Adaptive Snake River Broodstock Management

Snake River Fall Chinook

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Endemic Stock- Before Lyons Ferry Hatchery was Online

By the early 1970's, Snake River fall Chinook runs were at critically low levels. In an effort to rescue the stock, the National Marine Fisheries Service (NMFS) began trapping fall Chinook on the Snake River at Little Goose Dam in 1976. At that time, little was known about fall Chinook and whether or not they could be raised on river water from the Snake. As such, the adults trapped from Little Goose Dam in 1976, and more adults trapped from Ice Harbor Dam (IHD, 1977-1983), were transported to the Washington Department of Fisheries Kalama Fish Hatchery to begin the Snake River Fall Chinook Egg Bank Program (Bugert 1995). This effort was a jump start to the foreseen LSRCP Lyons Ferry Hatchery (LFH) fall Chinook program due to come online in 1984. Transported adults were spawned, reared, tagged, and released from KFH, where it was believed they would return as adults. This was done to minimize loss of returning adults that would occur from dam passage. Once LFH was built, returns to and gametes collected at KFH were taken to LFH to initiate the hatchery program in the Snake River. To spread some of the risk, some of the adults trapped at Ice Harbor were hauled to Hagerman Hatchery in Idaho where they were subsequently spawned, reared, and released into the Clearwater and Snake rivers. Figure 1 shows historical trapping locations of Snake River Broodstock. Numbers of fish trapped at KFH are not included below because those fish were progeny of fish trapped at IHD.

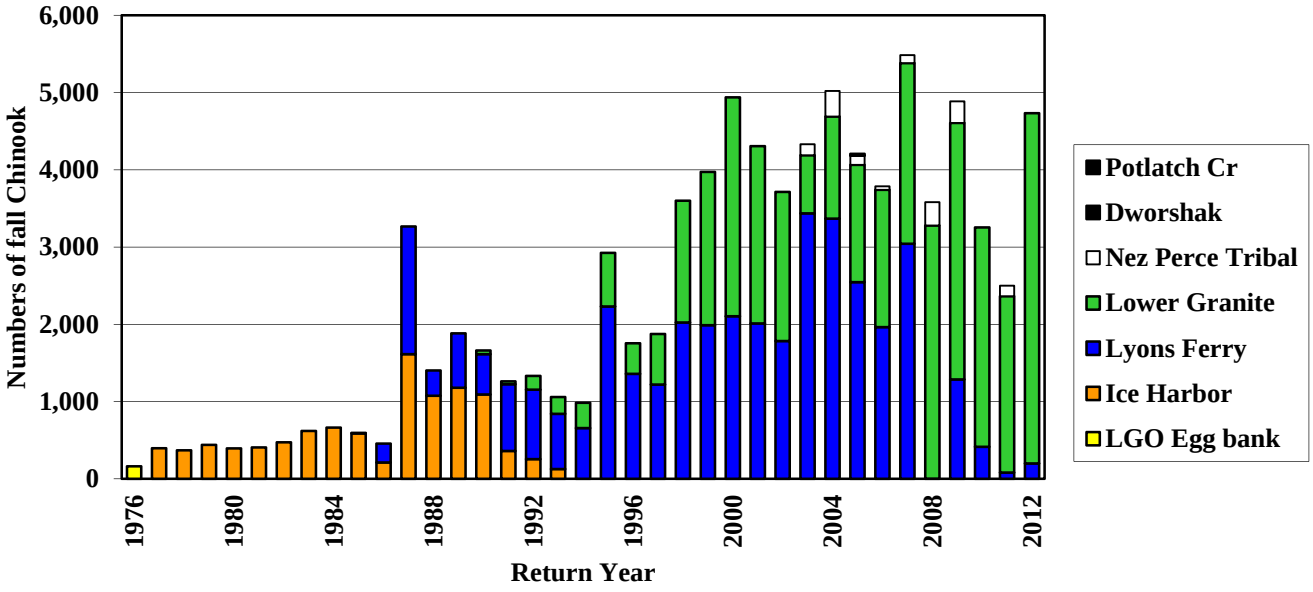


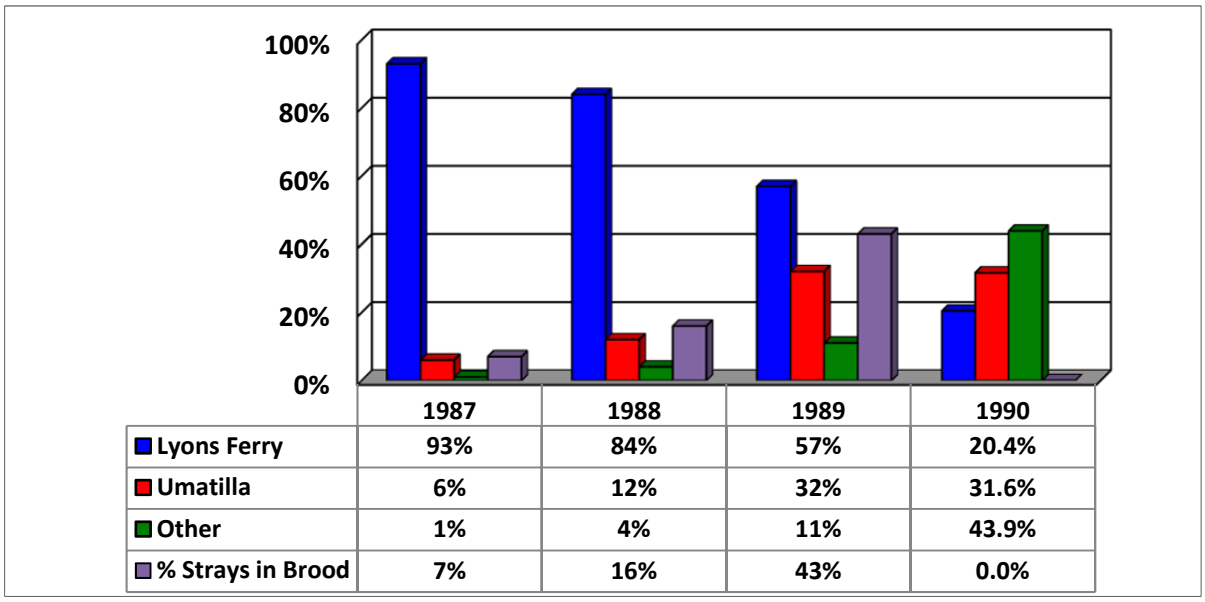
Figure 1. Numbers of fall Chinook trapped, by trapping locations, used for Snake River Fall Chinook Broodstock.

Primary Sources of Broodstock at LFH

In 1984 and 1985 the majority of the fish spawned at LFH came from KFH and IHD. In 1986, the first adult returns to LFH occurred and the Kalama Egg Bank Program was phased out by 1987. Specifics regarding changes to trapping locations for broodstock are discussed below.

Broodstock Integrity

As the number of strays increased to the Snake River basin, so did their presence in broodstock at LFH (Figure 2). In 1989 the stray rate had increased to an alarming level. Unfortunately those stray fish had already been mated with known origin Snake River hatchery fish. Prior to 1990, coded wire tags were not decoded before matings occurred; therefore strays were inadvertently included in the broodstock. Following the discovery that many strays had been included in the broodstock, it was agreed that the entire 1989 brood year would be marked and tagged, released as subyearlings, and be considered strays when they returned as adults.



	1987	1988	1989	1990
Lyons Ferry	93%	84%	57%	20.4%
Umatilla	6%	12%	32%	31.6%
Other	1%	4%	11%	43.9%
% Strays in Brood	7%	16%	43%	0.0%

Figure 2. Origin of fish (percentage) used for Snake River fall Chinook broodstock (1987-1990), and their total percent inclusion into the broodstock.

After 1989, spawning protocols at the hatchery were adapted such that; 1) Coded wire tags were decoded prior to mating fish to insure only known origin Snake River basin fish would contribute to the hatchery program, 2) broodstock was segregated by pond to evaluate stray rates for each trapping location, and 3) fish were given unique color coded tail tags to identify them by week of arrival so stray rates could be estimated by week, and 4) all subsequent releases from LFH were coded-wire tagged or elastomer tagged for positive identification (Mendel, 1998).

In 1990, fish were spawned in three groups; LFH tagged, foreign tagged (strays), and untagged. If the stray rate was deemed to be below an acceptable level during a particular week, foreign tagged and untagged adults would have been used in the LFH program. The stray levels in 1990 were appreciable and showed little variation among weeks of arrival, so only progeny of LFH tagged adults were retained for program use in that year.

Also in 1990, the Lower Granite Adult Trap began diverting coded wire tagged fall Chinook into the trap to help remove strays from the Snake River Basin, monitor stray rates at LGR Dam, and supplement broodstock at LFH. From 1991-1993, adipose clipped, presumably wire tagged, fish were trapped at IHR, LFH and LGR (1992 and 1993 only) to assure the origin of each fish was known before it was spawned and contributed to production.

While these new protocols were enacted to preserve the integrity of the Snake River fall Chinook stock, challenges occurred and WDFW and US v Oregon policy at the time would not allow the culling of strays or their gametes if they were needed elsewhere in the Columbia River basin. As such, identified strays were mated with other strays or unknown origin fish and the resulting stray/unknown progeny were marked and tagged and shipped out of the Snake River basin to other hatchery facilities in the Columbia River basin (mainly Klickitat Hatchery).

In 1994, managers decided to cease trapping at IHR Dam because of the high dip-in rate of Columbia River fish (Mendel et al 1997, Mendel 1998) and trapping efforts were focused farther up the Snake River (LFH and LGR). Also in 1994, Nez Perce Tribal Hatchery (NPTH) came online and broodstock collected at LGR Dam was shared between LFH and NPTH. Spawning protocols at NPTH and LFH are similar, although gonadotropin is used at NPTH to hasten gonad development of their broodstock. Through the years, spawning protocols have been effective at reducing the numbers of strays included in broodstock (Table 2).

Table 1. Comparison of percent strays in the run at Lower Granite Dam versus the percentage of strays included in broodstock at LFH, 2007-2012.

Return year	% Strays in Run at LGR	% Strays included in broodstock
2007	**1.5**	**0.0**
2008	**2.8**	**0.1**
2009	**1.7**	**0.1**
2010	**3.5**	**0.3**
2011	**1.2**	**1.2**
2012	**0.3**	**<0.1**

Inclusion of Natural Stock

In 2003, after several years of documenting low stray rates to the Snake Basin, mating protocols were changed to include unmarked/untagged fish in broodstock. To accomplish this change in protocol, the trapping system at LGR Dam was modified and the trap was programmed to shunt fish into the trap 4 times per hour, essentially trapping a percentage of the run, not just wire tagged fish. These changes not only resulted in the opportunity to collect natural origin fish for broodstock, but also provided sampling necessary to estimate the run composition at LGR Dam, including the origin and age composition of untagged returns using scale pattern analysis. Currently the primary trapping site is LGR and trapping at NPTH and LFH only occurs if co-managers agree that there is a possibility that broodstock may be limited.

In 2008, the validity of using scale pattern analysis to determine origin came into question and co-managers agreed that scales would no longer be used to determine origin of returning fall Chinook. Changes in the programs over the years have included multiple rearing locations, release locations, and sizes at release. Changes in the river system over the years have included multiple dam passage improvements and court ordered spill. These changes have affected the way the fish migrate and how much time they spend in freshwater, all affecting the way that the hatchery check on the scales appear and how reliably origin can be determined.

Although questions were raised about the origin (hatchery or natural) of untagged fish, Snake River fall Chinook programs strive to include natural origin fish in their broodstocks. Parentage Based Tagging (PBT) began at NPTH in 2008 and at LFH in 2011, effectively enabling us to genetically identify all untagged Snake River Hatchery returns starting in 2016. Any untagged fish that are not found in our PBT database will either be returns from out of basin strays or Snake River natural origin fish. We anticipate the majority of those fish will be natural origin, since the majority of strays we have encountered over the years are from fully tagged or marked releases.

Jacks

Jacks occur at a highly variable rate in nature (Table 3). Jacks in nature compete with males to spawn with females with an average relative success of 0.5. Spawning protocols at hatcheries essentially removes the competition which thereby increases the opportunity for jacks to contribute at a higher rate than in nature. Not only are jacks selected for use and allowed to cover all of a females eggs, the progeny are also given the survival benefit during rearing at the hatchery.

Table 2. Percentages of Chinook jacks found in nature and the percentage of offspring produced, and the relative success of jacks compared to males.

Study	Breeding groups	Life stage	Jacks in population	% of total offspring produced		Relative success Jack/male	
	n		range	mean	range	mean	range
Berntson et al. unpbl.	5	Rs	10-14%	7%	2-13%	0.61	.22-1.09
Williamson et al 2010	2	Rs	10-61%	27%	8-47%	0.45	.18-.71
Schroder et al 2011	7	Bs	7-13%	3%	1-5%	0.25	.14-.47
Berejikian et al 2010	4	Bs	25-50%	20%	9-33%	0.56	.15-1.0
Overall	**18**		**7-50%**	**14%**	**1-47%**	**0.50**	**0.14-1.09**

Table provided by Dr. Barry Berejikian NOAA, Seattle.

Inclusion of Jacks

Jacks have always been present. In 1975, NMFS counts at LGR indicated that 42% of the fall Chinook run from August to December were jacks, estimated by length (<53 cm) as they passed the counting window (NMFS unpublished data 1975), however this may be inflated by downriver harvest methods that remove mostly adults. Many of the yearling jacks are larger than 52 cm criteria used at the counting windows of the Snake and Columbia River Dams. Historical spawning protocols at LFH and NPTH state that jacks may be included in broodstock up to 15%. Jacks were originally estimated at the hatcheries by using the same fork length criteria used at dams. Using length to estimate jacks at the hatcheries is not precise because jacks from subyearlings and yearling releases overlap in fork length (Table 4), which may overestimate

subyearling jacks and underestimate yearling jacks. Another problem with using a universal fork length in protocols to determine which fish to spawn occurs when multiple trapping locations and differing compositions of fish at each location occur. For example, fish trapped at LFH are primarily yearlings while fish trapped at LGR are a mix of yearlings and subyearlings.

Table 3. Fork lengths of jacks and jills used in broodstock in 2010 by rearing type.

	Number of matings	Average fork length (cm)	Median fork length (cm)	SD of fork length (cm)	Min fork length (cm)	Max fork length (cm)
Jacks 1-salt						
H yearling	18	68	68	4.7	61	77
H reservoir reared	10	71	69	4.8	66	77
Unk reservoir reared	8	71	70	3.0	67	75
H subyearling	1	59	-	-	-	-
Unk subyearling	1	66	-	-	-	-
Jills 1-salt						
Unk subyearling reservoir reared	1	70	-	-	-	-
Unk reservoir reared	1	81	-	-	-	-

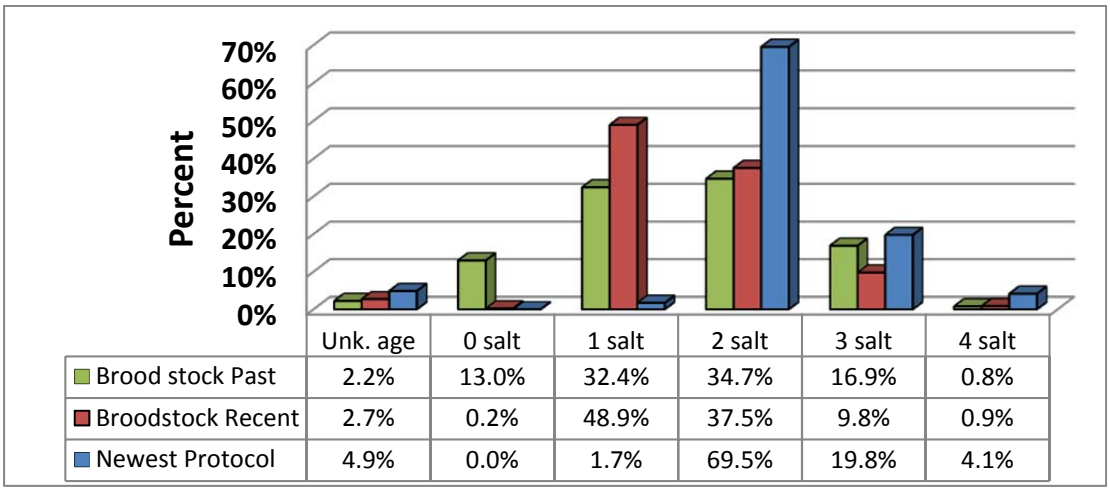
During 2009, several weeks into spawning at LFH, age was calculated based on CWT and scale age estimates rather than from a generic fork length. Subtracting the brood year and rearing age from the return year results in the salt water age of the return. For instance, a 2012 return of a brood year 2010 subyearling is calculated; 2012-2010-1=1 salt jack. Reworking historical data with this methodology resulted in extremely high estimates of jacks and jills contributing to past production (Table 5).

Table 4. Percentages of total matings at LFH that included one or two mini jacks, jacks, or jills, 2000-2009.

Year	% of total matings	0-salt Mini jack	1-salt jack	1-salt jill	Number of matings jack x jill
2000	80.4	195	609	157	127
2001	67.6	9	875	67	47
2002	31.8	5	348	6	4
2003	74.5	3	527	78	63
2004	77.6	34	941	254	204
2005	45.3	13	610	58	26
2006	70.6	1	525	123	94
2007	82.9	0	1136	477	405
2008	30.2	0	348	78	31
2009	70.3	1	547	513	152
2010	3.2	0	38	2	0
2011	4.6	0	23	36	2
2012	0.4	0	2	3	0
2000-2009 Average	**63.1**	**26**	**647**	**181**	**115**
2010-2012 Average	**2.7**	**0**	**21**	**16**	**1**

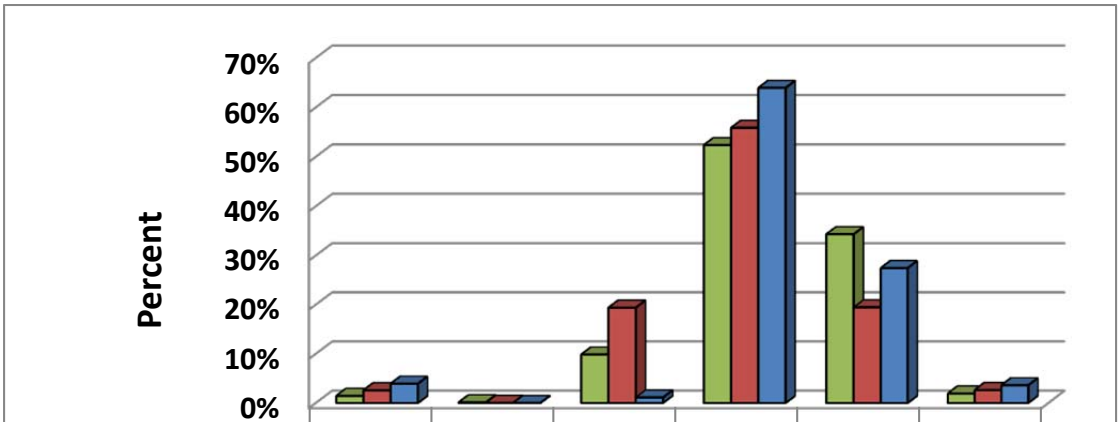
Following this discovery in 2009, mating protocols were modified to reduce the chance of mating jacks with jills and to maximize the use of older aged males. It has been suggested that use of random matings would result in long-term selection for younger age at maturity, even if jacks were excluded as spawners (Chen 2007 and Hankin 2009). In addition, if instead females were mated to males of a larger size, as is done in nature, then the long term-selection for young age at maturity could greatly be reduced. For a time during that year, small males were mated with larger females and any male used on a jill was also used on a larger female. This assured that the gametes of the male would contribute to production even if one of the females he was mated with was culled. The current goals are to use larger males with each female and to maximize the use of older, larger males, even if it that means using each male on multiple

female. Current trapping/hauling protocols target larger (generally above 75 cm fork length) older aged males and females. Mating protocols have greatly reduced the use of mini jacks, jacks, and jills at LFH (Table 5) since 2010. As a result of mating protocol changes, ages of males (Figure 3) and females (Figure 4) used as broodstock at LFH have shifted towards older aged fish.



	Unk. age	0 salt	1 salt	2 salt	3 salt	4 salt
Brood stock Past	2.2%	13.0%	32.4%	34.7%	16.9%	0.8%
Broodstock Recent	2.7%	0.2%	48.9%	37.5%	9.8%	0.9%
Newest Protocol	4.9%	0.0%	1.7%	69.5%	19.8%	4.1%

Figure 3. Salt water ages of males used as broodstock at LFH during 1991-1996, 2005-2009, and 2010-2012. Broodstock Past = 1991 to 1996, Broodstock Recent = 2005 to 2009, and Newest Protocol = 2010-2012.



	Unk. age	0-salt	1-salt	2-salt	3-salt	4-salt
Broodstock Past	1.4%	0.1%	9.9%	52.4%	34.3%	1.9%
Broodstock Recent	2.6%	0.0%	19.4%	55.9%	19.5%	2.6%
Newest Protocol	3.9%	0.0%	1.1%	63.9%	27.4%	3.6%

Figure . Salt water ages of females used as broodstock at LFH during 1991-1996, 2005-2009, and 2010-2012. Broodstock Past = 1991 to 1996, Broodstock Recent = 2005 to 2009, and Newest Protocol = 2010-2012.

Conclusions

The hatchery program has been highly adaptable and is striving to keep the integrity of the Snake River Stock intact, include natural origin fish into broodstock, and maintain a robust age structure of spawned fish contributing to production, as well as an ample proportion of older and larger adults in the Snake River returns for natural spawning and harvest. We will continue to minimize the use of jacks and jills and maximize the contribution of larger/older males by using them on multiple females if necessary, because of limitations on availability of large males. In 2017 we will analyze the return data and compare age composition of the returns to see if there has been a shift to older aged hatchery fish in the return. At that time the co-managers will consider changing to less emphasis on using larger, older broodstock and will reevaluate balancing the use of the broodstocking guidelines recommended by Hankin and random matings to increase genetic contribution (as recommended by geneticists). We will continue PBT profiling broodstock to assure untagged releases are identifiable at return to ensure naturally produced fall Chinook can be incorporated into hatchery broodstock at a higher rate.

Citations

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