Doğa - Tr. J. of. Zoology
14 (1990), 336-344
© TÜBİTAK

A PRELIMINARY STUDY ON THE LENGTH FREQUENCY ANALYSIS FOR ESTIMATION OF THE GROWTH PARAMETERS OF THE NORTH SEA MACKEREL (*SCOMBER SCOMBRUS* LINNAEUS, 1758) (*)

Eyüp Mümtaz TIRAŞIN
Dokuz Eylül University, Institute of Marine Sciences and Technology, İzmir—Türkiye

Received 18/1/1989

ABSTRACT: *The growth parameters of the North Sea mackerel* Scomber scombrus *Linnaeus, 1758, like most other temperate species, are estimated from length at age data. Ageing of mackerel is based on otolith reading. In this study, it was attempted to apply the latest versions of computerized length frequency analysis in order to estimate the growth parameters of the North Sea mackerel and also to compare the results with those obtained using length at age data.*

The growth parameters, L^{∞} and k values estimated by the length frequency analysis were considered very much acceptable when compared with the values from length at age data. The t_o value, however, could not be obtained through the length frequency analysis.

KUZEY DENİZİ USKUMRUSUNUN (*SCOMBER SCOMBRUS* LINNAEUS, 1758) BÜYÜME PARAMETRELERİNİN, BOY SIKLIĞI ANALİZİ İLE HESAPLANMASI ÜZERİNE BİR ÖN ÇALIŞMA

ÖZET: *Kuzey Denizi uskumrusu* Scomber scombrus *Linnaeus, 1758, büyüme parametreleri diğer ılıman türlerin pek çoğunda olduğu gibi, yaş—boy verilerinden hesaplanır. Uskumrunun yaş tayini otolit okumasına dayandırılır. Bu çalışmada, boy sıklığı analizinin en son geliştirilmiş bilgisayarlı uyarlamaları, Kuzey Denizi uskumrusunun büyüme parametrelerini elde etmek için kullanılmıştır. Ayrıca sonuçlar, yaş—boy verilerinden yararlanarak bulunan değerlerle karşılaştırılmıştır. Sonuçta, Boy sıklığı analiziyle hesaplanan büyüme parametreleri, L^{∞} ve k değerleri, kabul edilebilir nitelikte bulunmuş, ancak t_o değeri boy sıklığı analiziyle elde edilememiştir.*

(*) *The present study was supported by the Royal Norwegian Ministry of Foreign Affairs.*

A Preliminary Study on the Length Frequency Analysis *for Estimation* of the Growth Parameters of the North Sea Mackerel (Scomber Scombrus Linnaeus, 1758)

E. M. TIRAŞIN

INTRODUCTION

The ability to determine the growth parameters of a fish stock is an important tool in fisheries biology. The growth parameters of the North Sea mackerel *Scomber scombrus* Linnaeus, 1758, like most other temperate species, are estimated from length at age data. Ageing of mackerel is based on otolith reading, interpreting and counting of annuli formed during alternate periods of faster and slower growth (or no growth at all). For tropical species, it is in most cases, very difficult or almost impossible to determine age from the ossified structures since they do not show clear annual rings. Various alternatives have been proposed to study the growth of tropical fishes. The possibility of ageing fish by counting the tiny and numerous daily rings has been suggested but its application as a routine is precluded, since it is a costly and time consuming technique. Only its use in validation of other methods is foreseen as valuable application. Thus the length frequency analysis is the commonly used method for estimation of the growth parameters of fish stocks in tropics (1, 2).

The current study is an attempt to apply the latest versions of computerized length frequency analysis in order to estimate the growth parameters of the North Sea mackerel and also to compare the results with those obtained using length at age data. It is aimed to test the applicability of length frequency analysis for temperate species so as to reduce the labour intensive otolith readings.

MATERIAL AND METHODS

The material used for this study was obtained from the North Sea mackerel data collection of the Institute of Marine Research in Bergen (Norway). Several criteria were set to select the samples used in the present study. First, only the samples coming from purse–seiners were considered in order to reduce the effects of gear selection. Second, solely those which were taken in the period from 1970 to 1975 were chosen because, on one hand, after 1980 a possible mixture between the North Sea and the Western mackerel in the samples was expected (3) and on the other hand, the information on mackerel caught by purse–seiners in the period of 1976–1979 was insufficient. Figure 1 shows the sampling areas.

Estimation of the Growth Parameters:

1. Length at age data:

Only the strong 1969 year class of the North Sea mackerel was used for estimation of the parameters from length at age data (Table I). The scarce information on length at age data from the other year classes prevented them from being included in this study and a possible comparison of independent estimations. In order to get the estimates of $L\infty$ and k, the Gulland and Hoult Plot (4), Fabens' method (5) and Munro's method (6), which were included in the ELEFAN (Electronic Length Frequency Analysis) V computer programme (7), were employed. Also the graphic method of the Ford–Walford Plot (8, 9). was applied. For the estimation of t_o and k, the von Bertalanffy Plot (10) was used through the LFSA (Length Based Fish Stock Assessment) computer programme (11). Pauly's empirical formula (12) was also applied to estimate t_o.

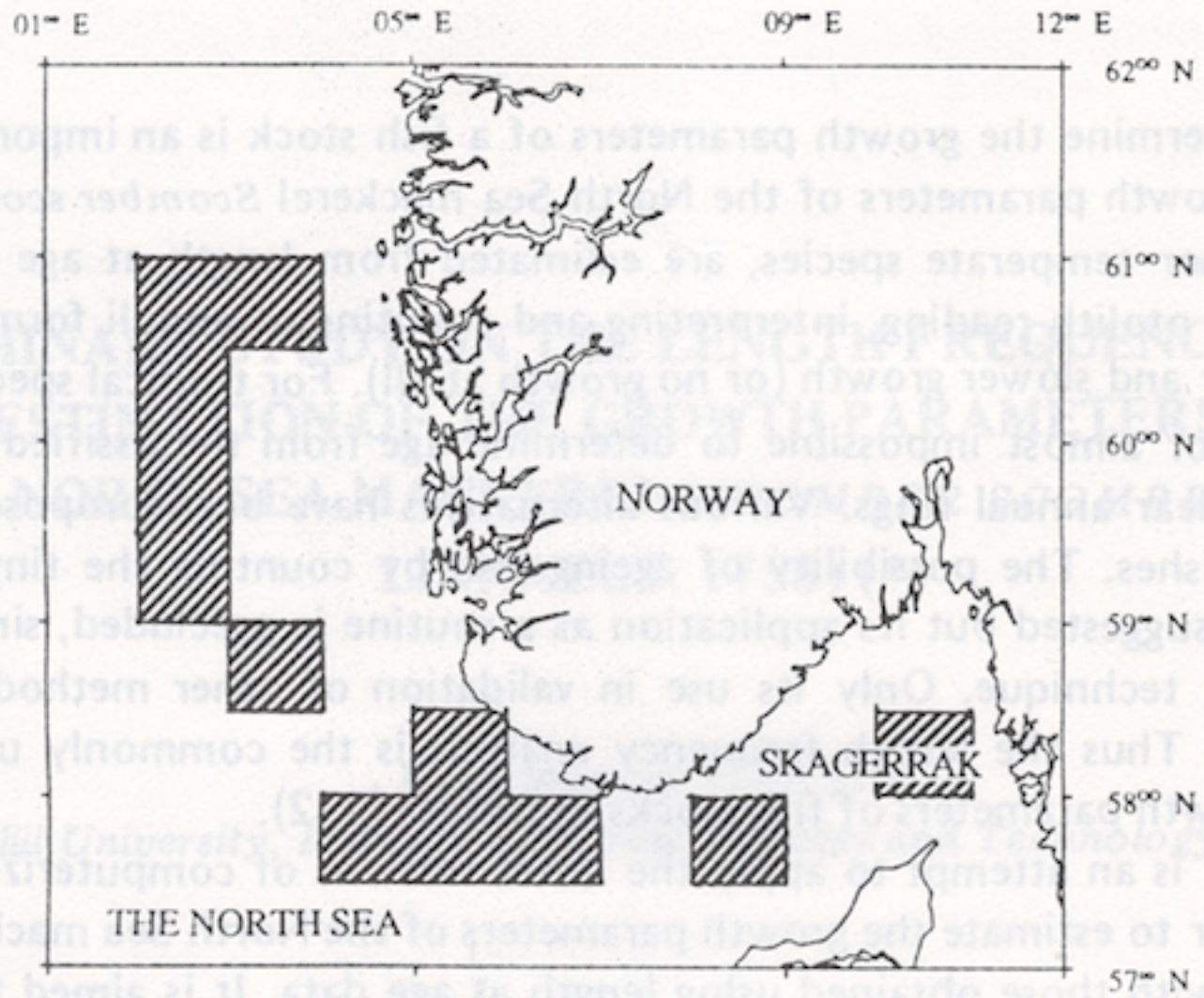


Figure 1. Sampling areas (shaded) in the North Sea

Table I. Basic Data Used for Length at Age Analysis

Age (yrs)	Number of fish N	Mean length (cm)	Number of sample #
1	183	28.1	4
2	359	32.4	5
3	138	35.3	2
4	238	36.2	4
5	116	37.5	2
6	180	38.3	4

2. Length frequency data:

The total lengths of 2196 individual fish from 24 to 49 cm were used in the calculations. The Bhattacharya method (13) implemented in the LFSA computer programme (11) was employed to split the composite distribution of lengths into separate normal distributions, so as to identify different cohorts contained in the samples. The mean lengths of components derived from the Bhattacharya method were plotted versus time series to obtain assumed cohorts using the modal progression analysis. Later, the values of length increment per time interval and the mid points of the corresponding length intervals were drawn along the Y and the X axes respectively and a straight line relationship was obtained. The X intercept gave the value of $L\infty$, while the slope equalled k (4). An estimation of t_o was attempted by following the von Bertalanffy Plot of the LFSA computer programme (11) and also by applying Pauly's empirical formula (12).

RESULTS

1. Estimates from length at age data:

Table II shows the growth parameters obtained by different methods carried out for length at age data. Sundenberg (14) reported that the Fabens' method gave a more accurate estimate of $L\infty$ compared to that of Gulland and Holt Plot. For that reason the $L\infty$ obtained by Fabens' method was used in the Munro's method, the von Bertalanffy Plot and Pauly's formula as well.

2. Estimates from length frequency data:

Figure 2 shows the resolution of length frequencies into normal distributions using the Bhattacharya method through the LFSA computer programme (11). The likely existence of five cohorts in the sampled population was shown in the modal progression graph (Figure 3). While the growth parameters $L\infty$ and k were estimated (Table III), the t_o could not be obtained by the von Bertalanffy Plot of the LFSA computer programme (11). Pauly's empirical t_o formula was applied with the $L\infty$ and k estimated by the Fabens' method.

Table II. The Growth Parameters Obtained from Length at Age Data by Different Methods. 95 % Confidence Limits (in Brackets) Were Calculated When Applicable

Methods	$L\infty$ (cm)	k (yr^{-1})	t_o (yrs)
Febens (5)	40.0 (±3.1)	0.45 (±0.23)	—
Ford (8)—Walford (9)	39.0	0.51	—
Gulland and Holt (4)	40.1	0.44 (±0.15)	—
Munro (6) (With Fabens' $L\infty$)	40.0	0.45 (±0.23)	—
Von Bertalanffy (10 (With Fabens' $L\infty$)	40.0	0.38 (±0.05)	−2.342
Pauly (12) (With Fabens' $L\infty$ and k)	40.0	0.45	−0.473
Pauly (12) (With Fabens' $L\infty$ and von Bertalanffy's K)	40.0	0.38	−0.39

Table III. The Growth Parameters Obtained from Length Frequency Data by Different Methods. 95 % Confidence Limits (in Brackets) Were Calculated When Applicable

Methods	$L\infty$ (cm)	k (yr^{-1})	t_o (yrs)
Fabens (5)	43.9 (±3.9)	0.41 (±0.25)	—
Gulland and Holt (4)	44.2	0.44 (±0.28)	—
Munro (6) (With Fabens' $L\infty$)	43.9	0.57 (±0.27)	—
Pauly (12) (With Fabens' $L\infty$ and k)	43.9	0.41	−0.442

A Preliminary Study on the Length Frequency Analysis *for Estimation* of the Growth Parameters of the North Sea Mackerel (Scomber Scombrus Linnaeus, 1758)

E. M. TIRAŞIN

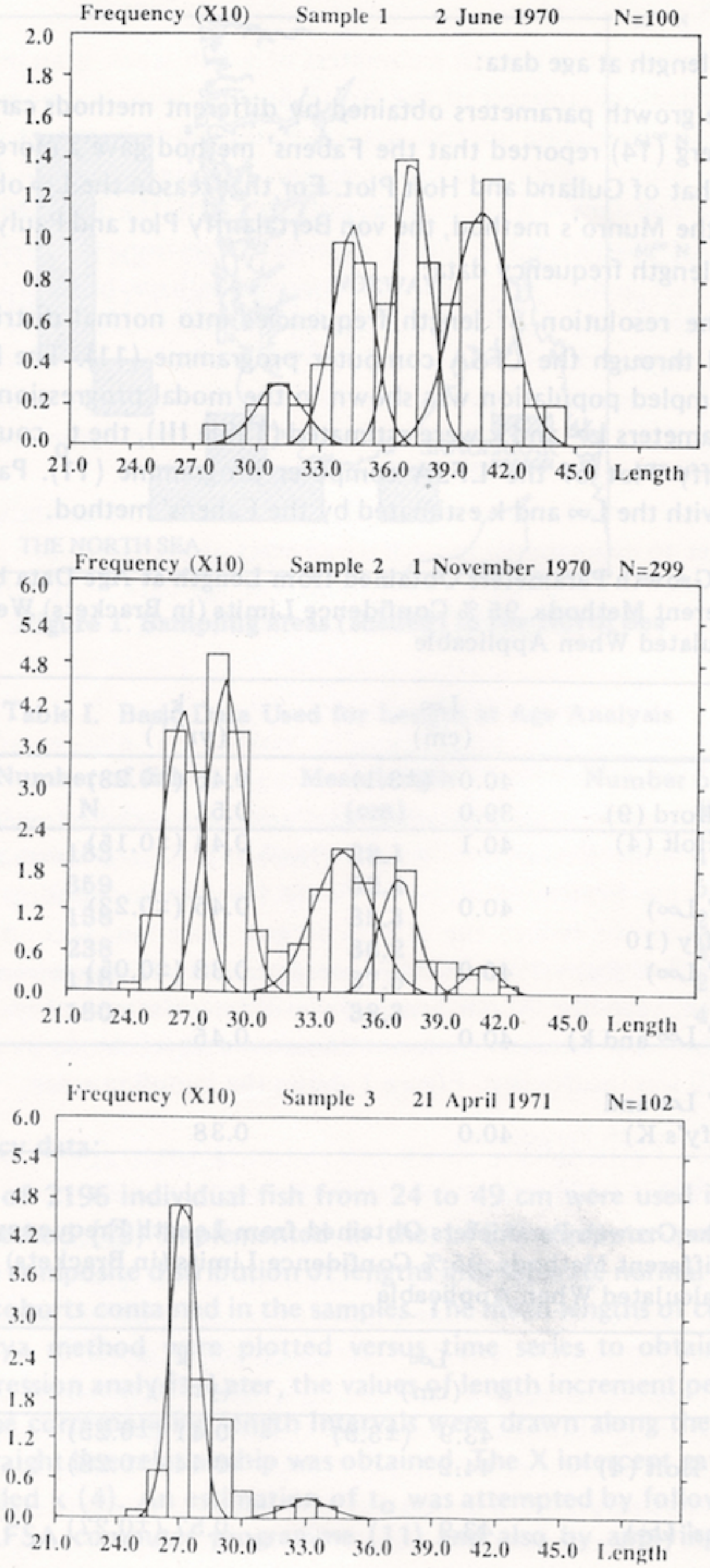


Figure 2 a. The normal distributions in the samples and sampling dates

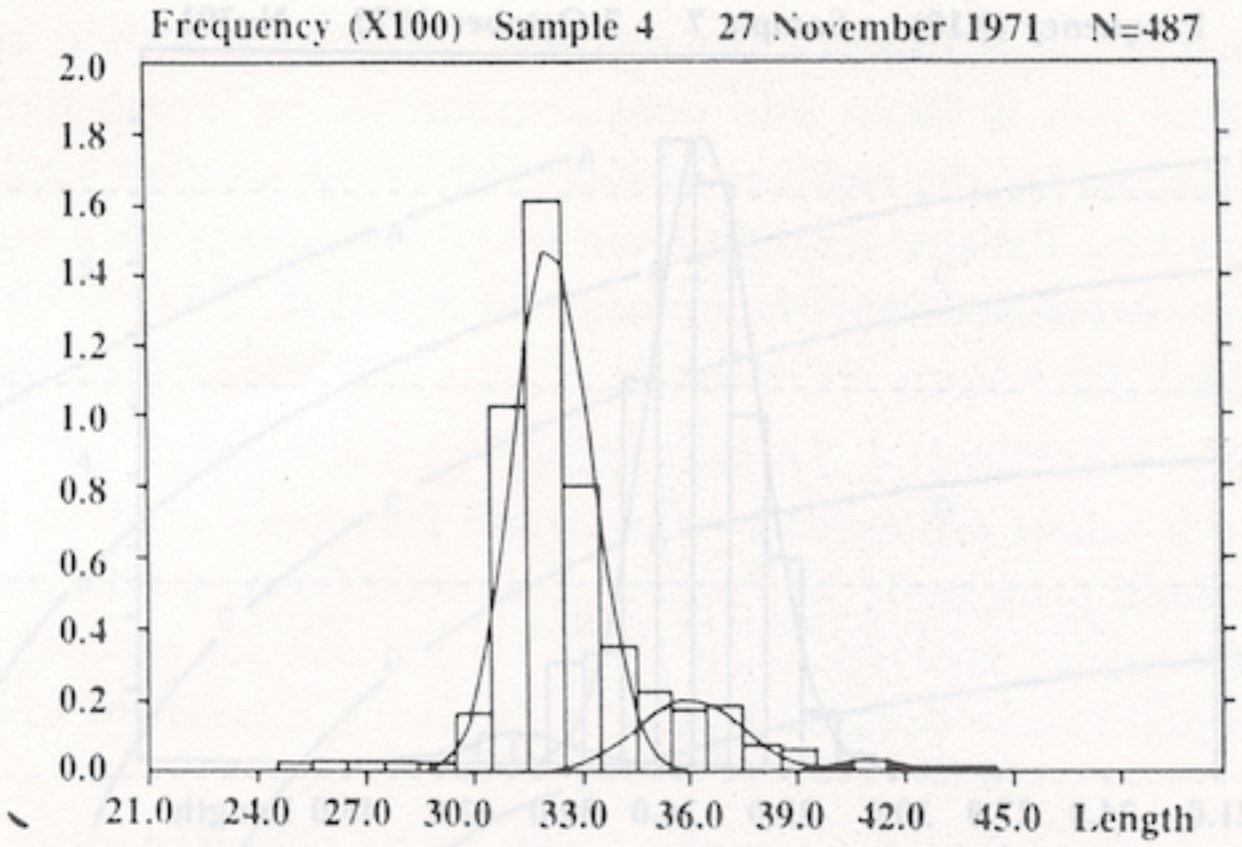


Figure 2 b. The normal distributions in the samples and sampling dates

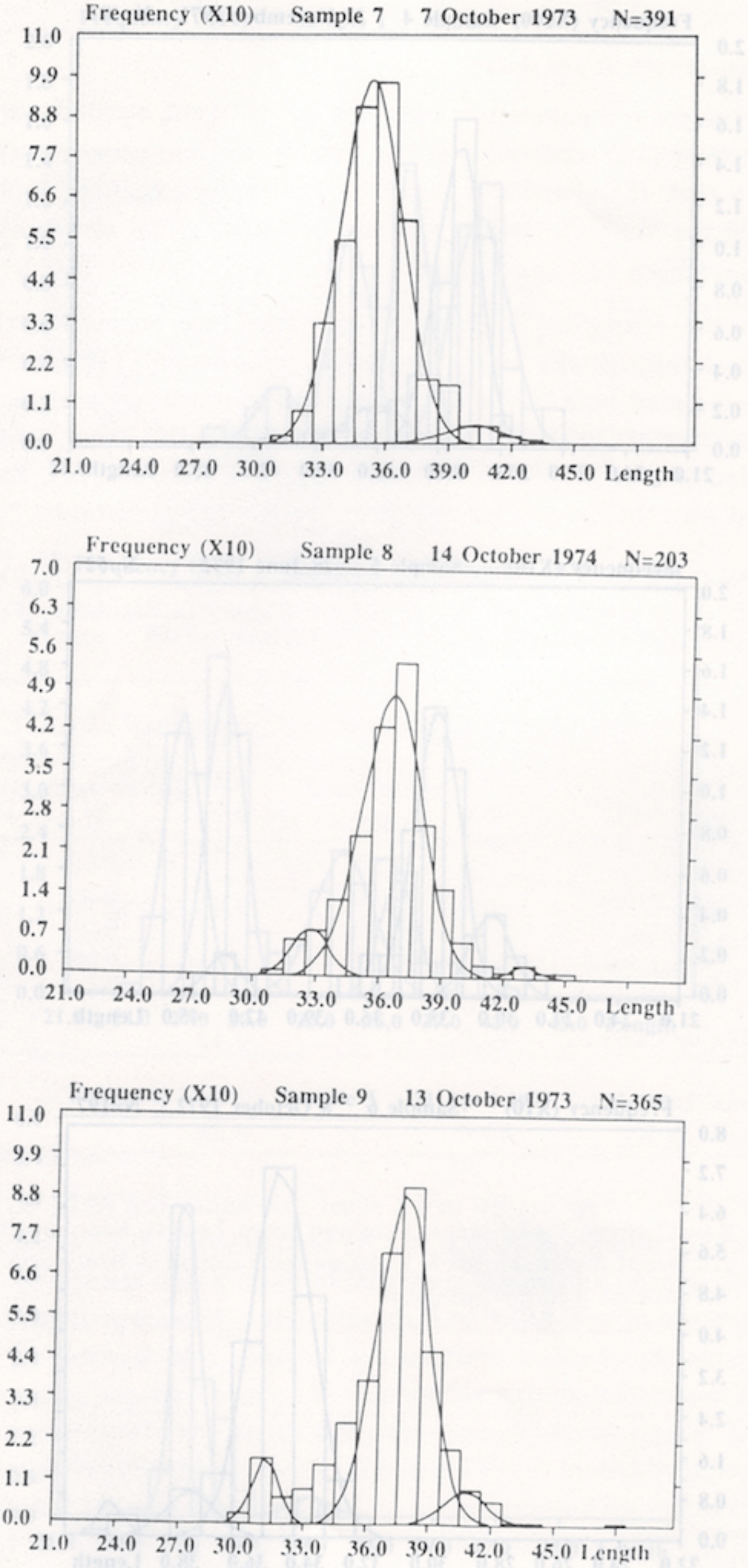


Figure 2 c. The normal distributions in the samples and sampling dates

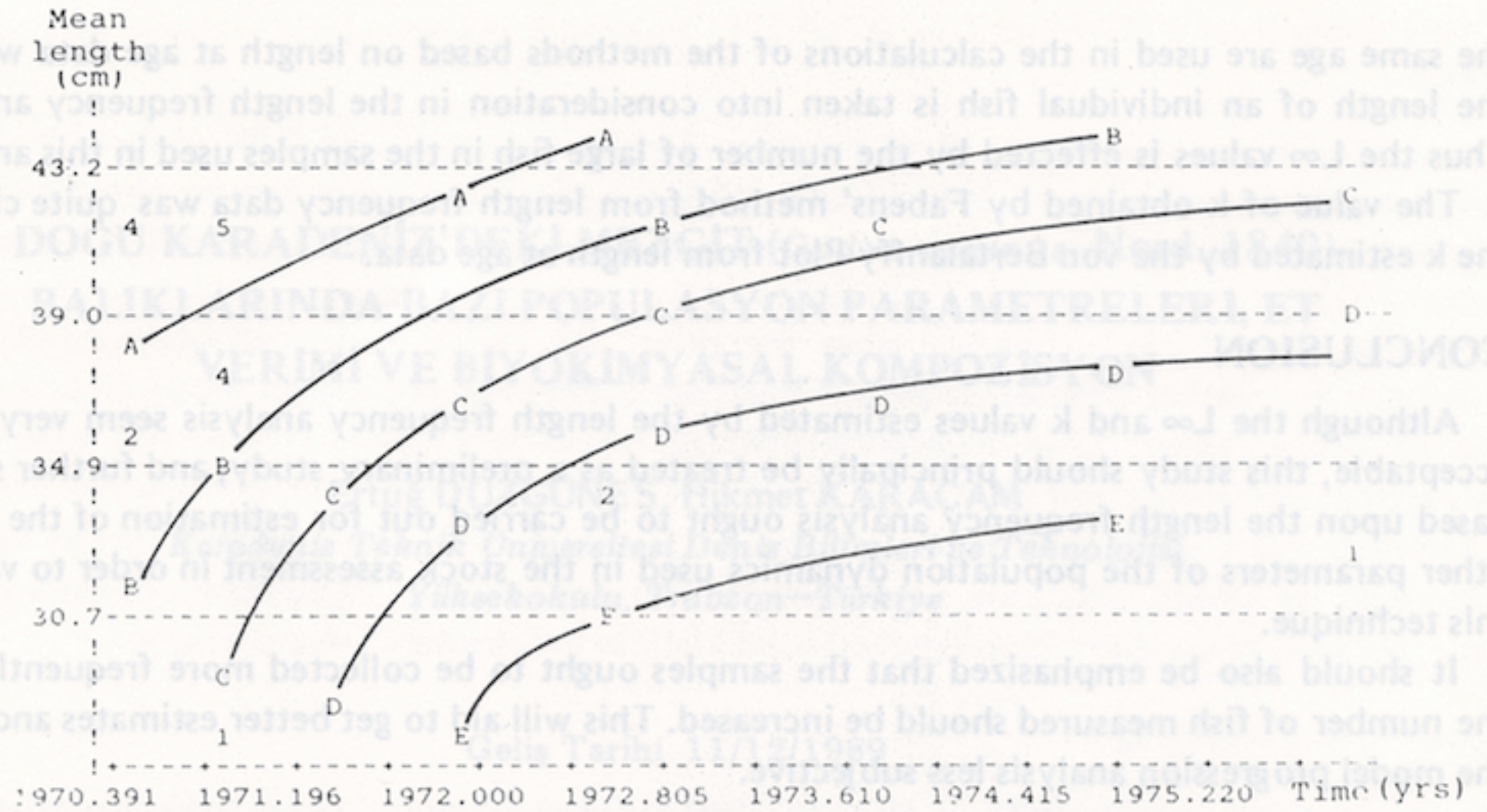


Figure 3. Modal progression graph

DISCUSSION

The most recent study estimating the growth parameters of the North Sea mackerel from length at age data is that of Castello and Hamre (15). They reported the parameters of the von Bertalanffy growth model based on back calculated length at age data, as $L\infty = 38.3$ cm, $k = 0.40$ per year and t_o "−2.027" years. These results are fairly similar to the ones obtained in the current study from length at age data, when the Fabens' method was applied to estimate $L\infty$ and, when the von Bertalanffy Plot with the Fabens' $L\infty$ was used to estimate the k and t_o. The resulted t_o values from Pauly's empirical formula were very low compared to the value obtained by the von Bertalanffy Plot (Table 2).

The $L\infty$ and k values estimated by Fabens' method from length frequency data slightly differed from those obtained by the Gulland and Holt Plot from the same data. The value of k obtained by the Munro's method was somewhat bigger than the values from the other two methods (Table 3). The possible reason for failure in the estimation of t_o value from length frequency data might be the fact that mackerel has a tendency to school consisting of more fish of approximately the same size rather than the same age (16). Thus older cohorts obtained by the Bhattacharya method might contain fish close to the same size but belonging to different age groups. Another additional factor might be the sampling. Especially in the period from 1973 to 1975 samples were collected less frequently and they contained only one month data for each year. This affected the following of cohorts during the modal progression analysis and made it less objective. The t_o value obtained by Pauly's formula has not been considered reliable since the t_o values obtained from length at age data by the same formula showed remarkably high deviation from the t_o of the von Bertalanffy Plot.

The $L\infty$ values estimated from length frequency data were relatively higher than those obtained from length at age data. The variation might occur because the average lengths of fish of

the same age are used in the calculations of the methods based on length at age data whereas the length of an individual fish is taken into consideration in the length frequency analysis. Thus the $L\infty$ values is effected by the number of large fish in the samples used in this analysis.

The value of k obtained by Fabens' method from length frequency data was quite close to the k estimated by the von Bertalanffy Plot from length at age data.

CONCLUSION

Although the $L\infty$ and k values estimated by the length frequency analysis seem very much acceptable, this study should principally be treated as a preliminary study, and further studies based upon the length frequency analysis ought to be carried out for estimation of the t_o and other parameters of the population dynamics used in the stock assessment in order to validate this technique.

It should also be emphasized that the samples ought to be collected more frequently, and the number of fish measured should be increased. This will aid to get better estimates and make the model progression analysis less subjective.

ACKNOWLEDGEMENTS

I owe very special thanks to Mr. Jeppe Kolding, Dr. Arne Johanessen and Mr. Terje Jörgensen for their continuous help during this study.

I am also grateful to the Royal Norwegian Ministry of Foreign Affairs for the scholarship granted to me during my stay in Norway, and to the Department of Fisheries Biology, University of Bergen and the Institute of Marine Research for providing the data and place.

REFERENCES

1. *Longhurst, A.R., Pauly, D.*, Ecology of Tropical Oceans, *California, USA, Academic Press Inc. Ltd. ICLARM Contr. 389, 1987.*

2. *Sparre, P., Introduction to Tropical Fish Stock Assessment*, FAO/DANIDA, GCP/INT/392/DEN, *Denmark, 71—181, 1986.*

3. *Bakken, E., Westgard, T.*, ICES CM/H: *65, 1986.*

4. *Gulland, J.A., Holt, S.J.*, J. Cons. int. Explor. Mer, *25, 1, 47—49, 1959.*

5. *Fabens, A.J.*, Growth, *29, 265—289, 1965.*

6. *Munro, J.L.*, J. Cons. int. Explor. Mer, *40, 2, 199—200, 1982.*

7. *Gayanilo, F.C., Soriano, M., Pauly, D.*, A. Draft Guide to the Complete ELEFAN, *Philippines, Software 2 Publ. ICLARM, Philippines, 52—63, 1988.*

8. *Ford. E.*, J. Mar. Biol. Assoc., *19, 305—384, 1933.*

9. *Walford, L.A.*, Biol. Bull., *90, 141—147, 1946.*

10. *Bertalanffy, L.*, Wilhelm Roux Arch. Entwicklungsmech., *131, 613—652, 1934.*

11. *Sparre, P.*, FAO Fish. Tech. Pap. *101, Suppl. 2, 1—134, 1987.*

12. *Pauly, D.*, J. Cons. int. Eplor. Mer, *39, 2, 175—192, 1980.*

13. *Bhattacharya, C. C.*, Biometrics, *23, 115—135, 1967.*

14. *Sundunberg, P.*, Cons. int. Exlor. Mer, *41, 248—258, 1984.*

15. *Castello, J.P., Hamre, J.*, ICES CM/H: *7, 1969.*

16. *Elting, A.T.G.W.*, J. Cons. int. Exlor. Mer, *41, 248—258, 1967.*