On the need to know the sex of the large yellowfin tagged when they are recovered by fisheries

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Summary

It has been often assumed based on the dominance of males at large sizes in the landing of purse seiners and longliners that natural mortality of spawning females was much higher than for males. This hypothesis is far to be demonstrated by scientific observation, when this higher natural mortality plays a major role in the results of modern stock assessment models and in the dynamics of these simulated stocks. The recent IOTC tagging programme will now allow to recover significant numbers of large tunas, especially yellowfin that are very well reported by most purse seiners. If scientists can identify the sex and growth rates of all these large tagged yellowfin, it should be easy to soon estimate if the observed differential sex ratio at size is due to a higher natural mortality of spawning females, or to their lower growth rate and lower L∞. This scientific result would obtained for the first time and it would probably be of key stone importance for all future yellowfin stock assessment world wide.

1- Introduction

A fundamental question in all stock assessment done on yellowfin (and to less degree on bigeye): A differential sex ratio at size has been permanently observed for all yellowfin stocks worldwide in the Atlantic, IO, East and West Pacific, but the biological causes explaining this sex ratio are still questionable: most stock assessment in the Pacific ocean (IATTC and SPC) have been assuming that the growth of male and female yellowfin is identical, and that the differential sew ratio at size is solely and well explained by a much higher natural mortality of female yellowfin starting at their 1st spawning.

These two conclusions concerning (1) a similar L ∞ and (2) a differential natural mortality of adults is far to be demonstrated by direct observations. The goal of this paper will be (1) to discuss this biological uncertainty of fundamental importance in modern stock assessment, as the biomass of the spawning stock are highly dependent of these 2 hypothesis and (2) to make a firm recommendation allowing to solve in the Indian Ocean these 2 basic biological uncertainties upon Growth and Mi as a function of sex.

2- Data used:

The basis data used in this paper are from various types and sources. The world wide biological data on sex ratio at size are taken from the literature, obtain from the various tuna RFO, or collected by scientists and technicians in cooperation with EU research programs in the Atlantic and Indian oceans.

The CAS table, estimating the total catches of yellowfin at size by each gear, has been estimated by the IOTC secretariat (M. Herrera)

The levels of natural mortality at age by sex used in the Pacific for stock assessment have been rebuilt, based on the figures published by IATTC, and these Mi by sex have been used to estimate the subsequent population sizes of the 2 sexes under given exploitation rates. The recoveries by sex of well identified tunas are unpublished data collected since July 2009 on French purse seiners landings by the IRD scientist (Patrice Dewals), these data will be routinely submitted to the IOTC secretariat.

3- Facts and hypothesis upon adult yellowfin

The differential sex ratio at size has been a constant in all the biological sampling done word wide on yellowfin: sizes at which females tend to be rare are variable between oceans, but the large yellowfin over 160 cm always tend to be males, see figure 1. It is quite clear that this marked differential sex ratio at size cannot be explained by changes of yellowfin sex, as hermaphrodism has never been noticed to occur in yellowfin.

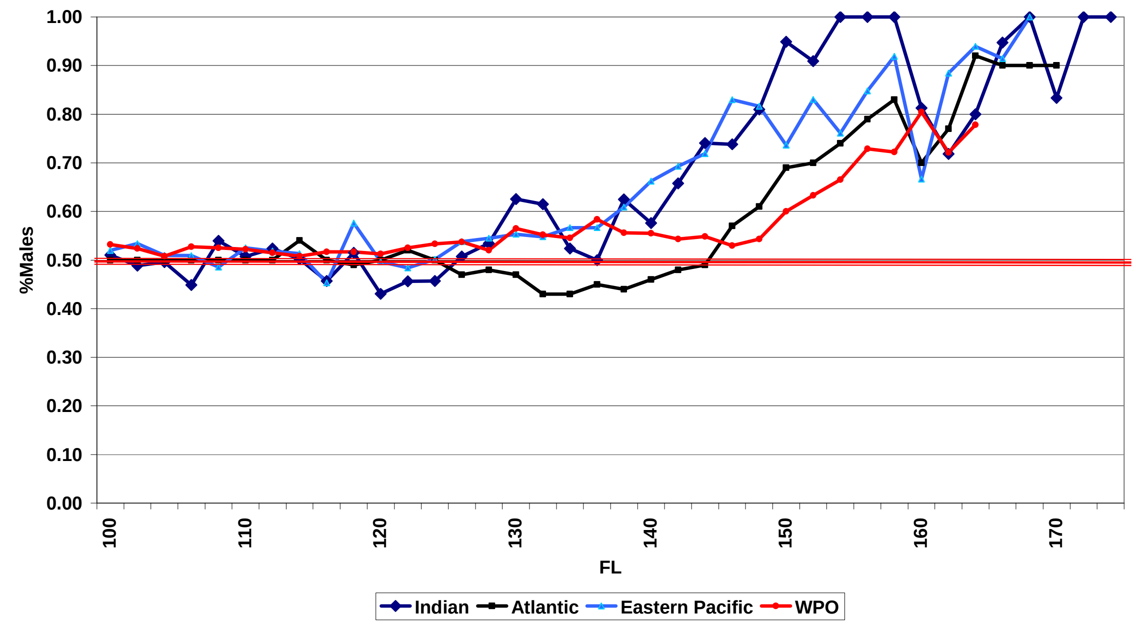

Figure 1: Example of sex ratio at size observed for yellowfin in various oceans.

In the Indian Ocean, this typical result has been historically obtained by Stequert during the eighties, and more recently, it has been fully confirmed by the biological sampling done since 2003 on the landing of the French PS fleet in the IOT cannery in Seychelles (a programme routinely funded by the EU Commission under its Data Collection Regulation framework).

Such differential sex ratio at size can be explained:

(1) by a higher Natural mortality of female after their first spawning at a size of about 1 meter. This hypothesis has been well accepted by the IATTC and SPC (WCPFC) when doing their yellowfin stock assessment. As a consequence they estimate the following pattern of sex specific natural mortality:

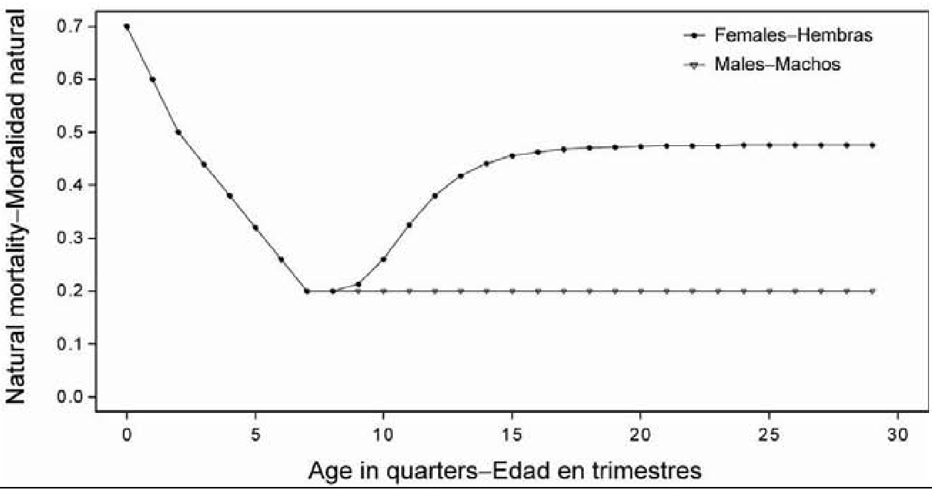

Figure 2: Quarterly levels of natural mortality at age assumed for the adult yellowfin in the Eastern Pacific ocean (taken from Maunder & Aires Da Silva 2009) *(NB: yearly rates of Mi are 4 times higher than these quarterly rates)*

These age specific rates of natural mortality by sex have been estimated to explain the observed pattern of sex ratio at size, based on the hypothesis/result that growth was identical for the 2 sexes. Such pattern of very high natural mortality of spawning females tend to play a major role in stock assessment models: due to this high M, the "theoretical spawning biomass" tend to be very low at increasing Fishing mortalities, then most often "easily" producing a declining recruitment in the simulated projections. As a result the very high natural mortality presently estimated for female yellowfin in many stock assessment tend to produce much more pessimistic stock status than the hypothesis of female having a lower L∞ and the same Natural mortality as males.

Furthermore, it can be noted that there is still a very weak biological knowledge upon the biological causes that could produce such massive mortality of female yellowfin in relation with their spawning. When there is no doubt that female yellowfin are investing a lot of energy in their spawning activity, as most tunas do, it remains totally unclear if this energy spent is a cause for a massive natural mortality. Many tuna biologists tend to think that this "Armaguedon" style spawning mortality is biologically quite unlikely. It can also be noted in such hypothesis, that Mi of spawning females are estimated at a very high yearly level of 2.0, i.e. loosing each year 85% of its population size! In such case, the growth curves of males and females are assumed to be identical, based on the fact that few ages reading done by sex on the yellowfin otoliths have not been able to show differential growth curves for the 2 sexes (Wild 1986).

As a consequence of these widely different natural mortalities, the numbers of males and females at a given size and at a given age tend to be widely different after a quite short period of time, for example as shown in the following figure simulating the decay of 2 groups of yellowfin, males and females, suffering the Mi pattern of figure2.

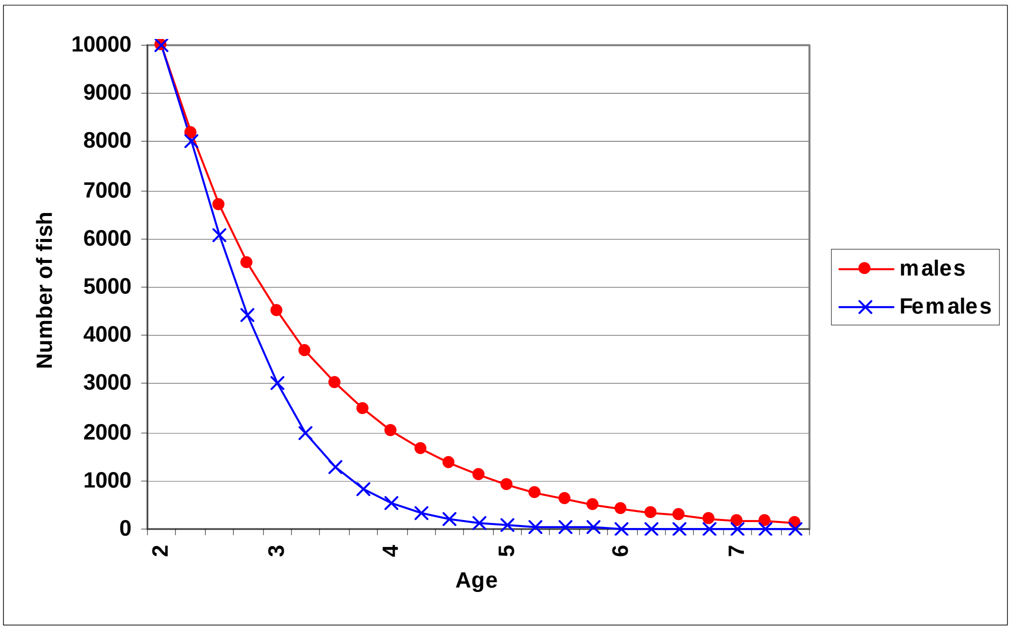

Figure 3: Simulated decay of a population of 10000 adult males and 10000 females, under the differential natural mortality at age assumed in figure 2.

In the real yellowfin stocks, the decay of the cohorts and the numbers of surviving males and females will be of course lower than in this figure, and in proportion of the fishing mortality equally receive by both sexes, also reducing the spawning biomass.

(3) However a lower L∞ of female yellowfin could also perfectly well explain the differential sex ratios: most human over 1.90 m are males, simply because L∞ of males is 12 cm larger for human males (European populations). This range of differential L∞, 12 cm, may also be valid for yellowfin tuna! Most species in the living world tend to show different maximal sizes for the 2 sexes: males being most often larger in the living world (from mammals to fishes), but females being sometimes much larger than males (SWO, marlins, etc..). In fact this hypothesis of a differential growth between the 2 sexes has not been fully supported by the Wild 1986 study, and it should be kept in mind that this author observed that the "***estimated growth rate of females (2.0cm/month) is slightly less than of males (2.4 cm/mo) at a length of 140 cm"***, leading the same author to the recommendation that "***the suspicion that the sexes grow differently should be examined more closely***". When unfortunately this 1986 recommendation by Alex Wild had no real follow up for any of the 4 yellowfin stocks managed by the 4 tuna RFOs.

In such context, our conclusion remains that tuna scientists should wonder if the conclusion that male and female have the same L infinity, is a real biological fact, or if it is mainly due to our weakness to evaluate their respective real L∞. This uncertainty is nowadays of increasing importance in all statistical stock assessment models that are explicitly estimating the size and fecundity of the spawning stocks. In the case of the yellowfin stock, it can easily be concluded:

(1) that the age readings of adult yellowfin are most often still questionable by their nature and very rare in their numbers. Probably, they are not fully demonstrative that the L∞ of males and females is really identical.

(2) that recoveries of adult yellowfin offer now a unique and fantastic opportunity to solve this major biological uncertainty.

4- A strong recommendation on the need to identify the sex of all the yellowfin recoveries

It can easily be assumed (probably without any risk of errors?) that the tagged population of small yellowfin less than 1 meter had a 50/50 proportion of males and females.
The goal of this recommendation is then to identify the sex and length of all the large adult yellowfin that will be recovered during the incoming years, most tagged surviving yellowfin being now at an adult stage (see SINTAG estimates). If this knowledge can be obtained on a significant numbers of fishes (for instance a minimum number of at least 100 individuals?) this result should allow:

(1) to evaluate the sex ratio of these recovered fishes: in the hypothesis of a higher natural mortality of spawning females (figure 2), recovered females should become very rare in the recoveries (compared to male), because the tagged population has been extinguished very quickly by its natural mortality (as in figure 2)
(2) to evaluate the relative growth rate of male and female yellowfin: in the hypothesis of a lower female $L\infty$, their growth rates between tagging and recoveries should be lower, and equal growth rates if $L\infty$ is identical for males and females.

Such identification of the sex and size of all the recovered adult yellowfin should then be considered with a high priority in the IOTTP program. This task is not very easily conducted, as it needs to have full contact with fishing vessels owners and stevedores, and an ad hoc organization to have access for scientists to the recovered landed fishes. However, the first experiment done by IRD and SFA scientists in Victoria port since July 2009 (only on French purse seiners caches) has been obtaining very promising results: 5 yellowfin already recovered during a period of low yellowfin caches, in a range of sizes between 121 cm (31kg) and 144 cm (59 kg), and showing 4 females and 1 male yellowfin (the larger fish: 144cm). Furthermore additional recoveries of 2 skipjack and 1 bigeye has been also obtained during this experimental sampling.

A full biological study on each of these sexed recoveries has been obtained: stomach content, otoliths, length-weight, condition factor, rate of lipids, relative weight of the liver vs body weight, etc. This small sample is not sufficient to reach quantitative conclusion on the sex ratio and on the growth of adult yellowfin by sex, but it is at least a strong proof that this sampling project is fully realistic. The same sampling should primarily target the yellowfin catches, but also the catches of tagged bigeye, as this species has been also facing the same type of biological uncertainty in its natural mortality of female in relation with their spawning activities. This matter is still questionable due to the weakness of sex ratio data on large bigeye, but some stock assessment models are also assuming a much higher natural mortality of spawning females based on these sex ratio at size.

5-Conclusion

Our conclusion and recommendation is that the IOTC scientific committee should make a strong recommendation targeting scientists of its member countries on the necessity to identify the sex and sizes of all the tagged yellowfin and bigeye recovered during the fishing and the landing operations. This sampling should target with a high priority 100% of the tuna landings of the purse seine fleet in Victoria and/or in or other ports (in Madagascar and Mauritius). The Spanish and Seychelles fleets of purse seiners, the 2 major ones active in the area should of course be the first target of this intensive sampling program. It should also target to obtain as much as possible the same result on the yellowfin and bigeye catches by longliners. It should also be envisaged and recommended to collect some sensitive and well selected part of females yellowfin during the spawning season when they show high gonad index, as a subsequent well define biochemical analysis should help to evaluate if these spawning females are in poor or in good biological condition during and after spawning, the factor explaining their very high natural mortality.

The scientific results that will soon be obtained by this program would be available the first time and they would probably be of key stone importance for all future yellowfin stock assessment world wide.

Literature

Mark N. Maunder and Alexandre Aires-Da-Silva 2009. Status of yellowfin tuna in the Eastern Pacific Ocean in 2008 and outlook for the future. Document IATTC stock assessmentRM-10-06a, 85p.

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