Age and growth of gilthead sea bream (*Sparus aurata* Linnaeus, 1758) from Northern Aegean Sea (Turkey)

Özgür Cengiz
Van Yüzüncü Yıl University, Fisheries Faculty, Van, Turkey (*ozgurcengiz17@gmail.com*)

ABSTRACT
The age and growth of gilthead sea bream (*Sparus aurata* Linnaeus, 1758) were studied in the present study. A total of 126 specimens were collected from commercial fishmongers during the period between January 2015 and December 2015 from the northern Aegean coasts of Turkey. Fork length and the total weight of aged specimens ranged from 29.5 to 418.0 cm and from 425.00 to 2100.00 g, with a mean of 38.5 cm and 101.23 g, respectively. The length-weight relationship was estimated as $W = 0.0053FL^{3.03}$ ($R^2 = 0.95$). The von Bertalanffy growth equations were computed as $L_\infty = 52.8$ cm, $k = 0.29$ year$^{-1}$, $t_0 = -1.25$ year for all samples. The growth performance index ($\Phi'$) was found as 2.91. There is no study on the biology of the species for the northern Aegean Sea. Therefore, this study provides valuable information for the species in this area.

Keywords: Gilthead Sea bream, Growth parameters, *Sparus aurata*, Northern Aegean Sea, Turkey.

1. INTRODUCTION
Life history traits like age, growth, reproduction and mortality are principal factors in fisheries research and management (Mgaya and Mahongo, 2017). Fish age is an important biological variable for calculating growth parameter and mortality (Campana, 2001). In this connection, von Bertalanffy (1934) growth parameters (VBGPs), essential for the development of a variety of fisheries models and the management of fisheries resources, could be used for the indirect estimation of other parameters using existing empirical equations (Froese and Binohlan, 2003). Examples of indirectly estimated parameters include: (a) natural mortality from growth parameters (Pauly, 1980) or from $t_{\text{max}}$ (Hoenig, 1983), (b) length at first maturity from $L_\infty$ and/or $K$ (Froese and Binohlan, 2000), (c) age at first maturity from $t_{\text{max}}$ (Froese and Binohlan, 2000), (d) optimum exploitation length from $L_\infty$ or length at first maturity (Froese and Binohlan, 2000), (e) trophic level from $L_{\text{max}}$ (Stergiou and Karpouzi, 2002), (f) mouth size from $L_{\text{max}}$ (Karpouzi and Stergiou, 2003), and (g) tail area from $L_{\text{max}}$ (Karachle and Stergiou, 2005).

The Sparidae is a family of the order Perciformes and contains 164 species in 38 genera (Eschmeyer’s Catalog of Fishes, 2020). Recently, the family Centracanthidae (picarels) has also been merged with the Sparidae (Santini et al., 2014) while they previously were listed as distinct and separate (Golani et al., 2006; Nelson, 2006; Mater et al., 2011). As far as it is known, 24 Sparidae species within 13 genera (*Boops* Cuvier, 1814; *Centracanthus* Rafinesque,
The genus *Sparus* is represented by one species, worldwide: *Sparus aurata* (Linnaeus, 1758). Gilthead sea bream (*Sparus aurata* Linnaeus, 1758), an inshore species that frequents *Posidonia oceanica* beds and rocky and sandy areas, is common in the Mediterranean Sea, but very rare in the Black Sea (Bânărescu, 1964). It is also present in the eastern part of the Atlantic Ocean, from Britain to Cape Verde and the Canaries (Bauchot and Hureau, 1986). This fish has a high commercial importance for fishery and aquaculture (Teles et al., 2018). For this reason, gilthead sea breams are captured with traditional bottom trawl nets, coastal purse-seines, bottom set longline and hand lines, and are regularly present to the markets in Turkey (Akyol and Gamsız, 2011). According to the Turkish Statistical Institute, *Sparus aurata* yield from fisheries and aquaculture production were 583.7 t and 109.749 t, respectively (TurkStat, 2021).

All over the world, the information on the age and growth of *Sparus aurata* were given in the Alexandria (Egypt) (Wassef, 1978), in the Bardawil lagoon (Egypt) (Ameran, 1992; Khalifa, 1995; Tharwat et al., 1998; Abd-Allah, 2004; Mokbel et al., 2020), in the Cádiz (Spain) (Arias, 1980), in the Ebre (Spain) (Suau and Lopez, 1976), in the eastern Adriatic (Croatia) (Kraljević et al., 1998), in the Graveyron and Thau (France) (Lasserre and Labourg, 1974; Lasserre (1976), in the Gulf of Gabes (Tunisia) (Hadj Taieb et al., 2013; 2015), in the Gulf of Lion (France) (Mercier et al., 2011), in the Mellah Lagoon (Algeria) (Chaoui et al., 2006), in the Mirna Estuary (Croatia) (Kraljević and Dulčić, 1997), in the Port Said (Egypt) (Mehanna, 2007), in the Segura (Spain) (Arnal et al., 1976). In the southern Aegean Sea, only one reference exists with information about its growth (Akyol and Gamsız, 2011), whereas, there is no study on the biology of the species for the northern Aegean Sea. The main objective of the present study was to determine age and growth of gilthead sea bream around the northern Aegean Sea to provide data on their biological information in a data-poor area.
2. METHODOLOGY
The northern Aegean coasts of Turkey are divided into sub-regions as the Saros Bay, the Gallipoli Peninsula, the Gökçeada and Bozcaada Islands and the Edremit Bay (Cengiz, 2021) (Fig 1). The northern Aegean areas are characterized by an extended continental shelf, smooth muddy/sandy bottoms and higher nutrient concentrations (Maravelias and Papaconstantinou, 2006) and have higher phytoplankton and zooplankton abundance compared with the southern Aegean Sea (Theocharis et al., 1999).

Figure 1. Northern Aegean coasts of Turkey (1: Saros Bay; 2: Gallipoli Peninsula; 3: Gökçeada Isl.; 4: Bozcaada Isl.; 5: Edremit Bay).

The individuals of sampled Sparus aurata from commercial fishmongers randomly were taken during the period between January 2015 and December 2015 from the northern Aegean coasts of Turkey. The samples were measured to the nearest centimeter (fork length), weighed to the nearest 0.01 g (total weight). The length-weight relationship was estimated by fitting an exponential curve, \( W = aL^b \) (Le Cren, 1951). Parameters \( a \) and \( b \) of the exponential curve were estimated by linear regression analysis over log-transformed data \( \log W = \log a + b\log L \), where \( W \) is the total weight (g), \( L \) is the fork length (cm), \( a \) is the intercept, and \( b \) is the slope or allometric coefficient, using the least-squares method. The \( b \) value that is higher than 3 shows positive allometric growth, while the \( b \) value that is lower than 3 indicates negative allometric growth. It is isometric growth when the \( b \) value is equal to 3 (Bagenal and Tesch, 1978). The growth type was identified by Student’s \( t \)-test.
The ages of the specimens were checked using scales. Scales were removed from the base of the pectoral fin and from the flanks below the dorsal fin. They were cleaned in 5% sodium peroxide and then immersed in glycerol in a black Petri dish, and annuli, defined as opaque and hyaline zones were counted by using a binocular microscope (Akyol and Gamsız, 2011). Growth parameters were estimated by using the von Bertalanffy growth equation: $L_t = L_\infty [1 - e^{-k(t-t_0)}]$, where $L_t$ is fish length (cm) at age $t$, $L_\infty$ is the asymptotic fish length (cm), $t$ is the fish age (years), $t_0$ (years) is the hypothetical time at which the fish length is zero, and $k$ is the growth coefficient (year$^{-1}$). FAO-ICLARM Stock Assessment Tools FISAT II) were used to estimate growth parameters, which were calculated with the non-linear least-squares method. The growth parameters obtained in this study were compared with the parameters obtained in other studies from various geographical areas using the growth performance index ($\Phi'$) (Pauly and Munro, 1984). It was estimated using the formula, $\Phi' = \log(k) + 2 \times \log(L_\infty)$.

3. RESULTS

The sample size is 126 individuals, coming from the commercial capture of the northern Aegean Sea coasts of Turkey. Faced with the impossibility of dissecting the fish, because they are intended for sale, then it has been considered all samples, as a whole. The mean ± standard error (and range) of fork length and the total weight of specimens were $38.5 \pm 0.34$ (29.5 – 48.0) cm (Fig 2) and $1090.00 \pm 30.86$ (425.00 – 2100.00) g, respectively. The length-weight relationship was estimated as $W = 0.0053FL^{3.03}$ ($R^2 = 0.95$) (Fig 3). The $b$-values and $t$-test results indicated positive allometric growth.

![Figure 2. The length-frequency distribution for all samples of Sparus aurata from Northern Aegean Sea (Turkey).](image-url)
Results obtained from the scale reading indicated that the ages of the fishes were found to be within the range of II to VI years. Table 1 indicated the fishes belonging to age groups III and IV were the most dominant. The von Bertalanffy growth equations were computed as \( L_\infty = 52.8 \text{ cm}, k = 0.29 \text{ year}^{-1}, t_0 = -1.25 \text{ year} \) for all samples (Fig 4). The growth performance index (\( \Phi' \)) was found as 2.91.

Table 1. The age-length key for all samples of *Sparus aurata* from Northern Aegean Sea (Turkey).

| Age (years) | N  | Length range (cm) | \( L_{\text{mean}} \pm \text{S.E.} \) |
|------------|----|-------------------|--------------------------------------|
| II         | 4  | 29.5 - 32.1       | 31.1 ± 0.55                          |
| III        | 77 | 31.2 - 42.0       | 37.0 ± 0.30                          |
| IV         | 25 | 38.0 - 42.3       | 40.0 ± 0.27                          |
| V          | 12 | 41.0 - 45.0       | 43.0 ± 0.43                          |
| VI         | 8  | 44.6 - 48.0       | 46.0 ± 0.33                          |

*Note:* N = sample size, S.E = standard error.

Figure 3. The length-weight relationships for all samples of *Sparus aurata* from Northern Aegean Sea (Turkey).

Figure 4. The growth curves for all samples of *Sparus aurata* from Northern Aegean Sea (Turkey).
Table 2. The length-weight relationships, growth parameters and growth performance indices of *Sparus aurata* reported in the previous literatures.

| References                          | Location                        | N  | Method | L∞  | K      | t0    | Age range (year) | Φ'   | a    | b    |
|-------------------------------------|---------------------------------|----|--------|-----|--------|-------|------------------|------|------|------|
| Lasserre and Labourg (1974)         | Graveyron (France)              | 126| Scales | 42.2| 0.45   | -0.45 | 1-4              | 2.90 | 0.0144 | 3.07  |
|                                     | Thau (France)                   | 713| Scales | 62.0| 0.22   | -0.77 | 1-4              | 2.93 | 0.0226 | 2.88  |
| Arnal et al. (1976)                 | Segura (Spain)                  | 135| LFA*   | 53.0| 0.31   | -     | 2-6              | 2.94 | 0.0289 | 2.90  |
| Lasserre (1976)                     | Graveyron (France)              | 94 | Scales | 53.4| 0.26   | -1.34 | 2-5              | 2.87 | 0.0541 | 2.61  |
|                                     | Thau (France)                   | 383| Scales | 57.6| 0.27   | -0.54 | 1-4              | 2.95 | 0.0121 | 3.06  |
| Suau and Lopez (1976)               | Ebre (Spain)                    | 611| LFA*   | 62.1| 0.17   | -0.53 | 1-7              | 2.82 | 0.0112 | 3.05  |
| Wassef (1978)                       | Alexandria (Egypt)              | -  | Scales | 70.6| 0.17   | -     | 1-5              | 2.93 | -     | -     |
| Arias (1980)                        | Cádiz (Spain)                   | 1775| Scales | 84.5| 0.13   | -1.58 | 1-7              | 2.97 | 0.0071 | 3.12  |
| Ameran (1992)                       | Bardawil lagoon (Egypt)         | -  | Scales | 38.0| 0.25   | -1.92 | 1-3              | 2.56 | -     | -     |
| Khalifa (1995)                      | Bardawil lagoon (Egypt)         | -  | Scales | 34.5| 0.24   | -1.41 | 1-6              | 2.46 | 0.014  | 2.98  |
| Kraljević and Dulčić (1997)         | Mirna Estuary (Croatia)         | 314| Otoliths | 59.7| 0.15   | -1.71 | 1-12             | 2.73 | 0.0112 | 3.05  |
| Kraljević et al. (1998)             | eastern Adriatic Sea (Croatia)  | 462| Scales | 84.9| 0.07   | -2.82 | 1-22             | 2.70 | 0.0101 | 3.08  |
| Tharwat et al. (1998)               | Bardawil lagoon (Egypt)         | -  | Scales | 38.5| 0.29   | -1.08 | -                | 2.63 | 0.013  | 3.03  |
| Abd-Allah (2004)                    | Bardawil lagoon (Egypt)         | -  | Scales | 34.0| 0.58   | -0.70 | -                | 2.83 | -     | -     |
| Chaoui et al. (2006)                | Mellah Lagoon (Algeria)         | 370| Scales | 55.3| 0.51   | -0.22 | 1-7              | 3.19 | 0.0129 | 3.06  |
| Mehanna (2007)                      | Port Said (Egypt)               | 1714| Otoliths | 37.9| 0.50   | -0.60 | 0-4              | 2.86 | 0.0123 | 3.02  |
| Akyol and Gamsiz (2011)             | southern Aegean Sea (Turkey)    | 476| Scales | 64.9| 0.14   | -2.47 | 2-7              | 2.77 | 0.0515 | 2.73  |
| Mercier et al. (2011)               | Gulf of Lion (France)           | 142| Otoliths | 72.3| 0.10   | -2.20 | 1-6              | 2.72 | 0.0093 | 3.11  |
| Hadj Taieb et al. (2013)            | Gulf of Gabes (Tunisia)         | 955| Otoliths | 38.2| 0.20   | -1.88 | 0-8              | 2.47 | 0.0107 | 3.07  |
| Hadj Taieb et al. (2015)            | Gulf of Gabes (Tunisia)         | 668| Scales | 47.1| 0.11   | -2.95 | 0-6              | 2.39 | 0.0107 | 3.07  |
| Mokbel et al. (2020)                | Bardawil lagoon (Egypt)         | 688| Otoliths | 32.1| 0.33   | -1.33 | 0-5              | 2.53 | 0.0132 | 3.02  |
| This study                          | northern Aegean Sea (Turkey)    | 126| Scales | 52.8| 0.29   | -1.25 | 2-6              | 2.91 | 0.0053 | 3.03  |

*length-frequency analysis, N = sample size, L∞ = theoretical asymptotic length, K = growth rate coefficient, t0 = theoretical age when fish length is zero, Φ' = growth performance index, a and b = the parameters of the relationships.
4. DISCUSSION

Table 2 summarized the results about the length-weight relationships (LWRs), the growth parameters and growth performance indices between the present study to previous ones. The $b$ values in LWRs change between 2.5 and 3.5 (Froese, 2006) or 2 to 4 (Tesch, 1971). In this study, $b$ value of *Sparus aurata* correspond to these expected ranges. Generally, the $b$ value procured from the same species could change depending on the degree of gonad maturity, sex, diet, sample preservation techniques, stomach fullness (Wootton, 1990; Cengiz et al., 2019), number of specimens analyzed, area/season effects, sampling duration (Moutopoulos and Stergiou, 2002), fishing gear used (Kapiris and Klaoudaos, 2011), and size selectivity of the sampling gear (İşmen et al., 2007).

Growth parameters ($L_\infty$, $K$ and $t_0$) are the basic input data into various models used for managing and assessing the status of the exploited fish stocks and these parameters facilitate the comparison between growth of fishes belonging to different species or to the same species at different times and different localities (Mehanna et al., 2018). The differences among all growth parameters could be attributed to a combination of sample characteristics (sample sizes and range of sizes), geographical differences and aging methodology used (Monterio et al., 2006), incorrect age interpretation (Matić-Skoko et al., 2007; Bayhan et al., 2008), size, quantity and quality of food and water temperature (Santic et al., 2002), and differences in length at first maturity (Champagnat, 1983). Besides, the selectivity of the fishing tool used can also affect the estimates of growth parameters (Ricker, 1969; Potts et al., 1998). Therefore, the possible reasons for the differences in the results between the other studies and this study may be related to one or more factors given above.

5. CONCLUSION

This study provided data on the key life history traits of *Sparus aurata*, which has been lacking in the studied region, allowing the development of sustainable management strategies. In times to come, appropriate surveys and long-dated studies could be required to confirm this preliminary estimating. More scientific research should be meticulously conducted to collect fundamental biological data. However, the information obtained from investigations such as the present research should be proclaimed to stakeholders (fishermen, middlemen, fisheries scientists, fishing management authorities etc.)

6. ACKNOWLEDGEMENTS

The author would like to thank the commercial fishermen.
7. REFERENCES

Abd-Allah, S.M. 2004. Biological studies for the fishery regulations and management of the Bardawil Lagoon. PhD. thesis, Suez: Suez Canal Univ.

Akyol, O & Gamsiz, K. 2011. Age and growth of adult gilthead seabream (Sparus aurata L.) in the Aegean Sea. Journal of the Marine Biological Association of the UK, 91(6): 1255–1259.

Ameran, M.A. 1992. Studies on fish production of Bardawil lagoon. MSc. thesis, Suez: Suez Canal Univ.

Arnal, J., Alcazar, A.G & Ortega, A., 1976. Observaciones sobre el crecimiento de la dorada (Sparus aurata L.) en el Mar Menor (Murcia). Boletín del Instituto Espagnol de Oceanografía, 221–222: 1–17

Arias, A. 1980. Crecimiento, régimen, alimentación y reproducción de la dorada (Sparus aurata L.) y del róbalo (Dicentrarchus labrax L.) en los esteros de Cádiz. Investigación Pesquera, 44: 59–83.

Bagenal, T.B & Tesch, F.W. 1978. Age and growth. In: Methods for Assessment of Fish Production in Fresh Waters. Bagenal, T. (eds), Oxford: IBP Handbook No. 3, Blackwell Science Publications, pp. 101–136.

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

Bayhan, B., Sever, T.M & Taskavak, E. 2008. Age, length-weight relationships and diet composition of scaldfish Arnoglossus laterna (Walbaum, 1792) (Pisces: Bothidae) in Izmir Bay (Aegean Sea). Journal of Animal and Veterinary Advances, 7: 924–929.

Bânârescu, P. 1964. Fauna republicii populare romine (Pisces- Osteichthes). Edit. Acad. Republ. Pop. Romine, Bucuresti, 960 pp.

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 Biology, 59(2): 197–242.

Champagnat, C. 1983. Peche, biologie et dynamique du tassergal (Pomatomus saltatrix Linnaeus, 1766) sur les cotes Senegalo-Mauritanienes. Travaux et Documents du L’ORSTOM, 168: 1–279.

Chaoui, L., Kara, M.H., Faure, E & Quignard, J.P. 2006. Growth and reproduction of the gilthead seabream Sparus aurata in Mellah lagoon (north-eastern Algeria). Scientia Marina, 70(3): 545–552.
Cengiz, Ö., Paruğ, Ş.Ş & Kızılkaya, B. 2019. Weight-length relationship and reproduction of bogue (Boops boops Linnaeus, 1758) in Saros Bay (Northern Aegean Sea, Turkey). KSU Journal of Agriculture and Nature, 22(4): 577–582.

Cengiz, Ö. 2021. Opercular girth, maximum girth and total length relationships for eight fish species from the Saros Bay (northern Aegean Sea, Turkey). The Palawan Scientist, 13(2): 25–36.

Eschmeyer’s Catalog of Fishes, 2020. Species by family/subfamily in Eschmeyer’s Catalog of Fishes.http://researcharchive.calacademy.org/research/ichthyology/catalog/SpeciesByFamily.asp#Sparidae. Accessed on 02 June 2020

Froese, R. 2006. Cube law, condition factor and weight-length relationships: history, meta-analysis and recommendations. Journal of Applied Ichthyology, 22(4): 241–253.

Froese, R & Binohlan, C. 2000. Empirical relationships to estimate asymptotic length, length at first maturity, and length at maximum yield per recruit in fishes, with a simple method to evaluate length frequency data. Journal of Fish Biology, 56(4): 758–773.

Froese, R & Binohlan, C. 2003. Simple methods to obtain preliminary growth estimates for fishes. Journal of Applied Ichthyology, 19(6): 376–379.

Froese, R & Pauly D. (Editors) 2022. FishBase. World Wide Web electronic publication. https://www.fishbase.se/identification/SpeciesList.php?genus=Sparus Accessed on 06 January 2022

Hadj Taieb, A., Ghorbel, M., Ben Hadj Hamida, N & Jarboui, O. 2013. Sex ratio, reproduction and growth of the gilthead sea bream, Sparus aurata (Pisces: Sparidae), in the Gulf of Gabes, Tunisia. Ciencias Marinas, 39(1): 101–112.

Hadj Taieb, A., Sley, A., Ghorbel, M & Jarboui, O. 2015. Age estimation and growth pattern of the gilthead seabream Sparus aurata (Pisces: Sparidae) of the Gulf of Gabes, Tunisia. Bulletin de la Société zoologique de France, 140(3): 153–162.

Hoenig, J.M. 1983. Empirical use of longevity data to estimate mortality rates. Fishery Bulletin, 81: 898–903.

İşmen, A., Özen, Ö., Altınağaç, U., Özekinci, U & Ayaz A. 2007. Weight-length relationships of 63 fish species in Saros Bay, Turkey. Journal of Applied Ichthyology, 23(6): 707–708.

Kapiris, K & Klaoudatos, D. 2011. Length-weight relationships for 21 fish species caught in the Argolikos Gulf (central Aegean Sea, eastern Mediterranean). Turkish Journal of Zoology, 35(5): 717–723.
Karachle, P.K & Stergiou, K.I. 2005. Morphometric relationships in fishes. *3rd FishBase Mini Symposium, Fish and More, 3*: 45–47.

Karpouzi, V.S & Stergiou, K.I. 2003. The relationships between mouth size and shape and body length for 18 species of marine fishes and their trophic implications. *Journal of Fish Biology, 62*(2): 1353–1365.

Khalifa, U. 1995. *Biological studies on gilthead bream, Sparus aurata in lake Bardwil*. MSc. thesis. Cairo, Fac. Sci. Cairo Univ.

Kraljević, M & Dulčić, J. 1997. Age and growth of gilt-head seabream (Sparus aurata L.) in the Mirna Estuary, Northern Adriatic. *Fisheries Research, 31*: 249–255.

Kraljevic, M., Dulcic, J & Tudor, M. 1998. Growth parameters of the gilt-head sea bream Sparus aurata L. in the eastern Adriatic (Croatian waters). *Periodicum Biologorum, 100*: 87–91.

Le Cren, E.D. 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (Perca fluviatilis). *Journal of Animal Ecology, 20*: 201–219.

Lasserre, G & Labourg, P.J. 1974. Comparison of growth of Sparus auratus L. in regions of Arcachon and Sète (2nd note). *Vie Et Milieu Serie A-Biologie Marine, 24*: 357–363.

Lasserre, G. 1976. *Dynamique des populations ichthyologiques lagunaires. Application à Sparus aurata*. PhD thesis, Univ. Montpellier II.

Maravelias, C.D & Papaconstantinou, C. 2006. Geographic, seasonal and bathymetric distribution of demersal fish species in the eastern Mediterranean. *Journal of Applied Ichthyology, 22*: 35–42.

Mater, S., Kaya, M & Bilecenoğlu, M. 2011. Türkiye Deniz Balıkları Atlası (4th ed). Ege Üniversitesi Basmevi, İzmir, Turkey, 169 p.

Matić-Skoko, S., Kraljević, M., Dulčić, J & 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*: 152–157.

Mehanna, S.F. 2007. A preliminary assessment and management of gilthead bream Sparus aurata in the Port Said fishery, the South-eastern Mediterranean, Egypt. *Turkish Journal of Fisheries and Aquatic Sciences, 7*: 123–130.

Mehanna, S.F., Osman, A.G.M., Farrag, M.M.S & Osman, Y.A.A. 2018. Age and growth of three common species of goatfish exploited by artisanal fishery in Hurghada fishing area, Egypt. *Journal of Applied Ichthyology, 34*: 917–921.

Mercier, L., Panfili, J., Paillon, C., N’Diaye, A., Mouillot, D & Darnaude, A.M. 2011. Otolith reading and multi-model inference for improved estimation of age and growth in the
gilthead seabream *Sparus aurata* (L.) *Estuarine Coastal and Shelf Science*, 92:534–545.

Mgaya, Y.D & Mahongo, S.B. 2017. *Lake Victoria fisheries resources* (Vol. 93). Springer International Publishing.

Mokbel, S.A., Ibrahim, N.K., Ahmed, M.S & Ibrahim, G.D. 2020. Age and growth of gilthead sea bream (*Sparus aurata*) from Bardawil Lagoon, North Sinai, Egypt. *Sinai Journal of Applied Sciences*, 9(1): 57–62.

Monteiro, P., Bentes, L., Coelho, R., Correia, C., Goncalves, J.M., Lino, P.G., Ribeiro, J & Erzini, K. 2006. Age and growth, mortality, reproduction and relative yield per recruit of the bogue, *Boops boops* Linn., 1758 (Sparidae), from the Algarve (south of Portugal) longline fishery. *Journal of Applied Ichthyology*, 22(5): 345–352.

Moutopoulos, D.K & Stergiou, K.I. 2002. Length-weight and length-length relationships of fish species from the Aegean Sea (Greece). *Journal of Applied Ichthyology*, 18(3): 200–203.

Nelson, J.S. 2006. Fishes of the World (4th ed). John Wiley & Sons, Inc., New York, 601 p.

Golani, D., Öztürk, B & Başısta, N. 2006. Fishes of the Eastern Mediterranean. Turkish Marine Research Foundation (TÜDAV), İstanbul, Turkey, 259 pp.

Paruğ, Ş.Ş & Cengiz, Ö. 2020. The maximum length record of the blackspot seabream (*Pagellus bogaraveo* Brünnich, 1768) for the Entire Agean Sea and Turkish Territorial Waters. *Turkish Journal of Agriculture-Food Science and Technology*, 8(10): 2125–2130.

Pauly, D. 1980. On the interrelationships between natural mortality, growth parameters, and mean environmental temperature in 175 fish stocks. *ICES Journal of Marine Science*, 39(2): 175–192.

Pauly, D & Munro, J.L. 1984. Once more on growth comparison in fish and invertebrates. *ICLARM Fishbyte*, 2: 1–21.

Potts, J.C., Manooch, III. C.S & Vaughan, D.S. 1998. Age and growth of vermillion snapper from the southeastern United States. *Transactions of the American Fisheries Society*, 127: 787–795.

Ricker, W.E. 1969. Effects of size-selective mortality and sampling bias on estimates of growth, mortality, production and yield. *Journal of the Fisheries Research Board of Canada*, 26: 479–541.
Santic, M., Jardas, I & Pallaoro, A. 2002. Age, growth and mortality rate of horse mackerel *Trachurus trachurus* (L.) living in the eastern Adriatic. *Periodicum Biologorum*, **104**: 165–173.

Santini, F., Carnevale, G & Sorenson, L. 2014. First multi-locus timetree of seabreams and porgies (Percomorpha: Sparidae). *Italian Journal of Zoology*, **81**(1): 55–71.

Stergiou, K.I & Karpouzi, V.S. 2002. Feeding habits and trophic levels of Mediterranean fishes. *Reviews in Fish Biology and Fisheries*, **11**: 217–254.

Suau, P & López, J. 1976. Contribución al estudio de la dorada, *Sparus aurata* L. *Investigación Pesquera*, 40: 169–199.

Teles, M., Reyes-López, F.E., Fierro-Castro, C., Tort, L., Soares, A.M.V.M & Oliveira, M. 2018. Modulation of immune genes mRNA levels in mucosal tissues and DNA damage in red blood cells of *Sparus aurata* by gold nanoparticles. *Marine Pollution Bulletin*, **133**: 428–435.

Tesch, F.W. 1971. *Age and growth*. In: Methods for assessment of fish production in fresh waters Ricker, W.E. (ed.). Oxford: Blackwell Scientific Publications, pp. 98–130.

Tharwat, A.A., Emam, W.M. & Ameran, M.A. 1998. Stock assessment of the Gilthead sea bream *Sparus aurata* from Bardawil lagoon, North Sinai, Egypt. *Egyptian Journal of Aquatic Biology and Fisheries*, **2**(4): 483–504.

Theocharis, A., Balopoulos, E., Kioroglou, S., Kontoyiannis, H & Iona, A. 1999. A synthesis of the circulation and hydrography of the South Aegean Sea and the Straits of the Cretan Arc (March 1994–January 1995). *Progress In Oceanography*, **44**: 469–509.

TurkStat. 2021. Fishery statistics. https://data.tuik.gov.tr/Bulten/Index?p=Su-Urunleri-2020-37252

von Bertalanffy. 1934. Untersuchungen über die Gesetzlichkeiten des Wachstums. *Wilhelm Roux’ Archiv für Entwicklungsmechanik der Organismen*, **131**: 613–652.

Wassef, E.A. 1978. *Biological and physiological studies on marine and acclimatized fish Chrysophrys auratus*. PhD. thesis. Cairo: Fac. Sci. Cairo Univ., 225 p.

Wootton, R.J. 1990. *Ecology of Teleost Fish*. Chapman and Hall, London.