Analysis of the effects of Somali piracy on the European tuna purse seine fisheries of the Indian Ocean

Chassot, E.[a,b], Dewals, P.[b], Floch, L.[a], Lucas, V.[c], Morales-Vargas, M.[a], Kaplan, D.[a]

[a] *Institut de Recherche pour le Développement, UMR 212 EME, Avenue Jean Monnet, BP 171, 34200 Sète cedex, FRANCE*
[b] *Institut de Recherche pour le Développement, UMR 212 EME, BP 570, Victoria, SEYCHELLES*
[c] *Seychelles Fishing Authority, BP 570, Victoria, SEYCHELLES*

Abstract

The European purse seine fishery of the Indian Ocean (IO) has been particularly affected by Somali piracy in the recent years. Consequently, several vessels left the IO and the overall carrying capacity of the fleet decreased by 25% between 2005-2008 and 2009. To address security issues, fishing companies defined in 2008 a large exclusion zone off the Somali coast that represented more than 25% of the total catch of the fishery during 2001-2007. The exclusion zone resulted in some reallocation of the European fleet toward the eastern part of the North equatorial area during the typical season of FAD-fishing (June-November) in the Somali basin. The European purse seine fleet catches in the exclusion zone decreased from an average of 90,000 t during 2001-2007 to less than 50,000 t in 2008. This was mainly due to the decrease in fishing effort, as measured by space occupancy, set number, and searching time for the French component of the fishery. The effort and catch concomitantly increased in the eastward part of the North equatorial area. Overall, the catch of the French fleet in the whole North equatorial area decreased by 5.4% in 2008 relative to 2001-2007 but increased by more than 25% relative to 2007. Considering a subset of French vessels that occurred in the IO

*Corresponding author
Email address: emmanuel.chassot@ird.fr (Chassot, E.)

during 2001-2010 confirmed that the vessels were able to recoup most losses in adjacent areas. In 2009, military and private security intervention reduced risk from piracy and enabled European purse seiners to move back to the Somali basin. The fishing effort of the fleet re-increased in the exclusion zone and led to catch levels similar to 2002-2007 for the French fleet while the effort and catches strongly decreased in the eastern part of the North equatorial area. Some changes in species composition, i.e. an increasing proportion of skipjack and bigeye, and size structure of the catch, i.e. smaller fishes, were observed in 2008-2009 due to the changes in spatial distribution of the French fleet as well as the increasing tendency to fish on log-associated schools. The current logistical constraints imposed on the French purse seiners, i.e. operating in pairs and fishing alternatively combined with the decrease in the number of vessels in the IO seems to have modified their fishing strategy by reducing their ability to explore large spatial areas and track free swimming schools. The increase in fishing on log-associated schools might have strong effects on the yield-per-recruit expected from the fishery as well as levels of bycatch that have not been monitored by EU observers since summer 2009.

Keywords: effort, fisheries, purse seine, Somali piracy, tropical tuna

1. Introduction

The recent years have seen a steady increase in piracy acts and armed robbery at sea in the world oceans. In the Indian Ocean, Somali pirate attacks have increased since the early 1990s within the Gulf of Aden and progressively expanded toward the east of the Indian Ocean (UNOSAT 2009). While Somali pirates generally targeted small cargo ships in strategic waterways for international trade, they have recently begun hijacking larger cargo vessels such as oil and chemical tankers on international voyages. Despite

the general recognition of the threat of Somali piracy as shown by the resolution 1838 of the United Nations Security Council and the implementation of a multinational coalition task force within the Gulf of Aden, the increase in anti-piracy efforts has not prevented pirate attacks that have become more and more numerous and successful over the recent years (UNOSAT 2009).

Since 2008, the fisheries of the Western Indian Ocean (WIO) have been increasingly subject to Somali piracy acts with a progressive geographical expansion in time toward the east of the Indian Ocean (Fig. 1). Several successful attacks occurred and resulted in the hijacking of Thai and European purse seiners, Chinese, Taiwanese and Kenyan longliners, as well as several other vessels operating in the WIO. Consequently, most of the Japanese, Korean, and Chinese-Taipei longliners have left the area of influence of the pirates for security reasons. In addition, the 4 Thai purse seiners fishing in the WIO recently left toward the Atlantic Ocean in order to avoid the piracy threat.

The European purse seiners have been particularly affected by Somali piracy. More than 20 attacks were performed against purse seiners and their supply vessels from May 2007 to May 2010. The Spanish vessels 'Playa de Bakio' and 'Alakrana' were hijacked in April 2008 and October 2009, respectively. As a result, the European fishing companies restricted the fishing areas in late 2008 by extending eastward a security border from 300 nm to 500 nm off the Somali coasts. The attack of the 'Felipe Ruano' in March 2009 as far as 59°E however showed the limits of establishing a security zone where 25% of the total catch of the European fleet was made on average during 2001-2007. To ensure security of the crew and to enable purse seiners to operate in the Somali basin, military

personnel boarded each purse seiner flying the French national flag from July 2009, at the beginning of the 'Somali season'. Similar measures were adopted a few weeks later (from mid-October to November 2009) for the Spanish and Seychelles-flagged vessels through the boarding of private security personnel. The boarding of military personnel has imposed several logistical constraints for the French purse seiners, i.e. (i) a decrease in crew aboard small vessels so as to board the military staff, (ii) changes in trip duration from 7 to 5 weeks according to military rotations, and (iii) the necessity for the vessels to operate in pairs with some maximum distance allowed between them and alternative fishing in some areas. Such constraints may have affected both the strategies and tactics of the fleet and resulted in changes in effort distribution and resulting catch.

The study aims to analyse the impact of the Somali piracy on the European purse seine fishery by describing the spatio-temporal changes in the activities, effort, and catches that took place in the fishery since 2008. Several fisheries indicators were used to investigate the changes that occurred in the recent years in relation to the increase in piracy activities focusing on: (i) the European purse seine fleet, (ii) the French component of the fleet, and (iii) a subset of vessels of the French fleet component that operated in the fishery during 2001-2010 for consistency reasons.

2. Materials and Methods

The three areas defined by Marsac et al. (2009) were considered to analyse changes in fishing activities, catch and effort data over 2001-2010: the East African EEZs (area 1), the purse seine fishing exclusion zone (area 2), and the northeast equatorial part of the Western Indian Ocean (area 3) (Fig. 1).

2.1. Fishery data

Fishing activities. Statistical data from the European fleet have been collected by the Institut de Recherche pour le Développement (IRD) and the Instituto Español de Oceanografia (IEO) in collaboration with the Seychelles Fishing Authority (SFA) since the development of the fishery in the early 1980s. Two major fishing modes are generally considered in purse seine fishing: log-associated and free swimming schools. The species and size composition strongly depend on the fishing mode (e.g. Pianet et al. 2010). The percentage of total catch and sets made on log-associated schools was used to describe the major characterics of the fishery over time for the 3 spatial areas considered in the analysis. The centroid of the fishing activities, computed as the average location of the sets weighted by catch, was used to investigate the temporal changes in the fishing grounds of the French purse seine fleet over time. The numbers of 1-degree squares of latitude and longitude where the vessels occurred and exerted some effort were used as indices of space occupancy by the fleet.

Catch data. A multispecies sampling has been conducted at port to correct for the catch species composition of the major tropical tunas recorded in the logbooks since the beginning of the fishery (Pallarés and Hallier 1997). While some changes in sampling design and processing occurred with the expansion of the fisheries throughout the 1980s (Pianet 1999, Pianet et al. 2000), the data processing is considered to be fully consistent since 1991. Monthly aggregated catch data available at a spatial resolution of 1-degree squares of latitude and longitude were first used for the whole European fleet over 2001-2009. In a second step, fine-scale operational data accounting for species composition correction were used for the French component of the fleet, i.e. including

French, Mayotte, and Italy-flagged vessels.

Effort data. The number of sets (total and positive, i.e. with catch) and searching time (expressed in d) were used as units of effort for the catch made on log-associated and free swimming schools, respectively. The searching time was obtained 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.

Size data. Size sampling has been routinely conducted since the early 1980s aboard European purse seiners during unloading and transhipment at the ports of Victoria, Seychelles and Diego-Suarez, Madagascar. The sampling consists in a two-step approach: (i) the wells are selected from among those containing homogeneous strata and (ii) fishes are then intended to be randomly collected, within size category, from the wells and measured.

3. Results

3.1. Fishing capacity

The number of vessels of the European purse seine fleet decreased from an average value of more than 51 during 2001-2008 to 44 in 2009 (Table 1). In the course of 2009, several vessels departed toward the Atlantic and Pacific Oceans and the amount of European purse seiners decreased to 38; this decrease having been partly compensated by the arrival of 2 new vessels in the French fleet: the 'Franche Terre' and the 'Manapany' in 2009 and 2010, respectively. The decrease in the number of vessels corresponded to a 25%-decrease of the total fleet carrying capacity between the period 2005-2008 ($\sim$ 63,000

GRT) and 2009 (48,000 GRT) (Pianet et al. 2010).

Table 1: Number of fishing vessels by country of the European purse seine fishery during 2005-2010. Vessels having made at least 1 set in a specific year are included (Pianet et al. 2010)

Year	France	Mayotte	Italy	Spain	Seychelles	Total
2005	16	0	1	20	11	48
2006	18	1	1	22	10	52
2007	17	2	1	21	10	51
2008	17	2	1	17	10	47
2009	16	2	1	15	10	44
2010	13	2	1	13	9	38

3.2. Fishing activities and effort

At the scale of the European purse seine fishery, the yearly variations in the number of 1-degree squares of latitude and longitude with positive catch showed a steady decrease in the East African EEZs and the purse seine fishing exclusion zone over 2001-2009. Similar results were obtained when only considering fishing on log-associated schools. The decrease in the extent of the fishing grounds in area 1, i.e. from 60 squares in 2002 to 17 squares in 2009, would be mainly related to the changes in fishing agreements between the European Union and the coastal East African countries over time. The decrease observed in the area 2, from 75 squares in 2002 to 61 squares in 2009, might reflect both the progressive decrease in the number of fishing vessels and the avoidance of the area of piracy influence (see below). By contrast and despite the decrease in the number of vessels, the number of squares visited in area 3 did increase from an average of about 280 squares during 2001-2007 to more than 340 squares in 2008-2009. Again, considering only log-associated schools led to similar results. This might reflect a reallocation of the effort toward more secured fishing grounds.

A similar decrease in the number of 1-degree squares of latitude and longitude with catch was observed for the French component of the fleet during 2001-2009. By contrat and compared to the whole fishery, the number of 1-degree squares where positive sets were made by the French vessels in area 3 increased from about 200 during 2001-2007 to 264 in 2008, but decreased to 190 in 2009, likely due to the overall decrease in the French fishing effort. The subset of vessels that operated in the WIO during 2001-2010 showed a clear decrease in the number of 1-degree squares with catch in area 2 from 2007 to 2008, i.e. from 59 to 33 squares, concomitantly with an increase in area 3, i.e. from 121 to 163 squares. Subsequently, the number of squares increased from 2008 to 2009 in area 2 and decreased in area 3, particularly where free-swimming schools were caught (Table 2).

Table 2: Yearly number of 1-degree squares of latitude and longitude with positive catch for a subset of 5 vessels of the French component of the European purse seine fleet having operated during 2001-2009

	Log-associated schools			Free swimming schools		
Year	Area 1	Area 2	Area 3	Area 1	Area 2	Area 3
2001	15	54	90	1	11	75
2002	41	67	126	7	17	58
2003	30	51	80	11	15	69
2004	24	33	117	13	25	84
2005	0	41	117	0	22	114
2006	11	56	109	3	22	86
2007	11	56	98	7	22	67
2008	7	33	129	5	4	78
2009	5	56	118	2	4	40

The patterns observed in fishing effort for the French fleet were very similar as for space occupancy, i.e. a reallocation of the fishing effort from area 2 to area 3 in 2008 in relation to the definition of the 500-nm exclusion zone and a return of the vessels towards

area 2 in 2009 thanks to the boarding of military personnel. A strong decrease in the number of sets made both on log-associated and free swimming schools was observed in area 2 in 2008 compared to the years 2006-2007, while the number of sets made on log-associated schools increased by 28% in area 3 in the same year (Fig. 5). In 2009, the number of sets made in area 2 re-increased to the levels observed in 2006-2007 while the number of sets decreased in area 3. The sets made in 2009 in area 2 were almost exclusively made on log-associated schools while the average percentage of sets on free swimming schools in this area during 2001-2007 was about 30%. The analyses of the sets made by the subset of vessels yielded similar results, i.e. a decrease in the effort in area 2 in 2008 concomitant with an increase in effort in area 3, followed by a reallocation of the effort in 2009 in area 2. The number of sets made by the subset of French vessels in area 2 in August-October 2009 was very high compared to the average period 2001-2008 (+20%). The size of the sets (t) made in 2009 in area 2 was high compared to 2007-2008, particularly in the size range of 30-60 t and with more than 40 sets $>$ 100 t (Fig. 6). Fishing effort expressed in searching time gave similar results as space occupancy and set numbers for the subset of French vessels (Figs. 7-8).

3.3. Fisheries production

Spatial distribution. The recommendation by the European fishing companies to avoid the marine area 500-nm off the Somali coast for security reasons resulted in major changes in the spatial distribution of the European purse seine fleet in the recent years (Fig. 2). The fleet moved toward the north east of area 2 in June-November 2008 compared to 2007. In 2009, the effort was reallocated to area 2 and the core of the catch was concentrated in a rather small area compared to precedent years. The subset

of selected French vessels also showed a strong displacement toward the eastern part of area 2 in 2008 and a move back toward the area centre in 2009 (Fig. 3). The temporal changes in the centroid of the catch showed a significant change in the longitude of the French fishing grounds in 2008, i.e. from an average location of 51.8°E (SD = 1.7°) during June-November 2001-2007 as far east as 55.7° during June-November 2009 (Fig. 4). The latitude of the catch significantly increased from an average of 1.8°S (SD = 1.6°) during 2001-2007 to extend beyond the equator at a value of 1.1°N in 2009.

Catch levels. The total catch of the European fleet in the Indian Ocean varied between about 290,000 t in 2001 to a maximum of more than 408,000 t in 2003, the annual average catch being 260,000 t during 2007-2009 (Fig. 9). The East African EEZs represented until 15% of the total catch of the fleet in 2004-2005 but decreased to less than 1% in 2006 with the end of the fishing agreements. Over 2001-2007, an average of about 26% and 35% of the total catch and of the catch on log-associated schools was respectively made in the the purse seine fishing exclusion zone (area 2) (Fig. 9). Over this period, 33%, 17%, and 26% of the catch of skipjack, yellowfin, and bigeye was made in area 2, respectively. The total catch in area 2 strongly decreased from an average of 90,000 t during 2001-2007 to less than 50,000 t in 2008 (-45%). Catch levels re-increased to 60,0000 t in 2009. Consequently, the percentage of total catch of the European fleet in area 2 decreased to 18.3% in 2008 and re-increased in 2009 to 23.4%. Concomitantly, the catch levels in area 3 increased to about 156,000 t in 2008 compared to an average of 133,000 t over 2001-2007 (+17%). The percentage of the total catch in area 3 increased from an average of 38% during 2001-2007 to reach 57% in 2008. Overall, the catch of the European purse seine fleet in areas 2-3 decreased in 2008 by more than 8% relative to

the annual average catch over 2001-2007 but increased by more than 25% compared to the year 2007 characterized by low catch levels both on log-associated and free swimming schools.

The area 2 represented a major fishing zone of the French component of the fleet in the last decade, but in lower proportion than for the whole European fleet. About 19% of the annual average catch of the French fleet was made in area 2 over 2001-2007 representing 27.3%, 11.6%, and 19% of the catch of skipjack, yellowfin, and bigeye, respectively. Similarly as observed for the whole fleet, the restricted access to area 2 resulted in a decrease of the catch in 2008 (-35%) in this area while the catch only increased in area 3 by 6.4% relative to 2001-2007. Overall, the catch of the French fleet in areas 2-3 decreased by 5.4% in 2008 relative to 2001-2007 but increased by more than 25% relative to 2007. The subset of selected vessels from the French purse seine fleet showed similar patterns. Area 2 represented major fishing grounds for the vessels, with an annual average catch of 33%, 17%, and 25% of the skipjack, yellowfin, and bigeye during 2001-2007, respectively. The catch was particularly low in 2008 in area 2 (5,100 t), showing a 38% decrease compared to 2001-2007 (annual average of 8,300 t) and a 32% decrease compared to 2007 (7,500 t). The reallocation of effort in area 3 (see above) led to a catch of 18,000 t in 2008 in area 3, i.e. 10% lower than the average catch during 2001-2009 but more than 50% higher than 2007. In 2009, the catch in area 2 increased to high levels of almost 13,000 t, i.e. 50% higher than the average catch over 2001-2007, while the catch in area 3 was very low ($\sim$ 10,000 t) due to the strong decrease in effort. This high catch was almost exclusively made on log-associated schools. Overall, although the cumulated catch of the selected vessels in 2008 appeared lower than the average

catch over the period 2001-2007, these levels were close to the average catch of years 2001, 2002, 2006, and 2007, i.e. when excluding the 2003-2005 period characterized by very high catches of yellowfin.

No significant change was observed in the species distribution of the catch at the scale of the European purse seine fleet in the recent years. By contrast, the increasing proportion of sets made on log-associated schools by the French fleet in 2008-2009 in areas 2 and 3 resulted in increasing proportion of skipjack and small bigeye in the catch. In particular, the proportion of skipjack and bigeye in area 2 reached 60% and 13% in 2008 and 2009, respectively. These patterns were also observed for the subset of French vessels for which the proportion of skipjack was higher than 63% in 2008-2009 in area 2 and close to 40% in 2009 in area 3.

Catch rates. No clear pattern was observed in the time series of catch rates of the French purse seine fleet computed both on log-associated and free swimming schools in each area.

Size distribution of the catch. Skipjack caught on log-associated schools by the French purse seiners in the fishing exclusion zone in 2008 were smaller (mode = 44 cm) than observed during 2001-2007 and 2009 (mode $\sim$ 47-49 cm) and of similar size as observed in the same year in area 3 (Fig. 10). Although no significant difference was found in the mean size distribution of skipjack caught over 2001-2007 between areas 2 and 3, skipjack caught in in 2009 in area 3 were smaller than in area 2 (Fig. 10a-c). These differences in size might stem from the changes of distribution and spatial contraction of the fleet in 2008 and 2009 (Fig. 3). No major difference in the distribution

of yellowfin caught on log-associated schools in area 2 was found between the period 2001-2007 and 2008 but the distribution in 2009 showed that there were very few fishes in the size range 50-55 cm (Fig. 10b). The size distribution of bigeye in area 2 was very similar throughout the period 2001-2009 (not shown). Similarly to skipjack and bigeye caught in area 3, yellowfin caught on log-associated schools in 2008 tended to be smaller than average (Fig. 10c-d).

4. Discussion

4.1. Decrease in fishing effort

The rationale put forward by the fishing companies and skippers for the decrease in the number of European purse seiners in the last two years in the Indian Ocean is the piracy threat. The reduction in fishing grounds, issues about the security of crews and vessels, as well as increase in costs associated with security resulted in the departure of more than 10 vessels that switched toward the Atlantic and Pacific oceans. In addition, several logistical constraints have been imposed on the French purse seine vessels through the boarding of military personnel, i.e. vessels have to operate in pairs and fish alternatively in areas-at-risk. This seems to have affected the strategy of the fleet by decreasing the ability of the fleet to explore large areas in research of free swimming schools. Consequently, the French purse seiners have preferentially targeted log-associated schools in 2009 and during the first semester 2010 (Floch et al. 2010). This strategy might result in increasing catch of juveniles of bigeye and yellowfin and have strong effects on the yield-per-recruit expected from the fishery. In addition, it should increase the levels of bycatch of the fishery since bycatch of bony fishes,

sharks, rays, and billfishes are essentially caught on log-associated schools (Romanov 2002, Amandè et al. 2008). Analysis of the fisheries data from the second semester 2010 should provide insights into these changes and confirm or infirm the observed trends.

4.2. Fleet reactivity

The European purse seiners have shown a strong ability to react to the limitation in the extent of fishing grounds by reallocating the fishing effort in other oceans and adjacent areas. In particular, considering a subset of vessels that operated during 2001-2010 in the IO showed that skippers were able to locate fishing grounds and maintain average catch levels in 2008. The total catch of these vessels even increased in 2008 by almost 20% relative to the year 2007 which was characterized by small catches both on log-associated and free swimming schools, which might be related to poor environmental conditions having affected purse seine catchability (Marsac 2010).

4.3. Other impacts of the Somali piracy

In addition to the European purse seine fishery, Somali piracy has also had an impact on several other industrial (Japanese, Taiwanese, and Korean longliners, Thai purse seiners) and artisanal fisheries. In the Seychelles, the extent of the fishing grounds of longliners and small artisanal boats has been strongly reduced by piracy influence and similar analyses could be conducted to assess the resulting changes in effort and catch. In a second step, the economic impact of the piracy might be evaluated through the use of statistical modelling approaches as used for assessing the influence of climate variability on the tuna economy of Seychelles (Robinson et al. 2010). Several scientific

projects relying on sampling-at-sea have also been impaired due to piracy threat and the EU purse seiner observer programme has been stopped since July 2009, preventing any estimate of tuna discard and bycatch for the European fishery since then.

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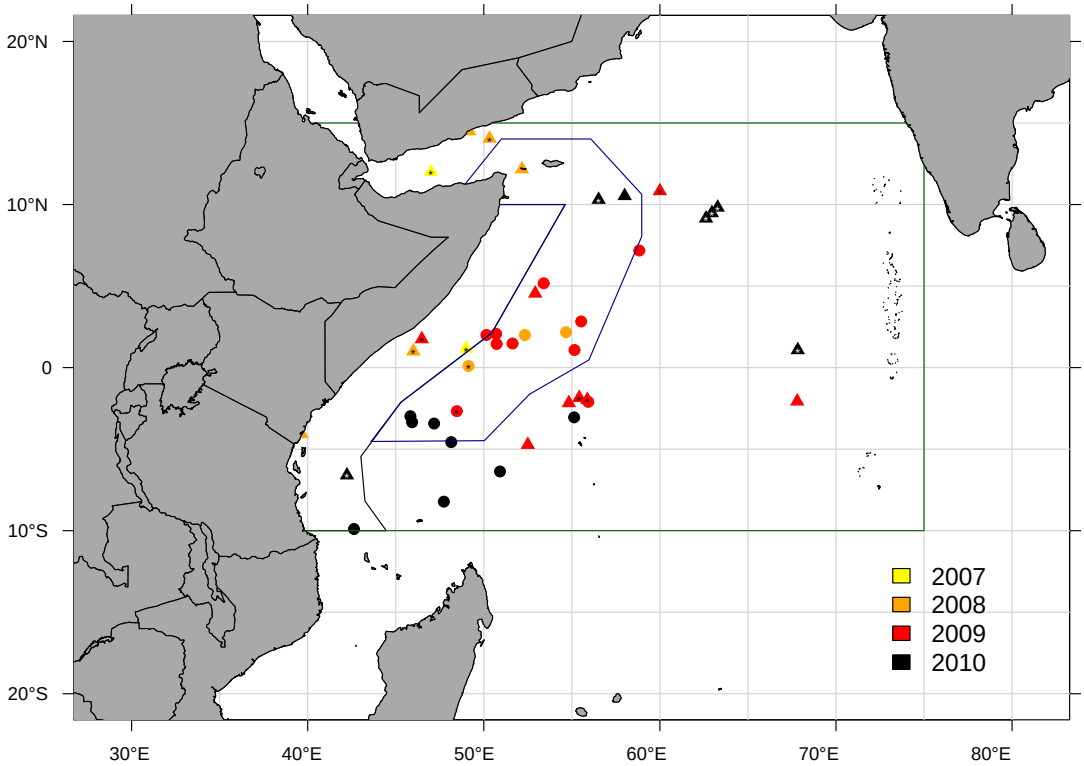
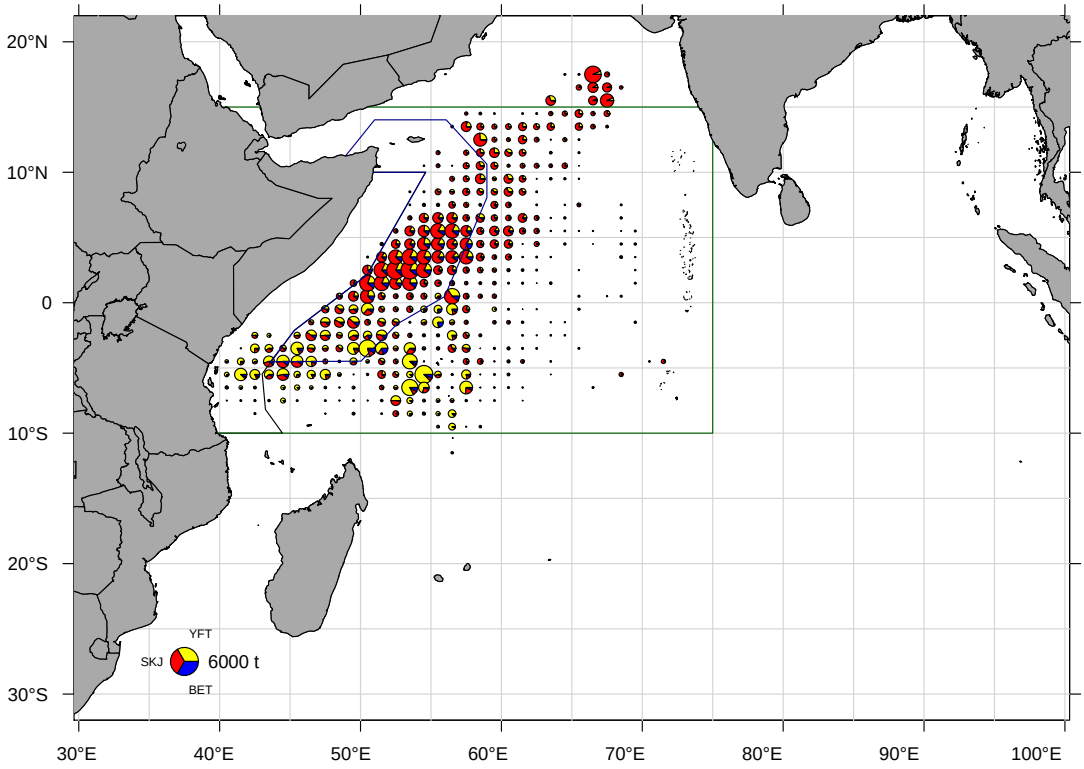
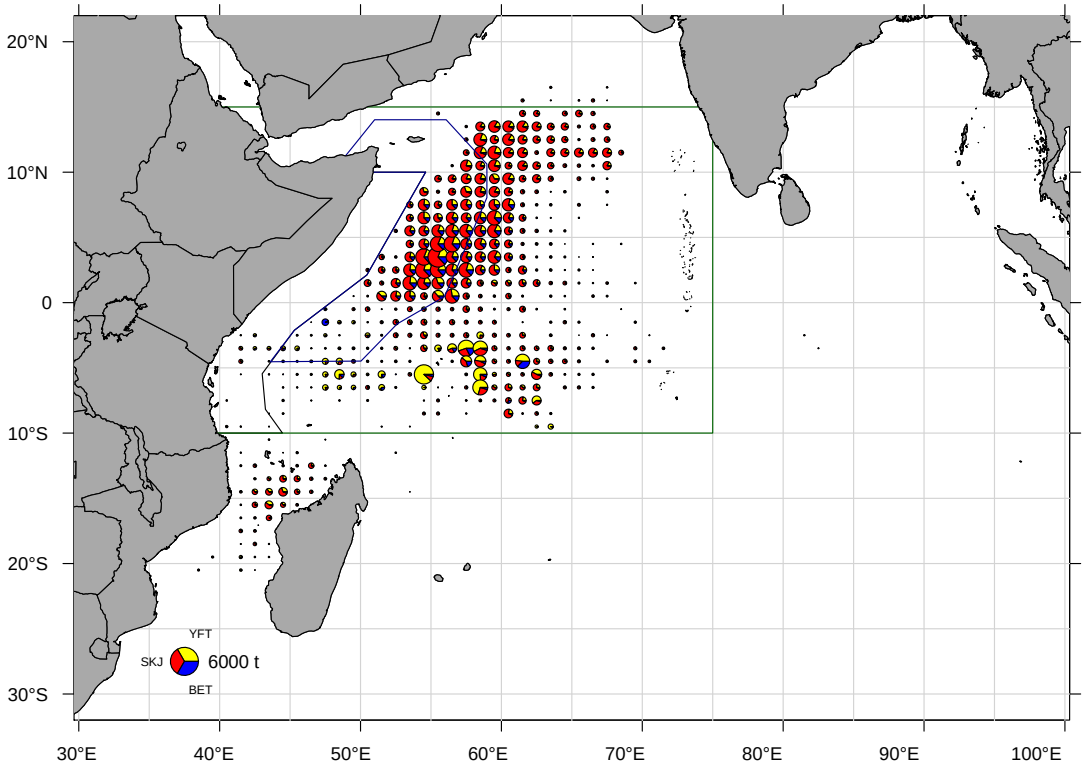


Figure 1: Yearly attacks of European purse seiners (circles) and other fishing vessels (triangles) during May 2007-May 2010 in the Western Indian Ocean. Stars in symbols indicate successful attacks resulting in hijacking. Lines delimit the 3 areas considered for the study: the East African EEZs (area 1; black), the purse seine fishing exclusion zone (area 2; blue), and the northeast equatorial part of the Western Indian Ocean (area 3; green).

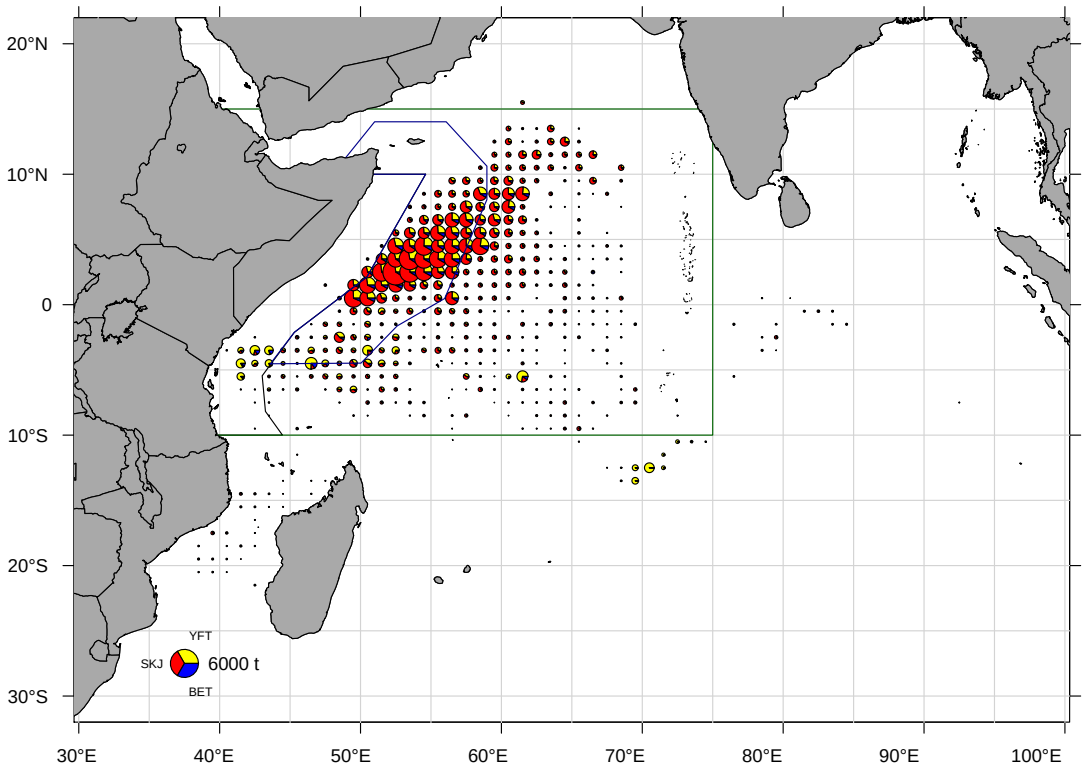


a: June-November 2007



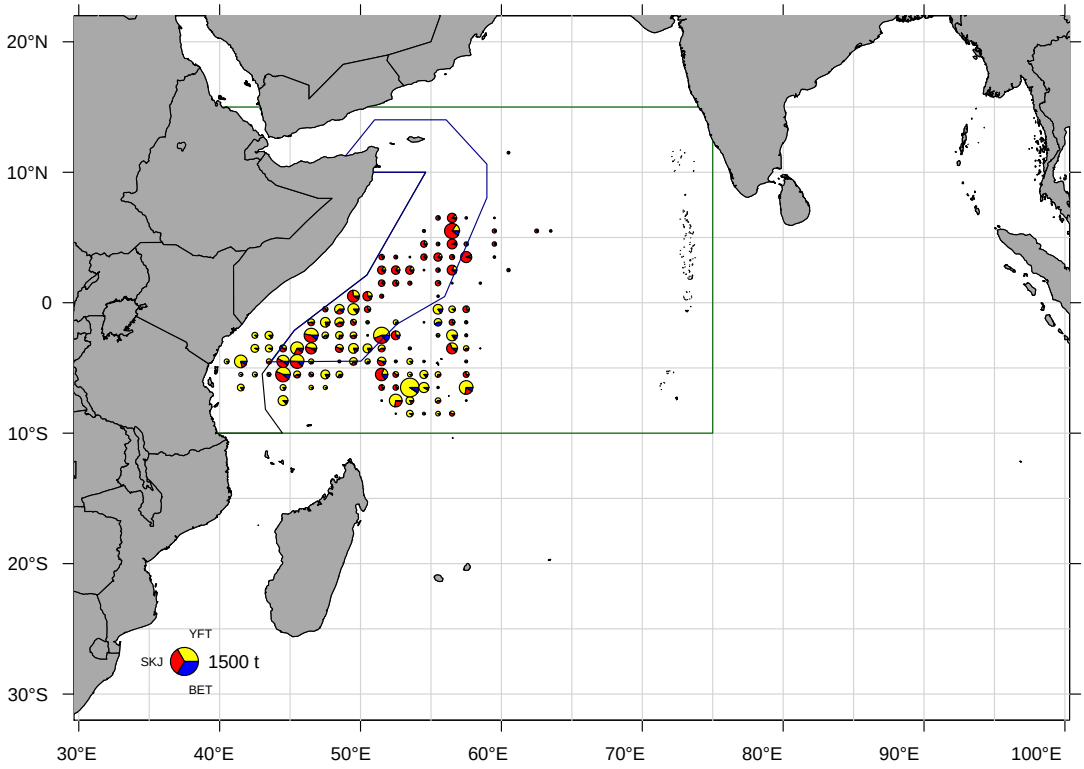
b: June-November 2008

Figure 2: Spatial distribution of the catch for the European purse seine fleet during June-November 2007-2009

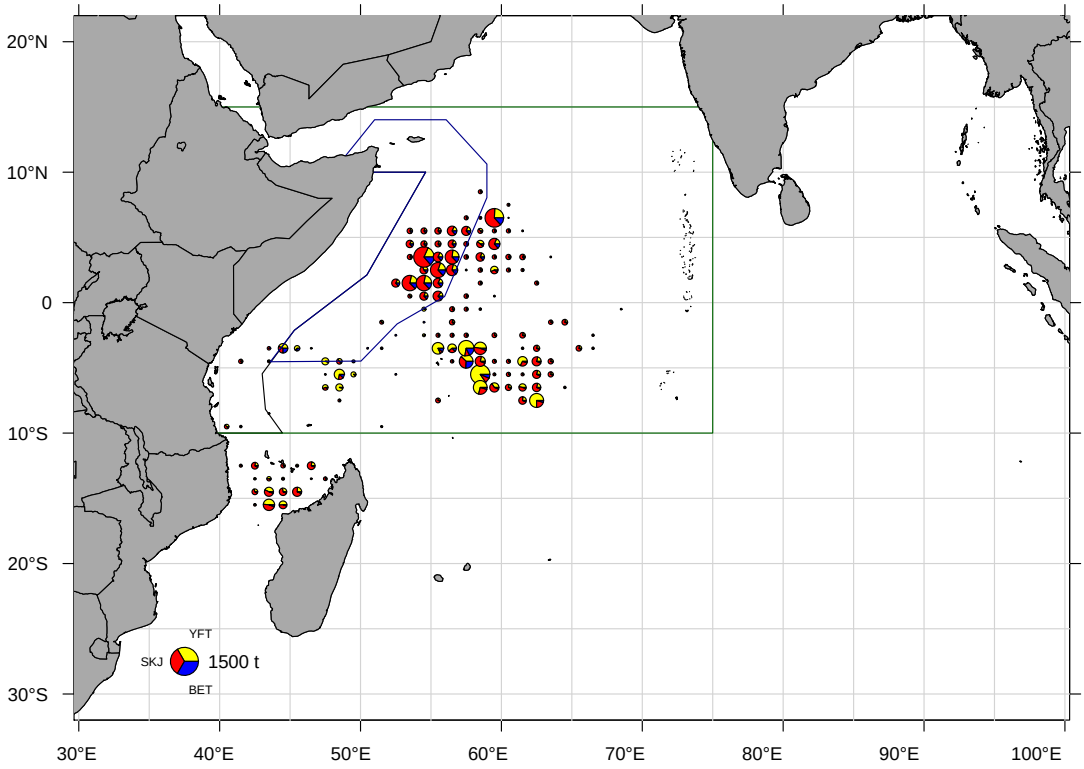


c: June-November 2009

Figure 2: Spatial distribution of the catch for the European purse seine fleet during June-November 2007-2009

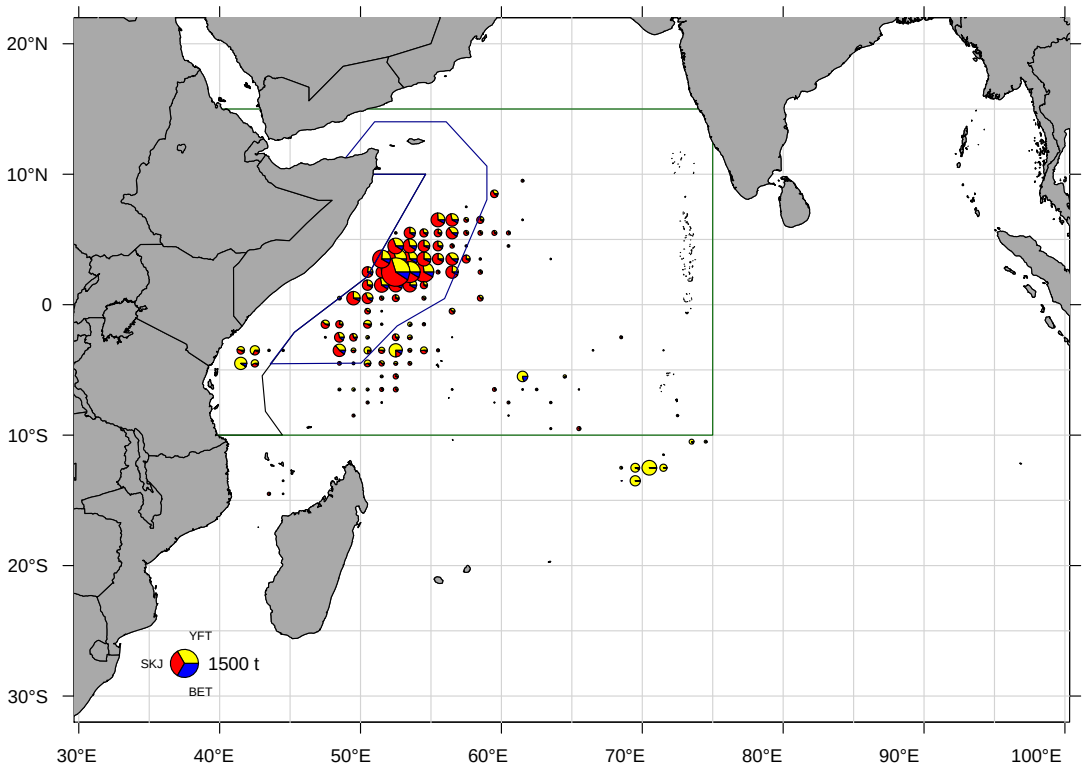


a: June-November 2007



b: June-November 2008

Figure 3: Spatial distribution of the catch for the subset of selected French purse seiners during June-November 2007-2009



c: June-November 2009

Figure 3: Spatial distribution of the catch for the subset of selected French purse seiners during June-November 2007-2009

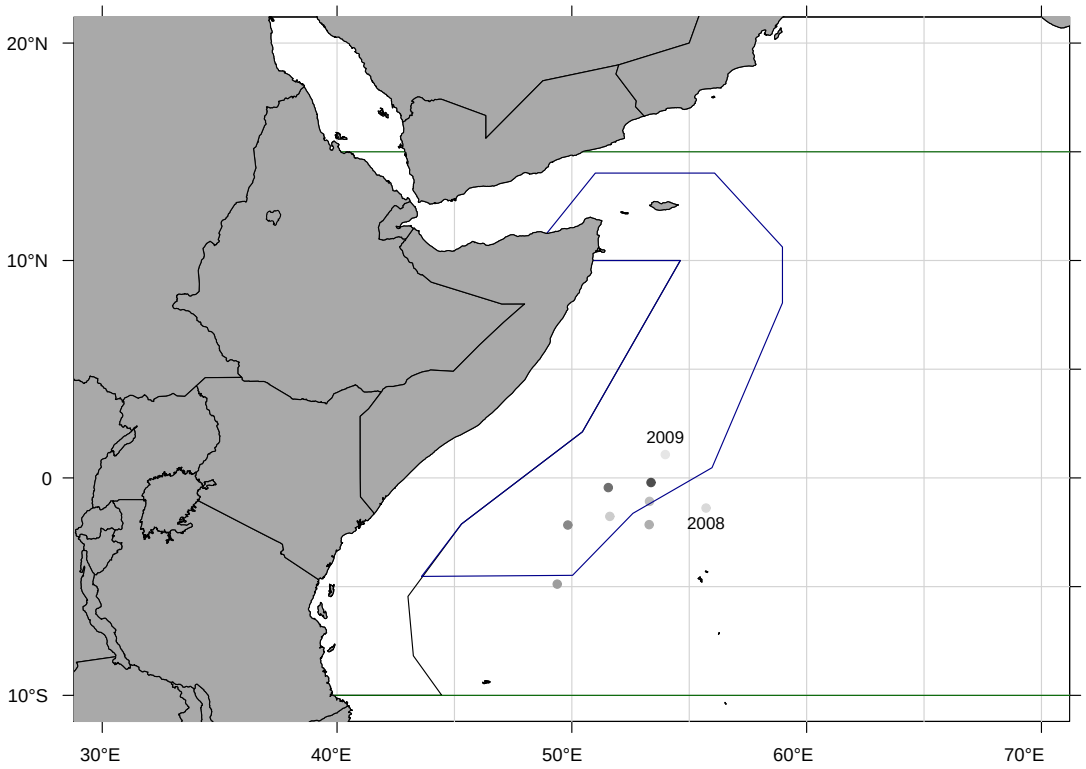


Figure 4: Centroid of the catch of the French purse seine fleet on log-associated and free swimming schools during June-November 2001-2009. Grey scale indicates years from black (2001) to lightgrey (2009)

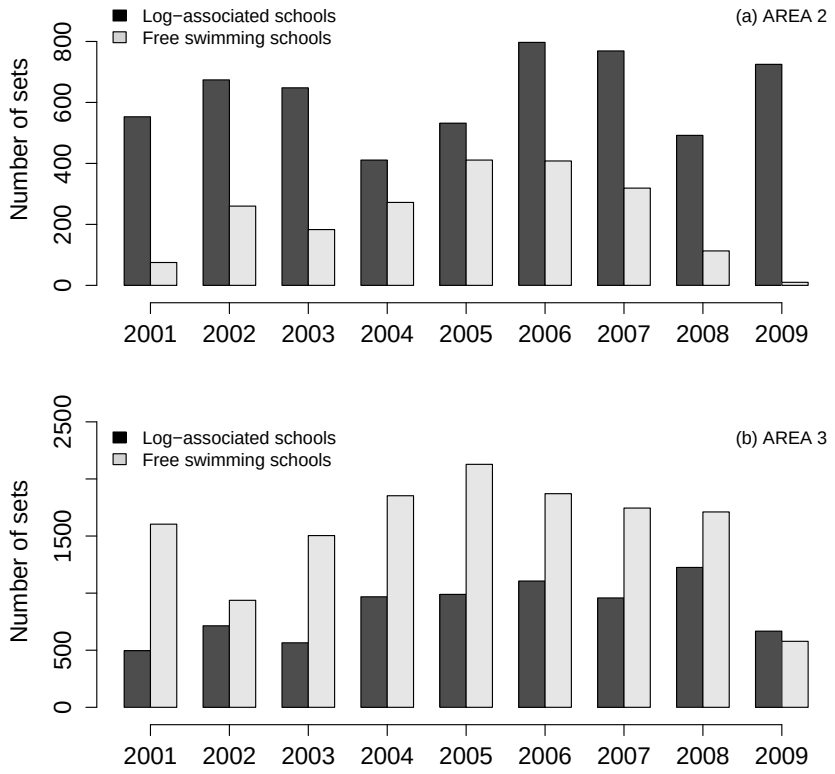


Figure 5: Number of sets on log-associated and free swimming schools for the French purse seine fleet during 2001-2009 in (a) the purse seine fishing exclusion zone (area 2) and (b) the northeast equatorial part of the Western Indian Ocean (area 3)

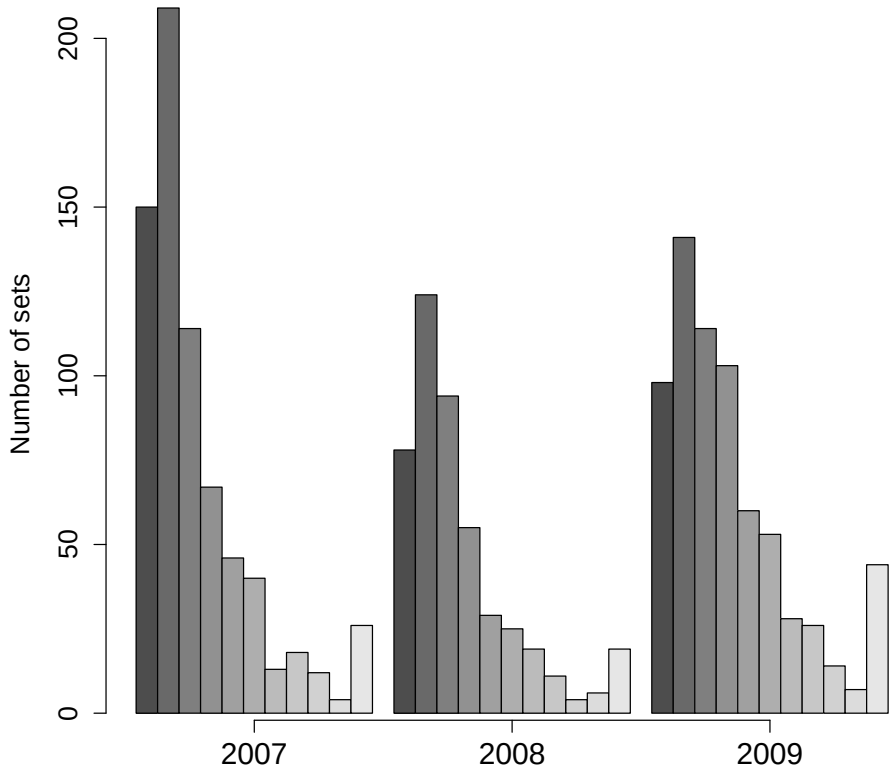


Figure 6: Number of sets by class of set size (t) on log-associated for the French purse seine fleet during 2007-2009 in the purse seine fishing exclusion zone (area 2). Barplots are given by steps of set size of 10 t, from 0-10 t (left black bar) to >100 t (right white bar)

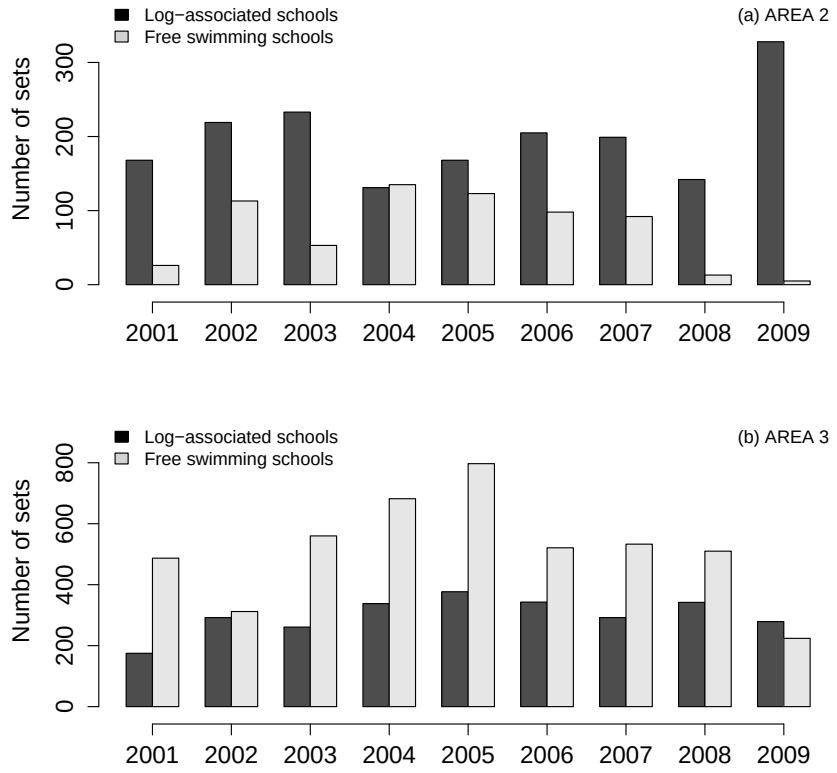


Figure 7: Number of sets on log-associated and free swimming schools for the subset of vessels from the French purse seine fleet during 2001-2009 in (a) the purse seine fishing exclusion zone (area 2) and (b) the north equatorial Indian Ocean (area 3)

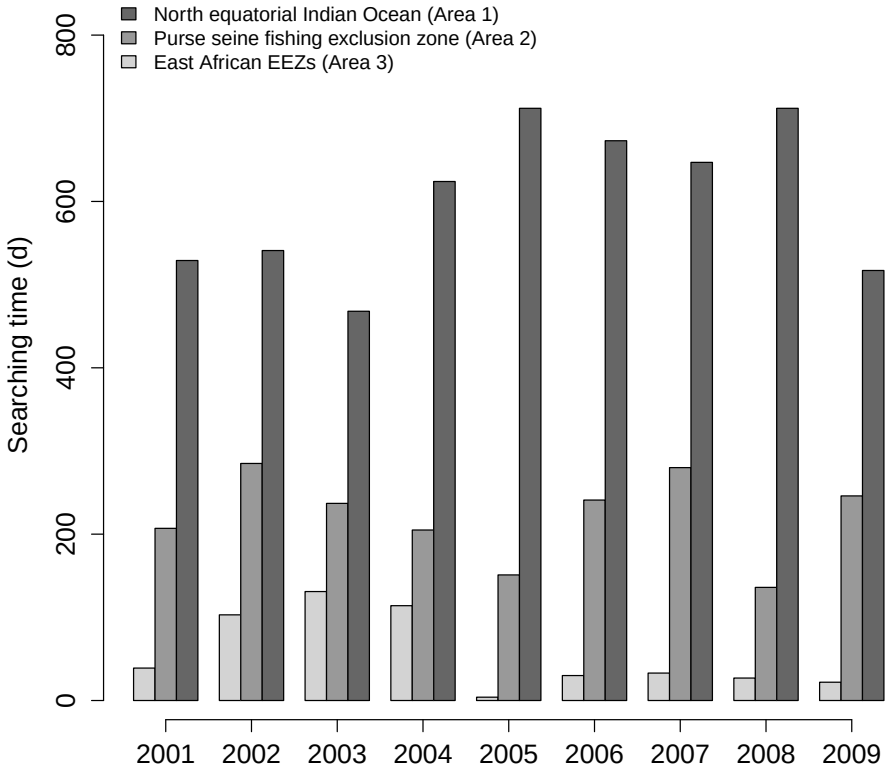
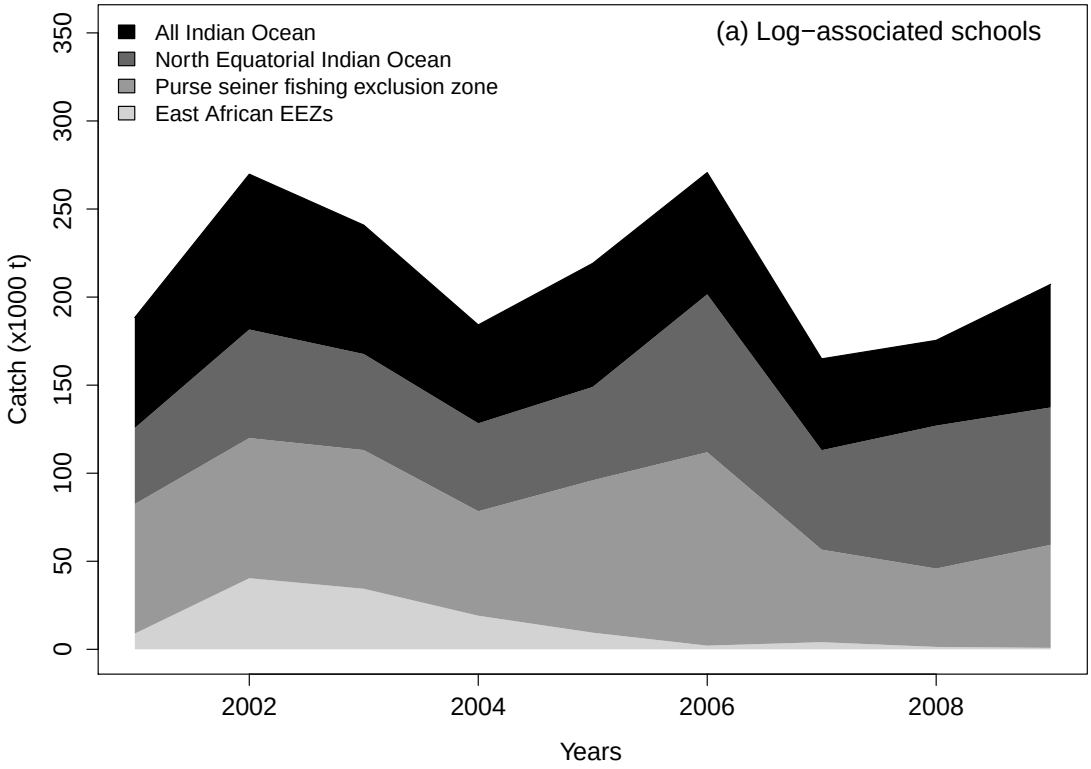
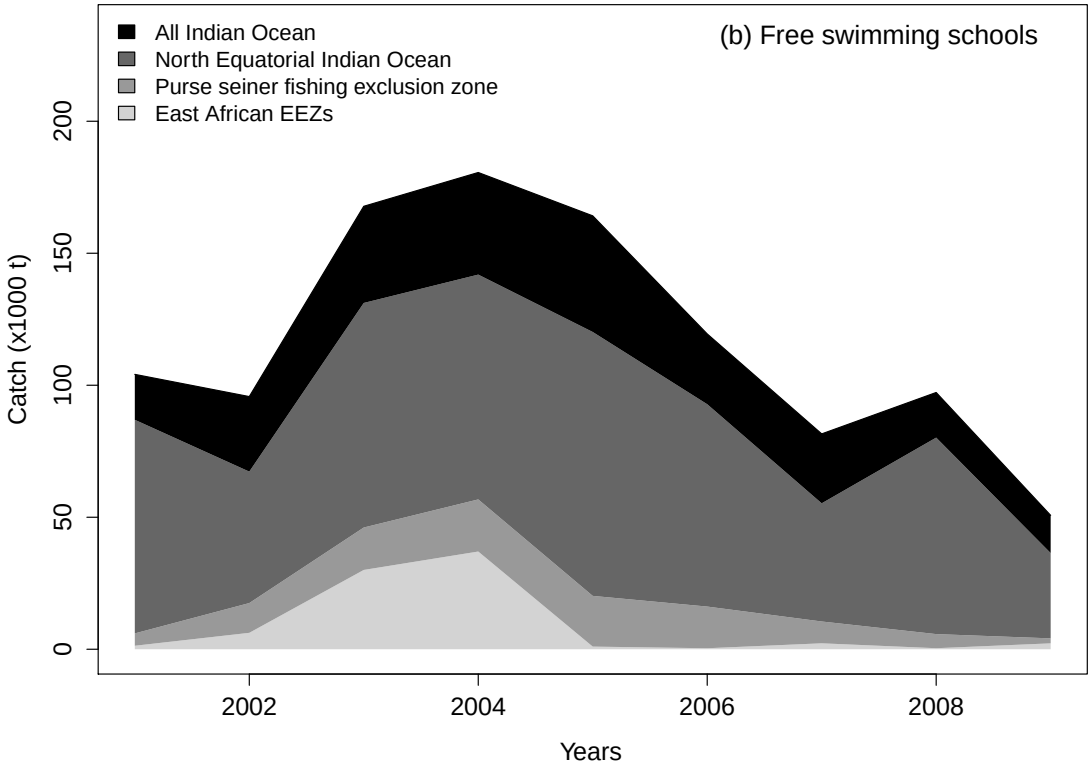


Figure 8: Fishing effort in searching days for the subset of vessels from the French purse seine fleet during 2001-2009

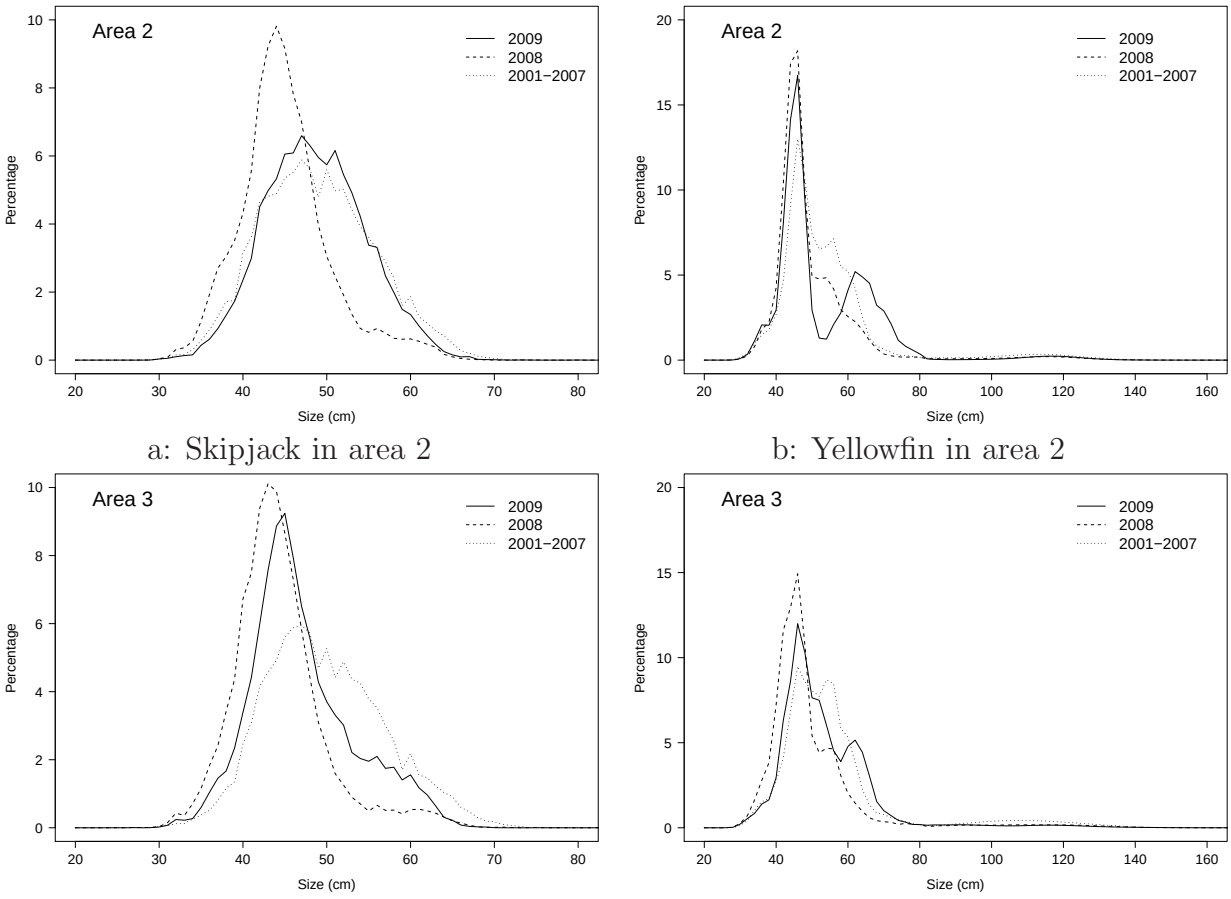


a



b

Figure 9: Total catch by area of the European purse seiners during 20001-2009 on (a) log-associated schools and (b) free swimming schools



a: Skipjack in area 2

b: Yellowfin in area 2

c: Skipjack in area 3

d: Yellowfin in area 3

Figure 10: Size distribution of skipjack and yellowfin caught on log-associated schools during 2001-2009 in (a-b) the purse seine fishing exclusion zone (area 2) and (c-d) the northeast equatorial part of the Western Indian Ocean (area 3)