Length-Weight Relationship and Growth Parameters of Grey Mullets (Pisces: Mugilidae) in Two Estuaries in Ghana

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Abstract

Grey mullet populations in the rivers Pra and Volta estuaries in Ghana were studied to provide information on their length-weight relationship and growth parameters. Fish samples were collected monthly for 18 months from local fishermen using cast net, drag net and gill nets. Six species of grey mullets were identified: sickle fin mullet, *Liza falcipinnis* (Valenciennes, 1836), large-scaled mullet, *Liza grandisquamis* (Valenciennes, 1836), grooved mullet, *Liza dumerilii* (Steindachner, 1870), white mullet, *Mugil curema* Vallenciennes, 1836, banana mullet, *Mugil bananensis* (Pellegrin, 1928) and striped mullet, *Mugil cephalus* Linnaeus, 1758. Length-weight relationship for the various species in the Volta and Pra estuaries, respectively, were: *L. falcipinnis*, $BW = 0.0158\ SL^{3.06}$ and $BW = 0.0255\ SL^{2.85}$; *L dumerillii*, BW = 0098 $SL^{3.24}$ and $BW = 0.0223SL^{2.92}$; *M. bananensis*, $BW = 0.0191SL^{3.03}$ and $BW = 0.0175\ SL^{3.10}$; *M. cephalus*, $BW = 0.0574\ SL^{3.14}$ and $BW = 0.0134\ SL^{3.17}$; *M. curema*, $BW = 0.0311\ SL^{2.85}$ and $BW = 0.0247\ SL^{2.5}$. That for *L. grandisquamis*, which was found only in the Pra estuary, was $BW = 0.0204\ SL^{3.01}$, indicating isometric growth since the regression coefficient *b* was not significantly different from 3.0 ($P > 0.05$). The regression coefficient *b* for the other species was either significantly higher or lower than 3.0 ($P < 0.01$), suggesting allometric growth. Except *L. dumerilli*, *L* and K for the same species from the two estuaries differed. The highest *L* of 56.6 cm (SL) and growth performance index ( ) of 4.99 were estimated for *M. cephalus*. The *L* estimated in the study indicates that the sizes of grey mullets in the two estuaries were smaller compared to the same species from other countries in the tropics.

Introduction

Grey mullets comprise a large number of closely related species and belong to the family Mugilidae. They are successful teleost fishes which make up an important and probably the most widely distributed commercial fishes in the coastal waters of tropical and subtropical regions of the world (Wijeyaratne & Costa, 1986; Koutrakis & Sinis, 1994). In Ghana, grey mullets are important in the lagoon, estuarine and inshore fisheries along the entire coast.

Most of the studies done on grey mullets focused on their food and feeding habits (De Silva, 1980; Ferrari & Chieregato, 1981; Ikomi, 1990; Blay, 1995ab; Dankwa *et al*., 2005). Not many studies have been conducted with respect to growth and length-weight relationship of these species. The importance of growth parameters and length-weight relationships has been emphasised by various researchers (Sparre *et al*., 1989; Pauly, 1993; King, 1996; García-Arteaga *et al*., 1997). These include the determination of body size as a function of age, morphological comparisons between populations of the same species, or between species, apart from using it in the calculation of the fish's average weight at a certain length class, and conversion of an equation of growth in length into an equation of growth in weight.

Growth parameters of some grey mullet species in wetlands in north-eastern Greece have been reported by Koutrakis & Sinis (1994), and from the Negombo Lagoon in Sri Lanka by Wijeyaratne & Costa (1987). King (1996) reported the length-weight relationship of *M. curema*, *M. cephalus* and *L. falcipinnis* from the Nigerian coast, while Ikomi (1990) reported that for *M. cephalus*

from the Niger Delta. The study sought to provide base line information on growth parameters and length-weight relationship of grey mullet populations in two estuaries in Ghana.

Materials and methods

Study sites

The study was conducted between February 1999 and July 2000 at the estuaries of River Pra and River Volta, both of which discharge into the Atlantic Ocean in the Gulf of Guinea. The two estuaries were chosen because of their location and the different ecological scenarios they offer (Fig. 1).

The River Volta estuary is located between latitudes 5° 30 and 6° N and longitudes 0° 30' and 1° E and lies within a coastal savanna zone that has an annual rainfall of between 750 and 1,250 mm (Dickson & Benneh, 1988). The estuary was about 1,200 m wide at the mouth. Beyond the mouth of the estuary, the water body covers an extensive area with a number of islands most of which have human settlements.

The River Pra estuary is located between latitudes 5° and 5° 3 N and longitudes 1° 30 and 2° W. The banks of the estuary are fringed by red mangroves (*Rhizophora* spp.) up to about 10 km inland (Obodai *et al*., 1996). The estuary was approximately 100 m wide at the point of entry into the sea. The basin lies in the moist evergreen forest zone of Ghana, with an annual rainfall of between 1,500 and 1,750 mm (Dickson & Benneh, 1988) and is subjected to impacts of mining activities.

Fish sampling and data analysis

Grey mullets were sampled from the two estuaries with a set of nets; a cast net, a drag net and a battery of mono- and multi-filament gill nets. Samples were also bought from local fishermen to augment those caught from experimental fishing to ensure that the samples reflected, as much as possible, the population structure of grey mullets in the estuaries. They were kept in 10% formalin and sorted out into the various species in the laboratory using identification keys of Schneider (1990). The total length (TL) and standard length (SL) of individuals of the different species of fish were measured to the nearest 1.0 cm, and the weight determined to the nearest 0.1 g using a measuring board and Sartorius balance, respectively.

The parameters *a* (intercept) and *b* (slope) of the length-weight relationship of the form $W = aL^b$ were estimated for the different species through logarithmic transformation, i.e. $\log W = \log a + b \log L$, with *a* and *b* estimated by ordinary least squares regression. Differences in the slopes of the regressions, *b*, between same species from the two sites were evaluated using Student's *t*-test.

The growth of all the mullet species from the two estuaries was assumed to conform to the von Bertalanffy growth function (VBGF) which has the basic form:

$$L_t = L \quad [1-\exp(-K(t-t_o))]$$

where L_t is the length at age t, L is the asymptotic length, K the growth constant and t_o the theoretical age at length zero. The ELEFAN I programme, as incorporated in the FISAT software (Gayanilo *et al*., 1995), was used to fit growth curves to the restructured length frequency data. This was based on preliminary estimates of the asymptotic length (L) obtained using the method of Wetherall (1986), which is also incorporated in the FISAT programme. The value of the growth constant K was obtained from the scanning routine in ELEFAN I.

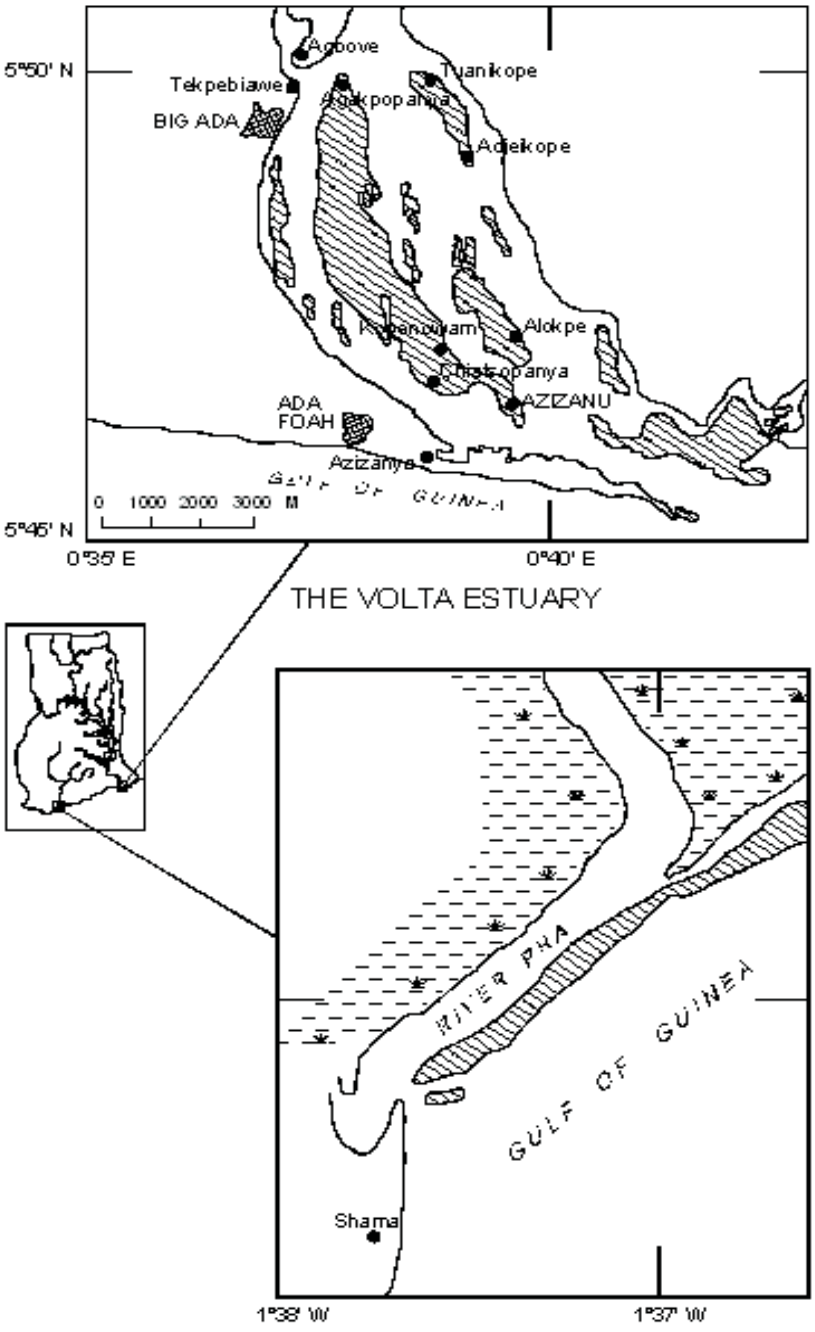


Fig. 1. Map showing the Volta and Pra estuaries

The theoretical age at length zero (t_o) was obtained from Pauly's (1979) equation:

$$\text{Log}_{10}(-t_o) = -0.392 - 0.275\ \text{Log}_{10} L - 1.038\ \text{Log}_{10} K$$

The growth performance index (□) was computed from the equation (Pauly & Munro, 1984): (□) = $\text{Log}_{10} K + 2\ \text{Log}_{10} L$

Results

Occurrence and size range of grey mullets caught

Six species of grey mullets and two genera, *Liza* and *Mugil*, were identified. The species were: sickle fin mullet, *Liza falcipinnis* (Valenciennes), large-scaled mullet, *Liza grandiaquamis* (Valenciennes), grooved mullet, *Liza dumerilii* (Staindachner), white mullet, *Mugil curema* Vallenciennes, banana mullet, *Mugil bananensis* (Pellegrin) and striped mullet, *Mugil cephalus* Linnaeus. With the exception of *L. grandisquamis*, which was found only in the Pra estuary, all the other species occurred in both estuaries.

The size range of the different species in the two estuaries is presented in Table 1. Specimens of each species from the Volta were comparatively bigger than those from the Pra estuary.

The exponent *b* or regression coefficient for a given species from the two estuaries was statistically different with the exception of *M. cephalus* (Table 2).

There was no significant difference between the regression coefficient *b* for *L. grandisquamis,* and 3.0 ($P > 0.05$), indicating isometric growth while in the other species the exponent was either significantly higher or lower ($P < 0.01$) than 3.0 suggesting allometric growth.

Growth parameters

Fig. 2a shows estimation of growth parameters using Wetherall's method for *M. bananensis* from the Volta estuary, providing estimate of L as 20.5 cm SL. The corresponding estimate of K was 0.78 year^{-1} from the scan plot (Fig. 2b), and the growth curve superimposed on the restructured length-frequency data is shown in Fig. 3. A summary of the growth parameters (K, L

TABLE 1

Size range of grey mullets caught in the Volta and Pra estuaries

Species	*Volta estuary*		*Pra estuary*	
	SL (cm)	*Wt (g)*	*SL (cm)*	*Wt (g)*
L. falcipinnis	3.8–32.9	1.1–262.3	4.2–21.7	1.3–205.6
L. dumerilii	4.5–23.3	1.6–216.3	4.7–23.0	2.3–238.7
L. grandisquamis	NA	NA	7.0–16.3	7.9–104.8
M. bananensis	5.4–19.5	3.6–174.5	4.7–19.3	2.1–153.2
M. curema	5.4–27.0	3.6–444.1	5.0–15.8	3.4–78.4
M. curema	7.7–57.0	10.2–3300	11.5–35.5	34.8–1250

NA- Not available

TABLE 2
Parameters of length-weight relationship and coefficient of determination (r^2) for grey mullet species from the Volta and Pra estuaries

Species	*Location*	*a ± SE*	*b ± SE*	r^2
L. falcipinnis	Volta	0.0158 ± 0.002	3.0561 ± 0.02	0.9928
	Pra	0.0255 ± 0.005	2.8507 ± 0.05	0.9500
L. dumerilii	Volta	0.0098 ± 0.003	3.2356 ± 0.03	0.9833
	Pra	0.0223 ± 0.003	2.9175 ± 0.03	0.9771
L. grandisquamis	Volta	NC	NC	NC
	Pra	0.0204 ± 0.004	3.0113 ± 0.03	0.9750
M. bananensis	Volta	0.0191 ± 0.002	3.0296 ± 0.02	0.9894
	Pra	0.0175 ± 0.003	3.1042 ± 0.03	0.9771
M. curema	Volta	0.0311 ± 0.002	2.8456 ± 0.03	0.9728
	Pra	0.0247 ± 0.004	2.9472 ± 0.04	0.9651
M. cephalus	Volta	0.0142 ± 0.002	3.1387 ± 0.02*	0.9944
	Pra	0.0134 ± 0.004	3.1708 ± 0.05*	0.9944

* No significant difference between slopes at 5% probability level. NC - Not caught.

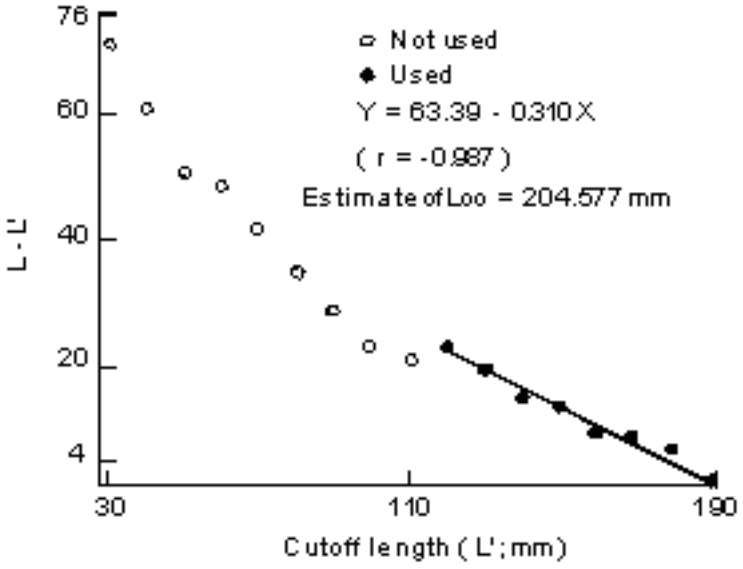
and t_0) and growth performance (□) is provided in Table 3 for all the species. A similar process was followed for the estimation of growth parameters for the other species from the two estuaries.

Apart from *L. dumerilii* whose L_∞ was similar in both estuaries, the L_∞ and K for the other species from each estuary were different. Growth performance (□) for the same species from both estuaries was, however, similar. The highest L_∞ in the Volta estuary was estimated for *M. cephalus,* while in the Pra estuary *L. dumerilii* had the highest estimate. It must be noted that no estimate was made for *M. cephalus* in the Pra estuary because of the small sample size.

Discussion

Growth of fish can be described as either allometric or isometric depending on the exponent b (regression coefficient) of the length-weight relationship which is normally between 2.0 and 4.0. The value $b = 3.0$ indicates that the fish grows symmetrically or isometrically while values other than 3.0 indicate allometric growth (Tesch, 1971). In isometric growth, the shape of the fish is maintained throughout life while aspects of the growth in populations that exhibit allometric growth may be out of proportion or the adults may appear different from the young ones (Tesch, 1971).

With the exception of *L. grandisquamis* from the Pra estuary, the exponent b of the length-weight relationship of all the other species was significantly different from 3.0 - an indication that grey mullets from the two estuaries exhibit allometric growth. A similar observation of allometric growth was made by King (1996) for *M. curema, M. cephalus* and *L. falcipinnis* on the Nigerian coast. *M. cephalus* from both estuaries exhibited



b

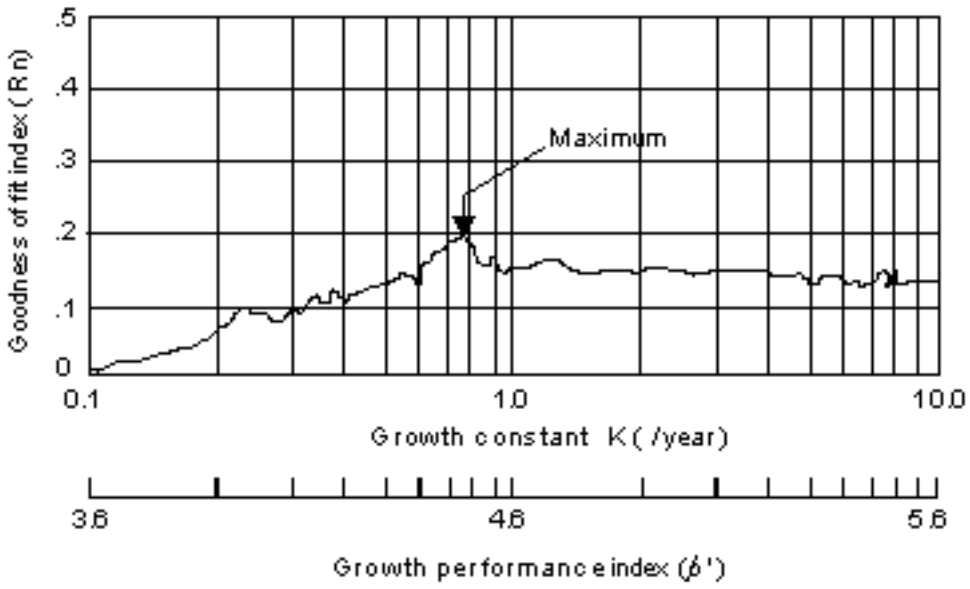


Fig. 2. Estimation of growth parameters - *M. bananensis* from the Volta estuary. Fig 2a - L from Wetherall plot; Fig. 2b - K from the scan routine showing the location of 'best' estimate of K = 0.78 yr

F

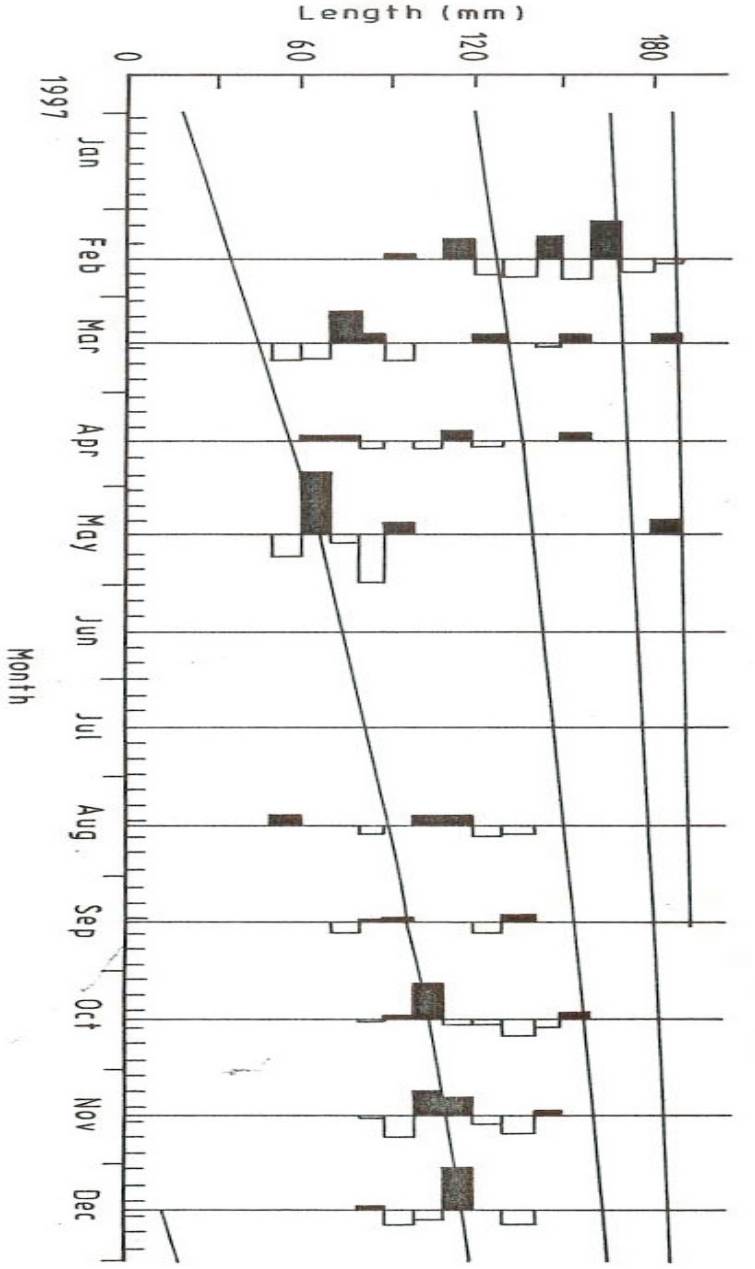


Fig. 3. Restructured length-frequency data with superimposed growth curve for *M. bananensis* from the Volta estuary. (L_∞ = 204.8 mm SL, K = 0.78 yr^{-1}, t_0 = - 0.07 and *Rn* = 0.159)

positive allometric growth, as reported for the species in the Niger Delta (Ikomi, 1990). The exponent *b* differed significantly for the same species in the two estuaries, except for *M. cephalus*.

The dissimilarity in *b* for a given species in the two estuaries indicates that the two habitats are different in terms of their impact on the shape of their fish populations. It is worth noting that the Pra estuary was more saline and turbid than the Volta estuary. Transparency ranged from 10 to 152 cm and 125 to 306 cm while salinity ranged from 0.07 to 16.0‰ and 0.06 to 8.17‰ in the Pra and Volta estuaries, respectively. Interpretation of the relationship of *M. cephalus* from the Pra estuary should, however, be treated with caution in view of the small sample size.

The growth parameters that were determined for the same species from the two estuaries were different. According to Sparre *et al.* (1989), growth parameters do not only differ from species to species but also among different populations of the same species. This may explain the different values obtained for the same species in each estuary. Apart from *L. dumerilii* from both estuaries whose L_∞ was similar, estimates for the species from the Volta estuary were relatively higher than those from the Pra estuary. All the species from the Volta estuary were comparatively larger than their counterparts from the Pra estuary. Fishing activities in and around the two estuaries were observed to be higher in the Pra than in the Volta estuary.

The preponderance of small-sized individuals in the samples from the Pra estuary could be an indication of overfishing which has, probably led to substantial reduction in the size of the species in that estuary. Apart from high fishing pressure it is

TABLE 3
Growth parameters (L , K, t_o) and growth performance index ( ) of grey mullets from the Volta and Pra estuaries

Species	*L (SL, cm)*	*K (year^{-1})*	*t_o (years)*	*f*
Volta estuary				
Liza falcipinnis	24.8	0.41	-0.225	4.41
Liza dumerilii	23.3	0.55	-0.169	4.50
Mugil curema	27.3	0.40	-0.224	4.48
Mugil bananensis	20.5	0.78	-0.122	4.51
Mugil cephalus	56.6	0.31	-0.239	4.99
Pra estuary				
Liza falcipinnis	22.0	0.42	-0.227	4.31
Liza dumerilii	23.3	0.42	-0.223	4.60
Liza grandisquamis	17.4	0.27	-0.382	4.66
Mugil curema	19.6	0.62	-0.156	4.38
Mugil bananensis	20.1	0.32	-0.308	4.09

also possible that low transparency in the Pra estuary due mainly to mining activities upstream could have adversely affected algal production and eventually growth of mullets. The growth performance index ( ) for the same species from both estuaries and among the various species was also similar except that of *M. cephalus*. This confirms the findings of Longhurst & Pauly (1987) that the growth performance index (( ) is constant for a given species and similar within related groups of species.

L and *K* of *M. cephalus* in the Negombo lagoon in Sri Lanka were 89.7 cm and 0.094 year^{-1}, respectively (Wijeyeratne & Costa, 1987). There are no estimates of growth parameters for the other species dealt with from previous studies; hence, no comparisons with populations from other areas could be made. However, specimens measuring 29.7 cm TL for *L. grandisquamis*, 41.0 cm TL for *L. falcipinnis* and 39.4 cm TL for *M. curema* have been reported from the Ébrié lagoon in Côte d'Ivoire (Alberet & Legendre, 1985). The estimated theoretical maximum sizes for the species in the current study suggest that the sizes of grey mullets in the two estuaries were, generally, relatively small.

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