AGE AND LENGTH COMPOSITION OF COLUMBIA BASIN SPRING AND SUMMER CHINOOK SALMON AT BONNEVILLE DAM IN 1994

Technical Report 95-1

Jeffrey K. Fryer
David R. Pederson
Matthew Schwartzberg

April 3, 1995

YAKAMA NEZ PERCE WARM SPRINGS UMATILLA

Columbia River Inter-Tribal Fish Commission
729 N.E. Oregon St., Portland, OR 97232
(503) 238-0667

AGE AND LENGTH COMPOSITION OF COLUMBIA BASIN SPRING AND SUMMER CHINOOK SALMON AT BONNEVILLE DAM IN 1994

Technical Report 95-1

Jeffrey K. Fryer
David R. Pederson
Matthew Schwartzberg

April 3, 1995

ABSTRACT

Representative samples of the 1994 Columbia Basin spring and summer adult chinook salmon populations were collected at Bonneville Dam. 1994 was the eighth year spring chinook salmon and the fifth year summer chinook salmon were sampled in this study. Fish were trapped, anesthetized, sampled for scales and biological data, allowed to revive, and then released. The scales were examined to estimate age composition. Based on scale analysis, five-year-old fish were estimated to comprise 40% of the spring chinook salmon and 50% of the summer chinook population. Four-year-old fish were estimated to comprise 57% of the spring chinook and 34% of the summer chinook population. Two-, three-, and six-year-old fish were estimated to comprise the remaining 3% of the spring chinook and 16% of the summer chinook population. Differences in age class returns were used to predict spring chinook population sizes for 1995.

An estimated 40% spring chinook and 18% of summer chinook salmon sampled were injured by marine mammals in 1994. Fifteen percent spring chinook and 9% of summer chinook salmon appeared to have cuts, gill net wounds, parasites, or other miscellaneous injuries. Seven percent of spring chinook salmon and 9% of summer chinook salmon were more than 5% descaled on at least one side of each specimen. No fish appeared to exhibit signs of gas bubble disease due to nitrogen supersaturation.

ACKNOWLEDGMENTS

We sincerely thank the following individuals for their assistance in this project: Diane Gardella, Doug Hatch, Nick Martin, and Matthew Schwartzberg, of the Columbia River Inter-Tribal Fish Commission; Lyle Gilbreath of the National Marine Fisheries Service; Mike Burner and Kevleen Fennell of the Oregon Department of Fish and Wildlife; Gary Johnson, Jim Kuskie, Dennis Schwartz, and Mary Todd Uhler of the US Army Corps of Engineers; Curt Knudsen and John Sneva of the Washington Department of Fisheries; and Roger Dick, Preston Harrison, Lynn Hatcher, Steve Parker, and Carl Settler 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. P00C1409445 for implementation of the US-Canada Pacific Salmon Treaty.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

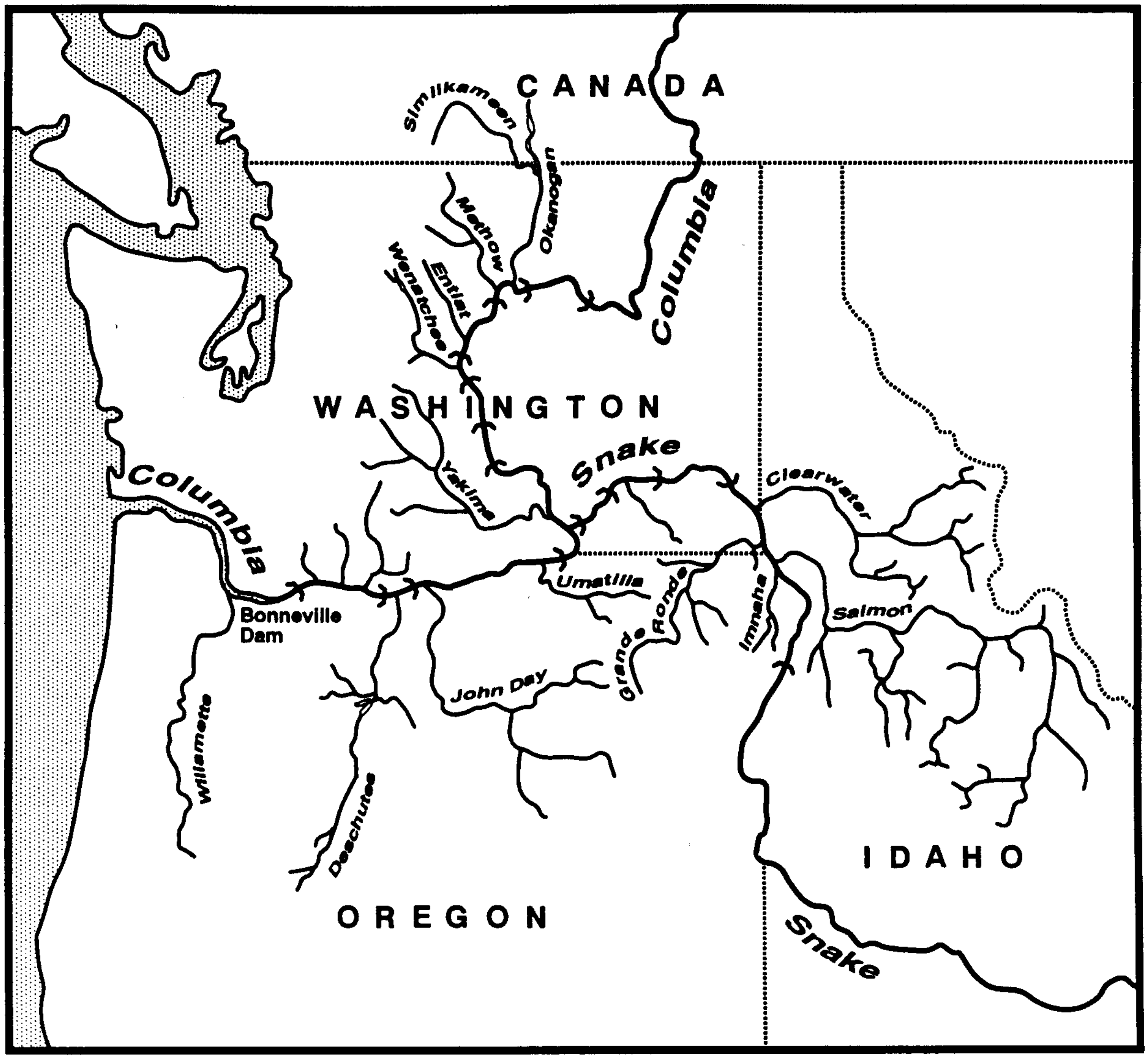
The Stock Assessment Project of the Columbia River Inter-Tribal Fish Commission (CRITFC) is a part of the US-Canada Pacific Salmon Treaty spawning escapement monitoring program (PST 1985). A principal aim of the project is the monitoring of the age and length-at-age composition of Columbia Basin salmonids, 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 1994 adult populations of upriver spring and summer chinook salmon[1] *Oncorhynchus tshawytscha*. Bonneville Dam, located at Columbia River kilometer 235, was the sampling site for this project (Figure 1). The spring chinook portion of the study began in 1987 and the summer chinook portion in 1990. Reports of previous results are available (Schwartzberg 1988, 1989; Schwartzberg and Fryer 1990; Fryer and Schwartzberg 1991a, 1991b, 1992, 1993, 1994; Fryer et al. 1992). Data from these studies were used to develop a linear relationship among age classes that was used to predict the 1995 population size of the predominant spring chinook salmon age class. The physical conditions of all fish sampled was evaluated using a visual assessment procedure developed in 1992. In 1994, fish sampled were also examined for evidence of nitrogen supersaturation resulting from increased water spill at mainstem Columbia River dams (Fryer 1994).

---

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.

Figure 1. **Map of the Columbia Basin including principal spring and summer chinook salmon spawning and rearing tributaries and Bonneville Dam.**



METHODS

Sampling Methods

A representative sample of the Columbia River spring and summer chinook salmon populations was collected at the Fisheries Engineering and Research Laboratory located adjacent to the Second Powerhouse of Bonneville Dam. Fish were trapped and anesthetized. Each fish was then sampled for scales, fork length measured and recorded, observed mark and/or tag information and other pertinent biological data was noted (Appendix A). Every fish was allowed to revive, 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 sample rejection rate, six scales were collected per fish (Knudsen 1990). Gender of collected specimens, all in early stages of sexual maturation, could not be determined.

Sample Design

Sampling was conducted one to two days per statistical week[2] from April 6 to July 27, 1994. Sampling was increased to three days per week from May 15 through June 15 to monitor for gas bubble disease[3]. The desired sample size for spring and summer chinook salmon was a minimum of 500 fish each. In past study years, this minimum number of fish has resulted in age composition estimates within preferred levels of precision and accuracy (d=0.05, α=0.10). Actual 1994 migratory timing was determined from post-season analysis of 1994 Bonneville Dam fish ladder counts (CRITFC 1994). To further improve

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 1994, for example, Statistical Week 15 began on April 3 and ended on April 9.

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

accuracy, composite age and length-at-age estimates were adjusted post-season for actual 1994 migration timing using a stratified sampling method that weighted weekly estimates proportionally.

Age Determination

Scales were prepared and mounted 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 personnel at the Harvest Management Division 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 method used for fish age description was that recommended by Koo (1955). 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.

Comparison of Age Composition Estimates

Inter-Annual Age Composition Estimates

Age composition estimates obtained during earlier years of this study, beginning in 1987 for spring chinook salmon and 1990 for summer chinook salmon, were compiled and compared with results from this year's work to explore inter-annual variation in age composition estimates.

Intra-Annual Age Composition Estimates

Age composition estimates obtained in 1994 from Bonneville Dam scale samples were compared to estimates from two independent sources to explore

differences in intra-annual age composition estimates. The first comparison was made with the percentage of chinook salmon estimated in visual Bonneville Dam fish ladder counts to be less than approximately 56 cm (22 in) in overall length (USACE 1992). These fish, called *jacks*, are typically of Age 0.1 or 1.1.

The second comparison was made with estimates obtained by the Washington Department of Fish and Wildlife's annual Corbett Test Fishery (Dammers 1994). This fishery is conducted approximately 32 km downstream of Bonneville Dam from April 2 through April 30 and uses 18.42 cm (7.25 in) mesh, multiwalled gillnets. The age distribution estimated by the Corbett Test Fishery and this study were compared (α=0.10) using a test of equality of two multinomial distributions (Mood et al. 1974).

Spring Chinook Salmon Run-Size Prediction

The progeny of a salmon population from a given year will return to freshwater as adult spawners during several different successive years. All progeny of a given year's spawning population are known collectively as a *brood*. Many salmon population-size prediction techniques are based on patterns in age composition from successive broods. Estimates of the progeny for each brood year were made by combining age composition estimates from previous studies (Schwartzberg 1988; Schwartzberg and Fryer 1989, 1990; Fryer and Schwartzberg 1991a, 1993, 1994; Fryer et al. 1992) with visual count data from Bonneville Dam (CRITFC 1995). It was noted 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. For example in 1994, using linear regression techniques, 23,400 (± 33,500, 90% bound) four-year-old fish had been predicted to return (Fryer and Schwartzberg 1994). A similar prediction technique is used herein to forecast returning four-year-old fish in 1995.

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. The mean lengths of spring chinook salmon sampled in this study were compared with mean lengths of fish captured in the Corbett test fishery using a two-sample t-test. Differences in the distribution of lengths of four- and five-year-old spring chinook between the two studies were tested using a Kolmogorov-Smirnov test (Hays 1988).

Fish Condition

Criteria were developed in 1992 to allow precise classification of the condition of sampled fish (Fryer and Schwartzberg 1993). In 1993, these criteria were slightly modified and again applied in 1993 and 1994. Each specimen was inspected for marine mammal injuries, descaling, gill net damage, cuts, bruises and other assorted injuries (Appendix A). Each fish was also examined for signs of gas bubble disease (Fryer 1994). Special attention was given to the eyes, mouth, operculum, lateral line and fins for the formation of observable gas bubbles.

RESULTS

Sample Design

In 1994, 524 spring chinook salmon were collected and sampled. Because their scales were unreadable, 9% of the total sample was subsequently rejected and not classified by age. Consequently, the total sample size used for the spring chinook salmon age and length-at-age composition estimates was 479 fish.

In 1994, 507 summer chinook salmon were collected and sampled in this study. Because their scales were unreadable, 10% of the total sample was rejected and not classified by age. Twenty-six additional fish appeared to have spent no winters in saltwater. (These fish are generally under 30 cm in length and are known locally as *minijacks.* We excluded information on minijacks 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 428 fish.

Age Composition Estimates

Spring Chinook Salmon

Four-year-old fish (Age 0.3 and 1.2 fish from the 1990 brood-year group), comprising 57% of the population, were estimated to be the predominant age class for spring chinook salmon (Table 1, Figure 2).

Summer Chinook Salmon

Five-year-old fish (Ages 1.3 and 0.4 fish from the 1989 brood year) were estimated to be the predominant age class for summer chinook salmon, comprising 50% of the population (Table 2).

Table 1. Age composition estimates of Columbia Basin spring chinook salmon sampled at Bonneville Dam in 1994.

			Brood Year and Age Class (Percentage)					
			1991	1990		1989		1988
Statistical Week	Sampling Dates	Sample Size	1.1	0.3	1.2	0.4	1.3	1.4
16	4/06,13	8			38		62	
17	4/20,22	82	1		73		26	
18	4/27,28	184	2	<1	69		28	
19	5/4,5	96	1	1	61		36	
20	5/11,13	28	11	4	46		39	
21	5/18,20	24	17		38	4	42	
22	5/23,25,27	38	3		26	3	66	3
23	5/31	19	5		32	5	58	
Population Estimate		479	3	1	56	<1	40	<1

Figure 2. Weekly age composition estimates for the three major Columbia Basin spring and summer chinook salmon brood-year sampled at Bonneville Dam in 1994.

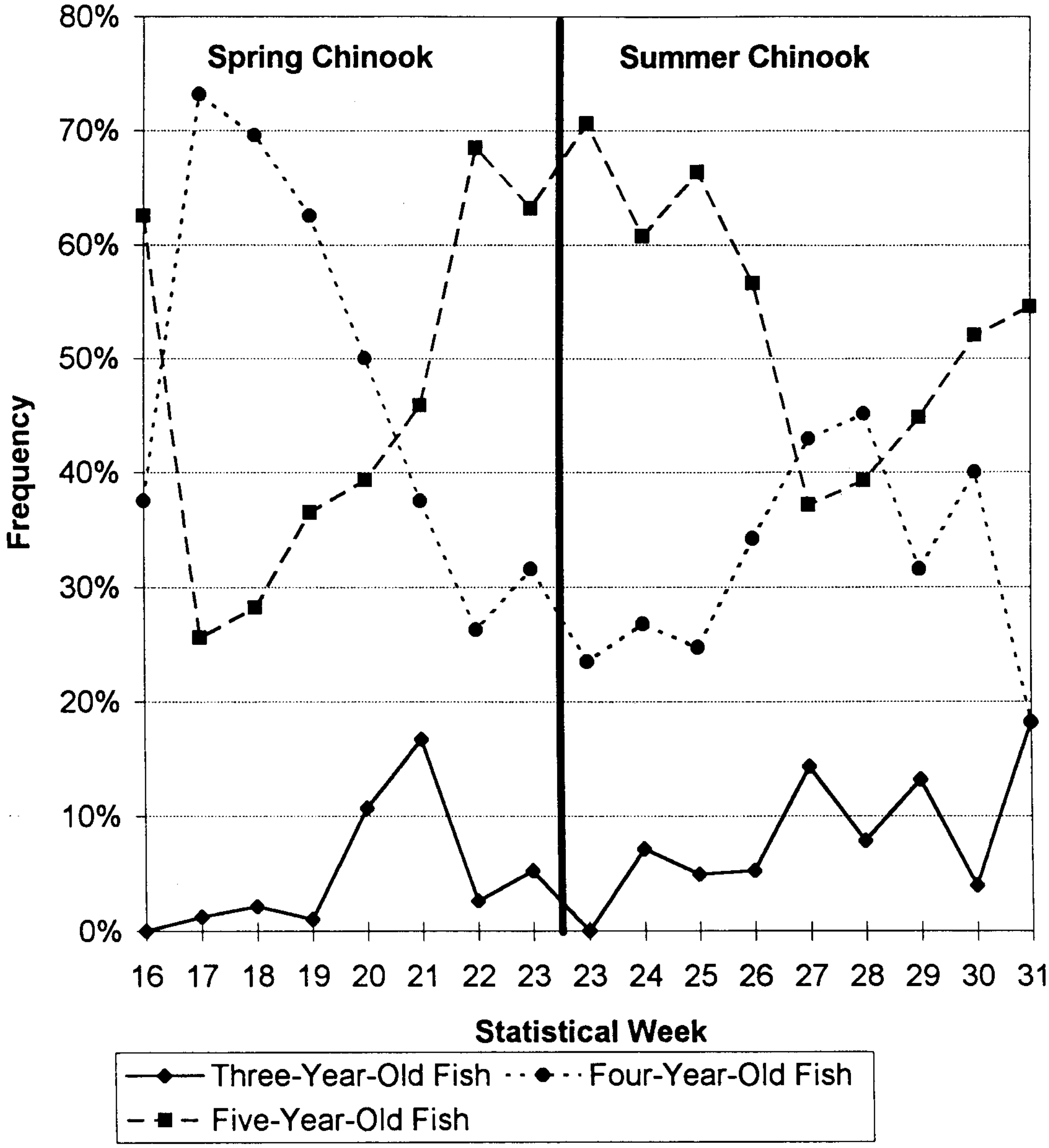


Table 2. Age composition estimates of Columbia Basin summer chinook salmon sampled at Bonneville Dam in 1994.

Statistical Week	Sampling Dates	Sample Size	Brood Year and Age Class (Percentage) 1992 0.1	1991 0.2	1991 1.1	1990 0.3	1990 1.2	1989 0.4	1989 1.3	1988 1.4
23	6/01,03	34				6	18	3	68	6
24	6/06,08,10	56	4	2	5	2	25	9	52	2
25	6/13,15,16	101	1		5	17	8	23	44	2
26	6/20,22	76	1	1	4	14	20	22	34	3
27	6/27	36	3	6	9	20	23	14	23	3
28	7/06,08	51	8	4	4	27	18	16	24	
29	7/11,13	38	8		13	21	11	8	37	3
30	7/20	25		4		24	16	12	40	4
31	7/27	11	9	9	9	18		9	45	
Population Estimate		428	4	3	5	18	16	14	36	2

Thirty-nine percent of the summer chinook salmon population was estimated to represent subyearling outmigrants of Ages 0.1, 0.2, 0.3, and 0.4 (collectively called herein *Age 0-plus*). The percentage of chinook salmon of Age 0-plus generally increased as the migration progressed (Figure 3).

Spring Chinook Salmon Run Size Prediction

In 1995, we predict that four-year-old adult spring chinook salmon abundance at Bonneville Dam will be 11,600 (±29,500, 90% bound [Figure 4]). If correct, this would be the lowest abundance of four-year-old returns in at least the past eight years, the time period this study has been conducted.

Comparison of Age Composition Estimates

Inter-Annual Age Composition Estimates

For the sixth year in the eight years of this study, the majority of the spring chinook salmon population returning in 1994 were estimated to be four-year-old fish (Figure 5). Five-year-old fish were the largest age class for summer chinook salmon for the third time in five years (Figure 6).

Intra-Annual Age Composition Estimates

Age 1.1 fish were estimated to comprise 3% of the composite 1994 spring chinook salmon sample. Visual fish ladder counts at Bonneville Dam estimated Age 1.1 fish to comprise 2% of the spring chinook salmon run (CRITFC 1994). Ages 0.1 and 1.1 fish were estimated to comprise 9% of the composite 1994 summer chinook salmon sample, compared to 10% based on fish ladder counts made at Bonneville Dam (CRITFC 1994).

The Corbett Test Fishery estimated that the 1994 spring chinook salmon population included 59% four-year-old fish, 40% five-year-old fish, and less than 1% six-year-old fish (n=80). Since the Corbett Test Fishery gear does not effectively capture smaller fish (W. Dammers, Washington Department of Fisheries, personal communication), no three-year-old fish were captured. The difference

Figure 3. Weekly freshwater age composition estimates of Columbia Basin spring and summer chinook salmon sampled at Bonneville Dam in 1994.

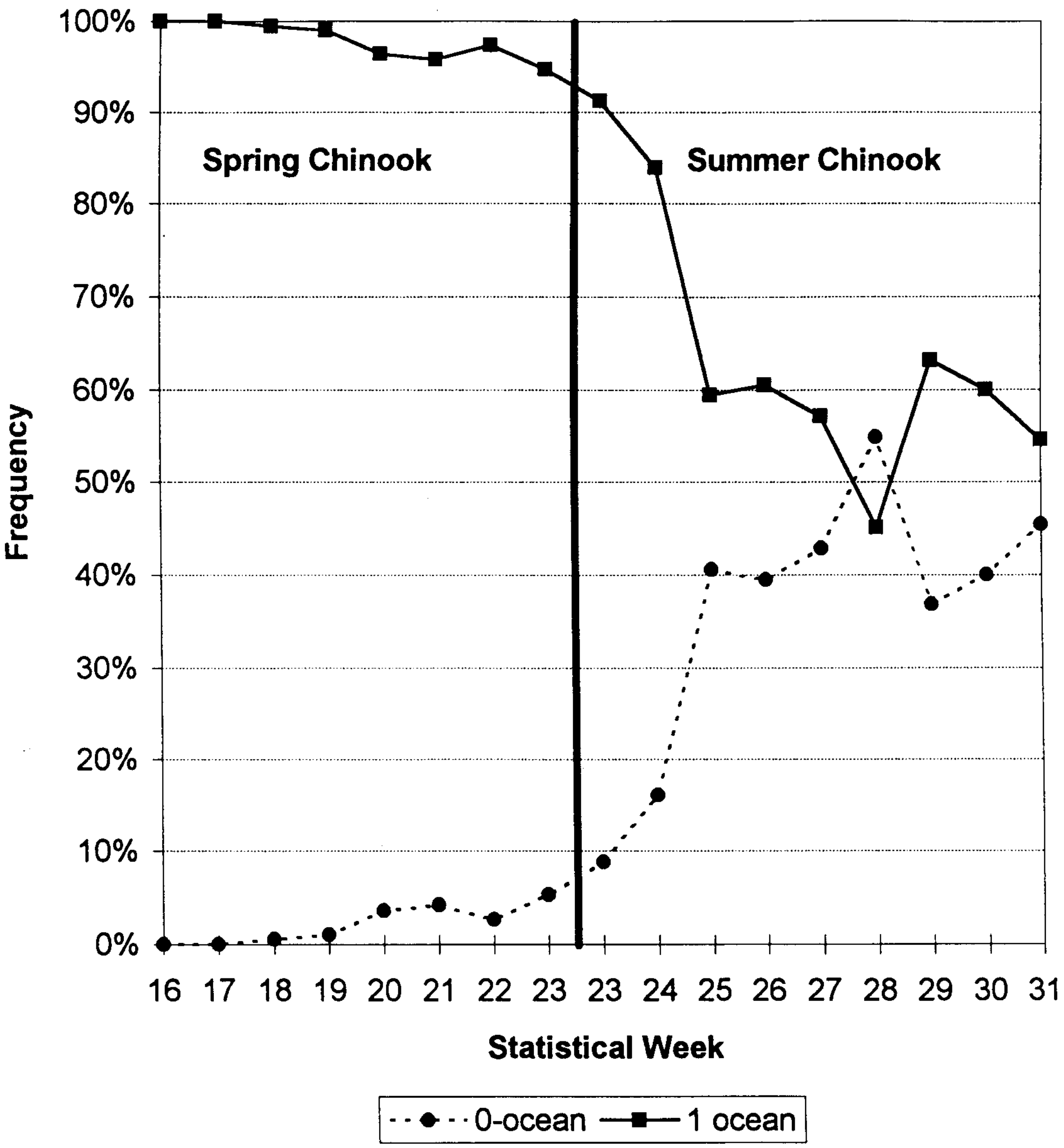


Figure 4. **Predicted 1995 four-year-old Columbia Basin spring chinook salmon abundance (at Bonneville Dam) based on a linear relationship between four-year-old and three-year-old fish abundance during brood years 1983 through 1991.**

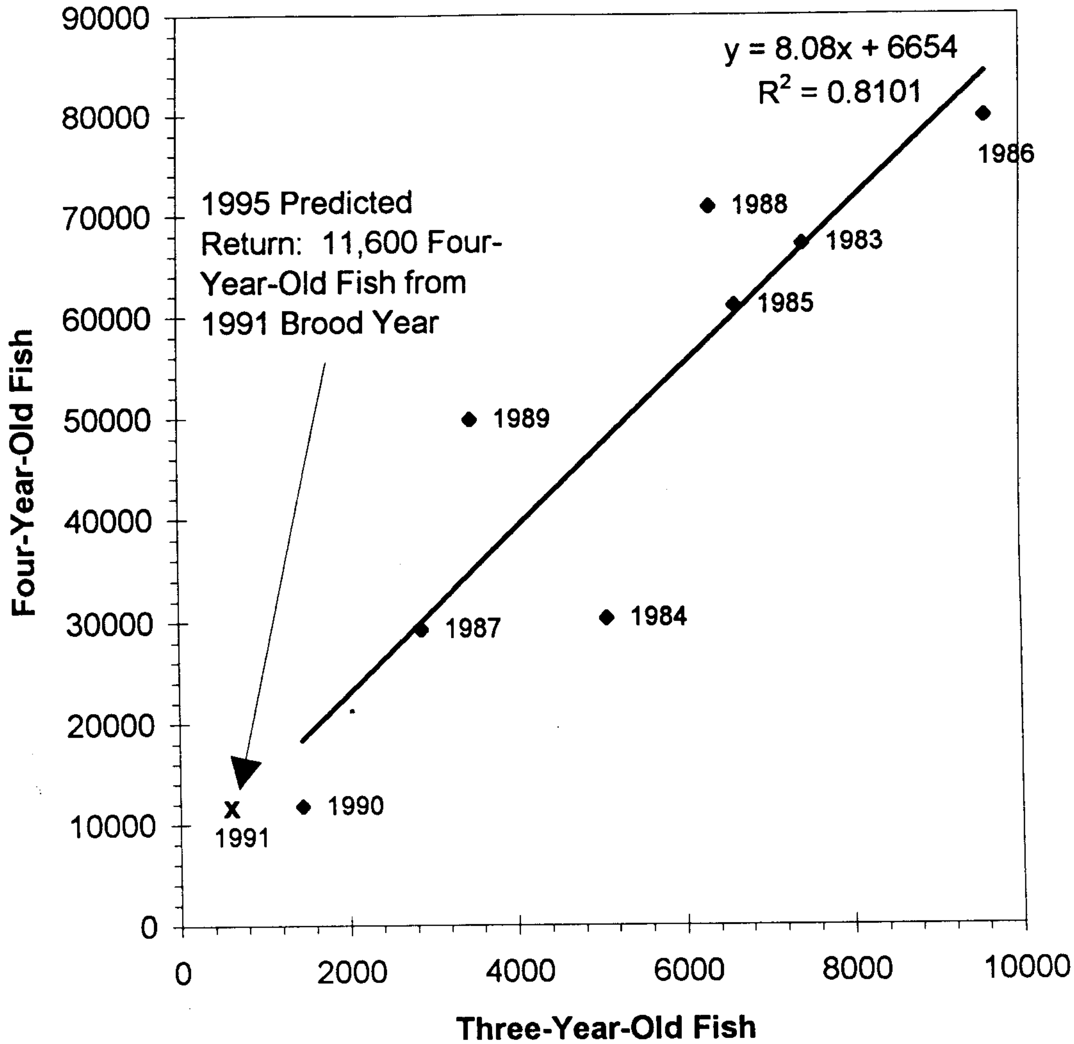


Figure 5. **Age composition estimates (%) by age class and brood year for Columbia Basin spring chinook salmon at Bonneville Dam from 1987 through 1994.**

Return Year	Age Class 0.1	0.2	1.1	0.3	1.2	0.4	1.3	1.4
1987	0	1	4	0	67	0	29	<1
1988	<1	1	6	1	31	<1	61	0
1989	0	<1	11	1	69	<1	18	<1
1990	0	1	3	<1	83	0	14	<1
1991	<1	<1	10	<1	48	0	40	<1
1992	0	<1	3	<1	78	0	18	<1
1993	0	0	1	0	45	0	53	<1
1994	0	0	3	1	56	<1	40	<1

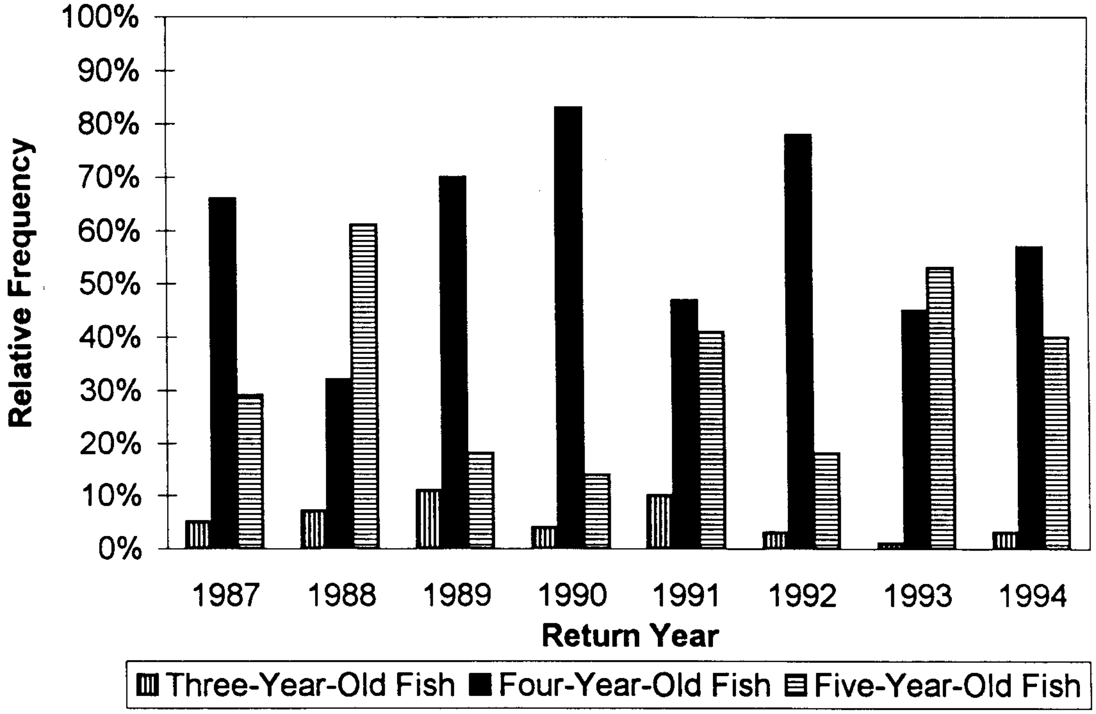
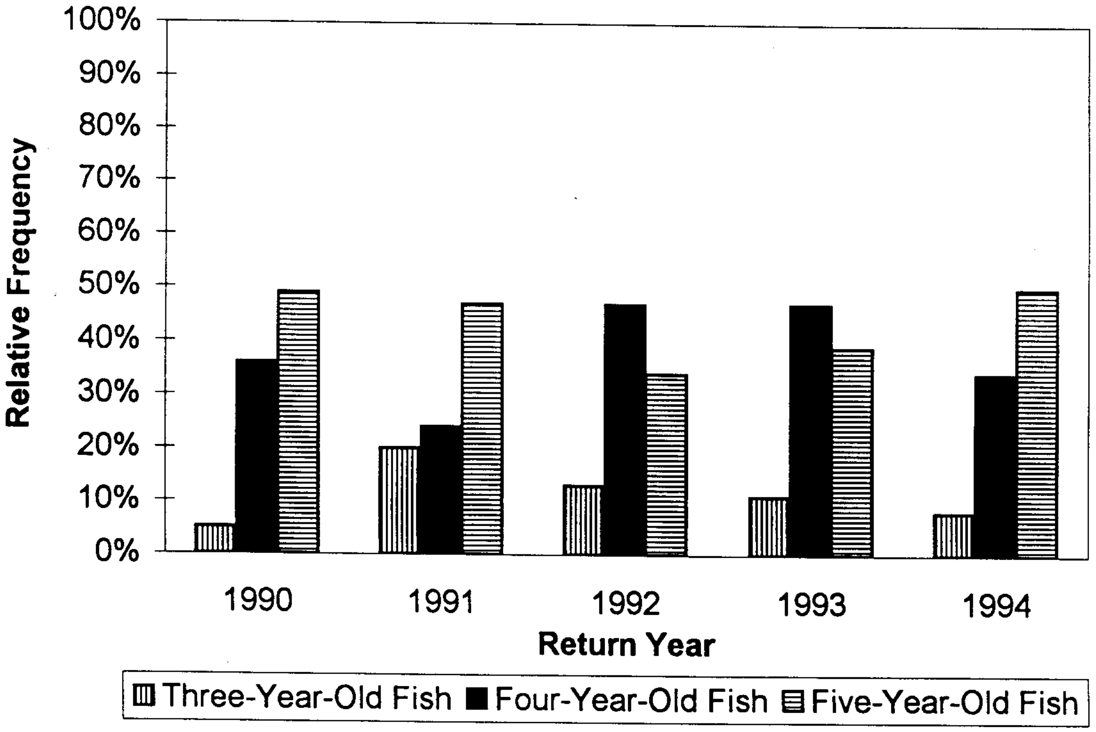


Figure 6. Age composition estimates (%) by age class and brood year for Columbia Basin summer chinook salmon at Bonneville Dam from 1990 through 1994.

Return Year	Age Class 0.1	0.2	1.1	0.3	1.2	0.4	1.3	0.5	1.4
1990	1	1	4	12	24	23	26	1	7
1991	5	3	17	7	17	16	31	1	2
1992	4	4	9	17	30	5	29	0	3
1993	<1	7	4	19	28	9	30	0	2
1994	4	3	5	18	16	14	36	0	2



between the 1993 Corbett Test Fishery spring chinook salmon age composition estimates and those presented in this study is not significant (p=0.23).

Length-at-Age Composition

Mean fork-lengths of spring chinook salmon sampled at Bonneville Dam ranged from 50.7 cm for Age 1.1 fish to 87.4 cm for Age 1.3 fish (Table 3). The largest fish sampled was a 104.0 cm Age 1.3 fish sampled in Statistical Week 19 and the smallest (excluding minijacks) was a 40.5 cm Age 1.1 fish sampled in Statistical Week 18. Mean fork-lengths for each by age class have displayed only small inter-annual variation since 1987 (Figure 7).

The mean fork-length of spring chinook salmon sampled in the Corbett Test Fishery was 73.1 cm for four-year-old fish and 86.5 cm for five-year-old fish. The difference between mean lengths for the Corbett Test Fishery and those reported in our study was not significant for either age class tested (p=0.09 for Age 4 fish, p=0.12 for Age 5 fish). No significant differences were apparent between the length frequency distribution of each study (Figure 8) for either four-year-old fish (p=0.37) or five-year old fish (p=0.45).

Mean fork-lengths of summer chinook salmon sampled at Bonneville Dam ranged from 41.2 cm for Age 0.1 fish to 90.3 cm for Age 0.4 fish (Table 4). The largest fish sampled were a 106.0 cm Age 0.4 fish sampled in Statistical Week 31 and a 106.0 cm Age 1.3 fish sampled in Statistical Week 28. The smallest fish sampled (excluding minijacks) was a 37.0 cm Age 0.1 fish in Statistical Week 24.

Fish Condition

Spring and summer chinook salmon sampled in 1994 showed much higher rates of injuries associated with marine mammal predation when compared to fish sampled in 1992 and 1993 (Table 5). The percentage of spring chinook salmon with evidence of marine mammal induced injuries has increased from 14% in 1992 to 23% in 1993 to 40% in 1994. The percentage of summer

Table 3. **Length-at-age estimates for Columbia Basin spring chinook salmon sampled at Bonneville Dam in 1994.**

	Brood Year and Age Class					
	1991	1990		1989		1988
	1.1	0.3	1.2	0.4	1.3	1.4
Statistical Weeks 15-16						
Mean Fork Length (cm)			70.0		90.1	
Minimum			60.5		84.5	
Maximum			75.0		94.0	
Standard Deviation			6.7		3.3	
Sample Size			3		5	
Statistical Week 17						
Mean Fork Length (cm)	51.0		73.0		85.6	
Minimum	51.0		60.5		71.0	
Maximum	51.0		84.5		102.5	
Standard Deviation	—		4.2		7.7	
Sample Size	1		60		21	
Statistical Week 18						
Mean Fork Length (cm)	46.1	70.0	71.6		83.6	
Minimum	40.5	70.0	85.0		67.0	
Maximum	52.0	70.0	57.5		95.0	
Standard Deviation	4.1	—	4.6		6.6	
Sample Size	4	1	127		52	
Statistical Week 19						
Mean Fork Length (cm)	49.5	73.5	71.6		87.2	
Minimum	49.5	73.5	57.0		71.5	
Maximum	49.5	73.5	82.5		104.0	
Standard Deviation	—	—	5.0		7.4	
Sample Size	1	1	59		35	
Statistical Week 20						
Mean Fork Length (cm)	52.7	76.0	72.1		86.2	
Minimum	50.5	76.0	63.5		79.0	
Maximum	55.5	76.0	79.5		93.0	
Standard Deviation	2.1	—	4.2		4.6	
Sample Size	3	1	13		11	
Statistical Week 21						
Mean Fork Length (cm)	52.4		76.2	79.0	88.2	
Minimum	44.5		70.0	79.0	81.5	
Maximum	57.5		87.5	79.0	99.5	
Standard Deviation	4.9		5.4	—	4.9	
Sample Size	4		9	1	10	
Statistical Week 22						
Mean Fork Length (cm)	47.5		75.2	83.0	86.6	76.5
Minimum	47.5		68.0	83.0	76.0	76.5
Maximum	47.5		81.0	83.0	99.5	76.5
Standard Deviation	—		4.2	—	4.7	—
Sample Size	1		10	1	25	1
Statistical Week 23						
Mean Fork Length (cm)	45.5		73.4	90.5	85.9	
Minimum	45.5		67.0	90.5	72.5	
Maximum	45.5		78.0	90.5	93.0	
Standard Deviation	—		3.8	—	8.0	
Sample Size	1		6	1	11	
1994 Composite						
Mean Fork Length (cm)	50.7	74.1	72.1	83.0	87.4	76.5
Minimum	40.5	70.0	57.0	79.0	67.0	76.5
Maximum	57.5	76.0	87.5	90.5	104.0	76.5
Standard Deviation	3.8	2.5	4.9	4.8	5.7	—
Sample Size	15	3	287	3	170	1

Figure 7. **Mean fork-lengths of spring chinook salmon sampled at Bonneville Dam from 1987 through 1994.**

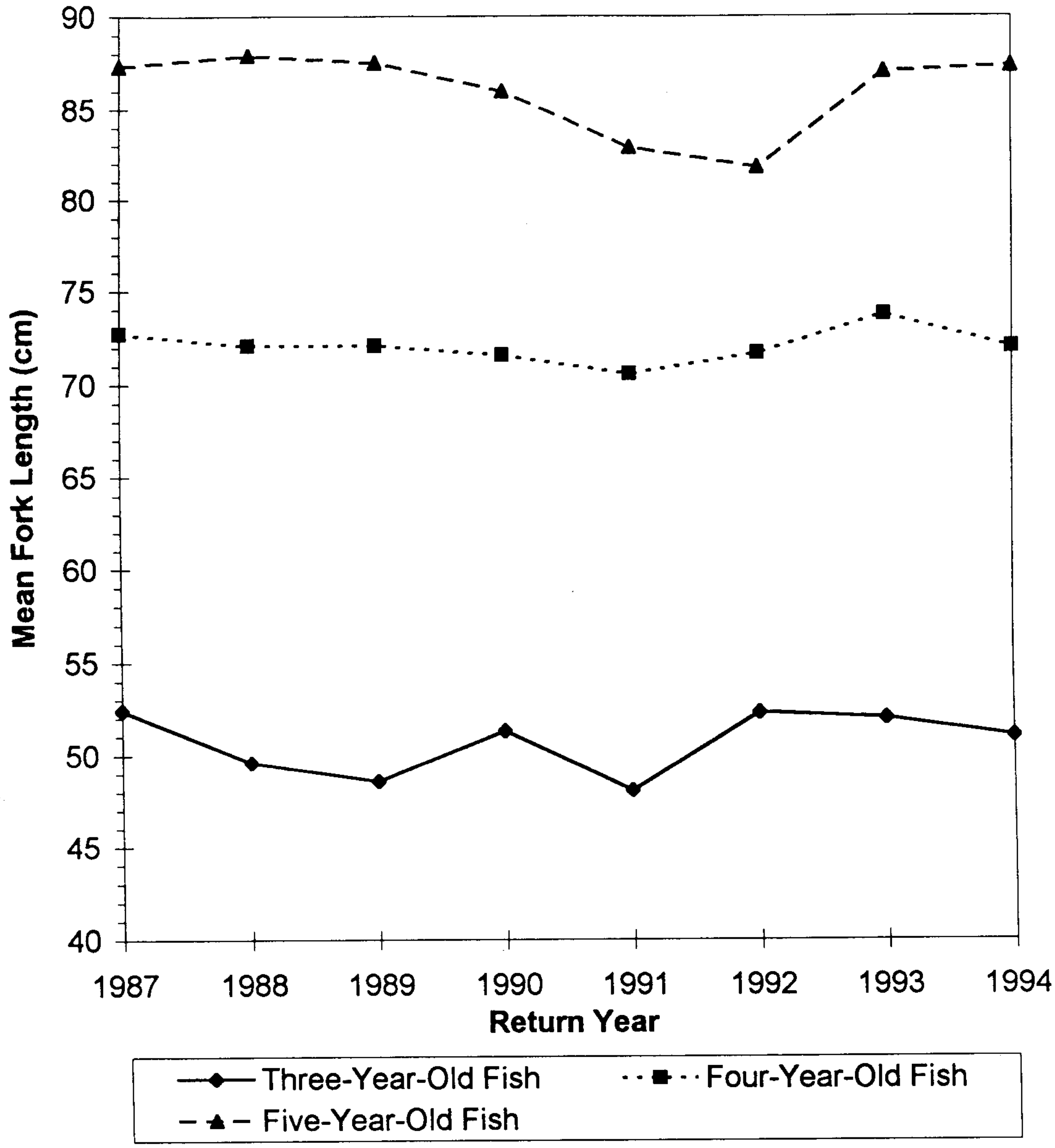
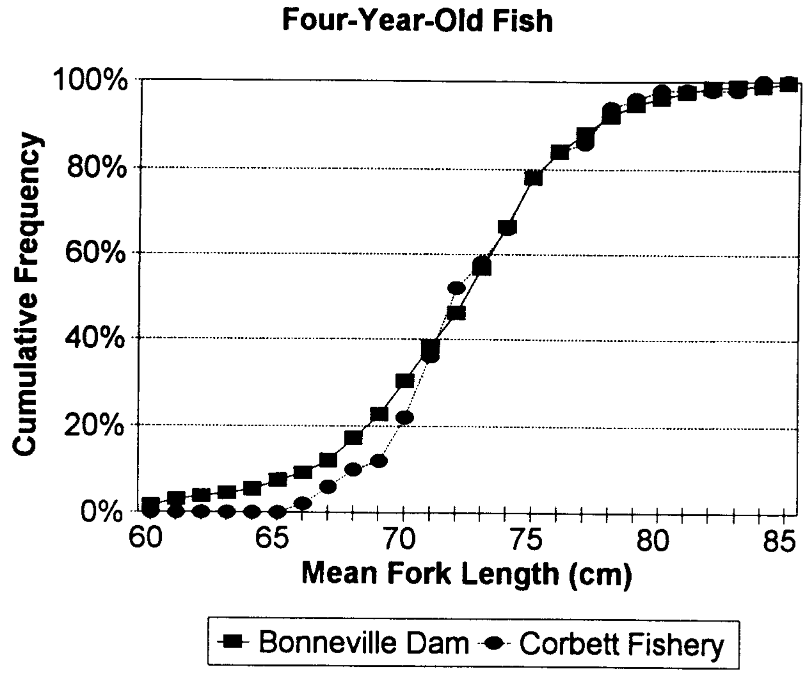


Figure 8. **Cumulative length distribution for four-year-old and five-year-old spring chinook salmon sampled at Bonneville Dam and in the Corbett test fishery in 1994.**



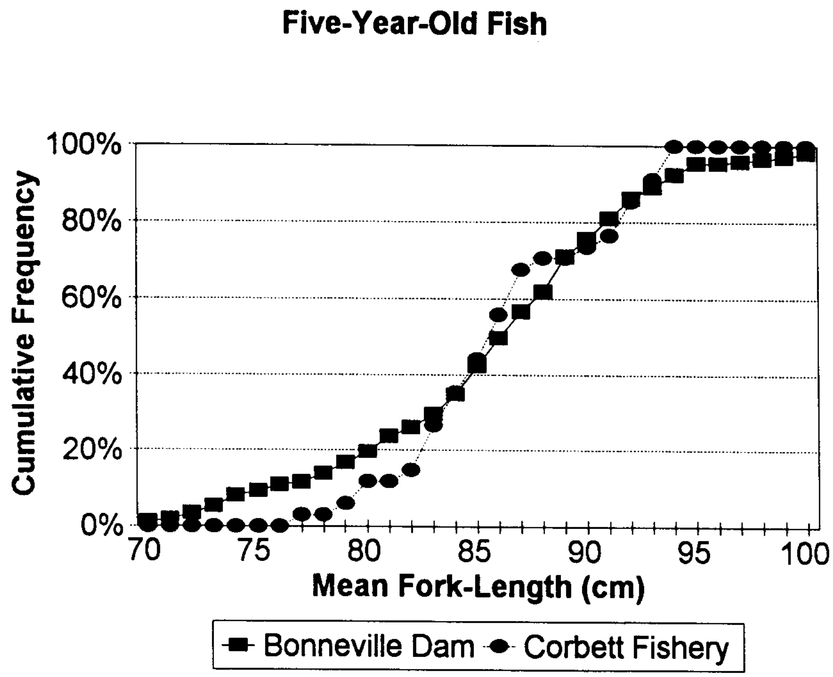


Table 4. Length-at-age estimates for Columbia Basin summer chinook salmon sampled at Bonneville Dam in 1994.

	Brood Year and Age Class								
	1992	1991		1990		1989		1988	
	0.1	0.2	1.1	0.3	1.2	0.4	1.3	0.5	1.4
Statistical Week 23									
Mean Fork Length (cm)				82.8	71.8	81.5	88.7		81.8
Minimum				80.5	58.5	81.5	44.0		81.0
Maximum				85.0	82.0	81.5	99.0		82.5
Standard Deviation				2.3	8.3	—	10.6		0.8
Sample Size				2	6	1	23		2
Statistical Week 24									
Mean Fork Length (cm)	39.5	55.0	49.8	83.5	74.4	95.9	88.8		102.0
Minimum	37.0	55.0	48.5	83.5	65.0	88.5	80.5		102.0
Maximum	42.0	55.0	51.5	83.5	84.5	104.0	98.0		102.0
Standard Deviation	2.5	—	1.3	—	5.3	5.0	3.8		—
Sample Size	2	1	3	1	14	5	29		1
Statistical Week 25									
Mean Fork Length (cm)	40.0		54.1	82.4	75.9	89.8	87.7		86.7
Minimum	40.0		51.0	66.0	68.5	80.5	68.0		68.0
Maximum	40.0		60.5	90.0	83.0	97.5	101.0		104.0
Standard Deviation	—		3.4	5.3	4.1	4.7	7.0		14.7
Sample Size	1		5	17	8	23	44		3
Statistical Week 26									
Mean Fork Length (cm)	45.5	77.5	48.5	80.9	75.8	91.3	88.5		91.0
Minimum	45.5	77.5	45.5	68.0	67.0	84.0	79.5		90.0
Maximum	45.5	77.5	52.5	89.5	84.0	99.0	98.0		92.0
Standard Deviation	—	—	2.9	5.2	4.7	4.0	5.1		1.0
Sample Size	1	1	3	11	15	17	26		2
Statistical Week 27									
Mean Fork Length (cm)	42.5	65.8	43.3	84.7	74.6	85.1	86.0		90.0
Minimum	42.5	55.0	37.5	76.0	66.0	79.5	67.5		90.0
Maximum	42.5	76.5	49.0	96.5	80.0	92.0	105.0		90.0
Standard Deviation	—	10.8	4.7	7.1	4.3	4.3	10.2		—
Sample Size	1	2	3	7	8	5	8		1
Statistical Week 28									
Mean Fork Length (cm)	41.1	49.8	53.0	81.7	77.1	91.3	85.9		
Minimum	40.0	47.5	48.5	68.5	71.5	81.0	72.5		
Maximum	42.5	52.0	57.5	94.0	96.5	97.5	106.0		
Standard Deviation	1.0	2.3	4.5	7.2	7.1	5.3	7.8		
Sample Size	4	2	2	14	9	8	12		
Statistical Week 29									
Mean Fork Length (cm)	40.7		50.0	80.5	79.9	84.5	84.7		84.0
Minimum	39.0		46.0	70.0	72.0	79.5	63.0		84.0
Maximum	43.5		54.0	97.0	86.5	91.5	96.5		84.0
Standard Deviation	2.0		3.3	8.0	5.3	5.1	8.6		—
Sample Size	3		4	8	4	3	14		1
Statistical Week 30									
Mean Fork Length (cm)		81.5		79.8	78.6	97.3	85.9		97.0
Minimum		81.5		70.5	70.5	93.5	74.0		97.0
Maximum		81.5		86.5	85.0	102.0	92.0		97.0
Standard Deviation		—		5.1	5.3	3.5	5.5		—
Sample Size		1		6	4	3	10		1
Statistical Week 31									
Mean Fork Length (cm)	40.5	75.0	50.0	81.3		106.0	83.8		
Minimum	40.5	75.0	50.0	80.5		106.0	77.5		
Maximum	40.5	75.0	50.0	82.0		106.0	91.0		
Standard Deviation	—	—	—	0.8		—	5.8		
Sample Size	1	1	1	2		1	5		
1994 Composite									
Mean Fork Length (cm)	41.2	65.3	49.1	81.9	75.7	90.3	87.3		89.5
Minimum	37.0	47.5	37.5	66.0	58.5	79.5	44.0		68.0
Maximum	45.5	81.5	60.5	97.0	96.5	106.0	106.0		104.0
Standard Deviation	1.8	8.7	3.7	6.4	5.5	4.5	7.4		9.0
Sample Size	13	8	21	68	68	66	171		11

Table 5. **Condition of Columbia Basin spring and summer chinook salmon sampled at Bonneville Dam, 1992-1994 (data given in percentages).**

Category	Spring Chinook 1994	Spring Chinook 1993	Spring Chinook 1992	Summer Chinook 1994	Summer Chinook 1993	Summer Chinook 1992
Marine Mammal Injuries						
Bite	11	1	2	4	3	1
Claw Rake	22	9	5	7	3	1
Twin Arches	14	13	8	9	4	2
Total Marine Mammal[a]	40	23	14	18	9	4
Descaling						
5-20% Descaling						
Right Side	5	1	0	6	1	1
Left Side	3	1	<1	7	3	1
Either	6	1	<1	9	3	1
>20% Descaling						
Right Side	0	<1	<1	<1	0	0
Left Side	0	1	1	0	<1	0
Either	0	1	1	<1	<1	0
General Injuries						
Bruises[b]	0	1		0	0	
Cuts	<1	1	<1	1	1	2
Eye	<1	0	0	0	1	0
Fin	5	1	<1	5	1	0
Fungus	1	1	<1	<1	1	0
Gash[b]	4	2		1	1	
Gas Bubble Disease[c]	0			0		
Gill Net	3	<1	1	2	0	<1
Fishing Hook	<1	<1	<1	<1	4	<1
Lamprey	1	<1	<1	1	1	0
Parasite	1	<1	2	1	0	0
Tail	4	4	1	1	2	1
Total General Injuries[a]	15	11	5	9	11	4

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.

b. Injuries of this type were not noted in 1992.

c. Gas bubble disease was not noted in 1992 or 1993.

chinook salmon with such injuries has similarly increased from 4% in 1992 to 9% in 1993 to 18% in 1994. The percentage of spring chinook showing other injuries has also increased from 5% in 1992 to 11% in 1993 to 15% in 1994. No fish showed any signs of gas bubble disease in 1994 (Fryer 1994).

DISCUSSION

Spring Chinook Salmon

In the study described herein, spring chinook salmon were sampled at Bonneville Dam to obtain age composition estimates. Our results were similar to those obtained in another study based on a different sampling technique (the Corbett Test Fishery). In four of the past six years (1989, 1990, 1992, and 1994) only very small differences were noted between the Corbett Test Fishery estimates and those of our study. However, we believe our study offers several potential and important advantages over the Corbett Test Fishery for spring chinook salmon age composition estimates. These benefits include the ability to obtain all data without killing any fish, the opportunity to obtain accurate weekly age composition estimates throughout the migratory period, and to sample smaller (three-year-old) fish.

When we apply the relative age composition estimates made in this study to the visual fish ladder counts from Bonneville Dam, we estimate that the four-year-old spring chinook salmon in 1994 totaled 11,700. This estimate varied substantially, but not significantly from our 1994 predicted return of 23,400± 33,500 four-year-old spring chinook salmon. Using the same techniques, we predict that 11,600 (±29,100) four-year-old fish will return to Bonneville Dam in 1995. Using linear regression techniques to make a prediction beyond the range of existing data will decrease the precision of the prediction (Neter et al. 1985), hence the wide confidence interval for the prediction presented.

Summer Chinook Salmon

Five-year-old fish were the predominant summer chinook salmon age class, for the first time in three years. No explanation is apparent for these changes in age composition. For the fifth consecutive year, there appears to be a trend in the percentage of subyearling fish to steadily increase throughout the migratory period. This trend likely continues into the fall chinook migration, which has been found to consist almost entirely of subyearling fish (US v. Oregon 1991, Fryer and Schwartzberg 1991b).

The study described in this report will be continued in future years to develop an accurate age and length-at-age composition database for the Columbia Basin upriver spring and summer chinook salmon populations. This information will aid fisheries managers in detecting and possibly explaining changes in the age composition of stocks. Patterns detectable in age and length-at-age composition of successive broods may allow managers to more accurately monitor the effects of ocean harvest restrictions imposed by the Pacific Salmon Treaty. As this study progresses, the database being created may also provide a basis for more accurate population size prediction models.

REFERENCES

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

Borodin, N. 1924. Age of shad *Alosa sapidissima* (Wilson) as determined by the scales. Transactions of the American Fisheries Society 54:178-184.

CRITFC (Columbia River Inter-Tribal Fish Commission). 1994. FISHCOUNT, Columbia River Basin computerized fish count database maintained by the Columbia River Inter-Tribal Fish Commission, Portland, Oregon.

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

Dammers, W. 1994. Columbia River Corbett area spring chinook test fishery 1994. Washington Department of Fisheries Progress Report. Battle Ground.

Fryer, J.K. 1994. Investigations of Adult Salmonids at Bonneville Dam for Gas Bubble Disease, 1994. Columbia River Inter-Tribal Fish Commission report prepared for the National Marine Fisheries Service. Portland, Oregon.

Fryer, J.K., C.E. Pearson, and M. Schwartzberg. 1992. Age and length composition of Columbia Basin spring chinook salmon at Bonneville Dam in 1991. Columbia River Inter-Tribal Fish Commission Technical Report 92-1. Portland, Oregon.

Fryer, J.K., and M. Schwartzberg. 1991a. Age and length composition of Columbia Basin spring chinook salmon sampled at Bonneville Dam in 1990. Columbia River Inter-Tribal Fish Commission Technical Report 91-1. Portland, Oregon.

Fryer, J.K., and M. Schwartzberg. 1991b. Age and length composition of Columbia Basin summer chinook salmon sampled at Bonneville Dam in 1990. Columbia River Inter-Tribal Fish Commission Technical Report 91-4. Portland, Oregon.

Fryer, J.K. and M. Schwartzberg. 1992. Age and length composition of Columbia Basin summer chinook salmon at Bonneville Dam in 1991. Columbia River Inter-Tribal Fish Commission Technical Report 92-4. Portland, Oregon.

Fryer, J.K. and M. Schwartzberg. 1993. Age and length composition of Columbia Basin spring and summer chinook salmon at Bonneville Dam in 1992. Columbia River Inter-Tribal Fish Commission Technical Report 93-3. Portland, Oregon.

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

Gilbert, C.H. 1913. Age at maturity of the Pacific coast salmon of the genus *Oncorhynchus.* United States Bureau of Fisheries Bulletin 32:1-22.

Hatch, D.R., D.R. Pederson, J.K. Fryer, and M. Schwartzberg. 1995. Wenatchee River salmon escapement using video tape technology in 1994. Technical Report 95-3. Portland, Oregon.

Hays, W.L. 1988. Statistics, fourth edition. Holt, Rinehart, and Winston, Inc. New York.

International North Pacific Fisheries Commission. 1963. Annual report — 1961. Vancouver, British Columbia.

Knudsen, C.M. 1990. Bias and variation in stock composition analyses due to scale regeneration. American Fisheries Society Symposium 7:127-133.

Koo, T.S.Y. 1955. Biology of the red salmon, *Oncorhynchus nerka* (Walbaum), of Bristol Bay, Alaska, as revealed by a study of their scales. Ph.D. thesis, University of Washington, Seattle.

Mood, A. M., F.A. Graybill, and D.C. Boes. 1974. Introduction to the theory of statistics. McGraw-Hill, Inc. New York.

Neter, J., W. Wasserman, and M.H. Kutner. 1985. Applied linear statistical models. Richard D. Irwin, Inc. Homewood, Illinois.

Post, G. W. 1983. Textbook of Fish Health. TFH Publications, Inc. Ltd. Neptune City, New Jersey.

PST (Pacific Salmon Treaty). 1985. Treaty between the United States of America and the government of Canada concerning Pacific salmon. Treaty Document Number 99-2, (entered into force March 18, 1985), 16 USC§§3631-3644 (1988).

Schwartzberg, M. 1988. Age and length composition of Columbia Basin spring chinook salmon sampled at Bonneville Dam in 1987. Columbia River Inter-Tribal Fish Commission Technical Report 88-1. Portland, Oregon.

Schwartzberg, M. 1989. Age and length composition of Columbia Basin spring chinook salmon sampled at Bonneville Dam in 1988. Columbia River Inter-Tribal Fish Commission Technical Report 89-1. Portland, Oregon.

Schwartzberg, M., and J.K. Fryer. 1990. Age and length composition of Columbia Basin spring chinook salmon sampled at Bonneville Dam in 1989. Columbia River Inter-Tribal Fish Commission Technical Report 90-1. Portland, Oregon.

USACE (U.S. Army Corps of Engineers). 1992. Annual fish passage report — 1992, Columbia and Snake river projects, Oregon and Washington. North Pacific Division, U.S. Army Engineer District, Portland.

U.S. v. Oregon Technical Advisory Committee. 1991. 1991 all species review, Columbia River fish management plan. Oregon Department of Fisheries and Wildlife, Columbia Regional Office, Clackamas.

Van Oosten, J. 1929. Life history of the lake herring *Leucichthys artedi* (Le Sueur) of Lake Huron as revealed by its scales, with a critique of the scale method. United States Bureau of Fisheries Bulletin 44:265-428.

Zar, J.H.. 1984. Biostatistical Analysis. Prentice-Hall, Inc. Englewood Cliffs, New Jersey.

Appendix A. 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 (Figure A1) and sample forms were used in 1993 and 1994 (Figure A2).

Figure A1. 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)
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

For all injuries, a plus (+) indicates the injury is judged severe (extensive scarring or blood/flesh visible). A check (√) indicates that the injury is judged to have recently occurred (i.e., on the upstream migration).

Figure A2. **Sampling Form used in Spring and Summer Chinook Salmon Sampling at Bonneville Dam in 1994.**

CRITFC STOCK IDENTIFICATION PROJECT SAMPLING FORM

LOCATION:________________ SPECIES:________________ PAGE:______OF______

DATE:________________ WEEK:________________ SAMPLERS:____________

Scale Card #	Position	Fork Length	Mid-Eye Length	Condition (1-5)	Gill Net Damage	Descaling Left	Descaling Right	Marine Mammal	General Injuires	Fin Clip	Comments	Scale Card #	Position	Fork Length	Mid-Eye Length	Condition (1-5)	Gill Net Damage	Descaling Left	Descaling Right	Marine Mammal	General Injuires	Fin Clip	Comments
	1												1										
	2												2										
	3												3										
	4												4										
	5												5										
	6												6										
	7												7										
	8												8										
	9												9										
	10												10										
	1												1										
	2												2										
	3												3										
	4												4										
	5												5										
	6												6										
	7												7										
	8												8										
	9												9										
	10												10										
	1												1										
	2												2										
	3												3										
	4												4										
	5												5										
	6												6										
	7												7										
	8												8										
	9												9										
	10												10										
	1												1										
	2												2										
	3												3										
	4												4										
	5												5										
	6												6										
	7												7										
	8												8										
	9												9										
	10												10										