Sharks and rays basic indicators from the French purse seine and longline fisheries in the western Indian Ocean

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Abstract

Sharks and rays, including several endangered species, are common bycatch in most IOTC fisheries but remain largely data-poor. Available information on these taxa is generally derived from onboard observer programs. French observer programs for purse seine and longline fisheries were initiated in 2005 and 2007, respectively, with coverage steadily increasing to the present. Here, we provide an overview of the available data and present basic abundance indicators for sharks and rays caught by French purse seine and longline fleets operating in the western Indian Ocean. For purse seine fisheries, indicators include the number of individuals per set and the proportion of sets with zero catch. For longline fisheries, indicators are expressed as the number of individuals per 1,000 hooks and the proportion of sets with zero catch. A total of 26 and 34 elasmobranch species have been recorded as bycatch in French purse seine and longline fisheries, respectively. In purse seine fisheries, the most frequently encountered species are silky shark (*Carcharhinus falciformis*; FAL), oceanic whitetip shark (*Carcharhinus longimanus*; OCS), pelagic stingray (*Pteroplatytrygon violacea*; PLS), and devil rays (*Mobula mobular*; RMM). In longline fisheries targeting swordfish, the most common elasmobranchs are blue shark (*Prionace glauca*; BSH), pelagic stingray (PLS), silky shark (FAL), and oceanic whitetip shark (OCS), while other species occur at much lower frequencies. To date, standardized catch-per-unit-effort (CPUE) indices have only been developed for blue shark

(BSH) and oceanic whitetip shark (OCS) using French longline observer data, and silky shark (FAL) using purse seine observer data.

Keywords

Elasmobranchs | CPUE | Bycatch | Purse seine | Longline | Western Indian Ocean

1. Introduction

Abundance indices for non-target species, such as sharks and rays, are essential for stock assessments, particularly for species under the IOTC mandate. However, these species are generally data-poor, and available information is largely derived from onboard observer programs. In the absence of fishery-independent data, standardized abundance indices are typically estimated from catch and effort data collected in commercial fisheries. Such fishery-dependent indices must be standardized to account for variability in factors such as fishing effort, fishing strategies, and habitat overlap, in order to provide reliable inputs for stock assessment (Maunder and Punt, 2004).

French purse seine and longline fleets operate in the western Indian Ocean and have observer programs since 2005 and 2007, respectively. Observer coverage has progressively increased, currently reaching approximately 45% of fishing effort for purse seiners and 15% for longliners. To date, standardized CPUE time series for blue shark (BSH) and oceanic whitetip shark (OCS) have been developed using French longline observer data (Sabarros et al., 2017; 2021; 2025; Tellier and Sabarros, 2025), and a standardized CPUE series for silky shark (FAL) has been proposed based on French purse seine data (Kaplan and Tolotti, 2023).

In this paper, we provide an overview of the available observer data on sharks and rays from French purse seine and longline fisheries operating in the IOTC area. We present basic occurrence and abundance indicators, including the yearly number of individuals per set for the purse seine, and per 1,000 hooks for the longline, as well as the proportion of zero-catch events for the different species.

2. Material and methods

2.1. Data

We used data collected by sea-going observers on French purse seine vessels (Sabarros et al., 2025). Data were collected through EU *Data Collection Framework* since 2005, and industry-funded observer program OCUP (*Observateur Commun Unique Permanent*) since 2014 (Goujon et al., 2017).

The number and proportion of observed sets are shown in Figure 1. A total of 14147 fishing operations was monitored between 2005 and 2025 (Figure 3).

We also used data collected by sea-going observers on French longline vessels (Bach et al., 2008; Bach and Sabarros, 2022) and data collected by fishermen themselves called "self-reported data" (Bach et al., 2013). Data were collected through CAPPER (2007-2008) and EU *Data Collection Framework* since 2009. The coverage in number of hooks monitored is presented in Figure 2. A total of 6158 fishing operations was monitored between 2007 and 2025 (Figure 4).

2.2. Indicators

Nominal catch-per-unit-effort (CPUE) indices for shark and ray species are presented for the entire study period, expressed as the number of individuals per set for purse seine, and per 1,000 hooks for longline (Table 1; Table 2; Figure 5; Figure 7). Yearly occurrence rates and the proportion of zero-catch sets are also shown for a selected subset of species (Figure 6; Figure 8).

Specifically for purse seine, we provide the relative proportion of individuals found in association with floating objects (FOB) and free-swimming tuna schools (FSC) (Figure 9).

3. Results

A total of 26 shark and ray species was caught in French purse seine operations (Table 1; Figure 5). Silky shark (FAL) largely dominates elasmobranch bycatch in this fishery with a mean occurrence rate at about 5 individuals per set, far exceeding that of all other species, which remain below 0.06 individuals per set (Table 1; Figure 5; Figure 7). The proportion of sets with zero FAL catch varied widely over time (24-92%; Table 1) but showed an overall decreasing trend throughout 2005-2025 (Figure 7). In contrast, all other species were rare and consistently exhibited near-100% zero-catch (Table 1; Figure 5; Figure 7). Oceanic whitetip shark (OCS), the second most abundant species (0.06 individuals per set), also exhibited a zero-catch rate ranging between 86 and 100% (Table 1; Figure 5; Figure 7).

The occurrence of elasmobranchs in sets on floating objects (FOB) versus free-swimming tuna school sets (FSC) greatly varies between species (Figure 9). Species such as blue shark (BSH), bigeye thresher (BTH), bull shark (CCE), silky shark (FAL), unidentified Mobulidae (MAN), oceanic whitetip shark (OCS), pelagic stingray (PLS), porbeagle (POR), pelagic thresher (PTH), giant manta ray (RMB), unidentified requiem shark (RSK), unidentified lanternshark (SHL), scalloped hammerhead (SPL), unidentified hammerhead (SPN), unidentified ray (SRX), and unidentified thresher shark (THR) are more commonly in FOB sets, while smoothtail mobula (RMO), Chilean devil ray (RMT), bowmouth guitarfish (RRY), and smooth hammerhead (SPZ) mostly occur in FSC sets. A few species such as devil

ray (RMM), shortfin mako (SMA), and tiger shark (TIG), are equally found associated with both school types.

Blue shark (BSH) is the most common elasmobranch in the French longline fishery, with an overall 2.65 individuals per 1,000 hooks (Table 2; Figure 7) and a proportion of zero-catch ranging between 3 and 26 % (Table 2; Figure 8). The nominal CPUE trend of BSH is slightly decreasing (Figure 8). Occurrence-wise, BSH is followed by pelagic stingray (PLS) with 1.54 individuals per 1,000 hooks, silky shark (FAL) with 0.34, oceanic whitetip shark (OCS) with 0.27, and the other elasmobranch species are below 0.12 (Table 2; Figure 7). The nominal CPUE of PLS shows a slightly decreasing trend, while FAL and OCS exhibit increasing trends (Figure 8). The proportion of zero-catch for PLS, FAL, and OCS, are respectively 20-55 %, 55-95 %, and 62-92 % (Table 2; Figure 8).

4. Discussion

The number of shark and ray species is relatively important in both fisheries – 26 species for the purse seine, and 34 for the longline – but most species have a very low occurrence rate and can therefore be considered as very rare – < 0.06 individuals per purse seine set, and < 0.12 individuals per 1,000 hooks deployed in longline. A limited number of species have an occurrence rate greater than those numbers: FAL, OCS, PLS, and RMM in purse seine, and BSH, PLS, FAL, and OCS in longline fishing operations. These species are potential candidates for CPUE standardization.

BSH is frequent in longline fishing operations, especially night and shallow swordfish-targeting longline performed by French longliners based in Reunion Island (Sabarros et al., 2013) due to feeding habit and habitat occupation that are similar at night between BSH and swordfish. The nominal CPUE of BSH exhibits a slight decreasing trend. CPUE standardization for this species has been regularly performed (Sabarros et al., 2017; 2021; 2025) and confirms a consistent slight decreasing abundance trend since 2011 in the southwestern Indian Ocean (Sabarros et al., 2025).

OCS is among the most common elasmobranch species in both fisheries. It is still relatively rare as it appeared at best in 12.5 % of purse seine sets, mostly in association with tuna schools under floating objects, and 38 % of longline sets, depending on the year. The trend of its nominal CPUE in purse seine is unclear but might be slightly increasing while it is clearly increasing in longline fishing sets. This increase is consistent with the trend of its standardized CPUE presented last year (Tellier and Sabarros, 2025).

FAL is very frequent in purse seine fishing operation, especially under floating objects. Its occurrence rate in purse seine sets consistently increased across the period, especially since 2017 when the quota on yellowfin was implemented which resulted in French purse seiners increasing fishing effort on floating objects while targeting less free-swimming tuna schools (Figure 10). The nominal CPUE of FAL also increased in longline data, which is probably due an increased fishing effort in the

Mozambique Channel in the latter years of the period (Sabarros et al., 2025), which should be considered in the standardization process when it will be carried out. The standardized CPUE of FAL based on purse seine data, notably focusing on FOB sets, showed a consistent increasing trend throughout the period (Kaplan and Tolotti, 2023).

RMM is the fourth most common elasmobranch species in purse seine fishing operation but has a very low occurrence rate, and high zero-catch rate (96-100 %). Despite RMM being a priority species in IOTC, it is very unlikely that we could calculate a standardized CPUE index for this species considering how rare it is and the fact that it is equally found in floating object-associated and free-swimming tuna school sets.

PLS bycatch occurs in both fisheries but is particularly prevalent in swordfish-targeting longline operations (shallow and night fishing), just after BSH. Based on its prevalence and zero-catch rate, CPUE standardization based on longline data could be attempted. However, PLS is not a priority species for IOTC nor it even has to be assessed by IOTC.

5. Conclusion

Due to the very low prevalence of most shark and ray species in the French purse seine and longline fisheries, only a limited number of species are suitable for CPUE standardization. Based on French observer data, standardized CPUE time series have been developed for BSH and OCS using longline data, and for FAL using purse seine data. At this stage, CPUE standardization could be attempted for FAL using longline data, and PLS using observer data from both fisheries.

6. Acknowledgments

We thank the observers and captains that collected data through EU DCF, OCUP and CAPPER data collection programs.

7. References

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8. Tables

Table 1. Summary table of sharks and rays in purse seine with CPUE as number of individuals per set for the whole period 2005-2025 (overall) and range among years, as well as range of zero-catch.

FAO code	Scientific name	N	CPUE overall	CPUE range	Zero-catch range
FAL	*Carcharhinus falciformis*	70684	4.9904	0.583-8.103	24.09-91.67
OCS	*Carcharhinus longimanus*	771	0.0544	0-0.127	87.5-100
PLS	*Pteroplatytrygon violacea*	424	0.0299	0-0.187	86.67-100
RMM	*Mobula mobular*	188	0.0133	0-0.088	96.41-100
RSK	*Carcharhinidae*	141	0.01	0-0.071	98.37-100
RMV	*Mobula spp*	120	0.0085	0-0.073	96.67-100
RHN	*Rhincodon typus*	90	0.0064	0-0.062	93.75-100
RMT	*Mobula tarapacana*	58	0.0041	0-0.042	95.83-100
RMB	*Mobula birostris*	57	0.004	0-0.016	98.69-100
SKH	*Selachimorpha (Pleurotremata)*	38	0.0027	0-0.038	99.41-100
SMA	*Isurus oxyrinchus*	16	0.0011	0-0.006	99.41-100
BSH	*Prionace glauca*	14	0.001	0-0.007	99.33-100
RRY	*Rhina ancylostoma*	5	4e-04	0-0.003	99.74-100
THR	*Alopias spp*	5	4e-04	0-0.002	99.85-100
PTH	*Alopias pelagicus*	4	3e-04	0-0.002	99.83-100
SPZ	*Sphyrna zygaena*	4	3e-04	0-0.003	99.91-100
SRX	*Rajiformes*	4	3e-04	0-0.003	99.73-100
TIG	*Galeocerdo cuvier*	4	3e-04	0-0.002	99.75-100
MAN	*Mobulidae*	2	1e-04	0-0.001	99.91-100
SPN	*Sphyrna spp*	2	1e-04	0-0.003	99.74-100
BTH	*Alopias superciliosus*	1	1e-04	0-0.002	99.83-100
CCE	*Carcharhinus leucas*	1	1e-04	0-0.001	99.91-100
POR	*Lamna nasus*	1	1e-04	0-0.001	99.92-100
RMO	*Mobula thurstoni*	1	1e-04	0-0.001	99.9-100
SHL	*Etmopterus spp*	1	1e-04	0-0.003	99.73-100
SPL	*Sphyrna lewini*	1	1e-04	0-0.003	99.74-100

Table 2. Summary table of sharks and rays in longline with CPUE as number of individuals per set for the whole period 2005-2025 (overall) and range among years, as well as range of zero-catch.

FAO code	Scientific name	N	CPUE overall	CPUE range	Zero-catch range
BSH	*Prionace glauca*	21950	2.6489	2.006-5.147	2.59-26.44
PLS	*Pteroplatytrygon violacea*	12783	1.5426	1.081-3.566	20.42-55
FAL	*Carcharhinus falciformis*	2853	0.3443	0.042-1.049	55.74-95.8
OCS	*Carcharhinus longimanus*	2240	0.2703	0.079-0.514	62.2-91.81
CWZ	*Carcharhinus spp*	984	0.1187	0-0.309	80.96-100
SKH	*Selachimorpha (Pleurotremata)*	564	0.0681	0-0.461	84.72-100
MAK	*Isurus spp*	540	0.0652	0-0.146	84.46-100
SPN	*Sphyrna spp*	452	0.0545	0-0.402	90.16-100
SMA	*Isurus oxyrinchus*	326	0.0393	0-0.228	78.16-100
TIG	*Galeocerdo cuvier*	268	0.0323	0-0.071	91.76-100
THR	*Alopias spp*	160	0.0193	0-0.051	94.64-100
SPL	*Sphyrna lewini*	117	0.0141	0-0.264	89.5-100
PTH	*Alopias pelagicus*	86	0.0104	0-0.25	95-100
PSK	*Pseudocarcharias kamoharai*	79	0.0095	0-0.171	87.36-100
BTH	*Alopias superciliosus*	63	0.0076	0-0.043	95.08-100
MAN	*Mobulidae*	60	0.0072	0-0.016	98.12-100
SPZ	*Sphyrna zygaena*	53	0.0064	0-0.111	88.52-100
ISB	*Isistius brasiliensis*	26	0.0031	0-0.012	98.26-100
RMM	*Mobula mobular*	23	0.0028	0-0.043	95.99-100
AML	*Carcharhinus amblyrhynchos*	22	0.0027	0-0.861	72.22-100
BLR	*Carcharhinus melanopterus*	17	0.0021	0-0.054	94.44-100
RMV	*Mobula spp*	17	0.0021	0-0.01	98.85-100
RMB	*Mobula birostris*	13	0.0016	0-0.016	98.17-100
LMA	*Isurus paucus*	7	8e-04	0-0.008	99.35-100
POR	*Lamna nasus*	6	7e-04	0-0.011	99.64-100
RAJ	*Rajidae*	6	7e-04	0-0.054	94.44-100
RMT	*Mobula tarapacana*	4	5e-04	0-0.004	99.52-100
ALS	*Carcharhinus albimarginatus*	3	4e-04	0-0.014	98.36-100
BRO	*Carcharhinus brachyurus*	3	4e-04	0-0.005	99.59-100
OSF	*Stegostoma fasciatum*	3	4e-04	0-0.005	99.54-100
CCE	*Carcharhinus leucas*	2	2e-04	0-0.003	99.78-100
CCP	*Carcharhinus plumbeus*	2	2e-04	0-0.002	99.78-100
SRX	*Rajiformes*	2	2e-04	0-0.002	99.78-100
SSQ	*Zameus squamulosus*	1	1e-04	0-0.002	99.76-100

9. Figures

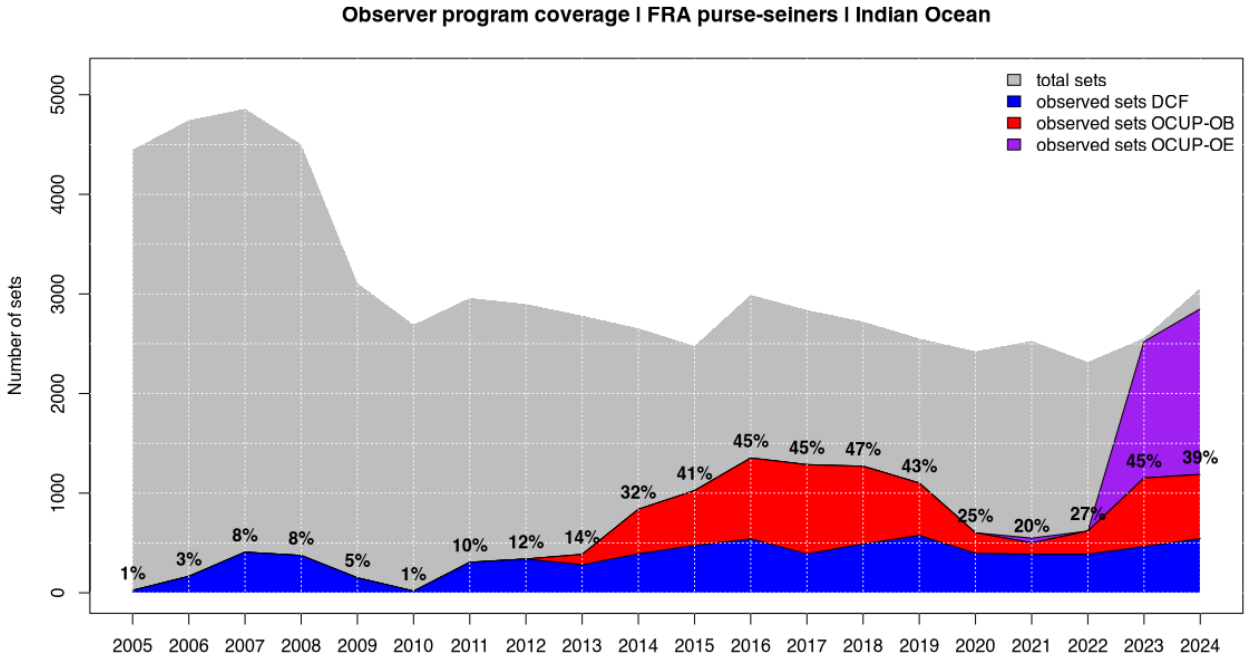

Figure 1. French purse seine observer coverage in number of sets between 2005 and 2024.

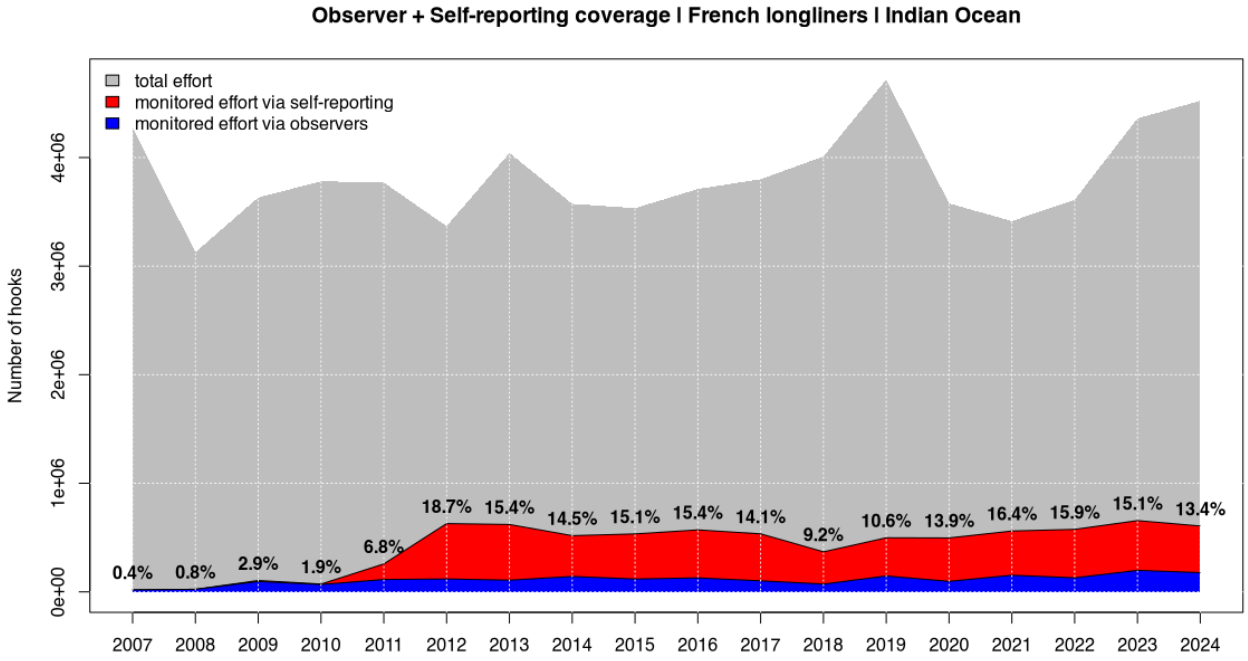

Figure 2. French longline observer and self-reporting effort coverage in number of hooks deployed between 2007 and 2024.

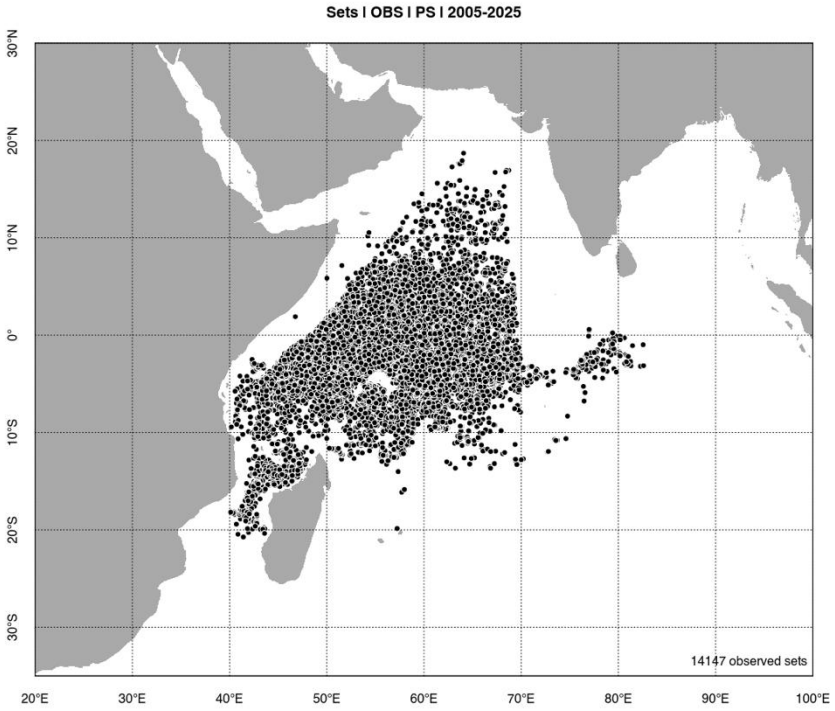

Figure 3. Distribution of French purse seine observed sets between 2005 and 2025.

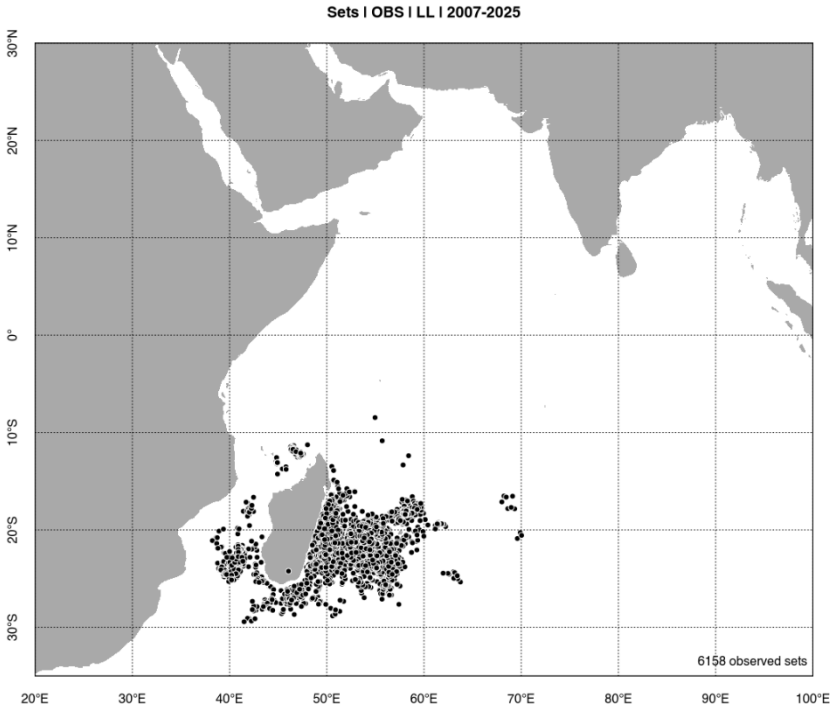

Figure 4. Distribution of French longline observed sets between 2007 and 2025.

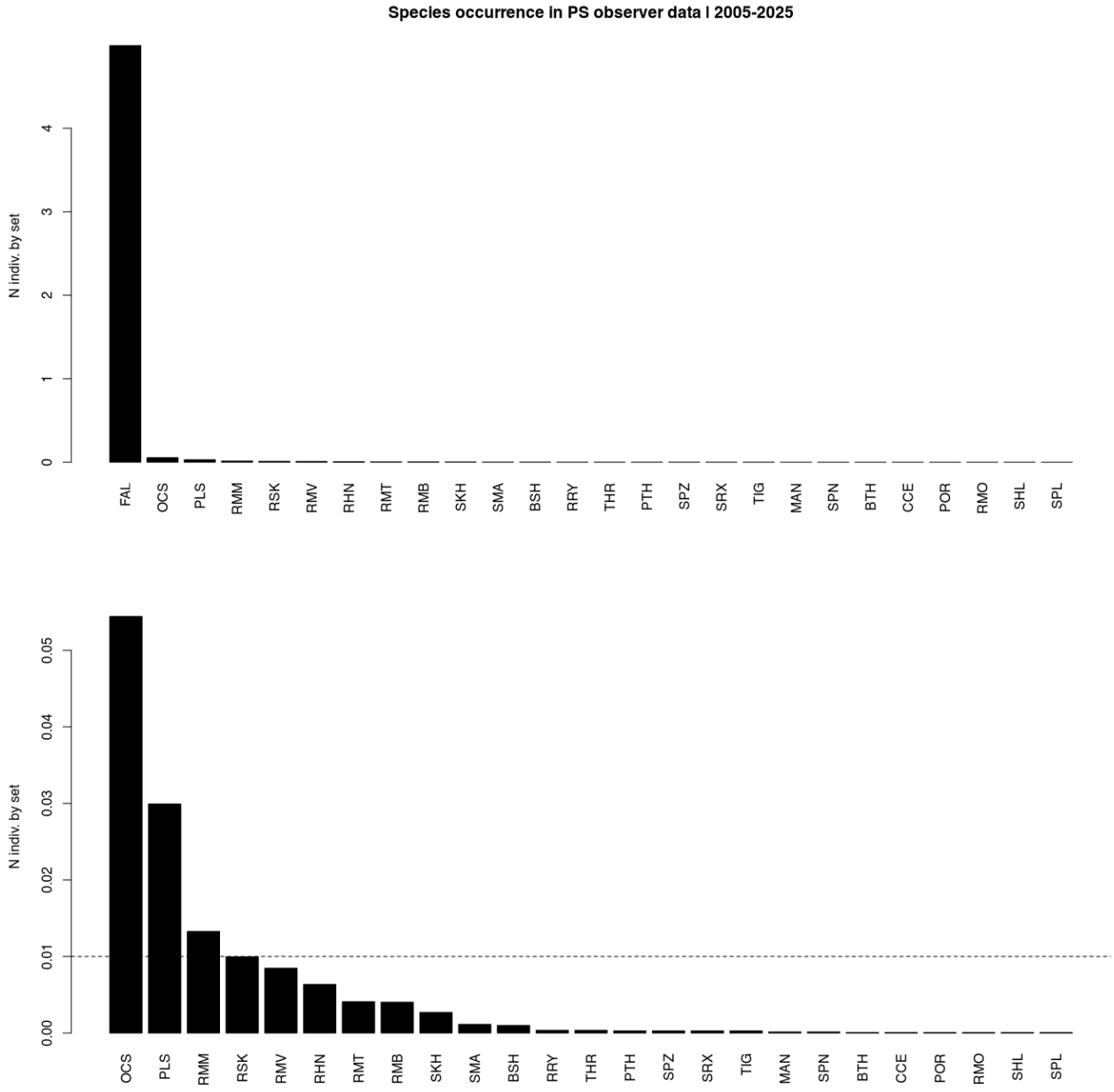

Figure 5. Sharks and rays occurrence in observed purse seine sets, including FAL (a) and excluding FAL (b).

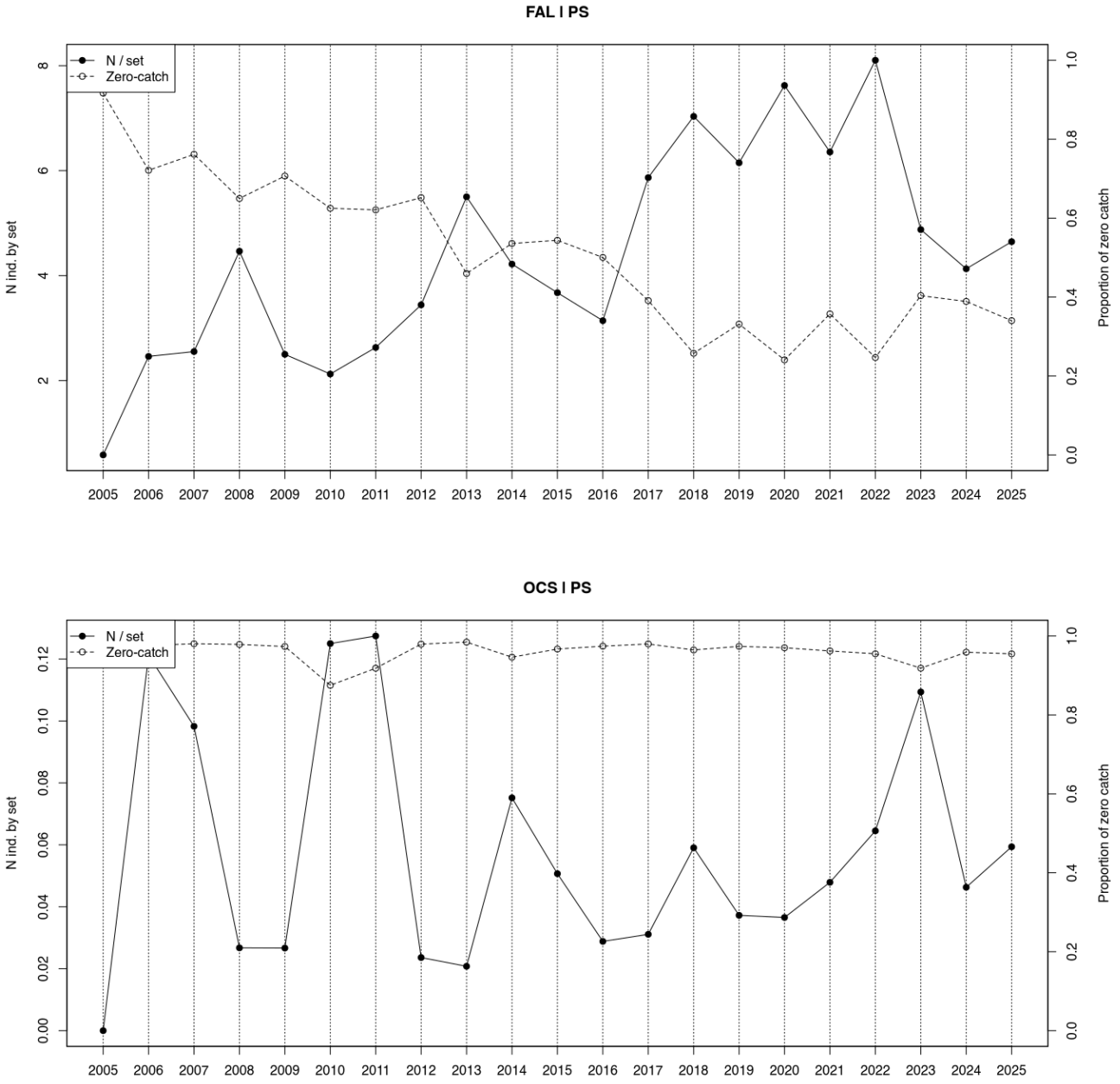

Figure 6. Sharks and rays indicators based on purse seine observer data (1 of 2).

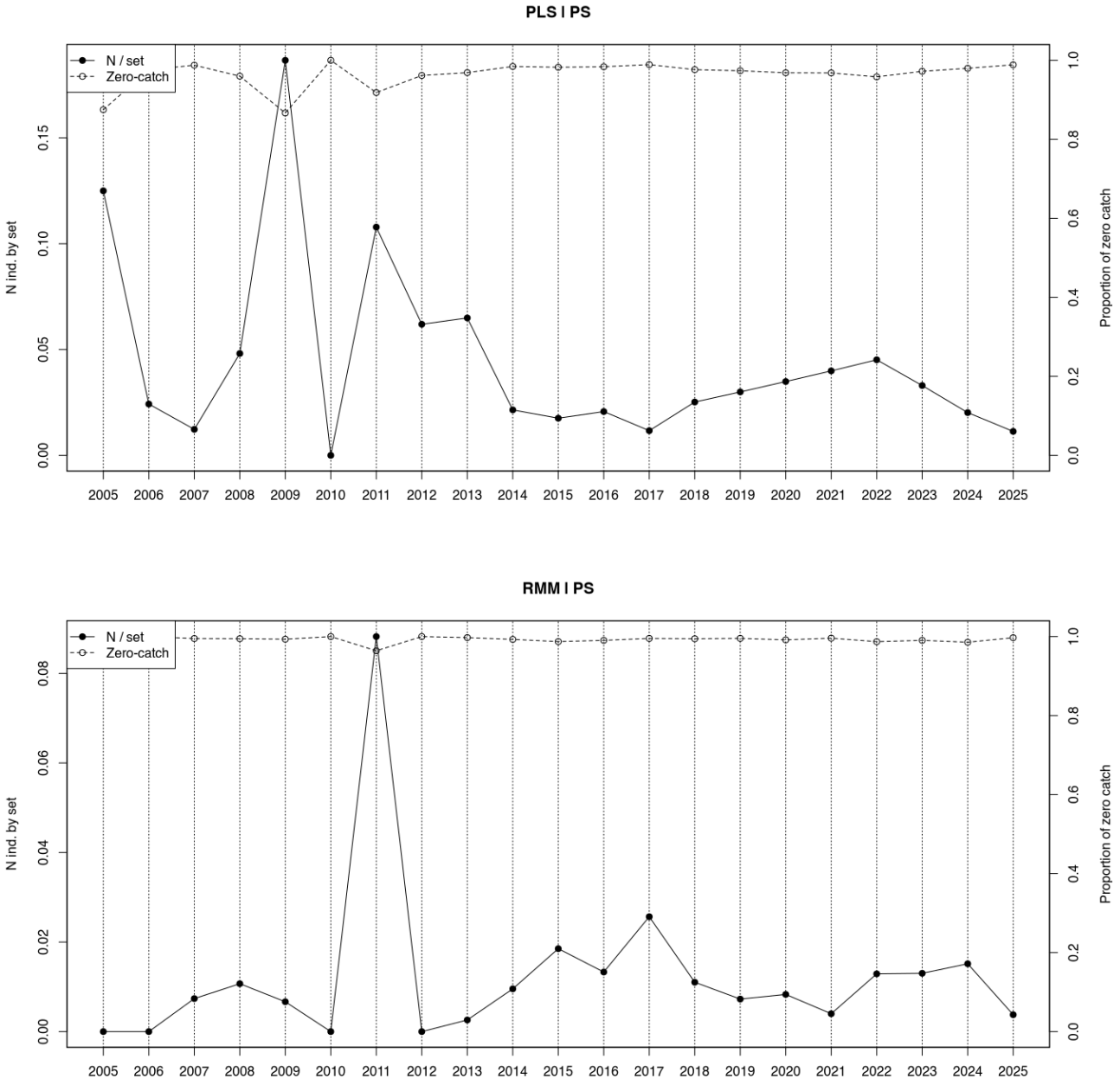

Figure 6. Sharks and rays indicators based on purse seine observer data (2 of 2).

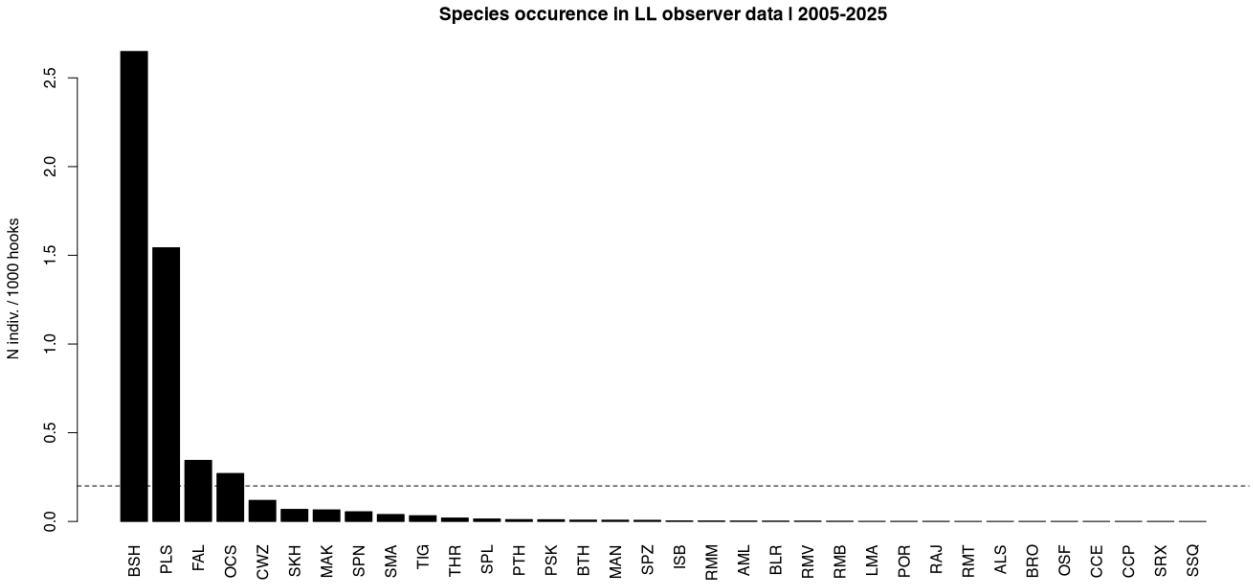

Figure 7. Sharks and rays occurrence in observed longline sets.

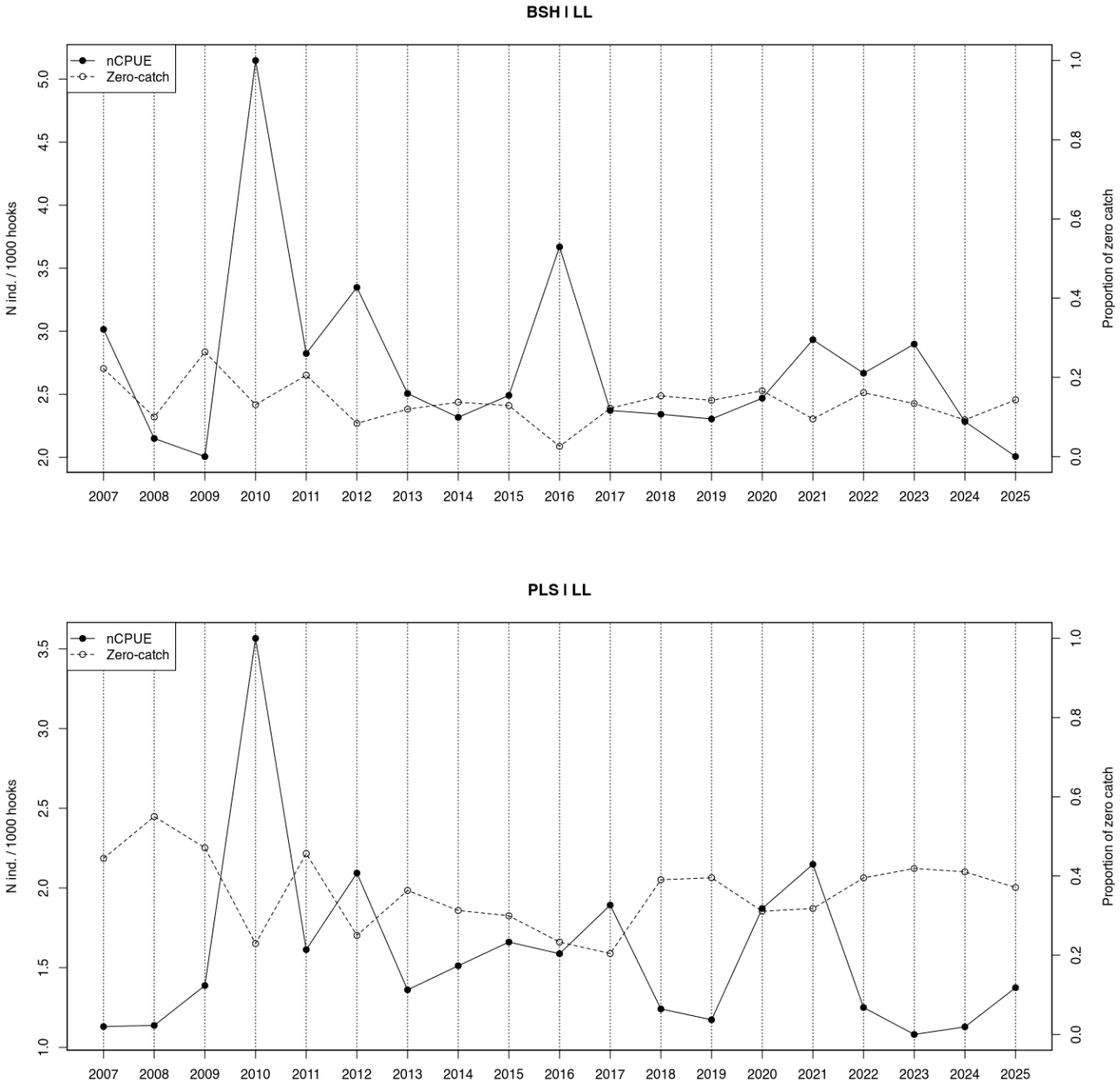

Figure 8. Sharks and rays indicators based on longline observer data (1 of 2).

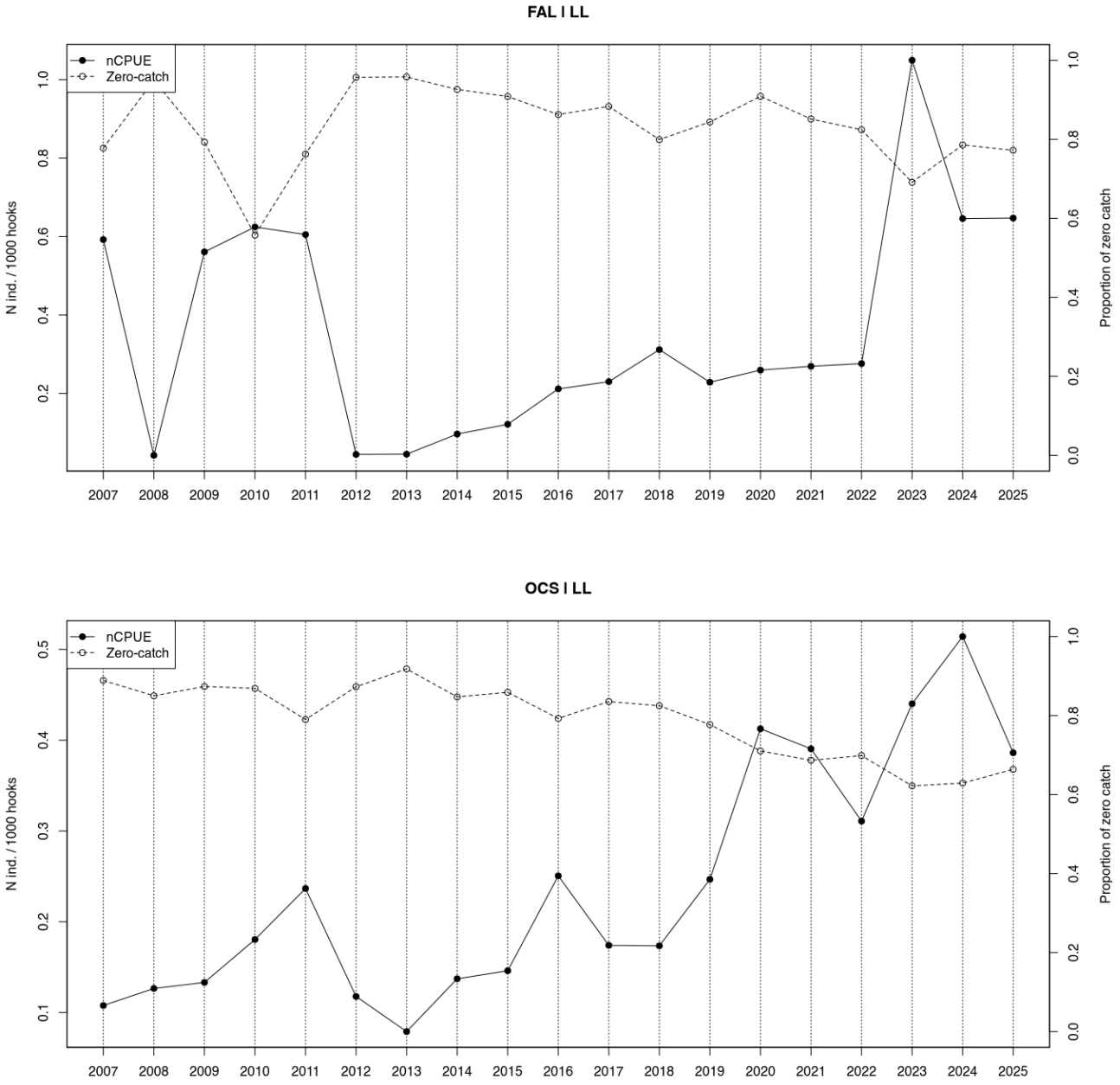

Figure 8. Sharks and rays indicators based on longline observer data (2 of 2).

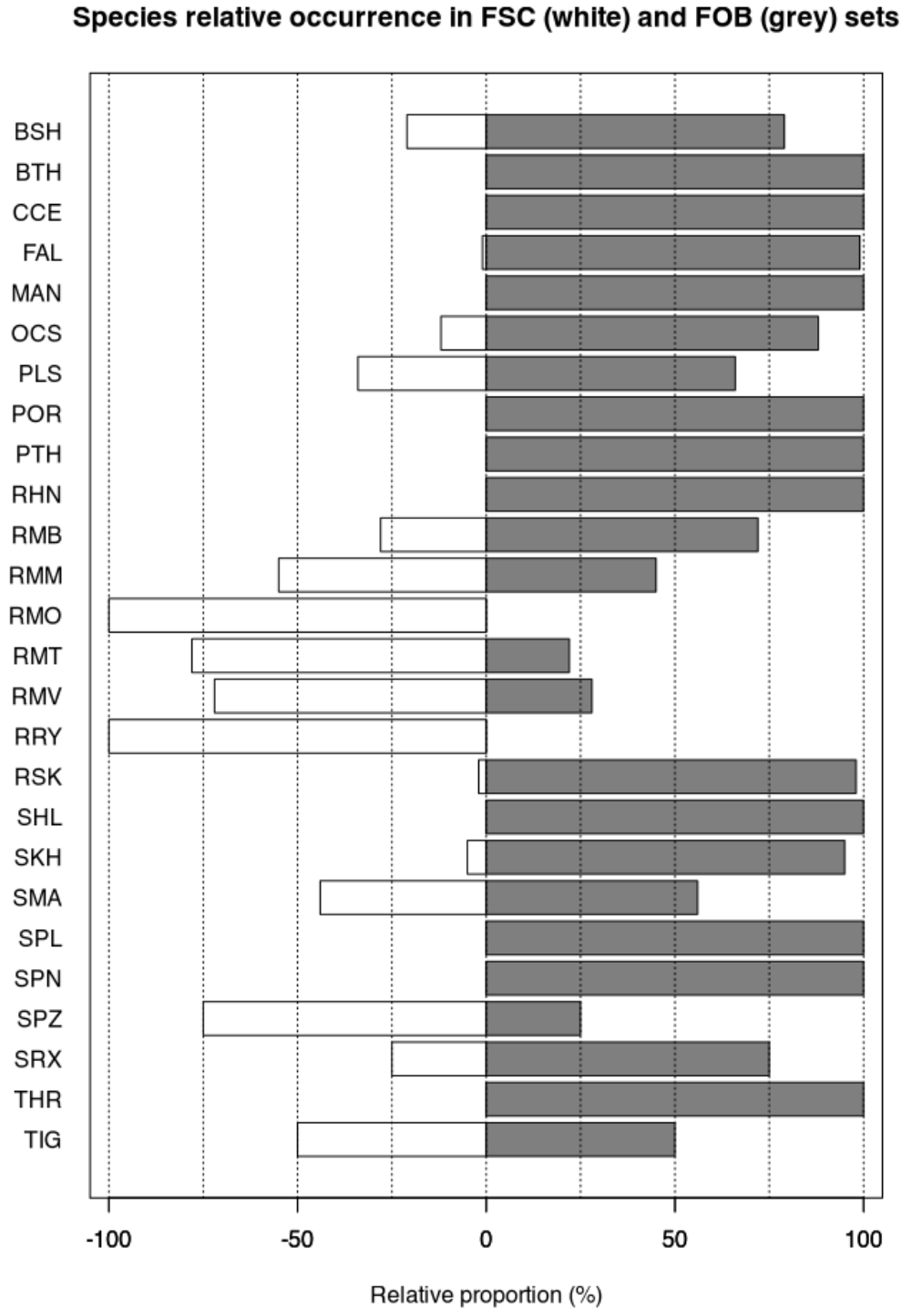

Figure 9. Sharks and rays occurrence relative to purse seine school type.

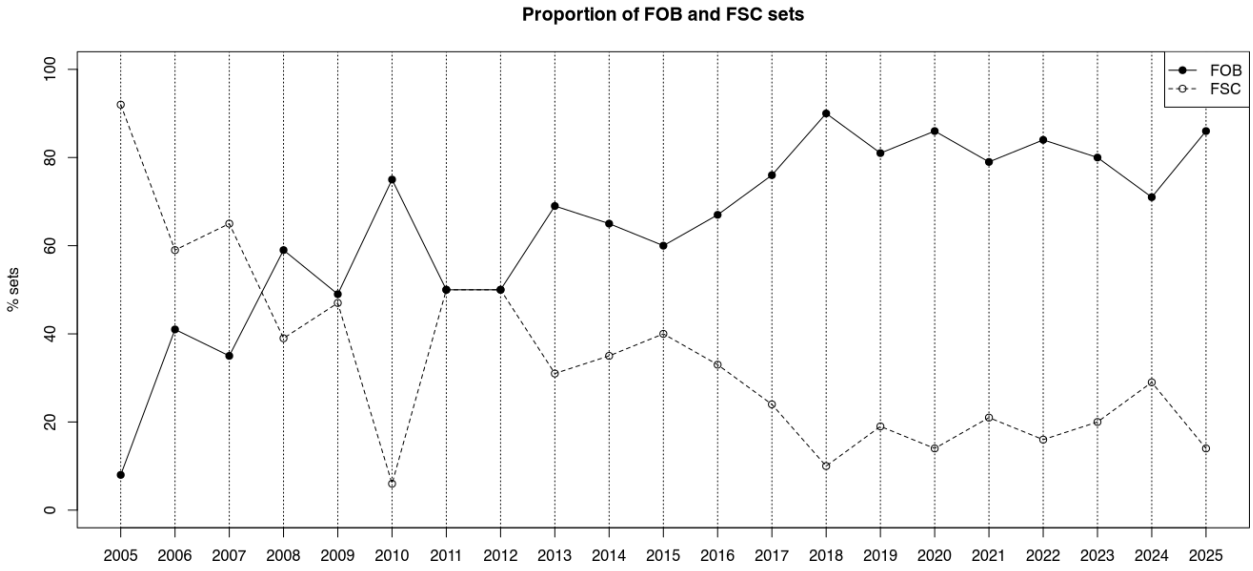

Figure 10. Proportion of FOB and FSC sets in the French purse seine fishery between 2005 and 2025.