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Age and Length Composition of Columbia Basin Chinook, Sockeye, and Coho Salmon at Bonneville Dam in 1999

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14 December 1999

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Technical Report 99-4

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ABSTRACT

Representative samples of adult 1999 Columbia Basin chinook (spring, summer, and fall), sockeye, and coho salmon populations were collected at Bonneville Dam. This was the thirteenth year spring chinook salmon, the tenth year summer chinook salmon, and the fifteenth year sockeye salmon were sampled in this study. It was the second year for sampling fall chinook and coho. Fish were trapped, anesthetized, sampled for scales and biological data, allowed to revive, and then released. The scales were examined to estimate age composition. The results of this project contribute to an ongoing database collection of Columbia Basin salmonid populations age class structure.

Based on scale analysis, four-year-old fish (from brood year 1995) were estimated to comprise 70% of the spring chinook, 39% of the summer chinook, and 62% of the fall chinook salmon population. Five-year-old fish (BY 1994) were estimated to comprise 7% of the spring chinook, 37% of the summer chinook, and 8% of the fall chinook population. Three-year-old fish were estimated to comprise 23% of the spring chinook, 21% of the summer chinook and 28% of the fall chinook salmon population. Two and six-year-olds accounted for the remaining 1% of spring chinook, 3% of summer chinook, and 2% of the fall chinook runs. The sockeye salmon population sampled at Bonneville was predominantly four-year-old fish (83%), and the coho population was entirely three-year-old fish (age 1.1).

Differences in age class returns over the past ten years were used to predict spring and summer chinook population sizes for 2000. Based on a regression with three-year-old returns, the relationship predicts four-year-old returns of 95,800 spring chinook and 14,900 summer chinook.

ACKNOWLEDGMENTS

We sincerely thank the following individuals for their assistance in this project: Chris Beasley, Bobby Begay, Doug Hatch, Marianne McClure, André Talbot, and Henry Yuen of the Columbia River Inter-Tribal Fish Commission; Brett 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, Tim King, Dan Rawding, and John Sneva of the Washington Department of Fisheries; and Chuck Gardee, James Kiona and Steve Parker of the Yakama Indian Nation.

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. Partial funding was also contributed for the monitoring of gas bubble trauma by the Bonneville Power Administration Intergovernmental Contract No. 95BI39681.

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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 report describes a project that uses scale-pattern interpretation techniques to estimate the age and length-at-age composition for the 1999 adult populations of chinook[1] *Oncorhynchus tshawytscha*, sockeye *Oncorhynchus nerka*, and coho salmon *Oncorhynchus kisutch*. Although 1999 was only the second year in which significant numbers of fall chinook and coho salmon were sampled, 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). 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 section of this report, but are part of our ongoing database collection for this project, are included in the appendix. These include length-at-age composition, fin-clip data results, and fish condition assessments for (Appendix A).

1. Columbia Basin upriver spring chinook salmon are defined as those chinook salmon migrating past Bonneville Dam before June 1. Columbia Basin summer chinook salmon are defined as those chinook salmon migrating past Bonneville Dam between June 1 and July 31 while later migrating chinook salmon are defined as fall chinook salmon.

METHODS

Sample Design

Sampling was conducted one to three days per statistical week[2] from April 7 to October 28. Sampling frequency was increased to monitor for symptoms of gas bubble trauma[3] and to achieve a minimum sample size of 500 fish each for spring, summer, and fall chinook salmon and for coho and sockeye salmon. In past study years, this minimum number of fish has resulted in age composition estimates with a precision of d=0.05 and accuracy α=0.10. The composite age and length-at-age estimates were calculated from weekly estimates weighted by the numbers of fish migrating past Bonneville Dam during the week of the sample (Fryer 1995). Dam counts of fish passage were obtained from DART (1999).

Sampling Methods

Representative samples of the Columbia River chinook, sockeye, and coho salmon populations 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 and returned to the exit fishway leading to one of the Bonneville Dam fish ladders. No fish were sacrificed in the study. 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. Gender of

2. Statistical weeks are sequentially numbered calendar-year weeks. Excepting the first and last weeks of most years, weeks are seven days long, beginning on Sunday and ending on Saturday. In 1999, for example, Statistical Week 15 began on April 4 and ended on April 10.

3. During this period, spill was increased at mainstem dams to aid juvenile fish migration. Increased spill can cause total dissolved gas supersaturation in water at dam tailraces, which may result in embolisms occurring in the tissue of fish residing in supersaturated water (Post 1983).

collected specimens, all in early stages of sexual maturation, could rarely be determined and was therefore not recorded.

Length Measurements

Fork lengths were measured to the nearest 0.5 cm. Mean lengths and measurements of variability were calculated for each age class and brood year, by weekly sampling period, and for the composite sample (Tables A3-A7).

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 1999, each specimen was inspected for marine mammal injuries, headburn, descaling, gill net abrasion, cuts, bruises and other assorted injuries (Appendix B). During spillway operation (April – July) sampling protocol includes monitoring salmonids for gas bubble trauma (Fryer 1994). Using a 2.5x magnification lens, fish are examined for air filled vessicles and/or hemmorrhaging along all fins, lateral line, eyes, and gill lamellae. Special attention was given to the eyes, mouth, operculum, lateral line and fins for the formation of observable gas bubbles.

Headburn, the exfoliation of skin and tissues of jaw and cranial region of salmonids, 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 throughout the basin (Elston 1996, Grosberg 1996).

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). Age estimates were corroborated by John Sneva of the Washington Department of Fish and Wildlife. Validation of ages (Beamish and McFarlane 1983) was not possible because no known-age fish were present in the sample.

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. All of the progeny returning from a spawning population is collectively called a brood. Many salmon forecast models are based on the relationship between a brood year spawning escapement and the corresponding total return (Bocking and Peterman 1988). Total return is obtained by tabulating the numbers of fish returning each calendar year at different ages by brood year[4] (Schwartzberg 1988; Schwartzberg and Fryer, 1990; Fryer and Schwartzberg 1991a, 1991b, 1993, 1994; Fryer et al. 1992; Hooff et. al. 1999). It was noted in the early years of this project that the number of three-year-old fish for a given brood year appeared to be a relatively good predictor of the number of subsequently returning four-year-old fish of the same brood year (Fryer and Schwartzberg 1994). A similar prediction technique is used herein to also forecast returning four-year-old and five-year-old fish in 2000.

4. Year of return – age of fish = brood year

RESULTS

Sample Design

To eliminate any possible sampling stress on fish, we did not conduct sampling when the temperature recorded at the total dissolved gas monitoring station in the Bonneville Dam forebay was above 70F. During the 1999 sampling season, although individual sampling dates were canceled due to this constraint, we were able to sample a minimum of one day per statistical week.

In 1999, 1,041 spring chinook salmon were sampled. Five percent of the fish sampled had damaged and/or unreadable scales and were subsequently rejected from our analyses. Consequently, the total sample size used for the spring chinook salmon age and length-at-age composition estimates was 982 fish.

Between 1 June and 28 July, 622 summer chinook salmon were sampled for this study. Nine percent of the fish sampled had unreadable scales and were excluded. We also excluded information on minijacks (fish generally under 30 cm in length which appeared to have spent no winters in saltwater) from this report because of their different life history and because sampling of these mini-jacks was non-random. Consequently, the total sample size for the summer chinook salmon age and length-at-age composition estimates was 564 fish.

Between 2 September and 28 October, scales were collected from 696 fall chinook individuals. Of these, 7% were unreadable, yielding a total sample size of 640 fish.

In 1999, 516 sockeye salmon were sampled. Unreadable scales accounted for 2% of the total sample. Therefore, the total sample size for the sockeye salmon age and length-at-age composition estimates was 502 fish.

Between 31 August and 28 October, 480 coho salmon were sampled at Bonneville Dam. The total sample size for coho salmon age and length-at-age estimates was 448 fish after rejecting 7% of the sample size due to unreadable scales.

Age Composition Estimates

Spring Chinook Salmon

Four-year-old fish (Ages 0.3 and 1.2 fish from the 1995 brood-year), comprised 70% of the spring chinook run (Table 1, Figure 1). Five-year-old fish (Age 1.3 from the 1994 brood-year) were 7%, and three-year-olds (age 1.1) were 23% of the 1999 run.

Summer Chinook Salmon

Five-year-old fish (Ages 0.4 and 1.3 from the 1994 brood-year), comprised 37% of the 1999 summer chinook run (Table 2, Figure 1). Four-year-old fish from the 1995 brood-year contributed 39% of the run, primarily of age class 1.2.

Fall Chinook Salmon

Fish from brood year 1995 (age class 0.3 and 1.2) made up 62%, while BY 1994 and BY 1996 (primarily age class 0.2) comprised 8% and 28%, respectively, of the 1999 fall run.

Table 1. Age composition of Columbia Basin spring chinook salmon sampled at Bonneville Dam in 1999.

Statistical Week	Sampling Dates	Ageable scales	Weekly run size	Age Composition by Brood Year and Age Class					
				1996		1995		1994	1993
				0.2	1.1	0.3	1.2	1.3	1.4
15	4/7	5	823				0.400	0.600	
16	4/14,16	50	3335				0.740	0.260	
17	4/21,23	141	6455		0.035		0.872	0.092	
18	4/28,30	155	9145		0.045		0.910	0.045	
19	5/4,5,7	181	10668		0.287		0.685	0.028	
20	5/10,12,14	259	8367		0.375		0.591	0.031	0.004
21	5/17,19,21	124	4531		0.492	0.016	0.452	0.040	
22	5/24,26,28	67	3091		0.448	0.030	0.433	0.090	
Cumulative		982	46415	0.000	0.225	0.004	0.698	0.072	0.001

Figure 1. Weekly age composition estimates for the three major Columbia Basin spring, summer, and fall chinook salmon age groups sampled at Bonneville Dam in 1999.

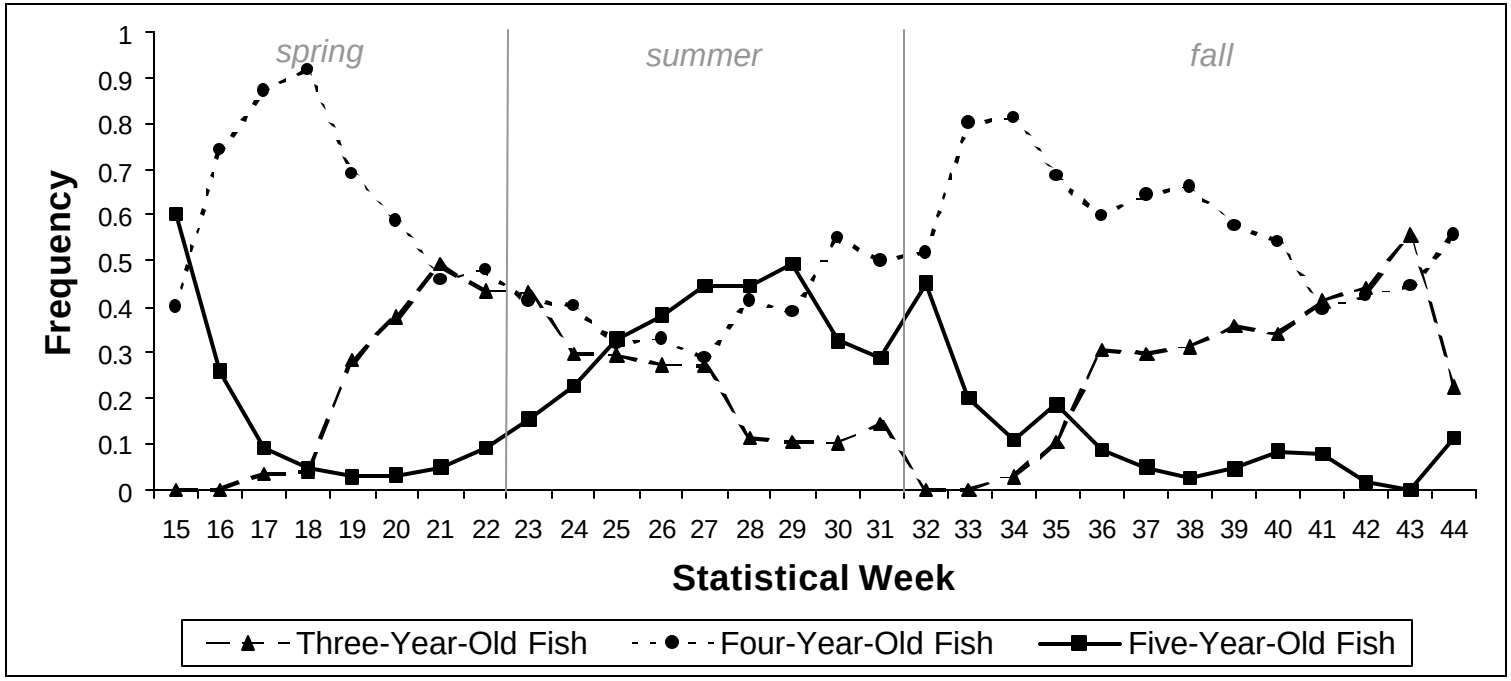
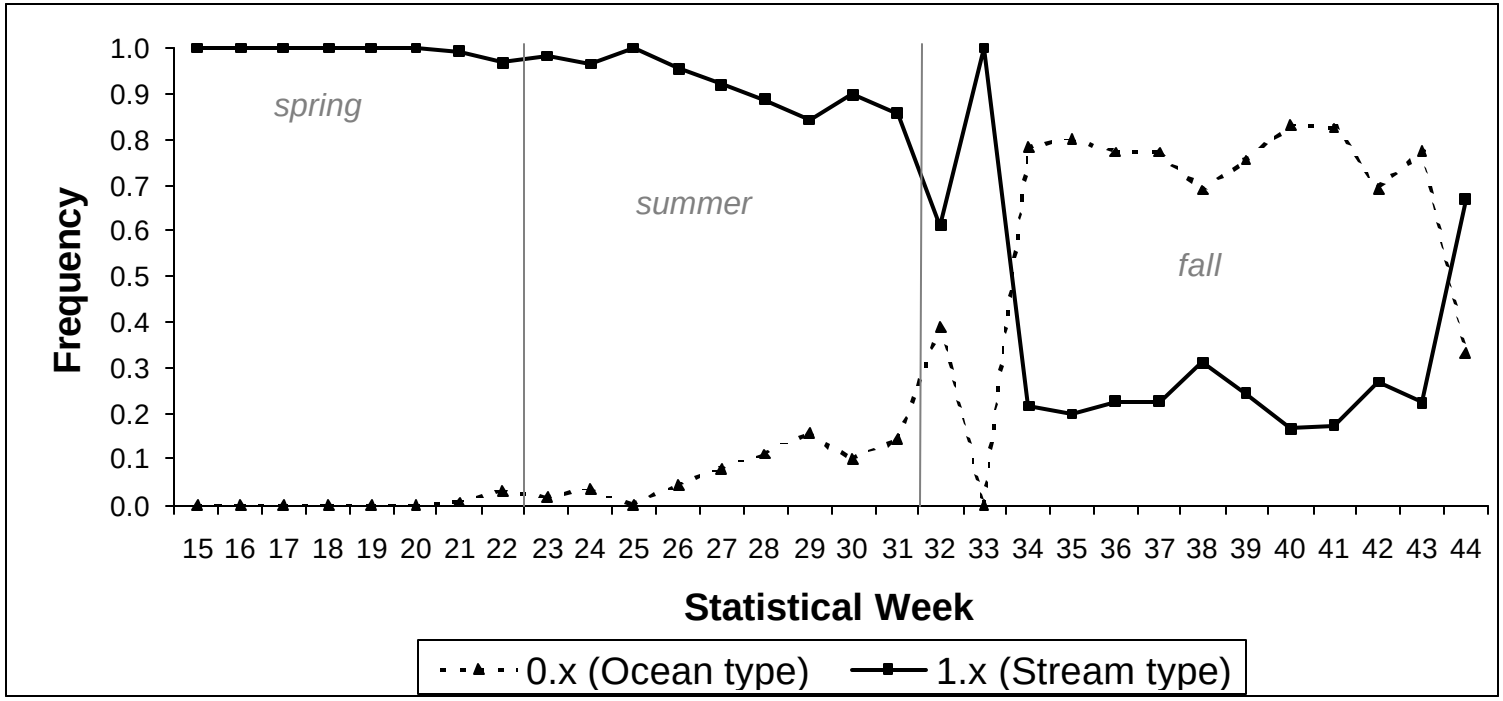


Figure 2. Weekly freshwater age composition estimates of Columbia Basin spring, summer, and fall chinook salmon sampled at Bonneville Dam in 1999[5].



[5] Note: small sample sizes during statistical weeks 33 (n=5 due to high temperature sampling constraints specified in protocol), 43 (n=9), and 44 (n=9).

Table 2. **Age composition of Columbia Basin summer chinook salmon sampled at Bonneville Dam in 1999**.

				Age Composition by Brood Year and Age Class								
				1997	1996		1995		1994		1993
Statistical Week	Sampling Dates	Ageable scales	Weekly run size	0.1	0.2	1.1	0.3	1.2	1.3	0.4	1.4
23	6/1, 3	58	1508		0.017	0.414		0.414	0.155		
24	6/7,9,11	56	2347		0.000	0.298	0.035	0.368	0.228		0.070
25	6/14,16,18	82	3718			0.293		0.317	0.329		0.061
26	6/21,23,25	110	4518			0.279	0.045	0.288	0.360	0.009	0.018
27	6/28, 7/1	63	4233		0.016	0.254	0.032	0.254	0.413	0.032	
28	7/7,9	64	4657			0.109	0.078	0.344	0.391	0.047	0.031
29	7/12,14,16	77	4006		0.013	0.091	0.091	0.299	0.442	0.052	0.013
30	7/21,23	40	2672		0.025	0.075	0.075	0.475	0.325		0.025
31	7/28	14	2533	0.071		0.143	0.071	0.429	0.286		
Cumulative		564	30192	0.006	0.007	0.205	0.051	0.338	0.349	0.020	0.024

Table 3. Age composition of Columbia Basin fall chinook salmon sampled at Bonneville Dam in 1999.

				Age Composition by Brood Year and Age Class									
Statistical Week	Sampling Dates	Ageable scales	Weekly run size	1997	1996		1995		1994		1993	
				0.1	0.2	1.1	0.3	1.2	0.4	1.3	0.5	1.4
32-33	8/2,8/4,8/9	38	6362				0.211	0.368	0.132	0.263		0.026
34	8/19	37	9558		0.027		0.622	0.189	0.108		0.027	0.027
35	8/24,26	86	24551		0.105		0.593	0.093	0.093	0.093	0.012	0.012
36	8/31, 9/2	92	62289		0.250	0.054	0.489	0.109	0.033	0.054		0.011
37	9/7,9/10	84	68614	0.012	0.238	0.060	0.488	0.155	0.036	0.012		
38	9/15,9/17	80	40116		0.263	0.050	0.413	0.250	0.013	0.013		
39	9/22/99	45	29509	0.022	0.267	0.089	0.422	0.156	0.044	0.000		
40	9/29,10/1	59	12481	0.034	0.322	0.017	0.441	0.102	0.034	0.051		
41	10/6,10/8	51	5959	0.098	0.353	0.059	0.275	0.118	0.078		0.020	
42	10/13,10/15	50	3071	0.080	0.340	0.120	0.280	0.160	0.020			
43	10/20	9	1688		0.444	0.111	0.333	0.111				
44	10/26,10/28	9	898	0.111	0.111	0.111	0.111	0.444		0.111		
Cumulative		640	265096	0.011	0.231	0.050	0.466	0.157	0.043	0.035	0.002	0.005

Sockeye Salmon

Four-year-old fish (primarily age 1.2 from the 1995 BY group), contributed to 83% of the total 1999 sockeye run (Table 4).

Coho Salmon

The 1999 coho run past Bonneville was 100% three-year-old fish (age 1.1) from the 1994 brood-year (Table 5).

2000 Spring and Summer Chinook Salmon Run Size Prediction

Based on a linear relationship between three-year-old and four-year old returns (from brood years 1984 – 1995) the estimated 2000 four-year-old adult spring chinook salmon abundance at Bonneville Dam is 95,800 (±36,800 90% bound [Figure 3]). A relationship between four-year-olds and five-year olds, albeit poorer than that existing between three-year-olds and four-year-olds, predicts that the 2000 five-year old adult abundance will be 12,000 (±31,500 90% bound [Figure 4]).

Likewise, the historic relationship between three and four-year-olds (from brood years 1987-1995) results in a prediction of 14,900 four-year-olds (±8,950 90% bound [Figure 5]) for the 2000 summer chinook run. The relationship between four and five-year-olds (from brood years 1986-1994) estimates a summer chinook run of 10,000 (±3,025 90% bound [Figure 6]) five-year-olds for the year 2000.

Table 4. Age composition of Columbia Basin sockeye salmon sampled at Bonneville Dam in 1999.

				Age Composition by Brood Year and Age Class					
				1996	1995		1994		1993
Statistical Week	Sampling Dates	Ageable scales	Weekly run size	1.1	1.2	2.1	1.3	2.2	2.3
24	6/7,9,11	8	308		0.875		0.125		
25	6/14,16,18	47	1350	0.064	0.872	0.021		0.043	
26	6/21,23,25	169	3627	0.030	0.888	0.012	0.024	0.036	0.012
27	6/28, 7/1	121	5496	0.140	0.752	0.017	0.025	0.058	0.008
28	7/7, 7/9	108	4447	0.065	0.833	0.028	0.037	0.028	0.009
29	7/12,14,16	39	1679	0.179	0.692	0.026	0.026	0.077	
30	7/21,23	8	694		0.625	0.250	0.125		
31	7/28	2	186		1.000				
Cumulative		502	17787	0.087	0.803	0.028	0.031	0.043	0.007

Table 5. Age composition of Columbia Basin coho salmon sampled at Bonneville Dam in 1999.

				Age Composition by Brood Year and Age Class		
Statistical Week	Sampling Dates	Ageable scales	Weekly run size	1997 0.1	1996 1.1	1995 1.2
36	8/31,9/2	18	2918		1.00	
37	9/7,9/10	56	8165		1.00	
38	9/15,9/17	75	13392		1.00	
39	9/22	29	6273		1.00	
40	9/29,10/1	56	5164		1.00	
41	10/6,10/8	54	2230		1.00	
42	10/13,10/15	75	2873		1.00	
43	10,20	37	2537		1.00	
44	10/26,10/28	48	938		1.00	
Cumulative		448	44490	0.00	1.00	0.00

Figure 3. **Predicted 2000 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 – 1995.**

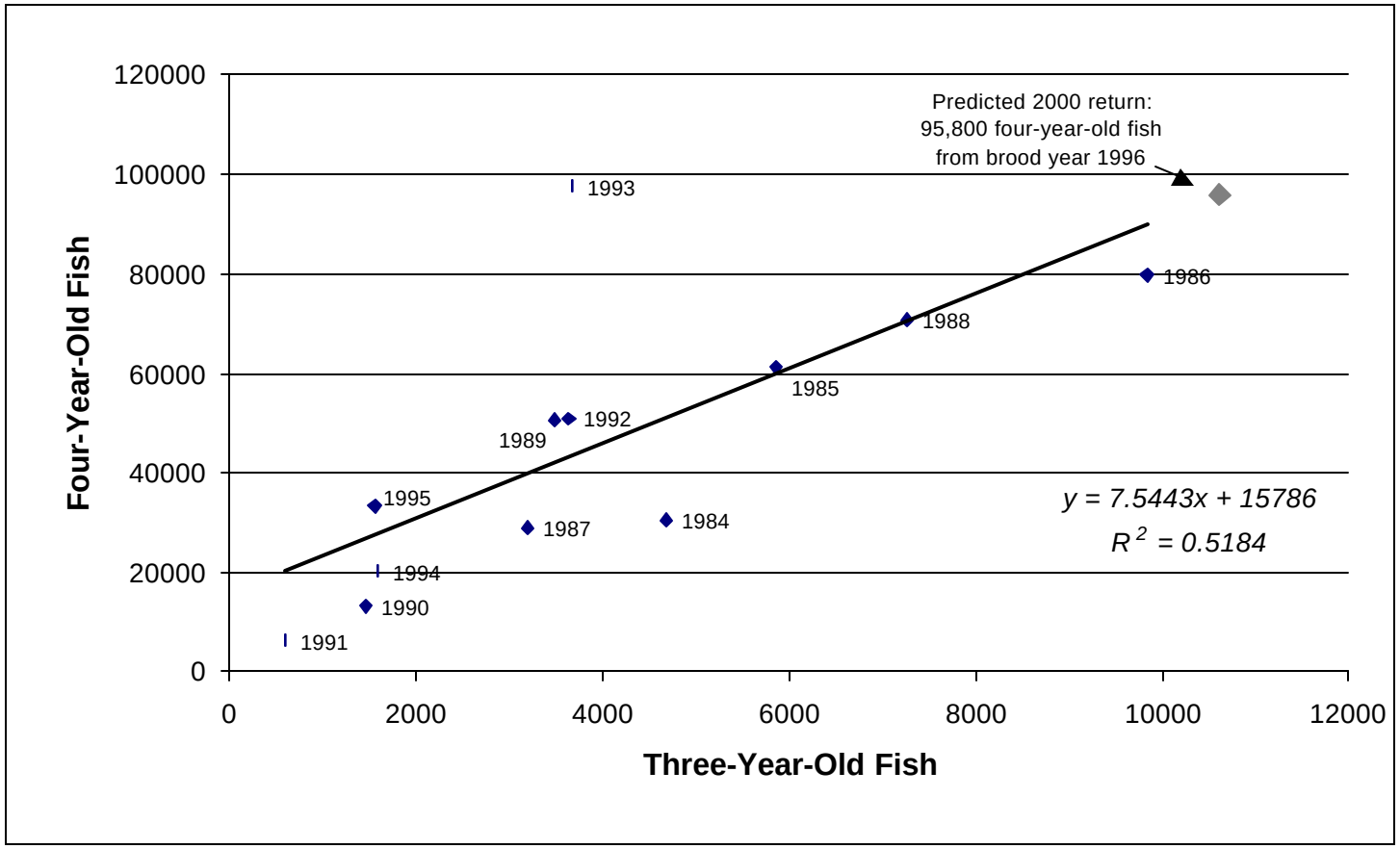


Figure 4. **Predicted 2000 five-year-old Columbia Basin spring chinook salmon abundance (at Bonneville Dam) based on a linear relationship between five-year-old and four-year-old fish abundance during brood years 1983 through 1994.**

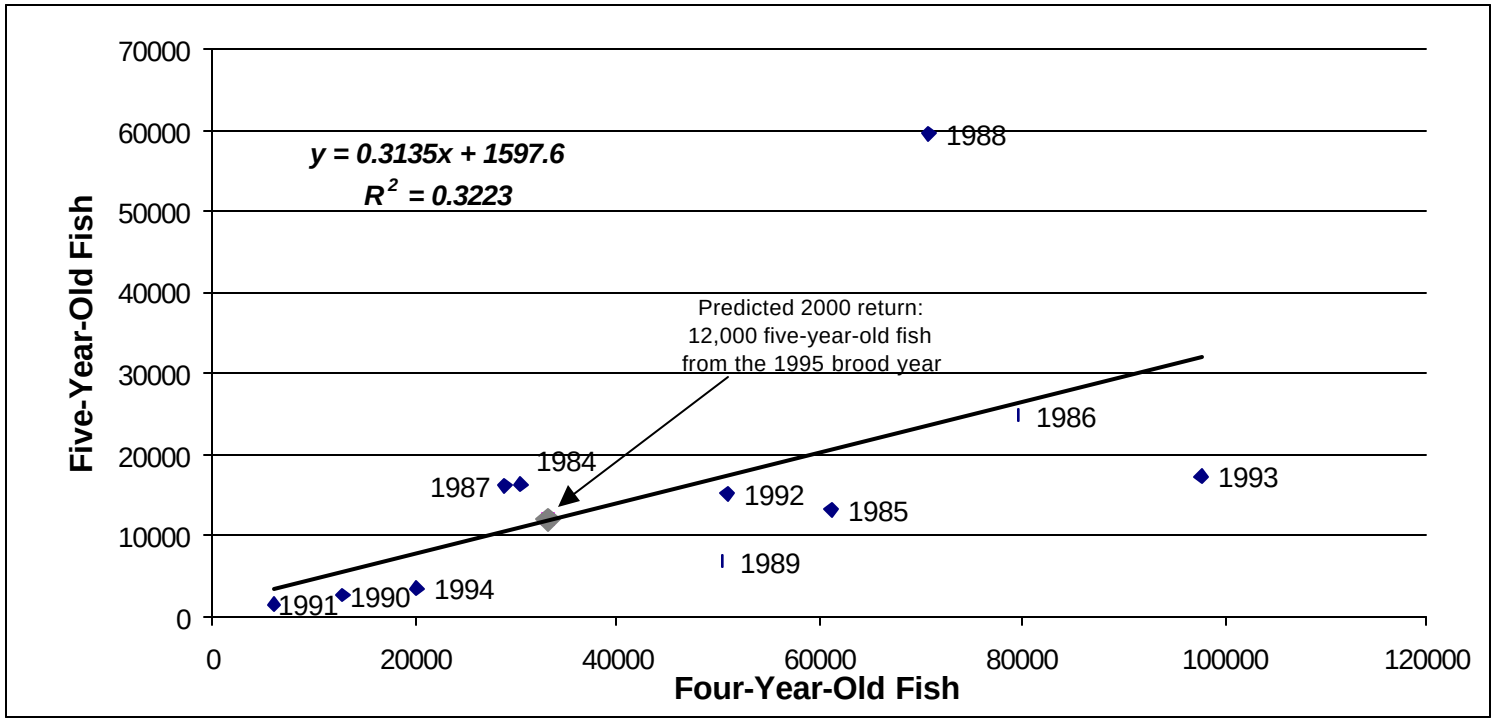


Figure 5. **Predicted 2000 four-year-old Columbia Basin summer chinook salmon abundance (at Bonneville Dam) based on a linear relationship between four-year-old and three-year-old fish abundance during brood years 1987 – 1995.**

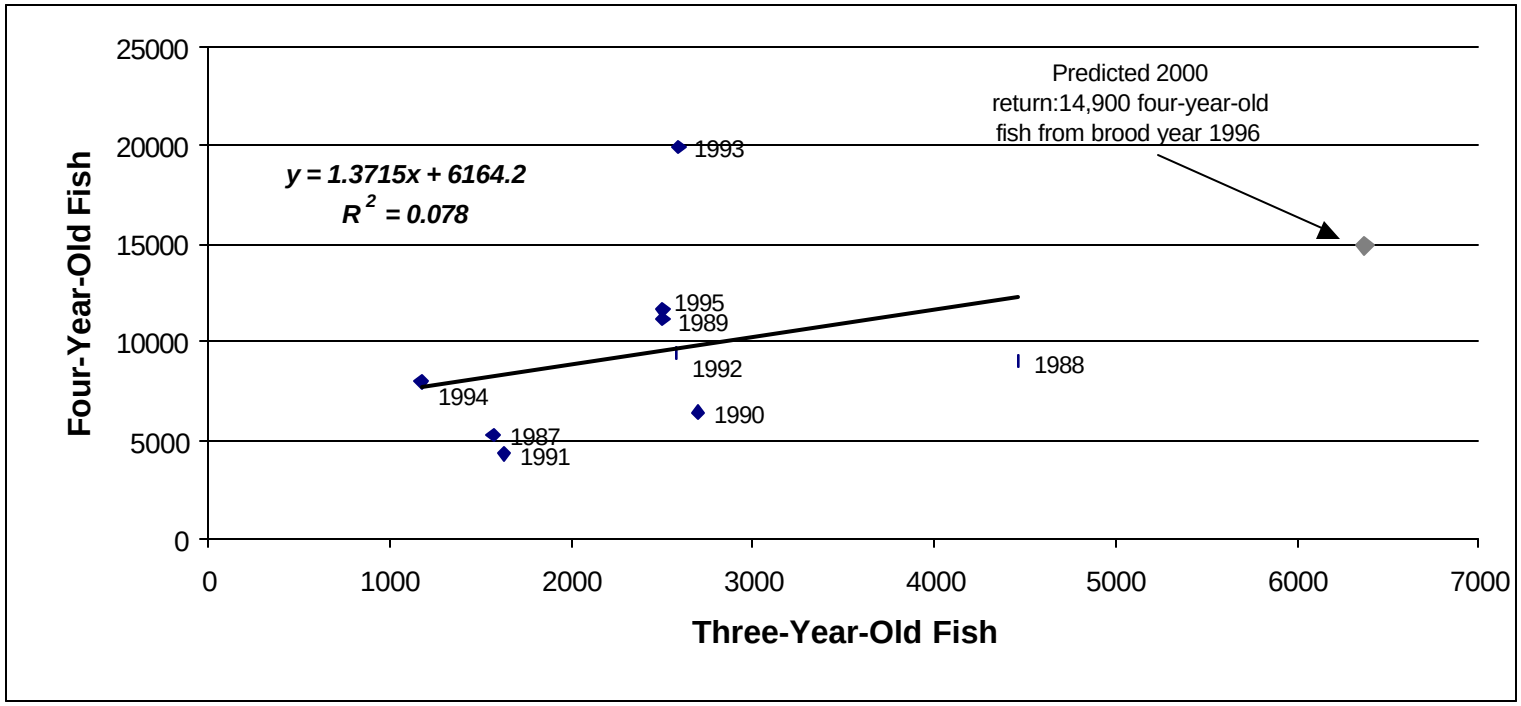
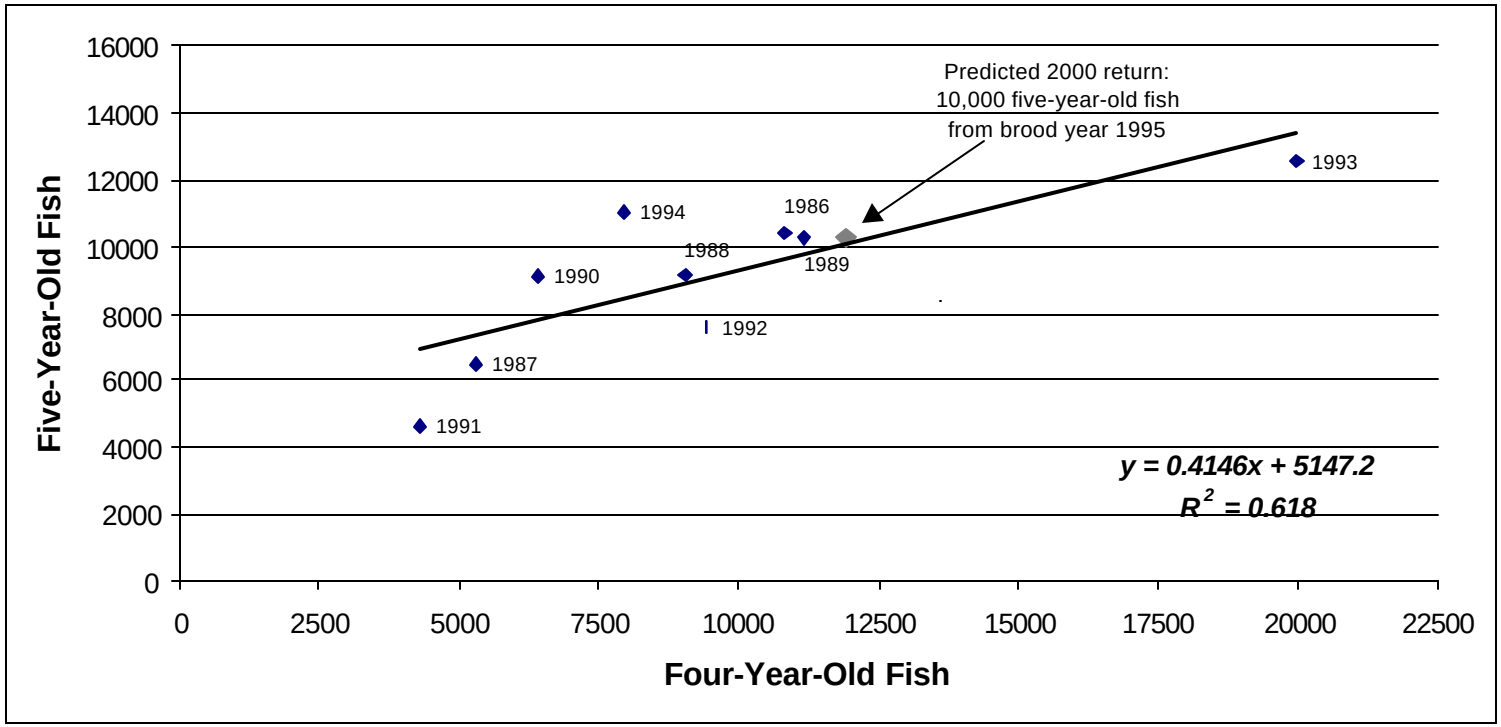


Figure 6. **Predicted 2000 five-year-old Columbia Basin summer chinook salmon abundance (at Bonneville Dam) based on a linear relationship between five-year-old and four-year-old fish abundance during brood years 1986 through 1994.**



DISCUSSION

The 1999 spring and summer chinook returns to Bonneville were comprised of a large proportion of jacks compared to past years of this decade. Using a standard relationship for predicting next years returns, our forecasts indicate a 2000 return of brood year 1996 four-year-olds to be 95,800 spring chinook and 14,900 summer chinook.

The study described in this report will be continued in future years to develop an accurate age and length-at-age composition database for Columbia Basin upriver salmonid populations. This information will aid fisheries managers in formulating spawner-return relationships, productivity analysis, and fore-casting. Continued creation of a database for detecting changes in age and length-at-age composition may allow managers to more accurately monitor the effects of ocean harvest restrictions imposed by the Pacific Salmon Treaty.

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Appendix A

Data Tables

Table A1. Total age composition (%) for ad clipped and non ad-clipped chinook, sockeye, and coho salmon sampled at Bonneville Dam in 1999.

	sample size (n)	unageable (%)		0.1		0.2	1.1		0.3	1.2		0.4	1.3		0.5	1.4		2.1		2.2		2.3
Spring Chinook																						
Fin- Clipped	455	6		0		0	31		1	64		0	4		0	0		0		0		0
No Fin Clips	586	5		0		0	21		0	71		0	8		0	0		0		0		0
Summer Chinook																						
Fin- Clipped	243	9		0		0	33		0	33		0	31		0	2		0		0		0
No Fin Clips	378	9		0		1	17		7	34		3	35		0	3		0		0		0
Fall Chinook																						
Fin- Clipped	96	13		1		20	8		20	40		1	5		0	4		0		0		0
No Fin Clips	601	8		2		23	4		46	13		6	4		1	0		0		0		0
Sockeye																						
Fin- Clipped	20	0		0		0	0		0	95		0	0		0	0		5		0		0
No Fin Clips	496	3		0		0	8		0	82		0	3		0	0		2		4		1
Coho																						
Fin- Clipped	237	5		0		0	100		0	0		0	0		0	0		0		0		0
No Fin Clips	244	9		0		0	100		0	0		0	0		0	0		0		0		0

Table A2. Percent of sampled chinook, coho and sockeye salmon at Bonneville Dam having fin clips by week in 1999.

Statistical Week	Spring Chinook	Summer Chinook	Fall Chinook	Sockeye	Coho
15	0%				
16	37%				
17	46%				
18	41%				
19	42%				
20	42%				
21	50%				
22	49%				
23		36%			
24		41%		0%	
25		40%		2%	
26		30%		2%	
27		39%		4%	
28		44%		7%	
29		42%		2%	
30		45%		13%	
31		57%		0%	
32			21%		
33			40%		
34			17%		
35			9%		
36			13%		33%
37			14%		29%
38			15%		46%
39			12%		57%
40			12%		38%
41			9%		58%
42			17%		58%
43			22%		68%
44			25%		56%
Total	**44%**	**39%**	**14%**	**4%**	**49%**

Table A3. Length-at-age estimates for Columbia Basin spring chinook salmon sampled at Bonneville Dam in 1999.

	Brood Year and Age Class				
	1996	1995		1994	1993
	1.1	0.3	1.2	1.3	1.4
Statistical Weeks 15					
Mean Fork Length (cm)	0.00	0.00	67.50	82.83	0.00
Minimum	0.00	0.00	69.00	87.00	0.00
Maximum	0.00	0.00	66.00	79.00	0.00
Standard Deviation	0.00	0.00	2.12	4.01	0.00
Sample Size	0	0	2	3	0
Statistical Week 16					
Mean Fork Length (cm)	0.00	0.00	74.33	88.35	0.00
Minimum	0.00	0.00	81.50	100.00	0.00
Maximum	0.00	0.00	67.70	75.00	0.00
Standard Deviation	0.00	0.00	3.25	6.19	0.00
Sample Size	0	0	37	13	0
Statistical Week 17					
Mean Fork Length (cm)	47.10	0.00	74.09	86.23	0.00
Minimum	49.50	0.00	84.00	98.00	0.00
Maximum	42.50	0.00	65.50	77.00	0.00
Standard Deviation	2.90	0.00	3.53	6.62	0.00
Sample Size	5	0	123	13	0
Statistical Week 18					
Mean Fork Length (cm)	46.21	0.00	74.35	84.08	0.00
Minimum	50.00	0.00	97.00	92.00	0.00
Maximum	44.00	0.00	52.00	79.00	0.00
Standard Deviation	2.02	0.00	4.74	5.41	0.00
Sample Size	7	0	142	6	0
Statistical Week 19					
Mean Fork Length (cm)	48.59	0.00	74.05	83.20	0.00
Minimum	78.00	0.00	84.50	91.50	0.00
Maximum	41.50	0.00	53.00	78.50	0.00
Standard Deviation	5.28	0.00	4.33	4.97	0.00
Sample Size	51	0	126	5	0
Statistical Week 20					
Mean Fork Length (cm)	49.87	0.00	74.69	84.56	97.00
Minimum	56.00	0.00	84.50	88.50	97.00
Maximum	42.00	0.00	60.50	78.00	97.00
Standard Deviation	3.13	0.00	3.91	3.73	-
Sample Size	97	0	153	8	1
Statistical Week 21					
Mean Fork Length (cm)	49.44	75.50	74.58	86.20	0.00
Minimum	57.00	76.00	85.50	92.50	0.00
Maximum	41.50	75.00	62.00	79.00	0.00
Standard Deviation	3.98	0.71	4.46	6.07	0.00
Sample Size	61	2	56	5	0
Statistical Week 22					
Mean Fork Length (cm)	49.78	74.25	73.34	87.00	0.00
Minimum	54.00	79.00	84.50	96.50	0.00
Maximum	41.50	69.50	62.00	77.50	0.00
Standard Deviation	3.60	6.72	5.49	6.96	0.00
Sample Size	30	2	28	7	0
1999 Composite					
Mean Fork Length (cm)	49.34	74.88	74.28	85.92	97.00
Minimum	78.00	79.00	97.00	100.00	97.00
Maximum	41.50	69.50	52.00	75.00	97.00
Standard Deviation	3.94	3.97	4.21	5.80	-
Sample Size	251	4	667	60	1

Table A4. Length-at-age estimates for Columbia Basin summer chinook salmon sampled at Bonneville Dam in 1999.

	Brood Year and Age Class						
	1996		1995		1994		1993
	0.2	1.1	0.3	1.2	0.4	1.3	1.4
Statistical Week 23							
Mean Fork Length (cm)	73.50	51.55	0.00	75.23	0.00	91.83	0.00
Minimum	73.50	58.00	0.00	85.50	0.00	100.00	0.00
Maximum	73.50	44.00	0.00	52.00	0.00	83.50	0.00
Standard Deviation	-	3.86	0.00	6.64	0.00	4.86	0.00
Sample Size	1	22	0	26	0	9	0
Statistical Week 24							
Mean Fork Length (cm)	0.00	52.59	76.75	76.88	0.00	91.58	94.50
Minimum	0.00	58.50	84.00	91.00	0.00	98.50	98.00
Maximum	0.00	44.00	69.50	64.00	0.00	85.00	93.00
Standard Deviation	0.00	4.07	10.25	6.63	0.00	3.92	2.35
Sample Size	0	17	2	21	0	13	4
Statistical Week 25							
Mean Fork Length (cm)	0.00	53.88	0.00	74.52	0.00	89.35	97.70
Minimum	0.00	60.00	0.00	86.50	0.00	101.00	110.00
Maximum	0.00	44.00	0.00	55.50	0.00	75.00	93.50
Standard Deviation	0.00	3.65	0.00	5.91	0.00	6.52	7.01
Sample Size	0	24	0	26	0	27	5
Statistical Week 26							
Mean Fork Length (cm)	0.00	54.45	83.50	75.08	105.00	88.74	92.75
Minimum	0.00	66.00	86.00	83.50	105.00	102.00	94.50
Maximum	0.00	42.00	81.00	61.00	105.00	77.00	91.00
Standard Deviation	0.00	5.39	1.80	6.09	-	6.37	2.47
Sample Size	0	31	5	32	1	40	2
Statistical Week 27							
Mean Fork Length (cm)	54.00	54.28	85.75	73.78	89.17	86.77	0.00
Minimum	54.00	57.50	93.00	83.00	99.00	98.50	0.00
Maximum	54.00	48.50	78.50	63.00	78.50	71.00	0.00
Standard Deviation	-	2.33	10.25	6.44	10.28	7.11	0.00
Sample Size	1	16	2	16	3	24	0
Statistical Week 28							
Mean Fork Length (cm)	0.00	54.63	74.80	71.78	93.33	85.10	85.75
Minimum	0.00	59.00	78.50	82.00	105.50	99.50	86.50
Maximum	0.00	48.00	64.00	60.50	82.50	72.00	85.00
Standard Deviation	0.00	4.00	6.21	6.49	11.56	5.78	1.06
Sample Size	0	8	5	20	3	25	2
Statistical Week 29							
Mean Fork Length (cm)	72.00	54.64	82.86	76.76	92.88	86.16	72.50
Minimum	72.00	62.00	89.00	90.00	97.00	94.50	72.50
Maximum	72.00	47.50	75.00	62.00	87.00	75.00	72.50
Standard Deviation	-	5.60	4.71	5.99	4.33	4.37	-
Sample Size	1		7	23	4	34	1
Statistical Week 30							
Mean Fork Length (cm)	62.50	52.33	81.17	74.42	0.00	86.50	96.00
Minimum	62.50	56.00	84.50	87.50	0.00	99.00	96.00
Maximum	62.50	46.00	77.50	59.50	0.00	73.50	96.00
Standard Deviation	-	5.51	3.51	7.00	0.00	6.52	-
Sample Size	1	3	3	19	0	13	1
Statistical Week 31							
Mean Fork Length (cm)	0.00	50.75	84.50	72.75	0.00	84.88	0.00
Minimum	0.00	55.00	84.50	85.00	0.00	90.50	0.00
Maximum	0.00	46.50	84.50	64.50	0.00	79.00	0.00
Standard Deviation	0.00	6.01	-	7.03	0.00	5.50	0.00
Sample Size	0	2	1	6	0	4	0
1999 Composite							
Mean Fork Length (cm)	65.50	53.50	80.98	74.83	93.09	87.74	92.80
Minimum	73.50	66.00	93.00	91.00	105.50	102.00	110.00
Maximum	54.00	42.00	64.00	52.00	78.50	71.00	72.50
Standard Deviation	9.08	4.32	6.04	6.42	8.50	6.12	7.90
Sample Size	4	130	25	189	11	189	15

Table A5. Length-at-age estimates for Columbia Basin fall chinook salmon sampled at Bonneville Dam in 1999.

	Brood Year and Age Class						
	1996		1995		1994		1993
	0.2	1.1	0.3	1.2	0.4	1.3	1.4
Statistical Week 32							
Mean Fork Length (cm)	0.00	0.00	84.75	74.85	92.50	89.22	89.00
Minimum	0.00	0.00	88.50	85.00	107.00	96.00	89.00
Maximum	0.00	0.00	79.00	65.00	86.00	82.00	89.00
Standard Deviation	0.00	0.00	3.71	6.65	8.82	5.12	-
Sample Size	0	0	6	10	5	9	1
Statistical Week 33							
Mean Fork Length (cm)	0.00	0.00	0.00	81.63	0.00	89.50	0.00
Minimum	0.00	0.00	0.00	85.00	0.00	89.50	0.00
Maximum	0.00	0.00	0.00	78.50	0.00	89.50	0.00
Standard Deviation	0.00	0.00	0.00	2.93	0.00	-	0.00
Sample Size	0	0	0	4	0	1	0
Statistical Week 34							
Mean Fork Length (cm)	68.00	0.00	82.22	77.00	96.50	0.00	101.50
Minimum	68.00	0.00	92.00	87.00	100.00	0.00	101.50
Maximum	68.00	0.00	71.00	67.00	92.00	0.00	101.50
Standard Deviation	-	0.00	5.73	7.82	3.32	0.00	-
Sample Size	1	0	23	7	4	0	1
Statistical Week 35							
Mean Fork Length (cm)	73.17	0.00	84.23	75.19	92.50	86.31	96.00
Minimum	83.00	0.00	97.00	82.00	102.50	98.00	96.00
Maximum	66.50	0.00	73.50	66.50	73.00	79.50	96.00
Standard Deviation	5.13	0.00	4.88	6.05	9.71	6.51	-
Sample Size	9	0	51	8	8	8	1
Statistical Week 36							
Mean Fork Length (cm)	72.74	58.30	83.92	72.95	93.67	84.40	84.00
Minimum	84.50	62.00	98.00	84.00	97.00	89.00	84.00
Maximum	61.00	50.00	73.00	64.00	87.00	79.50	84.00
Standard Deviation	6.55	4.74	5.33	6.26	5.77	4.17	-
Sample Size	23	5	45	10	3	5	1
Statistical Week 37							
Mean Fork Length (cm)	71.98	60.60	81.82	75.12	89.50	92.00	0.00
Minimum	79.00	63.00	90.00	85.00	96.00	92.00	0.00
Maximum	59.00	56.00	69.00	65.00	85.50	92.00	0.00
Standard Deviation	4.61	2.79	4.38	6.55	5.68	-	0.00
Sample Size	20	5	41	13	3	1	0
Statistical Week 38							
Mean Fork Length (cm)	67.65	56.50	81.32	74.53	86.00	80.00	0.00
Minimum	79.00	67.00	98.00	85.00	86.00	80.00	0.00
Maximum	56.00	49.00	70.00	63.50	86.00	80.00	0.00
Standard Deviation	6.81	6.96	4.90	5.74	-	-	0.00
Sample Size	20	5	33	20	1	1	0
Statistical Week 39							
Mean Fork Length (cm)	68.38	52.83	78.13	76.57	89.50	0.00	0.00
Minimum	77.50	56.00	93.50	87.00	93.00	0.00	0.00
Maximum	60.00	49.00	64.50	67.00	86.00	0.00	0.00
Standard Deviation	4.94	3.55	7.29	6.98	4.95	0.00	0.00
Sample Size	13	3	19	7	2	0	0
Statistical Week 40							
Mean Fork Length (cm)	69.89	63.00	78.92	72.38	87.83	91.25	0.00
Minimum	83.50	63.00	86.00	79.00	94.50	92.50	0.00
Maximum	60.00	63.00	71.00	61.00	82.50	90.00	0.00
Standard Deviation	6.77	-	4.50	5.21	6.11	1.77	0.00
Sample Size	19	1	24	8	3	2	0
Statistical Week 41							
Mean Fork Length (cm)	66.88	53.17	80.68	73.93	91.25	0.00	0.00
Minimum	75.00	57.50	90.00	81.00	105.00	0.00	0.00
Maximum	55.50	51.00	75.00	63.00	78.50	0.00	0.00
Standard Deviation	5.13	3.75	4.38	6.47	11.26	0.00	0.00
Sample Size	17	3	14	7	4	0	0

Table A5 (cont.). Length-at-age estimates for Columbia Basin fall chinook salmon sampled at Bonneville Dam in 1999.

	Brood Year and Age Class						
	1996		1995		1994		1993
	0.2	1.1	0.3	1.2	0.4	1.3	1.4
Statistical Week 42							
Mean Fork Length (cm)	70.06	57.92	81.00	72.19	78.00	0.00	0.00
Minimum	77.00	62.00	89.00	80.00	78.00	0.00	0.00
Maximum	63.00	49.00	68.50	63.00	78.00	0.00	0.00
Standard Deviation	4.05	4.86	5.88	7.60	-	0.00	0.00
Sample Size	17	6	14	8	1	0	0
Statistical Week 43							
Mean Fork Length (cm)	69.00	54.00	77.17	68.50	0.00	0.00	0.00
Minimum	81.00	54.00	82.00	68.50	0.00	0.00	0.00
Maximum	61.50	54.00	68.00	68.50	0.00	0.00	0.00
Standard Deviation	8.44	-	7.94	-	0.00	0.00	0.00
Sample Size	4	1	3	1	0	0	0
Statistical Week 44							
Mean Fork Length (cm)	74.00	58.50	84.00	77.25	0.00	71.00	0.00
Minimum	74.00	58.50	84.00	82.50	0.00	71.00	0.00
Maximum	74.00	58.50	84.00	66.00	0.00	71.00	0.00
Standard Deviation	-	-	-	7.60	0.00	-	0.00
Sample Size	1	1	1	4	0	1	0
1999 Composite							
Mean Fork Length (cm)	70.05	57.27	82.00	74.76	91.46	86.80	92.63
Minimum	84.50	67.00	98.00	87.00	107.00	98.00	101.50
Maximum	55.50	49.00	64.50	61.00	73.00	71.00	84.00
Standard Deviation	5.99	4.94	5.45	6.37	7.81	6.18	7.70
Sample Size	144	30	274	107	34	28	4

Table A6. Length-at-age estimates for Columbia Basin sockeye salmon sampled at Bonneville Dam in 1999.

	Brood Year and Age Class					
	1996	1995		1994		1993
	1.1	1.2	2.1	1.3	2.2	2.3
Statistical Weeks 24						
Mean Fork Length (cm)	0.00	51.07	0.00	47.00	0.00	0.00
Minimum	0.00	53.50	0.00	47.00	0.00	0.00
Maximum	0.00	47.00	0.00	47.00	0.00	0.00
Standard Deviation	0.00	2.28	0.00	-	0.00	0.00
Sample Size	0	7	0	1	0	0
Statistical Week 25						
Mean Fork Length (cm)	37.00	49.48	41.00	0.00	53.50	0.00
Minimum	38.00	55.00	41.00	0.00	56.50	0.00
Maximum	35.50	45.00	41.00	0.00	50.50	0.00
Standard Deviation	1.32	2.73	-	0.00	4.24	0.00
Sample Size	3	41	1	0	2	0
Statistical Week 26						
Mean Fork Length (cm)	35.90	49.40	42.25	54.25	52.25	57.00
Minimum	38.50	60.00	43.00	57.00	54.50	60.50
Maximum	32.50	27.00	41.50	51.00	51.00	53.50
Standard Deviation	2.72	4.10	1.06	2.50	1.29	4.95
Sample Size	5	150	2	4	6	2
Statistical Week 27						
Mean Fork Length (cm)	36.94	49.47	41.50	53.83	49.00	55.00
Minimum	45.00	56.50	42.00	54.50	51.00	55.00
Maximum	33.00	45.00	41.00	53.00	46.00	55.00
Standard Deviation	3.00	2.53	0.71	0.76	1.85	-
Sample Size	17	91	2	3	7	1
Statistical Week 28						
Mean Fork Length (cm)	36.50	48.23	41.83	54.63	47.67	49.00
Minimum	38.50	55.50	47.50	58.00	51.00	49.00
Maximum	35.00	36.50	38.00	51.50	45.00	49.00
Standard Deviation	1.47	3.02	5.01	2.69	3.06	-
Sample Size	7	90	3	4	3	1
Statistical Week 29						
Mean Fork Length (cm)	36.64	48.48	42.50	53.50	52.17	0.00
Minimum	39.00	53.50	42.50	53.50	55.00	0.00
Maximum	34.50	45.00	42.50	53.50	48.00	0.00
Standard Deviation	1.95	2.00	-	-	3.69	0.00
Sample Size	7	27	1	1	3	0
Statistical Week 30						
Mean Fork Length (cm)	0.00	48.40	42.50	55.00	0.00	0.00
Minimum	0.00	50.50	44.00	55.00	0.00	0.00
Maximum	0.00	46.00	41.00	55.00	0.00	0.00
Standard Deviation	0.00	1.85	2.12	-	0.00	0.00
Sample Size	0	5	2	1	0	0
Statistical Week 31						
Mean Fork Length (cm)	0.00	47.50	0.00	0.00	0.00	0.00
Minimum	0.00	47.50	0.00	0.00	0.00	0.00
Maximum	0.00	47.50	0.00	0.00	0.00	0.00
Standard Deviation	0.00	0.00	0.00	0.00	0.00	0.00
Sample Size	0	2	0	0	0	0
1999 Composite						
Mean Fork Length (cm)	36.68	49.26	41.95	53.75	50.62	54.50
Minimum	45.00	79.50	47.50	58.00	56.50	60.50
Maximum	32.50	27.00	38.00	47.00	45.00	49.00
Standard Deviation	2.39	3.63	2.42	2.67	2.97	4.74
Sample Size	39	413	11	14	21	4

Table A7. Length-at-age estimates for Columbia Basin coho salmon sampled at Bonneville Dam in 1999.

	Brood Year and Age Class	
	1996	1995
	1.1	1.2
Statistical Weeks 40		
Mean Fork Length (cm)	64.72	
Minimum	74.00	
Maximum	54.00	
Standard Deviation	5.55	
Sample Size	18	
Statistical Week 41		
Mean Fork Length (cm)	66.28	
Minimum	78.00	
Maximum	51.00	
Standard Deviation	5.70	
Sample Size	56	
Statistical Week 42		
Mean Fork Length (cm)	67.14	
Minimum	80.00	
Maximum	54.00	
Standard Deviation	5.85	
Sample Size	75	
Statistical Week 43		
Mean Fork Length (cm)	68.21	
Minimum	77.00	
Maximum	51.00	
Standard Deviation	5.56	
Sample Size	29	
Statistical Week 43		
Mean Fork Length (cm)	64.66	
Minimum	73.00	
Maximum	48.00	
Standard Deviation	5.36	
Sample Size	56	
Statistical Week 43		
Mean Fork Length (cm)	60.58	
Minimum	73.00	
Maximum	45.00	
Standard Deviation	8.36	
Sample Size	54	
Statistical Week 43		
Mean Fork Length (cm)	64.39	
Minimum	76.50	
Maximum	49.00	
Standard Deviation	6.41	
Sample Size	75	
Statistical Week 43		
Mean Fork Length (cm)	63.28	
Minimum	77.00	
Maximum	44.50	
Standard Deviation	8.55	
Sample Size	36	
Statistical Week 43		
Mean Fork Length (cm)	66.21	
Minimum	78.00	
Maximum	45.00	
Standard Deviation	7.95	
Sample Size	48	

Table A7 (cont.). Length-at-age estimates for Columbia Basin coho salmon sampled at Bonneville Dam in 1999.

1999 Composite	
Mean Fork Length (cm)	
Minimum	80.00
Maximum	44.50
Standard Deviation	6.95
Sample Size	447

Table A8. Composition (%) of observed injuries of Columbia Basin spring, summer, and fall chinook salmon sampled at Bonneville Dam in 1999.

Category	Spring Chinook 1999	Summer Chinook 1999	Fall Chinook 1999
Marine Mammal Injuries			
Bite	3	1	1
Claw Rake	8	3	2
Twin Arches	11	2	1
Total Marine Mammal[a]	22	6	4
Descaling			
5-20% Descaling			4
Right Side	9	6	3
Left Side	10	3	
Either			
>20% Descaling			
Right Side	<1	0	<1
Left Side	1	<1	0
Either			
General Injuries			
Cuts	1	<1	0
Head Injury	2	2	3
Head Burn	1	<1	0
Fin	12	3	4
Fungus	2	<1	<1
Gash[b]	5	1	2
Gas Bubble Disease	<1	0	0
Gill Net	<1	<1	1
Fishing Hook	<1	1	3
Lamprey	0	0	0
Parasite	2	1	<1
Total General Injuries[a]	26	9	14

a. Fish often displayed more than one type of marine mammal or general injury. Therefore, totals for these categories are not equal to the sum of the subcategories.

Table A9. Composition (%) of observed injuries of Columbia Basin sockeye and coho salmon sampled at Bonneville Dam in 1999.

Category	Sockeye 1999	Coho 1999
Marine Mammal Injuries		
Bite	<1	<1
Claw Rake	2	2
Twin Arches	1	1
Total Marine Mammal[a]	4	4
Descaling		
5-20% Descaling	6	3
Right Side	4	3
Left Side		
Either		
>20% Descaling		
Right Side	<1	6
Left Side	1	4
Either		
General Injuries		
Cuts	<1	0
Head	<1	1
Headburn	1	0
Fin	1	1
Fungus	<1	<1
Gash	1	1
Gas Bubble Disease	<1	n/a
Gill Net	<1	2
Fishing Hook	<1	1
Lamprey	0	0
Parasite	0	<1
Total General Injuries[a]	4	7

a. Fish often displayed more than one type of marine mammal or general injury. Therefore, totals for these categories are not equal to the sum of the subcategories.

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).

Figure B1. Fish condition assessment notation.

Injuries to be noted:

1. Gill net

2. Descaling, left side; estimate actual percentage descaled

3. Descaling, right side; estimate actual percentage descaled

4. Marine mammal injuries as follows:
   - **C**: Claw rake (2-3 or more parallel scratches on flanks of fish)
   - **G**: Twin arches (2-3 or more curved scratches on flanks of fish)
   - **B**: Bite (ragged wounds, often in caudal area)

6. 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

5. General injuries as follows:
   - **E**: Eye
   - **N**: Nose
   - **H**: Fishing hook
   - **P**: Parasite
   - **L**: Lamprey (circular wound)
   - **RP, LP, LV, RV, D, A, T** (Tail or Caudal Fin): Fin damage
   - **C**: Cut
   - **F**: Fungus
   - **B**: Bruise
   - **G**: Gash or lesion

Figure B2. Sampling Form used in Adult Salmonid Sampling at Bonneville Dam in 1999.

LOCATION:________ SPECIES:________ PAGE:____OF____

DATE:________ WEEK:________ WEATHER:________

CRITFC Stock Identification Project
Spring and Summer Sampling Form (8/98)

Fins--T A D RV LV RP LP Head--E N M Other-- H C B G F P L D Marine Mammal C G B N O

Position	Fork Length	Fin Clip	Condition (1-5)	Coloration (B,I,D)	Descaling left (%)	Descaling right (%)	Gill Net Damage	Marine Mammal	[illegible]	Fin Injuires	Other Inj. H,C,B,G,F,P,L	Head Inj. (E,N,M)	Headburn 1 (LD) Type	Headburn 1 (LD) Cover	Headburn 2 (RD) Type	Headburn 2 (RD) Cover	Headburn 3 (LL) Type	Headburn 3 (LL) Cover	Headburn 4 (RL) Type	Headburn 4 (RL) Cover	Overall %	Gas Bubble Trauma: Gas Bubble (Rank 0-4)	max GBT-fin (%)	max GBT-eye (%)	max GBT-mouth (%)	GBT in body (%)	Time of Day	Comments	Age	
1																											:			START TIME:
2																											:			
3																											:			Stop Time:
4																											:			
5																											:			SAMPLERS:
6																											:			
7																											:			Sample No.
8																											:			Chinook____
9																											:			Sockeye____
10																											:			Steelhead____
1																											:			
2																											:			Water Temp. °C
3																											:			
4																											:			
5																											:			Power House Op
6																											:			1 2 3 4 5 6 7 8
7																											:			Spill: YES NO
8																											:			Lead Time:
9																											:			
10																											:			
1																											:			Dam Count:
2																											:			Chinook____
3																											:			Sockeye____
4																											:			Steelhead____
5																											:			
6																											:			Ladder Count:
7																											:			Chinook____
8																											:			Sockeye____
9																											:			Steelhead____
10																											:			

DATA SHEET CODES Condition: 1 = Extremely poor; 2 = Poor; 3 = Fair; 4 = Good; 5 = Perfect Coloration: Bright Intermediate Dark

HEADBURN Location: 1 = Left Dorsal; 2 = Right Dorsal; 3 = Left Lateral; 4 = Right Lateral Type: Abrasion Lesion Blister Coverage: 1 = 1-25%; 2 = 26-50%; 3 = 51-100%

GAS BUBBLE TRAUMA: 0 = 0%; 1 = 1-5%; 2 = 6-25%; 3 = 26-50%; 4 = 51-100%