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NOTE ON THE YELLOWFIN CATCH AT SIZE BY LONGLINERS AND BY PURSE SEINERS IN THE ATLANTIC AND INDIAN OCEANS

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SUMMARY

This note makes a comparison between the yellowfin tuna (YFT) catch at size (CAS) of purse seiners (PS) and of longliners (LL) in the Atlantic and in the Indian Oceans. It shows that when the CAS of pursers and longliners are nearly identical in the Indian Ocean, they are widely different in the Atlantic, with yellowfin caught by purse seine being much larger than for longline-caught yellowfin. These differences may be artificial, for instance, being due to bias in the conversion between predorsal length (LD1) PS samples to fork length CAS, or to insufficient sampling of LL catches. It may also be due to the differential fishing zones of the two gears, PS fisheries being concentrated in the Gulf of Guinea where larger yellowfin are predominant. This heterogeneity in size caught probably corresponds to distinct selectivities at age exerted by these two gears. This differential pattern of selectivities should be better studied and introduced in the stock assessment models that are not stratified by areas, such as virtual population analysis.

RÉSUMÉ

Ce document présente une comparaison entre la prise par taille (CAS) de l'albacore (YFT) des senneurs (PS) et des palangriers (LL) dans les océans Atlantique et Indien. Il montre que les CAS des senneurs et des palangriers sont presque identiques dans l'océan Indien, mais sont très différentes dans l'Atlantique, les albacores capturés à la senne étant beaucoup plus grands que les albacores capturés à la palangre. Ces différences peuvent être artificielles, en raison par exemple du biais de la conversion de la longueur prédorsale (LD1) des échantillons capturés à la senne en CAS de longueur à la fourche ou en raison de l'échantillonnage insuffisant de prises réalisées à la palangre. Ces différences peuvent également s'expliquer par les différentes zones de pêche des deux engins, les pêcheries de senneurs se concentrant dans le golfe de Guinée où les albacores de grande taille sont prédominants. Cette hétérogénéité des tailles des spécimens capturés correspond probablement à diverses sélectivités par âge exercées par ces deux engins. Ce schéma de sélectivité différentiel devrait faire l'objet d'études plus approfondies et être inclus dans les modèles d'évaluation des stocks qui ne sont pas stratifiés par zone, tels que l'analyse de population virtuelle.

RESUMEN

En este documento se realiza una comparación de las capturas por talla (CAS) de rabil (YFT) realizadas por los cerqueros (PS) y los palangreros (LL) en los océanos Atlántico e Índico Demuestra que cuando la CAS de los cerqueros y los palangreros son casi idénticas en el océano Índico, son muy diferentes en el Atlántico, siendo el rabil capturado por los cerqueros mucho más grande que el rabil capturado por los palangreros. Estas diferencias podrían ser artificiales, debiéndose, por ejemplo, al sesgo en la conversión entre la longitud predorsal (LDI) de las muestras del cerco a la CAS en longitud a la horquilla, o a un muestreo insuficiente de las capturas del palangre. También podría deberse a zonas de pesca diferenciadas de los dos artes, estando concentradas las pesquerías de cerco en el golfo de Guinea, donde predominan los rabiles más grandes. Esta heterogeneidad en las tallas capturadas corresponde probablemente a las distintas selectividades por edad que ejercen ambos artes. Este patrón diferencial de selectividades debería estudiarse mejor e introducirse en los modelos de evaluación de stock que no están estratificados por áreas, como los análisis de población virtual.

KEYWORDS

Catch at size, Selectivity, Yellowfin, Fishery statistics

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1. Introduction

Catch at size (CAS) and/or catch at age (estimated from CAS) constitute a fundamental component in all analytical stock assessments such as VPA and ASPM and in statistical models such as MFCL and SS3. This note will compare the average CAS of large YFT taken during recent years by purse seiners (mostly caught on free schools, and mostly obtained from the EU PS CAS sampling) and by longliners in the Atlantic. It will also compare these results to the CAS of large YFT that have been estimated in the Indian Ocean. This comparison will be based on the hypothesis that these CAS are valid ones, and not the result of biased samples or of dubious data processing, but this uncertainty will also be discussed. The observed similarities and differences observed betwee these CAS will be subsequent discussed. The final goal of this comparison is to examine the validity of the frequent hypothesis that the selectivity of adult YFT in the longline fishery and in the free school PS fishery are identical (or similar) and at similar high levels (flat or dome shaped).

2. Average CAS of YFT by PS and LL

Figure 1 shows the average levels of CAS of large YFT caught by each gear caught during the last 20 years. These CAS are based on the size samples submitted by each CPC and they have been extrapolated to the total catches of each gear (a difficult work done each year by the ICCAT & IOTC secretariat).

This figure shows that **in the Atlantic**, the observed patterns of sizes caught by LL & by PS are showing similar larger sizes (about 180 cm) but showing widely different profiles:

- PS CAS of large YFT (free schools) showing a marked mode at 140-150 cm, and much lower catches in the size range of young adults caught between 90 cm and 140 cm.
- LL showing a mode between 120 & 140 cm, followed by a decline of their CAS. Total numbers of adult YFT caught by PS in the size range between 90 & 180 cm) are 2.6 larger than for LL!

On the opposite, the YFT CAS by gear observed in the Indian Ocean are very similar, even nearly identical, for PS and LL in terms of their profiles and absolute levels of CAS (same total CAS of adult YFT). The major difference that can be noticed in the Indian Ocean between these 2 CAS is the larger numbers of very large YFT caught by LL: for instance 2 times more YFT being caught at large sizes over 150 cm by LL than by PS. Data shown by figure 1 are also interestingly shown on figure 2, but now comparing the CAS of each gear in the 2 oceans. This alternate figure shows well how much the CAS by LL are quite similar in the 2 oceans (but with much lower levels of catches in the Atlantic), when on the opposite the average profile of PS CAS of large YFT tend to be widely or totally different in the 2 oceans: showing an average weight of large YFT (>90cm) of 50 kg in the Atlantic, but only 42 kg in the Indian ocean. It is also important to compare the total YFT CAS caught by the combined LL & PS fisheries in the 2 oceans, as this figure shows major differences in the profile of their combined CAS.

This figure shows that the combined CAS of adult YFT caught by LL+PS in the Atlantic and Indian ocean (that are very close to the total CAS of large YFT) are widely different:

- showing a mode at intermediate sizes of large YFT between 115 and 130 cm in the Indian ocean
- showing a mode at much larger sizes between 145 & 165 cm in the Atlantic Ocean, a mode mainly due to PS CAS.

Furthermore and as it is well shown by this figure 3, very large YFT caught at size over 160 cm are frequently caught in the Atlantic (21 % of total adult > 90 cm catches), when they are seldom caught in the Indian ocean (0.6 % of the total catches of adults larger than 90 cm).

3. Discussion

3.1 Overview of the discussion

These marked differences in the YFT PS & LL CAS of large YFT observed in the Atlantic have been seldom analyzed and discussed by ICCAT scientists, but they are important & interesting to discuss as they have potential implications in term of the quality of CAS statistics & of their role in analytical stock assessments. The first point of this discussion will be to examine

(a) if (& how much?) these apparent differences in the YFT Atlantic CAS of PS & LL could be mainly due to large statistical deficiencies & bias in the PS or/and LL CAS, or
(b) if they are real: how they could be explained? And what are their implications in term of stock assessment: what is the real selectivity at size/age of the 2 gears in the Atlantic?
(c) this discussion being also conducted comparing the CAS by gear observed in the Atlantic & in the Indian Ocean.

3.2 Large errors & bias in the PS or/and LL CAS?

The first question is to examine if these apparent differences between PS & LL CAS in the Atlantic are real ones, or due to bias in the size sampling of LL &/or PS.

3.2.1 Size sampling of YFT in the Atlantic LL fisheries

YFT catches by longliners are quite low, an average catch of only 23400 tons during the studied period 1990-2010 (when PS catches of large YFT are reaching 55400tons). Size sampling of these large YFT tunas have been quite limited during this period: an average of 6150 YFT measured yearly for size on longliners, then a quite low number compared to the EU PS showing an average number of about 47 200 large YFT measured each year. Then average sampling rates rate of 280 large YFT sampled per 1000 tons caught each year by LL, vs 850 large YFT sampled yearly per 1000 tons of large YFT landed by the EU PS. An additional point is that these YFT are caught by LL in a very large fishing area, see figure 4a, then in distinct ecosystems, and being caught in widely distinct areas where the YFT sizes are more heterogeneous than in the eastern equatorial area mainly fished by PS. These LL YFT correspond to a combination of catches in feeding strata at temperate latitudes and in spawning strata in warm subequatorial waters. Furthermore, size data are collected by many CPCs, independently and without a consistent homogeneity of the sampling process: size data on longliners have been collected in length or in weight, in straight or round fort length, by 1, 2 or 5 cm size intervals, and the time and area strata of these size samples are also widely heterogeneous (month or quarters, 1°, 5°, 5°-1°, 10°-20° squares (when the EU PS sampling has been always homogeneous in its sampling method and in its time & area strata. The raising process allowing to extrapolate LL samples to their CAS is also much more complex than for PS. This heterogeneity in size sampling of longliners and in their data processing introduces unknown but real uncertainties in the CAS of longline fleets estimated by the ICCAT secretariat.

In such a context of low sampling rate & of large & heterogeneous sampled strata, there is probably a serious uncertainty in the process leading to the extrapolation of size samples, also taking into account the uncertainties in the various strata substitutions that are needed to estimate the CAS, and to the estimated CAS. This basic uncertainty would need to be further studied by an ad hoc statistical analysis of the uncertainties in the estimated CAS of LL.

3.2.2 Size sampling of YFT in the PS fisheries

Thousands of size samples have been collected on large YFT caught by the EU purse seiners during recent years in the Atlantic on free schools. Furthermore, these size samples tend to cover quite well all the major fishing strata, then allowing to estimate a potentially valid CAS with very few strata substitutions. A positive point in this sampling of the EU PS CAS is also that the sampling method and the extrapolation of these samples have been fully consistent over time for the dominant fleet of the EU PS, allowing to consistently estimate PS CAS by 5° and month.

However there is a potentially serious pending (& cryptic….) problem in the CAS of PS submitted to RFO by the EU scientists: when these data have been submitted each year in fork length to ICCAT, all these samples have been measured in predorsal length and later converted in fork length using a fixed statistical conversion between LD1 & Fork length. This average LD1-FL relationship used and the number of YFT sampled in each class of LD1 are shown by figure 5a & 5b. This LD1 size sampling has been used for large YFT (and large BET) by the EU scientists since the late sixties because of 2 additive causes:

(a) the fact that many large YFT frozen in brine (as always for the PS catches) tend to be in bad shape, and often smaller in fork length than the real size of the fresh tunas
(b) the fact that LD1 measurements are more easy and faster to obtain, as they need much less handling to be measured.

However, a subsequent conversion from LD1 size samples to the FL size samples that are submitted to ICCAT (and to IOTC) is needed. This LD1-FL conversion has been done in the Atlantic since the early seventies by the EU scientists based on a sample of LD1-FL measurements that have been done during the early seventies by Caverivière 1976, but unfortunately the original LD1-FL length data of individual tunas leading to this conversion have been lost. The basis of the conversion presently done on a sample of 1975 LD1/FL size samples; based on this sample, each ½ cm class of LD1 (that are used to measure tuna sizes) is converted to the FL size distributions that were observed in this original sampling. As an example 100 YFT sampled at LD1 size between 42 & 42.5 cm will be assigned to the classes of FL shown by table 1. The estimated percentages of FL (by 2 cm class) are estimated for each ½ cm class of LD1 based on an average number of 47 fish that have been measured in each LD1 interval. Based on a new small sample recently done in Abidjan (still unpublished), it would appear that the conversion presently done between LD1 & LF sizes would still be valid and unchanged today, but this LD1-LF sampling would need to be updated and reinforced, well analysed and its results compared to the original results given by Caverivière 1976.

As a conclusion, when the size sampling of large YFT caught by PS appears to be very good in terms of number of tuna sampled and of its spatio temporal coverage, there are still some serious statistical questions that are pending on the validity of the LD1-FL conversion and then in the full validity of the estimated fork length CAS. This basic statistical uncertainty should be fully clarified as soon as possible by EU scientists. The basic recommendation being that a new large scale LD1-FL sample should be conducted by EU & associated scientists of PS caught YFT & BET. This large scale sample should for instance target to sample at least 100 YFT in each class of the 0.5 cm that are routinely used to measure YFT sizes.

3.3 If the differences in PS & LL CAS are real ones: why?

If the major differences in the LL & PS YFT CAS are confirmed to be real ones, these differences would need to be better explained by scientists, and these causes better incorporated in future analytical stock assessments. The differential pattern of CAS observed in the Atlantic between LL & PS (figure 1a) could for instance be easily explained by the different fishing strata of the 2 gears: when PS are mainly fishing in the Gulf of Guinea, longliners tend to fish in a much wider area (figure 4). Their is a clear overlap between the fishing zones of the 2 gears in the area 10°N-5°S, east of 25°W, but longliners are catching a majority of their YFT catches outside the core of this PS fishing zone and this geographical heterogeneity could partly explain the differences in CAS. This is because YFT caught by longliners in temperate areas are on the average showing smaller sizes, see figure 6 An average weight of 60 kg in the Gulf of Guinea (period 1990-2010), vs an average weight of 51 kg in the temperate areas for the YFT caught by LL at sizes over 90 cm (based on the ICCAT sample file).

Figure 6 also shows that the size distribution of YFT caught by LL in the Guinea Gulf, the main fishing zone of PS, are very similar to the PS CAS (much less fish at size under 140 cm and a mode at 152 cm, i. e. at size lower than the PS mode at 154 cm, but close to it (figure 8). It should be kept in mind, when comparing the CAS in the Indian and Atlantic oceans (figure 3) that the differences in the CAS observed in the Indian & Atlantic oceans could easily be explained by the differences in the growth curves of YFT in the 2 oceans: when YFT growth appears to be showing a multistanza pattern in both oceans, the estimated asymptotic sizes appears to be lower in the Indian Ocean: close to 140 cm in the IO and close to 180 cm in the Atlantic (but these 2 results remains somehow questionable….) (figure 7). However, this difference in the growth pattern of YFT in the 2 oceans, real or not, does not condition the main question discussed it this paper: why PS & LL CAS are identical in the IO and widely distinct in the Atlantic.

3.4 Real differences in PS & LL CAS : then what implication for the analytical stock assessments?

If this difference in PS & LL CAS is real in the Atlantic, and this is probably the case, then it should be carefully handled in analytical stock assessments. Most assessments done on the Atlantic YFT tend to assume that the selectivities of PS on free schools and of longliners on adult YFT are maximal and flat for all the adult ages (or showing a similar dome shape pattern). This working hypothesis would be fully valid for the Indian Ocean YFT because of the great similarities of the adult YFT CAS by LL & by PS. However, the widely distinct CAS of these 2 gears that has been repeatedly observed at least during the last 20 years would indicate that the selectivity curve on the adult YFT could be widely distinct for these 2 gears, probably because of geographical heterogeneity in their fishing zones. This question is important, as it tend to condition several of the main results obtained by analytical models, but this work would need additional studies. For instance, all VPAs ran under selectivity patterns of the 2 gears should be consistent with the observed CAS/CAA of large YFT in the LL & PS fisheries. This problem could of course be solved using well stratified geographical stock assessment models such as MFCL, as the geographical heterogeneity in the fished population would explain part/most of the differences in CAS, but these models tend to be quite difficult to handle, and basic VPAs are done without geographical stratification. This question of potential heterogeneity in selectivity patterns for all the assessment analysis done at the scale of the Atlantic should at least be kept in mind and preferably better studied.

4. Conclusion

The marked heterogeneity observed between the average CAS & CAA observed for the adult YFT caught by PS & by LL is clearly surprising and of great interest. Further studies should be done by the EU & other scientists (1) in order to validate the today CAS of PS, (2) to fully understand the cause of their differences and (3) to better evaluate the corresponding heterogeneity in the selectivity of PS & LL at the scale of the entire Atlantic ocean and the potential of this heterogeneity in the future use of the stock assessment models used by ICCAT. This quick analysis of the LL size samples is also leading to a recommendation that these size samples should be more homogeneous and following better ICCAT sampling rules (in terms of size measurements methods and reporting size measurements in homogeneous strata recommended by ICCAT)

Cited literature

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Gascuel D., Fonteneau, A., and Capisano, C. 1992. Modélisation d'une croissance en deux stances chez l'albacore (*Thunnus albacares*) de l'Atlantique Est. Aquat. Living Resour. 5: 155-172.

Table 1. example of LD1-FL conversion: LD1 class between 42 & 42.5 cm

FL cm	148	**150**	152	154	156	158	160	162
Numbers	4	**7**	16	23	23	16	7	4

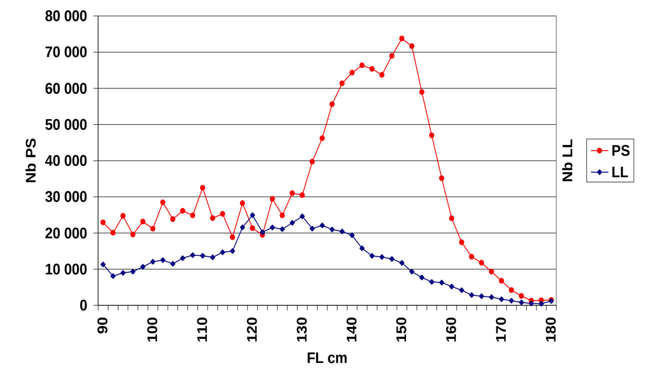


Figure 1 a. Average YFT CAS of PS & of LL in the Atlantic, period 1990-2010

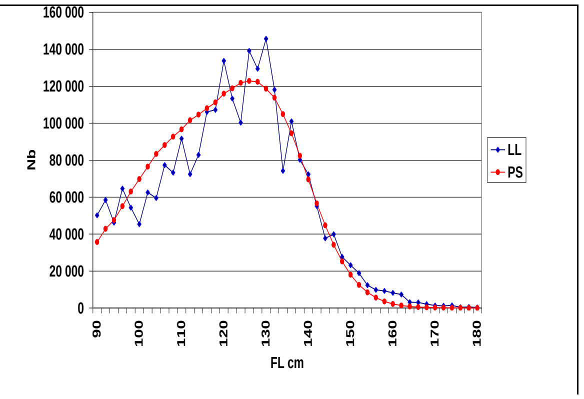


Figure 1 b. Average YFT CAS of PS & of LL in the Indian Ocean, period 1990-2010

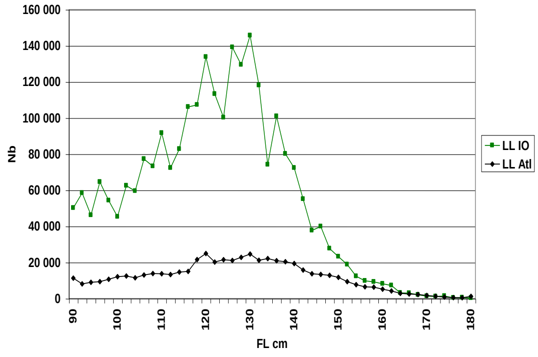


Figure 2a: Average CAS of LL in the 2 oceans

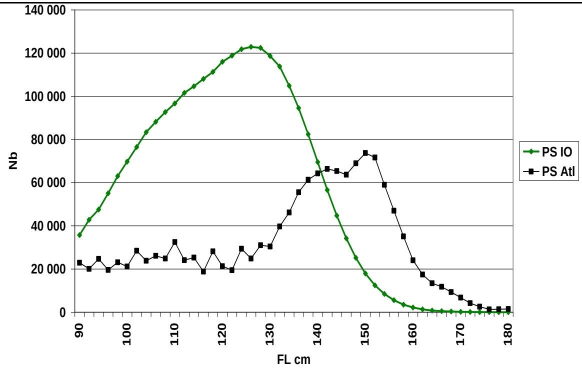


Figure 2b: Average CAS of PS in the 2 oceans

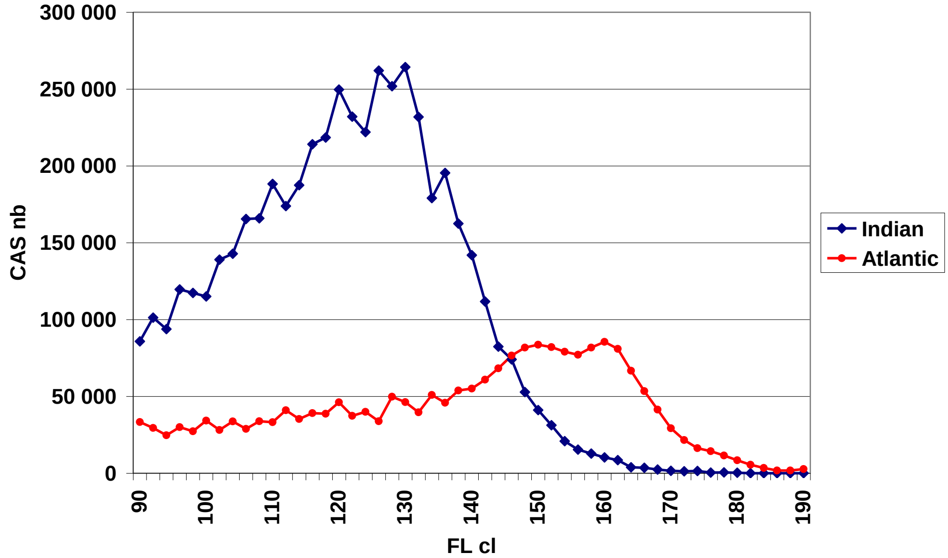
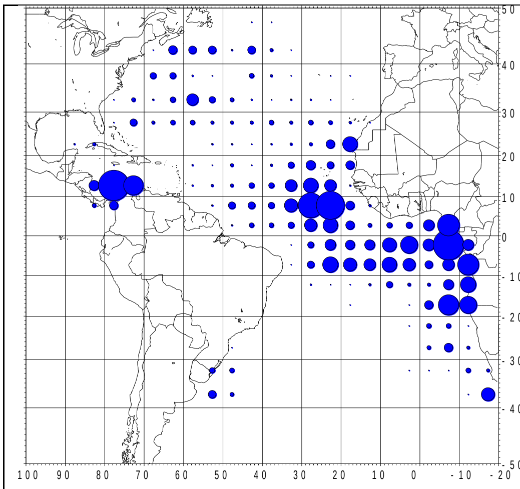


Figure 3. Total YFT CAS caught by the combined LL & PS in the Atlantic & Indian oceans



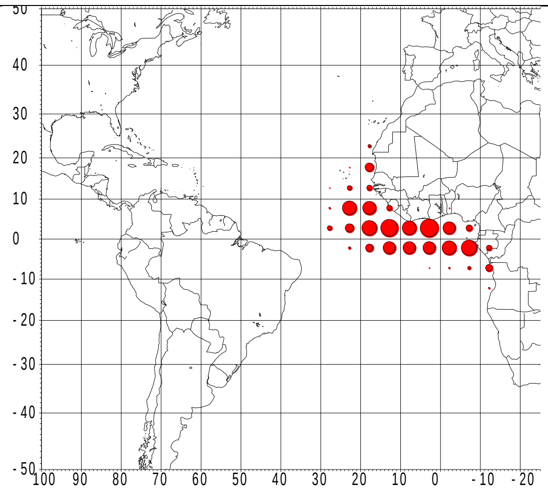


Figure 4a. Average catches of YFT caught by 5°squares of longliners during the 1990-2010 period

Figure 4b. Average catches of YFT caught by 5°squares of purse seiners during the 1990-2010 period

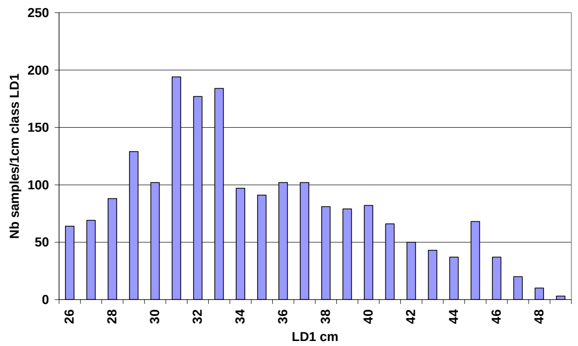


Figure 5a. Number of YFT sampled for LD1-FL in each 1cm class of LD1 in the Caverivière 1976 sample.

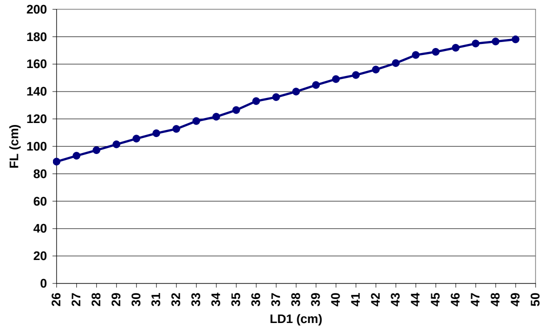


Figure 5b. Average relationship used to converts LD1 samples to FL CAS (based on the Caverivière 1976 sample)

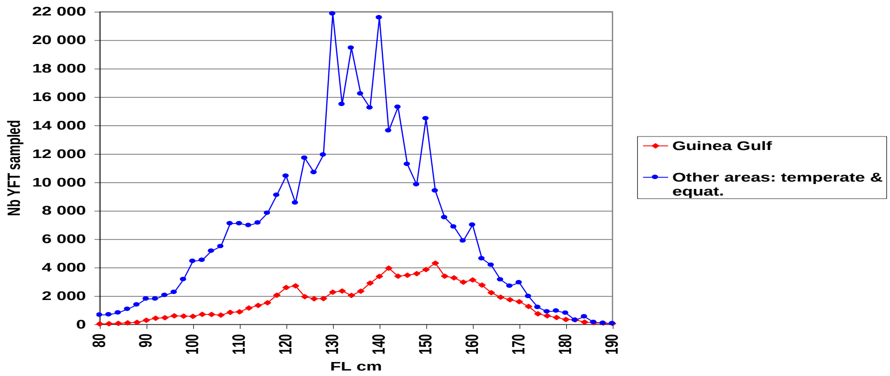


Figure 6. Average size distribution of YFT caught by LL in the 10°N-10°S area east of 20°W, and in the other areas of the Atlantic ocean, mainly temperate ones (period 1990-2010). Average weight Guinea Gulf=60kg (red), and 51 kg for the other areas (blue)

Figure 7a. Growth curve of YFT estimated in the Indian Ocean (Dortel 2011)

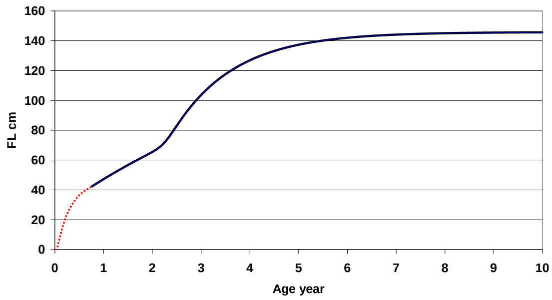


Figure 7b. Growth curve of YFT estimated in the Indian Ocean (Gascuel et al 1992)

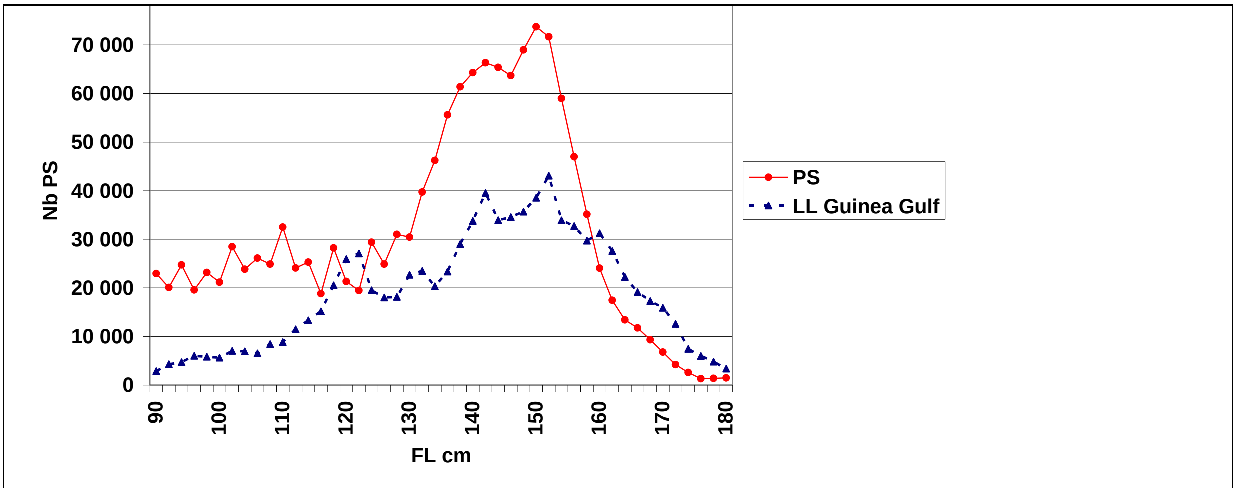


Figure 8. Average size distribution of YFT caught by LL in the 10°N-10°S area east of 20°W (cumulated samples) and PS CAS of large YFT (mainly caught in the same area)