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TECHNICAL REPORT 01-1

Age and Length Composition of Columbia Basin Chinook, Sockeye, and Coho Salmon at Bonneville Dam in 2000

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February 9, 2001

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ABSTRACT

In 2000, representative samples of adult Columbia Basin chinook (***Oncorhynchus tshawytscha***), sockeye (***O. nerka***), and coho salmon (***O. kisutch***), populations were collected at Bonneville Dam. Fish were trapped, anesthetized, sampled for scales and biological data, allowed to revive, and then released. Scales were examined to estimate age composition and the results contribute to an ongoing database for age class structure of Columbia Basin salmon populations. Based on scale analysis, four-year-old fish (from brood year (BY) 1996) were estimated to comprise 83% of the spring chinook, 31% of the summer chinook, and 32% of the upriver bright fall chinook salmon population. Five-year-old fish (BY 1995) were estimated to comprise 2% of the spring chinook, 26% of the summer chinook, and 40% of the fall chinook salmon population. Three-year-old fish (BY 1997) were estimated to comprise 14% of the spring chinook, 42% of the summer chinook, and 17% of the fall chinook salmon population. Two-year-olds accounted for approximately 11% of the fall chinook population. The sockeye salmon population sampled at Bonneville was predominantly four-year-old fish (95%), and the coho salmon population was 99.9% three-year-old fish (Age 1.1). Length analysis of the 2000 returns indicated that chinook salmon with a stream-type life history are larger (mean length) than the chinook salmon with an ocean-type life history. Trends in mean length over the sampling period were also analysis for returning 2000 chinook salmon. Fish of age classes 0.2, 1.1, 1.2, and 1.3 have a significant increase in mean length over time. Age classes 0.3 and 0.4 have no significant change over time and age 0.1 chinook salmon had a significant decrease in mean length over time. A year class regression over the past 11 years of data was used to predict spring and summer chinook salmon population sizes for 2001. Based on three-year-old returns, the relationship predicts four-year-old returns of 325,000 ($\pm$ 111,600, 90% Predictive Interval [PI]) spring chinook and 27,800 ($\pm$ 29,750, 90% PI) summer chinook salmon. Based on four-year-old returns, the relationship predicts five-year-old returns of 54,300 ($\pm$ 40,600, 90% PI) spring chinook and 11,000 ($\pm$ 3,250, 90% PI) summer chinook salmon. The 2001 run size predictions used in this report should be used with caution, these predictions are well beyond the range of previously observed data.

ACKNOWLEDGMENTS

We sincerely thank the following individuals for their assistance in this project: Rian Hooff, John Whiteaker, Randy Henry, Bobby Begay, Doug Hatch, André Talbot, Rishi Sharma, Stuart Ellis and Marianne McClure of the Columbia River Inter-Tribal Fish Commission; Bret Morgan of the Oregon Department of Fish and Wildlife; Eric Goedeke and Jennifer Sturgill of the US Army Corps of Engineers; Ted Bjornn, Steve Lee, Rudy Ringe and Dennis Quimps of the University of Idaho, Charlie Cochron, Dan Rawding, and John Sneva of the Washington Department of Fisheries.

This report is the result of research funded by US Government (Bureau of Indian Affairs, Department of Interior) Contract No. GTP00X90107 for implementation of the US-Canada Pacific Salmon Treaty.

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INTRODUCTION

The Stock Assessment Project of the Columbia River Inter-Tribal Fish Commission (CRITFC) is a part of the US-Canada Pacific Salmon Treaty spawning escapement-monitoring program (PST 1985). An objective of the project is the monitoring of the age and length-at-age composition of Columbia Basin salmonids, as well as the design and development of salmon stock identification techniques.

This project uses scale-pattern analysis to estimate the age and length-at-age composition for populations of chinook[1] (***Oncorhynchus tshawytscha***), sockeye (***O. nerka***), and coho salmon (***O. kisutch***). This study has been conducted since 1985 for sockeye, 1987 for spring chinook, and 1990 for summer chinook salmon (Schwartzberg 1988, 1989; Schwartzberg and Fryer 1990; Fryer and Schwartzberg 1991a, 1991b, 1992, 1993, 1994; Fryer et al. 1992; Hooff et. al. 1999a; Hooff et. al. 1999b). Upriver bright (URB) fall chinook and coho salmon were added in 1998 (Hooff et. al. 1999a, Hooff et. al. 1999b)[2]. Over the course of these studies, procedures have been developed to monitor symptoms of gas bubble trauma, marine mammal predation, and headburn (for description and identification protocols of these symptoms, refer to the Methods section and Appendix B).

Data that are not reported in the results, but are part of the data collected for this project, are in Appendix A. These include fin-clips observed, length-at-age composition, and assessments of fish condition and injuries.

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1. Columbia Basin upriver spring chinook salmon are defined as those migrating past Bonneville Dam before June 1. Columbia Basin summer chinook salmon are defined as those migrating past Bonneville Dam between June 1 and July 31, while later migrating chinook salmon are defined as fall chinook salmon.
2. Columbia Basin fall chinook salmon are divided into Tules and upriver brights. Tules typically spawn downstream of The Dalles, while upriver brights spawn upstream of The Dalles.

METHODS

Sample Design

Fish were sampled one or two days per statistical week[3] from April through October. The sample size goal is 500 fish each for spring, summer, and fall chinook salmon and for coho and sockeye salmon. In past study years, this sample size has resulted in desired levels of precision and accuracy ($d=0.05$, $\alpha=0.10$) for age composition estimates. The composite age and length-at-age estimates are calculated from weekly estimates post-stratified by the numbers of fish migrating past Bonneville Dam during the week of the sample (Fryer 1995). Year-to-date dam counts of fish passage were obtained from the Fish Passage Center (2000).

Sampling Methods

Representative samples of each species and population were collected at the Fisheries Engineering and Research Laboratory located adjacent to the Second Powerhouse of Bonneville Dam (river km 235). Fish were trapped and anesthetized. Each fish was then sampled for scales, measured for fork length, inspected for markings and/or tag information and noted for other pertinent biological information (Appendix B). All fish were revived in freshwater and returned to the exit fishway leading to one of the Bonneville Dam fish ladders. No fish were sacrificed. To minimize the scale sample rejection rate, six scales were collected per coho and chinook salmon sampled (Knudsen 1990). Four scales were collected from each sockeye salmon sampled. Tules, a dark-colored fall chinook salmon, are not sampled in our study with the URB fall chinook.

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3. 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 2000, for example, Statistical Week 15 began on April 3 and ended on April 9.

Length Measurements

Fork lengths were measured to the nearest 0.5 cm. Mean lengths and measurements of variability were calculated for each age class, by weekly sampling period, and for the composite sample (Appendix A). Composite samples are post-stratified by weekly run size. Possible changes in weekly mean length over the sampling period were analyzed by simple linear regression for each age class.

Fish Condition

Criteria were developed in 1992 to allow precise classification of the condition of sampled fish (Fryer and Schwartzberg 1993). These criteria have been expanded and refined in subsequent years so that, in 2000, each specimen was inspected for marine mammal injuries, headburn, descaling, gill net abrasion, gas bubble trauma (Fryer 1994), cuts, bruises, and other assorted injuries (Appendix B).

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). Assessment and classification protocols for headburn were added to our study in 1997, after reports of increased incidence and awareness of headburn throughout the basin (Elston 1996, Grosberg 1996).

Notation was also taken on fin clips and other tag types found on the fish.

Age Determination

Scales were selected, mounted, and pressed according to methods described in 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, Borodin 1924, Van Oosten 1929). A sample of scales was sent to John Sneva of the Washington Department of Fish and Wildlife for corroboration of age estimates. Validation of the ages estimated from scale patterns (Beamish and McFarlane 1983) was not possible because tagged fish were not sacrificed.

The European method for fish age description (Koo 1955) 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.

Spring and Summer Chinook Salmon Run-Size Prediction

Salmon mature and return to spawn between ages 2 and 7. The year when the parents spawned is referred to as the brood year (BY). All of the progeny returning from a spawning population is collectively called a brood. Many salmon forecast models are based on the relationship between the survivors within a single brood returning in successive years at different ages. It was noted in the early years of this project that the number of three-year-old fish for a given BY appeared to be a relatively good predictor of the number of subsequently returning four-year-old fish of the same BY (Fryer and Schwartzberg 1994). This relationship and a regression analysis are used herein to forecast returning four-year-old fish in 2001 from three-year-old fish of 2000. A similar relationship is used to forecast returning five-year-old fish in 2001 from four-year-old fish of 2000.

RESULTS

Sample Design

To reduce sampling stress on fish and the possibility of mortality, we did not conduct sampling when the river water temperature recorded at the total dissolved gas monitoring station in the Bonneville Dam forebay was above 21C. During the 2000 sampling season, sampling was precluded during statistical weeks 32-34, which is the beginning of the URB fall chinook salmon run, due to high water temperatures. The last sample date for summer chinook salmon was the 27th of July and sampling began for fall chinook on the 22nd of August.

This report does not include information on mini-jacks (fish generally under 30 cm in length which show a scale pattern that indicates they have not spent any winters in saltwater) because of their different life history and because collection protocol is not conducive for random sampling of mini-jacks.

Sampling periods, sample sizes, number of scales used in the age composition estimates, and run sizes for species and populations are tabulated in the Age Composition tables. Although some fish were removed from all age analyses because of damaged and/or unreadable scales (spring chinook 10%, summer chinook 9%, fall chinook 7%, sockeye 3%, and coho 5% of fish removed for unreadable scales) these fish were used in other analyses of other types of data collected during sampling.

Length Analysis

Chinook salmon that have a stream-type (Age 1.X) life history are consistently larger (mean length) than ocean-type (Age 0.X) chinook salmon with the same ocean age (Figure 1). As age increases so does the mean length. The mean length of chinook salmon for age classes of 0.2, 1.1, 1.2, and 1.3, when analyzed using a linear regression technique, showed a significant increase over the sampling period ($P < 0.001$ for Ages 0.2 and 1.1; $P < 0.05$ for Ages 1.2 and 1.3). The mean length of age classes 0.3 and 0.4 (Age 0.4 was not graphed in Figure 1) did not change significantly over time ($P = 0.36$ and 0.41, respectively). Mean length decreased significantly ($P < 0.05$) over the sampling period for Age 0.1 fish.

Fish Condition

Data analysis on a fish condition and fin-clips can be found in Appendix A. Gender of collected specimens, most in early stages of sexual maturation, could rarely be determined with certainty and therefore, was not recorded.

Age Composition Estimates

Spring chinook salmon returns were estimated to be predominately four-year-olds (83%) (Table 1, Figure 2). Less than 1% of the spring chinook salmon sampled had an ocean-type life history scale pattern (Table 1, Figure 3).

Summer chinook salmon were a mix of age classes with three-year-olds (42%) as the most abundant, but there were substantial proportions of four- (31%) and five-year-old fish (26%) as well (Table 2, Figure 2). Approximately 13% of the run had scale patterns indicating an ocean-type life history and 87% of the run had a stream-type life history (Table 2, Figure 3).

Upriver bright fall chinook salmon were also a mix of five- (40%) and four-year-old (32%) age classes (Table 3, Figure 2). Fourteen percent of the fall chinook salmon sampled had a stream-type life history (Table 3, Figure 3).

Sockeye salmon were estimated to be almost entirely four-year-old fish (95%) and almost all sockeye salmon (98.8%) spent one year in fresh water (Table 4).

The 2000 coho salmon run passing Bonneville was estimated as 99.9% three-year-old fish (Age 1.1) from the 1997 BY (Table 5). A very small percent of the run was two-year-old fish (Age 1.0) from the BY 1998.

Table 1. Weekly and cumulative age composition of Columbia Basin spring chinook salmon sampled at Bonneville Dam in 2000.

					Age Composition by Brood Year and Age Class			
					1997		1996	1995
Statistical Week	Sampling Date	Number Sampled	Number Ageable	Weekly run size	0.2	1.1	1.2	1.3
15[a]	4/7	17	16	17252			1.000	
16	4/12	77	71	25218		0.014	0.958	0.028
17	4/19,20	170	150	48457		0.053	0.927	0.020
18	4/26,27	103	89	38628		0.225	0.775	
19	5/3,4	160	149	36597		0.174	0.805	0.020
20	5/9,11	120	104	15455	0.010	0.365	0.567	0.058
21	5/16,18	100	93	8694		0.258	0.677	0.065
22[b]	5/23,25	77	67	9260		0.284	0.612	0.104
Cumulative		824	739	199561	0.001	0.143	0.832	0.024

a Weekly run size includes fish numbers from Weeks 12 – 14. Sampling started in Week 15.

b Weekly run size includes fish numbers from Week 23. Sampling ended in Week 22.

Figure 3. Weekly freshwater age composition estimates of Columbia Basin spring, summer, and upriver brights fall chinook salmon sampled at Bonneville Dam in 2000. Note: Sampling did not occur during weeks 32-34 due to high water temperatures.

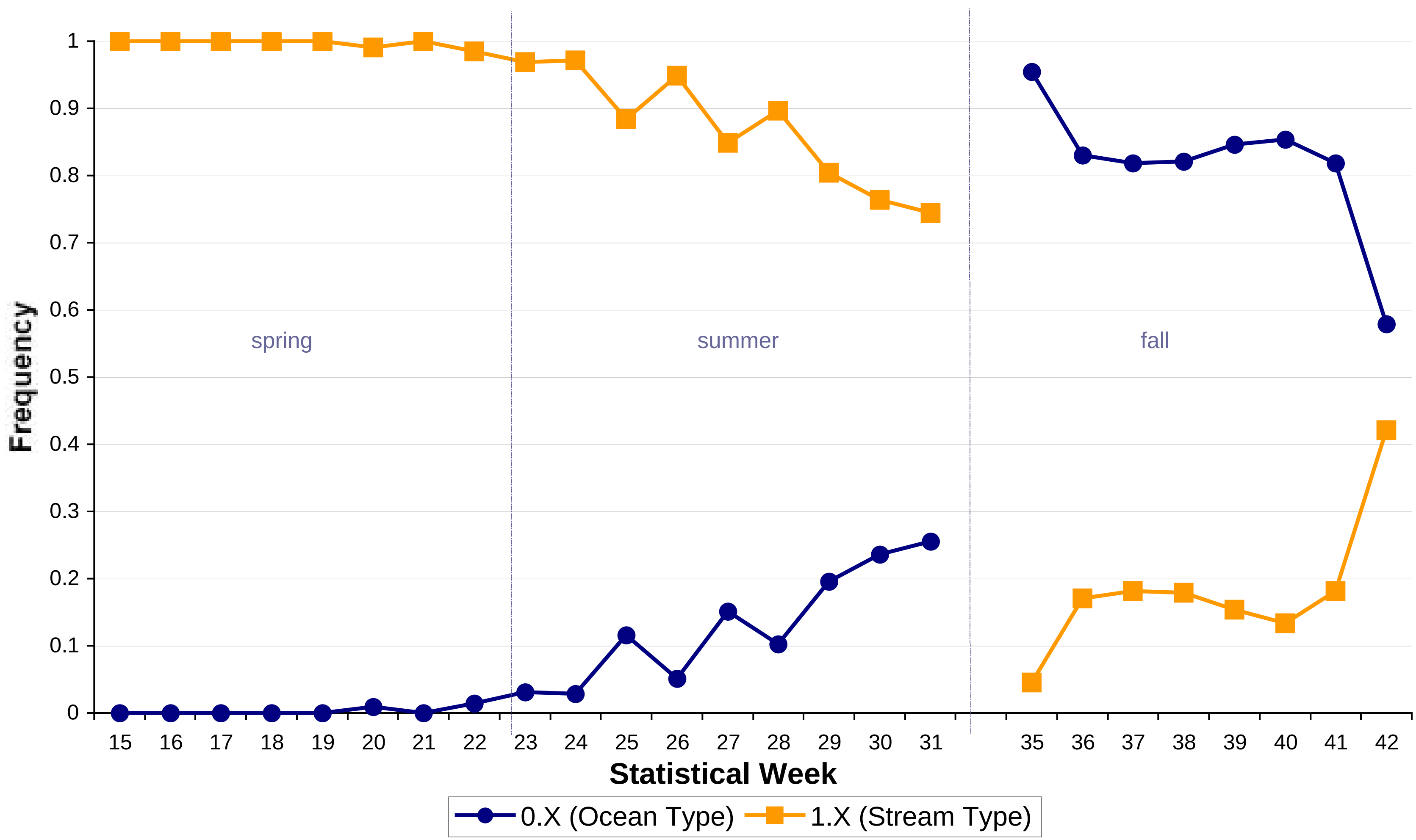


Table 2. Weekly and cumulative age composition of Columbia Basin summer chinook salmon sampled at Bonneville Dam in 2000.

					Age Composition by Brood Year and Age Class							
					1998	1997		1996		1995		1994
Statistical Week	Sampling Date	Number Sampled	Number Ageable	Weekly run size	0.1	0.2	1.1	0.3	1.2	0.4	1.3	1.4
23	6/1	36	32	2729		0.031	0.531		0.281		0.156	
24	6/6, 8	80	70	5330		0.029	0.443		0.400		0.129	
25	6/14	48	43	5683		0.023	0.326	0.070	0.256	0.023	0.302	
26	6/20, 21	42	39	6953			0.333	0.051	0.282		0.308	0.026
27	6/27, 29	72	66	6328		0.030	0.364	0.061	0.227	0.061	0.258	
28	7/5, 6	72	68	4281	0.015	0.015	0.471	0.029	0.250	0.044	0.176	
29	7/11, 13	54	46	4937	0.022	0.065	0.413	0.087	0.174	0.022	0.217	
30	7/18, 20	59	55	3708		0.036	0.400	0.091	0.145	0.109	0.218	
31[a]	7/25, 27	44	43	4221	0.047	0.023	0.372	0.140	0.163	0.047	0.209	
Cumulative		507	462	44170	0.008	0.027	0.394	0.059	0.247	0.032	0.229	0.004

a Weekly run size includes fish numbers from Week 32. Sampling ended in Week 31.

Table 3. Weekly and cumulative age composition of Columbia Basin upriver brights fall chinook salmon sampled at Bonneville Dam in 2000.

					Age Composition by Brood Year and Age Class								
					1998	1997		1996		1995		1994
Statistical Week	Sampling Date	Number Sampled	Number Ageable	Weekly run size	0.1	0.2	1.1	0.3	1.2	0.4	1.3	1.4
35[a]	8/22, 24	45	44	69874	0.091	0.136	0.023	0.295		0.432	0.023	
36	8/29, 31	87	82	53183	0.159	0.061	0.037	0.366	0.061	0.244	0.073	
37	9/5, 7	93	88	55029	0.057	0.193	0.023	0.250	0.068	0.318	0.091	
38	9/13, 14	110	106	32054	0.132	0.132	0.038	0.302	0.019	0.255	0.123	
39	9/18, 19	109	104	17634	0.106	0.183	0.038	0.183	0.019	0.375	0.087	0.010
40	9/26, 28	92	82	10001	0.146	0.159	0.098	0.232	0.012	0.317	0.024	0.012
41	10/3, 6	28	22	4026	0.136	0.182	0.045	0.227		0.273	0.136	
42[b]	10/10, 12	23	19	5950	0.158	0.158	0.105	0.105	0.105	0.158	0.211	
Cumulative		587	547	247751	0.109	0.138	0.034	0.285	0.035	0.325	0.073	0.001

a Weekly run size includes fish numbers from Weeks 32 – 34. Sampling started in Week 35.

b Weekly run size includes fish numbers from Weeks 43 - 48. Sampling ended in Week 42.

Table 4. Weekly and cumulative age composition of Columbia Basin sockeye salmon sampled at Bonneville Dam in 2000.

					Age Composition by Brood Year and Age Class					
					1997	1996		1995		1994
Statistical Week	Sampling Date	Number Sampled	Number Ageable	Weekly run size	1.1	1.2	2.1	1.3	2.2	2.3
22 - 23 [a]	5/25, 6/1	9	9	645		0.889	0.111			
24	6/6, 8	85	84	4455		0.940		0.012	0.048	
25	6/14	74	69	16122		0.986		0.014		
26	6/20, 21	180	175	43848	0.029	0.960	0.006		0.006	
27	6/27, 29	120	118	18892	0.034	0.949		0.017		
28	7/5, 6	73	71	6069	0.099	0.901				
29	7/11,13	25	23	2280	0.087	0.870				0.043
30 - 31 [b]	7/18, 20, 25	8	8	1083	0.750	0.125	0.125			
Cumulative		574	557	93394	0.037	0.945	0.005	0.006	0.005	0.001

a Weeks 22 and 23 were combined, due to small sample size (n=1) in Week 22.

b Weeks 30 and 31 were combined, due to small sample size (n=1) in Week 31.

Table 5. Weekly and cumulative age composition of Columbia Basin coho salmon sampled at Bonneville Dam in 2000.

Statistical Week	Sampling Date	Number Sampled	Number Ageable	Weekly run size	Age Composition by Brood Year and Age Class: 1998 1.0	1997 1.1
35[a]	8/22, 24	26	23	5467		1.000
36	8/29, 31	77	72	16284		1.000
37	9/5, 7	59	57	23587		1.000
38	9/13, 14	74	73	14244		1.000
39	9/18, 19	50	47	4885		1.000
40	9/26, 28	50	48	5161	0.020	0.980
41	10/3, 6	67	64	5798		1.000
42[b]	10/10, 12	85	80	21487		1.000
Cumulative		488	464	96913	0.001	0.999

a Weekly run size includes fish numbers from Weeks 31 – 34. Sampling started in Week 35.

b Weekly run size includes fish numbers from Weeks 43 - 48. Sampling ended in Week 42.

2001 Spring and Summer Chinook Salmon Run Size Prediction

Based on a linear relationship between three-year-old and four-year old returns (Figure 4) the estimated 2001 four-year-old adult spring chinook salmon abundance at Bonneville Dam is 325,000 (±111,600, 90% Predictive Interval [PI]). A relationship between four-year-olds and five-year-olds (Figure 5), albeit poorer than that existing between three-year-olds and four-year-olds, predicts that the 2001 five-year-old adult abundance will be 54,300 (±40,600, 90% PI).

For the 2001 summer chinook salmon run, the relationship between three- and four-year-olds (Figure 6) resulted in a prediction of 27,800 four-year-olds (±29,750, 90% PI). The relationship between four- and five-year-olds (Figure 7) predicted a summer chinook salmon run of 11,000 (±3,250, 90% PI) five-year-olds for the year 2001.

Figure 6. Predicted 2001 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 1996.

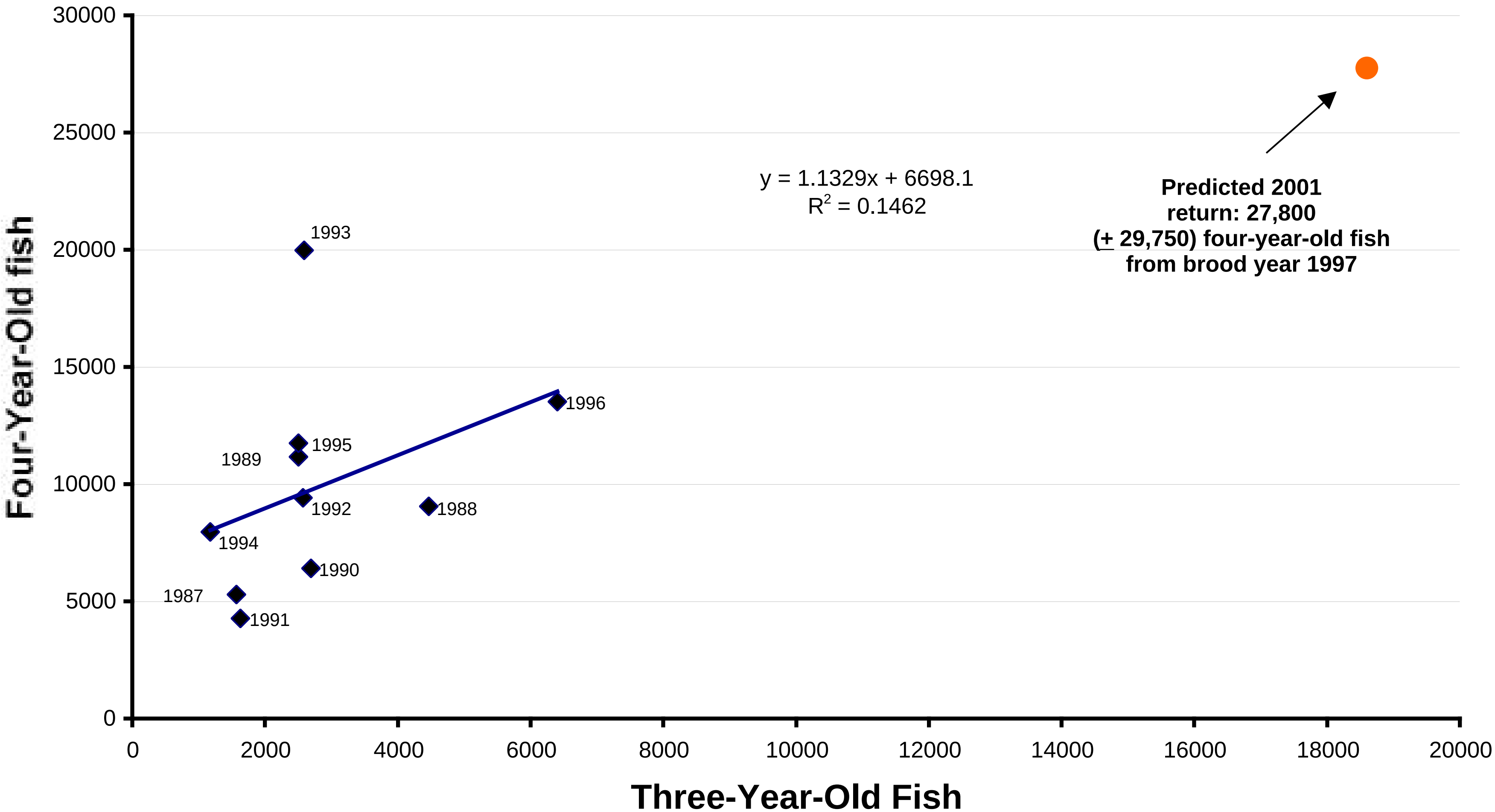
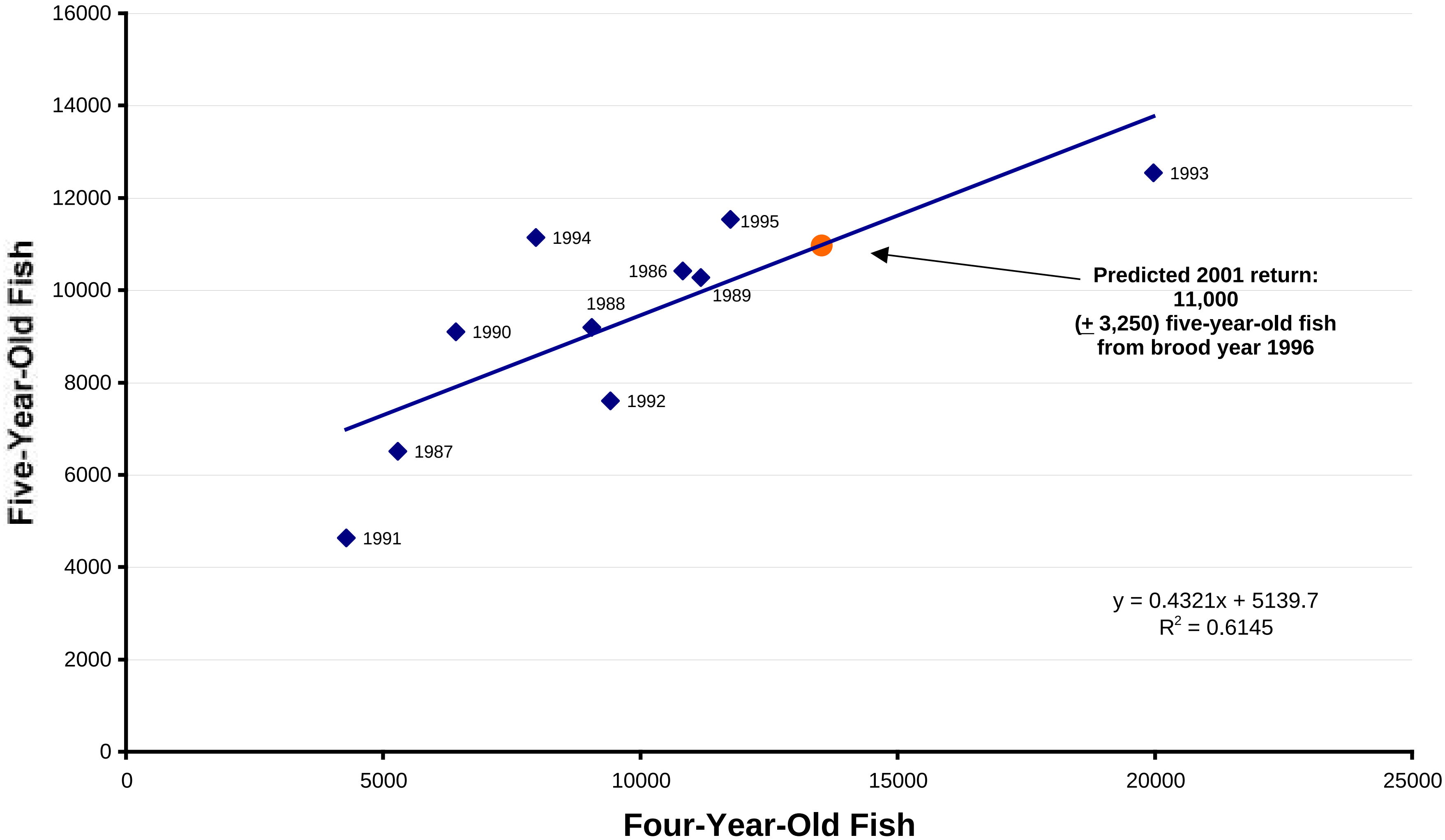


Figure 7. Predicted 2001 five-year-old Columbia Basin summer chinook salmon abundance (at Bonneville Dam) based on a linear relationship between five-year-old and four-year-old fish abundance during brood years 1986 through 1995.



DISCUSSION

This study offers a unique opportunity to obtain representative samples of multiple species from a large river over the entire period of their run. Although sockeye and coho salmon were only sampled over 10 and 8 weeks respectively, chinook salmon were sampled over 28 weeks, with the exception of 3 weeks when temperatures were too high to sample fish without potentially causing harm. Coho and sockeye salmon were overwhelmingly of a single age class (1.1 for coho and 1.2 for sockeye) throughout their runs; however, chinook salmon showed considerable variation in age structure (Figure 2). Four-year-old fish predominated among spring chinook, three-year-olds were a plurality of summer chinook, and five-year-olds were a plurality of URB fall chinook salmon.

The percentage of stream-type chinook salmon consistently decreased through the run until the final two weeks when sample sizes were small (Figure 3). What is surprising is the percentage of summer and fall chinook salmon estimated to be of stream-type (87% and 14% respectively). All natural stocks of upriver bright fall chinook as well as Mid-Columbia summer chinook salmon are generally considered to be ocean-type (Park 1969, Myers et al. 1998). Snake River summer chinook salmon are considered to be stream-type, but in most years they are a smaller portion of the run than Mid-Columbia summer chinook salmon.

The higher-than-expected percentage of stream-type fish among summer and fall chinook salmon can be partially explained by hatchery production practices. The vast majority of fall chinook reared at Lyons Ferry Hatchery on the Snake River and summer chinook reared at Wells and Eastbank hatcheries on the Mid-Columbia are released as yearlings. Another explanation may come from the effects of mainstem Columbia River hydroelectric dam construction and operations on juvenile salmon migration. Park (1969) found that the downstream migration of Mid-Columbia summer chinook salmon through Priest Rapids Dam occurred considerably later in 1965-1967 than 1954-1955 (Mains and Smith 1964) and that some fish over-wintered in lower Columbia River reservoirs. Park attributed changes in migratory timing to a decrease in flows in Columbia River impoundments. More recently, PIT tags inserted in out-migrating chinook salmon and monitored on the downstream migration have also found juvenile of chinook salmon stocks considered to have an ocean-type life history over-wintering in reservoirs (Arnsberg and Statler 1995). Scales from these over-wintering chinook salmon ("reservoir-reared") show a distinct pattern that is often seen in returning Columbia Basin summer and fall chinook salmon (John Sneva [WDFW-Olympia] letter to William P. Connor [USFWS-Ahsahka, ID], October 12, 1999).

The mean lengths of all but one of the significant salmon age classes sampled (5 of 6 chinook age classes in Figure 1, plus coho Age 1.1 and sockeye Age 1.2) increased over the period sampled. The sole exception was Age 0.1 chinook that showed a significant decrease of –0.33 cm per week between weeks 31 and 42. The mean increase ranged from 0.12 cm per week for Age 1.2 chinook salmon to 0.49 cm per week for Age 1.2 sockeye salmon. This weekly increment is likely a function of increased ocean residence time as well as possible stock specific differences in fish length and run timing. There is no apparent explanation for the decline in the mean size of Age 0.1 chinook salmon between week 31 and 42, although it may be partially a result of small sample sizes in weeks 31, 35, 41, and 42 (4 or fewer fish in all weeks).

Based on 1999 results, we made run size predictions for 2000 in Hooff et al. (1999b) using the methods discussed in this report. The predicted run size for 2000 returning four- and five-year-old summer chinook salmon was very close to predicted, but predictions for spring chinook salmon were not as good (Table 6). The 2000 return of four-year-old spring chinook salmon was much greater than predicted, surpassing even the upper bound of our estimate. Conversely, the estimated return of five-year-old spring chinook salmon was considerably less than that predicted, although within the predicted interval.

The 2001 run size predictions used in this report should be used with caution. For all age classes predicted, the estimated 2000 run size used in making the prediction for 2001 is beyond the range of previously observed data. For all but one of the predictions (2000 four-year-old summer chinook salmon to predict 2001 five-year-old summer chinook salmon), we are predicting returns considerably higher than the range of previous data. Using a regression to predict beyond the range of past data should be done with extreme caution because one cannot be sure that the regression function that fits the past data is appropriate over a wider range (Neter et al. 1985).

The difference between predicted and estimated 2000 spring chinook salmon run size also suggests that our 2001 spring chinook salmon predictions be treated with caution. The ratio of 2000 four-year-old returns to 1999 three-year-old returns was greater than expected, while the ratio of 2000 five-year-old returns to 1999 four-year-old returns was less than expected. It is possible that this may be due to changes in ocean habitat, or other changes in the environment faced by Columbia Basin spring chinook salmon, and that these same changes could impact 2001 returns. This suggests that our 2001 estimate of four-year-old returns could be low, while our 2001 estimate of five-year-old returns could be high. However, it seems unlikely that 2001 four-year-old returns could be larger than our predicted point estimate of 325,000 fish. Given how much greater this return would be than any observed in recent times, it is more likely that our prediction proves high.

Table 6. Predicted and estimated numbers of spring and summer chinook salmon returning to Bonneville Dam in 2000.

Species	1999 Report's Predicted (± 90%) for Year 2000	Year 2000 Estimated Number
Spring Chinook 4-year-old	95,800 (+ 36,800)	166,035
Spring Chinook 5-year-old	12,000 (+ 31,500)	4,790
Summer Chinook 4-year-old	14,900 (± 8,950)	13,516
Summer Chinook 5-year-old	10,000 (± 3,025)	11,528

This study is expected to continue to develop an accurate age composition and length-at-age database for Columbia Basin upriver salmon populations. This information provides unbiased estimates of the age composition of the terminal run, and improves forecasting of terminal runs, which are both important in improving the calibration of the Chinook Technical Committee's chinook model. The 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 imposed by the Pacific Salmon Treaty.

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<u>Appendix A</u>

Data Tables

Table A1. Total age composition (%) for fin-clipped and non fin-clipped chinook, sockeye, and coho salmon sampled at Bonneville Dam in 2000. Note: Age 1.0 chinook salmon ("mini-jacks") were omitted.

Age Composition (%) by Brood Year and Age Class

	Sample Size (n)	Ageable (n)	1998		1997		1996			1995			1994		
			0.1	1.0	0.2	1.1	0.3	1.2	2.1	0.4	1.3	2.2	0.5	1.4	2.3
Spring Chinook															
Fin - Clipped	370	336				27.1		71.7			1.2				
No Fin - Clips	454	403			0.2	11.2		82.9			5.7				
Summer Chinook															
Fin - Clipped	295	265	0.4			54.3	2.6	25.3			17.4				
No Fin - Clips	212	197	1.5		6.6	22.3	9.6	23.9		8.6	26.9			0.5	
Fall Chinook															
Fin - Clipped	73	66	10.6		6.1	21.2	21.2	7.6		21.2	10.6			1.5	
No Fin - Clips	514	481	12.1		16.0	2.3	26.6	2.7		32.0	8.1			0.2	
Coho															
Fin - Clipped	253	241				100.0									
No Fin - Clips	235	223		0.4		99.6									
Sockeye															
Fin - Clipped	25	25						100.0							
No Fin - Clips	549	532				4.5		93.0	0.6		0.8	0.9			0.2

Table A2. Percent of sampled chinook, coho, and sockeye salmon at Bonneville Dam having fin clips by statistical week and total sampled in 2000.

Statistical Week	Spring Chinook	Summer Chinook	Fall Chinook	Coho	Sockeye
12	x				
13	x				
14	x				
15	64.7				
16	57.1				
17	37.1				
18	55.3				
19	38.8				
20	40.8				
21	48.0				
22	46.8				c
23	x	55.6			0.0
24		56.3			0.0
25		50.0			2.7
26		57.1			6.7
27		51.4			3.3
28		68.1			9.6
29		66.7			0.0
30		71.2			0.0
31		40.9			c
32		x	x	x	x
33			x	x	x
34			x	x	x
35			13.3	50.0	
36			14.9	48.1	
37			14.0	42.4	
38			8.2	21.6	
39			11.0	18.0	
40			14.1	54.0	
41			17.9	68.7	
42			8.7	94.1	
43			x	x	
44			x	x	
45			x	x	
46			x	x	
47			x	x	
48			x	x	
Total Sampled	44.9	58.2	12.4	51.8	4.4

x Represents that a species was present, but sampling did not occur. Therefore, the percent in a sampled statistical week, before or after an x, is assumed to represent the weeks not sampled.
c Week combined with next or previous week due to low sample size.

Table A3. Length-at-age estimates for Columbia Basin spring chinook salmon sampled at Bonneville Dam in 2000. Composite estimates are weighted by weekly run size.

	Brood Year and Age Class			
	1997		1996	1995
	0.2	1.1	1.2	1.3
Statistical Week 15				
Mean Fork Length (cm)			71.34	
Maximum			79.00	
Minimum			63.50	
Standard Deviation			4.28	
Sample Size			16	
Statistical Week 16				
Mean Fork Length (cm)		52.00	72.57	80.75
Maximum		52.00	83.00	83.00
Minimum		52.00	61.00	78.50
Standard Deviation		0.00	3.63	3.18
Sample Size		1	68	2
Statistical Week 17				
Mean Fork Length (cm)		48.50	72.63	82.00
Maximum		59.00	81.50	87.00
Minimum		44.50	61.50	72.00
Standard Deviation		4.71	3.54	8.66
Sample Size		8	139	3
Statistical Week 18				
Mean Fork Length (cm)		49.38	72.09	
Maximum		59.00	82.00	
Minimum		43.00	61.50	
Standard Deviation		3.74	4.25	
Sample Size		20	69	
Statistical Week 19				
Mean Fork Length (cm)		50.77	72.57	86.67
Maximum		58.50	84.00	90.00
Minimum		44.00	61.00	84.00
Standard Deviation		3.31	4.72	3.06
Sample Size		26	120	3
Statistical Week 20				
Mean Fork Length (cm)	67.00	51.78	73.16	83.83
Maximum	67.00	59.00	82.50	93.50
Minimum	67.00	44.00	63.00	72.00
Standard Deviation	0.00	3.29	3.32	8.20
Sample Size	1	38	59	6
Statistical Week 21				
Mean Fork Length (cm)		51.30	73.26	84.58
Maximum		58.00	82.00	90.00
Minimum		44.00	63.00	74.50
Standard Deviation		3.11	4.54	5.63
Sample Size		24	63	6
Statistical Week 22				
Mean Fork Length (cm)		49.66	77.07	88.71
Maximum		57.50	82.00	95.50
Minimum		44.00	69.00	80.00
Standard Deviation		3.45	2.73	6.42
Sample Size		19	41	7
2000 Composite				
Mean Fork Length (cm)	67.00	51.90	72.58	85.25
Maximum	67.00	59.00	84.00	95.50
Minimum	67.00	43.00	61.00	72.00
Standard Deviation	0.00	4.30	4.01	6.78
Sample Size	1	136	575	27

Table A4. **Length-at-age estimates for Columbia Basin summer chinook salmon sampled at Bonneville Dam in 2000. Composite estimates are weighted by weekly run size.**

	Brood Year and Age Class							
	1998	1997		1996		1995		1994
	0.1	0.2	1.1	0.3	1.2	0.4	1.3	1.4
Statistical Week 23								
Mean Fork Length (cm)		54.00	51.91		74.72		86.40	
Maximum		54.00	56.50		80.00		92.50	
Minimum		54.00	45.00		69.00		78.00	
Standard Deviation		0.00	3.13		3.69		6.46	
Sample Size		1	17		9		5	
Statistical Week 24								
Mean Fork Length (cm)		60.00	50.52		75.91		88.11	
Maximum		61.00	57.50		82.00		98.00	
Minimum		59.00	42.50		70.00		80.00	
Standard Deviation		1.41	4.11		3.38		5.72	
Sample Size		2	31		28		9	
Statistical Week 25								
Mean Fork Length (cm)		65.00	54.32	85.00	75.91	97.00	87.69	
Maximum		65.00	61.00	92.50	81.50	97.00	94.00	
Minimum		65.00	48.00	76.50	68.00	97.00	80.50	
Standard Deviation		0.00	4.14	8.05	4.65	0.00	4.65	
Sample Size		1	14	3	11	1	13	
Statistical Week 26								
Mean Fork Length (cm)			52.89	87.25	72.46		86.42	102.50
Maximum			61.00	87.50	79.00		98.50	102.50
Minimum			45.50	87.00	61.00		76.50	102.50
Standard Deviation			3.56	0.35	5.87		6.22	0.00
Sample Size			13	2	11		12	1
Statistical Week 27								
Mean Fork Length (cm)		60.75	51.96	77.50	74.30	83.38	87.06	
Maximum		61.00	63.00	80.50	82.50	89.50	99.50	
Minimum		60.50	39.00	76.00	61.50	73.00	72.00	
Standard Deviation		0.35	6.90	2.12	6.02	7.72	8.27	
Sample Size		2	24	4	15	4	17	
Statistical Week 28								
Mean Fork Length (cm)	39.00	60.50	52.20	80.25	73.50	93.50	88.75	
Maximum	39.00	60.50	62.00	82.50	87.00	103.00	100.00	
Minimum	39.00	60.50	40.00	78.00	62.00	83.50	76.00	
Standard Deviation	0.00	0.00	5.35	3.18	8.38	9.76	5.86	
Sample Size	1	1	32	2	17	3	12	
Statistical Week 29								
Mean Fork Length (cm)	42.00	62.50	51.97	85.00	78.19	99.00	86.10	
Maximum	42.00	66.50	62.00	90.00	82.00	99.00	96.00	
Minimum	42.00	56.50	44.00	82.00	73.50	99.00	73.50	
Standard Deviation	0.00	5.29	5.04	3.56	3.62	0.00	7.81	
Sample Size	1	3	19	4	8	1	10	
Statistical Week 30								
Mean Fork Length (cm)		64.00	51.50	83.10	73.13	93.75	85.67	
Maximum		68.00	65.00	94.00	83.00	101.00	97.00	
Minimum		60.00	40.00	72.00	61.00	90.00	77.00	
Standard Deviation		5.66	6.99	8.07	7.87	4.62	5.52	
Sample Size		2	22	5	8	6	12	
Statistical Week 31								
Mean Fork Length (cm)	48.00	59.00	50.83	79.17	75.93	104.25	90.22	
Maximum	55.00	59.00	60.50	90.50	81.50	110.00	103.00	
Minimum	41.00	59.00	44.50	67.00	71.00	98.50	83.00	
Standard Deviation	9.90	0.00	4.24	7.97	3.97	8.13	6.38	
Sample Size	2	1	16	6	7	2	9	
2000 Composite								
Mean Fork Length (cm)	44.25	61.19	51.99	82.87	74.77	93.00	87.30	102.50
Maximum	55.00	68.00	65.00	94.00	87.00	110.00	103.00	102.50
Minimum	39.00	54.00	39.00	67.00	61.00	73.00	72.00	102.50
Standard Deviation	7.27	3.93	5.00	4.96	5.50	8.74	6.52	0.00
Sample Size	4	13	188	26	114	14	99	1

Table A5. **Length-at-age estimates for Columbia Basin upriver brights fall chinook salmon sampled at Bonneville Dam in 2000. Composite estimates are weighted by weekly run size.**

	Brood Year and Age Class							
	1998	1997		1996		1995		1994
	0.1	0.2	1.1	0.3	1.2	0.4	1.3	1.4
Statistical Week 35								
Mean Fork Length (cm)	47.75	64.50	54.00	85.92		89.76	93.00	
Maximum	52.00	76.00	54.00	92.00		102.00	93.00	
Minimum	44.50	59.00	54.00	80.50		73.00	93.00	
Standard Deviation	3.43	5.89	0.00	3.94		7.32	0.00	
Sample Size	4	6	1	13		19	1	
Statistical Week 36								
Mean Fork Length (cm)	46.46	65.50	55.17	83.97	74.50	90.25	88.92	
Maximum	50.50	72.00	59.00	94.00	86.00	100.00	96.00	
Minimum	41.00	59.00	52.00	73.00	59.00	83.00	84.00	
Standard Deviation	2.77	6.20	3.55	5.62	9.79	5.39	4.45	
Sample Size	13	5	3	30	5	20	6	
Statistical Week 37								
Mean Fork Length (cm)	47.90	66.65	52.50	85.45	75.75	92.36	86.31	
Maximum	52.00	73.00	54.00	98.00	92.00	103.00	93.00	
Minimum	44.00	59.00	51.00	80.00	65.00	84.50	72.00	
Standard Deviation	3.09	4.51	2.12	4.16	10.87	5.41	6.60	
Sample Size	5	17	2	22	6	28	8	
Statistical Week 38								
Mean Fork Length (cm)	47.10	65.46	62.25	82.23	72.25	90.07	90.65	
Maximum	51.50	83.50	66.50	93.00	76.00	99.00	103.00	
Minimum	42.00	49.50	57.00	57.50	68.50	83.00	70.00	
Standard Deviation	2.73	7.75	4.73	6.85	5.30	4.38	8.09	
Sample Size	14	14	4	32	2	27	13	
Statistical Week 39								
Mean Fork Length (cm)	47.09	63.66	56.13	82.05	80.00	92.01	86.17	100.00
Maximum	51.50	74.00	60.00	91.00	82.00	107.50	93.50	100.00
Minimum	41.00	54.50	52.50	74.50	78.00	82.00	78.00	100.00
Standard Deviation	3.22	4.40	3.47	3.88	2.83	5.28	5.62	0.00
Sample Size	11	19	4	19	2	39	9	1
Statistical Week 40								
Mean Fork Length (cm)	45.67	64.81	58.38	82.11	68.00	87.85	87.00	93.00
Maximum	50.00	71.00	65.00	98.50	68.00	95.50	89.00	93.00
Minimum	39.00	52.00	51.00	69.00	68.00	78.50	85.00	93.00
Standard Deviation	3.10	5.46	4.53	7.00	0.00	4.07	2.83	0.00
Sample Size	12	13	8	19	1	26	2	1
Statistical Week 41								
Mean Fork Length (cm)	46.00	68.00	65.00	84.20		90.08	89.33	
Maximum	48.00	78.00	65.00	91.00		94.00	100.00	
Minimum	44.00	55.00	65.00	77.00		86.00	82.00	
Standard Deviation	2.00	11.34	0.00	5.07		3.19	9.45	
Sample Size	3	4	1	5		6	3	
Statistical Week 42								
Mean Fork Length (cm)	43.33	72.17	55.75	89.25	74.00	86.17	85.88	
Maximum	45.00	76.00	57.00	91.50	75.00	92.00	92.00	
Minimum	41.00	68.00	54.50	87.00	73.00	80.50	79.50	
Standard Deviation	2.08	4.01	1.77	3.18	1.41	5.75	7.08	
Sample Size	3	3	2	2	2	3	4	
2000 Composite								
Mean Fork Length (cm)	46.90	65.41	57.66	84.48	74.86	90.66	88.18	96.50
Maximum	52.00	83.50	66.50	98.50	92.00	107.50	103.00	100.00
Minimum	39.00	49.50	51.00	57.50	59.00	73.00	70.00	93.00
Standard Deviation	3.13	5.81	4.67	4.75	8.16	6.16	6.63	4.95
Sample Size	65	81	25	142	18	168	46	2

Table A6. Length-at-age estimates for Columbia Basin sockeye salmon sampled at Bonneville Dam in 2000. Composite estimates are weighted by weekly run size.

	Brood Year and Age Class					
	1997	1996		1995		1994
	1.1	1.2	2.1	1.3	2.2	2.3
Statistical Week 23						
Mean Fork Length (cm)		48.69	42.00			
Maximum		51.50	42.00			
Minimum		45.50	42.00			
Standard Deviation		2.42	0.00			
Sample Size		8	1			
Statistical Week 24						
Mean Fork Length (cm)		49.27		54.00	49.88	
Maximum		55.00		54.00	54.00	
Minimum		43.00		54.00	45.50	
Standard Deviation		2.34		0.00	3.50	
Sample Size		79		1	4	
Statistical Week 25						
Mean Fork Length (cm)		49.81		55.50		
Maximum		55.50		55.50		
Minimum		43.00		55.50		
Standard Deviation		2.49		0.00		
Sample Size		68		1		
Statistical Week 26						
Mean Fork Length (cm)	39.50	50.43	42.00		51.50	
Maximum	41.00	55.50	42.00		51.50	
Minimum	37.00	44.00	42.00		51.50	
Standard Deviation	1.87	2.06	0.00		0.00	
Sample Size	5	168	1		1	
Statistical Week 27						
Mean Fork Length (cm)	39.25	50.20		53.50		
Maximum	40.50	56.00		56.00		
Minimum	37.50	44.00		51.00		
Standard Deviation	1.50	2.31		3.54		
Sample Size	4	112		2		
Statistical Week 28						
Mean Fork Length (cm)	40.14	50.21				
Maximum	43.00	61.00				
Minimum	36.00	46.00				
Standard Deviation	2.53	2.59				
Sample Size	7	64				
Statistical Week 29						
Mean Fork Length (cm)	38.75	50.50				59.50
Maximum	39.00	56.00				59.50
Minimum	38.50	40.50				59.50
Standard Deviation	0.35	3.34				0.00
Sample Size	2	20				1
Statistical Week 30						
Mean Fork Length (cm)	38.80	53.50	39.00			
Maximum	41.00	53.50	39.00			
Minimum	37.00	53.50	39.00			
Standard Deviation	1.63	0.00	0.00			
Sample Size	6	1	1			
2000 Composite						
Mean Fork Length (cm)	40.16	50.66	41.00	54.13	50.20	59.50
Maximum	43.00	61.00	42.00	56.00	54.00	59.50
Minimum	36.00	40.50	39.00	51.00	45.50	59.50
Standard Deviation	1.83	2.16	1.73	2.25	3.11	0.00
Sample Size	24	520	3	4	5	1

Table A7. Length-at-age estimates for Columbia Basin coho salmon sampled at Bonneville Dam in 2000. Composite estimates are weighted by weekly run size.

	1998 1.0	1997 1.1
Statistical Week 35		
Mean Fork Length (cm)		59.35
Maximum		69.00
Minimum		48.00
Standard Deviation		5.70
Sample Size		23
Statistical Week 36		
Mean Fork Length (cm)		62.01
Maximum		74.00
Minimum		47.00
Standard Deviation		6.28
Sample Size		72
Statistical Week 37		
Mean Fork Length (cm)		64.99
Maximum		78.00
Minimum		50.00
Standard Deviation		5.72
Sample Size		57
Statistical Week 38		
Mean Fork Length (cm)		67.82
Maximum		80.00
Minimum		54.00
Standard Deviation		5.53
Sample Size		73
Statistical Week 39		
Mean Fork Length (cm)		66.34
Maximum		79.50
Minimum		49.50
Standard Deviation		6.07
Sample Size		47
Statistical Week 40		
Mean Fork Length (cm)	42.50	63.72
Maximum	42.50	78.00
Minimum	42.50	52.00
Standard Deviation	0.00	7.13
Sample Size	1	47
Statistical Week 41		
Mean Fork Length (cm)		65.71
Maximum		79.00
Minimum		46.50
Standard Deviation		7.84
Sample Size		64
Statistical Week 42		
Mean Fork Length (cm)		65.42
Maximum		83.00
Minimum		49.00
Standard Deviation		8.34
Sample Size		80
2000 Composite		
Mean Fork Length (cm)	42.50	64.72
Maximum	42.50	83.00
Minimum	42.50	46.50
Standard Deviation	0.00	6.71
Sample Size	1	463

Table A8. Composition (%) of observed injuries of Columbia Basin chinook salmon sampled at Bonneville Dam in 2000.

Injury Category	Spring	Summer	Fall
Marine Mammal			
Bite	3.0	0.8	1.3
Claw Rake	6.3	2.0	1.7
Twin Arches	5.1	1.0	0.8
Total [a]	13.5	3.6	3.7
Descaling			
< 5%			
Right side	0.0	0.0	1.0
Left side	0.0	0.2	1.0
Total [b]	0.0	0.0	1.5
5-20%			
Right side	8.4	6.3	3.5
Left side	6.3	5.7	3.2
Total [c]	10.8	9.9	4.8
>20%			
Right side	0.7	0.6	0.0
Left side	0.4	0.2	0.2
Total [d]	1.0	0.6	0.2
Other Injuries			
Bruises	0.1	0.0	0.0
Cuts	0.4	0.0	0.3
Head Injury	1.0	2.4	3.2
Head Burn	1.0	0.0	0.0
Fin	4.9	2.8	2.6
Fungus	3.2	0.6	0.5
Gash	2.4	1.2	2.6
Gas Bubble Trauma	0.0	0.0	0.0
Gill Net	0.4	0.6	1.0
Fishing Hook	0.5	0.6	0.9
Lamprey	0.7	0.6	0.2
Parasite	2.7	0.6	0.0
Total [a]	13.1	8.3	9.2

a Totals, as percentages, do not represent the sum of subcategories, they are the number of fish with at least one injury. Fish often display more than one type of marine mammal or general injury.
b This total represents, as a percentage, the number of fish with descaling on either side, which is less than 5% descaled. If either side is > 5%, the fish moves into another category.
c This total represents, as a percentage, the number of fish with descaling on either side, which is 5 – 20% descaled. If either side is > 20% or both < 5%, the fish moves into another category.
d This total represents, as a percentage, the number of fish with descaling on at least one side that is > 20% descaled.

Table A9. Composition (%) of observed injuries of Columbia Basin sockeye and coho salmon sampled at Bonneville Dam in 2000.

Injury Category	Sockeye	Coho
Marine Mammal		
Bite	1.6	1.0
Claw Rake	2.1	4.5
Twin Arches	1.0	2.0
Total [a]	4.5	7.6
Descaling		
< 5%		
Right side	1.0	3.7
Left side	1.2	3.3
Total [b]	1.2	4.7
5-20%		
Right side	6.1	6.4
Left side	7.1	4.9
Total [c]	8.9	8.4
>20%		
Right side	0.2	0.6
Left side	0.0	0.4
Total [d]	0.2	0.4
Other Injuries		
Bruises	0.2	0.0
Cuts	0.0	0.4
Head Injury	0.2	3.1
Head Burn	0.2	0.0
Fin	0.7	2.0
Fungus	0.5	1.6
Gash	1.0	0.4
Gas Bubble Trauma	0.0	0.0
Gill Net	0.0	2.3
Fishing Hook	0.2	0.6
Lamprey	0.0	0.0
Parasite	0.2	0.0
Total [a]	2.8	8.8

a Totals, as percentages, do not represent the sum of subcategories, they are the number of fish with at least one injury. Fish often display more than one type of marine mammal or general injury.
b This total represents, as a percentage, the number of fish with descaling on either side, which is less than 5% descaled. If either side is > 5%, the fish moves into another category.
c This total represents, as a percentage, the number of fish with descaling on either side, which is 5 – 20% descaled. If either side is > 20% or both < 5%, the fish moves into another category.
d This total represents, as a percentage, the number of fish with descaling on at least one side that is > 20% descaled.

Appendix B

Description of fish condition assessment notation

Prior to 1992, sampling personnel had the option of noting fish condition in the comments section of the sampling form. This resulted in an assessment of fish condition, which varied with sampling personnel, sampling site, and sampling date. To standardize this information and allow meaningful comparisons of relative fish condition by date and/or site, new criteria and sample forms were developed for the 1992-sampling season (Fryer and Schwartzberg 1993). Slightly modified criteria have been used for sampling since 1997 to standardize assessment of gas bubble trauma (GBT) and headburn (Fig. B1 and B2).

In 2000, new Condition and Coloration criteria were developed to reduce subjectivity in data (Figure B1). Condition codes the penetration of the mark or injury instead of judging the condition of a fish in a range of 5 for perfect fish to a 1 for extremely poor condition fish.

Figure B1. Fish condition assessment notation.

1. Condition classification:
   - **5:** no marks or injuries, or marks and injuries do not break the skin
   - **4:** mark or injury breaks the skin
   - **3:** injury penetrates the muscle
   - **2:** injury penetrates a body cavity
   - **1:** missing large sections of body or appendages needed for locomotion

2. Coloration:
   - **B:** Bright (color match)
   - **I:** Intermediate (color match)
   - **D:** Dark (color match)

3. Descaling, left side; estimate actual percentage descaled

4. Descaling, right side; estimate actual percentage descaled

5. Gill net marks

6. Fin Injuries
   - **R:** Right
   - **L:** Left
   - **P:** Pectoral
   - **V:** Ventral
   - **D:** Dorsal
   - **A:** Adipose
   - **N:** Anal
   - **T:** Tail

7. Fin Injuries
   - **P**: Parasite
   - **L**: Lamprey (circular wound)
   - **C**: Cut
   - **F**: Fungus
   - **B**: Bruise
   - **G**: Gash or lesion

8. Head Injuries
   - **E**: Eye
   - **N**: Nose
   - **H**: Fishing hook

9. Marine mammal injuries as follows:

- **C**: Claw rake (2-3 or more parallel scratches on flanks of fish)
- **G**: Golden arches (2-3 or more curved scratches on flanks of fish)
- **B**: Bite (ragged wounds, often in caudal area)

10. Gas Bubble Trauma monitoring classification:

Rank	Percent area affected
0	0
1	1 to 5
2	6 to 25
3	25 to 50
4	>50

Figure B2. Sampling Form used in Adult Salmonid Sampling at Bonneville Dam in 2000.