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Checklist of Cartilaginous Species with Current Status and Conservation Strategies in Turkish Marine Waters

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Research Article

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Abstract

Cartilaginous fishes (Chondrichthyes) have 1282 species of sharks, batoids, and chimaeras worldwide. The class Chondrichthyes comprises 1226 species under the subclass Elasmobranchii and 56 species under the subclass Holocephali. The Mediterranean, particularly known for its rich diversity of cartilaginous species, is expected to suffer the most severe global decline in the number, diversity, and distribution of these species as a result of overfishing, with some species even facing extinction. The Mediterranean ecosystem is home to 89 cartilaginous species, containing 49 sharks, 38 batoids, and 2 chimaeras species. There are a total of 71 cartilaginous fish species in Turkish marine waters, 70 of which are elasmobranchs (38 shark and 32 batoid species) and 1 is a chimaera. Cartilaginous fishes are not the target of commercial fisheries in Türkiye, but are often unintentionally captured as bycatch through trawl, gillnet, and longline fisheries. Based on the IUCN Red List criteria, 27% of cartilaginous species are categorized as Vulnerable (VU), 26% as Endangered (EN), and 16% as Critically Endangered (CR) in Turkish marine waters. The remaining species are classified as follows: 14% as Near Threatened (NT), 13% as Least Concern (LC), and 4% as Data Deficient (DD). Numerous studies have been conducted in Turkish marine waters on the bio-ecology of cartilaginous species to support regulations to improve their conservation; however, genetic studies remain quite limited.

Keywords: *Elasmobranches, conservation, bio-ecology, genetics, Turkish marine waters.*

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Introduction

Cartilaginous fishes (Chondrichthyes) are jawed fish with skeletons consisting mainly of cartilage and have 1282 sharks, batoids (rays and skates), and chimaeras species worldwide, including 1226 species of the subclass Elasmobranchii (537 species of sharks in 34 families and 689 species of batoids in 20 families) and 56 chimaeras species of subclass Holocephali in 3 families (Nelson et al., 2016). Although cartilaginous species are prevalent in marine ecosystems and some are even found in freshwater habitats, the classification of these fishes remains ambiguous and is a subject of cogitating over for many species and genera (Ebert and Stehmann, 2013; Ebert et al., 2013; UNEP/MAP SPA/RAC, 2018). In particular, the Mediterranean is predominantly prone to unsteadiness in the taxonomic classification of cartilaginous species, largely due to the range of its basins and sub-basins (Iglesias, 2014). Negotiations have persisted regarding the presence of cartilaginous fish in these basins and the fluctuations in their abundance.

Cartilaginous fish, an evolutionarily conservative group of organisms, have been able to survive successfully in aquatic ecosystems for over 400 million years. Despite their survival and evolutionary stability, they are increasingly at risk of extinction due to strong fisheries pressure (direct or indirect). Since cartilaginous fishes can be found in similar habitats as target fish species, they are caught as bycatch during commercial fisheries and discarded due to their low or no commercial value (Cavanagh and Gibson, 2007). Evidence suggests that cartilaginous fish in the Mediterranean are declining in abundance, diversity, and distribution, facing a worse scenario than populations worldwide (Walker et al., 2005). These declines can be attributed to several factors, such as the semi-enclosed nature of the Mediterranean and intensive fisheries activities in coastal and pelagic waters, marine pollution, the degradation of vital nursery grounds and other important coastal habitats, uncontrolled coastal urbanization and unplanned human intervention as well as the *K*-selected life history characteristics of cartilaginous fishes (Cailliet et al., 2005; Kabasakal, 2021). Particularly, the reduction in species richness of the eastern basin caused by overfishing, leading to depletion and potentially even extinction of native cartilaginous species, has been compensated by the introduction of new Indo-Pacific origin species via the Suez Canal (Zenetos et al., 2010; Ferretti et al., 2013; Turan et al., 2018).

According to FAO's official fishery and aquaculture statistics, from 1950 to 2009, the peak landings of sharks and rays in the Mediterranean reached 16007 tons in 1988 and 498 tons in 2009, respectively. Furthermore, between 2010 and 2022, the highest recorded landing of sharks occurred in 2015, totalling 824 tons, while the peak landing for rays was in 2019, totalling 1710 tons. Chimaeras were captured in minimal quantities and their landings were recorded only in 2020, 2021, and 2022 as 0.07, 0.17, and 0.15 tons, respectively (Figure 1).

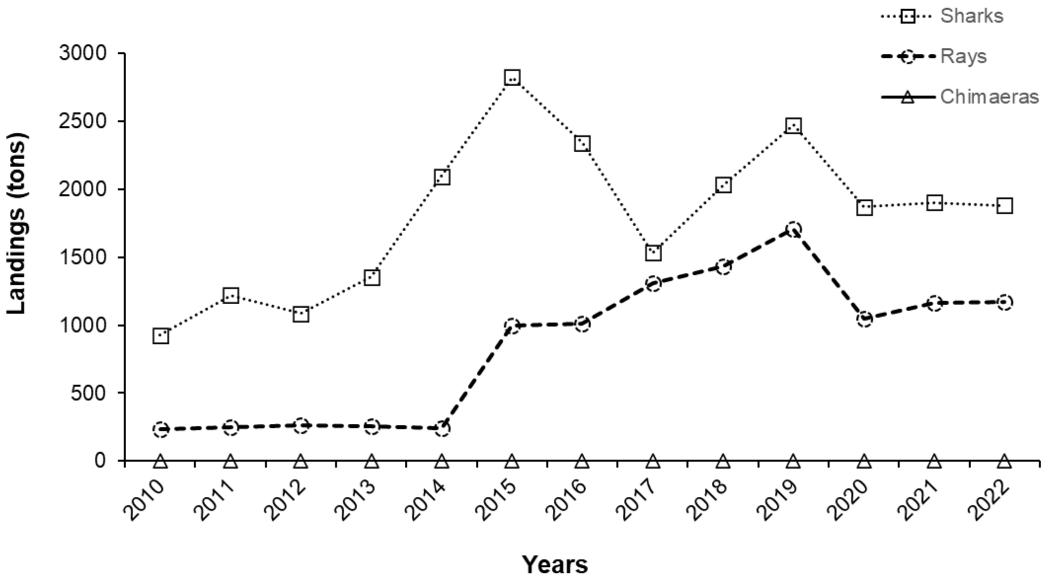

Figure 1. Landings of cartilaginous fishes in the Mediterranean during 2010-2022 (FAO, 2024).

In Turkish marine waters, cartilaginous fishes are also not the target of commercial fisheries and are often unintentionally captured as bycatch through trawl, gill-net, and longline fisheries (Turan and Ergüden, 2012; Yağlıoğlu et al., 2015; Ergüden et al., 2022). Additionally, larger species are frequently caught by purse-seine nets along the Turkish coasts (Başusta et al., 2016). Fisheries statistics of the Turkish Statistical Institute (TURKSTAT), categorizing “sharks”, “rays” and “angel sharks” within elasmobranchs between 2000 and 2023 indicate that the highest shark landing was recorded as 2880 tons in 2000, while the lowest decrease dramatically to 1.4 tons in 2023. The highest ray landing was recorded at 1100 tons in 2000, while the lowest dropped sharply to 0.7 tons in 2021. Angel sharks, caught in smaller quantities compared to sharks and rays, reached their peak landing of 60 tons in 2000, while their bottom amount declined to 0.2 tons in 2020 (Figure 2).

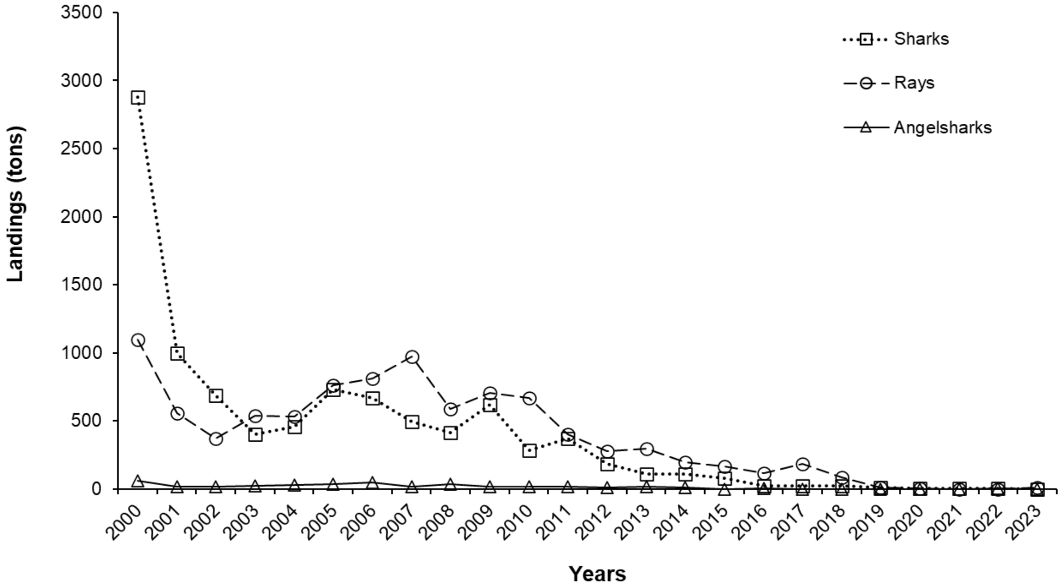

Figure 2. Landings of elasmobranchs in Turkish marine waters during 2000-2023 (TURKSTAT, 2024).

Elasmobranchs have been captured commercially in Türkiye since the 1990s and their consumption is very limited due to public taste preferences. However, their by-products and bioactive compounds hold substantial economic potential globally (Vennila et al., 2011; Fuochi et al., 2017; Seixas et al., 2020; Uyan et al., 2020a, 2021; Bak et al., 2022; Agustin et al., 2023; Aydoğdu et al., 2023; Coscueta et al., 2024; Lamas and Massa, 2024). Extracts rich in collagen and glucosamine from shark cartilage, especially, are used in health supplements and cosmetics (Merly and Smith, 2015; Isaacs and Hellberg, 2021; Li et al., 2022; Lu et al., 2022), and in wound healings (Musick, 2005; Tanna et al., 2020). Chondroitin sulphate ($C_{13}H_{21}NO_{15}S$) derived from shark cartilage is also a therapeutic used to relieve symptoms of osteoarthritis and other joint conditions (Volpi, 2009; Vazquez et al., 2013, 2020; Irianto, 2022; Brito et al., 2023). Shark liver oil, renowned for vitamins A and D, as well as omega-3 fatty acids, is popular as a nutritional supplement (Hole and Taylor, 1996; Turan et al., 2007; Venugopal et al., 2016; Yığın et al., 2019; Amri et al., 2021). Shark skin is used as a useful ingredient for the production and consumption of various leather products (Fofandi et al., 2020). Cartilaginous fish encounter anthropogenic threats owing to both being caught as bycatch and the intensive use of their by-products industrially, and therefore the need for effective conservation strategies is essential for their sustainability.

Research into their bio-ecological parameters and genetic diversity is essential for comprehending and protecting the health of marine ecosystems. Numerous studies, primarily on length-weight relationships, have been conducted to determine the bio-ecological characteristics of cartilaginous species in Turkish marine waters and to aid legal regulations; however, genetic studies have been quite scarce. Therefore, this review focuses on evaluating the list and current status and also possible conservation strategies from a bio-ecological and genetic perspective for cartilaginous fishes in Turkish marine waters.

Biodiversity and IUCN Status of Cartilaginous Fishes in Mediterranean Coasts of Türkiye

Located at the junction of three continents, Europe, Africa, and Asia, the Mediterranean connects to the Atlantic Ocean via the Strait of Gibraltar in the west, to the Red Sea *via* the Suez Canal in the southeast, and to the Black Sea through the Turkish Straits System consisting of the Dardanelles, the Sea of Marmara and the Bosphorus in the northeast (Oğuz et al., 1993). The Mediterranean is recognized as a biodiversity hotspot because of its diverse ecosystems, including coastal reefs, sea meadows, sandy bays, deep-sea coral communities, hydrothermal vents, muddy plains, and steep slopes (Danovaro et al., 2010). While it is noted for its Chondrichthyes-rich ecosystem, the Mediterranean also harbours the most endangered cartilaginous species compared to other seas worldwide (Dulvy et al., 2016). Serena et al. (2020) reported a total of 88 cartilaginous species in the latest cartilaginous checklist of the Mediterranean (including the Black Sea). However, Turan et al. (2021) reported whale shark *Rhincodon typus* off the Samandağ coast of Türkiye in the Northeastern Mediterranean and it was included in the Mediterranean and Turkish cartilaginous fish fauna inventory (Turan et al., 2024a). Turan et al. (2024b) reported the blonde ray *Raja brachyura* for the first time from Turkish marine waters that a female specimen was captured during a trawling survey on 17 March 2019 in Antalya Bay, north-eastern Mediterranean, making it the 14th Rajid species for Turkish marine ichthyofauna to date.

Thus, currently the Mediterranean is home to a total of 89 species of cartilaginous species, including 49 sharks, 38 batoids and 2 chimeras (1 of which is questionable) species. No less than 53% of cartilaginous species in the Mediterranean are classified as Vulnerable (VU), Endangered (EN) and Critically Endangered (CR), while a large proportion (20%) are still in the category of Data Deficient (DD) by the International Union for Conservation of Nature (IUCN) (Dulvy et al., 2014; Otero et al., 2019; Serena et al., 2020).

Up to date, cartilaginous fish taxa in Turkish marine waters were represented by a total of 71 species, comprising 70 species of Elasmobranchii (sharks and batoids) and 1 species of Holocephali (chimaera). Among elasmobranchs, sharks are represented by 38 species belonging to 19 families, and batoids by 32 species belonging to 10 families. The most dominant shark family in terms of species diversity on Turkish coasts is Carcharhinidae (9 species), followed by the families Triakidae (4 species), Squatinidae (3 species), Lamnidae (3 species), Hexanchidae (2 species), Squalidae (2 species), Alopiidae (2 species), Scyliorhinidae (2 species). The remaining families Echinorhinidae, Centrophoridae, Etmopteridae, Somniosidae, Oxynotidae, Dalatiidae, Rhincodontidae, Odontaspididae, Cetorhinidae, Pentanchidae, and Sphyrnidae are each represented by 1 species. Among batoids in Turkish marine waters, the family with the most species diversity is the Rajidae (14 species), followed by Dasyatidae (8 species), and Torpedinidae (3 species). The remaining families Rhinobatidae, Glaucostegidae, Gymnuridae, Aetobatidae, Myliobatidae, Rhinopteridae, and Mobulidae are each represented by 1 species. The current checklist showing the cartilaginous species distributed in Turkish marine waters and their IUCN status is summarized in Table 1.

Table 1. The checklist of cartilaginous fishes in Turkish marine waters, including their IUCN status (CR, Critically Endangered; EN, Endangered; VU, Vulnerable; NT, Near Threatened; LC, Least Concern; DD, Data Deficient) and distributions.

Family/Species	Common Name	IUCN Status	Distribution
Family Hexanchidae			
Heptranchias perlo (Bonnaterre, 1788)	Sharpnose seven-gill shark	DD	MS, AS
Hexanchus griseus (Bonnaterre, 1788)	Bluntnose six-gill shark	NT	MS, AS, SM, BS
Family Echinorhinidae			
Echinorhinus brucus (Bonnaterre, 1788)	Bramble shark	EN	MS, AS, SM
Family Squalidae			
Squalus acanthias Linnaeus, 1758*	Spotted spiny dogfish	EN	MS, AS, SM, BS
Squalus blainville (Risso, 1827)*	Longnose spurdog	DD	MS, AS, SM, BS
Family Centrophoridae			
Centrophorus uyato (Rafinesque, 1810)	Little gulper shark	EN	MS, AS, SM
Family Etmopteridae			
Etmopterus spinax (Linnaeus, 1758)	Velvet belly	VU	MS, AS
Family Somniosidae			
Somniosus rostratus (Risso, 1827)	Little sleeper shark	LC	MS, AS
Family Oxynotidae			
Oxynotus centrina (Linnaeus, 1758)*	Angular rough shark	EN	MS, AS, SM, BS
Family Dalatiidae			
Dalatias licha (Bonnaterre, 1788)	Kitefin shark	VU	MS, AS, SM

Family Squatinidae			
Squatina aculeata Cuvier, 1829*	Sawback angelshark	CR	MS, AS
Squatina oculata Bonaparte, 1840*	Smoothback angelshark	CR	MS, AS, SM
Squatina squatina (Linnaeus, 1758)*	Angelshark	CR	MS, AS, SM, BS
Family Rhincodontidae			
Rhincodon typus Smith, 1828	Whale shark	EN	MS
Family Odontaspididae			
Odontaspis ferox (Risso, 1810)	Smalltooth sand tiger	EN	MS, AS
Family Alopiidae			
Alopias superciliosus Lowe, 1841*	Bigeye thresher	VU	MS, AS, SM
Alopias vulpinus (Bonnaterre, 1788)*	Thresher shark	VU	MS, AS, SM, BS
Family Cetorhinidae			
Cetorhinus maximus (Gunnerus, 1765)*	Basking shark	EN	MS, AS
Family Lamnidae			
Carcharodon carcharias (Linnaeus, 1758)*	Great white shark	VU	MS, AS, SM
Isurus oxyrinchus Rafinesque, 1810*	Shortfin mako	EN	MS, AS
Lamna nasus (Bonnaterre, 1788)*	Porbeagle	VU	MS, AS, SM
Family Pentanchidae			
Galeus melastomus Rafinesque, 1810	Blackmouth catshark	LC	MS, AS, SM
Family Scyliorhinidae			
Scyliorhinus canicula (Linnaeus, 1758)	Smallspotted catshark	LC	MS, AS, SM, BS
Scyliorhinus stellaris (Linnaeus, 1758)	Nursehound	VU	MS, AS, SM
Family Triakidae			
Galeorhinus galeus (Linnaeus, 1758)*	Tope shark	CR	MS, AS, SM
Mustelus asterias Cloquet, 1819	Starry smoothhound	NT	MS, AS, SM, BS
Mustelus mustelus (Linnaeus, 1758)	Smoothhound	EN	MS, AS, SM, BS
Mustelus punctulatus Risso, 1827	Blackspotted smoothhound	VU	MS, AS, SM
Family Carcharhinidae			
Carcharhinus altimus (Springer, 1950)	Bignose shark	NT	MS
Carcharhinus brachyurus (Günther, 1870)	Copper shark	VU	MS
Carcharhinus brevipinna (Valenciennes, 1839)	Spinner shark	VU	MS, AS
Carcharhinus falciformis (Bibron, 1839)*	Silky shark	VU	MS
Carcharhinus limbatus (Valenciennes, 1839)	Blacktip shark	VU	MS
Carcharhinus obscurus (Lesueur, 1818)	Dusky shark	EN	MS
Carcharhinus plumbeus (Nardo, 1827)*	Sandbar shark	EN	MS, AS
Carcharias taurus Rafinesque, 1810	Sandtiger shark	CR	MS, AS
Prionace glauca (Linnaeus, 1758)*	Blue shark	NT	MS, AS
Family Sphyrnidae			
Sphyrna zygaena (Linnaeus, 1758)*	Smooth hammerhead	VU	MS, AS
Family Torpedinidae			
Tetronarce nobiliana (Bonaparte, 1835)	Electric ray	LC	MS, AS, SM
Torpedo marmorata Risso, 1810	Marbled electric ray	VU	MS, AS, SM
Torpedo torpedo (Linnaeus, 1758)	Common torpedo	VU	MS, AS, SM

Family Rhinobatidae			
Rhinobatos rhinobatos (Linnaeus, 1758)*	Common guitarfish	CR	MS, AS
Family Glaucostegidae			
Glaucostegus cemiculus (Geoffroy Saint-Hilaire, 1817)*	Blackchin guitarfish	CR	MS, AS
Family Rajidae			
Dipturus batis (Linnaeus, 1758)	Blue skate	CR	MS, AS, SM
Dipturus oxyrinchus (Linnaeus, 1758)	Longnosed skate	NT	MS, AS, SM
Leucoraja circularis (Couch, 1838)	Sandy ray	EN	MS, AS
Leucoraja fullonica (Linnaeus, 1758)	Shagreen ray	VU	MS, AS
Leucoraja naevus (Müller & Henle, 1841)	Cuckoo ray	LC	MS, AS, SM
Raja asterias Delaroche, 1809	Mediterranean starry ray	NT	MS, AS, SM
Raja brachyura Lafont, 1873	Blonde ray	NT	MS
Raja clavata Linnaeus, 1758*	Thornback ray	NT	MS, AS, SM, BS
Raja miraletus Linnaeus, 1758	Brown ray	LC	MS, AS, SM
Raja montagui Fowler, 1910	Spotted ray	LC	MS, AS, SM
Raja polystigma Regan, 1923	Speckled ray	LC	AS
Raja radula Delaroche, 1809	Rough ray	EN	MS, AS, SM
Raja undulata Lacepède, 1802	Undulate ray	EN	MS, AS
Rostroraja alba (Lacepède, 1803)	White skate	EN	MS, AS
Family Dasyatidae			
Bathytoshia lata (Garman, 1880)	Brown stingray	VU	MS, AS
Dasyatis marmorata (Steindachner, 1892)	Marbled stingray	NT	MS
Dasyatis pastinaca (Linnaeus, 1758)	Common stingray	VU	MS, AS, SM, BS
Dasyatis tortonesei Capapé, 1975	Tortonese's stingray	DD	MS, AS, SM
Himantura leoparda Manjaji-Matsumoto & Last, 2008	Leopard whipray	EN	MS
Himantura cf uarnak (Gmelin, 1789)	Honeycomb stingray	EN	MS
Pteroplatytrygon violacea (Bonaparte, 1832)	Pelagic stingray	LC	MS, AS
Taeniurops grabatus (Geoffroy St. Hilaire, 1817)	Round stingray	NT	MS
Family Gymnuridae			
Gymnura altavela (Linnaeus, 1758)	Spiny butterfly ray	EN	MS, AS, SM, BS
Family Aetobatidae			
Aetomylaeus bovinus (Geoffroy St. Hilaire, 1817)	Bull ray	CR	MS, AS, SM
Family Myliobatidae			
Myliobatis aquila (Linnaeus, 1758)	Common eagle ray	CR	MS, AS, SM
Family Rhinopteridae			
Rhinoptera marginata (Geoffroy St. Hilaire, 1817)	Lusitanian cownose ray	CR	MS, AS
Family Mobulidae			
Mobula mobular (Bonnaterre, 1788)*	Devil fish	EN	MS, AS
Family Chimaeridae			
Chimaera monstrosa Linnaeus, 1758	Rabbit fish	VU	MS, AS, SM

*, Cartilaginous fish species prohibited from catching along the Turkish coasts; MS, Mediterranean Sea; AS, Aegean Sea; SM, Sea of Marmara; BS, Black Sea.

Table 1 summarizes that in Turkish marine waters, 13 shark, 5 batoid, and 1 chimera species are classified as Vulnerable (VU), 11 shark and 8 batoid species are Endangered (EN), and 5 shark and 6 batoid species are Critically Endangered (CR). On the other hand, the Communiqué No. 5/1, published in the Official Gazette of the Republic of Türkiye, prohibits the catching of 18 shark species and 5 batoid species (indicated with the asterisks) to legally protect elasmobranch stocks in Turkish marine waters (Official Gazette, 2020). Nevertheless, catching of 1 shark (*Carcharias taurus*) and 4 batoid species (*Dipturus batis*, *Aetomylaeus bovinus*, *Myliobatis aquila*, *Rhinoptera marginata*) classified as CR, and 6 sharks (*Echinorhinus brucus*, *Centrophorus uyato*, *Rhincodon typus*, *Odontaspis ferox*, *Mustelus mustelus*, *Carcharhinus obscurus*) and 7 batoid species (*Leucoraja circularis*, *Raja radula*, *Raja undulata*, *Rostroraja alba*, *Himantura leoparda*, *Himantura uarnak*, *Gymnura altavela*) listed as EN, is not prohibited in Turkish marine waters.

Elasmobranchs are found along the coasts of the Mediterranean, Aegean Sea, Sea of Marmara, and Black Seas in Türkiye; however, chimaeras, represented by only one species, are found in all these seas except the Black Sea. The Mediterranean coast of Türkiye has the greatest diversity of cartilaginous fish, hosting 38 shark species, 31 batoid species and 1 chimera species, followed by the Aegean Sea coast with 31 shark species, 27 batoid species and 1 chimera species. The Sea of Marmara is home to 17 shark species, 16 batoid species and 1 chimera species. The Black Sea coast have the lowest diversity of cartilaginous fish in Türkiye, with 8 shark and 3 batoid species (Figure 3).

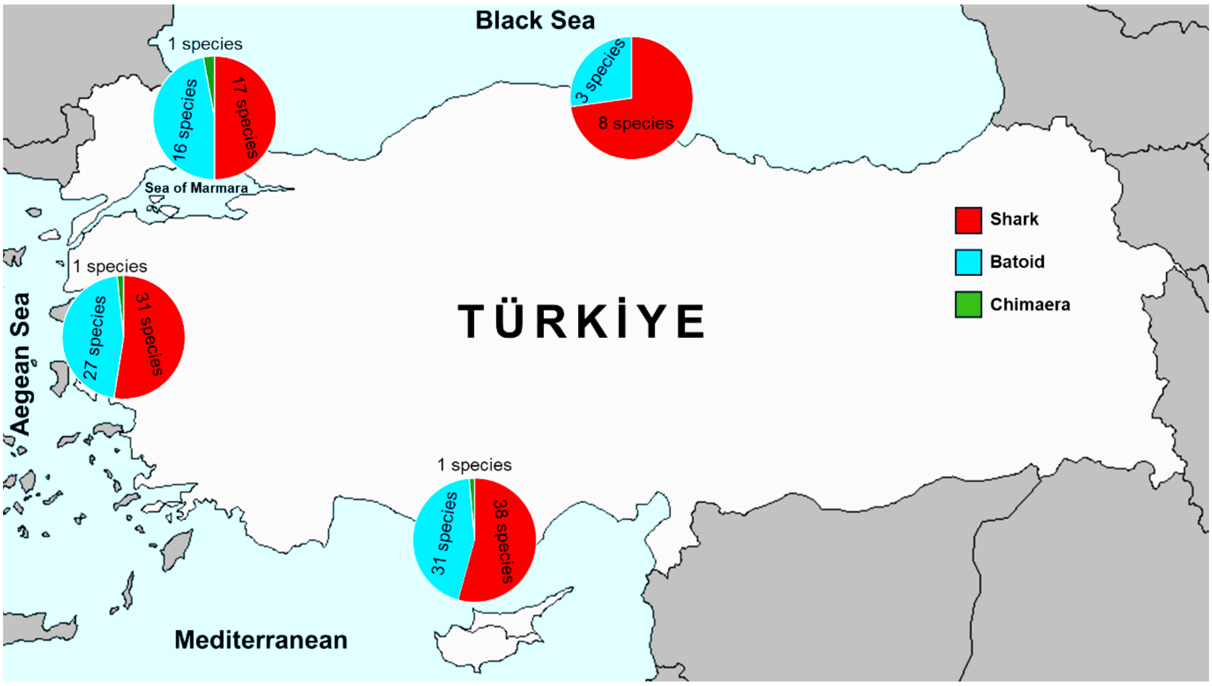

Figure 3. Map showing the distribution of cartilaginous fishes according to their numbers in each part of Turkish marine waters.

Bioecological and Genetic Studies of Cartilaginous Fishes in Turkish Coasts

Bioecological studies

To date, the most common type of bio-ecological research conducted on cartilaginous fishes distributed in Turkish marine waters has been length-weight relationship (LWR) and von Bertallanfy growth function (VBGF) parameters studies. To the best of our knowledge, a total of 90 studies about

LWRs on 37 species were identified, 23 studies of which also examined VBGF parameters. At the same time, a total of 3 studies focused solely on VBGF parameters were found for three different species. The complete inventory list summarizing the LWR and VBGF studies of cartilaginous species in Turkish marine waters is presented in Table 2.

Table 2. The inventory list of bio-ecological studies of cartilaginous fishes along the Turkish coasts.

References	Species	N	Sex	LWR parameters *a*	*b*	VBGF parameters L_∞	*k*	t_0	Study area
Cihangir et al. (1997)	*Scyliorhinus canicula*	586	∑	0.0010	3.20				Northern Aegean Sea
Avşar (2001)	*Squalus acanthias*	328	∑	0.0040	2.95	157	0.12	-1.30	SE Black Sea
Erdem et al. (2001)	*Raja clavata*	54	∑	0.0026	3.20				Southern Black Sea
Filiz and Mater (2002)	*Dasyatis pastinaca*	14	∑	0.0085	2.93				Northern Aegean Sea
	Mustelus mustelus	24		0.0008	3.32				
	Raja clavata	29		0.0016	3.29				
	Raja miraletus	13		0.0001	4.02				
	Scyliorhinus canicula	110		0.0016	3.18				
	Torpedo marmorata	20		0.0488	2.69				
İşmen (2003)	*Dasyatis pastinaca*	256	∑	0.0014	3.31	121.5	0.09	-1.61	Iskenderun Bay
Filiz and Bilge (2004)	*Chimaera monstrosa*	17	∑	0.0028	2.82				Sığacık Bay
	Dasyatis pastinaca	29		0.0149	2.81				
	Dipturus oxyrinchus	8		0.0007	3.40				
	Gymnura altavela	9		0.0268	2.96				
	Mustelus mustelus	35		0.0011	3.25				
	Myliobatis aquila	14		0.0008	3.34				
	Raja clavata	37		0.0016	3.30				
	Raja miraletus	13		0.0001	4.15				
	Scyliorhinus canicula	637		0.0012	3.26				
	Torpedo marmorata	37		0.0273	2.91				
Başçınar and Sağlam (2005)	*Raja clavata*	193	∑	0.0023	3.24				SE Black Sea
Demirhan et al. (2005)	*Raja clavata*	52	∑	0.0010	3.42				SE Black Sea
Düzgüneş et al. (2006)	*Squalus acanthias*	182	♀	0.0014	3.25				SE Black Sea
		85	♂	0.0010	3.31				
Karakulak et al. (2006)	*Dasyatis pastinaca*	12	∑	0.1168	2.12				Gökçeada Island
	Raja radula	25		0.0030	3.21				
	Torpedo marmorata	22		0.0139	3.10				
Türker-Çakır et al. (2006)	*Scyliorhinus canicula*	291	∑	6E-7	2.92				Edremit Bay
Demirhan and Can (2007)	*Raja clavata*	27	∑	0.0019	3.24				SE Black Sea
Demirhan and Seyhan (2007)	*Squalus acanthias*	151	♀	4E-7	3.51	137.73	0.12	1.67	SE Black Sea
		24	♂	8E-7	3.31	123.78	0.16	1.86	

	Dasyatis pastinaca	48		0.0126	3.30*				
	Dipturus oxyrinchus	118		0.0042	3.29				
	Etmopterus spinax	24		0.0017	3.27				
	Galeus melastomus	93		0.0024	3.03				
	Scyliorhinus canicula	1501		0.0017	3.17				
	Heptranchias perlo	14		0.0042	2.93				
	Hexanchus griseus	5		8E-5	3.82				
İşmen et al. (2007a)	*Mustelus mustelus*	26	∑	0.0013	3.19				Saros Bay
	Myliobatis aquila	14		0.0125	3.02				
	Raja clavata	112		0.0132	3.12*				
	Raja miraletus	30		0.0089	3.22*				
	Raja radula	49		0.0113	3.25*				
	Rostroraja alba	43		0.0066	3.20*				
	Squalus blainville	299		0.0034	3.06				
	Torpedo marmorata	20		0.0592	2.64				
İşmen et al. (2007b)	*Rhinobatos rhinobatos*	225	∑	0.0036	2.93	128.6	0.29	-0.89	Iskenderun Bay
	Dasyatis pastinaca	16		0.0149	3.25				
	Gymnura altavela	17		0.0449	2.84				
	Mustelus mustelus	17		0.0044	2.91				
Özaydın et al. (2007)	*Raja miraletus*	12	∑	0.0063	2.95				Izmir Bay
	Rostroraja alba	11		0.0090	3.47				
	Scyliorhinus canicula	187		0.0006	3.44				
	Torpedo marmorata	12		0.0535	2.39				
	Dasyatis pastinaca	334		0.0020	3.24				
	Gymnura altavela	107		0.0090	3.23				
Yeldan and Avşar (2007)	*Raja clavata*	77	∑	0.0037	3.08				NE Mediterranean
	Raja radula	295		0.0012	3.36				
	Raja asterias	113		0.0008	3.35				
Başusta et al. (2008)	*Rhinobatos rhinobatos*	66	♀	0.0014	3.16	154.88	0.13	-1.26	Iskenderun Bay
		49	♂	0.0012	3.19	121.65	0.31	-0.13	
Hepkafadar (2008)	*Mustelus mustelus*	190	∑	0.1060	2.27				Izmir Bay
	Dasyatis pastinaca	31		0.0102	3.37*				
	Gymnura altavela	9		0.0025	3.27*				
	Myliobatis aquila	39		0.0058	3.28*				
	Raja clavata	24		0.0335	2.89*				
	Raja miraletus	10		0.0346	2.82*				
İlkyaz et al. (2008)	*Raja polystigma*	18	∑	0.0218	3.05*				Izmir Bay
	Rostroraja alba	5		0.0083	3.13*				
	Scyliorhinus canicula	744		0.0012	3.29				
	Scyliorhinus stellaris	11		0.0020	3.23				
	Mustelus mustelus	148		0.0027	3.05				
	Torpedo marmorata	35		0.0232	2.98				
Yeldan et al. (2008)	*Raja clavata*	90	∑	0.0034	3.10	79.66	0.13	-3.03	NE Mediterranean
Türker-Çakır et al. (2008)	*Scyliorhinus canicula*	112	∑	2E-6	3.10				Edremit Bay

İşmen et al. (2009)	*Etmopterus spinax*	11	∑	0.0023	3.23				Saros Bay
	Galeus melastomus	303		0.0016	3.18				
	Scyliorhinus canicula	1888		0.0017	3.17				
	Scyliorhinus stellaris	12		0.0009	3.36				
	Hexanchus griseus	7		0.0002	3.61				
	Heptranchias perlo	18		0.0047	2.90				
	Mustelus asterias	7		0.0006	3.40				
	Mustelus mustelus	70		0.0034	2.98				
	Squalus acanthias	565		0.0037	3.04				
	Squalus blainville	27		0.0030	3.07				
Özütemiz et al. (2009)	*Galeus melastomus*	130	∑	0.0020	3.04				Sığacık Bay
	Squalus blainville	135		0.0010	3.30				
Yarmaz (2009)	*Dasyatis pastinaca*	10	∑	0.5092	1.76				Edremit Bay
	Mustelus mustelus	60		4.9504	1.77				
	Myliobatis aquila	12		0.0140	3.18				
	Raja clavata	33		0.0322	2.60				
	Raja miraletus	13		0.0215	2.57				
	Raja radula	23		0.0029	3.21				
	Scyliorhinus canicula	108		8E-6	2.88				
	Torpedo marmorata	9		0.1297	2.47				
Yeldan et al. (2009)	*Dasyatis pastinaca*	346	∑	0.0033	3.14	294.94	0.03	-2.20	NE Mediterranean
Yığın and İşmen (2009)	*Raja clavata*	226	∑	0.0016	3.32				Saros Bay
	Raja miraletus	52		0.0017	3.27				
	Raja radula	204		0.0020	3.32				
	Rostroraja alba	126		0.0019	3.27				
	Dasyatis pastinaca	71		0.0007	3.55				
	Dipturus oxyrinchus	179		0.0008	3.35				
	Myliobatis aquila	66		0.0002	3.56				
Bilge et al. (2010)	*Etmopterus spinax*	116	∑	0.0031	3.12				Sığacık Bay
Yığın and İşmen (2010a)	*Dipturus oxyrinchus*	89	♀	0.0008	3.37	233.88	0.04	-1.34	Saros Bay
		90	♂	0.0009	3.34	251.81	0.04	-0.92	
Yığın and İşmen (2010b)	*Rostroraja alba*	126	∑	0.0019	3.27	311	0.04	-0.25	Saros Bay
Bök et al. (2011)	*Raja asterias*	30	∑	2E-6	3.24				Northern Sea of Marmara
	Raja clavata	24		1E-5	2.87				
	Squalus blainville	18		4E-5	2.48				
	Squalus acanthias	8		3E-5	2.61				
Saygu (2011)	*Raja clavata*	792	∑	0.0018	3.25				Antalya Bay
	Raja miraletus	153		0.0011	3.43				
	Raja radula	62		0.0018	3.30				
	Dipturus oxyrinchus	105		0.0012	3.28				
	Dasyatis pastinaca	18		0.0018	3.37				
Başusta et al. (2012)	*Aetomylaeus bovinus*	22	∑	0.0194	2.90				Iskenderun Bay
	Raja clavata	75		0.0230	2.64*				
	Raja miraletus	22		0.0021	3.26*				
	Rhinobatos rhinobatos	20		0.0011	3.19				
	Glaucostegus cemiculus	262		0.0026	3.02				
	Gymnura altavela	104		0.0170	2.79*				
	Dasyatis pastinaca	417		0.0419	3.31*				
	Rhinoptera marginata	17		0.0100	2.14				
	Tetronarce nobiliana	92		0.0150	3.06				

Demirel and Dalkara (2012)	*Raja clavata*	170	∑	0.1130	2.42*				Sea of Marmara
	Scyliorhinus canicula	189		0.0040	2.86				
Güven et al. (2012)	*Centrophorus granulosus*	56	∑	0.0010	3.41				Antalya Bay
	Etmopterus spinax	150		0.0052	2.94				
	Galeus melastomus	544		0.0026	3.00				
	Heptranchias perlo	11		0.0021	3.08				
	Mustelus mustelus	4		0.0974	2.77				
	Scyliorhinus canicula	647		0.0012	3.27				
	Squalus blainville	177		0.0033	3.06				
Yığın and İşmen (2012)	*Dasyatis pastinaca*	52	♀	0.0008	3.51	186.54	0.05	-1.40	Northern Aegean Sea
		32	♂	0.0005	3.61				
Duman and Başusta (2013)	*Torpedo marmorata*	117	∑	0.0195	2.99	57.32	0.18	-0.39	Iskenderun Bay
Kasapoğlu and Düzgüneş (2013)	*Raja clavata*	63	∑	0.0100	3.29				Southern and SE Black Sea
Özdemir and Duyar (2013)	*Raja clavata*	102	∑	0.0027	3.18				Southern Black Sea
Bilge et al. (2014)	*Mustelus mustelus*	74	∑	0.0053	2.84				Sığacık Bay
	Mustelus punctulatus	52		0.0224	3.03				
	Raja miraletus	62		0.0008	3.44				
	Scyliorhinus canicula	144		0.0012	3.30				
	Scyliorhinus stellaris	92		0.0039	2.96				
	Torpedo marmorata	57		0.0519	2.72				
	Tetronarce nobiliana	73		0.0519	2.72				
Deval et al. (2014)	*Bathytoshia lata*	4	∑	0.0030	3.00				Antalya Bay
	Leucoraja circularis	6		0.0039	3.08				
Eronat and Özaydın (2014)	*Chimaera monstrosa*	97	∑	0.0076	3.27				Izmir and Sığacık Bays
	Dasyatis pastinaca	78		0.0011	3.45				
	Dipturus oxyrinchus	8		0.0017	3.13				
	Etmopterus spinax	129		0.0035	3.08				
	Galeus melastomus	235		0.0019	3.14				
	Mustelus mustelus	41		0.0010	3.27				
	Mustelus punctulatus	6		0.0224	3.04				
	Myliobatis aquila	54		0.0005	3.41				
	Raja asterias	17		0.0007	3.47				
	Raja clavata	137		0.0007	3.50				
	Raja radula	16		0.0017	3.33				
	Rostroraja alba	10		0.0016	3.32				
	Scyliorhinus canicula	1210		0.0012	3.26				
	Scyliorhinus stellaris	19		0.0006	3.46				
	Squalus blainville	308		0.0048	2.96				
	Torpedo marmorata	107		0.0230	2.95				
Yığın and İşmen (2014)	*Raja radula*	142	♀	0.0019	3.36	82.94	0.16	-0.59	Saros Bay
		113	♂	0.0022	3.30	74.70	0.20	-0.22	
Akalın et al. (2015)	*Gymnura altavela*	7	∑	0.0156	3.09				Çandarlı Bay
	Torpedo marmorata	10		0.0208	3.09				
Eronat and Özaydın (2015)	*Raja clavata*	106	♀	0.6420	2.84				Sığacık Bay
		81	♂	0.6560	2.78				
Özbek et al. (2015)	*Bathytoshia lata*	5	∑	1E-4	4.04				Antalya Bay
	Dasyatis marmorata	21		0.0020	3.23				
	Dasyatis pastinaca	391		0.0230	2.76				
Yapıcı et al. (2015)	*Rostroraja alba*	12	∑	0.0021	3.21				Sığacık Bay
Başusta (2016)	*Carcharhinus plumbeus*	55	∑	0.0100	2.87				Iskenderun Bay
Girgin and Başusta (2016)	*Dasyatis pastinaca*	209	♀	0.0272	3.06*				Iskenderun Bay
		175	♂	0.0247	3.08*				

Kaya and Başusta (2016)	*Tetronarce nobiliana*	93	∑	0.0151	3.06	74.47	0.11	-1.06	Iskenderun Bay
Özbek et al. (2016)	*Gymnura altavela*	172	∑	0.0031	2.93				Antalya Bay
Öztekin et al. (2016)	*Raja clavata*	62		0.0081	2.96				Gallipoli Peninsula
	Raja radula	10		0.0035	3.24				
	Rostroraja alba	11	∑	0.0012	3.37				
	Scyliorhinus canicula	22		0.0238	2.52				
	Squalus blainville	14		0.0053	2.95				
Yığın and İşmen (2016)	*Squalus acanthias*	346	♀			101.21	0.15	-0.68	Saros Bay
		274	♂			72.85	0.27	-0.24	
Çalık and Erdoğan-Sağlam (2017)	*Raja clavata*	10	∑	0.0010	3.44				SE Black Sea
Gönülal (2017)	*Dalatias licha*	4	∑	0.0184	3.20				Northern Aegean Sea
	Etmopterus spinax	12	∑	0.3514	1.76				
	Galeus melastomus	26	♀	0.0003	3.65				
		13	♂	0.1746	2.08				
	Mustelus mustelus	11	∑	0.0014	3.31				
	Prionace glauca	6	∑	0.0105	3.85				
	Scyliorhinus stellaris	28	∑	0.0410	3.10				
Özdemir (2017)	*Raja clavata*	259	∑	0.0013	3.35				Southern Black Sea
Yemişken (2017)	*Raja clavata*	66		0.0100	3.16				Iskenderun Bay
		19		0.0127	3.13				Gökçeada Island
	Scyliorhinus canicula	132		0.0012	3.30				Iskenderun Bay
		202		0.0029	3.03				Gökçeada Island
	Gymnura altavela	12		0.0059	3.03				Iskenderun Bay
	Glaucostegus cemiculus	16		0.0100	2.73				
	Raja asterias	55	∑	0.0009	3.44				
	Dasyatis pastinaca	13		0.4474	2.29				
	Galeus melastomus	30		0.0015	3.18				Gökçeada Island
	Squalus blainville	12		0.0010	3.38				
	Scyliorhinus stellaris	14		0.0018	3.20				
Başusta and Aslan (2018)	*Aetomylaeus bovinus*	47	♀	0.0625	2.90*	242.59*	0.05	-1.90	NE Mediterranean
		47	♂	0.0351	3.09*	238.43*	0.04	-2.98	
Bengil et al. (2018)	*Glaucostegus cemiculus*	117	∑	0.0021	3.12				Izmir Bay
		266		0.0015	3.66				Iskenderun Bay
Bilgin and Köse (2018)	*Raja clavata*	117	∑	0.0039	3.13				SE Black Sea
İşmen et al. (2018)	*Raja clavata*	130		0.0006	3.53				Sea of Marmara
	Scyliorhinus canicula	45	∑	0.0007	3.39				
	Torpedo marmorata	17		0.0195	2.98				
Kara et al. (2018)	*Raja clavata*	33	∑	0.0020	3.25				Izmir Bay
	Squatina squatina	3		0.0203	2.75				
Özcan and Başusta (2018a)	*Mustelus mustelus*	155	∑	0.0027	3.00	195.13	0.06	-4.27	Iskenderun Bay
Özcan and Başusta (2018b)	*Scyliorhinus canicula*	1150	∑	0.0013	3.23	56.70	0.20	-1.60	Iskenderun Bay
Torcu-Koç and Erdoğan (2018)	*Scyliorhinus canicula*	48	♀	0.0080	2.91				Bandırma Bay
		43	♂	0.0040	3.09				
Yeldan (2018)	*Gymnura altavela*	150	♀	0.1310	3.21	136.25*	0.38	-0.58	Iskenderun Bay
		134	♂	0.0990	3.14	131.25	0.25	-0.49	
Yeldan and Gündoğdu (2018)	*Dasyatis pastinaca*	72	∑	0.0390	2.93*	58.28*	0.06	-0.21	Iskenderun Bay
	Dasyatis marmorata	143		0.0480	2.94*	46.09*	0.36	-0.16	

Türker et al. (2019)	*Dasyatis pastinaca*	10	∑	0.1306	2.17				Edremit Bay
	Mustelus mustelus	60		0.1139	2.71				
	Myliobatis aquila	12		0.0014	3.18				
	Raja clavata	33		0.0322	2.56				
	Raja miraletus	13		0.0215	2.56				
	Raja radula	23		0.0029	3.21				
	Scyliorhinus canicula	108		6E-5	2.88				
	Scyliorhinus stellaris	8		0.0004	3.64				
	Torpedo marmorata	9		0.1297	2.47				
Başusta et al. (2020)	*Glaucostegus cemiculus*	166	♀	0.0018	3.10	187.17	0.19	-1.38	Iskenderun Bay
		125	♂	0.0017	3.12	144.85	0.32	-1.13	
Özdemir et al. (2020)	*Dasyatis pastinaca*	12	∑	0.0028	3.22				Southern Black Sea
Cabbar and Yığın (2021a)	*Scyliorhinus canicula*	1143	∑	0.0012	3.26				Gökçeada Island
	Scyliorhinus stellaris	110		0.0009	3.37				
	Galeus melastomus	795		0.0017	3.14				
	Etmopterus spinax	575		0.0036	3.02				
	Squalus acanthias	48		0.0023	3.16				
	Raja clavata	255		0.0009	3.45				
	Raja miraletus	29		0.0001	3.91				
	Dipturus oxyrinchus	36		0.0006	3.43				
Cabbar and Yığın (2021b)	*Raja clavata*	76	♀	0.0030	3.18	106.54	0.16	−0.28	Northern Aegean Sea
		28	♂	0.0223	2.68	101.71	0.18	−0.07	
Onay and Dalgıç (2021)	*Raja clavata*	478	∑	0.0027	3.20				SE Black Sea
Özdemir et al. (2021)	*Raja clavata*	430	∑	0.0032	3.25				Southern Black Sea
Soykan and Kınacıgil (2021)	*Dalatias licha*	42	∑	0.0180	2.87				Sığacık and Kuşadası Bays
	Etmopterus spinax	1057		0.0060	2.90				
	Galeus melastomus	1722		0.0025	3.00				
	Raja clavata	294		0.0012	3.36				
	Dipturus oxyrinchus	63		0.0007	3.37				
	Scyliorhinus canicula	2940		0.0015	3.19				
	Squalus acanthias	133		0.0020	3.22				
	Torpedo marmorata	70		0.0410	2.70				
Yığın and İşmen (2021)	*Raja miraletus*	52	∑	0.0017	3.27	62.43	0.28	-0.54	Saros Bay
Acarlı et al. (2022)	*Scyliorhinus canicula*	147	∑	0.0012	3.28				Gökçeada Island
Başusta et al. (2022)	*Rhinoptera marginata*	224	∑			178.60*	0.12	-2.08	Iskenderun Bay
Başusta and Özel (2022)	*Dipturus oxyrinchus*	143	♀	0.0023	3.10	152.55	0.06	-1.62	Iskenderun Bay
		112	♂	0.0009	3.34	161.73	0.06	-1.63	
Bengil (2022)	*Squalus blainville*	184	∑	0.0010	3.33				Eastern Mediterranean
Daban et al. (2022)	*Raja clavata*	147	♀	0.0007	3.53				Gökçeada Island
		115	♂	0.0012	3.38				
Dağtekin et al. (2022)	*Dasyatis pastinaca*	224	∑	0.0004	3.73				Southern Black Sea
	Raja clavata	1408		0.0042	3.09				
	Squalus acanthias	108		0.0068	2.87				
Gül et al. (2022)	*Oxynotus centrina*	21	∑	0.02	2.82				Sea of Marmara
Kabasakal and Özbek (2022)	*Oxynotus centrina*	18	♀	0.216	2.68				Mediterranean
		10	♂	0.134	3.04				

Karadurmuş (2022)	*Raja miraletus*	9	∑	0.0024	3.17				Sea of Marmara
	Raja clavata	40		0.0088	2.84				
	Scyliorhinus canicula	92		0.0265	2.62				
	Squalus acanthias	22		0.0073	2.89				
	Torpedo marmorata	46		0.0564	2.69				
Taylan et al. (2022)	*Dasyatis pastinaca*	349	∑	0.0022	3.18				Izmir Bay
	Torpedo marmorata	5		0.0108	3.20				
	Gymnura altavela	7		0.9109	3.22				
Özdemir et al. (2023)	*Squalus acanthias*	316	♀	0.0098	2.85				Southern Black Sea
		260	♂	0.0103	2.28				
Yığın et al. (2023)	*Raja clavata*	262	♀			102.46	0.16	0.72	Gökçeada Island
			♂			93.04	0.17	0.48	
Kabasakal et al. (2024)	*Squalus blainville*	39	♀	0.00005	3.81				Sea of Marmara
		28	♂	0.00002	3.11				
Özten et al. (2024)	*Myliobatis aquila*	41	♀	0.0012	3.20	164.08	0.95	-0.08	Saros Bay
		44	♂	(∑)	(∑)	138.59	0.90	-0.09	
Cengiz et al. (2024)	*Galeus melastomus*	106	♀	0.002	3.13				Mediterranean
		230	♂	0.003	2.94				
Şen and Özekinci (2024)	*Raja clavata*	50	∑	0.0013	3.33				Kemer Bay
	Torpedo marmorata	34		0.0422	2.77				
	Dasyatis pastinaca	8		0.0156	2.75				
Turan et al. (2024c)	*Squalus blainville*	48	∑	0.0005	3.03				Iskenderun Bay

N, number of sample studied; ♀, female; ♂, male; ∑, both sexes; *a*, intercept; *b*, slope; L_∞, asymptotic length; *k*, growth coefficient (year^{-1}); t_o, theoretical age at length equal to zero; *, using disc width.

Table 2 highlights that bio-ecological studies have been conducted on batoids 162 times, on sharks 102 times, and on chimeras only twice. In this context, the bio-ecologically most studied batoid species is *Raja clavata* (38 times), followed by *Dasyatis pastinaca* (24 times), *Torpedo marmorata* (17 times), *Raja miraletus* (14 times), *Gymnura altavela* and *Raja radula* (10 times each). Of the remaining species, *Dipturus oxyrinchus* was studied 6 times, *Myliobatis aquila* and *Rostroraja alba* were 8 times each, *Glaucostegus cemiculus* and *Raja asterias* were 4 times each, *Rhinobatos rhinobatos* and *Tetronarce nobiliana* were 3 times each, *Aetomylaeus bovinus*, *Bathytoshia lata*, *Dasyatis marmorata* and *Rhinoptera marginata* were 2 times each, *Leucoraja circularis* and *Raja polystigma* were once each. On the other hand, the shark species most frequently studied is *Scyliorhinus canicula*, researched 24 times, followed by *Mustelus mustelus* at 14 times, *Squalus acanthias* and *Squalus blainville* at 11 times each. The remaining species studied included *Galeus melastomus* (10 times), *Etmopterus spinax* and *Scyliorhinus stellaris* (8 times each), *Heptranchias perlo* (3 times), *Dalatias licha*, *Hexanchus griseus*, *Mustelus punctulatus*, and *Oxynotus centrina* (twice each), and *Carcharhinus plumbeus*, *Centrophorus granulosus*, *Mustelus asterias*, *Prionace glauca*, and *Squatina squatina* (once each). *Chimaera monstrosa*, the sole species of Chimaera in Turkish marine waters, has only been examined in two bio-ecological studies thus far.

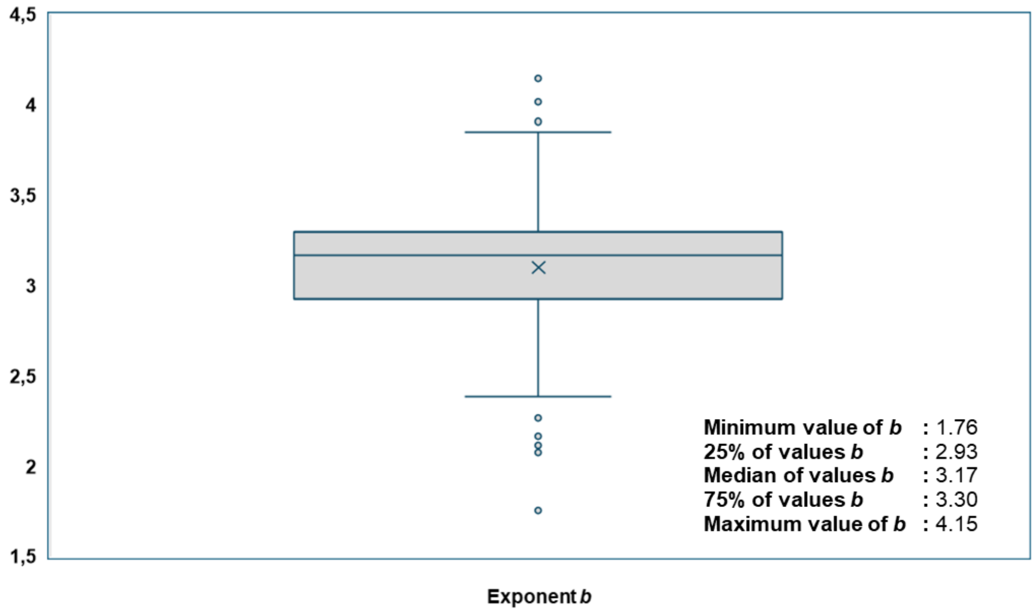

Figure 4. Box-Whiskers plots showing the exponent *b* of LWR studies conducted for 37 cartilaginous species on the Turkish coast. The central box covers 50% of the *b* values, the vertical line indicates the range of the values, and the horizontal line represents the median.

In general, the values of the exponent *b* are expected to vary between 2 and 4 (Tesch, 1971). Extreme exponent *b* values were obtained as 1.76 for *Dasyatis pastinaca* (Yarmaz, 2009) and *Etmopterus spinax* (Gönülal, 2017), and 4.15 for *Raja miraletus* (Filiz and Bilge, 2004) from the LWR studies in Turkish marine waters, probably due to the very low number of samples. The median of *b* is 3.17, with 25-75% of these values ranging between 2.93 and 3.30 (Figure 4). The mean value of all *b* is 3.10 (± 0.34), which is significantly different from 3.00 ($p < 0.05$).

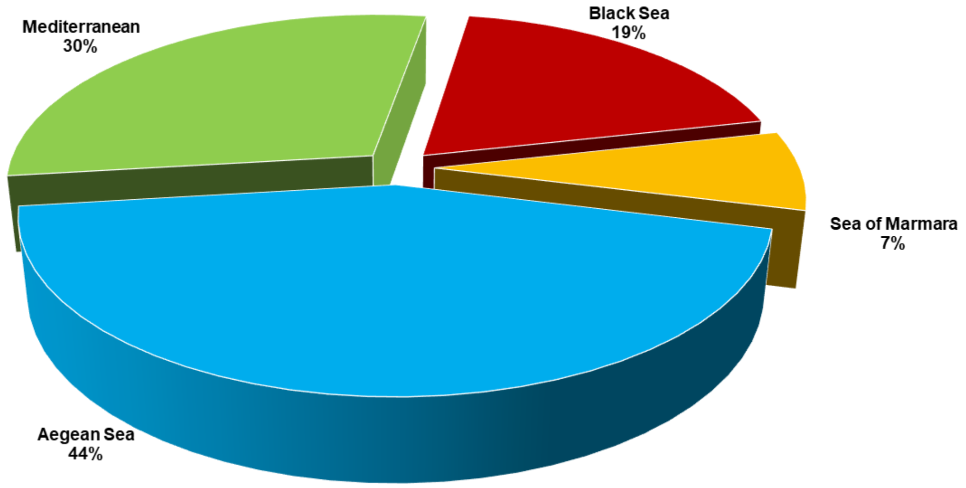

Figure 5. Percentage of studies on bio-ecological characteristics of cartilaginous species for each Turkish sea.

Figure 5 indicates that the part of the Turkish coast where cartilaginous species are most studied is the Aegean Sea, accounting for 44% with 42 instances, followed by the Mediterranean at 30% with 28 instances, the Black Sea at 19% with 18 instances, and the Sea of Marmara at 7% with 7 instances. Regarding the distribution of bio-ecological studies on the group of cartilaginous fish, in the Aegean Sea, 55% of 42 studies focused on batoids, 44% on sharks, and 1% on chimaeras; in the Mediterranean, 77% of 28 studies were on batoids and 23% on sharks; in the Black Sea, 74% of 18 studies focused on batoids and 26% on sharks; and in the Marmara Sea, 55% of 7 studies were on batoids and 45% on sharks (Figure 6).

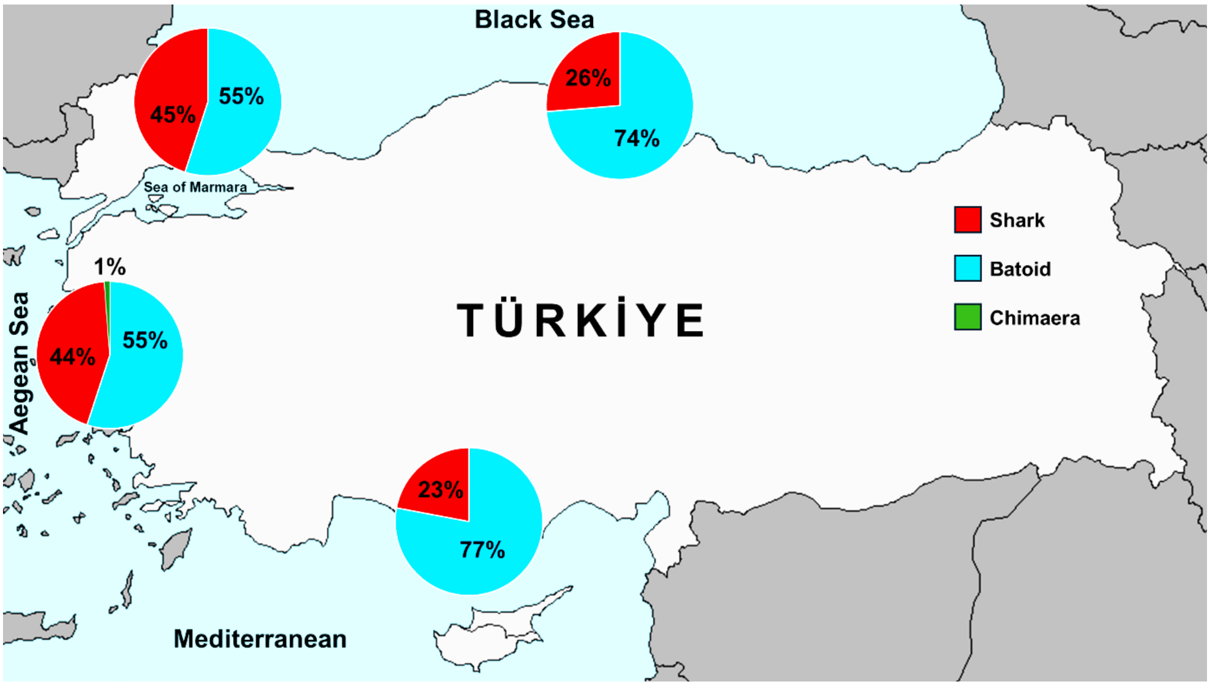

Figure 6. Map reflecting the percentage distribution of bioecological studies according to cartilaginous fish groups in each sea of Türkiye.

Genetic studies

Genetic studies published so far on cartilaginous fishes in Turkish marine waters are quite limited. There is no study other than Turan (2008), Bengil (2018), Bengil et al. (2019), Tüney-Kızılkaya and Bengil (2022) and Turan et al. (2024d).

Turan (2008) revealed the phylogenetic relationship and systematic patterns among nine skate species (*Rostroraja alba*, *Leucoraja fullonica*, *Dipturus oxyrinchus*, *D. batis*, *Raja clavata*, *R. montagui*, *R. asterias*, *R. miraletus*, and *R. radula*) in the Mediterranean and the Black Sea with the mtDNA *16S rRNA* dataset. 39 variable and 29 parsimony informative sites were provided from the *16S rRNA* sequences, and the average nucleotide diversity was found to be 0.018. Homogeneity was observed in the genetic distance values between *R. clavata* and *R. montagui*. The highest genetic difference value (0.040) was observed between *D. oxyrinchus* and *R. asterias*, while the lowest was observed between *R. montagui* and *R. miraletus*, and *R. clavata* and *R. miraletus*. The Neighbour-Joining phylogenetic tree revealed four evolutionary lineages; the first lineage included *R. clavata*, *R. montagui*, and *R. miraletus*, and in the second lineage, *L. fullonica* and *R. asterias* were grouped together. In the third lineage, *D. batis* and *D. oxyrinchus* were grouped together, resulting in a close relationship with *R. radula*. Moreover, *R. alba* was separated from other species as the most differently grouped species.

Bengil (2018) investigated the genetic characterization of nine elasmobranch species (*Carcharhinus plumbeus*, *Mustelus mustelus*, *M. punctulatus*, *Isurus oxyrinchus*, *Torpedo marmorata*, *Dasyatis pastinaca*, *Gymnura altavela* and *Squatina squatina*) from mtDNA *COI* dataset. In this PhD study, the obtained sequences were compared with other *COI* sequences in both GenBank and the BOLD system, a Neigbour-Joining tree was produced, and the results were also mapped by performing Network analysis.

Bengil et al. (2019) carried out the phylogenetic analysis of *Isurus oxyrinchus* on Eastern Mediterranean coasts of Türkiye using the mtDNA *COI* dataset. They created a phylogenetic mitochondrial haplotype network for the three individuals they used and showed that species with metapopulations were supported.

Tüney-Kızılkaya and Bengil (2022) performed genetic characterization of critically endangered angelsharks *Squatina squatina* and *S. aculeata* obtained from the Aegean Sea based on the mtDNA *COI* and *16S rRNA* sequences. The Neighbour Joining and Maximum Likelihood phylogenetic trees derived from both genes provide similar results, with both trees consisting of four main clades representing the same regional groups: Europe, North Africa, and Asia; South Africa; Australia; and North and South America. In both trees, *S. squatina* sample from the study formed a branch with other *S. squatina* sequences from GenBank. Similarly, *S. aculeata* specimen appeared on a branch among other *S. aculeata* sequences in GenBank. They emphasized that adopting morphological identification as the sole tool is not sufficient to accurately identify *Squatina* spp. and that both morphological and molecular tools should be used to taxonomically identify endangered shark species to secure their conservation status.

Turan et al. (2024d) determined the phylogenetic relationships of seven shark species (*Squalus blainville*, *Carcharhinus plumbeus*, *Galeus melastomus*, *Scyliorhinus canicula*, *Isurus oxyrinchus*, *Mustelus mustelus*, and *Oxynotus centrina*) collected from Iskenderun Bay, using mtDNA *Cyt b* region. 293 variable and 74 conservative nucleotide sites were obtained from *Cyt b* sequences, and 279 of them were informative. Overall nucleotide diversity was found to be 0.43. This study, in which the nucleotide diversity of *Cyt b* sequences was generally observed to be low, revealed that *Oxynotus centrina* had the lowest nucleotide diversity (0.024) and *Galeus melastomus* had the highest nucleotide diversity (0.087). The lowest genetic distance was between *M. mustelus* and *S. canicula*, and the highest between *G. melastomus* and *I. oxyrinchus*. The Neighbour-Joining tree identified two major phylogenetic nodes; at the first main node, *I. oxyrinchus* branched out as a single species, and at the second main node, four sub-branches were identified, with each sub-branch containing a species with a high bootstrap value. The maximum Parsimony tree also identified two major phylogenetic nodes but showed a different topology compared to the Neighbour-Joining tree. At the first node, *G. melastomus* was branched separately, at the second node, close groupings were observed in four sub-branches between *O. centrina* - *S. blainville* and between *C. plumbeus* - *I. oxyrinchus*. The study underlines the need for urgent conservation strategies adapted for these shark species due to low genetic diversity and the presence of regional haplotypes.

Conclusions

This paper focuses on the list of elasmobranch species and explores the status and conservation strategies of elasmobranch species based on available bio-ecological and genetic references in Turkish marine waters. A large part of the elasmobranchs distributed throughout Türkiye and even the Mediterranean are at risk of extinction. However, there are still knowledge gaps that need to be addressed for better understanding and protection. Stocks of cartilaginous fish in Türkiye have been decreasing for many years due to excessive and IUU fisheries (illegal, unregistered, and unregulated fishing) (Öztürk, 2009). Unfortunately, in Turkish fisheries statistics, elasmobranch data are used under general nomenclatures such as “sharks”, “angel sharks” and “rays”. The first step in developing conservation strategies for threatened cartilaginous species should be to include these fish, species by species, in official fisheries statistics.

On the other hand, studies on the distribution of elasmobranch species, determining their share in fishery activities and their bioecology are not sufficient to ensure sustainable stocks. Evaluating genetic diversity levels with bio-ecological parameters together is critically importance to manage effectively marine stocks (Uyan et al. 2024; Uyan and Turan, 2024). In addition, it is important to know the genetic variations are diverse in different mtDNA regions containing informative sites and nuclear markers to make regulations that support the sustainability and protection of elasmobranch stocks. Thus, there is an urgent need for species-specific conservation strategies and dynamic regulations based on the reproductive periods of elasmobranchs (Yığın et al., 2015).

Besides shark and batoid species, the catching of which is prohibited by Communiqué No. 5/1, according to the IUCN criteria, shark (*Carcharias taurus*) and batoid (*Dipturus batis*, *Aetomylaeus bovinus*, *Myliobatis aquila*, and *Rhinoptera marjinata*) species listed as Critically Endangered (CR), along with shark (*Echinorhinus brucus*, *Centrophorus uyato*, *Rhincodon typus*, *Odontaspis ferox*, *Mustelus mustelus*, and *Carcharhinus obscurus*) and batoid (*Leucoraja circularis*, *Raja radula*, *Raja undulata*, *Rostroraja alba*, *Himantura leoparda*, *Himantura uarnak*, and *Gymnura altavela*) species listed as Endangered (EN), should also receive legal protection in Turkish marine waters. Moreover, plans for the establishment of marine protected areas should be prioritized, considering the existence of important factors such as the destruction of elasmobranch habitats and harmful pollutants. Otherwise, many endangered cartilaginous species will inevitably become extinct in Turkish marine waters and these species will only be seen in books or museums in the future. Consequently, establishing collaborations between stakeholders, scientists, and policymakers to develop all these strategies is noteworthy in terms of the sustainability of cartilaginous fish stocks.

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Conflict of Interest

The authors declare that they have no competing interests.

Author Contributions

C.T., A.U., A.S., S.A.D., and D.E. drafted the main manuscript text. Authors reviewed and approved the final version of the manuscript.

Ethical Approval Statements

Local Ethics Committee Approval was not obtained because experimental animals were not used in this study.

Data Availability Statement

The data used in the present study are available upon request from the corresponding author.

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