DOI: 10.55268/CM.2024.54.116

GROWTH PATTERNS AND AGE DETERMINATION OF PIKED DOGFISH FROM ROMANIAN BLACK SEA WATERS: INSIGHTS FROM SPINES ANALYSIS

Mădălina Galaţchi[1*], Daniel Grigoraş[1], George Ţiganov[1], Nuri Başusta[2]

[1]National Institute for Marine Research and Development "Grigore Antipa", 300 Mamaia Blvd., RO -900591, Constanta, Romania
[2]Faculty of Fisheries, Firat University, 23119 Elâzığ Merkez/Elazığ, Türkiye
**Corresponding author: mgalatchi@alpha.rmri.ro*

ABSTRACT

Understanding the growth patterns and the age composition of *Squalus acanthias* (piked dogfish) populations, from Romanian marine area, helps to elaborate sustainable fisheries management practices because changes in population parameters could indicate shifts in prey availability, habitat quality issues, or fishing pressure.

In recent years, the official catches on the Romanian coast, of this economically valuable species in the entire Black Sea basin, have remained below one ton. Regarding the growth patterns, a slight increase in the average length value was observed, from 107,85 cm in 2022 to 116,88 cm in 2023. For age determination the method of analyzing the dorsal spines was used, considered the most appropriate. Thus, in 2022 mature specimens (19 years old) predominated, and in 2023, younger specimens (14 years old), but completely mature from a reproductive point of view, predominated. Analyzing age structure over time is important for predicting future population trends and implementing conservation measures as needed.

Keywords: piked dogfish, Romanian marine area, growth patterns, age, dorsal spines

INTRODUCTION

The piked dogfish or spiny dogfish (*Squalus acanthias,* Linnaeus 1758) has been reported to be more abundant in the Western Atlantic Ocean, Indo-Pacific, Mediterranean and Black Sea and rare in the Atlantic Arctic area (Hart, 1973; Schilling *et al.*, 2019).

The size reached by males, 1 - 1.5 m, is smaller than that of females, which reach up to 1.7 m. The weight of the specimens ranges from 6 to 14 kg. The skin is covered with small, placoid scales. Both dorsal fins are preceded by a spike. The grey-bluish shade predominates in the body coloration, the back and the lateral parts being pigmented with a variable number of bluish or white spots, more accentuated in the young specimens (Radu *et al.*, 2008; Niţă *et al.*, 2022).

Always restless, it lives mostly solitary, grouping in small numbers only during spawning. It approaches our shore from March to November. It is usually reported at sea at a depth of 50-70 m, in the mityloid-phaseolinoid zone. Being adapted to life in cold waters, dogfish do not have an intense metabolism and have a very slow growth rate (Radu *et al.*, 2008). Their longevity is not known exactly. Some estimates indicate the age of 35-40 years, but some specimens live up to 50-75 years. They reach sexual maturity at the age of 10-11 (males) and 18-21 (females). It is an ovoviviparous species. They mate in January-March.

After a very long gestation period (22-24 months), it expels between 2 and 11 juveniles, measuring 25-30 cm (Bănărescu, 1964). The slow growth, late sexual maturity, and the fact that females produce less than 10 offsprings on average a year make it very difficult for large dogfish populations to recover. Fearful predator, it feeds on fish such as anchovies, gobies, Atlantic mackerel and horse mackerel (Nițâ *et al.*, 2022).

In the Black Sea, the largest catches of dogfish are along the coasts of Turkey, although this fish is not a target species of fisheries, being yielded as by-catch in trawl and purse seine operations. In Romania, dogfish is caught mainly as by-catch of the sprat trawl fishery (SAF, 2023).

Although the presence of the Black Sea piked dogfish in Romanian catches is reported by fishermen to be increasing in the last year (Fig. 1), in the last decade due to the decrease of the trawling effort (Maximov *et al.*, 2008, Maximov *et al.*, 2010; Radu *et al.*, 2011a, 2011b), overexploitation and its late maturity, the species has become vulnerable at global level and endangered at European level (IUCN, 2024).

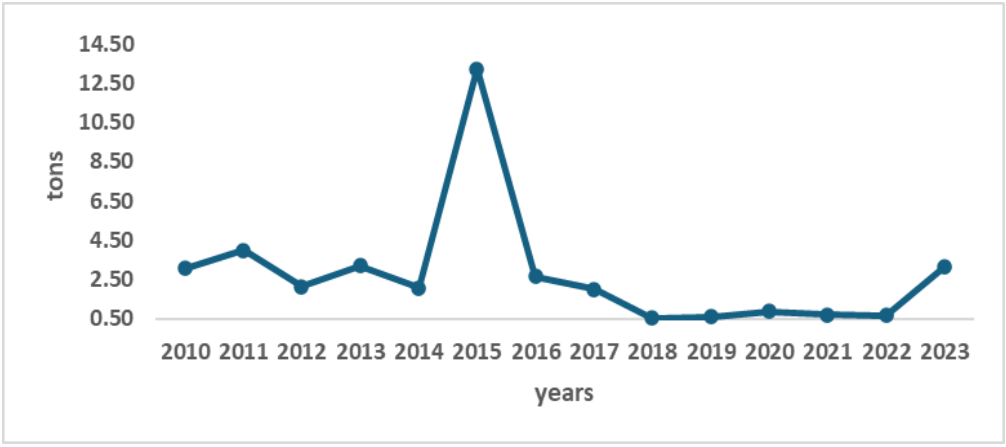

Fig. 1. Official dogfish landings at the Romanian Black Sea area (NIMRD data)

Over the last few years, data on seasonal and interannual variations in the biological parameters of piked dogfish in the Black Sea have been limited, which hampers the understanding of the current status of this vulnerable species and management options (Tserkova *et al.*, 2022).

If, as usual, to determine the age of fish, the analysis of otoliths and scales is used, age determination in cartilaginous fish poses several challenges because of the absence of those calcareous structures (Demirhan *et al.*, 2005). Additionally, fisheries regulations in certain Black Sea countries mandate the live release of these species, further complicating the availability of the methods for age determination.

The information regarding the growth patterns of fish species is crucial for ensuring sustainable fisheries management, conserving marine biodiversity, understanding ecological dynamics, and supporting economic benefits and age information contributes to the knowledge of fish life-history parameters and reproductive potential (Gallucci *et al.*, 2006; Yiğin and İşmen, 2016).

MATERIALS AND METHODS

The study is based on the data collected during the period 2022 - 2023. To obtain the information, samples were collected from research expeditions at sea with the research vessel "Steaua de Mare 1" equipped with demersal trawl fishing equipment (characteristics 22/27-34 m, horizontal trawl opening 13 m and vertical trawl opening 2 m) from National Institute for Marine Research and Development "Grigore Antipa" (NIMRD) covering the entire marine basin.

The collected individuals were analyzed in the laboratory obtaining information about total length, weight, sex, and age refitted to the length and weight-at-age data. The total length of each fish was measured to the nearest centimeter, and weight was determined using a balance with accuracy to the nearest gramme. Sex was determined by direct examination of the claspers of males with the naked eye (Avşar, 2001). For age, analysis the first and second (when it was possible) dorsal spine was removed by placing the knife posterior to the spine. A cut was made parallel to the base of the spine down into the muscle tissue (Demirhan *et al.*, 2005). After extraction, the spines were placed in labeled small recipients and frozen until the laboratory analysis (Fig. 2). The annual distinct growth-band patterns could be seen macroscopically (Campana *et al.*, 2006) but, for a better analysis, after each spine was cleaned of excessive muscle and tissue (Carbonara & Follesa, 2019) the growth-bands were identified using a binocular 20X.

In the age regarding process, information from the most recent meeting (December 2023 in Istanbul) of the group experts for determining the age of fish, which works within the framework of the General Fishery Commission for Mediterranean (GFCM) was decided to add 3 years to the number of rings because, the rings at the base are not easily visible (FAO, 2023).

Fig. 2. Spines extraction and examination (photos by Nuri Başusta, 2023)

Length-weight relationships were estimated by fitting an exponential curve, $W = aL^b$, to the data (Ricker, 1973; Ricker, 1975; Pauly, 1984). Parameters *a* and *b* of the exponential curve were estimated by linear regression analysis over log-transformed data.

The connection between variables *W* and *L* was calculated by the determination coefficient (r). When parameter *b* is statistically equal to 3, the growth is called isometric. When the *b* value is more than 3 the growth is positive allometric and negative allometric when the *b* value is less than 3 (Dutta *et al.*, 2012; Özdemir *et al.*, 2023).

Information regarding the biomass and abundance were statistically analyzed using the Biondex Script (version 2.0) running in the R program version 3.6.0.

RESULTS AND DISCUSSION

A total of 143 dogfish individuals were analyzed in the laboratory. Regarding sex ratio, in 2022 was identified only males (53 individuals) and in 2023 were identified only 2 females from the total of 85 individuals. This strange situation is most likely due to the solitary nature of the species and the fact that the males prefer the offshore areas, with greater depths (where trawling was mainly carried out) and the females prefer the areas closer to the coast, and they mix during the reproduction period (Radu *et al.*, 2008). Also, could be potentially connected to environmental conditions and related to latitudinal effects or plasticity of the reproductive cycle of this species (Natanson *et al.*, 2017).

A similar situation was also observed on the Bulgarian Black Sea coast (Tserkova *et al.*, 2022) and predominance of females in bycatches was found only in the spring season. On the other hand, in the reported dogfish like by-catch species on Turkish Black Sea coast, although females predominated, the difference from males it was small (Özdemir *et al.*, 2023).

Information regarding the abundance of the Black Sea dogfish is very important for advancing scientific knowledge to ensure sustainable fisheries and support economic-environmental stability. This comprehensive understanding helps promote the long-term health and resilience of this vulnerable fish species in the Black Sea.

The abundance analysis was carried out for the dogfish data, and it was observed that in the spring season the abundant areas are in the north and center part of the Romanian coast and for the autumn season center and south part (Fig. 3 to Fig. 6).

Recent study from Bulgarian coast (Tserkova *et al.*, 2022) indicate the same interannual fluctuations in abundance, but also indicated seasonal changes in the sex ratio and growth patterns of this species in the Western Black Sea. Future studies are needed regarding the food spectrum and the reproduction of these species to identify if there is a connection between the annual variation in abundance and the mentioned aspects.

Regarding the growth patterns, an increase in the average length value was observed from 107,85 cm ± 0.790 SD in 2022 to 116,88 cm ± 0.569 in 2023 (Fig. 7 and Fig. 8).

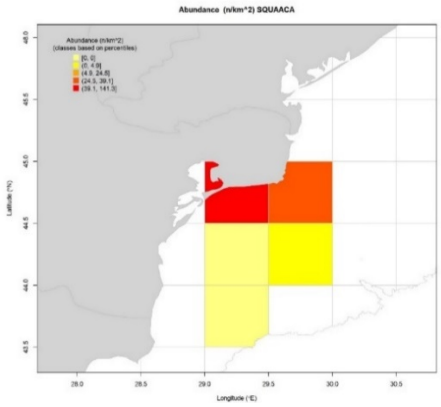

Fig. 3. Abundance index for dogfish in spring expedition, 2022 (NIMRD data)

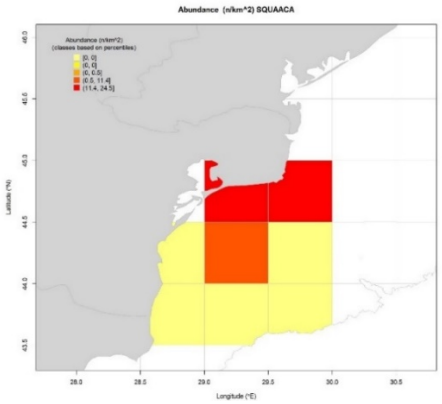

Fig. 4. Abundance index for dogfish in spring expedition, 2023 (NIMRD data)

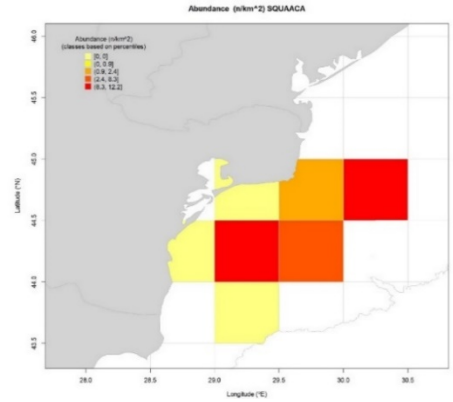

Fig. 5. Abundance index for dogfish in autumn expedition, 2022 (NIMRD data)

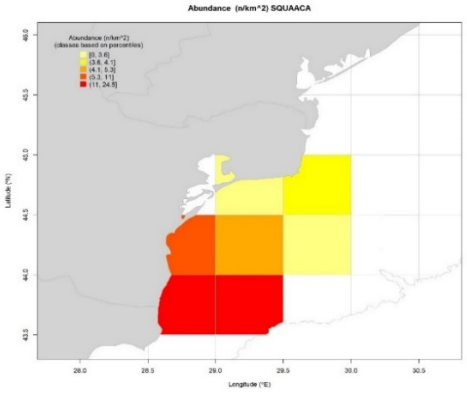

Fig. 6. Abundance index for dogfish in autumn expedition, 2023 (NIMRD data)

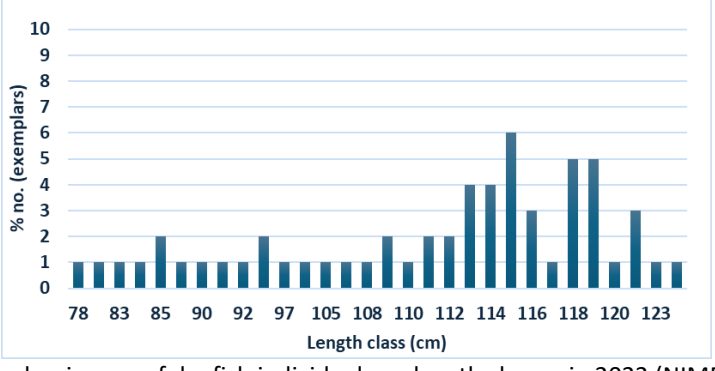

Fig. 7. Predominance of dogfish individuals on length classes in 2022 (NIMRD data)

Similar values were reported for individuals from Bulgarian marine area, more precisely 111,83 cm ±18,97 (Tserkova *et al.*, 2022) and 111,8 cm ± 0,77 in Turkish Black Sea area (Özdemir *et al.*, 2023). In the year 2022 the predominated length classes were between 114 cm and 122 cm.

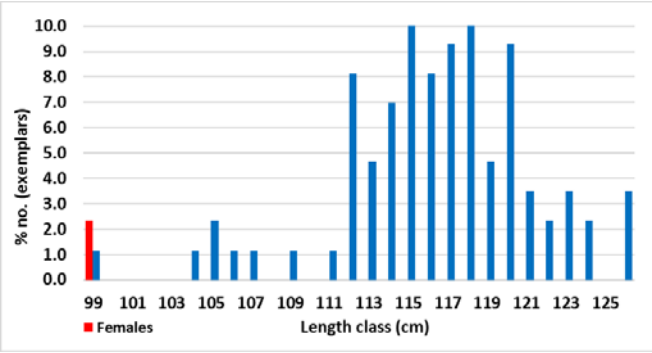

Fig. 8. Predominance of dogfish individuals on length classes in 2023 (NIMRD data)

For the individuals analyzed in the year 2023 the predominated length classes were between 113 cm to 123 cm. The weight – length correlation is a strong one, mainly observed on data from 2022 and a low correlation in 2023 data (Fig. 9 and Fig. 10).

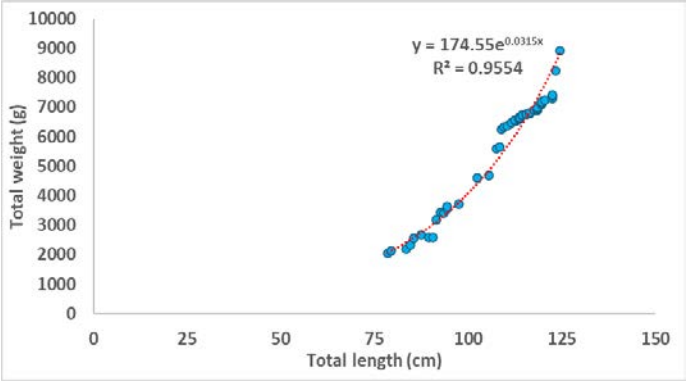

Fig. 9. Weight – length correlation of dogfish individuals on length classes in 2022 (NIMRD data)

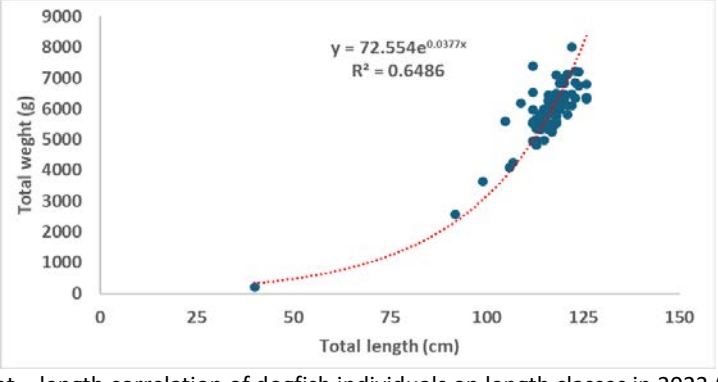

Fig. 10. Weight – length correlation of dogfish individuals on length classes in 2023 (NIMRD data)

The closer the value of r^2 is to 1, the closer the correlation between the analyzed values is (Fowler *et al.*, 1998). The parameters of the weight - length relation indicates a positive allometric growth (> 3) for both years and seasons (Table 1).

Table 1. Values of growth parameters for dogfish in Romanian Black Sea waters, 2022 and 2023 (NIMRD data)

	2022	**2023**
a	0,004	0,003
b	3,032	3,057

Data are comparable with that identified in Bulgarian analysis (Tserkova *et al.*, 2022) with the mention that positive allometric growth was identified only in spring and negative allometric was identified in autumn.

Age determination - insights from spines analysis

The understanding determination of fish age is a fundamental tool in estimation of the main biological parameters. Estimation of growth, mortality and longevity rates is, in fact, essential to resource evaluation, and it requires careful studies on the ageing of individuals (Carbonara & Follesa, 2019; Hoenig and Gruber, 1990; Goldman, 2005).

Regarding the knowledge of the age and growth of cartilaginous fish in the Black Sea there is little information available. Unlike bony fishes, which have scales and otoliths, in elasmobranchs age determination proves to be more complex (Carbonara & Follesa, 2019; Campana, 2014), both for the absence of these hard structures, and for the low level of calcification of the cartilaginous parts. Thus, the structures suitable for age reading in cartilaginous fishes are vertebrae and spines.

For age determination the method of analyzing the dorsal spines was used, being considered the most appropriate (Fig. 11).

Fig. 11. Photos with analyzed dogfish spines (original, NIMRD)

Thus, in 2022 mature specimens (19 years old) predominated, and in 2023, younger specimens (14 years old), but completely mature from a reproductive point of view, predominated (Table 2 and Table 3).

Table 2. Age - length information of dogfish specimens in 2022 (NIMRD, data)

Age (year)	Total no.	% from total no.	Wm (g)	Lm (cm)
14	4	7.54	2303.33±0.33	82.83±0.11
15	5	9.43	3043.02±2.24	91.70±1.08
16	3	5.67	4020.01±0.39	99.16±0.29
17	2	3.77	5100.01±1.31	105.02±1.81
18	6	11.32	6298.33±0.29	111.01±0.05
19	15	28.30	6822.50±2.78	115.12±2.45
20	9	16.98	6795.78±0.81	118.05±1.19
21	6	11.32	7217.17±1.25	120.16±1.77
22	3	5.67	7331.67±0.57	122.17±0.09

*Wm = medium weight; Lm = medium length

Table 3. Age - length information of dogfish specimens in 2023 (NIMRD, data)

Age (year)	Total no.	% from total no.	Wm (g)	Lm (cm)
11	3	3.53	3920.02±0.41	103.83±0.17
12	7	8.24	4318.57±1.37	109.21±0.68
13	16	18.82	5452.79±2.15	113.68±1.25
14	24	28.24	6016.70±1.81	116.71±2.12
15	19	22.35	6099.74±1.02	119.44±1.23
16	7	8.24	6758.39±0.53	121.64±0.45
17	5	5.87	6867.02±0.82	123.51±0.17
18	4	4.71	6952.51±1.14	125.25±0.29

*Wm = medium weight; Lm = medium length

In comparison with the individuals analyzed in the Turkish area of the Black Sea, where the oldest individuals were 14 years old (Avşar, 2001), in the present study individuals up to 22 years old were identified.

As a result of the identification of inconsistencies in the analysis and interpretation of Black Sea dogfish age, it is necessary to use a common method at the level of the Black Sea basin.

So, using dorsal spines to determine the age of the Black Sea dogfish has several advantages and some disadvantages (Table 4).

Table 4. Pros and cons aspects using the spine analysis method to determine the Black Sea dogfish's age

advantages	disadvantage
• accuracy and reliability (this method has been validated in various elasmobranchs species as an accurate and reliable indicator of age). • ease to collect (dorsal spines are relatively easy to collect). • non-lethal method (analyzing dorsal spines can often be done without killing the individuals, which is crucial for conservation efforts and studying protected species). • existing validation (this method has been widely used and validated in various studies across different elasmobranchs species and regions, providing a solid foundation of scientific literature and protocols). • cost-effectiveness (analyzing dorsal spines is generally less costly compared to other methods like genetic analysis and the analysis of the vertebrae sections).	• environmental influences (growth ring formation can be affected by environmental factors such as water temperature, food availability, these can affect the formation and clarity of growth rings, potentially leading to inaccurate age estimates). • specific validation required (the accuracy of dorsal spine analysis can vary between species and this method may need specific validation for Black Sea dogfish). • method limitations (errors in interpreting growth rings can occur, especially in older individuals where the rings might be closely spaced or less distinct. This can lead to underestimations or overestimations of age).

Balancing these pros and cons is essential for researchers to determine the most suitable approach for their specific study and conservation objectives (Goldman, 2005; Campana, 2014; Demirhan *et al.*, 2005; Carbonara & Follesa, 2019). In this regard, further research is needed to agree on the common use of an age analysis method for Black Sea elasmobranch species at a regional level.

CONCLUSIONS

The information regarding modification in the population parameters of fish species is crucial for ensuring sustainable fisheries management and to contribute to the conservation of marine biodiversity fauna.

In our study the weight - length relation indicates a positive allometric growth. Regarding the growth patterns, an increase in the average length value was observed from 107,85 cm ± 0.790 SD in 2022 to 116,88 cm ± 0.569 in 2023, an aspect that is not different that others reported in Black Sea studies.

Regarding the sex ratio, in 2022 were identified only male and in 2023 were identified only 2 females. This situation was observed also at the Bulgarian coast and could be potentially connected to environmental conditions.

For age determination the method of analyzing the dorsal spines was used, being considered to have many advantages. In the year 2022 mature specimens predominated and in 2023, the younger specimens but completely mature from a reproductive point of view, this highlights that the population is healthy and with an optimal degree of reproduction to ensure the evolution of the species.

Regional collaboration and the need for a common protocol to be used in analyzing the growth pattern of this vulnerable species is necessary to develop appropriate sustainable management.

Acknowledgement. This research was carried-out in the frame of the Project "Services for the realization and implementation of the National Program for Data Collection of the Romanian Fishing Sector, 2023".

REFERENCES

Avşar, D. (2001). Age, Growth, Reproduction and Feeding of the Spurdog (*Squalus acanthias* Linnaeus, 1758) in the South-eastern Black Sea. *Estuarine, Coastal and Shelf Science*, 52(2): 269-278. https://doi.org/10.1006/ecss.2000.0749

Bănărescu, P. (1964). Fauna of the Romanian People's Republic. Vol. XIII: Pisces - Osteichthyes (ganoid and bony fishes). Publishing House of the Academy of the Romanian People's Republic, 963 pp *(in Romanian)*.

Campana, S. E., Jones, C., McFarlane, G. A. & Myklevoll, S. (2006). Bomb dating and age validation using the spines of spiny dogfish (*Squalus acanthias*). *Environmental Biology of Fishes*, 77: 327–336.

Carbonara, P., Follesa, M.C., eds. (2019). Handbook on fish age determination: a Mediterranean experience. *Studies and Reviews*, 98, Rome, FAO, 192 pp.

Demirhan, S.A., Öğüt, H., Engin, S., Başusta, N. & Genç, E. (2005). Difficulties in Age Readings from Dorsal Spines of Spiny Dogfish *Squalus acanthias* L., 1758. In: The proceedings of the Workshop on Mediterranean Cartilaginous Fish with Emphasis on Southern and Eastern Mediterranean (Başusta N., Keskin C., Serena F., Seret B. (Eds). Turkish Marine Research Foundation. Istanbul, Publication no. 23, pp. 28-35, ISNB 975-8825-13-5.

Dutta, S., Maity, A., Chanda, A., Akhand, A., & Hazra, S. (2012). Length weight relationship of four commercially important marine fishes of Northern Bay of Bengal, West Bengal, India. Journal of Applied Environmental Biological Sciences, 2: 52-58.

FAO, (2023). https://www.fao.org/gfcm/activities/fisheries/cooperation/blacksea4fish/news (last accessed on 10.06.2024).

Fowler, J., Cohen L., Jarvis P. (1998). Practical Statistics for Field Biology, Wiley, pp. 131-135.

Gallucci, V., F., Taylor, I., G. and Erzini, K. (2006). Conservation and management of exploited shark populations based on reproductive value. *Canadian J. Fish. aquat. Sci.*, 63: 931–942.

Goldman, K.J. 2005. Age and growth of Elasmobranch fishes. In J.A. Musick & R. Bonfil, eds. Management techniques for Elasmobranch fisheries, pp. 76–102. FAO Fisheries Technical Paper No. 474. Rome, FAO.

Hart, J.L. (1973). Pacific fishes of Canada. *Bull. Fish. Res. Board Can*. 180: 740 p.

Hoenig, J.M. & Gruber, S.H. 1990. Life-history patterns in elasmobranchs: implications for fisheries management. In H.L. Pratt, Jr., S.H. Gruber & T. Taniuchi, eds. Elasmobranchs as living resources: advances in biology, ecology, systematics and the status of fisheries, pp. 1–16. Washington, DC, U.S. Department of Commerce, NOAA Technical Report, NMFS 90.

Yiğin, C., Ç. and İşmen, A. (2016). Age and Growth of Spiny Dogfish *Squalus acanthias* (Squalidae: Chondrichthyes) in the North Aegean Sea. *Pakistan journal of zoology*, 48: 1185-1191.

IUCN, 2024. https://www.iucnredlist.org/ja/species/91209505/48910866 (last accessed on 06.06.2024).

Maximov, V., Nicolaev, S., Radu, G., Staicu, I. (2008). Estimation of growing parameters for main demersal fish species in the Romanian Marine Area. *Cercetări marine - Recherches Marines,* 37: 289-304.

Maximov, V., Patras, E., Oprea, L., Radu, G., Zaharia, T. (2010). The Analysis of the Evolution of Fishing and the Biological Characteristics of the Main Species from the Romanian Pontic Basin, between 2000 and 2008. *J Environ Prot Ecol*, 3: 999-1007.

Natanson, L., McCandless, C., James, K., Hoey, J. (2017). Gestation period and pupping seasonality of female picked dogfish (*Squalus acanthias*) off southern new England, Fish Bull, 115: 473-483.

Niță, V., Nenciu, M., Galaţchi, M. (2022). Fish species of the Romanian coast. Updated atlas. Constanta, 152 pp. ISBN 978-973-0-36642-6.

Özdemir, S., Özsandıkçı, U., Duyar, A., (2023). Some Population Parameters of Picked Dogfish (*Squalus acanthias* L. 1758) Incidentally Captured in Commercial Fisheries in Southern Black Sea Shores and a First Record of Angular Rough shark (*Oxynotus centrina*, L. 1758) for Black Sea. Marine Science and Technology Bulletin. 12: 483-494. https://doi.org/10.33714/masteb.1369086

Pauly, D., (1980). On the interrelationships between natural mortality, growth parameters, and mean environmental temperature in 175 fish stocks. J. du Conseil, 39 (2).

Radu Ghe., Radu E., Nicolaev S., Anton E. (2008). Atlas of the main fish species from the Black Sea. Romanian marine fishery. Ed. Virom, Constanţa, 293 pp. ISBN 978-973-7895-32-5 (in Romanian).

Radu, G., Maximov, V., Anton, E. (2011a). Research on the status of the dogfish (*Squalus acanthias*) population in the Romanian marine area. Summary data on dogfish at Black Sea level. FAO/GFCM Workshop on Stock Assessment of Selected Species of Elasmobranchs in the GFCM Area. Brussels, Belgium, 12 - 16 December.

Radu, G. (2011B). Romanian Fishery Report 2010. The regular FOML R AG meeting of the BSC, Black Sea Commission Permanent Secretariat Premises, Istanbul, Turkey, 19 - 20 of September 2011.

Ricker, W.E. (1973). Linear regressions in fishery research, J. Fish. Res. Board Can., 30 (3): 409-434.

Ricker, W.E. (1975). Computation and interpretation of biological statistics of fish population, Bull. Fish. Res. Board. Can, 191 (382).

Schilling, B., Couperus, A. S., Bos, O. G. (2019). Fotogids mesopelagische vissen, Noordoost Atlantische Oceaan. Versie 1.0. [Photo guide mesopelagci fish, Northeast Atlantic Ocean. Version 1.0]. Waginengen Marine Research.

SAF, (2023). https://gfcmsitestorage.blob.core.windows.net/website/5.Data/SAFs/Demersal Species/2022/SAF_DGS_29_RefY2022.pdf

Tserkova, F., Mihneva, V., Pavlova, E., Penchev, F. (2022). Size and sex structure variations of picked dogfish *(Squalus acanthias*, Linnaeus, 1758) (Chondrichthyes-Elasmobranchii) in the Western Black Sea, *Regional Studies in Marine Science*, 52, https://doi.org/10.1016/j.rsma.2022.102298