TECHNICAL REPORT 99-3

Age and Length Composition of Columbia Basin Chinook, Sockeye, and Coho Salmon at Bonneville Dam in 1998

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31 March 1999

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ABSTRACT

Representative samples of adult 1998 Columbia Basin chinook (spring, summer, and fall) sockeye, and coho salmon populations were collected at Bonneville Dam. This was the twelfth year spring chinook salmon, the ninth year summer chinook salmon, and the fourteenth year sockeye salmon were sampled in this study. It was the first 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, five-year-old fish were estimated to comprise 46% of the spring chinook, 52% of the summer chinook, and 39% of the fall chinook salmon population. Four-year-old fish were estimated to comprise 50% of the spring chinook, 33% of the summer chinook, and 24% of the fall chinook population. Two-, three-, and six-year-old fish were estimated to comprise the remaining 4% of the spring chinook, 15% of the summer chinook and 36% of the fall chinook salmon population. The sockeye salmon population sampled at Bonneville was predominantly five-year-old fish (66%), and the coho population was almost entirely four-year-old fish (98%). Differences in age class returns over the past ten years were used to predict spring chinook population sizes for 1999.

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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 1998 adult populations of chinook[1] *Oncorhynchus tshawytscha*, sockeye *Oncorhynchus nerka*, and coho salmon *Oncorhynchus kisutch*. Although 1998 was the first 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.

Data that is not reported in the results section of this report, but is 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 assessment (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 6 to October 22. 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 (1998).

Sampling Methods

A representative sample of the Columbia River chinook, sockeye, and coho salmon populations was 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). Every fish was revived and then 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

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 1998, for example, Statistical Week 15 began on April 5 and ended on April 11.

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).

salmon sampled (Knudsen 1990). Four scales were collected from each sockeye salmon sampled. Gender of 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). 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 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. 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). 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 1999.

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

RESULTS

Sample Design

Water temperatures in the mainstem Columbia River were above 70F for an unprecedented period in 1998. 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. This prevented us from sampling from July 16 through September 9, and again from September 14-17.

In 1998, 562 spring chinook salmon were collected and sampled. Seven 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 522 fish.

Between 1 June and 16 July, 571 summer chinook salmon were collected and sampled in this study. Seven 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 used for the summer chinook salmon age and length-at-age composition estimates was 529 fish.

Between 10 September and October 22, scales were collected from 453 fall chinook individuals. Of these, 9% were unreadable, yielding a total sample size of 414 fish.

In 1998, 310 sockeye salmon were collected and sampled. Unreadable scales accounted for 5% of the total sample. Therefore, the total sample size used for the sockeye salmon age and length-at-age composition estimates was 296 fish.

Between 30 September and 22 October, 251 coho salmon were collected and sampled at Bonneville Dam. The total sample size for coho salmon age and length-at-age estimates was 229 fish after rejecting 9% 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 1994 brood-year), comprised 50% of the spring chinook run (Table 1, Figure 1). Five-year-old fish (Ages 0.4 and 1.3 from the 1993 brood-year) were 46% of the 1998 run.

Summer Chinook Salmon

Five-year-old fish (Ages 0.4 and 1.3 from the 1993 brood-year), comprised 52% of the 1998 summer chinook run (Table 2, Figure 1). Four-year-old fish from the 1994 brood-year (Ages 0.3 and 1.2) contributed 33% of the 1998 run. Subyearling outmigrants of Ages 0.1, 0.2, 0.3, and 0.4 (collectively herein referred to as *Age 0-plus*) contributed less than 1% of the 1998 run during the initial weeks of June, but significantly increased in frequency as the run progressed (Figure 2).

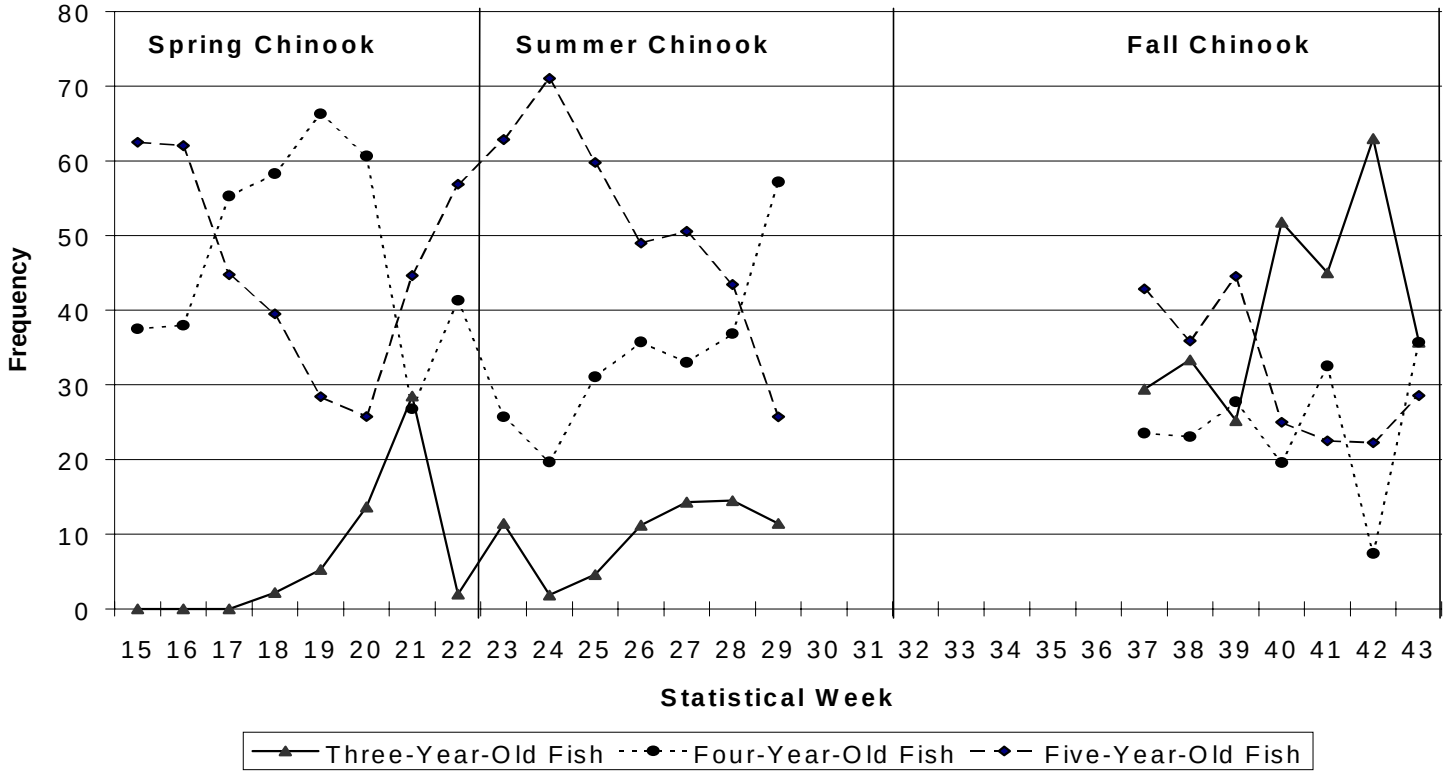
Fall Chinook Salmon

Ninety-six percent of the 1998 run was from three brood years-1993 (39%), 1994 (24%), and 1995 (32%) (Table 3, Figure 1). Eighty nine percent of the run were from subyearling outmigrants returning at Ages 0.1, 0.2, 0.3, and 0.4 (*Age 0-plus*). The percentage of chinook salmon of Age 0-plus was over

Table 1. Age composition (%) of Columbia Basin spring chinook salmon sampled at Bonneville Dam in 1998.

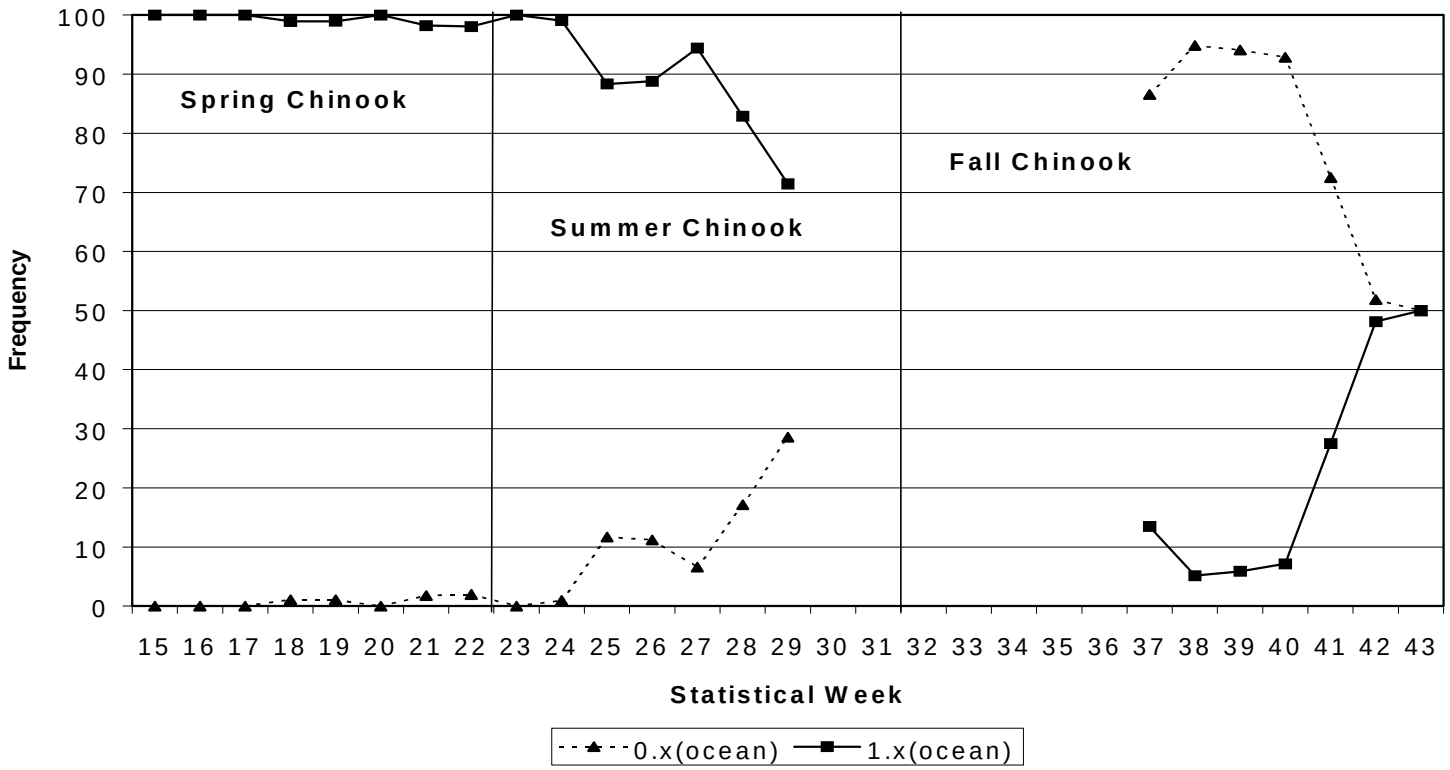
Statistical Week	Run Size	Sampling Dates	Sample Size	Age Composition (%) by Brood Year and Age Class							
				1995		1994		1993		1992	
				0.2	1.1	0.3	1.2	0.4	1.3		1.4
14, 15	4,875	4/3,8	8				38		63		
16	5,528	4/14,15,17	79				39		61		
17	8,859	4/20,21,24	76				53		47		
18	7,638	4/27,29;5/2	91		1		59	1	38		
19	4,772	5/4,6,8	95			1	65		28		
20	2,330	5/11,13,15	66		14		61		26		
21	2,180	5/18,20,22	56	2	27	2	25		45		
22	2,381	5/26,27,28	51		2	2	37	2	56		
Cumulative	38,563		522	<1	3	<1	50	<1	46		0

Figure 1. Weekly age composition estimates for the three major Columbia Basin spring, summer, and fall salmon age groups sampled at Bonneville Dam in 1998[5].



5. Statistical weeks 30-36 not sampled due to temperatures >70F.

Figure 2. Weekly freshwater age composition estimates of Columbia Basin spring, summer, and fall chinook salmon sampled at Bonneville Dam in 1998[6].



6. Statistical weeks 30-36 not sampled due to temperatures >70F.

Table 2. **Age composition (%) of Columbia Basin summer chinook salmon sampled at Bonneville Dam in 1998**.

Statistical Week	Run Size	Sampling Dates	Sample Size	Age Composition (%) by Brood Year and Age Class									
				1996	1995		1994		1993		1992		
				0.1	0.2	1.1	0.3	1.2	0.4	1.3	1.4		
23	1,874	6/01,04	35			11		26		63			
24	3,589	6/08,10,12	107		1	1		20		71	7		
25	3,834	6/16,17	87	1	2	5	5	26	6	53	3		
26	2,885	6/22,24,26	98		3	8	3	33	2	46	5		
27	2,904	6/29,7/01	91		1	13	1	32	5	43	3		
28	2,861	7/06,08	76	1	3	14	5	32	9	32	4		
29	2,264	7/14,16	35		9	6	14	40	14	11	6		
Cumulative	20,211		529	<1	3	8	4	29	5	47	4		

Table 3. Age composition (%) of Columbia Basin fall chinook salmon sampled at Bonneville Dam in 1998.

				Age Composition (%) by Brood Year and Age Class									
Statistical Week	**Run Size**	**Sampling Dates**	**Sample Size**	**1996**	**1995**		**1994**		**1993**		**1992**	
				0.1	**0.2**	**1.1**	**0.3**	**1.2**	**0.4**	**1.3**	**0.5**	**1.4**
32-37	121,856	9/10,11	119	3	29		20	3	34	9	1	1
38	35,656	9/18	39		33		21	3	36		5	3
39	18,866	9/21,23	119	1	25		24	3	42	3	2	
40	7,225	9/30, 10/2	56	4	46	5	18	2	25			
41	2,746	10/06,09	40		40	5	23	10	10	13		
42	1,448	10/13,15	27	7	41	22		7	4	19		
43-44	980	10/20,22	14		29	7	14	21	7	21		
Cumulative	188,777		414	1	31	1	21	3	34	5	2	1

85% during Statistical Weeks 37-40, before declining during Weeks 41 and 42 (Figure 2). The percentage of three-year-old fish increased during the migration, the percentage of five-year-old fish decreased, while the percentage of four-year-old fish remained relatively constant, though showing increasing week-to-week variation (Figure 1).

Sockeye Salmon

Five-year-old fish (Ages 1.3 and 2.2 from the 1993 brood-year group), contributed to 66% of the total 1998 sockeye run (Table 4).

Coho Salmon

The 1998 coho run past Bonneville was 98% four-year-old fish, Ages 1.2 from the 1994 brood-year (Table 5).

Spring Chinook Salmon Run Size Prediction

Based on a linear relationship between three-year-old and four-year old returns (from brood years 1984 – 1994) the estimated 1999 four-year-old adult spring chinook salmon abundance at Bonneville Dam is 23,600 (±36,300 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 1999 five-year old adult abundance will be 9,300 (±11,800 90% bound [Figure 4]).

Table 4. Age composition (%) of Columbia Basin sockeye salmon sampled at Bonneville Dam in 1998.

				Age Composition (%) by Brood Year and Age Class					
				1995	1994		1993		1992
Statistical Week	Run Size	Sampling Dates	Sample Size	1.1	1.2	2.1	1.3	2.2	2.3
24-25	2,142	6/12,16,17,19	87	10	13		68	8	1
26	3,761	6/22,24,26	87	10	9		67	13	1
27	3,141	6/29, 7/1	70	17	10	1	61	10	
28	2,146	7/6,8	36	47	8	3	33	8	
29	1,236	7/14,16	16	50	13	6	31		
Cumulative	12,426		296	22	10	1	57	9	1

Table 5. Age composition (%) of Columbia Basin coho salmon sampled at Bonneville Dam in 1998.

Statistical Week	Run Size	Sampling Dates	Sample Size	Age Composition (%) by Brood Year and Age Class		
				1995 1.1	1994 1.2	1993 1.3
40	7,158	9/30, 10/2	31		97	3
41	3,511	10/6,9	49	2	98	
42	3,203	10/13,15	91	1	99	
43	2,190	10/20/22	58	2	98	
Cumulative	12,426		229	1	98	2

Figure 3. **Predicted 1999 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 – 1994.**

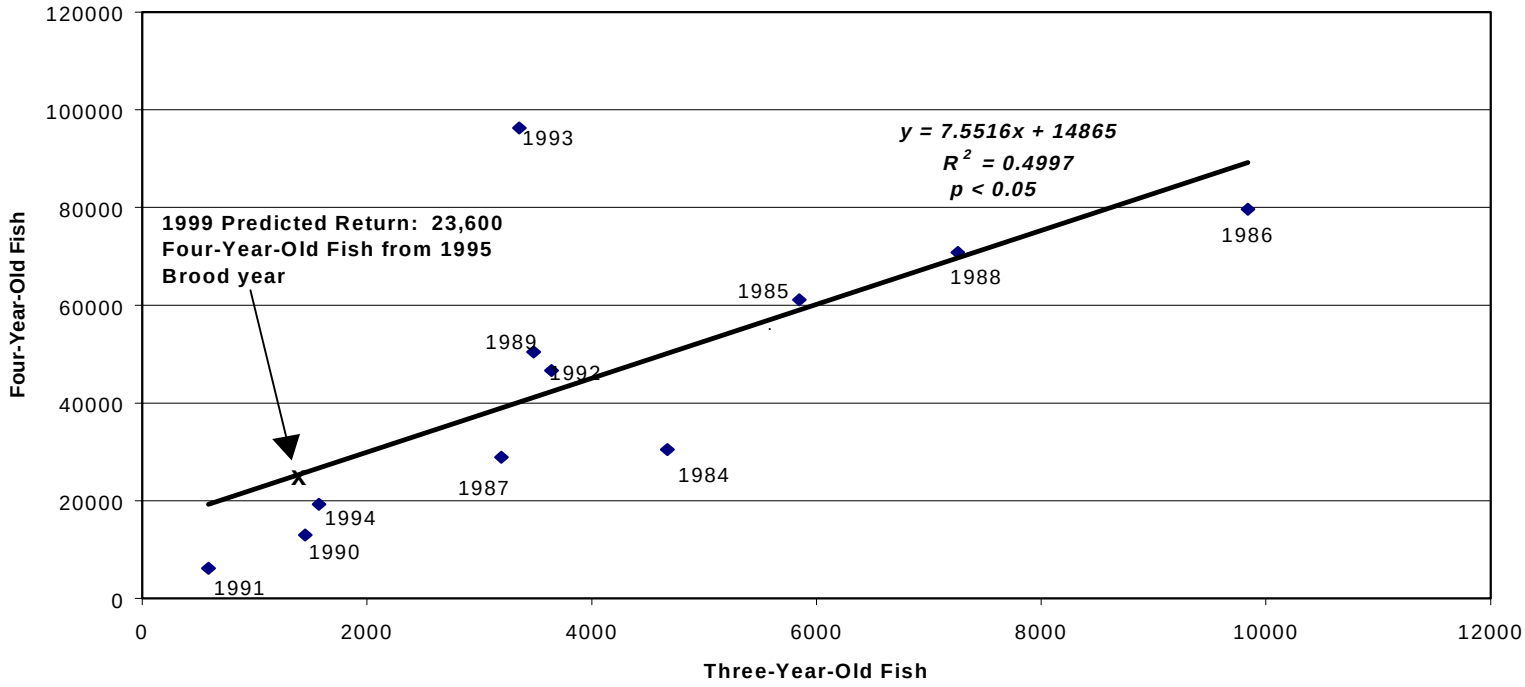
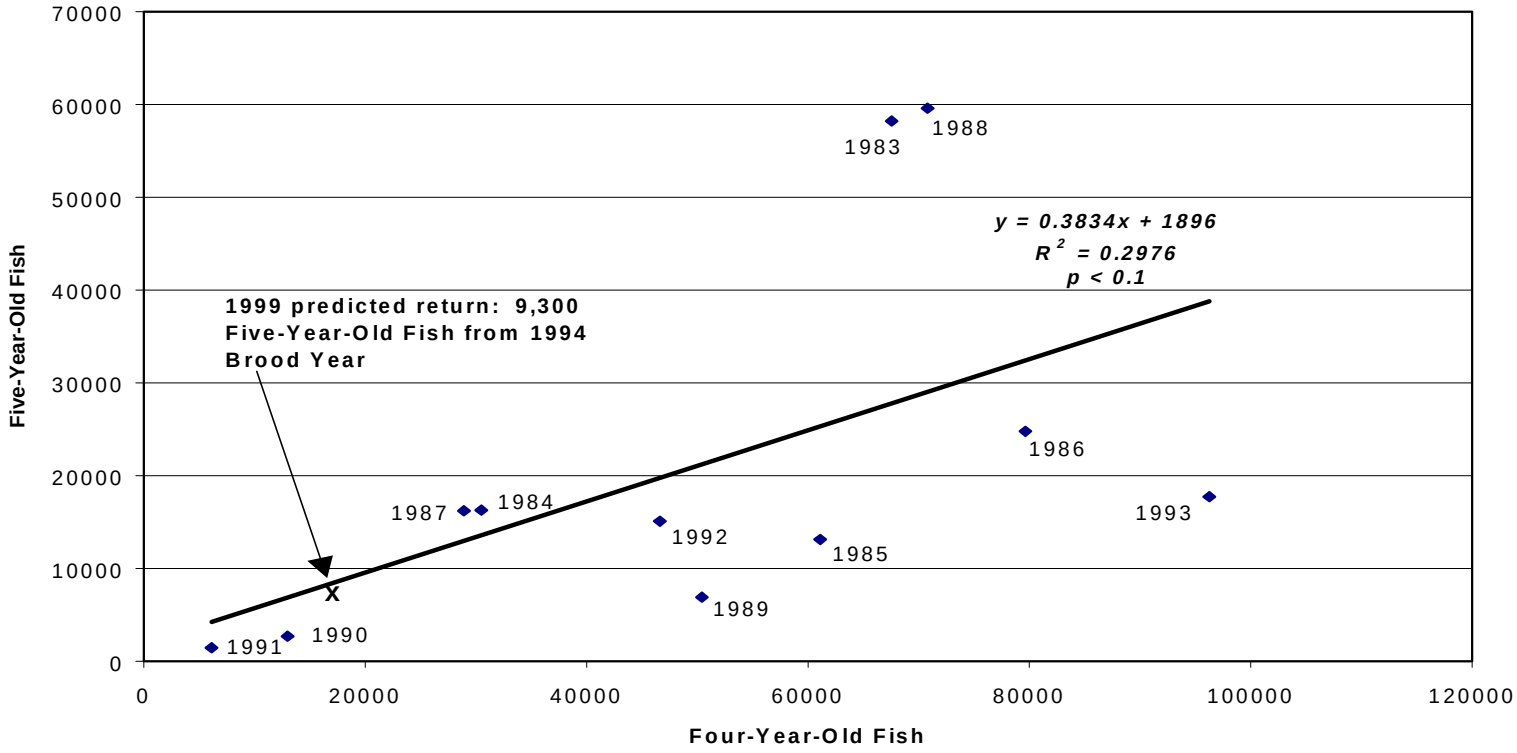


Figure 4. **Predicted 1999 five-year-old Columbia Basin spring chinook salmon abundance (at Bonneville Dam) based on a linear relationship between five-year-old and four-year-old fish abundance during brood years 1983 through 1993.**



DISCUSSION

Sampling was not conducted at Bonneville Dam in 1998 when temperatures exceeded 70F. Due to the extremely warm temperatures, greater than 70F, we were unable to sample during the period when approximately 51% of the fall chinook run passed Bonneville Dam. Based on historical temperature data, this year was only the second year in the past 19 years when more than 13% of the fall chinook salmon migration passed Bonneville Dam when temperatures exceeded 70F.

Seasonal trends in age distribution of chinook passing Bonneville Dam (Figure 1) suggest that the missing data from statistical weeks 30-36 could have had a deleterious effect of our 1998 age composition estimates of fall chinook. The late run abundance of three-year-old fish may result in a disproportionately large representation of younger fish.

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 1998.

	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	192	7					9			42			49									
No Fin Clips	370	7				<1	5		1	56		<1	39									
Summer Chinook																						
Fin- Clipped	181	13		1		1	13		1	27		1	51			6						
No Fin Clips	390	5		<1		2	5		4	30		7	49			4						
Fall Chinook																						
Fin- Clipped	55	15				40	11		11	11		17	9			2						
No Fin Clips	398	7		2		28	2		19	3		28	6		1	<1						
Sockeye																						
Fin- Clipped	7	14					17			67			17									
No Fin Clips	303	4					22			9			58					1		9		1
Coho																						
Fin- Clipped	212	8					1			98			1									
No Fin Clips	39	13					3			97												

Table A2. Percent of sampled chinook, coho and sockeye salmon at Bonneville Dam having fin clips by week in 1998.

Statistical Week	Spring Chinook	Summer Chinook	Fall Chinook	Sockeye	Coho
15	44				
16	47				
17	37				
18	34				
19	25				
20	35				
21	35				
22	24				
23		31			
24		34		0	
25		22		3	
26		28		1	
27		34		4	
28		40		0	
29		34		0	
37			12		33
38			8		
39			10		
40			15		71
41			22		81
42			15		89
43			0		92
Total	**34**	**32**	**12**	**2**	**84**

Table A3. Length-at-age estimates for Columbia Basin spring chinook salmon sampled at Bonneville Dam in 1998.

	Brood Year and Age Class						
	1995		1994		1993		1992
	0.2	1.1	0.3	1.2	0.4	1.3	1.4
Statistical Weeks 15							
Mean Fork Length (cm)				66.2		82.7	
Minimum				66.0		70.0	
Maximum				66.5		88.5	
Standard Deviation				0.3		1.4	
Sample Size				3		5	
Statistical Week 16							
Mean Fork Length (cm)				71.7		86.2	
Minimum				63.0		72.0	
Maximum				82.0		105.0	
Standard Deviation				4.5		6.1	
Sample Size				30		49	
Statistical Week 17							
Mean Fork Length (cm)				71.9		86.4	
Minimum				60.0		71.5	
Maximum				80.0		95.0	
Standard Deviation				4.2		5.2	
Sample Size				42		33	
Statistical Week 18							
Mean Fork Length (cm)		52.5		71.6	85.0	84.3	
Minimum		44.0		64.0	85.0	68.0	
Maximum		61.0		84.0	85.0	94.5	
Standard Deviation		12.0		4.3	-	6.2	
Sample Size		2		53	1	35	
Statistical Week 19							
Mean Fork Length (cm)		50.2	76.5	71.4		87.3	
Minimum		43.0	76.5	61.0		72.0	
Maximum		55.5	76.5	85.0		102.0	
Standard Deviation		5.5	-	4.7		6.9	
Sample Size		5	1	62		27	
Statistical Week 20							
Mean Fork Length (cm)		52.3		70.8		89.5	
Minimum		42.5		62.5		81.0	
Maximum		60.5		82.5		98.0	
Standard Deviation		5.3		4.3		4.9	
Sample Size		9		40		17	
Statistical Week 21							
Mean Fork Length (cm)	71.0	47.6		69.6		88.5	
Minimum	71.0	44.0		55.0		74.5	
Maximum	71.0	54.0		82.0		102.0	
Standard Deviation	-	3.2		7.6		7.3	
Sample Size	1	15		15		25	
Statistical Week 22							
Mean Fork Length (cm)		47.0	86.0	76.3		87.8	
Minimum		47.0	86.0	66.0		75.0	
Maximum		47.0	86.0	99.0		103.0	
Standard Deviation		-	-	9.2		5.8	
Sample Size		1	1	20		29	
1998 Composite							
Mean Fork Length (cm)	71.0	49.6	81.3	71.7	85.0	86.7	
Minimum	71.0	42.5	76.5	55.0	85.0	68.0	
Maximum	71.0	61.0	86.0	99.0	85.0	105.0	
Standard Deviation	-	5.1	6.7	5.3	-	6.3	
Sample Size	1	32	2	265	1	220	0

Table A4. Length-at-age estimates for Columbia Basin summer chinook salmon sampled at Bonneville Dam in 1998.

	Brood Year and Age Class								
	1996	1995		1994		1993		1992
	0.1	0.2	1.1	0.3	1.2	0.4	1.3	1.4
Statistical Week 23								
Mean Fork Length (cm)			57.8		75.5		91.2	
Minimum			43.0		52.0		77.5	
Maximum			76.5		87.0		105.0	
Standard Deviation			14.8		10.2		6.6	
Sample Size			4		9		22	
Statistical Week 24								
Mean Fork Length (cm)		72.0	56.0		76.9		88.8	95.3
Minimum		72.0	56.0		63		73.0	86.0
Maximum		72.0	56.0		87.0		99.0	99.0
Standard Deviation		-	-		6.2		5.0	5.2
Sample Size		1	1		19		76	8
Statistical Week 25								
Mean Fork Length (cm)	42.0	63.0	53.0	83.9	77.6	93.7	89.7	98.7
Minimum	42.0	63.0	51.0	74.5	67.0	86.0	70.5	96.0
Maximum	42.0	63.0	55.0	91.0	92.0	107.0	105.5	103.0
Standard Deviation	-	-	2	7.1	6.3	8.0	6.4	3.8
Sample Size	1	1	3	4	23	5	47	3
Statistical Week 26								
Mean Fork Length (cm)		63.2	55.1	78.6	74.7	92.3	89.5	92.5
Minimum		57.5	47.0	72.0	56.0	88.0	72.5	85.0
Maximum		67.0	60.0	86.0	94.0	95.5	98.0	102.0
Standard Deviation		5.0	5.2	5.9	9.0	3.4	5.2	7.3
Sample Size		3	8	4	31	4	44	4
Statistical Week 27								
Mean Fork Length (cm)		63.5	48.7	78.0	74.3	93.3	87.7	93.0
Minimum		63.5	44.0	78.0	62.0	91.0	57.0	82.0
Maximum		63.5	53.0	78.0	86.0	96.0	105.0	104.0
Standard Deviation		-	2.3	-	6.8	2.0	7.7	15.6
Sample Size		1	12	1	29	4	42	2
Statistical Week 28								
Mean Fork Length (cm)	40.5	62.5	52.5	81.8	70.8	89.8	89.0	95.7
Minimum	40.5	62.5	44.0	76.0	57.0	77.0	70.5	88.0
Maximum	40.5	62.5	61.5	87.0	87.0	99.0	103.0	101.0
Standard Deviation	-	-	6.2	5.5	6.9	7.6	7.6	6.8
Sample Size	1	1	10	3	25	8	25	3
Statistical Week 29								
Mean Fork Length (cm)		66.0	58.8	77.8	70.9	97.6	89.7	101.0
Minimum		62.0	50.5	67.0	57.5	94.5	76.5	99.0
Maximum		70.0	67.0	87.5	85.5	101.0	98.0	103.0
Standard Deviation		5.7	11.7	8.6	8.4	2.8	8.3	2.8
Sample Size		2	2	4	16	4	5	2
1998 Composite								
Mean Fork Length (cm)	41.3	64.7	52.8	80.3	74.3	92.8	89.1	95.6
Minimum	40.5	57.5	43.0	67.0	52.0	77.0	57.0	82.0
Maximum	42.0	72.0	76.5	91.0	94.0	107.0	105.5	104.0
Standard Deviation	1.1	4.4	6.9	6.5	7.8	6.1	6.2	6.4
Sample Size	2	9	40	16	154	25	261	22

Table A5. Length-at-age estimates for Columbia Basin fall chinook salmon sampled at Bonneville Dam in 1998.

	Brood Year and Age Class								
	1996	1995		1994		1993		1992	
	0.1	0.2	1.1	0.3	1.2	0.4	1.3	0.5	1.4
Statistical Week 37									
Mean Fork Length (cm)	58.8	68.9		86.6	72.6	92.8	89.1	103.0	92.5
Minimum	56.0	55.5		71.0	69.0	82.5	80.0	103.0	92.5
Maximum	62.0	84.0		98.0	77.0	114.0	97.0	103.0	92.5
Standard Deviation	3.0	7.0		6.4	3.3	6.7	5.4	-	-
Sample Size	3	35		24	4	40	11	1	1
Statistical Week 38									
Mean Fork Length (cm)		68.2		81.6	94.0	89.9		88.3	88.0
Minimum		54.5		70.5	94.0	77.0		85.0	88.0
Maximum		79.0		91.0	94.0	110.0		91.5	88.0
Standard Deviation		6.6		7.7	-	814		4.6	-
Sample Size		13		8	1			2	1
Statistical Week 39									
Mean Fork Length (cm)	56.5	70.0		86.5	74.4	88.4	86.2	94.3	
Minimum	56.5	49.0		74.5	65.0	69.0	85.5	92.0	
Maximum	56.5	89.0		101.0	82.5	108.0	87.0	96.5	
Standard Deviation	-	7.8		6.2	8.7	6.5	.1	3.2	
Sample Size	1	30		29	4	50	3	2	
Statistical Week 40									
Mean Fork Length (cm)	49.3	67.0	52.8	80.5	80.0	88.2			
Minimum	45.5	58.0	52.0	65.0	80.0	74.0			
Maximum	53.0	77.0	54.5	89.0	80.0	100.5			
Standard Deviation	5.3	4.6	1.4	6.5	-	7.0			
Sample Size	2	26	3	10.0	1	14			
Statistical Week 41									
Mean Fork Length (cm)		66.0	54.0	79.1	69.5	80.1	85.9		
Minimum		52.5	52.0	48.5	60.0	73.0	82.5		
Maximum		75.5	56.0	104.0	80.0	92.5	91.0		
Standard Deviation		6.3	2.8	15.0	8.3	9.0	3.3		
Sample Size		16	2	9	4	4	5		
Statistical Week 42									
Mean Fork Length (cm)	47.8	64.8	56.8		75.0	84.5	85.6		
Minimum	45.0	52.5	51.5		65.0	84.5	71.0		
Maximum	50.5	73.0	62.0		85.0	84.5	96.0		
Standard Deviation	3.9	6.4	4.5		14.1	-	10.3		
Sample Size	2	11	6		2	1	5		
Statistical Week 43									
Mean Fork Length (cm)		63.3	65.0	90.5	79.0	90.0	78.2		
Minimum		57.5	65.0	87.0	67.5	90.0	56.0		
Maximum		66.5	65.0	94.0	85.0	90.0	103.5		
Standard Deviation		4.0	-	5.0	10.0	-	23.91		
Sample Size		4	1	2	3	1	3		
1998 Composite									
Mean Fork Length (cm)	53.4	67.9	56.0	84.6	86.3	89.7	86.3	93.6	90.3
Minimum	45.0	49.0	51.5	48.5	56.0	69.0	56.0	85.0	88.0
Maximum	62.0	89.0	65.0	104.0	103.5	114.0	103.5	103.0	92.5
Standard Deviation	6.1	6.7	4.7	8.2	9.2	7.2	9.2	6.7	3.2
Sample Size	8	135	12	82	27	124	27	5	2

Table A6. Length-at-age estimates for Columbia Basin sockeye salmon sampled at Bonneville Dam in 1998.

	Brood Year and Age Class					
	1995	1994		1993		1992
	1.1	1.2	2.1	1.3	2.2	2.3
Statistical Weeks 24						
Mean Fork Length (cm)				58.5		
Minimum				58.0		
Maximum				59.0		
Standard Deviation				0.7		
Sample Size				2		
Statistical Week 25						
Mean Fork Length (cm)	38.9	50.1		56.5	52.1	56.0
Minimum	36.5	47.0		49.5	49.0	56.0
Maximum	41.0	53.0		62.0	58.0	56.0
Standard Deviation	1.7	2.0		2.6	3.2	-
Sample Size	9	11		57	7	1
Statistical Week 26						
Mean Fork Length (cm)	40.1	49.9		55.3	51.8	55.0
Minimum	37.0	48.0		48.0	48.0	55.0
Maximum	42.0	54.0		60.5	54.5	55.0
Standard Deviation	1.5	1.9		2.8	2.2	-
Sample Size	9	8		58	11	1
Statistical Week 27						
Mean Fork Length (cm)	39.6	50.9	54.0	54.2	50.8	
Minimum	34.0	46.0	54.0	46.0	47.0	
Maximum	44.0	54.5	54.0	61.5	53.5	
Standard Deviation	2.9	3.0	-	3.1	2.3	
Sample Size	12	7	1	43	7	
Statistical Week 28						
Mean Fork Length (cm)	39.6	50.0	45.0	54.8	47.7	
Minimum	37.0	46.0	45.0	51.0	46.0	
Maximum	42.5	54.0	45.0	66.0	49.0	
Standard Deviation	1.6	4.0	-	4.0	1.5	
Sample Size	17	3	1	12	3	
Statistical Week 29						
Mean Fork Length (cm)	39.9	49.3	44.0	53.9		
Minimum	37.0	49.0	44.0	53.0		
Maximum	42.0	49.5	44.0	55.0		
Standard Deviation	1.9	0.4	-	0.9		
Sample Size	8	2	1	5		
1998 Composite						
Mean Fork Length (cm)	39.6	50.2	47.7	55.4	51.2	55.5
Minimum	34.0	46.0	44.0	46.0	46.0	55.0
Maximum	44.0	54.5	54.0	66.0	58.0	56.0
Standard Deviation	2.0	2.3	5.5	3.0	2.7	0.7
Sample Size	55	31	3	177	28	2

Table A7. Length-at-age estimates for Columbia Basin coho salmon sampled at Bonneville Dam in 1998.

	Brood Year and Age Class		
	1995 1.1	**1994 1.2**	**1993 1.3**
Statistical Weeks 40			
Mean Fork Length (cm)		69.6	89.0
Minimum		63.0	89.0
Maximum		95.0	89.0
Standard Deviation		6.3	-
Sample Size		30	1
Statistical Week 41			
Mean Fork Length (cm)	51.5	69.1	
Minimum	51.5	48.0	
Maximum	51.5	80.0	
Standard Deviation	-	6.0	
Sample Size	1	48	
Statistical Week 42			
Mean Fork Length (cm)	39.0	65.5	
Minimum	39.0	46.5	
Maximum	39.0	80.0	
Standard Deviation	-	6.5	
Sample Size	1	90	
Statistical Week 43			
Mean Fork Length (cm)	44.5	66.3	
Minimum	44.5	50.0	
Maximum	44.5	77.5	
Standard Deviation	-	7.1	
Sample Size	1	57	
1998 Composite			
Mean Fork Length (cm)	45.0	67.0	89.0
Minimum	39.0	46.5	89.0
Maximum	51.5	95.0	89.0
Standard Deviation	6.3	6.7	-
Sample Size	3	225	1

Table A8. Composition (%) of observed injuries of Columbia Basin spring, summer, and fall chinook salmon sampled at Bonneville Dam in 1998.

Category	Spring Chinook 1998	Summer Chinook 1998	Fall Chinook 1998
Marine Mammal Injuries			
Bite	10	3	1
Claw Rake	19	3	5
Twin Arches	17	6	4
Total Marine Mammal[a]	36	11	9
Descaling			
5-20% Descaling			
Right Side	11	6	9
Left Side	10	7	8
Either	16	10	10
>20% Descaling			
Right Side	<1	0	0
Left Side	1	0	0
Either	1	0	0
General Injuries			
Bruises	0	0	0
Cuts	1	0	<1
Head Injury	5	4	2
Head Burn	<1	1	0
Fin	12	11	6
Fungus	<1	1	<1
Gash[b]	2	2	<1
Gas Bubble Disease	0	0	0
Gill Net	<1	<1	0
Fishing Hook	1	1	3
Lamprey	2	<1	0
Parasite	<1	0	<1
Total General Injuries[a]	20	15	12

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 1998.

Category	Sockeye 1998	Coho 1998
Marine Mammal Injuries		
Bite	1	1
Claw Rake	1	3
Twin Arches	5	6
Total Marine Mammal[a]	6	10
Descaling		
5-20% Descaling		
Right Side	6	4
Left Side	7	4
Either	10	5
>20% Descaling		
Right Side	<1	0
Left Side	0	0
Either	<1	0
General Injuries		
Bruises	0	1
Cuts	<1	1
Head	0	3
Headburn	0	<1
Fin	11	5
Fungus	1	1
Gash	6	<1
Gas Bubble Disease	0	n/a
Gill Net	0	1
Fishing Hook	0	1
Lamprey	0	0
Parasite	0	1
Total General Injuries[a]	16	10

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 1998.