

Preliminary analysis obtained by the recovery of tagged sexed yellowfin: sex ratio and growth

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1- Introduction:

Following the paper by Fonteneau and Dewals 2009 and the subsequent recommendation by the IOTC Scientific Committee in 2009, French scientists based in Seychelles have been recovering with the help of IOTC adult tagged tunas fished by French vessels and they have identified the exact size and the sex of these tagged tunas (otoliths are also collected for future age-reading). Among those recovered sexed tunas, a total of 33 large yellowfin have been recovered, after an average duration at sea of 3.1 years and at an average size of 132 cmⁱ. These tunas represent about 43 % of the large fishes recovered on board French purse seiners (when 205 large tagged YFT and BET were identified on the Spanish vessels, none of them being sampled by scientists.... unfortunately). The goal of this working paper will be to review these first results, analyzing the sex ratio of these recoveries and the differences in the growth pattern observed for males and females. The final goal of this preliminary paper is also to show the great interest of these first results, especially for yellowfin tuna, and to make a firm recommendation toward the 2010 IOTC scientific committee and to scientists working on these fisheries, that all the recovered tagged tunas tagged during the IOTTP should have their sex and size well identified by scientists.

2- Natural mortality and growth of adult yellowfin

There is a universal observation that male yellowfin tend to be widely dominant at large sizes and including in the Indian Ocean, see figure 1 showing the sex ratio at size observed for yellowfin tuna during the 2005-2009 period. This systematic male oriented sex ratio at size needs to be explained and it has been often hypothesized, for instance in the recent IATTC (Maunder and Da Silva 2009) and WCPFC stock assessment (Langley et al 2009), that this differential sex ratio was due to the higher natural mortality of adult female yellowfin, in relation with their spawning activity. In the Indian Ocean recent assessment of the yellowfin stock done in 2009 has been using a common growth for male and female yellowfin (Langley et al 2009) and a vector of natural mortality at age showing an increase level for adult female yellowfin (but much less than in the IATTC model)..

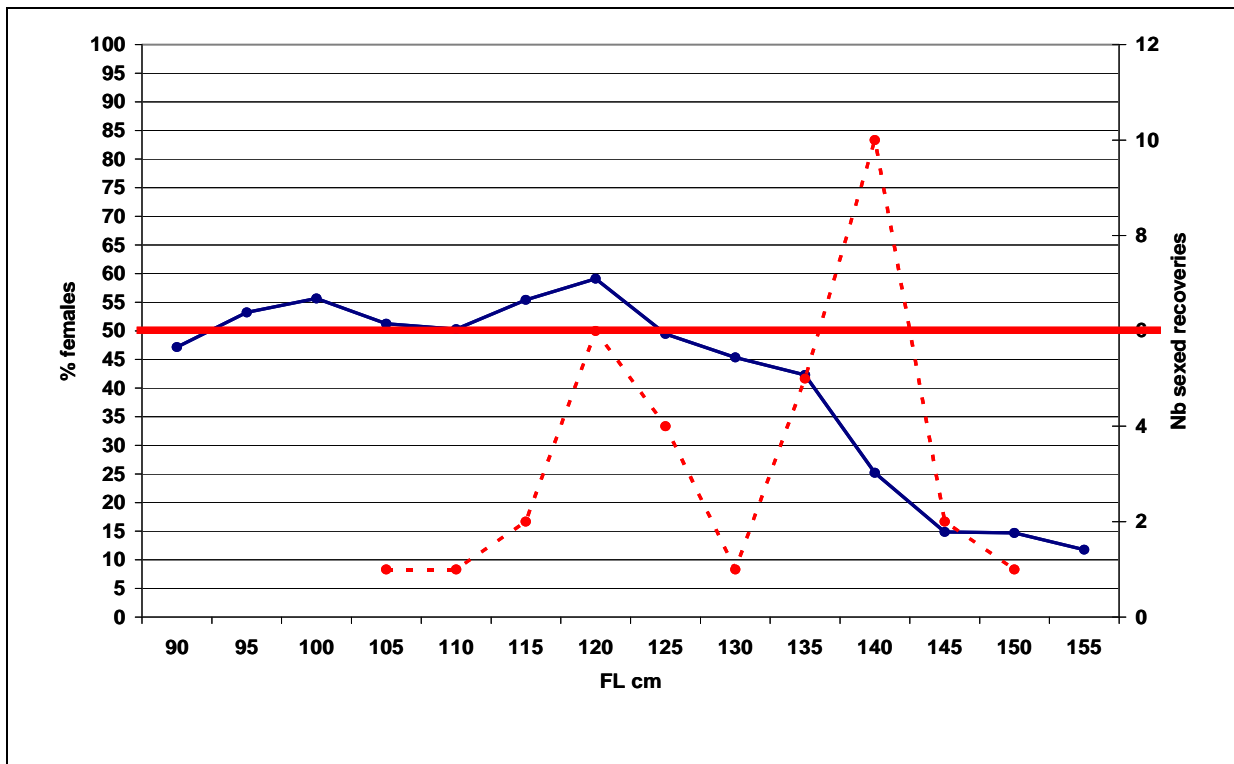


Figure 1: Sex ratio at size of yellowfin observed during the 2005-2009 period (4242 fishes sampled) and numbers at size of tagged yellowfin presently sampled (33 fishes)

On the other side, as none of the few study of yellowfin growth presently published (based on hard parts readings), has been able to identify a differential growth between the 2 sexes, most/all tuna scientists and RFOs tend to assume that growth is identical for both sexes (same L infinity). It can easily be hypothesized that as the reading of daily rings of adult yellowfin tend to be very difficult and uncertain, these age reading of hard part may not be adequate, daily rings being too small, to identify a small difference in growth between males and females.

One of the best example of these hypotheses of differential natural mortality explaining the sex ratio has been visible in all the recent stock assessment models used in the Eastern pacific yellowfin stock by the IATTC staff: this work is based on the Natural mortality at age shown by figure 2, when the growth pattern is assumed to be identical for males and females.

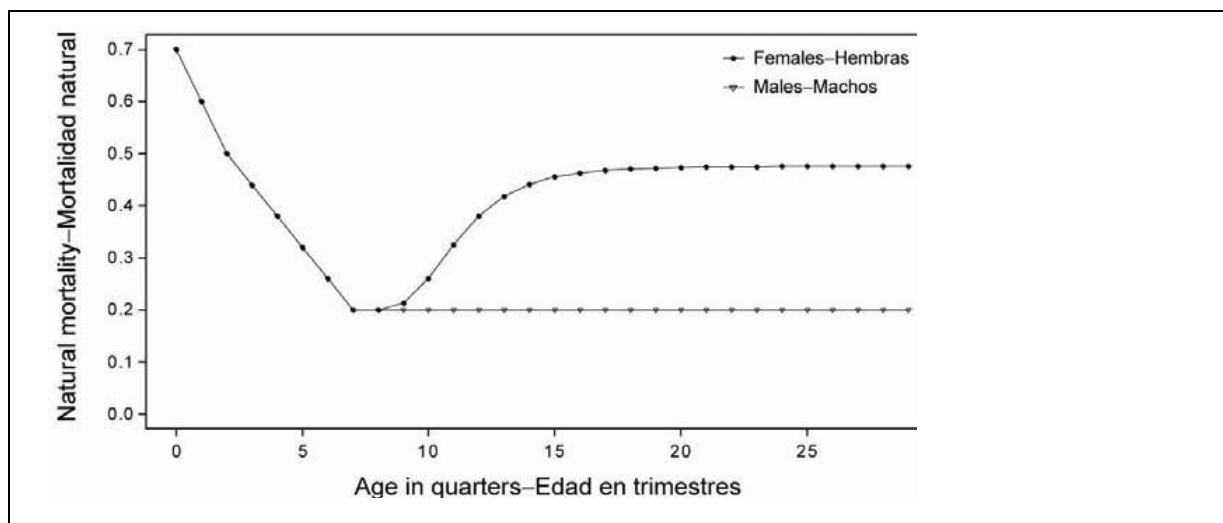


Figure 2: Natural Mortality at age of male (lower curve) et female (upper curve) yellowfin assumed by the IATTC in its recent stock assessment models. Note that M of adult male yellowfin is at 0.8 (then 45% of survivors at the end of each year), natural mortality of spawning females reaches 2.0 at an age of 4 years (corresponding to only 13% of survivors at the end of each year)

Such biological uncertainty is a major one in all statistical stock assessments applied on such stock: as the population of spawning females vanishes very quickly even for a virgin stock (figure 3), the size of this relatively small spawning population tend to be highly reduced when the stock is heavily exploited by fisheries making the stock even more vulnerable to over-exploitation. It is then of great biological interest, and also of great importance in all yellowfin stock assessments, to estimate correctly the growth and the relative natural mortalities of adult male and female yellowfin. It is obvious that the IOTTP offers now to the IOTC scientists a unique opportunity to solve this double uncertainty on growth and natural mortality of adult yellowfin, forever and for the 1st time worldwide: simply identifying the sex and sizes of all the recovered large yellowfin that are still caught by purse seine fisheries and landed in Seychelles. This sampling program has been initiated since July 2009 by French IRD scientists and later recommended by the IOTC scientific committee in December 2009. But unfortunately a recommendation not yet followed on Spanish and Seychelles purse seiners....

3- Preliminary results from the 33 large yellowfin presently sampled

3-1- Sample of large yellowfin already obtained

A total of 33 large yellowfin have been recovered and sampled by scientists, allowing to measure them perfectly and to identify their sex. The main information concerning these recovered sexed yellowfin is given in the following table 1.

Table 1: Main parameters of the present sample of sexed yellowfin recoveries

	Number	average size at tagging (cm)	Idem at recovery	days at liberty	Years at liberty	Growth rates	SD of growth rates
Female	17	61,2	126,2	1028	2,82	2,01	0,42
male	16	57,7	139,4	1234	3,38	2,07	0,38
Total	33	59,5	132,6	1128	3,09	2,04	0,39

3-2- Sex ratio

The sex ratio of the present sample is nearly showing a 50/50 rate: 17 females and 16 males, all at large sizes (all FL \geq 112 cm but one of 106 cm). Such sex ratio of recoveries appears to be totally consistent with observed sexed CAS of adult yellowfin, where recovered males are increasingly dominant at large sizes over 140 cm, as in the sex ratio of the catch at size, see figure 3

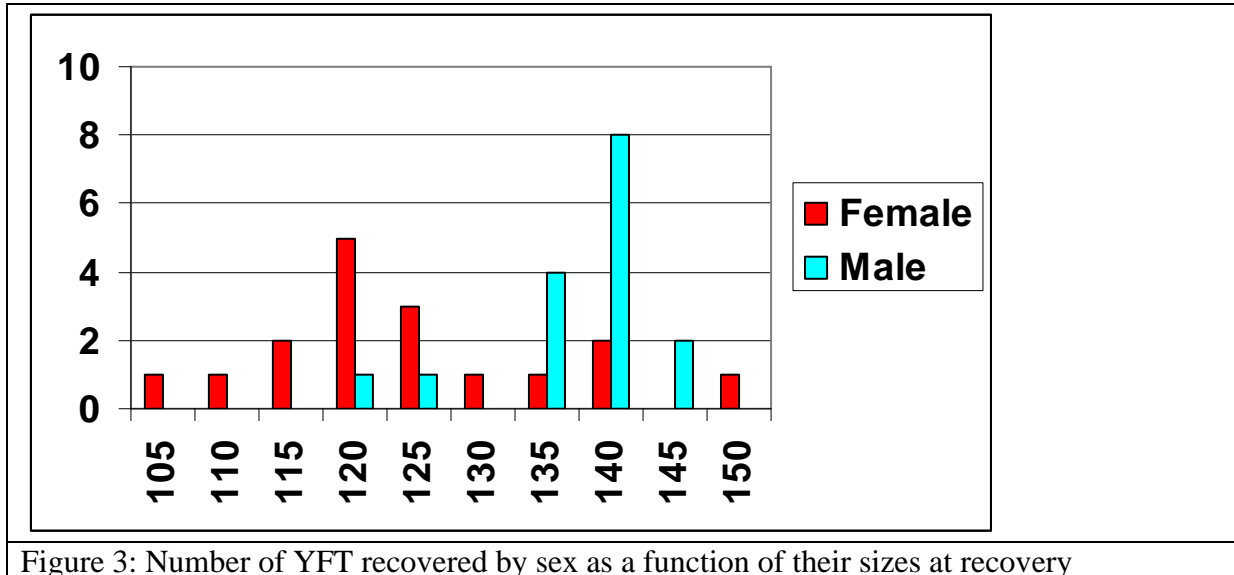


Figure 3: Number of YFT recovered by sex as a function of their sizes at recovery

On the other side this 50/50 sex ratio cannot correspond to the low percentage of adult females, for instance in the IATTC adult yellowfin population: in the IATTC population, because of the very high natural mortality of females, the number of females corresponds to only 30 to 20 % of the total population at the sizes/ages of the presently recovered tags (as old females tend to quickly vanish from the spawning population, see figure 2 and 4). A statistical random sampling of such a population of males and females with these 30% and 20% of females (vs 70% and 80% of males) shows that the probability to obtain a 17/16 sex ratio on such population of males and females is very low: for instance with a random sampling of such population with a small sample of 33 fishes, such 17/16 ratio of the 2 sexes as we have in our sample would be very rare or impossible to obtain. As a temporary conclusion, it could already be concluded, at least as a working hypothesis used in stock assessments, that the natural mortality of adult yellowfin females is not widely higher than M_i of males.

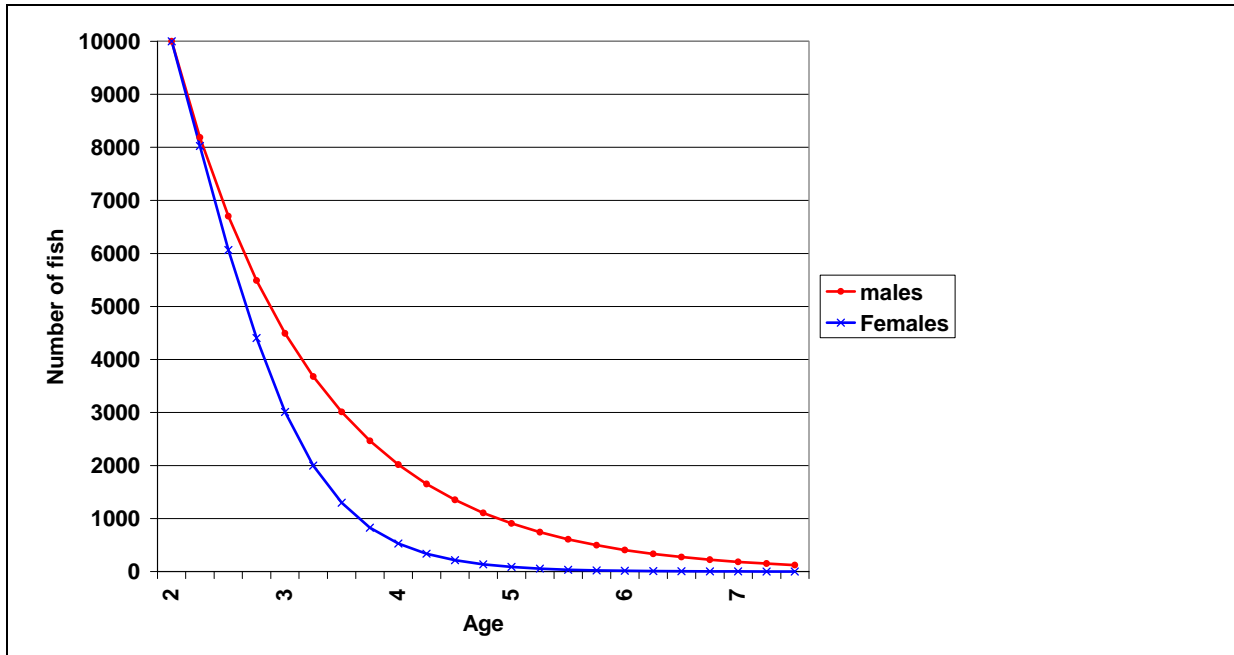


Figure 4: Decline of a population of adult yellowfin in the hypothesis of Mi presently assumed by the IATTC in its recent stock assessment.

3-3- Sexual growth

It should first be noted that the average growth rates in cm/month of males and females are nearly identical: 2.01 cm per month for the 17 females and 2.06 cm/month for the 16 males, probably a non significant difference, but taking into account the fact that the 17 recovered females in our sample have been tagged at a larger average size (61.2 cm) that the recovered males (57.7 cm), then 2.6 months older than males (following the Eveson et al 2008 growth). Furthermore, this difference in average size is occurring at the limit between the slow growth rate and the fast growth rate phases (between 50 and 60 cm) noted in yellowfin growth model (Eveson and Million 2008; Fonteneau and Gascuel 2008).

Females

All the 17 females but 1, are below the Eveson and Million 2008 curve, as they have been growing at a lower growth rate than in the model: an observation probably indicative of a lower L infinity of female yellowfin (Figure 5)

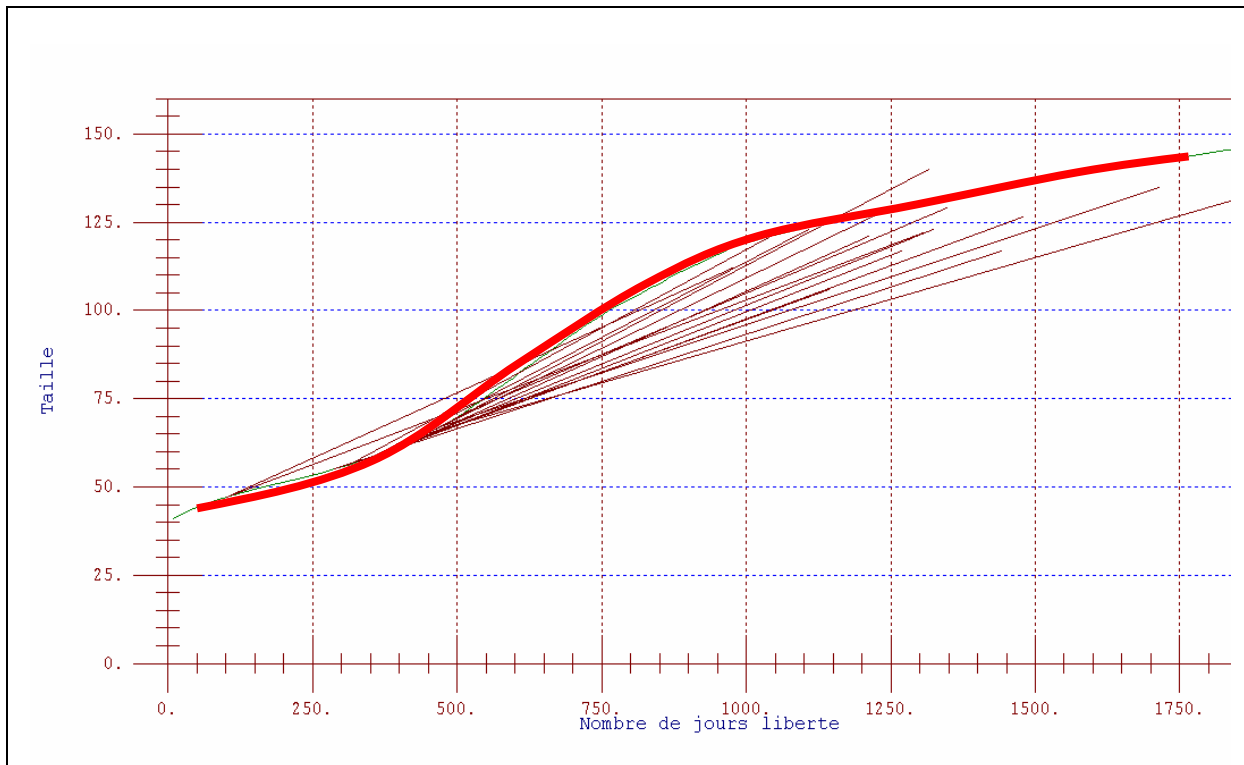


Figure 5: PLOTREC figure showing the theoretical growth curve of yellowfin as proposed by Eveson and Million 2008 and the apparent changes in size of the 17 recovered female yellowfin during their time at liberty

Males

Figure 6 shows that the 16 males have been growing at a symmetrical rate compared to the Eveson and Million 2008 growth model, most recoveries being taken close to their “expected” sizes, slightly above or under the theoretical curve.

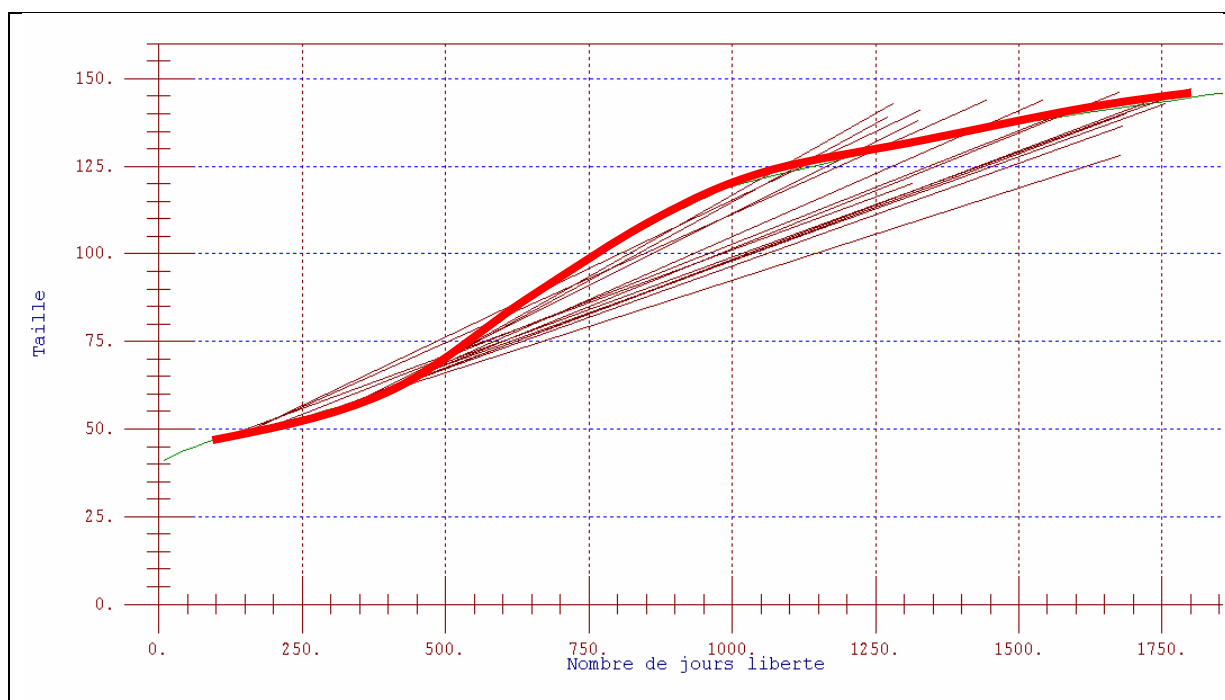


Figure 5: PLOTREC figure showing the theoretical growth curve of yellowfin proposed by Eveson and Million 2008 and the apparent changes in size of the 16 recovered male yellowfin during their time at liberty

It is striking to observe on the PLOTREC figures such differential growth of males and females, when the average growth rates are nearly identical. This fact is mainly due to the unexplained (and surprising?) difference in the tagged sizes (and age?) of our small sample of sexed tunas. On the other side, the PLOTREC figure has the major advantage to take into account the sizes (and ages) of the tagged tunas, and its message that female YFT are showing a lower L_{∞} than male YFT is probably very realistic, even taking into account the small size of this sample.

4- Conclusion and recommendation

The present sample of recovered sexed tunas is still limited, only 33 large yellowfin recovered today, but this small sample has been already providing various very interesting and convincing results, that are probably highly significant:

- (1) Spawning females do not show a higher natural mortality than males, at least not the large differences that have been often assumed in some stock assessment.
- (2) There is probably a differential growth between males and females yellowfin, female showing a significantly lower L_{∞} (about 10 cm lower?), such biological heterogeneity being quite universal in the living world, as the maximal sizes are seldom identical for males and females for most living species.

There is now clearly a deep need to reinforce this small sample of recovered sexed yellowfin tunas: targeting all the large yellowfin tunas landed in Victoria by French, Spanish and Seychelles fleets. Serious effort should immediately be developed in the Victoria harbor to identify the sex and to sample all recoveries of tagged yellowfin, especially on the Spanish and Seychelles fleets that have been reporting much more recoveries of adult yellowfin than the French fleet, but unfortunately still without any sexed sample.

Furthermore, the IOTC stock assessment should already try to incorporate these 2 hypothesis, at least as alternate stock assessment ones, in its incoming stock assessment work without waiting the analysis of an improved sample by a rank A paper (as it may take several years.....).

Acknowledgments:

This work has been conducted by Patrice Deals and his SFA team of field technicians. They should be deeply congratulated for this tiring and difficult additional task that has been conducted with a great efficiency!

All the skippers of the French purse seiners that have provided free of charge to the IRD scientists these large yellowfin¹ should also receive our full recognition of their full cooperation, as usual in fact!

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ⁱ During this sampling 9 bigeye between 110 and 129 cm were also sampled (5 males and 4 females) and 3 skipjack between 53 and 58 cm.

¹ Namely : the French purse seiners Trevignon, Torre Giulia, Glenan, Tallenduic, Cap St Vincent, Via Mistral, Via Avenir, Avel Vad, Drennec