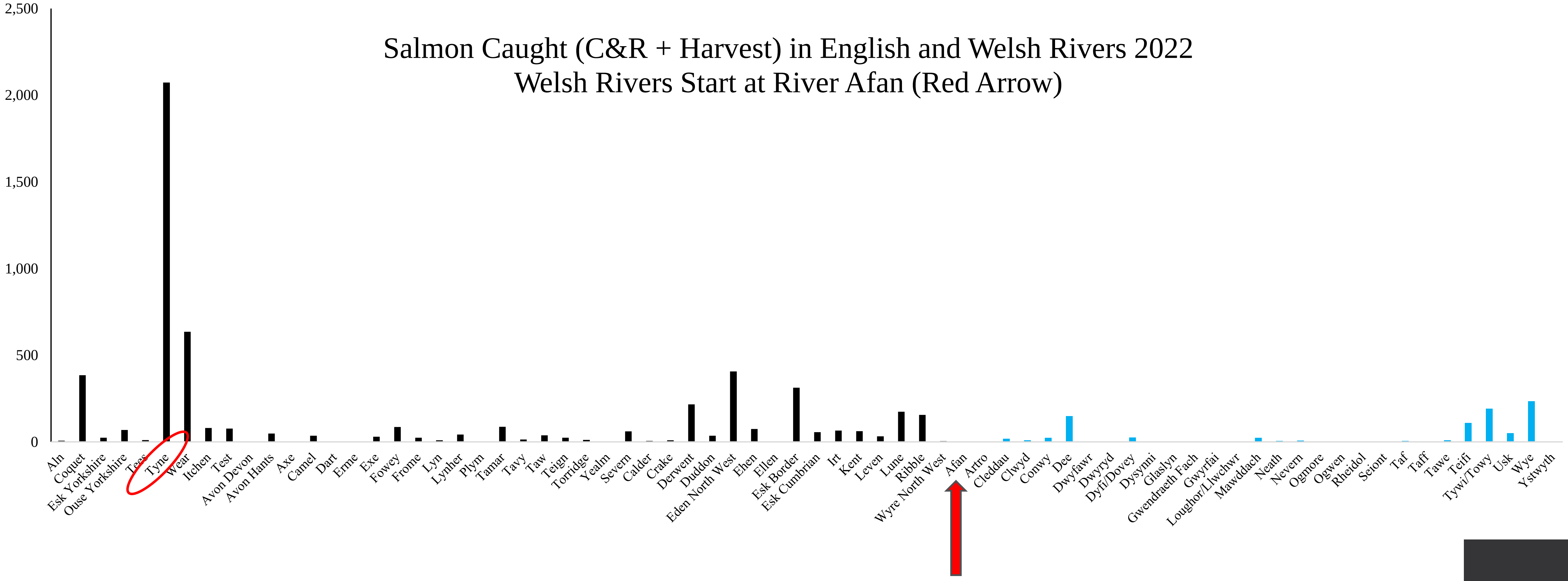
Rod Catch by River (2019)

Data Source: *Salmonid and Freshwater Fisheries Statistics for England and Wales, 2019 Version 1* (https://www.data.gov.uk)



Rod Catch by River (2022)

Data Source: *Salmonid and Freshwater Fisheries Statistics for England and Wales, 2022 Version 1* (https://www.data.gov.uk)



Interesting fact: Salmon nearly went extinct in the River Tyne in the 1950s (Milner et al. 2004)

A Hatchery Risk Conundrum?

The River Tyne

- Last remaining salmon hatchery in the UK (Kielder Hatchery for mandated dam mitigation)
- In 2022 the River Tyne was the **only river** out of the 64 Principal Salmon River stocks in England and Wales classified “not at risk”
- As of 2022 the Tyne is the **only river** projected to continue meeting its conservation status objective into 2027

Source: www.freeworldmaps.net

> It should be noted that rod catch trends on individual rivers have varied from much more severe declines to substantial recoveries (e.g., the River Tyne, where rod catch has increased considerably since the mid-1950s as the river recovered from industrial pollution, such that it contributed 32% of the total rod catch in England and Wales in 2022).

Salmon and Fisheries in England and Wales in 2022 (CEFAS, EA, NRW joint report)

Declaring a Salmon Emergency

4. Diagnosing the problems

The current 'salmonid emergency' has arisen against the backdrop of current management practices across many sectors, and it is therefore important that we determine where those practices need to change and how we bring that about.

Partner workshops

Between October and December 2019 NRW hosted special meetings of the Wales Fisheries Forum and all Local Fisheries groups. The many pressures identified are reported separately ('Note on stakeholder engagement: identifying the pressures on stocks', available from NRW), however the principal pressures that damage habitats and fish populations identified by all stakeholder groups were: -

- the damage to many of our rivers arising from agricultural pollution;
- the poor status of habitats in our rivers that constrains fish distribution and survival; and
- the unsustainable predation on impoverished juvenile salmonid populations by predatory birds. It was noted that predation is a natural phenomenon, but that this must be sustainable and potentially controlled when stocks are in very poor condition, as many are now.

Cyfoeth Naturiol Cymru
Natural Resources Wales

A PLAN OF ACTION FOR SALMON AND SEA TROUT IN WALES – TACKLING THE 'SALMONID EMERGENCY'

A Plan of Action for Salmon and Sea Trout in Wales – Tackling the 'Salmonid Emergency' (Natural Resources Wales 2020)

Tradeoffs

- If salmon & steelhead recovery is even possible it will <u>not</u> be achieved by limiting hatchery production
- There may be risks from the operation of hatcheries, but there are greater risks from habitat degradation, fragmented habitat, and increasing resource demands
- We must recognize hatcheries provide significant benefits:
  - Cultural
  - Economic
  - Recreational
  - Ecosystem benefits (prey, predator, marine-derived nutrients)
  - Population preservation
  - Reintroduction/recolonization
  - Buffering pinniped predation
  - Research, monitoring, and evaluation
- Recovery needs holistic, all-H approach – Not a focus strictly on harvest and hatcheries
- In many cases, hatchery production is required by law (e.g., dam mitigation) and court rulings (e.g., *U.S. v. Washington* proceedings)

Consequences to Us All

- Overt focus on theoretical hatchery impacts jeopardizes increased habitat restoration efforts and protection by misleading the public (the same is true for harvest)
  - Anti-hatchery advocates claim the opposite
  - No fishery benefits = no advocacy for resource protection
    - The black footed ferret scenario

- Small, rural economies reliant on fishing income have been harmed
- Recreational fishing culture harmed
- Tribal treaty rights and fishing culture harmed
- Too many consequences and the multitude of resulting repercussions

Questions & Answers