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TRENDS IN SIZE OF BRITISH COLUMBIA SALMON 1975-1982

by

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Data Sources

Most of the reports on salmon sizes prepared by K.V. Aro, H.T. Bilton, W. P. Wickett and myself (see References) a few years ago dealt with data through 1975. At the time we thought that information for a minimum of 10 additional years would be needed to determine whether observed trends would continue, or flatten out, or be reversed.

This interim report covers the subsequent seven-year period for which statistics are now available. The size data quoted are computed from the annual British Columbia Catch Statistics of the Canadian Department of Fisheries and Oceans. The suitability and reliability of such data, for this purpose, was examined and confirmed in Ricker (1981). The series used here include the most representative one for each species. In the case of chum, pink and sockeye salmon these are from the seine catches, wherever available; for chinooks the troll catch of "mixed springs" is best; and for cohos troll, seine and gillnet catches have all been used.

The geographical units for which sizes are available are the fisheries' Statistical Areas of British Columbia, which are grouped into 3 Districts. District 1 includes Areas 28 and 29, essentially the Fraser River Region. District 2 includes Areas 1-10, and 30, and lies north of Vancouver Island. District 3 includes everything else: Area 12 and part of 13 are in Johnstone Strait; the rest of 13 and Areas 14-18 are in the Strait of Georgia; Area 20 is the western part of the Strait of Juan de Fuca; and Areas 21-27 run north along the outer coast of Vancouver Island. Maps of these divisions have appeared in many Reports, for example in Ricker (1981).

Not all Areas provide size records for all species, usually because too few fish have been caught by the gear in question to provide usable figures. Extremes are Areas 19 (off Victoria), 22 (Nitinat Lake) and 28 (Howe Sound), where little or no commercial salmon fishing has been permitted in recent years; also, Area 30 is an offshore region where very little salmon fishing is done.

For all salmon species, year-to-year fluctuations in size tend to be large. To identify trends it is necessary to use some kind of averaging or regression technique. In this report the principal comparisons are between the 1976-82 average size and that for the previous decade, 1966-75. These will be called the "recent" changes - either increases or decreases. In some cases comparisons are made also with the mean for 1951-60, which is the first decade of sales-slip records.

Chinook Salmon

In the northern and central Areas 1-6 there has been a recent increase in size of troll-caught chinooks, by 0.1 to 1.3 kg in different Areas (Table 1, Fig. 1). But in most of these Areas chinooks are about 1.5-2 kg smaller than during the 1950s. In Areas 7-12 size continued to decrease after 1975, by 0.1-0.2 kg. In Strait of Georgia Areas 13, 17 and 18 there were larger decreases, amounting to 0.4-0.7 kg. In Juan de Fuca (Area 20) several years lack data, but 1979 and 1981 show improvement in size. Off Vancouver Island (Areas 21-27) weights since 1975 average 0.3-1.5 kg less than in the previous decade.

Mean sizes of "red spring" chinooks, caught by gillnet, were computed for 4 Areas since 1960 (Table 1). The weakness of gillnet data is that the size of nets used may have varied over the years; also, many are caught in nets set primarily for other species. For what it's worth, the average recent changes were a loss of 0.8 kg in Areas 3 and 12, and an increase of 0.4 kg in Area 20. The Fraser River gillnetted red chinooks have had no marked trend in size since 1964, when they rose abruptly to a level of about 0.8 kg larger than the average of the previous 6 years.

Coho Salmon

Based on troll catches for the whole fishing season, cohos in the northern Areas 1, 2E and 3 continued their decrease in size during 1976-82, losing 0.2-0.6 kg (Table 2). Areas 4 and 5 have variable sizes but a mean decrease of only 0.1-0.2 kg. Central Areas 6 and 7 have average increases of 0.1-0.4 kg, but their cohos are still 0.5-1.0 kg smaller than in 1951-60. Areas 8-11 are down by 0.1-0.3 kg, but Area 12 has an 0.1 kg increase. In Juan de Fuca and off Vancouver Island the previous decrease in size continued, especially in Areas 20-24 where they lost 0.4-0.5 kg as compared with 1966-75.

Trends in sizes of seined cohos since 1975 were not too different from the picture for trolls (Table 2, Fig. 2). Recent sizes were down in Areas 1-7, but by only 0.05-0.16 kg. In Areas 8 and 12, however, the losses were 0.4 and 0.6 kg. In Area 20, where there was little change in mean size from 1951-1960 to 1965-1975, the recent years showed a decline of 0.6 kg (Fig. 3). Data for Areas 24-27 are sparse, but are not in conflict with the picture from troll catches.

In the gillnet catches substantial recent size decreases of up to 0.6 kg are the rule, but in Areas 5 and 6 there was practically no change (Table 2). In all Areas the current sizes are much smaller than in 1951-60, the unweighted mean decrease being 0.9 kg. The picture in Area 20 is similar to that for seines (Fig. 3).

Because coho sizes increase considerably throughout the fishing season, Table 7 of Ricker and Wickett (1980) included mean sizes for troll-caught cohos in the statistical 5-week month of September, for 4 Areas; these are here extended to 1982 (Table 2, Fig. 4). In Areas 1 and 23 the recent decrease was considerably greater in September than in the all-year troll series - perhaps partly because the September fish are larger. In Area 12 September sizes decreased by 0.6 kg, whereas the all-year sizes indicated an increase of 0.1 kg.

There is a special situation in the strait of Georgia (Areas 13-18). Here trolls capture mainly the slow-growing locally-reared cohos, whereas seines and gillnets take mainly migrants from outside, which are larger and tend to appear later in the season. The troll-caught cohos had a slight trend upward during 1951-75, but have since decreased by 0.1-0.2 kg (Table 2). However, neither the increase nor the decrease is "significant", and none of the recent weights are as low as some during 1951-60. The same is true in the September-only series, where the mean decrease since 1975 in Area 17 is only 0.04 kg (Fig. 4). Unlike the local troll-caught fish, the sizes of the (mostly migrating) cohos obtained by seine and gillnet in the Strait of Georgia decreased substantially during 1951-75. This decrease has continued in Area 13, the only Area with adequate recent data (Table 2).

Odd-year Pink Salmon

Pink salmon of the odd-numbered and even-numbered lines differ so much in size that it is necessary to give them separate treatment. This means that there are only 4 even-years' sizes since 1975, and only 3 odd-years', with corresponding uncertainty about recent trends.

Based on seine catches, Areas 1-9 showed recent size increases in odd-numbered years of 0.17-0.39 kg, which were to within 0.1 kg of the level of the 1950s in Areas 5-7 (Table 3). There was almost no increase in Area 12, while in Areas 13, 18 and 20 the previous decline continued, with new lows in 1979 in two of these Areas.

It seemed possible that the continued declines in size of seine-caught pinks in the south, especially in Area 20, might be a result of the increasing troll fishery along the outer coast, which has been cropping off more of the larger pinks. So the average size of pinks taken by all gears was computed for Districts 1 and 3 (Areas 11-29), which in odd years include mainly Fraser-bound fish (Table 3, Fig. 5). But the mean size for 1977-81 was still small (down 0.10 kg, with a new low of 2.12 kg in 1979).

A similar all-gear computation for District 2 (Areas 1-10) confirmed the recent increase in size of odd-year pinks in that region; they were up by 0.19 kg from 1967-75, which brought them to within 0.12 kg of the mean of the 1950s. However, Fig. 5 shows that the recent increases have earlier parallels.

Even-year Pink Salmon

In Areas 2 through 8 the size of seined pinks of 1976-82 was up slightly over the previous decade, with a mean increase of 0.05 kg (Table 3). The all-gears average for the whole of District 2 was up 0.03 kg (Fig. 5). These increases are much less than in the odd-numbered years. Moreover, the 1966-74 even-year averages had been depressed by two years of exceptionally small pinks that were related to exceptional local abundances -- in Area 8 in 1968 and in Area 6 in 1972. There was no similar event during 1976-82, so the failure of mean size to make a more substantial gain during those years is disappointing. However, this picture conforms to the pattern of the previous 25 years, when the even-year pinks were subject to a more severe removal of larger individuals by the gillnet fishery than were the odd-year fish, and decreased in size much more rapidly (Table 3).

In the southern Districts even-year pinks are scarce, but the all-gears plot suggests a continued slow decrease in size (Table 3, Fig. 5). The recent average is 0.07 kg below than that of the previous decade -- much like the 0.10 kg decrease in the odd-year series.

Chum Salmon

In northern Areas 1-3 the seine-caught chums of 1976-82 varied from slightly smaller to slightly larger than in the previous decade, but were not as large as during the 1950s (Table 1, Fig. 7). In Areas 5-8 recent sizes were up by 0.2-0.6 kg, but were still smaller than in the 1950s except in Area 7. In Johnstone Strait Areas 12 and 13 the 1976-82 seined chums were up by 0.5-0.6 kg, and were of the largest size since the sales-slip records began. Area 20 (Juan de Fuca) had a small recent increase (0.1 kg), but was still 1.1 kg below 1951-60. In Areas 23-26 there has been little trend in size over the whole period starting in 1951, while Area 27 shows an increase of 1.0 kg - based on few fish, however.

Chums differ from pinks in that size selection by trolls has not been significant, and that selection by gillnets has been to remove more of the smaller fish (Ricker 1980a). This tends to increase progeny size within any age group, but it also favours survival of older ages, which are slow-growing. On balance, in 1980 the prediction was for a slow increase in chum sizes, or little change.

The larger of the recent changes were in fact increases, but it is not clear how great a role selection may have played in this. Environmental conditions presumably had an effect - perhaps the same conditions that increased the size of District 2 pink salmon, especially in odd years. However, the distribution of large increases was not altogether the same for the two species. They coincided in Areas 3 and 5-8; in Area 1 chums decreased while pinks increased; in Areas 12 and 13 chums increased markedly, whereas pinks had a small net decrease.

Sockeye

Table 3 summaries the mean sizes of seined sockeye. Trends since 1951 have everywhere been small, and have not been consistent between Areas. The 1976-82 means are all larger than those of the previous decade, but only slightly so in the important Areas. With or without allowance for cyclical norms, the variations in sockeye size do not agree well with those of pink salmon on either section of the coast. In particular, the marked increase in size of District 2 odd-year pinks since 1975 does not appear in the sockeye series, either in British Columbia or in Alaska (Table 4).

Sockeye sizes through 1980 were included in the 1982 Report. Sizes in the more important areas since then have been as follows, in kilograms.

Area	Seined					Gillnet			
	3	4	12	20	23	3	4	9	29AB
1981	2.24	2.11	2.68	2.63	2.00	2.57	2.25	2.66	2.64
1982	3.00	3.00	3.04	3.03	2.22	3.01	2.99	3.22	2.81

Areas 12, 20 and 29 included mostly Fraser River fish, which in 1982 had their quadrennial large run of large sized "late Shuswap" sockeye.

Discussion

An interesting feature of events since 1975 is the widespread slowdown or reversal of the decline in sizes of chinook and pink salmon in northern British Columbia (District 2), which contrasts with their continued decline in the south. In southeastern Alaska events closely paralleled those in District 2 (up to 1980 at least): the recent increase was 0.32 kg for chinooks and 0.19 kg for odd-year pinks (Table 4). Also, the year-to-year fluctuations in size in the two regions have been closely parallel in recent years. As in British Columbia, there was a much smaller recent change in size of Alaskan even-year pinks (+0.02 kg), while cohos maintained a slow decline (-0.17 kg).

Thus it seems clear that the causes of recent changes have been mainly environmental, and that they affected stocks that enter rivers along a stretch of coast from Queen Charlotte Sound to Yakutat, perhaps farther. It may seem surprising that environmental changes that were favorable for chinooks were not so for cohos. However, the two species typically occur at different depths, and chinooks tend to perform longer migrations.

What is not yet clear is whether the observed improvements in size will be sustained, or whether they represent merely "blips" in the long-term decline that began about 1950 for pinks and much earlier for chinooks. Certainly there have been similar short-term fluctuations in the past.

Why have chinooks and odd-year pinks from Cape Scott south not shared in the recent improvement? The only obvious answer is that they have encountered less favorable growing conditions, either on the high

seas or along their migration routes between the coast and the main foraging areas. They might, for example, have been more exposed to effects of the recent "El Niño" oceanic perturbation. Whatever the reason, the size decreases in this region are becoming more and more widely recognized and, for sport fishermen at least, more worrisome.

References

- RICKER, W. E.. 1980a. Changes in the age and size of chum salmon (Oncorhynchus keta). Can. Tech. Rep. Fish. Aquat. Sci. 930: 99 p.
- 1980b. Causes of the decrease in age and size of chinook salmon (Oncorhynchus tshawytscha). Can. Tech. Rep. Fish. Aquat. Sci. 944: 25 p.
1981. Changes in the average size and average age of Pacific Salmon Can. J. Fish. Aquat. Sci. 38: 1636-1656.
1982. Size and age of sockeye salmon (Oncorhynchus nerka) in relation to environmental factors and the fishery: Can. Tech. Rep. Fish. Aquat. Sci. 1115: 117 p.
- RICKER, W. E., H. T. BILTON, and K. V. ARO. 1978. Causes of the decrease in size of pink salmon (Oncorhynchus gorbuscha). Fish. Mar. Serv. Tech. Rep. 820: 93 p.
- RICKER, W. E, and W. P. WICKETT. 1980. Causes of the decrease in size of coho salmon (Oncorhynchus kisutch). Can. Tech. Rep. Fish. Aquat. Sci. 971: 63 p.

TABLE 1 Mean Whole weights in kilograms of "mixed" chinook salmon caught by troll, of "red spring" chinooks caught by gillnet, and of chum salmon caught by seine, in 24 statistical areas of British Columbia. A: 1951-60; B: 1966-75; C: 1976-82.

Stat. Area	Chinooks - troll			Chinooks - gillnet		Chums - seine		
	A	B	C	B	C	A	B	C
1	9.46	7.01	7.56	---	---	5.00	4.76	4.63
2E	7.80	6.36	6.44	---	---	4.53	4.34	4.42
2W	9.66	7.87	8.02	---	---	---	---	4.49
3	8.88	6.25	6.28	8.49	6.74	6.29	5.43	5.65
4	7.88	4.79	5.52	---	---	6.48	5.97	5.80
5	7.58	5.25	5.78	---	---	6.63	5.51	6.14
6	7.07	5.60	6.89	---	---	6.27	5.80	6.02
7	8.79	8.13	7.75	---	---	5.46	5.03	5.68
8	8.23	6.96	6.96	---	---	6.82	5.80	6.17
9	---	---	5.68	---	---	7.13	6.10	---
10	---	---	5.83	---	---	5.54	5.06	---
11	7.14	6.25	6.50	---	---	---	---	---
12	6.89	5.38	5.27	6.33	5.50	5.31	5.09	5.56
13	5.03	4.04	3.38	---	---	5.09	4.92	5.48
17	4.45	2.95	2.55	---	---	4.99	---	---
18	5.77	3.40	2.72	---	---	5.03	5.13	---
20	6.64	4.49	---	4.57	4.97	6.04	4.86	4.95
21	6.06	4.90	3.40	---	---	---	---	---
23	5.77	5.36	5.04	---	---	4.78	4.62	5.15
24	6.94	6.25	5.74	---	---	4.68	---	4.93
25	7.67	6.82	6.16	---	---	4.73	4.76	4.71
26	8.22	7.56	6.66	---	---	4.73	4.79	6.74
27	8.55	7.32	6.58	---	---	4.61	5.07	5.59
29	---	---	---	7.92	7.98	---	---	---

TABLE 2 Mean whole weight in kilograms of coho salmon caught by 3 different fishing gears in 24 statistical areas of British Columbia, and of cohos caught by troll during the 5-week statistical "month" of September in 4 Areas. A: 1951-60; B: 1966-75; C: 1976-82.

Stat. Area	Coho - troll			Coho - seine			Coho - gillnet			September Coho - troll		
	A	B	C	A	B	C	A	B	C	A	B	C
1	3.89	3.47	3.30	4.61	3.31	3.26	3.97	3.32	2.74	5.00	4.57	4.27
2E	---	3.47	2.92	3.94	3.82	3.68	4.49	4.17	4.00	---	---	---
2W	---	---	3.25	---	---	3.08	---	---	---	---	---	---
3	4.29	3.94	3.56	3.25	2.98	2.93	4.24	3.81	3.53	---	---	---
4	3.80	3.26	3.05	---	---	---	4.07	3.53	3.28	---	---	---
5	3.73	3.13	3.05	3.75	3.25	3.09	4.11	3.58	3.57	---	---	---
6	4.24	2.89	3.29	3.72	3.17	3.12	4.33	3.64	3.65	---	---	---
7	3.80	3.17	3.31	3.83	3.11	2.95	4.25	3.91	3.84	---	---	---
8	4.40	3.21	3.15	3.30	3.28	2.85	4.55	4.35	3.82	---	---	---
9	4.12	3.12	2.86	4.54	2.93	---	4.19	3.61	3.23	---	---	---
10	4.53	2.76	2.55	---	---	---	3.79	3.27	3.11	---	---	---
11	3.75	2.71	2.58	---	---	---	4.22	3.42	3.38	---	---	---
12	3.44	2.71	2.81	4.24	3.51	2.91	4.93	3.61	3.38	4.90	4.06	3.43
13	2.29	2.33	2.27	4.08	3.49	3.01	4.32	3.53	2.99	---	---	---
17	1.78	2.05	1.82	---	---	---	4.15	3.67	---	2.10	2.26	2.22
18	---	---	---	---	---	---	4.32	3.81	---	---	---	---
20	3.76	3.23	2.80	3.35	3.42	2.84	3.85	3.64	3.15	---	---	---
21	3.72	3.12	2.62	---	---	---	---	---	---	---	---	---
23	3.55	2.97	2.55	---	---	---	4.69	3.63	2.67	4.31	3.81	3.10
24	3.65	2.98	2.48	---	---	---	---	---	---	---	---	---
25	3.89	2.99	2.79	---	---	---	---	---	---	---	---	---
26	3.66	2.89	2.80	---	---	---	---	---	---	---	---	---
27	3.76	2.96	2.79	---	---	---	4.26	2.78	2.65	---	---	---
29AB	---	---	---	---	---	---	3.37	3.29	2.81	---	---	---

TABLE 3 Mean whole weights in kilograms of seine-caught pink and sockeye salmon in 14 statistical areas of British Columbia, and of pinks caught by all gears in two combinations of Areas (Districts 2 and 1 & 3). A: 1951-60; B: 1966-75; C: 1976-82.

Stat. Area	Odd-year pinks			Even-year pinks			Sockeye		
	A	B	C	A	B	C	A	B	C
1	2.46	1.96	2.18	2.14	1.60	1.55	2.20	2.57	2.79
2E	---	---	---	1.98	1.61	1.64	---	---	---
3	2.32	1.82	2.13	1.96	1.47	1.54	2.75	2.61	2.63
4	2.32	1.78	2.17	1.86	1.44	1.46	---	2.70	2.71
5	2.13	1.79	2.06	1.95	1.53	1.58	2.44	2.44	2.53
6	2.13	1.76	2.02	2.04	1.52	1.58	2.51	2.43	2.50
7	2.09	1.79	1.97	1.87	1.43	1.48	1.92	2.07	2.50
8	2.24	1.89	2.06	1.85	1.43	1.50	1.96	2.08	2.20
9	2.36	1.85	2.10	1.94	1.42	1.42	---	---	---
12	2.42	2.22	2.23	1.92	1.45	1.48	2.58	2.63	2.78
13	2.40	2.26	2.23	1.98	1.55	1.52	2.71	2.70	2.81
17	2.58	2.44	---	---	---	---	---	---	---
18	2.57	2.54	2.43	---	---	---	2.88	2.77	2.88
20	2.67	2.49	2.35	---	---	---	2.83	2.75	2.78
1-10	2.24	1.93	2.12	2.04	1.56	1.59	---	---	---
11-29	2.51	2.36	2.26	1.95	1.60	1.53	---	---	---

Table 4. Mean whole weights in kilograms of salmon caught by all fishing gears in Southeastern Alaska (Yakutat to Dixon Entrance). From data reported in Statistical Yearbooks of the International North Pacific Fisheries Commission.

Year	Chinooks	Cohos	Pinks	Pinks	Chums	Sockeye
1960	7.39	3.36	--	1.54	4.58	2.49
1961	5.90	4.04	2.36	--	4.26	3.00
1962	8.26	3.54	--	1.77	4.31	2.77
1963	7.76	3.67	1.41	--	3.99	2.49
1964	8.35	3.67	--	1.72	4.58	2.72
1965	9.57	3.99	1.77	--	4.63	2.77
1966	6.89	3.99	--	2.00	3.90	3.08
1967	6.85	4.08	2.04	--	4.35	2.86
1968	7.35	3.58	--	1.50	4.94	3.18
1969	6.12	3.31	1.95	--	4.17	2.63
1970	6.49	3.49	--	1.77	3.81	2.90
1971	6.17	3.54	1.68	--	3.54	2.90
1972	5.49	3.58	--	1.41	3.99	2.85
1973	6.26	3.36	1.63	--	4.40	3.13
1974	6.04	3.54	--	1.86	3.99	2.92
1975	5.99	3.27	1.75	--	4.25	2.82
1976	5.81	3.50	--	1.99	4.84	3.00
1977	6.63	3.96	2.22	--	4.61	3.16
1978	6.94	3.04	--	1.45	4.23	3.00
1979	6.78	3.13	1.79	--	4.32	2.89
1980	7.23	3.35	--	1.76	4.52	2.86
1966-75	6.36	3.57	1.81	1.71	4.13	2.93
1976-80	6.68	3.40	2.00	1.73	4.50	2.98

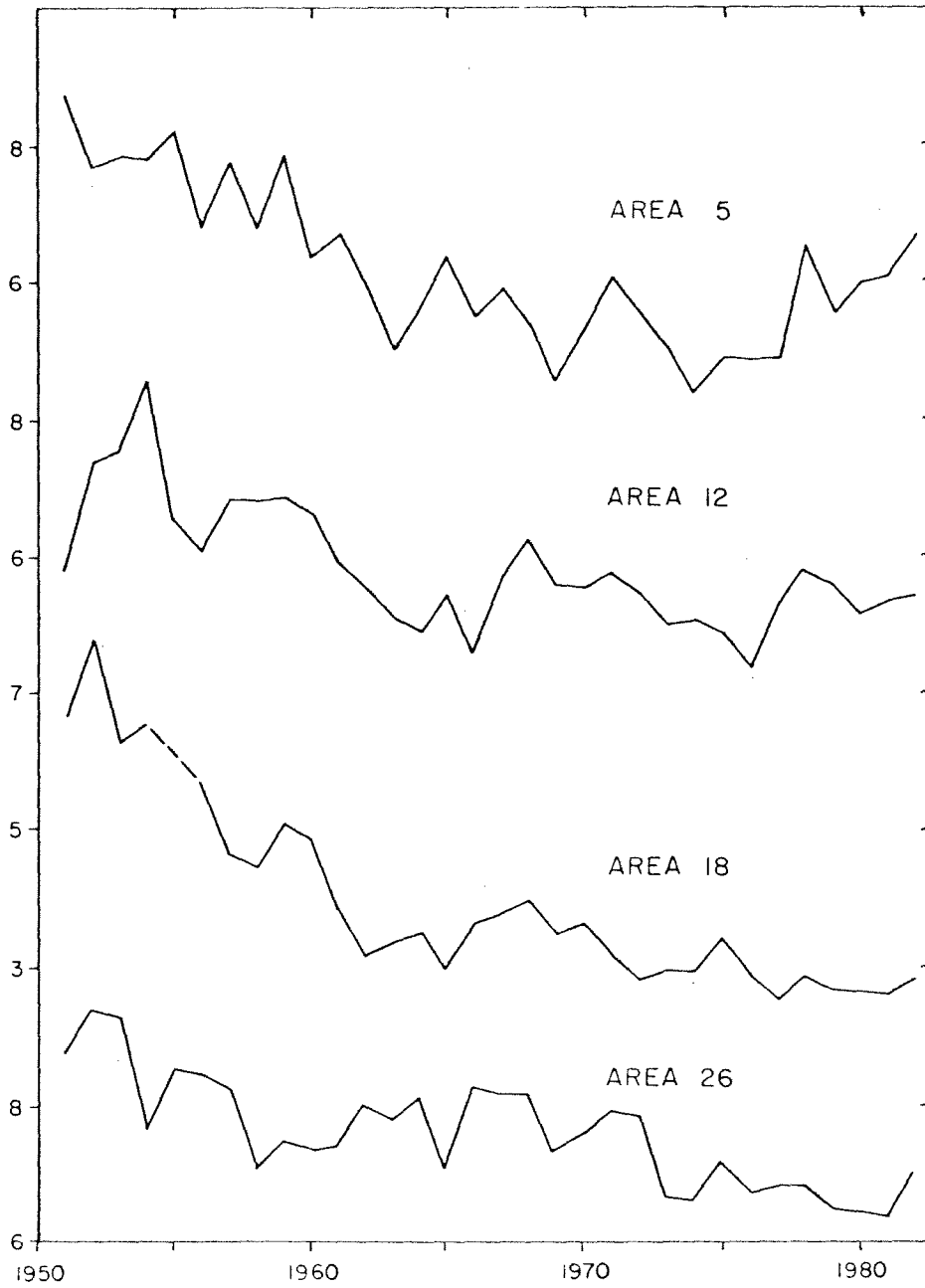


Fig. 1. Changes in mean whole weight of chinook salmon caught by troll in four Statistical Areas of British Columbia.

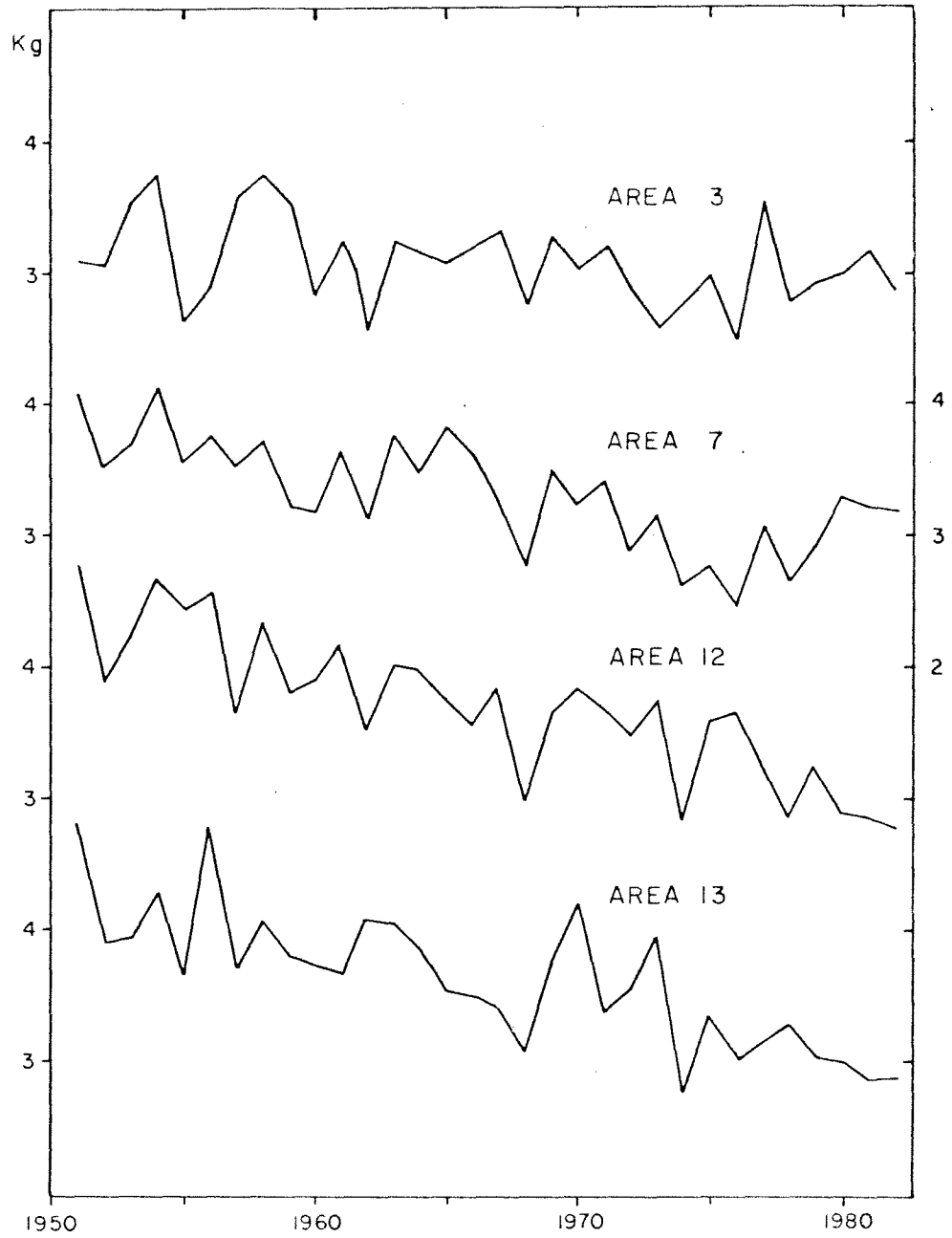


Fig. 2. Changes in mean whole weight of seine-caught cohos in four Statistical Areas.

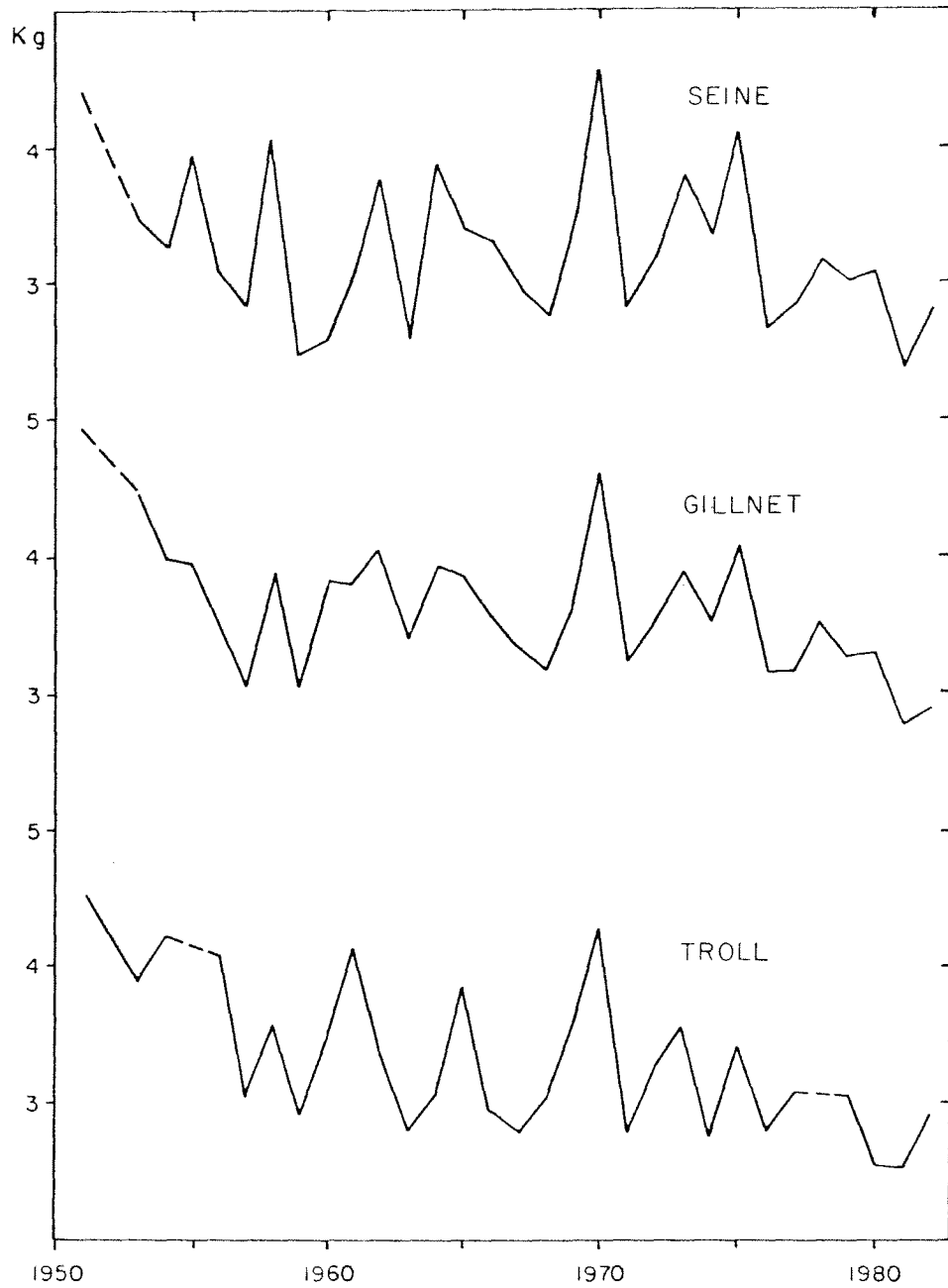


Fig. 3. Changes in mean whole weight of cohos caught by three different fishing gears in Statistical Area 20.

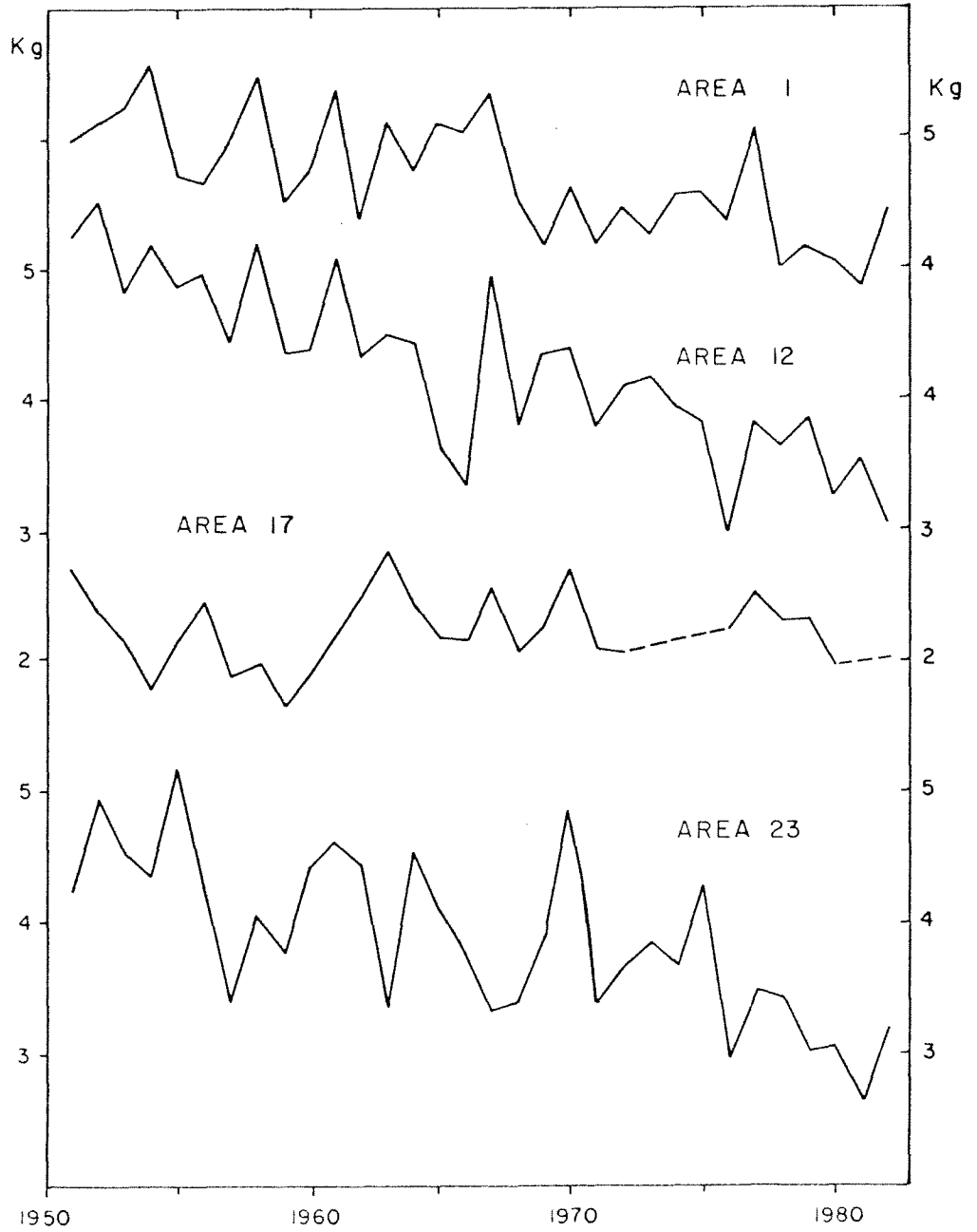


Fig. 4. Changes in mean whole weight of troll-caught cohos caught in four Areas during the statistical 5-week month of September.

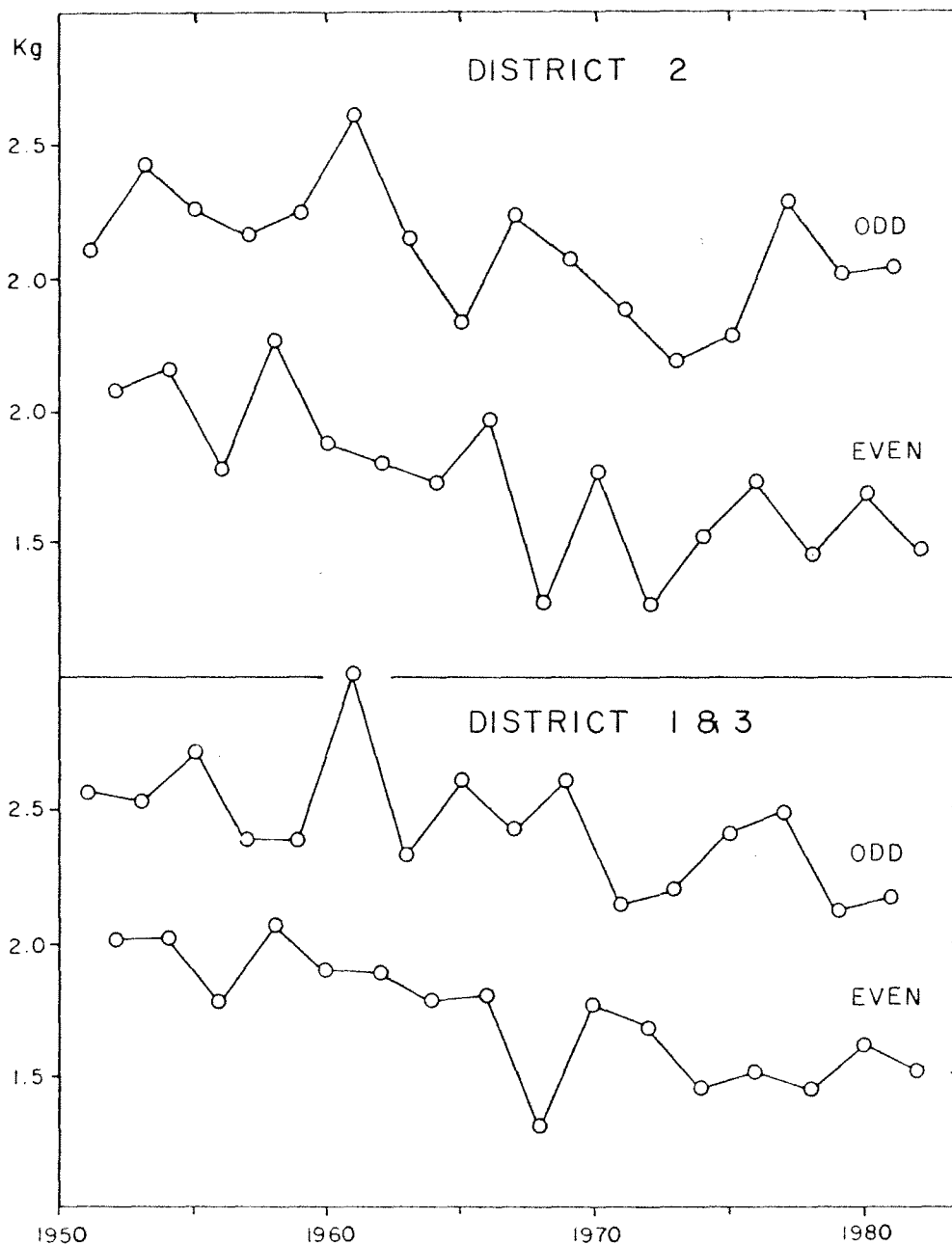


Fig. 5. Changes in mean whole weight of pink salmon, caught by troll, seine and gillnet combined, in northern British Columbia (District 2) and in southern British Columbia (Districts 1 and 3).

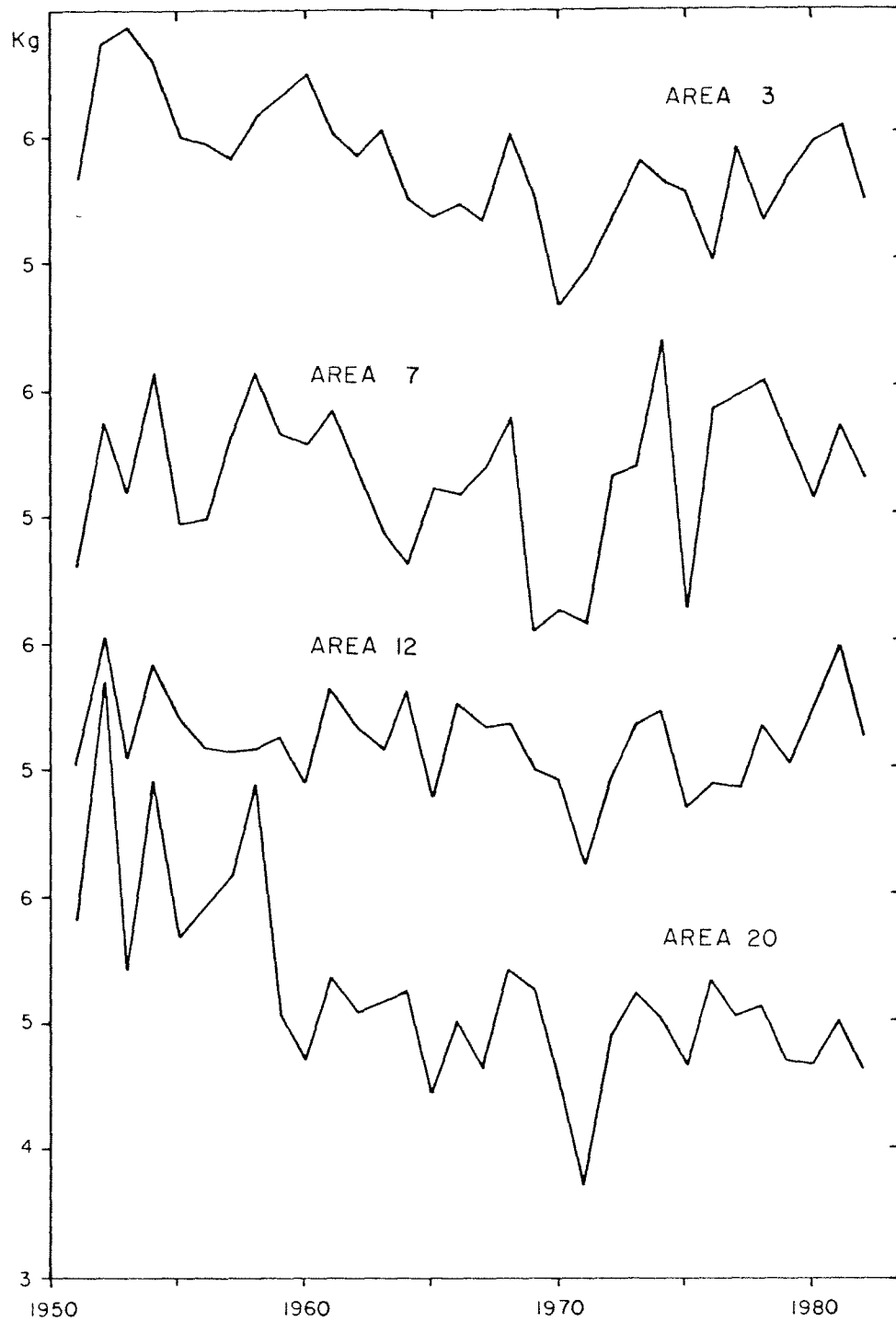


Fig. 6. Changes in mean whole weight of chum salmon by seine in four Statistical Areas.