Unexpected effects and unintended consequences: altering emergence timing induces variability in Chinook salmon life history

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Columbia River spring Chinook salmon life history is variable. 

“Spawning - Fall”

emergence

Precocious parr age 1

minijack age 2

Age-3 jack

Age-4

Age-5

maturation

fall smolting (age 1)

spring smolting (age 1+)

ocean rearing

fry

parr
10 years of sampling, >12,000 fish = 2 precocious parr (<0.02%)

Two important points:

1). this appears to be quite low

   data from other hatchery and wild populations

2). most of the fish were sampled for Ray Brunson
Why so few precocious parr?
One of the reasons CESRF is special: (there are many)

Seasonal timing for ponding fry
Many hatcheries alter emergence (ponding).

1. Synchronize ponding

- Compress (chill early egg take, warm later egg take)

- 3 months

- 3 weeks
Many hatcheries alter emergence (ponding) II. Pond “early” - longer growth period, clear egg stacks

Compress and shift early
(indicate at warm temp)

3 weeks

3 months
Many hatcheries alter emergence (ponding III). Pond “late” - avoid silting of ponds, smaller size

Compress and shift late
(incubate at cold temp)

3 months

Does late ponding affect rate of age-1 male maturation?

CESRF

3 weeks
What is “Natural Emergence Timing”? 
Greater variation in juvenile emergence timing (weeks) than adult spawning (days)

Adults spawn within a few days
But, progeny emerge/migrate over several months

“Natural” emergence timing greatly extended as compared to many hatcheries

Data kindly provided by Steve Schroder, Todd Pearsons, Anthony Fritts, Jen Scott, Jordan Vandal, Gene Sanborn (WDFW) and Curt Knudsen (Oncorh Consulting).
**Experimental Question:**

What is the effect of emergence timing on life-history variation?

**Experimental approach:**

Pond fry at 3 different photoperiods

1. December (early)
2. 15 February (middle)
3. 1 May (late)
Important!!

Purpose of experiment is to investigate life history variation; not, to develop protocols for CESRF (or any other hatchery).

My job is not to tell people what to do, my job is to help people understand their fish.
Growth rate is also important (Don Larsen *ad nausea*):


Experimental approach II:

feed fry at 3 different rates

Low
High
Satiation
Emergence time, growth and size were varied experimentally

Fish grown in experimental tanks NOAA Montlake
Monitor Autumnal Smolting: 24 hour seawater challenge

- **freshwater**
  - Parr: 0% survival
  - Smolts: 100% survival

- **sea water**
  - Parr: 0% survival
  - Smolts: 100% survival
Monitor Age-1 (precocious parr) Maturation:
  milt expression or simple dissection
Emergence and growth of fish did vary

Average size wild fish fall 93, 94 (Canyon - Union gap - Zillah) Beckman et al. 2000

Target size for tagging @ CESRF

Thanks to Charlie Strom and CESRF staff for eggs
Early emerging fish smolt in the autumn later emerging fish fish do not

% survival
24 hrs, 37.5 ppt seawater (Sept - Nov)

Early Emerge

Middle Emerge

Late Emerge

Feeding Rate
Late emerge fish do smolt the following spring
Early emerging fish have a high propensity for early male maturation (age 1) (precocious parr)

% maturing Males (% of total males)

Early Emerge

Middle Emerge

Late Emerge

Feeding Rate

We split egg lots between treatments ⇒ Absolutely no genetic difference between groups

0%
Conclusion: Emergence timing may provide another axis for life history variability
Early emergence accelerates life history

“Spawning - Fall”

emergence

Precocious parr
age 1

miniJack
age 2

fall smolting
(age 1)

Age-3 jack
Age-4
Age-5
maturation

ocean rearing

fry

parr

spring smolting
(age 1+)

Early emergence accelerates life history
Late emergence delays life history

“Spawning - Fall”

Early emergence
Precocious parr (age 1)
miniJack (age 2)
fall smolting (age 1)

Late emergence
Age-3 jack
Age-4
Age-5
maturation

Ocean rearing

Spring smolting (age 1+)

parr
10 years of sampling, >12,000 fish = 2 precocious parr (<0.02%)

Late emergence delays life history
Implications

What happens in the hatchery does not stay in the hatchery, long-term life history implications for altering emergence (ponding) time exist.

No easy answers for “best” rearing program - a series of trade-offs between male maturation, size (tagging targets), smolting and SAR.

Current rearing program (late ponding) mimics conditions found in head water streams (high elevation, cold - late emergence) and is favorable for yearling releases.