CRITFC

TECHNICAL REPORT 03-1

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Age and Length Composition of Columbia Basin Chinook, Sockeye, and Coho Salmon at Bonneville Dam in 2002

Denise A. Kelsey
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March 20, 2003

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ABSTRACT

In 2002, representative samples of migrating Columbia Basin chinook (*Oncorhynchus tshawytscha*), sockeye (*O. nerka*), and coho salmon (*O. kisutch*) adult populations were collected at Bonneville Dam. Fish were trapped, anesthetized, sampled for scales and biological data, revived, and then released. Scales were examined to estimate age composition; the results contributed to an ongoing database for age class structure of Columbia Basin salmon populations. Based on scale analysis of chinook salmon, four-year-old fish (from brood year [BY] 1998) comprised 86% of the spring chinook, 51% of the summer chinook, and 51% of the bright fall chinook salmon population. Five-year-old fish (BY 1997) comprised 13% of the spring chinook, 43% of the summer chinook, and 11% of the bright fall chinook salmon population. The sockeye salmon population at Bonneville was predominantly five-year-old fish (55%), with 40% returning as four-year-olds in 2002. For the coho salmon population, 88% of the population was three-year-old fish of age class 1.1, while 12% were age class 1.0. Length analysis of the 2002 returns indicated that chinook salmon with a stream-type life history are larger (mean length) at age than the chinook salmon with an ocean-type life history. Trends in mean length over the sampling period for returning 2002 chinook salmon were analyzed. Chinook salmon of age classes 1.2 and 1.3 show a significant increase in mean length over the duration of the migration. A year class regression over the past 14 years of data was used to predict spring, summer, and bright fall chinook salmon population sizes for 2003. Based on three-year-old returns, the relationship predicts four-year-old returns of 54,200 (± 66,600, 90% predictive interval [PI]) spring chinook, 23,800 (± 19,100, 90% PI) summer, and 169,100 (± 139,500, 90% PI) bright fall chinook salmon for the 2003 runs. Based on four-year-old returns, the relationship predicts five-year-old returns of 36,300 (± 35,400, 90% PI) spring, 63,800 (± 10,300, 90% PI) summer, and 91,100 (± 69,400, 90% PI) bright fall chinook salmon for the 2003 runs. The 2003 run size predictions should be used with caution; some of these predictions are well beyond the range of previously observed data.

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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 age and length-at-age composition of Columbia Basin salmonids, as well as the design and development of salmon stock identification techniques.

We use scale-pattern analysis to estimate the age and length-at-age composition for populations of chinook[1] (*Oncorhynchus tshawytscha*), sockeye (*O. nerka*), and coho salmon (*O. kisutch*). This study has been conducted since 1985 for sockeye, 1987 for spring chinook, and 1990 for summer chinook salmon (Schwartzberg 1988, 1989; Schwartzberg and Fryer 1990; Fryer and Schwartzberg 1991a, 1991b, 1992, 1993, 1994; Fryer et al. 1992; Hooff et al. 1999a; Hooff et al. 1999b; Kelsey and Fryer 2001, 2002). Bright fall chinook and coho salmon were added in 1998 (Hooff et al. 1999a; Hooff et al. 1999b; Kelsey and Fryer 2001, 2002)[2]. Over the course of these studies, we have developed procedures 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 the data collected for this project, are in Appendix A and B. These include clips (fin and other) and tags observed, length-at-age composition, and assessments of fish condition, coloration, and injuries.

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

METHODS

Sample Design

Fish were sampled one or two days per statistical week[3] from April through October. The sample size goal was 500 fish each for spring, summer, and fall chinook salmon, and for coho and sockeye salmon. In past study years, this sample size has resulted in desired levels of precision and accuracy (d=0.05, α=0.10) for age composition estimates. The composite age and length-at-age estimates are calculated from weekly estimates weighted by the number of each species migrating past Bonneville Dam during the week of the sample (Fryer 1995). Year-to-date dam counts of fish passage[4] were obtained from DART (2002) and the Fish Passage Center (2002).

Sampling Methods

Representative samples of each species and run were collected at the Adult Fish Facility located adjacent to the Second Powerhouse of Bonneville Dam (river km 235). Fish were trapped and anesthetized. Each fish was sampled for scales, measured for fork length, inspected for markings and/or tag information, and noted for other pertinent biological information (Appendix A and B). All fish were revived in freshwater and returned to the exit fishway leading to the Washington shore fish ladder. No fish were sacrificed. To minimize the scale sample rejection rate, six scales were collected per coho and chinook salmon sampled (Knudsen 1990). Four scales were collected from each sockeye salmon sampled. Tules, an early maturing, dark-colored fall chinook salmon (when observed at Bonneville Dam), were not sampled in our study with the bright fall chinook. Bright fall chinook salmon that migrate over Bonneville Dam consist of Upriver Brights and Mid-Columbia

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3. Statistical weeks are sequentially numbered calendar-year weeks starting with the week that includes January 1 (Week 1). Excepting the first and last weeks of most years, weeks are seven days long, beginning on Sunday and ending on Saturday. In 2002, for example, Statistical Week 14 began on March 31 and ended on April 6.
4. Dam counts for fall runs may be different than what is reported here, for dam counts are finalized several months after this report is completed.

Brights. Upriver Brights spawn in the Deschutes River and in the Columbia Basin upstream of McNary Dam. Mid-Columbia Brights spawn in the mainstem and small tributaries of the Columbia River between Bonneville and McNary Dams. In 2002, an ultrasound machine was tested for use in gender identification.

Length Measurements

Fork lengths were measured to the nearest 0.5 cm. Mean lengths and measurements of variability were calculated for each weekly sampling period and for the composite sample of each age class (Appendix A). Composite samples were weighted by weekly run size, if more than one fish represents the age class sample for a statistical week, in which sample(s) were caught. Possible changes in weekly mean length over the sampling period were analyzed by simple linear regression for each age class.

This report does not usually include information on chinook salmon mini-jacks (fish generally under 35 cm in length that show a scale pattern that indicates they have not spent any winters in saltwater) because they are generally not caught by the fisheries and random sampling can be difficult. In general, during the migration of coho salmon, we sample all sizes of coho salmon, which can include fish less than 35 cm.

Fish Condition

Criteria were developed in 1992 to classify the condition of sampled fish (Fryer and Schwartzberg 1993). These criteria have been expanded and refined in subsequent years so that, in 2002, each specimen was inspected for: coloration (a sign of maturation), marine mammal injuries, headburn, descaling, gill net abrasion, gas bubble trauma (Fryer 1994), cuts, bruises, and other assorted new and old injuries (Appendix A and B). New injuries were rated regarding their penetration into the flesh and body of the fish.

Headburn, the exfoliation of skin and tissues of the jaw and cranial region, has been identified as a possible stress indicator of high river flow conditions or spillway discharge from dams (Elston 1996). Assessment and classification protocols for headburn were added to our study in 1997, after reports of increased incidence and awareness of headburn throughout the basin (Elston 1996, Groberg 1996).

Fin clips and other visible tags found on the fish were also noted.

Fish Gender

In 2002, an ultrasound machine was tested periodically during the sampling season as a method for identifying a fish's gender at Bonneville Dam. A previous study (Pearson and Fryer 1993) demonstrated the usefulness of ultra sound for gender identification of Pacific salmon at locations nearer to spawning beds. It is expect that this tool will be available for gender identification in 2003 and that a protocol will be in place to sample chinook, sockeye, and coho salmon for female:male run proportions at Bonneville Dam. During the 2002 sampling season gender identification was completed on a proportion of the fish sampled on June 25th, July 11th and September 24th. While a fish was under sedation a 7.5 mhz ultrasound probe was placed approximately 3 – 4 cm behind the pectoral fins on the ventral side of the fish and an image of the gonads was recorded for later identification. Images were recorded on digital media for chinook, sockeye, and coho salmon on the dates listed above.

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, Rich and Holmes 1929). A sub-sample of scales was sent to John Sneva of the Washington Department of Fish and Wildlife for corroboration of age estimates. Validation of the ages estimated from scale patterns (Beamish and McFarlane 1983) is not possible because fish trapped for our project are not sacrificed or usually scanned for PIT tags. However, in 2002, we identified one chinook salmon (known age) by scanning for a PIT tag.

The European method for fish age description (Koo 1962) is used in this report. The number of winters a fish spent in freshwater (not including the winter of egg incubation) is described by an Arabic numeral followed by a period. The number following the period indicates the number of winters a fish spent in saltwater. Total age, therefore, is equal to one plus the sum of both numerals. For scale samples that are not readable, due to a damaged freshwater zone, a R.# (an R followed by a number) indicates the freshwater zone could not be read, but the saltwater winters were readable. An N indicates that neither zone could be read with any confidence.

Chinook Salmon Run-Size Prediction

Salmon mature and return to spawn at many ages, two to at least seven. The year when the parents spawned is referred to as the brood year (BY). All of the progeny returning from a spawning population is collectively called a brood. Many chinook salmon prediction or forecast models are based on the relationship between the survivors within a single brood returning in successive years at different ages.

In the early years of this project, it was noted that the number of three-year-old fish for a given BY appeared to be a relatively good predictor of the number of subsequently returning four-year-old fish of the same BY (Fryer and Schwartzberg 1994). This relationship and a regression analysis (Neter et al. 1985, Weisberg 1985) are used herein to predict the abundance (four-year-old fish in 2003) and the predictive interval ([PI] range), from a known value (the three-year-old fish that returned in 2002). A similar relationship is used to predict returning five-year-old fish in 2003 from four-year-old fish that returned in 2002. Our bright fall chinook predictions and data do not include Tule chinook salmon. Estimated abundances of Tule chinook (Fish Passage Center 2002) that migrated over Bonneville Dam were removed from the Bonneville Dam fall chinook salmon counts for an estimate of the bright fall chinook abundance over Bonneville Dam.

RESULTS

Sample Design

Fish were removed from age composition and length analyses because of damaged and/or unreadable scales (8.2% of spring chinook and summer chinook, 5.4% of fall chinook, 3.9% of sockeye, and 6.8 % of coho). However, these fish were used in analyses of other types of data collected during sampling.

Length Analysis

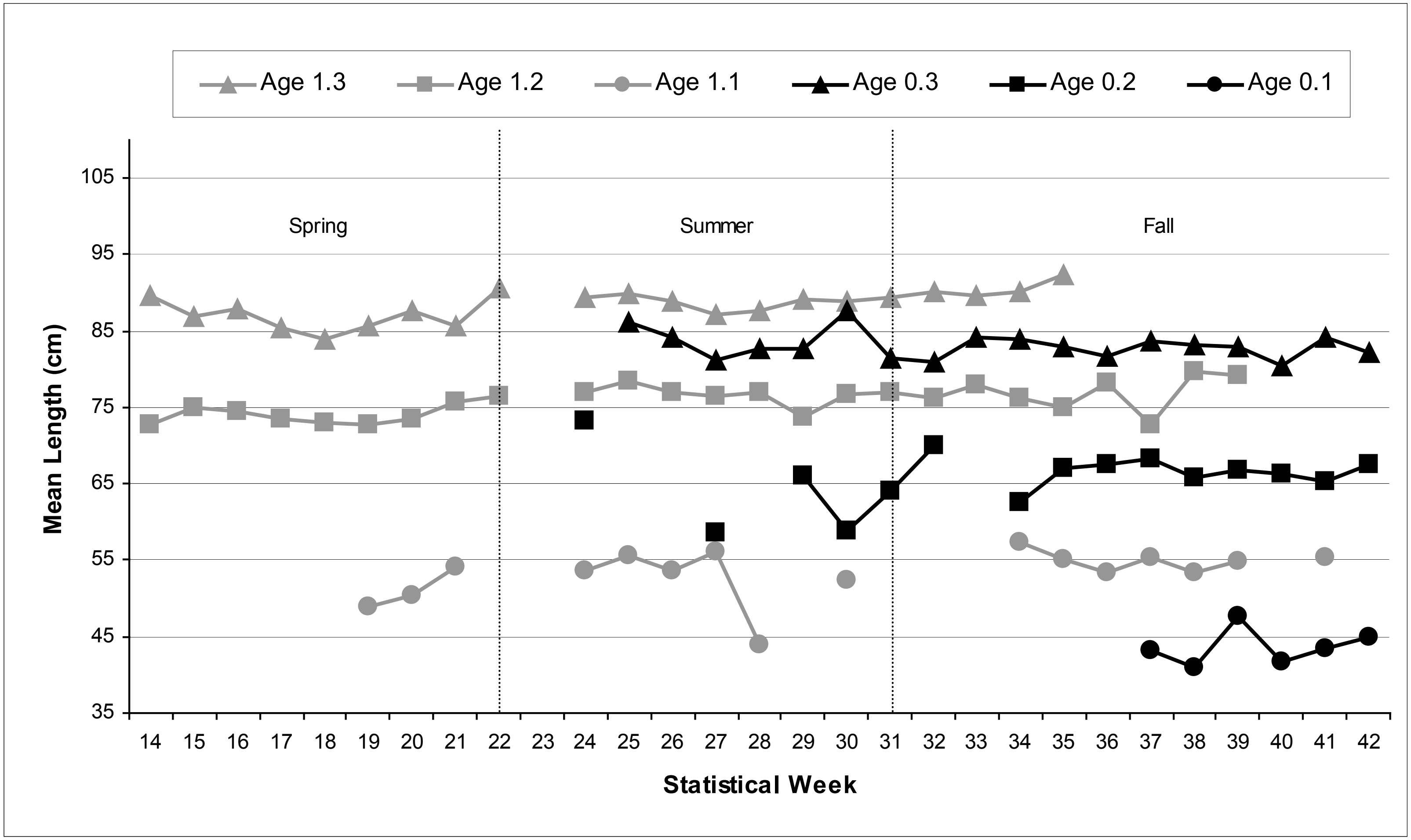
Chinook salmon that have a stream-type (age classes 1.X or 2.X) life history consistently have a greater mean length than ocean-type (age class 0.X) chinook salmon with the same ocean age (Figure 1). Also of note is that as total age increases so does the mean length.

The mean length of chinook salmon for age classes of 1.2 and 1.3, when analyzed using a simple linear regression technique, showed a significant increase over the sampling period ($P < 0.01$). The mean length of age classes 0.1, 0.2, 0.3, 0.4[5], and 1.1 did not change significantly over time (P = 0.29, 0.70, 0.26, 0.11, and 0.11, respectively).

Two age classes for coho salmon and three age classes for sockeye salmon were analyzed for a change in mean length over the sampling period. Age classes, 1.0 and 1.1, for coho salmon did not change significantly over time (P = 0.52 and 0.28). The mean length of any age class for sockeye salmon did not change significantly over time (P = 0.38, 0.10, and 0.06 for sockeye age classes 1.2, 1.3, and 2.2, respectively). However, both age classes 1.3 and 2.2 p-values are suggestive of a trend. If true, then in 2002 age class 1.3 had a negative trend of0.81 cm per week, while age class 2.2 had a positive trend of 0.21 cm per week.

5. Age classes 0.4 and 1.4 were not graphed in Figure 1, due to a very small sample size of age class 1.4.

Figure 1. Weekly mean length estimates of Columbia Basin chinook salmon by age class (showing stream- and ocean-type) sampled at Bonneville Dam in 2002. Note: Not all life history types were present each week of sampling. Sampling did not occur in Week 23.



Length-at-age data for salmon with damaged scales are located in Appendix A.

Fish Condition

Data analysis on clips, tags, and fish condition can be found in Appendix A and B. Clips this year consisted of only fin clips, with the adipose fin as the usual fin clipped for identification. However, fish also displayed ventral fin clips, and some fish had more than one fin clipped.

Information on fish injuries (marine mammal, net, and other specific and general injuries) is found in Appendix A. The extent to which fish had injuries penetrating into the body is found in Appendix B.

In 2001, new sampling protocols for a variety of conditions not observed before or not noted before was initiated mid-season. For the entire 2002 sampling season notation was taken on old completely healed wounds, deformities (which may or may not be caused by healing wounds), a red round sore/rash (1 cm in diameter) located on the ventral or lateral sides (below the lateral line), and bumps (the size of a single scale). A table of proportion of fish observed with each condition can be found in Appendix B.

Fish Gender

In 2002, poor image quality, recorded from the ultrasound machine for later identification of gender, resulted in only one set of fish identified to gender with any confidence. On September 24th, 47 bright fall chinook salmon and 36 coho salmon were identified to gender from the 62 bright fall chinook salmon and 50 coho salmon sampled on that day. For bright fall chinook salmon the female:male ratio on that day was 1:1.6 and for coho salmon it was 5:1. Length data and scales for aging were taken from these fish as part of the usual sampling protocol. Age-at-length data for these fish can be found in Appendix B.

Age Composition Estimates

Sampling periods, sample sizes, number of fish (from the original sample) with ageable scales used in the age composition estimates, and run sizes for species and populations are tabulated in age composition tables 1-4.

Spring chinook salmon returns were estimated to be predominately four-year-olds (85.7%, Table 1, Figure 2) with a small proportion of five-year-old fish (12.9%). One of the five-year-old chinook salmon we sampled this year was of age class 2.2 (two winter checks in freshwater and two winter checks in saltwater). Very few fish in our sample were aged as three-year-old fish (1.4%). All of the spring chinook salmon we sampled this year had a stream-type life history scale pattern (Table 1, Figure 3).

Summer chinook salmon were a mix of age classes, and in 2002, four-year-olds (51.4%) were the most abundant (Table 2, Figure 2) with the proportion of five-year-old fish at 43.1%. The three-year-old proportion of the summer run, like the spring run, was small (5.2%). One summer chinook salmon sampled this year was aged as a six-year-old fish (age class 1.4) and one was aged as a seven-year-old (age class 1.5). Twelve percent of the run had scale patterns indicating an ocean-type life history and 88% of the run had a stream-type life history (Table 2, Figure 3). We could confirm one summer chinook salmon age this year. On July 2nd a Rock Island hatchery fish was identified with a pit-tag reader as a three-winter-ocean fish. We age this fish as 1.3.

Bright fall chinook salmon were mostly three- (33.1%) and four-year-olds (50.8%), with smaller proportions of five- (11.2%) and two-year-old (4.7%) age classes (Table 3, Figure 2). Twenty percent of the fall chinook salmon sampled had a stream-type life history (Table 3, Figure 3).

Table 1. Weekly and cumulative age composition of Columbia Basin spring chinook salmon sampled at Bonneville Dam in 2002.

					Age Composition by Brood Year and Age Class			
Statistical Week	Sampling Date	Number Sampled	Number Ageable	Weekly run size	1999 1.1	1998 1.2	1997 2.2	1997 1.3
14[a]	4/3	25	20	6784		0.450		0.550
15	4/9	40	36	11649		0.722		0.278
16	4/16, 18	90	83	23962		0.880	0.012	0.108
17	4/23, 25	120	109	67660		0.917		0.083
18	4/30, 5/2	180	167	81891		0.922		0.078
19	5/7, 9	120	110	38201	0.036	0.836		0.127
20	5/14	56	52	18963	0.096	0.827		0.077
21	5/23	40	37	11859	0.054	0.730		0.216
22[b]	5/30	40	39	14936		0.667		0.333
Cumulative		711	653	275905	0.014	0.857	0.001	0.128
Ten Year Average		723	672	109892	0.063	0.783	0.000	0.149

Note: Age composition of ten year average may not add to 100%, not all age classes of previous years are displayed.

a Weekly run size includes fish numbers from Weeks 9 – 13. Sampling started in Week 14.

b Weekly run size includes only a portion of the fish numbers from Week 22. Spring chinook salmon run at Bonneville Dam officially ends on May 31st.

Figure 2. Weekly age composition estimates for the three major age groups of Columbia Basin spring, summer, and bright fall chinook salmon sampled at Bonneville Dam in 2002. Note: Sampling did not occur in Week 23.

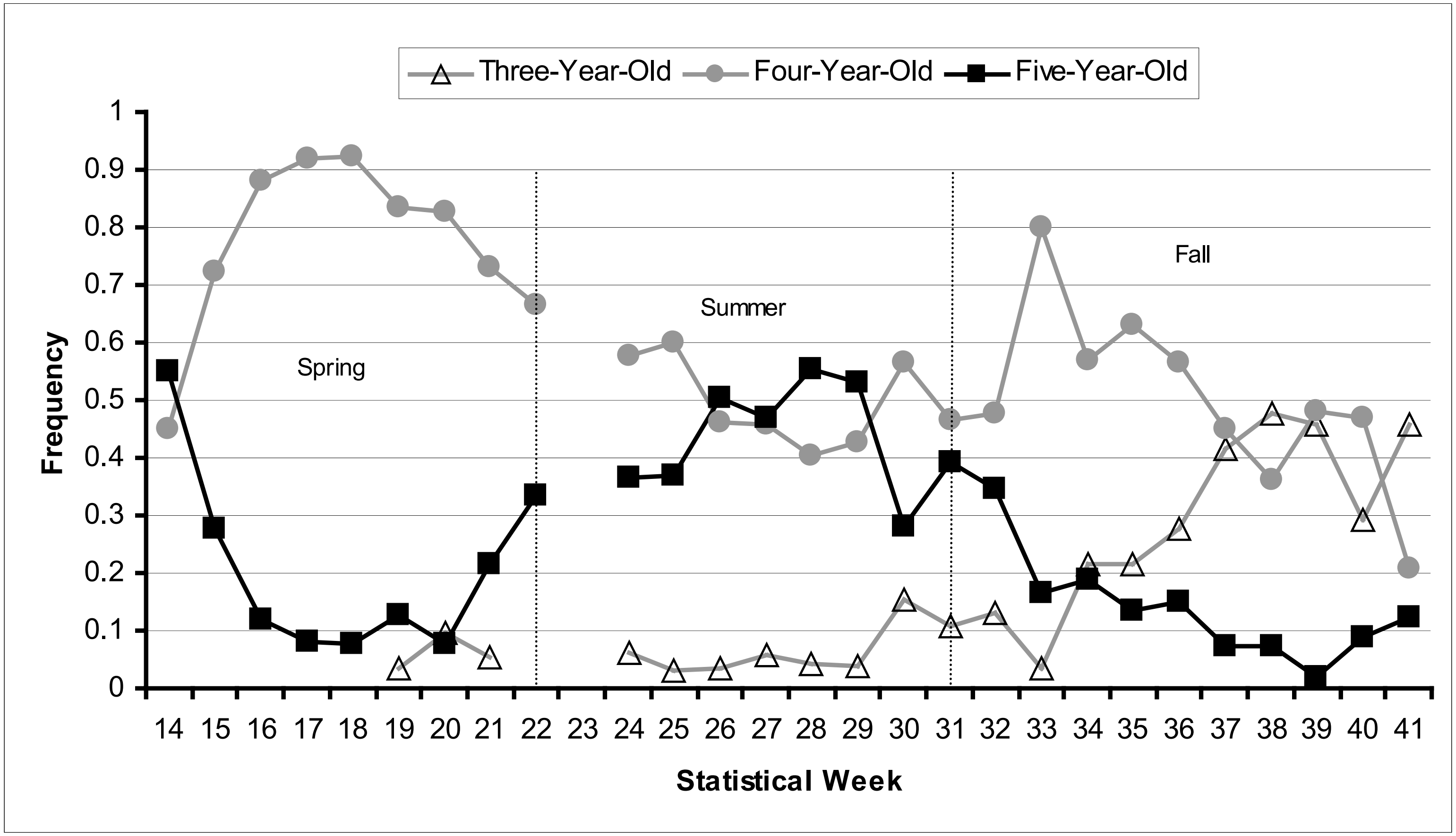


Figure 3. Weekly freshwater age composition estimates of Columbia Basin spring, summer, and bright fall chinook salmon sampled at Bonneville Dam in 2002. Note: Freshwater 2.X age class was not graphed. Sampling did not occur in Week 23.

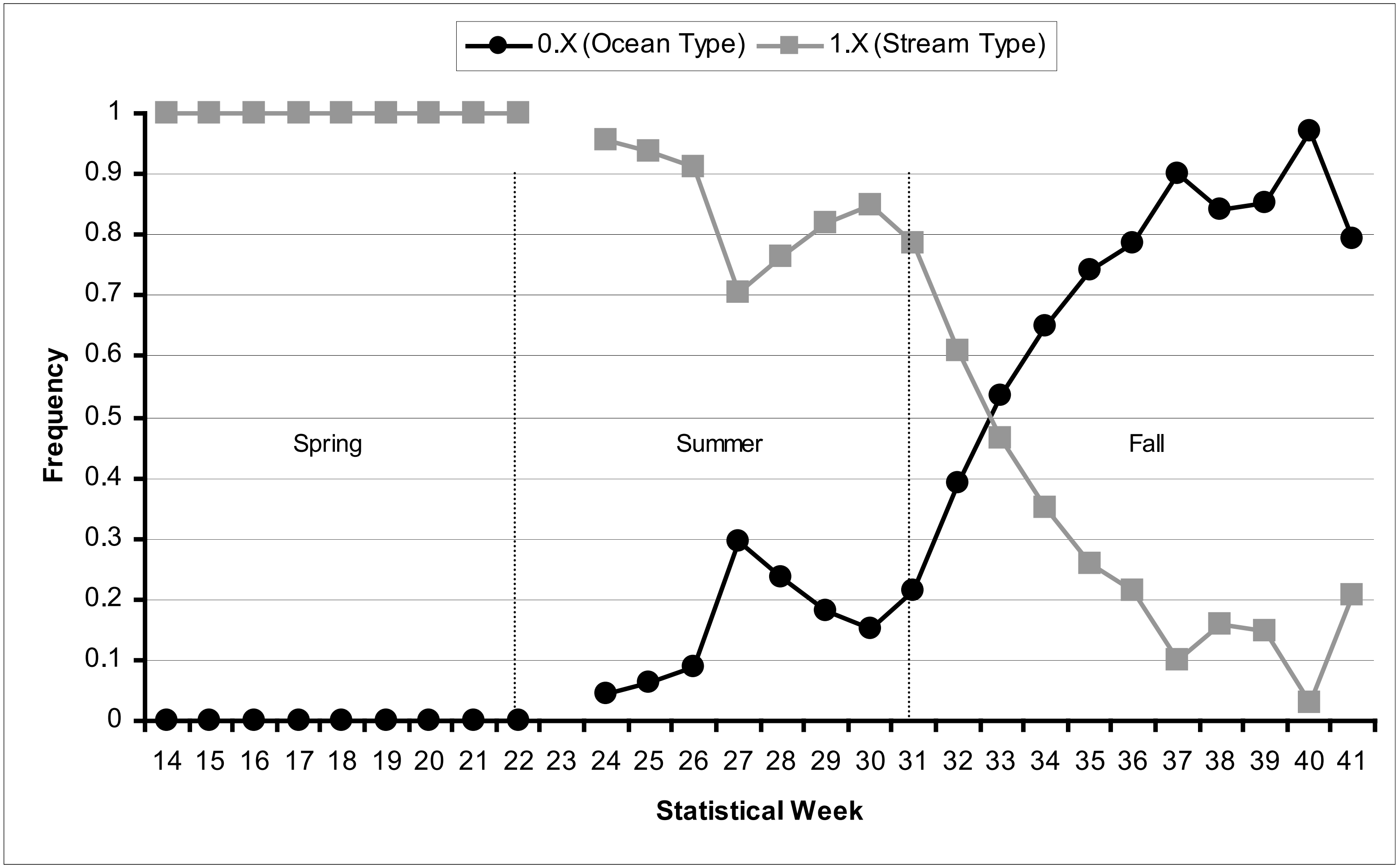


Table 2. Weekly and cumulative age composition of Columbia Basin summer chinook salmon sampled at Bonneville Dam in 2002. Note: Sampling did not occur in Week 23.

Statistical Week	Sampling Date	Number Sampled	Number Ageable	Weekly run size	Age Composition by Brood Year and Age Class: 1999		1998		1997		1996	1995
					0.2	1.1	0.3	1.2	0.4	1.3	1.4	1.5
24[a]	6/13	70	66	41178	0.030	0.030		0.576	0.015	0.348		
25	6/18, 20	100	95	21545		0.032	0.063	0.537		0.368		
26	6/25, 27	100	91	24024		0.033	0.066	0.396	0.022	0.484		
27	7/1, 2	100	85	16685	0.035	0.024	0.247	0.212	0.012	0.459	0.012	
28	7/11, 12	80	72	14033	0.014	0.028	0.181	0.222	0.042	0.514		
29	7/16, 18	80	77	8706	0.026	0.013	0.143	0.286	0.013	0.519		
30	7/25	50	46	6188	0.043	0.109	0.087	0.478	0.022	0.261		
31[b]	7/30	30	28	3029	0.071	0.036	0.107	0.357	0.036	0.357		0.036
Cumulative		610	560	135388	0.020	0.032	0.086	0.428	0.017	0.414	0.001	0.001
Ten Year Average		464	426	31676	0.026	0.149	0.094	0.399	0.052	0.244	0.027	0.000

Note: Age composition of ten year average may not add to 100%, not all age classes of previous years are displayed.

a Weekly run size includes a portion of the fish numbers from Week 22 and all of Week 23. Summer chinook salmon run at Bonneville Dam officially starts on June 1st and sampling did not occur in Week 23.

b Weekly run size includes only a portion of the fish numbers from Week 31. Summer chinook salmon run at Bonneville Dam officially ends on July 31st.

Table 3. Weekly and cumulative age composition of Columbia Basin bright fall chinook salmon sampled at Bonneville Dam in 2002.

Statistical Week	Sampling Date	Number Sampled	Number Ageable	Weekly run size	Age Composition by Brood Year and Age Class							
					2000	1999		1998		1997		1996
					0.1	0.2	1.1	0.3	1.2	0.4	1.3	1.4
32[a]	8/6	27	23	6579		0.087	0.043	0.217	0.261	0.087	0.261	0.043
33	8/13	33	30	7598		0.033		0.500	0.300		0.167	
34	8/20	39	37	20752	0.027	0.162	0.054	0.378	0.189	0.081	0.108	
35	8/27, 29	96	89	73067	0.022	0.169	0.045	0.472	0.157	0.079	0.056	
36	9/3, 5	100	94	75185	0.011	0.223	0.053	0.415	0.149	0.138	0.011	
37	9/10, 13	119	111	90537	0.063	0.378	0.036	0.396	0.054	0.063	0.009	
38	9/17, 19	69	69	44893	0.087	0.348	0.130	0.333	0.029	0.072		
39	9/24	50	48	22406	0.042	0.354	0.104	0.438	0.042	0.021		
40	10/1	35	34	11015	0.147	0.265	0.029	0.471		0.088		
41	10/11	24	24	5348	0.208	0.292	0.167	0.208		0.083	0.042	
42[b]	10/15	23	23	7037	0.130	0.478	0.043	0.217	0.043	0.043		0.043
Cumulative		615	582	364417	0.047	0.272	0.059	0.404	0.104	0.081	0.031	0.002
Five Year Average					0.046	0.246	0.034	0.361	0.091	0.159	0.050	0.009

Note: Age composition of five year average may not add to 100%, not all age classes of previous years are displayed.

a Weekly run size for Week 31 is only those fish passing Bonneville Dam after the 31st of July. Fall chinook run at Bonneville Dam officially starts on August 1st.

b Weekly run size includes fish numbers from Weeks 42 - 46 Sampling ended in Week 42.

Sockeye salmon were estimated to be mostly five-year-old fish (55.1%), with most of the remainder returning as four-year-old-fish (39.5%). This year almost half (45.9%) of the sockeye salmon spent more than one year in fresh water (Table 4). Age class 2.2 was the most abundant (41.1%) just above age class 1.2 (39.3%). Sockeye this year had an extensive combination of age classes including some 3.2 and 4.2 age class fish.

The 2002 coho salmon run passing Bonneville Dam was estimated as 86.9% three-year-old fish (age class 1.1) from the 1999 BY (Table 5), while 11.7% of the run were aged as two-year-old fish (age class 1.0). Our sample this year also included coho salmon with age classes of 2.0 and 2.1.

Table 4. Weekly and cumulative age composition of Columbia Basin sockeye salmon sampled at Bonneville Dam in 2002.

					Age Composition by Brood Year and Age Class									
					1999	1998		1997			1996		1995
Statistical Week	Sampling Date	Number Sampled	Number Ageable	Weekly run size	1.1	1.2	2.1	1.3	2.2	3.1	2.3	3.2	4.2
24[a]	6/13	11	11	1767		0.273		0.455	0.273				
25	6/18, 20	103	100	7400		0.220		0.250	0.460		0.030	0.030	0.010
26	6/25, 27	150	144	20428	0.007	0.431		0.104	0.458				
27	7/1, 2	120	115	13299	0.009	0.461	0.009	0.122	0.330		0.009	0.052	0.009
28	7/11, 12	111	107	4860	0.009	0.449		0.065	0.393	0.009	0.019	0.056	
29[b]	7/16, 18, 25	22	20	1854	0.100	0.150		0.100	0.450		0.050	0.150	
Cumulative		517	497	49608	0.010	0.393	0.002	0.139	0.411	0.001	0.011	0.030	0.004

a Weekly run size includes fish numbers from Week 21 - 24. Sampling began in Week 24.

b Weekly run size includes fish numbers from Weeks 29 - 36. Sampling ended in Week 30. Due to small sample size (n=3) in Week 30, Weeks 29 and 30 were combined.

Table 5. Weekly and cumulative age composition of Columbia Basin coho salmon sampled at Bonneville Dam in 2002.

Statistical Week	Sampling Date	Number Sampled	Number Ageable	Weekly run size	Age Composition by Brood Year and Age Class: 2000 1.0	1999 1.1	1999 2.0	1998 2.1
36[a]	8/20, 27, 9/3, 5	13	10	7599	0.200	0.800		
37	9/10, 12	47	44	21770	0.136	0.841	0.023	
38	9/17, 19	50	46	12398	0.196	0.761	0.043	
39	9/24	50	47	11171	0.128	0.872		
40	10/1	40	37	9561	0.054	0.946		
41	10/11	50	47	13149	0.043	0.936		0.021
42[b]	10/15	60	58	18520	0.086	0.914		
Cumulative		310	289	94168	0.117	0.869	0.011	0.003

a Weekly run size includes fish numbers from Weeks 30 – 36. Sampling started in Week 34, but due to small sample sizes, Weeks 34 - 36 were combined.

b Weekly run size includes fish numbers from Weeks 42 – 46. Sampling ended in Week 42.

Chinook Salmon Run-Size Prediction for 2003

Based on a linear relationship between three- and four-year-old returns (Figure 4) the predicted 2003 four-year-old adult spring chinook salmon abundance at Bonneville Dam will be 54,200 (± 68,650, 90% PI). A relationship between four- and five-year-olds (Figure 5), albeit poorer than that existing between three-year-olds and four-year-olds, predicts that the 2003 five-year-old adult abundance at Bonneville Dam will be 36,300 (± 35,400, 90% PI).

For the 2003 summer chinook salmon run at Bonneville Dam, the relationship between three- and four-year-olds (Figure 6) resulted in a prediction of 23,800 (±19,100, 90% PI) four-year-olds. The relationship between four- and five-year-olds (Figure 7) results in a prediction for summer chinook salmon run of 63,800 (± 10,300, 90% PI) five-year-olds for 2003.

For the 2003 bright fall chinook salmon run at Bonneville Dam, the relationship between three- and four-year-olds (Figure 8) results in an abundance of 169,100 (± 139,500, 90% PI) four-year-old fish. The relationship between four- and five-year-olds (Figure 9) results in a prediction for bright fall chinook salmon run of 91,100 (± 69,400, 90% PI) five-year-olds for 2003.

The predicted 2003 five-year-old adult summer and bright fall chinook salmon returning numbers are beyond existing data. These abundance estimates should be used with caution for we can not be sure that the regression function that fits the past data is appropriate over a wider range (Neter et al. 1985).

Figure 4. Predicted 20 03 four-year-old Columbia Basin spring chinook salmon abundance (at Bonneville Dam) based on a linear relationship between four-year-old and three-year-old fish abundance during brood years 1984 through 1999.

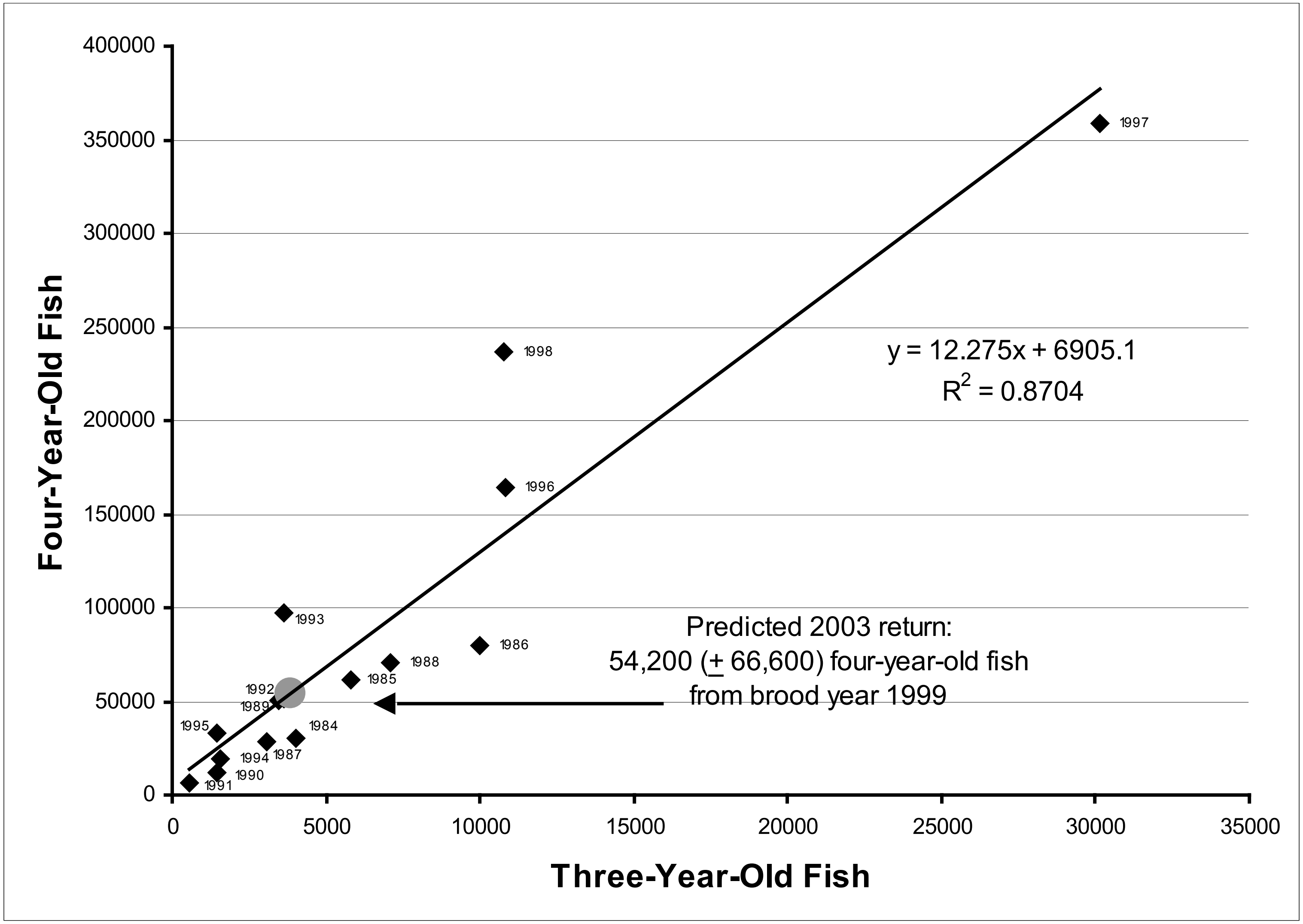


Figure 5. Predicted 2003 five-year-old Columbia Basin spring chinook salmon abundance (at Bonneville Dam) based on a linear relationship between five-year-old and four-year-old fish abundance during brood years 1983 through 1998.

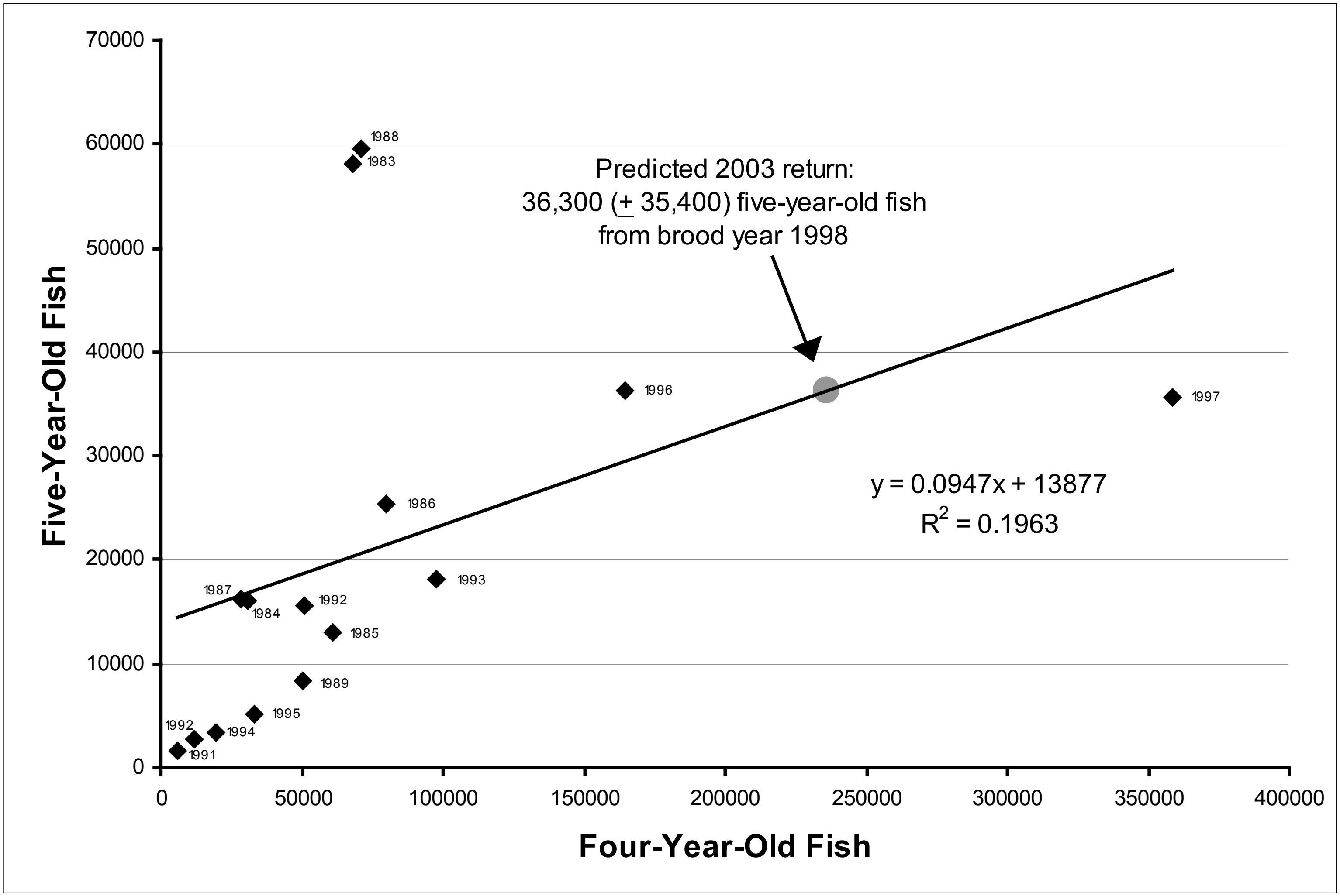


Figure 6. Predicted 2003 four-year-old Columbia Basin summer chinook salmon abundance (at Bonneville Dam) based on a linear relationship between four-year-old and three-year-old fish abundance during brood years 1987 through 1999.

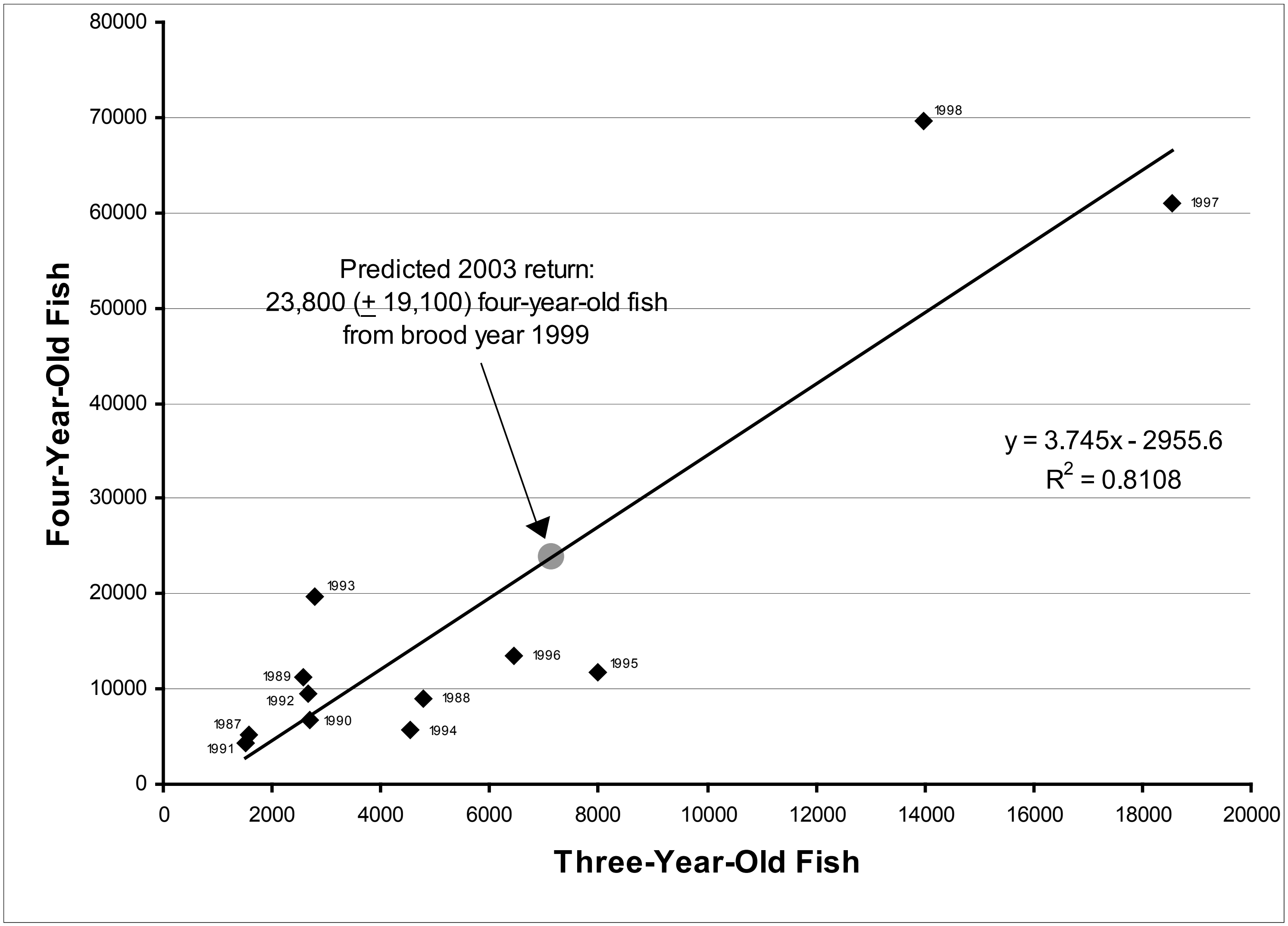


Figure 7. Predicted 2003 five-year-old Columbia Basin summer chinook salmon abundance (at Bonneville Dam) based on a linear relationship between five-year-old and four-year-old fish abundance during brood years 1986 through 1998.

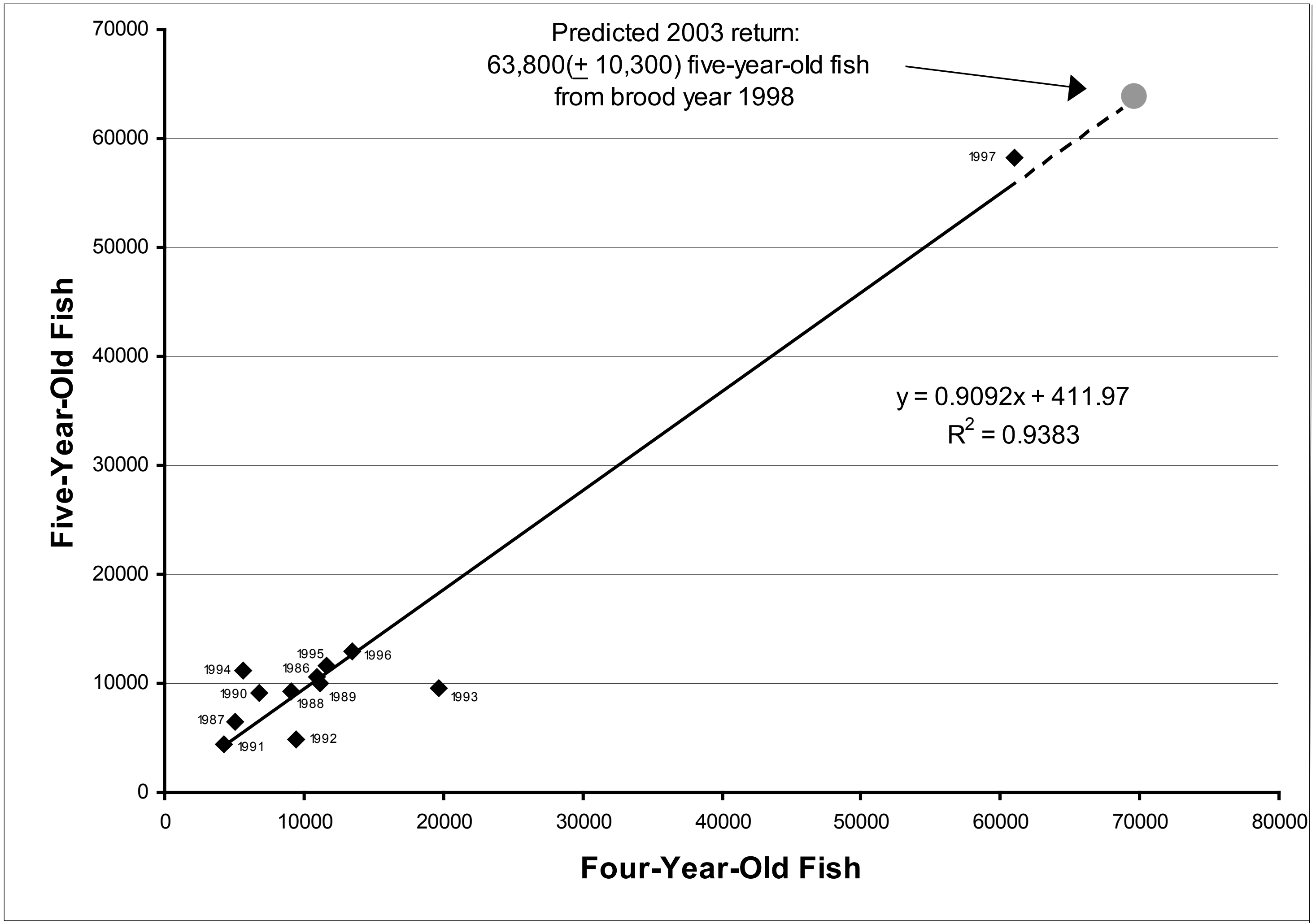


Figure 8. Predicted 2003 four-year-old Columbia Basin bright fall chinook salmon abundance (at Bonneville Dam) based on a linear relationship between four-year-old and three-year-old fish abundance during brood years 1994 through 1999.

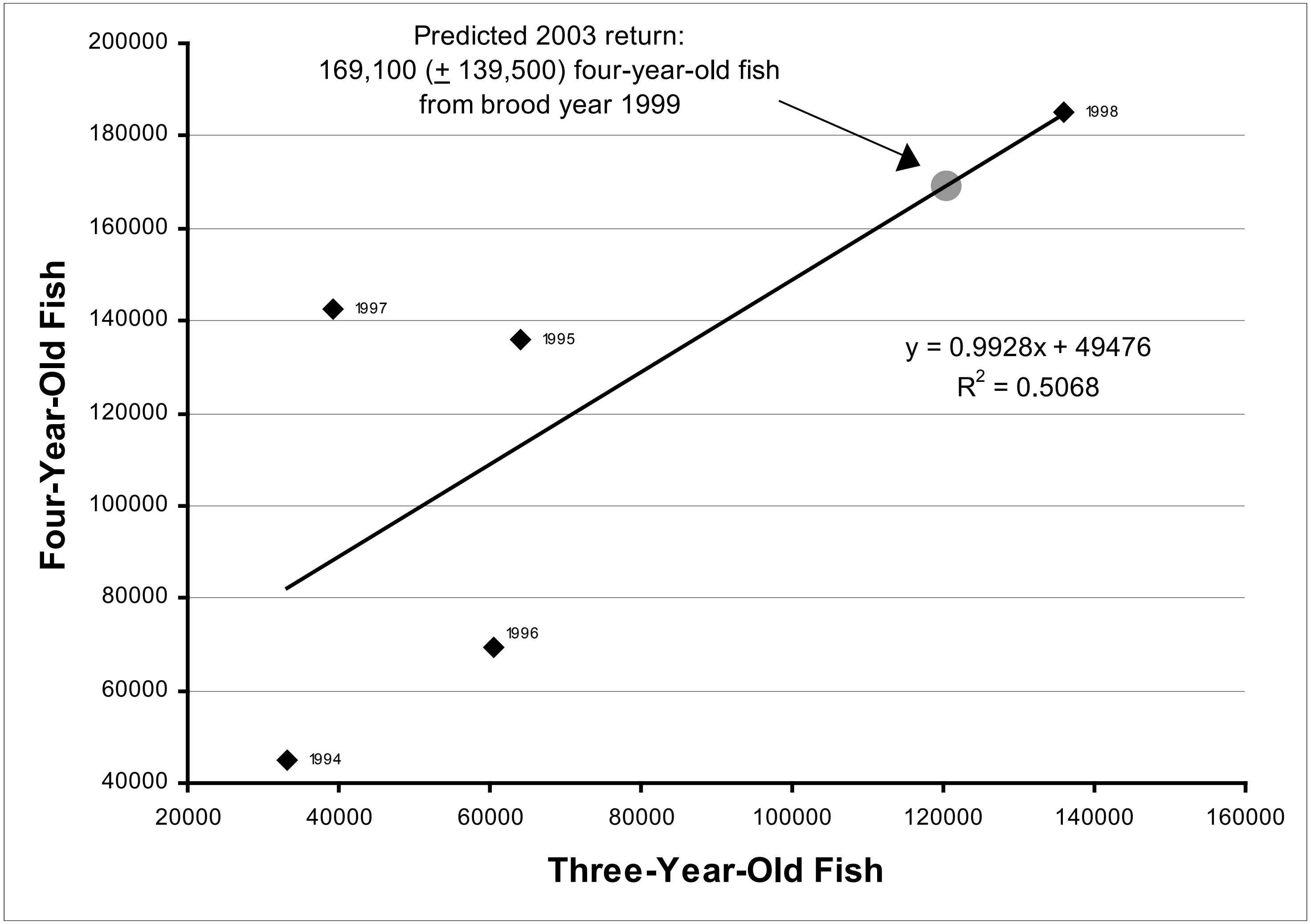
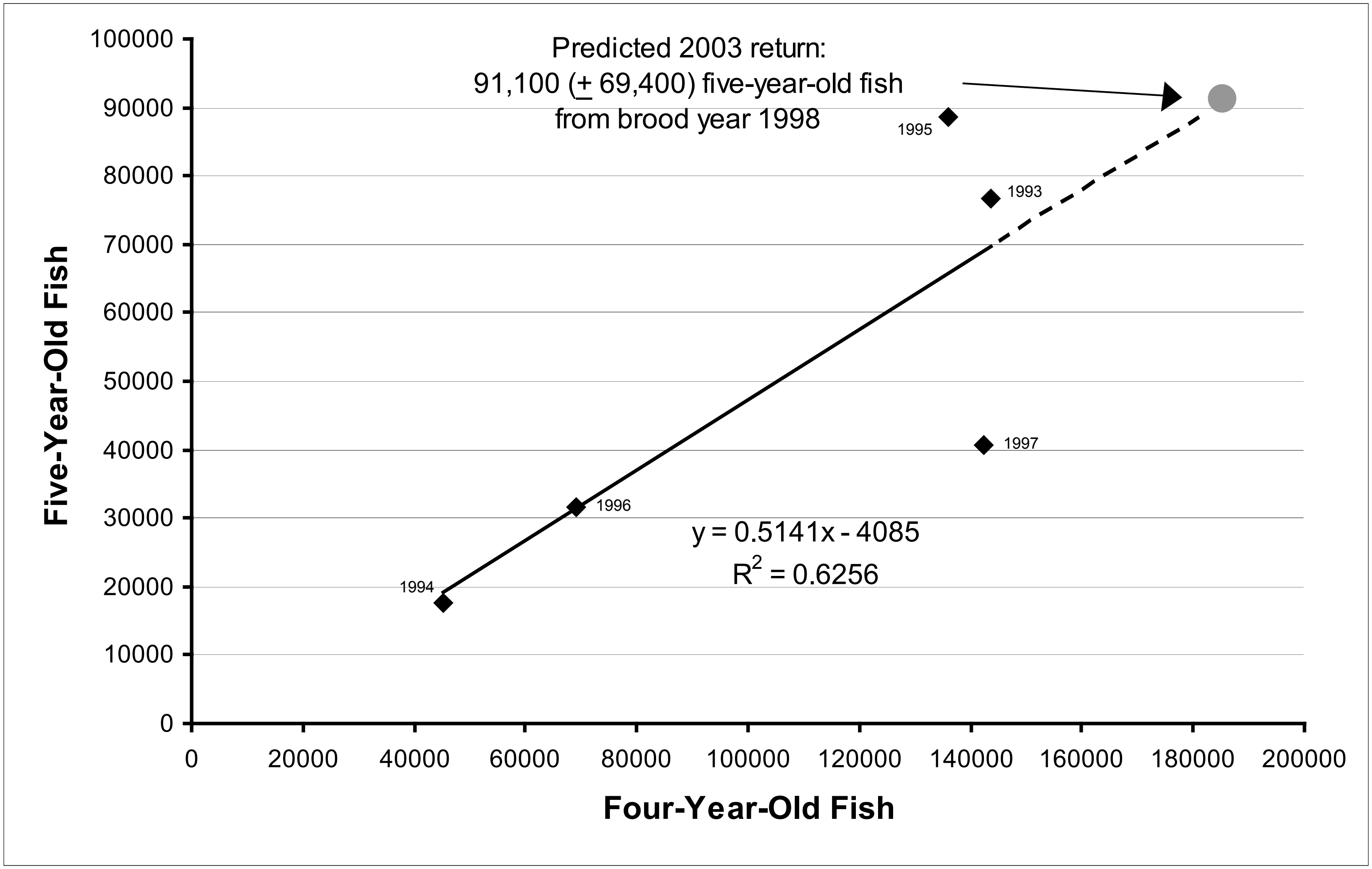


Figure 9. Predicted 2003 five-year-old Columbia Basin bright fall chinook salmon abundance (at Bonneville Dam) based on a linear relationship between five-year-old and four-year-old fish abundance during brood years 1993 through 1998.



DISCUSSION

This study offers a unique opportunity to obtain representative samples of multiple species from the Columbia River over the entire period of their run. Sockeye salmon were sampled for almost their entire run. This year Week 23 was the beginning of both the sockeye (less than 100 fish) and summer chinook (17,802 fish) salmon runs and sampling did not occur during that week. The chinook salmon runs (spring, summer, and fall) were sampled for 28 weeks (April into October) during their migration representing 97.4% of the entire chinook salmon run. Ninety percent of the coho salmon run was sampled over 9 weeks (August into October) during their migration.

Coho are usually a single age class (1.1) throughout their run. However, this year, a large proportion of coho salmon were jacks of age class 1.0, and we also had several coho that over-wintered twice in freshwater. Unlike previous years, the 1.2 age class did not predominate the 2002 sockeye salmon run, the percentage of five-year-olds was higher than the four-year-olds and the age class 2.2 was the most abundant. Chinook salmon show considerable variation in age structure (Figure 2). Usually the majority of spring and summer chinook salmon return as four-year-old fish. In 2002, proportions of five-year-olds had a stronger showing in the spring run and were almost the same proportion as the four-year-olds in the summer run, while the three-year-old proportion of the summer run was the lowest in several years. This year four-year-olds represented half of the bright fall run as they passed Bonneville Dam.

For the first time since CRITFC began sampling sockeye salmon at Bonneville Dam in 1985, sockeye salmon of age 3.2 and 4.2 were sampled. Fish of these age classes likely originated upstream of Wells Dam for, while these age classes were observed in sockeye salmon samples collected at Wells Dam, these age classes were not present in samples collected at Tumwater Dam. Whether these fish originated from Lake Osoyoos, or are kokanee originating elsewhere is unknown. It is possible that these fish are kokanee that migrated downstream from above Chief Joseph Dam or from Okanagan Lake during high flows in the spring of 2001 (Fryer and Kelsey 2003).

With the exception of two chinook salmon age classes (1.2 and 1.3), most of the salmon age classes sampled did not show any significant change in mean lengths over the sampling period. Age 1.2 chinook salmon had a significant increase of 0.16 cm per week, while age 1.3 chinook had a significant increase of 0.19 cm per week over the sampling period for 2002. In 2001, age 1.3 chinook salmon also had an increase in length (0.23 cm per week, Kelsey and Fryer 2001).

In 2002 we sampled all bright chinook salmon regardless of length (chinook salmon under 35 cm, which are locally known as mini-jacks, are not usually counted or sampled) during the fall run to obtain a better understanding of sizes of the Age 1.0 and 0.1 fish (these fish, under 35 cm and those of age class 1.0, were not used in any of the previous analyses). During the spring and summer chinook salmon runs our sample numbers, broken into age classes, appeared to indicate that our estimates of jack fish[6] were approximately half of the Bonneville jack count at the ladders for each of these runs. In the past, a cut off length of 35 cm (at counting windows and our criteria) has usually removed fish of age class 1.0, while keeping most of the 0.1 age class. At the end of the fall sampling period, we had collected data on 23 fish under 35 cm (the smallest mini-jack sampled was 28 cm long). Twenty of these fish were age class 1.0, two fish were age class 0.1, and one was not ageable. Approximately 9% of the fish under 35 cm were age class 0.1. Among all Age X.1 fish sampled in 2002, 6% were under 35 cm and are not usually sampled.

When comparing the age distribution of all fish sampled in our study between 35 and 49 cm[7] in length for 2001 and 2002, two-year old fish represent 90% of the fish in this length group, yet twice as many of these fish were of Age 1.0 in 2002 compared to 2001 (Figure 10). These Age 1.0 fish, rejected by us after aging scales, would be counted as jacks at dam counting windows due to their large size. In both years all fish of 35 and 49 cm in length represent about 10% of the total run (9.5% in 2001, 11% in 2002).

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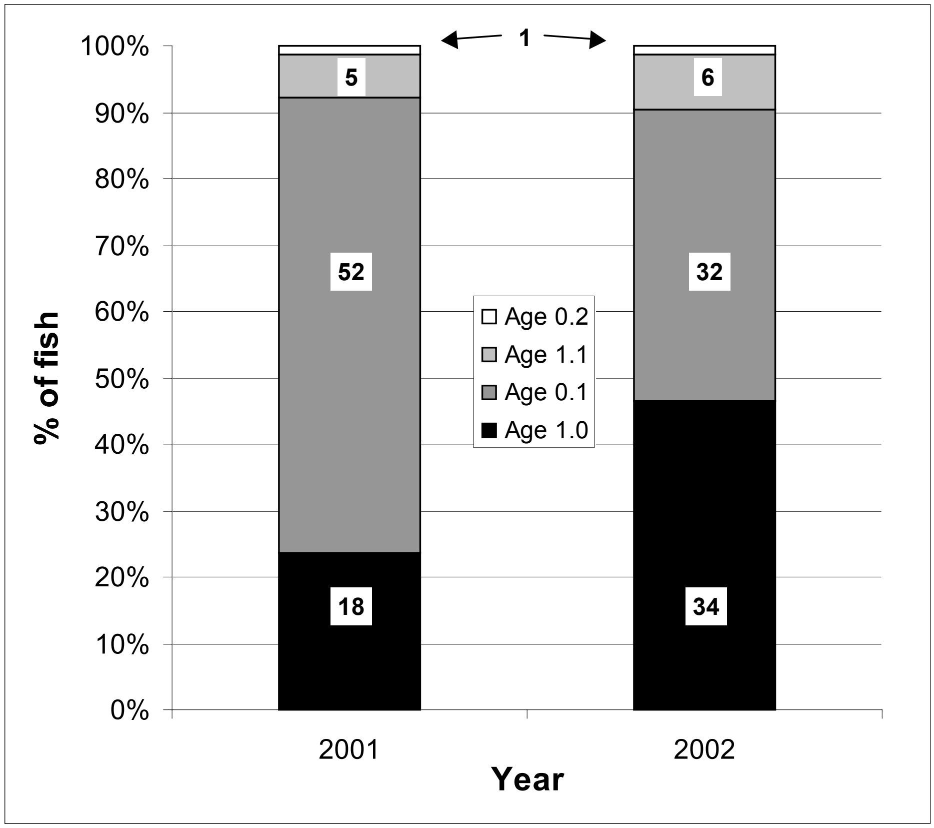
6. We define a chinook salmon jack by age class and is any fish that has spent one winter in salt water. The counting stations at the dams define a chinook salmon jack as any fish between the length of 35 – 56 cm.

7. The largest two-year-old jack sampled this year, or in 2001, was 49.0 cm.

Figure 10. Ages of bright fall chinook salmon 35 to 49 cm in length sampled in 2001 and 2002 at Bonneville Dam. Note: Numbers of fish in each class are located in the bars.



In 2001, during the sockeye run, a new condition was observed on the fish. This condition was manifested as one or more round red sore/rash (most were 1 cm in diameter) located on the ventral or lateral sides (below the lateral line) of the fish. It is suspected, but not confirmed, that this condition may be a sign of bacterial kidney disease (Carl Schreck, Oregon State University, personal communication During the remaining 2001 sampling season (including the remainder of the sockeye run and the summer chinook run, as well as the bright fall chinook and coho salmon runs) the presence of the condition was carefully noted. In 2002, the condition was noted for the entire sampling season – results from both sampling seasons are summarized in Appendix B. The increase in observed sores on spring and summer chinook salmon in 2002 may be an artifact of observer error, since the condition was first noticed on sockeye salmon (run peaks during mid-summer) well into the summer run and past the spring chinook salmon run, and the condition did not become part of sampling protocol until the end of the summer. However, the difference in proportions of sores for the 2001 (1.3%) and 2002 (43.3%) sampling season observed on sockeye cannot be completely explained by observer error. It is very unlikely that personnel missed this condition on 40% of the sockeye in 2001 – the condition is very visible against the coloration of sockeye. Since protocol was in place in 2001 for the entire runs of bright fall chinook and coho salmon the difference in percent between the two years can be compared. While the very large proportion of coho salmon observed with sores in 2001 (32.5%) dropped a little in 2002 (25%), bright fall chinook salmon increased in proportion of observed sores from 1.6% (2001) to 8.5% (2002). We will continue to monitor for this condition in 2003.

Based on 2001 results, we made run size predictions for four- and five-year-old spring, summer, and bright fall chinook salmon returning to Bonneville Dam in 2002 (Kelsey and Fryer 2002) using the methods discussed in this report. For the two principle age groups (four-year-old and five-year-old), we predicted 220,400 spring and 77,700 summer chinook versus estimated returns of 272,100 spring and 128,000 summer chinook salmon. Only one of the five age groups predicted in 2002 were within the 90% prediction interval (Table 6). We significantly underestimated the 2002 return of 4-year-old spring and both 4- and 5-year-old summer chinook, while significantly overestimating the return of 5-year-old bright fall chinook. We also overestimated the return of 5-year-old spring chinook, although the difference was not large. For both spring and summer chinook, the ratio of four-year-old fish returning in 2002 compared to three-year-old fish returning in 2001 was greater than observed in past years. Conversely, for both summer and fall chinook, the ratio of five-year-old fish returning in 2002 compared to four-year-old fish returning in 2001 was less than that observed in past years. It is hoped that additional years of data will help us explain these variations through the use of environmental variables such as ocean productivity indices, and thus result in more accurate predictions.

Table 6. Predicted and estimated abundance of chinook salmon returning to Bonneville Dam.

Species	2001 Report's Predicted (+ 90%) for Year 2002	Year 2002 Estimate	Predicted (+ 90%) for Year 2003
Spring Chinook 4-year-old	132,600 (+ 46,300)	236,400	54,200 (+ 66,600)
Spring Chinook 5-year-old	87,800 (+ 54,500)	35,700	36,300 (+ 35,400)
Summer Chinook 4-year-old	44,200 (+ 11,700)	69,700	23,800 (+ 19,100)
Summer Chinook 5-year-old	33,500 (+ 11,500)	58,300	63,800 (+ 10,300)
Bright Fall Chinook 4-year-old	--	185,200	169,100 (+ 139,500)
Bright Fall Chinook 5-year-old	77,100 (+ 25,800)	40,700	91,100 (+ 69,400)

2002 estimate is calculated using the proportion of X-year-old returning in 2002 multiplied by the count of spring, summer, and fall chinook at Bonneville Dam.

Our 2003 predictions, like the 2002 predictions, predict far beyond the range of previous data for five-year-old summer and bright fall chinook salmon. As we stated in previous reports (Kelsey and Fryer 2001, 2002), "we are predicting returns considerably higher than the range of previous data. Using a regression to predict beyond the range of past data should be done with extreme caution because one cannot be sure that the regression function that fits the past data is appropriate over a wider range (Neter et al. 1985)". Our four-year-old spring and bright fall predictions are also beyond the range of previous data, with the exception of the spring 1997 data point and the bright fall 1988 data point. Overall, we predict that the 2003 spring chinook return of four-year-old and five-year-old fish will be about half the 2002 return of 275,900 fish (Table 6). The Technical Advisory Committee (TAC), for U.S. v. Oregon, using similar techniques, also forecasts that approximately half the number of upriver spring chinook that returned in 2002 (145,500 fish) will return to the mouth of the Columbia River in 2003 (Espenson 2003, TAC 2002). For the four-year-old and five-year-old summer 2003 run, we predict a lower return than 2002, although our 2003 number is higher than what we predicted in 2002 (TAC used our forecasts). We predict that the 2003 bright fall chinook salmon run of four- and five-year-old fish will be less than 2002, but within the range of previous years. TAC is predicting a bright fall run equal or greater to the run in 2002 (Harlan and Roler 2003). Our prediction for four-year-old bright fall chinook salmon returning in 2003 should be treated with caution, as the prediction is based on a low number of data points, and this is the first year we are making a prediction for this age group.

This study is expected to continue to develop an accurate age composition and length-at-age database for Columbia Basin upriver salmon populations. This information provides unbiased estimates of the age composition of the terminal run, and improves predicting or forecasting of terminal runs, which are both important in improving the calibration of the Chinook Technical Committee's chinook model. The data will also aid fisheries managers in formulating spawner-return relationships, and analyzing productivity. Continued data collection on age composition and length-at-age will allow managers to more accurately monitor the effects of ocean harvest restrictions agreed upon by the Pacific Salmon Treaty.

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APPENDIX A

LIST OF TABLES

Table A1. Total age composition (%) for clipped and non-clipped chinook, sockeye, and coho salmon sampled at Bonneville Dam in 2002. Note: Age 1.0 chinook salmon ("mini-jacks") were omitted.

	Sample	Ageable	Age Composition (%) by Brood Year and Age Class: 2000		1999			1998			1997				1996			1995	
	Size (n)	(n)	0.1	1.0	0.2	1.1	2.0	0.3	1.2	2.1	0.4	1.3	2.2	3.1	3.2	1.4	2.3	1.5	4.2
Spring Chinook																			
Fin - Clipped	376	356				2.2			86.2			11.2	0.3						
No Fin - Clips	335	297				1.0			81.8			17.2	0.0						
Summer Chinook																			
Fin - Clipped	353	316			1.3	3.8		1.9	39.2		0.3	53.5				0.0		0.0	
No Fin - Clips	257	244			3.3	2.9		23.8	36.5		3.7	29.1				0.4		0.4	
Fall Chinook																			
Fin - Clipped	58	51	3.9		9.8	15.7		25.5	29.4		2.0	11.8				2.0			
No Fin - Clips	557	531	5.6		28.2	5.3		40.7	8.7		8.1	3.2				0.2			
Coho																			
Fin - Clipped	121	114		9.6		90.4	0.0			0.0									
No Fin - Clips	189	175		12.0		85.7	1.7			0.6									
Sockeye																			
Fin - Clipped	8	8				0.0			37.5	0.0		25.0	25.0	0.0	0.0		12.5		0.0
No Fin - Clips	509	489				1.0			38.4	0.2		13.5	41.3	0.2	3.7		1.2		0.4

Table A2. Percent of sampled chinook, coho, and sockeye salmon at Bonneville Dam having clips by statistical week and total sampled in 2002.

Statistical Week	Spring Chinook	Summer Chinook	Fall Chinook	Coho	Sockeye
11	x				
12	x				
13	x				
14	52.0				
15	55.0				
16	47.8				
17	52.5				
18	50.6				
19	51.7				
20	58.9				
21	72.5				x
22	50.0				x
23		x			x
24		51.4			0.0
25		61.0			1.9
26		53.0			1.3
27		62.0			0.8
28		65.0			2.7
29		56.3			0.0
30		62.0			a
31		43.3		x	x
32			40.7	x	x
33			24.2	x	x
34			12.8	a	x
35			10.4	a	x
36			8.0	23.1	x
37			4.2	36.2	
38			8.7	26.0	
39			2.0	34.0	
40			2.9	37.5	
41			4.2	48.0	
42			4.3	53.3	
43			x	x	
44			x	x	
45			x	x	
46					
47					
48					
% of Total Sampled	**52.9**	**57.9**	**9.4**	**39.0**	**1.5**

x Represents that a species was present, but sampling did not occur or a sample of the species was not caught. Therefore, the percent in a sampled statistical week, before or after an x, is assumed to represent the weeks not sampled. For example, spring chinook were first sampled in Week 14, this week is assumed to represent Weeks 11-13 as well.

a Week combined with next or previous week due to low sample size.

Table A3. Length-at-age estimates for Columbia Basin spring chinook salmon sampled at Bonneville Dam in 2002. Composite estimates (of age classes 1.1. 1.2 and 1.3) are weighted by weekly run size.

	Brood Year and Age Class			
	1999	1998	1997	
	1.1	1.2	1.3	2.2
Statistical Week 14				
Mean Fork Length (cm)		72.83	89.68	
Maximum		80.5	101.0	
Minimum		61.5	81.0	
Standard Deviation		5.23	5.82	
Sample Size		9	11	
Statistical Week 15				
Mean Fork Length (cm)		74.88	87.00	
Maximum		83.0	92.0	
Minimum		70.0	79.0	
Standard Deviation		3.38	3.92	
Sample Size		26	10	
Statistical Week 16				
Mean Fork Length (cm)		74.51	88.00	75.00
Maximum		85.5	101.0	75.0
Minimum		68.0	77.5	75.0
Standard Deviation		3.72	7.82	--
Sample Size		73	9	1
Statistical Week 17				
Mean Fork Length (cm)		73.42	85.50	
Maximum		83.0	95.5	
Minimum		61.5	76.0	
Standard Deviation		3.99	6.48	
Sample Size		100	9	
Statistical Week 18				
Mean Fork Length (cm)		73.06	84.00	
Maximum		84.5	96.0	
Minimum		62.0	71.0	
Standard Deviation		3.83	7.30	
Sample Size		154	13	
Statistical Week 19				
Mean Fork Length (cm)	48.88	72.74	85.64	
Maximum	58.5	84.5	95.5	
Minimum	44.5	62.5	73.5	
Standard Deviation	6.55	4.32	7.18	
Sample Size	4	92	14	
Statistical Week 20				
Mean Fork Length (cm)	50.30	73.42	87.63	
Maximum	61.5	86.0	93.0	
Minimum	38.5	61.5	83.0	
Standard Deviation	9.10	5.69	4.15	
Sample Size	5	43	4	
Statistical Week 21				
Mean Fork Length (cm)	54.00	75.65	85.63	
Maximum	54.0	85.0	93.0	
Minimum	54.0	63.5	72.5	
Standard Deviation	0.00	5.60	6.09	
Sample Size	2	27	8	
Statistical Week 22				
Mean Fork Length (cm)		76.56	90.69	
Maximum		81.5	97.5	
Minimum		68.0	80.5	
Standard Deviation		3.20	5.67	
Sample Size		26	13	
2002 Composite				
Mean Fork Length (cm)	50.24	73.57	86.84	75.00
Maximum	61.5	86.0	101.0	75.0
Minimum	38.5	61.5	71.0	75.0
Standard Deviation	6.92	4.00	6.93	--
Sample Size	11	550	91	1

Table A4. Length-at-age estimates for Columbia Basin summer chinook salmon sampled at Bonneville Dam in 2002. Composite estimates (of age classes 0.3, 1.2 and 1.3) are weighted by weekly run size.

	Brood Year and Age Class							
	1999		1998		1997		1996	1995
	0.2	1.1	0.3	1.2	0.4	1.3	1.4	1.5
Statistical Week 24								
Mean Fork Length (cm)	73.25	53.75		77.05	97.50	89.28		
Maximum	75.5	54.4		84.5	97.5	105.0		
Minimum	71.0	53.0		66.5	97.5	67.0		
Standard Deviation	3.18	1.06		4.75	--	7.62		
Sample Size	2	2		38	1	23		
Statistical Week 25								
Mean Fork Length (cm)		55.50	86.25	78.54		89.79		
Maximum		56.0	93.0	89.5		101.0		
Minimum		54.5	78.0	55.5		74.5		
Standard Deviation		0.87	6.37	6.93		6.11		
Sample Size		3	6	51		35		
Statistical Week 26								
Mean Fork Length (cm)		53.67	84.17	76.85	93.50	88.95		
Maximum		56.0	92.5	90.5	94.0	102.0		
Minimum		51.5	67.5	56.0	93.0	74.5		
Standard Deviation		2.25	9.03	8.46	0.71	6.32		
Sample Size		3	6	36	2	44		
Statistical Week 27								
Mean Fork Length (cm)	58.50	56.00	81.14	76.42	96.00	87.05	97.50	
Maximum	64.5	57.0	92.0	90.5	96.0	105.5	97.5	
Minimum	52.0	55.0	67.0	64.0	96.0	69.5	97.5	
Standard Deviation	6.26	1.41	6.73	8.60	--	7.70	--	
Sample Size	3	2	21	18	1	39	1	
Statistical Week 28								
Mean Fork Length (cm)	73.50	44.00	82.65	76.94	95.00	87.70		
Maximum	73.5	47.0	92.0	88.0	100.0	100.0		
Minimum	73.5	41.0	74.5	58.5	88.0	64.5		
Standard Deviation	--	4.24	4.87	8.46	6.24	6.88		
Sample Size	1	2	13	16	3	37		
Statistical Week 29								
Mean Fork Length (cm)	66.00	58.50	82.68	73.82	97.00	89.21		
Maximum	69.0	58.5	94.0	87.0	97.0	97.0		
Minimum	63.0	58.5	72.5	61.0	97.0	77.0		
Standard Deviation	4.24	--	6.36	6.98	--	4.11		
Sample Size	2	1	11	22	1	40		
Statistical Week 30								
Mean Fork Length (cm)	58.75	52.40	87.75	76.84	90.50	88.79		
Maximum	62.5	61.0	93.5	87.5	90.5	99.0		
Minimum	55.0	43.5	83.0	64.0	90.5	80.0		
Standard Deviation	5.30	6.26	4.87	6.40	--	5.41		
Sample Size	2	5	4	22	1	12		
Statistical Week 31								
Mean Fork Length (cm)	64.00	62.00	81.50	76.85	97.00	89.45		93.50
Maximum	66.0	62.0	85.0	87.0	97.0	106.0		93.5
Minimum	62.0	62.0	78.0	68.5	97.0	76.0		93.5
Standard Deviation	2.83	--	3.50	6.14	--	7.97		--
Sample Size	2	1	3	10	1	10		1
2002 Composite								
Mean Fork Length (cm)	64.42	53.55	82.94	77.12	95.00	88.76	97.50	93.50
Maximum	75.5	62.0	94.0	90.5	100.0	106.0	97.5	93.5
Minimum	52.0	41.0	67.0	55.5	88.0	64.5	97.5	93.5
Standard Deviation	7.11	5.26	7.29	6.53	3.63	7.09	--	--
Sample Size	12	19	64	213	10	240	1	1

Table A5. Length-at-age estimates for Columbia Basin bright fall chinook salmon sampled at Bonneville Dam in 2002. Composite estimates (of age classes 0.2, 0.3, and 1.2) are weighted by weekly run size.

	Brood Year and Age Class							
	2000	1999		1998		1997		1996
	0.1	0.2	1.1	0.3	1.2	0.4	1.3	1.4
Statistical Week 32								
Mean Fork Length (cm)		70.00	58.50	80.90	76.17	92.75	90.25	109.00
Maximum		73.0	58.5	89.5	89.0	95.5	98.0	109.0
Minimum		67.0	58.5	69.0	66.0	90.0	83.0	109.0
Standard Deviation		4.24	--	7.66	8.35	3.89	5.08	--
Sample Size		2	1	5	6	2	6	1
Statistical Week 33								
Mean Fork Length (cm)		63.50		84.10	78.06		89.70	
Maximum		63.5		93.0	80.5		101.5	
Minimum		63.5		64.0	74.0		81.0	
Standard Deviation		--		6.94	2.34		8.52	
Sample Size		1		15	9		5	
Statistical Week 34								
Mean Fork Length (cm)	40.50	62.50	57.25	83.86	76.29	89.00	90.25	
Maximum	40.5	69.0	61.5	94.0	84.5	91.0	95.0	
Minimum	40.5	44.0	53.0	73.0	69.0	86.0	83.0	
Standard Deviation	--	9.19	6.01	5.77	5.02	2.65	5.17	
Sample Size	1	6	2	14	7	3	4	
Statistical Week 35								
Mean Fork Length (cm)	40.50	67.00	55.00	82.87	74.89	93.57	92.40	
Maximum	43.5	83.0	60.0	94.0	86.5	98.0	105.0	
Minimum	37.5	55.0	51.0	69.5	60.5	84.0	76.0	
Standard Deviation	4.24	9.24	3.81	5.13	6.92	5.22	11.35	
Sample Size	2	15	4	42	14	7	5	
Statistical Week 36								
Mean Fork Length (cm)	43.50	67.45	53.50	81.69	78.14	93.46	93.50	
Maximum	43.5	79.5	61.5	98.5	87.0	106.0	93.5	
Minimum	43.5	51.5	46.0	71.0	66.0	83.0	93.5	
Standard Deviation	--	6.40	5.77	6.50	6.81	6.86	--	
Sample Size	1	21	5	39	14	13	1	
Statistical Week 37								
Mean Fork Length (cm)	43.21	68.23	55.38	83.66	72.75	94.64	85.00	
Maximum	49.0	86.0	62.5	96.0	81.0	105.0	85.0	
Minimum	39.0	52.5	49.0	60.5	62.5	88.0	85.0	
Standard Deviation	3.58	6.25	6.64	6.77	7.15	5.39	--	
Sample Size	7	42	4	44	6	7	1	
Statistical Week 38								
Mean Fork Length (cm)	40.92	65.75	53.50	83.17	79.75	89.10		
Maximum	44.5	76.5	62.0	94.0	84.0	98.0		
Minimum	37.5	52.0	45.0	73.5	75.5	83.0		
Standard Deviation	2.44	6.19	6.97	5.47	6.01	6.00		
Sample Size	6	24	9	23	2	5		
Statistical Week 39								
Mean Fork Length (cm)	47.75	66.85	54.80	82.90	79.25	86.00		
Maximum	48.5	74.0	66.5	90.5	81.0	86.0		
Minimum	47.0	60.5	42.0	74.5	77.5	86.0		
Standard Deviation	1.06	4.13	9.93	4.19	2.47	--		
Sample Size	2	17	5	21	2	1		
Statistical Week 40								
Mean Fork Length (cm)	41.70	66.22	50.50	80.34		89.67		
Maximum	44.5	74.5	50.5	86.0		92.0		
Minimum	40.0	57.0	50.5	76.0		86.5		
Standard Deviation	1.72	6.30	--	2.95		2.84		
Sample Size	5	9	1	16		3		
Statistical Week 41								
Mean Fork Length (cm)	43.50	65.36	55.38	84.10		90.75	95.00	
Maximum	47.5	74.0	64.0	86.5		91.5	95.0	
Minimum	41.0	57.0	51.0	82.5		90.0	95.0	
Standard Deviation	2.42	6.44	5.85	1.78		1.06	--	
Sample Size	5	7	4	5		2	1	
Statistical Week 42								
Mean Fork Length (cm)	44.83	67.59	50.50	82.30	70.00	93.00		102.50
Maximum	45.5	82.0	50.5	86.0	70.0	93.0		102.5
Minimum	44.0	57.5	50.5	79.0	70.0	93.0		102.5
Standard Deviation	0.76	7.53	--	2.89	--	--		--
Sample Size	3	11	1	5	1	1		1
2002 Composite								
Mean Fork Length (cm)	42.78	67.28	54.44	82.82	76.25	92.27	90.72	105.75
Maximum	49.0	86.0	66.5	98.5	89.0	106.0	105.0	109.0
Minimum	37.5	44.0	42.0	60.5	60.5	83.0	76.0	102.5
Standard Deviation	2.96	7.08	6.13	6.14	6.80	5.52	7.05	4.60
Sample Size	32	155	36	229	61	44	23	2

Table A6. Length-at-age estimates for Columbia Basin sockeye salmon sampled at Bonneville Dam in 2002. Composite estimates (of age classes 1.2, 1.3, 2.2, and 3.2) are weighted by weekly run size. Note: Due to small sample size, Week 30 (n=3) was combined with Week 29.

	Brood Year and Age Class								
	1999	1998		1997			1996		1995
	1.1	1.2	2.1	1.3	2.2	3.1	2.3	3.2	4.2
Statistical Week 24									
Mean Fork Length (cm)		50.50		58.00	51.33				
Maximum		51.5		61.0	54.0				
Minimum		49.0		53.5	48.0				
Standard Deviation		1.32		2.89	3.06				
Sample Size		3		5	3				
Statistical Week 25									
Mean Fork Length (cm)		51.45		57.64	51.79		58.00	51.17	59.50
Maximum		57.5		61.5	57.0		60.0	55.0	59.5
Minimum		46.0		54.0	46.5		54.5	48.0	59.5
Standard Deviation		2.75		2.17	2.35		3.04	3.55	--
Sample Size		22		25	46		3	3	1
Statistical Week 26									
Mean Fork Length (cm)	37.00	51.38		56.67	52.09				
Maximum	37.0	54.5		59.0	57.5				
Minimum	37.0	46.5		50.5	48.5				
Standard Deviation	--	1.98		2.37	1.80				
Sample Size	1	62		15	66				
Statistical Week 27									
Mean Fork Length (cm)	39.50	50.95	39.00	55.96	52.21		58.50	53.17	42.00
Maximum	39.5	55.0	39.0	59.5	58.5		58.5	56.0	42.0
Minimum	39.5	46.5	39.0	52.0	46.0		58.5	49.5	42.0
Standard Deviation	--	2.17	--	2.19	2.49		--	2.58	--
Sample Size	1	53	1	14	38		1	6	1
Statistical Week 28									
Mean Fork Length (cm)	39.00	50.64		57.64	51.75	36.50	54.50	54.33	
Maximum	39.0	56.0		61.5	56.0	36.5	56.5	58.0	
Minimum	39.0	44.0		54.5	45.0	36.5	52.5	51.5	
Standard Deviation	--	2.44		2.32	2.12	--	2.83	2.40	
Sample Size	1	48		7	42	1	2	6	
Statistical Week 29									
Mean Fork Length (cm)	37.75	52.00		52.50	52.83		55.00	52.83	
Maximum	39.0	52.5		54.50	56.00		55.0	55.0	
Minimum	36.5	51.5		50.50	49.50		55.0	51.0	
Standard Deviation	1.77	0.50		2.83	2.28		--	2.02	
Sample Size	2	3		2	9		1	3	
2002 Composite									
Mean Fork Length (cm)	38.20	51.15	39.00	56.85	52.05	36.50	56.64	53.02	50.75
Maximum	39.5	57.5	39.0	61.5	58.5	36.5	60.0	58.0	59.5
Minimum	36.5	44.0	39.0	50.5	45.0	36.5	52.5	48.0	42.0
Standard Deviation	1.35	2.15	--	2.31	2.06	--	2.81	2.79	12.37
Sample Size	5	191	1	68	204	1	7	18	2

Table A7. **Length-at-age estimates for Columbia Basin coho salmon sampled at Bonneville Dam in 2003. Composite estimates (of age classes 1.0 and 1.1) are weighted by weekly run size. Note: Due to small sample sizes, Weeks 34-36 were combined.**

	Brood Year and Age Class			
	2000	**1999**		**1998**
	1.0	**1.1**	**2.0**	**2.1**
Statistical Week 36				
Mean Fork Length (cm)	37.75	62.38		
Maximum	39.5	70.5		
Minimum	36.0	47.0		
Standard Deviation	2.47	6.84		
Sample Size	2	8		
Statistical Week 37				
Mean Fork Length (cm)	36.58	64.64	45.50	
Maximum	42.5	78.0	45.5	
Minimum	30.0	46.0	45.5	
Standard Deviation	4.32	8.20	--	
Sample Size	6	37	1	
Statistical Week 38				
Mean Fork Length (cm)	36.89	67.13	46.50	
Maximum	42.0	81.0	50.0	
Minimum	32.0	43.5	43.0	
Standard Deviation	3.48	9.01	4.95	
Sample Size	9	35	2	
Statistical Week 39				
Mean Fork Length (cm)	34.50	65.32		
Maximum	44.0	81.0		
Minimum	27.0	48.5		
Standard Deviation	5.79	8.61		
Sample Size	6	41		
Statistical Week 40				
Mean Fork Length (cm)	34.00	60.59		
Maximum	34.0	76.5		
Minimum	34.0	43.0		
Standard Deviation	0.00	8.79		
Sample Size	2	35		
Statistical Week 41				
Mean Fork Length (cm)	39.00	67.78		45.00
Maximum	39.0	81.5		45.0
Minimum	39.0	45.5		45.0
Standard Deviation	0.00	7.75		--
Sample Size	2	44		1
Statistical Week 42				
Mean Fork Length (cm)	37.80	69.99		
Maximum	41.0	81.0		
Minimum	35.0	54.0		
Standard Deviation	2.75	5.64		
Sample Size	5	53		
2002 Composite				
Mean Fork Length (cm)	36.72	65.97	46.17	45.00
Maximum	44.0	81.5	50.0	45.0
Minimum	27.0	43.0	43.0	45.0
Standard Deviation	3.55	7.73	3.55	--
Sample Size	32	253	3	1

Table A8. Length-at-age estimates for Columbia Basin salmon with unagable scales sampled at Bonneville Dam in 2003.

	Freshwater Unknown.Saltwater Winters					
	R.0	**R.1**	**R.2**	**R.3**	**R.4**	**N**
Spring Chinook						
Mean Fork Length (cm)		48.30	73.49	89.60		75.00
Maximum		57.5	81.5	97.0		75.0
Minimum		38.5	62.0	73.5		75.0
Standard Deviation		7.37	3.95	6.92		--
Sample Size		5	42	10		1
Summer Chinook						
Mean Fork Length (cm)		47.50	75.04	88.29	92.75	81.36
Maximum		47.5	88.0	96.0	96.5	96.5
Minimum		47.5	63.5	79.5	89.0	53.0
Standard Deviation		--	7.06	4.29	5.30	12.35
Sample Size		1	12	24	2	11
Bright Fall Chinook						
Mean Fork Length (cm)			70.55	84.47		66.33
Maximum			82.0	103.0		84.5
Minimum			62.0	73.0		39.5
Standard Deviation			7.11	6.91		15.09
Sample Size			10	16		7
Sockeye						
Mean Fork Length (cm)		46.63	52.08	58.75		53.00
Maximum		51.5	55.5	60.0		53.0
Minimum		36.0	43.5	57.5		53.0
Standard Deviation		7.25	3.13	1.77		--
Sample Size		4	13	2		1
Coho						
Mean Fork Length (cm)	48.50	64.75				57.40
Maximum	49.5	77.5				70.0
Minimum	47.5	51.0				36.0
Standard Deviation	1.41	7.39				12.80
Sample Size	2	14				5

Table A9. Composition (%) of observed injuries of Columbia Basin chinook salmon sampled at Bonneville Dam in 2002.

Injury Category	Spring	Summer	Fall
Marine Mammal			
Bite	1.1	0.3	0.5
Claw Rake	15.5	3.3	2.3
Twin Arches	3.4	1.1	1.3
Total[a]	**19.0**	**4.6**	**4.1**
Descaling			
< 3%			
Right side	20.3	17.5	16.7
Left side	19.8	18.5	18.4
Total[b]	**16.7**	**15.2**	**14.5**
3-19%			
Right side	16.3	14.3	13.3
Left side	14.8	11.3	10.9
Total[c]	**19.5**	**16.6**	**15.3**
≥20%			
Right side	0.8	0.8	0.5
Left side	1.5	0.0	0.5
Total[d]	**0.8**	**0.8**	**0.8**
Other Injuries			
Bruises	0.8	3.0	2.6
Cuts	1.0	0.7	0.5
Head Injury	8.3	11.0	13.0
Head Burn	0.6	0.0	0.0
Fin	16.7	10.0	13.5
Fungus	3.9	0.5	0.7
Gash	3.8	3.0	2.4
Gas Bubble Trauma	0.0	0.0	0.0
Gill Net	9.3	3.3	5.4
Fishing Hook	0.0	0.2	0.3
Lamprey	0.0	0.0	0.0
Parasite	0.4	0.0	0.2
Total[a]	**31.6**	**26.4**	**31.5**

a Totals, as percentages, do not represent the sum of subcategories, they are the number of fish with at least one injury. Fish can display more than one type of marine mammal or general injury.

b This total represents, as a percentage, the number of fish with descaling on either side, which is less than 3% descaled. If either side is ≥ 3%, the fish moves into another category.

c This total represents, as a percentage, the number of fish with descaling on either side, which is 3 – 19% descaled. If either side is > 19% the fish moves into another category.

d This total represents, as a percentage, the number of fish with descaling on at least one side that is ≥ 20% descaled.

Table A10. Composition (%) of observed injuries of Columbia Basin sockeye and coho salmon sampled at Bonneville Dam in 2002.

Injury Category	Sockeye	Coho
Marine Mammal		
Bite	1.0	0.0
Claw Rake	1.9	3.9
Twin Arches	1.4	1.9
Total[a]	**4.3**	**5.8**
Descaling		
< 3%		
Right side	38.1	23.5
Left side	42.0	28.1
Total[b]	**31.1**	**20.3**
3-19%		
Right side	25.0	22.3
Left side	25.0	16.8
Total[c]	**31.1**	**24.8**
≥20%		
Right side	1.0	3.2
Left side	1.4	1.9
Total[d]	**1.4**	**3.9**
Other Injuries		
Bruises	1.2	1.6
Cuts	2.1	0.6
Head Injury	3.9	16.1
Head Burn	0.0	0.0
Fin	8.3	15.2
Fungus	1.0	1.0
Gash	1.5	1.6
Gas Bubble Trauma	0.0	0.0
Gill Net	0.2	12.9
Fishing Hook	0.2	0.0
Lamprey	0.0	0.0
Parasite	0.0	1.0
Total[a]	**15.3**	**34.2**

a Totals, as percentages, do not represent the sum of subcategories, they are the number of fish with at least one injury. Fish can display more than one type of marine mammal or general injury.

b This total represents, as a percentage, the number of fish with descaling on either side, which is less than 3% descaled. If either side is ≥ 3%, the fish moves into another category.

c This total represents, as a percentage, the number of fish with descaling on either side, which is 3 – 19% descaled. If either side is > 19% the fish moves into another category.

d This total represents, as a percentage, the number of fish with descaling on at least one side that is ≥ 20% descaled.

APPENDIX B

LIST OF FIGURES

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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 (Figure B1). In recent years, GBT and headburn were not a priority and the sampling forms were changed to reflect this (Figure B2).

In 2000, new condition and coloration criteria were developed to reduce subjectivity in data (Figure B1). Condition codes the penetration of the mark or injury instead of judging the condition of a fish in a range of 5 for perfect fish to a 1 for extremely poor condition fish. For the year 2002 sampling period Table B1 displays the results from collection of condition and coloration data. Also starting in 2001 we noted old healed wounds, deformities (either resulting from a fish's genetic make up or an injury), and any new types of unexplained phenomena (Table B2).

Figure B1. Fish condition assessment notation.

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

2. Coloration:
   - **B**: Bright
   - **I**: Intermediate
   - **D**: Dark

3. Descaling, left side; estimate actual percentage descaled

4. Descaling, right side; estimate actual percentage descaled

5. Gill net marks

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

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

8. Head Injuries
    - **E**: Eye
    - **N**: Nose
    - **M**: Mouth
    - **J**: Jaw
    - **O**: Opercula/gill
    - **H**: Fishing hook

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

10. Gas Bubble Trauma monitoring
    - **0**: 0 % area affected
    - **1**: 1 to 5 % area affected
    - **2**: 6 to 25 % area affected
    - **3**: 26 to 50 % area affected
    - **4**: > 50 % area affected

11. Headburn

    Location:
    - **1**: Left dorsal
    - **2**: Right dorsal
    - **3**: Left lateral
    - **4**: Right lateral

    Severity:
    - **A**: Abrasion
    - **L**: Lesion
    - **B**: Blister

    Coverage:
    - **1**: 1 to 25 %
    - **2**: 26 to 50 %
    - **3**: > 50 %

LOCATION:__________ **SPECIES:**______**COHO**__________ **PAGE:**______**OF**______

DATE:__________ **WEEK:**__________ **Start WEATHER:**__________ **Stop WEATHER:**__________

CRITFC
Stock Identification Project

MARINE MAMMAL C G B N O **FINS** T AD D RV LV RP LP AN **OTHER** H C B G F P L D **HEAD** E N M J O

Updated 2/01

																Headburn					
Age	Age Comment	Card #	Position	Fork Length	Fin Clip	Condition (1-5)	Coloration (B,I,D)	Descaling left(%)	Descaling right(%)	Gill Net Damage	Marine M. (C,G,B)	N or O	Fin Injuires	Other Inj. H,C,B,G,F,P,L,D	Head Inj. E,N,M,J,O	Location (1-4)	Severity (A,L,B)	Coverage (1-3)	GBT	Time	Comments
			1																	:	
			2																	:	
			3																	:	
			4																	:	
			5																	:	
			6																	:	
			7																	:	
			8																	:	
			9																	:	
			10																	:	
			1																	:	
			2																	:	
			3																	:	
			4																	:	
			5																	:	
			6																	:	
			7																	:	
			8																	:	
			9																	:	
			10																	:	
			1																	:	
			2																	:	
			3																	:	
			4																	:	
			5																	:	
			6																	:	
			7																	:	
			8																	:	
			9																	:	
			10																	:	

START TIME: __________

STOP TIME: __________

SAMPLERS: __________

SAMPLE #
Coho __________
Chinook __________
Sockeye __________

Water T. °C
A Tank __________
R Tank __________
SPILL:
YES NO

Lead Time: __________

DAM COUNT:
Chinook __________
Coho __________
Sockeye __________

DATA ENTRY:
Computer __________
Check __________
Other __________

CODES

CONDITION
5 = marks? Do not break skin
4 = mark or injury breaks skin
3 = injury penetrates muscle
2 = injury penetrates body cavity
1 = missing large portion of body

COLORATION
Bright
Intermediate
Dark

HEADBURN
Location
1 = L dorsal
2 = R dorsal
3 = L lateral
4 = R lateral
Severity
A = abrasion
L = lesion
B = blister
Coverage
1 = 1 - 25 %
2 = 26 - 50%
3 = > 50 %

Figure B2. Sampling form used in adult salmonid sampling at Bonneville Dam in 2002.

Table B1. Composition (%) of observed condition and coloration categories of Columbia Basin salmon sampled at Bonneville Dam in 2002.

	Chinook Spring	Chinook Summer	Chinook Fall	Sockeye	Coho
Condition					
5	88.3	92.1	89.3	91.7	86.8
4	9.1	5.7	8.6	4.3	11.6
3	2.3	2.2	2.1	3.9	1.6
2	0.3	0	0	0.2	0
1	0	0	0	0	0
Color					
B	91.7	91.0	78.7	100.0	88.4
I	8.3	7.4	17.6	0	10.0
D	0	1.6	3.7	0	1.6

Table B2. Composition (%) of observed old wounds, deformities, or new phenomenon of Columbia Basin salmon sampled at Bonneville Dam in 2002.

New Data	Chinook Spring	Chinook Summer	Chinook Fall	Sockeye	Coho
Old Wound	9.0 (2.3)	14.4 (2.7)	13.2 (5.6)	11.0 (6.1)	11.9 (5.7)
Deformity	1.1 (0.8)	1.3 (0.4)	0.5 (0.5)	2.3 (0.5)	2.9 (2.1)
Sore / Rash	0.1 (0)	2.8 (0)	8.5 (1.6)	43.3 (1.3)	25.2 (32.5)
Wart / Bumps	0.1 (0)	0 (0)	1.0 (0.6)	0 (0)	11.9 (4.8)

Numbers in parenthesis are from 2001 sampling season.

Table B3. Summary of fin clips observed on Columbia Basin salmon sampled at Bonneville Dam in 2002.

	Chinook – Spring	Chinook – Summer	Chinook – Fall	Sockeye	Coho
Single Clip					
AD	358	348	58	6	121
LV	5	3	0	0	0
RV	0	2	0	2	0
Multi Clips					
AD/LV	12	0	0	0	0
AD/RV	1	0	0	0	0
Total Sample #	**711**	**610**	**615**	**517**	**310**

Table B4. Length-at-age data for female and male bright fall chinook and coho salmon.

Age Class	0.1	1.0	0.2	1.1	0.3	1.2	0.4	R.1	R.3	N
Bright Fall Chinook Female										
Mean Fork Length (cm)		32.33	68.75	66.50	82.00	77.50	86.00			28.00
Maximum		33.0	70.0	66.5	86.0	77.5	86.0			28.0
Minimum		32.0	67.5	66.5	78.5	77.5	86.0			28.0
Standard Deviation		0.58	1.77	--	2.83	--	--			--
Sample Size		3	2	1	8	1	1			1
Bright Fall Chinook Male										
Mean Fork Length (cm)	47.75	32.88	66.00	51.83	83.00				80.00	
Maximum	48.5	34.5	72.5	63.0	89.5				80.0	
Minimum	47.0	30.5	60.5	42.0	74.5				80.0	
Standard Deviation	1.06	1.70	4.10	10.56	5.75				--	
Sample Size	2	4	13	3	7				1	
Coho Female										
Mean Fork Length (cm)		35.75		64.23				70.50		
Maximum		44.0		76.5				72.5		
Minimum		27.0		49.0				68.5		
Standard Deviation		6.99		8.18				2.83		
Sample Size		4		24				2		
Coho Male										
Mean Fork Length (cm)				70.58						
Maximum				81.0						
Minimum				52.5						
Standard Deviation				9.54						
Sample Size				6						

Table B5. Summary of age and length data of Columbia Basin salmon observed with VI tags.

VI tags 2002			
Tag	**Date**	**Length**	**Age**
Left Eye Red	8/13	82.5	1.3
	8/20	81.0	1.2
	8/27	71.5	1.2
	9/3	51.0	1.1
	9/5	81.0	R.3
	9/13	73.0	1.2
		49.0	1.1
	9/17	62.0	1.1
	9/19	33.0	1.0
		34.5	1.0
		59.0	1.1
	9/24	34.5	1.0
	10/15	32.0	1.0
		102.5	1.4
Right Eye Green	9/19	32.0	1.0
	9/24	30.0	1.0
		33.0	1.0
Left Eye Green	9/13	36.0	1.0
	10/1	34.0	1.0
Left Eye Blue	9/24	28.0	N

Note: All fish listed above were adipose fin clipped.