CRITFC

TECHNICAL REPORT 11-08

Columbia River Inter-Tribal Fish Commission
503.238.0667
www.critfc.org
729 NE Oregon, Suite 200
Portland, OR 97232

AGE AND LENGTH COMPOSITION OF COLUMBIA BASIN CHINOOK AND SOCKEYE SALMON AND STEELHEAD AT BONNEVILLE DAM IN 2009

Denise Kelsey, Holly Ballantyne, John Whiteaker, and Jeffrey K. Fryer, Ph.D.

November 16, 2011

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Columbia River Inter-Tribal Fish Commission Technical Report
for
the Department of Interior Contract No. GTP00X90107
and
Bonneville Power Administration 2008-518-00

Denise Kelsey
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ABSTRACT

The Columbia River Inter-Tribal Fish Commission (CRITFC) conducts a field study at Bonneville Dam which first began in 1985 to assess the age, length-at-age, and stock composition of adult Pacific salmon migrating up the Columbia River. Adult spring, summer and fall Chinook salmon (*Oncorhynchus tshawytscha*), sockeye salmon (*O. nerka*) and steelhead (*O. mykiss*) were collected, sampled for scales and additional biological data, PIT tagged Chinook, steelhead and sockeye, revived and released. Caudal fin clips were also taken from Chinook, steelhead and sockeye for genetic analysis. Scales were examined to estimate age composition; the results contributed to an ongoing database for age structure of Columbia Basin salmon runs. A new Bonneville Dam fish trap configuration biased our Chinook sample in 2009 resulting in the proportion of smaller one-ocean Chinook sampled being higher than in the population as a whole. It is unknown whether the trap configuration affected other age classes or other species. Based on scale pattern analysis of our biased sample, three-year-olds were the most abundant age group for spring Chinook salmon comprising 48.5% of the run (see trap bias section). Three-year-olds were the most abundant age class for the summer Chinook making up 37.3% of the run, while four-year-olds were the most abundant for fall Chinook, at 57.5%. Three-year-olds were the most abundant age group for sockeye salmon comprising 79.8% of the run, and three-year-olds were the most abundant in steelhead comprising 50.8% of the run. A large percentage of the steelhead run (23.0%) had scales that could only be aged for saltwater winters. Using adipose fin clips, scale patterns, and dorsal fin condition for classification, the steelhead migration consisted of 73.8% hatchery- and 26.2% natural-origin steelhead. A-run steelhead, less than 78cm in length, comprised 92.2% of the steelhead run. B-run fish, equal to or greater than 78cm, comprised 7.8% of the run.

ACKNOWLEDGMENTS

We sincerely thank the following individuals for their assistance in this project: Bobby Begay, Ryan Branstetter, Jacinda Mainord, Doug Hatch, Richard McConville, Winfred Perez, Charles Torbek, Marc Whitman, David Graves, Henry Franzoni, Rishi Sharma, Stuart Ellis, Marianne McClure, and Phil Roger of the Columbia River Inter-Tribal Fish Commission; Ben Hausmann, and Jon Rerecich of the US Army Corps of Engineers.

This report is the result of research funded by US Government (Bureau of Indian Affairs, Department of Interior) Contract No. GTP00X90107 for implementation of the US-Canada Pacific Salmon Treaty and the Bonneville Power Administration project number 2008-518-00.

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INTRODUCTION

In 1985, the US-Canada Pacific Salmon Treaty was signed to manage research and enhance Pacific salmon (PSC 2000). The treaty established the Spawning Escapement-Monitoring program to assess indicator stocks within the Columbia River Basin and improve methods for providing population estimates, escapement monitoring, establishing spawner-recruit relationships and developing harvest management approaches (PST 1985). As part of this program, the Columbia River Inter-Tribal Fish Commission (CRITFC) has developed a comprehensive research strategy to monitor the age and stock composition of adult Pacific salmon returning to the Columbia River. This project has monitored the above Bonneville Dam adult migration of sockeye salmon (*Oncorhynchus nerka*) since 1985, spring Chinook salmon (*O. tshawytscha*) since 1987, summer Chinook salmon since 1990, and up-river bright fall Chinook salmon since 1998. Data on these runs are provided in near real time at www.critfc.org.

At the request of the NOAA Fisheries Northwest Fisheries Science Center, summer steelhead (*O. mykiss*) were added to our sampling regime in 2004. The Conservation Biology Division (NOAA Fisheries) formed the Mathematical Biology and Systems Monitoring Program to develop, in collaboration with the existing Salmon Science Programs and Salmon Recovery Planning Teams, quantitative tools for assessing population and habitat status and recovery potential and progress. Monitoring the age structure, hatchery fraction and stock composition of the adult Columbia River summer steelhead provides valuable information for this program.

Scale pattern analysis, the analysis of concentric rings or circuli to provide records of previous life history, is a common method for age determination in Pacific salmon (Nielsen and Johnson 1983). Fast summer growth widens the distances between circuli on the scale and slow winter growth shortens the distance between circuli. Typically, age can be determined by counting the number of winters observed on the scale (Gilbert 1912, Rich and Holmes 1928). This method is valuable in Pacific salmon management because scales can be collected without sacrificing the fish and scale samples can be collected, processed, and aged promptly. Problems with this method may include variability in scale growth, scale resorption, and difficulties in age validation (Knudsen 1990, Beamish and McFarlane 1983).

Scale pattern analysis can also be used for stock identification if distinctive patterns can be linked to specific stocks. This method has generally been successful in discriminating Columbia River sockeye partly because there are only two major runs of sockeye in the system, which experience dramatically different early rearing environments (Fryer 1995). However, this method was found to be less successful with Chinook salmon where numerous populations can exhibit similar scale growth patterns. Currently a coast wide genetic database is being developed to create baseline microsatellite and SNP (Single Nucleotide Polymorphim) genetic data for individual Chinook populations throughout the region. This baseline genetic stock information can be utilized in mixed stock sampling to distinguish individual stocks and will be useful for the Chinook sampling program at Bonneville Dam.

The primary objectives for the 2009 sampling year were to estimate the age composition and length-at-age composition of Chinook, sockeye and steelhead using scale pattern analysis, to forecast the 2010 run size for Chinook salmon using the age composition data, to PIT tag Chinook and sockeye salmon, and steelhead and to collect tissue samples for use in the development of a genetic stock monitoring and identification program for Chinook and sockeye, and steelhead.

METHODS

Study Area

Research was conducted at Bonneville Dam (river km 235), which is first dam encountered by salmonids on their migration upriver to spawn (Figure 1). The collection of salmon and steelhead occurs at the Adult Fish Facility (AFF) located on the Washington shore immediately downstream of Bonneville Dam. This facility uses a picket weir to divert migrating fish, ascending the Washington shore fish ladder, into the adult sampling facility collection pool. An attraction flow is used to draw fish through a false weir where they can be selected for sampling. Fish not selected and fish that have recovered from sampling are returned to the Washington Shore Fish ladder above the picket weir.

Chinook salmon generally migrate between March and November and are typically categorized into three races based on migration timing past Bonneville Dam. Chinook salmon passing Bonneville before June 1 are classified as spring Chinook, from June 1 through July 31 are classified as summer Chinook and fish passing after July are classified as fall Chinook. In recent years, fishery managers have used June 16 rather than June 1 to separate spring and summer Chinook salmon. However, in this report, we use the traditional June 1 cutoff.

The fall Chinook run consists of lower river tules and the Upriver bright fall Chinook. Tules are are considered a lower river fish with most spawning below Bonneville Dam, although a few return to hatcheries between Bonneville and The Dalles dams. They return from the ocean in their spawning colors. By contrast Upriver brights are still silver in color when returning from the ocean and spawn upstream of Bonneville Dam. The Pacific Salmon Commission is typically interested in only Upriver bright fall Chinook. However in 2009 other projects for genetic studies dictated that CRITFC start to sample tules that pass over Bonneville Dam.

Sockeye salmon typically migrate between May 15 and August 1 and summer-run steelhead between April 1 and October 31. The steelhead run is further divided into A- and B-run components based on length (equal or greater than 78 cm for B-run).

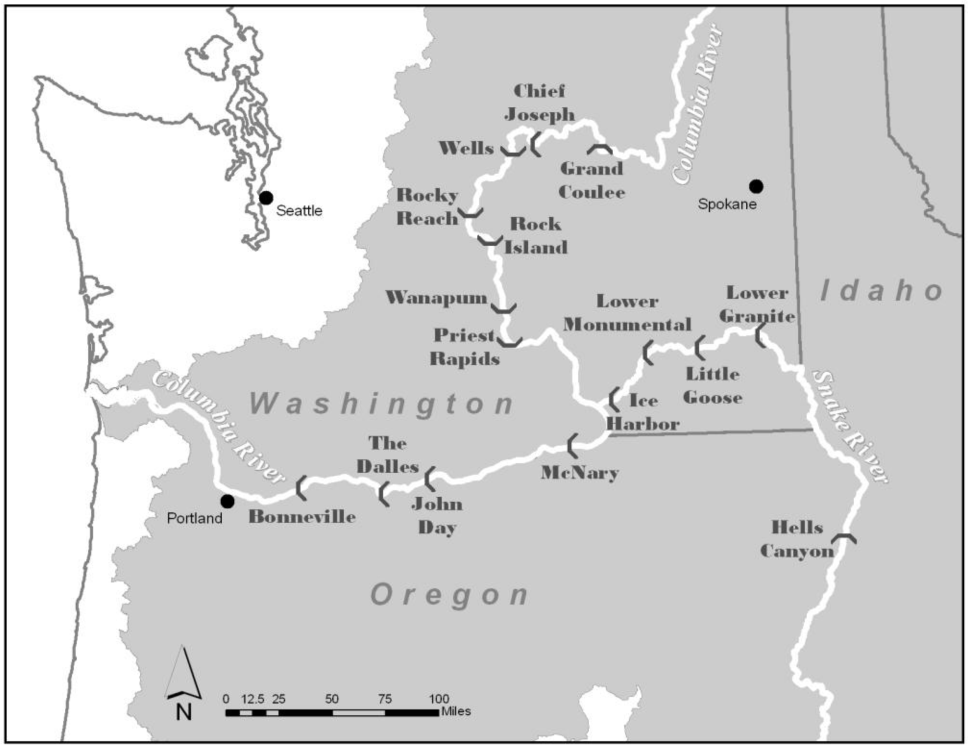

Figure 1. Map of the Columbia River displaying federal dams. Bonneville Dam (rkm 235).

Sample Design

Adult fish were sampled one to five days per Statistical Week[1] from March through October. A desired minimum sample size of 610 fish each was set for spring, summer, and fall Chinook, and sockeye salmon is required for age composition. This sample size was derived from simulations we conducted based on the work of Thompson (1987) and assumes that the sample is distributed approximately proportional to the weekly run size. It also assumes that our weekly sample represents a random sample of the run passing over Bonneville Dam that week. These sample sizes achieved precision and accuracy levels of $d=0.05$, $\alpha=0.10$ for age composition estimates. Additional samples were collected to buffer for unreadable scales, to provide more precision in weekly age composition estimates, as well as to meet the goals of other projects which deployed PIT tags and collected genetics samples. A steelhead sample size goal of one percent of the run was set by the U.S. v. Oregon Technical Advisory Committee. The composite age and fin clip estimates were calculated from weekly estimates weighted by the number of each species migrating past Bonneville Dam during the sample week (Fryer 1995). Weekly and annual fish passage[2] counts were obtained from Fish Passage Center (2009). In 2009, when the occasional tule made it into the sampling tank, genetic material was taken for genetic stock monitoring and

1. Statistical Weeks are sequentially numbered calendar-year weeks starting with the week that includes January 1 (Week 1). Excepting the first and last weeks of most years, weeks are seven days long, beginning on Sunday and ending on Saturday.
2. Tule fall Chinook counts are subtracted from the total fall Chinook counts to estimate the Upriver bright fall Chinook.

identification program. Tule sample numbers are not representative of the run and scales are not collected.

In 2009, a new center divider was installed which allowed CRITFC to drop only two pickets to divert fish into the AFF. Therefore, not all fish ascending the main ladder had to be diverted into the AFF ladder. CRITFC added some analysis of the impacts of the center divider after trapping began and it was observed that the size of fish was less than expected, and in the case of Chinook, overwhelmingly consisted of smaller one-ocean jacks. To investigate this phenomenon, we looked at the distribution of previously PIT tagged Chinook salmon (which were tagged as juveniles on, or prior to, their downstream migration) that used the Washington shore fish ladder. A statistical test comparing proportions in independent samples (Snedecor and Cochrane 1980) was used to compare the percentage of previously PIT tagged Chinook that were jacks (defined as one-ocean fish) passing on the AFF side of the ladder (subject to trapping) and the non-AFF side of the ladder (not subject to trapping) during trapping hours. There was insufficient data to look at other age classes or other species (steelhead and sockeye). We also looked at the percentage of previously PIT tagged fish, which were jacks, using other ladders that were not subject to trapping both during trapping and non-trapping hours to look at potential ladder biases.

Fish Collection

Fish of each species were trapped at the AFF and anesthetized. Chinook salmon under 36 cm in length were not sampled to exclude precocious juveniles (known as *minijacks*), which spend no winters in saltwater. We have excluded minijacks because sampling these fish, which can be very numerous in some years, would reduce our sample of larger fish which are of much greater interest for management and research. Steelhead under 36 cm were also excluded to avoid sampling rainbow trout. All sizes of sockeye salmon were sampled. Each fish was measured for fork length to the nearest 0.5 cm, checked for identifying fin marks, tags, coloration and condition. Scale samples were collected from all fish for aging and caudal fin tissue was collected for genetic stock composition analysis. These genetic samples will be used in the development of a genetic stock identification program for Columbia River salmon and steelhead. All fish sampled were scanned for PIT tags and any PIT tag codes recorded. In 2009, our goal was to PIT tag all Chinook and sockeye salmon, and steelhead sampled which had not been previously PIT tagged. Recently CRITFC has been collecting some data from a few tules that pass over Bonneville Dam. Currently only length and a genetic sample are collected. All fish were revived in a freshwater tank or pool and returned to a fishway leading to the Washington shore fish ladder.

Fish Coloration and Condition

Fish coloration and condition were recorded for all species at the time of sampling. Coloration was based on qualitative observations with the categories of Bright, Intermediate and Dark. Overall fish condition was also qualitatively assessed and classified on a scale of 1 to 5. Fish classified as a 5 had no major injuries that break the skin, 4 had injuries that broke the skin, 3 had injuries that penetrate the muscle tissue, 2 had injuries that penetrate a body cavity and 1 are fish missing large sections of the body. In addition to the fish condition classification, specific recognizable injuries or afflictions were recorded. These included percentage of descaling, marine mammal injuries, net damage, parasites, fungus, headburn[3], gas bubble trauma, deformities, and various other injuries.

Age Determination

To minimize the scale sample rejection rate, six scales (three per side) were collected for each Chinook and steelhead sampled (Knudsen 1990) and four scales (two per side) were collected from each sockeye salmon sampled. Scales were mounted and pressed according to methods described by Clutter and Whitesel (1956) and the International North Pacific Fisheries Commission (1963). Individual samples were visually examined and categorized using well-established scale age-estimation methods (Gilbert 1912, Rich and Holmes 1928). Only a subsample of scale ages could be validated (Beamish and McFarlane 1983) by using the tag code of previously PIT tagged fish. The total age from release to recapture at Bonneville Dam could be compared to that estimated from scale patterns.

The European method for fish age description (Koo 1962) is used in this report. The number of winters a fish spent in freshwater (not including the winter of egg incubation) is described by an Arabic numeral followed by a period. The number following the period indicates the number of winters a fish spent in saltwater. Total age, therefore, is equal to one plus the sum of both numerals. For steelhead only, if the saltwater winters can be determined regardless of a readable freshwater age, the age is reported as r.X (where X is the number of salt-winters) and used in age composition tables.

For the fall Chinook run, the tules that pass Bonneville Dam are removed from the run counts used in the age composition tables. We only report the Upriver brights age data, scales are not collected from tules for age analysis.

Age and Length-at-Age Composition

Age composition was estimated by weighting the proportion of each age class sampled by the total counts of each species passing Bonneville dam during each Statistical Week. Length-at-age composition estimates were not weighted by weekly run size.

Steelhead Hatchery/Wild Determination

Most hatchery reared steelhead in the Columbia River Basin are marked by removing a fin, typically the adipose fin. Crowded hatchery conditions also commonly result in erosion of the dorsal fin which is readily apparent in returning adults. Some hatchery-origin steelhead are released unmarked and to identify these individuals, dorsal fin erosion or scale pattern analysis methods were used. Hatchery steelhead typically experience faster freshwater growth which results in relatively wide spaces between circuli, whereas natural origin fish typically show much slower fresh water growth narrowing the distance between circuli. In addition, hatchery origin fish are reared to smolt in a single year whereas the natural origin fish tend to remain in fresh water for two or more years.

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3. Headburn, the exfoliation of skin and tissues of the jaw and cranial region, has been identified as a possible stress indicator of high river flow conditions or spillway discharge from dams (Elston 1996, Groberg 1996).

Steelhead A/B Run Determination

Steelhead are divided into A and B run steelhead, where A run steelhead are less than 78 cm in length while B run steelhead are greater than, or equal, to 78 cm in fork length. A-run steelhead occur throughout the Columbia and Snake river basins and rarely exceed the length of 78 cm, whereas B-run steelhead are thought to be produced only in the Clearwater, Middle Fork Salmon, and South Fork Salmon rivers and typically exceed 77.5cm (U.S. v. Oregon 1997). Determination of A-run or B-run was based on length measurement.

Steelhead Kelts

Unlike other species of Pacific salmon *(Oncorhynchus spp.)*, anadromous steelhead naturally exhibit varying degrees of iteroparity (repeat spawning). Successful steelhead iteroparity involves downstream migration of kelts (post-spawned steelhead) to the estuary or ocean environments (Hatch et al. 2003). During scale pattern analysis we found a few steelhead scales to have an iteroparous scale pattern. A kelt scale age is indicated through the use of the letter "S" to indicate spawning. For instance, a steelhead of Age 1.2S1 would have one freshwater annulus, two saltwater annuli, a spawning check, followed by one saltwater annulus. Note that scale resorption often occurs in kelts which can eliminate saltwater annuli marks so a kelt is likely older than would be indicated by summing the annuli.

Chinook Salmon Run-Size Prediction

Salmon mature and return to spawn between two and seven years of age. Age composition, life history and total age vary among species. For this analysis a brood year (BY) is defined as the year in which the eggs are fertilized and a brood is defined as all the returning progeny of a given BY. This run-size prediction model is based on the relationship between the survivors within a single brood returning at different ages in successive years.

Fryer and Schwartzberg (1994) determined that adult returns of Columbia basin Chinook are comprised almost entirely of 3, 4 and 5 year old fish, with the proportions of each age class being relatively constant across years. As such, the number of three-year-old fish for a given BY is a relatively good predictor of the number of four-year-old fish from the same BY that would return in the subsequent year. This relationship and a regression analysis (Neter et al. 1985, Weisberg 1985) were used to predict the abundance of four-year-old fish for 2009, based on the number of three-year-old fish estimated to have returned in 2008. Due to the late publish date of this report a similar relationship was not used to predict abundance of Chinook salmon for 2010.

RESULTS

Sampling

Sampling began on April 21 and ended October 21, 2009. A total of 961 spring Chinook were sampled, 923 summer Chinook and 1122 fall Chinook, 850 sockeye salmon, and 2473 steelhead were sampled. Almost all fish sampled were tagged with PIT tags for tracking and genetic samples were taken. For details of the PIT tag study see Fryer et.al 2011.

We attempted to avoid sampling salmonids that spent no winters in saltwater (such a Chinook are known as minijacks) by not selecting fish under 36 cm. However, in 2009, we did sample five Chinook salmon and one steelhead (length ranged from 37.5 to 42 cm), which spent no winters in saltwater (ages were 1.0 and 2.0). These fish were treated like other fish at the time of sampling, so that genetic samples were taken and they were tagged with PIT tags and tracked. For this age composition study, the Chinook were considered minijacks, while the steelhead was considered a rainbow trout, so they were excluded from further analysis.

Trap Bias

In 9 out of 23 Statistical weeks, the percentage of jacks on the near side of the center divider, and subject to sampling, was significantly greater than on the far side, where they were not subject to sampling. Over the entire run, this difference was highly significant ($p<0.001$). Furthermore, when the trap was in operation, 26.2% (496 out of 1877, Table 2) of previously PIT tagged Chinook passed on the near side compared to 43.8% (2127 out of 4933, Table 3) when the trap was not in operation. When the trap was not in operation, there was no significant difference in the distribution of jacks across the fish ladder for any week (Table 3) which suggests that it is the operation of the trap, combined with the center divider, which is causing a bias.

Table 1. Percentage of jacks among previously PIT tagged Chinook salmon passing the entrance of the Bonneville Dam fish trap on the near and far sides of the trap when the trap is in operation and the results of a test for the difference in independent proportions by statistical week in 2009.

	Pass Far Side (not subject to trapping)		Pass Near Side (subject to trapping)		P-value (significant results are in **bold and underlined**)
Statistical Week	N	Percent Jacks	N	Percent Jacks	
17	15	7%	5	20%	0.389
18	46	9%	14	7%	0.854
19	136	26%	29	34%	0.382
20	128	35%	33	91%	**<u>0.000</u>**
21	148	34%	53	43%	0.212
22	42	29%	14	14%	0.285
23	55	33%	23	52%	0.107
24	55	44%	16	56%	0.373
25	70	46%	16	81%	**<u>0.010</u>**
26	57	49%	7	86%	0.067
27	80	49%	18	94%	**<u>0.000</u>**
28	35	46%	11	82%	**<u>0.036</u>**
29	7	43%	2	100%	0.151
30	8	25%	1	0%	0.571
31	2	50%	1	100%	0.386
33	15	40%	3	100%	0.058
34	42	40%	11	64%	0.170
35	53	38%	18	61%	**<u>0.048</u>**
36	81	48%	24	67%	0.111
37	133	45%	76	79%	**<u>0.000</u>**
38	108	49%	59	86%	**<u>0.000</u>**
39	63	43%	43	81%	**<u>0.000</u>**
40	2	0%	9	89%	**<u>0.011</u>**
Cumulative	**1381**	**39%**	**496**	**67%**	**<u>0.000</u>**

Table 2. Percentage of jacks among previously PIT tagged Chinook salmon passing the entrance of the Bonneville Dam fish trap on the near and far sides of the trap when the trap is not in operation and the results of a test for the difference in independent proportions by statistical week in 2009.

	Pass far side		Pass near side		P-value (no significant results)
Statistical Week	N	Percent Jacks	N	Percent Jacks	
17	37	8%	36	20%	0.317
18	111	16%	111	7%	0.571
19	213	30%	205	34%	0.772
20	388	37%	279	91%	0.457
21	201	26%	121	43%	0.360
22	156	25%	100	14%	0.721
23	114	31%	93	52%	0.794
24	168	39%	102	56%	0.576
25	209	42%	81	81%	0.833
26	91	45%	29	86%	0.983
27	34	47%	14	94%	0.853
28	49	47%	13	82%	0.960
29	36	47%	22	100%	0.837
30	6	17%	5	0%	0.387
31	8	38%	8	100%	1.000
33	5	40%	4	100%	0.764
34	19	21%	18	64%	0.401
35	91	35%	46	61%	0.649
36	251	43%	173	67%	0.918
37	294	45%	354	79%	0.777
38	325	45%	315	86%	0.778
39	257	47%	232	81%	0.975
40	189	48%	134	89%	0.945
Cumulative	**2806**	**38%**	**2127**	**39%**	**0.701**

While conducting this analysis, we also looked at the percentage of previously tagged fish that were returning as jacks at each of the three ladders at Bonneville Dam (Washington shore, Oregon shore, and Bradford Island), when the trap was and was not operating (Table 4). Percentages differed greatly; though the overall weighted percentage of jacks at all ladders (48.2%) was surprisingly close to what passed through the trap entrance when the trap was in operation (46.1%).

Table 3. Percentage of previously PIT tagged Chinook that are jacks passing Bonneville Dam by ladder during all hours.

	Pass through Trap facility	Washington Shore fish ladder	Oregon Shore fish ladder	Bradford Island fish ladder	All ladders (weighted by abundance)
Trap in operation	71.7%	46.1%	60.4%	56.3%	53.0%
Trap not in operation		38.6%	59.1%	53.2%	46.9%
Overall		**40.0%**	**59.4%**	**53.9%**	**48.2%**
N	**746**	**7139**	**4335**	**1814**	**14934**

There was insufficient data to conduct trap bias analyses for other age groups of Chinook or for sockeye salmon or steelhead. No effort was made in subsequent analyses to correct for any of these trap biases.

Age Composition

Based on scale pattern analysis three-year-olds were the most abundant age group for spring Chinook salmon, comprising 48.5% of the spring Chinook migration (Table 5, Figure 2), likely due to the jack bias discussed in this report. Three-year-olds were also the most abundant group for summer Chinook salmon and four-year-olds were the most abundant for fall Chinook salmon, comprising 37.3% of the summer Chinook migration (Table 6, Figure 2) and 57.5% of the fall Chinook migration (Table 7, Figure 2). More than 61,000 tules passed Bonneville Dam in 2009. Data from Fish Passage Center starts the tule count on August 16th during the fall Chinook run. Tule numbers were removed from the run numbers in Table 7 for fall (Upriver bright) Chinook.

The percentage of ocean-type Chinook salmon (age 0.X) increased steadily through the run, from 0% in Statistical Week 20 to above 90% after Statistical Week 34 (Figure 3). Due to restricted hours and a complete shutdown of the AFF in week 32, there is a three week gap between week 30 and 34 when only one Chinook was sampled. A few steelhead were sampled in weeks 31 and 33.

The sockeye salmon run also was composed primarily of four-year-olds (79.8%), with three- and five-year-olds less abundant (Table 8).

The steelhead age composition was composed of mostly three-year-olds (50.8%) and four-year-olds (33.9%) (Table 9). Five-year-olds were 12.5% of the run. Steelhead with unageable freshwater, but ageable saltwater winters (r.X) make up a large portion of the run at 23.0%, if these fish are included with ageable fish and the data is analyzed for salt years only, then the major of steelhead are one-salts (67.8%) in 2009.

Aging validation from ageable scale patterns of 48 Chinook salmon that had been previously PIT tagged were correctly aged as follows: 20 out of 21 spring Chinook, all 14 summer Chinook, all 13 fall Chinook salmon, and 31 out of 33 steelhead. Only the total age could be compared, for it was not possible to separately validate freshwater and ocean age.

Table 4. Weekly and cumulative age composition of Columbia Basin spring Chinook at Bonneville Dam in 2009.

Age Composition by Brood Year and Age Class												
Statistical Week	Sampling Date	Number Sampled	Number Ageable	Weekly Run Size	2006	2005		2004			Fin Clips	
					1.1	1.2	0.3	2.1	1.3	0.4	Adipose	Other
17	4/21, 4/23, 4/24	41	35	11923	0.057	0.857	0.000	0.000	0.086	0.000	0.829	0.000
18	4/27-4/30, 5/1	66	56	23400	0.286	0.661	0.000	0.018	0.036	0.000	0.833	0.000
19	5/4-5/8	161	136	45824	0.551	0.434	0.000	0.000	0.015	0.000	0.807	0.006
20	5/11-5/15	172	149	45086	0.671	0.289	0.000	0.000	0.040	0.000	0.773	0.000
21	5/18-5/22	300	269	36039	0.487	0.424	0.000	0.000	0.082	0.007	0.787	0.003
22	5/26-5/29	221	188	18902	0.394	0.335	0.048	0.000	0.176	0.048	0.697	0.005
Cumulative		**961**	**833**	**181174**	**0.485**	**0.443**	**0.005**	**0.002**	**0.059**	**0.006**	**0.788**	**0.003**

The weekly run size for Statistical Week 17 includes Chinook salmon passing prior to Week 17.

We use May 31 as the end of the spring run, as is generally used in the region (http://www.fpc.org/documents/metadata/FPC_Adult_Metadata.html).

The United States v. Oregon Technical Advisory Committee (http://www.fws.gov/Pacific/fisheries/hatcheryreview/Reports/snakeriver/SR--079.2008-2017.USvOR.Management.Agreement_042908.pdf) uses June 15 as the end of the spring run.

Note – PIT tag data indicated that the new trapping configuration in year 2009 over-sampled one-ocean aged Chinook and under-sampled other age classes. This trap configuration may have created other biases we were unable to detect.

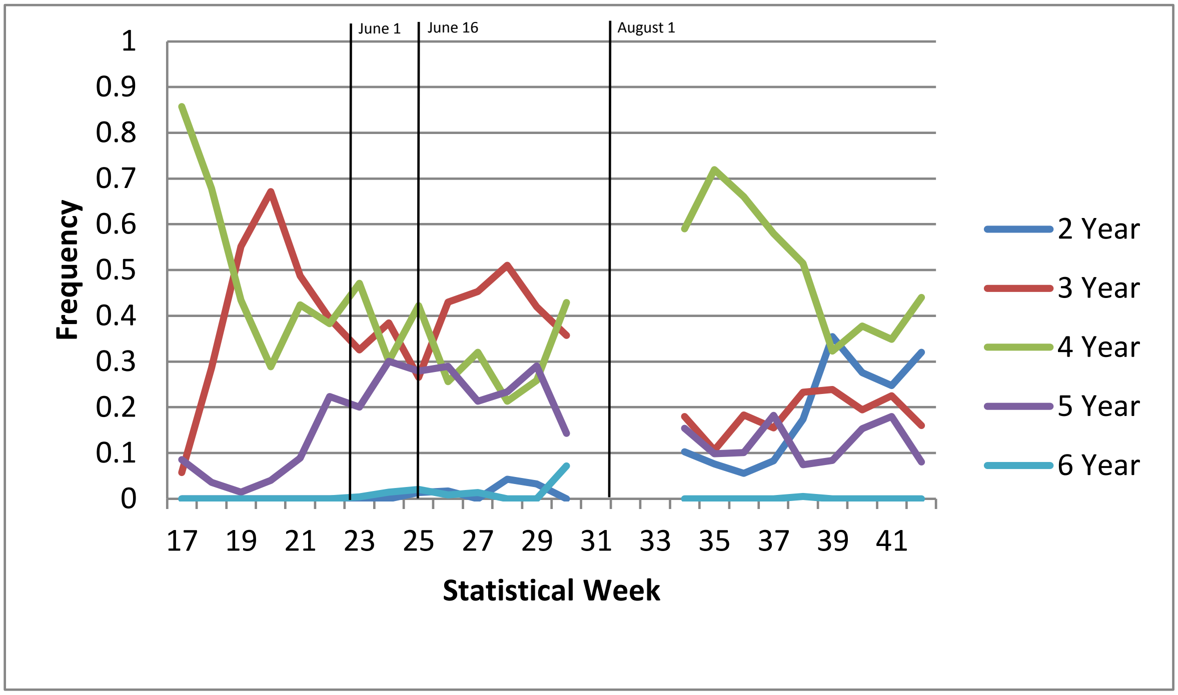

Figure 2. Weekly age composition estimates for age groups of Columbia Basin Chinook salmon sampled at Bonneville Dam in 2009. Due to high water temperatures, sampling hours and days were restricted in weeks 31 and 33 (very low numbers of Chinook salmon were trapped), and sampling was shut down completely in week 32.

Table 5. Weekly and cumulative age composition of Columbia Basin summer Chinook salmon sampled at Bonneville Dam in 2009.

					Age Composition by Brood Year and Age Class										
Statistical Week	Sampling Date	Number Sampled	Number Ageable	Weekly Run Size	2007	2006		2005		2004		2003		Fin Clips	
					0.1	0.2	1.1	0.3	1.2	0.4	1.3	1.4	0.5	Adipose	Other
23	6/1-6/5	272	240	18284	0.000	0.008	0.317	0.075	0.396	0.104	0.096	0.004	0.000	0.676	0.000
24	6/8-6/11	166	142	22175	0.000	0.021	0.359	0.106	0.197	0.099	0.204	0.014	0.000	0.687	0.006
25	6/15-6/18	166	147	25675	0.014	0.014	0.252	0.265	0.156	0.068	0.211	0.014	0.007	0.566	0.000
26	6/22-6/26	133	121	16481	0.017	0.025	0.405	0.149	0.107	0.083	0.207	0.008	0.000	0.662	0.000
27	6/29-7/2	81	75	14068	0.000	0.013	0.440	0.227	0.093	0.067	0.147	0.013	0.000	0.617	0.000
28	7/6-7/9	53	47	8584	0.043	0.064	0.447	0.149	0.064	0.043	0.191	0.000	0.000	0.660	0.000
29	7/13-7/17	35	31	6796	0.032	0.065	0.355	0.194	0.065	0.065	0.226	0.000	0.000	0.629	0.000
30	7/20-7/24	17	14	7289	0.000	0.000	0.357	0.214	0.214	0.000	0.143	0.071	0.000	0.588	0.000
Cumulative		**923**	**817**	**119352**	**0.010**	**0.021**	**0.351**	**0.170**	**0.178**	**0.075**	**0.179**	**0.013**	**0.001**	**0.636**	**0.001**

June 1 is designated as the start of the summer run and is generally used in the region (http://www.fpc.org/documents/metadata/FPC_Adult_Metadata.html).
The United States v. Oregon Technical Advisory Committee (http://www.fws.gov/Pacific/fisheries/hatcheryreview/Reports/snakeriver/SR--079.2008-2017.USvOR.Management.Agreement_042908.pdf) uses June 16 as the start of the summer run.
Under reduced sampling hours, due to high water temperature, we did not catch any Chinook in Week 31.
Note – PIT tag data indicated that the new trapping configuration in year 2009 over-sampled one-ocean aged Chinook and under-sampled other age classes. This trap configuration may have created other biases we were unable to detect.

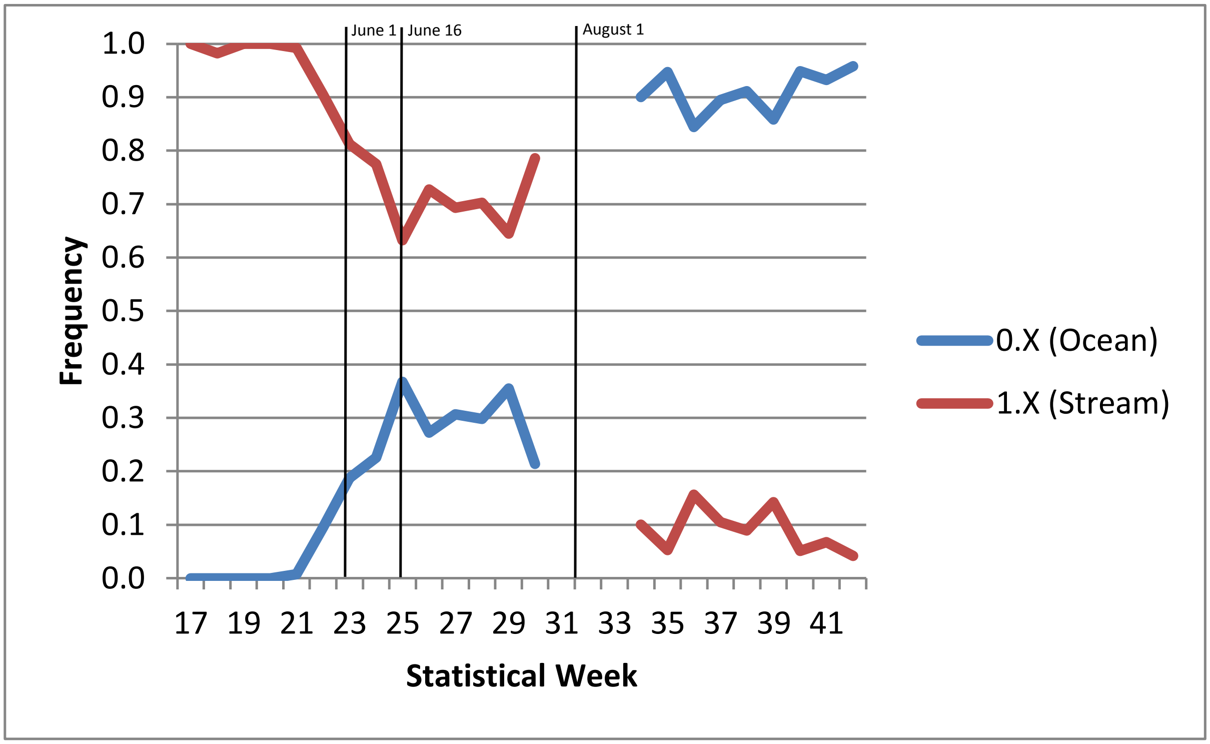

Figure 3. Weekly freshwater age composition estimates of Columbia Basin Chinook salmon sampled at Bonneville Dam in 2009. Due to high water temperatures, sampling hours and days were restricted in weeks 31 and 33 (very low numbers of Chinook salmon were trapped), and sampling was shut down completely in week 32.

Table 6. Weekly and cumulative age composition of Columbia Basin bright fall Chinook salmon sampled at Bonneville Dam in 2009.

Age Composition by Brood Year and Age Class														
Statistical	Sampling	Number	Number	Bright	2007	2006		2005		2004		2003	Fin Clips	
Week	Date	Sampled	Ageable	Run Size	0.1	0.2	1.1	0.3	1.2	1.3	0.4	0.5	Adipose	Other
33-34	8/11, 8/12, 8/18-8/21	44	40	36298	0.100	0.175	0.000	0.525	0.050	0.050	0.100	0.000	0.273	0.000
35	8/25-8/28	140	132	55572	0.076	0.068	0.038	0.705	0.015	0.000	0.098	0.000	0.171	0.000
36	9/1-9/4	121	109	78793	0.055	0.092	0.092	0.606	0.055	0.009	0.092	0.000	0.165	0.000
37	9/8-9/11	194	181	62677	0.083	0.077	0.077	0.569	0.011	0.017	0.166	0.000	0.191	0.000
38	9/14-9/18	219	202	48407	0.173	0.168	0.064	0.495	0.020	0.005	0.069	0.005	0.196	0.000
39	9/21-9/24	175	155	27975	0.355	0.129	0.110	0.290	0.032	0.000	0.084	0.000	0.200	0.000
40	9/28-10/2	108	98	12542	0.276	0.173	0.020	0.357	0.020	0.010	0.143	0.000	0.176	0.000
41	10/5, 10/6, 10/8, 10/9	95	89	7111	0.247	0.169	0.056	0.337	0.011	0.000	0.180	0.000	0.221	0.000
42-43	10/12, 10/13, 10/19-10/21	26	24	7855	0.333	0.083	0.042	0.458	0.000	0.000	0.083	0.000	0.192	0.000
Cumulative		**1122**	**1030**	**337230**	**0.129**	**0.113**	**0.063**	**0.546**	**0.029**	**0.012**	**0.107**	**0.001**	**0.192**	**0.000**

August 1 is the start of the fall run at Bonneville Dam, but due to high water temperatures, sampling did not occur in Week 32, fish passing Bonneville Dam during the beginning of the fall run are included in the Bright run size of Week 33-34. Very few Chinook were caught during week 33, these fish were included in week 34 age composition.

The weekly run size for week 42-43 includes all Chinook salmon passing Bonneville after the last date of sampling in week 43. Few fish were caught in week 43, they are included in week 42.

Tule numbers removed from Bright run size.

Note – PIT tag data indicated that the new trapping configuration in year 2009 over-sampled one-ocean aged Chinook and under-sampled other age classes. This trap configuration may have created other biases we were unable to detect.

Table 7. Weekly and cumulative age composition of Columbia Basin sockeye salmon sampled at Bonneville Dam in 2009.

Age Composition by Brood Year and Age Class												
Statistical Week	Sampling Date	Number Sampled	Number Ageable	Weekly Run Size	2006	2005		2004		2003	Fin Clips	
					1.1	1.2	2.1	1.3	2.2	2.3	Adipose	Other
23	6/3-6/5	10	10	1001	0.100	0.800	0.000	0.100	0.000	0.000	0.000	0.000
24	6/8-6/11	75	70	8007	0.014	0.800	0.000	0.071	0.114	0.000	0.000	0.000
25	6/15-6/18	200	195	42515	0.015	0.841	0.000	0.097	0.046	0.000	0.020	0.000
26	6/22-6/26	275	268	64451	0.101	0.817	0.011	0.041	0.030	0.000	0.051	0.022
27	6/29-7/2	196	186	46675	0.145	0.758	0.011	0.059	0.027	0.000	0.051	0.015
28	7/6-7/9	94	89	15174	0.326	0.584	0.045	0.011	0.022	0.011	0.011	0.000
Cumulative		**850**	**818**	**177823**	**0.107**	**0.787**	**0.011**	**0.058**	**0.036**	**0.001**	**0.038**	**0.012**

The weekly run size for week 23 includes sockeye salmon passing prior to this week. Similarly, the weekly run size for week 28 includes fish passing after this week.
Note – PIT tag data indicated that the new trapping configuration in year 2009 biased Chinook age composition. We were unable to detect whether or not any biases occurred that would affect sockeye age composition estimates.

Table 8. Weekly and cumulative age composition of Columbia Basin steelhead sampled at Bonneville Dam in 2009.

Age Composition by Brood Year and Age Class																							
Statistical	Sampling	Number	Number	Weekly	2006	2005		2004			2003			2002		Repeat	Ageable Salt-Winters			A-Run	Fin Clips		Wild
Week	Date	Sampled	Ageable	Run Size	1.1	1.2	2.1	1.3	2.2	3.1	2.3	3.2	4.1	3.3	4.2	Spawner	1	2	3	Comp	Adipose	Other	
17	4/21, 4/23, 4/24	8	5	2267	0.200	0.600	0.000	0.000	0.200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.250	0.750	0.000	1.000	0.750	0.000	0.250
18	4/27-5/1	8	7	234	0.000	0.857	0.000	0.000	0.143	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.125	0.875	0.000	1.000	0.750	0.125	0.250
19	5/4-5/8	11	6	350	0.333	0.500	0.000	0.000	0.000	0.000	0.000	0.167	0.000	0.000	0.000	0.000	0.182	0.818	0.000	1.000	0.818	0.000	0.182
20	5/11-5/15	17	12	511	0.000	0.833	0.000	0.083	0.083	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.941	0.059	0.941	0.824	0.059	0.118
21	5/18-5/22	11	8	679	0.000	0.875	0.000	0.000	0.125	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.091	0.909	0.000	1.000	0.818	0.091	0.182
22	5/26-5/29	19	14	680	0.214	0.714	0.000	0.000	0.071	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.316	0.684	0.000	1.000	0.684	0.000	0.053
23	6/1-6/5	36	22	1204	0.364	0.500	0.091	0.000	0.045	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.306	0.667	0.028	0.972	0.889	0.028	0.111
24	6/8-6/11	27	19	1753	0.263	0.474	0.000	0.053	0.158	0.000	0.000	0.000	0.000	0.000	0.000	0.053	0.280	0.680	0.040	0.963	0.852	0.037	0.148
25	6/15-6/18	18	10	1961	0.100	0.400	0.000	0.000	0.200	0.200	0.000	0.100	0.000	0.000	0.000	0.000	0.188	0.813	0.000	1.000	0.611	0.000	0.389
26	6/22-6/26	54	36	2869	0.361	0.389	0.056	0.000	0.111	0.028	0.000	0.028	0.000	0.000	0.000	0.028	0.442	0.596	0.000	0.963	0.704	0.111	0.222
27	6/29-7/2	60	44	6881	0.386	0.136	0.136	0.000	0.227	0.045	0.000	0.068	0.000	0.000	0.000	0.000	0.500	0.500	0.000	0.982	0.450	0.017	0.467
28	7/6-7/9	125	95	9972	0.337	0.242	0.200	0.000	0.147	0.032	0.011	0.021	0.011	0.000	0.000	0.000	0.589	0.403	0.008	0.992	0.536	0.056	0.400
29	7/13-7/17	303	234	17681	0.393	0.179	0.167	0.004	0.137	0.051	0.000	0.043	0.004	0.000	0.013	0.008	0.603	0.390	0.007	0.997	0.469	0.043	0.442
30	7/20-7/24	340	257	45307	0.459	0.191	0.222	0.000	0.070	0.027	0.000	0.016	0.004	0.000	0.000	0.012	0.711	0.289	0.000	0.991	0.541	0.068	0.365
31-32	7/27, 7/28	102	81	58384	0.333	0.210	0.222	0.000	0.111	0.086	0.000	0.025	0.000	0.000	0.000	0.012	0.673	0.327	0.000	0.980	0.461	0.059	0.431
32-33	8/11-8/14	189	138	154869	0.630	0.123	0.130	0.000	0.043	0.051	0.000	0.014	0.000	0.000	0.000	0.007	0.818	0.182	0.000	0.984	0.651	0.079	0.259
34	8/18-8/21	191	158	107420	0.614	0.165	0.120	0.000	0.082	0.013	0.000	0.000	0.006	0.000	0.000	0.000	0.764	0.236	0.000	0.979	0.728	0.068	0.230
35	8/25-8/28	129	95	59377	0.579	0.189	0.105	0.000	0.074	0.032	0.000	0.000	0.000	0.011	0.000	0.011	0.734	0.258	0.008	0.930	0.744	0.078	0.202
36	9/1-9/4	66	48	43233	0.563	0.250	0.042	0.000	0.125	0.000	0.000	0.000	0.000	0.000	0.000	0.021	0.677	0.323	0.000	0.894	0.773	0.106	0.182
37	9/8-9/11	90	74	28579	0.459	0.351	0.027	0.041	0.054	0.000	0.000	0.068	0.000	0.000	0.000	0.000	0.483	0.483	0.034	0.733	0.756	0.022	0.133
38	9/14-9/18	181	130	21236	0.362	0.454	0.054	0.046	0.069	0.000	0.000	0.015	0.000	0.000	0.000	0.000	0.424	0.531	0.045	0.718	0.762	0.061	0.171
39	9/21-9/24	121	94	13594	0.149	0.574	0.032	0.074	0.096	0.021	0.011	0.043	0.000	0.000	0.000	0.000	0.207	0.702	0.091	0.525	0.620	0.041	0.215
40	9/28-10/2	164	125	9172	0.224	0.560	0.000	0.112	0.048	0.000	0.008	0.032	0.000	0.016	0.000	0.000	0.245	0.638	0.117	0.506	0.817	0.091	0.085
41	10/5, 10/6, 10/8, 10/9	130	115	6594	0.122	0.548	0.009	0.287	0.026	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.155	0.558	0.287	0.408	0.762	0.054	0.046
42	10/12, 10/13	46	34	3682	0.118	0.559	0.029	0.235	0.029	0.029	0.000	0.000	0.000	0.000	0.000	0.000	0.174	0.609	0.217	0.478	0.696	0.043	0.109
43	10/19-10/21	27	23	6481	0.435	0.043	0.130	0.130	0.043	0.087	0.000	0.087	0.043	0.000	0.000	0.000	0.667	0.222	0.111	0.808	0.481	0.037	0.370
Cumulative		**2473**	**1884**	**604970**	**0.508**	**0.217**	**0.122**	**0.013**	**0.078**	**0.034**	**0.001**	**0.016**	**0.002**	**0.001**	**0.000**	**0.007**	**0.678**	**0.308**	**0.014**	**0.922**	**0.659**	**0.068**	**0.262**

The weekly run size for week 17 includes steelhead passing prior to this week. Similarly, the weekly run size for week 43 includes fish passing after this week.

Due to high water temperatures, sampling did not occur in week 32, fish passing Bonneville Dam during the missed week are included in the run size for weeks before and after.

Note – PIT tag data indicated that the new trapping configuration in year 2009 biased Chinook age composition. We were unable to detect whether or not any biases occurred that would affect steelhead age composition estimates.

Number ageable (fresh and salt years) is used to calculate the X.X age classes and repeat spawners.

All fish (except completely unageable and repeat spawners – total of 30) were used in the calculations of Ageable Salt-Winters.

B-run fish are 1 – A-run weekly proportion.

Length-at-Age Composition

Length-at-age composition estimates for all Chinook salmon are presented in Figure 4 and tables in the Appendix. Length-at-age tables for sockeye salmon and steelhead are also located in the Appendix.

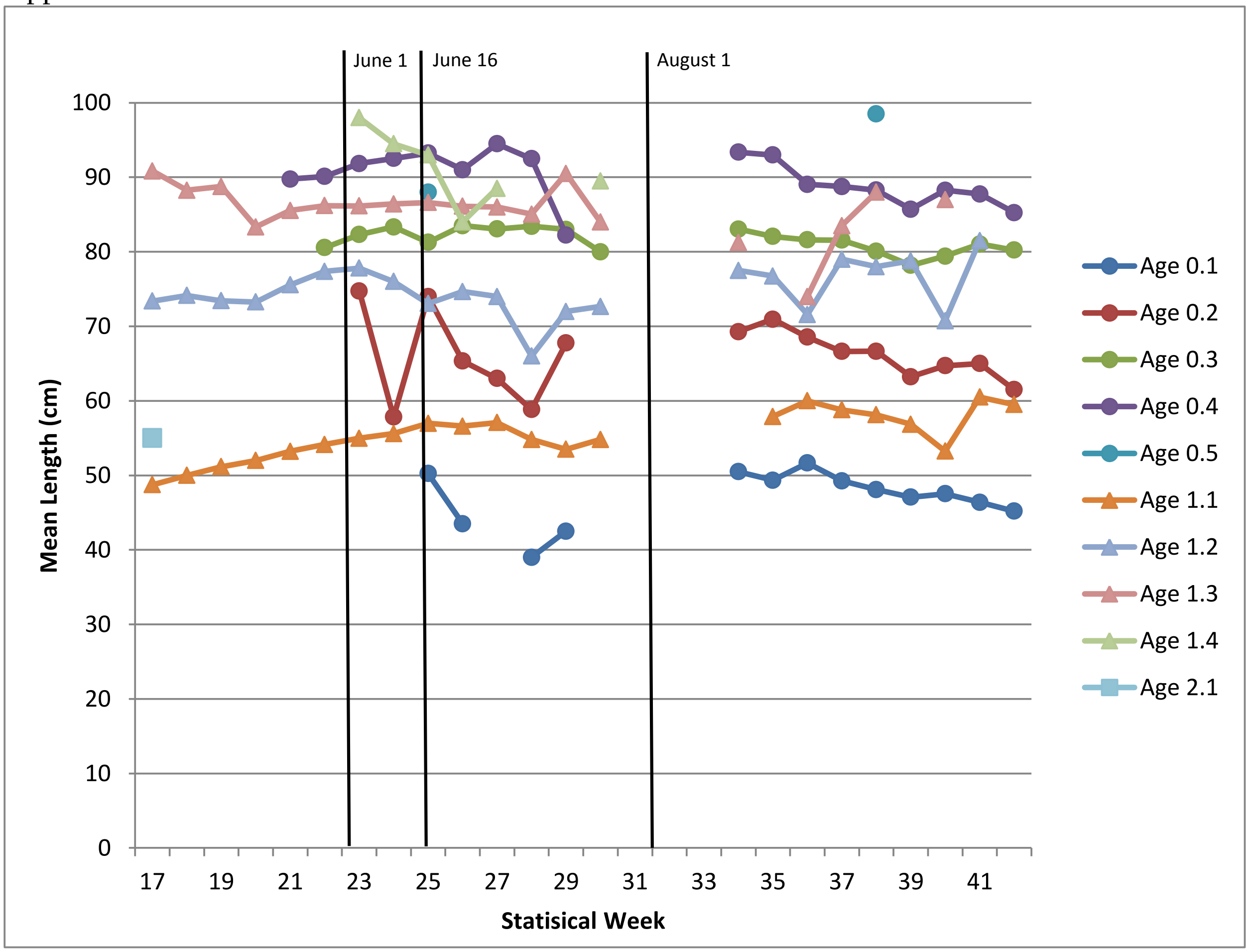

Figure 4. Weekly mean length estimates of the Columbia Basin Chinook salmon age classes sampled at Bonneville Dam in 2009. Sampling did not occur in Statistical Week 32, and was hours and days were restricted in weeks 31 and 33, due to high water temperatures, few Chinook salmon were caught during this time.

Fish Coloration and Condition

Bright coloration was observed in the majority of each species, 97.9% of spring Chinook, 86.8% of summer Chinook, 95.0% of fall Chinook, 100% of sockeye and 95.5% of steelhead. The highest condition rating of 5 was given to 93.4% of spring Chinook, 94.6% of summer Chinook, 94.6% of fall Chinook, 97.5% of sockeye and 89.9% of steelhead. Additional fish condition data can be found in the Appendix.

Chinook Salmon Run-Size Prediction for 2009

Generally CRITFC uses a linear relationship between the current season's three-year-old adult returns to estimated number of four-year-old spring Chinook salmon returning to Bonneville Dam for the next year. This same relationship exists for the current year's four-year-olds and next year's five-year-olds. However, due to several reasons, CRITFC did not get this report out in time for a prediction to have any meaning and therefore this report will not have predicted return numbers for 2010.

Based on the sampling year 2008 report (Torbek, et al. 2009), we made run size predictions for four- and five-year-old spring, summer, and bright fall Chinook salmon returning to Bonneville Dam in 2009 using the methods discussed in the 2008 report. For the two principle (non-jack) age groups (four-year-old and five-year-old), we predicted 285,600 spring, 109,400 summer, and 255,800 bright fall Chinook (Table 10). The Fish Passage Center (2009) reports estimated total returns (Tables 5-7) of 181,174 spring, 119,352 summer and 337,230 bright fall Chinook salmon passing Bonneville Dam (visual counts). These numbers are multiplied by the age composition proportions to produce the 2009 estimates for numbers of four- and five-year-old fish in the run (Table 10). For all age classes, but bright fall Chinook five-year-olds, our 2009 forecast overestimated the actual 2009 return. A new trap configuration in 2009 that selected for jacks (bias discuss in this report) throughout the Chinook salmon run, created an overestimate of the jack component in the run and an underestimate of the adult component. There is some evidence that the 2008 trap configuration, though different from that in 2009, also selected for jacks which would have increased our 2009 forecast for all age classes in Table 10.

Steelhead Hatchery/Wild Determination

The vast majority of hatchery raised steelhead are released with a clipped fin, typically an adipose fin. This clip is used primarily in harvest management purposes where some fisheries allow adipose clipped fish to be kept, while non-adipose clipped fish (assumed wild) are released. Separate visual counts are made at Columbia Basin mainstem dams for non-clipped steelhead, allowing managers to estimate the percentage wild fish in the run. However, poorly clipped adipose fins can grow back and there are a small number of hatchery programs that release steelhead unclipped. In the past, steelhead were raised in relatively crowded conditions at hatcheries, which meant that released fish commonly had so-called stubby dorsal fins (and sometimes other fins as well) from other juveniles nipping those fins. This meant that the vast majority of adipose clipped steelhead also had stubby dorsal fins. The stubby dorsal fin was used to determine fish origin in those cases where adipose fins grew back, or where hatcheries released unclipped steelhead. However, steelhead are increasingly raised at lower densities, which should make stubby dorsals more rare in the population. Therefore, we also used scale pattern analysis to classify some unclipped steelhead as hatchery fish. Wild-origin fish typically have freshwater scale patterns showing tight growth with two or more distinct check marks, which are winter annuli. Hatchery-origin fish show much greater freshwater growth and have much less distinct annuli. Our age composition results in Table 9 are based on interpretation of scale patterns. Based on adipose fin clips alone, we would have estimated that 34.1% of the run was of wild origin; including scale patterns reduced this to 26.2%.

Table 9. Predicted and estimated abundance of four- and five-year-old Chinook salmon returning to Bonneville Dam.

Chinook Run	2009 Forecast (+90%) From 2008 Report	Year 2009 Estimate From Age Comps
Spring Chinook 4-year-old	259,500 (+88,200)	81,200
Spring Chinook 5-year-old	26,100 (+38,900)	11,800
Summer Chinook 4-year-old	58,700 (+24,700)	41,300
Summer Chinook 5-year-old	49,700 (±9,300)	30,700
Bright Fall Chinook 4-year-old	218,600 (+97,200)	182,400
Bright Fall Chinook 5-year-old	37,200 (+46,000)	49,600

2009 estimate is calculated using the proportion of X-year-old returning in 2009 multiplied by the count of spring (ending May 31st), summer and fall Chinook at Bonneville Dam.

Steelhead A/B Run Determination

Assuming that A-run (less than 78 cm) and B-run (equal to or greater than 78 cm) steelhead can be differentiated by length alone, the majority of the steelhead run (92.2%) passing Bonneville Dam were A-run, and the remaining 7.8% were B-run. Although A-run steelhead dominate the run, the percentage of the B-run generally increases as the run progresses (Table 9 and Figure 5).

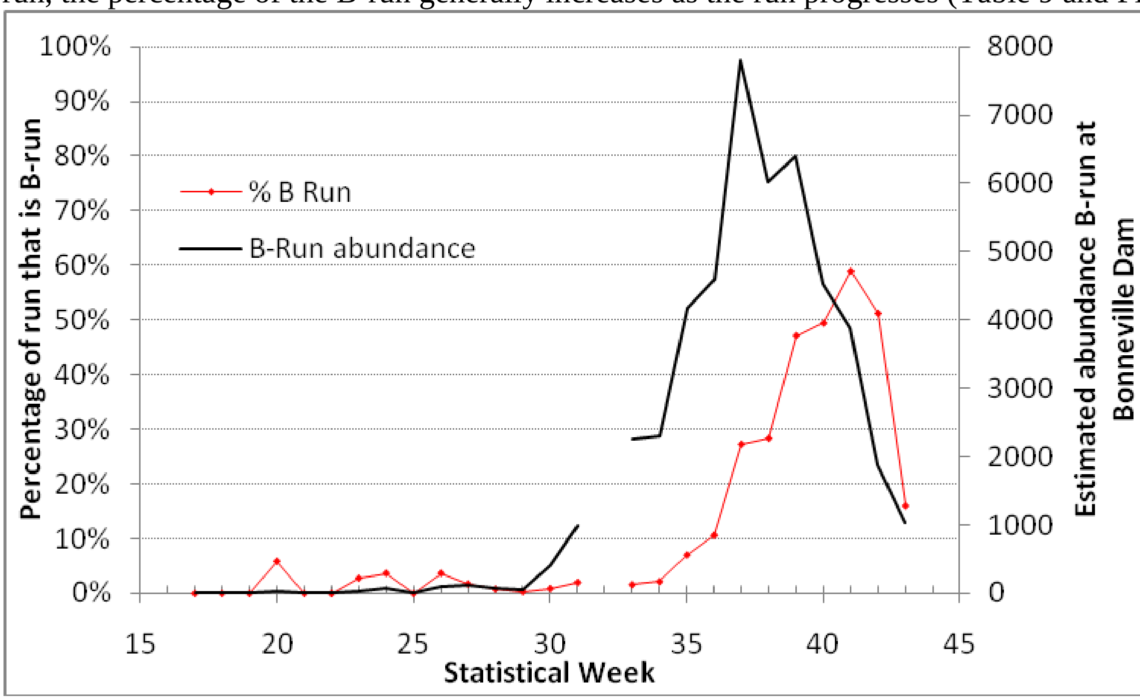

Figure 5. Percentage of B-run steelhead and the estimated B-run size passing Bonneville Dam by Statistical Week in 2009.

Steelhead Kelts

For 2009, we found 11 steelhead with spawning check marks in their scale patterns. The freshwater- and salt-winter annuli numbers varied greatly and two fish had unageable freshwater annuli. The age composition was; four - 2.1S1, two – 1.1S1, and one each of 2.1S, 2.2S, 2.2S1, r.1S1, and r.2S. All 11 steelhead were PIT tagged and tracked. Although none of the fish were adiposed clipped, the two 1.1S1 appeared to have freshwater scale patterns of hatchery fish. Over one hundred other steelhead PIT tagged during the 2009 season displayed migration behaviors that identified them as kelts (Fryer, et al. 2011).

DISCUSSION

High river water temperature has constrained our sampling efforts during most summer sampling seasons. The Fish Passage Operations and Management Committee also has modified sampling protocols for temperatures between 70°F (21.1°C) and 74°F (23.3°C) which restricts sampling to four days per week from 06:00 to 10:00 with no sampling allowed at temperatures above 74 °F. During the 2009 sampling season, sampling was restricted during weeks 31 and 33 and was stopped during week 32 due to high temperatures (Figure 6). The steelhead responded to the spike in temperature to 75°F (23.9°C) at the end of Statistical Week 31 by reducing their migration past Bonneville Dam only to resume as temperatures dropped below 71°F (21.7°C). Temperature did not appear to affect the timing of the fall Chinook migration as temperatures stayed relatively stable between August 5 and September 20, which was when the bulk of the fall Chinook passed.

In 2009, tissue samples (for DNA analysis) were collected from all Chinook and sockeye salmon, and steelhead that were sampled at the Adult Fish Facility at Bonneville Dam. This was the seventh year for Chinook salmon, the third year for sockeye salmon, and the sixth year for steelhead that we have collected genetic samples. In previous years steelhead genetic samples were collected by ODFW and WDFW. Significant progress has been made through the coast wide Chinook genetic database to assemble baseline genetic stock identification information for all Columbia River Chinook salmon populations. The development of baseline genetic stock information for steelhead and sockeye salmon are still incomplete. Once this baseline stock information is readily available, mixed stock sampling at Bonneville Dam will be a valuable tool for fisheries and ESA management within the Columbia River Basin.

This study was adversely affected by the trap configuration imposed in 2009 that biased our sample by causing us to sample a higher percentage of smaller one-ocean Chinook (jacks) than were present in the general fish population migrating in the ladder at the time of sampling. It is unknown why a higher percentage of jack Chinook chose the trap side of the divider. Whatever the reason, the bias adversely affects our age composition estimates for Chinook salmon. This type of analysis for trap bias requires a sufficient number of previously PIT tagged fish (from other studies) to determine if a bias exists. While sufficient numbers existed for Chinook, the sample of previously tagged sockeye and steelhead was too small to make any comparisons for these two species. Furthermore, there are also insufficient previously PIT tagged fish of any species to determine whether there were any stock composition or other biases.

The discovery of biases imposed by the trap configuration in 2009 resulted in an investigation and analysis of other potential biases imposed on the fish by dam configuration or operations. Fish passing Bonneville Dam may enter any one of four ladder entrances plus use the navigation locks. However, only fish using the Washington Shore ladder entrance can be trapped by the Adult Fish Facility and sampled. If any of the other three ladder entrances are attracting fish of different stocks, age, or length then this would be another source of bias. Also, we typically only trap and sample four to six hours daily during weekday mornings and early afternoon, suggesting another possible source of bias, if fish stock, sizes, or ages migrate at different times of the day or night. An analysis of the percentage of jacks passing through the different ladder entrances during hours of trapping and hours of not trapping, found that the percentage of jacks varied from 38.6% for those entering the Washington Shore ladder entrance during non-trapping hours to 60.4% at the Oregon Shore ladder during trapping hours. Given this variability, it was surprising that as a whole the percentage of PIT tagged Chinook passing Bonneville Dam that were jacks (48.2%) was close to the percentage of jacks passing through the Washington Shore ladder during hours the trap was in operation (46.1%). This suggests that, if we had been allowed to trap the entire ladder, rather than half the ladder, our estimated jack composition would have been within 2.1 percentage points (or 4.6%) of that for the entire population of previously tagged Chinook salmon passing Bonneville Dam. In future years, we will continue to look for possible biases in trapping, and if warranted, we may alter sampling hours and days in an effort to reduce sampling biases. Sampling other fish ladders at Bonneville Dam to reduce biases between ladders or Washington Shore versus Oregon shore is not feasible.

It is expected that this stock assessment study will continue to develop an accurate age composition and length-at-age database for Columbia Basin upriver salmon populations, and work towards improving the forecasting of terminal runs, which is important for the calibration of the PSC Chinook Technical Committee's Chinook model. These data will also aid fisheries managers in formulating spawner-return relationships and analyzing productivity. Continued data collection on age composition and length-at-age will allow managers to more accurately monitor the effects of ocean harvest restrictions agreed upon by the Pacific Salmon Treaty. The addition of steelhead to our normal sampling regime provides valuable information for NOAA-Fisheries and TAC for use in steelhead assessments, fisheries forecasting and harvest management. This study will work to improve accurate age determination, hatchery fraction, and stock identification and assessment.

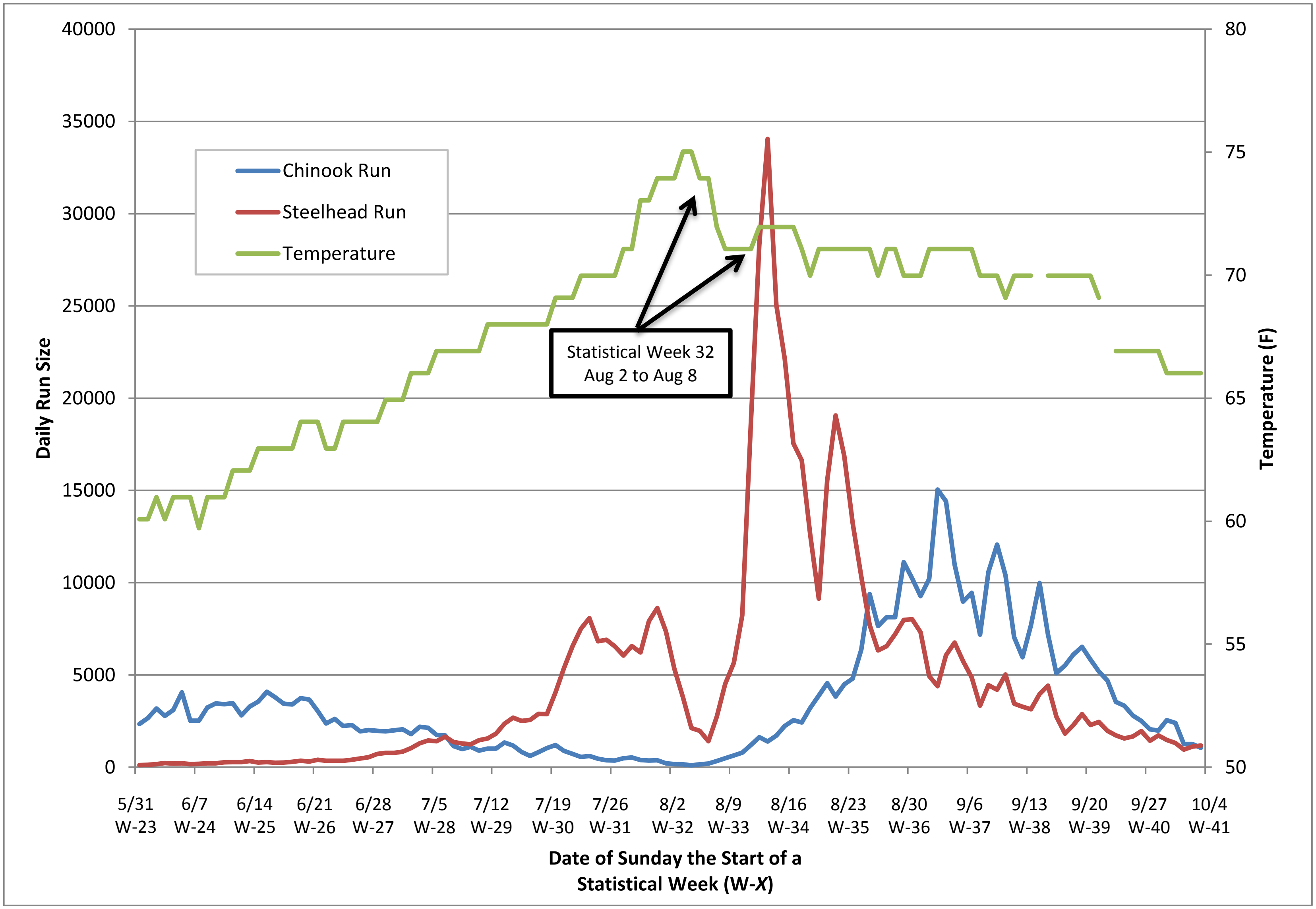

Figure 6. Chinook and steelhead daily run size and daily river temperature at Bonneville Dam from July 1 through September 30, 2009.

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APPENDIX

List of Tables

Table A1: Composition (%) of observed injuries of Columbia Basin Chinook and sockeye salmon and steelhead sampled at Bonneville Dam in 2009.

Injury category	Spring	Summer	Fall	Sockeye	Steelhead
Marine Mammal					
Bite	0.4	0.4	0.1	0.1	0.1
Scrape	22.9	18.3	4.0	6.1	17.6
Total	23.3	18.7	4.1	6.3	17.8
Descaling					
<3%					
Left side	0.9	0.4	0.2	1.8	1.9
Right Side	0.6	0.3	0.3	1.9	1.2
Total	1.0	0.4	0.1	1.3	1.7
3-19%					
Left side	13.6	18.9	19.9	35.5	18.3
Right Side	13.7	18.2	19.0	29.5	18.3
Total	19.6	25.4	21.6	39.3	23.4
>20%					
Left side	1.6	6.5	9.6	7.0	6.7
Right Side	1.0	6.6	12.5	7.0	6.7
Total	1.9	10.1	15.9	9.9	9.7
Other Injuries					
Bruise	0.3				0.1
Head Injury	3.3	3.9	6.4	0.9	4.4
Fin	9.3	7.3	6.9	2.8	13.0
Fungus	1.9	1.2	0.1		0.6
Gash		0.4	1.0	0.5	1.5
Gill Net	0.5	1.3	0.2	0.8	2.4
Lamprey	7.6	5.4	0.2	0.4	0.2
Parasite	2.0	1.3	0.5	1.5	0.3
Total	21.9	17.9	14.1	6.5	19.8

Totals do not represent the sum of subcategories, they are the number of fish with at least one injury.
Fish can display more than one type of marine mammal or general injury.
Descaling totals represent the percentage of fish with descaling on either side. Fish are recorded in the category of maximum descaling. For example, a fish 3-19% descaled on one side, and ≥20% descaled on the other, would be recorded as ≥20% descaled.

Table A2: Length-at-age estimates for Columbia Basin spring Chinook salmon sampled at Bonneville Dam in 2009.

Brood Year and	2006	2005			2004	
Age Class	1.1	1.2	2.1	0.3	0.4	1.3
Statistical Week 17						
Mean Fork Length (cm)	48.75	73.38				90.83
Maximum	52.0	80.5				93.0
Minimum	45.5	64.0				88.5
Standard Deviation	4.60	3.79				2.25
Sample Size	2	30				3
Statistical Week 18						
Mean Fork Length (cm)	50.00	74.14	55.00			88.25
Maximum	56.0	84.0	55.0			91.5
Minimum	42.5	64.0	55.0			85.0
Standard Deviation	3.65	4.71	----			4.60
Sample Size	16	37	1			2
Statistical Week 19						
Mean Fork Length (cm)	51.17	73.44				88.75
Maximum	59.0	84.0				94.0
Minimum	38.0	52.5				83.5
Standard Deviation	3.91	5.22				7.42
Sample Size	75	58				2
Statistical Week 20						
Mean Fork Length (cm)	51.99	73.27				83.33
Maximum	60.5	81.0				87.0
Minimum	44.0	58.0				81.0
Standard Deviation	3.39	5.00				2.27
Sample Size	99	43				6
Statistical Week 21						
Mean Fork Length (cm)	53.23	75.55			89.75	85.55
Maximum	64.0	85.0			94.5	99.5
Minimum	44.0	61.0			85.0	68.0
Standard Deviation	3.70	4.21			6.72	7.68
Sample Size	131	111			2	22
Statistical Week 22						
Mean Fork Length (cm)	54.15	77.37		80.56	90.11	86.20
Maximum	61.0	83.5		89.5	99.0	95.0
Minimum	43.0	69.0		72.0	85.0	77.0
Standard Deviation	3.81	3.10		5.42	4.05	4.72
Sample Size	74	63		9	9	33
2009 Composite						
Mean Fork Length (cm)	**52.11**	**74.75**	**55.00**	**80.56**	**89.93**	**87.15**
Maximum	**64.0**	**85.0**	**55.0**	**89.5**	**99.0**	**99.5**
Minimum	**38.0**	**52.5**	**55.0**	**72.0**	**85.0**	**68.0**
Standard Deviation	**0.41**	**0.80**	**----**	**5.42**	**1.88**	**2.37**
Sample Size	**397**	**342**	**1**	**9**	**11**	**68**

Table A3: Length-at-age estimates for Columbia Basin summer Chinook salmon sampled at Bonneville Dam in 2009.

Brood Year and	2007	2006		2005		2004		2003	
Age Class	0.1	0.2	1.1	0.3	1.2	0.4	1.3	1.4	0.5
Statistical Week 23									
Mean Fork Length (cm)		74.75	54.97	82.31	77.81	91.84	86.15	98.00	
Maximum		76.5	63.0	92.0	87.0	104.5	97.5	98.0	
Minimum		73.0	42.0	74.0	57.5	80.5	80.5	98.0	
Standard Deviation		2.47	4.17	5.46	4.54	5.81	4.61	----	
Sample Size		2	74	18	95	25	23	1	
Statistical Week 24									
Mean Fork Length (cm)		57.83	55.61	83.33	76.02	92.54	86.41	94.50	
Maximum		64.5	63.0	92.5	86.0	102.0	97.0	98.0	
Minimum		49.0	48.0	75.0	60.0	83.0	75.0	91.0	
Standard Deviation		7.97	3.82	4.92	6.76	5.72	5.17	4.95	
Sample Size		3	51	15	28	14	29	2	
Statistical Week 25									
Mean Fork Length (cm)	50.25	74.00	56.97	81.27	73.07	93.25	86.61	93.00	88.00
Maximum	56.0	78.0	81.5	95.5	85.5	109.0	97.5	95.0	88.0
Minimum	44.5	70.0	49.0	59.5	61.0	87.0	79.5	91.0	88.0
Standard Deviation	8.13	5.66	5.85	6.73	7.63	6.70	4.24	2.83	----
Sample Size	2	2	37	39	23	10	31	2	1
Statistical Week 26									
Mean Fork Length (cm)	43.50	65.33	56.61	83.50	74.65	91.00	86.10	84.00	
Maximum	48.0	69.0	67.0	97.5	83.0	97.5	101.0	84.0	
Minimum	39.0	59.5	45.5	70.0	58.0	81.0	77.0	84.0	
Standard Deviation	6.36	5.11	4.28	6.20	7.55	5.97	5.28	----	
Sample Size	2	3	49	18	13	10	25	1	
Statistical Week 27									
Mean Fork Length (cm)		63.00	57.08	83.06	74.00	94.50	86.00	88.50	
Maximum		63.0	68.5	96.5	82.5	99.5	95.0	88.5	
Minimum		63.0	41.5	73.0	62.5	90.0	67.5	88.5	
Standard Deviation		----	6.06	6.64	7.70	4.42	8.44	----	
Sample Size		1	33	17	7	5	11	1	
Statistical Week 28									
Mean Fork Length (cm)	39.00	58.83	54.81	83.43	66.00	92.50	85.06		
Maximum	40.0	64.5	65.0	90.0	72.0	93.0	98.0		
Minimum	38.0	52.0	44.5	76.5	61.0	92.0	72.5		
Standard Deviation	1.41	6.33	5.18	4.31	5.57	0.71	8.23		
Sample Size	2	3	21	7	3	2	9		
Statistical Week 29									
Mean Fork Length (cm)	42.50	67.75	53.50	83.00	72.00	82.25	90.50		
Maximum	42.5	72.5	62.5	88.5	76.0	84.5	100.0		
Minimum	42.5	63.0	43.0	75.5	68.0	80.0	86.0		
Standard Deviation	----	6.72	6.28	5.47	5.66	3.18	4.56		
Sample Size	1	2	10	6	2	2	7		
Statistical Week 30									
Mean Fork Length (cm)			54.80	80.00	72.67		84.00	89.50	
Maximum			64.5	87.0	79.5		86.5	89.5	
Minimum			39.5	75.0	65.5		81.5	89.5	
Standard Deviation			9.73	6.24	7.01		3.54	----	
Sample Size			5	3	3		2	1	
2009 Composite									
Mean Fork Length (cm)	**43.81**	**65.93**	**55.54**	**82.49**	**73.28**	**91.13**	**86.35**	**91.25**	**88.00**
Maximum	**56.0**	**78.0**	**81.5**	**97.5**	**92.5**	**109.0**	**102.0**	**98.0**	**98.0**
Minimum	**38.0**	**2.5**	**4.2**	**5.5**	**4.5**	**5.8**	**4.6**	**84.0**	**88.0**
Standard Deviation	**12.13**	**3.47**	**3.56**	**0.73**	**1.37**	**4.36**	**3.34**	**2.25**	**----**
Sample Size	**7**	**16**	**280**	**123**	**174**	**68**	**137**	**8**	**1**

Table A4: Length-at-age estimates for Columbia Basin bright fall Chinook salmon sampled at Bonneville Dam in 2009.

Brood Year and	**2007**	**2006**		**2005**		**2004**		**2003**
Age Class	**0.1**	**0.2**	**1.1**	**0.3**	**1.2**	**0.4**	**1.3**	**0.5**
Statistical Week 34								
Mean Fork Length (cm)	50.50	69.29		83.05	77.50	93.38	81.25	
Maximum	54.0	74.5		93.5	79.5	96.0	81.5	
Minimum	44.5	63.5		73.0	75.5	90.5	81.0	
Standard Deviation	4.53	3.91		4.50	2.83	2.56	0.35	
Sample Size	4	7		20	2	4	2	
Statistical Week 35								
Mean Fork Length (cm)	49.35	70.94	57.90	82.05	76.75	93.00		
Maximum	51.5	79.5	65.5	98.0	82.5	102.5		
Minimum	43.5	63.5	54.0	72.0	71.0	81.0		
Standard Deviation	2.45	5.42	4.48	5.27	8.13	6.50		
Sample Size	10	9	5	92	2	13		
Statistical Week 36								
Mean Fork Length (cm)	51.67	68.55	60.00	81.61	71.58	89.05	74.00	
Maximum	56.5	76.0	67.0	97.0	78.0	93.0	74.0	
Minimum	48.0	59.5	50.5	63.0	66.0	81.0	74.0	
Standard Deviation	3.03	4.99	4.61	6.61	4.60	3.84	----	
Sample Size	6	10	10	66	6	10	1	
Statistical Week 37								
Mean Fork Length (cm)	49.27	66.64	58.79	81.57	79.00	88.75	83.50	
Maximum	54.5	81.5	64.5	91.5	88.0	98.0	89.0	
Minimum	43.0	56.5	52.0	74.0	70.0	80.5	80.5	
Standard Deviation	3.25	6.96	3.42	3.83	12.73	4.39	4.77	
Sample Size	15	14	14	103	2	30	3	
Statistical Week 38								
Mean Fork Length (cm)	48.10	66.66	58.12	80.08	78.00	88.29	88.00	98.50
Maximum	58.0	84.0	69.5	95.0	83.0	97.0	88.0	98.5
Minimum	41.0	55.0	48.0	68.0	72.0	81.0	88.0	98.5
Standard Deviation	3.82	6.32	5.64	5.08	5.15	4.02	----	----
Sample Size	35	34	13	100	4	14	1	1
Statistical Week 39								
Mean Fork Length (cm)	47.06	63.23	56.85	78.18	78.80	85.71		
Maximum	54.5	76.5	67.0	92.0	81.0	91.5		
Minimum	40.0	42.0	48.0	61.0	75.5	78.5		
Standard Deviation	3.37	8.82	5.34	6.41	2.80	4.63		
Sample Size	55	20	17	45	5	12		
Statistical Week 40								
Mean Fork Length (cm)	47.54	64.71	53.25	79.41	70.75	88.25	87.00	
Maximum	54.5	81.0	53.5	91.0	78.5	92.5	87.0	
Minimum	40.0	54.0	53.0	61.5	63.0	85.5	87.0	
Standard Deviation	2.86	5.53	0.35	5.60	10.96	2.48	----	
Sample Size	27	17	2	35	2	14	1	
Statistical Week 41								
Mean Fork Length (cm)	46.39	65.00	60.50	81.03	81.50	87.75		
Maximum	52.0	73.5	64.5	89.0	81.5	93.5		
Minimum	40.5	58.0	54.0	71.5	81.5	80.0		
Standard Deviation	3.11	4.18	4.51	4.23	----	3.39		
Sample Size	22	15	5	29	1	16		
Statistical Week 42								
Mean Fork Length (cm)	45.19	61.50	59.50	80.23		85.25		
Maximum	48.0	63.0	59.5	85.5		86.5		
Minimum	40.0	60.0	59.5	73.5		84.0		
Standard Deviation	3.01	2.12	----	4.26		1.77		
Sample Size	8	2	1	11		2		
2009 Composite								
Mean Fork Length (cm)	**48.34**	**66.28**	**58.11**	**80.80**	**76.74**	**88.82**	**82.75**	**98.50**
Maximum	**58.0**	**84.0**	**69.5**	**98.0**	**88.0**	**102.5**	**89.0**	**98.5**
Minimum	**40.0**	**42.0**	**48.0**	**61.0**	**63.0**	**78.5**	**74.0**	**98.5**
Standard Deviation	**0.60**	**1.92**	**1.78**	**0.98**	**3.95**	**1.41**	**3.12**	**----**
Sample Size	**182**	**128**	**67**	**501**	**24**	**115**	**8**	**1**

Table A5: Length-at-age estimates for Columbia Basin sockeye salmon sampled at Bonneville Dam in 2009.

Brood Year and	2006	2005		2004		2003
Age Class	1.1	1.2	2.1	1.3	2.2	2.3
Statistical Week 23						
Mean Fork Length (cm)	38.50	52.63		57.00		
Maximum	38.50	55.00		57.00		
Minimum	38.50	49.50		57.00		
Standard Deviation	----	1.87		----		
Sample Size	1	8		1		
Statistical Week 24						
Mean Fork Length (cm)	39.50	51.57		58.40	52.69	
Maximum	39.50	56.50		60.50	56.00	
Minimum	39.50	38.00		57.00	48.50	
Standard Deviation	----	2.93		1.52	2.78	
Sample Size	1	56		5	8	
Statistical Week 25						
Mean Fork Length (cm)	38.67	51.75		58.16	52.56	
Maximum	39.50	57.00		62.00	57.50	
Minimum	37.00	43.50		53.00	42.50	
Standard Deviation	1.44	2.22		2.36	4.32	
Sample Size	3	164		19	9	
Statistical Week 26						
Mean Fork Length (cm)	38.50	51.33	39.33	55.41	51.19	
Maximum	42.50	64.50	40.00	58.00	55.50	
Minimum	34.50	40.50	38.50	52.00	45.00	
Standard Deviation	1.95	2.62	0.76	1.96	3.40	
Sample Size	27	217	3	11	8	
Statistical Week 27						
Mean Fork Length (cm)	40.17	50.75	44.25	55.23	52.00	
Maximum	44.50	57.00	45.00	58.00	55.50	
Minimum	37.00	42.50	43.50	53.50	48.50	
Standard Deviation	2.11	2.48	1.06	1.35	2.85	
Sample Size	27	140	2	11	5	
Statistical Week 28						
Mean Fork Length (cm)	38.48	49.54	41.63	55.00	51.00	53.00
Maximum	45.50	55.00	46.00	55.00	51.00	53.00
Minimum	35.50	44.50	39.00	55.00	51.00	53.00
Standard Deviation	2.34	2.63	3.09	----	0.00	----
Sample Size	29	52	4	1	2	1
2009 Composite						
Mean Fork Length (cm)	**38.97**	**51.26**	**41.74**	**56.53**	**51.89**	**53.00**
Maximum	**45.50**	**64.50**	**46.00**	**62.00**	**57.50**	**53.00**
Minimum	**34.50**	**38.00**	**38.50**	**52.00**	**42.50**	**53.00**
Standard Deviation	**0.38**	**0.37**	**1.27**	**0.45**	**1.61**	**----**
Sample Size	**88**	**637**	**9**	**48**	**32**	**1**

Table A6: Length-at-age estimates for Columbia Basin steelhead sampled at Bonneville Dam in 2009.

Ocean	Salt-Winters		
Age Class	**1**	**2**	**3**
Statistical Week 17			
Mean Fork Length (cm)	61.00	71.58	
Maximum	63.0	75.5	
Minimum	59.0	68.0	
Standard Deviation	2.83	2.82	
Sample Size	2	6	
Statistical Week 18			
Mean Fork Length (cm)	59.00	69.36	
Maximum	59.0	75.5	
Minimum	59.0	65.0	
Standard Deviation	----	3.50	
Sample Size	1	7	
Statistical Week 19			
Mean Fork Length (cm)	64.50	70.28	
Maximum	66.0	73.0	
Minimum	63.0	67.0	
Standard Deviation	2.12	1.94	
Sample Size	2	9	
Statistical Week 20			
Mean Fork Length (cm)		70.00	85.00
Maximum		75.0	85.0
Minimum		67.0	85.0
Standard Deviation		2.45	----
Sample Size		16	1
Statistical Week 21			
Mean Fork Length (cm)	54.50	69.85	
Maximum	54.5	74.0	
Minimum	54.5	67.0	
Standard Deviation	----	2.55	
Sample Size	1	10	
Statistical Week 22			
Mean Fork Length (cm)	51.67	68.59	
Maximum	54.0	75.0	
Minimum	50.0	66.0	
Standard Deviation	1.51	2.75	
Sample Size	6	11	
Statistical Week 23			
Mean Fork Length (cm)	53.18	68.54	78.50
Maximum	62.5	74.5	78.5
Minimum	48.0	63.0	78.5
Standard Deviation	4.15	3.55	----
Sample Size	11	24	1
Statistical Week 24			
Mean Fork Length (cm)	53.14	69.00	84.50
Maximum	58.0	75.0	84.5
Minimum	50.0	62.0	84.5
Standard Deviation	2.78	3.73	----
Sample Size	7	17	1
Statistical Week 25			
Mean Fork Length (cm)	56.00	68.50	
Maximum	60.5	73.5	
Minimum	47.5	62.5	
Standard Deviation	7.37	3.39	
Sample Size	3	13	

Ocean	Salt-Winters		
Age Class	**1**	**2**	**3**
Statistical Week 26			
Mean Fork Length (cm)	57.41	69.84	
Maximum	65.0	80.0	
Minimum	52.0	64.0	
Standard Deviation	3.24	3.62	
Sample Size	23	29	
Statistical Week 27			
Mean Fork Length (cm)	58.48	69.94	
Maximum	67.0	78.0	
Minimum	53.5	64.5	
Standard Deviation	3.73	3.16	
Sample Size	30	27	
Statistical Week 28			
Mean Fork Length (cm)	57.53	68.80	85.00
Maximum	69.5	77.5	85.0
Minimum	52.0	59.0	85.0
Standard Deviation	3.11	4.18	----
Sample Size	73	49	1
Statistical Week 29			
Mean Fork Length (cm)	57.79	69.08	78.00
Maximum	64.5	76.5	80.5
Minimum	52.5	58.0	75.5
Standard Deviation	2.23	3.46	3.54
Sample Size	181	117	2
Statistical Week 30			
Mean Fork Length (cm)	58.31	69.93	
Maximum	66.5	78.5	
Minimum	51.5	59.0	
Standard Deviation	2.65	3.75	
Sample Size	236	95	
Statistical Week 31			
Mean Fork Length (cm)	58.49	69.77	
Maximum	65.0	78.5	
Minimum	51.0	57.5	
Standard Deviation	2.98	5.10	
Sample Size	68	31	
Statistical Week 33			
Mean Fork Length (cm)	59.94	70.06	
Maximum	68.5	81.5	
Minimum	54.0	61.0	
Standard Deviation	2.58	4.31	
Sample Size	153	34	
Statistical Week 34			
Mean Fork Length (cm)	59.39	71.47	
Maximum	66.5	82.0	
Minimum	50.0	57.0	
Standard Deviation	3.00	5.13	
Sample Size	146	45	
Statistical Week 35			
Mean Fork Length (cm)	60.44	71.32	82.00
Maximum	68.5	82.5	82.0
Minimum	54.0	60.5	82.0
Standard Deviation	3.12	6.15	----
Sample Size	94	33	1

Ocean	Salt-Winters		
Age Class	**1**	**2**	**3**
Statistical Week 36			
Mean Fork Length (cm)	60.30	73.29	
Maximum	69.0	82.5	
Minimum	52.5	63.0	
Standard Deviation	3.19	5.56	
Sample Size	44	21	
Statistical Week 37			
Mean Fork Length (cm)	60.21	77.13	84.17
Maximum	69.0	89.0	87.0
Minimum	55.5	61.5	80.5
Standard Deviation	3.16	5.23	3.33
Sample Size	43	43	3
Statistical Week 38			
Mean Fork Length (cm)	61.03	76.67	83.56
Maximum	69.0	85.5	87.0
Minimum	55.0	62.0	80.5
Standard Deviation	3.12	4.94	2.31
Sample Size	75	94	8
Statistical Week 39			
Mean Fork Length (cm)	61.08	78.20	82.18
Maximum	69.5	87.5	90.5
Minimum	54.5	63.0	79.0
Standard Deviation	4.25	4.30	3.46
Sample Size	25	84	11
Statistical Week 40			
Mean Fork Length (cm)	60.48	78.93	84.74
Maximum	68.5	88.5	92.0
Minimum	55.0	68.0	76.0
Standard Deviation	3.08	4.32	3.74
Sample Size	40	104	19
Statistical Week 41			
Mean Fork Length (cm)	61.00	77.47	85.14
Maximum	69.0	86.0	91.0
Minimum	56.5	60.0	76.0
Standard Deviation	2.91	5.78	3.41
Sample Size	20	72	37
Statistical Week 42			
Mean Fork Length (cm)	65.31	78.52	87.20
Maximum	82.0	85.5	91.0
Minimum	58.0	71.5	80.5
Standard Deviation	7.28	3.85	3.17
Sample Size	8	28	10
Statistical Week 43			
Mean Fork Length (cm)	57.88	74.92	86.00
Maximum	62.5	84.5	96.5
Minimum	53.0	66.5	79.5
Standard Deviation	2.44	6.30	9.18
Sample Size	17	6	3
2009 Composite			
Mean Fork Length (cm)	**59.04**	**73.19**	**84.55**
Maximum	**82.00**	**89.00**	**96.50**
Minimum	**47.50**	**57.00**	**75.50**
Standard Deviation	**3.29**	**5.95**	**3.81**
Sample Size	**1309**	**1025**	**98**

Salt-Winters – number of winters in salt water, includes fish with unreadable freshwater age, does not include repeat spawners.