AGE AND LENGTH COMPOSITION OF COLUMBIA BASIN SPRING CHINOOK SALMON SAMPLED AT BONNEVILLE DAM IN 1988

Technical Report 89-1

Matthew Schwartzberg

January 6, 1989

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COLUMBIA RIVER INTER-TRIBAL FISH COMMISSION

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INTRODUCTION

The Stock Identification Project of the Columbia River Inter-Tribal Fish Commission (CRITFC) is a part of the U.S.-Canada Pacific Salmon Treaty spawning escapement monitoring program (Pacific Salmon Treaty 1985). The project is designed to develop and apply identification techniques to individual stocks or groups of stocks of Columbia Basin salmon originating above Bonneville Dam. Scale pattern analysis (SPA) is the primary study method.

This report summarizes age and length composition estimates for spring chinook salmon (*Oncorhynchus tshawytscha* Walbaum) sampled at Bonneville Dam in 1988. Bonneville Dam is located on the Columbia River at river kilometer 235 (Figure 1). At this sampling location, the spring chinook salmon population is composed of a mixture of both hatchery- and natural-origin stocks. Research was begun in 1986, and a report of 1987 results is available (Schwartzberg 1988).

METHODS

Sampling

To collect a representative sample of the spring chinook salmon population, fish were trapped at the Fisheries Engineering and Research Laboratory (FERL) located beside the Second Powerhouse (north side) of Bonneville Dam. Work was done with the assistance and cooperation of the U.S. Army Corps of Engineers, the National Marine Fisheries Service, and the Oregon Department of Fish and Wildlife.

The sample was composed of 536 fish (Table 1). This sample size was based on desired levels of precision and accuracy ($p = .05$, c.i. $= 0.90$; Bernard 1982). Weekly sample sizes were proportional to weekly run timing and passage averaged over the previous ten years (1977 - 1987) and were computed using Bonneville Dam fish ladder counts (Columbia River Inter-Tribal Fish Commission 1987). Six scales per fish were collected in 1988 to minimize the relatively high sample rejection rate experienced in the 1987 study.

Fish were anesthetized, quickly sampled for scales and biological data, allowed to recover, and then returned to the exit fishway leading to a primary fish ladder.

Figure 1. **Map of the Columbia Basin showing principal (upriver) spring chinook salmon spawning and rearing tributaries and Bonneville, McNary, Grand Coulee, and Hells Canyon dams.**

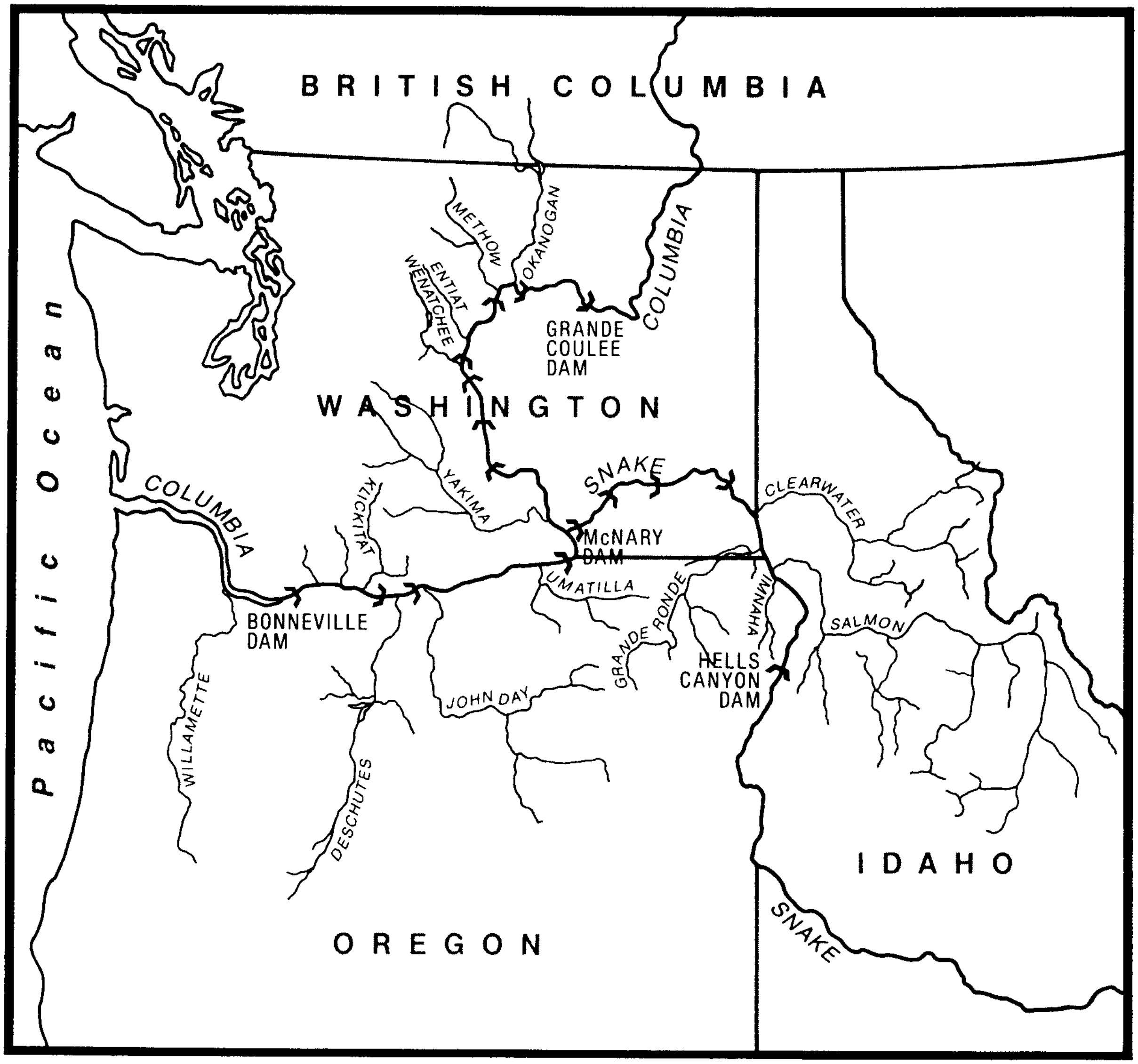


Table 1. Cumulative and weekly sample sizes for Columbia Basin spring chinook salmon sampled at Bonneville Dam in 1988.

Date	Statistical Week	10 yr. Avg.[1] (Cum.%)	Samp. Size (Cum. No.)	Samp. Size (Per Week)
3/29&31/88	14	0.03	19	19
4/05/88	15	0.12	63	44
4/11/88	16	0.26	143	80
4/19/88	17	0.43	232	89
4/26/88	18	0.61	326	94
5/03/88	19	0.77	413	87
5/09/88	20	0.88	472	59
5/17/88	21	0.95	509	37
5/23/88	22	1.00	536	27
Total				**536[2]**

1. The cumulative percentage is based on the proportional weekly migration rate for previous years' spring chinook counts at Bonneville Dam (ten-year average, 1977 -1987).
2. The total sample size (536) was based on the number of samples necessary to obtain a population composition estimate (p = 0.05, c.i. = .90) given three primary age categories within the population, an infinite estimated population size, and a 0.15 rate of unusable samples.

Observed mark and/or tag information was recorded. No live fish were sacrificed in the study. Consequently, sex of collected specimens, all in the earliest stages of sexual maturation, could not be determined. Field sampling procedures followed guidelines previously established for this project (Schwartzberg 1987).

Age Determination

Scales were prepared and mounted according to methods described in Clutter and Whitesel (1956) and the International North Pacific Fisheries Commission (1963). Individual samples were visually examined by CRITFC staff and were categorized using established scale age-estimation methods (Johnston 1905, Gilbert 1913, Van Oosten 1929). Age estimates were corroborated by personnel at the Columbia River Management Division of the Oregon Department of Fish and Wildlife and the Harvest Management Division of the Washington Department of Fisheries. Freeze-branded adult spring chinook salmon (marked in passage/transport studies) were used to validate scale derived ocean-age estimates. Fish with unique fin-clip marks were also used for age validation.

The method used for fish age description is that recommended by Koo (1955), which is sometimes referred to as the *European* method. 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 dot. The number of winters a fish spent in the ocean is indicated by the numeral following the dot. Total age is, therefore, equal to one plus the sum of both numerals.

Length Measurements

Fork lengths were measured to the nearest 0.5 cm. Mean lengths and measurements of variability were calculated for each age class and brood year, by weekly sampling period, and for the total sample.

RESULTS AND DISCUSSION

Age Composition

Five-year-old fish (ages 1.3 and 0.4 - 1983 brood) represented 0.54 of the total sample (Figure 2). This age class was predominant in six of the nine weekly sample periods (Table 2, Figure 3), ranging in proportion between 0.50 (statistical week 18) and 0.93 (statistical week 15). Four-year-old fish (ages 1.2 and 0.3 - 1984 brood) were second in abundance, comprising 0.37 of the total sample. Weekly proportions of four-year-old fish ranged between 0.07 (statistical week 15) and 0.59 (statistical week 19).

Three-year-old fish (ages 1.1 and 0.2 - 1985 brood) made up 0.09 of the total sample. Weekly proportions ranged between 0.00 (statistical weeks 14, 15, and 17) and 0.41 (statistical week 22). One two-year-old fish (age 0.1 - 1986 brood) was observed in statistical week 22.

Thirteen fish, or 0.02 of the total sample, were judged to be age *0-plus*, with eight age 0.3, three age 0.2, one age 0.1, and one age 0.4 sampled (Table 2). These fish are believed to have originated from the Little White Salmon National Fish Hatchery as a result of that hatchery's on-going accelerated rearing program. Age 0-plus fish are combined with their respective brood-year cohorts in the above summaries.

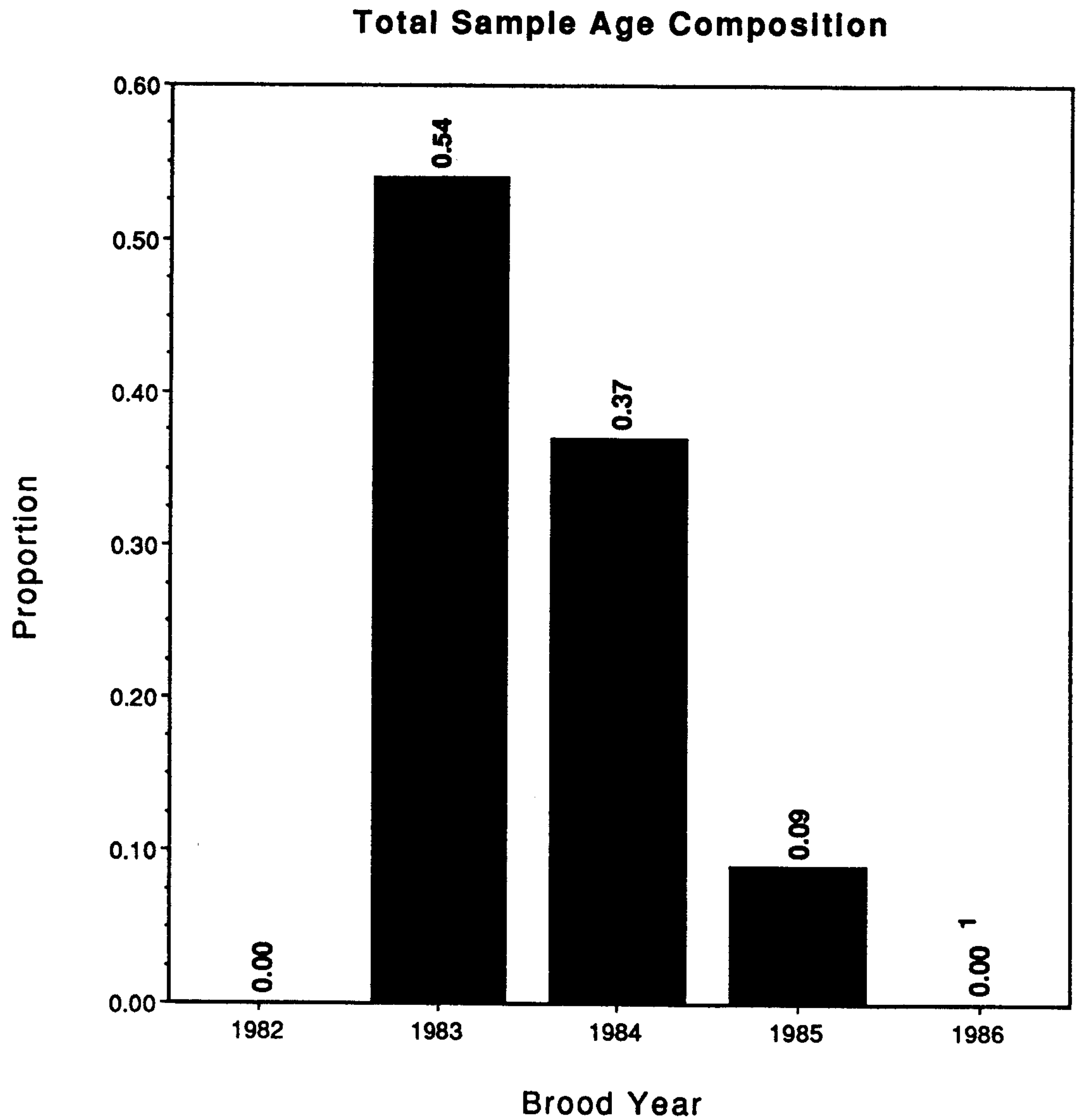
Five percent of the total sample was rejected and not classified by age because of unreadable scales.

Length-at-Age Composition

The average length of three-year-old fish (1985 brood) in the total sample was 49.6 cm. The 0.90 confidence interval was 39.1 to 60.1 cm (n = 46) (Table 3; Figure 4). The average length of four-year-old fish (1984 brood) was 72.1 cm, with a 0.90 confidence interval of 62.7 to 81.5 cm (n = 196). The average length of five-year-old fish (1983 brood) was 87.9 cm with a 0.90 confidence interval of 79.6 to 96.2 cm (n = 292).

Ten of eleven age 0-plus fish fell outside the 0.90 confidence intervals for their respective brood-year cohorts and were closer in length to those fish of the previous brood-year having an additional year's fresh-water growth (Table 3). The single age 0.1 fish sampled could not be compared in age to any brood-year cohort. The length of one age 0.3 fish was not recorded.

Figure 2. **Total age composition (by brood year) of Columbia Basin spring chinook salmon sampled at Bonneville Dam in 1988.**



1. The proportion of the 1986 brood was actually 0.00186 with one age 0.1 fish sampled.

Table 2. Weekly and total age composition of Columbia Basin spring chinook salmon sampled at Bonneville Dam in 1988.

Brood Year and Age Class[1]

Statistical Week	1986	1985		1984		1983	
	0.1	0.2	1.1	0.3	1.2	0.4	1.3
14				0.05	0.16		0.79
15					0.07		0.93
16		0.01		0.01	0.23		0.75
17					0.40		0.60
18			0.03	0.01	0.46		0.50
19			0.11	0.03	0.56		0.30
20		0.02	0.25	0.02	0.45		0.27
21			0.14	0.03	0.16		0.68
22	0.04	0.04	0.37	0.04	0.22	0.04	0.26
Total Sample	0.00[2]	0.01	0.08	0.01	0.36	0.00[2]	0.54

1. Rounding errors may have caused weekly sample proportions to not total 1.0.
2. The actual proportion is 0.002.

Figure 3. Weekly age composition (by brood year) of Columbia Basin spring chinook salmon sampled at Bonneville Dam in 1988.

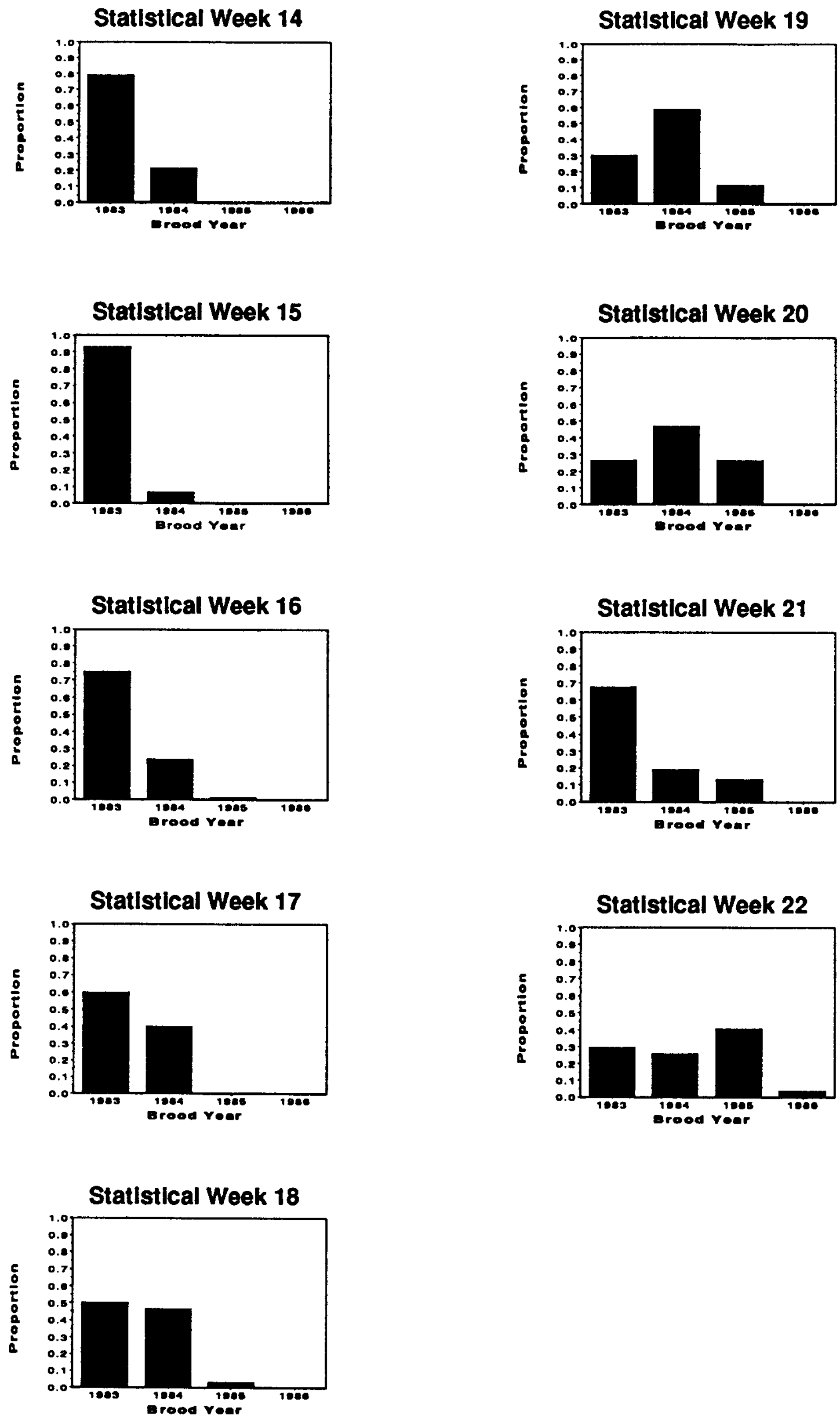
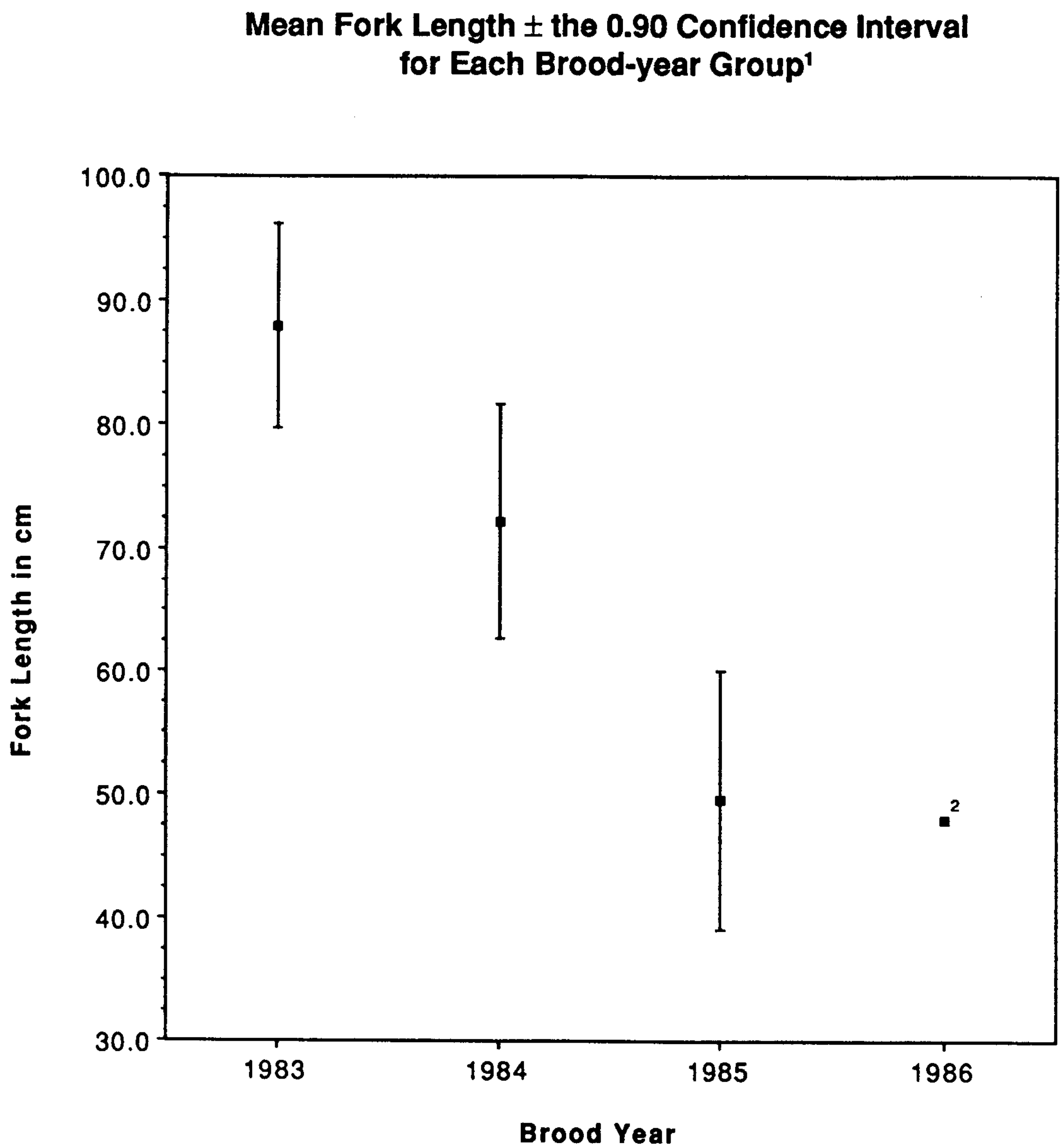


Table 3. Weekly and total length-at-age composition of Columbia Basin spring chinook salmon sampled at Bonneville Dam in 1988.

	Brood Year and Age Class						
	1986	1985		1984		1983	
	0.1	0.2	1.1	0.3	1.2	0.4	1.3
Stat. Wk. 14							
Avg. Fk. Len. (cm)				94.0	68.5		90.6
Min.				94.0	56.5		86.5
Max.				94.0	77.0		98.0
Std. Error				—	6.2		0.9
N in Group				1	3		15
Stat. Wk. 15							
Avg. Fk. Len. (cm)					65.7		88.2
Min.					61.5		80.0
Max.					68.0		101.0
Std. Error					2.1		0.7
N in Group					3		41
Stat. Wk. 16							
Avg. Fk. Len. (cm)		61.5		88.5	70.2		87.8
Min.		61.5		88.5	56.0		76.5
Max.		61.5		88.5	79.0		97.0
Std. Error		—		—	1.3		0.6
N in Group		1		1	18		60
Stat. Wk. 17							
Avg. Fk. Len. (cm)					71.9		88.3
Min.					56.0		76.5
Max.					85.5		99.0
Std. Error					1.1		0.6
N in Group					35		54
Stat. Wk. 18							
Avg. Fk. Len. (cm)			48.3	87.5	72.8		88.1
Min.			42.0	87.5	64.0		76.5
Max.			55.5	87.5	81.5		102.5
Std. Error			3.9	—	0.5		0.8
N in Group			3	1	43		47
Stat. Wk. 19							
Avg. Fk. Len. (cm)			48.7	82.0	71.6		85.2
Min.			37.0	77.5	63.0		69.5
Max.			55.5	86.5	79.0		95.5
Std. Error			1.8	4.5	0.6		1.2
N in Group			10	2	49		26
Stat. Wk. 20							
Avg. Fk. Len. (cm)		65.5	50.5	69.0	70.8		88.1
Min.		65.5	39.5	69.0	56.0		79.5
Max.		65.5	61.5	69.0	81.5		100.0
Std. Error		—	1.4	—	1.2		1.3
N in Group		1	15	1	26		16
Stat. Wk. 21							
Avg. Fk. Len. (cm)			49.3	N.A.	74.7		87.6
Min.			40.5	N.A.	68.5		75.5
Max.			58.5	N.A.	86.5		96.0
Std. Error			3.7	—	2.6		1.0
N in Group			5	1	6		25
Stat. Wk. 22							
Avg. Fk. Len. (cm)	48.0	57.0	46.1	79.5	71.8	81.5	88.7
Min.	48.0	57.0	38.0	79.5	68.5	81.5	77.0
Max.	48.0	57.0	53.0	79.5	78.0	81.5	97.0
Std. Error	—	—	1.3	—	1.5	—	2.6
N in Group	1	1	10	1	6	1	7
TOTAL							
Avg. Fk. Len. (cm)	48.0	61.3	48.8	83.2	71.6	81.5	87.9
Min.	48.0	57.0	37.0	69.0	56.0	81.5	69.5
Max.	48.0	65.5	61.5	94.0	86.5	81.5	102.5
Std. Error	—	2.5	0.9	3.2	0.4	—	0.3
N in Group	1	3	43	8	189	1	291

Figure 4. Total length-at-age composition of Columbia Basin spring chinook salmon sampled at Bonneville Dam in 1988.



1. Age 0-plus fish are included with their respective brood-year cohorts.
2. Only one fish was sampled of this brood year (age 0.4).

Discussion

Comparison of the above results to those obtained in 1987 (Schwartzberg 1988) indicates a substantial change in total-sample age compositions, particularly with regard to the two principal age-classes, ages 1.2 and 1.3. In 1987, ages 1.1, 1.2, and 1.3 fish respectively comprised 0.06, 0.66, and 0.28 of the total sample, whereas in 1988, they represented 0.08, 0.36, and 0.54. Predominance of age 1.3 fish in 1988 was also noted in known-stock samples of Columbia Basin spring chinook salmon from the Deschutes and Wenatchee Rivers (Schwartzberg and Fryer 1989a). Similarly, preliminary results of a 1988 Columbia Basin sockeye salmon stock-identification study (Schwartzberg and Fryer 1989b) show a higher proportion of three-ocean (age 1.3) fish than in the previous year. No explanation is apparent for this change in inter-annual age composition. Possible causes include changes in freshwater spawning, rearing, and out-migratory conditions, as well as in ocean growth, survival, and harvest management. Length-at-age composition remained relatively similar in the two study years, with mean fork-lengths differing by less than 1.0 cm for ages 1.2 and 1.3 fish and by 1.7 cm for age 1.1 fish ($p = 0.28$).

In 1987, more than 0.20 of the fish sampled were rejected from the analysis because scale regeneration prevented accurate age estimation. Consequently, six scales per fish were obtained in 1988 (rather than three, as in 1987). Total and weekly sample sizes were also upwardly adjusted. In 1988, only 0.05 of the fish sampled needed to be rejected from the analysis because of unreadable scales. Scale regeneration rates have been found to differ between stocks of Pacific salmon (Knudsen 1988). By lowering the scale rejection rate in 1988, biases related to potentially unequal, stock-specific scale regeneration rates may have been reduced.

Presence of additional known-age fish in the sample would offer an opportunity to further validate scale-age estimates. This would be particularly useful for age determination of accelerated-growth hatchery fish whose age is often difficult to accurately estimate from scale examination. Because fish were not sacrificed in this study, coded-wire tag information was unavailable for age-estimate confirmation. Some of the more recently introduced tagging methods, particularly the passive inductive transponder or *PIT tag* (Prentice, et al 1987), may provide the opportunity for systematic age validation in future years of this study.

One of the principal tools now used in Columbia Basin spring chinook salmon management is a linear forecasting run-size prediction model based on sibling age-class returns. The method requires accurate age-specific population abundance data.

A spring chinook test fishery, located approximately 32 km downstream from Bonneville Dam and conducted annually by the Washington Department of Fisheries (called the *Corbett fishery*), presently provides this data. The sampling period is, however, limited to April 1 through April 30, and 18.42 cm (7.25 in.)-mesh gillnets are used.

Age-composition estimates obtained from the Corbett test-fishery (n = 312) were compared to results obtained from the Bonneville Dam sampling program. Age 1.2 and 1.3 fish were estimated to respectively represent 0.42 and 0.54 of the test-fishery sample (Dammers, personal communication). Corbett gear does not effectively capture smaller fish and, therefore, age 0.2 and 1.1 fish were not accurately represented. For comparative purposes, fish of these age classes were removed from our study sample (0.09 of the total sample), yielding an age-composition profile of 0.39 age 1.2 and 0.60 age 1.3 fish. Using both adjusted and unadjusted data, the 1988 Corbett fishery age-composition estimates are consistent with results obtained in the 1988 Bonneville Dam sampling program. Comparisons made in 1987 between the two studies also yielded similar results.

This program will be continued in future years to develop an accurate age- and length-at-age composition data base for Columbia Basin spring chinook salmon stocks originating above Bonneville Dam. This information will aid fisheries managers in detecting and possibly explaining changes in population stock-composition and in monitoring the effects of ocean harvest regulations imposed by the Pacific Salmon Treaty. Reliable length-at-age information will be useful in research where scales and/or tags are not available, but where age estimates are nonetheless required. Such a data base could potentially provide assistance in the study of ocean growth rates. Over time, results of this research may also improve the predictive success of currently used spring chinook salmon population-abundance forecasting models.

LITERATURE CITED

Bernard, D.R. 1982. Statewide standards for sampling sizes for AWL (unpublished memorandum). Alaska Department of Fish and Game, Sports Fishery Division, 333 Raspberry Road, Anchorage, Alaska 99502.

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

Columbia River Inter-Tribal Fish Commission. 1987. FISHCOUNT, a computerized data base of Columbia Basin fish counts made at mainstem hydroelectric dams.

Dammers, W. Personal communication (preliminary data). Washington Department of Fisheries, Columbia River Fisheries Laboratory, 16118 N.E. 219th St., Battle Ground, Washington 98604

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

International North Pacific Fisheries Commission. 1963. Annual Report —1961.

Johnston, H.W. 1905. The scales of Tay salmon as indicative of age, growth, and spawning habitat. Scotland Fishery Board Annual Report 23(2):63-79.

Knudsen, C. 1988. Bias in stock separation analyses using scale patterns due to unequal scale regeneration rates. Paper submitted for publication to the International Symposium and Educational Workshop on Fish Marking Techniques, June 27 - July 1, 1988, University of Washington, Seattle, Washington.

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

Pacific Salmon Treaty. 1985. Treaty between the government of the United States of America and the government of Canada concerning Pacific salmon. Treaty document 99-2.

Prentice, E.F., T.A. Flagg, and S. McCutchen. 1987. A study to determine the biological feasibility of a new fish tagging system, 1986 - 1987. Bonneville Power Administration Annual Report of Research Project 83-319.

Schwartzberg, M. 1987. Columbia upriver salmon stock identification project — Field operations guide. Columbia River Inter-Tribal Fish Commission Technical Report 87-1.

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

Schwartzberg, M., and J. Fryer 1989a. Feasibility of Columbia Basin spring chinook salmon stock identification based on scale pattern analyses (in preparation). Columbia River Inter-Tribal Fish Commission Technical Report 89-3.

Schwartzberg, M., and J. Fryer 1989b. Identification of Columbia Basin sockeye salmon stocks based on scale pattern analyses, 1988 (in preparation). Columbia River Inter-Tribal Fish Commission Technical Report 89-2.

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