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Integrating Literature, Biodiversity Databases, and Citizen-Science to Reconstruct the Checklist of Chondrichthyans in Cyprus (Eastern Mediterranean Sea)

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Abstract: Chondrichthyans are apex predators influencing the trophic web through a top-down process thus their depletion will affect the remaining biota. Notwithstanding that, research on chondrichthyans is sparse or data-limited in several biogeographic areas worldwide, including the Levantine Sea. We revise and update the knowledge of chondrichthyans in Cyprus based on a bibliographic review that gains information retrieved from peer-reviewed and grey literature, Global Biodiversity Information Facility (135 records of at least 18 species) and the Ocean Biodiversity Information System (65 records of at least14 species), and the citizen science project Mediterranean Elasmobranchs Citizen Observations (117 records per 23 species). Our updated checklist reports 60 species that account for about 70% of the Mediterranean chondrichthyan biota. The list includes 15 more species than the previous checklist and our study reports three new species for Cyprus waters, namely the blackmouth catshark *Dalatias licha*, the round fantail stingray *Taeniurops grabatus*, and the sawback angelshark *Squatina aculeata*. Our research highlights the need for conservation measures and more studies regarding the highly threatened blackchin guitarfish *Glaucostegus cemiculus* and the devil ray *Mobula mobular*, and stresses the importance for training a new generation of observers to strengthen the knowledge and conservation of elasmobranchs in the region.

Keywords: cartilaginous fishes; threatened taxa; Levantine Sea; red list (IUCN); MECO project

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1. Introduction

Chondrichthyans (sharks, skates, rays, sawfish, and chimeras) play a pivotal role in the marine environment, providing stability to coastal and oceanic ecosystem structures and functions [1,2]. Nevertheless, they are heavily overfished worldwide [3,4], with targeted fisheries and bycatch constituting the most significant threats to the conservation of demersal and pelagic species [4,5]. This also holds true for the Mediterranean Sea, which used to be considered over the centuries as a chondrichthyan hotspot; at least 50% of its shark and ray species are now threatened with extinction, extirpation, and steep population declines [6–8]. Limited economic resources, political instability, difficulties in species identification, and low population densities also hamper the conservation of Mediterranean aquatic resources and, in general, of chondrichthyan species [7,9]. Illegal landings, mainly by North African fishing fleets, and slow progress in the implementation of an ecosystem approach to fisheries management—provisioned by the European Union (EU) Common Fisheries Policy and Food and Agriculture Organisation (FAO) declarations—are also jeopardizing population recoveries of these taxa in the Mediterranean Sea [8]. Finally, declines are generally happening before we gain reasonable knowledge of several cartilaginous taxa, with 13 species of those living in the Mediterranean Sea still listed as "data deficient" according to the Red List evaluation of the International Union for the Conservation of Nature (IUCN) [10].

Open-access databases and citizen science are rapidly, and cost-effectively improving the extent and reach of shared information on marine biodiversity, often filling long-lasting knowledge gaps [11,12]. Data sharing tools such as the Global Biodiversity Information Facility (GBIF, https://www.gbif.org/; accessed on 1 May 2020) and the Ocean Biodiversity Information System (OBIS, https://obis.org/; accessed on 1 May 2020) facilitate access to species records. Advances in social media and mobile-phone applications have strengthened citizen science [13], providing extensive information about occurrence data in several phylogenetic groups, including chondrichthyans [9,14–19]. The use of internet and crowdsourcing platforms for ecology (also known as "iEcology") moves beyond traditional research studies and generates data about ecological patterns and processes (e.g., species occurrences, distributional range shifts) from digitally stored sources that would otherwise be unavailable [20,21]. They provide access to an unprecedented source of information that scientists have only recently started to explore [15,22]. These "new-generation" tools are highly useful in supporting correct species identifications and creating more effective and data-driven conservation strategies.

We combined (i) an extensive literature review with information gained from (ii) the online GBIF and OBIS databases and (iii) a focused citizen science project (MECO, Mediterranean Elasmobranchs Citizen Observations) in order to update the knowledge about chondrichthyans living in Cypriot waters. Our aims were to revise the previous chondrichthyan checklist for Cyprus and subsequently better understand whether (i) citizen science can provide crucial data about the biology and ecology of threatened species; (ii) knowledge and conservation of elasmobranchs in the region can be pursued through various approaches.

2. Materials and Methods

2.1. Study Area

Cyprus is the third largest island in the Mediterranean Sea and is located in the Levantine Basin (eastern Mediterranean). Despite its small size (9.251 km^2), the marine waters of the Cyprus Exclusive Economic Zone represent a significant water body of the eastern Mediterranean, equal to 98.240 km^2 (Figure 1). These waters are characterised by low nutrient availability (ultra-oligotrophic waters) and low primary production [23], complex water circulation with seasonal variations, sea temperature ranging from about 16 to 28 °C throughout the year, and salinity reaching up to about 39 PSU [14]. The southern part experiences cooler waters due to upwelling caused by north-westerly winds [24,25]. The coastline is predominantly composed of sand-gravel in the south to south-eastern part,

whereas the south-western and the eastern coastline is dominated by rocky substrata [26]. The local marine ecosystems and species assemblages are undergoing rapid changes due to multiple pressures acting synergistically, including invasive species, climate change, habitat loss, pollution, and overexploitation [27].

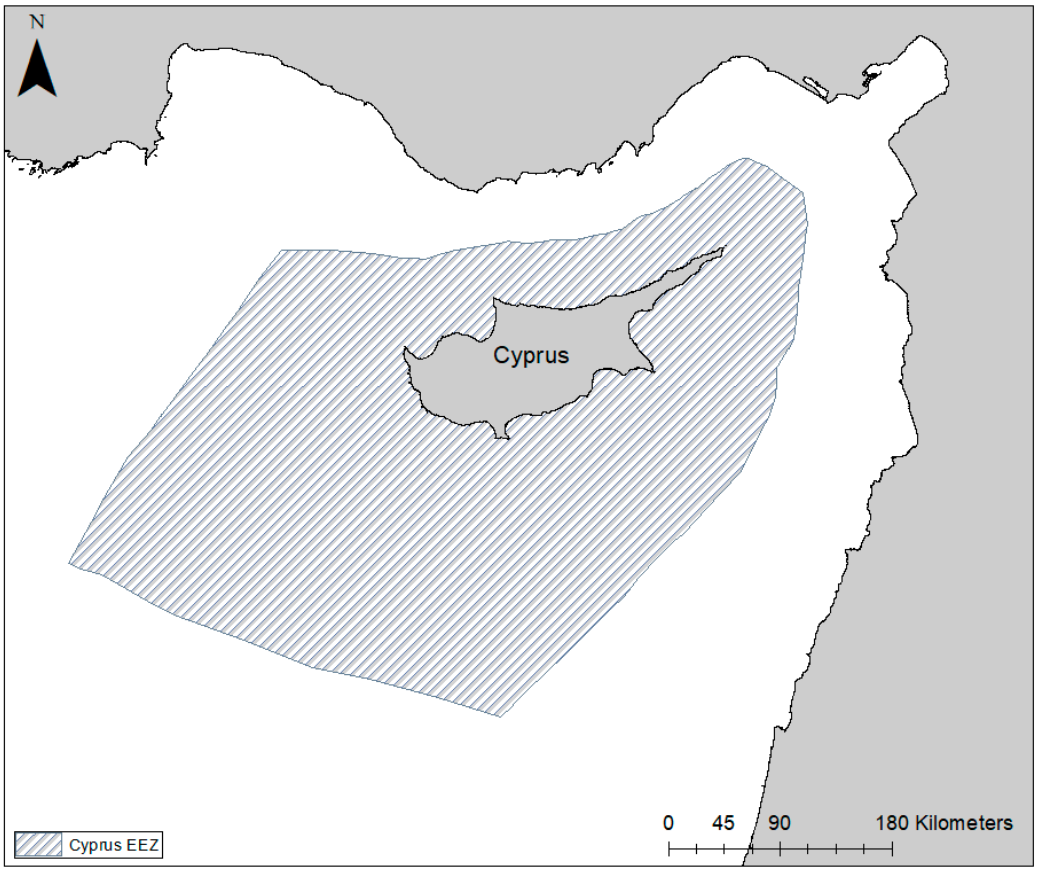

Figure 1. The Exclusive Economic Zone of the Republic of Cyprus. In the context of this study, all available information within this range was concentrated to produce an updated checklist of chondrichthyans in the region.

2.2. Literature Review

We conducted a systematic literature review (up to July 2020), applying the Preferred Reporting Items for Systematic Reviews and Meta-Analyses approach [28]. We collected chondrichthyan records from peer-reviewed publications archived in Google Scholar using the keyword "Cyprus" plus the search terms "chondrichthyan(s)", "elasmobranch(s)", "shark(s)", "batoid(s)", "ray(s)" and "skate(s)" to identify items with relevant titles, keywords, or abstracts. We selected "anytime" for the publication date. After duplicates were removed, 158 publications remained to be screened.

We furthermore searched for chondrichthyan records in government reports and policy documents. In particular, these included:

- CYP EU Data Collection Framework (DCF) reports, published between 2005–2019 and available at the following webpage: https://datacollection.jrc.ec.europa.eu/ars; accessed on 1 May 2021, including the scientific survey data of the International Bottom Trawl Survey in the Mediterranean (MEDITS);
- data published in two Department of Fisheries and Marine Research of Cyprus (DFMR) reports, which list 30 [29] and 45 chondrichthyan species [30], respectively.

Data retrieved from all the above-mentioned sources included (when available) the fish species, the year of sighting, the location, the depth, and the year of publication.

2.3. Global Biodiversity Information Facility (GBIF) and Ocean Biodiversity Information System (OBIS)

The Global Biodiversity Information Facility (GBIF) is the largest open-access primary biodiversity database and contains over 1.5 billion species occurrence records [12,31]. The Ocean Biodiversity Information System (OBIS), a global open-access database on marine biodiversity for science, conservation, and sustainable development, is focused on marine species and contains more than 6.5 million records for 137,215 species [32]. We searched GBIF and OBIS for chondrichthyan records from the Cyprus Exclusive Economic Zone (as defined above) and downloaded them. We checked pictures and records to exclude duplicates from the two databases and the MECO dataset and converted the data to the MECO database format for analysis (see below).

2.4. Citizen Science: The Mediterranean Elasmobranchs Citizen Observations (MECO) Project

The MECO project was launched in 2014 in response to enthusiastic scuba divers uploading pictures of sharks and rays from their dives [33]. It aims to collate knowledge on chondrichthyan occurrence, seasonality, and distribution using citizen science and social media. The project involves the collaboration of local scientists, which gradually expanded operation to eleven countries and ten Facebook groups (www.facebook.com/pg/theMECOproject; accessed on 1 May 2020). In MECO, participants report their sightings with photographic evidence. Scientific experts request further information, when needed, such as date, location, specimen length and weight, number of individuals observed, and depth of the observation (if applicable). The experts then check pictures for authenticity by using a Google automatic image recognition tool, and identify all original pictures to the lowest possible taxonomic level. Whenever possible, experts also record data such as maturity, gestation, and sex. Finally, there is also a two-way dialogue between citizen participants and scientific experts to retrieve historical records based on old pictures and social media posts.

2.5. Updated Taxonomy and Nomenclature

Bibliographic data were critically analysed and taxonomically updated to the latest nomenclature available. Specimens recorded through open-access databases and the MECO project were identified to the lowest taxonomic level possible following [34,35]. Species nomenclature follows the Eschmeyer's Catalog of Fishes [36].

3. Results

Updated Checklist of Chondrichthyans in Cyprus

The literature review revealed 12 publications reporting chondrichthyan records in Cypriot waters (Table 1 and references therein). Twenty more articles mentioned cartilaginous fishes to occur around Cyprus, but they did not have sufficient information about sightings to be included in our review (e.g., general reports with no coordinated or declared areas around Cyprus, reports of species found in auction markets, papers based on International Commission for the Conservation of Atlantic Tunas (ICCAT) data working with offshore longlining boats potentially in international waters, field identification guides, and publications from other locations (e.g., Spain) that appeared in the search), and thus were excluded.

Data mining in GBIF yielded 135 records, with over half of them (n = 85) recorded in 2009. Notably, 89 records (reported as MATERIAL_SAMPLE) were from scientific surveys (e.g., [37]), including 55 from the DFMR and 23 from Dr. Andrew Griffiths at the University of Exeter (United Kingdom). About a third of these records were reported as PRESERVED_SPECIMEN, mainly by DFMR. The majority (~71%) of these records regard specimens subsequently identified to the species level. Spurdog sharks of the genus *Squalus* Linnaeus, 1758 were the specimens most frequently reported (n = 39), followed by the marbled electric ray *Torpedo marmorata* (Risso, 1810) (n = 21). The blackmouth catshark *Galeus melastomus* (Rafinesque, 1810) and the thornback ray *Raja clavata* (Linnaeus, 1758)

were recorded ten times each. One of the DFMR records refers to the kitefin shark *Dalatias licha* (Bonnaterre, 1788), a species not recorded yet from Cyprus in the scientific literature (Table 1). Data mining in OBIS yielded 69 additional records of at least14 chondrichthyan species, with the majority of records (n = 48) coming from the BOLD Public Fish Data dataset (https://obis.org/dataset/292f775d-c300-4e21-8af2-b3b16a0a0ddc; accessed on 1 May 2020). No duplicates between OBIS and GBIF were found. Among records included, *Raja clavata* was the species most frequently reported, followed by the brown ray *Raja miraletus* Linnaeus, 1758 (n = 6) and by *T. marmorata* (n = 6).

Table 1. Updated checklist of chondrichthyan species recorded from Cyprus (eastern Mediterranean Sea), with number of records obtained through the various unpublished sources (GBIF, Gb; MECO, Me; OBIS, Ob) and references. Abbreviations used: * species newly recorded here; ** species listed with caution.

Taxon	Unpublished Data			References
	Gb	Me	Ob	
Order HEXANCHIFORMES F. de Buen, 1926				
Family Hexanchidae J. E. Gray, 1851				
Heptranchias perlo (Bonnaterre, 1788)	6	1	5	[29,30,38]; [39] (recorded from 2006); [40] (recorded from 2009)
Hexanchus griseus (Bonnaterre, 1788)		6		[17,29,30,38]; [40] (recorded from 2015); [41]
Hexanchus nakamurai Teng, 1962		1		[42]
Order LAMNIFORMES L. S. Berg, 1958				
Family Odontaspididae J. P. Müller & Henle, 1839				
Carcharias taurus Rafinesque, 1810				[29,30]
Odontaspis ferox (Risso, 1810)		1		[17,29,30,43]
Family Lamnidae J. P. Müller and Henle, 1838				
Carcharodon carcharias (Linnaeus, 1758)				[30]
Isurus oxyrinchus Rafinesque, 1810		10		[17,30]; [39] (recorded from 2006); [41]
Lamna nasus (Bonnaterre, 1788)				[30]; [39] (recorded from 2011)
Family Cetorhinidae Gill, 1861				
Cetorhinus maximus (Gunnerus, 1765)				[17,44]
Family Alopiidae Bonaparte, 1835				
Alopias superciliosus Lowe, 1841		1		[17]; [39] (recorded from 2010); [45]
Alopias vulpinus (Bonnaterre, 1788)				[29,30]
Order CARCHARHINIFORMES Compagno, 1977				
Family Pentanchidae Smith, 1912				
Galeus melastomus Rafinesque, 1810	10	1	5	[29,30,38,40]
Family Scyliorhinidae T. N. Gill, 1862				
Scyliorhinus canicula (Linnaeus, 1758)	8		5	[29,30,38]; [39] (recorded from 2006); [40] (recorded from 2005); [46,47]
Scyliorhinus stellaris (Linnaeus, 1758)				[30]; [40] (recorded from 2005)
Family Triakidae J. E. Gray, 1851				
Mustelus asterias Cloquet, 1819		1		[29,30]
Mustelus mustelus (Linnaeus, 1758)	1		1	[29,30]; [39] (recorded from 2006); [40] (recorded from 2006)
Mustelus punctulatus Risso, 1827	1			[30]
Family Carcharhinidae D. S. Jordan & Evermann, 1896	1	2		
** *Carcharhinus brevipinna* (Valenciennes, 1839)				[30]
** *Carcharhinus melanopterus* (Quoy & Gaimard, 1824)				[30]
Carcharhinus plumbeus (Nardo, 1827)		4		[30]
Prionace glauca (Linnaeus, 1758)				[29,30]; [39] (recorded from 2010)
Family Sphyrnidae T. N. Gill, 1872				
** *Sphyrna mokarran* (Rüppell, 1837)				[30]
Sphyrna zygaena (Linnaeus, 1758)				[29,30]

Table 1. *Cont.*

Taxon	Unpublished Data			References
	Gb	Me	Ob	
Order SQUALIFORMES Goodrich, 1909				
Family Dalatiidae J. E. Gray, 1851				
* *Dalatias licha* (Bonnaterre, 1788)	1			
Family Etmopteridae Fowler, 1934				
Etmopterus spinax (Linnaeus, 1758)	6		4	[30,38]; [40] (recorded from 2005); [43,48]
Family Oxynotidae Rafinesque, 1810				
Oxynotus centrina (Linnaeus, 1758)	2		1	[30,38]; [40] (recorded from 2006)
Family Centrophoridae Bleeker, 1859				
Centrophorus cf. *uyato* (Rafinesque, 1810)	5	2	5	[30]; [40] (recorded from 2009 as *Centrophorus granulosus*)
Family Squalidae Bonaparte, 1834	37			
Squalus acanthias Linnaeus, 1758				[29,30,38]; [40] (recorded from 2006); [46,47]
Squalus blainville (Risso, 1827)	1	5	5	[30,38]; [39] (recorded from 2006); [40] (recorded from 2011)
Order SQUATINIFORMES F. de Buen, 1926				
Family Squatinidae Bonaparte, 1838				
* *Squatina aculeata* Cuvier, 1829		1		
Squatina oculata Bonaparte, 1840				[15,30]
Squatina squatina (Linnaeus, 1758)	2			[29,30]
Order TORPEDINIFORMES F. de Buen, 1926				
Family Torpedinidae Bonaparte, 1838				
Tetronarce nobiliana (Bonaparte, 1835)				[29,30,38]; [39] (recorded from 2006); [40] (recorded from 2005);
Torpedo marmorata Risso, 1810	21	2	6	[29,30,38,46]; [40] (recorded from 2010); [47]
Torpedo torpedo (Linnaeus, 1758)				[29,30,38]; [40] (recorded from 2013)
Order RHINOPRISTIFORMES Naylor, et al., 2012				
Family Rhinobatidae J. P. Müller & Henle, 1837				
Rhinobatos rhinobatos (Linnaeus, 1758)				[29,30]
Family Glaucostegidae Bonaparte, 1846				
Glaucostegus cemiculus (Geoffroy St. Hilaire, 1817)	3	15		[30,46,47,49]
Order RAJIFORMES L. S. Berg, 1940				
Family Rajidae Bonaparte, 1831				
Dipturus oxyrinchus (Linnaeus, 1758)				[29,30,38]; [40] (recorded from 2005)
Leucoraja circularis (Couch, 1838)	5		4	[40] (recorded from 2009)
Leucoraja fullonica (Linnaeus, 1758)				[38]; [40] (recorded from 2012)
Leucoraja naevus (Müller & Henle, 1841)				[38]; [40] (recorded from 2015)
Raja asterias Delaroche, 1809				[29,30]; [40] (recorded from 2005)
Raja brachyura Lafont 1873				[40] (recorded from 2006)
Raja clavata Linnaeus, 1758	10		10	[29,38]; [39] (recorded from 2006); [40] (recorded from 2005); [46,47]
Raja miraletus Linnaeus, 1758	6		6	[29,30,38]; [40] (recorded from 2005); [46]
Raja montagui Fowler, 1910				[38]; [40] (recorded from 2005)
Raja polystigma Regan, 1923				[38]; [40] (recorded from 2006)
Raja radula Delaroche, 1809	5	1	2	[30,38]; [40] (recorded from 2006)
Raja undulata Lacepède, 1802				[40] (recorded from 2017)
Rostroraja alba (Lacepède, 1803)				[38]; [40] (recorded from 2015)

Table 1. *Cont.*

Taxon	Unpublished Data			References
	Gb	Me	Ob	
Order MYLIOBATIFORMES Compagno, 1973		6		
Family Dasyatidae D. S. Jordan, 1888	1			
Bathytoshia lata (Garman, 1880)		9		[30]; [40] (recorded from 2009, as *Dasyatis centroura*); [46]
** *Dasyatis marmorata* (Steindachner, 1892)		1		
Dasyatis pastinaca (Linnaeus, 1758)	3	11	2	[29,30,38]; [39] (recorded from 2006); [40] (recorded from 2005); [47]
Pteroplatytrygon violacea (Bonaparte, 1832)				[29,30]; [39] (recorded from 2006); [40] (recorded from 2018)
* *Taeniurops grabatus* (Geoffroy St. Hilaire, 1817)		2		
Family Gymnuridae Fowler, 1934				
Gymnura altavela (Linnaeus, 1758)		4		[29,30]
Family Aetobatidae White & Naylor, 2016				
Aetomylaeus bovinus (Geoffroy St. Hilaire, 1817)		10		[29,30,46]
Family Myliobatidae Bonaparte, 1835				
Myliobatis aquila (Linnaeus, 1758)				[46,47]
Family Rhinopteridae Jordan & Evermann, 1896				
Rhinoptera marginata (Geoffroy St. Hilaire, 1817)				[30]
Family Mobulidae Gill, 1893				
Mobula mobular (Bonnaterre, 1788)		2		[29,30]

The MECO project yielded 117 chondrichthyan observations of at least 23 different species. These sightings spanned the years 1970–2020, but most (78%) were from 2016–2019 (Table A1). Over half (54%) of the records were collected between June and September. Around half of the records came from recreational fishers (Figure 2B), 17% from scuba-divers (Figure 2C), 15% from snorkelers (Figure 2C), and 10% from professional fishers (Figure 2A). Most specimens were identified to species level, and the most common reports included the blackchin guitarfish *Glaucostegus cemiculus* (Geoffroy Saint-Hilaire, 1817) (n = 15), the common stingray *Dasyatis pastinaca* (Linnaeus, 1758) (n = 11), and the bull ray *Aetomylaeus bovinus* (Geoffroy St. Hilaire, 1817) (n = 10). Observations of the round fantail stingray *Taeniurops grabatus* (Geoffroy St. Hilaire, 1817) and of the sawback angelshark *Squatina aculeata* (Cuvier, 1829) also constituted the first records of these species in Cyprus (Table 1; Figure 3).

The updated checklist of chondrichthyans in Cyprus is reported in Table 1. It is now composed of 60 species, 15 more than the previous checklist (see [30]), with three species first recorded from Cyprus during this review.

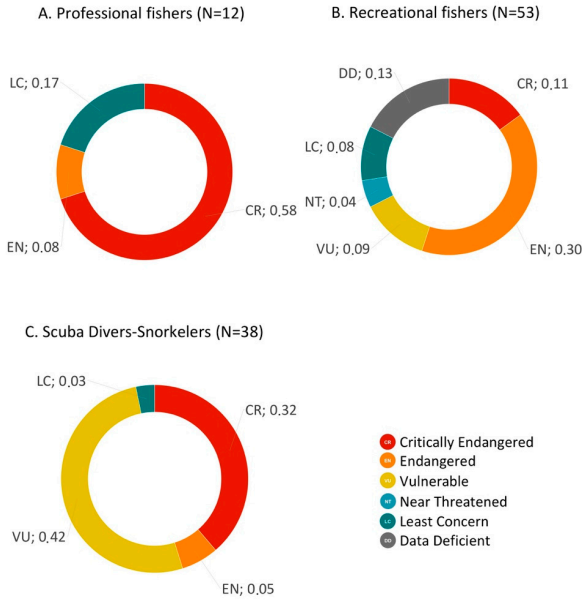

Figure 2. Percentage of observations per: (**A**) broader area as reported by citizen scientists to the MECO project (numbers represent the percentage of observations) and (**B**,**C**) types of observers (i.e., professional, recreational fishers, and scuba divers-snorkelers, respectively) in different conservation statuses. Critically Endangered (CR) = in a particular and extremely critical state; Endangered (EN) = very high risk of extinction in the wild; Vulnerable (VU) = meets one of the five red list criteria and thus considered to be at high risk of unnatural (human-caused) extinction without further human intervention; Near Threatened (NT) = close to being at high risk of extinction in the near future; Least Concern (LC) = unlikely to become extinct in the near future. Data Deficient (DD) = lack of sufficient data to evaluate the species status.

Figure 3. (**A**) Aggregation of *Mobula mobular* observed in 2020 in Cyprus. Photo credit: Marios Chisophorout. (**B**) A *Carcharhinus plumbeus* juvenile caught and released by a recreational fisher in 2018 in Cyprus. (**C**) A *Squatina aculeata* individual caught by a recreational fisher in 2020 in Cyprus. Photo credit: Stelios Kotzikas. (**D**) A female *Glaucostegus cemiculus* caught and released by a recreational fisher in 2010 in Cyprus. Photo Credit: Pampos Stavrou (**E**) A possible record of *Dasyatis marmorata* reported by Marine and Environmental Research Lab in 2020 from Cavo Greco, Cyprus. Photo Credit: Demetris Kleitou (**F**) A *Taeniurops grabatus* individual reported from a photo record that dates back in 1977 from Cyprus. Photo Credit: George Karamanos.

4. Discussion

The updated chondrichthyan fauna of Cyprus now includes 32 species of sharks and 28 species of batoids (skates and rays), and accounts for about 70% of the total chondrichthyan biota known from the Mediterranean Sea [7]. We do not expect that this list is complete or free from errors. In fact, shallow habitats around Cyprus are indeed targeted by recreational and professional fishers, and are regularly dived year-round by locals and tourists, thus providing a wealth of photographic records of inshore chondrichthyans. However, the deep-sea waters around Cyprus are almost unexplored, and this may be why, since the last list provided by [30], 15 new species have been recorded in the past 15 years. Finally, four species are listed here with caution, namely *Sphyrna mokarran* (Rüppell, 1837), *Carcharhinus brevipinna* (Valenciennes, 1839), and *Carcharhinus melanopterus* (Quoy & Gaimard, 1824), whose Mediterranean records are generally very scarce and often based on misidentifications [7], and *Dasyatis marmorata* (Steindachner, 1892), whose records should be confirmed through molecular means [7].

Despite these potential limitations, results of the present study confirm the importance of open-access biodiversity databases and citizen science approaches. Alongside these data, EU guidelines for data policy (EU REG 2017/1004), the Open Data Directive that entered into force on 16 July 2019 (Directive (EU) 2019/1024) to promote "open access policies" from publicly funded research and the FAIR (findability, accessibility, interoperability, and reusability) principles should be also taken into consideration for the elaboration of an open-access and transparent framework for commercial and survey fisheries data, in parallel to what is already in use for data in other areas including the ICES area. GBIF and OBIS records respectively accounted for 42.5% and 20.4% of the final dataset, including a species new for Cyprus. Funding and institutional support to such databases are critical, as these data may be useful in order to influence science-based policy decisions [12,50].

The citizen science MECO project yielded more than 100 unpublished elasmobranch records in a single year, including those of two species newly recorded here from Cyprus. It also allowed us to trace relevant data regarding historical ecology and species biology and ecology. As an example, until our work, the big eye thresher shark *Alopias superciliosus* Lowe, 1841 was only known from Cyprus based on records held in 2010 and 2015 [45]. We collected evidence that the species had been recorded from Cyprus since at least ~1970, but was probably misidentified in the past as the common thresher *Alopias vulpinus* (Bonnaterre, 1788). Our data also confirm the findings of [49], who suggested that Cyprus should be considered a crucial area for the conservation of *G. cemiculus*, a species listed as critically endangered by the IUCN Red List and whose populations have drastically decreased all along the African coastline due to overfishing [51]. In addition to Cyprus, this taxon now only survives in few locations in the Mediterranean Sea, namely, the Gulf of Gabes [52], the Israel coast [53], and Iskenderun Bay [54]. In addition, we recorded a pregnant *G. cemiculus*, suggesting that members of this species nurse and potentially spawn in Cyprus; a specimen of *A. bovinus* observed on different days in Akrotiri Bay (south coast of Cyprus), suggesting site fidelity by this species; migration routes by *M. mobular*, with aggregations of large specimens occurring in late winter–early spring; and in general, spawning aggregations of stingrays (*Dasyatis pastinaca* and *Bathytoshia lata*), with pregnant females observed during spring and summer seasons.

Apart from the data and the observations new reported here, we noticed that professional fishers communicated (caught) elasmobranchs listed as Vulnerable, Endangered, or Critically Endangered by the IUCN Red List in 67% of the cases, whereas this percentage decreased to 52% when analysing data provided by recreational fishers. These numbers agree with other Mediterranean studies; for example, about 50–60% of the elasmobranch landings in Greek sites were threatened species [55]. However, it is also possible that fishers mostly communicated to us species perceived as rare, while other common taxa (such as, for example, *Raja* species) were usually considered as of "no interest". Finally, we traced ten illegal fishing activities, accounting for 8% of the MECO records available. In addition, one participant posted on social media an encounter with the vulnerable species *Isurus*

oxyrinchus Rafinesque, 1810, but then a spear fisher used this information to locate and kill the fish. Although the fisher may have been potentially unaware of its protection status and conservation importance, the Department of Fisheries and Marine Research of Cyprus initiated legal procedures against him, with the results of this procedure still pending. Such information is vital in understanding interactions of fishers with vulnerable and threatened species as well as illegal incidents that might occur.

5. Conclusions

Our study highlights the knowledge gaps that exist in elasmobranch occurrence, ecology, and interactions with human activities. In response, Cyprus has recently increased the scientific team involved in the data collection framework through the DFMR, recognising a major opportunity for capacity building in monitoring programs with more on-board fisheries observations. Given the success of citizen science projects in other regions and the emergence of MECO project, the training of divers and snorkelers using bespoke local identification guides may offer another cost-effective means of obtaining data on diversity, abundance, and seasonality of elasmobranchs around Cyprus. Satellite tracking, acoustic tagging, and baited remote underwater video cameras may also offer a suite of more technical tools to recognise the importance of Cypriot waters for Mediterranean chondrichthyans. An ongoing EU-LIFE project (Elasmobranch Low Impact Fishing Experience) includes the training of monitoring authorities and fishers on species identification, relevant legislation, safe release of individuals, as well as satellite tagging to estimate mortalities following incidental by-catch. In addition, the DFMR, in cooperation with a regional FAO project (EastMed and General Fisheries Commission of Mediterranean), organised a tailored species identification webinar for scientific observers, officers, and control inspectors, in order to enhance data quality and acquisition. This activity is provisioned to be an ongoing process and was already proposed at the last EastMed project annual coordination committee meeting (by the Cyprus delegation) to have a regionalised application. The hope is that all these efforts will reduce fishing impacts and will turn the tide in favour of heightened protection of the Cypriot and Mediterranean chondrichthyans and biota in general.

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Appendix A

Table A1. Records of elasmobranchs reported to the Mediterranean Elasmobranchs Citizen Observations (MECO) project including information about the date, the area, the species, the number of individuals, the observation type, the animal status, the growth stage (A/J), the sex (M/F), the depth and the substrate.

Date	Time of Day	Area	Species	Count	Observation Type	Animal Status	A/J	M/F	Depth	Substrate
24 August 2019			*Aetomylaeus bovinus*	1	Scuba Diving-Snorkelling	Alive	Adult	Female		Unknown
9 August 2019		Cape Greco	*Aetomylaeus bovinus*	1	Scuba Diving-Snorkelling	Alive	Adult			Sandy
3 September 2019		Akrotiri Bay	*Aetomylaeus bovinus*	1	Scuba Diving-Snorkelling	Alive	Adult	Female		Unknown
31 October 2018			*Aetomylaeus bovinus*	2	Scuba Diving-Snorkelling	Alive	Adult		8 m	Unknown
16 June 2018		Ammochostos Bay	*Aetomylaeus bovinus*	1	Scuba Diving-Snorkelling	Alive	Adult			Rocky
27 August 2019		Ammochostos Bay	*Aetomylaeus bovinus*	1	Scuba Diving-Snorkelling	Alive	Adult		12 m	Sandy
27 August 2019	Daytime	Cape Greco	*Aetomylaeus bovinus*	1	Scuba Diving-Snorkelling	Alive	Adult			Sandy
14 August 2016		Akrotiri Bay	*Aetomylaeus bovinus*	1	Recreational	Alive	Adult			Sandy
3 September 2019		Akrotiri Bay	*Aetomylaeus bovinus*	1	Recreational	Alive	Adult			Rocky
6 August 2019	Daytime	Paphos	*Bathytoshia centroura*	1	Recreational	Killed/fished	Adult	Female	0	Unknown
2 May 2018		Cape Greco	*Bathytoshia centroura*	1	Scuba Diving-Snorkelling	Alive	Adult	Female		Unknown
29 July 2017		Akrotiri Bay	*Bathytoshia centroura*	1	Scuba Diving-Snorkelling	Alive	Adult			Unknown
28 June 2019		Cape Greco	*Bathytoshia centroura*	2	Scuba Diving-Snorkelling	Alive	Adult		12–15 m	Sandy
3 August 2019			*Bathytoshia centroura*	1	Scuba Diving-Snorkelling	Alive	Adult	Female		Unknown
23 July 2019			*Bathytoshia centroura*	1	Scuba Diving-Snorkelling	Alive	Adult	Female		Sandy
1 September 2018		Paphos	*Bathytoshia centroura*	3	Recreational	Caught and released	Adult	Female	2 m	Sandy
14 August 2016		Akrotiri Bay	*Bathytoshia centroura*	1	Recreational	Alive	Adult			Sandy
14 August 2017			*Carcharhinus brevipinna*	1	Recreational	Killed/fished	Adult		0	Unknown
23 February 2019			*Carcharhinus plumbeus*	1	Recreational	Caught and released	Juvenile			Unknown
5 April 2016		Paphos	*Carcharhinus plumbeus*	1	Recreational	Caught and released	Adult	Female		Unknown
20 August 2018		Akrotiri Bay	*Carcharhinus plumbeus*	4	Recreational	Caught and released	Juvenile			Unknown

Table A1. *Cont.*

Date	Time of Day	Area	Species	Count	Observation Type	Animal Status	A/J	M/F	Depth	Substrate
4 August 2019		Akrotiri Bay	*Carcharhinus* sp.	1	Recreational	Caught and released	Juvenile			Unknown
22 August 2019	Night	Larnaca Bay	*Carcharhinus* sp.	1	Recreational	Killed/fished	Juvenile		0	Unknown
5 October 2019	Daytime	Pervolia-Mazotos-Tochni	*Carcharhinus* sp.	1	Recreational	Killed/fished	Juvenile		0	Unknown
24 August 2019	Daytime	Akrotiri Bay	*Carcharhinus* sp.	1	Recreational	Killed/fished	Juvenile		0	Unknown
5 March 2019			*Carcharhinus* sp.	3	Professional	Killed/fished				Unknown
7 August 2017		Paphos	*Carcharhinus* sp.	1	Recreational	Caught and released	Juvenile			Unknown
9 August 2017		Paphos	*Carcharhinus* sp.	2	Recreational	Caught and released	Juvenile			Unknown
29 November 2010			*Centrophorus cfr. uyato*	1		Killed/fished	Adult			Unknown
6 January 2020	Daytime	Paphos	*Centrophorus cfr. uyato*	1	Recreational	Caught and released	Adult		0	Unknown
1 September 2019		Akrotiri Bay	*Dasyatidae*	1	Scuba Diving-Snorkelling	Alive	Juvenile		4 m	Sandy
18 August 2017		Akamas	*Dasyatidae*	1	Scuba Diving-Snorkelling	Alive	Juvenile			Unknown
7 August 2018		Akamas	*Dasyatidae*	1	Scuba Diving-Snorkelling	Alive	Juvenile			Sandy
2 August 2017		Akamas	*Dasyatidae*	4	Scuba Diving-Snorkelling	Alive	Adult	Male	5–6 m	Unknown
1 June 2019		Ammochostos Bay	*Dasyatidae*	1	Scuba Diving-Snorkelling	Alive	Juvenile			Sandy
4 July 2018		Akrotiri Bay	*Dasyatis pastinaca*	3	Scuba Diving-Snorkelling	Alive			4 m	Rocky
25 June 2018		Akamas	*Dasyatis pastinaca*	12	Scuba Diving-Snorkelling	Alive	Juvenile			Sandy
3 September 2019		Akrotiri Bay	*Dasyatis pastinaca*	1	Scuba Diving-Snorkelling	Alive	Juvenile			Sandy
		Paphos	*Dasyatis pastinaca*	1	Scuba Diving-Snorkelling	Alive		Female		Sandy
1 July 2017		Episkopi Bay	*Dasyatis pastinaca*	1	Scuba Diving-Snorkelling	Alive	Adult			Unknown
21 June 2017		Ammochostos Bay	*Dasyatis pastinaca*	1	Scuba Diving-Snorkelling	Alive	Juvenile			Sandy
23 September 2018		Paphos	*Dasyatis pastinaca*	1	Scuba Diving-Snorkelling	Alive				Sandy
9 June 2019		Ammochostos Bay	*Dasyatis pastinaca*	1	Scuba Diving-Snorkelling	Alive	Juvenile			Sandy
11 July 2019		Paphos	*Dasyatis pastinaca*	7	Scuba Diving-Snorkelling	Alive			5 m	Sandy
3 February 2019		Paphos	*Galeus melastomus*	1	Recreational	Caught and released				Unknown

Table A1. *Cont.*

Date	Time of Day	Area	Species	Count	Observation Type	Animal Status	A/J	M/F	Depth	Substrate
13 July 2016	Night	Akrotiri Bay	*Glaucostegus cemiculus*	1	Recreational	Killed/fished	Juvenile		0	Unknown
11 September 2018		Larnaca Bay	*Glaucostegus cemiculus*	1	Recreational	Caught and released	Adult	Male		Unknown
11 September 2018		Larnaca Bay	*Glaucostegus cemiculus*	1	Recreational	Caught and released	Adult			Unknown
2 April 2019			*Glaucostegus cemiculus*	1	Recreational	Caught and released	Juvenile	Male	2–3 m	Sandy
17 September 2019		Larnaca Bay	*Glaucostegus cemiculus*	1	Recreational	Killed/fished	Adult	Male	2–3 m	Sandy
8 February 2018		Akrotiri Bay	*Glaucostegus cemiculus*	1		Caught and released	Juvenile			Unknown
12 September 2015		Zygi	*Glaucostegus cemiculus*	1	Scuba Diving-Snorkelling	Alive	Adult			Seaweed beds or patches
		Paphos	*Glaucostegus cemiculus*	1	Recreational	Caught and released	Adult	Female		Unknown
18 August 2018		Larnaca Bay	*Glaucostegus cemiculus*	1	Recreational	Caught and released	Adult		2 m	Unknown
19 July 2018		Larnaca Bay	*Glaucostegus cemiculus*	1	Recreational	Caught and released	Adult	Male		Muddy
14 August 2016		Akrotiri Bay	*Glaucostegus cemiculus*	1	Recreational	Alive	Adult	Female		Sandy
11 October 2018		Cape Greco	*Gymnura altavela*	1	Scuba Diving-Snorkelling	Alive	Adult			Sandy
8 November 2018		Cape Greco	*Gymnura altavela*	1	Scuba Diving-Snorkelling	Alive	Adult			Sandy
14 June 2019		Cape Greco	*Gymnura altavela*	1	Scuba Diving-Snorkelling	Alive				Sandy
6 January 2020	Morning	Paphos	*Hexanchus griseus*	1	Recreational	Killed/fished	Adult		0	Unknown
7 May 2010	Morning	Zygi	*Hexanchus griseus*	1	Professional	Killed/fished			0	Unknown
25 July 2015	Daytime	Cape Greco	*Hexanchus* sp.	1	Recreational	Killed/fished	Adult		0	Unknown
14 May 2018		Larnaca Bay	*Isurus oxyrinchus*	1	Recreational	Caught and released	Juvenile		50 m	Unknown
25 June 2019	Daytime	Crhysochou Bay	*Isurus oxyrinchus*	1	Recreational	Killed/fished	Juvenile		90	Unknown
March 2008	Morning	Paphos	*Isurus oxyrinchus*	1	Professional	Killed/fished			0	Unknown
9 December 2016		Akrotiri Bay	*Isurus oxyrinchus*	1	Professional	Caught and released	Juvenile		0	Unknown
21 September 2009	Daytime	Akamas	*Isurus oxyrinchus*	1	Professional	Killed/fished	Adult		0	Unknown
15 July 2016	Morning	Paphos	*Isurus oxyrinchus*	1	Professional	Killed/fished	Adult		0	Unknown
23 March 2019		Akrotiri Bay	*Mobula mobular*	2	Scuba Diving-Snorkelling	Alive				Unknown
26 March 2020	Morning	Akamas	*Mobula mobular*	20		Alive	Adult		0	Unknown

Table A1. *Cont.*

Date	Time of Day	Area	Species	Count	Observation Type	Animal Status	A/J	M/F	Depth	Substrate
1 July 2019		Episkopi Bay	*Mustelus asterias*	2	Scuba Diving-Snorkelling	Alive			8 m	Rocky
5 April 2018		Akrotiri Bay	*Prionace glauca*	2		Alive			6 m	Unknown
16 May 2018		Landbased	*Raja radula*	1		Caught and released	Juvenile			Unknown
2 September 2018			*Squalus blainville*	1	Recreational	Caught and released				Unknown
4 February 2019		Paphos	*Squalus blainville*	1	Recreational	Caught and released	Juvenile			Unknown
22 August 2018		Larnaca Bay	*Squalus blainville*	2	Recreational	Killed/fished	Juvenile		350 m	Muddy
15 January 2019	Daytime	Paphos	*Squalus blainville*	1	Recreational	Caught and released	Juvenile		0	Unknown
29 April 2018		Paphos	*Squalus blainville*	1		Killed/fished				Unknown
17 December 2017		Akrotiri Bay	*Squalus* sp.	3	Scuba Diving-Snorkelling	Alive	Adult		210 m	Unknown
8 October 2019		Akrotiri Bay	*Torpedo marmorata*	1		Killed/fished	Adult		0.5	Sandy
April 2008	Daytime	Cape Greco	*Torpedo marmorata*	1	Scuba Diving-Snorkelling	Alive	Adult		14 m	Sandy
17 December 2019	Daytime		*Unknown*	1	Recreational	Killed/fished			0	Unknown
21 January 2019			*Unknown*	1	Scuba Diving-Snorkelling	Alive				Unknown
6 June 2019	Night	Akrotiri Bay	*Glaucostegus cemiculus*	1	Recreational	Caught and released	Juvenile			Unknown
19 July 2019	Morning	Paphos	*Hexanchidae*	1		Killed/fished			0	Unknown
16 May 2016	Night	Ammochostos Bay	*Hexanchus griseus*	1	Professional	Killed/fished	Adult		0	Unknown
16 July 2017		Larnaca Bay	*Hexanchus griseus*	1		Not Specified	Juvenile			Unknown
30 April 2018		Akrotiri Bay	*Hexanchus* sp.	1		Found dead		Male		Unknown
11 May 2019			*Hexanchus* sp.	1	Recreational	Killed/fished	Adult	Female		Unknown
10 May 2019	Noon	Ammochostos Bay	*Isurus oxyrinchus*	2	Professional	Killed/fished			50	Unknown
27 March 2017		Paphos	*Isurus oxyrinchus*	1		Killed/fished	Juvenile			Unknown
1970s		Chrysochou Bay	*Alopias superciliosus*	1	Professional	Killed/fished	Adult			Unknown
1970s		Akamas	*Isurus oxyrinchus*	1	Professional	Killed/fished	Adult			Unknown
1970s		Akamas	*Odontaspis ferox*	1	Professional	Killed/fished	Adult			Unknown
10 February 2020		Paphos	*Squatina aculeata*	1	Recreational	Killed/fished	Adult	Female		Unknown
1977		Akamas	*Taeniurops grabatus*	1	Recreational	Killed/fished	Adult			Unknown
3 September 2019		Akrotiri Bay	*Aetomylaeus bovinus*	1	Scuba Diving-Snorkelling	Alive	Adult	Female		Sandy
30 August 2018			*Bathytoshia centroura*	1	Scuba Diving-Snorkelling	Alive	Adult			Unknown
16 April 2019	Daytime	Paphos	*Carcharhinus brevipinna*	1	Recreational	Killed/fished	Adult		0	Unknown
20 March 2019	Daytime	Zygi	*Carcharhinus plumbeus*	1		Alive	Adult		0	Water column
13 August 2014	Daytime	Paphos	*Carcharhinus* sp.	1	Recreational	Killed/fished	Juvenile		0	Unknown
1 November 2014	Night		*Dasyatidae*	1	Recreational	Killed/fished	Adult			Unknown

Table A1. *Cont.*

Date	Time of Day	Area	Species	Count	Observation Type	Animal Status	A/J	M/F	Depth	Substrate
16 May 2015			*Dasyatis pastinaca*	1	Recreational	Caught and released	Juvenile			Unknown
15 June 2015	Daytime	Pervolia-Mazotos-Tochni	*Dasyatis pastinaca*	1	Recreational	Alive	Adult	Female		Sandy
5 August 2013		Crhysochou Bay	*Glaucostegus cemiculus*	1	Recreational	Caught and released	Juvenile			Unknown
7 September 2017		Paphos	*Glaucostegus cemiculus*	1	Recreational	Caught and released				Unknown
1 November 2015			*Glaucostegus cemiculus*	1	Recreational	Alive				Sandy
9 June 2015	Night	Paphos	*Gymnura altavela*	1	Recreational	Killed/fished	Adult			Unknown
24 April 2016	Morning	Pervolia-Mazotos-Tochni	*Hexanchus griseus*	1	Recreational	Killed/fished	Adult	Male	0	Unknown
23 November 2019	Daytime	Larnaca Bay	*Hexanchus griseus*	1	Recreational	Killed/fished	Adult	Female	0	Unknown
23 April 2016	Daytime	Akrotiri Bay	*Hexanchus nakamurai*	1	Recreational	Caught and released	Adult	Male	500	Unknown
24 April 2016		Akrotiri Bay	*Hexanchus* sp.	1	Recreational	Unknown				Unknown
27 December 2019	Daytime	Akrotiri Bay	*Prionace glauca*	1	Scuba Diving-Snorkelling	Alive			1	Sandy
27 November 2019	Morning	Akrotiri Bay	*Prionace glauca*	1		Alive			0	Unknown
14 July 2013		Pervolia-Mazotos-Tochni	*Taeniurops grabatus*	1	Recreational	Killed/fished	Adult		20 m	Unknown
21 March 2019	Daytime	Paphos	*Unknown*	1	Professional	Killed/fished	Adult		0	Unknown
30 June 2020	Daytime	Cape Greco	*Dasyatis marmorata*	1	Scuba Diving-Snorkelling	Alive	Adult			Seaweed beds or patches

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