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CAUSES OF THE DECREASE IN SIZE OF COHO SALMON

(ONCORHYNCHUS KISUTCH)

by

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ABSTRACT

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Cohos are caught mainly during their third year of life, and are growing rapidly throughout almost the whole of the fishing season. Because troll fishing becomes intensive earlier in the season than seining or gillnetting, troll-caught cohos tend to be smaller than those taken by the other gears when season-long averages are compared. But within a given month and Area, troll-caught cohos were usually larger than those taken by other gears. In terms of potential weight at maturity, troll-caught averaged 1.1 lb (500 g) larger than seined cohos, and gillnetted cohos were 0.75 lb (340 g) larger than those taken by seine. An exception to this pattern is that in Johnstone Strait and the Strait of Georgia the troll-caught cohos were smaller than those taken contemporaneously by the other gears. They are presumed to be mostly the local slow-growing fish that live in these Straits, whereas those caught in the Straits by gillnet and seine, mostly in August and September, are mainly immigrants from outside that have grown rapidly in the open waters and, being on their spawning migration, are no longer actively feeding and hence are little attracted by trolling gear. Apart from the small size of the Straits fish, there are no recognizable general trends in size with latitude along the British Columbia coast, although there are differences between Areas.

Coho salmon caught in British Columbia, outside the above Straits, decreased in mean seasonal size by about 25% or 2.23 lb (1010 g) between 1951 and 1975, and this represents about 2.7 lb (1220 g) when converted to size at maturity. From 1975 to 1979 there has been an additional decrease of about 0.3 lb, for a total of 3.0 lb (1360 g). Catches of all three fishing gears have exhibited about the same amount of decrease, indicating that the fish available had become smaller. The two Straits are again an exception; in them the cohos caught by troll in any given month did not have any sustained trend in size up to 1975, although the seined and gillnetted cohos decreased similarly to non-Strait Areas. From 1975 to 1979, however, the Straits' troll-caught cohos did become somewhat smaller.

Comparisons of coho sizes with ocean temperature series indicate a non-significant positive relationship which, if real, could account for a minor part of the change in coho size. Selection of the larger fish by trolls and gillnets can produce a change in the genetic composition of coho stocks by leaving smaller-than-average individuals for reproduction. From this point of view, the 2.7 lb decrease in size of cohos outside the Straits, corresponding to 0.37 lb per generation, represents the response to selection (R). The mean size difference between cohos caught by selective gears (trolls and gillnets) and those caught by seines is estimated to be about 1.0 lb. When the rate of mortality from fishing (including shaker loss) is 75-85%, age-3 spawners are estimated to be 1.1 to 1.6 lb smaller than in a stock that is not fished, which is the selection differential (S). This means that the heritability of adult size, the ratio R/S, lies between 0.23 and 0.35, which is a reasonable range of values. Hence it is

quantitatively possible that "outside" cohos decreased in size because of selection by the fishery.

There are several possible reasons why cohos resident in lower Johnston and Georgia Straits did not decrease in size during this period, in spite of intensive selection by the commercial troll fishery. One possibility is that the non-commercial troll fishery, which now captures more cohos in these Straits than commercial trollers do, has selection characteristics different from the commercial fishery because it tends to use lighter gear and to operate closer to shore. Another possibility is that cohos of hatchery origin may be somewhat larger than "wild" cohos, and in the Strait of Georgia hatchery fish have increased greatly in numbers over the past 2 or 3 decades. In the Strait of Juan de Fuca there has been an even greater build-up of hatchery fish (mainly migratory), and there the size of cohos taken in all three gears has been stable since 1957. A similar gradual replacement of natural by hatchery fish may account for the failure of Columbia River cohos to decrease in size (Gunsolus's data).

RÉSUMÉ

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La plupart des saumons cohos capturés ont trois ans. Leur croissance est rapide presque tout au long de la saison de pêche. On pratique la pêche à la cuiller de façon intensive plus tôt dans la saison que la pêche à la senne ou aux filets maillants; en conséquence, la comparaison des moyennes saisonnières révèle que les saumons cohos capturés à la cuiller sont généralement plus petits que ceux pris au moyen d'autres engins. Par contre, au cours d'un mois particulier et dans un secteur donné, les cohos capturés à la cuiller étaient habituellement plus grands que les autres prises. En termes de poids possible à l'âge adulte, les cohos pris à la cuiller pesaient en moyenne 1,1 lb (500 g) de plus que ceux pêchés à la senne; par ailleurs, les cohos capturés aux filets maillants pesaient 0,75 lb (340 g) de plus que ceux pris à la senne. Les détroits de Johnstone et de Géorgie constituent cependant des exceptions; les cohos pris à la cuiller y étaient plus petits que ceux pris, à la même période, au moyen d'autres engins. On suppose qu'ils proviennent en partie du stock local à croissance lente qui vit dans ces détroits, tandis que ceux capturés aux filets maillants et à la senne, surtout en août et en septembre, sont des migrateurs qui ont grandi rapidement en eaux libres; lors de leur migration en vue de se reproduire, ils ne se nourrissent plus activement et sont par conséquent moins attirés par les cuillers. Outre la petite taille des poissons des détroits, on n'a constaté aucun lien entre la taille et la latitude le long de la côte de la Colombie-Britannique, bien qu'on ait remarqué quelques différences entre les secteurs.

De 1951 à 1975, la taille moyenne saisonnière des saumons cohos capturés en Colombie-Britannique, à l'extérieur des détroits susmentionnés, a diminué d'environ 25 pour cent ou 2,23 lb (1 010 g), ce qui représente environ 2,7 lb (1 200 g) pour la taille à l'âge adulte. De 1975 à 1979, on a remarqué une diminution supplémentaire d'environ 0,3 lb, portant le total à 3 lb (1 360 g). La taille des prises capturées à l'aide des trois types d'engins a connu une diminution sensiblement équivalente, indiquant que les ressources disponibles sont plus petites. Cependant, les deux détroits font à nouveau exception; jusqu'en 1975, on n'a constaté aucune tendance valable concernant la taille des cohos qui y ont été pris au moyen de cuillers, bien que la taille des cohos capturés à la senne et aux filets maillants ait connu une diminution comparable à celle des poissons pris à l'extérieur des détroits. Par contre, de 1975 à 1979, la taille des cohos capturés à la cuiller dans les détroits a quelque peu diminué.

La comparaison de la taille des cohos et de données en séries des temperatures océaniqes a révélé une relation non significative qui, si elle était prouvée, pourrait expliquer partiellement les changements de taille des cohos. Des engins de pêche sélectifs comme les cuillers et les filets maillants permettent de capturer les gros poissons et peuvent provoquer une modification de la composition génétique des stocks de cohos, étant donné qu'il reste alors des spécimens plus petits que la moyenne pour la reproduction. Compte tenu de ce facteur, la diminution de 2,7 lb de la taille des cohos à l'extérieur des détroits, qui correspond à une diminution de 0,37 lb par génération, représente la réponse à la sélection (R). L'écart entre la taille moyenne des cohos pris à l'aide d'engins sélectifs (cuillers et filets maillants) et celle des prises capturées à la senne est d'environ une livre. Lorsque le taux de mortalité due à la pêche (y compris les prises échappées) est de 75 à 85 pour cent, les reproducteurs de trois ans pèsent de 1,1 à 1,6 lb de moins que s'ils appartenaient à un stock inexploité; il s'agit là de la différence attribuable à la sélection (S). Cela signifie que le potentiel d'incidence sur la taille des adultes, soit le rapport R/S, se situe entre 0,23 et 0,35, échelle de valeurs raisonnable. Ainsi, du point de vue quantitatif, il est possible que la diminution de la taille des cohos à l'extérieur des détroits soit attribuable à la pêche au moyen d'engins sélectifs.

Plusieurs raisons pourraient expliquer pourquoi la taille des cohos qui habitent la partie inférieure des détroit de Johnstone et de Géorgie n'a pas diminué au cours de cette période, malgré l'intense sélection attribuable à la pêche commerciale à la cuiller. L'une de ces raisons pourrait être que la pêche à la cuiller à des fins non commerciales, dont le rendement dans les détroits est supérieur à celui de la pêche commerciale, diffère de cette dernière à maints égards; ainsi, elle se pratique plus près des côtes et on utilise généralement des engins plus légers. Il est aussi possible que les cohos provenant des piscifactures soient un peu plus gros que les cohos qui vivent à l'état sauvage. Dans le détroit de Géorgie, le nombre de cohos provenant des piscifactures a considérablement augmenté depuis les deux ou trois dernières décennies. Dans le détroit Juan de Fuca, le nombre de poissons d'élevage (principalement migrateurs) a connu une hausse encore plus spectaculaire, et la taille des cohos capturés à l'aide des trois types d'engins est demeurée stable depuis 1957. Un remplacement progressif semblable des poissons à l'état sauvage par les poissons d'élevage pourrait aussi expliquer le maintien de la taille des cohos du fleuve Columbia (données de Gunsolus).

1. QUANTITIES OF COHOS CAUGHT AND FISHING SEASONS

1.1 LIFE HISTORY AND GROWTH

The great majority of coho salmon in the eastern Pacific have a rather simple life history. They spend one growing season in fresh water, usually in streams and rivers rather than in lakes. After migrating to sea in late May and June of their second year, they start to grow rapidly in the marine environment. During their second ocean year they leave the sea and return upriver at any time from July to December, but mostly in September and October.

Deviations from this pattern include the following. Some individuals spend two growing seasons in fresh water; these are scarce in the southern part of the range, but are commoner in Alaska. A fraction of the males, but as far as known no females, return to fresh water in the same year as they go to sea, being called grilse or jacks. As in other salmon, these early-maturing fish have a greater average growth rate than later-maturing ones, as was shown experimentally by Bilton (1978). Little is known about the actual fraction of males that mature early, and whether this varies from stock to stock. In spawning runs the number of jacks has been found to be somewhat greater (Foerster and Ricker 1953, Table 5) or somewhat less (Murphy 1952, Table 1) than the number of age 3 males. Gunsolus (1978, Table 9) estimated that jacks returning to Oregon hatcheries were about 4.5% of the total stock produced by a year-class (males plus females in the catch plus escapement), but this was after several generations of (probable) hatchery selection against jacks. Finally, a very few cohos spend three growing seasons in salt water.

Cohos are caught almost exclusively during their second year of ocean growth, which is usually their third year of life. During this time they are growing rapidly. Some idea of seasonal growth in the Strait of Georgia can be obtained from Figure 1. Open circles are the <u>estimated</u> average weights of cohos captured for tagging in 1927 by trolling off Deep Cove in Area 14, from Clemens' 1930 bulletin (adjacent days have been grouped into series of up to 7). Solid circles are the estimated average weights, when tagged, of cohos that were recaptured, for the tagging done in Area 17 near Nanaimo in 1928 (Clemens 1930, Table 3). The 1928 cohos were smaller than those of 1927, even though they include only fish later recaptured, which were found in 1927 to be about 7% larger than the mean weight of all that were tagged during the time interval in question. Clemens explains the smaller size in 1928 on the basis that smaller trolling gear was used that year, but there might also have been a real difference between the years, or the Areas, in rate of growth. Although these data may have bias due to selection by the troll gear and from personal error in estimating weights, they do illustrate the rapid growth early in the year that forms the basis for the present ban on commercial fishing at that time.

Figure 1 describes conditions in the Strait of Georgia, where the final weight achieved by cohos is considerably less than in "outside" regions. Table 1 shows mean weights of commercially-caught cohos in 1970 in Area 6 (central coast) and Area 20 (Strait of Juan de Fuca). Catches of all three gears suggest that these cohos from the outer coast more than double their weight between late June and mid September. Van Hyning (1951, Fig. 7) shows somewhat smaller relative increases for troll-caught cohos off Oregon in 1946-49: from about 5.5 lb (whole weight) in mid June to 9.5 lb in October.

1.2 FISHING SEASONS

During 1951-55 the commercial fishing season for cohos opened on June 1, but in 1956 this was advanced to June 15. On most of the coast it has remained at that date, but in 1965 and subsequently it was advanced to July 1 in the Strait of Georgia (Areas 13-18 and 29AB). Apart from regulations, there are differences between Areas and between fishing gears in the actual time when significant landings begin to be made. In some Areas troll catches have not usually appeared in any quantity until the second or third week of July. Gillnet and seine catches are mostly made in August and September, the seine catches tending to be a little later in recent years.

To estimate the mean time of the landings made by the different gears, monthly total weights were used. These, however, are "statistical months" that consist of 5 calendar weeks for July and October, and of 4 calendar weeks for the other months in which cohos are caught. The catch of each month was first considered to be centered at the middle of the month, except that June's catch was put at the start of the fourth quarter because of the closure during the first half of that month. A mean time in months was then computed by weighting each month by the total weight of fish landed. This mean time was then adjusted by the amount of the average time difference between the middle of each calendar month and the actual central date of each statistical month as determined by the position of the weeks on the calendar. The adjustment varied from -0.08 to +0.18 month. The adjusted mean times of landings are shown in Table 2 and Fig. 2. Notice the "cycles" with period of 6 to 8 days, that are best indicated in the troll catch but are suggested also in the catches of the other gears. These presumably have to do with patterns of fishing effort within the week, determined either by custom or by regulation.

The mean times of landings in Table 2 and Fig. 2 are based on weight, and troll catches average about a month earlier than those from the other gears. In terms of numbers, the difference would be about a week longer because the fish caught early in the season (mainly by trolls) are smaller than those taken later.

Sport fishing for cohos is carried on mostly in the Straits of Georgia and Juan de Fuca. It is governed by a 12-inch limit overall, with no seasonal restrictions except those imposed by the weather. In practice, sportsmen take few cohos from November to March inclusive, the main "blueback" season beginning some time in April.

Most sport fishing is done in the Straits of Georgia and Juan de Fuca (statistical Areas 13-20, 28 and 29 A, B, and C). Argue et al. (1977, Table 2) published a preliminary estimate of the mean number of cohos caught by sportsmen in those Areas during 1972-76. It was almost 5 times as large as the commercial troll catch, but not quite as large as the total commercial catch, mainly because of a large gillnet and seine fishery in Area 20. The schedule below shows the average numbers caught by all gears, in thousands (small differences from the figures of Argue et al. are due to rounding).

	Commercial fishery				Sport fishery
	Gillnet	Seine	Troll	Total	Mainly troll
Areas 13-19	23	24	97	144	-
Area 20	89	257	4	350	-
Area 29ABC	33	0	0	33	-
Total of above	145	281	101	527	470
Other Areas	347	189	2,266	2,802	35
Grand total	492	470	2,367	3,329	505

In terms of weight the sport catch would be considerably smaller, relative to the commercial, than the above figures indicate, because of the large numbers of small early-season "bluebacks" in the sport catch.

1.3 COHO LANDINGS IN BRITISH COLUMBIA

Information on coho sizes and commercial catches has been obtained from the British Columbia Catch Statistics, published annually by the Fisheries Service, Pacific Region. These provide the number and weight of fish captured in each of the Provinces's statistical Areas from 1951 onward. Table 3 gives the weight of cohos caught by each type of gear, and Table 4 shows the numbers.

2. SIZES OF COHO SALMON CAUGHT

2.1 COMPARISON OF BRITISH COLUMBIA STATISTICAL AREAS

The average weights shown in Tables 5-7 were computed only when at least 3000 lb of cohos had been caught in a given Area and time period, during 1951-72. For 1973-75 this limit was increased to 10,000 lb, because in those years weights were reported to the nearest 1000 lb, rather than 100 lb as previously. Weights of troll-caught fish are converted from dressed weight by dividing by 0.85.

Table 5 gives the mean size of cohos caught in most Areas from 1951 to 1975, while Table 5A continues the series through 1979. The averages are for the whole season, so differences between Areas may result from different seasonal deployments of the fishing gear. That is, if in one Area fishing is done mostly early in the season while the fish are small, the seasonal average weight of cohos for that Area will be less than in another Area where fishing is mostly later in the season. To check on this, comparisons were made of size of cohos caught in the same month in all Areas (Table 6), and of the size in individual months for all years in a few Areas (Table 7). These confirm the general picture given by whole-season averages.

The major difference in coho sizes along the coast of British Columbia is that those resident in the Strait of Georgia and southern Johnstone Strait grow more slowly than those outside these Straits. This is reflected in the very small size of the troll-caught cohos in Areas 13, 17, and 18 of Tables 5, 5A, and 6 (Fig. 3), while Area 12 is intermediate in this respect. No other decided trends are evident. The cohos seined and gillnetted off the west coast of Vancouver Island are larger than average for those gears, but they are not very numerous and are taken incidentally with other species, mostly late in the season when the fish are large.

2.2 COMPARISON OF ALASKAN STATISTICAL REGIONS

Table 8 gives mean whole weights of cohos caught in 8 Regions of Alaska, including those caught by all types of gears. There is some tendency for size to increase from north and west to south and east, but the differences are non-significant, and in any event the mixture of gears would make it difficult to reach firm conclusions.

2.3 COMPARISON OF FISHING GEARS

Gillnets and seines

In 16 out of 19 comparisons in Table 5, gillnetted cohos are larger than seine-caught, the mean difference being 0.81 lb (for all comparisons). A similar difference appears in comparisons within individual months (Table 6, 7). Among the 35 comparisons in Table 6, gillnetted fish are larger in 30 cases, smaller in 4, and the same in 1; the overall average difference is 0.54 lb. Similarly, in the 1963 line at the foot of Table 7, gillnetted cohos are larger than seined cohos in 2 cases out of 3, the third being equal; the mean difference is 0.52 lb. These differences must result from using a mean mesh size that will catch cohos somewhat larger than average size.

One apparent anomaly in Tables 5 and 6 is the small size of the gillnetted cohos from the Fraser River. The fish ascending that river are of course what remains after most of the selective fishing has occurred, but their mean weight is usually less than that of even the seined cohos from the adjacent Straits of Georgia and Juan de Fuca. The reason for the unusually small size of the river catch is evidently that many of them are taken in nets set primarily for sockeye or pink salmon, both of which are smaller than cohos, on the average.

Trolls and seines

Troll-caught cohos are usually much smaller than those taken by either gillnets or seines, when average size over the whole fishing season is considered (Table 5, Fig. 3). In only one Area were they the largest group, and in only three others did they exceed the seined fish. The reason for the generally small average size of troll-caught cohos is that many of them are taken early in the fishing season, which now starts June 16. At this time the fish have reached only half of their definitive size or less. Net-caught cohos are not taken in quantity until August and later, so are larger.

When cohos caught in the same month are considered, an interesting geographical difference becomes apparent. In Areas outside the Strait of Georgia and Johnstone Strait troll-caught cohos were larger than seined cohos in 23 out of 27 comparisons in Table 6 and in 35 out of 37 in Table 7 (one was equal). Throughout the Strait of Georgia the troll-caught cohos are smaller than seined cohos taken in the same month (Table 6), while figures for the marginal Upper Johnstone Strait region (Area 12) are mixed, but on average indicate somewhat smaller troll fish (Tables 6, 7). The reason probably has to do with the mixed origin of the cohos caught in the two Straits. These include the slow-growing cohos resident in the Straits, and the larger "open-ocean" cohos that come into the Straits in summer and autumn. The latter are on their spawning migration, and may have reduced their food intake as part of the physiological preparation for spawning. If so, they are not much attracted by trolling gear, but are still vulnerable to seines and gillnets.

The resident Straits fish too presumably decrease their food intake during maturation. This starts at different times for cohos of different stocks--over a period of 2 or 3 months, if observed differences in time of spawning are an indication. Thus some locally-reared feeding cohos that are vulnerable to trolling gear still are present in the Strait through October, although their numbers, as indicated by the troll catches, fall off markedly after August. Outside of the Strait and its marginal Areas, where this complication does not exist, the large size of the troll-caught cohos, compared with those seined in the same month, indicates that the troll fishery is selective for larger fish. The same is true for pink salmon (Ricker et al. 1978).

3. TRENDS IN SIZE OF COHOS WITH TIME

3.1 BRITISH COLUMBIA OUTSIDE OF THE STRAIT OF GEORGIA AND LOWER JOHNSTONE STRAIT, 1951-79

Wickett (1973, Fig. 10) illustrated the decrease in size of coho salmon caught in British Columbia, using the commercial statistics for 1951-71. The 20-year decrease was about 1.5 lb in the north (District 2) and about 1.0 lb in the south (Districts 1 and 3). (The smaller decrease in the latter group is because it includes the Straits Areas.) Since 1971 the decrease in size has continued in most Areas (Tables 5, 5A, 7, 9; Fig. 4-7). Excluding the Straits Areas 13, 17 and 18, the unweighted average 1951-75 changes from Table 9 are as follows:

	24-year change	
Gear	lb	%
Gillnet	-2.04	-21.0
Seine	-2.27	-24.3
Troll	-2.58	-28.6
Mean	-2.30	-24.8

Another comparison was made, using the data in Table 9, for the 13 Areas where entries for all three types of gear are available, and weighting them by the total number of cohos caught by all gears in each Area. The mean rates of change and 24-year cumulative changes were estimated as follows:

Gear	Rate	Total
Gillnets	-0.0973 lb/yr	-2.34 lb
Seines	-0.0880 lb/yr	-2.11 lb
Trolls	-0.0936 lb/yr	-2.24 lb
Mean	-0.0930 lb/yr	-2.23 lb

These figures are very similar to the unweighted ones above.

Because the decline has affected all types of gear almost equally, it points to a general decrease in size of the cohos available, not an effect that is peculiar to a particular type of fishing. Note that these are mean seasonal weights of the fish caught. If they were adjusted to weight at maturity, the decrease would be at least 20% greater, or 2.7 lb.

Most of the tabulations and analysis in this report are based on coho sizes through 1975. Data for 1976-79 are now available, and mean sizes are shown in Table 5A. If points based on these figures are added to graphs like Fig. 4-6, it is apparent that in most Areas cohos have continued to decrease in size through 1979; Fig. 7 shows a few examples. The easiest overall comparison for the recent period is between the 1976-79 observed sizes and the computed sizes for 1975 shown in Table 9. A summary follows:

	Number of cases in which the post-1975 size is: Larger	Smaller
Northern and central B.C. (Areas 1-10)	46	55
Areas 11 and 12	10	9
Str. of Georgia net-caught (Areas 13, 18)	0	8
Str. of Georgia troll-caught (Areas 13, 17, 18)	2	7
Fraser region (Area 29AB)	0	4
Juan de Fuca (Area 20)	2	9
West coast Vancouver I. (Areas 21-27)	13	25
Total	73	117

A 50:50 division above would have indicated that the decline in coho size had been halted. In fact, it continues on all sections of the coast, but perhaps more rapidly in the south than in the north. The mean 1951-79 decrease in size of "outside" cohos is close to 2.5 lb, or 3.0 lb in terms of weight at maturity.

3.2 STRAIT OF GEORGIA AND LOWER JOHNSTONE STRAIT

The cohos caught by seine and gillnet in Areas 13, 17 and 18 of Table 9 decrease in size with time, similarly to other parts of the coast. The troll-caught cohos, however, differ in that their average size has exhibited a small increase since 1951--about half a pound in the two Strait of Georgia Areas. One reason for the difference is obvious. The two successive changes in opening date for commercial fishing in the Strait--to June 15 in 1956 and to July 1 in 1965--have removed small early-season cohos from the catch and so increased average size for the year's total catch. By contrast, only a very small fraction of the gillnet or seine catch was ever taken in June, so the changes in opening date had very little effect on mean size in those fisheries.

Table 7 shows the sizes of cohos caught in single months in Strait of Georgia Areas 16 and 17, and for them there is no significant increase in the size of those caught by troll. But if the Straits' troll-caught cohos have not increased in size over the years, neither had they decreased up to 1975. In this the Strait of Georgia (and Lower Johnstone Strait) differ from all other parts of the coast. Table 7 shows a slight decrease for July in Area 16, and a slight increase for September in Area 17, neither close to significance. Cohos caught by gillnet and seine in the two Straits exhibit the usual decrease in size with time (Tables 5, 7). This difference between the gears supports the suggestion of Section 2.3, that in these Straits the trolls take mostly resident fish, while the other two gears take mostly migrants from outside.

Why should cohos resident in Georgia and Lower Johnstone Straits have escaped the general trend toward smaller size, at any rate up to 1975? As yet we can only make guesses about the cause or causes, guesses that can be tested by future events.

1. One hypothesis is that predacious fish populations that feed in the coho's ecological niche in the Strait may have decreased significantly during the past 25 years because of increased fishing. This could permit faster growth of all such predators, including cohos, because of less competition for food.

2. A second hypothesis is that hatchery-reared fish have become an increasing percentage of the cohos taken in the Strait <u>and</u> that these are, on average, somewhat larger than wild fish--a possibility discussed in Section 6.

3. A third hypothesis is that an increase in organic matter and inorganic nutrients poured into the Strait, by the Fraser River particularly, may have increased its basic productivity and, at 2 or 3 removes, the food available to cohos.

4. A fourth hypothesis is that the Strait cohos may already be so small that they are near the lower limit of effective size for the species in nature. For example, on at least some spawning grounds they are mixed with and must compete with the larger ocean-reared cohos. Here the smaller of the Strait cohos may have great difficulty in maintaining the preferred position of "dominant" male in the reproductive ritual. For this or other ecological reasons there could be natural selection against any further reduction in size of Strait cohos.

5. A fifth hypothesis is that non-commercial trolling, which now takes the larger share of the resident Strait cohos that are captured by troll (Section 1.2), has selection characteristics different from those of commercial trolling. The lighter gear and smaller hooks used by many sportsmen may permit the <u>larger</u> cohos to break lines or lures and dislodge hooks, and so escape capture. Also, much sport fishing is in shallow water or at shallow depths where smaller members of the coho population may be more apt to be found. Thus it is possible that the effect of selection by the sport fishery is opposite to that of the commercial fishery.

One or more of these five causes may have tended to increase growth rates of cohos reared in the Strait of Georgia, in opposition to the commercial-gear selection process making for slower growth, the result being the observed stand-off.

Considering the adjacent Areas, we find that Area 12, which includes Upper Johnstone Strait and the ocean nearby, is in one respect intermediate between the Strait of Georgia and the "outside" Areas. Its troll-caught cohos do decrease in size with time, but their mean size is less than that of the seined fish, both overall and within a single month (Table 7, 9). Area 19 has not had a commercial fishery in recent years, but Area 20 is revealing. The decrease in size of its troll-caught cohos in Table 5 is below average for outside Areas, while its gillnetted cohos decreased even less, and its seined cohos even increased very slightly. Also, there was no net decrease in the size of fish caught by any of the three gears from 1956 or 1957 to 1975. Of the 5 possible causes listed earlier, only numbers 2 and 5 would be likely to affect Area 20 cohos appreciably; the others could scarcly be significant in what is essentially an open-ocean habitat.

A comparison with sizes of chinook salmon is very suggestive. Those caught by the commercial troll fishery in Areas 17, 18, and 20 had no appreciable size trend from about 1961 to 1975 (Ricker 1980), whereas elsewhere decreases were the rule. Failure of the southern chinooks to decrease after 1961 is quite likely to have resulted from some of the same causes as suggested for cohos--especially the increase in hatchery fish and/or different selectivity characteristics of non-commercial and commercial trolling operations.

Data for 1976-79 (Table 5A) exhibit a decrease in size of Straits cohos, but it is too soon to know whether this will be a continuing trend. In the 4 years available, 7 of the 9 comparisons involving troll-caught fish indicate a size less than the 1975 size computed from the trend line.

3.3 BRITISH COLUMBIA SIZES IN EARLIER YEARS

Unfortunately there are no very informative comparisons to be made between coho sizes in 1951-79 and those in earlier years. Fraser (1921) tabulated length frequencies and mean weight at each half inch of length for cohos caught commercially in 1917. There is some ambiguity about the length that he used (Ricker 1980), but the overall mean weights that can be computed are not affected by this. After correcting one small printer's error, the mean weights in pounds are as follows:

Area	Locality	Sex	No.	Weights
13	Quathiaski	M	150	5.95
	Cove	F	248	5.58
14,16	Lasqueti	M	190	5.65
	Island	F	222	5.60
17	Nanaimo	M	234	6.31
		F	270	5.83
29	Fraser	M	43	6.67
	River	F	46	7.05

However, there is no information on either the dates these fish were caught, or the gear used, both of which have an important effect on the size of cohos obtained. The most that can be said is that in these Areas cohos in 1917 were not spectacularly larger or smaller than at the present time.

The weights of cohos tagged in 1927 and 1928 were discussed in Section 1.1 and are shown in Fig. 3. Most were taken too early in the season for comparisons to be made with recent weights.

Pritchard (1934, Tables 2-8) has reported the estimated weights at time of tagging of cohos that were recaptured from the taggings of 1929 and 1930. These are summarized in Table 10. They can be compared with the seasonal average weights of cohos caught in the same Area by the same gear in Table 5; also, and more satisfactorily, with the weights for the same month in the same or an adjacent Area in Table 7. In most cases the 1929-30 weights tend to be about a pound larger than those of recent years. However, Pritchard's weights are estimated, not observed, and there could easily be observer bias of half a pound or so with fish of this size. Also, as shown below, recaptured fish may be about 3% or 0.2-0.3 lb larger than the general group of fish tagged. We conclude that coho did not change much, if at all, between 1929-30 and 1951, but there may have been a small decrease in size.

Neave (1951, Table 7) lists fork length frequencies of cohos taken by troll for tagging in 1949. Mean lengths were as follows:

Areas	Location	Season	No.	Length
23,24	Off Ucluelet	May	26	508 mm
		June	21	573 mm
27	Off Quatsino	July	642	638 mm

Milne (1957) summarized the coho tagging experiments of 1949-51. His Table B is a comparison of length frequencies of the fish tagged and those recovered in seven experiments. Tables K-O give details of the size and dates for those recaptured in 1950 and 1951; the same information for 1949 is given by Neave (1951). From these sources a summary of mean lengths and times of tagging is presented in our Table 11. There are small differences in size at tagging between recaptured fish and the total group tagged: in 4 instances they are bigger, and in three they are smaller. Although none of the differences are large or "significant", the weighted net change is that the recaptured fish were 6.2 mm larger at tagging than those not recaptured, which would be about 3% by weight. This result is in the same direction as that reported by Clemens (1930) and described in Section 1.1. However, Clemens observed a larger <u>relative</u> difference. His fish were much smaller and involved a greater range of relative size, starting at 1 lb, so that effects of the tag or the trauma of capture could be relatively more severe on the smaller individuals among them. Also, the tag used in the 1920s was a strap tag at the base of the tail, whereas in the 1940s it was a Petersen disc tag through the back.

Unfortunately there are no recent lengths easily available, with which these earlier ones might be compared.

3.4 ALASKA

There has apparently been less change in size of cohos in Alaska than in British Columbia. None of the 8 correlations in Table 8 are "significant", but of course the data available cover a shorter interval of time than in British Columbia. Six of the correlations are negative and 2 positive, but the negative values for Bristol Bay and AYK both result from a 1961 weight that is scarcely believable. The figure most likely to reflect a real change in average weight of the stock is the decrease of 0.043 lb/year in Southeastern Alaska, where trolling has been the dominant method of taking cohos. This is a little less than half of the mean rate of decrease in size of troll-caught cohos in British Columbia.

4. COHO SIZE IN RELATION TO TEMPERATURE

4.1 BRITISH COLUMBIA

Table 13 relates coho sizes in 8 Areas to mean annual (August through July) ocean surface temperatures at three stations on the British Columbia coast (Ricker et al. 1978, Tables 16-18, Fig. 9, 10; see Fig. 2 for the location of the temperature stations). The temperature "residuals" used are the observed temperature less the temperature computed from a linear regression of temperature on time: and similarly for the coho weight residuals (Table 12). It is only the "same year" (S) temperatures in Table 13 that could have much <u>direct</u> effect on coho growth, for they encompass most of the time that the cohos caught in a given year have spent in salt water--from August of their first ocean year through July of their final ocean year. "Previous-year" (P) temperatures, ending July 31, could affect coho growth directly only during July and part of June of their first ocean year, but this early growth might set the stage for subsequent growth, to some extent. Also, the "P" temperatures might have an indirect effect over a longer period by way of, for example, an influence on the production of coho foods.

In the P-lines of Table 13 there are two positive correlations that reach the 95% level of significance, out of 24 possibilities. However, we should consider both the S and the P lines in assessing these, and two such correlations are about what are expected by chance, given 48 opportunities. There are 14 positive correlations out of 24 in the P lines, and the same number in the S lines. This is a non-significant difference from random expectation (4, as compared with the standard error of 3.46), but if there is any relationship between size and temperature, the suggestion is that it is positive.

4.2 ALASKA

Table 14 compares residuals of Alaska coho weights with residuals of same-year temperatures at the two northern British Columbia stations. Here there are 12 out of 16 positive correlations, 2 of which are beyond the 95% level of probability. This would be fairly good evidence for a positive effect of temperature on growth rate if the comparisons were all independent. However, the temperature residuals at the two stations are positively correlated, although not strongly so, so the indication is weakened to that extent. Also, it is unfortunate that Southeastern Alaska exhibits a negative relation with the closest temperature station, and only a very weak positive one with the other.

4.3 TRENDS IN SIZE AND IN ENVIRONMENTAL FACTORS

Comparisons of time series encounter the major difficulty that similar trends do not necessarily indicate a causal connexion. This is especially true when the series compared are monotonic: the trend is continuously either up or down. When the variates of two such series, A and B, are regressed, the regression coefficient of A on B will indicate the amount of change in A that is associated with a given change in B; but to deduce a causal relationship from this is to assume what we wish to prove. Such a relationship can of course be suggestive, but it requires confirmation by additional data, or from other kinds of information. For example, Wickett (1973) observed that the decrease in coho size from 1951 to 1971 (his Fig. 10) was parallelled by a decrease in ocean surface salinities at Langara Island and Cape St. James (his Fig. 1); and decreasing salinity was associated with a decrease in biogenic nutrients which, with a lag of a year or two, could mean a poorer food supply for salmon. However, starting about 1969 salinity began to increase again, but cohos continued to get smaller (our Fig. 7).[1]

In the case of temperature, whose direct effect on growth is mainly limited to the year in which it occurs, we can obtain at least a minimum estimate of the causal relationship between the two variates--temperature and coho size--by comparing the deviations (residuals) from their respective regressions on time. This is the procedure adopted in Sections 4.1 and 4.2 above. If temperature really has an effect on coho size, it should be apparent in individual years. If the effect is positive,

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[1]Salinity observations at Ocean Station P are used in Fig. 7 because those for the two shore stations are no longer available. At Cape St. James they have been discontinued entirely, while since 1969 those at Langara Island have been made with a hydrometer which has low precision and has produced wildly variable results (Wickett and Ballantyne 1978, and later data). Wickett (1973, Fig. 9) showed that from 1957 to 1965 Cape St. James monthly salinities were positively related to those 9 months earlier at Station P, and the Station P series has been maintained without loss of accuracy.

years of high temperature should tend to have large cohos, and vice versa, and this is tested by comparing the residuals of the two series.

Neither in British Columbia nor in Alaska was any "significant" association found between residuals of coho size and of ocean temperature. The average relationship was weakly positive, so that, if it proves to be real, size would have decreased slightly owing to the decrease in ocean temperature since 1950 (Ricker et al. 1978; Fig. 9, 10). However, computations of the amount of change, using GM regression coefficients (which are most favourable to temperature effects), show that the decrease in temperature could have contributed only insignificantly to the observed trend.

This result, of course, does not indicate that oceanic conditions are of little importance in determining coho sizes. The year-to-year variations in size shown in Table 5 are quite substantial, and they exhibit much agreement between Areas, particularly neighbouring Areas. In the warm year 1958, for example, cohos were almost everywhere larger than in adjacent years. Future analyses will undoubtedly uncover significant relationships between size and various oceanographic conditions, but there is no present evidence that they have been responsible for the long-term decrease.

5. EFFECTS OF THE FISHERY ON SIZE OF COHOS

5.1 DIRECT EFFECT OF THE TIME FISHING OCCURS

One possible cause of a decrease in mean size of cohos caught would be a shift in the fishing season. If there were a general shift to fishing earlier in the year, the cohos caught would be smaller because they would have achieved less of their definitive growth. Table 2 and Figure 2 show approximate mean dates of fishing in each year. The principal change is that over the years seining has tended to occur later in the season, the total shift being about 2 weeks. Trends for the other gears are small and non-significant. The mean date for all gears exhibits a slight shift toward later in the year, which again is non-significant. Thus there is no indication that the size decreases in Tables 5 and 9 have been caused by earlier fishing; if anything, they have occurred in spite of a small shift toward later fishing.

The above conclusion is supported by the weights of cohos caught in individual months, of which a random assortment is shown in Table 7. Omitting the troll-caught fish in the Strait Areas 16 and 17, these exhibit the same consistent decrease in size as do the averages for the whole season in Table 5. The mean decrease for September is 2.35 lb, which is not significantly different from the 2.7 lb for mature fish computed in Section 3.1. Thus the observed decrease in size of cohos must reflect a change in the size of the fish available; it is not an artifact resulting from change in seasonal patterns of fishing.

5.2 HEREDITARY CHANGE IN GROWTH RATE CAUSED BY SELECTIVE FISHING

The evidence cited in Section 2.3 shows that commercial trolls and gillnets are selectively harvesting the larger cohos. This leaves those of smaller average size to reproduce their kind each year--although there is, of course, much overlap in size between catch and escapement. In such situations the relation between cause and effect is described by the equation:

$$R = h^2 S \qquad (1)$$

where R is the response to selection (the size difference between parents and progeny); S is the selection differential (the difference in mean individual size between the total stock and the parents selected), and h^2 is the heritability of size in the particular situation. In turn, h^2 is a compound of additive genetic variance (tending to increase h^2) and phenotypic variability due to the environment (tending to decrease h^2).

On the hypothesis that all the change in coho size in Areas outside the Strait of Georgia has resulted from selection, we can estimate R from the observed mean decrease of 2.7 lb from 1951 to 1975, obtained in Section 3.1. During this 24-year period there were 8 3-year generations in the 1951 line, 7 in the 1952 line and 7 in the 1953 line; the mean number of generations is therefore 7.33. Dividing this into 2.7 lb gives a response of R = 0.37 lb/generation.

The problem is, is the observed selection sufficient to produce this response? In our situation the selection differential (S) is the average difference in individual weight between the unfished stock and the spawners, over the years. To estimate this, it is convenient to think of all the cohos caught as being of their final or potential weight, of which the weight achieved by those caught in September is a near approximation, and to assume that in other months the differences in mean weight between those caught by different gears are proportional to what they are in September. Table 6 gives weights in the Septembers of three years, with two Augusts for comparison. There is generally good consistency between the years and between the months; in August the weights, and the weight differences between gears, are of course smaller than in September of the same year. Omitting Areas 11-18 and 29AB, the mean September excess over seine weight for each selective gear in Table 6 is as follows:

	N	Mean, lb	Standard deviation	Standard error of mean
Gillnet less seine	15	0.747	0.457	0.118
Troll less seine	16	1.128	0.997	0.249

Considering that trolls have taken 3 times as many cohos as gillnets, a weighted mean estimate of the difference in potential weight between the catch of the two selective gears and that of the seines is 1.03 lb, with a standard error of about 0.25 lb.

In addition to its rather large sampling error, the 1.03 lb above presumably has a small bias in the direction of being too small, when considered as an estimate of difference in potential weight. This is because some cohos are still growing during September, and a larger portion of the September troll catch is probably taken during the first half of the month, when the fish average smaller, than is the case with the seine catch.

Eleven ocean tagging experiments were done between 1948 and 1951 in British Columbia waters and have been reported by Kauffman (1951), Neave (1951) and Milne (1957, Table 2). The returns of tags from the fishery amounted to between 5% and 31% in different experiments. More recently, Argue and Heizer (1974) have reported on taggings done in 1963-169. Twenty-one experiments in the northern Areas 1-6 gave fishery returns from 3% to 41% (mean 19%), while 52 experiments in Johnstone, Georgia and Juan de Fuca Straits (Areas 13-20) gave fishery returns from 1 to 67% (mean 23%). To represent rate of mortality caused by fishing all these figures must be adjusted upward because of (1) tagging mortality; (2) reduced vulnerability of the surviving tagged fish to capture; (3) failure to report recaptured tags; (4) death of tagged fish that are later hooked but escape from the hooks with injuries that are ultimately fatal; and (5) because the fish tagged had already survived part of the fishing season during the year of tagging. These effects cannot readily be quantified, but any one of them might double the observed rate of return of tags, so the total effect is a several-fold increase. Also, fishing effort has increased, so the percentages above are no longer current. Recent experiments in the Strait of Georgia, using cohos nose-tagged as smolts, indicate rates of exploitation of 79% to 84% (Bilton and Jenkinson 1980); this includes a large adjustment for non-reporting of tagged individuals, which are recognizable only by absence of the adipose fin. Any failure of mature cohos to return to the stream of release inflates these percentages, but substantial "shaker" losses must be added (Ricker 1976), so that the total percentage killed by the fishery may well exceed 90%. Argue and Heizer's tagging results suggest that rate of exploitation is, or was during the 1960's, somewhat less in "outside" Areas than in the Strait, so we use 75%, 80%, and 85% as possible estimates of the outside rate of mortality due to fishing, including shaker losses.

Using the 80% figure first, comparison of numbers caught (Table 4) indicates that 10% would be taken by seines, and 70% by the other gears, 80% in all. To calculate the selection differential from these data and the 1.03 lb difference in potential size obtained above, we can deal with two extreme situations. The argument is the same as in Ricker et al. (1978, Section 8.1), but written in a more general form. Consider a year-class of cohos that numbers N before fishing, and whose average weight at maturity would be y lb in the absence of fishing, so that the whole year-class would then weigh Ny lb.

Suppose that the selective fishing all occurs before the seining, and that the fish caught by selective gears would average x lb each if all were permitted to grow to their potential size. Then the difference between this and the potential size of the seine-caught fish is:

$$x - \frac{Ny - 0.7\ Nx}{N - 0.7\ N} = 1.03\ \text{lb}$$

Hence x = y + 0.309 lb, and the mean size of the fish in the non-selective seine catch and in the escapement is:

$$y + 0.309 - 1.03 = y - 0.721 \text{ lb}$$

Alternatively, suppose that the seining all occurs before the selective gears operate. In that case the seines take 0.1 Ny lb, and 0.9 Ny lb remain. The selective gears then remove 0.7 N fish that weigh y + 1.03 lb on the average, for a total of 0.7 N(y + 1.03) lb. Thus 0.1 Ny + 0.7 N(y + 1.03) lb are removed from the original Ny lb, and the difference remains, namely 0.2 N(y - 3.605) lb. The number of fish in the escapement is 0.2 N, so their average weight is:

$$y - 3.605 \text{ lb}$$

In fact, the principal selective gear, trolling, becomes intensive some time in July in most "outside" Areas, while gillnets and seines operate mainly in August and September. Thus the first escapement weight computed above is much more realistic than the second: that is, the difference between the average weight in the escapement and the "original" average weight is much closer to 0.721 lb than to 3.605 lb. If we give the former figure four times the weight of the latter, the mean escapement weight is 1.30 lb less than what it would be without fishing--which is the desired selection differential (S). Similar calculations using a 75% rate of mortality due to fishing (u') give the estimate S = 1.07 lb; for u' = 85%, S = 1.63 lb.

Using the above estimates of R and S we can estimate heritability (h^2) from expression (1):

For u' = 0.85: $h^2 = 0.37/1.63 = 0.23$
For u' = 0.80: $h^2 = 0.37/1.30 = 0.28$
for u' = 0.75: $h^2 = 0.37/1.07 = 0.35$

Are these reasonable estimates of the heritability of weight at maturity in cohos? Ricker, Bilton and Aro (1978) reviewed available information and obtained a mean h^2 value of about 0.3 for wild salmonids. It must be remembered that heritability is a function of environmental variability as well as innate variance, so can be expected to vary between species, between regions for the same species, and of course, between cultured and naturally-reared stocks. But from the h^2 values above, we may conclude that selection by the fishery is a very possible explanation for a large part or even all of the observed decrease in size of the cohos that live outside the Strait of Georgia.

There is another aspect of fishery selection that might change the amount of hereditary decrease in size. In coho reproduction, the age-2 "jacks" almost always play the role of "accessory" males that accompany a female and her age-3 "dominant" consort. They (and sometimes non-dominant age 3 males also) rush in alongside the pair to contribute their milt at the moment of egg deposition; but how effective they are, in competition with the larger fish, is anybody's guess. Jack cohos, although their mean growth rate exceeds that of later-maturing individuals, are exposed to only a limited fishery mortality toward the end of their second and final year of life, most of it "shaker" mortality if the size limit is strictly observed.

As a result, they are represented on the spawning grounds at several times the relative abundance they would have in an unfished stock. If their percentage representation has gradually increased as a result, it would tend also to increase the supply of genes favoring faster growth in the stock. But this process might be self-limiting, because increasing the proportion of fast-growing jacks in a year-class would mean decreasing the average size of age-3 males; and an age-3 male almost certainly contributes much more to reproduction than any single jack, perhaps more than a dozen or so jacks. A suitable combination of relative reproductive efficiencies would produce a standoff, whereby the jacks' relative immunity to fishing mortality would not alter the stock's pool of genes affecting growth rate.

The one time series available indicates that at Oregon hatcheries jacks did not increase in the year-classes 1963-1974 (Gunsolus 1978, Table 9). However, in hatcheries jacks are rarely if ever used for breeding, so that being spared by the fishery gives them little or no reproductive advantage under artificial conditions.

6. EFFECT OF HATCHERIES ON SIZE OF COHOS

During the period 1951-1975 the number of cohos reared in the Puget Sound hatcheries of the State of Washington increased substantially, although we have not seen the actual figures. Starting in 1974 the Capilano hatchery in British Columbia has made a contribution to the catch, and others have come in more recently. Hatchery cohos have appeared in the British Columbia commercial catches mainly in statistical Area 20 of the Strait Juan de Fuca and, especially since 1974, in the Strait of Georgia.

The pertinent question in the present context is whether or not hatchery-reared cohos tend to be of a different size from wild cohos in their second ocean year. Typically, hatchery coho smolts are released at a larger size than wild smolts, so might be expected to grow faster in the ocean and reach a larger final size. On the other hand, faster growth increases the fraction of males that mature at age 2 (Bilton 1978), and this increased deletion of faster-growing individuals decreases the average size of 3rd-year males below that it would otherwise be. However, it is almost certain that hatchery smolts tend to produce larger 3rd-year females, possibly males as well, because they are larger than wild smolts.

Thus an increase in the contribution of hatchery cohos to the Canadian catch would tend to increase the average size of the fish, and hence would retard the decrease in size caused by fishery selection. It may be significant that cohos from Juan de Fuca (Area 20), which must include a larger proportion of hatchery fish than those of any other "outside" Area in Table 5, did not decrease in size between 1957 and 1975, in the catches of all three gears. Similarly, the Strait of Georgia troll-caught cohos did not decrease in size from 1951 to 1975, although there other factors may play a role (Section 3.2). However, the 1976-79 statistics in Table 5A indicate a decrease in mean size in Areas 13-18 (Lower Johnstone and Georgia

Straits), and also in Area 20 (Juan de Fuca), so whatever was retarding the decrease in size in those regions is apparently in abeyance, temporarily at least.

Additional information related to this question is contained in the recent paper by Gunsolus (1978), who tabulates and discusses extensive data on the abundance and size of cohos in and near the State of Oregon for the years 1961 through 1977. Included are data on the mean size of cohos caught in the ocean troll fishery and in the Columbia River gillnets (Gunsolus's Table 16 and Figure 22, the latter reproduced here as Fig. 9). The year-to-year changes in mean weight of cohos taken by the two gears agree fairly well up to 1971, when a sustained decrease in size of the ocean fish begins. This decrease Gunsolus attributes to intensification of the troll fishery so that relatively more are taken early in the season while the fish are still small.

Comparing the year-to-year variations in mean weight in Oregon with those in British Columbia, shown in Table 5 and Figs. 4-7, the 1968-75 Columbia River pattern appears also in the Strait of Juan de Fuca and along most of the west coast of Vancouver Island (Areas 20-26), and among the seined and gillnetted fish from Area 13. Farther north the resemblance fades rapidly. The Strait of Georgia cohos (including the troll-caught fish from Area 13) show no trace of the Columbia River pattern. Also, nowhere in British Columbia is there much resemblance to the Oregon mean weights for 1961-67. Another finding (Gunsolus's Fig. 18) is a fairly good positive relation ($r = 0.730^{**}$) between the number of Oregon cohos caught in a given year and the average size of the cohos the previous year: the functional regression calculated from Gunsolus's figure indicates an additional 0.74 million fish for each pound of increase in weight the previous year. Thus good final-year growth of a particular brood is associated with good survival of the following brood, presumably because the latter too grows well during the same calendar year, i.e. its first year in the ocean.

What is of most interest here is the absence of any appreciable decrease in size of Columbia River cohos with time. If commercial trolling gear tends to select cohos of large size in British Columbia, it presumably does so farther south as well. Cohos entering the Columbia are what remain after a large troll fishery has harvested most of their siblings. Why then have not the Columbia cohos in Fig. 8 decreased in size? The number of smolts release by the region's hatcheries increased from less than a million in 1961 to 3.5 million in 1972, and has changed only slightly since (Gunsolus's Fig. 6). From about 1970 to 1977 estimates of wild cohos spawning in Oregon coastal streams decreased by 60%, and in Columbia tributaries by 90% (Gunsolus's Fig. 5)--presumably because percentage harvest has reached a figure that hatchery fish can sustain but many wild stocks cannot. The increase in hatchery smolt releases was accompanied by a rather steady increase in number of cohos harvested up to 1970. Since 1970 the harvest has fallen off somewhat, evidently because of the decline of wild-reared fish. If hatchery-reared cohos in this region are larger than wild-reared, whether by nature or by nurture, then the increase in the proportion of hatchery-reared fish in the population would have counteracted any tendency for the total population to decrease in average size because of selection by the trolls.

At present a very large proportion of the Oregon population is hatchery-reared, and the hatcheries have it in their power to maintain a large average size by breeding from the larger of the available spawners, thus maintaining a continuous counter-selection against the trolls. This of course will not help the wild stocks, but their survival seems precarious anyway, unless the overall rate of exploitation can be reduced.

7. FUTURE PROSPECTS

7.1 EFFECTS OF CHANGES IN GEARS USED AND IN FISHING SEASONS

In assessing future size trends it is important to distinguish between the size of cohos in the catch and the potential size of the fish in the population--the mean size they would achieve if all were permitted to grow to maturity. Mean size in the catch differs between gears and, for any particular gear, increases as the season progresses. Hence the overall mean size for the year will change if gears change, and particularly if fishing seasons change. For example, if trolling were to increase at the expense of other gears, yearly average sizes would be reduced because more cohos would be caught early in the season. If, on the other hand, the opening of the coho fishing season were to be delayed to July 15 or August 1, yearly mean sizes would immediately increase in those Areas where substantial numbers of cohos are today being captured before the date in question.

These considerations apply to all gears and all parts of the coast. But if there is no change in gears or fishing seasons, what is the prospect for change in size of the cohos caught, based on the growth potential of their populations? Here we must consider two types of population separately.

7.2 COHOS LIVING IN LOWER JOHNSTONE AND GEORGIA STRAITS

The slow-growing cohos that spend their marine life in these two straits, and are caught mainly by trolling, changed very little in size from 1951 to 1975 but have decreased a bit subsequently (Section 3.2). Predicting future mean sizes in this population, as distinct from the catches, seems impossible because we have not identified the reason or reasons either for the long absence of change in size or for the recent incipient decline.

Suppose, for example, that the Straits cohos maintained their size mainly because hatchery-bred individuals, averaging larger than the wild ones, became increasingly numerous, while fish of wild provenance decreased in mean weight because trolls in the straits select larger fish, just as they do outside. Then a stable overall mean size should continue as long as the hatchery product continues to increase in abundance relative to the wild fish. If hatchery production levels off, then a slow decrease in the combined mean weights should begin provided the abundance of the natural stocks has been maintained. But if hatchery stocks take over more or less completely, as seems to be happening in Oregon, mean size will be mainly controlled by whatever selection practices prevail in the hatcheries.

One of the alternative hypotheses about coho sizes in the Straits is that they were maintained by a balance between the possibly different selective characteristics of sport and commercial trolling (Secton 3.2). In that event we should expect little change in the years ahead. However, this possibility, like the previous one, is pure speculation at the present time.

Other possible influences on coho size in the Straits, outlined in Section 3.2, yield their own projections for the future, but there is little point in considering them all until there is evidence for their reality. At present there is no assured reason that Straits cohos should either decrease or increase in size in the immediate future. The 1976-79 decrease may be a minor fluctuation, or it might be the start of a trend similar to what has been occurring outside the Straits.

7.3 AREAS OUTSIDE LOWER JOHNSTONE AND GEORGIA STRAITS

A majority of cohos captured in British Columbia waters spend their ocean life outside of our "inland sea". In addition to those captured outside, this includes most of the cohos taken by gillnet and seine in the southern straits and the Fraser River. <u>If</u> kinds and quantities of fishing gear, and its seasonal deployment, remain much the same in the years ahead, there is little doubt that the mean size of these "outside" cohos will continue to decrease. The absolute rate of decrease will probably fall off, but the relative rate is likely to remain the same, for a while at least. The average decrease in size of cohos caught from 1951 to 1975 was calculated in Section 3.1 to be 2.2 lb, or 25% of the original mean weight; that is, from 8.8 to 6.6 lb. An additional 2.2 lb loss during the next 24 years would bring it down to 4.4 lb. Much more probable, however, would be a decrease of 25% of 6.6 lb = 1.6 lb, bringing the average to 5.0 lb at the end of the century. This is a total decrease in 48 years of 3.8 lb, or 43%--a worrisome figure, because it reflects a deterioration of the genetic makeup of the stocks affected.

The rate of decrease might be less than suggested above if some kind of genetic or ecological limit to size were being approached, but there is no suggestion of this in the data so far. Moreover, any such limit would almost certainly be accompanied by reduced productivity.

Suppose that hatcheries are developed to the point where they make an important contribution to the coho catch outside the Straits. Assume, as is probable, that the hatchery fish grow faster than the wild ones, either because they are from genetically fast-growing parents or because they are released at a larger mean size than wild smolts, or both. This will slow down the rate of decrease of size in the catch of any Area, insofar as both hatchery and wild fish are harvested in that Area. It will not reduce the rate of decrease in size of wild cohos unless, as seems unlikely, genetically fast-growing hatchery cohos stray in large numbers and breed with the wild stocks.

The catch from Area 20 in the Strait of Juan de Fuca consists mainly of large ocean-type cohos (Tables 5 and 5A). Because this Area straddles part of the migration route of cohos returning to the numerous Puget Sound hatcheries, its catch includes substantial numbers of hatchery-bred fish, and average size has been stabilized since 1957, perhaps because of increased hatchery contributions. Future trends will depend partly on hatchery breeding practices.

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Table 1. Mean whole weight in pounds of cohos caught in 1970 in two areas of large catches, by month and type of gear.

	Gillnet	Seine	Troll
Area 6			
June[a]	4.96	4.13	5.30
July	5.83	5.14	5.54
August	8.94	8.25	8.43
September	10.30	9.38	10.88
Area 20			
July[a]	6.61	6.49	7.83
August	8.15	8.88	9.37
September	10.51	10.29	9.99
October[b]	11.49	11.77	11.82

[a]Last 2 weeks only.
[b]First week only.

Table 2. Approximate mean time of capture of cohos in British Columbia, based on weight. The units are months with time 0 at the start of June 1. See the text for details.

	Gillnet	Seine	Troll
1952	3.14	2.79	2.25
1953	3.40	3.00	2.33
1954	3.57	3.22	2.44
1955	3.44	3.31	2.32
1956	3.06	2.76	2.05
1957	2.90	2.73	1.93
1958	3.15	2.80	2.19
1959	3.21	3.21	1.99
1960	3.22	2.81	2.03
1961	2.84	2.61	1.68
1962	2.88	2.90	1.81
1963	2.94	2.87	1.94
1964	3.02	2.95	2.04
1965	2.75	2.81	2.25
1966	3.15	3.12	2.13
1967	2.35	2.94	1.77
1968	2.88	2.76	1.86
1969	2.92	3.03	1.95
1970	3.03	3.23	1.99
1971	3.22	3.31	2.19
1972	3.09	3.06	2.26
1973	3.51	3.82	2.26
1974	2.90	3.30	1.87
1975	2.89	3.39	2.20
Mean	3.06	3.03	2.07

Table 3. Quantities of coho salmon landed in British Columbia, taken by commercial fishing gear of four types, in millions of pounds round weight.

Year	Gillnets	Seines	Trolls	Traps	Total
1951	8.7	6.7	19.5	0.2	35.1
1952	3.0	1.8	17.2	0.2	22.2
1953	4.7	4.6	13.7	0.1	23.2
1954	5.7	3.2	11.7	0.1	20.7
1955	6.0	4.0	13.5	0.1	23.6
1956	8.5	3.8	12.9	-	25.2
1957	5.4	2.9	14.4	0.1	22.8
1958	6.0	3.0	15.6	0.1	24.7
1959	5.1	2.8	11.7	0.0	19.6
1960	3.9	1.1	9.2	0.0	14.2
1961	6.4	3.6	14.8	0.0	24.7
1962	6.7	3.5	16.4	0.0	26.6
1963	5.9	3.5	16.1	0.0	25.5
1964	7.8	3.4	20.4	0.0	31.7
1965	9.0	4.2	23.5	0.0	36.7
1966	10.0	4.3	24.3	0.0	38.7
1967	5.6	2.8	14.1	0.0	22.5
1968	7.7	3.1	22.6	0.0	33.4
1969	3.5	1.4	12.7	0.0	17.6
1970	8.1	4.7	17.3	0.0	30.1
1971	5.5	4.2	21.4	0.0	31.1
1972	5.1	2.3	15.9	0.0	23.3
1973	4.0	4.6	16.3	0.0	24.9
1974	3.7	3.6	15.6	0.0	22.9
1975	3.4	4.2	9.5	0.0	17.1
Mean	5.98	3.49	16.01	0.04	25.52

Table 4. Number of cohos caught commercially in British Columbia, in thousands, and the numbers taken by different fishing gears.

		Gillnets		Seines		Trolls		Traps	
Year	Total	No.	%	No.	%	No.	%	No.	%
1951	3998	864	21.6	717	17.9	2398	60.0	19	0.5
2	2745	353	12.9	213	7.8	2162	78.7	18	0.7
3	2894	488	16.9	586	20.2	1804	62.3	16	0.6
4	2445	600	24.5	355	14.5	1482	60.6	7	0.3
5	2968	668	22.5	466	15.7	1827	61.6	7	0.2
6	3050	921	30.2	432	14.2	1697	55.6	-	-
7	3137	661	21.1	418	13.3	2043	65.1	15	0.4
8	2989	644	21.5	348	11.6	1988	66.5	10	0.3
9	2896	641	22.1	401	13.8	1854	64.0		
60	2031	470	23.1	148	7.3	1412	69.5		
1961	3297	722	21.9	461	14.0	2114	64.1	0	0
2	3626	799	22.0	447	12.3	2379	65.6	0	0
3	3421	691	20.2	469	13.7	2261	66.1	0	0
4	4148	926	22.3	410	9.9	2812	67.8	0	0
5	4443	1061	23.9	521	11.7	2861	64.4	0	0
6	5412	1244	23.0	563	10.4	3605	66.6	0	0
7	3302	747	22.6	403	12.2	2153	65.2	0	0
8	5257	1038	19.7	477	9.1	3741	71.2	0	0
9	2414	442	18.3	174	7.2	1798	74.5	0	0
70	3945	939	23.8	535	13.6	2471	62.6	0	0
1971	4788	714	14.9	616	12.9	3457	72.2	0	0
2	3359	659	19.6	331	9.9	2369	70.5	0	0
3	3531	484	13.7	564	16.0	2483	70.3	0	0
4	3724	512	13.7	513	13.8	2700	72.5	0	0
5	2332	432	18.5	496	21.3	1404	60.2	0	0
Total	86152	17720	20.6	11064	12.8	57275	66.5	92	0.1

Table 5. Mean round weight in pounds of coho salmon caught in most statistical areas of British Columbia, by type of gear. GN = gillnets; S = seines; T = trolls.

Year	Area 1			Area 2E			Area 3		
	GN	S	T	GN	S	T	GN	S	T
1951	10.26	9.54	8.31	11.46	9.69	9.93	9.93	6.82	9.07
1952	-	8.62	7.80	-	8.49	4.71	8.51	6.77	9.60
1953	7.16	9.66	10.36	10.36	8.20	4.69	10.92	7.75	11.78
1954	-	12.56	10.33	11.35	10.03	8.93	10.49	8.24	11.00
1955	-	10.88	8.35	9.46	7.29	9.19	8.98	5.77	8.18
1956	8.86	10.06	7.87	10.88	9.14	8.42	8.82	6.35	8.08
1957	9.33	10.24	7.98	-	10.40	8.65	9.05	7.82	9.45
1958	10.20	9.74	9.31	8.84	8.96	9.62	9.73	8.20	10.15
1959	7.93	-	7.98	-	8.52	7.93	8.61	7.76	9.31
1960	7.45	-	7.55	6.94	6.18	7.15	8.46	6.18	8.00
1961	7.69	9.27	7.44	10.11	8.73	7.29	8.98	7.08	9.67
1962	7.54	8.73	7.08	8.76	6.25	7.13	7.11	5.62	7.54
1963	10.09	9.95	8.69	9.93	10.21	7.35	8.58	7.09	9.84
1964	8.14	8.73	7.75	9.79	9.64	8.32	8.30	6.94	8.20
1965	9.03	9.40	8.71	9.59	8.32	9.34	8.85	6.82	9.68
1966	9.02	8.35	8.60	9.15	9.55	8.55	8.62	7.06	8.91
1967	9.05	9.65	9.07	10.39	10.58	8.55	8.86	7.27	9.59
1968	6.99	5.70	6.88	9.76	8.95	7.45	8.14	6.06	7.78
1969	7.41	6.65	7.58	8.85	9.01	8.11	8.08	7.21	8.38
1970	6.76	8.06	7.00	8.06	8.70	7.46	8.79	6.63	7.65
1971	8.23	8.55	8.08	9.70	4.32	8.09	8.70	7.03	8.60
1972	6.57	5.98	7.14	8.87	8.28	7.39	8.20	6.21	11.78
1973	6.70	7.63	7.85	9.27	8.80	7.51	8.40	5.65	7.82
1974	6.30	6.71	7.84	8.77	7.54	6.42	8.08	6.09	8.75
1975	6.12	5.60	6.40	-	-	6.99	8.04	6.52	7.68
Mean (1963)	8.18	8.76	8.08	9.57	8.55	7.81	8.77	6.84	9.06

Table 5 (cont'd)

	Area 4			Area 5			Area 6		
	GN	S	T	GN	S	T	GN	S	T
1951	9.40	-	8.15	9.72	8.57	9.05	10.50	8.99	10.59
1952	7.98	-	7.73	8.33	7.89	8.59	8.95	8.16	9.18
1953	10.37	-	10.41	10.65	9.85	8.02	9.89	7.84	9.26
1954	9.92	9.00	9.32	9.94	8.93	8.41	10.13	9.29	10.52
1955	8.54	-	7.52	8.65	7.97	8.34	9.03	8.11	9.24
1956	8.36	-	7.11	8.27	7.89	6.96	9.41	8.62	8.93
1957	8.63	-	7.95	8.91	7.60	8.14	9.50	8.19	9.31
1958	9.54	-	9.42	8.76	8.52	8.28	10.41	7.88	9.21
1959	8.97	-	8.13	9.28	7.82	8.49	9.53	8.00	9.16
1960	8.13	-	8.00	8.15	7.67	7.92	8.02	7.17	8.20
1961	8.56	-	8.26	8.87	7.90	7.31	9.64	8.21	8.34
1962	7.50	-	6.67	8.05	8.06	6.55	8.14	7.11	7.02
1963	8.90	-	8.26	8.11	8.45	8.62	9.44	8.97	8.38
1964	7.78	-	6.98	8.13	8.03	7.26	8.50	8.01	7.64
1965	8.69	-	8.41	8.79	9.45	9.45	9.23	8.61	9.71
1966	8.07	-	7.34	8.08	7.62	7.55	8.10	7.65	6.95
1967	7.92	-	7.86	8.41	7.60	7.55	9.06	7.82	7.40
1968	7.91	6.70	6.51	7.58	6.62	6.65	8.19	6.56	6.14
1969	7.84	-	7.66	8.20	7.87	7.06	9.37	8.13	7.48
1970	8.17	-	6.68	7.51	6.57	6.86	6.94	6.38	5.95
1971	8.14	6.37	7.72	8.25	7.90	7.34	9.01	8.29	7.04
1972	7.49	5.96	7.18	7.21	6.24	6.74	7.56	6.35	6.04
1973	7.53	6.08	7.05	7.41	6.74	6.85	7.89	6.60	6.06
1974	7.79	5.95	6.96	8.37	8.00	6.02	8.10	6.57	4.94
1975	6.97	5.48	7.01	7.85	6.44	6.46	6.06	5.53	5.66
Mean (1963)	8.36	-	7.78	8.46	7.85	7.62	8.82	7.72	7.93

Table 5 (cont'd)

	Area 7			Area 8			Area 9		
	GN	S	T	GN	S	T	GN	S	T
1951	10.63	9.00	9.52	10.68	8.63	10.62	10.47	8.39	10.38
1952	8.65	7.75	8.16	9.34	6.73	10.67	8.52	10.02	9.56
1953	9.98	8.16	7.05	10.83	7.56	9.98	8.90	7.79	7.47
1954	9.78	9.07	9.65	11.30	7.66	11.29	10.29	12.11	9.45
1955	9.23	8.07	8.14	9.97	6.36	8.18	9.15	9.56	8.88
1956	9.15	8.27	8.91	10.24	8.32	10.21	9.26	8.76	9.22
1957	9.15	7.78	8.45	9.68	6.98	9.44	8.70	-	8.99
1958	9.69	8.16	8.14	10.67	7.15	9.73	9.89	12.45	10.47
1959	9.04	7.08	8.00	8.70	6.20	8.66	8.58	11.36	8.26
1960	8.33	6.76	7.74	8.96	7.18	8.14	8.52	9.56	8.19
1961	9.87	8.00	9.22	9.58	8.29	9.14	9.55	9.08	9.57
1962	8.88	6.87	6.49	8.84	7.32	7.29	8.27	9.29	7.76
1963	9.54	8.26	8.66	9.76	8.17	8.36	8.96	-	6.94
1964	8.88	7.62	7.49	9.76	7.99	10.22	8.59	12.40	7.67
1965	9.43	8.39	9.84	9.99	7.89	10.20	8.99	7.66	9.15
1966	8.78	7.93	7.82	10.06	8.12	8.33	8.62	-	7.55
1967	8.67	7.11	7.27	10.68	7.06	7.64	7.49	-	5.95
1968	8.79	6.08	5.99	9.45	7.12	6.45	7.56	5.46	6.02
1969	9.28	7.72	7.86	10.20	8.86	8.65	8.52	7.24	6.73
1970	8.49	7.07	6.25	9.07	6.65	5.87	9.20	9.01	6.73
1971	9.06	7.49	6.91	9.89	7.87	7.18	8.63	5.63	7.24
1972	8.04	6.38	6.75	9.28	6.32	6.34	7.77	7.04	7.15
1973	8.34	6.98	6.81	10.01	7.42	7.18	6.85	6.26	6.60
1974	7.75	5.76	6.19	7.99	5.81	6.18	6.98	5.32	7.06
1975	8.10	6.09	7.93	9.20	7.05	6.92	8.01	5.71	7.73
Mean (1963)	9.02	7.51	7.81	9.77	7.39	8.52	8.65	6.15	6.86

Table 5 (cont'd)

	Area 10			Area 11			Area 12		
	GN	S	T	GN	S	T	GN	S	T
1951	9.36	8.62	11.69	9.20	8.60	9.60	10.87	10.47	8.29
1952	8.01	9.85	10.40	8.62		7.59	8.71	8.60	6.72
1953	8.45	-	-	8.45	9.51	7.64	10.13	9.31	7.22
1954	8.89	-	11.61	9.56	10.21	8.76	10.28	10.31	8.08
1955	8.47	-	9.29	10.25	-	7.69	10.32	9.75	7.47
1956	8.69	-	-	10.01	-	9.16	10.45	10.00	7.91
1957	8.50	-	9.12	9.19	-	8.46	8.71	8.48	7.72
1958	7.86	-	11.08	9.16	9.41	8.76	10.18	9.55	8.62
1959	7.88	-	8.46	9.32	-	7.13	9.54	8.38	6.89
1960	7.53	-	8.19	9.33	-	7.91	9.41	8.59	6.81
1961	6.77	9.30	8.81	7.58	10.50	5.86	9.66	9.20	7.06
1962	7.17	9.02	6.09	7.85	-	6.22	8.88	7.77	6.39
1963	7.51	-	9.04	6.58	-	6.60	9.36	8.82	7.28
1964	7.48	10.66	8.84	6.30	-	6.66	8.51	8.78	6.56
1965	7.42	-	8.72	7.15	-	8.64	8.09	8.29	7.11
1966	6.94	-	6.24	6.09	-	5.89	7.95	7.84	5.46
1967	6.61	-	5.66	7.87	10.59	5.73	7.66	8.40	5.29
1968	6.29	-	5.16	5.75	-	5.75	7.51	6.59	5.22
1969	6.58	-	6.01	6.51	-	6.08	8.13	8.04	6.79
1970	7.74	-	4.55	7.59	-	5.06	8.79	8.39	5.53
1971	7.74	-	6.11	8.05	7.54	6.44	8.32	8.08	7.08
1972	8.13	8.06	6.65	9.23	-	6.02	7.91	7.64	5.72
1973	7.25	-	7.26	8.81	-	6.89	8.26	8.23	6.88
1974	7.15	-	6.79	7.57	-	5.52	6.86	6.20	5.35
1975	7.63	-	6.34	7.96	-	6.33	8.13	7.89	6.33
Mean (1963)	7.68	-	8.09	8.16	-	7.06	8.90	8.54	6.79

Table 5 (cont'd)

	Area 13			Area 17			Area 18		
	GN	S	T	GN	S	T	GN	S	T
1951	10.31	10.62	5.36	10.14	10.68	5.11	10.57	9.08	5.94
1952	9.00	8.63	5.61	10.45	11.02	4.35	10.63	-	4.95
1953	9.30	8.74	4.53	9.28	5.17	3.98	10.06	-	5.65
1954	10.43	9.48	4.14	8.89	9.19	3.55	8.60	4.92	-
1955	10.07	8.12	4.69	8.79	-	3.59	7.05	-	-
1956	10.44	10.54	6.27	9.70	-	4.41	10.22	-	-
1957	9.03	8.21	5.11	9.08	-	3.76	9.04	-	-
1958	9.50	8.98	5.15	9.74	-	3.61	10.18	8.90	-
1959	8.77	8.36	4.22	8.69	-	3.38	9.31	5.86	-
1960	8.46	8.21	5.35	6.79	-	3.60	9.70	7.57	-
1961	8.65	8.11	4.71	8.90	-	3.36	10.58	10.37	-
1962	9.96	9.02	6.15	-	-	4.11	9.89	-	5.81
1963	9.08	8.90	6.08	-	-	4.31	8.28	-	5.72
1964	7.18	8.49	5.68	4.49	-	4.38	8.33	-	5.92
1965	8.23	7.76	5.44	8.96	-	4.34	7.55	-	5.87
1966	7.79	7.67	5.20	7.16	-	4.49	7.37	-	6.07
1967	6.57	7.49	4.78	-	-	4.24	-	-	5.56
1968	7.50	6.79	4.79	-	-	4.45	8.13	-	6.16
1969	8.91	8.27	5.39	9.13	-	4.82	8.75	6.78	-
1970	8.89	9.24	5.60	9.65	8.39	4.81	10.08	-	8.36
1971	7.17	7.47	4.73	5.34	4.73	4.20	5.18	5.96	4.31
1972	7.61	7.90	5.02	9.61	-	4.15	9.99	9.87	-
1973	9.17	8.75	5.06	7.67	-	5.04	9.32	-	5.01
1974	6.56	6.08	5.27	8.09	-	4.42	-	-	-
1975	7.63	7.36	5.58	-	7.10	4.60	-	7.10	-
Mean (1963)	8.65	8.37	5.20	8.44	7.78	4.20	8.94	7.64	5.79

Table 5 (cont'd)

	Area 20			Area 21	Area 23		
	GN	S	T	T	GN	S	T
1951	10.85	9.76	9.92	9.44	11.30	12.31	8.32
1952	-	-	9.28	10.42	11.26	11.70	8.61
1953	9.92	7.61	8.53	8.73	10.29	9.92	8.42
1954	8.80	7.22	9.28	7.27	10.76	11.36	8.26
1955	8.70	8.71	-	9.67	10.32	9.92	9.14
1956	7.86	6.85	9.02	8.05	9.81	10.61	8.22
1957	6.67	6.19	6.68	6.06	9.32	-	6.13
1958	8.53	8.92	7.84	7.91	10.62	-	8.01
1959	6.68	5.50	6.39	6.44	9.78	-	5.52
1960	8.40	5.72	7.64	7.92	9.83	-	7.61
1961	8.36	6.81	9.09	7.78	10.07	-	6.76
1962	8.89	8.32	7.39	7.13	10.59	-	7.27
1963	7.50	5.68	6.18	6.15	-	-	5.84
1964	8.63	8.55	6.72	6.93	-	-	7.13
1965	8.49	7.49	8.47	8.14	-	-	7.99
1966	7.86	7.27	6.48	6.68	-	-	6.68
1967	7.31	6.44	6.06	6.54	-	-	5.96
1968	6.96	6.04	6.71	6.12	-	-	5.89
1969	7.95	7.72	7.91	6.88	5.08	-	6.88
1970	10.15	10.06	9.42	9.11	9.41	12.08	7.96
1971	7.07	6.19	6.15	6.60	7.49	6.13	6.01
1972	7.70	7.04	7.24	7.52	8.92	8.33	6.61
1973	8.55	8.33	7.80	6.78	8.94	9.24	6.31
1974	7.73	7.38	6.04	5.76	-	-	5.78
1975	8.93	9.03	7.48	6.88	8.11	-	7.48
Mean (1963)	8.29	7.45	7.68	7.47	9.35	9.88	7.15

Table 5 (cont'd)

	Area 24			Area 25			Area 26		
	GN	S	T	GN	S	T	GN	S	T
1951	-	11.67	7.69	-	11.69	8.15		11.74	8.07
1952	-	11.55	9.35	-	11.59	11.06	-	-	9.39
1953	10.75	9.48	8.16	-	10.92	10.05	-	10.95	9.20
1954	-	9.47	8.88	-	11.02	9.46	-	11.49	8.86
1955	-	9.80	9.12	10.55	10.24	8.59	-	9.81	8.67
1956	9.64	9.01	7.88	11.51	11.27	7.66	-	11.02	6.69
1957	-	8.36	6.68	-	8.67	7.11	-	9.79	6.46
1958	10.29	10.11	8.64	11.88	11.73	9.18	-	11.67	8.87
1959	9.70	9.25	5.82	9.77	8.73	6.26	-	9.42	6.60
1960	8.35	9.22	8.25	10.04	9.20	8.27	10.37	9.77	8.02
1961	9.98	9.39	7.14	10.56	9.74	7.18	11.07	9.85	7.65
1962	10.23	7.89	8.62	10.87	10.78	8.44	11.40	10.97	7.28
1963	-	8.75	6.64	10.06	9.54	7.44	10.19	9.78	6.25
1964	-	-	8.59	11.97	11.90	8.80	-	-	7.78
1965	-	-	8.73	-	-	8.80	-	-	8.87
1966	-	-	6.96	-	-	7.09	-	-	7.08
1967	-	-	6.49	-	-	6.47	-	-	6.59
1968	-	5.57	6.07	-	-	5.86	-	-	5.61
1969	-	-	7.41	-	-	7.15	-	-	6.78
1970	-	-	7.62	10.93	10.64	7.14	-	7.00	7.08
1971	-	9.08	5.64	8.74	7.60	6.01	-	8.18	5.74
1972	-	8.40	6.65	9.45	8.64	6.56	10.38	9.55	6.53
1973	-	-	6.01	10.35	9.57	7.22	-	-	6.78
1974	-	-	5.44	9.57	8.13	5.69	9.62	8.43	5.16
1975	-	-	7.36	10.13	9.54	6.74	9.71	10.28	6.14
Mean (1963)	-	8.68	7.43	10.55	9.96	7.63	-	9.85	7.29

Table 5 (cont'd)

	Area 27			Area 29A+B
	GN	S	T	GN
1951	10.74	10.75	7.93	9.11
1952	-	8.93	9.05	7.36
1953	9.26	8.64	9.74	7.21
1954	10.67	9.66	9.62	7.28
1955	10.06	9.13	8.88	6.93
1956	8.13	8.56	8.51	8.32
1957	-	7.87	6.80	6.18
1958	8.22	9.96	8.24	7.47
1959	8.47	9.03	6.64	6.63
1960	9.65	8.83	7.38	7.78
1961	-	-	8.52	8.41
1962	-	-	6.85	8.16
1963	5.96	-	6.79	7.06
1964	5.53	-	7.00	8.24
1965	6.71	-	8.99	7.68
1966	6.59	-	6.22	7.17
1967	6.41	-	6.75	6.43
1968	5.68	-	6.09	6.41
1969	6.17	-	7.05	8.15
1970	5.16	-	6.67	8.88
1971	6.13	-	6.16	5.96
1972	6.40	-	6.88	7.32
1973	6.67	-	7.02	7.92
1974	5.84	-	5.78	7.10
1975	6.24	6.35	6.72	7.19
Mean (1963)	7.56	-	7.48	7.45

Table 5A. Mean round weight in pounds of cohos caught during 1976-79. Figures are shown whenever the total weight of catch tabulated in the statistics was 10 or greater, this being 10,000 lb in 1976 and 1977, 10,000 kg in 1978, and 1,000 kg in 1979. Weights based on tabulations between 10 and 29 are in parentheses.

	Gillnet				Seine				Troll			
Area	1976	1977	1978	1979	1976	1977	1978	1979	1976	1977	1978	1979
1	(5.95)	-	-	6.25	-	(8.98)	-	7.33	6.80	9.53	6.91	6.97
2E	(8.28)	9.06	9.14	-	6.22	8.99	-	-	5.84	7.44	6.69	6.39
3	8.40	9.12	6.98	7.67	5.46	7.74	6.06	6.38	8.23	9.61	7.40	7.58
4	7.90	7.84	6.96	7.30	-	7.19	(5.97)	7.28	6.06	8.14	6.78	7.39
5	7.52	8.70	7.62	8.21	(7.46)	7.65	-	6.71	5.66	8.19	5.83	7.45
6	7.33	(7.84)	7.70	7.49	6.17	7.17	6.08	6.75	5.97	8.00	6.89	7.24
7	7.78	8.03	8.19	8.31	5.43	6.77	5.83	6.40	6.31	8.17	6.85	6.72
8	9.22	8.25	7.71	8.75	5.93	5.82	5.72	6.77	6.58	7.97	6.54	6.76
9	6.48	7.28	6.66	7.24	5.54	(5.36)	-	-	5.55	6.49	6.03	6.69
10	6.00	7.12	(6.84)	7.19	-	-	-	-	5.33	6.86	(4.36)	5.95
11	-	8.03	(6.70)	7.67	-	-	-	-	5.82	6.54	5.29	6.01
12	6.84	6.75	7.56	7.50	5.83	7.13	6.27	7.10	5.51	6.75	5.94	6.72
13	-	5.15	5.64	-	6.67	6.87	7.16	6.63	5.08	5.41	5.41	5.17
14	7.83	-	-	(7.26)	(7.81)	-	-	-	4.18	4.79	4.46	4.47
15	-	-	-	-	-	-	-	-	4.61	4.98	4.86	4.69
16	-	-	-	-	-	5.03	-	-	(4.55)	-	(4.30)	4.33
17	-	-	-	-	-	-	-	-	(4.40)	4.35	4.34	4.34
18	-	-	-	-	-	(6.21)	-	(4.96)	-	-	-	(4.46)
20	6.93	7.14	7.71	7.17	5.85	6.25	6.94	6.65	(6.10)	6.78	-	6.68
21	-	-	-	-	-	-	-	-	5.46	6.40	5.71	5.66
23	4.98	(5.57)	6.94	5.83	-	(5.58)	-	(4.51)	4.95	6.14	5.54	6.04
24	-	-	-	-	-	-	-	-	4.73	5.57	5.18	5.81
25	-	-	-	-	-	(7.25)	(11.38)	-	5.41	6.25	5.96	6.37
26	-	-	-	-	-	-	-	-	5.25	6.48	6.41	6.31
27	5.72	5.33	-	(6.49)	(4.43)	5.75	-	5.90	5.28	6.42	5.98	6.18
29AB	6.05	5.12	6.74	6.10	-	-	-	-	-	(5.44)	(7.55)	5.89

Table 6. Mean whole weights in pounds of cohos caught by three different gears, in August and September. Figures in parentheses are based on 3,000-20,000 lb of fish. Underlined figures are the total catch, in thousands of pounds.

Area	Northern 3, 4	Hecate Str. West 2E	Hecate Str. East 5, 6	Central 7-10	Johnstone Str., etc. 11-13	Str. of Georgia 14-18	Fraser region 29AB	Outer Coast North 1,2W,30	Outer Coast South 27-21	Juan de Fuca 20,19
August 1960	493	209	783	958	436	254	40	301	812	121
Gillnet	7.84	-	8.03	8.20	7.49	(5.57)	5.94	(8.60)	-	6.58
Seine	(6.32)	(5.49)	7.83	7.25	7.84	(5.38)	-	-	-	6.76
Troll	8.36	7.29	8.30	7.57	7.18	4.63	-	8.86	8.73	-
August 1971	829	325	471	738	742	246	21	1,143	3,577	824
Gillnet	7.87	-	8.81	8.64	7.22	(4.94)	5.08	9.24	6.71	6.16
Seine	6.85	-	8.50	7.48	7.00	(4.53)	-	(9.24)	(6.25)	5.39
Troll	7.97	7.44	8.22	7.95	7.27	4.28	-	8.64	7.08	6.06
September 1960	432	71	250	445	468	196	91	100	303	249
Gillnet	9.69	(7.84)	9.40	10.52	10.13	6.57	7.62	-	-	8.32
Seine	-	(6.83)	8.70	9.70	9.84	(6.61)	-	-	-	-
Troll	10.24	7.87	9.63	9.85	8.52	4.93	-	10.36	9.54	(7.21)
September 1965	731	265	334	754	785	56	59	95	1,722	1,632
Gillnet	10.29	9.61	11.55	11.80	10.85	-	7.22	(9.66)	-	9.43
Seine	9.57	8.32	11.17	9.97	10.78	-	-	9.39	-	8.88
Troll	11.02	11.63	11.70	13.16	7.68	5.68	-	11.56	9.29	(9.69)
September 1971	654	151	123	695	1,552	167	197	130	2,744	2,680
Gillnet	9.34	9.40	9.45	9.81	8.89	5.44	5.72	(9.30)	(7.71)	7.13
Seine	8.81	(9.26)	8.33	8.86	8.52	5.53	-	9.08	(7.54)	6.36
Troll	9.45	9.83	(9.38)	9.64	8.33	4.67	-	9.23	7.43	(7.75)

Table 7. Mean whole weights of cohos caught in certain individual months and Areas. Figures in parentheses are based on 3,000-20,000 lb of fish.

	Central mainland			Johnstone Strait			Str. of Georgia
	Area 8--August			Area 12--September			Area 16--July
Year	Gillnet	Seine	Troll	Gillnet	Seine	Troll	Troll
1951	9.72	8.34	10.54	11.63	11.48	11.59	5.44
1952	9.12	8.11	10.13	10.41	11.03	12.15	4.28
1953	9.29	7.58	10.58	10.87	10.35	10.65	4.24
1954	10.14	8.88	11.73	11.22	11.04	11.44	3.98
1955	8.50	6.72	9.56	10.84	10.93	10.74	4.07
1956	9.31	8.68	10.21	11.40	11.34	10.95	5.34
1957	8.75	(9.19)	9.82	9.69	9.64	9.82	4.39
1958	10.45	7.79	10.93	11.25	11.50	11.47	3.88
1959	7.99	6.83	9.30	10.22	9.07	9.59	3.63
1960	8.22	7.35	8.06	10.57	9.95	9.63	5.04
1961	9.94	8.76	10.20	11.68	11.36	11.19	3.70
1962	8.47	7.40	9.06	10.57	10.56	9.52	4.80
1963	8.43	8.16	9.70	10.71	9.98	9.89	4.84
1964	8.87	7.76	9.58	10.52	10.43	9.72	4.58
1965	8.85	8.34	10.27	11.10	10.96	7.95	4.96
1966	8.46	7.50	9.28	9.27	9.35	7.32	4.53
1967	10.00	-	9.19	10.49	10.25	10.86	(4.17)
1968	7.96	6.75	7.87	8.72	7.68	8.36	(4.32)
1969	9.71	(8.42)	(8.62)	10.09	10.15	9.56	(4.84)
1970	9.13	7.13	7.22	10.23	9.36	9.67	4.31
1971	(8.12)	(5.74)	7.58	9.10	8.64	8.35	4.26
1972	7.96	6.31	7.92	9.68	9.29	8.99	(4.24)
1973	-	-	7.65	9.46	9.19	9.15	-
1974	8.49	6.67	6.67	8.85	7.97	(8.65)	(4.11)
1975	8.81	8.03	-	9.55	9.39	8.59	4.55
N	24	23	24	25	25	25	24
r	-0.367	-0.466*	-0.821**	-0.707**	-0.701**	-0.742**	-0.093
b	-0.0376	-0.0570	-0.1502	-0.0819	-0.1018	-0.1268	-0.0060
1951	9.38	8.32	10.96	11.31	11.26	11.35	4.50
1963	8.93	7.64	9.16	10.32	10.04	9.83	4.43
1975	8.48	6.95	7.36	9.34	8.81	8.31	4.36
Change	-0.90	-1.37	-3.60	-1.97	-2.45	-3.04	-0.14

Table 7 (cont'd)

	Strait of Georgia		Outer coast, NW			Vancouver I. west	
	Area 17--September		Area 1--September			Area 23--September	
Year	Gillnet	Troll	Gillnet	Seine	Troll	Gillnet	Troll
1951	8.23	6.00	(10.26)	-	11.01	(11.67)	9.33
1952	-	5.28	-	-	11.15	11.32	10.90
1953	(8.78)	4.77	-	-	11.52	10.53	9.94
1954	-	(3.97)	-	(12.25)	12.47	10.40	9.62
1955	(7.02)	4.74	-	(9.01)	10.39	9.95	11.45
1956	9.37	(5.43)	9.28	(10.47)	10.29	(9.57)	9.39
1957	-	(4.15)	9.26	(9.62)	11.01	-	7.49
1958	(7.72)	(4.35)	11.53	-	12.06	-	8.94
1959	(7.26)	(3.62)	(8.02)	-	9.93	-	8.32
1960	(5.89)	4.14	-	-	10.52	-	9.72
1961	-	(4.79)	(8.46)	-	11.84	-	10.15
1962	-	(5.47)	(9.18)	(9.37)	9.66	-	9.79
1963	-	(6.25)	10.37	(10.39)	11.27	-	7.39
1964	(5.83)	(5.31)	9.83	9.79	10.48	-	10.03
1965	-	(4.83)	(10.48)	(10.61)	11.27	-	9.04
1966	-	(4.78)	10.08	(9.18)	11.06	-	8.36
1967	-	(5.62)	10.78	-	11.73	-	7.32
1968	-	(4.55)	(8.81)	(7.01)	9.97	-	7.46
1969	-	(4.91)	(8.74)	-	(9.24)	-	8.61
1970	-	(5.92)	(9.57)	(9.47)	(10.16)	9.74	10.72
1971	(5.12)	4.59	(9.33)	-	9.23	(7.50)	7.42
1972	-	(4.55)	(8.97)	-	9.83	9.00	8.09
1973	-	-	-	-	9.40	9.10	8.45
1974	-	-	-	-	10.04	-	8.07
1975	-	-	-	-	10.06	9.33	9.42
N	9	22	17	11	25	11	25
r	-0.818**	+0.076	-0.157	-0.510	-0.573**	-0.781**	-0.443*
b	-0.1936	+0.0080	-0.0240	-0.1191	-0.0703	-0.0911	-0.0711
1951	8.71	4.83	9.89	11.03	11.57	10.83	9.87
1963	6.39	4.93	9.60	9.60	10.73	9.74	9.02
1975	4.06	5.02	9.31	8.17	9.88	8.64	8.16
Change	-4.65	+0.19	-0.58	-2.86	-1.69	-2.19	-1.71

Table 8. Mean whole weight in pounds of Alaska cohos in 8 statistical regions, and their regression on time. Area symbols are PWS = Prince William Sound and Copper and Bering Rivers; Cook = Cook Inlet; Kod = Kodiak; Chig = Chignik; AP = Alaska Peninsula and Aleutian Islands; BB = Bristol Bay; AYK = Arctic, Yukon and Kuskokwim.

	South-eastern	Central				Western		
		PWS	Cook	Kod	Chig	AP	BB	AYK
1960	7.4	6.4	5.8	7.1	8.3	6.8	6.7	6.7
1961	8.9	9.3	6.7	7.4	6.6	6.5	12.4	12.5
1962	7.8	7.9	6.4	6.6	6.7	6.9	6.3	5.7
1963	8.1	9.3	7.1	7.2	7.6	7.1	6.9	6.2
1964	8.1	12.2	6.3	8.1	6.0	7.6	6.0	5.4
1965	8.8	9.4	10.1	8.0	6.6	7.2	6.3	5.9
1966	8.8	9.3	6.4	8.4	7.8	9.3	7.5	6.5
1967	9.0	10.4	7.2	8.1	8.2	8.5	7.0	6.1
1968	7.9	9.6	5.8	8.2	-	-	5.6	7.3
1969	7.3	7.6	6.9	7.6	6.4	-	6.3	6.8
1970	7.7	9.5	6.8	8.0	6.8	7.7	7.2	7.3
1971	7.8	9.2	6.3	6.8	6.7	6.8	6.3	6.6
1972	7.9	7.3	6.2	7.7	6.8	7.0	7.1	7.1
1973	7.4	9.4	6.1	7.7	6.8	7.6	7.2	6.8
1974	7.8	7.5	7.0	7.9	7.0	7.1	7.4	7.0
Mean (1967)	8.05	8.95	6.74	7.65	7.01	7.39	7.07	6.90
a (1960)	8.36	9.11	6.86	7.41	7.25	7.21	7.65	7.28
b (slope)	-0.0432	-0.0234	-0.0185	+0.0342	-0.0340	+0.0265	-0.0833	-0.0536
r	-0.344	-0.074	-0.080	+0.288	-0.229	+0.162	-0.238	-0.144

Table 9. Trends in mean weight in pounds of cohos caught by three gears. N = number of years' data used; r = linear correlation coefficient; b = regression coefficient (lb/yr); 1951 and 1975 = computed sizes (lb) in the years indicated; change = computed changes in size between 1951 and 1975 (lb).

		Gillnet					
Region	Area	N	r	b	1951	1975	Change
Northern	3	25	-0.611**	-0.0669	9.57	7.97	-1.60
	4	25	-0.720**	-0.0791	9.31	7.41	-1.90
Hecate Str. W	2E	21	-0.485*	-0.0736	10.45	8.68	-1.77
Hecate Str. E	5	25	-0.717**	-0.0780	9.39	7.52	-1.87
	6	25	-0.726**	-0.1055	10.09	7.56	-2.53
Central mainland coast	7	25	-0.698**	-0.0639	9.79	8.25	-1.54
	8	25	-0.432*	-0.0445	10.30	9.23	-1.07
	9	25	-0.702**	-0.0860	9.68	7.63	-2.06
	10	25	-0.636**	-0.0663	8.47	6.88	-1.59
Johnstone Strait, etc.	11	25	-0.498**	-0.0857	9.18	7.13	-2.05
	12	25	-0.815**	-0.1178	10.32	7.49	-2.83
	13	25	-0.707**	-0.1114	9.99	7.32	-2.67
Strait of Georgia	17	20	-0.412	-0.0842	9.46	7.44	-2.02
	18	22	-0.373	-0.0755	9.85	8.04	-1.81
Fraser River	29	25	-0.137	-0.0152	7.63	7.27	-0.36
Outer Coast NW	1	22	-0.617**	-0.1148	9.56	6.80	-2.76
West Coast Vancouver I.	27	21	-0.852**	-0.2036	10.01	5.12	-4.89
	26	-					
	25	15	-0.496	-0.0647	11.33	9.77	-1.56
	24	-					
	23	18	-0.721**	-0.1355	10.98	7.73	-3.25
	21	-					
Str. of Juan de Fuca	20	24	-0.283	-0.0416	8.79	7.79	-1.00
Mean				-0.0857	9.70	7.65	-2.05
Percentage Change							-21.1%

Table 9 (cont'd)

		Seine					
Region	Area	N	r	b	1951	1975	Change
Northern	3	25	-0.387*	-0.0394	7.31	6.36	-0.94
	4	-					
Hecate Str. W	2E	24	-0.203	-0.0417	9.05	8.05	-1.00
Hecate Str. E	5	25	-0.617**	-0.0733	8.73	6.97	-1.76
	6	25	-0.693**	-0.0897	8.30	6.65	-2.15
Central	7	25	-0.718**	-0.0857	8.54	6.49	-2.05
mainland	8	25	-0.177	-0.0191	7.62	7.16	-0.46
coast	9	21	-0.647**	-0.1867	8.39	3.91	-4.48
	10	-					
Johnstone	11	-					
Strait, etc.	12	25	-0.762**	-0.1056	9.81	7.28	-2.53
	13	25	-0.626**	-0.0865	9.40	7.33	-2.07
Strait of	17	7	-0.514	-0.1214	9.24	6.32	-2.92
Georgia	18	10	-0.016	-0.0037	7.69	7.60	-0.09
Fraser River	29	-					
Outer Coast NW	1	23	-0.758**	-0.1720	10.83	6.70	-4.13
West Coast	27	11	-0.770*	-0.1339	9.74	6.52	-3.22
Vancouver I.	26	17	-0.676**	-0.1120	11.20	8.51	-2.69
	25	20	-0.585**	-0.0964	11.11	8.80	-2.31
	24	16	-0.664**	-0.1443	10.42	6.95	-3.47
	23	10	-0.597	-0.1210	11.34	8.44	-2.90
	21	-					
Str. of Juan de Fuca	20	24	+0.015	+0.0027	7.42	7.49	+0.07
Mean				-0.0905	9.26	7.08	-2.17
Percentage Change							-23.5%

Table 9 (cont'd)

Region	Area	Troll N	r	b	1951	1975	Change
Northern	3	25	-0.334	-0.0553	9.72	8.40	-1.32
	4	25	-0.579**	-0.0732	8.65	6.89	-1.76
Hecate Str. W	2E	25	-0.087	-0.0153	7.98	7.62	-0.36
Hecate Str. E	5	25	-0.692**	-0.0841	8.64	6.62	-2.02
	6	25	-0.897**	-0.1925	10.25	5.63	-4.62
Central mainland coast	7	25	-0.578**	-0.0865	8.84	6.77	-2.07
	8	25	-0.800**	-0.1727	10.59	6.44	-4.15
	9	25	-0.726**	-0.1286	9.58	6.50	-3.08
	10	23	-0.815**	-0.2346	10.91	5.28	-5.63
Johnstone Strait, etc	11	25	-0.740**	-0.1292	8.60	5.49	-3.11
	12	25	-0.682**	-0.0892	7.86	5.72	-2.14
	13	25	+0.105	+0.0079	5.10	5.29	+0.19
Strait of Georgia	17	25	+0.426*	+0.0287	3.87	4.56	+0.69
	18	13	+0.114	+0.0146	5.61	5.97	+0.36
Fraser River	29	-					
Outer Coast NW	1	25	-0.517**	-0.0680	8.89	7.25	-1.64
West Coast Vancouver I.	27	25	-0.727**	-0.1122	8.83	6.13	-2.70
	26	25	-0.710**	-0.1153	8.67	5.91	-2.76
	25	25	-0.711**	-0.1302	9.19	6.07	-3.12
	24	25	-0.605**	-0.0960	8.58	6.28	-2.30
	23	25	-0.581**	-0.0838	8.16	6.15	-2.01
	21	25	-0.565**	-0.0944	8.62	6.35	-2.27
Str. of Juan de Fuca	20	24	-0.507*	-0.0851	8.70	6.66	-2.04
Mean				-0.0907	8.44	6.27	-2.17
Percentage Change							-25.7%

Table 10. Mean estimated weights in pounds, at time of tagging, of cohos recaptured from taggings done in 1929 and 1930. Data from Pritchard (1934). Cohos from Areas 12 and 13 were captured for tagging by seine, all others by troll.

Tagging site			Recaptures	
Area	Locality	Time interval	No.	Av. wt.
1	North coast Graham I.	June 14-30	20	6.8
		July 2-30	75	8.6
		August 6-16	15	11.9
2W	West coast Graham I.	May 30-31	2	5.5
		July 12	1	16.0
		August 5-6	2	11.0
5	Banks Island	August 7-13	35	8.8
		September 8	1	11.0
6	Campania Sound	August 22-30	9	10.0
		September 3	3	10.3
7	Milbanke Sound	June 7-30	7	6.0
		July 3-27	23	7.3
		August 2-26	15	8.0
7	Goose Island	July 26	1	6.0
		August 4-26	18	7.9
12-13	Burke Channel and Fitzhugh Sound	August 19-29	57	8.6

Table 11. Comparison of mean fork lengths in millimetres of cohos tagged, and the length at tagging of those that were recaptured. Data from Neave (1951) and Milne (1957).

Areas	Locality	Season and year	Cohos tagged		Cohos recaptured	
			No.	Length	No.	Length
1,2W	North and west coasts of Graham I.	June 12-Aug. 5, 1951	674	668	49	666
20	Sooke traps	Sept. 10-20, 1951	145	671	31	695
23,24	Off Ucluelet	May 12-July 2, 1949	49	541	5	530
		June 1-Sept. 5, 1950	262	600	41	611
26	Off Kyuquot	July 5-Aug. 4, 1950	110	614	5	580
27,11	Off Quatsino and Cape Scott	July 5-Aug. 1, 1949	470	647	41	651
		July 8-Aug. 22, 1951	543	678	39	685

Table 12. Difference between observed weights in pounds of coho salmon and weights computed from the linear regression of weight on time, for 8 British Columbia statistical Areas. Weights are for gillnetted fish in Area 29, and for troll-caught fish in all other Areas.

Area	1	3	5	7	8	12	13	29
1951	-0.58	-0.65	+0.41	+0.68	+0.03	+0.43	+0.26	+1.48
1952	-1.02	-0.06	+0.03	-0.59	+0.25	-1.05	+0.50	-0.25
1953	+1.61	+2.17	-0.45	-1.62	-0.26	-0.46	-0.59	-0.39
1954	+1.64	+1.45	+0.02	+1.07	+1.22	+0.49	-0.98	-0.30
1955	-0.27	-1.32	+0.04	-0.35	-1.72	-0.03	-0.44	-0.64
1956	-0.68	-1.36	-1.26	+0.50	+0.48	+0.50	+1.13	+0.77
1957	-0.50	+0.06	0	+0.13	-0.11	+0.40	-0.04	-1.36
1958	+0.90	+0.82	+0.23	-0.09	+0.35	+1.38	-0.01	-0.05
1959	-0.37	-0.03	+0.52	-0.15	-0.55	-0.26	-0.94	-0.88
1960	-0.73	-1.22	+0.04	-0.32	-0.90	-0.25	+0.18	+0.29
1961	-0.77	+0.50	-0.49	+1.24	+0.28	+0.09	-0.47	+0.93
1962	-1.06	-1.57	-1.16	-1.40	-1.40	-0.49	+0.96	+0.70
1963	+0.62	+0.78	+0.99	+0.86	-0.16	+0.49	+0.89	-0.39
1964	-0.26	-0.80	-0.29	-0.23	+1.88	-0.14	+0.48	+0.81
1965	+0.77	+0.73	+1.99	+2.21	+2.03	+0.50	+0.23	+0.26
1966	+0.73	+0.02	+0.17	+0.28	+0.33	-1.06	-0.02	-0.23
1967	+1.27	+0.75	+0.26	-0.19	-0.18	-1.14	-0.45	-0.96
1968	-0.85	-1.00	-0.56	-1.38	-1.20	-1.12	-0.44	-0.96
1969	-0.09	-0.34	-0.07	+0.58	+1.17	+0.54	+0.15	+0.79
1970	-0.60	-1.02	-0.18	-0.95	-1.44	-0.64	+0.35	+1.54
1971	+0.55	-0.01	+0.38	-0.20	+0.04	+1.00	-0.53	-1.37
1972	-0.32	+3.22	-0.13	-0.27	-0.62	-0.27	-0.25	+0.01
1973	+0.46	-0.68	+0.06	-0.13	+0.39	+0.98	-0.21	+0.62
1974	+0.51	+0.30	-0.69	-0.66	-0.44	-0.46	-0.01	-0.18
1975	-0.85	-0.72	-0.16	+1.16	+0.48	+0.61	+0.29	-0.08

Table 13. Correlations between residuals of surface temperature at 3 coastal stations and residuals of weight of coho salmon in 8 British Columbia Areas. Weight residuals are from Table 12. S = temperature for the year ending July 31 of the year of the catch; P = temperature for the previous year.

		Statistical area							
	N	1	3	5	7	8	12	23	29A+B
Langara									
S	25	+0.173	-0.049	-0.010	-0.147	-0.031	-0.186	+0.000	+0.120
P	25	+0.015	-0.091	+0.092	+0.184	+0.266	+0.443*	-0.101	+0.026
Cape St. James									
S	24	+0.221	-0.047	+0.138	-0.089	+0.026	+0.165	-0.249	+0.028
P	24	+0.034	-0.140	+0.101	+0.012	+0.078	+0.156	-0.070	-0.045
Amphitrite									
S	25	+0.264	+0.211	+0.186	+0.010	+0.060	+0.144	-0.198	-0.008
P	25	-0.040	-0.234	+0.053	-0.102	+0.047	+0.411*	-0.087	-0.052

Table 14. Difference between observed weight in pounds of coho salmon and weights computed from the linear regression of weight on time, for 8 Alaksa statistical regions. See Table 8 for names of the regions.

	South-eastern	Central				Western		
		PWS	Cook	Kod	Chig	AP	BB	AYK
1960	-0.96	-2.71	-1.06	-0.31	+1.05	-0.41	-0.96	-0.58
1961	+0.58	+0.21	-0.14	-0.04	-0.62	-0.74	+4.83	+5.27
1962	-0.47	-1.16	-0.42	-0.88	-0.48	-0.36	-1.18	-1.47
1963	-0.13	+0.26	+0.30	-0.31	+0.45	-0.19	-0.50	-0.92
1964	-0.09	+3.18	-0.49	+0.55	-1.11	+0.28	-1.32	-1.67
1965	+0.66	+0.41	+3.33	+0.42	-0.48	-0.14	-0.93	-1.11
1966	+0.70	+0.33	-0.35	+0.78	+0.75	+1.93	+0.35	-0.46
1967	+0.94	+1.45	+0.47	+0.45	+1.19	+1.11	-0.07	-0.80
1968	-0.11	+0.68	-0.91	+0.52	-	-	-1.38	+0.45
1969	-0.67	-1.30	+0.21	-0.12	-0.54	-	-0.60	0
1970	-0.16	+0.62	+0.12	+0.25	-0.11	+0.22	+0.38	+0.56
1971	-0.08	+0.35	-0.36	-0.99	-0.18	-0.70	-0.43	-0.09
1972	+0.06	-1.53	-0.14	-0.12	-0.04	-0.53	+0.45	+0.46
1973	-0.40	+0.59	-0.52	-0.15	-0.01	+0.05	+0.63	+0.22
1974	+0.04	-1.28	+0.40	-0.01	+0.23	-0.48	+0.92	+0.47

Table 15. Correlations between residuals of coho weights in 8 Alaska Districts and residuals of mean annual (August through July) ocean surface temperatures at two coastal stations in northern British Columbia.

Station	Langara		Cape St. James	
District	N	r	N	r
Southeastern	15	-0.209	15	+0.018
Prince William Sound	15	+0.325	15	+0.562*
Cook Inlet	15	-0.272	15	+0.257
Kodiak	15	+0.481	15	+0.571*
Chignik	14	+0.216	14	-0.034
Alaska Peninsula	13	+0.070	13	+0.366
Bristol Bay	15	+0.103	15	+0.114
Arctic-Yukon-Kuskokwim	15	+0.192	15	+0.123

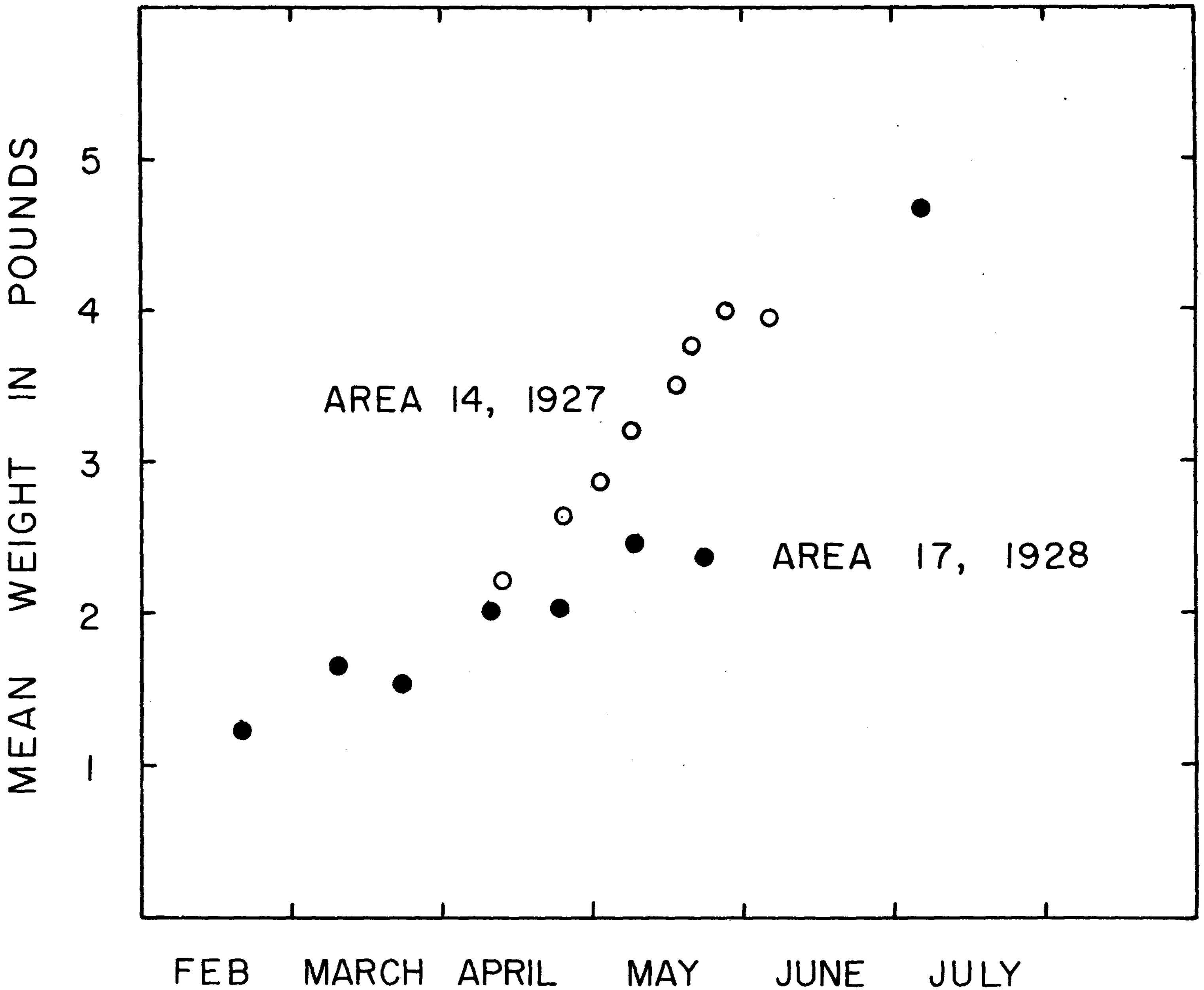

Fig. 1. Open circles: Means of estimated weights of cohos taken for tagging in Area 14 in 1927. Black circles: Means of estimated weights at tagging of cohos that were later recaptured, for taggings done in Area 17 in 1928. From data of Clemens (1930).

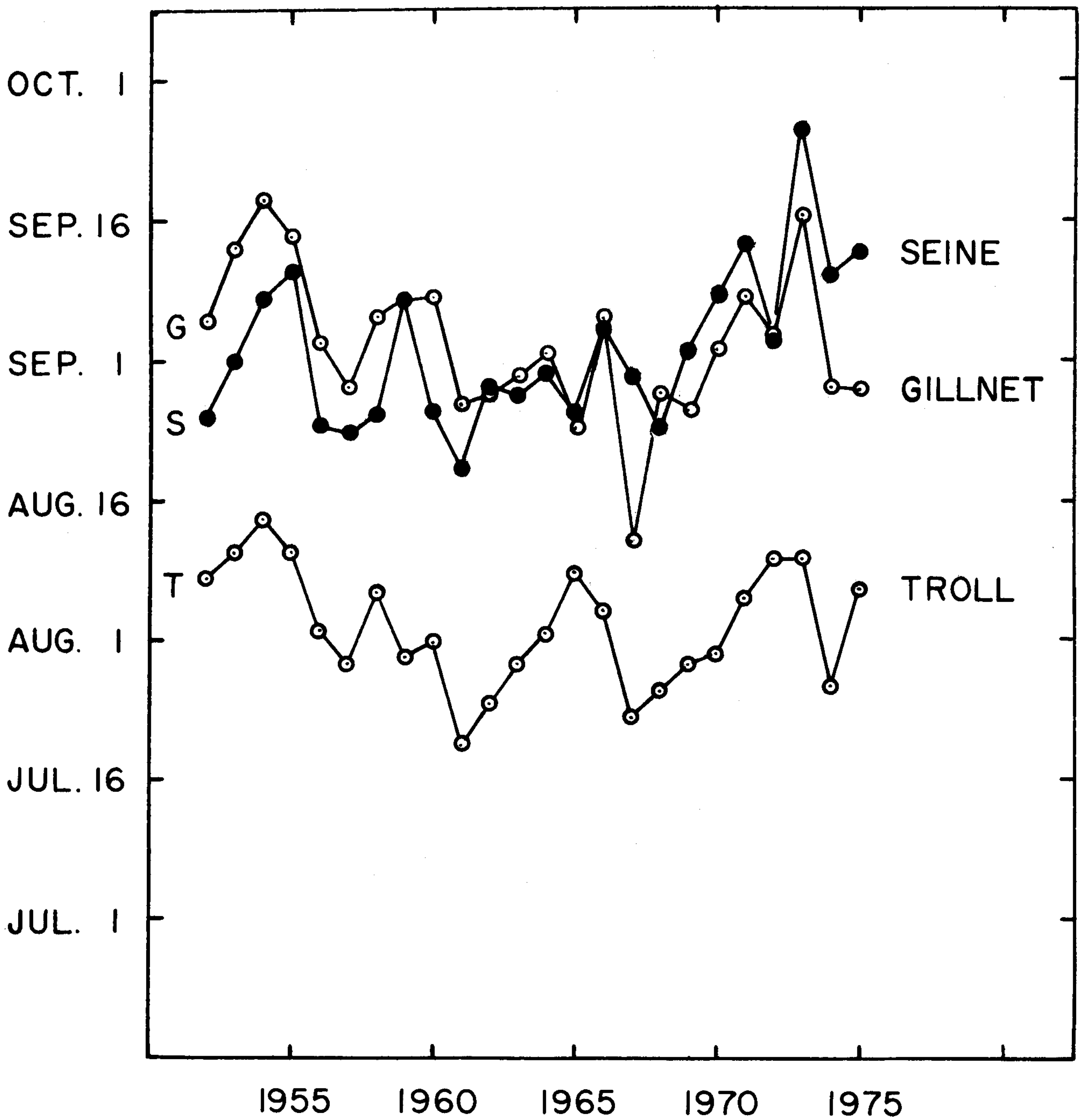

Fig. 2. Mean dates of capture of cohos in British Columbia by different gears, based on weight. Dates shown on the ordinate are accurate to within 1 day. See Table 2 for details.

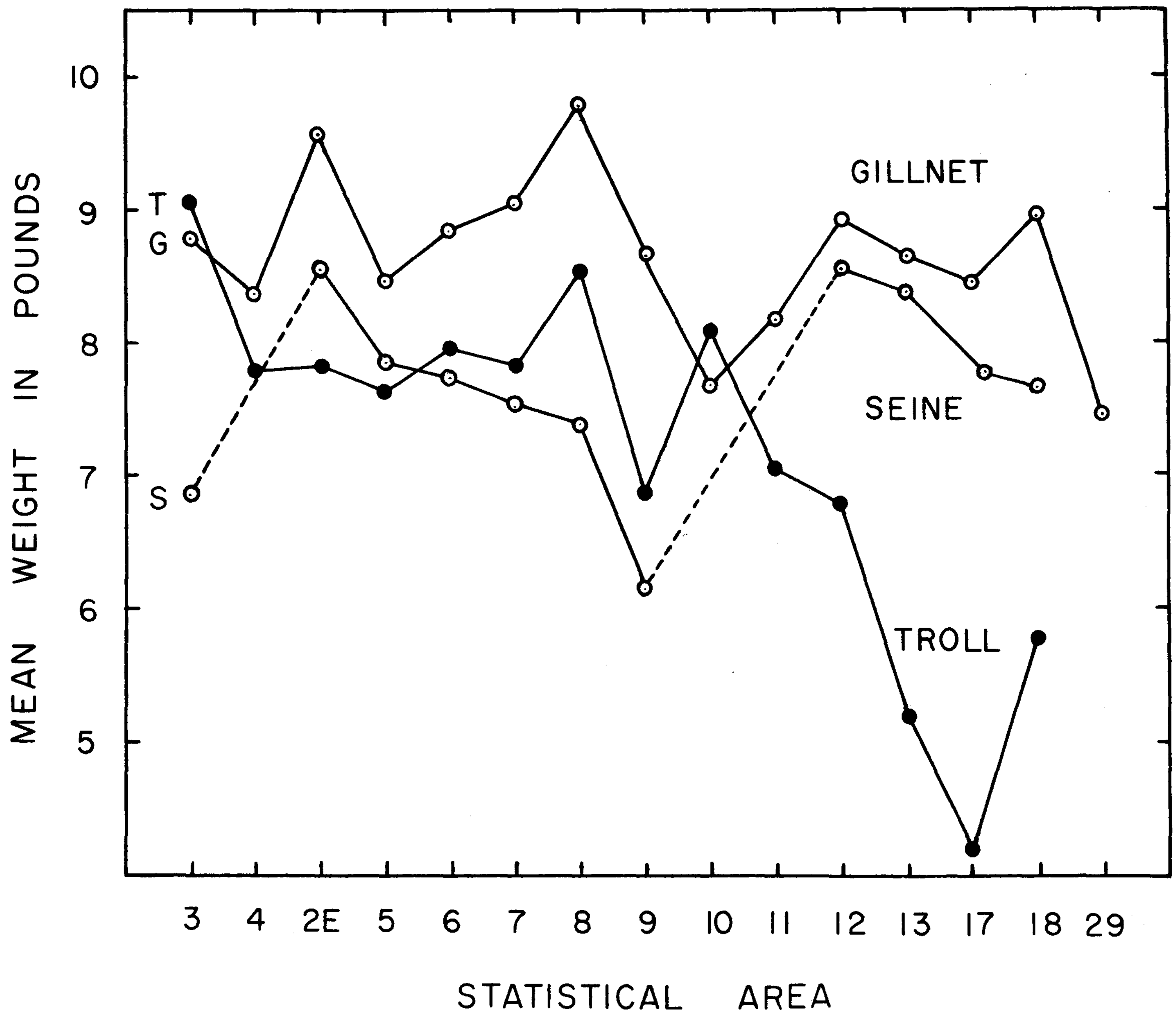

Fig. 3. Computed mean weight in 1963 of cohos caught by three different gears in statistical Areas of the British Columbia mainland coast and adjacent Straits, arranged from north to south.

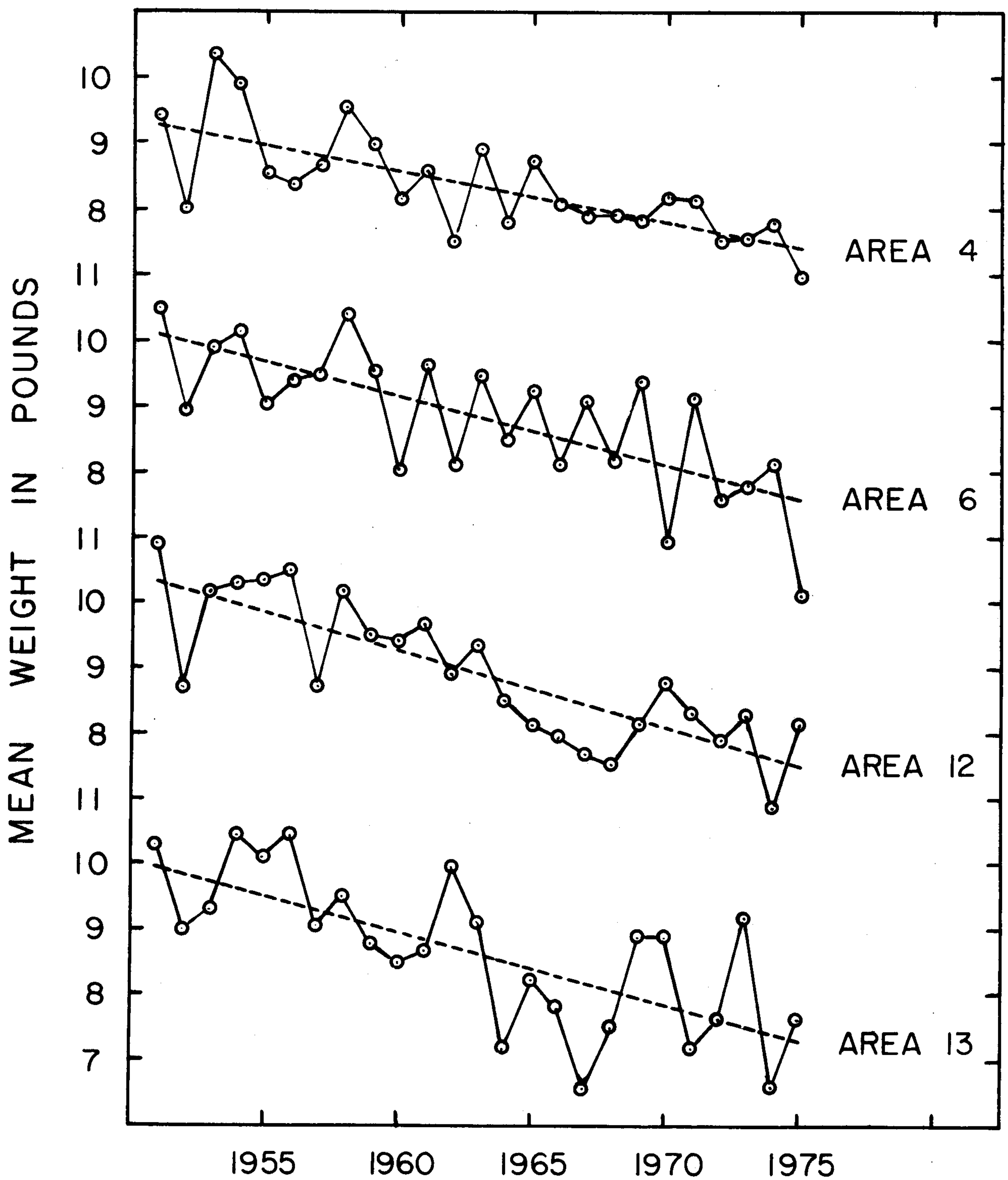

Fig. 4. Mean weight of cohos caught by gillnet in 4 statistical Areas, with linear trend lines. More complete data in Tables 5 and 9.

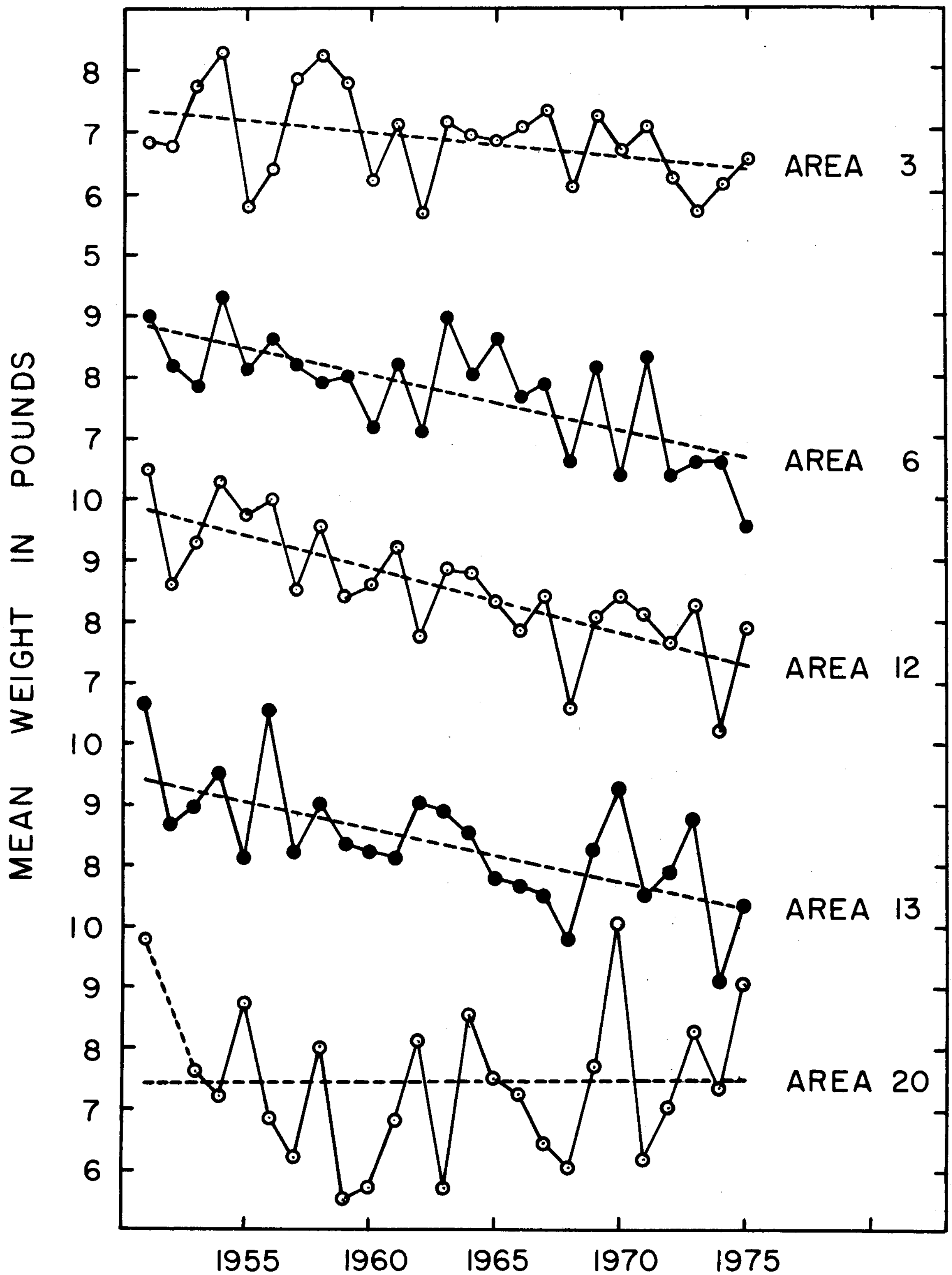

Fig. 5. Mean weight of cohos caught by seine in 5 statistical Areas, with linear trend lines. More complete data in Table 5 and 9.

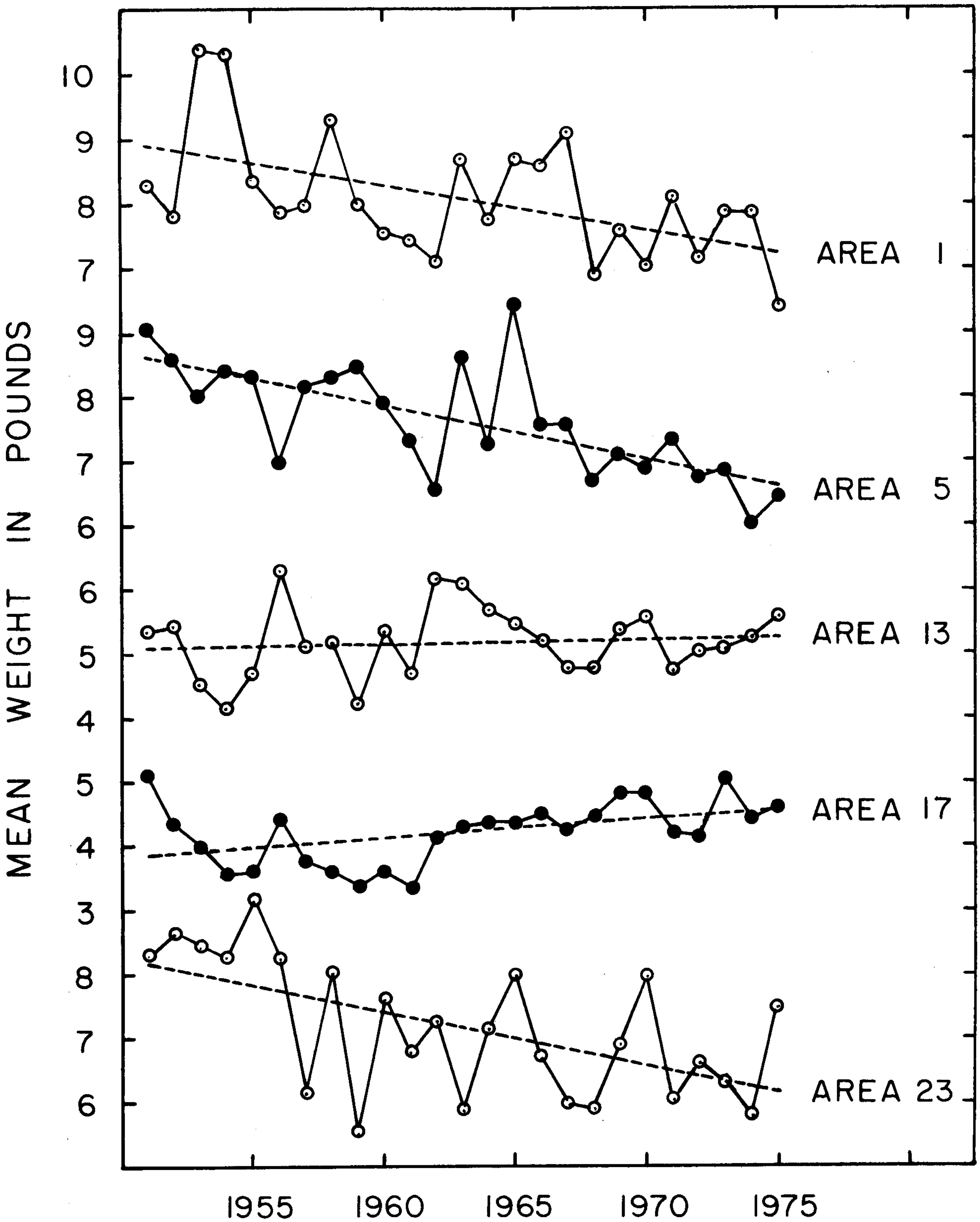

Fig. 6. Mean weight of cohos caught by troll in 5 statistical Areas, with linear trend lines. More complete data in Tables 5 and 9.

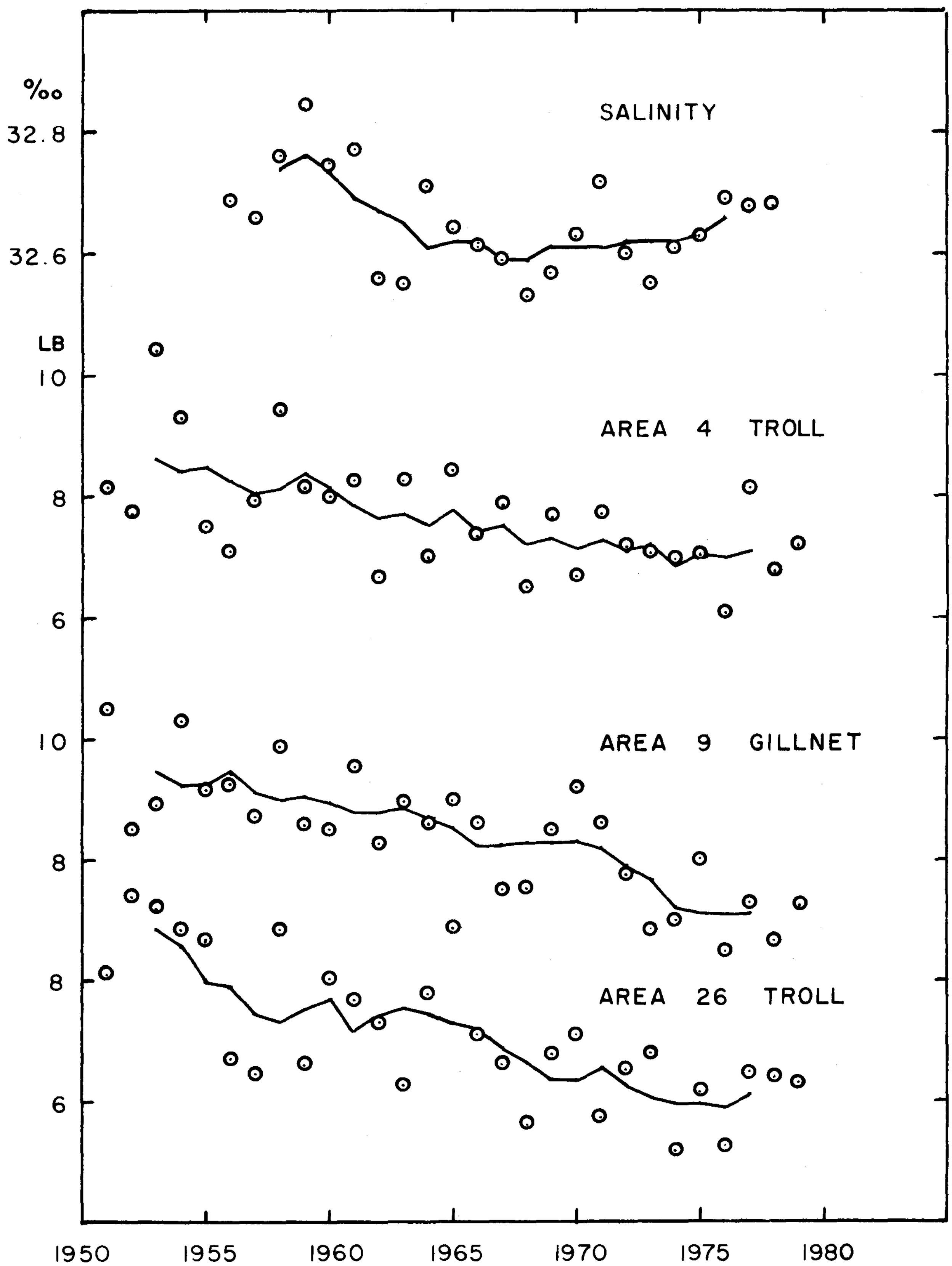

Fig. 7. Mean annual surface salinity at Station P (50°N, 145°W), and mean coho weights in the catch of 3 Areas. The trend lines are the data smoothed by a running average of 5.

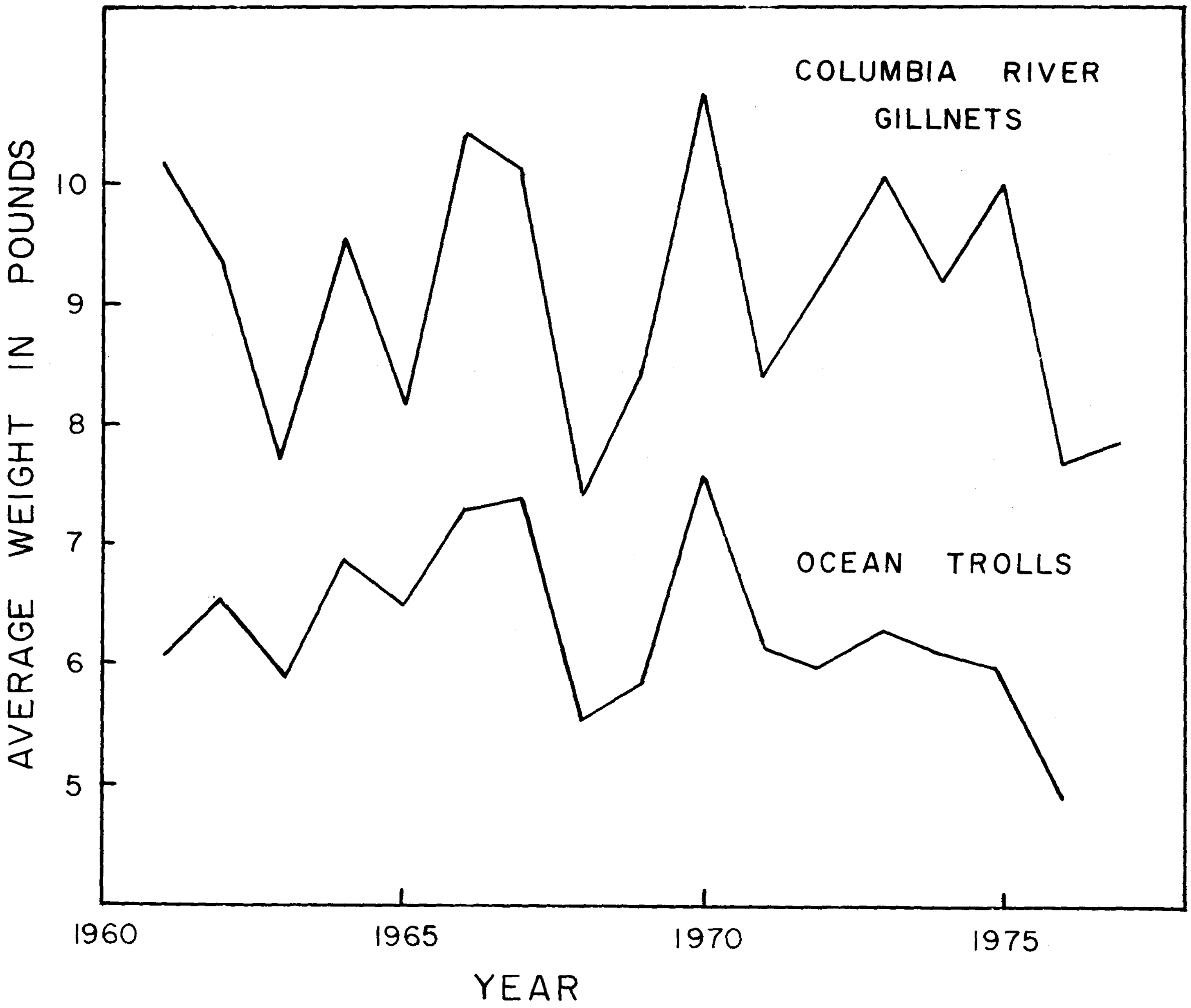

Fig. 8. Average weight of cohos harvested in the ocean troll fishery near Oregon, and of those caught by the Columbia River gillnet fishery. (Redrawn from Gunsolus 1978, Fig. 22.)