EXPLORATORY ANALYSIS OF BLUE SHARK CATCHES, *PRIONACE GLAUCA* (LINNAEUS, 1758) IN THE SPANISH MEDITERRANEAN WATERS

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SUMMARY

This study analyses information on blue shark catches from the longline fleet operating in Spanish Mediterranean waters. Data from observers and logbooks have been used to provide an exploratory analysis of the main factors associated with such catches. Catch per Unit of Effort (CPUE) has been calculated as the number of individuals caught per thousand hooks. Differences in catches and CPUEs have been observed for the different types of longline used, as well as spatio-temporal patterns. In addition, basic biological information on the BSH caught is provided. Further analysis can provide more accurate information on important aspects such as inter- and intra-annual variation in catches and identification of potential areas of higher concentration of catches of BSH.

RÉSUMÉ

Cette étude analyse des informations sur les captures de requin peau bleue réalisées par la flottille palangrière opérant dans les eaux espagnoles de la Méditerranée. Les données des observateurs et des carnets de pêche ont été utilisées pour fournir une analyse exploratoire des principaux facteurs associés à ces captures. La capture par unité d'effort (CPUE) a été calculée en tant que nombre de spécimens capturés par mille hameçons. Des différences dans les captures et les CPUE ont été observées pour les différents types de palangre utilisés ainsi que des schémas spatio-temporels. Ce document fournit également des informations biologiques de base sur les BSH capturés. Une analyse plus approfondie peut apporter des informations plus précises sur certains aspects importants, comme la variation inter-annuelle et intra-annuelle des captures et l'identification des zones potentielles de plus forte concentration de captures de BSH.

RESUMEN

Este estudio analiza la información sobre las capturas de tiburón azul de la flota palangrera que opera en aguas del Mediterráneo español. Se han utilizado los datos de los observadores y de los cuadernos de pesca para proporcionar un análisis exploratorio de los principales factores asociados a dichas capturas. La captura por unidad de esfuerzo (CPUE) se ha calculado como el número de ejemplares capturados por cada mil anzuelos. Se han observado diferencias en las capturas y las CPUE para los distintos tipos de palangre utilizados, así como patrones espaciotemporales. Además, se ofrece información biológica básica sobre el tiburón azul capturado. Un análisis más detallado puede proporcionar información más precisa sobre aspectos importantes como la variación interanual e intraanual de las capturas y la identificación de posibles zonas de mayor concentración de capturas de tiburón azul.

KEYWORDS

Prionace glauca; Spanish Mediterranean; catch; CPUE

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1. Introduction

Prionace glauca (Linnaeus, 1758) is a pelagic shark with a wide geographical distribution that occurs circumglobally in temperate and tropical waters (Mucientes *et al.,* 2023). Nowadays the blue shark (BSH) is mostly a bycatch of tuna and swordfish longline fisheries (Coelho *et al.,* 2017). It has been identified globally as Near Threatened by the IUCN Red List of Threatened Species (Rigby *et al*., 2019), due to high levels of unregulated exploitation, despite being one of the species with the highest known population growth rates among pelagic sharks (Mucientes *et al*., 2023). Genetic studies have found significant differences between individuals sampled in the Atlantic Ocean and the Mediterranean Sea (Nikolic *et al.,* 2022), where steep historic declines have been reported with biomass declining by 99.78% in Spanish waters in 25 years (1979-2004) according to Ferreti *et al.,* 2008. The blue shark is therefore listed as Critically Endangered in the Mediterranean Sea based on a past decline of up to 90% over three generations resulting from ongoing overfishing (Sims *et al.,* 2016). In Spain the blue shark is considered a commercial species and reported catches in the Spanish Mediterranean have been decreasing since 2015, standing currently at below 50 tons annually (Fishery Statistics Database, Spanish Ministry of Agriculture, Fisheries and Food).

This study shows an exploratory analysis of blue shark catches in the Spanish Mediterranean waters.

2. Material and Methods

The main source of information used here is data from observers from 2007 to 2022 on-board longliners in the Spanish Mediterranean Sea from the Spanish Institute of Oceanography (IEO-CSIC). This dataset accounts for information on the fishing trips, sets and catches for the main longline gears used in the Spanish Mediterranean waters, which have been identified as follows: drifting surface longline targeting swordfish (LLHB_SWO), drifting surface longline targeting bluefin tuna (LLHB_BFT), drifting surface longline targeting albacore (LLALB_ALB), drifting surface longline targeting little tunny (LLHB_LTA), drifting semi-pelagic longline targeting swordfish (LLSP1_SWO) and finally bottom longline targeting swordfish (LLPB_SWO). In addition to the target species and the fishing depth these gears also differ in the number of hooks deployed and the time of the year when the fishery occurs (**Table 1**).

We also used Logbook data from 2020 to 2022 from the Spanish Ministry of Agriculture, Fisheries and Food, which includes information on the fishing activities. Fishing trips from logbooks have been assigned to one of the above-mentioned gears after interviewing the skippers about aspects of the fishing trip such as the target species, the fishing depth and the number of hooks deployed.

3. Results

3.1 Sampling

A total of 1,970 fishing trips have been monitored by observers from 2007 to 2022 (**Table 2**), which corresponds to 4,454 fishing sets (**Table 3**). The number of trips and sets monitored by the observers varied depending on years and gears.

The spatial distribution of the fishing sets monitored changed across gears, with some sets corresponding to specific gears monitored located in specific areas (e.g., LLHB_LTA in the north-east coast of Spain) whereas other gears present a wider distribution through the Spanish Mediterranean coast (e.g., LLSP1_SWO) (**Figure 1**). Nevertheless, the spatial coverage of the fishing sets monitored by observers for each gear matches the spatial distribution of the fishing trips conducted by the longline fleet from 2020 to 2022 (**Figure 2**), which also shows a spatial segregation between different gears.

The majority of the trips conducted by the fleet from 2020 to 2022 corresponded to the gears targeting swordfish, both pelagic and semipelagic (LLHB_SWO and LLSP1_SWO) (**Table 4**), whereas the lowest number of trips conducted by the longline fleet corresponded to the drifting surface longline targeting little tunny (LLHB_LTA).

3.2 Blue shark catches

The number of fishing sets and individuals of blue shark caught monitored by observers varied across years and gears (**Tables 5** and **6**). Out of the 4,454 fishing sets monitored by the observers, blue shark was caught in 1,045 sets, which corresponds to a total of 2,964 individuals caught.

The highest percentage of sets with positive catches of blue shark from Observers data corresponded to the drifting surface longline targeting bluefin tuna (LLHB_BFT) and little tunny (LLHB_LTA), whereas the lowest percentage was observed in the bottom longline targeting swordfish (LLPB_SWO) (**Table 7**).

Spatial distribution of BSH shows areas with higher concentration of catches (**Figure 3**), such as the north-east coast of Spain, which also accounts for high effort covered by the observers and where catches of BSH occur for several gears like LLALB_ALB, LLHB_LTA and LLHB_SWO. High catches are also observed on the eastern part of the Alboran sea (south of Spain), where most effort is conducted with LLHB_SWO and LLSP1_SWO.

3.3 CPUE

The highest catches per unit of effort (number of individuals per thousand hooks) were observed with surface longline targeting bluefin tuna (LLHB_BFT) and little tunny (LLHB_LTA), whereas the lowest CPUEs were observed in the drifting semi-pelagic longline targeting swordfish (LLSP1_SWO) (**Table 7**, **Figure 4**).

There were inter-annual variations in the CPUE for the different gears sampled (**Figure 5**) with no clear temporal trend in the CPUE pattern. On the contrary, there were spatial variations in the CPUE for the different gears, which was higher in area 4_35000 (Alboran sea and south-east coast of Spain) and lowest in 1_35000 (waters around Balearic Islands) with intermediate CPUE values in area 1_40000 (north-east coast) for several gears like the surface longline targeting swordfish (LLHB_SWO) and the semi-pelagic longline targeting swordfish (LLSP1_SWO) (**Figure 6**).

3.4 Biological aspects of BSH catches

The largest individuals of BSH were caught with the semi-pelagic longline targeting swordfish (LLSP1_SWO), with a median of 150 cm and the smallest individuals were caught with surface longline targeting little tunny (LLHB_LTA) (**Figure 7**).

The majority of the individuals caught in sets monitored by observers were identified as indeterminate (**Table 8**). Out of the 2,964 individuals caught, 410 were identified as males, 341 as females and 2,213 as indeterminate. Per gear the proportion of sexed individuals indicated a very similar sex-ratio for males and females, being the proportion of males slightly higher than females.

In terms of the total length males were a bit larger than females and indeterminate individuals had the smallest length (both measured and estimated) (**Figure 8**).

4. Discussion

This paper provides an exploratory analysis of the catches and CPUE of BSH in the Spanish Mediterranean waters and shows preliminary results on the main aspects related to these catches such as the type of gear used, spatio-temporal patterns and basic biological information.

Among gears LLHB_BFT had the highest percentage of positive sets and observed CPUE of BSH, but this gear accounts for lower effort in terms of total effort conducted by the Spanish longline fleet in the Mediterranean. LLHB_SWO showed a smaller CPUE than LLHB_BFT, but it accounts for a much higher total amount of effort.

There is spatial segregation in the areas where the different gears are used, but also in the variation of the observed CPUEs. Further analysis should be conducted on the spatial patterns of the CPUE in order to detect possible areas of higher CPUE values. Nevertheless, this exploratory analysis shows the south-east coast and the north-east coast of Spain as potential areas of higher catches of BSH, whereas waters around the Balearic Islands seem to account for smaller catches.

Further work could be conducted to analyze potential temporal trends in the CPUE as well as estimations of annual indices of abundance and/or total estimated catches.

There were differences in the total length of the individuals caught by the different gears used, which might have impacts on the population. Further analysis can be conducted to elucidate the factors driving such differences in the size of the individuals caught.

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Table 1. Number of fishing trips per quarter of the year (Logbook data 2020-2022) and mean number of hooks deployed per set by gear.

Gear	1	2	3	4	Mean_n_hooks
LLALB_ALB	10	78	84	0	2,764
LLHB_BFT	93	117	59	43	2,463
LLHB_LTA	0	74	79	0	2,298
LLHB_SWO	0	368	411	991	2,200
LLPB_SWO	0	1	108	60	1,239
LLSP1_SWO	0	582	1562	280	2,069

Table 2. Number of fishing trips monitored from Observers data.

Gear	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total
LLALB_ALB	8	5	31	41	95	95	102	128	76	56	44	0	2	0	5	6	694
LLHB_BFT	0	0	2	0	1	0	0	0	0	0	0	19	0	0	0	0	22
LLHB_LTA	0	0	0	0	0	0	8	0	29	0	11	2	15	0	1	5	71
LLHB_SWO	17	8	55	77	8	40	25	23	8	12	32	6	9	15	17	31	383
LLPB_SWO	21	0	22	34	6	18	23	0	2	0	2	27	4	0	7	19	185
LLSP1_SWO	0	13	69	51	75	40	70	37	19	33	65	47	14	9	27	46	615
Total	46	26	179	203	185	193	228	188	134	101	154	101	44	24	57	107	1970

Table 3. Number of fishing sets monitored from Observers data.

Gear	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total
LLALB_ALB	15	21	49	73	124	206	161	159	120	98	70	0	3	0	15	25	1139
LLHB_BFT	0	0	2	0	3	0	0	0	0	0	0	21	0	0	0	0	26
LLHB_LTA	0	0	0	0	0	0	9	0	58	0	16	2	22	1	3	6	117
LLHB_SWO	69	35	95	99	12	122	53	47	14	42	135	20	15	31	26	77	892
LLPB_SWO	52	0	50	45	11	18	44	0	10	0	4	38	6	1	17	60	356
LLSP1_SWO	0	27	168	90	215	125	225	125	62	135	238	213	53	15	82	151	1924
Total	136	83	364	307	365	471	492	331	264	275	463	294	99	48	143	319	4454

Table 4. Number of fishing trips by gear from Logbook data and percentage of the total.

Gear	2020	2021	2022	Total	% of total
LLALB_ALB	17	102	53	172	3.4
LLHB_BFT	80	146	86	312	6.2
LLHB_LTA	83	14	56	153	3.1
LLHB_SWO	495	656	619	1,770	35.4
LLPB_SWO	13	33	123	169	3.4
LLSP1_SWO	430	1073	921	2,424	48.5
Total	1,118	2,024	1,858	5,000	

Table 5. Number of fishing sets monitored by Observers with positive catches of blue shark.

Gear	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total
LLALB_ALB	7	8	7	10	35	37	68	101	67	63	32	0	2	0	3	1	441
LLHB_BFT	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	14
LLHB_LTA	0	0	0	0	0	0	0	0	42	0	5	2	7	0	3	1	60
LLHB_SWO	1	7	13	28	4	29	18	13	4	14	40	15	6	6	13	33	244
LLPB_SWO	0	0	3	4	0	4	4	0	0	0	0	2	0	0	2	1	20
LLSP1_SWO	0	5	8	20	43	23	45	25	4	28	18	19	4	10	3	11	266
Total	8	20	31	62	82	93	135	139	117	105	95	52	19	16	24	47	1,045

Table 6. Number of individuals of blue shark by-caught from Observers data.

Gear	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total
LLALB_ALB	23	21	17	40	79	46	236	403	264	268	152	0	3	0	4	1	1,557
LLHB_BFT	0	0	0	0	0	0	0	0	0	0	0	84	0	0	0	0	84
LLHB_LTA	0	0	0	0	0	0	0	0	200	0	22	41	14	0	3	6	286
LLHB_SWO	1	10	34	66	9	57	35	18	5	34	95	97	13	12	32	86	604
LLPB_SWO	0	0	4	5	0	4	6	0	0	0	0	3	0	0	2	1	25
LLSP1_SWO	0	5	12	32	51	30	93	46	5	38	18	26	5	27	6	14	408
Total	24	36	67	143	139	137	370	467	474	340	287	251	35	39	47	108	2,964

Table 7. Total number of fishing sets monitored by observers, total number of fishing sets with positive catches of blue shark, percentage of sets with positive catches, mean CPUE (n/1000 hooks) and standard deviation of CPUE.

Gear	n_sets	n_sets_BSH	%_positive_sets	mean_CPUE	sd_CPUE
LLALB_ALB	1,139	441	0.39	1.3	1.43
LLHB_BFT	26	14	0.54	1.78	1.55
LLHB_LTA	117	60	0.51	1.6	1.29
LLHB_SWO	892	244	0.27	1.37	1.5
LLPB_SWO	356	20	0.06	1.13	0.73
LLSP1_SWO	1,924	266	0.14	0.83	0.98

Table 8. Total number of individuals caught by sex and gear and percentage of sexes.

Gear	males	females	indeterminate	Total	% males	% females	% indeterminate
LLALB_ALB	96	91	1,370	1,557	6	6	88
LLHB_BFT	2	1	81	84	2	1	96
LLHB_LTA	10	4	272	286	3	1	95
LLHB_SWO	130	99	375	604	22	16	62
LLPB_SWO	10	9	6	25	40	36	24
LLSP1_SWO	162	137	109	408	40	34	27

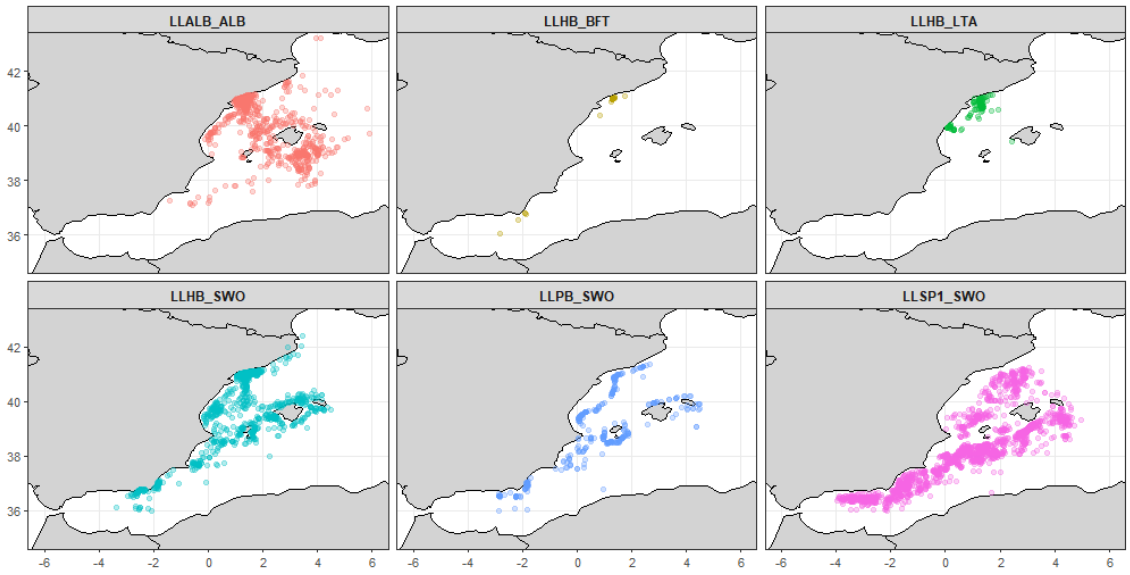

Figure 1. Fishing sets monitored by observers from 2007 to 2022 for the different gears used.

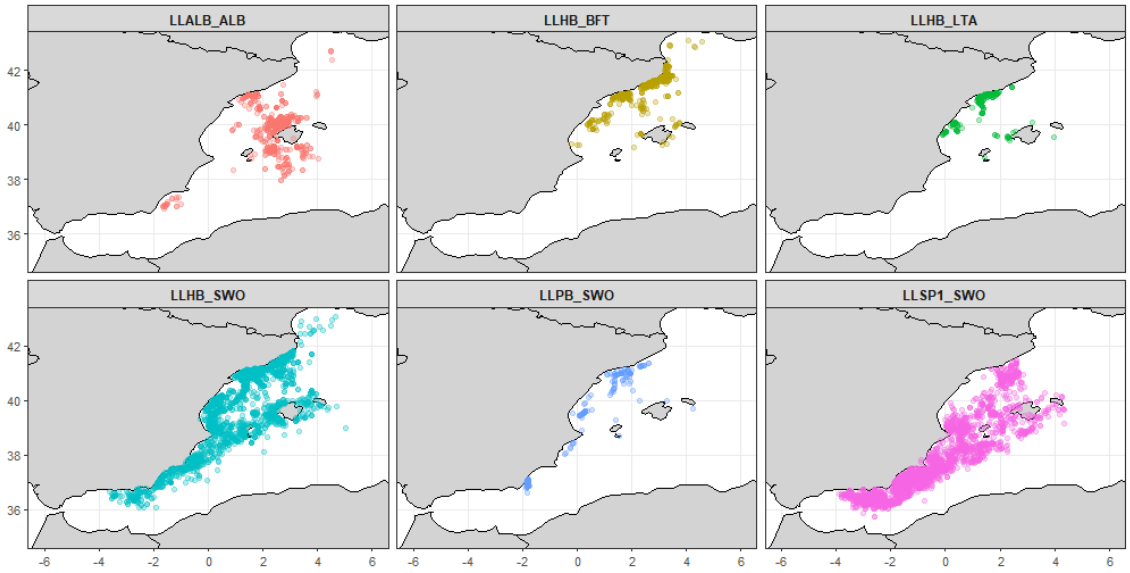

Figure 2. Mean position of the fishing trips conducted from 2020 to 2022 from Logbook data.

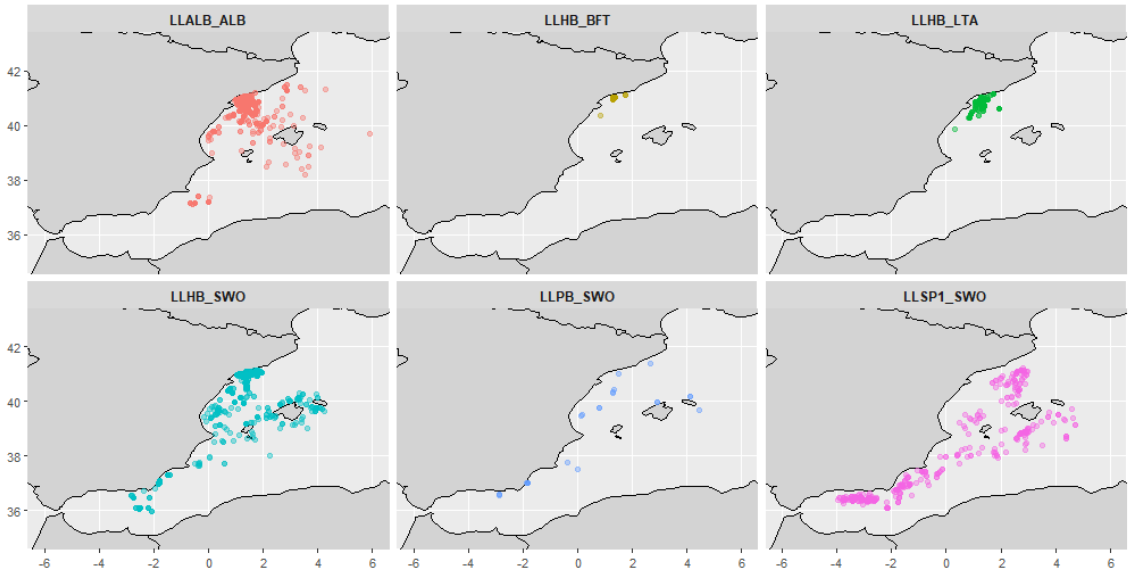

Figure 3. Catches of blue shark from Observers data (2007-2022) for the different gears used.

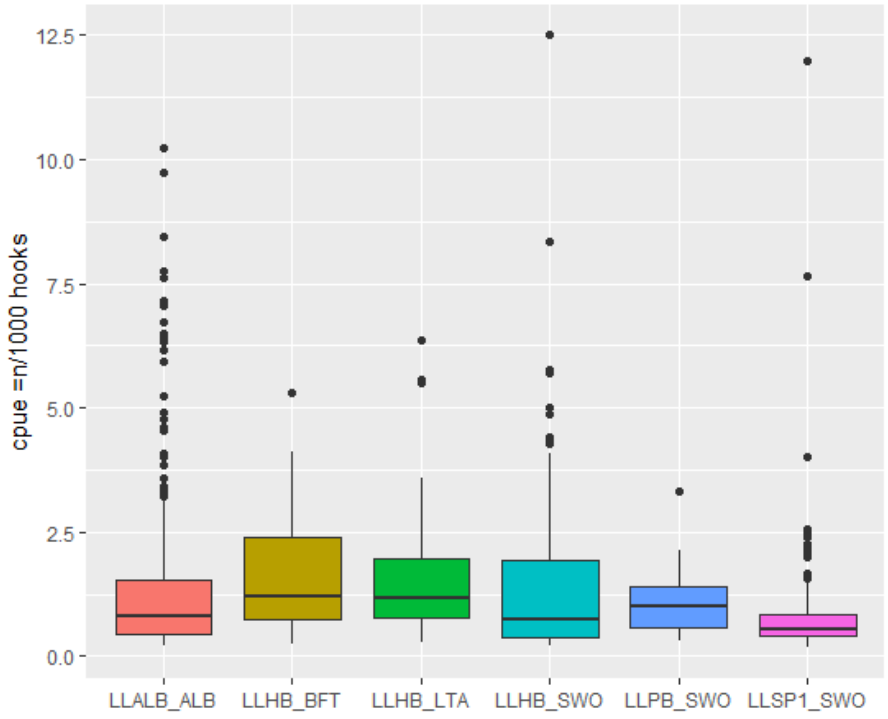

Figure 4. CPUE from Observers data for the different gears used.

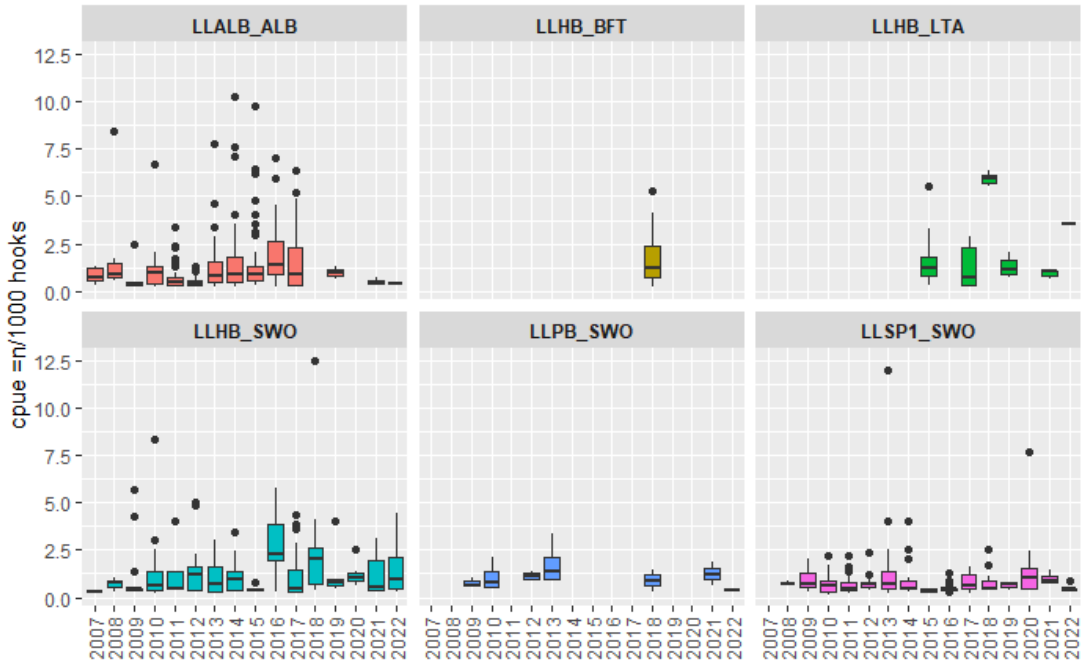

Figure 5. Time series of the CPUE from Observers data.

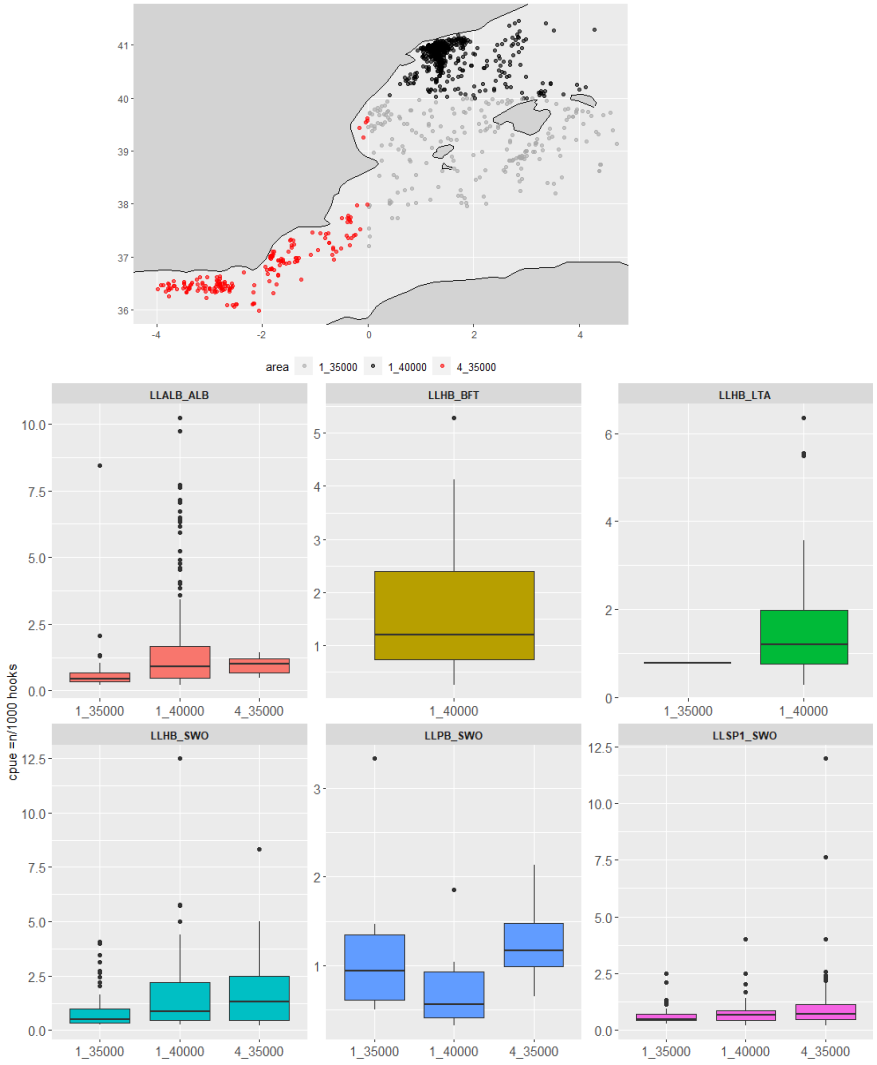

Figure 6. Spatial variation in CPUE per gear.

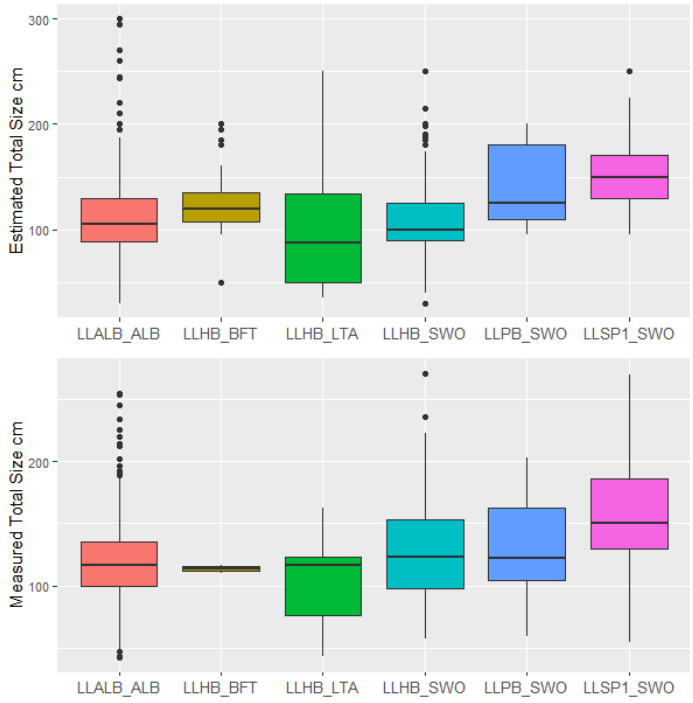

Figure 7. Total size of individuals caught (Observers data). Top figure: estimated size. Bottom figure: measured size.

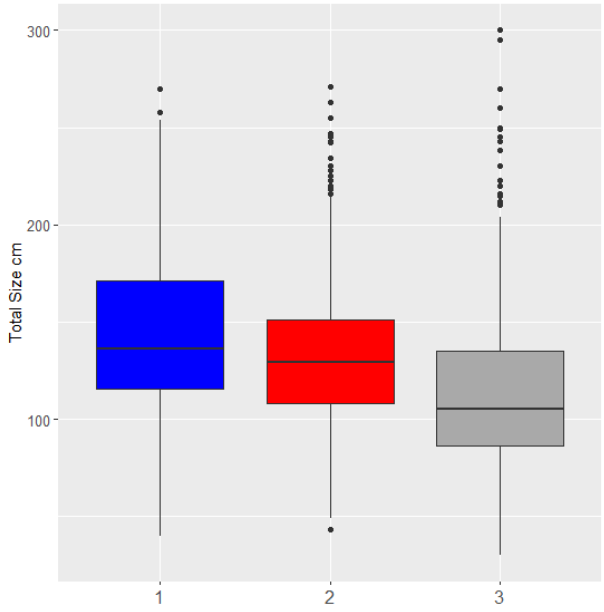

Figure 8. Total length of the individuals by sex. 1: male; 2: female; 3: indeterminate.