A Comparison of Length-Related and Age-Related Growth Parameters of Newaiby *Otolithes ruber* in Kuwait Waters*

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Abstract

The growth parameters of *Otolithes ruber* (Sciaenidae) were determined from both length-frequency and length-at-age data collected from Kuwait waters from 1984 to 1986. The similarity of the growth parameters is reflected in the small range of the parameter ϕ' ($=\log_{10}K+2\log L_\infty$) which indicates the compatibility of the two methods for this relatively short-lived species.

Introduction

The core of fish stock assessment is the knowledge of the growth of the population. Once estimated, growth parameters can be incorporated along with the mortalities and the catch into various stock assessment models to make inferences on the current status of the fishery and to infer the ability of the stock to sustain varying levels of exploitation.

The pattern of growth of most fish species can be expressed using von Bertalanffy growth equation (VBGF):

$$L_t = L_\infty (1-\exp(-K(t-t_0))) \quad \ldots 1)$$

where L_t is the mean length at age t
L_∞ is the asymptotic length
K is constant expressing the rate at which L_∞ is approached, and
t_0 is the "age" at zero length.

Length-at-age data are needed to estimate all three of these parameters. Ageing of fish is commonly obtained from annual marks in the otoliths and these marks are taken as related to periods of rapid and slow growth over an annual cycle, in relation to seasonal fluctuation of the environment.

In much of the tropics, because of the absence of strong seasonal fluctuations of environmental parameters, especially temperature, fish growth does not oscillate seasonally as strongly as it does in fish of temperate waters and hence, annuli marks are usually harder to identify. Consequently, ageing of tropical fish is often more difficult and stock assessment of tropical fish species is usually based on length-frequency analysis, from which the growth parameters L_∞ and K of the VBGF can also be estimated.

Length-frequency data, in addition to being easier to obtain than length-at-age data, have the advantage of being inexpensive since measured fish need not be purchased. This is of high concern in many areas (i.e., Kuwait) where stock assessment is required for expensive fish such as groupers whose market price may reach up to $8 per kg (Morgan 1984).

The fish species composition of the Arabian Gulf closely resemble those of tropical waters; however, the temperature may fluctuate up to 16°C and salinity to 18 ‰ in the course of an annual cycle (Lee 1983).

Ageing of fish in Kuwait waters, using annuli marks, has therefore been initiated for many species including newaiby *Otolithes ruber* (Samuel and Mathews 1985) which is in high demand in Kuwait and for which, catch-and-effort data are given by Morgan (1985). The purpose of this paper is to complement this work by estimating growth parameters of newaiby from both length-frequency (L/F) and length-at-age data.

Materials and Methods

Newaiby L/F data from 1984 to 1986 as well as length-at-age data for 1985 were collected on a monthly basis by the Mariculture and Fisheries Department, KISR. The data were based on fish caught by different gears, including traps and shrimp trawls, landed in Kuwait fish market as well as fish sampled at sea on board the *R.V. Bahith*. The lengths were measured from the tip of the snout to the end of the caudal fin (total length) to the nearest cm, then grouped into 2-cm classes, for the period 1984 to 1986[a]. For the 1985 samples, otoliths were collected from representative subsamples and ages were estimated from annuli.

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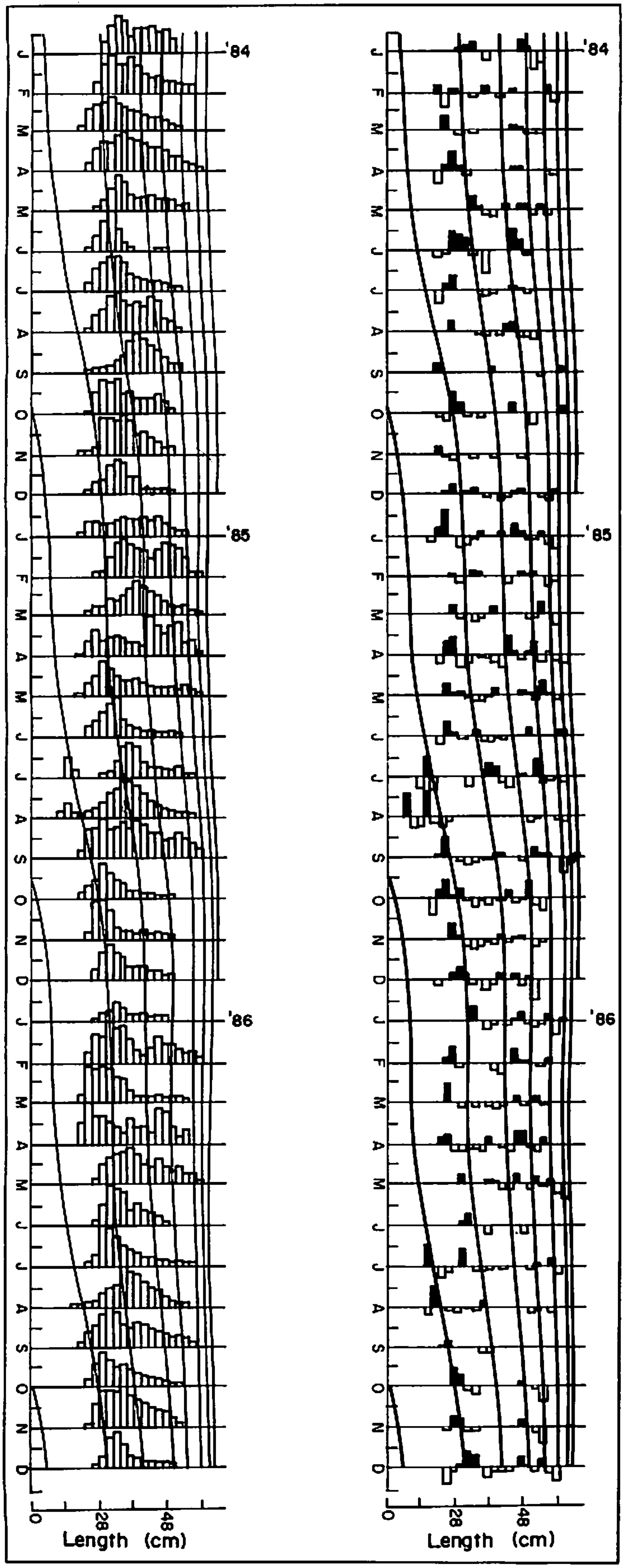
[a]These L/F data, illustrated on Fig.1, are available on request from the author.



Analysis of Data

1. *Length-frequency analyses*

A first estimate of L_∞ was obtained using the method of Wetherall (1986) as modified by Pauly (1986). A full complement of growth parameters was then obtained using ELEFAN I, and Somers' (1988) seasonally oscillating version of the VBGF, of the form.:

$$L_t = L_\infty\{1-\exp-[K(t-t_0)+S(t)-S(t_0)]\} \quad ...2)$$

where: L_t, L_∞, K, t_0 are as defined in equation 1;
C expresses the amplitude of the growth oscillations; and

$S(t) = (CK/2\pi) \sin 2\pi (t-t_s)$;
$S(t_0) = (CK/2\pi) \sin 2\pi (t_0-t_s)$ and

t_s relates the start of the sinusoid growth oscillation to t = 0.

Correction for Gear Selection

All fish are caught by gears that are selective for certain sizes; usually the small-sized ones escape, which affects the growth parameter estimates. However, L/F data can be corrected such as to take into account the fish that "ought to have been caught" had it not been for the effect of incomplete selection and/or recruitment (Pauly 1987). This approach was used here to estimate approximate probabilities of capture, correct the L/F data, and reestimate the growth parameters based on the corrected L/F data.

Length-at-Age Data

The length-at-age data used here are presented in Table 1. To account for seasonality, the ages were adjusted to take into account the sampling month relative to a nominal birthday of January 1, e.g., a fish of age 2 sampled in April was assigned an age of 2.29 years. The length-at-age data were analyzed using the software in Gaschütz et al. (1980), once without and once with the n values as weighting factors, and using a routine based on Morgan (1987), in Brey et al. (1987) for simultaneous analysis of L/F and length-at-age data.

This routine allows consideration of only ten age groups; thus, the means of the age groups were taken. The program sorted the ages in ascending order and derived, for each age pair (i.e., Age 1 and Age 2, Age 2 and Age 3...), a set of growth increments (Brey et al. 1987).

Fig. 1. Growth of newaiby* Otolithes ruber*, as estimated from length-frequency (L/F) data, collected in Kuwait (1984-1986). Right: original L/F data, showing fit of estimated curve. Left: restructured L/F data, as used by the ELEFAN I program to fit a seasonally oscillating growth curve.

Table 1. Mean length-at-age of newaiby (*Otolithes ruber*), based on otolith taken from fish sampled in Kuwait waters, in 1985.

Age (year)	Length (FL, cm)	n
0.54	10.5	10
0.63	19.5	27
0.71	15.2	22
0.79	19.5	19
0.88	23.0	17
0.96	24.4	10
1.04	23.4	83
1.13	24.0	43
1.21	23.8	36
1.29	25.8	32
1.37	24.9	66
1.46	26.9	78
1.54	30.4	9
1.63	27.9	43
1.71	28.9	22
1.79	29.7	25
1.88	31.4	21
1.96	30.2	33
2.04	32.9	79
2.13	34.4	32
2.20	34.0	101
2.29	38.0	45
2.37	33.2	17
2.46	31.8	27
2.54	34.3	6
2.63	33.6	16
2.71	36.5	17
2.79	35.8	7
2.88	39.7	9
2.96	35.5	6
3.04	41.0	6
3.13	44.6	14
3.20	43.4	9
3.29	43.4	8
3.37	48.0	48
3.71	45.5	2
3.88	43.0	1
4.04	49.0	2
4.20	48.0	1
4.29	47.5	2

A method similar to that of Appeldoorn (1987) incorporated in Brey et al. (1987) was then used to obtain growth parameter estimates from the growth increments; these parameters were then correlated with the growth parameters obtained from ELEFAN I (Morgan 1987; Brey et al. 1987). Based on this, a two-way table was constructed wherein the growth parameter L_∞ represents the x-axis and K the y-axis (leaving the other parameters constant), with the table entries consisting of values of $Rm = Rn + r^2/2$, where Rn is the goodness of fit index of ELEFAN I, pertaining to the L/F data, and r^2 the coefficient of determination resulting from the analysis of the growth increments.

Results and Discussion

The growth parameters of *O. ruber* estimated from the L/F data, from length-at-age data, and from the simultaneous analysis of L/F and length-at-age data are shown in Table 2. The estimate of the K parameter derived from the L/F data after correcting for gear selectivity ($K = 0.39\ year^{-1}$) is as expected slightly higher than for the unadjusted data ($K = 0.38\ year^{-1}$), which is due to the increase of the frequencies of the small-size class. When $L_\infty = 59$ cm was fixed, the K value estimated from the age data was very similar to that obtained from the L/F data indicating compatibility of the two data sets and methods (Table 2). This was confirmed by the simultaneous analysis of the L/F and length-at-age data, and by the ϕ' index ($=\log_{10}K + 2\log_{10}L_\infty$) of Pauly and Munro (1984).

The conclusion is thus that L/F data are sufficient, in this relatively short-lived species, to obtain reliable growth parameter estimates.

Table 2. Comparison of growth parameter estimates of Newaiby *Otolithes ruber* in Kuwait.

Parameter	L/F data alone: Not corr.	L/F data alone: Corr. for selection	Age data alone: L_∞ free	Age data alone: L_∞ fixed*	Age data + corr. L/F	Morgan (1984): L/F	Morgan (1984): Age
L_∞ (TL, cm)	59	59	78	59	59	68	70
K ($year^{-1}$)	0.38	0.39	0.19	0.35	0.35-0.40	0.26	0.24
ϕ' -	3.12	3.13	3.06	3.09	3.09-3.14	3.08	3.07
C -	0.90	0.90	0.93	0.28	0.90	0.99	1.00
WP -	0.13	0.11	0.38	0.33	0.13	0.39	0.30

*L_∞ at fixed value, and length at age date weighted by single size.

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