STATISTICS OF THE FRENCH PURSE SEINE FISHING FLEET TARGETING TROPICAL TUNAS IN THE ATLANTIC OCEAN (1991-2019)

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SUMMARY

This document presents an up-to-date summary of the French purse seine fleet targeting tropical tunas in the Atlantic Ocean. The statistics cover the period 1991-2019 and specifically focus on the activity of the last year of the fishery. Thus, in 2019, 10 French purse seiners operated in the eastern Atlantic Ocean. The total capacity weighted by the months of activity for each vessel is 9,946 t. The total nominal effort was of 2899 fishing days and 2278 sets. The total catch of the French component of the EU purse seine fleet of the Atlantic Ocean was 42,477 t, being composed of 41.3%, 45.1%, 11.5% of yellowfin, skipjack, and bigeye respectively and 2.1% of other species. The year 2019 is characterized by a general decreasing in catches, yield and CPUE, for the free school fishing mode. However, for the BET, an inverse pattern was observed along with a higher abundance of large individuals in catches on free school.

RÉSUMÉ

Ce document présente une synthèse actualisée de la flottille française de senneurs ciblant les thonidés tropicaux dans l'océan Atlantique. Les statistiques couvrent la période 1991-2019 et portent plus particulièrement sur l'activité de la dernière année de la pêcherie. Ainsi, en 2019, 10 senneurs français opéraient dans l'océan Atlantique Est. La capacité totale pondérée par les mois d'activité de chaque navire est de 9 946 t. L'effort nominal total était de 2.899 jours de pêche et de 2.278 calées. La prise totale de la composante française de la flottille de senneurs de l'Union européenne dans l'océan Atlantique était de 42.477 t, composée de 41,3% d'albacore, de 45,1% de listao et de 11,5% de thon obèse, et de 2,1% d'autres espèces. L'année 2019 est caractérisée par une diminution générale des captures, de la production et des CPUE, pour le mode de pêche sur banc libre. Cependant, en ce qui concerne le thon obèse, une tendance inverse a été observée ainsi qu'une plus grande abondance de grands spécimens dans les captures sur banc libre.

RESUMEN

Este documento presenta un resumen actualizado de la flota de cerco francesa que se dirige a los túnidos tropicales en el Atlántico. Las estadísticas cubren el periodo 1991-2019 y se centran específicamente en las actividades del último año de la pesquería. Por tanto, en 2019, 10 cerqueros franceses operaron en el Atlántico oriental. La capacidad total ponderada por los meses de actividad para cada buque es de 9.946 t. El esfuerzo nominal total fue de 2899 días de pesca y 2278 lances. La captura total del componente francés de la flota de cerco de la UE en el Atlántico fue de 42.477 t, compuesta por 41,3% de rabil, 45,1% de listado, 11,5% de patudo y 2,1% de otras especies. El año 2019 se caracteriza por un descenso generalizado en las capturas, el rendimiento y la CPUE para la pesca sobre bancos libres. Sin embargo, para el patudo se observó un patrón inverso junto con una mayor abundancia de ejemplares grandes en las capturas sobre bancos libres.

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Introduction

French tuna purse seiners have been fishing yellowfin tuna (*Thunnus albacares*, YFT), skipjack tuna (*Katsuwonus pelamis*, SKJ), and bigeye tuna (*Thunnus obesus*, BET) in the eastern Atlantic Ocean since the early 1960s. Tuna schools are harvested through two major fishing modes that result in different species and size composition of the catch, i.e. tunas in free-swimming schools (FSC) and tunas associated with drifting Floating OBjects (FOB) now predominated by artificial Fish Aggregating Devices (FAD) deployed by the fishing vessel. The French purse seine fishery has been monitored by the French National Research Institute for Sustainable Development (IRD) since the late 1960s in collaboration with the 'Centre de Recherches Océanologiques' (CRO, Ivory Coast) and the 'Centre de Recherches Océanographiques de Dakar-Thiaroye' (CRODT, Sénégal). In this document, we report a synthesis of the fishing activities of the French purse seiners during 1991-2019 based on the collection of logbooks, landing reports and sampling operations conducted at ports during unloading for target species (i.e. BET, SKJ, YFT).

1. Material and methods

1.1 Fishing data from professional activities

Logbooks and landing reports were collected in collaboration with fishing companies and covered 100% of the fishing trips that occurred during 1991-2019. For each trip, at unloading, shipment was sorted by species (and by commercial categories) and weight at the cannery. For each set, vessels crew reported in the logbook all information on their activities including:

- Catch weight visually assessed
- Raw species composition of the sets visually assessed
- Date of the sets;
- Geographic location of the sets.
- Activity and details on floating objects (mainly FAD), since 2014

1.2 Sampling

In 2019, 285 well samples were collected at unloading of French vessels in the ports of Abidjan and Dakar. These samples were used to estimate the size and species composition of the catch following a sampling and processing protocol common with purse seiners flying the flag of Spain and other flags associated with the French purse seine fleet (Pallarés and Petit, 1998[3]). A total of about 108 000 tunas counted and measured were used in the T3 (Traitement des Thons Tropicaux) processing of the French purse seine fishery data for 2019.

1.3 Fishing effort

Nominal fishing effort was derived from logbooks and expressed in days-at-sea and fishing days considering that fishing operations purse seiners occur only during daylight. Searching time (days), which accounts for the expected time required for setting the purse seine, was also used to describe the nominal purse seine effort. In the Atlantic Ocean, the maximum duration of a day for the purse seine fishing fleet targeting tropical tunas is 12 hours.

1.4 Fads Density of buoys (last update on data 2018)

Monthly $1\circ\times1\circ$ mean FAD density maps were calculated for the period 2010-2018. The period before 2010 was excluded because of less complete data availability during this earlier period. Basic filtering of raw FAD position data followed what has already been extensively published in Maufroy et al. (2015). Aberrant positions at the poles or international date line were removed, multiple positions for a single timestamp were averaged into a single position, and pairs of subsequent identical positions for the same buoy were consolidated into a single position.

The classification algorithm used to separate onboard FAD positions from in water FAF positions followed the basic outline of previous work (Maufroy et al. 2015), but was improved using an extended and more recent training dataset and by using better predictive variables. Better predictive variables include variables measuring variance in speed and temperature in the immediate vicinity of a position to be classified (3 previous positions, 3 subsequent positions and the given position for a total of 7 points). These variables were effective at filtering out boat data as

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[3] Pallarés, P., and Ch. Petit. 1998. Tropical tunas: new sampling and data processing strategy for estimating the composition of catches by species and sizes. Collect. Vol. Sci. Pap. ICCAT 48:230–246.

boat data is generally characterized by erratic swings in FAD position data. Individual, classified buoy trajectories were then interpolated at midnight GMT every day. For a given buoy, a trajectory was taken to be any contiguous set of positions without any gap superior to 5 days (i.e., individual buoys could have multiple such trajectories, each divided by a gap >5 days). Boat and water classifications were not directly taken into account for dividing up buoy trajectories, but instead the classification state was also linearly interpolated between data points with 0 associated with positions classified as onboard and 1 for positions classified in the water. This interpolated data was then filtered to remove boat positions and beaching events. A cutoff of 0.75 on the interpolated class of the position was used for selecting in water positions. The choice of 0.75 is largely arbitrary, but only affected a very small fraction of all positions (interpolated class between 0.75 and <1 represented only 0.4% of all interpolated in water positions). Beachings were identified as any set of 3 positions from the raw position data of a single buoy that are within 200m of the first position and separated in time by at least 1 day. These potential beachings were further filtered to remove any beaching events for which <90% of the positions between the beginning and the end of the beaching event were included in the beaching event based on the distance test. Any interpolated buoy positions between the beginning and end of beaching events were removed from the dataset. For each day, the at sea interpolated positions were aggregated on a 1∘×1∘ lon-lat grid. These daily raster maps were average over larger time periods (i.e., a month or a year) to produce average density maps.

The inverse of the annual, by-ocean observer-FADs identifier agreement rate was used as a raising factor to correct average density maps for missing data. Among the "agreeing identifiers", I included both observer buoy-deployment identifiers that match an identifier in the FADs trajectory database and observer identifiers that do not match, but for which there is a buoy position in the FADs database that is within 2.5 km and±12 hours of the observer data and for which the Levenshtein distance between the observer and corresponding FAD identifier is inferior or equal to 3.

2.   Results and interpretations

2.1   Fleet capacity

In 2019, 10 French purse seiners (**Figure 1**) operated in the eastern Atlantic Ocean and conducted a total of 93 fishing trips lasting on average 31 days. The fleet was composed of 2 vessels of carrying capacity (CC) of 600-800 t, 6 vessels of CC 800-1200 t, and 2 vessels of CC >1,200 t (**Table 1**). Total carrying capacity in 2019 is similar to the last years and confirm the trend to use larger vessels since 2009. The total capacity weighted by the months of activity for each vessel is 9 946 t.

2.2   Activity effort

The total nominal effort in 2019 for fishing[4] and searching[5] was respectively 2899 and 2421 days (**Figure 2 and Table 2**) which is similar to the trend of the last years. Indeed, after the drop from 1991 to 2008, activities duration slightly increased. Duration for both activities actually represent the half of the 1991's level.

2.3   Fishing sets

The total annual number of fishing sets in 2019 reached 2278 (1977 positive sets and 301 null sets). A total of 1148 sets were associated with FOBs (mainly FADs) and 1130 sets associated to free swimming schools (FSC) (**Table 3**). The proportion of positive sets is 98% of FOBs and 75% of FSC. In 2019, the percentage of FOB sets is **50%** in the range of value since 2012 confirming a consistency in fishing activity type (**Figure 3**).

2.4   Deployment of Fishing Aggregating Devices (FADs)

The deployment of Fishing Aggregating Devices (FADs) has been declared in logbooks of the purse seiners and supply vessel since 2014. In 2017, the French supply vessel left the Atlantic to the Indian ocean.

The number of deployments increased toward a maximum of 2514 in 2017, 229 per vessel. In 2019, the total number of deployments decreased to 2125 FADs, 212 per vessel. (**Table 4**).

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[4] Fishing time: Number of hours that a vessel is at sea for fishing activities.
[5] Searching time: Duration in hour for which vessel is considered searching for new schools (fishing time – sets' duration).

2.5 Spatial distribution of fishing

Spatial extent used by vessels slightly decreased in 2019 compared to 2018 but in the continuity of the trend of increasing since 2009 (**Figure 4 and table 5**). However, the area where catches occurred was stable since 2010. We could so conclude that the supplementary zone used by vessels served for other activities as FAD management or exploration. **Figure 5 and 6** respectively represent maps of the catches on FOB and FSC. In 2019, highest catches on FOB were located off the coast of Mauritania whereas they were located off the coast of Ivory coast and Guinea for FSC. Thus, the fishing effort shifted to the west part of the fishing ground resulting of the absence of an EU fishing agreement with the Gabon since 2017 (**Figure 7**).

2.6 Fisheries production, specific composition and size distribution

Total catch of tropical tuna in eastern Atlantic Ocean was marked since 1991 by a huge drop between 2003 and 2008 mainly due to the departure of vessels for Indian Ocean (**Figure 8**). For instance, the French fleet was composed of 14 vessels in 2003 and only 6 in 2007 (**Table 1**). In 2019, landings of the principal market tunas by the French purse seine fleet operating in the eastern Atlantic Ocean reached a total of 42477 t corresponding to a decrease of 17% compared to 2018. Those landings are composed of 41.4%, 45.1%, 11.4% and 2.1% of YFT, SKJ, BET and other species (**Table 6a**), respectively. Majority of the observed catch reduction occurred on FSC production (**Figure 9**). However, at the same time for this fishing mode the BET's catches almost doubled (1453t to 2860t).

Catch composition on FSC was usually dominated by YFT where as it was dominated by SKJ on FOB. In 2019, catches on FSC, YFT represented 79% of the total while SKJ and BET represented 6% and 15% of catches, respectively (**Figure 9**, **table 6b**). Catches on FOB were predominated by SKJ tuna representing 77% of the catch while YFT and BET tunas represented 11% and 9% of catches, respectively. Finally, species composition values were quite similar to last year's species composition whatever the school type (**Figure 9, table 6c**)

The size frequency distributions for the three species collected in 2019 for both FOB-associated and FSC fishing sets are quite similar with the average frequency distributions observed for the period 2014-2019 (**Figure 10**), FSC except for which large YFT and BET were more abundant. As a consequence, catch of larger fishes are higher than the mean of the period 2014 - 2018 (**Figure 11**).

2.7 3.8 Yield and Nominal catch per unit effort (CPUE)

Historically, the number of sets for FOB by searching day was between 0.2 and 0.3 until 2009, except around 1995 for which the rate peak to 0.38 (**Figure 12**). Since 2009, the number of sets for FOB by searching day leapt above 0.4 and continued to slightly increased. Regarding the FSC, this rate describes a bell-shaped curve starting around 0.5 in the 90's, peaking at 0.79 in 2008 before decreasing to 0.56 in 2018. In 2019, the number of sets per searching day decreased compared to 2018 and are similar (0.47) for both fishing mode (**Figure 12**, and **table 7**). At the same time, mean catches per set remained stable for FOB whatever the species (**Figure 12**, **table 8**) but decrease strongly for FSC (from 28t to 22t on average, **table 9**) with the highest value ever registered for BET (3.36t/set).

Nominal CPUE regarding the fishing time are similar to catch per set patterns, i.e. consistent to 2018 for FOB and huge decreasing for FOB (**Figure 13, table 10 and 11**).

2.8 Spatio-temporal distribution of buoys (last update data 2018)

Though the number of *in water* French FAD buoys found in FAD trajectory data was relatively stable over 2017, large increases were observed in the second halves of 2016 and 2018 (**Figure 14**). Overall, there has been a sustained increase in the number of FADs over the last half decade, increasing from <500 in water buoys per day in 2011 to over 1500 in water buoys at the end of 2018. The FAD density map for 2018 roughly follows the distribution of fishing activity, with areas of high density found in the Gulf of Guinea, off the southern part of West Africa and the coast of Angola (**Figure 15**). Maximum annual average density values were of order 6 FADs per 1∘×1∘ grid cell, but daily density values can be an order of magnitude larger than that in extreme cases. After accounting for the increasing overall number of FADs, the relative spatial distribution of FADs is for the most part stable across years, though high densities in some areas with more variable fishing activity (due to environmental variability or lack of fishing agreements permitting the French fleet to access some EEZs), such as off Western Africa, Angola or the EEZ of Gabon, are not consistently observed in all years (**Figure 15**).

3. Conclusion

The year 2019 is characterized by a general decreasing in catches, yield and CPUE, mainly for the free school fishing mode. However, for the BET, inverse pattern was observed along with a higher abundance of large individual in catches on free school. The pattern modification compared to the previous years might be due to the shift of the fishing grounds for the two fishing modes, i.e., free school and floating objects.

Table 1. Annual number of purse seiners by size categories and total carrying capacity of the European tropical tuna purse seine fishing fleet of the Atlantic Ocean during 1991-2019. Total carrying capacity (CC) was weighted by the proportion of the year at sea (in months).

Year	50-400	401-600	601-800	801-1200	1201-2000	>2000	Nb vessels	Nb vessels weighted	CC
1991	1.2	7.7	4.1	4.5	0	0	23	17.42	11854
1992	1	7.6	2	5.5	0	0	17	16.08	11457
1993	0.9	7.4	2.1	5.9	0	0	18	16.33	11870
1994	0.8	7.8	2.7	5.6	0	0	18	16.83	12121
1995	0	7.9	2	5	0	0	17	14.92	10863
1996	0	8.8	2	4.9	0	0	16	15.75	11243
1997	0	7.3	1.8	5	0.7	0	19	14.67	11331
1998	0	6.9	2	5.7	0	0	15	14.58	11071
1999	0	7.2	1.8	5	0	0	15	14	10538
2000	0	6.9	1.6	5	0	0	14	13.5	10248
2001	0	6.2	1.8	5.3	0.8	0	17	14	11314
2002	0	6.8	0.3	4.8	0.4	0	17	12.25	9602
2003	0	6.6	1	4.8	0	0	14	12.42	9625
2004	0	4.9	0.3	4.9	0	0	12	10.08	8349
2005	0	3.9	0	4.3	0	0	9	8.25	6980
2006	0	3.4	0	2	0	0	7	5.42	4040
2007	0.3	2.8	0	1.8	0	0	6	4.92	3609
2008	0	2.3	0.6	1.8	0	0	7	4.67	3687
2009	0	0.9	2	3	1.4	0	10	7.33	6907
2010	0	1	1.9	3.9	2.3	0	10	9.08	8875
2011	0	0.8	2	3.5	1.9	0	9	8.17	7976
2012	0	0	1.9	4.8	1.9	0	9	8.67	9016
2014	0	0	1.9	4.7	1.8	0	9	8.42	8745
2014	0	0	2	5	1.9	0	9	8.92	9271
2015	0	0	1.8	5	1.9	0	9	8.75	9146
2016	0	0	2	5.5	2	0	11	9.5	9861
2017	0	0	2	5.8	1.8	0	10	9.58	9858
2018	0	0	1.8	5.8	1.9	0	10	9.58	9935
2019	0	0	1.8	5.8	1.9	0	10	9.58	9946

Table 2. Annual nominal fishing effort of the French purse seine fishing fleet expressed in fishing and searching days during 1991-2019. Searching days was derived from the total time spent at sea corrected for periods of damage, route towards the harbour, and purse seine operation. The duration per day for fishing activities is 12 hours.

Year	Days at sea	Fishing days	Searching days	Number of sets	Number of sets/ Searching days
1991	5088	4843	4193	3247	0.77
1992	4627	4568	4069	2685	0.66
1993	4621	4576	3969	3232	0.81
1994	4847	4815	4225	3135	0.74
1995	4335	4293	3717	3126	0.84
1996	4618	4550	3910	3519	0.9
1997	4327	4300	3829	2598	0.68
1998	4396	4361	3837	2889	0.75
1999	4049	3933	3434	2745	0.8
2000	3968	3898	3419	2616	0.77
2001	4086	4049	3590	2500	0.7
2002	3468	3364	2955	2209	0.75
2003	3463	3360	2837	2838	1
2004	2942	2855	2469	2075	0.84
2005	2309	2274	1973	1613	0.82
2006	1453	1388	1189	1059	0.89
2007	1396	1322	1148	820	0.71
2008	1303	1263	1052	1018	0.97
2009	2075	2019	1693	1595	0.94
2010	2625	2549	2110	2133	1.01
2011	2290	2214	1821	1908	1.05
2012	2530	2474	2079	1913	0.92
2014	2402	2341	1921	2016	1.05
2014	2597	2545	2096	2122	1.01
2015	2453	2406	1975	2023	0.99
2016	2801	2706	2207	2359	1.06
2017	2853	2794	2302	2335	1.01
2018	2850	2798	2271	2480	1.09
2019	2829	2899	2421	2278	0.94

Table 3. Number of positive and null sets by fishing mode made by the French purse seine fishing fleet in the Atlantic Ocean during 1991-2019. FOB = Floating Object; FSC = Free-Swimming School.

	ALL			FOB			FSC		
	Total	Positive	Null	Total	Positive	Null	Total	Positive	Null
1991	3247	2521	726	853	772	81	2394	1749	645
1992	2685	2140	545	955	857	98	1730	1283	447
1993	3232	2650	582	1172	1116	56	2060	1534	526
1994	3135	2581	554	1377	1296	81	1758	1285	473
1995	3126	2508	618	1394	1294	100	1732	1214	518
1996	3519	2670	849	1347	1212	135	2172	1458	714
1997	2598	1908	690	816	725	91	1782	1183	599
1998	2889	2162	727	988	913	75	1901	1249	652
1999	2745	1995	750	720	653	67	2025	1342	683
2000	2616	1971	645	683	622	61	1933	1349	584
2001	2500	1904	596	630	560	70	1870	1344	526
2002	2209	1678	531	577	545	32	1632	1133	499
2003	2838	2263	575	701	662	39	2137	1601	536
2004	2075	1657	418	712	669	43	1363	988	375
2005	1613	1297	316	459	439	20	1154	858	296
2006	1059	828	231	221	214	7	838	614	224
2007	820	636	184	171	156	15	649	480	169
2008	1018	770	248	188	177	11	830	593	237
2009	1595	1253	342	451	400	51	1144	853	291
2010	2133	1725	408	872	826	46	1261	899	362
2011	1908	1503	405	645	586	59	1263	917	346
2012	1913	1556	357	900	813	87	1013	743	270
2014	2016	1631	385	824	748	76	1192	883	309
2014	2122	1810	312	932	884	48	1190	926	264
2015	2023	1736	287	960	907	53	1063	829	234
2016	2359	2008	351	949	905	44	1410	1103	307
2017	2335	1996	339	1044	1002	42	1291	994	297
2018	2480	2141	339	1204	1170	34	1276	971	305
2019	2278	1977	301	1148	1125	23	1130	852	278

Table 4. Number of Fishing Aggregating Devices (FADs) deployed by the French fleet from 2014 to 2019. NoFADsDep : Number of FADs deployed

FlagVesCod	Year	No Purse seiners	NoFADsDep Purse_Seiner	No Supply	NoFADsDep_ Supply	NoFADsDep by vessel	NoFADsDep Total
FRA	2014	9	595	0	239	93	834
FRA	2014	9	1009	1	340	135	1349
FRA	2015	9	1082	1	317	140	1399
FRA	2016	11	1434	1	357	149	1791
FRA	2017	10	1784	1	730	229	2514
FRA	2018	10	2486	0	0	249	2486
FRA	2019	10	2125	0	0	212	2125

Table 5. Annual number of 1-degree squares explored by the French purse seine fishing fleet during 1991-2019. #sets indicate squares where a least 1 fishing set was made.

Year	TOTAL	#sets	Catch >0	Effort > 1 d	Effort > 5 d
1991	389	292	272	313	213
1992	423	293	287	339	215
1993	374	270	260	296	192
1994	420	337	334	358	256
1995	405	307	299	329	200
1996	391	302	291	325	209
1997	464	334	295	373	220
1998	466	355	332	369	214
1999	365	272	260	290	184
2000	368	289	274	299	184
2001	412	283	272	322	195
2002	360	262	249	291	185
2003	358	247	240	267	163
2004	343	254	240	259	149
2005	350	232	216	257	137
2006	264	167	161	182	85
2007	296	167	154	207	84
2008	258	156	146	161	80
2009	332	221	206	228	121
2010	325	256	241	262	142
2011	364	248	235	257	128
2012	345	245	232	239	126
2014	369	239	230	245	122
2014	344	238	229	244	134
2015	274	219	212	207	122
2016	388	243	238	254	140
2017	363	250	246	251	137
2018	417	287	278	267	132
2019	396	275	270	266	143

Table 6a. Catch by species made on FOB-associated (FOB) and free-swimming schools (FSC) for the French purse seine fishing fleet in the Atlantic Ocean during 1991-2019.

Year	YFT	SKJ	BET	ALB	OTH	TOTAL
1991	30172	31814	3327	50	529	65893
1992	30778	20383	4985	451	236	56833
1993	33590	31537	10629	565	83	76404
1994	32381	30251	10075	130	140	72977
1995	27850	22542	6262	83	182	56919
1996	32179	21370	6778	191	184	60702
1997	29065	13335	4209	39	157	46805
1998	30468	14144	3641	40	146	48440
1999	28833	19457	3383	13	104	51791
2000	29506	16642	3936	23	94	50200
2001	31183	13774	3943	11	109	49020
2002	32982	13806	3597	18	113	50517
2003	32268	17318	3289	63	159	53096
2004	23413	19982	2417	19	168	45998
2005	22073	12606	1913	478	47	37117
2006	18353	5423	2402	347	10	26534
2007	13245	4427	781	12	248	18713
2008	15929	3661	989	50	0	20629
2009	18545	6602	2043	60	24	27274
2010	19974	13983	3199	109	99	37365
2011	21427	12088	3268	53	152	36990
2012	18243	11749	3574	161	273	33999
2013	20260	15559	3197	73	256	39345
2014	22192	16903	3763	49	151	43057
2015	20055	19893	2752	60	267	43027
2016	25684	18064	4387	65	481	48682
2017	25626	15295	3582	99	1128	45730
2018	24441	21926	3843	27	976	51214
2019	17554	19146	4859	18	899	42477

Table 6b. Catch by species made on free-swimming schools for the French purse seine fishing fleet in the Atlantic Ocean during 1991-2019.

Year	YFT	SKJ	BET	ALB	OTH	TOTAL
1991	25696	15349	826	50	417	42339
1992	24662	4013	1366	451	208	30700
1993	26867	7653	3776	565	11	38872
1994	23257	7979	1703	130	81	33150
1995	22301	4387	988	79	78	27834
1996	26430	4634	1837	191	11	33102
1997	24694	4259	1264	39	35	30290
1998	25799	5419	930	40	33	32221
1999	23038	7980	1067	13	30	32128
2000	25170	5435	1240	23	10	31878
2001	28094	4982	1608	11	33	34727
2002	28784	4498	1310	18	3	34614
2003	27936	6382	1456	63	4	35840
2004	19671	5380	516	19	73	25660
2005	19527	2801	749	472	0	23548
2006	17727	1498	1861	347	0	21433
2007	12733	970	455	12	0	14170
2008	15372	1558	598	50	0	17578
2009	17456	1071	1104	60	0	19691
2010	16973	2687	1668	97	8	21433
2011	19449	2646	1493	41	56	23685
2012	15486	414	1253	146	23	17323
2014	17784	3242	1224	58	47	22356
2014	17801	2303	1911	29	10	22055
2015	15849	2974	908	39	35	19805
2016	20942	3976	1748	42	68	26777
2017	21591	1226	1088	90	32	24028
2018	21729	3681	1453	26	19	26908
2019	15089	1109	2860	16	13	19086

Table 6c. Catch by species made on FOB-associated schools for the French purse seine fishing fleet in the Atlantic Ocean during 1991-2019.

Year	YFT	SKJ	BET	ALB	OTH	TOTAL
1991	4476	16465	2501	0	112	23554
1992	6116	16370	3619	0	28	26133
1993	6723	23884	6853	0	72	37532
1994	9124	22273	8372	0	59	39827
1995	5549	18155	5274	4	103	29084
1996	5750	16736	4941	0	173	27599
1997	4371	9076	2945	0	122	16515
1998	4669	8725	2712	0	113	16219
1999	5795	11478	2316	0	74	19663
2000	4335	11207	2696	0	84	18322
2001	3090	8792	2335	0	76	14292
2002	4198	9308	2287	0	110	15903
2003	4332	10937	1833	0	155	17256
2004	3742	14602	1901	0	94	20338
2005	2547	9805	1165	5	47	13569
2006	626	3925	541	0	10	5102
2007	512	3457	326	0	248	4543
2008	557	2103	391	0	0	3051
2009	1089	5531	939	0	24	7583
2010	3001	11297	1530	13	92	15932
2011	1978	9443	1776	12	96	13305
2012	2756	11335	2321	15	250	16677
2014	2476	12317	1972	15	208	16989
2014	4391	14599	1852	19	140	21002
2015	4206	16919	1844	22	232	23222
2016	4742	14088	2639	23	414	21905
2017	4035	14069	2494	9	1096	21702
2018	2712	18245	2390	1	957	24307
2019	2466	18037	1999	2	887	23391

Table 3. Number of sets per searching on FOB-associated (FOB) and free-swimming schools (FSC) for the French purse seine fishing fleet in the Atlantic Ocean during 1991-2019.

Year	ALL	FOB	FSC
1991	0.77	0.2	0.57
1992	0.66	0.23	0.43
1993	0.81	0.3	0.52
1994	0.74	0.33	0.42
1995	0.84	0.38	0.47
1996	0.9	0.34	0.56
1997	0.68	0.21	0.47
1998	0.75	0.26	0.5
1999	0.8	0.21	0.59
2000	0.77	0.2	0.57
2001	0.7	0.18	0.52
2002	0.75	0.2	0.55
2003	1	0.25	0.75
2004	0.84	0.29	0.55
2005	0.82	0.23	0.59
2006	0.89	0.19	0.7
2007	0.71	0.15	0.57
2008	0.97	0.18	0.79
2009	0.94	0.27	0.68
2010	1.01	0.41	0.6
2011	1.05	0.35	0.69
2012	0.92	0.43	0.49
2014	1.05	0.43	0.62
2014	1.01	0.44	0.57
2015	0.99	0.47	0.52
2016	1.06	0.43	0.63
2017	1.01	0.45	0.56
2018	1.09	0.53	0.56
2019	0.94	0.47	0.47

Table 4. Catch per unit of effort (in t per positive set) on FOB-associated schools for the French purse seine fishing fleet in the Atlantic Ocean during 1991-2019.

Year	YFT	SKJ	BET	ALB	OTH	TOTAL
1991	5.8	21.33	3.24	0	0.18	30.54
1992	7.14	19.1	4.22	0	0.59	31.05
1993	6.02	21.4	6.14	0	0.39	33.95
1994	7.04	17.19	6.46	0	0.56	31.24
1995	4.29	14.03	4.08	0	0.72	23.12
1996	4.74	13.81	4.08	0	0.46	23.09
1997	6.03	12.52	4.06	0	0.63	23.24
1998	5.11	9.56	2.97	0	0.86	18.5
1999	8.87	17.58	3.55	0	0.44	30.44
2000	6.97	18.02	4.33	0	0.65	29.97
2001	5.52	15.7	4.17	0	0.43	25.82
2002	7.7	17.08	4.2	0	0.3	29.28
2003	6.54	16.52	2.77	0	0.56	26.39
2004	5.59	21.83	2.84	0	0.29	30.55
2005	5.8	22.33	2.65	0.01	0.11	30.91
2006	2.93	18.34	2.53	0	0.06	23.85
2007	3.28	22.16	2.09	0	1.76	29.29
2008	3.15	11.88	2.21	0	0.21	17.45
2009	2.72	13.83	2.35	0	0.06	18.96
2010	3.63	13.68	1.85	0.02	0.11	19.29
2011	3.38	16.11	3.03	0.02	0.16	22.7
2012	3.39	13.94	2.85	0.02	0.38	20.59
2014	3.31	16.47	2.64	0.02	0.52	22.96
2014	4.97	16.51	2.1	0.02	0.45	24.05
2015	4.64	18.65	2.03	0.02	0.86	26.21
2016	5.24	15.57	2.92	0.03	0.88	24.63
2017	4.03	14.04	2.49	0.01	1.34	21.9
2018	2.32	15.59	2.04	0	1.05	21.01
2019	2.19	16.03	1.78	0	0.87	20.88

Table 5. Catch per unit of effort (in t per positive set) on free-swimming schools (FSC) for the French purse seine fishing fleet in the Atlantic Ocean during 1991-2019.

Year	YFT	SKJ	BET	ALB	OTH	TOTAL
1991	14.69	8.78	0.47	0.03	0.24	24.21
1992	19.22	3.13	1.06	0.35	0.33	24.09
1993	17.51	4.99	2.46	0.37	0.04	25.38
1994	18.1	6.21	1.33	0.1	0.31	26.04
1995	18.37	3.61	0.81	0.07	0.14	23
1996	18.13	3.18	1.26	0.13	0.11	22.81
1997	20.87	3.6	1.07	0.03	0.04	25.61
1998	20.66	4.34	0.74	0.03	0.11	25.88
1999	17.17	5.95	0.8	0.01	0.16	24.08
2000	18.66	4.03	0.92	0.02	0.02	23.65
2001	20.9	3.71	1.2	0.01	0.02	25.84
2002	25.41	3.97	1.16	0.02	0.04	30.59
2003	17.45	3.99	0.91	0.04	0.15	22.54
2004	19.91	5.45	0.52	0.02	0.07	25.97
2005	22.76	3.26	0.87	0.55	0	27.45
2006	28.87	2.44	3.03	0.57	0	34.91
2007	26.53	2.02	0.95	0.03	0	29.52
2008	25.92	2.63	1.01	0.08	0	29.64
2009	20.46	1.26	1.29	0.07	0	23.08
2010	18.88	2.99	1.86	0.11	0.01	23.84
2011	21.21	2.89	1.63	0.04	0.06	25.83
2012	20.84	0.56	1.69	0.2	0.05	23.34
2014	20.14	3.67	1.39	0.07	0.06	25.32
2014	19.22	2.49	2.06	0.03	0.03	23.83
2015	19.12	3.59	1.1	0.05	0.17	24.02
2016	18.99	3.6	1.58	0.04	0.14	24.36
2017	21.72	1.23	1.09	0.09	0.1	24.24
2018	22.38	3.79	1.5	0.03	0.05	27.74
2019	17.71	1.3	3.36	0.02	0.02	22.40

Table 6. Catch per unit of effort (in t per searching day) on FOB-associated schools for the French purse seine fishery in the Atlantic Ocean during 1991-2019.

Year	YFT	SKJ	BET	ALB	OTH	TOTAL
1991	1.07	3.93	0.6	0	0.03	5.62
1992	1.5	4.02	0.89	0	0.13	6.54
1993	1.69	6.02	1.73	0	0.11	9.55
1994	2.16	5.27	1.98	0	0.17	9.58
1995	1.49	4.88	1.42	0	0.25	8.05
1996	1.47	4.28	1.26	0	0.14	7.16
1997	1.14	2.37	0.77	0	0.12	4.4
1998	1.22	2.27	0.71	0	0.21	4.4
1999	1.69	3.34	0.67	0	0.08	5.79
2000	1.27	3.28	0.79	0	0.12	5.45
2001	0.86	2.45	0.65	0	0.07	4.03
2002	1.42	3.15	0.77	0	0.06	5.4
2003	1.53	3.86	0.65	0	0.13	6.16
2004	1.52	5.91	0.77	0	0.08	8.28
2005	1.29	4.97	0.59	0	0.02	6.88
2006	0.53	3.3	0.45	0	0.01	4.29
2007	0.45	3.01	0.28	0	0.24	3.98
2008	0.53	2	0.37	0	0.04	2.94
2009	0.64	3.27	0.55	0	0.01	4.48
2010	1.42	5.35	0.73	0.01	0.04	7.55
2011	1.09	5.19	0.98	0.01	0.05	7.31
2012	1.33	5.45	1.12	0.01	0.15	8.05
2014	1.29	6.41	1.03	0.01	0.2	8.94
2014	2.09	6.95	0.88	0.01	0.19	10.13
2015	2.05	8.24	0.9	0.01	0.38	11.57
2016	2.13	6.33	1.19	0.01	0.36	10.01
2017	1.75	6.11	1.08	0	0.58	9.53
2018	1.19	8.03	1.05	0	0.54	10.82
2019	1.02	7.45	0.83	0	0.41	9.70

Table 7. Catch per unit of effort (in t per searching day) on free-swimming schools (FSC) for the French purse seine fishery in the Atlantic Ocean during 1991-2019.

Year	YFT	SKJ	BET	ALB	OTH	TOTAL
1991	6.13	3.66	0.2	0.01	0.1	10.1
1992	6.06	0.99	0.34	0.11	0.1	7.6
1993	6.77	1.93	0.95	0.14	0.02	9.81
1994	5.5	1.89	0.4	0.03	0.09	7.92
1995	6	1.18	0.27	0.02	0.04	7.51
1996	6.76	1.19	0.47	0.05	0.04	8.51
1997	6.45	1.11	0.33	0.01	0.01	7.91
1998	6.72	1.41	0.24	0.01	0.04	8.42
1999	6.71	2.32	0.31	0	0.06	9.41
2000	7.36	1.59	0.36	0.01	0.01	9.33
2001	7.82	1.39	0.45	0	0.01	9.67
2002	9.74	1.52	0.44	0.01	0.02	11.73
2003	9.85	2.25	0.51	0.02	0.09	12.72
2004	7.97	2.18	0.21	0.01	0.03	10.39
2005	9.9	1.42	0.38	0.24	0	11.94
2006	14.91	1.26	1.57	0.29	0	18.02
2007	11.09	0.84	0.4	0.01	0	12.34
2008	14.62	1.48	0.57	0.05	0	16.72
2009	10.31	0.63	0.65	0.04	0	11.63
2010	8.04	1.27	0.79	0.05	0	10.16
2011	10.68	1.45	0.82	0.02	0.03	13.01
2012	7.45	0.2	0.6	0.07	0.02	8.34
2014	9.26	1.69	0.64	0.03	0.03	11.64
2014	8.48	1.1	0.91	0.01	0.01	10.51
2015	7.72	1.45	0.44	0.02	0.07	9.69
2016	9.41	1.79	0.79	0.02	0.07	12.07
2017	9.38	0.53	0.47	0.04	0.04	10.47
2018	9.57	1.62	0.64	0.01	0.02	11.86
2019	6.23	0.46	1.18	0.01	0.01	7.88
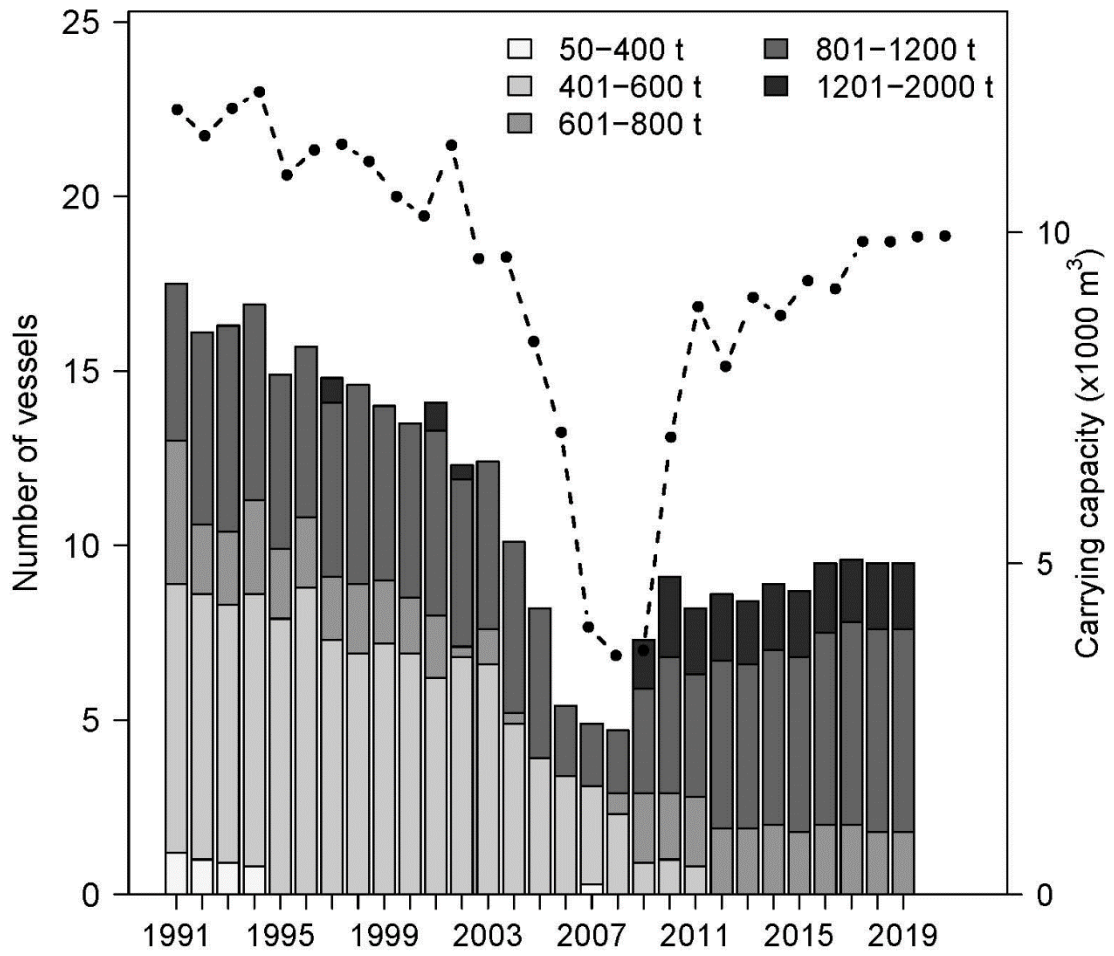
Figure 1. Fishing capacity of the French purse seine fishing fleet in the Atlantic Ocean. Annual changes in the number of purse seiners by tonnage categories (barplots) and total carrying capacity (dashed line with circles) during 1991-2019.
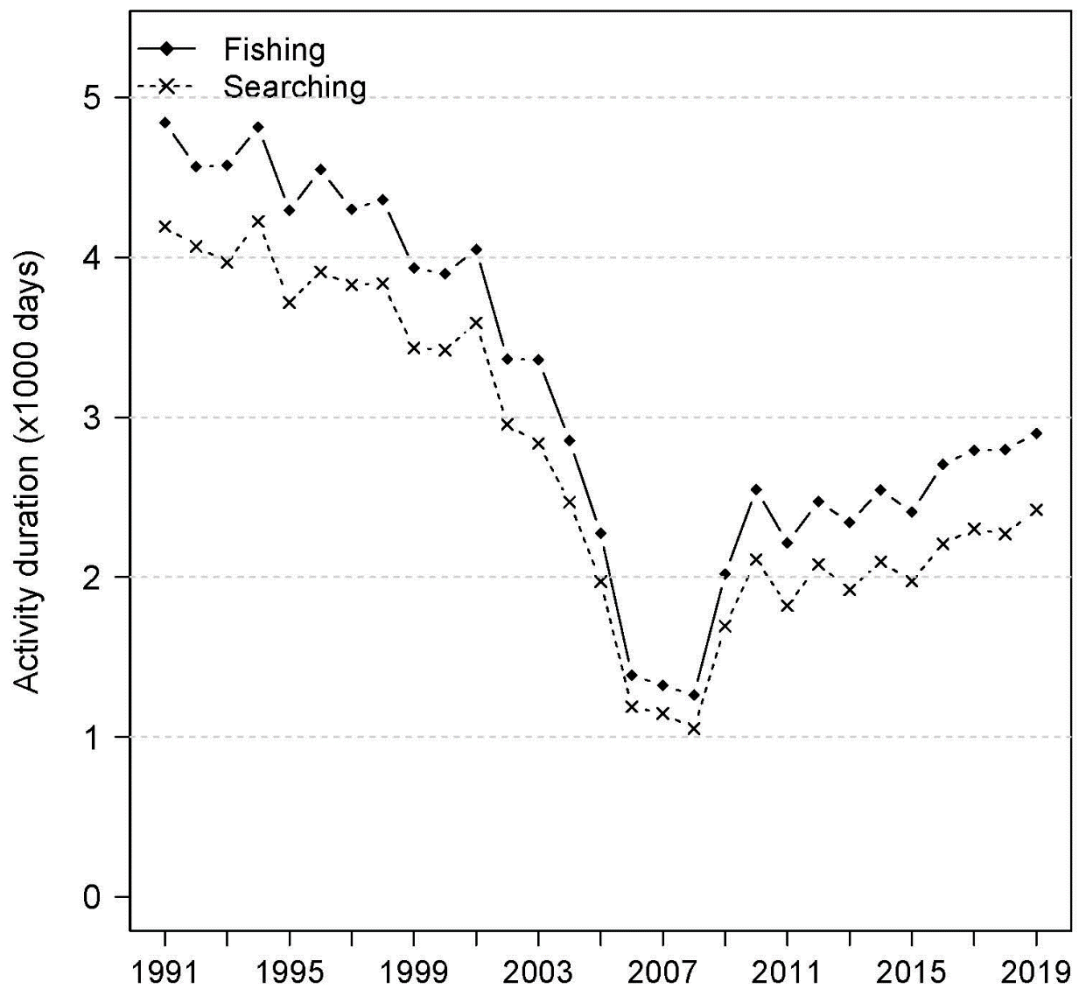
Figure 2. Changes in nominal effort over time. Annual total number of fishing and searching days for the French purse seine fishing fleet in the Atlantic Ocean during 1991-2019.
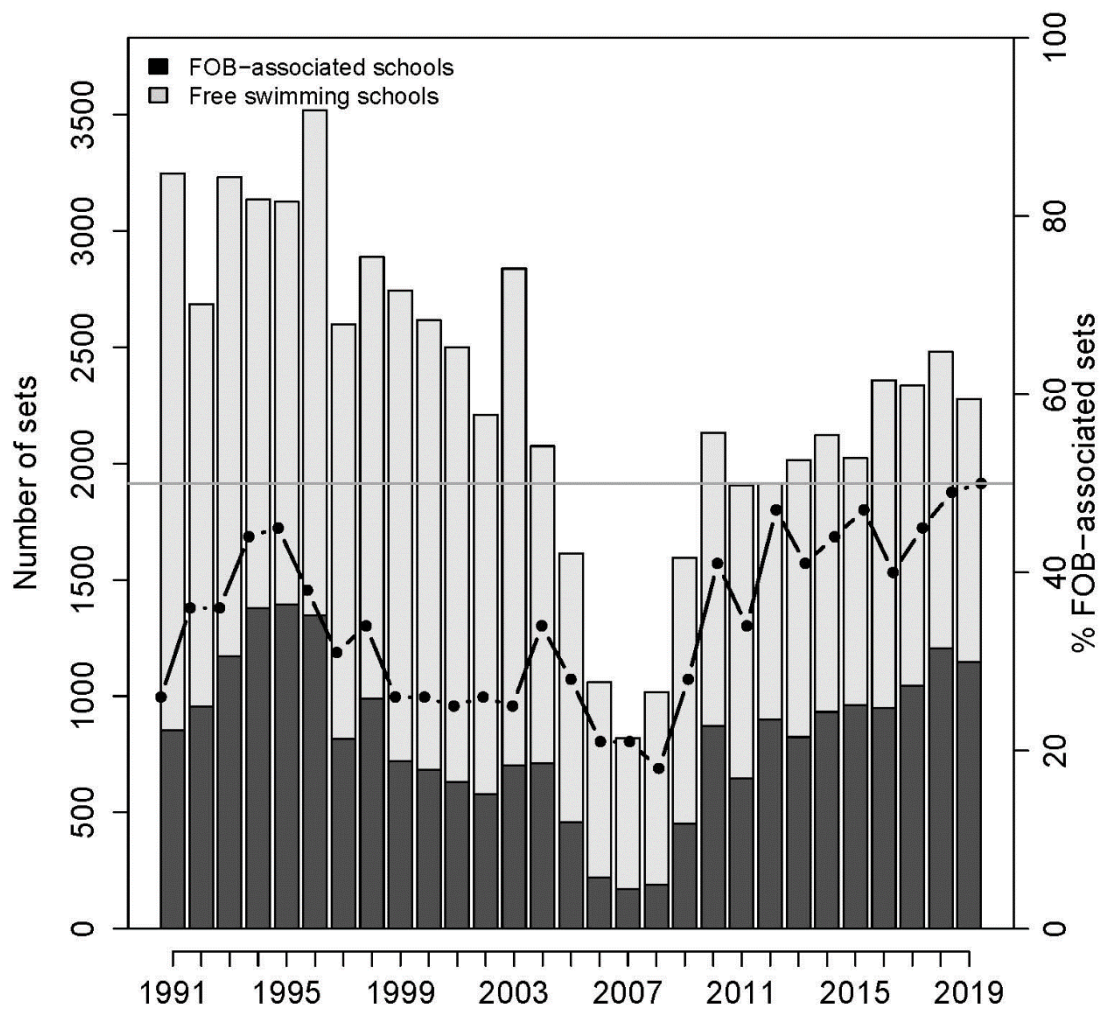
Figure 3. Fishing operations. Annual number of fishing sets in the French purse seine fishery on FOB- associated and free-swimming schools during 1991-2019. Line with solid circles indicates the percentage of sets on FOB-associated schools. Grey solid line indicates the 50% value.
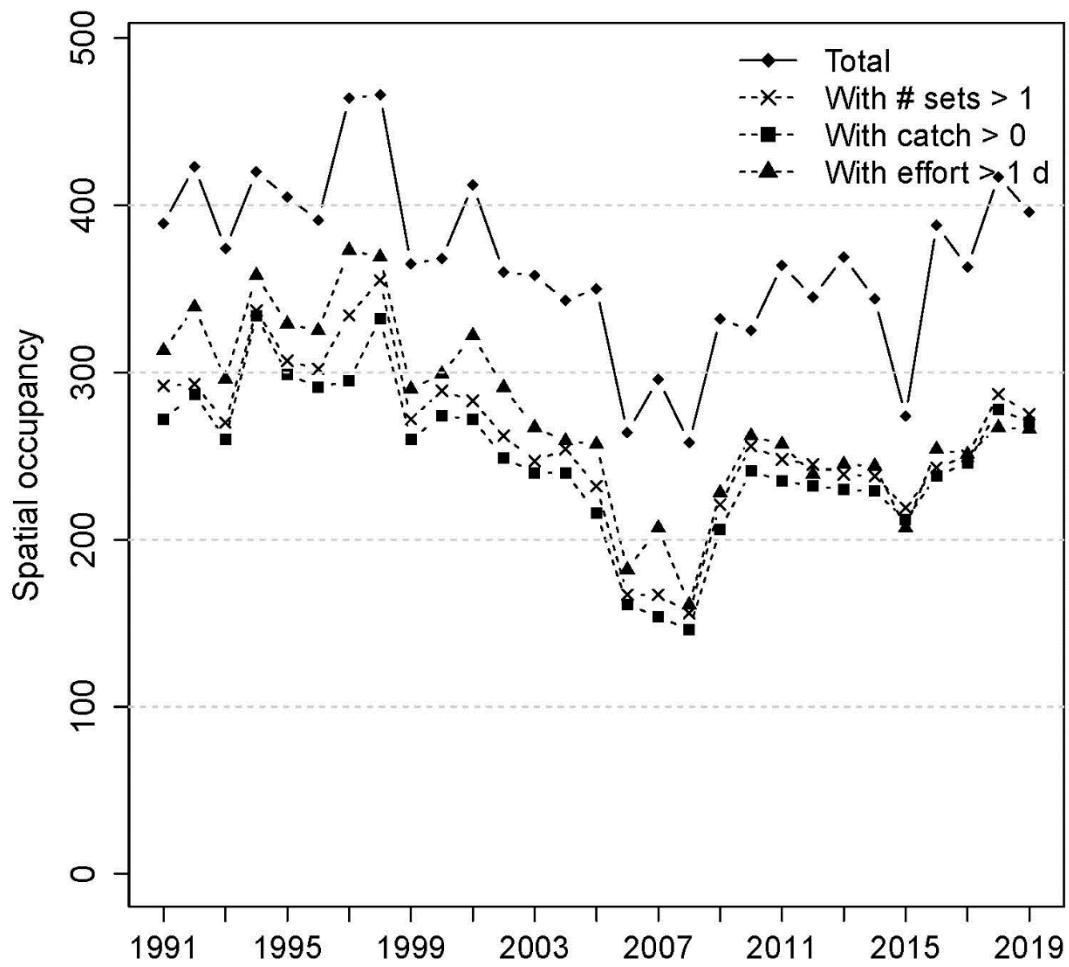
Figure 4. Changes in spatial extent of the fishery over time. Annual number of 1-degree squares explored by each vessel of the French purse seine fishing fleet during 1991-2019.
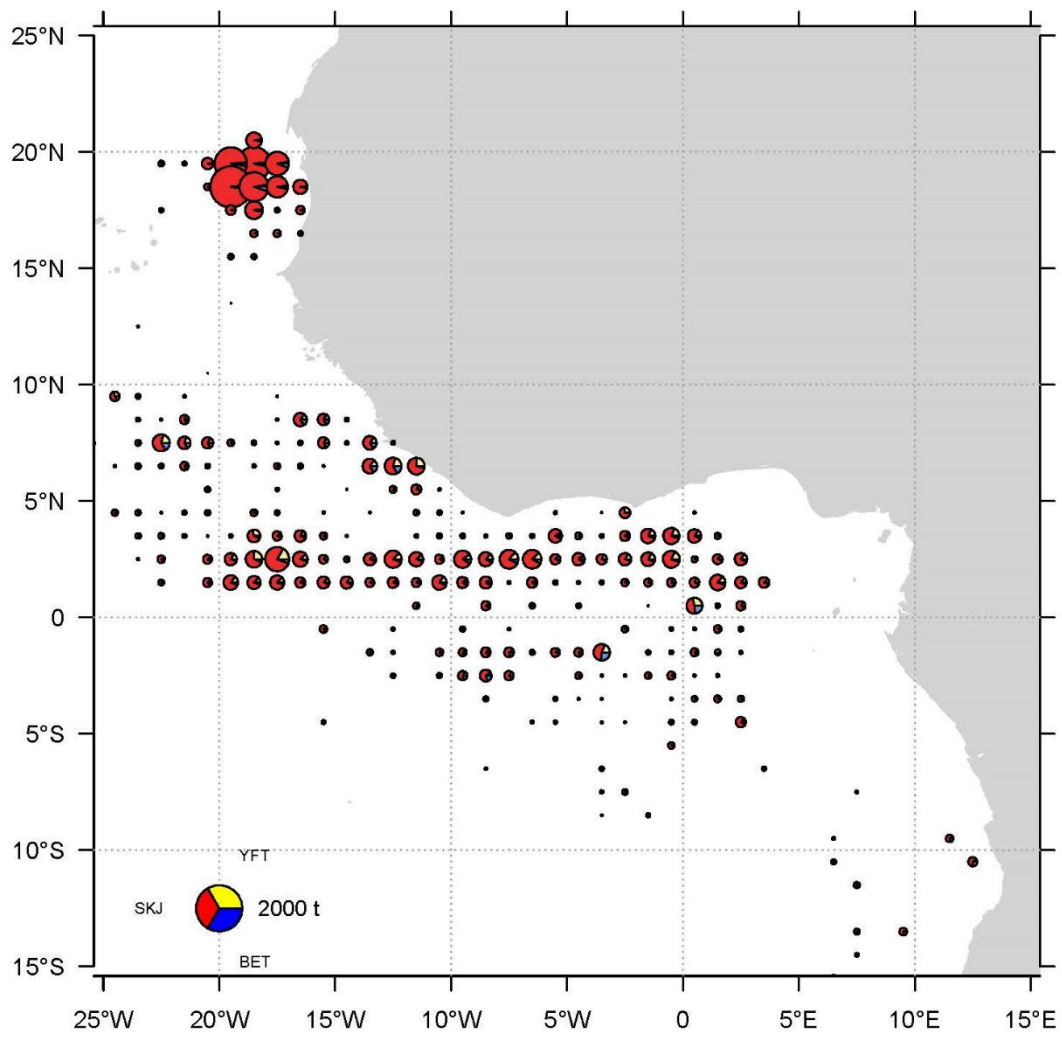
Figure 5. Spatial distribution of tuna catches of the French purse seine fishing fleet made on FOB- associated schools in 2019.
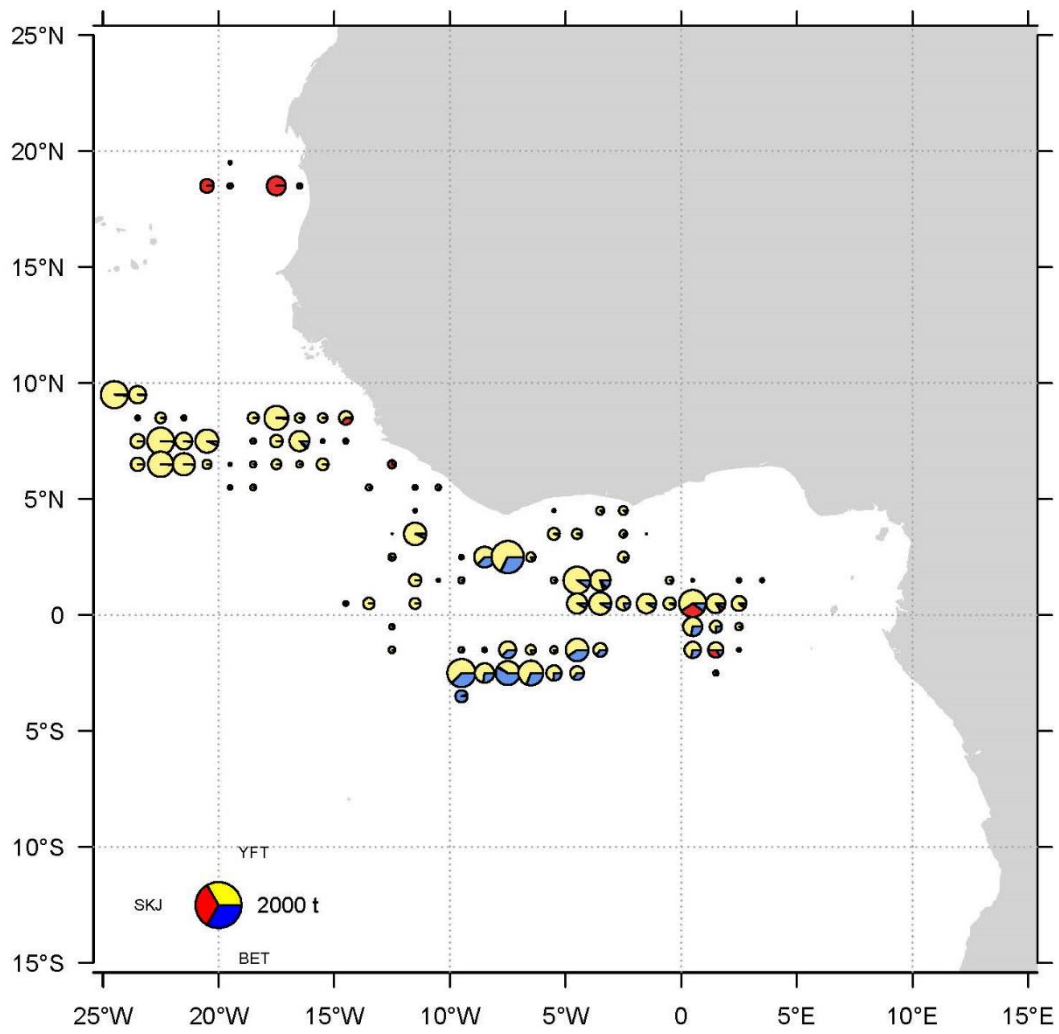
Figure 6. Spatial distribution of tuna catches of the French purse seine fishing fleet made on FSC- associated schools in 2019.
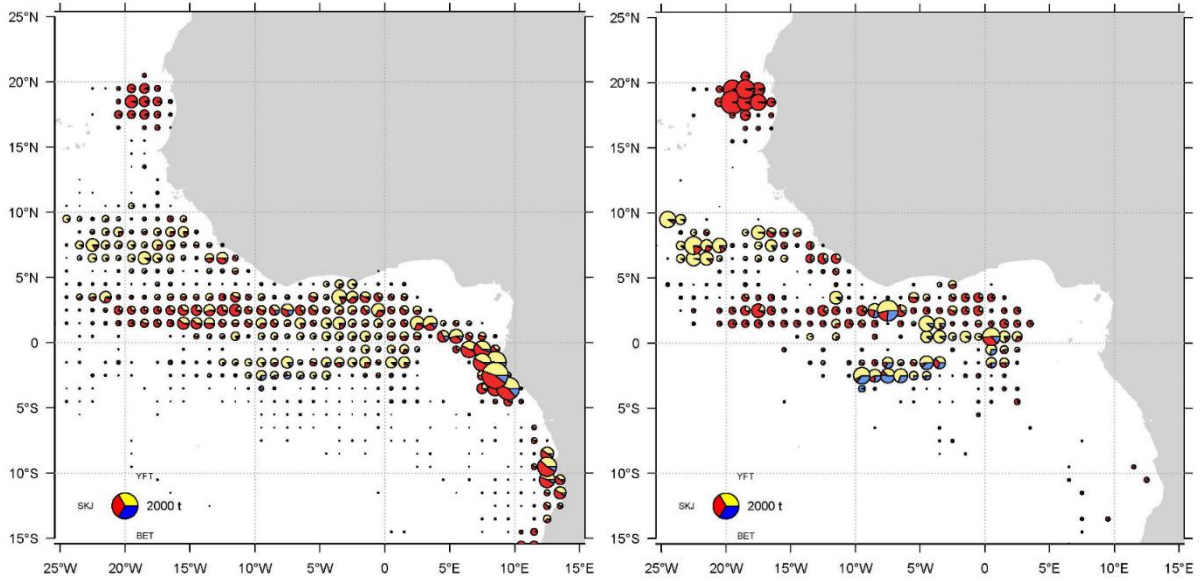
Figure 7. Maps of catches by species accounting all fishing mode in 2019 (left panel) and mean of the 2014 - 2018 period (right panel).
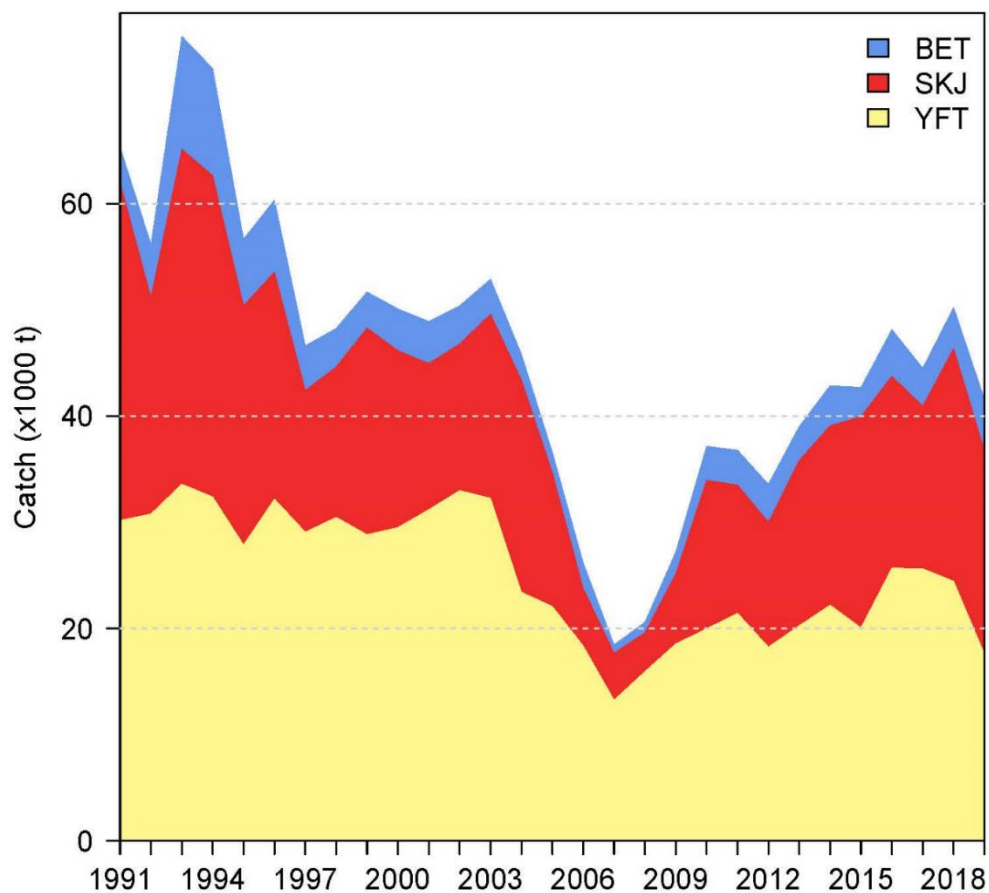
Figure 8. Total fishery production. Catch by species of the French purse seine fishing fleet during 1991-2019.
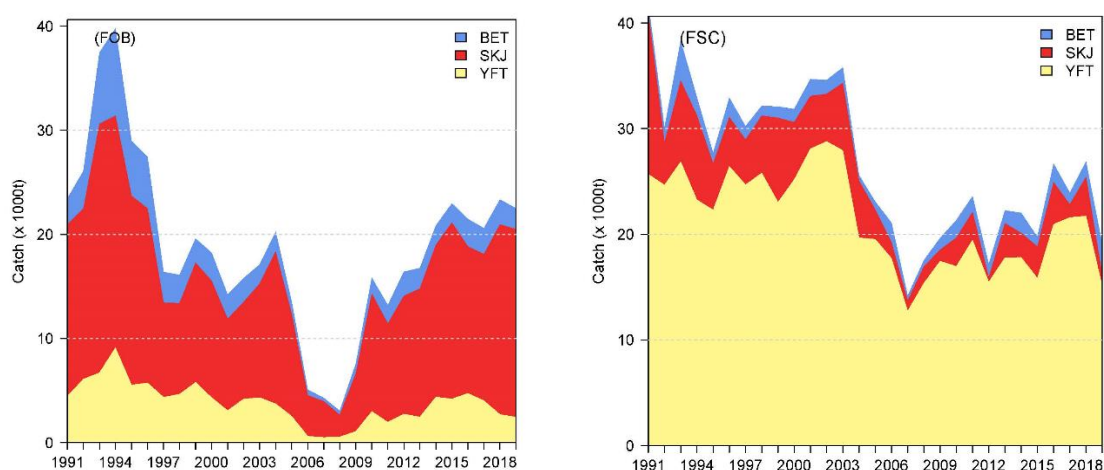
Figure 9. Fishery production by major fishing mode. Catch by species of the French purse seine fishing fleet on FOB-associated and free-swimming schools during 1991-2019.
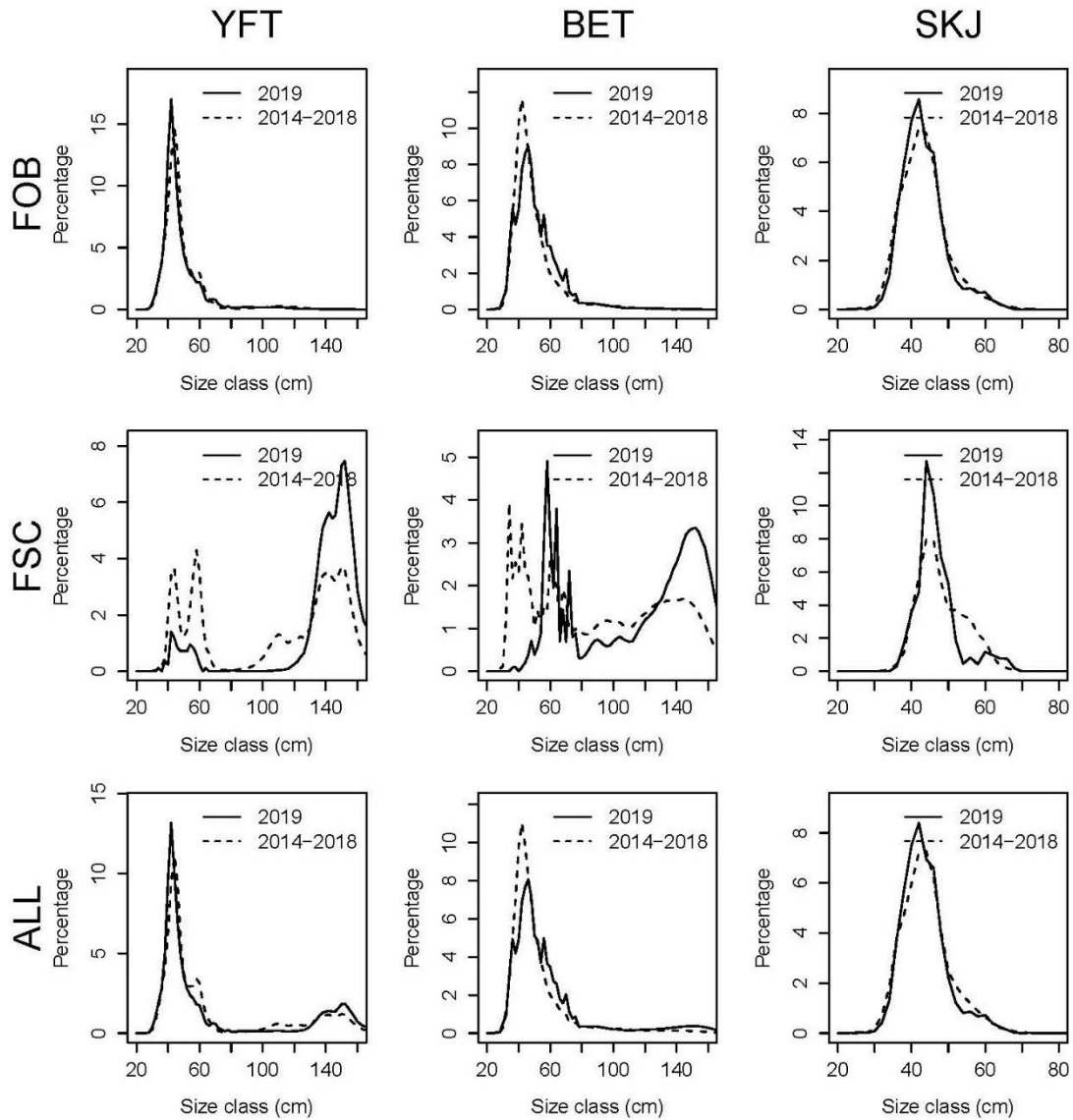
Figure 10. Distribution by size class of the catch (in percentage of the total number of fishes) for the French purse seine fleet in 2019 (solid line) and for an average year representing the period 2014-2018 (dotted line).
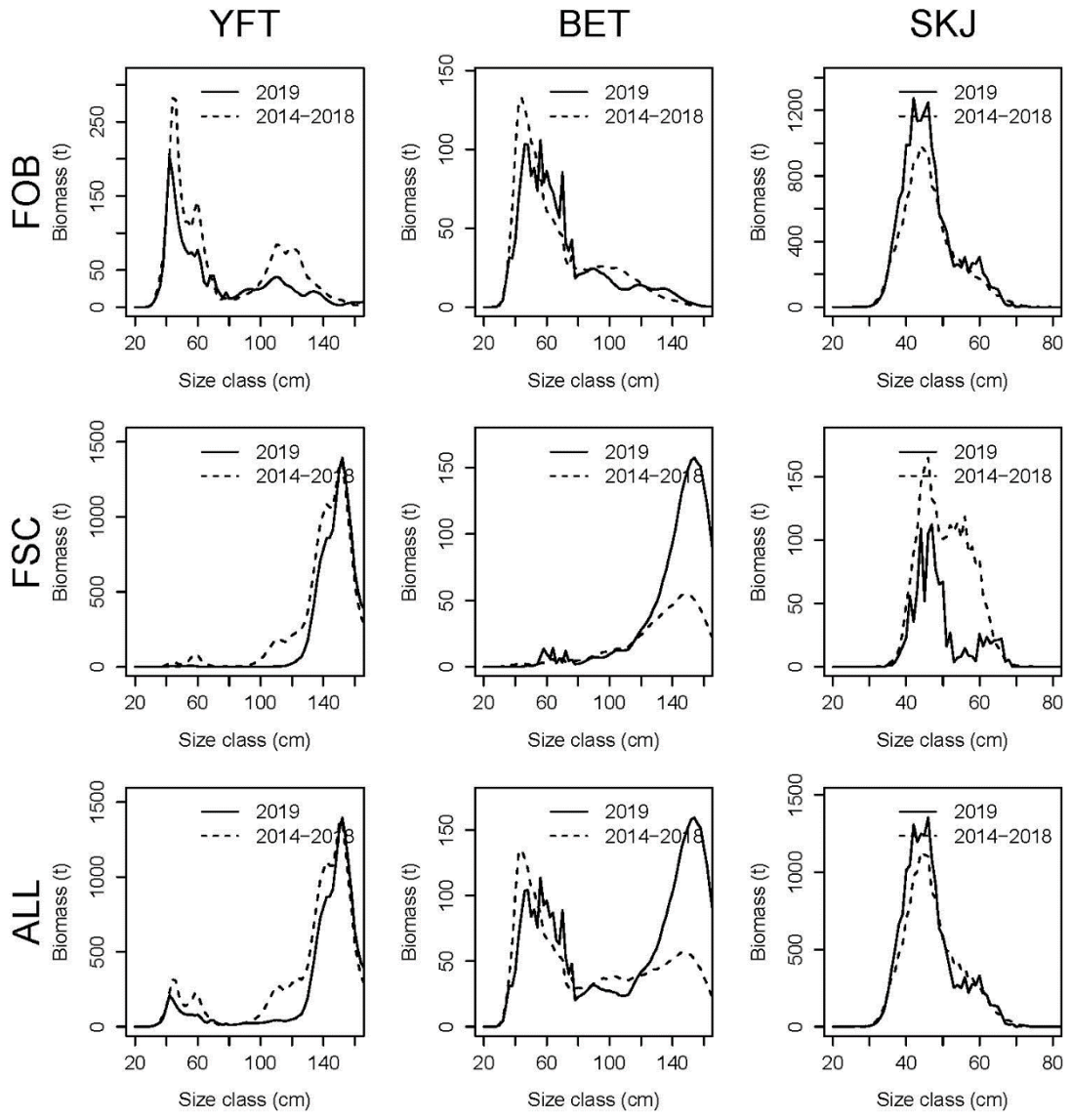
Figure 11. Weight distribution of the catch for the French purse seine fleet in 2019 (red line) and for an average year representing the period 2014-2018 (dotted line).
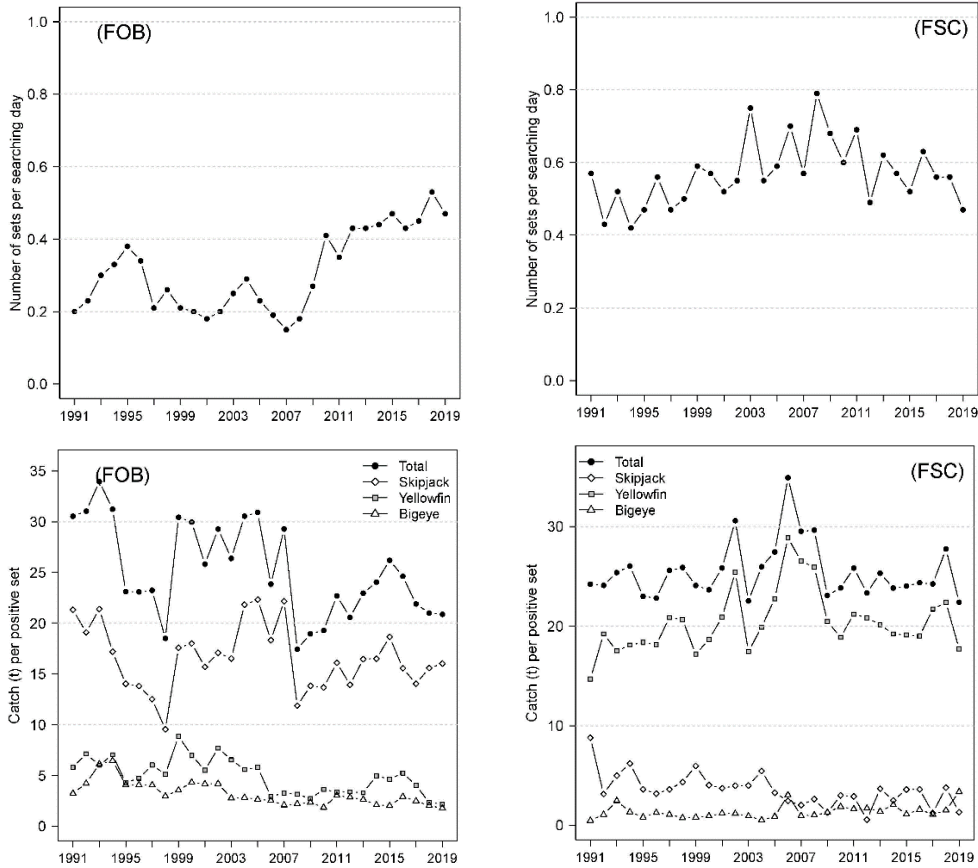
Figure 12. Annual number of sets per searching day and catch per positive set on FOB-associated (left panel) and free-swimming schools (right panel) for the French purse seine fishing fleet in the Atlantic Ocean during 1991-2019.
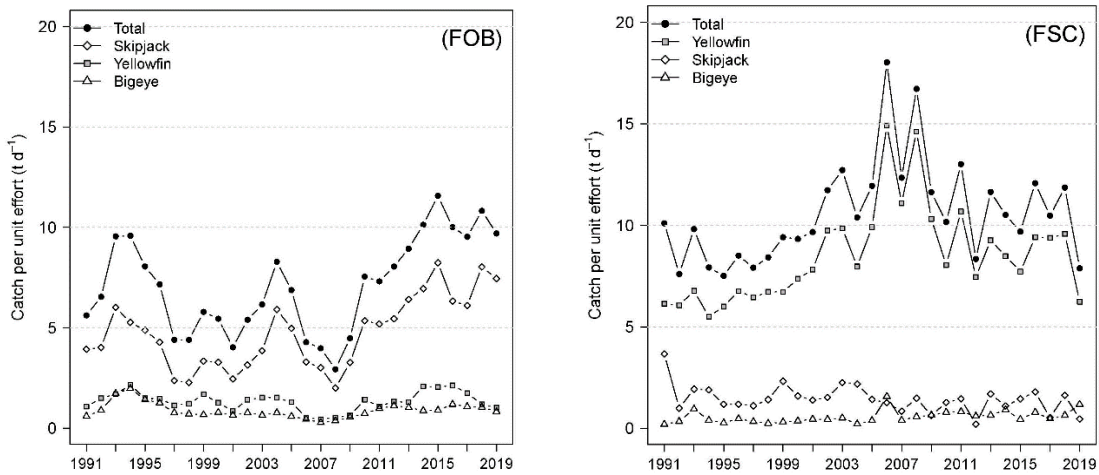

Figure 13. Annual catch rates (in t per searching day) of the French purse seine fishing fleet on FOB- associated and free-swimming schools in the Atlantic Ocean during 1991-2019.
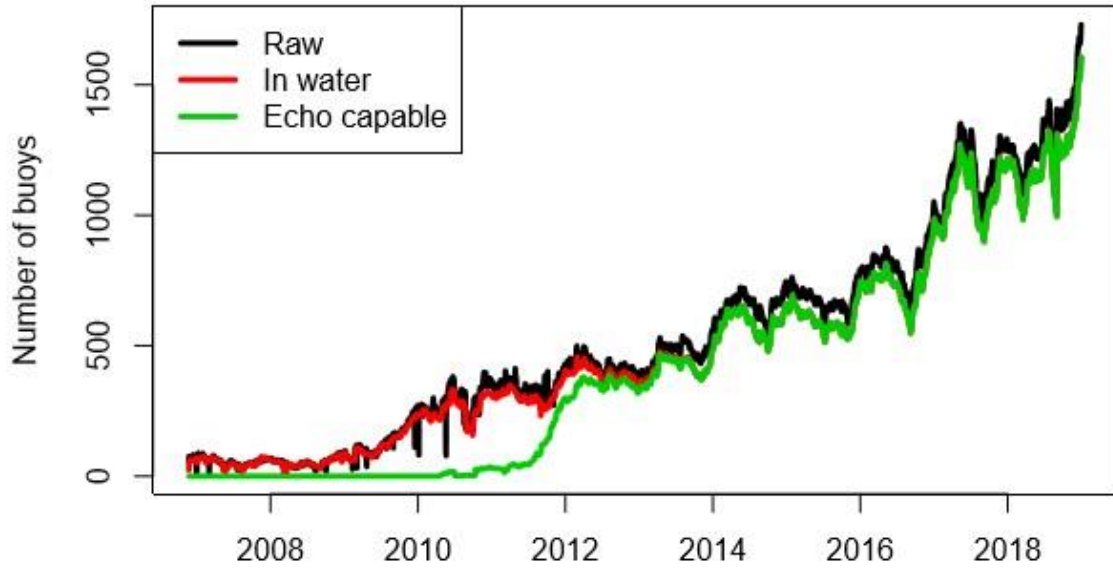
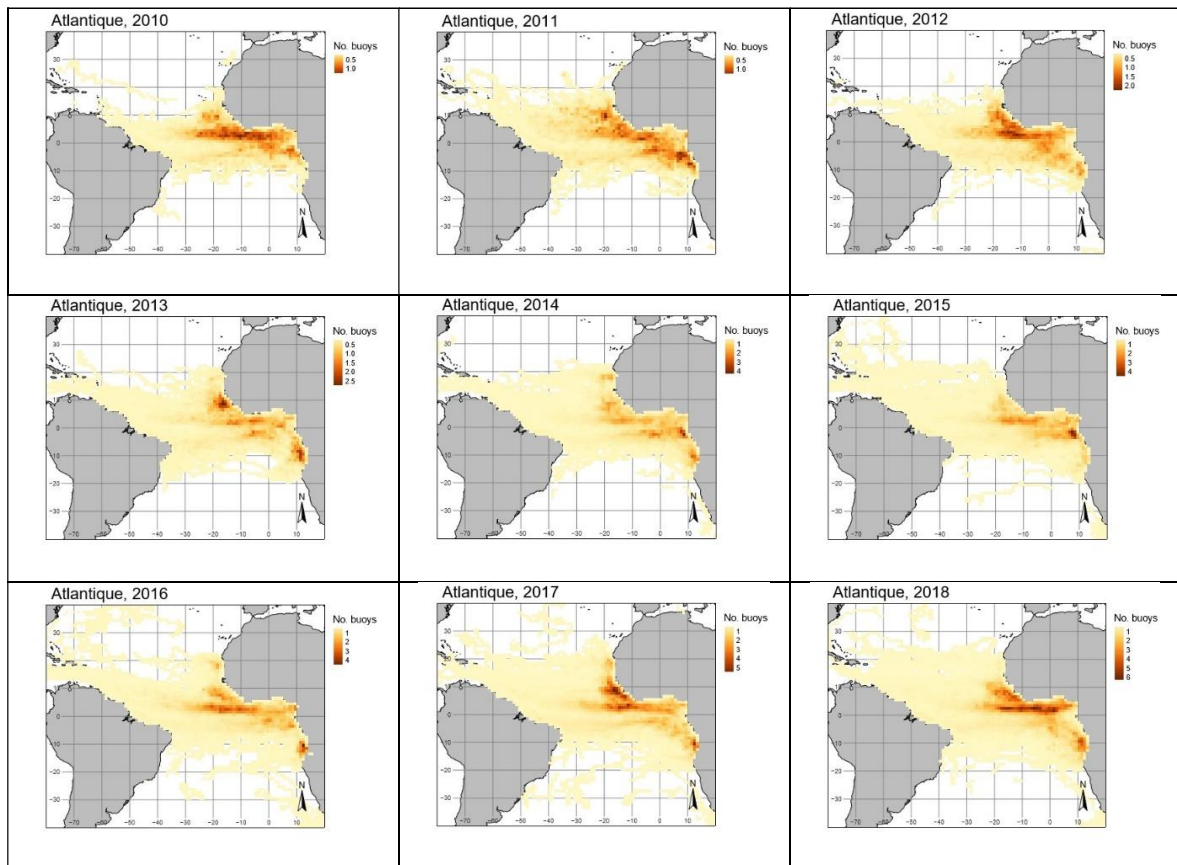**Figure 14.** Number of buoys in DB per day, Atlantic.

Figure 15. Annual fads density of buoys.