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# SOME OBSERVATIONS ON THE ABUNDANCE AND BIOMASS OF ELASMOBRANCH FISHES CAPTURED OVER STRATIFIED BOTTOM TRAWL SURVEYS FROM THE SPECIAL ENVIRONMENTAL PROTECTION AREA OF DATÇA-BOZBURUN (TÜRKİYE)

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**Abstract**

This study investigates the abundance and biomass of elasmobranch fishes (sharks and rays) within and outside the Datça-Bozburun Special Environmental Protection Area (SEPA) in Turkey, using data from stratified bottom trawl surveys conducted in 2009-2010. Elasmobranchs, a vital group in marine ecosystems, are increasingly at risk of extinction due to various anthropogenic threats, particularly overfishing. This research addresses the decline of elasmobranch populations in the Turkish Seas, where they have become increasingly scarce. The methodology involved six trawl hauls at depths greater than 100m, covering a total area of 1.20 km2, and the standardized catch per unit trawling area was calculated to estimate abundance and biomass. The Shannon-Wiener diversity index was used to assess species diversity within and outside the SEPA. Key findings reveal differences in elasmobranch communities inside and outside the protected area. Implications of the study emphasize the importance of marine protected areas for elasmobranch conservation in the face of overfishing and habitat degradation. The results of this study can be used in future assessments and fisheries management strategies.

**Keywords:** Biodiversity, conservation, elasmobranchs, marine protected area, overfishing, trawl surveys

## Introduction

The Elasmobranchii, an important and predominantly marine group of sharks and rays (hereafter referred to as elasmobranchs), includes over 1,200 species worldwide Ebert et al., 2021) They have inhabited diverse habitats, from shallow coastal waters to deep seas, for over 400 million years, and their endurance is a testament to the marvels of evolutionary biology. However, despite such notable evolutionary success, it is troubling that many species within this group now face a rising risk of extinction since they face many different threats and stress factors (IUCN, 2024). Among these various factors, they are particularly vulnerable in the face of human-induced changes, the most important threat is overfishing (Dulvy et al., 2014). Substantiated by recent studies showing a marked decrease in the population of several elasmobranchs in the Turkish Seas, once commonplace these species are now becoming increasingly scarce (TÜDAV, 2025; Filiz et al., 2018). Over the years, Turkish fisheries have contributed to the decline of elasmobranch populations, with at least twelve species being actively targeted (Filiz et al., 2002) until 1990 (Arpa, 2012; Kabasakal, 2018; Filiz et al., 2024). Though the commercial fisheries along the coasts of Türkiye have shifted focus from elasmobranchs, these marine creatures often end up as unintentional bycatch during coastal fishing activities (Soykan et al., 2016; Filiz et al., 2018). Today, fishing activities remain the most significant threat to elasmobranch populations in the Turkish Seas (Filiz et al., 2024). Türkiye has signed several significant agreements, such as the Barcelona, Bern, and CITES conventions. Given international agreements regarding to thirty-six sharks in Turkish seas, Bern covered only six shark species (16.7%), Barcelona accounted for twenty (55.6%) and CITES covered fifteen (41.7%) (Filiz et al., 2024). In contrast, national legislation (Anonymous, 2024-2028) covered seventeen shark species (47.2%) in the Turkish Seas (Filiz et al., 2024). Although laws play a critical role in protecting threatened and endangered species like elasmobranchs, a protection and management mentality that relies solely on laws is inadequate. In addition to laws, Marine Protected Areas are an important tool for conserving marine biodiversity, managing fisheries and, more recently, are increasingly advocated as a strategy for protecting or restoring elasmobranch populations (MacKeracher et al., 2019). Türkiye began declaring coastal and marine protected areas in 1988. There are approximately 15 marine and coastal protected areas, which include 10 Special Environmental Protection Areas (SEPA), 3 National Parks, 1 Nature Strict Reserve, and 1 Nature Park in Türkiye (Ceviz Sanalan et al., 2021). Approximately 2.083 km of the Turkish coastline is under protection, covering about 24% of the total coastline (MARIAS, 2024). Although they are an ecologically important group since they are indicators and guarantors of healthy marine ecosystems, the number of studies regarding their abundance and biomass are limited for Turkish seas (Keskin & Karakulak, 2006; İşmen et al., 2013; Özbek et al., 2015; Yağlıoğlu et al., 2015; Filiz et al., 2018; Soykan et al., 2016; Daban et al., 2021; Karadurmuş et al., 2024).

Based on trawl surveys, this study provides 2009-2010 information on the abundance and biomass of elasmobranch species within and outside the Datça-Bozburun SEPA (South Aegean Sea). It is also the first area-based study focusing on the abundance and biomass of elasmobranchs in a SEPA for Türkiye. We believe that the fishery-independent data provided nearly a decade ago will be an important data source for the future; (i) stock monitoring, (ii) protected-unprotected areas comparisons and, (iii) IUCN Red List assessments for elasmobranch species in the Turkish Seas.

## Material and Method

*Study Area*

The Datça-Bozburun SEPA declared in 1990 (Katağan et al., 2015) is one of Türkiye's most significant marine conservation zones (Figure 1). It consists of two peninsulas, Reşadiye (Datça

Peninsula) and Bozburun Peninsula, and is the largest SEPA of the Mediterranean basin covering an area of 1 443 km² with a total marine area of 763 km² (Bann & Başak, 2014). Recreational and commercial fishing activities are prohibited in this SEPA, which is indicated by 31221-numbered regulation implemented on 22 August 2020, and 6 areas have been closed to fishing have been established (Anonymous, 2024). In addition to its rich biodiversity, it is considered one of the Mediterranean's cleanest areas (Okuş et al., 2007). Trawling surveys were carried out with the permission decision numbered B.12.0.KKG.0.17/106.01-11-01-2867 Ministry of Agriculture and Rural Affairs (currently the Ministry of Agriculture and Forestry) (TrMAF, 2024). Ethical considerations were paramount throughout the research process. All applicable international, national, and/or institutional guidelines for the care and use of animals were followed. No shark and ray individuals were landed during the study, so formal consent is not required for this study.


**Figure 1.** Study area (Created from www.d-maps.com; is open data, licensed under the Open Data Commons Open Database License (ODbL))

*Data Collection*

Fishery-independent surveys were carried out between December 2009 and August 2010. We spatially matched our samples from inside (InSEPA) and outside (OuSEPA) the SEPA, choosing and carrying out six bottom trawling operations at the same depth strata (> 100 m in depth). In selecting this stratum, the effects of bottom trawling in the SEPA were kept to a minimum and conflict with traditional fishers was prevented. Haul durations ranged from 30 to 170 minutes (Table 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.

As soon as the catches were taken on deck, the elasmobranch species were identified to the species level, following (Whitehead et al., 1986; Golani et al., 2006) and their scientific names were checked against (FishBase, 2024). Then, they counted and weighed (with a 0.1 kg precision hand-held scale). Returning the sea of caught elasmobranchs was guaranteed right after being caught, and they were not subjected to any other pressure. All retained catches were identified as alive on deck, but their survival status after being discarded cannot be considered in this study. Their proportional abundance among the total fish catches and total elasmobranch fish was also calculated. The number of specimens (N) and the total weights (W) were recorded and their percentages (%N and %W) were calculated.

The swept area (SA, $km^2$) for each hauling was estimated as follows (Sparre & Venema, 1992):

$$SA= D \times h \times HLf$$

where,
h: length of the head-rope,
D: cover of distance,
HLf: fraction of the headrope length which was equal to the width of the path swept by the trawl (accepted as 0.5) (Pauly, 1980).

Raw data values of abundance and biomass were standardized using the SA method (as Catch per Unit Trawling Area, CPUA) 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 index (H') (Shannon and Weaver, 1963) was calculated for InSEPA and OuSEPA as follows:

$$H' = \sum_{i=1}^{S} - (Pi * \ln Pi)$$

where,
H´: Shannon-Wiener Diversity index,
Pi: fraction of the entire population made up of species I,
S: numbers of species richness,
Σ: sum of species 1 to species S

Data were calculated and evaluated using MS-Excel®. The species were classified according to the (IUCN, 2024) Red List for the Mediterranean.

**Results**

The survey consisted of six trawl hauls (on >100 m depth) and covered a total area of 1.20 $km^2$ (0.47 $km^2$ for InSEPA and 0.73 $km^2$ for OuSEPA) (Table 1). The distribution of elasmobranchs between InSEPA and OuSEPA are given in Table 2.

**Table 1.** Trawled area and duration of hauls on >100 m depth strata inside (InSEPA) and outside (OuSEPA) of the SEPA.

| Area | Trawl no | Trawl Coordinates (Start/Finish) | Duration (Hours:Minutes) | Swept Area ($km^2$) |
|---|---|---|---|---|
| InSEPA | 1 | 36°43'55''N-27°51'09''E/36°43'48''N-27°46'38''E | 1:27 | 0.15 |
| | 2 | 36°43'44''N-27°51'49''E/36°43'39''N-27°55'04''E | 1:58 | 0.11 |
| | 3 | 36°43'35''N-27°47'19''E/36°43'44''N-27°54'03''E | 2:20 | 0.21 |
| OuSEPA | 4 | 36°42'47''N-27°48'05''E/36°43'23''N-27°50'21''E | 0:30 | 0.07 |
| | 5 | 36°43'13''N-27°53'17''E/36°43'10''N-27°47'46''E<br>36°43'28''N-27°48'00''E/36°43'32''N-27°55'03''E | 2:25 | 0.39 |
| | 6 | 36°43'03''N-27°44'12''E/36°43'11''N-27°53'20''E | 2:50 | 0.27 |

**Table 2.** Comparison of catch between InSEPA and OuSEPA.

| Group | | InSEPA | OuSEPA |
|---|---|---|---|
| Elasmobranchs | Sp.N. | 4 sp. | 9 sp. |
| | N | 44 | 129 |
| | W | 66.9 | 60.6 |
| Total Catch | Sp.N. | 35 sp | 31 sp. |
| | N | 4934 | 3756 |
| | W | 289.0 | 234.0 |
| | ΣSA | 0.47 | 0.73 |

Sp.N: Species Number; N: Total number of specimens; W: Total weight of specimens as kg; ΣSA: Total Swept Area as km$^2$

A total of 127.5 kg of elasmobranch (n= 173) species were caught in the surveyed area. The findings showed the presence of ten elasmobranch species, including four sharks and six rays, belonging to seven families, with a total elasmobranch biomass of 226 kg km$^{-2}$ (Table 3). Elasmobranchs exhibited notable spatial heterogeneity between InSEPA and OuSEPA (Table 3). It was observed that abundance was higher (95) at OuSEPA while biomass was higher (142) at InSEPA (Table 3). Three rays (*Raja clavata, R. miraletus* and *R. radula*) were found both from InSEPA and OuSEPA (Table 3). Six species (*Myliobatis aquila, Scyliorhinus canicula, Squalus blainville, Torpedo nobiliana, Mustelus asterias* and *M. mustelus*) were sampled only from OuSEPA. Only one species (*Dasyatis pastinaca*) was collected from InSEPA (Table 3).

**Table 3.** Comparasion of chondrichthyan species abundance (A: N/km$^{-2}$) and biomass (B: kg/km$^{-2}$) in and out of the SEPA.

| Family | Species (IUCN RL*) | InSEPA | | OuSEPA | |
|---|---|---|---|---|---|
| | | A | B | A | B |
| **Dasyatidae** | *Dasyatis pastinaca* (VU) | 11 | 123 | | |
| **Myliobatidae** | *Myliobatis aquila* (VU) | -- | -- | 5 | 16 |
| **Rajidae** | *Raja clavata* (NT) | 4 | 10 | 2 | 1 |
| | *R. miraletus* (LC) | 4 | 6 | 8 | 5 |
| | *R. radula* (EN) | 2 | 3 | 10 | 15 |
| **Scyliorhinidae** | *Scyliorhinus canicula* (NE) | -- | -- | 51 | 12 |
| **Squalidae** | *Squalus blainville* (DD) | -- | -- | 2 | 2 |
| **Torpedinidae** | *Torpedo nobiliana* (NE) | -- | -- | 12 | 6 |
| **Triakidae** | *Mustelus asterias* (VU) | -- | -- | 1 | 3 |
| | *M. mustelus* (VU) | -- | -- | 4 | 24 |
| | **10 sp** | **21** (0.9%) | **142** (23.2%) | **95** (3.4%) | **84** (26.3%) |
| **Total Catch** | | **2319** | **615** | **2742** | **316** |

*according to IUCN 2024
The IUCN Red List of Threatened Species. Version 2024-2. https://www.iucnredlist.org (accessed: 29.11.2024). Only the Mediterranean was taken into account. The IUCN Red List Categories are: Not Evaluated (NE), Data Deficient (DD), Least Concern (LC), Near Threatened (NT), Vulnerable (VU), Endangered (EN).

The most abundant species were *Dasyatis pastinaca* (A= 11) for InSEPA *and Scyliorhinus canicula* (A= 51) for OuSEPA (Table 3). The highest biomass values were found as 123 (*D.*

*pastinaca*) and 24 (*M. mustelus*) for InSEPA and OuSEPA, respectively (Table 3). Shannon diversity index (H') varied from 0.96 (InSEPA) to 1.38 (OuSEPA).

Among the elasmobranch species, 60% are classified as near threatened (*Raja clavata*), vulnerable (*Dasyatis pastinaca, Myliobatis aquila, Mustelus asterias*, and *M. mustelus*), and endangered (*Raja radula*) (IUCN, 2023). The rest, 40%, of the elasmobranchs are either the least concern (*Raja miraletus*), data deficient (*Squalus blainvillei*) or not evaluated (*Scyliorhinus canicula* and *Torpedo nobiliana*) for the Mediterranean (IUCN, 2023) (Table 3).

## Discussion

Comparing and monitoring fish biomass is critically important for understanding the health of marine ecosystems and sustainable fisheries. Unfortunately, most elasmobranch fisheries are completely unmonitored and/or unmanaged (Shotton, 1999). For these reasons, the total elasmobranch biomasses obtained in previous studies and the survey details are compiled in Table 4.

**Table 4.** Comparison of total elasmobranchs species biomass (EB) according to earlier reports

| **ΣTH** | **ΣSA ($km^2$)** | **DR (m)** | **ΣESN** | **ΣEB ($kg/km^{-2}$)** | **Period** | **Locality** | **Reference** |
|---|---|---|---|---|---|---|---|
| 13 | ~ 0.38 | 40-500 | 11 | **~ 300.8** | 2001 | North Aegean Sea | Keskin & Karakulak (2006) |
| 117 | -- | 32-133 | 8 | **23** | 2011-2013 | Sea of Marmara | İşmen et al., (2013) |
| 52 | -- | 0- >100 | 20 | **190.1** | 2009-2010 | İskenderun Bay | Yağlıoğlu et al., (2015) |
| 18 | -- | 90-297 | 9 | **119.6** | 2009-2009 | Sığacık Bay | Soykan et al., (2016) |
| 52 | 4867 | 15-164 | 14 | **934.5** | 2023 | Sea of Marmara | Karadurmuş et al., (2023) |
| 6 | 1.20 | >100 | 10 | **226** | 2009-2010 | South Aegean Sea | Present study |

TH: Trawl Hauls; SA: Swept Area; DR: Depth Range; ESN: Elasmobranch Species Number

Considering the seas of Türkiye, elasmobranchs generally represented a higher biomass in the Sea of Marmara (934.5) and north Aegean Sea (300.8), except (İşmen et al., 2013) was the lowest (23) (Table 5).

The high biomasses observed in the Sea of Marmara may be attributed to the prohibition of bottom trawling and the occurrence of recent mucilage events (Karadurmuş & Sarı, 2024). It was observed that the biomass dropped in Sığacık (119.6) and İskenderun (190.1) Bays, which are the most productive trawl areas. Bottom trawl surveys are widely used for monitoring demersal stocks when a simple index of abundance is required for scientific and related work. From unfished stocks (or stocks for which no or few data on the fishery are available), preferably the unexploited stocks, biomass and annual yield estimates may also be derived by undertaking bottom trawl surveys (Sathianandan et al., 2017). However, estimating total biomass from the catch per unit of effort (or unit area) using a trawl survey involves several crucial assumptions, leaving such estimates rather imprecise. But we can resort to this method when we require immediate input to be generated, and the methodology is less time-consuming and easy to carry out (Sathianandan et al., 2017).

**Table 5.** Comparison of obtained elasmobranch species biomass (B: kg/km$^{-2}$) found on the same depth strata (> 100 m).

| Family | Species | This study | | L1 | L2 | L3 |
|---|---|---|---|---|---|---|
| | | InSEPA | OuSEPA | | | |
| Dasyatidae | *Dasyatis pastinaca* | 123 | -- | 2.9 | -- | 33.7 |
| Myliobatidae | *Myliobatis aquila* | -- | 16 | -- | -- | -- |
| Rajidae | *Raja clavata* | 10 | 1 | 14.6 | 77.6 | 36.9 |
| | *R. miraletus* | 6 | 5 | -- | 0.5 | -- |
| | *R. radula* | 3 | 15 | -- | -- | -- |
| Scyliorhinidae | *Scyliorhinus canicula* | -- | 12 | -- | 24.7 | 73.0 |
| Squalidae | *S. blainville* | -- | 2 | -- | -- | -- |
| Torpedinidae | *Torpedo nobiliana* | -- | 6 | -- | 1.5 | -- |
| Triakidae | *Mustelus asterias* | -- | 3 | -- | -- | -- |
| | *M. mustelus* | -- | 24 | -- | 3.1 | -- |

L1: from Sea of Marmara (İşmen et al.,, 2013)
L2: from Aegean Sea (Soykan et al., 2016)
L3: from Sea of Marmara (Karadurmuş & Sarı, 2024)

The protected areas within the Mediterranean are typically small and cover a common pool of species (Blowes et al., 2020). It's emphasized that abundance and biomass are often higher inside protected areas (McClure et al., 2020). Although elasmobranch total abundance and biomass differed between InSEPA and OuSEPA, the protected area (∑B= 615) supported a higher total biomass than the fished areas (∑B= 316) (Table 3). In this study, there was some evidence of protection effectiveness, supported by the higher in biomass in the protected area. Species richness is also often greater inside protected areas (Lester et al., 2009). Because of this, our lower value (H'= 0.96) for InSEPA indicates more diversity than for OuSEPA (H'= 1.38). So, once again, we understand that protecting critical habitats for reproduction and feeding is essential for the conservation of shark and ray populations (MacKeracher et al., 2019). Our trawling surveys show the status of elasmobranch populations in this ecologically important region. Leaving aside InSEPA (Datça-Bozburun SEPA), the presence of species like *Myliobatis aquila*, *Raja clavata*, *R. radula*, *Mustelus mustelus*, and *M. asterias* (Table 3) in the OuSEPA may mean that non-protected areas may also play a critical role as a habitat for these endangered species. In addition to registered or known protected areas, the Shark Specialist Group of the IUCN Species Conservation Commission has recently launched a conservation strategy with a holistic perspective. This pioneering initiative, denominated as Important Shark and Ray Areas (ISRAs), harnesses the collective expertise of specialists to demarcate discrete critical habitats indispensable to the survival of shark species. These ISRA designations serve as foundational pillars underpinning diverse, location-specific conservation and management undertakings spanning global aquatic domains, thus forging a unified front in the face of the burgeoning degradation confronting shark and ray populations (Jabado et al., 2023). The area we are discussing (OuSEPA) is proposed within ISRA's "Areas of Interest" (Jabado et al., 2023).

Our study showed that Datça-Bozburun SEPA provides good protection for elasmobranch species, and that areas immediately outside SEPA are also important habitats for elasmobranch species. Considering this information, it is recommended that the region considered as "Areas of Interest" by ISRA be urgently reviewed and accepted as an ISRA area. Like many marine protected areas, Datça-Bozburun SEPA faces threats from overfishing, pollution, and climate change. Ongoing efforts are needed to address these challenges and ensure the long-term health of the ecosystem.

## Conclusions

In conclusion, this study provides valuable insights into the abundance and biomass of elasmobranch fishes within and outside the Datça-Bozburun Special Environmental Protection Area. The findings underscore the importance of understanding the impacts of fishing activities on these vulnerable species. While the SEPA offers a degree of protection, the study highlights the continued threats faced by elasmobranch populations in Turkish Seas, emphasizing the need for comprehensive conservation strategies that extend beyond protected areas. These strategies should incorporate stricter regulations, promote sustainable fishing practices, and enhance habitat protection to ensure the long-term survival of these ecologically significant species.

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## Ethical approval

Not applicable

## Informed consent

Not available.

## Data availability statement

The authors declare that data can be provided by corresponding author upon reasonable request.

## Conflicts of interest

The authors declare no conflicts of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

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Conceptualization, H.F., S.Y., G.B.
Methodology, H.F., G.B., M.Ç., S.Y.
Software, H.F., M.Ç.
Validation, H.F., S.Y., G.B.
Investigation, H.F., S.Y.
Data curation, H.F., G.B.
Writing, original draft preparation, H.F.
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