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RECENT CHANGES IN THE GROWTH OF CLYDE SPRING SPAWNING HERRING

by

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Summary

1. There has been a major increase in the mean size at age of Clyde spring spawning herring for year-classes subsequent to that of 1963. On their second and third birthdays these fish, in the early 1970s, were about 6 cm and 2.5 cm longer respectively than in the early 1960s.

2. Much of the increase in mean length at age has been laid down during the first two growth periods. However, when correction is made for the inverse relationship between growth and the size attained at the start of a growth period, it can be shown that growth has also been greater in older age groups in the early 1970s.

3. The increased growth in the 0 and 1 group stages may have resulted from reduced intraspecific competition due to the poor recruitment to this stock since the strong 1962 year-class.

Introduction

In a previous paper (Saville 1963) attention was drawn to a change in the age composition of the commercial catches from the Clyde herring fishery, and to associated changes in the growth of the fish, between the decades immediately preceding and following the war. Since 1959 there has been a further increase in mean length at age of the herring landed by this fishery and some associated changes in the age composition of the catches. In this paper the growth data for the period 1960-72 are analysed, and discussed, in relation to changes in the catches of the commercial fishery and the stock abundance.

Material and Methods

The material used came from weekly samples of the catches of the commercial fishery in the Clyde area. Most of the samples were taken from ring net and pair trawl catches outwith the spawning season and from ring net and trammel net catches during the spawning season. From each sample 100 randomly selected fish were measured and aged, and separated into spring or autumn spawners from their otolith characteristics. The back-calculated length at the time of laying down the first winter ring (l_1) was also measured from scales of these fish.

Only spring spawned fish are considered here. For comparison of the mean length at age and growth increments of fish of different years or year-classes only fish caught in November-December for those in their second year of life, and only fish caught in stages V-VII in January-March for fish over 2 years old were used; the assumption being that little if any growth takes place between November and March.

Mean Lengths at Age

The mean lengths at age, obtained as described above, of each year-class sampled in the period 1960-72 are given in Table 1 with their 95% confidence limits and the numbers of fish sampled. The data given in this table would suggest that there was little difference in the size of the 2 year old fish landed by the fishery in the post-war period up to 1964. In 1965 and 1966, however, the size of these 2 year olds increased by about 3 cms, in 1967-69 by a further 1.5 cms, and in 1970-72 by a further 1.5 to 2 cms.

In the older age groups the increases in mean length at age are, as one would expect, smaller and less clear-cut. In the 3 year olds the mean lengths in 1962 and 1963 were significantly higher than those of the earlier post-war period but in 1964 fell back to about the same level. From 1965 onwards there was a fairly regular increase in the mean length of this age group, culminating in the fish of this age in 1970-72 being about 3 cm longer than in the early post war period. Similarly in the 4 year olds although there is some evidence of a gradual increase in mean length of about 1.5 cm between 1960 and 1969 the major increase in length took place between 1969 and 1970 when it increased by almost 2 cms. For fish more than 4 years old changes in mean length are rather more difficult to interpret because of the wide confidence limits of many of the annual values due to the small numbers sampled. However, in these older fish also there would appear to have been a gradual increase in length at age between 1962 and 1969, and a sharp increase of the order of 1.5-2 cms between 1970 and 1971.

The data in Table 1 are therefore fairly consistent in suggesting a gradual increase in the mean length of all age groups in the 1960's and a larger increase in all age groups between 1969 and the early 1970's.

Interpretation of the Growth Change

To analyse this change in mean lengths at age in more detail it is necessary to deal with year-classes individually during their life span in the fishery. Only in this way can the annual increments in growth be measured. These increments are given in Table 2, the first growth increment being the back calculated l_1, and the second increment the difference between the l_1 and the length given in Table 1 for that year-class at age 2. Subsequent increments are the length at age minus the length of the same year-class in the preceding year. These data show that for the year-classes 1957 to 1963, although the first growth increments were high for the 1958-1960 year-classes, there was no clear trend in first year's growth with an overall mean for these year-classes of 11.71 cms. In the 1964 and 1965 year-classes, however, there was an increase in first year growth of 1.5-2 cms and a further increase in the 1966-68 year-classes of about 1 cm.

The second growth increment shows a rather similar picture with no marked trend until the 1964 year-class. The second increments of the 1964 and 1965 year-classes, however, were about 1-1.5 cms greater than the overall mean of the preceding year-classes and there was a further increase of about 1 cm in the 1966 and 1968 year-classes. In the case of the second and subsequent growth increments, however, the absolute size of the growth gives a false impression of the true growth rate unless the size attained at the end of the preceding growth period is constant. Because in most fish the growth in any year is inversely related to the length attained at the end of the preceding year if growth conditions remained constant one would expect the second and subsequent growth increments to decrease as the preceding ones increased. In Figure 2a the second growth increment is plotted against the first growth increment for the year-classes 1958-68. The points for the

1958-63 year-classes fall on a regression line with a negative slope but the points for the 1964-1968 year-classes form a distinct group well above this line. For these year-classes the best measure of the real increase in growth in their second year is the difference between the growth actually achieved and that which would be predicted from the regression line fitted to the data for the 1958-1963 year-classes. Thus for the 1964 and 1965 year-classes the second increment would have been predicted as about 6.8 cms as against about 9.7 actually achieved, for the 1966-68 year-classes about 5.5 cms against the 10.5 achieved.

The third growth increments given in Table 2 would suggest that there had been some decrease in growth at this age in the year-classes subsequent to the 1963 one. Again, however, these increments should be related to the size attained at the start of the growth period in question. The data are given in Figure 2b. It can be seen that these data again fall into two groups, for the year-classes 1958-63 and the year-classes 1964-69 respectively. In this case, however, the distinction is rather in the differences in the initial lengths; one cannot fit a significant linear regression line to the 1958-63 year-class data, largely because of the very small range in initial lengths of these year-classes. Another factor which may have somewhat distorted the data for this period is that this increment is measured at the time of first spawning. If recruitment to the spawning stock in the 1958-63 year-classes was not complete at 3 years of age the increments may have been biased upwards for some or all of these year-classes. A highly significant regression line can be fitted to these data for all the year-classes considered and this is drawn in Figure 2b. Although this must be treated with some caution, for the reasons given above, as the basis from which to measure the real increments in growth it is the only one available for this growth period. It would suggest that the third increment for the 1959, 1963, 1967 and 1968 year-classes was rather above normal and for the 1958, 1961 and 1965 year-classes rather below normal.

The fourth and fifth growth increments are measured with considerably less precision for some year-classes because of the small numbers of fish sampled at the relevant ages. These data, however, are plotted in the same way in Figures 2c and 2d. Although in these cases it is more difficult to define the exact year when the change in growth occurred, they strongly suggest that for the 1966, 1967 and 1968 year-classes the growth at this part of the life-span was appreciably higher than for previous year-classes.

In Table 3 the increments or decrements of growth from the expected as measured by the regression lines on Figures 2a-c are given together with the absolute first growth increments. These data show in quantitative terms that there were appreciable increases in real growth in the first and second years of life for the 1964 and subsequent year-classes and in the fourth year of growth for the 1966 to 1968 year-classes. Although this cannot be quantified in the same way the fifth year would also appear to have shown enhanced growth for the 1966 to 1968 year-classes.

Discussion

Between the periods 1930-39 and 1949-59 there was an increase in mean size at age of Clyde spring spawning herring which resulted in the fish in the latter period being about as large as those one year older in the former period (Saville 1963). A secondary result of this was that the fish in the second period recruited to the fishery about one year earlier. In the period 1959 to 1964 the mean size at age of this stock was fairly stable but with the recruitment to the fishery of the 1964 year-class in the latter half of 1965 there was a further increase in the mean length of

2 year old herring of about 2.5 cms and subsequent increases in size at this age of succeeding year-classes which have resulted in their being 5 to 6.5 cms larger in 1970-72 than the mean for the post-war period up to 1964.

In the older age groups the increases in mean size at age between the period prior to 1965 and the 1970-72 period have been smaller as would be expected from the fact that growth increments for successive growth periods decrease proportionately to the size attained at the start of the growth period. Even in older fish, however, the mean size at age in 1970-72 is very significantly higher than in the early 1960's.

From back-calculated size at the time of laying down the first winter ring it would appear that much of the increase in size at age has resulted from increased growth during the first two growth seasons. Evidence of any increased growth in the third growth season is rather equivocal but this could be an artifact of the data, as discussed earlier. In the case of the 4th and 5th growth periods there is evidence of a significant increase in real growth in the case of the 1966-68 year-classes. The increased mean length at age of the 1964 and subsequent year-classes has resulted in some acceleration of recruitment to the spawning stock resulting in an increase of the proportion of a year-class taken as 2-year-olds in the spawning fishery. In the text-table below the percentages of the total catch of spawners taken as 2-year-olds for the more abundant post-war year-classes are given.

Year Class	1958	1961	1962	1965	1966
Percentage of 2-year-old catch of spawners to total catch of spawners	1.4	2.2	7.5	14.1	18.8

The increased size at age must have, in addition, had a major effect on the yield per recruit for this stock. From the weight-length relationship it can be calculated that the mean weights per age group at 1 January must have increased from 76 grams to 164 grams for 2-year-olds from 178 gm to 245 gm for 3-year-olds, and from 204 gm to 278 gm for 4-year-olds between the early 1960s and early 1970s.

In the case of the growth increase between the immediate pre-war and immediate post-war periods no explanation could be given as to the causative factors. No data are available to measure whether it was associated with an increase in the available food supply. However, in the period considered here there has been a major decrease in abundance of the Clyde spring spawning herring, largely resulting from a failure in recruitment subsequent to the strong 1962 year-class, and it therefore seems worthwhile to examine whether there is any relation between population size and changes in growth increments.

The Clyde spring spawning stock spends its adolescent period in the Clyde estuary but a major part of the adult stock leaves that area after spawning, returning to it thereafter only to spawn in succeeding years. The adolescent stages are principally distributed in the inner estuary while the spawning grounds, and the adult distribution during the spawning season, are in the outer part of the estuary (Wood, 1960). Accordingly it would appear likely that, if intra-specific competition for food is a factor affecting the growth rate, the population which would be in competition with regard to the first and second growth increments would be the 0 and 1 groups. In Figure 3 the first and second growth increments are plotted against indices of abundance of the 0+1 groups in the years of growth and regression lines fitted. Both regressions are significant at less than the 0.01 probability level.

As has been discussed earlier the measurement of the corrected values for the third increment are suspect and it therefore does not seem profitable to attempt to relate these to the population size. Subsequent increments are to a major extent laid down outside the Clyde, and not enough is known of the distribution of these fish during the season of growth to attempt to relate these to population abundance. During the first two growth periods, when most of the increase in growth has been achieved, the data are not inconsistent with the hypothesis that much of it can be accounted for by a decrease in interspecific competition.

References

Saville, A. 1963 Changes in the growth and age composition of herring in the Clyde estuary. Rapp. P.-v. Reun. Cons. perm. int. Explor. Mer, 154(32): 238-242.

Wood, H. 1960 The herring of the Clyde estuary. Mar. Res. Scot., 1:4-24.

Year	A G E (years) 2	3	4	5	6	7
1960	20.29 ± 0.23(114)	25.88 ± 0.08(1342)	28.46 ± 1.30(7)	28.86 ± 0.77(13)	29.15 ± 1.22(10)	27.25(1)
1961	20.68 ± 0.21(206)	25.01 ± 0.14(436)	27.17 ± 0.11(400)	29.45 ± 0.80(5)	29.75 ± 2.28(3)	31.41 + 2.03(3)
1962	20.80 ± 0.23(212)	27.32 ± 0.61(13)	27.59 ± 0.09(500)	28.64 ± 0.08(452)	29.58 ± 2.67(3)	30.54 + 0.79(12)
1963	20.50 ± 0.14(359)	26.68 ± 0.18(228)	27.85 ± 0.55(33)	29.13 ± 0.10(330)	29.52 ± 0.14(185)	30.33 ± 1.11(6)
1964	20.36 ± 0.16(228)	26.01 ± 0.11(794)	27.75 ± 2.01(7)	30.96 ± 0.97(7)	30.38 ± 0.34(19)	30.78 ± 0.37(14)
1965	23.06 ± 0.40(16)	26.62 ± 0.11(457)	27.94 ± 0.12(275)	28.75 ± 1.21(4)	29.85 ± 3.83(3)	30.15 ± 1.02(11)
1966	23.24 ± 0.15(256)	27.25 ± 0.48(26)	29.05 ± 0.07(633)	29.60 ± 0.11(229)	31.16 ± 0.94(6)	?
1967	25.03 ± 0.16(194)	27.29 ± 0.23(123)	28.48 ± 0.87(24)	29.95 ± 0.10(384)	30.02 ± 0.16(176)	30.50 ± 0.62(10)
1968	24.57 ± 0.23(73)	26.89 ± 0.15(289)	28.58 ± 0.26(71)	29.46 ± 0.81(4)	30.79 ± 0.14(155)	30.81 ± 0.22(127)
1969	24.51 ± 0.21(155)	27.99 ± 0.12(393)	28.74 ± 0.20(140)	29.35 ± 0.74(19)	30.00 ± 0.38(8)	30.96 ± 0.60(28)
1970	26.71 ± 0.69(15)	28.85 ± 0.19(255)	30.54 ± 0.14(296)	30.34 ± 0.44(61)	30.60 ± 1.35(7)	31.88 ± 0.64(11)
1971	25.82 ± 0.22(117)	28.99 ± 0.34(103)	30.79 ± 0.22(311)	32.52 ± 0.14(338)	32.12 ± 0.05(82)	32.51 ± 0.49(23)
1972	27.01 ± 0.47(31)	28.94 ± 0.24(216)	30.31 ± 0.75(31)	32.14 ± 0.69(29)	33.25 ± 0.90(19)	32.85 ± 1.54(5)

TABLE 2 Absolute Growth Increments of Clyde Spring Spawning Year-classes

Year-class	GROWTH INCREMENTS (cm) 1st	2nd	3rd	4th	5th
1957	10.97	?	?	1.29	1.47
1958	12.46	7.45	5.10	2.58	1.54
1959	12.25	8.04	7.03	0.53	3.11
1960	12.92	7.76	6.00	1.07	1.00
1961	10.38	10.42	5.21	1.93	1.66
1962	11.45	9.05	6.12	2.43	0.90
1963	11.55	8.81	6.89	1.23	1.03
1964	13.50	9.56	4.23	1.29	0.77
1965	13.27	9.97	3.65	1.85	1.60
1966	14.55	10.48	2.96	2.55	1.98
1967	14.41	10.16	4.29	1.93	1.35
1968	14.01	10.50	4.48	1.32	?
1969	?	?	2.23	?	?

TABLE 3 Growth Increments or Decrements from the Expected Growth

Year-class	GROWTH INCREMENTS OR DECREMENTS FROM EXPECTED GROWTH 1st growth year	2nd growth year	3rd growth year	4th growth year
1957	10.97	?	?	− 0.7
1958	12.46	− 0.5	− 1.2	+ 0.5
1959	12.25	0.0	+ 0.9	− 0.6
1960	12.92	+ 0.4	+ 0.2	− 0.4
1961	10.38	+ 0.1	− 0.6	+ 0.1
1962	11.45	0.0	+ 0.2	+ 0.7
1963	11.55	0.0	+ 0.8	0.0
1964	13.50	+ 2.8	− 0.3	+ 0.2
1965	13.27	+ 3.1	− 0.7	+ 0.5
1966	14.55	+ 5.0	− 0.4	+ 1.9
1967	14.41	+ 4.6	+ 0.6	+ 1.8
1968	14.01	+ 4.4	+ 0.9	+ 1.2

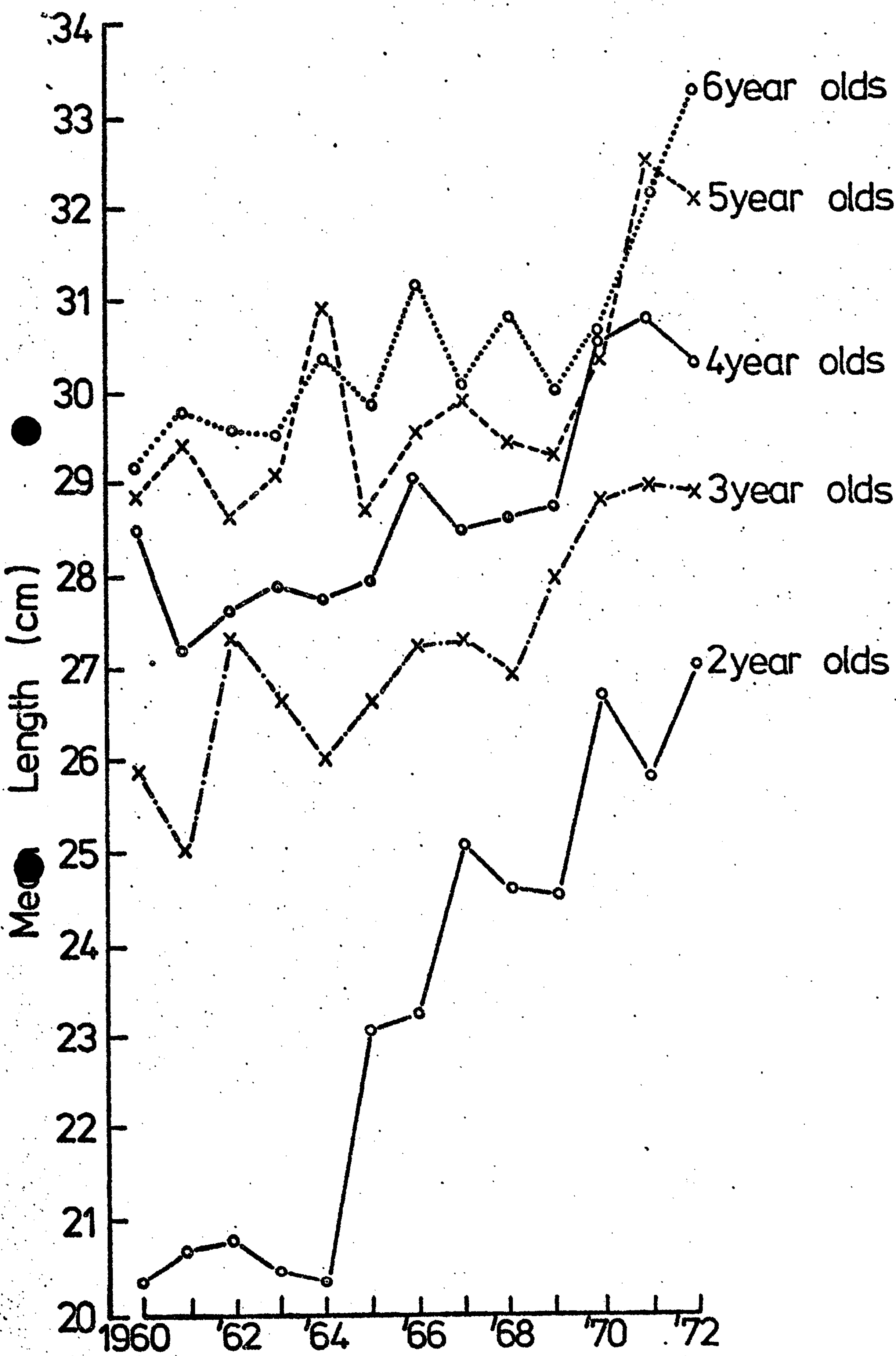

Figure 1. Mean length at age of Clyde Spring Spawning Herring 1960-1972.

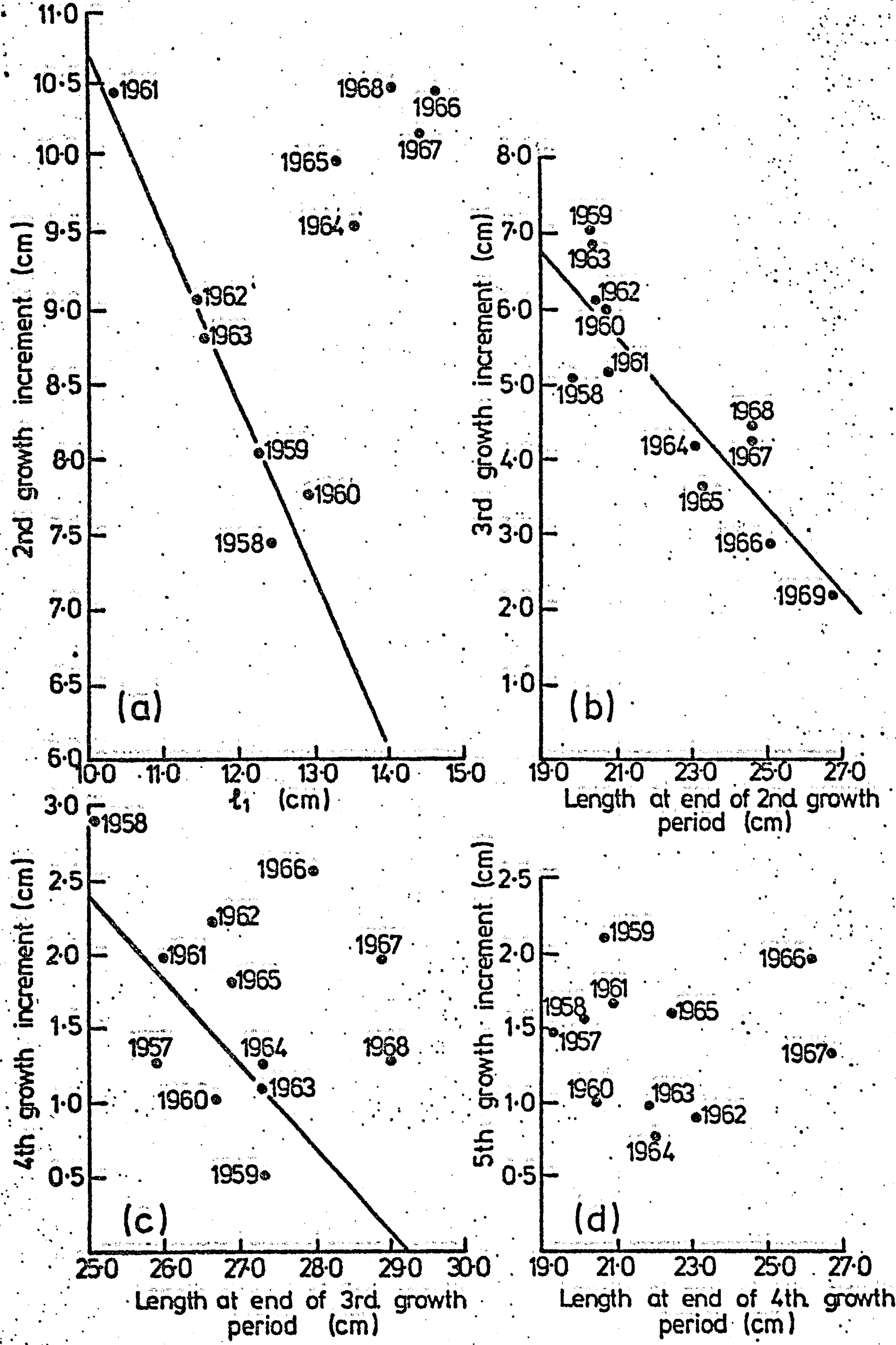

Figure 2. Regression of growth increment on length at end of preceeding growth period.

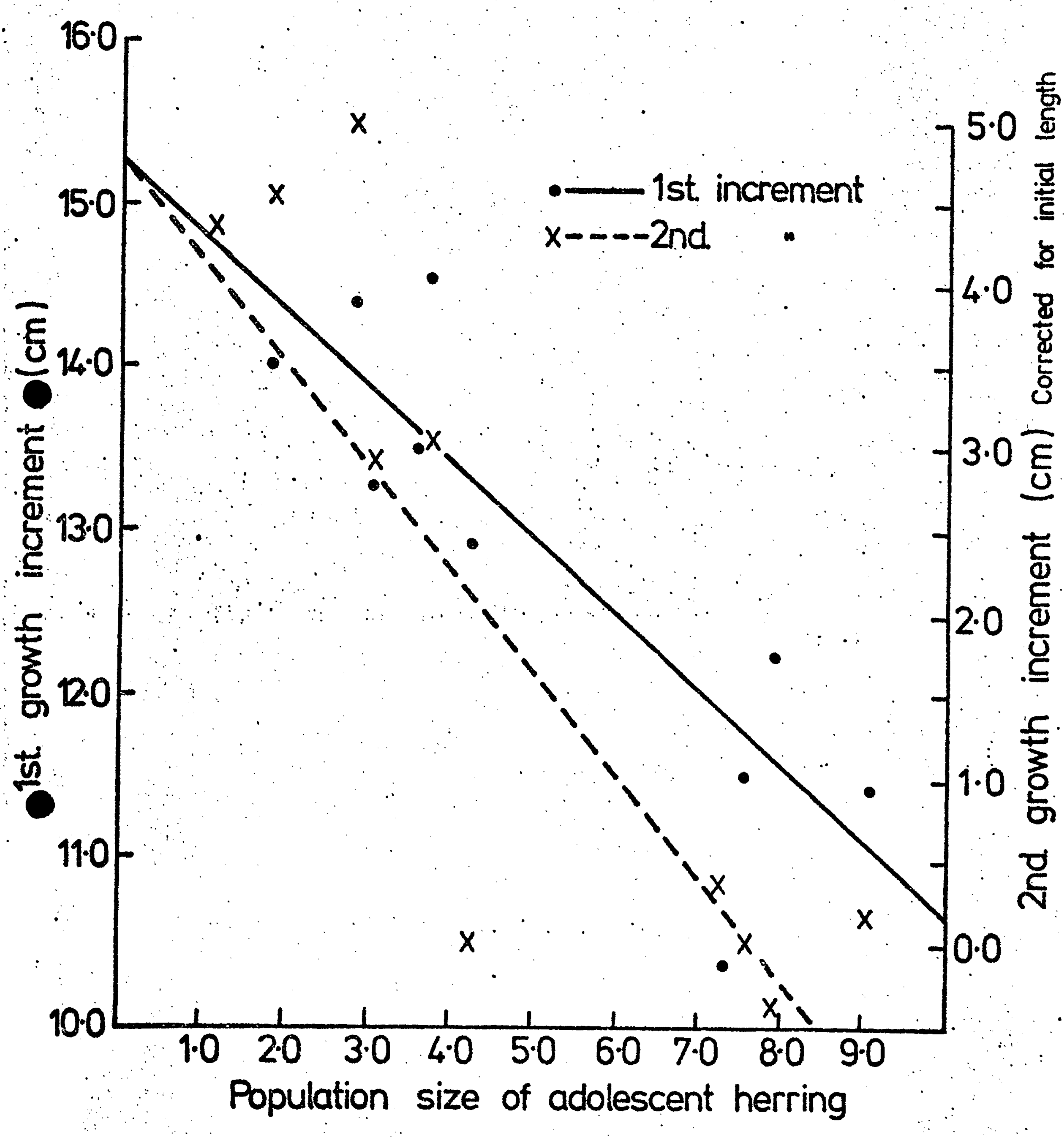

Figure 3. Regressions of 1st and 2nd growth increments on population of adolescent herring.