CRITFC

TECHNICAL REPORT 13-03

AGE AND LENGTH COMPOSITION OF COLUMBIA BASIN CHINOOK AND SOCKEYE SALMON AND STEELHEAD AT BONNEVILLE DAM IN 2012

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April 18, 2013

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Columbia River Inter-Tribal Fish Commission
Technical Report
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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, 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 both spring and summer Chinook salmon comprising, respectively, 86.1% and 61.7% of the runs. Three-year-olds were the most abundant age class for the fall Chinook salmon making up 46.2% of the run. Four-year-olds were the most abundant age group for sockeye salmon comprising 96.3% of the run, and four-year-olds were the most abundant in the steelhead run comprising 48.7% of the run. Steelhead data were analyzed for the salt years regardless of the freshwater phase, the majority of steelhead had two-salt winters (57.3%) in 2012. Using adipose fin clips, scale patterns, and dorsal fin condition for classification, the steelhead migration consisted of 66.3% hatchery- and 33.7% natural-origin steelhead. A-run steelhead, less than 78cm in length, comprised 85.3% of the steelhead run. B-run fish, equal to or greater than 78cm, comprised 14.7% 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 Polymorphism (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 2012 sampling year were to estimate the age composition and length-at-age composition of Chinook and sockeye salmon, and steelhead using scale pattern analysis, to forecast the future run size of Chinook salmon using the age composition data, to

PIT tag Chinook, sockeye, 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 tule and the upriver bright fall Chinook. Tules 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-run 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 from April 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 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 counts were obtained from Fish Passage Center (2012). In 2012, 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 the 2012 sampling season a picket lead drop and lift schedule was maintained in the Washington fish ladder to move salmon and steelhead into the AFF trap (Figure 2). Depending on adult salmon migration density, the four picket leads needed to be raised or lowered in varying numbers 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.

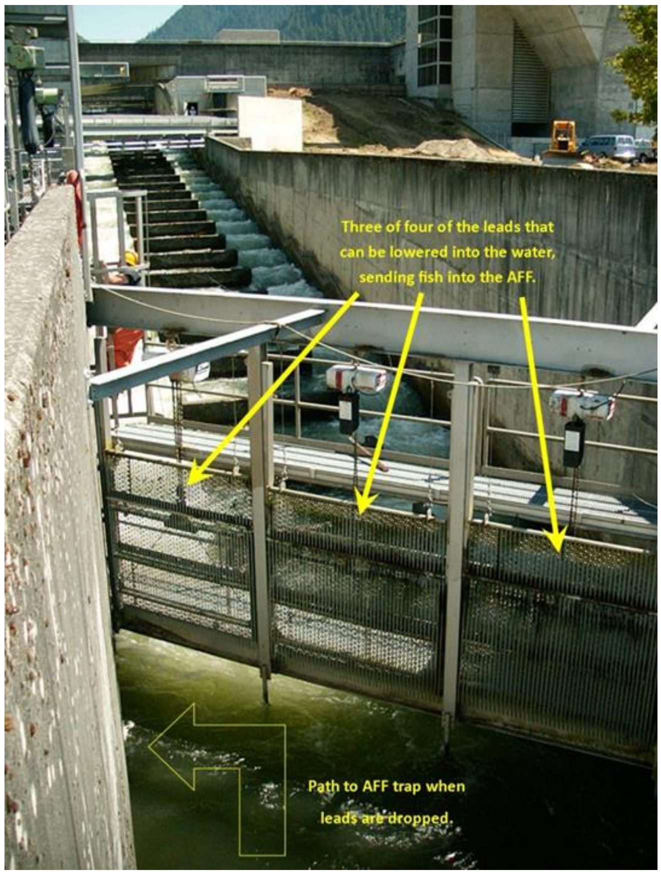

Figure 2. View of Washington Shore Fish Ladder and picket leads that diverted fish into the Bonneville Adult Fish Facility (AFF).

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 2012, 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. Scales were not collected from tules; all other data types and genetic samples were 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 whenever they were present on the fish and include percentage of descaling, marine mammal injuries, hooking injuries, and net damage. For all other types of injuries, the injury was only recorded if the injury reduced the condition of the fish from a 5 to 4 - 1. This change in protocol, from previous years, was necessary to reduce the amount of time spent on each fish so that more fish could be sampled and tagged.

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. If poor scale quality, particularly in the freshwater prevents age determination in all scales collected from a particular fish, no age is assigned. The exception is steelhead, where if saltwater age can be reliably determined, the age is designated as r.X where X is the saltwater age and "r" stands for regenerated.

For the fall Chinook run, 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 (tables in the Appendix) 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.

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 and is a separate age class in the age composition table.

Chinook Salmon Run-Size Prediction for 2013

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.

RESULTS

Sampling

Sampling began on April 23 and ended October 12, 2012. A total of 1163 spring Chinook, 467 summer Chinook, and 1870 fall Chinook salmon, 1637 sockeye salmon, and 1486 steelhead were sampled. During the fall run, 44 additional Chinook salmon were sampled and identified as tules. Genetic samples were taken and almost all fish sampled were tagged with PIT tags for tracking. The PIT tag study results are also reported on an annual basis and are available for download on the CRITFC website.

We attempted to avoid sampling salmonids that spent no winters in saltwater (such Chinook are known as minijacks) by not selecting fish under 36 cm. However, in 2012, we did sample two Chinook salmon (measuring 38.5 cm -spring run and 40 cm – summer run), which spent no winters in saltwater (age for both were 1.0). These fish were treated like other fish at the time of sampling; genetic samples were taken and they were tagged with PIT tags and tracked. For the purposes of this age composition study, these Chinook were considered minijacks and excluded from further analysis.

Age Composition

Based on scale pattern analysis, four-year-olds were the majority age group for spring Chinook salmon, comprising 86.1% of the spring Chinook migration (Figure 3, Table 1). Four-year-olds were the most abundant group for summer Chinook salmon comprising 61.7% of the summer Chinook migration (Figure 3, Table 2), and three-year-olds were the most abundant for fall Chinook salmon, at 46.2% of the fall run (Figure 3, Table 3). A portion of the fall run at Bonneville consists of tules, which we do not include in our analysis. Over 50,000 tules passed Bonneville Dam in 2012. 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 the analysis of fall (upriver bright) Chinook.

The percentage of ocean-type Chinook salmon (age 0.X) increased steadily through the run, from 0% in Statistical Week 17 to a peak of 95.3% in Statistical Week 39 (Figure 4). Sampling hours were restricted during Statistical Weeks 32, 33 and 34 due to high water temperatures.

Four-year-olds were the vast majority of the age groups for sockeye salmon (96.3%), the remaining percent of the run had double the number of five-year-old fish compared to the number of three-year-old number in 2012 (Table 4).

Four-year-olds comprised 48.7% of the steelhead run. Three-year-olds made up another significant portion at 30.7% while the remaining run consisted of smaller numbers of five-year-olds (16.5%) and six- and seven-year-olds age groups and repeat spawners made up the rest of the age groups (Table 5). Steelhead with unageable freshwater, but ageable saltwater winters (r.X) comprised 30.5% of the run. If these fish are included with ageable fish and the data are analyzed for salt years only, then the majority of steelhead had two-salt winters (57.3%) in 2012. However, one-salt winter steelhead made up a good portion of the run at 42.1%.

Aging validation from ageable scale patterns of 81 salmon or steelhead that had been previously PIT tagged (most likely as juveniles) were correctly aged as follows: all 24 spring Chinook, all 11 summer Chinook, all 16 fall Chinook salmon, all 3 sockeye salmon, and 24 out of 27 steelhead. Note that only total age since release could be validated; it normally was not possible to validate saltwater and freshwater separately.

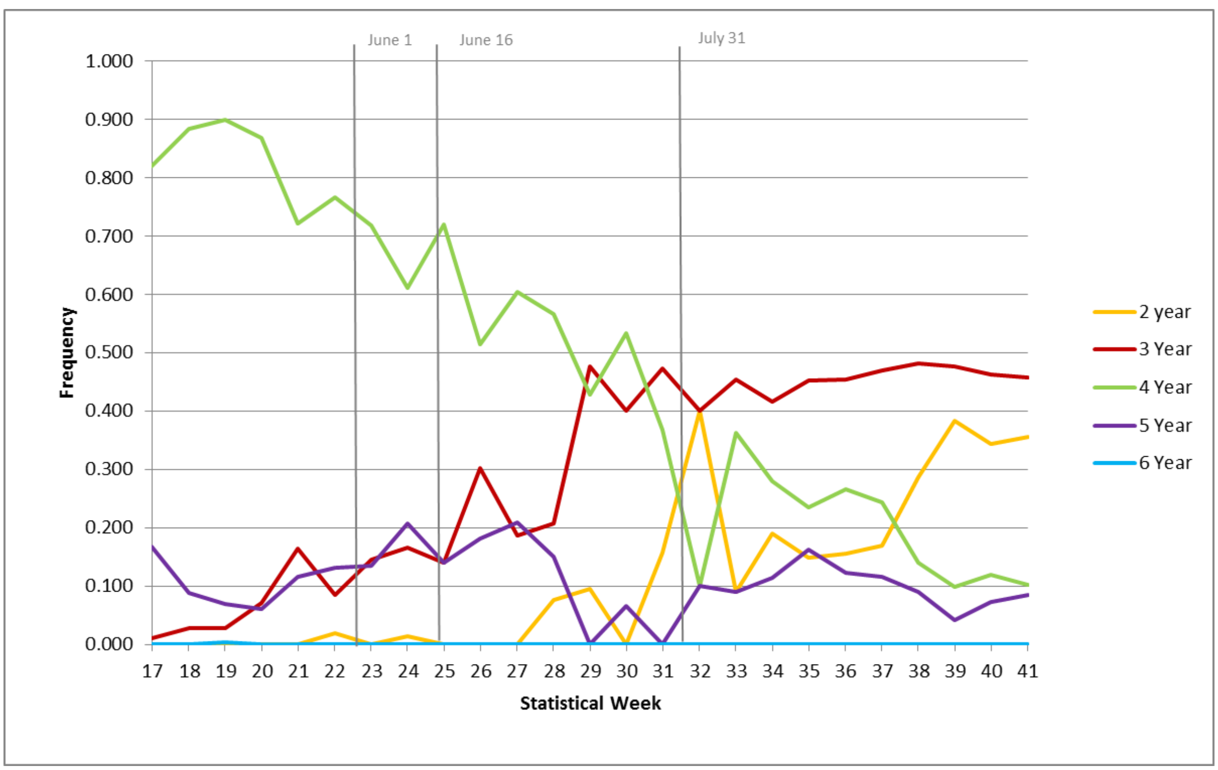

Figure 3. Weekly age composition estimates for age groups of Columbia Basin Chinook salmon sampled at Bonneville Dam in 2012. Due to high water temperatures, sampling hours were restricted in weeks 32-34.

Table 1. Weekly and cumulative age composition of Columbia Basin spring Chinook salmon at Bonneville Dam in 2012.

Statistical Week	Sampling Date	Number Sampled	Number Ageable	Weekly run size	Age Composition by Brood Year and Age Class								Adipose Clips	Adipose w/Other	Other Clips
					2010	2009		2008		2007		2006			
					0.1	0.2	1.1	0.3	1.2	0.4	1.3	1.4			
17	4/23 - 4/27	120	95	20944	0.000	0.011	0.000	0.000	0.821	0.000	0.168	0.000	94	0	0
18	4/30-5/04	221	182	15943	0.000	0.000	0.027	0.000	0.885	0.000	0.088	0.000	171	0	0
19	5/7-5/11	350	289	67461	0.000	0.000	0.028	0.007	0.893	0.000	0.069	0.003	239	0	0
20	5/14-5/18	235	198	41667	0.000	0.010	0.061	0.000	0.869	0.000	0.061	0.000	145	1	0
21	5/21-5/25	127	104	11133	0.000	0.029	0.135	0.010	0.712	0.010	0.106	0.000	72	0	0
22	5/28-5/31	109	88	8533	0.023	0.034	0.057	0.011	0.750	0.011	0.114	0.000	48	0	0
Cumulative		**1162**	**956**	**165681**	**0.001**	**0.008**	**0.041**	**0.004**	**0.857**	**0.001**	**0.086**	**0.001**	**769**	**1**	**0**

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.

Table 2. Weekly and cumulative age composition of Columbia Basin summer Chinook salmon at Bonneville Dam in 2012.

Statistical Week	Sampling Date	Number Sampled	Number Ageable	Weekly run size	Age Composition by Brood Year and Age Class: 2010	2009		2008		2007		Adipose Clips	Adipose w/Other	Other Clips
					0.1	0.2	1.1	0.3	1.2	0.4	1.3			
22	6/1	21	19	5040	0.000	0.000	0.053	0.053	0.737	0.000	0.158	9	0	0
23	6/4-6/8	112	96	12364	0.000	0.021	0.125	0.010	0.708	0.010	0.125	73	0	0
24	6/11-6/15	87	72	16611	0.014	0.028	0.139	0.097	0.514	0.056	0.153	51	0	0
25	6/18-6/22	56	50	16453	0.000	0.100	0.040	0.080	0.640	0.060	0.080	25	0	0
26	6/25-6/29	35	33	11982	0.000	0.091	0.212	0.242	0.273	0.061	0.121	20	0	0
27	7/2-7/6	46	43	10536	0.000	0.093	0.093	0.140	0.465	0.047	0.163	26	0	0
28	7/9-7/13	59	53	8937	0.075	0.094	0.113	0.094	0.472	0.075	0.075	34	0	0
29	7/16-7/20	21	21	5984	0.095	0.095	0.381	0.095	0.333	0.000	0.000	12	0	0
30	7/23-7/26	16	15	4583	0.000	0.133	0.267	0.067	0.467	0.067	0.000	11	1	0
31	7/30, 7/31	13	13	1408	0.154	0.538	0.000	0.154	0.154	0.000	0.000	4	0	0
Cumulative		**466**	**415**	**93898**	**0.018**	**0.077**	**0.136**	**0.103**	**0.514**	**0.045**	**0.107**	**265**	**1**	**0**

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 2012.

Statistical Week	Sampling Date	Number Sampled	Number Ageable	URB run size	Age Composition by Brood Year and Age Class: 2010	2009		2008		2007		Adipose Clips	Adipose w/Other	Other Clips
					0.1	0.2	1.1	0.3	1.2	0.4	1.3			
31	8/1-8/3	8	6	2866	0.167	0.333	0.000	0.167	0.333	0.000	0.000	3	0	0
32	8/6-8/9	11	10	5198	0.400	0.200	0.200	0.100	0.000	0.100	0.000	4	0	0
33	8/17	12	11	6599	0.091	0.455	0.000	0.273	0.091	0.000	0.091	6	0	0
34	8/20-8/24	141	132	16502	0.189	0.318	0.098	0.182	0.098	0.076	0.038	39	0	1
35	8/27-8/31	239	221	57777	0.149	0.403	0.050	0.186	0.050	0.127	0.036	79	0	2
36	9/4-9/7	268	251	85948	0.155	0.402	0.052	0.227	0.040	0.112	0.012	74	1	1
37	9/10-9/14	317	300	105582	0.170	0.420	0.050	0.220	0.023	0.113	0.003	101	0	0
38	9/17-9/21	370	355	70622	0.287	0.439	0.042	0.121	0.020	0.076	0.014	108	0	1
39	9/24-9/27	229	214	38151	0.383	0.449	0.028	0.089	0.009	0.033	0.009	60	0	0
40	10/1-10/5	164	151	16857	0.344	0.417	0.046	0.106	0.013	0.073	0.000	41	0	2
41	10/8-10/12	111	107	17857	0.355	0.421	0.037	0.065	0.037	0.084	0.000	28	0	0
Cumulative		**1870**	**1758**	**423959**	**0.220**	**0.413**	**0.049**	**0.175**	**0.034**	**0.094**	**0.014**	**543**	**1**	**7**

August 1 is the start of the fall run at Bonneville Dam.

Due to high water temperatures, sampling hours were restricted in weeks 32-34.

The weekly run size for week 41 includes all Chinook salmon passing Bonneville Dam after the last date of sampling in week 41.

Tule numbers passing Bonneville Dam per week are removed from the Bright (URB) run size.

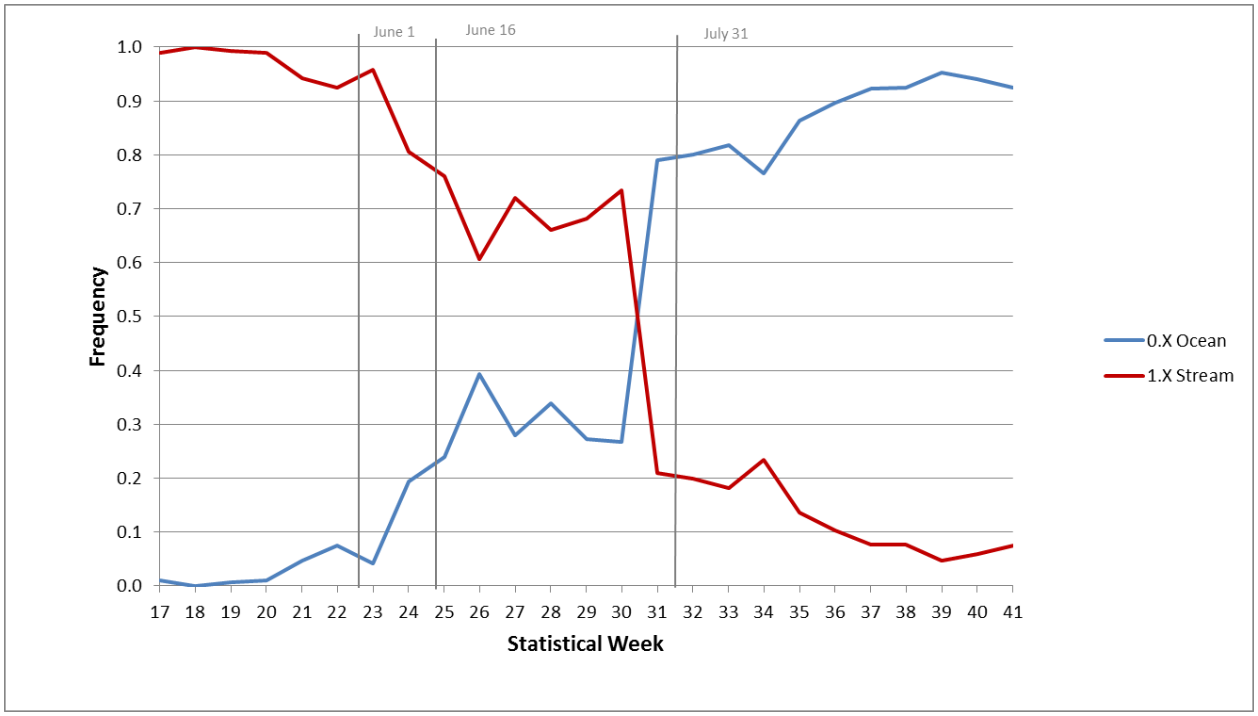

Figure 4. Weekly age composition estimates for age groups of Columbia Basin Chinook salmon sampled at Bonneville Dam in 2012. Due to high water temperatures, sampling hours were restricted in weeks 32-34.

Table 4. Weekly and cumulative age composition of Columbia Basin sockeye salmon at Bonneville Dam in 2012.

Statistical Week	Sampling Date	Number Sampled	Number Ageable	Weekly run size	Age Composition by Brood Year and Age Class: 2010	2009		2008		Adipose Clips	Adipose w/Other	Other Clips
					1.1	1.2	2.1	1.3	2.2			
22 - 23	5/30-6/1 & 6/4-6/8	69	66	4997	0.000	0.939	0.000	0.061	0.000	1	0	0
24	6/11-6/15	201	192	40159	0.010	0.958	0.000	0.026	0.005	3	0	0
25	6/18-6/22	408	395	140621	0.008	0.962	0.003	0.020	0.008	3	0	1
26	6/25-6/29	426	422	196832	0.021	0.955	0.002	0.005	0.017	7	0	0
27	7/2-7/6	374	365	98658	0.005	0.970	0.011	0.000	0.014	6	0	0
28	7/9-7/13	119	114	30577	0.009	0.956	0.009	0.009	0.018	1	0	1
29	7/16-7/20	24	23	2901	0.043	0.913	0.000	0.043	0.000	1	0	0
30 - 31	7/23-7/27 & 7/30 - 8/1	16	16	1104	0.067	0.813	0.063	0.000	0.063	2	0	1
Cumulative		**1637**	**1593**	**515849**	**0.013**	**0.959**	**0.004**	**0.011**	**0.013**	**24**	**0**	**3**

Statistical weeks 22-23 have been combined due to low sampling numbers at the beginning of the run.

Statistical weeks 30-31 have been combined due to low sampling umbers at the end of the run.

The weekly run size for week 22-23 includes sockeye salmon passing prior to this week. Similarly the weekly run size for week 30-31 includes fish passing after this week.

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Table 5. Weekly and cumulative age composition of Columbia Basin steelhead at Bonneville Dam in 2012.

Age Composition by Brood Year and Age Class

Statistical Week	Sampling Date	Number Sampled	Number Ageable	Weekly run size	2009	2008		2007			2006		2005	Repeat	Ageable Salt Winters			A-Run	Fin Clips			Wild
					1.1	1.2	2.1	1.3	2.2	3.1	2.3	3.2	4.2		1 ASW	2 ASW	3 ASW		Ad Clips	Ad + Other	Other	
17 - 19	4/23 - 4/27	11	5	4618	0.000	0.600	0.000	0.000	0.200	0.200	0.000	0.000	0.000	0.000	0.200	0.800	0.000	0.091	7	0	0	0.364
20	5/14-5/18	8	5	493	0.200	0.400	0.000	0.000	0.400	0.000	0.000	0.000	0.000	0.000	0.125	0.875	0.000	0.750	2	0	0	0.500
21	5/21-5/25	7	6	378	0.667	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.714	0.286	0.000	1.000	5	1	0	0.143
22	5/28-6/1	17	11	591	0.455	0.455	0.000	0.000	0.091	0.000	0.000	0.000	0.000	0.000	0.294	0.706	0.000	1.000	15	0	0	0.118
23	6/4-6/8	11	6	820	0.667	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.364	0.636	0.000	0.909	9	0	0	0.182
24	6/11-6/15	11	10	1389	0.500	0.200	0.100	0.000	0.200	0.000	0.000	0.000	0.000	0.000	0.545	0.455	0.000	1.000	7	1	0	0.273
25	6/18-6/22	9	8	2379	0.375	0.375	0.250	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.667	0.333	0.000	1.000	3	2	0	0.333
26	6/25-6/29	13	9	3179	0.111	0.444	0.111	0.000	0.333	0.000	0.000	0.000	0.000	0.000	0.308	0.692	0.000	1.000	6	0	0	0.462
27	7/2-7/6	16	11	5631	0.364	0.182	0.091	0.000	0.091	0.091	0.000	0.091	0.091	0.000	0.375	0.625	0.000	1.000	8	1	0	0.438
28	7/9-7/13	85	56	11750	0.232	0.357	0.161	0.000	0.161	0.018	0.000	0.054	0.000	0.018	0.422	0.578	0.000	0.988	36	5	1	0.459
29	7/16-7/20	129	87	20347	0.276	0.310	0.161	0.000	0.184	0.023	0.000	0.046	0.000	0.000	0.468	0.532	0.000	0.984	56	5	2	0.465
30	7/23-7/26	177	117	25991	0.256	0.410	0.145	0.000	0.111	0.026	0.000	0.051	0.000	0.000	0.425	0.575	0.000	1.000	85	13	3	0.401
31	7/30-8/3	143	101	25405	0.356	0.366	0.069	0.010	0.168	0.000	0.000	0.020	0.000	0.030	0.443	0.550	0.007	0.965	71	6	1	0.385
32	8/6-8/9	96	71	24423	0.423	0.225	0.099	0.000	0.155	0.028	0.000	0.056	0.000	0.028	0.532	0.468	0.000	0.990	49	9	0	0.365
33	8/17	39	20	21011	0.400	0.150	0.050	0.000	0.350	0.000	0.000	0.050	0.000	0.050	0.474	0.526	0.000	0.923	22	3	0	0.359
34	8/20-8/24	158	97	11982	0.381	0.309	0.113	0.000	0.144	0.010	0.000	0.021	0.000	0.021	0.532	0.468	0.000	0.943	88	12	2	0.335
35	8/27-8/31	145	98	15406	0.367	0.408	0.071	0.000	0.133	0.000	0.000	0.000	0.000	0.031	0.507	0.493	0.000	0.897	89	15	1	0.228
36	9/4-9/7	54	38	14218	0.342	0.526	0.079	0.000	0.026	0.000	0.026	0.000	0.000	0.026	0.453	0.528	0.019	0.759	29	5	1	0.333
37	9/10-9/14	36	25	12430	0.280	0.560	0.000	0.000	0.120	0.000	0.000	0.000	0.000	0.040	0.353	0.647	0.000	0.722	25	0	0	0.278
38	9/17-9/21	82	55	12060	0.200	0.673	0.036	0.036	0.055	0.000	0.000	0.000	0.000	0.000	0.247	0.716	0.037	0.549	56	3	0	0.256
39	9/24-9/27	70	51	7714	0.157	0.784	0.039	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.203	0.768	0.029	0.343	44	5	0	0.243
40	10/1-10/5	88	65	4847	0.138	0.769	0.000	0.031	0.062	0.000	0.000	0.000	0.000	0.000	0.148	0.830	0.023	0.409	54	3	1	0.295
41	10/8-10/12	81	63	8105	0.175	0.683	0.016	0.032	0.063	0.000	0.000	0.000	0.000	0.032	0.218	0.756	0.026	0.444	58	2	0	0.222
Cumulative		**1486**	**1015**	**235167**	**0.307**	**0.401**	**0.086**	**0.005**	**0.145**	**0.015**	**0.002**	**0.028**	**0.002**	**0.019**	**0.421**	**0.573**	**0.006**	**0.853**	**824**	**91**	**12**	**0.352**

Statistical weeks 17-19 have been combined due to low sampling numbers at the beginning of the run.

The weekly run size for weeks 17-19 includes steelhead passing prior to week 17. Similarly, the weekly run size for week 41 includes fish passing after this week.

Due to high water temperatures, sampling hours were restricted in weeks 32-34.

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 28) 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 the Appendix. Length-at-age tables for sockeye salmon and steelhead are also located in the Appendix.

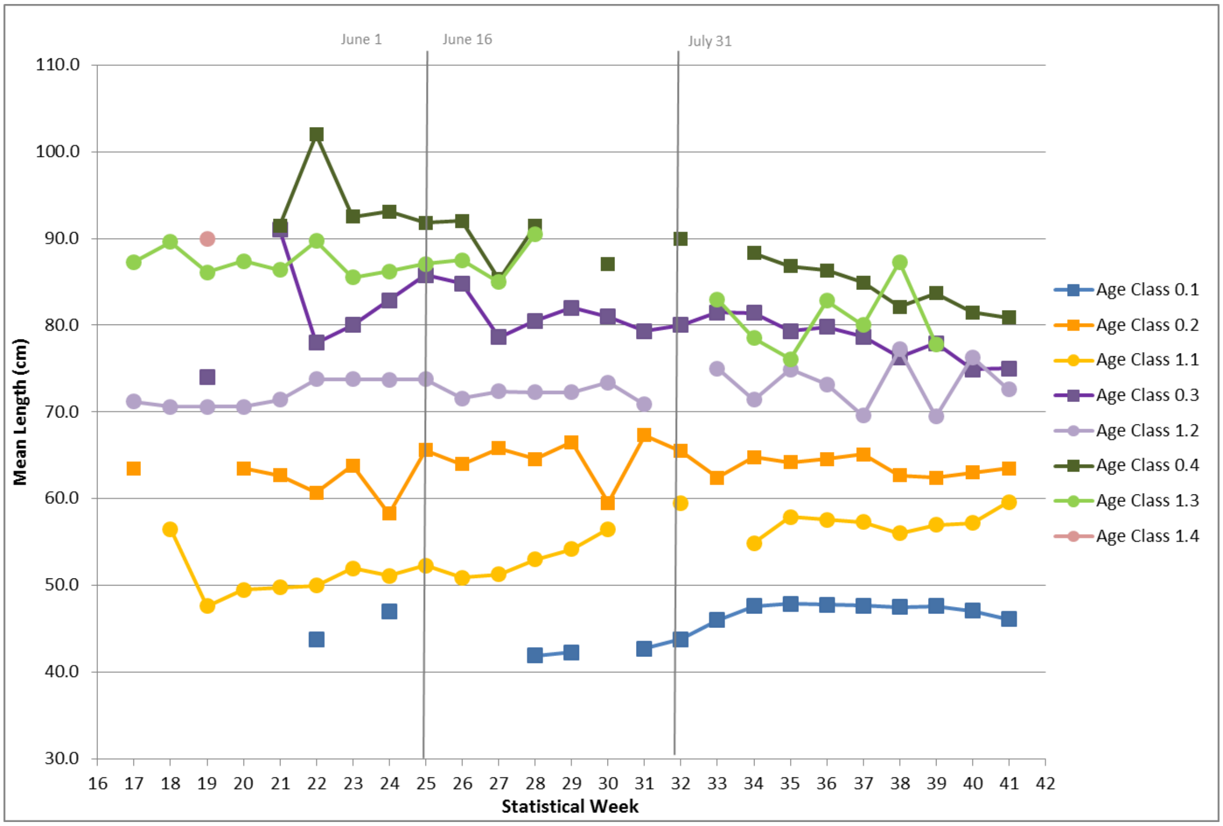

Figure 5. Weekly age composition estimates for age groups of Columbia Basin Chinook salmon sampled at Bonneville Dam in 2012. Due to high water temperatures, sampling hours were restricted in weeks 32-34.

Fish Coloration and Condition

Bright coloration was observed in the majority of each species: 70.5% of spring Chinook salmon, 75.9% of summer Chinook, 75.1% of fall Chinook, 100% of sockeye salmon and 95.7% of steelhead. The highest condition rating of 5 was given to 74.6% of spring Chinook, 82.4% of summer Chinook, 77.1% of fall Chinook, 92.4% of sockeye and 70.7% of steelhead. Additional fish condition data can be found in the Appendix (Note – due to protocol change, the number of some types of injuries reported were greatly reduced).

Chinook Salmon Run-Size Prediction for 2013

Using a linear relationship between the 2012 three- and four-year-old adult returns (Figure 6), the estimated number of four-year-old spring Chinook salmon returning to Bonneville Dam in 2013 is 127, 660 (±55,300, 90% prediction interval [PI]). Using the relationship between four- and five-year-olds to construct the model (Figure 7), albeit poorer than that existing between three-year-olds and four-year-olds, we predict that the 2013 five-year-old adult abundance at Bonneville Dam will be 49,095 (±21,350, 90% PI).

For the 2013 summer Chinook salmon run at Bonneville Dam, the relationship between three- and four-year-olds (Figure 8) results in a prediction of 35,180 (±17,200, 90% PI) four-year-olds. The relationship between four- and five-year-olds (Figure 9), the model predicts a return of 37,700 (±11,680, 90% PI) five-year-olds.

Based on the relationship between three- and four-year-olds (Figure 10), the model results in a prediction of 193,740 (±51,840, 90% PI) four-year-old Upriver Bright fall Chinook salmon returns for 2013. Using the relationship between four- and five-year-olds (Figure 11), the model results in a prediction of 28,740 (±37,960, 90% PI) returning five-year-olds.

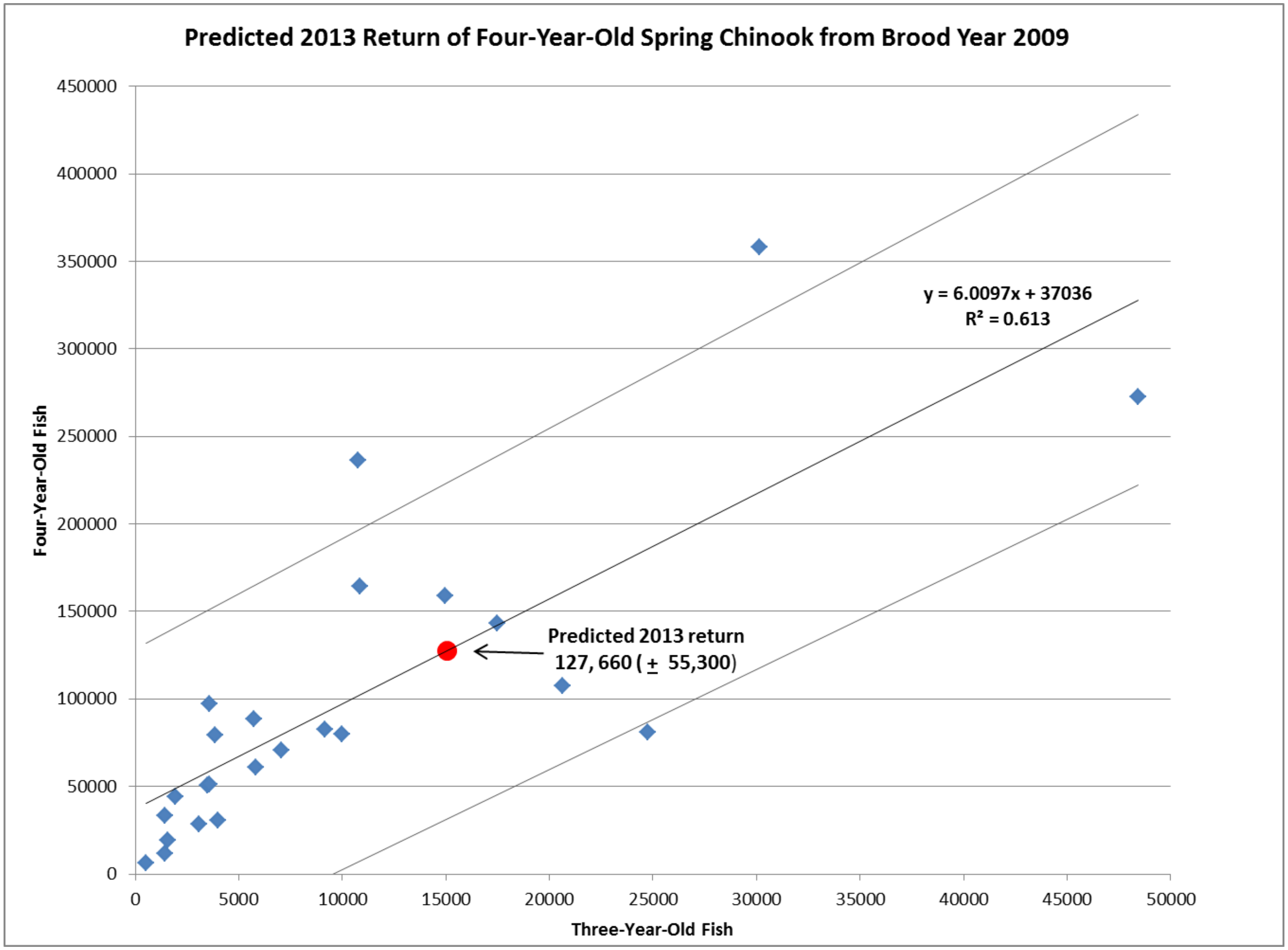

Figure 6. Predicted 2013 four-year-old Columbia Basin spring Chinook salmon abundance (at Bonneville Dam) based on a linear relationship between four-year-old and three-year-old fish abundance during brood years 1984 through 2008. Prediction intervals (90%) are also graphed.

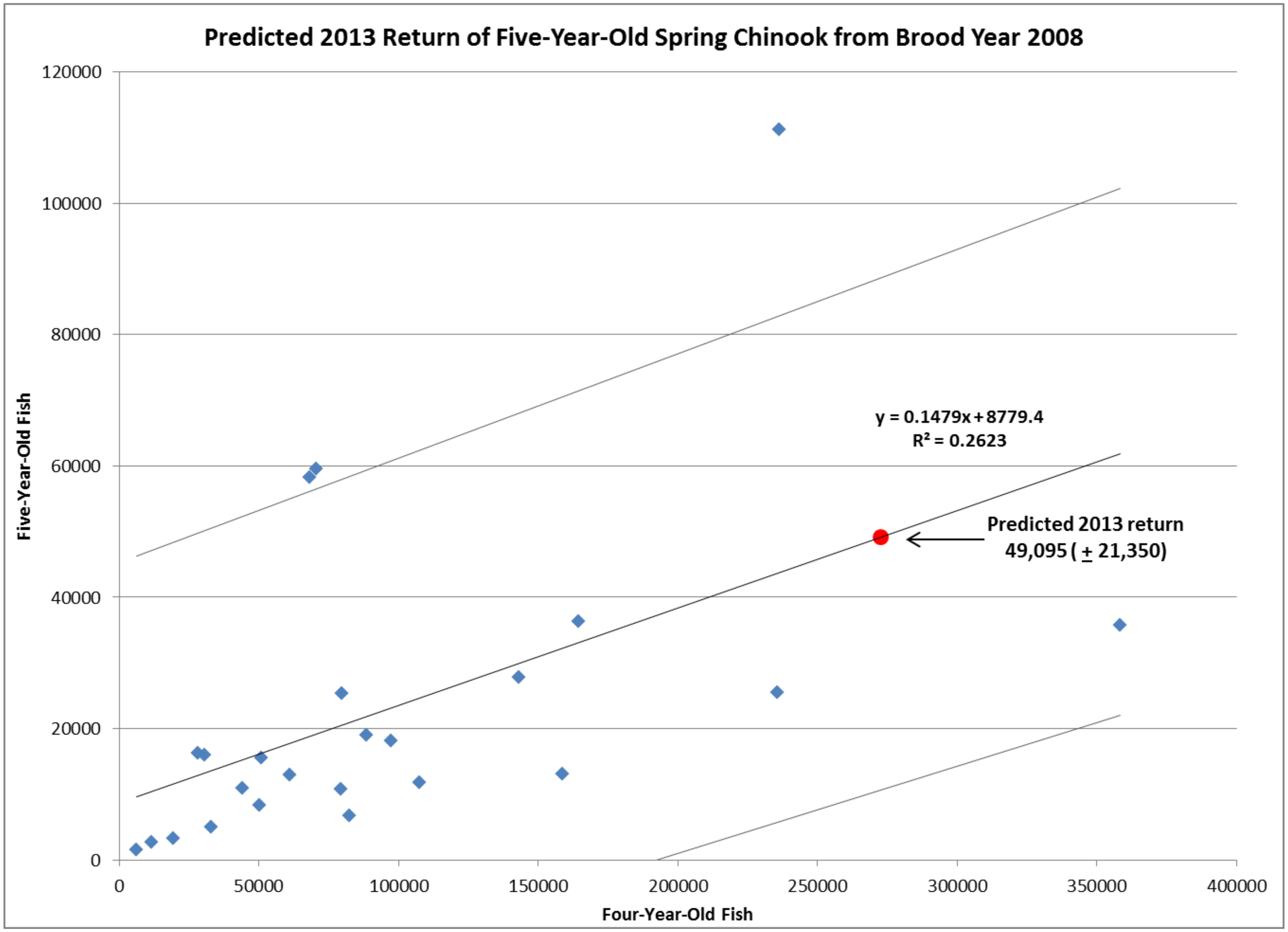

Figure 7. Predicted 2013 five-year-old Columbia Basin spring Chinook salmon abundance (at Bonneville Dam) based on a linear relationship between five-year-old and four-year-old fish abundance during brood years 1983 through 2007. Prediction intervals (90%) are also graphed.

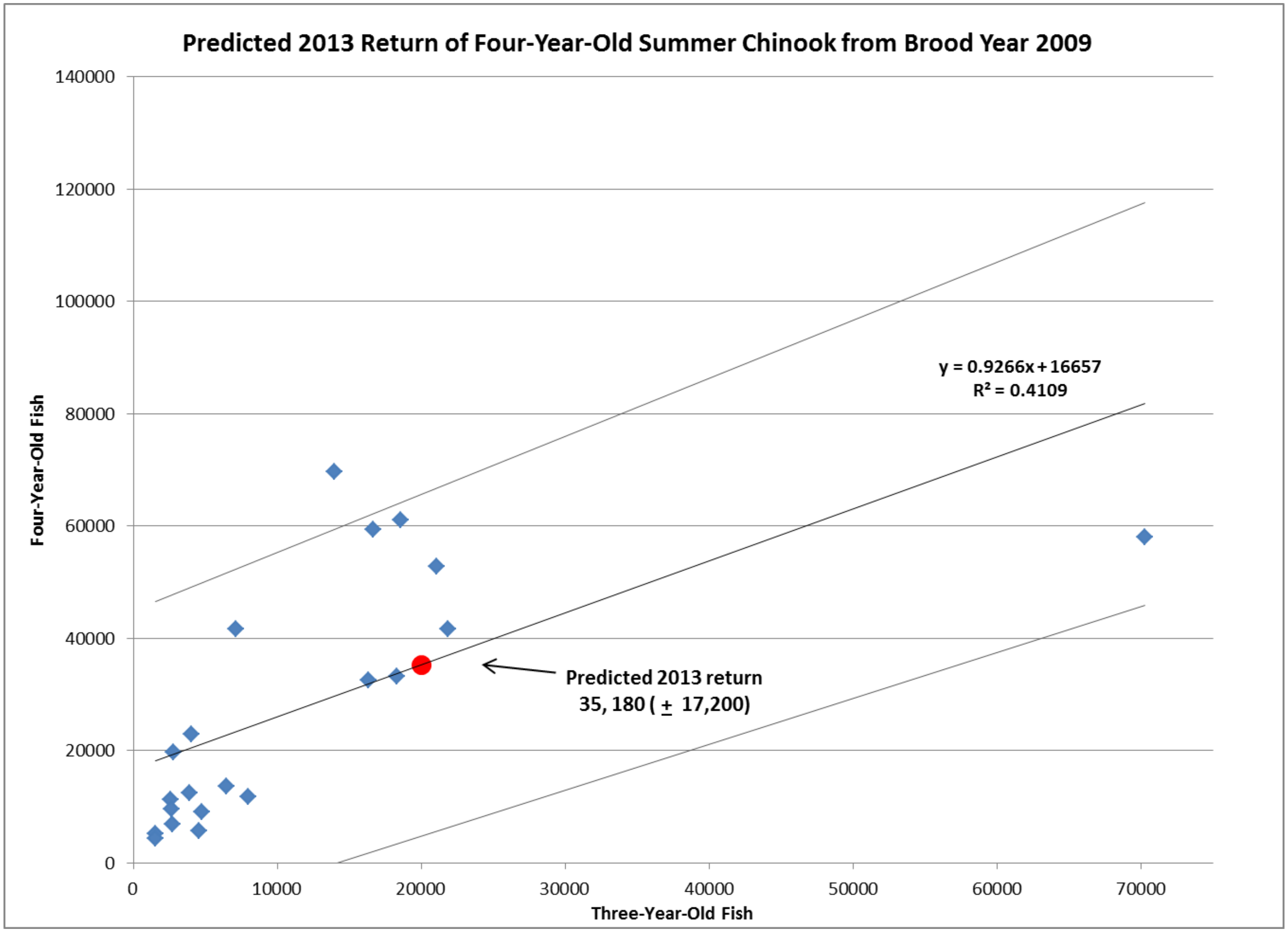

Figure 8. Predicted 2013 four-year-old Columbia Basin summer Chinook salmon abundance (at Bonneville Dam) based on a linear relationship between four-year-old and three-year-old fish abundance during brood years 1987 through 2008. Prediction intervals (90%) are also graphed.

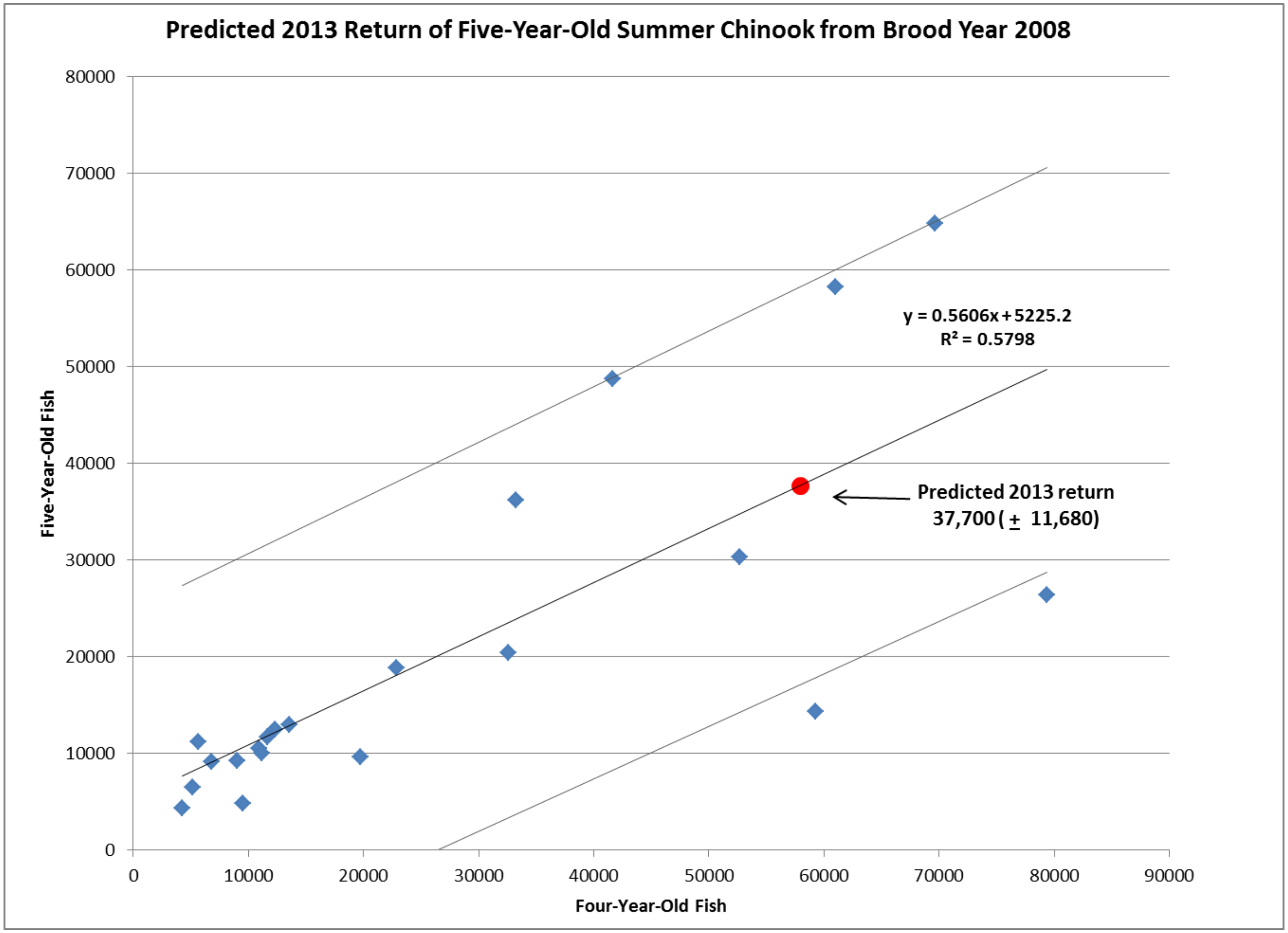

Figure 9. Predicted 2013 five-year-old Columbia Basin summer Chinook salmon abundance (at Bonneville Dam) based on a linear relationship between five-year-old and four-year-old fish abundance during brood years 1986 through 2007. Prediction intervals (90%) are also graphed.

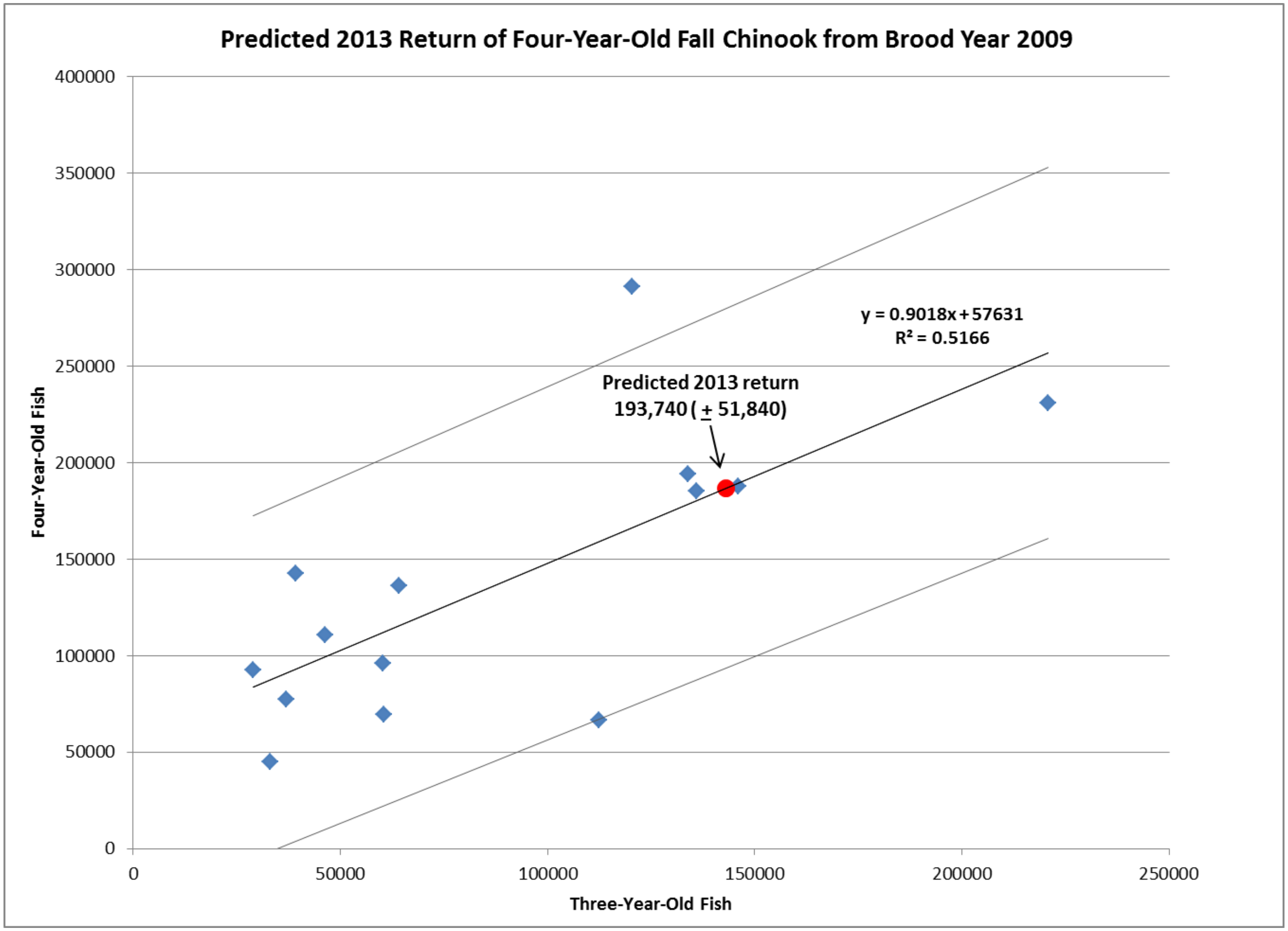

Figure 10. Predicted 2013 four-year-old Columbia Basin fall Chinook salmon abundance (at Bonneville Dam) based on a linear relationship between four-year-old and three-year-old fish abundance during brood years 1994 through 2008. Prediction intervals (90%) are also graphed.

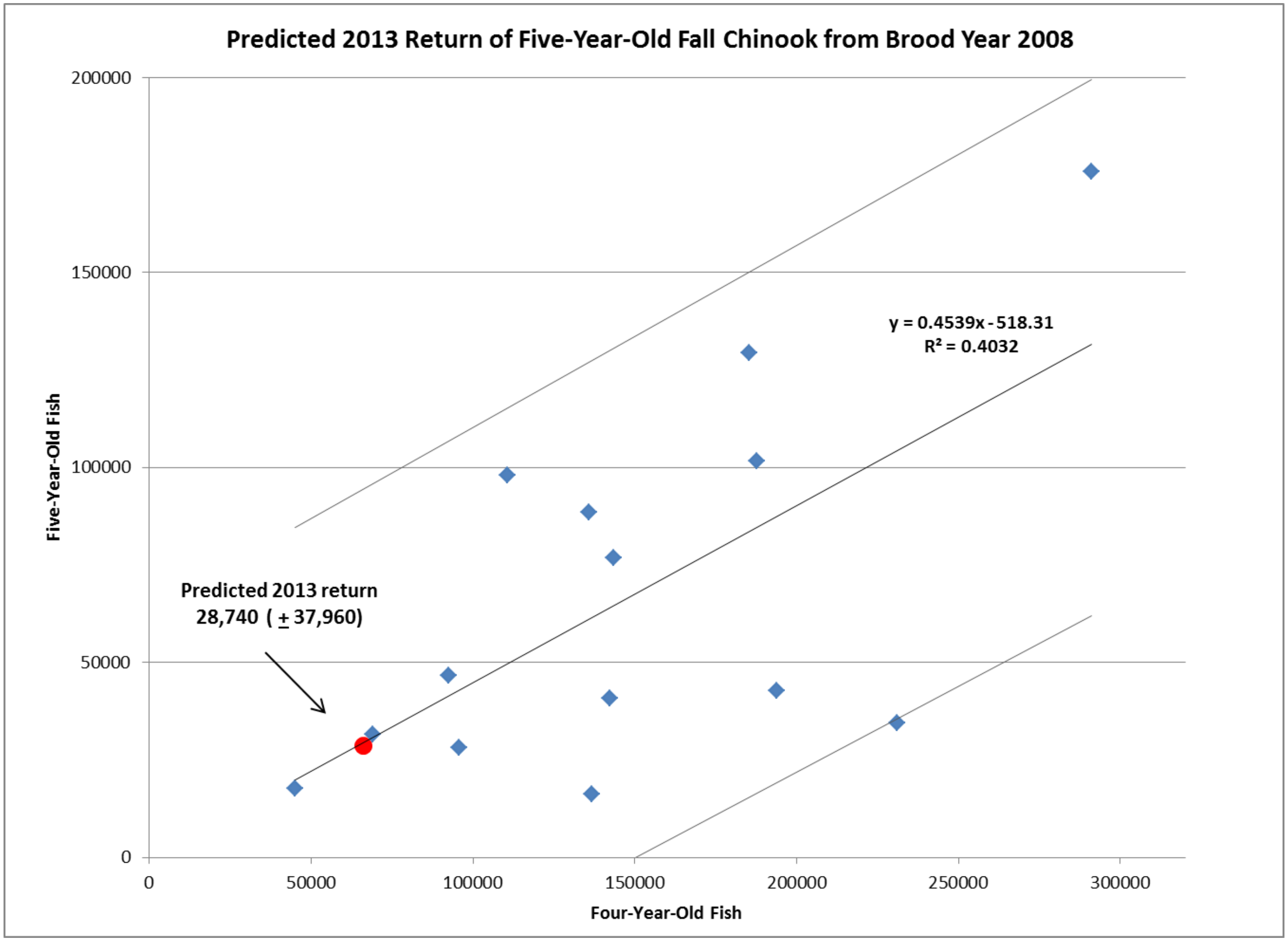

Figure 11. Predicted 2009 five-year-old Columbia Basin bright fall Chinook salmon abundance (at Bonneville Dam) based on a linear relationship between four-year-old and five-year-old fish abundance during brood years 1993 through 2007. Prediction intervals (90%) are also graphed.

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 the lack of an adipose fin clip alone, we would have estimated that 38.4% of the run was of wild origin; including scale patterns reduced this to 33.7%.

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 (85.3%) passing Bonneville Dam were A-run, and the remaining 14.7% were B-run. Although A-run steelhead dominated the run, the percentage of the B-run generally increases as the run progresses (Table 5 and Figure 12.

Steelhead Kelts

In 2012, we found 16 steelhead with spawning check marks in their scale patterns. The freshwater- and saltwater-winter annuli numbers varied greatly and six fish had unageable freshwater annuli. The age composition was: four 2.1S, three 2.2S, two each of r.1S1, r.2S and 1.1S1 and one each of r.S1, r.1S and 2.1S1. All 16 steelhead were PIT tagged and tracked. Three of the fish was adipose clipped and except for two of the adipose clipped steelhead, the other steelhead appeared to have freshwater scale patterns of wild fish. Using PIT tag detections during the spring months of 2012 after spawning, forty-nine steelhead PIT tagged during the 2011 season displayed migration behaviors that identified them as kelts (Jeff Fryer, CRITFC, personal communication).

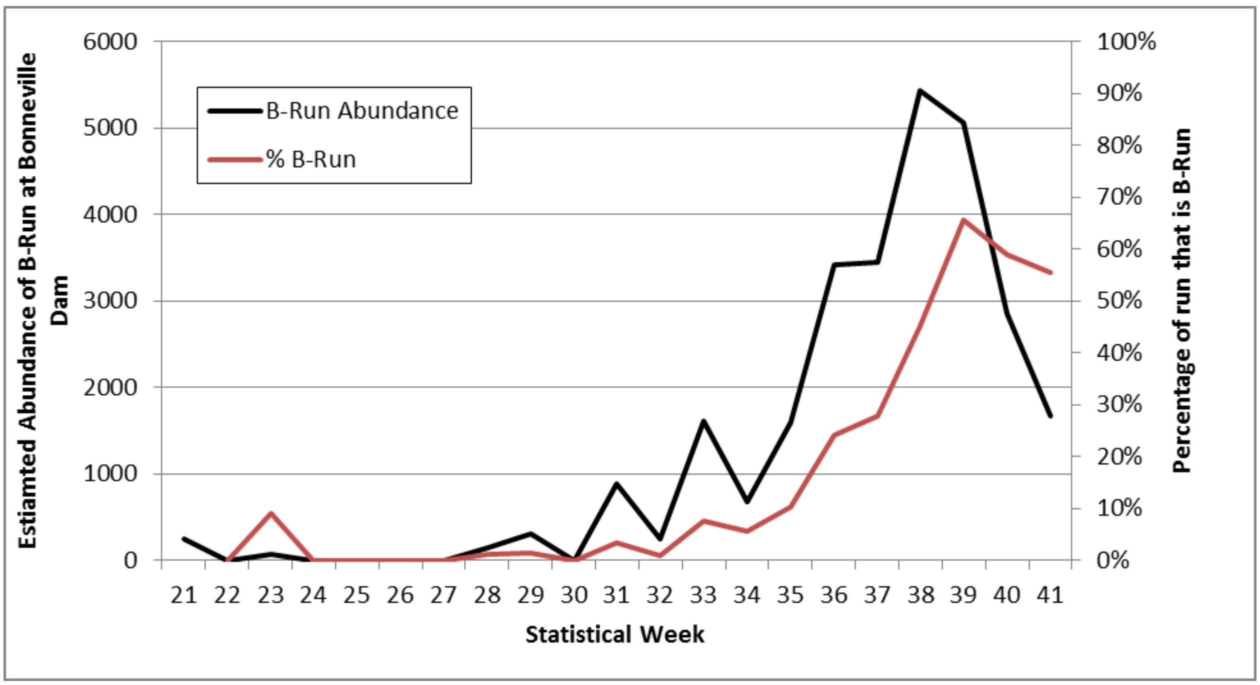

Figure 12. Weekly age composition estimates for age groups of Columbia Basin Chinook salmon sampled at Bonneville Dam in 2012. Due to high water temperatures, sampling hours were restricted in weeks 32-34.

DISCUSSION

High river water temperature has constrained our sampling efforts during most summer sampling seasons. Restrictions for days of sampling, and hours of the day that sampling can occur, are triggered when temperatures reach 70^{o}F (21.1^{o}C). During the 2012 sampling season, sampling was restricted during weeks 32-34 (Figure 7) as temperatures reached a high of 73.04^{o}F on August 18 in week 33. Steelhead continued to pass Bonneville Dam in relatively large numbers even though temperatures exceeded 70^{o}F, while the Chinook run rapidly increased in week 35 as temperatures dropped below 71^{o}F. Any link between temperature and passage numbers is much less apparent in 2012 than in previous years.

In 2012, 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 tenth year for Chinook salmon, the sixth year for sockeye salmon, and the ninth year for steelhead that we have collected genetic samples. 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 genetic reference baselines has been completed and now accurate genetic stock analyses are being performed using 192 genetic markers for both steelhead and Chinook salmon. In addition 96 genetic markers for sockeye salmon have been developed and samples have been analyzed (Hess et al. Annual Reports). Now that 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.

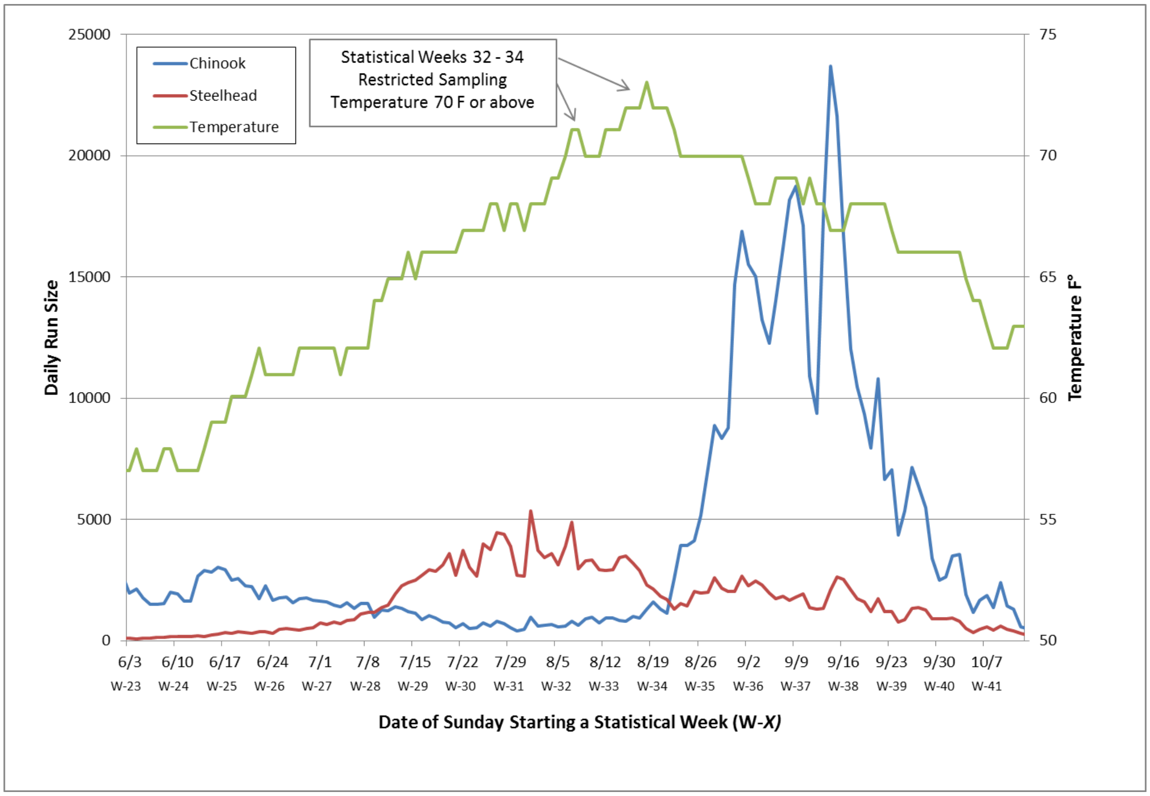

Figure 13. Weekly age composition estimates for age groups of Columbia Basin Chinook salmon sampled at Bonneville Dam in 2012. Due to high water temperatures, sampling hours were restricted in weeks 32-34.

REFERENCES

Beamish, R.J., and G.A. McFarlane. 1983. The forgotten requirement for age validation in fisheries biology. Transactions of the American Fisheries Society 112:735-743.

Clutter, R.I., and L.E. Whitesel. 1956. Collection and interpretation of sockeye salmon scales. International Pacific Salmon Fisheries Commission Bulletin 9.

Elston, R. 1996. Investigation of headburns in adult salmonids. Final Report 1996. DOE/BP-96-050-00. Bonneville Power Administration, Portland, Oregon.

Fish Passage Center. 2012. All Adult Counts and Brights vs. Tule fall Chinook at Bonneville Dam 2010. Online at: http://www.fpc.org/adultsalmon/adultqueries/Adult_Table_Submit.html and http://www.fpc.org/adultsalmon/adulthistory/bon_tule_brights_2012.html. Last accessed 2012.

Fryer, J.K. 1995. Columbia Basin sockeye salmon: Causes of their past decline, factors contributing to their present low abundance, and the future outlook. Ph.D. Thesis. University of Washington, Seattle.

Fryer, J.K., and M. Schwartzberg. 1994. Age and length composition of Columbia Basin spring and summer chinook salmon at Bonneville Dam in 1993. Columbia River Inter-Tribal Fish Commission Technical Report 94-1. Portland, Oregon.

Gilbert, C.H. 1912. Age at maturity of the Pacific coast salmon of the genus Oncorhynchus. Bulletin of the Bureau of Fisheries 32:1-22.

Groberg, W. 1996. Investigation of headburns in adult salmonids. Phase I: Examinations at Lookingglass Hatchery in 1996. Addendum to final report 1995. DOE/BP-96-050-00. Bonneville Power Administration, Portland, Oregon.

Hagerman Hatchery Evaluation Team. 2009. A review of literature and studies performed and/or compiled at the Hagerman National Fish Hatchery concerning soreback and dorsal fin erosion. US Fish and Wildlife Service. Boise, Idaho.

Hatch, Douglas R., Ryan Branstetter, Joe Blodgett, Bill Bosch, David Fast, and Todd Newsome. 2003. Kelt Reconditioning: A Research Project to Enhance Iteroparity in Columbia Basin Steelhead (Oncorhynchus mykiss) - 2003 Annual Report. Columbia River Inter-Tribal Fish Commission Technical Report 2000-017-00. Portland, Oregon.

Hess, J.E., Nathan Campbell, Andrew Matala, and Shawn Narum. *Year* Annual Report Genetic Assessment of Columbia River Stocks. Columbia River Inter-Tribal Fish Commission Technical

Report 2008-907-00. Portland, Oregon. Online at http://www.critfc.org/fish-and-watersheds/fishery-science/scientific-reports/.

International North Pacific Fisheries Commission. 1963. Annual report – 1961. Vancouver, Canada.

Knudsen, C.M. 1990. Bias and variation in stock composition estimates due to scale regeneration. Pages 63-70 in N.C. Parker, A.E. Giorgi, R.C. Heidinger, D.B. Jester, Jr., E.D. Prince, and G.A. Winans (editors). Fish-Marking Techniques. American Fisheries Society Symposium 7. Bethesda, Maryland.

Koo, T.S.Y. 1962. Age designation in salmon. Pages 37-48 in T.S.Y. Koo (editor). Studies of Alaska Red Salmon. University of Washington Press, Seattle, Washington.

Nielsen L.A. and D.L. Johnson, editors. 1983. Fisheries Techniques. American Fisheries Society USA.

Neter, J., W. Wasserman, and M.H. Kutner. 1985. Applied linear statistical models: regression, analysis of variance, and experimental designs. Irwin, Homewood, Illinois.

PST (Pacific Salmon Treaty). 1985. Treaty between the United States of America and the government of Canada concerning Pacific salmon. Treaty Document Number 99-2.

Rich, W.H., and H.B. Holmes. 1928. Experiments in marking young chinook salmon on the Columbia River, 1916 to 1927. Bulletin of the Bureau of Fisheries 44:215-64.

Thompson, Steven K. 1987. Sample size for estimating multinomial proportions. The American Statistician. 41:42-46.

U.S. v. Oregon Technical Advisory Committee. 1997. 1996 All Species Review Columbia River Fish Management Plan.

APPENDIX

List of Tables

Table A1. Composition (%) of observed injuries of Columbia Basin Chinook and sockeye salmon and steelhead sampled at Bonneville Dam in 2012.

Injury Category	Spring	Summer	Fall	Sockeye	Steelhead
Marine Mammal Bites & Scrapes	31.76	12.02	4.92	3.12	14.60
Descaling					
3-19%	4.73	27.04	34.65	44.96	16.15
>20%	0.69	2.79	3.21	3.36	2.96
Net Marks	2.41	0.64	3.53	1.47	9.56
Hook					
Hook Damage	1.10	2.79	2.57	0.37	2.89
Hook Present	0.34	0.21	0.05	0.00	0.40
Headburn	0.09	0.00	0.00	0.00	0.00
Other Injuries					
Bruise	0.00	0.00	0.11	0.00	0.07
Head Injury	0.60	1.29	6.63	0.37	1.68
Fin Injury	0.77	0.21	0.86	0.12	0.54
Fungus	0.77	0.21	0.00	0.00	0.00
Gash	1.46	3.43	6.84	2.81	11.51
Parasite	0.00	0.00	0.16	0.12	0.34
Total	**3.44**	**4.94**	**17.22**	**4.09**	**19.65**

Descaling percent is based on total body and was summarized into only two categories.

Totals under Other Injuries do not represent the sum of the injury subcategories, they are the number of fish with at least one of the injuries in the Other Injury category.

Note – due to protocol change, the number of Other injuries reported were greatly reduced (See Sample Design Section)

Table A2. Length-at-age estimates for Columbia Basin spring Chinook salmon sampled at Bonneville Dam in 2012.

Brood Year and	2010	2009		2008		2007		2006
Age Class	0.1	0.2	1.1	0.3	1.2	0.4	1.3	1.4
Statistical Week 17								
Mean Fork Length (cm)		63.50			71.24		87.30	
Maximum		63.5			84.0		102.0	
Minimum		63.5			60.5		78.0	
Standard Deviation		---			4.58		6.47	
Sample Size		1			77		15	
Statistical Week 18								
Mean Fork Length (cm)			56.50		70.63		89.63	
Maximum			61.5		83.0		94.0	
Minimum			46.5		62.0		84.0	
Standard Deviation			6.09		4.26		3.50	
Sample Size			5		160		16	
Statistical Week 19								
Mean Fork Length (cm)			47.63	74.00	70.62		86.13	90.00
Maximum			52.5	79.0	83.0		94.0	90.0
Minimum			44.5	69.0	59.0		76.0	90.0
Standard Deviation			2.68	7.07	4.59		4.53	---
Sample Size			8	2	257		20	1
Statistical Week 20								
Mean Fork Length (cm)		63.50	49.50		70.58		87.42	
Maximum		64.0	56.0		84.0		102.5	
Minimum		63.0	42.5		54.0		74.0	
Standard Deviation		0.71	4.49		5.42		7.18	
Sample Size		2	12		172		12	
Statistical Week 21								
Mean Fork Length (cm)		62.67	49.79	91.00	71.39	91.50	86.36	
Maximum		65.5	61.0	91.0	82.0	91.5	98.0	
Minimum		58.5	44.0	91.0	59.0	91.5	73.5	
Standard Deviation		3.69	4.35	---	4.75	---	6.67	
Sample Size		3	14	1	74	1	11	
Statistical Week 22								
Mean Fork Length (cm)	43.75	60.67	47.90	81.00	73.92	102.00	89.05	
Maximum	45.5	66.5	53.0	81.0	84.5	102.0	98.5	
Minimum	42.0	49.5	44.0	81.0	62.0	102.0	79.5	
Standard Deviation	2.47	9.67	3.68	---	4.60	---	5.97	
Sample Size	2	3	5	1	66	1	10	
2012 Composoite								
Mean Fork Length (cm)	**43.75**	**62.28**	**49.86**	**80.00**	**71.02**	**96.75**	**87.57**	**90.00**
Maximum	**45.5**	**66.5**	**61.5**	**91.0**	**84.5**	**102.0**	**102.5**	**90.0**
Minimum	**42.0**	**49.5**	**42.5**	**69.0**	**54.0**	**91.5**	**73.5**	**90.0**
Standard Deviation	**2.47**	**5.33**	**4.83**	**9.02**	**4.80**	**7.42**	**5.64**	**---**
Sample Size	**2**	**9**	**44**	**4**	**806**	**2**	**84**	**1**

Table A3. Length-at-age estimates for Columbia Basin summer Chinook salmon sampled at Bonneville Dam in 2012.

Brood Year and	2010	2009		2008		2007	
Age Class	0.1	0.2	1.1	0.3	1.2	0.4	1.3
Statistical Week 22							
Mean Fork Length (cm)			60.5	75	73.5		92
Maximum			60.5	75	83		94.5
Minimum			60.5	75	67		88
Standard Deviation			---	---	4.49		3.5
Sample Size			1	1	14		3
Statistical Week 23							
Mean Fork Length (cm)		63.75	51.96	80.00	73.79	92.50	85.50
Maximum		66.0	62.0	80.0	83.5	92.5	93.0
Minimum		61.5	48.0	80.0	60.5	92.5	75.5
Standard Deviation		3.18	3.43	---	5.29	---	6.17
Sample Size		2	12.00	1	68	1	12
Statistical Week 24							
Mean Fork Length (cm)	47.00	58.25	51.10	82.86	73.73	93.13	86.23
Maximum	47.0	62.0	59.0	90.0	83.0	95.0	92.0
Minimum	47.0	54.5	45.0	77.0	61.0	90.0	80.0
Standard Deviation	---	5.30	4.83	4.63	5.17	2.39	3.38
Sample Size	1	2	10	7	37	4	11
Statistical Week 25							
Mean Fork Length (cm)		65.60	52.25	85.75	73.76	91.83	87.13
Maximum		70.5	55.5	91.0	83.0	101.5	91.0
Minimum		59.0	49.0	77.0	61.0	87.0	80.5
Standard Deviation		4.76	4.60	6.08	5.35	8.37	4.73
Sample Size		5	2	4	31	3	4
Statistical Week 26							
Mean Fork Length (cm)		64.00	50.86	84.81	71.61	92.00	87.50
Maximum		67.0	58.5	90.0	81.0	94.0	94.0
Minimum		58.5	48.0	79.0	62.0	90.0	84.5
Standard Deviation		4.77	3.52	4.33	5.29	2.83	4.49
Sample Size		3	7	8	9	2	4
Statistical Week 27							
Mean Fork Length (cm)		65.75	51.25	78.58	72.38	85.25	85.00
Maximum		69.5	60.5	81.0	79.0	85.5	92.0
Minimum		58.5	46.0	75.5	64.5	85.0	78.5
Standard Deviation		4.94	6.61	2.01	4.53	0.35	4.25
Sample Size		4	4	6	20	2	7
Statistical Week 28							
Mean Fork Length (cm)	41.88	64.60	53.00	80.50	72.28	91.50	90.50
Maximum	48.0	67.0	56.0	87.0	80.0	98.0	101.0
Minimum	37.0	62.0	47.0	67.0	64.5	80.5	87.0
Standard Deviation	4.59	2.41	3.36	8.03	4.10	7.82	7.00
Sample Size	4	5	6	5	25	4	4
Statistical Week 29							
Mean Fork Length (cm)	42.25	66.50	54.19	82.00	72.29		
Maximum	43.5	71.0	63.0	82.0	80.5		
Minimum	41.0	62.0	48.0	82.0	66.0		
Standard Deviation	1.77	6.36	5.15	0.00	5.12		
Sample Size	2	2	8	2	7		
Statistical Week 30							
Mean Fork Length (cm)		59.50	56.50	81.00	73.43	87.00	
Maximum		63.5	63.0	81.0	84.0	87.0	
Minimum		55.5	52.0	81.0	64.5	87.0	
Standard Deviation		5.66	5.07	---	7.14	---	
Sample Size		2	4	1	7	1	
Statistical Week 31							
Mean Fork Length (cm)	43.50	64.93		78.00	69.25		
Maximum	46.0	72.0		81.0	73.5		
Minimum	41.0	56.0		75.0	65.0		
Standard Deviation	3.54	5.15		4.24	6.01		
Sample Size	2	7		2	2		
2012 Composite							
Mean Fork Length (cm)	**42.89**	**64.27**	**52.56**	**81.93**	**73.27**	**91.06**	**86.80**
Maximum	**48.0**	**72.0**	**63.0**	**91.0**	**84.0**	**101.5**	**101.0**
Minimum	**37.0**	**54.5**	**45.0**	**67.0**	**60.5**	**80.5**	**75.5**
Standard Deviation	**3.56**	**4.59**	**4.53**	**5.16**	**5.06**	**5.34**	**5.06**
Sample Size	**9**	**32**	**54**	**37**	**220**	**17**	**45**

Table A4. Length-at-age estimates for Columbia Basin fall Chinook salmon sampled at Bonneville Dam in 2012.

Brood Year and	2010	2009		2008		2007	
Age Class	0.1	0.2	1.1	0.3	1.2	0.4	1.3
Statistical Week 31							
Mean Fork Length (cm)	41.00	75.50		82.00	72.50		
Maximum	41.0	76.0		82.0	73.0		
Minimum	41.0	75.0		82.0	72.0		
Standard Deviation	---	0.71		---	0.71		
Sample Size	1	2		1	2		
Statistical Week 32							
Mean Fork Length (cm)	43.75	65.50	59.50	80.00		90.00	
Maximum	49.0	70.0	61.0	80.0		90.0	
Minimum	40.5	61.0	58.0	80.0		90.0	
Standard Deviation	3.80	6.36	2.12	---		---	
Sample Size	4	2	2	1		1	
Statistical Week 33							
Mean Fork Length (cm)	46.00	62.40		81.50	75.00		83.00
Maximum	46.0	70.0		88.5	75.0		83.0
Minimum	46.0	55.0		77.0	75.0		83.0
Standard Deviation	---	5.40		6.14	---		---
Sample Size	1	5		3	1		1
Statistical Week 34							
Mean Fork Length (cm)	47.58	64.75	54.88	81.35	71.42	88.25	78.50
Maximum	55.5	80.0	61.5	92.0	82.0	95.0	79.5
Minimum	40.0	50.0	48.0	72.0	51.0	76.0	76.5
Standard Deviation	3.79	6.16	4.53	5.10	7.88	5.95	1.17
Sample Size	25	42	13	24	13	10	5
Statistical Week 35							
Mean Fork Length (cm)	47.86	64.18	57.91	79.29	74.86	86.77	76.13
Maximum	55.0	79.0	63.0	87.5	80.0	95.0	79.0
Minimum	40.5	52.0	51.0	68.0	64.0	69.5	70.0
Standard Deviation	3.31	5.01	4.12	4.57	4.30	6.67	3.43
Sample Size	33	89	11	41	11	28	8
Statistical Week 36							
Mean Fork Length (cm)	47.85	64.57	57.58	79.82	73.15	86.30	82.83
Maximum	58.0	80.0	69.0	87.0	84.0	94.0	87.5
Minimum	40.0	52.0	47.5	68.0	63.0	79.0	77.0
Standard Deviation	4.25	5.97	6.41	5.11	5.90	4.37	5.35
Sample Size	39	100	13	57	10	28	3
Statistical Week 37							
Mean Fork Length (cm)	47.69	65.11	57.27	78.74	69.57	84.94	80.00
Maximum	57.0	76.0	63.0	94.0	75.5	99.0	80.0
Minimum	39.5	53.0	49.0	69.0	56.5	73.0	80.0
Standard Deviation	3.78	4.25	3.52	5.06	7.57	5.19	---
Sample Size	51	125	15	66	7	34	1
Statistical Week 38							
Mean Fork Length (cm)	47.50	62.74	55.97	76.28	77.21	82.07	87.30
Maximum	55.5	74.5	63.0	86.0	85.0	94.5	96.0
Minimum	39.0	51.0	48.0	66.0	67.0	65.5	82.0
Standard Deviation	3.46	4.65	4.79	4.52	7.14	6.69	6.30
Sample Size	102	155	15	43	7	27	5
Statistical Week 39							
Mean Fork Length (cm)	47.57	62.36	57.00	77.92	69.50	83.71	77.75
Maximum	55.5	78.0	61.0	89.0	74.0	93.5	86.0
Minimum	41.0	47.0	54.5	70.0	65.0	71.0	69.5
Standard Deviation	3.75	5.87	2.30	4.76	6.36	7.64	11.67
Sample Size	82	96	6	19	2	7	2
Statistical Week 40							
Mean Fork Length (cm)	47.12	62.98	57.21	74.90	76.25	81.50	
Maximum	56.0	75.0	65.0	79.0	78.0	86.0	
Minimum	39.0	54.5	52.5	68.0	74.5	78.0	
Standard Deviation	3.70	3.88	4.35	3.49	2.47	2.36	
Sample Size	52	63	7	15	2	11	
Statistical Week 41							
Mean Fork Length (cm)	46.12	63.53	59.63	75.00	72.63	80.89	
Maximum	54.0	74.0	62.0	81.0	74.0	86.0	
Minimum	40.0	55.0	55.0	68.0	71.0	76.0	
Standard Deviation	3.15	4.57	3.20	3.92	1.60	3.62	
Sample Size	38	45	4	7	4	9	
2012 Composite							
Mean Fork Length (cm)	**47.38**	**63.76**	**56.95**	**78.58**	**73.10**	**84.73**	**80.20**
Maximum	**58.0**	**80.0**	**69.0**	**94.0**	**85.0**	**99.0**	**96.0**
Minimum	**39.0**	**47.0**	**47.5**	**66.0**	**51.0**	**65.5**	**69.5**
Standard Deviation	**3.67**	**5.15**	**4.48**	**5.05**	**6.26**	**5.91**	**6.06**
Sample Size	**428**	**724**	**86**	**277**	**59**	**155**	**25**

Table A5. Length-at-age estimates for Columbia Basin sockeye salmon sampled at Bonneville Dam in 2012.

Brood Year and	2009	2008		2007	
Age Class	1.1	1.2	2.1	1.3	2.2
Statistical Week 22					
Mean Fork Length (cm)		46.00		52.50	
Maximum		46.5		52.5	
Minimum		45.5		52.5	
Standard Deviation		0.50		---	
Sample Size		3		1	
Statistical Week 23					
Mean Fork Length (cm)		49.73		57.17	
Maximum		55.0		57.5	
Minimum		44.0		57.0	
Standard Deviation		2.64		0.29	
Sample Size		59		3	
Statistical Week 24					
Mean Fork Length (cm)	37.50	49.63		57.40	56.00
Maximum	38.0	55.0		58.5	56.0
Minimum	37.0	44.0		56.0	56.0
Standard Deviation	0.71	1.96		1.08	---
Sample Size	2	184		5	1
Statistical Week 25					
Mean Fork Length (cm)	39.17	49.50	40.50	56.56	49.83
Maximum	39.5	57.0	40.5	59.0	51.0
Minimum	38.5	37.0	40.5	54.5	48.0
Standard Deviation	0.58	2.31	---	1.61	1.61
Sample Size	3	380	1	8	3
Statistical Week 26					
Mean Fork Length (cm)	40.17	49.73	40.00	58.00	51.00
Maximum	46.0	57.0	40.0	60.5	55.0
Minimum	38.0	40.0	40.0	55.5	47.5
Standard Deviation	2.63	2.12	---	3.54	2.81
Sample Size	9	403	1	2	7
Statistical Week 27					
Mean Fork Length (cm)	40.00	49.72	42.75		50.50
Maximum	40.0	56.0	47.5		52.5
Minimum	40.0	43.5	39.0		47.0
Standard Deviation	0.00	2.03	3.97		2.26
Sample Size	2	354	4		5
Statistical Week 28					
Mean Fork Length (cm)	38.00	49.67	40.00	53.00	49.50
Maximum	38.0	55.0	40.0	53.0	50.5
Minimum	38.0	42.5	40.0	53.0	48.5
Standard Deviation	---	2.16	---	---	1.41
Sample Size	1	109	1	1	2
Statistical Week 29					
Mean Fork Length (cm)	36.00	49.57		51.00	
Maximum	36.0	54.5		51.0	
Minimum	36.0	46.0		51.0	
Standard Deviation	---	2.03		---	
Sample Size	1	21		1	
Statistical Week 30					
Mean Fork Length (cm)	42.50	49.42	41.50		51.00
Maximum	42.5	53.5	41.5		51.0
Minimum	42.5	45.0	41.5		51.0
Standard Deviation	---	2.92	---		---
Sample Size	1	12	1		1
Statistical Week 31					
Mean Fork Length (cm)		53.00			
Maximum		53.0			
Minimum		53.0			
Standard Deviation		---			
Sample Size		1			
2012 Composite					
Mean Fork Length (cm)	**39.50**	**49.64**	**41.63**	**56.36**	**50.79**
Maximum	**46.0**	**57.0**	**47.50**	**60.50**	**56.0**
Minimum	**36.0**	**37.0**	**39.00**	**51.00**	**47.0**
Standard Deviation	**2.27**	**2.16**	**2.90**	**2.28**	**2.46**
Sample Size	**19**	**1526**	**8**	**21**	**19**

Table A6. Length-at-age estimates for Columbia Basin steelhead sampled at Bonneville Dam in 2012.

Ocean	Salt-Winters		
Age Class	1	2	3
Statistical Week 17			
Mean Fork Length (cm)		72.50	
Maximum		72.5	
Minimum		72.5	
Standard Deviation		---	
Sample Size		1	
Statistical Week 18			
Mean Fork Length (cm)	55.00	80.25	
Maximum	55.0	84.5	
Minimum	55.0	76.0	
Standard Deviation	---	6.01	
Sample Size	1	2	
Statistical Week 19			
Mean Fork Length (cm)	61.00	67.60	
Maximum	61.0	71.5	
Minimum	61.0	65.0	
Standard Deviation	---	3.13	
Sample Size	1	5	
Statistical Week 20			
Mean Fork Length (cm)	66.50	74.07	
Maximum	66.5	82.5	
Minimum	66.5	69.0	
Standard Deviation	---	5.26	
Sample Size	1	7	
Statistical Week 21			
Mean Fork Length (cm)	63.80	66.00	
Maximum	66.5	68.0	
Minimum	61.5	64.0	
Standard Deviation	2.17	2.83	
Sample Size	5	2	
Statistical Week 22			
Mean Fork Length (cm)	63.40	69.38	
Maximum	65.0	76.0	
Minimum	61.0	64.5	
Standard Deviation	1.47	3.71	
Sample Size	5	12	
Statistical Week 23			
Mean Fork Length (cm)	61.75	72.21	
Maximum	66.0	84.0	
Minimum	51.5	63.0	
Standard Deviation	6.93	6.66	
Sample Size	4	7	
Statistical Week 24			
Mean Fork Length (cm)	56.42	67.60	
Maximum	65.0	71.0	
Minimum	48.0	65.0	
Standard Deviation	6.86	2.61	
Sample Size	6	5	
Statistical Week 25			
Mean Fork Length (cm)	62.92	70.83	
Maximum	70.0	76.5	
Minimum	58.0	67.0	
Standard Deviation	4.52	5.01	
Sample Size	6	3	

Ocean	Salt-Winters		
Age Class	1	2	3
Statistical Week 35			
Mean Fork Length (cm)	57.92	73.19	
Maximum	68.5	86.0	
Minimum	51.0	61.5	
Standard Deviation	4.20	5.21	
Sample Size	72	70	
Statistical Week 36			
Mean Fork Length (cm)	56.60	75.52	86.00
Maximum	63.5	89.0	86.0
Minimum	51.5	62.0	86.0
Standard Deviation	3.33	6.32	---
Sample Size	24	28	1
Statistical Week 37			
Mean Fork Length (cm)	57.04	76.98	
Maximum	63.0	85.0	
Minimum	52.0	68.0	
Standard Deviation	3.61	4.35	
Sample Size	12	22	
Statistical Week 38			
Mean Fork Length (cm)	56.40	77.74	87.83
Maximum	61.0	89.0	90.0
Minimum	49.0	66.0	83.5
Standard Deviation	2.91	5.65	3.75
Sample Size	20	58	3
Statistical Week 39			
Mean Fork Length (cm)	60.96	80.51	86.50
Maximum	68.0	91.0	90.0
Minimum	56.0	69.5	83.0
Standard Deviation	3.30	4.25	4.95
Sample Size	14	53	2
Statistical Week 40			
Mean Fork Length (cm)	58.65	79.18	88.50
Maximum	72.0	89.0	90.0
Minimum	51.0	68.0	87.0
Standard Deviation	5.84	4.86	2.12
Sample Size	13	73	2
Statistical Week 41			
Mean Fork Length (cm)	60.00	79.89	87.50
Maximum	67.0	88.0	89.0
Minimum	53.0	69.0	86.0
Standard Deviation	3.91	4.93	2.12
Sample Size	17	59	2
2012 Composite			
Mean Fork Length (cm)	58.05	73.40	87.23
Maximum	72.0	91.0	90.0
Minimum	48.0	59.0	83.0
Standard Deviation	4.26	5.97	2.71
Sample Size	592	855	11

Ocean	Salt-Winters		
Age Class	1	2	3
Statistical Week 35			
Mean Fork Length (cm)	57.92	73.19	
Maximum	68.5	86.0	
Minimum	51.0	61.5	
Standard Deviation	4.20	5.21	
Sample Size	72	70	
Statistical Week 36			
Mean Fork Length (cm)	56.60	75.52	86.00
Maximum	63.5	89.0	86.0
Minimum	51.5	62.0	86.0
Standard Deviation	3.33	6.32	---
Sample Size	24	28	1
Statistical Week 37			
Mean Fork Length (cm)	57.04	76.98	
Maximum	63.0	85.0	
Minimum	52.0	68.0	
Standard Deviation	3.61	4.35	
Sample Size	12	22	
Statistical Week 38			
Mean Fork Length (cm)	56.40	77.74	87.83
Maximum	61.0	89.0	90.0
Minimum	49.0	66.0	83.5
Standard Deviation	2.91	5.65	3.75
Sample Size	20	58	3
Statistical Week 39			
Mean Fork Length (cm)	60.96	80.51	86.50
Maximum	68.0	91.0	90.0
Minimum	56.0	69.5	83.0
Standard Deviation	3.30	4.25	4.95
Sample Size	14	53	2
Statistical Week 40			
Mean Fork Length (cm)	58.65	79.18	88.50
Maximum	72.0	89.0	90.0
Minimum	51.0	68.0	87.0
Standard Deviation	5.84	4.86	2.12
Sample Size	13	73	2
Statistical Week 41			
Mean Fork Length (cm)	60.00	79.89	87.50
Maximum	67.0	88.0	89.0
Minimum	53.0	69.0	86.0
Standard Deviation	3.91	4.93	2.12
Sample Size	17	59	2
2012 Composite			
Mean Fork Length (cm)	58.05	73.40	87.23
Maximum	72.0	91.0	90.0
Minimum	48.0	59.0	83.0
Standard Deviation	4.26	5.97	2.71
Sample Size	592	855	11