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Age and growth of brown meagre *Sciaena umbra* (Sciaenidae) in the Adriatic Sea

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Abstract – Age and growth of the brown meagre *Sciaena umbra* (Sciaenidae) collected (n = 532) in the north-western Adriatic Sea was studied by means of transverse otolith sections. The maximum age estimated was 19 and 16 years for males and females, respectively. The length at age estimated for each sex indicated that females attain a larger size and grow slightly faster than males. Both marginal increment analysis and edge analysis confirmed that annuli are formed once a year, with opaque zones laid down in summer (June-July). Age readings were very precise, with a percentage agreement of 98% between readers and low values of the index of average percent error (0.9%) and coefficient of variation (1.3%). Von Bertalanffy growth function was fitted to age-length data, and growth parameters were estimated for males (L_∞ = 44.9 cm; k = 0.27, t_0 = −2.17 years) and females (L_∞ = 47.2 cm; k = 0.28, t_0 = −1.82 years). In both sexes of brown meagre, growth rate was high until they attain 2–3 years of age, i.e. at sexual maturity. Most of catches were obtained in late summer-early autumn. On the basis of present data, the sampled population of brown meagre mostly consisted of small fish younger than three years of age (about 90%). In addition, landings of this species in recent years largely decreased. As reported elsewhere in north-western Mediterranean, brown meagre stock in the Adriatic Sea showed clear signs of depletion, thus specific management measures for this species are urgently required.

Key words: Otolith / Age / Growth / Sciaenidae / Adriatic Sea

Résumé – Age et croissance du corb *Sciaena umbra* (Sciaenidae) en mer Adriatique. L'âge et la croissance du corb *Sciaena umbra* (Sciaenidae) est étudié d'après 532 spécimens collectés en mer Adriatique nord-ouest, et au moyen de coupes transversales d'otolithes. L'âge maximum est estimé à 19 et 16 ans, respectivement pour les mâles et les femelles. Pour chaque sexe, les tailles estimées correspondantes aux âges montrent que les femelles atteignent une plus grande taille et grandissent sensiblement plus vite que les mâles. Les analyses de l'accroissement marginal et du bord de l'otolithe confirment qu'un annulus est formé chaque année, avec une zone opaque déposée en été (juin-juillet). La précision des lectures d'âge est importante avec un pourcentage d'accord entre lecteurs de 98 % et de faible pourcentage moyen d'erreur (0,9 %), et un coefficient de variation (1,3 %). La fonction de croissance de von Bertalanffy est ajustée aux couples de données âge-taille, et les paramètres de croissance sont estimés pour les mâles (L_∞ = 44,9 cm ; k = 0,27, t_0 = −2,17 ans) et pour les femelles (L_∞ = 47,2 cm ; k = 0,28, t_0 = −1,82 ans). Chez les deux sexes du corb, le taux de croissance est élevé jusqu'à un âge de 2–3 ans, c'est-à-dire jusqu'à la maturité sexuelle. La majeure partie des captures sont obtenues vers la fin de l'été et le début de l'automne. Sur la base de ces données, la population échantillonnée consiste principalement en petits individus âgés de moins de 3 ans (90 % environ). De plus, les débarquements de cette espèce ont diminué fortement ces dernières années. Comme pour les stocks de corb du nord-ouest de la Méditerranée, le stock de corb de l'Adriatique montre clairement des signes de diminution, des mesures spécifiques de gestion seraient donc nécessaires et urgentes.

1 Introduction

In the Mediterranean Sea, the family Sciaenidae (croakers and drums) is represented by three genera, respectively *Argyrosomus*, *Sciaena* and *Umbrina* and five different species. The brown meagre, *Sciaena umbra* Linnaeus, 1758, is a common fish with a wide distribution, extending in the Eastern Atlantic coasts from Canary Islands to the English Channel and, throughout the Mediterranean Sea, to the Black Sea and Azov Sea (Chao 1986). It inhabits inshore waters down to about 180 m depth, living mainly in shelters on rocky bottoms or hidden within *Posidonia* beds (Tortonese 1975; Fischer et al. 1987; Harmelin 1991). It is generally a sedentary and gregarious fish, gathering in schools from 4–5 to more than 30 individuals, becoming more active nocturnally (Harmelin 1991; Harmelin and Marinopoulos 1993). Compared to other

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sciaenids, the brown meagre is a relatively small-sized fish, attaining a maximum size of 50 cm *SL* (Chao 1986).

S. umbra is abundant only in the south-western areas of the Mediterranean Sea, where it is locally exploited by the small-scale artisanal fisheries (Chakroun et al. 1982). Conversely, in the northern areas *S. umbra* is rarely caught and not recorded in the local fisheries statistics (Harmelin 1991). The stock abundance of *S. umbra* in the north-western Mediterranean Sea is currently declining, possibly due to overfishing and habitat degradation (Harmelin and Marinopoulos 1993).

Despite its wide distributional range, most data on biology of this species, such as feeding, reproduction and age and growth are limited to the south-western Mediterranean, namely the coastal waters off Tunisia (Chauvet 1991; Chakroun and Ktari 1981; Chakroun-Marzouk and Ktari 1985, 1998, 2001, 2003) and off Malta (Fiorentino et al. 2001; Ragonese et al. 2002, 2004).

The few available studies on age and growth of brown meagre provide rather different estimates of growth parameters and longevity (Ragonese et al. 2004), depending on different methodological approaches to study age and whether the full size range is available (Panfili and Morales-Nin 2002). Indeed, growth parameters of brown meagre were estimated by reading scales (Chakroun-Marzouk and Ktari 2003), burnt otoliths (Chauvet 1991) and otolith thin sections (Ragonese et al. 2004). Comparing with other studies using otoliths, Chakroun-Marzouk and Ktari (2003) reported a relatively low estimate of longevity. A possible explanation is that the use of scales could provide an underestimation of fish age due to scale resorption with growth, as observed in other species (Beamish and McFarlane 1983).

Aside from some studies on feeding habits of brown meagre (Fabi et al. 1998; Froglia and Gramitto 1998), no other biological data are currently available from the Adriatic Sea (north-western Mediterranean). This paper aims to extends the current knowledge of the age and growth of brown meagre to the north-western Adriatic Sea, using a validated otolith ageing method. The reliability of ageing estimates of brown meagre was tested evaluating the accuracy and precision of otolith readings, as well as comparing present results on growth parameters with those reported from other areas in the Mediterranean.

2 Materials and methods

Most specimens of brown meagre were collected in the north-western Adriatic Sea from August 1986 to September 1991, during a series of inshore bottom trawl surveys and artificial reef studies by trammel net sampling. Sampling sites were located between Ancona and Ravenna (Fig. 1), on sandy-muddy bottom from 10 to 15 m depth. Some additional samples were collected from landings of the commercial fishing fleet of Ancona from April 1995 to October 1997, in order to add larger (older) specimens to the previous sample. In any case, all fish were captured only in relatively shallow waters, i.e. in proximity of rocky habitat or artificial reefs which in the north-western Adriatic are restricted to coastal areas. The size range and number of specimens caught each year are summarized in Table 1.

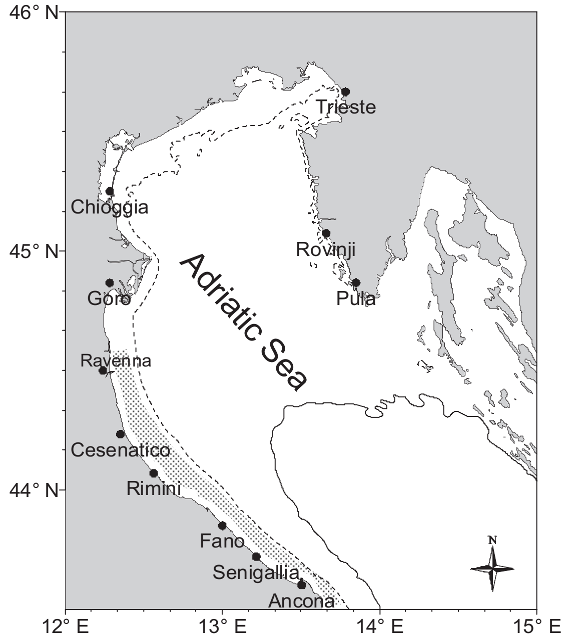

Fig. 1. Map of northern Adriatic Sea showing sampling area (shaded) of *Sciaena umbra*. Dotted and solid line indicate 20 m and 60 m depth isoline, respectively.

Table 1. Samples of *Sciaena umbra* collected in the Adriatic Sea, *n* = number of specimens.

Year	Size range (*TL* cm)	*n*
1986	20.5–23.5	4
1987	18.5–30.0	39
1988	18.0–36.0	29
1989	22.0–31.5	53
1990	13.0–36.5	96
1991	14.0–36.0	263
1995	17.0–48.5	23
1996	32.5–49.5	16
1997	16.0–48.0	9

Fish were measured for total length ($TL \pm 0.5$ cm), weighed for total weight ($TW \pm 1$ g) and sexed. Sagittal otoliths were removed from each specimen, cleaned and stored dry. Size-frequency distributions of males and females were compared using a two-sample Kolmogorov-Smirnov test (Sokal and Rohlf 1995). To test for any difference in otolith size, the weight of both right and left otoliths was recorded ($OW \pm 0.001$ g) and compared by a *t*-test for paired comparisons (Sokal and Rohlf 1995). One otolith chosen randomly from each pair was measured for maximum length along the sagittal plane ($OL \pm 0.01$ mm) using image analysis (Image-Pro Plus software package) linked to a binocular microscope by a CCD videocamera. Relationships between OL, OW and TL were evaluated by linear regression analysis.

Like most sciaenids, sagittal otoliths of brown meagre are very large and thick, so that they are unreadable if not sectioned. Hence, the right otolith was embedded in epoxy resin

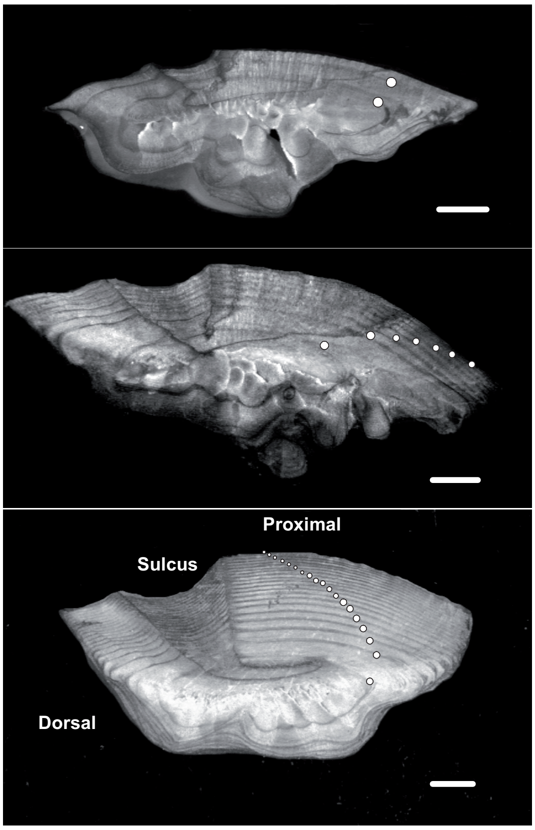

Fig. 2. Photomicrographs of the transverse sections through sagittal otolith of *Sciaena umbra*, aged 2 years (above), 7 years (middle) and 19 years (below). Dots indicate annuli; scale bars = 1 mm.

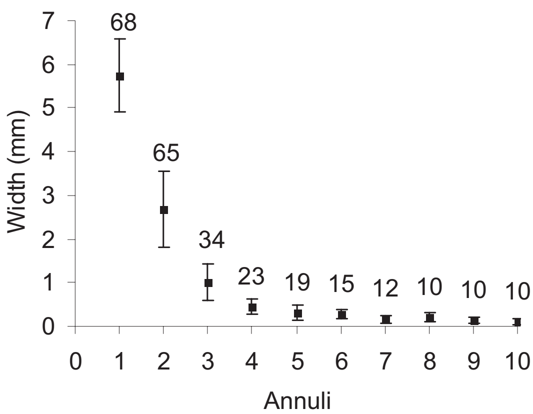

Fig. 3. Average width of annuli observed on otolith transverse sections of *Sciaena umbra* selected from the whole sampling period. Bars indicate standard deviation; total number of otoliths used for each age class is indicated above bars.

and transversely sectioned through the core with a Remet low-speed Micromet saw. Sections of about 700–800 μm thickness were stained with a Neutral Red Solution (Sigma) to enhance the contrast between opaque and translucent zones (Arneri et al. 1998) and seen under a dissecting microscope at low magnification (6–25 x) with reflected light and dark field. Under reflected light, the core and the opaque zones appeared as light rings and the translucent or translucent zones as dark rings (Fig. 2). The combination of each opaque zone and neighbouring translucent zone was considered to be an annulus, as reported in other sciaenids (Barbieri et al. 1994; Jones and Wells 1998). The count path of annuli was from the core towards the proximal margin of the otolith, where the pattern of accretion made annuli clearly evident. The width of each annulus was measured as maximum diameter (i.e. on a ventral-dorsal axis) ($\pm$ 0.01 mm).

Ages were assigned on the basis of counts of annuli. According to literature data on the spawning season (Chakroun-Marzouk and Ktari 1985, 1998; Fiorentino et al. 2001), August 1 was used as the birth date of brown meagre. To validate seasonality of deposition of opaque and translucent zones, the marginal increments were analyzed from all otolith samples (Beckman and Wilson 1995; Panfili and Morales-Nin 2002). In addition, the translucent margin was measured (Campana 2001) outside the first annulus along the ventral side of the otolith for all one year old fishes.

To assess ageing precision, all otolith sections were read independently by two different readers, without any ancillary data on fishes. Subsequently, disagreements were resolved through an additional reading with both readers. The index of average percent error (Beamish and Fournier 1981) and the mean coefficient of variation (Chang 1982), were calculated to estimate the relative precision between readings.

To evaluate growth, the von Bertalanffy growth function was fitted to the observed age-length data pairs using the program FISHPARM of the statistical package FSAS (Saila et al. 1988), applying the Marquardt algorithm for non-linear least squares parameter estimation. The von Bertalanffy growth parameters, i.e. the mean asymptotic length, L_∞, the Brody growth coefficient, k, and the hypothetical age at which the fish would have zero length, t_0 (Ricker 1975) were calculated for each sex (including undetermined fish) and for the whole population. Growth curve parameters were compared between sexes applying the likelihood ratio test (Kimura 1980). Following Haddon (2001), full data rather than mean length-at-age was used in this analysis. The growth performance index ($\Phi' = 2 \log L_\infty + \log k$) (Munro and Pauly 1983) was employed to compare growth of brown meagre from different sampling sites.

The length-weight relationship of fish was calculated for the whole population and for both sexes. The exponential equation $TW = a\,TL^b$, where TW is total weight (g), TL is total length of fish (cm) and a and b are regression parameters, was fitted to the data. An F-test was applied to test for difference in b between males and females (Sokal and Rohlf 1995). Furthermore, a t-test was applied to determine whether b values obtained from the linear regression differed significantly from $b = 3$, the value representing isometric growth, using the equation: $t = (b - 3)\, s_b^{-1}$, where s_b is the standard error (SE) of b.

All statistical analyses were performed with STATISTICA 5.0 (Statsoft) and FSAS software packages. In all statistical tests, rejection of the null hypothesis was based on $\alpha = 0.05$. For the TW-TL and OW-TL relationships, data were $\log_{10}$-transformed to correct for nonlinearity and heterogeneity of variances.

3 Results

3.1 Annulation pattern

The typical pattern consisted of an opaque core, surrounded on the proximal side by one translucent and one opaque zones, forming the first annulus. The width of the first annulus varied among fishes, and sometimes it was not clear, becoming almost continuous with the core. In some cases, this variation prevented identification of the first annulus. Subsequent annuli were very clear and wide, composed of a translucent zone and a narrower opaque zone. From the third annulus onwards, annuli became more regular and were composed of translucent and opaque zones of comparable width, showing an abrupt decrease of thickness and getting progressively narrower (Fig. 3). Interestingly, no overlap was found between annulus width in the first three years of life, indicating a progressive and discrete decrease in growth.

3.2 Fish size

Overall, 532 specimens of brown meagre were captured throughout the entire sample period. The overall sex ratio of males (255) and females (222) was 1.15:1, and not significantly different from 1:1 ($\chi^2 = 2.28$; $df = 1$; $p > 0.1$). Total length and weight frequency distributions of both sexes and unsexed fish were pooled and are summarized in Figs. 4a,b. The Kolmogorov-Smirnov test did not detect any significant differences ($p > 0.05$) in both frequency distributions between sexes. Unsexed fish (juveniles) measured from 13 to 29 cm (TL), whereas total length of males and females ranged from 16 to 48 cm and from 17 to 50 cm, respectively. Total weight ranged from 60 to 1664 g and from 60 to 1794 g for males and females, respectively. However, most of the fish captured were less than 500 g (92%).

3.3 Age composition, accuracy and precision

As expected, unsexed fish were 0–1 old juveniles (except for a 2 years old specimen), with gonads too small to be sexually determined macroscopically. Maximum age was 19 years for males and 16 years for females, respectively. Despite relatively high longevity, very few fish older than 4 years were captured over the entire sampling period. Indeed, approximately 90% of aged specimens were among 0 and 3 years, with a modal age of 1 year.

The annual periodicity of annulus deposition was confirmed by the edge analysis (Fig. 5a), indicating that translucent and opaque zones are formed once a year. The opaque zone was laid down in summer, between June and July. Conversely, the translucent zone is deposited during almost all the year, starting to form at the end of summer (September) (Fig. 5a). The width of the margin (i.e. the translucent zone beyond the first annulus) displayed a yearly sinusoidal cycle (Fig. 5b), with only one minimum in July. Lack of age 0+ fish in June-July also indicated summer deposition of the first opaque zone.

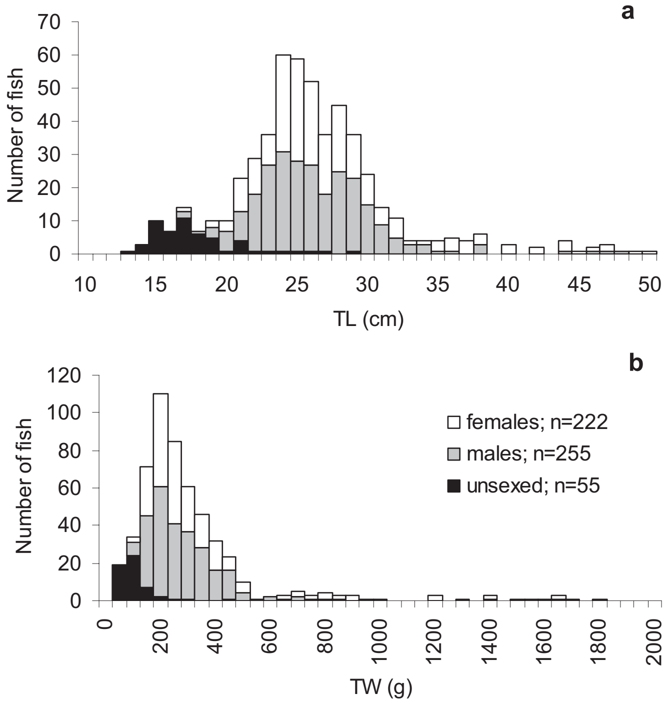

Fig. 4. Frequency distribution of total length (TL) (a) and total weight (TW) (b) for males, females and unsexed *Sciaena umbra* collected in the north-western Adriatic Sea from 1986 to 1991. n = total number of specimens.

Age readings between readers were precise, supporting the reliability of otolith sections for ageing brown meagre. The average percent error and CV were low (0.9% and 1.3%, respectively) with a percent agreement between readers of 98.1%. Age readings never disagreed more than one year, and all disagreements were due to difficulty in identifying the first annulus.

3.4 Otolith size-fish size relationships

Otolith maximum length (OL) and otolith weight (OW) ranged between 5.8 to 18.2 mm and 0.07 to 1.45 g, respectively. The relationship between OL and fish size (TL) was linear and allometric (Fig. 6a). In detail, two growth stanzas were observed, barely separated at about 30 cm TL by a slight step. Otolith maximum length was initially negatively allometric ($b = 0.73$; $SE = 0.0147$) but from 30 cm TL onwards it switched to nearly isometric ($b = 0.87$; $SE = 0.035$), although it differed significantly from unity (t-test; $t = 3.68$; $p < 0.01$). Interestingly, the allometric growth pattern between OL and TL changed at a fish size of about 30 cm TL, that roughly corresponds to the onset of sexual maturity (see below). On the other hand, the best fit between OW and fish size (TL) was curvilinear, explaining 95% of the otolith weight variation (Fig. 6b).

3.5 Fish length-weight relationships

No difference was found between the length-weight relationships calculated for males and females (F-test;

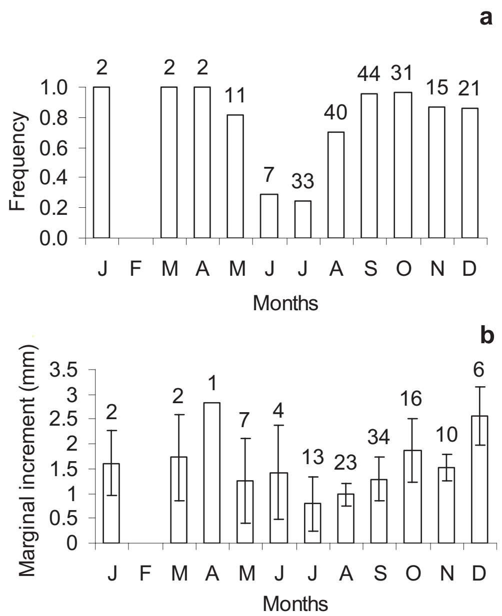

Fig. 5. Monthly change in relative frequency of translucent zone on the otolith edge (a) and mean monthly marginal increment (b) for *Sciaena umbra* selected from the whole sampling period. Bars indicate standard deviation; total number of otoliths used for each month is indicated above bars.

Table 2. Estimates of Von Bertalanffy growth parameters for *Sciaena umbra* in the Adriatic Sea. Standard errors in brackets.

Parameter	Males	Females	All
L_∞ (cm)	44.9 (1.50)	47.2 (1.08)	47.1 (0.96)
k	0.27 (0.03)	0.28 (0.02)	0.24 (0.02)
t_0 (year)	–2.17 (0.20)	–1.82 (0.14)	–2.25 (0.15)
Φ'	2.73	2.79	2.74

$df = 1.583$; $F = 0.36$; $p > 0.5$). As a result, data from both sexes and unsexed fish were pooled. The length-weight relationship for the whole population was described by the following equation:

$$TW = 7.15 \times 10^{-3}\ TL^{3.20} \quad r^2 = 0.98;\ n = 532;\ p < 0.01.$$

The slope of the regression line ($b = 3.20$; $SE = 0.017$) was significantly different from 3.00 (t-test for allometry; $t = 11.43$; $p < 0.01$), indicating a positive allometric growth.

3.6 Growth

The von Bertalanffy growth curves fitted to the observed age-length data pairs were estimated for each sex (including unsexed fish) and for the whole population (Fig. 7). Von Bertalanffy growth parameters and the derived growth performance index (Φ') are reported in Table 2. Both sexes of brown meagre showed a rapid increase in size during the first two to three years of life. Then the annual growth rate gradually decreased until seven years of age, remaining very low thereafter.

Results of the likelihood ratio tests indicated that the overall Von Bertalanffy growth function significantly differed between sexes ($\chi^2 = 8.21$; $df = 3$; $p < 0.05$). No comparison between single parameters was significant ($p > 0.1$ for all parameters), but comparisons using a combination of two parameters differed significantly between sexes ($p < 0.05$ for all comparison, Table 3). Remarkable difference in length-at-age data (Table 4) derived from the Von Bertalanffy growth function were observed between sexes (t-test for paired comparison; $t = 9.17$; $p < 0.001$), notably in fish older than 5 years, providing an explanation for the observed differences between growth curves. In both sexes, the annual growth rate ranged from 19 to 0.5 cm in the first 10 years of age, becoming virtually zero in older fish. Similarly, the index of growth performance Φ' was similar between sexes (Table 2).

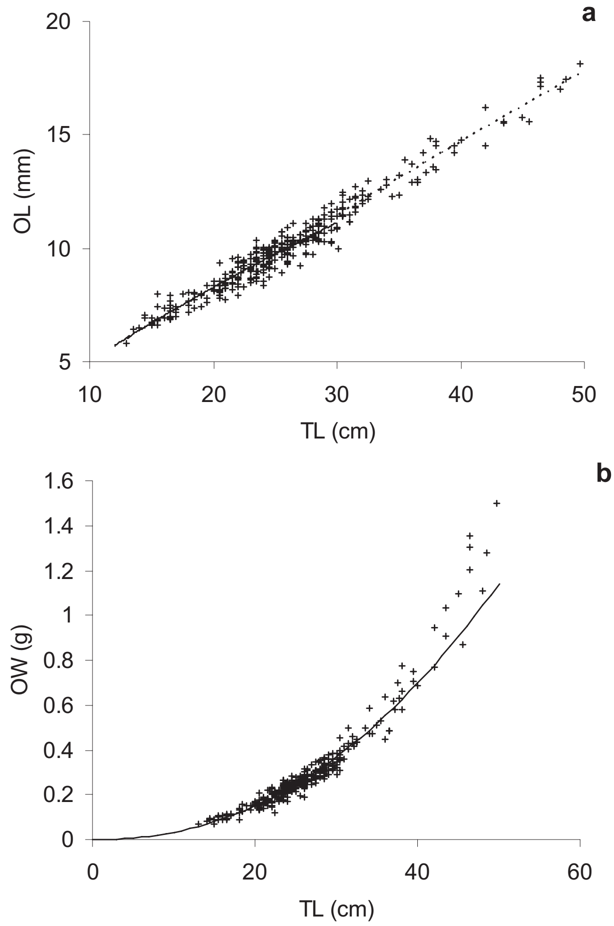

Fig. 6. Scatter plots and fitted regression lines of maximum otolith length (OL) (a) and otolith weight (OW) (b) versus fish length (TL). Fitted equations: $OW = 1.99 \times 10^{-4}\ TL^{2.21}$, $r^2 = 0.95$, $n = 310$; $OL = 0.93 + 0.73\ TL$, $r^2 = 0.90$, $n = 281$ for $TL < 30$ cm; OL $= 0.60 + 0.87\ TL$, $r^2 = 0.91$, $n = 60$ for $TL > 30$ cm.

4 Discussion

Sciaenids are characterized by having relatively large otoliths, as an adaptive feature associated with specialization in acoustic communication and marked nocturnal activity (Cruz and Lombarte 2004; Lombarte and Cruz 2007), making their collection and handling easy for ageing purposes.

Table 3. Likelihood ratio tests comparing Von Bertalanffy parameters estimates for both sexes of *Sciaena umbra* in the Adriatic Sea. Statistics are based on seven null hypothesis, assuming that each parameter or a combination of them do not differ between sexes. RSS = residual sum of squares.; df = degree of freedom; *significant at α = 0.05; ** significant at α = 0.01; ns = not significant.

Parameter	Males			Females			RSS	χ^2	df	p
	L_∞ (cm)	k	t_0 (year)	L_∞ (cm)	k	t_0 (year)				
Hypothesis										
Independent	44.9	0.27	–2.17	47.2	0.28	–1.82	2014			
H_0: $=L_\infty$; $=k$; $=t_0$	46.5	0.27	–2.00	46.5	0.27	–2.00	2071	8.21	3	*
H_0: $=L_\infty$	46.5	0.24	–2.30	46.5	0.29	–1.77	2024	1.48	1	ns
H_0: $=k$	44.6	0.28	–2.13	47.5	0.28	–1.85	2015	0.08	1	ns
H_0: $=t_0$	44.0	0.30	–1.97	47.9	0.26	–1.97	2027	1.90	1	ns
H_0: $=L_\infty$; $=k$	46.5	0.27	–2.01	46.5	0.27	–1.99	2070	8.05	2	**
H_0: $=L_\infty$; $=t_0$	46.5	0.27	–2.01	46.5	0.26	–2.01	2070	8.11	2	**
H_0: $=k$; $=t_0$	46.2	0.27	–2.01	46.7	0.27	–2.01	2062	6.99	2	*

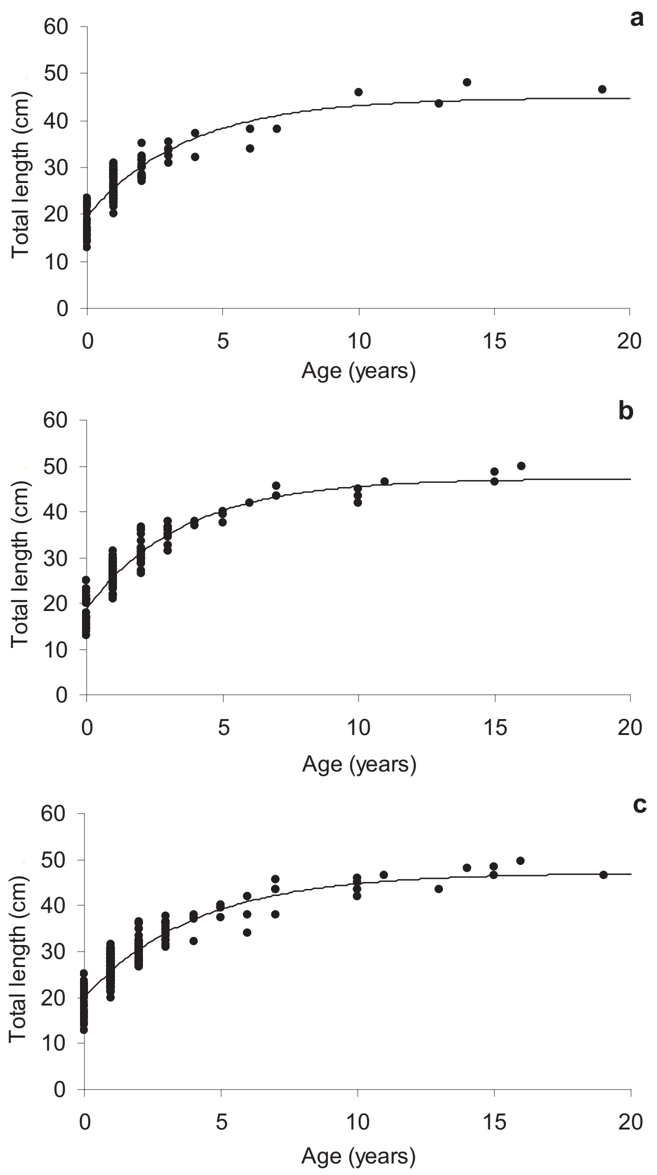

Fig. 7. Plots of age-length data and fitted Von Bertalanffy growth curves for males (a), females (b) and whole population (c) of *Sciaena umbra* from the north-western Adriatic Sea.

Table 4. Estimates of length-at-age and annual growth for *Sciaena umbra* in the Adriatic Sea.

Age Group	Length at age (cm)		Annual growth (cm)	
	Males	Females	Males	Females
0	19.8	18.9		
1	25.7	25.8	5.9	6.9
2	30.2	31.0	4.5	5.2
3	33.7	34.9	3.4	3.9
4	36.3	37.9	2.6	3.0
5	38.3	40.2	2.0	2.3
6	39.9	41.9	1.5	1.7
7	41.0	43.2	1.2	1.3
8	41.9	44.2	0.9	1.0
9	42.6	44.9	0.7	0.7
10	43.2	45.5	0.5	0.6
11	43.6	45.9	0.4	0.4
12	43.9	46.2	0.3	0.3
13	44.1	46.5	0.2	0.2
14	44.3	46.7	0.2	0.2
15	44.4	46.8	0.1	0.1
16	44.5	46.9	0.1	0.1
17	44.6	47.0	0.08	0.08
18	44.7	47.0	0.06	0.06
19	44.7	47.1	0.05	0.05

Moreover, huge consistency among repeated age readings and validation of annuli on otolith sections make them the most reliable hard part for ageing sciaenid fishes (Barger 1985; Beckman et al. 1989; Barbieri et al. 1994; Jones and Wells 1998; Ihde and Chittenden 2002). This is particularly true for the brown meagre, as reported in several studies dealing with age determination for this species (Chauvet 1991; Ragonese et al. 2004; Artüz 2006).

Using scales for ageing brown meagre, Chakroun-Marzouk and Ktari (2003) were able to provide an accurate estimate of age only for fish younger than 9 years, discarding more than 30% of their available sample. Conversely, by examining otolith sections it was possible to consistently determine age in fish of 20 years or older (Chauvet 1991; Ragonese et al. 2004; present study), almost without any discard. The

Table 5. Estimates of Von Bertalanffy growth parameters and age range for *Sciaena umbra* from different geographical areas. Φ' = growth performance index (see text).

	Area and source	L_∞ (cm)	k	t_0 (year)	Φ'	TL (cm)	Age (year)	n
Tunisian coast								
	Chauvet, 1991							
	females	53.9	0.190	–0.002	2.74	12.5–52.5	1–21	
	males	46.7	0.224	–0.120	2.69	12.4–44.5	1–15	
	Chakroun–Marzouk and Ktari, 2003							
	females	53.7	0.186	–0.828	2.73	13.4–49.6	1–9	484
	males	45.0	0.225	–0.817	2.66	13.6–44.4	1–9	394
Maltese coast								
	Ragonese et al., 2004							
	females	47.6	0.116	–6.132	2.42	31.1–48.5	3–26	51
	males	42.3	0.145	–5.765	2.41	30.5–43.0	3–17	129
Adriatic Sea								
	Present study							
	females	47.2	0.279	–1.823	2.79	20.0–49.7	0–16	118
	males	44.9	0.268	–2.168	2.73	16.5–48	0–19	128

high precision between readers in the present study support the conclusion that otolith sections are the most reliable method for ageing brown meagre.

Consistent with many other sciaenids, such as *Cynoscion nebulosus* (Nieland et al. 2002), *Cynoscion regalis* (Lowerre-Barbieri et al. 1994), *Micropogonias undulatus* (Barbieri et al. 1994), *Pogonias cromis* (Beckman et al. 1990) and *Sciaenops ocellatus* (Ross et al. 1995), our results showed annuli in otolith sections of brown meagre are deposited annually. As observed in *Micropogonias undulatus* (Barbieri et al. 1994), individual variation in the width of the first annulus accounted for disagreement between readings, probably linked to an extended spawning season from March to August (Chakroun-Marzouk and Ktari 2003).

The Von Bertalanffy growth function fitted to observed age-length data adequately modelled the growth of brown meagre, at least within the age range estimated. Both sexes increased rapidly in length until attaining sexual maturity at about three years of age, after which females reached a higher asymptotic length than males. High negative values of t_0 probably reflect the fast growth rates of juveniles. Comparing the growth parameters of brown meagre from different areas (Table 5), significant differences in growth rates and L_∞ (mainly of females) from the Tunisian coast and Adriatic Sea may indicate the existence of different populations. Fish sampled off Malta seem to be more similar to those of the Adriatic Sea (see Table 5), despite the relatively low growth coefficient (k) observed in both sexes, probably due to the lack of individuals younger than three years (Ragonese et al. 2004). The longevity of brown meagre was comparable among studies based on otolith readings (Chauvet 1991; Ragonese et al. 2004; present study), whereas it was significantly lower by examining scales (Chakroun-Marzouk and Ktari 2003). A similar discrepancy of longevity using otoliths and scales were recently indicated in another sciaenid, *Umbrina canariensis* (Hutchings et al. 2006).

On the basis of both laboratory observations and official landings statistics (Harmelin 1991; Fiorentini et al. 1997), the stock abundance of *S. umbra* in the north-western Mediterranean Sea experienced a sharp decline in the last four decades, becoming a species to be protected (Harmelin 1991; Chauvet 1991). Among possible causes, habitat degradation through reduction of *Posidonia* beds, pollution and overfishing are generally invoked (Harmelin and Marinopoulos 1993). Habitat degradation and pollution are linked because pollution is one of the main sources of perturbation which impact seagrass condition (Bouderesque et al. 2006).

As far as overfishing is concerned, our catch data strongly indicated stock depletion, at least in the Adriatic Sea. Bearing in mind the considerable sampling effort spent for the present study, in terms of temporal and geographical sampling coverage and different gears used, it can be reasonable to assume that our sample is representative for the population at sea. In recent years, landings of brown meagre decreased, and mostly (90%) consisted of small fish younger than three years of age. Although the maximum size observed in our sample is close to the maximum theoretical length, fish older than 7 years were extremely rare. As a result, the fishery almost exclusively targeted juvenile fish, with a detrimental effect on recruitment. The recent reduction of seagrass meadows where juveniles of brown meagre usually settled at 10–15 mm TL (Harmelin 1991), would hamper considerably the recruitment success. Yet, the marked spawning aggregations of this species in summer make it particularly vulnerable to fishing (Harmelin 1991; Fiorentino et al. 2001).

Paradoxically, on the basis of its life history, brown meagre may sustain fishing pressure to greater extent than other long-lived fish. Indeed, differently from long-lived fish which typically grow slowly and mature late (Beverton 1992), brown meagre attain sexual maturity and a large size quickly, namely at about less than 15% of their long life span. As a consequence, they can be reproductively active over a potential lifespan of at least 20 years. On the other hand, the long life observed in brown meagre suggests a low mortality rate for larger-older fish, providing concerns in sustaining heavy fishing pressure.

In conclusion, a common policy to implement specific management measures of this species over their range of distribution, along with a better insight on population dynamics, are urgently required, with the aim to enable population to a quick and lasting recovery, which is currently present only within marine protected areas.

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