Research in Marine Sciences
Volume 6, Issue 1, 2021
Pages 883 - 895

Pelagic larval duration and early growth of striped seabream, *Lithognathus mormyru*s inhabiting the Gökçeada shallow waters, Turkey

Hakan Ayyildiz*, and Aytaç Altin

Çanakkale Onsekiz Mart University, Gökçeada School of Applied Sciences, Department of Fisheries Technology, 17760, Gökçeada, Çanakkale, Turkey

Received: 2020-11-21 *Accepted: 2021-02-28*

Abstract

Otolith microstrure analysis was used to determine the pelagic larval duration (PLD), daily age, growth rates, hatching periods, and the mortality rates of the young of the year (YOY) striped seabream from Gökçeada, Turkey. This study was carried out in shallow waters (0-20 m) off the Gökçeada Island, Turkey, from June 2013 through June 2014. A total of 632 YOY striped seabream, *Lithognathus mormyrus* were measured and daily ages determined. Estimated ages from otolith daily growth increments (DGI) were found 28-218 days old. The indices for determining variability in daily age estimates (APE and CV) were 4.1 and 5.8%, respectively. The mean daily growth rate of YOY striped seabream was calculated as 0.317 mm/day. Individuals with YOY sea stingrays have been found to remain in the pelagic larval duration for an average of 26 days and settled in the demersal environment after the 26th days. The hatching times of striped seabream were backcalculated to occur between April and January, with relatively higher hatching frequencies in July and December. The instantaneous mortality coefficient was found as 0.0461, which represented around 4.61% of daily mortality. Sagittal otolith length (OL), width (OW), and radius (OR) were observed in the ranges of 0.741-3.283 mm, 0.586-1.921 mm, and 0.259-1.626 mm, respectively. Relationships between total length and otolith morphometric measurements (OL, OW, and OR) were described by linear equations.

Keywords: Lithognathus mormyrus*;* Pelagic larval duration; Otolith microstructure; Growth; Mortality.

* Corresponding Author's Email: ayyildizhakan@gmail.com

1. Introduction

Striped seabream, Lithognathus mormyrus (Linnaeus, 1758) is a species that lives in the East Atlantic Ocean (from Biscay Bay to Cape of Good Hope) and West Indian Ocean (from South Mozambique to Cape of Good Hope), the Mediterranean, the Black Sea, the Azov Sea and the Red Sea (Bauchot and Hureau, 1986; 1990, Harmelin-Vivien *et al.*, 1995) It is a demersal fish living in groups and prefers sandy, stony and seagrass habitats between 0 and 150 m depths (Bauchot and Hureau, 1986). This species, which belongs to the Sparidae family, is a protandric hermaphrodite (Bauchot and Hureau, 1986, 1990).

The striped seabream is important species for the coastal and lagoon fisheries in Turkey (Emre *et al.*, 2010). This species has high commercial value, with commercial landings 182 ton in 2018 The striped sea bream is mainly caught by trammel nets, gill nets and longlines from the Turkish coasts.

Spawning time of the striped seabream from the Thracian Sea and the Mediterranean coast of Spain is between May and September with a peak in June, July and August (Kallianiotis *et al.*, 2005; Suau, 1970). The maximum gonad activity was occurred between August and September in the East Atlantic Ocean (Lorenzo *et al.*, 2002). It has been reported that the spawning period of the striped seabream has reached the maximum density between August and September from the Canary Islands (Pajuelo *et al.*, 2002).

Population parameters, such as age, growth, reproduction and mortality, in the northern and middle Adriatic Sea (Kraljevic *et al.*, 1996; Kraljevic *et al.*, 1995), in the Thracian Sea (Kallianiotis *et al.*, 2005), in eastern Spanish coastal waters (Suau, 1970), in the central eastern Atlantic (Lorenzo *et al.*, 2002; Pajuelo *et al.*, 2002), on Sicilian coasts (Vitale *et al.*, 2011), in southern Portuguese coastal waters (Abecasis *et al.*, 2008; Monteiro *et al.*, 2010), in the Beymelek Lagoon (Emre *et al.*, 2010) and in Iskenderun Bay (Türkmen and Akyurt, 2003), have been studied. However, most of the studies conducted for the striped seabream focused on adult populations.

Information on early life stages is critical for understanding population traits, such as recruitment. The density of individuals in the early life stages of fish species will possibly cause a competition for prey. Therefore, it will play a significant role in the growth rates. Excessive density will also increase the possibility of high damage of the eggs and larvae from the predators. Intensity-dependent growth or survival rates have a significant impact on the recruitment of the adult stocks (Houde, 2008). Despite the importance on the early life stages of the striped seabream, very limited research has been conducted (Ayyildiz *et al.*, 2014b; Matic-Skoko *et al*., 2007).

Therefore, the main goal of the current study was to determine the pelagic larval duration, daily age, growth rates, hatching periods and the mortality rates of the young of the year (YOY) striped seabream from Gökçeada, Turkey, by using otolith microstructure.

2. Materials and methods

This study was carried out from the shallow waters (0-20 m) of Gökçeada Island, Turkey between June 2013 and June 2014 (Figure 1). The samples were collected using by a beach seine of 32 m in total length, with 15 m wing lengths. The net was constructed of 13 mm stretch mesh. The dimensions of the bag were 2 × 2 × 0.6 m, and the bag was constructed with 5 mm mesh.

2.1. Length-weight relationships

The striped seabream was measured for total length (TL) and total weight (W). The relation between the total length and the weight was calculated using a power function:

$W= aTL^b$

where, b is the regression coefficient and a is the regression constant. The regression parameters a, b and the coefficient of determination (R^2) were estimated for all individuals.

2.2. Daily age and growth

Sagittal otoliths of the striped seabream were extracted, dried and stored in eppendorf tubes. A total of 632 sagittal otoliths, covering all length classes, were mounted on a glass slide with thermoplastic cement. Each otolith was ground with a series of abrasive papers of decreasing roughness from 12 to 9 to 3 mm and polished with 0.3 mm alumina paste on a polishing cloth until daily rings were discernible from the centre to the edge (Jones, 1992; Secor *et al*., 1991). Counts of rings in each otolith were blind read; the information about fish length and date of capture was withheld from the reader. Sagittal otolith daily growth rings were counted from the core to the outer edge under a light microscope (Figure 2). Two readers independently counted the daily growth rings without prior knowledge of fish length. Estimates of the precision of growth ring counts between readers were determined by using the average percentage error (APE) of (Beamish and Fournier, 1981) and coefficient of variation (CV) (Chang, 1982).

The relationship between fish size (TL) and age (days) was assessed by linear regression which corresponds to an average growth rate (mm/day).

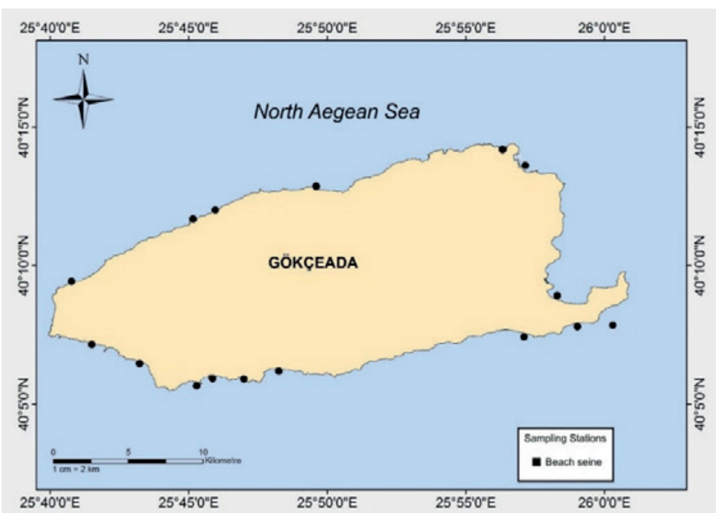

Figure 1. Sampling stations of the striped seabream, *Lithognathus mormyrus* caught by beach seine from the shallow waters of Gökçeada, Turkey

Figure 2. Images of the daily ages seen in a polished sagittal otolith of 41 mm TL YOY *Lithognathus mormyrus* aged 107 days

2.3. Settlement

Otolith daily growth increment widths of the striped seabream was measured by using Image J 1.52a software. The settlement mark was characterized by a rapid decrease in increment width (Type I) of the daily growth increments according to the definitions of Wilson and McCormick, (1999).

2.4. Hatch date distributions

Hatch date distributions were back-calculated by subtracting the number of otolith growth increments from the date of capture.

2.5. Daily mortality

For determination of the instantaneous mortality coefficient (Z), fish size was converted to age (d) according to the length–age relationships. Juvenile abundance was grouped into 20-day intervals. Estimates of Z were obtained using the age-based catch curve method of Ricker, (1975). A linear regression analysis was computed to the ln-transformed data set, and the slopes of regression lines represented the instantaneous mortality coefficients. Daily mortality percentages (DM) were expressed as: $DM = (1 - \exp(-Z)) * 100$

2.6. Otolith morphometry

Otolith length (OL), width (OW) and radius (OR) were measured to the nearest 0.01 mm using Q Capture Imaging Software. OL was defined as the longest axis between the anterior and posterior otolith edge and OW as a distance from the dorsal to the ventral edge. OR was measured as the longest axis between the nucleus and the posterior edge. Differences between left and right otoliths were tested by paired t-test. Furthermore, the relationships between the fish length and the otolith morphometry were investigated.

2.7. Statistical analysis

Paired t-tests can be used to reduce the effects of confounding factors in an observational study. There was no significant difference between the daily age estimates for the left and right otoliths (paired t-test: n= 30, $P > 0.05$). Therefore, only one otolith was randomly selected for daily age estimation. Statistical analyses were calculated by PAST version 3.26 package program (Hammer *et al*., 2001). Statistical significance level (α) was set at 0.05.

3. Results

A total of 632 YOY striped seabream specimens ranged in total length from 14 to 74 mm were sampled from Gökçeada shallow waters, between June 2013 and June 2014 (Figure 3). The parameters of the length–weight relationships are provided for all individuals in Figure 4.

3.1. Daily age and growth

Daily ages estimates were successfully determined from the 632 sagittal otoliths of YOY striped seabream that ranged in size from 14 to 74 mm TL from Gökçeada shallow waters (Table 1). Minimum daily age estimate was 28 day (for a fish at 14 mm TL), and the maximum was 218 day (for a fish at 73 mm TL). The APE and CV were calculated as 4.1 and 5.8%, respectively. The daily age groups between 48-67 and 108-127 days (for fish at 20-55 mm TL) was the dominant age groups (82.4%).

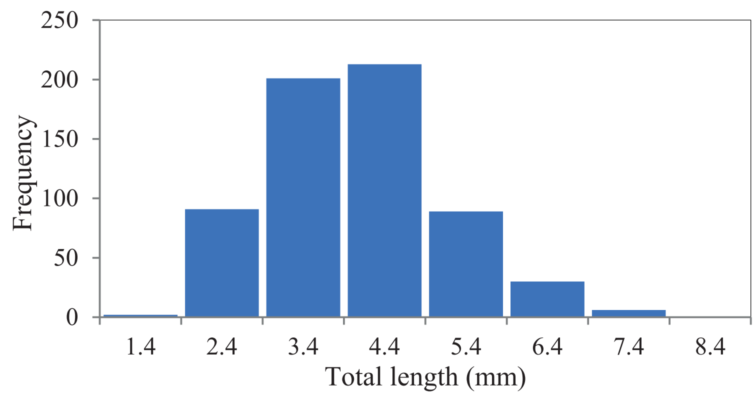

Figure 3. Length–frequency distribution of YOY *Lithognathus mormyrus* collected from the shallow waters of Gökçeada during the whole sampling period (June 2013 to June 2014), N= 632

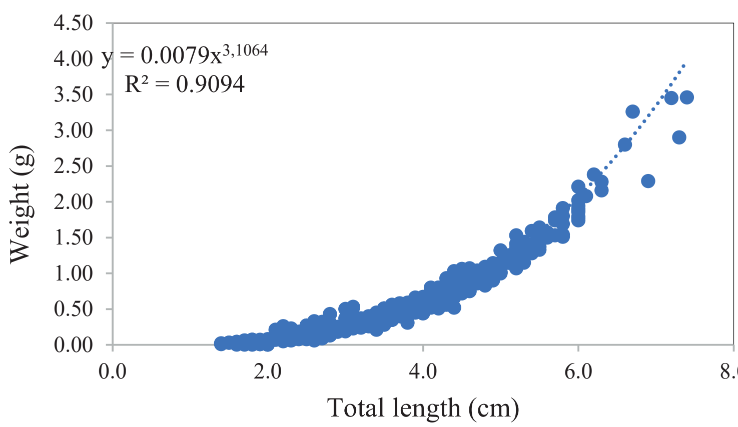

Figure 4. Length-weight relationships of the *Lithognathus mormyrus* from the shallow waters of Gökçeada

Table 1. Age–length key for YOY *Lithognathus mormyrus* from the shallow waters of Gökçeada, Turkey. N, total number of specimens per length/age group

Total Length Group (mm)	Daily Age										
	28-47	48-67	68-87	88-107	108-127	128-147	148-167	168-187	188-207	208-227	N
14-19	31										31
20-25	12	77									89
26-31	6	81	21								108
32-37		5	91	42	1						139
38-43			22	62	29	5					118
44-49			1	19	44	15	3				82
50-55				1	21	11	2	1			36
56-61					4	11	3	1	1		20
62-67							2	2	1		5
68-73							1		1	1	3
74-79										1	1
N	49	163	135	124	99	42	11	4	3	2	632

The mean daily growth rate of YOY striped seabream was calculated as 0.317 mm/day (Figure 5).

3.2. Settlement mark

According to Wilson and McCormick, (1999) definition it has been determined that the YOY striped seabream individuals collected from Gökçeada Island have a Type Ia settlement ring. According to this definition, the mean percentage decrease in increment width associated with Type Ia settlement-mark (Figure 6). We have determined that the YOY striped seabream individuals stayed in the pelagic larval duration for an average of 26 days and settled in the demersal environment after the 26th days.

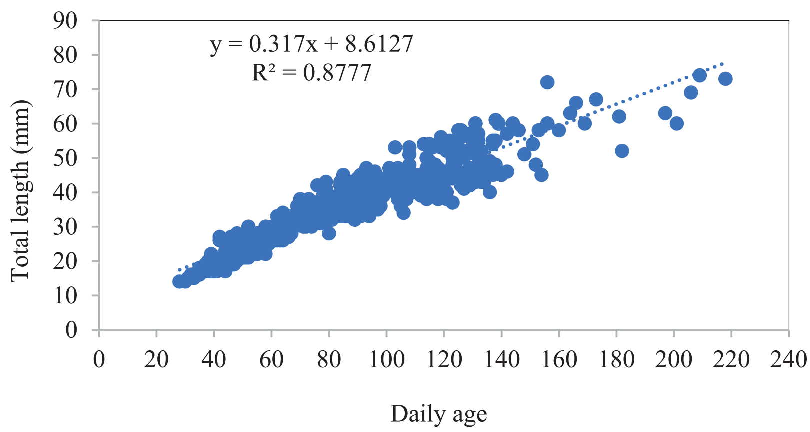

Figure 5. Age-length relationships estimated for YOY *Lithognathus mormyrus* collected from the shallow waters of Gökçeada, Turkey during June 2013-June 2014

3.3. Hatch date distributions

The back-calculated hatching times occurred between April and January, with relatively higher hatching frequencies in July and December (Figure 7).

3.4. Daily mortality

Data of natural logarithm of YOY abundance were plotted against age, and the mortality coefficients were estimated as the slopes of these linear regressions. The YOY striped seabream instantaneous mortality coefficient was 0.0461, which represented around 4.61% of daily mortality (Figure 8).

3.5. Otolith morphometry

Sagittal otolith length, width, and radius were observed in the ranges of 1.170-4.251 mm, 0.801-2.412 mm, and 0.477-2.071 mm, respectively (Table 2). Relationships between TL and otolith morphometric measurements (OL, OW, and OR) were described by linear equations (Table 3).

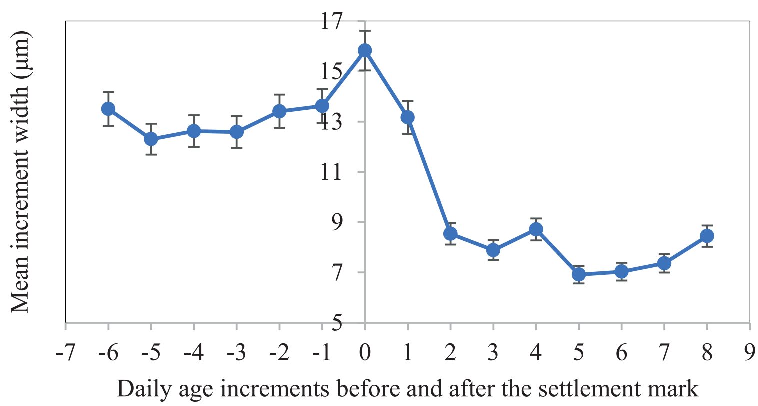

Figure 6. Mean increment widths before and after the settlement mark for YOY *Lithognathus mormyrus* collected from the shallow waters of Gökçeada, Turkey during June 2013-June 2014

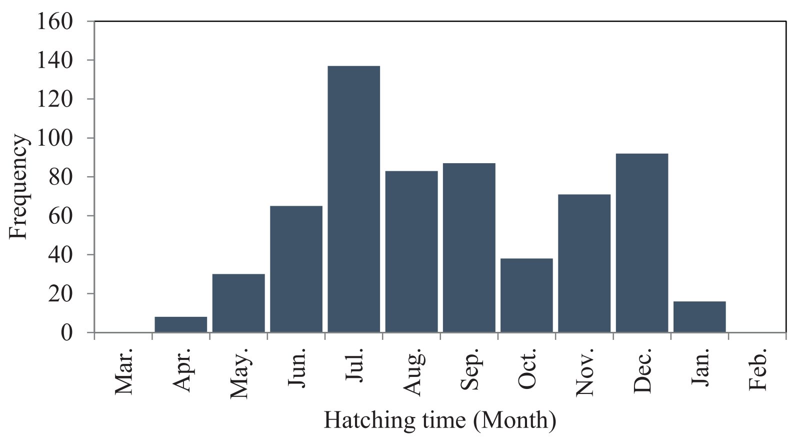

Figure 7. Hatching-time frequency distributions back-calculated by using daily age estimates and sampling dates of YOY *Lithognathus mormyrus* from the shallow waters of Gökçeada, Turkey, during June 2013-June 2014

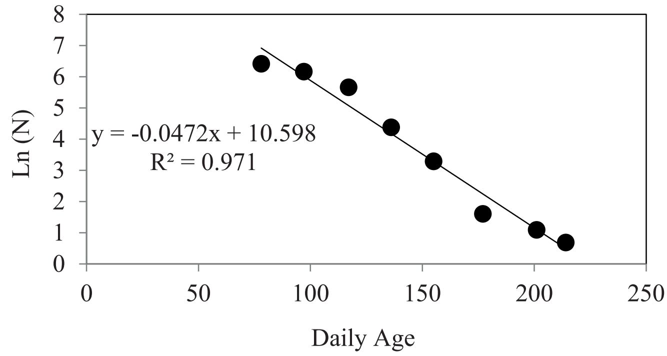

Figure 8. Relationships of Ln abundance at age of YOY *Lithognathus mormyrus* from the shallow waters of Gökçeada, Turkey, during June 2013–June 2014

Table 2. Otolith morphometric measurements of YOY *Lithognathus mormyrus* according to the length groups

Total length group (mm)	OL				OW				OR			
	Min.	Max.	Mean	Std	Min.	Max.	Mean	Std	Min.	Max.	Mean	Std
14-19	0.741	0.968	0.855	0.085	0.586	0.712	0.649	0.047	0.259	0.384	0.322	0.047
20-25	1.013	1.240	1.129	0.074	0.737	0.862	0.798	0.040	0.410	0.535	0.471	0.040
26-31	1.286	1.648	1.465	0.113	0.887	1.112	0.998	0.075	0.560	0.746	0.662	0.063
32-37	1.335	1.909	1.698	0.108	0.981	1.255	1.140	0.070	0.697	0.918	0.812	0.054
38-43	1.373	2.327	1.985	0.145	1.085	1.598	1.288	0.101	0.750	1.251	0.987	0.097
44-49	1.883	2.551	2.194	0.144	1.088	1.522	1.368	0.092	0.829	1.325	1.049	0.106
50-55	2.219	2.804	2.446	0.130	1.289	1.696	1.522	0.105	0.955	1.407	1.154	0.108
56-61	2.485	2.903	2.715	0.102	1.526	1.792	1.675	0.074	1.040	1.504	1.318	0.095
62-67	2.958	3.144	3.026	0.083	1.735	1.843	1.786	0.057	1.347	1.597	1.507	0.110
68-73	2.949	3.210	3.080	0.185	1.746	1.921	1.834	0.124	1.368	1.626	1.497	0.182
74-79	3.283	3.283	3.283	—	1.895	1.895	1.895	—	1.419	1.419	1.419	—

Table 3. Parameters of the linear relationship of the otolith morphometry (otolith length (OL), otolith width (OW), and otolith radius (OR)) with fish length and age for YOY *Lithognathus mormyrus* from Gökçeada, Turkey, during June 2013-June 2014. The number of specimens (n), y-intercept (a), slope of the regression line (b), and coefficient of determination (r2) are provided

		Total length				Age			
Otolith morphometry	n	a	b	r^2	*P*	a	b	r^2	*P*
OL	632	-2.34	22.046	0.915	<0.01	-14.801	60.07	0.726	<0.01
OW	632	-9.36	39.849	0.838	<0.01	-30.458	105.99	0.649	<0.01
OR	632	3.71	39.769	0.774	<0.01	5.347	104.69	0.595	<0.01

Table 3. Parameters of the linear relationship of the otolith morphometry (otolith length (OL), otolith width (OW), and otolith radius (OR)) with fish length and age for YOY *Lithognathus mormyrus* from Gökçeada, Turkey, during June 2013-June 2014. The number of specimens (n), y-intercept (a), slope of the regression line (b), and coefficient of determination (r^2) are provided

4. Discussion

Shallow waters are important for the YOY fish species and fisheries management. YOY striped seabream individuals settles into the shallow waters after the larval period and then recruits into the adult populations before reaching sexual maturity (Kallianiotis *et al*., 2005). In this study, we were caught YOY striped seabream individuals mostly between August and November from the shallow waters (0–2 m) of Gökçeada. We were obtained 98.9% of the all YOY striped seabream individuals from the depths between 0-2 m during the study period. The fact that individuals bigger than 70 mm TL could not be caught in the shallow waters (0-2 m) of Gökçeada, this can be considered as an indication that individuals larger than this size possibly migrate to deeper waters. Similarly, (Matić-Skoko *et al*., 2007) reported that the striped seabream, which reached 6-7 cm TL, were migrated to deeper waters by joining the adult population. It is also a possibility to consider that the larger size individuals who exhibit burial behavior in the sand for escaping the net.

This study examined the microstructure of the striped seabream otoliths, as well as the time of the settlement and hatching, through daily increment analysis on wild fish samples at early life stages. The daily age determination is widely used in stock assessments for fishery management since it was first used by (Pannella, 1971). Daily age formation in otoliths is a general phenomenon that has been validated for many fish species (Campana and Neilson, 1985; Jones, 1992). Therefore, formation of daily age on the otoliths of the striped seabream were assumed to occur daily. In the current study, light and dark daily age increments were observed in the sagittal otoliths of the striped seabream that collected from the shallow waters of Gökçeada. In addition, our results are acceptable values according to Campana, (2001) suggestion which acceptable levels for APE and CV were 5.5 and 7.6%, respectively.

Growth in larvae and juveniles is one of the most important factors for their survival. Because fast growing fish complete these critical period with the lowest mortality in a short time (Takahashi and Watanabe, 2004). Otolith microstructure is important for our understanding of the growth of fish (Sponaugle, 2010). There are very limited number of studies on the age and growth characteristics of young of the year striped seabream. Our findings are consistent with those of Ayyildiz *et al.* (2014b), who reported that the mean daily growth rates of striped seabream was 0.325 mm/day.

Detecting the settlement marks is very important for determining larval duration in many fish species (Wilson and McCormick, 1999). Settlement marks in the otoliths can be determined by the rapid decrease of the daily growth increment widths (Vigliola *et al*., 2000). The current study found that the YOY striped seabream individuals have a Type Ia settlement marks according to the Wilson and McCormick, (1999) definitions. Pelagic larval duration for the striped seabream was estimated to occur 26 days. In reviewing the literature, no data was found on the settlement time of the striped seabream.

Our results showed that the back-calculated hatching times occurred between April and January, with relatively higher hatching frequencies in July and December. The spawning period of the striped seabream was reported between June and November and the highest value between August and September in the Canary (Pajuelo *et al.*, 2002), and takes place between April and September on the Mediterranean coast of Eastern Spain (Suau, 1970). Previous research has indicated that the striped seabream spawning was occurred between May and September from the North Aegean Sea (Kallianiotis *et al.*, 2005). Another previous research findings from the shallow waters of Çanakkale showed that hatching times continued from April to January and reached the maximum level in August (Ayyildiz *et al.*, 2014b). The results of this study seem to be consistent with earlier studies.

Detecting the daily changes in the size of the fish can be used to estimate the percentage of survival of these individuals until they become adults (Houde, 1987). The results of this study showed that YOY striped seabream instantaneous mortality coefficient was calculated as 0.0461, which represented around 4.61% of daily mortality. As mentioned in the previous study conducted from Çanakkale, daily mortality of the striped seabream was 2.16% (Ayyildiz *et al.*, 2014b). As it is known, mortality rates can vary according to years and cohorts. The fact that the difference of the percentages of daily mortality in these two studies which conducted in very close regions, can be explained by the different biological and environmental conditions. The physiology, metabolic activities, behavior and growth of fish in the early life stages depending on the environmental factors. In the early life stages, the increase of the fish length will cause decreases of predator pressure, thus the mortality rates will decrease. Slow growing and small fish larvae are possibly more affected by predators than the others in the long term. This situation shows that the fast-growing species will have higher survival rates (Houde, 1987).

Conclusion

The findings of present study showed that total length and age can be estimated from its otolith morphometric measurements or vice versa. The OL was found to be a better parameter than the others (OW and OR) in estimating fish length and age. In recent years, researchers have reported that otolith morphometric characteristics could be used for age readings (Megalofonou, 2006; Skeljo and Ferri, 2012). Information about the otolith morphometry could possibly be important for the identification of fish species and determines the prey size that obtained from the stomach contents of piscivorous predators (Ayyildiz and Altin, 2018; Ayyıldız and Altin, 2019; Ayyildiz *et al.*, 2014a; Ayyildiz *et al.*, 2014b, Ayyildiz *et al.*, 2015; Rani *et al.*, 2019).

Acknowledgments

This study was funded by The Scientific and Technological Research Council of Turkey (project no.: 112Y062).

References

Abecasis, D., Bentes, L., Coelho, R., Correia, C., Lino, P. G., et al. 2008. Ageing seabreams: A comparative study between scales and otoliths. Fisheries Research, 89(1): 37-48. doi:10.1016/j.fishres.2007.08.013

Ayyildiz, H., and Altin, A. 2018. Age and growth rates at the early life stages of common pandora (Pagellus erythrinus) based on analysis of otolith microstructure. Fishery Bulletin, 116(2): 183-189. doi:https://doi.org/10.7755/FB.116.2.7

Ayyıldız, H., and Altin, A. 2019. Hatching Time and Early Growth of Diplodus sargus sargus

Inhabiting a Coastal Area of Gökçeada Island, Turkey. Thalassas: An International Journal of Marine Sciences, November 2019: 1-8. doi:10.1007/s41208-019-00185-9

Ayyildiz, H., Ozen, O., and Altin, A. 2014a. Growth and hatching of annular seabream, Diplodus annularis, from Turkey determined from otolith microstructure. Journal of the Marine Biological Association of the United Kingdom, 94(5): 1047-1051. doi:https://doi.org/10.1017/S002531541400040X

Ayyildiz, H., Ozen, O., and Altin, A. 2014b. Growth, mortality and hatch-date distributions of striped sea bream Lithognathus mormyrus inhabiting the Canakkale Strait, Turkey. Journal of the Marine Biological Association of the United Kingdom, 94(3): 607-613. doi:10.1017/s0025315413001847

Ayyildiz, H., Ozen, O., and Altin, A. 2015. Daily growth rates and hatch date distributions of common two-banded seabream, Diplodus vulgaris inhabiting the Canakkale shallow waters of Turkey. Journal of the Marine Biological Association of the United Kingdom, 95(1): 185-191. doi:10.1017/s0025315414001222

Bauchot, M. L., and Hureau, J. C. 1986. Sparidae. In Whitehead, P. J. P., Bauchot, M. L., Hureau, J. C., Nielsen, J., and Tortonese, E. (Eds.), Fishes of the North-Eastern Atlantic and the Mediterranean (Vol. II, pp. 883–907). Paris: UNESCO.

Bauchot, M. L., and Hureau, J. C. 1990. Sparidae. In Hureau, J. C., Karrer, C., Post, A., and Saldanha, L. (Eds.), Check List of the Fishes of the Eastern Tropical Atlantic (pp. 790-812): Clofeta II, UNESCO, Paris.

Beamish, R. J., and Fournier, D. A. 1981. A method for comparing the precision of a set of age-determinations. Canadian Journal of Fisheries and Aquatic Sciences, 38(8): 982-983. doi:10.1139/f81-132

Campana, S. E. 2001. Accuracy, precision and quality control in age determination, including a review of the use and abuse of age validation methods. Journal of Fish Biology, 59(2): 197-242. doi:10.1111/j.1095-8649.2001.tb00127.x

Campana, S. E., and Neilson, J. D. 1985. Microstructure of fish otoliths. Canadian Journal of Fisheries and Aquatic Sciences, 42(5): 1014-1032.

Chang, W. Y. B. 1982. A statistical-method for evaluating the reproducibility of age-determination. Canadian Journal of Fisheries and Aquatic Sciences, 39(8): 1208-1210. doi:10.1139/f82-158

Emre, Y., Balik, I., Sumer, C., Oskay, D. A., and Yesilcimen, H. O. 2010. Age, growth, length-weight relationship and reproduction of the striped seabream (Lithognathus mormyrus L., 1758) (Sparidae) in the Beymelek Lagoon (Antalya, Turkey). Turkish Journal of Zoology, 34(1): 93-100. doi:Doi 10.3906/Zoo-0808-13

Hammer, Ø., Harper, D. A. T., and Ryan, P. D. 2001. PAST: Paleontological Statistics Software Package for Education and Data Analysis. Palaeontologia Electronica, 4, 9 p. doi:http://palaeo-electronica.org/2001_1/past/issue1_01.htm

Houde, E. D. 1987. Fish Early Life Dynamics Recruitment Variability. American Fisheries Society Symposium, 2: 17-29.

Houde, E. D. 2008. Emerging from Hjort's shadow. Journal of Northwest Atlantic Fishery Science, 41: 53-70.

Jones, C. M. 1992. Development and application of the otolith increment technique. In Stevenson, D. K. and Campana, S. E.

(Eds.), Otolith microstructure examination and analysis (Vol. 117, pp. 1-11): Canadian Special Publication of Fisheries and Aquatic Sciences.

Kallianiotis, A., Torre, M., and Argyri, A. 2005. Age, growth, mortality, reproduction, and feeding habits of the striped seabream, Lithognathus mormyrus (Pisces : Sparidae), in the coastal waters of the Thracian Sea, Greece. Scientia Marina, 69(3): 391-404.

Kraljevic, M., Dulcic, J., Cetinic, P., and Pallaoro, A. 1996. Age, growth and mortality of the striped sea bream, Lithognathus mormyrus L, in the northern Adriatic. Fisheries Research, 28(4): 361-370.

Kraljevic, M., Dulcic, J., Pallaoro, A., Cetinic, P., and Jugdujakovic, J. 1995. Sexual-maturation, age and growth of striped sea bream, Lithognathus mormyrus L, on the eastern coast of the Adriatic sea. Journal of Applied Ichthyology, 11(1-2): 1-8.

Lorenzo, J. M., Pajuelo, J. G., Mendez-Villamil, M., Coca, J., and Ramos, A. G. 2002. Age, growth, reproduction and mortality of the striped seabream, Lithognathus mormyrus (Pisces, Sparidae), off the Canary Islands (Central-east Atlantic). Journal of Applied Ichthyology, 18(3): 204-209.

Matic-Skoko, S., Ferri, J., Kraljevic, M., and Dulcic, J. 2007. Growth of juvenile striped seabream, Lithognathus mormyrus (Teleostei : Sparidae), in the Adriatic Sea. Journal of Applied Ichthyology, 23(3): 286-287. doi:DOI 10.1111/j.1439-0426.2007.00841.x

Matić-Skoko, S., Kraljević, M., Dulčić, J., and Jardas, I. 2007. Age, growth, maturity, mortality, and yield-per-recruit for annular sea bream (Diplodus annularis L.) from the eastern middle Adriatic Sea. Journal of Applied Ichthyology, 23(2): 152-157.

Megalofonou, P. 2006. Comparison of otolith growth and morphology with somatic growth and age in young-of-the-year bluefin tuna. Journal of Fish Biology, 68(6): 1867-1878.

Monteiro, P., Bentes, L., Coelho, R., Correia, C., Erzini, K., and et al. 2010. Age and growth, mortality and reproduction of the striped sea bream, Lithognathus mormyrus Linnaeus 1758, from the south coast of Portugal (Algarve). Marine Biology Research, 6(1): 53-65. doi:Doi 10.1080/17451000903039731

Pajuelo, J. G., Lorenzo, J. M., Mendez, M., Coca, J., and Ramos, A. G. 2002. Determination of age and growth of the striped seabream Lithognathus mormyrus (Sparidae) in the Canarian archipelago by otolith readings and backcalculation. Scientia Marina, 66(1): 27-32.

Pannella, G. 1971. Fish Otoliths: Daily Growth Layers and Periodical Patterns. Science, 173(4002): 1124-1127. doi:10.1126/science.173.4002.1124

Rani, A., Rai, D., and Tyor, A. K. (2019). Morphometrics Analysis of Sagitta Otolith in Pool Barb, Puntius sophore (Hamilton, 1822). J Morphol Sci, 36(02): 085-090. doi:10.1055/s-0039-1683911

Ricker, W. (1975). A note concerning Professor Jolicoeur's comments. Journal of the Fisheries Board of Canada, 32(8): 1494-1498.

Secor, D. H., Dean, J. M., and Laban, E. H. 1991. Manual for otolith removal and preparation for microstructural examination.

Skeljo, F., and Ferri, J. 2012. The use of otolith shape and morphometry for identification and size-estimation of five wrasse species in predator-prey studies. Journal of Applied Ichthyology, 28(4): 524-530. doi:10.1111/j.1439-0426.2011.01925.x

Sponaugle, S. (2010). Otolith microstructure reveals ecological and oceanographic processes important to ecosystem-based management. Environmental Biology of Fishes, 89(3-4): 221-238. doi:10.1007/s10641-010-9676-z

Suau, P. 1970. Contribution to knowledge of biology of Lithognathus mormyrus (Sparidae). Investigacion Pesquera, 34(2): 237-265.

Takahashi, M., and Watanabe, Y. (2004). Staging larval and early juvenile Japanese anchovy based on the degree of guanine deposition. Journal of Fish Biology, 64(1): 262-267. doi:10.1046/j.1095-8649.2003.00283.x

Türkmen, M., and Akyurt, I. (2003). Growth characteristics, sex inversion and mortality rates of striped sea bream, Lithognathus mormyrus L., in Iskenderun bay. Turkish Journal of Zoology, 27: 323-329.

Vigliola, L., Harmelin-Vivien, M., and Meekan, M. G. 2000. Comparison of techniques of back-calculation of growth and settlement marks from the otoliths of three species of Diplodus from the Mediterranean Sea. Canadian Journal of Fisheries and Aquatic Sciences, 57(6): 1291-1299. doi:10.1139/cjfas-57-6-1291

Vitale, S., Arkhipkin, A., Cannizzaro, L., and Scalisi, M. 2011. Life history traits of the striped seabream Lithognathus mormyrus (Pisces, Sparidae) from two coastal fishing grounds in the Strait of Sicily. Journal of Applied Ichthyology, 27(4): 1086-1094. doi:10.1111/j.1439-0426.2011.01775.x

Wilson, D. T., and McCormick, M. I. 1999. Microstructure of settlement-marks in the otoliths of tropical reef fishes. Marine Biology, 134(1): 29-41. doi:10.1007/s002270050522