AGE AND LENGTH COMPOSITION OF COLUMBIA BASIN CHINOOK AND SOCKEYE SALMON AND STEELHEAD AT BONNEVILLE DAM IN 2006

Technical Report 07-04

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ABSTRACT

The Columbia River Inter-Tribal Fish Commission (CRITFC) conducted a field study at Bonneville Dam in 2006 to assess the age, length-at-age and stock composition of adult Pacific salmon migrating up the Columbia River. These data were then used to predict the 2007 Chinook salmon run. Adult spring, summer and fall Chinook salmon (*Oncorhynchus tshawytscha*), sockeye salmon (*O. nerka*) and summer-run steelhead (*O. mykiss*) were collected, sampled for scales and additional biological data, revived and released. Caudal fin clips were also taken from Chinook salmon and steelhead for later genetic analysis. Scales were examined to estimate age composition; the results contributed to an ongoing database for age structure of Columbia Basin salmon runs. Based on scale pattern analysis four-year-olds were the most abundant age group for spring Chinook salmon comprising 79.8% of the run. Five-year-olds were the most abundant age class for summer and fall Chinook making up 53.3% and 35.8% of their respective runs. Four-year-olds were the most abundant age group for sockeye salmon comprising 65% of the run, and three and four-year-old were the most abundant in steelhead comprising 39.7% and 35.4% respectively of the run. Based on fin marks for classification, the steelhead migration consisted of 70% hatchery- and 30% natural-origin steelhead. A-run steelhead, less than 78cm in length, comprised 71% of the steelhead run. B-run fish, equal to or greater than 78cm, comprised 29% of the run.

A year-class regression based on up to 19 years of data was used to predict spring, summer, and bright fall Chinook salmon population sizes for 2007. Based on three-year-old returns, the relationship predicts four-year-old returns of 55,400 (± 62,100, 90% predictive interval [PI]) spring Chinook, 13,600 (± 24,000, 90% PI) summer, and 116,200 (± 124,700, 90% PI) bright fall Chinook salmon for the 2007 runs. Based on four-year-old returns, the relationship predicts five-year-old returns of 13,700 (± 49,800, 90% PI) spring, 21,700 (± 9,200, 90% PI) summer, and 50,700 (± 44,200, 90% PI) bright fall Chinook salmon for the 2007 runs.

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INTRODUCTION

In 1985, the US-Canada Pacific Salmon Treaty was formed to manage research and enhance Pacific salmon (PSC 2000). The treaty established the Spawning Escapement-Monitoring program to assess indicator stocks within the Columbia River Basin and improve methods for providing population estimates, escapement monitoring, establishing spawner-recruit relationships and developing harvest management approaches (PST 1985). As part of this program, the Columbia River Inter-Tribal Fish Commission (CRITFC) has developed a comprehensive research strategy to monitor the age and stock composition of adult Pacific salmon returning to the Columbia River. This project has monitored the above Bonneville Dam adult migration of sockeye salmon (*Oncorhynchus nerka*) since 1985, spring Chinook salmon (*O. tshawytscha*) since 1987, summer Chinook salmon since 1990, and up-river bright fall Chinook salmon since 1998. Data on these runs are provided in near real time at www.critfc.org.

At the request of the NOAA Fisheries Northwest Fisheries Science Center, summer steelhead(*O. mykiss*) were added to our sampling regime in 2004. The Conservation Biology Division (NOAA Fisheries) formed the Mathematical Biology and Systems Monitoring Program to develop, in collaboration with the existing Salmon Science Programs and Salmon Recovery Planning Teams, quantitative tools for assessing population and habitat status and recovery potential and progress. Monitoring the age structure, hatchery fraction and stock composition of the adult Columbia River summer steelhead provides valuable information for this program.

Scale pattern analysis, the analysis of concentric rings or circuli to provide records of previous life history, is a common method for age determination in Pacific salmon (Nielsen and Johnson 1983). Fast summer growth widens the distances between circuli on the scale and slow winter growth shortens the distance between circuli. Typically, age can be determined by counting the number of winters observed on the scale (Gilbert 1913, Rich and Holmes 1929). This method is valuable in Pacific salmon management because scales can be collected without sacrificing the fish and scale samples can be collected, processed, and aged promptly. Problems with this method may include variability in scale growth, scale resorption, and difficulties in age validation (Knudsen 1990, Beamish and McFarlane 1983).

Scale pattern analysis can also be used for stock identification if distinctive patterns can be linked to specific stocks. This method has generally been successful in discriminating Columbia River sockeye partly because there are only two major runs of sockeye in the system, which experience dramatically different early rearing environments (Fryer 1995). However, this method was found to be less successful with Chinook salmon where numerous populations can exhibit similar scale growth patterns. Currently a coast wide genetic database is being developed to create baseline microsatellite and SNP (Single Nucleotide Polymorphim) genetic data for individual Chinook populations throughout the region. This baseline genetic stock information can be utilized in mixed stock sampling to distinguish individual stocks and will be useful for the Chinook sampling program at Bonneville Dam.

The primary objectives for the 2006 sampling year were to estimate the age composition and length-at-age composition of Chinook, sockeye and steelhead using scale pattern analysis, to forecast the 2007 run size for Chinook salmon using the age composition data, to PIT tag summer Chinook and sockeye salmon, and to collect tissue samples for use in the development of a genetic stock monitoring and identification program for Chinook salmon and steelhead.

METHODS

Study Area

Research was conducted at the Adult Fish Facility (AFF) located adjacent to the Second Powerhouse at Bonneville Dam (river km 235) on the north side of the Columbia River (Figure 1). This facility uses a picket weir to divert migrating fish, ascending the Washington shore fish ladder, into the adult sampling facility collection pool. An attraction flow is used to draw fish through a false weir where they can be selected for sampling. Fish not selected and fish that have recovered from sampling are returned to the Washington Shore Fish ladder above the picket weir.

Chinook salmon generally migrate between March and November and are typically categorized into three races based on migration timing past Bonneville Dam. Chinook salmon passing Bonneville from March 15 through June 15 are classified as spring Chinook, from June 16 through July 31 are classified as summer Chinook and August 1 through November 15 are classified as fall Chinook. The fall Chinook run consists of lower river Tules and the Upriver Bright fall Chinook. Based on the needs of the Pacific Salmon Commission, this study only collects information on Upriver Bright fall Chinook. Sockeye salmon typically migrate between May 15 and August 1 and summer-run steelhead between April 1 and October 31. The steelhead run is further divided into A- and B-run components based on length (greater than 78 cm for B-run).

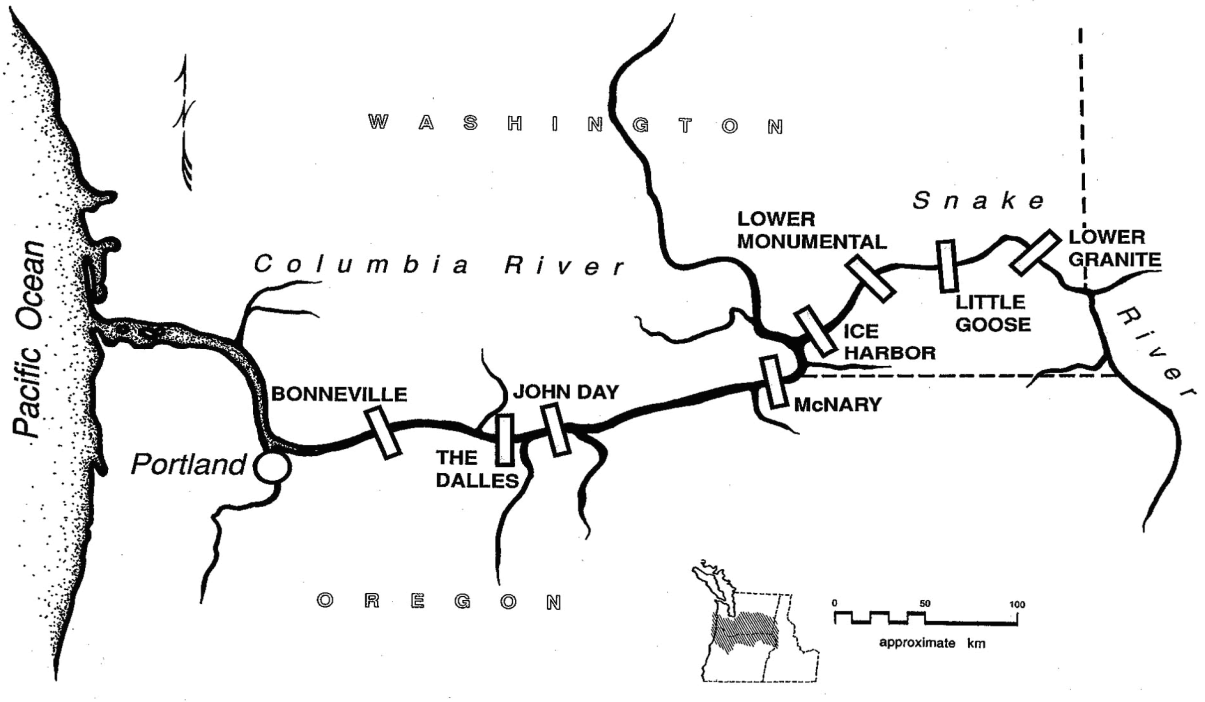

Figure 1. Map of the Columbia River displaying federal dams. Bonneville Dam (rkm 235)

Sample Design

Adult fish were sampled one to three days per Statistical Week[1] from March through October. A desired minimum sample size of 610 fish each was set for spring, summer, and fall Chinook, steelhead and sockeye salmon. This sample size was derived from simulations we conducted based on the work of Thompson (1987) and assumes that the sample is distributed approximately proportional to the weekly run size. It also assumes that our weekly sample represents a random sample of the run passing over Bonneville Dam that week. These sample sizes achieved precision and accuracy levels of $d=0.05$, $\alpha=0.10$ for age composition estimates. Additional samples were collected to buffer for unreadable scales as well as to provide more precision in weekly age composition estimates. The composite age and length-at-age estimates were calculated from weekly estimates weighted by the number of each species migrating past Bonneville Dam during the sample week (Fryer 1995). Weekly and annual fish passage[2] counts were obtained from DART (2006) and the Fish Passage Center (2006).

Fish Collection

Fish of each species were trapped at the AFF and anesthetized. Chinook salmon under 35 cm in length were not sampled to exclude precocious juveniles (known as *minijacks*). All sizes of sockeye and steelhead were sampled. Each fish was measured for fork length to the nearest 0.5 cm, checked for identifying fin marks, tags, coloration and condition. Scale samples were collected from all fish for aging and caudal fin tissue was collected from all Chinook salmon for genetic stock composition analysis. These genetic samples will be used in the development of a genetic stock identification program for Columbia River Chinook salmon. Beginning approximately May 15, all fish sampled were scanned for PIT tags and any PIT tag codes recorded. Summer Chinook and non-adipose clipped sockeye salmon sampled on or after June 14, 2006 were PIT tagged. All fish were revived in a freshwater tank or pool and returned to a fishway leading to the Washington shore fish ladder.

Fish Coloration and Condition

Fish coloration and condition were recorded for all species at the time of sampling. Coloration was based on qualitative observations with the categories of Bright, Intermediate and Dark. Overall fish condition was also qualitatively assessed and classified on a scale of 1 to 5. Fish classified as a 5 had no major injuries that break the skin, 4 had injuries that broke the skin, 3 had injuries that penetrate the muscle tissue, 2 had injuries that penetrate a body cavity and 1 are fish missing large sections of the body. In addition to the fish condition classification, specific recognizable injuries or afflictions were recorded. These included percentage of descaling, marine mammal injuries, net damage, parasites, fungus, headburn[3], gas bubble trauma, deformities, and various other injuries.

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1. 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 2006, for example, Statistical Week 15 began on April 9 and ended on April 15.
2. Tule fall Chinook counts are subtracted from the total fall Chinook counts to estimate the upriver bright fall Chinook.
3. 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, Groberg 1996).

Age Determination

To minimize the scale sample rejection rate, six scales (three per side) were collected for each Chinook and steelhead sampled (Knudsen 1990) and four scales (two per side) were collected from each sockeye salmon sampled. Scales were mounted and pressed according to methods described by 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 were independently reviewed by John Sneva of the Washington Department of Fish and Wildlife for corroboration of age estimates. Direct age validation (Beamish and McFarlane 1983) was not performed, as there were no marked fish whose age was known.

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.

Age and Length-at-Age Composition

Age composition was determined by weighing the proportion of each age class sampled by the total counts of each species passing Bonneville dam during each Statistical Week. The length-at-age composition for each species sampled was determined by calculating the mean length for each age class present during each Statistical Week.

Steelhead Hatchery/Wild Determination

Most hatchery reared steelhead in the Columbia River Basin are marked by removing a fin, typically the adipose fin. Some hatchery-origin steelhead are released unmarked and to identify these individuals scale pattern analysis methods were developed by Oregon Department of Fish and Wildlife (ODFW) to determine hatchery versus wild origin. Hatchery steelhead typically experience faster freshwater growth which results in relatively wide spaces between circuli, whereas natural origin fish typically show much slower fresh water growth narrowing the distance between circuli. In addition, hatchery origin fish are reared to smolt in a single year whereas the natural origin fish tend to remain in fresh water for two to three years.

Due to the wide variety of requests for hatchery and wild determinations by various agencies using different methods, we decided in 2006 to allow the managing agencies to make their own determinations based on the raw age, scale pattern, and fin mark data. For this report hatchery and wild determinations are based on fin clips alone.

Steelhead A/B Run Determination

A-run steelhead occur throughout the Columbia and Snake river basins and rarely exceed the length of 78 cm, whereas B-run steelhead are thought to be produced only in the Clearwater, Middle Fork Salmon, and South Fork Salmon rivers and typically exceed 78cm (Busby et al. 1996). Determination of A-run or B-run was based on length measurement.

Steelhead Gender Determination

Methods developed by ODFW were used in gender determination. Gender was determined by snout and/or body shape. Male steelhead tend to have a more protruding snout and may have beak development. Female steelhead tend to have a more rounded, short snout and a wider body near the anus indicating they contain roe.

Steelhead Kelts

Unlike other species of Pacific salmon *(Oncorhynchus spp.),* anadromous steelhead naturally exhibit varying degrees of iteroparity (repeat spawning). Successful steelhead iteroparity involves downstream migration of kelts (post-spawned steelhead) to the estuary or ocean environments (Hatch et al. 2003). During scale pattern analysis we found a few steelhead scales to have a iteroparous scale pattern. A kelt scale age is indicated through the use of the letter "S" to indicate spawning. For instance, a steelhead of Age 1.2S1 would have one freshwater annulus, two saltwater annuli, a spawning check, followed by one saltwater annulus. Note that scale resorption often occurs in kelts which can eliminate saltwater annuli marks so a kelt is likely older than would be indicated by summing the annuli. .

Chinook Salmon Run-Size Prediction

Salmon mature and return to spawn between two and seven years of age. Age composition, life history and total age vary among species. For this analysis a brood year (BY) is defined as the year in which the eggs are fertilized and a brood is defined as all the returning progeny of a given BY. This run-size prediction model is based on the relationship between the survivors within a single brood returning at different ages in successive years.

Fryer and Schwartzberg (1994) determined that adult returns of Columbia basin Chinook are comprised almost entirely of 3, 4 and 5 year old fish, with the proportions of each age class being relatively constant across years. As such, the number of three-year-old fish for a given BY is a relatively good predictor of the number of four-year-old fish from the same BY that would return in the subsequent year. This relationship and a regression analysis (Neter et al. 1985, Weisberg 1985) were used to predict the abundance of four-year-old fish for 2006, based on the number of three-year-old fish estimated to have returned in 2006. A similar relationship was used to predict abundance of five-year-old fish in 2007, from the estimated number four-year-old fish that returned in 2006.

RESULTS

Sampling

Chinook salmon (spring, summer and fall) were sampled for 21 weeks (April through October) during their migration. A total of 923 spring Chinook were sampled, 665 summer Chinook and 882 fall Chinook (Tables 1, 2 and 3 respectively). A total of 556 sockeye salmon were sampled (Table 4) over 8 weeks (June through July), and 1459 steelhead were sampled (Tables 5 and 6) over 28 weeks (April through October). Summer Chinook were not sampled during Statistical Week 31 and Fall Chinook were not sampled during Statistical Weeks 31 through 35 due to river water temperatures exceeding 21.1°C, which is approaching the lethal temperature for migrating adult Chinook salmon (McCullough 1999).

Age Composition

Based on scale pattern analysis four-year-olds were the most abundant age group for spring Chinook salmon, comprising 79.8% of the spring Chinook migration (Table 1, Figure 2). However, five-year-olds were the most abundant group for summer and fall Chinook salmon, comprising 53.3% of the summer Chinook migration (Table 2) and 35.8% of the fall Chinook migration (Table 3). Five-year-old fish were second most abundant for spring Chinook, while four-year-olds were second most abundant for summer and fall Chinook. For all three races, three-year-old fish were third most abundant.

Scale patterns indicated a steady increase in the percentage of ocean-type Chinook salmon from 0% in Statistical Week 21 to above 90% after Statistical Week 39, with a corresponding decrease in the percentage of stream-type Chinook salmon (Figure 3).

The Sockeye salmon run also was composed primarily of four-year-olds (65.0%), with five-, three-, and six-years-olds being less abundant (Table 4).

The steelhead age composition was composed of mostly three-year-olds (39.7%) and four-year-olds (35.4%) which based on fin clips and a single year of freshwater residence is likely due to the large percentage of hatchery origin fish in this run (Table 5, Table 6). Five-year-olds were the next most abundant at 19.1%.

Table 1. Weekly and cumulative age composition of Columbia Basin spring Chinook at Bonneville Dam in 2006.

Statistical Week	Sampling Date	Number Sampled	Number Ageable	Weekly Run Size	2003		2002		2001		2000
					0.2	1.1	0.3	1.2	0.4	1.3	1.4
17[a]	4/14,21,24,26,28	69	66	4455				0.894		0.091	0.015
18	5/1,5/3,5/5	200	177	23639		0.006	0.006	0.927		0.062	
19	5/8,5/10	160	132	40422				0.955		0.045	
20	5/16,5/17,5/19	150	129	17838		0.047		0.868		0.085	
21	5/22,5/24,5/26	100	90	8293		0.078		0.778		0.144	
22[b]	5/31,6/2	74	65	4670		0.092		0.769	0.046	0.077	0.015
23	6/5,6/7,6/9	100	90	13477	0.011	0.033	0.044	0.456	0.278	0.167	0.011
24[c]	6/12,6/14	70	65	13364		0.015	0.062	0.231	0.385	0.231	0.077
Through June 15		**923**	**814**	**126158**	**0.001**	**0.021**	**0.012**	**0.786**	**0.072**	**0.096**	**0.010**
Through May 31[d]		**718**	**622**	**97687**	**0.000**	**0.020**	**0.001**	**0.908**	**0.001**	**0.068**	**0.002**

Notes:

a The official spring Chinook salmon run begins on March 15 (Week 12). Sampling began in Week 16 but only five fish were sampled and were combined with Week 17. The weekly run size includes Chinook salmon passing Bonneville Dam in Weeks 12-17.

b. For the May 31 estimates, the spring Chinook run size for Week 22 includes fish passing Bonneville Dam for during the early part of Week 23 (May 27-31)

c. The weekly run size only includes those fish passing through June 15.

d. May 31 estimates are presented for a better comparison to previous years when the spring Chinook run at Bonneville Dam ended on May 31.

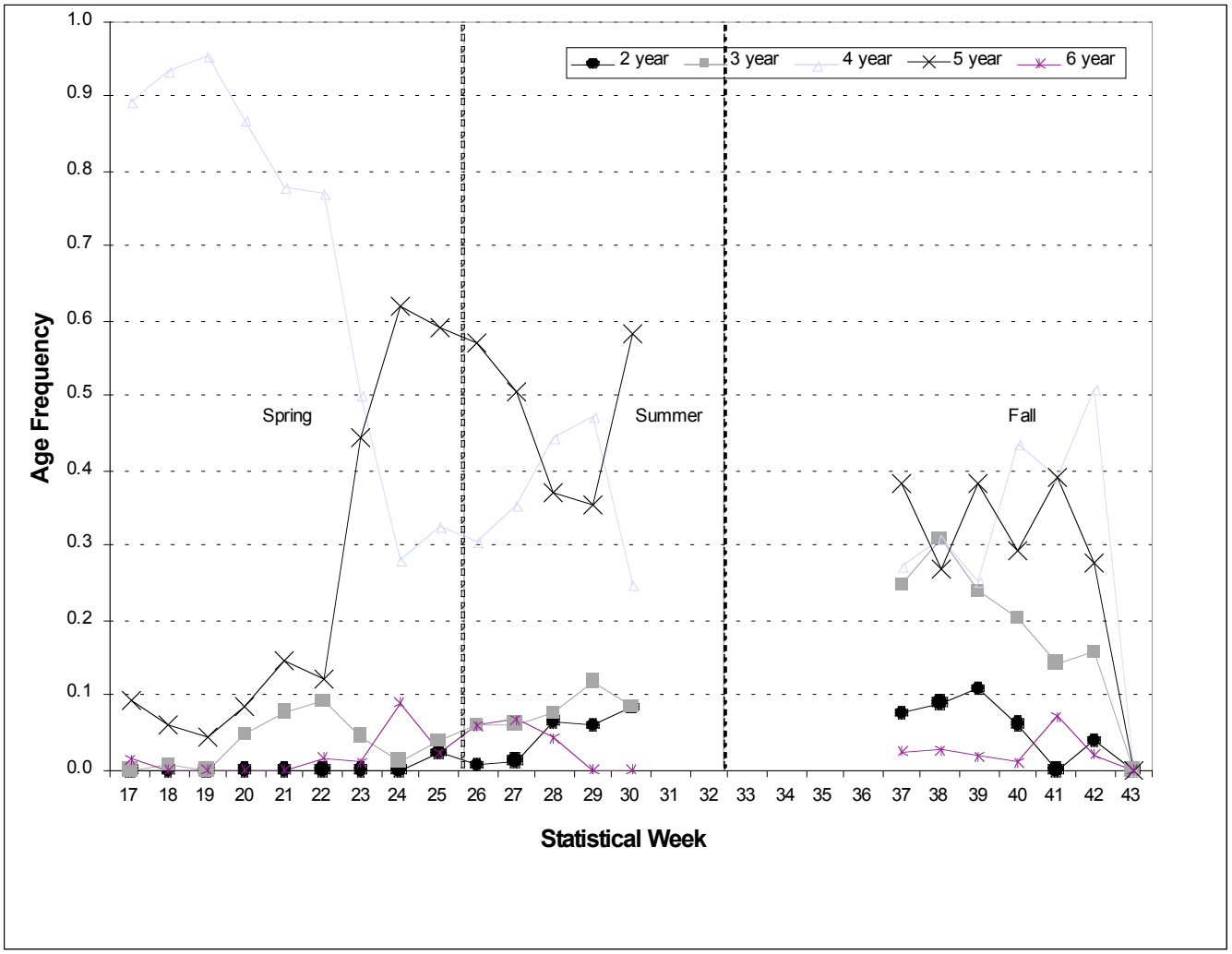

Figure 2. : Weekly age composition estimates for age groups of Columbia Basin Chinook salmon sampled at Bonneville Dam in 2006.

Table 2. Weekly and cumulative age composition of Columbia Basin summer Chinook salmon sampled at Bonneville Dam in 2006.

Statistical Week	Sampling Date	Number Sampled	Number Ageable	Weekly Run Size	2004	2003		2002		2001		2000
					0.1	0.2	1.1	0.3	1.2	0.4	1.3	1.4
24	6/16	24	24	4921				0.167	0.083	0.458	0.167	0.125
25	6/20,6/21,6/23	141	129	17374	0.023		0.039	0.171	0.155	0.434	0.155	0.023
26	6/26,6/28,6/30	190	170	19289	0.006	0.018	0.041	0.129	0.176	0.300	0.271	0.059
27	7/5,7/6,7/7	181	161	10271	0.012	0.006	0.056	0.224	0.130	0.298	0.205	0.068
28	7/10,7/12	100	92	6728	0.065	0.011	0.065	0.272	0.174	0.228	0.141	0.043
29	7/17,7/19,7/21	17	17	5192	0.059		0.118	0.412	0.059	0.235	0.118	
30	7/24,7/26	12	12	4044	0.083		0.083	0.167	0.083	0.333	0.250	
Cumulative		**665**	**605**	**67819**	**0.025**	**0.007**	**0.051**	**0.195**	**0.142**	**0.335**	**0.198**	**0.046**

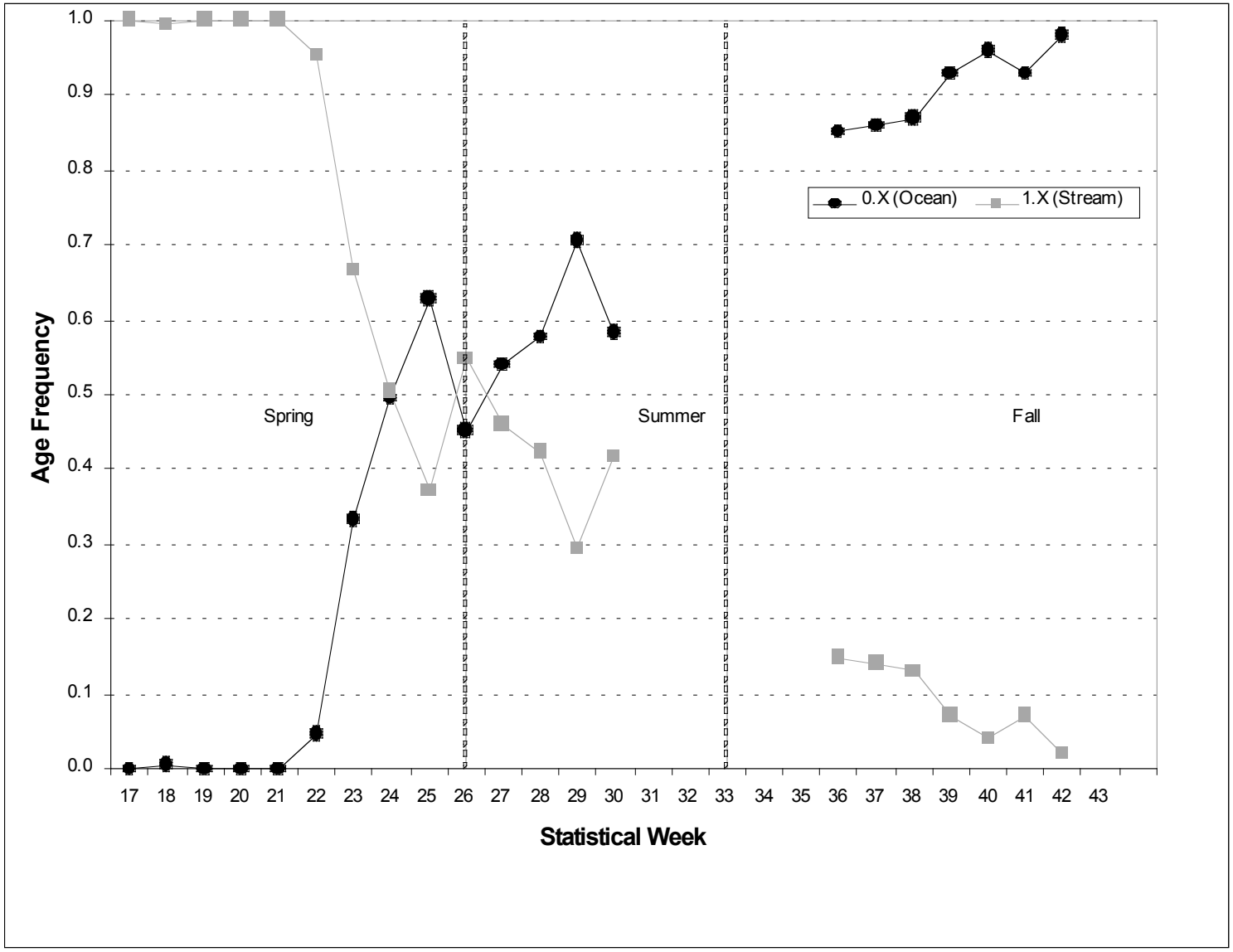

Figure 3. Weekly freshwater age composition estimates of Columbia Basin Chinook salmon sampled at Bonneville Dam in 2006.

Table 3. Weekly and cumulative age composition of Columbia Basin bright fall Chinook salmon sampled at Bonneville Dam in 2006.

Statistical Week	Sampling Date	Number Sampled	Number Ageable	Weekly Run Size	2004	2003		2002		2001		2000	
					0.1	0.2	1.1	0.3	1.2	0.4	1.3	1.4	0.5
36[a]	9/5,9/6,9/8	180	174	141610	0.075	0.103	0.063	0.305	0.034	0.356	0.029	0.011	0.023
37	9/11,9/13,9/15	180	170	36955	0.076	0.188	0.059	0.247	0.024	0.335	0.047	0.012	0.012
38	9/18,9/20,9/22	157	146	52238	0.089	0.247	0.062	0.281	0.027	0.240	0.027	0.014	0.014
39	9/25,9/27,9/29	177	167	28909	0.108	0.204	0.036	0.240	0.012	0.371	0.012	0.006	0.012
40	10/2,10/4,10/6	105	99	13339	0.061	0.202		0.404	0.030	0.293			0.010
41	10/10,10/12	30	28	5898		0.143		0.393		0.393			0.071
42[b]	10/17,10/19	53	51	6127	0.039	0.137	0.020	0.510		0.275		0.020	
Cumulative		**882**	**835**	**285076**	**0.078**	**0.157**	**0.054**	**0.297**	**0.028**	**0.330**	**0.027**	**0.011**	**0.019**

Notes:

a The fall Chinook run began on Week 31, however high temperatures prevented sampling prior to Week 36. The weekly run size for Week 36 includes 58,232 Chinook which passed during Weeks 30-35.

b. The weekly run size includes Chinook salmon passing from Weeks 43 through 47.

Length-at-Age Composition

Length-at-age composition estimates for all Chinook salmon are presented in Figure 4 and Appendix A.

Steelhead Hatchery/Wild Determination

When classifying hatchery and wild steelhead based on fin marks, the run consisted of 70.0% hatchery and 30.0% wild steelhead (Table 6).

Steelhead A/B Determination

Assuming that A-run (less than 78 cm) and B-run (greater than 78 cm) steelhead can be differentiated by length alone, the majority of the steelhead run (71.0%) passing Bonneville Dam were A-run, and the remaining 29.0% were B-run. Though A-run steelhead dominate the run, the percentage of B-run fish does generally increase as the run progresses (Table 6).

Steelhead Gender Determination

The 2006 steelhead consisted of 52.0% females and 48.0% males (Table 6).

Table 4. Weekly and cumulative age composition of Columbia Basin sockeye salmon sampled at Bonneville Dam in 2006.

Statistical Week	Sampling Date	Number Sampled	Number Ageable	Weekly Run Size	2003	2002		2001			2000		
					1.1	1.2	2.1	1.3	2.2	3.1	2.3	3.2	4.1
23	6/2,5,7,9	11	11	991		0.727			0.273				
24	6/12,6/14,6/16	81	74	5552		0.595	0.054	0.189	0.162				
25	6/20,6/21,6/23	95	92	9433		0.609		0.185	0.174	0.022	0.011		
26	6/26,6/28,6/30	169	165	12467		0.679	0.018	0.176	0.109	0.018			
27	7/5,7/6,7/7	138	127	5787	0.024	0.614	0.024	0.228	0.102	0.008			
28	7/10,12,17,19,21	62	58	2836	0.034	0.552	0.034	0.155	0.207	0.017			
Cumulative		**556**	**527**	**37066**	**0.006**	**0.630**	**0.021**	**0.182**	**0.144**	**0.014**	**0.003**	**0.000**	**0.000**

a Weekly run size includes sockeye passing Bonneville Dam between Weeks 20 and 22. Sampling began in Week 22 but only one fish was sampled, thus it was combined with Week 23.

b. Weekly run size includes sockeye salmon passing Bonneville Dam between Weeks 29 and 43. Sampling ended in Week 30.

Table 5. Weekly and cumulative age composition of Columbia Basin steelhead sampled at Bonneville Dam in 2006.

Statistical Week	Sampling Date	Number Sampled	Number Ageable	Weekly Run Size	2003	2002		2001			2000				1999		Repeat Spawner
					1.1	1.2	2.1	1.3	2.2	3.1	1.4	2.3	3.2	4.1	3.3	4.2	
16	4/21	5	4	932	0.250	0.750											
17	4/24,4/26,4/28	12	10	205	0.100	0.500		0.100	0.300								
18	5/1,5/3,5/5	5	4	212	0.750		0.250										
19	5/8,5/10	6	3	304	0.667				0.333								
20	5/16,5/17,5/19	10	8	405	0.250	0.625				0.125							
21	5/22,5/24,5/26	14	10	408	0.100	0.500		0.100	0.300								
22	5/31,6/2	10	6	486	0.500	0.167			0.167				0.167				
23	6/5,6/7,6/9	19	15	977	0.400	0.533	0.067										
24	6/12,6/14,6/16	9	6	1333	0.500	0.333	0.167										
25	6/20,6/21,6/23	17	12	1586	0.583	0.250			0.167								
26	6/26,6/28,6/30	83	67	3610	0.433	0.299	0.060	0.015	0.119				0.075				
27	7/5,7/6,7/7	77	67	5177	0.433	0.313	0.075		0.134	0.015			0.030				
28	7/10,7/12	130	105	9353	0.390	0.248	0.133		0.143	0.038			0.048				
29	7/17,7/19,7/21	18	15	12839	0.267	0.067	0.267	0.067	0.200	0.067					0.067		
30	7/24,7/26	39	27	15216	0.370	0.185			0.296				0.148				
31	7/31,8/1,8/2,8/3	73	56	23899	0.339	0.304	0.089		0.179	0.036			0.054				
32	8/7,8/9,8/10	26	20	38982	0.450	0.250	0.050		0.150				0.100				
33	8/14,8/15,8/16,8/17	58	52	35838	0.442	0.346	0.019	0.019	0.115	0.038				0.019			
34	8/21,8/22,8/23,8/24	15	12	30082	0.750	0.083			0.083								0.083
35	8/28,8/29,8/30,8/31	29	26	34175	0.423	0.423	0.038		0.077				0.038				
36	9/4,9/5,9/6,9/8	195	160	36676	0.388	0.394	0.013	0.119	0.019	0.013		0.019	0.038				
37	9/11,9/13,9/15	170	136	25160	0.199	0.404	0.022	0.272	0.059			0.007	0.022		0.007	0.007	
38	9/18,9/20,9/22	129	110	22977	0.282	0.400		0.273	0.009				0.018		0.009		0.009
39	9/25,9/27,9/29	154	135	10621	0.200	0.341	0.022	0.356	0.030	0.015	0.007	0.015			0.007		0.007
40	10/2,10/4,10/6	82	65	5772	0.154	0.523	0.062	0.169	0.015	0.015		0.015	0.031		0.015		
41	10/10,10/12	40	33	2456	0.333	0.455	0.061	0.091					0.030				0.030
42	10/17,10/19	30	25	2105	0.360	0.400		0.040	0.040	0.080			0.080				
43	10/24	4	4	1204		0.500		0.250	0.250								
Cumulative		**1459**	**1193**	**322990**	**0.397**	**0.312**	**0.042**	**0.076**	**0.101**	**0.014**	**0.000**	**0.003**	**0.039**	**0.002**	**0.004**	**0.001**	**0.009**

a. Sampling was limited to 4 hours per day (6am – 10 am) from week 29 through week 36 due to high water temperatures.

Table 6. Weekly and cumulative proportions of fin mark, gender, and A (less than 78cm) and B (greater or equal to 78cm) run composition of Columbia Basin steelhead sampled at Bonneville Dam in 2006.

Statistical	Sampling	Total Run		Unmarked Proportion				Fin Clips	
Week	Date	A run	B run	A run	B run	Female	Male	Adipose	Other
16	4/21	1.00	0.00	0.20	0.00	0.40	0.60	0.40	0.40
17	4/24,4/26,4/28	1.00	0.00	0.42	0.00	0.75	0.25	0.42	0.17
18	5/1,5/3,5/5	1.00	0.00	0.40	0.00	0.60	0.40	0.40	0.20
19	5/8,5/10	1.00	0.00	0.17	0.00	0.17	0.83	0.67	0.17
20	5/16,5/17,5/19	0.80	0.20	0.20	0.00	0.50	0.50	0.80	0.00
21	5/22,5/24,5/26	1.00	0.00	0.21	0.00	0.50	0.50	0.79	0.00
22	5/31,6/2	0.80	0.20	0.30	0.00	0.60	0.40	0.70	0.00
23	6/5,6/7,6/9	0.89	0.11	0.37	0.00	0.47	0.53	0.53	0.11
24	6/12,6/14,6/16	1.00	0.00	0.22	0.00	0.56	0.44	0.78	0.00
25	6/20,6/21,6/23	0.94	0.06	0.29	0.00	0.53	0.47	0.59	0.12
26	6/26,6/28,6/30	0.97	0.03	0.31	0.00	0.75	0.25	0.54	0.10
27	7/5,7/6,7/7	0.98	0.02	0.39	0.00	0.56	0.44	0.60	0.06
28	7/10,7/12	0.98	0.02	0.45	0.02	0.65	0.35	0.48	0.05
29	7/17,7/19,7/21	1.00	0.00	0.72	0.00	0.78	0.22	0.17	0.11
30	7/24,7/26	1.00	0.00	0.51	0.00	0.44	0.56	0.44	0.05
31	7/31,8/1,8/2,8/3	0.99	0.01	0.45	0.01	0.69	0.31	0.48	0.05
32	8/7,8/9,8/10	0.96	0.04	0.38	0.04	0.54	0.46	0.54	0.04
33	8/14,8/15,8/16,8/17	0.93	0.07	0.21	0.05	0.47	0.53	0.64	0.10
34	8/21,8/22,8/23,8/24	1.00	0.00	0.20	0.00	0.50	0.50	0.80	0.00
35	8/28,8/29,8/30,8/31	0.83	0.17	0.21	0.00	0.38	0.62	0.69	0.10
36	9/4,9/5,9/6,9/8	0.62	0.38	0.11	0.09	0.50	0.50	0.72	0.08
37	9/11,9/13,9/15	0.46	0.54	0.09	0.12	0.42	0.58	0.74	0.05
38	9/18,9/20,9/22	0.47	0.53	0.08	0.06	0.50	0.50	0.80	0.06
39	9/25,9/27,9/29	0.42	0.58	0.11	0.12	0.45	0.55	0.71	0.06
40	10/2,10/4,10/6	0.40	0.60	0.17	0.11	0.40	0.60	0.59	0.13
41	10/10,10/12	0.65	0.35	0.08	0.08	0.50	0.50	0.65	0.20
42	10/17,10/19	0.77	0.23	0.10	0.07	0.53	0.47	0.73	0.10
43	10/24	0.50	0.50	0.25	0.25	0.25	0.75	0.50	0.00
Cumulative		**0.71**	**0.29**	**0.23**	**0.06**	**0.52**	**0.48**	**0.63**	**0.07**

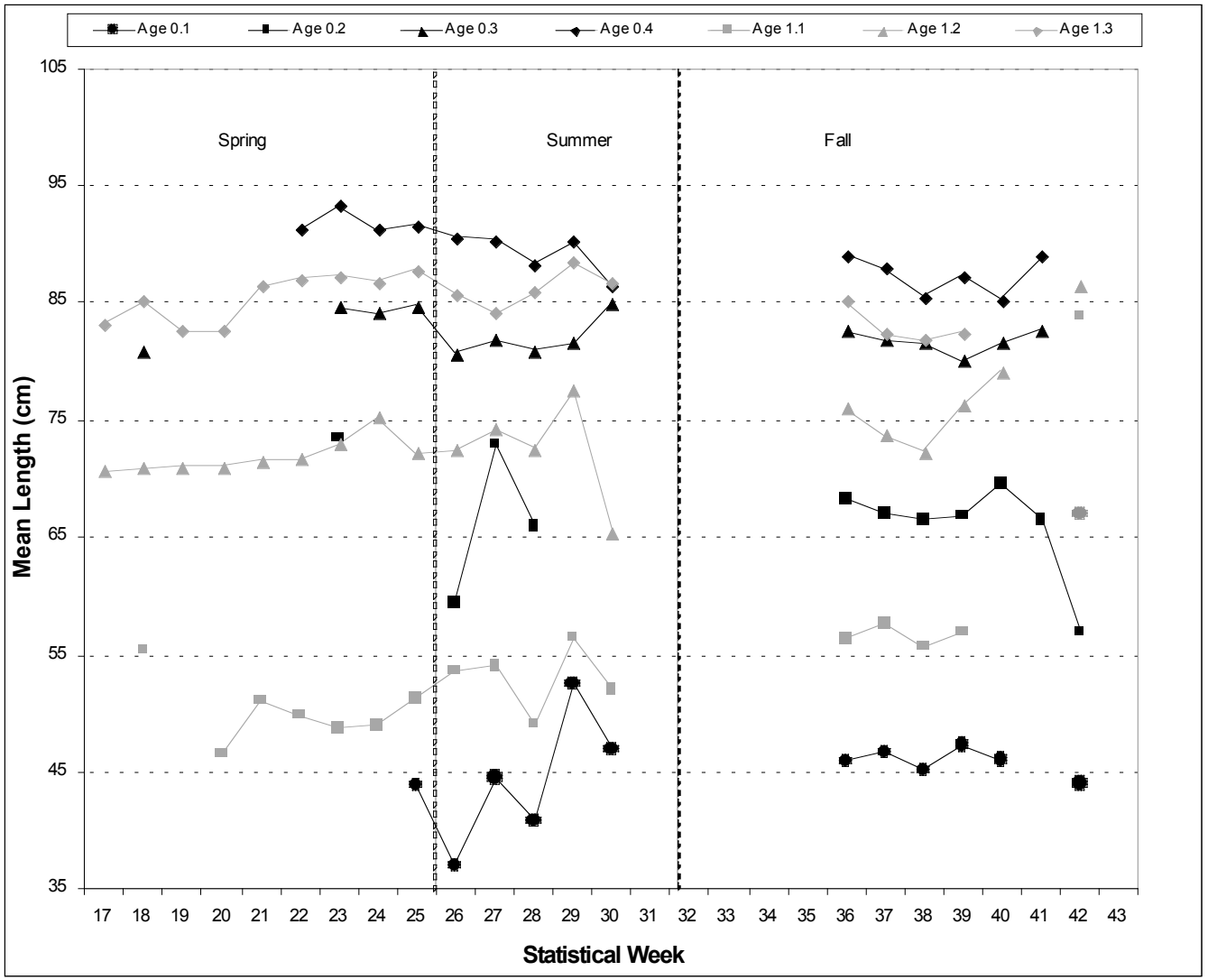

Figure 4. Weekly mean length estimates of common Columbia Basin Chinook salmon age classes (showing ocean- and stream-type) sampled at Bonneville Dam in 2006. Sampling did not occur during Weeks 31 through 35.

Fish Coloration and Condition

Bright coloration was observed in the majority of each species, 97.6% of spring Chinook, 95.5% of summer Chinook, 79.4% of fall Chinook, 100.0% of sockeye and 88.4% of steelhead. The highest condition rating of 5 was given to 85.6% of spring Chinook, 88.2% of summer Chinook, 79.4% of fall Chinook, 96.6% of sockeye and 83.4% of steelhead (Table 7). Additional fish condition data can be found in Appendix A.

Table 7. Composition (%) of observed coloration and condition of Columbia Basin salmon and steelhead at Bonneville Dam in 2006.

Species	Spring	Summer	Fall	Sockeye	Steelhead
Color					
Bright	97.6	95.5	79.4	100.0	88.4
Intermediate	2.4	4.2	15.5	0.0	11.2
Dark	0.0	0.3	5.1	0.0	0.4
Condition					
5	85.9	88.3	79.4	96.6	83.4
4	7.5	8.6	13.2	2.3	11.5
3	6.3	3.2	7.1	1.1	4.3
2	0.3	0.0	0.3	0.0	0.8
1	0.0	0.0	0.0	0.0	0.0

Chinook Salmon Run-Size Prediction for 2007

Using a linear relationship between the 2006 three- and four-year-old adult returns (Figure 5), the estimated number of four-year-old spring Chinook salmon returning to Bonneville Dam in 2007 is 55,400 (± 62,100, 90% prediction interval [PI]). Using the relationship between four- and five-year-olds to construct the model (Figure 6), albeit poorer than that existing between three-year-olds and four-year-olds, we predict that the 2006 five-year-old adult abundance at Bonneville Dam will be 13,700 (± 49,800, 90% PI).

For the 2006 summer Chinook salmon run at Bonneville Dam, the relationship between three- and four-year-olds (Figure 7) results in a prediction of 13,600 (± 24,000, 90% PI) four-year-olds. The relationship between four- and five-year-olds (Figure 8), the model predicts a return of 21,700 (± 9,200, 90% PI) five-year-olds.

Based on the relationship between three- and four-year-olds (Figure 9), the model results in a prediction of 116,200 (± 124,700, 90% PI) four-year-old Upriver Bright fall Chinook salmon returns for 2006. Using the relationship between four- and five-year-olds (Figure 10), the model results in a prediction of 50,700 (± 44,200, 90% PI) returning five-year-olds.

Based on the 2005 report (Whiteaker et al. 2006), we made run size predictions for four- and five-year-old spring, summer, and bright fall Chinook salmon returning to Bonneville Dam in 2006 using the methods discussed in this report. For the two principle age groups (four-year-old and five-year-old), we predicted 99,600 spring, 44,200 summer, and 186,400 bright fall Chinook versus DART (2006) and the Fish Passage Center (2006) estimated returns of 122,000 spring, 59,100 summer and 194,200 bright fall Chinook salmon. All six age groups predicted for 2006 were within the 90% prediction interval (Table 8). Overall, we predict the 2006 return of four- and five-year old spring, summer, and fall Chinook salmon will all be less than the 2006 return (Table 8).

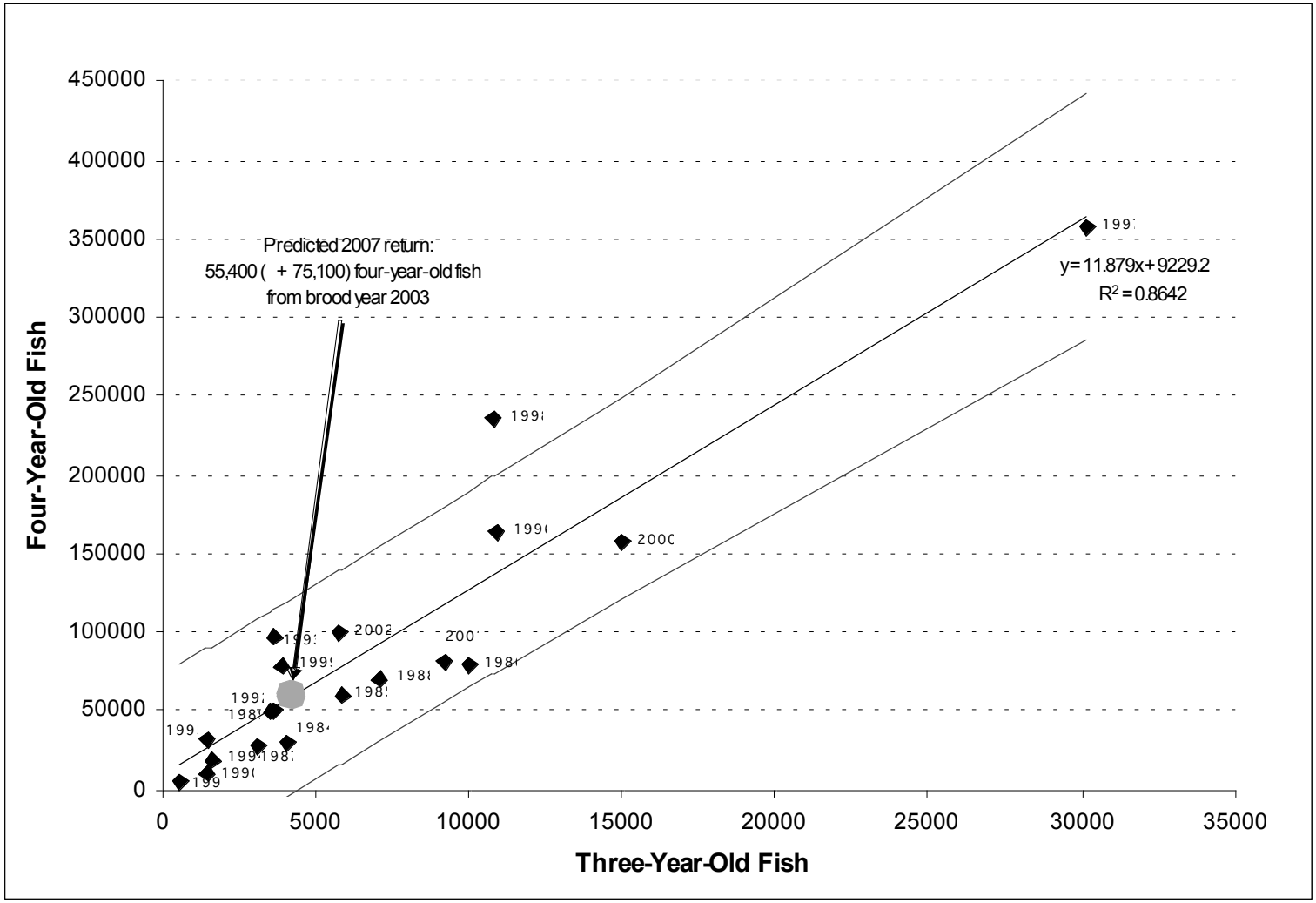

Figure 5. Predicted 2007 four-year-old Columbia Basin spring Chinook salmon abundance (at Bonneville Dam) based on a linear relationship between four-year-old and three-year-old fish abundance during brood years 1984 through 2002. Prediction intervals (90%) are also graphed.

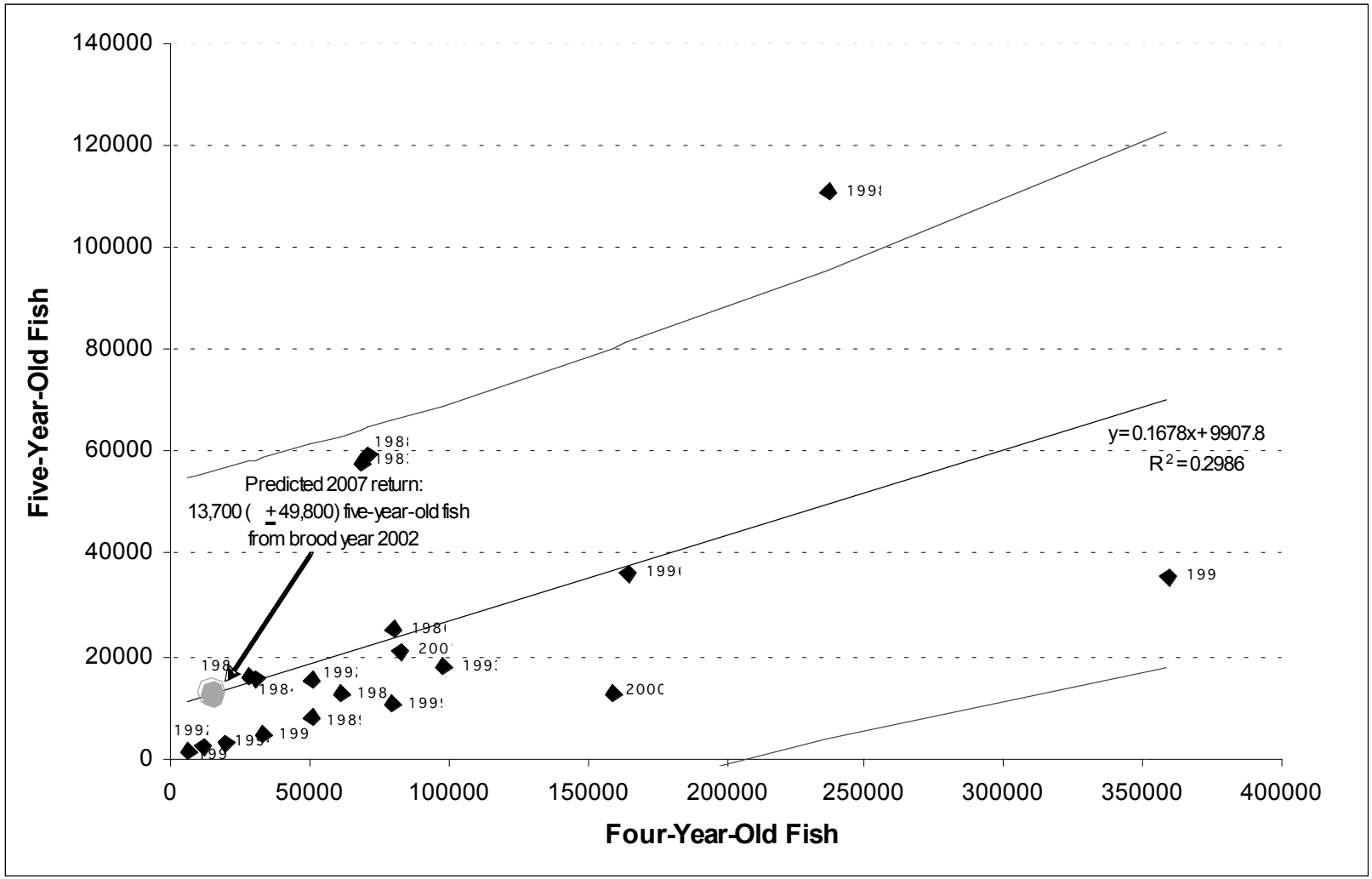

Figure 6. Predicted 2007 five-year-old Columbia Basin spring Chinook salmon abundance (at Bonneville Dam) based on a linear relationship between five-year-old and four-year-old fish abundance during brood years 1983 through 2001. Prediction intervals (90%) are also graphed.

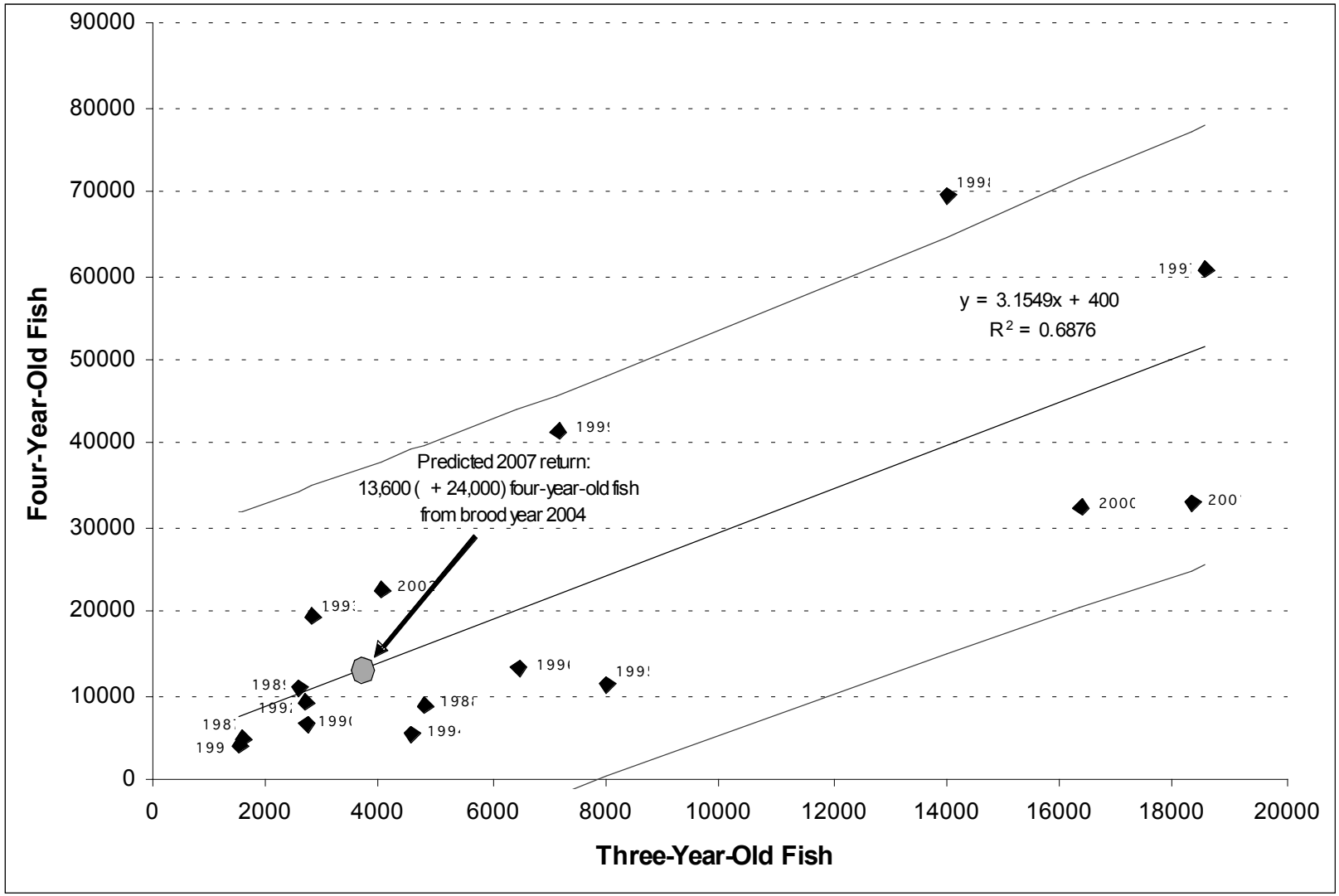

Figure 7. Predicted 2007 four-year-old Columbia Basin summer Chinook salmon abundance (at Bonneville Dam) based on a linear relationship between four-year-old and three-year-old fish abundance during brood years 1987 through 2002. Prediction intervals (90%) are also graphed.

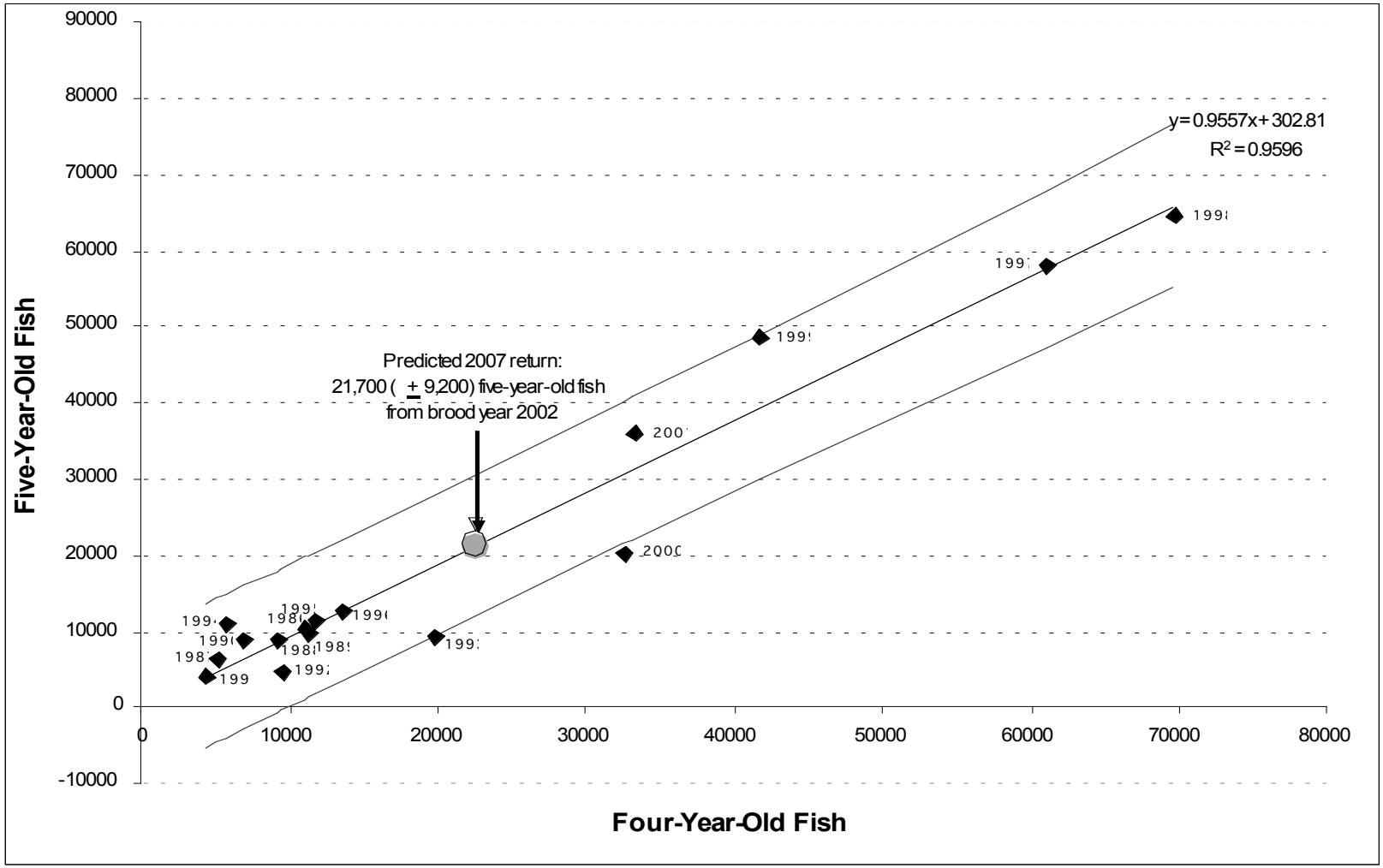

Figure 8. Predicted 2007 five-year-old Columbia Basin summer Chinook salmon abundance (at Bonneville Dam) based on a linear relationship between five-year-old and four-year-old fish abundance during brood years 1986 through 2001. Prediction intervals (90%) are also graphed.

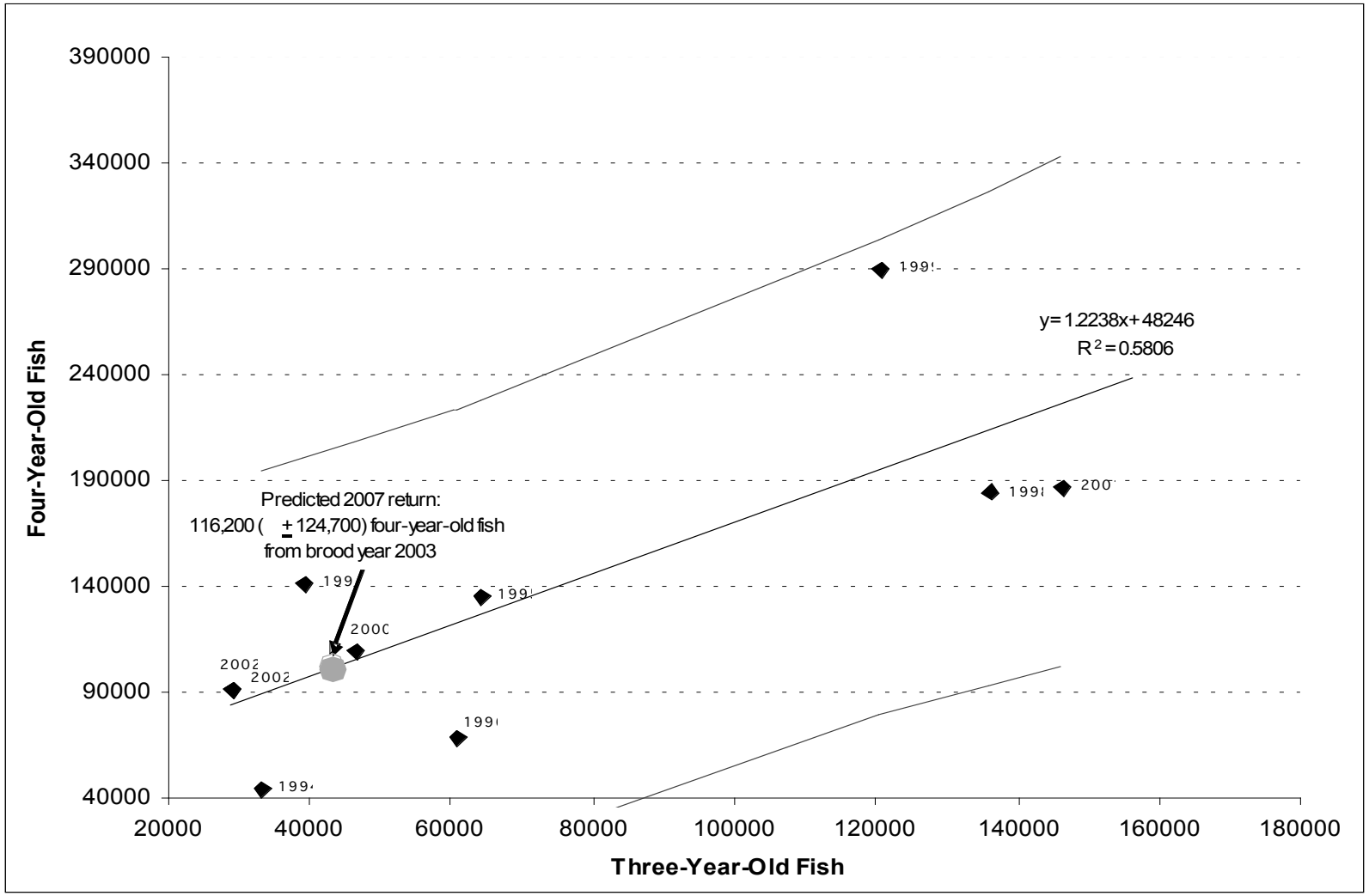

Figure 9. Predicted 2007 four-year-old Columbia Basin fall Chinook salmon abundance (at Bonneville Dam) based on a linear relationship between four-year-old and three-year-old fish abundance during brood years 1986 through 2002. Prediction intervals (90%) are also graphed.

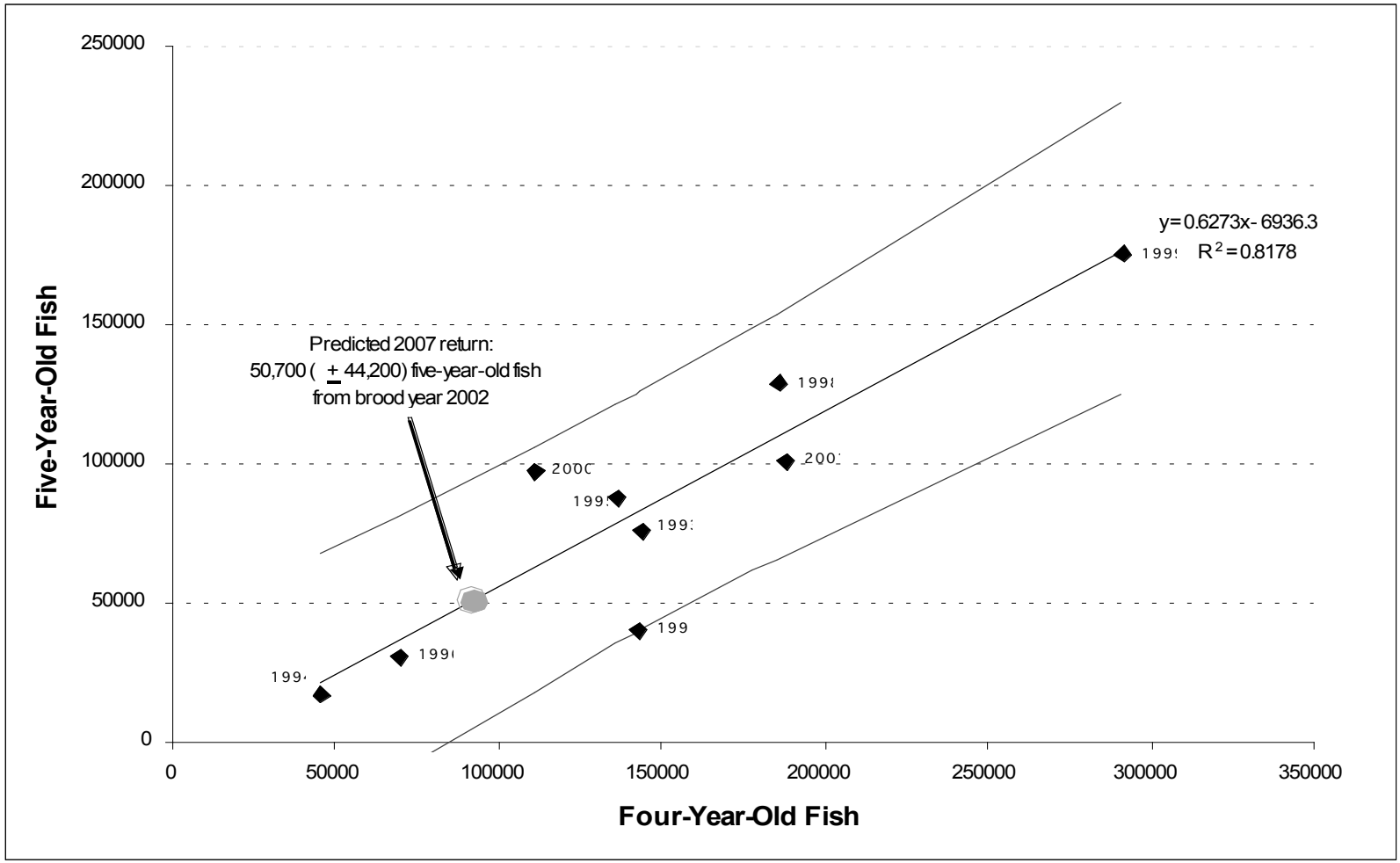

Figure 10. Predicted 2007 five-year-old Columbia Basin bright fall Chinook salmon abundance (at Bonneville Dam) based on a linear relationship between five-year-old and four-year-old fish abundance during brood years 1993 through 2001. Prediction intervals (90%) are also graphed.

Table 8. Predicted and estimated abundance of Chinook salmon returning to Bonneville Dam.

Species and age class	Predicted in 2005 report for 2006 (±90%)	2006 Estimate	2007 Prediction (±90%)
Spring Chinook 4-year-olds	75,700 (±63,100)	100,800	55,400 (±62,100)
Spring Chinook 5-year-olds	23,900 (±42,700)	21,200	13,700 (±49,800)
Summer Chinook 4-year-olds	13,200 (±32,600)	22,900	13,600 (±24,000)
Summer Chinook 5-year-olds	31,000 (±8,500)	36,200	21,700 (±9,200)
Bright Fall Chinook 4-year-olds	80,700 (±126,400)	92,600	116,200 (±124,700)
Bright Fall Chinook 5-year-olds	105,700 (±48,500)	101,600	50,700 (±44,200)

DISCUSSION

River Water Temperature

High river water temperature has constrained our sampling efforts during most summer sampling seasons. Our ESA section 10 permit allows sampling of Chinook salmon at temperatures up to 21.1^{o}C. The ACOE also has modified sampling protocols for temperatures between 21.1 and 23.3^{o}C with no sampling allowed at temperatures above 23.3^{o}C. Therefore, during the 2006 sampling season, fall Chinook were not sampled during Statistical Weeks 31 through 35. Unlike past years, we were not required to stop steelhead sampling due to high temperatures but we did follow the ACOE sampling restriction for temperatures over 21.1 C in 2006. McCullough (1999) asserts that temperatures exceeding 21^{o}C may delay the migration of Chinook salmon and Figure (11) appears to support that notion. Temperatures in this range do not appear to be as restrictive to the steelhead migration.

Genetic Sampling

In 2006, tissue samples (for DNA analysis) were collected from the majority of Chinook and steelhead that were sampled at the Adult Fish Facility at Bonneville Dam. This was the fourth full year for Chinook genetic collection and the third year that we collected samples from steelhead. In previous years steelhead genetic samples were collected by ODFW and WDFW. Significant progress has been made through the coast wide Chinook genetic database to assemble baseline genetic stock identification information for all Columbia River Chinook populations. The development of baseline genetic stock information for steelhead is still in its infancy. Once this baseline stock information is readily available, mixed stock sampling at Bonneville Dam will be a valuable tool for fisheries and ESA management within the Columbia River Basin.

Project Continuation

It is expected that this stock assessment study will continue to develop an accurate age composition and length-at-age database for Columbia Basin upriver salmon populations, and work towards improving the forecasting of terminal runs, which is important for the calibration of the PSC Chinook Technical Committee's Chinook model. These 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. The addition of steelhead to our normal sampling regime provides valuable information for NOAA-Fisheries and TAC for use in steelhead assessments, fisheries forecasting and harvest management. This study will work to improve accurate age determination, hatchery fraction, and stock identification and assessment.

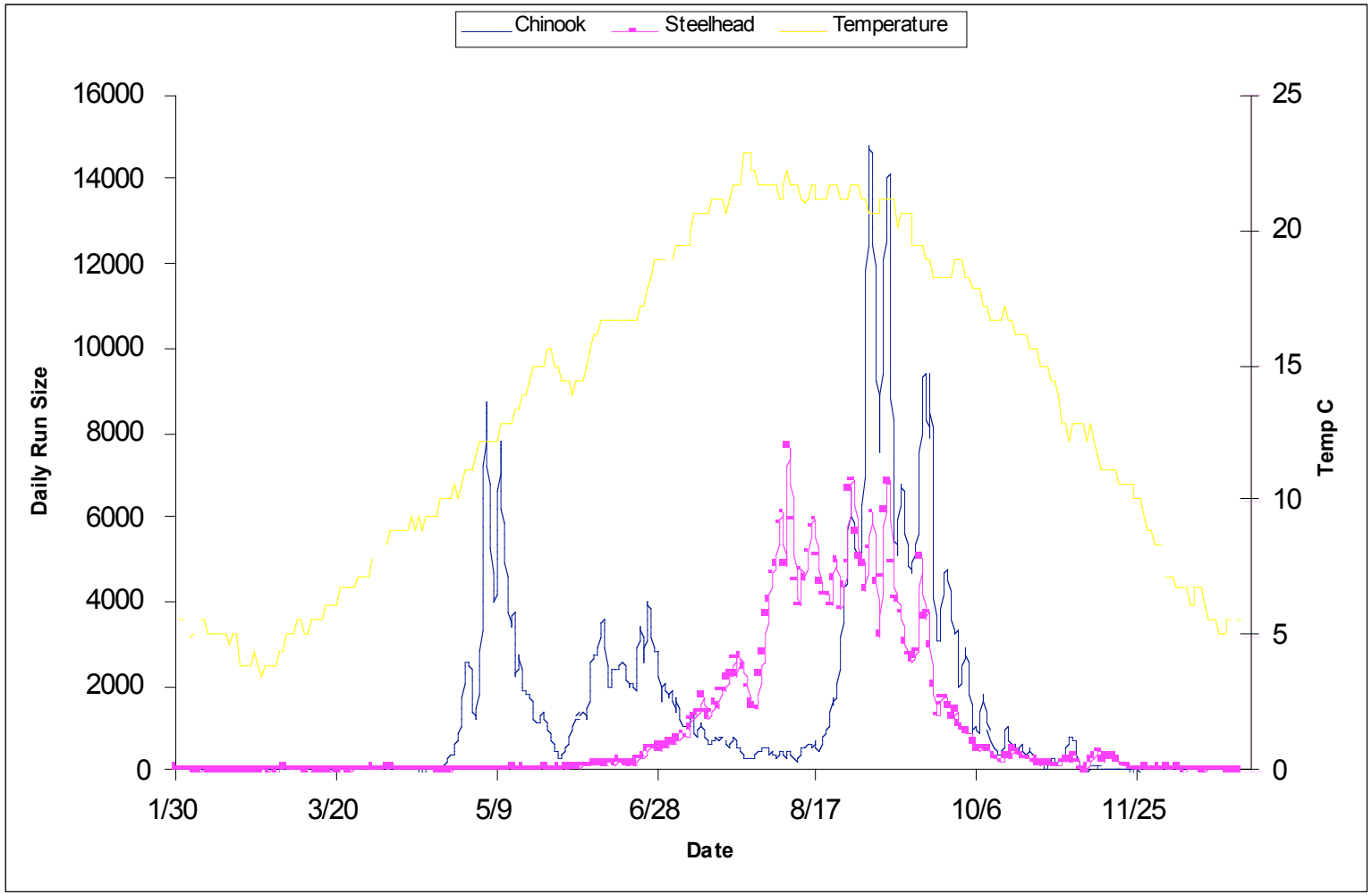

Figure 11. Chinook and steelhead daily run size and daily river temperature at Bonneville Dam from January 30 through December 31, 2006.

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APPENDIX A

LIST OF TABLES

Table A1: Percent of sampled Chinook, sockeye and steelhead at Bonneville Dam having identifying clips by Statistical Week and total sampled in 2006.

Statistical Week	Spring Chinook	Summer Chinook	Fall Chinook	Sockeye	Steelhead
11	X				X
12	X				X
13	X				X
14	X				X
15	X				X
16	X				80.0
17	77.0				58.3
18	67.5				60.0
19	73.8				83.3
20	66.0				80.0
21	67.0			X	78.6
22	54.1			X	70.0
23	36.0			X	63.2
24	32.9	29.2		6.8	77.8
25		27.0		4.3	70.6
26		40.5		3.6	63.9
27		34.8		0.8	66.2
28		34.0		1.7	53.8
29		29.4		X	27.8
30		X		X	48.7
31		X		X	53.4
32		X	X	X	57.7
33			X	X	74.1
34			X	X	80.0
35			X	X	79.3
36			7.2	X	80.0
37			8.9	X	78.8
38			2.5		86.0
39			3.4		77.3
40			0		72.0
41			3.3		85.0
42			1.9		83.3
43			X		X
44			X		X
45			X		X
46			X		X
47					X
48					X
Total	62.1	34.4	**5.8**	3.6	77.5

X Represents a week that a species was present, but sampling did not occur or sample sizes were small enough that data was pooled with the previous or subsequent week. Therefore, the percent in a Statistical Week before or after an X is assumed to represent the weeks during which sampling did not occur. For example, spring Chinook were first sampled in Week 15 and this week is assumed to represent Weeks 12 through 14 as well.

Table A2: Composition (%) of observed injuries of Columbia Basin Chinook and sockeye salmon and steelhead sampled at Bonneville Dam in 2006.

Injury Category	Spring	Summer	Fall	Sockeye	Steelhead
Marine Mammal					
Bite	0.8%	0.0%	0.5%	0.0%	0.3%
Golden Arches	17.8%	2.0%	1.5%	0.5%	3.8%
Scrape	8.9%	5.4%	4.2%	2.3%	10.1%
Total[a]	26.1%	6.9%	5.3%	2.9%	13.2%
Descaling					
<3%[b]					
Left side	3.4%	5.3%	4.6%	22.6%	7.4%
Right side	3.3%	3.3%	3.0%	20.6%	5.6%
Total	2.9%	5.7%	4.8%	21.2%	8.0%
3-19%					
Left side	13.9%	18.9%	10.1%	28.5%	15.1%
Right side	15.2%	19.4%	10.4%	31.1%	13.8%
Total[c]	0.9%	28.3%	14.4%	41.5%	19.8%
≥20%					
Left side	1.2%	1.8%	1.1%	2.7%	1.6%
Right side	0.9%	2.0%	2.4%	3.2%	1.9%
Total[c]	1.8%	3.2%	2.7%	4.7%	2.5%
Other Injuries					
Bruise	1.2%	2.3%	1.7%	1.7%	0.5%
Cut	0.4%	0.5%	0.0%	0.0%	1.9%
Head Injury	12.4%	11.7%	14.5%	1.6%	0.0%
Head Burn	0.3%	0.2%	0.0%	0.0%	0.0%
Fin	14.1%	13.5%	16.4%	1.3%	0.0%
Fungus	2.4%	2.0%	2.0%	2.0%	0.4%
Gash	2.8%	1.1%	3.7%	3.7%	3.6%
Gas Bubble Trauma	0.0%	0.0%	0.0%	0.0%	0.0%
Gill Net	1.4%	1.7%	1.7%	0.5%	3.8%
Fish Hook	0.6%	1.4%	0.9%	0.9%	0.3%
Lamprey	0.4%	0.5%	0.0%	0.0%	0.1%
Parasite	2.8%	3.6%	3.3%	0.0%	1.0%
Total[a]	31.6%	29.9%	33.8%	6.3%	26.5%

a Totals 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. Occasionally injuries are recorded but not described.

b Data not collected in 2005.

c This total represents the percentage of fish with descaling on either side. Fish are recorded in the category of maximum descaling. For example, a fish 3-19% descaled on one side, and ≥20% descaled on the other, would be recorded as ≥20% descaled.

Table A4: Length-at-age estimates for Columbia Basin spring Chinook salmon sampled at Bonneville Dam in 2006. Composite estimates of age classes are weighted by weekly run size.

Brood Year and	2003		2002		2001		2000
Age Class	0.2	1.1	0.3	1.2	0.4	1.3	1.4
Statistical Week 17							
Mean Fork Length (cm)				70.72		83.25	93.50
Maximum				87.50		90.50	93.50
Minimum				57.50		75.00	93.50
Standard Deviation				5.57		5.82	-
Sample Size				59		6	1
Statistical Week 18							
Mean Fork Length (cm)		55.50	81.00	71.00		85.14	
Maximum		55.50	81.00	85.00		93.50	
Minimum		55.50	81.00	56.00		79.50	
Standard Deviation		-	-	4.50		4.28	
Sample Size		1	1	163		11	
Statistical Week 19							
Mean Fork Length (cm)				71.03		82.58	
Maximum				82.00		87.00	
Minimum				57.00		77.50	
Standard Deviation				4.65		3.35	
Sample Size				125		6	
Statistical Week 20							
Mean Fork Length (cm)		46.58		71.13		82.64	
Maximum		50.50		83.50		92.50	
Minimum		42.00		56.50		77.00	
Standard Deviation		3.43		4.60		4.69	
Sample Size		6		112		11	
Statistical Week 21							
Mean Fork Length (cm)		51.14		71.56		86.46	
Maximum		56.50		85.00		93.50	
Minimum		45.50		51.50		77.50	
Standard Deviation		3.85		5.37		5.18	
Sample Size		7		70		13	
Statistical Week 22							
Mean Fork Length (cm)		49.92		71.70	91.33	87.10	83.00
Maximum		57.00		85.00	95.50	94.50	83.00
Minimum		42.50		60.00	88.00	73.00	83.00
Standard Deviation		4.94		5.33	3.82	8.71	-
Sample Size		6		50	3	5	1
Statistical Week 23							
Mean Fork Length (cm)	73.50	48.67	84.63	72.94	93.32	87.30	106.00
Maximum	73.50	51.00	90.50	81.50	99.50	96.00	106.00
Minimum	73.50	45.50	78.50	62.00	87.50	78.00	106.00
Standard Deviation	-	2.84	4.91	4.03	3.80	4.96	-
Sample Size	1	3	4	41	25	15	1
Statistical Week 24							
Mean Fork Length (cm)		49.00	84.25	75.17	90.68	86.57	97.10
Maximum		49.00	87.50	88.50	105.00	95.00	102.00
Minimum		49.00	80.00	63.00	77.00	71.00	92.50
Standard Deviation		-	3.28	7.52	7.48	6.56	3.42
Sample Size		1	4	15	25	15	5
2006 Composite							
Mean Fork Length (cm)	73.50	49.48	84.06	71.34	91.96	85.46	96.00
Maximum	73.50	57.00	90.50	88.50	105.00	96.00	106.00
Minimum	73.50	42.00	78.50	51.50	77.00	71.00	83.00
Standard Deviation	-	4.15	3.80	4.92	5.89	5.51	6.85
Sample Size	1	24	9	635	53	82	8

Table A5: Length-at-age estimates for Columbia Basin summer Chinook salmon sampled at Bonneville Dam in 2006. Composite estimates of age classes are weighted by weekly run size.

Brood Year and	2004	2003		2002		2001		2000
Age Class	0.1	0.2	1.1	0.3	1.2	0.4	1.3	1.4
Statistical Week 24								
Mean Fork Length (cm)				83.75	75.75	93.09	87.50	88.50
Maximum				91.50	78.50	100.50	93.50	93.00
Minimum				75.50	73.00	85.00	76.00	84.00
Standard Deviation				6.55	3.89	5.02	8.13	4.50
Sample Size				4	2	11	4	3
Statistical Week 25								
Mean Fork Length (cm)	43.83		51.20	84.84	72.25	91.65	87.90	94.50
Maximum	46.00		62.00	91.50	86.00	108.00	98.00	97.50
Minimum	42.00		41.50	78.00	52.00	81.00	80.00	89.00
Standard Deviation	2.02		8.50	3.75	8.50	5.12	5.95	4.77
Sample Size	3		5	22	20	56	20	3
Statistical Week 26								
Mean Fork Length (cm)	37.00	59.33	53.64	80.68	72.45	90.61	85.84	85.15
Maximum	37.00	66.00	62.00	99.00	89.00	100.50	103.00	98.50
Minimum	37.00	56.00	44.50	69.00	53.50	80.00	63.50	71.50
Standard Deviation	-	5.77	6.49	7.13	7.48	4.91	7.58	7.07
Sample Size	1	3	7	22	30	51	46	10
Statistical Week 27								
Mean Fork Length (cm)	44.50	73.00	54.06	81.89	74.31	90.36	84.21	85.14
Maximum	45.00	73.00	62.00	94.50	86.00	108.00	98.00	96.50
Minimum	44.00	73.00	51.00	63.50	59.50	75.00	72.00	68.50
Standard Deviation	0.71	-	3.66	7.30	7.35	6.56	6.75	8.55
Sample Size	2	1	8	36	21	48	33	11
Statistical Week 28								
Mean Fork Length (cm)	40.83	66.00	49.08	80.98	72.66	88.31	85.92	85.25
Maximum	47.00	66.00	57.00	92.50	82.00	98.50	91.00	92.00
Minimum	37.50	66.00	40.00	68.50	65.50	68.00	79.00	73.00
Standard Deviation	3.93	-	5.77	6.17	4.78	7.24	4.06	8.42
Sample Size	6	1	6	25	16	21	13	4
Statistical Week 29								
Mean Fork Length (cm)	52.50		56.50	81.57	77.50	90.25	88.50	
Maximum	52.50		60.50	91.00	77.50	96.50	93.00	
Minimum	52.50		52.50	69.00	77.50	84.00	84.00	
Standard Deviation	-		5.66	7.23	-	6.17	6.36	
Sample Size	1		2	7	1	4	2	
Statistical Week 30								
Mean Fork Length (cm)	47.00		52.00	85.00	65.50	86.50	86.67	
Maximum	47.00		52.00	99.00	65.50	92.00	91.00	
Minimum	47.00		52.00	71.00	65.50	76.00	82.50	
Standard Deviation	-		-	19.80	-	7.33	4.25	
Sample Size	1		1	2	1	4	3	
2006 Composite								
Mean Fork Length (cm)	43.00	63.40	52.53	82.12	72.92	90.65	85.86	86.39
Maximum	52.50	73.00	62.00	99.00	89.00	108.00	103.00	98.50
Minimum	37.00	56.00	40.00	63.50	52.00	68.00	63.50	68.50
Standard Deviation	4.50	7.33	5.90	6.70	7.13	5.81	6.70	7.59
Sample Size	14	5	29	118	91	195	121	31

Table A6: Length-at-age estimates for Columbia Basin bright fall Chinook salmon sampled at Bonneville Dam in 2006. Composite estimates of age classes are weighted by weekly run size.

Brood Year and	2003	2002		2001		2000		1999	
Age Class	0.1	0.2	1.1	0.3	1.2	0.4	1.3	0.5	1.4
Statistical Week 36									
Mean Fork Length (cm)	45.96	68.22	56.36	82.60	76.08	89.07	85.20	94.38	86.50
Maximum	54.50	74.50	63.00	99.00	80.00	102.00	93.50	97.50	94.00
Minimum	37.50	62.00	50.50	71.00	69.50	65.00	77.00	90.50	79.00
Standard Deviation	5.36	3.47	3.56	5.98	3.99	5.83	6.82	3.07	10.61
Sample Size	13	18	11	53	6	62	5	4	2
Statistical Week 37									
Mean Fork Length (cm)	46.69	67.05	57.55	81.93	73.75	87.94	82.44	89.75	91.25
Maximum	56.00	75.00	67.00	95.00	80.00	100.00	96.00	98.50	95.50
Minimum	41.00	56.50	49.00	69.00	62.00	73.00	70.50	81.00	87.00
Standard Deviation	4.03	4.38	5.51	5.33	8.26	6.38	8.09	12.37	6.01
Sample Size	13	32	10	42	4	57	8	2	2
Statistical Week 38									
Mean Fork Length (cm)	45.19	66.47	55.72	81.63	72.38	85.60	81.88	98.50	80.25
Maximum	52.00	74.00	64.00	102.50	77.00	94.50	87.50	100.00	83.50
Minimum	37.50	59.00	49.00	66.00	66.00	65.00	75.00	97.00	77.00
Standard Deviation	4.88	4.77	5.02	6.41	4.71	5.78	5.89	2.12	4.60
Sample Size	13	36	9	41	4	35	4	2	2
Statistical Week 39									
Mean Fork Length (cm)	47.28	66.94	56.92	80.15	76.25	87.40	82.50	99.75	84.00
Maximum	57.00	82.00	64.50	95.00	80.50	100.50	87.00	106.00	84.00
Minimum	39.50	50.00	51.00	62.00	72.00	74.50	78.00	93.50	84.00
Standard Deviation	4.28	6.61	6.22	6.58	6.01	4.85	6.36	8.84	-
Sample Size	18	34	6	40	2	62	2	2	1
Statistical Week 40									
Mean Fork Length (cm)	46.00	69.60		81.65	79.17	85.29		92.50	
Maximum	54.50	79.00		96.00	87.00	94.00		92.50	
Minimum	39.50	60.50		67.00	66.50	74.00		92.50	
Standard Deviation	6.05	5.65		6.09	11.07	4.48		-	
Sample Size	6	20		40	3	29		1	
Statistical Week 41									
Mean Fork Length (cm)		66.50		82.73		89.00		86.25	
Maximum		71.00		90.00		98.00		86.50	
Minimum		63.00		73.00		76.00		86.00	
Standard Deviation		3.42		5.22		6.78		0.35	
Sample Size		4		11		11		2	
Statistical Week 42									
Mean Fork Length (cm)	44.00	67.07	57.00	83.92		86.61			87.00
Maximum	45.50	71.00	57.00	97.00		99.00			87.00
Minimum	42.50	59.00	57.00	74.00		77.00			87.00
Standard Deviation	2.12	3.98	-	6.02		6.65			-
Sample Size	2	7	1	26		14			1
2006 Composite									
Mean Fork Length (cm)	46.26	67.35	56.64	81.94	75.32	87.46	83.05	93.73	85.88
Maximum	57.00	82.00	67.00	102.50	87.00	102.00	96.00	106.00	95.50
Minimum	37.50	50.00	49.00	62.00	62.00	65.00	70.50	81.00	77.00
Standard Deviation	4.63	5.12	4.75	6.06	6.35	5.78	6.76	6.64	6.51
Sample Size	65	151	37	253	19	270	19	13	8

Table A7: Length-at-age estimates for Columbia Basin sockeye salmon sampled at Bonneville Dam in 2006. Composite estimates of age classes are weighted by weekly run size.

Brood Year and	2003	2002		2001			2000
Age Class	1.1	1.2	2.1	1.3	2.2	3.1	2.3
Statistical Week 23							
Mean Fork Length (cm)		48.50			48.33		
Maximum		51.00			51.00		
Minimum		47.00			46.50		
Standard Deviation		1.36			2.36		
Sample Size		8			3		
Statistical Week 24							
Mean Fork Length (cm)		49.36	43.38	55.14	50.50		
Maximum		54.50	48.00	60.50	55.50		
Minimum		45.00	40.50	51.00	47.50		
Standard Deviation		2.11	3.25	2.22	2.61		
Sample Size		44	4	14	12		
Statistical Week 25							
Mean Fork Length (cm)		50.27		55.50	50.91	51.00	54.00
Maximum		57.00		63.00	58.00	53.50	54.00
Minimum		46.00		50.00	45.50	48.50	54.00
Standard Deviation		2.59		3.19	4.17	3.54	-
Sample Size		54		17	16	2	1
Statistical Week 26							
Mean Fork Length (cm)		49.76	41.33	54.69	49.83	49.33	
Maximum		55.50	44.00	60.50	53.50	52.50	
Minimum		45.00	38.00	46.00	45.00	46.50	
Standard Deviation		2.26	3.06	3.11	2.13	3.01	
Sample Size		112	3	29	18	3	
Statistical Week 27							
Mean Fork Length (cm)	39.50	49.47	41.67	55.12	48.50	43.50	
Maximum	41.00	56.00	44.00	58.00	53.00	43.50	
Minimum	37.00	45.00	39.50	51.50	41.50	43.50	
Standard Deviation	2.18	2.35	2.25	1.57	3.34	-	
Sample Size	3	78	3	29	13	1	
Statistical Week 28							
Mean Fork Length (cm)	36.00	49.08	40.25	54.11	49.67	53.00	
Maximum	36.00	54.50	41.00	59.50	53.00	53.00	
Minimum	36.00	45.00	39.50	49.00	46.00	53.00	
Standard Deviation	-	2.41	1.06	3.45	2.08	-	
Sample Size	1	32	2	9	12	1	
2006 Composite							
Mean Fork Length (cm)	38.63	49.62	41.92	54.97	49.85	49.50	54.00
Maximum	41.00	57.00	48.00	63.00	58.00	53.50	54.00
Minimum	36.00	45.00	38.00	46.00	41.50	43.50	54.00
Standard Deviation	2.50	2.33	2.64	2.64	3.01	3.73	-
Sample Size	4	328	12	98	74	7	1

Table A8: Length-at-age estimates for Columbia Basin steelhead sampled at Bonneville Dam in 2006.

Brood Year and	2003	2002		2001			2000			1999
Age Class	1.1	1.2	2.1	1.3	2.2	3.1	2.3	3.2	4.1	4.2
Statistical Week 16										
Mean Fork Length (cm)	61.00	62.80								
Maximum	61.00	69.00								
Minimum	61.00	54.00								
Standard Deviation	-	7.80								
Sample Size	1	3								
Statistical Week 17										
Mean Fork Length (cm)	59.50	70.00	50.50		70.50			63.30		
Maximum	59.50	74.50	50.50		70.50			63.50		
Minimum	59.50	65.00	50.50		70.50			63.00		
Standard Deviation	-	4.20	-		-			0.40		
Sample Size	1	6	1		1			2		
Statistical Week 18										
Mean Fork Length (cm)	58.20		63.50							
Maximum	59.50		63.50							
Minimum	57.00		63.50							
Standard Deviation	1.30		-							
Sample Size	3		1							
Statistical Week 19										
Mean Fork Length (cm)	58.80				76.50					
Maximum	65.00				76.50					
Minimum	52.50				76.50					
Standard Deviation	8.80				-					
Sample Size	2				1					
Statistical Week 20										
Mean Fork Length (cm)	70.50	71.20	60.00			63.00				
Maximum	70.50	80.00	60.00			63.00				
Minimum	70.50	66.00	60.00			63.00				
Standard Deviation	-	5.40	-			-				
Sample Size	1	5	1			1				
Statistical Week 21										
Mean Fork Length (cm)	65.50	71.10			70.80					
Maximum	65.50	76.00			76.00					
Minimum	65.50	63.50			66.00					
Standard Deviation	-	4.80			5.00					
Sample Size	1	6			3					
Statistical Week 22										
Mean Fork Length (cm)	57.50	69.00			68.00			69.50		
Maximum	69.00	69.00			68.00			69.50		
Minimum	50.50	69.00			68.00			69.50		
Standard Deviation	10.00	-			-			-		
Sample Size	3	1			1			1		
Statistical Week 23										
Mean Fork Length (cm)	57.30	69.10	68.00	78.00	66.00					
Maximum	70.00	71.00	68.00	78.00	68.50					
Minimum	49.00	65.50	68.00	78.00	63.50					
Standard Deviation	8.20	2.10	-	-	3.50					
Sample Size	5	5	1	1	2					

Brood Year and	2003	2002		2001			2000			1999
Age Class	1.1	1.2	2.1	1.3	2.2	3.1	2.3	3.2	4.1	4.2
Statistical Week 24										
Mean Fork Length (cm)	52.20	70.00	60.00							
Maximum	55.00	74.50	60.00							
Minimum	48.50	65.50	60.00							
Standard Deviation	3.30	6.40	-							
Sample Size	3	2	1							
Statistical Week 25										
Mean Fork Length (cm)	52.60	73.50			59.50			63.50		
Maximum	56.00	77.50			59.50			63.50		
Minimum	48.50	69.50			59.50			63.50		
Standard Deviation	2.30	4.00			-			-		
Sample Size	7	3			1			1		
Statistical Week 26										
Mean Fork Length (cm)	56.60	68.80	59.70		68.30			68.20		
Maximum	64.00	78.00	60.50		70.50			71.00		
Minimum	50.00	60.50	59.00		65.00			64.00		
Standard Deviation	3.70	5.30	0.80		1.70			3.70		
Sample Size	29	21	3		10			3		
Statistical Week 27										
Mean Fork Length (cm)	59.40	69.90	59.40		69.30	52.80		66.70		
Maximum	82.50	77.00	66.50		73.50	53.50		73.00		
Minimum	52.00	62.00	54.00		65.00	52.00		62.00		
Standard Deviation	6.90	4.20	5.20		2.70	1.10		5.70		
Sample Size	33	14	4		7	2		3		
Statistical Week 28										
Mean Fork Length (cm)	57.80	67.70	60.70		70.50	59.80		67.90		
Maximum	66.00	81.00	71.50		78.00	66.00		73.00		
Minimum	52.00	54.50	55.00		63.00	56.00		65.00		
Standard Deviation	3.20	5.60	4.60		4.20	4.30		3.50		
Sample Size	39	32	11		11	4		4		
Statistical Week 29										
Mean Fork Length (cm)	57.50	68.50	61.40		76.50	59.00		74.50		
Maximum	60.00	71.50	67.00		76.50	59.50		74.50		
Minimum	53.00	65.50	59.50		76.50	58.50		74.50		
Standard Deviation	3.20	4.20	3.20		-	0.70		-		
Sample Size	4	2	5		1	2		1		
Statistical Week 30										
Mean Fork Length (cm)	58.80	69.00			68.90	61.00		64.30		69.50
Maximum	66.50	73.00			75.00	61.00		66.00		69.50
Minimum	54.50	63.50			63.00	61.00		62.50		69.50
Standard Deviation	4.10	3.40			4.10	-		2.50		-
Sample Size	10	6			7	1		2		1
Statistical Week 31										
Mean Fork Length (cm)	60.40	70.10	58.70		69.40	56.00		70.80		81.50
Maximum	69.50	77.00	60.00		73.50	56.00		75.00		81.50
Minimum	55.00	61.00	56.00		60.00	56.00		66.50		81.50
Standard Deviation	4.00	4.20	1.60		3.90	-		6.00		-
Sample Size	20	16	5		10	1		2		1

Brood Year and	2003	2002		2001			2000			1999
Age Class	1.1	1.2	2.1	1.3	2.2	3.1	2.3	3.2	4.1	4.2
Statistical Week 32										
Mean Fork Length (cm)	57.70	69.40	56.00		72.10			67.50		
Maximum	61.50	74.50	56.00		79.50			67.50		
Minimum	53.50	66.00	56.00		64.50			67.50		
Standard Deviation	2.30	3.40	-		6.80			-		
Sample Size	9	5	1		4			1		
Statistical Week 33										
Mean Fork Length (cm)	57.10	69.40	63.00		70.70	57.70			61.50	
Maximum	63.50	79.00	63.00		78.50	61.00			61.50	
Minimum	51.00	63.00	63.00		62.50	54.00			61.50	
Standard Deviation	2.80	4.60	-		8.00	3.50			-	
Sample Size	24	19	1		3	3			1	
Statistical Week 34										
Mean Fork Length (cm)	59.70	73.00			74.00					
Maximum	68.00	73.00			74.00					
Minimum	55.50	73.00			74.00					
Standard Deviation	3.60	-			-					
Sample Size	9	1			1					
Statistical Week 35										
Mean Fork Length (cm)	59.30	74.50	56.00		71.00					
Maximum	64.00	84.50	56.00		77.50					
Minimum	53.00	64.50	56.00		64.50					
Standard Deviation	3.40	7.20	-		9.20					
Sample Size	11	12	1		2					
Statistical Week 36										
Mean Fork Length (cm)	58.50	77.70	59.80	84.80	72.50	66.00		81.90		76.50
Maximum	69.00	91.00	67.50	88.00	80.00	66.00		85.50		76.50
Minimum	51.50	59.50	52.00	80.50	65.00	66.00		75.50		76.50
Standard Deviation	3.30	8.00	11.00	2.30	10.60	-		3.50		-
Sample Size	62	71	2	11	2	1		6		1
Statistical Week 37										
Mean Fork Length (cm)	47.50	80.00	60.00	86.30	75.70	60.50	85.50	79.30		82.00
Maximum	47.50	92.50	60.00	94.00	85.00	60.50	89.50	84.50		82.00
Minimum	47.50	61.00	60.00	81.50	69.50	60.50	81.50	64.00		82.00
Standard Deviation	-	6.80	-	3.50	5.80	-	5.70	8.60		-
Sample Size	1	72	1	16	5	1	2	5		1
Statistical Week 38										
Mean Fork Length (cm)		79.80		87.80			87.50			
Maximum		92.50		94.50			87.50			
Minimum		65.00		81.50			87.50			
Standard Deviation		6.60		3.80			-			
Sample Size		58		18			1			
Statistical Week 39										
Mean Fork Length (cm)		81.10	60.00	86.50	72.80	57.00	82.00			
Maximum		93.50	60.00	97.00	78.50	57.00	82.00			
Minimum		66.00	60.00	79.50	67.00	57.00	82.00			
Standard Deviation		5.30	-	3.70	8.10	-	-			
Sample Size		65	1	25	2	1	1			

Brood Year and Age Class	2003 1.1	2002 1.2	2002 2.1	2001 1.3	2001 2.2	2001 3.1	2000 2.3	2000 3.2	2000 4.1	1999 4.2
Statistical Week 40										
Mean Fork Length (cm)		81.20	59.50	85.50	66.00	56.50		76.30		
Maximum		92.00	62.50	92.00	66.00	56.50		82.00		
Minimum		64.00	56.50	76.50	66.00	56.50		66.50		
Standard Deviation		4.70	4.20	5.50	-	-		8.53		
Sample Size		40	2	6	1	1		3		
Statistical Week 41										
Mean Fork Length (cm)		79.00	63.30	95.00						
Maximum		85.50	65.50	95.00						
Minimum		68.50	61.00	95.00						
Standard Deviation		5.90	3.20	-						
Sample Size		17	2	1						
Statistical Week 42										
Mean Fork Length (cm)		73.80	53.50	88.80		55.00		75.00		
Maximum		82.00	53.50	89.00		55.00		85.50		
Minimum		60.50	53.50	88.50		55.00		64.50		
Standard Deviation		7.50	-	0.40		-		14.80		
Sample Size		10	1	2		1		2		
Statistical Week 43										
Mean Fork Length (cm)		77.80		81.50	71.00					
Maximum		85.50		81.50	71.00					
Minimum		70.00		81.50	71.00					
Standard Deviation		11.00		-	-					
Sample Size		2		1	1					
2006 Composite										
Mean Fork Length (cm)	59.20	76.40	60.00	86.40	70.20	58.40	85.10	72.60	61.50	77.40
Maximum	82.50	93.50	71.50	97.00	85.00	66.00	89.50	85.50	61.50	82.00
Minimum	46.00	54.00	50.50	76.50	59.50	52.00	81.50	62.00	61.50	69.50
Standard Deviation	4.80	7.80	4.20	3.90	4.80	3.90	4.00	8.30	-	5.80
Sample Size	409	494	45	81	76	19	4	36	1	4