Coded-wire Tag Data Suggest a Decline in Size and Age of Upper Willamette Hatchery Spring Chinook Salmon

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Background

Harvest, hatcheries, and habitat alterations can impose selection on important traits of Pacific salmon *Oncorhynchus* spp. (Beacham 2010; Quinn et al. 2011; Quinn et al. 2004). Traits such as sex, size and age at maturity can affect population productivity and mean fitness.

Four Oregon Department of Fish and Wildlife hatcheries produce spring Chinook salmon (*O. tshawytscha*) in the Upper Willamette River (UWR) basin (Figure 1). These fish are harvested in ocean and river sport fisheries, commercial ocean fisheries, as well as commercial tangle and gill net fisheries in the Columbia River. Adult UWR spring Chinook are also used in reintroduction programs above high-head dams operated by the U.S. Army Corps of Engineers. Trends in fitness-related traits of this stock are therefore relevant to both economic and conservation interests.

In this study, we analyzed coded-wire tag (CWT) data to test for trends in sex ratio, and mean size and age at maturity of UWR spring Chinook collected as adults in the Willamette and Columbia rivers.

Methods

Data Collection

From RMIS*, we obtained data (fork length, sex, brood year, recovery year and location) for adult UWR hatchery spring Chinook sampled from Columbia River net fisheries, in-river sport fisheries, UWR hatcheries and UWR spawning ground surveys, from brood years 1989-2005.

Analysis

All analyses performed by brood year, and sample collection (net fisheries, sport fisheries, hatcheries and spawning grounds)

Used simple linear regression to:

1) Compare sex ratios against 1:1 in three sample collections
   - For 1:1 sex ratio, slope (or *b)*=1
2) Test for trend in proportion males to females
   - Points weighted by *n*
3) Test for relationship between mean age and brood year
   - Points weighted by *n*

Used multiple linear regression to:

1) Test for relationship between mean fork length with brood year, age and sex for age-4 and age-5 Chinook
   - AIC used for model selection

*Regional Mark Information System (www.rmpc.org)

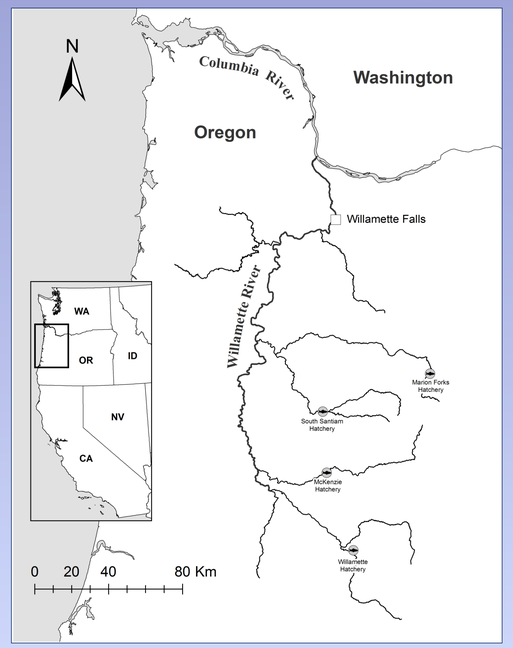

Figure 1. The Upper Willamette River, indicating locations of spring Chinook hatcheries.

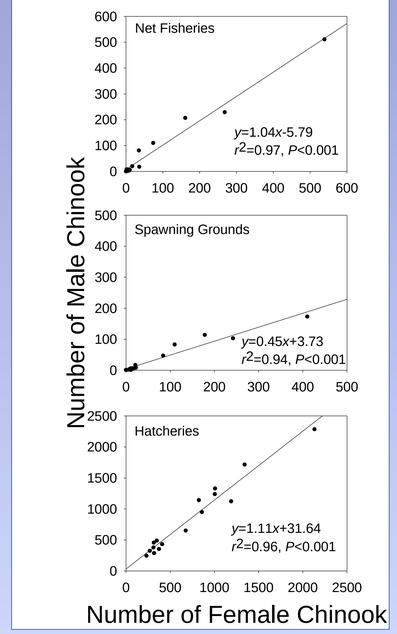

Figure 2. Relationships between the number of CWTs recovered from adult male and female Chinook.

Sample Collection (model R^2)	Variable	Coefficient	SE	*t*-statistic	*P*-value
	(Intercept)	5155.4	1749.7	2.95	0.003
Gill Nets	*year*	-2.2	0.9	-2.46	0.014
(R^2=0.403)	*age4*	-110.6	4.5	-24.50	<0.001
	female	-5997.7	2322.2	-2.58	0.010
	year×female	3.0	1.2	2.58	0.010
	(Intercept)	41743.0	3361.7	12.42	<0.001
Tangle Nets	*year*	-20.5	1.7	-12.17	<0.001
(R^2=0.403)	*age4*	-76.1	4.6	-16.42	<0.001
	female	-11729.4	4579.9	-2.56	0.011
	year×female	5.9	2.3	2.56	0.011
	(Intercept)	10882.7	2687.6	4.05	<0.001
Spawning Grounds	*year*	-5.0	1.4	-3.72	<0.001
(R^2=0.355)	*age4*	-9889.5	3705.9	-2.67	0.008
	female	-21.2	3.8	-5.54	<0.001
	year×age4	4.9	1.9	2.64	0.008
	(Intercept)	5333.2	380.3	14.02	<0.001
Hatcheries	*year*	-2.3	0.2	-11.79	<0.001
(R^2=0.442)	*age4*	-2444.3	397.1	-6.16	<0.001
	female	-1677.4	380.3	-4.41	<0.001
	year×age4	1.2	0.2	5.90	<0.001
	year×female	0.8	0.2	4.43	<0.001

Table 1. Coefficients and their standard errors (SE) for variables identified as significant predictors of mean fork length for upper Willamette River hatchery spring Chinook sampled from gill nets, tangle nets, spawning grounds and hatcheries.

Results and Conclusions

Sex Ratio (Figure 2)

No difference from 1:1 sex ratio for Chinook collected in net fisheries (*b*=1.035±0.087, 95% CI) or hatcheries (*b*=1.111±0.112, 95% CI), but female Chinook outnumbered males by nearly 2:1 on UWR spawning grounds (*b*=0.450±0.052, 95% CI).

Likely reflects behavior of females to remain on redds, while males continue to explore new areas, including fish collection sites.

Proportion of females taken by net fisheries declined by 2% per year (*t*=-4.36 on 11 df, *P*=0.001), but no trend observed for collections from spawning grounds or hatcheries (*P*>0.05).

Trend merits monitoring to determine if biologically significant.

Size (Table 1)

Mean fork length declined for age-5 males (coefficient of *year* in Table 1) in all sample collections, except sport fisheries.

Fork length of females increased or declined by lesser rates (than males) in net fisheries and hatcheries.

Fork length of age-4 Chinook declined at lesser rates (than age-5) for spawning grounds and hatcheries.

Net fisheries or hatchery influences may be driving decline.

Age (Figure 3)

We observed a decline in mean age only for Chinook sampled from spawning grounds.

Pattern of decline is driven by changes in ratio of age-4 and age-5 fish, which comprise 98% of samples from spawning grounds

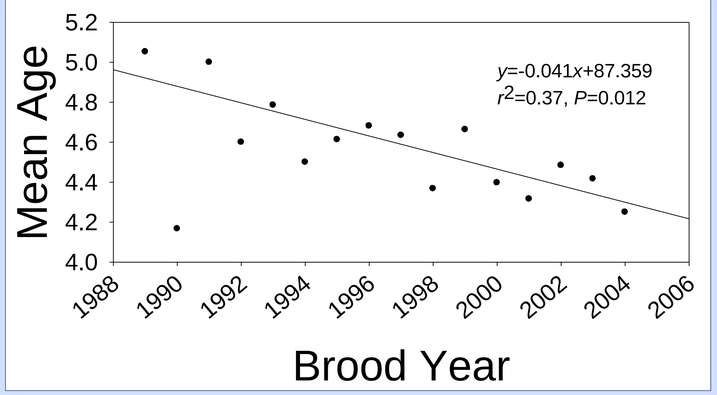

Figure 3. Relationship between brood year and mean age of adult spring Chinook recovered from UWR spawning grounds.

Acknowledgments

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