Scholars Academic Journal of Biosciences
Abbreviated Key Title: Sch Acad J Biosci
ISSN 2347-9515 (Print) | ISSN 2321-6883 (Online)
Journal homepage: https://saspublishers.com

OPEN ACCESS

N/A

Inventory and Dynamics of Fish Landings from Small-Scale Maritime Fisheries at the Fishing Port of the San-Pédro's Port (South-West, Côte d'Ivoire)

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DOI: 10.36347/sajb.2023.v11i10.002 | **Received:** 22.08.2023 | **Accepted:** 26.09.2023 | **Published:** 05.10.2023

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Abstract | **Original Research Article**

Knowledge of the fish fauna in Ivorian waters is of concern to both scientists and those responsible for developing the fishing industry. Indeed, the increasing intensification of the exploitation of fishery resources is raising real risks of regression and disappearance of certain species. With this in mind, a survey of fishing activities was carried out in the fishing port of San-Pédro between July and December 2021. The aim of this study was to take stock of the dynamics of fish landings from small-scale fishing in this fishing port. Sampling of landed fish was carried out between 08:00 and 12:00 in the morning in two campaigns according to the two seasons that prevail in the region, by visual differentiation in plastic containers followed by counting. Identification was carried out using the appropriate keys. The conservation status and vulnerability of the various specimens were determined according to IUCN criteria version 2023. The inventory showed that a total of 55 species of fish from 32 families and 14 orders were landed during the two study periods. These catches were dominated by the order Perciformes, which was the most diverse (56.36% of species) and the most preponderant (61.29% of individuals). Oceanodromous species dominated the catches during the long rainy season. On the other hand, benthic species were the most common during the long dry season. *Thunnus albacares* was the most abundant during the long dry season, while *Sardinella aurita* (26.8%) dominated during the long rainy season. The analysis of conservation status and vulnerability showed that 18 species of fish landed were of biological interest for conservation. The presence of endangered species such as *Rhinobatos cemiculus* means that fishermen need to be made more aware of the problem and their catches need to be monitored more closely in order to protect them.

Keywords: Dynamic, Fish landed; conservation status; fishing port; Autonomous Port of San Pedro; Côte d'Ivoire.

INTRODUCTION

Development projects in the town of San-Pédro, centred around the port, have led to heavy urbanisation of the town, with a population of around 390 654 (RGPH, 2021). This situation has led to an increased demand for protein, particularly from the fishing industry. This has led to an increase in fishing activities, especially tuna fishing beyond the maritime shelf (PASP, 2020). Knowledge of the fish fauna in Côte d'Ivoire's marine waters is of concern to both scientists and those responsible for developing the fishing industry. Indeed, the increasing intensification of the exploitation of fisheries resources in the marine environment poses real risks of regression and disappearance of certain species. With this in mind, an inventory of fishing activities was carried out in the fishing port of San-Pédro between July and December 2021. The aim of the study was to draw up an inventory of the dynamics of fish landings from small-scale fishing in this fishing port, with a view to assessing the extent to which sustainable management regulations are being taken into account by stakeholders in this sector.

MATERIALS AND METHODS

Study area

San-Pédro is located in the south-west of Côte d'Ivoire. It covers an area of 12,790 km², with a population of 390,654 (RGPH, 2021). The town is the capital of the Bas-Sassandra District and Region. The second largest port in Côte d'Ivoire, the Port Autonome de San-Pédro (PASP) is located on Côte d'Ivoire's south-western coastline bordering the Atlantic Ocean between 4° 44′ 41″ north, 6° 38′ 23″ west (Figure 1) (Horo &

Koffi, 2019). The region is also marked by a very high average hygrometry of 97 % and an average temperature of 25°C to 26°C (Allouko *et al*., 2022a). The San-Pédro port domain covers an area of around 2,000 hectares, 25% of which is currently occupied (PASP, 2020) (Figure 1).

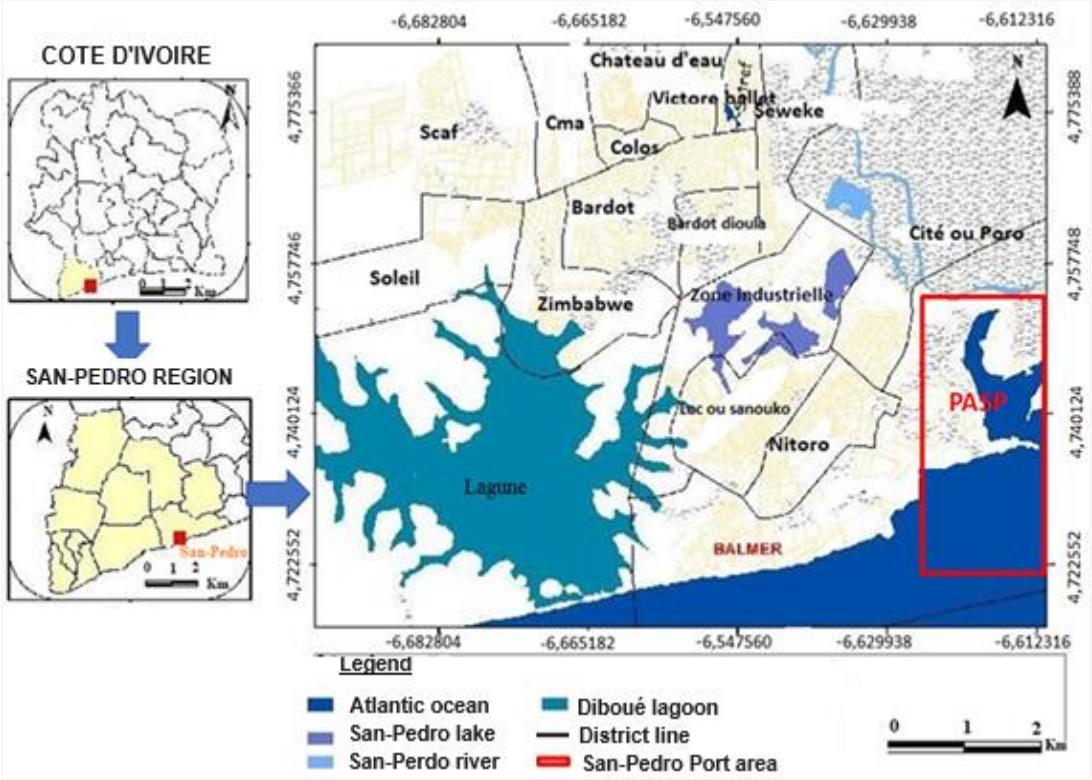

Figure 1: Location of San-Pedro's Port

Data Collection

Data collection on fishery products landed from small-scale fishing at the fishing port of the Port Autonome de San-Pédro (PASP) was carried out on a seasonal basis with two (2) sampling campaigns, one in July and the other in December during the dry and rainy seasons respectively.

Samples were collected from fishermen and retailers affiliated with the fishing port between 08:00 and 12:00 in the morning in two campaigns according to the two seasons that prevail in the region, by visual differentiation in plastic containers followed by counting. The various specimens of landed catches were collected in the jars by visual differentiation of the specimens and counted. The various specimens were then photographed and identified in the laboratory in order to determine the specific composition of the fish landed at the PASP fishing port.

The identification of the specimens encountered was carried out at the specific level using the works and determination keys proposed by Sonnenberg & Busch (2009) and Froese & Pauly (2023). The systematics of the species observed was updated using the Fishbase and Catalog of fishes links.

The conservation status and vulnerability of the various specimens were determined according to the criteria of the IUCN version 2023 (IUCN, 2023).

Data analysis

Species richness is the total number of species of artisanal fish landed during our study at the Autonomous Port of San-Pédro (Allouko *et al*., 2022b).

The occurrence of fish species is the ratio expressed as a percentage between the number of appearances of a species "i" per season and the total number of sampling seasons (Dajoz, 2000). It is used to obtain the constancy of a species in all the samples taken in the fishing port of San-Pédro (Paugy & Lévêque, 2006). The occurrence "F" is calculated according to the following formula:

$$F = 100 \times Fi / Ft$$

Where: Fi = number of occurrences of species "i" per season and Ft = total number of sampling seasons. The value of the occurrence makes it possible to determine two (2) categories of species: - F = 50%: by-catch species; - F = 100%: constant species.

The relative abundance of fish landed represents the ratio of the number of individuals of species (i) to the total number of individuals landed (Allouko *et al.* 2023). It reflects the numerical

importance of a species in the total number of fish landed at the fishing port of San-Pédro and is variable both in space and time. The formula is as follows:

$$Pi=100\times Ni/N.$$

Pi = Relative abundance of species i; Ni = Number of individuals of species i; N = Total number of individuals. In this study, relative abundance was used to determine ten (10) dominant species of fish landed at the fishing port of San-Pédro. These dominant species are those that represent at least 5% of the total number of fish landed during at least one of the two (2) seasons considered (Edia, 2008).

RESULTS AND DISCUSSION

RESULT

Specific compositions and occurrences of fish landed

A total of 55 species of fish were collected, divided into 32 families and 14 orders (Table I). The order of perciformes, with 31 species, i.e. 56.36% of the species richness, is the most diverse. On the other hand, the Batrachoidiformes, Gonorynchiformes, Lamniformes, Osteoglossiformes, Scorpaeniformes and Tetradoctiformes are less diverse, with one species each, or 0.02%.

The occurrences of fish species landed at the fishing port of San-Pédro are shown in Table I. Nine (9) species were consistently landed during the two climatic seasons. They represent 16.36% of species. On the other hand, the other 46 species, i.e. 83.64%, were recorded only once over the seasons.

The Perciformes order, with 2,078 individuals, accounted for 61.29% of all catches landed. It is followed by the Pleuronectiformes (388 individuals) and the Clupeiformes (370 individuals), which account for 11.44% and 10.91% of catches respectively. On the other hand, the Lamniformes order, with 5 individuals, or 0.15%, is less abundant in the catches landed.

Table I: Specific compositions and occurrences of artisanal marine fish landed at the fishing port of San-Pédro

Orders	Families	Species	IUCN	Vul	Habt	RS	DS	Occ (%)
Anguilliformes	Congridae	*Conger cinereus*	LC	TE (84 %)	BP	-	+	50
	Muraenidae	*Gymnothorax javanicus*	LC	TE (90 %)	BP	+	-	50
	Ophichthidae	*Quassiremus nothochir*	LC	ME (48 %)	B	-	+	50
Batrachoidiformes	Batracoïdidae	*Porichthys notatus*	LC	FM (28 %)	B	-	+	50
Beloniformes	Belonidae	*Belone belone*	LC	ME (49 %)	O	-	+	50
		Tylosurus crocodilus	LC	ME (47 %)	O	-	+	50
	Exocoetidae	*Cheilopogon pinnatibarbatus*	LC	M (39 %)	O	-	+	50
Carangiformes	Carangidae	*Carangoides chrysophrys*	LC	M (41 %)	BP	+	-	50
		Chloroscombrus chrysurus	LC	FM (28 %)	PC	+	-	50
Clupeiformes	Clupeidae	*Sardinella aurita*	LC	FM (29 %)	PC	+	+	100
Gonorynchiformes	Chanidae	*Chanos chanos*	LC	TE (90 %)	BP	-	+	50
Lamniformes	Lamnidae	*Isurus paucus*	EN	TE (90 %)	O	+	-	50
Myliobatiformes	Dasyatidae	*Fontitrygon margarita*	VU	TE (90 %)	B	+	-	50
		Pateobatis fai	VU	TE (90 %)	BP	+	-	50
		Dasyatis margarita	VU	TE (90 %)	B	-	+	50
	Mobulidae	*Mobula japonica*	NT	E (58 %)	BP	+	+	100
Osteoglossiformes	Notopteridae	*Notopterus notopterus*	LC	ME (49 %)	B	-	+	50
Perciformes	Bramidae	*Bramas Bramas*	LC	E (60 %)	PC	-	+	50
	Carangidae	*Seriola quinqueradiata*	LC	ME (52 %)	B	-	+	50
		Selene dorsalis	LC	F (25 %)	B	-	+	50
		Trachinotus ovatus	LC	ME (48 %)	PC	+	+	100
		Trachurus trachurus	VU	E (56 %)	O	+	-	50
	Haemulidae	*Pomadasys jubelini*	LC	M (36 %)	B	-	+	50
	Lobotidae	*Lobotes surinamensis*	LC	FM (34 %)	O	-	+	50
	Malancanthidae	*Branchiostegus japonicus*	LC	M (35 %)	B	-	+	50
	Polynemidae	*Eleutheronena tetradactylum*	NE	TE (90 %)	B	-	+	50
		Galeoides decadactylus	NT	FM (30 %)	B	+	-	50
	Scombridae	*Acanthocybium solandri*	LC	ME (46 %)	O	-	+	50
		Euthynnus affinis	LC	M (36 %)	PC	+	-	50
		Euthynnus alletteratus	LC	M (41%)	O	+	+	100
		Katsuwonus pelamis	LC	M (38%)	O	+	-	50
	Scombridae	*Sarda sarda*	LC	FM (33 %)	PC	+	-	50
		Scomberomorus niphonius	DD	FM (34 %)	PC	+	+	100
		Thunnus alalunga	LC	ETE (71 %)	O	+	+	100
		Thunnus albacares	LC	ME (46 %)	O	+	+	100
		Thunnus obesus	VU	E (56 %)	O	+	-	50
		Scomberomorus tritor	LC	M (38 %)	BP	+	-	50
	Serranidae	*Cephalopholis boenak*	LC	F (20 %)	BP	-	+	50
		Epinephelus aeneus	NT	E (58 %)	B	-	+	50

Orders	Families	Species	IUCN	Vul	Habt	RS	DS	Occ (%)
	Siganidae	*Siganus argentus*	LC	F (22 %)	B	-	+	50
	Sparidae	*Dentex angolensis*	NT	M (41 %)	B	+	-	50
		Pagellus bellottii	LC	ME (49 %)	BP	+	-	50
		Pagellus erythrinus	LC	M (40 %)	BP	+	+	100
	Sphyraenidae	*Sphyraena afra*	LC	TE (90 %)	PC	+	-	50
		Sphyraena novaehollandiae	NE	E (60 %)	O	-	+	50
	Sphyranidae	*Sphyraena sphyraena*	LC	TE (90 %)	O	+	-	50
		Pseudotolithus senegalensis	NE	M (42 %)	O	-	+	50
	Trichiuridae	*Trichiurus lepturus*	LC	ME (51 %)	BP	+	-	50
Pleuronectiformes	Cynoglossidae	*Cynoglossus canariensis*	NT	M (36 %)	B	+	+	100
		Cynoglossus senegalensis	NT	E (64 %)	B	+	-	50
	Soleidae	*Brachirus panoides*	LC	F (10 %)	B	-	+	50
Rajiformes	Rajidae	*Leucoraja erinacea*	LC	ME (50 %)	B	-	+	50
	Rhinobatidae	*Rhinobatos cemiculus*	CR	E (55 %)	B	-	+	50
Scorpaeniformes	Scorpaenidae	*Helicolenus dactylopterus*	LC	ETE (68 %)	B	-	+	50
Tetradoctiformes	Balistidae	*Balistes capriscus*	VU	ME (46 %)	O	+	-	50
Total = 14	**32**	**55**				**29**	**35**	

B = Benthic species, **PC** = Coastal pelagic species, **O** = Oceanodrone species, **BP** = Benthopelagic species, **DS**= Dry season, **RS** = Rainy season, **-** = No species, **+** = Species present. **Vul** = Vulnerability, **Occ** = Occurrences, **Hab** = Habitats, **UICN** = UICN Statut, **VU** = Vulnerable, **EN** = Threatened, **NT** = Near Threatened, **DD** = Data Missing, **CR** = Critical Threat Level, **LC** = Least Concern, **NE** = Not Assessed, **TE** = Very High, **ME** = Moderate to High, **FM** = Low Moderate, **M** = Moderate, **E** = High, **F** = Low, **ETE** = High to Very High.

Species with an occurrence score of 100 were collected during both seasons, whereas those with a score of 50 were recorded only once.

Relative abundance of dominant fish species

Specific richness analysis according to the two (2) climatic seasons indicates a high specific richness of landed fish (35 species) during the long dry season, compared with 29 species during the long rainy season. Nine (9) species are common to both (2) climatic seasons.

Figure 2 shows the seasonal distributions of the dominant species of fish landed at the fishing port of San-Pédro. *Thunnus albacares* (18.20%) and *Pagellus erythrinus* (12.89%) are more abundant during the dry season. *Chanos chanos* (16.69%), *Pomadasys jubelini* (12.13%) and *Sphyraena novaehollandiae* (11.83%) are only abundant during this season. In contrast, *Sardinella aurita* (28.82%) and *Thunnus alalunga* (15.08%) are abundant during the main rainy season. As for *Cynoglossus canariensis* (15.50%) and *Cynoglossus senegalensis* (10.73%), they are only abundant during this season. The abundance values between the main dry season and the main rainy season for the main species of fish landed did not vary significantly (Mann-Withney test, $P > 0.05$).

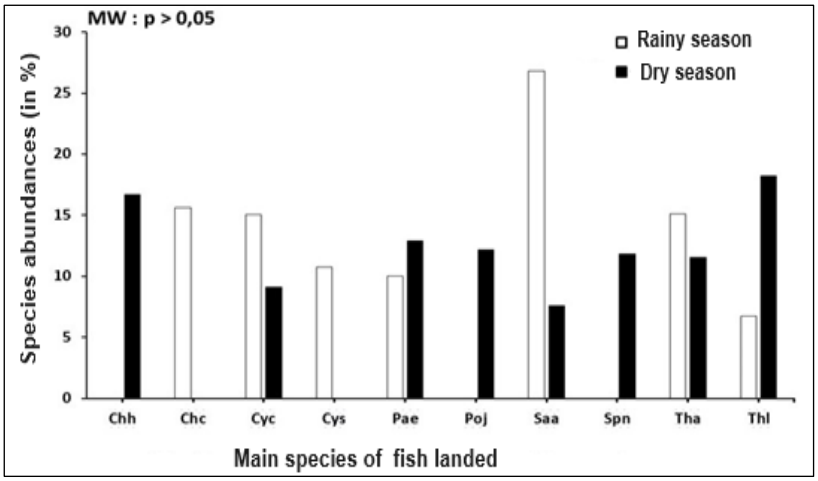

Figure 2: Seasonal distribution of the main species of fish landed at the fishing port of San-Pédro

DS = Dry season, **RS** = Rainy season. **Chc** = *Chloroscombrus chrysurus*, **Cyc** = *Cynoglossus canariensis*, **Poj** = *Pomadasys jubelini*, **Chh** = *Chanos chanos*, **Pae** = *Pagellus erythrinus*, **Cys** = *Cynoglossus senegalensis*, **Saa** = *Sardinella aurita*, **Spn** = *Sphyraena novaehollandiae*, **Tha** = *Thunnus alalunga* et **Thl** = *Thunnus albacares*

Analysis of fish habitat

Figure 3 shows the overall percentage proportions of fish species landed at the fishing port of San-Pédro according to their habitats. According to habitat, four types of species were landed at the PASP fishing port. These are: ocean-dwelling species, pelagic-

coastal species, bentho-pelagic species and benthic species (*Cf*. Table I). Benthic species are the most frequently observed (20 species, or 36%). However, the least observed are pelagic-coastal species (8 species, or 15%).

Data revealed analysis 10 main species classified into four habitats:

- Benthic species: Chloroscombrus chrysurus, Cynoglossus canariensis, Pomadasys jubelini ;
- benthopelagic species: *Chanos chanos, Pagellus erythrinus*;
- Pelagic-coastal species: *Cynoglossus senegalensis, Sardinella aurita*;
- Oceanodrom species: *Sphyraena novaehollandiae, Thunnus alalunga, Thunnus albacares*.

The seasonal proportions of fish species landed according to their habitats showed that Oceanodromous (9 species, i.e. 31.07%), benthopelagic (8 species, i.e. 27.5%) and pelagic-coastal (7 species, i.e. 24.13%) species are richer during the main rainy season. On the other hand, benthic species (16 species, or 45.72%) are more diverse during the long dry season. The species richness values between the long dry season and the long rainy season in the different habitat types did not vary significantly (Mann-Withney test, $P > 0.05$).

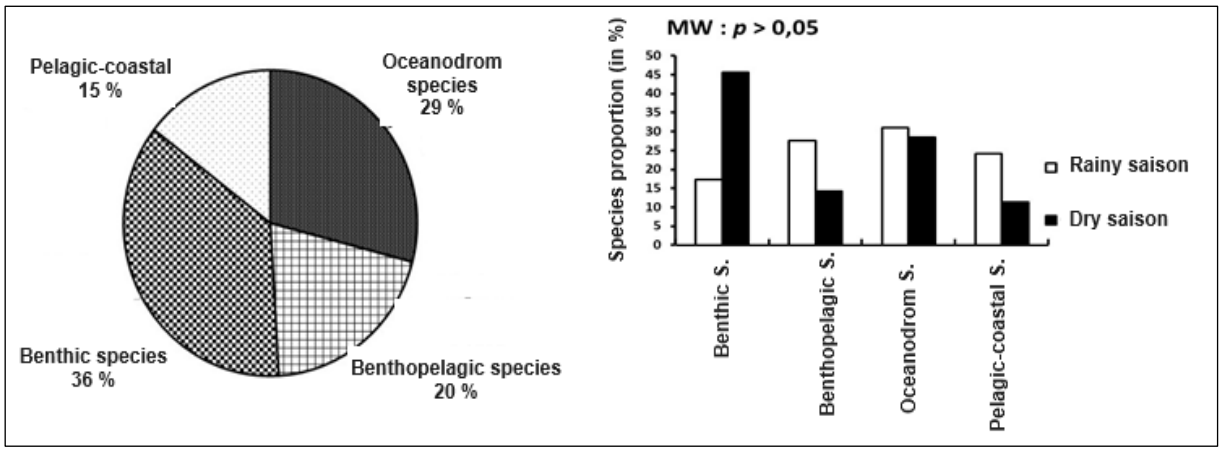

Figure 2: Overall percentage proportions of fish species from small-scale maritime fishing landed at the fishing port of San-Pédro according to their habitats

State of knowledge of the biological interest of landed fish

Analysis of the conservation status of the fish landed shows that 34 species (62%) are of least concern, 8 species (15%) are near threatened, 5 species (9%) are vulnerable (*Fontitrygon margarita, Trachurus trachurus, Pateobatis fai, Thunnus obesus, Balistes capriscus*), 4 species (7%) are endangered (*Eleutheronena tetradactylum, Dasyatis margarita, Isurus paucus, Pseudotolithus senegalensis*), and one species (*Rhinobatos cemiculus*) (2%) is critically endangered. 3 species (5%) were not assessed by the IUCN in 2023.

In terms of vulnerability, 24 species (43%) had a low vulnerability, 13 species (24%) had a low to moderate vulnerability, 10 species (18%) had a high vulnerability, 7 species (13%) had a moderate vulnerability and one species (*Rhinobatos cemiculus*) (2%) has a very high vulnerability of 95% (Figure 3).

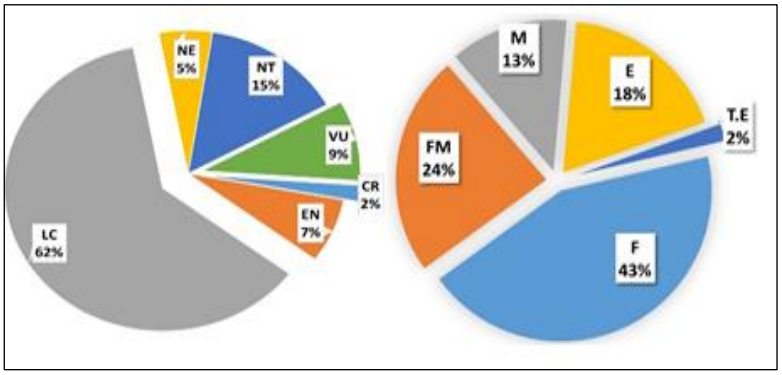

Figure 3: Proportions of fish species landed at the fishing port of San-Pédro according to their conservation status and vulnerability

NE = Not Evaluated, **LC** = Least Concern, **NT** = Near Threatened; **VU** = Vulnerable; **EN** = Endangered, **CR** = Critically Endangered; **F** = Low; **FM** = Low to Moderate; **E** = High; **TE** = Very High and **M** = Moderate.

DISCUSSION

In this study, the species richness of 55 fish species is higher than that reported by Tah *et al.,* (2015) who inventoried 43 species of fish landed in 2013 at the fishing port of the port of San-Pédro. This increase in the number of species can be explained by the size of the fishing area. Boats are going further and further out to sea to catch fish beyond the continental shelf (Koffié, 2010). Secondly, the fishing tools used are increasingly modern. This allows fishermen to diversify their catches. However, 19 species were not found in this study. This phenomenon is thought to be linked to the persistence of anthropogenic pressures on the marine environment, leading to the disappearance of species (Kouamélan *et al.,* 2003).

The seasonal distribution of the species richness of fish landed at the fishing port of San-Pédro indicates that the main rainy season is the period during which the lowest species richness was recorded (29 species). This low species richness could be explained by the difficult navigation during this period, when boats cannot sail long distances. In addition, *Sardinella aurita*, 28.82% of the catches, is very abundant during the main rainy season. This observation has already been made by Barry *et al.,* (2003), during the same period in the Senegalese fishing port. This result contradicts those of Laë *et al.*, (2013). These authors state that fish populations undergo significant seasonal variations due to ontogenetic migrations of species with a marine affinity, which explains the decrease in species richness during the dry season, although this corresponds to an outflow of reserve species, unlike during the rainy season. The predominance of benthic species in landings at the fishing port of San-Pédro is thought to be linked to the fact that fishermen off San-Pédro fish at depth near the coast (Koffié, 2010). In terms of the vulnerability and conservation status, the presence of critical and endangered species in landings in particular Rhinobatos cemiculus, which accounts for 2% of the species landed, is critically endangered and 95% highly vulnerable. The presence of this species in the landings would indicate non-compliance with regulations governing the capture of protected fish species by artisanal fishermen (Morin *et al*., 2010). Indeed, as fishermen and port control services are not always informed about the conservation status and vulnerability of species, they are not careful about the nature of the species caught.

CONCLUSION

The list of 55 species of fish landed at the fishing port of San-Pédro during this period is dominated by the order of perciformes. Benthic species were the most frequently observed. Oceanodromous species dominated catches during the main rainy season, while benthic species were the most common during the main dry season. *Thunnus albacares* was the most abundant during the long dry season, while Sardinella aurita dominated during the long rainy season. Five threatened species were observed, including endangered species (*Eleutheronena tetradactylum*, *Dasyatis margarita*, *Isurus paucus Pseudotolithus senegalensis)*, and critically endangered (*Rhinobatos cemiculus)*. In view of the presence of species of biological conservation interest, fishermen need to be made more aware of these species and catch controls need to be stepped up to safeguard them.

Acknowledgement

The authors would like to thank all the institutions that made this work possible, in particular the Autonomous port of San Pedro and the university Jean lorougnon Guédé authorities.

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