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Review Article

A REVIEW ON GROWTH OF SOME *DIPLODUS* SPECIES DISTRIBUTED WORLDWIDE

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ABSTRACT

Estimation of the growth parameters of fish are vital to understand their biology. For this purpose we collected studies that performed up to 2017 regarding the growth of species belonging to the *Diplodus* genus. Data were gathered from sources like Web of Science (webofknowledge.com), Scopus (scopus.com), Google Scholar (scholar.google.com), Researchgate (researchgate.com) and Academia (academia.edu). 79 datasets from 52 different studies belongs to 10 species were compiled. Reviewed studies were published between 1982 - 2017 and were performed in 26 different regions. It was determined that the most frequently studied species was *D. vulgaris* (n=23). Among growth parameters, it was determined that there is a negative relationship between K and L_∞, and K and t_{max}, there is a positive relationship between L_∞ and L_{max}. It was also found that there is a negative relationship between K and L_∞ vs latitude.

Keywords: Growth, *Diplodus*, Population dynamics, Life history parameters

Introduction

The *Diplodus* genus, distributed all around the world, have a significant economic importance (Gordoa and Moli, 1997; Pajuelo and Lorenzo, 2004; Soykan et al., 2015). Due to varied habitat preferences, these species can be found in different marine ecosystems such as rocky habitats and sandy bottoms. According to Fishbase, 21 species of this genus can be found in world seas (Froese and Pauly, 2017). While the main area of distribution for these species is the Mediterranean Sea and the Atlantic Ocean, they are also found in the Caribbean, Gulf of Mexico, the Indian Ocean, the Red Sea and the Persian Gulf (Figure 1, Sala and Ballesteros, 1997; Summerer et al., 2001; Froese and Pauly, 2017). Along with being a main target species for small scale, semi-industrial fisheries and sport fishing, a couple species belonging to this genus are also important with regards to aquaculture (Reina et al., 1994; Summerer et al., 2001). For this reason, their biology and population dynamics are essential.

While there are many studies regarding various biological characteristics of *Diplodus* species, studies conducted on age and growth are only available for 10 species (Appendix 1). Evaluating different species belonging to the same genus that show similar morphological and growth characteristics together offers significant advantages regarding population dynamics (Hilborn and Liermann, 1998; Helser et al., 2007). Compilation and reanalysis of growth studies help us for better understanding the changes in growth characteristics (Pilling et al., 2002; Helser and Lai, 2004; Helser et al., 2007). For this purpose the aim of this study is to gather age-growth studies performed on species belonging to *Diplodus* genus and to establish the variability in growth between species and regions. Finally, growth variety between species was addressed based on the relationships between growth parameters.

Compilation of Data from References

Studies performed up to 2017 regarding the growth of species belonging to the *Diplodus* genus (Figure 2) were gathered from sources like Web of Science (www.webofknowledge.com), Scopus (www.scopus.com), Google Scholar (www.scholar.google.com), Researchgate (www.researchgate.com) and Academia (www.academia.edu). Collected studies were carefully classified and necessary information was extracted (See appendix). This information includes the following: the location the study (latitude, longitude), length type (LT), L_∞, K, t_0, maximum age (t_{max}), minimum and maximum length (L_{min}, L_{max}), sex, age determination method (otolith reading (OR), scale reading (SR), length frequency method (LF)), sample size (N) and the year the study was performed (see Appendix).

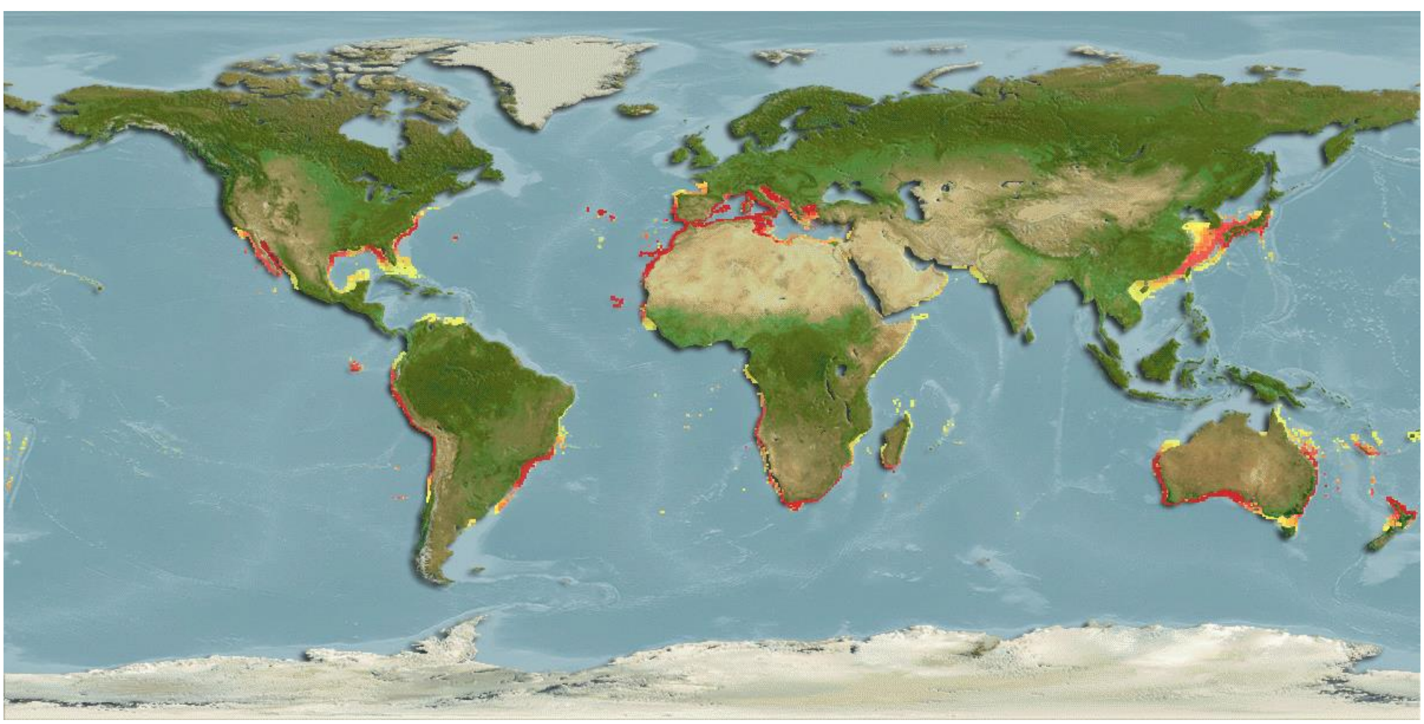

Figure 1. Distribution of the *Diplodus* genus (Fishbase 2017).

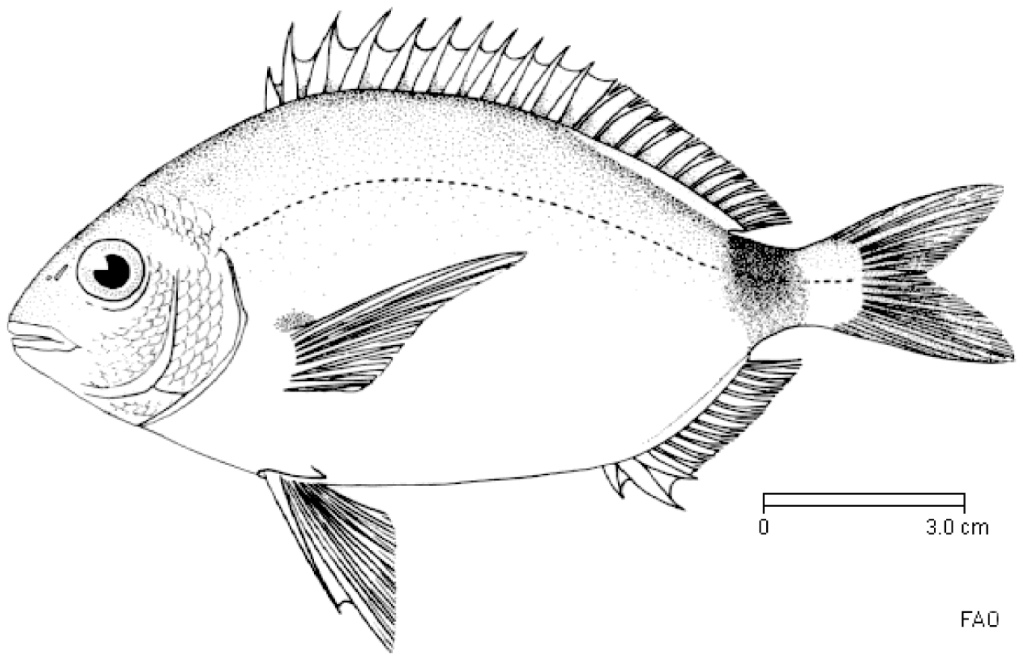

Figure 2. General appearance of *Diplodus* (*Diplodus annularis*, Source: Bauchot, (1987)

In cases where the studies compiled used different size types, the size-size relationship formula for the species involved presented in Fishbase (Froese and Pauly, 2017) was used for all size groups and L_{min}, L_{max} and L_{∞} values were transformed (Stergiou and Karachle, 2006; Froese, 2006; Gündoğdu and Baylan, 2016; Gündoğdu et al., 2016). For species where fork lengths were reported and to convert the fork lengths given to total length, the following formula taken from Fishbase (Froese and Pauly, 2017) were used.,

D. annularis: $TL = 0 + 1.09FL$

D. bellottii: $TL = 0 + 1.093FL$

D. capensis: $TL = 0.2554 + 1.163FL$

D. hottentatus: $TL = 0.2628 + 1.161FL$

D. sargus sargus: $TL = 0 + 1.088FL$

D. vulgaris: $TL = 0 + 1.15FL$

For studies where maximum length was not reported, if present the L_{max} value given in other studies from the same region, and if not the average L_{max} value given in Fishbase was used

In literature, fish growth is mostly expressed based on the von Bertalanffy growth model. Since this was the case for all literature collected, the parameters used in this model were taken directly without any recalculations. Latitude and longitude information for the study areas given in gathered studies were reproduced as averages. This way, the same latitude and longitude information is given for studies performed in the same area. It was thought that if done otherwise, taking close latitudes and longitudes for studies performed in the same area would increase the difficulty of the analysis and reduce the significance of the results.

The change of growth parameters and other life history parameters taken from the compiled studies relative to each other and latitude was analyzed using the Tableau 10.0 software. Separate and joint growth formula of all species were recalculated using the median values of all parameters and regression constants (slope) were analyzed using an independent sample t-test with SPSS v20 package software.

Assessment of Data and Discussion

79 datasets from 52 different studies were compiled in this study. This data set belongs to 10 different species. Studies were published between 1982 - 2017 and were performed in 26 different regions (Figure 3; Appendix 1).

Most studies were from around Canary Islands (n=14, 18%). Gathered studies are most frequently on the biology of *D. vulgaris* (n=23, 29%), *D. annularis* (n=17, 22%) and *D. sargus sargus* (n=15, 19%) species (Appendix 1). Age reading method was used in 71 studies (otolith reading in 45, scale reading in 26), while in 6 studies estimation was done using the length frequency method, and in 2 studies no information regarding this was given. Length measurements were done as total length (n=65) and fork length (n=14). It was determined that there was a significant amount of variation between number of observations in studies where growth parameter estimations were performed. In 7 estimates, >1000 individuals were used, while in 59 estimates the number of individuals used was <1000. It was determined that in 10 data sets the number of observations was not reported (Figure 4).

t_{max} value (1 year to 33 years) was reported in 71 data sets and L_{max} value (9,3 cm to 56,5 cm) was reported in 69 data sets. K, L_∞ and t_0 values were reported in all studies (Appendix 1). It was determined that the K value varied between 0.073 year^{-1} and 0,56 year^{-1}, the L_∞ value varied between 13.32 cm and 68.83 cm and t_0 value varied between -5.33 years and -0,02 years (Table 1).

It was determined that the L_{max}/L_∞ ratio varied between 0.52 and 1.84 for all studies, with an average of 0.95 (Table 1). The relationship between L_{max} and L_∞ was calculated together for all species and a positive and statistically significant correlation was discovered between them (r=0.827, P<0.05, $L_\infty = 4.42 + 0.95 * L_{max}$; Figure 4). It was determined that the relationship between t_{max} and K is negative and statistically significant (r=-0.41, P<0.05, $Ln(K) = -0.72 - 0.38 * Ln(t_{max})$; Figure 5). It was also determined that the relationship between K and L_∞ is negative and statistically significant (r=-0.71, P<0.05, $Ln(K) = 1.66 - 0.92 * Ln(L_\infty)$; Figure 5).

The relationship between latitude and von Bertalanffy parameters was determined to be negative for K and L_∞, and positive for t_0 (Figure 6). However, the relationships for all three parameters were found to be statistically insignificant (t-test, P>0.05; Figure 6).

Table 1. Descriptive statistics of the parameters belonging to the compiled studies

Parameters	Mean	Std.Error	Minimum	Median	Maximum
K	0.24	0.01	0.07	0.21	0.56
L_∞	35.3	1.48	13.32	33.3	68.8
t_0	-1.31	0.11	-5.33	-0.98	-0.02
L_{max}	32.6	1.29	9.30	32.0	56.5
t_{max}	10.0	0.60	1.00	9.00	33.0
L_{max}/L_∞	0.95	0.02	0.52	0.93	1.84

Table 2. Recalculated models using the median values taken from the compiled studies

Species	Estimated Model
D. annularis	$L_t = (20.37 * (1 - e^{-0.25(t+0.89)}))$
D. bellottii	$L_t = (28.42 * (1 - e^{-0.27(t+0.19)}))$
D. capensis	$L_t = (27.7 * (1 - e^{-0.31(t+1.05)}))$
D. cervinus	$L_t = (60.9 * (1 - e^{-0.15(t+0.76)}))$
D. holbrooki	$L_t = (33.28 * (1 - e^{-0.24(t+0.99)}))$
D. hottentotus	$L_t = (46.24 * (1 - e^{-0.15(t+2.15)}))$
D. puntazzo	$L_t = (36.84 * (1 - e^{-0.2(t+0.98)}))$
D. sargus cadenati	$L_t = (47.65 * (1 - e^{-0.14(t+1.98)}))$
D. sargus sargus	$L_t = (40.71 * (1 - e^{-0.18(t+0.86)}))$
D. vulgaris	$L_t = (33.3 * (1 - e^{-0.22(t+0.96)}))$
Total	$L_t = (33.3 * (1 - e^{-0.21(t+0.98)}))$

Figure 3. The distribution of the compiled studies

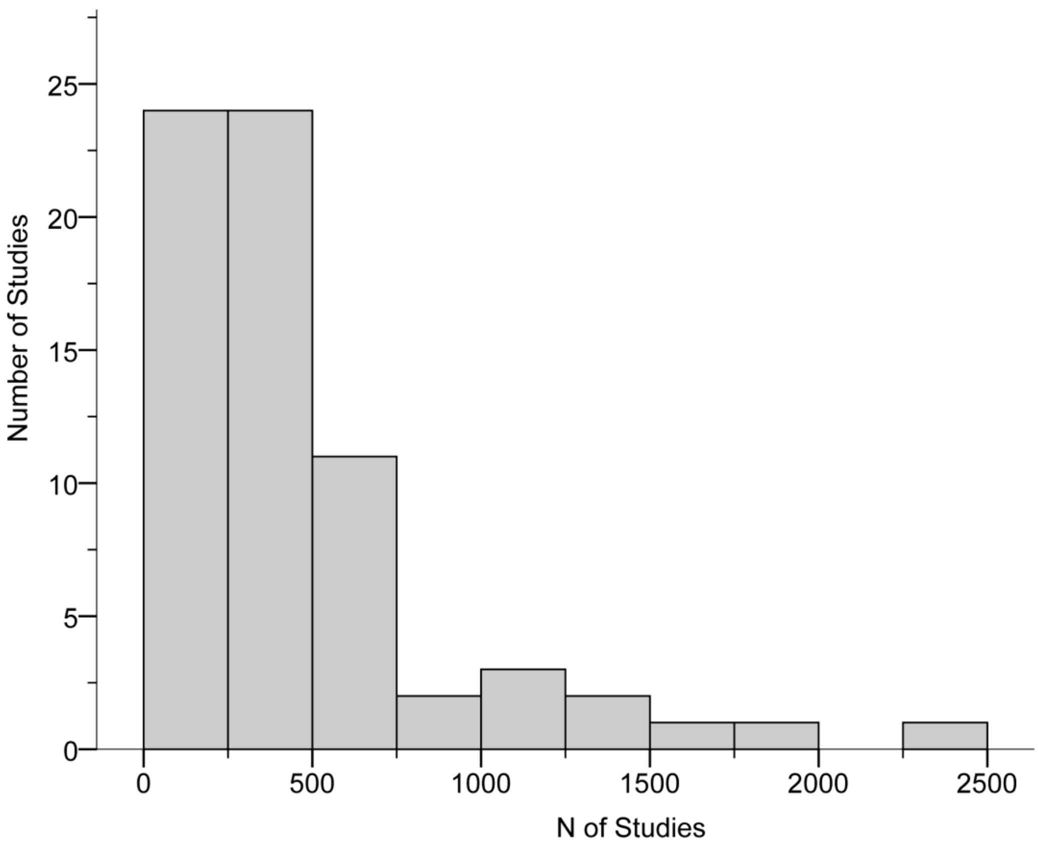

Figure 4. Frequency distribution of the sample sizes on which the biological parameters presented here were based (see Appendix 1).

The growth formula created based on the median values calculated using the entire data set is given in table 2. Estimated growth curves created with the help of these shared formulas are given in figure 7. As seen in figure 7, for the first three years, all species except for *D. annularis* demonstrate similar growth. It was seen that curves that match the initially rapid and later slowing growth with age posited in the general fish growth theory.

In this study, 52 studies performed in different regions around the world that include the biological parameters of 10 different species belonging to the *Diplodus* genus (Appendix 1). This study is one of the rare studies that considers the growth of the entirety of a certain genus at once, and it is the first study that considers the species belonging to the *Diplodus* genus together. Another similar study was performed by Helser et al. (2007) for the *Sebastes* genus, found in the Pacific Ocean. All studies other than our study and the Helser et al. (2007) study are studies where the growth parameters of more than one genus and species were considered together. These are Pauly (1978), Pauly (1980), Paul (1992), Stergiou (2000), Frisk et al. (2001), Stergiou and Karachle (2006), Apostolidis and Stergiou (2012), Apostolidis and Stergiou (2014) and Gündoğdu and Baylan (2016).

Aside from coloring, fish belonging to the *Diplodus* genus show similarities regarding many characteristics and have similar habitat demands (Summerer et al., 2001). This causes their feeding habits to be similar as well (Ventura et al., 2015). For this reason, considering the growth characteristics of fish belonging to the *Diplodus* genus together and in a comparative manner is quite reasonable.

Growth is the most studied subject, as it affects many life history parameters and involves a lot of basic information for fishing management (Helser and Lai, 2004). However, as stated above, the number of studies that consider different populations belonging to the same species or genus in a comparative manner is quite limited. Consequently, this study attempts to establish the relationship between various biological parameters and between some parameters and latitude through the compiled studies. Among these relationships, one of the most important is the relationship between K and L_∞. It is known that there's a negative relationship between these two parameters (Beverton and Holt, 1959; Adams, 1980; Pauly, 1980; Munro and Pauly, 1983; Pauly and Munro, 1984; Wootton, 2012). The negative correlation (-0.71) found in this study matches this general assumption (Figure 5). However, despite the presence of this negative relationship, in reality there's no direct evidence in natural populations regarding this negative correlation (Pilling et al., 2002; Helser and Lai, 2004). It is thought that the negative relationship between these two parameters arises from the mathematical nature of the von Bertalanffy growth model (Stergiou, 2000). The negative relationship between the K value and the t_{max} value (-0.41) was found to be similar to the value found in a multi-species study performed by Stergiou and Karachle (2006) (-0.37). If we consider Taylor (1958)'s $K = 3/t_{max}$ equation a general equation, it can be seen that this study has a result that is close to this value (Table 1).

L_{max}/L_∞ ratio (0.95) and the correlation between them (0.82) was found to be similar to the studies performed among different species (Stergiou and Karachle, 2006 (0.99); Apostolidis and Stergiou, 2014 (0.87); Gündoğdu and Baylan, 2016 (0.96)). And this shows that there's a relationship between these two parameters in general terms that is independent of species (Froese and Binohlan, 2000). Taylor (1958), Pauly and Munro (1984) and Froese and Binohlan (2000) state that fish usually live for 95% of the L_∞ value. And this shows that there's a relationship like $L_\infty \approx L_{max}/0.95$ between these two parameters, which fits the results we have found in this study.

Helser and Lai (2004) state that there's a relative relationship between growth parameters and latitude that is independent of statistical significance. According to this, K and L_∞ have a negative relationship with latitude, while t_0 has a positive relationship. Our findings are in the same direction. When Figure 6 is examined, it can be seen that K and L_∞ values have a negative relationship with latitude, while t_0 value has a relatively positive relationship.

Feeding habits, genetic relationships, food available in the environment, competition and temperature are the basic factors that determine the growth performance of a species (Jobling, 1981; Helser et al., 2007). For this reason, growth trends of species that are similar to each other with regards to these factors would be similar as well. Consequently, the results expressed in table 2 and figure 7 support this conclusion. The mtDNA based relationship study performed by Summerer et al. (2001) on the *Diplodus* genus partially supports the estimated growth model curves we have presented here. Moreover, in Summerer et al. (2001)' study, *D. cervinus* in a different cluster than other species. Similarly, *D. annularis* and other *Diplodus* species are considered separate to a point. Furthermore, the same reports put all species other than *D. annularis* and *D. cervinus* in *D. sargus* clades (Figure 8).

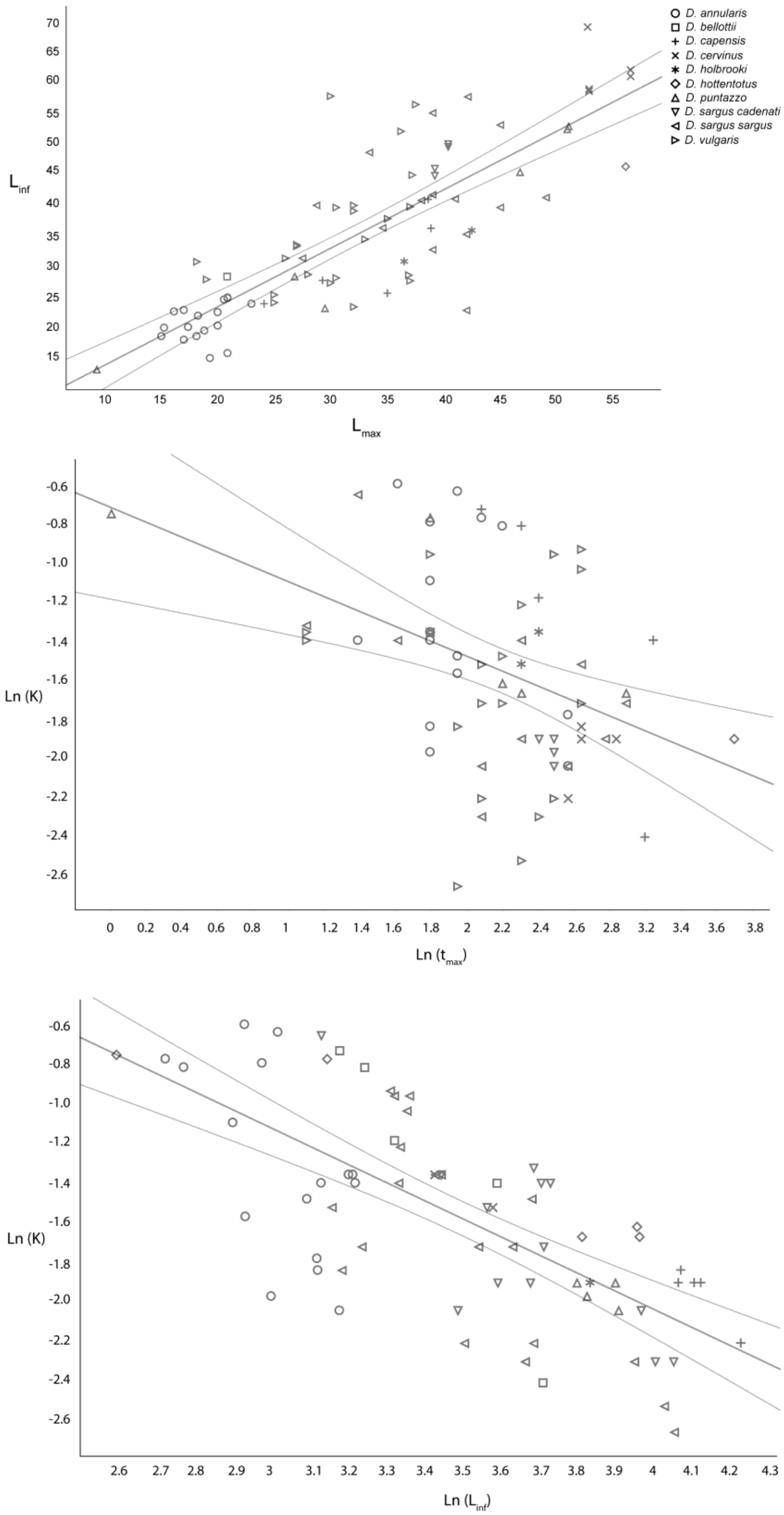

Figure 5. Relationships between von Bertalanffy growth parameters (a- L_∞ vs L_{max}, b- ln(K) vs t_{max}, c- ln(K) vs t_0) and the fitted curves belonging to those. The middle curve in each graph represents the fitted curve, and the other two represent the 95% confidence limits.

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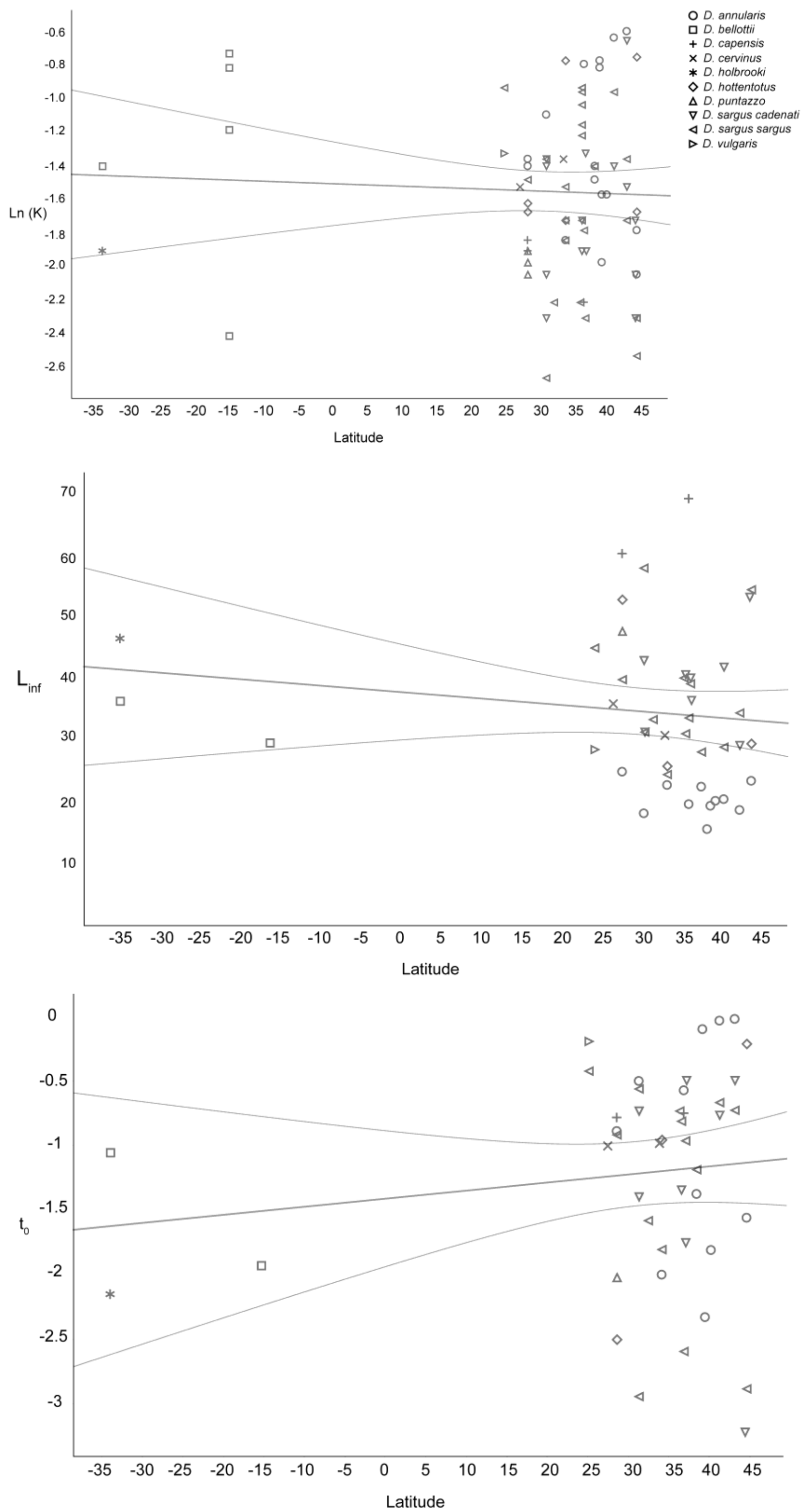

Figure 6. Relationships between growth parameters and latitude and the fitted curves belonging to those. The middle curve in each graph represents the fitted curve, and the other two represent the 95% confidence limits.

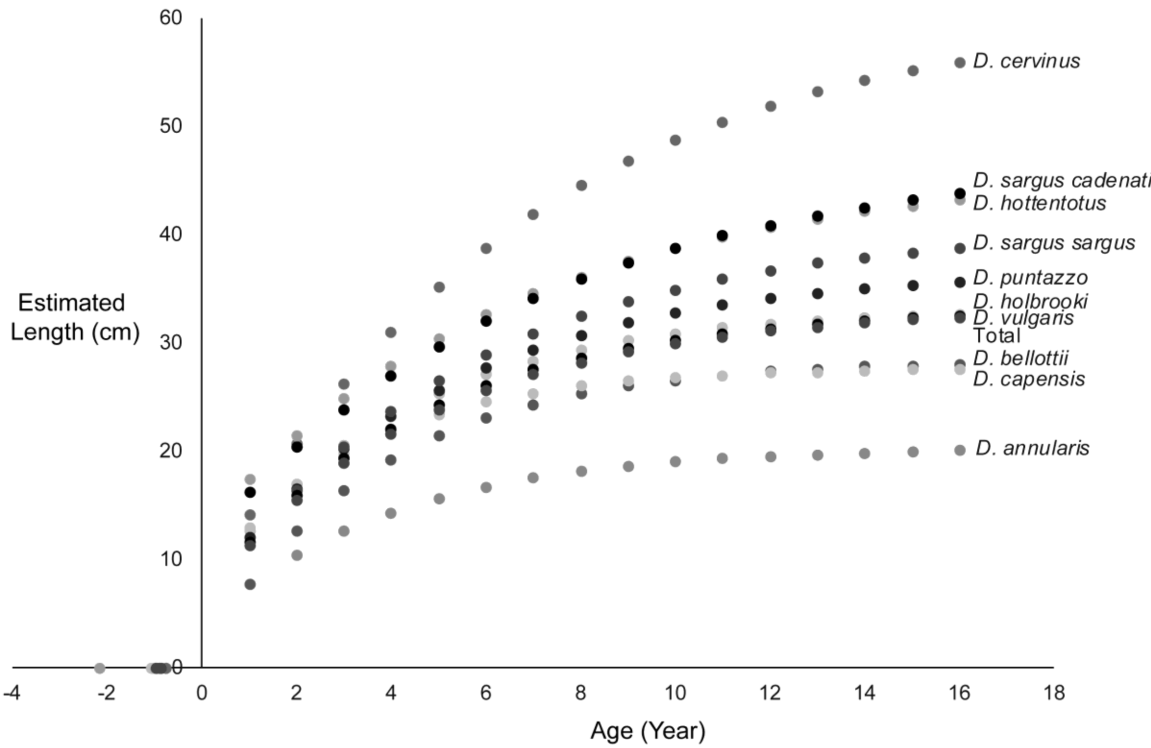

Figure 7. Estimated age-length curves the new models based on the median values provided

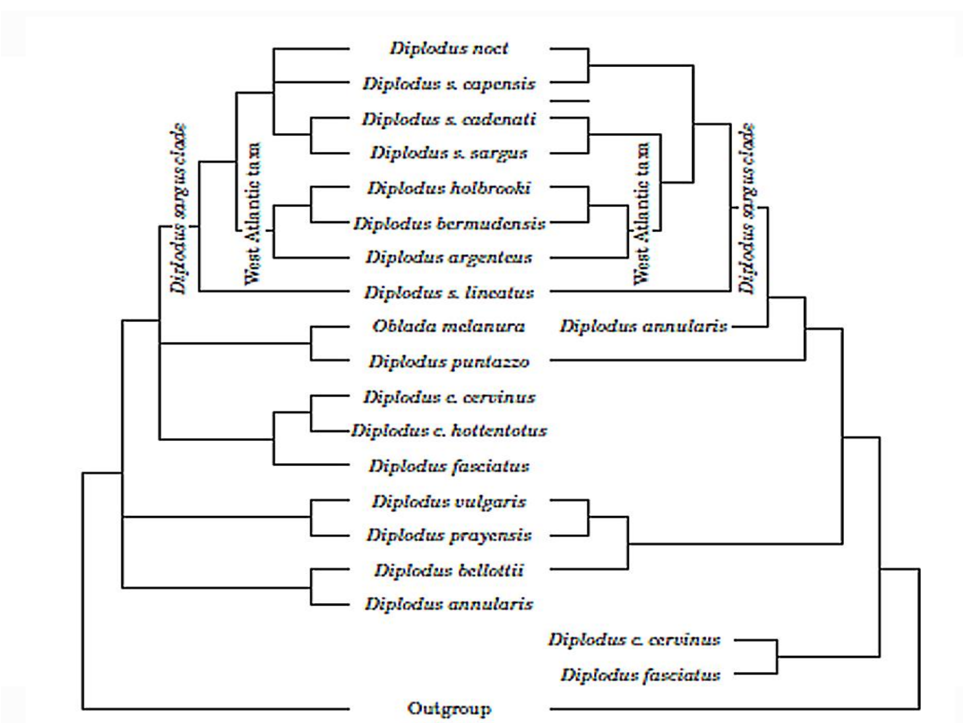

Figure 8. Relationship between genetic characteristics and morphology of genus *Diplodus*. The mtDNA (left) and morphological (right) comparison of species belonging to the *Diplodus* genus (Taken from Summerer et al. (2001).

Conclusion

Establishing the variation of growth parameters between populations and species is to key for ecological studies. Comparing growth models and parameters both systematically and over other variables would help us in understanding the growth characteristics of the genus and species involved. Comparative studies like these carry great significance to understand the biology of species that can be considered target species for fishing.

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Appendix

Biological parameters for various *Diplodus* stocks in various seas [K in yr^{-1}, L_∞ in cm, and t_0 in yr. Sex (M=males, F=females, B=combined). N denotes the number of individuals used for parameter estimation. Method denotes the method used for the estimation of age (O=otoliths, S=scales, LF=length-frequencies). L_{max} and t_{max} denote maximum body length, in cm, and maximum age, in yr, respectively. LT denotes type of length used in the original study (TL=total, FL=fork,). nr: not reported.

Species	Location	Country	LT	Sex	L_∞	K	t_0	t_{max}	L_{min}	L_{max}	L_{max}/L_∞	N	Method	Year	Author
D. annularis	Adriatic Sea	Coratia	TL	B	23,95	0,13	-1,66	13	3,3	23,0	0,960	786	SR	2000-2002	Matic-Skoko et al. (2007a)
			TL	B	22,60	0,17	-1,46	13	3,3	20,0	0,885	1872	SR	2000-2002	Matic-Skoko et al. (2004)
	Alexandria	Eygpt	TL	B	18,10	0,34	-0,50	6	9,0	17,0	0,939	466	SR	1980-1981	Wassef (1985)
	Annaba Gulf	Algeria	TL	B	19,54	0,46	-0,57	6	12,6	18,8	0,962	648	SR	nr	Nouacher and Djebar (2007)"
	Canary Islands	Spain	TL	M	24,57	0,26	-0,89	6	8,9	20,6	0,838	173	OR	1998	Pajuelo and Lorenzo (2002b)
			TL	F	24,96	0,25	-0,89	6	9,4	20,9	0,837	139	OR	1998	Pajuelo and Lorenzo (2002b)
			TL	B	24,79	0,26	-0,88	6	8,2	20,9	0,843	194	OR	1998	Pajuelo and Lorenzo (2001)
	Catalan Coast		TL	B	20,37	0,54	-0,03	7	9,0	20,0	0,982	180	OR	nr	Gordoa and Moli (1997)
	Mallorca ısland		TL	F	15,93	0,45	-0,12	9	9,0	20,9	1,312	166	OR	2007	Alos et al. (2010)
			TL	M	15,17	0,47	-0,07	8	8,4	19,3	1,272	141	OR	2007	Alos et al. (2010)
	Edremit Gulf	Turkey	FL	M	20,01	0,14	-2,93	6	8,2	15,3	0,763	330	OR	1997-1998	Torcu-Koç et al. (2002)*
			FL	F	18,76	0,21	-1,73	7	8,0	15,0	0,802	322	OR	1997-1998	Torcu-Koç et al. (2002)*
	İzmir Bay		FL	B	22,86	0,25	-1,45	4	8,5	17,0	0,744	160	LF	1997-1999	Kınacıgil and Akyol (2001)*
			TL	B	22,01	0,23	-1,30	7	7,7	18,3	0,831	2393	OR	2004-2007	Kınacıgil et al. (2008)
	Gulf of Gabes	Tunusia	TL	B	22,64	0,16	-2,00	6	8,4	16,1	0,712	nr	LF	nr	Bradai et al. (2001)
	Thermoikos Gulf	Greece	TL	B	20,10	0,21	-1,81		6,3	17,4	0,866	135	nr	nr	Froese and Pauly (2017)"
	Gulf of Lion	France	FL	B	18,66	0,56	-0,02	5	3,3	18,2	0,973	nr	SR	nr	Girardin (1978)*"
D. bellottii	Western Sahara	Morocco	FL	B	28,42	0,27	-0,19		8,9	20,8	0,733	nr	LF	1980-1982	Mennes (1985)*"
D. capensis	Tsitsikamma coast	South Africa	FL	B	36,19	0,25	-1,05	21	8,9	38,9	1,074	318	OR	1989-1990	Mann and Buxton (1997)*
	South Angola	Angola	FL	F	40,84	0,09	-4,40	20	8,9	38,6	0,946	326	OR	2008-2009	Richardson et al. (2011)*
			FL	M	27,70	0,31	-1,40	11	8,9	29,3	1,059	64	OR	2008-2009	Richardson et al. (2011)*"
			FL	F	25,61	0,45	-1,00	10	8,9	35,0	1,368	131	OR	2008-2009	Richardson et al. (2011)*
			FL	M	23,98	0,49	-0,90	8	8,9	24,1	1,005	57	OR	2008-2009	Richardson et al. (2011)*"

Species	Location	Country	LT	Sex	L_∞	K	t_0	t_{max}	L_{min}	L_{max}	L_{max}/L_∞	N	Method	Year	Author
D. cervinus	Canary Islands	Spain	TL	F	58,80	0,16	-0,80	14	16,0	52,8	0,898	327	OR	2000-2001	Pajuelo et al. (2003a)
			TL	M	60,90	0,15	-0,73	17	19,3	56,5	0,928	151	OR	2000-2001	Pajuelo et al. (2003a)
			TL	M	61,90	0,15	-0,84	17	19,3	56,5	0,913	114	OR	2000-2001	Pajuelo et al. (2003b)
			TL	F	58,40	0,15	-0,76	14	16,0	52,8	0,904	298	OR	2000-2001	Pajuelo et al. (2003b)
	Annaba Gulf	Algeria	TL	B	68,83	0,11	-0,75	13	9,8	52,7	0,766	190	OR	2001	Derbal and Kara (2013)
D. holbrooki	South Atlantic Bight	US	TL	B	35,80	0,22	-1,00	10	12,5	42,5	1,187	nr	OR	1971-1974	Darcy (1985)
	Off N. Carolina		TL	B	30,76	0,26	-0,98	11	5,5	36,5	1,187	349	OR	1993-1995	Manooch and Potts (1996)
D. hottentotus	Tsitsikamma coast	South Africa	FL	B	46,24	0,15	-2,15	33	1,6	56,1	1,213	281	OR	1989-1990	Mann and Buxton (1997)*"
D. puntazzo	Canary Islands	Spain	TL	M	52,70	0,19	-2,76	10	16,9	51,0	0,968	168	OR	2001-2003	Dominguez-Seoane et al. (2006)
			TL	F	52,30	0,20	-2,23	9	15,9	50,9	0,973	348	OR	2001-2003	Dominguez-Seoane et al. (2006)
	Gulf of Gabes	Tunusia	TL	B	28,39	0,18	-1,65		11,4	26,8	0,944	1335	OR	2008-2010	Chaouch et al. (2013)
	Gulf of Gabes		TL	B	23,19	0,47	-0,25	6	11,9	29,5	1,272	112	SR	nr	Bradai et al. (1998)
	Adriatic Sea	Coratia	TL	B	45,28	0,19	-0,31	18	13,3	46,7	1,031	598	SR	2004-2005	Kraljevic et al. (2007)
			TL	B	13,32	0,48	-0,11	1	1,6	9,3	0,698	663	LF	1991-1992	Matic-Skoko et al. (2007b)
D. sargus cadenati	Canary Islands	Spain	TL	F	49,90	0,13	-2,23	12	16,2	40,4	0,810	341	OR	2000-2001	Pajuelo and Lorenzo (2004)
			TL	M	44,70	0,15	-1,89	11	15,8	39,2	0,877	117	OR	2000-2001	Pajuelo and Lorenzo (2004)
			TL	F	49,40	0,15	-2,05	12	16,2	40,4	0,818	289	OR	2000-2001	Pajuelo and Lorenzo (2002a)
			TL	M	45,90	0,14	-1,91	12	15,8	39,2	0,854	97	OR	2000-2001	Pajuelo and Lorenzo (2002a)
D. sargus sargus	North Spain	Spain	TL	F	57,59	0,10	-5,33	8	26,0	42,1	0,731	102	OR	1983-1984	Pastor and Quadros (1996)
			TL	M	52,92	0,13	-3,73	8	24,5	45,0	0,850	91	OR	1983-1984	Pastor and Quadros (1996)
			TL	nr	48,48	0,18	-0,58		17,4	33,4	0,689	nr	nr	nr	Martinez-Pastor and Villegas-Cuadros (1996)"
	Catalan Coast		TL	B	41,70	0,25	-0,76	10	9,0	39,0	0,935	184	OR	nr	Gordoa and Moli (1997)
	South Portugal	Portugal	TL	B	39,55	0,15	-1,89	16	16,9	45,0	1,138	331	SR	1992-1999	Abecasis et al. (2008)"
			TL	B	40,93	0,18	-1,28	18	16,9	41,0	1,002	715	OR	1992-1999	Abecasis et al. (2008)"
			TL	B	41,20	0,18	-0,86		16,9	49,0	1,189	nr	OR	nr	Erzini et al. (2001)"
	Beymelek Lagoon	Turkey	TL	B	39,90	0,27	-1,75	3	10,0	28,7	0,719	355	SR	2006-2007	Balık and Emre (2016)

Species	Location	Country	LT	Sex	L_∞	K	t_0	t_{max}	L_{min}	L_{max}	L_{max}/L_∞	N	Method	Year	Author
D. sargus sargus	Gulf of Lion	France	TL	B	35,25	0,22	-0,84	14	6,0	42,0	1,191	484	SR	1980	Man-Wai and Quignard (1982)
			FL	B	22,86	0,53	-0,14	4	10,0	42,0	1,837	nr	SR	nr	Girardin (1978)*"
	Abu Qir Bay	Eygpt	TL	B	31,30	0,26	-0,73	6	7,5	27,5	0,879	746	SR	2008-2009	Mahmoud et al. (2010)
	Alexandria		TL	B	32,70	0,13	-1,84	13	11,2	39,0	1,193	nr	SR	nr	LahLah (2004)"
			TL	B	54,86	0,10	-2,06	8	11,2	39,0	0,711	604	SR	2008-2009	El-Maghraby et al. (1981)"
	North Sinai		TL	B	40,71	0,25	-0,28	5	11,0	38,0	0,933	991	SR	2010-2012	Al-Beak et al. (2015)
	East Algeria	Algeria	TL	B	36,30	0,15	-0,49	10	12,2	34,6	0,953	241	OR	2005-2006	Benchalel and Kara (2013)
D. vulgaris	Alexandria	Eygpt	TL	B	57,71	0,07	-2,94	7	11,2	30,0	0,520	410	SR	2008-2009	El-Maghraby et al. (1981)
	Abu Qir Bay		TL	B	31,30	0,26	-0,56	6	8,5	26,0	0,831	616	SR	1998-2008	Adam (2010)
	Adriatic Sea	Coratia	TL	M	56,25	0,08	-2,92	10	14,5	37,5	0,667	1620	SR	2005-2006	Dulcic et al. (2011)
			TL	F	51,96	0,10	-2,84	11	14,5	36,2	0,697	1333	SR	2005-2006	Dulcic et al. (2011)
	Gulf of Gabes	Tunusia	TL	B	24,14	0,16	-2,33	7	7,0	25,0	1,036	1097	SR	2006-2007	Hadj Taieb et al. (2013a)
			TL	B	25,40	0,18	-1,63	9	7,0	25,0	0,984	1097	OR	2008-2010	Hadj Taieb et al. (2013b)
			TL	B	23,47	0,22	-1,45	8	10,8	32,0	1,363	97	SR	nr	Bradai et al. (1998)
	Gulf of Tunu-sia		TL	B	39,90	0,11	-0,73	12	10,0	32,0	0,802	510	SR	2005-2006	Mouine et al. (2010)
			TL	B	39,00	0,10	-0,96	11	10,6	32,0	0,821	492	OR	2005-2006	Mouine et al. (2010)
	South Portugal	Portugal	TL	B	28,10	0,30	-1,62	10	12,5	30,5	1,085	374	OR	1992-1994	Gonçalves (2000)
			TL	B	39,60	0,32	-0,48		12,5	30,5	0,770	374	LF	1992-1994	Gonçalves (2000)
			TL	B	34,49	0,18	-1,27	14	9,0	33,0	0,957	377	SR	1992-1999	Abecasis et al. (2008)
			TL	B	27,40	0,40	-0,77	14	9,0	30,0	1,095	1076	OR	1992-1999	Abecasis et al. (2008)
			TL	M	28,60	0,36	-0,38	14	14,5	36,9	1,290	368	OR	1992-2000	Gonçalves et al. (2003)
			TL	F	27,67	0,39	-0,34	12	13,8	37,0	1,337	440	OR	1992-2000	Gonçalves et al. (2003)
	Gulf of Lion	France	TL	B	37,80	0,18	-0,83	8	10,0	35,0	0,926	556	SR	nr	Man Wai (1985)
			FL	B	30,79	0,26	-0,61	3	9,0	18,2	0,590	nr	SR	nr	Girardin (1978)*
	Canary Islands	Spain	TL	B	39,70	0,23	-0,91	9	13,0	37,0	0,932	488	OR	2000-2001	Pajuelo and Lorenzo (2003)
	Catalan Coast		TL	B	28,78	0,39	-0,66	6	8,0	28,0	0,973	201	OR	nr	Gordoa and Moli (1997)
	Benghazi Coasts	Libya	TL	B	33,30	0,11	-1,58	8	11,0	27,0	0,811	290	SR	2005	Saeid et al.. (2016)
	Scilia Strait	Italy	TL	B	33,50	0,17	-2,59		14,0	27,0	0,806	603	OR	1997-1999	Beltrano et al. (2003)
	İzmir Bay	Turkey	TL	B	27,96	0,25	-1,18	3	7,0	19,0	0,680	709	OR	2004-2007	Soykan et al. (2015)
	Western Sa-hara	Morocco	FL	B	44,85	0,40	-0,42		9,6	37,2	0,829	nr	LF	1980-1982	Mennes (1985)*"

* FL transformed to TL according to formula given in the manuscript

" L_{max}, L_{min} or both not reported in the original study. They are assigned from Fishbase or other studies carried at same location.

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