AGE AND LENGTH COMPOSITION OF COLUMBIA BASIN CHINOOK AND SOCKEYE SALMON AND STEELHEAD AT BONNEVILLE DAM IN 2008

Technical Report 09-05

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ABSTRACT

The Columbia River Inter-Tribal Fish Commission (CRITFC) conducted a field study at Bonneville Dam in 2008 to assess the age, length-at-age and stock composition of adult Pacific salmon migrating up the Columbia River. These data were then used to predict the 2009 Chinook salmon run. Adult spring, summer and fall Chinook salmon (Oncorhynchus tshawytscha), sockeye salmon (O. nerka) and summer-run steelhead (O. mykiss) were collected, sampled for scales and additional biological data, revived and released. Caudal fin clips were also taken from Chinook salmon and steelhead for later 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 four-year-olds were the most abundant age group for spring Chinook salmon comprising 75.1% of the run. Three-year-olds were the most abundant age class for fall Chinook and four-year-olds were the most abundant for the summer Chinook making up 50.9% and 58.6% of their respective runs. Four-year-olds were the most abundant age group for sockeye salmon comprising 89.1% of the run, and three and four-year-old were the most abundant in steelhead comprising 40.4% and 44.6% respectively of the run. Based on fin marks for classification, the steelhead migration consisted of 71.7% hatchery- and 28.3% natural-origin steelhead. A-run steelhead, less than 78cm in length, comprised 73% of the steelhead run. B-run fish, equal to or greater than 78cm, comprised 27% of the run.

A year-class regression based on up to 19 years of data was used to predict spring, summer, and bright fall Chinook salmon population sizes for 2009. Based on three-year-old returns, the relationship predicts four-year-old returns of 259,500 (± 88,200, 90% predictive interval [PI]) spring Chinook, 58,700 (± 24,700, 90% PI) summer, and 218,600 (± 67,200, 90% PI) bright fall Chinook salmon for the 2009 runs. Based on four-year-old returns, the relationship predicts five-year-old returns of 26,100 (± 38,900, 90% PI) spring 49,700 (± 9,300, 90% PI) summer, and 37,200 (± 46,000, 90% PI) bright fall Chinook salmon for the 2009 runs.

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INTRODUCTION

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

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

Scale pattern analysis, the analysis of concentric rings or circuli to provide records of previous life history, is a common method for age determination in Pacific salmon (Nielsen and Johnson 1983). Fast summer growth widens the distances between circuli on the scale and slow winter growth shortens the distance between circuli. Typically, age can be determined by counting the number of winters observed on the scale (Gilbert 1913, Rich and Holmes 1929). This method is valuable in Pacific salmon management because scales can be collected without sacrificing the fish and scale samples can be collected, processed, and aged promptly. Problems with this method may include variability in scale growth, scale resorption, and difficulties in age validation (Knudsen 1990, Beamish and McFarlane 1983).

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

The primary objectives for the 2008 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 2009 run size for Chinook salmon using the age composition data, to PIT tag summer Chinook and sockeye salmon, and to collect tissue samples for use in the development of a genetic stock monitoring and identification program for Chinook salmon and steelhead.

METHODS

Study Area

Research was conducted at the Adult Fish Facility (AFF) located adjacent to the Second Powerhouse at Bonneville Dam (river km 235) on the north side of the Columbia River (Figure 1). This facility uses a picket weir to divert migrating fish, ascending the Washington shore fish ladder, into the adult sampling facility collection pool. An attraction flow is used to draw fish through a false weir where they can be selected for sampling. Fish not selected and fish that have recovered from sampling are returned to the Washington Shore Fish ladder above the picket weir.

Chinook salmon generally migrate between March and November and are typically categorized into three races based on migration timing past Bonneville Dam. Chinook salmon passing Bonneville from March 15 through June 15 are classified as spring Chinook, from June 16 through July 31 are classified as summer Chinook and August 1 through November 15 are classified as fall Chinook. The fall Chinook run consists of lower river Tules and the Upriver Bright fall Chinook. Based on the needs of the Pacific Salmon Commission, this study only collects information on Upriver Bright fall Chinook. 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 (greater than 78 cm for B-run).

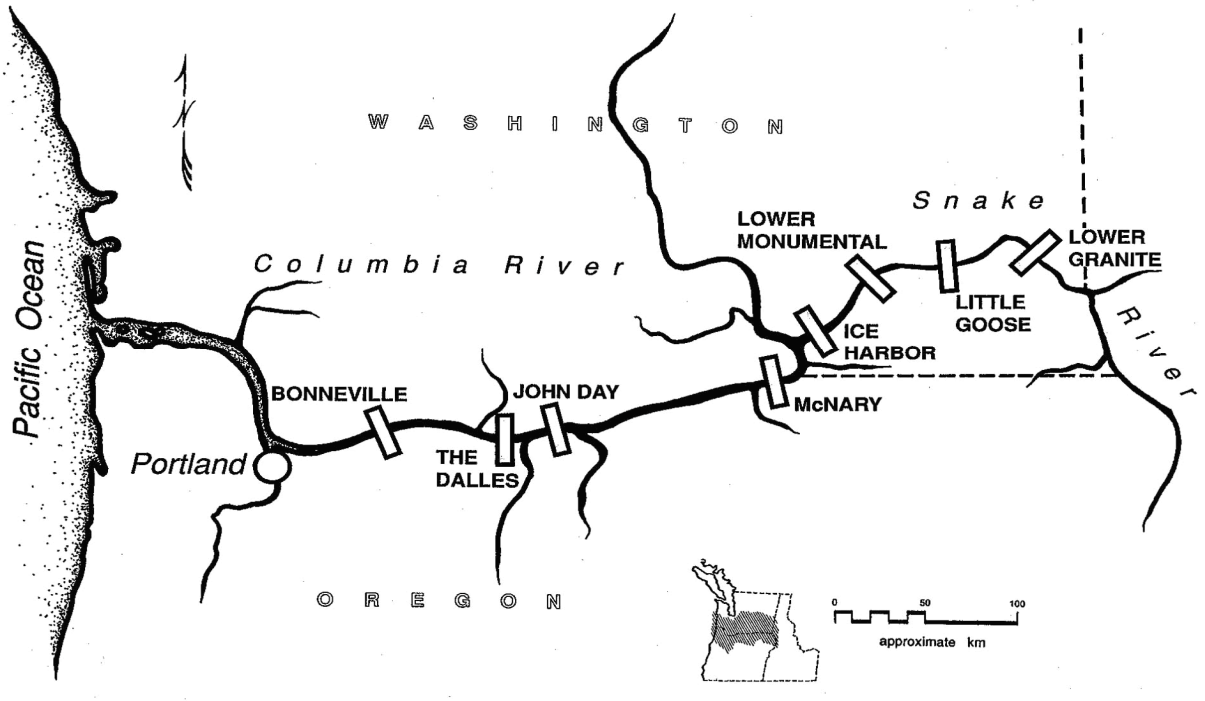

Figure 1. Map of the Columbia River displaying federal dams. Bonneville Dam (rkm 235)

Sample Design

Adult fish were sampled one to five days per Statistical Week[1] from March through October. A desired minimum sample size of 610 fish each was set for spring, summer, and fall Chinook, and sockeye salmon is required for age composition. Additional Chinook and sockeye were sampled to satisfy sample size requirements for other projects. 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. 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 length-at-age 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 (2008).

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*). All sizes of sockeye and steelhead 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 from all Chinook salmon for genetic stock composition analysis. These genetic samples will be used in the development of a genetic stock identification program for Columbia River Chinook salmon. All fish sampled were scanned for PIT tags and any PIT tag codes recorded. In 2008, our goal was to PIT tag all Chinook and sockeye salmon sampled which were not already PIT tagged. 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,

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. In 2006, for example, Statistical Week 15 began on April 9 and ended on April 15.
2. Tule fall Chinook counts are subtracted from the total fall Chinook counts to estimate the upriver bright fall Chinook.

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 1913, Rich and Holmes 1929). A sub-sample of scales were independently reviewed by John Sneva of the Washington Department of Fish and Wildlife for corroboration of age estimates. Direct age validation (Beamish and McFarlane 1983) was not performed, as there were no marked fish whose age was known.

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.

Age and Length-at-Age Composition

Age composition was determined by weighing the proportion of each age class sampled by the total counts of each species passing Bonneville dam during each Statistical Week. The length-at-age composition for each species sampled was determined by calculating the mean length for each age class present during each Statistical Week.

Steelhead Hatchery/Wild Determination

Most hatchery reared steelhead in the Columbia River Basin are marked by removing a fin, typically the adipose fin. Some hatchery-origin steelhead are released unmarked and to identify these individuals scale pattern analysis methods were developed by Oregon Department of Fish and Wildlife (ODFW) to determine hatchery versus wild origin. 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 to three years.

Due to the wide variety of requests for hatchery and wild determinations by various agencies using different methods, we decided in 2006 to allow the managing agencies to make their own determinations based on the raw age, scale pattern, and fin mark data. For this report hatchery and wild determinations are based on fin clips alone.

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

Steelhead A/B Run Determination

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 78cm (Busby et al. 1996). 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 a iteroparous scale pattern. A kelt scale age is indicated through the use of the letter "S" to indicate spawning. For instance, a steelhead of Age 1.2S1 would have one freshwater annulus, two saltwater annuli, a spawning check, followed by one saltwater annulus. Note that scale resorption often occurs in kelts which can eliminate saltwater annuli marks so a kelt is likely older than would be indicated by summing the annuli.

Chinook Salmon Run-Size Prediction

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

Fryer and Schwartzberg (1994) determined that adult returns of Columbia basin Chinook are comprised almost entirely of 3, 4 and 5 year old fish, with the proportions of each age class being relatively constant across years. As such, the number of three-year-old fish for a given BY is a relatively good predictor of the number of four-year-old fish from the same BY that would return in the subsequent year. This relationship and a regression analysis (Neter et al. 1985, Weisberg 1985) were used to predict the abundance of four-year-old fish for 2009, based on the number of three-year-old fish estimated to have returned in 2008. A similar relationship was used to predict abundance of five-year-old fish in 2009, from the estimated number four-year-old fish that returned in 2008.

RESULTS

Sampling

Chinook salmon (spring, summer and fall) were sampled for 26 weeks (April through October) during their migration. A total of 1004 spring Chinook were sampled, 1167 summer Chinook and 1301 fall Chinook (Tables 1, 2 and 3 respectively). A total of 1162 sockeye salmon were sampled (Table 4) over 8 weeks (June through July), and 2639 steelhead were sampled (Table 5) over 27 weeks (April through October).

Age Composition

Based on scale pattern analysis four-year-olds were the most abundant age group for spring Chinook salmon, comprising 75.1% of the spring Chinook migration (Table 1, Figure 2). Four-year-olds were also the most abundant group for summer Chinook salmon and three-year-olds were the most abundant for fall Chinook salmon, comprising 58.6% of the summer Chinook migration (Table 2) and 50.9% of the fall Chinook migration (Table 3). Three-year-old fish were second most abundant for spring and summer Chinook, while four-year-olds were second most abundant for fall Chinook. For spring and fall Chinook three-year-old fish were third most abundant while five-year-old summer Chinook were third most abundant. .

Scale patterns indicated a steady increase in the percentage of ocean-type Chinook salmon from 0% in Statistical Week 21 to above 90% after Statistical Week 39, with a corresponding decrease in the percentage of stream-type Chinook salmon (Figure 3).

The Sockeye salmon run also was composed primarily of four-year-olds (89.1%), with five-, and six-years-olds being less abundant (Table 4).

The steelhead age composition was composed of mostly four-year-olds (44.6%) and three-year-olds (40.4%) and based on a single year of freshwater residence is likely due to the large percentage of hatchery origin fish in this run (Table 5). Five-year-olds were the next most abundant at 11.4%.

Table 1. Weekly and cumulative age composition of Columbia Basin spring Chinook at Bonneville Dam in 2008.

Statistical	Sampling	Number	Number	Weekly	2006	2005	2004		2003			2002			Fin Clips	
Week	Date	Sampled	Ageable	Run Size	0.1	1.1	0.3	1.2	0.4	1.3	2.2	0.5	1.4	2.3	Adipose	Other
16	4/15,4/16,4/18	43	38	11083	0.000	0.026	0.000	0.763	0.000	0.211	0.000	0.000	0.000	0.000	0.895	0.000
17	4/22,4/23,4/25	117	101	11566	0.000	0.030	0.000	0.832	0.000	0.139	0.000	0.000	0.000	0.000	0.861	0.000
18	4/29,4/30,5/2	160	131	29779	0.000	0.061	0.000	0.870	0.000	0.069	0.000	0.000	0.000	0.000	0.908	0.000
19	5/6,5/7,5/8	180	157	30679	0.000	0.134	0.000	0.796	0.000	0.070	0.000	0.000	0.000	0.000	0.834	0.000
20	5/12,5/13,5/14,5/15	261	227	36638	0.004	0.256	0.000	0.709	0.000	0.035	0.000	0.000	0.000	0.000	0.899	0.000
21	5/19,5/20,5/22,5/24	91	83	12009	0.000	0.446	0.000	0.506	0.000	0.048	0.000	0.000	0.000	0.000	0.880	0.000
22	5/26,5/27,5/28,5/29	152	137	11385	0.000	0.307	0.007	0.606	0.000	0.073	0.000	0.000	0.007	0.000	0.803	0.000
Cumulative		**1004**	**874**	**143139**	**0.001**	**0.173**	**0.001**	**0.750**	**0.000**	**0.076**	**0.000**	**0.000**	**0.001**	**0.000**	**0.874**	**0.000**

Notes:

a Sampling began in Week 16. Weekly run size for week 16 includes spring Chinook passing prior to week 16

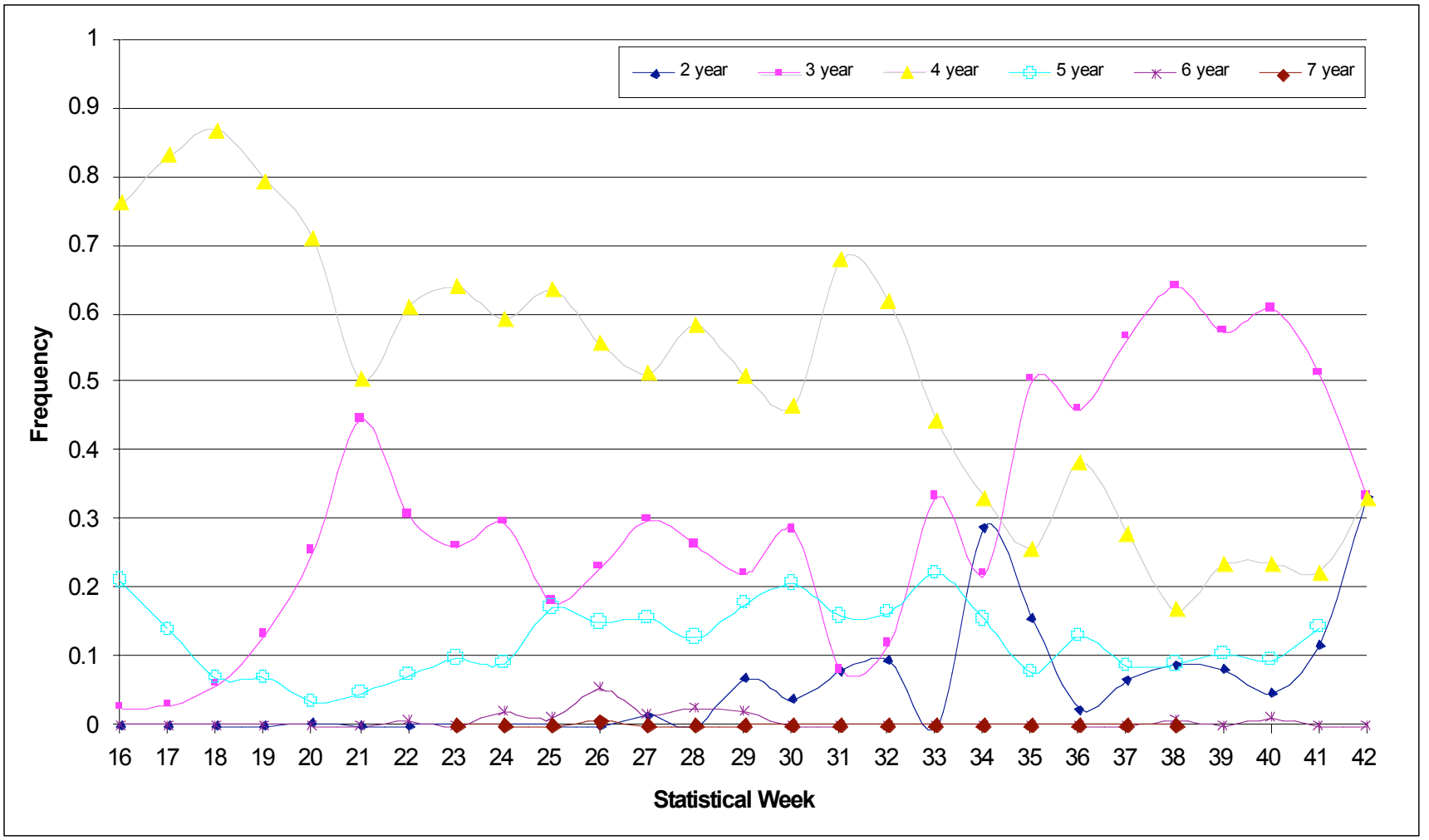

Figure 2. : Weekly age composition estimates for age groups of Columbia Basin Chinook salmon sampled at Bonneville Dam in 2008.

Table 2. Weekly and cumulative age composition of Columbia Basin summer Chinook salmon sampled at Bonneville Dam in 2008.

Statistical	Sampling	Number	Number	Weekly	2006	2005		2004		2003			2002			2001		Fin Clips	
Week	Date	Sampled	Ageable	Run Size	0.1	0.2	1.1	0.3	1.2	0.4	1.3	2.2	0.5	1.4	2.3	0.6	1.5	Adipose	Other
23	6/3,6/4,6/5,6/6	187	164	13203	0.000	0.018	0.244	0.030	0.610	0.000	0.091	0.006	0.000	0.000	0.000	0.000	0.000	0.396	0.000
24	6/10,6/11,6/12,6/13	104	98	15766	0.000	0.041	0.255	0.122	0.469	0.000	0.092	0.000	0.000	0.020	0.000	0.000	0.000	0.673	0.000
25	6/15,6/16,6/17,6/18,6/19	111	99	19655	0.000	0.051	0.131	0.253	0.384	0.010	0.162	0.000	0.000	0.010	0.000	0.000	0.000	1.000	0.000
26	6/23,6/24,6/25,6/26,6/27	159	147	15410	0.000	0.088	0.143	0.184	0.374	0.020	0.129	0.000	0.007	0.048	0.000	0.000	0.007	0.272	0.007
27	6/30,7/1,7/2,7/3	77	70	8914	0.014	0.100	0.200	0.214	0.300	0.014	0.143	0.000	0.000	0.014	0.000	0.000	0.000	0.829	0.000
28	7/6,7/7,7/8,7/9,7/10	178	156	5932	0.000	0.141	0.122	0.224	0.359	0.019	0.109	0.000	0.006	0.019	0.000	0.000	0.000	0.635	0.006
29	7/14,7/15,7/16,7/17,7/18	235	212	6026	0.071	0.137	0.085	0.189	0.321	0.038	0.142	0.000	0.000	0.019	0.000	0.000	0.000	0.175	0.000
30	7/21,7/22,7/23,7/24	87	77	3099	0.039	0.169	0.117	0.182	0.286	0.039	0.169	0.000	0.000	0.000	0.000	0.000	0.000	0.156	0.000
31	7/28,7/29,7/30,8/1	29	25	1887	0.080	0.040	0.040	0.320	0.360	0.040	0.120	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cumulative		**1167**	**1048**	**89892**	**0.009**	**0.071**	**0.172**	**0.174**	**0.412**	**0.013**	**0.126**	**0.001**	**0.002**	**0.018**	**0.000**	**0.000**	**0.001**	**0.583**	**0.002**

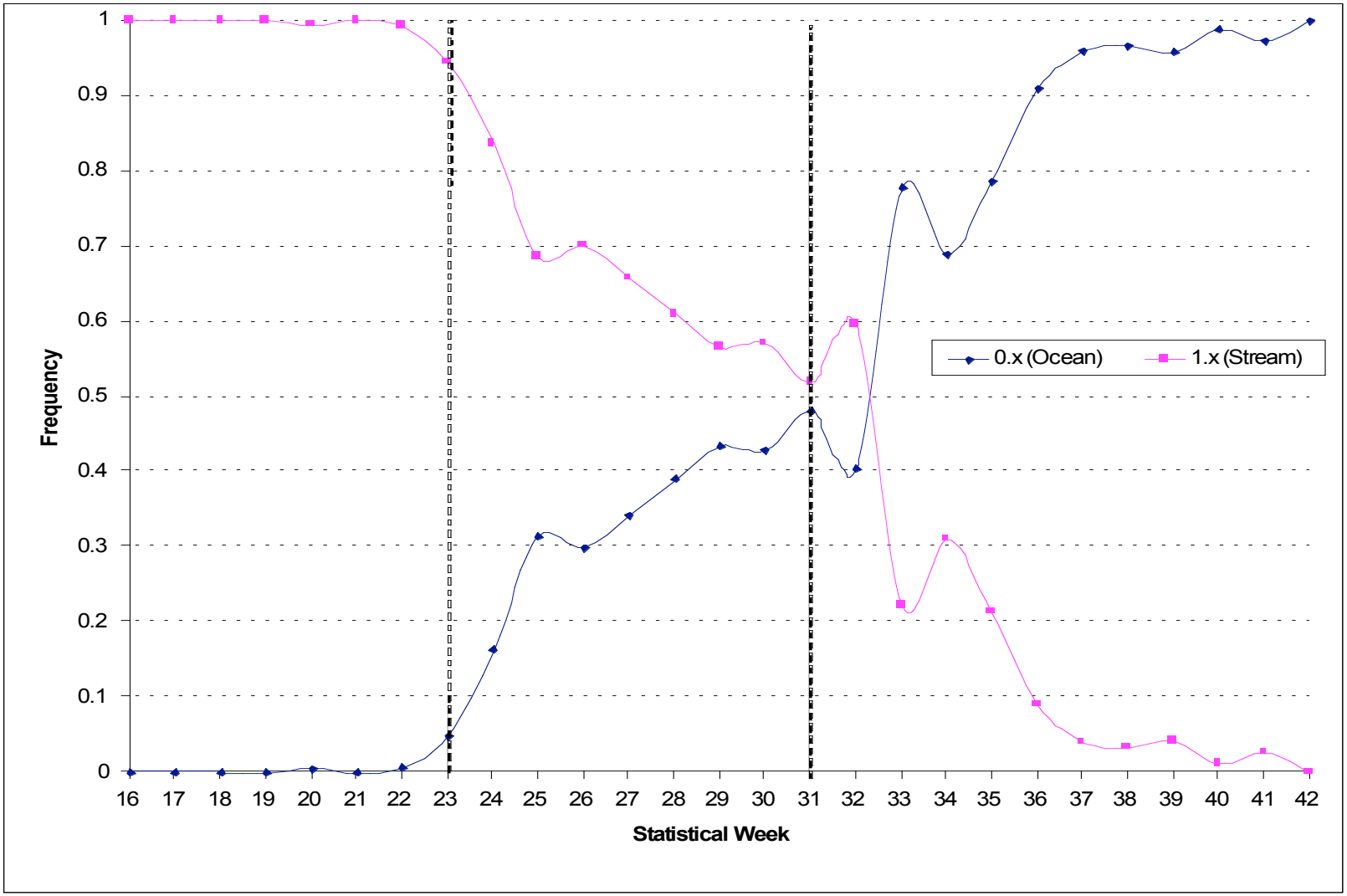

Figure 3. Weekly freshwater age composition estimates of Columbia Basin Chinook salmon sampled at Bonneville Dam in 2008. Spring Chinook migrate during weeks 16-23, summer Chinook during weeks 23-31 and fall Chinook after week 31.

Table 3. Weekly and cumulative age composition of Columbia Basin bright fall Chinook salmon sampled at Bonneville Dam in 2008.

Statistical Week	Sampling Date	Number Sampled	Number Ageable	Weekly Run Size	2006	2005		2004		2003		2002	
					0.1	0.2	1.1	0.3	1.2	0.4	1.3	1.4	0.5
31	7/28,29,30,8/1	10	9	642	0.000	0.111	0.111	0.333	0.333	0.111	0	0	0
32	8/4,5,6,7	45	42	3299	0.095	0.071	0.048	0.119	0.500	0.119	0.048	0	0
33	8/11,12,13,14	9	9	6816	0.000	0.222	0.111	0.333	0.111	0.222	0	0	0
34	8/18,8/21,8/22	53	45	14410	0.289	0.178	0.044	0.089	0.244	0.133	0.022	0	0
35	8/25,26,27,28	108	89	39828	0.157	0.404	0.101	0.146	0.112	0.079	0	0	0
36	9/2,3,4,5	185	167	62436	0.024	0.437	0.024	0.323	0.060	0.126	0.006	0	0
37	9/7,8,9,10,11	293	277	63077	0.069	0.563	0.004	0.245	0.032	0.083	0.004	0	0
38	9/14,15,16,17,18	225	212	34300	0.090	0.623	0.019	0.160	0.009	0.090	0	0.005	0.005
39	9/22,23,24,25,26	202	191	19045	0.084	0.560	0.016	0.220	0.016	0.094	0.010	0	0
40	9/29,30,10/1,2	90	84	10126	0.048	0.595	0.012	0.238	0.000	0.095	0	0	0.012
41	10/6,7,8,9,10	78	76	6024	0.118	0.500	0.013	0.211	0.013	0.145	0	0	0
42	10/14	3	3	3107	0.333	0.333	0	0.333	0	0.000	0	0	0
Cumulative		**1301**	**1204**	**263110**	**0.089**	**0.477**	**0.032**	**0.228**	**0.065**	**0.102**	**0.005**	**0.001**	**0.001**

Notes:

Length-at-Age Composition

Length-at-age composition estimates for all Chinook salmon are presented in Figure 4 and Appendix A.

Steelhead Hatchery/Wild Determination

When classifying hatchery and wild steelhead based on fin marks, the run consisted of 74.7% hatchery and 25.3% wild steelhead (Table 5).

Steelhead A/B Determination

Assuming that A-run (less than 78 cm) and B-run (greater than 78 cm) steelhead can be differentiated by length alone, the majority of the steelhead run (73%) passing Bonneville Dam were A-run, and the remaining 27% were B-run. Though A-run steelhead dominate the run, the percentage of B-run fish does generally increase as the run progresses.

Table 4. Weekly and cumulative age composition of Columbia Basin sockeye salmon sampled at Bonneville Dam in 2008.

Statistical Week	Sampling Date	Number Sampled	Number Ageable	Weekly Run Size	2005	2004		2003			Fin Clips	
					1.1	1.2	2.1	1.3	2.2	3.1	Adipose	Other
23	6/3,4,5,6	11	11	1181	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000
24	6/9,10,11,12,13,14,16	180	175	14849	0.023	0.954	0.006	0.006	0.011	0.000	0.006	0.000
25	6/15,16,17,18,19	363	354	77562	0.028	0.929	0.003	0.008	0.028	0.003	0.000	0.000
26	6/23,24,25,26,27	250	241	81214	0.058	0.880	0.029	0.004	0.029	0.000	0.008	0.000
27	6/30,7/1,7/2,7/3	200	194	30135	0.175	0.747	0.026	0.000	0.052	0.000	0.057	0.015
28	7/7,8,9,10	116	109	6367	0.275	0.670	0.018	0.000	0.028	0.009	0.000	0.000
29	7/14,15,16,17,18,21,23,28	42	41	2196	0.463	0.463	0.049	0.000	0.024	0.000	0.024	0.024
Cumulative		**1162**	**1125**	**213504**	**0.072**	**0.874**	**0.017**	**0.005**	**0.030**	**0.001**	**0.012**	**0.002**

Table 5. Weekly and cumulative age composition of Columbia Basin steelhead sampled at Bonneville Dam in 2008.

Statistical Week	Sampling Date	Number Sampled	Number Ageable	Weekly Run Size	2005	2004		2003			2002		2001	Repeat	Fin Clips		A-Run
					1.1	1.2	2.1	1.3	2.2	3.1	2.3	3.2	4.2	Spawner	Adipose	Other	Comp
16	4/15, 4/16, 4/18	3	3	289	0.667	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.000	0.000	1.00
17	4/22, 4/23, 4/25	4	2	276	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.000	0.000	1.00
18	4/29, 4/30, 5/2	2	2	325	0.000	0.500	0.000	0.500	0.000	0.000	0.000	0.000	0.000	0.00	1.000	0.000	1.00
19	5/6, 5/7, 5/8	1	1	301	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00	1.000	0.000	1.00
20	5/12, 5/13, 5/14, 5/15	2	2	259	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00	1.000	0.000	1.00
21	5/19, 5/20, 5/21, 5/22, 5/24	12	11	576	0.455	0.545	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.917	0.000	1.00
22	5/26, 5/27, 5/28, 5/29	27	23	620	0.348	0.565	0.043	0.000	0.043	0.000	0.000	0.000	0.000	0.00	0.852	0.000	0.89
23	6/3, 6/4, 6/5, 6/6	39	29	1005	0.517	0.414	0.069	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.923	0.000	0.97
24	6/9,6/10,6/11,6/12,6/13, 6/14	23	19	1663	0.316	0.632	0.000	0.000	0.000	0.053	0.000	0.000	0.000	0.00	0.913	0.000	1.00
25	6/15, 6/16, 6/17, 6/18, 6/19	14	12	3108	0.250	0.500	0.000	0.000	0.083	0.000	0.000	0.083	0.000	0.08	0.571	0.071	1.00
26	6/23, 6/24, 6/25, 6/26, 6/27	68	58	4755	0.310	0.431	0.103	0.000	0.086	0.017	0.000	0.052	0.000	0.00	0.588	0.029	0.97
27	6/30, 7/1, 7/2, 7/3	56	38	8243	0.263	0.342	0.132	0.000	0.132	0.079	0.000	0.053	0.000	0.00	0.536	0.000	1.00
28	7/10, 7/6, 7/7, 7/8, 7/9	198	151	17758	0.358	0.311	0.192	0.000	0.053	0.060	0.000	0.007	0.000	0.02	0.530	0.015	0.99
29	7/14, 7/15, 7/16, 7/17, 7/18	310	225	38017	0.480	0.196	0.222	0.000	0.036	0.053	0.000	0.004	0.000	0.01	0.500	0.058	0.97
30	7/21, 7/22, 7/23, 7/24	320	232	32977	0.560	0.142	0.181	0.000	0.017	0.060	0.000	0.026	0.000	0.01	0.606	0.056	0.99
31	7/28, 7/29, 7/30, 8/1	290	207	36102	0.671	0.140	0.077	0.000	0.053	0.024	0.000	0.024	0.000	0.01	0.707	0.072	0.98
32	8/4, 8/5, 8/6, 8/7	310	242	26624	0.649	0.157	0.079	0.000	0.074	0.012	0.000	0.029	0.000	0.00	0.716	0.055	0.96
33	8/11, 8/12, 8/13, 8/14	21	17	21052	0.706	0.059	0.118	0.000	0.118	0.000	0.000	0.000	0.000	0.00	0.762	0.143	0.95
34	8/18, 8/21, 8/22	42	33	18956	0.455	0.242	0.030	0.000	0.182	0.000	0.000	0.061	0.030	0.00	0.571	0.048	0.76
35	8/25, 8/26, 8/27, 8/28	58	45	23814	0.356	0.400	0.022	0.040	0.111	0.000	0.000	0.067	0.000	0.00	0.672	0.034	0.66
36	9/2, 9/3, 9/4, 9/5	144	106	41166	0.198	0.594	0.009	0.080	0.057	0.000	0.009	0.038	0.000	0.02	0.708	0.049	0.37
37	9/10, 9/11, 9/7, 9/8, 9/9	270	223	35191	0.166	0.695	0.004	0.040	0.081	0.000	0.000	0.009	0.004	0.00	0.767	0.037	0.35
38	9/14, 9/15, 9/16, 9/17, 9/18	153	119	24973	0.118	0.706	0.017	0.060	0.067	0.008	0.000	0.008	0.008	0.02	0.732	0.013	0.29
39	9/22, 9/23, 9/24, 9/25, 9/26	96	79	8410	0.165	0.684	0.013	0.110	0.013	0.000	0.000	0.000	0.000	0.01	0.802	0.063	0.30
40	10/1, 10/2, 9/29, 9/30	111	94	3678	0.149	0.628	0.043	0.090	0.064	0.000	0.011	0.011	0.000	0.01	0.721	0.099	0.38
41	10/10, 10/6, 10/7, 10/8, 10/9	60	47	1917	0.255	0.660	0.064	0.020	0.000	0.000	0.000	0.000	0.000	0.00	0.800	0.067	0.50
42	10/14	5	3	1183	0.333	0.667	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00	1.000	0.000	0.20
Cumulative		**2639**	**2023**	**353238**	**0.404**	**0.363**	**0.083**	**0.024**	**0.069**	**0.021**	**0.001**	**0.024**	**0.003**	**0.009**	**0.669**	**0.048**	**0.73**

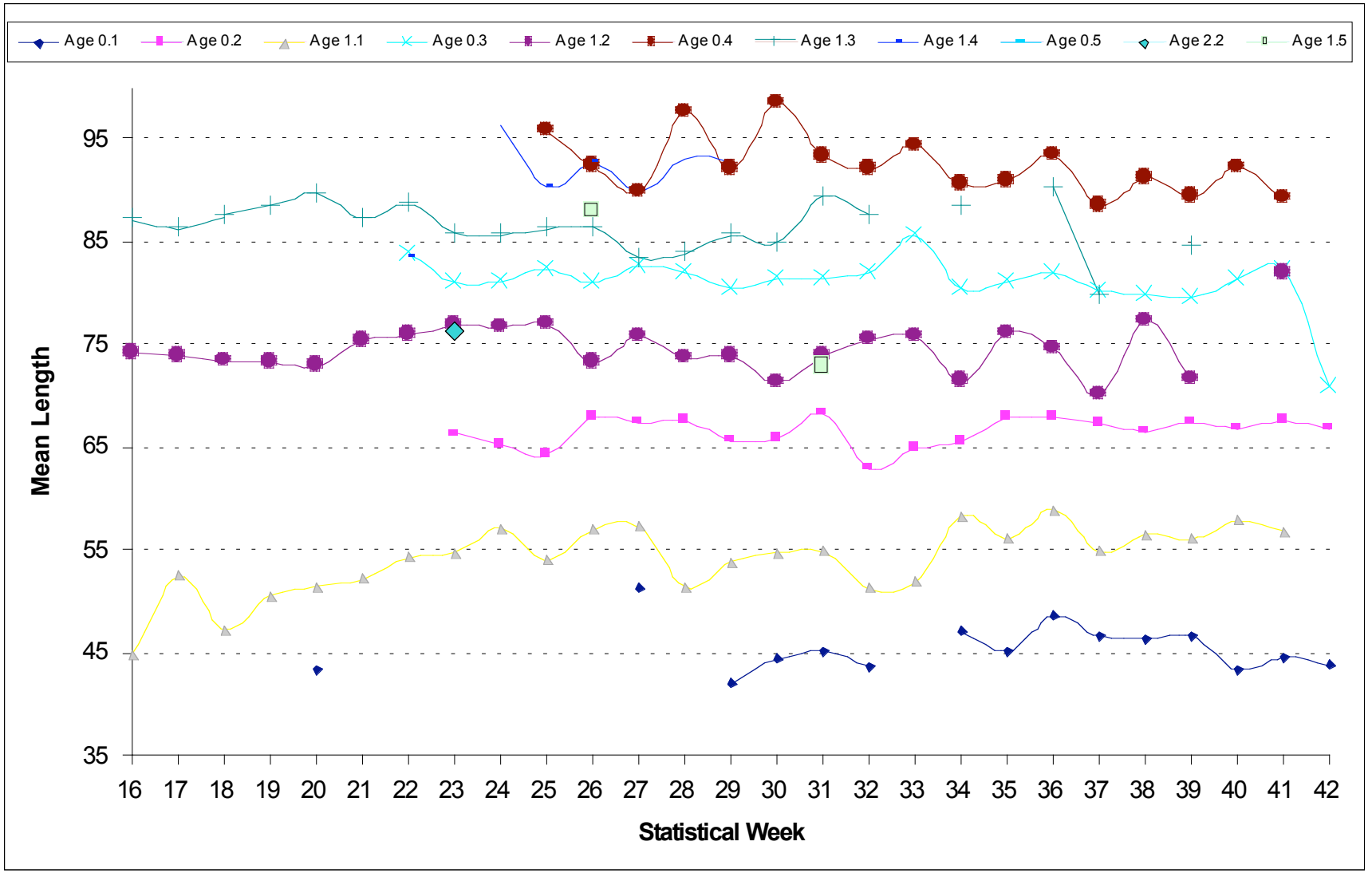

Figure 4. Weekly mean length estimates of common Columbia Basin Chinook salmon age classes (showing ocean- and stream-type) sampled at Bonneville Dam in 2008. Sampling did not occur during Weeks 31 through 35.

Fish Coloration and Condition

Bright coloration was observed in the majority of each species, 99.4% of spring Chinook, 96.8% of summer Chinook, 95% of fall Chinook, 99.9% of sockeye and 97.3% of steelhead. The highest condition rating of 5 was given to 91.7% of spring Chinook, 95.8% of summer Chinook, 94.7% of fall Chinook, 97.6% of sockeye and 94.7% of steelhead. Additional fish condition data can be found in Appendix A.

Chinook Salmon Run-Size Prediction for 2009

Using a linear relationship between the 2008 three- and four-year-old adult returns (Figure 5), the estimated number of four-year-old spring Chinook salmon returning to Bonneville Dam in 2009 is 259,100 (± 88,200, 90% prediction interval [PI]). Using the relationship between four- and five-year-olds to construct the model (Figure 6), albeit poorer than that existing between three-year-olds and four-year-olds, we predict that the 2009 five-year-old adult abundance at Bonneville Dam will be 26,100 (± 38,900, 90% PI).

For the 2009 summer Chinook salmon run at Bonneville Dam, the relationship between three- and four-year-olds (Figure 7) results in a prediction of 58,700 (± 24,700, 90% PI) four-year-olds. The relationship between four- and five-year-olds (Figure 8), the model predicts a return of 49,700 (± 9,300, 90% PI) five-year-olds.

Based on the relationship between three- and four-year-olds (Figure 9), the model results in a prediction of 218,600 (± 97,200, 90% PI) four-year-old Upriver Bright fall Chinook salmon returns for 2009. Using the relationship between four- and five-year-olds (Figure 10), the model results in a prediction of 37,200 (± 46,000, 90% PI) returning five-year-olds.

Based on the 2007 report (Whiteaker and Fryer 2007), we made run size predictions for four- and five-year-old spring, summer, and bright fall Chinook salmon returning to Bonneville Dam in 2008 using the methods discussed in this report. For the two principle age groups (four-year-old and five-year-old), we predicted 267,400 spring, 69,900 summer, and 142,500 bright fall Chinook versus the Fish Passage Center (2007) estimated returns of 113,972 spring, 65,252 summer and 105,266 bright fall Chinook salmon. All six age groups predicted for 2009 were within the 90% prediction interval (Table 8). Overall, we predict the 2009 return of four- and five-year old spring, summer, and fall Chinook salmon will all be less than the 2008 return (Table 8).

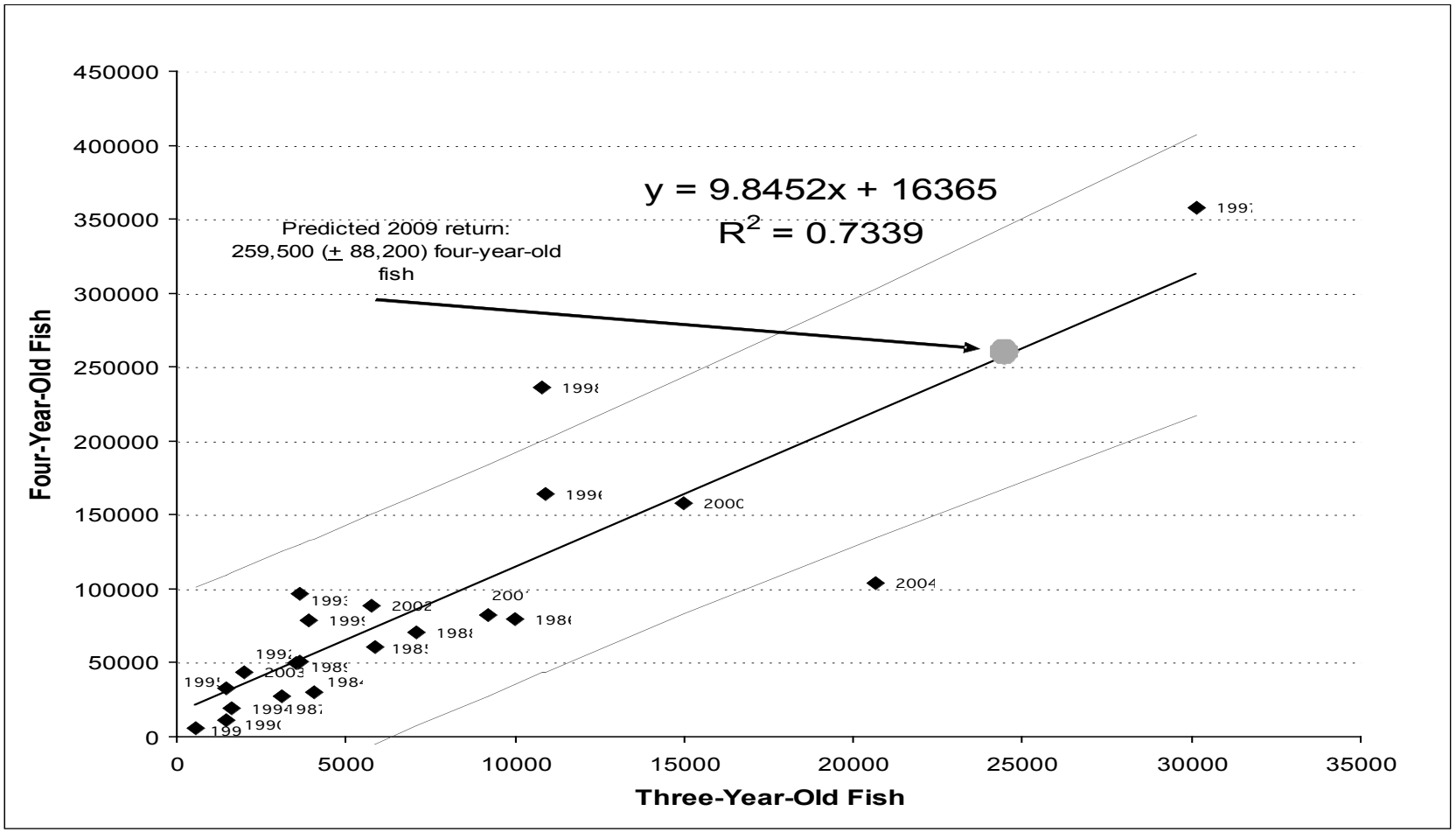

Figure 5. Predicted 2009 four-year-old Columbia Basin spring Chinook salmon abundance (at Bonneville Dam) based on a linear relationship between four-year-old and three-year-old fish abundance during brood years 1984 through 2002. Prediction intervals (90%) are also graphed.

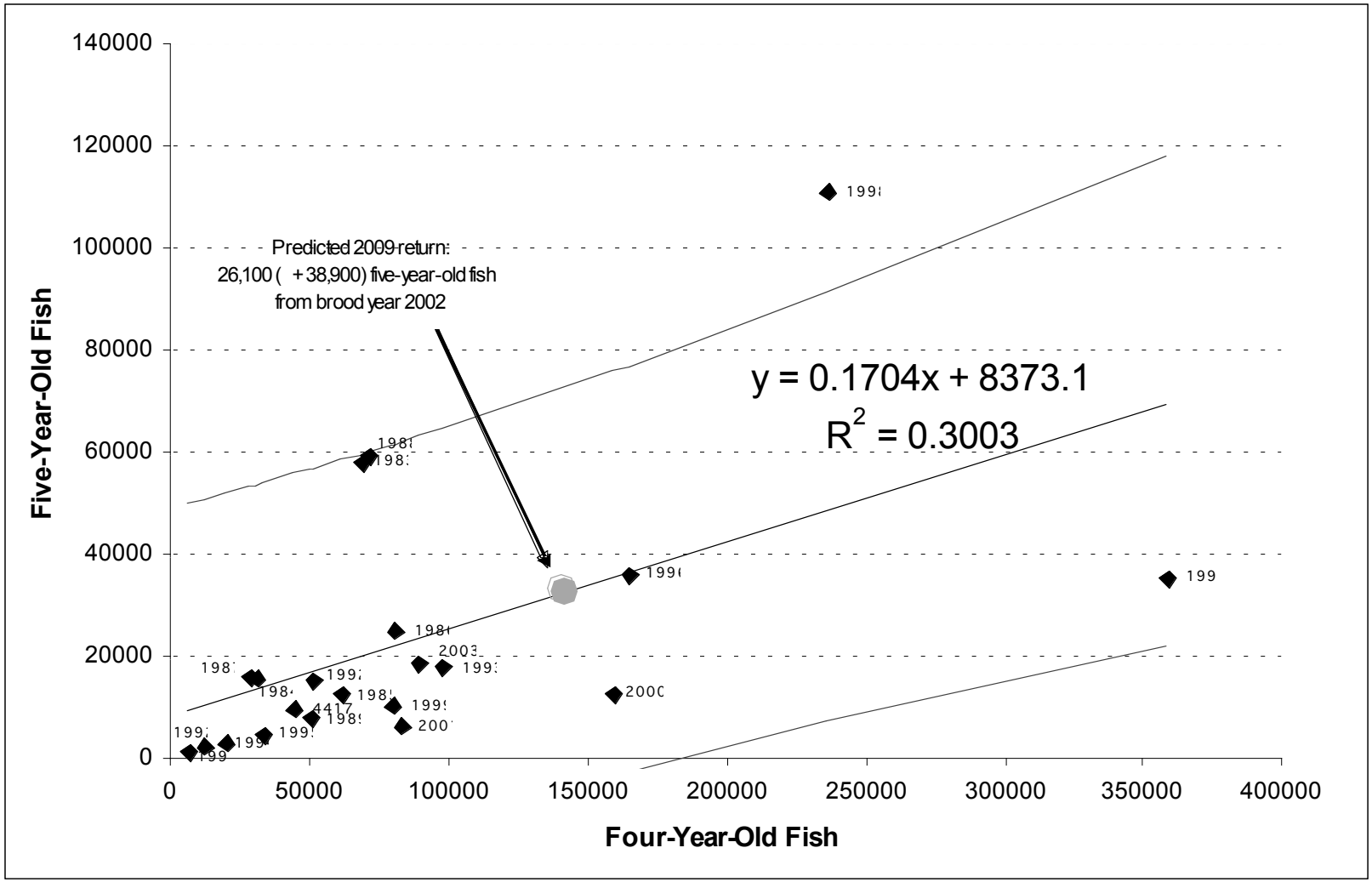

Figure 6. Predicted 2009 five-year-old Columbia Basin spring Chinook salmon abundance (at Bonneville Dam) based on a linear relationship between five-year-old and four-year-old fish abundance during brood years 1983 through 2001. Prediction intervals (90%) are also graphed.

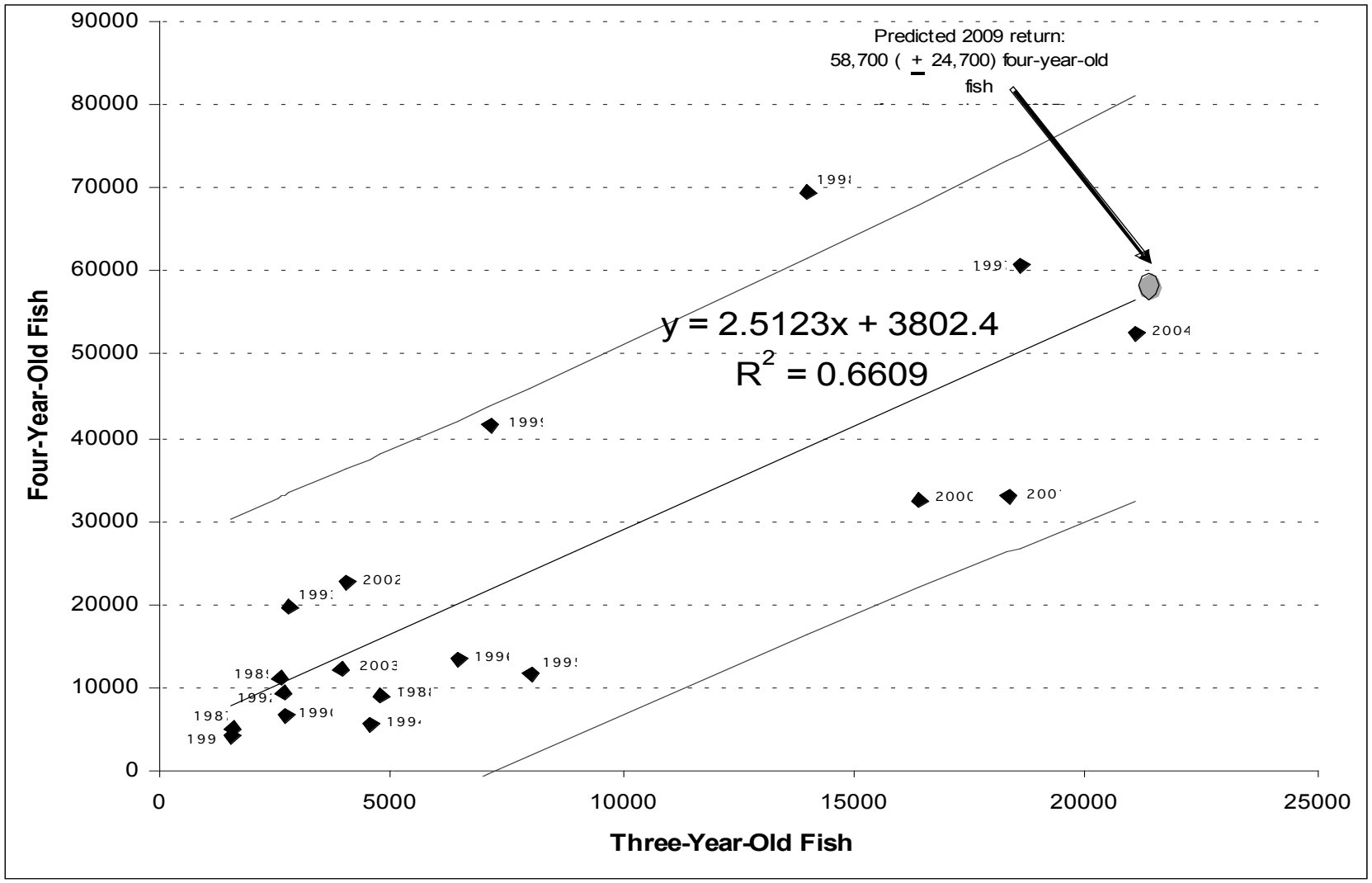

Figure 7. Predicted 2009 four-year-old Columbia Basin summer Chinook salmon abundance (at Bonneville Dam) based on a linear relationship between four-year-old and three-year-old fish abundance during brood years 1987 through 2002. Prediction intervals (90%) are also graphed.

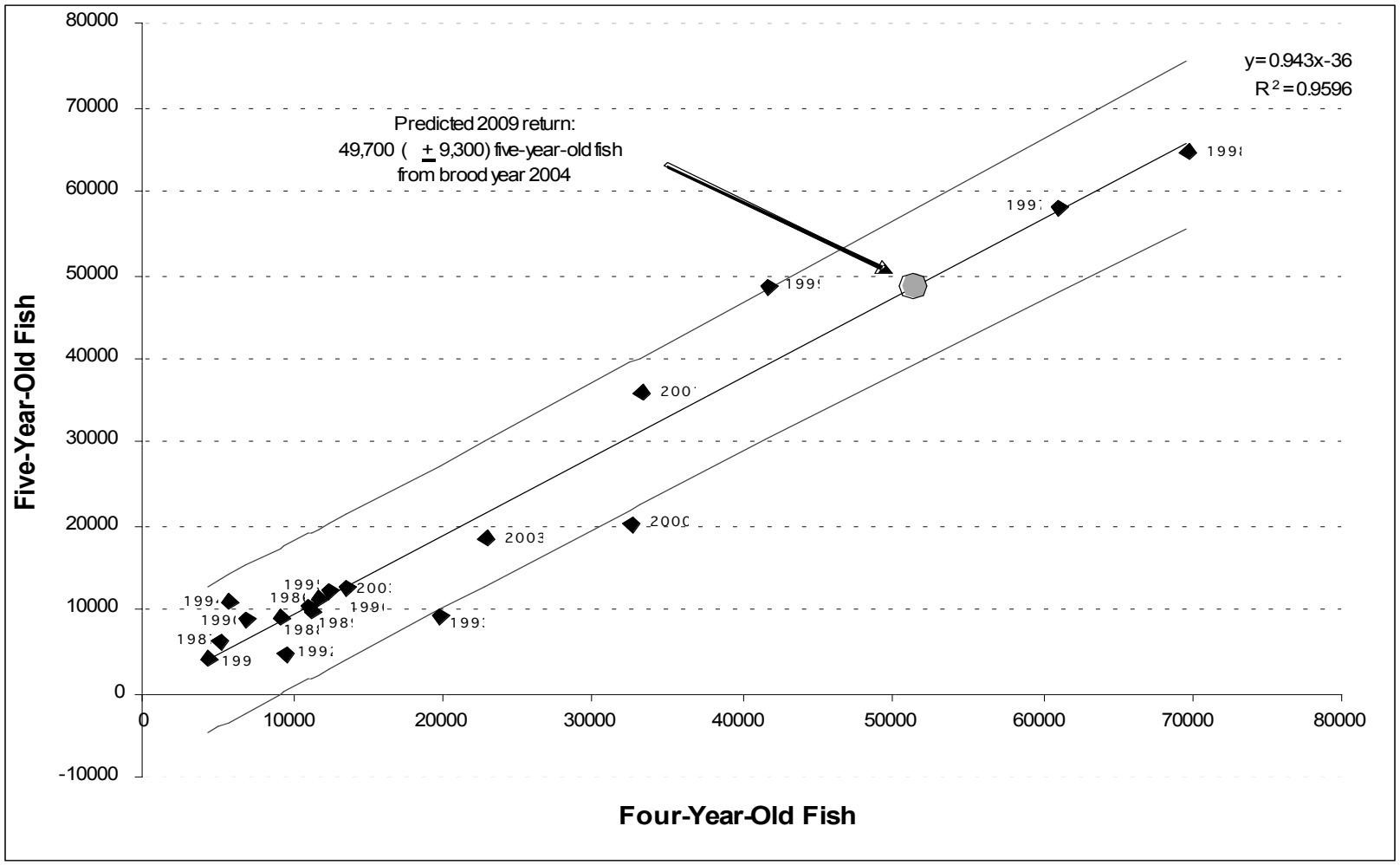

Figure 8. Predicted 2009 five-year-old Columbia Basin summer Chinook salmon abundance (at Bonneville Dam) based on a linear relationship between five-year-old and four-year-old fish abundance during brood years 1986 through 2001. Prediction intervals (90%) are also graphed.

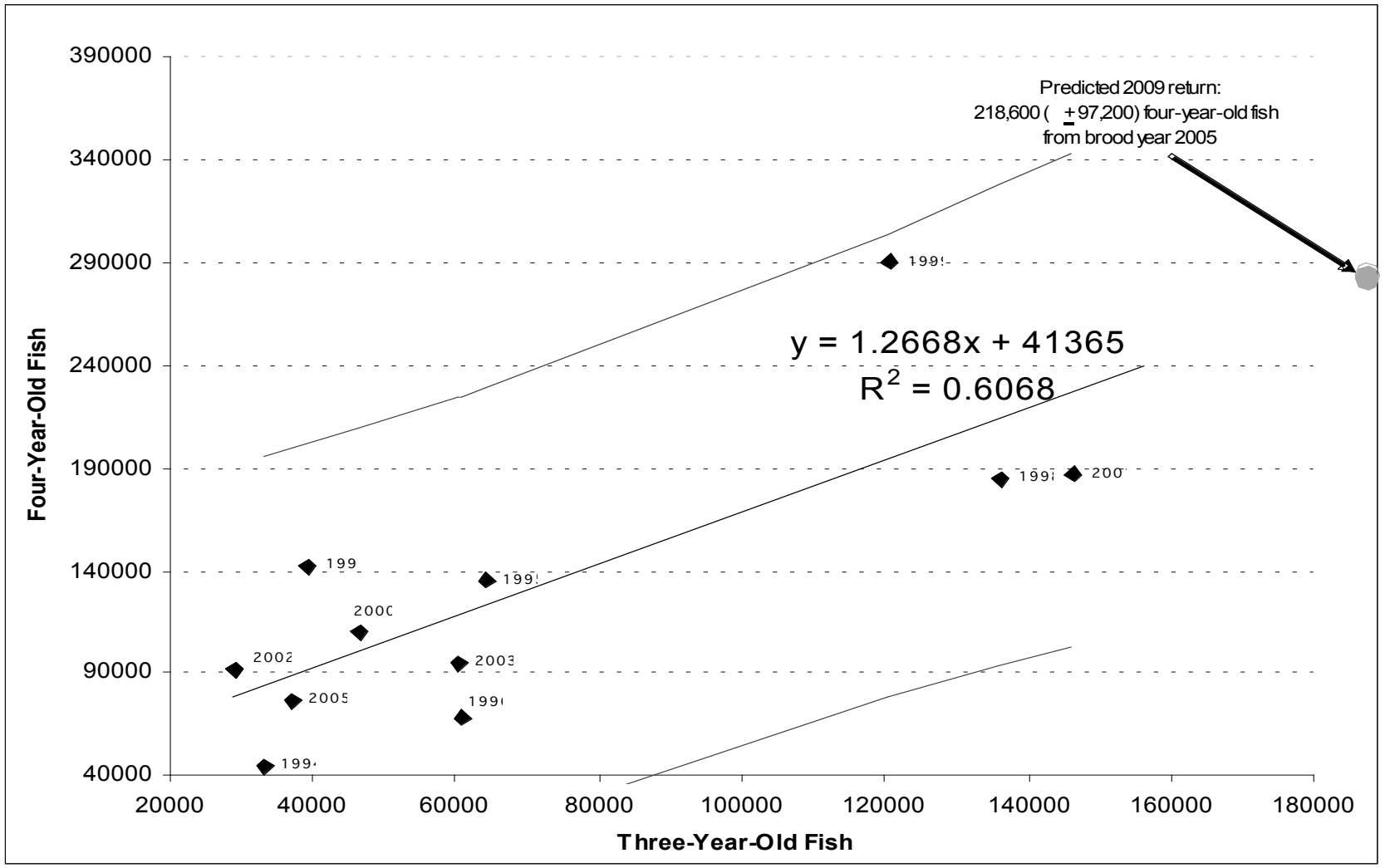

Figure 9. Predicted 2009 four-year-old Columbia Basin fall Chinook salmon abundance (at Bonneville Dam) based on a linear relationship between four-year-old and three-year-old fish abundance during brood years 1986 through 2002. Prediction intervals (90%) are also graphed.

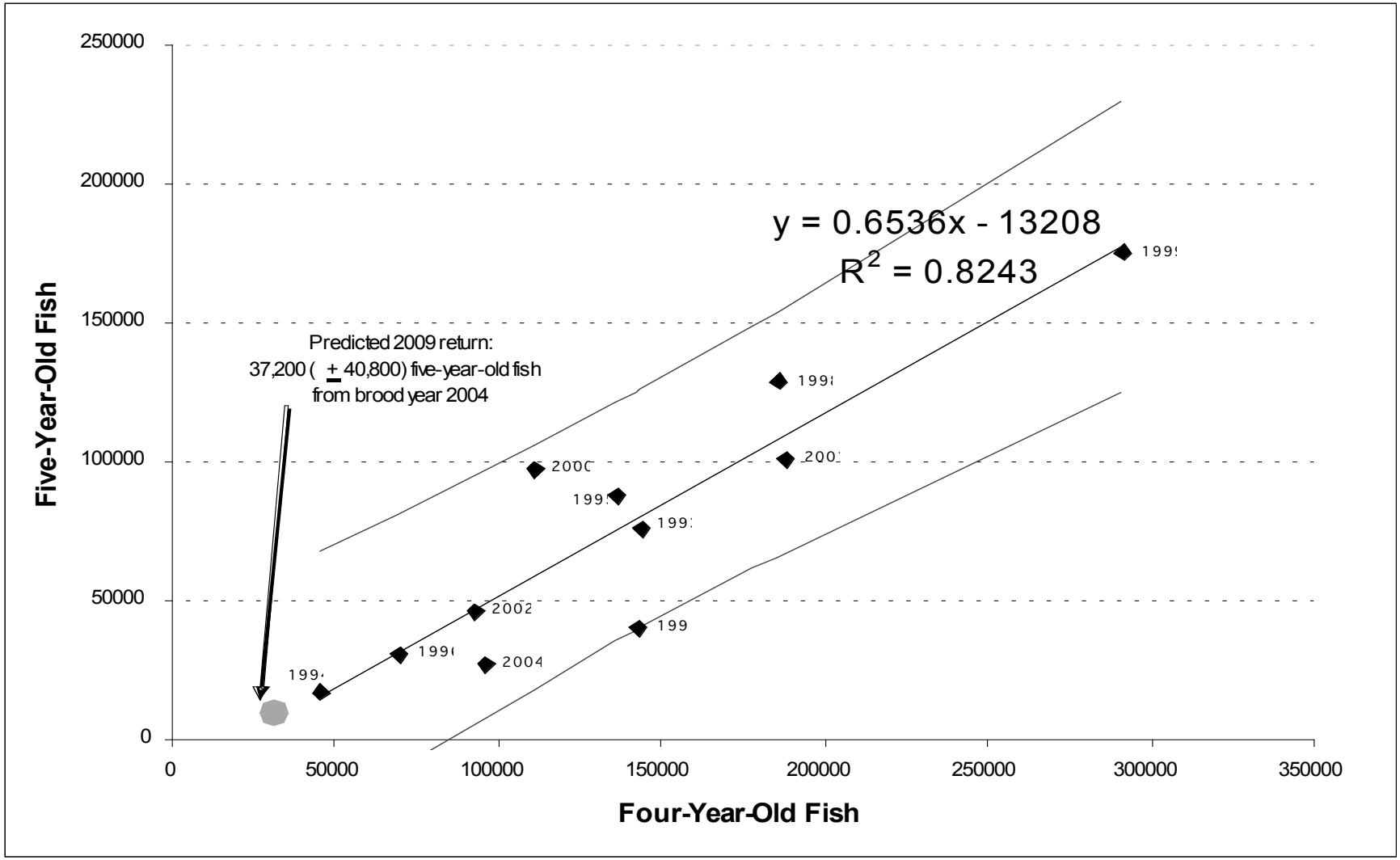

Figure 10. Predicted 2009 five-year-old Columbia Basin bright fall Chinook salmon abundance (at Bonneville Dam) based on a linear relationship between four-year-old and five-year-old fish abundance during brood years 1993 through 2001. Prediction intervals (90%) are also graphed.

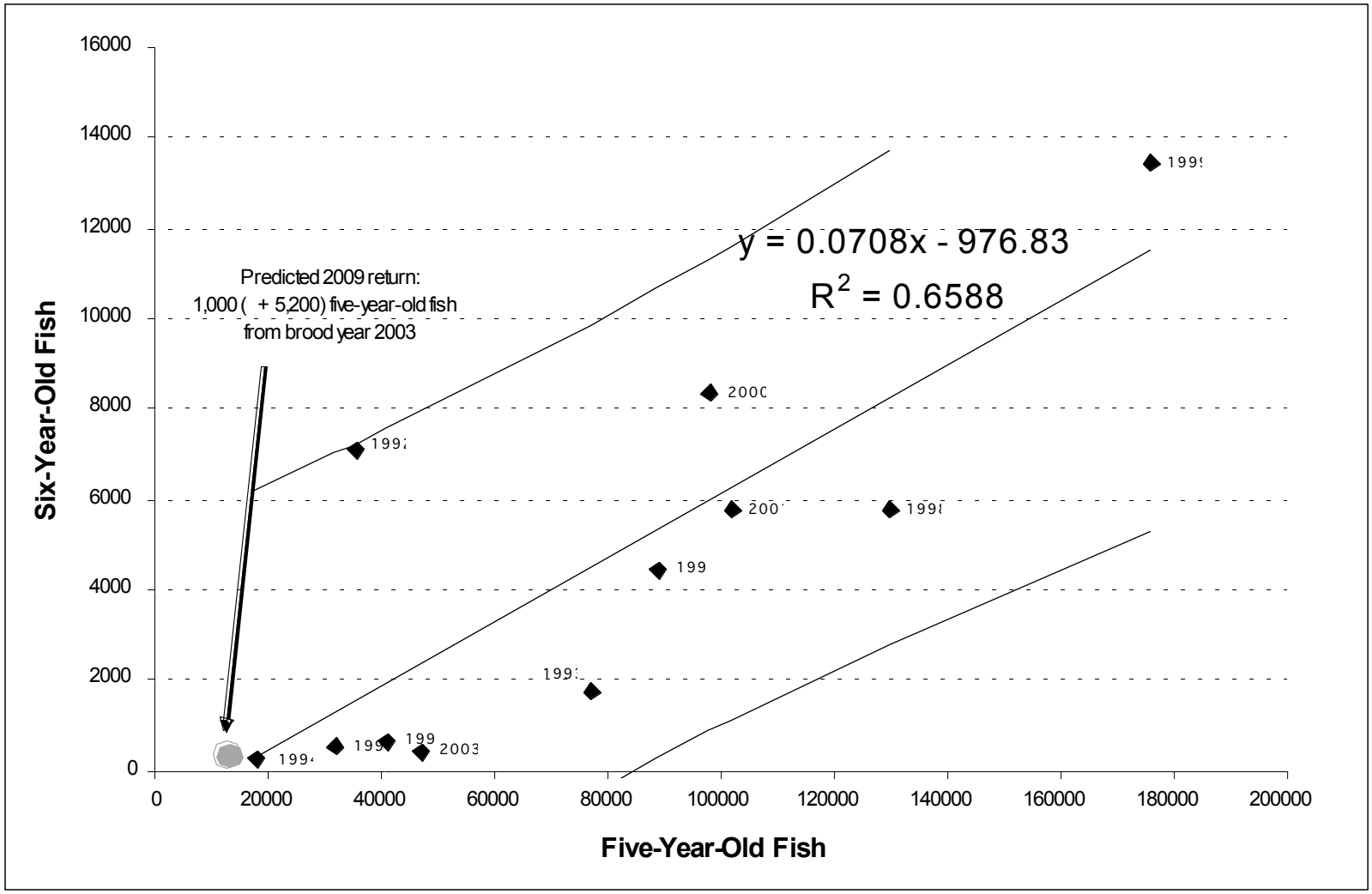

Figure 11. Predicted 2009 five-year-old Columbia Basin bright fall Chinook salmon abundance (at Bonneville Dam) based on a linear relationship between five-year-old and six-year-old fish.

Table 8. Predicted and estimated abundance of Chinook salmon returning to Bonneville Dam.

Species and age class	Predicted in 2007 report for 2008 (±90%)	2008 Estimate	2009 Prediction (±90%)
Spring Chinook 4-year-olds	251,100 (±65,700)	103,963	259,500 (±88,200)
Spring Chinook 5-year-olds	16,300 (±41,000)	10,009	26,100 (±38,900)
Summer Chinook 4-year-olds	58,300 (±26,300)	52,730	58,700 (±24,700)
Summer Chinook 5-year-olds	11,600 (±9,000)	12,522	49,700 (±9,300)
Bright Fall Chinook 4-year-olds	90,000 (±98,800)	77,162	218,600 (±97,200)
Bright Fall Chinook 5-year-olds	52,500 (±41,300)	28,104	37,200 (±46,000)

DISCUSSION

River Water Temperature

High river water temperature has constrained our sampling efforts during most summer sampling seasons. The ACOE also has modified sampling protocols for temperatures between 21.1 and 23.3^{o}C which restricts sampling to four days per week from 06:00 to 10:00 with no sampling allowed at temperatures above 23.3^{o}C. During the 2008 sampling season, sampling was not interrupted for more than a few days due to high temperatures. Unlike past years, we were not required to stop steelhead sampling due to high temperatures. McCullough (1999) asserts that temperatures exceeding 21^{o}C may delay the migration of Chinook salmon and Figure (12) appears to support that notion. Temperatures in this range do not appear to be as restrictive to the steelhead migration.

Genetic Sampling

In 2008, tissue samples (for DNA analysis) were collected from all Chinook and steelhead that were sampled at the Adult Fish Facility at Bonneville Dam. This was the sixth full year for Chinook genetic collection and the fifth year that we collected samples from steelhead. In previous years steelhead genetic samples were collected by ODFW and WDFW. Significant progress has been made through the coast wide Chinook genetic database to assemble baseline genetic stock identification information for all Columbia River Chinook populations. The development of baseline genetic stock information for steelhead is still in its infancy. 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.

Project Continuation

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.

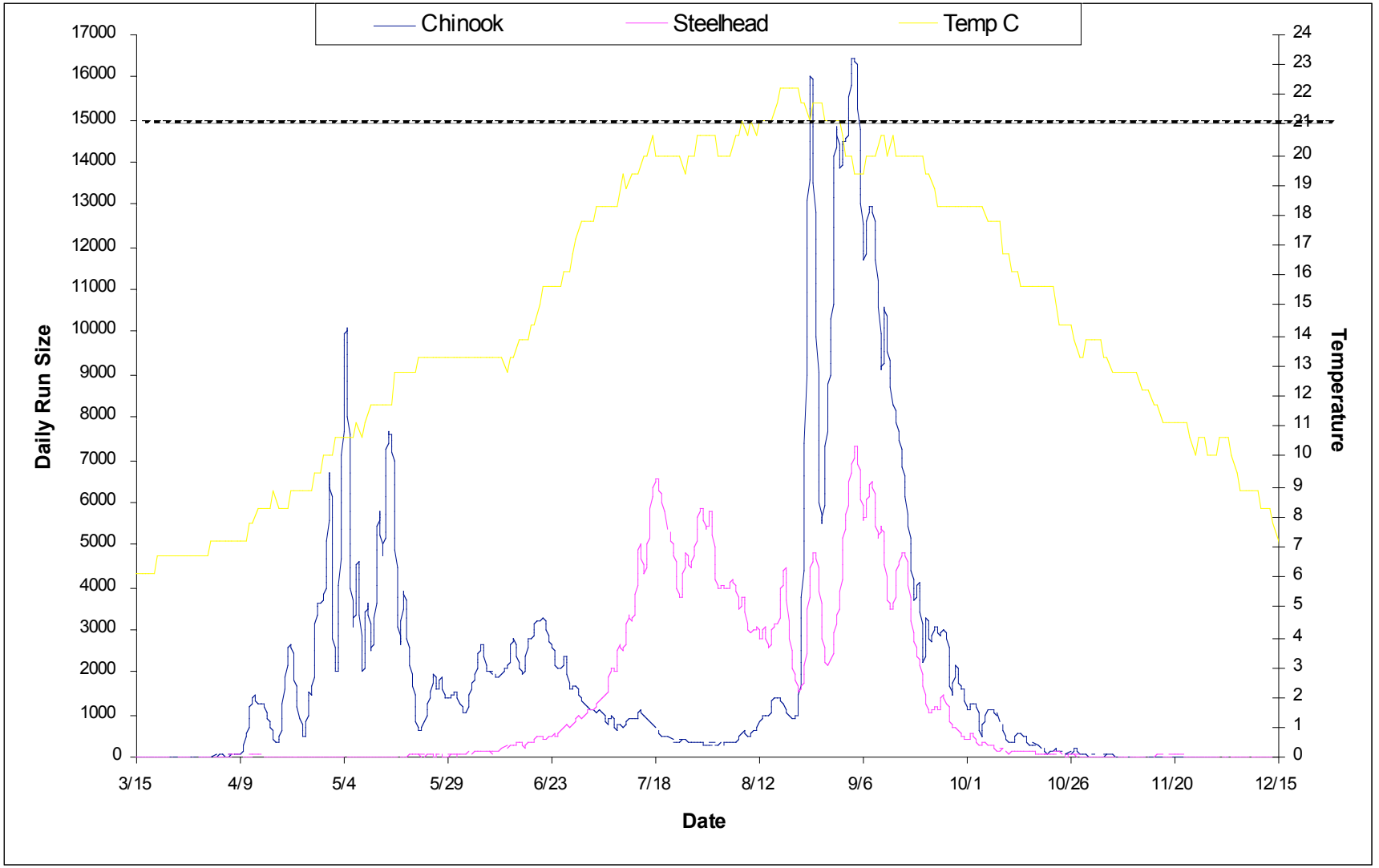

Figure 112. Chinook and steelhead daily run size and daily river temperature at Bonneville Dam from January 30 through December 31, 2006.

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APPENDIX A

LIST OF TABLES

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A6. Length-at-age estimates for Columbia Basin steelhead sampled at Bonneville Dam in 2008 44

Table A1: Composition (%) of observed injuries of Columbia Basin Chinook and sockeye salmon and steelhead sampled at Bonneville Dam in 2008.

Injury Category	Spring	Summer	Fall	Sockeye	Steelhead
Marine Mammal					
Bite	2.90%	0.30%	0%	0%	0%
Scrape	28.20%	11.50%	5.70%	5.70%	14%
Total	**31.10%**	**11.70%**	**5.70%**	**5.70%**	**14%**
Descaling					
<3%					
Left side	3.30%	1%	1.10%	4%	1.60%
Right side	1.40%	1.10%	0.80%	4%	1%
Total	**1.80%**	**1%**	**1.10%**	**2%**	**1.60%**
3-19%					
Left side	29.80%	22.10%	23.20%	57.70%	21.50%
Right side	28.30%	23.60%	22.80%	54.80%	21%
Total	**35.10%**	**30%**	**28.40%**	**64.70%**	**28.60%**
≥20%					
Left side	3.50%	5.10%	5.60%	5.90%	5%
Right side	4.50%	5.40%	6.20%	5.70%	4.60%
Total	**6.10%**	**8.20%**	**8.40%**	**8.70%**	**6.30%**
Other Injuries					
Bruise	0.10%	0.20%	0.10%	0%	0%
Head Injury	6.50%	3.70%	7.10%	0.70%	3.90%
Head Burn	0.40%	0%	0%	0%	0%
Fin	15.60%	12.90%	9.40%	4.70%	11.70%
Fungus	4.20%	1.10%	0.20%	1%	0.30%
Gash	0.90%	0.40%	0.80%	0.20%	0.90%
Gas Bubble Trauma	0%	0%	0%	0%	0%
Gill Net	1.80%	0.50%	0.50%	0.50%	3%
Lamprey		0.30%	0.10%		0.10%
Parasite	10.60%	1.40%	0.40%	4%	0.20%
Total	**40.10%**	**20.50%**	**18.60%**	**11%**	**20%**

a 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. Occasionally injuries are recorded but not described.

b Data not collected in 2005.

c This total represents the percentage of fish with descaling on either side. Fish are recorded in the category of maximum descaling. For example, a fish 3-19% descaled on one side, and ≥20% descaled on the other, would be recorded as ≥20% descaled.

Table A2: Length-at-age estimates for Columbia Basin spring Chinook salmon sampled at Bonneville Dam in 2008. Composite estimates of age classes are weighted by weekly run size.

Brood Year and	2006	2005	2004		2003	2002
Age Class	0.1	1.1	0.3	1.2	1.3	1.4
Statistical Week 16						
Mean Fork Length (cm)		45.00		74.28	87.25	
Maximum		45.00		85.50	101.00	
Minimum		45.00		66.00	76.50	
Standard Deviation		0.00		4.54	7.05	
Sample Size		1		29	8	
Statistical Week 17						
Mean Fork Length (cm)		52.67		74.03	86.39	
Maximum		57.50		83.00	92.50	
Minimum		46.50		66.00	79.00	
Standard Deviation		5.62		3.47	4.04	
Sample Size		3		84	14	
Statistical Week 18						
Mean Fork Length (cm)		47.44		73.58	87.56	
Maximum		52.00		85.00	98.50	
Minimum		42.00		62.00	72.00	
Standard Deviation		3.26		4.54	8.62	
Sample Size		8		114	9	
Statistical Week 19						
Mean Fork Length (cm)		50.75		73.45	88.68	
Maximum		62.50		83.50	98.00	
Minimum		42.00		61.00	82.00	
Standard Deviation		4.47		4.55	5.04	
Sample Size		20		125	11	
Statistical Week 20						
Mean Fork Length (cm)	43.50	51.57		73.17	89.81	
Maximum	43.50	58.50		84.00	101.00	
Minimum	43.50	44.50		60.00	76.00	
Standard Deviation	#DIV/0!	3.08		4.66	7.81	
Sample Size	1	57		161	8	
Statistical Week 21						
Mean Fork Length (cm)		52.36		75.50	87.50	
Maximum		62.00		83.00	93.00	
Minimum		45.50		69.00	83.00	
Standard Deviation		3.89		3.58	4.80	
Sample Size		37		42	4	
Statistical Week 22						
Mean Fork Length (cm)		54.46	84.00	76.14	88.80	83.50
Maximum		65.00	84.00	83.50	92.50	83.50
Minimum		46.00	84.00	66.50	83.50	83.50
Standard Deviation		3.37	0.00	4.05	2.73	0.00
Sample Size		42	1	83	10	1
2008 Composite						
Mean Fork Length (cm)	43.50	52.15	84.00	74.00	87.93	83.50
Maximum	43.50	65.00	84.00	85.50	101.00	83.50
Minimum	43.50	42.00	84.00	60.00	72.00	83.50
Standard Deviation	0.00	3.93	0.00	4.42	5.71	0.00
Sample Size	1	168	1	638	64	1

Table A3: Length-at-age estimates for Columbia Basin summer Chinook salmon sampled at Bonneville Dam in 2008. Composite estimates of age classes are weighted by weekly run size.

Brood Year and	2006	2005		2004		2003			2002		2001
Age Class	0.1	0.2	1.1	0.3	1.2	0.4	1.3	2.2	0.5	1.4	1.5
Statistical Week 23											
Mean Fork Length (cm)		66.33	54.83	81.20	77.05		86.00	76.50			
Maximum		73.00	65.00	85.00	84.50		101.50	76.50			
Minimum		61.00	46.50	74.50	62.00		76.00	76.50			
Standard Deviation		6.11	3.79	3.98	4.49		7.39	0.00			
Sample Size		3	40	5	100		15	1			
Statistical Week 24											
Mean Fork Length (cm)		65.38	57.21	81.29	76.79		85.78			96.50	
Maximum		75.00	64.50	89.50	89.50		92.50			99.00	
Minimum		60.50	49.00	75.00	59.50		76.50			94.00	
Standard Deviation		6.73	3.95	4.57	5.44		5.39			3.54	
Sample Size		4	24	12	46		9			2	
Statistical Week 25											
Mean Fork Length (cm)		64.40	54.08	82.50	77.09	96.00	86.47			90.50	
Maximum		67.00	60.50	93.50	87.50	96.00	94.00			90.50	
Minimum		62.50	48.50	71.50	66.00	96.00	80.50			90.50	
Standard Deviation		1.71	3.99	6.02	4.42	0.00	3.72			0.00	
Sample Size		5	13	25	38	1	16			1	
Statistical Week 26											
Mean Fork Length (cm)		68.04	57.15	81.17	73.38	92.50	86.58		94.50	92.86	88.00
Maximum		74.50	63.00	96.00	89.50	98.00	96.50		94.50	102.00	88.00
Minimum		62.50	43.50	69.00	52.00	88.00	72.00		94.50	78.00	88.00
Standard Deviation		4.11	5.13	5.80	6.84	5.07	6.43		0.00	7.50	0.00
Sample Size		13	20	27	55	3	19		1	7	1
Statistical Week 27											
Mean Fork Length (cm)	51.50	67.64	57.36	82.86	75.92	90.00	83.55			90.00	
Maximum	51.50	80.00	65.00	87.50	84.50	90.00	87.00			90.00	
Minimum	51.50	57.00	49.00	73.00	65.50	90.00	77.00			90.00	
Standard Deviation	0.00	7.57	5.32	4.80	5.31	0.00	3.30			0.00	
Sample Size	1	7	11	11	13	1	10			1	
Statistical Week 28											
Mean Fork Length (cm)		67.70	51.63	82.23	73.81	97.75	84.08		91.50	93.25	
Maximum		71.50	63.00	91.50	81.50	98.50	93.50		91.50	97.00	
Minimum		61.00	44.00	70.00	64.50	97.00	75.00		91.50	89.50	
Standard Deviation		4.40	6.99	5.56	4.76	1.06	5.75		0.00	5.30	
Sample Size		5	8	22	26	2	12		1	2	
Statistical Week 29											
Mean Fork Length (cm)	42.13	65.75	54.00	80.64	73.96	92.30	85.77			93.00	
Maximum	46.50	85.50	64.50	95.00	85.00	99.00	97.00			94.50	
Minimum	39.00	56.00	45.00	66.00	60.00	82.50	78.50			90.50	
Standard Deviation	2.44	6.43	7.18	7.54	5.50	6.56	4.93			2.18	
Sample Size	12	24	13	29	51	5	22			3	
Statistical Week 30											
Mean Fork Length (cm)	44.50	66.00	54.94	81.57	71.43	98.67	85.13				
Maximum	47.00	75.50	61.50	89.00	81.00	103.50	100.00				
Minimum	42.00	57.00	50.00	70.00	62.50	93.00	78.00				
Standard Deviation	3.54	5.15	3.34	4.82	5.36	5.30	6.58				
Sample Size	2	13	9	14	22	3	12				
Statistical Week 31											
Mean Fork Length (cm)	45.25	68.50	55.00	81.69	74.06	93.50	89.50				
Maximum	46.00	68.50	55.00	90.00	82.00	93.50	101.50				
Minimum	44.50	68.50	55.00	70.50	66.00	93.50	79.50				
Standard Deviation	1.06	0.00	0.00	7.34	4.38	0.00	11.14				
Sample Size	2	1	1	8	9	1	3				
2008 Composite											
Mean Fork Length (cm)	43.32	66.45	55.45	81.63	75.33	94.38	85.69	76.50	93.00	93.06	88.00
Maximum	51.50	85.50	65.00	96.00	89.50	103.50	101.50	76.50	94.50	102.00	88.00
Minimum	39.00	56.00	43.50	66.00	52.00	82.50	72.00	76.50	91.50	78.00	88.00
Standard Deviation	3.29	5.47	4.89	5.89	5.53	5.25	5.70	0.00	2.12	5.34	0.00
Sample Size	17	75	139	153	360	16	118	1	2	16	1

Table A4: Length-at-age estimates for Columbia Basin bright fall Chinook salmon sampled at Bonneville Dam in 2008. Composite estimates of age classes are weighted by weekly run size.

Brood Year and	2006	2005		2004		2003		2002	
Age Class	0.1	0.2	1.1	0.3	1.2	0.4	1.3	1.4	0.5
Statistical Week 31									
Mean Fork Length (cm)		68.00	51.50	80.50	75.83	81.00			
Maximum		68.00	51.50	82.50	82.50	81.00			
Minimum		68.00	51.50	78.50	69.50	81.00			
Standard Deviation		0.00	0.00	2.00	6.51	0.00			
Sample Size		1	1	3	3	1			
Statistical Week 32									
Mean Fork Length (cm)	43.75	63.17	51.50	82.20	75.60	92.20	87.75		
Maximum	47.00	69.00	53.00	86.00	84.50	95.00	89.50		
Minimum	41.00	57.00	50.00	76.50	57.50	84.50	86.00		
Standard Deviation	2.75	6.01	2.12	4.07	5.94	4.34	2.47		
Sample Size	4	3	2	5	21	5	2		
Statistical Week 33									
Mean Fork Length (cm)		65.00	52.00	85.83	76.00	94.50			
Maximum		66.00	52.00	92.50	76.00	96.00			
Minimum		64.00	52.00	78.00	76.00	93.00			
Standard Deviation		1.41	0.00	7.32	0.00	2.12			
Sample Size		2	1	3	1	2			
Statistical Week 34									
Mean Fork Length (cm)	47.27	65.63	58.50	80.63	71.59	90.75	88.50		
Maximum	55.00	76.00	62.00	90.00	80.00	97.50	88.50		
Minimum	38.00	58.50	55.00	66.00	58.50	82.00	88.50		
Standard Deviation	4.37	5.97	4.95	10.26	6.76	5.18	0.00		
Sample Size	13	8	2	4	11	6	1		
Statistical Week 35									
Mean Fork Length (cm)	45.36	67.96	56.28	81.31	76.25	91.00			
Maximum	61.00	78.00	64.00	89.50	85.00	100.00			
Minimum	38.00	52.50	49.00	75.50	64.50	83.50			
Standard Deviation	6.00	6.92	4.72	4.03	7.18	5.72			
Sample Size	14	36	9	13	10	7			
Statistical Week 36									
Mean Fork Length (cm)	49	68	59	82	75	94	91		
Maximum	50	79	67	99	91	105	91		
Minimum	48	49	52	59	64	84	91		
Standard Deviation	1.19	5.86	7.36	6.71	8.84	5.76	0.00		
Sample Size	4	73	4	54	10	21	1		
Statistical Week 37									
Mean Fork Length (cm)	47	67	55	80	70	89	80		
Maximum	52	82	55	97	75	96	80		
Minimum	40	52	55	69	61	80	80		
Standard Deviation	3.48	5.11	0.00	5.91	4.39	4.09	0.00		
Sample Size	19	156	1	68	9	23	1		
Statistical Week 38									
Mean Fork Length (cm)	46.47	66.66	56.63	80.01	77.50	91.34		78	101
Maximum	56.00	77.50	60.00	94.50	80.00	104.00		78	101
Minimum	38.50	54.00	53.50	68.50	75.00	79.50		78	101
Standard Deviation	4.65	4.96	3.61	6.76	3.54	6.39		0.00	0.00
Sample Size	19	132	4	34	2	19		1	1
Statistical Week 39									
Mean Fork Length (cm)	46.88	67.61	56.17	79.73	71.83	89.56	84.75		
Maximum	58.00	83.50	62.00	93.00	81.00	98.00	88.00		
Minimum	37.50	51.00	50.50	70.00	65.50	74.50	81.50		
Standard Deviation	5.26	4.97	5.75	5.17	8.13	6.64	4.60		
Sample Size	16	107	3	42	3	18	2		

Statistical Week 40									
Mean Fork Length (cm)	43.50	67.05	58.00	81.48		92.44			94.5
Maximum	46.00	82.50	58.00	95.00		98.00			94.5
Minimum	39.00	53.00	58.00	73.50		86.00			94.5
Standard Deviation	3.11	5.87	0.00	5.28		3.92			0.00
Sample Size	4	50	1	20		8			1
Statistical Week 41									
Mean Fork Length (cm)	44.72	67.76	57.00	82.41	82.00	89.41			
Maximum	53.50	82.00	57.00	98.00	82.00	96.00			
Minimum	38.00	50.00	57.00	73.00	82.00	82.50			
Standard Deviation	4.15	6.57	0.00	6.73	0.00	4.35			
Sample Size	9	38	1	16	1	11			
Statistical Week 42									
Mean Fork Length (cm)	44.00	67.00		71.00					
Maximum	44.00	67.00		71.00					
Minimum	44.00	67.00		71.00					
Standard Deviation	0.00	0.00		0.00					
Sample Size	1	1		1					
2008 Composite									
Mean Fork Length (cm)	46.25	67.32	56.24	80.89	74.28	90.82	86.29	78	97.75
Maximum	61.00	83.50	66.50	99.00	90.50	104.50	90.50	78	101
Minimum	37.50	48.50	49.00	59.00	57.50	74.50	80.00	78	94.5
Standard Deviation	4.49	5.43	4.66	6.06	6.67	5.56	4.05	0	4.60
Sample Size	103	607	29	263	71	121	7	1	2

Table A5: Length-at-age estimates for Columbia Basin sockeye salmon sampled at Bonneville Dam in 2008. Composite estimates of age classes are weighted by weekly run size.

Brood Year and	2005	2004		2003		2002
Age Class	1.1	1.2	2.1	1.3	2.2	2.3
Statistical Week 23						
Mean Fork Length (cm)		49.09				
Maximum		54.50				
Minimum		44.00				
Standard Deviation		3.46				
Sample Size		11				
Statistical Week 24						
Mean Fork Length (cm)	39.38	49.48	44.50	56.50	51.25	
Maximum	41.00	62.00	44.50	56.50	55.00	
Minimum	38.00	42.50	44.50	56.50	47.50	
Standard Deviation	1.25	2.65	-	#DIV/0!	5.30	
Sample Size	4	166	1	1	2	
Statistical Week 25						
Mean Fork Length (cm)	40.85	49.69	42.50	57.83	50.65	55.00
Maximum	44.00	56.50	42.50	61.00	57.50	55.00
Minimum	37.00	41.00	42.50	55.50	46.50	55.00
Standard Deviation	2.08	2.59	-	2.84	3.25	-
Sample Size	10	326	1	3	10	1
Statistical Week 26						
Mean Fork Length (cm)	39.75	49.71	43.64	54.50	50.29	
Maximum	44.00	58.50	45.00	54.50	56.00	
Minimum	37.00	43.50	41.00	54.50	45.00	
Standard Deviation	2.11	2.66	1.35	-	4.06	
Sample Size	14	211	7	1	7	
Statistical Week 27						
Mean Fork Length (cm)	40.33	49.58	42.00		50.80	
Maximum	44.50	57.00	44.00		57.00	
Minimum	38.00	43.50	39.00		47.00	
Standard Deviation	1.81	2.77	1.97		2.94	
Sample Size	33	145	5		10	
Statistical Week 28						
Mean Fork Length (cm)	39.72	48.55	42.25		50.67	58.00
Maximum	44.00	54.00	43.00		52.00	58.00
Minimum	36.50	43.50	41.50		49.50	58.00
Standard Deviation	1.40	2.49	1.06		1.26	#DIV/0!
Sample Size	30	73	2		3	1
Statistical Week 29						
Mean Fork Length (cm)	39.47	48.16	39.50		50.50	
Maximum	46.00	52.00	40.50		50.50	
Minimum	36.00	41.50	38.50		50.50	
Standard Deviation	2.63	3.26	1.41		-	
Sample Size	19	19	2		1	
2008 Composite						
Mean Fork Length (cm)	39.95	49.51	42.56	56.90	50.65	56.50
Maximum	46.00	62.00	45.00	61.00	57.50	58.00
Minimum	36.00	41.00	38.50	54.50	45.00	55.00
Standard Deviation	1.94	2.68	1.91	2.48	3.09	2.12
Sample Size	110	951	18	5	33	2

Table A6: Length-at-age estimates for Columbia Basin steelhead sampled at Bonneville Dam in 2008.

Week	Brood Year and Age Class	2005	2004		2003			2002			2001
		1.1	1.2	2.1	1.3	2.2	3.1	2.3	3.2	4.1	4.2
16	Fork Length (cm)	59.25	66.50								
	Maximum	63.50	66.50								
	Minimum	55.00	66.50								
	Standard Deviation	6.01	0.00								
	Sample Size	2.00	1.00								
17	Fork Length (cm)	66.50									
	Maximum	67.00									
	Minimum	66.00									
	Standard Deviation	0.71									
	Sample Size	2.00									
18	Fork Length (cm)		65.50		77.00						
	Maximum		65.50		77.00						
	Minimum		65.50		77.00						
	Standard Deviation		0.00		0.00						
	Sample Size		1.00		1.00						
19	Fork Length (cm)		72.50								
	Maximum		72.50								
	Minimum		72.50								
	Standard Deviation		0.00								
	Sample Size		1.00								
20	Fork Length (cm)		73.00								
	Maximum		75.50								
	Minimum		70.50								
	Standard Deviation		3.54								
	Sample Size		2.00								
21	Fork Length (cm)	69.50	71.83								
	Maximum	73.50	78.00								
	Minimum	66.00	70.00								
	Standard Deviation	3.22	3.13								
	Sample Size	5.00	6.00								
22	Fork Length (cm)	67.00	73.42	67.50		65.50					
	Maximum	69.00	82.50	67.50		65.50					
	Minimum	64.00	65.00	67.50		65.50					
	Standard Deviation	1.73	4.52	0.00		0.00					
	Sample Size	8.00	13.00	1.00		1.00					
23	Fork Length (cm)	68.30	72.46	55.75							
	Maximum	74.50	78.00	61.00							
	Minimum	53.00	68.00	50.50							
	Standard Deviation	5.33	3.17	7.42							
	Sample Size	15.00	12.00	2.00							

Week	Brood Year and Age Class	2005	2004		2003			2002			2001
		1.1	1.2	2.1	1.3	2.2	3.1	2.3	3.2	4.1	4.2
24	Fork Length (cm)	60.25	72.21				67.50				
	Maximum	67.00	75.50				67.50				
	Minimum	53.00	67.00				67.50				
	Standard Deviation	6.24	2.34				0.00				
	Sample Size	6.00	12.00				1.00				
25	Fork Length (cm)	62.17	70.25			69.00			69.50		
	Maximum	67.50	77.00			69.00			69.50		
	Minimum	56.00	65.00			69.00			69.50		
	Standard Deviation	5.80	4.70			0.00			0.00		
	Sample Size	3.00	6.00			1.00			1.00		
26	Fork Length (cm)	62.18	71.14	64.83		70.20	53.50		71.50		
	Maximum	75.00	78.50	68.50		75.00	53.50		72.50		
	Minimum	51.50	65.50	56.00		67.00	53.50		70.00		
	Standard Deviation	6.84	3.13	4.63		3.33	0.00		1.32		
	Sample Size	17.00	25.00	6.00		5.00	1.00		3.00		
27	Fork Length (cm)	57.90	72.08	57.00		70.70	59.00		75.50		
	Maximum	62.50	75.50	59.00		74.00	65.00		77.00		
	Minimum	51.50	67.00	53.50		65.00	53.00		74.00		
	Standard Deviation	3.46	2.64	2.57		3.42	6.00		2.12		
	Sample Size	10.00	13.00	5.00		5.00	3.00		2.00		
28	Fork Length (cm)	58.61	72.06	58.10		72.06	57.78		74.00		
	Maximum	68.00	78.50	65.00		75.00	61.50		74.00		
	Minimum	51.50	65.50	52.50		69.50	51.00		74.00		
	Standard Deviation	3.18	2.98	3.12		1.99	3.05		0.00		
	Sample Size	54.00	47.00	29.00		8.00	9.00		1.00		
29	Fork Length (cm)	58.62	71.24	58.74		70.31	57.96		72.50		
	Maximum	70.00	83.50	69.00		74.00	61.00		72.50		
	Minimum	52.00	60.50	53.50		68.50	54.00		72.50		
	Standard Deviation	3.47	4.83	3.29		1.77	2.16		0.00		
	Sample Size	107.00	44.00	50.00		8.00	12.00		1.00		
30	Fork Length (cm)	58.81	71.06	57.54		72.00	57.82		71.00		
	Maximum	67.50	81.50	63.00		73.50	61.50		76.50		
	Minimum	50.00	62.50	51.50		70.00	52.00		67.00		
	Standard Deviation	3.16	3.70	2.75		1.58	3.31		3.41		
	Sample Size	128.00	33.00	42.00		4.00	14.00		6.00		
31	Fork Length (cm)	58.74	69.91	58.72		69.73	57.60		70.70	63.00	
	Maximum	72.00	79.00	66.50		81.00	59.00		77.50	63.00	
	Minimum	51.50	59.00	54.50		62.50	55.50		68.00	63.00	
	Standard Deviation	3.47	4.35	3.62		5.35	1.39		3.95	0.00	
	Sample Size	138.00	29.00	16.00		11.00	5.00		5.00	1.00	

Week	Brood Year and Age Class	2005	2004		2003			2002			2001
		1.1	1.2	2.1	1.3	2.2	3.1	2.3	3.2	4.1	4.2
32	Fork Length (cm)	58.13	72.33	58.24		72.11	58.33		72.14		
	Maximum	71.00	85.50	64.00		83.50	61.50		82.00		
	Minimum	49.50	64.00	52.50		67.00	56.50		66.00		
	Standard Deviation	2.98	6.30	3.61		4.58	2.75		5.39		
	Sample Size	157.00	38.00	19.00		18.00	3.00		7.00		
33	Fork Length (cm)	58.96	76.50	57.75		76.25					
	Maximum	64.50	76.50	58.00		77.50					
	Minimum	55.00	76.50	57.50		75.00					
	Standard Deviation	2.74	0.00	0.35		1.77					
	Sample Size	12.00	1.00	2.00		2.00					
34	Fork Length (cm)	57.87	79.25	60.50		78.83			75.50		89.00
	Maximum	65.00	87.00	60.50		85.00			79.00		89.00
	Minimum	53.50	72.00	60.50		71.50			72.00		89.00
	Standard Deviation	3.19	5.13	0.00		4.61			4.95		0.00
	Sample Size	15.00	8.00	1.00		6.00			2.00		1.00
35	Fork Length (cm)	59.16	78.94	58.50	86.75	70.80			73.83		
	Maximum	73.00	86.00	58.50	88.50	76.50			78.50		
	Minimum	53.00	67.00	58.50	85.00	66.00			69.50		
	Standard Deviation	4.46	5.50	0.00	2.47	4.04			4.51		
	Sample Size	16.00	18.00	1.00	2.00	5.00			3.00		
36	Fork Length (cm)	59.98	80.52	60.00	87.94	80.08		87.00	82.62		
	Maximum	68.00	90.00	60.00	90.50	87.00		87.00	85.00		
	Minimum	51.00	67.00	60.00	84.50	72.00		87.00	78.00		
	Standard Deviation	3.79	4.71	0.00	2.48	5.72		0.00	3.15		
	Sample Size	21.00	63.00	1.00	8.00	6.00		1.00	4.00		
37	Fork Length (cm)	60.22	82.09	63.00	88.28	82.44			79.25		86.50
	Maximum	70.00	91.00	63.00	97.00	91.50			82.50		86.50
	Minimum	53.50	70.00	63.00	79.00	72.50			76.00		86.50
	Standard Deviation	4.30	4.44	0.00	5.24	5.10			4.60		0.00
	Sample Size	37.00	154.00	1.00	9.00	18.00			2.00		1.00
38	Fork Length (cm)	59.75	82.13	62.00	88.29	79.50	66.00		83.50		93.00
	Maximum	65.50	93.00	65.00	94.00	89.50	66.00		83.50		93.00
	Minimum	55.00	68.50	59.00	84.50	66.00	66.00		83.50		93.00
	Standard Deviation	4.01	4.33	4.24	3.51	8.54	0.00		0.00		0.00
	Sample Size	14.00	83.00	2.00	7.00	8.00	1.00		1.00		1.00
39	Fork Length (cm)	60.35	83.46	59.50	89.61	85.50					
	Maximum	69.50	94.00	59.50	93.50	85.50					
	Minimum	51.50	71.50	59.50	84.00	85.50					
	Standard Deviation	5.06	4.96	0.00	2.95	0.00					
	Sample Size	13.00	54.00	1.00	9.00	1.00					