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Coastal sharks and rays in the Northeastern Atlantic: From an urgent call to collect more data to the declaration of a marine corridor

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ABSTRACT

Globally, elasmobranchs have suffered severe population declines and are, therefore, under an urgent necessity of protection, particularly along the Northeastern Atlantic realm. However, a lack of ecological (e.g., abundance) knowledge across this realm limits the implementation of adequate conservation and management actions. Here, we collected 4873 fish visual census count data (sightings at 403 sites, from 37 published studies) of sharks, rays, and skates, from coastal areas (< 40 m depth) throughout the Northeastern Atlantic, covering a latitudinal extent of ca. 60° and 9 ecoregions. We recorded a total of 14 elasmobranch species, from a total of 341 sightings, and only 4 % of the counts reported any sighting. There is a severe lack of ecological data (e.g. abundance) from most ecoregions, particularly those in the nearshore continental northern Atlantic and tropical ecoregions. Nevertheless, our results showed that species richness and total abundance of elasmobranchs was higher in the eastern Atlantic oceanic archipelagos, such as Azores, Webbnesia (Madeira, Selvagens, and the Canary Islands) and Cabo Verde, compared to the other ecoregions. Our study calls for prioritising conservation efforts in these areas, a stronghold for these vulnerable taxa, in addition to the establishment of systematic monitoring programs. Refining Marine Protected Areas (MPAs), including declaration of local 'Sharks Sanctuaries', along a marine corridor encompassing these archipelagos, seem pertinent in this sense. This proposal is backed by the evident diversity and abundance patterns in nearshore waters, strong social and economic support, and political willingness to align science and marine policy, under international (EU) governance schemes.

1. Introduction

Elasmobranchs are a subclass of carnivorous and detritivorous fishes worldwide distributed, belonging to the class of chondrichthyans, which includes more than 1100 living species of marine sharks, rays, skates and chimaeras (Fricke et al., 2021). Sharks

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comprise more than 500 species, of which 31.2 % (167 of 536 evaluated species) may face extinction, according to the IUCN (International Union for Conservation of Nature) Red List of Threatened Species (www.iucnredlist.org). Rays (batoids) include more than 600 species, and 36 % are endangered (220 of 611 evaluated species, Dulvy et al., 2021). Various elasmobranch populations have been decimated from many coastal regions (Dulvy and Forrest, 2009; Dulvy et al., 2021). The continuous depletion of these top predators will cause catastrophic consequences for ecosystems and other species (Stevens et al., 2000). A substantial number of elasmobranchs are, moreover, understudied (ICES, 2020) and, therefore, considered as 'Data Deficient' by the IUCN Red List of Threatened Species, which means that there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status (Dulvy et al., 2021). In other words, their abundance patterns and habitat use, among other key ecological information, are largely unknown. A critical call to provide more data on this fish fauna is crucial to implement conservation and management actions (Dulvy et al., 2014; Martins et al., 2018), particularly for understudied nearshore habitats (MacNeill et al., 2020; Dulvy et al., 2021). Hence, research efforts that may contribute to evaluate the conservation status of elasmobranchs, especially those that are at risk, are urgent (Simpfendorfer et al., 2011; Pacoureau et al., 2021). Moreover, several international management and conservation agencies (FAO, Food and Agriculture Organization of the United Nations, ICCAT, The International Commission for the Conservation of Atlantic Tunas, IUCN, CMS, The Convention of Migratory Species, and CITES, The Convention on International Trade in Endangered Species of Wild Fauna and Flora) have stressed the need to identify and characterize nursery areas, migration routes, habitat use and preference, so this information can be incorporated in management plans and ensure the implementation of effective strategies (Heupel et al., 2007; Simpfendorfer et al., 2011).

Insight on latitudinal trends in elasmobranch diversity (e.g., species richness) mostly rely on species' distributions upon presence records (Guisande et al., 2012; Menegotto and Rangel, 2018). Abundance data, if available, have been majorly derived from commercial (including industrial) fisheries data; this is the case of bottom-trawling fisheries, for example from the North Sea (Daan et al., 2005; Campana et al., 2020) and longline fisheries (Pacoureau et al., 2021). In coastal (shallow) waters, however, the presence of elasmobranchs has been majorly derived from direct observations, for example via BRUVs (video techniques, MacNeill et al., 2020), SCUBA diving techniques (Underwater Visual Counts, UVCs, see Appendix A), and captures by recreational and artisanal fishing gears (Hiddink et al., 2019). There is, however, strong geographic bias in UVC data, e.g., towards the Indo-Pacific, with many uncovered areas across the globe's nearshore areas. Coastal waters (< 40 m depth) are often not sampled by industrial bottom-trawling and offshore longlines, despite being key habitats for the life cycle of elasmobranchs (Martins et al., 2018). Presence data is sufficient to evaluate species' distribution patterns, but abundance estimates are necessary to assess key ecological (biodiversity) descriptors and trends in population structure in the face of increasing anthropogenic pressures (Halpern et al., 2015).

The eastern Atlantic Ocean has been a centre of human development since ancient times, with numerous civilizations and empires crossing its waters through millennia (Lotze and Milewski, 2004; Fernandes et al., 2017). Marine biodiversity has been negatively affected by the historical exploitation of marine resources in this ocean basin, particularly at mid- and high-latitude regions (Rijnsdorp et al., 1996; Christensen et al., 2003; Bosch et al., 2021), inducing overfishing (Dulvy et al., 2021; Pacoureau et al., 2021), and including key resources such as cod (Kurlansky, 2013), or bluefin tuna (Mackenzie and Myers, 2007). In the Atlantic Ocean, more than a hundred species of elasmobranchs have been recorded (Walls and Dulvy, 2021). From this, an important number of species may be found on the coast, particularly epibenthic or demersal species (e.g., rays), while pelagic species (most sharks and Mobula rays) are found offshore, approaching coastal areas occasionally, for example for reproduction or feeding (Heyman et al., 2001; Williams et al., 2010). Sharks and rays in the Northeastern Atlantic already had high levels of extinction risk in the 1980 s; since then, their situation has steadily deteriorated and, between 1980 and 2015, the number of elasmobranchs catalogued as threatened has increased by 12 % (Walls and Dulvy, 2021). In fact, the extinction risk of Northeastern Atlantic elasmobranchs is larger than any globally assessed vertebrate group (Queiroz et al., 2016; Walls and Dulvy, 2021).

Differences in fish ecological data collection between tropical and temperate realms in the eastern Atlantic, including elasmobranchs, may have relevant imprints in the ecological knowledge of coastal fishes and their perceived conservation status. Fishes from cool-water regions have been traditionally studied through large-scale bottom trawling datasets (e.g. long-term recording programs within the EU Marine Strategy Framework Directive, Zampoukas et al., 2014; Campana et al., 2020), while fishes from tropical and warm-temperate regions have been mostly surveyed by underwater SCUBA-diving visual counts. In addition, there is very sparse ecological data of nearshore fishes from the relatively understudied tropical eastern Atlantic (Polidoro et al., 2017; Menegotto and Rangel, 2018; Bosch et al., 2021).

Considering the lack of ecological data (e.g., abundance patterns) on elasmobranchs in the eastern Atlantic, particularly in shallow waters, and the ecological importance of this group of cartilaginous fish (Heithaus et al., 2008), it is essential to provide more ecological data to promote efficient conservation (Fernandes et al., 2017). In this work, we initially compiled all available data on the occurrence and abundance of coastal (< 40 m depth) elasmobranchs across the Northeastern Atlantic basin using fisheries-independent methodologies, such as visual, non-destructive, SCUBA diving techniques. Specifically, we aimed to (i) describe how sampling effort via UVCs, a paramount sampling technique for nearshore fishes, has varied across ecoregions. Then, we compared (ii) the total number of taxa (species richness, a key biodiversity descriptor) and (iii) the total abundance of coastal elasmobranchs across ecoregions. From a conservation perspective, by filling these gaps, we identified data-deficient ecoregions, whilst describing ecoregions rich in the diversity and abundance of elasmobranchs, which should be considered priority areas for conservation and management. This includes delineating a marine corridor connecting areas that may be strongholds for some shark and ray species and even other marine megafauna in the region (McIvor et al., 2022).

2. Materials and methods

We compiled a database of UVCs carried out across the entire Northeastern Atlantic coasts, between the equator (ca. 0° of latitude) and the sub-polar region (ca. 60° of latitude). Initially, we searched for every published study targeting shallow water fishes, in the Web of Science and Google Scholar databases, with specific keywords, such as: 'coast* ', 'East* Atlantic', 'UVC* ', 'count* '', abundance* ', 'fish* ', and the name of each ecoregion for which the information was searched. In addition, we downloaded data available through the Reef Live Survey citizenship science database (RLS, www.reeflifesurvey.com). This is a public, open-access, database, where data is collected through a citizen science program under strict data quality control procedures (Edgar et al., 2020).

Most counts collected fish information via belt (= strip) transects (68 % of counts), while the remaining used stationary points (= point counts on a circular area of known radius, 32 %) (Appendix A). The UVC method is based on in situ visual counts of organisms through transects or stationary points, in all cases along a predefined area, identifying the species sighted and, generally, the number of individuals. While this technique is limited by ocean conditions (e.g. water visibility and turbulence), this is a non-aggressive technique with the local fauna, providing data on living species in the marine environment comparable to other techniques (Bosch et al., 2017). For every study, we extracted data on presence and abundance of elasmobranchs for each replicate (n), by taking advantage of data published in tables, figures, and appendices (Appendix A). The dimensions of counts varied from 10 m^2 to 1200 m^2, but majorly ranged between 100 and 500 m^2 (Appendix A and B). The depth of the census ranged between 1 and 40 m, with about 90 % of UVCs carried out in the first 20 m of depth, particularly between 7 and 12 m (Appendix C). About 80 % of UVCs were carried out on rocky reefs (Appendix D). The total survey area per site did not differ among most ecoregions, except between Webbnesia and the Celtic Seas and North Sea ecoregions (Appendix E). Studies limited to checklists, or exclusively providing qualitative abundances, were discarded. Overall, we compiled data from a total of 37 studies (Appendix A), including 403 sites and 4873 UVCs across the Northeastern Atlantic

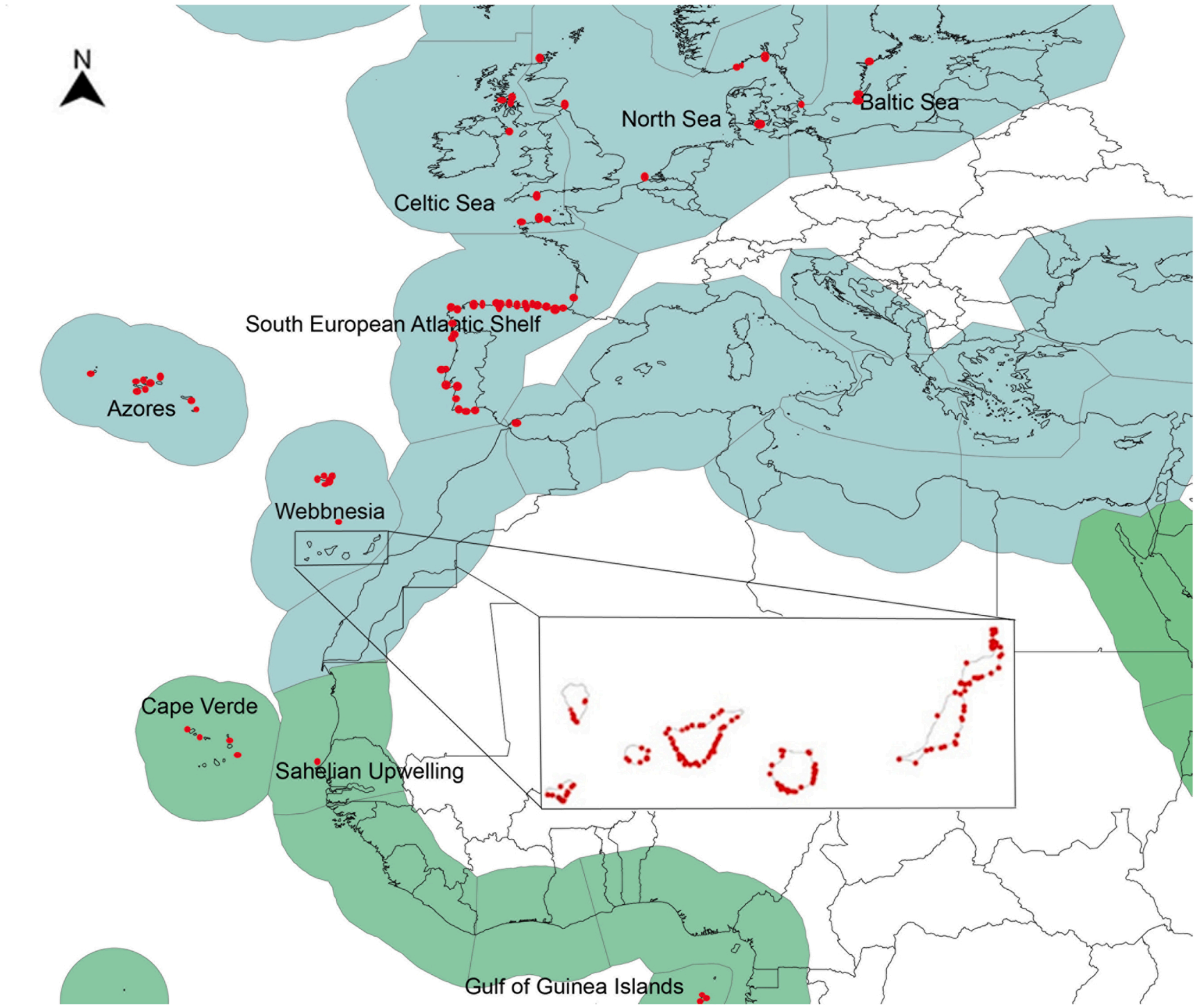

Fig. 1. Map of the Northeastern Atlantic, indicating sites where UVCs were implemented to describe occurrence and abundance patterns of nearshore elasmobranchs. The different ecoregions, where UVCs were undertaken, are indicated.

Table 1
Species of elasmobranchs accounted by this study at each ecoregion, including the total number of sightings, sites and counts.

Species	Common Name	IUCN Red List Status (Europe)	Azores	Baltic Sea	Webbnesia	Cabo Verde	Celtic Seas	Gulf of Guinea islands	North Sea	Sahelian Upwelling	South European Atlantic Shelf	Total
Aetomylaeus bovinus	Duckbill Eagle Ray	Critically Endangered			4							4
Bathytoshia lata	Brown Stingray	Vulnerable			3	1						4
Dasyatis pastinaca	Common Stingray	Data Deficient	28		22							50
Dasyatis spp.	–	–			12					1		13
Ginglymostoma cirratum	Atlantic Nurse Shark	Vulnerable				5						5
Gymnura altavela	Spiny Butterfly Ray	Endangered			26							26
Mobula birostris	Giant Manta Ray	Endangered	2									2
Mobula mobular	Spinetail Devil Ray	Endangered			1							1
Mobula tarapacana	Sicklefin Devilray	Endangered	5									5
Myliobatis aquila	Common Eagle Ray	Critically Endangered	7		35							42
Prionace glauca	Blue Shark	Near Threatened			1							1
Scyliorhinus canicula	Small Spotted Catshark	Least Concern					2					2
Squatina squatina	Angelshark	Critically Endangered			13							13
Taeniura grabata	Round Stingray	Data Deficient	2		16	8						26
Torpedo marmorata	Marbled Torpedo Ray	Data Deficient			11		1				2	14
Total sightings			44	0	275	14	3	0	0	1	4	275
Total sites			16	7	242	22	19	6	17	1	68	398
Total counts			663	171	2476	445	66	64	79	140	769	4873

Ocean (Fig. 1). Sites were grouped into the nine ecoregions that are found along the study region, where UVCs were undertaken, including: Azores, Baltic Sea, Cabo Verde, Celtic Seas, Gulf of Guinea Islands, North Sea, Sahelian Upwelling, South European Atlantic Shelf and Webbnesia (Spalding et al., 2007). The former ecoregion 'Macaronesia' (Azores, Madeira and Canary Islands, Spalding et al., 2007) was partitioned into 'Webbnesia' (Madeira, Selvagens and Canary Islands) and 'Azores', after a recent biogeographical reconfiguration for marine assemblages, including nearshore fishes (Freitas et al., 2019b). It is worth noting that no study was found for several ecoregions, including the Saharan Upwelling and three ecoregions from the Gulf of Guinea province (Gulf of Guinea West, Gulf of Guinea Upwelling, and Gulf of Guinea Central).

Total abundances, for each ecoregion, were summed and divided by the total area surveyed, to obtain an estimator of abundances per area (m^2). To allow meaningful comparisons of diversity across ecoregions, in terms of species richness, rarefaction curves (with confidence intervals) were obtained to represent how the number of species sighted at each ecoregion varied as a function of the number of sampled sites, except for those ecoregions that did not have any sighting. Because of varying survey areas and replication from site to site, we standarized all abundance data, at each site, per area (Ha). Rarefaction was implemented in the EstimateS program (Colwell, 2019).

3. Results

Fourteen species of elasmobranchs were registered (Table 1). According to the IUCN Red List of Threatened Species, three of these species are 'Critically Endangered': *Aetomylaeus bovinus* (Geoffroy St. Hilaire, 1817), *Myliobatis aquila* (Linnaeus, 1758), and *Squatina squatina* (Linnaeus, 1758); four are 'Endangered': *Gymnura altavela* (Linnaeus, 1758), *Mobula birostris* (Walbaum, 1792), *Mobula mobular* (Bonnaterre, 1788) and *Mobula tarapacana* (Philippi, 1892); *Prionace glauca* (Linnaeus, 1758) is 'Near Threatened'; *Ginglymostoma cirratum* (Bonnaterre, 1788) and *Bathytoshia lata* (Garman, 1880) are 'Vulnerable'. Moreover, three species are 'Data Deficient': *Dasyatis pastinaca* (Linnaeus, 1758), *Taeniura grabata* (Geoffroy St. Hilaire, 1817) and *Torpedo marmorata* Risso, 1810. In addition, we observed a 'Least Concern' species, *Scyliorhinus canicula* (Linnaeus, 1758). A total of 341 sightings, corresponding to 208 counts, were collected. Hence, only a 4 % of counts reported any elasmobranch sighting (Table 1).

The research effort, in terms of the total number of fish counts and area surveyed, considerably varied across the Northeastern Atlantic, with a disproportionately larger number of counts in Webbnesia, relative to any other ecoregion (Fig. 2a, Fig. 2b, Table 1). Overall, much research effort has focused on mid latitudes (25°-45° N), whereas research effort on both low (< 25°, ca. 10 % of total counts) and high latitudes (> 45° N, ca. 6 % of total counts) have been comparatively very limited, leaving an important spatial gap. The total number of elasmobranchs was particularly large on warm-temperate (Azores and Webbnesia) and tropical (Cabo Verde)

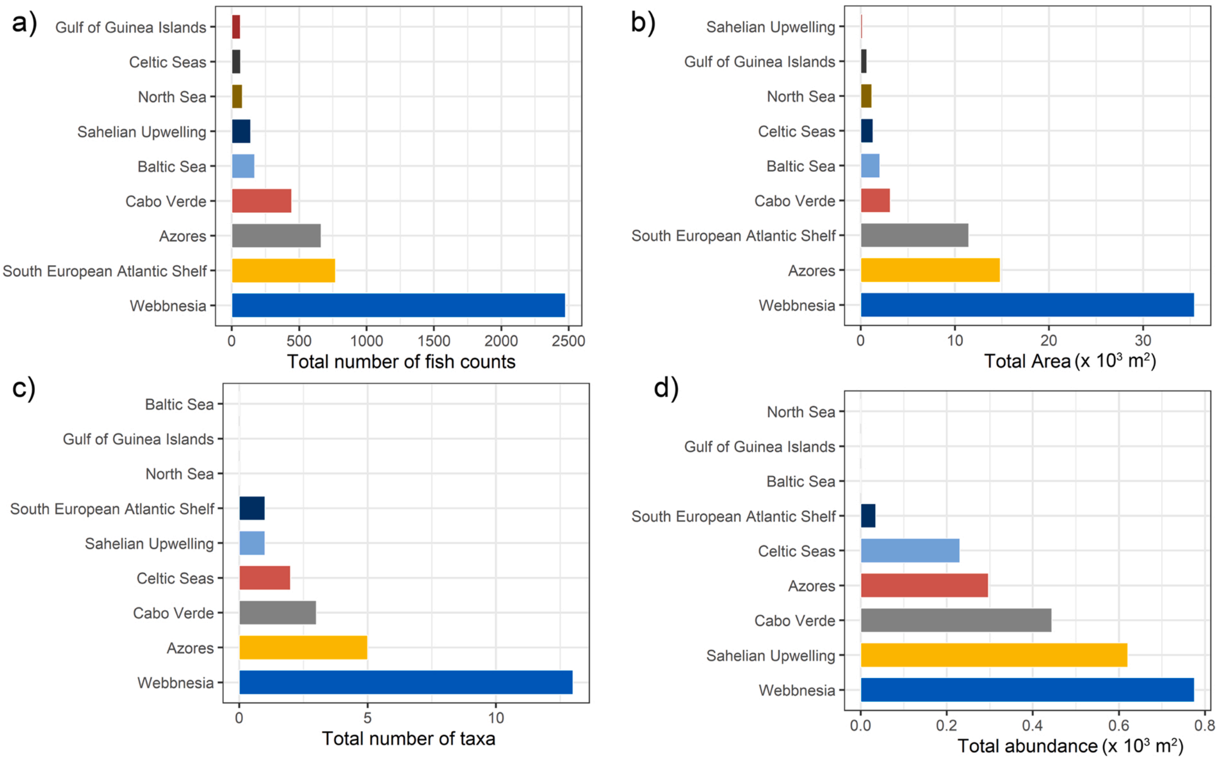

Fig. 2. Total (a) number and (b) area of fish UVCs in each ecoregion; total (c) number and (d) abundance of nearshore elasmobranch species in each ecoregion across the Northeastern Atlantic.

oceanic archipelagos, where between 3 and 10 elasmobranch species were observed (Fig. 2c). In contrast, no specimen was counted in The Baltic Sea, the North Sea, and the Gulf of Guinea Islands (Fig. 2c). A similar outcome was observed when differences in research effort (in terms of the number of sampled sites) across ecoregions is considered (Fig. 3). Azores had a considerably high number of elasmobranch species, despite a lower research effort than Webbnesia. On the contrary, the South European Atlantic Shelf had a low number of species, despite being the second ecoregion in terms of sampling effort. Similar to species richness, the abundance of coastal elasmobranchs was particularly large on warm-temperate Atlantic oceanic islands (Azores, and majorly in Webbnesia), relative to the other ecoregions (Fig. 2d). The large abundance observed in the Sahelian upwelling results from the low area sampled there.

4. Discussion

Spatial gaps in biodiversity sampling can hinder conservation of threatened marine elasmobranchs (Simpfendorfer et al., 2011; Dulvy et al., 2021; Pacoureau et al., 2021). Here, we firstly demonstrated that research efforts, both in term of the number and quantity (i.e. area), of shallow-water visual counts varied markedly across Northeastern Atlantic ecoregions. The marked differences in research effort are inevitable related to the performance of fish counts, which relies on SCUBA diving techniques, an activity that is facilitated by good visibility conditions, which are particularly found in warm-temperate Atlantic archipelagos, where a large sampling effort has been undertaken. Our study, therefore, initially encourages researchers to collect more data on these ecoregions with a severe deficit in sampling effort, e.g., high and low latitudes, including the tropical eastern Atlantic. A similar remark has been outlined previously (Menegotto and Rangel, 2018; Bosch et al., 2021), within a context to establish monitoring programs that follow systematic methods within a best practice of global observing system (Satterthwaite et al., 2021). One of the challenges for the implementation of conservation of elasmobranchs is continuous collection of data (i.e., monitoring programs), particularly for the elevated number of species considered as 'Data Deficient'. Until now, these species have been excluded from trajectories of extinction risks, even though some of them are predicted to be at risk (Walls and Dulvy, 2021). In turn, these 'Data Deficient' species are dismissed from priority species lists set by regional conventions and fisheries commissions (Bland et al., 2014), with the implicit presumption that the biology and threatening factors of both 'Data Deficient' and 'Data Sufficient' species are similar, which are an essential forerunner to potential species-specific protection (Bland et al., 2014; Walls and Dulvy, 2020).

Initially, comparisons in the abundance and diversity of elasmobranchs among ecoregions are difficult, and not only because of varying sampling efforts. For example, the Baltic Sea has a very low salinity hence and, therefore, much lower expected diversity relative to tropical and sub-tropical marine ecoregions. Even though our study has initially identified a larger sampling effort in the eastern Atlantic archipelagos (e.g., Webbnesia), we suggest the larger species richness, as indicated by rarefaction curves, and abundance of coastal elasmobranchs may be additionally explained by a range of ecological processes and concurrent human actions. Due to the absence of extensive continental shelfs, bottom-trawling has been hardly carried out in more than 1295 10^9 m^2 of Atlantic waters surrounding the Canary Islands, Madeira, Selvagens and the Azores (Stiles et al., 2010). This fishing modality is, moreover, currently banned around these archipelagos, a likely explanation for the large abundance and species richness of elasmobranchs (Brito et al., 2002; Das and Afonso, 2017; Tuya et al., 2021), particularly because threatened shark and ray species tend to have shallower depth distributions than non-threatened species (Walls and Dulvy, 2021). Still, elasmobranchs are incidentally captured, as by-catch, in certain fishing modalities, such as long-lines targeting, for example, the black scabbardfish (*Aphanopus carbo*) (Pajuelo et al., 2010) and swordfish (Morato et al., 2012). Within the group of Atlantic islands, the Azores has turned out to be a place of high elasmobranch biodiversity, despite the reduced sampling effort in relation to, for example, Webbnesia. The multitude of seamounts surrounding these islands, where devil rays (Sobral and Afonso, 2014) and sharks seem to concentrate (Morato et al., 2008), as well as the remoteness of this archipelago, being the most isolated in the Northeast Atlantic, far away from the extensively targeted areas by industrial fisheries in Europe, also help to explain this fact (Das and Afonso, 2017).

Madeira and the Canary Islands, both within the Webbnesia ecoregion, are closer to each other and to the African continent, which could somehow facilitate connectivity 'bridges' between these areas (Otero-Ferrer et al., 2017; Tuya et al., 2021), which share a large part of their biodiversity (Freitas et al., 2019b). Across Webbnesia, epibenthic elasmobranch species are sighted very commonly. The Canary Islands, for example, is an important stronghold of the Angelshark, *Squatina squatina* (Meyers et al., 2017; Lawson et al., 2019;

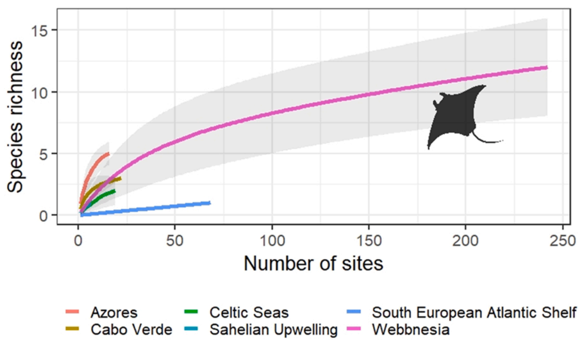

Fig. 3. Rarefaction curves for each Atlantic ecoregion denoting changes in species richness with research effort, in terms of the number of sampled sites.

Jiménez-Alvarado et al., 2020b). This is also the case of the Spiny Butterfly Ray, *Gymnura altavela* (Linnaeus, 1758), which can be observed very commonly throughout the year in these islands, where it congregates at specific times of the year (Tuya et al., 2020). Several sharks, moreover, are occasionally found in coastal waters (e.g., the smallmouth sand tiger, *Odontaspis ferox*, Barría et al., 2018; hammerhead sharks, *Sphyrna* spp., Brito et al., 2002), but have not been observed by means of UVCs, which may perform poorly to document sharks and rays (MacNeill et al., 2020 and references therein). From a conservation perspective, our data suggest that these eastern Atlantic archipelagos should be considered as important 'hubs' of, at least, coastal elasmobranchs. In areas where coastal sharks and rays have a strong interaction with humans (e.g., fishing, tourism and leisure activities), as Madeira and the Canary Islands (Abramic et al., 2020), knowledge on the ecology of these animals is relevant to improve conservation plans, as it has been established for cetaceans (Herrera et al., 2021). For populations inhabiting, permanently or temporarily, coastal habitats of oceanic islands, these may represent nursery and/or mating areas that can be critical for the sustainability of those populations. However, the importance of these habitats and their role for the sustainability of elasmobranch populations remains largely unknown.

It is noteworthy that previous latitudinal analysis of elasmobranch diversity across the eastern Atlantic did not highlight these oceanic archipelagos as distinguished 'hot spots' of elasmobranch diversity, relative to adjacent nearshore areas (Lucifora et al., 2011; Guisande et al., 2012; Derrick et al., 2020). This suggest that different outcomes may arise when quantitative ecological data is used, relative to presence records, which are often used from biogeographical on-line resources, such as IOBIS (www.iobis.org) and GBIF (www.gbif.org). Biodiversity estimates are intrinsically dependent on species' abundance patterns along large spatial scales (Edgar et al., 2017). Hence, it is not only that if occurrence records are biased in their collection, ecological models may be unrealistic, but also that inclusion of abundance data may reveal undescribed patterns in biodiversity (Hughes et al., 2021).

As previously indicated, we have identified large geographical gaps across the eastern Atlantic in the implementation of fish visual counts, a very cost-efficient tool to monitor populations of coastal species, including some elasmobranchs. This is not surprising at low latitudes (Menegotto and Rangel, 2018; Bosch et al., 2021; Hughes et al., 2021), though studies implemented through alterative techniques have revealed the presence of sharks, such as *Ginglymostoma cirratum* (Otero-Ferrer et al., 2020). This study calls for an urgent need to obtain more ecological data of nearshore elasmobranchs for these areas, e.g., abundance patterns through temporal and spatial scales. Since three, out the six ecoregions with low sampling effort (< 250 counts), are in Northern European waters and Europe's Blue Growth strategy is underpinned by promoting collection of scientific data (Fernandes et al., 2017), this outcome should encourage funding agencies to support coastal biodiversity studies in these Northern European ecoregions. A combination of various sampling techniques, such as UVCS, BRUVs, which have been largely implemented in other ocean basins (MacNeill et al., 2020), are recommended to complement fisheries surveys (Campana et al., 2020). More efforts to protect sharks and rays are necessary, taking into consideration the constant development of human activities along nearshore environments, including mining, offshore-aquaculture, renewable energy facilities, blue biotechnology, and tourism, which add over overfishing, the most pervasive human impact on this fish fauna (Dulvy et al., 2021). Without a doubt, the advent of citizen science programmes, in the last decade, represents an incomparable opportunity to fill this gap, such as is the case of the Reef Live Survey programme (Edgar et al., 2020), or the local 'PROMAR' network (www.redpromar.org) in the Canary Islands. Governmental agencies must concurrently implement monitoring programmes of this fish fauna to avoid overlooking the risks of extinction of species through comprehensive assessments, creating action plans to prevent more local extinctions and recover species (Walls and Dulvy, 2021; Dulvy et al., 2021).

International, cross-jurisdictional, conservation initiatives, such as the "Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic Area" (www.accobams.org), have been proved as very successful to promote the study, monitoring and conservation of marine mammals across the Mediterranean Sea and the adjacent Atlantic and Black Sea. Similarly, declaration of 'Shark Sanctuaries', defined as national prohibitions on the commercial fishing and trade of sharks, covering extensive areas, have been advocated as a key elasmobranch conservation tool (MacNeill et al., 2020; Chapman et al., 2021). Such sanctuaries can be declared in areas where local communities do not rely on the exploitation of elasmobranchs, for subsistence or other cultural, social, or economic reasons. In Webbnesia and the Azores, elasmobranch artisanal fisheries in coastal waters are limited, i.e. mainly catching Smooth-hound shark, *Mustelus mustelus* (Espino et al., 2022), and Tope shark, *Galeorhinus galeus*, for example in gill nets (Sobral, personal obs.), while a certain number of species (e.g., Angelshark, *Squatina squatina*) are captured as by-catch, for example in the trammel net fishery from the Canary Islands (Mendoza et al., 2018). Elasmobranchs are negligible in captures by recreational fishers, particularly spearfishermen in the Canary Islands (Jiménez-Alvarado et al., 2020a), though incidental catch by recreational anglers are reported (Barker et al., 2016), but not yet quantified. Artisanal fisheries have shown a declining trend in the number of vessels and fishers, as established by the EU (Goulding and Stobberup, 2015). Since across Azores, Webbnesia and Cabo Verde, there is a large recreational SCUBA diving industry, including expanding shark ecotourism (González-Mantilla et al., 2021), the economic feasibility and social acceptance of this conservation strategy seems to be particularly guaranteed. In this sense, for example, shark encounters are advertised by companies in the Canary Islands (N = 108), Cabo Verde (N = 8) and Azores (N = 4), respectively (González-Mantilla et al., 2021).

Migration (seasonal, daily) of some elasmobranchs could have biased our results, and we have to acknowledge such limitation. Initially, a considerable number of elasmobranchs inhabiting nearshore waters have reduced long-term dispersal. Most batoids, for example, have direct development of embryos inside the mother (McEachran and Capapé, 1984; Dulvy and Reynolds, 1997) and limited pelagic dispersal (di Santo & Kenaley, 2016). These species, moreover, lack 'rafting' capacities (drifting in the water column associated to objects) as juveniles (*sensu* Hachich et al., 2020), a mechanism that facilitate short-term dispersion among distant areas. Despite a lack of movement and genetic data, connectivity among these oceanic archipelagos, for most coastal elasmobranchs, is likely to be reduced. As a result, every archipelago may harbor a particular refuge. However, a cross-national and coordinated conservation strategy could benefit elasmobranchs with large dispersion capabilities, such as devil rays, *Mobula* spp., bentho-pelagic sharks, such as *Galeorhinus galeus*, and, most importantly, oceanic sharks (e.g., blue sharks *Prionace glauca*, shortfin mako *Isurus oxyrinchus*, and hammerhead sharks *Sphyrna* spp.) targeted by industrial long-line fisheries (Morato et al., 2012). Such large-scale conservation strategy, i.e., a marine corridor along the Canary Current, from the Azores to Cabo Verde, would also be politically possible. The governments of Cabo Verde, Spain, Portugal, and the regional governments of the Azores, Madeira and the Canary Islands, have adopted to pursue a common strategy to global challenges, including protection of marine resources and tourism development (Caña-Varona et al., 2019). Worldwide, nations have committed to protect endangered species, such as elasmobranchs (Dulvy et al., 2021), through various international biodiversity treaties and instruments (e.g. FAO Code of Conduct for Responsible Fisheries and the International Plan of Action for Conservation and Management of Sharks, the UN Decade of Ocean Science for Sustainable Development, 2021–2030, The Convention on the Conservation of Migratory Species of Wild Animals, CMS, and its Memorandum of Understanding on the Conservation of Migratory Sharks, CMS Sharks MOU), which provide a legal foundation for internationally coordinated conservation measures throughout species' ranges. Based on our data, we consider that a declaration of a 'Marine Corridor' for elasmobranchs in the Northeast Atlantic is an ideal case, which combines biological representativeness (i.e., large diversity and abundances), socio-economic support, and a common governance scheme, supported by international (EU) marine policies for outermost regions. Moreover, it is essential to consider an active and participatory involvement of the fishing sector, as well as strong political support, for the effective implementation of specific conservation and management actions within this corridor. This includes the declaration of potential 'no fishing zones' in critical areas for highly threatened species, development of management plans within MPAs, monitoring programs (fisheries and fisheries-independent), etc. To complement the establishment of such areas and associated conservation and management strategies, research efforts should focus on determining mechanisms of migration and gene flow, which can provide insight into the current and past levels of connectivity of elasmobranchs among the archipelagos.

In conclusion, using the limited research effort of elasmobranchs inhabiting shallow waters of the Northeastern Atlantic, we here have demonstrated large gaps in elasmobranchs abundance data in most coastal waters, except for the oceanic archipelagos of Azores, Webbnesia and Cabo Verde. These oceanic archipelagos are 'hot spots' of elasmobranch diversity and abundance, previously overlooked by studies using other sources of data. Additional economic, social and political support provide an ideal scenario to promote a protected marine corridor connecting these archipelagos, as well as aligning and creating synergies between various conservation and management bodies and treaties already in place.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

All data and R script to perform analysis are stored at https://github.com/ftuya/Atlantic-elasmobranchs.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at 10.1016/j.gecco.2022.e02261.

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