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Note

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

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Abstract – This paper compares the species composition of free swimming schools and schools associated with fish aggregating devices (or FADs) observed by scientists in the eastern equatorial Atlantic during the early eighties and late nineties. This comparison shows that in free swimming schools, big changes in the species composition have occurred. The main change is a rarefaction of mixed species free schools (skipjack and small yellowfin or bigeye). This change is probably a real biological one, and possibly a consequence of the large numbers of FADs seeded in the area since 1990. Nowadays, most small tuna living in the equatorial area appear to be concentrated under these drifting FADs instead of in free schools. Further study is recommended in order to evaluate the validity and interpretation of this result and to examine its implications.

tuna / fish aggregating device / FAD / species assemblage / behavior / schools / purse seine fishery / Eastern Central Atlantic

1. INTRODUCTION

The first goal of this paper is to describe the changes in the species composition of tuna schools in the period between 1981 and 1998, using observer data on the purse seine fleet fishing in the Gulf of Guinea. The second goal of the paper will be to discuss a possible explanation for the observed changes.

2. MATERIAL AND METHODS

Data used in this analysis was collected by scientific observers on board of French and Spanish vessels during two scientific programs, the ICCAT skipjack year program and the European Union bigeye tuna observer program. During the first period, 1981–1982 (skipjack year, Symonds et al., 1986), 172 positive sets were observed by scientists on free schools and 25 sets on natural floating objects. During the second period, from June 1997 to May 1999, a larger number of 1 577 positive sets was observed, 665 under (mostly artificial) floating objects, and 912 in free schools.

The comparison of the observed species composition during the two periods is based on a visual comparison of pie charts which show the estimated species composition of these 1 749 individual sets observed by scientists. Only the catches of the three major tuna species, yellowfin *Thunnus albacares*, skipjack *Katsuwonus pelamis* and bigeye *Thunnus obesus*, are shown in these pie charts. These three species are target of fishery and correspond to a large proportion (about 90 %) of the total purse seine catches. There is a potential bias in this observer data, especially in the first series, since some small bigeye may have been misidentified as yellowfin. However, this bias is probably a minor one, because the problem was already well identified in the area from routine species sampling since 1979. The observed sets have

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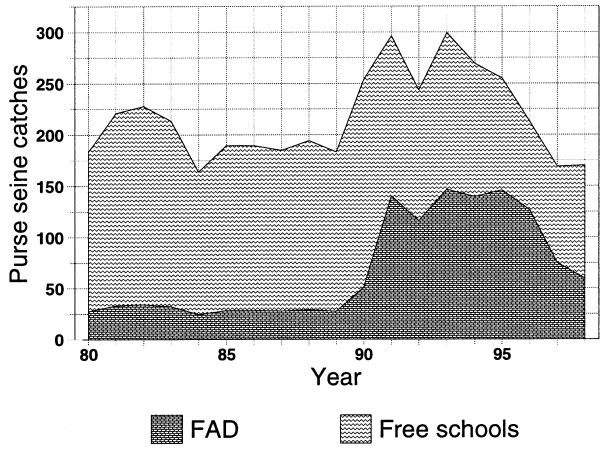

Figure 1. Total yearly catches by purse seine fishers in the Eastern Atlantic: total catches and catches under Fish Aggregating Devices, FADs.

been classified, in fishing zones and for each fishing mode (free schools or floating object schools), during each of the two periods. The average fishing zones of the purse seine fleet and the areas used in the pie chart are shown in *figure 1*. The basic fishery data of the purse seine fisheries (yearly catches, by species and for each fishing mode, free schools and FAD) are also available (ICCAT data) and they are used in order to interpret the observer data. The observed sets have been classified in each area (*figure 2*) by decreasing sizes during the two periods: *figures 3 a* and *b* show the 1981–1982 observations, while *figures 4 a* and *b* show results for the period 1998–1999.

These pie charts show the size and species composition of each set, as they were estimated 'by eye' by the various scientific observers on board French and Spanish purse seine fishers fishing in the Eastern Atlantic, during the fishing operations. During the first

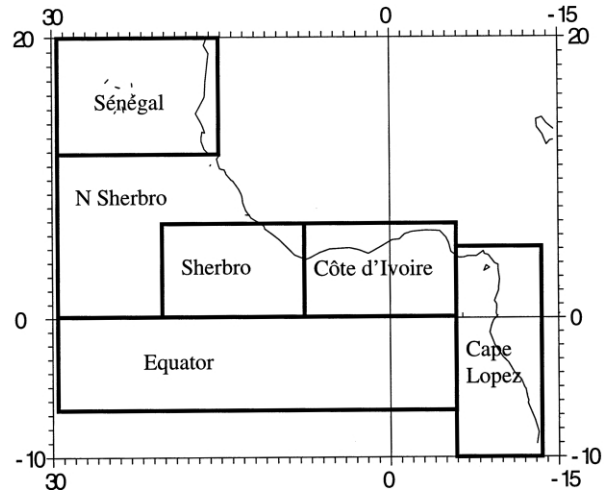

Figure 2. Statistical areas used to compare catches per set.

period, there is a bias in these figures, leading to an underestimation of the proportion of bigeye, since small yellowfin and small bigeye are difficult to distinguish during fishing operations, and also because the primary goal of the 1981–1982 research program was to estimate skipjack catches while bigeye tuna was the target species during the other research program.

3. RESULTS

3.1. Changes in fisheries

The purse seine fishery operating in the Eastern Atlantic has been well followed by scientists during the period covered by the study. A high percentage of log books (about 95%) was available during this period, and their data was submitted yearly to the ICCAT. The ICCAT data base shows that purse seine catches in the area (20° N–10° S, 30° W) form the major component of the Atlantic tuna fishery (purse seine fishers being responsible for about 58 % of the total tuna catch during the period 1980–1998).

Fishery data indicates that until the end of the 1980s, purse seine fishers were mostly fishing (about 85 %) on free schools, whereas only 15 % was taken under natural floating logs (Ariz et al., 1993). The ICCAT data base also indicates that since 1991 an increasing proportion of the catch was taken under artificial floating objects (or Fish Aggregating Devices, FADs). FAD-associated catches reached an average of 50 % of the purse seine catches during the period 1993–1996.

The present number of FADs seeded by fishermen in the Gulf of Guinea is unknown, but there are probably over 3 000 FADs deployed in this area, each equipped with a radio beacon and other accessories (Ménard, personal communication).

3.2. Observations 1981–1982

Even though only 197 positive sets were observed, it appears that the species composition on free swimming or log-associated schools was quite similar in most fishing zones (see *figures 3 a, b*). More important, during this period a large proportion of free swimming schools showed a high diversity in their species composition: often a mixture of yellowfin, skipjack and few bigeye (probably underestimated). This diversity of species composition was observed in all fishing zones, with the exception of the south equatorial area where only pure yellowfin schools were observed. It can also be noticed that various free swimming schools of pure skipjack were observed in the equatorial areas (North Sherbro and Ivory Coast areas, *figure 1*).

3.3. Observations 1998–1999

During this period, a total of 1 577 positive sets were observed, with 39 % under, mostly artificial,

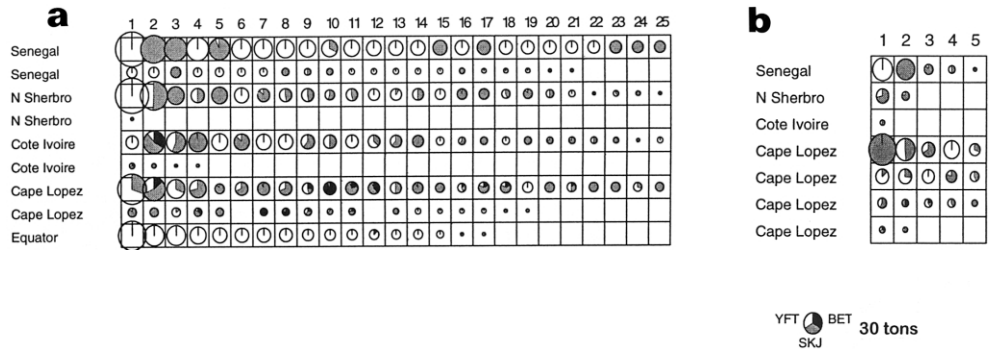

Figure 3. Catches per observed set, for all the observed sets (yellowfin, skipjack, and bigeye) estimated in each area by scientific observers during the 'Skipjack Year Program' (1981) on free schools (a) and on floating log schools (b). The areas used are the statistical areas indicated in *figure 2*. In each area, the sets were classified by decreasing rank of catches.

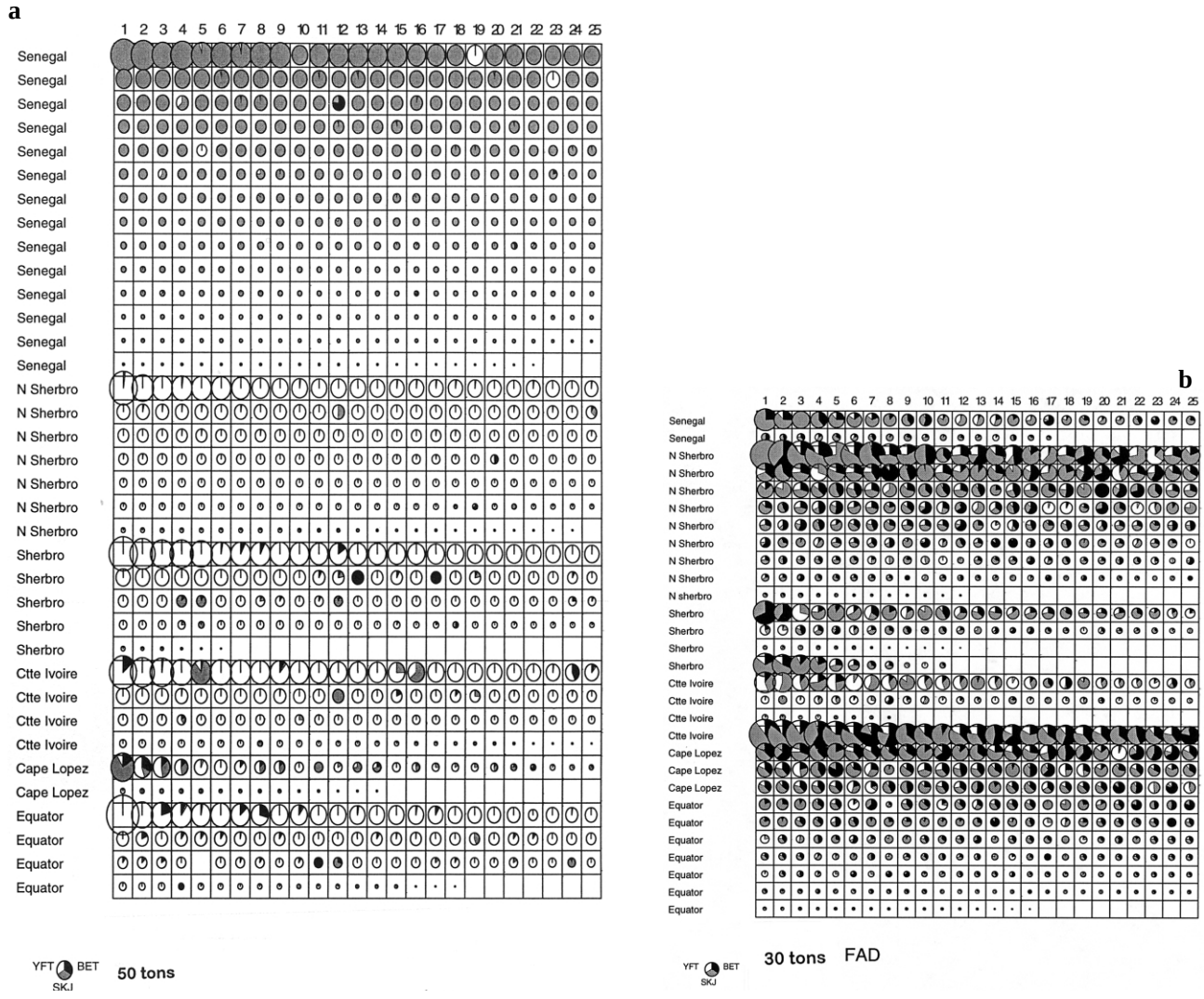

Figure 4. Catches of yellowfin, skipjack, and bigeye estimated in each area by scientific observers during the 'Bigeye Year Program' (1998–1999) in free schools (a), and in FAD-associated schools (b). The areas used are the statistical areas as indicated in *figure 1*. In each area, the sets are have been classified for each fishing mode by decreasing rank of catches.

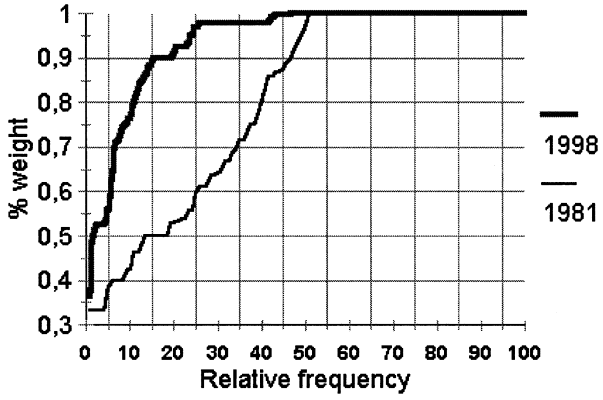

Figure 5. Percentage of the dominant tuna species in the tuna catches of free schools sets, observed by scientists during the Skipjack and Bigeye Programs in the FAD-abundant area south of 10° N, as a function of the numbers of sets observed in each of these two programs (percentage, shown in the *x* axis).

floating objects. It should be noticed that this ratio of FAD sets is quite low compared to the ratios observed during recent years. This was probably an effect of the seasonal moratorium on FADs, which produced a spectacular reduction of FAD-associated catches since 1997, following the closure of the most active FAD strata.

The species composition observed in free or in FAD sets shows very characteristic and different patterns. Free swimming schools were often monospecific: pure skipjack in the Senegal area, or pure yellowfin schools in most other areas. The yellowfin schools which were commonly observed in the Senegal area in 1981 were not observed in 1998. Two areas with generally stable species composition were the Cape Lopez area (mixed species schools) and the Equator area (pure yellowfin schools). Bigeye tuna were rare in most free schools, with some exception in Cape Lopez and Equator areas (where bigeye was observed in 46 % of free schools, with an average catch of 3 tons/set).

In most areas the species composition of FAD-associated sets show a mixture of yellowfin, skipjack and bigeye. These tuna are usually small or medium sized tuna, with an average weight of 2.8 kg for the three species combined (period 1991–1998). Bigeye tuna were observed in most schools, 90 % of FAD-associated sets, and with a significant average bigeye catch of 7.6 tons/set.

3.4. Comparison between the two periods

The comparison of observer data collected during the early 1980s and late 1990s shows striking differences in the observed species composition of individual sets. The major difference can be summarized by the percentage of plurispecific free schools observed during the two periods. *Figure 5* shows the percentages of the dominant tuna species in each observed free school.

During the skipjack program, about half of the free schools (48 %) observed in the FAD-abundant area south of 10° N were mixed species tuna schools (such a school being defined as a school in which the dominant tuna species forms less that 95 % of the total tuna catch in weight).

During the bigeye program, only 23 % of the same free schools observed in this area were mixed species schools.

For free swimming schools, a positive set usually catches the entire tuna school. Therefore the changes in catch per free school set will probably reflect changes in the school species composition. Unfortunately the statistical significance of these differences cannot be determined because of the low number of observations and because of the heterogeneity of the species composition in time and space. However, the hypothesis that these changes may correspond to real biological changes due to fishery deserves to be studied. It is important to better understand the potential causes and implications of these surprising changes.

4. DISCUSSION

At this stage, the working hypothesis is that free plurispecific schools of small tuna (skipjack, small yellowfin, and bigeye) were common during the early 1980s, but became rare during the late 1990s. It should first be noted that this decreased number of plurispecific schools with small tuna cannot be explained by a decreasing recruitment (for instance to a recruitment failure), primarily because the total number of small tuna caught in the area has been increasing or fluctuating without trend during the period.

A logical explanation may be that this change is a real one, and that it is due to the large number of FADs presently deployed in the equatorial area. Under this hypothesis, most (or nearly all) of the small tuna in the equatorial area (which is considered as a nursery and recruitment area for yellowfin, skipjack, and bigeye) are now concentrated under FADs, instead of being within free swimming schools or under the rare natural logs drifting in the coastal zones. If this conclusion is valid, this would imply that:

— small tuna in this area do show a strong behavioral association with FADs,

— because of this strong association, the large numbers of FADs presently seeded in the area may modify the vulnerability of small tuna to the purse seine fishers, and

— the traditional (e.g. before FADs) movement patterns of tuna and their biological characteristics may be modified in relation with the large numbers of FADs recently deployed in the area (Marsac et al., 2000).

5. CONCLUSION

It is too early to conclude firmly from the present observations, and further studies should be carried out as soon as possible in order to clarify the potential changes in the species composition of tuna schools in relation with the massive development of FADs. Priority should be given to the analysis of observations made during two other research programs that were not available during the present study; the ICCAT yellowfin year program conducted in 1987, before FADs, (with 102 positive sets observed), and the EU program conducted in 1995 (290 positive sets observed) upon fauna associated with tuna (Stretta et al., 1997). A comparative analysis with data from the eastern Pacific, another fishing zone with massive use of FAD and with large observer programs run by the IATTC, should also be analyzed in order to examine if similar changes were observed in the species composition of free schools. Furthermore, all potential implications for stock assessment and stock management of such rapid and important changes in the schooling behavior of tuna should be thoroughly evaluated.

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