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THE ABUNDANCE INDICES OF YOUNG FISH TAKEN IN THE ICES YOUNG HERRING SURVEYS IN RELATION TO RECRUITMENT TO THE NORTH SEA STOCK

by

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The principal purpose of the ICES Young Herring Surveys has been to obtain indices of abundance of 1-group herring which might be used for forecasting recruitment to the North Sea stocks. The surveys have been conducted each year since 1967 by a variety of participating countries with much variability in both ships and fishing gear used. The first coordinated surveys were made in 1960 and 1961 in association with the first Bløden herring tagging experiment.

The problem of comparability of the indices of abundance from the different vessels was discussed both in the Reports of the North Sea Young Herring Working Group in 1969 and 1974. (Anon, 1969, Anon 1975). In neither case was any method found which could be used with any degree of confidence for equating the catches per effort from the different participating research vessels. The catches per effort, thus, had to be taken at their face value if the surveys were to provide any estimate of recruit strength.

With the increasing number of countries participating in the surveys and the increased use of the surveys for gadoid recruitment estimates, the area coverage of the North Sea has increased. At the last meeting of the Working Group on North Sea Young Herring Surveys abundance indices of 1-group herring were obtained for a standardized set of statistical rectangles in order to make comparable abundance indices in relation to a fixed distributional area (Anon, 1974a).

Using the annual arithmetic mean abundances from this standard area a linear regression was obtained when the recruitment estimates of 1-group herring obtained from cohort analysis (VPA) were correlated with these indices of abundance from the catches per effort of the Young Herring Surveys.

This regression, Figure 1, has been used for prediction of the total recruitment. The regression parameters differ a little from those in the report due to the inclusion of the data for the 1971 year-class which are now available and revision of the cohort values (Anon, 1975b). The very high intercept on the y-axis contributes about 60% of the estimate of total recruitment at the mean value of the young herring abundance index, $\bar{x}$. With the low levels of abundance in recent years the prediction of total recruitment is largely dependent on the value of this intercept and could lead to overestimation of the real recruitment level.

Similar correlations have been obtained between the abundance indices of young cod in the surveys and total recruitment as found from cohort analysis (Anon, 1974b). It is the purpose of this paper to re-examine the nature of these correlations. The estimate of total recruitment from the cohort analysis is derived from the catches in number of a year-class at successive ages. These catches by age are derived from some form of age sampling combined with national catch data. The recruitment estimate may be considered to be an estimate of the absolute abundance with a random error, being normally distributed. The annual mean abundance indices from the trawl catches are derived from distributions which are non-normal. The form of these distributions may be Poisson, where the variance is equal to the mean, or that of some type of contagious distribution, where the variance is somewhat greater than the mean (Gulland 1956). The regression shown in Figure 1 may be regarded as statistically invalid, because in the calculation of the linear regression there is the underlying assumption that the variables are normally distributed. In the case of a Poisson distribution the variance is equal to the mean. Further, if a series of independent x_1, x_2, x_3 ..... each follow a Poisson distribution with means μ_1, μ_2, μ_3 ....., their sum follows a Poisson distribution with mean ($\mu_1 + \mu_2 + \mu_3$ .....) (Snedecor and Cochran 1971).

Gulland (1956) discussed the nature of the statistical distribution of trawl catches. If fish were distributed randomly, the distribution of catches would be Poisson. If fish are shoaling, however, the presence of one fish increases the

probability of another being present. The distribution then may be of the form of a negative binomial (Andersen 1964).

In 1960 and 1961 young herring surveys were made both in spring and autumn. It became apparent that the degree of shoaling was high in the autumn survey (Anon, 1969) and that the between-haul variance was far higher than in the spring surveys. In choosing a timing for the revised surveys in 1967, the results of these surveys and those from some further surveys by the Netherlands in 1965 and 1966 were considered. It was concluded that, by timing the survey for February, the 1-group herring were then not aggregated in discrete shoals and that in the survey the hauls could be made at random within each statistical rectangle. Thus on both theoretical and observational grounds the catch distribution could be expected to be of the form of a Poisson distribution.

The Working Group on the North Sea Herring Surveys (Anon, 1974a) concluded that the abundance indices from a standard set of statistical rectangles would be used for the annual abundance estimate. 53 rectangles were selected which had been worked in most years. Not all these rectangles were sampled each year and the numbers worked are given in Table 1.

In order to obtain a mean for the standard area it was necessary to interpolate values for the missing rectangles. During the period 1967-74 41 rectangles were common to all surveys and a mean abundance was calculated. For those years when catches were recorded in any of the remaining 12 rectangles the ratio of the abundance in that rectangle to the 41 rectangle mean was computed and a mean taken for all years available. This mean ratio per rectangle was used to interpolate a value by raising it by the 41-rectangle mean for the year with the missing value.

The 1965 survey had such a poor coverage that no attempt at standardizing has been made. 16 rectangles were common to the 1966 survey and the 1965-74 surveys. The same procedure was used as described above for interpolating 12 missing values. In the case of the 1961 survey a standard 45-rectangle mean abundance for the years

1971, 1972 and 1974 was taken, while for 1960 a 40-rectangle mean abundance was used based on the 1971-1974 surveys.

From these standardized areas annual means and variances were calculated (Table 2) and the correlation is shown in Figure 2. As Jones (1956) has noted, a square root transformation is appropriate to normalise such a distribution. Square roots have been taken of the abundance indices and an annual mean taken, with which the cohort estimates of recruitment have been correlated (Table 3 and Figure 3). The intercept on the y-axis is not significantly different from zero, and amounts to 38% of the value of the mean abundance.

In examining the coverage of the other surveys it became apparent that the distribution of the abundance indices in 1969 was atypical in that it was characteris by low abundances in the eastern North Sea and high abundances in the western area. This eastern area in that year was covered by the ERNEST HOLT. On re-examining the catch data of this vessel, it appears that she fished inefficiently as it was the first occasion the vessel had used the particular gear and it is possible that it was incorrectly rigged. A correlation of cohort stock with young herring abundance has been made excluding this survey (Figure 4). The effect of this is to reduce further the intercept and to increase the correlation coefficient.

Using this regression the stock strength of the 1972 year-class has been calculated from the abundance in the 1974 Young Herring Survey. This gives an estimate of the strength of this year-class as $4.47 \pm 3.8 \times 10^9$ fish. A number of other estimates of the strength of this year-class have been made by the Herring Assessment Working Group.

Regression of stock size from cohort analysis on catch per effort in the Young Herring Surveys gave estimates of the 1972 year-class of $4.5\text{-}5.7 \times 10^9$, but for the reasons explained previously this might be considered to be invalid statistically.

At the 1975 meeting of the Working Group this relation was further examined. Revised estimates of stock size were used but the intercept still made up 50% of the value of y and the mean catch per effort. The Group proceeded to reject the data for the year-classes 1963-67 and calculated a new regression based on the year-classes 1958, 1959, 1968, 1969, 1970 and 1971. This procedure gave a reduced intercept and the estimate for the 1972 year-class so obtained was 4.17×10^9. Nevertheless, the criticism of the statistical validity of the method still remains.

From the cohort analysis a recruit value of 4.96×10^9 was obtained; while from a correlation using estimates from the Bløden fishery and the cohort estimates a value of 2.7×10^9 was estimated. These estimates are well within the confidence limits of the value estimated in this paper.

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SNEDECOR and COCHRAN, 1971.

Table 1 Numbers of standard rectangles worked in each year

Year	Number sampled
1960	40
1961	45
1965	22
1966	32
1967	46
1968	45
1969	46
1970	49
1971	53
1972	53
1973	52
1974	53

Table 3 Stock of 1-group (CH 1975/H:2) and normalised abundance index from Young Herring Survey

Year	Stock of 1-group $\times 10^{-9}$	Normalised abundances
1974		17.3
1973	3.78	16.5
1972	5.69	25.6
1971	7.31	36.2
1970	3.35	19.1
1969	6.10	14.0
1968	6.24	15.5
1967	4.43	16.0
1966	5.02	24.0
1965	9.40	55.1
1961	1.63	11.4
1960	7.07	30.6

Table 2 Mean and variance of standardized abundances from Young Herring Surveys

Survey	Mean	Variance
1974	1138	13,647,982
1973	909	6,572,193
1972	1631	15,501,599
1971	2571	16,762,492
1970	1169	11,563,474
1969	472	1,053,170
1968	515	1,213,500
1967	625	1,922,842
1966	1296	7,799,158
1965	5020	57,585,916
1961	621	6,751,433
1960	2823	56,971,789

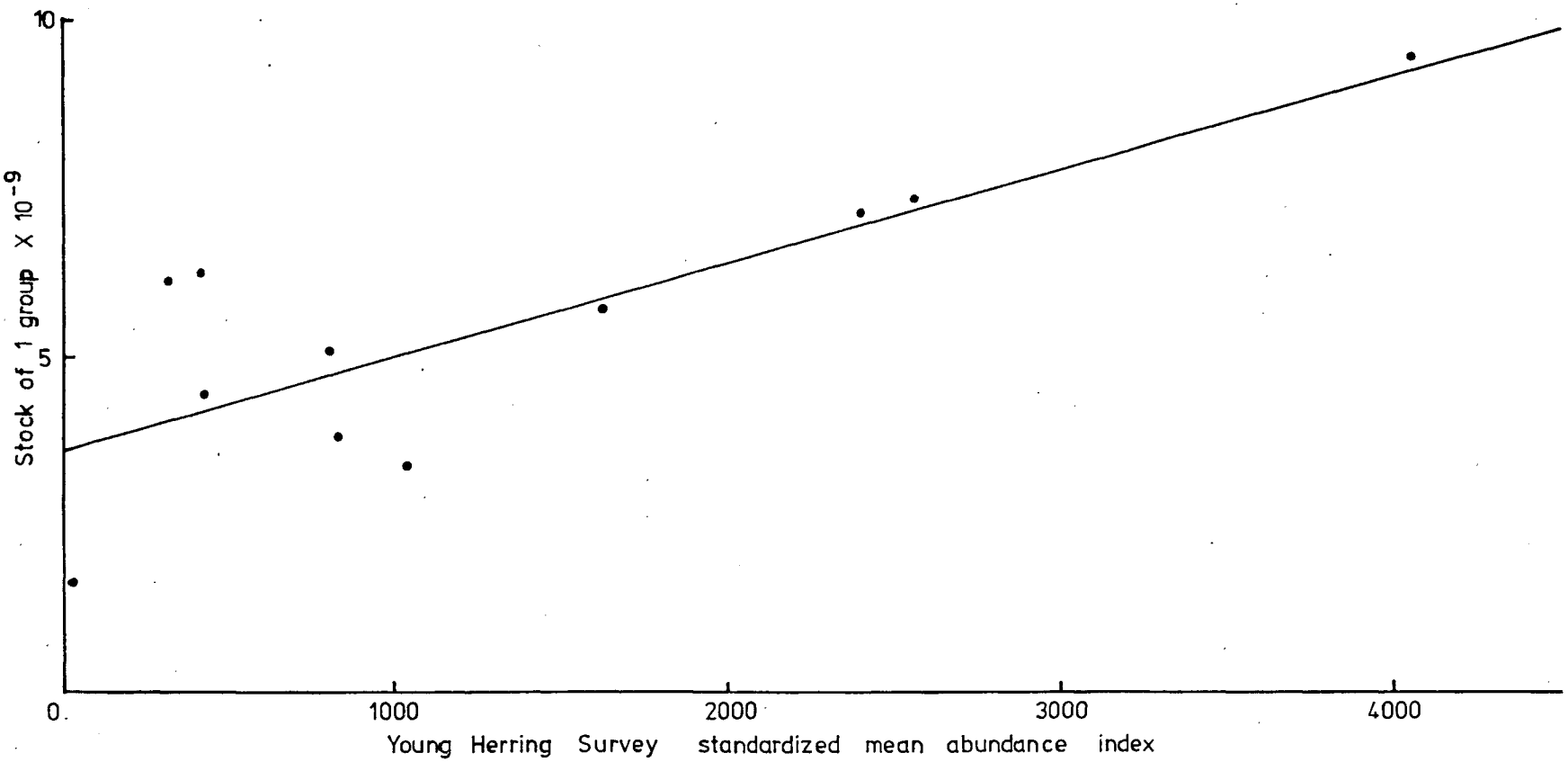

Figure 1 **Relation between year-class as 1-ringers from cohort analysis and arithmetic mean standardized catch per effort abundance in ICES Young Herring Surveys.**

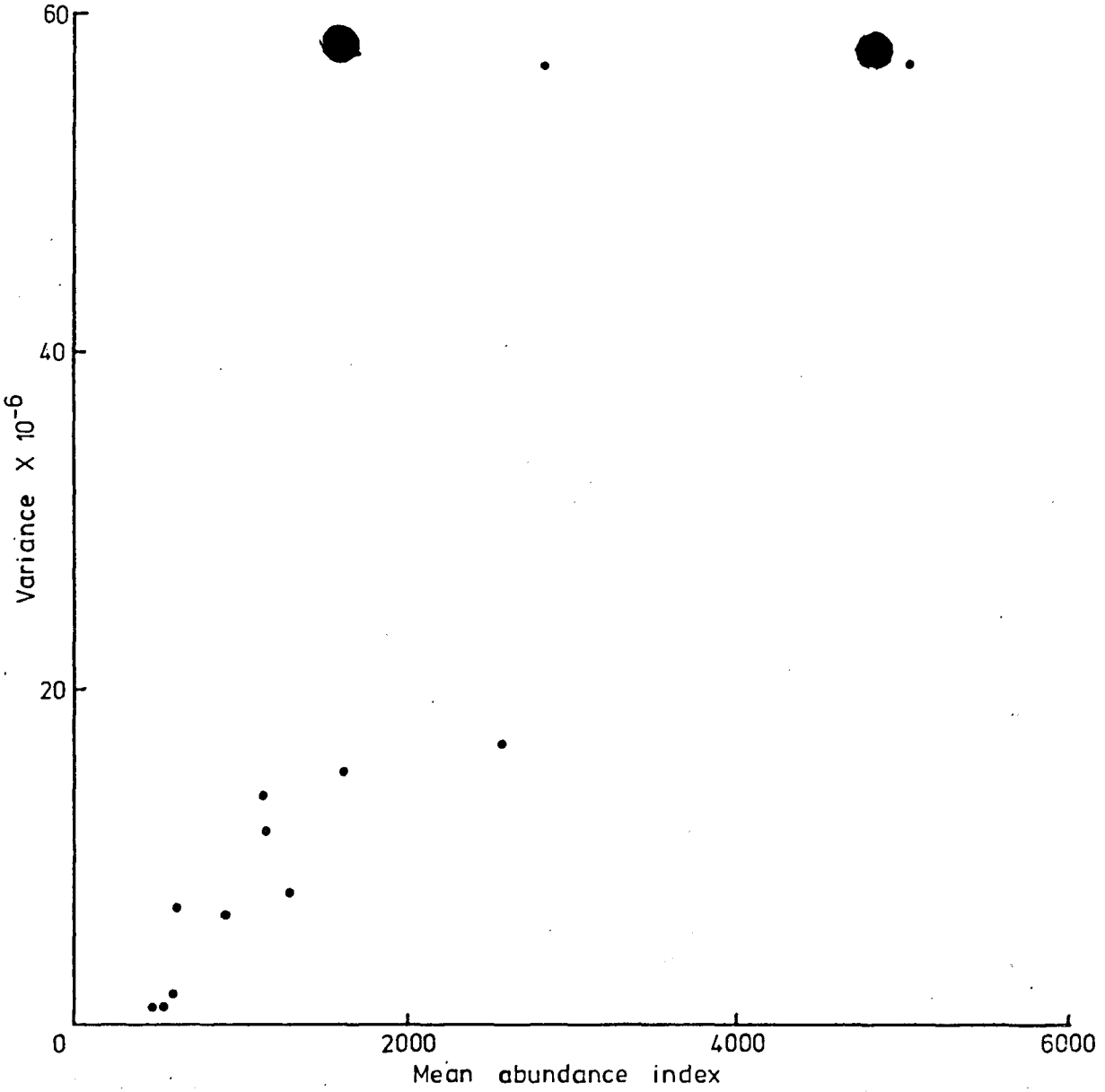

Figure 2 Relation between annual arithmetic mean and its variance from the standardized abundance index per rectangle in the Young Herring Surveys.

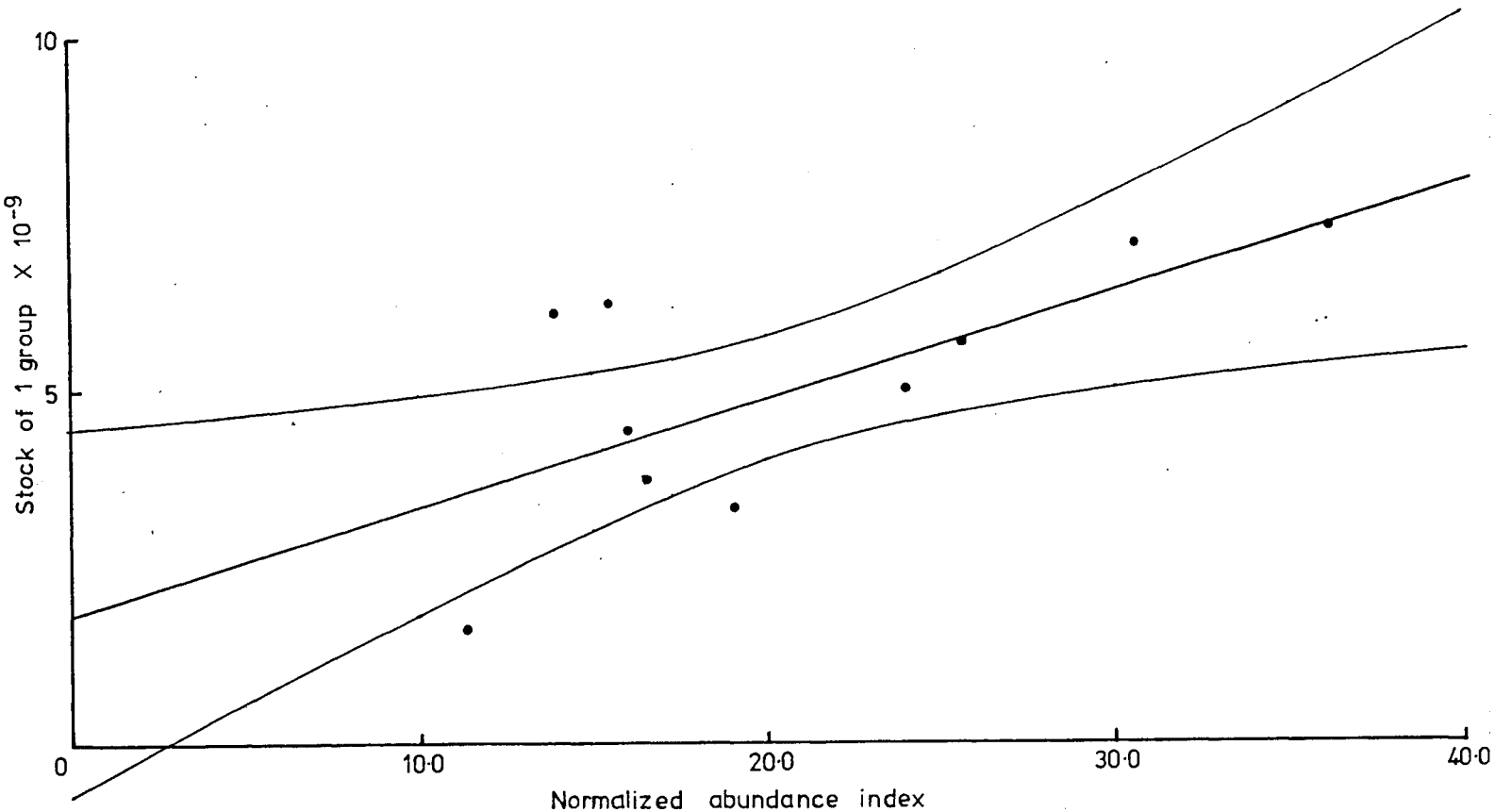

Figure 3 Regression of year-class strength on annual mean of normalized catch per effort data. Data for 1965 survey omitted due to poor coverage. Limits are shown at twice the standard error.

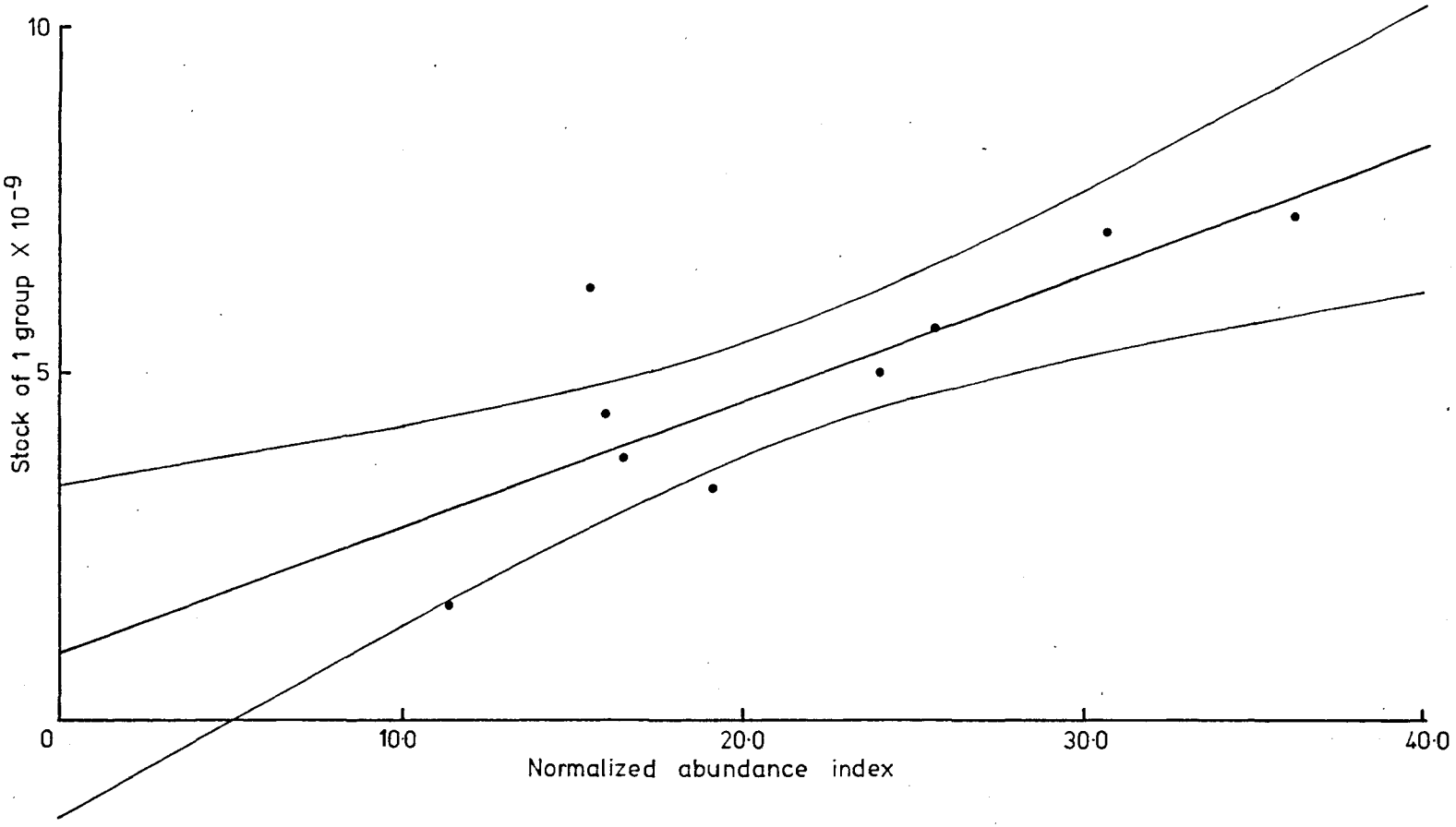

Figure 4 Regression of year-class strength on annual mean normalized catch per effort data. Data for both 1965 and 1969 omitted (see text). Limits are given at twice the standard error.