STATISTICS OF THE FRENCH PURSE SEINE FISHING FLEET TARGETING TROPICAL TUNAS IN THE ATLANTIC OCEAN (1991-2013)

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SUMMARY

*In 2013, the French purse seine fishing fleet of the Atlantic was composed of 9 vessels of individual capacity >600 t, which all represented a total carrying capacity of about 8,700 t of tuna. The total cumulated nominal effort exerted during the year was very similar to that of 2012, i.e. 2,340 and 1,920 fishing and searching days, respectively. The French purse seiners cumulated a total of more than 2,000 fishing sets, with 60% made on free-swimming schools (FSC) and 40% realised on schools associated with fish aggregating devices (FADs). Catches increased by 16% from 2012 to 2013 and reached a total of 40,000 t. They were composed of more than 50% of yellowfin tuna (*Thunnus albacares*), 40% of skipjack (*Katsuwonus pelamis*), and 8% of bigeye tuna (*Thunnus obesus*). More than 55% of the catch was made on FSCs, with large YFT representing 80% of the catch. SKJ predominated on FAD-associated schools (70%) while YFT and BET represented about 15% and 11% of the remaining FAD catch, respectively. Additional landings by the French purse seine fleet on the local market of Abidjan were estimated at about 2,700 t in 2013. They were composed of a combination of small tunas (*Auxis* spp. and *Euthynnus*), skipkack, and various tuna-like species described by fork length generally lower than 45 cm. The total bycatch discarded-at sea was estimated based on an observer program at about 1,900 t, i.e. less than 5% of the total tropical tuna landings. Some emblematic species caught as bycatch such as turtles and whale sharks were released with high survival rates.*

RÉSUMÉ

*En 2013, la flottille de senneurs français de l'océan Atlantique comprenait neuf navires ayant chacun une capacité de >600 t qui représentaient une capacité de transport totale d'environ 8.700 t de thons. L'effort nominal total cumulé exercé pendant l'année était très similaire à celui de l'année 2012, à savoir 2.340 et 1.920 jours de pêche et de recherche, respectivement. Les senneurs français ont cumulé un total de plus de 2.000 opérations de pêche, dont 60% de celles-ci ont été réalisées sur des bancs de poissons nageant librement (FSC) et 40% sur des bancs associés à des dispositifs de concentration de poissons (DCP). Les prises ont augmenté de 16% de 2012 à 2013 et ont atteint un total de 40.000 t. Elles étaient composées de plus de 50% d'albacore (*Thunnus albacares*), 40% de listao (*Katsuwonus pelamis*) et 8% de thon obèse (*Thunnus obesus*). Plus de 55% de la prise a été réalisée sur des bancs de poissons nageant librement, les grands albacores représentant 80% de la prise. Le listao était l'espèce prédominante des prises sur des bancs associés à des DCP (70%) alors que l'albacore et le thon obèse représentaient environ 15 et 11% des autres prises sous DCP, respectivement. Il a été estimé que les débarquements supplémentaires réalisés par la flottille de senneurs de l'UE-France sur le marché local d'Abidjan s'élevaient à 2.700 t en 2013. Ils étaient composés de thonidés mineurs (*Auxis* spp. et *Euthynnus*), de listao et de plusieurs espèces apparentées au thon dont la longueur à la fourche était généralement inférieure à 45 cm. La prise accessoire totale rejetée en mer a été estimée, sur la base d'un programme d'observateurs, à environ 1.900 t, à savoir moins de 5% des débarquements totaux de thonidés tropicaux. Quelques espèces emblématiques capturées accidentellement, telles que les tortues marines et les requins-baleines, ont été remises à l'eau avec des taux de survie élevés.*

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RESUMEN

En 2013, la flota de cerco francesa del océano Atlántico estaba compuesta por nueve buques con una capacidad individual de más de 600 t, lo que supone una capacidad de transporte total de aproximadamente 8.700 t. El esfuerzo nominal total acumulado ejercido durante el año fue muy similar al de 2012, es decir 2.340 y 1.920 días de pesca y búsqueda, respectivamente. Los cerqueros franceses acumularon en total más de 2.000 lances de pesca, y de ellos el 60% se realizó sobre banco libre (FSC) y el 40% sobre bancos asociados con dispositivos de concentración de peces (DCP). Las capturas se incrementaron en un 16% desde 2012 a 2013, y alcanzaron un total de 40.000 t. La composición era: más del 50% de rabil (Thunnus albacares), *40% de listado* (Katsuwonus pelamis) *y 8% de patudo* (Thunnus obesus). *Más del 55% de la captura se realizó sobre bancos libres, y el rabil grande representaba el 80% de la captura. El listado predominaba en los bancos asociados a DCP (70%), mientras que el rabil y el patudo representaban aproximadamente el 15% y el 11% del resto de la captura sobre DCP, respectivamente. Los desembarques adicionales de la flota de cerco francesa en el mercado local de Abiyán se estimaron en aproximadamente 2.700 t en 2013. Se componían de una combinación de pequeños túnidos* (Auxis spp. *y* Euthynnus), *listado y diversas especies afines a los túnidos descritas por una longitud a la horquilla generalmente inferior a 45 cm. La captura fortuita total descartada en el mar se estimó, basándose en un programa de observadores, en aproximadamente 1.900 t, es decir, menos del 5% de los desembarques totales de túnidos tropicales. Algunas especies emblemáticas capturadas como captura fortuita, como las tortugas y los tiburones ballena, fueron liberadas con elevadas tasas de supervivencia.*

KEYWORDS

Catch statistics, FAD, Free-swimming school, High seas fisheries, Purse seining

1. Introduction

Statistical data for the French purse seine fishing fleet have been collected by the 'Institut de Recherche pour le Développement' (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) since the 1980s. Tuna purse seiners target schools of yellowfin (*Thunnus albacares*), skipjack (*Katsuwonus pelamis*), and bigeye tuna (*Thunnus obesus*) through two major fishing modes that result in different species and size composition of the catch: free-swimming (or unassociated) schools (FSC) and fish aggregating device-associated (FAD) schools. A multispecies sampling has been implemented by IRD since 1980 to correct for the bias in the species composition of the purse seine catch declared by the skippers (Cayré 1984). Here, we report a synthesis of the fishing activities of the French purse seiners during 1991-2013 based on the collection of logbooks and landing reports combined with a fisheries observer program and the monitoring of landings on the local market of Abidjan.

2. Materials and methods

2.1 Data collection

The current data collection system is composed of three major components that give an overview of the different fishing activities of the purse seine fleet. First, the collection of logbooks and landing reports is done in collaboration with the fishing companies and it covers 100% of the fishing trips and activities. Sampling operations are made during the unloading of the purse seiners at fishing ports to estimate both size and species composition of the catch. Second, complementary sampling operations are conducted to estimate the landings destined to the local market of Abidjan, which are generally not reported in logbooks and include small and damaged tunas not purchased by tuna canneries as well as several other fish species. The sampling system was developed in the early 1980s and the current protocol is described in Chavance *et al.* (2011). Briefly, catches sold on the local market are derived from quantities estimated or weighted by port samplers during the unloading of each vessel and visual estimation of the species composition. Before 2005, species composition was corrected according to N'Goran (1999). Third, a fisheries observer program has started in 2005 for the French purse seine

fleet with the main objective of monitoring bycatch and discards-at-sea (Chavance *et al.* 2012). Bycatch is made of individuals of principal market tunas with length and/or state not adequate for commercialization and of untargeted species incidentally caught. The coverage of observations-at sea sharply increased in 2013 due to the combination of different observer programs and reached 41% of the fishery sets.

2.2 Data processing and analysis

The current sampling protocol, strata, and algorithms used for the lobgbook data processing were established during the European project 'Analyse du schéma d'échantillonnage multispécifique des thonidés tropicaux' (Pallarés and Hallier 1997). Overall, the processing aims to adjust the tropical tuna catch to the landings and estimate the size and species composition of the catch based on large sampling areas, fishing mode, and quarter (Pallarés and Petit 1998). In 2013, the data processing was based on the collection of 1,073 samples collected on European purse seiners and associated flags during unloading at port, which corresponded to a total of about 535,000 tunas counted and measured.

For observations at sea, raising procedures were made based on a selection of fishing trips during which all sets were sampled and the observed to total trip ratio. This method is considered simple and robust enough for three main reasons: (i) trips are used as the statistical unit because observers are onboard for a full trip, (ii) observed trips are shared among the whole fleet that is fairly homogeneous in size, and (iii) observed trips are spread over all the quarters (**Table 14**) (Amandè 2012). Raising by-catch levels has been shown to be biased for low-occurrence species (Amandè 2012). Here, the extrapolation followed two computation steps. First, when species annual occurrence was lower than 4%, the species was grouped at the family level. Second, only species or families reaching 4% of annual occurrence were kept as specific categories while the others were gathered in an "Others" category within each species group (tunas, other fishes, billfishes, sharks). These groups and their species composition are indicated in **Table 18**. Statistics relative to catch of emblematic species or species under specific resolution are indicated in numbers of individuals with estimates of survival when released at sea.

3. Fishing capacity and effort

In 2013, a total of 9 French purse seiners operated in the eastern Atlantic Ocean (**Figure 1**). The fleet was composed of 2 vessels of carrying capacity (CC) of 600-800 t, 5 vessels of CC 800-1200 t, and 2 vessels of CC >1,200 t (**Table 1**). The total capacity was similar to that of 2012 and equal to about 12,500 m^3, corresponding to 8,700 t of fish hold volume. The total nominal effort in 2013 was about 2,300 and 2,000 fishing and searching days, respectively (**Figure 2 and Table 2**). The effort was patchy and extended from the coasts of Guinea, up to 10°N, down to 10°S along the coasts of Angola (**Figure 3**). The spatial extent of the fishery was similar to 2012 corresponding to a total of 245 squares of 1° longitude and latitude where some effort was exerted in 2013 (**Figure 4** and **Table 3**). The total annual number of fishing sets was stable during 2010-2013 at about 2,000 sets y^{-1}, among which 40% were made on FAD-associated schools and 60% on FSCs (**Figure 5**). The proportion of success on FAD-sets was of 85% in 2013, similar to the average observed during 2008-2012 while the proportion of successful FSC sets was 70% (**Table 4**).

4. Fishery production

The total landings of the principal market tunas by the French component of the EU purse seine fleet of the Atlantic Ocean was about 40,000 t, being composed of more than 50%, 40%, and 8% of yellowfin, skipjack, and bigeye, respectively (**Table 5**). The total catch increased by 16% between 2012 and 2013, mainly due to an increase of the number of FSC sets that resulted in an increase in both YFT (+15%) and SKJ (+680%) catch (**Figure 6**). The substantial increase of SKJ catch on FSC was mainly explained by the access of the fleet to the fishing grounds of Gabon where free-swimming schools of SKJ are generally caught (**Figure 7 and Table 7**). Despite the decrease by 8% in the number of FAD sets in 2013, the total catch on FADs remained stable around 17,000 t, with SKJ representing more than 70% of the catch (**Table 6**). This was explained by a 20% increase in the SKJ catch per positive set from 2012 to 2013, from 14.5 to 17.5 t set^{-1} (**Figure 11c**). Meanwhile, the number of FSC sets per searching day increased by 25% from 0.5 to more than 0.6 set d^{-1} (**Figure 11b**) and the catch of YFT per positive set remained stable at more than 20 t set^{-1} (**Figure 11d**).

5. By-catch and discards

5.1 Landings on the local market

The total amount of landings destined to the local market of Abidjan was estimated at more than 2,500 t in 2013 and predominated by SKJ and other tuna species (**Table 13 and Figure 15**). Estimates suggest a strong decrease by about 50% between 2012 and 2013. Almost 10,000 individuals were measured in 2013, mainly SKJ and frigate tuna (*Auxis thazard*) (**Figure 16**). The large majority of tunas destined to the local market is characterized by small sized fishes, i.e. <1.5 kg, similarly to what was observed during 1998-2012 (**Figure 17**).

5.2 Observations-at-sea

About 90 species and species categories were encountered during purse seine fisheries observers programmes in the Atlantic Ocean (**Table 18**). A majority of species is considered to occur infrequently when it occurs in less than 8 sets among 100 (**Figure 20**). As shown by Amandè *et al.* (2012), this low occurrence of particular rare species weakens extrapolation of these observations to the whole fishery. This is particularly true when percentage of coverage of trips is low.

Acknowledgments

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Table 1. Annual number of purse seiners by size category and total carrying capacity of the European tropical tuna purse seine fishing fleet of the Atlantic Ocean during 1991-2013. Total carrying capacity (CC) was weighted by the proportion of the year at sea (in months).

table	50-400	401-600	601-800	801-1200	1201-2000	>2000	Total	CC
1991	2	9	6	6	0	0	23	11850
1992	1	8	2	6	0	0	17	11457
1993	1	8	3	6	0	0	18	11870
1994	1	8	3	6	0	0	18	12121
1995	0	10	2	5	0	0	17	10863
1996	0	9	2	5	0	0	16	11243
1997	0	10	2	5	2	0	19	11331
1998	0	7	2	6	0	0	15	11071
1999	0	8	2	5	0	0	15	10538
2000	0	7	2	5	0	0	14	10248
2001	0	7	2	7	1	0	17	11314
2002	0	8	3	5	1	0	17	9601
2003	0	8	1	5	0	0	14	9610
2004	0	6	1	5	0	0	12	8345
2005	0	4	0	5	0	0	9	6980
2006	0	4	0	3	0	0	7	4040
2007	0	3	0	2	0	0	5	3581
2008	0	3	2	2	0	0	7	3678
2009	0	1	2	4	3	0	10	6876
2010	0	1	2	4	3	0	10	8846
2011	0	1	2	4	2	0	9	7945
2012	0	0	2	5	2	0	9	8986
2013	0	0	2	5	2	0	9	8715

Table 2. Annual nominal fishing effort of the French purse seine fishing fleet in the Atlantic Ocean expressed in fishing and searching days during 1991-2013. Searching days was derived from the total time spent at sea corrected for periods of damage, route towards port, and purse seine operation.

Year	Fishing days	Searching days
1991	4843	4193
1992	4568	4069
1993	4576	3969
1994	4815	4225
1995	4293	3717
1996	4550	3910
1997	4300	3829
1998	4361	3837
1999	3933	3434
2000	3898	3419
2001	4049	3590
2002	3364	2955
2003	3360	2837
2004	2855	2469
2005	2274	1973
2006	1388	1189
2007	1278	1126
2008	1263	1052
2009	2019	1693
2010	2549	2110
2011	2214	1821
2012	2474	2079
2013	2341	1921

Table 3. Annual number of 1-degree squares explored by the French purse seine fishing fleet in the Atlantic Ocean during 1991-2013. #sets indicates 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	272	166	153	194	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
2013	369	239	222	245	122

Table 4. Number of positive and null sets by fishing mode made by the French purse seine fishing fleet in the Atlantic Ocean during 1991-2013. FAD = Fish Aggregating Device ; FSC = Free-Swimming School.

	ALL			FAD			FSC			
	Total	Positive	Null	Total	Positive	Null	Total	Positive	Null	% FAD
1991	3247	2521	726	853	772	81	2394	1749	645	26
1992	2685	2140	545	955	857	98	1730	1283	447	36
1993	3232	2650	582	1172	1116	56	2060	1534	526	36
1994	3135	2581	554	1377	1296	81	1758	1285	473	44
1995	3126	2508	618	1394	1294	100	1732	1214	518	45
1996	3519	2670	849	1347	1212	135	2172	1458	714	38
1997	2598	1908	690	816	725	91	1782	1183	599	31
1998	2889	2162	727	988	913	75	1901	1249	652	34
1999	2745	1995	750	720	653	67	2025	1342	683	26
2000	2616	1971	645	683	622	61	1933	1349	584	26
2001	2500	1838	662	630	546	84	1870	1292	578	25
2002	2209	1581	628	577	527	50	1632	1054	578	26
2003	2838	2197	641	701	649	52	2137	1548	589	25
2004	2075	1561	514	712	639	73	1363	922	441	34
2005	1613	1221	392	459	421	38	1154	800	354	28
2006	1059	821	238	221	214	7	838	607	231	21
2007	819	560	259	171	125	46	648	435	213	21
2008	1018	736	282	188	165	23	830	571	259	18
2009	1595	1154	441	451	367	84	1144	787	357	28
2010	2133	1658	475	872	794	78	1261	864	397	41
2011	1908	1363	545	645	510	135	1263	853	410	34
2012	1913	1495	418	900	784	116	1013	711	302	47
2013	2016	1548	468	824	705	119	1192	843	349	41

Table 5. Catch by species for the French purse seine fishing fleet of the Atlantic Ocean during 1991-2013.

Year	YFT	SKJ	BET	ALB	OTH	Total
1991	30172	31814	3327	50	554	65917
1992	30778	20383	4985	451	930	57526
1993	33590	31537	10629	565	500	76821
1994	32381	30251	10075	130	1118	73955
1995	27850	22542	6262	83	1099	57836
1996	32179	21370	6778	191	725	61243
1997	29065	13335	4209	39	503	47150
1998	30468	14144	3641	40	927	49221
1999	28833	19457	3383	13	507	52194
2000	29506	16642	3936	23	434	50540
2001	31183	13774	3943	11	275	49186
2002	32982	13806	3597	18	211	50614
2003	32268	17318	3289	63	616	53554
2004	23413	19982	2417	19	264	46094
2005	22073	12606	1913	478	47	37117
2006	18353	5423	2402	347	12	26536
2007	12775	4012	1485	12	98	18382
2008	15929	3661	989	50	37	20666
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	351	34077
2013	20260	15559	3197	73	443	39533

Table 6. Catch by species made on FAD-associated schools for the French purse seine fishing fleet of the Atlantic Ocean during 1991-2013.

Year	YFT	SKJ	BET	ALB	OTH	Total
1991	4476	16465	2501	0	136	23578
1992	6116	16370	3619	0	509	26614
1993	6723	23884	6853	0	432	37892
1994	9124	22273	8372	0	721	40489
1995	5549	18155	5274	4	933	29915
1996	5750	16736	4941	0	559	27985
1997	4371	9076	2945	0	457	16850
1998	4669	8725	2712	0	787	16893
1999	5795	11478	2316	0	289	19877
2000	4335	11207	2696	0	405	18643
2001	3090	8792	2335	0	243	14459
2002	4198	9308	2287	0	164	15957
2003	4332	10937	1833	0	372	17473
2004	3742	14602	1901	0	191	20435
2005	2547	9805	1165	5	47	13569
2006	626	3925	541	0	12	5104
2007	850	3112	489	0	98	4549
2008	557	2103	391	0	37	3088
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	312	16739
2013	2476	12317	1972	15	391	17173

Table 7. Catch by species made on free-swimming schools for the French purse seine fishing fleet of the Atlantic Ocean during 1991-2013.

Year	YFT	SKJ	BET	ALB	OTH	Total
1991	25696	15349	826	50	417	42339
1992	24662	4013	1366	451	421	30913
1993	26867	7653	3776	565	68	38929
1994	23257	7979	1703	130	397	33466
1995	22301	4387	988	79	166	27921
1996	26430	4634	1837	191	167	33258
1997	24694	4259	1264	39	46	30301
1998	25799	5419	930	40	140	32328
1999	23038	7980	1067	13	218	32316
2000	25170	5435	1240	23	30	31897
2001	28094	4982	1608	11	33	34727
2002	28784	4498	1310	18	46	34657
2003	27936	6382	1456	63	244	36081
2004	19671	5380	516	19	73	25660
2005	19527	2801	749	472	0	23548
2006	17727	1498	1861	347	0	21433
2007	11925	900	996	12	0	13834
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	39	17339
2013	17784	3242	1224	58	51	22360

Table 8. Number of sets per searching on FAD-associated (FAD) and free-swimming schools (FSC) for the French purse seine fishing fleet of the Atlantic Ocean during 1991-2013.

Year	ALL	FAD	FSC
1991	0.77	0.20	0.57
1992	0.66	0.23	0.43
1993	0.81	0.30	0.52
1994	0.74	0.33	0.42
1995	0.84	0.38	0.47
1996	0.90	0.34	0.56
1997	0.68	0.21	0.47
1998	0.75	0.26	0.50
1999	0.80	0.21	0.59
2000	0.77	0.20	0.57
2001	0.70	0.18	0.52
2002	0.75	0.20	0.55
2003	1.00	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	0.73	0.15	0.58
2008	0.97	0.18	0.79
2009	0.94	0.27	0.68
2010	1.01	0.41	0.60
2011	1.05	0.35	0.69
2012	0.92	0.43	0.49
2013	1.05	0.43	0.62

Table 9. Catch per unit of effort (in t per positive set) on FAD-associated schools for the French purse seine fishing fleet of the Atlantic Ocean during 1991-2013.

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	5.66	16.1	4.28	0	0.45	26.48
2002	7.97	17.66	4.34	0	0.31	30.28
2003	6.67	16.85	2.82	0	0.57	26.92
2004	5.86	22.85	2.97	0	0.3	31.98
2005	6.05	23.29	2.77	0.01	0.11	32.23
2006	2.93	18.34	2.53	0	0.06	23.85
2007	6.8	24.9	3.91	0	0.78	36.39
2008	3.38	12.75	2.37	0	0.22	18.72
2009	2.97	15.07	2.56	0	0.07	20.66
2010	3.78	14.23	1.93	0.02	0.12	20.07
2011	3.88	18.52	3.48	0.02	0.19	26.09
2012	3.52	14.46	2.96	0.02	0.4	21.35
2013	3.51	17.47	2.8	0.02	0.55	24.36

Table 10. Catch per unit of effort (in t per positive set) on free-swimming schools for the French purse seine fishing fleet of the Atlantic Ocean during 1991-2013.

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	21.74	3.86	1.24	0.01	0.03	26.88
2002	27.31	4.27	1.24	0.02	0.04	32.88
2003	18.05	4.12	0.94	0.04	0.16	23.31
2004	21.34	5.84	0.56	0.02	0.08	27.83
2005	24.41	3.5	0.94	0.59	0	29.44
2006	29.2	2.47	3.07	0.57	0	35.31
2007	27.41	2.07	2.29	0.03	0	31.8
2008	26.92	2.73	1.05	0.09	0	30.78
2009	22.18	1.36	1.4	0.08	0	25.02
2010	19.64	3.11	1.93	0.11	0.01	24.81
2011	22.8	3.1	1.75	0.05	0.07	27.77
2012	21.78	0.58	1.76	0.21	0.05	24.39
2013	21.1	3.85	1.45	0.07	0.06	26.52

Table 11. Catch per unit of effort (in t per searching day) on FAD-associated schools for the French purse seine fishing fleet of the Atlantic Ocean during 1991-2013.

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	0.75	2.76	0.43	0	0.09	4.04
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
2013	1.29	6.41	1.03	0.01	0.2	8.94

Table 12. Catch per unit of effort (in t per searching day) on free swimming schools for the French purse seine fishing fleet of the Atlantic Ocean during 1991-2013.

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	10.59	0.8	0.88	0.01	0	12.28
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
2013	9.26	1.69	0.64	0.03	0.03	11.64

Table 13. Landings on the local market.

Year	BET	BIL	FRI	LTA	PEL	SHX	SKJ	TRI	TUN	TUX	WAH	YFT	Total (t)
1991	141	161	0	0	639	27	881	87	0	4374	0	417	6729
1992	149	170	0	0	672	28	927	92	0	4598	0	439	7074
1993	223	255	0	0	1011	43	1394	138	0	6917	0	660	10641
1994	217	248	0	0	981	41	1352	134	0	6710	0	640	10324
1995	162	185	0	0	733	31	1011	100	0	5017	0	479	7719
1996	106	121	0	0	478	20	659	65	0	3270	0	312	5031
1997	97	111	0	0	438	18	604	60	0	2995	0	286	4608
1998	108	124	0	0	490	21	675	67	0	3351	0	320	5155
1999	124	142	0	0	563	24	776	77	0	3852	0	367	5926
2000	154	176	0	0	698	29	963	96	0	4778	0	456	7351
2001	118	135	0	0	536	23	738	73	0	3664	0	350	5637
2002	86	98	0	0	388	16	535	53	0	2654	0	253	4082
2003	99	114	0	0	450	19	621	62	0	3080	0	294	4738
2004	88	101	0	0	400	17	552	55	0	2738	0	261	4213
2005	222	68	444	102	178	9	918	8	0	76	28	251	2303
2006	79	37	217	145	1134	4	346	0	39	26	10	133	2169
2007	26	34	94	141	2	12	206	0	68	496	3	33	1116
2008	47	21	135	109	35	3	284	1	161	119	16	49	980
2009	150	30	264	207	160	1	1120	0	48	3	26	203	2210
2010	122	20	555	695	206	3	743	11	36	119	26	181	2717
2011	394	24	500	994	114	7	1480	23	104	430	17	344	4430
2012	192	38	605	1354	242	4	1646	72	17	638	0	347	5154
2013	56	18	520	720	140	18	463	14	156	449	0	129	2683
Total	**3160**	**2431**	**3334**	**4467**	**10688**	**418**	**18894**	**1288**	**629**	**60354**	**126**	**7204**	**112990**
%	**3%**	**2%**	**3%**	**4%**	**9%**	**0%**	**17%**	**1%**	**1%**	**53%**	**0%**	**6%**	**100%**

Table 14. Production.

Year	Quarter	Trip	Set	Day	Production
2013	1	16(88.9)	359(69.6)	449(77.4)	5573.4(63.7)
2013	2	2(8.3)	84(14.9)	89(13.5)	2030.4(20.1)
2013	3	11(45.8)	240(41.2)	292(45.5)	5661.1(38.7)
2013	4	4(25)	140(39.3)	245(47.3)	2699.6(48.1)

Table 15. Occurrence.

Species group	FAO Code	Scientific name	Occurrence
Tunas	YFT	*Thunnus albacares*	65.8
Tunas	SKJ	*Katsuwonus pelamis*	46.7
Other Fishes	TRI	*Balistidae*	37.2
Other Fishes	RRU	*Elagatis bipinnulata*	31.8
Other Fishes	DOX	*Coryphaenidae*	31.4
Other Fishes	CGX	*Carangidae*	29.9
Other Fishes	WAH	*Acanthocybium solandri*	26.9
Sharks	FAL	*Carcharhinus falciformis*	22.6
Tunas	BET	*Thunnus obesus*	20.2
Tunas	FRZ	*Auxis spp*	19
Other Fishes	LOB	*Lobotes surinamensis*	11.6
Other Fishes	KYP	*Kyphosus* spp	9.9
Other Fishes	BAZ	*Sphyraenidae*	9.7
Billfishes	BXQ	*Makaira spp*	9.1
Billfishes	SAI/SFA	*Istiophorus albicans/platypterus*	7.6
Other Fishes	SPA	*Ephippidae*	7.3
Other Fishes	FFX	*Monacanthidae*	6.1
Tunas	ALB	*Thunnus alalunga*	5.4
Tunas	EHZ	*Euthynnus spp*	4.4

Table 16. Discards.

Species group	FAO code	Scientific name	Discards
Tunas	SKJ	*Katsuwonus pelamis*	525
Tunas	EHZ	*Euthynnus* spp	407
Tunas	FRZ	*Auxis* spp	295
Sharks	FAL	*Carcharhinus falciformis*	148
Tunas	YFT	*Thunnus albacares*	114
Other Fishes	CGX	*Carangidae*	91
Tunas			71
Other Fishes	RRU	*Elagatis bipinnulata*	71
Sharks			60
Other Fishes	TRI	*Balistidae*	54
Tunas	BET	*Thunnus obesus*	29
Other Fishes			27
Other Fishes	WAH	*Acanthocybium solandri*	15
Other Fishes	DOX	*Coryphaenidae*	9
Billfishes	SAI/SFA	*Istiophorus albicans/platypterus*	2
Billfishes			2
Other Fishes	BAZ	*Sphyraenidae*	1
Billfishes	BXQ	*Makaira* spp	1
Other Fishes	LOB	*Lobotes surinamensis*	1
Other Fishes	KYP	*Kyphosus* spp	0

Table 17. Live releases and survival rate.

Species group	FAO Code	Scientific name	Number	Released alive	Survival rate
Cetaceans	FIW	*Balaenoptera physalus*	1	1	100
Sharks	RHN	*Rhincodon typus*	1	1	100
Turtles	DKK	*Dermochelys coriacea*	3	3	100
Turtles	LKV	*Lepidochelys olivacea*	37	37	100
Turtles	LKY	*Lepidochelys kempii*	13	12	92.3
Turtles	TTH	*Eretmochelys imbricata*	2	1	50
Turtles	TTL	*Caretta caretta*	22	21	95.5
Turtles	TTX	*Testitudines*	1	1	100
Turtles	TUG	*Chelonia mydas*	2	2	100

Table 18. Species composition.

Species group	FAO Code	Scientific name	Group code	Group name
Tunas	BET	*Thunnus obesus*	BET	*Thunnus obesus*
Tunas	KAW	*Euthynnus affinis*	EHZ	*Euthynnus* spp
Tunas	LTA	*Euthynnus alletteratus*	EHZ	*Euthynnus* spp
Tunas	BLT	*Auxis rochei*	FRZ	*Auxis* spp
Tunas	FRI	*Auxis thazard*	FRZ	*Auxis* spp
Tunas	FRZ	*Auxis* spp	FRZ	*Auxis* spp
Tunas	ALB	*Thunnus alalunga*	MAX	*Scombridae*
Tunas	SKJ	*Katsuwonus pelamis*	SKJ	*Katsuwonus pelamis*
Tunas	YFT	*Thunnus albacares*	YFT	*Thunnus albacares*
Other Fishes	GBA	*Sphyraena barracuda*	BAZ	*Sphyraenidae*
Other Fishes	BAF	*Ablennes hians*	BEN	*Belonidae*
Other Fishes	BTS	*Tylosurus crocodilus*	BEN	*Belonidae*
Other Fishes	3CUX	*Uraspis* spp	CGX	*Carangidae*
Other Fishes	CGX	*Carangidae*	CGX	*Carangidae*
Other Fishes	CXS	*Caranx sexfasciatus*	CGX	*Carangidae*
Other Fishes	NAU	*Naucrates ductor*	CGX	*Carangidae*
Other Fishes	RUB	*Caranx crysos*	CGX	*Carangidae*
Other Fishes	SDX	*Decapterus* spp	CGX	*Carangidae*
Other Fishes	USE	*Uraspis secunda*	CGX	*Carangidae*
Other Fishes	YTL	*Seriola rivoliana*	CGX	*Carangidae*
Other Fishes	DIO	*Diodontidae*	DIO	*Diodontidae*
Other Fishes	DIY	*Diodon hystrix*	DIO	*Diodontidae*
Other Fishes	CFW	*Coryphaena equiselis*	DOX	*Coryphaenidae*
Other Fishes	DOL	*Coryphaena hippurus*	DOX	*Coryphaenidae*
Other Fishes	DOX	*Coryphaenidae*	DOX	*Coryphaenidae*
Other Fishes	ECN	*Echeneidae*	ECN	*Echeneidae*
Other Fishes	EHN	*Echeneis naucrates*	ECN	*Echeneidae*
Other Fishes	HTL	*Phtheirichthys lineatus*	ECN	*Echeneidae*
Other Fishes	REO	*Remora remora*	ECN	*Echeneidae*
Other Fishes	RRL	*Remorina albescens*	ECN	*Echeneidae*
Other Fishes	ALM	*Aluterus monoceros*	FFX	*Monacanthidae*
Other Fishes	ALN	*Aluterus scriptus*	FFX	*Monacanthidae*
Other Fishes	FLY	*Exocoetidae*	FLY	*Exocoetidae*
Other Fishes	3MOP	*Molidae*	JHX	*Molidae*
Other Fishes	MOX	*Mola mola*	JHX	*Molidae*
Other Fishes	MRW	*Masturus lanceolatus*	JHX	*Molidae*
Other Fishes	RZV	*Ranzania laevis*	JHX	*Molidae*
Other Fishes	KYP	*Kyphosus* spp	KYP	*Kyphosus* spp
Other Fishes	KYS	*Kyphosus sectatrix*	KYP	*Kyphosus* spp
Other Fishes	KYV	*Kyphosus vaigiensis*	KYP	*Kyphosus* spp
Other Fishes	LOB	*Lobotes surinamensis*	LOB	*Lobotes surinamensis*
Other Fishes	BON	*Sarda sarda*	MAX	*Scombridae*
Other Fishes	MAX	*Scombridae*	MAX	*Scombridae*
Other Fishes	MZZ	*Osteichthyes*	MZZ	*Osteichthyes*
Other Fishes	LGH	*Lagocephalus lagocephalus*	PUX	*Tetraodontidae*
Other Fishes	PUX	*Tetraodontidae*	PUX	*Tetraodontidae*
Other Fishes	RRU	*Elagatis bipinnulata*	RRU	*Elagatis bipinnulata*
Other Fishes	BVP	*Balistes punctatus*	TRI	*Balistidae*
Other Fishes	CNT	*Canthidermis maculata*	TRI	*Balistidae*
Other Fishes	TRG	*Balistes carolinensis*	TRI	*Balistidae*
Other Fishes	TRI	*Balistidae*	TRI	*Balistidae*

Other Fishes	WAH	*Acanthocybium solandri*	WAH	*Acanthocybium solandri*
Billfishes	BIL	*Istiophoridae*	BIL	*Istiophoridae*
Billfishes	SPF	*Tetrapturus pfluegeri*	BIL	*Istiophoridae*
Billfishes	WHM	*Tetrapturus albidus*	BIL	*Istiophoridae*
Billfishes	BLM	*Makaira indica*	BXQ	*Makaira spp*
Billfishes	BUM	*Makaira nigricans*	BXQ	*Makaira spp*
Billfishes	SAI	*Istiophorus albicans*	SAI/SFA	*Istiophorus albicans/platypterus*
Billfishes	SWO	*Xiphias gladius*	SWO	*Xiphias gladius*
Sharks	FAL	*Carcharhinus falciformis*	FAL	*Carcharhinus falciformis*
Sharks	SMA	*Isurus oxyrinchus*	MAK	*Isurus spp*
Sharks	MAN	*Mobulidae*	MAN	*Mobulidae*
Sharks	MNT	*Manta spp*	MAN	*Mobulidae*
Sharks	RMB	*Manta birostris*	MAN	*Mobulidae*
Sharks	RMJ	*Mobula japanica*	MAN	*Mobulidae*
Sharks	RMM	*Mobula mobular*	MAN	*Mobulidae*
Sharks	RMV	*Mobula spp*	MAN	*Mobulidae*
Sharks	RHN	*Rhincodon typus*	RHN	*Rhincodon typus*
Sharks	BSH	*Prionace glauca*	RSK	*Carcharhinidae spp*
Sharks	CCE	*Carcharhinus leucas*	RSK	*Carcharhinidae spp*
Sharks	CVX	*Carcharhiniformes*	RSK	*Carcharhinidae spp*
Sharks	OCS	*Carcharhinus longimanus*	RSK	*Carcharhinidae spp*
Sharks	RSK	*Carcharhinidae spp*	RSK	*Carcharhinidae spp*
Sharks	2REX	*Requin non identifié*	SKX	*Elasmobranchii*
Sharks	SRX	*Raie non identifiée*	SKX	*Elasmobranchii*
Sharks	SPK	*Sphyrna mokarran*	SPY	*Sphyrnidae*
Sharks	SPL	*Sphyrna lewini*	SPY	*Sphyrnidae*
Sharks	SPY	*Sphyrnidae*	SPY	*Sphyrnidae*
Sharks	SPZ	*Sphyrna zygaena*	SPY	*Sphyrnidae*
Sharks	PLS	*Dasyatys (Pteroplatytrygon) violacea*	STT	*Dasyatidae*
Sharks	STT	*Dasyatidae*	STT	*Dasyatidae*
Turtles	DKK	*Dermochelys coriacea*	TTX	*Testitudines*
Turtles	LKV	*Lepidochelys olivacea*	TTX	*Testitudines*
Turtles	LKY	*Lepidochelys kempii*	TTX	*Testitudines*
Turtles	TTH	*Eretmochelys imbricata*	TTX	*Testitudines*
Turtles	TTL	*Caretta caretta*	TTX	*Testitudines*
Turtles	TTX	*Testitudines*	TTX	*Testitudines*
Turtles	TUG	*Chelonia mydas*	TTX	*Testitudines*
Cetaceans	FIW	*Balaenoptera physalus*	MYS	*Mysticeti*
Cetaceans	MYS	*Mysticeti*	MYS	*Mysticeti*
Cetaceans	SHW	*Globicephala macrorhynchus*	ODN	*Odontoceti*
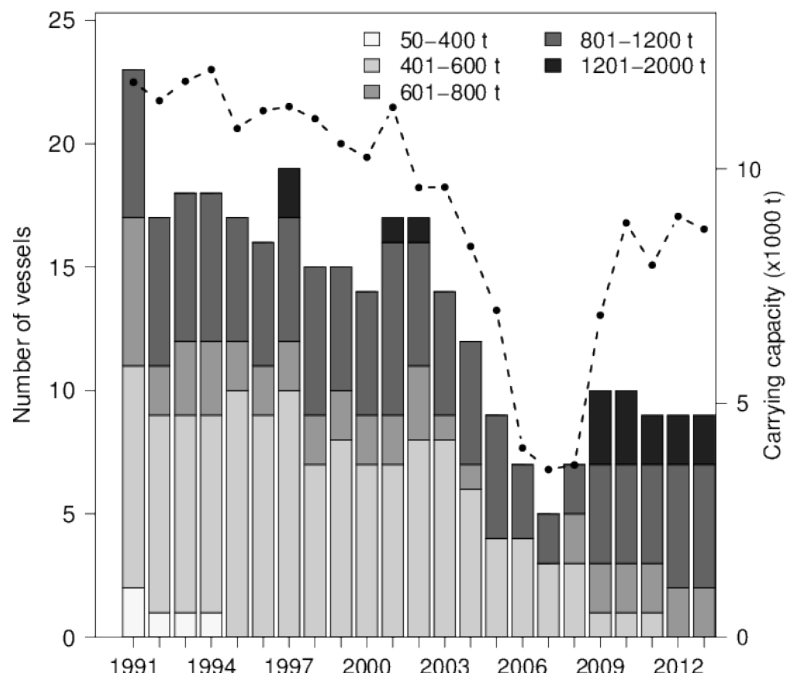
Figure 1. Fishing capacity of the French purse seine fishing fleet in the Atlantic Ocean. Annual changes in the number of purse seiners by size category (barplots) and total carrying capacity (dashed line with circles) during 1991-2013. Capacity was weighted by the proportion of year at sea (in months) for each purse seiner. Vessel size category (t) was computed as 0.7 times the capacity expressed in m^3.
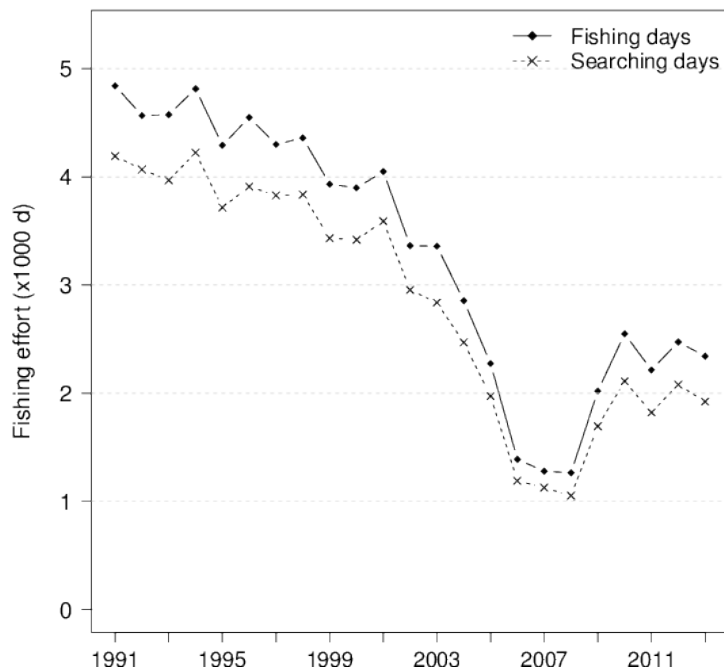
Figure 2. Changes in nominal effort over time. Annual total number of fishing and searching days for the French purse seine fishing fleet in the Atlantic Ocean during 1991-2013.
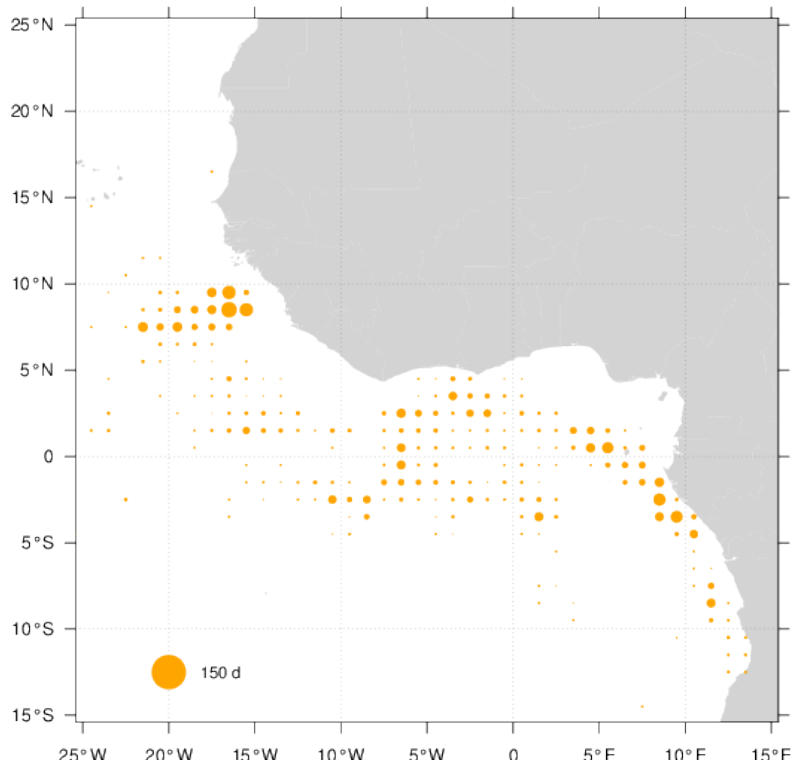
Figure 3. Fishing grounds. Spatial distribution of fishing effort (in searching days) of the French purse seine fishing fleet in 2013.
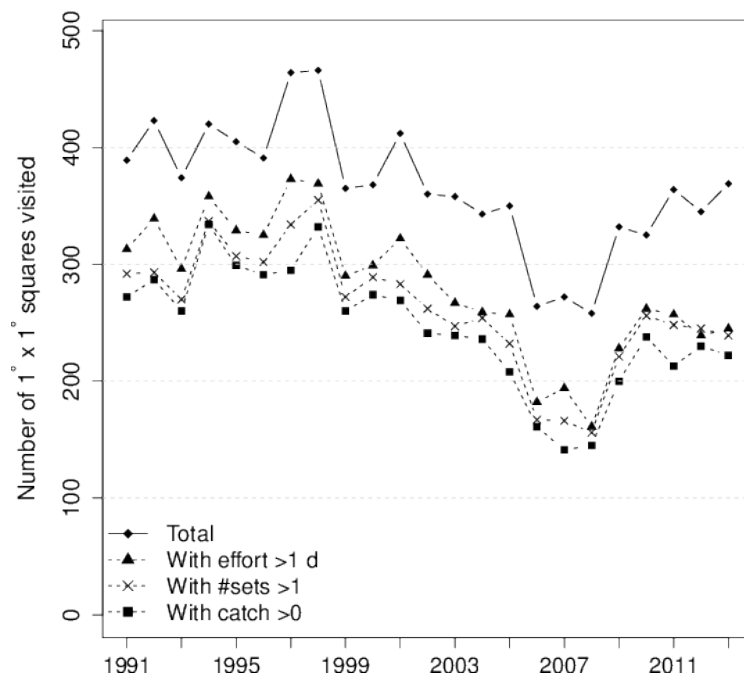
Figure 4. Annual number of 1-degree squares explored by the French purse seine fleet during 1991-2013.
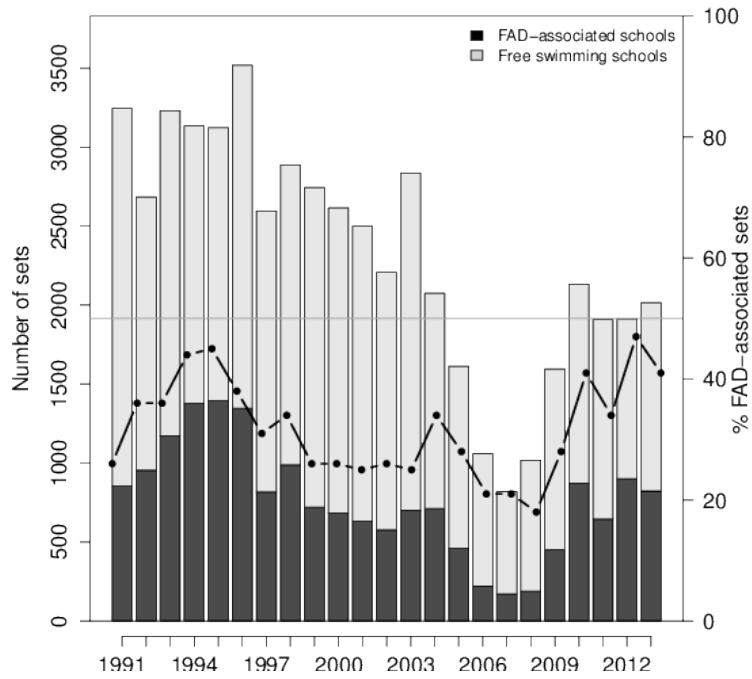
Figure 5. Fishing operations. Annual number of fishing sets in the French purse seine fishery on FAD-associated and free-swimming schools during 1991-2013. Line with solid circles indicates the percentage of sets made on FAD-associated schools over free-swimming schools. Grey solid line indicates the 50% value.
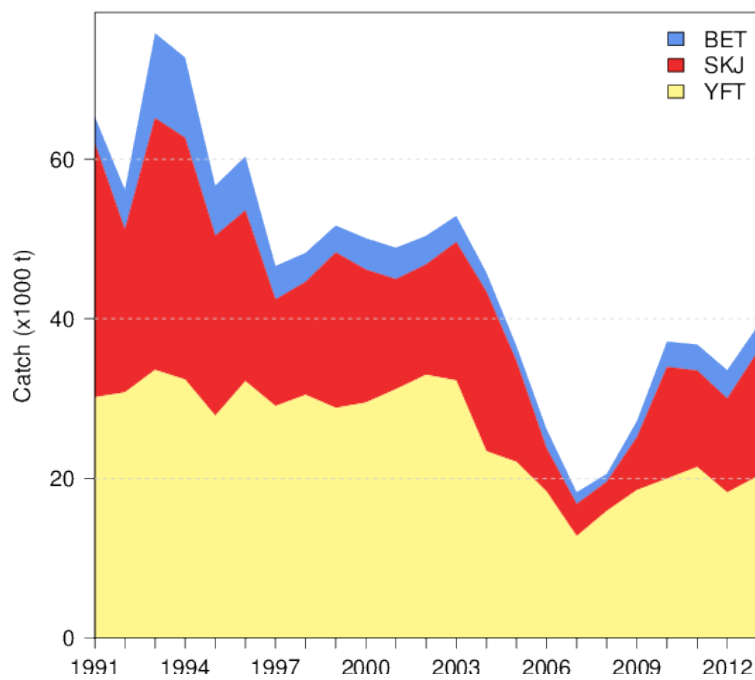
Figure 6. Total fishery production. Catch by species of the French purse seine fishing fleet during 1991-2013.
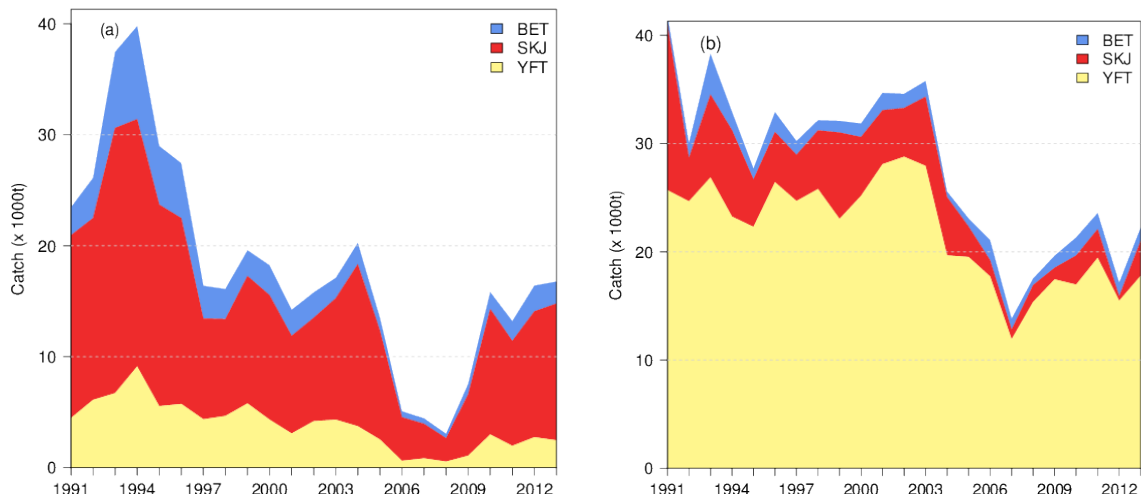
Figure 7. Fishery production by major fishing mode. Catch by species of the French purse seine fishing fleet on (a) FAD-associated and (b) free-swimming schools during 1991-2013.
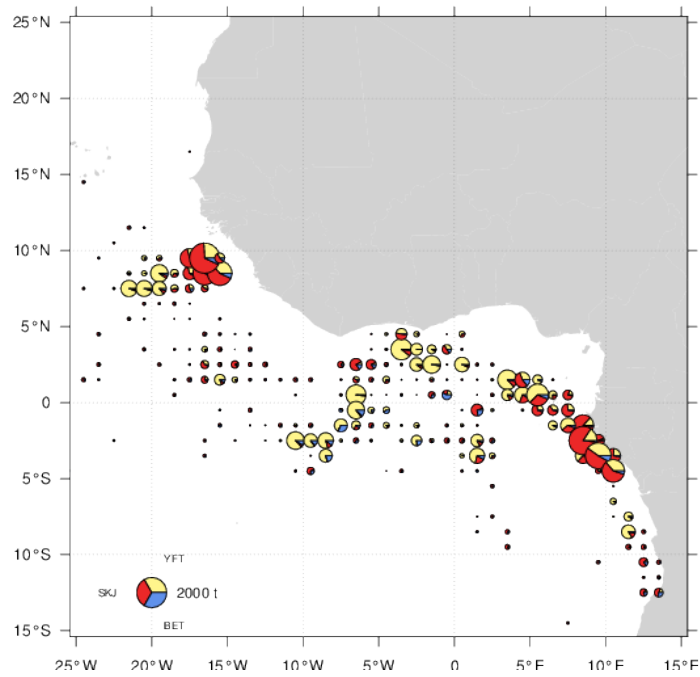
Figure 8. Spatial distribution of tuna catches of the French purse seine fishing fleet in 2013.
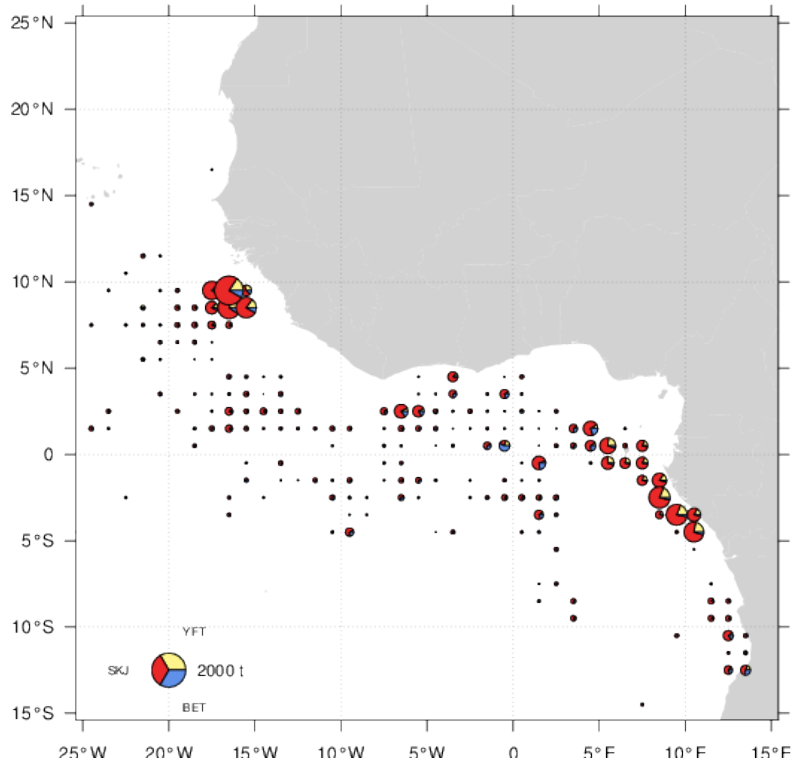
Figure 9. Spatial distribution of tuna catches of the French purse seine fishing fleet made on FAD-associated schools in 2013.
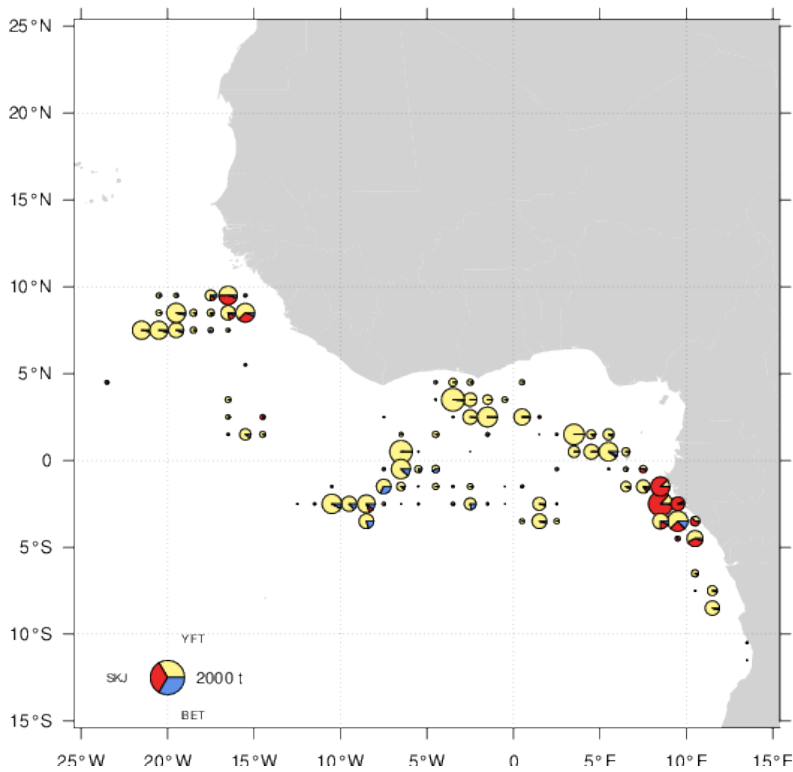
Figure 10. Spatial distribution of tuna catches of the French purse seine fishing fleet made on FSC-associated schools in 2013.
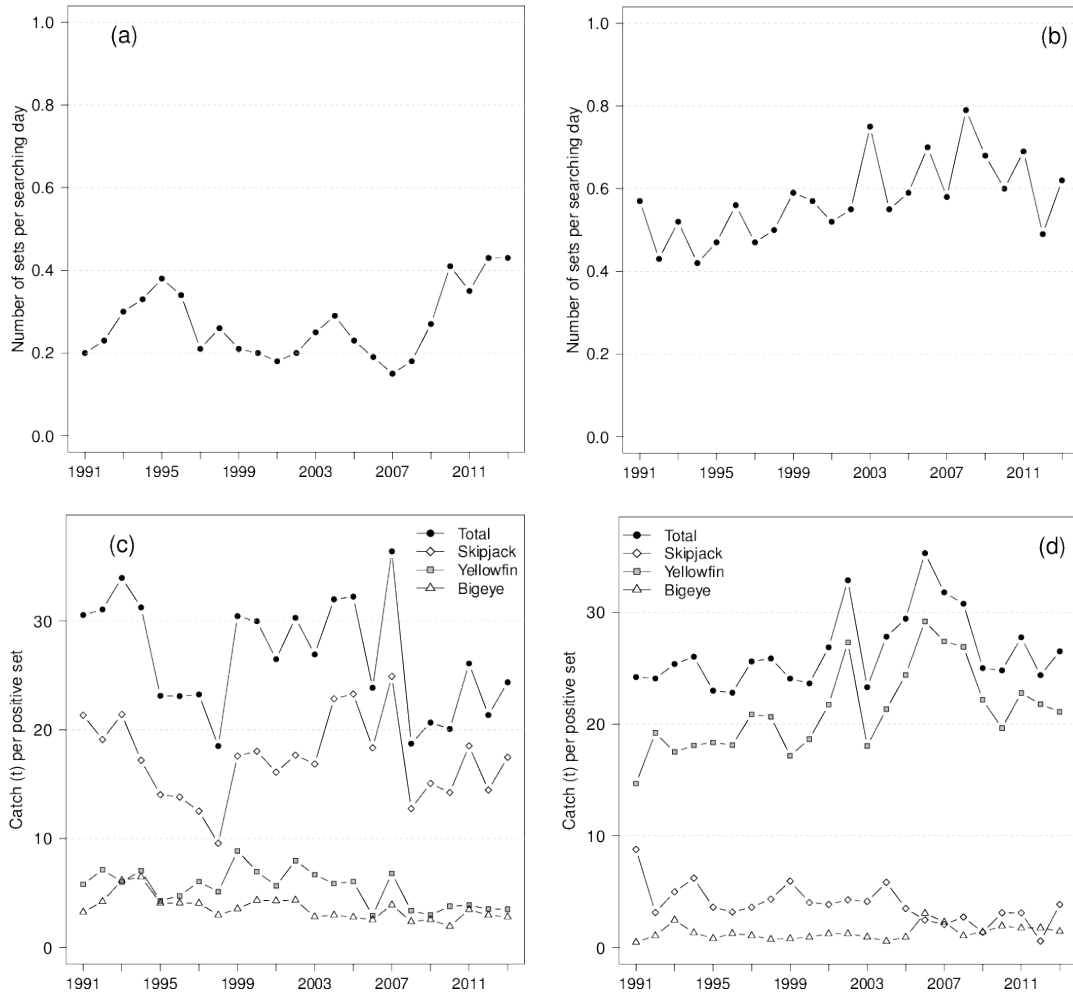
Figure 11. (a-b) Annual number of sets per searching day and (c-d) catch per positive set on (left panel) FAD-associated and (right panel) free-swimming schools for the French purse seine fishing fleet in the Atlantic Ocean during 1991-2013.
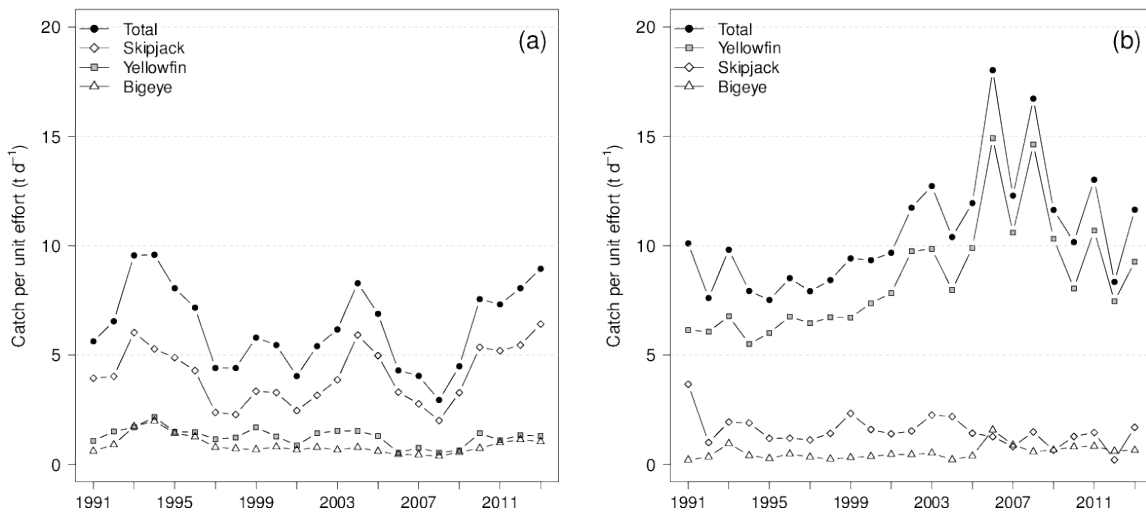
Figure 12. Annual catch rates (in t per searching day) of the French purse seine fishing fleet on (a) FAD-associated and (b) free-swimming schools in the Atlantic Ocean during 1991-2013.
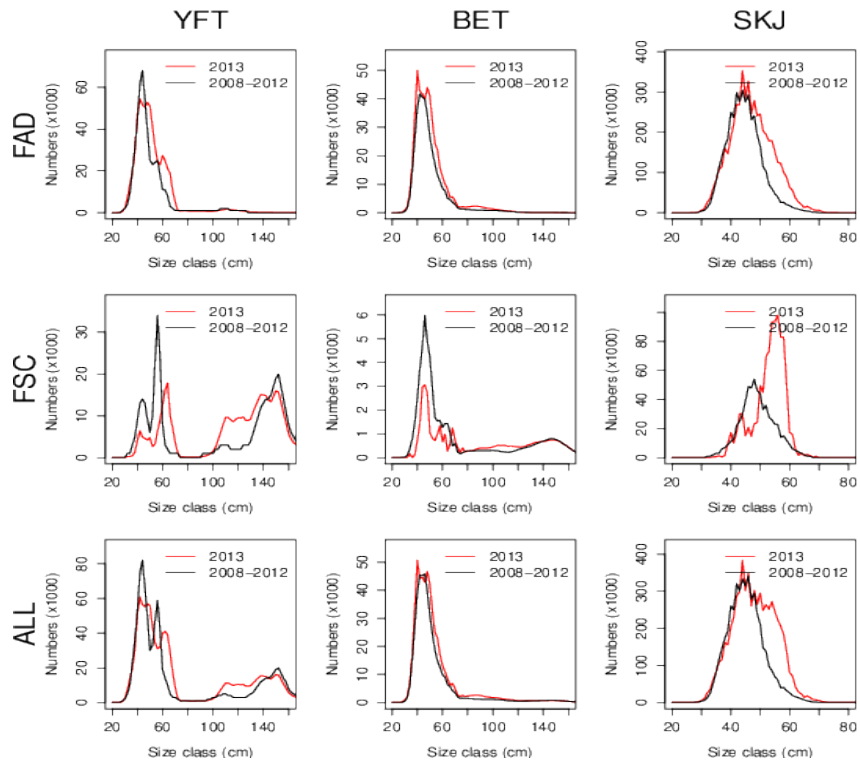
Figure 13. Size distribution of the catch (in numbers) for the French purse seine fleet in 2013 (red line) and for an average year representing the period 2008-2012 (black line).
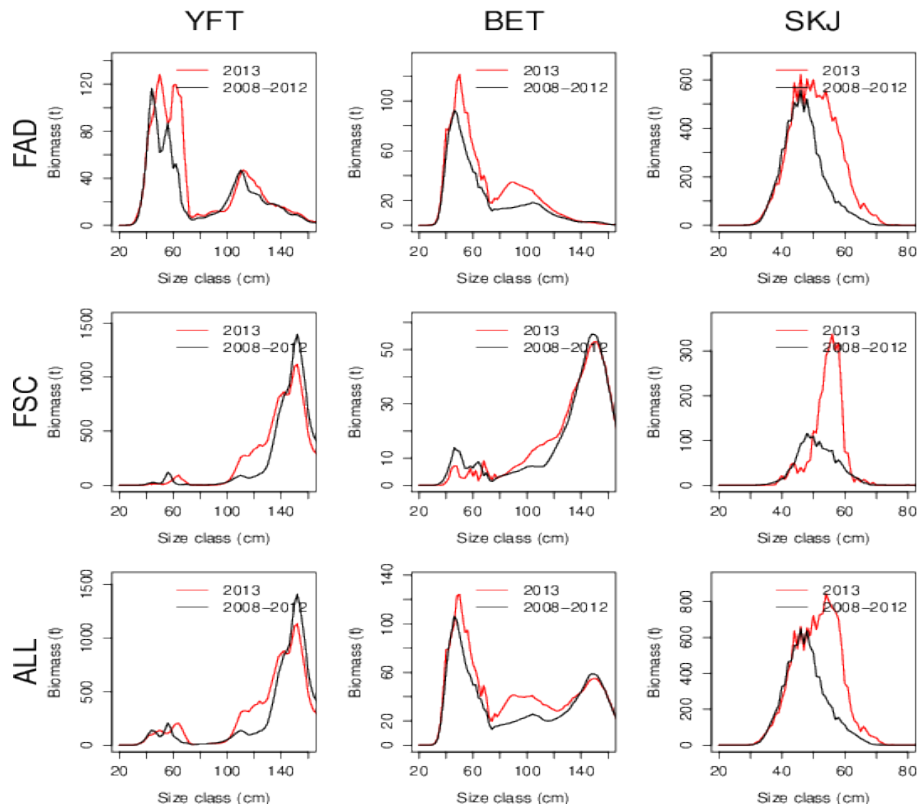
Figure 14. Size distribution (in weight) of the catch for the French purse seine fleet in 2013 (red line) and for an average year representing the period 2008-2012 (black line).

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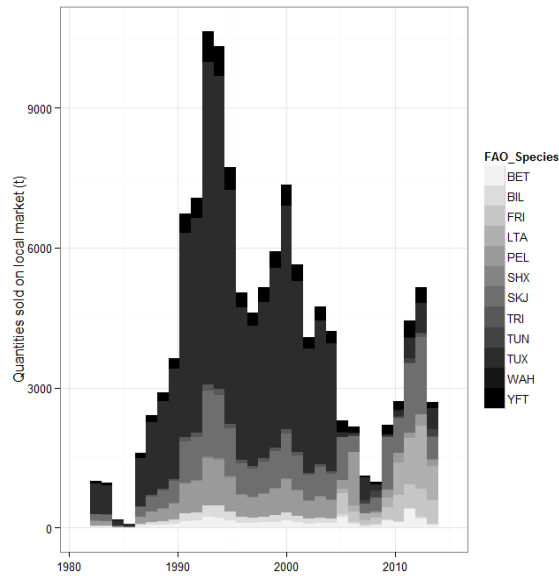
Figure 15. Estimates of annual landings (t) by the French purse seine fleet during 1982-2013 commercialized on the local market of Abidjan, Ivory Coast.
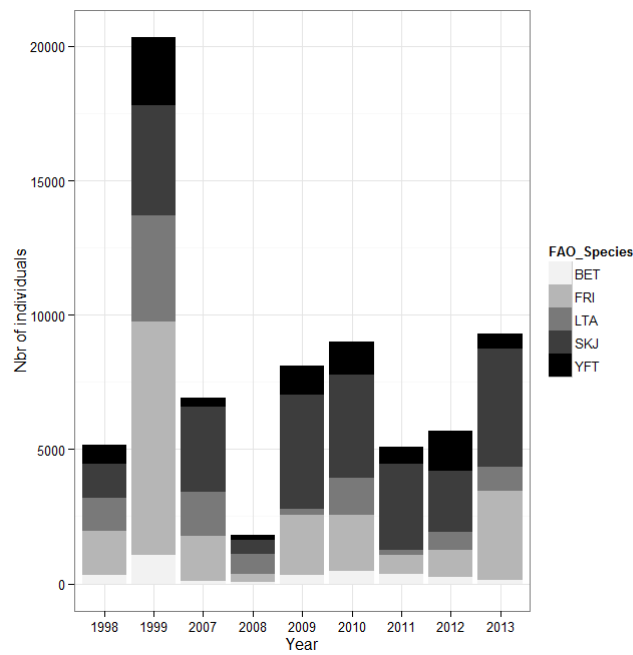
Figure 16. Number of individuals measured between 1998 and 2013 for the main tuna species commercialized on the local market of Abidjan, Ivory Coast.

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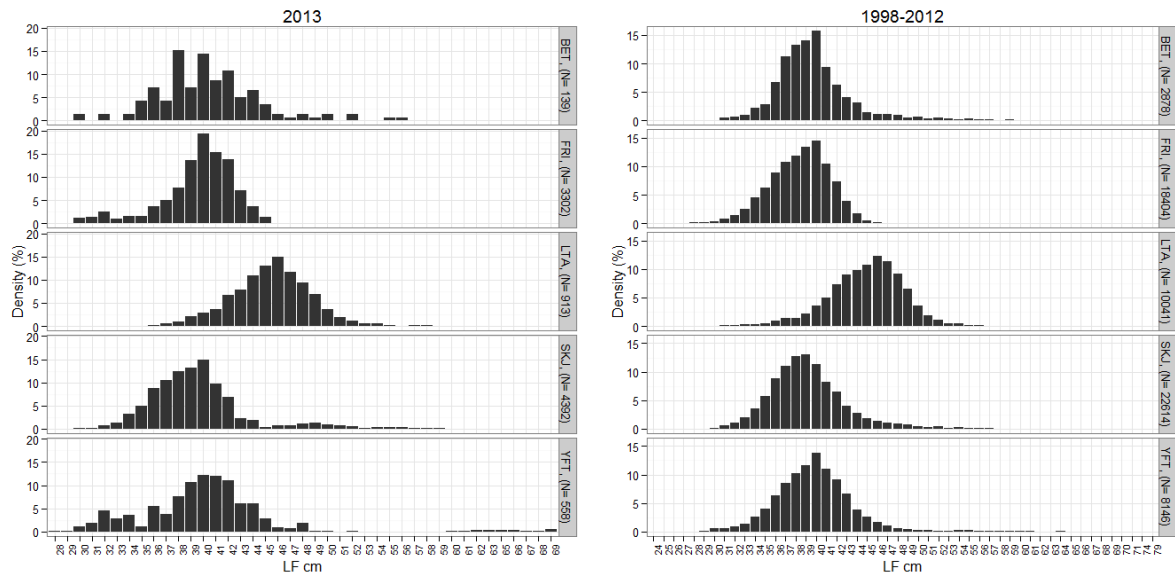
Figure 17. Size-density histograms of the main tuna species landed in Abidjan (Côte d'Ivoire) and commercialized on the local market in 2013 (left panel) and 1998-2012 (right panel). *N* indicates the number of fish measured.
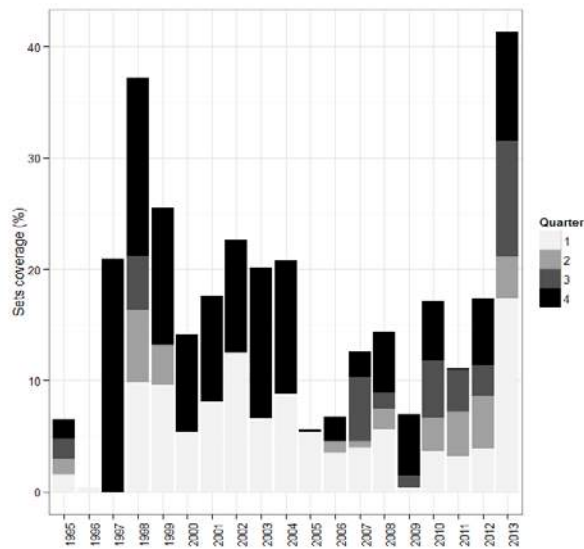
Figure 18. Coverage of the French purse seine observer programme during 1995-2013. Percentage of sets observed by quarter and year in the fishery.
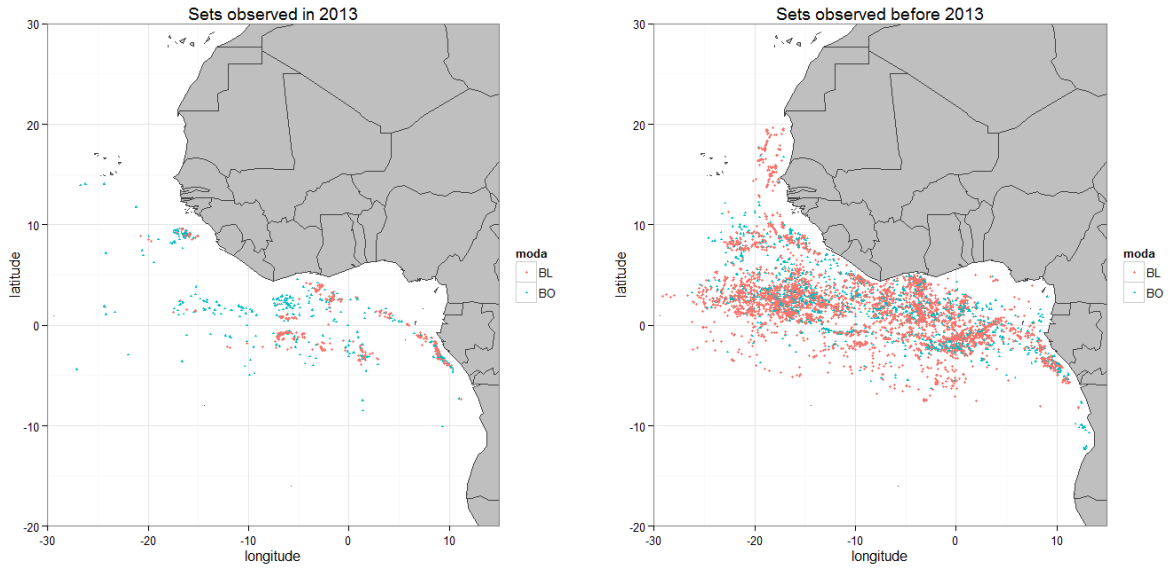
Figure 19. Spatial distribution of French purse seine fishing sets observed in 2013 (left panel) and before 2013 (right panel). *BL* = Free-swimming school; *BO* = FAD-associated school.
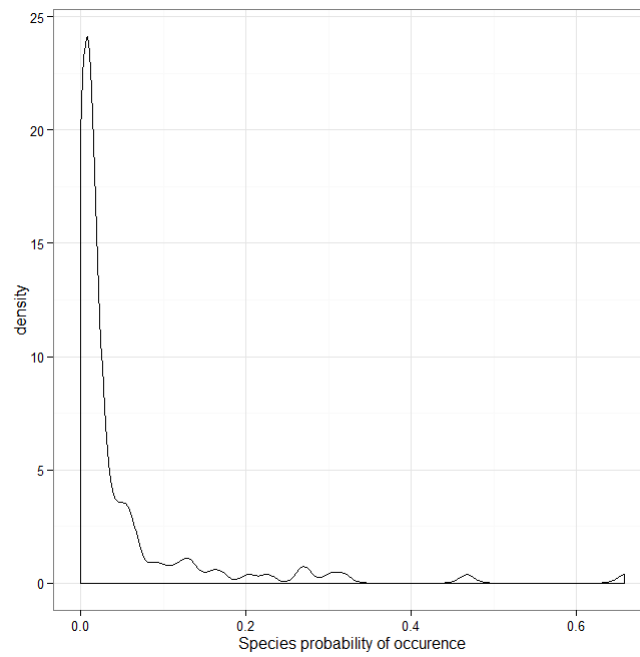
Figure 20. Annual mean probability of occurrence of species in observer programmes and indication of a "rarity" threshold near .004 (4%) (Source: observer data 2006-2014 for Indian and Atlantic Oceans).
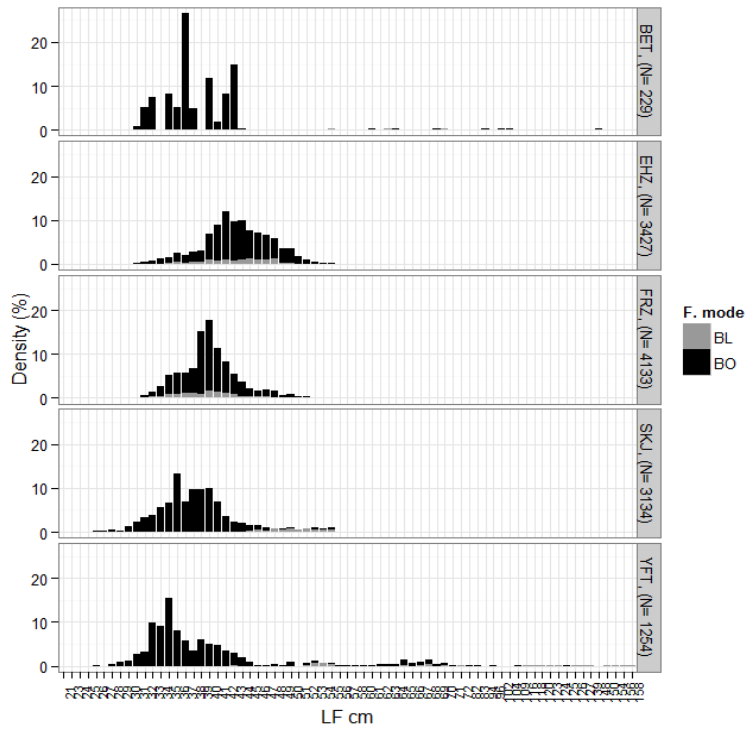
Figure 21. Size-density histograms of tunas discarded-at sea by the French purse seine fleet in 2013 in the Atlantic Ocean. *N* indicates the number of fish measured. *BL* = Free-swimming school; *BO* = FAD-associated school.
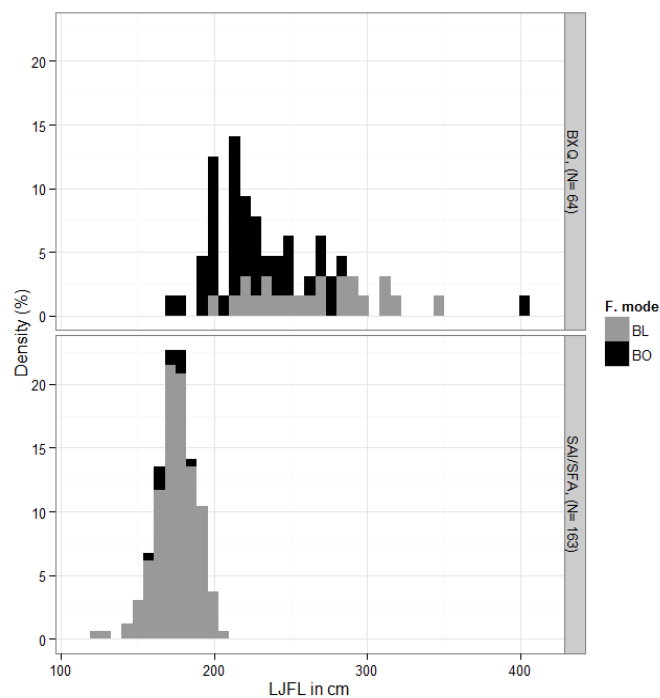

Figure 22. Size-density histograms of billfish discarded-at sea by the French purse seine fleet in 2013 in Atlantic Ocean. *N* indicates the number of fish measured. *BL* = Free-swimming school; *BO* = FAD-associated school; *LJFL* = Lower-Jaw-Fork-Length.
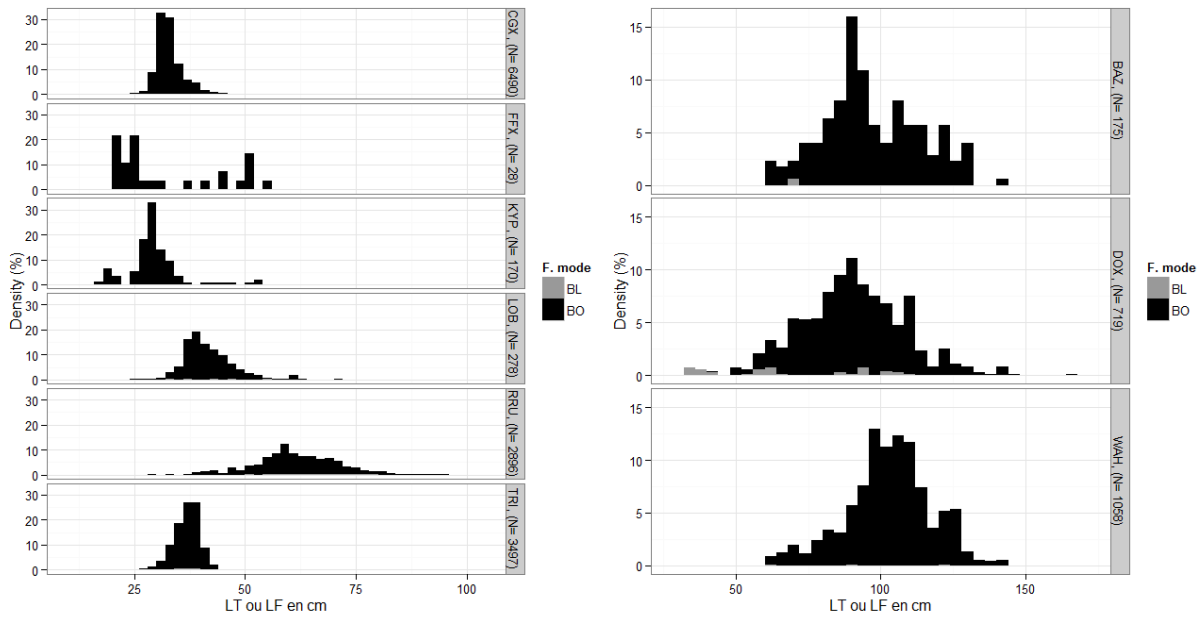
Figure 23. Size-density histograms of other fish species discarded-at sea by the French purse seine fleet in 2013 in the Atlantic Ocean. (Left panel) Fishes of maximum fork length <1 m (Right panel) Fishes of maximum fork length >1 m. *N* indicates the number of fish measured.
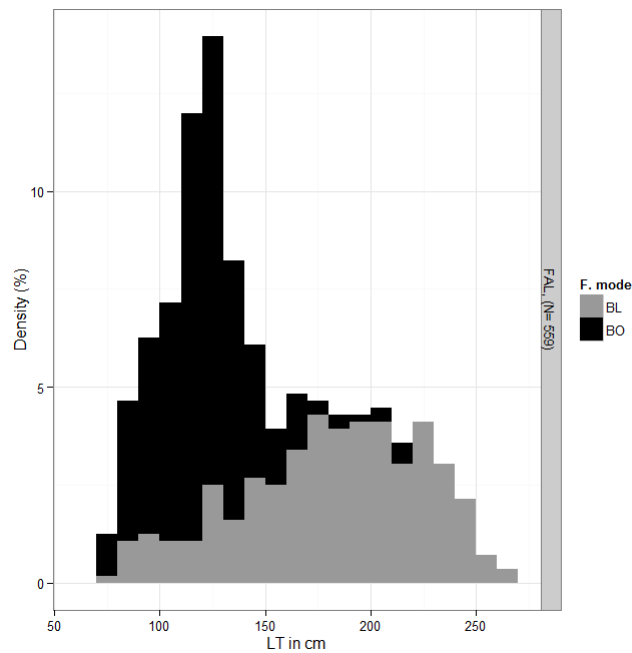

Figure 24. Size-density histograms of silky shark discarded-at sea by the French purse seine fleet in 2013 in the Atlantic Ocean. *N* indicates the number of fish measured. *LT* = Total length.