IDENTIFICATION OF COLUMBIA BASIN SOCKEYE SALMON STOCKS IN 2006

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ABSTRACT

In 2006, samples of adult Columbia Basin sockeye salmon *Oncorhynchus nerka* were collected at Bonneville Dam on the Columbia River as well as at Tumwater Dam on the Wenatchee River, and Wells Dam in the mid-Columbia River downstream of the Okanogan River. Tumwater and Wells dams were chosen to provide samples of sockeye salmon from the two principle stocks of Columbia Basin sockeye salmon, which originate from the Wenatchee and Okanogan basins. Age composition was estimated using scale pattern analysis from the sampled sockeye salmon passing the three dams. Four-year-old fish were estimated to comprise 65% of the mixed-stock sockeye salmon migrating past Bonneville Dam, 74% of the Okanogan stock migrating past Wells Dam, and 36% of the Wenatchee stock migrating past Tumwater Dam. Five-year-old fish were estimated to comprise 34% of the Bonneville Dam mixed-stock, 24% of the Okanogan stock, and 63% of the Wenatchee stock. Three-year-old fish were estimated to comprise 1% of the Bonneville Dam mixed-stock, 1% of the Okanogan stock and none of the Wenatchee stock. Scale pattern analysis techniques were used to estimate that 52% of the sockeye salmon passing Bonneville Dam were of Okanogan origin, 13% were of Wenatchee stock, with the remaining 34% not classified as to origin. The high estimate of unclassified stock is due to the high percentage of five-year-old fish combined with low sample sizes at Wells Dam making it not possible to differentiate these fish using scale patterns. A companion PIT tagging project estimated that 72.8% of the sockeye salmon passing Bonneville Dam were of Okanogan origin, with the remaining 27.2% of Wenatchee origin.

ACKNOWLEDGMENTS

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Sockeye salmon, *Oncorhynchus nerka,* is one of the species of Pacific salmon native to the Columbia River Basin. Before white settlers developed the region, it is estimated the Columbia Basin supported an annual sockeye salmon run averaging over three million fish (Northwest Power Planning Council 1986, Fryer 1995). Since the mid-1800's, however, this sockeye salmon population has severely declined. The estimated number of sockeye salmon entering the Columbia River over the most recent four year period (2003-2006) averaged 78,200 fish per year, though as recently as 1995-1998, the mean escapement was only 24,900 per year (DART 2005, Fish Passage Center 2005). The 2006 escapement of 37,066 to Bonneville Dam was the lowest since 1999.

The Columbia Basin sockeye salmon run was once composed of at least eight principal stocks (Fulton 1970, Fryer 1995). Today, only two major stocks remain[1] (Figure 1). From the 1960's through the early 1990's, both stocks were entirely naturally produced, originating in the Wenatchee River-Lake Wenatchee System (Wenatchee stock) and in the Okanogan River-Osoyoos Lake System (Okanogan stock). In the 1990's enhancement programs in both systems were initiated, each involving the capture of returning adults, spawning of the adults in hatcheries, and rearing of the offspring in net pens located in their respective rearing lakes before release (Hays 1992, Wells Project Coordinating Committee 1992). The Okanogan enhancement program was terminated following the 2000 release; however a similar program focusing on restoring sockeye salmon to Skaha Lake upstream of Osoyoos Lake began in 2003. The two remaining Columbia Basin sockeye salmon rearing areas differ markedly (Allen and Meekin 1980, Mullan 1986). Lake Wenatchee is oligotrophic, with relatively deep, cold, and biologically unproductive waters. Conversely, Osoyoos Lake has the shallow, warm, and agriculturally enriched waters characteristic of eutrophic lake habitats.

1 A small run of sockeye salmon return to the Snake River and are listed as endangered under the Endangered Species Act. These fish are almost entirely hatchery origin and adipose fin clipped. While an estimated 37,066 sockeye salmon passed Bonneville Dam in 2006, only 48 (0.13%) passed Ice Harbor Dam on the Snake River and only 17 (0.05%) of these passed Lower Granite Dam.

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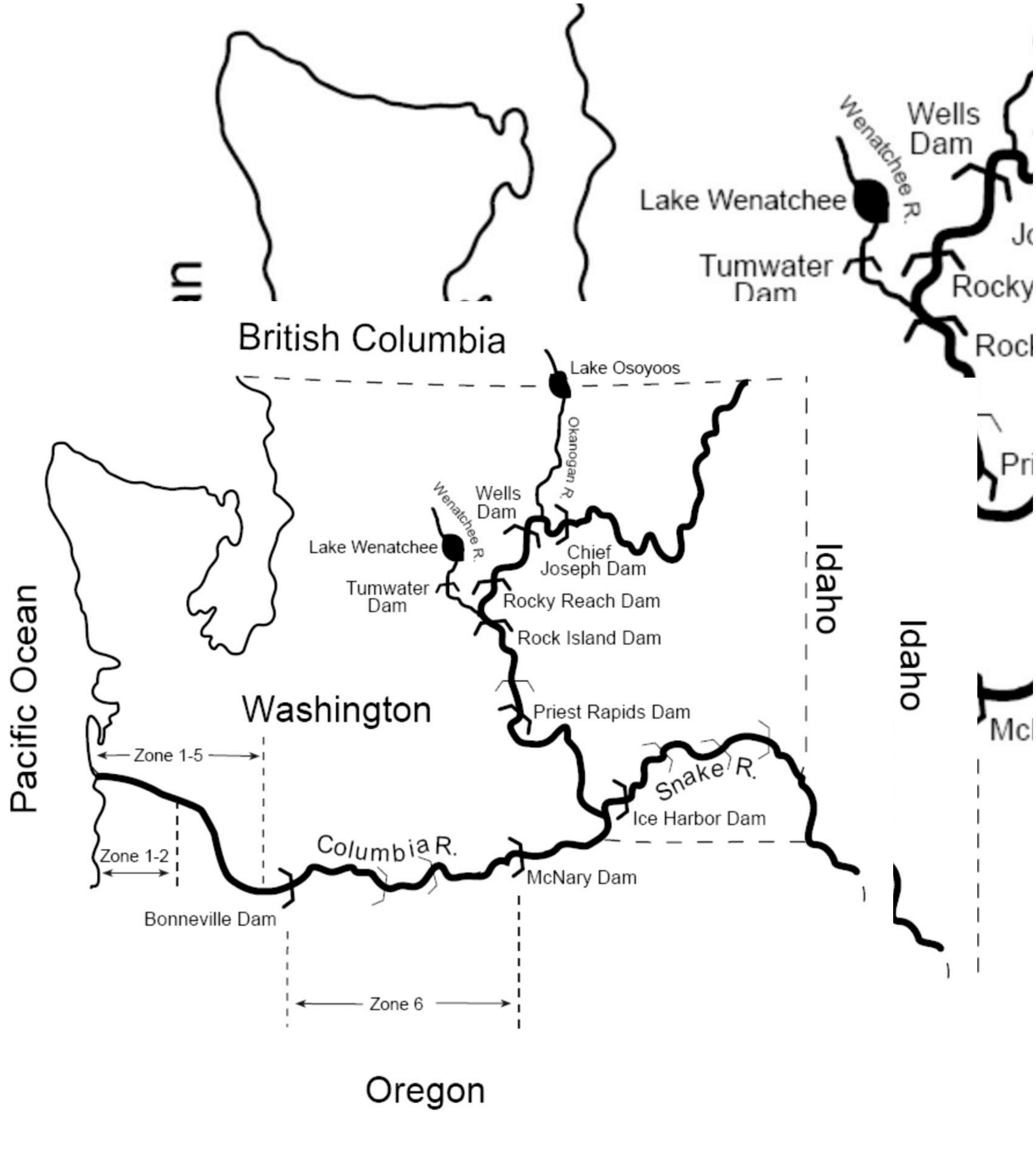

Reliable estimates of the overall run composition of Columbia Basin sockeye salmon stocks and the biological and migratory characteristics of each stock are useful for run-reconstruction studies permitting accurate population size predictions, escapement monitoring, establishing spawner-recruit relationships, and developing discrete stock approaches to Columbia River mainstem harvest management

Scale pattern analysis (SPA) has been the method of choice for our stock identification research and is a well-established stock identification and classification technique (Clutter and Whitesel 1956, Henry 1961, Mosher 1963, Anas and Murai 1969). In many species of fish, including Pacific salmon, the use of SPA as a tool for stock identification depends on a high correlation between individual fish growth and scale growth (Koo 1955, Clutter and Whitesel 1956). Fish growth and scale growth are influenced by genetic factors and by such environmental conditions as water temperature, length of growing season, and food availability. Stock identification based on SPA assumes that growth patterns will differ among groups or stocks throughout a species' range and that these differences will be consistently exhibited in the scales of entire individuals within groups or stocks of fish. Scale patterns for fish from the Wenatchee and Okanogan sockeye salmon stocks in past years have differed (Schwartzberg and Fryer 1988, 1989, 1990; Fryer and Schwartzberg 1991, 1993, 1994; Fryer et al. 1992; Fryer and Kelsey 2001, 2002, 2003; Fryer 2004, 2005, 2006), presumably reflecting differences in freshwater rearing conditions. In most years, Okanogan sockeye salmon scale samples have shown greater growth to both freshwater annulus and saltwater entry than have Wenatchee sockeye salmon scale samples.

This report presents estimates of the age and length-at-age composition of adult Columbia Basin sockeye salmon at Bonneville Dam in 2006. This report also presents age and length-at-age composition estimates from the Wenatchee stock collected at Tumwater Dam on the Wenatchee River and the Okanogan stock collected at Wells Dam. Data collected from our mid-Columbia sampling program was used to estimate stock composition of the Bonneville Dam mixed-stock in 2006. Mixed stock composition and known-stock age composition estimates were compared with those derived from a new study where most sockeye we sampled were also PIT tagged and these PIT tags detected at upstream dams (Fryer 2007).

METHODS

Sample Design

Sockeye salmon were sampled at Bonneville Dam (river km 235) one to three days per statistical week[2] in conjunction with a summer Chinook salmon *O. tshawytscha* sampling program (Whiteaker and Fryer 2007) as well as a sockeye PIT tagging program (Fryer 2007). Sockeye salmon were sampled at Wells Dam in conjunction with a Washington Department of Fish and Wildlife (WDFW) summer Chinook brood stock collection program, while sampling at Tumwater Dam was done in conjunction with another WDFW research project. The desired total sample size for age composition estimates at each site was a minimum of 500 fish at Bonneville Dam, and 400 fish at Tumwater and Wells dams. In previous study years (Fryer 1995), these minimum sample numbers have resulted in acceptable levels of precision (d=0.05) and accuracy (α=0.10). Smaller sample sizes are normally sufficient at Tumwater and Wells dams because the age composition tends to be more skewed towards one or two age classes than at Bonneville Dam. Daily counts of 2006 fish passage at fish ladders were obtained from DART (2006) and the Fish Passage Center (2006) for Bonneville and Wells dams and from WDFW for Tumwater Dam (Clint Deason, WDFW**,** October 27, 2006 e-mail, personal communication).

A stratified sampling method that weighted weekly age and length-at-age estimates by actual migratory timing was used to obtain composite estimates for the Wenatchee and Okanogan known-stocks as well as the Bonneville mixed-stock (Cochran 1977).

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2 Statistical weeks are sequentially numbered calendar-year weeks. Excepting the first and last week of most years, weeks are seven days long, beginning on Sunday and ending on Saturday. In 2006 for example, Statistical Week 24 began on June 11 and ended on June 17.

Sampling Methods

Data and scales from mixed sockeye salmon stocks (or mixed-stocks) were obtained from fish sampled at the Bonneville Dam Adult Fish Facility, located on the mainstem Columbia River. Each stock was also sampled in terminal areas to obtain representative scale samples specific to each of the two Columbia Basin sockeye salmon groups (or known-stocks). Wenatchee stock data and scales were collected at Tumwater Dam on the Wenatchee River (river km 53), and Okanogan stock data and scales were obtained at Wells Dam on the mainstem Columbia River (river km 830) just downstream from the mouth of the Okanogan River.

Fish were trapped and anesthetized. Each fish was then sampled for scales, measured for fork length, inspected for markings and/or tag information and noted for other pertinent biological information (Whiteaker and Fryer 2007). Fish were also scanned for PIT tags. At Bonneville Dam, if the fish was not adipose clipped, the fish was PIT tagged. Fish were then scanned again for the PIT tag and the PIT tag number recorded. All fish were revived in freshwater and returned to the exit fishway. Four scales per fish were collected to minimize the sample rejection rate. The gender of specimens collected at Bonneville Dam could not be determined because all were in the earliest stages of sexual maturation. The gender of some specimens collected at Tumwater and Wells dams could be determined, and this data was recorded.

Length Measurements

Fork lengths were measured to the nearest 0.5 cm at Bonneville, Wells, and Tumwater dams. Mean length and standard deviation were calculated for each age class, by weekly sampling period, and for the composite sample. Composite samples were weighted by weekly run size.

Age Determination

Scales were selected, 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, Borodin 1924, Van Oosten 1929). A sample of scales was brought to John Sneva of the Washington Department of Fish and Wildlife for corroboration of age estimates.

The European method for fish age description (Koo 1955) is used in this report. The number of winters a fish spent in freshwater (not including the winter of egg incubation) is described by an Arabic numeral followed by a period. The numeral following the period indicates the number of winters a fish spent in the ocean. Total age, therefore, is equal to one plus the sum of both numerals.

Weekly age composition estimates were compiled and weighted by weekly run size to estimate overall age composition at Bonneville, Wells, and Tumwater dams.

Scale Pattern Analyses

Scale pattern analysis (SPA) of circuli in freshwater- and early saltwater-growth zones was used to identify each known-stock sample and to also classify mixed-stock samples. The methodology was applied to the predominant Age 1.2 class from all stocks. Scale features were first measured using a computer and video camera based system (BioSonics Optical Pattern and Recognition System [OPRS]) that included a microscope (2x, 4x, 6.3x, and 10x objectives; a 1.0x, 1.25x, and 1.5x magnification changer; and a 2.5x photocompensation adapter), a secondary monitor (53 cm), and a digitizing tablet connected to a personal computer with a video frame-grabber board (BioSonics 1987). Acetate impressions of scales were placed under the microscope and projected onto the monitor using a 4.0x objective, 1.0x magnification changer, and 2.5x photo-compensation adapter. This lens configuration created a scale image initially viewed at 130x actual size.

Working from the top of the scale card, the first scale impression with no focus regeneration and clearly defined circuli was selected and the projected image was oriented diagonally with the clear (posterior) portion of the scale in the lower left corner of the screen. A reference line was drawn along the base of the scale image (Figure 2). The reference line was placed in the posterior field of the

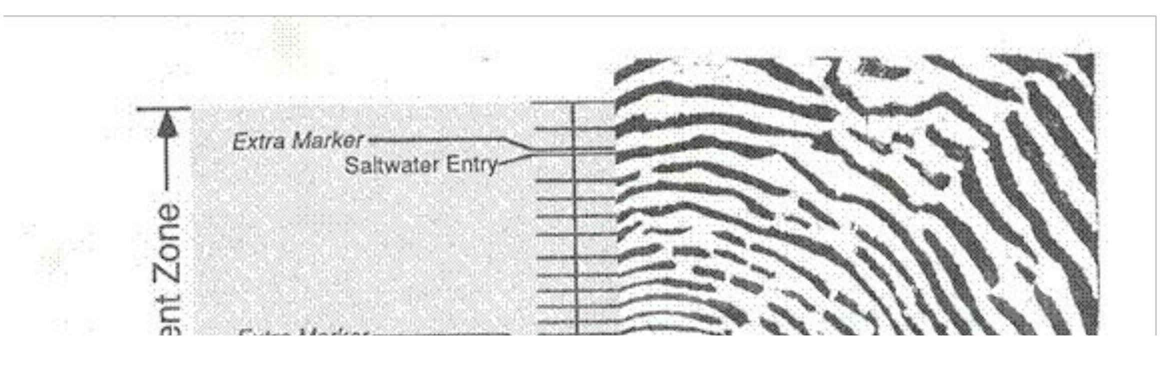
scale image so that the line bridged the end points of circuli in the first saltwater annulus (Fryer and Schwartzberg 1994). The objective was then changed to 10x, resulting in a viewed scale image 325x actual size, and a radial line was then drawn perpendicular to the reference line. Circuli positions were marked at the marginal (outermost) edge of their intersection with the radial line. The OPRS software (version 1.0) measured the distance from the scale focus to each circuli marker. The portion of the scale where circuli measurements were made included the entire freshwater zone and part of the early saltwater growth zone.

Additional artificial circuli markers were placed to permit measurement of other key scale-features, specifically, freshwater annulus and saltwater-entry point. These features were respectively indicated by two sets of closely spaced circuli markers. The 'extra markers' were placed immediately after and adjacent to the original circuli position markers and were interpreted and removed by data analysis programs used in subsequent procedures (Fryer and Schwartzberg 1993). The freshwater annulus-position marker was placed beside the last circulus in the freshwater annulus and the saltwater-entry marker was placed immediately after the first circulus in the ocean zone.

For SPA studies, the desired sample size was approximately 200 from each known-stock group for each age class analyzed (Conrad 1985)[3]. As in most previous years, the only age class with a sufficiently large sample size to justify using SPA was Age 1.2. For SPA analysis of mixed-stocks, 100 was the desired sample size (Conrad 1985), although the actual sample size used for the Bonneville mixed-stock has normally been much larger to permit more precise weekly stock composition estimates. No adipose-fin sockeye salmon were included in any of the samples studied due to small sample sizes as well

3 In many years, actual sample sizes have been considerably less due to low numbers of fish collected.

Figure 2. Age 1.2 Okanogan stock sockeye salmon scale showing growth and measurement zones.



as the fact that these were assumed to be from Snake River or Wenatchee River hatchery programs.

Statistical Analyses

A linear discriminant analysis technique developed by Fisher (1936) was used to differentiate stocks. Linear discriminant analysis permits the simultaneous use of many variables to form classification functions that typify and identify groups. This methodology has proven useful for determining the origins of individual fish stocks from mixed-stock samples (Bethe and Krasnowski 1977, Bethe et al. 1980, Major et al. 1978). Weekly stock composition estimates were weighted by the weekly run size to estimate the stock composition for the entire run.

Variables, composed of selected scale-measurements within the area from scale focus to Circulus 24, were tested to find those that most effectively characterized differences in growth between the two known stocks as well as between the two validation groups. As in previous years' studies, distances between four adjacent circuli (or triplets) were the primary variable tested (Davis 1987). Distance measurements and number of circuli from scale focus to saltwater-entry and from scale focus to freshwater annulus margin (anterior) were also among the variables tested.

Accuracy of the discriminant analyses was determined by classifying the pooled known-stock samples from a particular analysis and then comparing results to actual (verifiable) known-stock identities. A jackknife procedure (Lachenbruch 1975, Dixon et al. 1983) was employed to correct for systematically biased results that are created in known-stock classification when the same samples are used for both calculating the discriminant function and estimating its accuracy. The method developed by Cook and Lord (1978) and Cook (1983) was used to correct for misclassification of mixed-stock samples. Variances on mixed-stock classification estimates were also computed (Pella and Robertson 1979).

RESULTS

Sample Sizes

Final sample sizes used for age and length-at-age composition estimates were 527 Bonneville mixed-stock, 390 Wenatchee known-stock, and 238 Okanogan known-stock. Of the original 556 sockeye salmon sampled at Bonneville Dam, 5.9% of the total sample was rejected and not classified by age because of unreadable scales while scales were not collected for an additional 0.4% of the sample. For the same reason, 4.4% of the 408 Wenatchee, and 2.8% of the 245 Okanogan samples were rejected.

Age Composition

The predominant age class for the Bonneville mixed-stock as well as for the Okanogan known stock (Tables 1-2) was Age 1.2 fish which was estimated to comprised 63.0% of the run at Bonneville Dam and 72.4% of the run at Wells Dam. The Wenatchee known stock consisted of 40.9% age 1.3, 36.4% Age 1.2, and 21.2% Age 2.2 (Table 3).

Seventeen of the fish sampled at Bonneville Dam, representing 3.6% of the run, were adipose clipped These fish are most likely from the Wenatchee Eastbank supplementation program, although the remote possibility does exist that fish from a Snake River program may also be included. Fourteen of the adipose clipped fish were Age 1.2, one Age 2.2, and for one adipose clipped fish no scales were collected.

Of the 35 adipose clipped fish sampled at Tumwater Dam, representing 8.4% of the run, 31 were Age 1.2, one Age 2.2, and three had no scales that could be read for age. Of the three adipose clipped fish sampled at Wells Dam, representing 0.5% of the run, two were Age 1.2 and one was Age 2.2. Two of these three fish had scale patterns very similar to that of Wenatchee net pen sockeye salmon.

Length Composition

For the three principal age groups, 1.2, 1.3, and 2.2, Wenatchee sockeye salmon sampled at Tumwater Dam had a greater mean length than did Okanogan sockeye salmon at Wells Dam or the mixed stock at Bonneville Dam (Tables 4-6). This is likely, at least in part, due to the fact that many fish sampled at Tumwater Dam had well-developed secondary sexual characteristics, including the development of an elongated snout in the males, which would result in an increase in fork length.

Classification of Known-Stock Samples

The only age group for which sample sizes were large enough for SPA was Age 1.2. Known stock sample sizes for this age group were 127 Okanogan and 95 for the Wenatchee stock. The variable set chosen to classify known- and mixed-stock samples consisted of the distances between the focus and circuli 3, circuli 12 and 15, 15 and 18, and 18 and 21. The overall classification accuracy was 78.2% (Table 7). Classification was the same regardless as to whether we used the distance and number of circuli to freshwater annulus as variables as these variables were not selected by the discriminant function.

Classification of Mixed-Stock Samples

The percentage of Age 1.2 sockeye salmon of Wenatchee origin was 22% (σ=16%), with the remaining 78% (σ=16%) of Okanogan origin. In an effort to derive a weekly and total stock composition estimate for all age classes, other age classes sampled at Bonneville Dam were allocated to the two stocks (Fryer 1995). Given that no fish of Age 1.1 were found in the Wenatchee known-stock sample but were found in the Okanogan known-stock sample, Age 1.1 fish at Bonneville Dam were allocated to the Okanogan stock. The Age 1.3, 2.2 and 3.1 fish were considered to be of unknown origin since these age groups were found in both known stocks and there were insufficient samples to do SPA. Among all sockeye passing over Bonneville Dam in 2006, an estimated 13% (σ=16%) were of Wenatchee stock, 52% (σ=16%) were of Okanogan stock, and

Table 4. Length-at-age estimates for Columbia Basin sockeye salmon stocks sampled at Bonneville Dam in 2006.

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 5. Length-at-age estimates for Wenatchee sockeye salmon stocks sampled at Tumwater Dam in 2006.

Brood Year and Age Class	2002 1.2	2001 1.3	2001 2.2	2001 3.1	2000 2.3
Statistical Week 28					
Mean Fork Length (cm)	51.50	60.50	50.83		
Maximum	55.50	60.50	52.50		
Minimum	49.00	60.50	49.50		
Standard Deviation	2.47	-	1.53		
Sample Size	5	1	3		
Statistical Week 29					
Mean Fork Length (cm)	50.86	55.81	50.94		
Maximum	57.50	60.50	56.50		
Minimum	46.50	49.00	47.00		
Standard Deviation	2.23	2.50	2.07		
Sample Size	73	67	50		
Statistical Week 30					
Mean Fork Length (cm)	51.83	54.94	50.56	50.38	58.50
Maximum	59.00	60.00	57.00	53.00	58.50
Minimum	46.00	46.00	45.00	46.50	58.50
Standard Deviation	3.30	2.48	2.79	2.87	-
Sample Size	66	87	33	4	1
2006 Composite					
Mean Fork Length (cm)	51.33	55.35	50.79	50.38	58.50
Maximum	59.00	60.50	57.00	53.00	58.50
Minimum	46.00	46.00	45.00	46.50	58.50
Standard Deviation	2.80	2.54	2.35	2.87	-
Sample Size	144	155	86	4	1

Table 6. Length-at-age estimates for Okanogan sockeye salmon stocks sampled at Wells Dam in 2006.

Brood Year and	2003	2002		2001			2000	
Age Class	1.1	1.2	2.1	1.3	2.2	3.1	2.3	3.2
Statistical Week 28								
Mean Fork Length (cm)		51.26	43.00	54.50	50.92	54.50		
Maximum		55.50	43.00	56.00	56.50	54.50		
Minimum		47.50	43.00	53.00	47.50	54.50		
Standard Deviation		1.97	-	1.29	3.09	-		
Sample Size		68	1	4	12	1		
Statistical Week 29								
Mean Fork Length (cm)	40.00	49.08	40.75	54.90	49.77			
Maximum	41.00	54.50	41.00	57.50	53.00			
Minimum	39.00	40.50	40.50	53.00	45.00			
Standard Deviation	1.41	2.86	0.35	2.19	2.42			
Sample Size	2	42	2	5	11			
Statistical Week 30								
Mean Fork Length (cm)		49.71	41.75	52.17	49.82	48.50	53.00	50.88
Maximum		54.00	43.00	57.50	55.00	51.00	53.00	57.00
Minimum		43.00	40.50	45.50	45.00	46.00	53.00	46.50
Standard Deviation		2.55	1.77	4.80	2.93	3.54	-	4.85
Sample Size		45	2	9	19	2	1	4
Statistical Week 31								
Mean Fork Length (cm)		48.30		55.00				
Maximum		51.50		56.00				
Minimum		47.00		54.00				
Standard Deviation		1.99		1.41				
Sample Size		5		2				
2005 Composite								
Mean Fork Length (cm)	40.00	50.16	41.60	53.60	50.12	50.50	53.00	50.88
Maximum	41.00	55.50	43.00	57.50	56.50	54.50	53.00	57.00
Minimum	39.00	40.50	40.50	45.50	45.00	46.00	53.00	46.50
Standard Deviation	1.41	2.58	1.29	3.59	2.83	4.27	-	4.85
Sample Size	2	160	5	20	42	3	1	4

Table 7. Known-stock classification resulting from using the linear discriminant analysis with Columbia Basin sockeye salmon stocks sampled in 2006.

Stock	Percent Correct	Sample Classification *Wenatchee*	*Okanogan*
Wenatchee	77.5	69	20
Okanogan	78.9	28	105
Composite Accuracy	78.2		

Table 8. Weekly and composite sockeye salmon stock composition at Bonneville Dam as estimated by PIT tags in 2006 with a comparison to stock composition estimates derived from other methods.

Statistical Week	Percent Wenatchee	Percent Okanogan	Percent Unclassified
24	33.9	66.1	
25	37.0	63.0	
26	23.6	76.4	
27	16.7	83.3	
28	15.8	84.2	
Composite	27.2	72.8	
Dam Counts-(using Rocky Reach-Rock Island difference for Wenatchee estimate)	27.4	72.6	
Dam Counts-(Tumwater count as Wenatchee estimate)	18.1	81.9	
Scale Pattern Analysis	13.3	52.4	34.1
Visual Estimate from scale patterns	27.5	72.5	

34% (σ=2.4%) were of unknown origin (Table 8). If the stock composition of unknown-origin sockeye was similar to that of age groups that could be classified by stock, the resulting stock composition estimate would be 20.2% Wenatchee and 79.8% Okanogan.

In 2006, PIT tag data (Fryer 2007) provided a method of estimating total, and weekly, stock composition without the high percentage of unknown stock fish. This data is presented in Table 8 along with stock composition estimates from dam counts and a visual estimate from scale patterns (Fryer 2007).

DISCUSSION

The 2006 Columbia Basin sockeye salmon run of 37,006 fish at Bonneville Dam was lowest since 1999 and less than the most recent four-year (2002-2005) average of 71,300 fish. The 2006 run was typical in that Age 1.2 group made up the majority of the run at Bonneville, Wells, and Tumwater dams.

Over the 20 years this project has been conducted, we have normally been able to use scale pattern analysis to classify virtually all of the sockeye we sampled at Bonneville Dam. One reason that we have been able to do so is that, in most years, age classes other than 1.2. tend to be a relatively small proportion of the run at Bonneville Dam and tend to classify by age. Age 1.1 and 2.1 sockeye salmon have always been extremely rare to non-existent in our Wenatchee sample, but much more common in the Okanogan sample so we have always classify them as Okanogan stock (as we did in 2006). However, in most years Age 1.3 and 2.2 sockeye salmon have been relatively rare in the Okanogan sample (combined averaging about 11% of the run) and relatively common in the Wenatchee sample (combined averaging about 39% of the run) so we have been able to classify at least one of these age groups as Wenatchee stock. In a few years when Age 1.3 sockeye have been a significant component of both stocks, we have been able to use SPA to classify that age group. However, in 2006 these two age groups were a significant component of both stocks. We also had a relatively small sample size at Wells Dam that prevented gathering a large enough sample to do SPA on age classes other than Age 1.2; leading to our estimate of 34.1% as unclassified. The sample size was limited at Wells Dam because we only sample sockeye salmon in conjunction with a summer Chinook salmon broodstock collection program. In years of high summer Chinook salmon abundance at Wells Dam, as in 2006, the trap is not run long enough for us to reach our goal of 400 sockeye salmon sampled over the entire run. (And even if we had been able to sample 400 sockeye salmon at Wells, sample sizes still would have been small for Age 1.3 fish and marginal for Age 2.2 fish.)

We did have the benefit of receiving funding from the Pacific Salmon Commission Southern Fund to PIT tag most of the sockeye salmon we sampled. These fish were then detected at PIT tag detectors located in adult fish ladders at

McNary, Priest Rapids, Rock Island, Rocky Reach, and Wells dams. This allowed us to assign sockeye salmon passing upstream of Rock Island Dam to a particular stock. Those detected at Rocky Reach Dam comprised the Okanogan stock, and those detected at Rock Island Dam, but not Rocky Reach Dam, comprised the Wenatchee stock. The results of this study gave a stock composition estimate that was very similar to that estimated by mid-Columbia dam counts where the Rocky Reach count is the considered the Okanogan population while the difference between the Rock Island and Rocky Reach dam counts is considered the Wenatchee stock (Table 8). In addition, the study also concurred with past findings of this study where, in 2006 as in most other years, the proportion of Wenatchee stock sockeye declines while the proportion of Okanogan stock sockeye salmon increases as the run progresses at Bonneville Dam.

Three sockeye salmon sampled at Wells Dam in 2006 were adipose clipped. These fish were all Age 1.2 and were estimated to represent 0.5% of the run at Wells Dam. The only known source of adipose clipped sockeye salmon upstream of Rock Island Dam is the Skaha Lake reintroduction program, and fish from that program would have been returning as three year olds. Two of these fish had scale patterns similar to those of fish from the Lake Wenatchee supplementation program, suggesting that they may have ultimately returned to the Wenatchee River.

The estimated harvest in Zone 1-5 (downstream of Bonneville Dam) was four fish, with an additional 662 fish harvested in the Zone 6 (between Bonneville and McNary dams) tribal summer Chinook commercial fishery, while 935 sockeye were captured in the Zone 6 tribal ceremonial and subsistence fishery (December 7, 2006 e-mail from Stuart Ellis, CRITFC, personal communication). No scales were collected in 2006 from any sockeye captured in these fisheries so SPA could not be used to estimate the stock composition of these harvests, nor were these fish scanned for PIT tags.

Sockeye salmon are also harvested in tribal fisheries upstream of Wells Dam. In 2006, no sockeye were harvested by Colville tribal fishers upstream of Wells Dam, although 12 sockeye salmon were killed (out of 125 captured) as part of an evaluation of selective gear (Colville Confederated Tribes Fish and Wildlife

Department memorandum from Christopher J. Fisher to Enrique Patino dated January 15, 2007). The Okanagan Band tribal Lake Osoyoos gill net and Okanagan River snag fisheries combined caught less than 100 fish (Howie Wright, Okanagan Nation Alliance, February 2, 2007, personal communication). Given the low return past Tumwater Dam, there was no Lake Wenatchee sport fishery in 2006.

Research on Columbia Basin sockeye salmon will continue in 2007and we will continue to develop an age, length-at-age, and stock composition database for this population. Data obtained from this program may be useful to monitor the impact of future main-stem Columbia River fisheries, supplementation programs in the Wenatchee and Okanogan basins, as well as sockeye salmon stock recovery efforts in other Columbia River subbasins.

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