

STATISTICS OF THE FRENCH PURSE SEINE FISHING FLEET TARGETING TROPICAL TUNAS IN THE INDIAN OCEAN (1981-2018)

Laurent Floch*, Mathieu Depetris*, Patrice Dewals†, Antoine Duparc*, David Kaplan*, Julien Lebranchu*, Francis Marsac*, Marianne Pernak‡ and Pascal Bach†

SUMMARY

In 2018, a total of 14 French vessels operated in the eastern Indian Ocean including 12 purse seiners and 2 supplies. The total capacity weighted by the months of activity for each vessel is 11686t. The total nominal effort in 2018 was of 2885 fishing days and 2723 sets with 2463 sets on floating objects and 260 on free schools. In 2018, the percentage of sets on FOB was 90% and the catches reached 91%. The total catch of the French component of the EU purse seine fleet of the Indian Ocean was 84,729 t, being composed of 36%, 58%, and 6% of yellowfin tuna, skipjack tuna, and bigeye tuna respectively. Thus, the most noticeable change in 2018 is the shift of catches from the free school sets, dominated by yellowfin, to the associated school sets, dominated by skipjack. As a consequence, the increase in total catches mainly concerned the skipjack catches.

KEYWORDS : *Tropical tuna fisheries, French purse seining, free swimming school, fish aggregating devices, *Katsuwonus pelamis*, *Thunnus albacares*, *Thunnus obesus**

1 Introduction

French tuna purse seiners have been fishing yellowfin tuna (*Thunnus albacares*), skipjack tuna (*Katsuwonus pelamis*), and bigeye tuna (*Thunnus obesus*) in the Indian Ocean since the early 1980s. 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 dominated by artificial Fish Aggregating Devices (FAD). The French purse seine fishery activities and catches are monitored by the 'Institut de Recherche pour le Développement' (IRD) since the early 1980s in collaboration with the 'Seychelles Fishing Authority' (SFA). Here, we report a synthesis of the fishing activities of the French purse seiners during the period 1981-2018 based on the collection of logbooks and landing reports and sampling operations conducted at ports during unloading for target species (i.e skipjack, yellowfin tuna and bigeye tuna) which are analysed with the T3 process.

2 Material and methods

2.1 Fishing data from vessels reports

Logbooks and sale reports were collected in collaboration with fishing companies and covered 100% of the fishing trips that occurred during 1981-2018. For each trip, at unloading, shipment was sort by species (and by commercial categories) and weight at the cannery. For each set, the purse seine skippers reported in the logbook all information on vessel's activities including:

- Catch in weight (visually assessed)
- Raw species composition of the sets (visually assessed)
- Date of the sets
- Geographic location of the sets.

* MARBEC, IRD, Ifremer, Univ Montpellier, CNRS, Sète, France

† Centre de Recherches Océanologiques, BPV18, Abidjan, COTE D'IVOIRE

‡ Institut de Recherche pour le Développement, SFA, BP 570, Victoria, Seychelles

2.2 *Sampling*

In 2018, 429 well samples were collected at unloading of French purse seiners in the ports of Victoria. These samples were used to estimate the size and species composition of the catch following a sampling and processing protocol that is common through purse seiners flying the flag of Spain and other flags associated with the French purse seine fleet (Pallarès and Petit, 1998). A total of about 99 000 tunas counted and measured were used in the T3 (Traitement des Thons Tropicaux) processing of the French purse seine fishery data for 2018 (Duparc et al., 2018).

2.3 *Fishing effort*

Nominal fishing effort was derived from logbooks and expressed in days-at-sea and fishing days considering that fishing operations for 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 Indian Ocean, the maximum duration of a fishing day for purse seiners targeting tropical tunas is 13 hours.

2.4 *Density of FAD buoys*

Monthly $1^{\circ} \times 1^{\circ}$ mean FAD density maps were calculated for the period 2010-2018 from the geolocation reports of the buoys attached to the FADs. 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 timestep 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 FAD 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 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). Beaching events 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 beaching cases were further filtered to remove any beaching event 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 $1^{\circ} \times 1^{\circ}$ 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”, were 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.

3 Results and interpretations

3.1 Fleet capacity

In 2018, 12 French purse seiners (Fig. 1) operated in the Indian Ocean and conducted a total of 146 fishing trips lasting 23 days on average. The fleet was composed of 11 vessels of carrying capacity (CC) 800-1200 t, and 1 vessels of CC >1,200 t (Table 1). Total carrying capacity in 2018 is similar to the previous years (since 2009) with a steady proportion in the largest vessels since 2015. The total capacity weighted by the months of activity for each vessel is 11 686 t.

In 2018, 2 support vessels has been operating in the Indian Ocean in support of French purse seiners. Support vessel's activities mainly consist in searching for tuna schools and both deploying and managing the stock of FADs and associated buoys through deployment of FADs, visits and retrieval of some buoys or FADs that drift outside the purse seine fishing grounds. The French support vessel spent a total of 382 days at sea in 2018, contributing to 11,5% of the cumulated days at sea of the French fishing fleet (purse seiners and support vessels).

3.2 Fishing effort

The total nominal effort in 2018 for fishing and searching was about 2,900 and 2,800 days respectively (Fig. 2 and Table 2) which is similar to the trend of the last years. Since 2008, the fishing effort has decreased by 35% due to the departure of 5 vessels in the Atlantic Ocean

The total annual number of fishing sets in 2018 reached 2723 (2478 positive sets and 245 null sets). A total of 2463 sets were associated to FOBs and 260 sets associated to free swimming schools (FSC) (Table 3). The percentage of FOB sets is the highest value estimated since the beginning of the fishery with 90% (Fig.3) that corresponds to an increase of 18% compare to 2017. The proportion of positive sets is 94% on FOBs and 62% on FSC.

3.3 Deployment of Fishing Aggregating Devices (FADs) and buoys

In 2014, the increase in the number of seiners was linked to the integration of vessels under the Mayotte flag (Table 4). In 2016, a support vessel joined the French fleet followed by another in 2018.

In 2018, 4415 FADs were deployed by 12 purse seiners and 2 support vessels, an average of 315 per vessel. This number of purse seiners has been increasing since the start of deployments, and it increased by 17% in 2018 compared to 2017. The contribution of support vessels is 25% in 2018 with 1116 deployments.

Regarding deployments of beacons on objects already at sea (natural or artificial), the number was about 3000 in 2018 and 2017 with a decrease of 16% from 2016.

3.4 *Spatio-temporal distribution of buoys*

The number of in water French FAD buoys found in FAD trajectory data for the Indian Ocean increased steadily over the period 2013 to 2016 from roughly 1000 per day at the beginning of the period to over 4000 at the end (Fig. 4). Over the period 2017-2018, the number of active buoys has remained relatively stable, though a large apparent increase in the number at the end of 2016 and a large drop in July-August 2018 are suggestive of temporary issues with data transmission. Apart from the increase in the overall number of buoys, annual average FAD density maps (Fig. 5) are relatively stable across years, showing a consistent pattern with three primary zones of peak FAD density: (1) a latitudinal band roughly from Kenya to the Seychelles, as well as to the east of this zone, (2) a zone north of the equator and east of Somalia, and (3) a zone to the east of the Chagos / Maldives that is at times in continuity with the 2 prior zones. The relative importance of these three zones does vary somewhat from year to year. For example, in 2014, the second and third of the aforementioned zones are relatively absent from the density map.

3.5 *Fisheries production, specific composition and size distribution*

In 2018, landings of the main marketable tuna species (SKJ, YFT, BET) for the French purse seine fleet operating in the Indian Ocean reached a total of 84 729 t corresponding to an increase of 25% compared to 2017 (Fig.6). Those landings are composed of 36%, 58% and 6% of yellowfin, skipjack, bigeye tunas respectively (Table 6). Regarding by school type, catches on free schools sharply decreased but was balanced by the strong increase of catches on the associated schools. As a consequence, the increase in total catches mainly concerned the skipjack catches.

Furthermore, the species composition of catches on FSC in 2018 markedly varied compared to 2017. The catch composition on FSC was usually dominated by yellowfin tuna whereas it was dominated by skipjack tuna on FOB. However, Yellowfin tuna represented 56% in 2018 instead of 82% in 2017 while skipjack represented 36% and 6% respectively (Fig.7, right panel). Catches on FOB were predominated by skipjack tuna representing 60% of the catch while yellowfin and bigeye tunas represented 34% and 6% of catches, respectively (Fig.7, left panel).

Spatial extent used by vessels increased in 2018 following the trend since 2015 (Figure 8, Table 9). Figure 9 to 11 respectively represent maps of the fishing effort and catches on FOB and FSC.

The size frequency distributions for the three species collected in 2018 either for both FOB-associated and FSC fishing sets are quite similar with the average frequency distributions observed for the period 2013-2017 (Fig.12 & 13). Considering the mean weight of landed fish, it seems the average weight continue to increase for every species in FSC catches only (Fig.14). However, yellowfin caught seemed to be smaller in 2018 than in the 2014-2017 period, which could be related to the larger proportion of fishing activity spent on FADs.

4 **Conclusion**

Fisheries activities of the French fleet in Indian Ocean in 2018 was in the continuity of these last years in many aspects: fleet capacity, fishing effort. However, an increase of the percentage of catches on FOB which reach **91%** this year, inducing a large increase in skipjack catches. These trends could be explain with an increase of the deployment of FADs and a new strategy of fishing in the context of the quota of YFT

Acknowledgments We thank ORTHONGEL and all past and current personnel for helpful assistance in data collection and management.

Sampling operations were conducted by the Observatory of exploited pelagic tropical ecosystem, Ob7 of the IRD and technicians of the ‘Seychelles Fishing Authority’. The data used were collected through the Data Collection Framework (Reg 199/2008 and 665/2008) funded by both IRD and the European Union, and supported by the French Direction des Pêches Maritimes et de l’Aquaculture (DPMA). The Ob7 of the IRD is certified ISO 9001:2015 since February 2017.

5 References

Duparc, A., P. Cauquil, M. Depestris, P. Dewals, D. Gaertner, A. Hervé, J. Lebranchu, F. Marsac, and P. Bach. 2018. Assessment of accuracy in processing purse seine tropical tuna catches with the T3 methodology using French fleet data:1–19.

Pallarés, P., and C. 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.

Maufroy A, Chassot E, Joo R, Kaplan DM (2015) Large-Scale Examination of Spatio-Temporal Patterns of Drifting Fish Aggregating Devices (dFADs) from Tropical Tuna Fisheries of the Indian and Atlantic Oceans. *PLoS ONE* 10:e0128023. doi:10.1371/journal.pone.0128023

6 Figures

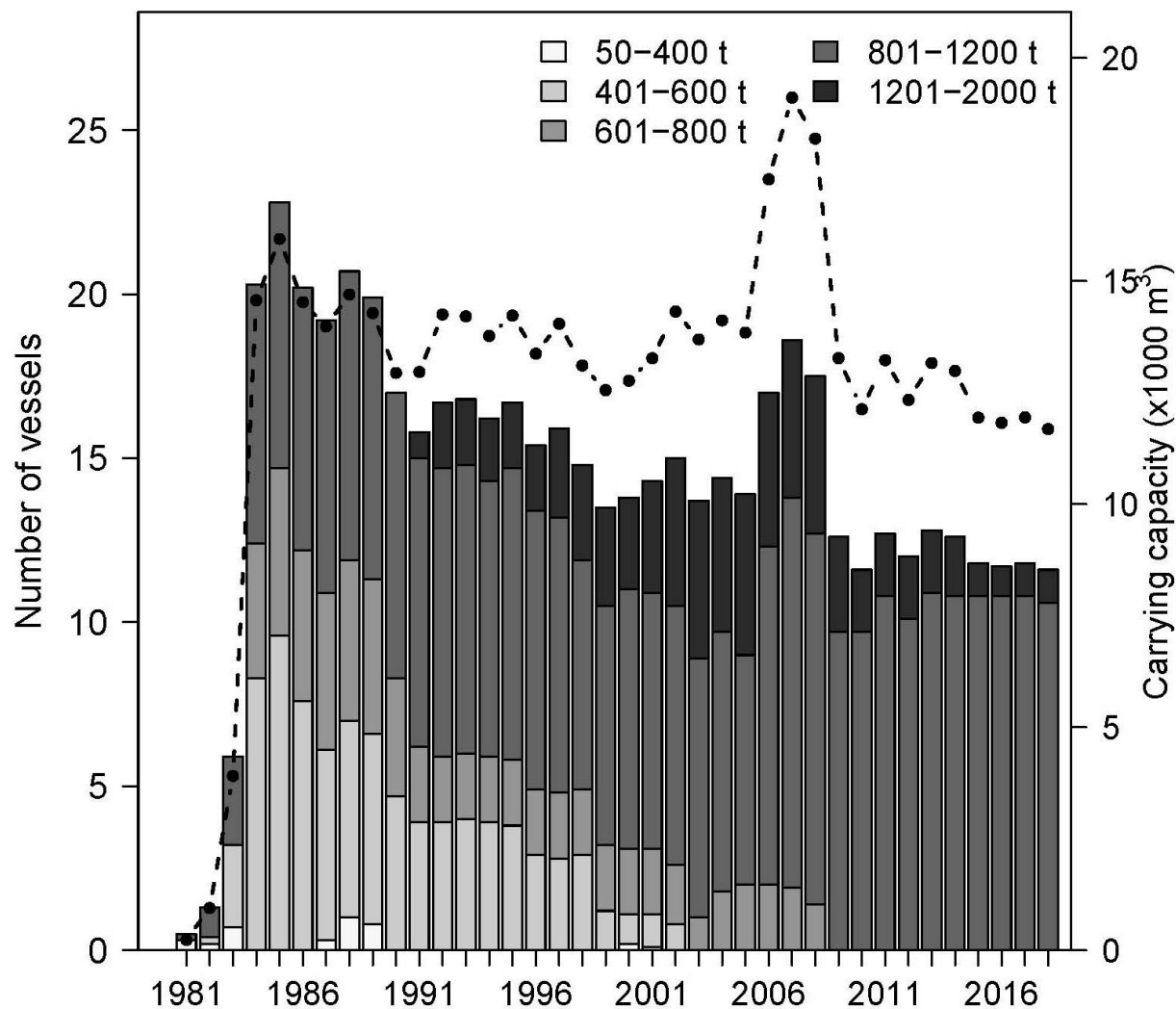


Figure 1 Fishing capacity of the French purse seine fishing fleet in the Indian Ocean. Annual changes in the number of purse seiners by tonnage category (barplots) and total carrying capacity (dashed line with circles) during 1981-2018.

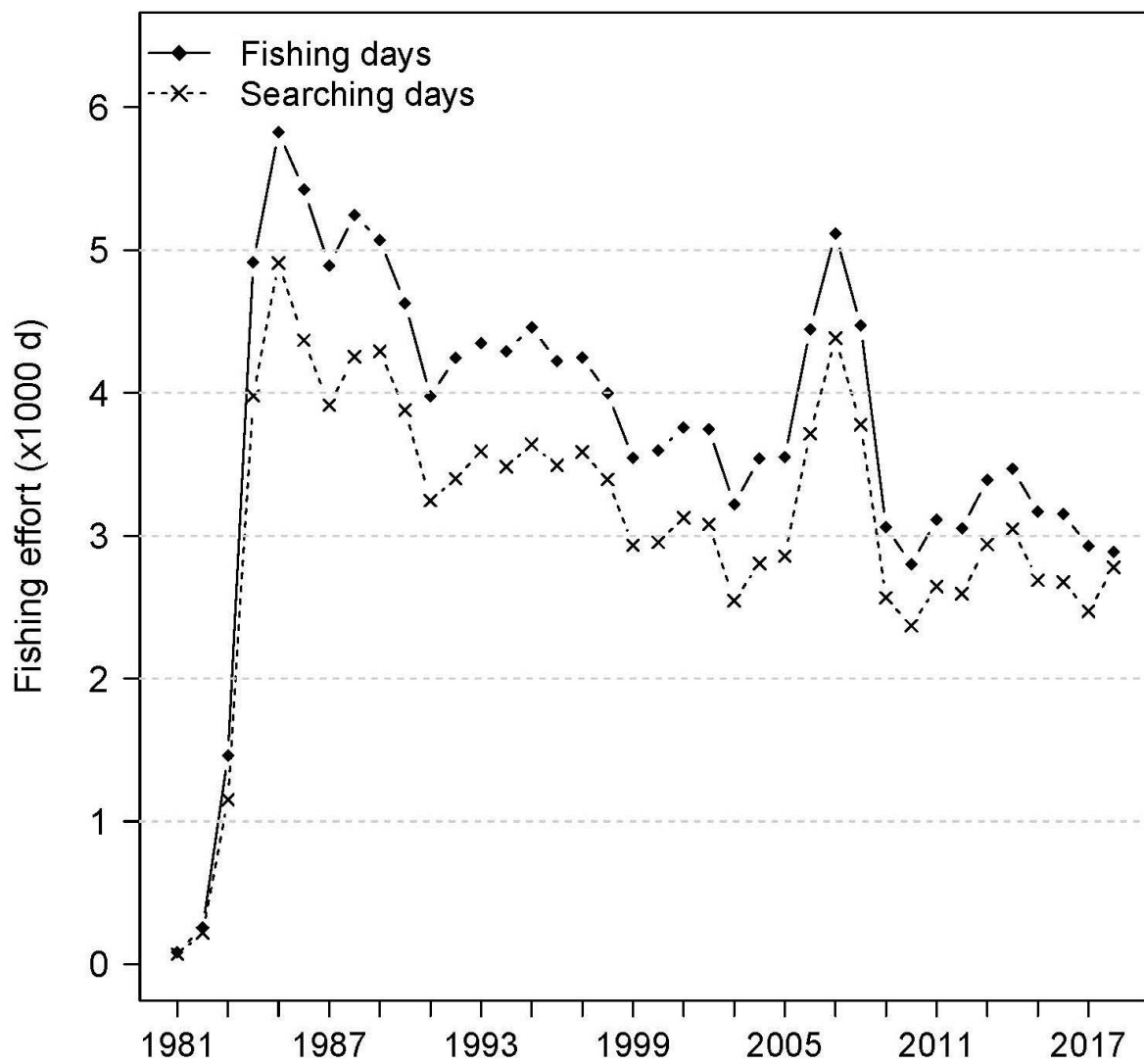


Figure 2 Changes in nominal effort over time. Annual total number of fishing and searching days for the French purse seine fishing fleet in the Indian Ocean during 1981-2018

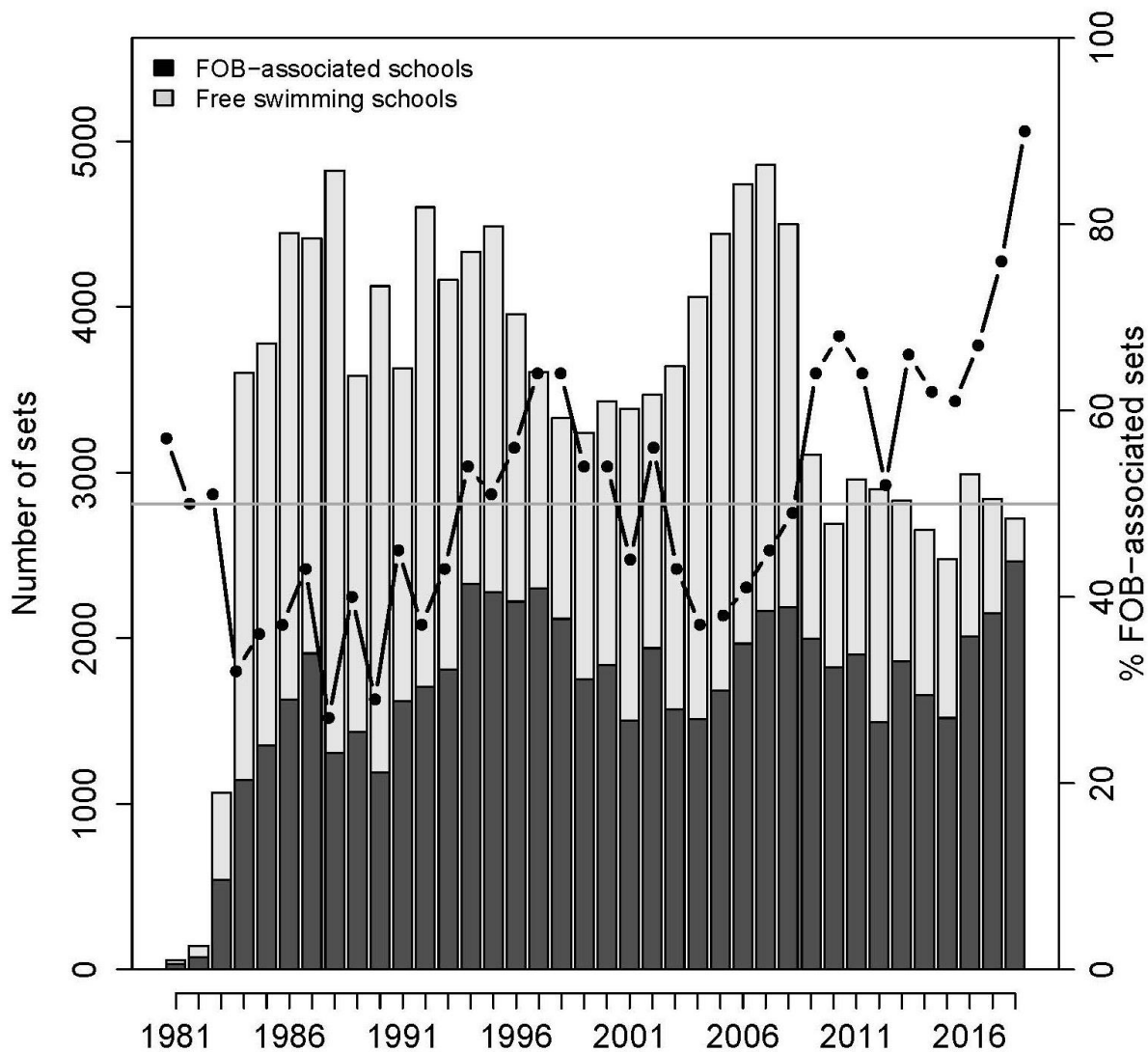


Figure 3 Fishing operations. Annual number of fishing sets in the French purse seine fishery on FOB-associated and free-swimming schools during 1981-2018. Line with solid circles indicates the percentage of sets on FOB-associated schools. Grey solid line indicates the 50% value.

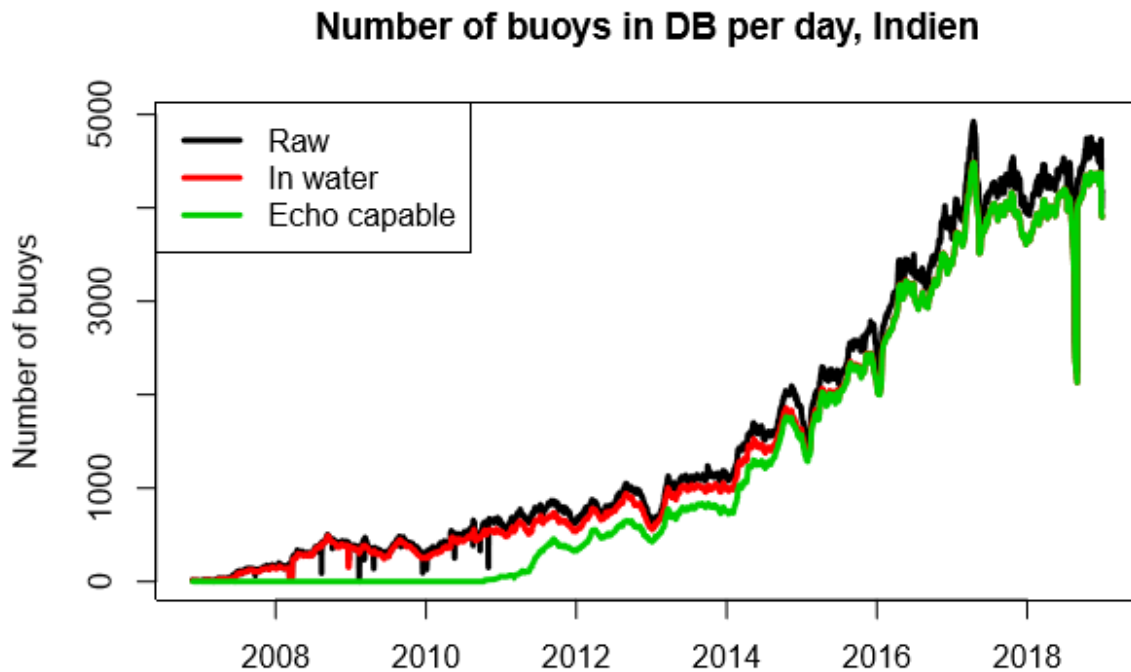


Figure 4. Number of buoys in DB per day, by the whole French purse seine fleet. Number of active buoys per day in the FAD trajectory data of the French fleet and associated vessels. Note that data include all buoys tracked by boats associated with the three French fishing companies, CFTO, SAPMER and Saupiquet, including those flagged under a different nation (e.g., Italy). Numbers have not been corrected for missing data (e.g., due to technical issues associated with data transmission and/or storage), but estimates of the amount of missing data are generally <10% for the period 2010-2013 and always <5% for the period 2014-2018, so the numbers presented are a good overall estimate of the total number of buoys. The "in water" curve represents the estimated number of buoys after application of a position classification algorithm to eliminate onboard positions and after interpolation over small gaps in the data (explaining how the number of in water buoys occasionally exceeds that in the raw data).

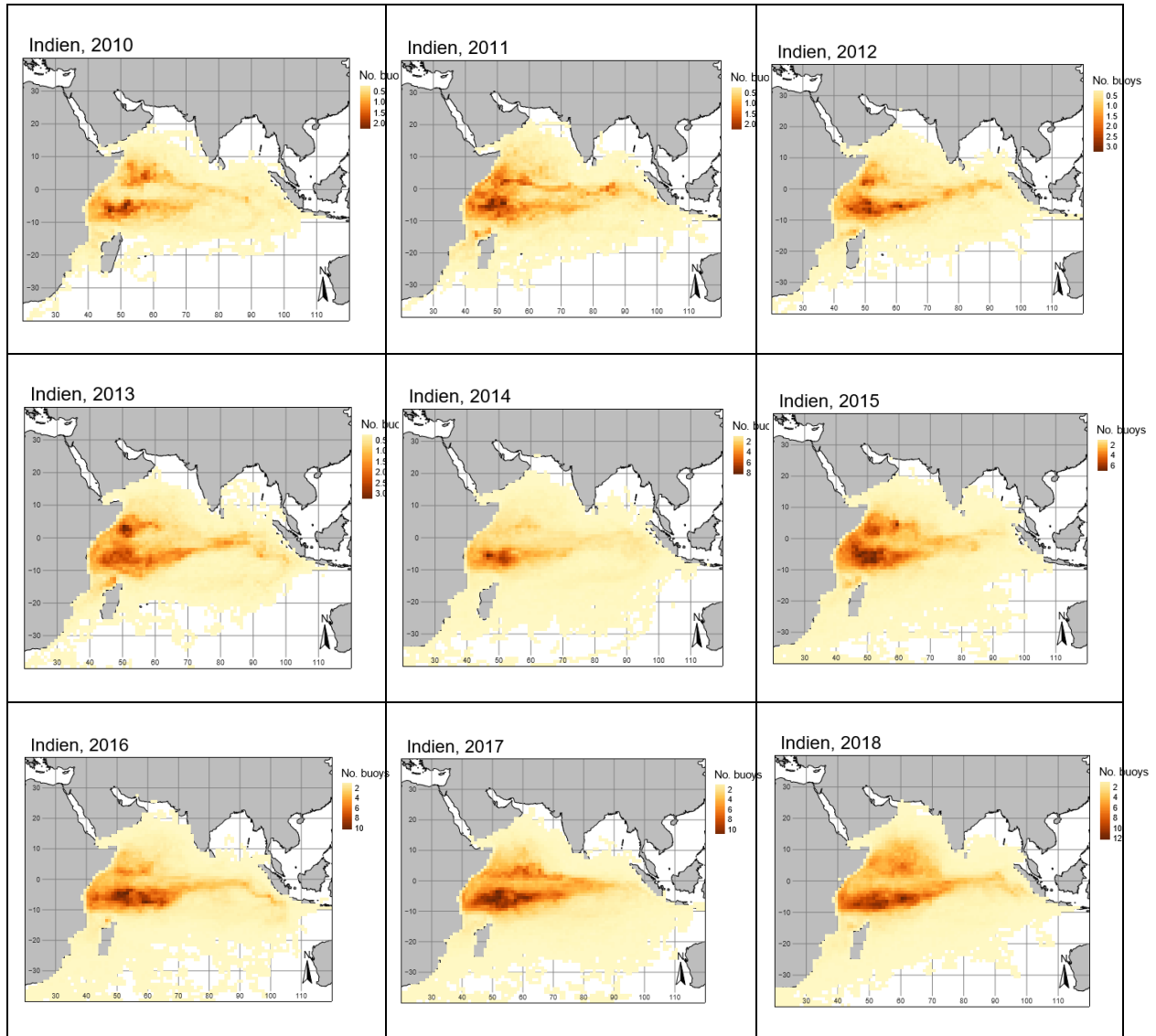


Figure 5. Annual fads density of buoys. Annual average maps of active, in-water FAD buoys used by the French fleet and associated vessels. Note that maps are corrected for missing data to best reflect the total absolute density of buoys and they include all buoys tracked by boats associated with the three French fishing companies, CFTO, SAPMER and Saupiquet, including those flagged under a different nation (e.g., Italy). Also note that the color bars are different for each figure so as to best represent the spatial variation in each year, as opposed to changes in absolute number of buoys across years. Please refer to Figure 4 for changes in the absolute number of buoys over time.

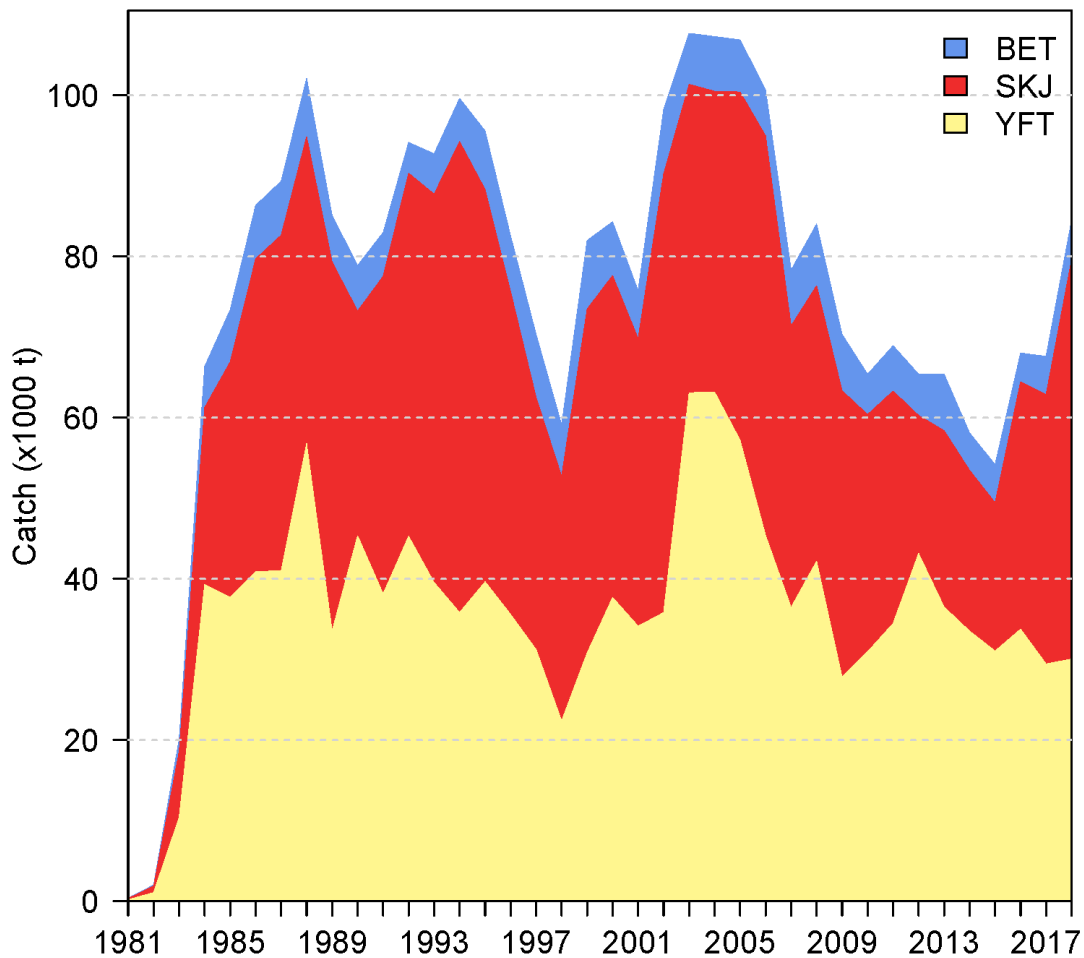


Figure 6 Total fishery production. Catch by species of the French purse seine fishing fleet during 1981-2018

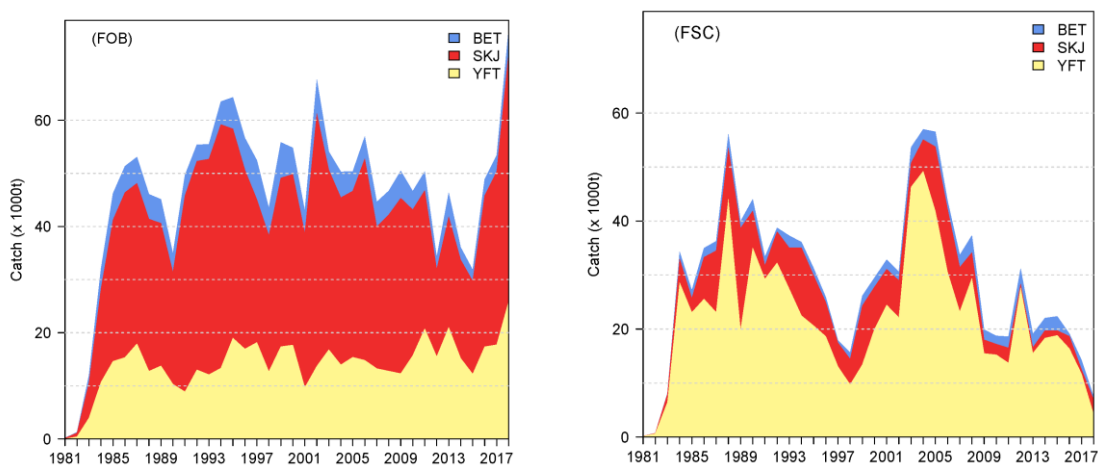


Figure 7 Fishery production by major fishing mode. Catch by species of the French purse seine fishing fleet on FOB-associated and free-swimming schools during 1981-2018

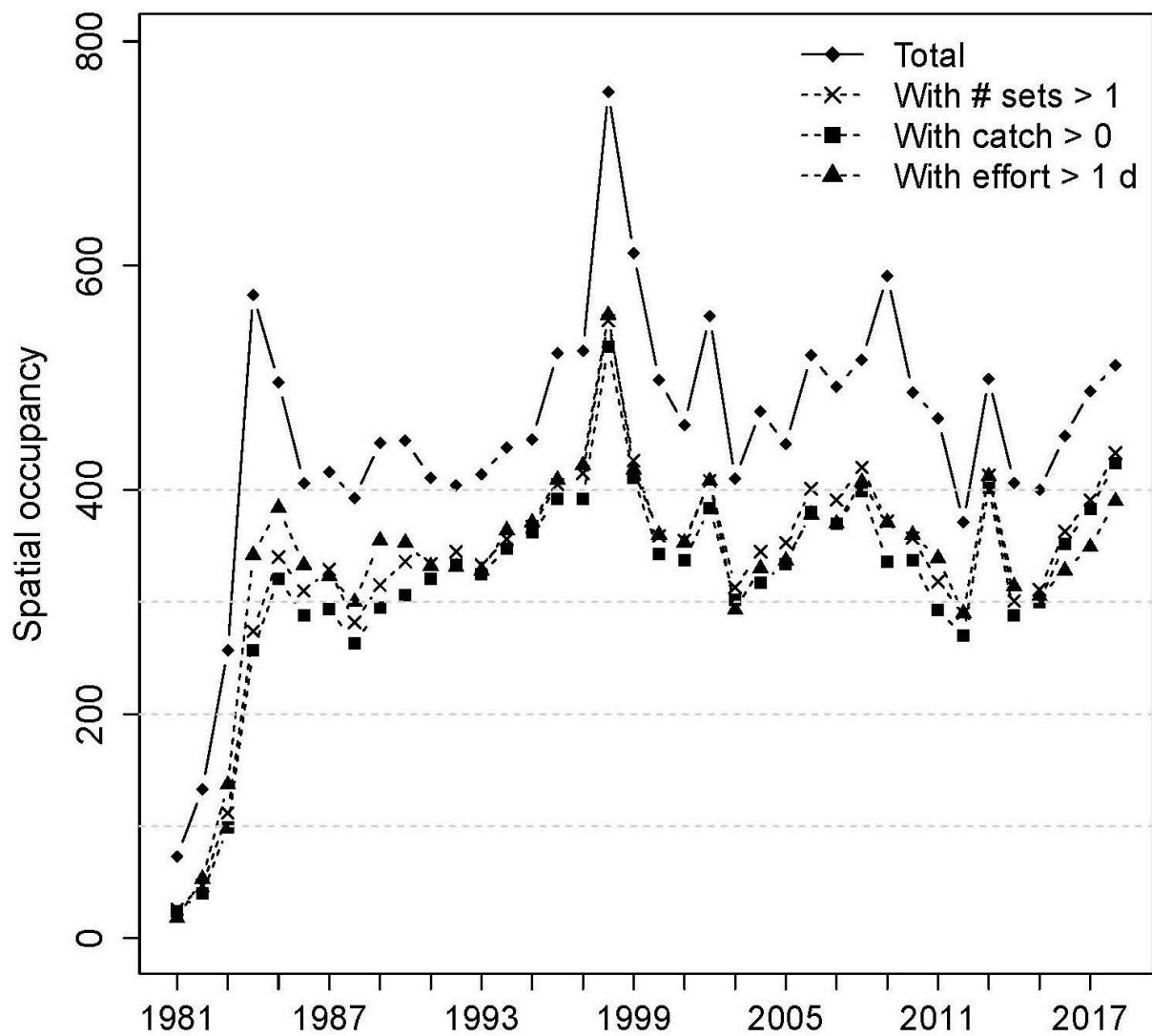


Figure 8 Changes in spatial extent of the purse seine fishery over time. Mean annual number of 1-degree squares explored by each vessel of the French purse seine fleet during 1981-2018.

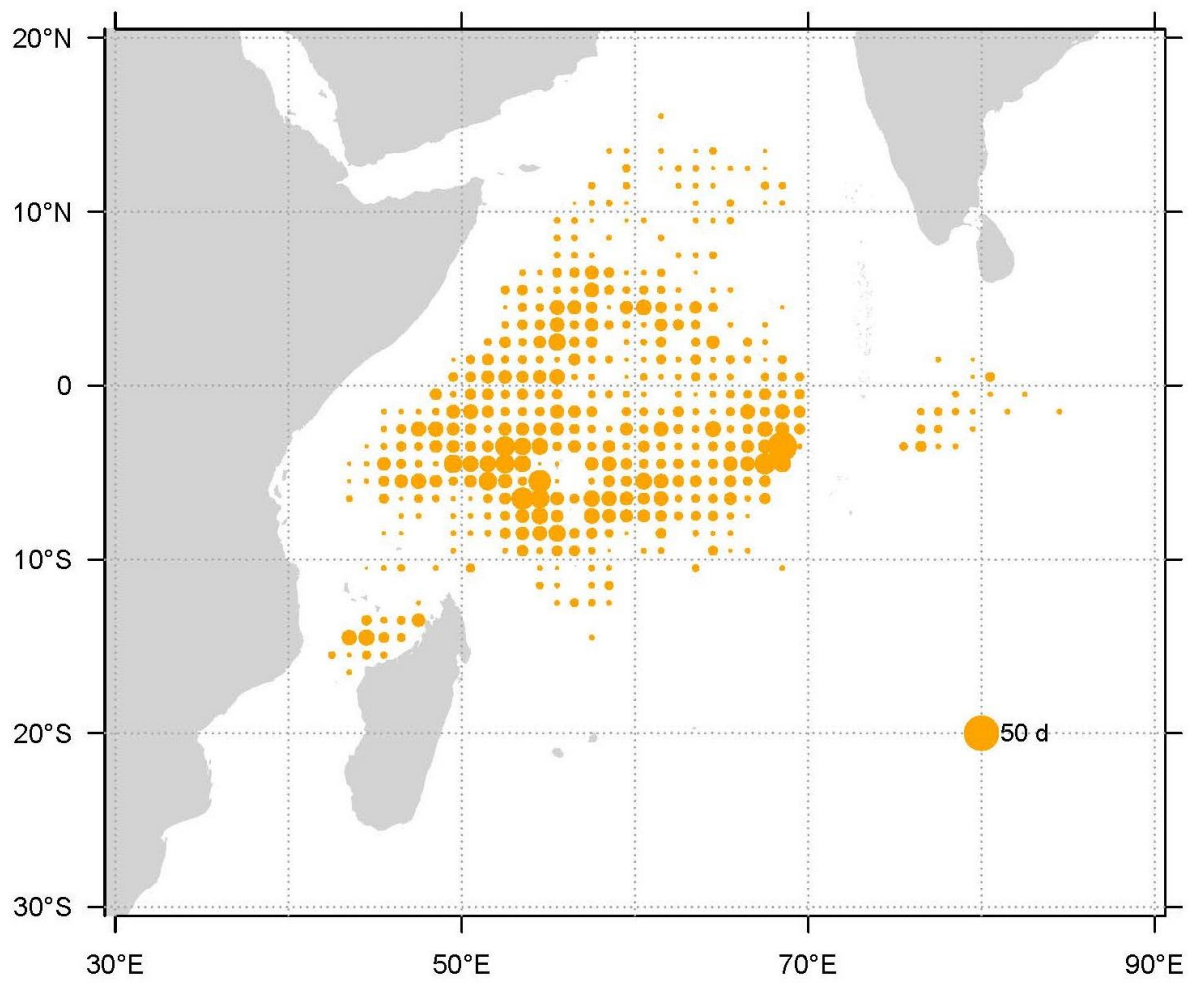


Figure 9 Fishing grounds. Spatial distribution of fishing effort (in searching days) of the French purse seine fishing fleet in 2018

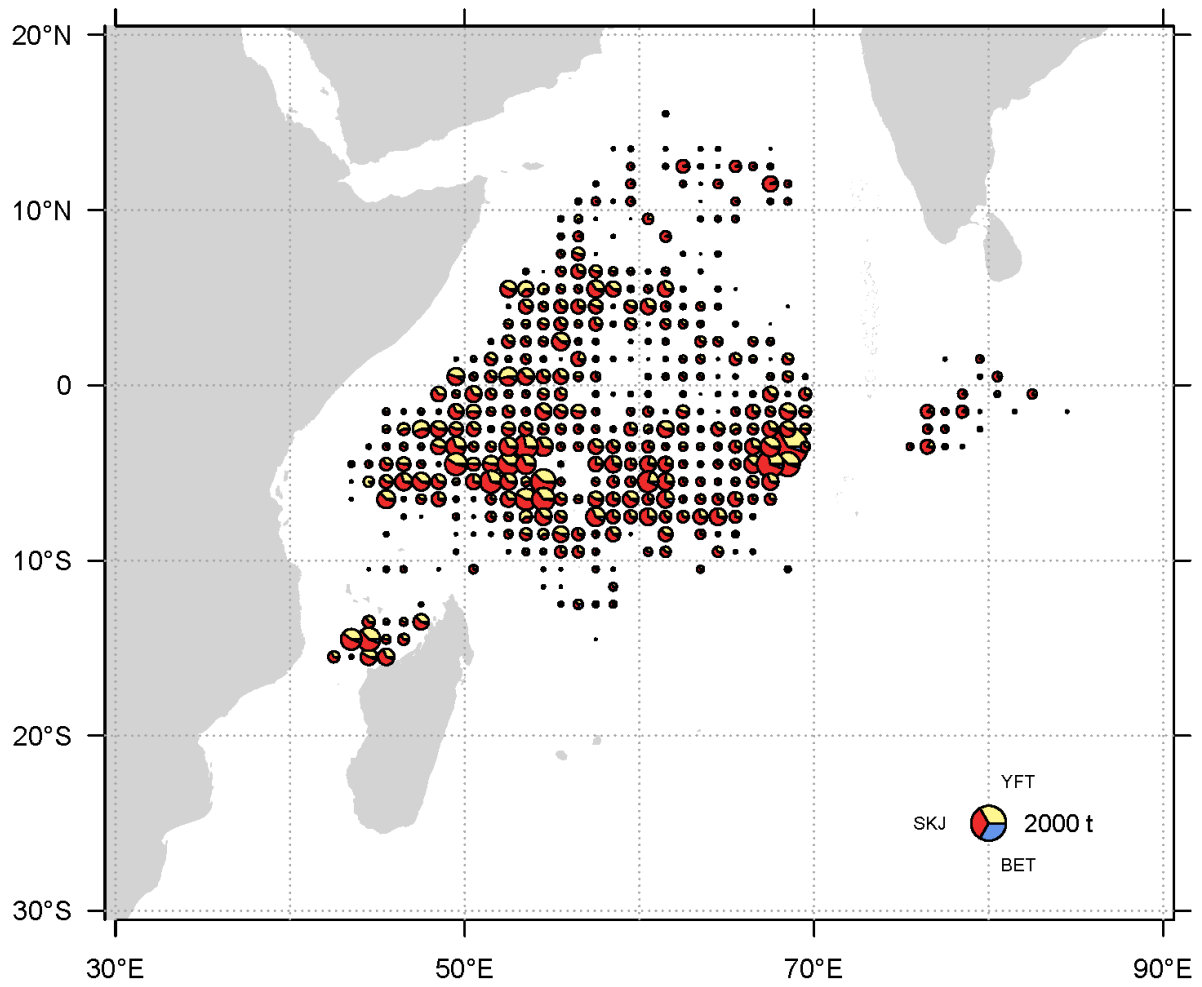


Figure 10 Spatial distribution of tuna catches of the French purse seine fishing fleet made on FOB-associated schools in 2018

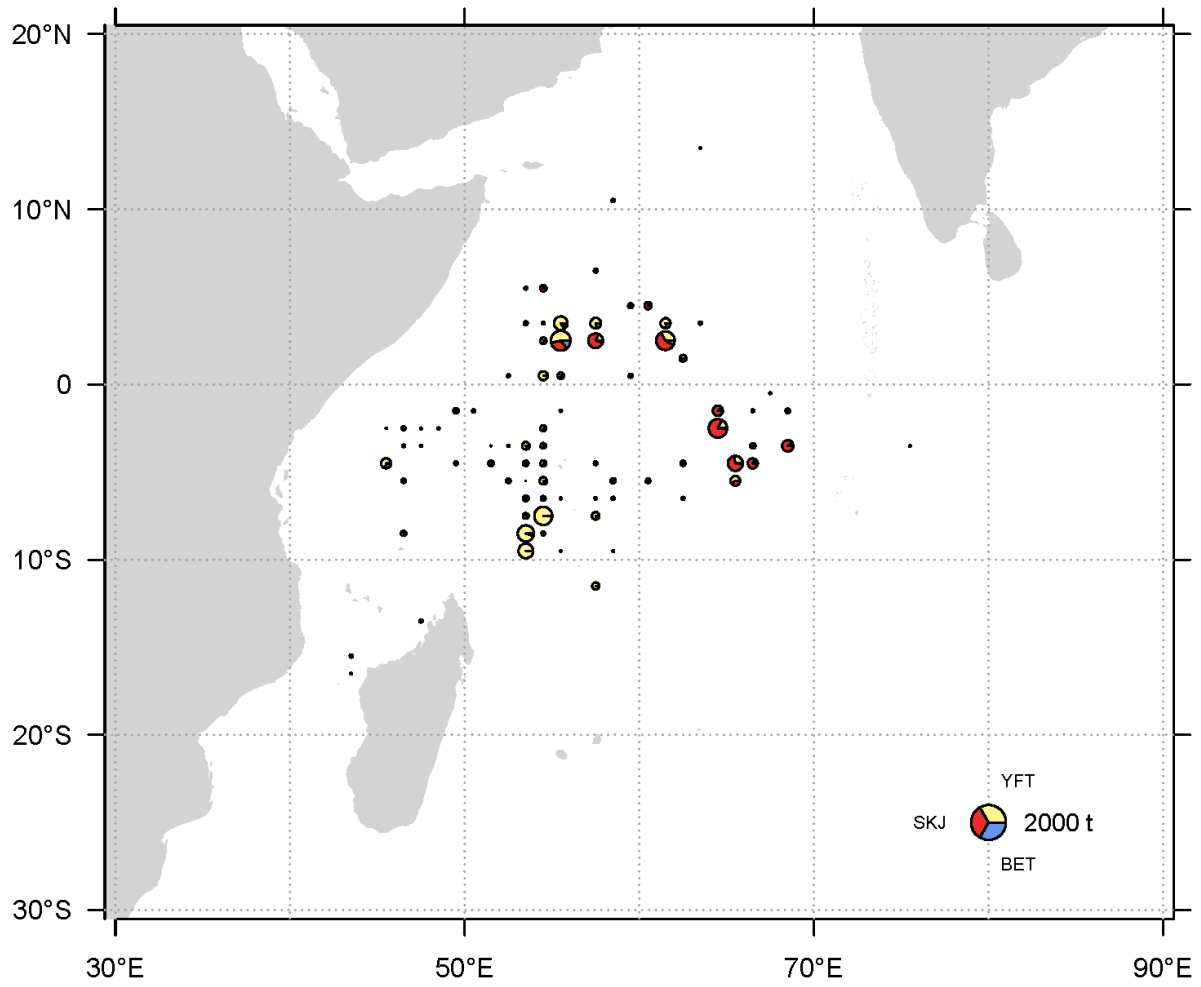


Figure 11 Spatial distribution of tuna catches of the French purse seine fishing fleet made on free swimming schools in 2018

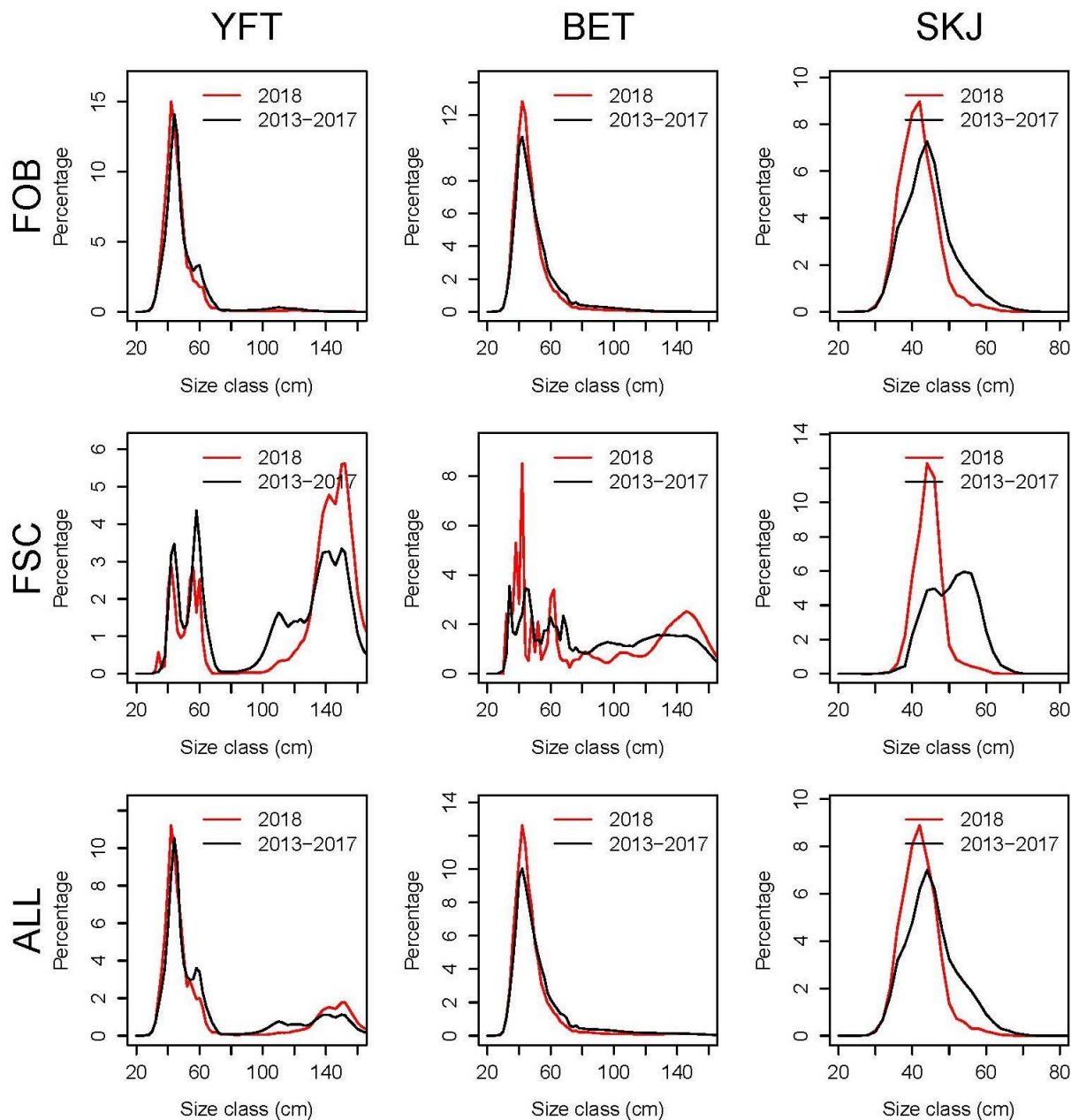


Figure 12 Distribution by size class of the catch (in percentage of the total number of fishes) for the French purse seine fleet in 2017 (red line) and for an average year representing the period 2012-2016 (black line)

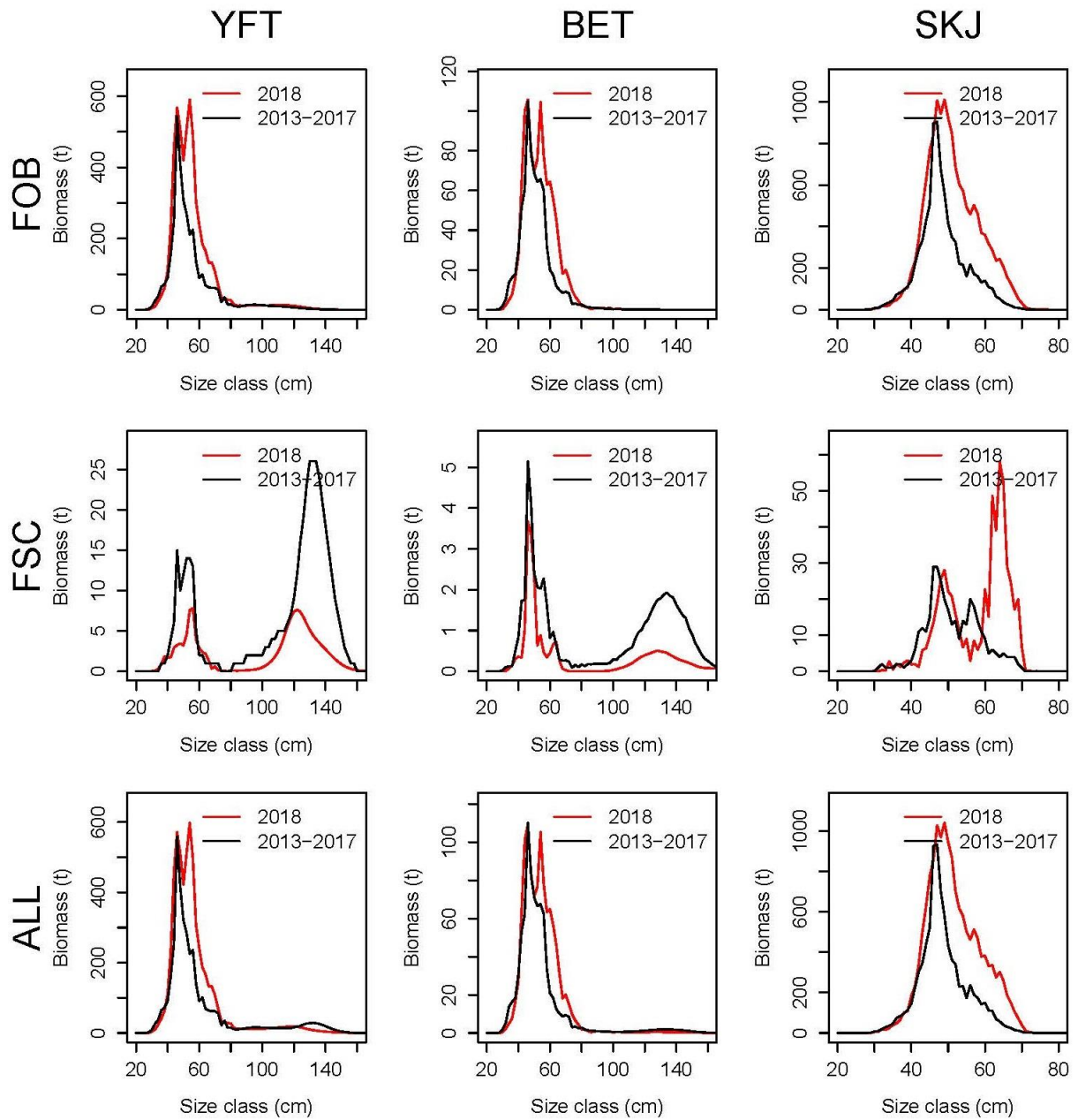


Figure 13 Size distributions in biomass of individuals by species and by fishing mode for the French purse seine fleet in 2018 (red line) and for an average year representing the period 2013-2017 (black line)

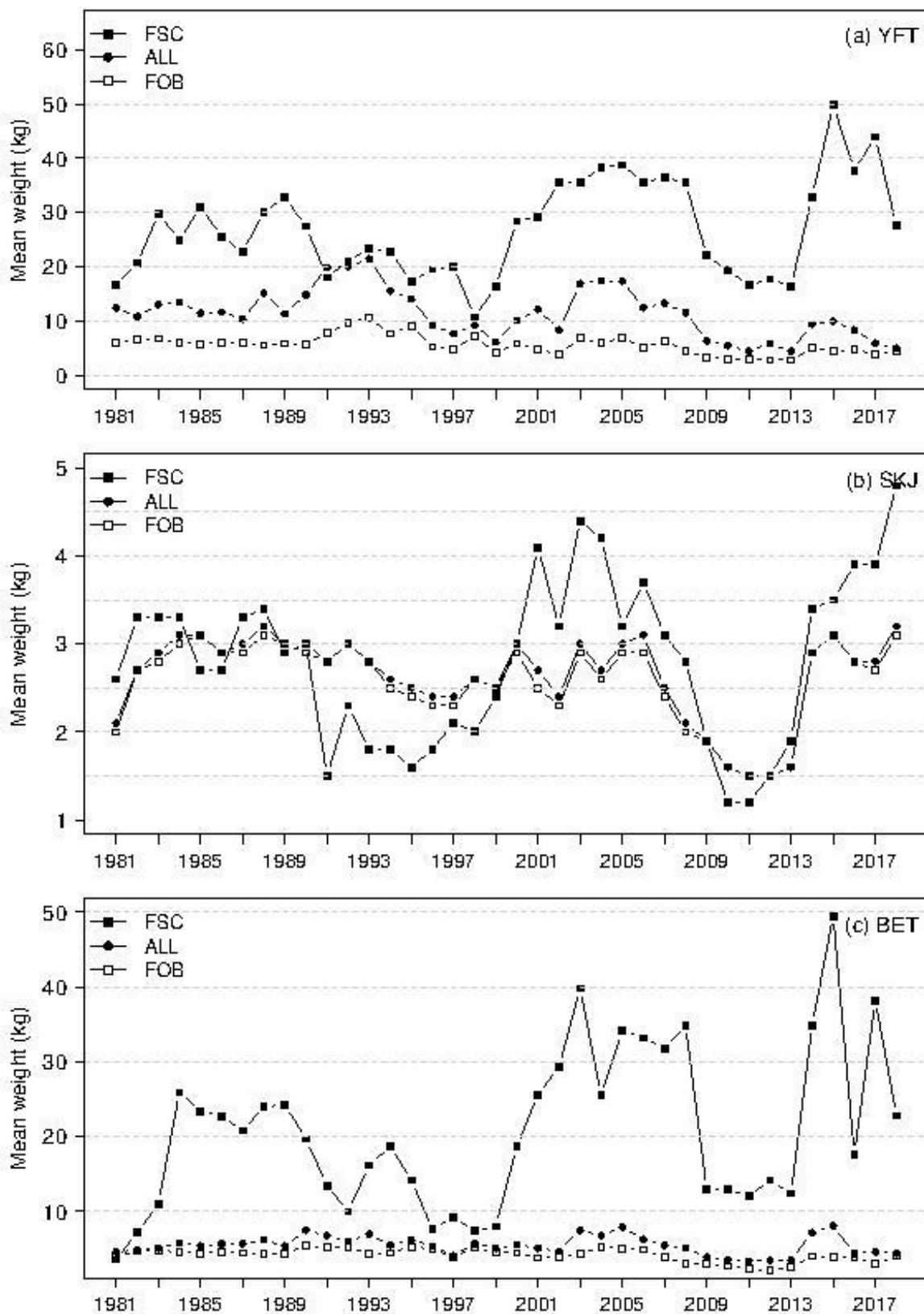


Figure 14 Annual time series of mean weight (kg) for (a) yellowfin, (b) skipjack, and (c) bigeye tuna by fishing mode during 1981-2018

7 Tables

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 Indian Ocean during 1981-2018. 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	11850
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	9601
2003	0	6.6	1	4.8	0	0	14	12.42	9610
2004	0	4.9	0.3	4.9	0	0	12	10.08	8345
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	3678
2009	0	0.9	2	3	1.4	0	10	7.33	6876
2010	0	1	1.9	3.9	2.3	0	10	9.08	8846
2011	0	0.8	2	3.5	1.9	0	9	8.17	7945
2012	0	0	1.9	4.8	1.9	0	9	8.67	8986
2013	0	0	1.9	4.7	1.8	0	9	8.42	8715
2014	0	0	2	5	1.9	0	9	8.92	9240
2015	0	0	1.8	5	1.9	0	9	8.75	9118
2016	0	0	2	5.5	2	0	11	9.5	9780
2017	0	0	2	5.8	1.8	0	10	9.58	9756
2018	0	0	0	10.6	1	0	12	11.58	11686

Table 2 Annual nominal fishing effort of the French purse seine fishing fleet expressed in fishing and searching days during 1981-2018. Searching days was derived from the total time spent at sea corrected for periods of damage, route towards port, and purse seine operation. The duration per day for fishing activities is 13 hours

Year	CC	Fishing days	Searching days
1981	233	84	69
1982	945	255	217
1983	3907	1460	1151
1984	14566	4914	3979
1985	15945	5823	4910
1986	14526	5424	4368
1987	13983	4892	3914
1988	14699	5245	4252
1989	14285	5069	4291
1990	12939	4627	3879
1991	12943	3977	3246
1992	14220	4245	3399
1993	14180	4349	3591
1994	13743	4291	3484
1995	14199	4460	3639
1996	13341	4222	3493
1997	14013	4249	3585
1998	13074	3997	3393
1999	12523	3543	2934
2000	12736	3596	2954
2001	13311	3757	3126
2002	14431	3745	3078
2003	13676	3220	2544
2004	14090	3541	2805
2005	13818	3549	2857
2006	17250	4445	3714
2007	19087	5115	4384
2008	18173	4471	3777
2009	13270	3060	2565
2010	12128	2801	2370
2011	13229	3113	2643
2012	12341	3052	2594
2013	13162	3391	2939
2014	12984	3467	3046
2015	11940	3167	2688
2016	11823	3152	2676
2017	11944	2928	2473
2018	2885	108	2777

Table 3 Number of positive and null sets by fishing mode made by the French purse seine fishing fleet in the Indian ocean during 1981-2018. FOB = Floating Object; FSC = Free-Swimming School

	ALL			FOB			FSC			
	Total	Positive	Null	Total	Positive	Null	Total	Positive	Null	
1981	56	37	19	32	24	8	24	13	11	57
1982	143	105	38	72	63	9	71	42	29	50
1983	1068	738	330	540	449	91	528	289	239	51
1984	3601	2077	1524	1143	888	255	2458	1189	1269	32
1985	3780	2108	1672	1353	1118	235	2427	990	1437	36
1986	4446	2257	2189	1628	1282	346	2818	975	1843	37
1987	4414	2592	1822	1908	1520	388	2506	1072	1434	43
1988	4824	2648	2176	1309	1104	205	3515	1544	1971	27
1989	3583	2083	1500	1436	1213	223	2147	870	1277	40
1990	4126	2322	1804	1189	991	198	2937	1331	1606	29
1991	3630	2448	1182	1622	1538	84	2008	910	1098	45
1992	4602	2980	1622	1708	1569	139	2894	1411	1483	37
1993	4164	2764	1400	1811	1612	199	2353	1152	1201	43
1994	4332	3099	1233	2326	2068	258	2006	1031	975	54
1995	4486	3066	1420	2276	2052	224	2210	1014	1196	51
1996	3956	2883	1073	2221	1956	265	1735	927	808	56
1997	3607	2714	893	2301	2035	266	1306	679	627	64
1998	3328	2454	874	2117	1828	289	1211	626	585	64
1999	3240	2371	869	1750	1553	197	1490	818	672	54
2000	3429	2526	903	1838	1568	270	1591	958	633	54
2001	3385	2370	1015	1501	1321	180	1884	1049	835	44
2002	3469	2539	930	1940	1745	195	1529	794	735	56
2003	3641	2344	1297	1570	1357	213	2071	987	1084	43
2004	4062	2382	1680	1511	1275	236	2551	1107	1444	37
2005	4442	2862	1580	1683	1473	210	2759	1389	1370	38
2006	4741	3000	1741	1967	1696	271	2774	1304	1470	41
2007	4857	2909	1948	2163	1698	465	2694	1211	1483	45
2008	4502	2954	1548	2186	1850	336	2316	1104	1212	49
2009	3108	2339	769	1998	1714	284	1110	625	485	64
2010	2691	2019	672	1825	1590	235	866	429	437	68
2011	2959	2144	815	1900	1631	269	1059	513	546	64
2012	2899	2107	792	1493	1276	217	1406	831	575	52
2013	2830	2125	705	1860	1629	231	970	496	474	66
2014	2655	2114	541	1657	1503	154	998	611	387	62
2015	2478	1921	557	1518	1399	119	960	522	438	61
2016	2991	2416	575	2009	1885	124	982	531	451	67
2017	2839	2410	429	2150	2007	143	689	403	286	76
2018	2723	2478	245	2463	2317	146	260	161	99	90

Table 4 Number of deployment of Fads and buoys 2013-2018

Year	Number of vessels		FADs		Buoys	
	PS	SV	PS	SV	PS	SV
2013	8		385	0	303	0
2014	13		914	0	2084	0
2015	12		1658	0	2562	0
2016	12	1	2184	272	3445	57
2017	12	1	2976	798	2834	199
2018	12	2	3299	1116	2448	480

FADs : Fishing Aggregating Device

PS : Purse Seiner

SV : Supply Vessel

Table 3 Catch by species of the French purse seine fishing fleet of the Indian Ocean during 1981-2018

Year	YFT	SKJ	BET	ALB	OTH	TOTAL
1981	188	158	23	0	56	425
1982	1081	792	145	0	0	2018
1983	10400	8153	1536	0	136	20225
1984	39268	21979	5081	224	102	66655
1985	37706	29183	6477	445	183	73994
1986	40911	38786	6636	200	177	86711
1987	41012	41620	6701	217	26	89576
1988	56766	38094	7251	177	19	102307
1989	33548	45750	5764	6	0	85068
1990	45351	27873	5663	36	31	78954
1991	38134	39388	5441	875	0	83837
1992	45282	45048	3822	1403	0	95555
1993	39539	48192	5015	310	0	93057
1994	35819	58430	5367	292	0	99908
1995	39636	48652	7280	350	0	95918
1996	35578	40056	6908	391	0	82933
1997	31227	31276	7824	539	0	70866
1998	22382	30340	6389	460	0	59571
1999	30799	42665	8518	154	0	82136
2000	37694	39935	6673	350	0	84652
2001	34127	35673	5956	659	15	76429
2002	35815	54405	7962	264	45	98492
2003	63101	38258	6334	608	31	108333
2004	63174	37323	6798	77	39	107411
2005	57198	43220	6453	86	0	106957
2006	45383	49573	5714	850	41	101560
2007	36455	34918	6928	335	0	78636
2008	42185	34186	7652	981	10	85013
2009	27807	35532	6991	295	0	70625
2010	30946	29432	5003	63	11	65455
2011	34468	28826	5635	575	0	69504
2012	43151	17120	5115	771	0	66156
2013	36511	21882	7015	331	0	65739
2014	33513	19944	4640	242	0	58339
2015	31046	18397	4730	216	0	54390
2016	33757	30698	3566	228	0	68249
2017	29442	33422	4742	149	13	67768
2018	30500	49001	4998	71	158	84729

Table 6 Catch by species made on FOB-associated schools for the French purse seine fishing fleet of the Indian Ocean during 1981-2018

Year	YFT	SKJ	BET	ALB	OTH	TOTAL
1981	37	128	20	0	56	240
1982	442	709	131	0	0	1282
1983	3959	6637	1381	0	136	12114
1984	10692	17600	3762	0	77	32130
1985	14623	26582	4993	14	167	46378
1986	15353	31040	4953	0	177	51522
1987	17926	30205	4937	0	3	53072
1988	12763	28633	4675	0	19	46090
1989	13769	26850	4499	0	0	45118
1990	10312	21046	3513	0	31	34902
1991	8886	36896	3858	0	0	49639
1992	13014	39286	3112	9	0	55421
1993	12111	40582	2769	5	0	55467
1994	13340	45866	4313	23	0	63543
1995	19002	39380	5933	17	0	64332
1996	16944	33741	5975	70	0	56730
1997	18173	26882	7389	67	0	52511
1998	12680	25599	5173	13	0	43464
1999	17389	31759	6692	103	0	55943
2000	17699	32142	4960	43	0	54845
2001	9678	29045	4206	108	15	43052
2002	13704	47527	6385	0	45	67661
2003	16810	33837	3429	0	31	54106
2004	13959	31473	4882	0	39	50352
2005	15399	31270	3667	0	0	50336
2006	14818	37920	4172	0	41	56951
2007	13254	26695	4662	3	0	44613
2008	12784	29427	4486	2	10	46710
2009	12320	33004	5125	10	0	50459
2010	15704	27461	3474	32	11	46682
2011	20755	26017	3555	45	0	50372
2012	15484	16442	2287	30	0	34243
2013	21008	20814	4506	32	0	46360
2014	15180	18540	2334	36	0	36090
2015	12216	17500	2105	44	0	31865
2016	17368	28420	3097	61	0	48948
2017	18282	31403	2910	54	13	52661
2018	26312	46275	4446	66	158	77257

Table 7 Catch by species made on free-swimming schools for the French purse seine fishing fleet of the Indian Ocean during 1981-2018

Year	YFT	SKJ	BET	ALB	OTH	TOTAL
1981	151	31	4	0	0	185
1982	638	83	14	0	0	736
1983	6441	1516	155	0	0	8111
1984	28576	4380	1319	224	25	34525
1985	23083	2601	1484	432	16	27615
1986	25558	7747	1683	200	0	35189
1987	23086	11415	1764	217	23	36505
1988	44003	9461	2575	177	0	56217
1989	19779	18900	1265	6	0	39951
1990	35039	6827	2150	36	0	44052
1991	29248	2492	1583	875	0	34198
1992	32268	5762	710	1394	0	40134
1993	27428	7611	2246	305	0	37590
1994	22479	12564	1054	269	0	36365
1995	20634	9272	1348	333	0	31587
1996	18633	6315	933	321	0	26203
1997	13054	4394	434	472	0	18355
1998	9702	4742	1215	448	0	16107
1999	13410	10907	1826	51	0	26193
2000	19995	7793	1713	307	0	29808
2001	24450	6627	1750	551	0	33377
2002	22111	6878	1578	264	0	30831
2003	46291	4422	2906	608	0	54226
2004	49215	5850	1916	77	0	57058
2005	41799	11950	2786	86	0	56620
2006	30564	11653	1542	850	0	44609
2007	23201	8224	2265	332	0	34023
2008	29401	4758	3166	979	0	38303
2009	15487	2527	1866	285	0	20166
2010	15242	1971	1529	31	0	18774
2011	13713	2809	2080	530	0	19132
2012	27668	678	2828	740	0	31913
2013	15503	1068	2509	299	0	19380
2014	18333	1404	2306	206	0	22249
2015	18830	897	2625	173	0	22525
2016	16388	2278	468	166	0	19301
2017	11680	828	1680	95	0	14284
2018	4188	2726	553	5	0	7472

Table 8 Number of sets per searching day on FOB-associated (FOB) and free-swimming schools (FSC) for the French purse seine fishing fleet of the Indian Ocean during 1981-2019

Year	ALL	FOB	FSC
1981	0.75	0.43	0.32
1982	0.61	0.31	0.3
1983	0.86	0.43	0.42
1984	0.84	0.27	0.57
1985	0.71	0.25	0.46
1986	0.94	0.34	0.6
1987	1.04	0.45	0.59
1988	1.05	0.28	0.76
1989	0.77	0.31	0.46
1990	0.98	0.28	0.7
1991	1.03	0.46	0.57
1992	1.25	0.46	0.79
1993	1.07	0.47	0.6
1994	1.15	0.62	0.53
1995	1.14	0.58	0.56
1996	1.05	0.59	0.46
1997	0.93	0.59	0.34
1998	0.91	0.58	0.33
1999	1.02	0.55	0.47
2000	1.07	0.57	0.5
2001	1	0.44	0.56
2002	1.04	0.58	0.46
2003	1.32	0.57	0.75
2004	1.34	0.5	0.84
2005	1.43	0.54	0.89
2006	1.18	0.49	0.69
2007	1.02	0.46	0.57
2008	1.1	0.53	0.57
2009	1.12	0.72	0.4
2010	1.05	0.71	0.34
2011	1.03	0.66	0.37
2012	1.03	0.53	0.5
2013	0.89	0.58	0.3
2014	0.8	0.5	0.3
2015	0.85	0.52	0.33
2016	1	0.67	0.33
2017	0.97	0.74	0.24
2018	0.8	0.73	0.08

Table 9 Annual number of 1-degree squares explored by the French purse seine fishing fleet during 1981-2018. #sets indicates squares where at least 1 fishing positive set was made.

Year	TOTAL	#sets	Catch >0	Effort > 1 d	Effort > 5 d
1981	73	26	24	18	0
1982	133	47	40	53	10
1983	257	112	99	137	60
1984	574	274	257	342	182
1985	496	340	321	384	267
1986	406	310	288	333	223
1987	416	329	294	323	206
1988	393	282	263	300	210
1989	442	315	295	355	229
1990	444	336	306	353	215
1991	411	334	321	332	203
1992	404	345	333	331	198
1993	414	333	325	328	218
1994	438	356	348	364	231
1995	445	367	362	371	232
1996	522	405	392	409	245
1997	524	415	392	422	258
1998	755	551	528	556	245
1999	611	426	411	418	196
2000	498	359	343	360	201
2001	458	355	337	353	219
2002	555	408	384	408	237
2003	410	313	302	293	186
2004	470	345	317	330	171
2005	441	353	334	337	198
2006	520	401	380	378	220
2007	492	391	370	370	242
2008	516	420	399	407	245
2009	591	372	336	371	189
2010	487	357	337	360	186
2011	464	318	293	339	162
2012	371	290	270	290	184
2013	499	413	402	412	221
2014	406	301	288	314	190
2015	400	311	300	305	182
2016	448	363	352	328	183
2017	488	391	383	349	203
2018	511	433	424	390	212