STATISTICS OF THE FRENCH PURSE SEINE FISHING FLEET TARGETING TROPICAL TUNA IN THE INDIAN OCEAN (1981-2020)

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SUMMARY

This document presents an updated summary of the French purse seine fleet targeting tropical tunas in the Indian Ocean. The statistics cover the period 1981-2020 and specifically focus on the activity of the last year of the fishery. In 2020, a total of 13 French vessels operated in the western Indian Ocean including 10 purse seiners and 3 support vessels. The total capacity weighted by the months of activity for each vessel is 10626t. The total nominal effort in 2020 was of 1805 fishing days and 2414 sets with 1898 sets on floating objects and 516 on free schools. The total catch of the French component of the EU purse seine fleet of the Indian Ocean was 58149t, being composed of 42.2%, 52.6%, 4.5% and 0.8% of yellowfin tuna, skipjack tuna, bigeye tuna and other species respectively. The most noticeable change in 2020 was the decrease of 17.7% for the total of catches in comparison to 2019, respectively 58149t and 70622t. Remarkably, yellowfin tuna and skipjack tuna proportion of catches in 2020 for free swimming school returned to the proportion prevailing before 2018, after 2 years of a different fishing strategy targeting skipjack tuna on free swimming school.

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). In this report, we summarize the fishing activities of the French purse seiners during the period 1981-2020 based on the data collection of logbooks, landing reports and sampling operations conducted at ports during unloading for target species (i.e skipjack, yellowfin tuna and bigeye tuna). Catches were estimated with the T3 process (described in Duparc et al.2018).

2 Material and methods

2.1 Fishing data from vessels reports

Logbooks and landings reports were collected in collaboration with fishing companies with 100% trip coverage for all years but 8 years since 1984 and greater than 97% coverage in all years. For each trip, at unloading, the fish is sorted by species (and by commercial categories) and weighted at the cannery. For each set, the purse seine skippers report 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.
- Activity and details on floating objects (mainly FAD), since 2013

2.2 Sampling

In 2020, 85 well samples were taken at the unloading of French purse seiners in the port of Victoria instead of 329 in 2019. This sharp drop is due to the sanitary constraints of the covid19 pandemic for the sampling from April to October 2020. 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 EU-Spain and other flags associated with the EU-French purse seine fleet (Pallarès and Petit, 1998). A total of about 21 200 tunas measured were used in the T3 (Traitement des Thons Tropicaux) treatment (Duparc et al., 2018) of the French purse seine fishery data for 2020.

2.3 Fishing effort

Nominal fishing effort was computed from logbooks data (location and activity) and expressed in fishing days or searching days. The fishing time (day) is defined as the period of the day where vessels can carry out their fishing activities (searching for school, hauling, taking catch onboard). Therefore, activities preventing fishing activities are not accounted for (example: landing, damage repairs or moving to port). Searching time (days) corresponds to the period where vessels is considered searching for fish schools, and was calculated by the difference between the fishing time and the catch time (estimation based on its relationship with the set size). Efforts are express in day, which corresponds to the period of the day where the daylight is sufficient to enable fishing activities and is equal to 13 hours in the Indian Ocean (instead of 24h).

2.4 dFAD density map estimation

In brief, the methodology used for calculating French dFAD tracking buoy density maps involves the following steps:

1) Basic filtering of the data to remove aberrant information
2) Classification of positions into onboard and at sea classes using a random forest algorithm
3) Interpolation of buoy trajectories at midnight each day
4) Elimination of beached positions and positions classified as onboard a vessel
5) Aggregation of remaining positions into daily, instantaneous $1° \times 1°$ density raster maps
6) Averaging of daily maps over annual time periods
7) Correction of nominal densities using annual raising factors based on the inverse of the fraction of known buoy identifiers in observer data per ocean and year

Basic filtering of data followed previously published literature (e.g., Maufroy et al. 2015[1]). Aberrant positions at the poles or international date line were removed, multiple positions for a single timestamp were averaged into a single position, and pairs of subsequent identical positions for the same buoy were consolidated into a single position. Note that this filtering did not remove any class of positions that could be considered true positions (e.g., it did not remove beached positions or positions on land).

[1] 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

The classification algorithm used to separate onboard FAD positions from in water positions is an improvement on that presented in Maufroy et al. (2015[2]) that has been previously described in Imzilen et al. (2021). In brief, improvements include an extended and more recent training dataset and the use of better predictive variables related to the variance in speed and temperature in the immediate vicinity of a position to be classified. The algorithm is highly accurate, with an overall estimated error rate of ~2.3% that reduces to ~0.2% when considering just at sea positions (Imzilen et al. 2021).

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 interpolation of class was only non-trivial for interpolations at dates falling between pairs of subsequent positions, one of which was classified as onboard and the other of which was classified as at sea. Only 1.1% of all interpolated positions had interpolated classifications states different from 0 and 1.

This interpolated data was then filtered to remove boat positions and beaching events. A minimum 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 (data with interpolated class between 0.75 and <1 represented only 0.36% of all interpolated *in water* positions).

Identification of beaching events is described in detail elsewhere (e.g., Imzilen et al. 2021). In brief, beachings were identified as any set of 3 positions from the raw position data of a single buoy that are within 200m of the first position and separated in time by at least 1 day. These potential beachings were further filtered to remove any beaching events for which <90% of the positions between the beginning and the end of the beaching event were included in the beaching event based on the distance test. Conditions on proximity to land, depth or classification of preceding positions as *at sea* were not pertinent for density calculations as the objective was to remove all positions that were abnormally stationary. Any interpolated buoy positions between the beginning and end of the resulting beaching events were removed from the dataset before estimating densities.

For each day, the *at sea*, non-beached interpolated positions were aggregated on a $1^\circ \times 1^\circ$ lon-lat grid. These daily raster maps were average over annual time periods to produce annual average nominal density maps. These nominal density maps were corrected for partial coverage by our dFAD tracking buoy database. 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," we included both observer buoy-deployment identifiers that match an identifier in the dFAD tracking buoy trajectory database and observer identifiers that do not match, but for which there is a buoy position in the tracking buoy database that is within 2.5 km and ± 12 hours of the observer data and for which the Levenshtein distance between the observer buoy identified and corresponding buoy identifier in the trajectory database is inferior or equal to 3.

As observer data before ~2010 are quite limited and dFAD tracking buoy data is known to be incomplete before this time period (Maufroy et al. 2015), dFAD tracking buoy densities are only estimated for the period 2010-2020. For the year 2010 in the Indian Ocean, the amount of observer data is very limited (9 buoy identifiers). As such and given that the results for the two oceans for this year were not statistically different, I have merged the observer data for the two oceans when calculating the raising factor for 2010 for the Indian Ocean.

[2] Imzilen T, Lett C, Chassot E, Kaplan DM (2021) Spatial management can significantly reduce dFAD beachings in Indian and Atlantic Ocean tropical tuna purse seine fisheries. *Biological Conservation* **254**:108939. doi:10.1016/j.biocon.2020.108939

3 Results and interpretations

3.1 Fleet capacity

In 2020, 10 French purse seiners (Figure 1) operated in the Indian Ocean and conducted a total of 118 fishing trips lasting 22 days on average (Table 2). The fleet was composed of 7 vessels of carrying capacity (CC) 800-1200 t, and 3 vessels of CC >1,200 t (Table 1). The total carrying capacity weighted by the months of activity for each vessel in 2020 is 10626t with a decrease of 12% compared to 2019.

In 2020, 3 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 448 days at sea in 2020, contributing to 14% of the 3188 cumulated days at sea of the French fishing fleet (purse seiners and support vessels).

3.2 Fishing effort

The total nominal effort in 2020 for fishing days and searching days was 1805 and 1415 respectively (Figure 2 and Table 2). Since the peak in 2007, the fishing effort has decreased by 65% due to the departure of 7 vessels.

The total annual number of fishing sets in 2020 decreased by 6% compared to 2019 and reached 2414 (2102 positive sets and 312 null sets) (Table 3).

In 2018, the percentage of FOB sets (90%) was the highest value estimated since the beginning of the fishery (Figure3). In 2020 and 2019, respectively 75% and 79%, the percentages returned to values close to 2017 and previous years. The success rate of catches is 95% on FOBs and 56% 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, one support vessel joined the French fleet followed by two more vessels in 2018 and 2019.

In 2020, 4153 FADs were deployed by the 10 purse seiners and the 3 support vessels, i.e. an average of 319 per vessel, with a contribution of 31% by the support vessels. The number of FADs deployments amounted 6621 with a contribution of 20% by the support vessels.

3.4 dFAD indicators

Time series of active buoys

The number of active (i.e., transmitting position information) dFAD buoys per day in our trajectory database reaches a maximum of around 4,000 for the Indian Ocean in mid-2019 (Figure 11). The decline in the number of active buoys since mid-2019 is very likely due to a combination of missing Satlink trajectory data and the effects of COVID-19.

Maps of dFAD densities

Apart from the increase in the overall number of buoys, annual average dFAD tracking buoy density maps for the Indian Ocean (Figure 3.8) 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 varies somewhat from year to year. For example, in 2014, the second and third of the aforementioned zones are relatively absent from the density map. Maximum annual average density values for the Indian Ocean were of order 15 dFADs per grid cell (Figure 12), but daily density values (not shown) can be an order of magnitude larger than this in extreme cases.

3.5 Fisheries production and specific composition

In 2020, 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 58149t corresponding to a decrease of 17.7% compared to 2019 (Figure 6). Those landings are composed of 42.2%, 52.6% and 4.5% of yellowfin, skipjack, bigeye tunas respectively (Table 5).

The species composition of catches returned to the values of the time series before 2018 (Table 5). On free swimming school, the species composition was dominated in 2020 by yellowfin tuna, a usual pattern seen before 2018 (Table 7). The years 2018 and 2019 were different with a large proportion of skipjack tuna due to a fishing strategy targeting this species on free swimming schools.

Spatial extent used by vessels has fluctuated since a decade with a slight decreasing trend (Figure 8, Table 9). Figure 9, 10a, 10b and 10c respectively represent maps of the fishing effort and catches on all schools, floating object associated schools and free swimming school. The areas East of Chagos Islands as well as the Mozambique channel were not exploted anymore and catch were concentrated between Seychelles and the African coast.

4 Conclusion

The most noticeable change in the French purse seine fishery in 2020 was the decrease of 17.7% for the total of catches in comparison to 2019, respectively 58149t and 70622t.

Fisheries activities of the French fleet in Indian Ocean in 2020 confirm a return to strategies used before 2018 in terms of percentages of sets by fishing mode (Table 3) and proportion of catches by species (Table 5, 6, 7).

Remarkably, yellowfin tuna and skipjack tuna proportion of catches in 2020 for free swimming school returned to the proportion prevailing before 2018 after 2 years of a different fishing strategy targeting skipjack tuna on free swimming schools.

5 Acknowledgments

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6 References

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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

7 Figures

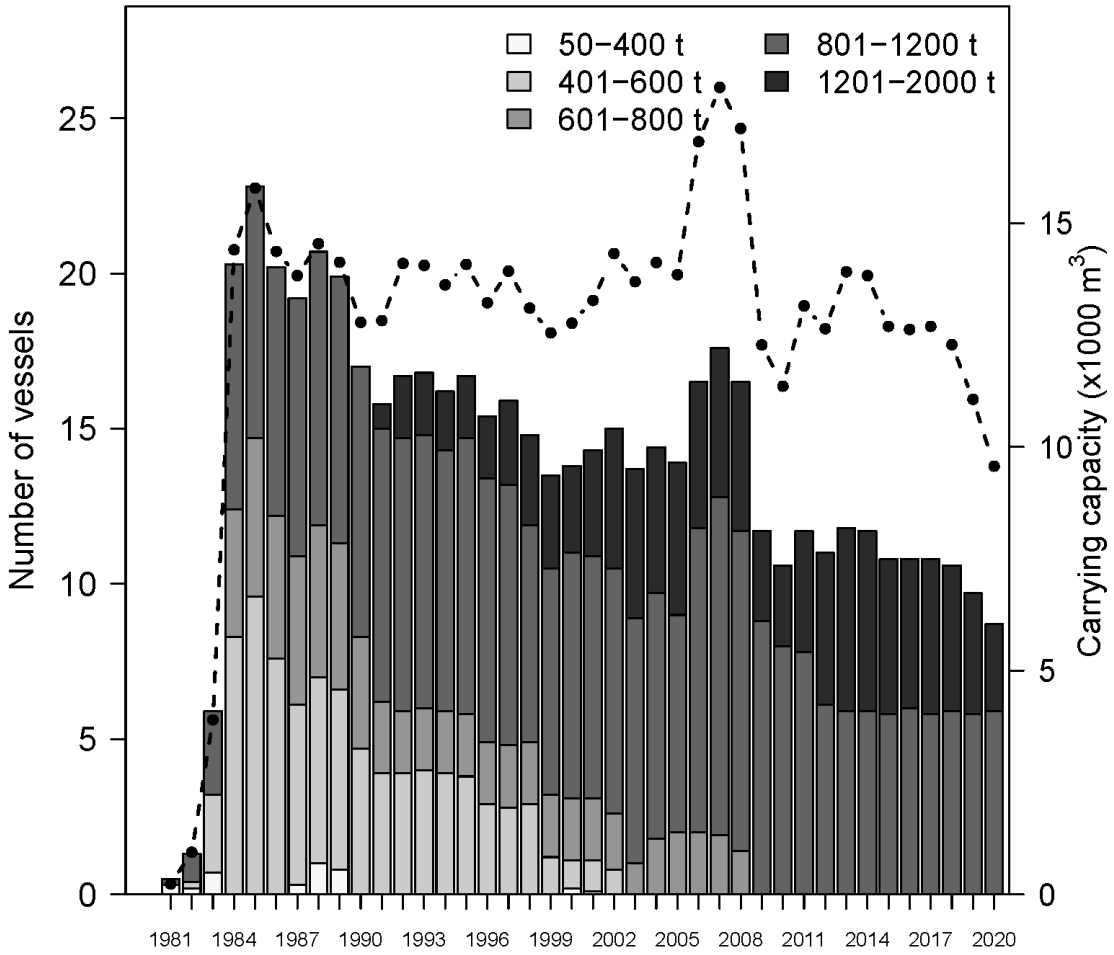

Figure 1 Fishing capacity of the French purse seine fishing fleet in the Indian Ocean. Annual changes in the number of purse seiners by tonnage category (barplots) and total carrying capacity (dashed line with circles) during 1981-2020.

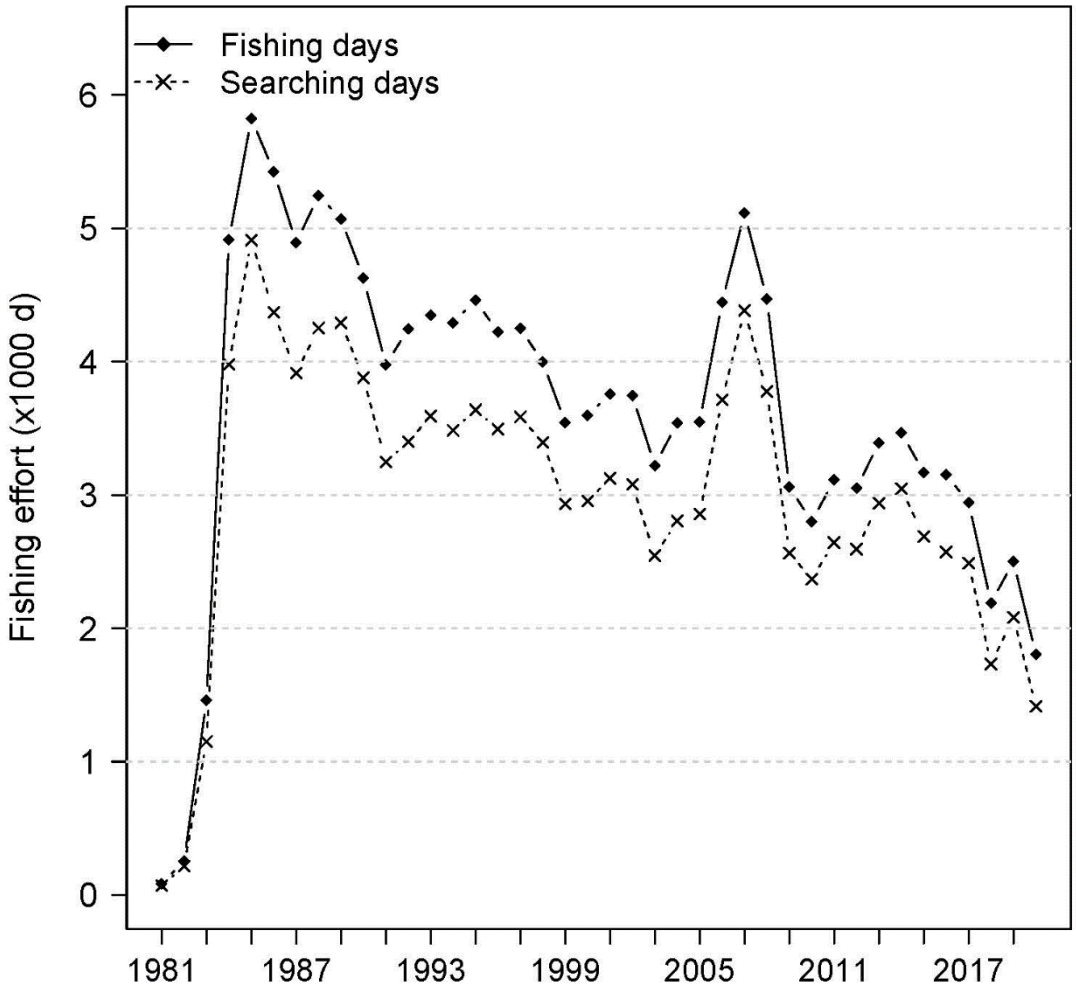

Figure 2 Changes in nominal effort over time. Annual total number of fishing and searching days for the French purse seine fishing fleet in the Indian Ocean during 1981-2020

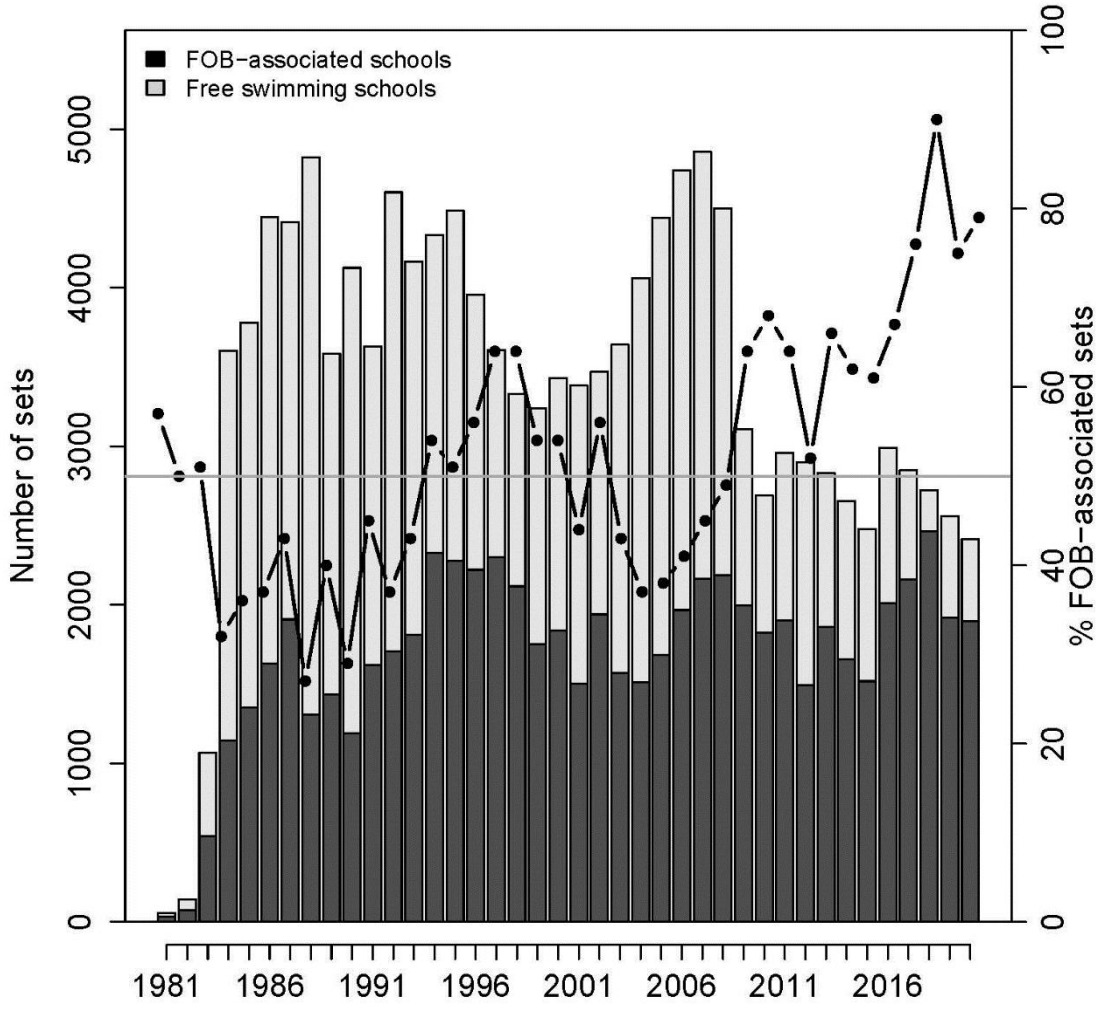

Figure 3 Fishing operations. Annual number of fishing sets in the French purse seine fishery on FOB-associated and free-swimming schools during 1981-2020. Line with solid circles indicates the percentage of sets on FOB-associated schools. Grey solid line indicates the 50% value.

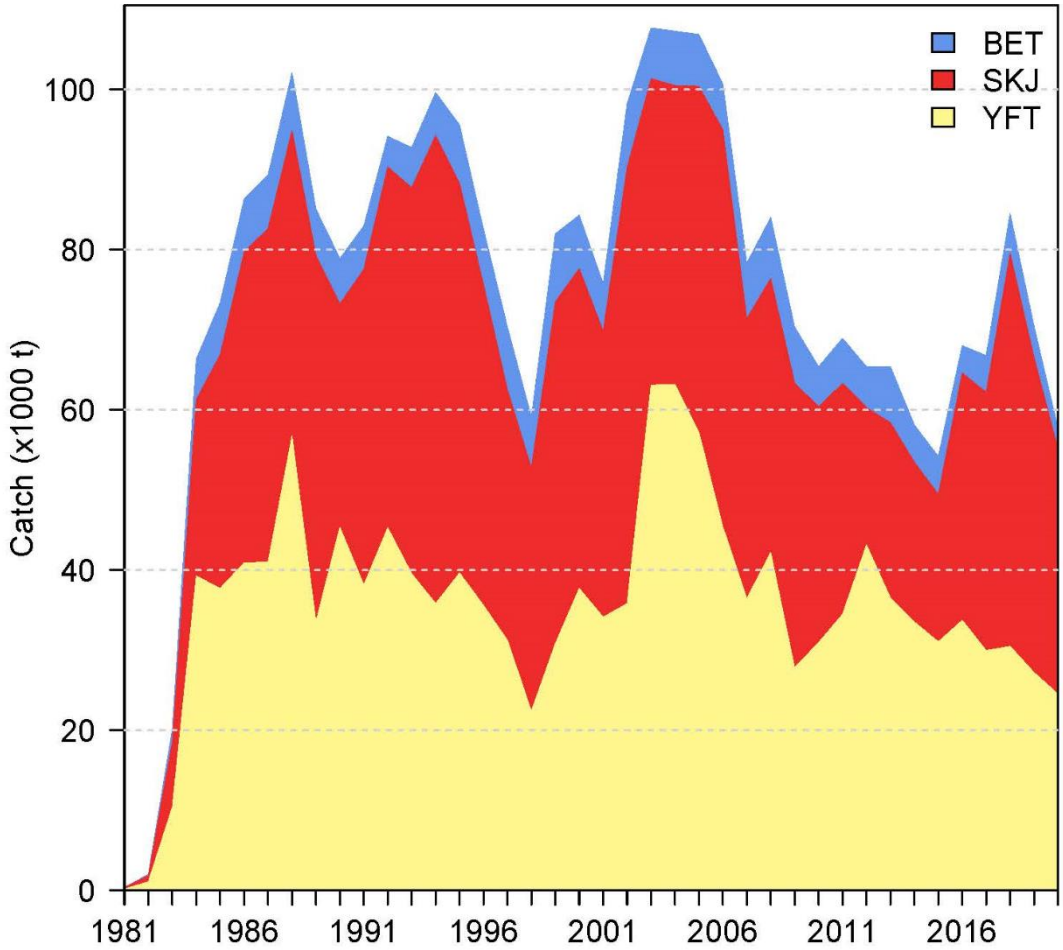

Figure 6 Total fishery production. Catch by species of the French purse seine fishing fleet during 1981-2020

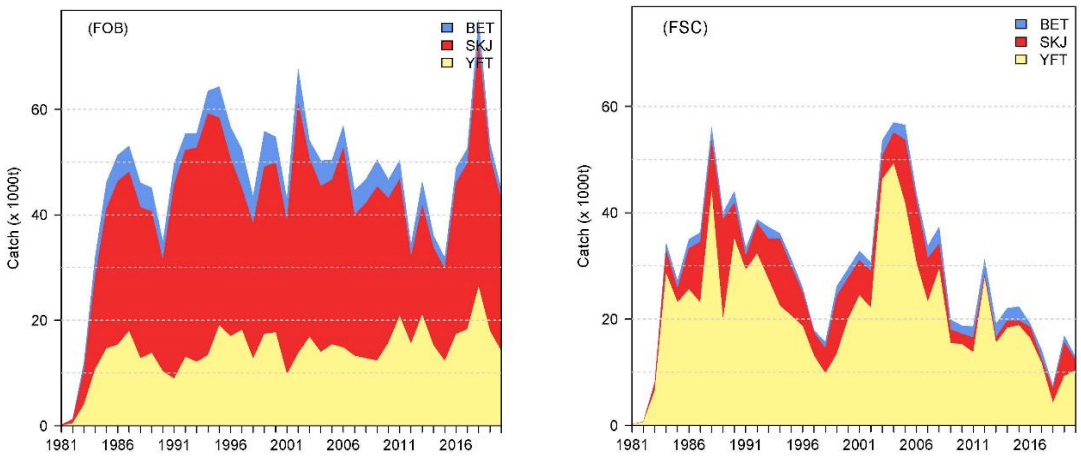

Figure 7 Fishery production by major fishing mode. Catch by species of the French purse seine fishing fleet on FOB-associated and free-swimming schools during 1981-2020

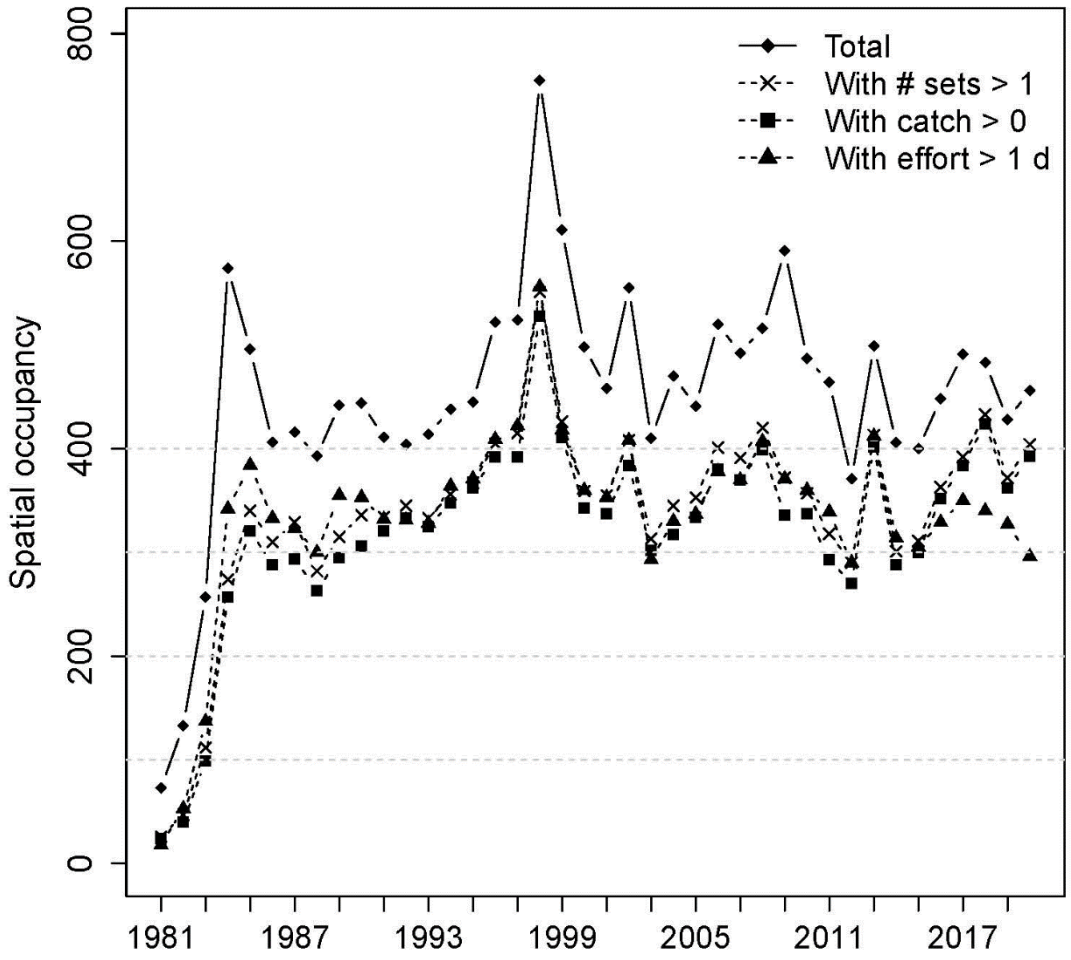

Figure 8 Changes in spatial extent of the purse seine fishery over time. Mean annual number of 1-degree squares explored by each vessel of the French purse seine fleet during 1981-2020.

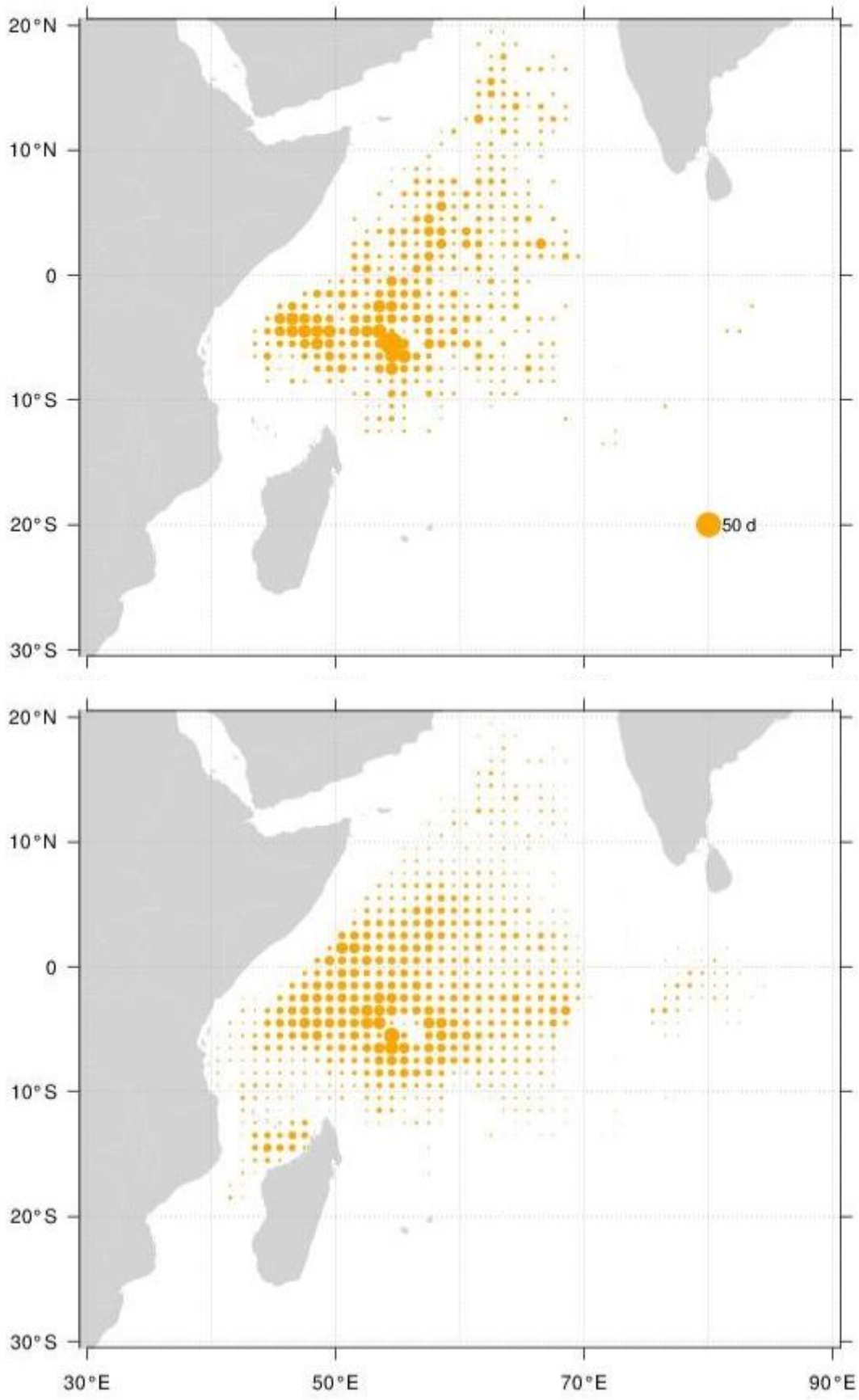

Figure 9 Fishing grounds. Spatial distribution of fishing effort (in searching days) of the French purse seine fishing fleet in 2020 (up panel) and with an average from 2015 to 2019 (down panel).

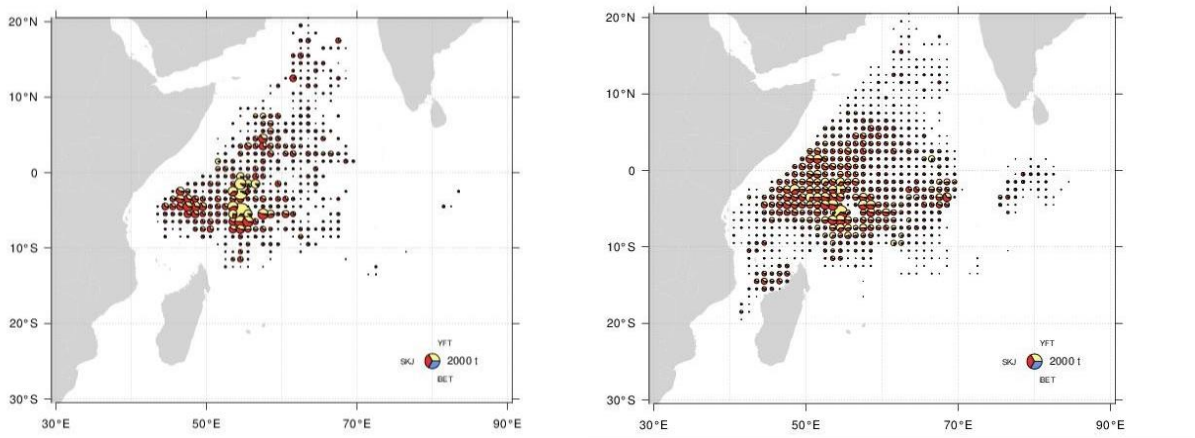

Figure 10a Spatial distribution of tuna catches of the French purse seine fishing fleet made on all schools type in 2020 left panel, 2015-2019 right panel

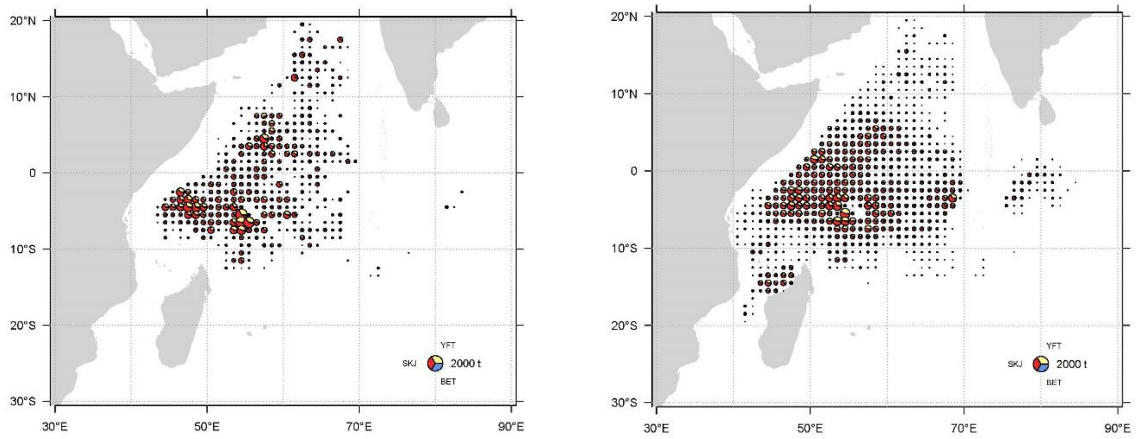

Figure 10b Spatial distribution of tuna catches of the French purse seine fishing fleet made on FOB-associated schools in 2020 left panel, 2014-2018 right panel

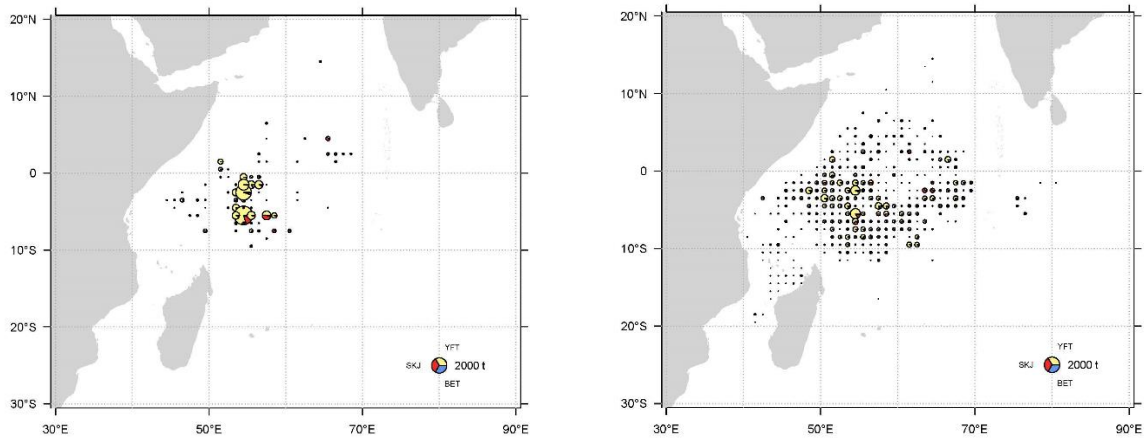

Figure 10c Spatial distribution of tuna catches of the French purse seine fishing fleet made on free swimming schools in 2020, left panel, 2015-2019 right panel

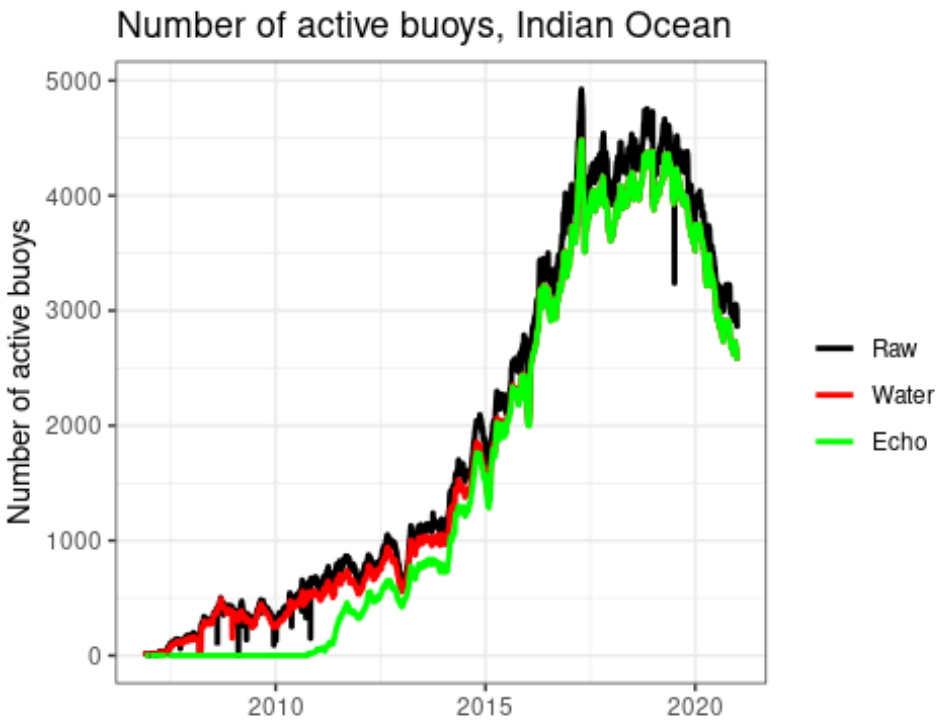

Figure 11 Time series of the number of active (i.e., transmitting position information) buoys per day in the French dFAD tracking buoy database for the Indian Ocean.

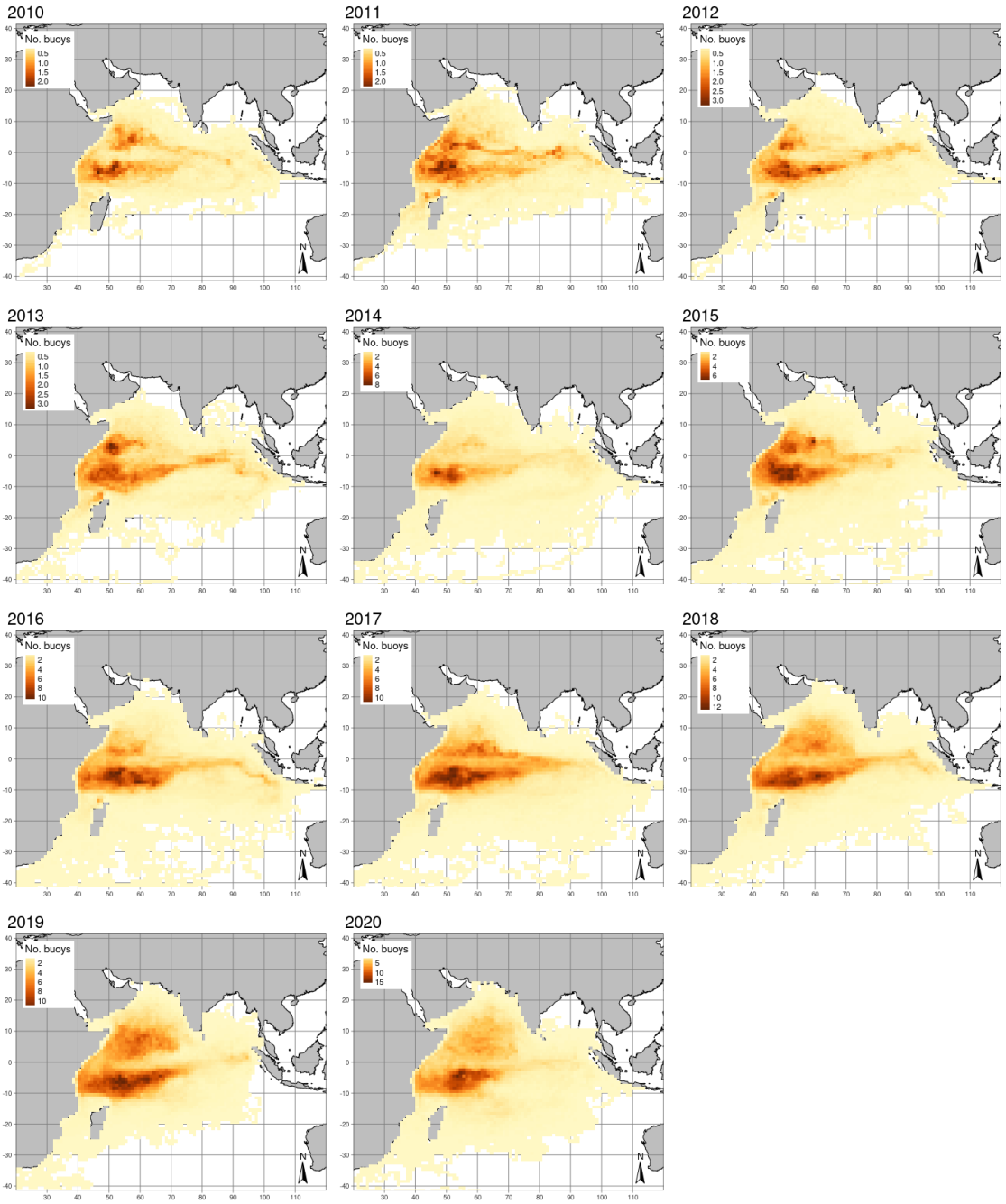

Figure 12 Estimated dFAD tracking buoy densities as a function of year for the Indian Ocean. Numbers indicate the average number of active (i.e., transmitting position information), in-water dFAD tracking buoys per 1° × 1° *cell per day.*

8 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 1981-2020. 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
1981	1	0	0	1	0	0	2	0.42	233
1982	1	1	0	2	0	0	4	1.25	944
1983	1	6	0	5	0	0	12	5.83	3902
1984	0	11	6	9	0	0	26	20.25	14412
1985	0	11	6	9	0	0	26	22.75	15791
1986	0	9	5	8	0	0	22	20.17	14372
1987	1	6	5	9	0	0	21	19.17	13830
1988	1	6	5	9	0	0	21	20.67	14545
1989	1	6	5	9	0	0	21	19.92	14131
1990	0	7	5	9	0	0	21	16.92	12788
1991	0	4	3	9	2	0	18	15.92	12828
1992	0	4	2	9	2	0	17	16.75	14101
1993	0	4	2	9	2	0	17	16.75	14061
1994	0	4	2	9	2	0	17	16.25	13624
1995	0	4	2	9	2	0	17	16.67	14080
1996	0	3	2	10	2	0	17	15.42	13223
1997	0	3	2	10	4	0	19	15.83	13932
1998	0	3	2	8	3	0	16	14.83	13105
1999	0	2	2	8	3	0	15	13.5	12554
2000	1	1	2	8	3	0	15	13.83	12767
2001	1	1	2	10	5	0	19	14.33	13276
2002	0	1	2	8	5	0	16	15	14323
2003	0	0	1	8	5	0	14	13.75	13697
2004	0	0	2	8	5	0	15	14.42	14123
2005	0	0	2	9	5	0	16	13.92	13851
2006	0	0	2	11	5	0	18	16.92	17268
2007	0	0	2	12	5	0	19	18.58	19098
2008	0	0	2	12	5	0	19	17.5	18176
2009	0	0	0	12	6	0	18	12.58	13253
2010	0	0	0	9	4	0	13	11.58	12416
2011	0	0	0	9	4	0	13	12.67	14123
2012	0	0	0	9	6	0	15	12	13697
2013	0	0	0	7	6	0	13	12.83	14973
2014	0	0	0	7	6	0	13	12.67	14795
2015	0	0	0	7	5	0	12	11.83	13751
2016	0	0	0	7	5	0	12	11.75	13596
2017	0	0	0	7	5	0	12	11.83	13754
2018	0	0	0	7	5	0	12	11.58	13346
2019	0	0	0	7	5	0	12	10.67	12118
2020	0	0	0	7	3	0	10	9.75	10626

Table 2 Annual nominal fishing effort of the French purse seine fishing fleet expressed in fishing and searching days during 1981-2020. 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	Number of trips	Average duration in days	Fishing days	Set duration in days	Searching days
1981	3	27	84	14	69
1982	11	21	255	39	217
1983	61	23	1460	309	1151
1984	186	26	4914	935	3979
1985	231	25	5823	912	4910
1986	212	25	5424	1056	4368
1987	212	23	4892	979	3914
1988	235	23	5245	993	4252
1989	211	24	5069	778	4291
1990	179	25	4627	748	3879
1991	164	26	3977	731	3246
1992	172	26	4245	846	3399
1993	174	26	4349	757	3591
1994	174	26	4291	807	3484
1995	177	26	4460	821	3639
1996	147	30	4222	730	3493
1997	148	30	4249	664	3585
1998	134	30	3997	604	3393
1999	139	27	3543	610	2934
2000	160	24	3596	642	2954
2001	142	29	3757	631	3126
2002	171	27	3745	667	3078
2003	194	19	3220	676	2544
2004	183	21	3541	735	2805
2005	178	21	3549	692	2857
2006	182	24	4445	730	3714
2007	158	33	5115	732	4384
2008	171	31	4471	694	3777
2009	132	26	3060	494	2565
2010	112	28	2801	431	2370
2011	126	26	3113	471	2643
2012	119	27	3052	459	2594
2013	122	29	3391	450	2939
2014	126	29	3467	421	3046
2015	117	28	3167	479	2688
2016	134	24	3152	582	2571
2017	138	23	2943	455	2488
2018	146	21	2190	457	1732
2019	131	21	2501	418	2082
2020	118	22	1805	390	1415

Table 3 Number of positive and null sets by fishing mode made by the French purse seine fishing fleet in the Indian ocean during 1981-2020. FOB = Floating Object; FSC = Free-Swimming School

Year	A-Total	A-Positive	A-Null	L-Total	L-Positive	L-Null	F-Total	F-Positive	F-Null	% Fob
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	2415	576	2009	1884	125	982	531	451	67
2017	2850	2421	429	2160	2017	143	690	404	286	76
2018	2723	2478	245	2463	2317	146	260	161	99	90
2019	2561	2186	375	1918	1802	116	643	384	259	75
2020	2414	2102	312	1898	1805	93	516	297	219	79

Table 4 Number of deployment of Fads and buoys 2015-2020

	Number of vessels		FADs		Buoys	
Year	PS	SV	PS	SV	PS	SV
2013	8		104	0	406	0
2014	13		905	0	2978	0
2015	12		1642	0	4201	0
2016	12	1	2181	272	5620	329
2017	12	1	2945	797	5743	996
2018	12	2	3293	1167	5738	1653
2019	12	3	2433	1111	4753	1681
2020	10	3	2862	1291	5281	1339

FADs : Fishing Aggregating Device

PS : Purse Seiner

SV : Supply Vessel

Table 5 Catch by species of the French purse seine fishing fleet of the Indian Ocean during 1981-2020

Year	%YFT	YFT	%SKJ	SKJ	%BET	BET	%ALB	ALB	%OTH	OTH	TOTAL
1981	44.1	188	37.2	158	5.4	23	0	0	13.2	56	425
1982	53.6	1081	39.2	792	7.2	145	0	0	0	0	2018
1983	51.4	10400	40.3	8153	7.6	1536	0	0	0.7	136	20225
1984	58.9	39268	33	21979	7.6	5081	0.3	224	0.2	102	66655
1985	51	37706	39.4	29183	8.8	6477	0.6	445	0.2	183	73994
1986	47.2	40911	44.7	38786	7.7	6636	0.2	200	0.2	177	86711
1987	45.8	41012	46.5	41620	7.5	6701	0.2	217	0	26	89576
1988	55.5	56766	37.2	38094	7.1	7251	0.2	177	0	19	102307
1989	39.4	33548	53.8	45750	6.8	5764	0	6	0	0	85068
1990	57.4	45351	35.3	27873	7.2	5663	0	36	0	31	78954
1991	45.5	38134	47	39388	6.5	5441	1	875	0	0	83837
1992	47.4	45282	47.1	45048	4	3822	1.5	1403	0	0	95555
1993	42.5	39539	51.8	48192	5.4	5015	0.3	310	0	0	93057
1994	35.9	35819	58.5	58430	5.4	5367	0.3	292	0	0	99908
1995	41.3	39636	50.7	48652	7.6	7280	0.4	350	0	0	95918
1996	42.9	35578	48.3	40056	8.3	6908	0.5	391	0	0	82933
1997	44.1	31227	44.1	31276	11	7824	0.8	539	0	0	70866
1998	37.6	22382	50.9	30340	10.7	6389	0.8	460	0	0	59571
1999	37.5	30799	51.9	42665	10.4	8518	0.2	154	0	0	82136
2000	44.5	37694	47.2	39935	7.9	6673	0.4	350	0	0	84652
2001	44.7	34127	46.7	35673	7.8	5956	0.9	659	0	15	76429
2002	36.4	35815	55.2	54405	8.1	7962	0.3	264	0	45	98492
2003	58.2	63101	35.3	38258	5.8	6334	0.6	608	0	31	108333
2004	58.8	63174	34.7	37323	6.3	6798	0.1	77	0	39	107411
2005	53.5	57198	40.4	43220	6	6453	0.1	86	0	0	106957
2006	44.7	45383	48.8	49573	5.6	5714	0.8	850	0	41	101560
2007	46.4	36455	44.4	34918	8.8	6928	0.4	335	0	0	78636
2008	49.6	42185	40.2	34186	9	7652	1.2	981	0	10	85013
2009	39.4	27807	50.3	35532	9.9	6991	0.4	295	0	0	70625
2010	47.3	30946	45	29432	7.6	5003	0.1	63	0	11	65455
2011	49.6	34468	41.5	28826	8.1	5635	0.8	575	0	0	69504
2012	65.2	43151	25.9	17120	7.7	5115	1.2	771	0	0	66156
2013	55.5	36511	33.3	21882	10.7	7015	0.5	331	0	0	65739
2014	57.4	33513	34.2	19944	8	4640	0.4	242	0	0	58339
2015	57.1	31046	33.8	18397	8.7	4730	0.4	216	0	0	54390
2016	49.4	33719	45.2	30876	5	3425	0.3	228	0	0	68247
2017	44.8	29961	48.2	32233	6.9	4590	0.2	149	0	2	66935
2018	36	30484	57.9	49032	5.9	4984	0.1	71	0.2	158	84729
2019	38.5	27208	55.7	39357	5.5	3890	0.1	56	0.2	111	70622
2020	42.2	24525	52.6	30569	4.5	2621	0.2	101	0.6	332	58149

Table 6 Catch by species made on FOB-associated schools for the French purse seine fishing fleet of the Indian Ocean during 1981-2020

Year	%YFT	YFT	%SKJ	SKJ	%BET	BET	%ALB	ALB	%OTH	OTH	TOTAL
1981	15.2	37	53.2	128	8.1	20	0	0	23.4	56	240
1982	34.5	442	55.3	709	10.2	131	0	0	0	0	1282
1983	32.7	3959	54.8	6637	11.4	1381	0	0	1.1	136	12114
1984	33.3	10692	54.8	17600	11.7	3762	0	0	0.2	77	32130
1985	31.5	14623	57.3	26582	10.8	4993	0	14	0.4	167	46378
1986	29.8	15353	60.2	31040	9.6	4953	0	0	0.3	177	51522
1987	33.8	17926	56.9	30205	9.3	4937	0	0	0	3	53072
1988	27.7	12763	62.1	28633	10.1	4675	0	0	0	19	46090
1989	30.5	13769	59.5	26850	10	4499	0	0	0	0	45118
1990	29.5	10312	60.3	21046	10.1	3513	0	0	0.1	31	34902
1991	17.9	8886	74.3	36896	7.8	3858	0	0	0	0	49639
1992	23.5	13014	70.9	39286	5.6	3112	0	9	0	0	55421
1993	21.8	12111	73.2	40582	5	2769	0	5	0	0	55467
1994	21	13340	72.2	45866	6.8	4313	0	23	0	0	63543
1995	29.5	19002	61.2	39380	9.2	5933	0	17	0	0	64332
1996	29.9	16944	59.5	33741	10.5	5975	0.1	70	0	0	56730
1997	34.6	18173	51.2	26882	14.1	7389	0.1	67	0	0	52511
1998	29.2	12680	58.9	25599	11.9	5173	0	13	0	0	43464
1999	31.1	17389	56.8	31759	12	6692	0.2	103	0	0	55943
2000	32.3	17699	58.6	32142	9	4960	0.1	43	0	0	54845
2001	22.5	9678	67.5	29045	9.8	4206	0.3	108	0	15	43052
2002	20.3	13704	70.2	47527	9.4	6385	0	0	0.1	45	67661
2003	31.1	16810	62.5	33837	6.3	3429	0	0	0.1	31	54106
2004	27.7	13959	62.5	31473	9.7	4882	0	0	0.1	39	50352
2005	30.6	15399	62.1	31270	7.3	3667	0	0	0	0	50336
2006	26	14818	66.6	37920	7.3	4172	0	0	0.1	41	56951
2007	29.7	13254	59.8	26695	10.5	4662	0	3	0	0	44613
2008	27.4	12784	63	29427	9.6	4486	0	2	0	10	46710
2009	24.4	12320	65.4	33004	10.2	5125	0	10	0	0	50459
2010	33.6	15704	58.8	27461	7.4	3474	0.1	32	0	11	46682
2011	41.2	20755	51.6	26017	7.1	3555	0.1	45	0	0	50372
2012	45.2	15484	48	16442	6.7	2287	0.1	30	0	0	34243
2013	45.3	21008	44.9	20814	9.7	4506	0.1	32	0	0	46360
2014	42.1	15180	51.4	18540	6.5	2334	0.1	36	0	0	36090
2015	38.3	12216	54.9	17500	6.6	2105	0.1	44	0	0	31865
2016	35.5	17360	58.7	28750	5.7	2775	0.1	61	0	0	48946
2017	34.7	18280	59.6	31400	5.5	2910	0.1	54	0	2	52645
2018	34	26298	59.9	46303	5.7	4433	0.1	66	0.2	158	77257
2019	33.4	17949	61.3	33007	5	2698	0.1	41	0.2	110	53805
2020	31.2	14135	63.6	28768	4.5	2017	0	14	0.7	331	45265

Table 7 Catch by species made on free-swimming schools for the French purse seine fishing fleet of the Indian Ocean during 1981-2020

Year	%YFT	YFT	%SKJ	SKJ	%BET	BET	%ALB	ALB	%OTH	OTH	TOTAL
1981	81.5	151	16.5	31	1.9	4	0	0	0	0	185
1982	86.7	638	11.3	83	2	14	0	0	0	0	736
1983	79.4	6441	18.7	1516	1.9	155	0	0	0	0	8111
1984	82.8	28576	12.7	4380	3.8	1319	0.7	224	0.1	25	34525
1985	83.6	23083	9.4	2601	5.4	1484	1.6	432	0.1	16	27615
1986	72.6	25558	22	7747	4.8	1683	0.6	200	0	0	35189
1987	63.2	23086	31.3	11415	4.8	1764	0.6	217	0.1	23	36505
1988	78.3	44003	16.8	9461	4.6	2575	0.3	177	0	0	56217
1989	49.5	19779	47.3	18900	3.2	1265	0	6	0	0	39951
1990	79.5	35039	15.5	6827	4.9	2150	0.1	36	0	0	44052
1991	85.5	29248	7.3	2492	4.6	1583	2.6	875	0	0	34198
1992	80.4	32268	14.4	5762	1.8	710	3.5	1394	0	0	40134
1993	73	27428	20.2	7611	6	2246	0.8	305	0	0	37590
1994	61.8	22479	34.5	12564	2.9	1054	0.7	269	0	0	36365
1995	65.3	20634	29.4	9272	4.3	1348	1.1	333	0	0	31587
1996	71.1	18633	24.1	6315	3.6	933	1.2	321	0	0	26203
1997	71.1	13054	23.9	4394	2.4	434	2.6	472	0	0	18355
1998	60.2	9702	29.4	4742	7.5	1215	2.8	448	0	0	16107
1999	51.2	13410	41.6	10907	7	1826	0.2	51	0	0	26193
2000	67.1	19995	26.1	7793	5.7	1713	1	307	0	0	29808
2001	73.3	24450	19.9	6627	5.2	1750	1.7	551	0	0	33377
2002	71.7	22111	22.3	6878	5.1	1578	0.9	264	0	0	30831
2003	85.4	46291	8.2	4422	5.4	2906	1.1	608	0	0	54226
2004	86.3	49215	10.3	5850	3.4	1916	0.1	77	0	0	57058
2005	73.8	41799	21.1	11950	4.9	2786	0.2	86	0	0	56620
2006	68.5	30564	26.1	11653	3.5	1542	1.9	850	0	0	44609
2007	68.2	23201	24.2	8224	6.7	2265	1	332	0	0	34023
2008	76.8	29401	12.4	4758	8.3	3166	2.6	979	0	0	38303
2009	76.8	15487	12.5	2527	9.3	1866	1.4	285	0	0	20166
2010	81.2	15242	10.5	1971	8.1	1529	0.2	31	0	0	18774
2011	71.7	13713	14.7	2809	10.9	2080	2.8	530	0	0	19132
2012	86.7	27668	2.1	678	8.9	2828	2.3	740	0	0	31913
2013	80	15503	5.5	1068	12.9	2509	1.5	299	0	0	19380
2014	82.4	18333	6.3	1404	10.4	2306	0.9	206	0	0	22249
2015	83.6	18830	4	897	11.7	2625	0.8	173	0	0	22525
2016	84.8	16359	11	2126	3.4	650	0.9	166	0	0	19301
2017	81.7	11681	5.8	833	11.8	1680	0.7	95	0	0	14289
2018	56	4186	36.5	2729	7.4	551	0.1	5	0	0	7471
2019	55.1	9259	37.8	6350	7.1	1192	0.1	15	0	1	16817
2020	80.6	10391	14	1801	4.7	604	0.7	88	0	1	12884

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 1981-2020

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	1.07	0.72	0.35
2017	1.06	0.8	0.26
2018	1.45	1.31	0.14
2019	0.96	0.72	0.24
2020	1.57	1.24	0.34

Table 9 Annual number of 1-degree squares explored by the French purse seine fishing fleet during 1981-2020. #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
2019	428	372	362	328	168
2020	456	404	393	296	103