High rates of precocious male maturation, “minijacks”, in spring Chinook salmon hatchery programs: Prevalence, causes and potential solutions.

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Kathy Cooper, Paul Parkins - University of Washington

Dave Fast, Charles Strom, Mark Johnston, - Yakama Nation Fisheries
Spring Chinook Salmon

Spawning - Fall

Fry

Parr

Sub-adults

Anadromous Fish

Age-1 “Precocuous parr”

Age-2 “Minijacks”

Age-3 M

Age-4

Age-5

Ocean to river in spring

Ocean

1+ yr

Spring

Smolting
Variation in Age of Male Maturity

Factors Affecting Age of Maturation

- Genetics
- Environment
  - temperature
  - food availability
  - food quality

The Hatchery environment can significantly influence age of maturation
We've been monitoring the physiology of Cle Elum Hatchery Spring Chinook since implementation in 1997.
On average 50% of male Yakima hatchery spring Chinook precociously matured at age-2

<table>
<thead>
<tr>
<th>BY</th>
<th>Release #</th>
<th>% of males</th>
<th># Minijacks</th>
</tr>
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<tbody>
<tr>
<td>1997</td>
<td>386,048</td>
<td>44%</td>
<td>84,931</td>
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<tr>
<td>1998</td>
<td>589,683</td>
<td>72%</td>
<td>211,107</td>
</tr>
<tr>
<td>1999</td>
<td>758,789</td>
<td>50%</td>
<td>189,697</td>
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<tr>
<td>2000</td>
<td>834,285</td>
<td>37%</td>
<td>153,508</td>
</tr>
<tr>
<td>2001</td>
<td>370,236</td>
<td>52%</td>
<td>95,520</td>
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</table>

Avg. 50%

How do we assess precocious male maturation?
Age-2 immature male chinook salmon

Testes

May
Age-2 precocious male chinook salmon

Testes
Plasma 11-ketotestosterone (11-KT)

- Major androgen in teleost fish
- Instrumental in the regulation of spermatogenesis
Laboratory based studies have clearly established that 11-ketotestosterone (11-KT) is significantly elevated in precocious males as much as a year prior to mating.
Every March the Yakima Chinook are screened for pathology just prior to volitional release.
Consequences of high levels of precocious maturation

- Ecological impacts
- Genetic impacts
- Increased straying
- Skewed gender ratio
- Loss of adult productivity
Critical periods for maturation decision - based on body size/growth rate

- **Fall decision period**
  - Fast growth = Yes
  - Immature

- **Spring decision period**
  - Fast growth = Yes
  - Mature
  - Fast growth = Yes
  - Immature
  - Spawning

Body weight (g)
Comparison of wild and hatchery growth and minijack rates

Fall decision period

Body Weight (g)

Minijacks (%)
Results from this study provided the basis for production scale rearing regimes (BY 2002-2004)

Lab scale studies:
- Autumn Growth Rate
- Body size

Growth rate was adjusted via ration (BY 2002-2004)

Pond 4/14/05

Growth rate was adjusted via ration (BY 2002-2004)

2.5-5°C

High 30/#

Low 45/#
Did Growth Modulation reduce the minijack rate?
Minijack rates before release were consistently lower in the Low growth Trt.
The bigger they are at release, the higher the minijack rate
(BY X acc.site, BY 2000-BY 2005)
What happened to juvenile and adult survival?
Juvenile Survival Index to McNary Dam is lower for the Low growth fish

Modified from Neeley 2004-2006
Adult Return, is lower for Low Growth Trt.

Brood Year 2002

Brood Year 2003

Brood Year 2004

Bosch 2007
Loss due to Precocious maturation

Loss due to small smolt size

How do we produce large fish that still grow slow in the autumn maturation initiation period? Earlier Pond Time
- Where do the minijacks go?
- How do hatchery rates compare with wild rates?
Minijack rates of wild fish are approx. 1/10-1/20th that of hatchery fish.
There is a positive (but not significant) relationship between minijacks released and minijacks captured at Prosser Dam.

\[ R^2 = 0.43 \]
\[ P = 0.08 \]
Higher minijack rates at time of release correlate with gender ratios skewed in favor of females during smolt migration.

\( R^2 = 0.67 \)

\( p < 0.0001 \)
How unique is this issue to Yakima Spring Chinook?
Winthrop Hatchery

Yakima Hatchery (BY’01)

18g = 25/#

Log GSI

Leavenworth Hatchery

19g = 24/#

Log GSI

Entiat Hatchery

22g = 22/#

Log GSI

Log 11-KT

Log 11-KT

BY 03 13%
BY 04  8%
BY 05 11%

Winthrop Hatchery

24g = 19/#

Log GSI

Precocious parr

BY 03 23%
BY 04  28%
BY 05 35%

Precocious males
Acknowledgments (most important slide)

- Cle Elum Hatchery Staff
- Ray Brunson, Joy Evered, Sonia Mumford, Chris Paterson-USFWS Pathology Lab, Olympia, WA.
- Todd Pearsons and staff-WDFW
- Bill Bosch-Yakama Nation
- Doug Neeley-Instats consulting
- Leroy Senator and staff-Yakama Nation, Chandler Smolt by-pass facility, Prosser Dam,
- Steve Croci, Dan Davies, Al Jensen, Chris Pasley, Craig Eaton, Jason Reeves -Leavenworth Hatchery Complex Facilities
- Debbie Docherty-BPA contract #200203100
- NOAA Biop funding
Shifting ponding date of fry

Early Pond / High Growth

Late Pond / Low Growth

Critical Period

NOAA hatchery Seattle

Early Pond / Low Growth

Critical Period

Early Pond date 4 Jan.

Later Pond date 6 Feb.
Egg incubation temperature significantly influences life-history composition.

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<tr>
<th>Prec. Parr</th>
<th>Mini-Jack</th>
<th>Tot.</th>
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<tbody>
<tr>
<td>32%</td>
<td>40%</td>
<td>72%</td>
</tr>
<tr>
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<td>47%</td>
<td>80%</td>
</tr>
<tr>
<td>22%</td>
<td>25%</td>
<td>52%</td>
</tr>
<tr>
<td>17%</td>
<td>31%</td>
<td>48%</td>
</tr>
<tr>
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<td>35%</td>
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