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ARTICLE

Overfishing of Threatened Bycatch Species in a Marine Protected Area: The Elasmobranchs of Banc d'Arguin, Mauritania

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ABSTRACT

Elasmobranch (rays and sharks) populations are vulnerable to overexploitation due to their slow growth, late maturity, and low fecundity. Industrial fishery impacts on sharks and rays are known, whereas impacts of artisanal fisheries are less understood. We quantified catches of sharks and rays in artisanal fisheries at the Parc National du Banc d'Arguin (Banc d'Arguin), Mauritania (West Africa) during 1998–2020, a period when fishing effort increased around 2006, catches increased, but catch-per-unit-effort declined substantially. Shark nets and meagre fixed gill nets were used to catch elasmobranchs, with catches comprising over 60% of elasmobranch species. Therefore, elasmobranchs were not bycatch, but rather, the target of fisheries. Of 33 elasmobranch species captured, 94% of shark species and 76% of ray species are threatened with extinction. We recommend that management approaches should focus on fishing locations with the highest occurrence of threatened elasmobranch species in catches, through new regulations on fishing gear types and discouragement of trade in elasmobranch products from Banc d'Arguin.

1 | Introduction

Elasmobranch species (rays and sharks) face threats of extinction globally and are among the most threatened groups of vertebrate species. According to recent estimates, one-third of all shark and ray species are currently threatened with extinction due to overfishing and habitat degradation (Dulvy et al. 2021), particularly for larger species (Dulvy et al. 2014; Fernandes et al. 2017). Sharks and rays are susceptible to fishing pressure due to their relatively large reproductive and maximum body sizes and low intrinsic population growth rates due to slow individual growth, late maturity, and low fecundity (Dulvy et al. 2014; Parton, Galloway, and Godley 2019). Elasmobranch species also face threats from habitat degradation, especially along coastal areas used by many species in some phases of their life-history (e.g., mangroves, Knip et al. 2010).

Impacts of small-scale fisheries are often considered more sustainable than impacts of industrial fisheries, and also provide crucial ecosystem services to coastal communities (Campredon and

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Cuq 2001). However, artisanal fisheries worldwide have intensified over time and increased in size in many regions (Palomares and Pauly 2019). Artisinal fisheries now contribute to up to half of global fisheries yield (Teh and Pauly 2018; Derrick et al. 2023) and therefore may significantly impact coastal resources. Impacts of artisanal fisheries on vulnerable species, such as sharks and rays, within coastal marine protected areas in the West African region are largely unknown, which is especially important due to deteriorating conservation status of sharks and rays in the region (Dulvy et al. 2021), the high proportion of endemic species in the region (Stein et al. 2018), and use of coastal areas by elasmobranchs in early life stages and for feeding (Knip et al. 2010; Leurs et al. 2023).

The West African region contains large coastal ecosystems, such as the Banc d'Arguin in Mauritania and the Bijagós Archipelago in Guinea-Bissau, which are considered hotspots for many shorebird species (Catry et al. 2016; Oudman et al. 2020), commercial fish species (Binet et al. 2013; Correia et al. 2021), and threatened endemic species of sharks and rays (Stein et al. 2018; Leurs et al. 2023; de la Hoz Schilling et al. 2024). The Banc d'Arguin was therefore identified as a global priority area for conservation of endemic shark and ray species (Stein et al. 2018). This importance is illustrated by the recent discovery of the false shark ray (*Rhynchorhina mauritaniensis*), which is a unique large-bodied species of wedgefish only known from shallow waters of the Banc d'Arguin (Séret and Naylor 2016), and by exceptionally high biodiversity identified through eDNA research in the Banc d'Arguin (de la Hoz Schilling et al. 2024).

Oceanic upwelling, combined with shallow nursery grounds, qualify the Mauritanian coast as one of the most productive and richest fishing grounds in the world (Alder and Sumaila 2004; Merem et al. 2019) that attracts national and international fishing fleets (Leurs et al. 2021). Sharks and rays using coastal areas within the region are potentially threatened by industrial fisheries operating directly outside coastal areas (Leurs et al. 2021), but also by fisheries within these shallow-water areas (Lemrabott et al. 2023; Dia et al. 2023).

This study presents a historical and current perspective on shark and ray fisheries within the Banc d'Arguin. We analyzed fisheries-dependent data collected for over two decades at the main landing sites within the national park. To gain more insight into status of fisheries within the Banc d'Arguin, a landing-site survey initiated in 1997 is still ongoing. As part of this program, fish landings by local Imraguen people were recorded in all nine fishing villages within Banc d'Arguin boundaries (Figure 1). 'Imraguen' is a local name used to indicate an ancient nomadic community, with the meaning 'those who gather life'. The Imraguen settled in small villages at the coast of the Banc d'Arguin in the early 1930s to practice subsistence fishing of mullet (*Mugil cephalus*), on foot (Maigret and Abdallahi 1976). Traditionally, species targeted by these fisheries were teleosts, particularly mullet, meagre (*Argyrosomus regius*), and several other species, such as tilapia (*Sarotherodon melanotheron*) and catfish (*Arius* sp.), but fisheries have increasingly targeted elasmobranch species (Lemrabott et al. 2023, 2024).

More than 30 elasmobranch species have been documented from waters of the Banc d'Arguin, some using the area as a nursery and feeding area (Ducrocq 2004; Valadou, Brêthes, and Inejih 2006). Although elasmobranch populations within the Banc d'Arguin have been fished for over four decades, their current abundance and status are uncertain. We assembled statistics from landing site surveys to assess the historical and current status of large-bodied sharks (nine species of hammerhead and requiem sharks), large benthopelagic rays (eagle ray, *Aetomylaeus bovinus*, and cownose ray, *Rhinoptera marginata*) and blackchin guitarfish (*Glaucostegus cemiculus*) within the national park's borders (Table 1). Our objectives were to determine if: (1) elasmobranch landings, total effort, and gear-specific effort trended temporally within the Banc d'Arguin during 1998–2020; and (2) identify potential management opportunities to conserve sharks and rays within the Banc d'Arguin more effectively.

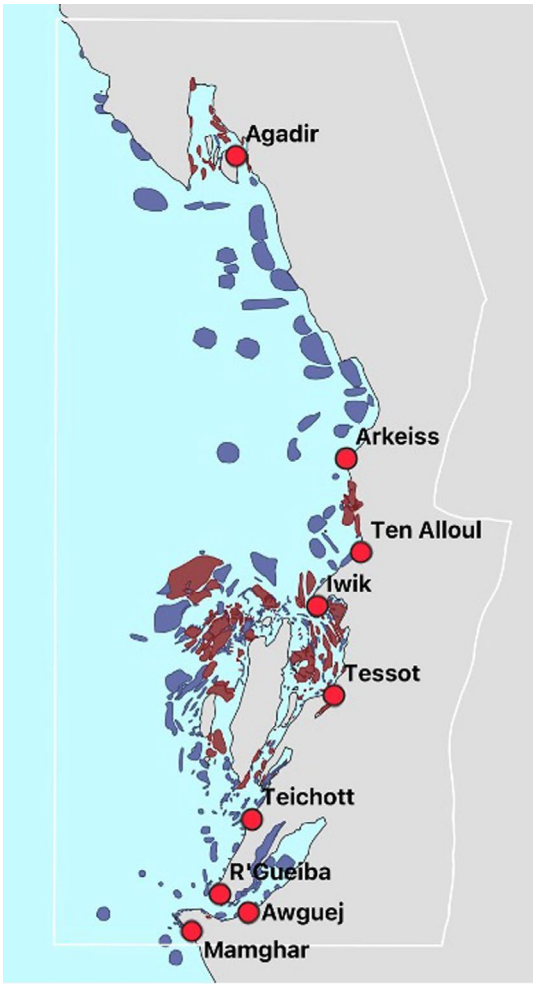

FIGURE 1 | Parc National du Banc d'Arguin in Mauritania, West Africa (white boundary), showing Imraguen villages (red circles) and boundaries of fishing areas identified by fishers ($n > 500$, shaded areas). Intertidal fishing areas (i.e., exposed during low tide) are shown in red, and subtidal fishing areas are shown in blue.

2 | Materials and Methods

2.1 | Study Area

The Parc National du Banc d'Arguin is a 12,000 km^2 shallow intertidal area (< 20 m depth) off the coast of Mauritania (national park since 1976, governed by IUCN, West Africa; Figure 1),

TABLE 1 | Elasmobranch species (sharks and rays) caught, focal group, IUCN red list status (CR, critically endangered; EN, endangered; VU, vulnerable, NT near threatened), and maximum size (Max TL), caught by artisanal fisheries in the Parc National du Banc d'Arguin, Mauritania (West Africa) during 1998–2020.

	Focal group	Species	English name	IUCN red list status	Max TL (cm)
1		*Sphyrna mokarran*	Great Hammerhead	CR	610
2	Large sharks	*Sphyrna lewini*	Scalloped Hammerhead	CR	430
3	Large sharks	*Carcharhinus obscurus*	Dusky Shark	EN	420
4	Large sharks	*Carcharhinus plumbeus*	Sandbar Shark	EN	300
5		*Carcharhinus signatus*	Night Shark	EN	280
6		*Mustelus mustelus*	Common Smoothhound	EN	200
7		*Paragaleus pectoralis*	Atlantic Weasel Shark	EN	140
8	Large sharks	*Sphyrna zygaena*	Smooth Hammerhead	VU	500
9	Large sharks	*Ginglymostoma cirratum*	Atlantic Nurse Shark	VU	430
10		*Carcharhinus falciformis*	Silky Shark	VU	350
11	Large sharks	*Negaprion brevirostris*	Lemon Shark	VU	340
12	Large sharks	*Carcharhinus brevipinna*	Spinner Shark	VU	300
13	Large sharks	*Carcharhinus limbatus*	Blacktip Shark	VU	286
14		*Rhizoprionodon acutus*	Milk Shark	VU	175
15		*Leptocharias smithii*	Barbeled Houndshark	VU	77
16	Large sharks	*Galeocerdo cuvier*	Tiger Shark	NT	750
17		*Rhynchobatus luebberti*	African Wedgefish	CR	300
18		*Glaucostegus cemiculus*	Blackchin Guitarfish	CR	242
19	Large rays	*Aetomylaeus bovinus*	Duckbill Eagle Ray	CR	222
20	Large rays	*Rhinoptera marginata*	Lusitanian Cownose Ray	CR	200
21		*Myliobatis aquila*	Common Eagle ray	CR	183
22		*Rhinobatos rhinobatos*	Common Guitarfish	CR	147
23		*Rhinobatos irvinei*	Spineback Guitarfish	CR	100
24		*Rhinobatos albomaculatus*	Whitespotted Guitarfish	CR	75
25		*Gymnura altavela*	Spiny Butterfly Ray	EN	400
26		*Bathytoshia centroura*	Roughtail Stingray	VU	300
27		*Dasyatis hastata*	Roughtail Stingray	VU	104
28		*Fontitrygon margarita*	Daisy Whipray	VU	100
29		*Dasyatis pastinaca*	Common Stingray	VU	69.5
30		*Gymnura micrura*	Smooth Butterfly Ray	NT	137
31		*Dasyatis marmorata*	Marbled Stingray	NT	60
32		*Fontitrygon margaritella*	Pearl Whipray	NT	30
33		*Raja miraletus*	Brown Skate	LC	63

Ramsar Wetland site (site number 250; 1982), and UNESCO World Heritage site (reference no. 506; 1989). The Banc d'Arguin is a complex network of intertidal flats, seagrass beds, and tidal channels. The Banc d'Arguin, due to its ecological role and value for elasmobranch conservation, was once described as one of the largest sanctuaries for sharks and rays in Africa and the Atlantic Ocean (Ducrocq 2004). In nine fishing villages within the Banc d'Arguin, 114 registered fishing boats operated as the maximum number of boats with exclusive access to park waters. Fishing during single-day or multi-day trips is increasingly conducted year-round. Fishing rights are exclusive to local Imraguen communities, and fishing is restricted

to artisanal methods and non-motorized wooden sailing boats called "lanches" (Lemrabott et al. 2023, 2024).

2.2 | Data Processing and Analyses

Banc d'Arguin artisanal fisheries have been monitored since 1997 jointly by the local fisheries institute, Institut Mauritanien de Recherches Océanographiques et des Pêches (IMROP), and Banc d'Arguin authorities. At six landing sites, a scientific team of researchers, assisted by local community members trained by IMROP, collected information on landings by fishing trip. A random sub-sample of trips was monitored, with boat captains and fishers voluntarily sharing details of catches, locations, and duration of fishing trips that were recorded by fisheries researchers (Lemrabott et al. 2023).

Shark and ray catch and effort data were analyzed from 1998 to 2020 to quantify temporal trends in the fishery. Catch-per-unit-effort (CPUE) was used as an index of elasmobranch relative abundance. Catch, effort, and CPUE were quantified for total catch of all species and for focal species groups, including large-bodied sharks, large benthopelagic rays, and Blackchin guitarfish *Glaucostegus cemiculus*. Catch, effort, and CPUE were described in relation to month and year using generalized additive models with a Gaussian distribution (gam() function; Wood 2004) in the "mgcv" package with restricted maximum likelihood (REML; Wood 2017) in R v.4.3.1 (R Core Team). Total fishing effort included handlines, mullet nets, meagre nets, and shark nets (Table 2). Detailed analysis was limited to effort and catch data from shark and mullet net fisheries only.

Detailed analyses of species groups focused on the 10 most-caught elasmobranch species (Table 1): (1) large-bodied sharks (requiem sharks Carcharhinus spp., hammerhead sharks *Sphyrna* spp., lemon shark *Negaprion brevirostris*, and tiger shark *Galeocerdo cuvier*); (2) large benthopelagic rays (duckbill eagle ray *Aetomylaeus bovinus*, Lusitanian cownose ray *Rhinoptera marginata*); and (3) blackchin guitarfish (*Glaucostegus cemiculus*). The occurrence of individual species of sharks and rays was reported in catches during 1998–2020. The term "threatened" referred to species assessed as vulnerable (VU), endangered (EN), or critically endangered (CR) by IUCN.

3 | Results

3.1 | Temporal Trends in Fishing Effort, Catch, and CPUE

Monthly and interannual variation explained 68% of variation in total effort, 49% of variation in total catch, and 52% of variation in CPUE during 1998–2020 (Table 3). Total fishing effort doubled during 1998–2020, from a mean of ~1000 days at sea during 1998–2005 to more than 2000 days at sea during 2007–2020 (Figure 2A). Coincidentally, catch increased 2.6 times during 1998–2010, from an average of 50 t per month in 2005 to an average of 130 t per month in 2010, after which catch declined back to an average of ~50 t per month by 2020 (Figure 2B). CPUE decreased 86.7% during 1998–2020, from an average of 150 kg/day during 1998–1999 to 20 kg/day in 2020 (Figure 2C).

TABLE 2 | Local name, English name, mesh sizes, and fishing method of gear types used by artisanal fisheries in the Parc National du Banc d'Arguin, Mauritania, West Africa, during 1998–2020.

Local name	English name	Mesh sizes (mm)	Fishing method
Filet courbine	Meagre net	> 200	Fixed floating gill net & seine fishing
Filet tollo	Shark net	140–180	Fixed floating gill net
Filet mulet	Mullet net	100–120	Fixed floating gill net & seine fishing
Ligne a main	Handline	100–120	Handlining

TABLE 3 | Effects of year, month, and year × month interaction on total effort (days at sea) total catch (weight in kg), and CPUE (kg/day at sea) of artisanal fisheries in the Parc du National du Banc d'Arguin, Mauritania, West Africa, during 1998–2020. Effects estimated in generalized additive models (GAM), wherein edf = effective degrees of freedom; R^2 (adj) = for monthly adjusted R^2; Dev. expl. = deviance explained; and *p*-value per smoother.

Response	edf	R^2 (adj)	Dev. expl. (%)	*p*
Total effort		0.65	68	
s(year)	7.8			< 2e-16
s(month)	6.7			< 2e-16
s(year, month)	10.8			< 2e-16
Total catch		0.44	49	
s(year)	5.7			< 2e-16
s(month)	7.9			< 2e-16
s(year, month)	10.0			0.00903
CPUE		0.47	52	
s(year)	7.6			< 2e-16
s(month)	7.7			< 2e-16
s(year, month)	8.7			< 2e-16

Overall fishing effort during 1998–2020 included four gear types: handlines, mullet nets, meagre nets, and shark nets (Table 2). The stepwise increase in total fishing effort in 2006, when total effort more than tripled, was driven by increased use of shark nets that represented ~5%–30% of total effort thereafter, with a decreasing trend by 2020 (Figure 3A). Catches

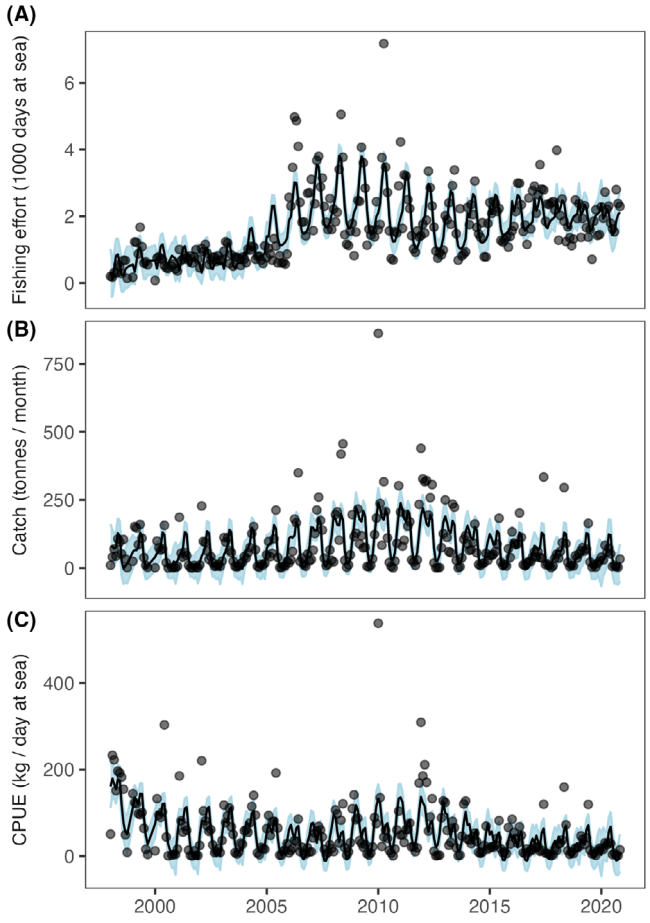

FIGURE 2 | Fishing effort (1000 days at sea, A), total catch (tons, B), and catch-per-unit-effort (kg/day at sea, CPUE, C) per month of all elasmobranch species caught in shark, meagre, and mullet-net, and handline artisanal fisheries in the Parc National du Banc d'Arguin, Mauritania, West Africa, during 1998–2020. Monthly summed data = points, model fit = black lines, and 95% confidence interval = light blue.

in shark nets consisted of > 70% elasmobranchs (Figure 3B). Meagre nets caught a large fraction of total catches during 1998–2020, and effort with meagre nets expanded with the increase in total effort in 2006. Catches in meagre nets consisted of 60% elasmobranchs (Figure 3B). Handlines accounted for < 10% of total fishing effort during 1998–2020 (Figure 3A), and elasmobranchs were less than 10% of handline catches in weight (Figure 3B). Mullet net fisheries were a substantial proportion of total effort (Figure 3A), but elasmobranch catches were low (Figure 3B).

When effort by shark nets and meagre nets increased in 2006, the relative fraction of elasmobranch catches increased in relation to teleost catches (Figure 4). Relative to teleosts, catches in shark nets included increasing proportions of sharks (Figure 4A) and ray catches in meagre nets steadily increased (Figure 4B). The relative proportion of sharks and rays increased through years to exceed teleost catches (Figure 4A,B). While for shark nets, CPUE of all species groups fluctuated in the period 1998–2020, meagre nets show a more consistent trend with increasing ray CPUE and decreasing shark CPUE, as well as decreasing other species CPUE.

3.2 | Species-Group Trends and Species-Specific Occurrences

During 1998–2020, CPUE of large sharks and blackchin guitarfish decreased, while CPUE of large benthopelagic rays increased (Figure 5). CPUE of large sharks decreased from 9 kg/day in 1998–1999 to below 2.5 kg/day from 2010 onwards (Figure 5A), and CPUE of blackchin guitarfish also decreased from 60 kg/day in 1998–1999 to below 12 kg/day (Figure 5B). In contrast, CPUE of large benthopelagic rays increased from less than 10 kg/day before 2005 to 30–40 kg/day during 2008–2011 and declined thereafter to 10 kg/day by 2020 (Figure 5C).

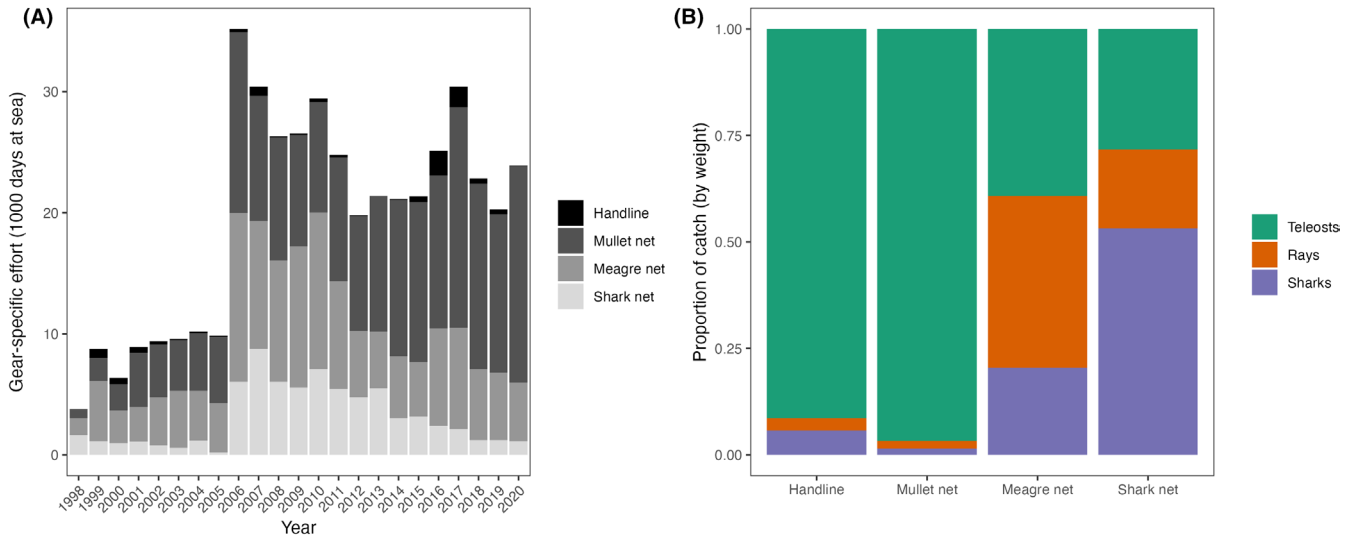

FIGURE 3 | Annual effort by shark, meagre, and mullet-net, and handline (1000 days at sea, A) and the proportion of teleosts, rays, and sharks in annual catches (weight per gear type, B) in artisanal fisheries in the Parc National du Banc d'Arguin, Mauritania, West Africa, during 1998–2020.

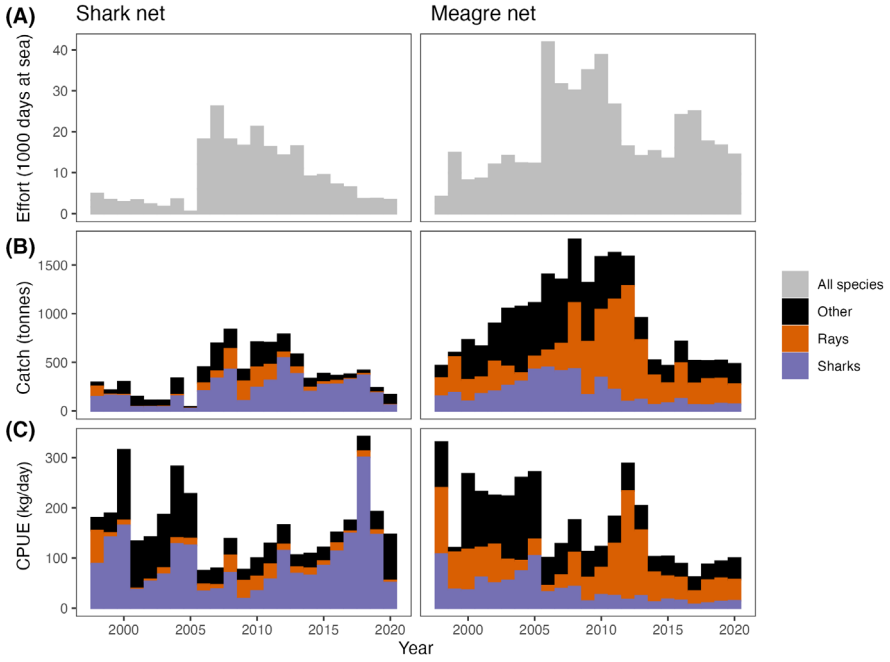

FIGURE 4 | Annual total fishing effort (1000 days at sea, A), total catch (tons, B), and catch per unit of effort (CPUE, kg/day at sea, C) of sharks (purple), rays (orange), and other fish species (black) in shark nets (left) and meagre nets (right) in artisanal fisheries in Parc National du Banc d'Arguin, Mauritania, West Africa, during 1998–2020.

Of 33 species of elasmobranchs caught during 1998–2020, 16 were sharks and 17 were rays (Figure 6). Most species (85%, $n = 28$) were listed as threatened with extinction as IUCN CR, EN, or VU, and were larger than 150 cm (64%, $n = 21$). The occurrence of large shark and ray species in catches increased during the first half of the study period (before 2010; Figure 6). Of all elasmobranch species caught, nine were not observed in landings for more than a decade.

4 | Discussion

Based on over 20 years of fisheries-dependent data, we show how fisheries on shark and ray species in the Banc d'Arguin (PNBA) changed from relatively low effort to fisheries increasingly targeting sharks and rays until catches severely declined between 2010 and 2020. We interpret the decrease in catch-per-unit-effort (CPUE) to represent a decreasing abundance of these vulnerable species within the national park.

The elasmobranch fishery in Banc d'Arguin is not for local consumption, because the local community does not consume elasmobranchs (Lemrabott et al. 2024). Elasmobranch harvest that began in the Banc d'Arguin in the early 1980s (Lemrabott et al. 2024) was incentivized by emerging international trade in shark fins and dried ray meat that Imraguen fishers within the Banc d'Arguin accessed through international trade networks (Ducrocq 2004). Initially, elasmobranchs were considered bycatch in fisheries targeting large-bodied teleost species like meagre (*Argyrosomus regius*). However, elasmobranchs were 60% of catches in meagre nets and 75% in shark nets that often occur in shallow areas, especially the intertidal zones that rays inhabit (Dia et al. 2023; Leurs et al. 2023). Our results therefore indicate that elasmobranchs are not bycatch in Banc d'Arguin, but are targeted species, especially in shark nets, a gear type specifically used to catch sharks, and the use of large-mesh meagre nets in intertidal waters to catch rays that are designed to catch pelagic species.

Within boundaries of the Banc d'Arguin, targeted harvest of sharks and rays is illegal (Diop and Dossa 2011), although harvest of these species developed into an important economic driver of fisheries in the park in recent decades compared to traditional teleost fisheries (Lemrabott et al. 2024). The first priority for improvement would be reinforcement of regulations against targeted elasmobranch fisheries in locations with high occurrence of threatened species in catches. Furthermore, use of large-mesh nets should be banned in areas with elasmobranchs and in shallow waters or tidal channels frequented by guitarfish, cownose rays, and eagle rays during tidal movements (Leurs et al. 2023).

Elasmobranch species that are most threatened at a global level were among the highest catches in Banc d'Arguin, which further deteriorates the conservation status of these species (Stein et al. 2018; Dulvy et al. 2021) in the region and undermines the potentially important role that areas like the Banc d'Arguin play in the life cycle of these threatened elasmobranch species (Leurs et al. 2023). Globally, elasmobranchs are threatened by targeted harvest or as bycatch in small-scale or industrial fishing (Stevens et al. 2000; Fernández, Salmerón, and Ramos 2005; Dulvy et al. 2021; Leurs et al. 2021). Within Banc d'Arguin, 85% of elasmobranch species captured in fisheries are currently threatened with extinction, including 10 species (36%) that are critically endangered. In general, fish species of large maximum size (> 149 cm) are especially vulnerable to exploitation (Fernandes et al. 2017). In Banc d'Arguin, many elasmobranch species we studied reached large maximum size (most

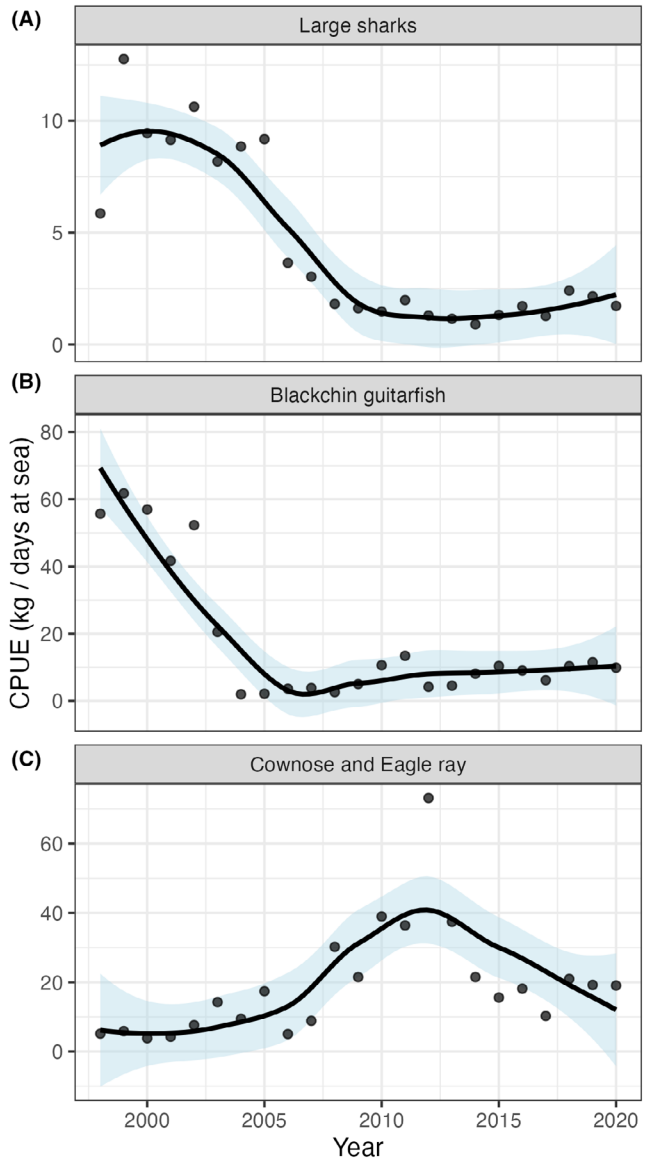

FIGURE 5 | Catch-per-unit-effort (CPUE, in kg/day at sea) of large sharks (hammerhead, requiem, nurse, lemon, and tiger sharks); (A), blackchin guitarfish (B) and rays (Lusitanian cownose ray and duckbill eagle ray); (C), in shark nets and meagre nets in artisanal fisheries in the Parc National du Banc d'Arguin, Mauritania, West Africa, during 1998–2020. Fits were estimated with generalized additive models (GAM, $R^2 = 0.98$ for large sharks, 0.87 for Blackchin guitarfish, and 0.69 for large rays). Yearly summed data = points; model fit = black lines, and 95% confidence interval = light blue.

> 200 cm), although small juveniles suffered high fishing mortality when using intertidal and shallow-water habitats during early life stages (Knip et al. 2010; Leurs et al. 2023). This implies that exploitation in this national park may impose a critical bottleneck on species with slow life-histories that are threatened with extinction and depend on these habitats.

We found that populations of elasmobranch species were declining severely in Banc d'Arguin, with most commonly caught species likely disappearing if negative trends are not reversed, similar to global records for large sharks that are among the first species to disappear from coastal ecosystems (Dulvy et al. 2014).

In Banc d'Arguin, the state of large sharks suggests a shifting baseline, because major changes to the fish community and fishing practices were before the first year of our study, 1998 (Lemrabott et al. 2024). Hammerhead sharks have decreased and rays *Rhinobatos irvinei*, *Rhynchobatus luebberti*, *Myliobatis aquila*, and *Fontitrygon margarita* were sighted only a few times during our study period and then disappeared from catches after 2009. This latter observation may in part be caused by misidentification of species due to these species being difficult to differentiate from similar species within the Fontitrygon genus (Lemrabott et al. 2023, 2024). Banc d'Arguin is especially important for blackchin guitarfish (*Glaucostegus cemiculus*), with adults and juveniles using the park as a mating and nursery area (Valadou, Brêthes, and Inejih 2006). This species declined to critically low abundance since fisheries started in the 1990s (Lemrabott et al. 2024; Boulay 2013), that likely targeted this species for its relatively large fins as an alternative for large shark species that had already been depleted (Kyne et al. 2020). Large-bodied rays were subjected to high fishing pressure since 2007, with CPUE declining since 2012 and remaining low through 2020.

Increased catches of threatened species, along with the apparent decrease of elasmobranch diversity over time (based on trends in catch composition), raise concern for elasmobranchs in Banc d'Arguin, because sharks and rays are an important predatory group that occupy trophic roles as both top- and meso-predators in marine systems (Heupel et al. 2014; Navia et al. 2016). In large intertidal areas, such as the Banc d'Arguin, their loss can have potential implications for ecological functioning of an ecosystem (Leurs et al. 2023). We found that some elasmobranch species may already have disappeared, were close to disappearance, or their abundance was now too low to fulfill their ecological roles in Banc d'Arguin. Our results are alarming because other iconic elasmobranch species have already disappeared completely or from parts of West Africa, including sawfish species (*Pristis* spp.), false shark ray (*Rhynchorhina mauritaniensis*), and the African wedgefish (*Rhynchobatus luebberti*) (Campredon and Cuq 2001; Jabado 2006; Séret and Naylor 2016; Moore 2017). Overall, such trends simplify food webs in large intertidal ecosystems (removal of large predatory species and a shift to predominant milk shark and stingray presence), with possible consequences for ecological functioning if ecological redundancy among predators is too low (Ripple et al. 2016).

Our findings support a need for improved management of sharks and rays within the Banc d'Arguin. Elasmobranchs were often caught in meagre nets intended for fishing meagre offshore and in shark nets specialized for sharks, because meagre nets were used outside the species season and habitat and were deployed year-round in shallow intertidal habitats used by rays (Lemrabott et al. 2023). Such large-mesh nets intended for fishing teleosts are used to target rays in shallow habitats. Compared to fast-growing teleost species that can sustain moderate levels of exploitation, the same fishing pressure and selectivity can severely impact slow-growing elasmobranchs (Dulvy et al. 2021). Clearly, the bycatch label used to tolerate landings of elasmobranchs by authorities at Banc d'Arguin is misleading if elasmobranchs are targeted by specialized nets set in habitats frequented by elasmobranchs during tidal movements. Only elasmobranchs captured in mullet nets, in which they comprise less than 10% of the catch, should be considered bycatch.

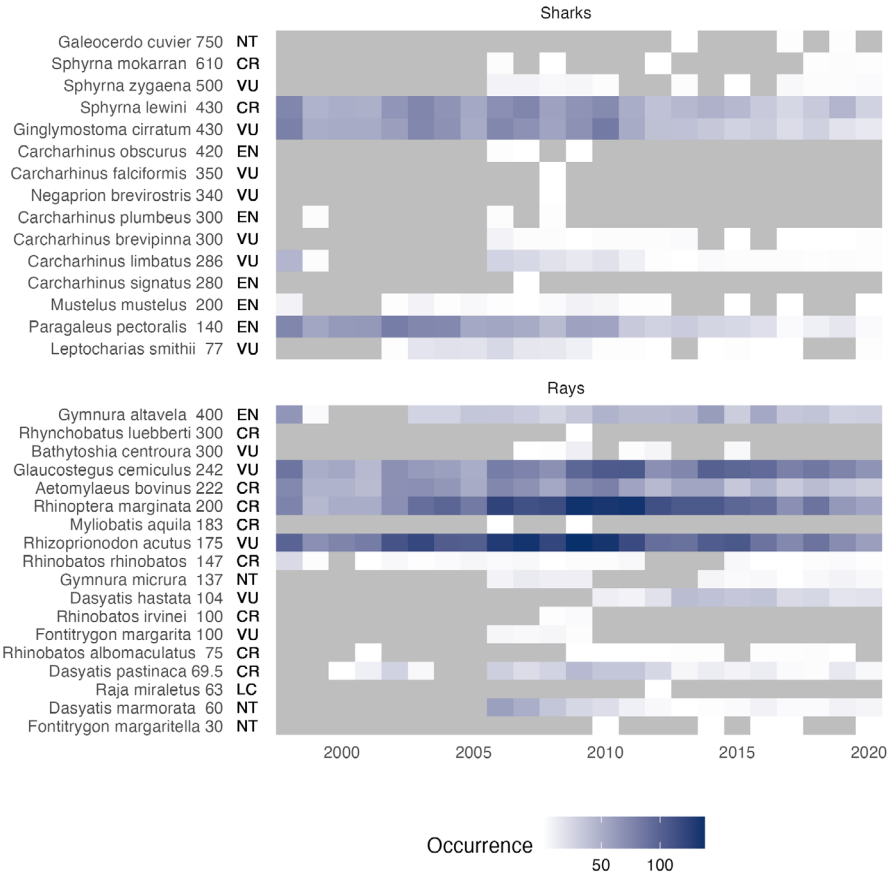

FIGURE 6 | Species occurrence in catches of sharks (top) and rays (bottom), in decreasing order of maximum size, with IUCN threat level per species, in artisanal fisheries in the Parc National du Banc d'Arguin, Mauritania, West Africa, during 1998–2020. Gray indicates missing value.

Managers of the Parc National du Banc d'Arguin are facing a challenging task to stop unsustainable fishing of threatened elasmobranch species. During 2006–2020, total catches of elasmobranchs increased faster than in the preceding period. Initially, catches targeted teleost fish; however, following crashes of catches of Blackchin guitarfish and large shark species, catches of large ray species increased, a species group not previously targeted in the area. We suggest the following steps towards management of elasmobranch species within Banc d'Arguin: (1) reduce fishing effort directed towards sharks and rays by closing fishing areas with high shark and ray catches for large-mesh nets or shark-specific gear types; and (2) enforce the ban on trade in shark and ray products originating from within the Banc d'Arguin through trade controls and onboard catch controls. For these measures to be successful, promotion and availability of an alternative, sustainable fishery practice or alternative incomes for local Imraguen fishers is needed.

Conclusions regarding fisheries of elasmobranch species in the Banc d'Arguin hold globally, for improved conservation and management of these often-threatened fish species. The Banc d'Arguin is a national park and a world heritage site. Protection of the ecosystem and natural richness would seem more feasible in national parks and protected areas. Our study shows how this nevertheless poses a challenge for managers and conservationists and in regional as well as global context this works highlights that simply announcing a protected area cannot alone protect vulnerable habitats and species. Fishing effort at locations surrounding protected areas must be limited and fishing effort within habitats with high occurrence of sharks and rays in the catches should be reduced or stopped entirely. The reinforcement of steps like these deserves attention that most likely relies on support from beyond the local management in order to be successful.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are openly available in the Research Data Repository of the University of Groningen at https://doi.org/10.34894/XQPPDT.

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