Snake River Hatchery Fall Chinook Salmon Age-at-Release Performance Evaluation White Paper

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Background

Hatchery production is an integral part of Snake River fall Chinook Salmon management, with multiple parties involved. A highly coordinated monitoring and evaluation effort is in place to generate information critical for future regional recovery planning, hatchery production, harvest planning and management. Due to the differing management perspectives/priorities among the managing entities of the Snake River fall Chinook hatchery program, this document is structured as a white paper meant to inform decisions. Recommendations based upon the presented data are being deferred to other management forums.

This white paper provides a summary of Snake River fall Chinook Salmon survival and harvest, with an emphasis on the comparison among hatchery yearling and subyearling release groups released downstream and upstream of Lower Granite Dam (LGR). Since being listed as threatened under the Endangered Species Act (ESA) in 1992 Snake River fall Chinook Salmon returning to LGR have made an astonishing rebound, increasing from less than a thousand fish in the 1990's to over seventy-five thousand fish in 2013 (Figure 1). The increased abundance of fall Chinook Salmon in the Snake River Basin was achieved in large part by the use of a hatchery program consisting of diverse release locations and rearing strategies. Releases began downstream of LGR at Washington Department of Fish and Wildlife's Lyons Ferry Hatchery in 1984, and have since expanded to include releases upstream of LGR from the Nez Perce Tribe's Fall Chinook Acclimation Program (FCAP) in 1996, an Idaho Power Company hatchery program in 2001, and most recently, the development of the Nez Perce Tribe Hatchery Complex in 2003.

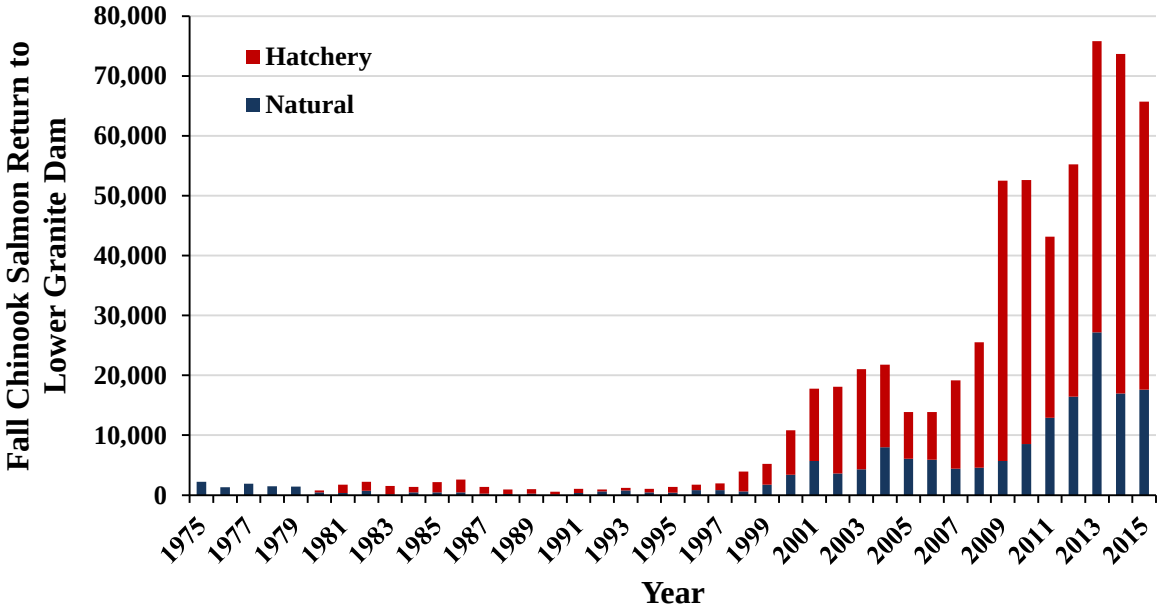

Figure 1. Estimated returns of hatchery and natural Snake River fall Chinook Salmon to LGR (1975 – 2015).

Beyond providing a boost in returns to LGR and to the natural spawning population, Snake River fall Chinook Salmon hatchery programs have provided significant out-of-basin

benefits. In recent years Snake River fall Chinook Salmon returns have provided a valuable boost to tribal and non-tribal Ocean and Columbia River fisheries as well as emerging Snake River sport and Tribal fisheries (Figure 2; Young et al. 2012; Regional Mark Information System)

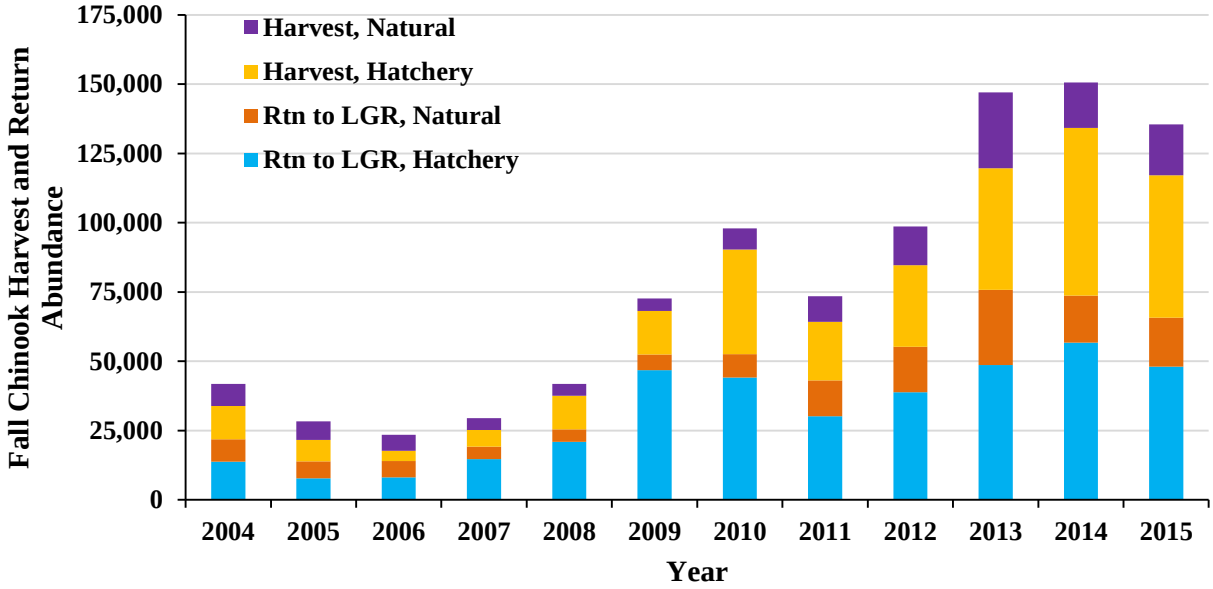

Figure 2. Yearly estimate of the number of hatchery and natural Snake River Fall Chinook that contribute to harvest and returns to LGR.

Snake River fall Chinook Salmon hatchery production, release sites, marking, tagging, and egg distribution have been directed by the *U.S. vs Oregon* Management Agreement. Production table B4B within the current 2008 – 2017 Agreement not only identifies and lists release sites and strategies, but also prioritizes the hatchery programs should egg collections fall short of that needed for the entire Snake River Basin hatchery program (Appendix Table A1). This table is the basis for the metrics presented in this report.

This report provides multiple performance metrics for Snake River fall Chinook Salmon that were released as juveniles into the Snake River Basin from 2006 through 2011. This report compares performance of subyearling and yearling fall Chinook Salmon by release location and rearing strategy (subyearling or yearling) for 1) smolt to adult return rates (SAR), 2) harvest rates, 3) smolt to adult survival rates (SAS), 4) age composition at adult return, 5) size composition at return, and 6) return timing at Bonneville Dam. These metrics provide information that is critical for regional recovery planning, hatchery management, and harvest planning and management.

The hatchery programs evaluated in this white paper are solely funded by the Bonneville Power Administration, Idaho Power Company, and the Lower Snake River Compensation Plan.

Methods

In an attempt to present the data in a comparable and consistent manner, a series of definitions/criteria were developed to promote the greatest amount of utility when comparing and contrasting the different release sites and strategies. These definitions/criteria include:

1. Data presented are annual averages of fish harvested and fish returning to LGR from release years 2006 – 2011, with the exception of Passive Integrated Transponder (PIT) tag based adult run timing data which is a pooled average of 2011 – 2015 return years.
2. All comparisons made for Smolt to Adult Returns (SAR), Smolt to Adult Survival (SAS), and Harvest were only done between groups that have both an Adipose Clip and a Coded Wire Tag (ADCWT). A summary of release groups used in the comparison are presented in Table 1. (Note: SAR calculations differ from Comparative Survival Study (CSS) PIT tagged based methods which use number smolts passing Lower Granite Dam instead of number of fish released).
3. Harvest data through return year 2014 is considered complete, however data from the 2015 return year may not be complete due to reporting deadlines stipulated by the Regional Mark Information System (RMIS). Harvest data was downloaded from RMPC.org on 12/15/2015.
4. Harvest data incorporates sport and commercial tribal and nontribal harvest in the ocean and Columbia River. Due to the paucity of ADCWT recoveries (<1-2% of total recoveries) in the Snake River and Columbia River tributary fisheries (i.e. Deschutes River), harvest data from those two areas were excluded. Harvest data was also excluded from sport and tribal fisheries conducted upstream of Lower Granite Dam.
5. Passage timing graphs incorporate all PIT tags associated with an individual release, regardless of mark type.
6. Jack and Adult calculations were based on ocean age, <u>not</u> fork length. Jacks are defined as one ocean age fish regardless of age at release (subyearling or yearling) or size. Minijacks (0 ocean), averaging 27% of total yearling returns to LGR (unpublished data), were excluded from all calculations. Minijacks are rarely observed in returns from subyearling releases.
7. To accurately evaluate differences between yearling and subyearling release groups, release years, rather than brood years, were compared in the analyses.
8. Due to an egg shortage in brood year 2006, eggs were not available for multiple releases in 2007. To ensure all groups were compared equally, release year 2007 was excluded from all analyses.

Methods and calculations specific to each metric are discussed in the results section of this report. Where appropriate, additional tables and box plots that accompany the figures are provided in an Appendix.

For the following analyses, multiple data sources were used and includes data downloaded from the Pacific States Marine Fisheries Commission PTAGIS and RMIS databases, as well as annual Snake River fall Chinook Salmon Lower Granite Dam run reconstruction estimates (Young *et al*. 2012).

Table 1. Snake River fall Chinook Salmon AD/CWT release groups used in the analysis.

US v OR Priority[1]	Age[2]	Release Group/Site	Juvenile Rearing Site[3]	Release Subbasin	Release Strategy
1	1+	Lyons Ferry Onstation	LFH	Snake/Below LGR	Acclimation
2	1+	Pittsburg Landing	LFH	Snake	Acclimation
3	1+	Big Canyon	LFH	Clearwater	Acclimation
4	1+	Captain John Rapids	LFH	Snake	Acclimation
5	0+	Lyons Ferry Onstation	LFH	Snake/Below LGR	Acclimation
6	0+	Captain John Rapids	LFH	Snake	Acclimation
7	0+	Big Canyon	LFH	Clearwater	Acclimation
8 &10	0+	Pittsburg Landing	LFH	Snake	Acclimation
9	0+	Hells Canyon Dam/OFH	OFH	Snake	Direct
11	0+	Couse Creek	LFH	Snake	Direct
13[4]	0+	Grande Ronde River	LFH/IRR	Grande Ronde	Direct
15	0+	Hells Canyon Dam/Uma/IRR	UFH/IRR	Snake	Direct
16[4]	0+	Grande Ronde River	LFH/IRR	Grande Ronde	Direct
17	0+	Hells Canyon Dam/Uma/IRR	UFH/IRR	Snake	Direct

[1] Release Groups 12 and 14 were associated with the transportation study and are not considered a long term release strategy.
[2]Age at release: Yearling - 1+; Subyearling - 0+
[3]Lyons Ferry Hatchery (LFH); Oxbow Fish Hatchery (OFH); Umatilla Fish Hatchery (UFH); Irrigon Fish Hatchery (IRR)
[4]Grande Ronde River: Due to an egg shortage, an ADCWT group was not released in 2008.

Results

Smolt to Adult Return Rates

Smolt to adult return rates (SAR) were calculated as: (Total number of ADCWT fish returning to LGR / Total number of ADCWT fish released) x 100. The number of fish returning to LGR was calculated using current run reconstruction methods developed by Young et al. (2012). Comparisons of SAR's were made among release sites (Figure 3, Table A2, Figure A1) and between yearling and subyearling release strategies (Figure 4, Table A3, Figure A1).

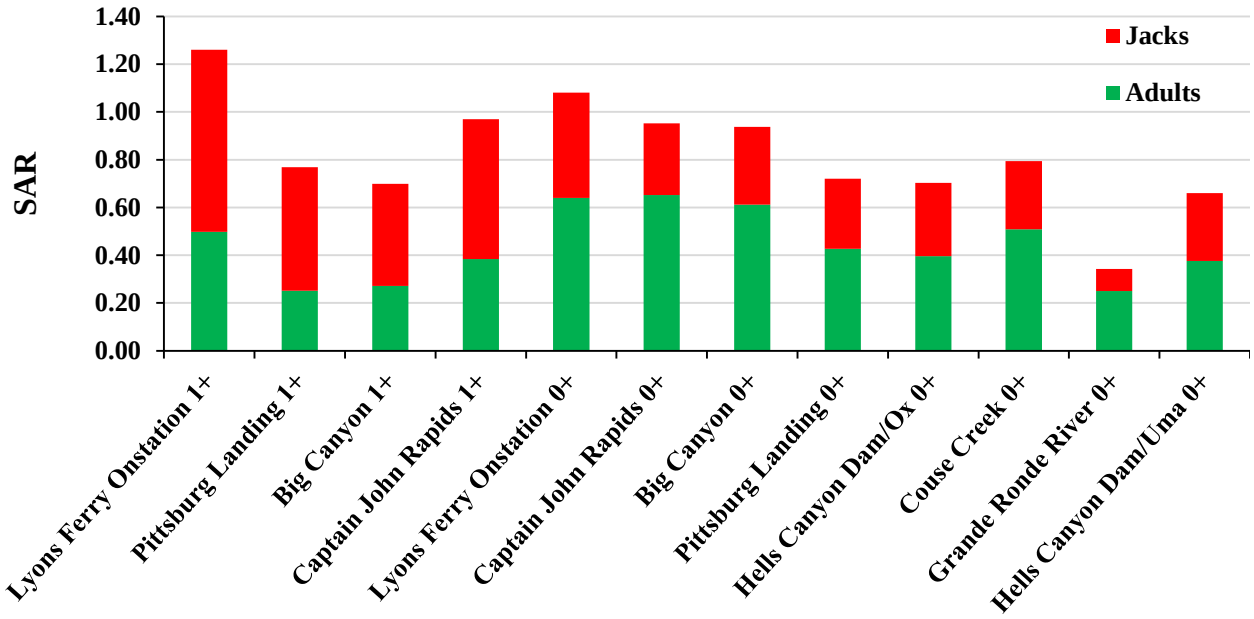

Figure 3. Average SAR and age composition of returning adults from Snake River fall Chinook Salmon hatchery yearling (1+) and subyearling (0+) release groups (Release Years 2006, 2008-2011).

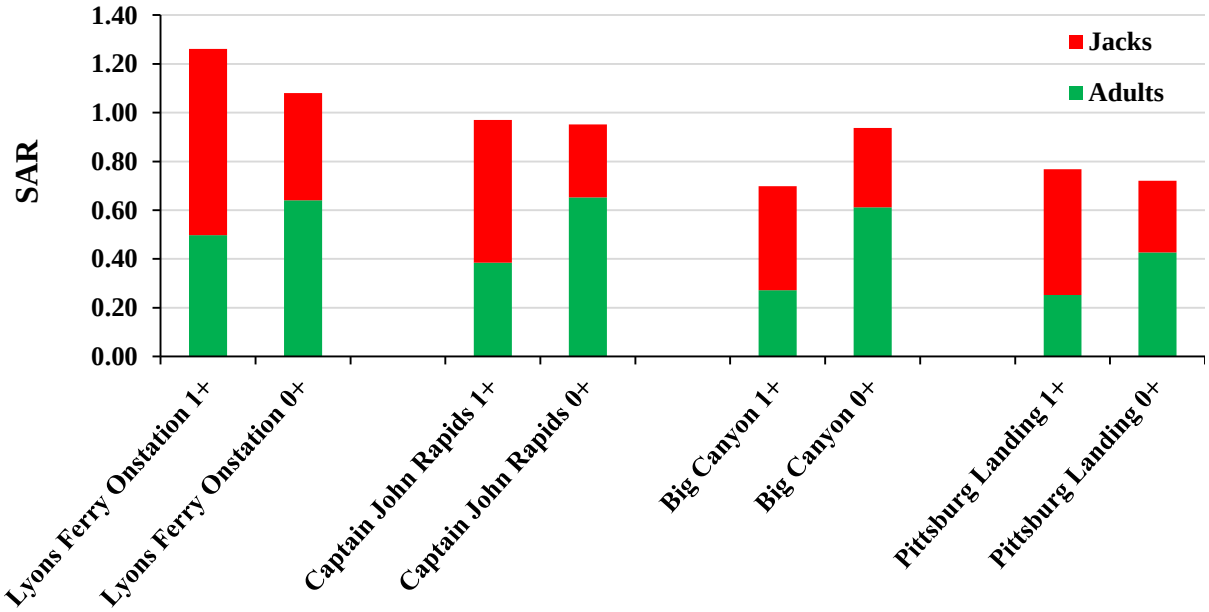

Figure 4. Comparison of average SAR and age composition of returning adults by common release site from Snake River fall Chinook Salmon yearling (1+) and subyearling (0+) hatchery releases (Release Years 2006, 2008-2011).

Harvest Rates

Harvest data were obtained from the RMIS database and include harvest reported primarily through 2014, although some 2015 data was reported. Harvest rates for each of the hatchery release groups were calculated as: (Total number of estimated ADCWT fish harvested) / (Total number of ADCWT fish released) x 100. Harvest rates presented here includes all tribal and non-tribal sport and commercial harvest in the ocean and Columbia River, but does not include harvest of fish in the tributaries of the Columbia River and fish harvested in the Snake River upstream and downstream of LGR due to their small contributions (<1-2%). Comparisons of harvest rates were made between release sites (Figure 5, Table A4, Figure A2) and between yearling and subyearling release strategies (Figure 6, Table A5, Figure A2).

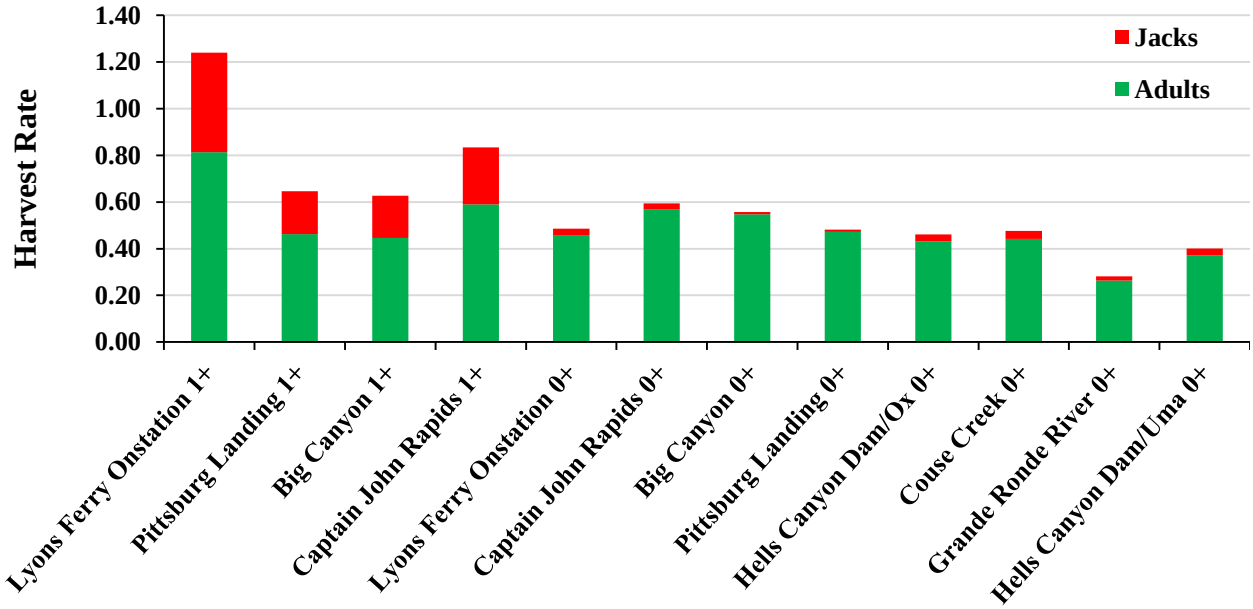

Figure 5. Average harvest rate and age composition of Snake River fall Chinook Salmon yearling (1+) and subyearling (0+) hatchery release groups (Release Years 2006, 2008-2011).

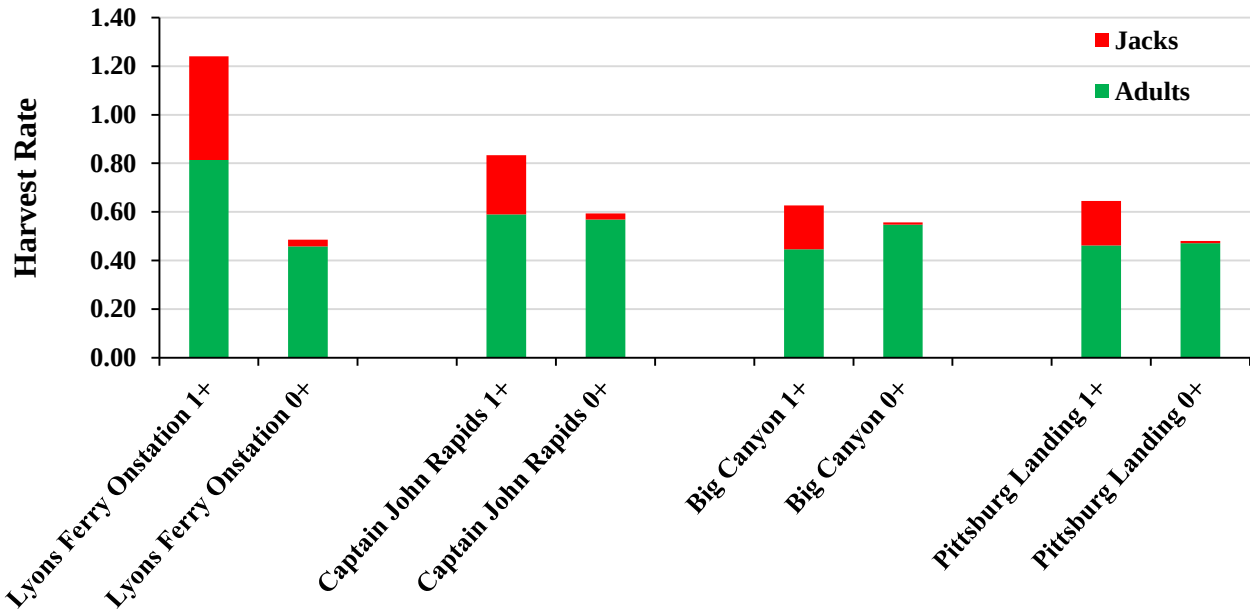

Figure 6. Comparison of average harvest rate and age composition by common release site of Snake River fall Chinook Salmon yearling (1+) and subyearling (0+) hatchery releases (Release Years 2006, 2008-2011).

Smolt to Adult Survival Rates

Smolt to adult survival rates (SAS) were calculated as: (Total number of ADCWT estimated in harvest + number of ADCWT fish estimated at LGR) / (Total number of ADCWT fish released) x 100. Comparisons of SAS were made between release sites (Figure 7, Table A6, Figure A3) and between yearling and subyearling release strategies (Figure 8, Table A7, Figure A3).

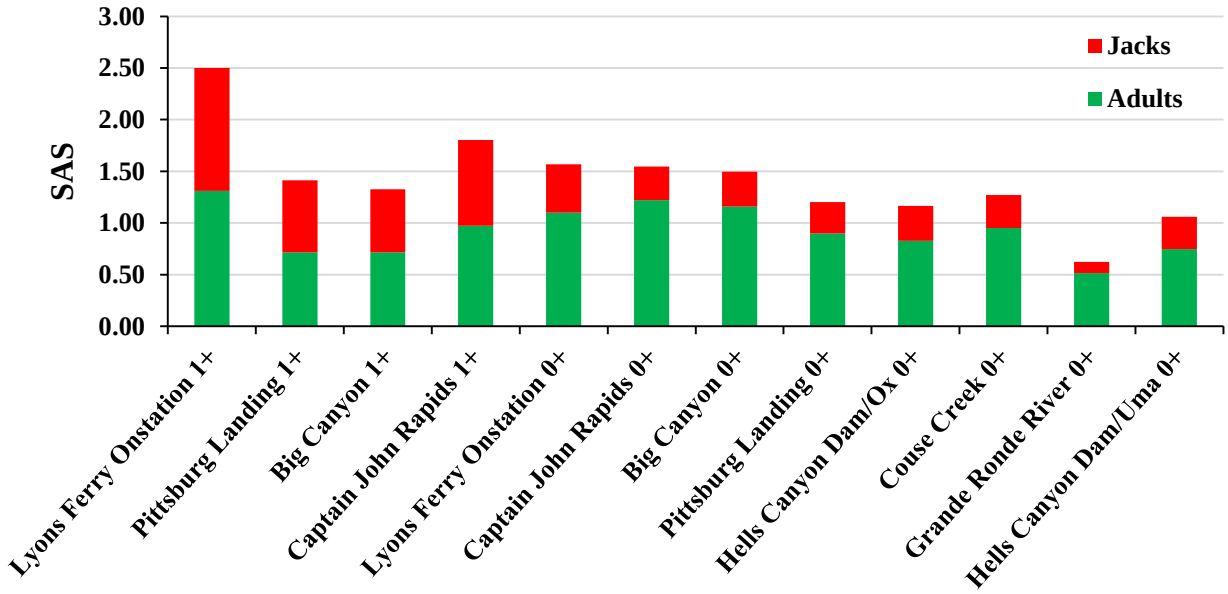

Figure 7. Average SAS and age composition of Snake River fall Chinook Salmon yearling (1+) and subyearling (0+) hatchery release groups (Release Years 2006, 2008-2011).

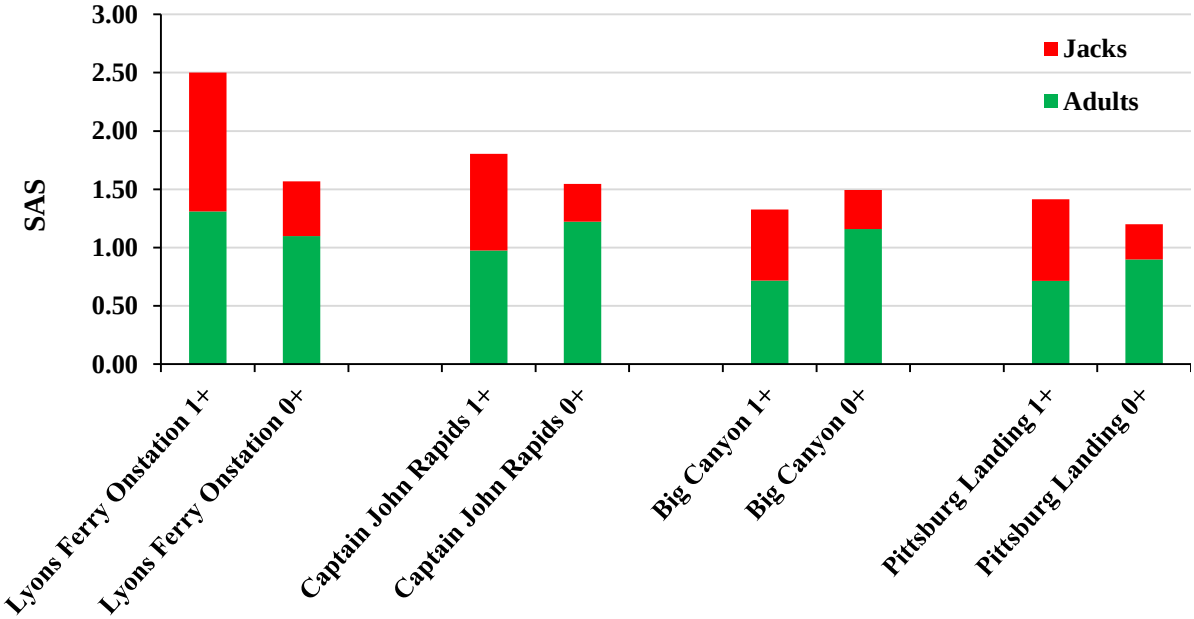

Figure 8. Comparison of average SAS and age composition by common release site of Snake River fall Chinook Salmon yearling (1+) and subyearling (0+) releases (Release Years 2006, 2008-2011).

Size of Snake River fall Chinook within Harvest and Return to Lower Granite Dam

Harvest length data were obtained from fish measured as part of fishery sampling and reported to the RMIS database. Length data presented from LGR were obtained as part of the

directed sampling effort at the LGR adult trap. If larger than 30 centimeters (cm), mini-jacks are included in the LGR metrics. Fish with known lengths were separated into four categories: 30 – 52 cm; 53 – 69 cm, 70 – 79 cm and ≥ 80 cm and the percentage of each category represented in the harvest and return to LGR samples were compared for yearlings and subyearlings (Figure 9).

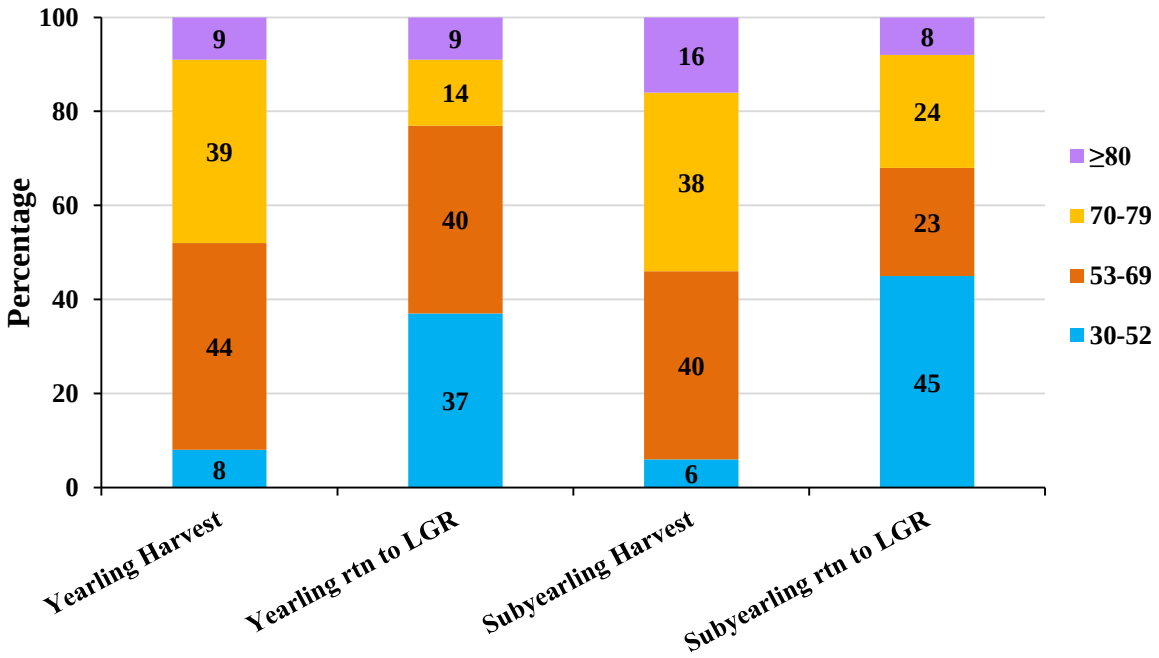

Figure 9. Comparison of the average length (centimeters) distribution of adult returns from yearling (1+) and Subyearling (0+) releases of fall Chinook Salmon that were intercepted in a fishery and those that were not intercepted in a fishery and returned to LGR (Release Years 2006-2011). Numbers within each bar graph represent the percentages by length category.

Run Timing Comparisons

Average run timing of PIT tagged Snake River fall Chinook Salmon adults at Bonneville Dam for return years 2011 - 2015 were compared among release sites for yearling (Figure 10) and subyearling (Figure 11) release groups and between all yearling and subyearling groups (Figure 12).

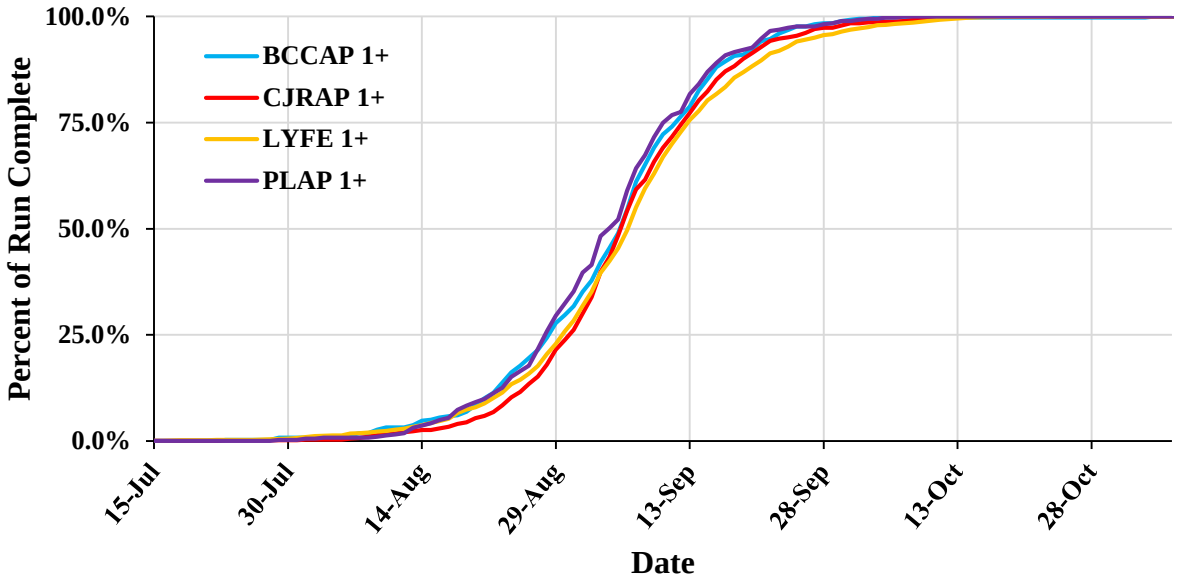

Figure 10. Average run timing at Bonneville Dam of adults returning from Yearling (1+) releases of fall Chinook Salmon (2011-2015).

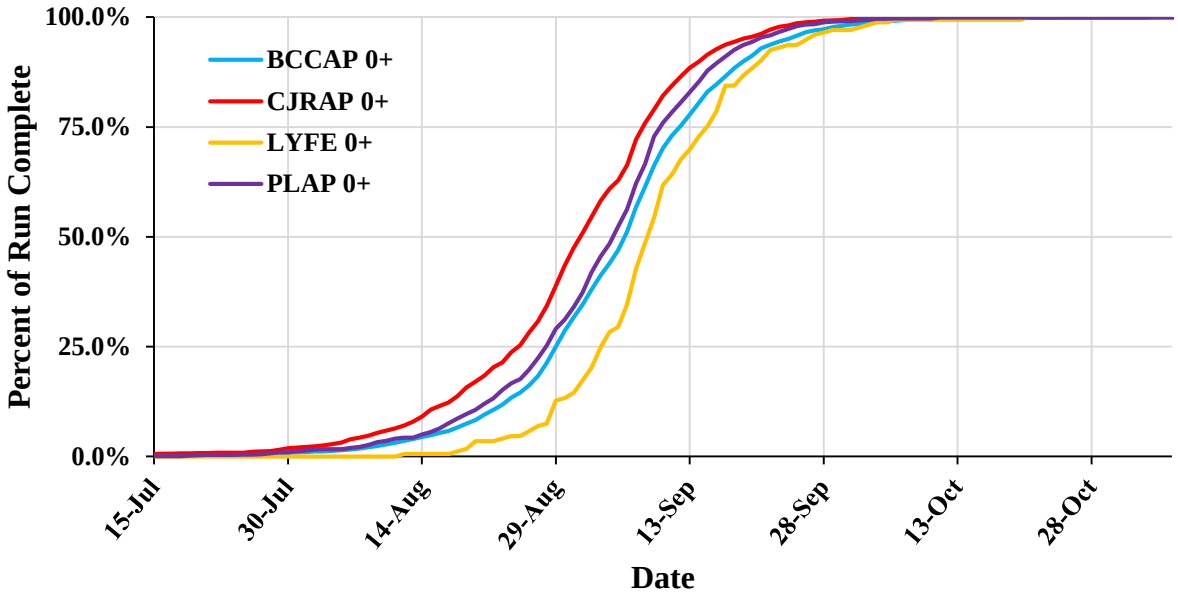

Figure 11. Average run timing at Bonneville Dam of adult returns from subyearling (0+) releases of fall Chinook Salmon (2011-2015).

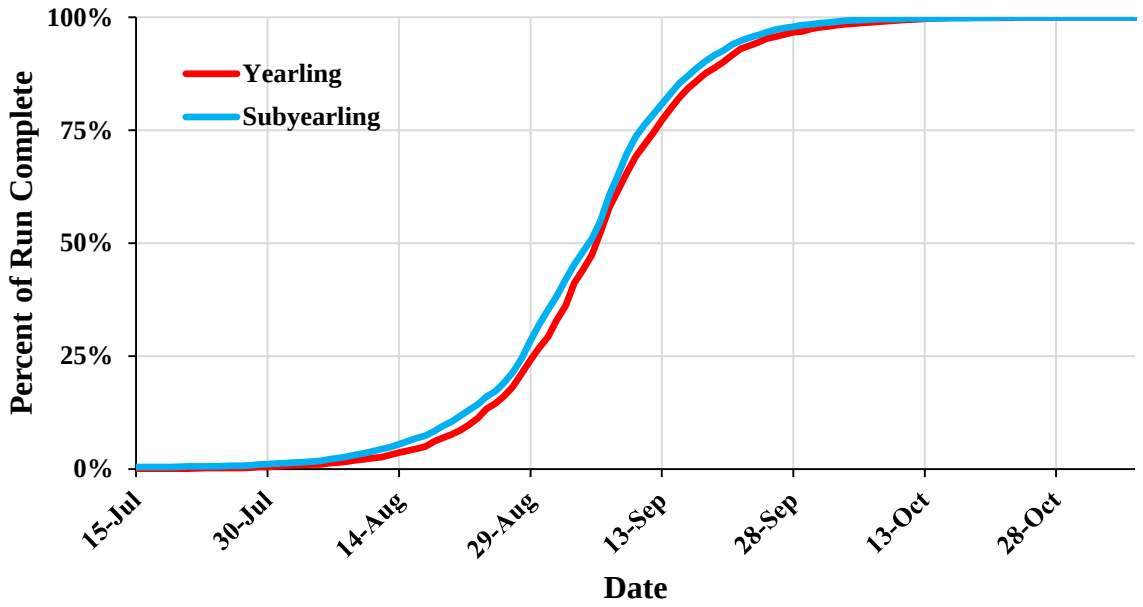

Figure 12. Average run timing at Bonneville Dam of adult returns from yearling and subyearling releases of fall Chinook Salmon (2011-2015).

Citations

Regional Mark Information System (RMIS). Regional Mark Processing Center, Pacific States Marine Fisheries Commission, 205 SE Spokane Street, Suite 100 Portland, Oregon 97202. http://www.rmpc.org/

Young, W.P., S. Rosenberger and D. Milks. 2012. Snake River Fall Chinook Salmon Run Reconstruction at Lower Granite Dam; Methods for Retrospective Analysis. Nez Perce Tribe, Department of Fisheries Resources Management. http://www.nptfisheries.org/PublicationLibrary.aspx

Appendix

Table A1. Revised production table listing Snake River fall Chinook Salmon production priorities for Lyons Ferry Hatchery per the US v OR Management Agreement, Table B4B, for brood years 2008-2017.

Priority	Production Program				
	Rearing Facility	Number	Age	Release Location(s)	Marking
1	Lyons Ferry	450,000	1+	On station	225KAdCWT 225K CWT
2	Lyons Ferry	150,000	1+	Pittsburg Landing	70K AdCWT 80K CWT only
3	Lyons Ferry	150,000	1+	Big Canyon	70K AdCWT 80K CWT only
4	Lyons Ferry	150,000	1+	Captain John Rapids	70K AdCWT 80K CWT only
5	Lyons Ferry	200,000	0+	On station	200K AdCWT
6	Lyons Ferry	500,000	0+	Captain John Rapids	100K AdCWT 100K CWT only 300K Unmarked
7	Lyons Ferry	500,000	0+	Big Canyon	100K AdCWT 100K CWT only 300K Unmarked
8	Lyons Ferry	200,000	0+	Pittsburg Landing	100K AdCWT 100K CWT only
9	Oxbow	200,000	0+	Hells Canyon Dam	200K AdCWT
10	Lyons Ferry	200,000	0+	Pittsburg Landing	200K Unmarked
11	Lyons Ferry	200,000	0+	Direct stream evaluation Near Captain John Rapids	200K AdCWT
12	DNFH/Umatilla	250,000	0+	Transportation Study[a]	250K PIT Tag only
13	Irrigon[b]	200,000	0+	Grande Ronde River	200K AdCWT
14	DNFH/Umatilla	78,000	0+	Transportation Study[a]	78K PIT tag only
15	Irrigon[c]	200,000	0+	Hells Canyon Dam	200K AdCWT
16	Irrigon[b]	200,000	0+	Grande Ronde River	200K Unmarked
17	Irrigon[c]	600,000	0+	Hells Canyon Dam	600K Ad only
TOTAL	**Yearlings**	**900,000**			
	Subyearlings	**3,528,000 (of which 328,000 are for Transportation Study)**			

[a] USACOE Transportation Study wild surrogate groups direct stream released into the Clearwater and mainstream Snake River
[b] for logistical purposes, fish are reared at Irrigon in lieu of Lyons Ferry. (LSRCP);
[c] for logistical purposes, beginning in 2010, fish are reared at Irrigon in lieu of Umatilla

Table A2. Average SAR and age composition of returning adults from Snake River fall Chinook Salmon hatchery yearling (1+) and subyearling (0+) release groups (Release Years 2006, 2008-2011).

			SAR %					
Priority	Age	Release Site	Adults by age	Rank	J by age	Rank	sum A+J	Rank
1	1+	Lyons Ferry Onstation	0.50	5	0.76	1	1.26	1
2	1+	Pittsburg Landing	0.25	11	0.52	3	0.77	7
3	1+	Big Canyon	0.27	10	0.43	5	0.70	10
4	1+	Captain John Rapids	0.38	8	0.59	2	0.97	3
5	0+	Lyons Ferry Onstation	0.64	2	0.44	4	1.08	2
6	0+	Captain John Rapids	0.65	1	0.30	8	0.95	4
7	0+	Big Canyon	0.61	3	0.33	6	0.94	5
8	0+	Pittsburg Landing	0.43	6	0.29	9	0.72	8
9	0+	Hells Canyon Dam/Ox	0.40	7	0.31	7	0.70	9
11	0+	Couse Creek	0.51	4	0.29	10	0.79	6
13	0+	Grande Ronde River	0.25	12	0.09	12	0.34	12
15	0+	Hells Canyon Dam/Uma	0.38	9	0.29	11	0.66	11

Table A3. Comparison of average SAR and age composition of returning adults by common release site from Snake River fall Chinook Salmon yearling (1+) and subyearling (0+) hatchery releases (Release Years 2006, 2008-2011).

		SAR %		
Release site	Age at Release	Adults by age	J by age	Sum A+J
Lyons Ferry Onstation 1+	Yearling	0.50	0.76	1.26
Lyons Ferry Onstation 0+	Subyearling	0.64	0.44	1.08
Captain John Rapids 1+	Yearling	0.38	0.59	0.97
Captain John Rapids 0+	Subyearling	0.65	0.30	0.95
Big Canyon 1+	Yearling	0.27	0.43	0.70
Big Canyon 0+	Subyearling	0.61	0.33	0.94
Pittsburg Landing 1+	Yearling	0.25	0.52	0.70
Pittsburg Landing 0+	Subyearling	0.43	0.29	0.72

Table A4. Average harvest rate and age composition of Snake River fall Chinook Salmon yearling (1+) and subyearling (0+) hatchery release groups (Release Years 2006, 2008-2011).

			Harvest Rate # Recovered/# Released			
Priority	Age	Release Site	Adults	Jacks	A+J	Rank
1	1+	Lyons Ferry Onstation	0.81	0.43	1.24	1
2	1+	Pittsburg Landing	0.46	0.18	0.65	3
3	1+	Big Canyon	0.45	0.18	0.63	4
4	1+	Captain John Rapids	0.59	0.24	0.83	2
5	0+	Lyons Ferry Onstation	0.46	0.03	0.49	7
6	0+	Captain John Rapids	0.57	0.02	0.59	5
7	0+	Big Canyon	0.55	0.01	0.56	6
8	0+	Pittsburg Landing	0.47	0.01	0.48	8
9	0+	Hells Canyon Dam/Ox	0.43	0.03	0.46	10
11	0+	Couse Creek	0.44	0.03	0.48	9
13	0+	Grande Ronde River	0.26	0.02	0.28	12
15	0+	Hells Canyon Dam/Uma	0.37	0.03	0.40	11

Table A5. Comparison of average harvest rate and age composition by common release site of Snake River fall Chinook Salmon yearling (1+) and subyearling (0+) hatchery releases (Release Years 2006, 2008-2011).

	Harvest Rate # Recovered/# Released		
Release Site	Adults	Jacks	A+J
Lyons Ferry Onstation 1+	0.81	0.43	1.24
Lyons Ferry Onstation 0+	0.46	0.03	0.49
Captain John Rapids 1+	0.59	0.24	0.83
Captain John Rapids 0+	0.57	0.02	0.59
Big Canyon 1+	0.45	0.18	0.63
Big Canyon 0+	0.55	0.01	0.56
Pittsburg Landing 1+	0.46	0.18	0.65
Pittsburg Landing 0+	0.47	0.01	0.48

Table A6. Average SAS and age composition of Snake River fall Chinook Salmon yearling (1+) and subyearling (0+) hatchery release groups (Release Years 2006, 2008-2011).

			SAS %					
Priority	Age	Release Site	Adults by age	Rank	J by age	Rank	sum A+J	Rank
1	1+	Lyons Ferry Onstation	1.31	1	1.19	1	2.50	1
2	1+	Pittsburg Landing	0.71	11	0.70	3	1.41	6
3	1+	Big Canyon	0.72	10	0.61	4	1.33	7
4	1+	Captain John Rapids	0.97	5	0.83	2	1.80	2
5	0+	Lyons Ferry Onstation	1.10	4	0.47	5	1.57	3
6	0+	Captain John Rapids	1.22	2	0.32	8	1.55	4
7	0+	Big Canyon	1.16	3	0.34	7	1.49	5
8	0+	Pittsburg Landing	0.90	7	0.30	11	1.20	9
9	0+	Hells Canyon Dam/Ox	0.83	8	0.34	6	1.16	10
11	0+	Couse Creek	0.95	6	0.32	9	1.27	8
13	0+	Grande Ronde River	0.51	12	0.11	12	0.62	12
15	0+	Hells Canyon Dam/Uma	0.75	9	0.31	10	1.06	11

Table A7. Comparison of average SAS and age composition by common release site of Snake River fall Chinook Salmon yearling (1+) and subyearling (0+) releases (Release Years 2006, 2008-2011).

		SAS %		
Release site	Age at Release	Adults by age	J by age	Sum A+J
Lyons Ferry Onstation 1+	Yearling	1.31	1.19	2.50
Lyons Ferry Onstation 0+	Subyearling	1.10	0.47	1.57
Captain John Rapids 1+	Yearling	0.97	0.83	1.80
Captain John Rapids 0+	Subyearling	1.22	0.32	1.55
Big Canyon 1+	Yearling	0.72	0.61	1.33
Big Canyon 0+	Subyearling	1.16	0.34	1.49
Pittsburg Landing 1+	Yearling	0.71	0.70	1.41
Pittsburg Landing 0+	Subyearling	0.90	0.30	1.20

Figure A1. Box plots and annual estimates (dots) of percent deviation from the mean smolt to adult return (SAR) rate to Lower Granite Dam for Snake River adult, jack and total subyearling (0+) and yearling (1+) hatchery release groups (left) and pairwise release location comparisons (right). The mean SAR is represented by the dashed line. Horizontal solid lines in each box is the median SAR from release year 2006, 2008 – 2011 and the boxes represent the 25th and 75th percent deviation from the median. LFH – Lyons Ferry Hatchery; CJA – Captain Johns Rapids; PLA – Pittsburg Landing; BCA – Big Canyon; CC – Couse Creek; GR – Grande Ronde; HCD OX – Hells Canyon Dam, Oxbow; HCD UM – Hells Canyon Dam, Umatilla.

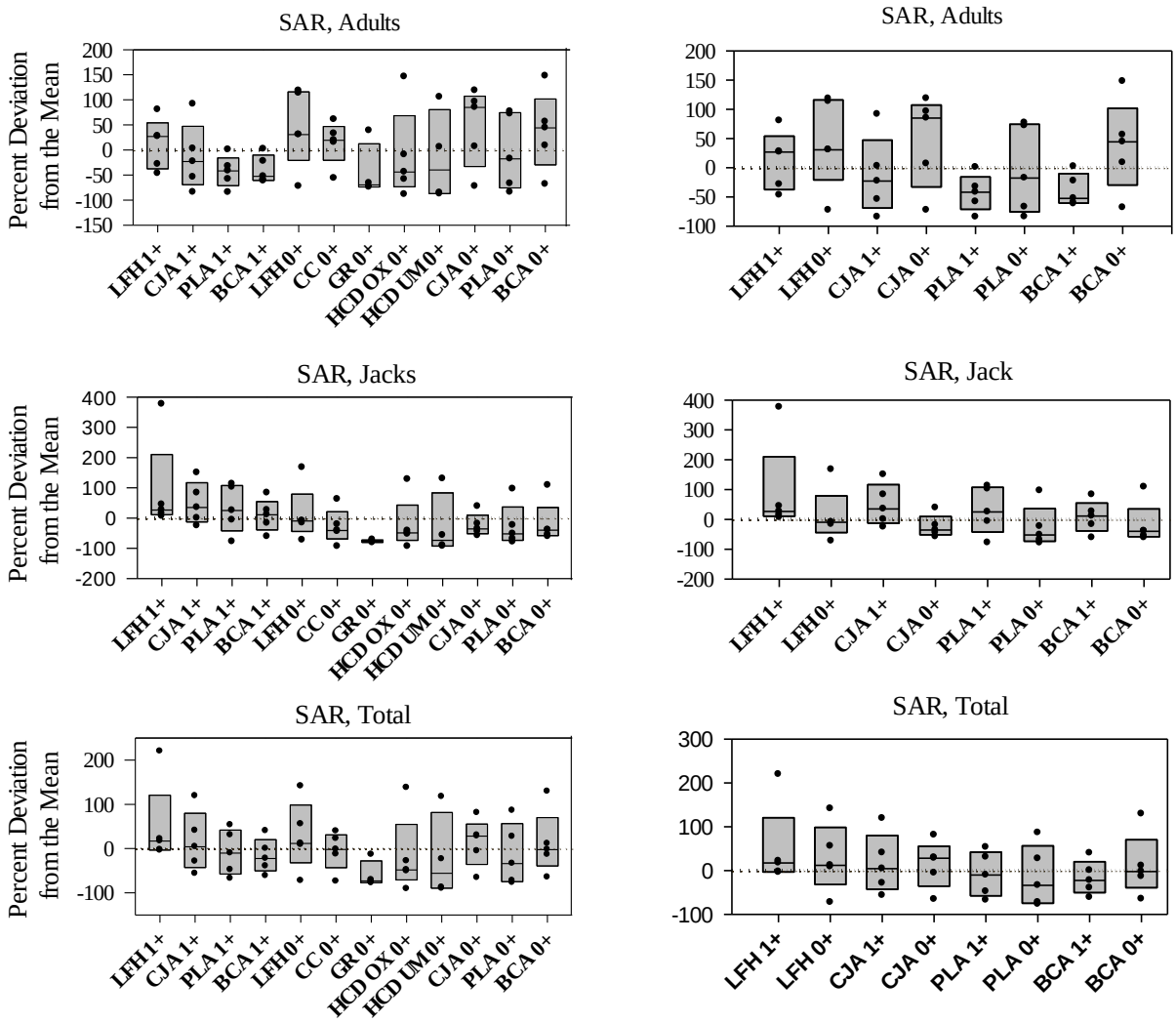

Figure A2. Box plots and annual estimates (dots) of percent deviation from the mean harvest rate for Snake River adult, jack and total subyearling (0+) and yearling (1+) hatchery release groups (left) and pairwise release location comparisons (right). The mean harvest rate is represented by the dashed line. Horizontal solid lines in each box is the median harvest rate from release year 2006, 2008 – 2011 and the boxes represent the 25th and 75th percent deviation from the median. LFH – Lyons Ferry Hatchery; CJA – Captain Johns Rapids; PLA – Pittsburg Landing; BCA – Big Canyon; CC – Couse Creek; GR – Grande Ronde; HCD OX – Hells Canyon Dam, Oxbow; HCD UM – Hells Canyon Dam, Umatilla.

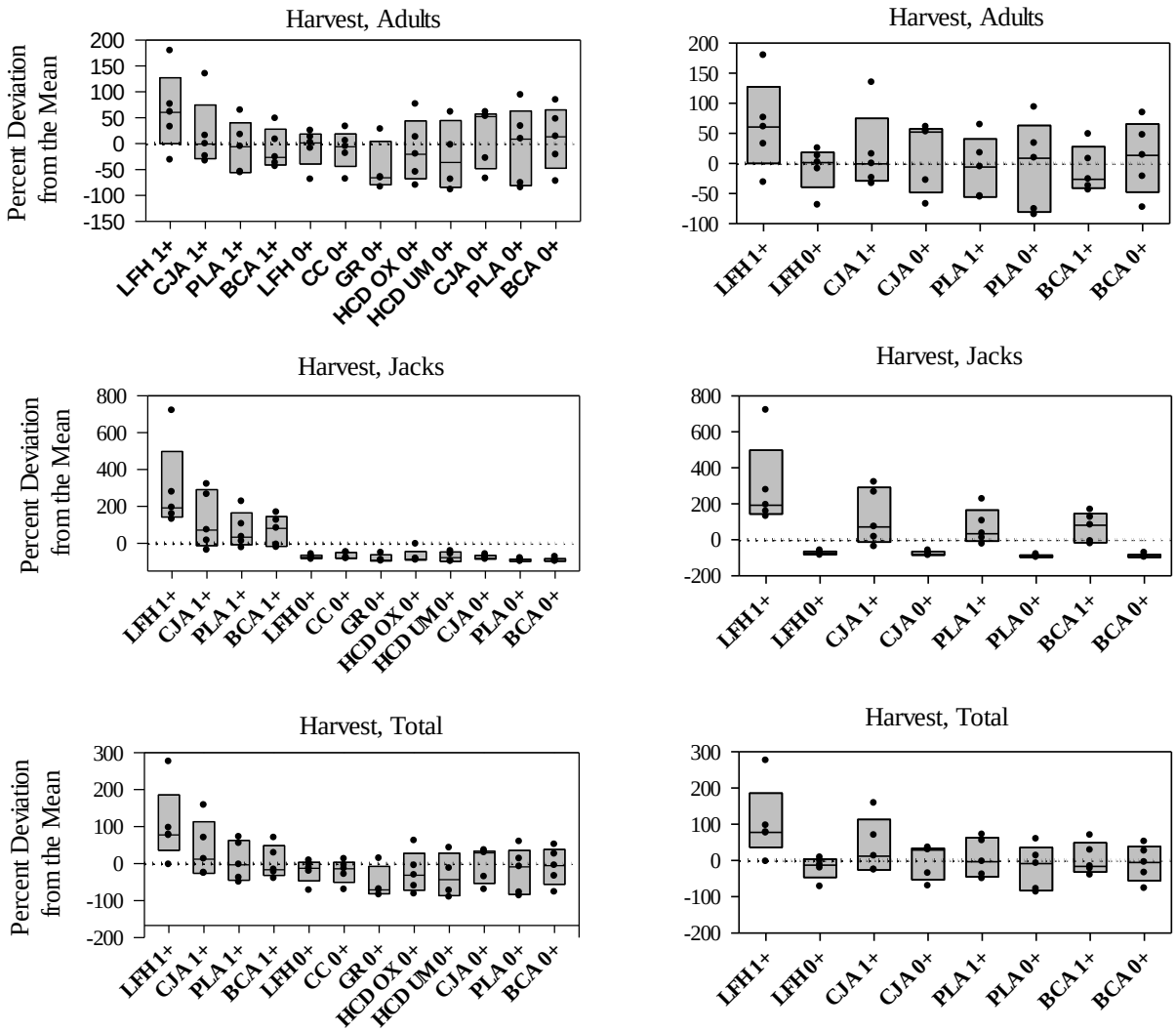
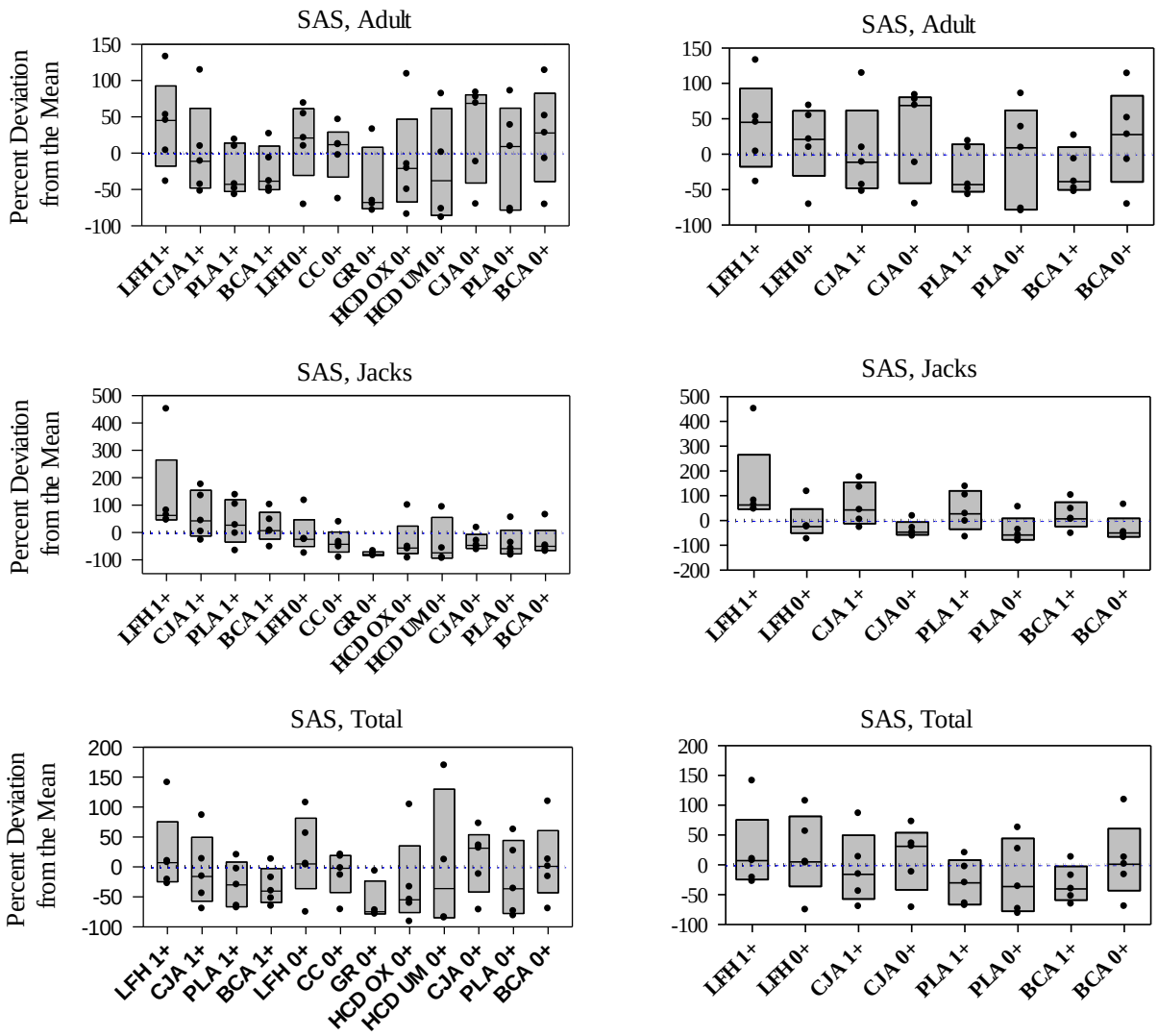
Figure A3. Box plots and annual estimates (dots) of percent deviation from the mean smolt-to-adult survival (SAS) rate for Snake River adult, jack and total subyearling (0+) and yearling (1+) hatchery release groups (left) and pairwise release location comparisons (right). The mean SAS is represented by the dashed line. Horizontal solid lines in each box is the median SAS of release years 2006, 2008 – 2011 and the boxes represent the 25th and 75th percent deviation from the median. LFH – Lyons Ferry Hatchery; CJA – Captain Johns Rapids; PLA – Pittsburg Landing; BCA – Big Canyon; CC – Couse Creek; GR – Grande Ronde; HCD OX – Hells Canyon Dam, Oxbow; HCD UM – Hells Canyon Dam, Umatilla.