

**STATISTICS OF THE FRENCH PURSE SEINE FLEET
TARGETING TROPICAL TUNAS IN THE ATLANTIC OCEAN
(1991-2011)**

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SUMMARY

The French purse seine fleet of the Atlantic Ocean was comprised of 9 large-size purse seiners in 2011 that represented a total carrying capacity of about 8,000 m³. Total catches were about 37,000 t and comprised of 58% yellowfin, 33% skipjack and 9% bigeye, respectively. After a period of decrease since the early 1990s, the fishing effort of the fleet has been increasing since 2007 to reach more than 1,800 searching days in 2011. The increase in effort has been associated with an extension of the fleet fishing grounds in recent years and characterized by an increase in the number of sets. More than 1,900 fishing sets were made in 2011 as compared to about 800 in 2007. The percentages of sets made on FAD-associated schools increased since 2007 to reach 41% in 2010 and 34% in 2011, corresponding to 36% of the total catch in recent years. No clear trend was apparent in the time series of catch rates (expressed in t per searching day) for bigeye and skipjack in each fishing mode of the fishery while yellowfin caught on free-swimming schools showed an apparent increasing trend since the early 1990s. The mean weight in the catch of the three tropical tunas did not show any clear pattern during 1991-2011 for both FAD-associated and free-swimming schools, except for bigeye that seem to show an increasing mean weight since the mid-2000s.

RÉSUMÉ

En 2011, la flottille de senneurs français de l'océan Atlantique comprenait neuf grands senneurs qui représentaient une capacité de transport totale d'environ 8.000 m³. Les prises totales se sont élevées à environ 37.000 t et se composaient de 58% d'albacore, 33% de listao et de 9% de thon obèse. Après une période de déclin depuis le début des années 90, l'effort de pêche de la flotte augmente depuis 2007 pour atteindre plus de 1.800 jours de recherche en 2011. La hausse de l'effort a été associée à un élargissement des zones de pêche de la flottille au cours de ces dernières années et elle s'est caractérisée par une augmentation du nombre d'opérations. En 2011, plus de 1.900 opérations de pêche ont été réalisées par rapport à environ 800 en 2007. Le pourcentage des opérations réalisées sur des bancs associés à des DCP a augmenté depuis 2007, pour atteindre 41% en 2010 et 34% en 2011, ce qui correspond à 36% de la capture totale de ces dernières années. Aucune tendance n'est apparue clairement dans la série temporelle des taux de capture (exprimée en t par jour de recherche) du thon obèse et du listao dans chaque mode de pêche de la pêcherie, tandis que, depuis le début des années 90, l'albacore capturé dans des bancs libres fait apparaître une tendance ascendante apparente. Le poids moyen de la capture des trois thonidés tropicaux n'a dégagé aucune tendance claire entre 1991 et 2011 à la fois pour les bancs associés à des DCP et les bancs libres, exception faite du thon obèse dont le poids moyen semble augmenter depuis le milieu des années 2000.

RESUMEN

La flota de cerco francés del océano Atlántico estaba compuesta en 2011 por 9 cerqueros de gran tamaño que representaban una capacidad de transporte total de aproximadamente 8.000 m³. Las capturas totales se situaron en aproximadamente 37.000 t, y estuvieron compuestas en un 58% por rabil, en un 33% por listado y en un 9% por patudo, respectivamente. Tras un periodo de descenso desde principios de los 90, el esfuerzo pesquero de la flota ha ido aumentando desde 2007 hasta alcanzar más de 1.800 días de búsqueda en 2011. El aumento en

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el esfuerzo ha estado asociado con una ampliación de los caladeros de la flota en años recientes y se caracteriza por un aumento en el número de lances. En 2011 se realizaron más de 1900 lances en comparación con los aproximadamente 800 de 2007. Los porcentajes de lances realizados en bancos asociados con DCP aumentaron desde 2007 para alcanzar el 41% en 2010 y el 34% en 2011, correspondiendo al 36% de la captura total en años recientes. En la serie temporal de tasas de captura para el patudo y el listado (expresada en t por día de búsqueda) no aparecía ninguna tendencia clara en cada modo de pesca de la pesquería, mientras que el rabil capturado sobre banco libre mostraba una tendencia ascendente clara desde principios de los 90. El peso medio en la captura de las tres especies de túnidos tropicales no mostraba ningún patrón claro durante 1991-2011 ni para los bancos asociados con DCP ni para los bancos libres, excepto para el patudo que parecía mostrar un peso medio ascendente desde mediados de la primera década del 2000.

KEYWORDS

Fish aggregating device, Free swimming school, Katsuwonus pelamis, Purse seine fishing, Thunnus albacares, Thunnus obesus

1. Introduction

Statistical data for the French purse seine fleet in the Atlantic Ocean have been collected by the “Institut de Recherche pour le Développement” (IRD) since the early 1960s. French purse seiners target 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: FAD-associated (FAD) and free swimming schools (FSC). The acronym “FAD”, which stands for drifting fish aggregating device, is used here to describe any type of floating object used for increasing tuna catchability. This includes natural objects (e.g. logs, palm branches) and anthropogenic floating objects, such as man-made bamboo rafts equipped with radio-range beacons, satellite transmitters or scanning sonars. Fishing sets made on whales were classified as free swimming school sets whereas sets made on whale sharks (*Rhincodon typus*) were classified as FAD sets (Pallarés and Hallier 1997). The fleet activities are described through a suite of fisheries indicators that provide information on fishing effort, catch, catch rates, size structure and mean weights for the 3 principal market tropical tunas, with a particular focus on the year 2011.

2. Fishing capacity and effort

2.1 Fishing fleet

The number of vessels of the French purse seine fishing fleet steadily decreased from more than 20 in 1991 to a minimum of 5 in 2007. Since then, the number of vessels increased to about 10 during 2009-2011 (**Figure 1 and Table 1**). The size of the vessels progressively increased in the French purse seine fishery over the last 20 years. The number of small-sized vessels (capacity < 600 t) decreased throughout the 1990s and 2000s while medium-sized vessels (between 600 and 800 t) remained in activity and large vessels (> 1,200 t) coming from the Indian Ocean entered the fishery in 2009. The fleet was characterized by a diversity of vessel sizes in the recent years (**Figure 1**).

2.2 Carrying capacity

The total carrying capacity of the French purse seine fleet remained stable at about 11,000 m³ during 1991-2001 and then started to decrease to reach a minimum of about 3,600 m³ in 2007, corresponding to 4 and 3 vessels of capacity of 400-600 t and 800-1200 t, respectively (**Table 1**). Since then, the capacity re-increased to less than 8,000 m³ in the recent years (**Figure 1**). The mean carrying capacity of the French purse seiners steadily increased from less than 700 m³ in the early 1990s to an average close to 1,000 m³ during 2009-2011 (Pearson's $r = 0.8$; slope = +11 m³ y⁻¹; p-value < 0.001).

2.3 Fishing and searching days

Fishing effort expressed in searching time (days) was computed by subtracting the time spent setting the gear from the fishing time. The time spent setting the gear was estimated by regressions linking duration and size of sets, from at-sea measurements made by scientific observers. The total number of fishing and searching days showed similar patterns over 1991-2011, *i.e.* a continuous decrease from the early 1990s to minimums of about 1,250 and 1,000 fishing and searching days in 2008, respectively, followed by an increase to average levels at about 2,250 and 1,850 fishing and searching days, respectively (**Figure 2**).

2.4 Fishing grounds

Fishing grounds of the French purse seine fishing fleet in 2011 were scattered all around the Gulf of Guinea in 2011, with some effort concentrated off the coasts of Gabon, along the Cap Lopez (**Figure 3**). The spatial extent of the fishery, as measured by the numbers of 1x1 squares with effort or catches, indicated a regular decrease from the 1990s to the late 2000s concomitantly with the decrease in the number of active purse seiners (**Figure 4**). The total number of squares explored by the fleet decreased from about 400 (SD = 24) in the early 1990s to a minimum of 258 in 2008. The spatial extent of the fishery increased since then to more than 350 1x1 squares in 2011. Temporal trends were very similar whatever the criterion considered, *i.e.* positive sets, catch or threshold in fishing time.

2.5 Fishing activities

The total annual number of fishing sets made by the French purse seine fleet showed a general pattern consistent with the annual variations in carrying capacity and fishing effort of the fleet (**Table 4**). The fleet showed a decrease in the number of sets from more than 3,000 in the early 1990s to less than 1,000 in 2006-2008 (**Figure 5**). The total number of sets increased to about 2,000 in 2010-2011. The annual changes in the number of sets on free-swimming schools showed a pattern very similar to the number of sets made on FAD-associated schools (Pearson's $r = 0.67$, p -value < 0.001). The percentage of FAD-associated over free swimming schools decreased over the 1990s and 2000s, reaching a minimum of 18% in 2008, concomitantly with the decrease in the number of purse seiners. This suggested that the French vessels that remained in the Atlantic Ocean highly specialised on targeting free-swimming schools. The arrival of 3 large purse seiners from the Indian Ocean in 2009 resulted in an increase by 70% of the percentage of FAD-associated sets that reached about 35% during 2009-2011.

The percentage of successful sets (*i.e.* positive tuna catch) made on FAD-associated schools has been high and stable over the period 1991-2011, the mean annual value of 92% varying between a minimum of 89% in 2009 and a maximum of 97% in 2006. Meanwhile, the percentage of successful sets on free swimming schools decreased from about 73% in the early 1990s to about 65% in the late 1990s. Since then, the success of purse seine operations on unassociated schools increased and has been stable at 73% (SD = 1.7%) during the last decade.

3. Fisheries production

3.1 Catch levels

The overall trend in total catch of the French purse seine fishery of the Atlantic Ocean was similar to the trends in annual changes in the number of purse seiners and fishing effort, *i.e.* declining catches until 2007 followed by an increase in the recent years (**Figure 6**). Yellowfin dominated the catch and its percentage showed an increasing trend from about 45% in the early 1990s to about 70% during 2006-2009. Skipjack showed an opposite decreasing trend from more than 40% in the early 1990s to less than 20% in 2008, in relation with the increasing proportion of FAD-associated schools in the catch. Bigeye percentage in the catch, as derived from multispecies samplings conducted at unloading (Pallarés and Hallier 1997), varied between 5% and 14% and showed a decreasing trend similar to skipjack throughout the 1990s and early 2000s.

Catches on FAD-associated schools showed a major decrease from more than 30,000 t in the early 1990s to 3,000 t in 2008 (**Figure 7a**). Skipjack dominated the FAD-associated catch with a percentage varying between 50% and 70% while yellowfin and bigeye percentages varied between 12-29% and 9-20%, respectively. Catches on free-swimming schools remained stable during 1991-2003 at about 34,000 t, yellowfin representing more than 75% (SD = 6.6%) of the catch throughout this period (**Figure 7b**). Total catches then strongly declined to about 15,000 t during 2007-2008 and re-increased to more than 20,000 t during 2009-2011. The annual percentage of bigeye in the catch on free-swimming schools varied between a minimum of 2% in 1991 to a maximum of 9.7% in 1993 with an mean of 4.8% (SD = 2.1%).

3.2 Spatial distribution of the catch

The French purse seine fishing fleet occurred in 2011 in the traditional fishing grounds of the Gulf of Guinea (**Figures 8-9**). The catches were scattered in the whole Gulf with some major fishing grounds off the coasts of Guinea (18-22W and 7-10N), Ghana (0-5W and 5S-5N), and along the coast of Gabon (**Figure 8**). Catches on FAD-associated schools, predominated by skipjack, were widely distributed and characterized by small catch levels except in the Cap Lopez area, i.e. a median catch of 28 t y⁻¹ per 1°x1° square (**Figure 10**). The fishing grounds along the Gabonese coast have represented a major part of FAD-associated catches in the last decades, e.g. 39% in 2011 and more than 35% during 2006-2011 (**Figure 11**). Catches made on free-swimming schools in 2011 were more concentrated in space than for FAD-associated catches, i.e. 122 vs. 208 1°x1° squares, respectively (**Figure 12**). The distribution of annual catch levels per 1°x1° square was described by higher levels than on FAD-associated schools, with a median value of 93 t y⁻¹. Catches on free-swimming schools were also quite high in 2011 along the Gabonese coast and characterized by a high proportion of skipjack (> 50%) as compared to the other fishing grounds for free-swimming schools. The Cap Lopez area represented about 17% of the catch on free-swimming schools during 2006-2011 (**Figure 13**).

3.3 Catch rates

No clear trend was apparent in the time series of skipjack and bigeye catch rates (expressed in t per searching day) for both fishing modes combined while yellowfin showed an apparent increasing trend since the early 1990s (**Figure 14**). Yellowfin catch rates were always higher than for skipjack and bigeye and increased from more than 7 t d⁻¹ in the early 1990s to more than 15 t d⁻¹ in 2006 and 2008; they reached an average of about 10.7 t d⁻¹ during 2009-2011. Skipjack catch rates for both fishing modes combined varied interannually between a minimum of 3.5 t d⁻¹ in 1997 to a maximum 8.1 t d⁻¹ in 2004. Bigeye catch rates were low and showed a high interannual variability during 1991-2011 with values ranging from 0.8 t d⁻¹ to 2.7 t d⁻¹.

Skipjack caught on FAD-fishing showed high interannual fluctuations in catch rates in a range of 2-6 t d⁻¹, the catch rates exceeding 5 t d⁻¹ during 2010-2011. Yellowfin and bigeye catch rates on FAD-associated schools showed decreasing trends throughout the 1990s and 2000s as a result of the combination of increasing targeting of free-swimming schools and the current inability of searching time to distinguish between time periods devoted to searching for tuna schools and to cruising towards satellite-tracked FADs (**Figure 15a**). Time series of catch rates for skipjack and bigeye caught on free-swimming schools did not show any trend during 1991-2011 (**Figure 15b**). Catch rates were low and varied between 0.2-1.6 t d⁻¹ and 0.6-3.7 t d⁻¹ for bigeye and skipjack, respectively. Yellowfin catch rates on free-swimming schools showed an increasing trend during 1991-2011 with high variability in the recent years (**Figure 15b**). Yellowfin catch rates exceeded 10 t d⁻¹ in 2011.

3.4 Size structure of the catch

The size structure of the catch on both fishing modes was very similar for the 3 tuna species between 2011 and the average year representing the period 2006-2010 (**Figures 16-17**). Numbers of fishes caught were higher in 2011 due to the low effort and catch observed during 2006-2008. The sizes of yellowfin caught on FAD-associated schools showed a major mode between 40 and 70 cm and a smaller mode around 110-120 cm. Numbers of bigeye caught on FAD-associated schools were dominated by juvenile fishes of median size 50 cm.

Skipjack caught on FAD-associated schools showed a unique size mode in the range 40-50 cm. Size-frequency histograms expressed in biomass showed that large yellowfin and bigeye dominated the catches on free-swimming schools while the large numbers of small fishes caught represented a small proportion of the catch for this fishing mode (**Figure 17**).

3.5 Mean weight in the catch

The mean weight in the catch of the major tropical tunas highly differed between fishing modes without any clear pattern during 1991-2011 except for bigeye caught on free-swimming schools (**Figure 18**). The overall mean weight of yellowfin in the catch was driven by the catch on unassociated schools. For this fishing mode, the mean weight of yellowfin decreased from more than 40 kg in 1991 to about 20 kg in the early 2000s, before progressively increasing thereafter to reach about 40 kg in 2007-2008. It decreased since then to about 30 kg in the recent years (**Figure 18a**). The mean weight of skipjack was stable at about 2 kg during 1991-2011 and similar between both fishing modes during 1991-2005 (**Figure 18b**). The mean weight of skipjack caught on free-swimming schools increased to exceed 3 kg in 2007 before decreasing to about 2.4 kg in 2010-2011. The

mean weight of bigeye associated with FADs varied around 4 kg during 1991-2007 while bigeye caught on free-swimming schools showed an increase in weight in the last decade from about 5 kg in 2004 to more than 20 kg during 2006-2011; the weight of bigeye exceeded 25 kg in 2011 (**Figure 18c**).

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4. References

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Table 1. Annual number of purse seiners by GRT category and total carrying capacity (GRT) of the French tropical tuna purse seine fishing fleet of the Atlantic Ocean during 1991-2011. Total carrying capacity (CC) was weighted by the proportion of the year at sea (in months).

<i>Year</i>	<i>50-400</i>	<i>401-600</i>	<i>601-800</i>	<i>801-1200</i>	<i>1201-2000</i>	<i>>2000</i>	<i>Total</i>	<i>CC</i>
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

Table 2. Annual fishing effort of the French purse seine fishery in the Atlantic Ocean expressed in fishing and searching days during 1991-2011. Searching days were derived from the total time spent at sea corrected for periods of damage, route towards port, and purse seine operation.

<i>Year</i>	<i>Fishing days</i>	<i>Searching days</i>
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

Table 3 Annual number of 1-degree squares explored by the French purse seine fleet in the Atlantic Ocean during 1991-2011.

<i>Year</i>	<i>TOTAL</i>	<i>#sets</i>	<i>Catch >0</i>	<i>Effort > 1 d</i>	<i>Effort > 5 d</i>
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

Table 4. Number of positive and null sets by fishing mode made by the French purse seine fleet of the Atlantic Ocean during 1991-2011.

	<i>ALL</i>			<i>LOG</i>			<i>FREE</i>		
	<i>Total</i>	<i>Positive</i>	<i>Null</i>	<i>Total</i>	<i>Positive</i>	<i>Null</i>	<i>Total</i>	<i>Positive</i>	<i>Null</i>
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	819	635	184	171	156	15	648	479	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

Table 5. Catch by species for the French purse seine fishery of the Atlantic Ocean during 1991-2011.

<i>Year</i>	<i>YFT</i>	<i>SKJ</i>	<i>BET</i>	<i>ALB</i>	<i>OTH</i>	<i>TOTAL</i>
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

Table 6. Catch by species made on FAD-associated schools for the French purse seine fishery of the Atlantic Ocean during 1991-2011.

<i>Year</i>	<i>YFT</i>	<i>SKJ</i>	<i>BET</i>	<i>ALB</i>	<i>OTH</i>	<i>TOTAL</i>
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

Table 7. Catch by species made on free swimming schools for the French purse seine fishery of the Atlantic Ocean during 1991-2011.

<i>Year</i>	<i>YFT</i>	<i>SKJ</i>	<i>BET</i>	<i>ALB</i>	<i>OTH</i>	<i>TOTAL</i>
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

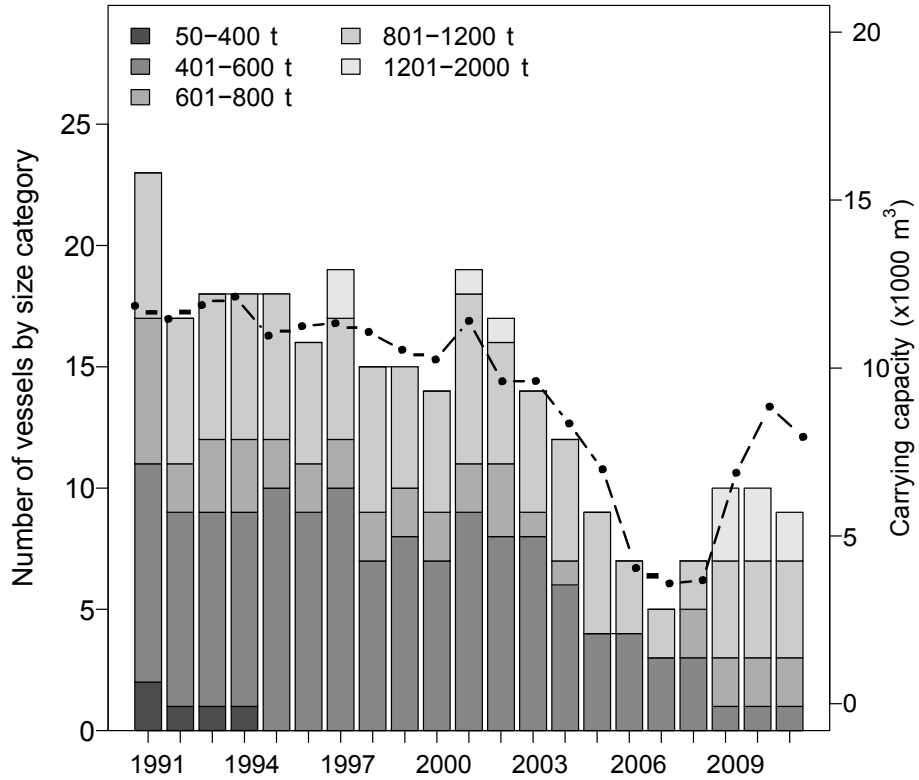


Figure 1. French fishing capacity in the Atlantic Ocean; annual changes in the number of vessels by size category (barplots) and total carrying capacity (solid line with circles) of the French fishing fleet of the Atlantic Ocean during 1991-2011. Annual values of capacity were weighted by the proportion of the year at sea (in months). The vessel size category (t) was computed as 0.7 times the capacity expressed in m^3 .

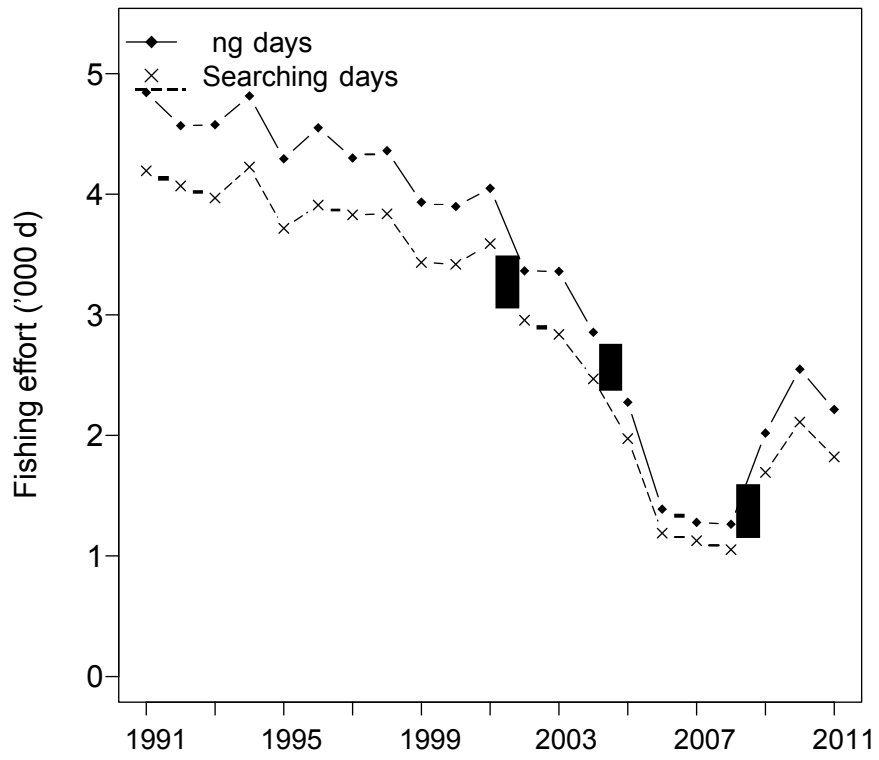


Figure 2. Annual total number of fishing and searching days for the French purse seine fleet in the Atlantic Ocean during 1991-2011

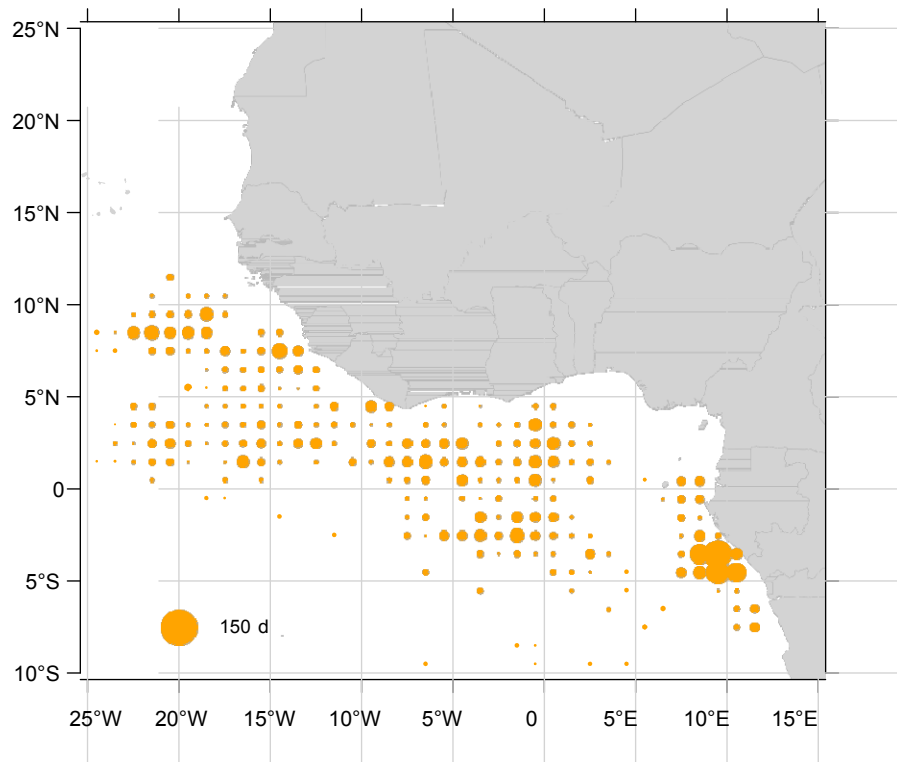


Figure 3. Spatial distribution of fishing effort (in searching days) of the French purse seine fishing fleet in 2011.

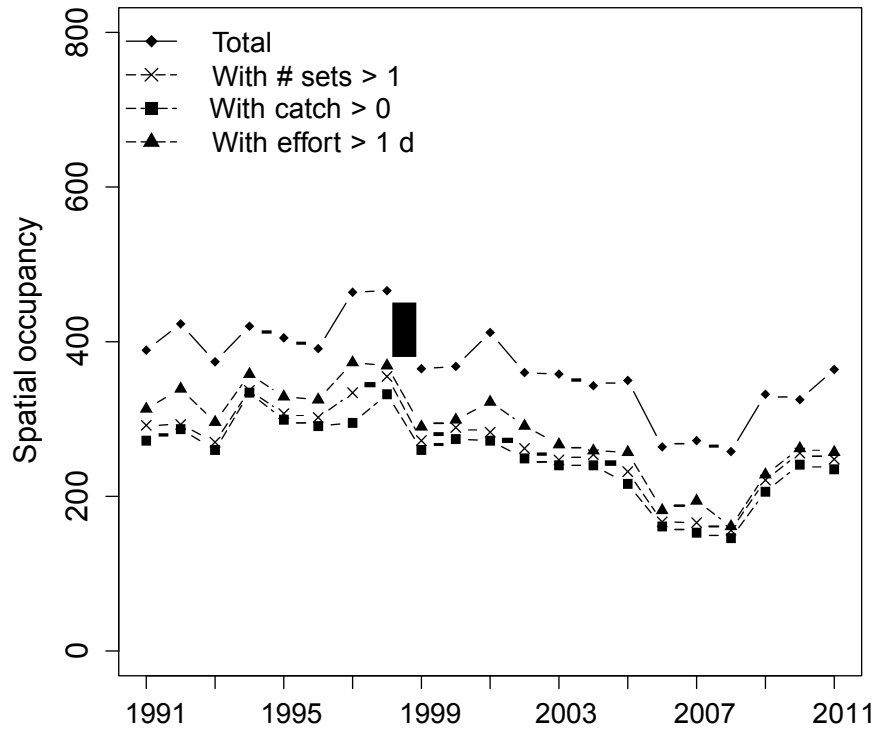


Figure 4. Annual number of 1-degree squares explored by the French purse seine fleet during 1991-2011.

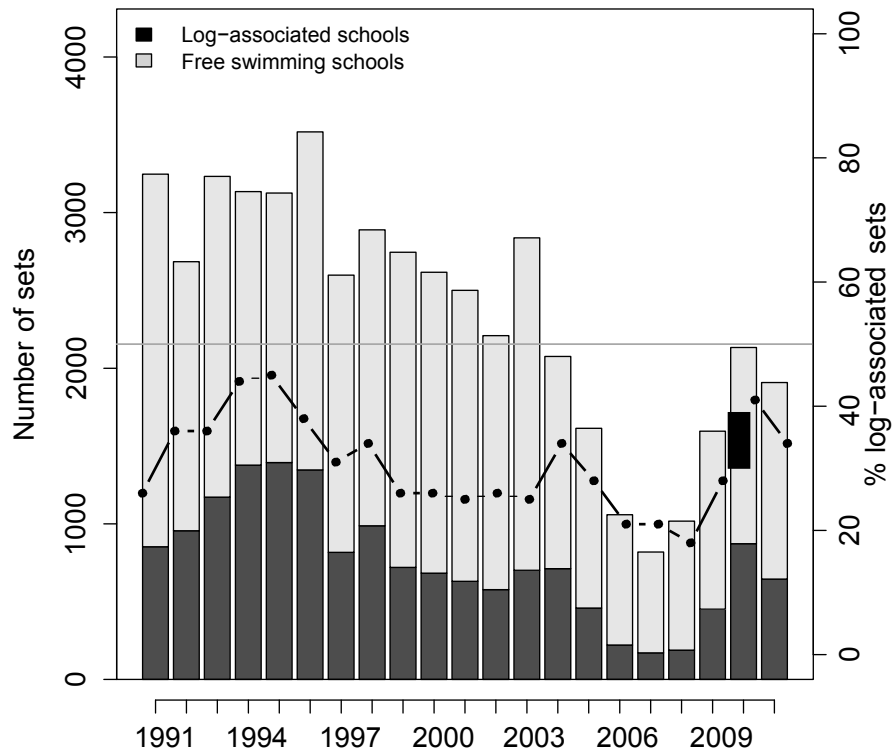


Figure 5. Annual number of fishing sets in the French purse seine fishery on FAD-associated and free swimming schools during 1991-2011. Line with solid circles indicates the percentage of sets made on FAD-associated schools over free swimming schools. Grey solid line indicates the 50% value.

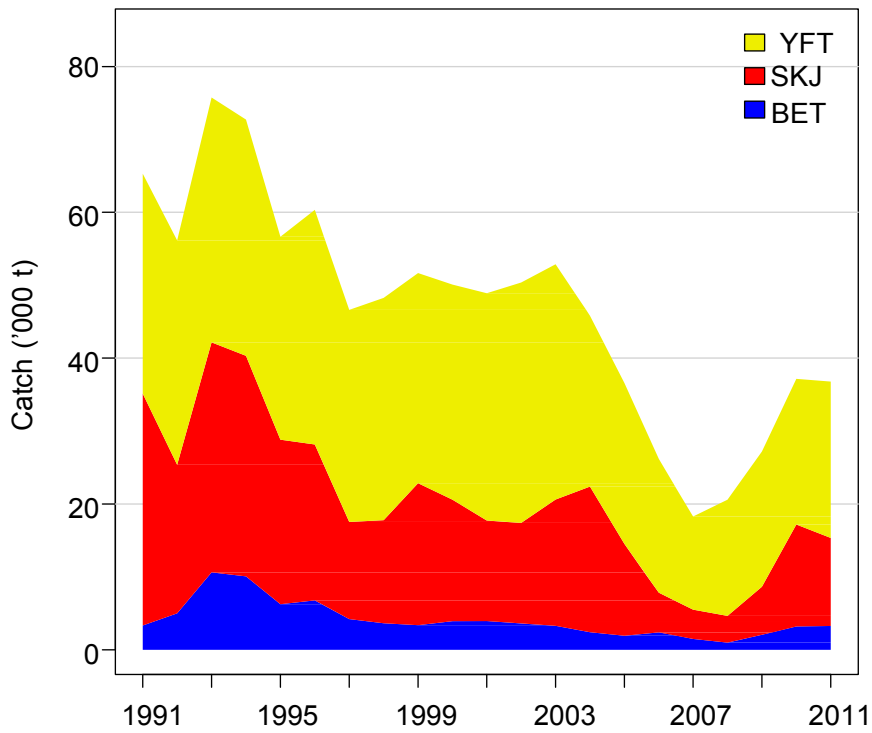


Figure 6. Catch by species of the French purse seine fishing fleet in the Atlantic Ocean during 1991-2011.

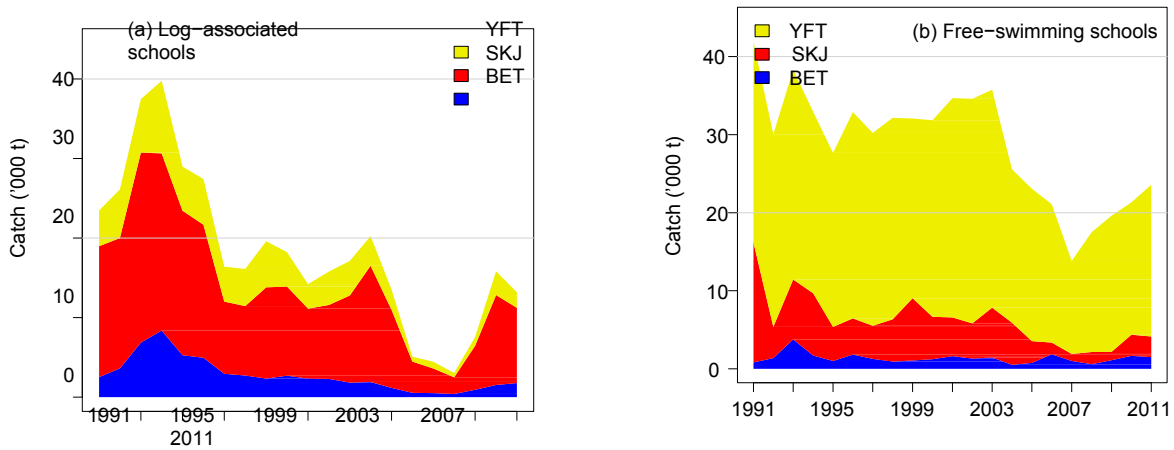


Figure 7. Catch by species of the French purse seine fishing fleet in the Atlantic Ocean on (a) FAD- associated schools and (b) free swimming schools during 1991-2011.

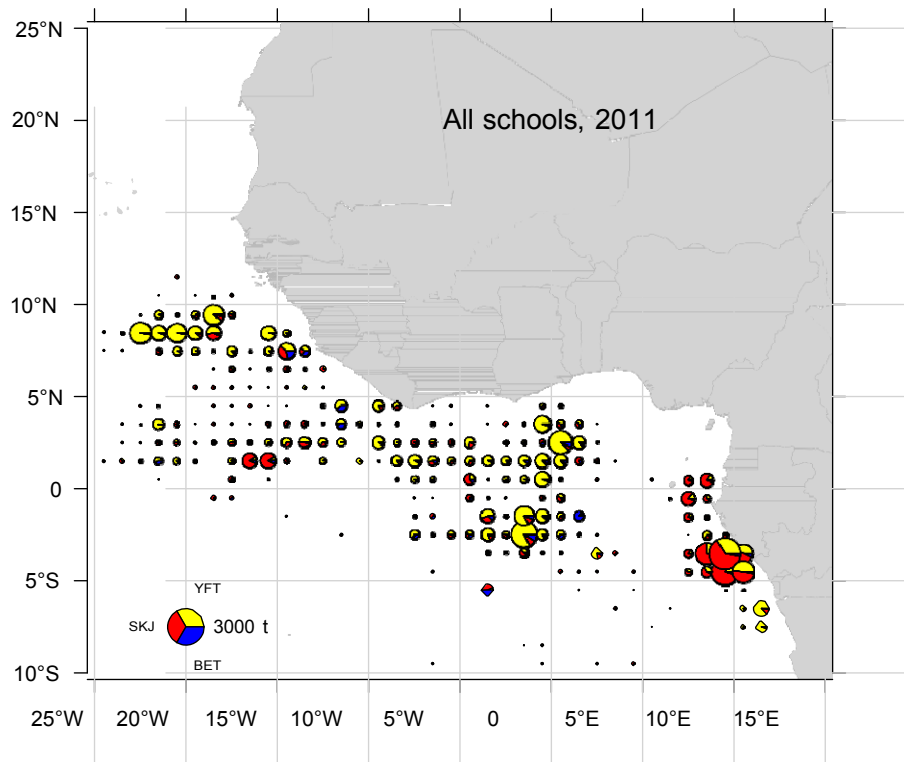


Figure 8. Spatial distribution of tuna catches of the French purse seine fishing fleet in 2011.

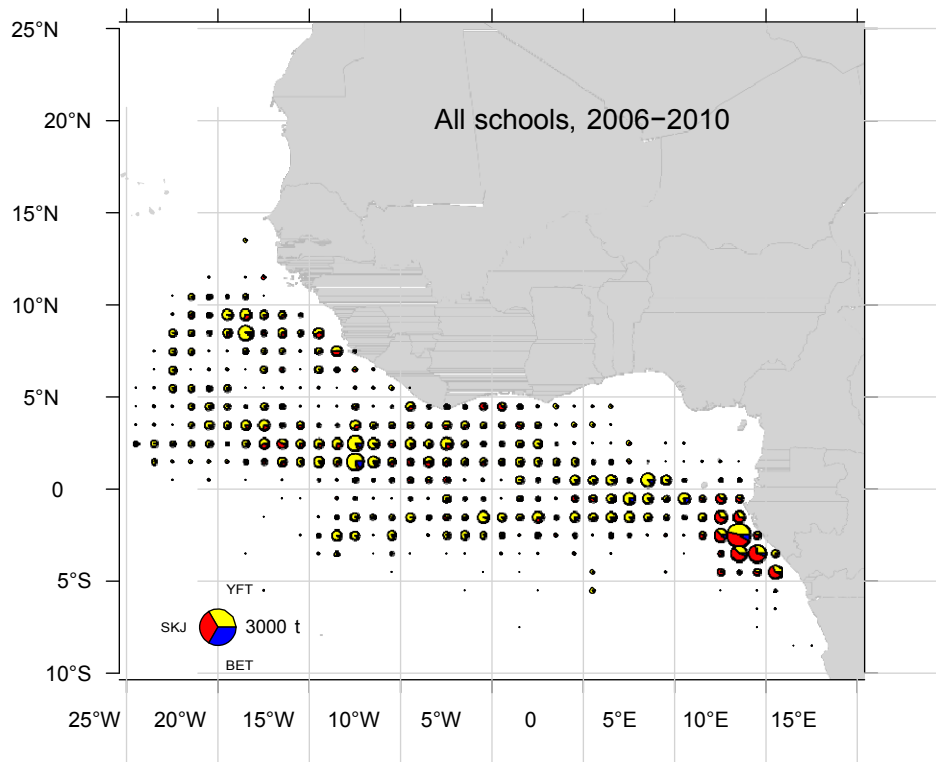


Figure 9. Spatial distribution of tuna catches of the French purse seine fishing fleet in 2006-2010.

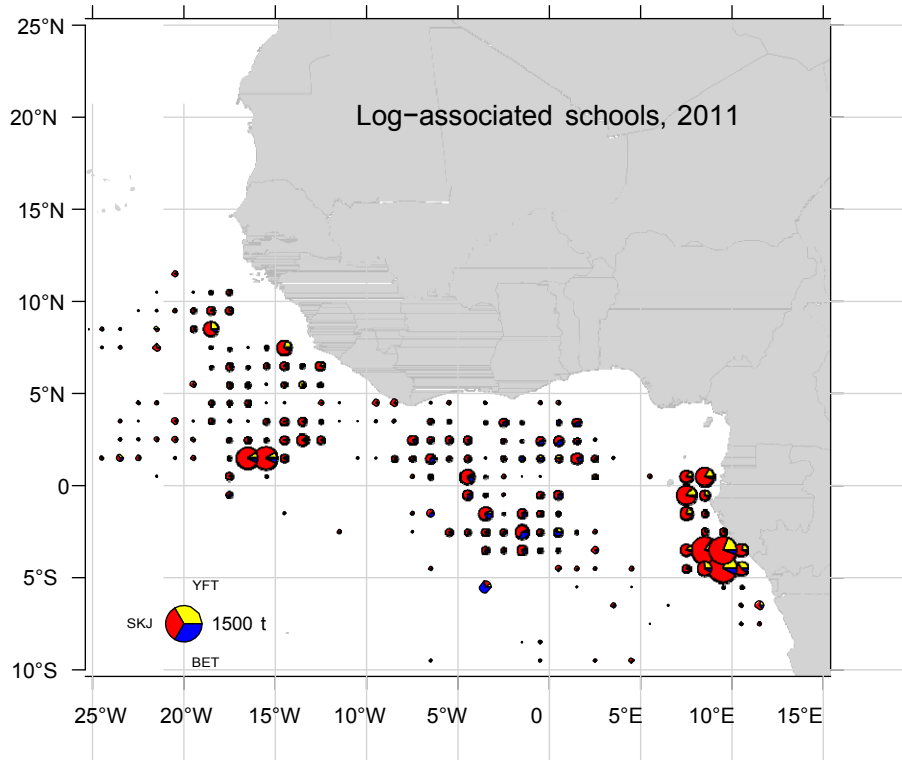


Figure 10. Spatial distribution of tuna catches of the French purse seine fishing fleet on FAD-associated schools in 2011.

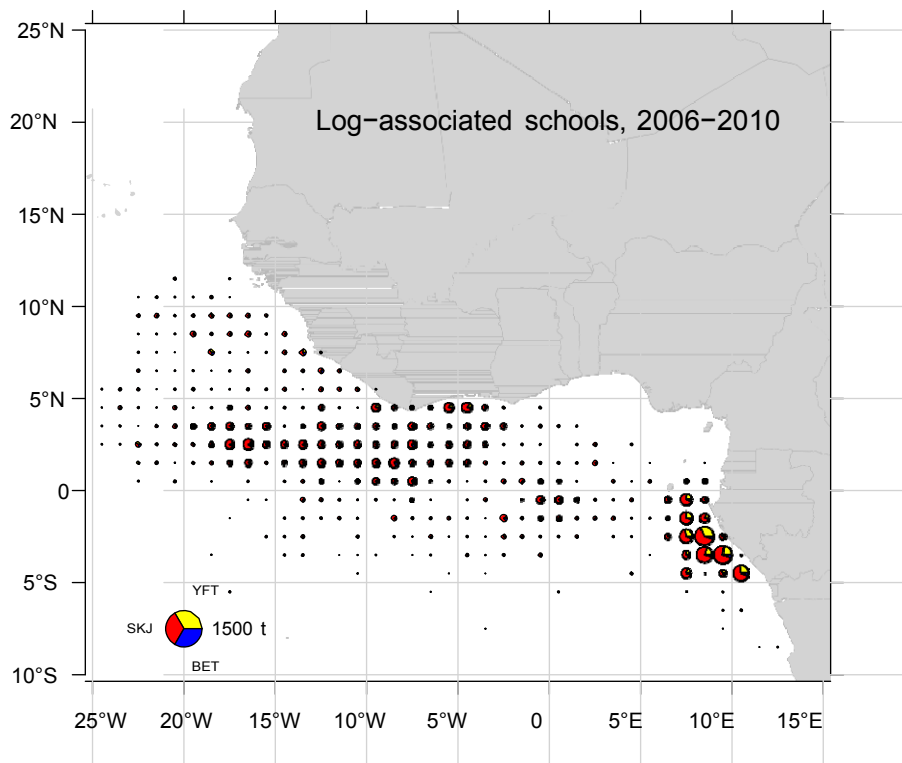


Figure 11. Spatial distribution of tuna catches of the French purse seine fishing fleet made on FAD- associated schools in 2006-2010.

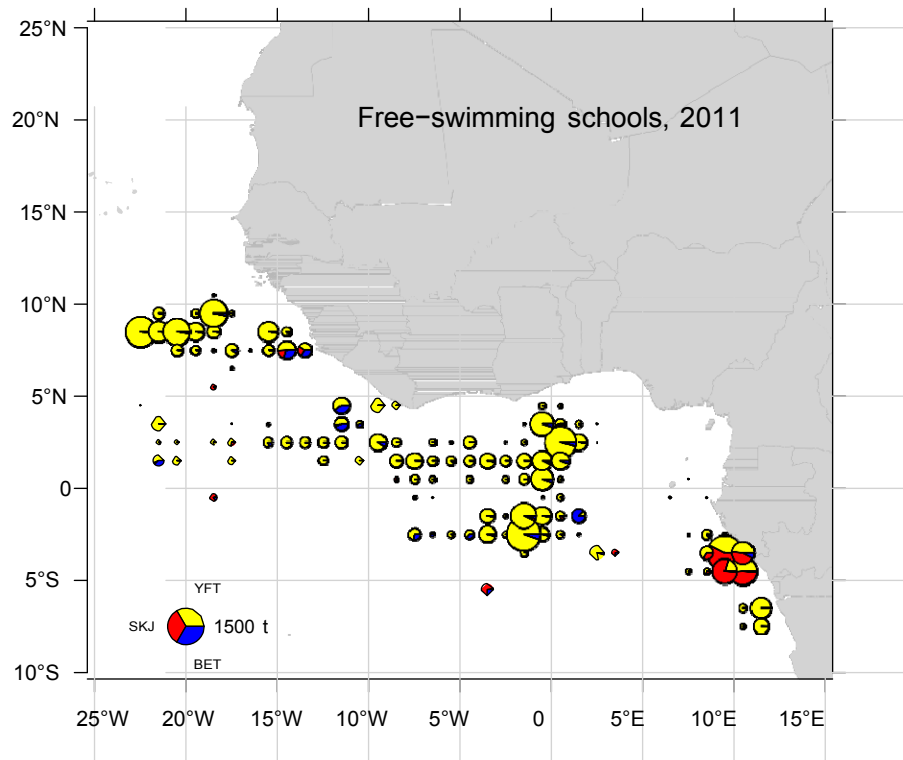


Figure 12. Spatial distribution of tuna catches of the French purse seine fishing fleet made on free swimming schools in 2011.

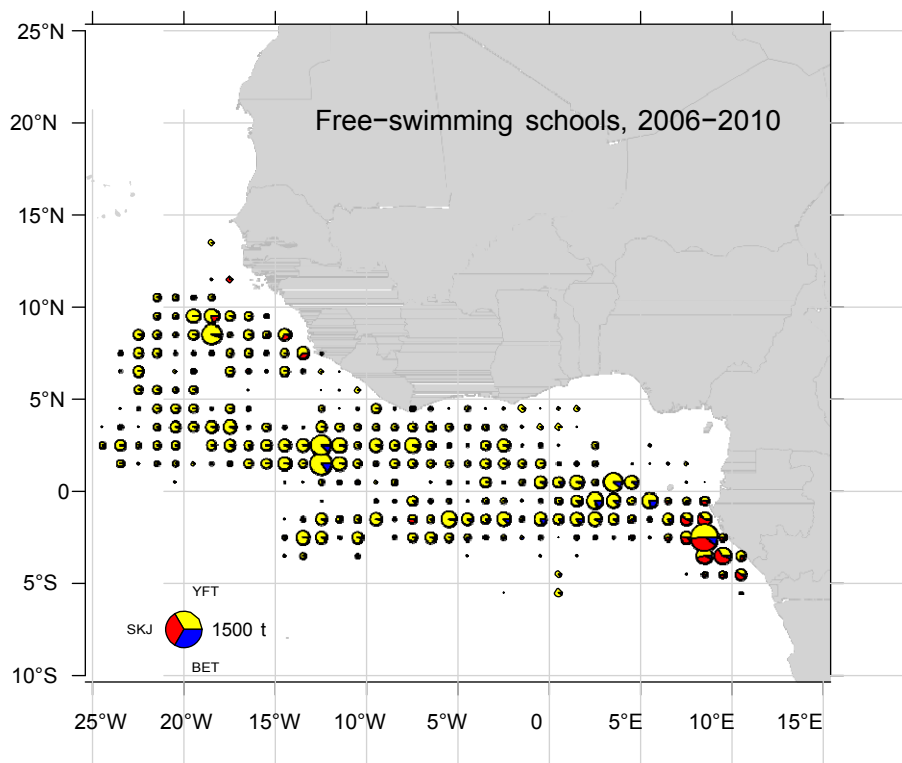


Figure 13. Spatial distribution of tuna catches of the French purse seine fishing fleet made on free swimming schools in 2006-2010.

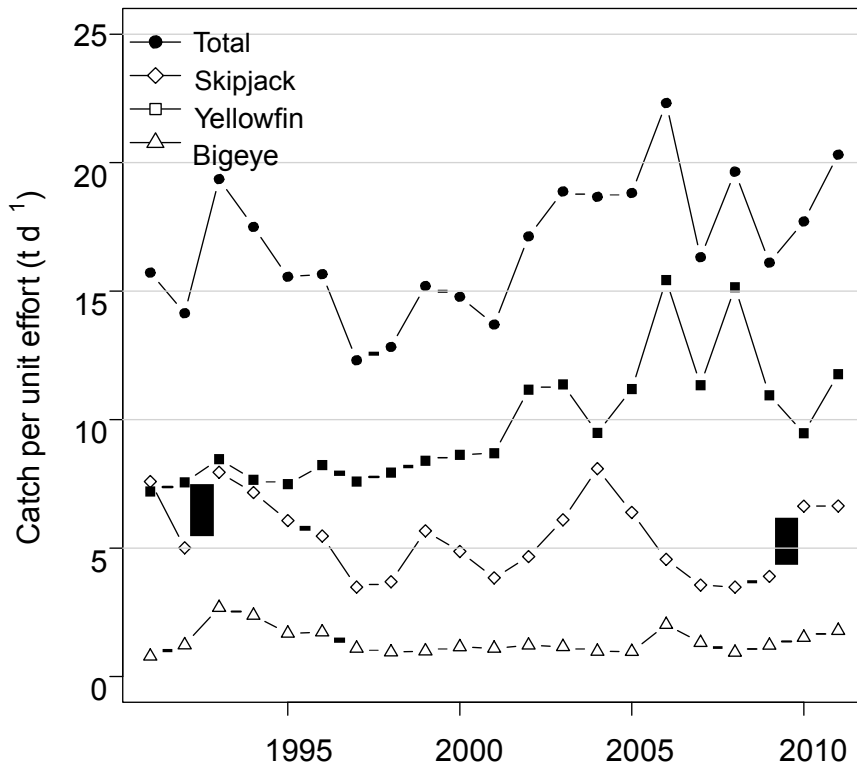


Figure 14. Annual catch rates (in t per searching day) of the French purse seine fleet in the Atlantic Ocean during 1991-2011.

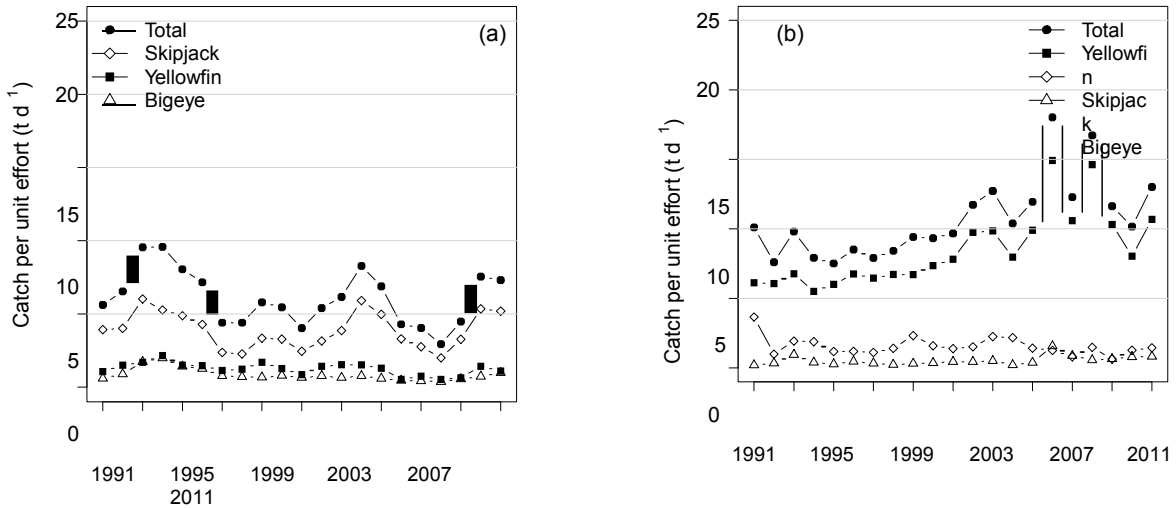


Figure 15. Annual catch rates (in t per searching day) of the French purse seine fleet on (a) FAD-associated and (b) free swimming schools in the Atlantic Ocean during 1991-2011.

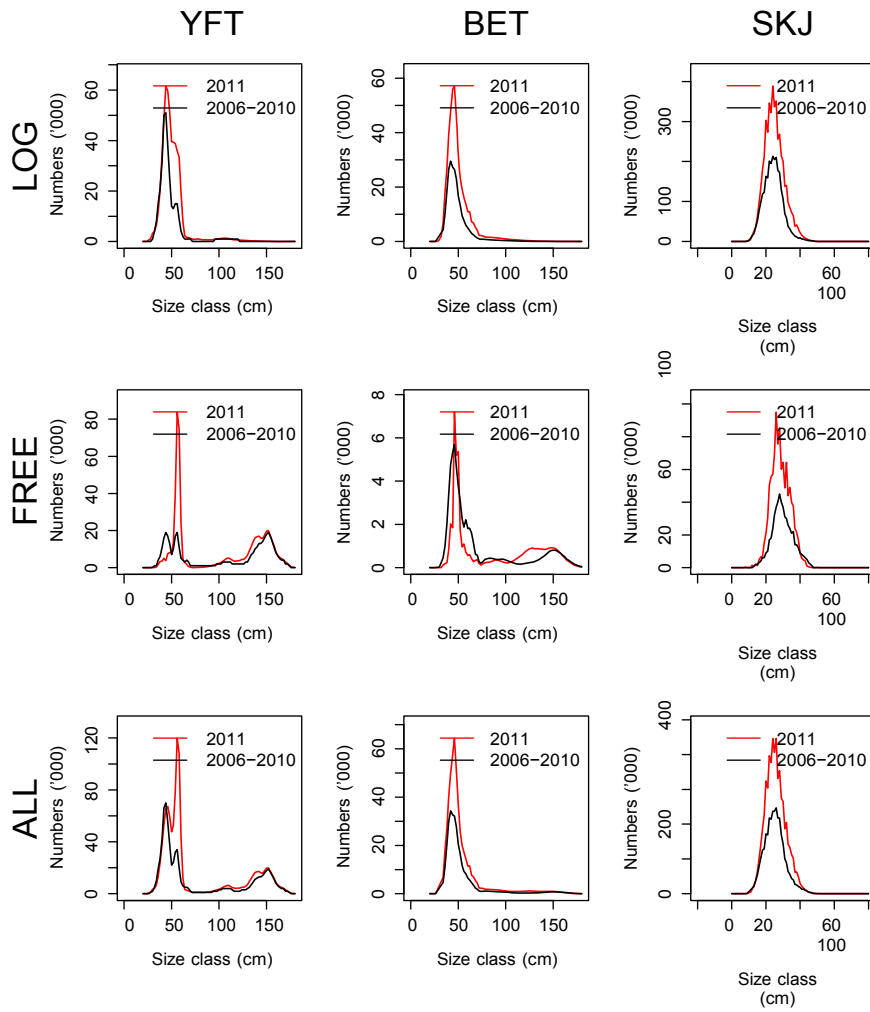


Figure 16. Size distribution (in numbers) of the species-specific catch for the French (and associated flags) purse seine fleet in 2011 and for an average year representing the period 2006-2010.

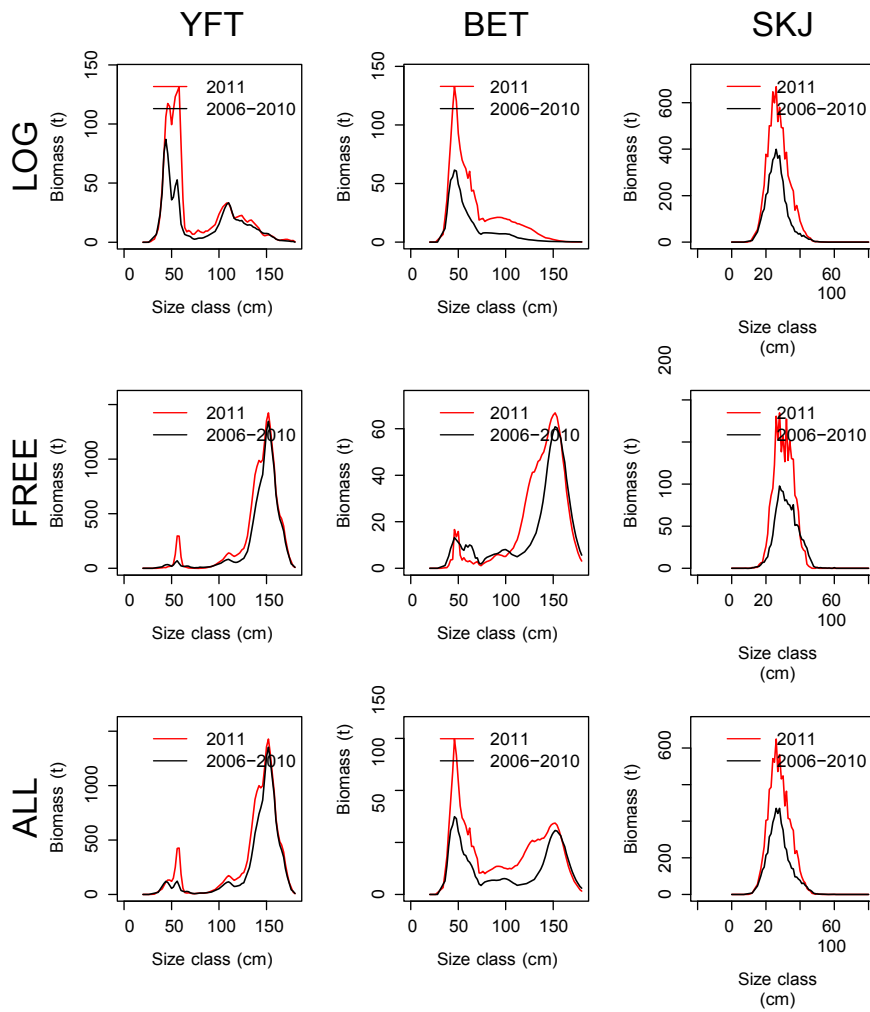


Figure 17. Size distribution (in weight) of the French purse seine fleet in 2011 and for an average year representing the period 2006-2010.

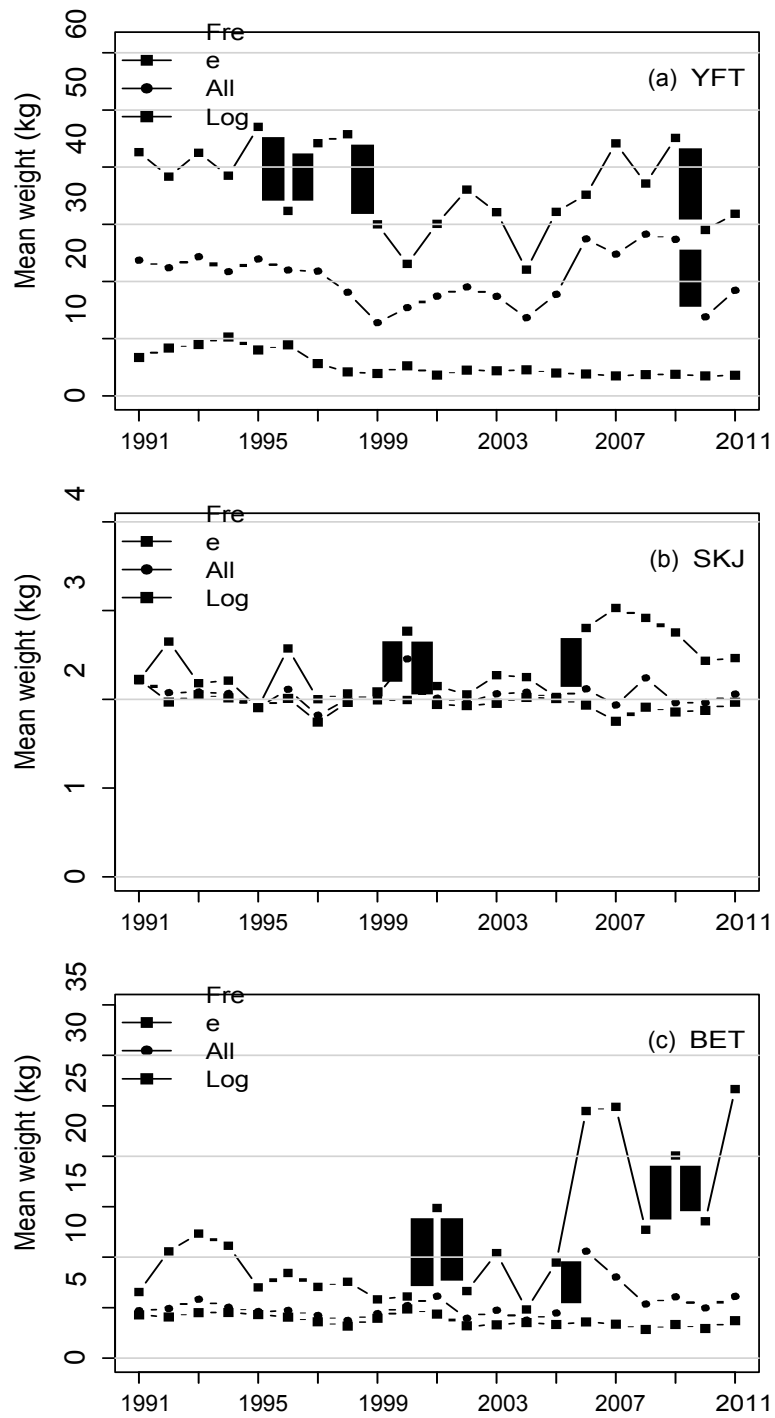


Figure 18. Annual time series of mean weight (kg) for (a) yellowfin, (b) skipjack, and (c) bigeye tuna for each fishing mode during 1991-2011.