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RESEARCH ARTICLE

Chondrichthyan fishes in catch composition of the bottom trawl fishery on the coast of Didim, Turkey

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Abstract

Data collected by 11 scientific bottom trawling operations from three different depth layers (≤50 m, 51-100 m, 101-200 m) in 2009 and 2010 on the Didim (southern Aegean Sea, Aydın) coast were used to describe the distribution and abundance of Chondrichthyes species. A total of 15 species were recorded. At present, insufficient data prevent us from quantifying the impact of this fishery on these species, but our findings highlighted the importance of researches to assess the abundance and geographic extent of these populations.

Keywords: Sharks, rays, trawling, fisheries-independent data

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Introduction

Of the 73 confirmed cartilaginous fish species in the Mediterranean (IUCN 2016), 67 (91.8%) were distributed in the Turkish marine waters (Bilecenoğlu *et al*. 2014). The main knowledge on the cartilaginous fishes in Turkish waters dates back to the early 20th century (e.g., Deveciyan 1915; Ninni 1923; Erazi 1942; Akşıray 1987). In recent years, some inventory studies enabled us to better evaluate the cartilaginous fish fauna (e.g. Bilecenoğlu *et al*. 2002, 2014; Kabasakal 2002). There are some studies regarding cartilaginous fishes, generally fishery-dependent, in Turkish waters (e.g. Gücü and Bingel 1994; Filiz and Mater 2002; Filiz and Toğulga 2002; Keskin and Karakulak 2006; Yeldan and Avşar 2006). Especially in the 2000's, to varying degrees, researchers undertook surveys throughout much of the Turkish waters and they were collected in workshop proceedings (Başusta *et al*. 2006). More recently, there seems to be an increased interest in studies regarding chondrichthyan species in Turkish waters (e.g., Güven *et al*. 2012; Yeldan *et al*. 2013; Saygu and Deval 2014; Deval *et al*. 2014; Özgür Özbek *et al*. 2015; Yağlıoğlu *et al*. 2015; de Meo *et al*. 2017). In

spite of all endeavours, the chondrichthyan species along the coasts of Turkey have received little attention and are poorly understood. In this respect, a specific national action plan has recently been proposed for the conservation of cartilaginous fishes in Turkish waters (TÜDAV 2017).

Catch and landing data of commercial fisheries are often insufficient because of a general lack of species-specific recording (Filiz and Toğulga 2002). The uncertainties in historical total landing data attributable to the common practice of recording catch generically, e.g. as "dogfish and sharks", rather than by species, makes fishery-independent data from surveys an important source for studying the distribution and relative abundance of chondrichthyans. In the present study, data collected during one year by scientific (fishery-independent) surveys were used in order to identify chondrichthyan species, present along the coast of Didim, and to describe their distribution and abundance. Such information will, we believe, help resolve the issue of identifying appropriate stocks for the management.

Materials and Methods

Fishery-independent surveys were carried out between December 2009 and August 2010 on the coast of Didim, in the area within the specified coordinates (37º38'73N-27º01'07E; 37º37'09N-27º06'52E; 37º00'42 N-28º06'52E; 37º07'21N-27º32'15E) (Figure 1). A commercial trawler (F/V Akyarlar, 22.6 m length, 485 HP) maintained at 2.2–2.5 knots and equipped with a conventional bottom trawl net of 44 mm codend mesh size with a head-rope length of 40 m was used. Haul durations ranged from 1 to 1.5 hours. Eleven bottom trawling operations in three depth zones (Strata A: ≤50 m with eight trawl operations, St. B: 51-100 m with two trawl operations, and St. C: 101-200 m with only one trawl operation) were conducted (Table 1).

As soon as the catches were taken on deck, the cartilaginous fish were identified to the species level, following Whitehead *et al*. (1984) and Golani *et al*. (2006), counted, and weighed (with 0.1 kg precision handbag). Their proportional abundance among the total fish catch and total cartilaginous fish was also calculated. The number of specimens (N) and the total weights (W) were recorded and their percentages (%N and %W) were calculated for each depth. The swept area (SA) for each hauling was estimated as follows: SA= 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)]. Raw data values of abundance and biomass were standardized using swept area method for the estimation of the number of individuals per unit area (n km^{-2}) and weight per unit area (kg km^{-2}). As a qualitative description of the species in the area, Shannon-Wiener diversity (H') was calculated for each stratum.

Table 1. Trawled area and duration of hauls per depth strata in the study area

Depth Strata	Trawl Coordinates	Duration (min)	Sampling Period
≤50 m	37º22'509"N/27º11'533"E 37º26'793"N/27º12'216"E	105	December 2009
	37º28'377"N/27º09'700"E 37º37'091"N/27º06'520"E	120	December 2009
	37º37'314"N/27º06'002"E 37º38'739"N/27º01'077"E	70	December 2009
	37º38'697"N/27º00'326"E 37º38'708"N/27º00'390"E	124	March 2010
	37º31'842"N/27º08'262"E 37º36'036"N/27º06'739"E	91	April 2010
	37º29'060"N/27º09'420"E 37º33'970"N/27º08'310"E	103	July 2010
	37º34'140"N/27º08'270"E 37º38'275"N/27º03'210"E	150	July 2010
	37º20'100"N/27º11'040"E 37º18'960"N/27º14'480"E	95	August 2010
51-100 m	36º41'312"N/27º41'501"E 36º41'742"N/27º42'276"E	93	January 2010
	37º00'808"N/28º03'205"E 37º00'423"N/28º06'523"E	85	April 2010
101-200 m	36º42'780"N/27º48'091"E 36º43'387"N/27º50'350"E	90	January 2010

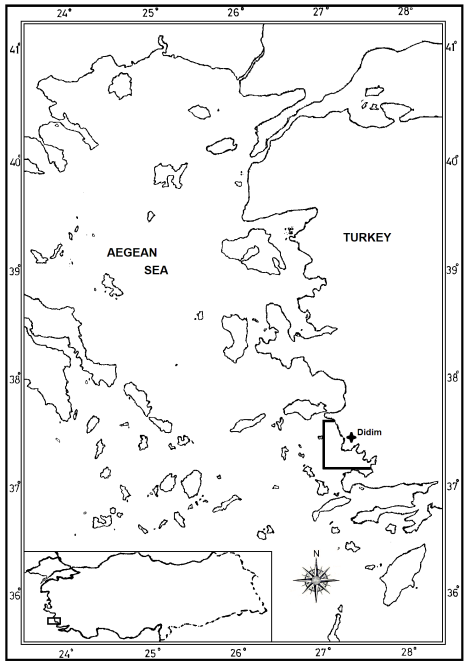

Figure 1. Map of the study area (Didim, south Aegean Sea)

Results

A total of 15 Chondrichthyes species (17.4% of 86 species) belonging to 9 families were identified and collected from 11 hauls. This comprised 0.6% in abundance and 13.1% in biomass of total catch (Table 2). In the Strata A, 11 species were caught, while in the Strata B, 8 species and in the Strata C, 4 species were caught (Table 2).

Table 2. Number of species (Sp.N), specimens (N), and biomass (W) of Chondrichthyes and Actinopterygii collected in this study

Family		Strata A	Strata B	Strata C
Chondrichthyes	Sp.N.	11 (17.2%)	8 (17.8%)	4 (30.8%)
	N	161 (0.6%)	18 (0.6%)	10 (9.9%)
	W	156.9 (12.4%)	28.1 (16.4%)	4.2 (59.5%)
	Total	Sp.N= 15 (17.4%)	N= 189 (0.6%)	W= 189.2 (13.1%)
Actinipterygii	Sp.N.	53 (82.8%)	37 (82.2%)	9 (90.1%)
	N	28093 (99.4%)	2752 (99.4%)	91 (90.1%)
	W	1108.0 (87.6%)	143.1 (83.6%)	2.8 (40.5%)
	Total	Sp.N=71 (82.6%)	N= 30936 (99.4%)	W= 1253.9 (86.9%)
Total Catch		Sp.N= 86	N= 31125	W= 1443.1

Table 3. Abundance and biomass of chondrichthyan species by depth strata Abd: abundance (n/km^{-2}); Bio: biomass (kg/km^{-2})

Family	Species	Strata A		Strata B		Strata C	
		Abd	**Bio**	**Abd**	**Bio**	**Abd**	**Bio**
Dasyatidae	*Dasyatis pastinaca*	20.9	23.9	30.0	45.0		
Gymnuridae	*Gymnura altavela*	6.8	6.9				
Triakidae	*Mustelus mustelus*	29.1	44.8	10.0	22.0		
	Mustelus asterias					26.3	52.6
Myliobatidae	*Myliobatis Aquila*	4.7	2.6	10.0	11.0		
	Aetomylaeus bovinus			5.0	2.0		
Rajidae	*Raja clavata*	2.0	0.9	10.0	42.0	52.6	7.9
	Raja miraletus	14.9	13.3	15.0	5.0	105.3	10.5
	*Raja radula**	14.2	8.4				
Scyliorhinidae	*Scyliorhinus canicula*	1.4	0.4				
	Scyliorhinus stellaris	2.0	0.4				
Squalidae	*Squalus blainvillei*			5.0	1.0	78.9	39.5
Squatinidae	*Squatina squatina*			5.0	13.0		
Torpedinidae	*Torpedo marmorata*	10.8	3.9				
	Torpedo nobiliana	2.0	0.6				

* indicates Mediterranean endemic species according to Melendez *et al*. (2017).

Raja clavata and *R. miraletus* were caught in all three depth strata (Table 3). In addition, six species (*Gymnura altavela*, *R. radula*, *Scyliorhinus canicula*, *Scyliorhinus stellaris*, *Torpedo marmorata*, and *Torpedo nobiliana*) were collected only in Strata A, 2 (*Squatina squatina*, and *Aetomylaeus bovinus*) in Strata B and only one (*Mustelus asterias*) in Strata C (Table 3). In all depth strata, Rajidae and Triakidae represented 30.2 and 24.3%, respectively, of the Chondrichthyes collected (Table 3).

The most abundant species were *Mustelus mustelus*, *Dasyatis pastinaca*, *Raja miraletus* and *Raja radula*. The first one was caught down to 100 m, with the highest biomass (Table 3). Shannon diversity index (H') varied from 2.58 (St. A) to 0.88 (St. C).

Among the Chondrichthyes species in this fishery area 53.3% are classified as near threatened (*Raja clavata*, *Scyliorhinus stellaris*), vulnerable (*Dasyatis pastinaca*, *Gymnura altavela, Mustelus mustelus, Myliobatis aquila*), endangered (*Raja radula*) or critically endangered (*Squatina squatina*) (IUCN, 2018). The rest, 46.7%, of the Chondrichthyes species are either the least concern (*Mustelus asteries*, *Raja miraletus*, *Scyliorhinus canicula*) or data deficient (*Aetomyleus bovinus*, *Squalus blainvillei*, *Torpedo marmorata*, *Torpedo nobiliana*) (IUCN, 2018).

Discussion

Ellis *et al*. (2005) stated that "the data from fishery-independent surveys is especially important", and as in countries like Turkey where accurate commercial landing data for many chondrichthyan species lack, each dataset being fishery-independent like this study should be considered important. The survey was designed primarily to assess the chondrichthyans and represented the investigation on chondrichthyan species carried out in three depths strata with the same gear. It is important that 184 of the approximately 700 studies on cartilaginous fishes in the Mediterranean Sea have been provided by Turkish researchers (TÜDAV 2017). It can be said that, however, Turkish researchers have not given sufficient importance to studies that provide detailed and comparable information about the distribution of cartilaginous fish species in certain depth zones.

The cartilaginous fish species obtained from this study were usual species obtained from other studies with similar methods. When similar depth zones are considered, it is seen that species number ranged between two (Deval *et al*. 2014; E in Table 4) and 20 (Yağlıoğlu *et al*. 2015; C in Table 4), which can be attributed by the difference of sampling areas and design of the studies.

Regarding depth-related changes in species, Keskin and Karakulak (2006) showed a tendency to increase with depth from six species (40-50 m) to nine species (300-500 m) (B in Table 4). However, it is not seen as a clear tendency in Yağlıoğlu *et al*. (2015), presenting eight species between 0 and 50 m, then 15 between 50 and 100 m, followed by the drop to seven in the depth over 100 m (C in Table 4). Özgür Özbek *et al.* (2015) reported that the frequency of occurrence generally decreased from shallow to deep waters in *Dasyatis* species. De Meo *et al*. (2017) reported that, in general, biomass was found to be higher at shallow depths, decreasing going offshore. In our study, Shannon-Wiener diversity index (H') was different among the depths, the highest value was found in Stratum A

(2.58), then 2.26 in Stratum B, and decreased to 0.88 in Stratum C. It could be assumed that the diversity was higher, because there were eight trawl operations in stratum A and only one operation in Stratum C.

Table 4. Changes of chondrichthyan species by depth strata

Species	≤50m	51-100	>101 m	Rarity**
Aetomylaeus bovinus	AC			AC
Carcharhinus altimus		C		
Carcharhinus plumbeus		C	D	
Centrophorus granulosus			D	
Dalatias licha			D	
Dasyatis pastinaca	AC	ACG	CG	
Dasyatis centroura			E	E
Dipturus oxyrinchus			BC	BC
Etmopterus spinax			BD	
Galeus melastomus			BCD	B
Gymnura altavela	AC	C	C	
Heptranchias perlo			D	
Isurus oxyrinchus		C		
Leucoraja circularis			E	
Mustelus mustelus	A	AC	D	
Mustelus asterias			A	A
Myliobatis aquila	A	A		
Oxynotus centrina		CG	CD	C
*Raja asterias**	B	B	B	
Raja clavata	ABCG	ABCG	ABCFG	A
Raja miraletus	ABC	ACG	ABF	BC
*Raja radula**	AC	B		BC
Rhinobatos spp.	C	C	CF	
Rhinoptera marginata		C		
Rostraraja alba	B	B	B	
Scyliorhinus canicula	ABG	BCG	BCD	AC
Scyliorhinus stellaris	A	CG	C	AC
Squalus acanthias		G		
Squalus blainvillei		A	ABD	AB
Squatina squatina		AC		AC
Torpedo marmorata	ABC	G	G	B
Torpedo nobiliana	A			A
Torpedo torpedo	C			

A: This study; B: Keskin and Karakulak (2006); C: Yağlıoğlu *et al*. (2015); D: Güven *et al*. (2012); E: Deval *et al*. (2014); F: Saygu and Deval (2014); G: Ismen *et al.* (2013).
* indicates Mediterranean endemic species according to Melendez *et al*. (2017).
** Species were classified as rare when the frequency of occurrence index ≤ 25% according to Yağlıoğlu *et al*. (2015).

The abundance of some species appeared to be depth-dependent. *Torpedo* spp. were confined to water shallower than 50 m (Table 4). However, some species probably exist over a wider depth range, such as *D. pastinaca*, *G. altavela*, *M. mustelus, R. asterias*, *R. clavata*, *R. miraletus*, *Rhinobatos* spp, *R. alba*, *S. canicula, S. stellaris* and *T. marmorata* (Table 4). *Etmopterus spinax* and *Galeus*

melastomus preferred deeper depths (Table 4) especially deeper than 200 m as indicated by Massuti and Moranta (2003). Only *R. clavata* was present at all depths in almost all studies (Table 4). *Carcharhinus* spp. and *Isurus oxyrinchus*, which are also listed in Table 4, are generally caught as a bycatch in pelagic fisheries, thus they were not found in our survey.

Most of the chondrichthyans are vulnerable to overexploitation by fishing either directly or indirectly (bycatch) (IUCN 2018). Turkish fisheries targeted some shark species until 1990 (Kabasakal 1998; Arpa 2012). Other chondrichthyans have not been and are not currently targeted by commercial fisheries operating along the coast of Turkey, but are taken as bycatch in the coastal fishery. Indeed, several chondrichthyan species that once were widespread and abundant are now uncommon and rare in Turkish waters (TÜDAV 2017). At least 15 species now seemed as rare in Turkish waters (Table 4). Among the species presented in Table 4, only *Carcharhinus plumbeus* and *Squalus acanthias* have protection in the Turkish seas (Anonymous 2016a, b). In addition to the protected species in Anonymous (2016a, b), *Squantina oculata*, *Squantina squantina*, *Squantina aculeata*, *Rhinobatos rhinobatos*, *Rhinobatos cemiculus*, *Oxynotus centrina*, *Mobula mobular*, *Mobula japonica*, *Alopias vulpinus*, *Isurus oxyrinchus*, *Hexanchus griseus* and *Sphyrna zygaena* must be protected (TÜDAV 2017). Prohibition of landing the endangered species, as well as vulnerable/threatened ones, along with the development and adaptation of gears that meet discard-reduction objectives will promote the sustainable management of chondrichthyan populations. Knowledge of chondrichthyan species along the Turkish coasts remains limited and further works are required. It seemed that there is a strong need especially for biomass and stock studies and data regarding their biology and detailed fishery statistics.

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Didim kıyısında (Türkiye) dip trolü balıkçılığı av kompozisyonundaki Kıkırdaklı balıklar

Öz

Didim (güney Ege Denizi, Aydın) kıyılarında 2009 ve 2010 yıllarında üç farklı derinlik tabakasından (≤50 m, 51-100 m, 101-200 m) yürütülen 11 bilimsel trol çekiminden elde edilen veriler, Chondrichthyes türlerinin dağılımı ve bolluğunu belirlemek için

kullanılmıştır. Çalışma sonunda 15 tür saptanmıştır. Şu an için, elimizdeki veri bu tür balıkçılığın bu türlerde yaptığı etkiyi ortaya koymamızı engellemektedir, ancak bulgularımız bu türlerin bolluğu ve coğrafi dağılımını değerlerdirmek için bu tür araştırmaların yürütülmesinin önemli olduğunu vurgulamıştır.

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