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CATCH, ESCAPEMENT AND STOCK-RECRUITMENT FOR BRITISH COLUMBIA CHINOOK SALMON SINCE 1951

by

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ABSTRACT

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British Columbia stocks of chinook salmon are believed to be overexploited. This report describes historic changes in catch and spawning escapement of B.C. chinook, and derives a stock-recruitment relationship from these data. Coastwide catch of B.C. chinook has increased about two times since 1951. Landings by trollers, seiners and sportsmen have all increased while landings by gillnetters have decreased. The areas of concentration of fishing effort for each gear have not changed greatly since 1951. The average age composition of the catch has not changed greatly since 1951. The average size of chinook in the catch has, however, decreased. Escapement to all spawning populations has declined about 50% since 1951. All regions of the coast, and all sizes of spawning population have shown similar declines except the Fraser River. Escapement to the Fraser has remained relatively constant, largely due to curtailment of the rivermouth gillnet catch. Stock and recruitment analysis shows that B.C. chinook stocks are overexploited, but that this is a recent phenomenon. Optimum escapement for B.C. chinook is in the range 200-250 thousand.

Key words: chinook salmon, catch, escapement, stock-recruitment

RÉSUMÉ

Healey, M. C. 1982. Catch, escapement and stock-recruitment for British Columbia chinook salmon since 1951. Can. Tech. Rep. Fish. Aquat. Sci. 1107: iv + 77 p.

On croit que les stocks de saumons quinnats de la Colombie-Britannique sont surexploités. Le présent rapport décrit les variations des prises et du nombre de saumons quinnats de remonte en Columbie-Britannique pendant les vingt dernières années et montre la relation stock-recrutement tirée de ces données. Les prises effectuées sur toute la côte de la Colombie-Britannique ont presque doublé depuis 1951. Les débarquements des pêcheurs à la traîne, à la seine et des pêcheurs sportifs ont augmenté tandis que ceux des pêcheurs au filet maillant ont diminué. Les zones de concentration de l'effort de pêche pour chaque engin n'ont pas beaucoup changé depuis 1951. La composition par âge moyen des prises n'a guère varié depuis 1951, mais la longueur moyenne a diminué. Le nombre de saumons de remonte a baissé d'environ 50% depuis cette date. Toutes les régions de la côte et toutes les populations reproductrices accusent une baisse semblable, sauf le Fraser. Le nombre de saumons de remonte dans ce fleuve est demeuré relativement constant, surtout par suite de la réduction des prises aux filets maillants à l'embouchure. L'analyse des stocks et du recrutement démontre que les stocks de saumons quinnats de la Colombie-Britannique sont surexploités, mais que le phénomène est récent. Le nombre optimal de saumons de remonte pour le saumon quinnat de la C.-B. varie de 200 000 à 250 000.

Mots-clés: saumon quinnat, prise, saumon de remonte, relation stock-recrutement.

INTRODUCTION

The chinook salmon (Oncorhynchus tshawytscha) is the least abundant of the five species of Pacific salmon on the North American coast. Nevertheless, chinook make a substantial contribution to sport and commercial fisheries all along the coast. Recent dramatic expansion of the British Columbia (B.C.) sport and troll fisheries for chinook coupled with declines in their spawning escapement have aroused concern that B.C. chinook are severely overexploited. Yet, an analytical basis for overexploitation has not been clearly stated.

Since 1951 systematic records have been kept of annual catch and spawning escapement of B.C.'s chinook salmon stocks. Information has also been collected, from time to time, on age and size composition of catch and escapement. More recently, information has been gathered on stock composition of U.S. and Canadian fisheries. The purpose of this report is, by means of this information, to describe historical changes in the B.C. fishery for chinook and the stocks which support it, to derive a stock-recruitment relationship for B.C. chinook, and to assess the degree of overexploitation of B.C. chinook.

SOURCES OF INFORMATION

Catch by Canadian commercial fishermen was taken from the summaries of B.C. catch statistics for 1951-1979 published by the Economics Branch of the Department of Fisheries and Oceans. These publications record catch for each gear (troll, gillnet, seine, and for the early 1950s, traps) for each statistical month in each of 32 areas of the coast (Fig. 1). Statistical months correspond approximately to calendar months but are of exactly 4 or 5 wk duration. Data come from sales slips made out at the time fish are landed and sold. There are several problems with these data. The date the fish are landed is recorded rather than the date of capture. For gillnetters and seiners, which land their fish regularly, the difference is small. But for trollers, which may accumulate their catch for several days or weeks before landing, the difference can change the statistical month of capture. As trollers have become more sophisticated, the average length of their trips has increased. Currently ice boats stay at sea about 12 days, while freezer boats can stay out as long as 60 days between landings. Thus the accuracy of timing of catch data for trollers is poor. Trollers on an extended trip may also fish in several statistical areas, yet normally only one is recorded in the catch statistics. The area of capture data for trollers are, therefore, inaccurate. Reported landings by gear may be incorrect, particularly in recent years, as some net caught chinook are landed and sold as troll caught and undersized chinook in the net fisheries may be sold as another species. Reported fishing effort may be too high as casual fishermen may incorrectly report their fishing effort in order to meet Unemployment Insurance Commission requirements. Most important, however, not all salmon sales result in a sales slip. Some fish are sold directly to individuals, and some to brokers. These sales may not appear in the catch statistics. Total catch data are, therefore, underestimates of the true total catch.

For the period 1951-1961 the annual statistical reports of the economics branch record the weight of catch only. All other years record catch in numbers as well. Catch in numbers for 1951-1961 is reported in the weekly catch reports of the Department of Fisheries and Oceans. These data have been summarized by Mr. Vic Aro of the Resource Services Branch and I have used his summaries in preparing this document (Vic Aro pers. comm. 1981).

Sport catch of chinook has been recorded annually since 1953. Estimates of sport catch are derived from surveillance at launch ramps and marinas to record salmon catch per boat, and estimates of the number of boats engaged in the fishery. Data from sport log books, and voluntary returns of coded wire tagged chinook in 1977 suggested that existing estimates of sport catch were too low by a factor of at least 2-3 (Argue, Coursley and Harris 1977). Recent data from creel censuses and further analysis of coded wire tag returns support the suggestion that previous estimates of sport catch were two to three times too low (Heizer pers. comm. 1981; Riddell pers. comm. 1981, 1982).

The catch of chinook by British Columbia fishermen is not representative of the coastwide catch of chinook originating from spawning populations in B.C. Chinook disperse mainly north along the coast during their ocean residence, and there is also some southward dispersal. Chinook originating from British Columbia, therefore, contribute to commercial and sport catches in both Washington and Alaska, while chinook from Washington and Oregon contribute to commercial and sport catch in B.C. Chinook catch statistics for both Alaska and Washington were, therefore, examined. Annual catch of chinook in southeast Alaska, the principal area of interception of B.C. chinook in Alaska, was taken from various sources. For 1951-1959 data were from the Alaska Commercial Salmon Catch Statistics, 1951-1959, published by the U.S. Fish and Wildlife Service. For 1960-1977 data were from the statistical leaflets published by the Alaska Department of Fish and Game. Catch data for 1978-1979 were provided by Mr. Vic Aro of the Pacific Biological Station, Nanaimo, from computer printouts sent to him by the Alaska Department of Fish and Game (Vic Aro pers. comm. 1981). Data on the annual catch of chinook in Washington State were taken from Fisheries Statistical reports published annually by the Washington Department of Fisheries. Presumably these data suffer from inaccuracies similar to those of the Canadian catch data. Summaries of commercial and sport catch data were used to assist in tabulating catch for all years and for determining catch in specific interception areas of U.S. fisheries (Aro and McDonald 1974; Aro, Miller, and McDonald 1977).

Catches by Washington, British Columbia and Alaska fishermen are a mixture of fish of both Canadian and U.S. origin. Catch data were segregated into Canadian and U.S. fish by means of percentage composition estimates employed in the U.S./Canada salmon interception negotiations (Table 1). Where Canadian and U.S. estimates of interception rates differed, I used the Canadian estimates. I summed estimates of the catch of Canadian fish in each fishery to obtain an estimate of total coastwide catch of Canadian fish. The empirical basis for the percentage of chinook from each country in each fishery is, in many instances, weak. The percentages do, however, represent the best current estimates of composition by country of origin. More recent tagging data, although as yet incomplete, suggest that the stock compositions in Table 1 are reasonably accurate (Dr. B. Riddell pers. comm. 1982). The estimates of composition are from tagging done in the 1960s and 1970s. The estimates may, therefore, be less reliable for segregating catch data for the 1950s.

Estimates of the Native Indian subsistence catch in British Columbia rivers are made by local Fishery Officers. McKay (1977) compiled the province wide estimates of subsistence catch for 1955-74. Estimates for 1975-79 were provided by Mr. Vic Aro (pers. comm. 1981).

Information on spawning escapement in British Columbia rivers has been recorded annually since 1951 by Fishery Officers and Guardians in the various regions of the province. These data are available from the Department of Fisheries and Oceans, and have been summarized from time to time in internal reports. Data presented herein are taken from the original spawning ground reports.

Escapement estimates throughout the province are based on visual counts of fish. Observations are made from the stream bank, from boats, from aircraft, and occasionally by snorkelling. The counting system used depends on accessibility of the spawning area and its physical features. Methodology is not standardized between observers or between rivers within an area. Rivers also vary considerably in their accessibility, and in the ease with which fish may be seen on the spawning grounds and in holding pools.

The accuracy of any particular count of fish depends on a variety of factors including the conditions in the stream at the time counts are made (water depth, turbidity, etc.), the number of visits to the stream and how the visits are distributed over the spawning period, the configuration of the stream, the method of counting used, the experience of the officer both with the particular stream and with techniques of counting fish. In some instances actual counts are "corrected" for fish not seen, while in other instances they are not. Escapement estimates thus vary considerably in accuracy. The concensus among those familiar with the data seems to be that chinook escapements are underestimated. The degree of underestimation is a matter of debate, and probably varies widely among spawning populations. Estimates by mark-and-recapture or by residence time techniques done in conjunction with visual counts suggest that the routine spawning ground counts underestimate the true population by a factor of two or slightly greater (Neilson and Geen 1981; Anonymous 1979; Mr. R. Hilland pers. comm. 1982; M. Healey unpub. data).

The relative accuracy of counts from the 1950s compared with the 1970s is also of concern. Two opposing points of view exist. The first holds that accessibility to spawning grounds has improved over the years and that the tools and techniques for making counts have also improved so that recent counts are likely to be more accurate than in the past. According to this point of view, counts from the 1950s underestimate the true spawning population to a greater degree than do recent counts. The second point of view holds that in the past Fishery Officers had more time to devote to making escapement counts, and that, since Fishery Officers tended to remain in a district longer than they do today, they were also more familiar with rivers in the district. Thus, according to this point of view, escapement counts from the 1950s are probably at least as good as recent counts. There is no way ever to resolve this difference of opinion. In this report I take the point of view that escapement counts are equally accurate throughout the period of record.

Information on age and size composition of the catch and escapement has not been collected annually, nor have all areas of the coast received the same attention. Nevertheless, some data exist for almost all areas of the coast, and sufficient years of data exist in some areas to permit examination of trends. In most instances ages were determined from scales. The difficulty in reliably ageing chinook from scales is well documented (Godfrey et al. 1968). The resorption of scales in spawning fish, and the fact that chinook may spend some time in fresh water before spawning, thus increasing the degree of resorption, contributes further to the difficulty of ageing chinook from spawning ground samples.

RESULTS

CATCH BY B.C. FISHERMEN

Catch, in numbers of chinook, by B.C. fishermen has increased from 1951-1979 (Table 2, Fig. 2). The rate of increase was slow during the 1950s, catch rising from about 876 thousand fish in 1951 to about 1,220 thousand in 1958. After 1958 catch dropped dramatically to a low of 756 thousand fish in 1961. Catch increased from 1961 until 1971 when it reached 1.7 million fish. Since 1971 catch has been fairly stable. Greatest reported catch was 1.8 million in 1976 (Table 2, Fig. 2). Overall, therefore, catch has increased about 2-fold since 1951 and about 2.5-fold since the low catch in 1961.

The different gear types show different trends in catch. Most chinook are caught by trolling, and the proportion of total catch increased from 527 to 734 thousand between 1951 and 1956 then decreased to 459 thousand between 1956 and 1961. After 1961 troll catch increased almost continuously (the exception being a period of stable catch between 1966 and 1970) to a peak of 1.27 million in 1971. Since 1971 troll catch has gradually declined (Fig. 3).

Gillnet catch has constituted 9-27% of total catch between 1951 and 1979 with a trend toward lower percentage contribution particularly in recent years (Table 3). There was no strong trend in numbers landed before 1970, and catch fluctuated around 220 thousand fish. Since 1970, however, gillnet catch has decreased considerably. There have been no catches above 200 thousand since 1972 and recent catches have been less than 150 thousand (Table 2, Fig. 3).

Seine catch of chinook was small, only 18-49 thousand fish, or 2-7% of total catch, between 1951 and 1964. Since 1964 seine catch has increased steadily and in 1979 was 186 thousand fish, 11% of total catch (Table 3, Fig. 3). Seine catch now exceeds gillnet catch in numbers and is about the same in weight (Table 2). In addition, seiners catch a large number of small chinook that are often marketed as another species. The exact size of this catch is unknown, but could be as high as 300-400 thousand fish.

Recorded sport catch increased gradually from 83 to 165 thousand between 1953 and 1958, declined to 77 thousand between 1958 and 1961, then remained relatively constant until 1967. After 1967 sport catch increased steadily to 292 thousand fish in 1976. The recorded sport catch has constituted 7-17% of the total catch of chinook (Tables 2, 3, Fig. 3). Note, however, that the true sport catch may be considerably higher.

Catch of chinook in Native Indian subsistence fisheries has been 15-28 thousand fish since 1955, or about 2% of the total catch (Tables 2, 3). The accuracy of these data is very uncertain, but since they represent such a small percentage of total catch the errors are of small concern in assessing total catch. The distribution of this catch relative to the strength of local spawning populations may, however, be of concern, particularly as most chinook spawning populations are small.

Catch in weight in the commercial fishery has shown historic trends similar to, but less dramatic than, catch in numbers. Catch in weight was fairly constant from 1951-1958, averaging about 5,800 t. Between 1958 and 1961 catch weight dropped to 3,900 t, then increased again, peaking at 7,900 t in 1971. Since 1971 catch weight has been fairly constant, averaging about 7,300 t (Table 2, Fig. 2). The increase in landed weight over the period 1951-1979 has, therefore, been about 1.5 times, and since the low catch in 1961 the increase has been about two times, somewhat less than the increase in numbers landed over the same time period.

DISTRIBUTION OF CATCH BY STATISTICAL AREA

The statistical areas of greatest catch have remained remarkably constant over time. Since area of capture data are unreliable for trollers, regions of the coast should be examined without stressing individual statistical areas. By far the greatest proportion of the troll catch (51-60% of the total numbers caught) comes from the west coast of Vancouver Island (statistical areas 21-27). Johnstone and Georgia straits (statistical areas 12-19) have contributed 12-26% of the catch, while the central and north coasts (statistical areas 1-11) have contributed 12-30% of the catch (Table 4). The contribution from the west coast of Vancouver Island has declined slightly over the years while the contribution from the central and north coasts has increased slightly and the contribution from Johnstone and Georgia straits has remained about the same (Table 4). Because chinook disperse mainly northward along the coast from their natal stream this shift of troll catch to the north means that the fishery is being directed more toward Canadian fish and less toward Columbia River fish.

By far the greatest proportion of the gillnet catch of chinook (42-64% of the total catch) has come from the Fraser River fishery (statistical area 29). Two other important catch areas are the Nass and Skeena rivers (statistical areas 3 and 4) together comprising 10-16% of total catch (Table 5). Over the years the contribution from these three areas has tended to decline while some other areas have increased in importance, particularly areas 8, 9, and 20.

Seine net catch of chinook is concentrated in statistical areas 12 and 20, these areas together comprising 42-72% of their total catch (Table 6). Most of the remaining seine catch has come from areas 3, 5-8 and 13. Recently seiners have begun to land significant numbers of chinook caught in areas 1 and 2, while catch in areas 5 and 8 has declined (Table 6).

Overall, therefore, there has been a relatively small change in both the distribution of chinook catch coastwide, and in the proportion of the catch taken by each gear. Most of the catch is taken in areas where there is a great mixture of stocks (the troll fishery, the seine net fishery in areas 12 and 20, the Strait of Georgia sport fishery). These factors suggest that the intensity of exploitation may not differ greatly between stocks, and that any increase in exploitation rate has been relatively uniform among stocks.

EFFORT AND CATCH-PER-UNIT-EFFORT

Troll fishing effort has fluctuated widely over the period 1951-1979 but, overall, shows an increasing trend from 120 thousand days in the early 1950s to 140 thousand days in the late 1970s (Table 7). Effort was high in 1951-1952, dropped sharply to the lowest recorded values in 1954-1956, then increased sharply again in 1957-1958. From 1958-1971 effort increased gradually with some fluctuation. In 1972-1975 effort again dropped sharply and then increased equally sharply from 1975-1979, with 1979 having the greatest recorded days of fishing effort. Catch-per-unit-effort (C/E, calculated as the ratio of catch in pieces to effort in boat days) for trollers has varied 3.1-9.4 with lowest values during the low catch period of 1960-1963 and highest values during the high catch period of 1974-1976 (Table 7).

Gillnet effort has declined dramatically from around 200 thousand days early in the 1950s to slightly over 100 thousand days in the early 1970s (Table 7). In 1974, recording of gillnet effort changed from days of fishing to numbers of landings. Number of landings will be slightly less than the number of days of fishing. Presumably, however, gillnet effort has continued to drop, because the number of landings has declined over the period 1974-1979. Gillnet C/E, however, increased from less than 1.5 fish in the early 1950s to 1.7-2.0 fish in the early 1970s and appears to have remained constant or possibly to have increased slightly since 1973 (Table 7). This increase in C/E may reflect the fishing pattern imposed on gillnetters through area closures. It may also reflect greater concentration on chinook by gillnetters because the relative value of chinook has increased.

Seine effort has varied 9-19 thousand days over the years but shows no overall trend (Table 7). As with gillnetters, recording of seine effort changed in 1974 from days of fishing to landings. Seine vessel C/E, however, has increased dramatically from slightly over two fish in the early 1950s to over nine fish in the early 1970s, and appears to have continued to increase since the change in recording of effort in 1974 (Table 7). It seems clear that since 1964 seiners have concentrated more on chinook, although for both seiners and gillnetters most chinook are still caught incidentally in fisheries for pink and sockeye.

AVERAGE WEIGHT IN THE CATCH

The average weight of chinook in the commercial catch, estimated as landed weight/landed places, has declined for all three gear types (Table 8). Troll caught fish averaged 5.3-6.4 kg (dressed weight) in the early 1950s but were only 4.2-4.9 kg in the late 1970s. Gillnet caught fish averaged 7.1-8.0 kg (round weight) in the early 1950s, but this dropped to 5.9-6.6 kg in the late 1970s. Seine caught fish averaged 4.8-5.4 kg (round weight) in the early 1950s, but averaged only 3.9-4.9 kg in the late 1970s (Table 8). The decline in size of chinook to some degree reflects the elimination of older age classes from the populations as the fishery has intensified. As will be shown later, however, the average age in the catch has changed little since 1951. There may also have been genetic selection for smaller fish (Ricker 1980).

COASTWIDE CATCH OF BRITISH COLUMBIA CHINOOK

Marine tagging of maturing chinook salmon between 1924 and 1960, tagging of Columbia River hatchery releases in the 1960s and tagging of U.S. and B.C. hatchery releases in the 1970s have provided information on the intermingling of U.S. and B.C. stocks of chinook in the ocean. Reports of the Informal Committee on Chinook and Coho (1969) and the Technical Committee on Salmon Interceptions (1975-1979) defined areas of interception and rates of interception of U.S. fish in B.C. and of B.C. fish in U.S. waters (Table 1). Applying these rates of interception to historic catch data provides estimates of the catch of B.C. chinook by each gear and fishery (Table 9).

The historic trend in catch of B.C. fish by B.C. fishermen is essentially the same as that for total catch--an overall decline in gillnet catch, especially in the 1970s, and increases in catch by other gear, resulting in a 2-fold increase in total catch. B.C. chinook comprise about 97% of the B.C. gillnet catch, and 86% of the B.C. seine catch but only 42% of the B.C. troll catch (Tables 2, 9).

Washington State net, troll, and sport fisheries all take a share of B.C. chinook. Catch of B.C. fish in Washington State net fisheries has ranged from 12 to 98 thousand and shows an increasing trend (Table 9). Washington State troll catch of B.C. chinook was 19 to 25 thousand in the early 1950s, slightly larger than the net catch during the same period. Since that time troll catch has declined while the net catch has increased. Sport catch of B.C. chinook in Washington has ranged from 38 to 12 thousand and shows an increasing trend (Table 9). Sport catch of B.C. chinook was consistently higher than either net or troll catch in Washington until recent years when net catch has been greater. The net catch is primarily of chinook bound for the Fraser River.

Catch of B.C. chinook in Alaska net fisheries has ranged from 3 to 23 thousand fish, and, although rather variable, has tended to decline (Table 9). Catch of B.C. chinook in the Alaskan troll fishery has been more constant, ranging 71-189 thousand, but it too has tended to decline somewhat.

Total coastwide catch of B.C. chinook based on these estimates has ranged from a low of 680 thousand in 1961 to a high of 1,368 thousand in 1977 (Table 9, Fig. 4). Catches in the early 1950s were about 66% of recent catches. The coastwide catch of B.C. chinook has increased, therefore, but to a lesser extent than the catch of chinook by B.C. fishermen. Interception of U.S. chinook by B.C. fishermen appears now to be greater than it was in the past.

ESCAPEMENT

Spawning escapement estimates have been made for 326 chinook populations throughout British Columbia. The quality of these estimates varies considerably as noted earlier. Some populations, particularly the smaller ones, have not been counted each year. This, together with water conditions that make some populations uncountable from time to time, has resulted in many blanks in the escapement record. For many years escapements were recorded as a letter which represented a range of population sizes within which the observer felt the true population lay. For escapements recorded in this way I assigned a numeric value equal to the midpoint of the range of population sizes represented by the letter. In recent years escapements have been recorded as the observer's best numeric estimate of total population.

Because of concern over the accuracy of the escapement estimates and the many blanks in the data, I have summarized escapement in several ways hoping, by this means, to avoid gross errors in interpretation. I estimated total escapement to all known populations for each year as the sum of observed escapements plus the sum of average escapements for those populations either not observed or not observable that year. I also calculated total escapement to 142 populations for which there were 20 or more years of escapement counts and compared this with escapement to all known populations. Again I used average escapement values for each population to fill blanks in the escapement record. Presumably those populations which have been most regularly counted are the most accessible, or have had special effort devoted to them for some other reason, and these counts should be most reliable. Trends in escapement to all known populations and to those with 20 or more years of record should be comparable, otherwise doubt is cast on any interpretation of trends in escapement. I subdivided escapement data by region of the province (north coast, areas 1-5; central coast, areas 6-11; Johnstone and Georgia straits, areas 12-19 and 28; west coast Vancouver Island, areas 20-27; Fraser River, area 29). I compared trends in escapement between regions, both as total escapement to the region, and as relative change in abundance within populations. I subdivided escapement data by size of spawning population, size being the average escapement to the population for the years for which there are records. Size categories were: less than 200 fish, 200-1000 fish, 1000-5000 fish, and more than 5000 fish. I compared escapement trends between population sizes. This latter comparison should provide insight into the resilience of different sized spawning populations in the face of increasing exploitation. Finally, I examined upriver spawning stocks in the Skeena and Fraser rivers separately as these are likely to contain the highest percentage of stream type fish (chinook which migrate to sea after 1 yr in fresh water). Throughout I emphasized trends rather than estimated population sizes. Although there are many potential sources of error in the escapement record, I feel it is probably a reliable index of spawning population abundance and will demonstrate real trends in escapement.

Data for 326 spawning populations of chinook are summarized in Table 10. The populations are grouped by statistical area, and for each population the number of years for which escapement has been reported, the average escapement, minimum escapement, and the maximum escapement are shown. By population size category there are 159 populations averaging fewer than 200 spawners, but 57 of these have been observed only occasionally. One hundred four populations averaged 200-1000 spawners, 53 populations averaged 1000-5000 spawners, and only 10 populations averaged over 5000 spawners. Clearly the majority of chinook spawning populations are very small (Table 10). Total escapement to all known populations shows a definite decline, and this decline is paralleled by populations with 20 or more years of escapement records (Fig. 5). Total escapement was estimated to be 300-400 thousand in the early 1950s, but recently has been 200 thousand or less, a 42% decline. Small catches by B.C. fishermen in the years 1960-1962 are reflected in small escapements. With the exception of this unexplained dip in escapements the decline in escapements has been relatively smooth and continuous since 1951.

A high proportion of B.C. chinook spawn in rivers tributary to the Johnstone-Georgia Strait region, including the Fraser River. In the early 1950s about 50% of the escapement went to rivers in this region with the remaining 50% spread fairly evenly among the other regions of the coast (Table 11). Recently the proportion of coastwide escapement to rivers in the Johnstone-Georgia Strait region has risen to almost 60%, mainly because escapement to the Fraser River has remained relatively constant while escapement has declined everywhere else (Table 11). Rivers of the north coast, Johnstone-Georgia Strait excluding the Fraser, and west coast Vancouver Island have all shown about a 50% decline in escapement since the early 1950s and the central coast has shown a 40% decline. The Fraser, however, has declined less than 10% in recorded escapement, and even this small apparent decline is due mainly to the large escapement estimate for 1952.

Poor chinook returns during 1960-1962 present a perplexing problem. Although overall escapement was low during these years not all regions of the coast had low escapement specific to 1960-1962. All regions had periods of low escapement of varying length in the late 1950s and early 1960s (Table 11). North coast escapements were low during 1960-1962. Central coast escapements were variable from 1951-1962, but were relatively low during

1959-1962. Johnstone-Georgia Strait escapements were relatively low only during 1960-1961 and west coast Vancouver Island escapements were low throughout 1959-1963. The low overall escapement during 1960-1962 thus resulted from the (possibly fortuitous) coincidence of periods of low escapement in all regions. Other periods of low escapement have occurred in each region, but 1960-1962 were the only years when low escapements coincided throughout the coast.

I examined individual populations in each region with more than 15 yr of escapement records to determine the proportion of declining, stable, or increasing populations. I grouped the populations into five categories based on the ratio of escapement for the years 1971-1975 to escapement for the years 1951-1955: 1. Ratio equal to or less than 0.5; 2. Ratio between 0.5 and 0.75; 3. Ratio between 0.75 and 1.25; 4. Ratio between 1.25 and 1.5; 5. Ratio greater than or equal to 1.5.

In all regions except the Fraser River, the majority of populations have declined, and usually the greater number have declined more than 50% (Table 12). The west coast Vancouver Island region is particularly bad in this regard with 31 of 48 populations having declined more than 50%. In the Fraser River, declines and increases have been almost equal with a slight edge in declines. That the Fraser is unique in not showing overall decline in escapement is emphasized by comparing the Fraser with the Skeena, the second largest chinook producing river system in B.C. The Skeena shows the pattern typical of the rest of the province, a 47% decline in estimated escapement and most populations (17 of 21 with more than 15 yr escapement records) showing a decline.

All sizes of spawning population show comparable declines in escapement (Fig. 6). Populations averaging less than 200 fish declined from 1951 until about 1972, but recently appear to have increased slightly. For these populations the ratio of escapements for 1975-1979 to those for 1951-1955 is 0.60, or about a 40% decline. Populations averaging 200-1000 spawners have shown wide fluctuations in average abundance and lowest recorded escapements were in 1960-1961. The trend in escapement to these populations is still clearly downward, however, and the ratio of escapements for 1975-1979 to those for 1951-1955 is 0.50. Populations averaging 1000-5000 fish also show wide fluctuations in average abundance over the years, and again 1960-1961 were years of low escapement. Nevertheless escapements have declined and the ratio of escapements for 1975-1979 to those for 1951-1955 is 0.56. The few populations averaging over 5000 spawners fluctuated widely in abundance during the 1950s, but since 1960 escapements have been lower, less variable and declining (Fig. 6). The ratio of escapements for 1975-1979 to those for 1951-1955 in these populations is 0.52.

I examined escapement to subregions of the Fraser and Skeena river systems to determine whether escapement to upriver spawning grounds had declined more or less than escapement to downriver spawning grounds (Table 13). I presumed that upriver populations would have the highest proportion of stream type chinook. The behaviour of "stream" type chinook (returning to the river in spring and summer, holding in the river for several weeks or months before spawning, migrating long distances up large rivers, remaining as juveniles for a year in freshwater before migrating to sea) suggest that these fish may be subject to higher and more variable natural mortality than "ocean" type chinook (those which migrate to sea during their first year of life). Stream type chinook might, therefore, suffer overexploitation at lower fishing intensity than ocean type chinook, and this should be reflected in a greater decline in their escapement compared with ocean type.

The Skeena River is divided into four subregions. Subregions 1 and 2 divide up the main river and its tributaries below the confluence of the Bulkley River, subregion 2 being the further upstream. Subregion 3 is the Bulkley River drainage, and subregion 4 is the upper Skeena River. All subregions of the Skeena show declining escapement (Table 13), however, the two upriver subregions show, on average, a greater decline. The Fraser River is divided into seven subregions, and it is more difficult to segregate these into clearly downstream and upstream. Subregion 0 covers the drainage above Harrison Lake, which, although "downriver" represents a significant migration for chinook and includes at least one known spring run stock. Subregions 1-3 are more clearly downriver, but include the Chilliwack River stock which is known to be mainly stream type fish. Subregions 5-7 are, undoubtedly, upriver. For the Fraser, therefore, comparisons will be made between subregions 1-3 and subregions 5-7, and further between subregions 1-3 and known spring migrant chinook stocks (Table 13). Populations in subregions 1-3 show some evidence of decline, the ratio of escapements 1975-1979 to 1951-1955 ranging 0.55-0.73. Upriver populations in subregions 5-7, however, show no evidence of consistent decline. In fact, the escapement to subregion 6 appears to have increased since 1951. Nor do the known spring runs of chinook show clear evidence of decline. Although escapement to these populations was low in the 1960s, recent escapements have been as large as those in the early 1950s. Overall, therefore, upriver or spring runs of chinook appear not to have suffered greater declines in escapement than downriver, or fall runs. Four populations in the Fraser, however, are known to comprise mainly stream type fish (92-100%). These are the Chilliwack-Vedder, Adams, Deadman, and Nicola River populations. All four of these populations show declines of over 50% in escapement since 1952. Thus, while there appears to be no general evidence for decline in upriver populations of chinook in the Fraser River, at least some known populations of stream type fish have declined considerably in spawner abundance.

AGE COMPOSITION OF CATCH AND ESCAPEMENT

Age and size composition of the troll catch has been investigated in several regions of the coast a number of times since the early 1900s (Milne 1964; Ball and Godfrey 1967, 1968a, b, c, 1969, 1970). Age and sex composition of the gillnet catches in the Fraser, Nass, and Skeena rivers have also been investigated several times since the 1950s (Godfrey 1968; Ginetz 1976; Ball and Godfrey 1967, 1968 a, b; Starr, Cross and Fraser 1980). There are a number of problems with interpretation of these data. The adequacy of sampling to provide data representative of the catch is often not discussed. Even supposing catch sampling was adequate it is difficult to relate catch data to the population at large since all types of fishing are selective to some degree, and fishing techniques have changed considerably over the years.

Despite these problems variations in age structure between regions and between years suggested by the data seem reasonable, and some qualitative generalizations may be made.

Chinook captured by trolling are older on average as one moves north along the coast, and those captured in the Strait of Georgia are youngest of all. These observations are consistent with the known northward dispersal of chinook from their natal streams, so that the older fish occur further north. Because of the relatively high production of chinook from the Columbia River and Strait of Georgia areas the south coast of B.C. tends to be dominated by younger chinook from these populations, and the north coast and Alaska by the older fish form these populations. The protected waters of the Strait of Georgia are an important nursery ground for first and second ocean year chinook, and, since the minimum size for commercially caught fish is less in the Strait of Georgia than elsewhere on the coast, the average size and age of chinook caught in the Strait tends to be low.

The difference in average age between fish caught off the west coast of Vancouver Island and off the north coast has been about 0.25 yr since the 1920s (Table 14). Chinook captured in the 1920s were, on average, a year older in all parts of the coast than they are today. There has, however, been little change in average age of the catch since the 1950s, probably because the introduction of the 26-in minimum size limit in 1955 for fish caught outside Georgia Strait has prevented any further reduction in average age of the catch.

Both stream and ocean type fish occur in the troll catch, and the proportion of stream type increases as one moves northward. With the exception of the north coast, the occurrence of stream type fish has declined to about 1/6 what it was in the 1920s. This fact suggests a severe decline in the abundance of stream type fish. Changes in the way chinook scales are interpreted, however, may also have biased the apparent proportions.

Stream type fish were older on average than ocean type fish in all samples except the 1929-30 sample from the north coast. The difference in age is about 0.5 yr in most samples. Recent catches in the troll fishery have been dominated by 3- and 4-yr-old fish (85-95%) with 3-yr-old fish predominant throughout the coast (46-64%). Ocean type fish form over 90% of the catch. Considered separately stream type fish are mainly 4 and 5 yr old in the north coast and 4 yr old elsewhere.

The Fraser River gillnet catch has been sampled fairly regularly since 1952, and these data appear reasonably comparable between years. Average age of the total catch has not shown any particular trend (Table 14). The average age of both stream and ocean type fish considered separately, hwoever, has increased. The failure of the total catch to show an increase in average age is due to fewer stream type fish, which average about 0.5 yr older than ocean type fish, in the catch (Table 14).

During 1964-1966 test gillnetting with nets of varying mesh size was undertaken in the estuaries of the Fraser, Skeena, and Nass rivers and the age structure of the fish captured was analysed (Godfrey 1968). Unfortunately, the mesh sizes used in the test netting are not recorded. The age structure of test net catch is not comparable with the commercial catch made at the same time but the test netting does permit comparison among the three rivers for 1964-1966.

There was little difference in the average age of chinook captured in the three rivers (Table 14), in particular there was no indication that fish returning to spawn in the northern rivers were older. If anything, chinook returning to spawn in the Nass River were younger than those returning to the other two rivers. Commercial gillnet catch sampling in the Skeena in 1973-1975, however, yielded fish older than those returning to the Fraser during the same time period (Table 14).

Among the three rivers stream type chinook made up 13-48% of both test net samples and commercial catch samples (Table 14), and in all rivers stream type fish averaged about 0.5 yr older than ocean type fish. In both the Fraser and Skeena rivers the proportion of stream type fish in the catch has declined in recent years (Table 14). Whether this is due to a real decline in the abundance of stream type fish, or to curtailment of early season gillnet fishing is uncertain. Certainly early season gillnet effort on both rivers has been cut back substantially.

Test netting samples from 1964-1966 also provided data on the relative age of males and females and the proportions of the two sexes in the samples although it is possible that jack males were still undersampled. In the Fraser River males were only slightly more abundant than females in the samples. In both the Skeena and Nass, however, males greatly outnumbered females, particularly among the stream type fish (Table 15). Females of both stream and ocean type fish were consistently older than males, the difference being about 0.5 yr for the Fraser and 1.0 yr for the Skeena and Nass (Table 15). The difference between the river systems in this regard appears to be due to the relatively greater abundance of 3-yr-old males in the Nass and Skeena as compared to the Fraser.

Since a high proportion of the chinook caught by B.C. fishermen are of U.S. origin the age composition of the commercial catch is not truly representative of the age at capture of Canadian chinook. Information on the age at capture for B.C. stocks of chinook is becoming available through the recovery of tagged hatchery and wild fish. Preliminary results will be presented here based on returns from 1974-1976 of 1971-1974 brood year chinook from the Big Qualicum, Capilano, Puntledge and Robertson Creek hatcheries (J. McDonald pers. comm. 1979). None of the brood years was fully represented in the returns examined. Proportional representation of particular broods at several ages could be estimated, however, and these proportions used to calculate percentage age composition over all ages. Age composition averaged for the various gear types show troll catch dominated by age 3 fish and the net catch by age 4 fish (Table 16). Sport caught fish were considerably younger, mainly 2 yr old, and averaged only 2.4 yr. This is due both to the smaller legal size for sport caught fish, and to the intensity of sport fishing in the Strait of Georgia, a nursery area for juveniles.

The age structure of samples from spawning grounds varies considerably among spawning populations both within and beween river systems (Table 17). Some populations show a high proportion of 2-yr-old jack males, while others seldom have jacks. The average ages of spawning ground samples from both the Skeena and Fraser rivers are reasonably comparable to the age of recent samples from the rivermouth gillnet fisheries. In both instances, however, it is likely that smaller and younger fish are under represented. The true average age of spawning populations may, therefore, be somewhat less than that shown in Table 17. The sampling of spawning populations is, as yet, rather sketchy and inadequate. Based on present data there is no indication of any trend in average age of spawning populations between southern and northern river systems.

SIZE AT AGE IN THE CATCH

Ball and Godfrey (1968 a, b, 1969, 1970) published data on size at age in the troll catch for 1966-1969. Ocean type fish aged 2-6 and stream type fish aged 3-6 were represented in the samples. Size was measured as orbit-hypural length and the samples were grouped within four regions of the coast: north coast (statistical areas 1-5), central coast (statistical areas 6-12), west coast Vancouver Island (statistical areas 21-27) and Strait of Georgia (statistical areas 13-19). Because of the wide ranging habits of chinook, selectivity of the troll gear, size limits prohibiting the landing of small fish, and size dependent maturation, the sizes of fish in the catch are never representative of any stock at any age. The size of ocean type fish aged 2 and 3 and stream type fish aged 3 and 4 is overestimated because of minimum size limits on the catch. The size of older fish is underestimated because of the early departure of larger fish for the spawning grounds. Size at age may be compared among regions of the coast, however, and, for those fish which are fully recruited, or almost fully recruited to the legal size (aged 4 and older), the catch is a fair representation of the fish available for capture.

I shall make two comparisons using data from Ball and Godfrey's reports averaged for 1966-1969: first, I shall compare size at age among regions using samples taken in July. These were the largest and most complete samples. Data from other months yield comparable conclusions. Second, I shall compare size of ocean type fish aged 4 and 5 among months for each area. These were the only fully recruited ages of ocean type fish present in sufficient abundance to merit comparison. Stream type fish aged 5 were also reasonably abundant, but indicated a trend comparable with the ocean type fish.

There were no consistent differences in size at any age among regions of the coast, with the exception that fish in the Strait of Georgia were smaller in their second ocean year than those from other regions of the coast. This difference merely reflects the smaller minimum size limit applied to chinook captured in the Strait of Georgia. It appears, therefore, that fish of the same age are of comparable size all along the coast (Table 18).

The average size of fish aged 4 and 5 in the catch increased with time (Table 19). Average monthly size increments ranged 0.47-3.18 cm among ages and regions, and over all ages and regions averaged 1.34 cm. This rate of increase in size is presumably lower than the rate of growth of chinook owing to the maturation and exodus from the fishing grounds of larger fish within each age class. The increase in length of fish available for capture is, nevertheless, significant, and, based on length/weight relationships in Ball and Godfrey (1968a, b, 1969, 1970), represents a gain in weight of about 0.5 kg per month for 4- and 5-yr-old fish.

STOCK AND RECRUITMENT FOR B.C. CHINOOK

There are not sufficient data for any one chinook stock to permit calculation of a stock and recruitment relationship. A preliminary examination of stock and recruitment may, however, be made on a coast wide basis. This approach may be justified as follows: escapement data show that most chinook spawning populations have declined about the same degree regardless of abundance or geographic location, suggesting a similar response by most stocks to the coastwide increase in exploitation. Catch data suggest that chinook are harvested in large mixtures of stocks, and that coastwide fishing patterns have remained relatively constant, so that exploitation rate may have been more or less uniform among stocks, and increases in exploitation rate may have affected most stocks equally. Finally, Ricker (1973) shows that, even when stocks in a mixed stock fishery differ substantially in productivity, the stock-recruitment curve derived from catch and escapement gives a good approximation to the sustainable yield from the mixture of stocks. Thus a coastwide stock and recruitment relationship may be a useful management tool for B.C. chinook salmon.

I used the estimated total coastwide catch of B.C. chinook and the estimated total escapement of all B.C. spawning populations in developing the stock and reruitment relationship (Tables 9, 11). I estimated catch at age from total catch by means of the preliminary age composition data for tagged fish (Table 16). I treated gillnet, seine and trap caught fish as net caught fish and divided them into age classes accordingly. I presumed native subsistence catch had an age composition similar to the spawning escapement, and separated this catch plus escapement into age classes by means of the average age composition of spawning populations throughout B.C. (Table 17).

In the analysis, stock was the total escapement for any particular year. Recruitment from that stock was the sum of catch and escapement at all ages resulting from that stock (Table 20). Recruitment for the most recent years of escapement data are only partially complete. For 1974-1976 I estimated total expected recruitment from the ratio of partial recruitment to total recruitment for brood years that were fully represented. The development of a coastwide stock and recruitment relationship thus involved a number of assumptions:

1. Coastwide escapement estimates since 1951 have been a constant proportion of total escapement: This should be true if the escapement data are used to represent stock in the relationship. The alternative to this assumption, that escapement estimates are an increasing proportion of total escapement (i.e., recent estimates are better), will increase the estimate of replacement stock size in the analysis, but will have little effect on the stock for maximum yield.

2. The available age composition data from spawning ground surveys are, when averaged, a realistic estimate of the age of spawning populations throughout the coast: some smoothing of percentages was used in setting the average age composition. Likely errors in age composition include the presence of more older fish in earlier years, and variation in jack returns between populations and between brood years. The results of the stock and recruitment analysis for chinook, however, should be relatively insensitive to moderate errors in age composition.

3. Reported catch data are accurate: reported catch is almost certainly a minimum estimate of true catch, particularly in the case of sport catch and seine catch. The effect of adjusting sport catch upward is considered in the analysis.

4. The estimated rates of interception used to calculate coastwide catch of Canadian chinook are realistic and applicable to historic catch data: certainly the values employed are preliminary and should be improved as more tag recovery data are analysed. Substantial errors in the interception estimates could have a major effect on the stock and recruitment relationship. Nevertheless, the values used are the best currently available and preliminary results from more recent tagging programs suggest that the interception rates used in this manuscript are reasonably correct. Changes in interception rates have probably occurred over time, so that interception rates applicable to the early 1970s are unlikely to represent accurately the interception rates in the early 1950s. One likely contributor to historic variation in interception rates is the expansion of the U.S. hatchery program. The effect of increased hatchery production on the estimates of recruitment is examined in the analysis.

5. Age composition data for hatchery tag returns from the commercial and recreational fisheries are a realistic estimate of the age composition of Canadian fish of all stocks caught by each gear: this is probably not strictly true, but the results of the analysis are relatively insensitive to moderate errors in age composition.

Table 20 shows the stock and recruitment data based on the catch and escapement information presented earlier. Since the analysis is intended to represent stock and recruitment for wild stocks of chinook, I subtracted an estimate of the contribution of Canadian hatchery fish to the catch from the recruitment figures (Table 20). Mr. Doug Swain (pers. comm. 1981) estimated the contribution of hatchery fish to the catch each year from coded wire tag returns.

I calculated a stock and recruitment relaionship of the Ricker type from these data (Table 21, R1) following the methods given by Ricker (1975). The parameters of the Ricker equation indicate a replacement stock size of 608 thousand, and a stock size for maximum yield of 186 thousand with maximum yield of 1,111 thousand (Table 22, Fig. 7). The stock size for maximum yield is similar to recent escapement estimates, so that virtually all the data points are on the descending right limb of the Ricker curve. More points on the ascending left limb of the curve would be required to locate precisely the stock size necessary for maximum yield.

I investigated the effect of underestimating sport catch by recalculating recruitment using three times the reported sport catch (Table 21, R2, Fig. 7). This resulted in a small increase in the replacement stock size to 645 thousand, but a similar stock size for maximum yield (Table 22).

The impact of U.S. hatchery production on the stock and recruitment relationship was more difficult to estimate. Releases of chinook by Washington State hatcheries are available for 1951-1976 (Mr. Doug Swain pers. comm. 1981) (Fig. 8) and indicate a dramatic increase in U.S. hatchery releases since 1951. it is possible, therefore, that much of the apparent increase in catch of Canadian chinook over the years is due to increased U.S. hatchery production. I prorated the percentage of Canadian chinook in the coastwide catch by means of the Washington State hatchery releases and the following assumptions:

1. Washington State hatchery releases are an adequate index of total U.S. hatchery releases from both Federal and State hatcheries in Washington and Oregon. Wahle and Smith (1978) give total U.S. hatchery releases of chinook for 1960-1976 and the correlation between Washington State releases and total releases for this time period was: $r=+0.72$. It seems reasonable, therefore, to use the Washington State releases as an index of total U.S. hatchery releases.

2. For the period 1971-1975, hatchery chinook constituted 60% and wild chinook 40% of total chinook production from Washington and Oregon. I base these percentages on impressions gained from conversations with State fishery biologists.

3. There is a 3-yr lag between hatchery release and contribution to the fishery.

4. For the period 1971-1975, the stock composition values in Table 1 are correct.

From assumptions 1-3 I calculated the proportional contribution of hatchery fish to total U.S. chinook produced by 5-yr period. For example, the calculation of contribution for 1951-1955 is:

$$H1 = 0.6 \text{ (releases for 1948-1952)/(releases for 1968-1972)}.$$

The values for each 5-yr period are shown in Table 23. In future equations I shall designate these values Hi for the "i"th 5-yr period. The proportional wild contribution to total production is then:

$$Wi = 1 - Hi$$

These values are also given in Table 23.

From reports of the Technical Committee on Salmon Interceptions, I calculated the overall proportion of U.S. fish in interception fisheries of Alaska, British Columbia and Washington (Table 24). In future equations I shall designate each of these values as Pga where the subscripts g and a refer to gear and region.

It follows then, if U.S. wild production has remained constant over the period, that the proportion of U.S. hatchery fish in any interception fishery catch for any 5-yr period would be:

$$H5Pga(Hi/H5) = HiPga \qquad (1)$$

and the proportion of wild fish would be:

$$W5pga \qquad (2)$$

where H5 and W5 are the proportions of hatchery and wild fish for the 1971-1975 period.

The proportion of U.S. fish in any interception fishery for any 5-yr period is the sum of 1 and 2 above and the proportion of Canadian fish is 1 minus this sum or:

$$1 - (Hi + W5)Pga \qquad (3)$$

Values of 3 for the various interception fisheries in each 5-yr period are presented in Table 25.

The above calculations assume that U.S. wild chinook production has remained constant since 1951. Yet the prevailing belief is that wild chnook production has declined over this period by about 50%. If I include this assumption in the calculations then relative wild production has declined from 1 in 1951-1955 to 0.5 in 1975-1980 (Table 23). If I designate this proportion as Ci then the estimate of the proportion of wild U.S. chinook in any interception fishery for any 5-yr period becomes:

$$W5Pga(Ci/C5) \qquad (4)$$

and the proportion of Canadian fish in the interception fisheries becomes:

$$1 - (Hi + CiW5/C5)Pga \qquad (5)$$

Values of 5 for the various interception fisheries are also shown in Table 25.

Equation 3 represents the most optimistic consideration of the consequences of U.S. hatchery production and is the most pessimistic with respect to Canadian chinook production. Equation 5 is perhaps more realistic. Both corrections to the interception rates must, however, be regarded as highly speculative.

I estimated new coastwide catches of Canadian chinook from the total catches in interception fisheries and the proportions in Table 25. I then segregated these catches into ages by the age composition data presented earlier and calculated two new estimates of recruitment (R3 and R4, Table 21). R3 assumes U.S. hatchery production was added to a constant U.S. wild production while R4 assumes that U.S. wild production declined 50% while U.S. hatchery production increased.

I generated a final set of recruitment estimates (R5, Table 21) by combining the assumptions of increased U.S. hatchery production, reduced U.S. wild production (as in R4 above) and underestimation of sport catch by 3X (as in R2 above).

I calculated stock and recruitment parameters for each of the new estimates of recruitment (Table 22). In all three analyses the stock necessary for maximum recruitment and stock necessary for maximum yield were higher than in the previous analyses and were highest (292,000 and 242,000 respectively) in the analysis in which I assumed that U.S. hatchery production was added to a constant U.S. wild production (Table 22, Fig. 7). Equilibrium stock size was also higher in these analyses.

In all analyses, except that involving R3, the stock size for maximum yield was in the range of recent escapement estimates (Table 22), and even for the analyses involving R3 the stock size for maximum yield was less than 250 thousand. This stock and recruitment analysis indicates that Canadian chinook stocks have only recently become overexploited and that the coastwide spawning stock size for maximum yield is probably somewhere in the range 200-250 thousand.

The above analyses take the escapement record at face value, and stock sizes for maximum yield are in the units of the escapement record. Since it appears that the escapement record may underestimate the true spawning population by about two times, I recalculated stock and recruitment parameters for each of the five estimates of recruitment but using two times the stock size in Table 21 and adjusting recruitment values accordingly. These parameters are presented in Table 22.

The values of α and β in these analyses are about half or slightly less than those in the previous analyses. The values of S for maximum recuitment are more than two times larger and the values of maximum recruitment are somewhat larger than those in the previous analyses. The ascending and descending limbs of the stock-recruitment curves are considerably less steep, however, (Fig. 9). Values of S for MSY are about two times those in the previous analyses and range 375-494 thousand. A "true" escapement of around 440 thousand may, therefore, be optimum for B.C. spawning populations.

Since there is unlikely to be any dramatic change in spawning escapement estimation in B.C. in the next few years, the analyses using two times the stock values have limited immediate practical application. Four important points may, however, be made from these analyses:

1. The five analyses employing one times the stock values in Table 21 have "a" values ($\log_e \alpha$) between 2.6 and 3.1. According to Ricker (1975), values this high should be rare. The analyses employing two times the stock values have much lower "a" values. Thus it seems unlikely that chinook are unusual with regard to the "a" value, but rather that the high "a" values in the first set of analyses are merely a consequence of underestimating stock size.

2. Optimum escapement in the first set of analyses is low compared with on-site subjective estimates of the amount of available spawning gravel

and optimum escapements for individual chinook populations. Optimum escapements in the second set of analyses are much closer to the subjectively determined optimum. Thus another apparent desparity in the first set of analyses may be a consequence of the escapement record underestimating true escapement.

3. If new techniques providing less biased estimates of chinook escapement are adopted, the interpretation of stock and recruitment parameters must be adjusted accordingly.

4. Finally, and most importantly, when estimating how much catch must be forgone to bring chinook escapement back up to optimum it must be remembered that one chinook in units of the escapement record is really about two fish in the true escapement. In other words, to increase the coastwide escapement estimate by 50 thousand, at least 100 thousand maturing chinook must be forgone in the catch.

CONCLUSIONS

When faced with data of uncertain quality, the fishery manager has two options. He can reject the data and work from some other base of information. Or he can make the best interpretation possible from the imperfect data. In the case of chinook the data presented here, although of uncertain quality, are the only data available for B.C. chinook. In my view, therefore, the only available option is to see what can be made of these data. A number of conclusions are, I believe, reasonable from the data. Coastwide catch of chinook originating from B.C. appears definitely to have increased, although the increase has been less than the increase in catch by B.C. fishermen. The heavy interception of Columbia River chinook by B.C. trollers has permitted the catch by B.C. fishermen to increase more rapidly than the catch of B.C. chinook. Catch by all gear types has increased, however, except for the gillnet catch. Reduced returns to the Fraser River mouth have resulted in curtailment of the rivermouth gillnet fishery to preserve spawning escapements.

Catch of B.C. chinook in U.S. fisheries has increased only in the Washington net and sport fisheries. Estimated catch of B.C. chinook in the Washington troll and the Alaska troll and net fisheries has decreased. Thus, while B.C. fishermen have taken an increasing number of Washington and Columbia River chinook, the overall catch of B.C. chinook in U.S. fisheries has remained about the same.

Overall, recruitment to B.C. chinook stocks appears to have increased 0-34% depending on the assumptions used in calculating the contribution of B.C. stocks to coastwide fisheries.

Although catch of chinook has increased, the apparent distribution of fishing effort among statistical areas has not changed appreciably. Localization of fishing effort within statistical areas has probably shifted somewhat, but greatest catches are still taken in the same areas of the coast as they were in the 1950s. Relative contribution to the total catch has shifted somewhat among gear types with seine and sport contribution increasing, gillnet contribution declining, and troll contribution stable. The changes in fishing pattern and contribution by each gear type have been relatively small, however, and in my view suggest that the increase in exploitation rate over the years has been relatively uniform for most chinook stocks.

The increase in catch of chinook by B.C. fishermen has been accompanied by a general increase in catch-per-unit-effort. Ordinarily an increase in catch-per-unit-effort is taken as an indicator of increasing stock abundance. Fish finding and catching technology in the salmon fishery has improved so much over the years, however, that any increase in catch-per-unit-effort is more likely to represent improved capture techniques and/or greater concentration of the fishing gear on chinook. The increase in fishing power of the salmon fleet could even mask an overall decline in stock size, so that increases in catch-per-unit effort should not be taken even as an indicator of a healthy stock.

Chinook caught in the more northerly areas of the coast are older, on average, than those caught in the south, but there is no evidence for a progressive decline in average age in the catch since 1951. The average weight of fish landed by all gear does appear to have declined over this period, however. Whether this represents genetic selection for smaller fish as suggested by Ricker (1980), or whether it is merely an artifact of poor data about age composition and average weight is uncertain.

While coastwide catch of B.C. chinook has increased, coastwide escapement has declined. Despite the obvious reservations one must have about the escapement data, I believe this conclusion is reasonable. Obviously if these trends of increasing catch and declining escapement continue long enough, there must ultimately be a collapse of the stocks. Increasing catch coupled with smaller reproductive stock and more youthful age composition are, however, also characteristics of a healthy developing fishery. From a fishery management point of view, the trick is to identify the stock size that will produce a high and stable yield.

Stock and recruitment analysis is one technique for predicting spawning stock size for maximum yield. Although no stock of Pacific salmon is managed directly by a stock and recruitment relationship, the notion of stock and recruitment pervades most thinking about management regulations. In the absence of well worked out stock and recruitment relationships, some arbitrary estimate of "optimum" escapement is normally set as a management goal. Knowledge of stock and recruitment parameters is, therefore, desirable to guide management decisions about escapement levels to maintain high and stable yield. While it is always better to perform the analysis on individual spawning stocks, to avoid confusion in the interpretation due to mixing stocks of different productive capacity, adequate data rarely exist for any single population, let alone all spawning populations within a geographic region. In the case of B.C. chinook the only possible analysis at present is for a mixture of all spawning populations in the province. I have already given several reasons for believing that exploitation rate and increases in exploitation rate of B.C. chinook have been relatively uniform, and that the response to increasing exploitation has also been uniform across spawning populations, so that a single stock and recruitment relationship is reasonable.

A Ricker type (Ricker 1975) stock and recruitment relationship fits the coastwide stock and recruitment data very well, and the parameters of the relationship are similar regardless of the set of assumptions used to generate the recruitment estimates. The analysis shows that escapement has only recently fallen below the stock required for maximum recruitment, and that this stock lies somewhere in the range 200-250 thousand. The escapement figures used were considered only to be an index of the true spawning population abundance. The real number of spawners required may be closer to 440 thousand.

It is encouraging that the parameters of the stock and recruitment curve for B.C. stocks are similar to those calculated for Columbia River stocks prior to damming of the river (Van Hyning 1973). It may be that chinook stocks throughout the coast have a similar productivity (barring some catastrophic remodelling of their habitat like the damming of the Columbia River), and that a single stock and recruitment relationship is a useable management tool.

The implications of this analysis are that coastwide chinook stocks are not yet seriously overexploited. But the apparent steepness of the ascending left limb of the stock recruitment relationship implies that severe overfishing is a real possibility. Stock size for maximum yield appears to be in the range 200-250 thousand of the escapement index. Since the stock and recruitment curve has a reasonably flat dome, little production would be lost by aiming for the upper rather than the lower escapement figure, and this would provide a cushion against slipping down the steep left hand limb of the curve. Aiming for historic escapement levels appears, at this stage, to be unnecessary for maintaining high and stable chinook production in B.C.

I must emphasize that the foregoing analysis is preliminary at best and is based on information in which no one has a great deal of confidence. Generating adequate stock and recruitment data is, obviously, a long term undertaking. Nevertheless, I believe that we should direct our attention to this job. In my view it is appropriate to select a few populations within the Province as indicators of chinook productivity and concentrate attention on them. Special attention should be given to selecting both stream type and ocean type populations and populations from the major geographic and climatic regions of the Province. Stream type chinook deserve greater attention in B.C. in particular because there is some evidence that their escapements may have declined more than escapements of ocean type chinook. A study of carefully selected groups of populations, such as suggested above, would, I believe, provide a better picture of coastwide production and variation in productivity than would attempting to monitor all populations.

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Table 1. Canadian estimates of the percent of Canadian fish in British Columbia and United States fisheries. Source: U.S. Canda technical committee on salmon interceptions.

	Fishing Area												
	Alaska	British Columbia											Washington Oregon
Fishery		1-2	3	4	5	6-12	13-19 28	20	21-24	25-27	30	29	
Canadian													
Troll	40	50	95	75	50	60	86	50	20	25	60	80	10
Net						97		50					
Sport							83						
Alaska													
Troll	41												
Net	28												
Wash/Or.													
Troll													24
Net													86
Sport													36

Table 2. Catch of chinook by B. C. Fishermen in Thousands of fish and metric tons for 1951-79.

	TRAPS		TROLL		GILLNET		SEINE		SPORT		SUBSISTENCE		TOTAL CATCH	
Year	PIECES	TONS[1]	PIECES	TONS	PIECES	TONS	PIECES	TONS	PIECES	TONS[2]	PIECES	TONS[3]		
1951	14	139	527	3245	224	1677	45	238					910[4]	5617[4]
52	17	177	647	3984	220	1554	28	135					1012[4]	6168[4]
53	15	155	703	4118	237	1895	41	228	83	188			1099[5]	6720[5]
54	11	117	578	3206	264	2101	25	138	88	200			986[5]	5898[5]
55	14	149	589	3136	231	1653	38	201	104	236	20	136	996	5511
56			734	3797	212	1616	37	142	123	280	18	123	1124	5958
57	9	81	723	3741	187	1169	18	99	151	343	18	123	1106	5556
58	13	122	729	3508	288	1994	38	216	165	375	20	136	1253	6351
59			674	3342	259	2013	35	197	136	309	23	157	1127	6018
1960			495	2471	210	1583	37	200	110	250	17	116	869	4620
61			459	2302	170	1177	49	247	77	175	15	102	770	4003
62			470	2264	204	1275	45	182	102	232	16	109	837	4062
63			555	2643	210	1296	37	214	97	220	16	109	915	4482
64			666	3284	265	1988	34	225	80	182	17	116	1062	5795

Table 2 (cont'd)

Year	TRAPS		TROLL		GILLNET		SEINE		SPORT		SUBSISTENCE		TOTAL CATCH	
	PIECES	TONS[1]	PIECES	TONS	PIECES	TONS	PIECES	TONS	PIECES	TONS[2]	PIECES	TONS[3]		
65			697	3383	211	1356	73	422	76	173	20	136	1077	5470
66			895	4346	216	1442	54	342	105	239	15	102	1285	6471
67			799	4034	257	1789	74	445	80	182	15	102	1225	6552
68			806	4188	214	1606	62	394	96	218	19	130	1197	6536
69			853	4183	175	1178	72	366	99	225	21	143	1220	6095
1970			818	3837	258	1498	137	568	139	316	29	198	1381	6417
71			1270	5880	214	1376	109	428	123	280	22	150	1738	8114
72			1223	5434	216	1491	113	460	154	350	28	191	1734	7926
73			1091	4916	183	1207	151	583	148	336	21	143	1594	7185
74			1178	5218	155	985	134	532	159	361	25	170	1651	7266
75			1103	4858	169	1033	139	559	204	464	32	218	1647	7132
76			1249	5332	168	1029	126	493	292	664	32	218	1867	7736
77			1111	4659	191	1131	193	928	255	580	39	265	1789	7563
78			1033	5115	149	990	185	888	276	627	31	210	1674	7830
79			997	4308	146	888	186	905					1636[6]	6938[6]

1) Trap caught fish assumed equal in weight to seine caught fish.
2) Estimated by assuming 2.27 kg per fish.
3) Estimated by assuming 6.82 kg/fish.
4) Sport catch estimated at 80 thousand fish and 182 tons, subsistence catch estimated at 20 thousand fish and 136 tons.
5) Subsistence catch estimated at 20 thousand fish and 136 tons.
6) Subsistence catch estimated at 31 thousand fish and 210 tons. Sport catch estimated at 276 thousand fish and 627 tons.

Table 3. Percentage contribution to total chinook catch by gear type.

	TROLL		GILLNET		SEINE		SPORT		SUBSISTENCE	
Year	PIECES	WEIGHT	PIECES	WEIGHT	PIECES	WEIGHT	PIECES	WEIGHT	PIECES	WEIGHT
1951	58	58	25	30	5	4	9	3	2	2
52	64	65	22	25	3	2	8	3	2	2
53	64	61	22	28	4	3	8	3	2	2
54	59	54	27	36	3	2	9	3	2	2
55	59	57	23	30	4	4	10	4	2	2
56	65	64	19	27	3	2	11	5	2	2
57	65	67	17	21	2	2	14	6	2	2
58	58	55	23	31	3	3	13	6	2	2
59	60	56	23	33	3	3	12	5	2	3
1960	57	53	24	34	4	4	13	5	2	3
61	60	58	22	29	6	6	10	4	2	3
62	56	56	24	31	5	4	12	6	2	3
63	61	59	23	29	4	5	11	5	2	2
64	63	57	25	34	3	4	8	3	2	2
65	65	62	20	25	7	8	7	3	2	2
66	70	67	17	22	4	5	8	4	1	2
67	65	62	21	27	6	7	7	3	1	2
68	67	64	18	25	5	6	8	3	2	2
69	70	69	14	19	6	6	8	4	2	2
1970	59	60	19	23	10	9	10	5	2	3
71	73	72	12	17	6	5	7	3	1	2
72	71	69	12	19	7	6	9	4	2	2
73	68	68	11	17	9	8	9	5	1	2
74	71	72	9	14	8	7	10	5	2	2
75	67	68	10	15	9	8	12	7	2	3
76	67	69	9	13	7	6	16	9	2	3
77	62	62	11	15	11	12	14	8	2	4
78	62	65	9	13	11	11	16	8	2	3
79	61	62	9	13	11	13	17	9	2	3

Table 4. Troll catch by statistical area by 5 yr period for 1951-1979 as % of total catch.

STATISTICAL	TIME PERIOD					
AREA	1951-55	1956-60	1961-65	1966-70	1971-75	1976-79
Alaska	-	0.0	0.7	1.7	0.3	0.0
1	5.2	3.8	5.6	7.0	6.0	5.2
2E	1.4	1.4	1.6	2.1	3.4	4.0
2W	0.7	0.5	0.8	1.2	1.3	2.3
3	1.3	1.8	1.4	1.4	1.0	0.5
4	3.6	2.6	3.5	3.0	2.4	1.0
5	4.0	2.0	4.2	4.9	4.0	1.0
6	0.5	0.7	3.2	2.3	2.0	1.3
7	1.4	1.7	2.8	2.6	2.5	3.0
8	0.5	0.5	0.4	0.6	0.9	1.1
9	0.1	0.1	0.1	0.2	0.3	0.7
10	0.0	0.1	0.2	0.7	0.4	0.4
30	0.1	0.1	0.1	0.1	0.3	0.3
11	0.1	0.1	0.2	0.5	2.0	2.7
12	2.8	4.2	3.4	4.7	1.5	1.9
13	3.9	4.7	3.2	2.3	2.3	4.0
14	2.1	2.9	3.4	3.0	3.4	5.4
15	1.1	2.3	1.5	1.6	2.2	1.7
16	3.4	3.5	2.4	1.2	1.4	1.3
17	2.2	5.1	5.6	3.7	6.3	7.6
18	0.1	0.1	0.8	0.6	0.4	0.5
19	0.1	0.3	0.7	0.0	0.0	0.0
20	0.1	0.2	1.1	0.3	0.1	0.1
21	2.1	0.8	2.2	1.8	3.9	3.6
22	0.0	0.0	0.0	0.0	0.0	0.0
23	28.0	35.4	33.7	34.1	33.8	30.7
24	10.8	7.2	7.7	7.7	6.9	9.1
25	10.1	10.2	2.7	1.8	1.4	1.9
26	3.8	4.4	3.7	3.5	2.5	3.3
27	1.6	2.5	2.4	2.6	2.2	2.9
C	0.4	0.0	0.0	2.1	3.9	1.9
28	0.6	1.0	0.5	0.1	0.0	0.0
29	0.1	0.4	0.5	0.5	0.9	0.5
Total Catch	3043804	3355140	2852094	4171328	5865492	4390718

Table 5. Gillnet catch by statistical area by 5 yr period for 1951-79 as % of total catch.

STATISTICAL	TIME PERIOD					
AREA	1951-55	1956-60	1961-65	1966-70	1971-75	1976-79
Alaska	-	-	-	-	-	-
1	0.0	0.0	0.1	0.8	0.8	0.2
2E	0.0	0.0	0.0	0.1	0.1	0.0
2W	0.0	0.0	0.0	0.0	0.0	0.0
3	5.4	8.5	5.3	6.7	6.0	4.3
4	11.0	7.8	6.4	9.2	5.6	5.6
5	0.3	0.5	4.0	1.6	0.8	0.4
6	0.9	1.0	4.7	2.1	2.3	0.6
7	0.5	0.7	1.7	1.4	3.7	1.4
8	3.7	4.7	5.9	5.6	5.4	6.1
9	2.2	2.1	2.5	3.3	4.7	5.7
10	1.0	1.4	3.4	3.7	1.8	1.9
30	-	-	-	-	-	-
11	0.1	0.1	0.1	0.5	0.2	0.4
12	3.3	2.6	4.2	4.9	3.6	4.6
13	2.0	2.9	0.9	1.2	0.8	1.5
14	0.3	0.4	0.1	0.0	0.1	0.0
15	0.2	0.9	0.5	0.2	0.1	0.1
16	2.0	1.6	1.4	1.1	0.6	0.2
17	0.8	0.6	0.3	0.1	0.3	0.2
18	0.1	0.1	0.1	0.0	0.1	0.0
19	0.0	0.0	0.0	0.0	-	-
20	0.5	2.2	4.6	9.6	6.4	5.5
21	0.1	0.4	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.1	0.0
23	1.0	0.5	0.3	0.4	2.6	18.0
24	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.2	0.1	0.0	0.2	0.0
26	0.0	0.0	0.0	0.0	0.0	0.0
27	0.0	0.0	0.1	0.5	1.4	0.4
C	-	-	-	-	-	-
28	0.5	0.2	0.1	0.0	0.0	0.5
29	64.3	60.4	53.0	46.9	52.3	42.2
Total Catch	1175396	1157107	1060155	1119671	936493	654287

Table 6. Seine catch by statistical area by 5 yr period for 1951-79 as % of total catch.

STATISTICAL AREA	TIME PERIOD 1951-55	1956-60	1961-65	1966-70	1971-75	1976-79
Alaska	-	-	-	-	-	-
1	0.1	0.1	0.8	0.6	1.6	2.1
2	0.0	0.0	0.0	0.1	0.3	8.2
3	3.2	5.2	6.4	7.2	4.8	7.0
4	0.0	0.0	0.0	0.1	1.3	0.9
5	2.0	2.1	5.4	3.7	1.4	0.4
6	8.2	6.1	15.7	12.9	9.7	5.9
7	2.3	1.6	4.7	4.9	9.4	7.8
8	13.6	11.0	14.5	11.4	10.7	5.6
9	0.5	0.1	0.1	1.9	2.6	1.9
10	0.0	0.0	0.0	0.0	0.1	0.0
30	-	-	-	-	-	-
11	0.0	0.0	0.0	0.0	0.0	0.0
12	19.2	32.0	25.8	38.9	18.2	21.7
13	9.1	9.6	3.9	6.5	5.7	7.8
14	1.7	2.1	0.3	0.0	0.0	0.1
15	0.0	0.0	0.0	0.0	0.0	0.0
16	0.4	0.5	0.3	0.3	1.2	0.7
17	0.3	0.2	0.2	0.0	0.2	0.2
18	0.2	0.4	0.1	0.2	0.3	0.7
19	0.1	0.3	0.1	0.0	0.0	0.0
20	34.4	24.6	20.8	32.7	26.5	20.2
21	3.2	2.7	0.2	0.0	0.0	0.0
22	0.1	0.0	0.1	0.0	0.0	0.0
23	0.8	0.2	0.0	0.2	3.5	8.2
24	0.1	0.1	0.2	0.0	0.0	0.1
25	0.2	0.7	0.1	0.3	2.0	0.1
26	0.0	0.2	0.0	0.0	0.2	0.1
27	0.1	0.1	0.0	0.0	0.0	0.4
C	-	-	-	-	-	-
28	-	-	-	-	-	-
29	-	-	-	-	-	-
Total Catch	176372	165492	238186	325899	646065	690819

Table 7. Recorded fishing effort (Thousands of fishing days) and catch per fishing day (numbers) for each year.

	Troll		Gillnet		Seine	
Year	Effort	C/E	Effort	C/E	Effort	C/E
1951	132.9	4.0	235.5	1.0	17.1	2.6
52	130.2	5.0	167.2	1.3	10.3	2.7
53	120.8	5.8	204.4	1.2	19.2	2.1
54	109.1	5.3	201.3	1.3	16.9	1.5
55	113.0	5.2	165.1	1.4	17.0	2.2
56	107.3	6.8	148.8	1.4	13.6	2.7
57	123.3	5.9	128.2	1.5	12.9	1.4
58	132.8	5.5	174.8	1.6	14.9	2.6
59	130.1	5.2	139.9	1.9	12.9	2.7
1960	132.1	3.7	143.7	1.5	13.4	2.8
61	148.5	3.1	149.9	1.1	13.6	3.6
62	133.6	3.5	149.5	1.4	14.9	3.0
63	130.1	4.3	121.4	1.7	12.2	3.0
64	147.0	4.5	137.2	1.9	12.4	2.7
65	142.0	4.9	110.0	1.9	11.0	6.6
66	148.4	6.0	121.7	1.8	12.9	4.2
67	147.6	5.4	126.0	2.0	13.0	5.7
68	154.5	5.2	137.2	1.6	14.9	4.2
69	138.5	6.2	98.5	1.8	8.9	8.1
1970	155.0	5.3	129.9	2.0	16.0	8.6
71	156.0	8.1	105.7	2.0	11.2	9.7
72	140.6	8.7	108.5	2.0	14.8	7.6
73	132.5	8.2	108.6	1.7	16.7	9.0
74	125.7	9.4	88.5*	1.8	12.8*	10.4
75	121.1	9.1	60.6*	2.8	10.4*	13.3
76	133.6	9.8	77.7*	2.2	13.8*	9.1
77	147.1	7.6	83.2*	2.3	16.0*	12.0
78	149.8	6.9	68.8*	2.2	13.1*	14.0
79	162.7	6.1	52.1*	2.8	12.1*	15.4

*Deliveries reported rather than days fishing

Table 8. The average weight (kg) of chinook captured by each gear (estimated as weight landed/numbers landed). Troll in dressed weight, gillnet and seine in round weight.

Year	Troll	Gillnet	Seine
1951	6.18	7.49	5.41
52	6.43	7.06	4.82
53	5.86	7.40	5.56
54	5.57	7.96	5.52
55	5.32	7.16	5.29
56	5.18	7.62	3.74
57	5.17	6.25	5.50
58	4.81	6.92	5.68
59	5.11	7.77	5.43
1960	5.00	7.54	5.40
61	4.93	6.92	5.04
62	4.82	6.51	4.04
63	4.76	6.20	5.78
64	4.93	7.50	6.62
65	4.85	6.43	5.78
66	4.86	6.68	6.33
67	5.05	6.96	6.01
68	5.20	7.50	6.35
69	4.90	6.73	5.08
1970	4.69	5.81	4.15
71	4.63	6.43	3.93
72	4.44	6.90	4.07
73	4.51	6.60	3.86
74	4.43	6.35	3.97
75	4.40	6.11	4.14
76	4.27	6.12	3.91
77	4.19	5.92	4.81
78	4.95	6.64	4.80
79	4.32	6.08	4.86

Table 9. Catch of B.C. Chinook in various coastal fisheries and the B.C. subsistence catch.

	British Columbia						Washington			Alaska		Total
Year	Trap	Gillnet	Seine	Troll	Sport	Subsistence	Net	Troll	Sport	Net	Troll	Catch
1951	7223	223061	34640	194344	66400*	20000*	16482[1]	19452[1]	47412	6202	184984	820200
52	8446	218825	20262	268790	66400*	20000*	18952[1]	23958[1]	76608	22665	183219	928215
53	7294	236323	31631	315157	68915	20000*	18665[1]	24651[1]	43704	9445	189637	965422
54	5583	262458	21109	221449	73358	20000*	18657[1]	22576[1]	64584	14577	141084	865435
55	7132	227901	30566	207581	86079	20474	18215[1]	22620[1]	58824	12949	133644	815985
56		209957	28866	263318	101991	18498	14769[1]	17362[1]	74772	10058	80955	820546
57	4470	183993	15534	285504	125099	17811	15472[1]	21250[1]	90360	7938	110426	877857
58	6738	284176	35637	338254	136811	19956	16042[1]	15872[1]	59436	10368	117228	1040518
59		255864	29325	293405	112808	22693	17604[1]	11891[1]	44136	12946	130580	931252
1960		205762	33279	222110	91598	16832	20402	11011	37872	7634	115898	762398
61		163684	40063	209863	63600	15011	18825	16056	47520	7066	83753	665441
62		199416	40901	222026	84738	15641	11559	14823	46512	8953	71167	715736
63		206344	32435	254459	80727	15795	27801	16233	63108	4145	99908	800955
64		260909	32234	284129	66668	16890	23145	12493	39024	7764	135079	878335

Table 9 (Cont'd)

		British Columbia					Washington			Alaska		Total
Year	Trap	Gillnet	Seine	Troll	Sport	Subsistence	Net	Troll	Sport	Net	Troll	Catch
65		204050	65986	278074	63311	19595	27988	5733	40500	7981	106079	819297
66		208385	47604	350753	87139	14652	36275	11081	51192	7298	115653	930032
67		251164	68806	342741	66292	14860	43348	3324	43146	7368	112616	953665
68		206906	57050	330243	79921	19410	29784	2841	45540	7570	124827	904092
69		164676	61949	344163	82523	20553	34365	2813	45072	6673	118893	881683
1970		233406	105404	347457	115517	28504	59484	4579	52800	4960	124740	1076851
71		203511	90596	549838	101907	22082	74304	12486	58449	6316	127682	1247171
72		210736	98014	536680	127593	27747	42570	17590	73332	12435	99337	1246034
73		176933	126574	421355	123046	20597	50310	11584	76010	10066	126136	1142611
74		149066	114891	470688	131907	24891	50052	15851	98018	6846	132073	1194283
75		165609	126691	466574	169313	32269	85692	13817	125200	3743	117808	1306716
76		162942	110412	510406	242692	32433	62709	17593	100697	2959	94787	1337630
77		181732	164318	487906	211671	39428	85352	17739	60664	3750	111429	1363989
78		145647	172595	440421	228780	31329	85364	15194	69637	(3750)	154006	1346723
79		145061	169242	466784	(228780)	(31329)	98412	8597	(69637)	(3750)	138670	1360262

*Sport catch for 1951-52 assumed 80 thousand, subsistence catch 1951-54 assumed 20 thousand.

() Catch data not available asssumed the same as the last recorded year.

[1]Washington net and troll catch not given for specific interception areas. Catch in interception areas estimated from total catch and % of total catch in interception areas from 1960-79.

Table 10. Minimum, maximum and mean escapement to chinook spawning rivers and years of recorded escapement for each river.

Statistical Area & River	Years of Record	Escapement min	max	mean
Area 1				
Yakoun	23	400	15000	2422
Area 3				
Donahue Ck	10	75	400	208
Khutzeymateen	14	25	3500	1159
Kitsault	22	25	800	522
Chambers Ck	13	25	1500	219
Georgie	10	200	1500	755
Kingolith Ck	8	100	750	331
Kwinamass	26	200	3500	1425
Iknook Ck	2	75	100	88
Nass River Harbour	1	750	750	750
Zaulzap	1	25	25	25
Oweegee	6	50	500	242
Seaskinnish	25	150	3500	1050
Cranberry	14	400	3500	2100
Kwinnigeese	11	100	7500	1082
Meziadin	11	250	1500	843
Tseax	26	200	7500	1802
Kiteen	11	40	1500	499
Damdochax	8	350	8000	3506
Ishkinish	15	100	3500	1483
Ensheshee	1	50	50	50
Kinsuch	1	30	30	30
Area 4				
Big Falls Ck	13	20	75	40
Diana Ck	5	75	400	185
Johnstone Ck	28	200	7500	2059
Khyex	12	10	750	125
Kloiya	26	100	1500	423
Ecstall	22	450	3500	1941
Johnston Lk	5	25	200	60
Cedar	23	25	3500	617
Shawatlan	3	8	200	78
Clear Ck	24	25	400	173
Kitsumkalum (upper)	10	200	400	280
Deep Ck	16	10	400	83
Exchamsiks	16	15	300	87
Fiddler Ck	14	25	200	120
Cullon Ck	11	25	25	25
Dog Tag Ck	11	25	25	25
Gitnadoix	14	25	750	266
Kasiks	16	25	400	228

Table 10 (cont'd)

Statistical Area & River	Years of Record	min	Escapement max	mean
Kitsumkalum	16	750	7500	4363
Lakelse	26	25	400	206
Stephens L Ck	17	25	750	168
Kispoix	25	25	15000	2574
Kitwanga	24	75	400	166
Seguinea	6	25	75	38
Zymagotits	13	25	200	89
Zymoetz	15	25	400	190
Nangeese	11	25	200	70
Sweetin	12	25	400	117
Andalas	1	50	50	50
Date	3	25	50	33
Exstew	6	25	75	54
Goat	1	25	25	25
Kitseguecla	1	25	25	25
Kleanza	2	25	25	25
McCully	5	15	75	33
Lean-to	1	25	25	25
Skeena R (West)	4	200	1500	850
Sockeye	5	25	25	25
Williams	1	25	25	25
Dry	1	25	25	25
Spring	2	25	75	50
Star	1	25	25	25
Club (upper)	3	25	100	50
Bear R	29	800	65000	8440
Bulkley (lower)	12	34	500	240
Bulkley (upper)	27	15	2000	692
Morice	29	1700	15000	7396
Nanika	14	25	400	110
Bear Lk	4	100	1000	633
Buck	2	25	50	38
Suskwa	5	25	400	120
Findlay	4	25	1000	270
McDonnell Lk	1	200	200	200
Lower Babine #4	28	12	9000	3046
Lower Babine #5	27	100	3000	749
Nichyeskwa	16	50	800	273
Nilkitkwa Lk	3	50	250	117
Area 5				
Kumealon Ck	9	25	400	189
Area 6				
Aaltanhash	17	2	400	113
Bish Ck	5	25	400	180

Table 10 (cont'd)

Statistical Area & River	Years of Record	min	Escapement max	mean
Brim	20	25	3500	602
Dala	27	25	7500	1435
Kemano	26	500	3500	2038
Kildala	26	75	1500	608
Kitlope	28	25	7500	2511
Hirsch Ck	17	15	750	201
Khutze	18	20	1500	646
Kitimat system	28	1000	20000	4036
Kowesas	10	20	200	52
Little Wadeene	20	25	3500	562
Quaal	8	200	400	375
Tsaytis	11	20	3500	631
Wadeen	17	50	7500	1846
Wahoo Ck	11	25	1500	311
Chist Ck	11	20	750	330
Canoona	1	25	25	25
Carter	1	25	25	25
Don	2	25	25	25
Evelyn	1	25	25	25
Fosh	4	10	400	122
Gilttoyees	1	200	200	200
Kiltuish	3	25	400	167
Kishkosh Inlet	1	25	25	25
McKay	4	25	25	25
Scow Bay	1	75	75	75
Soda Ck	2	25	75	50
Humphrey's Ck	3	25	75	42
Nalabeelah Ck	4	25	25	25
Bear	7	25	75	32
Poison	1	25	25	25
Kitkiata	1	25	25	25
Area 7				
Kianet	2	25	25	25
Area 8				
Bella Coola-Atnarko	29	3500	75000	22293
Dean	18	750	4000	2708
Kimsquit	15	25	3500	733
Kwatna	16	25	1500	539
Noeick	3	100	750	367
Area 9				
Chackawalla	22	25	750	172
Clyak	9	25	75	34
Dallery Ck	12	30	200	102

Table 10 (cont'd)

Statistical Area & River	Years of Record	min	Escapement max	mean
Kilbella	20	25	1500	290
Neechanz	13	25	400	100
Sheemahant	5	25	200	95
Tzeo	8	25	50	34
Wannock	27	600	7500	2463
Wash Wash	15	10	200	67
Ashlum Ck	6	10	25	20
Genesee Ck	1	+	+	+
Inziana	2	+	+	+
McNair Ck	1	+	+	+
Area 10				
Docee	28	25	5000	1259
Nekite	7	20	100	47
Smokehouse	1	+	+	+
Area 11				
Waump Ck	1	25	25	25
Area 12				
Franklin	16	75	1500	594
Folmore	7	25	200	121
Kakweiken	28	25	750	318
Kingcome	28	50	7500	2255
Klina-Klini	28	400	15000	6975
Kokish	9	25	400	164
Kwalate Point	10	25	200	95
Nimpkish System	29	400	15000	6757
Sim Ck	10	400	750	505
Wakeman	25	1242	200	3500
Adam	17	25	750	297
Ahnuhatti	16	25	750	886
Barnard Bay Ck	2	25	25	25
Glendale Ck	2	25	25	25
Keogh	1	25	25	25
Robbers Knob Ck	2	25	25	25
Tuna	1	25	25	25
Area 13				
Armor de Cosmos Ck	20	8	75	28
Apple	13	75	1500	487
Campbell	29	750	7500	3672
Cumsack Ck	17	25	3500	474
Homathko	29	1500	7500	4276
Oxford Ck	29	25	1500	456
Phillips	29	200	1500	588

Table 10 (cont'd)

Statistical Area & River	Years of Record	Escapement min	max	mean
Quatum	12	200	25	1500
Quinsam	12	25	468	94
Salmon	29	400	3500	1019
Southgate	29	1500	7500	4276
Stafford	25	25	200	71
Teaquahan	29	75	750	278
Fraser Bay Ck	1	25	25	25
Heydon Ck	2	25	25	25
Hyacinth Ck	2	25	25	25
Area 14				
Englishman	18	25	115	55
Little Qualicum	29	75	7500	763
Oyster	9	25	200	40
Puntledge	29	150	15000	2531
Big Qualicum	29	750	8309	1705
Area 15				
Brem	8	25	2000	1066
Klite Ck	23	25	7500	1473
Little Toba	18	50	8000	1848
Toba	23	750	12000	4163
Area 16				
Skwawka	8	25	100	53
Tzoonie	13	25	400	77
Area 17				
Chemanus	22	16	225	76
Nanaimo	29	200	3500	2093
Area 18				
Cowichan	29	3500	15000	6897
Goldstream	17	2	75	27
Koksilah	29	50	750	255
Area 20				
Gordon	28	25	3500	396
San Juan	29	25	7500	927
Sook	25	6	3500	737
Area 22				
Nitinat	28	400	3500	1702
Area 23				
China Ck	10	10	75	32

Table 10 (cont'd)

Statistical Area & River	Years of Record	Escapement		
		min	max	mean
Coer-D'alene Ck	10	2	50	25
Cous Ck	12	15	25	24
Effingham	19	27	25	50
Franklin	14	25	90	37
Henderson Lk	29	150	1500	584
Nahmint	29	200	3500	1181
Sarita	29	75	750	413
Somass system	29	7500	15000	10241
Toquart	27	25	750	151
Area 24				
Bedwell	24	10	1500	297
Cypre	29	10	750	197
Ice	21	10	400	130
Kennedy (lower)	29	50	1500	573
Megin	29	6	1500	505
Moyeha	29	6	750	305
Sidney	26	6	750	167
Tofino Ck	20	10	750	165
Tranquil Ck	28	4	750	342
Watta Ck	23	10	200	53
Area 25				
Brodick Ck	5	25	25	25
Burman	28	75	7500	1540
Canton	26	25	600	230
Conuma	29	25	3500	952
Deserted	22	25	750	217
Espinosa Ck	15	25	400	64
Gold	28	25	7500	1565
Hois Ck	6	25	50	29
Jacklah	19	25	200	52
Kleeptee Ck	16	5	200	53
Leiner	28	25	1500	246
Mamat	8	25	75	34
Moyah Ck	25	1	700	149
Park	17	25	200	49
Sucwoa	22	20	1500	373
Tahsis	29	25	1500	398
Tlupana	22	20	400	59
Tsowwin	25	10	750	170
Zeballos	28	25	750	132
Little Zeballos	26	10	900	84
Area 26				
Amai	11	25	25	25

Table 10 (cont'd)

Statistical Area & River	Years of Record	min	Escapement max	mean
Artlish	28	25	3500	712
Battle Bay	12	25	75	38
Chamiss	9	25	25	25
Clannick	8	5	25	23
Kauwinch	25	4	750	204
Kaouk	28	50	3500	645
Kashutl	13	12	200	41
Malkscope	17	10	400	133
McKay Cove Ck	16	3	400	64
Narrowgut	12	25	200	44
Naspart	6	2	75	30
Ououkinish	19	25	400	142
Power	27	6	1500	262
Tasish	28	25	7500	1656
Area 27				
Cayeghle Ck	7	25	100	44
East Ck	21	2	700	143
Klaskish	16	25	1500	255
Mahatta	8	20	150	98
Colonial Ck	8	20	500	143
Marble Ck	28	40	8000	1506
Goodspeed	8	25	1100	219
Area 28				
Capilano	8	44	3000	707
Ashlu Ck	28	25	2000	528
Cheakamus	28	150	3500	1494
Mamquam	28	25	1500	341
Squamish	29	3500	35000	12190
Area 29				
Birkenhead	28	100	3500	748
Portage Ck	26	25	750	136
Seton	26	10	200	44
Yolakom	20	3	450	96
Upper Pitt	28	200	7500	1279
Big Silver	28	24	300	102
Chehalis	25	25	750	142
Douglas Ck	14	25	25	25
Harrison	28	3500	75000	14607
Maria	27	25	400	132
Sloquet Ck	4	25	750	250
Stave	14	25	200	41
Chilliwack	28	25	750	339
Slesse Ck	9	25	75	36

Table 10 (cont'd)

Statistical Area & River	Years of Record	Escapement min	max	mean
Adams	28	400	3500	1893
Barriere	28	10	400	95
Besette	12	15	50	26
Bonaparte	22	10	400	91
Clearwater	25	200	7500	1926
Coldwater	26	200	1500	587
Deadman	27	10	750	322
Eagle	28	200	3500	1002
Finn Ck	28	200	3500	756
Lemieux Ck	9	25	400	97
Little	28	100	1500	456
Louis Ck	27	25	750	271
Lower Shuswap	28	1500	15000	5996
Nahatlatch	20	25	400	100
North Thompson	21	400	3500	1673
Nicola	26	400	7500	4015
Raft	28	25	1500	464
Regchristie Ck	6	25	200	150
Salmon	27	200	7500	998
Seymor	13	10	7500	709
South Thompson	26	25	7500	3997
Spius	24	25	1200	306
Thompson	22	25	4000	2138
Upper Shuswap	27	300	1500	794
Bowron	28	400	3500	968
Chilcoten	28	400	1500	705
Chilko	28	400	11000	3473
Cottonwood	28	75	400	154
Horsefly	28	25	750	190
Quesnel	28	400	2500	905
Taseko	22	50	750	464
West Road	16	200	1900	744
Goat/West Twin/Milk	9	25	75	42
Holmes/Nevin/Horsey	10	25	750	287
Swift Ck	10	75	200	173
Elkin Ck	9	100	450	261
Chilako	19	25	200	99
Driftwood	10	3	3500	386
Endako	20	6	75	27
Fraser at Tete Jaune'	28	200	7500	2217
Kazckek Ck	16	25	75	34
Kuzkwa Ck	23	25	200	77
McGreggor	26	125	1500	725
Middle	13	12	25	24
Morkill	11	170	400	234
Nechako	26	75	3500	961

Table 10 (cont'd)

Statistical Area & River	Years of Record	min	Escapement max	mean
Ormond Ck	7	4	25	22
Salmon	21	10	750	267
Stellako	27	25	1500	167
Slim Ck	18	500	1500	908
Stuart	28	48	1500	417
Tachie	10	7	75	27
Torphy	19	200	1500	524
Willow	24	25	750	130
Walker	6	200	200	200
Mahood	10	109	450	257

Table 11. Chinook escapement (Thousands of fish) to 5 regions of the B. C. Coast 1951-1979.

Year	Coastal Region by Statistical Area					
	1-5	6-11	12-19 & 28	20-27	29	All
1951	49	31	94	48	(133)	355
52	55	55	94	62	133	399
53	67	35	101	49	89	341
54	70	108	115	36	68	397
55	75	40	101	31	56	303
56	72	63	82	36	38	291
57	82	34	82	31	51	280
58	85	60	87	33	78	342
59	43	31	78	23	57	332
1960	58	30	64	24	36	212
61	46	39	57	24	33	199
62	48	44	74	23	49	238
63	65	82	68	29	48	292
64	59	67	81	49	56	312
65	58	45	98	31	44	276
66	52	64	78	39	44	277
67	66	57	56	32	54	265
68	60	62	67	32	47	268
69	61	31	62	28	59	241
1970	41	29	96	29	65	260
71	41	67	61	28	61	258
72	38	39	62	28	48	215
73	52	47	72	34	80	285
74	49	44	55	27	78	253
75	37	18	51	23	77	206
76	25	40	54	24	46	189
77	38	42	51	22	84	237
78	35	35	41	20	79	210
79	26	29	49	21	64	189

Table 12. Escapement trends for individual populations within each of 5 coastal regions. Trend is calculated as is (Σ75-79 escapement)/(Σ51-55 escapement). Populations are grouped into 5 categories of this ratio (<0.5; 0.5-0.75; 0.75-1.25; 1.25-1.5; >1.5). Percent of Propulations in each category shown in brackets.

Coastal Region	No. of Pops with >15 yr data	Ratio (75-79)/(51-55)				
		<0.5	0.5-0.75	0.75-1.25	1.25-1.5	>1.5
Areas 1-5	26	12(46)	3(12)	5(19)	3(12)	3(12)
Areas 6-11	20	9(45)	5(25)	4(20)	1(5)	1(5)
Areas 12-19 & 28	34	10(29)	7(21)	11(32)	1(3)	5(15)
Areas 20-27	48	31(65)	5(10)	9(19)	1(2)	2(4)
Area 29	51	15(29)	7(14)	10(20)	1(2)	18(35)
All Areas	179	77(43)	27(15)	39(22)	7(4)	29(16)

Table 13. Escapement (Thousands of fish) to subregions of the Skeena River (Area 4) and the Fraser River (Area 29) averaged by 5 year periods.

	Subregion								Spring
YEARS	0	1	2	3	4	5	6	7	Runs
Skeena									
1951-55		5.7	10.7	19.8	6.5				
56-60		6.9	13.9	37.2	8.0				
61-65		5.5	5.7	13.0	3.6				
66-70		4.9	7.6	10.7	2.7				
71-75		3.4	10.3	10.5	2.0				
76-79		2.1	9.5	7.1	1.3				
76-79/51-55		0.37	0.89	0.36	0.20				
Fraser									
1951-55	1.0	1.1	29.4	0.5		40.2	3.9	10.4	13.0
56-60	1.5	1.5	9.6	0.6		26.8	5.0	6.9	7.9
61-65	1.0	1.3	7.5	0.4		23.5	7.8	4.5	5.3
66-70	1.0	0.9	8.4	0.1		28.7	10.0	4.7	5.9
71-75	0.6	2.0	23.5	0.1		27.1	10.3	5.7	6.8
76-79	0.7	0.8	16.1	0.3		27.3	12.2	10.9	11.4
76-79/51-55	0.70	0.73	0.55	0.60		0.68	3.13	1.05	0.88

Table 14. Average age of salmon in the troll fisheries around Queen Charlotte Islands & Hecate Strait, Central coast, Georgia Strait and the West Coast of Vancouver Island, and in the gillnet fisheries of the Fraser, Skeena & Nass rivers for various time periods.

FISHERY	YEARS	Reference	$\bar{x}$ AGE ALL FISH	$\bar{x}$ AGE SUB 1	$\bar{x}$ AGE SUB 2	PERCENT SUB 2
Queen Charlotte Is	1929-30	1	4.75	4.78	4.67	23.0
and Hecate Strait	1952-55	1	3.60	3.58	3.96	5.6
Troll	1966-68	2	3.68	3.54	4.14	20.6
Central Troll	1966-69	2	3.54	3.44	4.53	9.3
Georgia Strait	1916-17	1	3.48	3.26	3.95	28.0
Troll	1927-28	1	4.01	3.99	4.10	17.5
	1952-59	1	3.04	2.99	3.60	6.5
	1966-69	2	3.08	3.06	3.56	3.4
West Coast Vancouver	1926-29	1	4.48	4.36	4.94	20.0
Island Troll	1949-50	1	3.26	3.20	3.70	12.4
	1952-59	1	3.26	3.18	3.79	10.9
	1966-69	2	3.43	3.41	3.92	3.9
Fraser River	1952-59	1	3.52	3.36	3.83	34.4
Gillnet	1964-69	4	3.87	3.59	4.32	42.8
	1964-66*	3	3.99	3.81	4.33	33.7
	1975-77	4	3.73	3.62	4.45	12.8
Skeena River	1964-66*	3	3.98	3.81	4.17	48.1
Gillnet	1973-75	5	4.48	4.25	5.06	28.1
Nass River Gillnet	1964-66*	3	3.73	3.51	4.03	46.2

1 Milne 1964

2 Ball & Godfrey 1968, 1969, 1970

3 Ball & Godfrey 1968

4 Starr, Cross & Fraser 1980 ms

5 Ginety 1976

* Test netting

Table 15. Average age of male & female ocean & stream type chinook from test net samples in the Fraser, Skeena & Nass Rivers 1965-66 and sex ratio of the catches.

River	Ocean Type ♂ age	♀ age	♂:	Stream Type ♂ age	♀ age	♂ : ♀
Fraser	3.59	4.04	1.04:1.0	4.13	4.56	1.11:1.0
Skeena	3.47	4.19	1.15:1.0	3.87	5.00	2.71:1.0
Nass	3.02	4.32	1.64:1.0	3.84	4.82	3.91:1.0

Table 16. Age composition of B. C. Chinook in various fisheries based on returns of tagged fish from B.C. hatcheries.

Fishery	Percent of age 1	2	3	4	5	6	mean age
Troll	0	10	50	25	10	5	3.5
Net	0	12	32	52	3	1	3.5
Sport	0.5	63	30	6	0.5	0	2.4

Table 17. Age composition of spawning populations (percent) based on spawning ground surveys.

Population		Age				
	2	3	4	5	6	mean age
Skeena: Kispiox			8	54	38	5.3
Bear	19	12	57	18		3.9
Morice		4	47	39	10	4.6
Babine	3	18	51	23	5	4.1
Kalum		1	12	35	49	5.2
Skeena mean	4.4	7.0	35.0	33.8	20.4	4.6
Kitimat		35	49	16		3.8
Bella-Coola-Atnarko	1	8	50	39	2	4.3
Fraser: Birkenhead	1	40	48	11		3.7
Tete Jaune		43	57			3.6
Shuswap		35	57	5		3.6
Chilko		20	78			3.7
Adams	18	18	59	6		3.6
Deadman	3	30	65	2		3.7
Neehako		23	48	28		4.0
Fraser mean	3.0	29.9	58.9	7.4		3.7
Cowichan	18	25	54	3		3.5
Chemanus		38	54	8		3.7
Big Qualicum	45	25	29	1		2.9
Quinsam	0.5	4.5	37	46	11	4.6
Robertson Creek	38	25	16	21		3.2

Table 18. Comparison of size of chinook (orbit-hypural length cm ±SE) at age in the troll catch between regions of the coast for July averaged over the years 1966-69.

Age	North Coast	Central Coast	West Coast Vancouver Is	Strait of Georgia
2_1	43.1±1.3	41.1±0.5	44.1±2.3	40.5±0.2
3_1	54.2±0.4	53.7±0.6	54.0±0.7	53.7±1.2
4_1	67.5±0.9	68.8±0.7	67.9±1.2	68.9±0.7
5_1	75.6±0.4	78.6±0.7	75.3±0.6	77.8±3.8
6_1	80.7±4.7	82.4±1.3	77.7±2.5	-
3_2	48.2±0.4	45.4±1.4	48.2±1.0	42.6±0.6
4_2	62.4	61.0±1.2	59.4±1.1	64.3±0.8
5_2	71.6±1.0	76.8±2.1	72.8±0.6	71.0±2.6
6_2	-	83.5±3.5	-	-

Table 19. Comparison of size (orbit-hypural length cm ± SE) among months for ages 4 & 5 in different regions of the coast.

Region	Age	April	May	June	July	Aug.	Sept.
North Coast	4	-	65.6±0.6	65.2±0.4	67.5±0.9	67.5±1.0	-
	5	-	74.6±1.4	73.1±0.4	75.6±0.4	76.0±0.4	-
Central	4	-	-	66.4±0.7	68.8±0.7	70.2±1.3	
Coast	5	-	-	76.7±0.5	78.6±0.7	80.1±0.8	
West coast	4	62.6±0.4	63.9±0.2	65.2±1.1	67.9±1.2	66.8±1.0	67.2±0.2
Vancouver Is	5	70.4±1.3	69.7±1.2	73.6±1.7	75.3±0.6	74.2±1.5	75.8±2.7
Strait of	4	60.0±0.5	65.3±1.9	67.4±1.3	68.9±0.7	68.2±1.4	67.6±0.8
Georgia	5	73.5	71.9±4.1	73.4±2.7	77.8±3.8	78.0±6.6	89.4

Table 20. Stock & Recruitment for B. C. chinook in thousands of fish.

Brood Year	Stock	Troll Catch	Net Catch	Recruitment Sport Catch	Subsistence Catch	Escapement	Hatchery Contribution	Total Recruitment, Wild Stocks.
1951	354	393	303	135	20	322		1173
52	398	376	283	145	19	304		1127
53	341	390	254	171	19	294		1128
54	397	423	299	189	20	314		1245
55	304	437	311	181	20	301		1250
56	291	399	293	169	18	250		1129
57	279	345	255	144	17	226		987
58	343	325	254	131	16	235		961
59	331	340	264	122	16	269		1011
1960	212	387	297	136	17	289		1126
61	197	421	307	115	18	383		1144
62	239	426	307	111	16	276		1136
63	293	461	336	119	16	266		1198
64	312	462	323	124	18	261		1188

Table 20 (cont'd)

Brood Year	Stock	Troll Catch	Net Catch	Recruitment Sport Catch	Subsistence Catch	Escapement	Hatchery Contribution	Total Recruitment, Wild Stocks.
65	276	474	309	118	21	251		1173
66	277	500	346	131	25	253		1255
67	265	550	367	150	24	248		1339
68	267	633	372	168	25	241		1439
69	240	627	364	187	23	257		1458
1970	261	590	343	212	26	243		1414
71	258	608	361	245	30	223	5	1462
72	217	609	354	264	32	207	29	1437
73	284	617	397	286	35	215	47	1503
74	253	(615)	(406)	(296)	(33)	(207)	69	1488
75	207	(607)	(415)	(287)	(32)	(201)	(56)	1486
76	189	(602)	(399)	(297)	(31)	(201)	(155)	1375

( )Estimated from partial recruitment.

Table 21. Stock & Recruitment estimates for wild Canadian chinook populations coastwide with several corrections applied.
R_1 = uncorrected recruitment.
R_2 = 3 X sport catch.
R_3 = corrected for increased U.S. hatchery production.
R_4 = corrected for increased U.S. hatchery production and decreased U.S. wild production.
R_5 = corrected for increased U.S. hatchery production, decreased U.S. wild production and 3 X the sport catch.
All in thousands of fish. See text for details of corrections and rationale.

Brood Year	Stock (S)	R_1	R_2	R_3	R_4	R_5
1951	354	1173	1443	1587	1389	1693
52	398	1127	1417	1536	1351	1709
53	341	1128	1470	1471	1305	1689
54	397	1245	1623	1568	1419	1859
55	304	1250	1612	1562	1401	1875
56	291	1129	1467	1386	1246	1652
57	279	987	1275	1174	1062	1390
58	343	961	1223	1077	993	1267
59	331	1011	1255	1116	1039	1297
60	212	1126	1398	1254	1166	1452
61	197	1144	1374	1315	1226	1508
62	239	1136	1358	1292	1218	1450
63	293	1198	1436	1339	1281	1527
64	312	1188	1436	1316	1256	1526
65	276	1173	1409	1286	1237	1483
66	277	1255	1517	1384	1335	1607
67	265	1339	1639	1429	1394	1692
68	267	1439	1775	1491	1486	1829
69	240	1458	1832	1484	1475	1825
70	261	1414	1838	1450	1456	1864
71	258	1462	1952	1551	1439	1869
72	217	1437	1965	1498	1452	1968
73	284	1503	2075	1565	1596	2222
74	253	1488	2080	1521	1567	2235
75	207	1486	2060	1485	1547	2131
76	189	1375	1969	1379	1440	2060

Table 22. Parameters of Stock & Recruitment calculated for each of five recruitment estimates in Table 21 using both 1 X stock and 2 X stock values in Table 21. Values for stock and recruits are in thousands. The stock and recruitment relationship fitted is: $R=\alpha Se^{-\beta S}$.

Parameters	R_1	R_2	R_3	R_4	R_5
At 1 X stock					
α	16.4	22.3	13.2	14.9	20.1
β	-0.0046	-0.0048	-0.0034	-0.0040	-0.0042
$SD\beta$	0.0004	0.0006	0.0004	0.0005	0.0006
Stock for Max Recruits	217	208	292	249	238
Max recruits	1313	1703	1424	1364	1757
Stock for MSY	186	185	242	210	209
MSY	1111	1507	1158	1136	1534
Replacement stock	608	645	755	672	713
At 2 X stock					
α	8.37	10.7	6.77	7.42	11.3
β	-0.0020	-0.0020	-0.0014	-0.0017	-0.0020
$SD\beta$	0.0002	0.0002	0.0002	0.0002	0.0003
Stock for Max Recruits	503	490	704	602	495
Max recruits	1548	1933	1755	1644	2067
Stock for MSY	375	389	494	435	398
MSY	1114	1497	1165	1132	1623
Replacement stock	1068	1163	1347	1207	1202

Table 23. Relative contribution of hatchery and wild chinook to total U.S. chinook production and relative decline in U.S. wild chinook production by 5-yr periods for 1951-1980. See text for explanation of calculations and assumptions.

	Period						Notation
Contributor	51-55	56-60	61-65	66-70	71-75	76-80	i
Hatchery	0.05	0.21	0.38	0.45	0.60	0.59	H_i
Wild	0.95	0.79	0.62	0.55	0.40	0.41	W_i
Decline in wild	1.0	0.9	0.8	0.7	0.6	0.5	C_i

Table 24. Proportion of U.S. fish in interception area catches of chinook by gear type for the period 1971-1975.

Gear	Region Alaska	British Columbia	Washington
Troll	0.59	0.53	0.76
Net	0.72	0.10	0.14
Sport	-	0.17	0.64

Notation: Each value is a P_{ga} where a designates region and g designates gear.

Table 25. Revised proportion of Canadian chinook in interception fisheries by gear type by 5-yr period. Revision 1 assumes that U.S. hatchery production has been added to a constant, U.S. wild production while revision 2 assumes that U.S. hatchery production has been added to a declining U.S. wild production. See text for details of calculations.

Region	Gear	Period 51-55	56-60	61-65	66-70	71-75	76-80
			Revision 1				
Alaska	troll	0.73	0.64	0.54	0.50	0.41	0.42
	net	0.68	0.56	0.44	0.39	0.28	0.29
B.C.	troll	0.76	0.68	0.59	0.55	0.47	0.48
	net	0.96	0.94	0.92	0.91	0.90	0.90
	sport	0.92	0.90	0.87	0.86	0.83	0.83
Washington	troll	0.66	0.54	0.41	0.35	0.24	0.25
	net	0.94	0.91	0.89	0.88	0.86	0.86
	sport	0.71	0.61	0.50	0.46	0.36	0.39
			Revision 2				
Alaska	troll	0.58	0.52	0.46	0.46	0.41	0.46
	net	0.48	0.42	0.34	0.34	0.28	0.34
B.C.	troll	0.62	0.57	0.52	0.51	0.47	0.51
	net	0.93	0.92	0.91	0.91	0.90	0.91
	sport	0.88	0.86	0.85	0.84	0.83	0.84
Washington	troll	0.45	0.38	0.31	0.30	0.24	0.30
	net	0.90	0.89	0.87	0.87	0.86	0.87
	sport	0.54	0.48	0.42	0.41	0.36	0.41

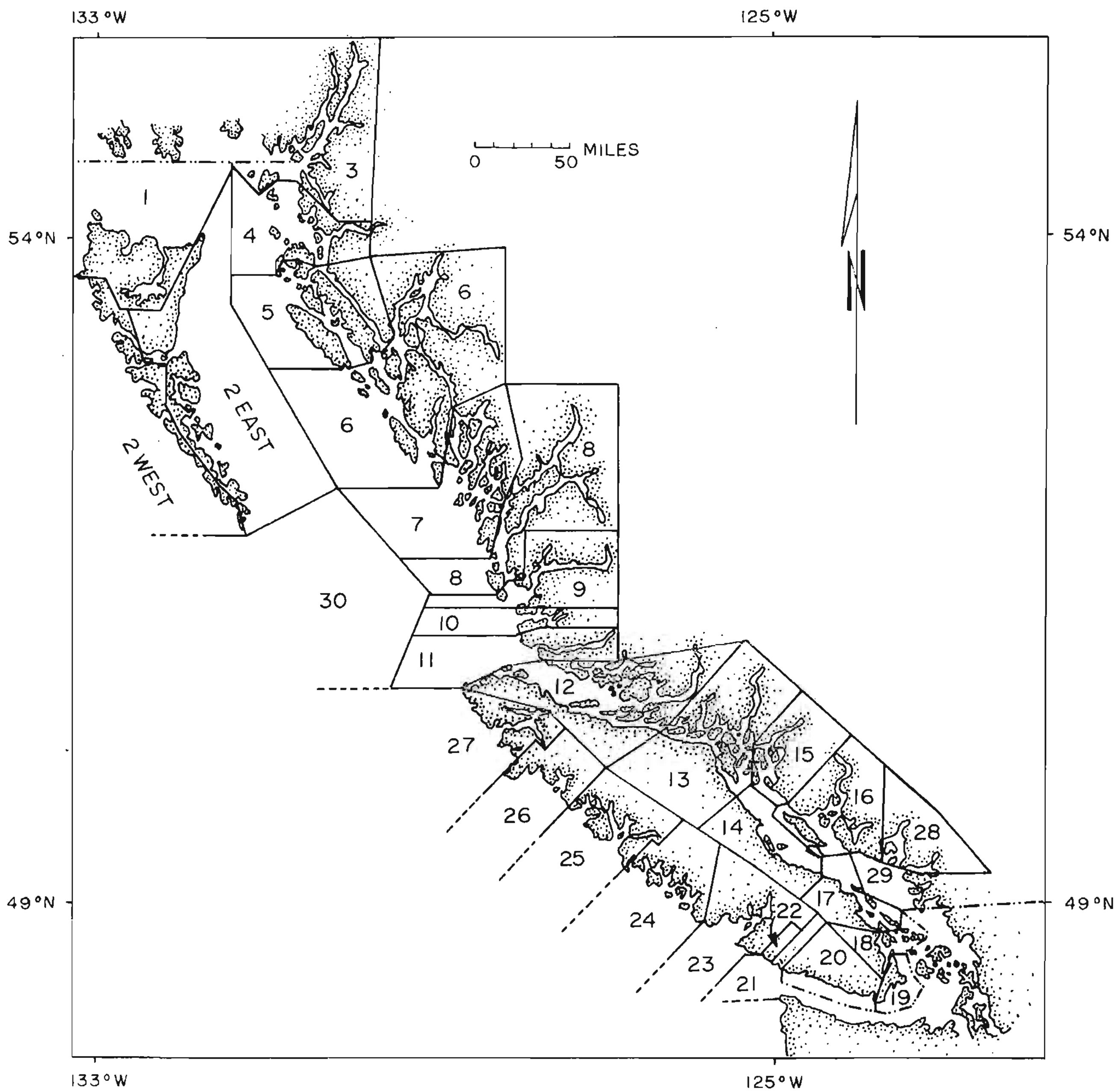

Fig. 1. Map of the B.C. coast showing the fishery statistical areas.

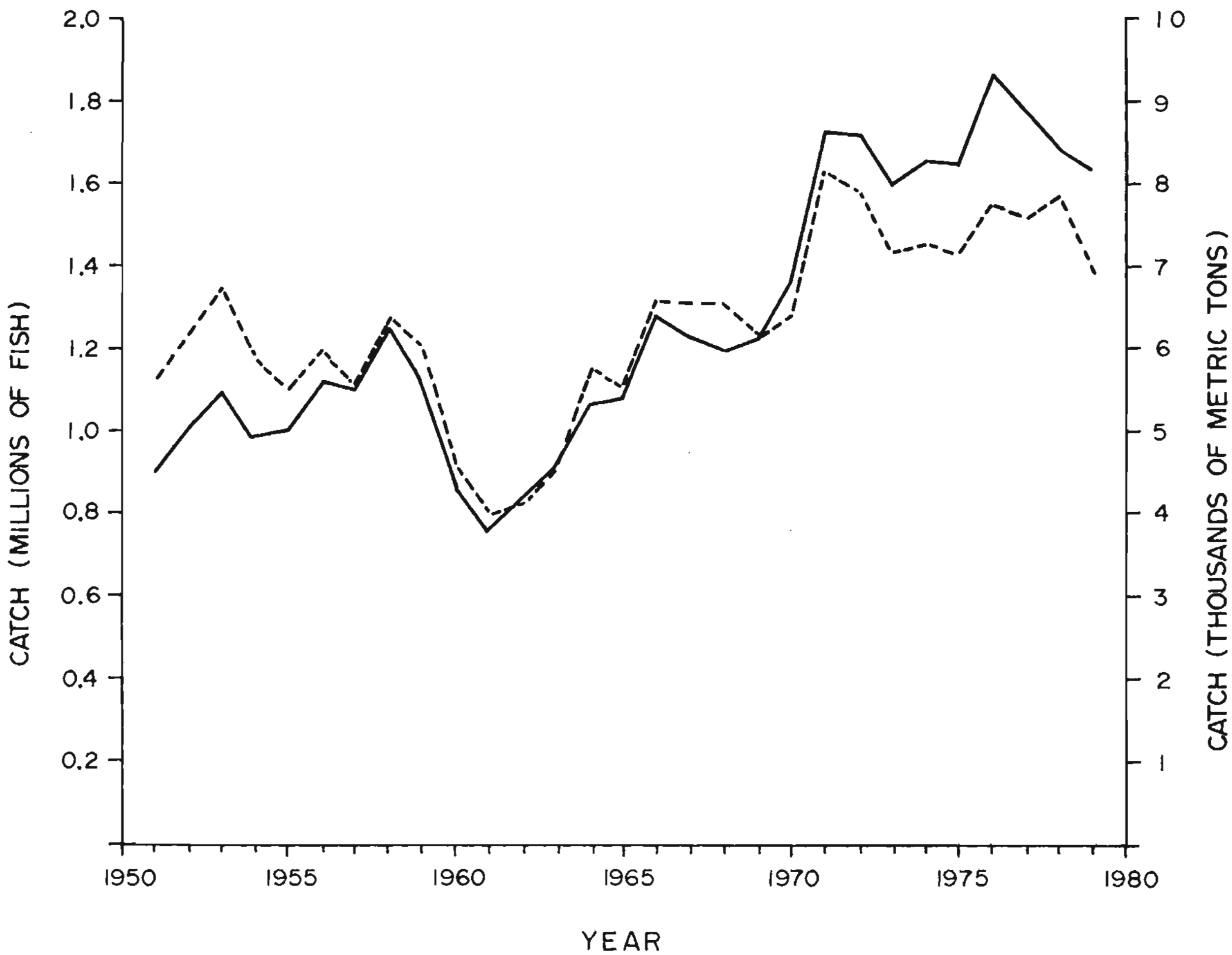

Fig. 2. The catch of chinook salmon by B.C. fishermen in numbers (solid line) and weight (dashed line).

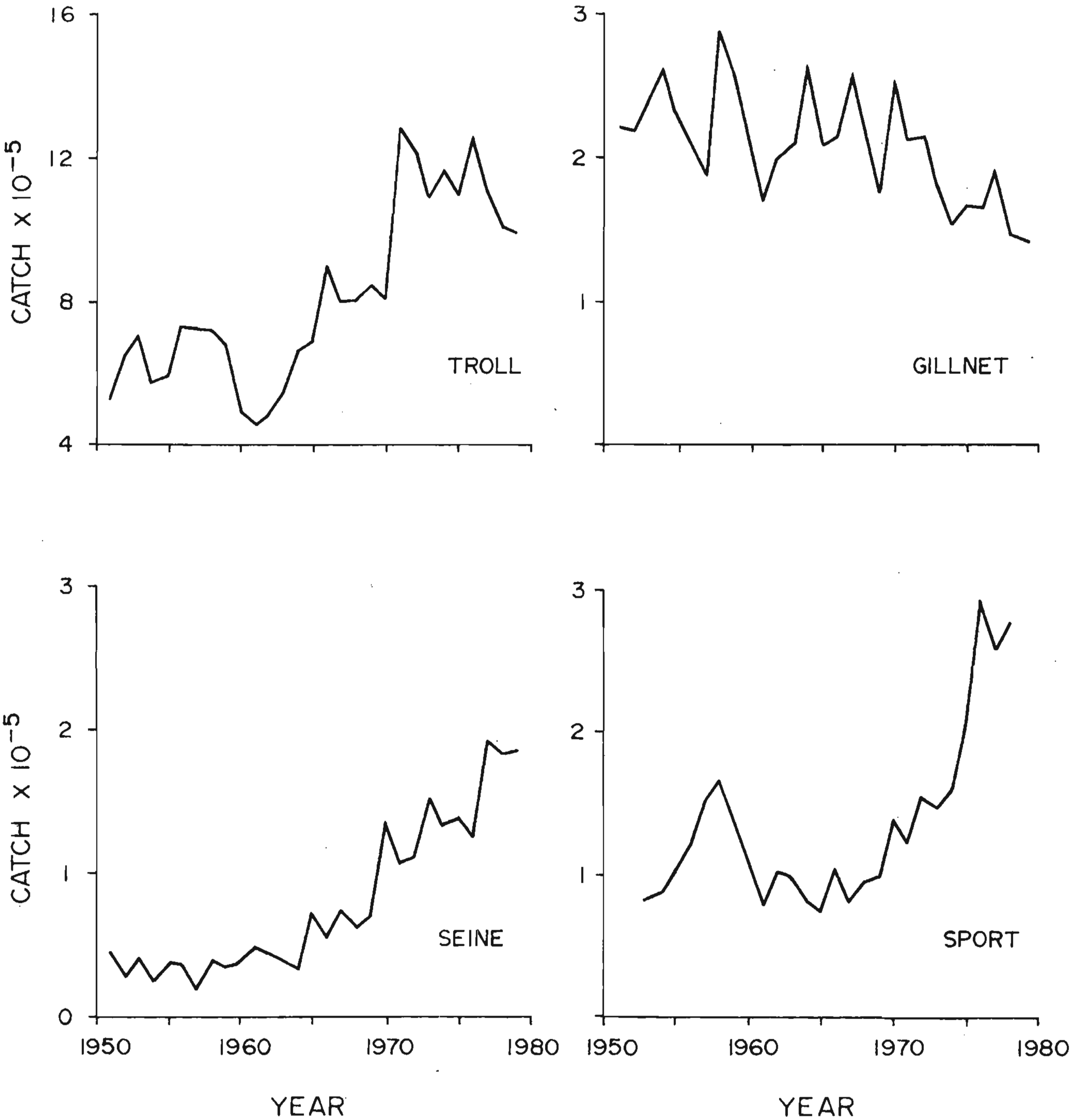

Fig. 3. The catch of chinook salmon in numbers by B.C. fishermen using different fishing gear. Note the different scale for the troll catch.

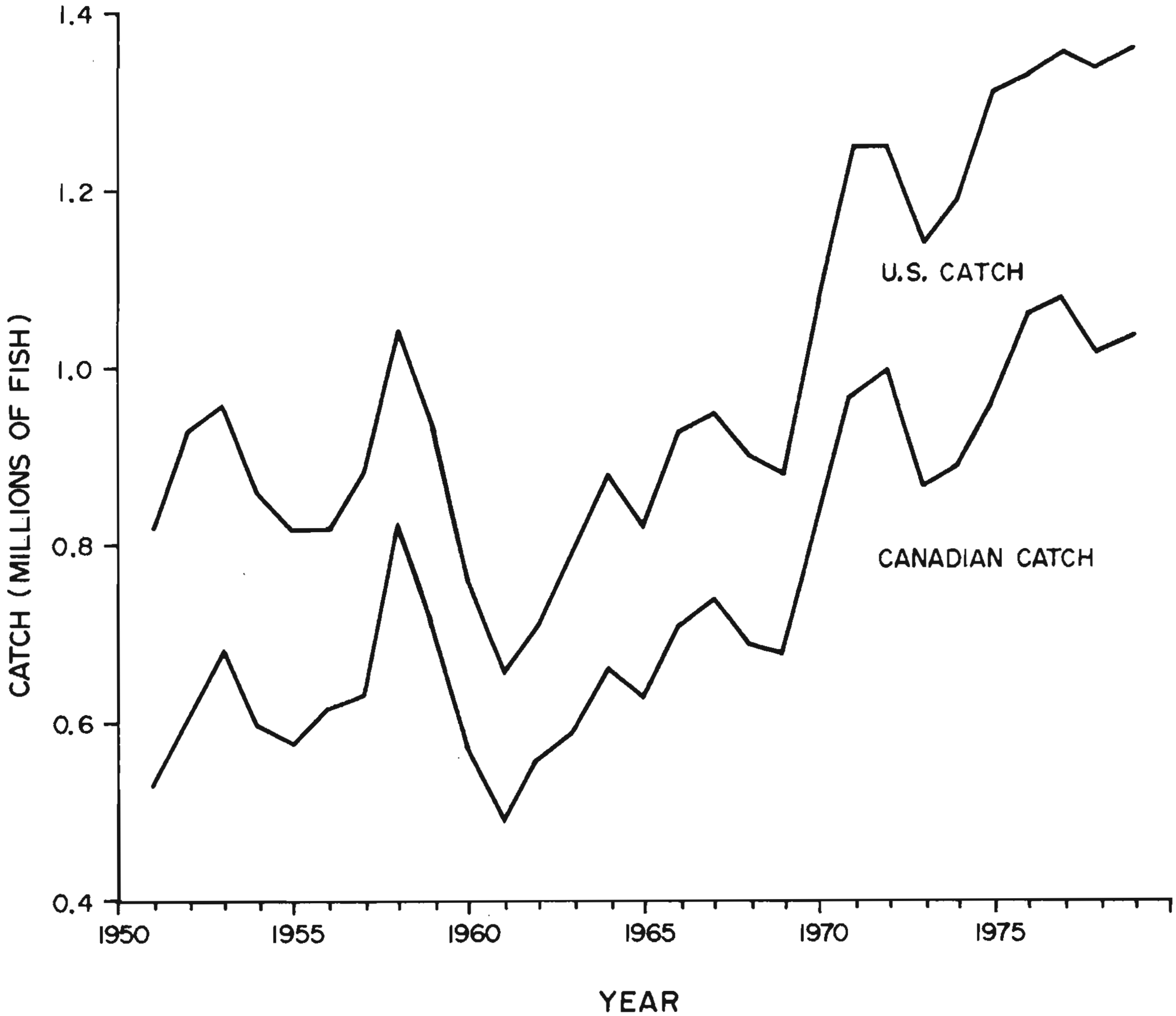

Fig. 4. The coastwide catch of chinook salmon of B.C. origin by B.C. and U.S. fishermen.

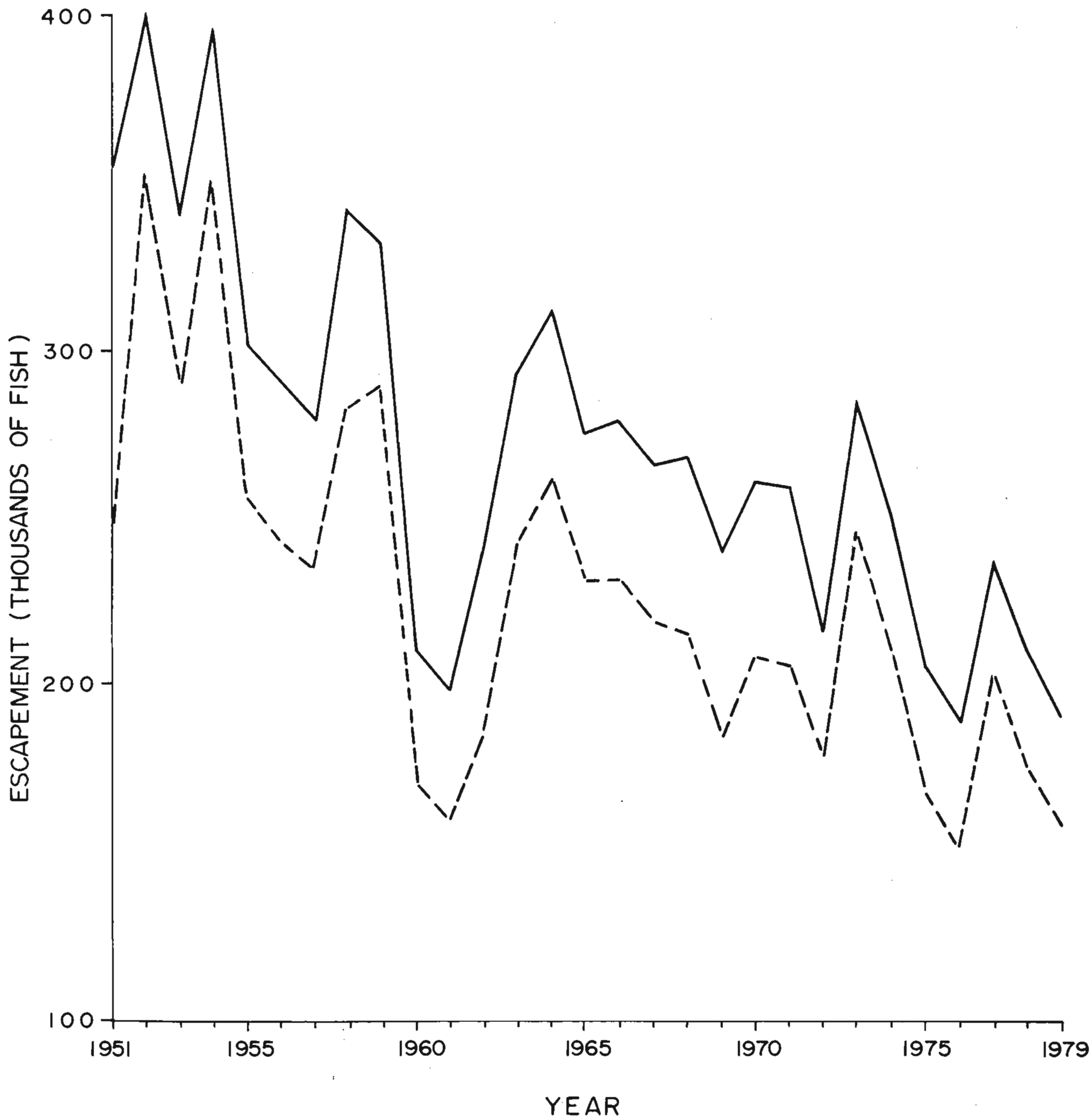

Fig. 5. The total escapement to all chinook salmon spawning populations in B.C. (solid line) and to populations for which there are more than 20 yr of records (dashed line).

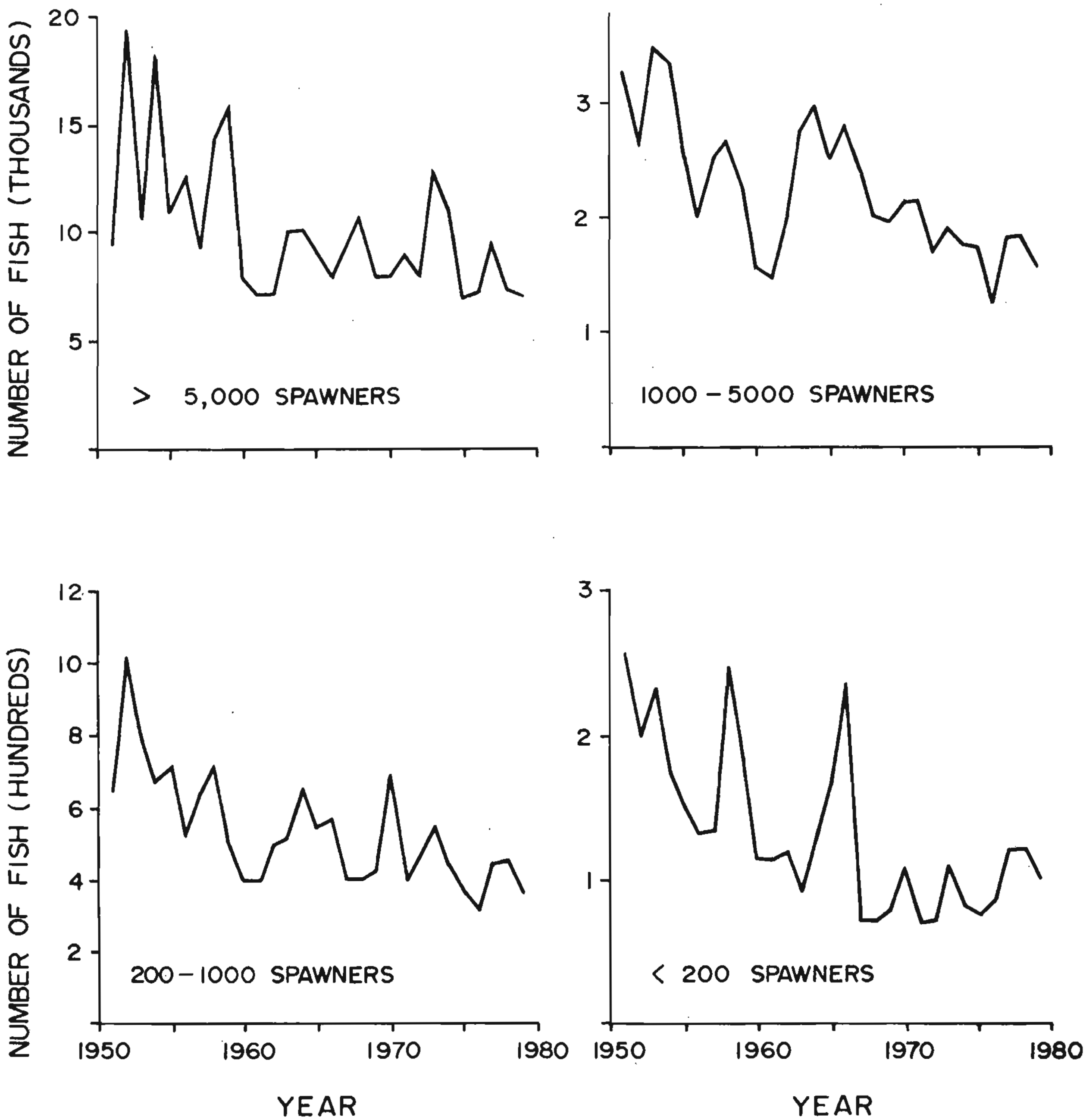

Fig. 6. The average escapement to chinook salmon spawning populations of different abundance.

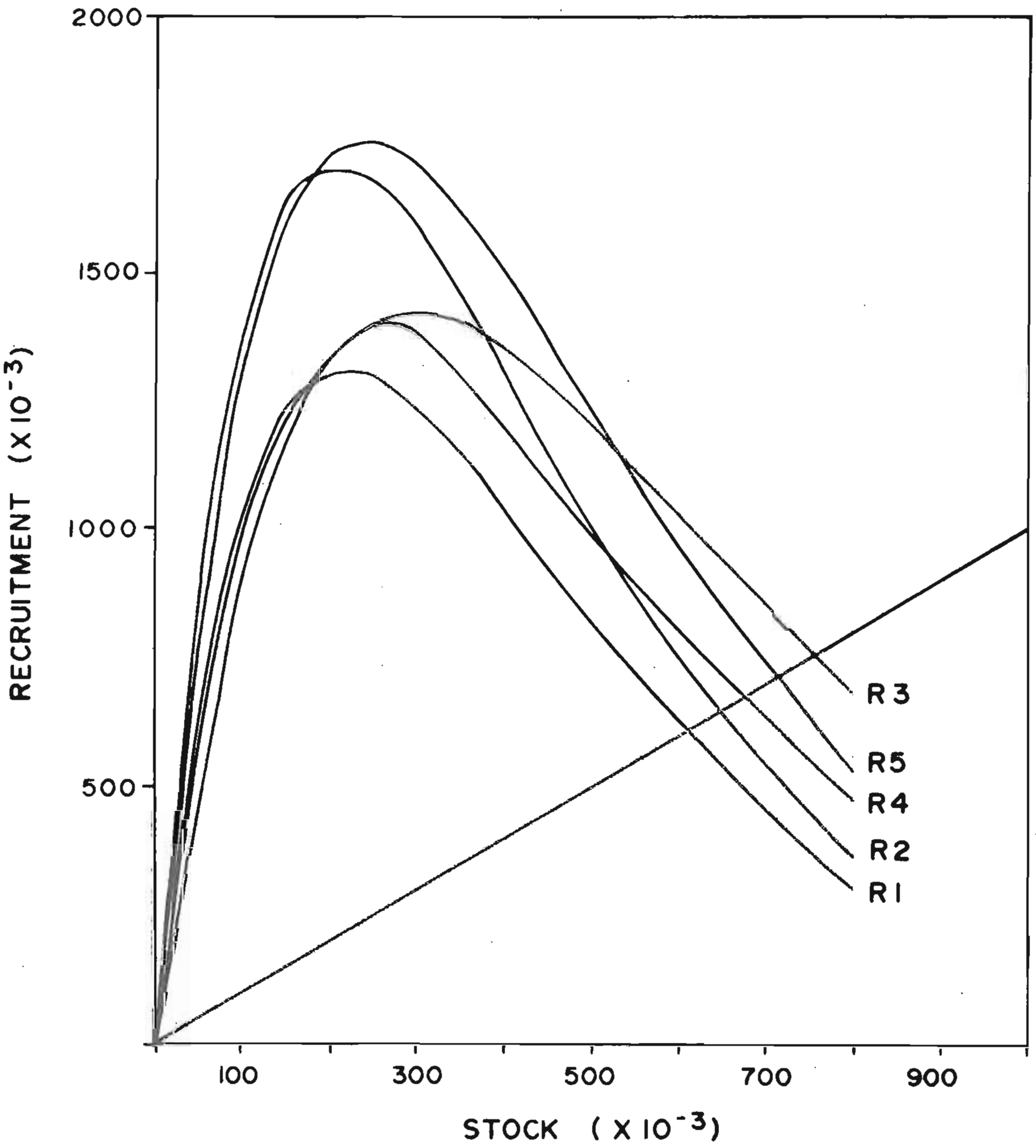

Fig. 7. Stock and recruitment curves for B.C. chinook. R1 to R5 refer to the separate estimates of recruitment in Table 21. These estimates are based on different assumptions (see text). These curves are calculated using 1X the stock values in Table 21.

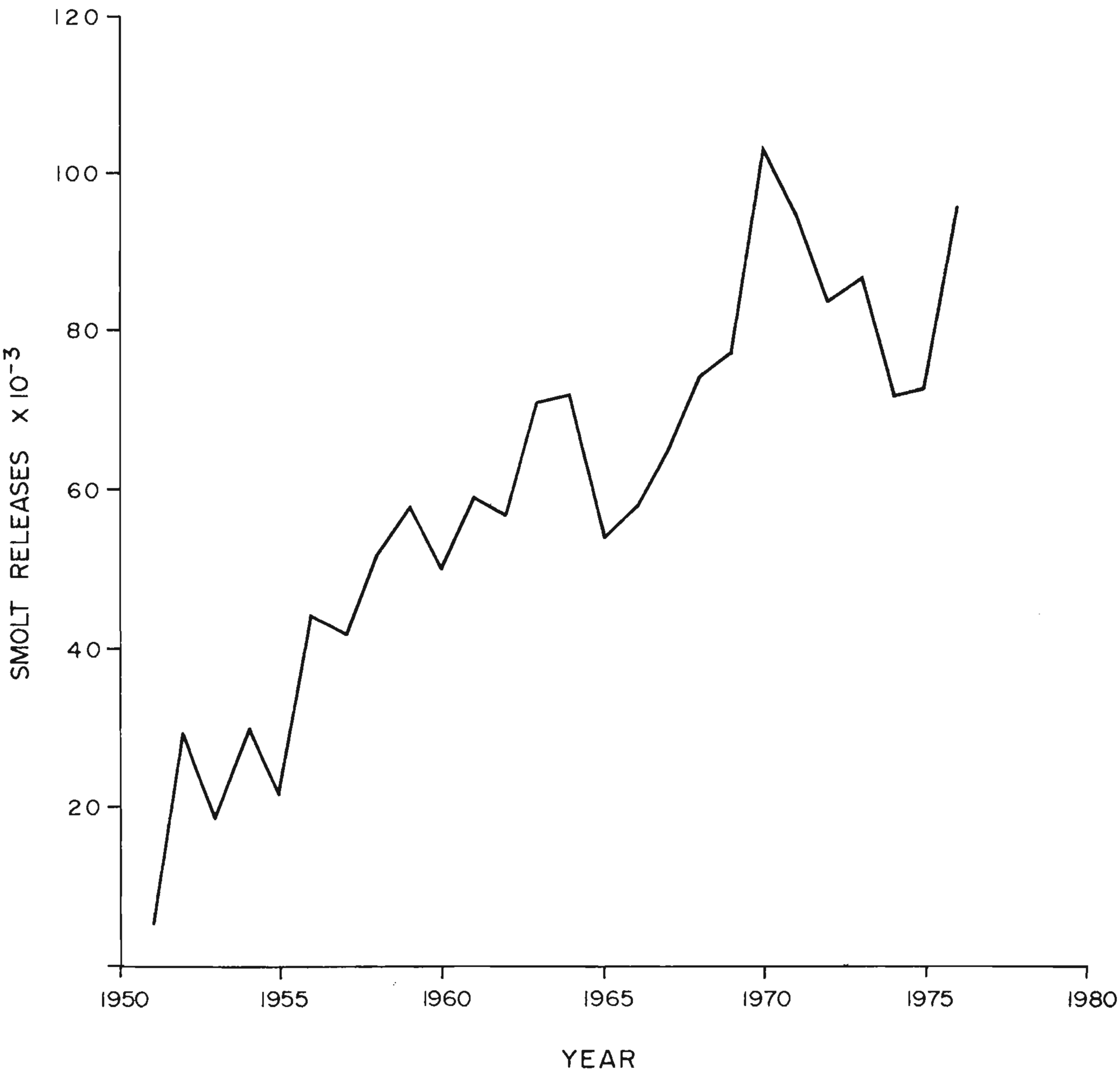

Fig. 8. Chinook smolts released from Washington State hatcheries 1951-1976.

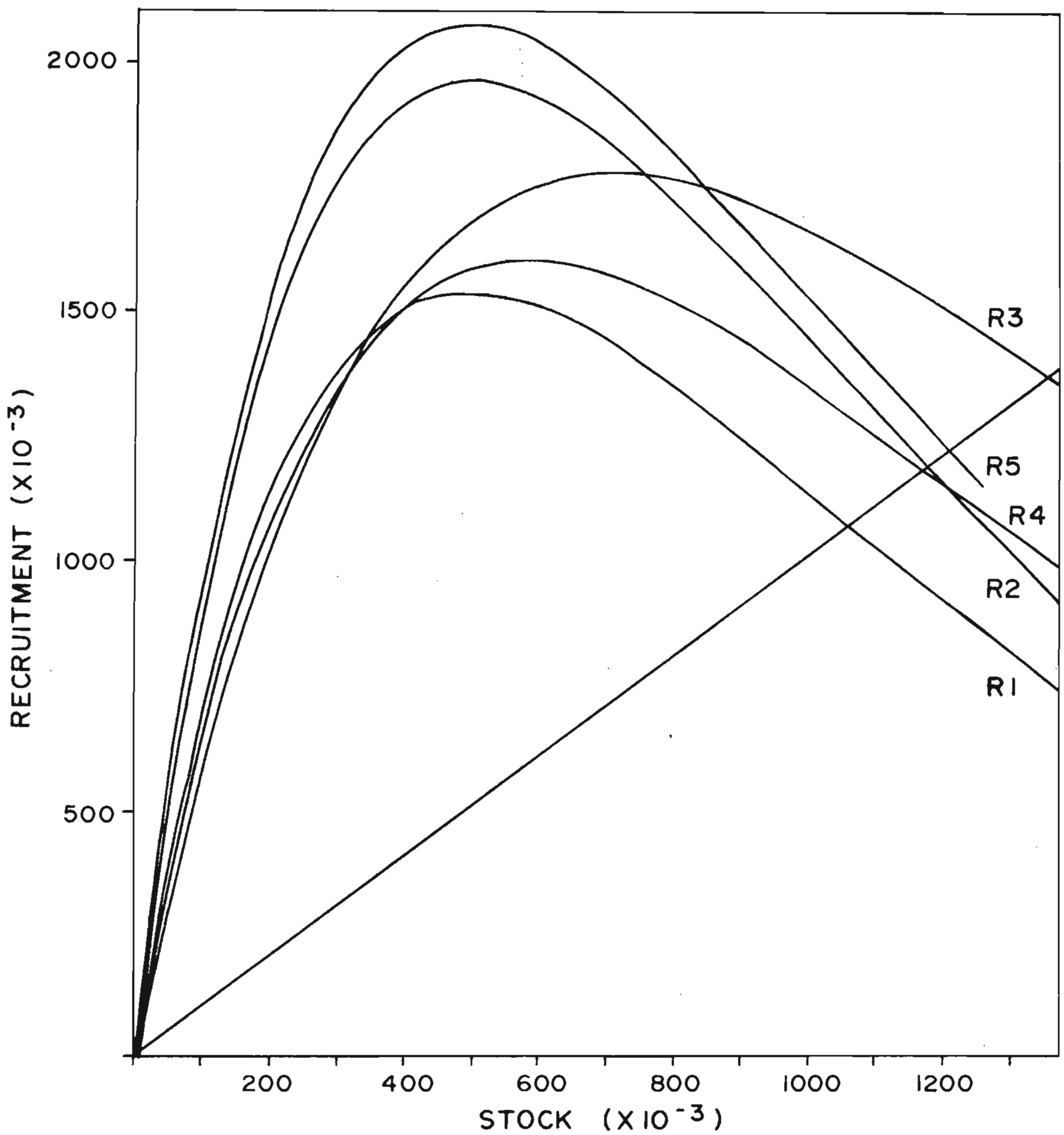

Fig. 9. Stock and recruitment curves for B.C. chinook. R1 to R5 are as in Fig. 7. These curves are calculated using 2X the stock values in Table 21 (see text).