

Statistics of the European purse seine fishing fleet and associated flags targeting tropical tunas in the Indian Ocean (1981-2011)

L. Floch^{a,*}, A. Delgado de Molina^{b,*}, C. Assan^{c,*}, P. Dewals^d, J.J. Areso^e, Chassot E.^a

^a*Institut de Recherche pour le Développement, UMR 212 EME (IRD/Ifremer/Université de Montpellier 2)
Avenue Jean Monnet, BP 171, 34 203 Sète Cedex, FRANCE*

^b*Instituto Español de Oceanografía, PO Box 1373, S/C Tenerife, SPAIN*

^c*Seychelles Fishing Authority, BP 570, Victoria, SEYCHELLES*

^d*Institut de Recherche pour le Développement, SFA, BP 570, Victoria, SEYCHELLES*

^e*Spanish Fisheries Office, P.O.B 497, Victoria, SEYCHELLES*

Abstract

In 2011, the European and associated flags purse seine fishing fleet of the Indian Ocean was composed of 34 vessels of individual carrying capacity > 800 t, which all represented a total carrying capacity of about 45,000 t. The total cumulated nominal effort was of more than 9,500 and 7,700 fishing and searching days, respectively. The total number of fishing sets was less than 10,000 with more than 70% realised on FAD-associated schools. Total fishery catches were of about 260,000 t and composed of 42%, 49%, and 8% of yellowfin, skipjack, and bigeye, respectively. Albacore and neritic tunas represented less than 0.5% of the purse seine catch. Sets on FAD-associated schools have a high level of success (i.e. 94% vs. 55% for free-swimming schools (FSC) in 2011), and resulted in 80% of the total catch. Catch rates expressed in tonnes per searching day were high in 2010-2011 for FAD-associated schools (i.e. > 15 t d⁻¹ for skipjack and close to 10 t d⁻¹) while rates for FSC appeared rather low (i.e. 4.5 t d⁻¹ for yellowfin) and stable during 2009-2011. The size-structure of the catch in 2011 was similar to 2006-2010 except for skipjack caught on free-swimming schools characterized by a median fork length of 47 cm (i.e. 2.1 kg) as compared to 50 cm (i.e. 2.6 kg) during 2006-2010. In 2009-2011, the mean weight in the catch for the 3 species has substantially decreased as compared to the mid-2000s.

Keywords: fish aggregating device, free-swimming school, *Katsuwonus pelamis*, purse seine fishing, *Thunnus albacares*, *Thunnus obesus*

*Corresponding authors

Email addresses: Laurent.Floch@ird.fr (L. Floch), alicia.delgado@oceanografia.es (A. Delgado de Molina), cassan@sfa.sc (C. Assan)

Contents

1	Introduction	2
2	Fishing capacity and effort	3
2.1	Fishing fleet	3
2.2	Carrying capacity	3
2.3	Fishing and searching days	4
2.4	Fishing grounds	5
2.5	Fishing activities	5
3	Fisheries production	9
3.1	Catch levels	9
3.2	Spatial distribution of the catch	10
3.3	Catch rates	11
3.4	Size structure of the catch	12
3.5	Mean weight in the catch	13
4	References	18
5	Appendix tables	21

1. Introduction

Statistical data for the European purse seine fishing fleet have been collected by the “Institut de Recherche pour le Développement” (IRD; ex-ORSTOM), the Instituto Español de Oceanografía (IEO) and the Seychelles Fishing Authority (SFA) since the arrival of the first purse seiners in the Indian Ocean in the early 1980s. European 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 weight in the catch for the 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 European purse seine fishing fleet rapidly increased from 2 in 1981 to 48-50 in 1984-1985 with the arrival of vessels from the Atlantic Ocean (Fig. 1 and Tables 1,2). After a decrease to 37 in 1986, the number of vessels progressively increased throughout the 1990s to reach a maximum of 57 in 1997. Since then, the number of vessels steadily decreased to a minimum of 34 in 2011. Meanwhile, the size of the vessels progressively increased in the European purse seine fishery over the last 30 years. The number of small-size vessels (capacity < 600 t) decreased throughout the 1980s and 1990s while medium-size vessels (capacity between 601-800 t) disappeared from the fishery in the late 2000s (Fig. 1).

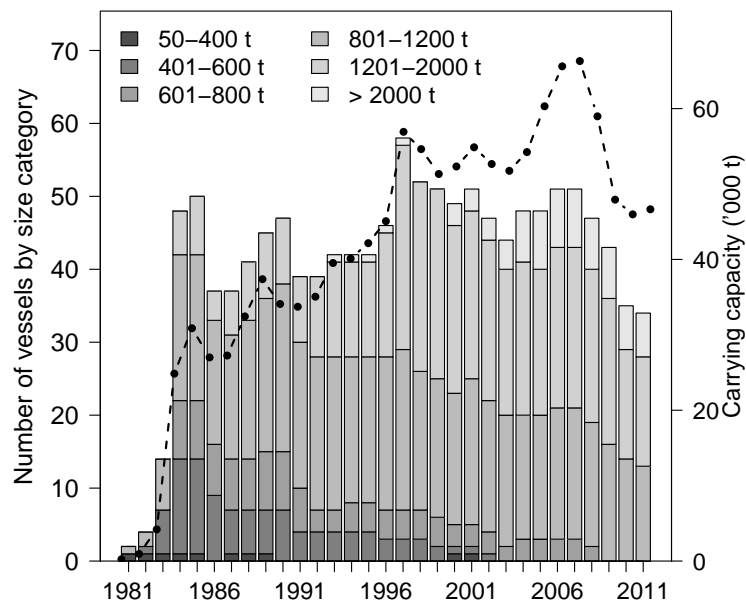


Figure 1: Fishing capacity of the European purse seine fleet in the Indian Ocean. Annual changes in the number of purse seiners by size category (barplots) and total carrying capacity (solid line with circles) during 1981-2011. Capacity was weighted by the vessel-specific proportion of the year at sea (in months). The vessel size category (t) was computed as 0.7 times the capacity expressed in m^3

2.2. Carrying capacity

The total carrying capacity expressed in tonnage strongly increased from 233 t in 1981 to about 30,000 t in the mid-1980s. The overall capacity of the fleet increased steadily throughout the 1990s and 2000s to a maximum of 65,000 t in 2006-2007 (Fig. 1). In the

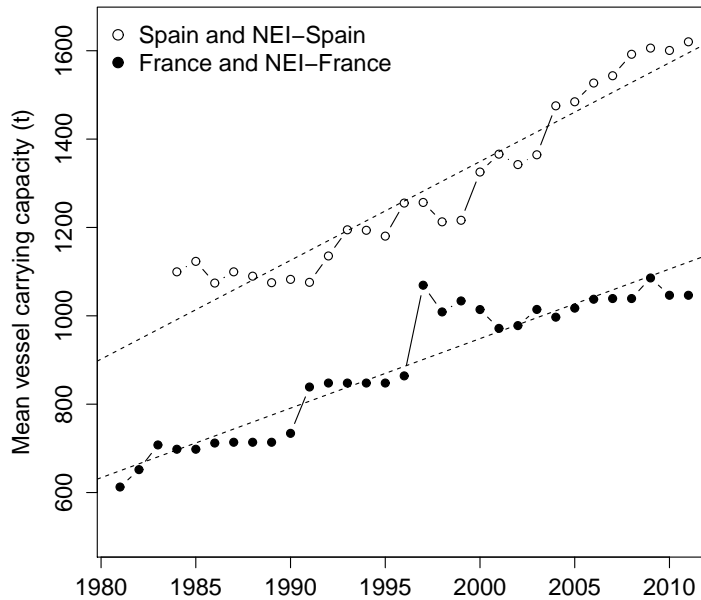


Figure 2: Changes in mean vessel carrying capacity for the French and Spanish components of the European purse seine fishing fleet in the Indian Ocean, 1981-2011. The vessel-specific carrying capacity was weighted by the relative annual catch of each purse seiner. Dotted lines indicate mean linear regressions

recent years, the total capacity of the European fleet decreased to about 46,000 t during 2010-2011. The overall mean vessel carrying capacity of the European purse seiners increased from about 600 t in the early 1980s to more than 1,300 t from the mid-2000s (slope = $+25 \text{ t}^{-1}$, p -value < 0.001), with Spanish (and associated flags) larger than French (and associated flags) vessels (Fig. 2).

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 effort is currently not distinguished between fishing on FAD-associated schools and free-swimming schools. The total number of fishing and searching days showed similar patterns over 1981-2011 with a major increase in the mid-1980s, a progressive increase until 1997, and a decrease thereafter until 2009-2011 characterized by high interannual variability (Fig. 3). In 2011, the total nominal fishing effort of the European purse seine fleet was of about 9,500 and 7,700 fishing days and searching days, respectively.

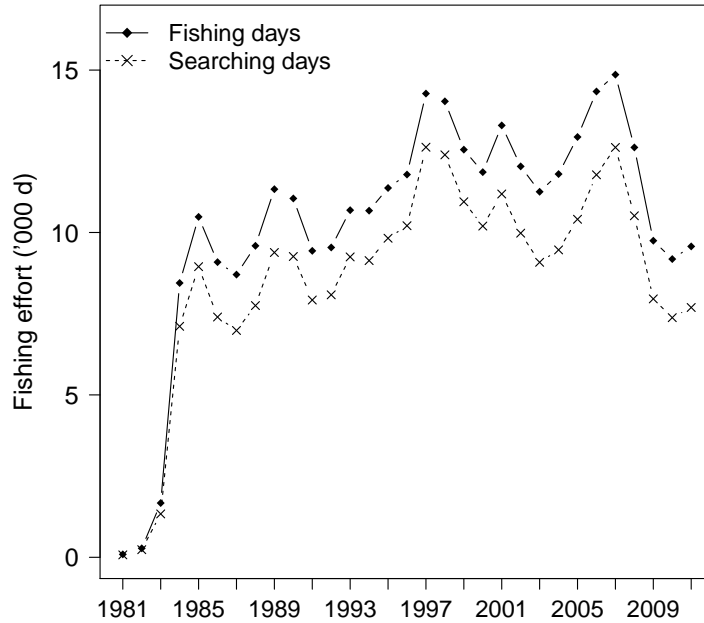


Figure 3: Changes in nominal effort over time. Annual total number of fishing and searching days for the European purse seine fishing fleet in the Indian Ocean during 1981-2011

2.4. Fishing grounds

The overall geographic extent of the fishing grounds of the European purse seine fleet steadily increased from about 450 squares in the mid-1980s to about 730 squares in the late 2000s (slope = $+15 \text{ y}^{-1}$, p -value < 0.001). The major increase in the fishing grounds observed in 1997-1999 is related to a climatic event that has been described elsewhere (Murtuggude 1999, Murtugudde et al. 2000) and led the purse seiners to explore the eastern part of the Indian ocean for fishing (Ménard et al. 2006). Selection criteria based on minimum effort (i.e. effort > 1 fishing day) or catch (i.e. positive set or catch) did not modify the temporal changes in spatial extent.

In 2011, the main fishing grounds of the European purse seine fleet were located in the equatorial area of the Western Indian Ocean, i.e. within the area of latitude 10°N - 10°S and longitude 45° - 65°E , as well as in the north of the Mozambique Channel (Fig. 5). Some fishing operations occurred southeast of the Seychelles islands and east of the Chagos archipelago.

2.5. Fishing activities

Similarly to the temporal trends in the number of purse seiners and nominal fishing effort, the total number of fishing sets steadily increased from more than 7,000 in 1986 to a

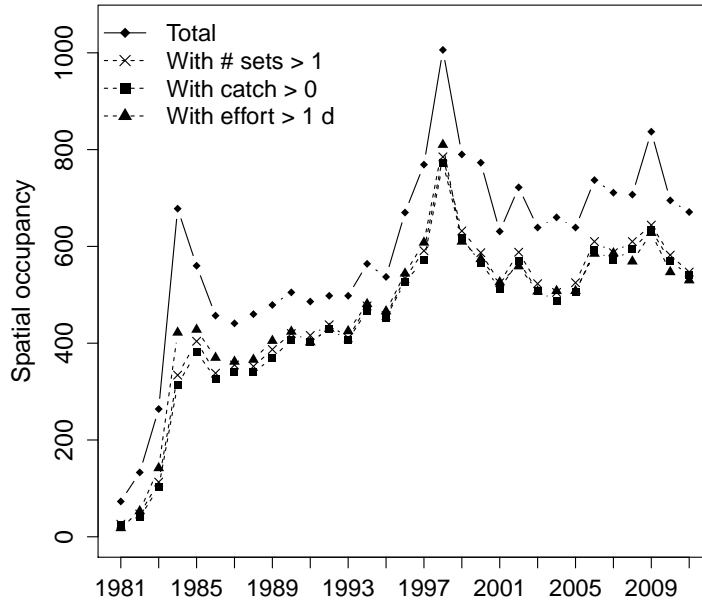


Figure 4: Changes in spatial extent of the fishery over time. Annual number of 1-degree squares explored by the European purse seine fishing fleet during 1981-2011

maximum of about 13,000 in 2005-2006 (Fig. 6 and Table 5). With the decrease in the number of vessels, the number of sets decreased since then to an average value of 9,300 (SD = 270) during 2009-2011. The number of FAD sets showed a continuous increase over the whole period 1981-2011, even during the last decade in which the number of purse seiners decreased. By contrast, fishing operations on tuna free-swimming schools showed a high interannual variability with major activities in 1989 and during 2004-2007. The number of FSC sets strongly decreased in the recent years to an average value of 2,400 (sd = 290) in 2009-2011. The percentage of FAD-fishing sets over FSC sets increased from the mid-1980s to a maximum of 66% in 1997 during the El-Niño event before decreasing to about 45% during 2003-2005. Since then, it increased and showed a major shift upward between 2008 and 2009-2011 that might be partly related to the threat of Somali piracy (Chassot et al. 2010). This has resulted in FAD-fishing representing 75% of all sets of the European purse seine fleet in the recent years.

The success of FAD-fishing sets has been high during 1981-2011 (Fig. 7). The percentage of successful sets showed an apparent increase from an average value of 87% (SD = 4%) during the 1980s to 93% (SD = 1%) throughout the 1990s-2000s. After a period of decrease during 1981-1986, the percentage of successful FSC sets showed an increase from about 40% in 1986 to an average value of about 55% (SD = 4.5%) throughout the 1990s and 2000s.

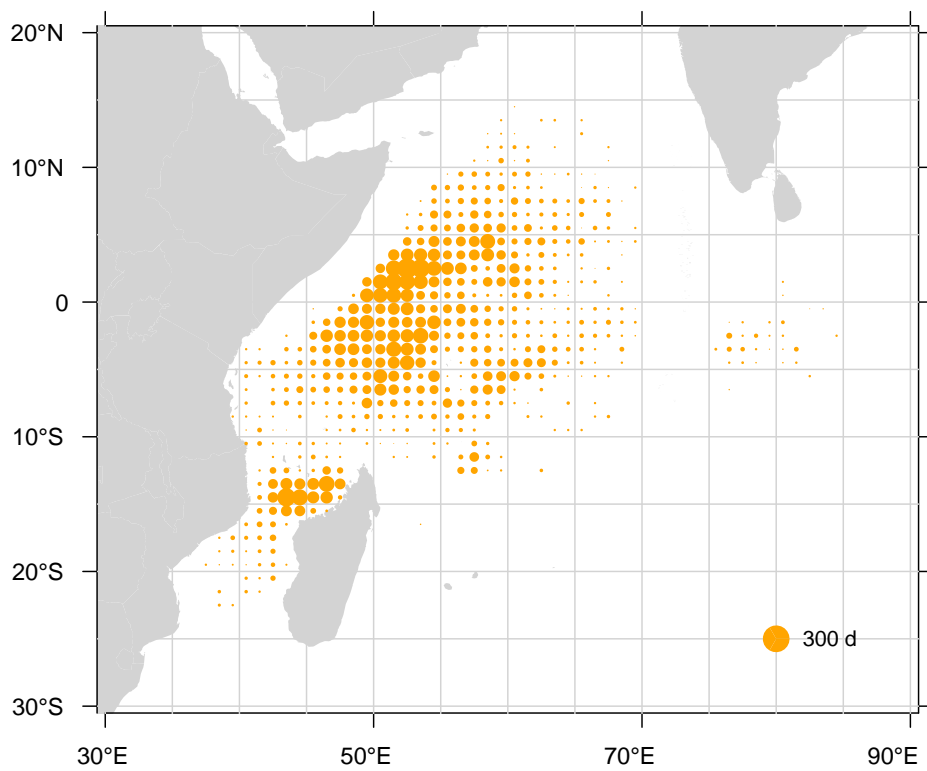


Figure 5: Fishing grounds. Spatial distribution of fishing effort (in searching days) of the European purse seine fishing fleet in 2011. Fishing/searching time is allocated to the positions of fishing activities and does not distinguish between fishing modes

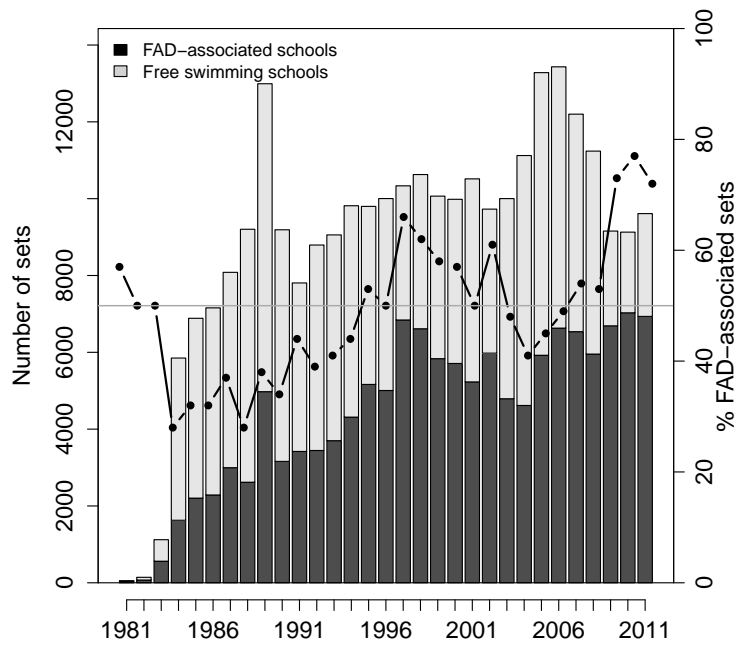


Figure 6: Fishing activities. Annual number of fishing sets in the European purse seine fishery on FAD-associated and free-swimming schools during 1981-2011. Line with solid circles indicates the percentage of sets made on FAD-associated schools over free-swimming schools. Grey solid line indicates the 50% value

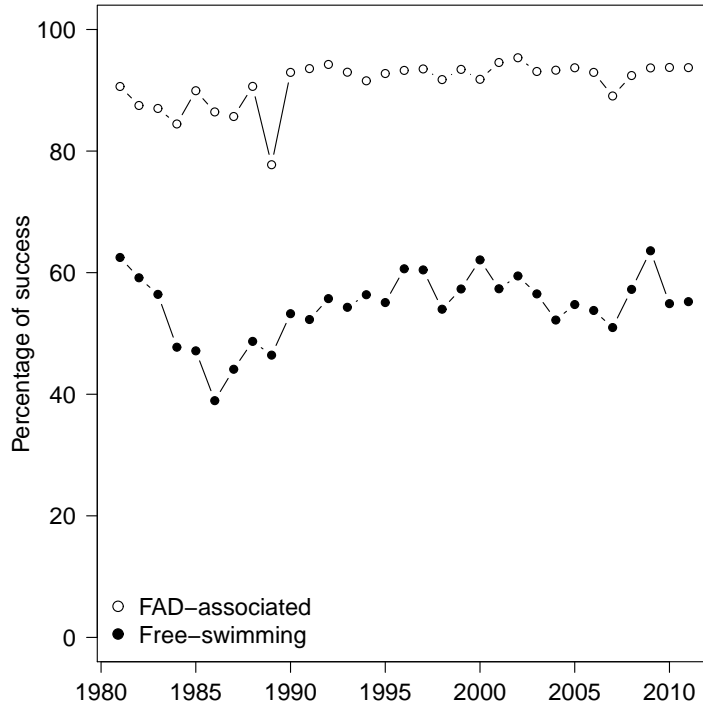


Figure 7: Success of fishing sets. Annual percentage successful sets on FAD-associated schools and free-swimming schools in the European purse seine fishery during 1981-2011

3. Fisheries production

3.1. Catch levels

The total catch of the European purse seine fleet steadily increased from the early 1980s to exceed 400,000 t in 2003, with an average catch of about 390,000 t (SD = 17,000 t) during 2003-2006 (Fig. 8 and Table 6). These high levels were mainly explained by the high levels of catches of yellowfin on free-swimming schools that stemmed from high tuna concentrations and large schools during this period (Fig. 9) (Tohir 2009). Despite similar levels of nominal effort in 2007, the total catch strongly decreased due to smaller catch rates (see section 3.3) that might be in part related to the deepening of the mixed layer depth and an associated decrease in catchability (Marsac 2011). As a result of the decrease in effort, the total catch has decreased in the recent years at an average value of about 265,000 t (SD = 7,650 t) during 2008-2011. Recent catch level are similar to the average catch observed during 1994-1997 for a nominal effort (in searching days) that has decreased by 20% between the 2 periods.

Fisheries catches on FAD-associated schools showed a continuous increase from the early 1980s to the 2000s during which they reached an annual average of about 215,000 t characterized by high interannual variability (Fig. 9a). Skipjack was preponderant in the FAD-catch over the period 1981-2011 with an average percentage of 63% (SD = 6.5%) while yellowfin

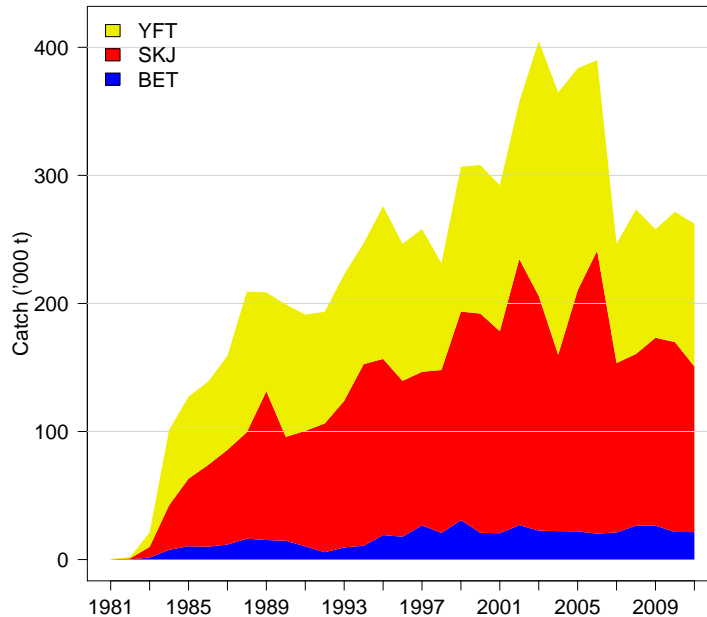


Figure 8: Total fishery production. Catch by species of the European purse seine fishing fleet during 1981-2011

contributed to an average of 28% (SD = 5%) of the catch on FAD-associated schools. Estimates of bigeye in the FAD-catch, derived from multispecies samples at unloading (Pallarés and Hallier 1997), varied between 3.9% in 1993 and 12.8% in 1997 with a mean value of 8.7%.

Catches on free-swimming schools showed a high interannual variability over 1981-2011 without any trend (Fig. 9b). The period 1997-1999 was characterized by low catches of yellowfin while catch levels for this species appeared very high during 2003-2005. Since then, the FSC catch has decreased to an average value of 50,000 t during 2009-2011, i.e. the lowest catches on free-swimming schools since 1984. Yellowfin have always been preponderant in FSC catches with a yearly average of 70% (SD = 9.5%).

3.2. Spatial distribution of the catch

In 2011, the catch of the European purse seine fleet was distributed in its traditional fishing grounds of the Western Indian Ocean (Fig. 10). With the exception of the east of the Seychelles, the distribution of the total catch was very similar to the distribution of FAD-fishing, i.e. along the Somali EEZ boundary from 5°S up to 10°N and in the north of the Mozambique Channel. The bulk of the catch appeared concentrated northwest of the Seychelles while little catch was made between 50-55°E and south of 5°S as compared to the period 2006-2010 (Fig. 19). Yellowfin was important in the catch on FAD-associated schools and characterized by an average percentage per 1x1° square of 35% as compared to 24% during 2006-2010 (Figs. 11-19). Catches on free-swimming schools were scattered all around the Seychelles and predominated by yellowfin while skipjack was preponderant in

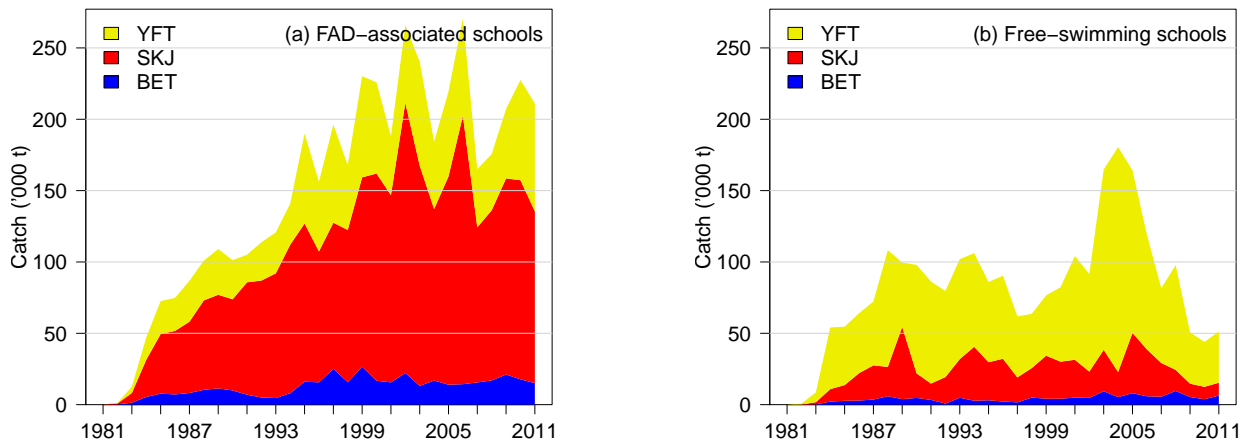


Figure 9: Fishery production by major fishing mode. Catch by species of the European purse seine fishing fleet on (a) FAD-associated and (b) free-swimming schools during 1981-2011

the FSC catches in the Mozambique Channel (Fig. 12).

3.3. Catch rates

Raw catch rates expressed in tonnes per searching day (t d^{-1}) for the 3 principal market tunas showed an increasing trend over 1981-2011 (slope = $+0.75 \text{ t d}^{-1} \text{ y}^{-1}$, p -value < 0.001) with low values in 1997-1998 and 2007 (Fig. 13). Catch rates for skipjack and yellowfin were in the same order of magnitude and exhibited similar trends over time (adjusted Pearson $r = 0.69$, p -value < 0.001). Raw catch rates for bigeye also showed an increasing trend during 1981-2011 (slope = $+0.06 \text{ t d}^{-1} \text{ y}^{-1}$, p -value < 0.001). In 2011, catch rates for yellowfin, skipjack, and bigeye were 14.5 , 16.8 , and 2.8 t d^{-1} , respectively.

Catch rates on FAD-associated schools for the 3 species combined steadily and significantly increased during 1981-2011 (slope = $+0.65 \text{ t d}^{-1} \text{ y}^{-1}$, p -value < 0.001) and reached a maximum of more than 30 t d^{-1} in 2010 (Fig. 14a). Skipjack, yellowfin, and bigeye catch rates showed increasing trends during 1981-2011 with some high interannual variability. Catch rates appeared exceptionally small in 2007 for both skipjack (8.6 t d^{-1}) and yellowfin (3.2 t d^{-1}). Catch rates for skipjack were always higher than for yellowfin with an average difference of about 8.7 t d^{-1} ($\text{SD} = 2.3 \text{ t d}^{-1}$) during 2001-2011. Catch rates for yellowfin on FAD-associated schools were maximum in 2010-2011 with a value of about 9.7 t d^{-1} .

Yellowfin catch rates predominated for sets made on free-swimming schools and did exhibit high interannual variability without any trend (Fig. 14b). Catch rates were low during

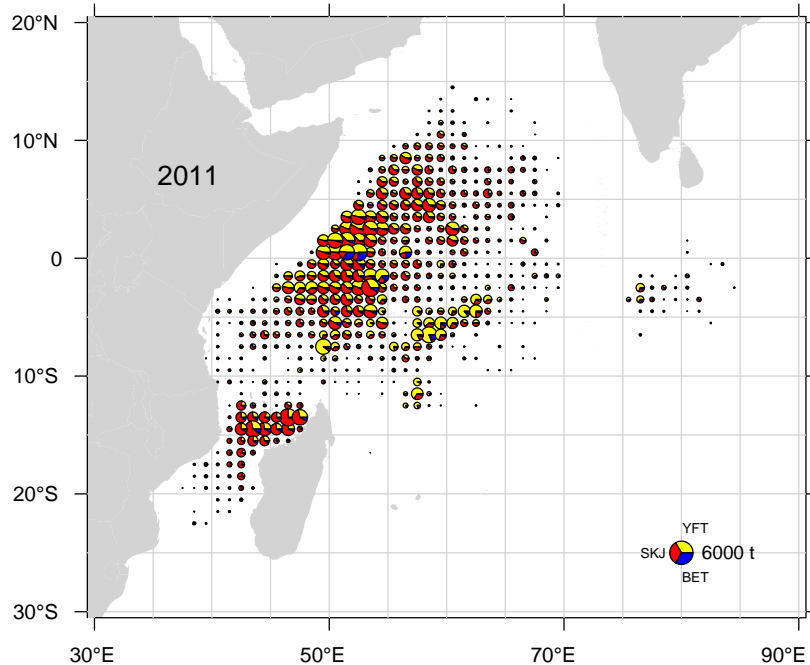


Figure 10: Spatial distribution of tuna catches of the European purse seine fishing fleet in 2011

1997-1999 ($< 3.5 \text{ t d}^{-1}$) and exceptionally high during 2003-2005 ($> 13.5 \text{ t d}^{-1}$). In 2011, the catch rate of yellowfin in free-swimming schools was about 4.5 t d^{-1} . Catch rates for skipjack showed a high interannual variability during 1986-2011 (mean = 2.4 t d^{-1} , SD = 1 t d^{-1}) and a decreasing trend in the recent years, with catch rates around 1.2 t d^{-1} during 2009-2011. Annual catch rates for bigeye in free-swimming schools were described by a high variability and showed a shift from a mean value around 0.4 t d^{-1} during the mid-1980s to the mid-1990s to a mean annual value of 0.6 t d^{-1} throughout the 2000s.

3.4. Size structure of the catch

The size structure of the catch (expressed in number) in 2011 appeared similar for the 3 tuna species to the average year representing the period 2006-2010, with the exception of skipjack caught on free-swimming schools that were smaller (Fig. 15). The size-frequency distributions of yellowfin and bigeye caught on log-associated schools were described by 2 modes for small (46 cm) and intermediate sizes (56 cm). Larger yellowfin ($> 80 \text{ cm}$) were caught on FAD-associated schools but more seldomly while bigeye were almost only juvenile fishes. Skipjack showed a unique mode described by a median size of 46 cm with minimum

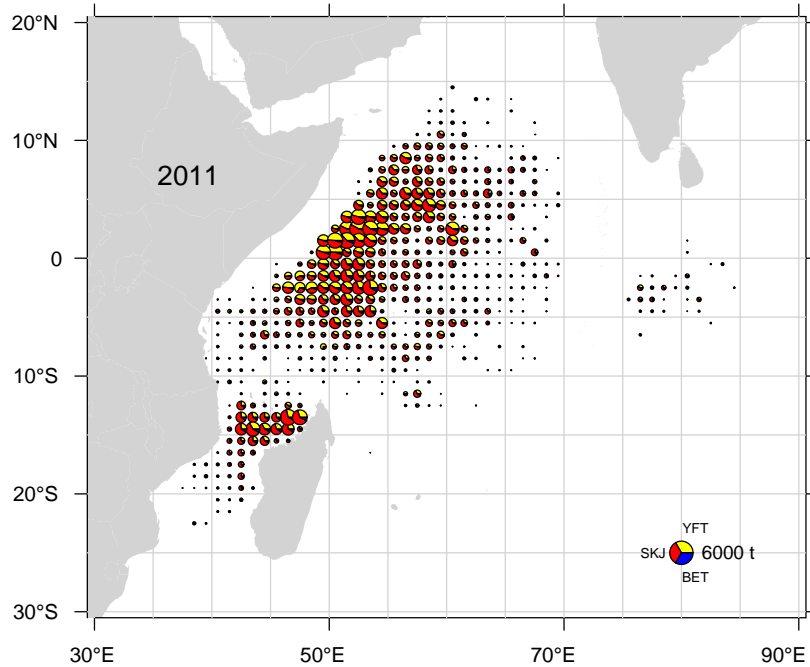


Figure 11: Spatial distribution of tuna catches of the European purse seine fishing fleet made on FAD-associated schools in 2011

and maximum observed sizes of 28 and 82 cm, respectively.

Similarly, the biomass of fish caught by size class showed overall similar patterns between 2011 and 2006-2010 except for skipjack caught smaller on free-swimming schools in 2011 (Fig. 16). In relation with the decrease in activities on free-swimming schools, the biomass of large yellowfin and bigeye (> 100 cm) caught was lower in 2011 than for the average year 2006-2010.

3.5. Mean weight in the catch

Time series of the mean weight in the catch for the principal market tropical tunas were computed as the species-specific annual biomass over the total number of fishes caught. The mean weight highly differed between fishing modes and showed strong interannual variations during 1982-2011 (Fig. 17). The mean weight of yellowfin caught on free-swimming schools showed high variability with very low values in 1989 and 1998-1999. It was high during 2002-2008, i.e. > 35 kg. Since then, the mean weight decreased to about 24 kg during 2009-2011 (Fig. 17a). The mean weight of yellowfin in the catch made on FAD-associated

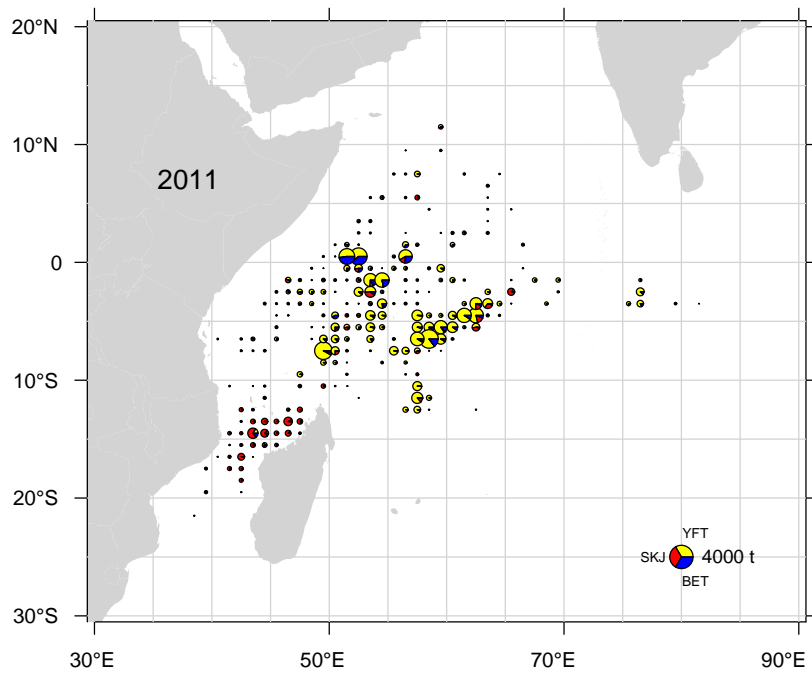


Figure 12: Spatial distribution of tuna catches of the European purse seine fishing fleet made on free-swimming schools in 2011

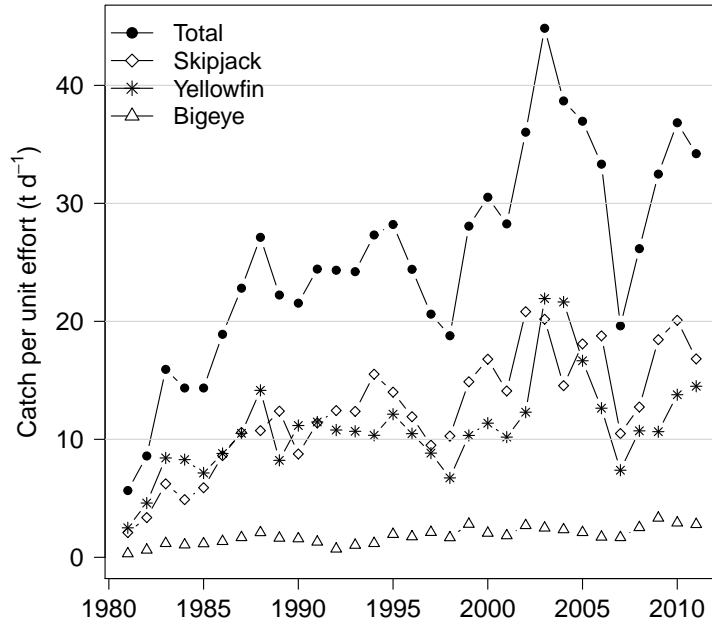


Figure 13: Annual catch rates (in t per searching day) of the European purse seine fishing fleet in the Indian Ocean during 1981-2011

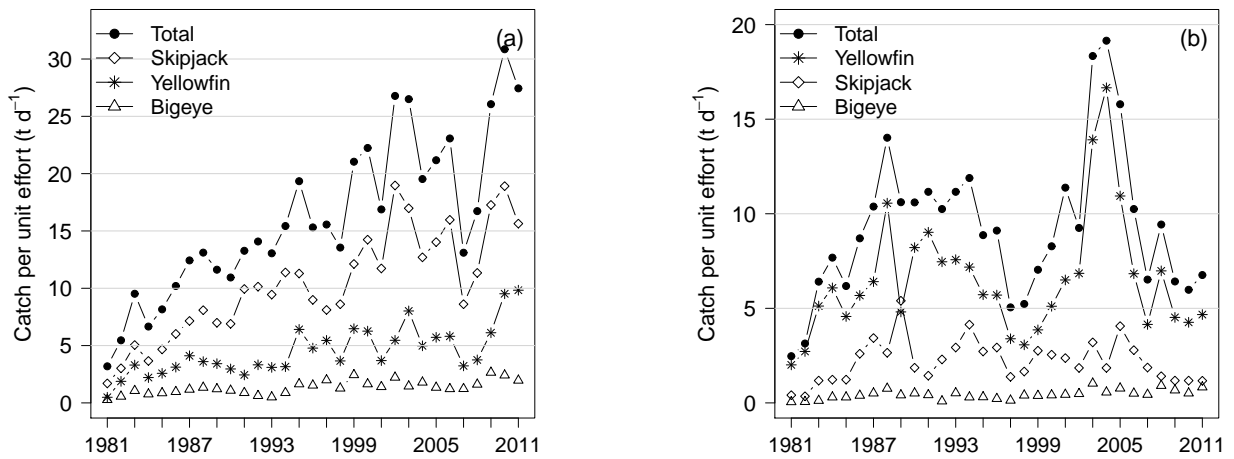


Figure 14: Annual catch rates (in t per searching day) of the European purse seine fishing fleet on (a) FAD-associated and (b) free-swimming schools in the Indian Ocean during 1981-2011

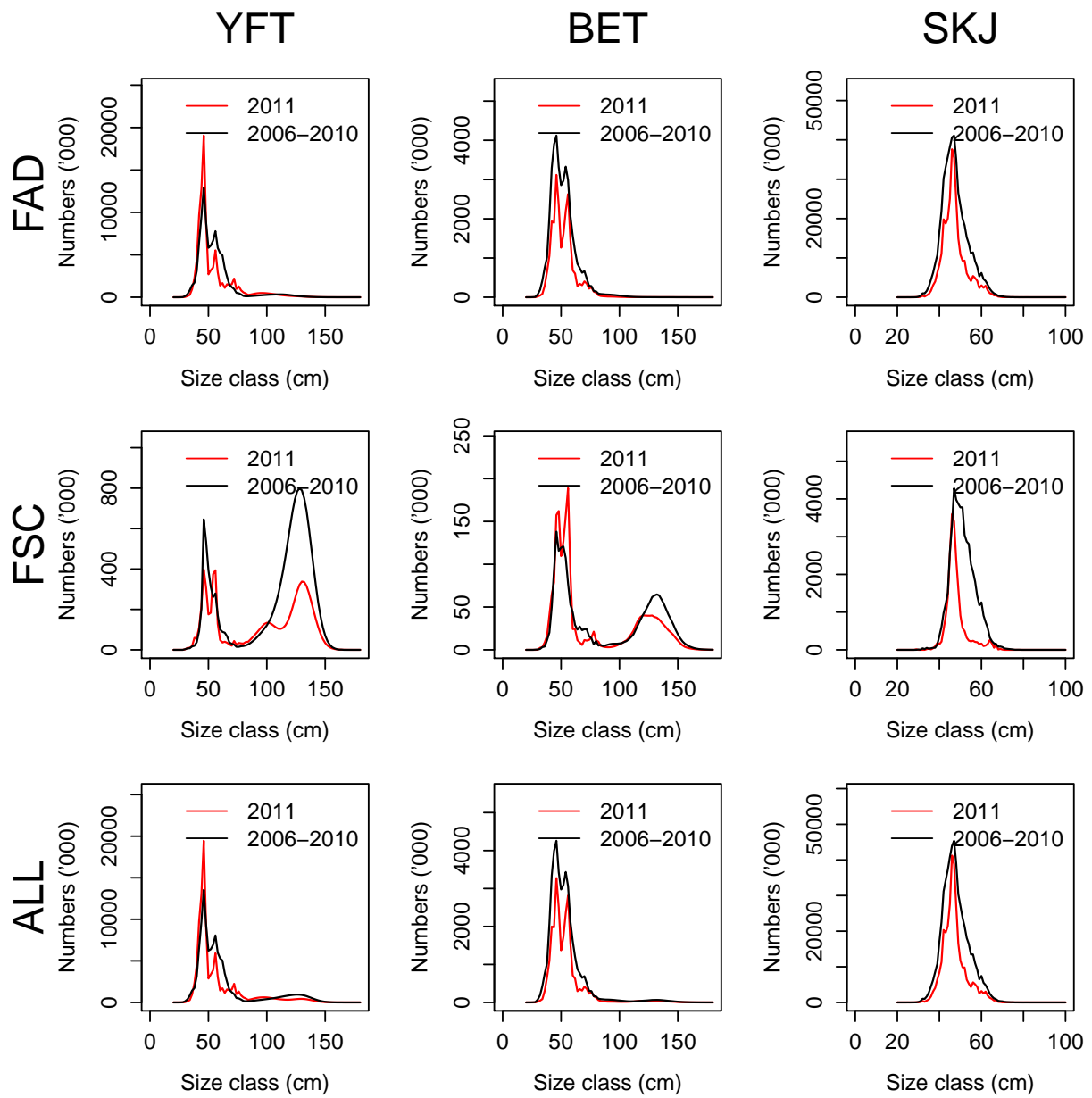


Figure 15: Size structure of the catch. Size distribution (in numbers) of the species-specific catch for the European purse seine fishing fleet in 2011 (red line) and for an average year representing the period 2006-2010 (black line)

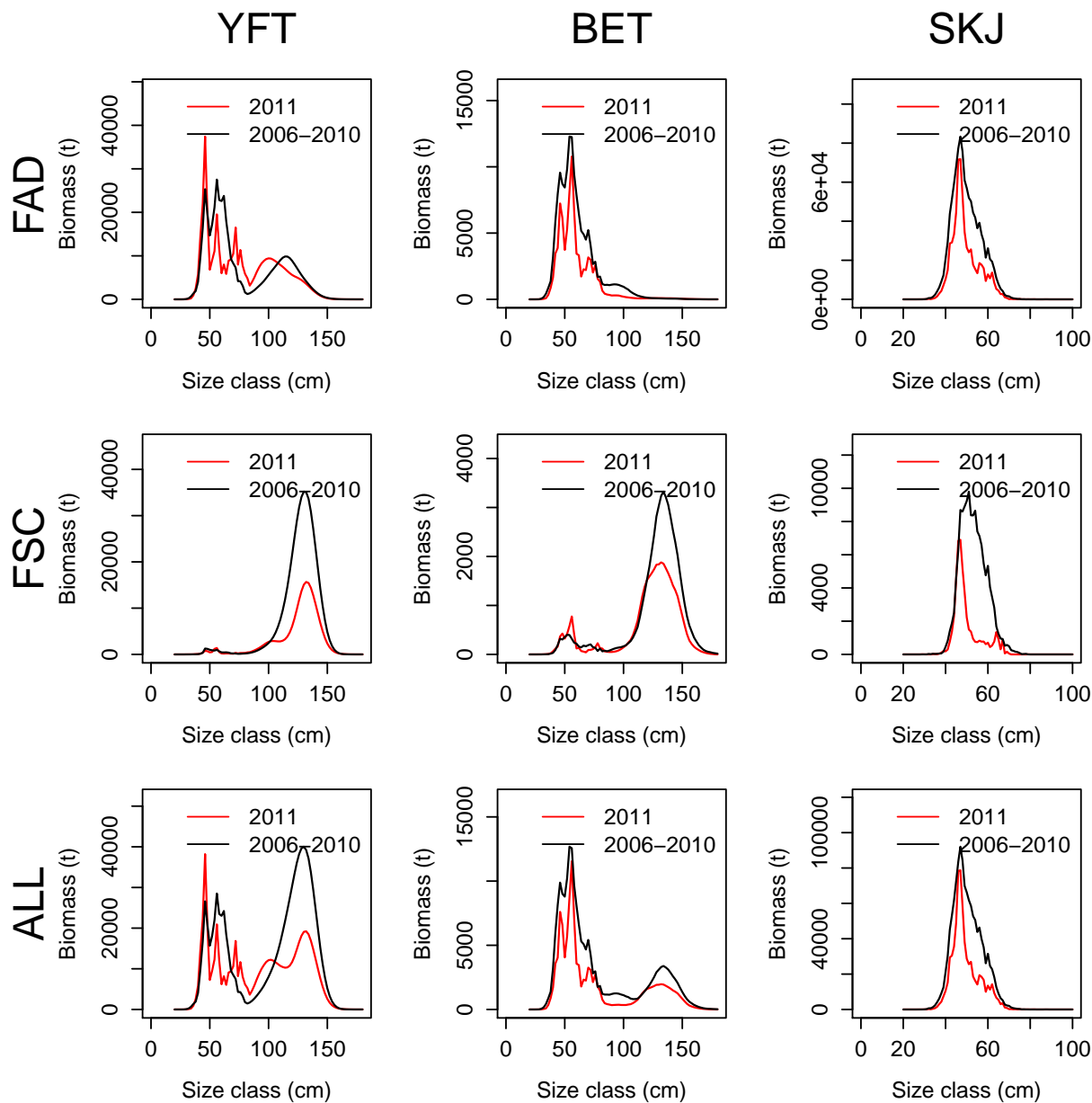


Figure 16: Size structure of the catch. Size distribution (in weight) of the European purse seine fishing fleet in 2011 (red line) and for an average year representing the period 2006-2010 (black line)

schools decreased from about 9 kg in the mid-1990s to about 5 kg throughout the 2000s. In 2011, the mean weight of yellowfin caught on FAD-associated schools was 4.6 kg.

The overall mean weight of skipjack has been driven by the mean weight of skipjack caught on FAD-associated schools and shown a strong decrease since the mid-1980s from more than 3.5 kg in 1987 to about 2.3 kg during 2007-2011 (Fig. 17b). The mean weight of skipjack caught on free-swimming schools has shown strong interannual fluctuations over time and a strong and significant decrease from about 3.6 kg during 2000-2006 to 2.4 kg during 2009-2011.

The mean weight of bigeye showed a high interannual variability during 1983-2011 and varied from a maximum of 7.2 kg in 1991 to a minimum of 3.9 kg in 1997 (Fig. 17c). It showed strong interannual variations for individuals caught on free-swimming schools with a temporal pattern similar to yellowfin tuna. The mean weight of bigeye caught on FAD-associated schools showed a significant decrease during 1986-2011 (slope = -0.05 kg^{-1} , p -value < 0.01) with high interannual variations. In 2011, the mean weight of bigeye caught on free-swimming schools and FAD-associated schools was 18.9 kg and 3.7 kg, respectively.

Acknowledgments. We thank ORTHONGEL, ANABAC and OPAGAC and all past and current personnel for helpful assistance in data collection and management. We are particularly grateful to Renaud Pianet, Viveca Nordstrøm and Alain Fonteneau for their dedication to the monitoring of tropical tuna fisheries and their support to the Observatoire Thonier. This work was financed by the European Data Collection Framework (DCF, Reg 199/2008 and 665/2008) and supported by the Direction des Pêches Maritimes et de l’Aquaculture (DPMA) and the Spanish Fisheries Department.

4. References

- Chassot, E., P. Dewals, L. Floch, V. Lucas, M. Morales-Vargas, and D.M. Kaplan. 2010. Analysis of the effects of Somali piracy on the European tuna purse seine fisheries of the Indian Ocean. Proceedings of the 13th Session of the IOTC Scientific Committee. IOTC-2010-SC-09, 26p.
- Marsac, F. 2011. Outline of climate and oceanographic conditions in the Indian Ocean: an update to August 2011. Proceedings of the 13th Session of the IOTC Working Party on Tropical Tunas, IOTC-2011-WPTT13-11, 32p. *Presentation*.
- Ménard, F., F. Marsac, E. Bellier, and B. Cazelles. 2007. Climatic oscillations and tuna catch rates in the Indian Ocean: a wavelet approach to time series analysis. *Fisheries Oceanography* 16: 95–104.
- Murtugude, R. G., S. R. Signorini, J. R. Christian, A. J. Busalacchi, C. R. McClain, and J. Picaut. 1999. Ocean color variability of the tropical Indo-Pacific basin observed by SeaWiFS during 1997–1998. *Journal of Geophysical Research* 104: 18351–18351.
- Murtugude, R. G., J. P. McCreary, and A. J. Busalacchi. 2000. Oceanic processes associated with anomalous events in the Indian Ocean with relevance to 1997-1998. *Journal of Geophysical Research* 105: 3295–3306.

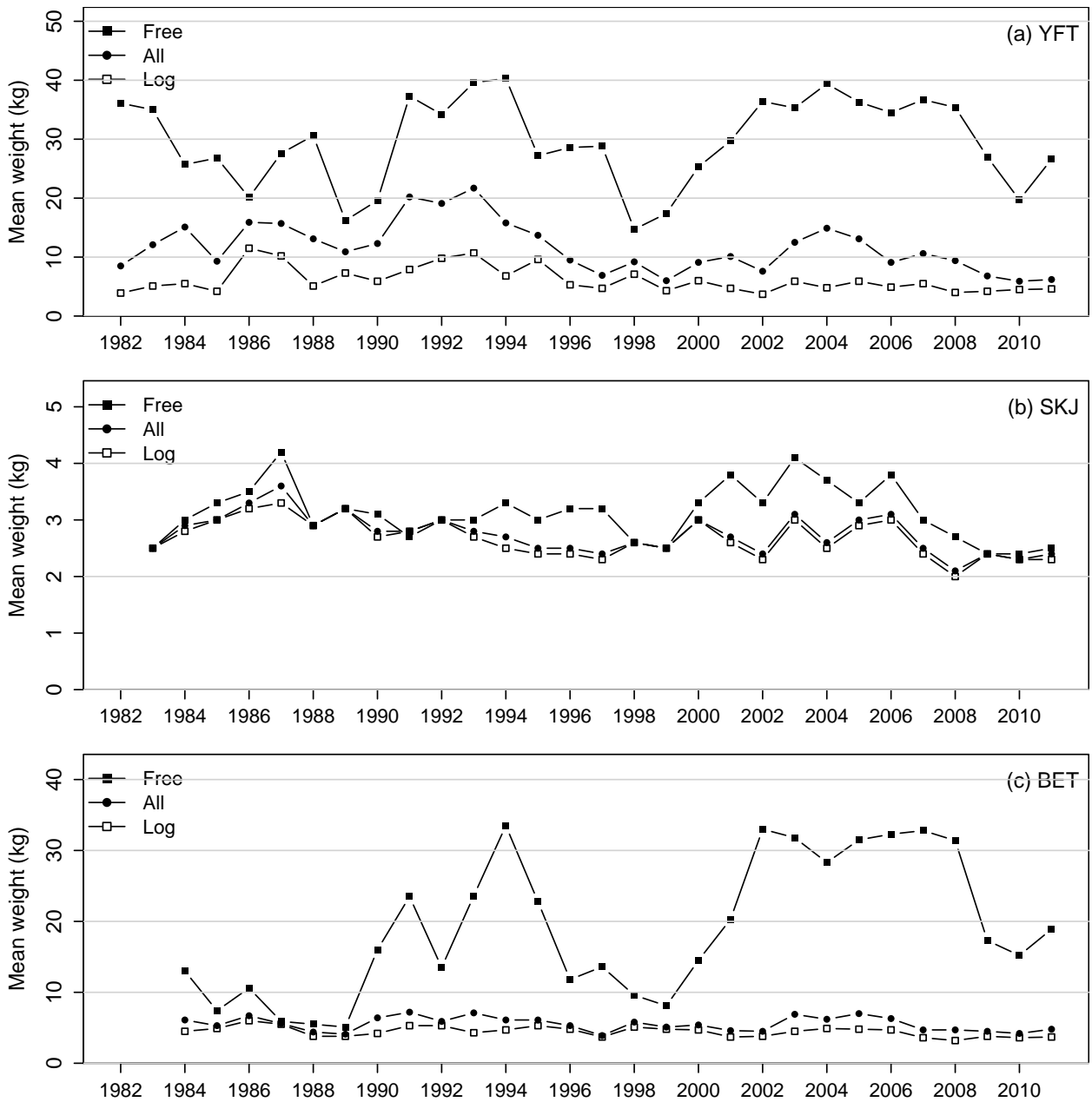


Figure 17: Mean weight in the catch. Annual time series of mean weight (kg) for (a) yellowfin YFT, (b) skipjack SKJ, and (c) bigeye BET in the catch of the European purse seine fishing fleet during 1982-2011

Pallarés, P & J.P. Hallier. 1997. Analyse du schéma d'échantillonnage multispécifique des thonidés tropicaux (Programme n° 95/37), Technical report, IEO/ORSTOM

5. Appendix tables

Table 1: Annual number of vessels by size category and total carrying capacity for the European tropical tuna purse seine fishing fleet of the Indian Ocean during 1981-2011. 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	Total	CC
1981	1	0	0	1	0	0	2	233
1982	1	1	0	2	0	0	4	945
1983	1	6	0	7	0	0	14	4199
1984	1	13	8	20	6	0	48	24848
1985	1	13	8	20	8	0	50	30871
1986	0	9	7	17	4	0	37	27003
1987	1	6	7	17	6	0	37	27252
1988	1	6	7	19	8	0	41	32443
1989	1	6	8	21	9	0	45	37379
1990	0	7	8	23	9	0	47	34089
1991	0	4	6	20	9	0	39	33723
1992	0	4	3	21	11	0	39	35055
1993	0	4	3	21	13	1	42	39521
1994	0	4	4	20	13	1	42	40113
1995	0	4	4	20	13	1	42	42153
1996	0	3	4	21	17	1	46	45069
1997	0	3	4	22	28	1	58	56919
1998	0	3	4	19	26	0	52	54627
1999	0	2	4	19	26	0	51	51329
2000	1	1	3	18	23	3	49	52321
2001	1	1	3	20	23	3	49	54870
2002	0	1	3	18	22	3	46	52652
2003	0	0	2	18	20	4	44	51751
2004	0	0	3	17	21	7	48	54234
2005	0	0	3	17	20	8	48	60309
2006	0	0	3	18	22	8	51	65605
2007	0	0	3	18	22	8	51	66302
2008	0	0	2	17	21	7	47	58975
2009	0	0	0	16	20	7	43	47925
2010	0	0	0	14	15	6	35	45975
2011	0	0	0	13	15	6	34	46648

Table 2: Annual number of vessels by flag for the European tropical tuna purse seine fishing fleet of the Indian Ocean during 1981-2011

year	France	FRAT	Spain	Ivory coast	Panama	Seychelles	Malta	St Vincent	Iran	Italy	Belize	Total
1981	2	0	0	0	0	0	0	0	0	0	0	2
1982	4	0	0	0	0	0	0	0	0	0	0	4
1983	12	0	0	2	0	0	0	0	0	0	0	14
1984	26	0	14	6	1	0	1	0	0	0	0	48
1985	26	0	16	6	1	0	1	0	0	0	0	50
1986	22	0	12	1	1	0	1	0	0	0	0	37
1987	21	0	14	0	1	0	1	0	0	0	0	37
1988	21	0	18	0	1	0	2	0	0	0	0	42
1989	21	0	21	0	1	0	2	0	0	0	0	45
1990	21	0	21	0	3	0	2	0	0	0	0	47
1991	18	0	17	0	3	0	1	0	0	0	0	39
1992	17	0	18	0	3	0	1	0	0	0	0	39
1993	17	0	19	0	4	0	2	0	0	0	4	46
1994	17	0	18	0	3	0	0	0	0	0	4	42
1995	17	0	19	0	3	0	1	0	0	0	4	44
1996	17	0	22	0	3	0	0	0	0	0	4	46
1997	19	0	23	0	4	5	0	4	0	1	5	65
1998	16	0	20	0	2	5	0	0	0	1	4	52
1999	15	0	20	0	2	5	0	0	0	1	4	51
2000	15	0	17	0	1	6	0	0	0	1	5	50
2001	18	2	17	0	1	9	0	0	2	1	5	59
2002	16	2	18	0	1	7	0	0	0	1	0	49
2003	14	0	18	0	1	11	0	0	0	1	1	50
2004	15	0	20	0	1	13	0	0	1	1	0	52
2005	16	0	20	0	0	11	0	0	0	1	0	48
2006	17	1	22	0	0	10	0	0	0	1	0	51
2007	17	2	21	0	0	10	0	0	0	1	0	51
2008	17	2	17	0	0	10	0	0	0	1	0	47
2009	15	3	15	0	0	10	0	0	0	1	0	44
2010	8	5	13	0	0	9	0	0	0	0	0	35
2011	8	5	13	0	0	8	0	0	0	0	0	34

Table 3: Annual nominal fishing effort of the European purse seine fleet expressed in fishing and searching days during 1981-2011. Searching days was derived from the total time spent at sea corrected for periods of damage, route towards port, and purse seine operation

Year	Fishing days	Searching days
1981	91	75
1982	277	235
1983	1671	1336
1984	8445	7111
1985	10481	8948
1986	9087	7398
1987	8704	6984
1988	9590	7750
1989	11333	9384
1990	11048	9261
1991	9435	7921
1992	9539	8081
1993	10687	9248
1994	10672	9135
1995	11370	9823
1996	11784	10209
1997	14277	12625
1998	14038	12390
1999	12551	10946
2000	11858	10198
2001	13297	11185
2002	12035	9979
2003	11254	9082
2004	11799	9464
2005	12940	10407
2006	14341	11776
2007	14860	12619
2008	12619	10514
2009	9747	7956
2010	9182	7378
2011	9571	7691

Table 4: Annual number of 1-degree squares explored by the European purse seine fishing fleet during 1981-2011

Year	TOTAL	#sets>0	Catch>0	Effort>1 d	Effort>5 d
1981	73	26	25	18	
1982	133	47	40	53	10
1983	264	113	102	142	62
1984	678	334	314	422	225
1985	560	404	382	428	336
1986	457	338	327	370	270
1987	441	355	341	362	254
1988	460	352	340	366	263
1989	479	387	369	405	284
1990	505	420	407	424	311
1991	486	416	403	402	292
1992	498	438	429	430	329
1993	498	411	407	425	301
1994	564	477	467	481	348
1995	537	457	453	466	325
1996	670	534	527	544	394
1997	769	591	571	608	417
1998	1006	785	773	810	540
1999	790	632	617	610	407
2000	773	587	566	574	378
2001	631	525	513	526	394
2002	722	588	569	559	412
2003	639	523	508	507	351
2004	660	505	487	508	340
2005	639	525	505	508	365
2006	737	610	592	585	409
2007	711	587	571	586	415
2008	707	610	594	569	436
2009	837	644	634	628	418
2010	695	582	569	547	364
2011	671	547	541	530	344

Table 5: Number of positive and null sets by fishing mode made by the European purse seine fishing fleet of the Indian ocean during 1981-2011

	ALL			FAD			FSC		
	Total	Positive	Null	Total	Positive	Null	Total	Positive	Null
1981	56	44	12	32	29	3	24	15	9
1982	143	105	38	72	63	9	71	42	29
1983	1122	805	317	562	489	73	560	316	244
1984	5851	3391	2460	1628	1375	253	4223	2016	2207
1985	6886	4189	2697	2204	1982	222	4682	2207	2475
1986	7157	3873	3284	2286	1976	310	4871	1897	2974
1987	8082	4811	3271	2997	2568	429	5085	2243	2842
1988	9204	5580	3624	2618	2373	245	6586	3207	3379
1989	12992	7591	5401	4976	3869	1107	8016	3722	4294
1990	9190	6148	3042	3160	2937	223	6030	3211	2819
1991	7806	5493	2313	3419	3199	220	4387	2294	2093
1992	8793	6227	2566	3444	3246	198	5349	2981	2368
1993	9057	6349	2708	3700	3440	260	5357	2909	2448
1994	9816	7051	2765	4313	3949	364	5503	3102	2401
1995	9799	7343	2456	5164	4790	374	4635	2553	2082
1996	10003	7699	2304	5006	4669	337	4997	3030	1967
1997	10334	8509	1825	6842	6398	444	3492	2111	1381
1998	10628	8236	2392	6614	6069	545	4014	2167	1847
1999	10066	7877	2189	5835	5452	383	4231	2425	1806
2000	9984	7896	2088	5710	5242	468	4274	2654	1620
2001	10515	7977	2538	5230	4946	284	5285	3031	2254
2002	9728	7930	1798	5979	5701	278	3749	2229	1520
2003	10002	7405	2597	4792	4461	331	5210	2944	2266
2004	11123	7704	3419	4616	4307	309	6507	3397	3110
2005	13281	9579	3702	5923	5550	373	7358	4029	3329
2006	13432	9820	3612	6630	6162	468	6802	3658	3144
2007	12200	8709	3491	6538	5823	715	5662	2886	2776
2008	11238	8528	2710	5954	5503	451	5284	3025	2259
2009	9157	7836	1321	6690	6267	423	2467	1569	898
2010	9129	7743	1386	7029	6590	439	2100	1153	947
2011	9611	7978	1633	6935	6500	435	2676	1478	1198

Table 6: Catch by species for the European purse seine fishing fleet of the Indian ocean during 1981-2011

Year	YFT	SKJ	BET	ALB	OTH	TOTAL
1981	188	158	23	0	56	425
1982	1081	792	145	0	0	2018
1983	11248	8323	1577	0	136	21284
1984	58901	34784	7556	509	267	102017
1985	64007	52796	10413	670	489	128376
1986	65114	63749	10008	208	743	139823
1987	73421	73907	11750	217	43	159338
1988	109696	83232	16293	242	732	210194
1989	77147	116231	15249	6	0	208633
1990	103406	81119	14666	207	61	199459
1991	90816	90187	10305	2189	39	193536
1992	87157	100540	5752	3196	0	196645
1993	98753	114432	9485	1243	0	223913
1994	94448	141781	10808	2516	0	249553
1995	119187	137545	19135	1217	0	277084
1996	106994	121706	17839	1476	1221	249236
1997	111529	119875	26721	1869	201	260195
1998	83344	127319	20722	1310	0	232695
1999	113111	162850	30779	521	18	307279
2000	115952	171189	20903	1069	2149	311262
2001	114017	157747	20541	1239	22596	316140
2002	122774	207712	26941	712	1371	359511
2003	199137	183295	22573	1476	736	407217
2004	204762	137736	22201	240	1098	366036
2005	173396	188214	22009	169	848	384635
2006	148791	220989	20202	1358	1017	392357
2007	93139	132322	21147	714	285	247606
2008	112736	133997	26582	1391	304	275010
2009	84700	146780	26465	422	65	258431
2010	101675	148263	21544	207	56	271746
2011	111514	129349	21439	725	37	263064

Table 7: Catch by species made on FAD-associated schools for the European purse seine fishing fleet of the Indian ocean during 1981-2011

Year	YFT	SKJ	BET	ALB	OTH	TOTAL
1981	37	128	20	0	56	240
1982	442	709	131	0	0	1282
1983	4408	6752	1417	0	136	12714
1984	15680	26045	5426	0	230	47381
1985	23072	41797	7705	14	461	73050
1986	23105	44535	7159	0	693	75491
1987	28688	49925	8179	0	20	86812
1988	27890	62689	10387	0	602	101567
1989	32057	65605	11389	0	0	109051
1990	27383	63896	9958	35	61	101333
1991	19339	78748	6975	54	25	105141
1992	26833	81959	5001	14	0	113807
1993	28702	87351	4658	9	0	120720
1994	28825	103978	8059	88	0	140950
1995	62992	110856	16085	49	0	189982
1996	48776	91772	15620	93	0	156261
1997	68772	102395	25107	185	0	196459
1998	45336	106692	15739	130	0	167897
1999	70853	132641	26654	108	16	230272
2000	63826	145198	16766	116	881	226787
2001	41306	131243	15604	125	566	188843
2002	54444	189264	22200	16	1278	267203
2003	72833	154242	13185	6	420	240686
2004	47120	120195	16902	2	617	184835
2005	59498	145979	13984	20	802	220282
2006	68380	188082	14350	0	901	271713
2007	40774	108675	15581	7	248	165284
2008	39377	119219	16972	35	294	175897
2009	48720	137402	21116	26	64	207328
2010	70207	139544	17770	42	56	227618
2011	75582	120319	15088	45	37	211071

Table 8: Catch by species made on free-swimming schools for the European purse seine fishing fleet of the Indian ocean during 1981-2011

Year	YFT	SKJ	BET	ALB	OTH	TOTAL
1981	151	31	4	0	0	185
1982	638	83	14	0	0	736
1983	6839	1571	159	0	0	8570
1984	43221	8739	2130	509	37	54636
1985	40935	10999	2708	656	28	55326
1986	42009	19214	2849	208	51	64331
1987	44733	23982	3571	217	23	72526
1988	81806	20543	5906	242	130	108626
1989	45090	50626	3860	6	0	99583
1990	76023	17223	4708	172	0	98126
1991	71477	11439	3330	2135	14	88395
1992	60324	18581	751	3182	0	82838
1993	70051	27081	4827	1234	0	103193
1994	65623	37803	2749	2428	0	108603
1995	56195	26689	3050	1168	0	87102
1996	58218	29934	2219	1383	1221	92975
1997	42757	17480	1614	1684	201	63736
1998	38008	20627	4983	1180	0	64798
1999	42258	30209	4125	413	2	77007
2000	52126	25991	4137	953	1268	84475
2001	72711	26505	4936	1114	22030	127297
2002	68330	18448	4741	696	93	92308
2003	126304	29053	9389	1470	316	166532
2004	157642	17541	5299	238	481	181201
2005	113898	42234	8025	149	46	164353
2006	80411	32908	5852	1358	116	120644
2007	52365	23647	5566	707	37	82322
2008	73360	14779	9610	1355	10	99113
2009	35980	9379	5349	396	0	51104
2010	31468	8720	3775	166	0	44129
2011	35932	9030	6351	680	0	51992

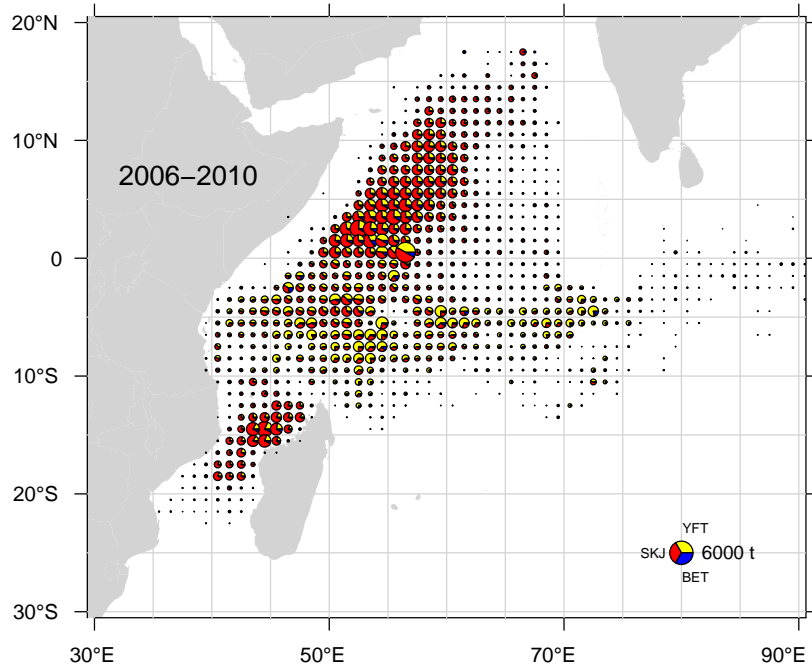


Figure 18: Spatial distribution of tuna catches of the European purse seine fishing fleet in 2006-2010

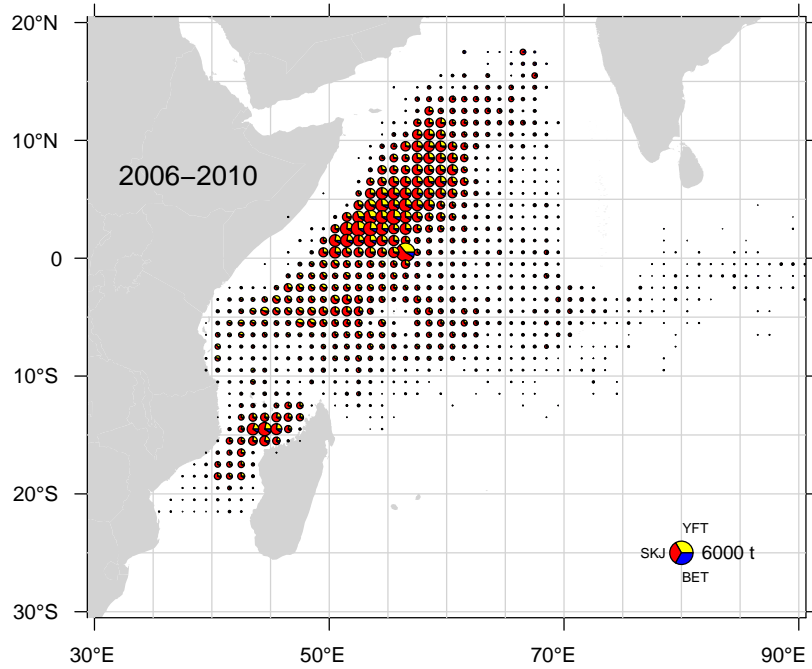


Figure 19: Spatial distribution of tuna catches of the European purse seine fishing fleet made on FAD-associated schools in 2006-2010

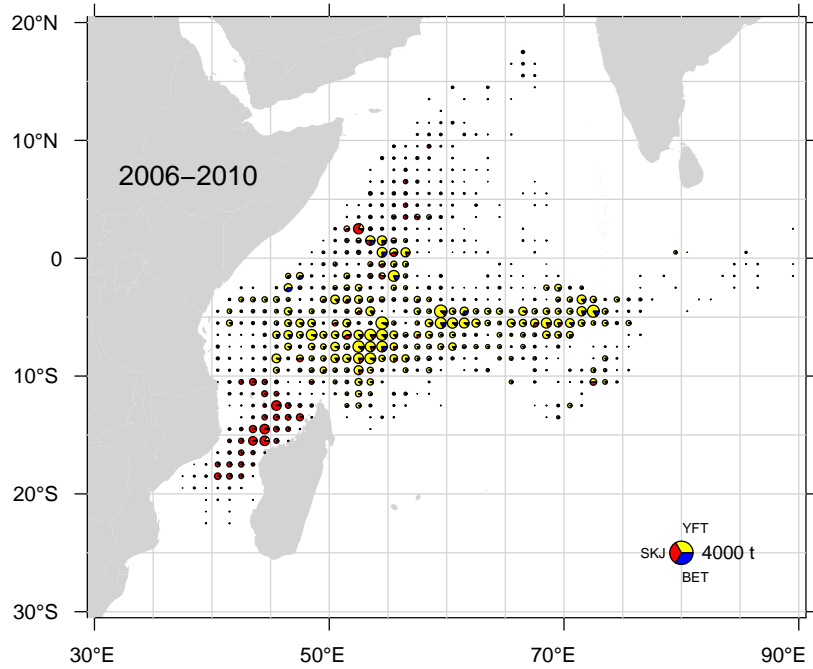


Figure 20: Spatial distribution of tuna catches of the European purse seine fishing fleet made on free-swimming schools in 2006-2010