AGE AND LENGTH COMPOSITION OF COLUMBIA BASIN CHINOOK AND SOCKEYE SALMON AND STEELHEAD AT BONNEVILLE DAM IN 2010

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December 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

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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. Based on scale pattern analysis of our sample, four-year-olds were the most abundant age group for spring Chinook salmon comprising 91.6% of the run. Four-year-olds were the most abundant age class for the summer Chinook making up 70.1% of the run, while three-year-olds were the most abundant for fall Chinook, at 53.6%. Four-year-olds were the most abundant age group for sockeye salmon comprising 92.9% of the run, and four-year-olds were the most abundant in the steelhead run comprising 44.2% of the run. The unageable freshwater-, but ageable saltwater-winters (r.X) steelhead were a large proportion of run at 22.7%. Using adipose fin clips, scale patterns, and dorsal fin condition for classification, the steelhead migration consisted of 64.1% hatchery- and 35.9% natural-origin steelhead. A-run steelhead, less than 78cm in length, comprised 80.2% of the steelhead run. B-run fish, equal to or greater than 78cm, comprised 17.8% of the run.

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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, up-river bright fall Chinook salmon since 1998, and summer steelhead (*O. mykiss*) were added to our sampling regime in 2004. Data on these runs are provided in near real time at www.critfc.org.

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 Single Nucleotide Polymorphim (SNP) genetic data for individual salmon and steelhead 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 sampling program at Bonneville Dam.

The primary objectives for the 2010 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 2011 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.

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

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.

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).

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, α=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 proportions 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 (2010). In 2010, genetic material was taken for genetic stock monitoring and identification program for all salmon and steelhead, including tules. Tule sample numbers are not representative of the run and scales are not collected.

In 2009, a new center divider was installed which would allow two pickets to drop while the two remaining pickets were left up (Figure 2). This configuration was supposed to divert only a portion of the fish ascending the main ladder into the AFF ladder for sampling, while the remaining fish moved continued unobstructed within the main ladder. Results from the 2009 field season demonstrated that this trap configuration was heavily biased towards smaller Chinook which confounded our results (Fryer et al. 2011). The divider was removed for the 2010 sampling season and a picket lead drop and lift schedule was implemented instead. Depending on adult salmon migration density the four picket leads needed to be raised or lowered in varying numbers and to allow some fish to bypass the AFF trap, while reducing possible trap related bias. For the exact details see the trapping protocols on the US Army Corps of Engineers website (http://www.nwd-wc.usace.army.mil/tmt/documents/ fpp/2010/changes/APPG_TRAP_Revised_20100519.pdf).

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[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.

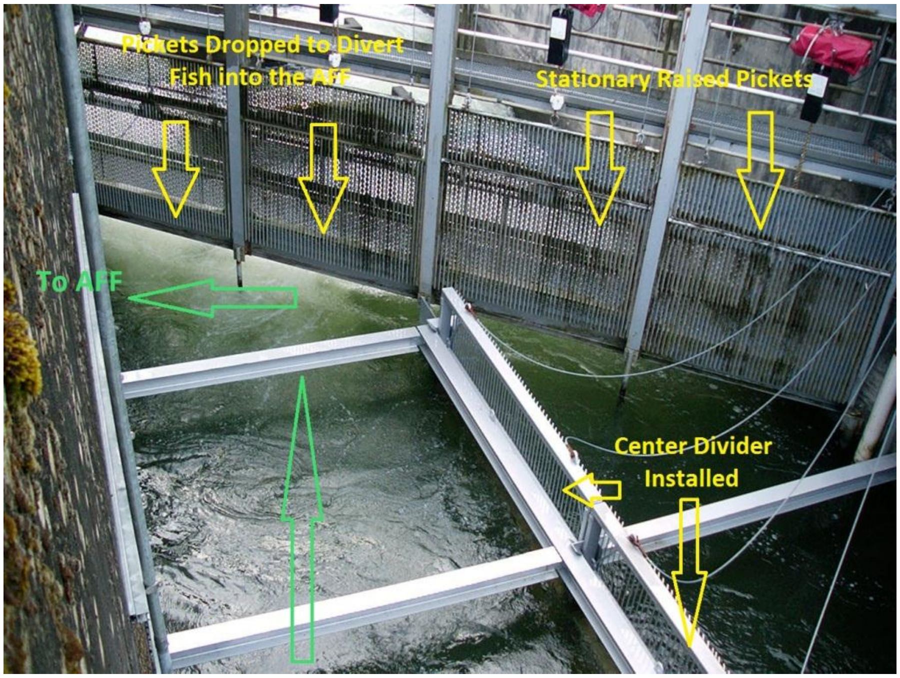

Figure 2. Picket leads with 2009 center divider that diverted fish into the Bonneville Adult Fish Facility.

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 2010, 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 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

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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).

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.

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. A 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. The CRITFC uses this relationship and a regression analysis (Neter et al. 1985, Weisberg 1985) to predict the abundance of four-year-old fish for the next year, based on the number of three-year-old fish estimated to have returned in this sample year. Due to the late publish date of this report this relationship and a regression analysis was not used to predict abundance of Chinook salmon for 2011.

RESULTS

Sampling

Sampling began on April 12 and ended October 21, 2010. A total of 1022 spring Chinook were sampled, 510 summer Chinook and 1144 fall Chinook (67 of which were tules), 918 sockeye salmon, and 1760 steelhead were sampled. Almost all fish sampled were tagged with PIT tags for tracking and genetic samples were taken. The PIT tag study results are also reported on an annual basis and can be found on the CRITFC website http://fishery.critfc.org/FiSci/Tech_rep.aspx.

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 2010, we did sample two Chinook salmon (lengths were 37 and 46 cm), which spent no winters in saltwater (ages were 1.0). 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 and were excluded from further analysis.

Trap Bias

In 2010, the divider in the main ladder that had caused a bias selection for one-ocean jack Chinooks during the 2009 season was removed and a new picket lead protocol was used to move fish through the main ladder and also allowed for trapping at the same time. Preliminary analysis of the data did not indicate that the new protocol was causing any selection bias.

Age Composition

Based on scale pattern analysis four-year-olds were the majority age group for spring Chinook salmon, comprising 91.7% of the spring Chinook migration (Figure 3, Table 1). Four-year-olds were also the most abundant group for summer Chinook salmon comprising 70.1% of the summer Chinook migration (Figure 3, Table 2) and three-year-olds were the most abundant for fall Chinook salmon, 53.6% of the fall run (Figure 3, Table 3). Over 120,000 tules passed Bonneville Dam in 2010. Data from Fish Passage Center starts the tule count on August 15th during the fall Chinook run. Tule numbers were removed from the run numbers in Table 3 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 19 to 100% in Statistical Week 43 (Figure 4). Due to restricted hours in week 33 and a complete shutdown of the AFF in week 34, there is a week gap in sampling data for Chinook salmon and steelhead, and reduced numbers of Chinook salmon in the week before and after the shutdown.

The sockeye salmon run was also composed overwhelmingly of four-year-olds (92.9%), with small percentages of three- and five-year-old fish (Table 4).

Four-year-old steelhead comprised 44.2% of the run, with three- and five-year-olds comprising similar, but smaller portions of the run (26.3% and 26.1% respectively) (Table 5). Fish with unageable freshwater, but ageable saltwater winters (r.X) comprised 22.7% of the run. If these fish are included with ageable fish and the data is analyzed for salt years only, then the major of steelhead are two-salts (60.2%) in 2010.

Aging validation from ageable scale patterns of 34 Chinook salmon that had been previously PIT tagged were correctly aged as follows: all 18 spring Chinook, all 5 summer Chinook, all 11 fall Chinook salmon, and 21 out of 23 steelhead. Only the total age could be compared, for it was not possible to separately validate freshwater and ocean age.

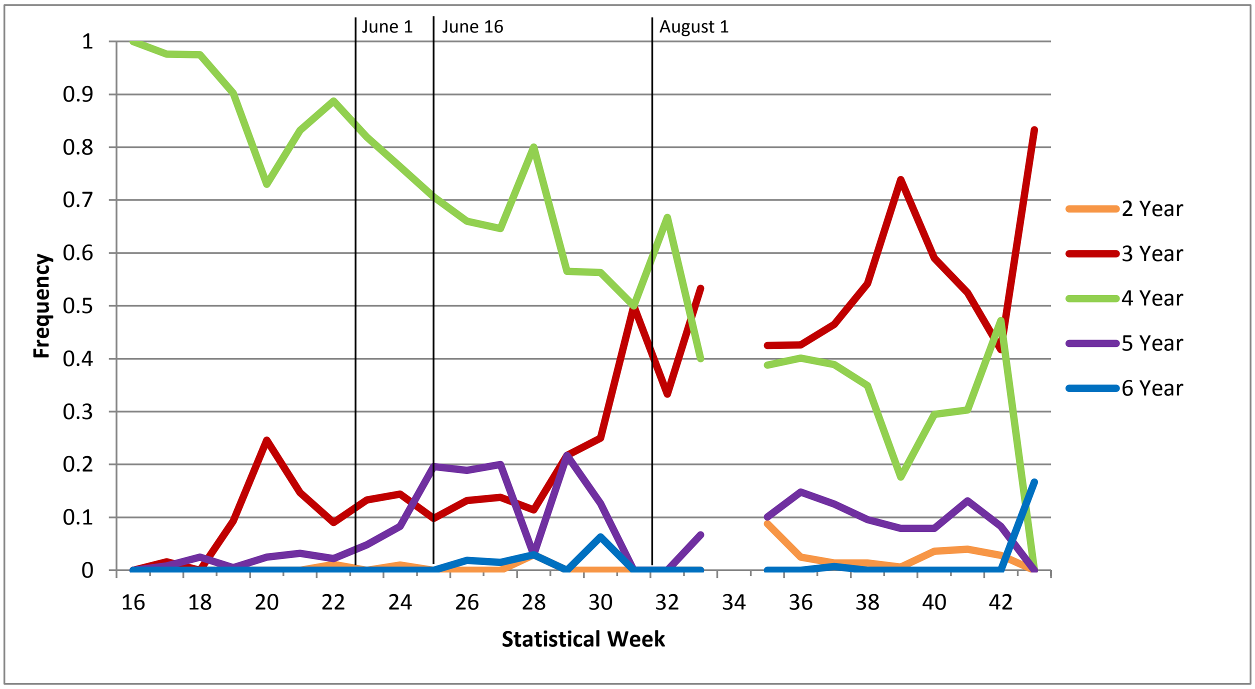

Figure 3. Weekly age composition estimates for age groups of Columbia Basin Chinook salmon sampled at Bonneville Dam in 2010. Due to high water temperatures, sampling hours and days were restricted in week 33 (low numbers of Chinook salmon were trapped), and sampling was shut down completely in week 34.

Table 1. Weekly and cumulative age composition of Columbia Basin spring Chinook salmon at Bonneville Dam in 2010.

Statistical Week	Sampling Date	Numbers Sampled	Number Ageable	Weekly Run Size	2008	2007		2006	2005		Adipose Clips	Other Clips
					0.1	0.2	1.1	1.2	0.4	1.3		
16	4/12 - 4/16	40	38	37616	0.000	0.000	0.000	1.000	0.000	0.000	0.750	0.000
17	4/19, 4/21 - 4/23	151	127	51037	0.000	0.000	0.016	0.976	0.000	0.008	0.801	0.013
18	4/26 - 4/30	235	197	54220	0.000	0.000	0.000	0.975	0.000	0.025	0.732	0.004
19	5/3 - 5/7	235	194	48375	0.000	0.000	0.093	0.902	0.000	0.005	0.770	0.009
20	5/10, 5/12 - 5/14	147	122	36014	0.000	0.008	0.238	0.730	0.000	0.025	0.667	0.007
21	5/17 - 5/21	112	95	11725	0.000	0.000	0.147	0.821	0.011	0.021	0.580	0.000
22	5/24 - 5/27	101	89	18048	0.011	0.000	0.090	0.876	0.011	0.011	0.743	0.010
Cumulative		**1021**	**862**	**257035**	**0.001**	**0.001**	**0.067**	**0.917**	**0.001**	**0.013**	**0.740**	**0.007**

The weekly run size for Statistical Week 16 includes Chinook salmon passing prior to week 16.
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.

Table 2. Weekly and cumulative age composition of Columbia Basin summer Chinook salmon at Bonneville Dam in 2010.

Statistical Week.	Sampling Date	Numbers Sampled	Number Ageable	Weekly Run Size	2008 0.1	2007 0.2	2007 1.1	2006 0.3	2006 1.2	2005 0.4	2005 1.3	2004 1.4	Adipose Clips	Other Clips
23	6/1 - 6/4	111	105	16402	0.000	0.000	0.133	0.029	0.790	0.000	0.048	0.000	0.613	0.000
24	6/7 - 6/11	114	97	13268	0.010	0.000	0.144	0.021	0.742	0.031	0.052	0.000	0.605	0.000
25	6/14 - 6/18	60	51	18979	0.000	0.000	0.098	0.098	0.608	0.039	0.157	0.000	0.633	0.000
26	6/21 - 6/25	55	53	23306	0.000	0.038	0.094	0.113	0.547	0.057	0.132	0.019	0.527	0.000
27	6/28 - 7/2	70	65	16843	0.000	0.046	0.092	0.154	0.492	0.062	0.138	0.015	0.629	0.000
28	7/7 - 7/9	43	35	11033	0.029	0.000	0.114	0.086	0.714	0.000	0.029	0.029	0.698	0.000
29	7/12 - 7/16	25	23	6092	0.000	0.043	0.174	0.000	0.565	0.174	0.043	0.000	0.600	0.000
30	7/19 - 7/23	16	16	3780	0.000	0.125	0.125	0.125	0.438	0.063	0.063	0.063	0.688	0.000
31	7/26 - 7/29	16	14	3504	0.000	0.357	0.143	0.000	0.500	0.000	0.000	0.000	0.563	0.000
Cumulative		**510**	**459**	**113207**	**0.004**	**0.032**	**0.115**	**0.082**	**0.619**	**0.042**	**0.094**	**0.011**	**0.449**	**0.000**

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.

Table 3. Weekly and cumulative age composition of Columbia Basin fall Chinook salmon at Bonneville Dam in 2010.

Statistical Week	Sampling Date	Numbers Sampled	Number Ageable	URB Run Size	2008	2007		2006		2005		2004		Adipose Clips	Other Clips
					0.1	0.2	1.1	0.3	1.2	0.4	1.3	0.5	1.4		
32	8/4 - 8/6	7	6	3117	0.000	0.333	0.000	0.167	0.500	0.000	0.000	0.000	0.000	0.286	0.000
33-34	8/10 - 8/13	18	15	7248	0.000	0.333	0.200	0.133	0.267	0.000	0.067	0.000	0.000	0.278	0.000
34-35	8/24 - 8/26	88	80	42579	0.088	0.325	0.100	0.175	0.213	0.088	0.013	0.000	0.000	0.295	0.000
36	8/30 - 9/3	181	162	67821	0.025	0.370	0.056	0.290	0.111	0.148	0.000	0.000	0.000	0.271	0.000
37	9/7 - 9/10	159	144	85679	0.014	0.444	0.021	0.181	0.208	0.118	0.007	0.000	0.007	0.390	0.000
38	9/13, 9/14, 9/16, 9/17	153	146	65325	0.014	0.521	0.021	0.274	0.075	0.082	0.014	0.000	0.000	0.320	0.000
39	9/20 - 9/24	174	165	77228	0.006	0.691	0.048	0.109	0.067	0.079	0.000	0.000	0.000	0.299	0.000
40	9/27 - 10/1	150	139	35715	0.036	0.554	0.036	0.180	0.115	0.079	0.000	0.000	0.000	0.233	0.000
41	10/5 - 10/8	103	99	15501	0.040	0.495	0.030	0.263	0.040	0.121	0.010	0.000	0.000	0.184	0.000
42	10/11 - 10/13	37	36	6078	0.028	0.278	0.139	0.222	0.250	0.083	0.000	0.000	0.000	0.216	0.000
43	10/20, 10/21	6	6	5617	0.000	0.833	0.000	0.000	0.000	0.000	0.000	0.167	0.000	0.167	0.000
Cumulative		**1076**	**998**	**411908**	**0.024**	**0.490**	**0.046**	**0.200**	**0.132**	**0.098**	**0.006**	**0.002**	**0.001**	**0.221**	**0.000**

August 1 is the start of the fall run at Bonneville Dam.
Due to high water temperatures, sampling did not occur in week 34, fish passing Bonneville Dam during the missed week are included in the run size for the weeks before and after.
The weekly run size for week 43 includes all Chinook salmon passing Bonneville Dam after the last date of sampling in week 43.
Tule numbers removed from the Bright run size.

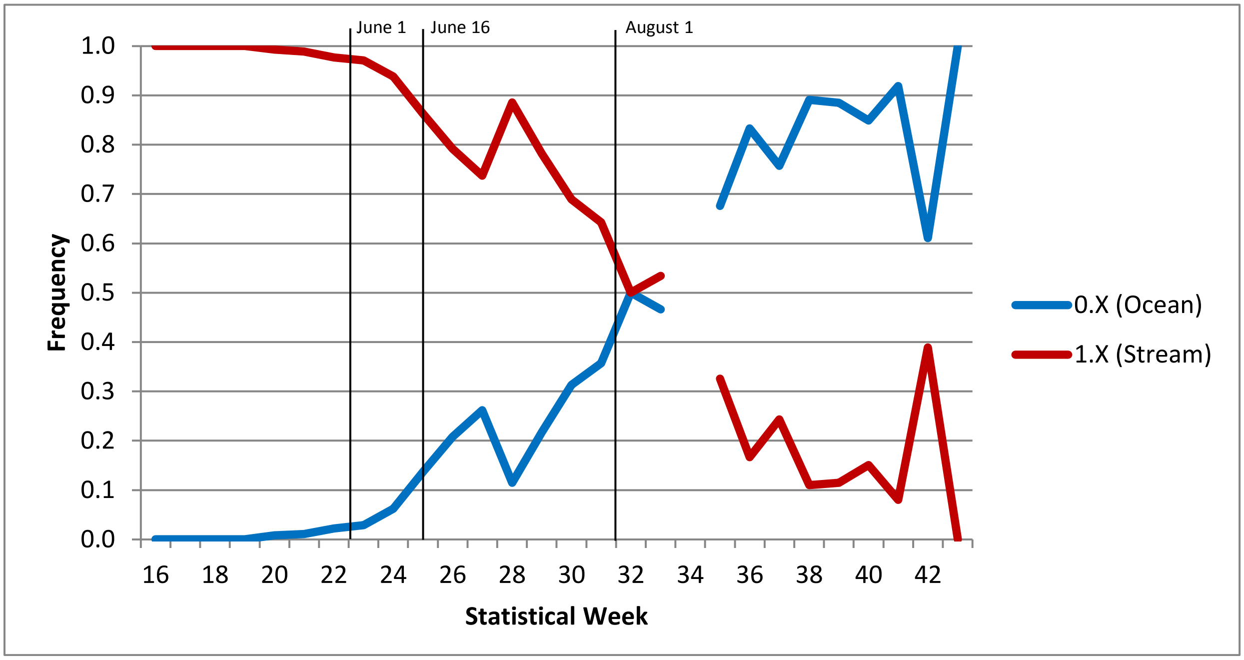

Figure 4. Weekly freshwater age composition estimates of Columbia Basin Chinook salmon sampled at Bonneville Dam in 2010. Due to high water temperatures, sampling hours and days were restricted in week 33 (low numbers of Chinook salmon were trapped), and sampling was shut down completely in week 34.

Table 4. Weekly and cumulative age composition of Columbia Basin sockeye salmon at Bonneville Dam in 2010.

Statistical Week	Sampling Date	Numbers Sampled	Number Ageable	Weekly Run Size	2007	2006		2005		Adipose Clips	Other Clips
					1.1	1.2	2.1	1.3	2.2		
22-23	5/24 - 5/27, 6/1 - 6/4	34	32	1129	0.063	0.906	0.000	0.000	0.031	0.000	0.000
24	6/7 - 6/11	62	62	4776	0.032	0.952	0.000	0.016	0.000	0.000	0.000
25	6/14 - 6/18	224	219	51141	0.000	0.895	0.009	0.041	0.055	0.049	0.000
26	6/21 - 6/25	262	257	182178	0.012	0.914	0.000	0.039	0.035	0.038	0.000
27	6/28 - 7/2	206	193	90356	0.010	0.959	0.005	0.005	0.021	0.044	0.000
28	7/7, 7/8, 7/9	84	82	44082	0.049	0.951	0.000	0.000	0.000	0.024	0.012
29	7/1 - 7/16	46	45	12863	0.067	0.867	0.044	0.022	0.000	0.000	0.000
Cumulative		**918**	**890**	**386525**	**0.016**	**0.925**	**0.004**	**0.026**	**0.029**	**0.037**	**0.001**

A small sample size in Statistical Week 22 (n=2) led to Statistical weeks 22 and 23 being pooled.
The weekly run size for week 22-23 includes sockeye salmon passing prior to these weeks. Similarly the weekly run size for week 29 includes fish passing after this week.

Table 5. Weekly and cumulative age composition of Columbia Basin steelhead at Bonneville Dam in 2010.

Statistical Week	Sampling Date	Numbers Sampled	Number Ageable	Weekly Run Size	2007	2006		2005			2004			2003		Repeat Spawner	Ageable Salt-Winters			A-Run	Fin Clips		Wild
					1.1	1.2	2.1	1.3	2.2	3.1	2.3	3.2	4.1	3.3	4.2		1	2	3		Adipose	Other	
16	4/12 - 4/16	5	5	5529	0.200	0.600	0.000	0.000	0.000	0.000	0.000	0.200	0.000	0.000	0.000	0.000	0.200	0.800	0.000	0.800	0.800	0.200	0.200
17	4/19, 4/21 - 4/23	4	2	585	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.667	0.333	0.000	1.000	1.000	0.250	0.000
18	4/26 - 4/30	5	2	548	0.000	0.500	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.500	0.500	0.000	1.000	0.800	0.000	0.200
19	5/3 - 5/7	13	11	769	0.091	0.818	0.091	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.167	0.833	0.000	1.000	0.769	0.000	0.077
20	5/10, 5/12 - 5/14	15	7	990	0.000	0.857	0.143	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.133	0.800	0.067	0.867	0.733	0.000	0.200
21	5/17 - 5/21	13	8	640	0.000	0.875	0.000	0.000	0.125	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.846	0.615	0.000	0.462
22	5/24 - 5/27	22	9	687	0.444	0.333	0.000	0.000	0.111	0.000	0.000	0.111	0.000	0.000	0.000	0.000	0.227	0.773	0.000	0.955	0.909	0.000	0.091
23	6/1 - 6/4	26	16	1117	0.188	0.625	0.000	0.000	0.125	0.000	0.000	0.062	0.000	0.000	0.000	0.000	0.154	0.846	0.000	0.923	0.731	0.038	0.269
24	6/7 - 6/11	55	41	1619	0.220	0.585	0.000	0.000	0.171	0.000	0.000	0.024	0.000	0.000	0.000	0.000	0.164	0.836	0.000	0.964	0.600	0.000	0.345
25	6/14 - 6/18	31	23	4089	0.087	0.696	0.000	0.000	0.087	0.043	0.000	0.087	0.000	0.000	0.000	0.000	0.097	0.903	0.000	1.000	0.645	0.032	0.290
26	6/21 - 6/25	36	24	8778	0.208	0.208	0.042	0.000	0.417	0.000	0.000	0.125	0.000	0.000	0.000	0.000	0.206	0.794	0.000	0.944	0.361	0.000	0.639
27	6/28 - 7/2	62	49	15842	0.224	0.245	0.082	0.000	0.327	0.061	0.000	0.041	0.000	0.000	0.020	0.000	0.393	0.607	0.000	0.984	0.403	0.016	0.500
28	7/7 - 7/9	89	65	28182	0.185	0.277	0.138	0.000	0.338	0.031	0.000	0.015	0.000	0.000	0.000	0.015	0.326	0.674	0.000	0.989	0.348	0.056	0.596
29	7/12 - 7/16	180	139	43227	0.216	0.259	0.187	0.000	0.273	0.022	0.000	0.036	0.000	0.000	0.000	0.007	0.429	0.571	0.000	0.972	0.411	0.033	0.539
30	7/19 - 7/23	286	228	38295	0.382	0.298	0.114	0.000	0.145	0.013	0.000	0.039	0.000	0.000	0.000	0.009	0.505	0.495	0.000	0.990	0.570	0.038	0.360
31	7/26 - 7/29	180	148	39776	0.358	0.291	0.095	0.000	0.189	0.027	0.000	0.034	0.000	0.007	0.000	0.000	0.472	0.522	0.006	0.972	0.572	0.056	0.350
32	8/4 - 8/6	130	96	44117	0.396	0.198	0.167	0.010	0.208	0.010	0.000	0.000	0.000	0.000	0.000	0.021	0.551	0.441	0.008	0.969	0.577	0.031	0.369
33-34	8/10 - 8/13	135	96	50314	0.458	0.219	0.052	0.000	0.240	0.010	0.010	0.010	0.000	0.000	0.000	0.000	0.515	0.478	0.007	0.941	0.652	0.030	0.296
34-35	8/24 - 8/26	77	64	35629	0.250	0.375	0.031	0.047	0.281	0.000	0.000	0.016	0.000	0.000	0.000	0.000	0.276	0.684	0.039	0.688	0.610	0.052	0.338
36	8/30 - 9/3	63	45	21563	0.133	0.578	0.044	0.067	0.133	0.000	0.022	0.022	0.000	0.000	0.000	0.000	0.177	0.726	0.097	0.476	0.683	0.000	0.254
37	9/7 - 9/10	63	47	25716	0.085	0.617	0.021	0.106	0.149	0.000	0.021	0.000	0.000	0.000	0.000	0.000	0.111	0.794	0.095	0.365	0.730	0.016	0.238
38	9/13 - 9/17	35	30	19278	0.100	0.567	0.000	0.200	0.133	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.086	0.743	0.171	0.257	0.771	0.029	0.143
39	9/20 - 9/24	116	90	11249	0.067	0.578	0.000	0.211	0.089	0.000	0.022	0.000	0.011	0.022	0.000	0.000	0.069	0.690	0.241	0.241	0.716	0.026	0.198
40	9/27 - 10/1	60	47	8393	0.021	0.596	0.021	0.277	0.043	0.000	0.043	0.000	0.000	0.000	0.000	0.000	0.035	0.649	0.316	0.283	0.767	0.067	0.117
41	10/5 - 10/8	35	27	3656	0.037	0.519	0.000	0.259	0.148	0.000	0.000	0.037	0.000	0.000	0.000	0.000	0.029	0.714	0.257	0.171	0.686	0.114	0.171
42	10/11 - 10/13	19	16	2152	0.062	0.562	0.000	0.188	0.125	0.000	0.000	0.062	0.000	0.000	0.000	0.000	0.105	0.737	0.158	0.421	0.579	0.053	0.263
43	10/20, 10/21	5	5	3863	0.000	0.400	0.600	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.600	0.400	0.000	0.800	0.400	0.000	0.600
Cumulative		**1760**	**1340**	**416603**	**0.263**	**0.352**	**0.090**	**0.039**	**0.209**	**0.013**	**0.005**	**0.024**	**0.000**	**0.001**	**0.001**	**0.005**	**0.358**	**0.602**	**0.041**	**0.802**	**0.581**	**0.037**	**0.359**

The weekly run size for week 16 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 34, fish passing Bonneville Dam during the missed week are included in the run size for the weeks before and after.
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 26) 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 5 and Appendix. Length-at-age tables for sockeye salmon and steelhead are also located in the Appendix.

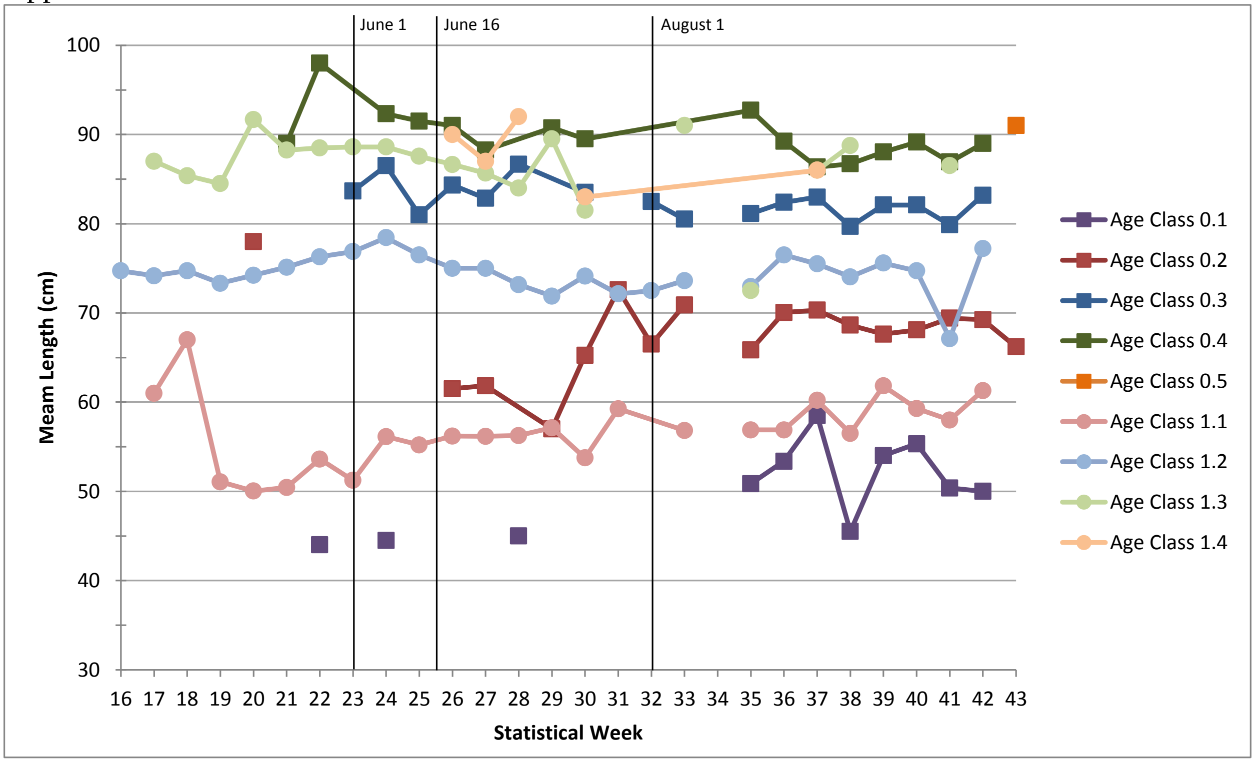

Figure 5. Weekly mean length estimates of Columbia Basin Chinook salmon age classes sampled at Bonneville Dam in 2010. Due to high water temperatures, sampling hours and days were restricted in week 33 (low numbers of Chinook salmon were trapped), and sampling was shut down completely in week 34.

Fish Coloration and Condition

Bright coloration was observed in the majority of each species, 83.5% of spring Chinook, 65.7% of summer Chinook, 66.2% of fall Chinook, 100% of sockeye and 90.6% of steelhead. The highest condition rating of 5 was given to 90.1% of spring Chinook, 89.0% of summer Chinook, 93.1% of fall Chinook, 90.3% of sockeye and 77.7% of steelhead. Additional fish condition data can be found in the Appendix.

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 (Hagerman Hatchery Evaluation Team 2009). 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 5 are based on interpretation of scale patterns. Based on adipose fin clips alone, we would have estimated that 41.9% of the run was of wild origin; including scale patterns reduced this to 35.9%.

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 (82.0%) passing Bonneville Dam were A-run, and the remaining 18.0% were B-run. Although A-run steelhead dominate the run, the percentage of the B-run generally increases as the run progresses (Table 5 and Figure 6).

Steelhead Kelts

In 2010, we found six steelhead with spawning check marks in their scale patterns. The freshwater- and salt-winter annuli numbers varied greatly and one fish had unageable freshwater annuli. The age composition was; three - 2.1S1 and one each of 2.1S, 3.2S, and r.1S1. Five of the six steelhead were PIT tagged and tracked. None of the fish were adiposed clipped and the five with ageable freshwater zones appeared to have freshwater scale patterns of wild fish. Eighty-five other steelhead PIT tagged during the 2010 season displayed migration behaviors that identified them as kelts (Jeff Fryer, CRITFC, personal communication) during the months after spawning.

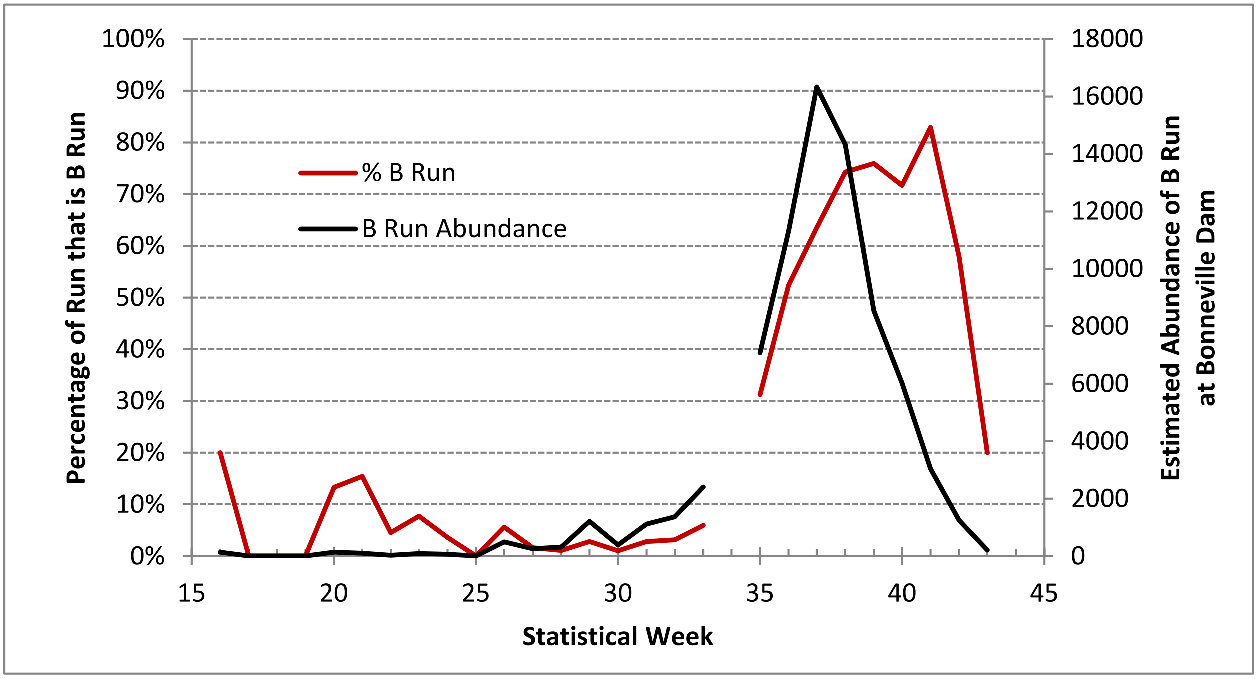

Figure 6. Percentage of B Run steelhead and the estimated B Run size passing Bonneville Dam by Statistical Week in 2010. Due to high water temperatures sampling was shut down completely in week 34.

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 2010 sampling season, sampling was restricted during week 33 and was stopped during week 34 due to high temperatures (Figure 7). The steelhead responded to the spike in temperature to 73°F (22.8°C) at the end of Statistical Week 33 by reducing their migration past Bonneville Dam only to resume as temperatures dropped below 71°F (21.7°C). For 2010, high temperatures occurred in the middle of August and numbers of fall Chinook quickly rose after the peak of high temperatures was over.

In 2010, 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 eighth year for Chinook salmon, the fouth year for sockeye salmon, and the seventh 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 genetic database to assemble baseline genetic stock identification information for all Columbia River salmon and steelhead populations. The development of baseline genetic stock information is still incomplete, but it is expect that 196 genetic markers for both steelhead and Chinook salmon and 96 genetic markers for sockeye salmon will be complete in 2012. 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.

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.

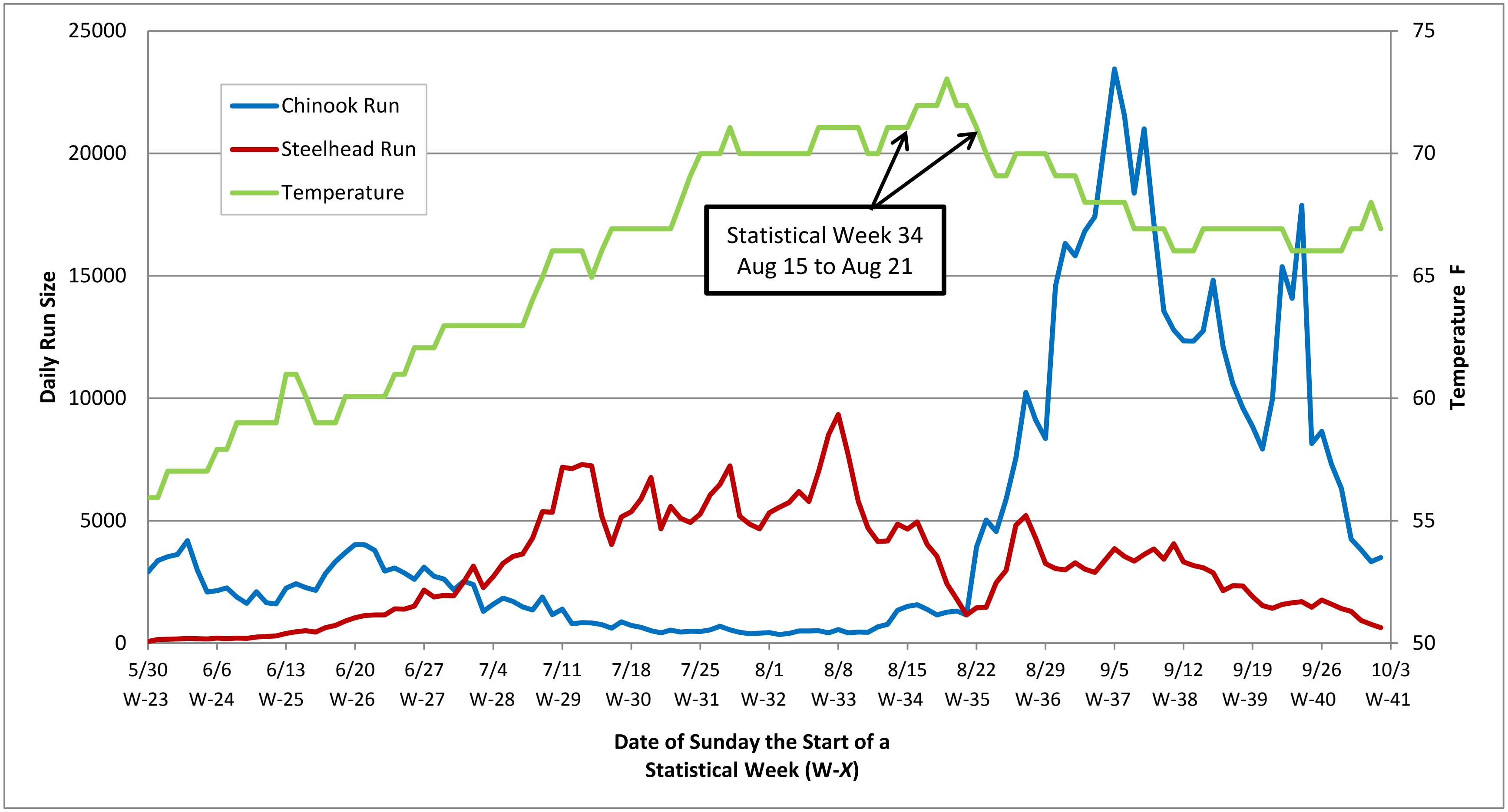

Figure 7. Chinook and steelhead daily run size and daily river temperature at Bonneville Dam for May 30 through October 3, 2010 (statistical weeks 23 through 41).

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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 2010.

Injury category	Spring	Summer	Fall	Sockeye	Steelhead
Marine Mammal					
Bite	2.4	3.5	4.1	2.1	6.4
Scrape	16.0	12.9	11.5	13.1	23.4
Total	**18.3**	**16.5**	**15.6**	**15.1**	**29.8**
Descaling					
<3%					
Left side	0.5	---	0.2	---	---
Right Side	1.1	0.2	0.2	---	0.1
Total	**0.8**	**---**	**0.1**	**---**	**0.1**
3-19%					
Left side	4.6	3.5	13.8	26.7	6.4
Right Side	4.9	3.1	15.5	22.5	5.2
Total	**7.3**	**5.3**	**16.3**	**31.0**	**7.9**
≥20%					
Left side	0.4	0.8	4.4	2.1	2.7
Right Side	0.3	0.8	4.8	2.7	2.3
Total	**0.6**	**1.4**	**6.6**	**3.8**	**3.1**
Other Injuries					
Bruise	0.3	1.0	0.1	0.2	0.2
Head Injury	5.3	5.9	11.5	2.3	10.1
Fin	18.9	14.5	11.3	4.7	15.6
Fungus	3.6	1.8	---	0.5	0.7
Gash	0.2	0.6	0.4	0.8	2.4
Gill Net	0.4	0.8	0.8	0.5	1.5
Lamprey	5.5	4.9	37.4	1.2	12.4
Parasite	4.2	10.6	12.7	26.8	21.2
Total	**31.5**	**33.5**	**57.3**	**34.4**	**50.1**

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 side, would be recorded as ≥20% descaled.

Table A2. Length-at-age estimates for Columbia Basin spring Chinook salmon sampled at Bonneville Dam in 2010.

Brood Year and	2008	2007		2006	2005	
Age Class	0.1	0.2	1.1	1.2	0.4	1.3
Statistical Week 16						
Mean Fork Length (cm)				74.72		
Maximum				85.5		
Minimum				66.0		
Standard Deviation				4.36		
Sample Size				38		
Statistical Week 17						
Mean Fork Length (cm)			61.00	74.17		87.00
Maximum			61.0	86.0		87.0
Minimum			61.0	65.0		87.0
Standard Deviation			---	3.94		---
Sample Size			1	124		1
Statistical Week 18						
Mean Fork Length (cm)				74.74		85.38
Maximum				87.0		89.0
Minimum				65.0		81.0
Standard Deviation				3.92		3.35
Sample Size				191		4
Statistical Week 19						
Mean Fork Length (cm)			51.06	73.32		84.50
Maximum			65.5	86.0		84.5
Minimum			42.5	57.5		84.5
Standard Deviation			6.34	4.71		---
Sample Size			17	174		1
Statistical Week 20						
Mean Fork Length (cm)		78.00	50.04	74.23		91.67
Maximum		78.0	56.0	87.5		98.0
Minimum		78.0	44.5	56.0		86.0
Standard Deviation		---	2.09	4.83		6.03
Sample Size		1	28	87		3
Statistical Week 21						
Mean Fork Length (cm)			50.43	75.13	89.00	88.25
Maximum			58.0	86.0	89.0	88.5
Minimum			42.0	63.5	89.0	88.0
Standard Deviation			4.40	4.32	---	0.35
Sample Size			14	78	1	2
Statistical Week 22						
Mean Fork Length (cm)	44.00		53.62	76.29	98.00	88.50
Maximum	44.0		61.0	89.5	98.0	88.5
Minimum	44.0		48.0	665.0	98.0	88.5
Standard Deviation	---		3.96	4.54	---	---
Sample Size	1		8	77	1	1
2010 Composite						
Mean Fork Length (cm)	**44.00**	**78.00**	**50.96**	**74.46**	**93.50**	**87.75**
Maximum	**44.0**	**78.0**	**65.5**	**89.5**	**98.0**	**98.0**
Minimum	**44.0**	**78.0**	**42.0**	**56.0**	**89.0**	**81.0**
Standard Deviation	**---**	**---**	**4.42**	**4.41**	**6.36**	**4.13**
Sample Size	**1**	**1**	**68**	**769**	**2**	**12**

Table A2. Length-at-age estimates for Columbia Basin summer Chinook salmon sampled at Bonneville Dam in 2010.

Brood Year and	2008	2007		2006		2005		2004
Age Class	0.1	0.2	1.1	0.3	1.2	0.4	1.3	1.4
Statistical Week 23								
Mean Fork Length (cm)			51.23	83.67	76.88		88.60	
Maximum			57	87.0	85.0		92.5	
Minimum			48	81.0	62.0		84.0	
Standard Deviation			2.35	3.06	4.57		3.19	
Sample Size			13	3	83		5	
Statistical Week 24								
Mean Fork Length (cm)	44.50		56.14	86.50	78.44	92.33	88.60	
Maximum	44.5		65.0	89.0	87.0	98.0	93.0	
Minimum	44.5		50.0	84.0	64.0	83.0	81.0	
Standard Deviation	---		4.32	3.54	4.81	8.14	4.52	
Sample Size	1		14	2	72	3	5	
Statistical Week 25								
Mean Fork Length (cm)			55.20	81.00	76.50	91.50	87.56	
Maximum			60.0	90.0	87.0	95.0	94.0	
Minimum			45.0	73.5	60.0	88.0	82.0	
Standard Deviation			5.99	7.57	6.02	4.95	4.20	
Sample Size			5	5	31	2	8	
Statistical Week 26								
Mean Fork Length (cm)		61.50	56.20	84.33	75.00	91.00	86.67	90.00
Maximum		65.0	58.5	90.0	88.0	96.0	96.0	90.0
Minimum		58.0	53.0	80.0	65.0	85.0	75.0	90.0
Standard Deviation		4.95	2.02	3.95	5.64	5.57	6.73	----
Sample Size		2	5	6	29	3	7	1
Statistical Week 27								
Mean Fork Length (cm)		61.83	56.17	82.85	75.00	88.25	85.67	87.00
Maximum		67.0	59.0	91.5	88.0	93.0	92.0	87.0
Minimum		59.0	54.0	80.0	54.0	82.0	77.0	87.0
Standard Deviation		4.48	1.97	3.65	7.29	5.01	5.38	---
Sample Size		3	6	10	32	4	9	1
Statistical Week 28								
Mean Fork Length (cm)	45.00		56.25	89.67	73.18		84.00	92.00
Maximum	45.0		62.5	93.0	85.5		84.0	92.0
Minimum	45.0		51.0	78.0	64.0		84.0	92.0
Standard Deviation	---		4.84	7.77	6.76		---	---
Sample Size	1		4	3	25		1	1
Statistical Week 29								
Mean Fork Length (cm)		57.00	57.12		71.88	90.75	89.50	
Maximum		57.0	60.0		82.0	95.0	89.5	
Minimum		57.0	53.0		63.0	83.0	89.5	
Standard Deviation		---	3.01		6.46	5.68	---	
Sample Size		1	4		13	4	1	
Statistical Week 30								
Mean Fork Length (cm)		65.25	53.75	83.50	74.14	89.50	81.50	83.00
Maximum		67.5	57.0	86.0	81.5	89.5	81.5	83.0
Minimum		63.0	50.5	81.0	64.5	89.5	81.5	83.0
Standard Deviation		3.18	4.60	3.54	5.10	---	---	---
Sample Size		2	2	2	7	1	1	1
Statistical Week 31								
Mean Fork Length (cm)		72.60	59.25		72.14			
Maximum		75.5	63.0		79.5			
Minimum		69.0	55.5		63.0			
Standard Deviation		3.11	5.30		5.56			
Sample Size		5	2		7			
2010 Composite								
Mean Fork Length (cm)	**44.75**	**66.08**	**55.01**	**83.56**	**76.13**	**90.50**	**87.00**	**88.00**
Maximum	**45.0**	**75.5**	**65.0**	**93.0**	**88.0**	**98.0**	**96.0**	**92.0**
Minimum	**44.5**	**57.0**	**45.0**	**73.5**	**54.0**	**82.0**	**75.0**	**83.0**
Standard Deviation	**0.35**	**6.49**	**4.12**	**4.76**	**5.80**	**5.16**	**4.83**	**3.92**
Sample Size	**2**	**13**	**55**	**31**	**299**	**17**	**37**	**4**

Table A3. Length-at-age estimates for Columbia Basin fall Chinook salmon sampled at Bonneville Dam in 2010.

Brood Year and	2008	2007		2006		2005		2004	
Age Class	0.1	0.2	1.1	0.3	1.2	0.4	1.3	0.5	1.4
Statistical Week 32									
Mean Fork Length (cm)		66.50		82.50	72.50				
Maximum		67.0		82.5	81.0				
Minimum		66.0		82.5	62.5				
Standard Deviation		0.71		---	9.34				
Sample Size		2		1	3				
Statistical Week 33-34									
Mean Fork Length (cm)		70.90	56.83	80.50	73.62		91.00		
Maximum		77.0	61.0	83.0	79.0		91.0		
Minimum		61.5	54.5	78.0	66.5		91.0		
Standard Deviation		6.54	3.62	3.54	5.45		---		
Sample Size		5	3	2	4		1		
Statistical Week 34-35									
Mean Fork Length (cm)	50.86	65.85	56.88	81.14	72.97	92.71	72.50		
Maximum	54.5	73.5	64.0	93.0	85.0	97.0	72.5		
Minimum	47.0	55.0	47.0	52.5	57.0	89.0	72.5		
Standard Deviation	2.91	4.12	6.79	10.24	7.57	2.55	---		
Sample Size	7	26	8	14	17	7	1		
Statistical Week 36									
Mean Fork Length (cm)	53.38	70.05	56.89	82.40	76.50	89.23			
Maximum	56.5	81.0	62.5	90.0	85.5	97.5			
Minimum	50.5	62.0	49.0	71.5	66.5	77.5			
Standard Deviation	2.84	4.38	4.79	4.48	5.24	5.31			
Sample Size	4	60	9	47	18	24			
Statistical Week 37									
Mean Fork Length (cm)	58.50	69.83	60.20	83.10	75.50	86.62	86.00		86.00
Maximum	60.5	91.5	67.5	96.5	86.0	96.0	86.0		86.0
Minimum	56.5	56.5	52.5	69.0	62.5	81.0	86.0		86.0
Standard Deviation	2.83	6.66	6.08	6.76	6.73	4.25	---		---
Sample Size	2	63	5	26	30	17	1		1
Statistical Week 38									
Mean Fork Length (cm)	45.50	68.63	56.50	79.69	74.05	86.71	88.75		
Maximum	45.0	78.0	64.0	91.5	81.0	94.5	91.5		
Minimum	46.0	54.0	50.5	62.5	67.0	75.0	86.0		
Standard Deviation	0.71	5.29	6.87	4.86	4.08	4.82	3.89		
Sample Size	2	76	3	40	11	12	2		
Statistical Week 39									
Mean Fork Length (cm)	54.00	67.58	59.44	81.69	75.59	88.04			
Maximum	54.0	85.0	67.5	91.0	84.0	95.0			
Minimum	54.0	51.0	53.0	68.0	68.0	83.0			
Standard Deviation	---	4.84	5.07	6.70	5.54	3.93			
Sample Size	1	114	8	18	11	13			
Statistical Week 40									
Mean Fork Length (cm)	53.70	67.69	57.00	82.10	74.72	89.14			
Maximum	59.0	80.0	60.0	92.0	86.0	97.0			
Minimum	49.0	57.0	55.0	74.0	62.5	83.0			
Standard Deviation	3.67	4.17	1.97	3.95	6.72	4.66			
Sample Size	5	77	5	25	16	11			
Statistical Week 41									
Mean Fork Length (cm)	50.38	69.41	58.00	79.88	67.12	86.92	86.50		
Maximum	55.0	80.0	63.0	93.0	72.0	96.5	86.5		
Minimum	44.5	60.0	52.5	59.0	65.0	81.0	86.5		
Standard Deviation	4.37	4.18	5.27	6.97	3.33	5.76	---		
Sample Size	4	48	3	26	4	12	1		
Statistical Week 42									
Mean Fork Length (cm)	50.00	69.25	61.30	83.19	77.22	89.00			
Maximum	50.0	77.0	66.5	90.0	82.0	92.0			
Minimum	50.0	61.0	56.0	77.0	68.0	85.0			
Standard Deviation	---	5.26	4.24	3.92	5.26	3.61			
Sample Size	1	10	5	8	9	3			
Statistical Week 43									
Mean Fork Length (cm)		66.20						91.00	
Maximum		73.0						91.0	
Minimum		59.5						91.0	
Standard Deviation		4.89						---	
Sample Size		5						1	
2010 Composite									
Mean Fork Length (cm)	**51.98**	**68.54**	**57.84**	**81.48**	**74.79**	**88.27**	**85.58**	**91.00**	**86.00**
Maximum	**60.5**	**91.5**	**67.5**	**96.5**	**86.0**	**97.5**	**91.5**	**91.0**	**86.0**
Minimum	**44.5**	**51.0**	**47.0**	**52.5**	**57.0**	**75.0**	**72.5**	**91.0**	**86.0**
Standard Deviation	**4.07**	**5.05**	**4.92**	**5.90**	**6.28**	**4.84**	**6.88**	**---**	**---**
Sample Size	**26**	**486**	**47**	**207**	**123**	**99**	**6**	**1**	**1**

Table A4. Length-at-age estimates for Columbia Basin sockeye salmon sampled at Bonneville Dam in 2010.

Brood Year and	2007	2006		2005	
Age Class	1.1	1.2	2.1	1.3	2.2
Statistical Week 22-23					
Mean Fork Length (cm)	40.50	48.84			54.00
Maximum	41.0	54.0			54.0
Minimum	40.0	43.0			54.0
Standard Deviation	0.71	2.48			---
Sample Size	2	28			1
Statistical Week 24					
Mean Fork Length (cm)	40.50	49.59		60.00	
Maximum	41.0	54.0		60.0	
Minimum	40.0	44.0		60.0	
Standard Deviation	0.71	2.41		---	
Sample Size	2	59		1	
Statistical Week 25					
Mean Fork Length (cm)		49.95	43.00	57.00	51.71
Maximum		55.0	43.5	59.0	57.5
Minimum		44.0	42.5	55.0	47.5
Standard Deviation		2.31	0.71	1.64	3.09
Sample Size		196	2	9	12
Statistical Week 26					
Mean Fork Length (cm)	39.67	50.69		57.20	51.78
Maximum	42.5	57.0		62.0	55.5
Minimum	38.0	42.0		52.0	49.5
Standard Deviation	2.47	2.11		2.90	1.89
Sample Size	3	234		10	9
Statistical Week 27					
Mean Fork Length (cm)	43.00	50.95	39.00	55.00	53.88
Maximum	45.5	58.0	39.0	55.0	55.5
Minimum	40.5	46.0	39.0	55.0	53.0
Standard Deviation	3.54	2.13	---	---	1.18
Sample Size	2	185	1	1	4
Statistical Week 28					
Mean Fork Length (cm)	40.75	50.93			
Maximum	42.5	59.5			
Minimum	39.5	45.0			
Standard Deviation	1.32	2.75			
Sample Size	4	78			
Statistical Week 29					
Mean Fork Length (cm)	40.83	50.05	42.25	60.00	
Maximum	43.5	55.0	43.0	60.0	
Minimum	39.0	46.0	41.5	60.0	
Standard Deviation	2.36	2.34	1.06	---	
Sample Size	3	38	2	1	
2010 Composite					
Mean Fork Length (cm)	**40.78**	**50.42**	**41.90**	**57.27**	**52.15**
Maximum	**45.5**	**59.5**	**43.5**	**62.0**	**57.5**
Minimum	**38.0**	**42.0**	**39.0**	**52.0**	**47.5**
Standard Deviation	**1.93**	**2.33**	**1.78**	**2.37**	**2.50**
Sample Size	**16**	**818**	**5**	**22**	**26**

Table A5. Length-at-age estimates for Columbia Basin steelhead sampled at Bonneville Dam in 2010.

Ocean Age Class	Salt-Winters 1	2	3
Statistical Week 16			
Mean Fork Length (cm)	57.00	73.50	
Maximum	57.0	79.5	
Minimum	57.0	68.0	
Standard Deviation	---	4.71	
Sample Size	1	4	
Statistical Week 17			
Mean Fork Length (cm)	59.25	70.00	
Maximum	62.0	70.0	
Minimum	56.5	70.0	
Standard Deviation	3.89	---	
Sample Size	2	1	
Statistical Week 18			
Mean Fork Length (cm)	57.00	70.00	
Maximum	57.0	70.0	
Minimum	57.0	70.0	
Standard Deviation	---	---	
Sample Size	1	1	
Statistical Week 19			
Mean Fork Length (cm)	63.00	70.70	
Maximum	63.5	73.0	
Minimum	62.5	69.0	
Standard Deviation	0.71	1.32	
Sample Size	2	10	
Statistical Week 20			
Mean Fork Length (cm)	62.50	70.29	82.50
Maximum	63.0	83.5	82.5
Minimum	62.0	66.0	82.5
Standard Deviation	0.71	4.63	---
Sample Size	2	12	1
Statistical Week 21			
Mean Fork Length (cm)		73.00	
Maximum		80.0	
Minimum		66.0	
Standard Deviation		4.74	
Sample Size		13	
Statistical Week 22			
Mean Fork Length (cm)	57.90	71.53	
Maximum	67.5	80.0	
Minimum	48.0	65.0	
Standard Deviation	8.12	3.97	
Sample Size	5	17	
Statistical Week 23			
Mean Fork Length (cm)	60.38	71.07	
Maximum	64.0	79.0	
Minimum	51.0	65.0	
Standard Deviation	6.26	3.70	
Sample Size	4	22	
Statistical Week 24			
Mean Fork Length (cm)	54.38	69.83	
Maximum	60.0	79.0	
Minimum	51.0	58.5	
Standard Deviation	2.99	4.39	
Sample Size	8	46	
Statistical Week 25			
Mean Fork Length (cm)	50.67	70.57	
Maximum	55.0	76.5	
Minimum	48.0	64.0	
Standard Deviation	3.79	3.28	
Sample Size	3	28	

Ocean Age Class	Salt-Winters 1	2	3
Statistical Week 26			
Mean Fork Length (cm)	57.64	72.25	
Maximum	64.5	80	
Minimum	54.5	55	
Standard Deviation	3.56	4.69	
Sample Size	7	26	
Statistical Week 27			
Mean Fork Length (cm)	57.46	69.80	
Maximum	67	86	
Minimum	51	60	
Standard Deviation	4.16	4.35	
Sample Size	24	37	
Statistical Week 28			
Mean Fork Length (cm)	56.61	69.80	
Maximum	67	80	
Minimum	50	63	
Standard Deviation	3.91	3.34	
Sample Size	27	58	
Statistical Week 29			
Mean Fork Length (cm)	57.19	70.99	
Maximum	65	84	
Minimum	50	53	
Standard Deviation	2.86	4.26	
Sample Size	76	100	
Statistical Week 30			
Mean Fork Length (cm)	58.15	70.30	
Maximum	65.5	79.5	
Minimum	50	62	
Standard Deviation	2.86	3.15	
Sample Size	143	140	
Statistical Week 31			
Mean Fork Length (cm)	58.25	70.65	82.5
Maximum	67	81	82.5
Minimum	51	62	82.5
Standard Deviation	2.50	3.65	---
Sample Size	85	94	1
Statistical Week 32			
Mean Fork Length (cm)	58.61	71.21	83
Maximum	75	82.5	83
Minimum	53.5	65	83
Standard Deviation	3.78	3.82	---
Sample Size	70	56	1
Statistical Week 33-34			
Mean Fork Length (cm)	57.58	72.22	80
Maximum	65	82.5	80
Minimum	49.5	65	80
Standard Deviation	3.20	4.07	---
Sample Size	69	64	1
Statistical Week 34-35			
Mean Fork Length (cm)	58.24	75.15	84.33
Maximum	62	90.5	87
Minimum	53.5	62	81
Standard Deviation	2.15	6.09	3.06
Sample Size	21	52	3

Ocean Age Class	Salt-Winters 1	2	3
Statistical Week 36			
Mean Fork Length (cm)	60.59	77.68	83.33
Maximum	68.5	85.0	86.0
Minimum	54.0	66.5	81.5
Standard Deviation	3.77	5.58	1.94
Sample Size	11	45	6
Statistical Week 37			
Mean Fork Length (cm)	60.86	79.30	84.58
Maximum	65.0	88.5	87.0
Minimum	57.5	67.0	82.0
Standard Deviation	2.75	5.06	1.86
Sample Size	7	50	6
Statistical Week 38			
Mean Fork Length (cm)	58.83	80.27	86.25
Maximum	66.0	88.0	90.0
Minimum	55.0	71.5	83.5
Standard Deviation	6.21	4.44	2.81
Sample Size	3	26	6
Statistical Week 39			
Mean Fork Length (cm)	59.88	80.86	85.77
Maximum	66.0	89.5	93.5
Minimum	57.0	70.0	75.5
Standard Deviation	3.45	4.42	4.11
Sample Size	8	80	28
Statistical Week 40			
Mean Fork Length (cm)	60.00	79.12	85.00
Maximum	62.5	87.0	93.0
Minimum	57.5	64.0	77.0
Standard Deviation	3.54	5.92	4.44
Sample Size	2	37	18
Statistical Week 41			
Mean Fork Length (cm)	60.00	80.50	86.06
Maximum	60.0	87.5	91.0
Minimum	60.0	67.0	79.0
Standard Deviation	---	4.58	4.10
Sample Size	1	25	9
Statistical Week 42			
Mean Fork Length (cm)	60.25	79.64	88.00
Maximum	63.0	87.0	90.0
Minimum	57.5	74.0	85.0
Standard Deviation	3.89	3.81	2.65
Sample Size	2	14	3
Statistical Week 43			
Mean Fork Length (cm)	59.67	80.50	
Maximum	64.5	86.5	
Minimum	53.5	74.5	
Standard Deviation	5.62	8.49	
Sample Size	3	2	
2010 Composite			
Mean Fork Length (cm)	**58.01**	**73.34**	**85.25**
Maximum	**75.0**	**90.5**	**93.5**
Minimum	**48.0**	**53.0**	**75.5**
Standard Deviation	**3.36**	**5.83**	**3.75**
Sample Size	**587**	**1060**	**83**