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RESEARCH ARTICLE

Community Structure of Gurnards in Relation to Different Environmental Variables in Antalya Gulf

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Abstract: Fish assemblages have not been studied at the family level using comprehensive environmental variables. Ecological studies focusing on spatiotemporal density (abundance and biomass) and morphometry (size and inter-traits relationships) of fish species have been highly limited in the Mediterranean Sea, particularly in the Turkish Levant coast. Gurnards (Family: Triglidae) have received little attention in ecological research. In the present study, in order to outline the spatiotemporal dynamic of density and morphometry in space (region and bottom depth) and time (season) alongside environmental parameters, gurnards collected seasonally from a study conducted on shelf/shelf break of the Antalya Gulf in 2014-2015 (de Meo et al. 2018) were studied. A total of 79 stations were sampled in year period (22 stations in May, 17 in August, 21 in October and 19 in February). Of the total stations, occurrence of the gurnards in stations varied between 4 (*Trigla lyra*) and 34 (*Lepidotrigla cavillone*). The gurnards were represented by six species in Antalya Gulf. In general, the small-sized specimens (*L. cavillone* and *L. dieuzeidei* < 15 cm) outnumbered the larger specimens (*Chelidonichthys lucerna, C. cuculus, C. lastoviza* and *T. lyra*) in the gurnard population. The species were significantly differentiated by the bottom depth, followed by the depth-gradient environment. Shallow water, middle shelf and deeper water species were distinguished among the six species. The gurnards avoided the seagrass meadows. Only *Chelidonichthys lastoviza* was found close to the meadow beds. Small-sized species had more abundance than large-sized species on bare bottoms. Large-sized species exhibited greater sizes in eutrophic areas compared to those in oligotrophic areas, whereas small-sized species had similar sizes in both trophic states, leading to differences in their growth types. Overall, females outnumbered the males for all species and the species exhibited a size-dependent sexual dimorphism with the females being longer and heavier than the males. Assemblage of six gurnard species was correlated with depth, thus bottom type (coarse to fine material of sediment from coast to open water) and chl-*a* and fine bioseston. With respect to fish-epibenthic fauna relation, the gurnard community was correlated primarily with Decapoda and Holothuroidea and secondarily with Crinoidea, followed by Ophiuroidea. The gurnards were distributed specifically at different depths of the shelf/break, preferring bare bottoms in general with depth-graded environment in space and time.

Anahtar kelimeler:

Kırlangıç balıkları
Yoğunluk
Balık karakterleri
Mekansal-zamansal ekolojik dağılım
Levantin Denizi

Antalya Körfezi'ndeki Farklı Çevresel Değişkenlere Bağlı Olarak Kırlangıç Balıklarının Topluluk Yapısı

Öz: Balık toplulukları kapsamlı çevresel değişkenlerle familya düzeyinde incelenmemiştir. Balık türlerinin mekansal-zamansal yoğunluğunu (bolluk ve biyokütle) ve morfometrisini (boyut ve aralarındaki ilişkiler) belirlemek için ekolojik çalışma Akdeniz'de, özellikle Türk Levant kıyılarında oldukça sınırlı olmuştur. Ekolojik çalışma için göz ardı edilen balık familyalarından olan Triglidea'dır. Mekansal (bölge ve dip derinliği) ve zamansal (mevsim) yoğunluk ve morfometrinin mekansal-zamansal dinamiklerini çevresel parametrelerle özetlemek için, 2014-2015 yıllarında Antalya Körfezi'nin kıta sahanlığı/sahan kırığında yürütülen bir çalışmadan mevsimsel olarak toplanan kırlangıç balıkları değerlendirilmiş ve ardından istatistiksel analizler kullanılarak yorumlanmıştır (de Meo ve vd. 2018). Yıl içindetoplam 79 istasyon örneklendi (22 istasyon Mayıs'ta, 17 istasyon Ağustos'ta, 21 istasyon Ekim'de ve 19 istasyon Şubat'ta). Toplam istasyonlarda, gurnard balığının varlığı 4 (*Trigla lyra*) ile 34 istasyon (*Lepidotrigla cavillone*) arasında değişti. Kırlangıç balıkları Antalya Körfezi'nde altı türle temsil edilmiştir. Genel olarak, kırlangıç balık türü popülasyonunda küçük boyutlu türler (*L. cavillone* ve *L. dieuzeidei* < 15 cm) büyük türlerden (*Chelidonichthys lucerna, C. cuculus, C. lastoviza,* ve *T. lyra*) sayıca daha fazlaydı. Örnekler, dip derinliğine, ardından derinlik bağlı çevresel parametrelere göre önemli ölçüde farklılaşmıştır. Altı tür arasında sığ su, orta sahan ve daha derin su türleri ayırt edilmiştir. Kırlangıç balıkları çayırlık alandan uzak kaldı. Çayır yatağına yakın sadece *Chelidonichthys lastoviza* bulundu. Çayırların bulunmadığı çıplak dipte, küçük boylu türler büyük boylu türlerden daha fazla bolluğa sahipti. Daha büyük boylu türler ötrofik alana kıyasla oligotrofik alanda daha küçük boyuta sahipti, ancak küçük boyutlu türler karşılaştırmalı olarak benzer aralıklarda ölçüldü, bu da karşılaştırmada büyüme tipini değiştirdi. Genel olarak, tüm türlerde dişi bireyler erkeklerden daha fazlaydı ve türler boyut olarak eşeysel dimorfizme sahipti; dişi bireyler erkeklerden daha uzun ve daha ağırdı. Altı kırlangıç balığı türünün topluluğu dip derinliğiyle, dolayısıyla dip tipi (kıyıdan açık su tabanına kadar sedimanın kaba ila ince malzemesi) ve chl-*a* ve ince biyosestonla ilişkilendirildi. Balık-epibentik fauna ilişkisi açısından, kırlangıç balık topluluğu öncelikle Decapoda ve Holothuroidea ile ve ikincil olarak Crinoidea ile, ardından Ophiuroidea ile ilişkilendirildi. Kırlangıç balıkları, kıta sahanlığın/kırığın farklı derinliklerine tür bazında dağılmış olup, genel olarak mekansal ve zamansal dip derinliği bağlı çevre ile çıplak dipleri tercih etmektedir.

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Introduction

Besides their worldwide occurrence in temperate and tropical marine waters (about 114-125 triglid species belonging to 8 genera) (Colloca et al., 2019; Dobroslavić et al., 2021), the sea robins or gurnards are widely distributed in the Mediterranean Sea, represented by eight species. They are found on the shelf and shelf slope (Colloca et al., 2019). Gurnards have been valued commercially and also are considered by-catch and discard fish in some cases (Machias et al., 2001). Concerns on commercial gurnard fisheries are minimal, with only large specimens caught as by-catch being valued for food (Colloca et al., 2019). The gurnards inhabit sandy and muddy bottoms and feed mainly on epibenthic fauna (Platella and Potter, 1999). Therefore, from an ecology standpoint, studying gurnards' feeding behavior is important to study prey-predator interaction (Platella and Potter, 1999), spatiotemporal density and morphometry distribution in different locations. Recently, Colloca et al., (2019) highlighted the significance of gurnards with respect to their spatiotemporal distribution in the western Mediterranean Sea, noting that the abundance of coastal species has been declining compared to the deep-dwelling gurnards over the past 2 decades.

Understanding the life history patterns of fish species is crucial for effective fisheries management across different temporal and spatial scales. The main factor which affects the local distribution and abundance patterns of fish assemblages in space and time is the bottom depth inducing different bottom type and seasonal hydrography of the water column and food availability (e.g. Demestre et al., 2000; Kallianiotis et al., 2000; Araújo et al., 2002; Katsanevakis et al., 2009). All these factors are well known to influence the distribution of density and size traits of the gurnards (Colloca et al., 2003).

Levantine Basin, one of the largest Mediterranean basins under the influence of climate chance, is characterized by high temperature and the "tropicalization" of the subtropical climate, inducing high salinity and extreme oligotrophy (Sisma-Ventura et al., 2017). Climate related changes could reduce discharge rates of some rivers feeding the Levantine basin, located in the eastern Mediterranean Sea. Gulf of Antalya is one of the ultra-oligotrophic regions of the eastern Mediterranean Sea (Sisma-Ventura et al., 2017) and is impacted by the introduction of non-indigenous species primarily via Suez Canal, followed by the Atlantic rim current and ballast waters. The Turkish coastal area, Antalya, Mersin and Iskenderun harbors in particular, has economical and strategical importance and is under the pressure exerted by the inputs of organic material and chemical pollutants derived from intense urbanization, maritime, touristic and agricultural activities (Polat-Beken et al., 2009; de Meo et al., 2018).

In the Mediterranean Sea and its basins, gurnards have been studied in terms of their spatial or temporal or both spatial and temporal distribution of demersal catch values using specimens considered as by-catch or discard fish (e.g. Machias et al., 2001; Damalas et al., 2010; Ordines et al., 2014; Farriols et al., 2017; Colloca et al., 2019). Gurnards were also studied for their population growth dynamic parameters (e.g. Papaconstantinou, 1984, 1986; İşmen et al., 2004; İlhan and Toğulga, 2007; Ragonese and Bianchini, 2010; Türker et al., 2010; Mehanna, 2022; Şirin et al., 2024) and population structure (e.g. Tsimenides et al., 1992; Terrats et al., 2000; Merigot et al., 2007; Massuti and Renones, 2005; Ihsanoglu et al., 2016). Majority of the studies focused on a single species, overlooking the interaction among other gurnard species collectively. Some researchers studied diet (Caragitso and Papaconstantinou, 1994; Terrats et al., 2000; Boudaya et al., 2007; Stagioni et al., 2012; Montanini et al., 2017; İlhan 2019) and reproduction (e.g. Boudaya et al., 2008; Dobroslavić et al., 2021) of the gurnards. Numerous other studies have analyzed the distribution patterns of fish communities in the Levantine Sea, but their ecological interactions have barely been outlined regarding density and size of specimens in space and time. However, ecological studies on fishes are highly limited in the literature, and the studies were conducted in a wide range of the stratified bottom depths without considering certain specific environmental variables in relation to the fish community. Fishery biologists measured generally basic physical parameters (temperature and salinity of the water). With limited environmental variables such CTD (temperature and salinity), the first ecological study performed on gurnards was conducted in the Cretan waters (Tsimenides et al., 1992). In Turkey, only few studies on the ecology with comprehensive environmental parameters are available (de Meo et al., 2018). Ecological studies at the fish family level are important because they highlight the ecology of a specific family, unaffected by the species of other families. This approach reflects the ecological patterns of the most abundant and dominant fish species within the same study. (Mutlu et al., 2021, 2022b, e, f).

Regarding the density and morphometry, the objective of the present study was to investigate the spatial and temporal structure of gurnard assemblages found over the shelf of Antalya Bay and to determine their response to various environmental variables.

Material and Methods

Details of fish sampling and environmental parameters are given in a paper published by de Meo et al., (2018). Briefly, specimens of the family Triglidae were collected using an otter bottom trawl (mesh size 44 mm in diamond, head rope length: 35 m) from the continental shelf and shelf break of Gulf of Antalya, Türkiye. The temporal trawl samplings were conducted in May, August, October 2014 and February 2015 to study the density of the species in space and time. Spatial samplings were performed in three different transects (R1, R2 and R3) each having a bottom depth of 10, 25, 75, 125 and 200 m and one riverine coastal transect (R4) on the shelf and one of the transects was located in non-fishing zone (R3) (Fig. 1). Furthermore, there were two shelf break sampling stations located on a bottom depth of 300 m, one for R3 (non-fishing zone), and one for pooled region of R1-R2 (fishing zone). Trawl sampling duration was 30 minutes. After recovery of the trawl on board of R/V "Akdeniz" from each sampling, the fish and other materials were sorted, identified, and number of individuals and total weight were determined on board. For laboratory work, the significant parts of the total catch were frozen at -18 ^{o}C. but when in doubt, further detailed identification was performed in the laboratory (de Meo et al., 2018).

After each trawl operation, the environmental parameters were recorded and analyzed for ecological studies. The parameters were composed of physical (sea surface and near-bottom temperature, salinity, density, pH and dissolved oxygen), chemical (chlorophyll-*a*, suspended matter: seston, tripton and bioseston in three size fractions separated using sieves of 1, 0.5 and 0.063 mm), and optical (Photosynthetically Active Radiation and Secchi disk depth) measurements and materials. Furthermore, bottom types of sampling ground were determined using a scientific echo sounder by a software of Visual Bottom Typer, VBT (BioSonics inc.). Details of the environmental parameters measurements and analyses were given in a paper published by de Meo et al., (2018).

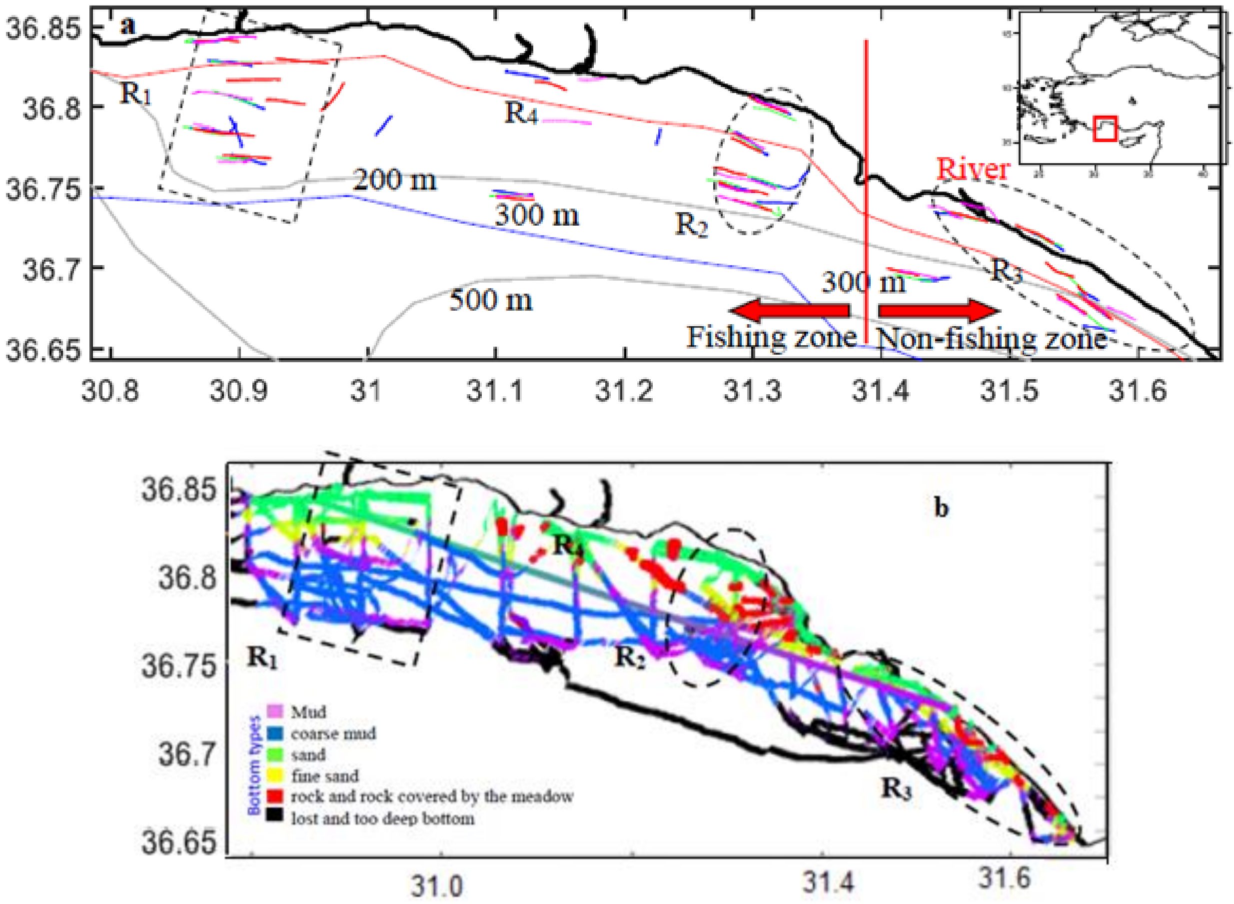

Figure 1. Seasonal trawl sampling track lines during 2014–2015 (blue; spring 2014, green; summer 2014; red; autumn 2014 and magenta; winter 2015), and two miles border for prohibition of the fishery, red line and 12 miles border, blue line, and fixed depths are in the order of the shallowest to the deepest bottom depths from the coast to open water seaward in each of regions (R1-R3) (a), and the study area showing different bottom types (BT) from the acoustical track lines by the echo sounder in 2014–2015 (b) (from Garuti and Mutlu 2021).

The catch data of each fish species were then converted to biomass (kg/km^2) and abundance (ind/km^2) taking the trawling distance converted from GPS data and trawl effective width (35 m * 0.5; 0.5 is a constant suggested by Pauly, (1980). In addition to weight and number of individuals, individual total length and weight of were recorded in a precision of mm and 0.0001 g, respectively. Sex was determined from gonads. Sex ratio was calculated using female (F)/Male (M).

For statistical analyses, univariate analyses and multivariate analyses were used to determine faunal assemblage and fauna-environment relation. Univariate analyses were used for assessing dominance (DO% equal to number of stations with occurrence of the species / total station number*100), frequency occurrence (FO%), numerical occurrence (NO%) (Holden and Raitt 1974), and Soyer index was used for the determination of constant DO%>50), common (25≤DO%≤50) and rare (DO%<25) species in the study area (Soyer, 1970). Univariate analyses were used also for estimating length distribution and histograms, length-weight relationship (power fit regression and Pearson correlation) and their sexual difference (Analysis of Covariance: ANOCOVA), significance (student t-test), difference in abundance, biomass, length weight and sex ratio among the transect, season and bottom depths (Three and One -way Analysis of Variance: ANOVA) and growth type (t-testing difference of estimated slope from an isometric growth, value 3). The post-hoc test (LSD, least significant difference) was then applied to each variable separately for each factor (way). The data was checked for random distribution, taking the mean-variance dependence into account for each factor (way) (FAO, 1991), and then, the data was log10-transformed before any statistical analyses. A COST function (Shimazaki and Shinomoto 2007) was applied to length data to estimate the optimal bin size (size class). Accordingly, the empirical methods for the bin size selection in a bar graph histogram in an order are as follows : i) estimation of the number of sequences required for the histogram, and ii) estimation of the scaling exponents of the optimal bin size were corroborated by theoretical analysis derived for a generic stochastic rate process by dividing the observation period T into N bins of width Δ from the measurement (iii), and counting the frequency (ki) of ith bin size (iv), and then constructing the mean and variance of the number of ki (v) before repeating that computing the cost function changing the bin size Δ to search for minimum $C\Delta*$ (vi) which is the optimum bin size for the measurement. Thereafter, Kernel Density Function (KDF) was applied to the length-frequency data to determine the length cohorts. The choice of interval width (bin width/band width) is one of the central problems in density estimation within discriminated growth cohorts. There are several ways to select an appropriate bin width for histograms; frequency polygons, or averaged shifted histograms and a bandwidth for the KDF. The KDF are superior at recovering interesting structure (Scott, 1979). All statistical analyses were performed using the statistical tool of MATLAB (R2021a, MathWorks, Inc.). The length frequency plot of three abundant gurnard species was formed using FISAT II software (vers. 1.2.2., Gayanilo and Pauly 2001).

A data matrix of the gurnard abundances was subjected to canonical correspondence analysis (CCA) to cluster the stations to estimate the gurnard species-environment relation and the gurnard species-mega benthic fauna (Garuti and Mutlu 2021; Patania and Mutlu 2021) relation using CANOCA (VER 4.5.). According to high explained variance in total, CCA1 and CCA2 elucidating best the relationships were taken into account of the cluster estimation. In the present study, all statistical tests were significantly accepted at $p < 0.05$.

Results

In the shelf and shelf break waters of Antalya Gulf, specimens of family Triglidae were represented with six species (Table 1). The most encountered species were *Lepidotrigla cavillone* and *Trigloporus lastoviza* (accepted valid name as *Chelidonichthys lastoviza*), and both species were assigned as common species according to Soyer index (Soyer, 1970). However, there was no constant gurnard species in the study area (DO%>50) (Table 1). The rest of the species were considered as rare (DO%<25) (Table 1).

Table 1. Annual percent dominance (DO%), frequency of occurrence (FO%) and numerical occurrence in abundance (NO%) and biomass (BO%) of gurnards and all species (165 species caught during the present study) and catch amount in average ± standard deviation (Avg±SD) and maximum abundance: Max (A in ind/trawl) and weight (B in kg/trawl). Tot denotes total number of individuals captured with trawl for each species.

Species		Triglidae species				All species			Catch in A			Catch in B	
	Abb.	DO%	FO%	NO%	BO%	FO%	NO%	BO%	Avg±SD	Max	Tot	Avg±SD	Max
Chelidonichthys cuculus (Linnaeus, 1758)	*Ccuc*	7.59	6.32	2.71	3.19	0.12	<0.01	0.08	27±202	1792	100	0.51±3.86	34.17
Chelidonichthys lucerna (Linnaeus, 1758)	*Cluc*	17.72	14.74	1.16	2.48	0.12	<0.01	0.07	11±35	211	44	0.39±1.29	9.96
Lepidotrigla cavillone (Lacepède, 1801)	*Lcav*	43.04	35.79	65.65	53.44	0.29	0.03	1.42	644±2485	16060	1752	8.45±32.48	217.03
Lepidotrigla dieuzeidei Blanc & Hureau, 1973	*Ldie*	16.46	13.68	17.59	19.74	0.29	0.01	0.52	173±657	4737	595	3.12±13.92	108.93
Trigla lyra Linnaeus, 1758	*Tlyr*	5.06	4.21	3.54	2.78	1.94	1.23	0.07	35±238	2064	83	0.44±2.97	25.80
Chelidonichthys lastoviza (Bonnaterre, 1788)	*Tlas*	30.38	25.26	9.35	18.37	1.94	3.25	0.49	92±251	1393	255	2.91±8.28	43.41

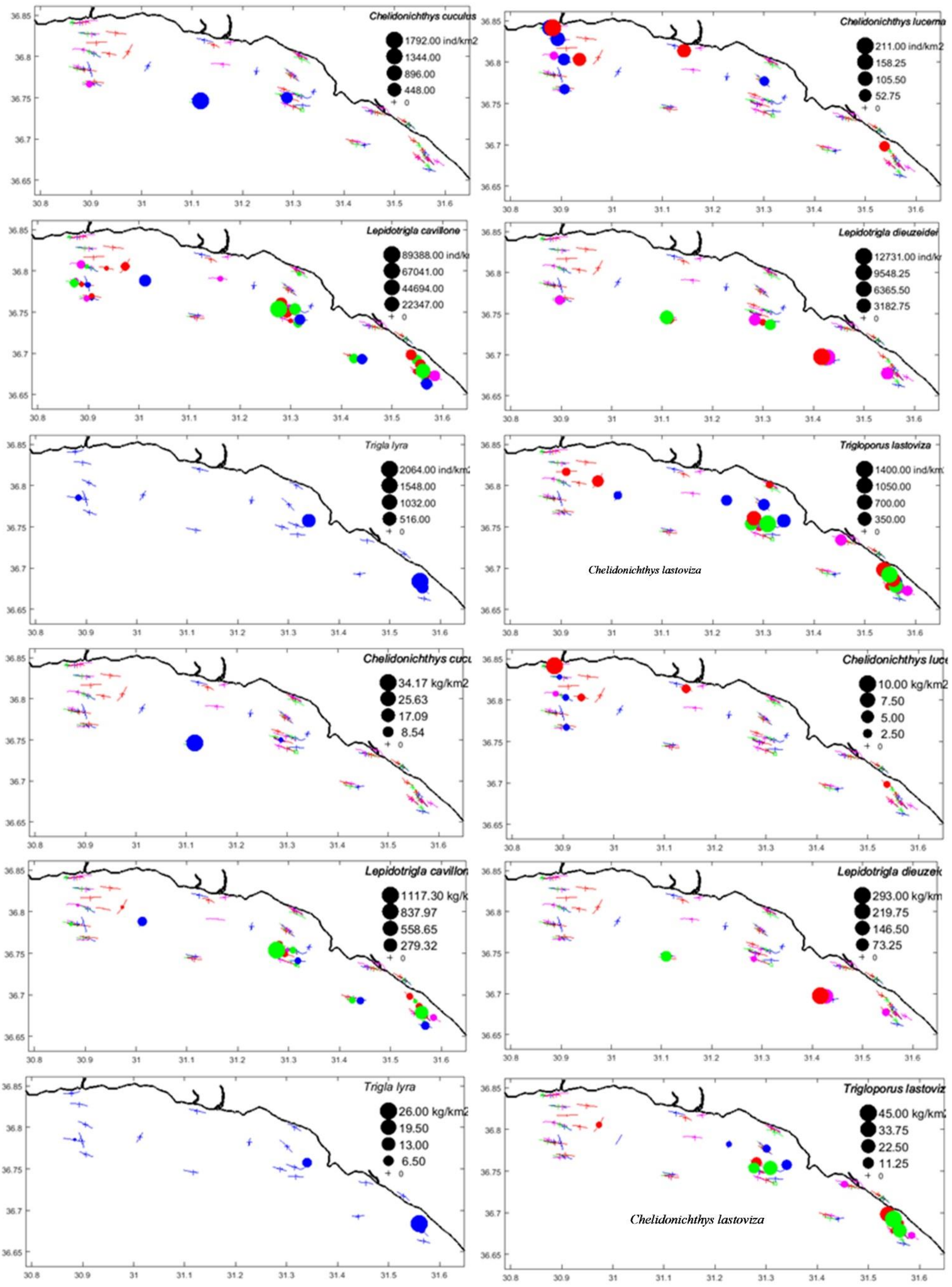

Figure 2. Spatiotemporal distribution of abundance (ind/km^2) (upper panel) and biomass (kg/m^2) (lower panel) of the gurnard species. Color of circle shows season (Blue denotes May, red August, green October and magenta February)

The species with the highest frequency of occurrence (FO%) was the same as the most commonly encountered species within the gurnard family. The abundance of gurnards was, in general, very low among all 165 species (Table 1).

The most abundant species (NO%) was *Lepidotrigla cavillone*, followed by *Lepidotrigla dieuzeidei*. Numerical occurrence of gurnards in abundance (NO%) and biomass (BO%) among all species was also very low (NO%<3.3%) (Table 1).

Temporal and spatial variations of CPUE

Bottom depth segmentation was observed for the distribution of the gurnard species on the shelf-shelf break zone (Fig. 2). There were species found at shallow and middle shelf water; *Chelidonichthys lucerna* was distributed at 10-75 m, ubiquitous shelf species; *C. lastoviza* at 10-200 m, deep shelf species: *T. lyra* at 100-125 m, and deep shelf/break species; *C. cuculus* at 125-300 m and *L. dieuzeidei* at 200-300 m, and ubiquitous shelf/shelf break species; *L. cavillone* at 10-300 m (Table 2, Fig. 2).

The maximum abundance among gurnards varied between 211 ind/km^2 (*C. lucerna*) and 89388 ind/km^2 (*L. cavillone*), followed by 12731 ind/km^2 (*L. dieuzeidei*) (Fig. 2). Catch amount was also similar to the abundance distribution. *C. cuculus* and *C. lucerna* dominated the R1, the rest of the species occurred abundantly in R2 and R3 (Table 2, Fig.2).

The regional significant difference in abundance was estimated only for *C. lucerna* which had higher abundance in R1 than R2 and R3 ($p < 0.05$; Tables 2-3, Fig. 2). However, there was no significant seasonal difference in the abundance of each gurnard species (Tables 2-3, Fig. 2). Seasonal mean abundance varied between 0.6 ind/km^2 (*C. lucerna*) and 640 ind/km^2 (*L. dieuzeidei*) (Table 2, Fig. 2). The maximum seasonal abundance of *C. cuculus* was estimated in May, *C. lucerna* in May and October, *L. cavillone* in August and October, *L. dieuzeidei* in October and February and *C. lastoviza* in August (Table 2, Fig. 2). Depth-wise difference in abundance was significantly assessed only for *L. dieuzeidei* and *C. lastoviza* ($p < 0.05$; Tables 2-3, Fig. 2). The maximum depth-wise abundance of *C. cuculus* was estimated at 300 m, *C. lucerna* at 10 m, *L. cavillone* at 100-125 m, followed by 75 m, *L. dieuzeidei* at 300 m and *C. lastoviza* at 50 m, followed by 75 m (Table 2, Fig. 2).

Maximum catch in weight was found for *L. cavillone* (53.4% of BO%) with a mean of 8.45±32.48 kg/trawl, followed by *L. dieuzeidei* (19.7% of BO%) with 3.12±13.92 kg/trawl (Table 1). Regional difference in biomass occurred only for *C. lastoviza*, and no seasonal difference was observed for any of the gurnard species. Depth-wise difference was observed for *L. dieuzeidei* and *C. lastoviza* at $p < 0.05$ (Table 3). Maximum biomass was estimated for *L. cavillone* and then *L. dieuzeidei* (Fig. 2). The lowest maximum biomass was estimated for *C. lucerna* and followed by *T. lyra* (Fig. 2). Regional, seasonal and depth-wise distributions of gurnard biomasses were similar to the corresponding distribution of the abundance.

Sex distribution in space and time

Overall, female specimens outnumbered the males (Table 2, Fig. 3). Female abundance was significantly different among the regions for *C. lucerna*, and depth-wise difference in female abundance was present for only *C. lastoviza* and *L. dieuzeidei* ($p < 0.05$; Tables 2-3, Fig. 3). However, there was no significant seasonal difference in the abundance of female specimens. Regarding to males, there was only depth-wise significant difference, and this difference was estimated for only three gurnard species ($p < 0.05$; Table 3).

Female/male abundance ratio showed that females predominated in the population and varied between 2.25 and 5.44 for *C. cuculus*, between 0.56 and 1.56 for *C. lucerna*, between 0.25 and 2.83 for *L. cavillone*, between 0.68 and 4.10 for *L. dieuzeidei*, and between 0.08 and 6.65 for *C. lastoviza* (Table 2, Fig. 3). However, all specimens of *T. lyra* were determined as females (Fig. 3).

Morphometry distribution in space and time

Length of the six gurnard species ranged from 4 cm to 24.9 cm (*Chelidonichthys cuculus*), followed by 24.7 cm (*Chelidonichthys lastoviza*), and weight from 0.78 g (*Chelidonichthys cuculus*) to 142.18 g (*Chelidonichthys lastoviza*). In general, the small-sized specimens (< 15 cm) outnumbered the larger specimens in the gurnard population (Figs. 4-6).

COST function and Kernel Density Function (KDF) estimated number of length cohorts as 4+ (*Chelidonichthys cuculus*), 1+ (*Chelidonichthys lucerna*), 4+ (*Lepidotrigla cavillone*), 4+ (*Lepidotrigla dieuzeidei*), and 3+ (*Chelidonichthys lastoviza*) for each species (Fig. 4). Notably, number of specimens induced precision in the estimation of cohort. For instance, Fig. 5 showed a clear separation in the estimation of length cohorts for three abundantly found species: 4+ for *L. cavillone* and 6+ for *C. lastoviza* (Fig. 5). However, there was no clear length cohort discrimination with and exception of samples in February for *L. dieuzeidei* (Fig. 5).

Table 2. Mean± standard deviation (SD) of the biomass (B in kg/km^2), abundance (A in ind/km^2) of combined specimens, females (F) and males (M), female/male abundance ratio (F/M), length (L in cm) and weight (W in g) in space (region and bottom depth) and time (season) and sex only for L and W. ID: insufficient data for the statistical analyses of the species (see Fig. 2), and empty cells denote no occurrence of specimens at the factor (see Fig. 2)

Species	Factor	B	A	F	M	F/M	L	W
C. cuculus								
Region	R1	1.32±0.75	69.6±39.9	0.5±0.3	0.3±0.1	1.6± 0.2	12.8±0.6	25.7±3.5
	R2	0.08±0.80	7.7±42.4	0.1±0.3	0.1±0.1	1.0± 0.2	9.2±1.1	11.3±6.4
	R3						22.5±2.2	100.2±12.9
Season	M	1.63±0.82	88.8±43.0	0.7±0.3	0.3±0.1	3.84±1.59	11.3±0.5	19.5±3.6
	A			0.1±0.3	0.1±0.1	1.0± 0.2	19.8±1.3	71.6±8.6
	O	0.01±0.84	0.7±44.1	0.04±0.3			12.1±3.1	16.1±19.4
	F	0.02±0.88	1.0±46.3		0.1±0.1		13.3±3.1	19.1±19.4
Depth	10							
	25							
	75							
	125	0.15±1.05	13.6±55.4	0.2±0.4	0.1±0.1	2.25±0	8.8±1.4	10.6±9.5
	200	0.03±1.09	1.6±57.6	0.08±0.4	0.1±0.2	0.8± 0.3	12.7±2.7	17.6±17.9
	300	4.27±1.34	224.0±70.6	2.0±0.5	1.1±0.2	5.44±0	13.5±0.7	31.5±4.8
Sex	M						12.9±0.8	28.3±5.8
	F						13.6±1.0	29.9±7.5
C. lucerna								
Region	R1	0.73±0.23	23.6±6.3	0.6±0.1	0.6±0.1	1.20±0.48	14.4±0.6	32.7±4.0
	R2	0.01±0.24	0.8±6.7	0.08± 0.1	0.1±0.1	0.8± 0.1	16.8±1.4	41.4±9.7
	R3	0.06±0.23	1.0±6.5				19.7±3.6	62.6±23.8
Season	M	0.28±0.25	15.8±7.0	0.4±0.1	0.4±0.2	1.20±0.60	12.1±0.6	19.5±4.3
	A			0.1±0.2			17.3±1.0	44.0±7.0
	O	0.75±0.26	17.7±7.2	0.3±0.2	0.2±0.2	0.56±0.78	16.3±0.6	42.0±4.3
	F	0.06±0.27	0.6±7.6	0.05±0.2	0.3±0.2	1.00±1.36	21.8±2.8	101.1±18.5
Depth	10	0.95±0.31	30.4±8.6	0.7±0.2	0.7±0.2	1.56±0.77	14.0±0.6	30.4±4.4
	25	0.11±0.33	8.5±9.2		0.4±0.2	0±0.94	12.4±1.3	17.3±8.7
	75	0.33±0.32	8.5±8.9	0.5±0.2	0.1±0.2	1±0.77	16.4±1.0	44.2±6.8
	125			0.07±0.2	0.1±0.2	0.7± 0.2	16.3±2.3	34.6±15.2
	200	0.13±0.35	1.9±9.6	0.08±0.2	0.1±0.2	1±1.33	20.6±2.3	69.5±15.2
	300							
Sex	M						14.4±0.7	30.3±5.0
	F						14.8±0.8	35.7±5.2
L. cavillone								
Region	R1	0.11±0.11	0.7±0.2	1.1±2.1	1.1±2.2	1.19±0.35	9.1±0.1	9.5±0.5
	R2	0.43±0.12	1.2±0.2	8.1±2.2	7.3±2.4	1.25±0.32	8.8±0.1	9.2±0.1
	R3	0.53±0.11	1.4±0.2	7.5±2.1	7.6±2.3	1.54±0.29	9.9±0.1	12.7±0.2
Season	M	0.26±0.12	0.7±0.2	1.9±2.3	1.6±2.4	1.44±0.46	10.2±0.1	13.6±0.4
	A	0.63±0.14	1.6±0.3	9.3±2.6	9.9±2.7	1.13±0.34	9.3±0.1	10.9±0.2
	O	0.34±0.13	1.2±0.2	7.2±2.3	6.3±2.5	1.34±0.31	9.0±0.1	9.9±0.2
	F	0.22±0.13	0.9±0.3	3.2±2.4	3.5±2.6	1.36±0.39	9.4±0.1	10.4±0.3

Table 2. Continued

Depth	10	0.005±0.14	0.1±0.2	0.06±2.7		1.00±0.99	9.3±1.0	10.9±3.6
	25	0.007±0.15	0.1±0.3	0.07±2.9	0.1±3.1	0.25±0.99	8.4±0.6	7.1±2.1
	75	0.62±0.14	1.9±0.3	10.5±2.8	10±2.9	1.41±0.33	8.6±0.1	8.4±0.1
	125	0.79±0.15	2.1±0.3	10.3±2.9	12.1±3.1	0.83±0.33	9.6±0.1	11.5±0.2
	200	0.39±0.16	1.5±0.3	5.9±3.0	4.8±3.2	1.70±0.35	9.8±0.1	12.4±0.3
	300	0.31±0.19	0.7±0.4	2.8±3.7	2.7±3.9	1.01±0.70	11.8±0.1	20.6±0.5
Sex	M						9.4±0.14	11.2±0.2
	F						9.5±0.1	11.4±0.2
L. dieuzeidei								
Region	R1	2.04±7.08	121.7±324.3	2.9±1.6	2.3±1.5	4.10±2.01	11.0±0.1	16.7±0.4
	R2	0.31±7.52	49.3±344.8	0.5±1.7	0.8±1.6	0.68±3.18	8.8±0.2	9.1±0.8
	R3	18.42±7.22	891.3±330.7	3.7±1.6	4.2±1.5	0.96±2.01	11.1±0.1	17.5±0.3
Season	M							
	A	2.86±8.87	190.4±406.8	4.2±2.0	2.9±1.8	1.34±2.31	10.9±0.1	16.7±0.4
	O	14.49±7.98	640.4±366.0	2.2±1.8	2.6±1.6	0.89±2.67	11.2±0.1	19.1±0.5
	F	8.83±8.39	520.7±384.8	3.3±1.9	4.3±1.7	3.73±2.07	10.4±0.1	14.0±0.4
Depth	10							
	25							
	75							
	125							
	200	2.36±9.44	239.5±425.8	4.3±2.0	3.7±1.6	3.59±1.78	9.4±0.1	10.8±0.4
	300	61.57±11.56	2963.4±521.5	16.3±2.5	17.8±2.0	0.86±1.78	11.4±0.1	18.6±0.2
Sex	M						10.8±0.1	16.3±0.4
	F						11.0±0.1	16.9±0.4
T. lyra								
Region		ID	ID	ID	ID	ID	ID	ID
Season		ID	ID	ID	ID	ID	ID	ID
Depth		ID	ID	ID	ID	ID	ID	ID
Sex		ID	ID	ID	ID	ID	ID	ID
C. lastoviza								
Region	R1	0.11±1.35	5.2±46.0	0.1±0.5	0.1±0.8	4±5.46	12.0±0.9	21.3±6.5
	R2	2.64±1.44	125.4±48.9	1.8±0.6	2.2±0.9	1.06±1.82	11.8±0.2	19.9±1.4
	R3	5.73±1.38	151.0±46.9	2.0±0.5	2.8±0.8	2.57±1.57	14.6±0.2	36.3±1.3
Season	M	1.34±1.50	49.0±50.3	0.8±0.6	0.6±0.9	1.41±2.10	13.6±0.4	29.0±3.0
	A	5.76±1.71	191.1±57.3	2.2±0.7	3.6±1.0	0.37±2.57	13.1±0.2	27.7±1.5
	O	3.11±1.54	95±51.5	1.3±0.6	1.8±0.9	0.98±1.81	13.5±0.3	30.4±2.1
	F	0.75±1.62	26.7±54.2	0.6±0.7	0.4±1.0	6.65±2.57	12.7±0.5	25.5±3.7
Depth	10	0.04±1.70	1.3±55.4		0.1±1.0		14.5±2.5	31.0±16.5
	25	0.76±1.83	22.6±59.5	0.6±0.7	0.5±1.1	1.00±3.32	14.2±0.6	32.3±4.1
	75	8.33±1.76	317.7±57.3	4.1±0.7	5±1.0	1.31±2.03	12.4±0.2	23.2±1.3
	125	3.27±1.83	76.6±59.5	1.3±0.7	1.5±1.1	5.33±2.57	15.3±0.4	40.7±2.6
	200	0.13±1.90	1.9±61.9		0.1±1.1		16.3±1.8	48.5±11.6
	300							
Sex	M						13.4±0.2	28.8±1.5
	F						13.9±0.2	32.6±1.7

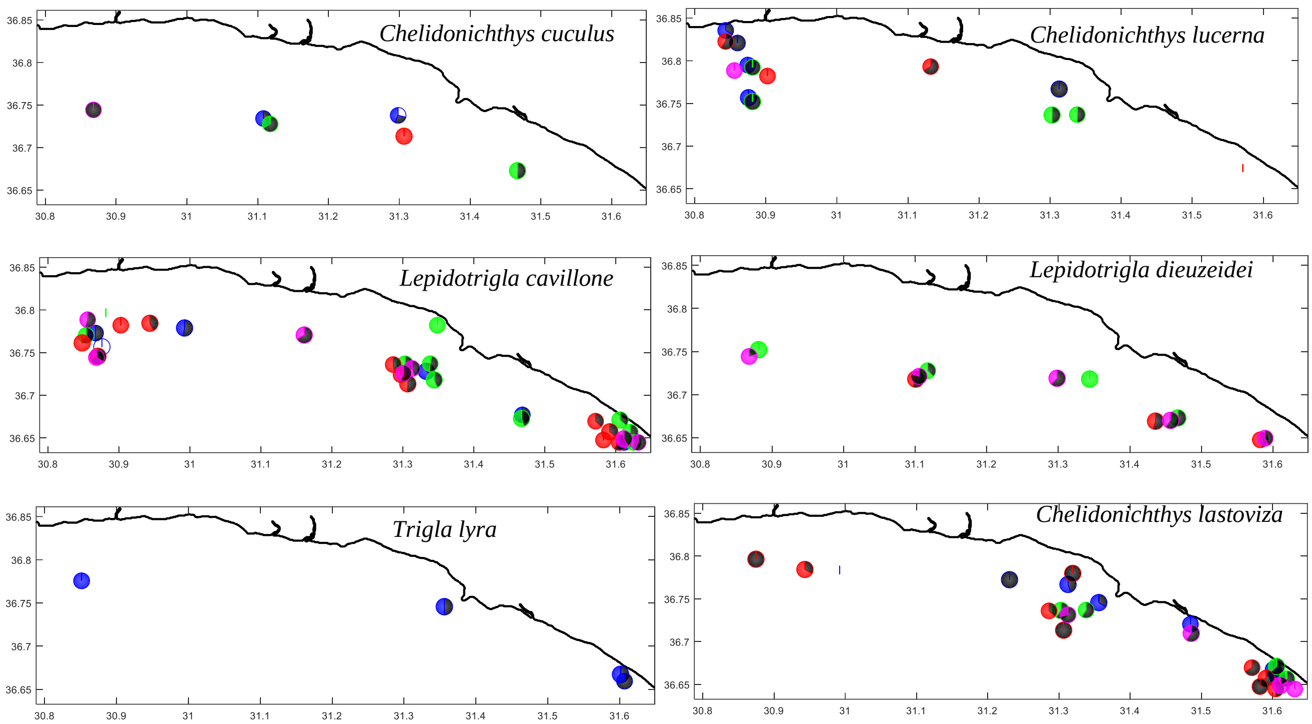

Figure 3. Spatiotemporal of percent sex composition within the circle. Color of circle edge shows season (Blue denotes May, red August, green October and magenta February) and color in circle denotes percent pie of male (black), female (seasonal color) and juvenile or identified sex (white)

Overall, there were significant differences in the length among each of the regions, seasons and bottom depths ($p < 0.05$; Table 3). However, there was no significant regional difference in the length for *C. lucerna* and seasonal difference for *C. lastoviza* (Table 3). Average length of all species increased with the bottom depths. In general, the length was significantly larger in R3 (unfished zone) than that in R1-R2 (Table 2). The larger specimens occurred in October for *C. cuculus*, in February for *C. lucerna*, in May for *L. cavillone*, in October for *L. dieuzeidei*, and in May for *C. lastoviza* (Table 3, Fig. 5).

Regarding to individual maximum weight, heavy species (W> 100 g) were *C. cuculus*, *C. lucerna* and *C. lastoviza*. The rest was lighter fish (W<50 g) (Fig. 6). Only *L. cavillone* and *L. dieudeidae* differed in individual weight significantly among all factors of regions, seasons and bottom depths (Table 3). Individual weight of *C. cuculus* was significantly differentiated by region and season, *C. lucerna* by season and depth, and *L. dieuzeidei* by region and depth (Table 3). Individual weight increased with bottom depths, and heavier specimens occurred in R3 (non-fishing zone, Fig. 1). Specifically, seasonally, species which had heavier specimens in the summer was *C. cuculus*, *L. cavillone*, in the autumn was *L. dieuzeidei* and *C. lastoviza*, and in the winter was *C. lucerna*. Secondary peak in the weight occurred in the winter for *L. cavillone* and spring for *C. lastoviza* (Table 2).

There was no significant sexual dimorphism in size (length and weight) for *C. lucerna*. Only the length of *C. cuculus* was significantly longer in females than males. The rest of the species had sexual dimorphism in sizes, females being longer and heavier than the males (Tables 2, 3, Fig. 6).

Regarding to statistical rejection (t-test) of the null hypothesis (H_0) for Pearson correlation (H_0: r=0), intercept (H_0: a=0) and slope (H_0: b=0) of regression, the length-weight relationships were significantly established using a power fit model of the regression (Fig. 6). ANOCOVA analysis showed that the LWR was significantly different among the sexes for only *L. dieuzeidei* at $p < 0.05$ (Table 3). Regional differences in the LWR occurred for *C. cuculus*, seasonal difference for *L. cavillone* and *L. dieuzeidei*, and depth-wise difference for *L. dieuzeidei* (Table 3).

Table 3. ANOVA results of the biomass (B), abundance (A) of combined specimens, females (F) and males (M), female/male abundance ratio (F/M), length (L), weight (W) and length-weight relationship (LWR) in space (region and bottom depth) and time (season) and sex only for L, W and LWR with the growth type; I: isometric growth, P: positive allometry and N: negative allometry. LWR was tested using ANOCOVA test. ID: insufficient data for the species, and empty cells denote no occurrence of species at the factor

Species	B	A	F	M	F/M	L	W	LWR
C. cuculus								
Region	0.5861	0.6022	0.6533	0.4541	0.9365	**0.0000**	**0.0000**	**0.0395**
Season	0.4272	0.3944	0.3655	0.4063	0.3969	**0.0001**	**0.0001**	0.4813
Depth	0.2723	0.2796	0.1483	**0.0243**	ID	**0.0246**	0.1486	
Sex						**0.0221**	0.4900	0.181 (N)
C. lucerna								
Region	0.1259	**0.0462**	**0.0489**	0.1202	0.6012	0.2754	0.5497	0.8424
Season	0.1985	0.1957	0.5112	0.5362	0.8203	**0.0000**	**0.0001**	
Depth	0.5204	0.3206	0.3368	0.5472	0.6693	**0.0177**	**0.0334**	
Sex						0.2264	0.2162	0.078 (I)
L. cavillone								
Region	0.5642	0.5317	0.0824	0.1579	0.5888	**0.0000**	**0.0000**	0.0982
Season	0.1583	0.1584	0.1294	0.1427	0.9445	**0.0000**	**0.0000**	**0.0045**
Depth	0.4035	0.4205	0.0574	0.0702	0.4175	**0.0000**	**0.0000**	**0.0009**
Sex						**0.0000**	**0.0000**	0.639 (P)
L. dieudeidae								
Region	0.2739	0.2542	0.5381	0.4310	0.5002	**0.0000**	**0.0000**	0.1601
Season	0.5867	0.5890	0.4249	0.3324	0.6432	**0.0000**	**0.0000**	**0.0024**
Depth	**0.0022**	**0.0008**	**0.0000**	**0.0000**	0.3052	**0.0000**	**0.0000**	0.4284
Sex						**0.0000**	**0.0087**	**0.014** (P)
T. lyra								
Region	ID	ID	ID	ID	ID	ID	ID	ID
Season	ID	ID	ID	ID	ID	ID	ID	ID
Depth	ID	ID	ID	ID	ID	ID	ID	ID
Sex	ID	ID	ID	ID	ID	ID	ID	0.992 (N)
C. lastoviza								
Region	**0.0333**	0.1110	0.0817	0.1044	0.7701	**0.0000**	**0.0000**	0.9307
Season	0.1492	0.1723	0.3970	0.1240	0.2887	0.5292	0.6333	
Depth	**0.0066**	**0.0017**	**0.0016**	**0.0065**	0.8482	**0.0000**	**0.0000**	
Sex						**0.0000**	**0.0000**	0.680 (I)

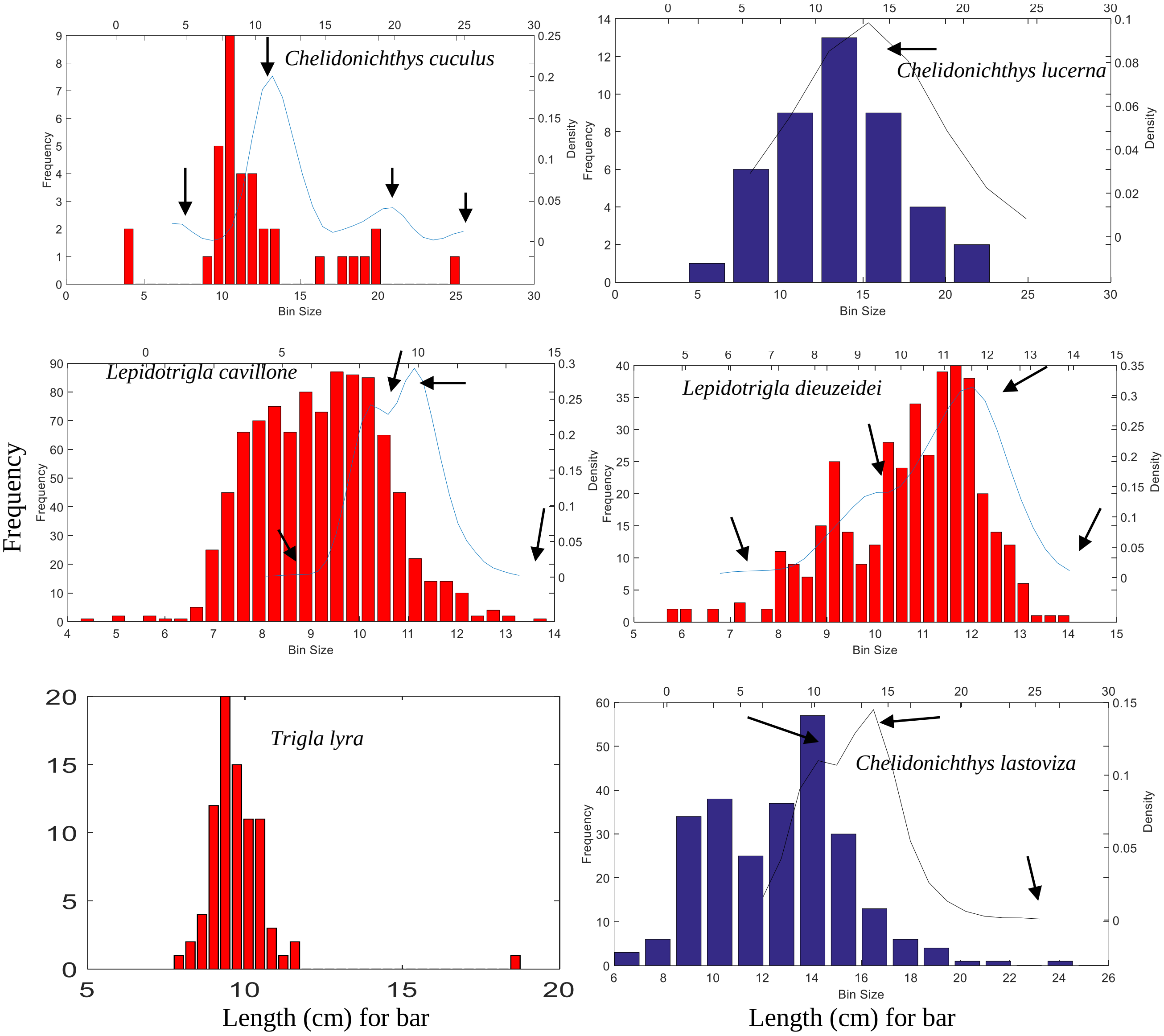

Figure 4. Annual length frequency histograms of the gurnard species. Bin size means length class in cm. Curves shows modal length classes derived from the kernel density function. Arrow showed cohort in mode of the size

Species which had isometric growth was *C. lucerna* and *C. lastoviza*, negative allometry was found for *C. cuculus* and *T. lyra*, and positive allometry for *L. cavillone* and *L. dieuzeidei*; females showed positive allometry, and males had isometric growth (Table 3, Fig. 6).

Ecological distribution in space and time

Regarding to species-abiotic environment relation, six gurnard species was assembled and positively correlated with the bottom depth and negatively correlated with the bottom type (coarse to fine material of sediment from coast to open water bottom) on CCA1 axis (Table 4, Fig. 7a). There was a shelf species community (bottom depth < 200 m) and a deep water community (bottom depth ≥ 200 m): *C. cuculus* and *L. dieuzeidei*, respectively. Shelf species community was separated with two depth segmentations: shallow water (bottom depth < 75 m) but abundantly found at the shallowest depth: *C. lucerna* and ubiquitous shelf species but abundantly found at middle depth (bottom depth >75 m till 125 m): *L. cavillone* and *C. lastoviza* (Table 2, Fig. 7a). On CCA1, there were slight negative correlations between fish species-limited environment relation (chl-*a* and fine bioseston) (Table 4, Fig. 7a). However, season and region did not dictate the gurnard community (Fig. 7b, c). The CCA1 was statistically proved with Monte Carlo test (F: 8.639, p: 0.0020). This co-linearity and correlation on CCA1 was elucidated with a percent variance of 34.0 (Table 4).

On CCA2, the species community was governed with positive effect of constitutes of total suspended matter (all fractions of seston and fine materials of tripton) and negative effect of concentrations of sea surface and subsurface chl-*a* (Table 4, Fig. 7a). However, physical environments were not correlated with co-linearity by the species. All CCA axes were statistically proved with Monte Carlo test (F: 2.175, p: 0.0020). The species-environment relation on CCA2 was discriminated with an explained percent variance of 23.5 of the total variance (Table 4).

Regarding to species-biotic environment relation with the mega-benthic fauna, the species community was positively correlated with specimens of decapoda and holothuroidea on CCA1 (Table 5, Fig. 7d). The CCA1 was not significantly validated with Monte Carlo test (F: 7.659, p: 0.0640). This co-linearity and correlation on CCA1 was elucidated with a percent variance of 43.0 of the total variance (Table 5). On CCA2, there was positive correlation between the gurnard species and Crinoidea, followed by Ophiuridea (Table 5, Fig. 7d). The species-environment relation on CCA2 was discriminated with an explained percent cumulative variance of 72.5 of the total variance (Table 5). All CCA axes were statistically proved with Monte Carlo test (F: 1.643, p: 0.0340).

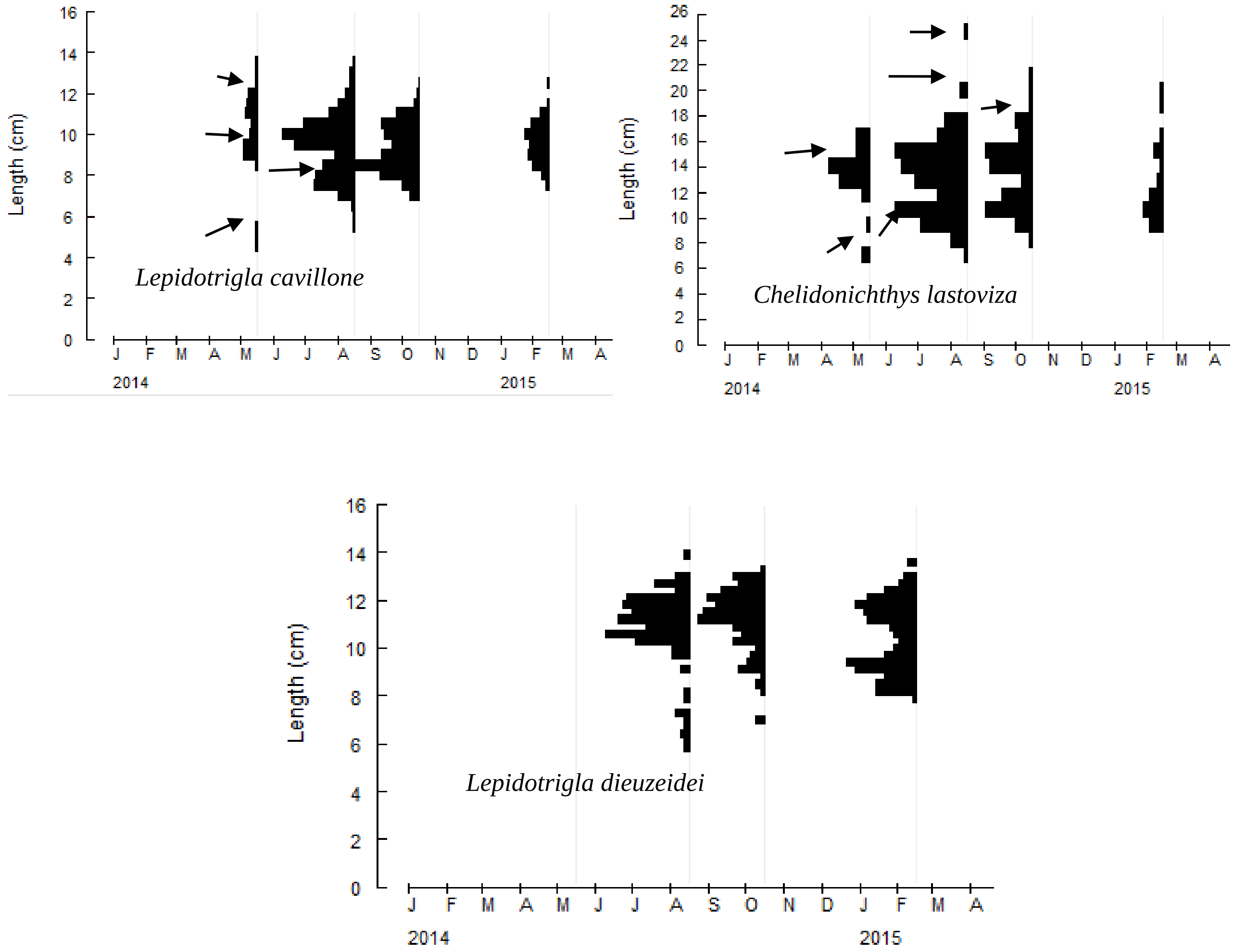

Figure 5. Temporal distribution of total length-frequency data of three abundant gurnard species caught in the present study area. Arrow shows size cohort mode

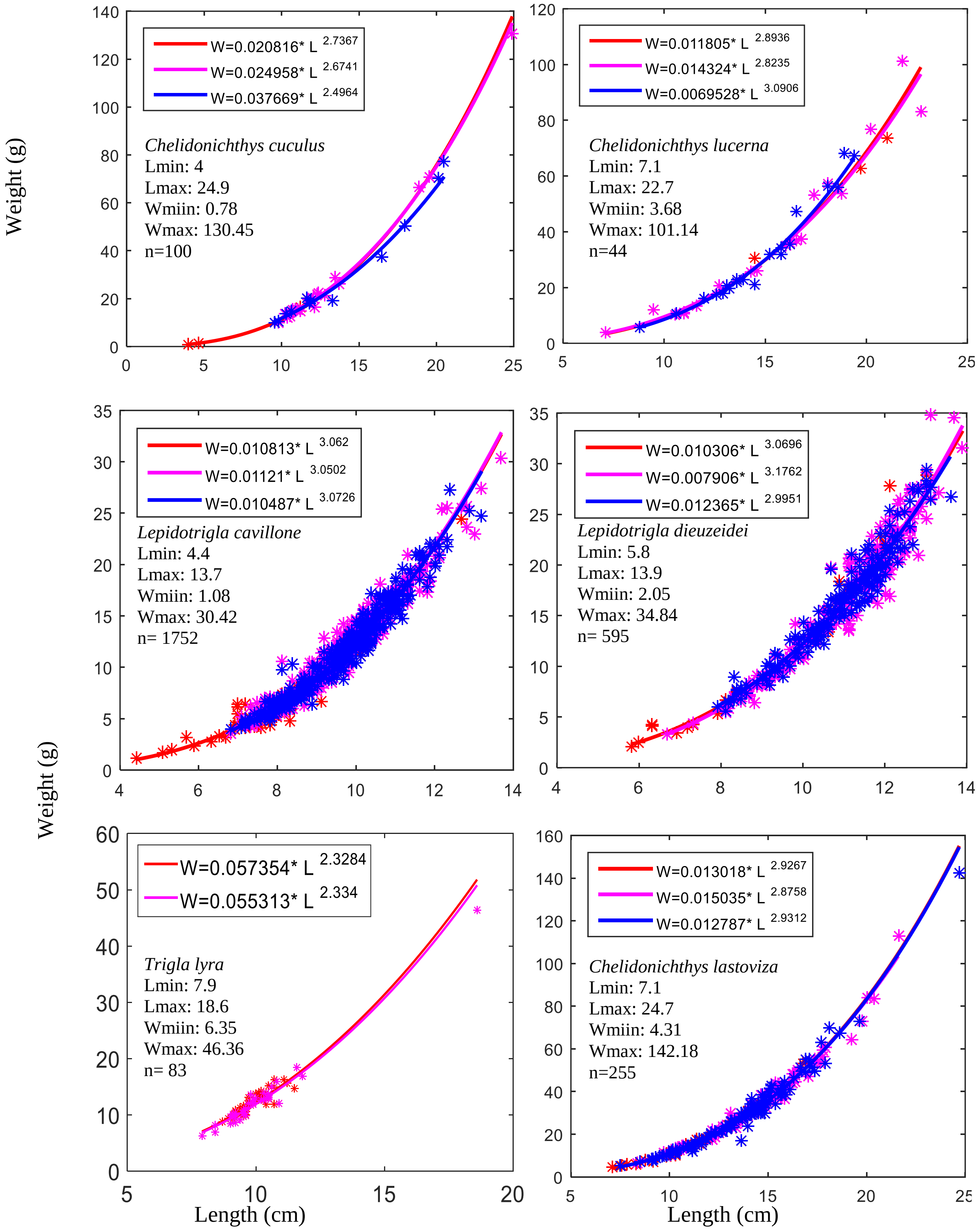

Figure 6. Length-weight relationships of the gurnard species. Females in pink, males in blue, combined specimens including unsexed individuals also in red. n is number of individuals

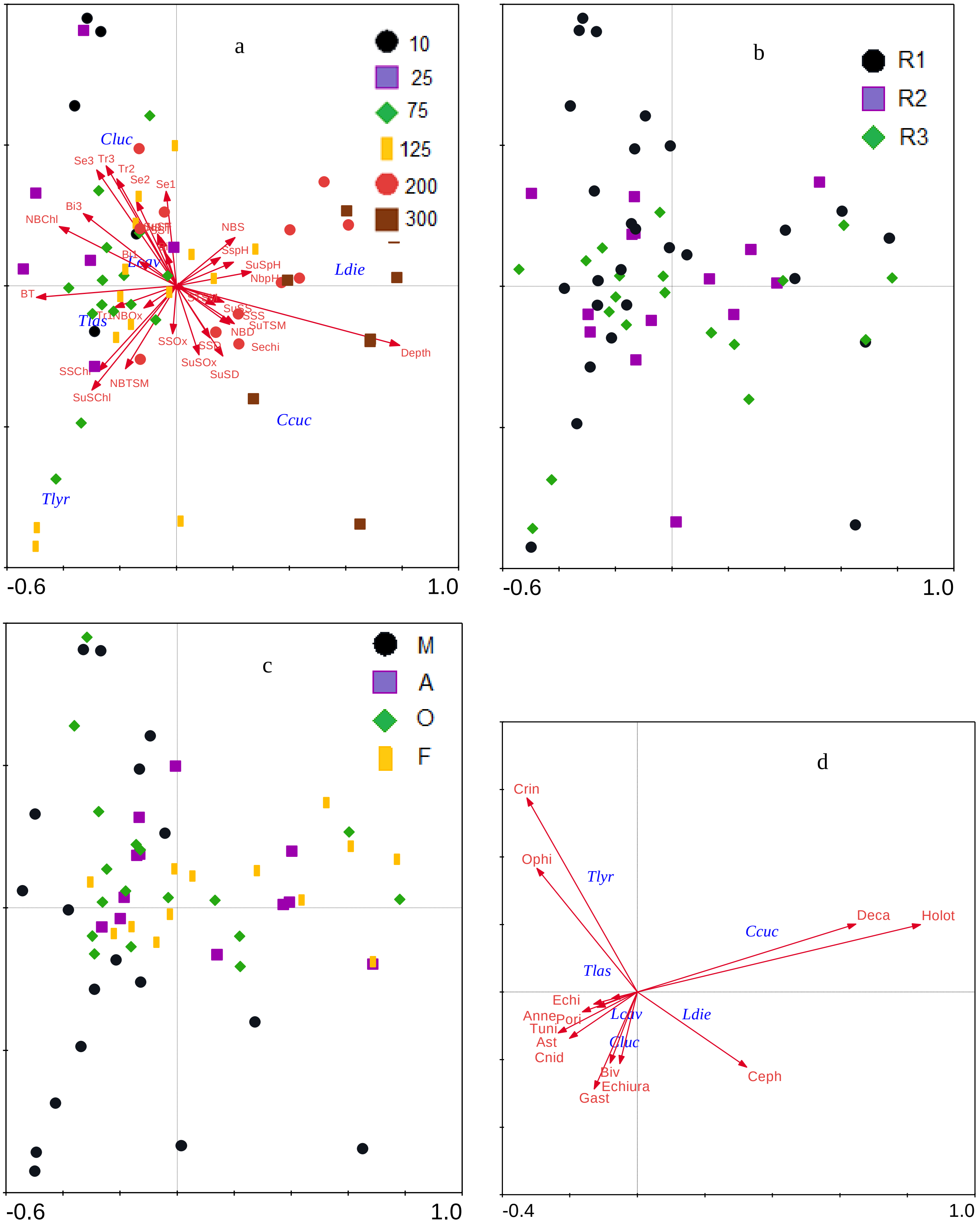

Figure 7. Triplot of Canonical Correspondence Analyses (CCA) of the gurnard fishes' log10-transfomed abundance in trawls classified by the bottom depth (a), region (b) and season (c) with the environmental parameters and megafaunal abundance (d) (see Table 1 for the abbreviations of the fish species and Table 4 for environmental parameters, and Table 5 for the megafaunal species abbreviations)

Table 4. Summary of statistical measures of the characteristics of gurnard abundance in relation to the environmental variables for the CCA. Environmental parameters with the abbreviations used in statistical analyses (prefixes for the abbreviations: SS, sea surface, Su; subsurface and NB; near-bottom water)

Variables	Abb	CCA1	CCA2
Bottom depth (m)	Depth	**0.7481**	-0.1842
Total Suspended Matter (g/m^3)	STSM	0.0323	-0.0121
Total Suspended Matter (g/m^3)	SuTSM	0.1311	-0.0592
Total Suspended Matter (g/m^3)	NBTSM	-0.1703	-0.2572
Secchi disk depth (m)	Sechi	0.1941	-0.1178
Oxygen (mg/l)	SSOx	-0.0125	-0.1483
Oxygen (mg/l)	SuSOx	0.0759	-0.2138
Oxygen (mg/l)	NBOx	-0.1086	-0.0689
Temperature (°C)	SST	-0.0518	0.1502
Temperature (°C)	SuST	-0.0631	0.1608
Temperature (°C)	NBT	-0.0621	0.1591
Salinity (PSU)	SSS	0.1594	-0.0507
Salinity (PSU)	SuSS	0.1530	-0.0460
Salinity (PSU)	NBS	0.1959	0.1504
pH	SspH	0.1478	0.0886
pH	SuSpH	0.1914	0.0740
pH	NbpH	0.2513	0.0438
Density, σ_t	SSD	0.1125	-0.1613
Density, σ_t	SuSD	0.1556	-0.2174
Density, σ_t	NBD	0.1782	-0.1190
Chl-*a* (mg/l)	SSChl	-0.2610	**-0.2648**
Chl-*a* (mg/l)	SuSChl	-0.2824	**-0.3233**
Chl-*a* (mg/l)	NBChl	**-0.3922**	0.1841
Seston - 1 mm (g/m^3)	Se1	-0.0342	**0.2934**
Seston – 0.5 mm (g/m^3)	Se2	-0.1337	**0.2639**
Seston – 0.063 mm (g/m^3)	Se3	-0.2670	**0.3594**
Bioseston - 1 mm (g/m^3)	Bi1	-0.1237	0.0754
Bioseston – 0.5 mm (g/m^3)	Bi2	-0.0334	0.0985
Bioseston – 0.063 mm (g/m^3)	Bi3	**-0.3113**	0.2244
Tripton – 1 mm (g/m^3)	Tr1	-0.2072	-0.0671
Tripton – 0.5 mm (g/m^3)	Tr2	-0.1993	**0.3318**
Tripton – 0.063 mm (g/m^3)	Tr3	-0.2357	**0.3723**
Bottom types (see Fig. 1b)	BT	**-0.4693**	-0.0355
Eigenvalues :		0.703	0.487
Species-environment correlations :		0.945	0.873
Cumulative percentage variance			
of species data :		24.9	42.2
of species-environment relation:		34.0	57.5

Table 5. Summary of statistical measures of the characteristics of gurnard species abundance in relation to the mega-benthic fauna abundances for the CCA

Taxa	Abb	CCA1	CCA2
Decapoda	Deca	**0.4870**	0.1331
Annelida	Anne	-0.0895	-0.0301
Cnidaria	Cnid	-0.1514	-0.0903
Echinodermata,Asteroidea	Ast	-0.1766	-0.0801
Echinodermata,Crinoidea	Crin	-0.2463	**0.3802**
Echinodermata,Echinoidea	Echi	-0.0571	-0.0127
Echinodermata,Holoturidea	Holot	**0.6311**	0.1324
Echinodermata,Ophiuridea	Ophi	-0.2241	**0.2424**
Echiura	Echiura	-0.0393	-0.1402
Mollusca,Bivalvia	Biv	-0.0609	-0.1389
Mollusca,Cephalopoda	Ceph	0.2437	-0.1469
Mollusca,Gastropoda	Gast	-0.0961	-0.1899
Porifera	Pori	-0.0975	-0.0237
Tunicata	Tuni	-0.1226	-0.0387
Eigenvalues :		0.410	0.281
Species-environment correlations :		0.753	0.661
Cumulative percentage variance			
of species data :		4.5	24.5
of species-environment relation:		43.0	72.5

Discussion

Biomass estimation is of paramount importance in the stock assessment of aquatic organisms, particularly fish, as it allows extrapolation or interpolation of biomass to both non-stratified and stratified areas under investigation. Gurnards are particularly suitable for stock assessment and biomass estimation as they are true demersal fish, not semi-demersal. This makes them ideal for efficient sampling with bottom trawls. However, the species could be highly influenced by trawl fisheries. For instance, *L. cavillone* highly contributed to fishing effort levels in the trawl fishery in the western Mediterranean Sea (Farriols et al., 2017). Gurnards were considered discard fishes before. In Greek waters (Ionian Sea and Aegean Sea), about 39%-49% (with a mean of 44%) of the total catch (vertebrates and invertebrates) by bottom trawls was discarded including only *L. dieuzeidei* (Machias et al., 2001). *L. cavillone* (3.14% of the total catch) and *T. lyra* (0.17%) were discarded in the Aegean Sea (Damalas et al., 2010). After gurnards became the target species in demersal fisheries, their abundance was studied. *C. cuculus* and *T. lastoviza* are important species as by-catch in the western Mediterranean (Ordines et al., 2014). *C. cuculus* had a relative dominance of 26.3% in the Croatian waters, Adriatic Sea, at depths extending to 500 m (Vallisneri et al., 2014) which was deeper than the maximum sampling depth (300 m) in the present study.

Of the total number of 8 gurnard species belonging to 4 genera reported from the Mediterranean Sea (Colloca et al., 2019) and 6-8 species in the eastern Mediterranean Sea with 6 species in Greek waters (Terrats et al., 2019) and 8 species in the Turkish seas (Bilecenoğlu and Taşkavak, 1999) and Levant waters (Bilecenoğlu et al., 2014), 6 species were detected on the bottom of shelf (10-200 m) /shelf break (300 m) zone in the Antalya Gulf. In the sea of Marmara, five gurnard species were updated to 7 species recently (Daban et al., 2021; Bilecenoğlu 2024), eight species in the Turkish Aegean Sea and three species in the southern Black Sea were reported (Bilecenoğlu, 2024). The same species reported in the present study were also found in Cretan waters (Tsimenides et al., 1992). Common species distributed over the study area were dominant species such as *L. cavillone* and *C. lastoviza* occurred in the Antalya Gulf whereas *C. cuculus* and *L. dieuzeidei* preferred substantially greater depths (> 125 m). *L. cavillone*, which was found at 30 m - 330 m, was the most common species in the Mediterranean Sea (Collaco et al., 1997). However, *T. lyra* was encountered once in the spring (May). This could be due to the rare occurrence of the species or seasonal ontogenic migration toward deeper waters than our sampling depths. In the Aegean Sea and the Sea of Marmara, abundance of *T. lyra* increased at depths down to 200 m (Damalas et al., 2010 and Daban et al., 2021), followed by a decrease at greater depths (Damalas et al., 2010). *L. cavillone* was found as the third dominant species among demersal fish on the continental shelf of the Gulf of Lions (north-western Mediterranean Sea) (Merigot et al., 2007). *C. cuculus* was distributed at depths of 70-235 m (DO%: 29-36%), *L. cavillone* at 41-167 m (30-49%), *C. lucerna* at 70-74 m (2%), and *T. lyra* at 103-416 m (17-30%) around Balearic Islands (Massuti and Renones 2005). In Greek waters, *C. cuculus* (5-30 cm in length) were distributed at depths of 97-298 m, *T. lastoviza* (5-25 cm; two size classes) at 32 -191 m, and *L. cavillone* (4-14 cm) at 54-216 m (Terrats et al., 2000). In Saros Gulf, five gurnard species were reported, four of which were the same species reported in the present study with the exception of *C. cuculus*, and they accounted for 3.4% of the total catch (Ihsanoglu et al., 2016). All five species were abundantly found at depths of 50-100 m, and followed a decreasing trend as a factor of depth down to 500 m (Ihsanoglu et al., 2016). *T. lyra* was mostly found between 100 - 200 m in the Sea of Marmara (Şirin et al., 2024).

Regardless of species' preference of depth, small-sized gurnard (*L. cavillone* and *L. dieuzeidei*) specimens (L<15 cm, Mutlu et al., 2022a) were numerically abundant and dominant in the gurnard population while larger specimens were less abundant relative to their corresponding biomass. With high abundance in coastal waters, Vallisneri et al., (2011) estimated three size classes (5-15 cm, 15-32 cm, and >32 cm in range of 6.3-41.5 cm with a mean of 20.8 cm) of *C. lucerna* in the Adriatic Sea, which included more size classes than our estimate (5-23 cm). This could be due to the habitat preference of *C. lucerna* for sand bottoms (Tunesi et al., 2006); R2-R3 were covered by *P. oceanica*, and R1 was bare bottom in the present study area (Levantine Sea). Differences in size classes between the two studies could also be attributed to variations in the trophic levels of the two seas. Similar to our estimates, *L. cavillone* had four modal size classes in Sicilian waters (Ragonese and Bianchini, 2010).

Some of the gurnards exhibited transect-wise difference in density within the study area. R3 had higher mean abundance and biomass than the species dominant in R1-R2. R3 is a non-fishing zone closed to the trawl fishery. Such marine protected areas sustain the stock of the species such as *C. lucerna* and *C. lastoviza*. *T. lyra* and *C. lucerna* had CPUE higher in the Sea of Marmara than our estimates whereas the rest of the species had similar CPUE in comparison (Daban et al., 2021). In Türkiye, the 2-nautical mile (nm) area from the coast is closed to fishery, but open to artisanal fishery, the 12 nm border is the open fishery area seaward, accessible year-around. Notably, the 2 nm area has been updated to 3 nm, recently (Deval and Mutlu, 2024). Antalya Gulf is one of the oligotrophic basins of the Mediterranean Sea (Sisma-Ventura et al., 2017). Therefore, Coll et al (2010 classified Antalya as a low-diversity area in terms of cartilaginous fishes. Recently, Deval and Mutlu (2024) have upgraded the number of cartilaginous species for the Antalya Gulf. de Meo et al., (2018) detected 147 fishes, Patania and Mutlu (2021) 59 megabenthic crustaceans and Garuti and Mutlu (2021) 90 non-crustacean megabenthic species in the present study. The Gulf of Antalya is fished by 16 trawlers that operate in the study area annually during the fishing season. The fishing fleet concentrates in the area between the two-mile limit and the 200-meter isobaths, mainly in the R1-R2 region. The specific fishing effort is 2.6 hours per day per boat (9310 hours in total) during the fishing season (Mutlu et al., 2022b). This fishing pressure suggested that unprotected area (R1-R2) could be affected by the artisanal fishery during ontogenic distribution of the reproduction period and biological cycle of the gurnards (e.g. Colloca et al., 1997; Boudaya et al., 2008; Dobroslavić et al., 2021). Similarly, *L. cavillone* dominating the middle shelf had higher abundance in the summer than the spring in the central Tyrrhenian Sea (Collaco et al., 1997).

For many taxa of the nektonic or benthic organisms, bottom depth segmentation is valid for restricting their spatial distribution and the bottom depth, followed by season, is a primary factor influencing their distribution. The shelf is generally segmented with classification of lower (depth ≤ 25 m) shelf, middle shelf (25-125 m) and upper shelf (> 125 m) for fish (de Meo et al., 2018), megabenthic fauna (Patania and Mutlu 2021; Garuti and Mutlu 2021) and macro benthic fauna (Mutlu and Ergev 2008, 2012, 2013; Mutlu et al., 2010; Mutlu, 2015) in the Levantine Sea. Besides, the ubiquitous species can peak at certain depth intervals with their density distribution varying during different seasons of the year. In Cretan shelf/slope bottoms, *C. lastoviza* was the contributor species to fish assemblage at 50 m, and *L. cavillone* at 100 m with 5% of the density (Kallianiotis et al., 2000). *L. cavillone* was one of the abundant species in the middle shelf of the central Mediterranean Sea (Collaco et al., 2003). This resulted in depth-wise differences in the density of a species both on the shelf, and along the shelf slope. A study conducted at the shallower waters (<10 m) of the Gulf of Fos, France in 1983-1985 by Letourneur et al., (2001) showed similar mean abundance and biomass of *L. cavillone* and *C. lucerna* to those observed at corresponding depths in our study.

In the present study, the morphometry of the gurnards was overall differentiated by the bottom depth, season and sex of the specimens. Additionally, regional differences were observed, with larger and heavier specimens found in the protected area (R3) compared to the unprotected area (R1-R2). Morphometry can be influenced by several factors and stressors in the marine environment, i.e. bottom depth geographical coordinate, physical variables, and sex of specimens of fish etc on a broad scale, and season, physicochemical variables, food availability, habitat types, trophic level, occurrence of non-indigenous and indigenous species, and Levantine nanism, depending on biology and reproduction demands of the species (Mutlu et al., 2023) etc on a fine scale in loci such as the present study area. Coastal waters of R2 and R3 featured a habitat type with seagrass meadow (Mutlu et al., 2022c) and R1 and R2 had two dominant seaweeds (Mutlu et al., 2022d). For instance, *C. lucerna* preferred sandy bottoms among four different bottom types including *P. oceanica* (Tunesi et al., 2006) and similarly, we found the species to be abundant at R1, an unvegetated bottom with *P. oceanica*. Farre et al., (2016) concluded that morphospaces exhibited lower richness of body forms for demersal fish assemblages, including gurnards having negative morphospace values (elongated shapes) with increasing depth in the western Mediterranean Sea. Larger specimens (L>7.5 cm) of *L. cavillone* was dominant in the spring when maturity decreased with depth and peaked at the middle shelf. In contrast, smaller specimens (L ≤ 7.5 cm) were more abundant in the summer in the central Tyrrhenian Sea, with length decreasing with depth (Collaco et al., 1997). Despite difference in size classes between the Adriatic Sea (Vallisneri et al., 2011) and Levantine Sea (the present study), *C. lucerna* had similar length-weight relationships for sexed and unsexed specimens. In İzmir Gulf (Aegean Sea), all morphometry and their relationship were overestimated compared to our estimates (İlhan and Toğulga 2007). However, *L. dieuzeidei* had similar size structure and relationship between the Adriatic Sea (Dobroslavić et al., 2021) and Antalya Gulf. *C. lastoviza* had similar length range in both Antalya Gulf and Egyptian Mediteraanean waters with slightly higher slope in LWR in comparison, and both populations showed isometric growth (Mehanna, 2022), but had higher size structure in the Saronikos Gulf in 1980s (Papaconstantinou, 1986). In Iskenderun Gulf, characterized by high fishing pressure and eutrophic region, *C. lucerna* had similar size range and growth type (İşmen et al., 2004) to our estimates which had lower size structure values compared to the Tunisian waters (Boudaya et al., 2008), but had higher size structure values in the Thermaikos Gulf in 1980s (Papaconstantinou, 1984) and in the Sea of Marmara (Eryilmaz and Meriç, 2005). Even if there were similar size ranges of *C. cuculus* between the Croatian and Antalya Gulf, slopes (positive allometry) of the LWR was rather higher than our estimates (negative allometry), resulting in different growth types with high abundance in the Adriatic Sea (Vallisneri et al., 2014). All four common species excluding *C. cuculus,* had longer body size in Saros Gulf, Aegean Sea compared to the the present study area, with nearly higher slopes in the LWR (Ihsanoglu et al., 2016). Asimilar comparison was observed with gurnards in Edremit Gulf, Aegean Sea (Uçkun, 2005).

Ecological studies on fishes are highly limited in the literature, and existing studies cover a wide range of the stratified bottom depths as fishery biologists have not considered measuring certain specific environmental variables. In general, only basic physical parameters (temperature and salinity) were reported. With limited environmental variables such CTD (temperature and salinity), the first ecological study performed on gurnards was conducted in the Cretan waters (Tsimenides et al., 1992). In Türkiye, there are few studies on ecology that include comprehensive environmental parameters. (de Meo et al., 2018; Daban et al., 2021). Ecological studies at the family level are important to elucidate the patterns of the most abundant and dominant species within the same family (Mutlu et al., 2021, 2022b, e, f). Specimens of *L. cavillone* in Izmir Gulf showed similar size structure to our estimates (Türker et al., 2010).

Regarding to diet of the gurnards for the species-megabenthic fauna relation, *C. lucerna* fed mostly on Brachyura, *C. lastoviza* on Mysidacea, followed by Brachyura, *L cavillone* on Mysidacea, followed by Amphipoda, and *T. lyra* on Gastropoda, followed by Brachyura in the Edremit Gulf, Aegean Sea (İlhan 2019). In the Greek waters, *C. cuculus* fed mainly on Mysidacea and Euphausiacea, *T. lastoviza* and *L. cavillone* mainly on Mysidacea (Terrats et al.,, 2000) and *T. lyra* on Mysidacea (Caragitso and Papaconstantinou. 1994). *C. lastoviza* fed on crustaceans, mostly mysids and decapods in the Tunisian watres (Boudaya et al., 2007). Both, *C. cuculus* and *C. lucerna* feed mostly on crustaceans in the Adriatic Sea (Montanini et al., 2017) and *C. lucerna* on crustaceans (Decapoda: Brachyura) in the Italian Adriatic waters (Stagioni et al., 2012). In the present study, deep-water gurnard species (*C. cuculus* and *L. dieuzeidei*) were correlated with decapods and specimens of Holothuroidea which increased with depth.

In conclusion, of the 8 gurnard species reported in the Turkish marine waters, 6 species were found on the shelf/shelf break in the present study. The most dominant species were *L. cavillone* and *C. lastoviza* and there were no consistently present gurnard species in the study area. The abundantly found species were *L. cavillone* and *L. dieuzeidei*. Gurnards were very low in number and biomass as compared to other 165 species found in the present study. Shallow and middle shelf water gurnard species was *C. lucerna* distributed at 10-75 m, ubiquitous shelf species *C. lastoviza* at 10-200 m, deep shelf species *T. lyra* at 100-125 m, deep shelf/break species *C. cuculus* at 125-300 m and *L. dieuzeidei* at 200-300 m, and ubiquitous shelf/shelf break species was *L. cavillone* at 10-300 m. The maximum abundance among gurnards varied between 211 ind/km^2 (*C. lucerna*) and 89388 ind/km^2 (*L. cavillone*), followed by

12731 ind/km^2 (*L. dieuzeidei*). Maximum catch in weight was found for *L. cavillone* (53.4%) with 8.45±32.48 kg/trawl on average, followed by *L. dieuzeidei* (19.7%). Overall, female specimens outnumbered the males. Female/male abundance ratio showed that females predominated in the population and varied between 2.25 and 5.44 for *C. cuculus*, between 0.56 and 1.56 for *C. lucerna*, between 0.25 and 2.83 for *L. cavillone*, between 0.68 and 4.10 for *L. dieuzeidei*, and between 0.08 and 6.65 for *C. lastoviza.* Lengths of six gurnard species ranged from 4 cm to 24.9 cm (*C. cuculus*), followed by 24.7 cm (*C. lastoviza*), and weights from 0.78 g (*C. cuculus*) to 142.18 g (*C. lastoviza*). In general, the small-sized specimens (< 15 cm) outnumbered the larger specimens. In terms of individual maximum weight, the heavier fish species (W > 100 g) were *C. cuculus, C. lucerna, and C. lastoviza*, while the rest were lighter fish species (W < 50 g). The species exhibiting isometric growth were *C. lucerna* and *C. lastoviza*, while negative allometry was observed in *C. cuculus* and *T. lyra*, and positive allometry was observed in *L. cavillone* and *L. dieuzeidei*; females showed positive allometry, and males isometric growth. Regarding the species-abiotic environment relationship, six gurnard species were grouped and positively correlated with bottom depth, while negatively correlated with bottom type. This was followed by a positive effect of total suspended matter (including all fractions of seston and fine materials of tripton) and a negative effect of sea surface and subsurface chl-*a*.

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Conflict of Interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

Author Contributions

Erhan Mutlu: Onboard works, Project administration, Supervision, Software, Data analyzes, Writing, Funding acquisition. Ilaria de Meo: Onboard works, Laboratorial works, Measurements, Data entry. Claudia Miglietta: Onboard works, Laboratorial works, Measurements, Data entry. Mehmet Cengiz Deval: Onboard works, Laboratorial works, Measurements, Data entry.

Ethics 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 (Protocol no: 2013.12.03).

References

Araújo, F.G., de Azevedo, M.C., de Araújo, S.M., Pessanha, A.L.M., Gomes, I.D., & da Cruz-Filho, A.G. (2002). Environmental influences on the demersal fish assemblages in the Sepetiba Bay, Brazil. *Estuaries* 25:441–450

Bilecenoğlu, M., & Taşkavak, E. (1999). General characteristics of the Turkish marine ichthyofauna. *Zool Middle East* 18(1):41-56, DOI: 10.1080/09397140.1999.10637781

Bilecenoğlu, M., Kaya, M., Cihangir, B., & Çiçek, E. (2014). An updated checklist of the marine fishes of Turkey. *Turk. J. Zool.* 38(6), 10. https://doi.org/10.3906/zoo-1405-60

Bilecenoğlu, M. (2024) Diversity of fishes along the coasts of Türkiye. *Turk. J. Zool.* 48:589-616 doi:10.55730/1300-0179.3197

Boudaya, L., Neifar, L., Taktak, A., Ghorbel, M., & Bouain, A. (2007). Diet of *Chelidonichthys obscurus* and *Chelidonichthys lastoviza* (Pisces: Triglidae) from the Gulf of Gabes (Tunisia). *J Appl Ichthyol*. 23:646–653

Boudaya, L., Neifar, L., Rizzo, P., Badalucco, C., Bouain, A., & Fiorentino, F. (2008). Growth and reproduction of *Chelidonichthys lucerna* (Linnaeus) (Pisces: Triglidae) in the Gulf of Gabes, Tunisia. *J Appl Ichthyol*. 24:581–588

Caragitso E., & Papaconstantinou C. (1994) Feeding habits of piper (*Trigla lyra*) in the Saronikos Gulf (Greece). *J Appl Ichthyol.*10:04-113

Coll, M., Piroddi, C., Steenbeek, J., Kaschner, K., Ben Rais Lasram, F., Nike Bianchi, C., Corbera, J., Dailianis, T., Danovaro, R., Estrada, M., Froglia, C., Galil, B.S., Gasol, J.M., Gertwagen, R., Gil, J., Guilhaumon, F., Kesner-Reyes, K., Kitsos, M.S., Koukouras, A., Lampadariou, N., Laxamana, E., Lopez-Fe de la Cuadra, C.M., Lotze, H.K., Martin, D., Mouillot, D., Oro D., Raicevich, S., Rius-Barile, J., Saiz-Salinas, J.I., San Vicente, C., Somot, S., Templado, J., Turon, X., Vafidis, D., Villanueva, R., & Voultsiadou, E. (2010). The biodiversity of the Mediterranean Sea: estimates, patterns, and threats. *PLoS One* 5(8):e11842. https://doi.org/10.1371/journal. pone.0011842.

Colloca, F., Cardinale, M., Belluscio, A., & Ardizzone, G. (2003). Pattern of distribution and diversity of demersal assemblages in the central Mediterranean sea. *Estuar Coast Shelf Sci.* 56:469–480

Colloca, F., Cardinale, M., & Ardizzone, G.D. (1997) Biology, spatial distribution and population dynamics of *Lepidotrigla cavillone* (Pisces: Triglidae) in the Central Tyrrhenian Sea. *Fish Res.* 32:21-32

Colloca, F., Milisenda, G., Capezzuto, F., Cau, A., Garofalo, G., Jadaud, A., Kiparissis, S., Micallef, R., Montanini, S., Thasitis, I., Vallisneri, M., Voliani, A., Vrgoc, N., Zupa, W. & Ordines, F. (2019). Spatial and temporal trend in the abundance and distribution of gurnards (Pisces: Triglidae) in the northern Mediterranean Sea. *Sci Mar.* 101-116. https://doi.org/10.3989/scimar.04856.30A

Daban, B., İşmen, A., Şirin, M., Yığın, C.Ç., & Arslan İhsanoğlu, M. (2021). Analysis of demersal fish fauna off the sea of Marmara, Turkey. *COMU J Mar Sci Fish.* 4(1):20-31. DOI: 10.46384/jmsf.912403

Damalas, D., Maravelias, C.D., Katsanevakis, S., Karageorgis, A.P., & Papaconstantinou, C. (2010). Seasonal abundance of non-commercial demersal fish in the eastern Mediterranean Sea in relation to hydrographic and sediment characteristics. *Estuar Coast Shelf Sci.* 89:107-118

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. *Mar Biodiver.* 48(4):2105-2118. Doi:10.1007/s12526-017-0739-7

Demestre, M., Sanchez, P., & Abello, P. (2000). Demersal fish assemblages and habitat characteristics on the continental shelf and upper slope of the north-western Mediterranean. *J Mar Biol Assoc UK.* 80:981–988

Deval, M.C., & Mutlu, E. (2024). Spatio-temporal density of the demersal Chondrichthyes assemblage in an upper bathyal of the eastern Mediterranean Sea. *Mar Biodiver.* 54:31. https://doi.org/10.1007/s12526-024-01423-x

Dobroslavić, T., Conides, A., Šprem, J.S., Glamuzina, B., & Bartulović, V. (2021). Reproductive strategy of spiny gurnard Lepidotrigla dieuzeidei Blanc and Hureau, 1973 from the south-eastern Adriatic Sea. *Acta Adriat.* 62(1):49 - 62

Eryilmaz, L., & Meriç, N. (2005). Some Biological Characteristics of the Tub Gurnard, *Chelidonichthys lucernus* (Linnaeus, 1758) in the Sea of Marmara, *Turk J Veter Animal Sci*. 29(2):27.

FAO, (1991) *Lecture notes prepared for the training workshop on the statistical treatment and interpretation of marine community data*. FAO/IOC/UNEP Training Workshop, Alexandria, Egypt. FAO: Rome, Italy. 212 pp.

Farré, M, Tuset, V.M., Cartesa, J.E., Massutí, E., & Lombarte, A. (2016). Depth-related trends in morphological and functional diversityof demersal fish assemblages in the western Mediterranean Sea. *Prog Oceanogr*. 147:22–37

Farriols, T.M., Ordines, F., Somerfield, P.J, Pasqual, C., Hidalgo, M., Guijarro, B., & Massutí, E. (2017). Bottom trawl impacts on Mediterranean demersal fish diversity: Not so obvious or are we too late? *Continent Shelf Res*. 137:84–102

Garuti, A., & Mutlu, E. (2021). Spatiotemporal and ecological distribution of megabenthic non-crustacean invertebrates in an ultraoligotrophic gulf, the eastern Mediterranean Sea. *J Mar Syst*. 224:103644. Doi:10.1016/j.jmarsys.2021.103644

Gayanilo, F.C., & Pauly, D. (2001). FAO-ICLARM fish Stock assessment Tools (FISAT II ver. 0.4.1). FAO, Rome.

Holden, M.J., & Raitt, D.F.S. (1974). *Manual of fisheries science. Part 2-Methods of resource investigation and their application*. Documents Techniques FAO sur les Peches (FAO)-Documentos Tecnicos de la FAO sobre la Pesca (FAO).

Ihsanoglu, M.A, Ismen, A., & Yigin, C.C. (2016). Distribution and population structure of gurnard species (Triglidae) in Saros Bay (north Aegean Sea, Turkey). *Rapp Comm int. Mer Médit*. 41:378-378

İlhan, D(U)., & Toğulga, M. (2007). Age, growth and reproduction of tub gurnard *Chelidonichthys lucernus* Linnaeus, 1758 (Osteichthtyes: Triglidae) from İzmir Bay, Aegean Sea, Eastern Mediterranean. *Acta Adriat.* 48(2):173 - 184

İlhan, D. (2019). Edremit Körfezi'nde dağılım gösteren beş kırlangıç balığı (Triglidae) türünün besin tercihleri. Acta *Aquat Turc.* 15(3):347-353. https://doi.org/10.22392/actaquatr.529907

İşmen, A., İşmen, P., & Başusta, N. (2004). Age, growth and reproduction of tub gurnard (*Chelidonichthys lucerna* L. 1758) in the Bay of İskenderun in the Eastern Mediterranean. *Turk J Veter Animal Sci.* 28(2):7.

Kallianiotis, A., Sophronidis, K., Vidoris, P., & Tselepides, A. (2000). Demersal fish and megafaunal assemblages on the Cretan continental shelf and slope (NE Mediterranean): seasonal variation in species density, biomass and diversity. *Prog Oceanogr.* 46:429–455

Katsanevakis, S., Maravelias, C.D., Damalas D., Karageorgis A.P., Tsitsika E.V., Anagnostou C., & Papaconstantinou C. (2009). Spatiotemporal distribution and habitat use of commercial demersal species in the eastern Mediterranean Sea. *Fish Oceanogr.* 18:439–457

Letourneur, Y., Darnaude, A., Salen-Picard, C., & Harmelin-Vivien, M. (2001). Spatial and temporal variations of fishassemblages in a shallow Mediterranean softbottomarea (Gulf of Fos, France). *Oceanol Acta.* 24:273–285

Machias, A., Vassilopoulou, V., Vatsos, D., Bekas, P., Kallianiotis, A., Papaconstantinou, C., & Tsimenides, N. (2001). Bottom trawl discards in the northern Mediterranean Sea. *Fish Res.* 53:181-195.

Massuti, E., & Renones, O. (2005). Demersal resource assemblages in the trawl fishing grounds off the Balearic Islands (western Mediterranean). Sci Mar 69(1):167-181. DOI:https://doi.org/10.3989/scimar.2005.69n1167

Mehanna, S.F. (2022). Population parameters and reproductive biology of the streaked gurnard, *Chelidonichthys lastoviza* (Bonnaterre, 1788) in the Egyptian Mediterranean waters (GFCM-GSA 26). *Iran J Ichthyol.* 9(4):233-243

Merigot, B., Bertrand, J.A., Mazouni, N., Mante, C., Durbec, J-P., & Gaertner, J-C. (2007). A multi-component analysis of species diversity of groundfish assemblages on the continental shelf of the Gulf of Lions (north-western Mediterranean Sea). *Estuar Coast Shelf Sci.* 73:123-136

Montanini, S., Stagioni, M., Benni, E., & Vallisneri, M. (2017). Feeding strategy and ontogenetic changes in diet of gurnards (Teleostea: Scorpaeniformes: Triglidae) from the Adriatic Sea. *Europ Zooll J.* 84(1):356-367. DOI: 10.1080/24750263.2017.1335357

Mutlu, E. (2015). Broad-scale ecological distribution of dominant macrozoobenthic taxa ofthe northern Cilician shelf, eastern Mediterranean Sea: crustaceans. *Turk J Zool*. 39:888-905. doi:10.3906/zoo-1407-8

Mutlu, E., Çinar, M.E., & Ergev, M.B. (2010). Distribution of soft-bottom polychaetes of the Levantine coast of Turkey, eastern Mediterranean Sea. *J Mar Sys.* 79:23–35. Doi:10.1016/j.jmarsys.2009.06.003

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

Mutlu, E., de Meo, I., Miglietta, C., & Deval, M.C. (2022e). Keystone Porgy species (Sparidae) overcome the alien Randall's threadfin bream (*Nemipterus randalli*) for catch balance in space on an oligotrophic Levant shelf or vice versa? *COMU J Mar Sci Fish.* 5(2):119-142. doi:10.46384/jmsf.1159667

Mutlu, E., Deval, M.C., De Meo, I., Saygu, İ., & Miglietta, C. (2022b). Spatiotemporal density and ecology of batoids (Elasmobranchii) along a Turkish shelf-upper slope of the Mediterranean Sea during years 2009–2015. *Thalassas*. 38(1):57-69. Doi:10.1007/s41208-021-00391-4

Mutlu, E., & Ergev, M.B. (2008). Spatio-temporal distribution of soft-bottom epibenthic fauna on the Cilician shelf (Turkey), Mediterranean Sea. *Rev Biol Trop.* 56(4):1919-1946. Doi: 10.15517/rbt.v56i4.5770

Mutlu, E., & Ergev, M.B. (2012). Distribution of soft-bottom mollusks (Mollusca) in Mersin Bay (eastern Mediterranean Sea). *Turk J Zool.* 36(4):430-446. Doi:10.3906/zoo-1103-15

Mutlu, E., & Ergev, M.B. (2013). Depth-related gradient of soft-bottom crustacean distribution along the Cilician shelf. *Turk J Zool.* 37:262-276. Doi:10.3906/zoo-1204-3

Mutlu, E., Meo, Id., Miglietta, C., & Deval, M.C. (2023). Ecological indicative stressors of native vs non-native fish in an ultra-oligotrophic region of the Mediterranean Sea. *Sustainability*. 15:2726. https://doi.org/10.3390/su15032726

Mutlu, E., Miglietta, C., De Meo, I., & Deval, M.C. (2022a). Length-weight relationships of 107 osseous and 9 cartilaginous fish species on a shelf-break zone of the eastern Mediterranean Sea. *Cah Biol Mar.* 63:19-2. DOI: 10.21411/CBM.A.DEBDACF1

Mutlu, E., Miglietta, C., Meo, I., & Deval, M.C. (2022f). Spatiotemporal and bioecological distribution of four commercial Mullid species in an ultraoligotrophic Mediterranean gulf. *Turk J Zool*. 46(6):5. https://doi.org/10.55730/1300-0179.3103

Mutlu, E., Olguner, C., Gökoğlu, M., & Özvarol, Y. (2022c). Seasonal growth dynamics of *Posidonia oceanica* in a pristine Mediterranean gulf. *Ocean Sci J.* 57(3):381-397. Doi:10.1007/s12601-022-00078-8

Mutlu, E., Olguner, C., Gökoğlu, M., & Özvarol, Y. (2022d). Population dynamics and ecology of *Caulerpa prolifera* vs *Caulerpa taxifolia* var. *distichophylla* within a Levantine gulf. *Thalassas.* 38(2):1311-1325. Doi:10.1007/s41208-022-00477-7

Ordines, F., Farriols, M., Lleonart, J., Guijarro, B., Quetglas, A., & Massutí, E. (2014). Biology and population dynamics of by-catch fish species of the bottom trawl fishery in the western Mediterranean. *Medit Mar Sci.* 15(3):613–625. https://doi.org/10.12681/mms.812

Papaconstantinou, C. (1984). Age and growth of the yellow gurnard (*Trigla lucerna* L. 1758) from the Thermaikos Gulf (Greece) with some comments on its biology. *Fish Res.* 2:243-255

Papaconstantinou, C. (1986). The life history of rock gurnard (*Trigloporus lastouiza*, Briinn. 1768) in the Saronikos Gulf. *J Appl Ichthyol.* 2:75-86

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

Pauly, D. (1980). On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. *J Cons CIEM.* 39(3):175-192.

Platella, M.E., & Potter, I.C. (1999). Partitioning of Habitat and Prey by Abundant and Similar-sized Species of the Triglidae and Pempherididae (Teleostei) in coastal waters. *Estuar Coast Shelf Sci.* 48:235–252

Polat-Beken, Ç., Tolun, L., Avaz, G., Dönertas, A., Ediger, D., Telli-Karakoç, F., & Tugrul, S. (2009). DPSIR applied to 4-large Turkish coastal cities: Mersin, Antalya, Izmir and Kocaeli. Proceedings of the International Workshop on the Impact of Large Mediterranean Coastal Cities on Marine Ecosystems, Alexandria, 10-12 February 2009

Ragonese, S., & Bianchini, M.L. (2010). Historical growth and mortality "benchmark" values of *Lepidotrigla cavillone* (Pisces-Triglidae) in the Strait of Sicily (Mediterranean Sea). *J Appl Ichthyol*. 26:113–115

Scott, D.W. (1979). On optimal and data-based histograms. *Biometrika*. 66:605-610.

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

Şirin, M., Daban, I.B., İhsanoğlu, M.A., İşmen, A., & Yiğin, C.Ç. (2024). Population Structure, Age, Growth and Reproduction Biology of Piper Gurnard, *Trigla lyra* (Linnaeus, 1758) in the Sea of Marmara, Turkey. *Thalassas*. 40:735–742. https://doi.org/10.1007/s41208-023-00621-x

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. *Mar Chem*. 196:13–23.

Soyer, J. (1970). Bionomie benthique du plateau continental de la côte catalane française Volume III - Les peuplements de Copepodes harpacticoides (Crustacea). *Vie et Milieu*. 21(2B):337-551

Stagioni, M., Montanini, S., & Vallisneri, M. (2012). Feeding of tub gurnard *Chelidonichthys lucerna* (Scorpaeniformes: Triglidae) in the north-east Mediterranean. *J Mar Biol Assoc*. UK 92(3):605–612. doi:10.1017/S0025315411000671

Terrats, A., Petrakis, G., & Papaconstantinou, C. (2000). Feeding habits of *Aspitrigla cuculus* (L., 1758) (red gurnard), *Lepidotrigla cavillone* (Lac., 1802) (large scale gurnard) and *Trigloporus lastoviza* (Brunn., 1768) (rock gurnard) around Cyclades and Dodecanese Islands (E. Mediterranean). *Medit Mar Sci*. 1(1):91–104. https://doi.org/10.12681/mms.280

Tsimenides, N., Machias, A., & Kallianiotis, A. (1992). Distribution patterns of triglids (Pisces: Triglidae) on the Cretan shelf (Greece), and their interspecific associations. *Fish Res*. 15:83-103

Tunesi, L., Molinari, A., Salvati, E., & Mori, M. (2006). Depth and substrate type driven patterns in the infralittoral fish assemblage of the NW Mediterranean Sea. *Cybium*. 30(2):151-159

Türker, İ., Gülnur, M., Ozan, S., & Kınacıgil, H.T. (2010). Growth and reproduction of large-scaled gurnard (*Lepidotrigla cavillone* Lacepède, 1801) (Triglidae) in the central Aegean Sea, eastern Mediterranean. *Turk J Zool*. 34(4):5. https://doi.org/10.3906/zoo-0906-47

Uçkun, D. (2005) Edremit Körfezi'nde Triglidae familyası (Kırlangıç Balıkları)'na ait türlerin yaş ve büyüme özelliklerinin incelenmesi. "Investigation of the age and growth characteristics of the species belonging to the family Triglidae in Edremit Bay". *E.Ü. Su Ürün Der*. 22(3-4):363–369.

Vallisneri, M., Stagioni, M., Montanini, S., & Tommasini, S. (2011). Body size, sexual maturity and diet in *Chelidonichthys lucerna* (Osteichthyes: Triglidae) from the Adriatic Sea, north eastern Mediterranean. *Acta Adriat*. 51(1):141 - 148

Vallisneri, M., Tommasini, S., Stagioni, M., Manfredi, C., Isajlović, I., & Montanini, S. (2014). Distribution and some biological parameters of the red gurnard, *Chelidonichthys cuculus* (Actinopterygii, Scorpaeniformes, Triglidae) in the north-central Adriatic Sea. *Acta Ichthyol Piscat*. 44 (3):173–180. DOI: 10.3750/AIP2014.44.3.01