

# Alaska Hatchery Research Program:

A comprehensive approach to  
investigate hatchery/wild interactions

**International Year of the Salmon Synthesis Symposium**

**Hatching Plans: The Future of Fisheries Enhancement Programs**

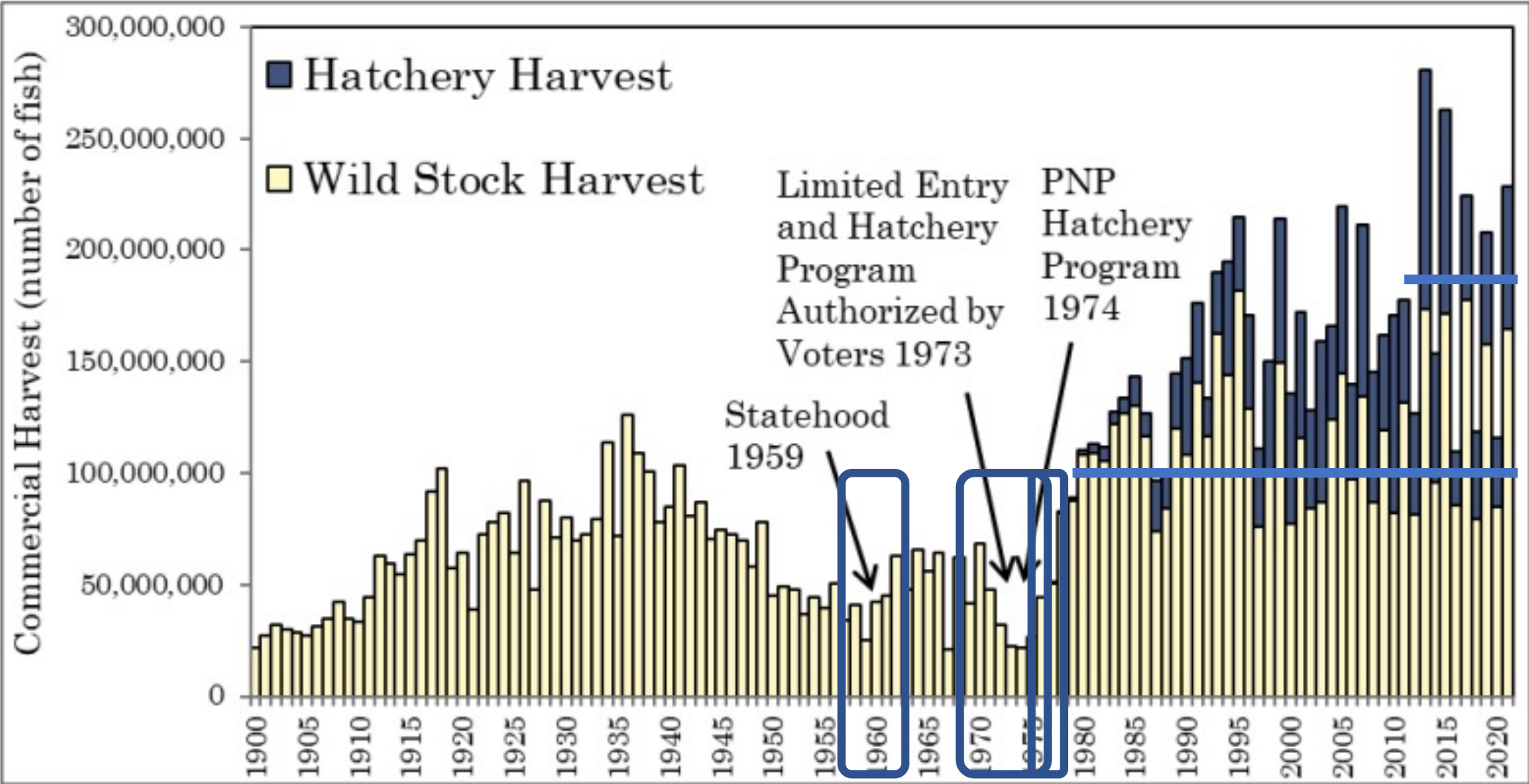
**Chris Habicht and Bill Templin  
Alaska Department of Fish and Game  
Division of Commercial Fisheries**



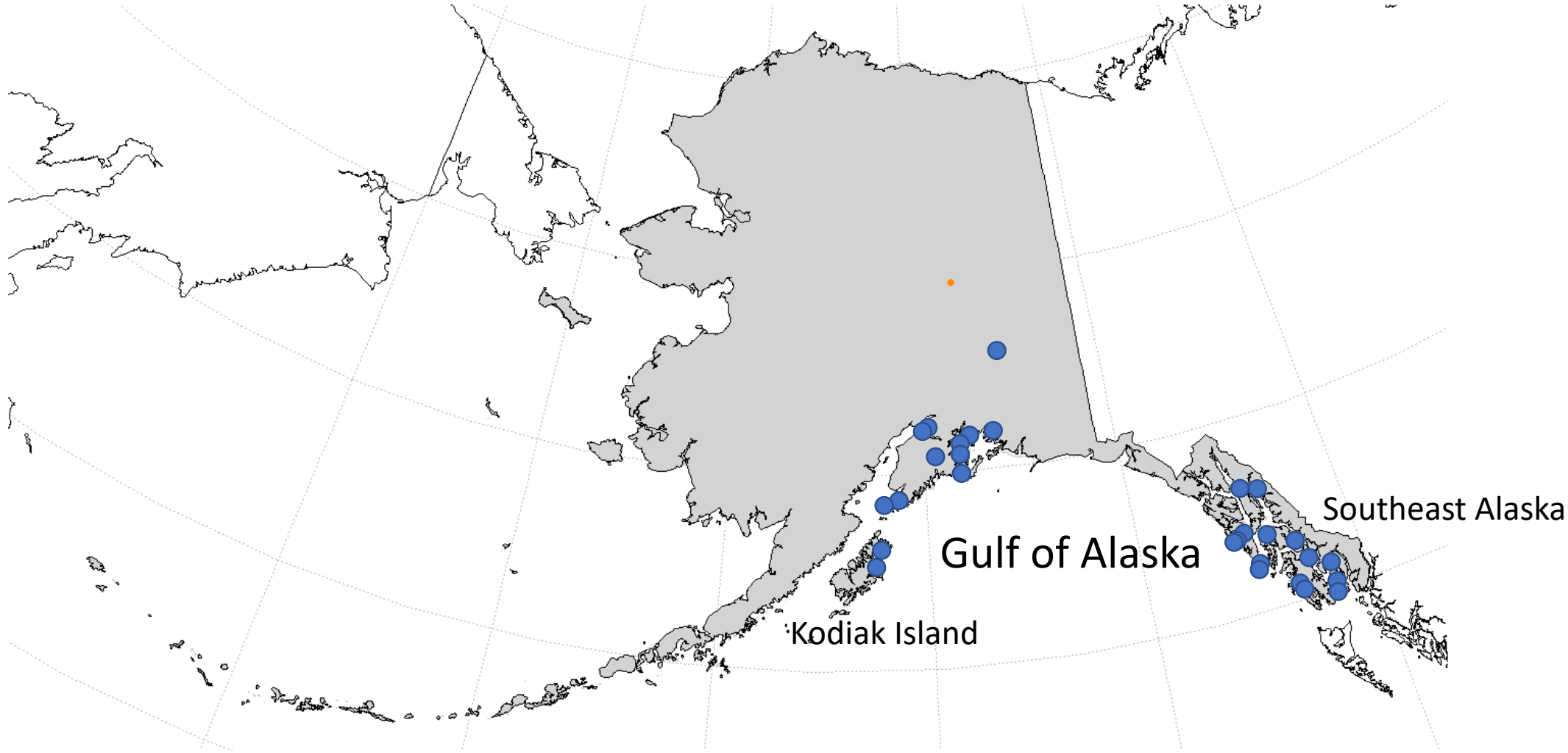
# Outline

- Background to study
- Components that led to a successful project
  - Assemble experts
  - Ask answerable questions
  - Adapt
  - Communicate
- Science and Policy

# Commercial salmon harvest in Alaska, 1900-2021



# Locations of Anadromous Pacific Salmon Hatcheries in Alaska



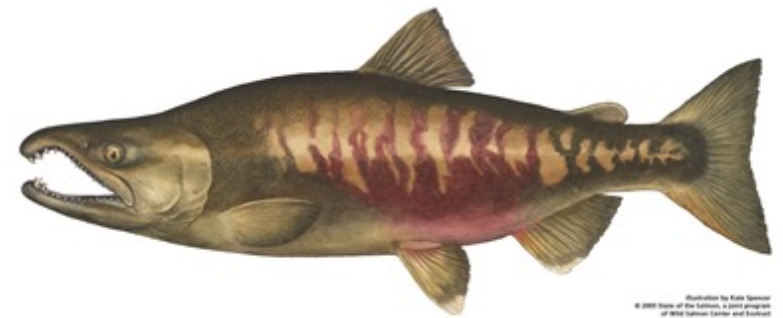
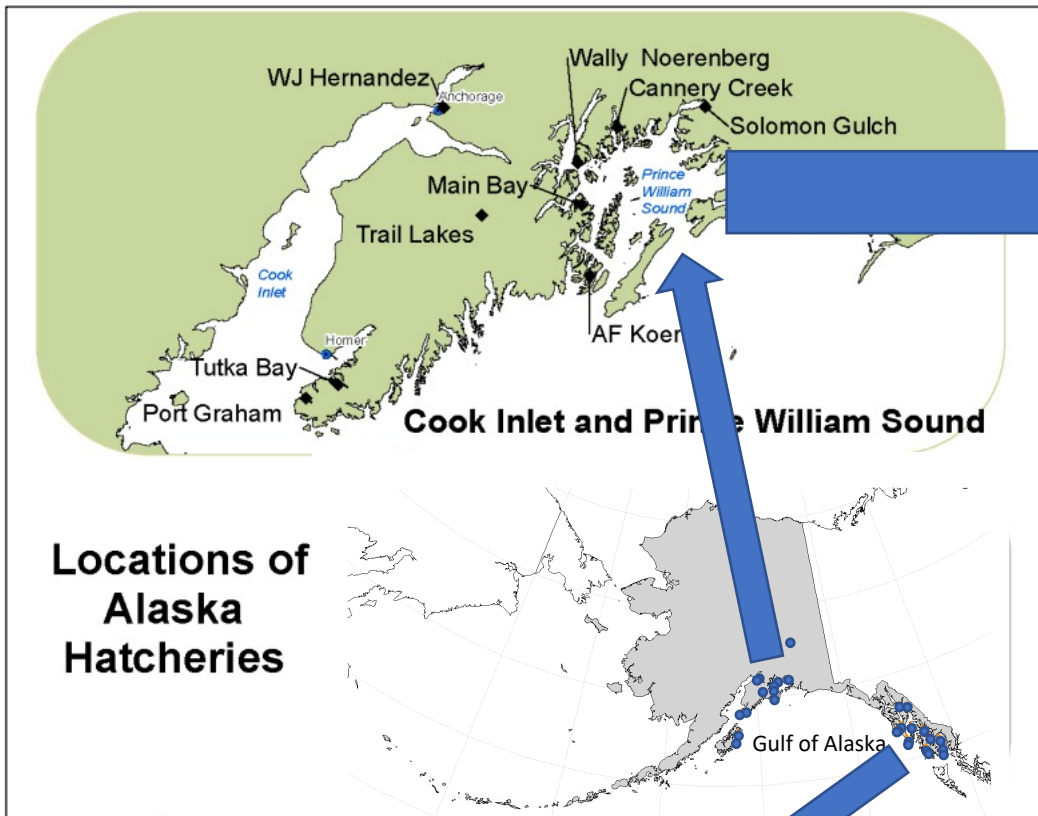
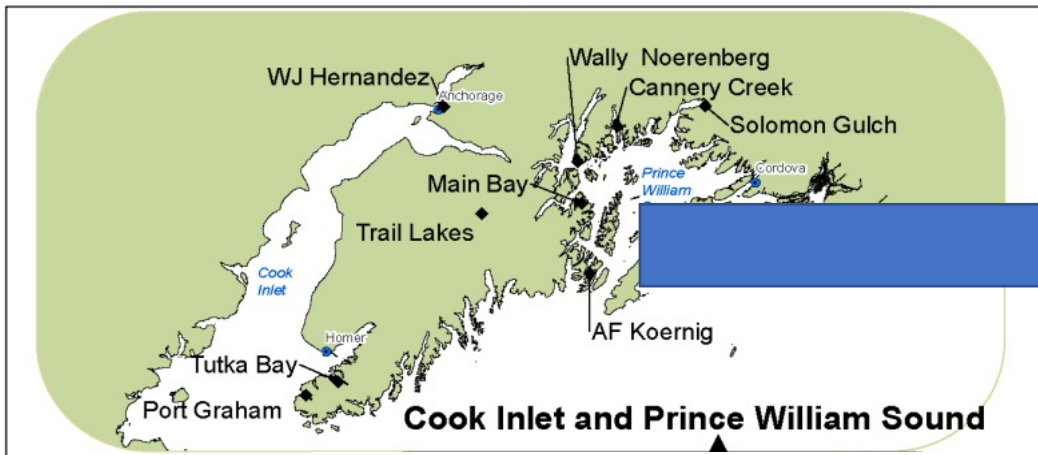


Figure 4.—Salmon hatcheries currently operating in Alaska.



**Locations of Alaska Hatcheries**

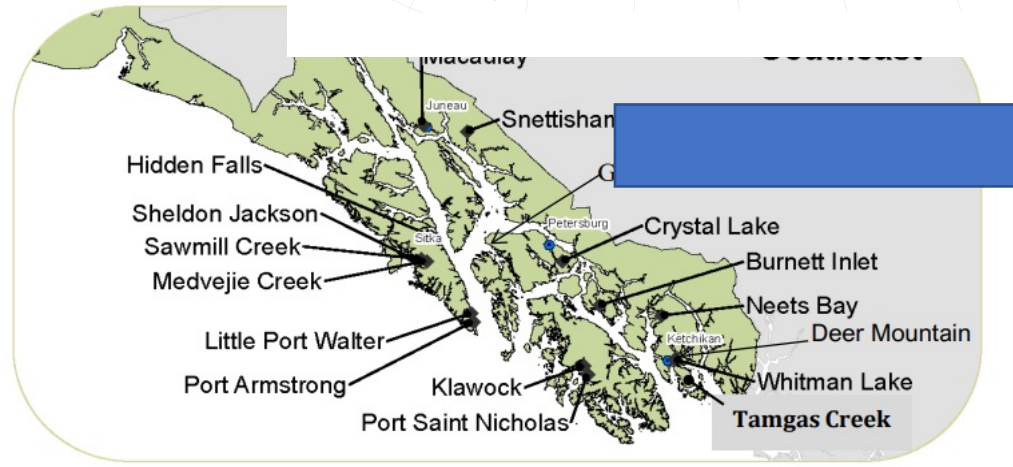
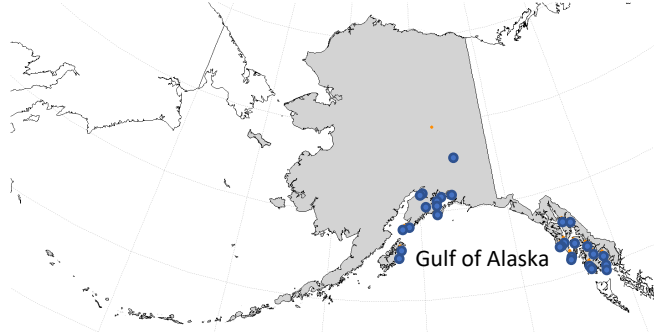


Figure 4.—Salmon hatcheries currently operating in Alaska.

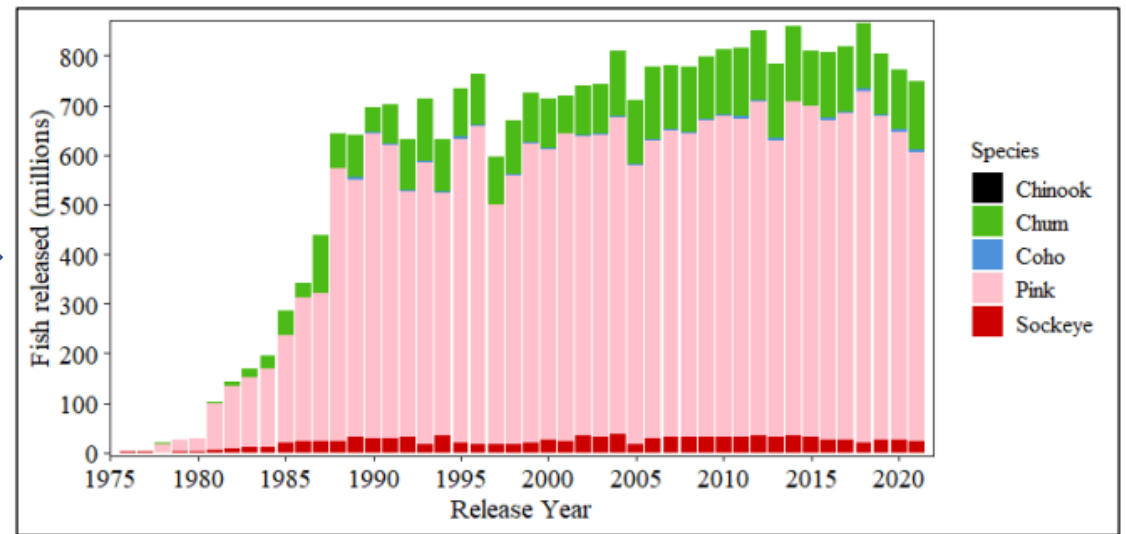


Figure 16.—Total salmon released for Prince William Sound Alaska hatchery programs, 1975–2021.

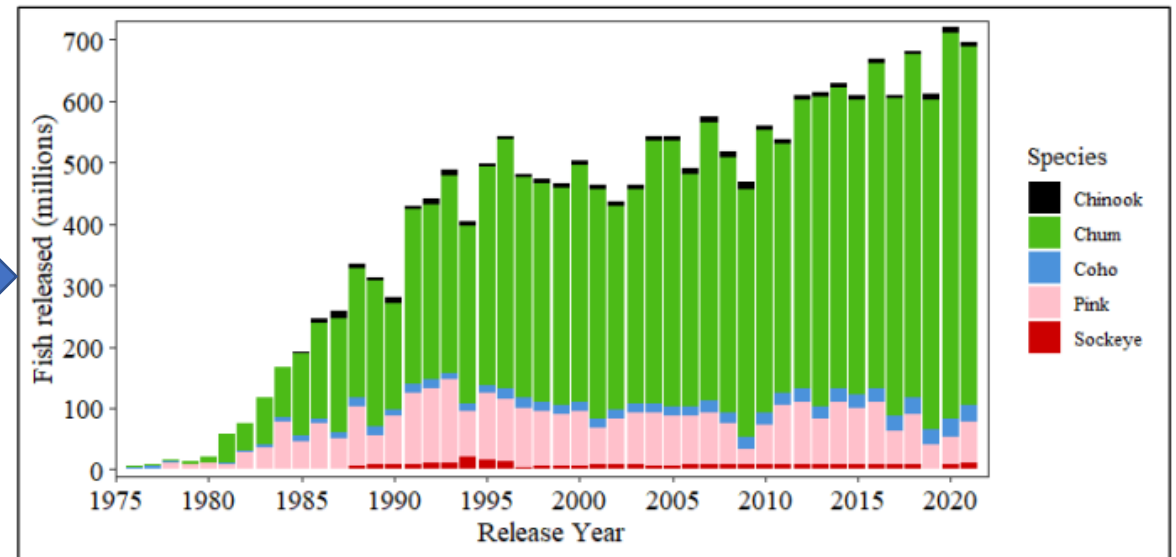


Figure 13.—Total salmon released for Southeast Alaska hatchery programs, 1975–2021.



# Published Hatchery/Natural Fitness Studies

## Steelhead

433

### Differential reproductive success of sympatric, naturally spawning hatchery and wild steelhead trout (*Oncorhynchus mykiss*) through the adult stage

Jennifer E. McLean, Paul Bentzen, and Thomas P. Quinn

## MOLECULAR ECOLOGY

Molecular Ecology (2011) 20, 1860–1869 doi: 10.1111/j.1365-294X.2011.03058.x

### Reduced reproductive success of hatchery coho salmon in the wild: insights into most likely mechanisms

YÉRONIQUE THÉRIAULT,\* GREGORY R. MOYER,<sup>†</sup> LAURA S. JACKSON,† MICHAEL S. BLOUIN‡ and MICHAEL A. BANKS\*

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

Hitoshi Araki,\* Becky Cooper, Michael S. Blouin

Pacific every year (7, 8). Although most of these hatchery programs are meant to produce fish for harvest, an increasing number of captive breeding programs are releasing fish to restore declining natural populations (6, 9). Hatchery fish bred in the wild, and many natural populations are affected by hatchery fish. The use of hatchery-reared fish as broodstock (parents of hatchery fish) for many generations has resulted in ind-

Molecular Ecology (2007) 16, 953–966 doi: 10.1111/j.1365-2006.01206.x

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

HITOSHI ARAKI,\* ROBIN S. WAPLES,† WILLIAM R. ARDREN,‡ BECKY COOPER,\* and MICHAEL S. BLOUIN\*

## biology letters

Conservation biology

with captive-bred organisms (supplementation) are not clear yet. Any negative effects of captive breeding are especially relevant for salmonid species because of the worldwide decline of native salmonid populations and the huge scale of hatchery programmes to compensate for those losses. Firstly, there is scant evidence that adding captive-bred organisms has boosted the long-term productivity of wild salmonid populations (Fraser 2008). Secondly, supplementation of declining wild populations entails risks such as disease introductions, increased competition for resources, and genetic changes in the supplemented population (Waples & Drake 2004). The genetic risk results because artificial environments can select for captive-bred individuals that are maladapted to the natural environment (hereafter 'the wild'). For example, genetically-based

### Carry-over effect of captive breeding reduces reproductive fitness of wild-born descendants in the wild

Hitoshi Araki<sup>1</sup>, Becky Cooper and Michael S. Blouin

## Transactions of the American Fisheries Society

Publication details, including instructions for authors and subscription information: <http://www.tandfonline.com/loi/taf2>

### Diminished Reproductive Success of Steelhead from a Hatchery Supplementation Program (Little Sheep Creek, Imnaha Basin, Oregon)

Evans A. Bertson\*, Richard W. Carmichael<sup>†</sup>, Michael W. Flesher<sup>‡</sup>, Eric J. Ward<sup>§</sup> & Paul Moran<sup>¶</sup>

### Genetic adaptation to captivity can occur in a single generation

Mark R. Christie<sup>1</sup>, Melanie L. Marline<sup>1</sup>, Rod A. French<sup>2</sup>, and Michael S. Blouin<sup>1</sup>

<sup>1</sup>Department of Zoology, Oregon State University, Corvallis, OR 97331-2934, and <sup>2</sup>Oregon Department of Fish and Wildlife, The Dalles, OR 97058-4364

Edited by Fred W. Allendorf, University of Montana, Missoula, MT, and accepted by the Editorial Board November 11, 2011 (received for review July 14, 2011)

Captive breeding programs are widely used for the conservation and restoration of threatened and endangered species. Nevertheless, captive-born individuals frequently have reduced fitness when

have a high standing mutational load or spend many generations in captivity (9). Unintentional domestication selection, on the other hand, can rapidly reduce fitness in the wild, especially if

## Chinook

North American Journal of Fisheries Management 28:1472–1485, 2008  
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DOI: 10.1577/M07-109.1

[Article]

### Use of Parentage Analysis to Determine Reproductive Success of Hatchery-Origin Spring Chinook Salmon Outplanted into Shitike Creek, Oregon

JASON BAUMSTEGER<sup>1</sup>

U.S. Fish and Wildlife Service, 1440 Abernathy Creek Road, Longview, Washington 98622, USA

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ROBERT SPATEBOELTS<sup>2</sup> AND GEOFF FITZGERALD<sup>3</sup>

Confederated Tribes of the Warm Springs Reservation of Oregon, Department of Natural Resources, Warm Springs, Oregon 97791, USA

WILLIAM R. ARDREN<sup>4</sup>

U.S. Fish and Wildlife Service, Abernathy Fish Technology Center, 1440 Abernathy Creek Road, Longview, Washington 98622, USA

10.1577/M07-109.1

1840

### Factors influencing the relative fitness of hatchery and wild spring chinook salmon (*Oncorhynchus tshawytscha*) in the Wenatchee River, Washington, USA

Kevin S. Williamson, Andrew R. Murdoch, Todd N. Pearsons, Eric J. Ward, and Michael J. Ford

## MOLECULAR ECOLOGY

Molecular Ecology (2012) 21, 5236–5250 doi: 10.1111/j.1365-2006.01206.x

### 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,<sup>†</sup> JASON L. VOGEL,<sup>‡</sup> JEFF J. STEPHENSON,\* DOUG D. NELSON<sup>†</sup> and SHAWN R. NARUM<sup>†</sup>

## Evolutionary Applications

Evolutionary Applications ISSN 1752-4571

### Reproductive success of captive bred and naturally spawned Chinook salmon colonizing newly accessible habitat

Joseph H. Anderson,<sup>1,2</sup> Paul L. Faulds,<sup>2</sup> William I. Atlas<sup>1,4</sup> and Thomas P. Quinn<sup>1</sup>

<sup>1</sup> School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA, USA  
<sup>2</sup> Seattle Public Utilities, Seattle, WA, USA  
<sup>3</sup> Present address: Northwest Fisheries Science Center, National Marine Fisheries Service, Seattle, WA, USA  
<sup>4</sup> Present address: Department of Biological Sciences, Simon Fraser University, Burnaby, BC, Canada

**Keywords:** conservation, dams, hatchery, natural selection, pedigrees, reintroduction, sexual selection

**Abstract:** Captively reared animals can provide an immediate demographic boost in reintroduction programs, but may also reduce the fitness of colonizing populations. Construction of a fish passage facility at Landsburg Diversion Dam on the Cedar River, WA, USA, provided a unique opportunity to explore this trade-off. We thoroughly sampled adult Chinook salmon (*Oncorhynchus tshawytscha*) at the onset of colonization (2003–2009), constructed a pedigree from genotypes at 10 microsatellite loci, and calculated reproductive success (RS) as the total number of returning adult offspring. Hatchery males were consistently but not significantly less productive than naturally spawned males (range in relative RS: 0.70–0.90), but the pattern for females varied between years. The sex ratio was heavily biased toward males; therefore, inclusion of the hatchery males increased the risk of a genetic fitness cost with little demographic benefit. Measurements of natural selection indicated that larger salmon had higher RS than smaller fish. Fish that arrived early to the spawning grounds tended to be more productive than later fish, although in some years, RS was maximized at intermediate dates. Our results underscore the importance of natural and sexual selection in promoting adapta-

## Coho

2343

### Changes in run timing and natural smolt production in a naturally spawning coho salmon (*Oncorhynchus kisutch*) population after 60 years of intensive hatchery supplementation

Michael J. Ford, Howard Fuss, Brant Boeltis, Eric LaHood, Jeffrey Hard, and Jason Miller

## MOLECULAR ECOLOGY

Molecular Ecology (2011) 20, 1860–1869 doi: 10.1111/j.1365-294X.2011.03058.x

### Reduced reproductive success of hatchery coho salmon in the wild: insights into most likely mechanisms

YÉRONIQUE THÉRIAULT,\* GREGORY R. MOYER,<sup>†</sup> LAURA S. JACKSON,† MICHAEL S. BLOUIN‡ and MICHAEL A. BANKS\*

<sup>1</sup>Central Oregon Interagency Station, Hatfield Marine Science Center, Department of Fisheries and Wildlife, Oregon State University, 2030 SE Marine Science Drive, Newport, OR 97365, USA, <sup>2</sup>Oregon Department of Fish and Wildlife, 4192 N Unqua Highway, Roseburg, OR 97470, USA, <sup>3</sup>Department of Zoology, 3029 Cordley Hall, Oregon State University, Corvallis, OR 97331, USA

**Abstract:** Supplementation of wild salmonids with captive-bred fish is a common practice for both commercial and conservation purposes. However, evidence for lower fitness of captive-reared fish relative to wild fish has accumulated in recent years, diminishing the apparent effectiveness of supplementation as a management tool. To date, the mechanisms responsible for these fitness declines remain unknown. In this study, we showed with molecular parentage analysis that hatchery coho salmon (*Oncorhynchus kisutch*) had lower reproductive success than wild fish once they reproduced in the wild. This effect was more pronounced in males than in same-aged females. Hatchery spawned fish that were released as unfed fry (age 0), as well as hatchery fish raised for one year in the hatchery (released as smolts, age 1), both experienced lower lifetime reproductive success (RS) than wild fish. However, the subset of hatchery males that returned as 2-year olds (jacks) did not exhibit the same fitness decrease as males that returned as 3-year olds. Thus, we report three lines of evidence pointing to the absence of sexual selection in the hatchery as a contributing mechanism for fitness declines of hatchery fish in the wild: (i) hatchery fish released as unfed fry that survived to adulthood still had low RS relative to wild fish, (ii) age-1 male hatchery fish consistently showed a lower relative RS than female hatchery fish (suggesting a role for sexual selection), and (iii) age-2 jacks, which use a sneaker mating strategy, did not show the same declines as 3-year olds, which compete differently for females (again, implicating sexual selection).

**Keywords:** captive breeding, parentage analysis, reproductive success, salmonids, sexual selection, supplementation

Received 20 January 2010; revision received 14 January 2011; accepted 18 January 2011

## Chum

781

### Reproductive behavior and relative reproductive success of natural- and hatchery-origin Hood Canal summer chum salmon (*Oncorhynchus keta*)

Barry A. Berejikian, Donald M. Van Doornik, Julie A. Scheurer, and Richard Bush

**Abstract:** Estimates of the relative fitness of hatchery- and natural-origin salmon can help determine the value of hatchery stocks in contributing to recovery efforts. This study compared the adult to fry reproductive success of natural-origin summer chum salmon (*Oncorhynchus keta*) with that of first- to third-generation hatchery-origin salmon in an experiment that included four replicate breeding groups. Hatchery- and natural-origin chum salmon exhibited similar reproductive success. Hatchery- and natural-origin males obtained similar access to nesting females, and females of both types exhibited similar breeding behavior and duration. Male body size was positively correlated with access to nesting females and reproductive success. The estimates of relative reproductive success (hatchery/natural = 0.83) in this study were similar to those in other studies of other anadromous salmonids in which the hatchery population was founded from the local natural population or much earlier than those in studies that evaluated the lifetime relative reproductive success of local hatchery populations.

# Hatchery/Natural Fitness

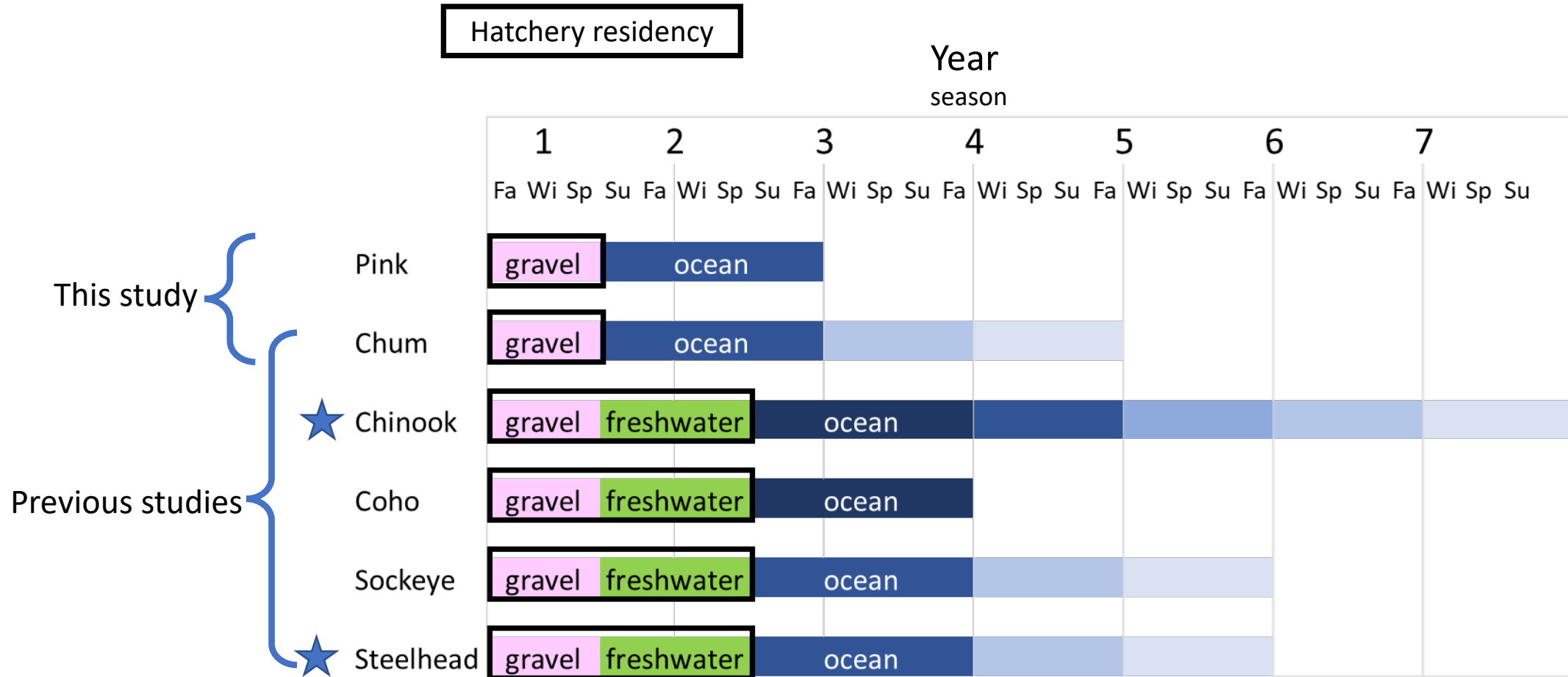
## Difficulty with Applying Previous Studies

- No studies in Alaska
- Different Context: e.g., compromised habitats
- Non-local and small brood stock population sizes
- Different hatchery objectives (harvest vs mitigation)
- Species with different life histories



# Hatchery/Natural Fitness

## Different Time in Hatchery Setting

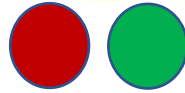


# Assemble Experts: Science Panel for the Alaska Hatchery Research Program

Members since inception



John H. Clark



Government (state, federal)



Industry (hatcheries, processors)



University

Past members



Added members





# Planning: Funding for the Alaska Hatchery Research Program



Anticipated total:  
\$16.9M



# Ask Answerable Questions

The Panel raised three priority questions:

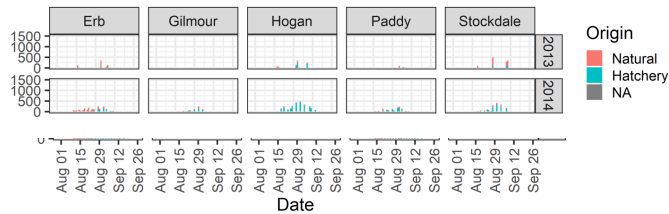
1. What is the genetic stock structure of pink and chum salmon in each region?
2. What is the extent and annual variability in straying of hatchery pink salmon in Prince William Sound (PWS) and chum salmon in PWS and Southeast Alaska (SEAK)?
3. What is the impact on fitness (productivity) of wild pink and chum salmon stocks due to straying of hatchery pink and chum salmon?



# Adapting: Nature did not get the memo, so program adapted

Augmented:

Field data: Lots of variation

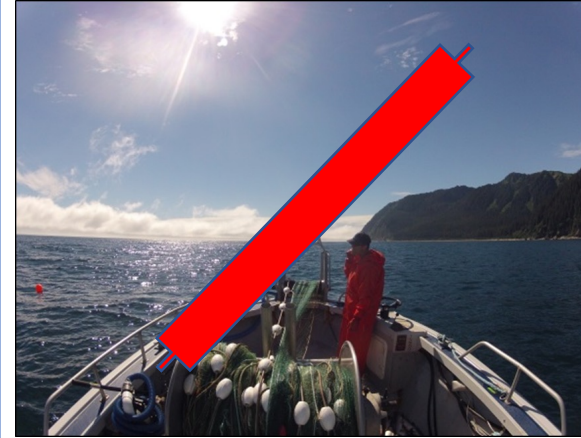


Sample all fish possible



Reduced:

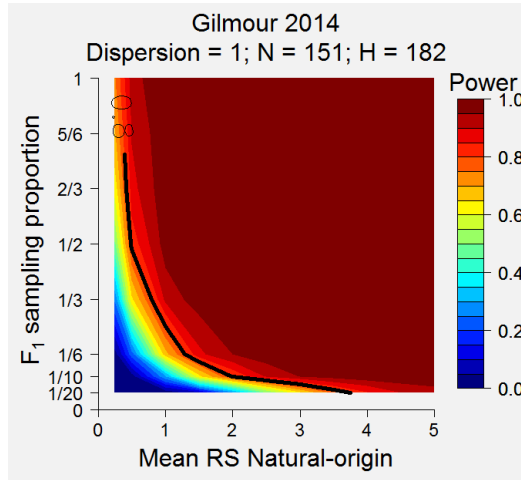
Run reconstruction/  
stray assessment



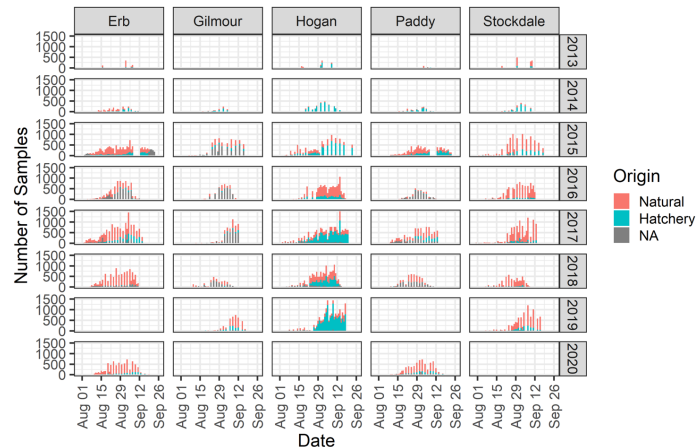
Fitness



Power analysis: need more samples



More years: grand parentage



Eliminated alevin sampling



Figure 17. Redd pumping on Stockdale Creek, April, 2014.

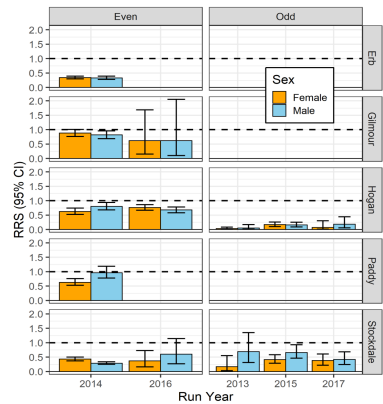
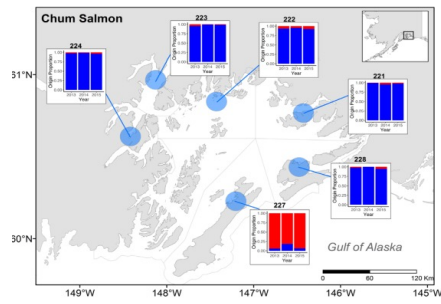
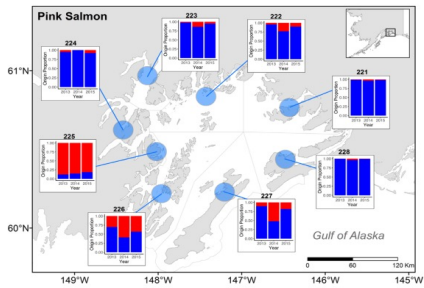
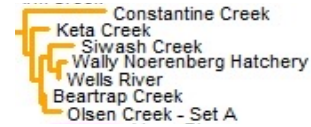
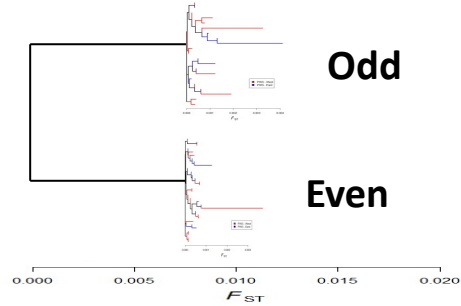


# Findings:

## Prince William Sound

Pink

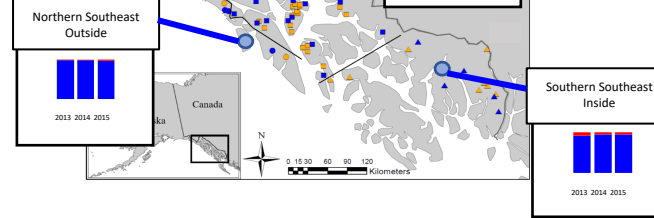
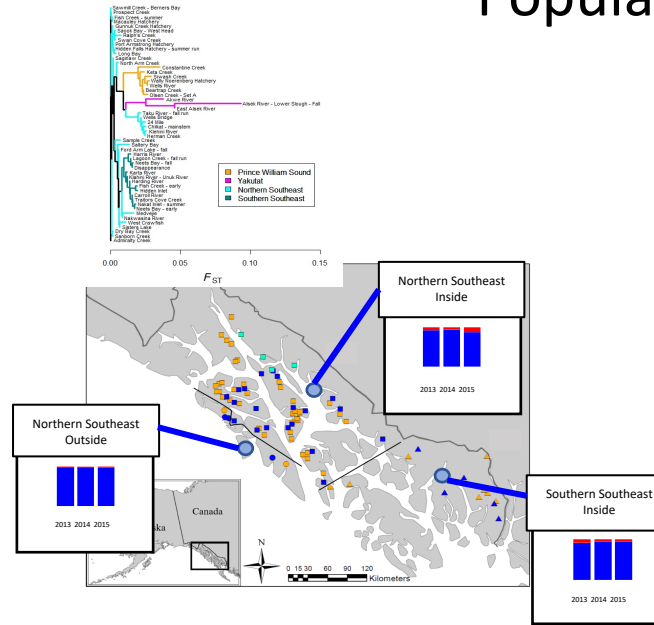
Chum



NA

## Southeast Alaska

Chum



TBA

## Population structure exists:

PWS	pink: even < odd;
SEAK	chum: run timing, geography
SEAK	chum: summer/fall, geography

## Hatchery fish found in streams:

PWS	pink: 5% - 15%;
	chum: 3% - 9%
SEAK	chum: 2% - 8%

## Hatchery fish have lower fitness (productivity)

PWS	pink: high variation; 50% RRS average
SEAK	chum: TBA

Knudsen, E.E., Rand, P.S., Gorman, K.B., Bernard, D.R. and Templin, W.D., 2021. Hatchery-origin stray rates and total run characteristics for Pink Salmon and Chum Salmon returning to Prince William Sound, Alaska, in 2013–2015. *Marine and Coastal Fisheries*, 13(1), pp.41-68.

Josephson, R., Wertheimer, A., Gaudet, D., Knudsen, E.E., Adams, B., Bernard, D.R., Heintz, S.C., Piston, A.W. and Templin, W.D., 2021. Proportions of hatchery fish in escapements of summer-run Chum Salmon in Southeast Alaska, 2013–2015. *North American Journal of Fisheries Management*, 41(3), pp.724-738.

Shedd, K.R., Lescak, E.A., Habicht, C., Knudsen, E.E., Dann, T.H., Hoyt, H.A., Prince, D.J. and Templin, W.D., 2022. Reduced relative fitness in hatchery-origin Pink Salmon in two streams in Prince William Sound, Alaska. *Evolutionary applications*, 15(3), pp.429-446.

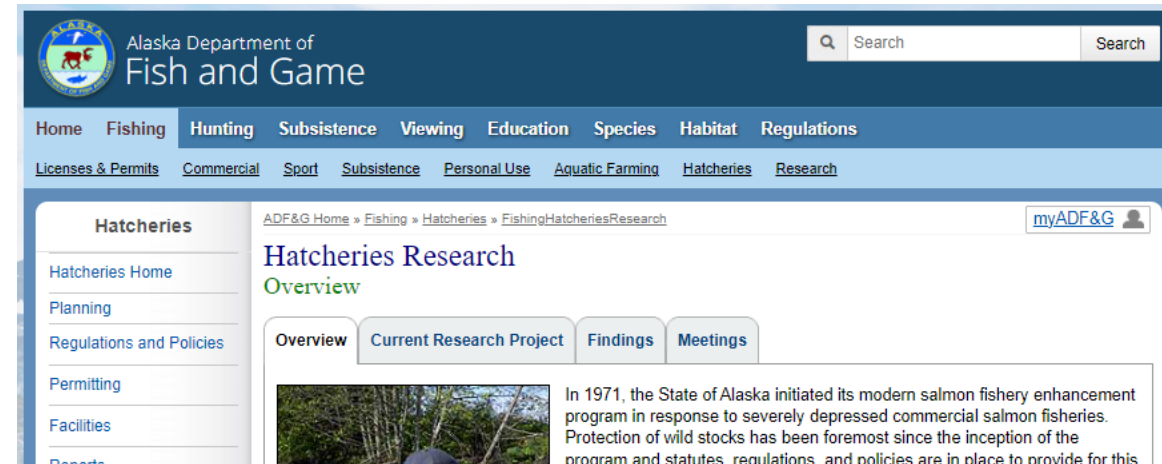
# Communicating: Public and professional contexts



ORIGINAL ARTICLE |  Open Access |  






## Reduced relative fitness in hatchery-origin Pink Salmon in two streams in Prince William Sound, Alaska

Kyle R. Shedd , Emily A. Lescak, Christopher Habicht, E. Eric Knudsen, Tyler H. Dann, Heather A. Hoyt, Daniel J. Prince, William D. Templin



<https://www.adfg.alaska.gov/index.cfm?adfg=fishingHatcheriesResearch.main>

North American Journal of Fisheries Management

Article |  Open Access |    

## Proportions of Hatchery Fish in Escapements of Summer-Run Chum Salmon in Southeast Alaska, 2013–2015

Ronald Josephson , Alex Wertheimer, David Gaudet, E. Eric Knudsen, Benjamin Adams, David R. Bernard, Steven C. Heinl, Andrew W. Piston, William D. Templin

Marine and Coastal Fisheries  
Dynamics, Management, and Ecosystem Science

Featured Paper |  Open Access |  

## Hatchery-Origin Stray Rates and Total Run Characteristics for Pink Salmon and Chum Salmon Returning to Prince William Sound, Alaska, in 2013–2015

E. Eric Knudsen , Peter S. Rand, Kristen B. Gorman, David R. Bernard, William D. Templin

# Application of Science to Policy

The AHRP is providing valuable biological information for understanding the interaction between hatchery and wild pink and chum salmon.

- Scientifically answerable questions
- Appropriate study design

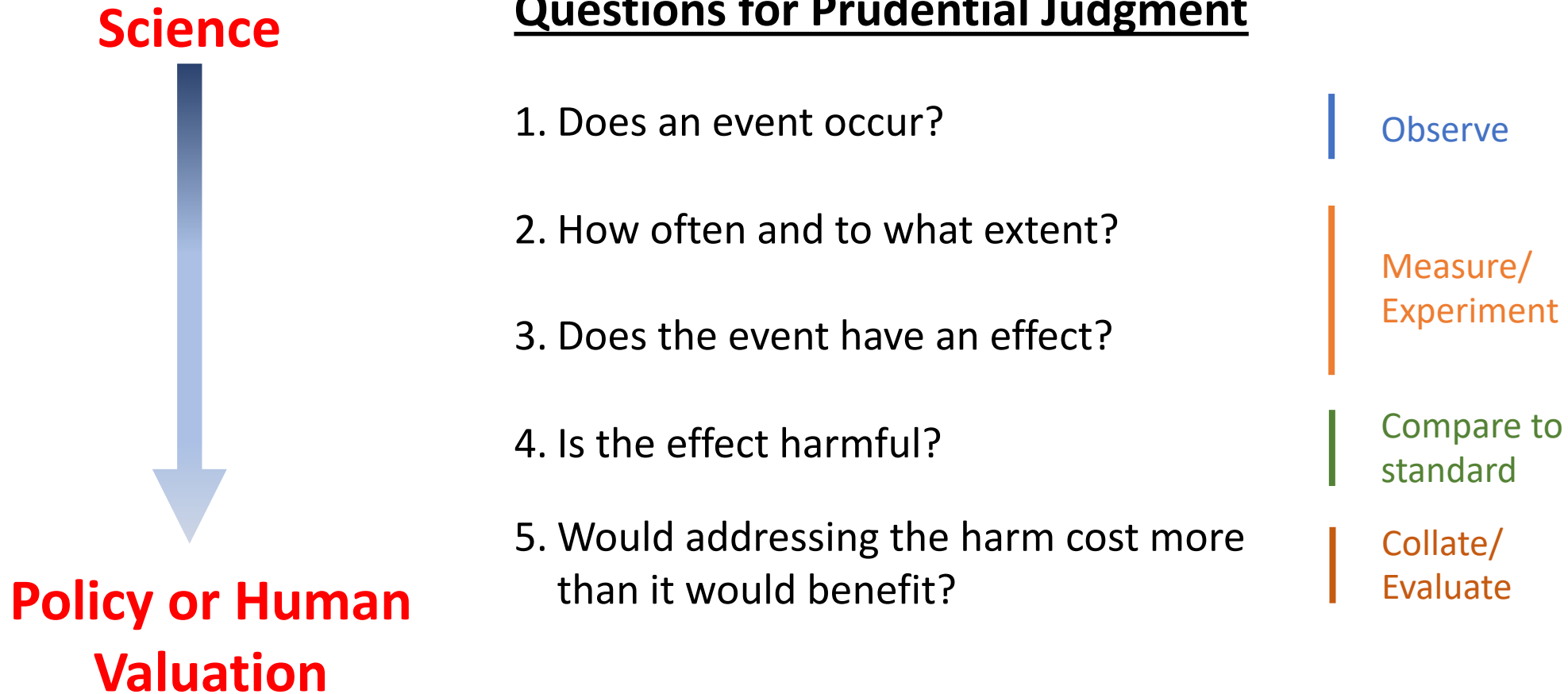
However, more than biology must be considered when making decisions about salmon resources:

1) Biological, 2) Social, 3) Economic, and 4) Cultural

**The interface of science and policy is where scientific knowledge is incorporated into belief/value systems to provide a bridge for decision making.**

# Application of Science to Policy

## Proposed Model for Science – Policy Dialogue



# Application of Science to Policy

## Example Application

**Science**



**Policy or Human  
Valuation**

### Issue: PWS pink salmon hatchery fish spawning in streams

1. Are hatchery pink salmon spawning in streams in Prince William Sound? **YES**
2. Which streams have spawning hatchery pink salmon and how many are present? **Streams near hatcheries, and 5% – 15%**
3. Does the presence of spawning hatchery pink salmon have an effect on wild pink salmon populations? **Yes, for short-term production; Maybe, for other definitions of “effect”**
4. Is the effect of hatchery-origin pink salmon spawning with wild pink salmon harmful? **Maybe; requires definition of harm and the mechanism**
5. Would the cost to restrain hatchery-origin pink salmon from spawning in streams outweigh the benefit from reducing the interaction? **Maybe; what is the cost relative to the benefit?**



# Proposed Path Forward

## Need:

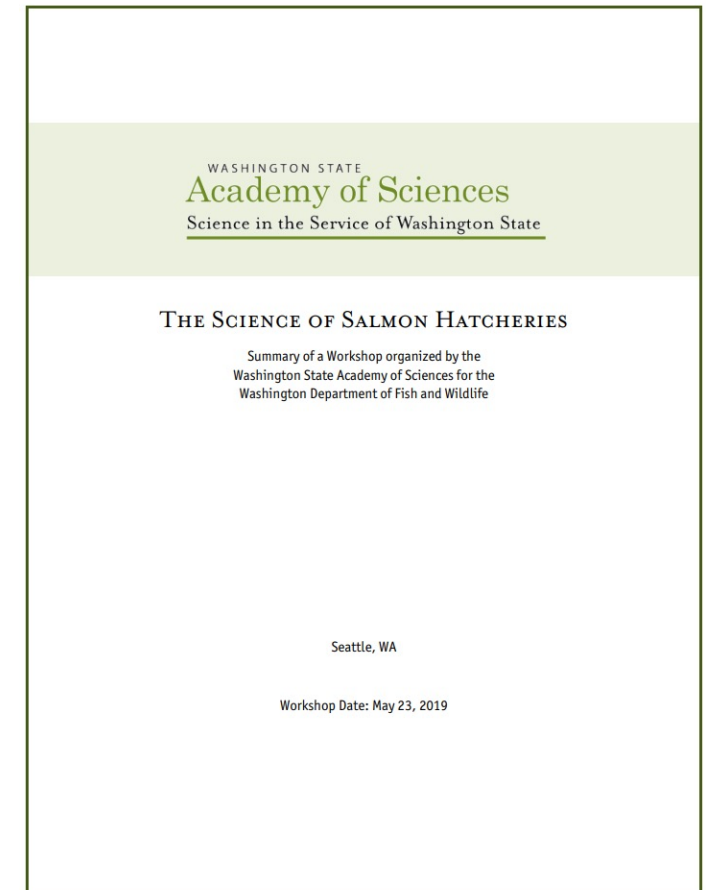
1. More pink salmon fitness results expected in next couple of years
2. Chum salmon fitness results pending
3. Questions 4 & 5 require definitions of **harm**, **cost** and **benefit** and the means to weigh them

Proposal: Convene a working group of agency staff, stakeholders and subject matter experts to:

1. Review current state of knowledge
2. Identify issues, concerns, and data needs
3. Develop framework for risk/benefit assessment
4. Provide ADF&G with recommendations

## Implementation Needs:

1. Define scope
2. Identify facilitator group
3. Seek funding







Questions?

07.30.2014