Chapter 3

Overfishing of threatened bycatch species in a marine protected area: the elasmobranchs of the Banc d'Arguin, Mauritania

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Manuscript

Abstract

Elasmobranch (i.e., shark and rays) populations are vulnerable to overexploitation due to their generally slow growth, late maturity, and low fecundity. Now that these species are amongst the most threatened marine fish, their continued exploitation raises concerns at a global level. Although the impact of industrial fisheries on elasmobranchs has been documented on a global and regional scale, information on the effects of coastal (artisanal) fisheries remains scarce, especially for the data-deficient West African region. We describe the historical trends between 1998 and 2020 in catches of sharks and rays in the artisanal fisheries in the Parc National du Banc d'Arguin (PNBA), Mauritania (West Africa). We show that 16 shark and 17 ray species are captured in this area, of which 15 (94%) and 13 (76%) species are threatened with extinction, respectively. Initially caught as bycatch in the local small-scale fishery targeting migratory teleosts, elasmobranch fishing has been practiced in the PNBA for over four decades. Within the park, two main gear types are used to catch elasmobranchs- shark and meagre fixed gill nets- with catches comprising over 60% of elasmobranchs. This indicates that elasmobranchs are not only considered bycatch but targeted elasmobranch fisheries are also common. Fishing effort increased in 2006 and has remained high recently, whereas catch-per-unit-effort and occurrences of once common species have declined. Our results highlight significant declines in the catches of elasmobranch species, representing a decline in the population of these species. We propose that conservation and management approaches in the national park should focus on restricting fishing in areas with the highest occurrence of threatened species in the catches, introducing new regulations on fishing gear types, and restricting trade in elasmobranch products from the PNBA.

Introduction

Elasmobranch species (i.e., sharks and rays) are threatened globally and are now one of the most threatened vertebrate species groups. According to recent estimates, one-third of all shark and ray species are currently threatened with extinction, with overfishing and habitat degradation being the main anthropogenic threats (Dulvy *et al.* 2021). Generally, larger shark and ray species experience disproportionally more significant threats (Dulvy *et al.* 2014, Fernandes *et al.* 2017). Sharks and rays are susceptible to increased fishing pressure due to their relatively large body size and low intrinsic population growth due to K-selected life history traits (i.e., slow individual growth rates, late maturity, and low fecundity, Dulvy *et al.* 2014, Parton *et al.* 2019), but are also vulnerable to other threats, such as habitat degradation due to their use of coastal areas (e.g., mangroves, Knip *et al.* 2010).

Small-scale fisheries are often considered relatively more sustainable compared to industrial fisheries. In the context of ecosystem services, these traditional and subsistence fisheries are central to coastal communities (Campredon and Cuq 2001). However, artisanal fisheries worldwide have developed over the past decades, causing these fisheries to increase in size in most regions (Palomares & Pauly, 2019). These fisheries contribute to up to half the global yield in fisheries (The & Pauly 2018, Derrick *et al.* 2023) and can thus have a significant impact on coastal resources. The effect of these fisheries on vulnerable species such as sharks and rays within coastal marine protected areas in the West African region remains unknown. This is especially concerning due to the deteriorating conservation status of sharks and rays within the region (Dulvy *et al.* 2021), the high proportion of endemic species within the region (Stein *et al.* 2018), and their use of coastal areas during early life stages and as feeding refugia (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.* 2015, Oudman *et al.* 2020), commercial fish species (Binet *et al.* 2013, Correia *et al.* 2021), and in particular for threatened endemic species of sharks and rays (Stein *et al.* 2018, Leurs *et al.* 2023). It is therefore identified as a global priority area for the 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*), a unique large-bodied species of wedgefish only known from the shallow waters of Banc d'Arguin (Séret and Naylor 2016). 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), attracting both 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 these coastal areas (Leurs *et al.* 2021) and also face a potential threat from fisheries occurring within these shallow-water areas (Lemrabott *et al.* 2023).

This study presents a historical and current perspective on shark and ray fisheries within the Banc d'Arguin National Park (PNBA). For this, we use fisheries-dependent data collected at the main landing sites within the national park for over two decades. To gain more insight into the status of fisheries within the PNBA, a landing site survey was initiated in 1997 and is still ongoing. As part of this program, fish landings are recorded in all nine fishing villages within the boundaries of PNBA (Figure 3.1). Traditionally, species targeted in the artisanal Imraguen fisheries were limited to teleosts, mainly mullet (*Mugil cephalus*), meagre (*Argyrosomus regius*), and several other species, such as tilapia and catfish. However, fisheries have increasingly also targeted elasmobranch species (Lemrabott *et al.* 2023, Lemrabott *et al. 2024*).

More than 30 elasmobranch species have been documented from the waters of the PNBA, with some of them using this area as nursery and feeding areas (Ducrocq 2004, Valadou *et al.* 2006). Although the elasmobranch populations within the PNBA have been fished for over four decades, their current conservation status remains uncertain. We report the statistics of these landing site surveys specifically to determine the historical and current status of large-bodied sharks (i.e., hammerhead and requiem sharks), large rays (i.e., eagle and cownose rays) and guitarfishes (i.e., blackchin guitarfish, *Glaucostegus cemiculus*) within the borders of the national park. Specifically, we aim to (1) determine the spatiotemporal trends in elasmobranch landings within the PNBA from 1998 until 2020, (2) describe the trend of total effort and gear-specific effort, and (3) identify potential management opportunities to conserve sharks and rays within the PNBA more effectively.

Methods

Study area

The Banc d'Arguin (PNBA) is a 12,000 km^2 shallow intertidal area (<20 m depth) off the coast of Mauritania (West Africa; Figure 3.1) and is both a Ramsar Wetland site (1983) and UNESCO World Heritage site (1989). The PNBA comprises a complex network of intertidal flats, seagrass beds and tidal channels. The PNBA, due to its ecological role

and the high 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). 114 fishing boats are operational in the nine fishing villages within the PNBA, making up currently the maximum number of vessels with exclusive access to the park's waters. Fishing is conducted during single-day or multiple-day trips and is increasingly year-round. Fishing rights are exclusive to the local Imraguen communities, subject to the use of artisanal fishing methods and non-motorized wooden sailing boats known as "lanches" (Lemrabott *et al.* 2023, Lemrabott *et al.* 2024).

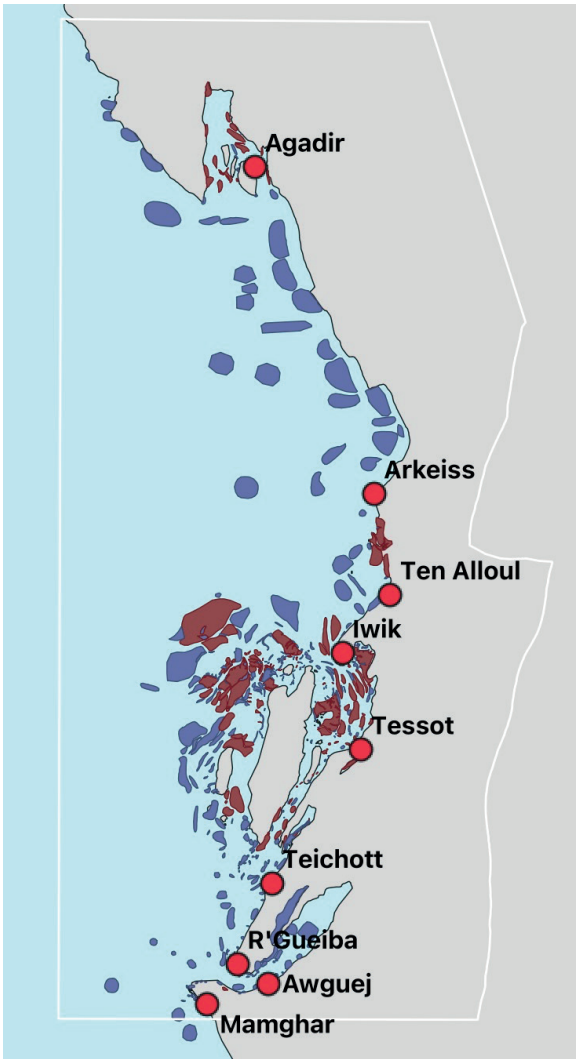

Figure 3.1 Map of the Parc National du Banc d'Arguin (PNBA) in Mauritania, showing the Imraguen villages (red circles) and boundaries of fishing areas as identified by fishers within PNBA (n > 500). Fishing areas considered intertidal (i.e., exposed during low tide) are indicated in red and subtidal fishing areas in blue.

Data processing and analyses

Banc d'Arguin artisanal fisheries have been monitored since 1997 in the framework of a joint monitoring program between IMROP and the PNBA. At six landing sites, local community members trained by the National Fisheries Institute of Mauritania IMROP assist a team of scientific researchers in collecting data. Boat captains and fishers volunteer to share details on catches and the fishing trip, which the fisheries researchers are permitted to record. A more detailed description of the landing site monitoring program and reporting on catch data is provided in Lemrabott *et al.* (2023).

Table 3.1 Characteristics of gear types and fishing methods in the Banc d'Arguin small-scale fisheries.

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 3.2 Species categories used.

Category	Species	English name	Maximum size (cm)
Large sharks	*Carcharinus brevipinna*	Spinner shark	300
	Carcharinus limbatus	Blacktip shark	286
	Carcharinus obscurus	Dusky shark	420
	Carcharinus plumbeus *Carcharhinus spp.*	Sandbar shark	300
	Sphyrna lewini	Scalloped hammerhead shark	430
	Sphyrna zygaena	Smooth hammerhead shark	500
	Ginglymostoma cirratum	Atlantic nurse shark	430
	Negaprion brevirostris	Lemon shark	340
	Galeocerdo cuvier	Tiger shark	750
Guitarfish	*Glaucostegus cemiculus*	Blackchin guitarfish	242
Large rays	*Rhinoptera marginata*	Lusitanian cownose ray	200
	Aetomylaeus bovinus	Duckbill eagle ray	222

We analyzed the data on shark and ray catches from 1998 to 2020. First, we analyzed the temporal trends in the total fishing effort and catches of this fishery. The total effort summarizes the effort accounted for by four different gear types in these fisheries: handlines, mullet nets, meagre nets, and shark nets (Table 3.1). Handline fishing comprises a small fraction of the total effort, and in this fishery, less than 10% of catches in terms of weight are comprised of elasmobranchs (Figure 3.5A). Although mullet net fisheries represent a substantial proportion of total effort, elasmobranch

catches are generally low (Figure 3.5A, 3.5B). Fisheries using shark nets and meagre nets constitute a significant part of the total fishing effort (> 50% in the first half of the reporting period), and catches with these gear types comprise a large portion of elasmobranchs (~70% and 60% of the catch in weight, respectively). Therefore, we limited data analysis to the effort and catch data of shark and meagre net fisheries.

We determined the catch-per-unit-effort (CPUE) as an indicator for changes in elasmobranch abundance. We used generalized additive models with a Gaussian distribution to assess changes in the three main focus species groups (i.e., large-bodied sharks, large benthopelagic rays and guitarfish). For this, we used the gam() function of the 'mgcv' package with restricted maximum likelihood (REML; Wood, 2017) in R v.4.3.1 (R Core Team). To produce a more detailed analysis of the species groups of interest, we focused on elasmobranchs with high conservation value, which are among the top ten most caught species. Species-group analyses were therefore limited to (1) large-bodied sharks (i.e., requiem sharks Carcharhinus spp., hammerhead sharks *Sphyrna spp.*, lemon sharks *Negaprion brevirostris*, and tiger sharks *Galeocerdo cuvier*), (2) large benthopelagic rays (i.e., duckbill eagle rays *Aetomylaeus bovinus*, Lusitanian cownose rays *Rhinoptera marginata*), and (3) guitarfishes (i.e., blackchin guitarfish *Glaucostegus cemiculus*) (Table 3.2). In addition, we report the occurrence of sharks and rays in catches between 1998 and 2020 at a species level.

Results

Long-term trend of total fishing effort, catch, and CPUE

The total fishing effort shows a significant increase, from a mean of ~1,000 days at sea from 1998 to 2005 to more than twice as high from 2007 and onwards (Figure 3.2A). This trend in fishing effort comprises four gear types: handlines, mullet nets, meagre nets, and shark nets (Table 3.1). In terms of fishing effort, handlines are used for <10% of the total fishing effort and the catch comprises less than 10% of elasmobranchs (i.e., in terms of weight; Figure 3.3). Mullet nets are used more as their proportion of the total fishing effort varies between 20 and 65%, though elasmobranch catches are generally low. Fisheries using shark- and meagre nets constitute a substantial part of the total fishing effort. However, this has decreased from approximately 50% of the total fishing effort between 1998 and 2010 to approximately 30% in the last four years (2016-2020). The catches of these nets comprise 60 to 75% of elasmobranchs (Figure 3.3).

The catch increase corresponds with the rise in total fishing effort, from 50 tons per month in 2005 to approximately 130 tons per month in 2010 (Figure 3.2B). After 2010, catches show a decreasing trend to approximately 50 tons per month in 2020. The decrease in CPUE indicates that daily catches have decreased from 150kg/day in 1998/1999 to about 20 kg/day in 2020 (R^2 = 0.47; Figure 3.2C). This is an overall difference of 86.7% in elasmobranch landings between the start and the end of the study period. Considering the monthly variation in catches, month and year explained 52% of the deviance in CPUE of elasmobranchs (Table 2).

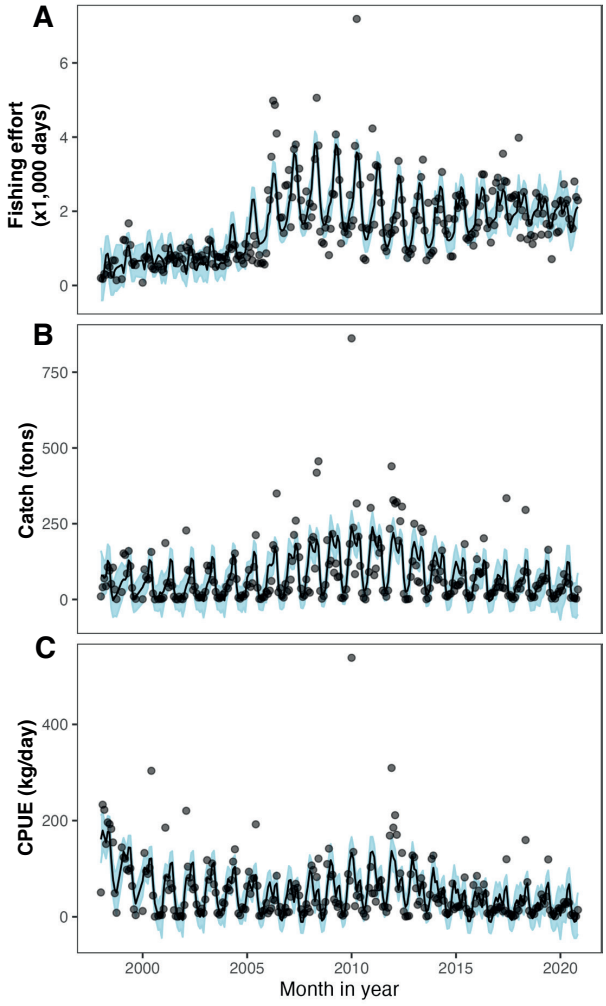

Figure 3.2 Overall trends during the entire study period in (A) fishing effort (in 1,000 sea days), (B) total catch (in tons), and (C) catch-per-unit-effort (CPUE in kg/days) per month for all elasmobranch species caught in shark, meagre, and mullet nets, and handlines. Plots indicate model fit (black lines) and 95% confidence interval (light blue).

Gear-specific analysis shows that the use of shark and meagre nets increased in 2005 and 2006, though fishing effort with either net was subsequently reduced towards the end of the study period (Figure 3.4). Catches of sharks constituted 54% of catches with shark nets, which was higher compared to ray catches in these nets (19%, Figure 3.3A). Similarly, ray catches were considerably higher in meagre nets (41%) than shark catches (21%, Figure 3.3A). Ray caches were low (<380 tons per year) in the period 1998-2006 and were relatively high between 2008 and 2012 (550 to 1200 tons per year; Figure 3.4B). After 2012, ray catches decreased to less than 50 tons/year in shark nets and to 250 tons/year in meagre nets from 2017 onward (Figure 3.4). Gear-specific CPUE for shark nets was higher for sharks between 2016 and 2019, with between 120 and 300 kg/day. The CPUE of rays in meagre nets was highest between 2011 and 2013, with 110 to 220 kg/day (Figure 3.4).

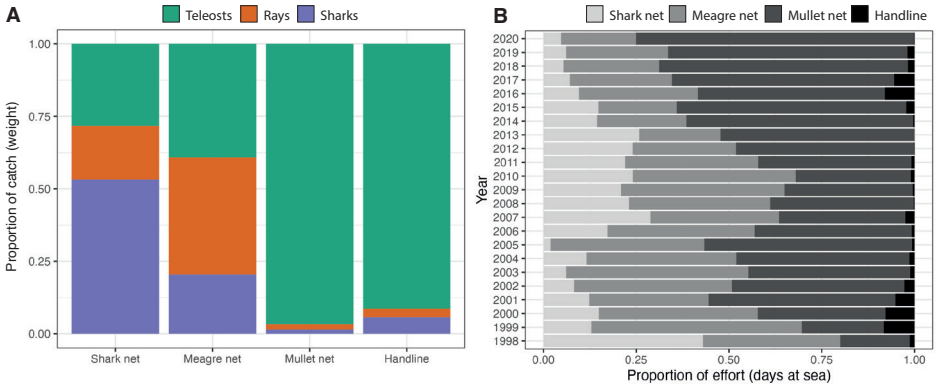

Figure 3.3 (A) The proportion of teleosts, rays and sharks in the annual catches in weight (tons). (B) The proportion of fishing effort that a gear type is used annually (in terms of sea days).

Table 3.3 Summary table of the generalized additive model (GAM) results for total effort (days at sea), total catch (weight in kg), and CPUE (kg/day at sea) overall gear types from 1998 to 2020 in Banc d'Arguin (edf: effective degrees of freedom; R-sq (adj): adjusted R-squared, and Dev. expl.: Deviance explained, p-value per smoother).

Response	edf	R-sq. (adj)	Dev. expl. (%)	p-value
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

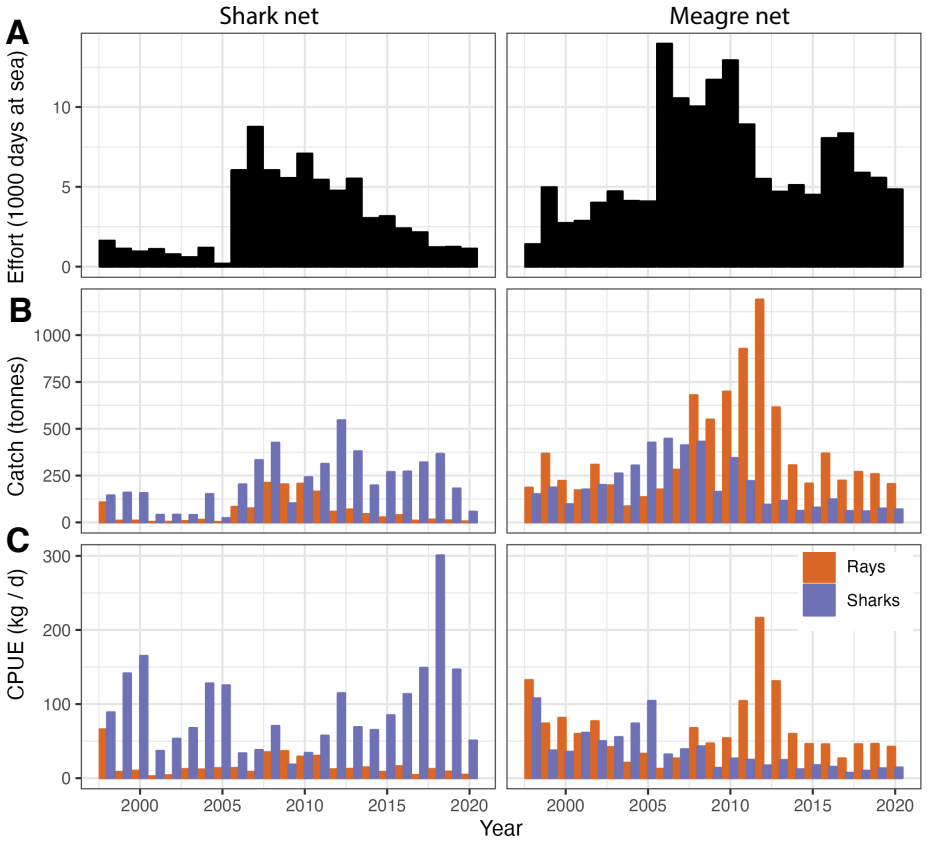

Figure 3.4 (A) Overall annual total fishing effort (in 1,000 sea days), (B) total catch (tons), and (C) catch per unit of effort (kg/sea day) (CPUE) for sharks (purple) and rays (orange) in shark nets (left) and in meagre nets (right).

Species group trends and species-specific occurrences

The CPUE of large sharks (Figure 3.5A) and blackchin guitarfish (Figure 3.5B) decreased prior to 2010 to remain below a CPUE of 2.5 and 12 kg/day for these two species groups, respectively. Contrastingly, the CPUE of the large benthopelagic rays increased during this period from a CPUE below 10 kg/day before 2005 to a CPUE between 30 and 40 kg/day between 2008 and 2011 (Figure 3.5C). After 2011, the CPUE of this species declined continuously, with the CPUE approaching 10 kg/day in 2020. To further explain these species group trends, we show the species-specific occurrence in catches over the 1998 to 2020 period within the PNBA (Figure 3.6). In total, 33 species of elasmobranchs (16 sharks and 17 rays) were identified at the species-level during the study period (Figure 3.6).

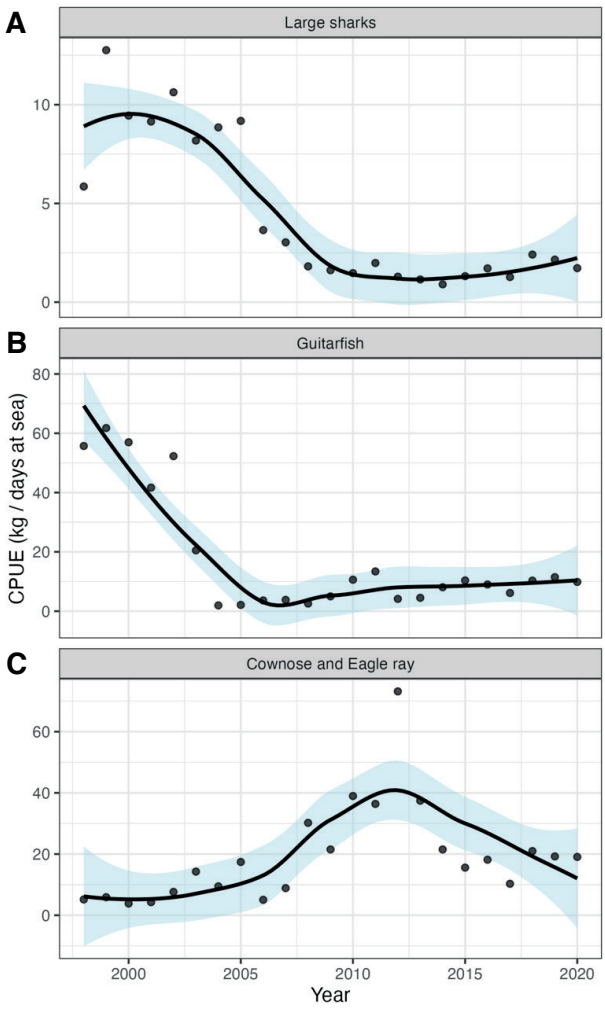

Figure 3.5 Trends in catch-per-unit-effort (CPUE) in focal species groups of elasmobranchs of (A) large sharks (i.e., hammerhead sharks, requiem sharks, nurse shark, lemon shark and tiger shark), (B) blackchin guitarfish and (C) rays (i.e., Lusitanian cownose ray and duckbill eagle ray), landed by shark nets and meagre nets over the study period 1998-2020. Plots indicate a fitted trend (black) through the summed annual data with a 95% confidence interval (blue; Table 4).

The majority of these species (85%, n = 28) are currently listed as threatened with extinction (i.e., IUCN category Critically Endangered, Endangered, and Vulnerable) and are generally species that attain large maximum sizes (> 150 cm). We show that the occurrence of large shark and ray species in catches in the PNBA is higher during the first half of the study period (i.e., before 2010) and that the occurrence of smaller-bodied species (e.g., milk shark *Rhizoprionodon acutus*, and stingray species *Dasyatis*/*Fontitrygon spp.*) remained throughout the study period (Figure 3.6). Of all elasmobranch species confirmed in the catches within the PNBA, nine species were not observed in the landings for more than a decade.

Table 3.4. Summary table of the generalized additive model (GAM) results for sharks, blackchin guitarfish and rays CPUE in shark nets and meagre nets derived from 1998 to 2020 in Banc d'Arguin (edf: effective degrees of freedom; R-sq (adj): R squared adjusted, and Dev. expl.: deviance explained).

Fishery	Response	edf	R-sq. (adj)	Dev. expl. (%)	p-value
Large sharks	CPUE	7.4	0.98	99	< 0.001
Blackchin guitarfish	CPUE	4.6	0.87	90	< 0.001
Large rays	CPUE	5.8	0.69	77	< 0.001

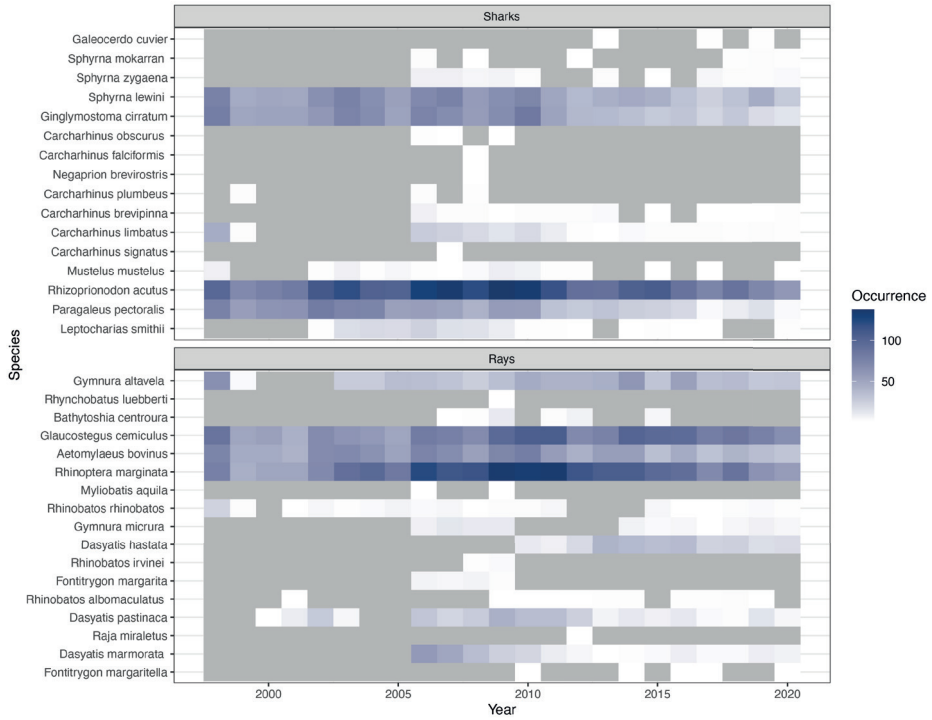

Figure 3.6 Species occurrence in the catches, organized by year and by decreasing the maximum size of the species for the two elasmobranch species groups (A) sharks, and (B) rays. Gray values indicate missing values.

Discussion

Based on over twenty years of fisheries-dependent data, we show how fisheries on shark and ray species in the Banc d'Arguin (PNBA) changed from small-scale to more commercialized fisheries targeting sharks and rays until catches severely declined (between 2010 and 2020). We interpret the decrease in CPUE to represent a decreasing abundance of these vulnerable species within the national park. Catches of large sharks, guitarfish, and large rays (i.e., eagle and cownose rays) decreased respectively by 90%, 80% and 50% between 1998 and 2020.

The elasmobranch fishery in PNBA is not driven by local demand as the local communities do not consume elasmobranch species. Therefore, commodities are exported to (international) markets. Substantial elasmobranch catches in the PNBA did not commence until the early 1980s (Lemrabott *et al. in press*). This practice was incentivized by the emerging international trade in shark fins and dried ray meat, and Imraguen fishers within the Banc d'Arguin gained access to international trade networks (Ducrocq 2004). Initially, elasmobranchs were considered bycatch in large-bodied teleost fisheries targeting species like meagre (*Argyrosomus regius*). However, we show that elasmobranchs represent 60% and 70% of the total catches in gear types used in meagre fisheries and by using shark nets, respectively. These catches often occur in shallow areas, especially in the intertidal which rays frequently use. Our results, therefore, indicate that elasmobranchs in PNBA are not bycatch but represent targeted catches, especially due to the existence of a gear type specifically used to catch sharks (i.e., shark nets) and the deployment of large-mesh meagre nets (pelagic species) in intertidal waters to target rays.

Within the boundaries of the PNBA, targeted catches of sharks and rays are illegal (Diop and Dossa 2011), but we show that the capture of these species has developed into an important economic driver of fisheries within the park over the past decades compared to the traditional teleost fisheries (Lemrabott *et al. in press*). To improve the situation for elasmobranchs in the PNBA, the priority is to implement regulations against targeted elasmobranch fisheries in locations with high occurrences of threatened species. Furthermore, deployment of large mesh-size nets should be discontinued in occurrence areas of elasmobranchs and shallow waters or tidal channels frequented by guitarfish, cownose rays and eagle rays during their tidal movements (Leurs *et al.* 2023).

Among elasmobranch species, the ones most threatened at a global level encompass the highest catches, further deteriorating the conservation status of these species (Stein *et al.* 2018, Dulvy *et al.* 2021) within the region and undermining the potentially important role that areas like the PNBA play in the lifecycle of these threatened elasmobranch species (Leurs *et al.* 2023). Globally, elasmobranchs are threatened by

targeted catches or as bycatch in small-scale or industrial fishing (Stevens *et al.* 2000, Fernández *et al.* 2005, Dulvy *et al.* 2021, Leurs *et al.* 2021). Within the Banc d'Arguin, 85% of elasmobranch species captured in the fisheries are currently threatened with extinction, including ten species (36%) that are critically endangered. In general, fish species with large maximum sizes (> 149 cm) are especially vulnerable to exploitation (Fernandes *et al.* 2017). Many of the elasmobranchs we studied reach large maximum sizes (most > 200cm). However, in the PNBA ecosystem, the smaller, juvenile individuals are often the ones experiencing high mortality through fisheries due to their use of the intertidal and shallow-water habitats as a refuge during early life stages (Knip *et al.* 2010, Leurs *et al.* 2010). This implies that exploitation in this national park may impose a critical bottleneck for species with slow life histories that are often already categorized as threatened with extinction and which depend on these habitats.

We show that elasmobranch species are declining severely in populations in the Banc d'Arguin, with the most common species likely disappearing from the area if these negative trends are not reversed. Some large *Carcharhinidae* and Sphyrnidae sharks fished earlier in the 1980s for their high-priced fins (Lemrabott *et al.* 2024) have not been recorded in the landings over the last decades. Hammerhead sharks have experienced similar decreasing trends. The rays *Rhinobatos irvinei*, *Rhynchobatus luebberti*, *Myliobatis aquila*, and *Fontitrygon margarita* were sighted only a few times during the study period and then disappeared from the catches from 2009 onwards, which may also be caused by misidentification of species due to these species being difficult to differentiate from similar species (e.g., within the Fontitrygon genus). The Banc d'Arguin is especially important for blackchin guitarfish (*Glaucostegus cemiculus*), with adults and juveniles using the PNBA as mating and nursery areas (Valadou *et al.* 2006). This species showed declines in its CPUE to critically low levels since targeted catches started in the 1990s (Lemrabott *et al.* 2024, Boulay 2013), likely motivated by the demand for its relatively large fins as an alternative after the depletion of large sharks (Kyne *et al.* 2020). These large-bodied rays have been subject to high fishing pressure, which is evident from their significant declines in CPUE before 2005, after which CPUE remained low for the remainder of the study period.

The increased catches of threatened species and the decrease of elasmobranch diversity over time raise concerns for elasmobranchs in the PNBA. Sharks and rays represent an important predatory group, occupying 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 PNBA, their loss can potentially affect the ecological functioning of these large intertidal systems (Leurs *et al.* 2023). Our results show that in the Banc d'Arguin, some elasmobranch species may have already disappeared or are close to disappearance, or their abundance is now so low that their ecological roles are

redundant. These results are alarming as other iconic elasmobranch species have already disappeared from the West African region, such as sawfishes (*Pristis spp.*), the false shark ray (*Rhynchorhina mauritaniensis)* and the African wedgefish (*Rhynchobatus luebberti*) have disappeared entirely or from parts of the region (Campredon and Cuq 2001, Jabado *et al.* 2006, Séret and Naylor 2016, Moore 2017). Overall, this may lead to a simplification of the food web of these large intertidal ecosystems. For instance, the increase in catches of sharks in the last years of the study period is caused by an increase in catches of milk sharks, a relatively fast-growing shark species. This simplification of elasmobranch communities and a shift towards fast-growing species (i.e., small-bodied sharks and small stingrays) can have consequences for the ecological functioning of coastal ecosystems.

Our findings lead to several suggestions for improved management of sharks and rays within the PNBA. Elasmobranchs were often caught in the meagre nets deployed in shallow waters and in the sharks nets specialized for capturing sharks. This is because meagre nets are used outside the target species' season and habitat and are deployed year-round in the shallow intertidal habitats of rays. In addition, meagre nets have larger mesh sizes than shark nets, originally intended to prevent the capture of smaller non-target species. As such, it is large mesh-sized nets intended for fishing of teleost that are effectively used to target rays in shallow water habitats and to interfere with their tidal movements from and to intertidal habitats (Leurs *et al.* 2023). Compared to fast-growing teleosts that can sustain levels of exploitation, applying the same fishing pressure and techniques to elasmobranchs can significantly impact their slow-growing populations. The label bycatch used to tolerate the landings of elasmobranchs by the authorities at Banc d'Arguin has been misleading, as they are targeted by specialized nets set in habitats frequented by elasmobranchs through their tidal movements. Only some elasmobranchs captured in mullet nets (comprising less than 10% of the catch) should be reasonably considered bycatch.

The managers of the Parc National du Banc d'Arguin face a challenging task to stop unsustainable fishing of threatened elasmobranchs. In 2006-2020, total catches of elasmobranchs increased with the expansion of the fishery to include species not targeted before (e.g., the large rays). We suggest the next step towards effective management of elasmobranch species within the PNBA include: (1) lowering fishing effort directed towards sharks and rays by closing fishing areas with high shark and ray catches for large mesh-sized nets or shark-specific gear types and (2) enforce the ban on trade in shark and ray products originating from within the PNBA with trade controls and onboard catch controls. These measures are unlikely to be successful without ensuring the promotion and availability of an alternative, sustainable fishery practice or alternative incomes for local Imraguen fishers.