Indian J. Fish., 66(3): 12-23, 2019
DOI: 10.21077/ijf.2019.66.3.76966-02

Somatic growth and age of selected commercial fish species of the Cullera Coast, Iberian Peninsula, south-east Spain

ANGELA-MARIA JARAMILLO-LONDONO[1], ALEJANDRA-VANINA VOLPEDO[2], JOSE-LUIS DIAZ-AREVALO[3], MARIA-EUGENIA RODRIGO-SANTAMALIA[4] AND VICENT BENDITO-DURA[5]

[1]*Faculty of Environmental Engineering. University Santo Tomas, Carrera 9 #51-11, Bogota, Colombia*
[2]*Center for Transdisciplinary Studies of Water, Faculty of Veterinary Sciences, University of Buenos Aires National Council of Scientific and Technical Research, Argentina*
[3]*National University of Colombia. Bogota, Colombia*
[4]*Mediterranean Agroforestry Institute, Polytechnic University of Valencia, Vera Road s/n 46022, Valencia, Spain*
[5]*D.I.H.M.A. Ecology Laboratory, Polytechnic University of Valencia, Cn de Vera s/nº 46071. Valencia, Spain*
e-mail:angelajaramillo@usantotomas.edu.co

ABSTRACT

This work provides data on the somatic growth and age of selected commercial fish species of the Cullera Coast, Spain. The biological information available that permits responsible fishery management of these species is relatively scarce. This study was conducted in the Bay of Cullera, Spain (39º 12' to 38º 59' N; 0º 09' to 0º 15' W) and selected benthic fish species were analysed that are frequently fished by trammel nets (mesh size 28-76 mm) at a maximum depth of 30 m. Maturity, age and growth of 63 torpedoes (*Torpedo torpedo*); 115 red scorpionfish (*Scorpaena scrofa)*; 280 red mullets (*Mullus surmuletus*); 139 stargazers (*Uranoscopus scaber*) and 476 Portuguese soles (*Dagetichthys lusitanicus*) were analysed. The data obtained in this study revealed that 50% of individuals of all species reached sexual maturity at TL (total length) of 20.0-36.5 cm and at an age of 2-6 years. The von Bertalanffy growth equation derived were: $TL=37.0\ [1 - e^{(-0.2(t + 0.33))}]$; $TL=31.5\ [1 - e^{(-0.38(t+0.54))}]$; $TL=35.5\ [1 - e^{(-0.2(t+2.08))}]$ and $TL=34.3[1 - e^{(-0.14(t+2.16))}]$ for *S. scrofa, M. surmuletus*; *U. scaber* and *D. lusitanicus* respectively.

Keywords: Age, Commercial fish, *Dagetichthys lusitanicus,* Growth, *Mullus surmuletus, Scorpaena scrofa, Torpedo torpedo, Uranoscopus scaber*

Introduction

Fishing resources are showing signs of overexploitation in the Mediterranean Sea, as in most fishing areas worldwide (FAO, 2012; Abalo-Morla, 2015, Tsikliras *et al*., 2015). Knowledge on the biology of fish species of commercial interest is a fundamental tool for the design of sustainable fisheries management measures. According to FAO (2012), Mediterranean fishing areas are facing problems, due to the fact that fish catch have reduced by 15%. In Cullera (Spain), 30,028 and 27,158 t of fish were caught in 2009 and 2010, respectively, which represents 9.6% reduction in one year.

Along the Cullera Coast, traditional fishing is a long-established activity, with 792 t of fish caught in 2009, 773 t in 2010, and less than 500 t in 2014 (FAO, 2014, Abalo-Morla, 2015). Some important commercial species include *Mullus surmuletus* (Linnaeus, 1758), *Scorpaena scrofa* (Linnaeus, 1758), *Dagetichthys lusitanicus* de Brito Capello (1868) and *Uranoscopus scaber* (Linnaeus, 1758) and *Torpedo torpedo* (Linnaeus, 1758). The available biological information that permits responsible fishery management of these species is relatively scarce except for *M. surmuletus* for which a great deal of biological information is available (Suau and Vives, 1957; Morales-Nin, 1991; Reñones *et al*., 1995; Labropoulou *et al*., 1997; Machias *et al*., 1998; Mazzola *et al*., 1999; Aguirre, 2000; Lombarte *et al*., 2000; Morato *et al*., 2001; Lloret and Lleonart, 2002; Machias and Labropoulou, 2002; Tserpes *et al*., 2002; Aguirre and Sanchez, 2005; Mahe *et al*., 2005; Mata *et al*., 2008).

The objective of the present study was to contribute to the knowledge on the age and growth of selected species caught by traditional fishing practices in the Bay of Cullera, Valencia, south-eastern Iberian Peninsula, to aid in the sustainable fishery management of these species.

Materials and methods

The samples used in the present study were collected from the fishing port of Cullera in Spain (39º 12' - 38º 59' N; and 0º 09' - 0º 15' W), caught by trammel nets (mesh size 28-76 mm).

Fishes were collected on a weekly basis, for eight months between July 2004 to January 2006 (March, April,

May, June, July and October 2005 and January 2006), from Cullera Harbour, in order to cover all seasonal periods. Thirty samplings were done, during which fish of the selected species *viz*., *T. torpedo*, *M. surmuletus*, *U. scaber*, *S. scrofa* and *D. lusitanicus*, were collected. Samples were stored at -18ºC until processing in the laboratory. The specimens were identified using appropriate keys (Corbera *et al*. 2000; Whitehead *et al*. 2001; Froese and Pauly, 2008).

Total length (TL) (±0.1 mm) and total fresh weight (TW) (±0.05 g) were recorded and gender was determined. Sagittal otoliths were removed to determine the age of the fish and to calculate age-size relationships based on the von Bertalanffy growth equation by considering males, females and all specimens (Granado, 1996; Sparre and Venema, 1997). The sagittae of the following 4 species: *S. scrofa* (N=40), *M. surmuletus* (N=29), *U. scaber* (N=24) and *D. lusitanicus* (N=121) were analysed. Males and females were segregated, TL was measured in mm, and sagittae were removed from the otic capsules to examine their morphology and morphometry under a stereoscopic microscope to the nearest 0.1 mm (Jaramillo *et al*., 2014). Otolith morphological descriptions are based on the terminology proposed by Volpedo and Echeverría (2000) and Tused *et al*. (2008). For the determination of sexual maturity, the scale proposed by Holden and Raitt (1975) was adapted in four phases for *M. surmuletus*, *D. lusitanicus*, *S. scrofa* and *U. scaber* and adapted to three phases for *T. torpedo.* The von Bertalanffy growth parameters were estimated by the Marquardt algorithm using the FiSAT II (FAO-ICLARM Fish Stock Assessment Tools) (Gayanilo *et al*., 1996) and FISHPARM (Prager *et al*., 1987) computer programs.

The existence of significant differences in TL and fresh weight was analysed in each species according to the season of the year and gender using Analysis of Variance (ANOVA). Normality (Kolmogorov-Smirnov test) and homogeneity (Levene test) assumptions were checked. The size-weight relation of fish was determined by linear regression analysis, using weight as the dependent variable following logarithmic data transformation. The statistical data analysis was done using the software SPSS 16.0 for Windows (SPSS Inc.) and Statgraphics Centurion XV, version 15.2.06.

Results and discussion

Table 1 summarises the main sample characteristics according to species, gender and size range. The smallest sizes were equivalent to the smallest fish that are allowed to be caught with trammel nets. TL ranged between 9 and 44 cm. No specimens that exceeded the characteristic maximum sizes per species were encountered. In general terms, there was no evidence of variation in individual mean size throughout the sampling period.

Size-weight relationship

Length-weight relationships (LWRs) are the most used tool to estimate fish growth, as well as population biomass and different morphological relationships (Roul, 2017). For size-weight relation ($W= aL^b$) for the species under study, the functions fitted very well ($r^2>0.93$). For *M. surmuletus*, *D. lusitanicus* and *U. scaber,* b value of >3 was estimated, while for *S. scrofa* and *T. torpedo,* it was found to be <3. In the five species studied, the b value range was between 2.92 for *S. scrofa* and 3.26 for *D. lusitanicus* (Fig.1).

Although only a small sample obtained by commercial and artisanal landings was considered in this study, it was observed that only *S. scrofa* presented isometric growth (t=1.946, d.f.=76, p=0.252). The remaining species showed different growth patterns based on the sizes considered in this study (*M. surmuletus*: t=4.6, d.f.=150, p<0.05; *D. lusitanicus*: t= 7.03, d.f.=450, p<0.05; *T. torpedo*: t=2.3, d.f.=61, p<0.05; *U. scaber*: t=0.63; d.f.=125, p<0.05). When b<3, which was the case for *T. torpedo,* it was found that the fish grew more in length than in relation to weight, when b>3 (*M. surmuletus*, *D. lusitanicus,* and *U. scaber*), as the fish grew in length, the weight also increased. These variations in fish growth patterns indicate that the fish population ranged from immature to fully mature individuals. The differences in weight for all the sampled batches could be attributed to individual condition factors, as some authors suggest that these patterns reflect the priorities of vital functions, for *e.g.*, feeding, locomotion and respiration (Osse and van den Boogaart, 1995; Post and Parkinson, 2001; Fafioye and Oluajo, 2005).

Table 1. Sample characteristics according to species, gender and size

Characteristics	*M. surmuletus*	*D. lusitanicus*	*S. scrofa*	*T. torpedo*	*U. scaber*
Total (n)	280	476	115	63	139
Females (n)	73	313	41	33	70
Males (n)	79	149	39	30	59
Sex not determined (n)	128	14	35	0	0
TL (mm) ± SD	194.3 ± 27.2	232.8 ± 34.0	227.0 ± 56.7	256.2 ± 108.3	229.2 ± 41.0
Min. TL (mm)	147	145	89	115	139
Max. TL (mm)	285	343	370	442	355

This relationship was also evaluated by considering both fish genders with a Student's t-test. No significant differences were found between the slopes of the weight-length relation between males and females for any of the species studied (Table 2).

The TL-weight relation of *M. surmuletus* studied by Morales-Nin (1991) in fish from Majorca (Spain) was recorded at b=2.91 in the whole sample; the values being b=2.92 for females and b=2.66 for males. These results do not coincide with those obtained in the present work. As Morales-Nin (1991) mentioned, this might be because the work considered small-sized fish. Conversely, Renones *et al.* (1995) found similar b values to those reported herein, with both males and females showing positive allometric growth (b=3.11 in females, b= 3.07 in males and b=3.12 in all specimens) in fish from the Balearic Islands (Spain). Mahe *et al.* (2005) also noted positive allometric growth for red mullets in the

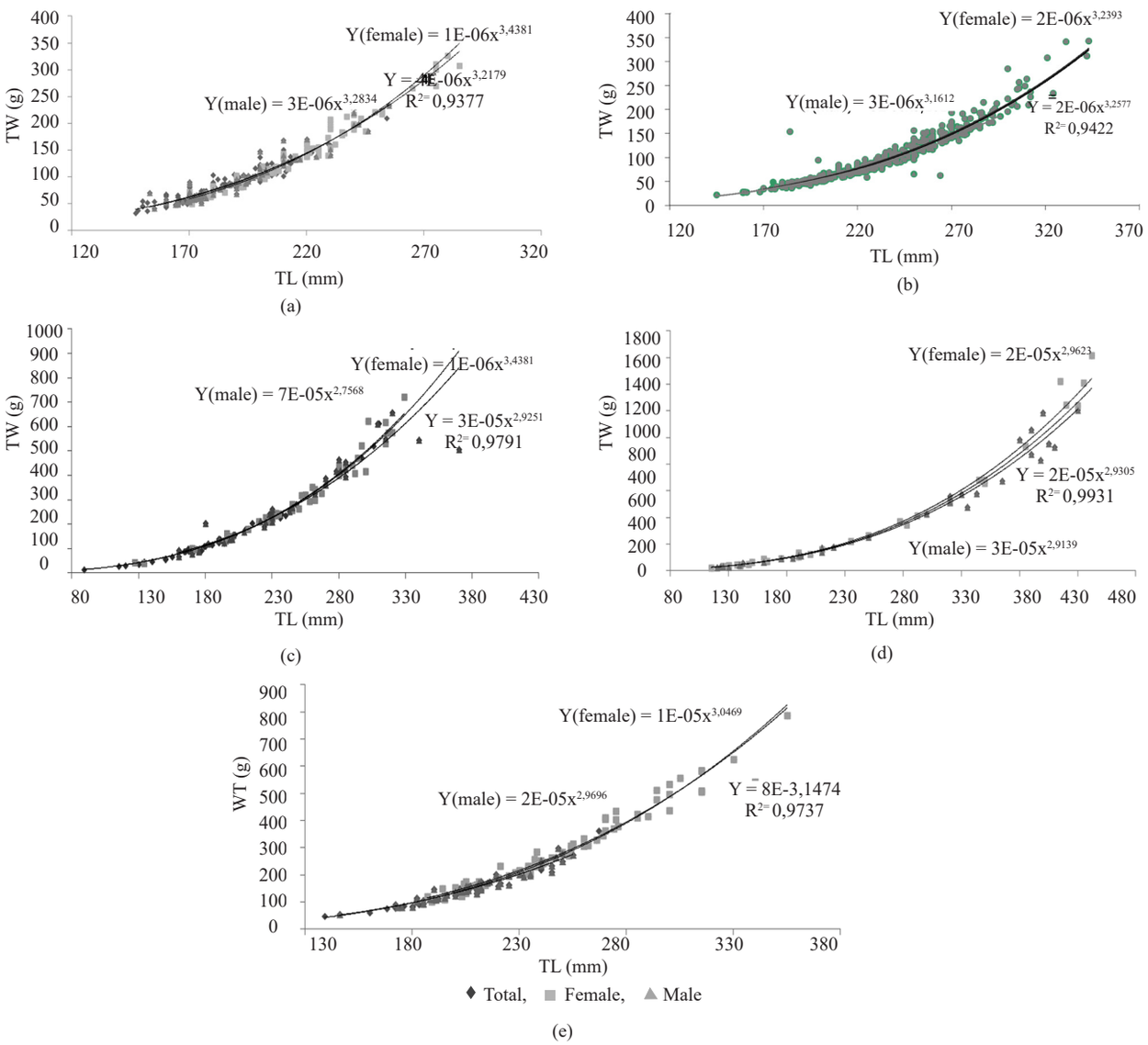

Fig.1. Size-weight relationship of the species studied. (a): *M. surmuletus*, (b): *D. lusitanicus,* (c): *S.scrofa*, (d): *T.torpedo,* (e): *U. scaber*

Table 2. Differences in the size-weight relation between genders ($p<0.05$). Student's t-test, d.f.: degrees of freedom.

Species	t	d.f.	p
M. surmuletus	1.009	148	0.258
D. lusitanicus	0.891	458	0.254
S. scrofa	1.316	76	0.164
T. torpedo	0.797	59	0.374
U. scaber	0.631	125	0.382

North Sea (b=3.18 for females, b=3.25 males), as did Mata *et al*. (2008) in the Atlantic Ocean (b=3.2). The differences in b values may be due to several factors such as sample size, length range covered, type of habitat, ontogenetic development, season, population, sex, gonad maturity, diet and health (Roul *et al*., 2017).

Information about the size-weight relation in *D. lusitanicus* is very scarce. The only reference found is that of Mata *et al*. (2008) for the Atlantic coastal waters of Spain (b=3.2). The literature on *S. scrofa* reports b values that oscillate between 2.7 and 3.3 (Campillo, 1992; Dulcic and Kraljevic, 1996; Stergiou and Moutopoulos, 2001; Moutopoulos and Stergiou, 2002; Valle *et al.,* 2003; Mendes *et al.,* 2004; Karakulak *et al*., 2006; Ozaydin and Taskavak, 2006; Ferreira *et al*., 2008; Crechriou *et al.*, 2013; Moutopoulos *et al*., 2013). For *T. torpedo*, Consalvo *et al.* (2007) described negative allometric growth for both females (b=2.86) and males (b=2.73) on the Italian Mediterranean Sea coast. Moreover, similar works conducted on *T. californica* (Neer and Cailliet, 2001) found that the TL-weight relation equalled $y=0.00002\ x^{3.02}$ in females and $y=0.00004\ x^{2.87}$ in males. For *U. scaber*, Sanz (1985) reported a relationship in which the length exponent (b) for males was 2.96 and b=3.03 for females, which is similar to the findings reported herein. Similar data were reported by other authors such as Dulcic and Kraljevic (1996), Abdallah (2002), Mendes *et al.* (2004), Karakulak *et al*. (2006), Sangun *et al*. (2007), Ak *et al.* (2009), Giacalone *et al*. (2010), Bok *et al*. (2011), Crechriou *et al.* (2013), Kasapoglu and Duzgunes (2013) and Moutopoulos *et al*. (2013).

Size-gender relationship vs. seasonality

The possible differences in fish sizes in relation to gender and the time of the year in which they were caught were statistically examined by ANOVA (Table 3). The results revealed that, significant differences were found only for size between males and females in *M. surmuletus* and *D. lusitanicus*, as females were considerably larger than males. In general, it would appear that mean fish size did not vary for any of the studied species during the sampling period.

In the typical landings of *M. surmuletus,* males with TL<20 cm predominated. However, larger sizes (>20 cm) corresponded to females. No male with TL over 25 cm was found. Similar results were obtained for *D. lusitanicus, S. scrofa* and *U. scaber,* among which larger-sized females predominated. The dominance of females may be due to the fact that, when reaching larger size, they are more easily captured with the trammel net. The TL of *T. torpedo* males was longer than that of females. Regarding differences in fish size in relation to gender for *M. surmuletus,* some authors (Renones *et al*., 1995; Mahe *et al*., 2005) have found that, at the same age, females were much bigger than their male counterparts, which is in agreement with our results. For *U. scaber,* the differences found in the present study are similar to those reported by Sanz (1985) in the Gulf of Valencia, who discovered that females (23.47 ± 0.22 cm) were larger in size than males (20.06 ± 0.21 cm). No publilished information on these aspects are available for *D. lusitanicus, S. scrofa* or *T. torpedo*. In relation to differences between genders, we found that there is a general trend whereby females reach larger sizes, especially in *M. surmuletus* and *D. lusitanicus*.

Size-sexual maturity relationship and reproductive potential

The results reveal that 50% of the *M. surmuletus* samples reached sexual maturity at TL of 20 cm (TL of 21cm in females and 17.5 cm for males), whereas *D. lusitanicus* reached sexual maturity at TL of 25

Table 3. Differences in fish size in relation to gender and time of year ($p<0.05$).

Species	Comparisons	F	d.f.	M
M. surmuletus	Gender	34.18	1	<0.05
	Time of year	1.47	3	0.23
	Gender x Time interaction	1.5	3	0.22
D. lusitanicus	Gender	8.2	1	<0.05
	Time of year	1.23	3	0.3
	Gender x Time interaction	0.16	3	0.92
S. scrofa	Gender	2.93	1	0.18
	Time of year	2.89	3	0.18
	Gender x Time interaction	2.17	3	0.22
T. torpedo	Gender	0.69	1	0.41
	Time of year	1.02	2	0.37
	Gender x Time interaction	0.09	2	0.91
U. scaber	Gender	0.23	1	0.63
	Time of year	1.91	2	0.15
	Gender x Time interaction	1.35	2	0.26

d.f. : Degrees of freedom

cm (25 cm in females, 22 cm in males), *S. scrofa* at 25 cm (28 cm in females, 22.5 cm in males), *T. torpedo* at a TL of 36.5 cm (34.5 cm in females, 36.5 cm in males) and *U. scaber* at a TL of 23.5 cm (24 cm in females, 21 cm in males) (Table 4).

In most species, 50% of individuals reached sexual maturity at TL of <25 cm and at TL>25 cm, most individuals were adults and had reproduced at least once, except for *T. torpedo* (Fig. 2).

The reproductive potential of the different species was evaluated in order to determine the relationship that they maintain with their ecosystem. *M. surmuletus* (1.08) and *S. scrofa* (0.95) recorded the highest values, reflecting stable populations, followed by *T. torpedo* (0.91) and *U. scaber* (0.84), with over 80%. while, *D. lusitanicus* recorded a value under 50% (0.48), indicating that this species was in a state of expansion with a larger number of females recorded than males.

Morales-Nin (1991) studied the biological parameters of the red mullet *M. surmuletus* from the Majorca Coast in the Spanish Mediterranean Sea and recorded sizes between 10 and 27 cm. In that study, 50% of the females reached maturity at a TL of 15 cm, while males reached maturity at somewhat longer TL, during spring, the optimal season of reproduction. In studies by Renones *et al*. (1995) and Mahe *et al.* (2005) on *M. surmuletus*, females reached their initial sexual maturity at TL of 16.8-17.0 cm, but males did so at 15 cm. These authors confirmed that all individuals with TL under 13 cm were immature and that it was difficult to determine gender. However, they were

Table 4. Number of mature individuals according to size

Size class	*M. surmuletus*		*D. lisitanicus*		*S. scrofa*		*U. scaber*		*T. torpedo*	
	No. of findividuals	% Maturity	No. of individuals	% Maturity	No. of individuals	% Maturity	No. of individuals	% Maturity	No. of individuals	% Maturity
<150	5	0.0	1	0.0	10	0.0	2	0.0	15	0.0
150-160	10	4.6	3	0.0	3	2.8	1	0.0	2	0.0
160-170	43	4.6	4	0.0	7	2.8	1	0.0	3	0.0
170-180	53	9.2	10	0.0	7	2.8	7	3.1	2	0.0
180-190	27	1.5	30	0.0	7	5.6	12	3.1	4	0.0
190-200	35	9.2	46	1.7	9	5.6	12	12.5	2	0.0
200-210	32	16.9	41	3.4	5	2.8	21	9.4	3	0.0
210-220	23	13.8	49	6.0	4	2.8	11	12.5	1	0.0
220-230	20	16.9	55	6.9	11	11.1	9	6.3	1	0.0
230-240	11	7.7	59	10.3	8	5.6	18	9.4	0	0.0
240-250	5	6.2	39	12.9	6	2.8	10	12.5	2	0.0
250-260	4	3.1	46	16.4	4	2.8	7	9.4	0	0.0
260-270	1	0.0	30	12.1	6	13.9	7	0.0	0	0.0
270-280	4	4.6	24	12.1	4	5.6	4	0.0	1	0.0
280-290	1	1.5	13	6.0	6	8.3	4	3.1	2	3.8
290-300	0	0.0	10	5.2	5	8.3	5	6.3	4	7.7
300-310	0	0.0	16	6.9	13	16.7	8	12.5	0	0.0
310-320									3	11.5
320-330									1	3.8
330-340									1	3.8
340-350									4	15.4
350-360									0	0.0
360-370									1	3.8
370-380									1	3.8
380-390									3	11.5
390-400									1	3.8
400-410									1	7.7
410-420									2	7.7
420-430									1	7.7
430-440									1	3.8
>440									1	3.8
Total	280	100	476	100	115	100	139	100	63	100

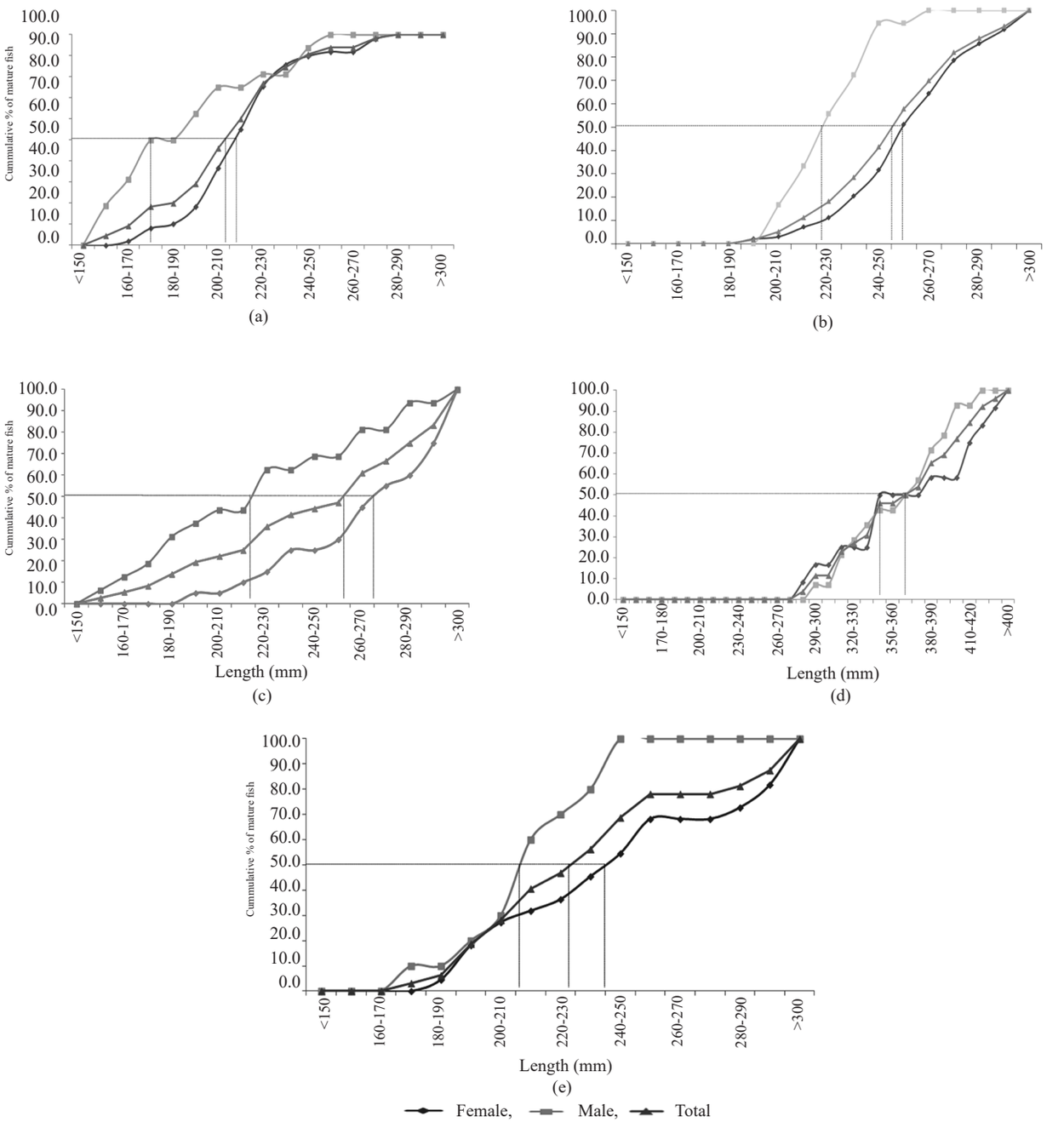

Fig.2. Size at which 50% of individuals reached sexual maturity. (a) *M. surmuletus*, (b) *D. lusitanicus,* (c) *S. scrofa*, (d) *T. torpedo,* (e) *U. scaber*

sexual maturity for red mullets in the North Sea was achieved with TL of 16.9 cm for females and 16.4 cm for males. These sizes differ from our data, as in our study 50% of the individuals reached initial maturity at TL of around 20 cm (21 cm in females and 17.5 cm in males).

There is no published information regarding the size at which *D. lusitanicus* individuals reach initial sexual maturity. Information about the size at maturity in *S. scrofa* is very scarce. Bradai and Bouain (1991) established the size at maturity for *S. scrofa* at 12.4 cm in females and 14.3 cm in males. However, this study did not include mature specimens, and they established that the spawning period occurred between July and September, based on histological observations of the gonads and the values of the gonadosomatic index. They

also explained that it is possible that spawning takes place in a place outside fishing or coastal areas. Matic-Skoko *et al.* (2015) established that the length of immature individuals of *S. scrofa* ranged from 9.3 to 30 cm with an average TL of 18.1 cm. They found that the mean size at first maturity of the large red scorpionfish in the study area differed significantly between sexes (males 24.9 cm, females 29.0 cm). These estimated values are relatively high considering the lengths of smallest mature male and female (18-20 cm). In the present study, 50% of individuals reached initial sexual maturity at a size of around 25 cm (28.0 cm in females, 22.5 cm in males). These data agree with the findings of *Matic-Skoko et al.* (2015), who stated that a notable difference with Bradai and Bouain (1991) is possibly related to different environmental conditions and/or different fishing pressure.

In a study by Abdel-Aziz (1994), conducted in Egypt, *T. torpedo* males were initially mature at TL of 18 cm, while the TL was 21.8 cm for females. Consalvo *et al.* (2007) found that the size at which female *T. torpedo* reached their initial maturity was 25.8 and 24.9 cm for males. According to the data obtained in our study, 50% of the *T. torpedo* population reached initial sexual maturity at much larger sizes, with an average of 36.5 cm (34.5 cm in females, 36.5 cm in males).

Boundka *et al*. (1998) stated that female *U. scaber* progress from juvenile phase to mature stage when reaching a size of between 13.5 and 15.5 cm, while this size was 11.0 to 12.5 cm in males. These results were similar to those found by Kutlu and Karayucel (2011), who reported that the first reproduction lengths in *U. scaber* were 11.76 and 13.75 cm for males and females, respectively. In our case, 50% of the *U. scaber* specimens reached initial sexual maturity at larger sizes, with an average of 23.5 cm (24.0 cm in females, 21.0 cm for males). We noted that the sizes at which our specimens reached maturity were somewhat larger than those recorded in other studies. This may be due to the fact that, in this study only very few specimens were captured since stargazers are caught mainly as bycatch in gillnets.

The proportion of females and males provides information about the reproductive potential of these species. Although in the present work we found that the proportion between males and females was balanced, this may be due to relatively small sample size and to the fact that we obtained only commercial size fishes.

Age and growth

There are only a few studies on age determination by reading rings on the otoliths of the four teleost species used in our study. In red mullets, only some aspects of biology have been studied, including age and growth (Morales-Nin, 1991; Renones *et al*., 1995; Labropoulou *et al*. 1997; Lombarte *et al*., 2000; Vassilopoulou *et al*., 2001; Mendes *et al*., 2004; Barnes, 2008; Mehana, 2009). Table 5 shows the results of the age analysis done with the otoliths. The results indicate that *M. surmuletus* specimens corresponded to age classes 1-4, with the most abundant ages between 2 and 3 years. Considering that the initial maturity of this species is reached at TL of around 20 cm, and given the results on age, it can be suggested that fish reproduce at the age of 3 years and that the minimum fishing size is at 1 year of age. In this species, reading ages is complicated given the vast amount of false rings (4 to 5) between each pair of genuine rings (*annuli*). Our results agree with the studies of Morales-Nin (1991), Renones *et al*. (1995) and Mehana (2009), where the length range of the striped red mullet catch was reported as 10-32 cm and the maximum age as six years.

D. lusitanicus presented individuals with age classes between 4 and 12 years and with greatest fish abundance between 5 and 9 years. In this species, 50% of individuals had reached initial maturity with a TL of about 25 cm; that is to say, those fish over 7 year age class and the minimum fishing size corresponded to fish in age class 4 or below. There is no published information regarding the age of *D. lusitanicus.* In *S. scrofa,* there were individuals of 1-8 years, and age class 6 was most abundant, even though the sample was distributed more or less homogeneously. Of all specimens, 50% reached initial maturity at TL of around 25 cm, which corresponded to the age class of 5 years. The only data with which it is possible to make a comparison are those reported by Bradai and Bouain (1991) from Tunisian waters and Matic-Skoko *et al*. (2015) from Egyptian waters; both studies found 15 age classes, and age classes 3 and 4 were predominant in the total catch. *U. scaber* showed age classes from 1-8 years, with age classes 2 and 3 showing the highest abundance. The size of *U. scaber* at which 50% of its population had already reached initial maturity (23.5 cm) corresponded to age class 3. Literature regarding the age of *U. scaber* were found lacking. The size-age relation of all four fish species for males and females and for the sample as a whole, in accordance with the growth parameters *viz.,* asymptotic length (L_∞), instantaneous growth rate (K) and fish length in time ($0\text{-}t_0$), were estimated using the von Bertalanffy growth curve (Fig. 3).

The males of *M. surmuletus* and *S. scrofa* showed a lower instantaneous growth rate than females, while the opposite was seen for the other two species, except for *S. scrofa,* in which males presented shorter asymptotic length than females. When comparing our results with those of other studies (Morales-Nin, 1991; Renones *et al*. 1995; Aguirre, 2000), we found similarities. For

M. surmuletus studied by Morales-Nin (1991) in the waters of Majorca, L_∞ of 29.8 cm was determined, which was longer for females (34.5 cm) than for males (23.3 cm). The L_∞ value of females was relatively larger than that reported in our work, while the total values and those recorded for males were slightly lower. The growth rate (k= 0.2376) was somewhat lower than that found in our work (k=0.379), which is somewhat higher and was probably due to the use of juveniles in curve estimations.

Renones *et al*. (1995) studied this same relationship in *M. surmuletus* in the waters of Majorca and obtained similar results. The size of the specimens caught were around 10 and 32 cm, and they belonged to age classes 0-4. Growth parameters reported by these authors for the whole population were L_∞ = 31.28 cm, k= 0.211 and t_0= -2.348. These data are lower than those reported in this study. This may be because we did not use juveniles in our curve estimations, as reported by Morales-Nin (1991).

Aguirre (2000) performed a growth curve estimation for *M. surmuletus* based on the modal progression of size classes using the same parameters estimated by other authors to obtain L_∞ = 44.12 (21.5-32.5) cm, k= 0.27 (0.11-0.50) and t_0= -0.07 (-0.12 to -3.65). The present work studied a population in which size ranged from 5.5 to 29.0 cm, with 11 cm long individuals aged 1 year, 18 cm long ones aged 2 years and 25 cm long ones aged 3 years. Values from this study were also within the ranges reported by different authors cited by Aguirre (2000).

It is possible to compare the results obtained for *D. lusitanicus* with those by Cabral *et al*. (2003a). They studied specimens from the Atlantic Ocean, which measured between 15 and 48 cm TL, with a maximum age of 8 years. In the present work, sizes recorded were not so long, although there were individuals whose age classes ranged from 4 to 12 years. As Cabral *et al*. (2003a) included large-sized fish, the L_∞ values were much higher than those we recorded (56 cm for females and 49 cm for males) and the growth rate was also higher (k= 0.21 for females and k=0.27 for males). Regarding the age of *S. scrofa,* Bradai and Bouain (1991) stated that the smallest female found (TL=124 mm) corresponded to an age of 3 years, and that the smallest male measured 143 mm at the age of 4 years. In *U. scaber,* from the south-eastern regions of the Black Sea, the growth parameters fell within the length range of 5.2 and 21.9 cm. L_∞ of 26.3, k=0.339 and an age range between 1 and 5 years were obtained for the whole population (Demirhan *et al*., 2007). These results are similar to those determined in the present work, although with a lower L_∞ because our sample was larger in size.

Table 5. Details of age analysis of *M. surmuletus*, *D. lusitanicus, S. scrofa* and *U. scaber*

Species	Age	Frequency	Mean TL	Min. TL	Max. TL
M. surmuletus	1	2	16.2	15.5	17.0
	2	12	18.7	16.4	23.0
	3	14	23.4	19.3	26.5
	4	2	27.8	27.5	28.0
D. lusitanicus	4	8	18.3	15.9	19.8
	5	23	21.2	17.0	27.2
	6	24	22.7	17.0	29.0
	7	23	23.3	20.6	27.0
	8	24	26.8	22.3	34.3
	9	15	26.0	20.0	30.6
	10	1	25.5	25.5	
	11	2	27.0	26.1	27.8
	12	1	26.0	26.0	
S. scrofa	1	1	8.6	8.6	
	2	9	13.7	11.5	17.0
	3	5	18.7	17.0	20.1
	4	2	24.5	23.5	25.5
	5	6	20.2	17.5	23.3
	6	10	26.9	22.0	34.0
	7	6	30.5	25.0	37.0
	8	1	32.0	32.0	
U. scaber	1	2	20.8	20.5	21.0
	2	8	20.1	16.0	27.0
	3	7	21.1	17.3	26.9
	4	3	27.8	25.0	30.0
	5	2	23.5	23.4	23.5
	6	1	31.5	31.5	
	8	1	31.5	31.5	

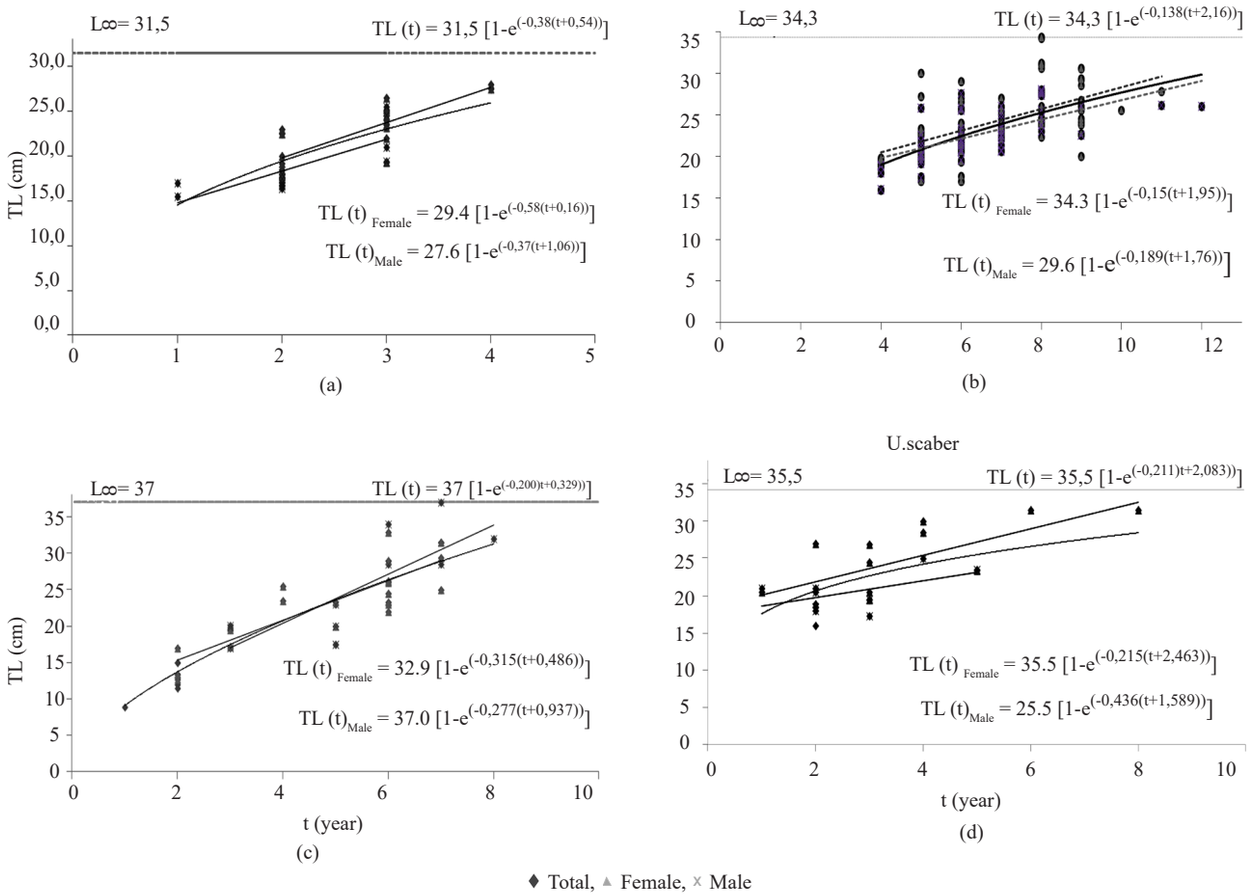

Fig. 3. von Bertalanffy growth curves and parameters**.** (a) *M. surmuletus*, (b) *D. lusitanicus,* (c) *S. scrofa*, (d) *U. scaber*

Acknowledgements

The authors are grateful to Cullera's artisanal fishermen for their support in fish sample collection, Gloria Cantos for her atssistance with sample processing and Roman Porras for his help with identification. We are grateful to the Department of Territory and Housing, Valencian Governmen, the University of Buenos Aires and, to the National Scientific and Technical Research Council (CONICET) for the financial support to this project.

References

Abalo Morla, S. 2015. *The role of traditional knowledge in environmental sustainability: The case of the fishermen of Cullera and Gandia.* Master thesis, Polytechnic University of Valenca. http://hdl.handle.net/10251/54958 (In Spanish).

Abdallah, M. 2002. Length-weight relationship of fishes caught by trawl off Alexandria, Egypt. *Naga ICLARM Q.* 25(1): 19-20.

Abdel-Aziz, S. H. 1994. Observations on the biology of the common torpedo (*Torpedo torpedo*, Linnaeus, 1758) and marbled electric ray (*Torpedo marmorata*, Risso, 1810) from Egyptian Mediterranean waters. *Aust. J. Mar. Freshw. Res.,* 45: 693-704. https://doi.org/10.1071/MF9940693.

Aguirre, H. 2000. *Biological and ecological aspects of Mullus barbatus L. 1758, mud mullet and Mullus surmuletus L. 1758, rock mullet in the North-Western Mediterranean.* Ph. D. Thesis, Polytechnic University of Catalonia, Spain, 261 pp. (In Spanish).

Aguirre, H. and Sánchez, P. 2005. Distribution of the trophic resource between *Mullus barbatus* and *M. surmuletus* in the Catalan Sea (North-western Mediterranean). *Ciencias Marinas,* 31(2): 429-439. DOI:10.7773/cm.v31i2.52 (In Spanish).

Ak, O., Kutlu, S. and Aydin, I. 2009. Length-weight relationship for 16 fish species from the Eastern Black Sea, Türkey. *Turk. J. Fish. Aquat. Sci.*, 9: 125-126.

Barnes, M. K. S. 2008. *Mullus surmuletus,* striped red mullet. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme [on-line]. Plymouth Marine Biological Association of the United Kingdom, UK.

Bok, T. D., Gokturk S. D., Kahraman A. E., Alicli T. Z., Acun T. and Ates C. 2011. Length-weight relationships of 34 fish

species from the Sea of Marmara, Turkey. *J. Anim. Vet. Adv*., 10(23): 3037-3042.

Boundka, B., Ktari, M. H. and Quignard, J. P. 1998. Sexuality, sexual cycle and reproduction of the Uranoscope (*Uranoscopus scaber*) of Tunisia. *Vie Milieu,* 48(1): 63-69. (In French).

Bradai, M. N. and Bouain, A. 1990. Diet of *Scorpaena porcus* and *S. scrofa* (Teleostei, Scorpaenidae) of the Gulf of Gabes, Tunisia *Cybium,* 14: 207- 216. (In French).

Bradai, M. N. and Bouain, A. 1991. Reproduction of *Scorpaena porcus* (Linne, 1758) and *Scorpaena scrofa* (Linne, 1758) (Pisces, Scorpaenidae) from the Gulf of Gabes *Oebalia,* 17: 167-180. (In French).

Cabral, N. H. 2000. Comparative feeding ecology of two sympatric soles: *Solea solea* and *Solea senegalensis* within the nursery areas of the Tagus Estuary. *J. Fish Biol.,* 57: 1550-1562. https://doi.org/10.1111/j.1095-8649.2000.tb02231.x.

Cabral, H. N. 2002. On the occurrence of some rare flatfish species in south European Atlantic waters. *Thalassas,* 18(1): 31-38.

Cabral, H. N., Catarino, A. I., Figueiredo, J., Garcia, J. and Henriques, M. 2003a. Feeding ecology, age, growth and sexual cycle of the Portuguese sole, *Synaptura lusitanica*. *J. Mar. Biol. Ass. U.K.,* 83: 613-618.

Cabral, H. N., Marques, J. F., Rego, A. L., Catarino, A. I., Figueiredo, J. and Garcia, J. 2003b. Genetic and morphological variation of *Synaptura lusitanica* Capello, 1868, along the Portuguese coast. *J. Sea Res.,* 50: 167-175. https://doi.org/10.1016/S1385-1101(03)00060-1.

Campillo, A. 1992. *The French fisheries of the Mediterranean: Synthesis of knowledge.* French Research Institute for the Exploitation of the Sea, France. 206 pp. (In French).

Capape, C., Guelorget, O., Vergne, Y. and Quignard, J. P. 2006. An unusual nineocellated common torpedo, *Torpedo torpedo* (Linnaeus, 1758) (Chondrichthyes: Torpedinidae), from southern France. *Acta Adriat.,* 47(1): 73-78.

Consalvo, I., Scacco, U., Romanelli, M. and Vacchi, M. 2007. Comparative study on the reproductive biology of *Torpedo torpedo* (Linnaeus, 1758) and *T. marmorata* (Risso, 1810) in the central Mediterranean Sea. *Scientia Marina,* 71(2): 213-222.

Coker, T., Akyol, O., Ozaydin, O., Leblebici, S. and Tosunoglu, Z. 2008. Determination of batch fecundity in *Uranoscopus scaber* Linnaeus, 1758 from the Aegean Sea, Turkey. *J. Appl.Ichthyol.,* 24: 85-87.

Corbera, J., Sabates, A. and Garcia-Rubies, A. 2000. *Sea fishes of the Iberian Peninsula: Field Guide,* Ed. Planet, Barcelona, Spain, 75 pp. (In Spanish).

Crechriou, R., Neveu, R. and Lenfant, P. 2013. Length-weight relationship of main commercial fishes from the French Catalan coast. *J. Appl. Ichthyol.,* 29: 1191-1192.

Demirhan, S. A., Can, M. F. and Seyhan, K. 2007. Age and growth of stargazer (*Uranoscopus scaber* L., 1758) in the south-eastern Black Sea. *J. Appl. Ichthyol.,* 23: 692-694.

Dulcic, J. and Kraljevic, M. 1996. Weight-length relationship for 40 fish species in the eastern Adriatic (Croatian waters). *Fish. Res.,* 28(3): 243-251. https://doi.org/10.1016/0165-7836(96)00513-9.

Fafioye, O. O. and Oluajo, O. A. 2005. Length-weight relationships of five fish species in Epe Lagoon, Nigeria. *Afr. J. Biotechnol.,* 4(7): 749-751.

FAO 2012. *The state of world fisheries and aquaculture.* Food and Agriculture Organisation, Rome, Italy, 243 pp.

FAO 2014. *The state of world fisheries and aquaculture*. Food and Agriculture Organisation, Rome, Italy, 243 pp. http://www.fao.org/3/a-i3720e.pdf.

Ferreira, S., Sousa, R., Delgado, J., Carvalho, D. and Chada, T. 2008. Weight-length relationships for demersal fish species caught off the Madeira Archipelago (eastern-central Atlantic). *J. Appl. Ichthyol.,* 24: 93-95. DOI: 10.1111/j.1439-0426.2007.01027.x.

Gayanilo, F. C. Jr., Sparre, P. and Pauly, D. 1996. *The FAO-ICLARM Stock Assessment Tools (FiSAT) User's Guide*. *FAO Computerized Information Series (Fisheries).* No. 8*,* Food and Agriculture Organisation, Rome, Italy, 126 pp.

Froese, R. and Pauly, D. 2008. *FishBase. World Wide Web electronic publication*. www.fishbase.org, version (02/2008).

Giacalone, V. M., D'Anna, G., Badalamenti, F. and Pipitone, C. 2010. Weight-length relationships and condition factor trends for thirty-eight fish species in trawled and untrawled areas off the coast of northern Sicily (Central Mediterranean Sea). *J. Appl. Ichthyol.,* 26: 954-957. https://doi.org/10.1111/j.1439-0426.2010.01491.x.

Granado, C. 1996. Fish ecology. *Sevilla University Publications Secretariat Series: Sciences*, 45: 353 pp. (In Spanish).

Harmelin-Vivien, M. L., Kaim-Malka, R. A., Ledoyer, M. and Jacob-Abraham, S. S. 1989. Food partitioning among scorpaenid fishes in Mediterranean seagrass beds. *J. Fish Biol.,* 34:715-734. https://doi.org/10.1111/j.1095-8649.1989.tb03352.x

Huet, L., Goosse, V., Parmentier, E. and Vandewalle, P. 1999. About some skeletal particularities of the first vertebrate related to the mode of prey capture in *Uranoscopus scaber* (Uranoscopidae). *Cybium,* 23(2): 161-167.

Jaramillo, A. M., Tombari, A. D., Benedito, V., Rodrigo, M. E. and Volpedo, A. V. 2014. Otolith eco-morphological patterns of benthic fishes from the coast of Valencia (Spain). *Thalassas,* 30(1): 57-66.

Karakulak, F. S., Erk, H. and Bilgin, B. 2006. Length-weight relationships for 47 coastal fish species from the northern Aegean Sea, Turkey. *J. Appl. Ichthyol.,* 22: 274-278.

Kasapoglu, N. and Duzgunes, E. 2013. Length-weight relationships of marine species caught by five gears from the Black Sea. *Mediterr. Mar. Sci.,* 15(1): 95-100. DOI: 10.12681/mms.463.

Labropoulou, M., Machias, A., Tsimenides, N. and Eleftheriou, A. 1997. Feeding habits and ontogenic diet shift of the striped red mullet, *Mullus surmuletus* Linnaeus, 1758. *Fish. Res.,* 31: 257-267. https://doi.org/10.1016/S0165-7836(97)00017-9.

Lloret, J. and Lleonard, J. 2002. Recruitment dynamics of eight fishery species in the north-western Mediterranean Sea. *Scientia Marina,* 66(1): 77-82.

Lombarte, A., Recasens, L., González, M. and Gil De Sola, L. 2000. Spatial segregation of two species of mullidae (*Mullus surmuletus* and *M. barbatus*) in relation to habitat. *Mar. Ecol. Prog. Ser.,* 206: 239-249. DOI: 10.3354/meps206239.

Machias, A., Somarakis, S. and Tsimenides, N. 1998. Bathymetric distribution and movements of red mullet *Mullus surmuletus*. *Mar. Ecol. Prog. Ser*., 166: 247-257. DOI: 10.3354/meps166247.

Machias, A. and Labropoulou, M. 2002. Intra-specific variation in resource use by red mullet, *Mullus barbatus*. *Estuar. Coast. Shelf Sci.,* 55:565-578. https://doi.org/10.1006/ecss.2001.0924.

Mahe, K., Destombes, A., Coppin, F., Koubbi, P., Vaz, S., Le Roy, D. and Carpentier, A. 2005. Red mullet *Mullus surmuletus* (L. 1758) in Eastern Channel and North Sea. *Contract Report IFREMER/CRPMEM Nord-Pas-de-Calais*. 187 pp. (In French).

Mata, A. J., Morales, J. and Márquez, L. 2008. Weight-length relationships for 26 demersal fish species of the Spanish south-Atlantic coastal waters. *J. Appl. Ichthyol.,* 24: 330-333.

Matic-Skoko, S., Staglicic, N., Kraljevic, M., Pallaoro, A. and Dulcic, J. 2014. The biological traits of the large red scorpionfish, *Scorpaena scrofa*: Temporal and ontogenetic dynamics. *Estuar. Coast. Shelf Sci.,* 152: 91-99. http://dx.doi.org/10.1016/j.ecss.2014.11.019.

Mazzola, A., Lopiano, L., La Rosa, T. and Sarà, G. 1999. Diel feeding habits of juveniles of *Mullus surmuletus* (Linneo, 1758) in the lagoon of the Stagnone di Marsala (Western Sicily, Italy). *J. Appl. Ichthyol.,* 15: 143-148.

Mehanna, S. F. 2009. Growth, mortality and spawning stock biomass of the striped red mullet *Mullus surmuletus* in the Egyptian Mediterranean waters. *Medit. Mar. Sci.,* 10(2): 5-17.

Mendes, B., Fonseca, P. and Campos, A. 2004. Weight-length relationships for 46 fish species of the Portuguese west coast. *J. Appl. Ichthyol.,* 20: 355-361. DOI: 10.1111/j.1439-0426.2004.00559.x

Morales-Nin, B. 1991. Biological parameters of the *Mullus surmuletus* rock mullet (L. 1758), in Mallorca. *Bol. Inst. Esp. Oceanogr.,* 7(2): 139-147. (In Spanish).

Morato, T., Afonso, P., Lourinho, P., Barreiros, J. P., Santos, R. S. and Nash, R. D. M. 2001. Length-weight relationships for 21 coastal fish species of the Azores, north-eastern Atlantic *Fish. Res.,* 50: 297-302.

Moutopoulos, D. K. and Stergiou, K. I. 2002. Length-weight and length-length relationships of fish species of the Aegean Sea (Greece). *J. Appl. Ichthyol.,* 18(3): 200-203. DOI: 10.1046/j.1439-0426.2002.00281.x.

Moutopoulos, D. K., Ramfos, A., Mouka, A. and Katselis, G. 2013. Length-weight relations of 34 fish species caught by small-scale fishery in Korinthiakos Gulf (Central Greece). *Acta Ichthyol. Piscat*., 43(1): 57-64.

Neer, J. and Cailliet, G. 2001. Aspects of the life history of the Pacific electric ray, *Torpedo californica* (Ayres). *Copeia,* 3: 842-847.

Osse, J. W. M. and van den Boogaart, J. G. M. 1995. Fish larvae, development, allometric growth, and the aquatic environment. *ICES Mar. Sci. Symp*., 201: 21-34. https://doi.org/10.1016/S0044-8486(97)00126-9.

Ozaydin, O. and Taskavak, E. 2006. Length-weight relationships for 47 fish species from Izmir Bay (eastern Aegean Sea, (Turkey). *Acta Adriat.,* 47(2): 211-216.

Post, J. C. and Parkinson, E. A. 2001. Energy allocation strategy in young fish: allometry and survival. *Ecology,* 82(4): 1040-1051. https://doi.org/10.1890/0012-9658(2001)082[1040:EASIYF]2.0.CO;2.

Prager M. H., Saila, S. B. and Recksiek, C. W. 1987. FISHPARM: a microcomputer program for parameter estimation of nonlinear models in fishery science. *Old Dominion University Oceanography Technical Report*, 87(10):1-37.

Reñones, O., Massuti, E. and Morales-Nin, B. 1995. Life history of the red mullet *Mullus surmuletus* from the bottom-trawl fishery off the Island of Majorca (north-west Mediterranean). *Mar. Biol.,* 123: 411-419. DOI: 10.1007/BF00349219.

Roul, S. K., Retheesh, T. B., Ganga, U., Abdussamad, E. M., Rohit, P. and Jaiswar, A. K. 2018. Length-weight relationships of five needlefish species from Kerala waters, south-west coast of India. *J. Appl. Ichthyol.,* 34: 190-192.

Roul, S. K., Retheesh, T. B., Prakasan, D., Abdussamad, E. M. and Rohit, P. 2017. Length-weight relationship of *Thryssa malabarica* (Bloch, 1795) and *Thryssa dayi* Wongratana, 1983 from Kerala, south-west coast of India. *J. Appl. Ichthyol*., 33: 1247-1248. https://doi.org/10.1111/jai.13485.

Roul, S. K., Kumar, R. R., Ganga, U. and Rohit, P. 2017. Length-weight relationship of *Rastrelliger brachysoma* (Bleeker, 1851) and *Rastrelliger faughni* Matsui, 1967 from the Andaman Islands, India. *J. Appl. Ichthyol*., 33: 1266-1267. https://doi.org/10.1111/jai.13469.

Sangun, L., Akamca, E. and Akar, M. 2007. Weight-length relationships for 39 fish species from the North-Eastern Mediterranean coast of Turkey. *Turk. J. Fish. Aquat. Sci.,* 7: 37-40.

Sanz, A. 1985.. Contribution to the study of the biology of *Uranoscopus scaber* Linnaeus, 1758 (Osteichthyes, Uranoscopidae) of the western Mediterranean, *Investigacion pesquera* 49 (1): 35-48 (In Spanish).

Sparre, P. and Venema, S. C. 1997. Introduction to the evaluation of tropical fishery resources, Part I, *FAO Fish. Tech. Pap., 306.1 Rev. 2.* Food and Agriculture Organisation, Rome, Italy, 420 pp.

Stergiou, K. I. and Moutopoulos, D. K. 2001. A review of length-weight relationships of fishes from Greek marine waters. *Naga ICLARM Q.*, 24(1&2): 23-39.

Suau, L. and Vives, F. 1957. Contribution to the study of mud mullet (*Mullus barbatus*) in the western Mediterranean. *Investigacion Pesquera*, 9: 97-118 (In Spanish).

Tserpes, G., Fiorentino, F., Levi, D., Cau, A., Murenu, M., Zamboni, A. and Papaconstantinou, C. 2002. Distribution of *Mullus barbatus* and *Mullus surmuletus* (Osteichthyes: Perciformes) in the Mediterranean continental shelf: implications for management. *Scientia Marina*, 66 (2): 39-54.

Tsikliras, A. C., Dinouli, A., Tsiros, V. Z. and Tsalkou, E. 2015. The Mediterranean and Black Sea fisheries at risk from overexploitation. *PLoS One*, 10(3), e0121188. doi:10.1371/journal.pone.0121188.

Tuset, V. M., Lombarte, A. and Assis, C. A. 2008. Otolith atlas for the Western Mediterranean, North and Central Eastern Atlantic. *Scientia Marina*,72(1): 7-198.

Valle, C., Bayle, J. T. and Ramos, A. A. 2003. Weight-length relationships for selected fish species of the western Mediterranean Sea. *J. Appl. Ichthyol.,* 19: 261-262. https://doi.org/10.1046/j.1439-0426.2003.00492.x.

Vassilopoulou, V., Papaconstantinou, C. and Christides, G. 2001. Food segregation of sympatric *Mullus barbatus* and *Mullus surmuletus* in the Aegean Sea. *Isr. J. Zool.,* 47(3): 201-211.

Volpedo, A. V. and Echeverría, D. D. 2000. *Catalog and otolith keys for the identification of fish from the Argentina Sea. Fish of economic importance*. Dunken, Buenos Aires, 88 pp.

Whitehead, P. J. P., Bauchot, M. L., Hureau, J. C., Nielson, J. and Tortonese T. 2001. *Fishes of the north-eastern Atlantic and the Mediterranean*. World Biodiversity Database CD-ROM Series. ETI UNESCO, Amsterdam, The Netherlands.

Wootton, R. J. 1999. Ecology of teleost fishes*,* 2nd edn. *Fish and Fisheries Series 24.* Kluwer Academic Publishers, Dordrecht,The Netherlands, 386 pp.

Date of Receipt : 14.03.2018
Date of Acceptance : 20.08.2019