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On the recent steady decline of skipjack caught by purse seiners in free schools sets in the eastern Atlantic and western Indian oceans.

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Summary

This paper is making an analysis of the species composition and the relative importance of skipjack in the free schools catches of the EU purse seiner fleets in the Atlantic and Indian oceans. This paper shows during recent years simultaneous changes and a steady decline of skipjack in the free schools catches simultaneously occurring in the two oceans. It is concluded that the potential causes of this decline should be better analyzed by scientists, but that this change could probably be due to the increased and very large numbers of FADs that have been seeded by purse seiners during recent years. In this hypothesis, most of the skipjack stocks would be today abandoning their original free schools and would now be associated to FADs. This biological change would follow a trend already observed from observer data in the Atlantic during the 1980-2000 period.

1-Introduction

It has been recently noticed by some ICCAT and the IOTC scientists that changes have been recently occurring in the species composition of free schools catches, and especially a decline in the proportion of skipjack in the free schools sets. The goal of this working paper is to examine the nature, period and scale of these changes and to discuss its potential causes.

2-Material and methods

This work is primarily using the basic catch & effort statistics by 1° and by fishing mode (free schools or FADs) that have been submitted to the ICCAT and to the IOTC by the EU scientists for their purse seine fisheries. These files have been used to make average fishing maps of skipjack caught in free schools during various periods and to calculate the yearly nominal CPUEs of skipjack in the free school fishery (combining all the EU and associated flags purse seiners independently of their flags) and the yearly percentages of skipjack in the free schools sets. This work is also using the basic sampling data obtained on the EU purse seiners landed catches, i. e. the multispecies size samples converted to their

equivalent in weight sampled by species and by 1° square (the so called SPECIES file described by Fonteneau et al 2007). This files allows to do ternary plots (as described by Fonteneau & al 2009) that are showing well the changes in the sampled species composition in any peculiar time and area strata.

3-Results

3-1- Atlantic Ocean

Figure 1 is showing that (1) when skipjack was significantly caught in free schools with quite high CPUEs during most years of the 1992-2005 period (left), (2) Free school skipjack CPUEs have been quite low during recent years. Based on this figure, fishing maps of skipjack caught in free schools sets will be made during 2 distinct periods: the historical period 1991-2005 showing quite high CPUEs and the recent period showing lower CPUEs (2006-2013).

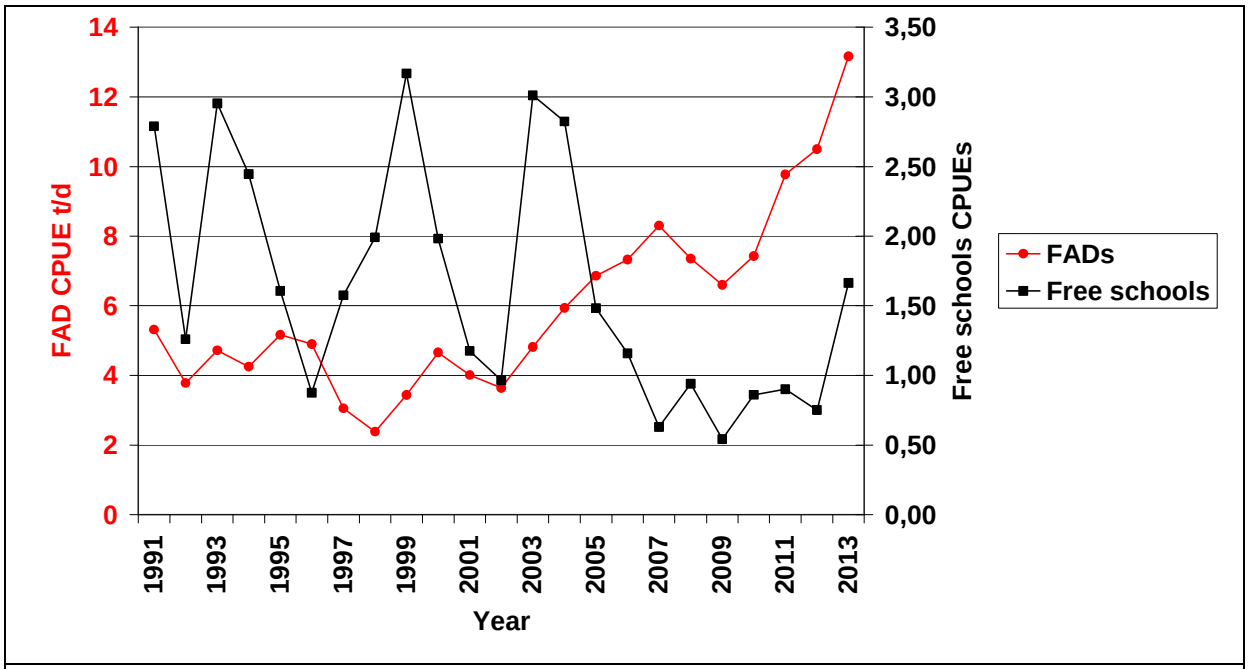


Figure 1. Yearly skipjack free schools and FADs CPUEs of the EU and associated flags purse seiners in the Eastern Atlantic.

This figure is showing that, after a 1991-2004 period of stable nominal CPUEs (average 4.3 t/d), these FAD nominal CPUEs of skipjack have been widely and steadily increasing since 2004 and reaching level over 13t/day in 2013. On the opposite, when the free schools CPUEs of skipjack were fluctuating without trend during the early years (average CPUE= 2.0t/day), they are now fluctuating at a lower average level of only 1.0 t/day. When the ratio of the average nominal skipjack FAD and free schools CPUEs was at a level of 2.1 during the early period, it has been reaching an average level of 8.7 during recent years. It can also be noted that the average catch per set of skipjack caught in each free school sets has been showing a marked decline since 2006 (average catch per set during the 2006-2013 at 3.8 t/positive set, i.e. about half of the catch per set observed during the previous period 1991-2005 (EU purse seiners, data sets built during the ICCAT WG in 2014).

The average yearly percentages of skipjack in the free schools catches are also an important factor to consider (figure 2). This figure tend to show a decline in the percentage of

skipjack in the free schools fishery: an average of 24 % of skipjack in these catches during the 1991-2004 period, and an average of only 14 % of skipjack since 2004.

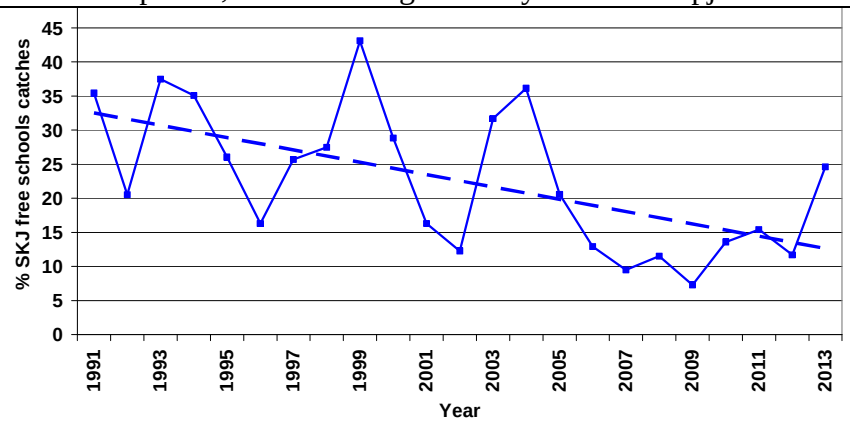


Figure 2: Percentage of skipjack sampled in the free school catches of EU and associated flags purse seiners caught in the eastern Atlantic Ocean .

This decline of the amount of skipjack caught in free school sets is also well visible on fishing maps of recent years (figure 3b), compared to historical fishing maps (3b).

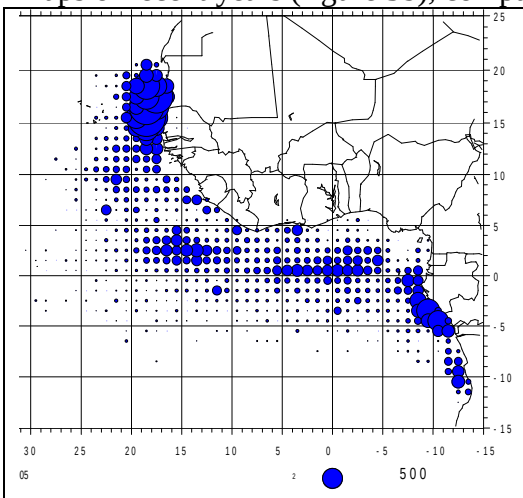


Figure 3a: Average skipjack catches /EU purse seiners on Free schools sets 1991-2005

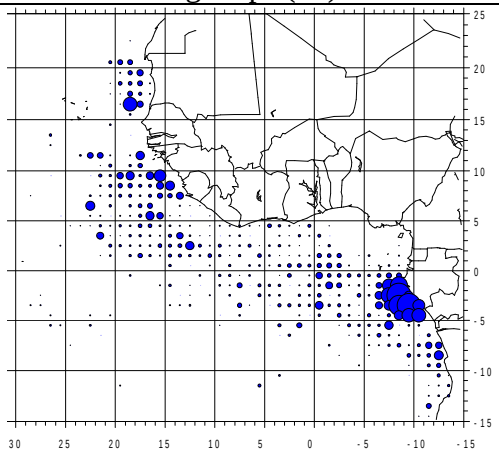


Figure 3b: Average skipjack catches /EU purse seiners on Free schools sets 2006-2013

These 2 fishing maps are showing major changes and a major shrinkage in the free schools skipjack fishing zones in the Atlantic, the Cape Lopez area being now the only area still showing significant skipjack catches on free schools during recent years.

It is also important to examine the changes in the species composition of free schools sets at the level of the entire fishing zone. This result is well shown by the DeFinetti plots that are showing the frequency (in percentage) of each of the multispecies composition in weight of the yellowfin, skipjack and bigeye in the very large numbers of samples collected in the Atlantic (and also in the Indian ocean) by scientific staff during the landing operations in Abidjan and in Dakar (Fonteneau & al 2009).

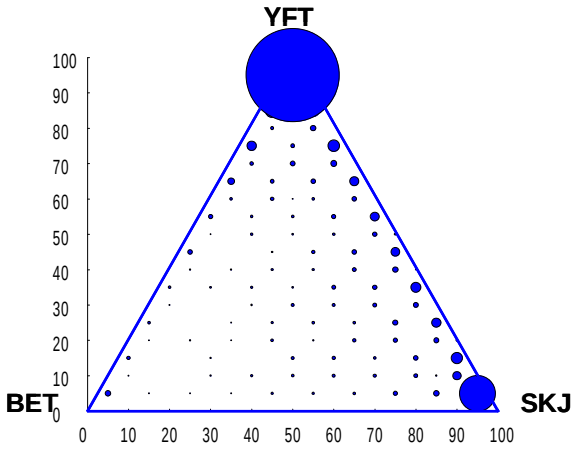


Figure 4a: Definetti plot of Atlantic free schools sets species composition based on all the samples caught during an historical period 1991-2005

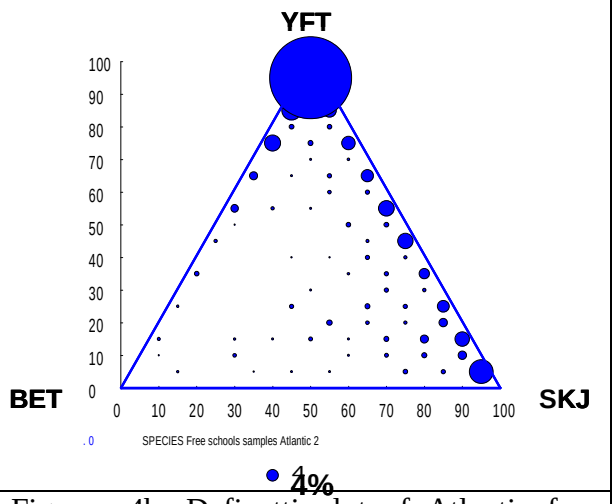


Figure 4b: Definetti plot of Atlantic free schools sets species composition based on all the samples caught during recent years 2006-2013

This figure shows that the pattern of free schools samples species composition was quite similar between the 2 periods, both periods being widely dominated by pure yellowfin samples (most often large yellowfin): 69% and 63% of pure yellowfin samples during the 2 periods. However, it should be noticed that there was also between the 2 periods a marked decline in the proportion of pure skipjack free schools from 10 % to 5 % of the sampled schools.

3-2- Indian Ocean

Figure 5 is showing that (1) when skipjack was significantly caught in free schools with quite high CPUEs during most years of the 1992-2005 period (average CPUE over 2t/day) (left), (2) Free school skipjack CPUEs have been steadily declining during recent years, and they are very low in 2013. Based on this figure, fishing maps of skipjack caught in free schools sets are made during 2 distinct periods: the historical period 1990-2006 showing quite high CPUEs and the recent period showing lower CPUEs (2007-2013). When the ratio of the average nominal skipjack FAD and free schools CPUEs was at a level of 4.6 during the early period, it has been reaching an average level of 10.7 during recent years.

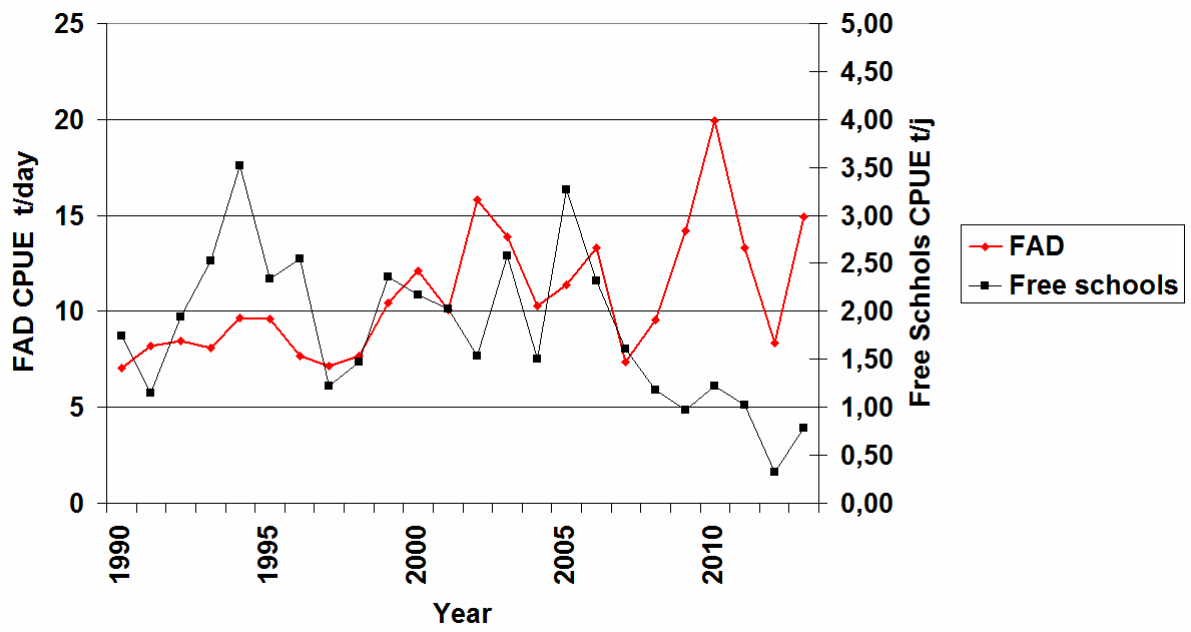


Figure 5. Yearly skipjack free schools and FADs CPUEs of the EU and associated flags purse seiners in the Indian Ocean.

The average yearly percentages of skipjack in the free schools catches are also an important factor to consider (figure 6). This figure tend to show a decline in the percentage of skipjack in the free schools fishery: an average of about 30 % of skipjack in these catches during the early years and an average of about 10 % of skipjack in 2012-2013 .

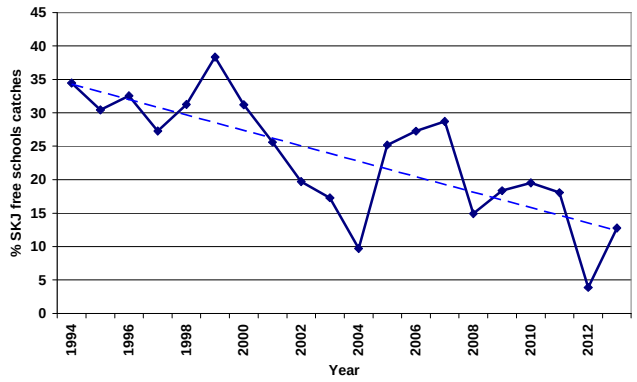


Figure 6: Percentage of skipjack in the free school catches of EU and associated flags purse seiners caught in the Indian Ocean

Untill recently, skipjack caught in FS were significant in quantities: **25** % of total Free Schools catches, but a majority of these skipjack free schools catches were obtained on peculiar schools with dominant skipjack, these skipjack schools being also caught in peculiar

time & area strata, & not at all in the entire free schools fishing zones, that are widely driven by schools of pure large yellowfin.

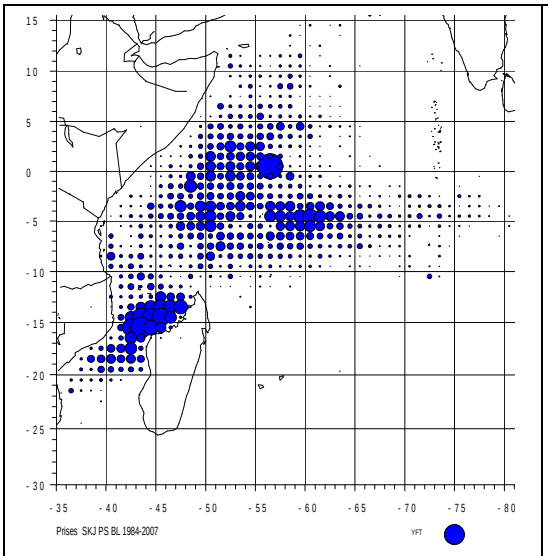


Figure 7a: Average skipjack catches /EU purse seiners on Free schools sets 1991-2006

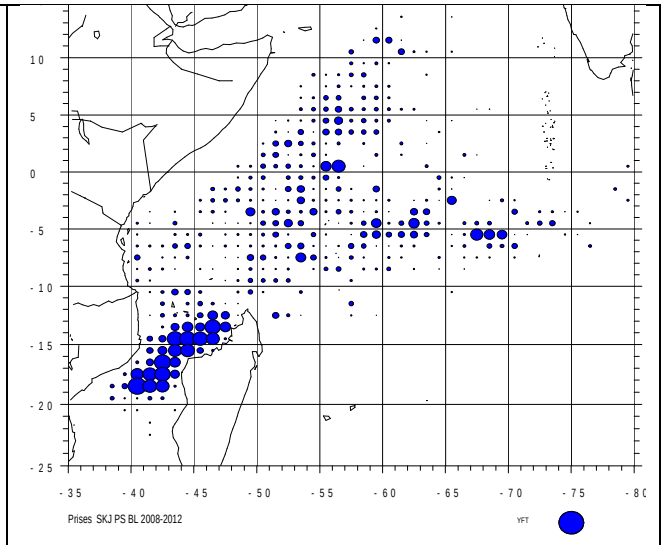


Figure 7b: Average skipjack catches /EU purse seiners on Free schools sets 2007-2013

The DeFinetti plots have been also used to examine changes in the free schools sets samples collected in the Indian ocean) by scientific staff (mainly in Victoria, but also in various other ports) during the landing operations (Fonteneau and al 2009).

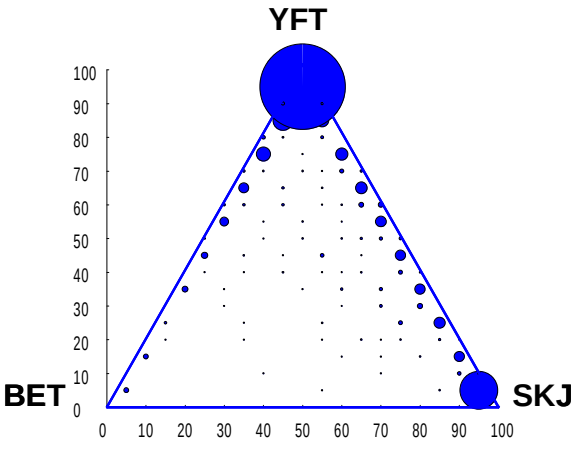


Figure 8a : Definetti plot of Indian Ocean free schools sets species composition based on all the samples caught during an historical period 1991-2006

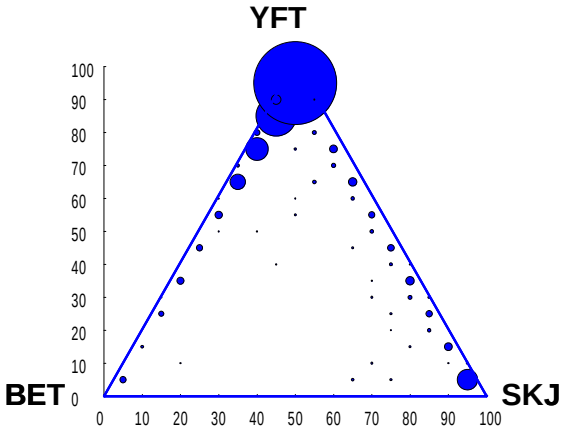


Figure 8b : Definetti plot of Indian Ocean free schools sets species composition based on all the samples caught during recent years 2007-2013

This figure shows that the pattern of free schools samples species composition was quite similar between the 2 periods dominated by 64% of pure yellowfin samples; however, it

should be noticed that there was a marked decline in the proportion of skipjack and especially a decline of pure skipjack schools from 12.5% to 4% of the sampled schools.

It should also be noted that another remarkable and unexplained change in the species composition of the tuna schools has been also observed in 2012 & 2013 for FAD sets in their main FAD fishing grounds off Somalia: when skipjack was by far the dominant species in this fishery since its beginning, it has been noticed that in 2012 and 2013, yellowfin catches were equivalent or dominant ones in the FAD catches in this area, see figure 9 showing this major change in the species composition. It should also be noticed that these much larger catches of yellowfin associated to FADs were showing the typical quite small sizes of this group of tunas at an average weight under 5 kg.

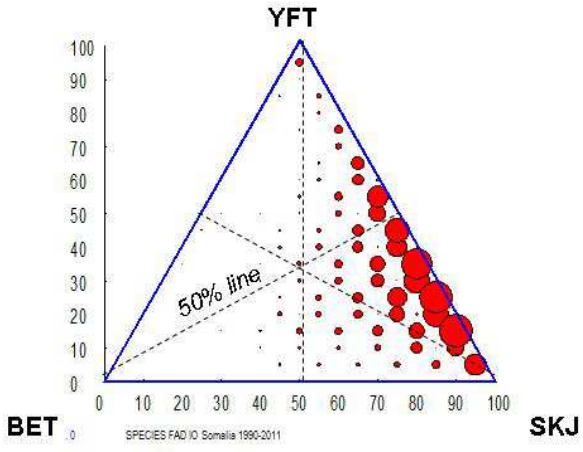


Figure 9a Historical Definetti plot of FAD schools sets samples in the Somalia area: period 1990-2006

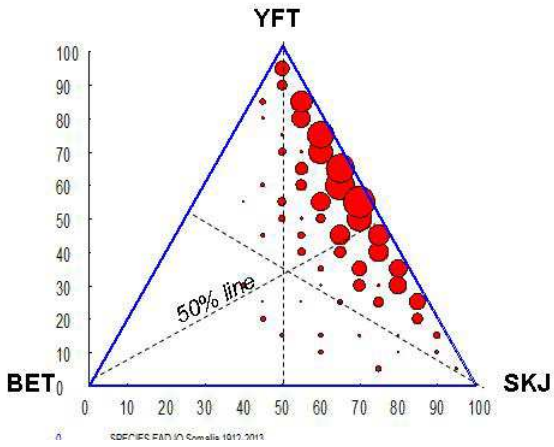


Figure 9b Today Definetti plot of FAD schools sets samples in the Somalia area: period 2007-2013

It should be recognized that this important biological change remains widely unexplained: it may simply be due to large and increasing recruitments of yellowfin (probably an unrealistic hypothesis?), and/or to low skipjack recruitments. It may also be due to unknown changes in the configuration of FADs that would increase the FAD catchability of small yellowfin. This change may also be linked to the very numbers of FADs that have been released by purse seiners during recent years in the area. Causes and mechanisms of this important change in species composition of FAD catches remains unexplained but they should be investigated.

3-3- Overview of these skipjack declines

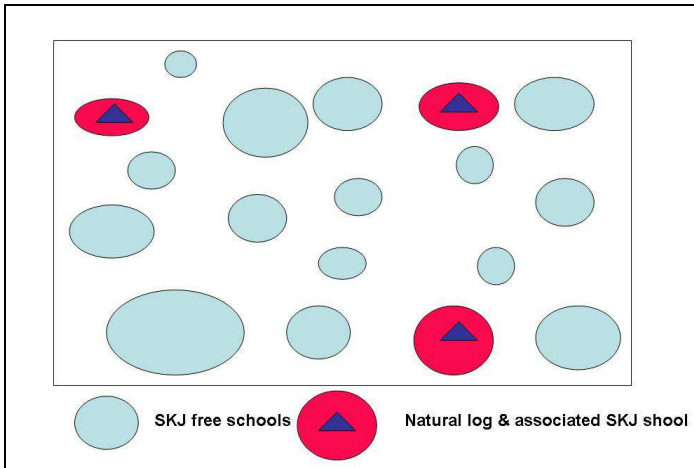
The changes that have been simultaneously observed during recent years in the catches and CPUEs of free schools skipjack sets in both the Atlantic and the Indian oceans are clearly remarkable ones. It is striking that such major changes have not yet been fully analyzed and discussed by ICCAT or IOTC scientists, but these changes should clearly be better analyzed and explained by scientists. This wok should preferably be conducted in close cooperation between the ICCAT & the IOTC scientists, because of the great similarities in the events that have been observed in the 2 oceans.

4- Discussion: why these marked simultaneous declines of skipjack caught in free schools?

Skipjack caught in free schools are most often mixed with other species, especially small yellowfin, and sometimes in minor quantities with large yellowfin. The observed declines observed in the free schools skipjack abundance are in fact probably quite trivial and easy to understand, and simply occurring because of the following reasons:

(1) During the early periods of the purse seine fisheries (before 1990) there were relatively few natural logs drifting in the Atlantic and in the Indian oceans, and these logs were mainly coastal, and concentrated in peculiar time and area strata, close to the major rivers. On the other side, the skipjack biomass was probably higher during this early period, simply because of the lower skipjack catches (and lower fishing mortality: in the early periods, the skipjack stock was not far from its virgin status): in this context of a large skipjack biomass and of quite rare floating logs, most skipjack had no choice but to live and to travel either in free schools in pure skipjack schools, or mixed with juvenile yellowfin and bigeye. This basic arithmetic of the skipjack biomass and numbers of floating objects explains well why skipjack were commonly caught in free schools sets in the early purse seine fisheries (figure 10a).

(2) During recent years, when very large numbers of FADs have been seeded everywhere in the intertropical skipjack habitat. Knowing the strong behavioural tendency of skipjack to be associated with floating objects, it is not surprising that a large fraction of the skipjack stocks are now associated to FADs, and then more seldom caught in free schools (figure 10b). This rule would also potentially apply to small yellowfin and small bigeye that are also sometimes caught in free schools sets, but that are also showing a strong behavioural tendency to be associated to FADs. This decline in the free schools skipjack biomass probably took place under a combination of 2 processes: a decline in the numbers of free schools and/or a decline in the sizes of these schools. It should be kept in mind that when tuna schools are too small in size (for instance smaller than 5 or 10 tons), and then they will not be interesting for purse seine fishermen and they will not be visible in the catch & effort fishery data. These basic conceptual changes in the numbers of floating objects and in the sizes of skipjack free schools are tentatively shown by the following figure 10.



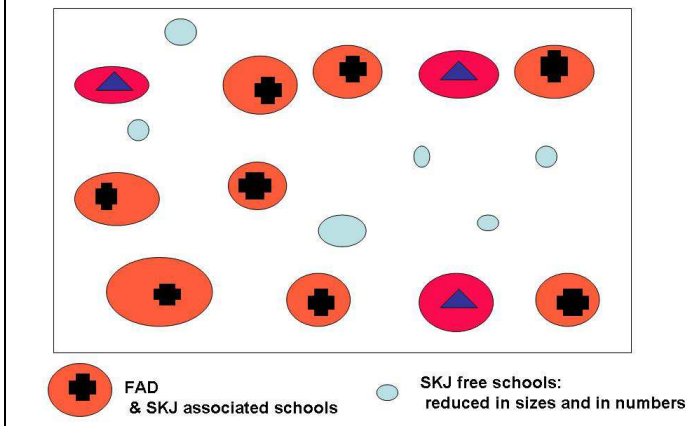


Figure 10: Conceptual changes in the numbers of natural logs and numbers/sizes of skipjack schools in the early purse seine fisheries before 1990 (10a: upper figure), and today after the seeding of very large numbers of artificial FADs (lower figure 10b)

It should be noticed that this decline in the frequency of skipjack (and also of small yellowfin and bigeye) in free swimming schools has been also observed in the Atlantic ocean from observer data during the period 1980-1998, i.e. at the beginning of the FAD fisheries. This decline was analyzed and discussed by Fonteneau and al 2000. It was already hypothesized in this paper that this decline of small tunas in free schools was probably due to the increase of artificial FADs.

As a consequence, it should be envisaged that the relationship between free school biomass & free schools CPUEs are not linear ones, CPUEs probably showing excessive declines when free schools sizes are too small to be profitable for purse seine sets. The concept of this non linear relationship is shown by the following figure 11.

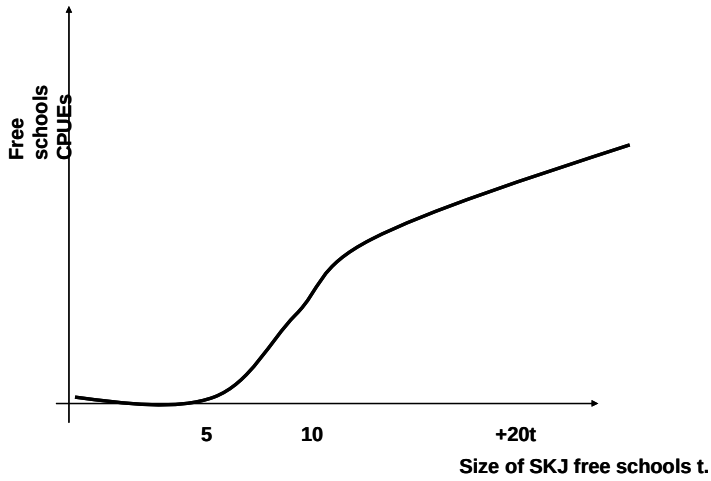


Figure 11: Conceptual expected relationship between the sizes of the schools (3 species combined) and the CPUEs

However, it should be kept in mind that this relationship would solely be valid for purse skipjack free schools that are in fact quite rare in both the Atlantic & Indian oceans (figure 4 and 8): a great majority of the skipjack caught in free schools sets are caught in multispecies sets and seldom in pure skipjack sets.

Alternate hypothesis explaining these declines of skipjack apparent abundance should of course be explored by scientists, but at this stage there are strong reasons to consider that this decline probably correspond to SKJ behavioural changes and to FADs, not to corresponding declines in the stock biomasses.

5- Conclusion

This analysis of the basic IOTC & ICCAT catch/effort data has been showing that major declines in the apparent abundance of free schools skipjack have been observed in the purse seine fisheries during recent years in both the Atlantic and Indian oceans. These declines are probably due to the steady increase of very large numbers of FADs released by purse seiners during the last 10 years in these 2 oceans. In this hypothesis, these observed declines in skipjack free schools CPUEs would have very little to do (or nothing) with declines in the skipjack stock biomass (as it was assumed by Sharma et al 2012 in their stock assessment analysis of the skipjack stock in the Indian ocean). On the other side, these major changes would simply appear to be one of the visible consequences of FAD being ecological traps: most of the skipjack biomass in the Atlantic & IO being now more or less permanently associated to FADs and then following the movement patterns of FADs, that are primarily driven by surface currents instead of showing the natural movement patterns shown by free schools during millions of years.

Alternate potential hypothesis explaining these changes should also be explored by ICCAT and IOTC scientists.

Litterature

Fonteneau A., J. Ariz, D. Gaertner, V. Nordstrom. and P. Pallares. 2000. Observed changes in the species composition of tuna schools in the Gulf of Guinea between 1981 and

1999, in relation with the Fish Aggregating Device fishery. Aquat. Living Resour. 13(4) 2000, 253-257.

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