Differences in egg size between natural-origin and genetically similar hatchery-origin winter steelhead in Abernathy Creek, Washington

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Natural Reproductive Success and Demographic Effects of Hatchery-Origin Steelhead in Abernathy Creek, Washington

Project number 2003-063-00

Goal

The ability of hatchery-origin adults to reproduce successfully and contribute genetically, via supplementation to the recovery of naturally spawning steelhead populations is still a major uncertainty in the Pacific Northwest

Goal

Evaluate relative reproductive success between hatchery-origin and natural-origin steelhead trout, simultaneously investigating methods of operating a conservation hatchery and the effectiveness of artificial production of an integrated broodstock on recovery

Importance of egg size

- Large eggs produce large fry

Beacham T.D., F.C. Withler, and R.B. Morley. 1985. Effect of egg size on incubation time and alevin and fry size in chum salmon (*Oncorhynchus keta*) and coho salmon (*Oncorhynchus kisutch*). Canadian Journal of Zoology, 63(4): 847-850.

Thorpe, J.E., M.S. Miles, and D.S. Keay. 1984. Developmental rate, fecundity and egg size in Atlantic salmon, *Salmo salar* L. Aquaculture, 43: 289-305

Importance of egg size

- Early fry survival is positively correlated to fry size

Heath D.D., C.W. Fox, and J.W. Heath. 1999. Maternal effects of offspring size: variation through early development of Chinook salmon. Evolution, 53(5): 1605-1611.

Einum, S. and I.A. Fleming. 2000. Selection against late emergence and small offspring in Atlantic salmon (*Salmo salar*). Evolution, 54(2): 628-639

Importance of egg size

- Fry survival varies with extreme changes in environmental conditions

Good, S.P., J.J. Dodson, M.G. Meekan, and D.A.J. Ryan. 2001. Annual variation in size-selective mortality of Atlantic salmon (*Salmo salar*) fry. Can. J. Fish. Aquat. Sci.58:1187-1195.

Drought conditions – selective mortality was relatively weak and directed towards the smaller fry

Flood conditions – selective mortality was relatively strong and directed towards the larger fry

Factors influencing egg size

- Egg size is correlated with female body size – larger females produce larger eggs

Fleming, I.A., and M.R. Gross. 1990. Latitudinal clines: a trade-off between egg number and size in Pacific salmon. Ecology 71: 1-11

Beacham, T.D., and C.B. Murray. 1993. Fecundity and egg size trends among North American Pacific salmon (*Oncorhynchus*). Journal of Fish Biology 42: 485-508.

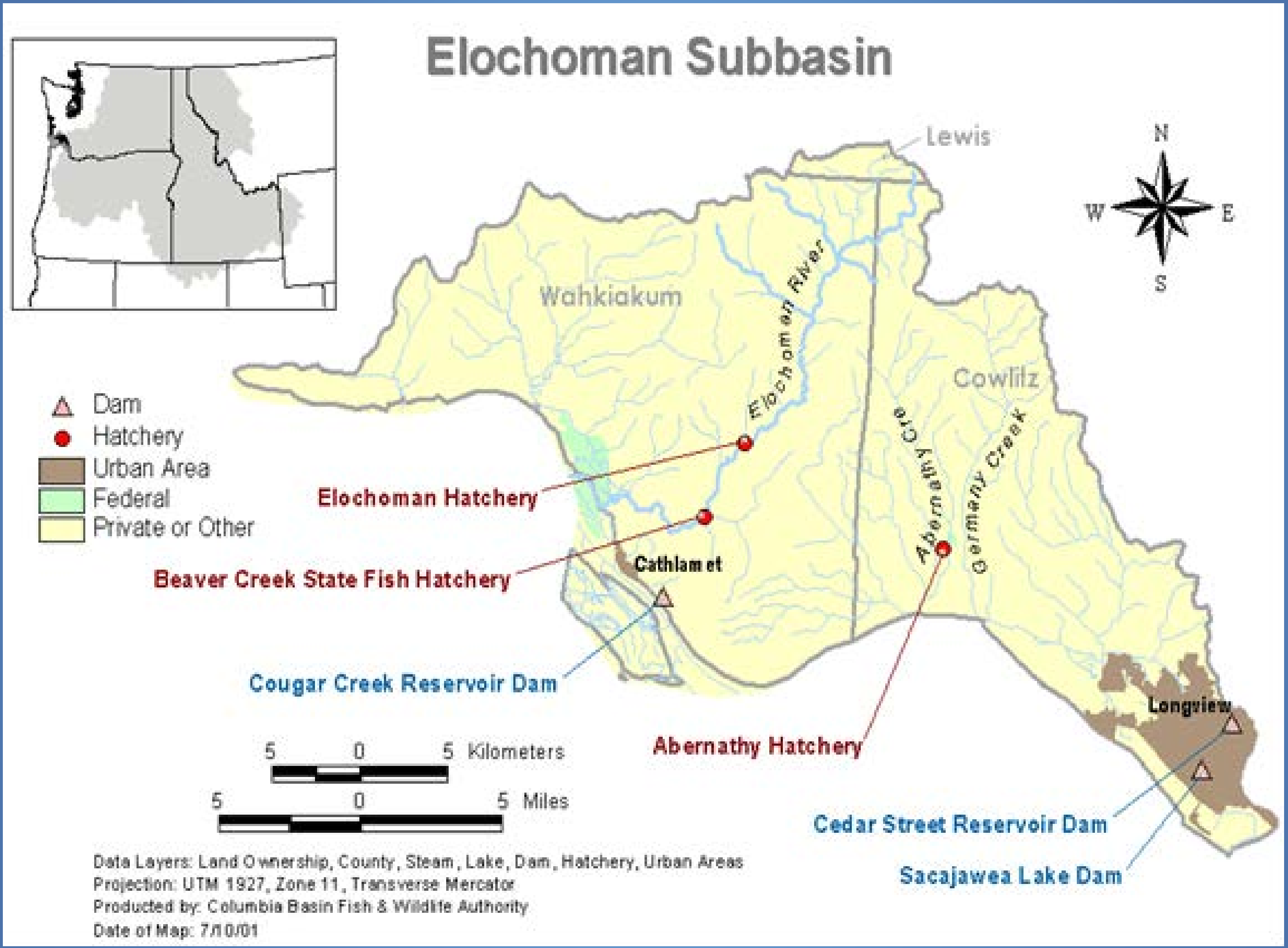
Factors influencing egg size

- Rapid early growth is associated with smaller eggs

Thorpe, J.E., M.S. Miles, and D.S. Keay. 1984. Developmental rate, fecundity and egg size in Atlantic salmon, *Salmo salar* L. Aquaculture, 43: 289-305

Morita, K., S. Yamamoto, Y. Takashima, T. Matsuishi, Y. Kanno, and K. Nishimuta. 1999. Effect of maternal growth history on egg number and size in wild white-spotted char (*Salvelinus leucomaenis*). Can. J. Fish. Aquat. Sci. 56: 1585-1589.


Fish Hatchery
Open
8:00 A.M. to 4:30 P.M.
U.S. Fish and Wildlife Service
Abernathy Fish
Technology
Center


Elochoman Subbasin
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Elochoman River
Cowlitz
Abernathy Cre
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Dam
Hatchery
Urban Area
Federal
Private or Other
Elochoman Hatchery
Beaver Creek State Fish Hatchery
Cathlamet
Cougar Creek Reservoir Dam
Longview
Abernathy Hatchery
5 0 5 Kilometers
5 0 5 Miles
Cedar Street Reservoir Dam
Sacajawea Lake Dam
Data Layers: Land Ownership, County, Steam, Lake, Dam, Hatchery, Urban Areas
Projection: UTM 1927, Zone 11, Transverse Mercator
Producted by: Columbia Basin Fish & Wildlife Authority
Date of Map: 7/10/01

Natural origin juveniles collected for captive broodstock in 1999, 2000, and 2001

Captive broodstock spawned at age 3 in 2002, 2003, and 2004

Females 402-424 mm

Males 410-447 mm

Conservation Hatchery Goals

- Produce hatchery origin adults that are genetically and phenotypically similar to natural origin adults : genetics, age composition, Wt, FL, run timing, spawn timing, fecundity

- Produce hatchery origin smolts that are genetically and phenotypically similar to natural origin smolts : genetics, age composition, Wt, FL, physiology, body composition

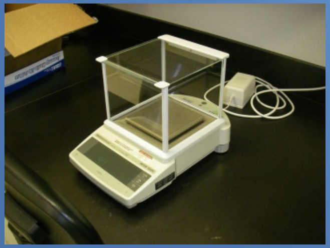
Egg size vs Fecundity

- Some females partially spawn prior to capture, this prevents an accurate determination of total egg fecundity.
- Natural origin females are live spawned, resulting in the collection of only a percentage of total egg number.

  In live spawning 113 hatchery origin females, an average of 72.4% of total egg mass was obtained, range: 46.2 – 93.9%

Methods

- Starting in 2005 sea run adults were trapped and spawned with the goal of using 2/3 hatchery origin (HOR) and 1/3 natural origin (NOR) steelhead to maintain genetic similarity between natural and hatchery populations.
- HOR females were anesthetized, euthanized, bled, and spawned by incision
- NOR females were anesthetized, live spawned by hand stripping, and released
- A female was spawned into a bucket, eggs were poured into a screened colander to remove excess fluid, and a random sample of 50 eggs were collected
- Each egg of the sample was individually weighed to the nearest one thousandth of a gram using a Mettler Toledo PG503-S scale



Results: Life History comparison

NOR pre-hatchery influence

- Smolts: out-migrating at one (19%), two (65%), and three (16%) years of age.
- Saltwater age for females captured 2005-2008, N=49, 51% 2 salt, 49% 3 salt
- Six age classes of returning females: 1.2, 2.2, 3.2, 1.3, 2.3, and 3.3

HOR

- Smolts: forced released at one year of age
- Saltwater age for females captured 2005-2008, N=126, 86.5% 2 salt, 13.5% 3 salt
- Two age classes of returning females: 1.2 and 1.3

Results: age 2 salt females

Origin	Weight (g)	FL(mm)	ova wt	N
HOR	2810.7	647.1	0.104	375
NOR	2907.4	648.7	0.134	27

Results: age 2 salt females

Hypothesis: no significant difference between 2 salt HOR and NOR

HOR to NOR	p values
Weight (g)	NS
Fork Length (mm)	NS
Ova Weight (g)	***

Traits for 2 salt HOR and NOR are significantly different (***p<.001) or not (NS)

Results: age 2 salt females

Hypothesis: no linear correlation among traits within each population, 2 salt HOR and 2 salt NOR

	HOR		NOR	
	r	2 tailed p	r	2 tailed p
Weight & Fork Length	0.88	***	0.94	***
Weight & Ova Weight	0.40	***	0.67	***
Fork Length & Ova Weight	0.14	**	0.61	***

Traits for 2 salt HOR and NOR are significantly different (**p<.01, ***p<.001)

Results: age 3 salt females

Origin	Weight (g)	FL(mm)	ova wt	N
HOR	4145.3	736.6	0.123	58
NOR	4226.2	744.8	0.142	13

Results: age 3 salt females

Hypothesis: no significant difference between 3 salt HOR and NOR

HOR to NOR	p values
Weight (g)	NS
Fork Length (mm)	NS
Ova Weight (g)	**

Traits for 3 salt HOR and NOR are significantly different (**p<.01) or not (NS)

Results: age 3 salt females

Hypothesis: no linear correlation among traits within each population, 3 salt HOR and 3 salt NOR

	HOR		NOR	
	r	2 tailed p	r	2 tailed p
Weight & Fork Length	0.92	***	0.94	***
Weight & Ova Weight	0.21	NS	0.26	NS
Fork Length & Ova Weight	0.21	NS	0.12	NS

Traits for 3 salt HOR and NOR are significantly different (***p<.001) or not (NS)

Conclusions

- Egg size is not the same in two genetically similar populations that differ in early life history. Hatchery origin females produce smaller eggs, which may result in smaller fry with lower survival.

- In the hatchery population, 86.5% of the females return as age 2 salt. Low variability in egg size within the population may reduce survival by reducing adaptability in a naturally changing environment.

Potential future work

- Determine if years in the creek affects egg size for NOR and HOR juveniles by conducting freshwater age scale analysis for sampled adults.
- Examine egg size and fecundity for one and two year HOR smolts by rearing to maturity in the hatchery.
- Examine histology of ovarian tissue of one and two year HOR smolts for signs of atresia under various rearing regimes.