# AGE AND LENGTH COMPOSITION OF COLUMBIA BASIN SUMMER CHINOOK SALMON AT BONNEVILLE DAM IN 1991

*Technical Report 92-4*


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February 19, 1992


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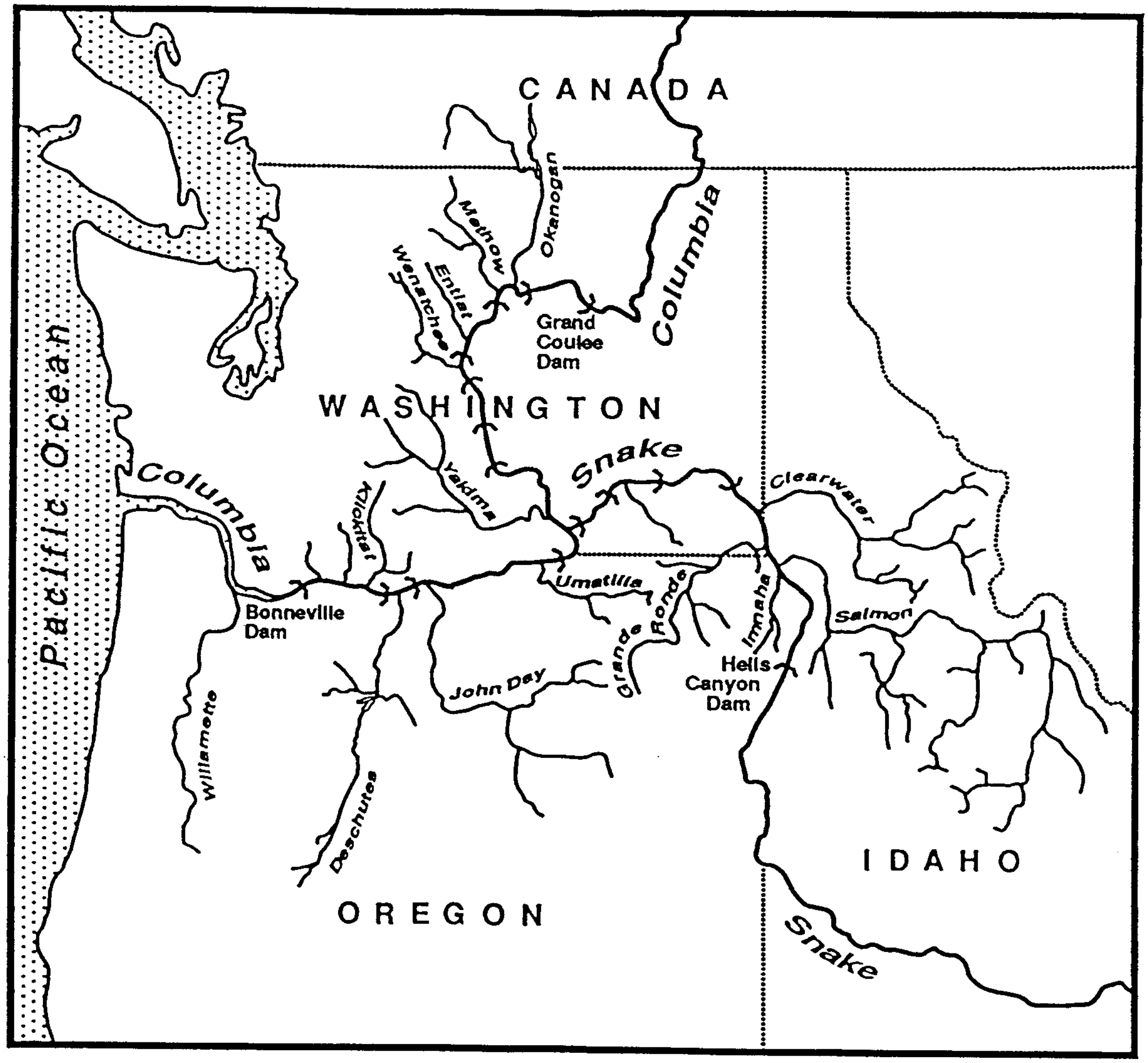
## INTRODUCTION

The Stock Assessment 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 (PST 1985). A principal aim of the project is the design and development of salmon stock identification techniques.

This report uses scale pattern analysis techniques to summarize the 1991 age and length-at-age composition estimates for summer chinook salmon, *Oncorhynchus tshawytscha* (Walbaum). Bonneville Dam, located at Columbia River kilometer 235 was the sampling site for this project (Figure 1). Columbia Basin summer chinook salmon are defined as those chinook salmon passing Bonneville Dam between June 1 and July 31. Earlier migrating chinook salmon are known as spring chinook salmon. Later migrating chinook salmon are known as fall chinook salmon. One goal of this project is to specify other criteria for categorizing and identifying the three groups of chinook salmon. This summer chinook salmon study began in 1990 (Fryer and Schwartzberg 1991a) but similar studies of spring chinook salmon were conducted from 1987 through 1991 (Schwartzberg 1988, 1989; Schwartzberg and Fryer 1990; Fryer and Schwartzberg 1991b, Fryer et al. 1992).

Figure 1. Map of the Columbia Basin including principal summer chinook salmon spawning and rearing tributaries and Bonneville, Grand Coulee, and Hells Canyon dams.



# METHODS

## Sampling Methods

In order to collect a representative sample of the Columbia River summer chinook salmon population, fish were sampled at the Fisheries Engineering and Research Laboratory located adjacent to the Second Powerhouse of Bonneville Dam. Fish were trapped, anesthetized, sampled for scales and biological data, allowed to revive, and then returned to the exit fishway leading to one of the Bonneville Dam fish ladders. To minimize the sample rejection rate, six scales were collected per fish (Knudsen 1990). Fork length measurements were recorded along with observed mark and/or tag information. No fish were sacrificed in the study. Therefore, gender of collected specimens, all in early stages of sexual maturation, could not be determined.

## Sample Design

Because of the relatively small population sizes of adult summer chinook salmon (CRITFC 1992), it was unclear whether sufficient samples could be collected at Bonneville Dam to meet the minimum overall desired level of precision and accuracy ($d=0.05$, $\alpha=0.10$). Therefore, as in 1990, neither composite nor weekly sample size goals were set. Generally, sampling was conducted two days per week for approximately six hours per day.

Actual 1991 migratory timing was determined from post-season analysis of 1991 Bonneville Dam fish ladder counts (CRITFC 1992). To further improve accuracy, composite age and length-at-age estimates were adjusted post-season for actual 1991 migration timing using a stratified sampling method (Fryer, in preparation) that weighted weekly estimates.

## Age Determination

Scales were prepared and mounted according to methods described in Clutter and Whitesel (1956) and the International North Pacific Fisheries Commission (1963). Individual samples were visually examined and categorized using well-established scale age-estimation methods (Johnston 1905, Gilbert 1913, Van Oosten 1929). Age estimates were corroborated by personnel at the Harvest Management Division of the Washington Department of Fisheries. Validation of ages (Beamish and McFarlane 1983) was not possible because no known-age fish were present in the sample.

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

## Length Measurements

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

# RESULTS

## Sample Design

Of the 289 fish collected in this study, eight percent of the total sample was rejected and not classified by age because of unreadable scales. An additional nine percent of the sample consisted of very small fish, known locally as *minijacks*. These fish were generally under 30 cm in length and spent little time in saltwater. Due to the different life history of minijacks, and the fact that sampling of these fish was conducted in a non-random manner, fish estimated to have spent no winters in saltwater were excluded from the analysis. The total sample size used for the age and length-at-age composition estimates made in this study was 241 fish (Table 1).

Operational difficulties, resulting from large numbers of shad migrating through the lower Columbia River in early June, resulted in the closing of the Bonneville Dam fish trap for most of Statistical Week 23 and all of Statistical Week 24. Therefore, data for Statistical weeks 23 and 25 were pooled. Data for Statistical weeks 30 and 31 were pooled since only five fish were sampled in Statistical Week 31.

## Age Composition Estimates

Five-year-old fish (from the 1986 brood-year group, including Age 0.4 and 1.3 fish) were estimated to be the predominant age class, comprising 47% of the sample. Five-year-old fish were the predominant age class in Statistical weeks 23-25, 27, 29, and 30 and were co-dominant in Statistical Week 26 (Figure 2). Four-year-old fish (from the 1987 brood-year group, including Age 0.3 and 1.2 fish) were estimated to comprise 24% of the sample, while three-year-old fish (from the 1987 brood-year group, including Age 0.2 and 1.1 fish) made up an additional 20% of the sample. Two- and six-year-old fish made up five and three percent of the sample, respectively.

Table 1. Age composition estimates of Columbia Basin summer chinook salmon sampled at Bonneville Dam in 1991 with composite 1990 estimates included for comparison purposes.

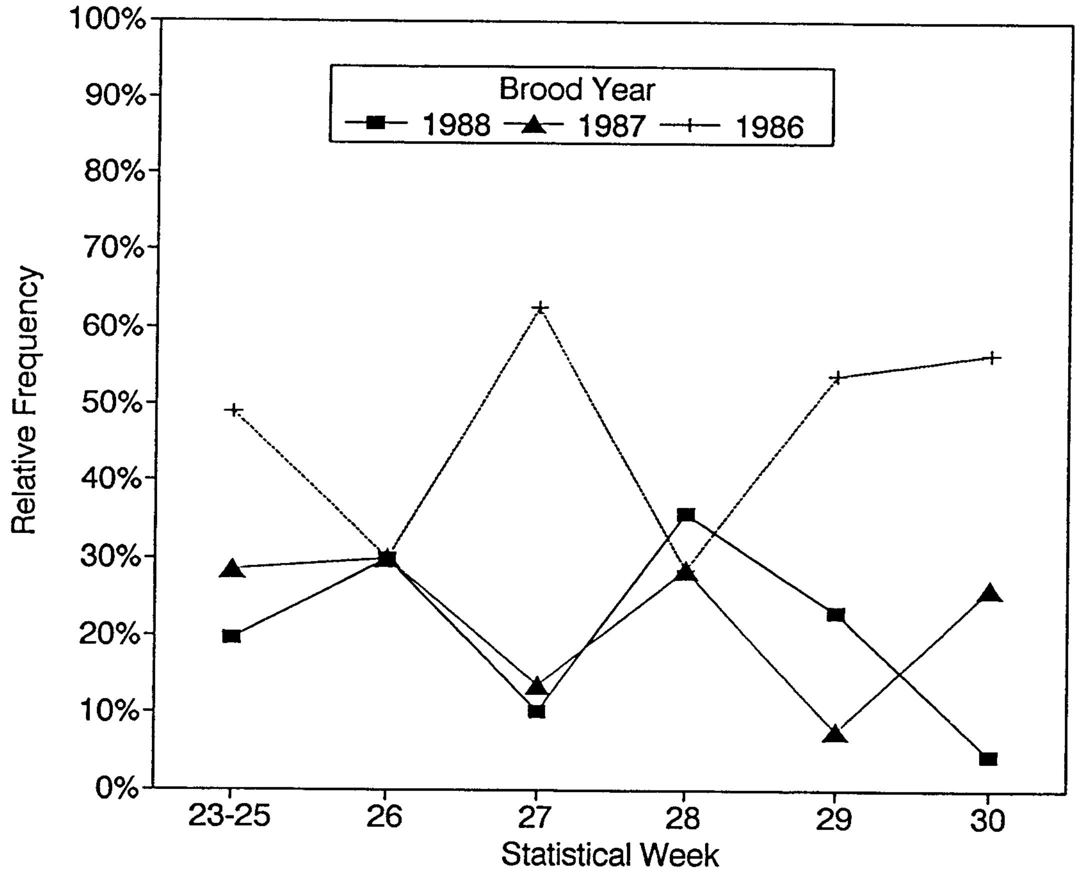
Brood Year and Age Class

| Statistical Week | Sampling Dates | Sample Size | 1989 | 1988 | | 1987 | | 1986 | | 1985 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0.1 % | 0.2 % | 1.1 % | 0.3 % | 1.2 % | 0.4 % | 1.3 % | 0.5 % | 1.4 % |
| 23-25 | 6/05,19,20 | 112 | | 1 | 19 | 7 | 21 | 17 | 32 | 1 | 2 |
| 26 | 6/26,28 | 20 | 10 | 5 | 25 | | 30 | 10 | 20 | | |
| 27 | 7/03,05 | 59 | | 3 | 7 | 8 | 5 | 17 | 46 | 10 | 3 |
| 28 | 7/10,12 | 14 | 7 | 7 | 29 | 14 | 14 | 7 | 21 | | |
| 29 | 7/17,19 | 13 | 15 | 8 | 15 | | 8 | 15 | 38 | | |
| 30-31 | 7/24,26,31 | 23 | 9 | | 4 | 13 | 13 | 26 | 30 | | 4 |
| **1991** Composite Sample | | 241 | 5 | 3 | 17 | 7 | 17 | 16 | 31 | 1 | 2 |

Brood Year and Age Class

| | Sample Size | 1988 | 1987 | | 1986 | | 1985 | | 1984 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 0.1 % | 0.2 % | 1.1 % | 0.3 % | 1.2 % | 0.4 % | 1.3 % | 0.5 % | 1.4 % |
| 1990 Composite Sample | 569 | 1 | 1 | 4 | 12 | 24 | 23 | 26 | 1 | 7 |

Figure 2. **Weekly age composition estimates for the three major Columbia Basin summer chinook salmon brood year age classes sampled at Bonneville Dam in 1991.**



Chinook salmon spending no winters in freshwater before outmigrating, which are known as subyearlings with the age designation 0.x, were estimated to comprise 32% of the population. Yearlings, denoted as being of Age 1.x, were estimated to comprise the remaining 68% of the population. Yearlings predominated in all statistical weeks but the amount of predominance steadily decreased as the migration progressed (Figure 3).

**Length-at-Age Composition**

Mean fork lengths of summer chinook salmon sampled at Bonneville Dam ranged from 41.3 cm for Age 0.1 fish to 95.4 cm for Age 1.4 fish (Table 2). The largest fish sampled was an 105.0 cm Age 0.5 fish sampled in Statistical Week 25 while the smallest (excluding minijacks) was a 31.5 cm Age 0.1 fish sampled in Statistical Week 29.

Figure 3. Freshwater age composition of Columbia Basin summer chinook sampled at Bonneville Dam in 1991.

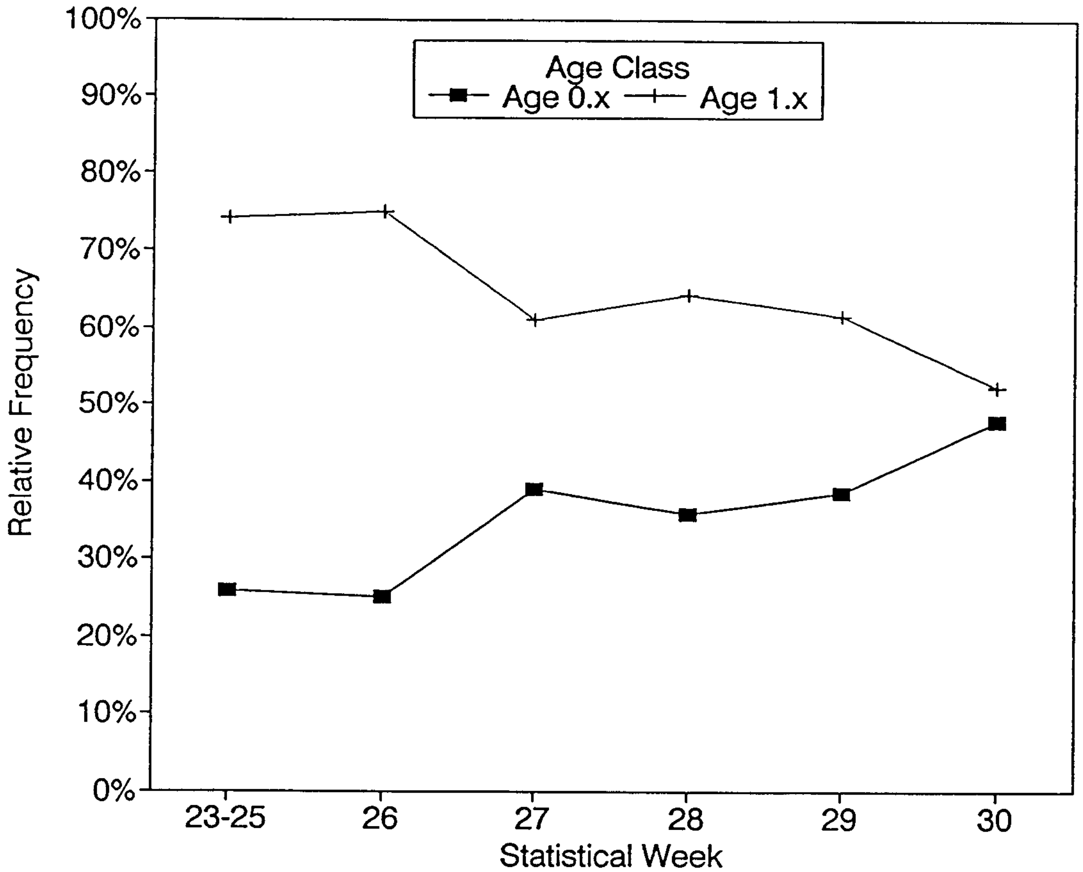


Table 2. Weekly and total length-at-age estimates of Columbia Basin summer chinook sampled at Bonneville Dam in 1991.

Brood Year and Age Class

| | 1989 | 1988 | | 1987 | | 1986 | | 1985 | |
|---|---|---|---|---|---|---|---|---|---|
| | 0.1 | 0.2 | 1.1 | 0.3 | 1.2 | 0.4 | 1.3 | 0.5 | 1.4 |
| **Statistical Week 25** | | | | | | | | | |
| Mean Fork Length (cm) | | 60.0 | 51.5 | 88.5 | 51.5 | 92.0 | 88.5 | 105.0 | 95.2 |
| Minimum | | 60.0 | 35.0 | 82.5 | 35.0 | 82.0 | 76.5 | 105.0 | 95.0 |
| Maximum | | 60.0 | 62.0 | 98.5 | 62.0 | 103.0 | 97.0 | 105.0 | 95.5 |
| Standard Deviation | | — | 6.4 | 4.4 | 6.4 | 5.1 | 5.9 | — | 0.2 |
| Sample Size | | 1 | 21 | 8 | 24 | 19 | 36 | 1 | 2 |
| **Statistical Week 26** | | | | | | | | | |
| Mean Fork Length (cm) | 52.8 | 59.0 | 54.8 | | 81.2 | 92.0 | 87.4 | | |
| Minimum | 49.5 | 59.0 | 50.6 | | 75.0 | 90.5 | 84.0 | | |
| Maximum | 56.0 | 59.0 | 60.5 | | 84.5 | 93.5 | 91.5 | | |
| Standard Deviation | 3.3 | — | 3.9 | | 3.2 | 1.5 | 3.2 | | |
| Sample Size | 2 | 1 | 5 | | 6 | 2 | 4 | | |
| **Statistical Week 27** | | | | | | | | | |
| Mean Fork Length (cm) | | 70.0 | 57.6 | 87.7 | 74.2 | 97.2 | 90.6 | 91.2 | 95.5 |
| Minimum | | 68.5 | 55.0 | 80.0 | 73.5 | 82.5 | 77.5 | 85.5 | 91.5 |
| Maximum | | 71.5 | 60.0 | 98.0 | 75.5 | 104.0 | 97.5 | 98.5 | 99.5 |
| Standard Deviation | | 1.5 | 2.0 | 6.9 | 0.9 | 6.4 | 5.0 | 5.0 | 4.0 |
| Sample Size | | 2 | 4 | 5 | 3 | 10 | 27 | 6 | 2 |
| **Statistical Week 28** | | | | | | | | | |
| Mean Fork Length (cm) | 42.0 | 67.5 | 64.0 | 84.2 | 78.2 | 95.5 | 87.8 | | |
| Minimum | 42.0 | 67.5 | 47.5 | 79.0 | 74.0 | 95.5 | 77.0 | | |
| Maximum | 42.0 | 67.5 | 65.0 | 89.5 | 82.5 | 95.5 | 96.0 | | |
| Standard Deviation | — | — | 6.6 | 5.2 | 4.3 | — | 8.0 | | |
| Sample Size | 1 | 1 | 4 | 2 | 2 | 1 | 3 | | |
| **Statistical Week 29** | | | | | | | | | |
| Mean Fork Length (cm) | 36.0 | 62.5 | 54.5 | | 70.5 | 96.2 | 87.4 | | |
| Minimum | 31.5 | 62.5 | 52.0 | | 70.5 | 90.0 | 76.0 | | |
| Maximum | 40.5 | 62.5 | 57.0 | | 70.5 | 102.5 | 97.0 | | |
| Standard Deviation | 4.5 | — | 2.5 | | — | 6.2 | 7.9 | | |
| Sample Size | 2 | 1 | 2 | | 1 | 2 | 5 | | |
| **Statistical Week 30** | | | | | | | | | |
| Mean Fork Length (cm) | 40.3 | | 55.0 | 82.7 | 77.7 | 92.4 | 87.8 | | 89.0 |
| Minimum | 38.6 | | 55.0 | 77.0 | 72.5 | 75.5 | 72.5 | | 89.0 |
| Maximum | 42.0 | | 55.0 | 92.0 | 83.5 | 103.0 | 94.0 | | 89.0 |
| Standard Deviation | 1.8 | | — | 6.6 | 4.5 | 9.0 | 8.0 | | — |
| Sample Size | 2 | | 1 | 3 | 3 | 6 | 7 | | 1 |
| **1991 Composite** | | | | | | | | | |
| Mean Fork Length (cm) | 41.3 | 63.7 | 53.9 | 86.5 | 75.8 | 94.6 | 88.5 | 92.7 | 95.4 |
| Minimum | 31.5 | 59.0 | 35.0 | 77.0 | 52.4 | 75.5 | 72.5 | 85.5 | 89.0 |
| Maximum | 56.0 | 75.0 | 65.0 | 98.5 | 84.0 | 104.0 | 97.5 | 105.0 | 99.5 |
| Standard Deviation | 7.3 | 4.6 | 5.0 | 5.5 | 5.3 | 5.5 | 6.4 | 6.7 | 3.6 |
| Sample Size | 7 | 6 | 37 | 18 | 39 | 40 | 82 | 7 | 5 |

## DISCUSSION

As in 1990, validation of summer chinook age estimates was not possible because known-age specimens were not present in the sample in 1991. The age estimation methods used in this study, and a large proportion of the resultant age estimates, were reviewed and supported by experienced scale analysts from a different agency. Nevertheless, freshwater annulus position (or its very existence) in summer chinook salmon scales was often difficult to determine because this scale feature was often difficult to distinguish from the scale check associated with saltwater entry.

The total number of summer chinook salmon sampled in 1991 (241) was much smaller than in 1990 (569). Although roughly the same sampling effort was expended in 1991 as in 1990, there were 21% fewer summer chinook salmon passing Bonneville Dam in 1991 (21,953 fish) than in 1990 (28,021 fish, CRITFC 1991). Also contributing to the smaller sample sizes was the closing of the fish trap due to problems caused by shad passage for one and a half weeks in 1991 compared to one week in 1990. This closure occurs in early June, which is typically a time of peak summer chinook salmon passage. Small sample sizes, uncertainties in age estimation procedures, and an inadequate sample during the early part of the migration all imply that the accuracy and precision of age composition estimates presented in this report are lower than those from previous spring and summer chinook studies (Schwartzberg 1988, 1989; Schwartzberg and Fryer 1990; Fryer and Schwartzberg 1991a; Fryer and Schwartzberg 1991b; Fryer et al. 1992).

The estimated age composition of the 1991 salmon summer chinook population differed from that estimated in 1990 (Table 2). While the percentage of the predominant five-year-old age class was similar in both years (49% in 1990 and 47% in 1991), the percentage of four year old fish dropped from 36% in 1990 to 24% in 1991. Conversely, the percentage of three year old fish increased from 5% of the population in 1990 to 20% in 1991.

The percentage of subyearlings decreased from 38% in 1990 to 32% in 1991. As was observed in 1990, the percentage of subyearlings steadily increased through the migration. In 1990, this trend was noted to have continued into the fall chinook salmon migration during August and September. No fall chinook salmon were sampled in 1991 to determine if there was a similar trend.

This sampling program will continue in future years to develop an accurate age- and length-at-age composition database. Such information will aid fishery managers in detecting, and possibly explaining, changes in the composition of stocks. Detectable patterns in age and length-at-age composition of successive brood groups may allow managers to more accurately monitor the effects of ocean harvest restrictions, such as those imposed by the Pacific Salmon Treaty (PST 1985). As this study progresses, the database being created may also provide a foundation for future population size prediction models.

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