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Temporal changes in some Rajiformes species of cartilaginous fish (Chondrichthyes) from the west coast of İskenderun Bay (northeastern Mediterranean)

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Abstract: Some Rajiformes species among the cartilaginous fish (Chondrichthyes) that are distributed on the west coast of the Gulf of İskenderun were seasonally obtained by bottom trawling from 2 different depth layers between the years 2004 and 2011. The spatiotemporal changes in catch per unit effort (CPUE) values were investigated by considering 2 depth contours (10 and 20 m). Six species belonging to 6 different Rajiformes families were identified during the sampling period, including *Dasyatis pastinaca* (common stingray), *Gymnura altavela* (spiny butterfly ray), *Rhinobatos rhinobatos* (common guitarfish), *Raja radula* (rough ray), *Myliobatis aquila* (common eagle ray), and *Torpedo marmorata* (marbled electric ray). A general linear model was used to analyze the changes in the total and separate weights of cartilaginous fish. For this purpose, the logarithms of CPUE values in weight were classed according to the depth, season, and years. Seasonal variations and year–season 2-way interactions were found to be highly significant for total cartilaginous CPUE values ($P < 0.01$). The annual changes in *R. rhinobatos* were the only significant annual difference ($P < 0.05$), while the year–season interactions of *D. pastinaca* were found to be significant ($P < 0.01$). The seasonal variations of *D. pastinaca* and *G. altavela* were also highly significant ($P < 0.01$).

Key words: Cartilaginous fishes (Chondrichthyes), İskenderun Bay, biomass

1. Introduction

İskenderun Bay is important to the fishing industry of Turkey, and is also a region drawing much attention due to its development in terms of the maritime trade industry and coastal sections. Therefore, the living communities of the Gulf remain under stress because of pollution resulting from the gradual increase in industrial plants, as well as the pressure of increased fishing activity. This is due to the fact that İskenderun Bay has very high fishery potential owing to its rich fish and invertebrate species. Therefore, it has been exposed to intense fishing over a long period.

The fishing activities in this region not only have a direct effect on the target species, but also affect biodiversity, efficiency, and habitat, thereby resulting in indirect changes in the related section ecosystems, according to Rice and Gislason (1996) and Bas (2005). Cartilaginous fish (Chondrichthyes) are among the species that are not exploited, despite representing an important component of the trawl fisheries in the region (21.65%; Demirci, 2003), according to Ellis et al. (2002). The cartilaginous fish, which are completely discarded or evaluated as having low economic value, are not specifically targeted during fishing. Hence, the stocks of these species with low economic value face the unfortunate danger of crashing for a short time, according to Musick et al. (2000). This leads to a considerable decrease in the cartilaginous fish populations, which, like other more economically valuable populations, form the upper ring of the food chain. In this context, the decline of some cartilaginous fish populations has become an international problem and many organizations state that urgent measures are needed to protect these fish (UNEP-MAP RAC/SPA, 2003).

One of the qualitative and quantitative studies on the fish fauna in the Gulf of İskenderun was conducted by Bingel (1987). The study aimed to address coastal fishing in the eastern Mediterranean and the structure of fishing areas. It was reported in this study that there are more cartilaginous fish than there are fish with economic value. Similarly, it was reported, in the bottom trawling samples from the northeastern Mediterranean carried out by Gücü and Bingel (1994) between 1980 and 1984 that the species obtained as biomass from fishing were cartilaginous fish. Basusta (1997) carried out a taxonomic study on the cartilaginous fish in İskenderun Bay and determined 19 cartilaginous fish species. Demirci (2003) estimated the biomass of the species that are nontarget demersal stock

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in the Gulf of İskenderun. Yeldan (2005) determined the bioecological properties of the Rajiformes that were caught in the gulfs of İskenderun and Mersin; Yeldan and Avşar (2006) investigated the sediment structure of the areas containing common stingrays and rough rays living in the northeastern Mediterranean. Despite these intensive efforts, it is impossible to report that the studies related to the situation of cartilaginous fish stocks throughout the gulf are sufficient.

Although the cartilaginous fish fauna of the Mediterranean has been studied over many years, there are significant gaps in the literature concerning the biology, ecology, population dynamics, and status of the stocks of many species, as also mentioned in the study by Kabasakal (1998). Accordingly, due to the challenging nature of objective hypothesis acquisition from the available results, scientific studies need to be performed in a more comprehensive manner, which will enable a better understanding with regard to the ecological role of cartilaginous fish.

In the present study, the statuses of the stocks are set forth by determining the seasonal availability and the values of CPUE pertaining to the cartilaginous fish propagating in the Yumurtalık coastal zone of the Gulf of İskenderun as biomass. The study endeavored to probe the changes taking place during the years 2004–2011. Furthermore, it is considered that the results obtained will make a major contribution to future studies.

2. Materials and methods

This study was carried out between 2004 and 2011 at the 2 transects in the coastal area between Yumurtalık and Botaş in İskenderun Bay, in the northeastern Mediterranean. The coordinates of the 10 and 20 m transects are as follows: from 35°52′08″E, 36°49′10″N to 35°54′20″E, 36°51′19″N and from 35°53′14″E, 36°48′15″N to 35°55′35″E, 36°50′23″N, respectively (Figure 1). The data was obtained from 58 seasonal bottom trawl tows at 10- and 20-m depth contours. The duration of each tow was 1 h.

As soon as the samples were taken on deck, the cartilaginous fish were separated to the species level, counted, and weighed. The CPUE values for the cartilaginous fish were determined in terms of weight and number. Their proportional abundance among the total catch and total cartilaginous fish was also calculated.

The variations in total and separate CPUE values (by weight) were grouped by year, season, and depth contour before being analyzed with a general linear model (GLM). Other GLMs were used in order to analyze the comparative abundance separately by year. For this purpose, the data were grouped by species. The statistical analyses were conducted on only 3 dominant species. Before the analyses were conducted, the data had been transformed into the natural logarithm to satisfy the necessary assumptions, normality and homoscedasticity. The F test was used to evaluate the statistical significance of the factors (year, season, and depth contour). Tukey's test was performed to evaluate significant differences (Sokal and Rohlf, 1969). The statistical analyses were conducted using the R 2.15 statistical language and environment (R Core Team, 2012).

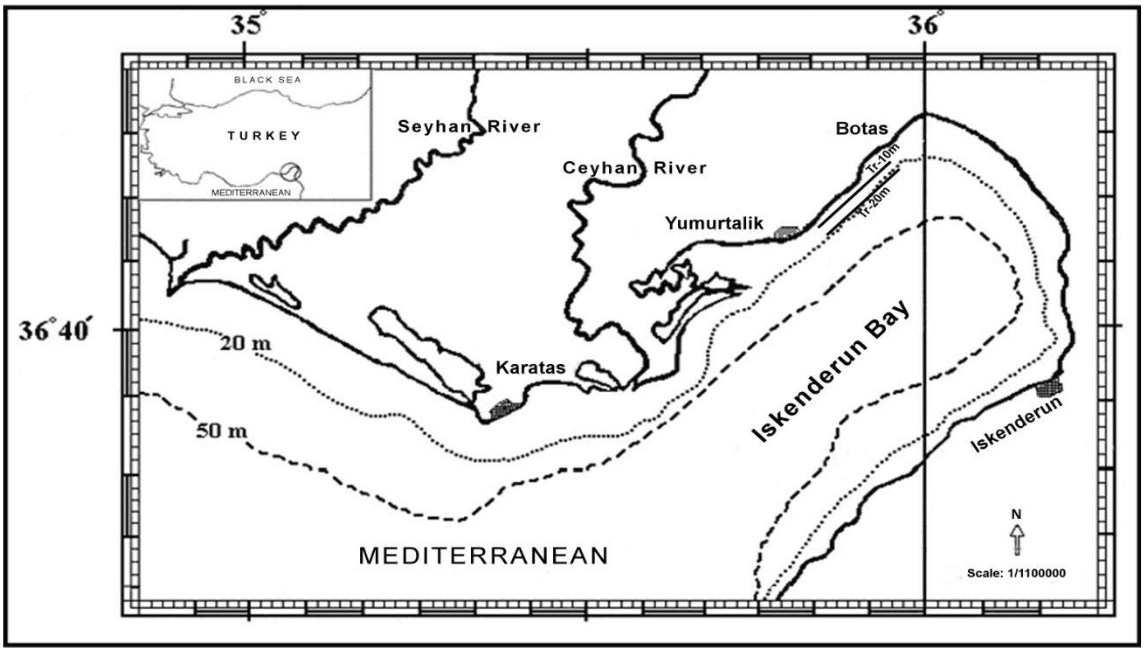

Figure 1. Sampling area (trawling stations at 10 and 20 m).

3. Results

During the study period, 6 cartilaginous species from 6 different Rajiformes families were sampled. The cartilaginous fish were the second most dominant group in the total trawl catch. It was established that the highest availability generally belonged to *D. pastinaca*. *R. rhinobatos* was second, and was followed by *G. altavela*. The specific statistical analyses were conducted considering these 3 species. During the sampling period, it was found that *M. aquila*, *R. radula*, and *T. marmorata* were represented by a lower rate of availability than other species in terms of years (Table).

In terms of year, throughout the study it was found that the lowest total of cartilaginous fish was obtained in 2004 with a value of 21.44 kg h^{-1}, and the highest was in 2009 with a value of 52.84 kg h^{-1} (Table). The annual variations among the total cartilaginous fish CPUE values were not statistically significant. Similarly, in terms of total CPUE values, annual variations in species were also found to be significant except for *R. rhinobatos* ($P < 0.05$). The annual variations in specifically grouped total cartilaginous fish are shown in Figure 2.

The comparative biomasses of the 3 dominant cartilaginous species did not differ statistically from the

Table. The annual average CPUE in weight and number and their proportions in total catch of the sampled species. W: weight (kg h^{-1}), N: individual (number h^{-1}) (different letters show significant differences among years).

Species	Years	N	W	%W
DASYATIDAE *D. pastinaca*	2004	27	11.59a	16.96
	2005	39	12.41a	24.61
	2006	36	11.87a	24.61
	2007	49	16.00a	53.81
	2008	61	23.54a	56.74
	2009	48	13.81a	30.44
	2010	50	20.20a	37.77
	2011	30	7.94a	23.20
Total	-	42.50	14.67	33.52
GYMURIDAE *G. altavela*	2004	6	5.65a	11.00
	2005	12	4.24a	16.70
	2006	7	7.69a	38.45
	2007	17	7.31a	37.40
	2008	11	7.31a	26.00
	2009	11	4.45a	25.60
	2010	17	5.22a	21.35
	2011	17	8.59a	23.17
Total		12.22	6.31	15.66
RHINOBATHIDAE *R. rhinobatos*	2004	4	4.20ab	5.49
	2005	18	17.84ab	39.90
	2006	4	4.33ab	20.44
	2007	14	7.97ab	25.70
	2008	13	7.61ab	19.00
	2009	25	32.24a	69.30
	2010	4	0.81b	1.93
	2011	20	15.94ab	32.29
Total		12.75	11.37	26.75

Species	Years	N	W	%W
RAJIDAE *R. radula*	2006	2	0.75	0.29
	2007	1	0.13	0.77
Total		0	0.44	0.13
MYLIOBATIDAE *M. aquila*	2005	1	1.68	2.80
	2006	2	0.08	4.31
	2007	1	0.63	0.14
	2008	3	0.09	5.15
	2009	4	2.38	14.17
	2010	6	4.03	3.51
	2011	1	3.75	2.80
Total		2.83	1.81	5.01
TORPEDINIDAE *T. marmorata*	2005	1	0.06	0.12
	2006	1	0.00	0.01
	2007	3	0.09	0.24
	2008	4	0.07	0.13
	2010	3	0.24	1.08
Total		2.40	0.16	0.32
Total	2004	36	21.44	33.45
	2005	70	36.23	84.13
	2006	49	24.72	88.11
	2007	84	32.13	69.94
	2008	90	38.67	107.02
	2009	87	52.88	139.64
	2010	77	30.50	65.64
	2011	72	36.22	81.46
General total		70.63	34.10	83.67

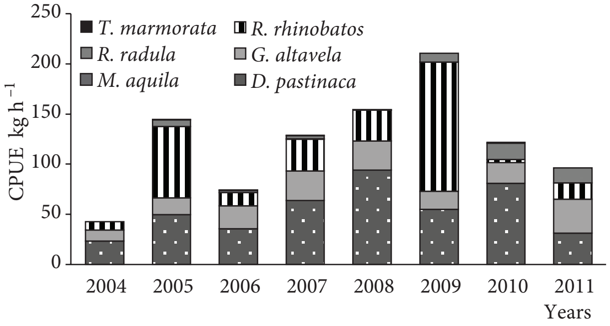

Figure 2. Change in the mean CPUE values of cartilaginous fishes by year.

others in the years between 2004 and 2009. Although the results of 2011 were similar to those of other years, *R. rhinobatos* biomass decreased significantly in 2010 in comparison to other species ($P < 0.05$).

The seasonal variations in total cartilaginous fish were highly significant ($P < 0.01$). Thus, the cartilaginous fish biomass is at its highest in spring and lowest in autumn. Significant seasonal variations were also obtained in *D. pastinaca* ($P < 0.01$) and *G. altavela* ($P < 0.01$), whereas significant variations were not obtained in *R. rhinobatos*. The maximal CPUE values of *D. pastinaca* obtained in the spring differed significantly from those of other seasons ($P < 0.05$). The winter (maximal) and spring (minimal) CPUE values of *G. altavela* were found to be different ($P < 0.01$). Figure 3 shows the interseasonal variations in the total and separate mean CPUE values of cartilaginous fish. Year–season 2-way interactions of total cartilaginous fish and *D. pastinaca* were also significant ($P < 0.01$). However, this significance seemed to result from the dramatic increase in *D. pastinaca* in the winter of 2010.

The depth-dependent variations in total cartilaginous fish were insignificant. The total product obtained from 10 m was 37.89 kg h^{-1} and from 20 m it was 32.67 kg h^{-1}. The specific variations were also insignificant. Figure 4 shows the depth-dependent differences in specific CPUE values.

4. Discussion

No comprehensive study has been carried out with respect to the density and availability of the fauna of cartilaginous fish in İskenderun Bay or with respect to addressing the status of the stock. In our study, in total there were 58 bottom trawling tows performed at the research site between 2004 and 2011. The proportional availability of cartilaginous fish within the catch composition was determined on both a seasonal and an annual basis, and studies are still in progress.

While 6 families were found in the Yumurtalık coastal zone in this study, Bingel (1987) did not evaluate the cartilaginous fish on the basis of species but calculated the total biomass thereof. Bingel (1987) reported that the cartilaginous fish ranked second out of the total catch in terms of biomass. Similarly, Basusta (1997) encountered 19 families of Chondrichthyes in his study covering the entire bay, and it was interpreted that this was because the study site covered a broader area and included different depth layers. In this study, within the trawling catch compositions it was determined that cartilaginous fish ranked second after bony fish in terms of biomass. It could therefore be said that both of the studies performed were in accord with each other in terms of results. In another study that included İskenderun Bay, Kabasakal (2002) sampled *Rhinoptera marginata*, *R. rhinobatos*, *T. marmorata*, and *G. altavela* in the bay. This present study includes 3 additional species compared to Kabasakal (2002); however, *R. marginata* was not sampled. The sampling station used by Kabasakal (2002) was localized around the eastern shores of İskenderun Bay, which have completely different ecological properties. Therefore, it could be claimed that this might be the reason for the differences between the 2 studies.

It was seen that there is more biomass in the species *D. pastinaca*, *G. altavela*, and *R. rhinobatos* compared to the species *M. aquila*, *R. radula*, and *T. marmorata* (Table; Figure 4). The annual variations in CPUE values of total

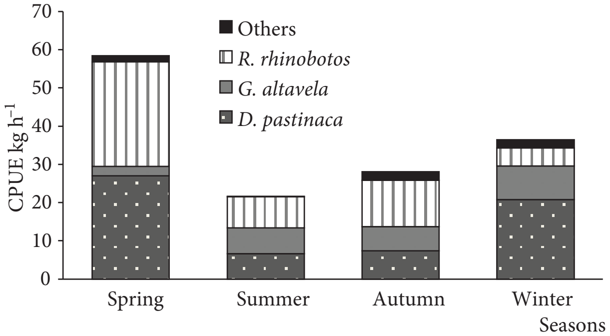

Figure 3. The mean seasonal CPUE values of species between 2004 and 2011.

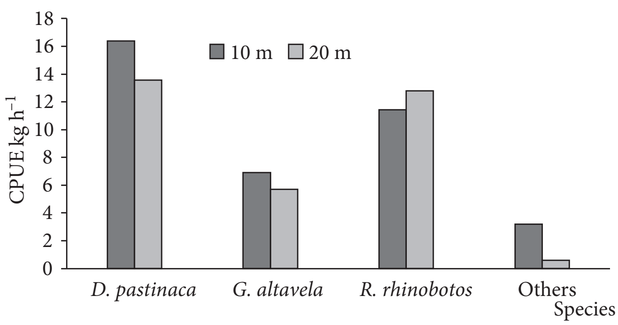

Figure 4. The mean CPUE change in layers of depth, between 2004 and 2011.

cartilaginous species as an indicator of total biomass were not significant. A similar tendency was also observed in the specific biomasses of *D. pastinaca* and *G. altavela*. *R. rhinobatos* was the only species that had significant annual variations. It is highly likely that this significant variation arises from the drastic CPUE decrease in *R. rhinobatos* in 2010. The comparative analysis results also support this hypothesis, which means that the differences among species' CPUE were insignificant except for in 2010. The significant annual fluctuations were only observed in *R. rhinobatos*, which was the only economically important cartilaginous species in the area (Karalar, 2005). The other cartilaginous fish were generally thrown away alive, while the *R. rhinobatos* were not. It is clearly known that drastic fluctuations have been observed in exploited fish populations (Avşar, 2005). Therefore, it could be claimed that the biomasses of the cartilaginous species were generally similar during the study period. This means there might not be an intensive comparison between species. However, the feeding behavior of the species was quite similar to the findings reported by Ismen et al. (2007) and Yeldan (2005).

The seasonal changes in total cartilaginous fish were highly significant ($P < 0.01$). In order to explain the changes observed in the density of these species, many factors must be considered, including environmental conditions such as the properties of the water mass as well as predator–prey relationships, daily migrations, breeding and feeding migrations, and the fishery, according to Bianchi (1992), Koslow (1993), and Gordon et al. (1995). Consequently, it was considered that the differences observed between the species in terms of biomass are the result of these factors. The seasonal variations in *D. pastinaca* ($P < 0.01$) and *G. altavela* were also significant ($P < 0.01$). The CPUE values of *D. pastinaca* were at a minimum in summer, which is the spawning season (Ismen, 2003). Therefore, the spawning area might not coincide with the sampling area for this species. The other species that had significant seasonal variations was *G. altavela*, which had a large biological gap in the study area. Therefore, a consistent interpretation could not be achieved.

Assuming that, as according to Basusta (1997), Mater et al. (2005), and Yeldan and Avşar (2006), cartilaginous fish are a demersal species propagating on sandy and muddy surfaces, it can be said that the findings suggest that these species prefer both layers of depth in terms of the conformity of surface structure (Figure 4). Therefore, the change according to the depth in terms of availability is insignificant, as expected.

Consequently, what is addressed is the current situation of cartilaginous fish with a high catching efficiency among the demersal species within the area where the study was conducted. All of the findings derive from that study; thus the data have been obtained to contribute to future studies with respect to these species. In addition, assessing the biomass and density of the species as well as the monitoring thereof without imperiling the future propagation of cartilaginous fish in the study site is very important. Allowing species to rejuvenate in order to ensure the sustainability of fishing is equally important. In this context, it is hoped that the evaluation of the situation by scientific commissions, and taking into consideration the reported results thereof, can lead to future studies and therefore to future regional fishing activities.

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