International Council for the Exploration of the Sea

C. M. 1977 / M: 4
Anadromous and Catadromous Fish Committee

Otolith length/fish length relationship of Leptocephali, elvers and sub-adults (reared) eels (Anguilla anguilla)

by

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ABSTRACT

The otoliths length and the total fish length of 9 Leptocephali, 29 elvers and 51 sub-adults eels were measured. For the 51 eels a significant correlation between otolith and fish length was found, no similar correlation was found for Leptocephali and elvers because of their similar total length. It was found that the growth of the otoliths from Leptocephali and elvers differ from the growth of those from herring larvae.

RESUMÉ

La longeur des otolithes et la longeur totale de poisson de 9 leptocéphales, 29 civelles et 51 anguilles sous-adultes furent mesurées. Une corrélation significative entre la longeur d'otolithe et de poisson a été constatée en ce qui concerne les 51 anguilles, et aucune corrélation semblable n'a été découverte pour les leptocéphales et les civelles à cause de leur longeur totale semblable. On a découvert que la croissance des otolithes à partir de leptocéphales et de civelles diffère de la croissance de ceux à partir de larves de hareng.

INTRODUCTION

Otoliths are used extensively in fisheries biology for the determination of age and growth (Tesch 1968) and usually show a good correlation to the fish length which may be used for the back calculation of length at age.

While for adult fish much work has been done, little is known about the otoliths of the early stages of life of fish. HEMPEL and H. TERKEL (1957 - 1959) investigated the development of the herring (Clupea harengus) otolith mainly during the first year of life. Since eels are doing a real metamorphosis in early stages of life it was of interest to find out if there is any correlation between otolith length and fish length as well as the otoliths form at that stage.

In addition, it was investigated what kind of variation in the otolith length of eels which were reared in tanks for two years, show when they are at almost the same age, but in a different total length because of their individual variation of growth.

MATERIAL AND METHODS

The material used in this study was obtained and is constituted as follows:

1. Nine Leptocephali in stages 1-4 of metamorphosis caught at the continental slope south west of Ireland during 1976 ($51^{o}25'$ N / $12^{o}00'$ E) and preserved in neutralized formaldehyde.
2. Twentythree fresh, almost unpigmented glass eels, caught along the French coast during 1976 and 1977.
3. Six elvers kept and fed for 10 days in a tank at 23^{o}C. These elvers showed partial pigmentation.
4. Fiftyone eels obtained from a stock reared from the elver stage in tanks at 23 ± 2^{o}C for a period of two years. The eels were fed with trash fish supplemented with fish meal. After the 2 year period a large degree of variation in length was evident. The largest eel measured 61 cm and the smallest 9,5 cm total length. No diseases were evident throughout the 2 year period.

The otoliths of the Leptocephali and the elvers were removed at 12,5 magnification under a stereo microscope. They were measured for length using a slide micrometer and graded ocular.

The otoliths of the eels reared for two years were removed from the ventral side of the exposed neurocranium and measured for length using a sliding vernier caliper accurate to 0,01 mm.

RESULTS AND DISCUSSION

The results of the investigation are illustrated in Fig. 1. A correlation and a regression formula was calculated for the otolith length/fish length relationship of the eels fed for two years. Correlation and regression was calculated by the method of least squares, and was found to be:

$y = 0{,}04x + 0{,}58$, with a correlation coefficient of $r^2 = 0{,}85$ ($n = 51$), where y = otolith length and x = fish length.

The relationship between fish length and otolith length of the eels fed for 2 years was found to be in close correlation to the results found by Penaz and Tesch (1970). Of interest in this case is the fact that all eels apart from the elvers and the Leptocephali were kept from the glass eel stage onwards under the same conditions. After 2 years the eels were found to range in length from 9,5 cm to 61 cm total length. Various authors have found the same large variation in the length of reared eels (See Koops, 1965 and others).

The fact that otoliths length of this sub-adults eels correlate to the fish-length and not to their age, is a contradiction to the work of K. MÖLLER (1953) who found for the Chub Leuciscus cephalus L.) a correlation between otoliths weight and fishage. Therefore, as a consequence, it is impossible to determine the eels age by using the otolith length and probably the otoliths weight for the back calculation method as mentioned by MÖLLER.

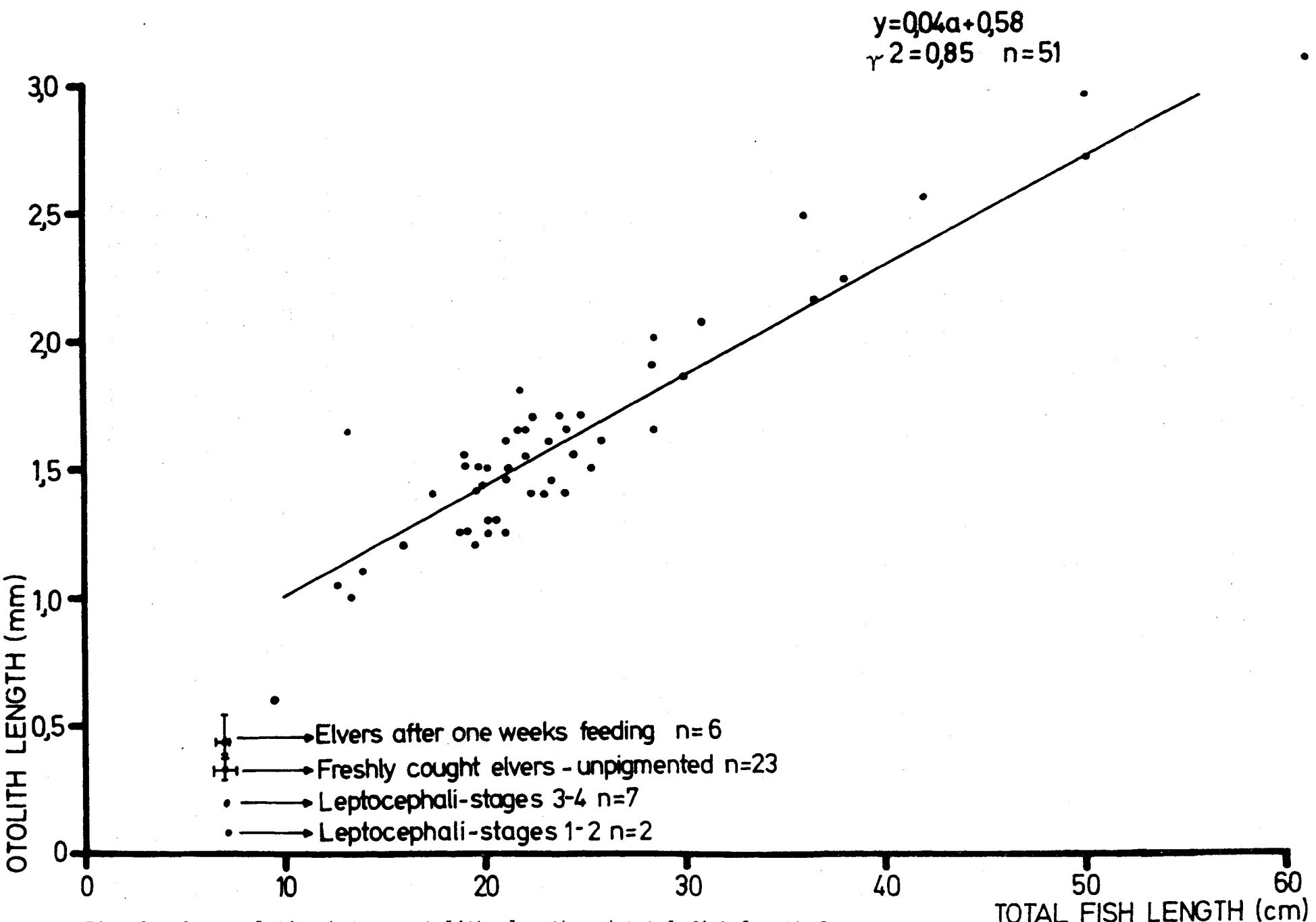

Fig. 1: A correlation between otoliths length and total fish length for Leptocephali, elvers and sub-adult eels. For further explanation see text.

Of primary importance from the data illustrated in Fig. 1 is the non-linear relationship between the otolith and fish lengths of the Leptocephali and the elvers combined as a unit and the larger reared eels. The non-linearity is probably due to the similar length shown by the Leptocephali and the elvers (x = 6,91 cm $\pm$ 0,36 cm) and therefore results in a similar otolith length (x = 0,33 mm $\pm$ 0,07 mm).

A further point of interest from this figure are the mean otolith lengths and fish lengths of Leptocephalii in stages (after Strubberg 1913), 1 and 2 Leptocephali in stages 3 and 4, freshly caught, almost unpigmented elvers and elvers having been kept for a period of 10 days. Although the Leptocephali in stages 1 and 2 are slightly larger than these in the ensuing stages, the otoliths are relatively smaller. Since the otoliths of Leptocephali, as well as glass eel, have a typical measure, it might be possible to find which eel-stage they belong to according to their size.

Of interest is the description in the book of SINHA and JONES (1975) of otoliths from elver that just arrived in fresh water and also demonstration of an 0.44 mm small otolith with a centre of 0.3 mm (surrounded by a ring) which has according to our measurements the same measure of otoliths of Leptocephali from stage 2 to 3. Since the duration of metamorphosis from such Leptocephalus to elvers which just enter in fresh water is much shorter than a year and even a season, it seems to be very questionable to identify this ring structure as an annual or a seasonal ring which might cause a wrong age determination for glass eels.

Fig. 2a shows a series of otoliths of eels in various stages of development, from Leptocephali (stages 1-2) up to eels with a total length of 21,7 cm. From this illustration, as well as the data in Fig. 1, it may be concluded that the growth of the otolith is continuous throughout the process of

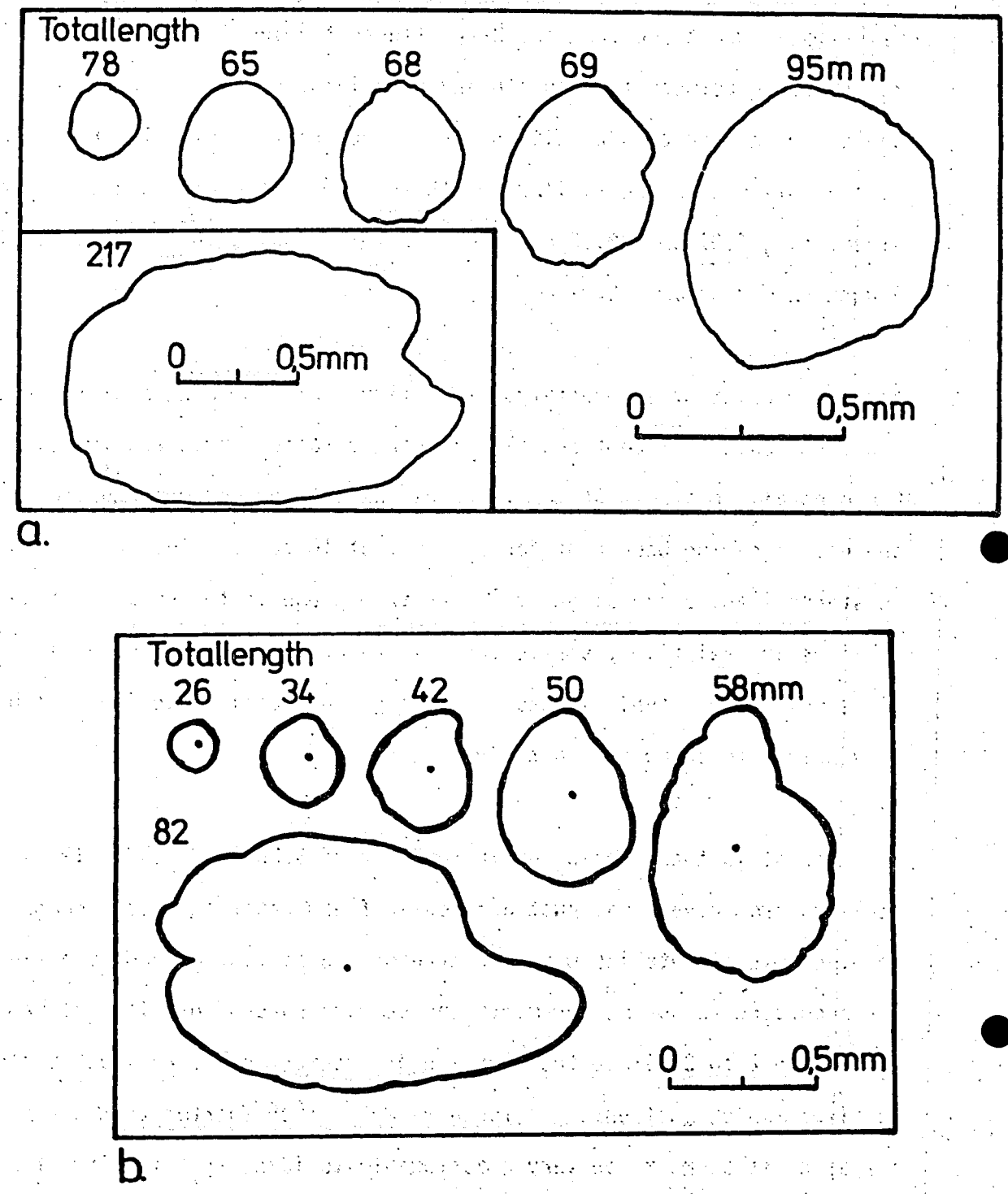

Fig. 2: Change in shape of otoliths

(a) During the metamorphosis of Leptocephalus up to sub-adult eels in different stages.
From the left to the right:
1. Leptocephalus stage 1-2
2. Leptocephalus stage 2-3
3. Glass eel unpigmented
4. Glass eel 10 days kept
5. 9,1 cm eel, 2 years fed
6. 22 cm eel 2 years fed

(b) From herring during the first year of life (HEMPEL 1957-1959)

metamorphoses and during further growth although the Leptocephali are larger in total length than the glass eels.

The continual change in the shape of the eels otoliths during their metamorphosis and afterwards, show a strong similarity to the changing of otoliths shape which HEMPEL (1957 - 1959) found for herring. Fig. 2b.

A comparison of Fig. 2a and 2b shows that heering larvea have larger otoliths, relatively to their total length of body than Leptocephali and elvers. On the other hand the growth increase of the otoliths from Leptocaphalus to elver is more rapid than in herring larvae.

The otoliths of the Leptocephali and glass eels of A.anguilla show typical Anguilliform features, as proposed by HECHT (in press).

The sagittae of these two stages may be described in detail as follows: Circular in geometric shape; marginal perimeter smooth; sulcus acusticus open anteriorly, closed posteriorly, and poorly, divided into ostium and cauda; colliculum homomorph and relatively well developed; cristae superior and inferior well developed; antirostrum and excisura ostii absent; rostrum small but present; medial surface flat; lateral surface strongly convex.

The sagittae of larger eels (larger than ca. 18 cm) differ from those of the above stages in the following aspects: Antirostrum and excisura ostii are now present. The sagittae have also become more oval in geometric shape. Moreover, the lateral side becomes less convex.

The growth rates of the tank reared eels, used in part of this investigation cannot be compared to free living animals. The results, apart of being of extreme interest, should also serve as an indication that age and growth of A.anguilla be approached with extreme caution by possibly using a combination of various methods as described in the EIFAC Technical Paper on age determination of eels (Rome 1975). Considering the above evidence, although calculated on a relatively small number of fishes, it would seem that the length frequency method of age determination would be the least accurate.

ACKNOWLEDGEMENTS

We would like to thank Dr. F. W. TESCH of the Biol. Anst. Helg. Zentrall, Hamburg, for providing the Leptocephali and for his constructive criticism.

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