

PLOTREC, A GRAPHIC SOFTWARE FOR PLOTTING THE APPARENT GROWTH OF RECOVERED FISHES IN ASSOCIATION WITH THEORETICAL GROWTH CURVES

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SUMMARY

This paper describes a small graphical software which draws figures showing on the same plot (1) any type of theoretical growth curve and (2) the size changes observed for tagged fishes between their tagging and recovery as a function of their time at liberty. The small PLOTREC software appears to be interesting because it allows to immediately visualize in a simple way, the apparent growth of fishes in comparison with growth models.

INTRODUCTION: GOAL OF THE SOFTWARE

The goal of this small software is to draw figures showing the fit between (1) a theoretical growth model and (2) a set of recovery data obtained after tagging operations providing for a number of individuals triplets of information: size at tagging, size at recovery, numbers of days at liberty. The growth model is obtained, either from the same data of recovered tags, or using another method such as modal progression or hard parts reading. This growth model can also be a model obtained upon another stock, allowing an immediate visual comparison between the growth model on this foreign stock and the apparent growth shown by the recovered fishes. This program is still a prototype as only three simple growth models are presently available in PLOTREC: a linear growth, a Von Bertalanffy growth and a two stanza model. In the future any other growth model (such as the various two stanza models increasingly used for various tuna stocks) could easily be introduced as alternative options for this software.

PLOTREC description

This software is working in a very simple way in two successive steps:

The first step will draw the line of the theoretical growth curve in a diagram of x-y axis, where the x axis is the time spent in days (between day 0 and a given maximum age selected by the user) and the y axis is the size of the fish (between size 0 and a given maximum size selected by the user). The present beta version of PLOTREC is allowing only 3 potential growth models (linear, Von Bertalanffy, Nedler), but it will be developed in the near future in order to incorporate other growth models, such as Richards or Gascuel and al. models.

The second step will draw, for each recovered fish, a line showing its apparent growth over the time spent at sea. The initial point of this line is position on the theoretical growth

curve, at the age corresponding to the estimated size at which the fish was tagged and released. The right point of the line will correspond to the duration of liberty at sea (x axis) and the size at recovery (y axis).

This software is written in FORTRAN 90 and is using the graphic facilities of this FORTRAN for its output. The parameters corresponding to the growth curve (model of growth and corresponding growth parameters) are given by the user as well as the maximum duration and maximum size plotted in each graph. The recovery file will be given as triplets of: (1) sizes at tagging and (2) size at recovery followed by (3) duration of liberty in days (see example given in annex). The growth parameters will be given in the same units (for instance centimeters and days).

Examples of PLOTREC output

Used as a complement to the various statistical models which are used to estimate growth curves and their parameters, this small software can easily provide a comprehensive overview of the distribution of recovery data (sizes, duration, numbers, anomalies in sizes) and a visual understanding of the validity of the fit between the growth model and the recovered tags.

This set of observations is well demonstrated by the following examples taken on various tuna stocks.

Skipjack growth

The skipjack recoveries observed in the Indian Ocean (Maldives) were kindly provided by S. Adam (Maldivian tagging, Adam 1999) and used in this example. They were plotted in relation with the three growth curves estimated (1) in the Indian Ocean, (2) in the Atlantic (Bard et Antoine 1986), (3) in the Western Pacific and in the Eastern Pacific (Joseph). They suggest that the growth of Maldivian skipjack would be very similar to the growth of skipjack in the Atlantic, and very different from the growth estimated from tagging in the Western and Eastern Pacific (e.g. much slower).

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Atlantic Yellowfin

The recovery data given by ICCAT were plotted on the Von Bertalanffy model proposed by Sakagawa and Le Guen 1973 (figure 2a) and on the two stanza and 5 parameters growth model proposed by Gascuel and al in 1992. Both models were tuned on size distribution and on modal progressions. This comparative plot confirms that this model does not well describe the apparent growth of small individuals (fig. 2a), while the two stanza model shows a much better fit (but not a perfect one, especially for many large yellowfin showing an apparent growth slower than the model) with the recovery data (fig.2b).

Atlantic bigeye growth

The recovery data of BET tunas obtained during the IRD-ISRA program "Mattes Associées aux Canneurs" or MAC, were kindly given to us by their owners (Hallier and Diouf) and plotted against the Marcille et al 1978 growth curve (obtained from modal progression on Atlantic BET), and on the Tankevich 1981 growth curve (obtained in the Indian Ocean using BET vertebrae readings). This comparison shows a good fit between the Atlantic recoveries and

Marcille 1978 model, but quite a poor fit with Tankevich 1981 growth (tagged fishes growing slower than the model), and a quite good fit with the growth parameters given by Stequert 2000 on Indian Ocean BET using daily age readings.

CONCLUSION

The small PLOTREC software appears to be interesting, allowing to immediately visualize in a simple way, the apparent growth of fishes recovered during a tagging program in comparison with any potential growth model. The present version of this program is still provisional but already available to interested users. This version should be improved to allow the incorporation of other growth models (such as the various multi stanza models recently proposed for various tuna stocks, such as the Atlantic or Western Pacific Yellowfin, southern bluefin, etc..) and a fully flexible use of the software. Any proposal or comments targeting such further improvement and development of this software will be welcomed by the authors.

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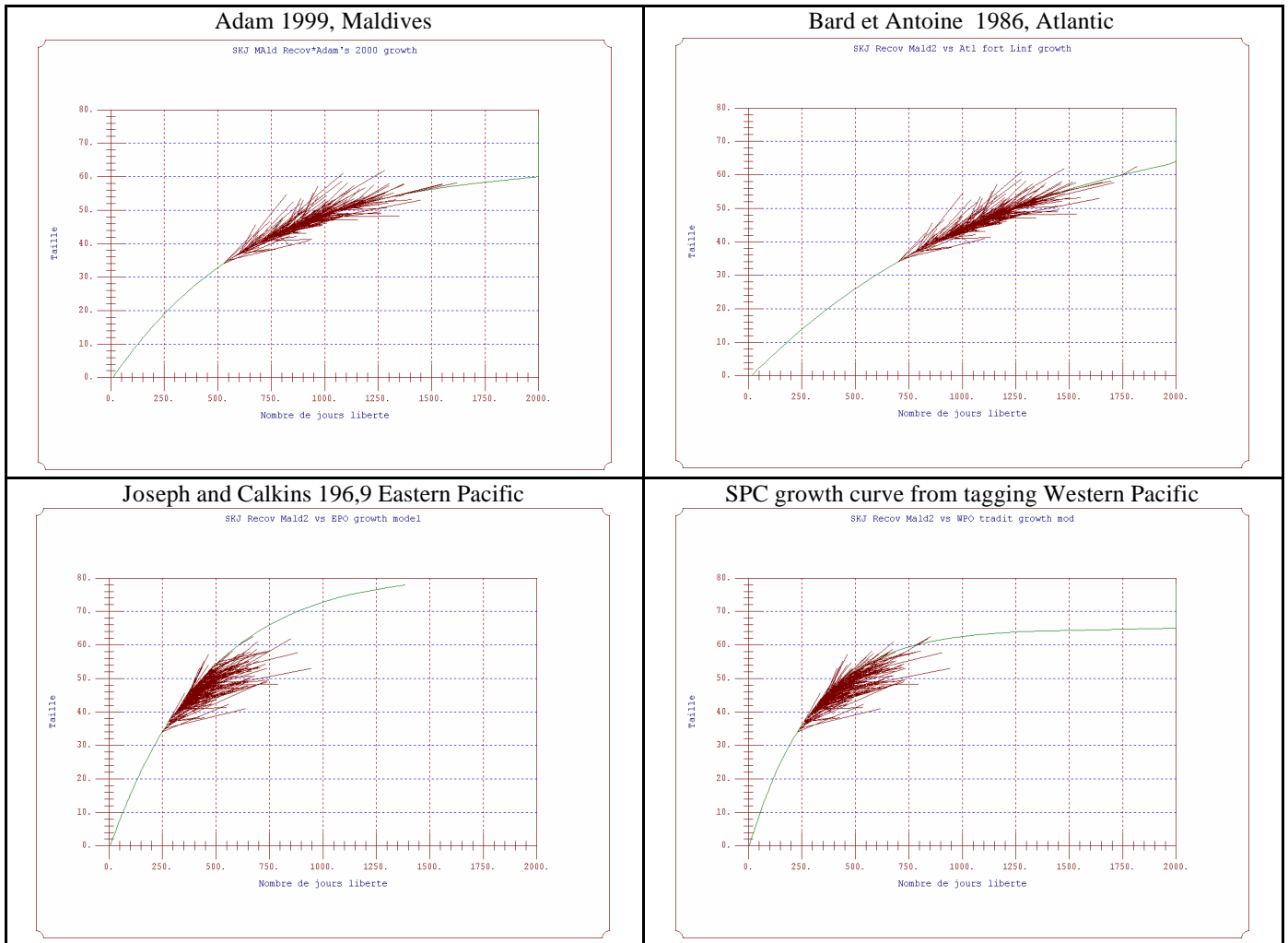


Figure 1: Example of skipjack growth: recoveries after more than 35 days at liberty observed during the second Maldivian tagging program versus (1a) the Adam 2000 growth curve, (1b) the Atlantic growth curve given by Bard et Antoine 1986, (1c) the Eastern Atlantic growth curve proposed by Joseph, and (1d) the Western Pacific growth curve estimated by SPC (all curves obtained from tagging).

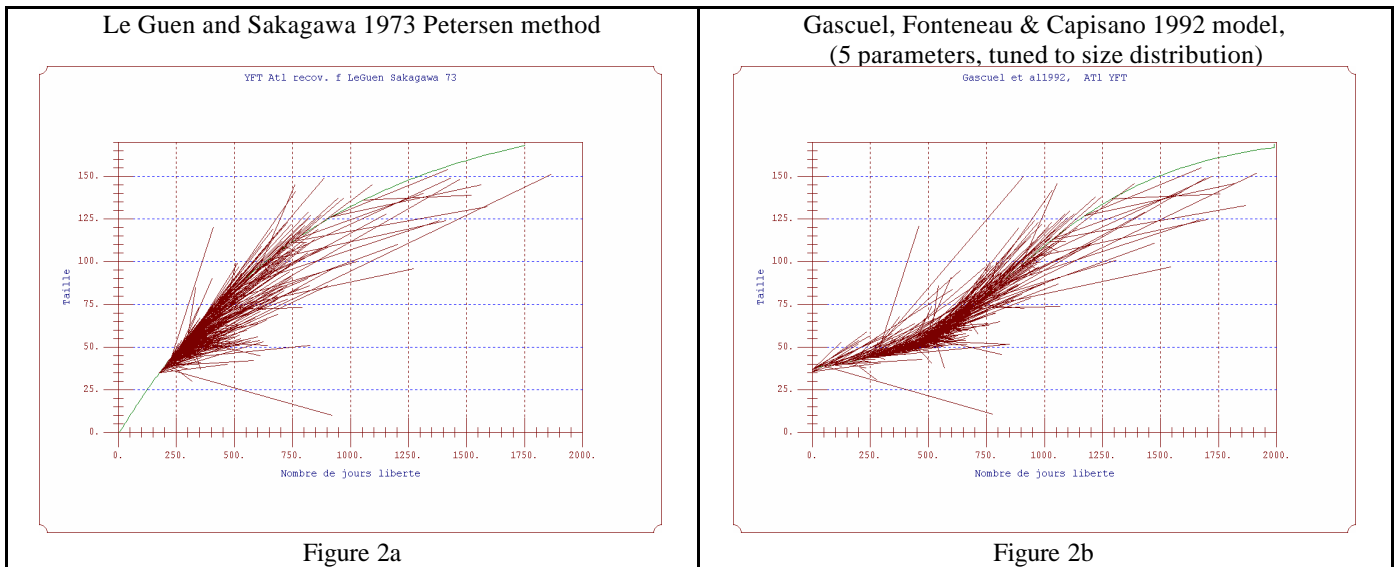
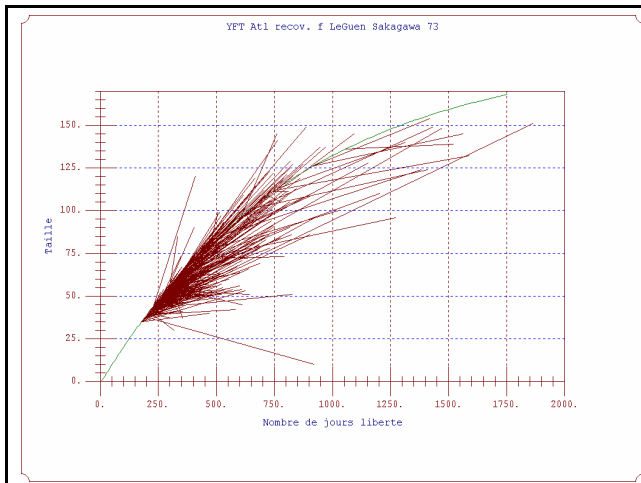
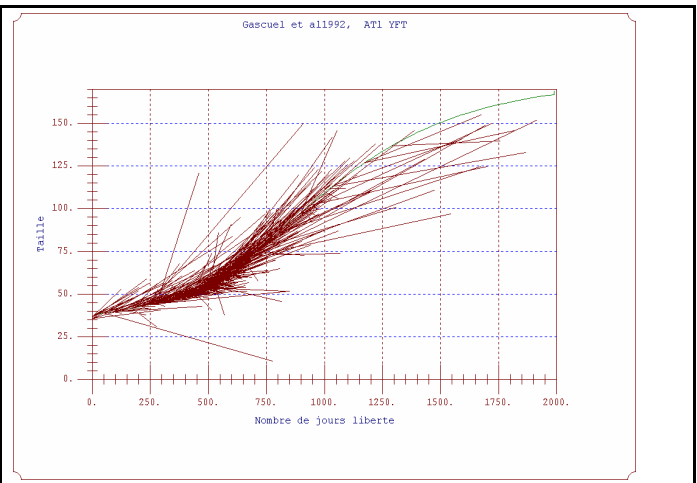


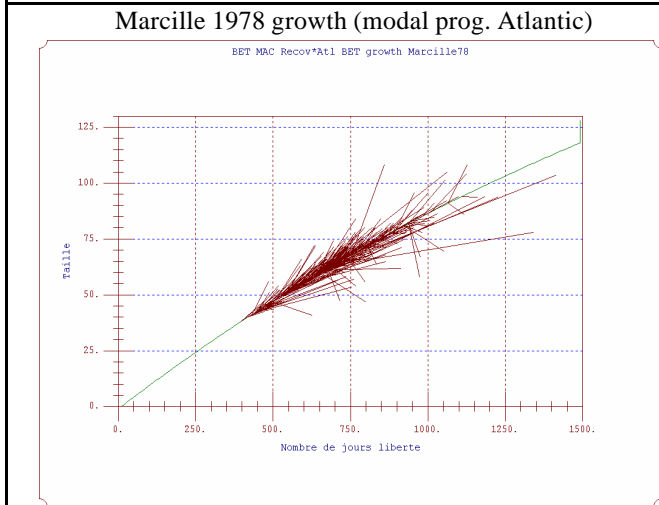
Figure 2: Example of yellowfin growth in the Atlantic. Recovery data (more than 30 days at liberty) plotted on the growth curve proposed by Le Guen et Sakagawa 1972 (figure 2a) and on the two stanza growth curve proposed by Gascuel and al in 1992.



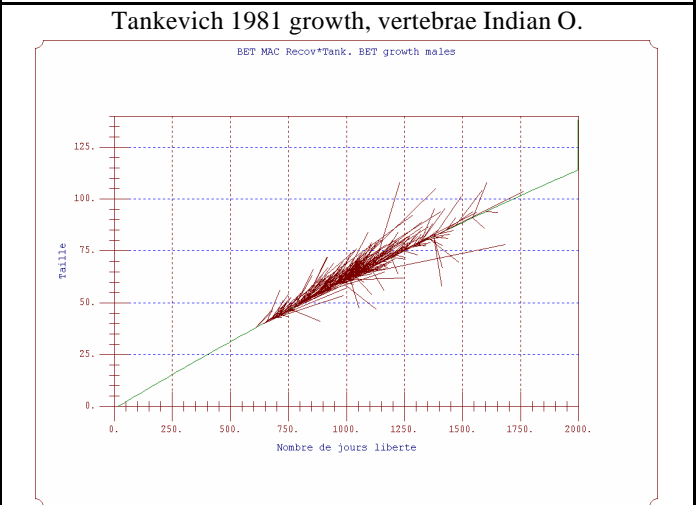
Marcille 1978 growth (modal prog. Atlantic)



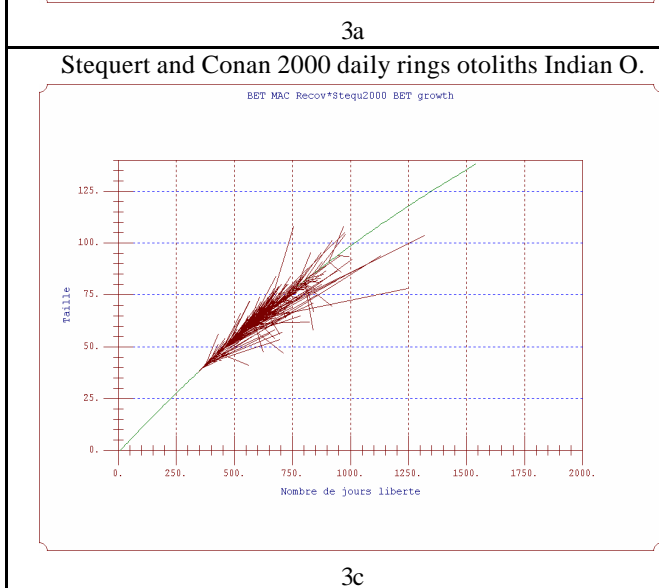
Tankevich 1981 growth, vertebrae Indian O.



3a



3b



3c

Figure 3: Example of bigeye growth curves plotted with the BET recoveries observed during the MAC program (data kindly given to us by Hallier and Diouf). Figure 3a showing the recoveries on the Marcille 1978 growth curve (modal progression in the Atlantic), figure 3b showing the same recoveries on the Tankevich 1981 Indian Ocean growth (vertebrae readings) and 3c on the Stequert and Conan growth curve (otolith daily readings).