Marine Policy 143 (2022) 105159

Contents lists available at ScienceDirect

Marine Policy

journal homepage: www.elsevier.com/locate/marpol

"Every fish in the sea is meat and so are guitarfishes": Socio-economic drivers of a guitarfish fishery in Ghana

Issah Seidu [a,b,*], Francoise Cabada-Blanco [c,g], Lawrence K. Brobbey [d], Berchie Asiedu [e], Paul Barnes [c], Moro Seidu [b], Nicholas K. Dulvy [f]

[a] Department of Wildlife and Range Management, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana
[b] AquaLife Conservancy, P.O. Box SN 228. Santasi, Kumasi, Ghana
[c] EDGE of Existence Program, Zoological Society of London, UK
[d] Department of Silviculture and Forest Management, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana
[e] Department of Fisheries and Water Resources, University of Energy and Natural Resources, Ghana
[f] Department of Biological Sciences, Simon Fraser University, Burnaby, BC, Canada V5A 1S6
[g] Institute of Marine Sciences, School of Biological Sciences, University of Portsmouth, PO1 2DY United Kingdom

ARTICLE INFO

Keywords:
Bycatch
Small-scale fisheries
Livelihoods
Sharks
Elasmobranch
CITES

ABSTRACT

Rhino rays, such as guitarfishes, are increasingly targeted or retained as incidental catch and have become an economically important component in fisheries worldwide. Despite their importance, information about the catch and socioeconomics of these fisheries are virtually non-existent in West Africa. We address a significant knowledge gap about the characteristics and drivers of guitarfish fisheries in four key ray-fishing communities in the Western and Central Regions in Ghana. We conducted landing and market surveys of guitarfishes over 80 days from November 2020 to August 2021. We also interviewed 51 fishers actively involved in the guitarfish fishery across the four communities during this period using semi-structured interviews. The findings confirm the likely disappearance of sawfishes *Pristis* spp., as most fishers have not captured any in their lifetime. We also confirm no known catches of the African wedgefish *Rhynchobatus luebberti*. Our surveys documented 537 individuals from four guitarfish species across the various landing and market sites. The spineback guitarfish (*Rhinobatos irvinei*) was the most frequently landed species comprising 71 % ($n = 383$) of all guitarfishes, with 57 % of the specimens not yet sexually mature. Most fishers (71 %) stated that catches of the two larger guitarfishes (blackchin guitarfish *Glaucostegus cemiculus* and common guitarfish *Rhinobatos rhinobatos*) have declined by 80–90 % based on their recollection. At the same time, over half (59 %) of the fishers indicated that the catches of the smaller guitarfishes (spineback guitarfish and whitespotted guitarfish *Rhinobatos albomaculatus*) have declined by 40–60 %. The main drivers for the catch or retention of guitarfishes were for both international trade of their fins, and meat which are both traded locally (45 % of 51 fishers) and used as a source of food for local consumption (37 %). While we know high economic value drives the catch and trade of giant guitarfishes and wedgefishes, we show that this trade extends to the other guitarfish species. The interviews and contemporary pattern of catches are consistent with a serial depletion of rhino rays from the largest, most valuable species to the remaining smaller-bodied, less valuable guitarfishes. We recommend the development of national regulations for their protection complemented by education programs to ensure that fishers are aware of the threatened status of guitarfishes.

1. Introduction

Recovery potential is more limited for some groups of marine species whose life-history traits and lack of management make them highly vulnerable to overexploitation. Such is the case of rhino rays, which belong to the order Rhinopristiformes and comprise the families Glaucostegidae (giant guitarfishes), Pristidae (sawfishes), Rhinidae (wedgefishes), Rhinobatidae (guitarfishes), and Trygonorrhinidae (banjo rays) [44]. Many rhino rays are characterized by long life spans, slow growth, late maturity, and low fecundity, making many intrinsically sensitive to

* Corresponding author at: Department of Wildlife and Range Management, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.
E-mail address: antwiseidu88@gmail.com (I. Seidu).

https://doi.org/10.1016/j.marpol.2022.105159
Received 15 February 2022; Received in revised form 31 May 2022; Accepted 1 June 2022
Available online 10 June 2022

overfishing [17,21,78]. These life-history traits hinder the recovery of populations under fishing pressure.

The IUCN Red List reassessment of all Chondrichthyans revealed that rhino rays are among the most threatened and evolutionary distinct species [22,43,77]. Rhino rays are increasingly targeted or retained as incidental catch in many fisheries and have thus become an essential component of landings worldwide for their value rather than their volume [83]. Their meat is mainly consumed locally, while their “white” fins are considered the highest quality and, thus, the most valuable of shark fins ([37,74,53]). Guitarfishes are susceptible to capture in various fishing gears, including gillnets, longlines, and demersal trawls [6,31,64,65,66]. The high demand for their products, susceptibility to being caught by various fishing gears, and intense fishing pressure are all critical drivers of population decline globally [50,37,85].

In the West African sub-region (eastern Atlantic, from Mauritania to Angola), most species of rhino ray were previously described as abundant and among the most caught sharks and rays by fishers in marine waters [50,52]. However, there has been a decline in most of these species’ populations across their ranges and a likely extinction of sawfishes in most West African countries [50,52,86]. Further, based on species richness, endemism, and evolutionary distinctiveness, the West Africa region is one of five global hotspots for the conservation of sharks and rays [18,77]. Despite the region’s global importance, the biology and status of sharks and rays in this region is poorly understood ([20,53]).

In Ghana, sharks and rays are primarily caught in small-scale artisanal fisheries that utilize wooden canoes ranging in size from small (4–8 m long and 1–2 m wide) to large (16–25 m long and 2–4 m wide) and fitted with outboard motors ranging from 15 to 40 horse power (HP) [73]. Sharks and rays are mainly targeted with drift gillnets with auxiliary longlines and bottomset gillnets, respectively (Seidu, I. pers. obs). Shark and ray fisheries are an important component of food security, employment, and income for coastal communities in Ghana [30,49,73]. Yet, species-specific baseline fisheries data that is essential for monitoring the populations of targeted species and for developing even rudimentary conservation strategies in support of meeting international commitments such as the Food and Agriculture Organization of the United Nations (FAO) National Plan of Action for the Conservation and Management of Sharks (NPOA-Sharks) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), are largely unavailable [49,72].

Fishery-dependent data on sharks and rays reported by the Scientific Committee of the Fisheries Commission of Ghana to the FAO are aggregated at a higher taxonomic resolution as “sharks, rays and nei”; a reporting category that does not distinguish species-specific composition and hinders the monitoring of catches of individual species, which can mask the declines and disappearance of the most sensitive species [19,26]. Such bulk reporting categories further ignore the distinctions and prioritization of species requiring urgent conservation attention, such as rhino rays [45]. Furthermore, the demand for high-value shark and ray products, especially fins for the international market, has increased over the past three decades ([15]). As a result, specialized fisheries targeting elasmobranchs have developed in Ghana, and a decline of teleost fish species has exacerbated the targeting of elasmobranchs ([70]). Thus, in many fishing communities, elasmobranchs are now explicitly targeted to support the livelihoods of fishers and are no longer simply the result of the incidental catch of mixed fisheries [70]. For example, a recent study by Seidu et al. [73] reported some fishers and traders generate between 80 % and 100 % of their income from shark fisheries and/or trade with the consumption of shark meat becoming common in coastal communities of Western Ghana. Further, rhino rays too, constitute economically important landings and support fisher livelihoods and rural economies. However, information on the catch composition, catch trends, and the socio-economic and trade dynamics of rhino rays are virtually non-existent in Ghana and elsewhere in West Africa.

Interview data in Ghana suggests that at least two species of guitarfishes, blackchin guitarfish *Glaucostegus cemiculus* and common guitarfish *Rhinobatos rhinobatos*, are caught by fishers. Additionally, opportunistic photographs of landings indicate that *G. cemiculus* was the most caught guitarfish species [63]. A recent study documented three guitarfish species in the elasmobranch catch landings of artisanal fishers in Western Ghana, whereby the spineback guitarfish *Rhinobatos irvinei* constituted 4 % of the total ray landings, and the *R. rhinobatos* and *G. cemiculus* each constituted 1.5 % of ray landings [72]. Further, interview data from fishers in Western Ghana on historical catch trends of elasmobranchs indicated that *R. irvinei* and *G. cemiculus* were once abundant in the 1980s, but have been severely depleted as of the 2020s (Seidu et al., under review). Indeed, guitarfishes and other rhino rays are considered among the top elasmobranch families most at risk of extinction, with two-thirds of guitarfish (Rhinobatidae) species listed as threatened with extinction [22]. Evidence on the number of these threatened species being landed in Ghana suggests the country should be considered a priority country for the conservation of rhino rays.

In this article we provide species-specific data on the catch composition and trends, and on the trade and socio-economic motives for the target of guitarfishes in key ray fishery communities in Western and Central coastal regions of Ghana. Species-specific data on guitarfishes are critical for monitoring the trends of exploited populations and can form the basis for developing management strategies to safeguard these species from the brink of extinction. Specifically, we addressed the following research questions: (1) what is the size, distribution and sex ratio of landed guitarfish? (2) How has the catch composition of guitarfishes changed? (3) What are the exact locations and seasons for the catch of most guitarfishes? and (4) What are the motivations for targeting or retaining guitarfishes in Ghana?

2. Materials and methods

2.1. Study area

Ghana is located west of the Gulf of Guinea (5°7’53.436’’ N and 1°16’46.1064’’ W) and has a 550 km long coastline with approximately 90 lagoons and associated wetlands [39]. The coastline is demarcated into three geomorphic units – West, Central, and East Coast. The study was conducted in four coastal communities: Axim and Adjoa located in Western Region and Apam and Winneba in the Central Region (Fig. 1). These four communities were selected because: (1) many fishers were willing to cooperate with the researchers for both landing survey and to participate in semi-structured interviews; (2) fishing is exclusive to artisanal fishers; and (3) rays form a significant component of elasmobranch landings. Fishing operations are conducted all year round in these study communities although the major fishing season is between August and December.

2.2. Fishing practices in the study communities

The four study communities have landing sites near to market sites. The communities used drift gillnets, bottomset gillnets, longlines, handlines, trolling lines, purse seine nets, beach seine nets, and ring nets. Sharks and rays are mainly caught with three gear types in two combinations: (1) drift gillnets complemented with longlines, and (2) bottomset gillnets. We selected and interviewed fishers who predominantly use bottomset gillnets for their fishing operation. The bottomset gillnets are used in coastal habitats to target demersal fishes such as rays, skates, guitarfish, cassava fish (*Pseudotolithus senegalensis*) and anchovy. The bottomset gillnets are made of polyethylene monofilament fishing line. The size of the bottomset gillnets ranges from 90 to 180 m in length and 1.3 m to 2.8 m in depth [73]. It has mesh sizes of 23.5–24 cm. Crew operating bottomset gillnets range in size between three and six fishers and the nets are deployed and retrieved manually by the fishers from wooden canoes.

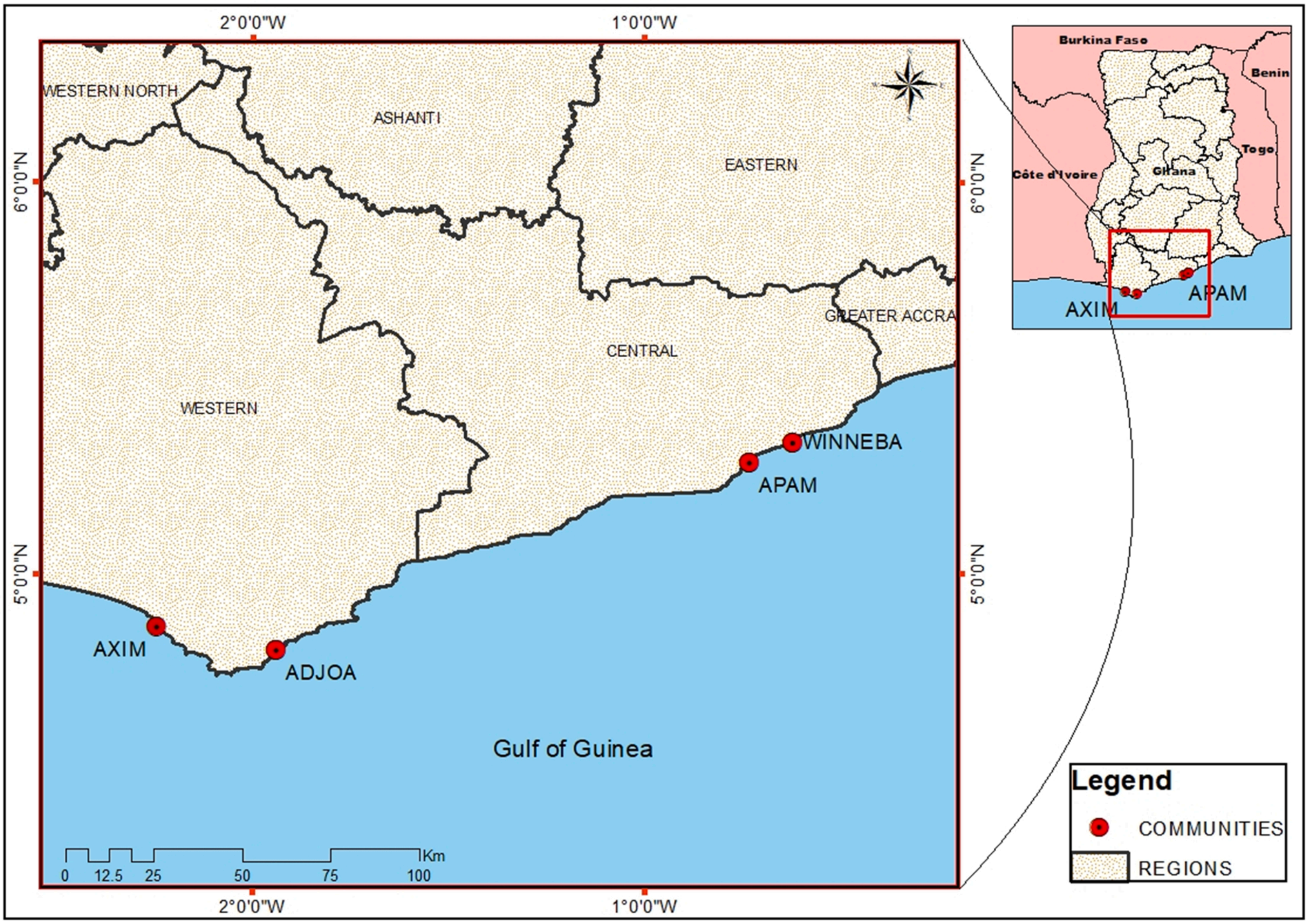

Fig. 1. Map of Ghana showing Western and Central Regions, with the four study communities.

Wooden canoes are the only vessels used by artisanal fishers in Ghana. Artisanal elasmobranch fishers use three types of canoe; small canoes (4–8 m long and 1–2 m wide), medium canoe (9–15 m long and 1–2 m wide) and large (16–25 m long and 2–4 m wide) [73,72]. The small canoes range from 4 to 8 m long and 1–2 m wide, with 8 HP, 25 HP or 40 HP outboard motors. They were mostly used by the interviewed fishers operating with the bottomset gillnets and were equipped for one to two days fishing trips. The interviewed fishers used an average of 17 nets. Nets are normally set at 17:00–18:00 h and allowed to soak in water between three to five hours before they are retrieved, especially at low tides.

2.3. Data collection

2.3.1. Size and sex composition of landed guitarfish

We monitored guitarfish catches at landing and market sites in each community. Monitoring was carried out for 28 days in Apam, 20 days in Winneba, 15 days in Adjoa, and 17 days in Axim between November 2020 and August 2021. We were unable to sample guitarfish during two periods in these months: February, owing to long uninterrupted shortages of premix fuel which halted fishing operations in most fishing communities; and in June and July 2021 owing to Ministerial Directives which declared a closed season for both artisanal and semi-industrial fleets between 1st July and 31st July 2021. Data were collected between 07:00 and 17:00 and lasted between six and eight hours per visit.

For each specimen encountered we recorded the species name, sale price, total length (TL), and sex. Some fishers were unwilling to participate in the study so we only recorded specimens from fishers who permitted us to take measurements of their catch. Furthermore, we only identified and measured specimens encountered whole. Specimens were identified to the lowest taxonomic level using identification keys from Last et al. [44]. Sale prices were determined from observing the negotiations between fishers and traders and through informal discussions with them. The TL of each guitarfish to the nearest cm was measured as the distance between the upper caudal fin lobe and the tip of the snout. Sex were recorded based on the presence/absence of claspers, which are visible from an early stage of development on the inside edge of the pelvic fins (Capapé and Zaouali, [11]). Clasper length and degree of calcification was measured as an indicator of sexual maturity in males [64,65,66]. Specimens were considered immature if claspers were short and flexible. Males characterized by partially calcified claspers were categorized as immature, while specimens exhibiting elongated and calcified claspers were considered fully matured adults. It was not possible to determine the maturity stage of female specimens. However, we tentatively provided the proportion of maturity of all the species of guitarfish recorded by comparing the species-specific size classes with the reported size at maturity [65,44,74].

2.3.2. Interviews with fishers

Face-to-face interviews were carried out between June to August 2021. Data were collected using a structured questionnaire containing a mixture of open and closed questions designed to gather both qualitative and quantitative information. Fishers were selected for the interview using snowball sampling, where participants were asked to recruit a fisher who targeted guitarfish, other rays, and demersal species [55]. We used snowball sampling because most fishers in the study communities were aware of the controversies surrounding the shark and ray fin trade, making it difficult for some of them to respond to researchers.

In total we interviewed 51 fishers across the four fishing communities. We read standardized questions which were identical across interviews and communities. Fishers were interviewed at their convenience, typically in the landing sites or their homes. Each interview took approximately 45–60 min to complete. All interviews were conducted by the first author and local collaborators in the local dialects of Fante, Nzima and Ahanta and were later transcribed into English.

The questionnaire was designed to collect data about: i) the socio demographics of fishers; ii) local taxonomy iii) catch and catch trends; iii) seasonality; iv) fishing areas; v) motivation for catching or retaining guitarfish; vi) consumption patterns vii) trade of guitarfish; and viii) attitudes and perceptions toward guitarfish.

To understand local taxonomy and verify the ability of fishers to distinguish local species of guitarfish, a species-identification exercise was conducted with the fishers during the interviews. Fishers were shown photographs of all the guitarfishes as well as the sawfishes and African wedgefish reported in Ghana and asked questions related to species identification, the number of guitarfishes and local names. We analyzed local taxonomy of fishers by aggregating and computing the number of fishers who were able to identify guitarfish based on their experience and those who depended on the morphology or physical features on the species using the photo ID. Questions also focused on motivations or socio-economic incentives for the target or retention of guitarfish, consumption patterns and trade dynamics especially the sale prices and to who and where the meat and fins are sold, as well as attitudes towards guitarfish. Fishers were asked to state their rate of consumption of guitarfish categorized as often (i.e., once or more per week); sometimes (once per month); rarely (once or only a few times per year); and never (never at all).

2.3.3. Ethics

All guitarfish specimens examined in this study were landed by artisanal fishers and were already dead upon inspection. The permission to conduct interviews at the various fishing communities were granted by the Chief fishers and their elders. Consent was obtained from all fishers prior to them being interviewed. The purpose of the interview and the absence of financial incentives or benefits from participation were explained in local dialects to all fishers. Anonymity of responses and the voluntary nature of information provided were informed prior to the interviews. All interview procedures were approved and performed in accordance with the Human Ethics guidelines of the Zoological Society of London EDGE of Existence Programme.

2.3.4. Data analysis

2.3.4.1. Species size and sex structure. All measured specimens were used to determine size compositions and sex ratios for each species landed. Total length data were tested for normality and homoscedasticity using Shapiro-Wilk and two-tailed variance ratio test (Zar, [87]). When the test revealed that the data are normally distributed and of equal variance, a two-tailed t-test was employed to test the hypothesis that the mean sizes of females and males per species did not differ significantly at the alpha level of 0.05. Size data that did not meet these assumptions were evaluated using two tailed non-parametric Mann-Whitney U tests. The sex ratio for each species was compared to the 1:1 parity using the Chi-square test of independence with Yate's correction for continuity. All statistical tests were performed using PAST version 3.12 [58].

2.3.4.2. Interview data. Observations and interview notes from the fieldwork were compiled, translated into English, coded into themes. Thematic analysis was primarily used for analyzing qualitative interview data. Responses from the interviews were cross-checked and aggregated manually when necessary. Open codes were created based on the content of the responses and in some cases axial coding was used to group responses with similar open codes. The data were stored and standardized in Microsoft Excel and analyzed (using descriptive statistics) in MS Excel spreadsheet and further presented in tables and figures where necessary. The quantitative data from the questionnaire were coded and analyzed using the Statistical Package for Social Sciences (SPSS) software, version 20.

3. Results

3.1. Species composition of landed guitarfishes

A total of 537 guitarfishes comprising four species were recorded during the 80 days of survey. Apam community in the Central Region had the highest catch with a total of 444 guitarfish (Table 1). The spineback guitarfish *Rhinobatos irvinei* was the most frequently landed species ($n = 383$, 71 %) in all the study communities. The whitespotted guitarfish *Rhinobatos albomaculatus* was only recorded in Apam and Winneba communities, all in the Central Region. Male specimens were common and constituted 57 % of the total individuals of guitarfishes landed.

3.2. Size and sex structure of guitarfish

Most 56 % ($n = 303$) guitarfishes landed were not sexually mature based on the reported sizes at maturity [65,44,74]. The male ($n = 306$) to female ($n = 231$) sex ratio of all the four guitarfish species landed was 1.3: 1.

3.2.1. Glaucostegus cemiculus

Based on reported size at maturity of *G. cemiculus* [74], 70 % ($n = 14$) males and 92 % ($n = 13$) females were likely sexually immature (Fig. 2A). However, eight male specimens were classified as mature based on clasper calcification. Slightly more (59 %) landed specimens of *G. cemiculus* ($n = 34$) examined were males (Table 2). Mean size of males and females were similar (Mann –Whitney $U = 102.5$, $p = 0.195$).

3.2.2. Rhinobatos irvinei

Assuming that male *R. irvinei* reach maturity at approximately 42 cm TL (based on [65], size at maturity for female unknown), only 43 % ($n = 89$) of male individuals landed were mature (Fig. 2). However, based on clasper calcification, only 47 % of male specimens were matured. Significantly more (56 %) landed specimens of *R. irvinei* ($n = 383$) were males ($\chi^2 = 4.83$, $p = 0.03$) (Table 2). Mean male sizes (61.9 ± 20.9 cm) were similar to that of the females (61.5 ± 22.5 cm) ($t = 0.221$, $p = 0.83$).

3.2.3. Rhinobatos albomaculatus

Based on Jabado et al. [65] reported size at maturity of *R. albomaculatus* (46 cm TL for males and 52 cm TL for females) only 33 % ($n = 19$) males and 45 % ($n = 13$) female individuals examined in landings were matured (Fig. 2). However, 42 % of male specimens were matured based on clasper calcification. Significantly more (55 %) landed specimens of *R. albomaculatus* ($n = 86$) were female. The mean sizes of males were similar to that of the females (Mann –Whitney $U = 799$, $p = 0.715$).

3.2.4. Rhinobatos rhinobatos

Using the reported minimum size at maturity of *R. rhinobatos* (56–79 cm TL for male and 64–85 cm TL for female; [44]) and clasper calcification all male specimens and 89 % of females landed were mature. Slightly more landed specimens of *R. rhinobatos* were females (53 %). The mean size of male specimens was similar to the females ($t = 0.659$, $p = 0.51$).

Table 1
Composition of landed guitarfishes in the Western and Central Ghana, with the IUCN Red List of Threatened Species status (as of November 2021).

Species name	IUCN Red List Status	Ref.	Western Ghana		Central Ghana		Relative catch (%)
			Adjoa	Axim	Apam	Winneba	
Glaucostegus cemiculus	Critically Endangered A2d	[61]	6 (20 %)	7 (23 %)	18 (4 %)	3 (9 %)	34 (6 %)
Rhinobatos albomaculatus	Critically Endangered A2d	[65]	–	–	79 (18 %)	7 (22 %)	86 (16 %)
Rhinobatos irvinei	Critically Endangered A2d	[65]	14 (47 %)	18 (58 %)	330 (74 %)	21 (66 %)	383 (71 %)
Rhinobatos rhinobatos	Critically Endangered A2bd	[65]	10 (33 %)	6 (19 %)	17 (9 %)	1 (3 %)	34 (6 %)
Total			30	31	444	32	537

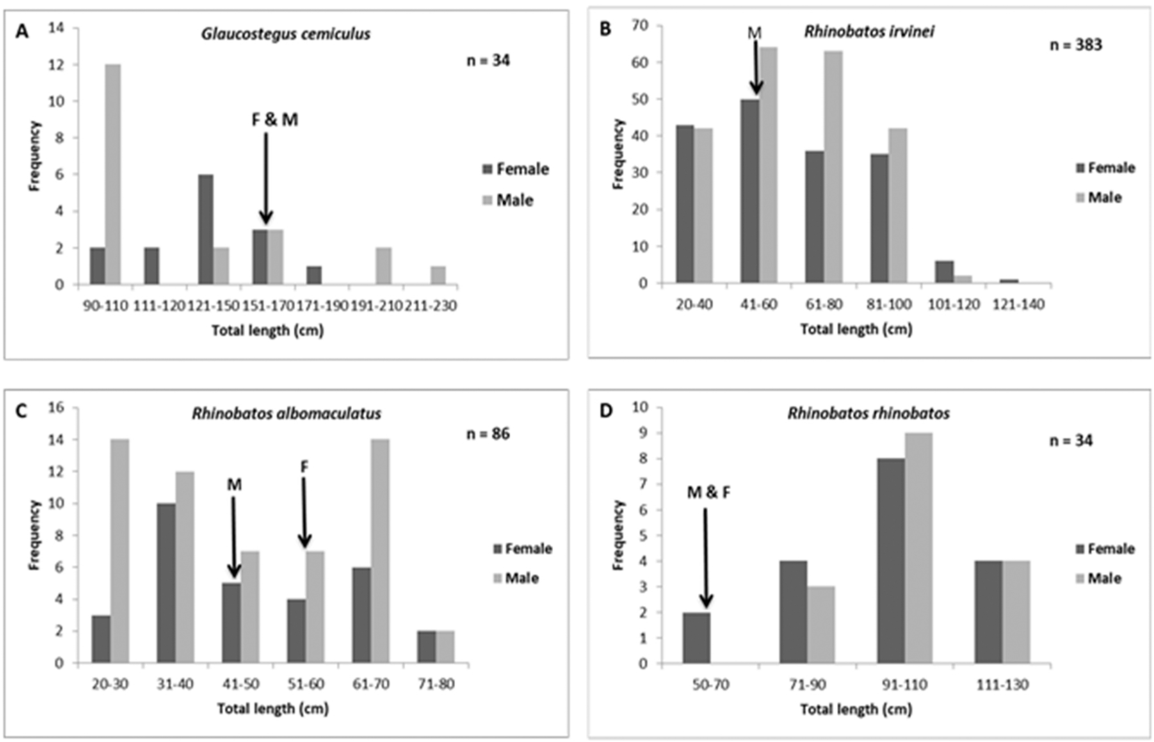

Fig. 2. Size frequency distribution of guitarfish species in the various study communities. Black bars denote female and grey bars denote male individuals. The total number of individuals measured (n) are also given. Arrows represent published minimum size at maturity for females (F) and males (M) [65,44,74].

Table 2
Observed number of individuals, male to female sex ratios (M:F), chi-square test, minimum, maximum sizes and mean size (TL cm ± S.D.) of landed guitarfishes.

Guitarfish Species	Sex	Number	Sex ratio (M:F)	χ^2	Minimum	Maximum	Mean (SD)
Glaucostegus cemiculus	M	20	1.4:1	$\chi^2 = 1.06$	91	211	127.0 ± 40.63
	F	14		$p = 0.30$	97	189	136.5 ± 23.6
Rhinobatos irvinei	M	213	1.3: 1	$\chi^2 = 4.83$	20	98	61.9 ± 20.9
	F	170		$p = 0.03$	25	96	61.5 ± 22.5
Rhinobatos albomaculatus	M	57	2:1	$\chi^2 = 9.12$	25	77	46.6 ± 16.1
	F	29		$p = 0.003$	27	72	46.8 ± 13.9
Rhinobatos rhinobatos	M	16	1: 1.1	$\chi^2 = 0.12$	71	121	99.94 ± 14.0
	F	18		$p = 0.73$	64	130	96.4 ± 16.5

3.3. Socio-economic characteristics of interviewed fishers

All 51 fishers interviewed were men because women are prohibited from fishing in the study communities. Women are actively engaged in buying, processing and trading fish. Many of the fishers (51 %) were canoe owners who own one to four vessels each. Most interviewed fishers (43 %) were aged 41–60 and the years of fishing experience ranged from 3 to 45 years. Formal education attainment among fishers was low. Fishers came from four ethnic groups, with majority belonging to the Fante ethnic group (Table 3).

3.3.1. Fisherfolk taxonomic knowledge of guitarfishes

Over half of the fishers (57 %) depended on their experience on capturing and handling guitarfish species to identify them, while others (39 %) relied mostly on the species' morphological characteristics, which include size, color, markings, spines, snout, fins, and teeth, amongst others. Fishers identified only one to two species of the four guitarfish species to be present in Ghanaian waters. Most fishers ($n = 49$) distinguished guitarfish into two categories of large and small, while only two fishers identified all guitarfish as congener species. Of the 49 fishers, 78 % identified *Rhinobatos irvinei* and *Rhinobatos albomaculatus* in one category of small guitarfish, referred to as "Esenekyi" in local Fante dialect, while 82 % categorized *Rhinobatos rhinobatos* and

Table 3
Socio-demographic characteristics of respondents in the study communities.

Variables	Adjoa	Axim	Apam	Winneba	Sum (average)
Total fishers	9 (17.6 %)	14 (27.5 %)	17 (33.3 %)	11 (21.6 %)	51
Canoe owners	3 (33 %)	7 (50 %)	11 (65 %)	5 (45 %)	26 (51 %)
Age in years					
< 20	3	2	4	1	10 (20 %)
20–40	2	3	4	4	13 (25 %)
41–60	4	5	7	6	22 (43 %)
61–80	0	4	2	0	6 (12 %)
Educational level					
No education	5	11	10	8	34 (67 %)
Junior school	4	3	4	2	13 (25 %)
Senior High	0	0	3	1	4 (8 %)
Tertiary	0	0	0	0	0
Years of fishing experience (S.D.)	3–40 (23.2 ± 15.4)	3–29 (13.1 ± 8.4)	5–41 (18.7 ± 13.7)	6–45 (16.1 ± 11.9)	3–45 (17.4 ± 12.5)
Ethnic groups					
Fante	1	8	11	8	28 (55 %)
Ahanta	6	2	1	0	9 (18 %)
Nzima	2	4	2	2	10 (20 %)
Ewe	0	0	3	1	4 (8 %)

% represents percent of total respondents for each variable. Year of fishing experience presented in mean and standard deviation.

Glaucostegus cemiculus as large guitarfishes referred to as "Esene wire-kyire". Most of the fishers (65 %) were unable to identify the African wedgefish *Rhynchobatus luebberti*, which is meant to be range from Mauritania to Congo, as many of them have not observed or caught the species before. Few fishers (21 %) could identify the African wedgefish and had seen it before. Similarly, most of the fishers (73 %) were unable to identify sawfishes, presumably because they had never seen them before. Most of the fishers indicated that they have not observed or caught sawfishes in their lifetime except eight older fishers who reported that they used to observe and/ or catch these species in the mid-1970s to early 1990s.

3.3.2. Guitarfish landing abundance and composition

Seventy-one per cent ($n = 36$) of fishers reported difficulties in catching guitarfish and perceived their stocks to be depleted. Of the 49 fishers who categorized guitarfish into small and large 53 % ($n = 26$) reported that the "small guitarfishes" (*Rhinobatos irvinei* and *R. albomaculatus*) have declined, while 43 % ($n = 21$) indicated a stable catch in their number. For the "large guitarfishes" (*Glaucostegus cemiculus* and *Rhinobatos rhinobatos*), 73 % of fishers indicated that the catch of these species have severely declined. Two fishers stated that the large guitarfishes have always been the rarest species in their catch since they began fishing. Six (12 %) of the fishers stated that the catch of these large guitarfish had increased compared to when they began fishing. Fishers who reported an increase in the catch of the large guitarfish cited an increase in the number and sizes of their fishing nets as the primary reasons for getting more catch. Another reason is the increase in their fishing distance and durations on the sea as one fisher explained:

> "We were only embarking on return fishing trip when I started fishing and were also not going far to target these large guitarfish. My crew members and I are now using more nets and traveling further distances to target these guitarfish. These large guitarfishes are no longer coming close to coast as they used to do. We have now discovered the habitats in the sea where the bigger guitarfishes inhabit and therefore we have to go far and spend more days in the sea to target them". (A fisher, Adjoa, 07/2021)

When asked to estimate guitarfish catch rates in the current year (2021), most fishers ($n = 35$) indicated that they catch on average 13–30 small guitarfishes in a fishing trip, while some fishers ($n = 24$) reported that they catch over 30 individuals in a fishing trip. For large guitarfishes, 78 % of fishers stated that they catch 2–8 individuals per trip. Only five respondents indicated that they catch over ten individuals now but two were quick to add that they needed to spend more time on the sea before they get such numbers.

Most fishers (82 %) stated that the sizes of the guitarfish they catch have reduced and that they are now catching smaller individuals now compared to when they began fishing. Only six fishers stated that the sizes of guitarfishes have not changed and that they are invariably catching the same sizes in the course of their fishing activities. A fisher reported that:

> "It is very rare getting the large guitarfishes these days. Even the smaller ones, I do not get enough quantity to sell. Fins of these species are very expensive but I do not get some to sell to offset my debt. I have now decided to focus my effort on other bony fishes to provide for my family. My income has reduced tremendously and I am very worried. Very soon, my debt will rise tremendously and I will have to run away as many of the fishers have done in this community". (A fisher, Axim, 06/2021)

When asked to compare the abundance of guitarfish catch to 10 years ago, most fishers (71 %) stated that the abundance of the large guitarfishes have declined by a range of 80–90 %, while 59 % indicated that the abundance of smaller guitarfishes have reduced by 40–60 %.

When queried about the reasons for the changes in catch abundance and sizes of guitarfish, 38 fishers responded and gave varied reasons for the changes. Most of the fishers (76 %) cited an increasing number of fishers and fishing nets as well as light fishing (using artificial light or light attractors for attracting fish, with the aim of increasing catch) (66 %) as the primary reasons for the reduction in abundance and sizes of guitarfish catch (Fig. 3). The emergence and operations of industrial trawlers (58 %) was also cited as a major cause for the changes in composition of guitarfish species in the study communities.

3.3.3. Catch locations and seasonality

All fishers indicated that they catch guitarfishes in the coastal habitats. Many fishers reported that the areas they used to fish have changed dramatically and that they embark on longer fishing trips than when they began fishing. Most fishers stated that they used to fish near to the shore (nine to 16 km away from their landing sites) seven to ten years ago, but now they must travel over 20 km to their fishing grounds to target guitarfish, rays and other bony fishes. Fishers indicated that they currently spend two to four days on the sea before they can catch substantial numbers of guitarfish and other teleosts. Fifty-three percent of fishers ($n = 27$) stated that their fishing depth ranges from 10 to 40 m, while 39 % set their gears less than 10 m deep. Many fishers attributed the reasons for the changes in their fishing grounds to the movement of

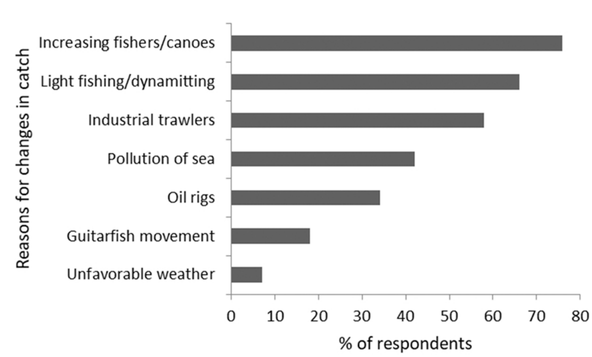

Fig. 3. Reasons reported by interviewed fishers for the changes in guitarfish catch composition.

guitarfish. They reported that the food available in the near coast has been depleted by fishers using light fishing, dynamite, and other chemicals and that guitarfishes are now moving far from shorelines to different habitats where food is available. Fishers described their main fishing areas where they mostly target guitarfish and other demersal species as clean sandy seabeds and areas characterized by a mixture of sand and gravel, with very cold environments. Fishers reported that guitarfish mostly eat from rocky seabeds but always return to sandy seabeds to rest and reproduce and this is where they target them. Some fishers reported that guitarfishes inhabit in the same habitats as sea turtles and that they mostly catch the two species concurrently with their nets.

Fishers gave a range of months for the timing of peak catch of guitarfishes. Of the 14 fishers interviewed in Axim community, nine indicated that guitarfish are mostly caught from December to February, while only three fishers reported that September to December was the ideal period for catching large quantities of guitarfish. Most fishers ($n = 7$ out of 9 respondents, 78 %) in the Adjoa community indicated that the catch frequency for guitarfish increases in the months of September to November. Most fishers ($n = 11$ out of 17 respondents) in Apam community reported that guitarfish were more present or easier to catch in August–December. At Winneba community, most fishers ($n = 6$ out of 11 respondents, 54 %) stated that the best period to catch large quantities of guitarfish is from April to May. Three fishers in Winneba indicated that guitarfish could be caught all year round and mostly depend on the fishing distance and duration crew members spend on the sea.

3.3.4. The motivations for fishing for guitarfishes

Fishers were asked about their motivations for the target or retention of guitarfish. Sale of fins and meat (45 %) and as source of food or sustenance (37 %) were the main drivers for the catch or retention of guitarfish, with gift/barter and animal feed comprising a smaller percentage of use (Fig. 4). Fishers reported that fins of large individuals are sold separately from their meat, while small-sized specimens are sold with fins attached. The fins are usually sold to local merchants who act as middlemen between the fishers and foreigners in the Adjoa, Apam and Winneba communities. One fisher from Winneba reported that he wanted to sell his fins directly to the foreigners, as he learnt they buy fins at a very high price. However, all efforts to get access to these foreign nationals have proven futile as the foreigners do not usually want to unveil themselves to fishers in their community. Most fishers ($n = 9$) in Axim reported that they sell their fins directly to foreign nationals from The Gambia, Mali and Senegal. Only four fishers in Axim stated that they sell their fins to local merchants.

The sale prices of guitarfish fins are generally higher than the meat. The sale prices of fins vary and mostly depend on the size and dry weight. The prices quoted by fishers as of the year 2021 range from GH¢ 150 to GH¢ 300 per kg (USD 25.40 to USD 50.80 per kg). A fisher who reported catching three large guitarfish during April 2021 indicated that he sold their fins for GH¢ 420 (USD 71.20) for all the three guitarfish individuals. This was the maximum price of fins of guitarfish reported to have been sold by the interviewed fishers in the study communities. Respondents indicated that the fin prices of guitarfish have been stable for two years, but marginally increase during certain seasons, particularly during lean seasons when many canoe owners halt their fishing operations.

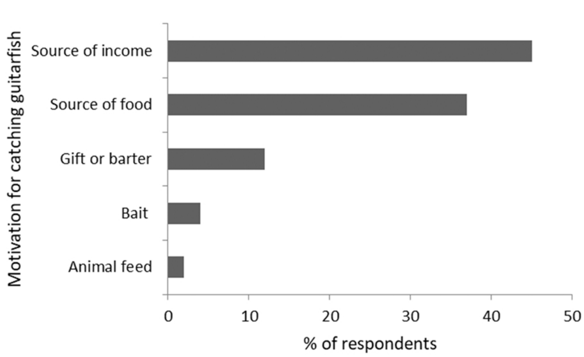

Fig. 4. Stated motivation for targeting or retaining guitarfishes by interviewed fishers in the study communities.

3.3.5. Trade in guitarfish meat

The prices at first sale of 422 specimens of the four guitarfish species commonly landed in the study communities were documented from November 2020 to August 2021 (Table 3). Fishers sold guitarfish specimens wholly to traders as no mechanisms were put in place to measure them. Prices of guitarfishes depend largely on the sizes of the specimens. *Glaucostegus cemiculus* meat was sold for an average of GH¢ 13.50 (USD 2.30) per specimen in Adjoa to GH¢ 200.00 (USD 33.90) per specimen in Apam. *Rhinobatos rhinobatos* meat was sold for the highest price in Adjoa (GH¢ 17.10 or USD 2.80 per specimen), followed by Axim (GH¢ 14.70 or USD 2.49) (Table 4). *Rhinobatos albomaculatus* was recorded only in Apam and Winneba and was sold at a comparatively cheaper price in these communities (Table 4). Individual guitarfish is sold to local merchants and local consumers. The local merchants sold the meat immediately in fresh state or preserve them with salt and later smoke and/or sun dry them (called "Kako" in local dialects) before they are sold in various markets, primarily in local markets of the various study communities, Takoradi in the Western Region, Tema in Greater Accra Region, or Kumasi in the Ashanti Region. The prices of meat are normally adjusted every time and this depends on the negotiation skills of fishers. Many fishers ($n = 28$) stated that they self-finance their fishing trips, while some ($n = 15$) acquire loans from banks and local merchants. In most cases, fishers pay local merchants in kind by selling their meat directly to them at comparatively cheaper prices.

3.3.6. Consumption patterns of guitarfishes by focal study communities

Guitarfish meat consumption was common among fishers in the study communities (Fig. 5). Nearly half of respondents in the various fishing communities ate guitarfish "often" or "sometimes" and mostly preferred the smaller individuals. Most fishers indicated that the meat of the smaller individuals is somehow soft and succulent and thus boil faster and taste better than the matured and larger ones. Many fishers who consumed guitarfishes at their various homes indicated that they mostly do not salt and sun-dry or smoke them. At Adjoa community, 78 % of fishers consume guitarfish "often" or "sometimes". Most fishers (50 %) in Axim stated that they often eat guitarfish meat, while many respondents in Apam (53 %) and Winneba (45 %) communities ate guitarfish "sometimes". A fisher stated that;

> "Let me tell you my son. Every fish in the sea is meat and so are guitarfishes. We eat and sell what our hands possess. We do not have any choice in our consumption because we do not get diverse fish as we used to do in the previous years. Shark and ray meat are increasingly sustaining our homes these days". (Fisher, Apam, 08/2021)

Table 4
Prices at first sale per specimen of guitarfish among the fishing communities.

Guitarfish	Mean price (GH¢/whole specimen)			
	Axim	Adjoa	Apam	Winneba
Glaucostegus cemiculus	86.6 (7)	13.5 (6)	200.0 (18)	123.3 (3)
Rhinobatos albomaculatus	–	–	5.4 (17)	2.2 (6)
Rhinobatos irvinei	11.3 (18)	6.4 (14)	7.4 (287)	2.6 (17)
Rhinobatos rhinobatos	14.7 (6)	17.1 (10)	11.0 (12)	3.0 (1)

Notes: 1. The number of specimens used to calculate mean values is reported in parentheses. 2. As of the time of data collection, USD 1 was equivalent to GH¢ 5.9

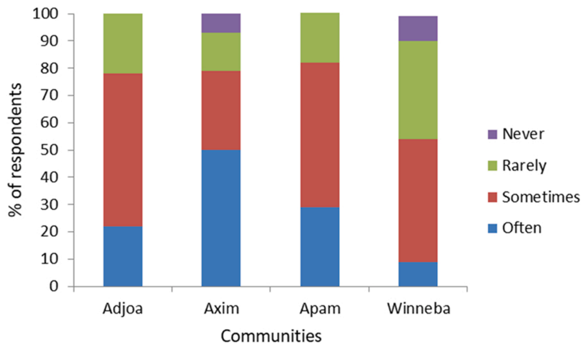

Fig. 5. Consumption pattern of guitarfish among fishers in the four study communities.

3.3.7. *Fisher attitudes toward guitarfishes*

Fishers exhibited divergent attitudes towards guitarfish species. Of the 51 respondents, 19 fishers viewed guitarfish as just another fish, which support their livelihoods in terms of providing them with income and food. Most fishers regarded guitarfish as important species which play a key ecological role in the marine environment, with 17 fishers saying that guitarfish are important to the marine health and 11 fishers indicating that they are indicators that other bony fishes and sea turtles are present. Only four fishers were unable to provide any response to this question.

Most respondents (78 %) expressed concerns about the current status of guitarfish in Ghana and felt concern about the future sustainability of their stocks. However, when queried about the future protection of guitarfish species in Ghana, only nine fishers stated that guitarfish should be protected to ensure sustainable catch. Most respondents (75 %) stated that guitarfish should not be protected in Ghana. Reasons given by fishers included 'guitarfishes providing them substantial income and when protected will have adverse impacts on their livelihoods ($n = 22$)', 'God is already protecting guitarfish and all animals in the sea ($n = 11$)', and 'there is no need to invest in protecting guitarfish species because their stocks are already depleted ($n = 6$)'. Three fishers did not provide any response to this particular question. One fisher indicated that:

> "The population of our fishing communities is increasing and fishing is our main job. We are also part of the country and we too have to survive as others are doing in the big cities and so there is a need to catch guitarfish and other fish. Nobody should stop us from catching these species and other animals in the sea. We don't even fish all year round. We fish every three to four days and so I believe these periods allow the fish to grow and replenish. Besides, we use nets that do not catch the smaller individuals, which will eventually grow for the sustainability of these fish". (Fisher, Apam, 07/2021)

4. Discussion

4.1. *Guitarfish composition, sex and size structure*

This study provides the first description of landed species composition, size and sex structure as well as the socioeconomics of artisanal fishery impacts on guitarfishes in Ghana. Though the lack of historical information on the artisanal fishery precludes a comparison with the past status of this guitarfish fishery, the data provide a baseline for future assessments of these demersal fisheries and more specifically, guitarfishes. All the guitarfish species that have been recorded in this study are of conservation concern listed as Evolutionary Distinct and Globally Endangered Species (EDGE; www.edgeofexistence.org; Stein et al., [77]) and categorized as Critically Endangered globally on the IUCN Red List of Threatened Species ([22]; IUCN, 2021).

Male-dominated sex ratios were documented for *Rhinobatos albomaculatus* and *R. irvinei*, which may indicate sexual segregation; a phenomenon which is relatively common in elasmobranchs [75]. Similarly, sexual segregation has been reported for *G. cemiculus* and *R. rhinobatos* in The Gambia (Moore et al., [53]) and some species of rhino rays in the Arabian Sea and adjacent waters [37].

In the present study, *G. cemiculus* constituted only 6 % of the total individuals landed in the study communities. The species was historically abundant from Mauritania to Sierra Leone, but the populations have significantly declined in most of it range in the sub-region [50,43] and was reported to be rare in Moroccan waters [68,25], which reflects the species landings in Ghana. Conversely, the species was commonly caught in some areas in the southern Mediterranean [23,48,56], and from southern Turkey to Israel along the eastern Mediterranean coastline [32,48,69] and was also considered a commercially important species in Libya [80]. The predominance of male *G. cemiculus* specimens contrasts with the findings of Moore et al. [53], who found female specimens of *G. cemiculus* dominating in landings in The Gambia. The maximum TL recorded for *G. cemiculus* in this study (TL = 199 cm) was less than the maximum recorded length (245 cm) for this species in Senegal during landing site surveys from 1994 to 2000 (Seck et al., [71]) and was also smaller than the maximum reported TL of 265 cm recorded by Séret [74]. Further, Moore et al. [53] recorded a maximum TL of 240.1 cm for this species in The Gambia, which was higher than the maximum TL recorded in this study. *Glaucostegus cemiculus* is reported to mature between 138 and 154 cm TL for males and 153 and 174 cm TL for females ([74,81,71]), which suggests that majority of the specimens recorded in this present study were immature. This supports the findings of Valadou et al. [81] where most specimens landed were reported as immature in Mauritania.

Landings were dominated by *R. irvinei*, which constituted 78 % of total individuals recorded across all the study communities. This high predominance of this species in Ghana contrasts the findings of Diop and Dossa [50], where the species was recorded in low numbers in landing site surveys in The Gambia, Guinea and Senegal. Similarly, the species was not recorded during landing site surveys conducted annually between 2010 and 2018 in The Gambia (Moore et al., [53]).

The present study failed to record *R. albomaculatus* in Western Ghana, which corroborates a recent study where a total of 2157 elasmobranchs comprising 20 shark and 14 ray species were recorded over the course of 9 months [72]. The few records of *R. albomaculatus* in the present study concurs with the findings of Ishihara and Kimono [35], where only four specimens of this species were recorded in Ghana in demersal fish surveys conducted between 2000 and 2003. Similarly, this species was only recorded in Guinea during landing site surveys across the sub-regional Fisheries Commission region [50]. Cruise reports from the "Dr. Fridtjof Nansen" surveys indicate that this species was frequently caught in 2004 (Congo, Gabon, and Angola), in 2006 (Nigeria, Cameroon, São Tomé and Principe, Gabon, and Congo), in 2007 (Angola) and in 2008 (Côte d'Ivoire, Ghana, Benin, Togo, Cameroon, São Tomé and Principe, Gabon, and Congo), particularly in the waters of Gabon where, when captured, it represented between 1.13 % and 9.96 % of the total catch with up to 102 individuals caught in one tow [40,42,41]. However, the species has since declined across the West African region and subsequent surveys undertaken in Gabon and Congo in 2010 failed to record this species [51]. The maximum recorded total length of 77 cm in this study is close to the maximum reported total length of 80 cm for this species [65].

Similar to the findings of the present study, *Rhinobatos rhinobatos* was not recorded in abundance in The Gambian artisanal fishery (Moore et al., [53]). Only single individuals or small numbers either as fresh landings or on drying racks were frequently recorded at landings, markets, and processing sites in The Gambia (Moore et al., [53]), and this was consistent with our observations of this species in landing and market sites. Similarly, the species was reported to be rare in Moroccan waters [68] and less abundant in Gabon [56]. In contrast to this study, *R. rhinobatos* was frequently recorded from Mauritania to Sierra Leone along the West Coast [50]. The species was also reported to be common along the southern and eastern coasts of the Mediterranean, with a higher concentration occurring in Egypt [1], Israel [32], Lebanon [48], Libya [80], Syria [69], Tunisia [23] and Turkey (Ismen and Ismen, 2007). The minimum TL of 15 cm reported by Ambrose et al. [3] for *R. rhinobatos* is remarkably lower than the 55 cm TL recorded as the minimum total length for this species in this study. It is worthy to note that Ambrose et al. [3] recorded only two individuals of *R. rhinobatos,* which ranged from 15 to 28 cm, TL while conducting research on bycatch composition in coastal shrimp trawls fisheries in Nigeria. Başusta et al. [7] also recorded a small specimen of *R. rhinobatos* (35 cm TL), which was also lower than the minimum total length recorded in the present study. In Israeli waters, a maximum TL of 185 cm was recorded for this species [24], which is higher than the maximum TL (144 cm) of this study. Capapé et al. [13] reported that the maximum TL of sexual maturity of *R. rhinobatos* was 62–66 cm TL for males and 78 cm TL for females in Senegal, which is lower than the reported size at maturity of 65–75 cm for males and 70–85 cm for females reported for this species from Tunisia [12] and 65–76 cm TL for males and 74–98 cm TL females in Egypt [1].

4.2. Social dimension of guitarfish fishery

Similar to other parts of the world [33,38], fishers in Ghana were unable to taxonomically differentiate between morphologically similar species pairs such as *G. cemiculus* and *R. rhinobatos*, as well as *R. albomaculatus* and *R. irvinei*. Thus, the inability of fishers to distinguish morphologically similar species of guitarfishes prompted their responses to focus on the two categories of large-bodied individuals and small-bodied individuals, which seems to be well-known to most fishers in the study communities. The wide inter- and intra-variation in morphology and coloration among species in the families Rhinidae and Rhinobatidae pose a challenge to their identification worldwide [54]. Such was the case of the three species of *Rhynchobatus* that could not be reliably separated in the field but have been managed as a single group in Queensland, Australia [84]. Such identification challenges may hinder the effective management of threatened species [54], as there is the potential to miss species requiring urgent conservation efforts.

Fishers' interview responses indicate that there is a likely local extinction of sawfishes and African wedgefish, as well as a decline in the number and sizes of guitarfishes in Ghana. As expected, fishers in the Western Region have indicated in a recent study that sawfishes have disappeared from their catch (Seidu et al. under review). Additionally, sawfishes are reported to be extinct in Ghana [63], which reflects the threat category of the species globally [22,86]. The responses of fishers in the present study on sawfishes agree with their last observations which date back to the early 1960 s in most states in the Eastern Central and Southeast Atlantic Ocean, extending from Mauritania to Angola [34]. A survey of the literature generated historical mentions of sawfishes from Senegal (1841–1902), The Gambia (1885–1909), Guinea-Bissau (1912), Guinea (1900–1964), Liberia (1927), Côte d'Ivoire (1881–1923), Ghana (1947–1964), Togo (1963–1964), Benin (1963–1964), Nigeria (1963–1964), Cameroon (1907–1964), Gabon (1963–1964), the Democratic Republic of the Congo (1886–1964), Angola (1949–1964), and Namibia (1900–1974) [10,34]. The last documented West Africa regional capture of Sawfishes (*Pristis pectinata* and *P. pristis*) was from 2005 in Nord de Caravela at Guinea-Bissau [36,67]. Fernandez-Carvalho et al. [28] assessment of the risk of extinction of largetooth sawfish estimated a lower probability of extinction ($p = 0.25$) due to nine recent sightings in the 2000 s in the Northern West African sub-region and near certain probability of extinction ($p = 0.99$) in southern areas of West Africa (Cameroon to Namibia) [28]. Furthermore, similar recent surveys conducted in the sub-Saharan region, which include The Gambia, Guinea-Bissau, and Senegal indicated that many respondents have never sighted sawfishes or have only encountered them occasionally during their lifetimes [47,46].

The lack of recent observations by fishers of the African wedgefish may indicate a possibly local disappearance of the species in Ghanaian waters, which supports our recent landing sites surveys where the species was not recorded in the Western Region [72]. This finding also reflects the current status of the species across the region, where captures are now rare in many countries and the species is known to have disappeared from a significant part of the region [50,43]. Taken together there appears to have been a temporal serial depletion of species starting with the extinction of sawfishes, followed by wedgefishes and giant guitarfishes and now we are witnessing the decline of guitarfishes. This pattern provides another case study alongside the serial depletion of the great whales, Atlantic skates, pelagic sharks and Gulf of California sharks ([2,19,76]).

Direct analysis of changes in abundance trends of guitarfishes using classical scientific data is challenging because only interview data on *G. cemiculus* and *R. irvinei* in Western Ghana exist (Seidu et al. under review). The interview data indicates that these two species used to be abundant in the 1980s but have significantly declined in the 2020s, which corroborates the current catch abundance of guitarfish reported by fishers in the present study. Globally, many rhino rays are under threat of extinction and have been reported as the most threatened group of marine fauna requiring urgent conservation attention [43,54,86]. The high rates of exploitation and growing global trade in their products have resulted in the population decline of rhino rays ([37,54]).

Similar to our findings, fishers in the Bay of Bengal, Bangladesh, reported that the number and size of rhino rays have decreased over the last five to ten years [33], which can partially be attributed to the high intrinsic sensitivity of elasmobranch species to overfishing, that puts them at greater risk from increasing fishing pressure in mixed-species fisheries [6,21,22,29,78]. These characteristics, compounded by other attributes such as their preference for shallow, soft-sediment coastal habitats, which are easily accessible to intensive fisheries, and their high economic value, means that their populations face an enormous threat from fisheries [54]. Overfishing is the major cause of population declines and extinction risk of elasmobranchs, particularly in the coastal zone [22] and all other marine fishery resources in Ghana [60]. Overfishing in Ghana in the last two decades has been caused by the overwhelming increase in fishing effort from both artisanal and industrial fleets [57]. In the last decade, the total reported shark catches fluctuated considerably, increasing intermittently on average of 2000 tons per year in Ghana. Elasmobranch catches peaked up to 10,104 tons in 2013 and then declined to 8152 tons in 2015 [27]. In 2018, however, the catch estimate trends indicate a sharp decline of shark landed to 1878 tons [26].

Given that rhino rays have a high extinction risk and low recovery potential [17,43], the rate at which the species populations have declined as reported by fishers in Ghana is alarming because the low rate of conservation management is being outpaced by the rapid rate of decline. The increasing depletion of these species and other elasmobranchs may be attributed to two main reasons. Firstly, in many fishing communities in Ghana, employment options and availability of alternative income opportunities at the community level are not readily available [4]. Therefore, dependence on marine resources for subsistence and cash income is typically high [59,73] and it is thus not uncommon that more fishers are targeting and/or retaining bycaught guitarfish. Secondly, although the Fisheries Laws of Ghana and customary practices in some coastal communities prevent Illegal, Unreported and Unregulated fishing methods, such as light fishing and inshore trawling, most artisanal fishers do not comply with these regulations [62,5,72]. This is because the high benefits of using such fishing methods in terms of increased catch outweigh any potential penalties from being caught (Seidu et al. under review). In addition, patrolling and enforcement of such regulations aimed at mitigating the adverse impacts on fishery resources are not very effective at the community level.

Coastal communities globally have relied on rhino rays as a source of marine protein since the Bronze ages [79]. In the West African sub-region, especially in Ghana, The Gambia, Guinea, and Senegal, shark fishing became a commercial interest by 1930s [70]. The exploitation of sharks was mainly done to meet market demand for human consumption and for the extraction of liver oil for medical purposes [70]. In the study communities, guitarfishes were regularly landed and fishers confirmed their catch in every fishing trip. Thus, guitarfishes likely provide a regular source of income and sustenance for these fishing communities. The consumption of guitarfish meat is still part of the traditional diet, as fishers rely mostly on their local resources for their livelihoods (I. Seidu pers. obs.). Further, as in other countries, the demand for shark products and especially their meat for local consumption and fins for international export is increasing the trade in these species [6,50]. These activities pose enormous challenges for guitarfish conservation in Ghana and many other maritime countries in West Africa.

While consumption of guitarfish meat is prevalent in the study communities, the fishery is largely driven by the trade of fins and meat. Rhino ray products are among the most highly valued marine fishes in both local and international markets [37,43]. While we have known of the high value driving catch and trade of giant guitarfishes and wedgefishes [14], our study demonstrates that this trade is now extended to other guitarfishes as the giant guitarfishes and wedgefishes are becoming increasingly scarce. The most valuable product is the fins, which are sold at high prices in the international fin markets [33]. The different range in sale prices of fins and meat in the various study sites is partially explained by the variability in prices offered by traders and the relationships among the key stakeholders in the elasmobranch fishery. In some fishing communities, traders have forged long-term relationships with fishers and this may prompt the reduction in prices of fins or meat sold to them. Further, traders who provide funds to support a particular canoe business have the opportunity to buy the meat or fins at comparatively cheaper prices. Similarly, fishers stated different prices for different guitarfish products in the Bay of Bengal, Bangladesh [33]. Generally, there was a high demand for guitarfish fins and meat, with fresh meat sold to local traders. Most traders then slice the fresh meat, salt and sun-dry or smoke them before they are destined for the local Ghanaian markets to be sold for local consumption. The high consumption of rhino rays in the various fishing communities reflects the consumption patterns of shark meat in other localities in Indian Ocean [82], United Arab Emirates [38], Madagascar [16], and the other West African countries [50].

5. Conclusions and policy implications

This study found that four guitarfish species are landed in Ghana, of which *Rhinobatos irvinei* is the most predominant in fisher catches. There appears to be sexual segregation within *R. albomaculatus* and *R. irvinei*, as male specimens dominated the landings. Further, except for *R. rhinobatos* where most specimens landed were mature, most landed specimens of other guitarfish species were below the reported minimum total length for maturity and thus immature.

Fishers reported a reduction in the abundance and sizes of guitarfishes, which was attributed to overfishing. Fishers response indicated that guitarfishes feed from the rocky seasbeads and they target them in the sandy seabeads where they rest and reproduce. This suggests the need to understand migrations pattern or movement of guitarfish along the coast. The sale of fins and meat for income and as source of food was the main motivation for the catch or retention of guitarfish, which suggests that they will continue to be landed in Ghana to meet fishers' daily sustenance. Here, we show that trade is now being extended to drive fisheries for the other guitarfishes, as the giant guitarfishes and wedgefishes become increasingly scarce.

From the findings of this study, most fishers indicated that these guitarfishes need no protection whatsoever. These responses may be borne out of inadequate information to inform their decisions about the extinction risk of rhino rays. Therefore, an increase in sensitization programs regarding the threats faced by guitarfishes and regulations for other threatened elasmobranchs are warranted in Ghana. For effective conservation, fishers could be educated on species identification and safe release protocols, and should be incentivized to voluntary release guitarfishes. This will be essential in the short-term to mitigate local extinctions of any of the remnant guitarfish species in Ghana. Such interventions could be considered within the structure of a mitigation hierarchy to ensure a sequence of avoid and minimize capture, increase live release, and compensate small-scale fishers for catch losses, say through a bycatch tax (Booth et al., [9,8]).

The development of a formal national strategy for the conservation of guitarfishes in Ghana is strongly recommended. This strategy should be based on sound knowledge, and this study thus provides a precursor for such an effort. Activities towards the development of such a strategy should be focused at the local level and actively involve community members from key guitarfish-fishing communities, which will likely be the most effective means of protecting them in Ghana. However, whether fishers and other local stakeholders will be inclined to support the protection of guitarfishes largely depends on how their socio-economic wellbeing is addressed. Most fishers solely depend on marine resources for their livelihoods [73], and, therefore, any management interventions should counterbalance the impact the intervention will have on many of the fishers in these fishing communities.

CRediT authorship contribution statement

Issah Seidu: Conceptualization, Investigation, Methodology, Formal analysis, Funding acquisition, Writing – original draft, Writing – review & editing. **Francoise Cabada-Blanco**: Supervision, Methodology, Writing – original draft, Writing – review & editing. **Lawrence K. Brobbey**: Supervision, Data curation, Writing – review & editing. **Paul Barnes**: Supervision, Data curation, Writing – review & editing. **Berchie Asiedu**: Methodology, Writing – review & editing, Supervision, Formal analysis. **Moro Seidu**: Investigation, Writing – review & editing. **Nicholas K. Dulvy**: Supervision, Conceptualization, Methodology, Formal analysis, Writing – review & editing.

Acknowledgements

This work was supported by the Fondation Segre EDGE Fellowship Program, Save Our Seas Foundation [464], Marine Conservation Action Fund of the New England Aquarium, and Rufford Foundation [33214-B]. Issah Seidu thanks the Zoological Society of London EDGE of Existence Programme team members for their training, advice and mentoring. Nicholas K. Dulvy was supported by Discovery and Accelerator grants from Natural Science and Engineering Research Council [RGPIN-2019-04631] and the Canada Research Chair program [950-228186].

Our heartfelt appreciation to Prof. Emmanuel Danquah, Prof. Bernard Séret and Prof. S. K. Oppong for their immense contribution, advice and guidance towards the successful completion of the study. Finally, the authors thank Moro Seidu, Bukari Saphianu, Paul Tehoda, Emmanuel Amoah, Clement Sullibie Saagulo Naabeh and Adomako Ohene as well as the local volunteers Isaac Assefuah, Kingsford Amankwah, Jona Aquah, Timothy Amiah and Ben Adjei for their role in field data gathering. We are grateful to the staff of the Western and Central Regional Fisheries Commission, chiefs, Chief Fishers and their elders, fishers, and people of the four study communities for their cooperation and support in making this study possible.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.marpol.2022.105159.

References

[1] S.H. Abdel-Aziz, A.N. Khalil, S.A. Abdel-Maguid, Reproductive cycle of the common guitarfish, Rhinobatos rhinobatos (Linnaeus, 1758), in Alexandria waters, Mediterranean Sea, Mar. Freshw. Res. 44 (3) (1993) 507–517.

[2] K.R. Allen, Conservation and Management of Whales, University of Washington Press, Seattle, USA, 1980.

[3] E.E. Ambrose, B.B. Solarin, C.E. Isebor, A.B. Williams, Assessment of fish by-catch species from coastal artisanal shrimp beam trawl fisheries in Nigeria, Fish. Res. 71 (1) (2005) 125–132.

[4] B. Asiedu, F.K. Nunoo, Alternative livelihoods: a tool for sustainable fisheries management in Ghana, Int. J. Fish. Aquat. Sci. 2 (2) (2013) 21–28.

[5] B. Asiedu, P. Okpei, F.K.E. Nunoo, P. Failler, A fishery in distress: an analysis of the small pelagic fishery of Ghana, Mar. Policy 129 (2021), 104500.

[6] E. Barrowclift, A.J. Temple, S. Stead, N.S. Jiddawi, P. Berggren, Social, economic and trade characteristics of the elasmobranch fishery on Unguja Island, Zanzibar, East Africa, Mar. Policy 83 (2017) 128–136.

[7] A. Başusta, N. Başusta, J.A. Sulikowski, W.B. Driggers III, S.A. Demirhan, E. Cicek, Length–weight relationships for nine species of batoids from the Iskenderun Bay, Turkey, J. Appl. Ichthyol. 28 (5) (2012) 850–851.

[8] H. Booth, D. Squires, E. Milner-Gulland J., The mitigation hierarchy for sharks: A risk-based framework for reconciling trade-offs between shark conservation and fisheries objectives. Fish and Fisheries 269 (289) (2020).

[9] H. Booth, W. Arlidge N., D. Squires, E. Milner-Gulland J., Bycatch levies could reconcile trade-offs between blue growth and biodiversity conservation, Nature Ecology & Evolution 5 (6) (2021) 715–725.

[10] G.H. Burgess, J.F. Carvalho, J.L. Imhoff, An evaluation of the status of the largetooth sawfish, Pristis perotteti, based on historic and recent distribution and qualitative observations of abundance, Fla. Mus. Nat. Hist. Rep. 2009 (2009) 1–93.

[11] C. Capapé, J. Zaouali, Distribution and reproductive biology of the blackchin guitarfish, Rhinobatos cemiculus (Pisces: Rhinobatidae), in Tunisian waters (central Mediterranean). Marine and Freshwater Research 45 (4) (1994) 551–561.

[12] C. Capapé, R. Ben Brahim, J. Zaouali, Aspects de la biologie de la reproduction de Rhinobatos rhinobatos (Rhinobatidae) des eaux tunisiennes, Icthyophysiol. Acta 20 (1997) 113–127.

[13] C. Capapé, A. Gueye-N'diaye, A.A. Seck, Observations Sur la Biologie De La Reproduction De La Guitare Commune, Rhinobatos rhinobatos (L., 1758) (Rhinobatidae) De La Presqu'ile Du CAP-VERT (S Enegal, Atlantique oriental tropical), Ichtyophysiol. Acta 22 (1999) 87–101.

[14] C.P.P. Choy, R.W. Jabado, N. Clark-Shen, D. Huang, M.Y. Choo, M. Rao, Unraveling the trade in wedgefishes and giant guitarfishes in Singapore, Mar. Policy 136 (2022), 104914.

[15] S.C. Clarke, M.K. McAllister, E.J. Milner-Gulland, G.P. Kirkwood, C.G. Michielsens, D.J. Agnew, M.S. Shivji, Global estimates of shark catches using trade records from commercial markets, Ecol. Lett. 9 (10) (2006) 1115–1126.

[16] G. Cripps, A. Harris, F. Humber, S. Harding, T. Thomas, A preliminary value chain analysis of shark fisheries in Madagascar. Indian Ocean Commission Report, Food and Agriculture Organization of the United Nations, 2015, p. 82.

[17] B.M. D'Alberto, J.K. Carlson, S.A. Pardo, C.A. Simpfendorfer, Population productivity of shovelnose rays: inferring the potential for recovery, PLoS ONE 14 (2019), e0225183, https://doi.org/10.1101/584557.

[18] D.H. Derrick, J. Cheok, N.K. Dulvy, Spatially congruent sites of importance for global shark and ray biodiversity, PLoS One 15 (2020), e0235559, https://doi.org/10.1371/journal.pone.0235559.

[19] N.K. Dulvy, J.D. Metcalfe, J. Glanville, M.G. Pawson, J.D. Reynolds, Fishery stability, local extinctions and shifts in community structure in skates, Conserv. Biol. 14 (2000) 283–293, https://doi.org/10.1046/j.1523-1739.2000.98540.x.

[20] N.K. Dulvy, C.A. Simpfendorfer, L.N. Davidson, S.V. Fordham, A. Bräutigam, G. Sant, D.J. Welch, Challenges and priorities in shark and ray conservation, Curr. Biol. 27 (11) (2017) R565–R572.

[21] N.K. Dulvy, S.L. Fowler, J.A. Musick, R.D. Cavanagh, P.M. Kyne, L.R. Harrison, J. K. Carlson, L.N.K. Davidson, S. Fordham, M.P. Francis, C.M. Pollock, C. A. Simpfendorfer, G.H. Burgess, K.E. Carpenter, L.V.J. Compagno, D.A. Ebert, C. Gibson, M.R. Heupel, S.R. Livingstone, J.C. Sanciangco, J.D. Stevens, S. Valenti, W.T. White, Extinction risk and conservation of the world's sharks and rays, eLife 3 (2014), e00590, https://doi.org/10.7554/eLife.00590.

[22] N.K. Dulvy, N. Pacoureau, C.L. Rigby, R.A. Pollom, R.W. Jabado, D.A. Ebert, B. Finucci, C.M. Pollock, J. Cheok, D.H. Derrick, K.B. Herman, C.S. Sherman, W. J. VanderWright, J.M. Lawson, R.H.L. Walls, J.K. Carlson, P. Charvet, K.K. Bineesh, D. Fernando, G.M. Ralph, J.H. Matsushiba, C. Hilton-Taylor, S.V. Fordham, C. A. Simpfendorfer, Overfishing drives over one third of all sharks and rays toward a global extinction crisis, Curr. Biol. 31 (2021) 4773–4787, https://doi.org/10.1016/j.cub.2021.08.062 (.e8).

[23] K. Echwikhi, B. Saidi, M.N. Bradai, A. Bouain, Preliminary data on elasmobranch gillnet fishery in the Gulf of Gabès, Tunisia, J. Appl. Ichthyol. 29 (5) (2013) 1080–1085.

[24] D. Edelist, New length–weight relationships and L max values for fishes from the S outheastern M editerranean Sea, J. Appl. Ichthyol. 30 (3) (2014) 521–526.

[25] F.F. Litvinov, S. Kudersky, Intra-range Boundaries in Western African Elasmobranch Species as A Reason for Stock Unit Delimitation, ICES CM, 2004.

[26] FAO, Fisheries and Aquaculture Software. FishStatJ-software for Fishery Statistical Time Series, FAO Fisheries and Aquaculture Department, Rome, 2021.

[27] FAO, Global Capture Production 1950–2015, Fisheries and Aquaculture Department, 2017. ⟨http://www.fao.org/fishery/statistics/global-production/en⟩.

[28] J. Fernandez-Carvalho, J.L. Imhoff, V.V. Faria, J.K. Carlson, G.H. Burgess, Status and the potential for extinction of the largetooth sawfish Pristis pristis in the Atlantic Ocean, Aquat. Conserv.: Mar. Freshw. Ecosyst. 24 (4) (2013) 478–497.

[29] I.C. Field, M.G. Meekan, R.C. Buckworth, C.J.A. Bradshaw, Susceptibility of sharks, rays and chimaeras to global extinction, Adv. Mar. Biol. 56 (2009) 275–363, https://doi.org/10.1016/s0065-2881(09)56004-x.

[30] S.L. Fowler, R.D. Cavanagh, M. Camhi, G.H. Burgess, G.M. Cailliet, S.V. Fordham, C.A. Simpfendorfer, J.A. Musick, Sharks, Rays and Chimeras: the Status of the Chon-drichthyan Fishes. Status Survey, IUCN/SSC Shark Specialist Group, IUCN, Gland and Cambridge, 2005, p. 461.

[31] K.B. Glaus, I. Adrian-Kalchhauser, S. Piovano, S.A. Appleyard, J. M. Brunnschweiler, C. Rico, Fishing for profit or food? Socio-economic drivers and fishers' attitudes towards sharks in Fiji, Mar. Policy 100 (2019) 249–257.

[32] D. Golani, Cartilaginous fishes of the Mediterranean coast of Israel, in: N. Başusta, Ç. Keskin, F. Serena, S. Bernard (Eds.), International Workshop on Cartilaginous Fishes in the Mediterranean, Turkish Marine Research Foundation, Istanbul, Turkey, 2006, pp. 95–100.

[33] A.B. Haque, M. Washim, N.G. D'Costa, A.R. Baroi, N. Hossain, R. Nanjiba, N. A. Khan, Socio-ecological approach on the fishing and trade of rhino rays (Elasmobranchii: Rhinopristiformes) for their biological conservation in the Bay of Bengal, Bangladesh, Ocean Coast. Manag. 210 (2021), 105690.

[34] L.R. Harrison, N.K. Dulvy, Sawfish: A Global Strategy for Conservation, IUCN Species Survival Commission's Shark Specialist Group, 2014.

[35] H. Ishihara, H. Kimoto, Elasmobranchs collected in the Fisheries Resource Survey in Ghana, Kaiyo Gougai 45 (2006) 37–45.

[36] J.M. Ballouard, D. Buccal, A. Cadi, Contribution à la mise en œuvre du Plan Sous Régionale d'Action pour la conservation et la gestion des populations de Requins en Afrique de l'Ouest - Statut et conservation des poissonsscies: Rapport de mission Guinée Bissau du 09 novembre au 12 décembre 2006, Noé Conservation and the Centro de Investigiçao Pesqueira Aplicada (CIPA), 2006.

[37] R.W. Jabado, The fate of the most threatened order of elasmobranchs: Shark-like batoids (Rhinopristiformes) in the Arabian Sea and adjacent waters, Fish. Res. 204 (2018) 448–457.

[38] R.W. Jabado, S.M. Al Ghais, W. Hamza, A.C. Henderson, The shark fishery in the United Arab Emirates: an interview based approach to assess the status of sharks, Aquat. Conserv.: Mar. Freshw. Ecosyst. 25 (6) (2015) 800–816.

[39] K.A.A. deGraft-Johnson, J. Blay, F.K.E. Nunoo, C.C. Amankwah, Biodiversity threats assessment of the Western Region of Ghana, The integrated coastal and fisheries governance (ICFG) initiative Ghana, 2010.

[40] J.O. Krakstad, C. Ekaete Isebor, O. Alvheim, Surveys of the Fish Resources of the Eastern Gulf of Guinea. Nigeria, Cameroon, São Tomé & Principe, Gabon and Congo. Survey of the Pelagic and Demersal Resources 9 June–20 July 2006, Institute of Marine Research, Bergen, Norway, 2006.

[41] J.O. Krakstad, N. Luyeye, C.E. Isebor, E. Lundsor, Surveys of the Pelagic Fish Resources of Congo, Gabon and Cabinda, Angola, Cruise reports "Dr. Fridtjof Nansen". Institute of Marine Research, Bergen, Norway, 2004.

[42] J.O. Krakstad, F. Vaz-Velho, B.E. Axelsen, A. Barradas, D. Zaera, H. Lutuba, Q. Fidel, Surveys of the Fish Resources of Angola No2 – Survey of the Pelagic Resources Cruise Report No 6/2007, Cruise reports "Dr. Fridtjof Nansen". Institute of Marine Research, Bergen, Norway, 2008.

[43] P.M. Kyne, R.W. Jabado, C.L. Rigby, M.A. Gore, C.M. Pollock, K.B. Herman, N. K. Dulvy, The thin edge of the wedge: extremely high extinction risk in wedgefishes and giant guitarfishes, Aquat. Conserv.: Mar. Freshw. Ecosyst. 30 (7) (2020) 1337–1361.

[44] P. Last, G. Naylor, B. Séret, W. White, M. de Carvalho, M. Stehmann (Eds.), Rays of the World, CSIRO publishing, 2016.

[45] J.M. Lawson, R.P. Pollom, C. Gordon, J. Barker, E.K.M. Meyer, H. Zidowitz, J. R. Ellis, G. Morey, S.L. Fowler, A. Bartoli, D.A. Jiménez, S.V. Fordham, R. Sharp, A. R. Hood, N.K. Dulvy, Global extinction risk and conservation of Critically Endangered angel sharks in the Eastern Atlantic and Mediterranean Sea, Int. Counc. Explor. Seas. J. Mar. Sci. 77 (2020) 12–29, https://doi.org/10.1093/icesjms/fsz222.

[46] R.H. Leeney, P. Poncelet, Using fishers' ecological knowledge to assess the status and cultural importance of sawfish in Guinea-Bissau, Aquat. Conserv.: Mar. Freshw. Ecosyst. 25 (3) (2015) 411–430.

[47] R.H. Leeney, N. Downing, Sawfishes in The Gambia and Senegal–shifting baselines over 40 years, Aquat. Conserv.: Mar. Freshw. Ecosyst. 26 (2) (2016) 265–278.

[48] M. Lteif, Biology, Distribution and Diversity of Cartilaginous Fish Species along the Lebanese Coast, Eastern Mediterranean (Doctoral dissertation), Université de Perpignan, 2015.

[49] M.J. Gelber, Plenty of Fish in the Sea? Shark Fishing and the Fin Trade in Ghana: A Biting Review (Master Degree Thesis). University of Florida, in Gainesville, FL, USA, 2018.

[50] M.S. Diop, J. Dossa, 30 Years of Shark Fishing in West Africa: Development of Fisheries, Catch Trends, and Their Conservation Status in Sub-regional Fishing Commission Member Countries, FIBA, 2011.

[51] S. Mehl, D. Zaera, J. Dias de Sousa Lopes, Surveys of the Pelagic Fish Resources of Gabon, Congo, DRC, Angola and Namibia. Part I. Gabon and Congo, Cruise reports "Dr. Fridtjof Nansen". Institute of Marine Research, Bergen, Norway, 2010.

[52] B. Meissa, D. Gascuel, Overfishing of marine resources: some lessons from the assessment of demersal stocks off Mauritania, ICES J. Mar. Sci. 72 (2) (2015) 414–427.

[53] A. Moore, B. Séret, R. Armstrong, Risks to biodiversity and coastal livelihoods from artisanal elasmobranch fisheries in a Least Developed Country: The Gambia (West Africa). Biodiversity and Conservation 28 (6) (2019) 1431–1450.

[54] A.B. Moore, Are guitarfishes the next sawfishes? Extinction risk and an urgent call for conservation action, Endanger. Species Res. 34 (2017) 75–88.
[55] M. Naderifar, H. Goli, F. Ghaljaie, Snowball sampling: a purposeful method of sampling in qualitative research, Strides Dev. Med. Educ. 14 (2017) 3.
[56] B. Newell, Status Review Report of Two Species of Guitarfish: Rhinobatos rhinobatos and Rhinobatos cemiculus, Report to National Marine Fisheries Service, Office of Protected Resources, 2017, p. 62.
[57] F.K.E. Nunoo, B. Asiedu, J. Olauson, G. Intsiful, Achieving sustainable fisheries management: a critical look at traditional fisheries management in the marine artisanal fisheries of Ghana, West Africa, J. Energy Nat. Resour. Manag. (JENRM) 2 (2015) 1.
[58] O. Hammer, D.A.T Harper, P.D. Ryan, PAST: paleontological statistics software package for education and data analysis, Version 2.03, Paleontol. Electron., vol. 4 (issue 1), 2001, 9. Encontrado em, 3.
[59] P.K. Ofori-Danson, D.B. Sarpong, U.R. Sumaila, F.K. Nunoo, B. Asiedu, Poverty measurements in small-scale fisheries of Ghana: a step towards poverty eradication, J.: Curr. Res. J. Soc. Sci. 5 (3) (2013) 75–90.
[60] R. Overå, Modernisation narratives and small-scale fisheries in Ghana and Zambia, Forum Dev. Stud. 38 (3) (2011) 321–343.
[61] P.M. Kyne, R.W. Jabado, Glaucostegus cemiculus, The IUCN Red List of Threatened Species 2019: e.T104050689A104057239, 2019. ⟨https://dx.doi.org/10.2305/IUCN.UK.2019-2.RLTS.T104050689A104057239.en⟩. (Accessed 28 January 2022).
[62] R. Afoakwah, M.B.D. Osei, E. Effah, A Guide on Illegal Fishing Activities in Ghana. USAID/Ghana Sustainable Fisheries Management Project. Coastal Resources Center, Graduate School of Oceanography, University of Rhode Island, Narragansett, RI. Prepared by the University of Cape Coast, Ghana. GH2014_SCI048_UCC, 2018, 64.
[63] R.H. Leeney, E. & Quayson, Short note: an assessment of the status of sawfishes and of guitarfish landings in artisanal fisheries in Ghana, Aquat. Conserv.: Mar. Freshw. Ecosyst.
[64] R.W. Jabado, E. Chartrain, M. Dia, G. De Bruyne, P. Doherty, D. Derrick, A.B. Williams, I. Seidu, G.H.L. Leurs, K. Metcalfe, A. Tamo, A. Soares, W.J. VanderWright, A. Ba, J. Dossa, M. Diop, Rhinobatos irvinei, The IUCN Red List of Threatened Species 2021: e.T161409A124479989, 2021. ⟨https://dx.doi.org/10.2305/IUCN.UK.2021-1.RLTS.T161409A124479989.en⟩. (Accessed 28 January 2022).
[65] R.W. Jabado, M. Dia, G. De Bruyne, A.B. Williams, I. Seidu, E. Chartrain, G.H.L. Leurs, A. Tamo, K. Metcalfe, P. Doherty, A. Soares, J. Dossa, W.J. VanderWright, D. Derrick, M. Diop, Rhinobatos albomaculatus, The IUCN Red List of Threatened Species 2021: e.T161320A124465045, 2021. ⟨https://dx.doi.org/10.2305/IUCN.UK.2021-1.RLTS.T161320A124465045.en⟩. (Accessed 28 January 2022).
[66] R.W. Jabado, N. Pacoureau, M. Diop, M. Dia, A. Ba, A.B. Williams, J. Dossa, L. Badji, I. Seidu, E. Chartrain, G.H.L. Leurs, A. Tamo, G. Porriños, W.J. VanderWright, D. Derrick, P. Doherty, A. Soares, G. De Bruyne, K. Metcalfe, Rhinobatos rhinobatos, The IUCN Red List of Threatened Species 2021: e. T63131A124461877, 2021. ⟨https://dx.doi.org/10.2305/IUCN.UK.2021-1.RLTS.T63131A124461877.en⟩. (Accessed 28 January 2022).
[67] M. Robillard, B. Séret, Cultural importance and decline of sawfish (Pristidae) populations in West Africa, Cybium 30 (4) (2006) 23–30.
[68] S.Y. Gulyugin, F.F. Litvinov, A.M. Sirota, The distribution and relative abundance of elasmobranch species along North-Western African shelf and slope (from Gibraltar to 16 N) as compared to retrospective data (70s–80s) and environment, CM 2006/D, 2006, 3.
[69] A. Saad, M. Ali, B. Séret, Shark explotation and conservation in Syria, in: N. Başusta, Ç. Keskin, F. Serena, S. Bernard (Eds.), International Workshop on Cartilaginous Fishes in the Mediterranean, Turkish Marine Research Foundation, Istanbul, Turkey, 2006, pp. 202–208.
[70] A. Sall, P. Failler, B. Drakeford, A. March, Fisher migrations: social and economic perspectives on the emerging shark fishery in West Africa, Afr. Identit. 19 (3) (2021) 284–303.
[71] A. Seck A., Y. Diatta,, M. Diop, O. Guélorget,, C. Reynaud, C. Capapé, Observations on the reproductive biology of the blackchin guitarfish, *Rhinobatos cemiculus* E. Geoffroy Saint-Hillaire, 1817 (Chondrichthyes, Rhinoabatidae) from the coast of Senegal (Eastern Tropical Atlantic). Scientia Gerundensis 27 (2004) 19–30.
[72] I. Seidu, D. van Beuningen, L.K. Brobbey, E. Danquah, S.K. Oppong, B. Séret, Species composition, seasonality and biological characteristics of Western Ghana`s elasmobranch fishery, Reg. Stud. Mar. Sci. (2022), 102338.
[73] I. Seidu, L.K. Brobbey, E. Danquah, S.K. Oppong, D. van Beuningen, M. Seidu, N. K. Dulvy, Fishing for survival: importance of shark fisheries for the livelihoods of coastal communities in Western Ghana, Fish. Res. 246 (2022), 106157.
[74] B. Séret, Rhinobatidae. Guitarfishes. pp. 1357–64, in: K. Carpenter, N. de Angelis (Eds.), The Living Marine Resources of the Eastern Central Atlantic. Volume 2. Bivalves, Gastropods, Hagfishes, Sharks, Batoid Fshes and Chimaeras. FAO Species Identifcation Guide for Fishery Purposes, FAO, Rome, 2016, pp. 665–1509.
[75] D.W. Sims, Differences in habitat selection and reproductive strategies of male and female sharks, Sex. Segreg. Vertebr. (2005) 127–147.
[76] O. Sosa-Nishizaki, E. García-Rodríguez, C.D. Morales-Portillo, J.C. Pérez-Jiménez, M. del Carmen Rodríguez-Medrano, J.J. Bizzarro, J.L. Castillo-Géniz, Fisheries interactions and the challenges for target and nontargeted take on shark conservation in the Mexican Pacific, Adv. Mar. Biol. (2020) 39–69.
[77] R.W. Stein, C.G. Mull, T.S. Kuhn, N.C. Aschliman, L.N.K. Davidson, J.B. Joy, G. J. Smith, N.K. Dulvy, A.Ø. Mooers, Global priorities for conserving the evolutionary history of sharks, rays, and chimaeras, Nat. Ecol. Evol. 2 (2018) 288–298, https://doi.org/10.1038/s41559-017-0448-4.
[78] J.D. Stevens, R. Bonfil, N.K. Dulvy, P.A. Walker, The effects of fishing on sharks, rays, and chimaeras (chondrichthyans), and the implications for marine ecosystems, ICES J. Mar. Sci. 57 (3) (2000) 476–494.
[79] M. Uerpmann, H.P. Uerpmann, Fish exploitation at Bronze Age harbour sites in the Arabian Gulf area, Paléorient (2005) 108–115.
[80] UNEP: MAP: RAC/SPA, Chondrichthyan Fishes of Libya: Proposal for a Research Programme, United Nations Environment Programme, Mediterranean Action Plan, Regional Activity Centre for Specially Protected Areas, Tunis, Tunisia, 2005, 31.
[81] B. Valadou, J.C. Brêthes, C.A.O. Inejih, Biological observations on five species of Elasmobranchs from the Banc d'Arguin National Park (Mauritania), Cybium: Int. J. Ichthyol. 30 (4) (2006) 313–322.
[82] S. Vannuccini, Shark Utilization, Marketing and Trade, Food & Agriculture Org, 1999.
[83] J. White, M.R. Heupel, C.A. Simpfendorfer, A.J. Tobin, Shark-like batoids in Pacific fisheries: prevalence and conservation concerns, Endanger. Species Res. 19 (3) (2013) 277–284.
[84] J. White, C.A. Simpfendorfer, A.J. Tobin, M.R. Heupel, Spatial ecology of shark-like batoids in a large coastal embayment, Environ. Biol. Fish. 97 (7) (2014) 773–786.
[85] W.T. White, Dharmadi, Species and size compositions and reproductive biology of rays (Chondrichthyes, Batoidea) caught in target and non-target fisheries in eastern Indonesia, J. Fish Biol. 70 (6) (2007) 1809–1837.
[86] H.F. Yan, P.M. Kyne, R.W. Jabado, R.H. Leeney, N.K. Davidson, D.H. Derrick, B. Finucci, R.P. Freckleton, S.V. Fordham, N.K. Dulvy, Overfishing and habitat loss drives range contraction of iconic marine fishes to near extinction, Sci. Adv. 7 (2021), eabb6026, https://doi.org/10.1126/sciadv.abb6026.
[87] J. Zar H.. Biostatistical analysis,5th, Upper Saddle River, NJ, 2010.