Doc. IOTC-2008-WPTT-4

A working proposal for a Yellowfin growth curve to be used during the 2008 yellowfin stock assessment

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Summary

This paper explains why the modelled growth curve proposed for YFT and using the Laslett et al model is heavily biased and that it should not be used to do the stock assessment analysis during the Bangkok meeting. An alternate ad hoc observed growth curve and a subsequent method allowing to slice the Catch at age table into a catch at age is proposed. The paper also recommends to model the YFT growth using a 3 stanza model.

1-Introduction

It was agreed during the WPTDA held in July 2008 that the growth curve of yellowfin should preferably be based on the results that were then expected to be obtained by the Laslett & al 2004 model. The support for this model was justified by the fact that this statistical model is presently one of the best one available to estimate a growth curve from recovery data, but this support to this model was given quite blindly and without examining its results.

However some questions and doubts upon the use of the Laslett & all model were expressed by Fonteneau just after the WPTDA meeting, and upon the fact that the anchoring point of the growth curve agreed by the WPTDA at 6 month and 34 cm will be a major source of trouble in the model fit. Cf the July mail by Fonteneau:

"*I am sending to you these thinking upon future yellowfin growth modelling in order to avoid dangers in this future model data are unchanged. On the 1st appended figure*[1] *you can see the growth estimated for yellowfin using the simple Fonteneau Gascuel method. I am deeply convinced that these results are very clear and strong, and showing very well the growth rates at least in the 40 to 90 cm range and for instance the logical fast growth rates for smaller fishes tagged 40-45 cm followed by the slow growth of juveniles in the 45 to 60 cm range. If I am OK our plan is to Model a 2 stanza growth model similar to Richard's function. And we agreed to anchor this growth at 6 months and 34 cm. This is perfect for me, and well in agreement with the new age readings of very small yellowfin in the 20 to 40 cm range. But my today important point is that our future growth model should necessarily follow a fast growth pattern in the 34cm to 45 cm range of sizes. It should be forbidden to start the slow growth plateau at 34 cm our agreed anchorage point. If we do it, I think that our growth model will be inconsistent, even if we can obtain a best fit! The alternate solution being to move to a human growth model at 6 or 7 parameters covering growth in a full range between birth, assuming a size zero at age zero, probably a realistic hypothesis? and our assumed L infinity at 154 cm or 146 cm.*"

[1] Reference to figure 5 of this paper

This tuning problem was easy to “expect” simply because yellowfin tuna at 34 cm are in their early growth stanza, and showing a very fast growth between birth and about 43 cm. If scientists want to be realistic in the modelling of yellowfin growth in the Indian Ocean from birth to death, they would definitely need to use more complex 3 stanza models than can handle the various growth stanza of a yellowfin (Human growth being also a perfect example of such complexity, see Karlberg 1987 and figure 1).

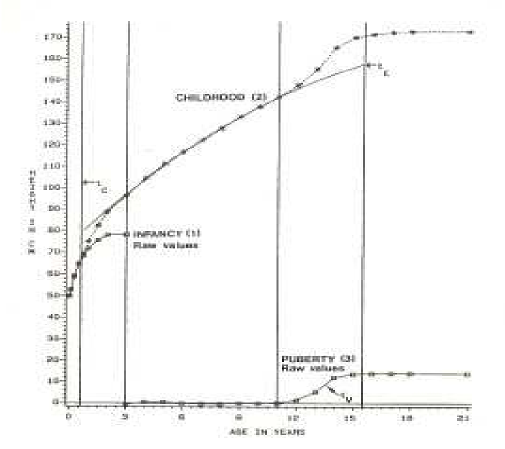

Figure 1: Typical 3 stanza human growth: infancy, childhood and puberty (From Karlberg 1987), *strangely a growth pattern than can be easily extrapolated to yellowfin*

The goal of this working paper is simply to examine the potential problems faced by the present yellowfin growth results before approving these results, and in fact as these results appear to me quite unsatisfactory, the final goal of this paper will be to propose a working hypothesis for a more realistic growth that could be used in the SA, waiting a more realistic 3 stanzan growth model.

2- Why the present yellowfin growth estimated by the Paige model is not realistic for stock assessment anaylisi?

The analysis of the growth rates at sizes estimated by the new growth model appears to be quite inconsistent with the apparent growth rates as estimated by the Fonteneau and al 2008 method (when these growth rates appear to be quite unbiased for sizes < 1m), see figure 2:

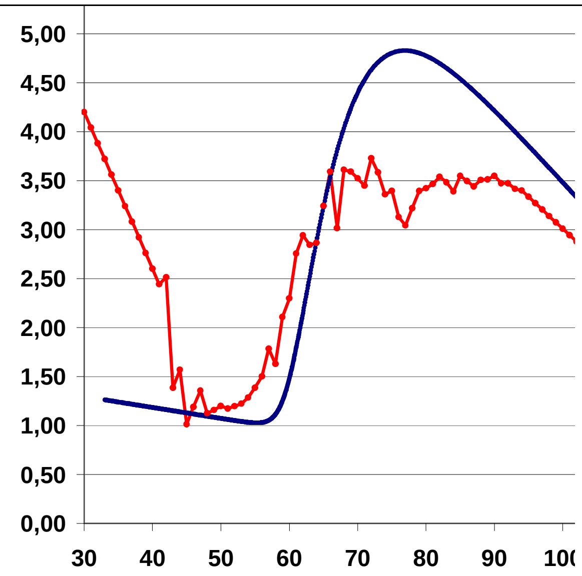

Figure 2: Growth rates at size presently estimated by the Laslett and al model (blue curve) and growth rate estimated by the Fonteneau & al method between 30 and 100 cm

It can be noted that:

(1) as expected, the modelled growth rates are very low(under 1.3 cm /month) in the entire range of fork length between 33 cm (600 g) and 58 cm (3.5 kg). As a consequence, there is a quite long duration of 22.3 months (nearly 2 years) in the modelled growth between these 2 sizes. This major difference in the estimated growth rates is difficult to understand, and the

(2) on the opposite, based on the realistic hypothesis of a fast growth of babies-yellowfin between birth and 43cm (see next paragraph), there is only a short period of 15 months between these 2 sizes.

(3) the modelled growth of medium size yellowfin between 70 and 100 cm (i.e. during the puberty of yellowfin) is much faster than the “observed” one (i.e. well above the growth rates estimated, with a quite low uncertainty, in this range of size by the Fonteneau & al method. These very fast growth rates are also for me widely questionable. This lack of agreement in this range of sizes between the recovery data and the modelled growth is also well shown by a PLOTREC[2] diagram. Such diagram showing the theoretical growth curve and the observed changes at sizes shows a strange pattern of residuals in this range of size, most recovered fishes showing a slower than expected growth (when of course they are fully symmetrical when plotted on the Fonteneau and al observed growth pattern).

[2] PLOTREC : see Fonteneau and Nordstrom 2000

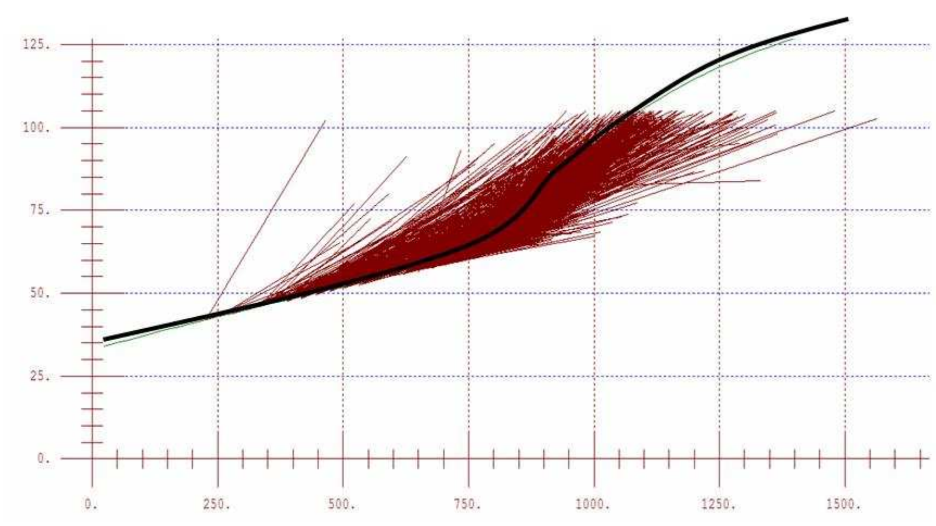

Figure 3: Modelled growth curve and observed recoveries in a range of sizes between 65 and 105 cm for all recoveries with more than 60 days at sea.

(4) It can be noted furthermore that when the Laslett & al model tries to estimate the between fishes growth variability, this result may also be widely questionable, at least in the present set of recoveries dominated by maturing yellowfin, at the age of puberty: it can well be hypothesized that the growth rates of individual yellowfin at puberty sizes (for instance in the 70-100 cm) is dominated by the age at which each fish start to mature. This variability of growth rates may have nothing to do with the variability of L infinity between individual adult yellowfin. This type of uncertainty is for instance also faced in human growth: measuring the variance of growth rates at puberty does not allow to estimate the variability of adult sizes (our human L infinity), see figure 4 taken from Karlberg.

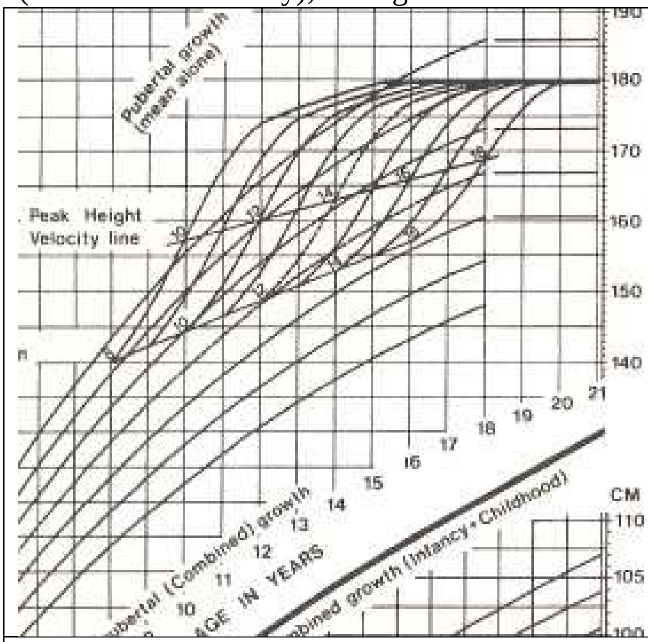

Figure 4: Variability of human pubertal growth as a function of age and size (taken from Karlberg 1987)

As a conclusion, it may be quite dangerous to accept the presently modelled growth: even if this choice was done by the July WPTDA its results appear to be quite inconsistent with recovery data, and probably biased, simply due to the fact that this model is probably mis-specified: a 2 stanza model should not be used to describe the 3 stanza growth pattern that is clearly apparent for Indian Ocean yellowfin after the tagging programme.

Due to this relative "failure" of the recommended growth model, it was attempted to build a more realistic "ad hoc growth curve" that could be used in the Bangkok SA

3- Using a more realistic 3 stanza empirical growth? At least temporarily….

A growth curve has been built, simply attempting to obtain a realistic growth curve that can be used to model the real complex 3 stanza growth pattern of yellowfin, from its birth until its death, that has been clearly emerging from tagging results, as well as from other data, after the July 2008 tagging data analysis.

It was estimated that such ad hoc growth curve should urgently be build as a SA working hypothesis, as none of our present growth model (CB, Gascuel et al, Laslett et al, etc…) can handle well such complex 3 stanza growth, very similar to a "human growth", and totally different from the traditional Von Bertalanffy growth curve used until recently on yellowfin.

The proposal for such an "ad hoc observed growth" is based upon the following facts, method and hypothesis:

(1) The backbone of the proposal is based on the growth rates at sizes estimated by the Fonteneau and al 2008 method in a range of sizes between 40 and 93 cm, a range of sizes with significant numbers of recoveries and without significant bias in the Fonteneau & al method (Chassot simulations during the July 2008 WG).
These growth rates at size are shown on the following figure

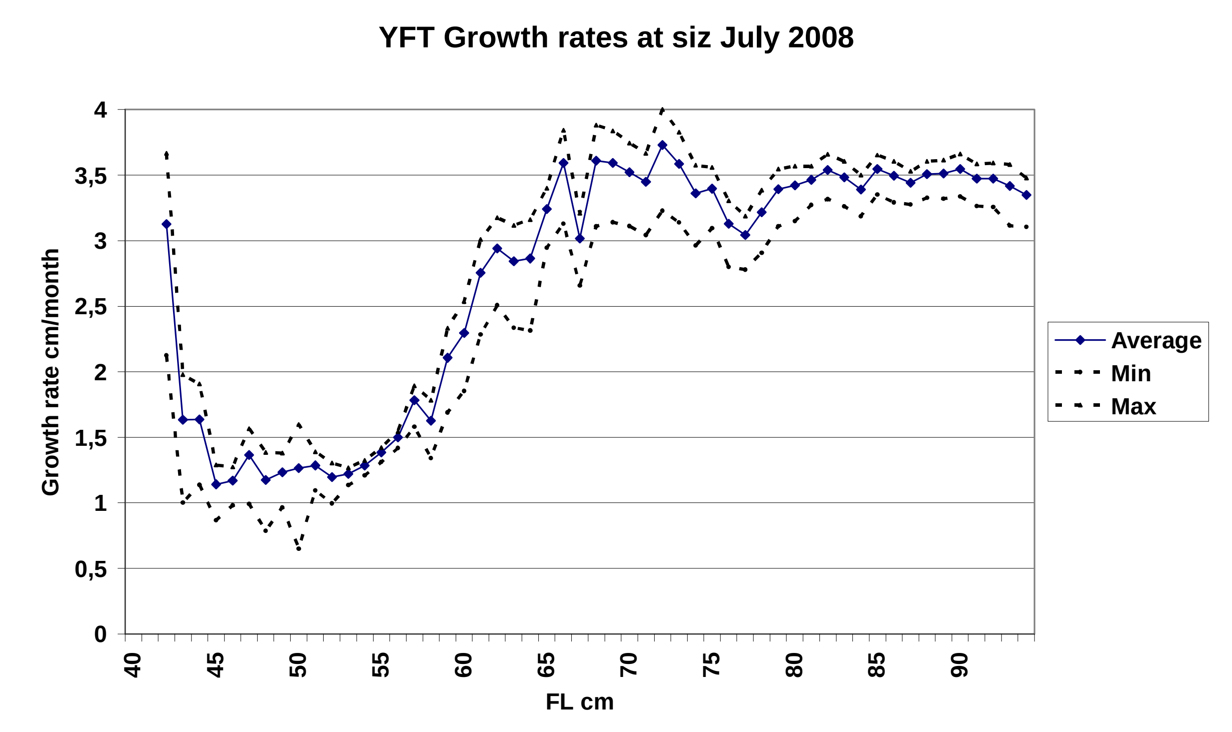

Figure 5: Growth rates at size presently estimated by the Fonteneau and al method for yellowfin smaller than 100cm and estimated uncertainty in these average growth rates.

(2) Growth of juvenile yellowfin between birth and 43 cm (only 1 kg) is assumed to be very fast (no doubt!), with a linear decline of growth rates at size between birth and 43 cm (then similar to a Juvenile Von Bertalanffy growth curve) , and with an anchoring point of this curve at 6 month and 33 cm.

(3) Growth of adult yellowfin at sizes over 93 cm are assumed to be showing a linear decline of growth rates at size (the following a Von Bertalanffy model) towards a L infinity anchored at 146 cm. Such L infinity was chosen at 5% under the maximum sizes of large yellowfin over 1m presently taken by all the fisheries.

(4) These growth rates by 2 cm intervals are of course easily converted in a typical growth curve, converting each 2 cm interval into their corresponding estimated durations (number of days), and then putting in relation the fork length and corresponding age in cumulated days and in years.

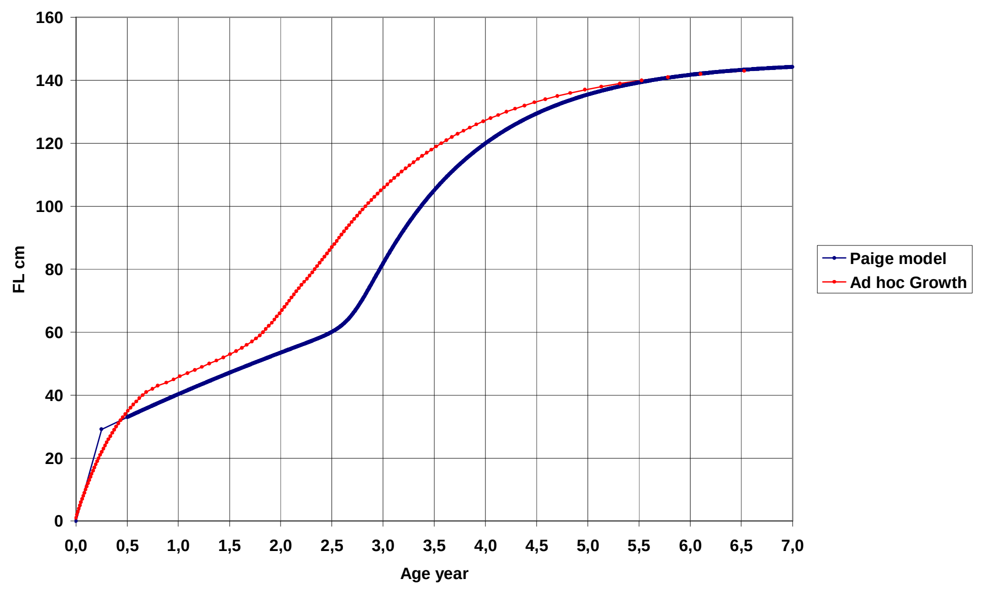

Figure 6: yellowfin growth curve estimated by Paige and the Laslett model, and yellowfin ad hoc growth curve presently estimated and proposed as a working hypothesis.

(5) this ad hoc average growth curve was later used to build a quarterly slicing table of catch at sizes, allowing to later estimate a matrix of catch at age: this table was built (a) assuming a dominant spawning season in the first quarter of each year (based on the Hassani and Stequert and recent unpublished sampling of gonads at the Victoria cannery) and (b) fixing slicing limits at the median points between 2 successive cohorts; catches in the last interval being from a 6 + group at sizes over 142 cm (quarter 1 &2) and 144 cm (quarter 3 &4).

This slicing pattern is shown by the following figure 7:

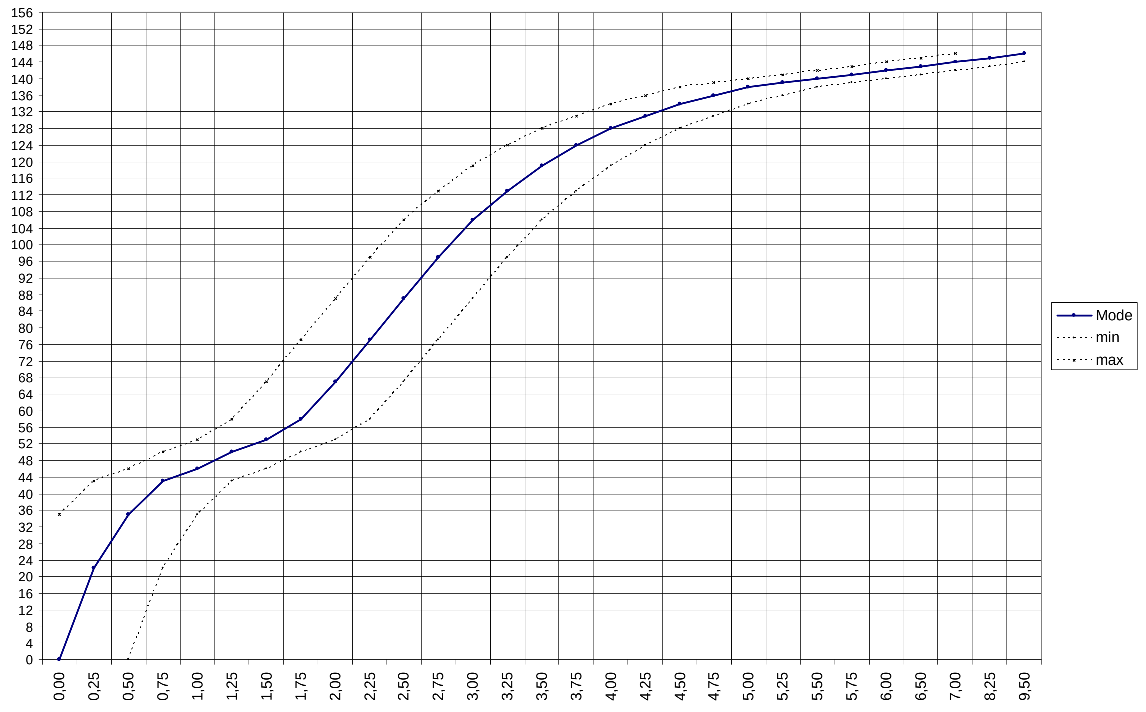

Figure 7: Proposed basis for a slicing table: the main line shows the modal quarterly growth, and the upper and lower dotted lines show the slicing limit of the larger and smaller fishes at each quarter and cumulated as being the catch of this cohort during this quarter.

These slicing limits between successive cohorts had to be rounded using the basic 2 cm size classes of the IOTC data base, and using the following slicing table (keeping in mind that it would be quite easy and much better to use slicing limits at a millimetre level, and later doing the slicing of each 2 cm class assuming a constant catch in each interval of 1 millimetre).

Age	Classe	quarter			
		1	2	3	4
0	Min	0	0	0	0
	Max	20	30	46	50
1	Min	22	32	48	52
	Max	52	58	66	76
2	Min	54	60	68	78
	Max	86	96	106	112
3	Min	88	98	108	114
	Max	118	124	128	130
4	Min	120	126	130	132
	Max	134	136	138	138
5	Min	136	138	140	140
	Max	140	140	142	142
6	Min	142	142	144	144
	Max	200	200	200	200

It can fist be noted that the age 6 is an age 6 + combining a wide range of potential ages of fishes caught at FL over 142 and 144 cm. The real longevity of yellowfin remain widely unknown, but there are great expectations that the long term recoveries of adult yellowfin tagged during the IOT tagging program should soon allow to solve this major uncertainty. This slicing table is of course far to be optimal as it cannot incorporate the variability of ages at given sizes. However such slicing method has been often used in various tuna stock assessments (North albacore in the Pacific, Atlantic Yellowfin, etc) and the results of these analysis have estimated to be quite consistent. Its results could at least be used to explore some of the potential consequences in our present problem in growth modelling.

4-Conclusion

The main goals of this paper were to show the difficulties to model the growth of yellowfin tuna based on the results of the tagging programme. There is no doubt now that the traditional Von Bertalanffy model is totally inconsistent to model the complex growth pattern now observed from the tagging results. There is a high probability that these results are widely significant and fully representative of the yellowfin growth, even if some selectivity bias in the purse seine fishery may have introduced some minor bias in these results.

One of the conclusion of this working paper is that the 2 stanza model (from Laslett et al 2002) previously agreed by the WG used cannot describe the yellowfin growth from birth to death, and that its present results are possibly widely biased and not realistic to estimate a catch at age table from the catch at size table.

It can also be noted that this proposed growth curve:

- is in full agreement with the historical results of modal progression analysis (Petersen method) done by Marsac 1992
- is in close agreement with the validated age reading of tagged YFT (Morrize results, this meeting)
- is in close agreement by the results of the MF-CL model presented to this WG: its “best” growth being very similar to my ad hoc growth pattern, and very far from the Laslett & al growth model.

It is then recommended that the proposed empirical and ad hoc growth curve associated to a slicing of the CAS table should be used at least as a comparative working hypothesis in the Bangkok analytical stock assessment work.

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