Online ISSN: 2588-3526

Journal of Wildlife and Biodiversity

DOI: 10.22120/jwb.2020 .136094.1185

Special issue 68-77 (2020)

Challenges for Biodiversity and Conservation in the Mediterranean Region

(http://www.wildlife-biodiversity.com/)

Research Article

Can opportunistic methodologies provide information on elasmobranchs? A case study from Seas around Turkey

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Received: 20 August 2020 / Revised: 5 September 2020 / Accepted: 1 October 2020 / Published online: 8 October 2020 Ministry of Sciences, Research, and Technology, Arak University, Iran.

Abstract

Research on shark and ray species in Turkey is limited and mostly conducted by destructive methods. Unfortunately, many of these species are threatened or near extinction, and still, there are many species with limited or no information. This fact raises concern on what method of research should be conducted on elasmobranchs with conservation in mind. And this initiated the idea of non-lethal or opportunistic sampling methodologies for obtaining required knowledge. Collecting genetic information without additional pressure by lethal approaches, using the latest technology from other disciplines, citizen science to learn about spatial-temporal distribution or population dynamics, and collecting bycatch individuals with no usage can be listed among the most popular methodologies. This study aimed to show how effective were opportunistic methods to obtain information on these threatened species without adding more sampling pressure on their populations.

Keywords: Data collection, Sharks, Rays, The Mediterranean Sea, The Black Sea

Introduction

Elasmobranchs or cartilaginous species, more popularly known as sharks, rays, and skates, are apex predators in marine ecosystems. These species have survived mostly. However, some species are recently extinct either regionally or globally, and many are threatened due to overfishing (Serena 2015). Knowledge of their general biology is limited, and further research is needed especially when 1 out of 5 species is Data Deficient in the Mediterranean Sea (Dulvy *et al*. 2016). Though it is crucial to obtain biological information, it is also as essential to lead little destruction as possible to the populations since already most of the elasmobranchs are in a declining trend in the Mediterranean Sea due to high fisheries mortality (Damalas and Vassilopoulou 2011, Dulvy *et al*. 2016, Bengil and Başusta 2018). The Turkish fauna', 68 species, 70% is somewhat common bycatch (Bengil and Başusta 2018). The percentage or biodiversity of fishing gears is diverse due to species' characteristics (Huse *et al.* 2000, Jordan *et al.* 2013). But generally, as a result of their opportunistic feeding behaviour longlines, and trammel nets are among the top perpetrators for high bycatch numbers (Bengil and Başusta

2018). Unfortunately, many of these incidental catch results with mortality (Coelho *et al.* 2012, Ward-Paige *et al.* 2012), and the individuals are discarded into the sea. This fact raises concerns about how a research method on elasmobranchs should be conducted on behalf of conservation. The method should be built up the optimization with a non-lethal approach or opportunistic sampling methodologies for providing knowledge to fill the gap. Collecting genetic information with a non-lethal way (or no contribution to lethal procedures), using the latest technology from other disciplines, citizen science to learn about spatial-temporal distribution or population dynamics, and collecting bycatch individuals that have no usage can be listed among the most popular methodologies (Braccini *et al.* 2006, Lieber *et al.* 2013, Barbini *et al.* 2015, Moore 2017).

In this regard, this study aimed to determine if opportunistic methodologies were enough to produce information on these threatened species without adding more pressure on their populations. Therefore, a study was designed by opportunistic approaches to collect elasmobranch specimens between May 2015 and February 2018 throughout the coasts of seas around Turkey. An extensive evaluation was assessed on the potential of the method for the bio-ecological properties of the elasmobranch and its advantage and disadvantage.

Material and methods

To collect bycatch elasmobranch specimens throughout the Turkish coasts, an information network of fishers was established at the beginning of the study (the Black Sea, Sea of Marmara, Aegean Sea, and the Mediterranean Sea). The collection of the specimens started in May 2015. It continued till February 2018, till the beginning of the banned, April 2018, to fish or land some elasmobranch species in any part of Turkish waters (Official Gazette 2018). Individuals were obtained opportunistically via information networks, meaning the collection of dead bycatch individuals. As an approach of citizen science, questionnaires were conducted not only on fishers but also on local businesses and university students from all over the locations from the Aegean Sea to the Levantine Sea (Fig. 1). Before the questionnaire began, a short explanation was given to the participant. Each group, local businesses, students, and fishers were asked different questions to increase knowledge production. To fishers, besides questions on their fisheries practice (gear they use, which species they commonly bycatch, etc.) they were also asked about their age, how long they have been fishing, and to produce as much knowledge as possible on the past and current status of elasmobranchs in their areas. To local businesses and students' questions were mainly on to measure their awareness and their knowledge of elasmobranchs in their regions.

Regions where individuals were collected, were coasts off Samsun in the Black Sea; Edremit Bay, Izmir Bay, Ildiri Bay, Sıgacık Bay, Kusadası Bay, Gokova Bay in the Aegean Sea; Fethiye Bay, Antalya Bay, Mersin Bay, and Iskenderun Bay in the Levantine Sea. It should also be noted that only individuals that were hauled dead were collected during the study period. If the individual was alive when hauled, we asked the fishers to release it back. Landed individuals were collected fresh if possible else were stored frozen as whole or cut in parts depending on his/her possibility till we were able to collect. A set of photographs of the individual was received in this case for possible identification was made through them. Individuals were identified by using Compagno (1984) and Serena (2005) and recent taxonomic status were checked from Froese and Pauly (2019). The individual was measured using a measuring board with 1 mm sensitivity and scaled using an electronic scale with 0.01 g sensitivity.

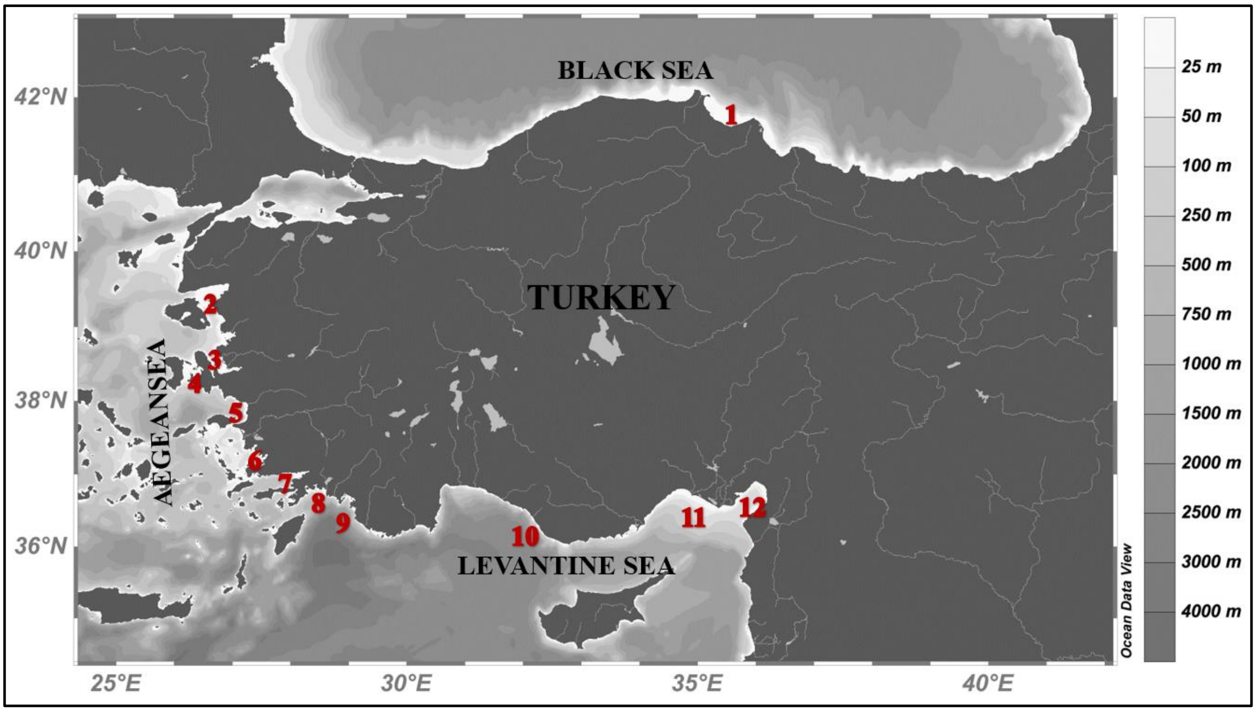

Figure 1. Locations where specimens were obtained and in Aegean and Levantine where the questionnaires were conducted, are shown in numbers. (1: Samsun, 2: Izmir Bay, 3: Ildırı Bay, 4: Sıgacik and Kusadasi Bay, 5: Gokova Bay, 6: Fethiye Bay, 7: Antalya Bay, 8: Iskenderun Bay).

A digital caliper with a sensitivity of 1 mm, was used for the embryos' length in case of existence. Sex was macroscopically determined from the presents or absence of claspers. According to their reproductive strategy, the maturity stages of the species were determined using the ICES (2013) scale. To reserve, a small part of tissue was taken from each individual and are stored in absolute ethanol for later further genetics studies.

Results

A total of 189 individuals belonging to 17 species were collected during the study period. The location and species that were obtained are given in Table 1. Though the number of species is high, some species had a higher frequency than others (Table 2). The highest number of individuals was from *G. cemiculus*, with 117, where further information on its biology and ecology can be found in Bengil *et al.* (2018) and Bengil *et al.* (2020a). Among the two juvenile *I. oxyrinchus* that was obtained, one was the smallest female found in the eastern Mediterranean (further information can be found in Bengil *et al.* (2019).

Among 17, six species were represented with only one individual, and in some cases was possible to produce some information on their reproduction, such as from, pregnant near-term, *M. asterias*. According to the embryos' development stage, parturition occurs between February and March in the Levantine Sea (Fig. 2a). Also, another pregnant individual, a *Raja radula*, with developing egg cases and many follicles in different development stages (Figure 2b) was obtained in May 2015, which indicated continuous reproduction. In addition to observing pregnant individuals, it was possible to get neonate or juvenile individuals as well. Besides the above-mentioned *I. oxyrinchus* and *G: cemiculus*, neonates and juveniles belonging to *T. marmorata* (Fig. 3), *M. aquila*, and *G. altavela* were also obtained from Gediz Lagoon and outer-eastern Izmir Bay. According to these juveniles, it can be concluded that this area is a breeding and nursery ground for some elasmobranch species, specifically for batoids. Furthermore, all three individuals of *C. plumbeus* (one, smallest among, from Gokova Bay in October 2017 and two, both 6 cm larger, from Iskenderun Bay in January 2018) were close to length at birth length indicating that they were newborns and both Gokova and Iskenderun Bay could be nursery areas.

Figure 2. Example photos for pregnant specimens; A. *M. asterias* embryos, B. *R. radula* with the egg cases

Except two species (*S. blainville* and *D. pastinaca*) two *I. oxyrinchus*, 84 *G. cemiculus*, two *S. squatina*, three *C. plumbeus*, one G. altavela, one *M. asterias*, one *M. aquila*, five M. mustelus, six *M. punctulatus*, one *A. bovinus*, one *R. miraletus*, six R. radula, two *S. canicula*, and two *T. marmorata* individuals had food items in their stomachs. Though the number of full stomachs was limited and not enough for statistical analyses, it was observed that in the stomachs of shark species, there were mainly bony fish remains, secondary crustaceans and/or cephalopods. In batoid or ray species, the main find was observed to be crustacean species, and some mollusks as their body type also suggest, but some bony fishes were also found.

Figure 3. A photo of the neonate *T. marmorata*

A total of 236 questionnaires (43 local businesses, 86 with local fishermen, and 107 students), excluding vague and contradictive answers, were conducted throughout Turkey's coasts in the eastern Mediterranean. Questionnaires with local businesses showed that 85 % of them know the existence of shark or ray species in their region, and half of these people think sharks are in decline, but they have no idea about batoid species. All participants reported remembering somewhat large or impressive shark catches in their region. In students' case, 95 % of them did not know the existence of shark or ray species on Turkish coasts, and the students who have known either had someone in their family as a fisherman or liked fishing. Both for local businesses and students, 97 % did not have anyone in their family who is a fisherman. Regarding fishermen, participants age ranged between 24 to 55 years old and the average year of fishing was 14. Most have started fishing with one of their relatives (father, brother, or uncle) from 10. List of shark or ray species they commonly bycatch is given in Table 3. Concerning which fishing gear catches most shark or ray species was, for sharks longlines and for rays longlines and nets. Though 60 % of the fishermen don't sell their bycatch elasmobranchs and "mostly" release alive, 40 %, especially fishermen in the Levantine Sea, reported selling their bycatch or even precisely target (mainly guitarfish species and stingrays) during off-seasons, during bans for bony fishes. Almost all the fishermen, except 7, thinks that the population of these species is declining. On the historical photos, fishermen showed some images of noticeably big individuals dating back to the 80s but did not want to share because they were also in the picture. But it was possible to identify the species, and there was a Thresher, three were either Sharpnose Sevengill Shark or Bluntnose sixgill shark, and two were Shortfin Mako. Among these species, according to the fisherman, Thresher has become rare in their area (Izmir Bay). Other reported species are still caught periodically in the Levantine Sea.

Table 1. Species and the areas that were obtained. (1: Samsun Bay, 2: Izmir Bay, 3: Ildırı Bay, 4: Sıgacik and Kusadasi Bay, 5: Gokova Bay, 6: Fethiye Bay, 7: Antalya Bay, 8: Iskenderun Bay).

Species	**Black Sea**	**Aegean Sea**				**Levantine Sea**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Carcharhinus plumbeus (Nardo, 1827)					+			+
Mustelus asterias Cloquet, 1819						+		
Mustelus mustelus (Linnaeus, 1758)		+	+					
Mustelus punctulatus Risso, 1827		+						
Scyliorhinus canicula (Linnaeus, 1758)		+	+	+				
Isurus oxyrinchus Rafinesque, 1810		+			+	+		
Squalus blainville (Risso, 1827)								+
Torpedo marmorata Risso, 1810		+	+	+				
Dasyatis pastinaca (Linnaeus, 1758)		+		+				
Gymnura altavela (Linnaeus, 1758)		+						
Myliobatis aquila (Linnaeus, 1758)		+		+				
Aetomylaeus bovinus (Geoffroy Saint-Hilaire, 1817)		+						
Raja miraletus Linnaeus, 1758		+						
Raja clavata Linnaeus, 1758	+							
Raja radula Delaroche, 1809		+	+	+				
Glaucostegus cemiculus (Geoffroy Saint-Hilaire, 1817)		+			+			
Squatina squatina (Linnaeus, 1758)					+			

Discussion

Similar opportunistic approaches for data production have shown significant results in many cases from various parts of the world's oceans. Such as a study conducted on bycatch individuals in Australia provided successful results that produced extensive information on shortnose spurdog' (*Squalus megalops* (Macleay, 1881)) biology (Brancchini 2006), a data deficient species, between a sampling period of October 2002 and April 2004. Another study by using citizen scientists' reports, social and mass media searches, interviews with fishers was able to identify potentially important areas in Greece for endangered guitarfish species (Giovos *et al.*

2018a). Further, a recent study from Turkey by gathering various media tools were able to show rare and large sharks species status in the region (Kabasakal and Bilecenoglu 2020). A survey of another vulnerable group, cetaceans, used questionnaires and discovered a higher dependency of cetaceans to the fishery for all regions and regional differences in interaction characteristics (Bengil *et al.* 2020b). Besides such large species, there are also opportunistic or citizen science-based studies on threatened (Mavruk *et al.* 2018) or invasive (Giovos *et al.* 2018b) marine species that show the effectiveness of such methodologies. These examples also show that it is possible to produce information no matter the taxa.

Table 2. Number of species and some of their morphological parameters

Species	N	Total length (cm)			Total weight (g)		
		Min	Max	Ave	Min	Max	Ave
Isurus oxyrinchus*	2	Details on Bengil *et al.* (2019)					
Glaucostegus cemiculus*	117	Details on Bengil *et al*. (2018)					
Squalus blainville	1			647			1250
Squatina squatina	2	69.5	83.5	76.5	3190	5140	4165
Carcharhinus plumbeus	3	73.0	79.9	77.5	2958.09	3205	3081.55*
Dasyatis pastinaca	8	35.3	106.2	550.63	262.25	1271	877.64
Gymnura altavela	4	23	33.2	27.275	383.59	802.43	555.87
Mustelus asterias	1			97.3			3465
Myliobatis aquila	2	46.4	53.1	49.75	250	475.35	362.68
Mustelus mustelus	6	45.70	125.50	86.87	30.20	657.50	274.64
Mustelus punctulatus	8	40.9	53.3	48.84	175.4	479.3	386.83
Aetomylaeus bovinus	1			72.7			736.5
Raja miraletus	1			37.5			262.4
Raja radula	9	32.4	53.3	43.31	256.55	941.29	552.71
Scyliorhinus canicula	6	34.9	68.6	49.45	200	1465	614.26
Torpedo marmorata	17	9.20	41.5	24.3	17.17	2030.00	459.50
Raja clavata	1**						

*On of the individual was obtained without its dorsal, pectoral, and pelvic fins, so the average weight was only estimated from two individuals

**only a piece of the individual's tissue was obtained

Table 3. Species reported by fishermen that are commonly caught are listed in alphabetical order.

Type	List of Species	Common English Name	Location
Sharks	*Alopias vulpinus*	Thresher	Aegean - Mediterranean
	Centrohporus granulosus	Gulper shark	Mediterranean
	Heptranchias perlo	Sharpnose Sevengill Shark	Mediterranean
	Hexanchus griseus	Bluntnose sixgill shark	Mediterranean
	Mustelus asterias	Starry smooth-hound	Mediterranean
	Mustelus mustelus	Smooth-hound	Aegean - Mediterranean
	Oxynotus centrina	Angular rough shark	Aegean - Mediterranean
	Scyliorhinus canicula	Lesser-spotted dogfish	Aegean - Mediterranean
	Scyliorhinus stellaris	Nursehound	Aegean - Mediterranean
Batoids	*Dasyatis pastinaca*	Common stingray	Aegean - Mediterranean
	Dipturus oxyrinchus	Long-nosed skate	Aegean - Mediterranean
	Glaucostegus cemiculus	Blackchin guitarfish	Mediterranean
	Gymnura altavela	Spiny butterfly ray	Aegean - Mediterranean
	Myliobatis aquila	Common eagle ray	Aegean - Mediterranean
	Raja asterias	Mediterranean starry ray	Aegean - Mediterranean
	Raja clavata	Thornback ray	Aegean - Mediterranean
	Raja miraletus	Brown ray	Aegean - Mediterranean
	Raja radula	Rough ray	Aegean - Mediterranean
	Rhinobatos rhinobatos	Guitarfish	Mediterranean
	Rostroraja alba	White skate	Aegean - Mediterranean
	Squatina squatina	Angelshark	Mediterranean
	Torpedo marmorata	Marbled electric ray	Aegean - Mediterranean
	Torpedo torpedo	Common torpedo	Mediterranean

As mentioned before elasmobranchs make the large percent of the bycatch in Turkey, where 65% of these species are threatened (Bengil and Başusta 2018). Though elasmobranchs are not in Turkish cuisine, 38 of them have commercial value either for consumption in touristic areas or exportation (Filiz and Toğulga 2002, Ceyhan *et al*. 2010). Therefore, the rest are mostly discarded if not used for longlines as bait. This study demonstrated the availability of increased understanding in various bio-ecological properties of the species, even though some deficiency, under consideration using an opportunistic methodology to obtain information on these threatened species without adding more pressure on their populations. Moreover, the opportunistic method also makes it possible to achieve relatively more on a threatened species without additional lethal sampling and an indication of fisheries' pressure. The advantages and disadvantages of the method were summarized in Table 4.

The study method provided strong evidence on a breeding and nursery ground in Izmir Bay for *T. marmorata*, *M. aquila,* and *G. altavela*, *I. oxyrinchus* (Bengil *et al.* 2019), *G. cemiculus* (Bengil *et al.* 2020). Additionally, three *C. plumbeus* were close to the reported size at birth for the Mediterranean Sea (Bradaï *et al.* 2005). Since Gökova Bay is already known nursery ground (Bilecenoglu 2008), finding two juveniles suggests that Iskenderun Bay and its adjacent waters are also nursery grounds for this species, which previously reported catches also offers (Yemisken *et al.* 2014, Basusta 2016, Filiz 2019). Moreover, pregnant individuals of *M. asterias* and *R. radula* provided information on the species' reproduction biology as the first time in the Turkish waters. In *M. asterias* case, according to the status of the embryos, it indicated that parturition occurs late winter-early spring in the eastern Mediterranean, as Farrell *et al.* (2010) have reported for the north-east Atlantic Ocean. According to previous studies from other parts of the Mediterranean Sea, it is possible to come across *R. radula* carrying egg cases. The reproduction continues yearlong (Kadri *et al.* 2013) parallel to the observations in this study that different stages of follicles. Regarding the questionnaires, it was possible to glimpse the past status of elasmobranchs and an idea on their biodiversity in these areas of the eastern Mediterranean. According to questionnaires, large sharks were common, where, now, they became scarce (Kabasakal and Bilecenoglu 2020). A study by Kabasakal and De Maddalena (2011) used a photo taken of a female *I. oxyrinchus* in the 1950s, reported the largest individual, which encourages historical photographs as a data source. Moreover, questionnaires have the potential to draw a baseline on the diversity of the elasmobranchs in a specific region.

Table 4. Advantages and disadvantages of opportunistic methodologies

Advantages	Disadvantages
Producing information with less impact on species (such as extracting as much information from one individual)	Could be costly (depending on the laboratory work such as isotope analyses or DNA sequencing)
Good information network	Needs of good information network
Sampling a larger area	Limited to your information network range
observing more gears at the same time	Limited assessment of the region, depth, or sampling gear
Able to obtain information on multiple species	May need extended time for data accumulation on a particular species

Conclusion

Even though it is a concrete fact that data produced from one or few individuals belonging to a species may not give definite conclusions on the biology of the species, it has merit contribution to fill some specific information on the species' biology and ecology. Maybe using pure luck, it is possible to obtain a very key or even first information on an endangered or rare species through opportunistic methodologies, as shown in this study, where you may not achieve with years of traditional sampling methodologies. On the other hand, the method might not agree with some specific research questions and doesn't allow the assessment for the effects of time, region, depth, or sampling gear to be tested (Bracchini 2006) and might take an extended time for data accumulation. However, not putting extra pressure on robust scientific methods on threatened species is a motivation point for conservational or monitoring studies. Therefore, it is possible to provide a broad range of information via opportunistic methodologies without aiding in these threatened species' extinction.

Acknowledgments

This study was funded by three "The Rufford Foundation" projects numbered 17514-1, 20115-2, and 23747-B. This study is part of a Doctor of Philosophy (Ph.D.) thesis of Elizabeth Grace Tunka BENGİL, conducted in Ege University Graduate School of Natural and Applied Science. The author would like to thank to Dr. Alp SALMAN, Dr. Fethi BENGİL, Dr. Sinan MAVRUK, Dr. İsmet SAYGU, Dr. Meryem AKALIN, Dr. İnci TÜNEY KIZILKAYA and fishers for their valuable help during sample collection and laboratory studies, Özgür Can AVCI and Fırat TOMRUKCU for their contribution during questionnaires.

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