Research Update: Potential Hatchery Effects on Natural Systems

A Presentation to the House Fisheries Special Committee

March 14, 2023

Alaska Department of Fish and Game

Bill Templin

Outline for Presentation

1. Responsibility and Mission
2. Alaska's Hatchery Program
3. Alaska Hatchery Research Program - Hatchery/Wild Interactions Study
4. Application of Science
5. Pink Salmon and Competition at Sea

1. Responsibility and Mission

Constitutional Provision for Sustained Yield

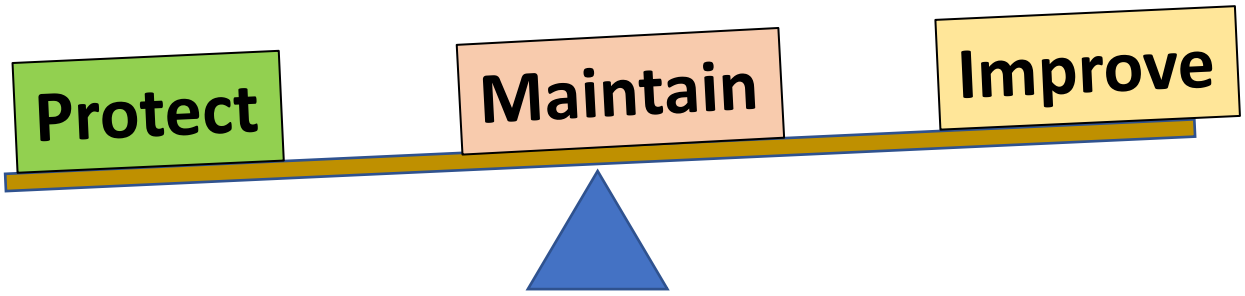
Article VIII, Sec(4). Fish, forests, wildlife, grasslands, and all other replenishable resources belonging to the State shall be utilized, developed, and maintained on the sustained yield principle, subject to preferences among beneficial uses.

1. Responsibility and Mission

Alaska Department of Fish and Game Mission Statement

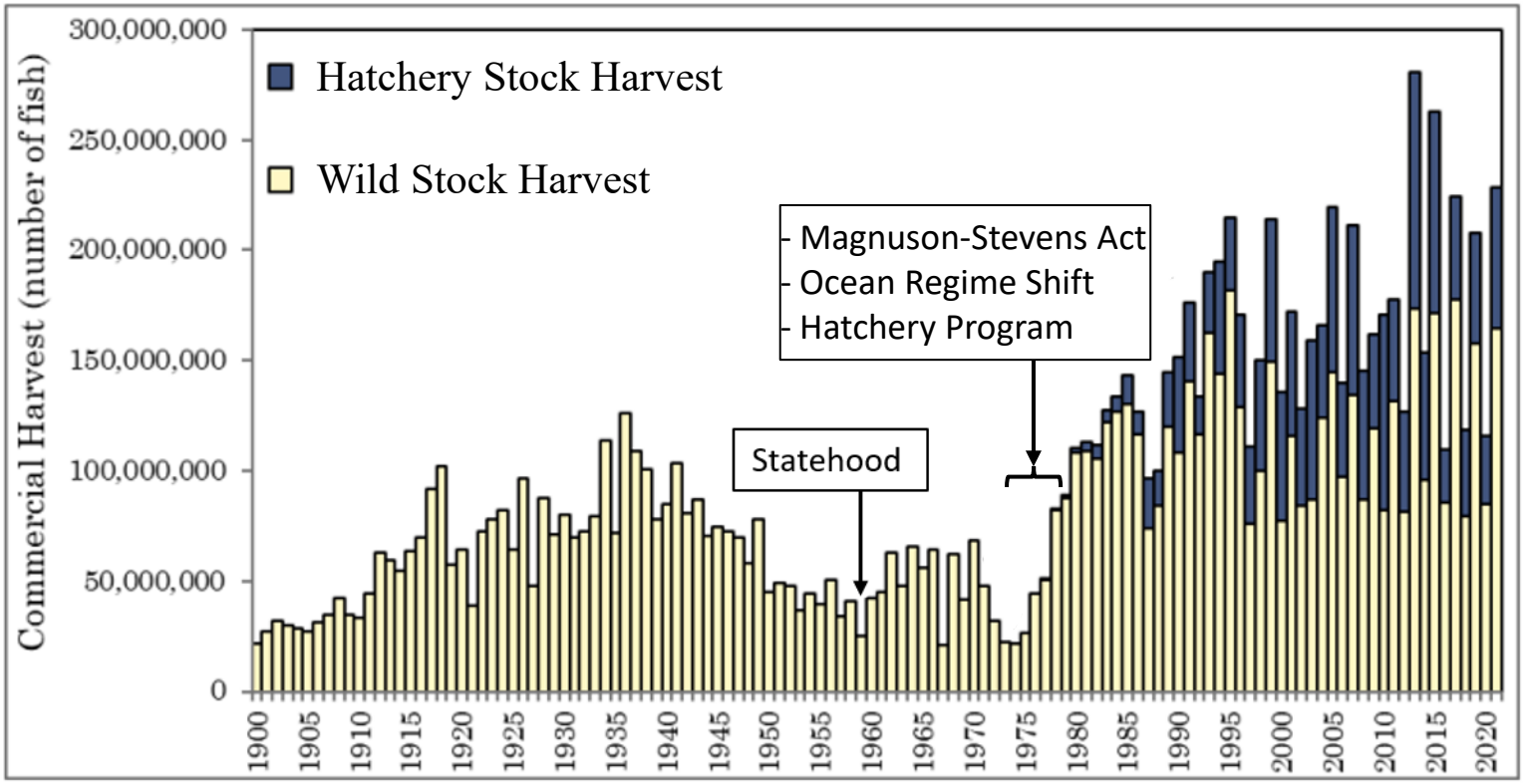
To protect, maintain, and improve the fish, game, and aquatic plant resources of the state, and manage their use and development in the best interest of the economy and the well-being of the people of the state, consistent with the sustained yield principle.

Management Equilibrium



2. Alaska's Hatchery Program

Commercial salmon harvest in Alaska, 1900-2021

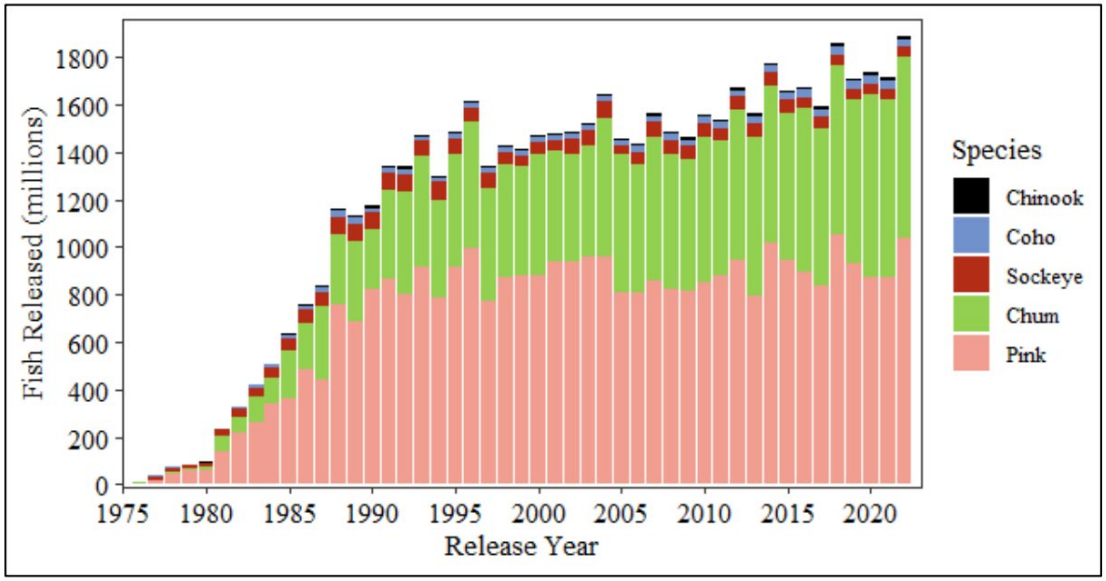


- Hatcheries began making substantial contributions to harvest in 1980's
- Hatcheries produced ~30% of the harvest, 2009-2021
- Hatchery production is most the harvest of pink and chum salmon in PWS and chum salmon in SEAK

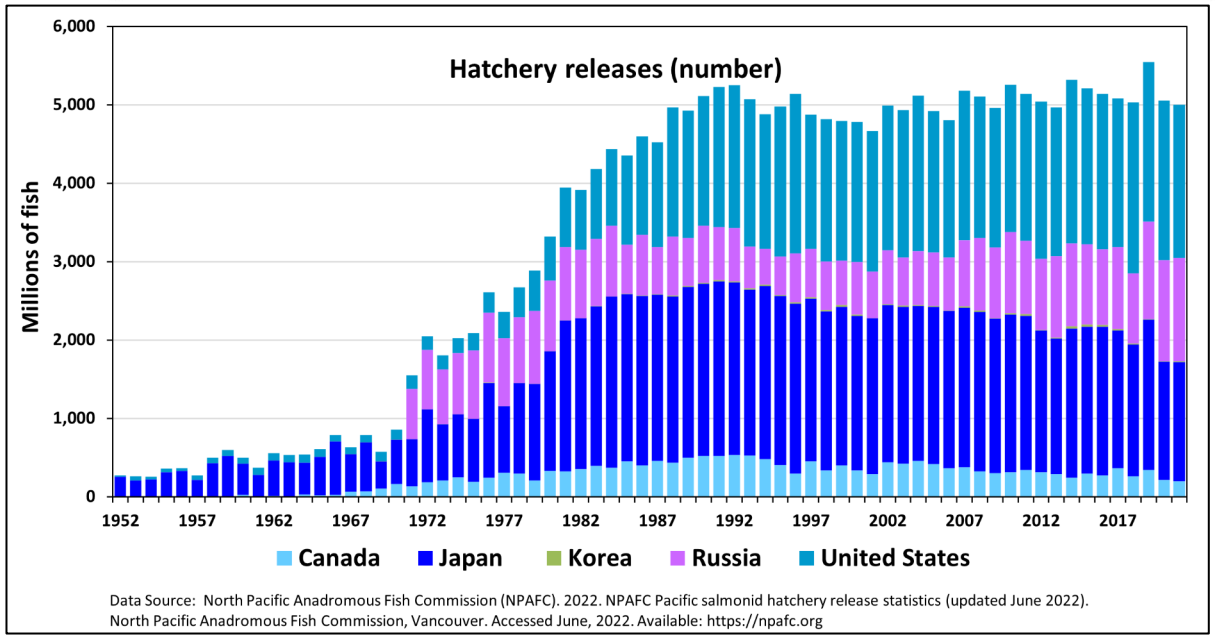
Wilson, L. 2022. Alaska salmon fisheries enhancement annual report 2021. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 5J22-02, Juneau.

2. Alaska's Hatchery Program

Alaska hatchery releases by species, 1976-2022



Increasing international hatchery releases, 1952-2021, coincides with developing production in Alaska



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3. AHRP - Hatchery/Wild Interactions

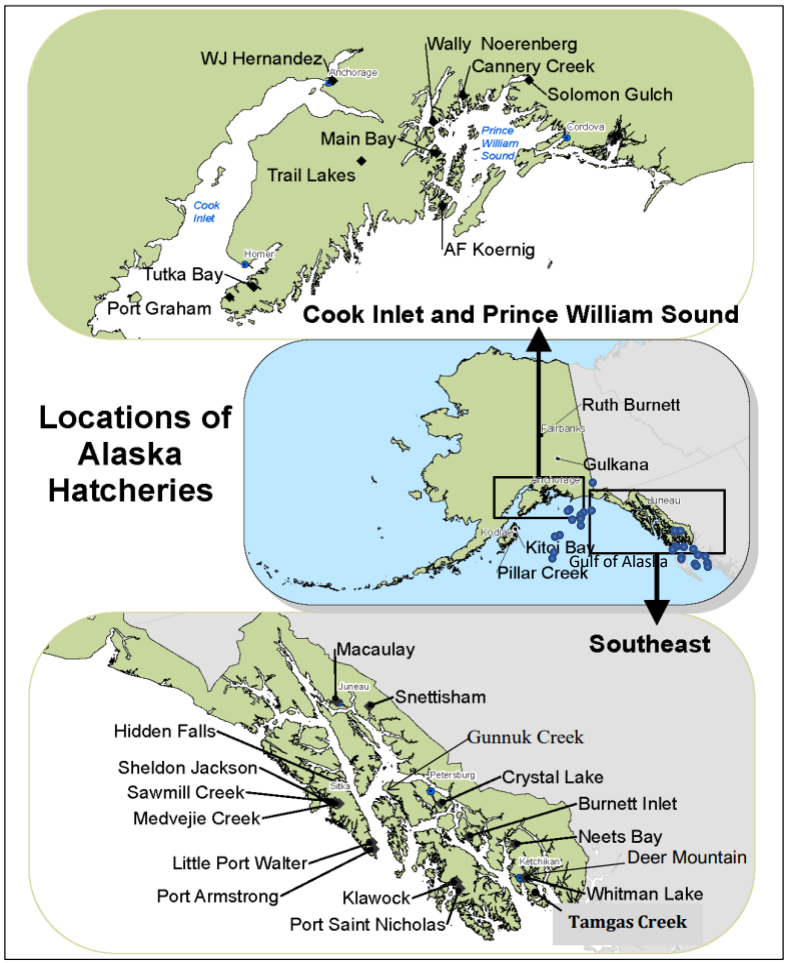


Figure 4.–Salmon hatcheries currently operating in Alaska.

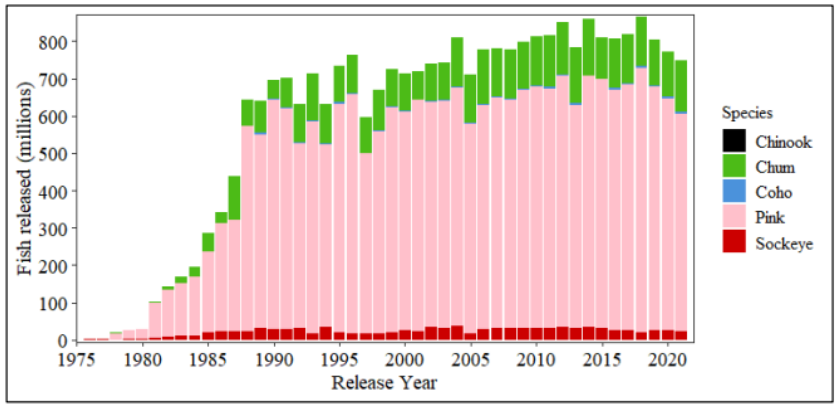


Figure 16.–Total salmon released for Prince William Sound Alaska hatchery programs, 1975–2021.

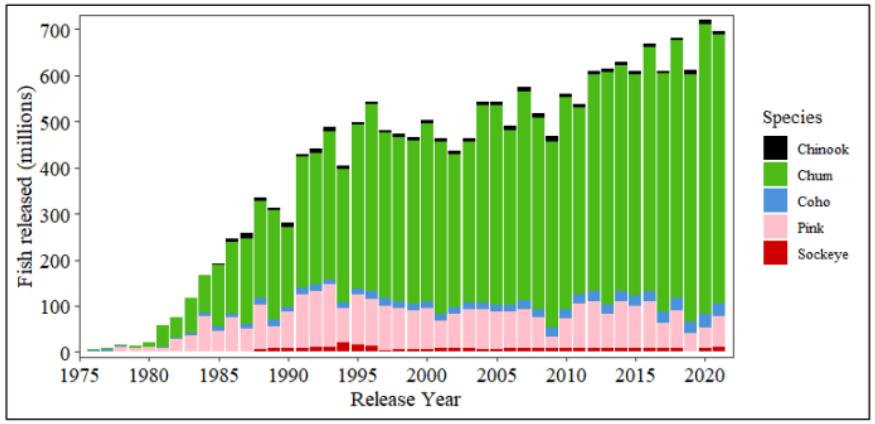


Figure 13.–Total salmon released for Southeast Alaska hatchery programs, 1975–2021.

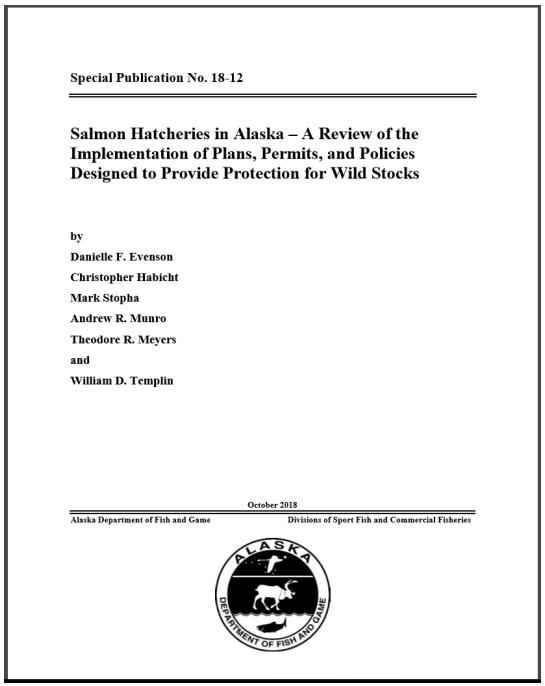
Wilson, L. 2022. Alaska salmon fisheries enhancement annual report 2021. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 5J22-02, Juneau.

2. Alaska's Hatchery Program

Alaska's Precautionary Approach

Policy and Implementation

1. Alaska's approach structured by policies, processes, plans, and permits
2. Elements used to implement
   - Management
     - Wild stock conservation priority
     - Management for sustained yield
     - Assessment of stock interaction: fisheries and escapement
   - Fish health
     - Hatchery inspections
     - Disease reporting and history
   - Genetics
     - Use appropriate local stocks
     - Identify significant or unique wild stocks, wild stock sanctuaries
     - Assessment of hatchery/wild stock interaction and impacts



Special Publication No. 18-12

Salmon Hatcheries in Alaska – A Review of the Implementation of Plans, Permits, and Policies Designed to Provide Protection for Wild Stocks

by
Danielle F. Evenson
Christopher Habicht
Mark Stopha
Andrew R. Munro
Theodore R. Meyers
and
William D. Templin

October 2018
Alaska Department of Fish and Game | Divisions of Sport Fish and Commercial Fisheries

Alaska Department of Fish and Game, Special Publication No. 18-12

3. AHRP - Hatchery/Wild Interactions

Large-scale salmon releases raise concern for effect on wild stocks

Do hatchery fish detrimentally affect productivity and sustainability of wild stocks?

Published Hatchery/Natural Fitness Studies

Steelhead

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

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

VÉRONIQUE THÉRIAULT,* GREGORY R. MOYER,*† 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

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

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

Hitoshi Araki*,†, Becky Cooper and Michael S. Blouin

Transactions of the American Fisheries Society

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

Genetic adaptation to captivity can occur in a single generation

PNAS

Chinook

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

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

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*

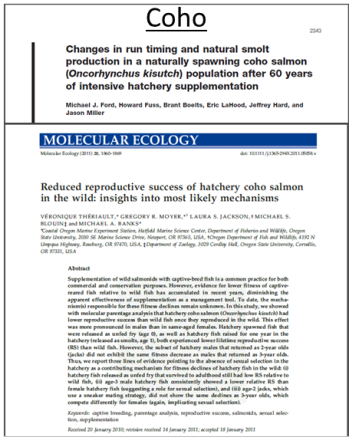
Evolutionary Applications

ORIGINAL ARTICLE

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

Joseph H. Anderson, Paul L. Faulds, William I. Atlas and Thomas P. Quinn

Coho



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

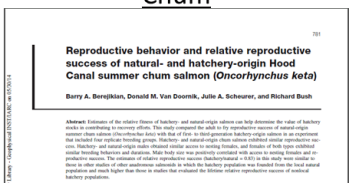
Michael J. Ford, Howard Fuss, Brant Boelts, Eric LaHood, Jeffrey Hard, and Jason Miller

MOLECULAR ECOLOGY

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

VÉRONIQUE THÉRIAULT,* GREGORY R. MOYER,*† LAURA S. JACKSON,‡ MICHAEL S. BLOUIN§ and MICHAEL A. BANKS*

Chum



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

3. AHRP - Hatchery/Wild Interactions

Difficulty with Applying Previous Studies

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

3. AHRP - Hatchery/Wild Interactions

Alaska Hatchery Research Program – Hatchery/Wild Interactions Study

Hatchery operators proposed that ADF&G organize science panel to design/implement a research project to inform resource management decisions about hatchery/wild interactions.

Funding would be provided by State of Alaska, Hatchery Operators and Industry

The Panel raised three (answerable) priority questions in Alaska context:

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?

3. AHRP - Hatchery/Wild Interactions

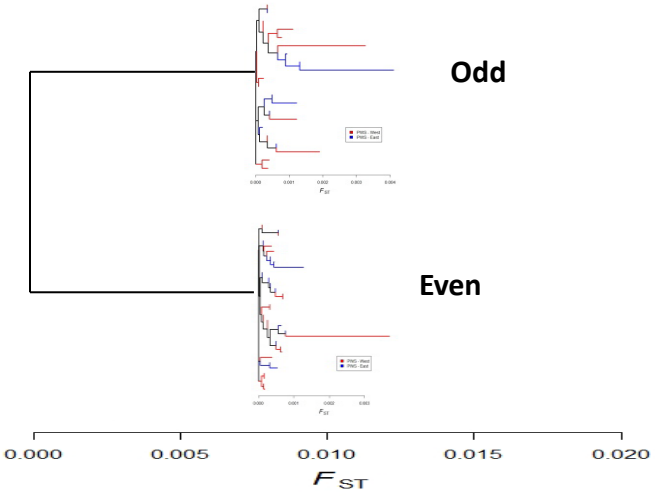
1. What is the genetic stock structure of pink and chum salmon in each region?

Population structure exists and is shallower in pink than in chum

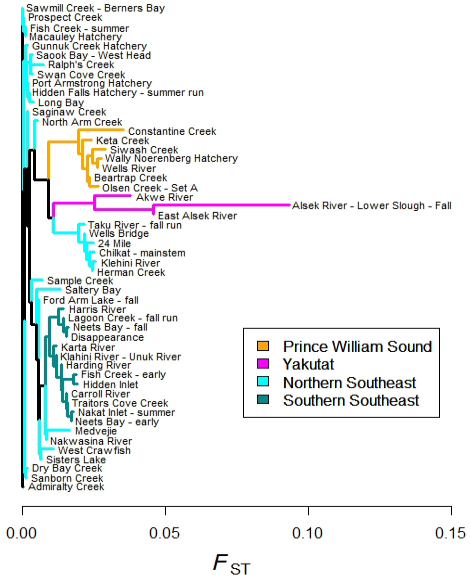
Drivers of structure:

- Pinks: even vs odd; deeper structure in odd lineages
- Chums: run timing, geography

PWS Pink



PWS and SEAK Chum



3. AHRP - Hatchery/Wild Interactions

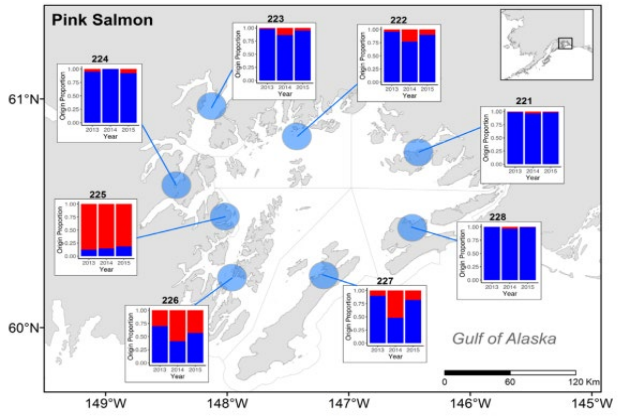
2. What is the extent and annual variability in straying of hatchery pink salmon in Prince William Sound (PWS) and chum salmon in PWS and Southeast Alaska (SEAK)?

Hatchery fish were found in streams

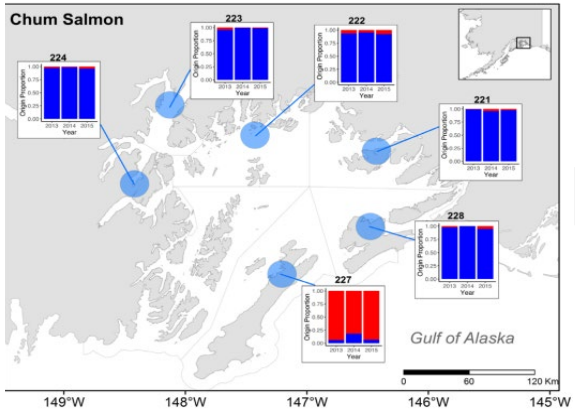
Regional annual estimates:

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

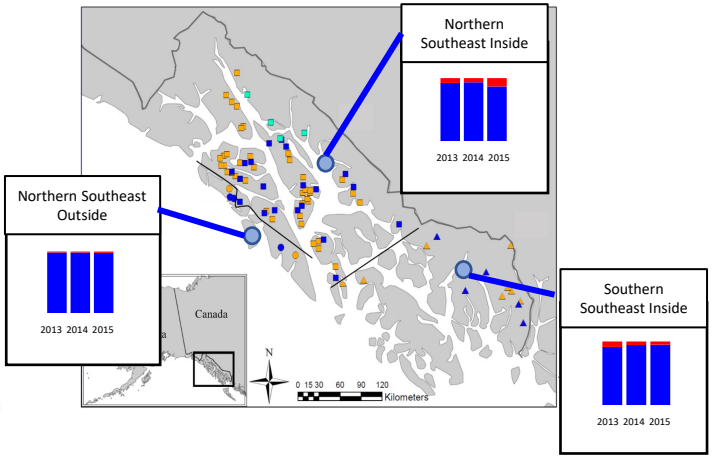
PWS : Pink



PWS : Chum



SEAK : Chum

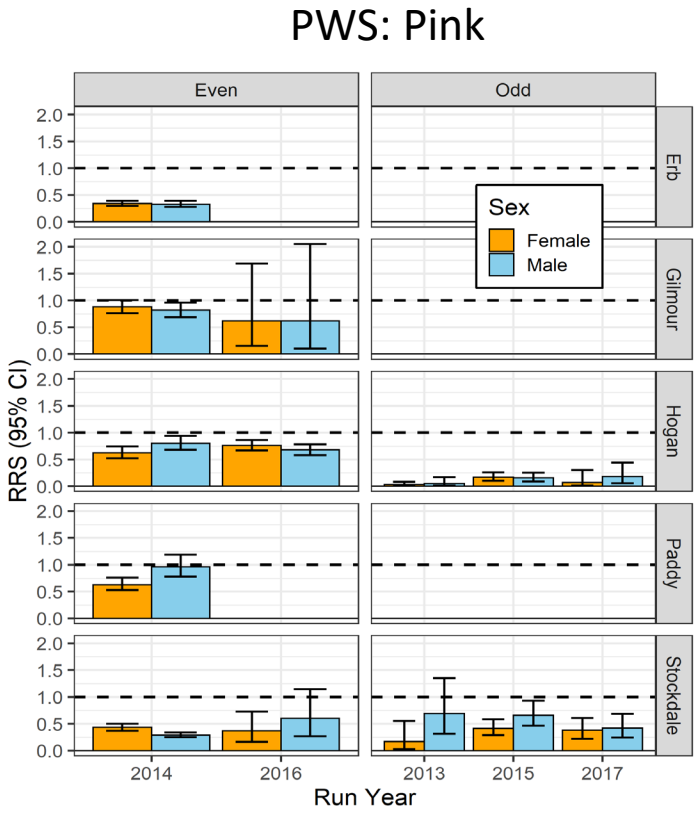


Knudsen, E.E., Rand, P.S., Gorman, K.B., Bernard, D.R. and Templin, W.D., 2021. Hatchery-origin stray rates and total run characteristics for Pink Salmon and Chum Salmon returning to Prince William Sound, Alaska, in 2013–2015. *Marine and Coastal Fisheries*, *13*(1), pp.41-68.

Josephson, R., Wertheimer, A., Gaudet, D., Knudsen, E.E., Adams, B., Bernard, D.R., Heinl, 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.

3. AHRP - Hatchery/Wild Interactions

3. What is the impact on fitness (productivity) of wild pink and chum salmon stocks due to straying of hatchery pink and chum salmon?



PWS pink salmon:

- Hatchery fish have lower fitness (productivity) in natural streams
- High variation; 50% RRS average
- Not all streams/brood years analyzed

SEAK Chum salmon:

- Last year of field sampling 2023
- No analysis yet

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.

3. AHRP - Hatchery/Wild Interactions

Communicating: Public, regulatory, and professional contexts

Peer-reviewed Journal Publications

Evolutionary Applications
Evolutionary approaches to environmental, biomedical and socio-economic issues
Open Access

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

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

State of Alaska Website

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

Public, Regulatory, Professional Meetings:

- 5 public information
- 5 Board of Fisheries
- 10 professional scientific

4. Application of Science - AHRP

The AHRP is providing valuable biological information to understand interactions between hatchery and wild pink and chum salmon

- Scientifically answerable questions
- Appropriate study design
- Alaska context

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

- Biological
- Social
- Economic
- Cultural

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

4. Application of Science - AHRP

Some questions that are not addressed by AHRP

- What are the competition and predation effects of hatchery fish?
  - Within and across species
  - Within marine and freshwater habitats
- Do hatchery fish reduce genetic resilience of wild populations?
- If changes in productivity are observed, what mechanisms could be driving these differences?
- How do these hatchery fish in wild systems affect assessment of escapement?
- How will findings affect policy?

4. Application of Science - AHRP

Department is assessing risk

- What we have now:
  - Genetic stock structure
  - Wild system productivity
  - Hatchery proportions in streams
  - Some relative productivity measures hatchery-origin PWS pink salmon
- What we are working on now:
  - Comparing contemporary and historical population structure
  - Productivity estimates – PWS pink >50%; SEAK chum - final field season
- Once all AHRG results are complete:
  - Interpretation of productivity in context
  - Implications for assessment of escapement
- Continuing literature review
  - Genetic resilience of wild populations
  - Competition and predation effects of hatchery fish
    - Within and across species
    - Within marine and freshwater habitats
- Analyses and interpretation will inform resource management decisions

4. Application of Science - AHRP

Proposed Model for Science – Policy Dialogue

Science

Policy or Human Valuation

Questions for Prudential Judgment

1. Does an event occur?
2. How often and to what extent?
3. Does the event have an effect?
4. Is the effect harmful?
5. Would addressing the harm cost more than it would benefit?

Observe

Measure/ Experiment

Compare to standard

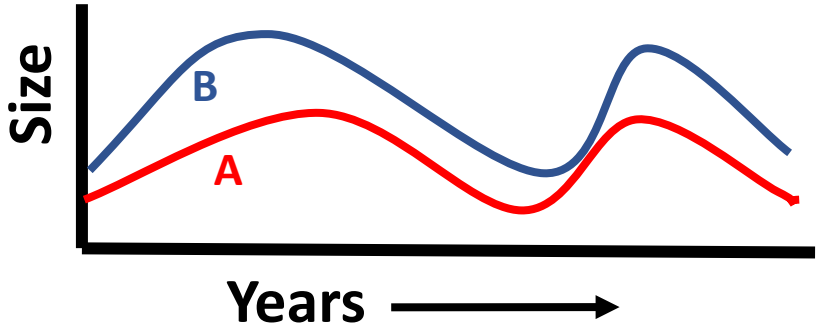
Collate/ Evaluate

5. Pink Salmon and Competition at Sea

Marine competition statements are about causes and effects; usually based on an apparent relationship

Simple example

Observation that the sizes of species A and B change together



Four possible explanations

1. Chance [no cause]
2. Change in A causes change in B
3. Change in B causes change in A
4. Changes in size in A & B are caused by something else

5. Pink Salmon and Competition at Sea

Establishing Causal Relationships

Best support – Controlled studies/experiments

Acceptable support; not definitive – Observed association/correlation in data

Requires:

1. Assumptions of cause and effect relationships
2. Higher standard to be met

Correlative evidence is strongest when

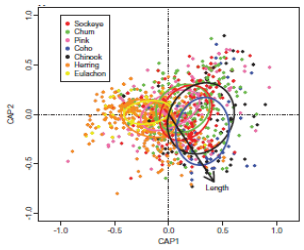
1. *correlation is high,*
2. *found consistently across multiple situations,*
3. *there are no competing explanations, and*
4. *the correlation is consistent with mechanistic explanations that can be supported by experimental evidence*

(Hill 1965; Hilborn 2016)

5. Pink Salmon and Competition at Sea

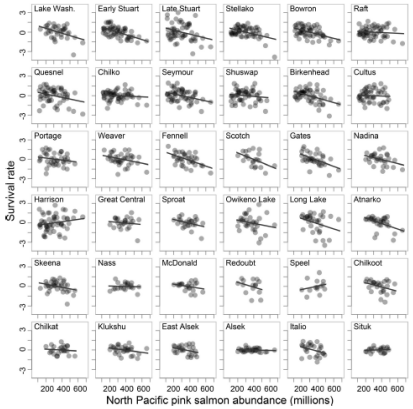
Scientific Literature on Interspecific Salmon Competition

1. Diet overlap and diet shifts



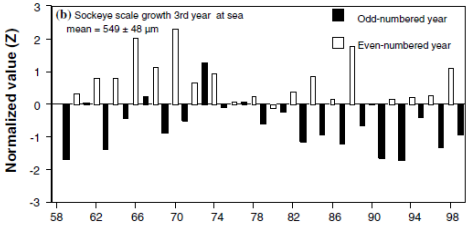
Osgood et al. 2016

2. Asynchronous abundance, productivity, or survival trends (one species ↑ when the other is ↓)



Ruggerone & Connors 2015

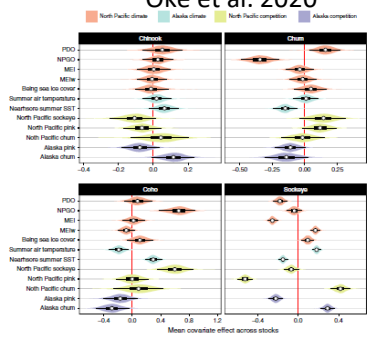
3. Competitor abundance associations with growth patterns (when abundance of a species is ↑, growth of another species is ↓)



Ruggerone & Nielsen 2004

4. Competitor abundance associations with age at maturity patterns (when abundance of a species is ↑, age at maturity of another species is ↓)

Oke et al. 2020



5. Pink Salmon and Competition at Sea

"resource vacuum and altered community composition left behind as pink salmon migrate…. suggest that they have a destabilizing effect on the ecosystem" – Springer & van Vliet 2014

"The consistent pattern of findings from multiple regions of the ocean provides evidence that interspecific competition can significantly influence salmon population dynamics and that pink salmon may be the dominant competitor among salmon in marine waters."

"All these data suggest that though salmon species consume a large amount of food, especially during periods of high abundance, their role in trophic chains is far from being highly important."

"the potential for food resources to limit salmon production across the North Pacific continues to be vigorously debated"

"This suggests that hatchery production has contributed to the depressed productivity of sockeye salmon in British Columbia, some of which have recently been assessed as at risk of extinction"

"Salmon input into the trophic structure of pelagic communities is generally low, and an additional several hundred thousand tons of artificially reared salmon cannot significantly change this trophic structure."

"Unfortunately, it is difficult to argue and refute fantasies of this kind and sometimes its impossible because of their absurdity." – Shuntov et al. 2017

5. Pink Salmon and Competition at Sea

Opposing Perspectives

Convinced

- Evidence generally based on correlations; direct assessment not required/possible
- Evidence found consistently across multiple situations
- Salmon-centric
- Odd/even lifecycle pattern (pink salmon) viewed as natural experiment
- Largely draws from English-written journals

Not Convinced

- Assessing cause should include direct evidence for/against causal links
- Evidence of no relationships are often ignored or not published
- Pelagic ecosystem-centric
- Alternative 2-year patterns should be considered (e.g., other species like squid)
- Draws from English and non-English language journals

5. Pink Salmon and Competition at Sea

Approaches to investigate competition in support of department mission

1) Involvement with marine salmon surveys
   a) Northern Bering Sea & SE Coastal Mainland juvenile cruises
   b) Salmon winter cruises 2019; 2020
   c) International Year of Salmon (IYS) 2022

2) Salmon Ocean Ecology Program (SOEP)
   a) New juvenile surveys – Southern Bering Sea & W Gulf of Alaska
   b) Collaborations with NOAA and UAF

3) Confirm quality of salmon ocean abundance data; Relies on NPAFC data
   a) A. Munro (ADF&G) chair of assessment working group
   b) Working on update/upgrade to data set

4) Coordination of international marking and tagging of hatchery salmon (NPAFC)
   a) D. Oxman (ADF&G) chair of marking working group
   b) Production, distribution, survival, and detection of hatchery fish from all nations

5) Coordination of international salmon genetic baselines/applications (NPAFC)
   a) B. Templin (ADF&G) chair of stock ID working group
   b) Developing genetic baselines and analyses for marine applications
   c) Pink salmon and other species range expansions in Arctic to west and east

6) Literature review


Questions?
07.30.2014