Alaska Salmon Hatchery Reports:
Research and related issues

Bill Templin
Board of Fisheries Work Session
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Anchorage

RC 39
Outline

I. Definitions
II. Alaska’s Precautionary Approach
III. Update on the Alaska Hatchery Research Program
IV. Studies germane to PWS hatchery/wild interactions
V. Genetic effects
VI. Carrying capacity
VII. Review of literature
VIII. Identified research needs
Working definitions

Precautionary Principle  Rule or Standard
When human activities may lead to morally unacceptable harm that is scientifically plausible but uncertain, actions shall be taken to avoid or diminish that harm.  - COMEST/UNESCO

Precautionary Approach  Method
A set of agreed cost-effective measures and actions, including future courses of action, which ensures prudent foresight, reduces or avoids risk to the resources, the environment, and the people, to the extent possible, taking explicitly into account existing uncertainties and the potential consequences of being wrong.  - S. Garcia, FAO Fisheries Dept

(5) in the face of uncertainty, salmon stocks, fisheries, artificial propagation, and essential habitats shall be managed conservatively as follows:

(A) a precautionary approach, involving the application of prudent foresight that takes into account the uncertainties in salmon fisheries and habitat management, the biological, social, cultural, and economic risks, and the need to take action with incomplete knowledge, should be applied to the regulation and control of harvest and other human-induced sources of salmon mortality; a precautionary approach requires

(i) consideration of the needs of future generations and avoidance of potentially irreversible changes;

(ii) prior identification of undesirable outcomes and of measures that will avoid undesirable outcomes or correct them promptly;

(iii) initiation of any necessary corrective measure without delay and prompt achievement of the measure's purpose, on a time scale not exceeding five years, which is approximately the generation time of most salmon species;

(iv) that where the impact of resource use is uncertain, but likely presents a measurable risk to sustained yield, priority should be given to conserving the productive capacity of the resource;

(v) appropriate placement of the burden of proof, of adherence to the requirements of this subparagraph, on those plans or ongoing activities that pose a risk or hazard to salmon habitat or production;

(B) a precautionary approach should be applied to the regulation of activities that affect essential salmon habitat.
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VIII. Identified research needs
1. Overview of the structure of Alaska’s approach – Policies, Plans, Permits
2. Elements used for implementation of policies
   – Management
   – Fish health
   – Genetics
3. Case studies
   – Southeast Alaska king salmon
   – Prince William Sound pink salmon
4. Recommendations
Alaska’s Precautionary Approach

Relevant policy elements

1. Management
   - Wild stock conservation priority
   - Management for sustained yield
   - Assessment of stock interaction: fisheries and escapement

2. Fish Health
   - Hatchery inspections
   - Disease reporting and history

3. Genetics
   - Use appropriate local stocks
   - Identify significant or unique wild stocks, and wild stock sanctuaries
   - Assessment of hatchery/wild stock interaction and impacts
Hatchery Reform In the Pacific Northwest
Hatchery Scientific Research Group

- US Congress established in 2000 to evaluate hatchery and wild salmon interactions
- Charged with reviewing all hatchery programs in the Pacific Northwest
- Intent to use science to direct reform
- Continual process
Definitions

**Precaution** is taking protective measures in advance to avoid harm

**Policies** constitute the framework for the precautionary approach to hatchery production of salmon in Alaska

**Implementation** is the application of precautionary policies to specific species at a given time and location
Alaska’s Precautionary Approach
Policy and Implementation

Case studies

– Southeast Alaska king salmon
  Smaller releases for diverse fisheries
  Longer hatchery residency
  Larger life history variation

– Prince William Sound pink salmon
  Larger releases for commercial fisheries
  Shorter hatchery residency
  Smaller life history variation
  Higher wild stream hatchery proportions
Policy and Implementation

Recommendations:

1. Clarify the *Genetic Policy* and technical terms:
   - Define significant and unique stocks and sanctuaries
   - Revisit criteria intended to ensure stock diversity among hatcheries
   - Provide guidance for protection of donor stocks

2. Improve communication of policies, plans, and processes to regulatory bodies and stakeholders

3. Continue basic research:
   - To understand population structure
   - To understand homing and the effects of straying
   - To increase hatchery diversity
Two issues emerged that need to be addressed. Neither has a simple answer.

What does the presence of hatchery strays in wild streams mean:

1. When assessing genetic risk?

2. When assessing escapement?
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Alaska Hatchery Research Program
Background & Overview

• Why the program was initiated
• Program structure
• Key questions addressed
• Results
• Private non-profit (PNP) hatcheries account for ⅓ of the commercial harvest

• Alaska hatchery releases:
  – 39% are pink salmon in PWS
  – 28% are chum salmon in SEAK

• Hatchery straying documented in both regions

• Unknown if these hatchery strays affect fitness of wild salmon

• Previous research found fitness impacts to wild stocks, but in other species and using other practices

• Alaska policy mandates sustainable productivity of wild stocks

• PNP operators proposed that ADF&G organize a science panel of experts to design and implement a long term research project to inform future resource management decisions

Alaska commercial harvest of wild and hatchery salmon, 1977-2016.

Why pursue this research?

Large-scale salmon releases raise concerns for wild stock impacts

– Do hatchery fish detrimentally affect productivity and sustainability of wild stocks?
Tool for detecting hatchery fish
Otolith Thermal Marking

Alaska marks > 80% of hatchery fish ~ 1.2 Billion
(100% for PWS and SEAK pink and chum)

NPAFC Voucher DB (Images & Data): http://npafc.taglab.org/MarkSummary.asp
Otolith Mark Use 1
In-Season Harvest Monitoring

Example: Pink salmon, PWS SW District, 2015

Otolith Mark Use 2
Measure Straying

Are hatchery fish straying? If so, how many fish are straying?

- Prince William Sound and SE Alaska - pink & chum
  Alaska Hatchery Research Program (2013-2023)
- Lower Cook Inlet - pink
  Otis and Hollowell (2014-2017)
- SE Alaska - chum
  Heinl and Piston (2008-2010)
- Prince William Sound - pink, chum & sockeye
  Joyce and Evans (1997-1999)
Are there effects of straying on productivity?

Numerous studies, but may not be directly applicable to pink and chum in Alaska

- Different life histories (king, coho, steelhead)
  - Freshwater residence time
  - Life span and age structure

- Different hatchery practices
  - Local broodstock
  - 10,000 + parents spawned
  - Limited holding or feeding
How do we obtain the information needed to answer questions?

- Funding partnership: State, Operators & Industry
- Fundamental questions aimed at examining impacts of hatchery straying on fitness of wild stocks

- Pink and chum salmon PWS
- Chum salmon SEAK
Panel Charge –

Translate questions into specific research projects. Develop a framework for research that could be used to address these questions.

Panel Makeup – 13 members:

- Alaska Department of Fish and Game
- National Marine Fisheries Service
- University of Alaska
- Aquaculture associations
AHRP Structure

Science Panel

State
- Genetics Lab
  - Population structure; fitness study
- Mark Lab
  - Otolith aging; thermal markings
- Regional Offices
  - Field logistics; escapement surveys

Contractor
- PWSSC
  - Field operations in PWS
- SSSC
  - Field operations in SEAK
AHRP Research Questions

1) What is the genetic stock structure of pink and chum in PWS and SEAK?

2) What is the extent and annual variability of straying?

3) What is the impact on fitness (*productivity*) of natural pink and chum stocks?
AHRP Research Questions

1) What is the genetic stock structure of pink and chum in PWS and SEAK?

Pink salmon in PWS

- Ecologically important, but shallow, structure observed in even and odd years (1990s)
- Re-examine structure with new samples and new markers (2013-2015)
- Compare 1990s structure to present structure

Chum salmon in PWS and SEAK

- Temporal and regional structuring observed within SEAK and PWS (1990s & 2013).
- Examine fine-scale structure using updated methods

Field and laboratory work completed
Report on odd-year pink salmon available
AHRP Research Questions

1) What is the genetic stock structure of pink and chum in PWS and SEAK?

Among pink salmon populations

AHRP Research Questions

1) **What is the genetic stock structure of pink and chum in PWS and SEAK?**

Across the range of Pink Salmon populations

2) What is the extent and annual variability of straying?

– Proportions of hatchery fish in streams
– 28 study streams; 488 site visits; 105,500 samples

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<td>0.045</td>
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<td>0.018</td>
<td>0.099</td>
<td>0.000</td>
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<td>Northwestern (224)</td>
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<td>0.001</td>
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<tr>
<td>Overall</td>
<td>0.044</td>
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<td>0.095</td>
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</table>

Range by district
0 - 90%

Annual weighted average
4-15%
2) What is the extent and annual variability of straying?
Stream sampling – Pink salmon

Overall an estimated 4.4% of an estimated 16.4 million spawners were of hatchery-origin.

Overall an estimated 14.8% of an estimated 5.9 million spawners were of hatchery-origin.

Overall an estimated 9.5% of an estimated 42.0 million spawners were of hatchery-origin.

AHRP Research Questions

2) **What is the extent and annual variability of straying?**

Stream sampling – Chum salmon (2013-2015)

- Proportions of hatchery fish in streams
- PWS: 17 study streams; 222 site visits; 17,000 samples
- SEAK: 32 study streams; 352 site visits; 29,400 samples

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<thead>
<tr>
<th></th>
<th>PWS</th>
<th>SEAK</th>
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<td>Average in District</td>
<td>0-85%</td>
<td>2-13%</td>
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<tr>
<td>Annual Average</td>
<td>3%</td>
<td>5-9%</td>
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<td>Montague (227)</td>
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<td>0.022</td>
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<td>Overall</td>
<td>0.028</td>
<td>0.032</td>
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<td>0.019</td>
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<td>Northern Southeast Inside</td>
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<td>Southern Southeast</td>
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<tr>
<td>Overall</td>
<td>0.073</td>
<td>0.054</td>
<td>0.092</td>
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</table>

2) *What is the extent and annual variability of straying?*

Ocean sampling 2013–2015 (PWS only)

– Proportions of hatchery fish in run
– Results (7,800 samples):
  • Pink salmon: 55-86%
  • Chum salmon: 51-73%

<table>
<thead>
<tr>
<th>Species Common Name</th>
<th>Year</th>
<th>Hatchery Proportion</th>
<th>SE</th>
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<td>Pink Salmon</td>
<td>2013</td>
<td>0.679</td>
<td>.016</td>
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<tr>
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<td>2014</td>
<td>0.864</td>
<td>.03</td>
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<td></td>
<td>2015</td>
<td>0.549</td>
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<tr>
<td>Chum Salmon</td>
<td>2013</td>
<td>0.725</td>
<td>.019</td>
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<tr>
<td></td>
<td>2014</td>
<td>0.511</td>
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<tr>
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<td>2015</td>
<td>0.688</td>
<td>.015</td>
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</table>
AHRP Research Questions

2) What is the extent and annual variability of straying?

Wild and Hatchery run size estimates

– Preliminary PWS run size estimates; 2013-2015 (Thousands)

<table>
<thead>
<tr>
<th>Species</th>
<th>Natural spawners</th>
<th>Hatchery strays</th>
<th>Total spawners</th>
<th>Natural run</th>
<th>Hatchery run</th>
<th>Total run</th>
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<tbody>
<tr>
<td>Pink salmon</td>
<td></td>
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<tr>
<td>2013</td>
<td>15,698</td>
<td>701</td>
<td>16,399</td>
<td>33,096</td>
<td>69,888</td>
<td>102,985</td>
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<td>2014</td>
<td>5,130</td>
<td>741</td>
<td>5,872</td>
<td>6,960</td>
<td>42,757</td>
<td>49,718</td>
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<td>2015</td>
<td>37,972</td>
<td>4,009</td>
<td>41,981</td>
<td>63,531</td>
<td>77,335</td>
<td>140,866</td>
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<tr>
<td>Chum salmon</td>
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<tr>
<td>2013</td>
<td>894</td>
<td>50</td>
<td>944</td>
<td>1,141</td>
<td>3,007</td>
<td>4,148</td>
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<tr>
<td>2014</td>
<td>925</td>
<td>49</td>
<td>975</td>
<td>1,175</td>
<td>1,228</td>
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<td>2015</td>
<td>890</td>
<td>28</td>
<td>919</td>
<td>1,128</td>
<td>2,484</td>
<td>3,612</td>
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AHRP Research Questions

Wild and Hatchery harvest rate estimates; PWS Pink

3) What is the impact on fitness (productivity) of natural pink and chum stocks?

Fitness – the ability to survive and reproduce

[average contribution by average individual to next generation]

If hatchery fish are less fit in wild streams, then

1. Hatchery fish will produce fewer offspring
2. Wild fish will produce fewer offspring due to interbreeding.
### 3) What is the impact on fitness (productivity) of wild pink and chum stocks?

**Relative reproductive success (2013-2023)**

Identify number of offspring produced by hatchery- and wild-origin parents

Follow 2 broodyears for 2 generations

PWS pink salmon:  6 streams; 689 site visits; 168,800 samples (2013-2017)

SEAK chum salmon: 4 streams; 146 site visits; 11,800 samples (2013-2017)

**AHRP Research Questions**

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<td>Chum</td>
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<td>BY 1</td>
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<td>$F_2$</td>
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<tr>
<td>Pink</td>
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<td>Odd BY 1</td>
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<td>Even BY 2</td>
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<td>$F_0$</td>
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**Sampling Year**
AHRP Summary

Information was needed to assess impact of hatcheries on wild stocks

AHRP designed to address three specific research questions

1. Genetic population structure
   • Odd and even year completed; reports in process
   • Historical analysis; in process

   • Hatchery proportions in escapement; completed and reported
   • Estimate of hatchery and wild returns; completed and reported
   • Estimate of hatchery and wild harvest rates; completed and reported

3. Effect of strays on fitness
   • Sampling in PWS; completed
   • Processing and analysis in PWS; in process
   • Sampling, processing and analysis in SEAK; in process
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Purpose
Intended to collect baseline data associated with 2 recently reopened hatcheries.

Methods
• 8-16 streams surveyed each year
• Core streams visited at least twice per year
• Collected otoliths from spawned-out carcasses (fresh and old)
Results

- Hatchery % varied widely among streams and across years within streams
- LCI hatchery % were highest in samples collected from streams closest to hatchery release sites (<6 mi)
- PWS hatchery % in LCI streams was highly variable, unexpectedly high (up to 87%) in some streams
- Across years more PWS marks were found than LCI marks in samples from streams outside hatchery SHAs.
- Observing PWS hatchery pink salmon in LCI streams 150-300 miles away demonstrates a broader scope of interaction than expected.
Prince William Sound chum study

- Straying observed
- Collections:
  - Pre-hatchery: 1964 - 1984
  - Recent: 2008 - 2010
- Questions:
  - Are old and new collections similar?
  - Do new collections look more like the hatchery than old collections?
Results

Archived scale samples: 1964–1982

Contemporary tissues: 2008–2010

NJ of pairwise Fst

Time
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Understanding Potential Genetic Effects of Straying

1. Conceptual framework linking fitness to genetic integrity
2. Hierarchical definition of straying
3. Simple models to describe mechanisms
4. Case studies to illustrate these concepts
   - PWS pink salmon
   - SEAK king salmon
**Genetic Policy:** Maintain fitness of wild stocks in presence of enhancement programs

1. Fitness is maintained by conserving genetic integrity
2. Genetic integrity is maintained by reducing introgression
3. Reducing introgression is maintained by reducing straying
Mechanisms affecting fitness

- **Introgression of maladapted genes**
  - **Cause**: Non-local or domesticated stock
  - **Result**: Reduced fitness = less productivity

- **Loss of variation among sites**
  - **Cause**: Stocks become more similar
  - **Result**: Reduced resilience = variable productivity

- **Loss of variation within sites**
  - **Cause**: Low hatchery broodstock sizes
  - **Result**: Reduced fitness and resilience
Local adaptations in wild fish may be lost if...

1. Hatchery fish are genetically different from wild fish
2. Hatchery fish stray into wild spawning areas
3. Stray hatchery fish spawn with wild fish
4. Hatchery fish genes introduced into wild fish gene pool (Introgression)
Straying definitions

- Adult
- Harvested
- Natal habitat
  - Homing
- Non-natal habitat
  - (uncommitted)
  - Stray (dies)
  - Genetic stray (spawns)
  - Introgression (successful hybridization)

Genetic effects
Straying definitions

- Adult
- Non-natal habitat (uncommitted)
  - Stray (dies)
  - Genetic stray (spawns)
  - Introgression (successful hybridization)

- Natal habitat
  - Homing

- Harvested

Genetic effects
Straying definitions

Adult

Non-natal habitat (uncommitted)

Homing

Natal habitat

Harvested

Stray (dies)

Genetic stray (spawns)

Introgression (successful hybridization)

Genetic effects
Local adaptations in wild fish may be lost if...

1. Hatchery fish are genetically different from wild fish
2. Hatchery fish stray into wild spawning areas
3. Stray hatchery fish spawn with wild fish
4. Hatchery fish genes introduced into wild fish gene pool (Introgression)

5. Effect of introgression depends on:
   - Degree of adaptation among wild stocks
   - Divergence between hatchery and wild stocks
     - Non-local hatchery broodstock
     - Domestication of hatchery broodstock
Local stock, no adaptation among sites, no domestication

Each of these ovals represents a wild pink salmon population. Differences in color will represent differences in adaptation. Here, all 5 populations are genetically the same.
Local stock, no adaptation among sites, no domestication

Genetic effects

Time

First generation

A few generations

Many generations (equilibrium)

No introgression

Introgression

Hatchery

First generation

A few generations

Many generations (equilibrium)

Hatchery
Local stock, no adaptation among sites, no domestication

Genetic effects

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<tr>
<td>A few generations</td>
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<td></td>
</tr>
<tr>
<td>Many generations (equilibrium)</td>
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</tbody>
</table>

Hatchery
No adaptation among sites and non-local hatchery stocks

Genetic effects

First generation

A few generations

Many generations (equilibrium)

Time

No introgression

Introgression

Hatchery

First generation

A few generations

Many generations (equilibrium)
Adaptation among sites, local stock

Genetic effects

Time

No introgression

Introgression

First generation

A few generations

Many generations (equilibrium)
No adaptation among sites and domestication

Genetic effects

- First generation
- A few generations
- Many generations (equilibrium)

Time

No introgression

Introgression

Hatchery
Adaptation among sites and domestication

Genetic effects

Time:  
- First generation: No introgression
- A few generations: No introgression
- Many generations (equilibrium): Introgression
Can hatchery stock be considered “local”?  

“Yes”  
• All stocks originated within PWS  
• “Local” under *Genetic Policy*  
• Very shallow population structure within PWS  

“Maybe”  
• Hatchery stocks selected based on run timing for management needs  
• East-side stock used in west-side hatchery  

“No”  
• PWS hatchery fish in Lower Cook Inlet not “local” under *Genetic Policy*
Case study: PWS pink salmon

Is there adaptation among spawning sites?

“Yes”
- Observed life history differences:
  - Upstream/intertidal spawning in streams
  - Run timing differences among districts

“No”
- Life history differences could be genetically and/or environmentally mediated
- Small genetic differentiation at neutral loci is consistent with high natural gene flow
Case study: PWS pink salmon

Are hatchery pinks domesticated?

“Yes”
- Domestication documented in other Pacific salmon species
- Lack of selection could allow retention of genes maladapted for wild environment

“No”
- Less opportunity for selection for pink salmon in PWS than other Pacific salmon species:
  - Shorter hatchery residence and fewer life stages
  - Pink salmon egg to fry mortality in hatchery is small
  - Hatcheries do not purposely select for traits
Case study: SEAK king salmon

Can hatchery stock be considered “local”?  
- All SEAK stocks  
- Hatcheries in sensitive zone use nearby stocks

Is there adaptation among spawning sites?  
- Larger genetic differences  
- More diverse life histories

Are hatchery kings domesticated?  
- One stock purposely divergent  
- Longer hatchery residence increases potential

Straying low due to hatchery siting  
Farragut River may be a concern
Genetic effects

Is genetic effect negative for wild stock sustainability?

Productivity increases in PWS may be due to environmental conditions, not enhancement: replacement not augmentation

However...

Estimates of wild-origin returns to PWS from AHRP study indicate largest wild returns on record
Outline

I. Definitions
II. Alaska’s Precautionary Approach
III. Update on the Alaska Hatchery Research Program
IV. Studies germane to PWS hatchery/wild interactions
V. Genetic effects
VI. Carrying capacity
VII. Review of literature
VIII. Identified research needs
Carrying capacity is the number of organisms that an ecosystem can sustainably support.

– Changes over time
  • Abundance of predators
  • Supply of food
  • Competition
  • Physical factors affect distribution and productivity; “Patchiness”

Usually defined for a single species or population in a defined, more uniform area (e.g., sheep in a pasture or fish in a lake)

Much more difficult in a large, variable area and with multiple species.
Carrying capacity in production models

- Expected annual abundance of spawners when the stock has not been subject to fishing ($S_{eq}$)
- Number of spawners that produce the same number of recruits
Factors affecting carrying capacity in freshwater

- Limited spawning ground (Among adults)
  - Superimposition of reds
  - Spawning in marginal areas
  - Egg retention/death
  - Interference of spawning from aggression

- Limited rearing resources (Among juveniles)
  - Trophic production in lakes
  - Quantity/quality of riparian habitats
Carrying capacity in production models

Simple compensation

Overcompensation

\[ S_{EQ} \]

Spawning Abundance (S)

Production (R)

Beverton-Holt

Ricker

Why is carrying capacity of the ocean hard to measure?

- Many different species with varying relationships
- Large scale environment with varying conditions “patchiness”
- Complexity means no simple answers

Where could salmon reach carrying capacity?

<table>
<thead>
<tr>
<th></th>
<th>Juvenile</th>
<th>Immature</th>
<th>Adult</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshwater</td>
<td>rearing</td>
<td></td>
<td>spawning</td>
</tr>
<tr>
<td>Marine</td>
<td>nearshore</td>
<td>open ocean</td>
<td>open ocean</td>
</tr>
</tbody>
</table>
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RCs Submitted in July 2018

"...recent scientific publications...have provided cause for great concern over the biological impacts associated with continued release of very large numbers of hatchery salmon into the North Pacific...”

10 peer-reviewed scientific documents submitted in support

Areas of concern
1. Salmon abundance and biomass
2. Diet and feeding ecology/trophic effects
3. Interspecies interactions (correlations)
4. Phenotypic and life history changes
5. Population resiliency
Questions implicit with respect to areas of concern

• Are pink salmon a major driver of North Pacific ecosystem?
• Does pink salmon abundance affect other species?
• Does alternating pink abundance drive patterns in other species?
• Do patterns indicate system is near carrying capacity?
• Will more hatchery pink salmon compound the effect?
1. Salmon abundance and biomass


- Only available estimates
- Compiled available data to make “best” estimates
- Relies upon many assumptions – critical data are absent

Assumptions (selected):
- Does not include non-NPAFC countries (N. Korea & China)
- Reported harvest incomplete – Russia poaching
- Expanded escapement for areas with incomplete coverage (e.g. AK & BC)
- Spawning abundance estimated from harvest data and harvest rate - many areas (e.g. Asia)
2. Diet and feeding ecology/trophic effects

Myers et al. (2004) Diet Overlap and Potential Feeding Competition Between Yukon River Chum Salmon and Hatchery Salmon in the Gulf of Alaska in Summer


Aydin (2000) Trophic Feedback and Carrying Capacity of Pacific Salmon (Oncorhynchus spp.) on the high seas of the Gulf of Alaska

• Research into feeding ecology and diet overlap

• Critical information for understanding relationships and complexity

• Basic research needed
  • How do salmon experience ocean environment (e.g. The Blob)
  • Not necessarily designed to test hypotheses of effect
North Pacific Ocean ecosystem
It is complicated... along the way.

Review of Literature

Shaul & Geiger (2016) Effects of climate and competition for offshore prey on growth, survival, and reproduction potential of coho salmon in southeast Alaska
3. Interspecies interactions (correlations)

Do the strong abundance cycles of odd- and even-year runs of pink salmon affect inter-specific growth and survival?

Springer et al. (2018) Transhemispheric ecosystem disservices of pink salmon in a Pacific Ocean macrosystem

Batten et al. (2018) Pink salmon induce a trophic cascade in plankton populations in southern Bering Sea and around the Aleutian Islands

Use Ruggerone & Irvine data to find correlations

Draw conclusions but do not test hypotheses

Shaul & Geiger (2016) Effects of climate and competition for offshore prey on growth, survival, and reproduction potential of coho salmon in southeast Alaska

Have a hypothesis – a good example of trying to better understand interactions

Missing key piece of linking data – squid abundance
Review of Literature

Correlation ≠ Causation

Need plausible, testable hypothesis

Ruggerone and Irvine (2018)
4. Phenotypic and life history changes

Is high salmon abundance causing phenotypic and life history changes in other species of salmon?

Studies that document changes in size at age, age at maturity and body size

Lewis et al. (2015) Changes in Size and Age of Chinook Salmon Oncorhynchus tshawytscha Returning to Alaska

Jeffrey et al. (2017) Changes in body size of Canadian Pacific salmon over six decades

Shaul & Geiger (2016) Effects of climate and competition for offshore prey on growth, survival, and reproduction potential of coho salmon in southeast Alaska

see also Ohlberger et al. (2018) Demographic changes in Chinook salmon across the Northeast Pacific Ocean
4. Phenotypic and life history changes

Purpose of some studies was to document changes
- not to test the cause
- postulate potential causes

Studies such as Jeffrey et al. examined trends over time and tested for potential correlates
- looked at many variables
- different species responded differently
5. Population resilience

Is hatchery production augmenting or replacing natural production?
OR
Are wild salmon populations resilient to large scale hatchery releases over a prolonged period?

• Not directly related to the statement in the emergency petition
• Study found
  • Hatchery production was to support recovery
  • natural production responded positively to stopping hatchery releases
Summary

Measuring ocean carrying capacity and knowing when reached is a complex issue

- Contribution of hatchery salmon also difficult to assess

Much research in this area

- No comprehensive unequivocal assessment
- Requires piecing together bits of data and information
  - Quality, applicability, and utility
Summary

Next steps

• Rigorously designed studies to answer specific question(s) with testable hypotheses, identify data needs

Not within capacity of ADF&G

• Collaborate with other researchers
• Coordinate and guide research with other agencies and countries (NOAA, NPAFC, IYS)
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Precautionary Approach
SSFP 5 AAC 39.222(c)(3) and (5)

(A) a precautionary approach, involving the application of prudent foresight that takes into account the uncertainties in salmon fisheries and habitat management, the biological, social, cultural, and economic risks, and the need to take action with incomplete knowledge, should be applied to the regulation and control of harvest and other human-induced sources of salmon mortality; a precautionary approach requires

(N) conservation and management decisions for salmon fisheries should take into account the best available information on biological, environmental, economic, social, and resource use factors;

(O) research and data collection should be undertaken to improve scientific and technical knowledge of salmon fisheries, including ecosystem interactions, status of salmon populations, and the condition of salmon habitats;

(P) the best available scientific information on the status of salmon populations and the condition of the salmon's habitats should be routinely updated and subject to peer review;
Identified research needs

1. Continue building genetic baselines for pink and chum salmon
2. Estimate hatchery contribution to harvests in LCI and Kodiak
3. Design and implement comprehensive surveys for hatchery strays
4. Collaborate with other efforts (IYS, NPAFC or OCC) on studies:
   – Testing hypothesized links between pink salmon and other species
   – Examining nearshore ecology of pink salmon juveniles
5. Extend AHRP-related studies
6. Design program to evaluate hatchery release strategies to improve homing and reduce straying