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RESEARCH ARTICLE

Spatio-temporal patterns of abundance, biomass and length-weight relationships of *Gymnura altavela* (Linnaeus, 1758) (Pisces: Gymnuridae) in the Gulf of Antalya, Turkey (Levantine Sea)

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Abstract

The present paper reports the abundance and biomass of *Gymnura altavela* (Linnaeus, 1758) at various depth levels and seasons in the Gulf of Antalya, Mediterranean cost of Turkey. A total of 116 hauls were carried out between August 2009 and April 2010 seasonally in the Gulf of Antalya at six stations and six depth levels (25, 50, 75, 100, 150, 200 m) using a commercial bottom trawl. From 40 hauls, 172 individuals were sampled and the frequency of occurrence was 41.67% at the depths between 25 and 100 m, but absent at 150 and 200 m. The overall mean abundance and biomass was 27.98 ind./km^2 and 167.76 kg/km^2. Total length-weight (TL-W), disc length–weight (DL-W) and disc width–weight (DW-W) relationship were described as $W = 0.031*TL^{2.93}$; $W = 0.064*DL^{2.94}$ and $W = 0.007*DW^{3.03}$, respectively. The highest TL, DL and DW values in the Mediterranean Sea are reported.

Keywords: Spiny butterfly ray, *Gymnura altavela*, seasonal trawl survey, Antalya, Mediterranean Sea, length-weight relationship

Introduction

The spiny butterfly ray, *Gymnura altavela*, occurs in the eastern Atlantic Ocean from Portugal to Angola including the Canary Islands, Madeira, and the Mediterranean and Black Seas, also in the western Atlantic Ocean from Massachusetts to Argentina (Bauchot 1987; Serena 2005). It is a demersal species found on sandy and muddy bottoms from shallow waters to 100 m (Brito 1991). It feeds on all kinds of animals living on the bottom but prefers fish and cephalopods (Bauchot 1987). It is Critically Endangered in the Mediterranean where it is now rare or absent throughout its entire former range and assessed as Vulnerable in the Global Red List of IUCN (Vooren *et al.* 2007; Abdul Malak *et al.* 2011). It is incidentally caught by trawl and artisanal (trammel and longlines) fisheries (Bauchot 1987). The wings of the species are marketed fresh, but mostly chilled and frozen on the markets of Sicily and Morocco, rarely elsewhere (Bauchot 1987).

G. altavela exhibits ovoviviparity and has an annual reproductive cycle with a gestation period of six months producing 2-7 young (McEachran and Capapé 1984; Bradai *et al.* 2012). The maximum width of disc is reported as 400 cm, total length as 285 cm (Bauchot 1987) and weight as 60.0 kg (International Game Fish Association 1991). Age, size, growth and reproduction data of this species from other regions were reported from the Aegean Sea (Filiz and Bilge 2004), the eastern Mediterranean Sea (Başusta and Erdem 2000; Yeldan and Avşar 2007; Başusta *et al.* 2012; Alkusairy *et al.* 2014), the central Mediterranean Sea (Capapé *et al.* 1992; El Kamel *et al.* 2009), the Adriatic Sea (Dulcic *et al.* 2003), and the Atlantic Ocean (Bigelow and Schroeder 1953; Daiber and Booth 1960; Günther 1870; Maigret and Ly 1986; Crawford 1993; Wigley *et al.* 2003).

Bottom trawl surveys are widely used for monitoring demersal stocks and the mean catch (either in weight or in numbers) per unit of effort (CPUE) or per unit of area (CPUA) is an index of the stock abundance (Spare and Veneme 1992). The studies reporting the presence or CPUE/CPUA values of *G. altavela* in trawl hauls from Turkey have been mostly concentrated in the Gulfs of İskenderun, Mersin and Adana (The Japan International Cooperation Agency (JICA) 1993; Gücü and Bingel 1994; Başusta and Erdem 2000; Salihoğlu and Mutlu 2000; Başusta 2002; Çiçek 2006; Yeldan and Avşar 2006, 2007; Başusta *et al.* 2012; Yeldan *et al.* 2013; Yemişken *et al.* 2014). Saygu (2011) reported the CPUE values and length–weight relationship (LWR) of *G. altavela* from the Gulf of Antalya, although the sampling area only covered a limited area of the "trawl zone" in the Gulf and did not represent the whole population of the Gulf. In the present study, we aimed to eclucidate the status of the *Gymnura altavela* stock according to seasons, depth levels and locations in the Gulf of Antalya with the most detailed data collected so far in the region.

Materials and Methods

This research was carried out between August 2009 and April 2010, seasonally in the Gulf of Antalya, between the depths of 25- 200 m, using a commercial bottom trawl. A total of 116 hauls were carried out at the depths of 25, 50, 75, 100, 150, 200 m, at six stations seasonally. However, 20 hauls at the depths of 150 and 200 m were not taken into account, since *G.altavela* was not sampled at these depth levels.

Study Area

The Gulf of Antalya is located in the Northeastern Levantine Basin and is characterized by high temperature, salinity and oligotrophy (Figure 1).

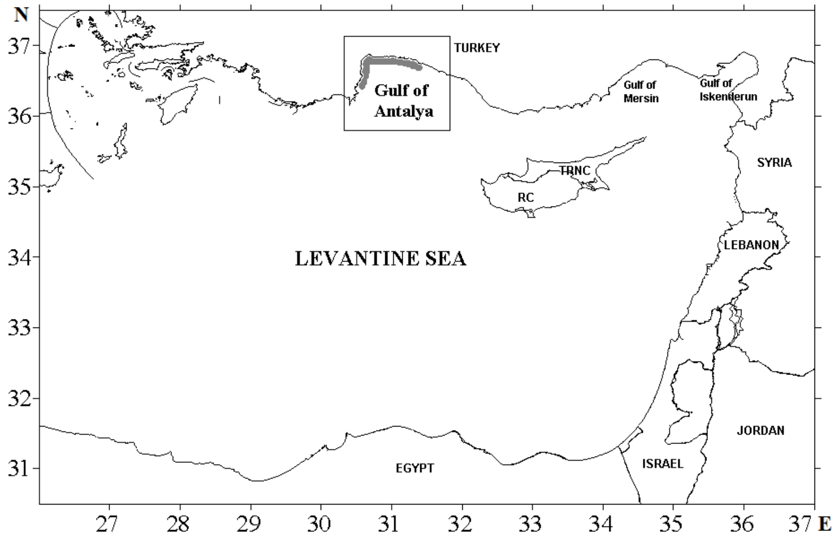

Figure 1. Map of the Gulf of Antalya-Turkey (NE Mediterranean Sea), showing the sampling area in grey color inside the rectangle
(TRNC: Turkish Republic of Northern Cyprus, RC: Republic of Cyprus)

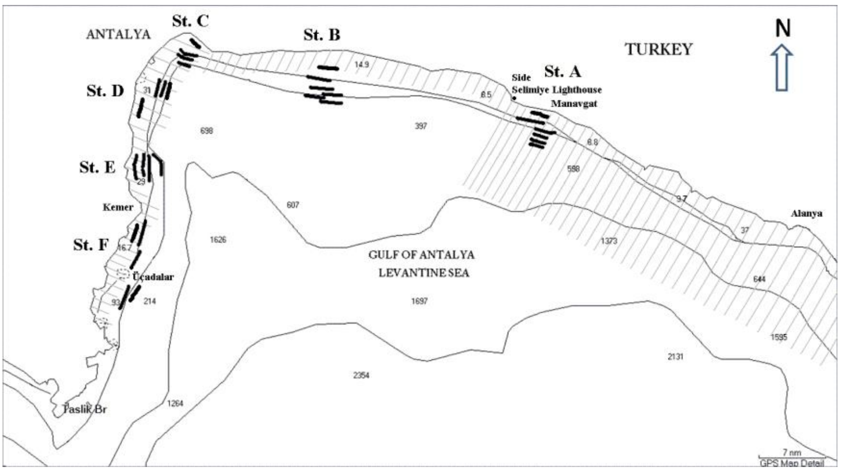

Figure 2. Map of the Gulf of Antalya- Turkey (NE Mediterranean Sea) showing the six sampling stations (named A, B, C, D, E, F from east to west) and the location and depth levels of 29 trawl hauls. The areas marked with grey lines showing "no-trawl zones".

The geographical coordinates of 29 trawling areas at six stations vary between N36° 52’ 485 - 36° 23’ 000 - E31° 32’ 322 - 30° 29’ 488 (Figure 2). Samplings were carried out at six depth levels (25, 50, 75, 100, 150, 200 m) at stations A and B. Because of the narrow and steep continental shelf, trawling at 150 and 200 m depth levels, however, could not be realized at station C, D and E and 200 m at station F. The research was conducted seasonally, both in “closed fishing” season (August 2009) and “open fishing” seasons (November 2009, February 2010 and April 2010) and both in the no-trawl zones and open areas.

Turkish national regulation on commercial fisheries covers a complex scheme of open/closed zones and seasons for trawl fisheries (Anonymous 2012). Bottom trawling is prohibited during the fishing year within 2 NM off the coast and between 15 April and 25 September in territorial waters where trawling is permitted. The commercial trawl area and the no-trawl zones in the Gulf of Antalya are described in detail by Ozgur Ozbek *et al.* (2013; 2015).

Sampling Methods

A total of 116 hauls were carried out at the depths of 25, 50, 75, 100, 150, 200 m, at six stations seasonally during the daytime. The duration of each haul was limited to an hour. Trawling was carried out by a commercial fishing vessel “Akyarlar” which was 24.80 m long with 450 HP engine. The cod-end mesh size was 22 mm (knot to knot) and the average towing speed was 2.5 NM/h.

G.altavela individuals were sorted from the total catches and counted on board. Subsequently, all fish obtained per station were measured (total length (TL), disc length (DL), and disc width (DW)) to the nearest 0.5 cm immediately after capture, and weighed (wet weight, WW: ±1.0 g). The specimens were released back to the sea after measured.

Data Analyses

This study was a part of the bottom trawl surveys for monitoring demersal stocks in the Gulf of Antalya. The total catch from each haul was identified to species, counted, weighed and the stock amount was calculated according to the swept area method; the abundance and catch weight (Cw) divided by the swept area (a) for each species and for each haul (Spare and Veneme 1992).

The swept area (a) for each hauling was estimated thus: $a = D.h.X$ (h: length of the head-rope, *D:* cover of distance, X: fraction of the headrope length which was equal to the width of the path swept by the trawl (accepted as 0.5). The coordinates of the trawl operation was recorded by 30 seconds intervals by GPS and the cover of distance was calculated by summing the distances between the recorded coordinates.

Abundance (number of individuals per km^2) and biomass (g per km^2) per sampling was calculated, and the mean values were computed according to seasons, stations and depth levels. Length–weight relationships were assessed from measurements of total length (TL), disc length (DL), disc width (DW) and total wet weight (g). The curve parameters a and b were determined by *log*-transformation of raw data. Growth curves were obtained from straight line for regression between total weight and length; where W is the weight of the fish in grams (dependent variable), L is the total length (TL), disc length (DL), disc width (DW) in cm (independent variable), a is the regression constant related to body form and b is the regression coefficient indicating isometric growth when equal to 3: $\log W = \log a + b * \log L$. The theoretical equation of the length-weight relationship followed the power function of the form: $W = aL^b$, where W is wet weight (g) and L is the total length (TL), disc length (DL), disc width (DW) in cm. This relationship was determined for the entire sampling seasons.

Differences in total length and weight of the specimens and mean biomass per abundance were tested among seasons, stations and depth levels by means of one-way Analysis of Variance (ANOVA). Fisher's LSD (Least Significant Difference) test was used for pairwise comparison among seasons, stations and depth levels by using STATISTICA software package (Statsoft 2004 Version 7). All the statistical analyses were considered at significance level of 5%. Differences in slopes and intercepts of length-weight relationships between seasons were tested with Analysis of Covariance (ANCOVA). Departures of slope from the general length-weight relationship have been interpreted as a measure of differential body condition between size classes, i.e. steeper slopes meaning better condition of large individuals compared to smaller ones and vice versa. ANCOVA was performed using GraphPad Prism (GraphPad Software 2007 Version 5).

Results

During the entire research period 172 individuals of *Gymnura altavela* were collected. The specimens were sampled from 40 of 116 hauls at the depths between 25 and 100 m but absent at 150 and 200 m. The frequency of occurrence was 41.67% at the depths between 25 and 100 m. The overall mean abundance and biomass was 27.98 ind./km^2 and 167.76 kg/km^2 (Table 1).

G. altavela was sampled in all seasons (Table 1), however there was no seasonal variation in the mean abundance and biomass ($p > 0.05$). Seasonal difference was only found in the mean biomass per abundance (W/N) which was highest in summer ($p < 0.05$). The frequency of occurrence, the mean abundance and biomass were also highest in summer and lowest in winter.

G.altavela was abundant in all six stations (Figure 3). The mean abundance and biomass were highest in St. D (81.29 ind./km^2; 620.57 kg/km^2). According to the results of the Fisher's LSD test for pairwise comparison, the variations among stations was only significant between St. D and others ($p < 0.05$). The highest mean abundance and biomass values were recorded at 25 m depth (38.39 ind./km^2; 257.49 kg/km^2). The bathymetric variations in the mean abundance and biomass were not significant ($p > 0.05$).

Table 1. The mean abundance (ind./km^2) and biomass (kg/km^2) of *G.altavela* caught in the Gulf of Antalya according to seasons (Mean abundance (ind./km^2(±se)), percentage (%), mean biomass (kg/km^2(±se)), frequency of occurrence (F%), mean biomass/ mean abundance (W/N))

Season	**No. of hauls**	**ind./km^2 (±se)**	**%**	**kg/km^2 (±se)**	**%**	**F%**	**W/N**
Summer	24	53.37±16.96	47.7	404.97±200.52	60.3	62.50	7.59
Autumn	24	20.60±6.52	18.4	75.73±26.92	11.3	50.00	3.68
Winter	24	4.66±2.23	4.2	14.92±6.98	2.2	20.83	3.20
Spring	24	33.28±25.92	29.7	175.42±131.41	26.1	33.33	5.27
Total	96	27.98±8.02	100.0	167.76±61.30	100.0	41.67	6.00

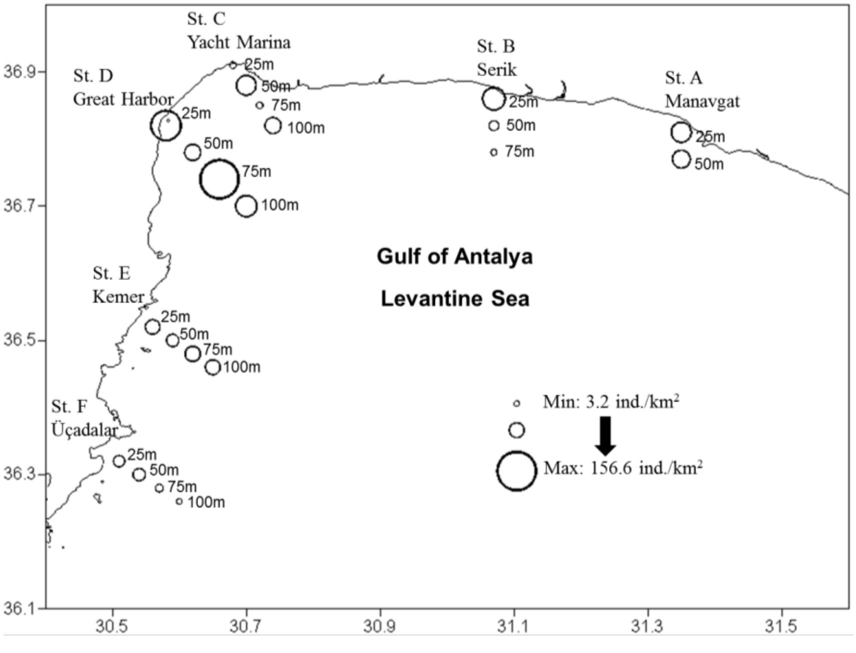

Figure 3. The mean abundance (ind./km^2) of *G.altavela* caught in the Gulf of Antalya according to stations and depth levels (average of four seasons)

The total length (TL) ranged from 27 to 112 cm; disc length (DL) from 20 to 92 cm; disc width (DW) from 39 to 165 cm and wet weight (W) from 0.4 to 36 kg. The mean TL was calculated as 59.58 cm; DL as 46.14 cm; DW as 85.68 cm and W as 6.35 kg. The descriptive statistics were given according to seasons in Table 2.

For the comparison of the length-weight relationship parameters with previous and future studies, both the general total length (TL) - wet weight (W); disc length (DL) - wet weight (W) and disc width (DW) - wet weight (W) relationships were described according to seasons in Table 3. All relationships were highly significant ($p < 0.0001$) and R^2-values were greater than 0.90. The general relationships or all 172 specimens were described by the equations: $W = 0.031*TL^{2.93}$; $W = 0.064*DL^{2.94}$ and $W = 0.007*DW^{3.03}$.

The results of ANCOVA (Table 4) showed that the slopes of the seasonal length-weight relationships differed significantly in summer-winter, autumn-spring and winter-spring for TL-W, showing higher value in spring following by summer, autumn and winter. The slopes of the DL-W relationships only differed in autumn-spring and DW-W in summer-autumn and autumn-spring.

The differences in TL, DL, DW and W of the specimens were statistically significant among stations and depth levels ($p < 0.05$). According to the results of the Fisher's LSD test for pairwise comparison, there were bathymetric differences only between 25 m- 100 m and 50 m- 100 m. The mean values were highest at 100 m and lowest at 50 m depth (Figure 4). The mean values were also lower in Sts. A, B and F compared to Sts. C, D and E (Figure 4). Seasonal variations were only significant for TL and W ($p < 0.05$) due to higher values in summer (Figure 4); however not significantly different among other seasons.

Discussion

Gymnura altavela is not sought after by commercial fisheries, but are taken as bycatch and marketed fresh and salted or used as bait (Bauchot 1987; McEachran and de Carvalho 2002; Serena 2005). It is listed as Critically Endangered and its population is apparently dwindling across its range linked to intensive trawling, particularly of its juvenile stage of life history stage (Stevens *et al.* 2000; Abdul Malak *et al.* 2011).

Previously, the presence of *G. altavela* in the Mediterranean Sea was reported from the Black Sea (Whitehead *et al.* 1984–1986; Yankova *et al.* 2014), Marmara Sea (Whitehead *et al.* 1984–1986), Aegean Sea (Filiz and Mater 2002; Filiz and Bilge 2004; Özbilgin *et al.* 2006; Gurbet *et al.* 2013), eastern Mediterranean Sea (JICA 1993; Gücü and Bingel 1994; Başusta and Erdem 2000; Salihoğlu and Mutlu 2000; Başusta 2002; Çiçek 2006; Yeldan and Avşar 2007; Saygu 2011; Başusta *et al.* 2012; Yeldan *et al.* 2013; Alkusairy *et al.* 2014; Yemişken *et al.* 2014), central Mediterranean Sea (Capapé *et al.* 1992; El Kamel *et al.* 2009; Psomadakis *et al.* 2009; Relini *et al.* 2010), and Adriatic Sea (Dulcic *et al.* 2003).

Table 2. Descriptive statistics for G.altavela according to seasons (N: sample size; min: minimum; max: maximum; S.D.: standard deviation)

Seasons	N	Total Length (cm)				Length of Disc (cm)				Width of Disc (cm)				Weight (g)			
		Mean	S.D.	Min.	Max.	Mean	S.D.	Min.	Max.	Mean	S.D.	Min.	Max.	Mean	S.D.	Min.	Max.
Summer	89	62.61	20.83	27.0	112.0	48.54	16.71	20.0	92.0	90.07	29.25	39.0	165.0	7841.57	8118.07	400.0	36000.0
Autumn	32	52.69	11.62	36.0	82.0	41.08	8.77	29.0	65.0	76.91	17.51	53.0	126.0	3985.94	2712.49	1200.0	14250.0
Winter	7	49.07	15.57	31.5	72.0	38.29	10.98	28.0	55.0	71.29	18.99	51.0	98.0	3314.29	2568.03	1000.0	7400.0
Spring	44	60.16	12.07	36.0	95.0	46.22	9.52	27.5	74.0	85.46	17.58	51.0	135.0	5530.68	4096.91	1000.0	20700.0
Overall	172	59.58	17.64	27.0	112.0	46.14	13.97	20.0	92.0	85.68	24.89	39.0	165.0	6348.84	6515.73	400.0	36000.0

Table 3. L-W relationship parameters for *G.altavela* according to seasons (N: sample size; TL= total length (cm); DL = length of disc (cm); DW = width of disc (cm); W: weight (g); a = intercept; b = slope of the linear regressions; S.E.: standard error; C.I.: confidence interval; r^2 = coefficient of determination)

Seasons	N	LWR parameters (TL-W)					LWR parameters (DL-W)					LWR parameters (DW-W)				
		a	*b*	SE (b)	95% C.I. (b)	r^2	A	b	SE (b)	95% C.I. (b)	r^2	A	b	SE (b)	95% C.I. (b)	r^2
Summer	89	0.026	2.975	0.050	2.875 to 3.075	0.976	0.069	2.923	0.029	2.865 to 2.981	0.991	0.006	3.071	0.040	2.991 to 3.151	0.9853
Autumn	32	0.075	2.714	0.115	2.479 to 2.948	0.949	0.079	2.882	0.067	2.746 to 3.018	0.984	0.027	2.717	0.079	2.556 to 2.878	0.9754
Winter	7	0.189	2.465	0.369	1.518 to 3.413	0.900	0.078	2.873	0.254	2.221 to 3.525	0.963	0.007	3.003	0.362	2.072 to 3.934	0.9323
Spring	44	0.014	3.115	0.084	2.946 to 3.284	0.971	0.038	3.065	0.061	2.941 to 3.189	0.983	0.006	3.059	0.057	2.944 to 3.175	0.9855
Overall	172	0.031	2.929	0.041	2.849 to 3.009	0.968	0.064	2.937	0.024	2.889 to 2.985	0.988	0.007	3.028	0.031	2.966 to 3.089	0.9821

Table 4. Results of analysis of covariance (ANCOVA) showing pairwise differences between seasons, depth levels and stations of the length–weight relationships (TL= total length (cm); DL = length of disc (cm); DW = width of disc (cm); W: weight (g)). Significant differences (<0,05) are indicated in the probability (*p*) in bold.

ANCOVA - Comparison	**TL-W**				**DL-W**				**DW-W**			
	Slope		**Intercept**		**Slope**		**Intercept**		**Slope**		**Intercept**	
Compared seasons	***F***	***p***	***F***	***p***	***F***	***p***	***F***	***p***	***F***	***p***	***F***	***p***
Summer-Autumn	3.679	0.058	0.432	0.513	0.245	0.622	0.380	0.539	11.811	**0.001**		
Summer-Winter	5.168	**0.025**			0.110	0.741	1.393	0.241	0.104	0.748	0.164	0.687
Summer-Spring	1.336	0.250	6.043	**0.015**	3.622	0.059	7.164	**0.008**	0.015	0.901	0.549	0.460
Autumn-Winter	0.930	0.341	0.299	0.588	0.003	0.958	0.932	0.341	1.692	0.202	0.904	0.348
Autumn-Spring	8.479	**0.005**			4.030	**0.048**			13.112	**0.001**		
Winter-Spring	9.812	**0.003**			1.505	0.226	0.214	0.646	0.097	0.756	0.051	0.821

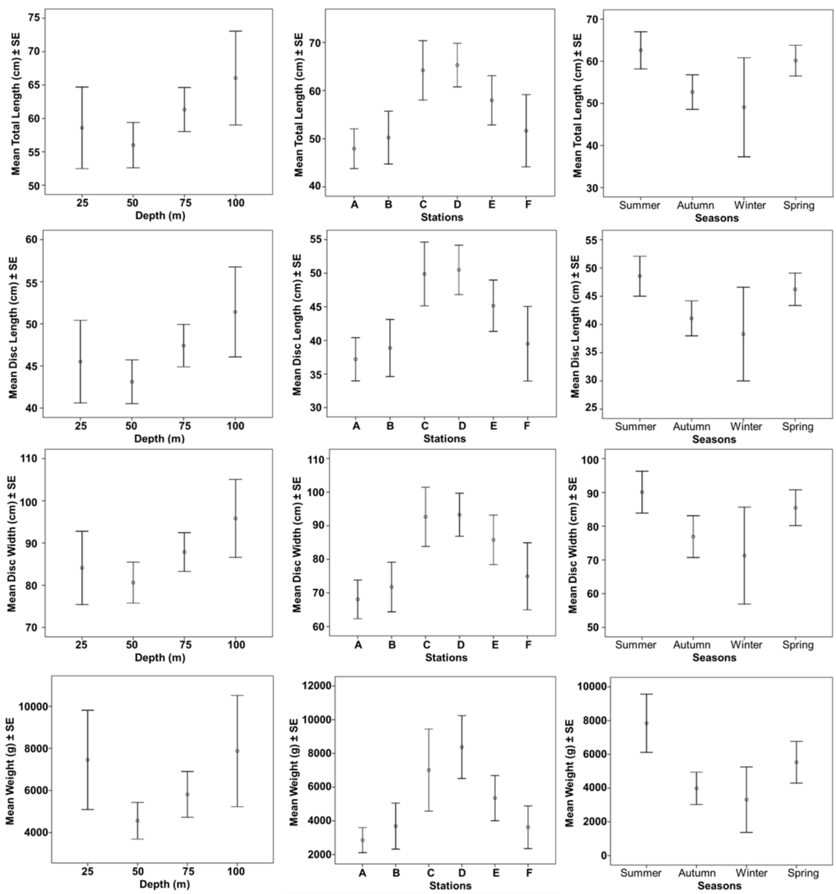

Figure 4. Mean total length (cm) ± SE, mean length of disc (cm) ± SE, mean width of disc (cm) ± SE, and mean weight (g) ± SE values of *G. altavela* according to season, station and depth levels in the Gulf of Antalya.

The studies reporting the CPUE/CPUA values of *G. altavela* in trawl hauls comparing with the present results are given in Table 5. For the comparison to the previous studies, the overall average abundance and biomass of *G. altavela* were calculated both, according to the CPUA (ind./ km^2; kg/km^2) and CPUE (ind./hour; kg/hour) for each and overall depth levels. The CPUE values vary from 0.6 kg/hour in Adana (Çiçek 2006) to 26.7 kg/hour in İzmir (Özbilgin *et al.* 2006) and 0.7 ind/hour in Antalya (Saygu 2011) to 17 ind/hour in İskenderun, Turkey (Yeldan *et al.* 2013). The CPUA values vary from 4.6 kg/km^2 in Adana (Çiçek 2006) to 257.49 kg/km^2 in Antalya (present study).

Lower values reported by Saygu (2011) at 20-50 m depths of the Gulf of Antalya could be related to the difference of the sampling areas. The present study covers both “trawl zones” and “no-trawl zones”, however the study area of Saygu (2011) covers only the trawl zone of the Gulf of Antalya coresonds to St. B in this study. The values seem to be similar when the results of Saygu (2011) were only compared with the mean CPUE values of St. B (1.1 ind./hour; 3.7 kg/hour). Thus the difference can be interpreted as the fishing pressure on the population of the species in the “trawl zones” of the Gulf of Antalya. Higher value reported by Özbilgin *et al.* (2006) in Izmir Bay, Aegean Sea, however, could be due to the higher oligotrophic conditions in the eastern Levantine.

The descriptive statistics and L-W relationship parameters compared with previous studies are given in Table 6. *G. altavela* reaches up to 400 cm DW (McEachran and Capapé 1984) and 285 cm TL (Bauchot 1987). In the Mediterranean Sea, however, the present study reports the highest TL, DL and DW values. The maximum sizes in the Mediterranean Sea tend to be smaller than those reported for the same species in the Atlantic, mainly due to the oligotrophic conditions and overfishing (Lleonart *et al.* 1998).

The present study reports the first detailed information on the spatial and temporal distribution of *G. altavela* in the northeastern Mediterranean Sea. It was found to inhabit sandy and muddy habitats shallower than 100 m in the coastal waters of the Gulf of Antalya. The highest mean abundance and biomass values were recorded at 25 m depth and the frequency of occurrence decreased from shallow to deep waters. However, mean length and weight of the individuals were higher at deeper waters. Smaller individuals in shallow and larger individuals in deeper waters were also reported previously for *Epinephelus aeneus* in the Gulf of Antalya (Ozgur Ozbek *et al.* 2013).

The mean abundance and biomass were much higher in St. D (inside the Gulf) where “no trawl zone” exists. However, the frequency of occurrence was highest in St. E. Larger individuals were also found in these stations. These stations are close to the Great Harbor and tuna farms which may attract larger individuals. Ozgur Ozbek *et al.* (2013) also reported the presence of larger individuals of *Epinephelus aeneus* in St. E in the Gulf of Antalya.

Table 5. Comparison of the mean abundance and biomass of *G.altavela* to the previous studies (CPUA= Catch per Unit Trawling Area (ind./km^2, kg/km^2); CPUE= Catch per Unit Trawling Effort (ind./time, kg/time))

Location	Date	Depth (m)	CPUA-CPUE	Source
E Mediterranean Sea	Summer, 1991	20-100 m	26.3 kg/km^2	1
Mersin Bay- Turkey (NE Med. Sea)	23 July 1996	0-25	650 g/30 min	2
Mersin Bay- Turkey (NE Med. Sea)	23 July 1996	25-50	4650 g/30 min	2
Mersin Bay- Turkey (NE Med. Sea)	29 Aug. 1996	0-25	2150 g/30 min	2
Mersin Bay- Turkey (NE Med. Sea)	29 Aug. 1996	50-100	4000 g/30 min	2
Mersin Bay- Turkey (NE Med. Sea)	13 Sep. 1996	0-25	1400 g/30 min	2
Mersin Bay- Turkey (NE Med. Sea)	16 Oct. 1996	0-25	850 g/30 min	2
Average of 5 hauls in Mersin Bay- Turkey	July- Dec.1996	0-25	1010 g/30 min	2
Average of 5 hauls in Mersin Bay- Turkey	July- Dec.1996	25-50	930 g/30 min	2
Average of 4 hauls in Mersin Bay- Turkey	July- Dec.1996	50-100	1000 g/30 min	2
Average of 14 hauls in Mersin Bay- Turkey	July- Dec.1996	0-100	979 g/hour	2
Mersin Bay- Turkey (NE Med. Sea)	17 June 1998	0-25	12667 g/30 min	2
Mersin Bay- Turkey (NE Med. Sea)	14 July 1998	25-50	3400 g/30 min	2
Mersin Bay- Turkey (NE Med. Sea)	28 Sep. 1998	25-50	1650 g/30 min	2
Mersin Bay- Turkey (NE Med. Sea)	28 Sep. 1998	50-75	9000 g/30 min	2
Mersin Bay- Turkey (NE Med. Sea)	22 Oct. 1998	50-75	4100 g/30 min	2
Mersin Bay- Turkey (NE Med. Sea)	22 Oct. 1998	50-75	10000 g/30 min	2
Mersin Bay- Turkey (NE Med. Sea)	23 Oct. 1998	25-50	9100 g/30 min	2
Average of 20 hauls in Mersin Bay- Turkey	April- Oct.1998	0-100	2627 g/hour	2
Average of 24 hauls in Karataş/Adana -Turkey (NE Med.)	2002-2003	0-20	575 g/hour	3
Average of 24 hauls in Karataş/Adana -Turkey (NE Med.)	2002-2003	0-20	4600 g/km^2	3
Average of 6 hauls in İzmir Bay-Turkey (E. Aegean Sea)	2002	35-55	20 kg/45 min	4
Average of 17 hauls in Gulf of Antalya - Turkey	2009-2010	20-50	0.67 ind/hour-3.31 kg/hour	5
İskenderun Bay- Turkey (NE Med. Sea)	2004	10-20	6 ind/hour-5.65 kg/hour	6
İskenderun Bay- Turkey (NE Med. Sea)	2005	10-20	12 ind/hour-4.24 kg/hour	6
İskenderun Bay- Turkey (NE Med. Sea)	2006	10-20	7 ind/hour-7.69 kg/hour	6
İskenderun Bay- Turkey (NE Med. Sea)	2007	10-20	17 ind/hour-7.31 kg/hour	6
İskenderun Bay- Turkey (NE Med. Sea)	2008	10-20	11 ind/hour-7.31 kg/hour	6
İskenderun Bay- Turkey (NE Med. Sea)	2009	10-20	11 ind/hour-4.45 kg/hour	6
İskenderun Bay- Turkey (NE Med. Sea)	2010	10-20	17 ind/hour-5.22 kg/hour	6
İskenderun Bay- Turkey (NE Med. Sea)	2011	10-20	17 ind/hour-8.59 kg/hour	6
Average of 58 hauls in İskenderun Bay- Turkey	2004-2011	10-20	12.22 ind/hour-6.31 kg/hour	6
Average of 24 hauls in Gulf of Antalya - Turkey	Aug. 2009- April 2010	25	38.39 ind/km^2-257.49 kg/km^2 2.57 ind/hour-16.93 kg/hour	7
Average of 24 hauls in Gulf of Antalya - Turkey	Aug. 2009- April 2010	50	24.08 ind/km^2-109.26 kg/km^2 1.66 ind/hour-7.51 kg/hour	7
Average of 24 hauls in Gulf of Antalya - Turkey	Aug. 2009- April 2010	75	32.67 ind/km^2-168.90 kg/km^2 2.32 ind/hour-12.04 kg/hour	7
Average of 24 hauls in Gulf of Antalya - Turkey	Aug. 2009- April 2010	100	16.78 ind/km^2-135.38 kg/km^2 1.16 ind/hour-9.46 kg/hour	7
Average of 96 hauls in Gulf of Antalya - Turkey	Aug. 2009- April 2010	25-100	27.98 ind/km^2-167.76 kg/km^2 1.93 ind/hour-11.49 kg/hour	7

Source: 1) JICA (1993), 2) Salihoğlu & Mutlu (2000), 3) Çiçek (2006), 4) Özbilgin *et al.* (2006), 5) Saygu (2011), 6) Yeldan *et al.* (2013), 7) Present study

Table 6. Descriptive statistics and L-W relationship parameters for *G.altavela* compared with previous studies (N: sample size; TL= total length (cm); DL= length of disc (cm); DW= width of disc (cm); min: minimum; max: maximum; a= intercept; b= slope of the linear regressions).

Study area	N	Length Type	Sex	Size Range (cm)		LWR parameters		Source
				Min.	Max.	a	b	
Madeira		DW	male	-	106.80	-	-	1
NE coast of America (W Atlantic)		DW	female	-	208.20	-	-	2
Delaware Bay (W Atlantic)	19	DW	mixed	-	-	0.00035	2.97	3
Delaware Bay (W Atlantic)		DW	male	-	124.40	-	-	3
Delaware Bay (W Atlantic)		DW	female	-	203.20	-	-	3
		DW		-	400.00	-	-	4
Mauritania (N. Atlantic)		TL		-	140.00	-	-	5
		TL	-	-	285.00	-	-	6
Tunisia (C. Med.)	96	DW	female	-	162.00	-	-	7
Tunisia (C. Med.)	68	DW	male	-	114.00	-	-	7
Florida, USA	1	TL	unsexed	125.00	125.00	-	-	8
İskenderun Bay-Turkey (E Med.)	1	TL	-	35.60	35.60	-	-	9
Southern Adriatic Sea	1	TL	male	60.10	60.10	-	-	10
Southern Adriatic Sea	1	DW	male	87.60	87.60	-	-	10
Southern Adriatic Sea	1	DL	male	44.10	44.10	-	-	10
NE coast of the United States	16	DW	mixed	52.00	187.00	0.00000	3.3060	11
NE coast of the United States	67	DW	mixed	38.00	210.00	0.00000	3.1787	11
NE coast of the United States	1138	DW	mixed	20.00	217.00	-	-	11
N Aegean Sea - Turkey	9	TL	unsexed	37.50	72.00	0.0268	2.96	12
Cilician coastal basin-Turkey (NE Med.)	38	TL	male	30.70	83.50	0.0057	3.358	13
Cilician coastal basin-Turkey (NE Med.)	69	TL	female	30.20	79.80	0.0011	3.208	13
Cilician coastal basin-Turkey (NE Med.)	107	TL	mixed	30.20	83.50	0.009	3.234	13
Tunisia (C. Med.)	1	TL	male	36.60	36.60	-	-	14
Tunisia (C. Med.)	1	TL	female	37.00	37.00	-	-	14
Tunisia (C. Med.)	1	DL	male	27.50	27.50	-	-	14
Tunisia (C. Med.)	1	DL	female	28.00	28.00	-	-	14
Tunisia (C. Med.)	1	DW	male	54.60	54.60	-	-	14
Tunisia (C. Med.)	1	DW	female	54.60	54.60	-	-	14
Gulf of Antalya-Turkey (NE Med.)	13	TL	female	42.70	90.00	-	-	15
Gulf of Antalya-Turkey (NE Med.)	6	TL	male	43.50	55.70	-	-	15
Gulf of Antalya-Turkey (NE Med.)	13	DW	female	61.10	130.00	-	-	15
Gulf of Antalya-Turkey (NE Med.)	6	DW	male	64.50	80.70	-	-	15
Gulf of Antalya-Turkey (NE Med.)	19	TL	mixed	-	-	0.0554	2.785	15
Gulf of Antalya-Turkey (NE Med.)	19	DW	mixed	-	-	0.0150	2.851	15
İskenderun Bay-Turkey (E Med.)	104	DW	mixed	30.00	127.00	0.017	2.7948	16
Syria (E Med.)	51	DW	male	35.00	89.30	0.000003	3.136	17
Syria (E Med.)	63	DW	female	34.00	134.20	0.000003	3.136	17
Gulf of Antalya-Turkey (NE Med.)	172	TL	mixed	27.00	112.00	0.031	2.929	18
Gulf of Antalya-Turkey (NE Med.)	172	DL	mixed	20.00	92.00	0.064	2.937	18
Gulf of Antalya-Turkey (NE Med.)	172	DW	mixed	39.00	165.00	0.007	3.028	18

Source: 1) Günther (1870), 2) Bigelow and Schroeder (1953), 3) Daiber and Booth (1960), 4) McEachran and Capapé (1984), 5) Maigret and Ly (1986), 6) Bauchot (1987), 7) Capapé *et al.* (1992), 8) Crawford (1993), 9) Başusta and Erdem (2000), 10) Dulcic *et al.* (2003), 11) Wigley *et al.* (2003), 12) Filiz and Bilge (2004), 13) Yeldan and Avşar (2007), 14) El Kamel *et al.* (2009), 15) Saygu (2011), 16) Başusta *et al.* (2012), 17) Alkusairy *et al.* (2014), 18) Present study

Although the depth levels of 75, 100 m of St. E and F were located outside 2 NM off the coast, due to the limited trawl area; commercial trawlers generally do not prefer these areas for trawl. The lowest mean abundance and biomass found in St. F could be related to the narrow continental shelf in this station. The possible fishing effect can be seen in St. B with the lowest frequency of occurrence and also low mean abundance and biomass. Similar lowest values for *Dasyatis pastinaca* in St. B were also reported previously in the Gulf of Antalya (Ozgur Ozbek *et al.* 2015). All sorts of trawling has been prohibited in St. A since 2005. Slightly higher abundance and biomass in St. A compared to St. B which is the main commercial trawl area in the Gulf, may be interpreted as the recovery of the stock in the "no-trawl zone". Smaller individuals were found in St. A. The fry and juveniles of *G. altavela* were previously reported to enter the lagoons and estuaries to find sufficient resources and to develop (McEachran and de Carvalho 2002; El Kamel *et al.* 2009). Thus they may prefer St. A as a breeding ground where is at the mouth of the Manavgat River. Similar distribution patterns were also previously reported for *E. aeneus* and *D. pastinaca* (Ozgur Ozbek *et al.* 2013; 2015)

The parameter *b* represents growth allometric rate, and indicates isometric growth when equal to 3. The slopes of length–weight relationships varied widely between locations. None of the studies, however, investigated its temporal fluctuations according to the size class, which indicates relative body condition, between seasons. In this study, differences in allometric coefficients were recorded between seasons. Mean TL and weight of the specimens, *b*-value and mean biomass per abundance were highest in spring and summer. It could possibly be related to the presence of mature individuals with higher gonado-somatic ratio although the gonado-somatic index was not calculated in this study. However, various factors may be responsible for the differences in parameters of the length-weight relationships among seasons, such as temperature, salinity, food (quantity, quality and size), sex, time of year and stage of maturity (Pauly 1984; Weatherley and Gill 1987).

The impact of fishing on chondrichthyan stocks around the world is currently the focus of considerable international concern. Most chondrichthyan populations are of low productivity relative to teleost fishes and when taken as by-catch, they are often subjected to high fishing mortality. At the species level, fishing may alter size structure and population parameters in response to changes in species abundance (Stevens *et al.* 2000).

The present study showed that *Gymnura altavela* is captured commonly in the Gulf of Antalya (NE Mediterrranean Sea). The high catchability of this species shows that trawling seem to represent a risk for the population of this species in the Gulf of Antalya. There is insuffficent scientific data to prepare a sustainable management plan for the demersal resources in the Gulf of Antalya. Foe example, it is essential to determine the spawning and nursery grounds of the demersal species and declare these areas as "No Take Zones" which is going to affect postively not only these species but also the whole ecoystem they live in.

More detailed studies are necessary on the biology and ecology of *Gymnura altavela* in the region; however, this is the most detailed study on spatio-temporal distribution and length-weight relationship of this species. The results of this study can be useful for future decisions on declaration of "No Take Zones" or protected areas in the Gulf of Antalya.

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Antalya Körfezi'nde kazık kuyruk vatoz balığı, *Gymnura altavela* (Linnaeus, 1758) (Pisces: Gymnuridae)'nın bolluk, biyokütle ve boy-ağırlık ilişkisinin mevsimsel ve mekansal değişimi

Özet

Bu çalışmada kazık kuyruk vatoz balığı, *Gymnura altavela* (Linnaeus, 1758)'nın Antalya Körfezi'nde mevsim, istasyon ve derinliklere göre bolluk ve biyokütlesi ve elde edilen 172 bireyin boy-ağırlık ilişkileri bildirilmektedir. Ağustos 2009- Nisan 2010 tarihleri arasında mevsimsel olarak, altı istasyonda ve altı farklı derinlikte (25, 50, 75, 100, 150, 200 m), toplam 116 trol çekiminin 40'ında *G. altavela* örneklenmiştir. Görülme sıklığı 25-100 m derinlikler arasında % 41,67 olup, 150-200 m derinliklerde ise bulunmamaktadır. Ortalama bolluk 27,98 birey/km^2 ve biyokütle 167,76 kg/km^2 olarak hesaplanmıştır. Boy-ağırlık ilişklerine ait denklemler (total boy (TL), disk boyu (DL), disk eni (DW), ağırlık (W)), $W = 0.031*TL^{2.93}$; $W = 0.064*DL^{2.94}$ ve $W = 0.007*DW^{3.03}$ olarak ifade edilmiştir. Mevcut verilere göre, bu çalışmada *G. altavela* için Akdeniz'deki en yüksek TL, DL ve DW değerleri bildirilmektedir.

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