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# CHANGES IN THE AGE AND SIZE OF CHUM SALMON (*Oncorhynchus keta*)

by

W. E. Ricker

Department of Fisheries and Oceans
Resource Services Branch
Pacific Biological Station
Nanaimo, British Columbia V9R 5K6

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ABSTRACT

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The mean weights of chum salmon caught during the 1960's and 1970's ranged from 7 lb in western Alaska to amost twice that figure in central British Columbia, then decresed to 11 lb in southern British Columbia, but the progression was not completely regular. The decrease southward in British Columbia resulted from a decrease in average age; within the Province size at a given age changed very little with latitude.

Between 1951 and 1975 the chum salmon caught in most British Columbia statistical areas have decreased in size, but by only about 1 lb on the average. Between 1957 and 1972 their average age increasd by about 0.3 yr, because fish of age 0.2 became scarcer while age 0.4 became more plentiful. In the Northern District the increase in mean age may be mainly or wholly a result of selection by the gillnet fishery, whose catch averaged 1.12 lb smaller than that of the seine fishery. Paradoxically, the decrease in average size might result from the same selection, for the age 0.2 fish grow much faster than older ones, and the progressive loss of their genes favoring rapid growth has to some extent affected the other ages also, because of cross-age mating. This effect of selection is, however, opposed by within-age selection favoring the survival of larger size, and the age 0.4 fish, which are farthest from the selected size range, did exhibit a small increase in size with time.

In the Southern and Fraser Districts the difference in size between seined and gillnetted fish is much less than in the north, and is insufficient to explain the observed increase in mean age. No other explanation has been identified; it may be something related to the major fluctuation in abundance of the southern chums.

There is sporadic information on age and size of chums before 1951. The earliest is for the Strait of Georgia in 1916-17, when chums caught did not differ significantly in age or size from modern catches. During 1945-49 chums caught were smaller in most Areas than since that time, as shown by indepedent length and weight sammples. Because pink salmon also were small in some of those years, the effect of widespread, and as yet unidentified, unfavorable physical or biological conditions is indicated.

Both in British Columbia and in Alaska, size of chums at a given age has decreased since 1951 along with a general decrease in ocean temperatures. To determine whether this is an accidental or a meaningful coincidence, the residuals of temperature and size from their respective linear regressions on time were computed and compared, during 1951-1975. Weight residuals were positiviely but weakly correlated with temperature residuals in the last year (approximately) of life, and negatively correlated with the temperature 1 or 2 years earlier. However, all such correlations were small; the corresponding regressions were only 1/3 to 1/10 of the change in weight actually observed, and were sometimes of the wrong sign. In addition, chums were small during the late 1940s when temperatures were high. Thus it is still problematical whether ocean temperature changes, within the range observed, have had any significant effect on the size of chum salmon in British Columbia.

Key words: Chum salmon, age, growth, selection, temperature.

# RÉSUMÉ

Ricker W. E. 1980. Changes in the age and size of chum salmon (*Oncorhynchus keta*). Can. Tech. Rep. Fish. Aquat. Sci. 930: 99 p.

Le poids moyen des saumons kéta capturés pendant les années 1960 et 1970 allait de 7 livres dans l'ouest de l'Alaska à près de deux fois ce poids dans le centre de la Colombie-Britannique, puis descendait jusqu'à 11 livres dans le sud de la Colombie-Britannique, sans toutefois que la progression soit très régulière. La diminution en direction du sud, notée en Colombie-Britannique, provenait d'un abaissement de la moyenne d'âge; dans la province, la taille à un âge donné variait très peu avec la latitude.

Entre 1951 et 1975, les saumons kéta capturés dans la plupart des zones statistiques de la Colombie-Britannique ont présenté une diminution de la taille, qui reste toutefois de l'ordre d'une livre en moyenne. Entre 1957 et 1972, l'âge moyen a augmenté d'environ 0,3 an, parce que les poissons d'âge 0.2 étaient plus rares alors que les poissons d'âge 0.4 étaient plus nombreux. Dans le district du nord, l'augmentation de l'âge moyen peut provenir principalement ou en partie de la sélection pratiquée par la pêche au filet maillant, dont les prises étaient en moyenne inférieures de 1,12 livres à celles de la pêche à la seine. De façon paradoxale, on peut attribuer la diminution de la taille moyenne à la même sélection, car les poissons d'âge 0.2 grandissent beaucoup plus rapidement que les poissons plus âgés, et la perte progressive des gènes qui favorisent une croissance rapide a dans une certaine mesure affecté aussi les autres âges, à cause du croisement des âges à la reproduction. Cet effet de la sélection est toutefois en contradiction avec la sélection au sein d'une classe d'âge, qui favorise la survie des poissons de plus grande taille, et d'ailleurs, les poissons d'âge 0.4, qui sont les plus éloignés de la fourchette de taille choisie, ont présenté une légère <u>augmentation</u> de taille en fonction du temps.

Dans les districts du sud et du Fraser, la différence de taille entre les poissons capturés à la seine et au filet maillant est bien moindre que dans le nord, et ne suffit pas a expliquer l'augmentation observée de l' âge moyen. On n'a pu apporter aucune autre explication; ce phénomène semble quelque peu en rapport avec l'importante fluctuation de l'abondance des saumons kéta du sud.

On ne possède que des données éparses sur l'âge et la taille des saumons kéta avant 1951. Les premières données concernent le détroit de Georgie en 1916-1917, et les prises de cette époque ne différaient pas sensiblement des prises actuelles en âge ni en taille. Dans la période 1945-1949, les saumons kéta capturés étaient, dans la plupart des zones, plus petits que par la suite, comme le montrent la longueur et le poids d'échantillons indépendants. Étant donné que les saumons roses étaient aussi de petite taille pendant certaines de ces années, il semble que l'on pourrait incriminer des conditions physiques ou biologiques défavorables et largement répandues mais non encore déterminées.

En Colombie-Britannique comme en Alaksa, la taille des saumons kéta à un âge donné a diminué depuis 1951, en même temps qu'on notait une baisse générale de la température de l'océan. Pour déterminer s'il s'agit la d'une coincidence ou d'un phénomene significatif, on a calculé et comparé les résidus de la température et de la taille à partir de leurs régressions linéaires respectives dans le temps, pour la période 1951-1975. Les résidus des poids ont pu être mis en corrélation faiblement positive avec les résidus de la température au cours de la dernière année (approximative) de vie, et en corrélation négative avec la température un ou deux ans auparavant. Toutefois, toutes ces corrélations étaient faibles; les régressions correspondantes concernaient seulement 1/3 à 1/10 de la modification de poids réellement observée, et portaient parfois le signe opposé aux prévisions. En outre, les saumons kéta étaient petits pendant la fin des années 1940, période où les températures étaient élevées. On ne sait donc pas encore si le modifications de la température de l'océan, dans la zone étudiée, ont eu un effet notable sur la taille du saumon kéta en Colombie-Britannique.

Mots clés: saumon kéta, âge, croissance, sélection, température.

# 1. CHUM SALMON LIFE HISTORY AND FISHERY

## 1.1. CONVENTIONS AND NOTATION

In this report ages of salmon are designated by the "European" system. For example, a fish of age 0.3 has no freshwater annulus and has laid down 3 annuli in salt water, being in its 4th year of life; this corresponds to $4_1$ in the Gilbert system. When computing average ages in terms of completed annuli, the "0." prefix is omitted.

The principal length used here is the postorbital-hypural or simply "hypural" length, measured from the hind margin of the orbit (eye socket) to the end of the hypural bone of the tail, identified externally by flexing the tail to show a crease. The distance measured is the horizontal distance between these parts when the fish is laid flat on a board, not the distance along the body surface.

Two other lengths used in the original data are converted to postorbital-hypural length. Fork length is converted by dividing by the factor 1.25, a simplication of the expression on page 913 of Ricker (1964), which can be used with little or no loss of accuracy. The length used by Fraser (1920, 1921) is equal to about 0.97 times fork length, as explained in Section 3.5, and hence is converted to hypural by dividing by 1.212.[1] Finally, the mid-eye to end of hypural (MEHP) length used by Helle (1979) is converted to postorbital-hypural by multiplying by 0.98.

To relate whole weights to lengths equation (3) of Ricker (1964) has been used, after checking it with additional data:

$$\log w = -2.220 + 3.2 \log \ell \qquad (1)$$

where weights (w) are in grams and lengths ($\ell$) are in centimetres of fork length. Here we use natural instead of base-10 logarithms. With lengths converted to the postorbital-hypural unit in millimetres, and with weights in grams or pounds, the resulting expressions are:

$$\ln w(g) = -11.766 + 3.2 \ln \ell \qquad (2)$$

$$\ln w(lb) = -17.883 + 3.2 \ln \ell \qquad (3)$$

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[1]Ricker (1964, p. 912) used the factor 1.075 rather than 1/0.97 to convert Fraser's lengths to fork lengths; however, the percentage increases in weight, shown in his Table 6, are decreased only slightly.

## 1.2 LIFE HISTORY OF CHUM SALMON

Studies of chum salmon life history have been made by Fraser (1920, 1921), Neave (1953) and others. In British Columbia the fry go to sea early in life, typically after very little or no feeding in fresh water. They mature mainly after 3 or 4 growing seasons in the ocean, but fish with 5 growing seasons are fairly common in northern British Columbia and Alaska. There are also negligible numbers, almost always less than 1%, that mature after 2 or 6 growing seasons.

Bilton et al. (1965-1968) and Jenkinson et al. (1969-1973) have tabulated comprehensive data on ages of British Columbia chums in catches sampled over the years 1957-1972. Table 1 shows examples from the northern, the middle, and the southern parts of the province.

British Columbia chum salmon are wide-ranging in the ocean. Tagged individuals have migrated to our coast from as far west as 169° West Longitude (Neave et al. 1976). High-seas distributions based on scale characteristics are given by Tanaka et al. (1969, Fig. 18, 20), for British Columbia and southeastern Alaska together. Most were east of 170° W, although there was a small penetration of immature individuals as far west as 172° E in July-September of their third and fourth ocean years. Chums return to coastal regions only as they are approaching maturity, so that in our waters there is no harvesting of chums one or more years before maturity, such as occurs with chinook salmon. The Japanese high-seas fishery, which does take immature chums, has operated only west of 175° W, so has probably taken very few chums of Canadian origin.

Among Pacific salmon, age of maturity and rate of growth are inversely correlated, a fact which has been known at least since the time of Fraser (1920). Ignoring the very rare ages 0.1 and 0.5, in our waters the faster-growing chums tend to mature at age 0.2, those of moderate growth rate at age 0.3, and slow growers at age 0.4. However, the correlation, although strong, is far from perfect, and there is considerable overlap in size between all three ages (Fraser 1920, 1921; Palmer 1972; Helle 1979, Fig. 14). Tables 5-8 and Fig. 3 of Ricker (1964) show examples of actual average growth rates throughout life, obtained by back-calculation from scale annuli.

One result of the above negative correlation is that there is less difference in size between maturing fish of the different ages than there would be otherwise. Table 2 shows that there is a tendency for the size difference to be somewhat greater in the northern part of the province than in the south. Unweighted averages for the available Areas are: fish of age 0.3 are 28% heavier than age 0.2, while fish of age 0.4 are 42% heavier than age 0.2 and 11% heavier than age 0.3.

These figures apply to the <u>catches</u>. Population values would be somewhat larger because of the selectivity of gillnets for smaller chums, described in Section 3.3. This is apparent in the Area 29 (Fraser River) figures, where the catch is nearly all taken by gillnet; here age 0.4 exceeds age 0.3 in weight by only 3% (Table 2). However, even unselected population values of these ratios would be much smaller than the ratio of mean weight at maturity to the weight of the same fish at the last scale annulus, formed less than a year earlier. the contrast between weights of maturing and immature chums of a given age is shown for two British Columbia regions in Table 3. The maturing fish of age 0.2 were 2.5 to 3 lb heavier than the immatures of that age, even though the matures had an abbreviated final growing season. Similar differences occur in samples from other regions, as shown in Tables 5 and 8 of Ricker (1964). In Table 3 the 0.3:0.2 ratio of weights of maturing individuals is 1.29 for the Strait and 1.39 for Area 8 -- similar to the figures in column 8 of Table 2. By contrast, the corresponding maturing:immature weight ratios are 1.70 and 1.82, or even somewhat larger if the fish that will mature during age 0.4 are taken into account.

In subsequent Sections of this report it will be assumed that age of maturity of chum salmon is determined partly by environmental factors and partly by heredity; further, that the hereditary component is susceptible to change by selection. The same dual control of biological characteristics is rather general in salmon (Ricker 1972).

### 1.3 FISHING GEARS AND CATCHES

For maps of the statistical divisions of British Columbia and Alaska see Figures 1 and 2 of Ricker et al. (1978).

Tables 4-6 show the commercial landings of chum salmon from all important statistical Areas of British Columbia during 1951-75. Almost all are caught either by gillnet or by purse seine, which in recent years have taken more or less equal shares, on the average (Table 7). However, seines tend to take more than gillnets when chums are abundant, and vice versa. Trollers now take a few chums, particularly in Areas 6 and 7, but their catch is less than 1% of the total. There is also a small Indian subsistence fishery for chums, mainly in rivers.

Before 1951 statistics of the British Columbia chum fishery are poor. The available information was summarized by Hoar (1951), but unfortunately he failed to publish his summary tables. The sources he used were mainly the Annual Reports of the British Columbia Commissioner of Fisheries and of the Canadian Department of Fisheries. Data on chum salmon canned were fairly good, but for those processed in other ways they were very sketchy.

## 2. CHANGES IN THE AGE OF BRITISH COLUMBIA CHUM SALMON

### 2.1 TRENDS DURING 1957-1972

From 1957 to 1972 collections of scales were taken annually from commercial landings of chum salmon captured by seine and gillnet in most of the important statistical Areas. Ages were read, and a mean value for each Area was computed by weighting the age composition for each week by the landings during that week. The data are available in the series of reports by H. T. Bilton, D. W. Jenkinson and their colleagues. Additional data on Fraser River chums are available in a report by Palmer (1972).

Accuracy of age-reading of chum salmon scales has been tested by Tanaka et al. (1969, Tables 1, 2). Agreement between readers was generally good. In making comparisons over a series of years consistency is more important than absolute accuracy. For the 1957-72 period, it is fortunate that two investigators (Bilton and Jenkinson) were involved throughout.

Table 8 shows the mean ages, with the regression on time for every Area that had collections in 5 or more years and which spanned most of the time interval. In every case the trend has been for an increase in age. The estimated rate of increase in mean age varies from 0.0093 to 0.0405 yr per year. This means a total increase of 0.139 to 0.608 yr during the 15 years over which most of the observations were made. Mean ages of course have considerable year-to-year variability, mostly a result of variations in year-class strength. Although only two of the regressions reach the 95% level of significance, nevertheless the probability of all 14 of them being of the same sign by chance is extremely small -- only $0.5^{13} = 0.000122$.

In Section 7.1 reasons are given for the view that the increase in age may have had partly different causes in the Northern and Southern Districts. However, the prevalence of positive regressions in each District separately is statistically significant: $0.5^{7} = 0.0078$ for the north, and $0.5^{5} = 0.031$ for the south (including Fraser). Thus an average trend toward older ages can be considered almost certain, in both parts of the Province.

Palmer's (1972) study of the Fraser River chums extended from 1960 through 1969. His samples were of three sorts. The "Cottonwood" samples were from a "test" gillnet fishery in the south arm of the Fraser about half way from the New Westminster bridge to the Strait. The "Silverdale" samples were from chums taken about 15 km downstream from Mission, for the purpose of tagging. They were captured by beach seines in 1960-63 and by gillnet in 1964-69. The "Spawning Ground" samples were a composite group from the Fraser and its tributaries below Hope.

Mean ages were calculated from Palmer's Table 33, and are compared with those from the Area 29 catch camples in Table 8A. There is usually remarkably good agreement among the four figures for a given year. The only exception is that the Area 29 sample in 1965 was substantially older than any of Palmer's samples; but even this lies within reasonable limits of sampling error. A low mean age in 1962 appears in all the samples, and also in neighbouring Areas as far north as Area 12, but not beyond (Table 8).

Because they span only a short period of time, none of the age series in Table 8A has a "significant" trend; and in fact there may have been less change during most of this period than before or after (Fig. 1). However, the trends are all positive, in line with the general increase in age observed in the longer series of Table 8.

## 2.2 BRITISH COLUMBIA AGES IN EARLIER YEARS

There are several sources of information about chum salmon ages before the 1950s. Fraser (1920, 1921) made age determinations of chums caught in 1916 and 1917 (Tables 9, 10), while Pritchard (1943) examined samples taken between 1928 and 1942 (Table 10). In both cases the samples were taken from commercial catches, but no details are available concerning the gear used or the date the catches were made. Wickett (1946) reported on the ages of chums taken by seine for tagging in Johnstone Strait in 1945, and in this case dates are available. Additional commercially-caught samples were taken in 1946-48 (Table 11), whose ages are given by Wickett (1947) and Robertson (1948). Lastly, seine samples for tagging were taken in 1950 (Chatwin 1953) and 1953 (observations supplied by J. M. Manzer).

Comparing statistical Areas in Tables 10 and 11 with the same or neighbouring Areas in Table 8 reveals the following picture. Fraser's ages in 1916-17 and a few of Pritchard's ages (for 1929-30 in Areas 12 and 13, and Area 25 in 1934) lie within the range of the recent observations. Similarly all the 1945-48 ages are similar to recent figures except for Areas 12 and 20 in 1948, which are somewhat higher but well within the limits of random variability. On the other hand, most of Pritchard's ages are substantially greater than anything observed since 1944; they vary from mean ages of 3.23 to 4.17, and this over a period from 1928 to 1942 (Table 10). While we cannot now affirm that the chums of that period and in those Areas did not achieve these mean ages, neither can we accept them uncritically. Other possibilities are that the sampling was done early in the run when larger fish predominate, or that the samplers tended to select the larger individuals. In the latter connexion, the 1929-30 ages from Areas 12 and 13 being close to recent means for those Areas may reflect the fact that in those years scales were taken from chums used for tagging, hence would be likely to include a representative range of sizes. It is also possible that Pritchard's criterion for rejecting false annuli was less stringent than that used in later years, or perhaps even that false annuli were more numerous and/or more convincingly developed at that time.

The above is not meant to imply that the more recent samples of Table 8 are perfectly representative of the chum salmon stocks. On the contrary, they are probably biased toward younger ages because they include chums caught both in seines and in gillnets, and the latter have tended to select the smaller individuals (Table 12).

## 2.3 AGES AT OLSEN CREEK, ALASKA

Helle (1979) has reported a 19-year intensive study of the chum salmon that enter Olsen Creek, Prince William Sound. His Table 3 shows that the percentage of fish of age 0.4 increased rather steadily from 1959 to 1972, starting at 4% and reaching 67% in 1972, after which they decreased again, reaching a low of 1.5% in 1977. Helle also gives the percentages of the different ages in each year-class in his Table 4, which is a better way to consider the data, but the trends with time are much the same.

To make Helle's figures comparable to our Table 8, average ages for each year (not year-class) have been computed from his Table 3, giving males and females equal weight. These are compared with four British Columbia Areas in Fig. 1. While mean age increased from 1959 to 1972 both at Olsen Creek and in British Columbia, otherwise there is little resemblance between the series. The years of large mean age usually do not coincide, and the range of mean ages is much greater at Olsen Creek. Also, whereas the Olsen Creek chums exhibited their most rapid increase in age from 1966 to 1972, this was a time of slow increase or no increase in the British Columbia Areas. Unfortunately there are no British Columbia data since 1972, the time during which Olsen Creek ages decrease again. I conclude that the changes in mean age at Olsen Creek had a different cause from those in British Columbia -- a question discussed in Section 7.

## 3. SIZE OF CHUM SALMON CAUGHT IN BRITISH COLUMBIA

### 3.1 MEAN WEIGHTS, 1951-1975

The mean weight of chums caught in different statistical Areas varies by 3 or 4 lb (Table 12, Fig. 2-4). Differences between Areas are similar for seined and gillnetted fish (Fig. 4). On the average, sizes are larger in the Northern District, and are also more variable between Areas: the north has both the largest fish (Area 9) and the smallest (Area 2E).

For the purpose of comparing chum sizes with environmental factors, the mean weights for the three statistical Districts were used in most cases (Table 13). The Northern District includes Areas 1-10; the Southern, Areas 11-27. The Fraser District is here represented by Areas 29A and B; the small catches of subareas C and D are not included.

### 3.2 WEIGHTS IN EARLIER YEARS

#### Fraser's samples

The first record of weights of samples of chum salmon in British Columbia is by Fraser (1921). He measured and weighed chums from three Strait of Georgia localities in 1917, tabulating mean weights for each half-inch interval of length. Approximate figures for 1916 can be obtained by using his length distributions for that year (Fraser 1920) and the corresponding weights for 1917. With some minor corrections for typesetter's errors in the tables, average weights by age-group and sex are shown in Table 14, and for the age-groups as a whole in Table 15. For Area 17 these weights are similar to those obtained in recent years (Table 12). The Area 18 Chemainus chums are considerably smaller than those of recent samples from Area 18, mainly because age 0.3 fish are few, but partly because the fish are rather small both at age 0.3 and at age 0.2. It probably represents a local stock of chums from the Chemainus River, unless, of course, the fishery that produced the sample was highly selective.

## Hoar's data

A second source of information on chum sizes pertains to the 1940's, as presented by Hoar (1951). His Table 5 shows that mean weight tends to decrease as the season advances. The estimated rates of decrease are from 0.12 to 0.83 lb/week in different Areas and years, although the true range is doubtless considerably less because of sampling variability. The data were obtained by fishing companies in order to establish a basis for pricing chums by the pound rather than by the piece.

The mean weights shown for 1944-47 in Table 16 are generally smaller than those obtained in 1916-17, and also smaller than those observed since 1950 (Table 12).

## Fisheries Association series

Godfrey (1959b) published a graph of trends in mean weight of seine-caught chums from 1946 to 1958, based on data obtained from the Fisheries Association of British Columbia (Fig. 5). Average weights are shown for 5 regions (combinations of Areas), and figures measured from the graph are shown in Table 17. Weights shown for the 1940's are generally similar to those given by Hoar for an Area in the same region (Table 16), which is not surprising considering that they are based partly on the same data.

All five regions show a gradual increase in chum size from 1946 to 1952-54, after which size levels off. During 1951-58, the time of overlap with the sales-slip series of Table 12 and Fig. 2 and 3, the Association weights are usually a little smaller than sales-slip weights from Areas within the same region, but the year to year variations tend to be similar (Table 18). However, whereas the sales-slip weights tend to decrease with time starting in 1951 or 1952, most of the Association weights exhibit a net increase from 1951-52 to 1957-58 (Fig. 5).

This brings up the question of the reality or otherwise of the low weights obtained by the Association during the 1940's. A relevant fact is that the Association's pink salmon weights show a similar increase from 1946 to 1952-54, and that the 1946 pinks were much the smallest during that period (Godfrey 1959a). As Godfrey (1959a) points out, if exceptionally unfavourable ocean conditions made for very small pinks in 1946, we should expect chums to be rather small in 1946, and because of their longer life history, also in 1947 and perhaps even in 1948; and these years do in fact have the smallest chums in Table 17.

What is less easily explained is the difference in trend, from 1951 to 1958, between the Association's and the sales-slip figures (Table 18). If the Association were gradually improving its coverage or procedures during this time and so gradually obtained larger mean weights that finally came close to sales-slip averages, then it seems reasonable that their 1946-50 weights would have been obtained by the earlier less-perfect procedures. If so, the averages for 1946-50 might be too low by a pound or so; but the depression of 1946-48 would remain, although reduced in magnitude.

Fisheries Research Board samples of 1945, 1947, and 1948

Wickett (1946) reported mean weights by week and by age-group of chums seined for tagging in Johnstone Strait in 1945, and the overall mean weight for the season can be obtained by weighting each unit by the number of fish included (Table 15). Also shown in Table 15 are Robertson's (1948) weights of chums in catch samples of 1947 and 1948. The 1945 weights are smaller than most of those of 1916 and 1917, both for individual ages and overall, but are a little larger than those of the years immediately following. Weights in the 1947-48 samples are sometimes larger, sometimes smaller, than the Fisheries Association's average for the region in which the sample is located (Table 17). Chums in the Area 20 Sooke sample of Table 15 are considerably larger than the figure for the Association's West Coast region, but Area 20 fish are regularly larger than those from the other Areas that contribute to that region (Table 18).

## 3.3 COMPARISON OF GEARS

In 16 of the 20 comparisons that are possible in Table 12, the gillnetted chums were smaller than those caught by seine. The unweighted mean difference for all comparisons is 0.57 lb. However, there is a marked difference between the Northern and Southern Districts in this respect (Table 43). The weight difference between the gears averages 1.12 lb in Areas 1-10, and only 0.13 lb in Areas 11-27. Why should this be? The small size of gillnetted chums is partly due to the fact that many of them are taken in nets set primarily for pink salmon, which are much smaller fish. In the Southern District in even years there are very few pinks south of Area 13, so this source of selection is absent in those years. Also, in British Columbia pinks tend to run earlier than chums, but in both odd and even years there is much more overlap in the times of the main pink and chum runs in the north than in the south, which means that pink-directed gillnets catch more chums in the north than in the south. In addition, the size difference between pinks and chums is greater in the north, so that pink-directed gillnets are of smaller mesh and would be more selective for the smaller chums.

Some chums are taken in nets set for sockeye, which are smaller than chums but larger than pinks. Sockeye tend to run earlier than either pinks or chums, so few chums are taken during the regular sockeye season. However, some gillnetters in the late fishery for chums may use sockeye nets in order to avoid an extra investment in gear; and at the same time they increase their chances of taking a certain number of (more valuable) cohos.

In Areas 1, 6, and 7 enough chums were taken by troll to give some idea of selection by this gear. Because the data are all later than 1960, comparisons based on the actual corresponding years were computed, as follows:

| | Number of years | Weight in pounds | | |
|---|---|---|---|---|
| | | Gillnet | Seine | Troll |
| Area 1 | 12 | 9.85 | 10.61 | 10.62 |
| Area 6 | 8 | 11.08 | 12.60 | 12.10 |
| Area 7 | 13 | 10.09 | 11.14 | 10.99 |

Evidently the troll-caught fish are closest to the seined fish in size.

## 3.4 MEAN LENGTHS, 1958-1972

The observations published by Bilton, Jenkinson and colleagues (1965-73) provide lengths of fish sampled in most of the important fishing areas during 1957-72. In 1958 and subsequently the postorbital-hypural length was used. Tables 19-32 summarize these lengths, together with their linear correlations and regressions on time, as well as a computed length for 1963. The data are best for chums of age 0.3, for which more than 100 fish were usually available in each Area, occasionally more than 1,000, and rarely less than 30. To maintain accuracy, no sample of 4 fish or less was included in calculating the regressions; there were actually only 3 such instances. For chums of ages 0.2 and 0.4 far fewer measurements were available, so no lower limit was put on the size of sample used in calculating the regressions; the loss of degrees of freedom would more than counter-balance the increase in individual accuracy. Naturally the age 0.2 regressions, and particularly those for age 0.4, have much larger sampling errors than those for age 0.3.

As expected, length increases with increasing age. Males are usually larger than females of the same age; the few contrary examples are almost certainly an artifact of sampling. For fish of a given age and sex, mean length shows no significant change from north to south in the Province, although for ages 0.3 and 0.4 the trend is slightly downward (Fig. 4). Hence, the decrease in overall mean weight from north to south results mainly from the increasing representation of the age 0.2 chums in the southern catches.

Additional lengths for the Fraser River (ages 0.2 and 0.3 only) are available in Appendix F of Palmer (1972). They are in fork length, and can be made comparable with Table 32 by dividing by 1.25. In general, Palmer's lengths support the Area 29 data in Table 32, an interesting feature of both being the small size of the chums of both ages in 1965. A similar situation in the same year is evident in Areas as far north as 12, or perhaps even 9, but not beyond (Tables 19-31); it appears also in Table 12 as low mean weights in Areas 12, 13, 20, and 29.

## 3.5 LENGTHS IN EARLIER YEARS

### Fraser's lengths

The 1916-17 samples of chums reported by Fraser (1920, 1921) were measured, but there is ambiguity about what length measurement he used. He says "the length as here considered does not include the caudal fin rays" (1920, p. 165); but one wonders whether he measured to the place where the rays are first externally visible, or to where they begin at the tip of the hypural bone, a point that can be found by flexing the tail. Also, was the measurement the horizontal distance when the fish was lying flat on a board or ruler, as is the present custom, or did he lay a tape over the contour of the body from snout to tail?

The best clue to what actually was done is a comparison of Fraser's weights with his lengths, on the assumption that the weight-length relation in 1917 was similar to that in recent years, i.e. agrees with equations (1)-(3). On this basis Fraser's lengths are about 0.97 times present-day fork length or 1.212 times postorbital-hypural length. This probably means that he measured to the point where the fin rays are first visible externally, using a tape stretched over the contour of the body. Using this conversion factor, Fraser's lengths in millimetes of the postorbital-hypural unit are shown in Table 9.

The four groups in Table 9 are remarkably similar in respect to mean length at a given age and sex. Also, there are no significant differences between Table 9 and modern mean lengths in the same general region, shown in Table 29.

### Fisheries Research Board samples, 1945-53

Chum salmon samples were taken for age determination in two to several statistical Areas in most years from 1945 through 1953, and their mean lengths are shown in Table 11. Compared with the figures in Tables 19-32, lengths in the 1940s average considerably less than from 1958 onward, with 1950 and 1953 showing improvement. Figure 6 compares 1945-53 lengths with the mean of male and female lengths in 1958-72, for age 0.3 only.

In general, these lengths confirm the evidence of the Fisheries Association weights in Figure 5, that chums were in fact small during 1946-48.

## 3.6 RELIABILITY OF THE DATA

The mean weights in Table 12 were calculated from statistics published by the Canadian Department of Fisheries and Oceans, Pacific Division. These statistics are compiled from sales slips made out for each primary delivery of salmon from fisherman to buyer. The slips include both the number and the weight of the fish caught. Weight is always obtained directly, for the fish are paid for by the pound. For landings of up to a few dozen, or perhaps 100 or so, the fish are counted individually. For large landings it is clear that an average weight is sometimes used to compute the numbers. This average may be based on a sample from that landing, or from a general "feel" about how large the fish look, or how large the fish have been in other recent landings. This of course introduces the possibility of error, but indirect evidence shows that it is not important for our purpose.

A strong indication that available average weights reliably reflect the size of the fish is given by the consistency of the data. Variations in size from year to year are similar between adjacent Areas and between the two types of gear (Table 12). This, however, does not completely exclude the possibility of human bias producing artificial trends with time, or artificial differences between gears.

The fact that the mean size of most species of salmon has decreased since 1951 (Ricker et al. 1978, and MSS) raises the question of whether the weights or numbers recorded on the sales slips might have become more (or less) accurate as the years went by. This seems improbable *a priori*, and there are several indications that this kind of bias is actually unimportant or absent. Any such changing bias would presumably apply to all species of salmon more or less equally, and (less certainly) to all Areas equally. In fact, however, the mean sizes of the 5 species of salmon have changed at quite different rates, both absolute and relative, and for any one species there have been important differences between Areas (Fig. 2, 3). Area differences were particularly marked among pink salmon, where the net decrease in size varied from 0.5 to 1.5 lb over 24 years (Ricker et al. 1978). Furthermore, the even-year pinks decreased at a much faster rate than those of the odd years, which could scarcely be a result of any kind of human error.

There are important differences in the reported sizes of chum salmon taken in a given Area by different kinds of fishing gears (Table 12, Fig. 4), and this is true for other species as well as chums. Is it possible that human bias plays a role here? There is no incentive for fishermen or buyers to underestimate or overestimate numbers, and presumably they check each other on weights. Thus it is difficult to imagine how artificial differences in mean weights between gears could arise. Furthermore, any such artificial difference would presumably be consistent between species. In fact, however, among pink and coho salmon gillnetted fish tend to be larger than seined fish, whereas among chums the seined fish are usually larger. This can be explained on the basis of mesh sizes used in the gillnets, but there could scarcely be a human bias that operates in opposite directions for different species.

Finally, in the case of chum salmon two types of information can be compared: mean weights taken from sales slips, and mean lengths from the sampling program and (for the Fraser) from Palmer's (1972) work. As discussed in Section 4.1, for the two more abundant ages mean length has decreased since 1957 similarly to mean weight, and there is also much similarity in the year to year variability in the two series (compare Tables 12 and 19-32, also Fig. 4). Thus two completely independent procedures corroborate each other.

There remains the possibility, indeed the inevitability, of accidental errors in the original records, in copying, or in the computations of this report. I can only say that reasonable care, repetition and cross-checking have been used at all stages. Tables 12 and 34 were inspected for unusually high or low mean weights, and most of the few that were found could be corrected by consulting the original records. The remainder were omitted if completely unreasonable, but otherwise were allowed to stand. The surviving errors of these and other types are evidently too few and too small to spoil the consistent picture of variation and change in mean size.

# 4. TRENDS IN SIZE OF CHUM SALMON WITH TIME

## 4.1 BRITISH COLUMBIA

Regression lines fitted to the weight data of Table 12 are shown in Table 33. Among 43 sequences, 35 indicate a decrease in size, of which 9 have a probability of significance of 95% or better. Of the 8 increases, 1 is "significant". The weighted mean rate of decrease is 0.032 lb/yr in the gillnet catch and 0.063 lb/yr in the seine catch. The corresponding 24-year percentage decreases (6.6 and 12.4%) are much smaller than the percentage decreases observed among pink, coho and chinook salmon, but somewhat larger than those for sockeye.

The Table 33 data are shown below grouped by Districts and Areas, the mean of the Areas in each group being weighted as their total catches in Tables 4-6.

| | 24-year change in weight, lb | |
|---|---|---|
| | Gillnet | Seine |
| Northern District | | |
| Areas 1-10 | -0.73 | -2.01 |
| Fraser District | | |
| Area 29 | -1.52 | - |
| Southern District | | |
| Areas 11-13, 20 | -0.99 | -1.04 |
| Areas 17, 18, 23-27 | -0.33 | -0.12 |

The greater rate of decrease in the seine catch, as compared with the gillnet catch, is practically limited to the Northern District. The above grouping of Areas within the Southern District is between those dominated by chums of Fraser River origin, and those whose chums are mostly from local stocks. In the former there is a size decrease (in the seine catch) about half as large as in the Northern District, whereas among the local stocks there is only a little net decrease in size in either series. Within the latter group, Areas 25-27, near the northwestern tip of Vancouver Island, show a net increase in size that is probably real, and which must reflect some peculiarity of the local stocks or fisheries.

Trends with time in lengths obtained from the sampling program are shown in Tables 19-32. Data for Areas 14, 16, 17, 22, 25, and 26 cover too short an interval to be of interest in this connexion. Areas 18 and 23 have a longer time range, but include only 5 samples each. What remains in Areas 3-10, 12, 13, 20, and 29. Dividing these similarly to the previous schedule produces the following breakdown of the changes in length:

| | | Areas 3-10 | | Areas 12, 13, 20, 29 | |
|---|---|---|---|---|---|
| Age | Sex | Increases | Decreases | Increases | Decreases |
| 0.2 | M | 2 | 6 | 0 | 4 |
| | F | 2 | 6 | 0 | 4 |
| 0.3 | M | 1 | 7 | 0 | 4 |
| | F | 0 | 8 | 0 | 4 |
| 0.4 | M | 4 | 4 | 2 | 2 |
| | F | 5 | 3 | 1 | 3 |

In both groups of Areas there is an overwhelming excess of decreases in length among the two younger ages, and a more or less even split for age 0.4. Most of the individual regressions in the 12 Areas are not "significant", but in combination they clearly indicate a decline in length among the two younger ages. Of the 48 possibilities there, 8 have 95% probability or better, and 4 of these are beyond the 99% level. Chance expectation would be 2 or 3 at 95% and either 1 or 0 at 99%. The age 0.4 group has only 1 example at 95%, which is the number expected by chance in 24 samples.

Average rates of change in length for the two groups, weighted as the catch from each Area, are shown below, in mm/yr.

| | Areas 3-10 | | Areas 12, 13, 20, 29 | |
|---|---|---|---|---|
| | Male | Female | Male | Female |
| Age 0.2 | -0.73 | -0.76 | -2.42 | -2.15 |
| Age 0.3 | -0.69 | -1.55 | -2.03 | -1.66 |
| Age 0.4 | +0.24 | +0.12 | -0.99 | -0.96 |

The decreases are less in the northern areas than in the southern. They are largest at age 0.2, usually somewhat less at age 0.3, and very much less at age 0.4. In fact, age 0.4 in the northern Areas exhibited a small net increase in length.

It should be remembered that any given change in length implies a greater change in weight among the older (larger) chums than among the younger (smaller) ones.

## 4.2 ALASKA

Mean sizes of chum salmon caught in Alaska, as reported in the Statistical Yearbooks of the International North Pacific Fisheries Commission, are smaller than any in British Columbia (Table 34, Fig. 7). Within that State, computed 1963 size becomes generally smaller going north and west, varying from 9.6 lb in southeastern Alaska to 6.7 lb in Bristol Bay. However, few chums are taken in the Western Region, and those few may be mainly incidental to other fisheries.

Helle (in press) sampled chums in 5 Alaskan spawning streams over a series of years during the 1970s. His Figure 6 indicates a decrease in mean size from south to north in Alaska, except that in the most northern samples, taken near Kotzebue, the fish were a little larger than at Olsen Creek. The largest spawners sampled were from Fish Creek, a tributary of the Salmon River close to the Canadian boundary near Hyder. These averaged about 627 mm long at age 0.3 (postorbital-hypural length, sexes averaged). This is larger than the mean length of the catch for any British Columbia Area in Tables 19-32; but the catches sampled were partly of gillnetted fish, which are small, and in any event more variation is to be expected between individual stocks than between means for statistical Areas.

The regressions at the foot of Table 34 show no consistent trend in size with time. There are 3 positive and 5 negative regressions, none significant. Even if significant, it would require detailed knowledge of the fishery in each Area to sort out possible effects of trends in kinds of gear used and incidental capture by other fisheries. However, the trend in southeastern Alaska is negative, and is similar in magnitude to that in adjacent Areas of British Columbia (Table 33).

Helle's (1979) Table 8 and Figures 15 and 16 show the mean lengths of chum spawners of 3 ages and both sexes at Olsen Creek from 1959 through 1978. The trends in length are all downward, although only one is "significant" (99% level); they are shown below, converted to the postorbital-hypural length unit:

| | Males | | | Females | | |
|---|---|---|---|---|---|---|
| Age | 0.2 | 0.3 | 0.4 | 0.2 | 0.3 | 0.4 |
| No. of years (N) | 17 | 19 | 16 | 13 | 19 | 17 |
| Correlation (r) | -0.618** | -0.303 | -0.119 | -0.432 | -0.438 | -0.097 |
| Slope (b), mm/yr | -1.420 | -0.745 | -0.347 | -1.154 | -1.014 | -0.273 |
| 1963 length, mm | 507 | 550 | 576 | 507 | 542 | 556 |

The estimated rates of decrease (b above) are, on the average, less than half as large as those typical of British Columbia catch samples from 1957 to 1972 (Tables 19-32). As in British Columbia, the rate of change at age 0.4 is much less than at younger ages.

A noteworthy feature of Helle's Fig. 16 is the fact that there is no clear relation between mean length at a given age and the changes in age composition discussed in Section 2.3. For example, lengths decreased abruptly while mean age was increasing from 1969 to 1971, but they increased in 1972 when age reached its peak, and again in 1973 when it was still large. From 1973 onward all 6 age-sex groups in Helle's Fig. 16 continued their slow decrease in size, as mean age decreased rapidly (our Fig. 1).

# 5. RELATION OF SIZE OF CHUM SALMON TO POPULATION ABUNDANCE

## 5.1 CHUM SIZES AND REGIONAL ABUNDANCE

In seven important chum-producing Areas a comparison was made between individual size and total landings of chums in the Area (Table 35). The 13 correlations are all positive, and two are "significant". The 13 estimates were combined into a single estimate of the correlation, $r = 0.261$, using the z-transformation of Fisher (1950, Section 35). Overall significance is estimated from the value $z = 0.267$, which is normally distributed with a variance of 1/263, and is thus 4.3 times its standard error and highly significant. Although real, the mean correlation is not large. It accounts for only $0.261^2 = 6.8\%$ of the observed variability in size from year to year, but this of course implies a somewhat larger percentage of the true variability in size, if sampling error were to be eliminated.

Because abundance of chum salmon tends to vary similarly over broad sections of the coast, the above relationship could reflect the influence of either the abundance in each local Area, or the general abundance in the region. Either way, a positive relation between size and abundance seems unexpected; we normally anticipate that, if there is any relation at all, the abundant broods should grow more slowly. However, the mean weights of Table 12 include fish of two important ages, 0.2 and 0.3. Suppose that an unusually numerous year-class turns up. Its first effect will be to reduce the mean size of all fish caught during the year it is age 0.2, because the small 0.2 fish will then outnumber the older ones. The following year, when the year-class is of age 0.3, it will increase the mean size of chums in the total run because 0.3 fish will then be unusually numerous. But in most or all year-classes and Areas the number of chums that mature during age 0.3 exceeds the number that mature during age 0.2, and they are also larger in size, so the net result is a positive correlation between the weight of all chums landed in a given year and their mean individual weight. The progress of an unusually weak year-class through the fishery produces the same positive correlation.

This scenario can be tested by using the information on ages reported by Bilton and colleagues (Table 8), in combination with both weight and length data. The southern part of the province has been selected for this analysis. The total catch of Areas 11-29 each year (Tables 5 and 6) was divided between ages 0.2, 0.3, and 0.4 using the simplifying assumption that fish of all ages are of the same average size. This gives age 0.2 fish too much weight and age 0.4 too little, in comparison with the dominant age 0.3 (Section 1.1); but the differences are small in relation to other sources of error, and they are consistent, so that comparisons between years are not much affected. Percentage occurrences of ages 0.2, 0.3, and 0.4 were averaged for Areas 12, 13, 20, and 29, and applied to the total weight of catch in Areas 11-29 each year to estimate the actual weight of chums caught of each age (Table 36). In thousands of pounds, the total catch from a year-class varied from 860 for the 1962 brood to about 38,000 for the 1968 brood and probably 40,000 or more for the 1969 brood. However, the range of sizes of the year-classes, as distinct from the catches taken from them, would not be this great, because of greater restrictions on fishing during years of low abundance.

There is a strong contrast between the abundant year-classes of 1968 and 1969, and the smaller year-classes that preceded and followed them. In 1971 the average size of chums in the catch as a whole decreased to 9.15 lb because of the influx of numerous 0.2 fish of the 1968 year-class and the low abundance of previous year-classes (column 9 of Table 36). In 1972 mean weight rose to 11.02 lb, when 0.3 fish were abundant. In 1973 it reached 11.83 lb, when age 0.3 fish of the big 1969 year-class dominated the catch, and there were probably a fair number of 0.4s of the 1968 brood.

Turning to lengths, columns 6 and 7 of Table 36 are an index of the mean size of age 0.2 and 0.3 chums of the year-classes in column 1, based on the average length of both sexes of chums caught by seine in Areas 12, 13, and 20, and those caught by gillnet in Area 29. (Figures in brackets include an interpolation of one or two missing lengths.) These lengths, like the weights in column 9, reflect the general decrease in size of chums, amounting to about 2 mm or 0.06 lb per year. To test for a relationship between individual size and abundance, the residuals of the lengths from their respective regression lines were obtained -- that is, the observed value less the computed value. In Table 37 these residuals are regressed on the index of year-class abundance. The correlations are negative, but are small and completely non-significant. The effect indicated for both ages is a decrease of a little more than 1 mm per 10 million lb of catch, so an effect of this order is possible, but not proven.

### 5.2 CHUM SIZES AND TOTAL SALMON LANDINGS

Table 38 compares the mean size of chum salmon with the total landings of all species of salmon, both for British Columbia and for the whole northeastern Pacific. The correlations are mostly positive, but none are either "significant" or very large. Thus there is at most a very weak suggestion of a possible relationship, which is of the opposite sign to what would be expected if competition in the ocean were a factor affecting the size of chums.

## 6. RELATION OF CHUM SALMON SIZE AND AGE TO OCEAN TEMPERATURE

### 6.1 GENERAL CONSIDERATIONS

A pattern of increasing age and decreasing size of salmon might correspond to a simple model of the effect of a decrease in ocean temperature. Age at maturity is determined partly by rate of growth, particularly in the second year of life (Helle 1979, p. 73). Hence if cooler temperatures decrease growth rate, more chums will mature at the older ages. This will have opposed effects on the mean size of the populations at maturity: the larger number of older fish makes for an increase in overall mean size, but this is opposed by the generally slower growth rate. If the latter effect prevails, then we have a combination of increasing age and decreasing mean size.

The effect of decreasing temperature and growth rate on size at a given age is also equivocal. The part of the population that is shifted to older ages by the cooler temperature will include mainly those whose hereditary growth potential is least. Those that remain will be the genetically faster growers, so that there might even be an <u>increase</u> in size at the youngest age, along with the increase in average age. Or this effect could be swamped by the direct effect of temperature-induced slower growth.

So far we have been assuming that a lower temperature means slower growth. But this is not necessarily true. Brett et al. (1969) showed for sockeye that optimum temperature for growth is a function of the ration available: if less than the maximum ration was supplied, the fish grew fastest at a lower temperature. Accordingly the effect of ocean temperature on chum salmon growth, at a given age in a given year, will depend on whether food for fish of that age is scarce or abundant.

The above considerations indicate that temperature changes may affect both age and size in unexpected ways, so that careful analysis is essential.

## 6.2 BRITISH COLUMBIA

### Weight

Both ocean surface temperatures and weights of chum salmon have had downward trends since 1951. We could, of course, correlate weight and temperature directly and obtain an estimate of the degree of relationship. But even if this proved to be statistically significant, it would not necessarily mean that there was any causal or "true" relationship between size and temperature, because of the well-known danger of accidental correspondences between monotonic time series. However, a minimum estimate of the true relationship can be obtained by using residuals of weight (R in Table 13), these being the observed weight in each year less the weight calculated from the linear regression of weight on time. These are then correlated with the residuals of temperature, similarly calculated and shown in Table 18 of Ricker et al. (1978). While this relationship may underestimate the total effect of temperature on weight, it represents all that we can be sure of.

The "r" columns of Table 39 show correlations between residuals of weight and of temperature for the three statistical Districts and for four temperature stations. Three of these are coastal, and are located on Figure 1 of Ricker et al. (1978), while Station P is at 50° N, 145° W. For the three coastal stations the same-year correlations (S) are all positive, but are small and individually non-significant. Correlations with temperatures of the previous (P) and antepenultimate (A) years are all negative, and the latter are mostly at about the 90% level of significance. Station P correlations are also negative for the antepenultimate years, but are mixed otherwise; all are small.

The data are perhaps regular enough to invite speculation about causal effects. In line with the results of Brett et al. (1969), described earlier, one might postulate that food was adequate for these chums during the final ocean year and permitted a positive response to temperature; while in the second last year, and particularly during the antepenultimate year, appropriate food was scarcer, so that lower temperatures were more favorable for growth.

In Sections 3.2 and 3.5 it was shown that both the Fisheries Association weights and the FRB length samples indicated that in the years 1946 and 1947 chum salmon were small (Tables 11 and 17). During these years coastal ocean temperatures were below the trend line (Ricker et al. 1978, Figures 9 and 10), and although the Station P temperatures were probably high, the record for those years is imperfect. The minimum of pink salmon size came in 1946, and that for chums in 1947. But temperatures in those years had decreased only modestly; they continued to decrease until 1949 to 1951 at different stations, while the size of chums increased (Table 17). This seems to rule out any simple overall positive relation between size and temperature.

What about an inverse relationship? Given a preponderance of negative correlations between size and temperature, a decrease in temperature should make for increase in size, and an increase actually occurred during the latter half of the 1940s. But the temperature decrease continued through the 1950s and 1960s, whereas chum sizes began to decrease after 1952 at latest, and continued to decrease throughout those decades.

However, it would be rash to affirm that observed variations in temperature over the last 35 years have been of no significance for the growth of chum salmon. For one thing, we have dealt only with yearly averages, whereas in some months of the year temperature may be more important than it is in others. Also, the possible confounding effects of changes in age of maturation with growth rate, and of the level of food supply, may be sufficient to defeat any analysis based solely on observed size at maturity. It is certain that some factor or combination of factors in the ocean environment must be mainly responsible for the large short-term fluctuations in the size of pink and chum salmon, and it would be very surprising if temperature were not somehow involved. Hence the question of longer-term effects must be left open.

### Age

Is it possible that a decrease in ocean temperature could have caused the trend toward older ages shown in Table 8? The only known basis for such an effect would be as an indirect effect of a reduction in growth rate. Helle (1979) found that age of maturity was best correlated with growth during the second year of ocean life. This is the next-to-last (P) growing season for chums maturing at age 0.2, and the antepenultimate (A) season for age 0.3 -- both of which exhibit negative correlations in Table 39. Hence the effect of decreasing temperature should have been to increase growth rate during the critical second growing season. This in turn makes for earlier maturity and a decrease in average age, instead of the observed increase.

## 6.3 ALASKA

Alaska chum size residuals are compared with ocean surface temperature residuals at the two northern coastal stations in British Columbia and with Station P (Table 40). Two "significant" values occur, but they would be expected by chance in 72 comparisons. Overall there are 36 positive and 36 negative values. The only possibly significant pattern is that in the antepenultimate year the coastal stations have 15 out of 16 negative values; this resembles the situation in British Columbia, and invites the same speculation. In Alaska, however, the Station P correlations do not follow the same trend.

Evidence for a positive relation between sea surface temperature and growth has been obtained for Olsen Creek chums by Helle (1979, p. 53-71). It was obtained both for first year growth, as indicated by the number of scale circuli laid down, and also for the comparison between temperature and size at maturity. In both cases the temperatures used were measured in or close to the region where the salmon were known to be during at least part of the year in question. It is true that Helle's correlations are between the observed data rather than the residuals, hence they do not exclude the possibility that part of the correlation is due to downward trends in temperature and in size that are completely unrelated. However, the final-year relationship is supported by the fact that in any given year all three ages of chums tended to vary in size in the same direction -- either larger than average or smaller than average. Correlations were largest and were "significant" for summer air and sea temperatures, while correlations of length with winter and spring sea temperatures were non-significant but suggestive. Notice that this positive relationship is concordant with the excess of positive correlations for same-year temperatures in Table 39 (11 out of 12), and to a less extent in Table 40 (15 out of 24). Also, it may not be accidental that Prince William Sound has the largest positive correlations in Table 40.

Given that ocean temperatures have trended downward from 1959 to 1978, the above correlations provide qualitative evidence that the decrease in size of Olsen Creek spawners is a result of the cooling, in part at least. However, it is interesting that the size of chums <u>caught</u> in Prince William Sound during 1960-74 <u>increased</u>, their correlation with time being at about a 92% confidence level (Table 34).

## 6.4 QUANTITATIVE RELATIONSHIPS

The correlations in Tables 39 and 40 provide indications, although not proof, that decreasing ocean temperatues may have played a role in the decrease in size of chum salmon, and this is supported by Helle's (1979) study. Hence it is of some interest to calculate the degree of change indicated by the relationships in Table 39, even though they are all non-significant. For this purpose the standard major axes or GM functional regressions[2] of Ricker (1973) are shown in the "v" columns of Table 39, these being estimates of the amount of change in size per degree Celsius for each comparison. Figure 25 of Helle (1979) shows a temperature effect of similar magnitude: the GM regression of length on temperature, converted to weight at the mean observed length, is +0.89 lb/°C.

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[2] If ordinary regressions of size on temperature are preferred, they are equal to the products rv in Table 39; they indicate far less effect of temperature on size.

Two different approaches are used. On the one hand, we might argue that the best index of temperature effect on growth is the mean of the regressions (S, P, and A in Table 39) for three successive years of life. On the other hand, Helle's observation that adult size is strongly correlated with sea surface temperature in the final year of life suggests using only the same-year (S) regressions.

1. The three-year relationship is shown in Table 41. The means of the S, P, and A regressions in Table 39 for each temperature station and fishery District are shown in columns 3, 5, and 7 of Table 41. The resulting computed changes in size per year are in columns 4, 6, and 8. The last row of Table 41 is the observed rate of change in size of chums, from Table 13. There is only one among the 12 computed changes that has the same sign as the observed -- that for Station P and the Northern District -- and it is only 1/7 as large as the observed. All the rest call for an increase in chum size, instead of the observed decrease.

2. The single-year relationships are given in Table 42. In this case the Northern and Southern Districts have computed mean rates of change of the same sign as the observed. The Fraser District is of the opposite sign, which results from the negative correlation for Station P; the other three temperature stations have positive correlations and hence negative rates of change. However, in all cases the observed rate of change in weight is considerably larger than that calculated: about 7 times as large in the Northern District, and 3 times as large in the Southern. For the Fraser, if the anomalous Station P value be omitted, the calculated mean rate of change is -0.0061 lb/yr, as compared with the observed -0.0599, which is 10 times as great.

I conclude that while sea temperature (or associated factors) has probably played some role in the trends in size of British Columbia chum salmon, the rates of decrease of available temperature series are quantitatively insufficient to account for the observed decreases in size since 1951. Nor does it seem likely that there exists, somewhere out in the Pacific, an undiscovered region of much faster temperature decrease where chums might have spent a good deal of their ocean life.

Comparisons can also be made between temperatures and the mean lengths at age shown in Tables 19-32. A general search for correspondences or contrasts between highs and lows of the two series turned up no promising leads. The residuals of length for 4 Areas in the southern half of the province, shown in Table 37, were tested against temperature residuals and produced only very small and non-significant correlations.

## 7. EFFECT OF THE FISHERY ON AGE AND SIZE OF CHUM SALMON

### 7.1 EFFECT ON AGE

#### British Columbia

Given the observed selection of smaller chum salmon by gillnets (Table 12), chums of age 0.2 have been more heavily harvested than age 0.3, and chums of age 0.4 have been less heavily harvested than age 0.3, especially in northern British Columbia. Because age of maturity in salmon is partly heritable, this could be a cause of the decrease in age 0.2 and increase in age 0.4 seen in Table 1, and hence of the increase in mean age shown in Table 8.

There is, however, one feature of the data that seems inconsistent with such an explanation, or at least calls for special consideration. In Table 43 the differences between the weights of seined and gillnetted fish are compared with the rates of increase in age in the same Areas. In spite of the fact that the weight differences are much smaller in the Southern District than in the Northern, age increased a little more rapidly in Fraser-related southern Areas than in the north, and apparently twice as fast in the two other southern Areas. Another difference between the two regions was indicated in Section 4.1: in the Southern District the rate of decrease in weight in the seine catches was similar to that in the gillnet catches, whereas in the Northern District it was almost 3 times as great.

Considering the Northern District first, is the difference in size between seined and gillnetted chums (1.12 lb) sufficient to have caused the mean increase in age observed there (0.0168 yr per year)? The 0.0168 yr/yr rate of increase in age corresponds to 0.0622 yr per generation, if generations average 3.7 years long in the Northern District. Assuming that the heritability of age is 0.3 -- that is, similar to that of length (Ricker et al. 1978) -- the "selection differential" is 0.0622/0.3 = 0.21 yr. This means that the spawners in each generation would have to average 0.21 yr older than the mean age of the stock before fishing, in order to account for the whole of the increase in age.

We need, then, a plausible model in which the mean age of the spawners is 0.21 yr greater than that of the unfished stock, and there is 1.12 lb difference in size between the seined and gillnetted fish. In a sense it is easy to construct such a model, because in the absence of factual information we are free to vary the percentage of each age captured by the gillnets, and also the amount by which the gillnetted fish of each age are smaller than those in the unfished population. Table 44 is such a model, based on the assumption that the seining precedes the gillnetting, so that mean age in the seine catch is the same as in the unfished population.

Although this model meets the required control figures, shown in the last line, it does so only with difficulty. The vulnerabilities of the three ages to gillnets, shown in the 3rd line, exhibit rather extreme differences, but this is necessary in order to satisfy the 0.21 yr intensity of selection. And this means that there cannot be much difference between the weight of each age in the gillnet catch (line 5) and its original weight (line 1). Furthermore, the model's postulate that all seining be done before there is any gillnetting is not completely appropriate. The opposite assumption, that gillnetting precedes seining, would mean that the (unselected) seined fish have the same mean weight as the spawners. In the Table 44 example the latter weight can be calculated as 14.94 lb, which is 1.76 lb greater than the mean gillnet weight, i.e. more than 1.12 lb. So any overlap of the two types of fisheries makes Table 44 even less realistic.

The above constraints are eased if heritability is somewhat greater than 0.3, or if some appreciable part of the increase in age of chums has been due to environmental causes. In fact, a contribution from these sources amounting to 1/4 to 1/3 of the observed increase in age would free the model from any obvious conflict with reality. Another possible source of error lies in the fact that the difference between sizes of fish in the catch is a mean for the period 1951-75, while the increase in age is measured from, at most, 1957 to 1972 (Table 8).

Table 44 and similar models do not, then, demonstrate that all of the increase in age in the Northern District has been a result of selective fishing. Considering sampling error, they do show that this is possible, and that there has certainly been some large contribution from the fishery to the increase in age.

Turning now to the Southern and Fraser Districts, they exhibit one obvious difference from the north in their recent histories. Tables 4-6 show that the 1960s were a period of generally low chum abundance, followed by an amazing recovery in 1972 and 1973, then a decline. But the Southern District was far more seriously affected by these changes than the Northern. In most Areas on either side of Vancouver Island a combination of scarcity and fishing closures reduced catches to zero or nearly so for a period up to a decade long. The Fraser River stock and the catches of its satellite Areas 12, 13, and 20 were less seriously affected, but even they decreased to about a tenth of the yield of the early 1950s. One result of the scarcity is that age samples tend to be poor in much of the Southern District. Of the age series for which a trend is computed in Table 8, Areas 18 and 23 have only 5 or 6 observations, mostly in the early 1960s but including 1972. The correlations are non-significant, and the trend arises from the fact that the only late sample was in a year when almost nothing but age 3 was present in the population. Thus these two estimated age increases are almost certainly too large to be representative.

What then about Areas 12, 13, 20, and 29, comprising the Fraser and Areas that contain a large proportion of Fraser-bound fish? For one thing, the 0.11 lb weighted mean difference in weight between seined and gillnetted fish has a very large sampling error, because it depends mainly on only two Areas, 12 and 13, one of which has an anomalous positive difference between seine and gillnet. Apart from that, 0.11 lb is too small to be representative because there is no entry for Area 29, where very little seining is done. However, the Area 29 gillnet fishery is highly selective of the smaller chums, as shown by the small difference in weight between age 4 and age 3 in the catch (Table 2). For this reason the 0.11 lb difference might be increased to 0.2 or even 0.3 lb, but it is still much less than in the Northern District.

The mean rate of increase in age, 0.0179 yr/yr, corresponds to 0.063 yr per generation if generations averaged 3.5 years long in the south. This in turn means that the intensity of selection is 0.21 yr, given that heritability is 0.3. However, in any model similar to Table 44 this intensity is quite inconsistent with a size difference between seined and gillnetted fish of only 0.2-0.3 lb. We must conclude either (1) that sampling errors are too great to make a useful comparison possible; or (2) that, as suggested earlier, the time discrepancy between the two sets of data has introducted error; or (3) that fishery selection makes only a minor contribution to the increase in age in southern British Columbia, the remainder being from causes not yet identified but possibly associated with the major fluctuation in abundance that occurred there. Or it may be some combination of the above, and in this unsatisfactory state we must leave it.

The rather rapid rate of decrease of age 0.2 chums in Table 1 invites speculation about their future, on the assumption that present causes of that decrease will continue to operate. For extrapolation into the future, however, the linear trend model is not appropriate. Genetical theory and experience indicate that the disappearance of any character from a large population should be asymptotic rather than sudden. This is most easily modelled by regressing the logarithms of the percentage occurrences against time, as shown for age 0.2 in Table 1. In all three Areas the logarithms have a slightly better correlation with time than the original data do. The resulting rates of decrease in logarithm are not significantly different between Areas (Table 1). The mean is 0.0910 natural log units per year, corresponding to an 8.70% decrease of the percentage each year: for example, from a computed 39.57% for Area 20 in 1963 to 36.13% in 1964. Using this mean rate of decrease, and the computed percentages for each Area, the percentage of age 0.2 chums will have decreased to the values shown below by 1980 and 1990:

| | 1963 percentage of age 0.2 | Projected percentage in | |
|---|---|---|---|
| | | 1980 | 1990 |
| Area 3 | 10.34 | 2.2 | 0.9 |
| Area 12 | 24.63 | 5.2 | 2.1 |
| Area 20 | 39.57 | 8.4 | 3.4 |

Although this calculation is subject to considerable random error, the effective disappearance of age 0.2 from our chum salmon stocks is not far off, if the present pattern of change continues.

## Olsen Creek

A warning against overconfident extrapolation is provided by the chum ages at Olsen Creek (Fig. 1). If the data series had ended in 1972 or 1973, we would be tempted to predict the early dominance of age 0.4 in this stock, and the effective disappearance of age 0.2. What actually happened, through 1978, is exactly the reverse.

The most intriguing information related to this sequence of ages is the fact that the mean age at maturity of a brood tended to increase with its total abundance (Helle 1979, Fig. 29). The variability is large, but the correlation is significant ($r = 0.515^*$, $N = 17$). The parallel with recent events in southern British Columbia is obvious, but in neither case has a causal mechanism associating age and abundance been suggested, nor is it known whether one exists. To some extent the relationship in

Helle's Fig. 29 may be confounded with the size-of-spawners relationship in his Fig. 31 (see below); for example, the years 1970-72 had spawners of below-average size which produced broods small in numbers. Reduced growth and hence older ages resulting from competition for food among the more numerous Olsen Creek broods seems unlikely, because when age of maturity is being determined, in the second year of ocean life, the fish are far out at sea in a region they share with many other stocks and species.

We can also consider the possibility, mentioned by Helle, that selection may play some role in these age changes. Gillnet selectivity is not a factor, because the Prince William Sound catches are made almost wholly by purse seine. However, fishing there is regulated with respect to the abundant pink salmon, rather than the much less numerous chums. Helle says that chums begin spawning in Olsen Creek 2 weeks before the fishing season opens, also that older chums tend to spawn earlier in the season than younger ones. He also observed (his Fig. 31) that in years when the spawning chums were large, the production of adult progeny per spawner was up to 5 times as great as when they were small, and less than half of this could stem from the greater egg production of the larger fish. If we assume (what may or may not be true) that progeny survival was a function of spawner size only, independent of age, this means that the older fish at Olsen Creek have a strong selective advantage, possibly sufficient to account for their observed increase up to 1972.

But why then did mean age decrease abruptly after 1972? Contributing to it was the fishing closure of 1974, which may have permitted some resurgence of smaller and younger fish among the progeny of that year. Beyond that one can only speculate. For example, the extremely poor survival and low mean age of the progeny of the 1972 spawning might have been due to causes that permitted fry from only the later (hence younger) spawners to survive. Also, one wonders a bit about the generality of the observed large increase in recruitment with increase in parental size. If larger chums have always been so superior as parents, why did not natural selection long ago boost mean size in this stock into a more favorable range?

Thus the selection effect is not a satisfactory explanation of the changes in mean age at Olsen Creek, on the basis of present information, although it has likely played some role. Whatever the complete explanation may be, we should not be surprised that a single stock experiences more volatile changes in age structure and other characteristics than do the aggregates of numerous stocks that occupy the various statistical Areas of British Columbia.

## 7.2 EFFECT ON SIZE

There are antagonistic hereditary effects on size involved in the selection of smaller chums by gillnets.

1. For one thing, an increase in average age, as described in Section 7.1, should tend to increase average size in the stock and hence in the catch, because the older fish caught are somewhat larger than the younger ones, although not by any large amount (Section 1.1).

2. Furthermore, the removal of the smaller individuals <u>within</u> each age-group of maturing fish makes for an hereditary increase in size, for it is well established that rate of growth in salmon, and in fishes generally, can be modified by selection.

3. On the other hand, the increase in average age implies a tendency to decrease growth rate, because among salmon age at maturity and growth rate are strongly inversely correlated, as discussed in Section 1.2. Ricker's (1964) British Columbia examples are shown in terms of weight in Table 3 here. Helle (1979) found the same situation in Olsen Creek chums. For cohos there is an experimental demonstration by Bilton (1978, Tables 1-4): for example, the largest third of each group of smolts released on June 10 produced 77-83% of the "jacks" that returned to the stream in the year of release, as compared with 22-39% of the age 0.2 fish that returned the following year. Thus the decrease in chums of age 0.2, and the increase in age 0.4, both imply a decrease in the population's supply of genes promoting fast growth. Because chums do not pair up strictly according to age, the result is an hereditary decrease in growth rate at all ages.

I know of no way of computing beforehand how these three effects will balance out in a given situation, but if the Northern District chums have decreased in size mainly because of the same selective process that increased their age, then effect (3) above has prevailed so far. In this context, it is noteworthy that the mean change in size of the northern age 0.4 chums was a small <u>increase</u>, instead of the much larger decreases exhibited by the two younger ages (Section 4.1). The 0.4s are farthest from the range of lengths taken preferentially by gillnets, so effects (1) and (2) above are relatively stronger, and effect (3) is weaker, than among ages 0.2 and 0.3.

In any event, we should expect change in size by selection, as a percentage of the original size, to be a slower process among chum salmon than among pink salmon, for three reasons. The first is that among chums selection itself has antagonistic aspects, as described above, whereas this is not true of pinks because of their single age of maturity. The second reason is that the chum life-history averages about 1.8 times as long as the pink life history (Section 1.1), so that selection of any given intensity would change relative size only about 56% as fast in absolute time. A third reason is that the troll fishery takes a considerable quantity of pinks and for them it is selective for large size, whereas few chums are taken by troll and those that are taken appear to be no larger than seine-caught fish (Section 3.3). And the fact is that the observed mean rate of decrease in relative size of the northern British Columbia chums is much less than among pinks.

## 7.3 DIFFERENT RATES OF DECREASE IN SIZE OF CHUMS CAUGHT BY GILLNET AND BY SEINE

An important feature of the Northern District chums in Tables 12 and 33 is the slower rate of decrease in size of the gillnetted fish in all Areas except 10, as compared with those caught by seine. The weighted means are 0.030 lb/yr for gillnets and 0.084 lb/yr for seines. A difference in the same direction and of similar absolute (but greater relative) magnitude was observed among pink salmon (Ricker et al. 1978, Tables 9 and 10). In both cases there is a basis for the difference in the fact that gillnetters can adjust the size of mesh in their nets to conform to a change in the average size of the target species. In the case of chum salmon, however, little or no adjustment may have been necessary. As the fish became smaller, their mean size would come closer to the point of maximum vulnerability of a net of a given mesh, assuming that in the beginning this mesh captured more fish in the lower part of the original size range. Thus the overall rate of decrease in size of the chums caught by gillnet would be less than for those caught by seines, which are presumed to catch all sizes equally well. If this shift in size were insufficient to explain the observed difference in rates of decrease, it is possible that during the period 1957 to 1972 gillnetters slightly increased the average size of mesh in nets that caught chums.

In the Southern District there is little difference between the weighted mean rates of decrease of gillnetted and seined chum salmon. The contrast with the north is at least partly because of differences in the sizes and quantitites of gillnets used, as described in Section 3.3.

## 7.4 FUTURE TRENDS

Given that present kinds and relative amounts of fishing gear continue to be employed in northern British Columbia, there is a good prospect that the average age of maturing chum salmon will continue to increase. Age 0.2 could soon cease to be an important component of any northern stock, and somewhat later age 0.4 may approach equality with age 0.3. However, not even a tentative prediction seems possible for the southern Areas until there is some good lead to the mechanism of the change in age there.

Predictions of trends in average size of chums are even more hazardous, because the three effects described in Section 7.2 have not been separately quantified. In addition, environmental temperature may make a small contribution to change in size of chums, whose future direction will depend on the direction of temperature change.

The decrease in chum size that has occurred during the past 25 years is appreciable, but it cannot be considered a major problem. An average loss of about 1 lb from fish that weigh 10 or 11 lb can be tolerated. Even an additional loss of a pound during the next 25 years, if it occurs, would be unfortunate but not catastrophic. But it is not at all certain that that much additional decrease will occur. My feeling (it is nothing more) is that if age 0.2 becomes largely eliminated from the populations, or perhaps before that, the effect of an older mean age and of within-sage selection at all ages will begin to prevail over the negative effect of the loss of genes for fast growth caused by the decrease in younger fish. If so, we can look forward to a reversal of the downward trend in size and the start of an increase. In the long run the average sizes of 1951 might again be reached or exceeded, but it would be by a stock of considerably older mean age.

In Areas 1-10 this presumes, of course, that present fishing and selection patterns will continue, but this is perhaps the least certain aspect of the forecast. In the southern Areas no prediction is possible until the causes of size change there are better identified.

## 8. DISCUSSION

This study of chum salmon age and size has provided repeated surprises. 1. To start with a technical matter, I was surprised when a significant positive correlation emerged between mean weight and abundance over a series of years, and surprised again when it proved to be an artifact caused by variable year-class strength. 2. It is unlikely that anyone could have predicted that during 1957-72 the average size of chum salmon would have decreased at the same time as their average age increased. 3. Equally unexpected, even if easily explained, was the fact that chums caught by gillnet are usually smaller than those caught by seine, when the opposite situation prevails among pink and coho salmon. 4. And it was only at a late stage of this study that the surprising differences between northern and southern British Columbia in respect to the chum salmon and its fisheries were recognized and appreciated. 5. When ages were compared over the years, it turned out that Pritchard had obtained unusually large average ages during the middle 1930s and early 1940s -- much older than had been observed in 1916-17 or from the 1950s onward. This was especially remarkable because in the years immediately following chums were unusually small, as reported by Godfrey and confirmed by the length samples reported here. 6. But in spite of all vicissitudes, the mean age and mean size of chums in the Strait of Georgia have apparently suffered little if any net change from 1916-17 to the present. 7. Finally, I was surprised when the correlations between the adult size of chum salmon and ocean temperature proved to be predominantly positive for temperatures in the final year of life, and predominantly negative for temperatures one or two years earlier.

Concerning the points above, Nos. 5 and 6 must be regarded as somewhat problematical, but the remainder are clear enough. The decrease in size since 1950 appears in both the length and the weight data, which were taken independently, while the increase in age is based on many thousands of scales read by the same team of investigators. The smaller size of gillnetted fish is a rather consistent feature of the commercial statistics. In the Northern District it provides an adequate explanation for much, possibly even all, of the increase in age, on the basis of selection. It may also explain at least part of the decrease in size, but in an indirect manner which as yet lacks any quantitative demonstration, and which suggests that a reversal of the trend should soon begin (Section 7.2). In the Southern District the observed difference between the size of seined and gillnetted chums is much less, and there must be a reason or reasons not yet identified for most of the increase in age there; it may possibly be related to the chum scarcity of the 1960s.

Points 5 and 6 above depend on work done by two biologists no longer living, C. McLean Fraser and Andrew L. Pritchard. Both are remembered as careful and conscientious investigators, but there may be room for doubt about the representativeness of their sampling, or about the criteria they used in interpreting scale markings. It is a pity that data on the size of the fish that provided Pritchard's ages are no longer available.

As mentioned earlier, the average net decrease in size of chums since 1950 is only about a tenth of their initial size. This is no great cause for alarm, particularly as there is some reason to anticipate that an upward trend will soon begin, at least in the north. Also, the increase in average age of chums is a favorable development; evidence concerning ocean mortality rates indicates a net increase in the bulk of a year-class (growth less natural mortality) during its final year in the ocean (Ricker 1964). Thus from any given downstream smolt migration the weight of catch taken should be larger from a stock of older mean age. Also, if the superior recruit-to-spawner ratio characteristic of the larger spawners at Olsen Creek proves to the a general phenomenon, that too will help to increase yields.

Returning to the original theme of this Discussion, my prediction is that the future has more surprises in store for us. The present analysis has taken so many unexpected turns that it seems unlikely that we have yet reached the end of the maze. New data, and continued study of the old, should provide additional insights into the biology of this interesting and important species of salmon.

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Table 1 . Percentage representation of the three major age groups in the chum catches of three British Columbia Areas, after eliminating ages 0.1 and 0.5.

| | Area 3 | | | | Area 12 | | | | Area 20 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age | 0.2 | 0.3 | 0.4 | ln 0.2 | 0.2 | 0.3 | 0.4 | ln 0.2 | 0.2 | 0.3 | 0.4 | ln 0.2 |
| 1957 | 10.8 | 77.7 | 11.5 | 2.38 | - | - | - | - | - | - | - | - |
| 1958 | 12.5 | 73.4 | 14.1 | 2.53 | - | - | - | - | 69.7 | 28.4 | 1.9 | 4.24 |
| 1959 | 16.9 | 62.4 | 20.7 | 2.83 | 31.6 | 66.1 | 2.3 | 3.45 | 29.3 | 70.2 | 0.5 | 3.38 |
| 1960 | 18.3 | 80.4 | 1.3 | 2.91 | 42.3 | 56.4 | 1.3 | 3.74 | 67.6 | 31.8 | 0.6 | 4.21 |
| 1961 | 5.8 | 91.0 | 3.2 | 1.76 | 10.0 | 88.0 | 2.0 | 2.30 | 27.0 | 72.0 | 1.0 | 3.30 |
| 1962 | 36.1 | 31.8 | 32.1 | 3.59 | 64.0 | 33.1 | 2.9 | 4.16 | 83.2 | 15.5 | 1.3 | 4.42 |
| 1963 | 21.6 | 77.0 | 1.4 | 3.07 | 38.5 | 60.6 | 0.8 | 3.65 | 49.1 | 50.4 | 0.5 | 3.89 |
| 1964 | 5.6 | 91.7 | 2.7 | 1.72 | 13.3 | 85.4 | 1.2 | 2.59 | 71.8 | 27.2 | 1.0 | 4.27 |
| 1965 | 6.8 | 72.3 | 20.8 | 1.92 | 8.4 | 84.2 | 7.4 | 2.13 | 11.4 | 88.2 | 0.4 | 2.43 |
| 1966 | 5.8 | 89.3 | 4.9 | 1.76 | 26.1 | 68.7 | 5.2 | 3.26 | 45.2 | 50.1 | 4.7 | 3.81 |
| 1967 | 21.9 | 58.0 | 20.1 | 3.09 | 38.4 | 53.3 | 8.3 | 3.65 | 59.8 | 38.9 | 1.3 | 4.09 |
| 1968 | 1.8 | 91.4 | 6.8 | 0.59 | 15.5 | 83.8 | 0.7 | 2.74 | 18.6 | 80.0 | 1.3 | 2.92 |
| 1969 | 15.0 | 55.9 | 29.1 | 2.71 | 38.5 | 55.9 | 5.6 | 3.65 | 16.7 | 80.2 | 3.0 | 2.82 |
| 1970 | 2.8 | 96.1 | 1.1 | 1.03 | 5.0 | 94.2 | 0.8 | 1.61 | 26.2 | 72.4 | 1.4 | 3.27 |
| 1971 | 17.3 | 43.3 | 39.4 | 2.85 | 32.6 | 54.5 | 12.9 | 3.48 | 50.8 | 44.7 | 4.5 | 3.93 |
| 1972 | 1.7 | 94.7 | 3.6 | 0.53 | 7.8 | 89.5 | 2.7 | 2.05 | 2.0 | 97.3 | 0.7 | 0.69 |
| N | 16 | 16 | 16 | 16 | 14 | 14 | 14 | 14 | 15 | 15 | 15 | 15 |
| r | -0.303 | +0.060 | +0.135 | -0.454 | -0.353 | +0.255 | +0.406 | -0.365 | -0.504 | +0.480 | +0.380 | -0.539* |
| b | -0.594 | +0.243 | +0.351 | -0.0877 | -1.454 | +1.105 | +0.351 | -0.0683 | -2.829 | +2.709 | +0.118 | -0.1169 |
| 1963 | 13.44 | 73.79 | 12.77 | 2.336 | 30.21 | 66.79 | 2.99 | 3.204 | 47.55 | 51.07 | 1.37 | 3.678 |

Table 2. Mean lengths and relative weight indices of chum salmon of 3 ages caught in 12 statistical Areas of British Columbia. Columns 2-4: means of male and female computed lengths in 1963, from Tables 19-32 Columns 5-7: corresponding weights computed from expression (3); actual mean weights would be about 5% greater. Columns 8-10: ratios of relative weights.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|
| | 1963 lengths, mm | | | Weight index, lb | | | Weight ratios | | |
| Area | 0.2 | 0.3 | 0.4 | 0.2 | 0.3 | 0.4 | 3/2 | 4/3 | 4/2 |
| 3 | 546 | 602.5 | 630 | 9.8 | 13.5 | 15.5 | 1.37 | 1.15 | 1.58 |
| 4 | 564 | 615.5 | 643.5 | 10.9 | 14.4 | 16.6 | 1.32 | 1.15 | 1.52 |
| 5 | 555.5 | 608 | 632 | 10.4 | 13.9 | 15.7 | 1.33 | 1.13 | 1.51 |
| 6 | 564.5 | 614.5 | 626.5 | 10.9 | 14.3 | 15.3 | 1.31 | 1.06 | 1.40 |
| 7 | 550 | 593 | 613 | 10.1 | 12.8 | 14.2 | 1.27 | 1.11 | 1.41 |
| 8 | 569.5 | 619 | 637.5 | 11.2 | 14.7 | 16.1 | 1.31 | 1.10 | 1.44 |
| 9 | 576 | 615.5 | 631 | 11.7 | 14.4 | 15.6 | 1.24 | 1.08 | 1.34 |
| 10 | 567.5 | 612 | 637.5 | 11.1 | 14.2 | 16.1 | 1.27 | 1.14 | 1.45 |
| 12 | 571.5 | 609 | 628.5 | 11.4 | 13.9 | 15.4 | 1.23 | 1.11 | 1.36 |
| 13 | 568.5 | 608 | 621.5 | 11.2 | 13.9 | 14.9 | 1.24 | 1.07 | 1.33 |
| 20 | 555.5 | 593.5 | 619 | 10.4 | 12.8 | 14.7 | 1.24 | 1.14 | 1.41 |
| 29 | 570.5 | 613 | 619 | 11.3 | 14.2 | 14.7 | 1.26 | 1.03 | 1.30 |
| Mean | 563.2 | 608.6 | 628.2 | 10.9 | 13.9 | 15.4 | 1.28 | 1.11 | 1.42 |

Table 3. Weights in pounds that correspond to mean lengths of chum salmon in two British Columbia samples, both at the time of capture, and at the end of previous growing seasons as calculated from scale annuli. Computed from lengths of Fraser (1920, p. 210) and of Bilton (in Ricker 1964, Table 6) using equation (3) and length conversion factors given in Section 1.1.

| Age at maturity | Sample size | Weight at annuli and in final year | | | | |
|---|---|---|---|---|---|---|
| | | 1st | 2nd | 3rd | 4th | 5th |
| | | Lower Strait of Georgia, 1916 | | | | |
| 0.2 | 774 | 0.68 | 3.9 | 9.4 | | |
| 0.3 | 1203 | 0.54 | 3.0 | 7.3 | 12.4 | |
| 0.4[a] | 22 | 0.50 | 2.7 | 6.2 | 10.8 | 15.8 |
| | | Area 8, 1960 | | | | |
| 0.2 | 100 | 0.53 | 4.3 | 11.0 | | |
| 0.3 | 96 | 0.45 | 3.5 | 8.4 | 15.3 | |
| 0.4[a] | 4 | 0.24 | 2.4 | 7.0 | 13.9 | 20.3 |

[a]The unusually large weight of age 0.4 fish in Area 8 probably stems simply from the small size of the sample. In the Strait of Georgia it is influenced by the fact that 86% of the sample were males. In both cases the bias decreases the contrast between maturing and non-maturing individuals at earlier ages.

Table 4. Landings of chum salmon in British Columbia's Northern District, by Areas, in thousands of pounds.

| | | | | | Northern District (2) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Area | 1 | 2E | 2W | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Total |
| 1951 | 681 | 2760 | 2190 | 3281 | 880 | 972 | 5608 | 4265 | 7203 | 460 | 154 | 28454 |
| 1952 | 27 | 747 | 376 | 1442 | 532 | 360 | 1316 | 1803 | 2631 | 638 | 140 | 10012 |
| 1953 | 158 | 255 | 1056 | 2366 | 775 | 842 | 3160 | 4977 | 6102 | 436 | 354 | 20481 |
| 1954 | 387 | 3698 | 2338 | 1217 | 1946 | 1158 | 4553 | 4591 | 2838 | 853 | 296 | 23875 |
| 1955 | 65 | 506 | 180 | 766 | 409 | 243 | 540 | 1887 | 1804 | 333 | 327 | 7060 |
| 1956 | 190 | 444 | 798 | 4277 | 643 | 323 | 1247 | 2198 | 3183 | 153 | 159 | 13615 |
| 1957 | 647 | 224 | 74 | 2703 | 538 | 806 | 2763 | 5093 | 3184 | 274 | 322 | 16628 |
| 1958 | 113 | 163 | 81 | 2328 | 616 | 713 | 4527 | 3215 | 4172 | 1009 | 168 | 17105 |
| 1959 | 21 | 0 | 144 | 2321 | 467 | 191 | 296 | 743 | 988 | 183 | 132 | 5486 |
| 1960 | 20 | 33 | 15 | 2329 | 310 | 434 | 1561 | 1391 | 1803 | 289 | 302 | 8487 |
| 1961 | 11 | 657 | 32 | 1268 | 396 | 414 | 1477 | 1156 | 2331 | 253 | 164 | 8159 |
| 1962 | 33 | 1156 | 14 | 380 | 299 | 1092 | 2392 | 2912 | 4562 | 332 | 263 | 13435 |
| 1963 | 43 | 44 | 1138 | 334 | 310 | 650 | 1653 | 2081 | 3632 | 295 | 254 | 10434 |
| 1964 | 144 | 5475 | 1981 | 1123 | 490 | 1227 | 2396 | 2918 | 4037 | 400 | 371 | 20562 |
| 1965 | 86 | 645 | 798 | 431 | 94 | 597 | 1912 | 580 | 647 | 113 | 106 | 6009 |
| 1966 | 218 | 1271 | 541 | 848 | 517 | 1718 | 3114 | 3198 | 2572 | 219 | 99 | 14315 |
| 1967 | 252 | 3651 | 390 | 1352 | 351 | 297 | 858 | 916 | 1203 | 256 | 201 | 9727 |
| 1968 | 300 | 5855 | 674 | 3044 | 619 | 1739 | 4493 | 4386 | 3740 | 574 | 597 | 26021 |
| 1969 | 387 | 489 | 468 | 848 | 204 | 221 | 587 | 1730 | 920 | 390 | 264 | 6508 |
| 1970 | 289 | 3014 | 1646 | 1852 | 354 | 792 | 2850 | 7332 | 4170 | 1291 | 529 | 24119 |
| 1971 | 343 | 2603 | 682 | 752 | 432 | 328 | 707 | 2698 | 730 | 207 | 96 | 9578 |
| 1972 | 475 | 2613 | 1187 | 3951 | 1457 | 1408 | 6048 | 6809 | 3135 | 362 | 358 | 27803 |
| 1973 | 615 | 4503 | 688 | 2957 | 1117 | 313 | 2061 | 14131 | 3207 | 656 | 536 | 30784 |
| 1974 | 215 | 1517 | 694 | 2723 | 835 | 196 | 2321 | 7277 | 2962 | 643 | 195 | 19578 |
| 1975 | 116 | 19 | 416 | 308 | 218 | 125 | 198 | 1520 | 1487 | 88 | 62 | 4557 |
| 1951-75 | 5836 | 42342 | 18601 | 45201 | 14809 | 17159 | 58638 | 89807 | 73243 | 10707 | 6449 | 382792 |

Table 5. Landings of chum salmon in British Columbia's Southern District, by Areas, in thousands of pounds.

| | Southern District (3) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Area | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| 1951 | 35 | 11118 | 8781 | 1318 | 156 | 1180 | 1257 | 680 | 4 | 96 |
| 1952 | 1 | 4807 | 3941 | 455 | 78 | 858 | 1341 | 320 | 0 | 31 |
| 1953 | 83 | 10445 | 7393 | 1093 | 105 | 2038 | 894 | 262 | 1 | 105 |
| 1954 | 29 | 14078 | 10931 | 942 | 151 | 1728 | 2953 | 791 | 1 | 82 |
| 1955 | 66 | 3700 | 2202 | 89 | 88 | 293 | 414 | 87 | 1 | 215 |
| 1956 | 28 | 3895 | 2128 | 83 | 51 | 183 | 123 | 117 | 1 | 18 |
| 1957 | 118 | 2775 | 1101 | 65 | 52 | 75 | 296 | 370 | 0 | 34 |
| 1958 | 47 | 5684 | 4074 | 812 | 48 | 953 | 628 | 476 | 46 | 298 |
| 1959 | 49 | 5358 | 3425 | 447 | 168 | 1153 | 414 | 446 | 2 | 388 |
| 1960 | 173 | 3641 | 2070 | 116 | 42 | 334 | 145 | 144 | 1 | 153 |
| 1961 | 84 | 1978 | 974 | 134 | 41 | 322 | 40 | 220 | 7 | 146 |
| 1962 | 25 | 955 | 590 | 128 | 14 | 319 | 0 | 445 | 0 | 146 |
| 1963 | 4 | 1926 | 1298 | 0 | 0 | 2 | 1 | 151 | 1 | 212 |
| 1964 | 13 | 1326 | 224 | 0 | 0 | 1 | 1 | 35 | 0 | 405 |
| 1965 | 6 | 212 | 41 | 0 | 0 | 0 | 3 | 0 | 0 | 234 |
| 1966 | 3 | 494 | 72 | 0 | 0 | 0 | 4 | 2 | 0 | 281 |
| 1967 | 43 | 1000 | 628 | 0 | 0 | 1 | 0 | 0 | 0 | 202 |
| 1968 | 110 | 4443 | 2992 | 0 | 0 | 1 | 0 | 129 | 0 | 301 |
| 1969 | 114 | 2322 | 2816 | 0 | 0 | 215 | 94 | 49 | 0 | 193 |
| 1970 | 39 | 4428 | 3716 | 67 | 56 | 619 | 209 | 66 | 0 | 255 |
| 1971 | 19 | 713 | 186 | 0 | 0 | 3 | 6 | 1 | 0 | 219 |
| 1972 | 48 | 8085 | 6703 | 1394 | 265 | 291 | 920 | 415 | 0 | 2137 |
| 1973 | 223 | 13463 | 13571 | 2040 | 2 | 1964 | 263 | 388 | 0 | 1987 |
| 1974 | 99 | 1591 | 1318 | 135 | 0 | 2 | 191 | 1 | 0 | 869 |
| 1975 | 55 | 2515 | 1412 | 535 | 0 | 8 | 90 | 4 | 0 | 420 |
| 1951-75 | 1514 | 110952 | 82587 | 9853 | 1317 | 12543 | 10287 | 5599 | 65 | 9427 |

Table 5 (cont'd)

| Southern District (3) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Area | 21 | 22 | 23 | 24 | 25 | 26 | 27 | Total |
| 1951 | 15 | 339 | 935 | 212 | 889 | 225 | 1696 | 28936 |
| 1952 | 1 | 0 | 494 | 142 | 508 | 77 | 78 | 13132 |
| 1953 | 2 | 662 | 2022 | 529 | 2232 | 900 | 386 | 29152 |
| 1954 | 54 | 2919 | 3873 | 1182 | 2204 | 781 | 631 | 43330 |
| 1955 | 7 | 83 | 1193 | 223 | 634 | 59 | 146 | 9500 |
| 1956 | 34 | 1300 | 2586 | 562 | 884 | 395 | 468 | 12856 |
| 1957 | 0 | 1013 | 1206 | 344 | 760 | 660 | 233 | 9102 |
| 1958 | 0 | 2248 | 1051 | 249 | 1230 | 929 | 21 | 18794 |
| 1959 | 0 | 0 | 766 | 359 | 779 | 949 | 157 | 14860 |
| 1960 | 0 | 516 | 704 | 283 | 988 | 1256 | 512 | 11078 |
| 1961 | 1 | 0 | 341 | 158 | 859 | 536 | 2 | 5843 |
| 1962 | 0 | 0 | 426 | 192 | 480 | 320 | 4 | 4044 |
| 1963 | 0 | 0 | 2 | 92 | 535 | 151 | 5 | 4380 |
| 1964 | 0 | 0 | 2 | 0 | 538 | 3 | 3 | 2551 |
| 1965 | 0 | 0 | 1 | 1 | 0 | 1 | 9 | 508 |
| 1966 | 0 | 0 | 0 | 1 | 0 | 2 | 14 | 873 |
| 1967 | 0 | 0 | 2 | 1 | 1 | 0 | 7 | 1885 |
| 1968 | 0 | 0 | 2 | 3 | 2 | 3 | 37 | 8023 |
| 1969 | 0 | 0 | 11 | 1 | 36 | 1 | 15 | 5867 |
| 1970 | 4 | 0 | 204 | 15 | 987 | 15 | 72 | 10752 |
| 1971 | 1 | 0 | 240 | 28 | 602 | 71 | 48 | 2137 |
| 1972 | 0 | 13552 | 420 | 346 | 1063 | 117 | 53 | 35809 |
| 1973 | 5 | 2045 | 1100 | 9 | 1572 | 272 | 140 | 39044 |
| 1974 | 0 | 0 | 8 | 2 | 0 | 0 | 2 | 4218 |
| 1975 | 1 | 0 | 30 | 4 | 717 | 436 | 312 | 6539 |
| 1951-75 | 125 | 24677 | 17619 | 4938 | 18500 | 8159 | 5051 | 323213 |

Table 6. Landings of chum salmon in British Columbia's Fraser District, by Areas, and total for the Province, in thousands of pounds.

| Area | Fraser District (1) | | | | British Columbia Total |
|---|---|---|---|---|---|
| | 28 | 29AB | 29CD | Total | |
| 1951 | 478 | 4882 | 843 | 6203 | 63593 |
| 1952 | 1349 | 6248 | 1115 | 8712 | 31856 |
| 1953 | 725 | 3396 | 669 | 4790 | 54423 |
| 1954 | 1178 | 5760 | 303 | 7241 | 74446 |
| 1955 | 372 | 1159 | 88 | 1619 | 18179 |
| 1956 | 89 | 844 | 23 | 956 | 27427 |
| 1957 | 66 | 1263 | 180 | 1509 | 27239 |
| 1958 | 16 | 1765 | 424 | 2205 | 38104 |
| 1959 | 152 | 2189 | 421 | 2762 | 23108 |
| 1960 | 4 | 535 | 21 | 560 | 20125 |
| 1961 | 7 | 435 | 158 | 600 | 14602 |
| 1962 | 0 | 427 | 138 | 565 | 18044 |
| 1963 | 0 | 450 | 192 | 642 | 15456 |
| 1964 | 6 | 537 | 257 | 800 | 23913 |
| 1965 | 2 | 75 | 49 | 126 | 6643 |
| 1966 | 0 | 104 | 61 | 165 | 15353 |
| 1967 | 0 | 399 | 220 | 619 | 12231 |
| 1968 | 0 | 1931 | 522 | 2453 | 36497 |
| 1969 | 0 | 782 | 231 | 1013 | 13388 |
| 1970 | 0 | 1655 | 387 | 2042 | 36913 |
| 1971 | 0 | 164 | 47 | 211 | 11926 |
| 1972 | 0 | 2236 | 697 | 2933 | 66545 |
| 1973 | 0 | 1645 | 657 | 2302 | 72130 |
| 1974 | 0 | 876 | 239 | 1115 | 24911 |
| 1975 | 0 | 562 | 201 | 763 | 11859 |
| 1951-75 | 4444 | 40319 | 8143 | 52906 | 758911 |

Table 7. Number of chum salmon landed in British Columbia, in thousands.

| | Gillnet | Seine | Troll | Total |
|---|---|---|---|---|
| 1971 | 844 | 405 | 14 | 1263 |
| 1972 | 2989 | 3076 | 11 | 6076 |
| 1973 | 3046 | 3170 | 22 | 6238 |
| 1974 | 1408 | 778 | 16 | 2202 |
| 1975 | 609 | 526 | 13 | 1148 |
| Mean | 1779 | 1591 | 15 | 3385 |

Table 8. Mean age of chum salmon, in years completed, based on determinations by Bilton and colleagues (1965, etc.). Correlations (r) and regressions (b) on time in years are shown at the foot of the table, together with the computed mean age in 1963.

| | Area | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2E&W | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 13 |
| 1957 | | | 3.01 | 3.00 | 2.91 | - | - | - | - | - | - | - |
| 1958 | | | 3.02 | 3.04 | 2.98 | 3.00 | 2.93 | 2.94 | 2.93 | - | - | 2.62 |
| 1959 | | | 3.04 | - | 2.81 | 2.64 | 2.77 | 2.78 | - | 2.67 | 2.71 | 2.66 |
| 1960 | | | 2.83 | 2.84 | 2.39 | 2.36 | 2.41 | 2.43 | 2.26 | 2.29 | 2.59 | 2.59 |
| 1961 | | | 2.97 | 2.95 | 2.97 | 2.72 | 2.45 | 2.66 | 2.70 | 2.58 | 2.92 | 2.91 |
| 1962 | | | 2.96 | 2.96 | 2.89 | 2.80 | 2.61 | 2.54 | 2.76 | 2.86 | 2.39 | 2.19 |
| 1963 | | | 2.81 | 2.75 | 2.55 | 2.37 | 2.47 | 2.53 | 2.43 | 2.32 | 2.62 | 2.65 |
| 1964 | | 2.78 | 2.97 | 2.96 | 2.81 | 2.82 | 2.93 | 2.99 | 2.96 | 2.42 | 2.88 | 3.00 |
| 1965 | | 2.98 | 3.14 | 3.00 | 2.92 | 2.95 | 2.85 | 3.17 | 2.91 | 3.08 | 2.98 | 2.94 |
| 1966 | | | 2.99 | 2.98 | 2.92 | 2.92 | 2.86 | 2.77 | 2.86 | 2.86 | 2.79 | - |
| 1967 | | | 2.98 | 3.03 | 2.84 | 2.99 | 2.79 | 2.86 | 2.79 | 2.66 | 2.70 | 2.43 |
| 1968 | | | 3.06 | 3.02 | 2.97 | 2.98 | 2.84 | 2.99 | 2.98 | 2.95 | 2.85 | 2.78 |
| 1969 | | | 3.14 | 2.98 | 3.52 | 2.98 | 2.46 | 2.40 | 2.32 | 2.88 | 2.67 | 2.60 |
| 1970 | | | 2.98 | 3.13 | 2.95 | 2.94 | 2.88 | 2.95 | 2.92 | 2.82 | 2.96 | 2.81 |
| 1971 | | | 3.22 | 3.14 | 2.75 | - | - | 2.93 | - | - | 2.80 | 2.85 |
| 1972 | 2.90 | 2.92 | 3.02 | 3.05 | 3.05 | 2.95 | 2.85 | 3.00 | - | - | 2.95 | 2.95 |
| N | 1 | 3 | 16 | 15 | 16 | 14 | 14 | 15 | 12 | 12 | 14 | 14 |
| r | - | - | 0.426 | 0.500 | 0.343 | 0.535* | 0.255 | 0.318 | 0.345 | 0.536 | 0.444 | 0.321 |
| b | - | - | 0.00929 | 0.01045 | 0.01712 | 0.02809 | 0.01159 | 0.01668 | 0.02591 | 0.03787 | 0.01796 | 0.01561 |
| 1963 | | | 2.994 | 2.969 | 2.863 | 2.774 | 2.703 | 2.763 | 2.717 | 2.642 | 2.727 | 2.683 |

Table 8 (cont'd)

| | Area | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 14 | 16 | 17 | 18 | 20 | 22 | 23 | 24 | 25 | 26 | 27 | 29 |
| 1957 | | | | | | | | | | | | 2.78 |
| 1958 | | | | | 2.32 | | | | | | | 2.43 |
| 1959 | | 2.67 | | | 2.70 | | 2.61 | | 2.41 | 2.45 | | 2.60 |
| 1960 | 2.58 | 2.55 | 2.55 | 2.42 | 2.33 | | 2.55 | 2.60 | 2.20 | 2.37 | 2.08 | 2.66 |
| 1961 | 2.91 | 2.83 | | 2.77 | 2.74 | | 2.49 | 2.60 | 2.75 | 2.87 | | 2.94 |
| 1962 | 2.24 | 2.24 | | 2.16 | 2.18 | | 2.42 | 2.50 | 2.57 | 2.50 | | 2.25 |
| 1963 | | | | 2.72 | 2.51 | | | | 2.30 | 2.54 | | 2.72 |
| 1964 | | | | 2.35 | 2.29 | | | | 2.67 | | | 2.87 |
| 1965 | | | | | 2.90 | | | | | | | 2.99 |
| 1966 | | | | | 2.59 | | | | | | | 2.95 |
| 1967 | | | | | 2.42 | | | | | | | 2.48 |
| 1968 | | | | | 2.82 | | | | | | | 2.80 |
| 1969 | | | | | 2.86 | | | | | | | 2.65 |
| 1970 | | | | | 2.75 | | | | | | | 2.91 |
| 1971 | | | | | 2.54 | | | | | | | - |
| 1972 | | | 2.95 | 2.96 | 2.99 | 2.98 | 2.93 | | | | | 2.98 |
| N | 3 | 4 | 2 | 6 | 15 | 1 | 5 | 3 | 6 | 5 | 1 | 15 |
| r | - | - | - | 0.581 | 0.533* | - | 0.837 | - | - | - | - | 0.393 |
| b | - | - | - | 0.04046 | 0.02982 | - | 0.03141 | - | - | - | - | 0.01908 |
| 1963 | - | - | - | 2.536 | 2.536 | - | 2.606 | - | - | - | - | 2.714 |

Table 8A. Mean age in years completed of chum salmon sampled at three localities in the Fraser River watershed, and a comparison with the Area 29 catch samples. Data from Palmer (1972, Table 33), and Table 8. Symbols are as in Table 8.

| | Cottonwood drift | Silverdale | Spawning grounds | Area 29 catch |
|---|---|---|---|---|
| 1960 | - | 2.64 | 2.62 | 2.66 |
| 1961 | 2.90 | 2.93 | 2.89 | 2.94 |
| 1962 | 2.17 | 2.15 | 2.28 | 2.25 |
| 1963 | 2.66 | 2.68 | 2.62 | 2.72 |
| 1964 | 2.73 | 2.79 | 2.78 | 2.87 |
| 1965 | 2.61 | 2.76 | 2.74 | 2.99 |
| 1966 | 2.83 | 2.92 | 2.93 | 2.95 |
| 1967 | 2.52 | 2.45 | 2.45 | 2.48 |
| 1968 | 2.80 | 2.72 | 2.91 | 2.80 |
| 1969 | 2.51 | 2.57 | 2.68 | 2.65 |
| N | 9 | 10 | 10 | 10 |
| r | +0.031 | +0.007 | +0.213 | +0.070 |
| b | +0.0025 | +0.0005 | +0.0147 | +0.0054 |
| 1963 | 2.632 | 2.660 | 2.668 | 2.723 |

Table 9. Mean lengths of chum salmon sampled by Fraser (1920, 1921), with his lengths in inches converted to postorbital-hypural lengths in millimeters using the factor 20.95. Numbers of specimens are in parentheses.

| | | | Age 0.1 | Age 0.2 | | Age 0.3 | | Age 0.4 | |
|---|---|---|---|---|---|---|---|---|---|
| Area | Year | Locality | M | M | F | M | F | M | All ages |
| 13-18, 29 | 1916 | Strait of Georgia | - | 545 | 528 | 599 | 566 | - | 567 |
| | | | - | (395) | (379) | (767) | (436) | - | (1977) |
| 17 | 1917 | Little Qualicum R. | 440 | 557 | 543 | 610 | 587 | 645 | 586 |
| | | | (1) | (83) | (75) | (232) | (83) | (3) | (477) |
| 17 | 1917 | Nanaimo | - | 557 | 543 | 610 | 585 | 650 | 564 |
| | | | - | (116) | (150) | (58) | (53) | (1) | (378) |
| 18 | 1917 | Chemainus | - | 545 | 530 | 597 | 585 | - | 543 |
| | | | - | (65) | (61) | (4) | (9) | - | (139) |

Table 10. Estimated mean ages of chum salmon, in years completed, in samples taken before 1950. Data are from Pitchard (1943).

| Area | Locality | 1916 | 1917 | 1928 | 1929 | 1930 | 1933 | 1934 | 1935 | 1940 | 1941 | 1942 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Virago Sound & Naden Harbour | | | 3.47 | | | | | | | | |
| 2W | Athlow Bay | | | 3.50 | | | | | | | 3.92 | |
| 2E | Skidegate Inlet & Vicinity | | | | | | | | | 3.78 | | 4.17 |
| 12&13 | Johnstone Strait | | | | 2.93 | 2.70 | | | | | | |
| 13-17 | Johnstone & Georgia Straits | | | | | | | | | | 3.86 | |
| 17 | Little Qualicum River | 2.67 | 2.63 | 3.23 | | | | | | | | |
| 17-18 | Nanaimo to Crofton | 2.54 | 2.25 | | | | | | | | | |
| 23 | Barkley Sound | | | | | | | | | | 3.56 | |
| 25 | Nootka Sound | | | | | | 3.49 | 2.94 | 3.23 | | 3.32 | |

Table 11. Age and postorbital-hypural length in millimetres of chum salmon sampled from commercial catches in 1945-53 from data of Wickett (1946, 1947), Robertson (1948), Chatwin (1953), and unpublished observations supplied by J. M. Manzer. Lengths are converted from fork length using the factor 1.25.

| Year | Area | Age 0.2 | | Age 0.3 | | Age 0.4 | | Mean age | Total no. |
|---|---|---|---|---|---|---|---|---|---|
| | | No. | L. | No. | L. | No. | L. | | |
| 1945 | 12 | 203 | 533 | 1115 | 563 | 16 | 596 | 2.86 | 1334 |
| | 13 | 159 | 535 | 584 | 558 | 8 | 574 | 2.80 | 751 |
| 1946 | 6 | 408 | 532 | 321 | 562 | 31 | 585 | 2.50 | 760 |
| | 8 | 48 | 578 | 75 | 631 | 13 | 657 | 2.74 | 136 |
| | 9 | 91 | 579 | 95 | 599 | 9 | 629 | 2.58 | 195 |
| | 12 | 21 | - | 68 | - | 0 | - | 2.76 | 89 |
| | 20 | 26 | 558 | 91 | 584 | 7 | 598 | 2.85 | 124 |
| | 23 | 198 | 545 | 565 | 562 | 6 | 572 | 2.75 | 769 |
| 1947 | 7 | 81 | 541 | 292 | 551 | 14 | 589 | 2.83 | 387 |
| | 8 | 304 | 549 | 828 | 573 | 56 | 573 | 2.79 | 1188 |
| | 9-10 | 39 | 571 | 241 | 597 | 22 | 626 | 2.94 | 302 |
| 1948 | 6 | 10 | 494 | 101 | 551 | 0 | - | 2.91 | 111 |
| | 8 | 24 | 545 | 95 | 591 | 8 | 640 | 2.87 | 127 |
| | 12 | 2 | 522 | 28 | 555 | 2 | 569 | 3.00 | 32 |
| | 20 | 12 | 547 | 24 | 591 | 8 | 632 | 2.91 | 44 |
| 1950 | 12 | 103 | 517 | 695 | 580 | 33 | 632 | 2.91 | 831 |
| | 12[a] | 46 | 535 | 404 | 582 | 20 | 633 | 2.94 | 470 |
| | 13 | 108 | 537 | 652 | 581 | 19 | 627 | 2.87 | 779 |
| | 29[b] | 6 | 545 | 115 | 586 | 4 | 660 | 2.98 | 125 |
| 1953 | 12 | 224 | 576 | 243 | 621 | 13 | 652 | 2.56 | 480 |
| | 13 | 822 | - | 680 | - | 35 | - | 2.49 | 1537 |

[a]Taken late in the season - November.
[b]These are fish tagged in Area 12 and recaptured in Area 29.

Table 12. Mean whole weight in pounds of chum salmon caught in most of the British Columbia statistical areas, separated by gear. GN = gillnets; S = seines; T = troll. Where some years are missing, the "mean" value is the weight for 1963 computed from the linear regression of weight on time.

| | Area 1 | | | Area 2E | | Area 3 | | Area 4 | |
|---|---|---|---|---|---|---|---|---|---|
| | GN | S | T | GN | S | GN | S | GN | S |
| 1951 | 9.77 | 10.53 | - | 9.39 | 9.07 | 10.55 | 12.52 | 12.54 | - |
| 1952 | - | 10.93 | - | 10.27 | 10.33 | 12.61 | 14.85 | 14.23 | - |
| 1953 | 10.38 | 11.47 | - | 9.02 | 9.39 | 11.95 | 15.20 | 13.84 | - |
| 1954 | 11.08 | 11.45 | - | 10.75 | 11.30 | 12.65 | 14.62 | 16.13 | 15.28 |
| 1955 | - | 11.11 | - | 9.51 | 8.94 | 10.98 | 13.23 | 13.81 | 14.89 |
| 1956 | 9.21 | 10.99 | - | 9.78 | 9.18 | 11.24 | 13.18 | 12.52 | 12.41 |
| 1957 | 11.35 | 11.33 | - | 10.29 | 10.62 | 11.28 | 13.04 | 15.11 | 14.59 |
| 1958 | 11.38 | 12.37 | - | 8.54 | 10.70 | 12.57 | 13.57 | 14.18 | - |
| 1959 | - | 9.06 | - | - | - | 13.33 | 14.05 | 14.63 | - |
| 1960 | 9.22 | - | - | 10.14 | 10.43 | 12.02 | 14.35 | 14.53 | 14.29 |
| 1961 | 9.12 | - | - | 9.79 | 10.00 | 11.70 | 13.27 | 14.93 | 13.33 |
| 1962 | 9.69 | 13.48 | 12.99 | 10.49 | 11.28 | 11.99 | 12.89 | 13.88 | - |
| 1963 | 8.48 | - | 8.86 | 8.27 | 7.95 | 11.23 | 13.37 | 11.56 | 13.81 |
| 1964 | 10.10 | 9.70 | 11.46 | 9.61 | 9.60 | 11.92 | 12.18 | 12.78 | 13.70 |
| 1965 | 7.47 | 8.56 | 8.08 | 8.53 | 8.38 | 10.04 | 11.84 | 11.95 | - |
| 1966 | 9.68 | 10.61 | 10.05 | 9.38 | 9.69 | 11.47 | 12.07 | 13.84 | - |
| 1967 | 9.99 | 10.46 | 10.78 | 8.67 | 9.74 | 11.59 | 11.81 | 13.21 | - |
| 1968 | 11.97 | 12.65 | 12.55 | 10.14 | 10.66 | 12.60 | 13.24 | 13.73 | 13.35 |
| 1969 | 10.62 | 10.54 | 10.33 | 9.81 | 8.30 | 12.73 | 12.13 | 12.28 | - |
| 1970 | 8.59 | 8.83 | 9.55 | 8.33 | 8.10 | 9.96 | 10.31 | 10.58 | - |
| 1971 | - | 9.48 | 8.60 | 8.46 | 8.88 | 10.87 | 10.89 | 11.05 | 12.41 |
| 1972 | 9.17 | 10.24 | 9.28 | 9.26 | 9.30 | 11.09 | 11.75 | 12.14 | 12.86 |
| 1973 | 10.85 | 11.73 | 10.56 | 10.25 | 10.72 | 12.04 | 12.81 | 12.46 | 13.07 |
| 1974 | 10.36 | 11.11 | 10.65 | 10.00 | 10.72 | 12.66 | 12.36 | 13.58 | 14.16 |
| 1975 | 9.66 | 9.45 | 11.12 | 8.68 | - | 11.06 | 12.33 | 10.57 | 6.57 |
| Mean (1963) | 9.92 | 10.74 | (10.55) | 9.48 | 9.70 | 11.69 | 12.87 | 13.20 | 13.43 |

Table 12 (cont'd)

| | Area 5 | | Area 6 | | | Area 7 | | |
|---|---|---|---|---|---|---|---|---|
| | GN | S | GN | S | T | GN | S | T |
| 1951 | 10.23 | 14.83 | 11.31 | 12.81 | - | 9.70 | 10.16 | - |
| 1952 | 11.51 | 17.93 | 13.07 | 14.47 | - | 10.25 | 12.74 | - |
| 1953 | 10.17 | 14.08 | 12.12 | 15.44 | - | 10.12 | 11.46 | - |
| 1954 | 12.30 | 16.31 | 13.22 | 15.45 | - | 11.57 | 13.54 | - |
| 1955 | 11.94 | 15.32 | 11.04 | 15.36 | - | 9.81 | 10.89 | - |
| 1956 | 11.24 | 13.45 | 10.47 | 11.25 | - | 9.96 | 10.99 | - |
| 1957 | 10.85 | 12.30 | 10.68 | 12.15 | - | 10.16 | 12.46 | - |
| 1958 | 13.05 | 13.17 | 12.95 | 15.16 | - | 11.65 | 13.52 | - |
| 1959 | 11.94 | 15.20 | 11.87 | 12.93 | - | 10.29 | 12.45 | - |
| 1960 | 11.06 | 13.58 | 11.80 | 13.31 | - | 10.96 | 12.28 | - |
| 1961 | 11.25 | 14.28 | 11.42 | 13.76 | - | 10.58 | 12.85 | 12.82 |
| 1962 | 12.05 | 12.79 | 12.26 | 13.56 | 13.84 | 10.99 | 11.86 | 13.55 |
| 1963 | 10.15 | 11.39 | 9.79 | 11.00 | 10.64 | 9.35 | 10.75 | 9.95 |
| 1964 | 10.29 | 11.70 | 10.17 | 11.45 | 10.45 | 9.59 | 10.24 | 10.73 |
| 1965 | 10.61 | 13.09 | 11.04 | 12.85 | 11.85 | 8.90 | 11.51 | 11.45 |
| 1966 | 11.60 | 13.24 | 11.91 | 13.58 | 14.52 | 10.77 | 11.43 | - |
| 1967 | 11.50 | 13.01 | 11.34 | 12.70 | - | 10.52 | 11.89 | - |
| 1968 | 12.25 | 13.91 | 11.89 | 13.69 | 13.60 | 11.08 | 12.76 | 12.28 |
| 1969 | 9.66 | 10.63 | 9.42 | 10.92 | - | 8.82 | 9.02 | 9.74 |
| 1970 | 9.54 | 11.11 | 9.83 | 11.24 | 9.28 | 9.06 | 9.41 | 9.07 |
| 1971 | 10.06 | 10.95 | 10.19 | 11.50 | - | 9.18 | 9.16 | 8.94 |
| 1972 | 11.94 | 13.41 | 11.77 | 13.40 | 12.62 | 10.49 | 11.76 | 10.60 |
| 1973 | 11.84 | 13.25 | 11.83 | 13.17 | - | 10.92 | 11.87 | 11.29 |
| 1974 | 12.03 | 9.65 | 13.30 | 15.00 | - | 12.94 | 14.12 | 11.34 |
| 1975 | 9.53 | 12.28 | 11.39 | 12.67 | - | 9.24 | 9.46 | 11.16 |
| Mean (1963) | 11.14 | 13.23 | 11.44 | 13.15 | (12.25) | 10.28 | 11.54 | (11.60) |

Table 12 (cont'd)

| | Area 8 | | Area 9 | | Area 10 | | Area 11 | |
|---|---|---|---|---|---|---|---|---|
| | GN | S | GN | S | GN | S | GN | S |
| 1951 | 11.91 | 12.37 | 12.19 | 12.11 | 10.72 | 11.32 | 10.08 | 8.53 |
| 1952 | 13.56 | 15.09 | 14.76 | 18.74 | 12.44 | 13.09 | 10.62 | - |
| 1953 | 13.82 | 16.70 | 13.96 | 13.14 | 11.74 | 14.50 | 10.42 | 10.50 |
| 1954 | 14.32 | 16.39 | 16.51 | 19.03 | 12.70 | 11.25 | 10.87 | 10.39 |
| 1955 | 13.15 | 16.13 | 15.52 | 16.81 | 11.90 | - | 10.70 | - |
| 1956 | 12.95 | 14.14 | 13.76 | 12.90 | 11.68 | 10.36 | 10.86 | - |
| 1957 | 11.90 | 13.77 | 12.96 | - | 10.94 | - | 9.84 | - |
| 1958 | 13.31 | 15.75 | 16.36 | 17.29 | 13.97 | - | 12.42 | 11.48 |
| 1959 | 13.10 | 16.38 | 14.35 | 16.20 | 12.35 | - | 10.52 | - |
| 1960 | 12.43 | 13.54 | 13.84 | 15.00 | 12.47 | 12.74 | 10.37 | - |
| 1961 | 12.85 | 14.55 | 13.91 | 12.97 | 12.52 | 11.78 | 11.32 | 10.07 |
| 1962 | 12.95 | 13.30 | 14.45 | 14.07 | 12.57 | 11.57 | 11.94 | - |
| 1963 | 11.44 | 11.29 | 11.74 | - | 11.46 | 10.64 | 11.45 | - |
| 1964 | 11.63 | 11.59 | 11.74 | - | 10.61 | 10.49 | 9.97 | - |
| 1965 | 13.01 | 13.38 | 12.27 | - | 11.20 | - | 10.53 | - |
| 1966 | 12.89 | 12.85 | 12.98 | - | 11.88 | 10.42 | 13.09 | - |
| 1967 | 13.37 | 13.22 | 13.12 | 13.28 | 12.07 | - | 10.85 | 10.90 |
| 1968 | 13.05 | 13.50 | 13.78 | 14.46 | 11.93 | 11.59 | 11.12 | - |
| 1969 | 9.46 | 9.07 | 9.88 | 10.68 | 10.07 | 10.71 | 10.04 | - |
| 1970 | 11.31 | 12.30 | 11.95 | 13.89 | 10.52 | - | 9.89 | - |
| 1971 | 11.79 | 13.28 | 12.32 | 13.00 | 11.00 | - | 9.43 | - |
| 1972 | 13.18 | 14.18 | 12.96 | 13.55 | 10.61 | 10.61 | 10.44 | - |
| 1973 | 12.90 | 12.32 | 13.73 | 14.92 | 12.37 | 12.45 | 8.14 | - |
| 1974 | 14.50 | 15.52 | 15.39 | 16.05 | 14.08 | - | 10.99 | - |
| 1975 | 10.86 | 11.63 | 10.19 | 11.02 | 11.15 | - | 9.99 | - |
| Mean (1963) | 12.63 | 13.69 | 13.38 | 14.46 | 11.80 | 11.42 | 10.64 | - |

Table 12 (cont'd)

| | Area 12 | | Area 13 | | Area 17 | | Area 18 | |
|---|---|---|---|---|---|---|---|---|
| | GN | S | GN | S | GN | S | GN | S |
| 1951 | 10.79 | 11.09 | 10.71 | 10.89 | 10.55 | 10.58 | 10.67 | 11.09 |
| 1952 | 12.03 | 13.32 | 11.64 | 12.47 | 11.51 | 11.74 | 12.62 | 12.57 |
| 1953 | 11.19 | 11.25 | 11.35 | 10.82 | 10.66 | 10.00 | 10.87 | 10.92 |
| 1954 | 11.97 | 12.82 | 12.87 | 12.15 | 11.58 | 12.42 | 10.90 | 10.92 |
| 1955 | 11.62 | 11.96 | 12.41 | 11.74 | 11.00 | 11.29 | 11.58 | 11.89 |
| 1956 | 11.13 | 11.39 | 11.55 | 11.00 | 10.80 | 11.05 | 10.79 | 10.53 |
| 1957 | 11.16 | 11.37 | 11.22 | 11.34 | 10.90 | 10.64 | 11.12 | 11.52 |
| 1958 | 11.27 | 11.38 | 11.27 | 10.84 | 10.65 | 10.35 | 10.38 | 10.41 |
| 1959 | 11.55 | 11.61 | 11.41 | 10.92 | 10.81 | 10.94 | 10.76 | 11.03 |
| 1960 | 11.05 | 10.85 | 10.53 | 10.09 | 9.78 | - | 10.03 | 10.04 |
| 1961 | 12.00 | 12.45 | 11.36 | 11.61 | 10.90 | - | 11.44 | 11.88 |
| 1962 | 11.90 | 11.81 | 10.77 | 11.18 | - | - | 10.86 | 11.08 |
| 1963 | 11.22 | 11.41 | 10.69 | 11.04 | - | - | 16.52 | 11.28 |
| 1964 | 12.27 | 12.39 | 11.89 | 12.64 | - | - | 10.59 | 11.31 |
| 1965 | 12.21 | 10.57 | 9.23 | 10.34 | - | - | - | - |
| 1966 | 12.44 | 12.17 | 12.57 | 11.78 | 10.92 | - | - | - |
| 1967 | 11.37 | 11.79 | 10.12 | 10.26 | - | - | - | - |
| 1968 | 11.52 | 11.83 | 11.00 | 11.22 | - | - | 10.71 | 11.01 |
| 1969 | 10.51 | 11.03 | 10.31 | 10.52 | 10.43 | - | 10.67 | 11.27 |
| 1970 | 10.65 | 10.86 | 10.78 | 10.92 | 10.59 | 10.46 | 11.07 | - |
| 1971 | 9.76 | 9.39 | 9.71 | 9.33 | 7.86 | - | - | - |
| 1972 | 10.78 | 10.88 | 10.76 | 10.88 | 10.14 | 10.03 | 10.72 | 11.11 |
| 1973 | 11.39 | 11.86 | 11.90 | 11.78 | 11.33 | 12.52 | 11.55 | 11.79 |
| 1974 | 11.48 | 12.07 | 11.31 | 11.61 | 11.28 | 11.42 | - | - |
| 1975 | 10.34 | 10.40 | 10.35 | 10.19 | 10.22 | 10.39 | - | - |
| Mean (1963) | 11.34 | 11.52 | 11.11 | 11.10 | 10.61 | 10.98 | 11.26 | 11.20 |

Table 12 (cont'd)

| | Area 20 | | Area 23 | | Area 24 | | Area 25 | |
|---|---|---|---|---|---|---|---|---|
| | GN | S | GN | S | GN | S | GN | S |
| 1951 | 9.85 | 12.83 | 9.91 | 10.60 | 10.27 | 9.34 | - | 9.31 |
| 1952 | - | 16.97 | 10.74 | 11.05 | - | 10.64 | 11.09 | 10.78 |
| 1953 | 10.20 | 12.02 | 10.01 | 10.25 | 9.92 | 9.46 | 10.60 | 10.53 |
| 1954 | 12.48 | 15.26 | 11.62 | 12.26 | 11.38 | 12.32 | 12.26 | 12.72 |
| 1955 | 11.07 | 12.57 | 10.25 | 10.59 | 11.02 | 10.55 | 10.59 | 10.88 |
| 1956 | 10.84 | 13.12 | 10.09 | 10.02 | 9.32 | 10.52 | 10.75 | 9.99 |
| 1957 | 10.72 | 13.65 | 10.62 | 10.52 | 10.25 | 10.26 | 9.85 | 9.76 |
| 1958 | 10.01 | 15.20 | 10.15 | 10.04 | 9.03 | 10.41 | 10.72 | 10.64 |
| 1959 | 10.61 | 11.15 | 10.10 | 9.80 | 9.23 | 9.69 | 10.20 | 9.99 |
| 1960 | 9.63 | 10.41 | 9.82 | 10.20 | 9.27 | 9.93 | 9.57 | 9.59 |
| 1961 | 10.81 | 11.89 | 10.19 | 10.80 | 10.01 | 10.58 | 10.73 | 11.00 |
| 1962 | 10.56 | 11.25 | 11.05 | 12.18 | 10.58 | 11.15 | 11.13 | 11.61 |
| 1963 | 10.58 | 11.44 | - | - | 9.57 | 10.44 | 9.68 | 9.73 |
| 1964 | 10.83 | 11.60 | - | - | - | - | 11.05 | 11.96 |
| 1965 | 9.92 | 9.85 | - | - | - | - | - | - |
| 1966 | 10.34 | 11.08 | - | - | - | - | - | - |
| 1967 | 9.64 | 10.19 | - | - | - | - | - | - |
| 1968 | 11.14 | 11.95 | - | - | - | - | - | - |
| 1969 | 10.39 | 11.65 | - | - | - | - | - | 10.72 |
| 1970 | 9.81 | 10.13 | 9.45 | 10.27 | - | - | 9.53 | 9.45 |
| 1971 | 9.17 | 8.22 | 9.23 | 9.53 | - | 8.10 | 9.21 | 9.15 |
| 1972 | 10.43 | 10.86 | 10.22 | 10.82 | 9.96 | 10.26 | 10.10 | 10.35 |
| 1973 | 11.16 | 11.55 | 10.91 | 11.77 | - | - | 10.93 | 11.16 |
| 1974 | 10.66 | 11.12 | - | 8.55 | - | - | 10.99 | 11.20 |
| 1975 | 10.35 | 10.31 | 10.33 | - | - | - | 10.94 | 11.46 |
| Mean (1963) | 10.48 | 11.85 | 10.25 | 10.49 | 9.59 | 10.06 | 10.51 | 10.57 |

Table 12 (cont'd)

| | Area 26 | | Area 27 | | Area 29A+B |
|---|---|---|---|---|---|
| | GN | S | GN | S | GN |
| 1951 | 9.47 | 9.41 | 9.64 | 9.62 | 11.79 |
| 1952 | - | 11.08 | - | 10.31 | 13.33 |
| 1953 | - | 10.31 | 9.83 | 9.82 | 12.34 |
| 1954 | - | 12.48 | 11.36 | 12.06 | 13.37 |
| 1955 | - | 10.67 | 10.12 | 9.86 | 12.44 |
| 1956 | 10.75 | 10.10 | 9.72 | 9.60 | 12.27 |
| 1957 | 10.62 | 9.91 | 9.84 | 9.70 | 12.13 |
| 1958 | 10.56 | 10.64 | - | 11.35 | 11.21 |
| 1959 | 9.67 | 10.14 | 9.63 | 10.57 | 11.82 |
| 1960 | 9.74 | 9.57 | 8.95 | 8.70 | 11.01 |
| 1961 | 10.83 | 11.23 | - | - | 12.31 |
| 1962 | 10.82 | 11.21 | - | - | 11.84 |
| 1963 | 10.02 | 10.53 | - | - | 11.82 |
| 1964 | - | - | - | - | 13.02 |
| 1965 | - | - | 13.07 | - | 10.25 |
| 1966 | - | - | 11.05 | - | 11.80 |
| 1967 | - | - | 13.02 | - | 11.15 |
| 1968 | - | - | 11.89 | - | 12.12 |
| 1969 | - | - | 11.54 | - | 11.34 |
| 1970 | - | - | 10.78 | - | 11.42 |
| 1971 | 8.95 | 8.88 | 10.49 | - | 9.65 |
| 1972 | - | - | 10.52 | - | 11.44 |
| 1973 | 10.62 | 11.07 | 10.88 | 10.40 | 12.12 |
| 1974 | 10.29 | 10.90 | 12.31 | - | 12.00 |
| 1975 | 10.81 | 11.39 | 10.70 | 11.94 | 10.40 |
| Mean (1963) | 10.24 | 10.58 | 10.74 | 10.52 | 11.78 |

Table 13. Mean weights in pounds (W) and their residuals from the regression on time (R), for British Columbia chum salmon caught by gillnets and seines. Regressions and residuals are based on the 24-year period 1951-74. r = correlation coefficient; b = regression coefficient (lb/yr); 1963 = computed weight in 1963.

| | Northern (2) | | Southern (3) | | Fraser (1) | |
|---|---|---|---|---|---|---|
| District | W | R | W | R | W | R |
| 1951 | 11.94 | -1.04 | 10.94 | -0.57 | 11.78 | -0.71 |
| 1952 | 13.76 | +0.89 | 12.64 | +1.17 | 13.30 | +0.87 |
| 1953 | 13.19 | +0.42 | 11.34 | -0.10 | 12.45 | +0.08 |
| 1954 | 14.23 | +1.57 | 12.38 | +0.98 | 13.43 | +1.17 |
| 1955 | 11.94 | -0.62 | 11.58 | +0.21 | 12.50 | +0.25 |
| 1956 | 11.55 | -0.90 | 10.71 | -0.62 | 12.20 | +0.01 |
| 1957 | 11.48 | -0.87 | 10.87 | -0.42 | 12.01 | -0.12 |
| 1958 | 13.33 | +1.08 | 10.87 | -0.39 | 11.20 | -0.87 |
| 1959 | 13.28 | +1.14 | 10.95 | -0.27 | 11.78 | -0.23 |
| 1960 | 12.45 | +0.41 | 10.19 | -1.00 | 11.07 | -0.88 |
| 1961 | 12.40 | +0.47 | 11.44 | +0.29 | 12.28 | +0.39 |
| 1962 | 12.35 | +0.52 | 11.25 | +0.14 | 11.40 | -0.43 |
| 1963 | 10.33 | -1.40 | 10.88 | -0.20 | 11.94 | +0.17 |
| 1964 | 10.40 | -1.22 | 11.94 | +0.90 | 13.05 | +1.34 |
| 1965 | 10.53 | -0.99 | 10.42 | -0.59 | 10.34 | -1.31 |
| 1966 | 11.98 | +0.57 | 11.56 | +0.59 | 11.92 | +0.33 |
| 1967 | 10.73 | -0.58 | 10.86 | -0.07 | 11.81 | +0.28 |
| 1968 | 11.95 | +0.75 | 11.44 | +0.54 | 10.81 | -0.66 |
| 1969 | 9.77 | -1.33 | 10.57 | -0.29 | 11.38 | -0.03 |
| 1970 | 9.72 | -1.28 | 10.61 | -0.22 | 11.41 | +0.06 |
| 1971 | 9.49 | -1.40 | 9.30 | -1.49 | 9.73 | -1.56 |
| 1972 | 11.37 | +0.58 | 10.62 | -0.13 | 11.44 | +0.21 |
| 1973 | 11.48 | +0.80 | 11.61 | +0.89 | 12.08 | +0.91 |
| 1974 | 13.02 | +2.44 | 11.31 | +0.63 | 11.97 | +0.86 |
| 1975 | 10.23 | -0.24 | 10.50 | -0.14 | 10.40 | -0.65 |
| N | 24 | | 24 | | 24 | |
| r | -0.559** | | -0.361 | | -0.495* | |
| b | -0.1042 | | -0.0360 | | -0.0599 | |
| 1963 | 11.73 | | 11.07 | | 11.77 | |

Table 14. Mean whole weight in pounds of chum salmon from the Strait of Georgia, with the number of fish weighed in parentheses. From data of Fraser (1920, 1921).

| | | | Age 0.1 | Age 0.2 | | Age 0.3 | | Age 0.4 | |
|---|---|---|---|---|---|---|---|---|---|
| Area | Year | Location | M | M | F | M | F | M | All |
| 17 | 1916 | Nanaimo, L. Qualicum | - | 9.66 | 8.85 | 12.99 | 11.37 | - | 11.12 |
| | | | - | (395) | (379) | (768) | (436) | - | (1978) |
| 17 | 1917 | Little Qualicum R. | 5.5 | 10.48 | 9.72 | 13.88 | 12.23 | 15.97 | 12.34 |
| | | | (1) | (83) | (75) | (232) | (83) | (3) | (477) |
| 17 | 1917 | Nanaimo | - | 10.19 | 9.29 | 13.45 | 11.78 | 16.5 | 10.58 |
| | | | - | (116) | (150) | (59) | (53) | (1) | (379) |
| 18 | 1917 | Chemainus | - | 8.56 | 8.07 | 11.60 | 10.54 | - | 8.56 |
| | | | - | (65) | (61) | (4) | (9) | - | (139) |

Table 15. Mean whole weight in pounds of chum salmon in catch samples reported by Fraser (1920, 1921), Wickett (1946) and Robertson (1948), without distinction of sex. Numbers of fish weighed are in parentheses.

| | | | Age | | | | |
|---|---|---|---|---|---|---|---|
| Year | Area | Location | 0.1 | 0.2 | 0.3 | 0.4 | All |
| 1916 | 17 | Nanaimo, L. Qualicum | - | 9.26 | 12.40 | - | 11.12 |
| | | | - | (774) | (1204) | - | (1978) |
| 1917 | 17 | Little Qualicum River | 5.5 | 10.12 | 13.45 | 15.97 | 12.34 |
| | | | (1) | (158) | (315) | (3) | (477) |
| 1917 | 17 | Nanaimo | - | 9.68 | 12.66 | 16.5 | 10.58 |
| | | | - | (266) | (112) | (1) | (379) |
| 1917 | 18 | Chemainus | - | 8.32 | 10.87 | - | 8.56 |
| | | | - | (126) | (13) | - | (139) |
| 1945 | 12 | Upper Johnstone Strait | - | 8.68 | 10.19 | 11.72 | 9.98 |
| | | | - | (203) | (1115) | (16) | (1334) |
| 1945 | 13 | Discovery Passage | - | 8.85 | 10.19 | 11.13 | 10.03 |
| | | | - | (159) | (584) | (8) | (751) |
| 1947 | 7 | Namu | - | 8.4 | 9.2 | 11.5 | 9.12 |
| | | | - | (81) | (292) | (14) | (387) |
| 1947 | 9-10 | Rivers and Smith's Inlets | - | 10.4 | 11.6 | 12.1 | 11.48 |
| | | | - | (39) | (241) | (22) | (302) |
| 1948 | 6 | Butedale | - | 7.2 | 10.1 | - | 9.84 |
| | | | - | (10) | (101) | - | (111) |
| 1948 | 8 | Dean Channel and Koeye R. | - | 9.9 | 12.3 | 15.3 | 12.04 |
| | | | - | (24) | (95) | (8) | (127) |
| 1948 | 12 | Growler Cove | - | 8.0 | 9.0 | 10.0 | 9.00 |
| | | | - | (2) | (28) | (2) | (32) |
| 1948 | 20 | Sooke | - | 8.8 | 11.8 | 13.5 | 11.29 |
| | | | - | (12) | (24) | (8) | (44) |

Table 16. Mean weights of chum salmon caught by seine in various British Columbia Areas during 1944-47. Figures for 1944 are for specific dates, from Table 6 of Hoar (1951). Figures for 1945-47 are from Hoar's Table 5, and represent the seasonal mean computed from the regression equation tabulated. The last 3 columns are mean weights for more recent years, from Table 33: observed weights (O) for 1951, and means calculated from the regression equation for 1951 and 1975 (C).

| Area | Locality | Dates | 1944 | 1945 | 1946 | 1947 | 1951(O) | 1951(C) | 1975(C) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Sewell | Sep. 12 | 9.53 | | | | 10.53 | 11.24 | 10.24 |
| 2E | Selwyn and Cumshew | Sep. 12-13 | 9.35 | | | | 9.07 | 9.93 | 9.47 |
| 2E | Deena River | Sep. 15 | 8.26 | | | | 9.07 | 9.93 | 9.47 |
| 3 | Nass Steamboat Channel | Aug. 8-9 | 11.56 | | | | 12.52 | 14.21 | 11.54 |
| 6 | Fin I. and Whale Channel | Aug. 16-17 | 10.50 | | | | 12.81 | 13.95 | 12.35 |
| 6 | Butedale | July 12-Sep. 27 | | 11.82 | 12.82 | 9.95 | 12.81 | 13.95 | 12.35 |
| 6 | Klemtu | July 21-Sep.27 | | 10.50 | | 9.60 | 12.81 | 13.95 | 12.35 |
| 8 | Namu | Aug 3-Sep.28 | | | 9.24 | | 12.37 | 15.19 | 12.20 |
| 12 | Alert Bay | Sep. 21 | 11.25 | | | | 11.09 | 12.04 | 11.01 |
| 12 | Growler Cove | Sep. 20-21 | 11.22 | | | | 11.09 | 12.04 | 11.01 |
| 13 | Bear River | Sep. 26 | 10.46 | | | | 10.89 | 11.49 | 10.73 |
| 12+13 | Port McNeill to Seymour Narrows | Aug. 9-Nov. 16 | | 10.07 | 10.07 | 10.14 | 10.99 | 11.76 | 10.87 |
| 23 | Kildonan | Sep. 22-Nov. 9 | | | 9.34 | 9.56 | 10.60 | 10.82 | 10.15 |
| 25 | Ceepeecee | Sep. 20-Nov. 9 | | | 9.36 | 9.52 | 9.31 | 10.50 | 10.65 |

Table 17. Mean whole weights in pounds of chum salmon, from Fisheries Association records (Godfrey 1959).

| Region<br>Areas | Queen Charlotte<br>1 + 2 | Northern<br>3-7(part) | Central<br>7(part)-10 | Southern<br>11-18,28,29 | West coast Vancouver I.<br>20-27 |
|---|---|---|---|---|---|
| 1946 | 8.17 | 9.81 | 10.91 | 9.55 | 8.82 |
| 1947 | 7.81 | 9.78 | 10.08 | 9.55 | 8.76 |
| 1948 | 8.97 | 11.14 | 11.14 | 10.01 | 8.69 |
| 1949 | 7.65 | 12.10 | 11.47 | 9.25 | 9.32 |
| 1950 | 9.17 | 10.65 | 11.14 | 10.94 | 9.62 |
| 1951 | 9.30 | 13.25 | 11.90 | 10.91 | 9.81 |
| 1952 | 10.62 | 14.11 | 13.12 | 12.69 | 10.81 |
| 1953 | 9.96 | 14.11 | 12.53 | 10.91 | 10.08 |
| 1954 | 11.12 | 14.58 | 14.11 | 12.39 | 12.46 |
| 1955 | 9.07 | 13.45 | 12.03 | 11.20 | 10.54 |
| 1956 | 9.46 | 12.06 | 12.03 | 10.74 | 9.95 |
| 1957 | 10.69 | 15.54 | 12.03 | 11.34 | 10.15 |
| 1958 | 11.61 | 14.35 | 14.11 | 12.13 | 10.64 |

Table 18. Comparison of mean weights in pounds of seined chum salmon obtained in 5 regions by the Fisheries Association, with mean weights of seined chums in component Areas obtained from sales slips. The means shown are <u>not</u> weighted by the quantity of fish caught.

| | 1951 | 1952 | 1953 | 1954 | 1955 | 1956 | 1957 | 1958 |
|---|---|---|---|---|---|---|---|---|
| Areas 1 and 2 | 9.3 | 10.6 | 10.0 | 11.1 | 9.1 | 9.5 | 10.7 | 11.6 |
| Area 1 | 10.5 | 10.9 | 11.5 | 11.4 | 11.1 | 11.0 | 11.3 | 12.4 |
| Area 2E | 9.1 | 10.3 | 9.4 | 11.3 | 8.9 | 9.2 | 10.6 | 10.7 |
| Mean | 9.8 | 10.6 | 10.2 | 11.4 | 10.0 | 10.1 | 11.0 | 11.6 |
| Areas 3-7(part) | 13.3 | 14.1 | 14.1 | 14.6 | 13.5 | 12.1 | 15.5 | 14.3 |
| Area 3 | 12.5 | 14.8 | 15.2 | 14.6 | 13.2 | 13.2 | 13.0 | 13.6 |
| Area 4 | - | - | - | 15.3 | 14.9 | 12.4 | 14.6 | - |
| Area 5 | 14.8 | 17.9 | 14.1 | 16.3 | 15.3 | 13.4 | 12.3 | 13.2 |
| Area 6 | 12.8 | 14.5 | 15.4 | 15.4 | 15.4 | 11.2 | 12.2 | 15.2 |
| Area 7 | 10.2 | 12.7 | 11.5 | 13.5 | 10.9 | 11.0 | 12.5 | 13.5 |
| Mean (omitting Area 4) | 12.6 | 15.0 | 14.0 | 15.0 | 13.7 | 12.2 | 12.5 | 13.9 |
| Areas 7(part)-10 | 11.9 | 13.1 | 12.5 | 14.1 | 12.0 | 12.0 | 12.0 | 14.1 |
| Area 7 | 10.2 | 12.7 | 11.5 | 13.5 | 10.9 | 11.0 | 12.5 | 13.5 |
| Area 8 | 12.4 | 15.1 | 16.7 | 16.4 | 16.1 | 14.1 | 13.8 | 15.8 |
| Area 9 | 12.1 | 18.8 | 13.1 | 19.0 | 16.8 | 12.9 | - | 17.3 |
| Area 10 | 11.3 | 13.1 | 14.5 | 11.2 | - | 10.4 | - | - |
| Mean (omitting Area 10) | 11.6 | 15.6 | 13.8 | 16.3 | 14.6 | 12.7 | - | 15.5 |
| Areas 11-18, 28, 29 | 10.9 | 12.7 | 10.9 | 12.4 | 11.2 | 10.7 | 11.3 | 12.1 |
| Area 12 | 11.1 | 13.3 | 11.2 | 12.8 | 12.0 | 11.4 | 11.4 | 11.4 |
| Area 13 | 10.9 | 12.5 | 10.8 | 12.2 | 11.7 | 11.0 | 11.3 | 10.8 |
| Area 17 | 10.6 | 11.7 | 10.0 | 12.4 | 11.3 | 11.0 | 10.6 | 10.4 |
| Mean | 10.9 | 12.5 | 10.7 | 12.5 | 11.7 | 11.1 | 11.1 | 10.9 |
| Areas 20-27 | 9.8 | 10.8 | 10.1 | 12.5 | 10.5 | 9.9 | 10.1 | 10.6 |
| Area 20 | 12.8 | 17.0 | 12.0 | 15.3 | 12.6 | 13.1 | 13.6 | 15.2 |
| Area 23 | 10.6 | 11.0 | 10.2 | 12.3 | 10.6 | 10.0 | 10.5 | 10.0 |
| Area 24 | 9.3 | 10.6 | 9.5 | 12.3 | 10.6 | 10.5 | 10.3 | 10.4 |
| Area 25 | 9.3 | 10.8 | 10.5 | 12.7 | 10.9 | 10.0 | 9.8 | 10.6 |
| Area 26 | 9.4 | 11.0 | 10.3 | 12.5 | 10.7 | 10.1 | 9.9 | 10.6 |
| Area 27 | 9.6 | 10.3 | 9.8 | 12.1 | 9.9 | 9.6 | 9.7 | 11.4 |
| Mean | 10.2 | 11.8 | 10.4 | 12.9 | 10.9 | 10.6 | 10.6 | 11.4 |

Table 19. Mean postorbital-hypural lengths in millimetres of chum salmon in statistical Area 3 (Nass) of British Columbia, by age and sex, from catches taken by gillnet and seine. From data of Bilton and colleagues (1965-1973). N = number of years available; r = correlation coefficient between length and time; b = rate of change in length, in mm/yr; 1963 = computed size in 1963. Note that during 1957-63 ages 0.1 and 0.5 are not reported. Lengths for 1957 are converted from fork length, and are not used in the regressions.

| | Age 0.2 | | Age 0.3 | | Age 0.4 | |
|---|---|---|---|---|---|---|
| | M | F | M | F | M | F |
| 1957 | 554 | 539 | 611 | 578 | 635 | 597 |
| 1958 | 548 | 561 | 613 | 589 | 640 | 614 |
| 1959 | 554 | 542 | 638 | 610 | 663 | 630 |
| 1960 | 545 | 551 | 623 | 589 | 687 | 636 |
| 1961 | 559 | 564 | 600 | 579 | 609 | 598 |
| 1962 | 565 | 552 | 613 | 588 | 628 | 599 |
| 1963 | 540 | 529 | 621 | 599 | 643 | 610 |
| 1964 | 528 | 531 | 612 | 584 | 651 | 636 |
| 1965 | 503 | 542 | 612 | 584 | 658 | 614 |
| 1966 | 499 | 540 | 585 | 567 | 637 | 602 |
| 1967 | 554 | 554 | 622 | 591 | 642 | 606 |
| 1968 | 600 | 584 | 629 | 602 | 649 | 627 |
| 1969 | 556 | 528 | 624 | 595 | 646 | 606 |
| 1970 | 536 | - | 609 | 581 | 650 | 604 |
| 1971 | 537 | 506 | 599 | 562 | 628 | 571 |
| 1972 | 511 | 539 | 614 | 576 | 634 | 594 |
| N | 15 | 14 | 15 | 15 | 15 | 15 |
| r | -0.195 | -0.361 | -0.218 | -0.436 | -0.217 | -0.532* |
| b | -1.1214 | -1.5461 | -0.6357 | -1.2357 | -0.8643 | -2.0714 |
| 1963 | 545 | 547 | 616 | 589 | 646 | 614 |

Table 20. Chum lengths in Area 4 (Skeena). See Table 19 for details.

| | Age 0.2 | | Age 0.3 | | Age 0.4 | |
|---|---|---|---|---|---|---|
| | M | F | M | F | M | F |
| 1957 | 602 | 497 | 664 | 610 | 699 | 624 |
| 1958 | 568 | 560 | 634 | 604 | 667 | 640 |
| 1959 | - | - | - | - | - | - |
| 1960 | 573 | 548 | 639 | 599 | 708 | 680 |
| 1961 | 598 | 571 | 639 | 597 | 658 | 624 |
| 1962 | 580 | 564 | 636 | 601 | 631 | 605 |
| 1963 | 551 | 544 | 625 | 598 | 670 | 622 |
| 1964 | - | - | - | - | - | - |
| 1965 | - | - | 549 | 561 | - | - |
| 1966 | - | 540 | 661 | 608 | - | - |
| 1967 | 562 | 557 | 630 | 598 | 674 | 621 |
| 1968 | 621 | 604 | 659 | 621 | 591 | 643 |
| 1969 | 549 | 529 | 610 | 583 | 641 | 621 |
| 1970 | - | - | 571 | 587 | - | 578 |
| 1971 | 542 | 529 | 605 | 593 | 599 | 599 |
| 1972 | 520 | 532 | 622 | 579 | 647 | 610 |
| N | 10 | 11 | 12[a] | 13 | 10 | 11 |
| r | -0.444 | -0.335 | -0.450 | -0.286 | -0.587 | -0.585 |
| b | -2.6113 | -1.6640 | -2.357 | -0.9479 | -4.2167 | -3.1775 |
| 1963 | 572 | 556 | 634 | 597 | 657 | 630 |

[a]1965 is omitted because based on only 3 specimens.

Table 21. Chum lengths in Area 5 (Ogden-Principe Channels, etc.). See Table 19 for details.

| | Age 0.2 | | Age 0.3 | | Age 0.4 | |
|---|---|---|---|---|---|---|
| | M | F | M | F | M | F |
| 1957 | 578 | 553 | 614 | 585 | 642 | 566 |
| 1958 | 563 | 559 | 618 | 598 | 641 | 623 |
| 1959 | 548 | 542 | 647 | 616 | 648 | 633 |
| 1960 | 543 | 539 | 605 | 590 | - | 635 |
| 1961 | 567 | 569 | 625 | 600 | 652 | 618 |
| 1962 | 568 | 557 | 622 | 602 | 640 | 602 |
| 1963 | 560 | 549 | 621 | 602 | 637 | 615 |
| 1964 | - | - | - | - | - | - |
| 1965 | 571 | 537 | 603 | 587 | 667 | 632 |
| 1966 | 539 | 535 | 608 | 586 | 622 | 632 |
| 1967 | 569 | 554 | 624 | 604 | 639 | 603 |
| 1968 | 553 | 561 | 617 | 592 | 626 | 599 |
| 1969 | 605 | 570 | 668 | 618 | 679 | 616 |
| 1970 | 581 | 576 | 630 | 582 | 699 | 577 |
| 1971 | 556 | 545 | 621 | 558 | 592 | 580 |
| 1972 | 502 | 536 | 615 | 582 | 671 | 646 |
| N | 14 | 14 | 13* | 13* | 13 | 14 |
| r | -0.060 | +0.062 | -0.146 | -0.704 | +0.118 | -0.378 |
| b | -0.3009 | +0.1826 | -0.3581 | -2.1475 | +0.7088 | -1.6889 |
| 1963 | 559 | 552 | 620 | 596 | 645 | 619 |

*1969 is omitted because based on only 2(M) and 3(F) specimens.

Table 22. Chum lengths in Area 6 (Whale Channel, etc.). See Table 19 for details.

| | Age 0.2 | | Age 0.3 | | Age 0.4 | | Age 0.5 |
|---|---|---|---|---|---|---|---|
| | M | F | M | F | M | F | F |
| 1958 | 578 | 538 | 628 | 597 | 615 | 600 | - |
| 1959 | 578 | 565 | 656 | 608 | 678 | 631 | - |
| 1960 | 582 | 565 | 631 | 603 | 660 | 603 | - |
| 1961 | 578 | 565 | 626 | 602 | 648 | 613 | - |
| 1962 | 591 | 571 | 630 | 610 | 637 | 609 | - |
| 1963 | 552 | 543 | 621 | 591 | 600 | 566 | - |
| 1964 | 546 | 538 | 614 | 587 | 630 | 607 | - |
| 1965 | 566 | 556 | 629 | 600 | 667 | 645 | - |
| 1966 | 550 | 555 | 614 | 587 | 623 | 596 | - |
| 1967 | 549 | 547 | 609 | 592 | 620 | 597 | - |
| 1968 | 628 | 579 | 639 | 606 | 678 | 603 | - |
| 1969 | 598 | 576 | 677 | 616 | 677 | 627 | - |
| 1970 | 584 | 557 | 624 | 588 | 680 | 657 | - |
| 1971 | - | - | - | - | - | - | - |
| 1972 | 515 | 528 | 616 | 578 | 626 | 580 | 642 |
| N | 14 | 14 | 14 | 14 | 14 | 14 | - |
| r | -0.184 | -0.083 | -0.070 | -0.374 | +0.165 | +0.067 | - |
| b | -1.1746 | -0.2959 | -0.2923 | -0.9320 | +1.0556 | +0.3746 | - |
| 1963 | 573 | 556 | 630 | 599 | 644 | 609 | - |

Table 23. Chum lengths in Area 7 (Bella Bella). See Table 19 for details.

| | Age 0.1 | Age 0.2 | | Age 0.3 | | Age 0.4 | | Age 0.5 |
|---|---|---|---|---|---|---|---|---|
| | F | M | F | M | F | M | F | M |
| 1858 | - | 544 | 552 | 592 | 599 | 592 | 608 | - |
| 1959 | - | 528 | 534 | 583 | 586 | 605 | 593 | - |
| 1960 | - | 566 | 565 | 598 | 594 | 605 | 604 | - |
| 1961 | - | 561 | 564 | 617 | 601 | 650 | 606 | - |
| 1962 | - | 576 | 571 | 613 | 603 | 641 | 605 | - |
| 1963 | - | 537 | 538 | 580 | 584 | 599 | 591 | - |
| 1964 | - | 519 | 539 | 583 | 580 | 616 | 592 | - |
| 1965 | - | 562 | 548 | 618 | 594 | 643 | 614 | - |
| 1966 | - | 553 | 555 | 602 | 588 | 610 | 608 | - |
| 1967 | - | 562 | 561 | 602 | 598 | 623 | 610 | - |
| 1968 | 456 | 549 | 559 | 622 | 596 | 629 | 641 | 687 |
| 1969 | - | 556 | 552 | 566 | 569 | 663 | 637 | 600 |
| 1970 | - | 538 | 533 | 579 | 556 | - | - | - |
| 1971 | - | - | - | - | - | - | - | - |
| 1972 | - | 507 | 517 | 560 | 553 | 560 | 569 | - |
| N | - | 14 | 14 | 14 | 14 | 13 | 13 | - |
| r | - | -0.278 | -0.396 | -0.334 | -0.694** | -0.015 | +0.107 | - |
| b | - | -1.2509 | -1.3923 | -1.5219 | -2.5941 | -0.1016 | +0.4817 | - |
| 1963 | - | 549 | 551 | 596 | 590 | 621 | 605 | - |

Table 24. Chum lengths in Area 8 (Bella Coola). See Table 19 for details.

| | Age 0.2 | | Age 0.3 | | Age 0.4 | | Age 0.5 |
|---|---|---|---|---|---|---|---|
| | M | F | M | F | M | F | M |
| 1958 | 560 | 562 | 600 | 596 | 639 | 612 | - |
| 1959 | 541 | 543 | 641 | 628 | 650 | 594 | - |
| 1960 | 589 | 573 | 639 | 617 | 690 | 639 | - |
| 1961 | 575 | 567 | 636 | 612 | 621 | 621 | - |
| 1962 | 616 | 600 | 650 | 632 | 665 | 632 | - |
| 1963 | 559 | 552 | 632 | 611 | 626 | 605 | - |
| 1964 | 529 | 543 | 609 | 588 | 664 | 626 | - |
| 1965 | 576 | 556 | 639 | 594 | 665 | 639 | - |
| 1966 | 569 | 573 | 615 | 594 | 645 | 607 | - |
| 1967 | 575 | 571 | 635 | 613 | 646 | 621 | 688 |
| 1968 | 563 | 561 | 636 | 606 | 670 | 644 | - |
| 1969 | 550 | 540 | 605 | 592 | 679 | 628 | - |
| 1970 | 590 | 570 | 630 | 601 | - | - | - |
| 1971 | 609 | 588 | 654 | 620 | 673 | 628 | - |
| 1972 | - | - | 639 | 608 | - | - | - |
| N | 14 | 14 | 15 | 15 | 13 | 13 | - |
| r | +0.232 | +0.122 | +0.151 | -0.230 | +0.362 | +0.384 | - |
| b | +1.3473 | +0.4989 | +0.5429 | -0.6857 | +1.8449 | +1.4120 | - |
| 1963 | 569 | 570 | 629 | 609 | 654 | 621 | - |

Table 25. Chum lengths in Area 9 (Rivers Inlet). See Table 19 for details.

| | Age 0.2 | | Age 0.3 | | Age 0.4 | | Age 0.5 | |
|---|---|---|---|---|---|---|---|---|
| | M | F | M | F | M | F | M | F |
| 1958 | 603 | 580 | 634 | 607 | 653 | 627 | - | - |
| 1959 | - | - | - | - | - | - | - | - |
| 1960 | 596 | 579 | 633 | 606 | 663 | 577 | - | - |
| 1961 | 602 | 577 | 651 | 615 | 648 | 598 | - | - |
| 1962 | 629 | 614 | 656 | 645 | 664 | 658 | - | - |
| 1963 | 565 | 550 | 624 | 597 | 555 | 617 | - | - |
| 1964 | 545 | 548 | 616 | 576 | 661 | - | - | - |
| 1965 | 542 | 544 | 589 | 565 | 631 | 632 | - | - |
| 1966 | 576 | 572 | 633 | 595 | 649 | 614 | - | 542 |
| 1967 | 574 | 565 | 627 | 607 | 643 | 621 | - | - |
| 1968 | 567 | 552 | 630 | 599 | 660 | 670 | 713 | - |
| 1969 | 565 | 544 | 631 | 578 | 649 | 620 | - | 679 |
| 1970 | 560 | 546 | 594 | 560 | 577 | - | - | - |
| N | 12 | 12 | 12 | 12 | 12 | 10 | - | - |
| r | -0.608* | -0.617* | -0.473 | -0.571* | -0.263 | +0.374 | - | - |
| b | -4.1764 | -3.4809 | -2.4691 | -3.5835 | -2.4578 | +2.7246 | - | - |
| 1963 | 583 | 569 | 630 | 601 | 641 | 621 | - | - |

Table 26. Chum lengths in Area 10 (Smith Inlet). See Table 19 for details.

| | Age 0.2 | | Age 0.3 | | Age 0.4 | | Age 0.5 |
|---|---|---|---|---|---|---|---|
| | M | F | M | F | M | F | F |
| 1959 | 538 | 544 | 631 | 583 | 631 | 600 | - |
| 1960 | 594 | 580 | 626 | 601 | 690 | 622 | - |
| 1961 | 575 | 569 | 619 | 588 | 670 | - | - |
| 1962 | 619 | 606 | 654 | 644 | 640 | 628 | - |
| 1963 | 559 | 550 | 609 | 591 | 585 | - | - |
| 1964 | 539 | 551 | 614 | 590 | 774 | 604 | - |
| 1965 | 578 | 551 | 620 | 591 | 651 | 616 | - |
| 1966 | 562 | 557 | 647 | 606 | 612 | - | - |
| 1967 | 566 | 564 | 617 | 600 | 620 | 618 | - |
| 1968 | 554 | 561 | 624 | 593 | 702 | 636 | 652 |
| 1969 | 594 | 589 | 624 | 603 | 671 | 629 | - |
| 1970 | 542 | 539 | 603 | 571 | - | - | - |
| N | 12 | 12 | 12 | 12 | 11 | 8 | - |
| r | -0.162 | -0.140 | -0.308 | -0.180 | +0.063 | +0.552 | - |
| b | -1.1189 | -0.7657 | -1.2448 | -0.8846 | +0.9818 | +1.8508 | - |
| 1963 | 570 | 565 | 626 | 598 | 658 | 617 | - |

Table 27. Chum lengths in Area 12 (upper Johnstone Strait). See Table 19 for details.

| | Age 0.1 | Age 0.2 | | Age 0.3 | | Age 0.4 | | Age 0.5 |
|---|---|---|---|---|---|---|---|---|
| | M | M | F | M | F | M | F | M |
| 1958 | - | 584 | 583 | 614 | 606 | 626 | 635 | - |
| 1959 | - | 579 | 563 | 622 | 609 | 609 | 611 | - |
| 1960 | - | 573 | 573 | 618 | 603 | 672 | 596 | - |
| 1961 | - | 582 | 582 | 627 | 611 | 672 | 629 | - |
| 1962 | - | 618 | 601 | 631 | 616 | 663 | 628 | - |
| 1963 | - | 562 | 551 | 610 | 594 | 629 | 599 | - |
| 1964 | - | 570 | 568 | 626 | 606 | 649 | 639 | - |
| 1965 | 500 | 538 | 548 | 590 | 582 | 627 | 611 | - |
| 1966 | 466 | 587 | 572 | 618 | 599 | 643 | 611 | - |
| 1967 | - | 562 | 557 | 625 | 606 | 621 | 613 | - |
| 1968 | - | 579 | 569 | 608 | 592 | 619 | 620 | 689 |
| 1969(1) | 347 | 572 | 561 | 629 | 605 | 655 | 626 | - |
| 1969(2) | - | 545 | 554 | 606 | 597 | 628 | 607 | - |
| 1970 | - | 541 | 538 | 584 | 576 | 638 | - | - |
| 1971 | - | 547 | 554 | 588 | 583 | 605 | 592 | - |
| 1972 | - | 544 | 548 | 596 | 587 | 620 | 610 | - |
| N | - | 16 | 16 | 16 | 16 | 16 | 15 | - |
| r | - | -0.607* | -0.635** | -0.548* | -0.658** | -0.350 | -0.302 | - |
| b | - | -2.9246 | -2.2966 | -1.9085 | -1.7220 | -1.6610 | -0.9865 | - |
| 1963 | - | 574 | 569 | 616 | 602 | 640 | 617 | - |

Table 28. Chum lengths in Area 13 (lower Johnstone Strait). See Table 19 for details.

| | Age 0.2 | | Age 0.3 | | Age 0.4 | |
|---|---|---|---|---|---|---|
| | M | F | M | F | M | F |
| 1958 | 564 | 568 | 615 | 602 | 643 | 620 |
| 1959 | 566 | 558 | 618 | 606 | 643 | 614 |
| 1960 | 572 | 569 | 612 | 603 | 628 | 586 |
| 1961 | 598 | 587 | 617 | 608 | 638 | 621 |
| 1962 | 620 | 625 | 659 | 649 | 664 | 550 |
| 1963 | 555 | 553 | 612 | 600 | 610 | - |
| 1964 | 571 | 568 | 618 | 604 | 650 | 706 |
| 1965 | 521 | 542 | 579 | 569 | 621 | 601 |
| 1966 | - | - | - | - | - | - |
| 1967 | 556 | 552 | 599 | 591 | 625 | 614 |
| 1968 | 566 | 575 | 610 | 601 | 631 | - |
| 1969 | 550 | 551 | 603 | 599 | 625 | 620 |
| 1970 | 574 | 562 | 593 | 586 | 644 | 522 |
| 1971 | 544 | 547 | 578 | 576 | 603 | 588 |
| 1972 | 546 | 545 | 600 | 588 | 624 | 622 |
| N | 14 | 14 | 14 | 14 | 14 | 12 |
| r | -0.421 | -0.433 | -0.569* | -0.507 | -0.444 | -0.159 |
| b | -2.1744 | -2.0133 | -2.4341 | -2.0302 | -1.5486 | -1.4429 |
| 1963 | 569 | 568 | 613 | 603 | 635 | 608 |

Table 29. Chum lengths in Areas 14, 16, 17 and 18 (Strait of Georgia). See Table 19 for details.

| | Age 0.2 | | Age 0.3 | | Age 0.4 | |
|---|---|---|---|---|---|---|
| | M | F | M | F | M | F |
| | Area 14 - Courtenay | | | | | |
| 1960 | 558 | 554 | 605 | 592 | 605 | - |
| 1961 | 565 | 568 | 601 | 609 | 620 | - |
| 1962 | 619 | 616 | 647 | 648 | 664 | 650 |
| | Area 16 - Pender Harbour | | | | | |
| 1959 | 572 | 574 | 616 | 606 | 638 | 610 |
| 1960 | 562 | 572 | 599 | 596 | 640 | - |
| 1961 | 575 | 577 | 602 | 608 | 600 | - |
| 1962 | 622 | 624 | 646 | 648 | 650 | 652 |
| | Area 17 - Nanaimo | | | | | |
| 1972 | 557 | 539 | 587 | 581 | 602 | - |
| | Area 18 - Gulf Islands | | | | | |
| 1960 | 564 | 569 | 595 | 591 | 602 | - |
| 1961 | 562 | 563 | 603 | 596 | 680 | - |
| 1962 | 591 | 585 | 641 | 629 | 550 | - |
| 1963 | 565 | 554 | 608 | 595 | - | - |
| 1964 | - | - | 601 | - | - | - |
| 1972 | 542 | 581 | 590 | 583 | - | - |
| N | 5 | 5 | 6 | 5 | - | - |
| r | -0.664 | +0.405 | -0.374 | -0.421 | - | - |
| b | -2.3970 | +1.0708 | -1.5679 | -1.5386 | - | - |
| 1963 | 566 | 570 | 608 | 600 | - | - |

Table 30. Chum lengths in Area 20 (Strait of Juan de Fuca). See Table 19 for details.

| | Age 0.1 | | Age 0.2 | | Age 0.3 | | Age 0.4 | |
|---|---|---|---|---|---|---|---|---|
| | M | F | M | F | M | F | M | F |
| 1958 | - | - | 560 | 547 | 596 | 559 | 618 | 640 |
| 1959 | - | - | 557 | 549 | 612 | 599 | 635 | 625 |
| 1960 | - | - | 563 | 563 | 601 | 595 | 616 | 610 |
| 1961 | - | - | 562 | 553 | 601 | 589 | 580 | 610 |
| 1962 | - | - | 599 | 588 | 630 | 610 | 643 | 655 |
| 1963 | - | - | 561 | 549 | 596 | 584 | 620 | - |
| 1964 | 496 | 466 | 563 | 558 | 624 | 612 | 645 | 623 |
| 1965 | - | - | 525 | 521 | 579 | 567 | 625 | 635 |
| 1966 | 429 | 503 | 552 | 550 | 590 | 578 | 599 | 583 |
| 1967 | - | - | 550 | 538 | 597 | 581 | 620 | 601 |
| 1968 | - | 455 | 568 | 559 | 596 | 583 | 617 | 593 |
| 1969 | - | 505 | 538 | 538 | 600 | 582 | 625 | 598 |
| 1970 | - | - | 548 | 542 | 575 | 571 | 684 | 568 |
| 1971 | - | - | 543 | 535 | 573 | 562 | 587 | 563 |
| 1972 | - | - | 562 | 543 | 590 | 574 | 610 | 618 |
| N | - | - | 15 | 15 | 15 | 15 | 15 | 14 |
| r | - | - | -0.357 | -0.415 | -0.544* | -0.388 | +0.033 | -0.644* |
| b | - | - | -1.3107 | -1.4071 | -1.9429 | -1.3786 | +0.1857 | -3.7192 |
| 1963 | - | - | 559 | 552 | 601 | 586 | 621 | 617 |

Table 31. Chum lengths in Areas 23, 25 and 26 (West coast of Vancouver Island). See Table 19 for details.

| | Age 0.2 | | Age 0.3 | | Age 0.4 | |
|---|---|---|---|---|---|---|
| | M | F | M | F | M | F |
| | Area 23 - Barkley Sound | | | | | |
| 1959 | 561 | 551 | 601 | 590 | 633 | 583 |
| 1960 | 554 | 552 | 576 | 571 | 570 | 570 |
| 1961 | 548 | 555 | 576 | 573 | 577 | 585 |
| 1962 | 604 | 606 | 642 | 634 | 610 | - |
| 1972 | 540 | 546 | 585 | 573 | 608 | 574 |
| N | 5 | 5 | 5 | 5 | 5 | 4 |
| r | -0.350 | -0.191 | -0.112 | -0.192 | +0.120 | -0.353 |
| b | -1.6661 | -0.9025 | -0.5866 | -0.9729 | +0.5921 | -0.4182 |
| 1963 | 561 | 562 | 596 | 588 | 600 | 578 |
| | Area 25 - Nootka | | | | | |
| 1959 | 539 | 548 | 576 | 582 | 625 | 617 |
| 1960 | 549 | 548 | 575 | 572 | - | - |
| 1961 | 556 | 544 | 583 | 578 | 571 | 568 |
| 1962 | 603 | 600 | 622 | 616 | 634 | 608 |
| 1963 | 550 | 545 | 584 | 580 | 620 | 570 |
| 1964 | 562 | - | 602 | - | - | - |
| | Area 26 - Kyuquot | | | | | |
| 1959 | 555 | 563 | 600 | 596 | 595 | - |
| 1960 | 555 | 549 | 578 | 573 | 600 | 580 |
| 1961 | 557 | 555 | 584 | 577 | 606 | 550 |
| 1962 | 597 | 604 | 635 | 625 | 637 | 625 |
| 1963 | 545 | 544 | 587 | 578 | 565 | - |

Table 32. Chum lengths in Area 29 (Fraser). See Table 19 for details.

| | Age 0.2 | | Age 0.3 | | Age 0.4 | |
|---|---|---|---|---|---|---|
| | M | F | M | F | M | F |
| 1957 | 568 | 550 | 622 | 590 | 651 | 606 |
| 1958 | 572 | 565 | 609 | 595 | 540 | 610 |
| 1959 | 576 | 564 | 624 | 609 | 613 | 600 |
| 1960 | 582 | 573 | 627 | 610 | 635 | 614 |
| 1961 | 571 | 573 | 616 | 598 | 638 | 605 |
| 1962 | 650 | 622 | 661 | 648 | 683 | 653 |
| 1963 | 566 | 559 | 616 | 599 | 646 | 590 |
| 1964 | 576 | 572 | 636 | 622 | 660 | 628 |
| 1965 | 524 | 566 | 595 | 581 | 607 | - |
| 1966 | 563 | 574 | 605 | 593 | 630 | 589 |
| 1967 | 567 | 566 | 617 | 604 | 633 | 617 |
| 1968 | 576 | 571 | 618 | 606 | 634 | 635 |
| 1969 | 558 | 547 | 612 | 606 | 628 | 632 |
| 1970 | 560 | 542 | 600 | 591 | 607 | 595 |
| 1971 | - | - | - | - | - | - |
| 1972 | 564 | - | 601 | 594 | 621 | 613 |
| N | 14 | 13 | 14 | 14 | 14 | 13 |
| r | -0.322 | -0.334 | -0.430 | -0.271 | +0.148 | +0.077 |
| b | -1.9728 | -2.2033 | -1.6876 | -1.0148 | +1.1047 | +0.3256 |
| 1963 | 575 | 566 | 620 | 606 | 625 | 613 |

Table 33. Trends in mean weight in pounds of chum salmon caught by two gears. N = number of years' data used; r = linear correlation coefficient; b = regression coefficient (lb/yr); 1951 and 1975 = computed sizes (lb) in the years indicated; change = computed change in size between 1951 and 1975 (lb). Weighted means are weighted as total 1951-75 landings in each Area, from Tables 4-6.

| | | Gillnet | | | | | | Seine | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Region | Area | N | r | b | 1951 | 1975 | Change | N | r | b | 1951 | 1975 | Change |
| Northern | 1 | 21 | -0.102 | -0.0155 | 10.10 | 9.73 | -0.37 | 22 | -0.262 | -0.0417 | 11.24 | 10.24 | -1.00 |
| | 3 | 25 | -0.127 | -0.0150 | 11.85 | 11.44 | -0.41 | 25 | -0.693** | -0.1113 | 14.21 | 11.54 | -2.67 |
| | 4 | 25 | -0.593** | -0.1155 | 14.58 | 11.81 | -2.77 | 14 | -0.565** | -0.1564 | 15.31 | 11.55 | -3.76 |
| Hecate | 2E | 24 | -0.269 | -0.0272 | 9.80 | 9.15 | -0.65 | 23 | -0.137 | -0.0193 | 9.93 | 9.47 | -0.46 |
| Strait | 5 | 25 | -0.176 | -0.0234 | 11.43 | 10.87 | -0.56 | 25 | -0.696** | -0.1746 | 15.33 | 11.14 | -4.19 |
| | 6 | 25 | -0.216 | -0.0317 | 11.83 | 11.07 | -0.76 | 25 | -0.341 | -0.0667 | 13.95 | 12.35 | -1.60 |
| Central | 7 | 25 | -0.025 | -0.0033 | 10.31 | 10.23 | -0.08 | 25 | -0.255 | -0.0489 | 12.13 | 10.96 | -1.17 |
| | 8 | 25 | -0.295 | -0.0450 | 13.17 | 12.09 | -1.08 | 25 | -0.492* | -0.1244 | 15.19 | 12.20 | -2.99 |
| | 9 | 25 | -0.456* | -0.1034 | 14.63 | 12.15 | -2.48 | 20 | -0.405 | -0.1156 | 15.84 | 13.07 | -2.77 |
| | 10 | 25 | -0.155 | -0.0212 | 12.05 | 11.54 | -0.51 | 15 | -0.636* | -0.0663 | 12.21 | 10.62 | -1.59 |
| | 11 | 25 | -0.231 | -0.0308 | 11.01 | 10.27 | -0.74 | 6 | +0.531 | +0.0590 | 9.72 | 11.14 | +1.42 |
| Johnstone | 12 | 25 | -0.321 | -0.0283 | 11.68 | 11.00 | -0.68 | 25 | -0.383 | -0.0430 | 12.04 | 11.01 | -1.03 |
| Strait | 13 | 25 | -0.379 | -0.0442 | 11.64 | 10.58 | -1.06 | 25 | -0.304 | -0.0318 | 11.49 | 10.73 | -0.76 |
| S. Georgia | 17 | 19 | -0.330 | -0.0322 | 11.00 | 10.23 | -0.77 | 14 | -0.033 | -0.0029 | 11.02 | 10.95 | -0.07 |
| and Juan | 18 | 19 | +0.003 | +0.0006 | 11.25 | 11.26 | +0.01 | 18 | +0.007 | +0.0006 | 11.20 | 11.21 | +0.01 |
| de Fuca Str. | 20 | 24 | -0.206 | -0.0194 | 10.71 | 10.24 | -0.47 | 25 | -0.683** | -0.1757 | 13.96 | 9.74 | -4.22 |
| Fraser | 29A+B | 25 | -0.530** | -0.0635 | 12.54 | 11.02 | -1.52 | - | | | | | |
| West coast | 23 | 17 | -0.218 | -0.0158 | 10.43 | 10.05 | -0.38 | 17 | -0.239 | -0.0281 | 10.82 | 10.15 | -0.67 |
| of Vancouver | 24 | 12 | -0.359 | -0.0715 | 10.45 | 8.73 | -1.72 | 15 | -0.309 | -0.0459 | 10.60 | 9.50 | -1.10 |
| Island | 25 | 19 | -0.247 | -0.0236 | 10.80 | 10.23 | -0.57 | 21 | +0.054 | +0.0064 | 10.50 | 10.65 | +0.15 |
| | 26 | 13 | +0.082 | +0.0066 | 10.17 | 10.33 | +0.16 | 17 | +0.066 | +0.0072 | 10.49 | 10.66 | +0.17 |
| | 27 | 19 | +0.498* | +0.0730 | 9.86 | 11.61 | +1.75 | 12 | +0.345 | +0.0452 | 9.98 | 11.06 | +1.08 |
| Mean | | | | -0.0296 | 11.42 | 10.71 | -0.71 | | | -0.0540 | 12.21 | 10.96 | -1.30 |
| Weighted mean | | | | -0.0318 | | | -0.76 | | | -0.0634 | | | -1.52 |

Table 34. Mean whole weight in pounds (W) of chum salmon caught in 8 Areas of Alaska, and residuals (R) from their regression on time. PWS = Prince William Sound, Copper and Bering Rivers; Cook = Cook Inlet; Kod = Kodiak; Chig = Chignik; AP = Alaska Peninsula and Aleutian Islands; BB = Bristol Bay, AYK = Arctic area and the Yukon and Kuskokwim Rivers. r = linear correlation coefficient; b = regression coefficient (lb/yr); 1963 = computed weight in 1963.

| | South-eastern | | Central | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | PWS | | Cook | | Kod | |
| | W | R | W | R | W | R | W | R |
| 1960 | 10.1 | +0.28 | 8.0 | +0.13 | 6.7 | -1.04 | 6.8 | -1.25 |
| 1961 | 9.4 | -0.35 | 7.8 | -0.16 | 7.3 | -0.41 | 9.6 | +1.58 |
| 1962 | 9.5 | -0.18 | 7.3 | -0.72 | 8.0 | +0.32 | 8.0 | +0.01 |
| 1963 | 8.8 | -0.81 | 9.3 | +1.21 | 7.2 | -0.44 | 7.2 | -0.76 |
| 1964 | 10.1 | +0.56 | 8.8 | +0.63 | 8.4 | +0.79 | 8.4 | +0.46 |
| 1965 | 10.2 | +0.73 | 7.5 | -0.74 | 8.7 | +1.13 | 8.2 | +0.29 |
| 1966 | 8.6 | -0.80 | 8.6 | +0.29 | 7.5 | -0.04 | 7.7 | -0.18 |
| 1967 | 9.6 | +0.27 | 8.3 | -0.09 | 8.1 | +0.59 | 8.2 | +0.34 |
| 1968 | 10.9 | +1.64 | 7.4 | -1.06 | 8.3 | +0.83 | 8.1 | +0.27 |
| 1969 | 9.2 | +0.01 | 8.5 | -0.03 | 7.3 | -0.14 | 7.8 | 0. |
| 1970 | 8.4 | -0.72 | 8.2 | -0.41 | 7.1 | -0.31 | 7.1 | -0.68 |
| 1971 | 7.8 | -1.25 | 9.2 | +0.52 | 6.3 | -1.07 | 6.8 | -0.95 |
| 1972 | 8.8 | -0.18 | 8.7 | -0.05 | 6.9 | -0.44 | 7.9 | +0.18 |
| 1973 | 9.7 | +0.79 | 9.6 | +0.75 | 7.4 | +0.10 | 8.4 | +0.70 |
| 1974 | 8.8 | -0.04 | 8.6 | -0.30 | 7.4 | +0.13 | - | - |
| N | 15 | | 15 | | 15 | | 14 | |
| r | -0.385 | | +0.471 | | -0.226 | | -0.151 | |
| b | -0.0700 | | +0.0736 | | -0.0339 | | -0.0268 | |
| 1963 | 9.61 | | 8.09 | | 7.64 | | 7.97 | |

Table 34 (cont'd)

| | Central | | Western | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Chig | | AP | | BB | | AYK | |
| | W | R | W | R | W | R | W | R |
| 1960 | 6.5 | -0.84 | 6.8 | +0.01 | 6.2 | -0.50 | - | - |
| 1961 | 7.0 | -0.34 | 6.8 | -0.01 | 6.9 | +0.21 | - | - |
| 1962 | 7.2 | -0.13 | 7.1 | +0.26 | 6.8 | +0.11 | 6.7 | -0.04 |
| 1963 | 7.2 | -0.13 | 6.4 | -0.46 | 6.3 | -0.38 | 6.1 | -0.68 |
| 1964 | 8.8 | +1.47 | 7.7 | +0.82 | 7.1 | +0.43 | 6.9 | +0.04 |
| 1965 | 7.5 | +0.17 | 6.5 | -0.40 | 7.0 | +0.33 | 6.3 | -0.60 |
| 1966 | 7.5 | +0.18 | 6.6 | -0.33 | 7.5 | +0.84 | 8.0 | +1.06 |
| 1967 | 8.3 | +0.98 | 7.4 | +0.46 | 6.8 | +0.15 | 7.6 | +0.62 |
| 1968 | - | - | - | - | 6.3 | -0.35 | 7.7 | +0.66 |
| 1969 | 6.8 | -0.52 | - | - | 6.2 | -0.44 | 6.6 | -0.49 |
| 1970 | 6.9 | -0.41 | 6.0 | -1.01 | 5.9 | -0.73 | 7.0 | -0.11 |
| 1971 | 6.7 | -0.61 | 6.8 | -0.24 | 6.3 | -0.33 | 6.6 | -0.60 |
| 1972 | 7.6 | +0.29 | 7.3 | +0.22 | 6.6 | -0.02 | 7.6 | +0.35 |
| 1973 | 7.4 | +0.09 | 7.4 | +0.33 | 7.0 | +0.39 | 7.5 | +0.22 |
| 1974 | 7.1 | -0.20 | 7.3 | +0.22 | 6.9 | +0.29 | 6.9 | -0.44 |
| N | 14 | | 13 | | 15 | | 13 | |
| r | -0.018 | | +0.213 | | -0.069 | | +0.313 | |
| b | -0.0024 | | +0. | | -0.0068 | | +0.0472 | |
| 1963 | 7.33 | | 6.86 | | 6.68 | | 6.80 | |

Table 35. Correlations between total landings and mean weight of chum salmon in 7 Areas.

| Area | Gillnets | | Seines | |
|---|---|---|---|---|
| | N | r | N | r |
| 1 | 23 | +0.428* | 25 | +0.030 |
| 3 | 25 | +0.122 | 25 | +0.140 |
| 4 | 25 | +0.333 | 14 | +0.320 |
| 7 | 25 | +0.329 | 25 | +0.128 |
| 8 | 25 | +0.130 | 25 | +0.081 |
| 25 | 19 | +0.406 | 21 | +0.290 |
| 29A+B | 25 | +0.559** | - | - |

Table 36. Approximate computation of strengths of year-classes of chum salmon in Districts 1 and 3 combined, and comparison with size estimates. See the text for details.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|
| | Catch at age, $10^4$ lb | | | Total catch | Mean length at age, mm | | Year of age | Mean wt that yr | Total catch that yr |
| Year-class | 0.2 | 0.3 | 0.4 | $10^4$ lb | 0.2 | 0.3 | 0.3 | lb | $10^4$ lb |
| 1953 | ? | 740 | 19 | ? | - | - | 1957 | 12.12 | 1061 |
| 1954 | 275 | 926 | 23 | 1224 | - | 600 | 1958 | 12.16 | 2100 |
| 1955 | 1155 | 1135 | 10 | 2300 | 568 | 612 | 1959 | 11.38 | 1762 |
| 1956 | 604 | 611 | 13 | 1228 | 564 | 609 | 1960 | 10.59 | 1164 |
| 1957 | 542 | 538 | 10 | 1090 | 571 | 608 | 1961 | 12.06 | 644 |
| 1958 | 92 | 96 | 3 | 191 | 576 | 638 | 1962 | 11.52 | 461 |
| 1959 | 355 | 310 | 14 | 679 | 615 | 601 | 1963 | 11.43 | 502 |
| 1960 | 190 | 227 | 3 | 420 | 557 | 618 | 1964 | 12.41 | 335 |
| 1961 | 94 | 54 | 4 | 152 | 568 | 580 | 1965 | 10.25 | 63 |
| 1962 | 6 | 72 | 8 | 86 | (536) | (600) | 1966 | 11.71 | 104 |
| 1963 | 27 | 132 | 7 | 166 | (570) | 602 | 1967 | 10.85 | 250 |
| 1964 | 110 | 837 | 27 | 974 | 556 | 602 | 1968 | 11.78 | 1048 |
| 1965 | 202 | 424 | 10 | 636 | 570 | 604 | 1969 | 11.14 | 688 |
| 1966 | 237 | 1118 | 32 | 1387 | 554 | 584 | 1970 | 10.63 | 1279 |
| 1967 | 151 | 108 | 46 | 305 | 551 | (578) | 1971 | 9.15 | 235 |
| 1968 | 95 | 3649 | ? | 3744+ | (545) | 591 | 1972 | 11.02 | 3874 |
| 1969 | 178 | 3800± | ? | 4000± | (552) | - | 1973 | 11.83 | 4135 |
| 1970 | - | - | - | - | - | - | 1974 | 11.70 | 533 |
| 1971 | - | - | - | - | - | - | 1975 | 10.32 | 730 |
| N | - | - | - | - | 15 | 15 | - | 16* | - |
| r | - | - | - | - | -0.486 | -0.557* | - | -0.360 | - |
| b | - | - | - | - | -1.9607 | -1.9000 | - | -0.0624 | - |
| 1963 | - | - | - | - | 561.6 | 598.0 | - | 11.1514 | - |

*1957, 1974 and 1975 are omitted.

Table 37. Column 2: year-class weights from Table 36. Columns 3 and 4: residuals from the regression on time of the mean lengths of the year-class at ages 0.2 and 0.3. At the foot of the table are correlations and regressions of columns 3 and 4 on column 2.

| 1 | 2 | 3 | 4 |
|---|---|---|---|
| Year-class | Year-class weight $10^4$ lb | Residuals of lengths, mm | |
| | | Age 0.2 | Age 0.3 |
| 1954 | 1224 | - | -15 |
| 1955 | 2300 | -9 | -1 |
| 1956 | 1228 | -11 | -3 |
| 1957 | 1090 | -2 | -2 |
| 1958 | 191 | +5 | +30 |
| 1959 | 679 | +46 | -5 |
| 1960 | 420 | -10 | +14 |
| 1961 | 152 | +3 | -22 |
| 1962 | 86 | -27 | 0 |
| 1963 | 166 | +8 | +4 |
| 1964 | 974 | -4 | +6 |
| 1965 | 636 | +12 | +10 |
| 1966 | 1387 | -2 | -9 |
| 1967 | 305 | -3 | -13 |
| 1968 | 3744± | -7 | +2 |
| 1969 | 4000± | +2 | - |
| N | - | 15 | 15 |
| r | - | -0.102 | -0.080 |
| b | - | -0.001283 | -0.001031 |
| a | - | +1.55 | +0.74 |

Table 38. Correlations between mean weight (D) or residuals of mean weight (R) of British Columbia chum salmon and the total weight of salmon landed of all species, 1951-75.

| Period | Canadian landings 1951-75 | Canadian and United States landings 1952-74 |
|---|---|---|
| N | 25 | 23 |
| Northern (2) | | |
| D | +0.214 | - |
| R | +0.185 | -0.035 |
| Southern (3) | | |
| D | +0.130 | - |
| R | +0.291 | +0.341 |
| Fraser (1) | | |
| D | +0.255 | - |
| R | +0.240 | +0.110 |

Table 39. Correlations (r) and functional regressions (v, in lb per degree C) between residuals of mean weight of chum salmon and residuals of August through July mean surface temperatures at four stations. Correlations are with temperature series ending in the same year (S), the previous year (P) and the year before that (A). There are 25 comparisons for Langara and Amphitrite, 24 for Cape St. James and Station P.

| | Northern (2) | | Southern (3) | | Fraser (1) | |
|---|---|---|---|---|---|---|
| | r | v | r | v | r | v |
| Langara | | | | | | |
| S | +0.031 | +0.47 | +0.164 | +0.78 | +0.090 | +0.67 |
| P | -0.054 | -2.11 | -0.038 | -1.27 | -0.091 | -1.46 |
| A | -0.346 | -2.04 | -0.334 | -1.23 | -0.336 | -1.42 |
| Cape St. James | | | | | | |
| S | +0.026 | +0.43 | +0.246 | +0.72 | +0.193 | +0.63 |
| P | -0.086 | -2.04 | -0.145 | -1.33 | -0.156 | -1.53 |
| A | -0.359 | -2.10 | -0.239 | -1.26 | -0.258 | -1.48 |
| Amphitrite | | | | | | |
| S | +0.145 | +0.48 | +0.236 | +0.79 | +0.158 | +0.69 |
| P | -0.012 | -1.96 | -0.051 | -1.18 | -0.081 | -1.35 |
| A | -0.233 | -1.86 | -0.316 | -1.12 | -0.262 | -1.29 |
| Station P | | | | | | |
| S | +0.325 | +2.37 | +0.030 | +1.43 | -0.131 | -1.62 |
| P | +0.133 | +2.34 | -0.101 | -1.41 | -0.001 | -1.63 |
| A | -0.108 | -2.34 | -0.150 | -1.41 | -0.220 | -1.62 |

Table 40. Correlations between residuals of surface temperature (August-July mean) at three stations and residuals of weights of chum salmon in 8 Alaska areas during 1960-74. Symbols are as in Table 34.

| | South-eastern | Central | | | | Western | | |
|---|---|---|---|---|---|---|---|---|
| | | PWS | Cook | Kodiak | Chignik | AP | BB | AYK |
| N | 15 | 15 | 15 | 15 | 14 | 13 | 15 | 13 |
| Langara | | | | | | | | |
| S | +0.151 | +0.212 | +0.023 | +0.004 | +0.013 | -0.123 | -0.255 | -0.001 |
| P | -0.058 | -0.280 | +0.307 | +0.202 | +0.124 | +0.090 | +0.013 | -0.508 |
| A | -0.185 | -0.051 | -0.226 | -0.676** | -0.265 | -0.493 | -0.279 | -0.016 |
| Cape St. James | | | | | | | | |
| S | -0.023 | +0.353 | +0.078 | +0.077 | +0.227 | +0.083 | -0.025 | +0.172 |
| P | -0.145 | -0.373 | +0.254 | -0.149 | +0.095 | +0.119 | -0.183 | -0.375 |
| A | -0.147 | -0.067 | -0.190 | -0.202 | -0.284 | -0.547 | -0.140 | +0.116 |
| Station P | | | | | | | | |
| S | +0.019 | +0.181 | -0.050 | -0.040 | -0.016 | +0.053 | +0.170 | +0.333 |
| P | +0.138 | +0.321 | +0.058 | +0.634* | +0.250 | +0.465 | +0.087 | -0.211 |
| A | +0.448 | -0.317 | +0.124 | -0.004 | -0.068 | +0.108 | -0.143 | +0.080 |

Table 41. Mean rate of change in size with temperature, computed as the mean of the S, P and A regressions in Table 39, and the corresponding size change in pounds per year, for the British Columbia statistical Districts. v = means of three regressions in Table 39; z = those means multiplied by the rate of change in temperature shown in column 2.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|
| | Temperature change[a] °C/yr | Northern (2) | | Southern (3) | | Fraser (1) | |
| | | v lb/°C | z lb/yr | v lb/°C | z lb/yr | v lb/°C | z lb/yr |
| Langara | -0.01305 | -1.228 | +0.0160 | -0.576 | +0.0075 | -0.734 | +0.0096 |
| Cape St. James | -0.01182 | -1.239 | +0.0146 | -0.622 | +0.0074 | -0.792 | +0.0094 |
| Amphitrite | -0.00307 | -1.112 | +0.0034 | -0.500 | +0.0015 | -0.650 | +0.0020 |
| Station P | -0.01960 | +0.790 | -0.0155 | -0.463 | +0.0091 | -1.623 | +0.0318 |
| Mean | | | +0.0012 | | +0.0046 | | +0.0110 |
| Actual change | | | -0.1042 | | -0.0360 | | -0.0599 |

[a]Rates of change correspond to the temperature series used to calculate the temperature residuals. For Station P they are from the bottom panel of Table 17 of Ricker et al. (1978); for the other stations they are from the top panel of that Table.

Table 42. Mean rate of change in size with temperature, from the S lines of Table 39, and the corresponding size change in pounds per year, for the British Columbia statistical Districts. v = regressions from the S lines of Table 39; z = those regressions multiplied by the rate of change in temperature shown in column 2.

| | Temperature change °C/yr | Northern (2) | | Southern (3) | | Fraser (1) | |
|---|---|---|---|---|---|---|---|
| | | v lb/°C | z lb/yr | v lb/°C | z lb/yr | v lb/°C | z lb/yr |
| Langara | -0.01305 | +0.47 | -0.0061 | +0.78 | -0.0102 | +0.67 | -0.0087 |
| Cape St. James | -0.01182 | +0.43 | -0.0051 | +0.72 | -0.0085 | +0.63 | -0.0074 |
| Amphitrite | -0.00307 | +0.48 | -0.0015 | +0.79 | -0.0024 | +0.69 | -0.0021 |
| Station P | -0.01960 | +2.37 | -0.0465 | +1.43 | -0.0280 | -1.62 | +0.0318 |
| Mean | | | -0.0148 | | -0.0123 | | +0.0034 |
| Actual change | | | -0.1042 | | -0.0360 | | -0.0599 |

Table 43. Mean difference in weight between seined and gillnetted chums, 1951-75, from Table 12, and calculated rates of increase in age, 1957-72, from Table 8. The means are weighted as the number of millions of pounds of chums caught in each Area in 1951-75, from Tables 4-6.

| Northern District | | | Fraser-related Areas | | | Other Southern Areas | | |
|---|---|---|---|---|---|---|---|---|
| Area | Weight difference (lb) | Rate of increase (yr/yr) | Area | Weight difference (lb) | Rate of increase (yr/yr) | Area | Weight difference (lb) | Rate of increase (yr/yr) |
| 1 | 0.82 | - | 12 | 0.18 | 0.0180 | 17 | 0.37 | - |
| 2E | 0.22 | - | 13 | -0.01 | 0.0156 | 18 | -0.06 | 0.0405 |
| 3 | 1.18 | 0.0093 | 20 | 0.37 | 0.0298 | 23 | 0.24 | 0.0318 |
| 4 | 0.23 | 0.0104 | 29 | - | 0.0191 | 24 | 0.47 | - |
| 5 | 2.09 | 0.0171 | - | - | - | 25 | 0.06 | - |
| 6 | 1.71 | 0.0281 | - | - | - | 26 | 0.34 | - |
| 7 | 1.26 | 0.0116 | - | - | - | 27 | -0.22 | - |
| 8 | 1.06 | 0.0167 | - | - | - | - | - | - |
| 9 | 1.08 | 0.0259 | - | - | - | - | - | - |
| 10 | -0.38 | 0.0379 | - | - | - | - | - | - |
| Weighted means | 1.12 | 0.0168 | - | 0.11 | 0.0179 | - | 0.18 | 0.0340 |

Table 44. Example of a chum salmon stock fished selectively by gillnets whose catch averages 1.12 lb less than the original unfished stock and where the spawners are 0.21 yr older than the original stock.

| | Age | | | Total | Mean weight | Mean age |
|---|---|---|---|---|---|---|
| | 0.2 | 0.3 | 0.4 | | | |
| Original weights | 12 lb | 15 lb | 17 lb | | | |
| Original frequency | 300 | 600 | 100 | 1,000 | 14.30 lb | 2.80 yr |
| Rate of exploitation by gillnets | 70% | 25% | 5% | | | |
| Gillnet catch | 210 | 150 | 5 | 365 | | |
| Gillnet weights | 11.95 lb | 14.8 lb | 16.3 lb | | 13.18 lb | |
| Spawners | 90 | 450 | 95 | 635 | | 3.01 yr |
| Change | - | - | - | - | -1.12 lb | +0.21 yr |

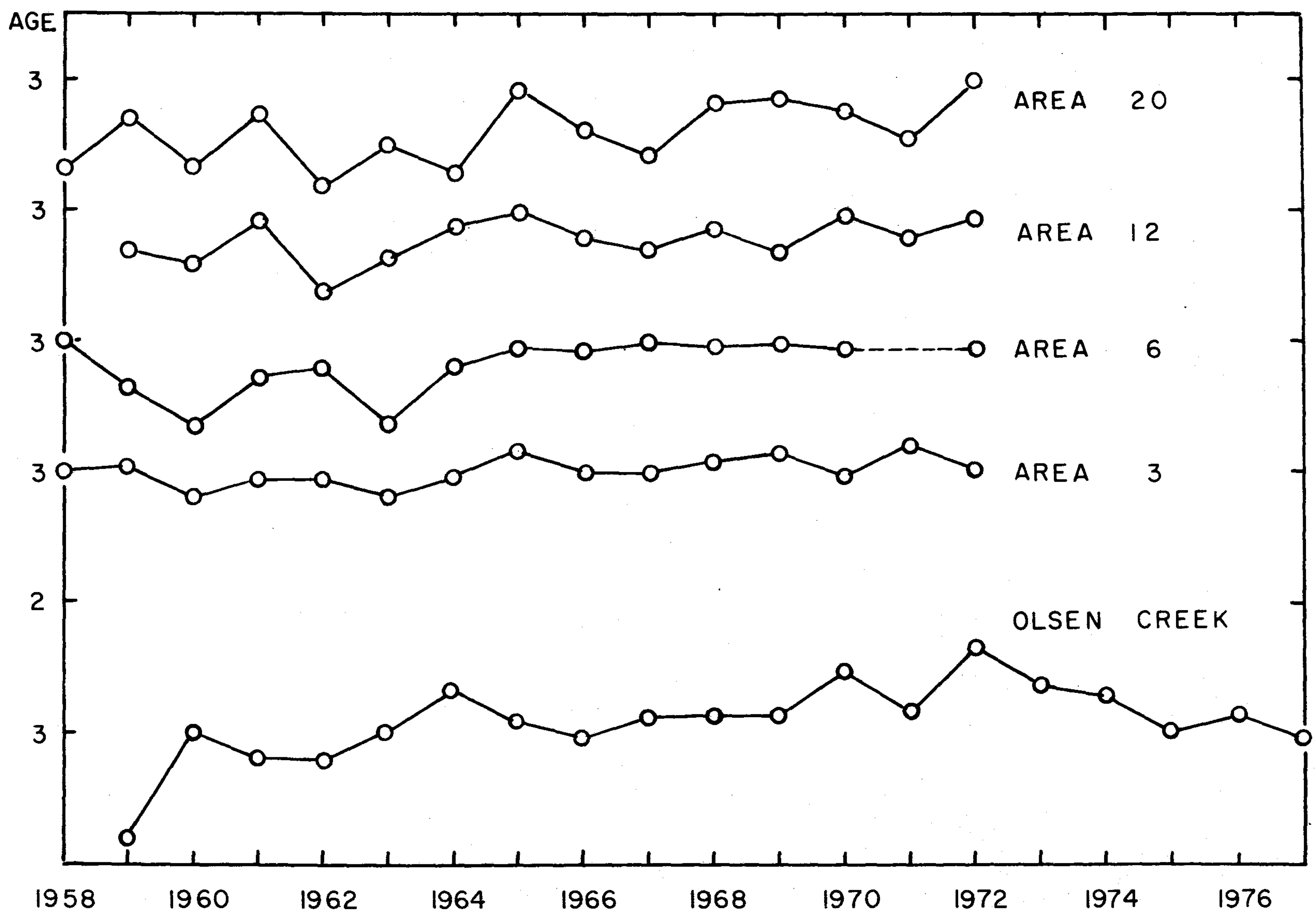


Fig. 1. Mean age (number of scale annuli completed) of chum salmon spawners at Olsen Creek, Alaska, and of the catch in four British Columbia statistical Areas.

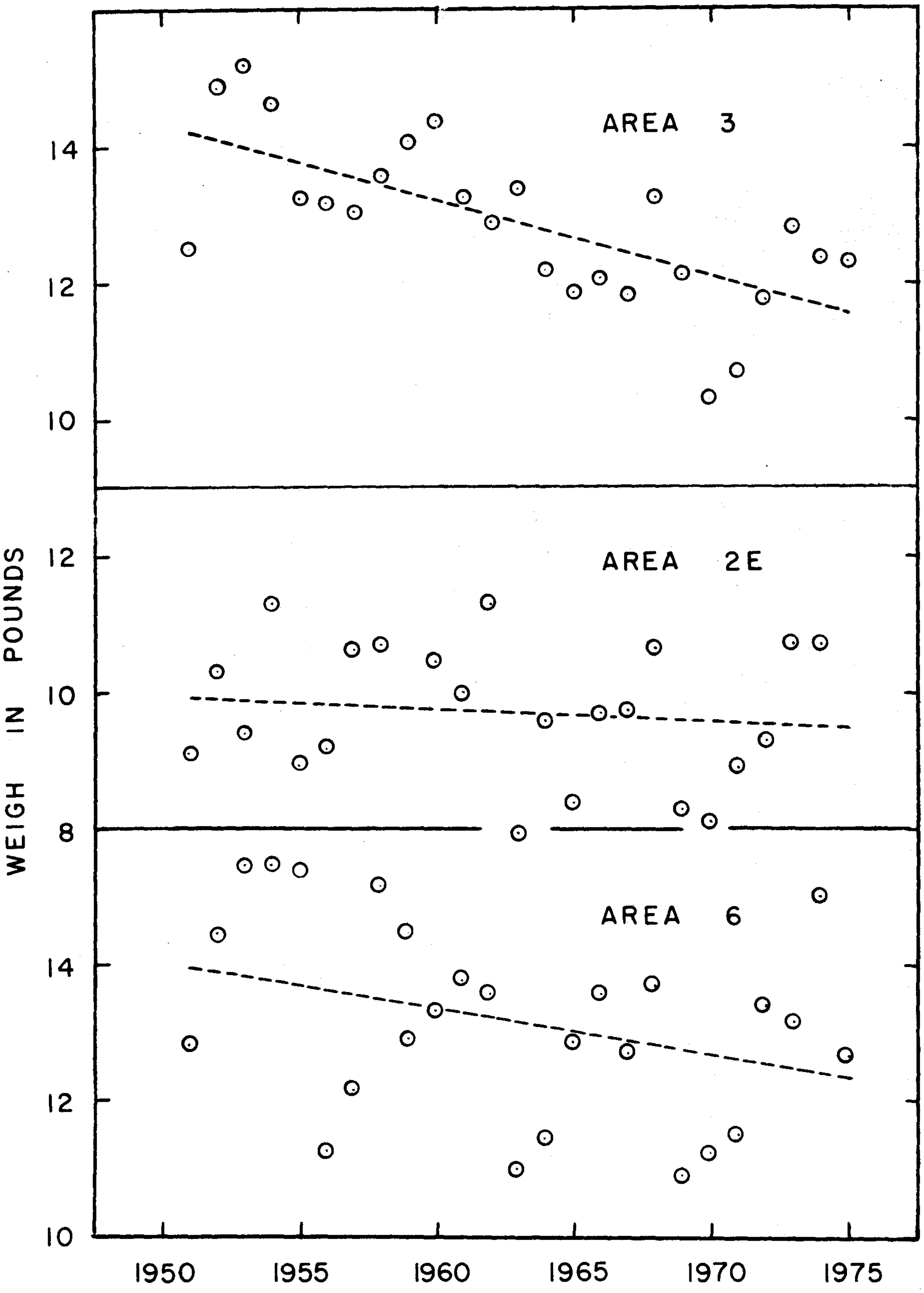


Fig. 2. Mean weights of chum salmon caught by seine in British Columbia statistical Areas 3, 2E, and 6.

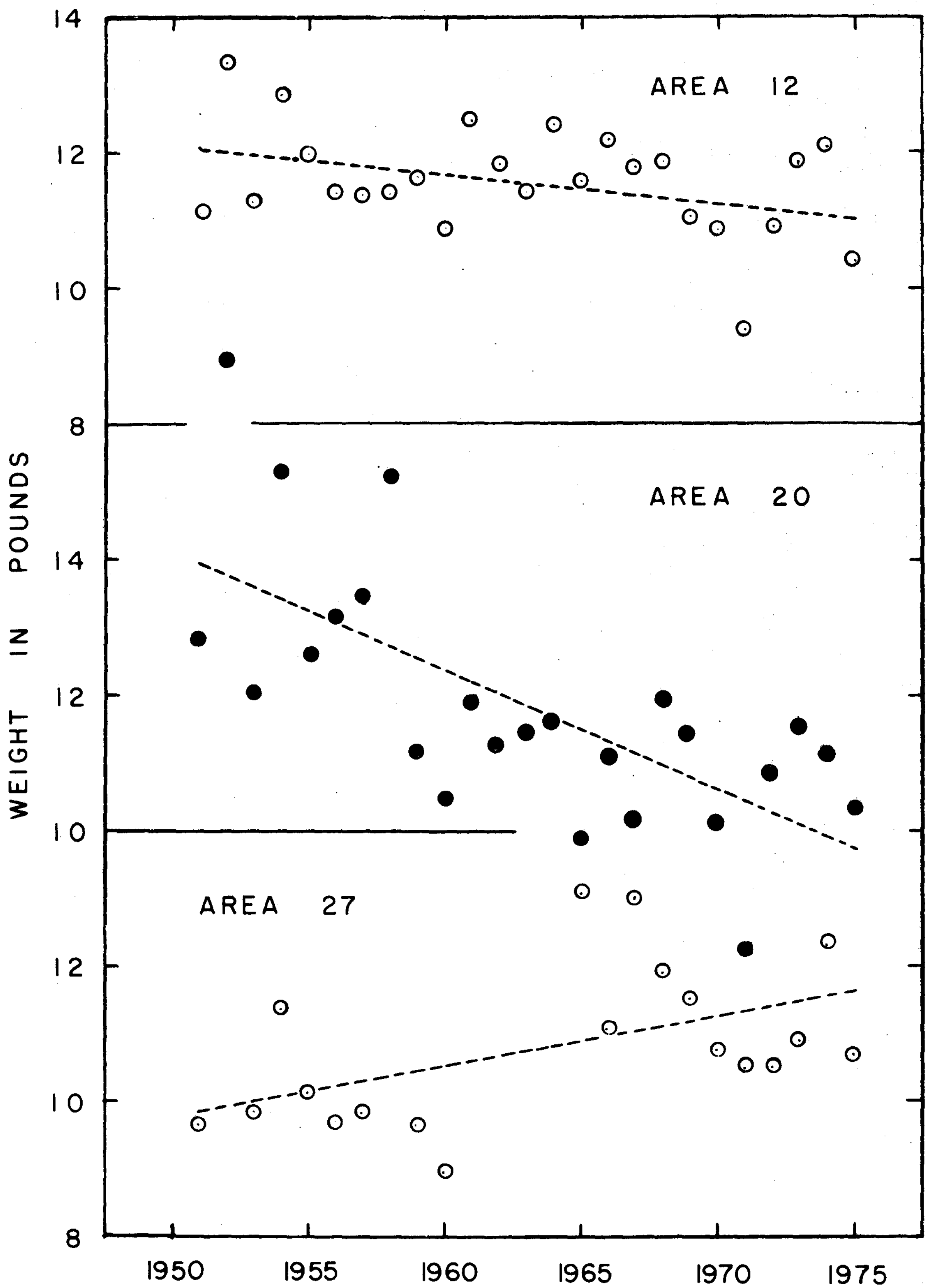


Fig. 3. Mean weights of chum salmon caught by seine in Areas 12 and 20, and of those caught by gillnet in Area 27.

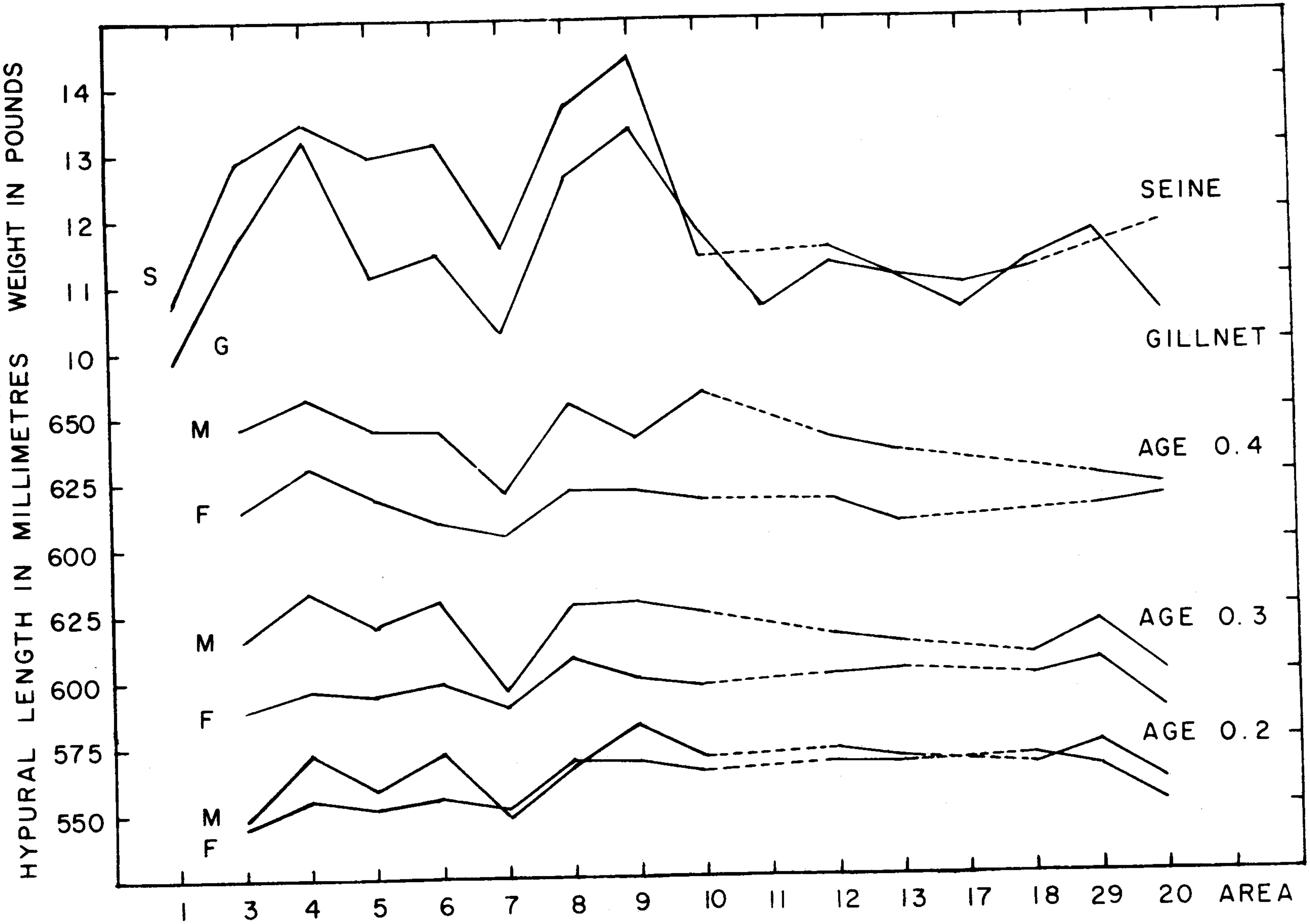


Fig. 4. Mean computed 1963 weights and lengths of chum salmon caught in British Columbia statistical Areas, arranged from north to south.

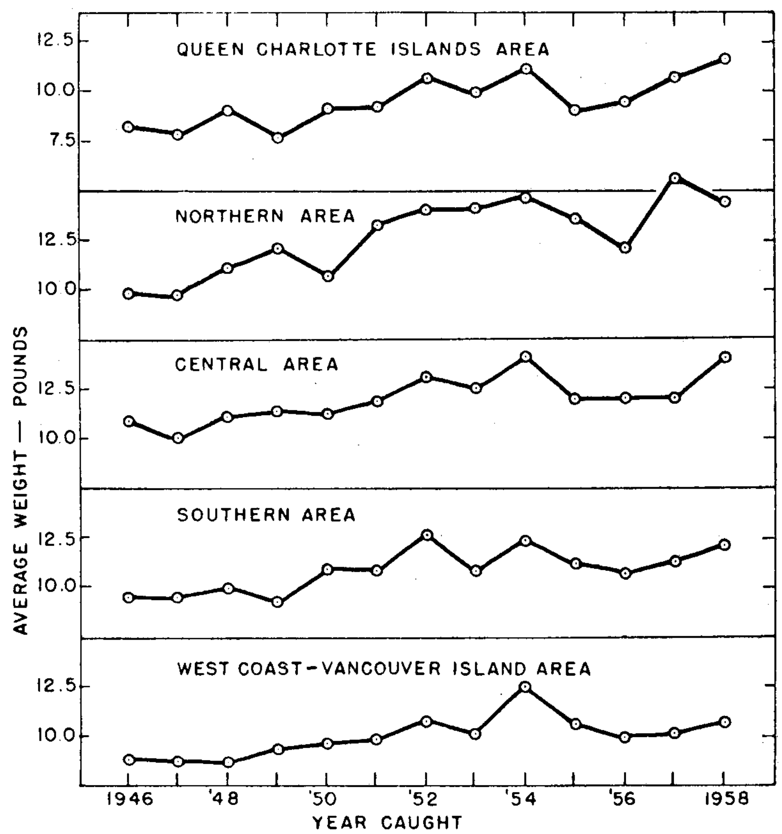


Fig. 5. Mean weights of chum salmon in five British Columbia regions, from Fisheries Association samples. See the text for the geographical limits of the regions. From Godfrey (1959b).

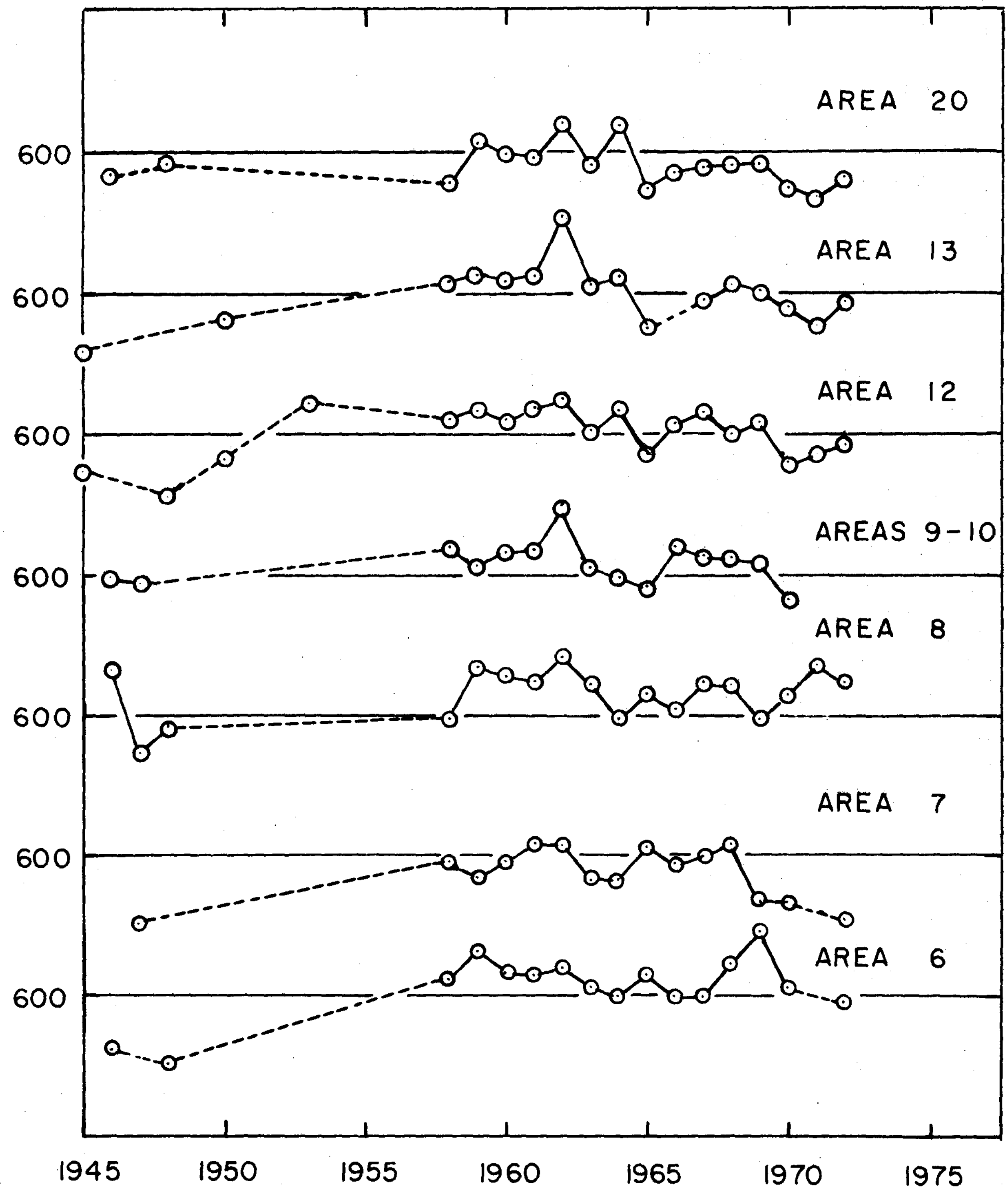


Fig. 6. Mean postorbital-hypural lengths of chum salmon of age 0.3 in seven Areas where observations were made sometime during 1945-53. The ordinate interval is 100 mm.

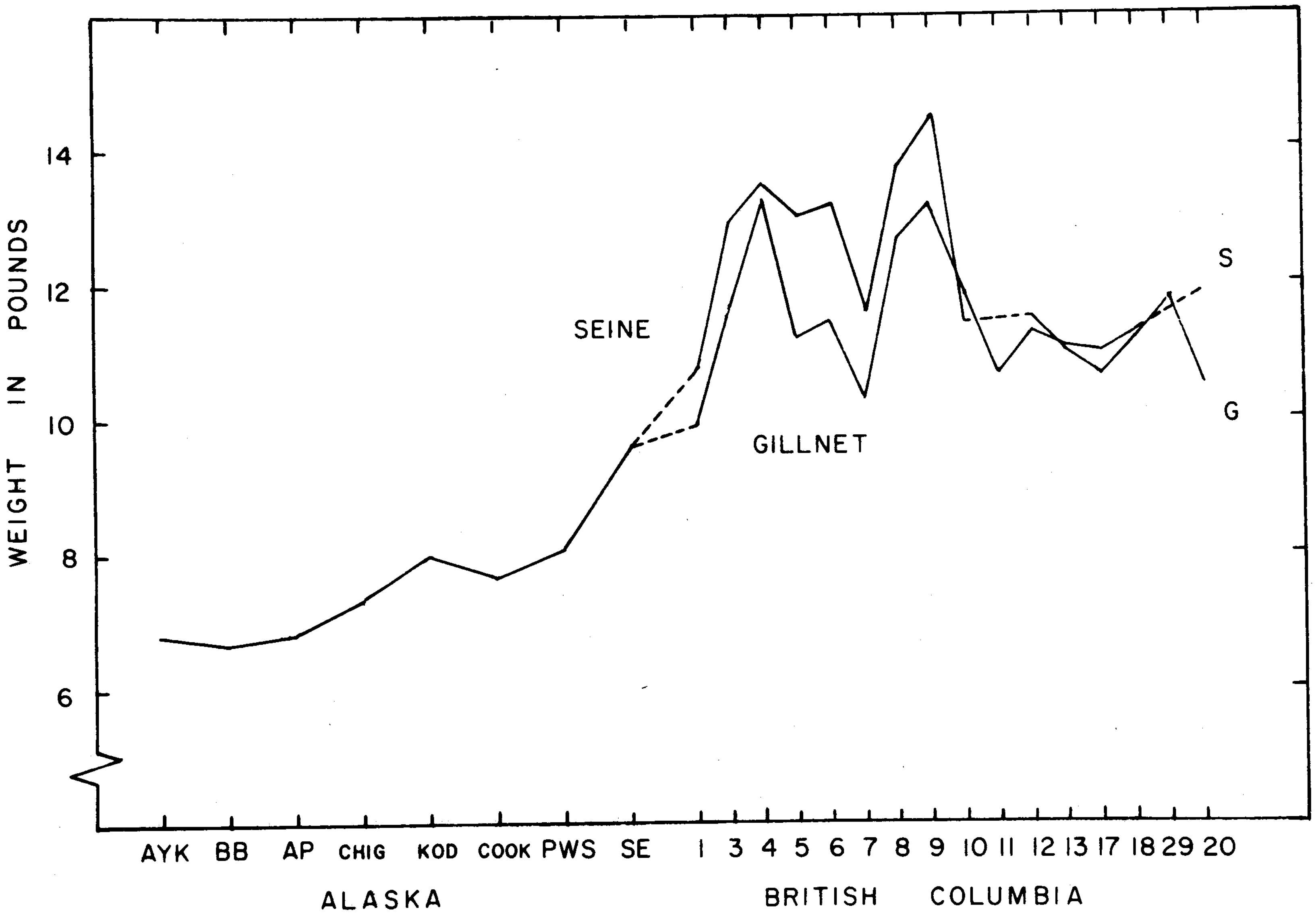


Fig. 7. Computed mean weight of chum salmon in 1963 in statistical Regions and Areas of Alaska and British Columbia, arranged from northwest to southeast. See Table 34 for identification of the Alaska Regions.