Acta Biologica Turcica, 35(2), A2:1-22, 2022 Received 25 Jan. 2022; Accepted 17 Mar. 2022; Published Online 22 Mar. 2022

ACTA BIOLOGICA TURCICA

© 1950-1978 Biologi, Türk Biologi Dergisi, Türk Biyoloji Dergisi, Acta Biologica

E-ISSN: 2458-7893, http://www.actabiologicaturcica.com

Research article

Biometrical distribution of sharks in a low Elasmobranchs-diversified shelf, the eastern Mediterranean Sea

Erhan MUTLU[1,*], M. Cengiz DEVAL[1], Claudia MIGLIETTA[2], Ismet SAYGU[3], Ilaria de MEO[4]

[1]Akdeniz University, Fisheries Faculty, Main Campus, Antalya, Turkey

[2]Via Andrea Doria 38, Cellino San Marco (Br), 72020, Italy

[3]Çukurova University, Fisheries Faculty, Adana, Turkey

[4]Inland Norway University of Applied Sciences, Faculty of Applied Ecology, Agricultural Sciences and Biotechnology, Campus Evenstad, Elverum, Norway

*Corresponding author e-mail: emutlu@akdeniz.edu.tr

Abstract: Spatiotemporal distribution of sharks collected by the Otter trawl in 2009-2011 and 2014-2015 was studied for their biometrical characteristics, and fish assemblage and ecology in shelf-slope of Antalya Gulf. Four species was found only on the shelf, two species from middle shelf to shelf break and three species from shelf edge to shelf break. *Scyliorhinus canicula* was the most abundant and the most frequently occurred species during 2009-2010 and then occurrence of *S. canicula* decreased. The rarest species were *Etmopterus spinax* and *Oxynotus centrina*. Average annual abundance was above 800 ind/km^2 in 2010-2011 and below 50 ind/km^2 in 2014-2015. Species richness decreased from winter to spring. Abundance ranged from 5 ind/km^2 in June to 964 ind/km^2 in August. Sallower zone inhabited lower number of species than the deeper zone. Abundance increased from shallower to the deeper waters. The species had a positive allometric or isometric growth. Unimodal species peaked at 75-100 m and at 300 m. Ubiquitous species had a bimodal distribution. The species were discriminated from the deeper water to the shallower water. The species-environment relation was correlated positively by the bottom depths, followed negatively by Secchi disk depth, and water salinity and positively by near-bottom chl-*a* and finest bioseston.

Keywords: Chondrichthyans, sharks, density distribution, biometry, ecology, eastern Levant.

Citation: Mutlu, E., Deval, M.C., Miglietta, C., Saygu, I., & Meo, I. (2022). Biometrical distribution of sharks in a low Elasmobranchs-diversified shelf, the eastern Mediterranean Sea. *Acta Biologica Turcica,* 35(2), A2:1-22.

Introduction

Chondrichthyans (or cartilaginous fishes) populations are vulnerable to overfishing, local extirpation and population collapse from which they are slow to recover (Fowler et al., 2005; Garofalo et al., 2013; Ramírez-Amaro et al., 2020) even though they act as top predators in the trophic food web (Galván-Magaña et al., 2019). K-selected life history characteristics (eg. slow growth, late age at maturity, low fecundity and productivity), combined with the tendency of many species to aggregate by age, sex and reproductive stage, have serious implications for the sustainability of fisheries for cartilaginous species, particularly for apex predators with few or no natural enemies and naturally small populations, even at their centres of distribution (Stevens et al., 2000; Fowler et al., 2005). Besides the spatiotemporal variation (Follesa et al., 2015), the anthropogenic sources (trawling, pollution; low survival rate and recovery to sea, the injury of individuals, and intensive scientific studies, and the drastic changes in the environmental conditions) have induced abundance of the Elasmobranches to be fluctuated in time and space (Ligas et al., 2010; Gurbet et al., 2013; Barría et al., 2015; Galván-Magaña et al., 2019).

A total of 89 species of Chondrichthyes recorded in the Mediterranean Sea, 49 are sharks, and 57 species were assessed in the IUCN Red List of Threatened Species (Guijarro et al., 2012; Dulvy et al., 2014; Mancusi et al., 2020; Serena et al., 2020). In general, about half of

Elasmobranches comprised the sharks in the different regions of the Mediterranean Sea (Bertrand et al., 2000; Follesa et al., 2019), but this ratio is comparatively less or similar in the Turkish Mediterranean waters (Yağlıoğlu et al., 2015; Güven et al., 2012; de Meo et al., 2018). Currently, 38 species of sharks are occurred in Turkish waters (Kabasakal, 2021; Turan et al., 2021).

The Mediterranean studies on the sharks were sufficiently conducted on a wide variety of topics through reproduction biology (e.g. Capapé et al., 2014), biological aspects (Aranha et al., 2009), diet (Follesa et al., 2019), population dynamics (Ivory et al., 2004), habitats (Lauria et al., 2015), morphometrical measurements (Evagelopoulos et al., 2017), sex composition and spatio-temporal distribution (D'Onghia et al., 1995; Follesa et al., 2019) of single chondrichthyan species, and fish assemblages and associations (Moranta et al., 2008), density trend from the long-term time series data (Jukic-Peladic et al., 2001; Ramírez-Amaro et al., 2020), fishery impact (Barausse et al., 2014), by-catch and discards (Damalas and Vassilopoulou, 2011), illegal fishing (Giovos et al., 2020), conservation (Dulvy et al., 2014), the red list (Mancusi et al., 2020), and ecology (Barria et al., 2015) of the chondrichthyan fishes. The studies were contributed from a broad Mediterranean part located between Crete and Straits of Gibraltar. The Levantine Sea was not however significantly studied for the Elasmobranches. Most of the studies in the Levantine Sea were conducted in the Turkish waters of a particular bay (Iskenderun Bay, a lesser extend to Mersin Bay and Antalya Gulf). The other studies were published on the elasmobranches from the Turkish waters of the Aegean Sea, particularly Saros Bay.

The Turkish studies on sharks were focused mostly on length-weight relationships (e.g. Filiz and Mater, 2002; Ismen et al., 2009; Yemişken et al., 2019a, b), record of species occurrence (Akyol et al., 2015), population dynamics (Özcan and Basusta, 2018a, b), stomach contents (Kabasakal, 2001; Bengil et al., 2018), reproduction biology (Koç and Erdoğan, 2018), discards (Yağlıoglu et al., 2015), sex ratios and spatio-temporal distributions (Kabasakal et al., 2017). The studies above were conducted in the Iskenderun Bay (the easternmost Mediterranean Sea) and Saros Bay (the northernmost Aegean Sea), and a lesser extend to Antalya Gulf with the studies only on length-weight relationships (Güven et al., 2012) and fish assemblage and ecology including the sharks (de Meo et al., 2018). Recently, Kabasakal (2021) reviewed the current status of shark fauna of Turkish waters based on available data, recorded during the last three decades.

Shark species of the present study were examined for their spatiotemporal distribution of their biometry (primarily on density; abundance and biomass, and secondarily on morphometrics) in a sensitive area of the Turkish Mediterranean Sea, the Gulf of Antalya which is characterized as one of the poorest biodiversity of the Elasmobranches in the Mediterranean Sea (Coll et al., 2010). Regarding their ecological importance in the marine environment and the recent historical lack of comprehensive information on their distribution and ecology in the Turkish Mediterranean waters, the aim of this study is to provide baseline information on bathymetric and seasonal ecological distribution and biometrical patterns (density, morphometric traits, and sex composition) of the sharks in a region of the most ultra-oligotrophic waters (Sisma-Ventura et al., 2017) of the Mediterranean Sea and to determine their biometrical dynamics and the species-environment relationship.

Material and Method

The material and method of the present study was well described and detailed in a previously published paper (Mutlu et al., 2022).

Sample collection

Shark samples were collected from two bottom trawl (Otter trawl; 88 mm-wing mesh size and a code-end having diamond mesh of 44 mm of) surveys including both fishery period (15 September–15 April) and non-fishery period (16 April–14 September) in the Antalya Bay (Figure 1) of the Turkish Mediterranean coast during years 2009-2011 and 2014 and 2015.

The first survey was performed monthly throughout October 2009–June 2011 and covered two sub-regions R1 (bottoms unvegetated by the meadows) and R2 (shallower bottoms less than 30 m, vegetated by the meadows), both open to the fishery (Figures 1a, c). The samplings were carried out at four depth strata of 0–50, 50–100, and 100–200 m on the shelf and 200–300 m on shelf break. The towing duration varied between 1 h and 4 h (Figure 1a). However, the environmental parameters were not measured.

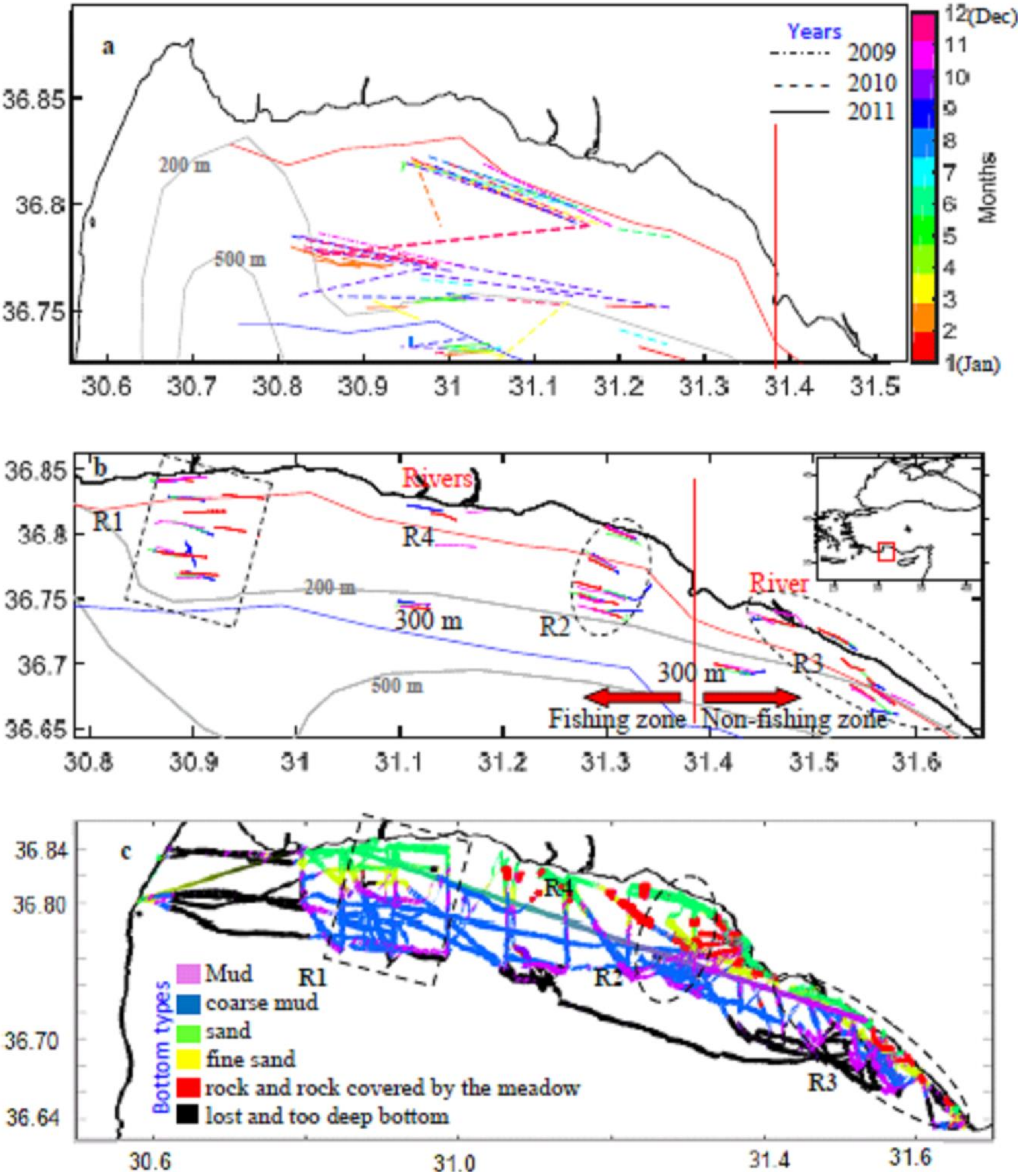

Figure 1. Monthly (1; January to 12; December on color bar) trawl sampling track lines during 2009-2011- and two-miles border for prohibition of the fishery, red line and 12 miles border, blue line (a), and study area in red frame and track lines of the seasonal trawl towing during 2014-2015 (blue; May 2014, green; August 2014; red; October 2014 and magenta; February 2015). Standard fixed depths are in the order of the shallowest to the deepest bottom depths from the coast to open water seaward in each of regions (R1-R3) (b) and the study area showing the different bottom types from the acoustical track lines by the echosounder during 2014-2015 (c).

In the second survey, fish samples were collected seasonally in May 2014 and August, October, and February 2015 on the shelf and shelf break (Figure 1b). To determine the sharks' ecological preference, the environmental parameters were measured simultaneously as previously described by de Meo et al. (2018) and Mutlu et al. (2021). The study area was divided into three sub-regions (R1, R2, and R3 which has been prohibited by the trawl fishery throughout year) and each region had 5 fixed sampling stations located at 10 m, 25 m, 75 m, 125 m, and 200 m bottom depths and 300 m only once at each of R1, R2, and R3 (Figure 1b). For riverine effects on the elasmobranchs, a region R4, which was restricted coastally by a deepest bottom of 75 m, was added to the present study. The trawling was kept to be standard duration (30 min) for all sampling. All specimens of elasmobranchs were individually measured for their body length (mm), width (mm), and weight (0.01 g) on board then recovered to the sea. The individual sex was determined from specimens having the claspers or not.

Data standardization

Data of most studies were analyzed based on the number of individuals and weight per haul for the elasmobranchs. A total of 1241 specimens of sharks were captured during the present study (Table 1). The total number of individuals and weight per haul were converted to abundance (ind/km^2) and biomass (kg/km^2) over the swept area, since trawling durations were not fixed between two different surveys. For the swept area, geographical coordinates of Differential-Global Positioning System (D-GPS) recording data at every 1 sec were converted to the swept area with estimations of the trawling distance multiplied with sweeping width calculated by multiplying the floatline length (35 m) with a multiplier of 0.5 (Pauly, 1980).

Statistical analyses

Spatiotemporal distribution of the sharks was evaluated by interpreting the results of the following the statistical methods and analyses. Soyer's index based on dominance (*D%*), frequency of occurrence (*FO%*), and numerical occurrence (*NO%*) were evaluated to determine constancy of the species occurrence in the study area (Soyer, 1970).

The total length-weight of the species individuals was regressed using power-fit model of the regression equation and the equations were tested for the difference among sex and spatiotemporal factor using Analysis of Covariance (ANOCOVA) of the statistical tools of the MatLab (vers. 2021a, Mathworks Inc.). Length frequency was based on bin size estimates from the COST function (Shimazaki and Shinomoto, 2007) for each species. The kernel density function (KDF) was used to estimate number of cohorts and length ranges of each cohort for each species.

The following statistical analyses were applied to test for differences in the variables (biomass, abundance, total individual length and weight, and sex ratio; female:male) obtained from the species among the time (month and year) and space (depth and region). Three-way analysis of variance (3-way ANOVA) was subjected to the abundance among time, depths, and regions. The Post-hoc test (LSD, least significant difference) was then applied to each variable separately for each factor (way). All statistical analyses were performed using the statistical tool of MatLab. Faunistic characteristics of the elasmobranchs were represented by mean number of species (*S*), abundance (*N*), Margalef's richness index (*d*), Pielou's evenness index (*J'*), and Shannon-Weiner diversity index (*H'*) estimated using PRIMER (PRIMER, vers.6+).

Furthermore, Bray-Curtis similarities based on $\log_{10}$-transformed abundances of the sharks were applied to PERMANOVA to test the differences among the sampling years, month and bottom depths using PRIMER. The abundance of elasmobranch species including batoids was subjected to canonical correspondence analysis (CCA) to cluster the stations to estimate the shark species-environment relationship and the shark species-megabenthic fauna and osseous fish relationship (Garuti and Mutlu, 2021; Patania and Mutlu, 2021; de Meo et al., 2018, respectively), as megabenthic fauna was the presumed food of the sharks for a period of 2014–2105 using CANOCA (vers. 4.5). Spearman correlation was applied between abundances of the shark species and megabenthic species, and osseous fish.

Table 1. Annual summary and conclusion of the measurements and estimates for the shark species (Abbs; abbreviations used in the analyses); densities (prefix, minimum; M - maximum; Mx and average; A ± SD, of abundance in ind/km^2; suffix, A and biomass in kg/km^2; B), sex composition; SxR (female:male ratio; zero, 0 means that only male present and 2 means only female present), size range; SR (total length, cm in 2009-2011 and body width, cm in 2014-2015), number of cohorts estimates; #C, length/width-weight relationships (regression coefficients, *a* and *b*, **bold values** for the combined periods), growth type (T; isometric; I and allometric; negative; N and positive, P), depth ranges; DR (m) and month; M when the maximum abundance was recorded. No: insufficient data or no species found. * rare species.

Ordo/Species	Abbs	MA - MxA	AA	MB - MxB	AB	SxR	LR	#C	*a*	*b*	T	n	DR	M
Carcharhiniformes		**7.07-16895**	**8.24-1478**	**0.29-1241**	**10.98-102.75**	**0-1.05**	**9-90.2**	**8-14**					**30-300**	**2,6-8**
		20.00-485.00	**24.0-189.12**	**0.37-48.45**	**16.24-36.66**	**0-0.98**	**12.1-59.5**	**1-8**					**75-300**	**2,8**
*Carcharhinus plumbeus**	*C pl*	30 -30	30	30 - 32.11	32.11	0:1	90.20	No	No	No	No	1	30	7
		24.00 -24.00	24.00	36.66 - 36.66	36.66	0:1	59.50	No	No	No	No	1	75	8
Galeus melastomus	*G me*	12.48- 2072.1	384.49 ± 752.22	0.29 - 51.87	10.98 ± 18.28	0.57	13.0-50.1	8	0.0022	3.065	P	132	200-300	2
		No - No	No	No - No	No	No	No	No	No	No	No	0	No	No
*Mustelus mustelus**	*M mu*	7.07 - 10.43	8.24 ±1.89	4.10 - 23.57	13.98 ± 9.73	1:0	52.0-87.4	No	0.0102	2.754	N	4	30-40	6
		No - No	No	No - No	No	No	No	No	No	No	No	0	No	No
Scyliorhinus canicula	*S ca*	35.61 - 16895	1478.0 ±3691.8	3.51 - 1241.6	102.75 ± 267.06	1.05	9-39	14	0.0016	3.169	P	967	200-300	8
		20.00 - 485.00	189.12 ±186.61	0.37 - 48.45	16.24 ± 18.99	0.98	12.1-39.5	8	0.0013	3.505	P	71	200-300	2
Squaliformes		**23.16-502.27**	**23.16-502.27**	**3.56-61.85**	**6.87-61.85**	**0.75-2**	**13-61.7**						**200-300**	**3-7**
		0-0	**0-0**	**0-0**	**0-0**									
Etmopterus spinax	*E sp*	502.27 - 502.27	502.27	8.70 - 8.70	8.70	0.87	13-19	No	0.0055	2.914	N	43	300	3
		No - No	No	No - No	No	No	No	No	No	No	No	0	No	No
*Oxynotus centrina**	*O ce*	23.16 - 23.16	23.16	61.85 - 61.85	61.85	1:0	51-61.7	No	No	No	No	2	300	7
		No - No	No	No - No	No	No	No	No	No	No	No	0	No	No
*Squalus blainvillei**	*S bl*	35.61 - 73.67	54.17 ± 19.04	3.56 - 9.91	6.87 ± 3.18	0.75	22-42	No	0.0048	2.968	I	8	200-300	5
		No - No	No	No - No	No	No	No	No	No	No	No	0	No	No
Squatiniformes		**12.34-12.34**	**12.34-12.34**	**46.16-46.16**	**46.16-46.16**	**1:0**	**80.4-80.4**						**200-200**	**5**
		22.00-102.00	**55.00-59.00**	**12.25-252.17**	**69.47-196.95**	**0-2**	**44.0-79.0**						**10,75-200**	**8,10**
*Squatina oculata**	*S oc*	12.34 - 12.34	12.34	46.16 - 46.16	46.16	1:0	80.4	No	No	No	No	1	200	5
		25.00 - 102.00	55.00 ± 41.22	12.25 - 107.23	69.47±50.38	2:1	48.2-79.0	No	0.0315	2.673	N	5	10, 200	8
*Squatina squatina**	*S sq*	No - No	No	No - No	No	No	No	No	No	No	No	0	No	No
		22.00 - 92.00	59.00 ± 35.17	15.64 - 252.17	196.95 ± 118.38	0:1	44-77.5	No	0.0079	3.013	I	6	75-200	10

Results

Twenty species of elasmobranches were recorded in the present study, of which representing 9 species of sharks, and 11 batoids, including 1 guitarfish, 4 rays and 6 skates (Mutlu et al., 2022). Eight shark species were found in 2009-2011 whilst only 4 species were in 2014-2015. Four species were found only on the shelf, two species in a zone from middle shelf to shelf break (300 m) and three species from shelf edge to shelf break. However, any constant and common species was not estimated according to Soyer's index in the pooled periods. *Scyliorhinus canicula* was the common species and the most frequently occurred species (*D%*=42.50% and *FO%*=50.00%), followed by *Galeus melastomus* (17.50% and 20.59%) during 2009-2010. *S. canicula* became a rare species (*D%*=11.39%) and was the most dominant and the most frequently occurred species (56.25%) during 2014-2015. *S. canicula* comprised numerically (abundance) of 89.29% (*NO%*) of the total abundance of all species. *S. canicula* was numerically (abundantly) occurred species in 2009-2011 (89.77%) and 2014-2015 (81.12%). The rarest species were *Etmopterus spinax* and *Oxynotus centrina* among the other rare species in the study area (Table 1).

Spatiotemporal distribution

Of 9 shark species identified in the present study, 4 species belonged to order Carcharhiniformes, and followed by 3 Squaliform and 2 Squatiniform sharks, which are representing 8 families (Table 1).

Scyliorhinus canicula (Linnaeus, 1758) (Carcharhiniformes: Scyliorhinidae): The small-spotted catshark was recorded only between a seafloor depth of 200 m and 300 m during 2009-2011 and 2014-2015

(Figure 2). The maximum biomass and abundance were recorded at 300 m in August of 2010 and May of 2011 (Table 1). In 2014-2015, maximum abundance and biomass were estimated to be 485 ind/km^2 and 50 kg/km^2, respectively, during the cold seasons (Figure 2).

Overall, the female and male individuals shared the population fifty-fifty percent in the first survey whereas the population was overall mostly dominated by the males in the second survey (Figure 2). The total length of the species varied between 9 cm and 39.5 cm (Figure 3). The length distribution was significantly different among the year, months, and sexes ($p = 0.038$, 4.23×10^{-19} and 1.63×10^{-8}), but was not among the bottom depths ($p = 0.196$). The COST function estimated the optimum length class interval as 0.5 cm for a length distribution in a range of 9 cm to 39 cm (Figure 3). The KDF estimated number of cohorts as 14+ during 2009-2011, and the population was dominated by cohorts 6, and followed by 4 of 8+ cohorts in 2014-2015 (Table 1, Figure 3). The length (cm) - weight (g) relationships were significantly different among the months and sexes (ANOCOVA, $p = 4.95 \times 10^{-19}$ and 9.16×10^{-11}, respectively) but was not among the years and bottom depths ($p = 0.080$ and 0.119, respectively). All sex (total; regardless of sex, female and male) showed a positive allometric growth ($t = 3.95$, 2.41 and 3.88, $n = 63$, 40 and 23, respectively) (Table 1).

Galeus melastomus Rafinesque, 1810 (Pentanchidae): The blackmouth catshark was caught at depth of around 300 m, and mostly during the cold-water months (December-March/April) in years 2010 and 2011. The maximum biomass was about 50 kg/km^2 and abundances about and greater than 2000 ind/km^2 (February). However, the species was not encountered in 2014-2015 (Table 1). The biomasses were not significantly different among the years, and the bottom depths ($p = 0.636$ and 0.776, respectively) but was among the months ($p = 0.0066$). The biomasses varied between < 0.6 ± 0.17 kg/km^2 (January and April) and 4.07 ± 0.17- 8.91 ± 0.17 kg/km^2 (the rest of months). The females outnumbered the males in the population at 200-250 m (the ratios: 2.7 ± 0.5) while the males were dominated at 300 m (0.3± 0.2). The total length of *G. melastomus* varied between 13 cm and 51 cm. The total length was longer (24.5 ± 0.7 cm) in 2010 than 2011 (20.8 ± 0.5 cm). The individuals had longer body in January (25.7± 2.1 cm) and in July (31.3 ± 1.1 cm) than the other months (about 21 cm). The length was similar (21.2-22.6 ± 0.6 cm) between the sexes. Estimated number of the cohort was about to be 5+ and 7-8+ (Table 1). The population was predominated by cohort C III, followed by C II and C IV. Female ($W=0.0018L^{3.132}$) and male ($W=0.0023L^{3.045}$) individuals had positive allometric growths significantly ($t = 6.27$ and $n = 58$, and 2.15 and 73, respectively).

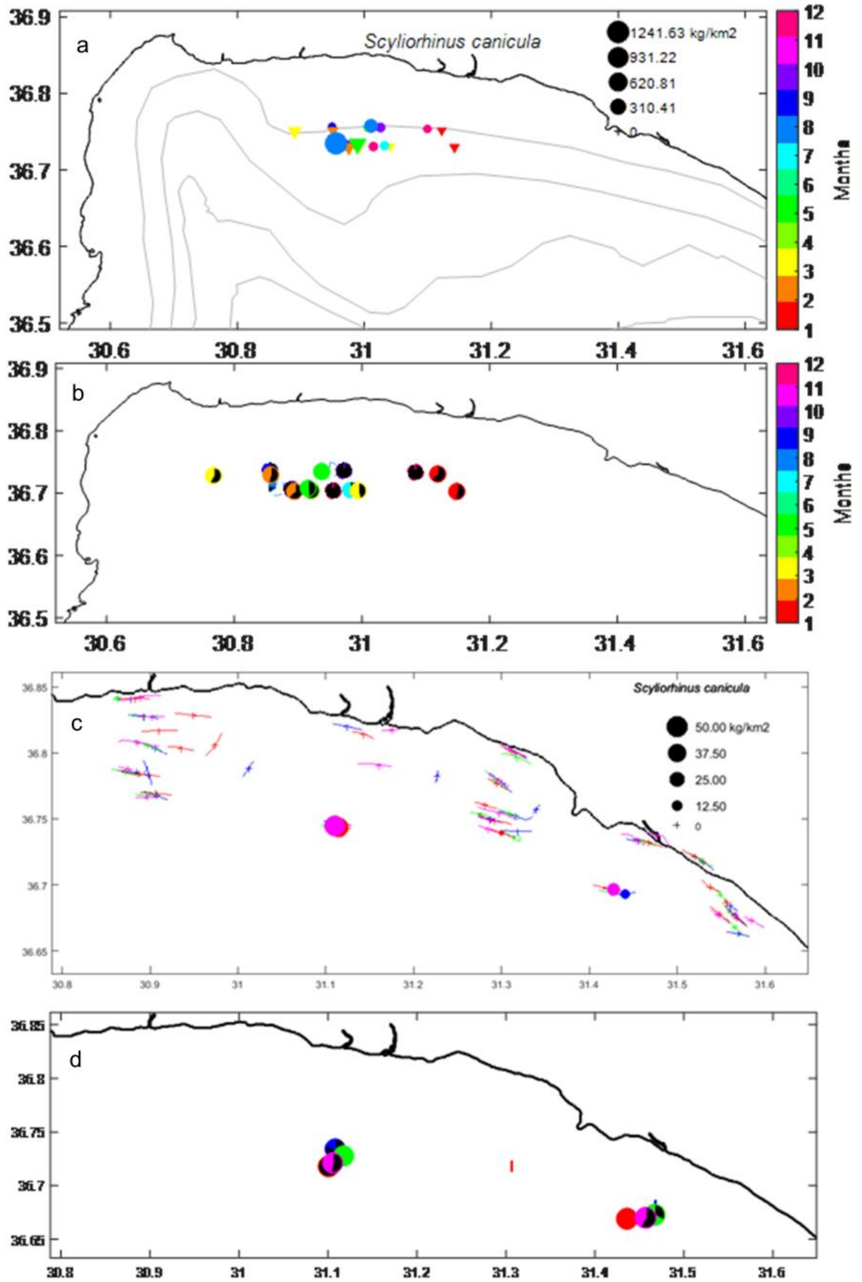

Figure 2. Monthly average biomass in kg/km^2 (a) and percent sex composition (b) of *Scyliorhinus canicula* in years 2009-2011, and seasonal biomass (c) and percent sex composition (d) in 2014-2015 (blue; May 2014, green; August 2014; red; October 2014 and magenta; February 2015. Colors for sex composition; Females followed seasonal colors and males; black, and juveniles; white).

Etmopterus spinax (Linnaeus, 1758) (Squaliformes: Etmopteridae): The velvet belly lanternshark was observed only at 300 m in 2009-2011, and was not caught in 2014-2015. The species was recorded only in March possessing the coldest sea surface temperature of the year. The biomass was 8.71 kg/km^2 and the abundance was 502 ind/km^2 (Table 1). Sex composition was shared almost fifty-fifty percent by the males and females (Table 1). The total length varied between 13 cm and 19 cm for the females and 14-18 cm for the males. Specimens of 14-16 cm length were dominated in the population. The length (cm)-weight (g) relationship established from 43 individuals was $W=0.0055L^{2.914}$ (total; regardless of sex, $n = 43$), $W=0.0047L^{2.972}$ for females ($n = 20$), and $W=0.0067L^{2.843}$ for males ($n =$

23). Length-weight regression constants were significantly different among the sexes ($p = 3.31 \times 10^{-210}$). Males and female specimens had a negative allometric growth ($t = -339.251$ and 60.5418, respectively) (Table 1).

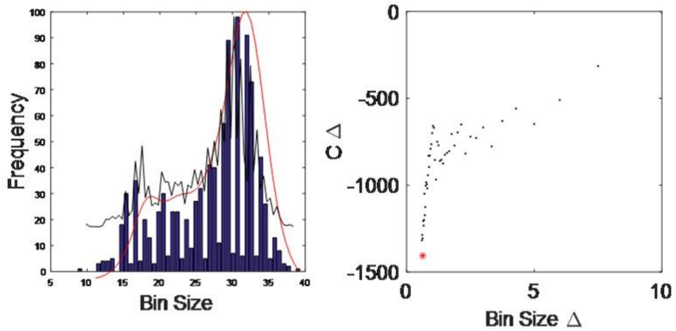

Figure 3. *Scyliorhinus canicula*: Length-frequency histogram with solution of KDF (a, black curve based on the length edges estimation by KDF; red curve based on 30 size classes) in a size class interval estimated by COST function (b), *; optimum length class interval in cm.

Squalus blainvillei (Risso, 1827) (Squalidae): The longnose spurdog was found at 200 m-300 m and occurred two times in years 2009-2011; May and December. The maximum biomass and abundance were measured in May (Table 1). The females occurred at 200 m, and males at 300 m. The biomass was not significantly among the years, months (7.13 ± 4.49 kg/km^2 in December 2010, and 6.74 ± 3.17 kg/km^2 in May 2011), and bottom depths ($p = 0.954$, 0.954 and 0.379, respectively). The total length of the specimens varied between 29.3 ± 4.2 cm and 34.3 ± 5.4 cm ($p = 0.4917$). Average female length was 38.8± 4.1 cm and the male was 26.6 ± 3.1 cm ($p = 0.0544$) (Table 1). The length-weight equations were fitted with $W=0.0048L^{2.968}$ for unisex, $W=0.0015L^{3.294}$ for female and $W=0.0047L^{2.978}$ for male individuals.

Faunistic characteristics

Average number of shark species varied between 1 sp (year 2009) and 3 spp (2010 and 2011), and was tended to decrease by year (Figure 4a); 5-6 spp in 2010-2011 to 1-4 spp in 2014-2015. Similar to the biomass distribution, average abundance ranged from 18 ind/km^2 (2014) to 1157 ind/km^2 (2011), was overall above 800 ind/km^2 in 2010-2011, and was below 50 ind/km^2 in 2014-2105 (Figure 4a). Margalef's species richness varied between 0.567 and 0.747 in 2009-2011 and increased to 1.049 owing to Pielou's evenness (0.692) having higher values in 2014-2015 than that (0.449) in 2009-2011 (Figure 4a). Therefore, the Shannon-Wiener diversity index demonstrated an increasing trend from 0.133-0.723 in 2009-2011 to 0.959 in 2014-2015, but decreased on average (Figure 4a).

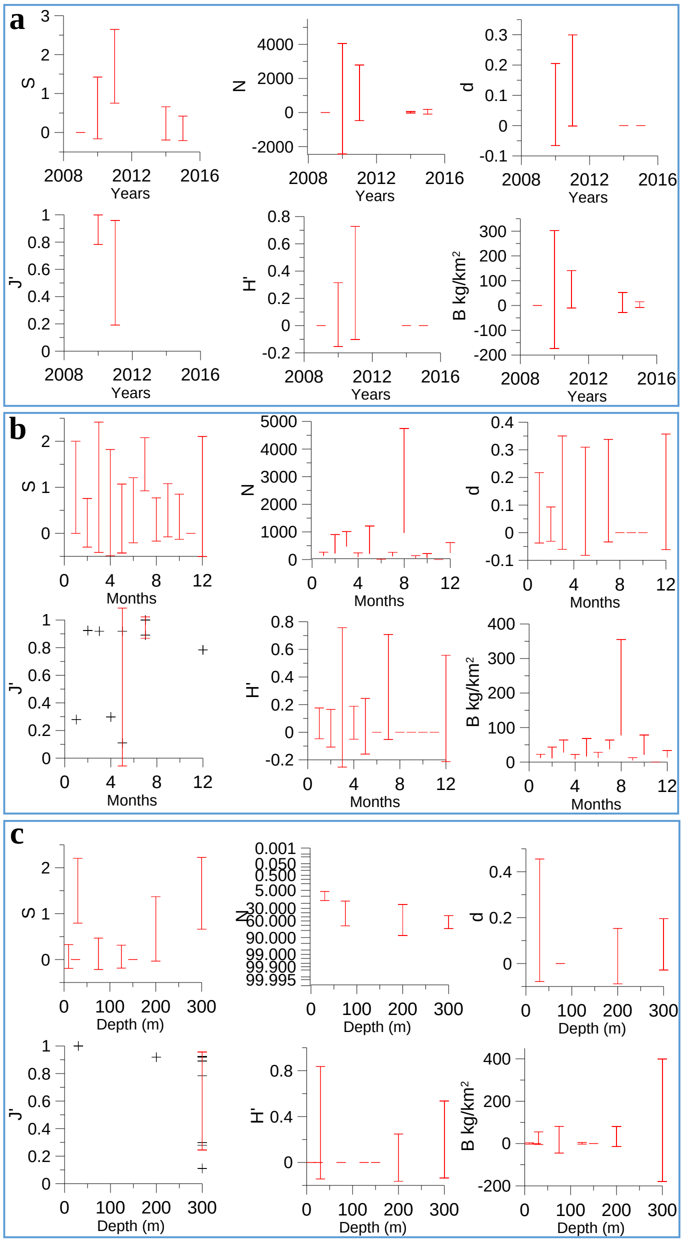

Figure 4. Average and standard deviation of faunistic traits (*S*; number of species, *N*; abundance ind/km^2, *d*; Margalef's species richness index, *J'*; Pielou's evenness index, *H'*; Shannon-Weiner diversity index and *B*; biomass kg/km^2) of the sharks among the years (a), months (b) and bottom depths (c).

By month, average number of the species varied between 1 sp (August-October) and 3 spp (March, May and December), but between 1 sp (June) and 5 spp (July) on non-average, and between 2 and 3 spp in the rest of months (Figure 4b). Monthly average abundance ranged from 5 ind/km^2 in June to 964 ind/km^2 in August, followed by 470 ind/km^2 in March and 235 ind/km^2 in December and May in similar to the biomass distribution (Figure 4b). The richest month in species was July (d = 0.837), followed by October (0.481) contrasted to the evenness indices; the highest value in February-March (J'=0.985-0.775) and December (0.687), and the lowest values, $J' <$ 0.200 in August, May and January. The diversity index was at minima in November and June and at maxima March and July (H' = 0.85) (Figure 4b).

Number of the species decreased by seafloor depth from 10 m to 125 m and was then tended to increase by the greater depth (Figure 4c). Average abundance increased from the shallower waters (3-10 ind/km^2) to the deeper waters (235 ind/km^2 at 200 m and 1643 ind/km^2 at 300 m). However, the intermediate depth (125-150 m) was almost devoid of the sharks (Figure 4c). The species richness decreased by depth whereas the evenness indices were not clear owing to insufficient data. The diversity indices (0.635-0.289) were fluctuated in similar number of species by the bottom depth (Figure 4c).

Community assemblage and ecology

The CCA was resulted in that the fish assemblages were organized primarily depending on the bottom depths (Figure 5a, Table 2). The fish communities were discriminated on CCA1 axis with an explained variance of 14.6% and 20.6% of the total variance in the species data and species-environment relation, respectively (Table 2). This discrepancy was significantly approved by the Monte Carlo test (F = 4.446 and p = 0.002) at $p < 0.05$. An intermediate seafloor depth of 125 m was determined to classify the fish assemblages; the shallow and the deep water (Figure 5a). The sharks did not approach the shallower water, and occurred at 75-125 m (*C. plumbeus* and *S. squatina*) and the greater depth (*S. canicula*) (Figure 5). Furthermore, the shark species were negatively correlated with Secchi disk depth and water salinity, and positively with near-bottom chl-*a* and seston, mostly bioseston on CCA1 axis (Figure 5a, Table 2). However, seasonal discrimination did not occur (Figure 5b). The CCA2 axis was explained with a cumulative variance of 25.9% of the total for the species data, and 35.9% for the species-environment relation. The fish assemblage was negatively correlated with water salinity and density and positively with the finest bioseston (Figure 5a, Table 2). The relationship was significantly proofed by the Monte Carlo test (F = 2.038 and p = 0.004).

Table 2. Summary of statistical measures of the characteristics of Elasmobranches' species abundance and environmental variables for the CCA. Environmental parameters with the abbreviations used in statistical analyses (Prefixes for the abbreviations: SS, sea surface, Su; Sub-surface and NB; Near-bottom water).

Variables abbreviated	Variables	Axis1	Axis2
Depth	Bottom depth (m)	**-0.8652**	-0.1940
SSOx	Oxygen (mg/l)	0.2134	-0.1828
SuSOx	Oxygen (mg/l)	0.0350	-0.1754
NBOx	Oxygen (mg/l)	0.0329	-0.2579
SST	Temperature (°C)	-0.0875	0.1218
SuST	Temperature (°C)	-0.0640	0.1227
NBT	Temperature (°C)	-0.0515	0.1363
SSS	Salinity (PSU)	**-0.3244**	-0.2308
SuSS	Salinity (PSU)	**-0.3235**	**-0.3286**
NBS	Salinity (PSU)	0.1300	-0.0914
SSpH	pH	-0.0473	-0.1970
SuSpH	pH	-0.0410	-0.0394
NBpH	pH	-0.0617	-0.2281
SSD	Density, σ_t	-0.1977	**-0.3128**
SuSD	Density, σ_t	-0.2020	**-0.3317**
NBD	Density, σ_t	-0.1316	-0.2627
STSM	Total Suspended Matter (g/m^3)	0.0758	-0.1171
SuTSM	Total Suspended Matter (g/m^3)	-0.1176	0.0167
NBTSM	Total Suspended Matter (g/m^3)	-0.0172	-0.0007
SSChl	Chl-*a* (mg/l)	-0.0261	0.1853
SuSChl	Chl-*a* (mg/l)	0.0132	0.1603
NBChl	Chl-*a* (mg/l)	**0.5936**	0.2689
Sechi	Secchi disk depth (m)	**-0.4964**	0.0363
Se1	Seston - 1 mm (g/m^3)	0.2112	0.2176
Se2	Seston – 0.5 mm (g/m^3)	**0.3446**	0.2755
Se3	Seston – 0.063 mm (g/m^3)	**0.4057**	0.1799
Bi1	Bioseston - 1 mm (g/m^3)	**0.3079**	0.1326
Bi2	Bioseston – 0.5 mm (g/m^3)	**0.3736**	0.2143
Bi3	Bioseston – 0.063 mm (g/m^3)	**0.5605**	**0.3784**
Tr1	Tripton – 1 mm (g/m^3)	0.1720	0.0432
Tr2	Tripton – 0.5 mm (g/m^3)	0.2241	0.1881
Tr3	Tripton – 0.063 mm (g/m^3)	**0.3421**	0.1218
BT	Bottom types	0.2398	-0.0926
Eigenvalues		0.749	0.579
Species-environment correlations		0.957	0.901
Cumulative percentage variance of species data		14.6	25.9
of species-environment relation		20.2	35.9

Megabenthic fauna could be a group of the presumed food of the Elasmobranches. The species data, and the species-megafauna relation was explained by a variance of 8.8%, and 28.2% on the CCA1 (Figure 5, Appendix 1). This explanation was not however significantly discriminated by the Monte Carlo test ($F = 4.057$, $p = 0.2720$). *S. canicula* and *C. plumbeus* were correlated with Holoturidea (significantly Spearman-correlated with *Parastichopus regalis;* species in red denotes negative correlation), Cephalopoda (*Illex coindetti, Loligo vulgaris, Rossia macrosoma, Sepietta neglecta* and *Sepietta oweniana,* and *Sepia officinalis*), and Decapoda *(Aegaeon lacazei, Chlorotocus crassicornis, Pagurus alatus, Parapenaeus longirostris, Plesionika edwardsii, Plesionika heterocarpus, Charybdis longicollis* and *Medorippe lanata*) on the CCA1 axis. *Scyliorhinus oculata* was correlated with Gastropoda (*Hexaplex trunculus* and *Hypselodoris infucata*) and Bivalvia (*Pincatada radiata*) on the CCA1 axis (Fig. 5c and Appendix 1). On the CCA2, *S. squatina* was slightly correlated with Ophiuridea (*Ophiopsila aranea*) and Sipunculida (*Onchnesoma steenstrupii steenstrupii*) (Figure 5c, Appendix 1).

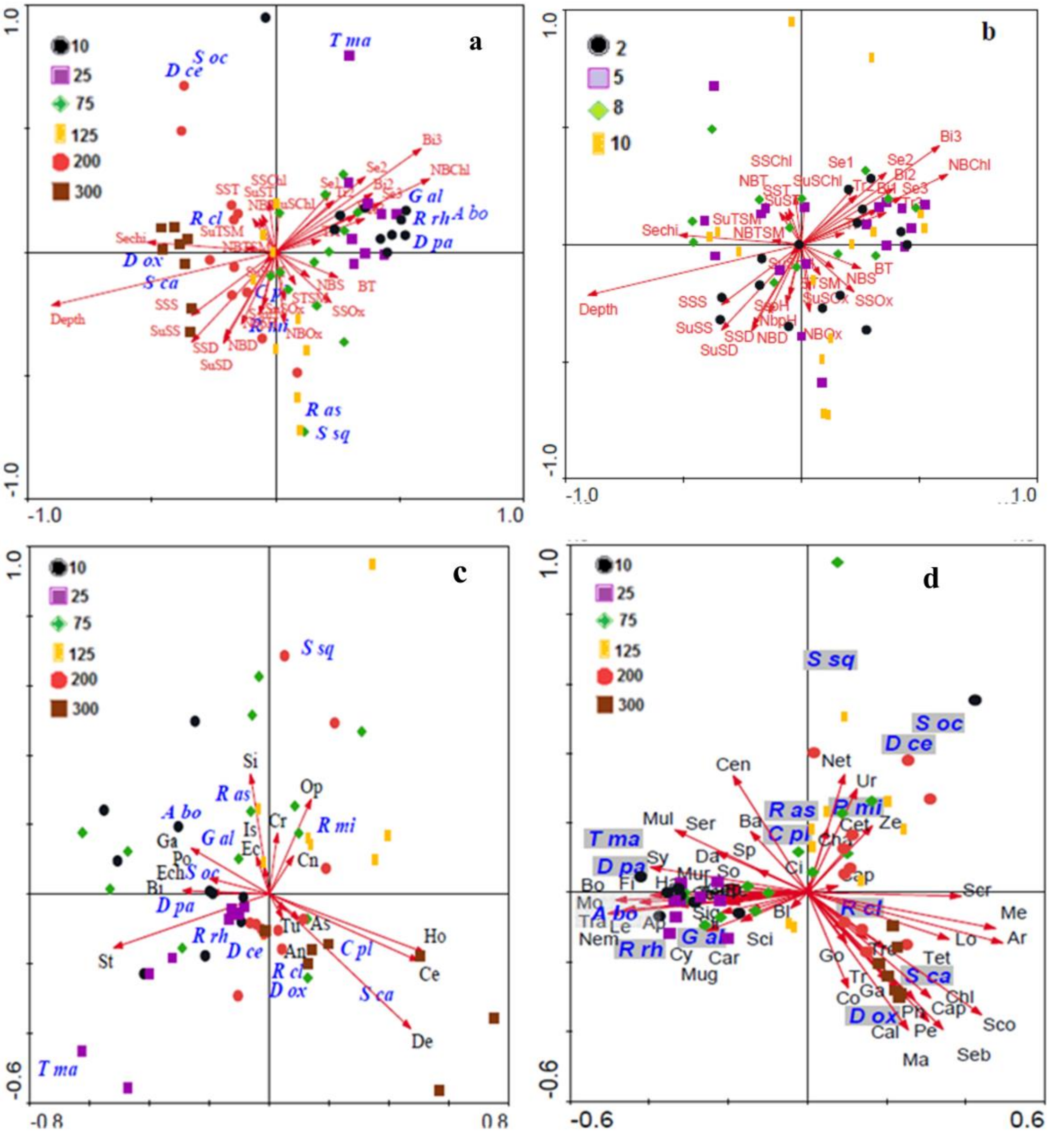

Figure 5. Triplot of Canonical Correspondence Analyses (CCA) of Elasmobranches' log10-transformed abundance (see Tables 1, 2 for the abbreviation) at the sampling stations classified by the bottom depth (a) and the months (b; 2; February, 5; May, 8; August, and 10; October) with the environmental parameters (arrow), Elasmobranches-megabenthic fauna relation (arrow; see Appendix 1 for abbreviations of the megabenthic taxa) (c), and Elasmobranches-osseous fish relation (arrow; see Appendix 2 for abbreviations of osseous fish family) (d).

The Elasmobranches-osseous fish (classified at the family level) relation was explained with a variance of 18.6% on the CCA1 (Figure 5d, Appendix 2), and significantly proofed by the Monte Carlo test ($F = 2.181$, $p = 0.006$). *S. canicula* was significantly correlated with many families: Argentinidae (*Argentina sphyraena* and *Glossanodon leioglossus*), Chlorophthalmidae (*Chlorophthalmus agassizi*), Lophiidae (*Lophius budegassa*), Macrouridae (*Coelorinchus caelorhincus* and *Hymenocephalus italicus*), Merlucciidae (*Merluccius merluccius*), Scophthalmidae (*Lepidorhombus whiffiagonis*), Scorpaenidae (*Scorpaena elongata, Scorpaena porcus, Scorpaena scrofa* and *Scorpaena notata*) and Sebastidae (*Helicolenus dactylopterus*). On the CCA2, *C. plumbeus* was positively correlated with Centracanthidae (*Centracanthus cirrus*), and *S. squatina* and *S. oculata* with Nettastomatidae (*Nettastoma melanurum*) and Uranoscopidae (*Uranoscopus scaber*).

The depth was the most important factor to assemble the Elasmobranches' fish species (Table 3). Monte Carlo test used in PERMANOVA showed that year and depth and their interaction differentiated the Elasmobranches significantly at $p < 0.05$ (Table 3). However, there was no significantly difference in the Elasmobranches among the moth, hence water temperature.

Discussions

The Adriatic Sea and the Gulf of Antalya are the poorest areas in Elasmobranches' species diversity which decreased from the westernmost to easternmost of the Mediterranean Sea (Coll et al., 2010). Therefore, species of the Elasmobranches are endangered and under threatened list in the world (Dulvy et al., 2014; Mancusi et al., 2020). Furthermore, the anthropogenic sources including fishing effort affected the Elasmobranches (Garofalo et al., 2003). Species richness of the sharks decreased from 9 species in 2009-2015 to 5 species in 2019-2020; 1 shark (*M. mustelus*) on the middle shelf, 1 shark (*S. canicula*) on the shelf edge, and 4 sharks (*S. canicula*, *G. meastomus*, *E. spinax* and *S. blainville*) on the shelf break (unpublished data, M. Cengiz Deval) in the present study area. This trend was observed in the Mediterranean Sea (Ramírez-Amaro et al., 2020; Damalas and Vassilopoulou, 2011; Abella and Serena, 2005; Marongiu et al., 2020).

Some of the shark species occurred abundantly in the warm months (May-August), and some in the cold months (February – March) (Tables 1, 4). On the shelf the sharks found at depths greater than 50 m constituted very low biomass (< 2.5 kg/km^2; < 3% of the total biomass) (Yağlıoğlu et al., 2015).

One of the major factors to stress the abundance of the Elasmobranches is the fishery by the bottom trawling (Tiralongo et al., 2018). The Antalya Gulf was fished by the 16 trawl boats annually visiting the present study area during a fishing season (Mutlu et al., 2022): A specific fishing effort of 2.6 h/d/boat (a total of 9310 h) was performed during the fishing period. The number of species and species richness seemed to be unaffected with the fishing effort. However, Spearman correlation analysis showed that there was no significant correlation between the faunistic characters and the fishing effort at $P < 0.05$. Excluding the evenness, the faunistic characters were slightly lower during the non-fishing period than the fishing period (Mutlu et al., 2022).

Table 3. Results of 3-way Permutated-MANOVA test of log$_{10}$-transformed abundances of the Elasmobranches for the differences among years (model; fixed), months (random) and bottom depths (fixed) and Monte Carlo test (*p*MC).

Source	***df***	***SS***	***MS***	***F***	***p***	***p*MC**
Year	4	14606	3651.5	2.562	0.184	**0.004**
Month	11	21530	1957.3	0.628	0.975	1
Depth	9	1.01×10^5	11246	5.328	**0.001**	**0.001**
Year x Month	3	4100.8	1366.9	0.438	0.963	0.998
Year x Depth	5	6372.6	1274.5	5.445	0.125	**0.002**
Month x Depth	21	41575	1979.8	0.635	0.995	0.999
Year x Month x Depth	1	242.67	242.67	7.78×10^{-2}	0.998	1
Residuals	56	1.74×10^5	3115.7			
Total	118	4.56×10^5				

Spatiotemporal distribution

Scyliorhinus canicula had the highest abundances in winter and summer in the eastern, in summer in the central, and in autumn in the western parts of the Mediterranean Sea (Table 4). Overall, the female specimens were dominant in the population in the western Mediterranean Sea. This dominance was tended to decrease from the west through the centre to the east in the entire Mediterranean Sea excluding F:M=1.93 estimated in an eutrophic area, Iskenderun Bay (Yemişken et al., 2019a) (Table 4). The total length was generally shorter in the present study than the other studies conducted in the different basins of the Mediterranean seas (Table 4). Ramírez-Amaro et al. (2020) estimated that minimum number of length cohort was 5+ and the females were longer than the males. *Scyliorhinus canicula* showed negative allometric and isometric growth (Table 4).

Galeus meastomus had the highest density in spring-autumn (Table 4) contrasted to the present study. Total length was smaller in the cold seas relatively than the warm seas of the Mediterranean Sea (Table 4). Female specimens outnumbered the males in the eastern Mediterranean Sea whereas the ratio was statistically 1:1 in the western Mediterranean Sea (Table 4). However, the males outnumbered females in the Algerian waters. *G. melastomus* produced a cohort number of 8+ (Table 4). *G. melastomus* grew isometrically in the northern waters but positive-allometrically in the southern waters of the Mediterranean basin (Table 4).

Etmopterus spinax was found abundantly in the warm seasons in the different locations of the Mediterranean Sea (Table 4). Sex ratio was not different from ratio 1:1 (Table 4). Total length increased by the sea floor depth (Table 4). Number of length cohorts was overall more than 7 in the Mediterranean Sea (Table 4). The species had generally isometric growth and the *b* value was higher than that estimated in the present study (Tables 1, 4).

Squalus blainville occurred frequently in autumn, followed spring-summer in the central Mediterranean Sea (Ragonese et al., 2013), similar to that observed in May during the present study (Tables 1, 4). *S. blainvillei* was abundantly found two times higher in September-October (females comprising of 47.5% of the catches) than in April (females 54.5% of the catches) in the slope of the Ionian Sea (Sion et al., 2003) owing to both the density/depth and biomass/depth relation (Marongiu et al., 2017). On comparison, sex ratio, and total length of the species varied among the different regions of the Mediterranean seas (Table 4). Annual mean total length and number of cohorts were longer and higher in the northern than that in the central and the southern Aegean Sea, respectively (Kousteni et al., 2017). *S. blainvillei* had a cohort of 7+ in the slope of Ionian Sea (Sion et al., 2003). *S. blainvillei* had an isometric growth or positive allometry in the Mediterranean Sea but negative allometry in the Sea of Marmara (Table 4).

Faunistic characters

The species richness and abundances have decreased in the different seas of the Mediterranean Sea due to the fishing pressure, and anthropogenic and ecological impacts (Jukic-Peladic et al., 2001; Barausse et al., 2014). Therefore, the indices were affected during the first 5 years of a period 2005-2015, followed by stability during the last five years (Ramírez-Amaro et al., 2020). The fishery has moved globally from the shelf to the slopes (Cau, 2008), followed by that the Elasmobranches were highly affected in the deeper water as compared with that in the shallower waters (Marongiu et al., 2017). A long-term series analysis (1965-2009) showed that the species density (abundance and biomass) and richness were tended to decrease in time due to abrupt increase occurred in fishing effort derving seasonal biological cycle of nektobenthic elasmobranches off Balearic Islands (Guijarro et al., 2012). The *H’* values for the sharks were high throughout the year, but were the minimum in summer, and the *d* was the highest in spring, and the *J’* increased from summer to winter in the Syrian coasts (Alkusairy and Saad, 2018). However, Filiz et al. (2018) showed that number of species, abundance and biomass of the cartilaginous fish decreased by the bottom depths in a Turkish shelf of the central Aegean Sea as contrasted to that of the present study area. Unimodal species of the shallower waters peaked in abundance at 75-100 m while unimodal species of the deeper waters peaked at 300 m (Table 1). Adult *S. canicula* produced bimodal abundance along the depth gradients as follows: its abundance was more pronounced at zone of 30-150 m than zone of 300-400 m, but its juveniles showed a unimodal distribution peaked at the greater depths (150 - 300 m) in the Cantabrian Sea, Atlantic Ocean (Olaso et al., 2005). However, *S. canicula* was distributed in a response with a unimodal distribution peaked at 300 m to the bottom depth in Balearic Islands and Algerian waters (Ordines et al.,

2011) as observed similarly in the present study. Adults of *G. melastomus* were bimodally distributed across the seafloor depth (primary mode at 300-500 m, and secondary mode at 500-600 m), but its juveniles occurred relatively in the shallower water (Olaso et al., 2005). *E. spinax* was responded unimodally to the bottom depth but the modal depth was shallower in Algerian water than the Balearic waters (Ordines et al., 2011).

Faunal assemblages and ecology

Depending on the species-environment relation, there was a contrary between sea surface temperature and biomass of sharks in the northern Mediterranean Sea (Follesa et al., 2019). The depth, seafloor morphology and temperature were the main factors for distribution of the elasmobranches in the central Mediterranean Sea (Lauria et al., 2015). Ordines et al. (2011) clustered two bathymetric assemblages of 29 Elasmobranches' species in the Balearic and Algerian waters, and those were the assemblages found on continental shelf (45-180 m and 45-225 m, respectively), and shelf-break (180-270 m and 225-330 m, respectively) as we estimated similarly (10-75 m, 125 m, and 200-300 m).

Marongiu et al. (2017) assembled the sharks, regardless of small-scaled zonal distribution as follows: neritic, and oceanic stratum in the central Mediterranean Sea. Bertrand et al. (2000) confirmed similar distribution for the other regions of the Mediterranean Sea. *S. canicula* co-existed with the fish assemblage occurred at a deep water of > 125 m and its abundnace increased from fresh through brackish to marine waters considering changes in water salinity (Quigley, 2019). Gouraguine et al. (2011) clustered four depthwise groups of assemblages composed of 27 chondrichthyan species off Balearic Islands and a zone of 55-185 was characterized with *S. canicula* and other cartilaginous fish constituted 50% of the total abundance, but a zone of 190-290 m only by *S. canicula* alone. *S. squatina* preferred the dense and saline waters as contrasted by *S. oculata* (Gouraguine et al., 2011).

Besides the bathymetrical assemblages, the sharks were ecologically affected by the global atmospheric-ocean relation which could change the assemblage. The biomass of *S. canicula* was tended to increase by the fisheries shifted from the shelf to the slope (Ligas et al., 2010). *G. melastomus* was impacted by the North Atlantic Oscillation (NAO) index in Tuscany Bay (Ligas et al., 2010). Furthermore, abundance of *E. spinax* decreased with the O_2 owing to increased temperature and salinity in Levantine Intermediate Water influenced by the NAO during 1970s and 1980s in the slope of the western Mediterranean Sea. However, this dynamic had a lesser effect to *G. melastomus* (Cartes et al., 2013).

Taking the assemblages into the shark species-megabenthic fauna relation, Mulas et al. (2019) assembled significantly distribution of *S. canicula* with Decapoda (Anomura), Euphausiacea and Mollusca (Cephalopoda). As a indication of shark species-megabenthic fauna relation, *S. canicula* fed primarily on crustaceans and teleost fish, and secondarily on cephalopods, annelids and isopods (Valls et al., 2011). Preference of *S. canicula* to megabenthic fauna as its food varied between regions of the Mediterranean Sea (Gravino et al., 2010); Bengil et al., 2018); Kousteni et al., 2018). In the Adriatic Sea, *S. canicula,* a teuthivorous fish, ingested large quantities of cephalopods (Šantić et al., 2012). *S. canicula* fed particularly on natantian and reptantian crustaceans together with teleosts (Valls et al., 2011); Šantić et al., 2012).

Regarding to shark species-osseous fish relation, *S. canicula* fed mainly on the teleosts composed abundantly of *Gadiculus argenteus* and *Argentina sphyraena* in the eastern Aegean Sea (Bengil et al., 2018), and on *Trachurus trachurus* and *Macroramphosus scolopax* off Malta (Gravino et al., 2010). In Iskenderun Bay, *S. canicula* fed on teleost and crustaceans (Özcan and Başusta, 2015). However, *S. canicula* fed mainly more on decapods (76.6%) than teleost (15.3%) in the central Adriatic Sea (Šantić et al., 2012), but fed mainly on teleost in the northern Aegean Sea (Kabasakal, 2001).

Table 4. Biometrical traits (L; total length in cm; C#: number of length cohort, F:M; female:male ratio, b; slope of the length-weight relationship or growth type: N, negative, I; isometric and P; positive allometry, and M; month or season when the abundance was at maxima) of the shark species obtained from the different regions of the Mediterranean Sea to compare with the results of the present study in Table 1 (red number; regions or locations in the Mediterranean Sea, and blue number; citation number at footnote below this table). * rare species and occasional visitor.

Species	L	C#	F:M	b	M
E. spinax	14.5-24.8 5, 40		1:1 4,5; 5,40	3.03 M-3.08 5, 40	Mar-Jul 3,4
	15-35 3,4; 6,10, 43			2.97-2.84 M 3,4	Spr-Aut 21, 42
G. meastomus	27 -63 M; 32-70 F 20, 3	6-8+ 19, 41	53.9:46.1 20, 3	I 13, 49	Spr-Sum 20, 3
	17.5-27.2 F; 12.6-31.2 M 13, 49		1.73 13, 49	P 11, 39	Spr-Aut 12, 42; 14, 12
	25-56 M 2, 14		1.04 14, 12		
	19.2 11, 39		0.54 2, 14		
	85 22,1				
S. canicula	10-71 M; 10-70 F 9, 26	5+ 6, 43	1.41 9, 26	I 13, 38; 18; 25; 16, 29, 39	Feb, Aug 11, 22
	18-47 16, 29		1.12 16, 29	N 13, 47; 18; 25; 16, 29, 39	Jun 7, 13
	12-51 10, 37		0.97-1.15 21, 9, 36; 1, 31		Aut 12, 41
	28-52.5 15 21, 9, 36; 1, 31		0.96 10, 37		Jun 10, 37
	14-87 F; 14-47 M 6, 43		1.93 10, 49		Aut 21, 9
	50 22, 1				Spr-Sum 5, 8, 36
	48 1, 16; 16, 29				
S. blainville	29-82 F, 28-78 M 20, 3	10.8±4.1,2.86±4.5,	47.5:52.5 8, 46	3.07 (I) F, 3.09 (I)M 17, 7	Aut 21, 42
	42.1-75.0 10, 48	9.18±1.55 1, 32	42.7:57.3 20, 3	3.23 (P)F, 3.20 (P)M 15, 33	Sum 20, 3
	28 18, 39	7+ 8, 46	1:0.73 18, 39	2.47 16, 6	Sep-Oct 8, 46
	27.2–75.9, 18.0–56.5, 35.5–44.0 1, 32		1.5, 1.41, 1.22 1, 32	N, I 13, 38, 47	
	20.1-84 F, 18-61.5 M 15, 33		52:48 15, 33	P 1, 16; 10, 37	
	18.2-77.9 F, 18.0-179.9 M 7, 30		1.26 7, 30	3.25 F, 3.16 M 8, 46; 7, 30	
	23.2-83.4M, 24.7-100 F 21, 34		1.15 21, 34	3.10 F, 3.08 M 21, 30	
	38-56 16, 6				
*C. plumbeus**	46-250 M, 45-300 F 20, 3		66.8:43.2 20, 3		Warm 21, 44; 18, 17
					Aut 2, 23; 20, 3
M. mustelus			1:1 18, 19, 21,47	3.33 18, 19, 21,47; 10, 37; 21, 45	Aut 21, 42
*O. centrina**	22.5-65 Turkish Seas, 27				
*S. oculata**					
S. squatina				N 4, 28	Aut 21, 42

Locations: 1: Aegean Sea, 2: Algerian waters, 3. Azores, 4: Central Mediterranean Sea, 5: French waters, 6: Gibraltar Straits, 7: Greek Aegean Sea, 8: Ionian Sea, 9: Irish and Celtic Seas, 10: Iskenderun bay, 11. Izmir bay, 12: Malta, 13: Northern Aegean, 14: Portugal waters, 15: Sardinia Island, 16: Sea of Marmara, 17: Sicilian channel, 18: southern Turkish Aegean Sea, 19: Strait of Sicily, 20: Syrian waters, and 21: Tunisia-Malta-Sicily.

Citations: 1: Abella and Serean (2005); 2: Akyol et al. (2015); 3: Alkusairy and Saad (2018); 4: Aranha et al. (2009); 5: Bilge et al. (2010); 6: Bök et al. (2011); 7: Cannizzaro et al. (1995); 8: Capape et al. (2008); 9: Capape et al. (2014); 10: Coelho and Erzini (2010); 11: Corsini and Zava (2007); 12: Costa et al. (2005); 13: D'Onghia et al. (1995); 14: Darna et al. (2018); 15: Ergüden et al. (2019); 16: Evagelopoulos et al. (2017); 17: Filiz (2019); 18: Filiz and Bilge (2004); 19: Filiz and Mater (2002); 20: Fortibuoni et al. (2016); 21: Gönülal (2017); 22: Gurbet et al. (2013); 23: Hemida et al. (2002); 24: Holcer and Lazar (2017); 25: Işmen et al. (2009); 26: Ivory et al. (2004); 27: Kabasakal (2010); 28: Kara et al. (2018); 29: Koç and Erdoğan (2018); 30: Kousteni and Megalofonou (2011); 31: Kousteni et al. (2010); 32: Kousteni et al. (2017); 33: Marongiu et al. (2020); 34: Marouani et al. (2012); 35: Megalofonou and Damalas (2004); 36: Mnasri et al. (2012); 37: Özcan and Başusta (2018a, b); 38: Öztekin et al. (2016); 39: Özütemiz et al. (2009); 40: Porcu et al. (2013); 41: Ragonese et al. (2009); 42: Ragonese et al. (2013); 43: Ramírez-Amaro et al. (2020); 44: Saidi et al. (2005); 45: Saidi et al. (2008); 46: Sion et al. (2003); 47: Turker et al. (2018); 48: Yemişken et al. (2019a); 49: Yemişken et al. (2019b); 50: Yığın et al. (2016); 51: Yığın et al. (2019); 52: Zava et al. (2016).

Acknowledgments

We commemorated Prof. Dr. Ferit Bingel, who passed away in 2021, and introduced the fishery science to Turkey. The present study was funded by the Scientific Research Coordination Unit of Akdeniz University, within framework of three projects, Project no: 2010.02.0121.026 and 2011.02.0121.022 principally coordinated by M. Cengiz Deval, and 2014.01.0111.001, principally coordinated by Erhan Mutlu. This study was a part of Ilaria de Meo's MSc thesis and Claudia Miglietta's MSc thesis covering only period of years 2014-2015. We thank Gokce Ozgen, Ahmet Şahin, M. Tunca Olguner and Cansu Olguner, and crew of "R/V Akdeniz Su" for their helps on board. We thank two anonymous reviewers for their constructive comments.

Conflicts of Interest

No potential conflict of interest was reported by the authors.

Ethical Approval

The authors declare that all applicable guidelines for sampling, care and experimental use of animals in the study have been followed in compliance with ethical standards approved by the Akdeniz University.

Funding

The present study was funded by the Scientific Research Coordination Unit of Akdeniz University, within framework of three projects, Project no: 2010.02.0121.026 and 2011.02.0121.022, and 2014.01.0111.001.

References

Abella, A. J., & Serena, F. (2005). Comparison of Elasmobranch catches from research trawl surveys and commercial landings at Port of Viareggio, Italy, in the last decade. *Journal of Northwest Atlantic Fishery Science,* 35, 345–356. https://doi.org/10.2960/J.v35.m526.

Akyol, O., Ünal, V., & Capapé, C. (2015). Occurrence and Biological Observations on Angel Shark *Squatina squatina* (Chondrichthyes: Squatinidae) from the Turkish Waters (Eastern Mediterranean). *Turkish Journal of Fisheries and Aquatic Science,* 15, 925-929. https://doi.org/10.4194/1303-2712-v15_4_17

Alkusairy H., & Saad A. (2018). Species composition, diversity and length frequency of by-catch sharks from the Syrian Coast. *International Journal of Research Studies in Zoology*, 48(1), 11-21. doi:10.20431/2454-941X.0401003.

Aranha, A., Menezes, G., & Pinho, M. R. (2009). Biological aspects of the velvet belly lantern shark, *Etmopterus spinax* (Linnaeus, 1758) off the Azores, North East Atlantic. *Marine Biology Research*, 5(3), 257-267. https://doi.org/10.1080/17451000802433175

Barausse, A., Correale, V., Curkovic, A., Finotto, L., Riginella, E., Visentin, E., & Mazzoldi, C. (2014). The role of fisheries and the environment in driving the decline of elasmobranchs in the northern Adriatic Sea. *ICES Journal of Marine Science,* 71(7), 1593–1603. https://doi.org/10.1093/icesjms/fst222.

Barría, C., Coll, M., & Navarro, J. (2015). Unravelling the ecological role and trophic relationships of uncommon and threatened elasmobranchs in the western Mediterranean Sea. *Marine Ecology Progress Series,* 539, 225-240. https://doi.org/10.3354/meps11494.

Bengil, F., Bengil, E. G. T., Mavruk, S., Hera, O., Karaman, O. D., & Ozaydin, O. (2018). Feeding Ecology of Four Demersal Shark Species (*Etmopterus spinax, Galeus melastomus, Scyliorhinus canicula* and *Squalus blainville*) from the Eastern Aegean Sea. *Turkish Journal of Fisheries and Aquatic Science,* 19(6), 475-484. doi:10.4194/1303-2712-v19_6_03.

Bertrand, J., Sola, G.de., Papaconstantinou, L., Relini, C., & Souplet, G. A. (2000). Contribution on the distribution of elasmobranchs in the Mediterranean (from the MEDITS surveys). *Biologia Marina Mediterranea*, 7(1), 385–399.

Bilge, G., Filiz, H., & Tarkan, A. N. (2010). Length-weight relationship of velvet belly lantern shark *Etmopterus spinax* (Linnaeus, 1758) in Sıgacık Bay (Aegean Sea). *Journal of Fisheries and Aquatic Sciences,* 25(1), 1-8. (in Turkish).

Bök, D.T., Göktürk, D., Kahraman, A.E., Alılçı, T.Z., Acun, T., & Ateş, C. (2011). Length-weight relationships of 34 fish species from the Sea of Marmara, Turkey. *Journal of Animal and Veterinary Advances,* 10(23), 3037-3042.

Cannizzaro, L., Rizzo, P., Levi, D., & Gancitano, S. (1995). Age determination and growth of *Squalus blainvillei* (Risso, 1826). *Fisheries Research,* 23, 113-125. https://doi.org/10.1016/0165-7836(94)00333-R.

Capapé, C., Reynaud, C., Vergne, Y., & Quignard, J.-P. (2008). Biological observations on the smallspotted catshark *Scyliorhinus canicula* (Chondrichthyes: Scyliorhinidae) off the Languedocian coast (southern France, northern Mediterranean). *Pan-American Journal of Aquatic Sciences,* 3(3), 282-289.

Capapé, C., Mnasri-Sioudi, N., Kamel-Moutalibi, O. E., Boumaïza. M., Ben Amor. M. M., & Reynaud, C. (2014). Production, Maturity, Reproductive Cycle and Fecundity of Small_Spotted Catshark, *Scyliorhinus canicula* (Chondrichthyes: Scyliorhinidae) from the Northern Coast of Tunisia (Central Mediterranean). *Journal of Ichthyology,* 54(1), 111–126. https://doi.org/10.1134/S0032945214010020.

Cartes, J. E., Fanelli, E., Lloris, D., & Matallanas, J. (2013). Effect of environmental variations on sharks and other top predators in the deep Mediterranean Sea over the last 60 years. *Climate Research,* 55, 239–251. https://doi.org/10.3354/cr01137.

Cau, A. (2008). Relazione finale: Valutazione Risorse Demersali –Gruppo Nazionali Demersali –G.R.U.N.D. –GSA 11 – Mari circostanti la Sardegna. Ministero delle Politiche Agricole Alimentari e Forestali.

Coelho, R., & Erzini, K. (2010). Depth distribution of the velvet belly, *Etmopterus spinax*, in relation to growth and reproductive cycle: The case study of a deep-water lantern shark with a wide-ranging critical habitat. *Marine Biology Research,* 6(4), 381-389. https://doi.org/10.1080/17451000802644706.

Coll, M., Piroddi, C., Steenbeek, J., Kaschner, K., Lasram, L. B. R., Aguzzi, J., Ballesteros, E., Bianchi, C. N., Corbera, J., Dailianis, T., Danovaro, R., Estrada, E., Froglia, C., Galil, B., Gasol, J. M., Gertwagen, R., Gil, J., Guilhaumon, F., Kesner-Reyes, K., Kitsos, M. S., Koukouras, A., Lampadariou, N., Laxamana, E., Lopez-Fe, C. M., De la C., Lotze, H. K., Martin, D., Mouillot, D., Oro, D., Raicevich, S., Rius-Barile, J., Saiz-Salinas, J.I., Vicente, C.S., Somot, S., Templado, J., Turon, X., Vafidis, D., Villanueva, R., & Voultsiadou, E. (2010). The Biodiversity of the Mediterranean Sea: Estimates, Patterns, and Threats. *PLoSONE,* 5(8), e11842. https://doi.org/10.1371/journal.pone.0011842.

Corsini, M., & Zava B. (2007). Recent capture of *Squatina oculata* and *Squatina aculeata* from Sodecanese Islands (SE Aegean Sea, eastern Mediterranean). *Biologia Marina Mediterranea,* 14(2), 352-353.

Costa, M. E., Erzini, K., & Borges, T. C. (2005). Reproductive biology of the blackmouth catshark, *Galeus melastomus* (Chondrichthyes: Scyliorhinidae) off the south coast of Portugal. *Journal of the Marine Biological Association of the United Kingdom,* 85, 1173-1183. https://doi.org/10.1017/S0025315405012270.

D'Onghia, G., Matarrese, A., Tursi, A., & Sio, L. (1995). Observations on the depth distribution pattern of the small-spotted catshark in the North Aegean Sea. *Journal of Fish Biology,* 47, 421–426. https://doi.org/10.1111/j.1095-8649.1995.tb01911.x

Damalas, D., & Vassilopoulou, V. (2011). Chondrichthyan by-catch and discards in the demersal trawl fishery of the central Aegean Sea (Eastern Mediterranean). *Fisheries Research,* 108, 142–152. https://doi.org/10.1016/j.fishres.2010.12.012.

Darna, S. A., Bendiab, A. A. T., Mouffok, S., Belmahi, A.-E., & Bouderbala, M. (2018). Observation on distribution, biology, growth, diet and feeding strategy of blackmouth catshark *Galeus melastomus* (Rafinesque, 1810) (Chondrichthyes Scyliorhinidae) in Western Algerian coast. *Biodiversity Journal,* 9(4), 357–368. https://doi.org/10.31396/Biodiv.Jour.2018.9.4.357.368.

de Meo, I., Miglietta, C., Mutlu, E., Deval, M. C., Balaban, C., & Olguner, M. T. (2018). Ecological distribution of demersal fish species in space and time on the shelf of Antalya Gulf, Turkey. *Marine Biodiversity,* 48, 2105–2118. https://doi.org/10.1007/s12526-017-0739-7.

Dulvy, N. K., Fowler, S. L., Musick, J. A., Cavanagh, R. D., Kyne, P. M., Harrison, L. R., Carlson, J. K., Davidson, L. N. K., Fordham, S. V., Francis, M. P., Pollock, C. M., Simpfendorfer, C. A., Burgess, G. H., Carpenter, K. E., Compagno, L. J. V., Ebert, D. A., Gibson, C., Heupel, M. R., Livingstone, S. R., Sanciangco, J. C., Stevens, J. D., Valenti, S., & White, W. T. (2014). Extinction risk and conservation of the world's sharks and rays. *eLife*, 3, e00590. https://doi.org/10.7554/eLife.00590.

Ergüden, D., Ayas, D., Gürlek, M., Karan, S., & Turan, C. (2019). First documented smoothback angelshark *Squatina oculata* Bonaparte, 1840 from the North-Eastern Mediterranean Sea, Turkey. *Cahiers de Biologie Marine,* 60, 189-194. https://doi.org/10.21411/CBM.A.23607FF9

Evagelopoulos, A., Batjakas, I., & Koutsoubas, D. (2017). Length–weight relationships of 9 commercial fish species from the North Aegean Sea. *Acta Adriatica,* 58(1), 187–192. https://doi.org/10.32582/aa.58.1.15.

Filiz, H. (2019). Year-Round Aggregation of Sandbar Shark, *Carcharhinus plumbeus* (Nardo, 1827), in Boncuk Cove in the southern Aegean Sea, Turkey (Carcharhiniformes: Carcharhinidae). *Zoology in the Middle East,* 65(1), 35-39. https://doi.org/10.1080/09397140.2018.1540148.

Filiz, H., & Bilge, G. (2004). Length–weight relationships of 24 fish species from the North Aegean Sea, Turkey. *Journal of Applied Ichthyology,* 20, 431–432. https://doi.org/10.1111/j.1439-0426.2004.00582.x.

Filiz, H., & Mater, S. (2002). A preliminary study on length-weight relationship for seven elasmobranch species from North Aegean Sea, Turkey. *Ege Journal of Fisheries and Aquatic Sciences,* 19, 401-409.

Filiz, H., Yapıcı, S., & Bilge, G. (2018). Chondrichthyan fishes in catch composition of the bottom trawl fishery on the coast of Didim, Turkey. *Journal of Black Sea/Mediterranean Environment,* 24(1), 28-37.

Follesa, M. C., Marongiu, M. F., Zupa, W., Bellodi, A., Cau, A., Cannas, R., Colloca, F., Djurovic, M., Isajlovic, I., Jadaud, A., Manfredi, C., Mulas, A., Peristeraki P., Porcu C., Ramirez-Amaro S., Jiménez F.S., Serena F., Sion L., Thasitis I., Cau A., & Carbonara P. (2019). Spatial variability of Chondrichthyes in the northern Mediterranean. *Scientia Marina,* 83, 81-100. https://doi.org/10.3989/scimar.04998.23A.

Fortibuoni, T., Borme, D., Franceschini, G., Giovanardi, O., & Raicevich, S. (2016). Common, rare or extirpated? Shifting baselines for common angelshark, *Squatina squatina* (Elasmobranchii: Squatinidae), in the Northern Adriatic Sea (Mediterranean Sea). *Hydrobiologia,* 772, 247–259. https://doi.org/10.1007/s10750-016-2671-4.

Fowler, S.L., Cavanagh, R.D., Camhi, M., Burgess, G.H., Cailliet, G.M., Fordham, S.V., Simpfendorfer, C.A., & Musick, J.A. (2005). *Sharks, Rays and Chimaeras: The Status of the Chondrichthyan Fishes*. Status Survey. IUCN/SSC Shark Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK. x + 461 pp

Galván-Magaña, F., Castillo-Geniz, J. L., Hoyos-Padilla, M., Ketchum, J., Klimley, A. P., Ramírez-Amaro, S., Torres-Rojas, Y. E., & Tovar-Ávila, J. (2019). Shark ecology, the role of the apex predator and current conservation status. *Advances in Marine Biology,* 83, 61–114. https://doi.org/10.1016/bs.amb.2019.08.005.

Garofalo, G., Gristina, M., Fiorentino, F., Fulgosi, F. C., Norrito, G., & Sinacori, G. (2003). Distributional pattern of rays (Pisces, Rajidae) in the Strait of Sicily in relation to fishing pressure. *Hydrobiologia,* 503, 245-250. https://doi.org/10.1023/B:HYDR.0000008487.25578.d4

Garuti A, & Mutlu, E. (2021). Spatiotemporal and ecological distribution of megistobentic non-crustacean invertebrates in an ultra-oligotrophic gulf, the eastern Mediterranean Sea. *Journal of Marine Systems,* 224, 103644. https://doi.org/10.1016/j.jmarsys.2021.

Giovos, I., Arculeo, M., Doumpas, N., Katsada, D., Maximiadi, M., Mitsou, E., Paravas, V., Aga-Spyridopoulou, R. N., Stoilas, V.-O., Tiralongo, F., Tsamadias, I. E., Vecchioni, L., & Moutopoulos, D. K. (2020). Assessing multiple sources of data to detect illegal fishing, trade and mislabelling of elasmobranchs in Greek markets. *Marine Policy,* 112, 103730. https://doi.org/10.1016/j.marpol.2019.103730.

Gönülal, O. (2017). Length-weight relationships of 16 fish species from deep water of northern Aegean Sea (500-900m). *Turkish Journal of Fisheries and Aquatic Science,* 17, 995-1002. https://doi.org/10.4194/1303-2712-v17_5_14

Gouraguine, A., Hidalgo, M., Moranta, J., Bailey, D. M., Ordines, F., Guijarro, B., Valls, M., Barberá, C., & Mesa, A. De. (2011). Elasmobranch spatial segregation in the western Mediterranean. *Scientia Marina,* 75(4), 653-664. https://doi.org/10.3989/scimar.2011.75n4653.

Gravino, F., Dimech, M., & Schembri, P. J. (2010). Feeding habits of the small-spotted catshark *Scyliorhınus canicula* (l., 1758) in the central Mediterranean. CIESM meeting, Rapp. Comm. int. Mer Médit., 39.

Guijarro, B., Quetglas, A., Moranta, J., Ordines, F., Valls, M., González, N., & Massutí, E. (2012). Inter- and intra-annual trends and status indicators of nektobenthic elasmobranchs off the Balearic Islands (northwestern Mediterranean). *Scientia Marina* 76(1), 87-96. https://doi.org/10.3989/scimar.03432.22A.

Gurbet, R., Akyol, O., Yalcın, E., & Ozaydın, O. (2013). Discards in bottom trawl fishery in the Aegean Sea (Izmir Bay, Turkey). *Journal of Applied Ichthyology,* 29, 1269–1274. https://doi.org/10.1111/jai.12243.

Güven, O., Kebapcıoğlu, T., & Deval, M. C. (2012). Length–weight relationships of sharks in Antalya Bay, eastern Mediterranean. *Journal of Applied Ichthyology,* 28, 278–279. https://doi.org/10.1111/j.1439-0426.2011.01823.x.

Hemida, F., Seridji, R, Labidi, N., Bensaci, J., & Capapé, C. (2002). Records of *Carcharhinus* spp. (Chondrichthyes: Carcharhinidae) from off the Algerian coast (southern Mediterranean). *Acta Adriatica,* 43, 83–92.

Holcer, D., & Lazar, B. (2017). New data on the occurrence of the critically endangered common angelshark, *Squatina squatina*, in the Croatian Adriatic Sea. *Natura Croatica,* 26(2), 313-320. https://doi.org/10.20302/NC.2017.26.23

Ismen, A., Yığın, C. C., Altınağaç, U., & Ayaz, A. (2009). Length-weight relationships for ten shark species from Saros Bay (North Aegean Sea). *Journal of Applied Ichthyology,* 25(S1), 109-112. https://doi.org/10.1111/j.1439-0426.2009.01263.x.

Ivory, P., Jeal, F., & Nolan C. P. (2004). Age determination, growth and reproduction in the lesser-spotted dogfish, *Scyliorhinus canicula* (L.). *Journal of Northwest Atlantic Fishery Science,* 35, 89–106. https://doi.org/10.2960/J.v35.m504.

Jukic-Peladic, S., Vrgoc, N., Krstulovic-Sifner, S., Piccinetti, C., Piccinetti-Manfrin, G., Marano, G., & Ungaro, N. (2001). Long-term changes in demersal resources of the Adriatic Sea: comparison between trawl surveys carried out in 1948 and 1998. *Fisheries Research,* 53(1), 95–104. https://doi.org/10.1016/S0165-7836(00)00232-0.

Kabasakal, H. (2001). Preliminary data on the feeding ecology of some selachians from the north-eastern Aegean Sea. *Acta Adriatica,* 42(2), 15-24.

Kabasakal, H. (2010). Historical and contemporary records of the angular rough shark *Oxynotus centrina* (Chondrichthyes); Oxynotidae) in Turkish waters. *Mediterranean Marine Sciences,* 11(2), 361-368. https://doi.org/10.12681/mms.84.

Kabasakal, H. (2021). A review of shark biodiversity in Turkish waters: updated inventory, new arrivals, questionable species and conservation issues. *Annales, Series Historia Naturalis,* 31, 181-194.

Kabasakal, H., Karhan, S. Ü., & Sakınan, S. (2017). Review of the distribution of large sharks in the seas of Turkey (Eastern Mediterranean). *Cahiers de Biologie Marine,* 58, 219-228. https://doi.org/10.21411/CBM.A.96D9F948.

Kara, A., Saglam, C., Acarli, D., & Cengiz, O. (2018). Length-weight relationships for 48 fish species of the Gediz estuary, in Izmir Bay (Central Aegean Sea, Turkey). *Journal of the Marine Biological Association of the United Kingdom,* 98(4), 879-884. https://doi.org/10.1017/S0025315416001879.

Koç, H. T. & Erdoğan, Z. (2018). Length-Weight Relationships, Reproduction, Hepatosomatic Index of The Lesser Spotted Catshark, *Scyliorhinus canicula* [L.] The Sea of Marmara, Turkey. *Journal of Balikesir University Institute of Science and Technology,* 20(2), 98-108. https://doi.org/10.25092/baunfbed.411802.

Kousteni, V., & Megalofonou, P. (2011). Reproductive biology and embryonic development of *Squalus blainvillei* in the eastern Mediterranean Sea. *Scientia Marina,* 75(2), 237-249. https://doi.org/10-3989/scimar.2011.75n2237.

Kousteni, V., Karachle, P. K., & Megalofonou, P. (2017). Diet of the small-spotted catshark *Scyliorhinus canicula* in the Aegean Sea (eastern Mediterranean). *Marine Biology Research,* 13(2), 161-173. https://doi.org/10.1080/17451000.2016.1239019.

Kousteni, V., Karachle, P. K., Megalofonou, P., & Lefkaditou, E. (2018). Cephalopod prey of two demersal sharks caught in the Aegean Sea (eastern Mediterranean). *Journal of the Marine Biological Association of the United Kingdom,* 98(1), 81–88. https://doi.org/10.1017/S002531541700159X.

Kousteni, V., Kontopoulou, M., & Megalofonou, P. (2010). Sexual maturity and fecundity of *Scyliorhinus canicula* (Linnaeus, 1758) in the Aegean Sea. *Marine Biology Research,* 6, 390-398. https://doi.org/10.1080/17451000903233771.

Lauria, V., Gristina, M., Attrill, M.J., Fiorentino, F., & Garofalo, G. (2015). Predictive habitat suitability models to aid conservation of elasmobranch diversity in the central Mediterranean Sea. *Scientific Reports,* 5, 13245. https://doi.org/10.1038/srep13245 1.

Ligas, A., Bertolini, D., Mancusi, C., Reale, B., Ria, M., Sartor, P., Sbrana, M., Serena, F., Voliani, A., & Ranieri, S. De. (2010). Temporal evolution of landings of elasmobranches in Tuscany (Mediterranean Sea). *Biologia Marina Mediterranea,* 17(1), 220-223.

Mancusi, C., Baino, R., Fortuna, C., De Sola, L., Morey, G., Bradai, M., Kallianotis, A., Soldo, A., Hemida, F., Saad, A., Dimech, M., Peristeraki, P., Bariche, M., Clò, S., De Sabata, E., Castellano, L., Garibaldi, F., Lanteri, L., Tinti, F., Pais, A., Sperone, E., Micarelli, P., Poisson, F., Sion, L., Carlucci, R., Cebrian-Menchero, D., Séret, B., Ferretti, F., El-Far, A., Saygu, I., Shakman, E., Bartoli, A., Guallart, J., Damalas, D., Megalofonou, P., Vacchi, M., Bottaro, M., Notarbartolo Di Sciara, G., Follesa, M., Cannas, R., Kabasakal, H., Zava, B., Cavlan, G., Jung, A., Abudaya, M., Kolitari, J., Barash, A., Joksimovic, A., Marčeta, B., Gonzalez Vilas, L., Tiralongo, F., Giovos, I., Bargnesi, F., Lelli, S., Barone, M., Moro, S., Mazzoldi, C., Charis, C., Abella, A., & Serena, F. (2020). MEDLEM database, a data collection on large Elasmobranchs in the Mediterranean and Black Seas. *Mediterranean Marine Science,* 0, 276-288. https://doi.org/10.12681/mms.21148.

Marongiu, M. F., Porcu, C., Bellodi, A., Cannas, R., Carbonara, P., Cau, A., Coluccia, E., Moccia, D., Mulas, A., Pesci, P., & Follesa, M. C. (2020). Abundance, distribution and reproduction of the Data-Deficient species (*Squalus blainville*) around Sardinia Island (central western Mediterranean Sea) as a contribution to its conservation. *Marine and Freshwater Research*, 72(1), 118-130 https://doi.org/10.1071/MF19372.

Marongiu, M. F., Porcu, C., Bellodi, A., Cannas, R., Cau, A., Cuccu, D., Mulas, A., & Follesa, M. C. (2017). Temporal dynamics of demersal chondrichthyan species in the central western Mediterranean Sea: The case study in Sardinia Island. *Fisheries Research,* 193, 81-94. https://doi.org/10.1016/j.fishres.2017.04.001.

Marouani, S., Kadri, H., Saidi, B., Morize, E., Bouain, A., & Bradai, M. N. (2012). Age, growth, longevity, natural mortality and maturity of the longnose spurdog, *Squalus blainvillei* (Chondrichthyes: Squalidae), in the Gulf of Gabès (Central Mediterranean Sea). *Cahiers de Biologie Marine,* 53, 197-204.

Megalofonou, P., & Damalas, D. (2004). Morphological and biological characteristics of a gravid angular rough shark (*Oxynotus centrina*) and its embryos from the Eastern Mediterranean Sea. *Cybium,* 28(2), 105-110.

Mnasri, N., Olfa, E. M., Boumaiza, M., Reynaud, C., & Capapé, C. (2012). Food and feeding habits of the small-spotted catshark, *Scyliorhinus canicula* (Chondrichthyes: Scyliorhinidae) from the northern coast of Tunisia (central Mediterranean). *Cahiers de Biologie Marine*, 53(1), 139-150.

Moranta, J., Quetglas, A., Massutí, E., Guijarro, B., Hidalgo, M., & Diaz, P. (2008). Spatio-temporal variations in deep-sea demersal communities off the Balearic Islands (western Mediterranean). *Journal of Marine Systems,* 71, 346–366. https://doi.org/10.1016/j.jmarsys.2007.02.029.

Mulas, A., Bellodi, A., Cannas, R., Carbonara, P., Cau, A.,·Marongiu, M. F., Pesci, P., Porcu, C., & Follesa, M. C. (2019). Resource partitioning among sympatric elasmobranchs in the central-western Mediterranean continental shelf. *Marine Biology,* 166, 153. https://doi.org/10.1007/s00227-019-3607-0.

Mutlu, E., de Meo, I., & Miglietta, C. (2021). Spatio-temporal distribution of pufferfish (Tetraodontidae) along the Turkish coast of the Mediterranean Sea. *Mediterranean Marine Science,* 22(1), 1-19. https://doi.org/10.12681/mms.23481.

Mutlu, E., Deval, M. C., de Meo, I., Saygu, I., & Miglietta, C. (2022). Spatiotemporal density and ecology of batoids (Elasmobranchii) along a Turkish shelf-upper slope of the Mediterranean Sea during years 2009–2015. *Thalassas: An International Journal of Marine Sciences,* 38, 57-69. https://doi.org/10.1007/s41208-021-00391-4.

Olaso, I., Velasco, F., Sánchez, F., Serrano, A., Rodríguez-Cabello, C., & Cendrero, O. (2005). Trophic relations of lesser-spotted catshark (S*cyliorhinus canicula*) and blackmouth catshark (*Galeus melastomus*) in the Cantabrian Sea. *Journal of Northwest Atlantic Fishery Science,* 35, 481–494. https://doi.org/10.2960/J.v35.m494.

Ordines, F., Massutí, E., Moranta, J., Quetglas, A., Guijarro, B., & Fliti, K. (2011). Balearic Islands vs Algeria: two nearby western Mediterranean elasmobranch assemblages with different oceanographic scenarios and fishing histories. *Scientia Marina,* 75(4), 707-717. doi:10.3989/scimar.2011.75n4707.

Özcan, E. I., & Başusta N. (2018a). Preliminary study on age, growth and reproduction of *Mustelus mustelus* (Elasmobranchii: Carcharhiniformes: Ttriakidae) inhabiting the gulf of Iskenderun, north-eastern Mediterranean Sea. *Acta Ichthyologica et Piscatoria,* 48(1), 27–36. https://doi.org/10.3750/AIEP/02295.

Özcan, E. İ., & Başusta, N. (2015). Stomach contents of the Lesser Spotted Dogfish, (*Scyliorhinus canicula* (Linnaeus, 1758)) inhabiting Northeastern Mediterranean. *Ege Journal of Fisheries and Aquatic Sciences,* 32(4), 193-195. https://doi.org/10.12714/egejfas.2015.32.4.03.

Özcan, E. I., & Başusta, N. (2018b). Some population parameters of *Scyliorhinus canicula* (Linnaeus, 1758) from the northeastern Mediterranean Sea. *Journal of Black Sea/Mediterranean Environment,* 24(1), 51-64.

Öztekin, A., Özekinci, U., & Daban, İ. B. (2016). Length-weight relationships of 26 fish species caught by longline from the Gallipoli peninsula, Turkey (northern Aegean Sea). *Cahiers de Biologie Marine,* 57, 335-342.

Özütemiz, Ş., Kaya, M., & Özaydın, O. (2009). Growth and Feeding Characteristics of Two Sharks Species [*Galeus melastomus* Rafinesque, 1810 and *Squalus blainvillei* (Risso, 1826)] from Sığacık Bay (Aegean Sea). *Ege Journal of Fisheries and Aquatic Sciences,* 26(3), 211-217.

Patania, A., & Mutlu, E. (2021). Spatiotemporal and ecological distribution of megabenthic crustaceans on the shelf-shelf break of Antalya Gulf, the eastern Mediterranean Sea. *Mediterranean Marine Science,* 22(3), 446-465. https://doi.org/10.12681/mms.26142.

Pauly, D. (1980) On the interactionships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. *Conseil Permanent International pour l'Exploration de la Mer,* 39(3), 175–192.

Porcu, C., Marongiu, M., Follesa, M., Bellodi, A., Mulas, A., Pesci, P., & Cau, A. (2013). Reproductive aspects of the velvet belly lantern shark *Etmopterus spinax* (Condrichthyes: Etmopteridae), from the central western Mediterranean sea. Notes on gametogenesis and oviducal gland microstructure. *Mediterranean Marine Science,* 15(2), 313-326. https://doi.org/10.12681/mms.559.

Quigley, D. T. G. (2019). Observations on euryhalinity in the Small-spotted Catshark *Sycliorhinus canicula* (L.). *Porcupine Marine Natural History Society Bulletin,* 12, 57-62.

Ragonese, S., Nardone, G., Ottonello, D., Gancitano, S., Giusto, G., & Sinacori, G. (2009). Distribution and biology of the Blackmouth catshark *Galeus melastomus* in the Strait of Sicily (Central Mediterranean Sea). *Mediterranean Marine Science,* 10(1), 55-72. https://doi.org/10.12681/mms.122.

Ragonese, S., Vitale, S., Dimech, M., & Mazzola, S. (2013). Abundances of Demersal Sharks and Chimaera from 1994-2009 Scientific Surveys in the Central Mediterranean Sea. *PLoSONE,* 8(9), e74865. https://doi.org/10.1371/journal.pone.0074865.

Ramírez-Amaro, S., Ordines, F., Esteban, A., García, C., Guijarro, B., Salmerón, F., Terrasa, B., & Massutí E. (2020). The diversity of recent trends for chondrichthyans in the Mediterranean reflects fishing exploitation and a potential evolutionary pressure towards early maturation. *Scientific Reports,* 10, 547. https://doi.org/10.1038/s41598-019-56818-9.

Saidi, B., Bradai, M. N., & Bouain, A. (2008). Reproductive biology of the smooth-hound shark *Mustelus mustelus* (L.) in the Gulf of Gabe`s (south-central Mediterranean Sea). *Journal of Fish Biology,* 72, 1343–1354. https://doi.org/10.1111/j.1095-8649.2008.01801.x.

Saidi, B., Bradai, M. N., Bouain, A., Guelorget, O., & Capape C. (2005). The reproductive biology of the sandbar shark, *Carcharhinus plumbeus* (Chondrichthyes: Carcharhinidae), from the Gulf of Gabes (southern Tunisia, central Mediterranean). *Acta Adriatica* 46(1), 47–62.

Šantić, M., Rađa, B., & Pallaoro, A. (2012). Feeding habits of smallspotted catshark (*Scyliorhinus canicula* Linnaeus, 1758) from the eastern central Adriatic Sea. *Marine Biology Research* 8(10), 1003-1011. doi:10.1080/17451000.2012.702912.

Serena, F., Abella, A.J., Bargnesi, F., Barone, M., Colloca, F., Ferretti, F., Fiorentino, F., Jenrette, J., & Moro, S. (2020) Species diversity, taxonomy and distribution of Chondrichthyes in the Mediterranean and Black Sea. *The European Zoological Journal* 87, 497-536. doi: 10.1080/24750263.2020.1805518.

Shimazaki, H., & Shinomoto, S. (2007). A method for selecting the bin size of a time histogram. *Neural Computation* 19, 1503–1527. doi:10.1162/neco.2007.19.6.1503.

Sion, L., D'Onghia, G., Tursi, A, & Mytilineou, C. (2003). First data on distribution and biology of *Squalus bainvillei* (Risso, 1826) from the Eastern Mediterranean Sea. *Journal of Northwest Atlantic Fishery Science* 31, 213-219. doi:10.2960/J.v31.a16.

Sisma-Ventura, G., Bialik, O. M., Yam, R., Herut, B., & Silverman, J. (2017). $p\mathrm{CO_2}$ variability in the surface waters of the ultra-oligotrophic Levantine Sea: Exploring the air–sea CO_2 fluxes in a fast warming region. *Marine Chemistry* 196, 13-23. http://dx.doi.org/10.1016/j.marchem.2017.06.006.

Soyer, T. (1970). Bionomie benthique du plateau continental de la cote catalane Française. III: Les peuplements de Copepodes Harpacticoides (Crustacea). *Vie Et Millieu* 21, 377-511.

Stevens, J.D., Bonfil, R., Dulvy, N., & Walker, P. (2000). The effects of fishing on sharks, rays, and chimaeras (chondrichthyans): and the implications for marine ecosystems. *ICES Journal of Marine Sciences* 57, 476–494. doi:10.1006/jmsc.2000.0724.

Tiralongo, F., Messina, G., & Lombardo, B. (2018). Discards of elasmobranchs in a trammel net fishery targeting cuttlefish, *Sepia officinalis* Linnaeus, 1758, along the coast of Sicily (central Mediterranean Sea). *Regional Studies in Marine Science* 20, 60–63. https://doi.org/10.1016/j.rsma.2018.04.002.

Turan, C., Gürlek, M., Ergüden, D., & Kabasakal, H. (2021). A new record for the shark fauna of the Mediterranean: Whale shark, *Rhincodon typus* Smith, 1828 (Orectolobiformes: Rhincodontidae). *Annales, Series Historia Naturalis* 31, 167-172.

Türker, D., Zengin, K., & Tünay, Ö. K. (2018). Length-weigth relationships for nine chondrichthyes fish species from Edremit Bay (North Aegean Sea). *Turkish Journal of Fisheries and Aquatic Science* 19(1), 71-79. http://doi.org/10.4194/1303-2712-v19_1_09.

Valls, M. A., Ordines, F., & Moranta, J. (2011). Feeding ecology of demersal elasmobranchs from the shelf and slope off the Balearic Sea (western Mediterranean). *Scientia Marina* 75(4), 633-639. doi:10.3989/scimar.2011.75n4633.

Yağlıoglu, D., Deniz, T., Gurlek, M., Erguden, D., & Turan, C. (2015). Elasmobranch bycatch in a bottom trawl fishery in the Iskenderun Bay, northeastern Mediterranean. *Cahiers de Biologie Marine* 56, 237-243.

Yemişken, E., Eryılmaz, L., Megalofonou, P., & Yıldız, T. (2019a). Length-weight relationships of nine common demersal Elasmobranch species from the Eastern Mediterranean. *Cahiers de Biologie Marine* 60, 293-297. doi:10.21411/CBM.A.5F43BEFA.

Yemişken, E., Navarro, J., Forero, M., Megalofonou, P., & Eryilmaz, L. (2019b). Trophic partitioning between abundant demersal sharks coexisting in the North Aegean Sea. *Journal of the Marine Biological Association of the United Kingdom* 99, 1213–1219. doi:10.1017/S0025315419000110.

Yığın, C. Ç., İşmen, A., & Önal, U. (2016). Occurrence of a rare shark, *Oxynotus centrina* (Chondrichthyes: Oxynotidae), from Saros Bay, North Aegean Sea, Turkey. *Journal of Black Sea/Mediterranean Environment* 22(1), 103-109.

Yığın, C.Ç., Işmen, A., Daban, B., Cabbar, K., & Önal, U. (2019). Recent findings of rare sharks, *Squatina oculata* Bonaparte, 1840 and *Squatina squatina* (Linnaeus, 1758) from Gökçeada Island, Northern Aegean Sea, Turkey. *Journal of Black Sea/Mediterranean Environment* 25(3), 305-314.

Zava, B., Fiorentino, F., & Serena, F. (2016). Occurrence of juveniles *Squatina oculata* Bonaparte, 1840 (Elasmobranchii: Squatinidae) in the Strait of Sicily (Central Mediterranean). *Cybium* 40(4), 341-343.

Appendix 1. Summary of statistical measures in relation of Elasmobranches' abundance to megazoobentic abundances for the CCA.

Taxa abbreviated	Taxa	Axis1	Axis2
An	Annelida	0.0356	-0.0514
Cn	Cnidaria	0.0626	0.0810
As	Echinodermata, Asteroidea	0.0780	-0.0536
Cr	Echinodermata, Crinoidea	0.0212	0.1303
Ec	Echinodermata, Echinoidea	-0.0121	0.0584
Ho	Echinodermata, Holoturidea	**0.4009**	-0.1249
Op	Echinodermata, Ophiuridea	0.1088	**0.2026**
Ech	Echiura	-0.1506	0.0040
Bi	Mollusca, Bivalvia	-**0.2228**	0.0071
Ce	Mollusca, Cephalopoda	**0.3847**	-0.1425
Ga	Mollusca, Gastropoda	-**0.2017**	0.0980
Po	Porifera	-0.1538	0.0336
Si	Sipunculida	-0.0483	**0.2563**
Tu	Tunicata	0.0429	-0.0355
De	Crustacea, Decapoda	**0.3653**	**-0.2868**
Is	Crustacea, Isopoda	-0.0329	0.0809
St	Crustacea, Stomatopoda	**-0.4001**	-0.1144
Eigenvalues		0.452	0.370
Species-environment correlations		0.771	0.741
Cumulative percentage variance:			
of species data		8.8	16.0
of species-environment relation		28.2	51.4

Appendix 2. Summary of statistical measures in relation of Elasmobranches' abundance to abundances of the Osteichthyes families for the CCA.

Families abbreviated	**Families**	**Axis 1**	**Axis 2**
Ap	Apogonidae	**-0.3225**	-0.0370
Ar	Argentinidae	**0.4826**	-0.1428
Ba	Balistidae	-0.1401	0.1723
Bl	Blenniidae	-0.0409	-0.0446
Bo	Bothidae	**-0.4747**	-0.0214
Cal	Callionymidae	0.2480	**-0.3872**
Cap	Caproidae	0.2649	**-0.3032**
Car	Carangidae	-0.1644	-0.0814
Cap	Carapidae	0.0748	0.0192
Cen	Centracanthidae	-0.1837	**0.3301**
Cet	Centriscidae	0.1077	0.1386
Cep	Cepolidae	-0.1589	-0.0083
Cha	Champsodontidae	0.0495	0.1807
Chl	Chlorophthalmidae	**0.3047**	**-0.2972**
Ci	Citharidae	0.0060	0.0289
Co	Congridae	0.1001	**-0.2700**
Cy	Cynoglossidae	**-0.2484**	-0.1087
Da	Dactylopteridae	-0.1971	0.0172
Ec	Echeneidae	-0.1472	-0.0106
Fi	Fistulariidae	**-0.3882**	-0.0076
Ga	Gadidae	0.1971	**-0.2500**
Go	Gobiidae	0.0902	-0.1078
Ha	Haemulidae	-0.2228	-0.0196
La	Labridae	-0.2013	0.0051
Le	Leiognathidae	**-0.4930**	-0.0587
Lo	Lophiidae	**0.3499**	-0.1322
Ma	Macrouridae	**0.3002**	**-0.3648**
Me	Merlucciidae	**0.4651**	-0.1012
Mo	Monacanthidae	**-0.4151**	-0.0278
Mug	Mugilidae	-0.1947	-0.0307
Mul	Mullidae	**-0.3275**	0.1768
Mur	Muraenesocidae	-0.2009	-0.0196
Nem	Nemipteridae	**-0.4515**	-0.0536
Net	Nettastomatidae	0.0913	**0.3339**
Pe	Peristediidae	0.2390	**-0.3003**
Ph	Phycidae	0.2257	**-0.2766**
Sca	Scaridae	-0.2009	-0.0196
Sci	Sciaenidae	-0.1447	-0.0500
Sco	Scophthalmidae	**0.4300**	**-0.3462**
Scr	Scorpaenidae	**0.3801**	-0.0098
Seb	Sebastidae	**0.3352**	**-0.3863**
Ser	Serranidae	-0.2248	0.1152
Sig	Siganidae	-0.2126	-0.0298
Sil	Sillaginidae	-0.2150	-0.0565
So	Soleidae	-0.2114	0.0199
Sp	Sparidae	-0.1245	0.0652
Sy	Synodontidae	**-0.3889**	0.0720
Ter	Terapontidae	-0.1971	-0.0155
Tet	Tetraodontidae	0.1936	-0.1602
Tra	Trachinidae	**-0.4542**	-0.0489
Trc	Trachichthyidae	0.1470	-0.1319
Tr	Triglidae	0.0959	-0.1428
Ur	Uranoscopidae	0.1219	**0.2925**
Ze	Zeidae	0.1595	0.1882
Eigenvalues		0.789	0.645
Species-environment correlations		0.978	0.982
Cumulative percentage variance:			
of species data		15.4	28.0
of species-environment relation		18.6	33.7