THE RELATIONSHIP OF AGE TO LENGTH IN PUGET SOUND RESIDENT CHINOOK SALMON

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The majority of chinook salmon (*Oncorhynchus tshawytscha*, Walbaum) caught in Puget Sound are fall-run stocks with similar periods of fresh-water residence. These salmon spawn in October and November, the young migrate into tidal waters during the following year, and many spend a substantial portion of their lives within Puget Sound where they are subjected to an intense year-round sport fishery. Puget Sound is here defined as Washington waters south and east of a line from Tongue Point in the Strait of Juan de Fuca to Deception Pass at the north end of Whidbey Island.

Since the age composition of the catch varies with the abundance and availability of the various year classes, regulation of minimum catch size, and angler selectivity, proper management of the fishery requires quantitative knowledge of the age groups involved. With a sixteen-inch minimum size limit, the majority of chinook salmon taken in Puget Sound by sport fishing are in their second, third and fourth years. These fish can be aged by microscopic examination of the scales but the method is time consuming, requires considerable skill and judgment and some scales cannot be aged due to their structure or regeneration. Separation of the three age groups dominant in the fishery is simplified if they can be distinguished by length alone.

Methods and Materials

Examination of the monthly length samples taken during 1956, 1957 and 1958 failed to reveal significant differences in the ranges of corresponding modal length groups between years. The three years of length samples combined, provided monthly samples of from 253 to 965 fish (average 611). For most months, modal groups could be distinguished and were interpreted as age groups. When modal groups were not easily discernible, weights were calculated from a length-weight formula (Fry and Hughes, 1951), and the weight of samples plotted by centimeter interval. This was especially useful in isolating modal groups of the relatively few larger salmon which were of considerable importance in terms of weight.

Separation of year classes was made visually where depressions between modes occurred. Figure 1 shows the separation of age groups using length frequencies. In this case, the more easily discernible depressions between the modes in February are used to judge where their most probable location

is in January. Figure 2 makes clear the usefulness of plotting the weight of the sample by length interval by comparing for a single month, data prepared by both length frequency and weight of sample. The accuracy of aging Puget Sound chinook salmon from their lengths was tested against aging from scale reading as follows:

1. Data reported on by Pressey (1953), wherein chinook salmon were aged, were compared with aging of the salmon from their lengths.
2. Three scale readers independently read single scales from 100 chinook salmon and the concensus of their findings was compared with ages of those fish as determined from their lengths. Concensus is here defined as agreement between two or more scale readers.
3. Marked chinook salmon believed to be the 1956 brood were aged by both methods and the findings compared.

In all cases, the salmon involved were from the Puget Sound sport fishery.

Results

Inspection of the data led to the establishment of a length interval for each age group for each month of the year. Thus, even though age groups overlap, a fish of a particular length is assigned to a particular age group (Table 1).

TABLE 1—Expected total length in inches of chinook salmon age groups in the Puget Sound sport fishery by month.

MONTH	Age group I	II	III	IV
January	..	< 16	16–26	> 26
February	..	< 17	17–26	> 26
March	..	< 18	18–27	> 27
April	..	< 18	19–28	> 28
May	..	< 19	19–29	> 29
June	..	< 20	20–31	> 31
July	..	< 22	22–32	> 32
August	< 14	14–23	23–32	> 32
September	< 14	14–25	25–32	> 32
October	< 15	15–26	26–32	> 32
November	< 15	15–26	> 26	..
December	< 15	15–26	> 26	..

Comparisons of aging by length with aging by scale reading

1. From Pressey's raw data there were available 1,739 usable age determinations and their matching lengths. These fish were again aged by the use of Table 1. It was first determined whether the methods agreed or disagreed on the age of individual fish (Table 2). Of 1,739 salmon compared, the two methods agreed on 1,516, or in 87.2 per cent of these individual cases.

TABLE 2—Comparison of length method and scale reading method in aging individual chinook salmon.

Age group	Agree	Disagree	Per cent agreement
I	6	10	37.5
II	840	77	91.6
III	493	73	87.1
IV	177	63	73.8
Total	1,516	223	87.2

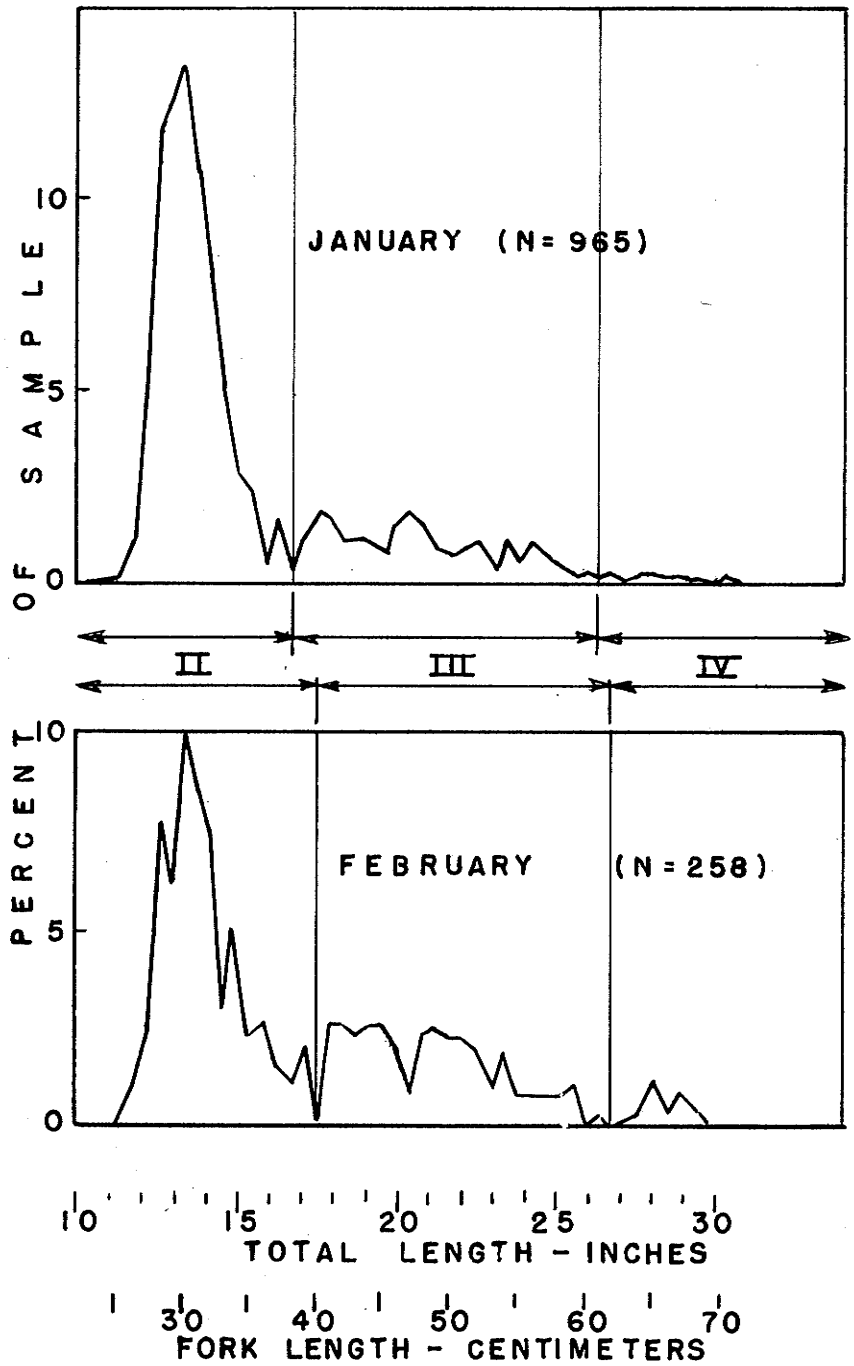
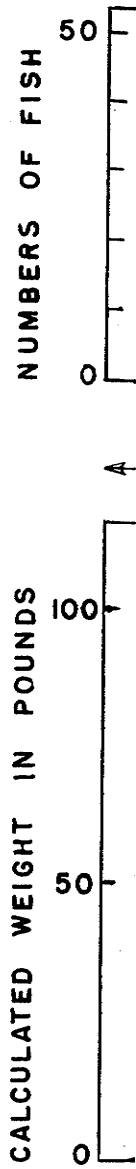


FIGURE 1—Composite January and February length-frequency curves for Puget Sound sport-caught chinook by age class, 1956-1958.



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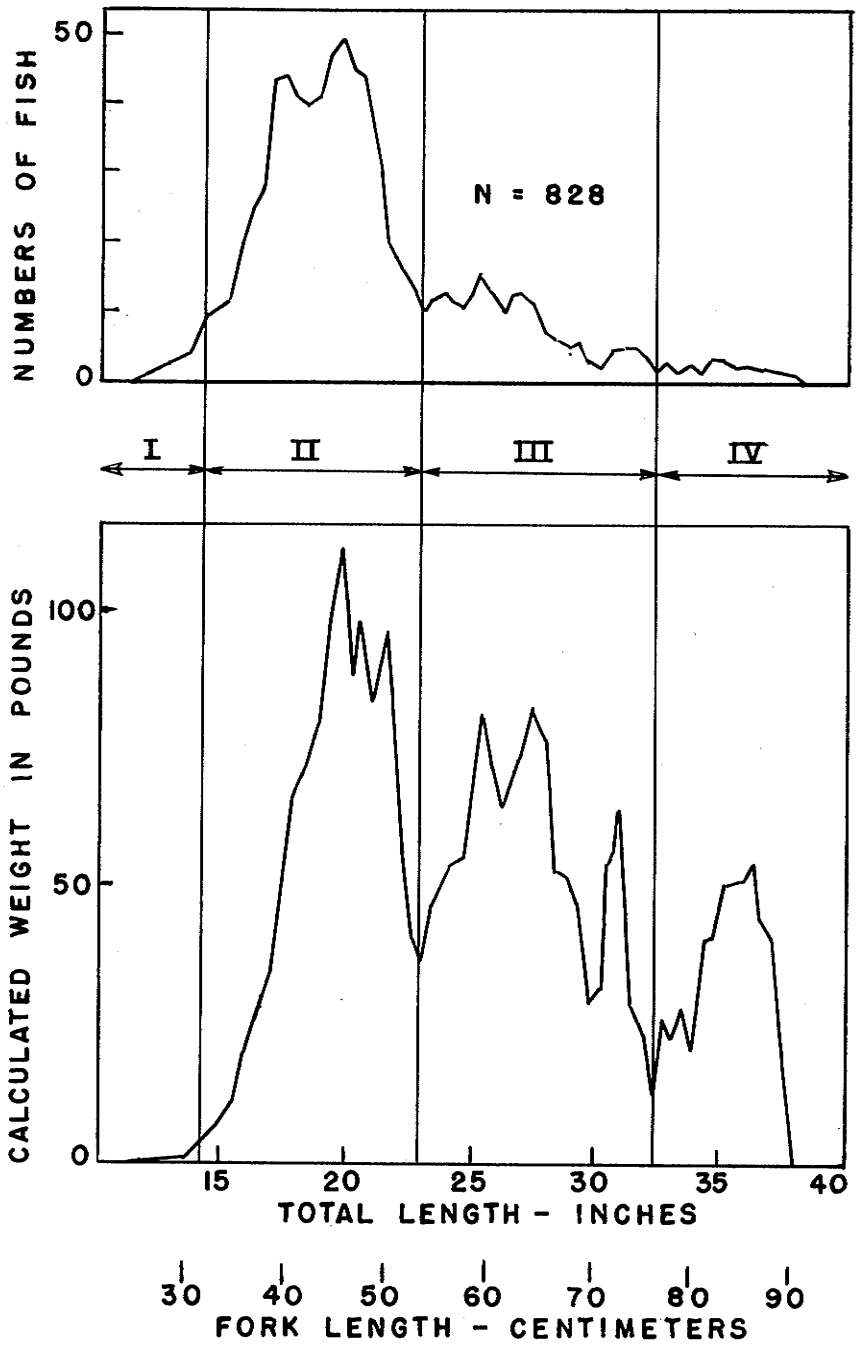

FIGURE 2—Composite August length-frequency and calculated weight curves for Puget Sound chinook by age class, 1956-1958 (smoothed by three's).

Pressey's work showed size overlap in successive year classes of Puget Sound chinook. However, in determining the contribution of the year classes to the fishery, the overlap errors tend to cancel. For example, using Table 1, certain large two-year-old chinook will be called three-year-old fish, while small three-year-old fish will be called two-year-olds. The possibility does exist, however, that a very successful brood may overlap in size with a brood which has failed, causing a proportionately large error in allotting salmon to the weaker brood and a less serious error with the stronger brood. The results of grouping the fish by age are shown in Table 3.

TABLE 3—Comparison of length method and scale reading method in separating chinook into age groups.

Age group	I	II	III	IV	V	Total
Agree	6	871	566	228	0	1603
Disagree	10	46	53	12	15	136
Per cent agreement	37.5	95.0	91.4	95.0	0.0	92.2

When fish are aged, the information usually desired is the number of fish in each age group or year class. In such a case, the age of any fish is only important as it contributes to the group. In this respect, aging from length alone grouped the fish in agreement with scale reading at a 92.2 per cent level.

2. In another comparison with scale reading, single scales from 100 chinook of various sizes were read from acetate impressions and were also aged using only the length of the fish. The scales were read independently by three experienced co-workers. The only data furnished these three were the species and the month the scales were taken. Due to regeneration or improper impressions, the scale readers deemed from 30 to 34 scales unreadable.

Under the conditions previously outlined, the individual readers agreed with their concensus in 97.1, 88.6, and 88.6 per cent of the cases. When the salmon were aged by length alone, the results agreed with the consensus of the scale readers 88.6 per cent of the time.

3. A release of 1,413,627 chinook of the 1956 brood bearing the both ventral fin mark was made into the Deschutes River, in Southern Puget Sound, on July 30, 1957. This mark was unduplicated in Puget Sound on the 1956 brood, but a plant of 100,859 identically marked, had been made of the 1955 brood in the Lake Washington ship canal. This latter release apparently failed since no marks were recovered, as two-year-olds before the 1956 brood was available to the fishery. Marked salmon from the other waters rarely enter Puget Sound and the plants which might have interfered were relatively small as is shown in Table 4.

TABLE 4—Chinook salmon releases of the 1955, 1956, and 1957 broods bearing the both-ventral fin mark.

Brood year	Area of release	Number of chinook
1955	Lake Washington ship canal, Puget Sound	100,859
1955	Umpqua River, Oregon	22,533
1956	Deschutes River, Puget Sound	1,413,627
1956	Umpqua River, Oregon	31,744
1957	American River, California	50,000

The scale reader who had agreed 97.1 per cent of the time with the consensus as mentioned previously, was furnished with acetate impressions of

two scales from each of 51 Puget Sound, both-ventral marked salmon thought to be of the 1956 brood. Two readings were made on each fish and those which did not agree on two readings were read a third time. The fish were also aged from length alone. The results of these determinations are shown in Table 5.

TABLE 5—Brood year assignment of marked chinook salmon by reading scales and from length.

	Brood year				Per cent
	1955	1956	1957	1958	1956 brood
Scale method	6	45	0	0	88.2
Length method	1	48	1	1	94.1

Since either of the above combinations of ages was possible, this test showed that both methods agreed with the hypothesis that the great majority of the both-ventral marked chinook were of the 1956 brood.

Discussion

This particular age-length relationship should be applied only to Puget Sound resident chinook salmon. A comparison of work by Van Hyning (1951) with Pressey's results and unpublished data of the Washington Department of Fisheries, indicates that Puget Sound resident chinook have slower marine growth than ocean residents and are, therefore, not comparable. Inclusion of mature migrants from the ocean in the length samples was not found to materially affect the use of the length-age intervals as established. The Puget Sound sport fishery is selective to chinook salmon during their feeding and growing period and the catch of mature fish migrating from the ocean is quite limited in time, area and numbers.

There are a number of advantages in aging salmon from their lengths. By using Table 1, chinook from the Puget Sound sport fishery can be aged quickly anywhere by use of a measuring tape, and in contrast to scale-reading, no special skill or experience is needed. In addition, some salmon cannot be aged from the scales due to scale structure or regeneration but these same fish can be readily aged from length. The aging of Puget Sound resident chinook salmon from length alone is as accurate as determining the age by reading scales. Aging of chinook salmon by length alone will result in consistent interpretation by avoiding the need for experience and judgment required in scale reading. The method is much less time consuming than scale aging and will result in either man hours saved in aging studies or in more data for the same effort. A disadvantage is the error involved when the overlapping lengths of two broods are from a very strong brood and a very weak brood.

Summary

1. Puget Sound chinook salmon were divided into age groups by length from inspection of length-frequency and length-weight frequency plots.

2. Comparison with an earlier age analysis using scale reading showed an 87.2 per cent agreement in aging individual fish and 92.2 per cent agreement in separating chinook into age groups.

3. A sample of 100 chinook salmon were aged from scales by three experienced scale readers and from length alone. Aging by length agreed with the scale readings of the individual scale readers nearly as well as they agreed with each other.

4. The scales of 51 double fin marked chinook believed to be of the 1956 brood were read and the fish were also aged from length. Both methods agreed with the hypothesis that the great majority of the salmon were of the 1956 brood.

5. Aging of Puget Sound resident chinook salmon from length is as accurate as aging by scale reading, requires less experience and is less time consuming.

Acknowledgments

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