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INTRODUCTION

The purpose of this report is to compare the incidence of circuli formed after the annulus (Fig. 1) (referred to here as "new growth"[1]) on the scales of early migrants with that on scales of the late migrants for the years 1958 to 1965.

METHODS

Seaward-migrating sockeye were trapped at the outlet of Nilkitkwa Lake (Fig. 2) and were sampled for length, sex, and age. Age was determined from scales taken within an area just dorsal to the lateral line and slightly caudal to the dorsal fin. All scales were examined using a microprojector at a magnification of 100 diameters. The positions of circuli of the projected scale image were reproduced on graph paper and counted. A total of 7,193 scales of yearling sockeye from seven emigrant runs was examined. The number of circuli formed prior to annulus formation and following the annulus (new growth) were recorded. Scale characters of samples of migrants from the early and late runs were compared.

Annual average fish lengths, number of circuli to the annulus, and number of new growth circuli on scales of yearling sockeye from the early and late runs were calculated from weekly averages of each measurement. In 1958, 1962, and 1964 the early run (originating from the North Arm—Nilkitkwa areas) included the run up to May 29, and in 1960, 1961, 1963, 1965 up to May 22. Those fish migrating after these dates were designated as late-run migrants.

RESULTS

In most years the average lengths of fish in daily samples declined within a few days after the run began, then increased gradually until migration ceased in early summer (Fig. 3). In 5 out of 7 years the late run migrants were statistically significantly larger in size than the early run migrants (Table 1).

Increased migrant size was associated with an increased number of circuli laid down up to and including the annulus (Fig. 3); in 5 of the 7 years the scales of late run migrants had, on the average, significantly more circuli up to and including the annulus (Table 1) than early run migrants.

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[1]Called by some authors as "spring growth" (Clutter and Whitesel, 1956), "new summer growth" (Burgner, 1962) and "plus growth" (Koo, 1962).

In general, there was some tendency for early-run migrant scales to have more new growth circuli than scales of late-run migrants (Fig. 3). In 2 years, scales of early-run migrants averaged significantly more new growth circuli (Table 1). In 3 other years early-run migrants had on the average more new growth circuli, but the differences were not statistically significant. The average number of new growth circuli on scales from early-run migrants ranged from 0.83 to 2.65 circuli and for late-run migrants from 0.26 to 1.46 circuli (Table 3). The average number of new growth circuli was not related to the estimated numbers of migrants leaving the lake in either the early or late runs ($r = 0$).

For scales of migrants from each of the runs, the average number of circuli before annulus formation was compared with average number of new growth circuli (Fig. 4 and 5). Amongst the early-run fish, in 4 of the 7 years there were significant negative correlations (Table 2). Similarly for the late run fish, in 6 of the 7 years significant negative correlations were indicated. Thus for both runs, in most years, numbers of circuli prior to and including the annulus, and new growth circuli were negatively correlated.

For all years, for scales examined from the early and late runs, new growth was evident on 8.9-43.4% of the scales (Table 3). Scales of early-run migrants had a higher average incidence of scales with new growth (23.8%) than the late-run migrants (15.7%). Amongst both the early- and late-run migrants there were no correlations between the percentage of scales in the samples with new growth, and the estimated number of migrants leaving the lake each year ($r = +0.550$, $n = 7$ and $r = +0.254$, $n = 7$, respectively).

In only 3 of 7 years was there a significant difference in total circuli (number of circuli before and including the annulus plus new growth circuli) between early- and late-run migrants (Table 1). The absence of a difference in total circuli between early and late migrants in most years was likely a result of the observed inverse relationship between the number of circuli before the annulus and the number of new growth circuli.

DISCUSSION

A positive relationship between the number of circuli and the length of the fish is generally accepted and has been documented by many authors. For example, Clutter and Whitesel (1956) demonstrated a high positive correlation between number of circuli and length of Fraser River seaward sockeye migrants. Such is also the case for Babine sockeye yearlings (Fig. 6). Thus the observed differences in numbers of circuli on scales of sockeye yearlings from the early and late runs from Babine Lake indicate differences in size of fish at annulus formation between the two groups.

The scales of early-run migrants in most years carried fewer circuli prior to the annulus than did scales of late-run migrants, indicating they had grown less prior to formation of the annulus. Furthermore, for most years, there was some tendency for scales of the early-run migrants to have more new-growth circuli than scales of migrants from the late run, indicating that the early-run migrants originating from the North Arm—Nilkitkwa areas tended to grow more in their second year up to the time of their migration than the late-run migrants from the main lake.

Nevertheless, in most years the number of new growth circuli on the scales of late-run yearlings from the main lake tended to increase as the migration season progressed, indicating that migrants of the late run had continued to grow until the time of their migration from the lake.

These findings differ in part from those of Burgner (1962) and Koo (1962). They observed that sockeye smolts emigrating from lakes of the Wood River system, Alaska, early in the spring were small and exhibited few or no new-growth circuli. Those emigrating later, after the spring overturn, were increasingly larger as the season progressed and exhibited increasing numbers of new-growth circuli. Thus the earliest Babine smolts, unlike those from Wood River, put on considerable growth after annulus formation, but prior to migration. However, late-run migrants in both systems reflect a period of growth prior to migration.

The inverse relationship between number of circuli prior to the annulus and number of new-growth circuli after the annulus on the scales of Babine sockeye smolts agrees with the findings of Gilbert (1916) and Koo (1962). Gilbert observed that Chilcotin Lake yearling sockeye scales which displayed no new-growth circuli were those with the greatest number of circuli to the annulus. Koo observed the same phenomenon for sockeye smolts and adults from the Wood River system. The results of the above studies (including the present one) suggest that yearling sockeye which were smaller in their first year grew considerably more in their second year up to the time they migrated, than did those which had grown relatively well in their first year. Why are there relatively high numbers of new-growth circuli on the scales of the earliest of the early-run migrants? Only speculation is possible. Their presence could be due to differences in environmental conditions or to differences in the time of annulus formation among various lake populations.

The relatively shallow North Arm—Nilkitkwa area of Babine Lake probably cools earlier in the fall than the Main Lake area. If annulus formation relates to onset of colder temperatures (plus food reduction, etc.), then North Arm fish will presumably begin annulus formation first. Main Lake fish can go deep into the lake and perhaps continue to grow for several weeks until winter temperatures finally retard their growth which is reflected in the formation of the annulus. In the spring the North Arm—Nilkitkwa area usually warms up more rapidly than does the Main Lake area, and hence the early-run migrants which originate mainly from this area might commence new growth earlier in the season than do late-run migrants from the Main Lake.

Thus, we suspect that the time of annulus formation is different among various lake populations. Recent findings of Mr. J. G. McDonald (pers. comm.) suggest that the times when the annulus begins forming and is completed on scales of underyearling sockeye and kokanee may be quite variable among different segments of the Babine Lake population.

ACKNOWLEDGMENTS

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Table 1. Mean length of fish, number of circuli to annulus, and number of new growth circuli on scales of yearling sockeye from early and late runs from Babine Lake for the years 1958, and 1960-65.

Year		Mean length		Mean no. circuli to annulus		Mean no. new growth circuli		Mean total no. circuli	
		Early	Late	Early	Late	Early	Late	Early	Late
1958	$\bar{\bar{x}}$	80.26	85.56	11.88	12.55	1.33	0.59	13.21	13.14
	n	3	3	3	3	3	3	3	3
	t	<u>3.34</u>		1.58		0.85		0.06	
1960	$\bar{\bar{x}}$	74.66	85.03	10.35	13.12	1.32	1.12	11.67	14.25
	n	3	6	3	6	3	6	3	6
	t	<u>4.03</u>		<u>8.83</u>		0.44		<u>5.21</u>	
1961	$\bar{\bar{x}}$	75.12	81.27	10.78	12.46	0.98	1.46	11.76	13.92
	n	4	4	4	6	4	6	4	6
	t	<u>3.37</u>		<u>3.84</u>		1.76		<u>5.20</u>	
1962	$\bar{\bar{x}}$	81.56	82.22	10.43	12.69	2.65	0.59	13.08	13.28
	n	3	4	3	4	3	4	3	4
	t	0.29		<u>15.26</u>		<u>2.98</u>		0.28	
1963	$\bar{\bar{x}}$	75.95	81.42	10.84	13.01	1.14	0.46	11.98	13.48
	n	4	4	4	4	4	4	4	4
	t	<u>4.43</u>		<u>7.71</u>		<u>3.70</u>		<u>5.70</u>	
1964	$\bar{\bar{x}}$	75.00	79.80	10.70	11.56	0.83	0.26	11.73	11.83
	n	3	3	3	3	3	3	3	3
	t	<u>2.54</u>		<u>4.37</u>		1.32		0.28	
1965	$\bar{\bar{x}}$	78.10	79.90	11.66	12.17	1.04	0.39	12.70	12.56
	n	2	2	2	2	2	2	2	2
	t	1.03		2.53		1.61		0.26	

Note: Underlined t values indicate significance at the 5% level of probability. n is the number of weekly averages.

Table 2. Correlation between mean number of circuli to the annulus and mean number of new growth circuli on scales of yearling sockeye, for early and late runs from Babine Lake, 1958, and 1960-65.

Year		Early run	Late run	Total run
1958	r	-0.453	-0.775	-0.834
	n	13	14	14
1960	r	-0.609	-0.842	-0.811
	n	11	14	14
1961	r	-0.804	-0.474	-0.424
	n	12	14	15
1962	r	-0.903	-0.752	-0.861
	n	13	10	15
1963	r	-0.533	-0.927	-0.650
	n	13	11	16
1964	r	-0.240	-0.959	-0.483
	n	7	4	10
1965	r	-0.481	-0.907	-0.497
	n	12	7	12

Note: Underlined r values indicate significance at the 5% level of probability.

Table 3. Estimates of the numbers of smolts, mean number of circuli to the annulus, and new growth circuli on scales of yearling sockeye for the early and late runs from Babine Lake, 1958, and 1960-65.

Year	Early run				Late run				Total no. scales examined
	Mean no. circuli to the annulus	Mean no. new growth circuli	% scales with new growth	No. of smolts ($\times 10^6$)	Mean no. circuli to the annulus	Mean no. new growth circuli	% scales with new growth	No. of smolts ($\times 10^6$)	
1958	11.88	1.33	8.9	14.4	12.55	0.59	12.0	8.4	1,334
1960	10.35	1.32	15.9	26.0	13.12	1.12	12.5	31.1	1,684
1961	10.78	0.98	13.2	7.5	12.46	1.46	20.8	13.3	1,414
1962	10.43	2.65	35.5	4.7	12.69	0.59	9.1	12.4	1,555
1963	10.84	1.14	23.6	7.5	13.01	0.46	16.0	6.8	624
1964	10.70	0.83	23.9	18.0	11.56	0.26	19.7	32.0	269
1965	11.66	1.04	43.4	4.6	12.17	0.39	20.1	21.4	313

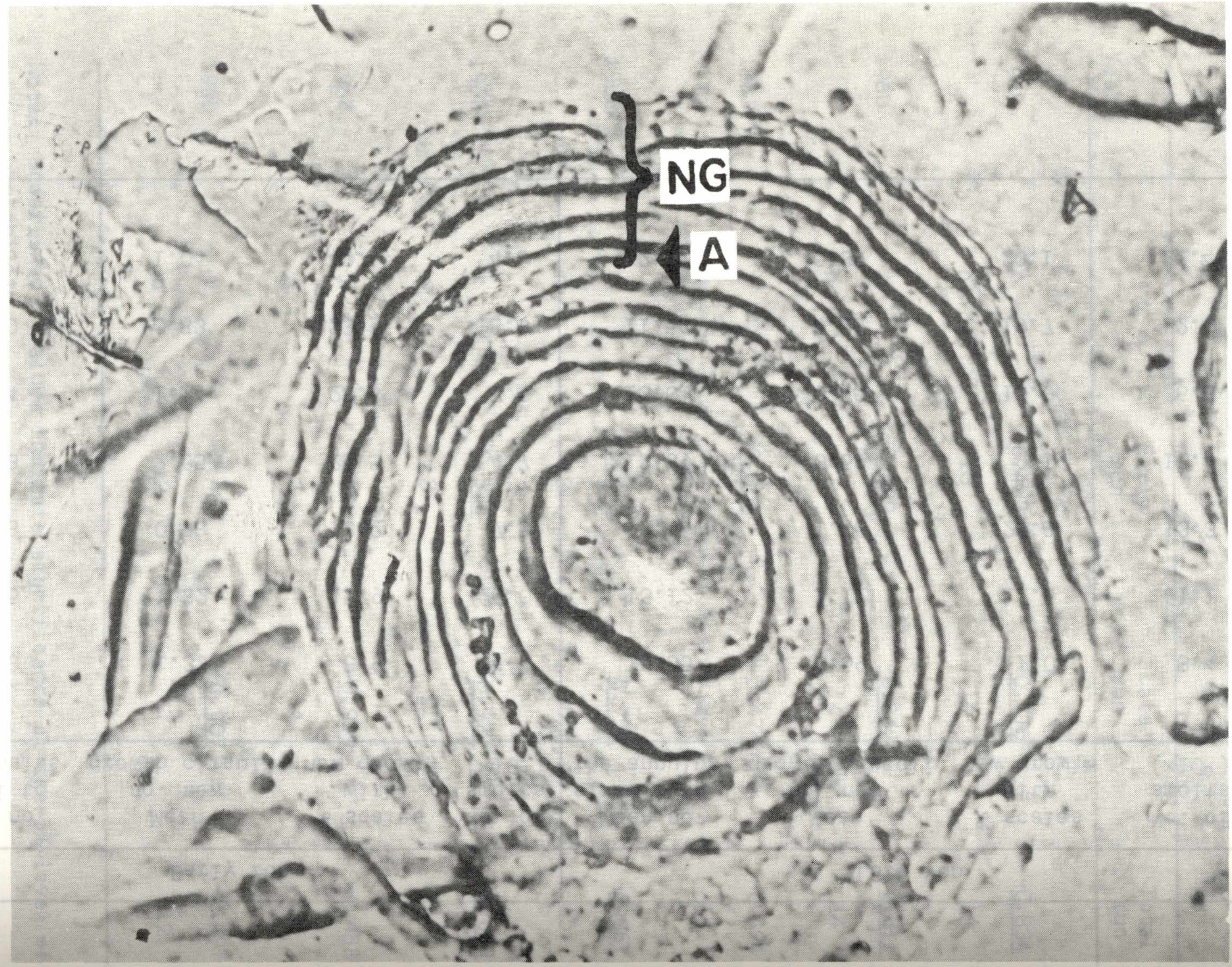

Fig. 1. Scale from a Babine sockeye smolt. A - annulus, NG - new growth.

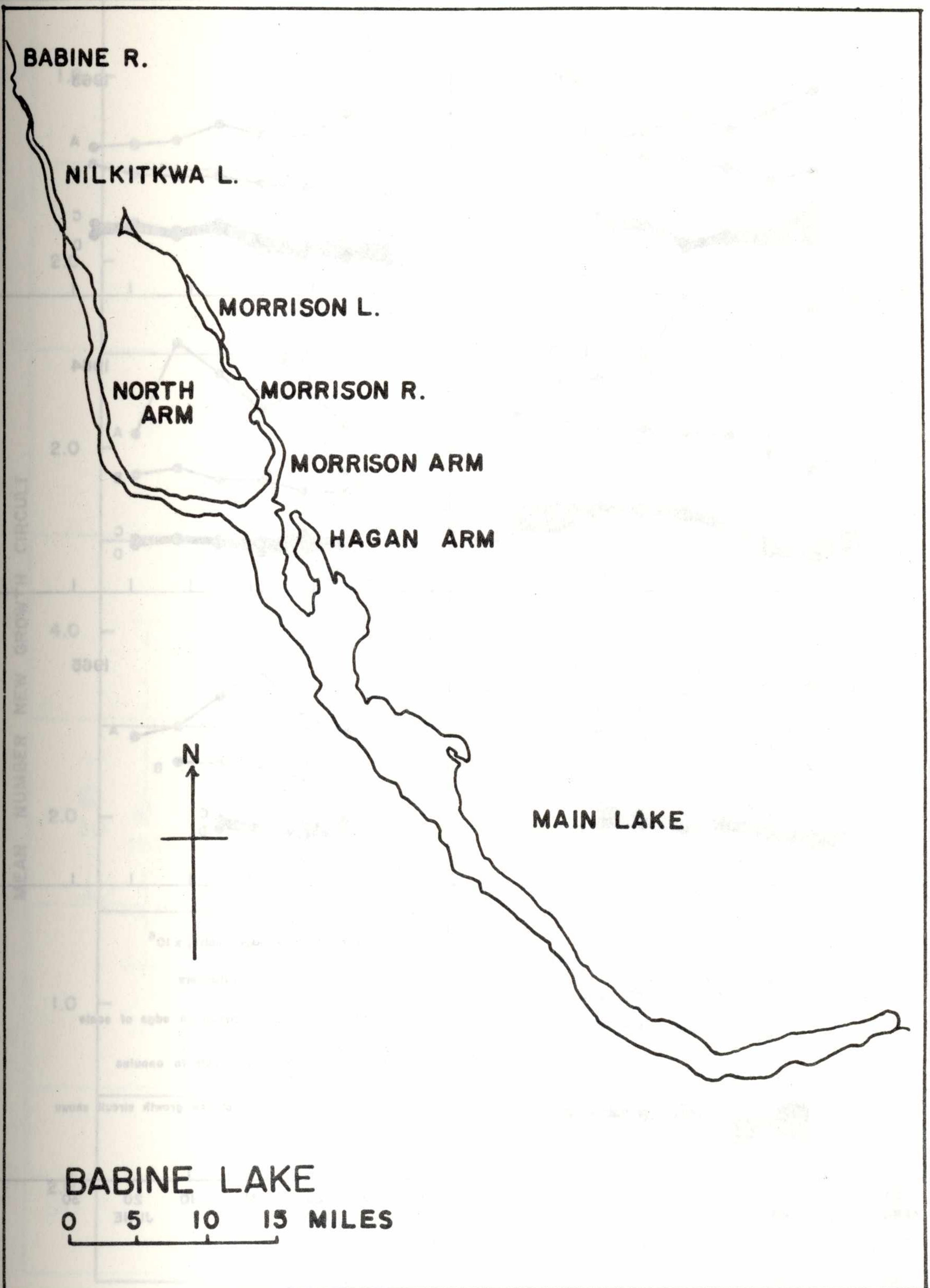

Fig. 2. Babine Lake.

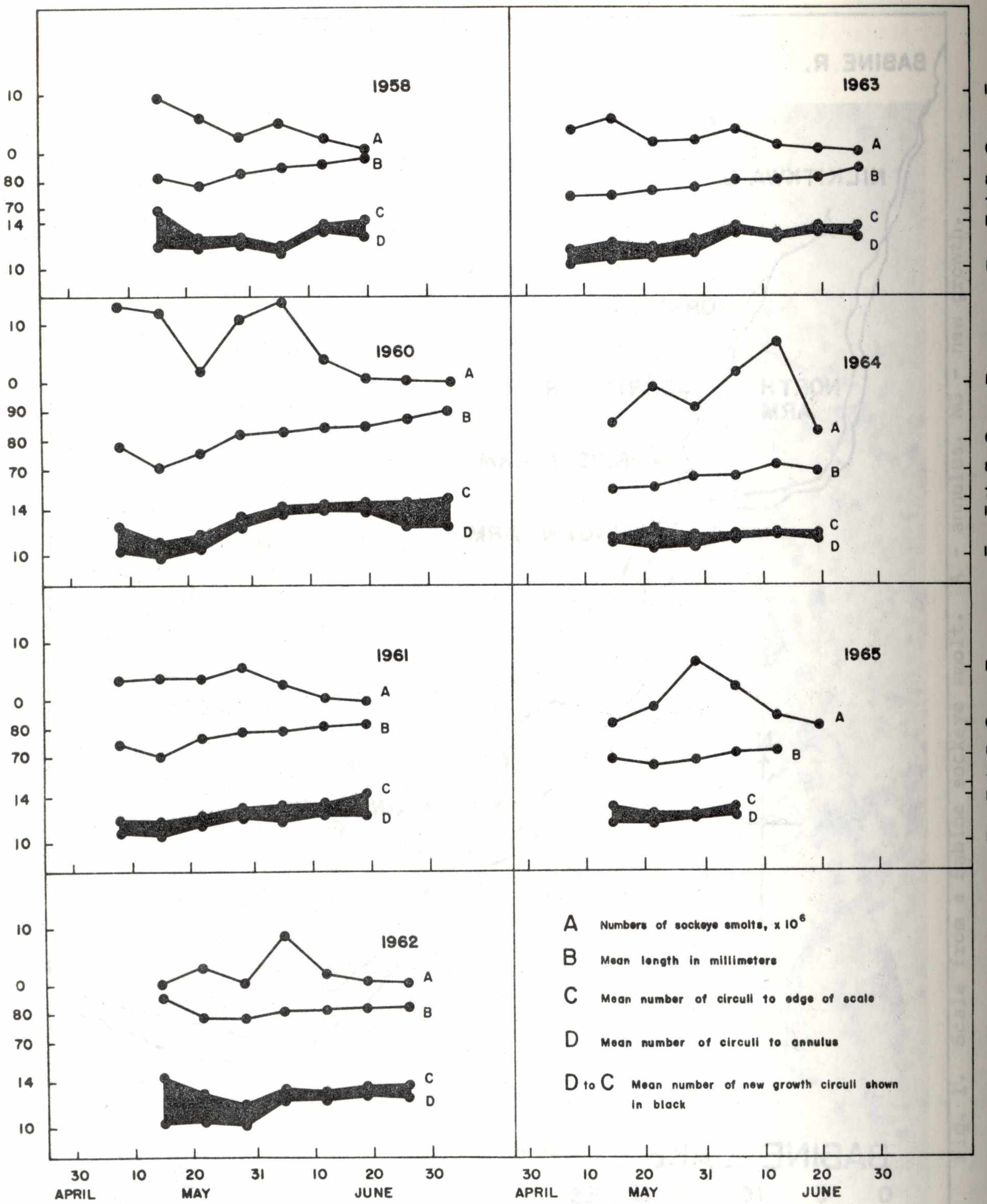

Fig. 3. Estimated weekly numbers of Babine sockeye smolts, weekly mean lengths and mean numbers of circuli on their scales, May-June 1958 and 1960-65.

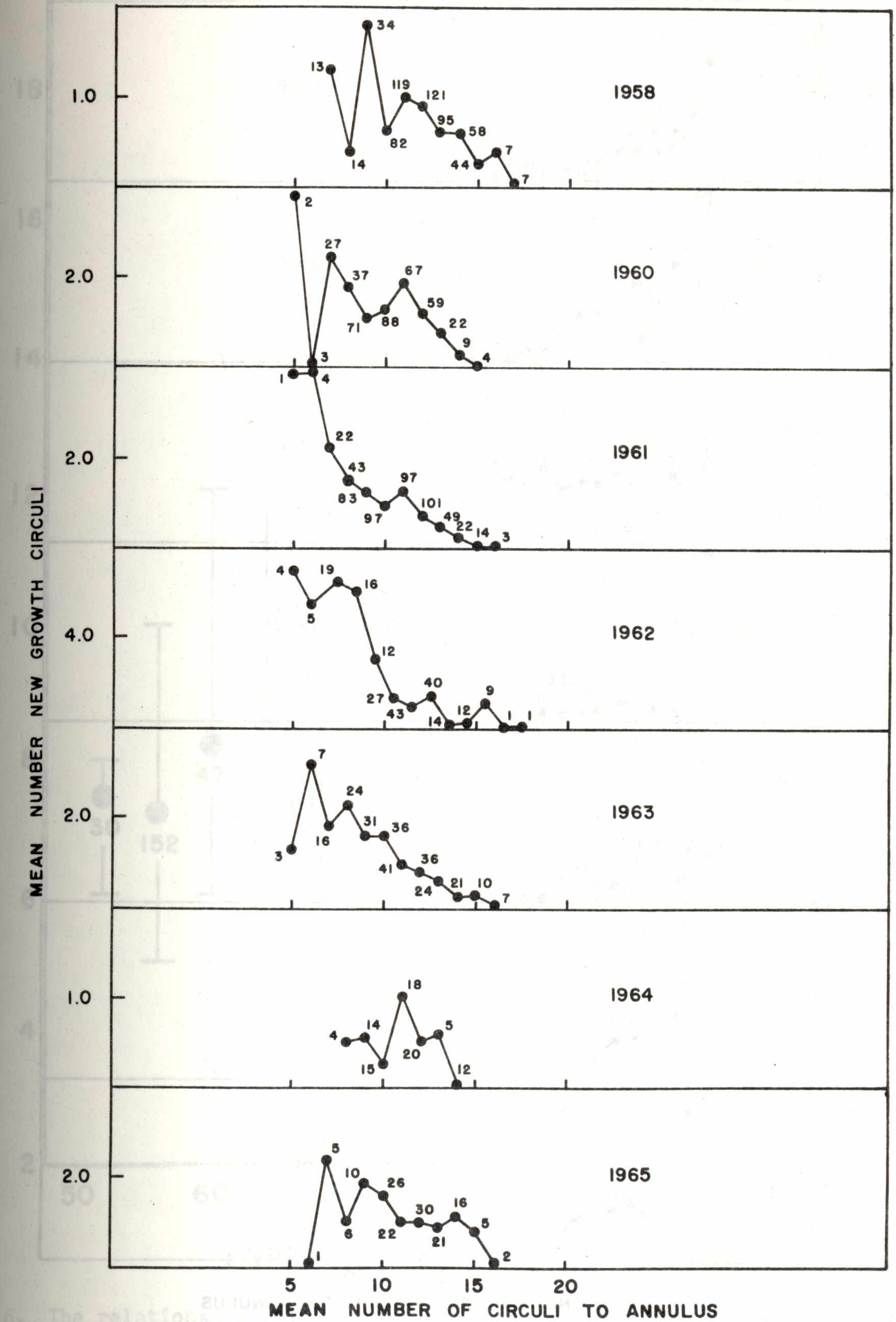

Fig. 4. Early-run migrants. Mean number of new-growth circuli against the mean number of circuli to the annulus on scales of Babine smolts, 1958 and 1960-65.

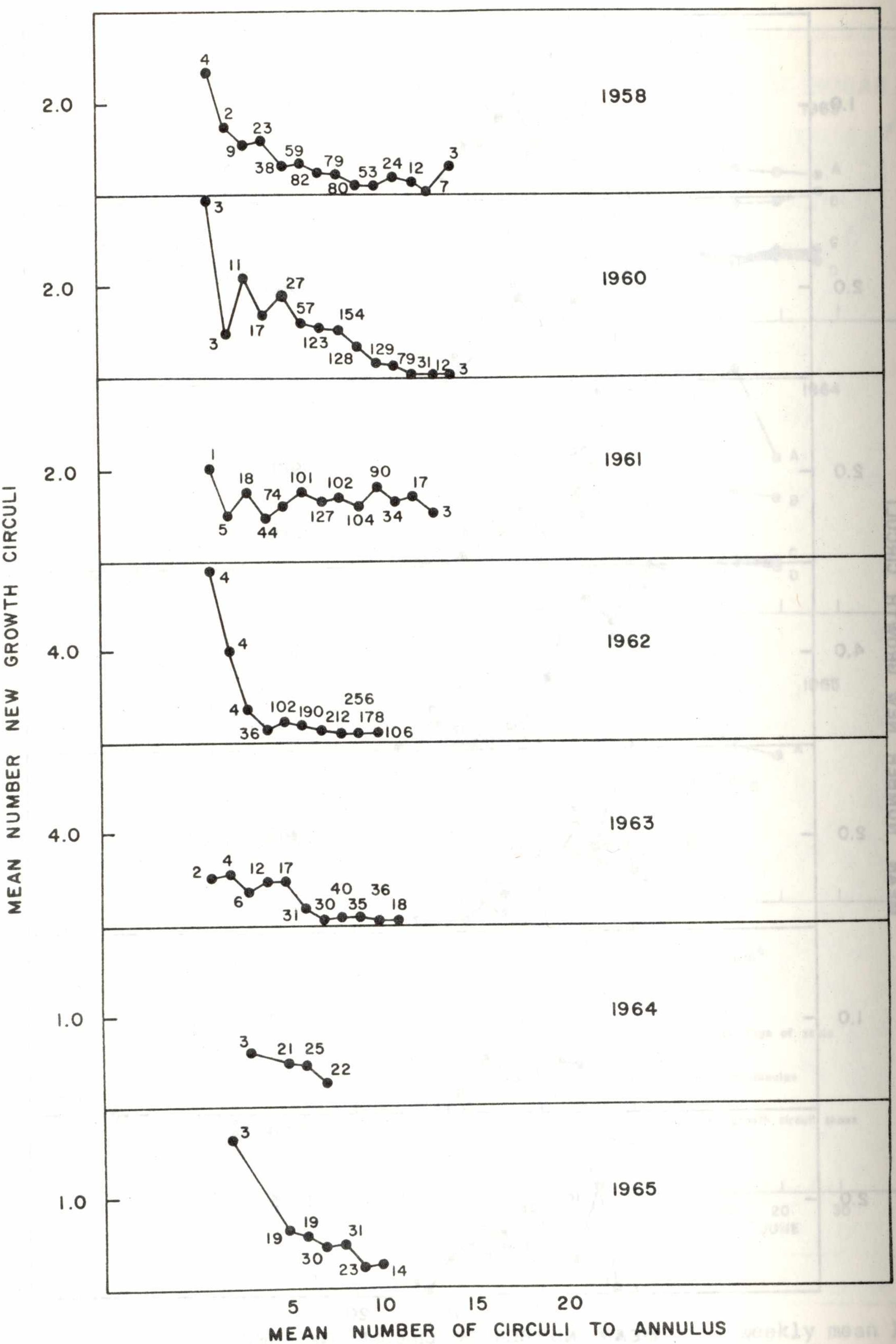

Fig. 5. Late-run migrants. Mean number of new-growth circuli against mean number of circuli to the annulus on scales of Babine smolts, 1958 and 1960-65.

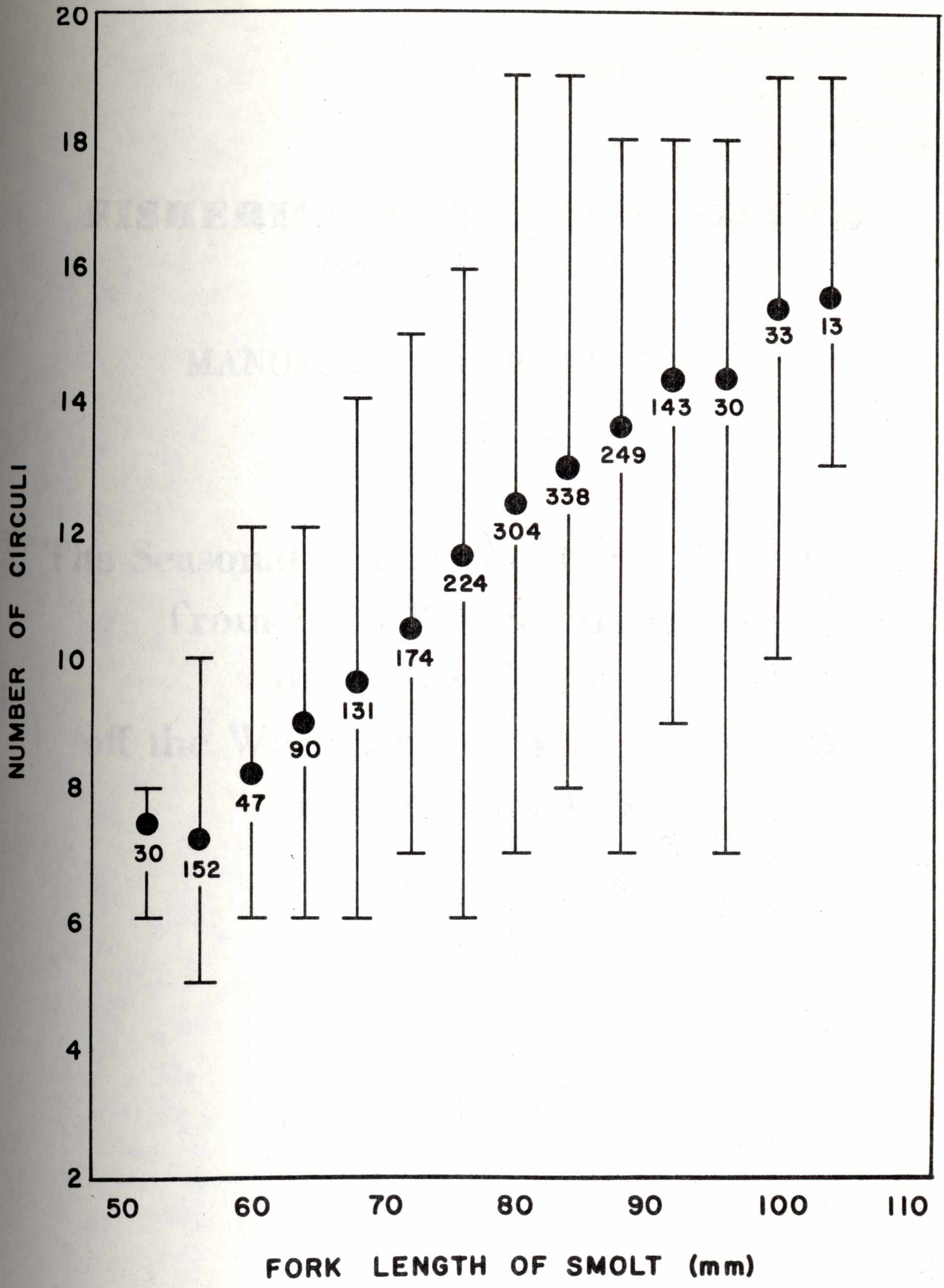

Fig. 6. The relationship between number of circuli and the length of Babine sockeye yearlings, from the smolt run of 1960. The average numbers of circuli, the ranges, and the sample sizes are shown.