PRELIMINARY RESULTS ON AGE AND GROWTH DETERMINATION, DAILY INCREMENT, OF TROPICAL TUNAS [1]

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ABSTRACT

*Investigation on age and growth determination of tropical tunas, yellowfin tuna (*Thunnus albacares*); bigeye tuna (T. obesus) and skipjack (*Katsuwonus pelamis*), which was sampled from port sampling at Phuket port, Thailand, and observed on board during April 1999 to May 2001. Results of the present study describe tuna otolith extraction, preparation and morphology of tropical tunas. Length-length relationships of yellowfin tuna show the equations as follow: $FL = 4.0719HL-8.258$, $LD_1 = 0.9401HL+4.8960$, $FL = 3.6880 LD_1-5.777$ while bigeye tuna were as follow: $FL = 3.7269 HL-11.898$, $LD_1 = 0.979HL+2.3372$, $FL = 3.6528LD_1-15.251$. Only regression line between otolith length and fork length of yellowfin can be expressed by the equation as $OL = 10.110 + 4.8312FL$. The preliminary on ageing analysis of bigeye tuna based on otolith microstructure is presented.*

INTRODUCTION

Tropical tunas, yellowfin tuna (*Thunnus albacares*); bigeye tuna (*T. obesus*) and skipjack (*Katsuwonus pelamis*); are a large, long-lived, high migratory pelagic fish with a circumglobal distribution between 40°N and 40°S (Collette and Nauen, 1983). Three species of tunas account for the largest share of the total catch and also for the largest increase during the last decade in Indian Ocean, and increased sharply compared to the plateau over the previous five years in the Eastern Indian Ocean (EIO). Since the mid-1980s, landings of yellowfin, skipjack and bigeye tuna from industrial purse seine and longline fleets have been increasing in this area (Anon., 2000).

The age and growth of tropical tunas have been studied by several authors using different methods such as modal analysis of length frequencies in the catches (Brouard et al.,1984; Wankowski,1981; Suda and Kume, 1967; Chantawong, 1999), the deposition of rings in scales (Yukinawa and Yabuta, 1963) or vertebrae, and the analysis of tagging data (Bayliff, 1988; Lehodey and Leroy, 1999). There is relatively scarce on age determination by otolith, especially, in the Indian Ocean.

A lot of uncertainties remains about the growth parameters estimates produced in these analyses because of the restricted size range of samples (in particular the lack of small fish of yellowfin and bigeye), the lack of validation in the hypothesis of annual or semi annual marks on the hard parts, the problems in the inherent to the length frequency method, and the conflicting results regarding sexual differences in the growth of large fish or the existence or not of a phase of decreasing growth rate for fish during morphological and physiological adaptations (Lehodey et. al., 1999).

The objective of the present study is to investigate method of otolith extraction, otolith morphology, length-length relationship and ageing of tropical tunas. It is expected that these information will be fruitful for tuna biology and fisheries in the Indian Ocean.

1 This paper will present at the 3rd Working Party on Tropical Tunas, IOTC, hold at Victoria, Seychelles, 19 to 27 June 2001.

MATERIALS AND METHOD

Sampling area and duration

Since the late-1993s, landings of commercial purse seiner and longliner landed their catch at Phuket port, Thailand. The total landing fro m 1993 to 2000 showed fluctuations trend, from 1,750 to 34,032 tons, the highest peak pronounced in 1993. The main fishing grounds of these industrial fleets have located in the EIO. In this study, we collected the samples from port sampling which landed at Phuket port and observation on board that caught in EIO, 5^o N to10^{o}S and 80^{o}E to 95^{o}E, during April 1999 to May 2001.

Data collection and analysis

Tuna samples have been collected for otolith and length measurement particularly; otolith lenth (OL, mm), head length (HL, cm), length at first dorsal fin (LD_1, cm) and fork length (FL, cm). Fig 2 illustrates all of tuna length measurement, Table 1 describes number of otolith samples and range of size distribution of each specie in this study. The relationship between the OL of tropical tunas and FL was examined by regression analysis based on a significance level of α=0.05.

Length-length relationships between the HL and FL, LD_1; LD_1 and FL were calculated using regression analysis for yellowfin and bigeye tuna. Table 1 showed number of tuna samples and minimum-maximum of size distribution.

Table 1 *Number of samples and samples and range of size distribution of tropical tunas from April 1999 to May 2001.*

Tuna	Otolith and FL measurement[1]			FL-HL-LD_1 measurement[2]			
	N	Min-max		N	Min-max		
		OL	FL		FL	HL	LD_1
yellowfin	17	6.8-9.8	40.5-58.7	597	90.7-169.0	27.1-45.7	25.1-41.6
bigeye	7	5.9-9.8	41.8-72.0	210	81.4-188.5	22.2-51.9	24.5-54.5
skipjack	12	4.3-7.9	42.2-61.5	-	-	-	-
Total	36			807			

Remarks: 1, samples was taken from purse seine and longline
2, samples was taken from longline
N, Number of sample

RESULTS AND DISCUSSION

Otoliths extraction

Otoliths were collected from frozen fish (purse seine) and chilled fish (longline) during field sampling. Morales-Nin (1992) reported a good storage method (e.g. freezing and chilled) with out risk of partial thawing of otolith sample due to temperature change, which would degrade otolith quality. The removing otolith as transverse section on skull, cranium, until reach chamber of inner ear by sharp knife, remove brain and will get otolith in the inner ear, that located in both of saccule. Otoliths are removed carefully by forceps and taken off the otolithic membrane by brush pen, cleaned with water and ethanol, after that stored and labeled the dry otolith in plastic vial in room temperature. Above procedure were followed Secor et al. (1991); Morales-Nin (1992); Stevenson and Campana (1992).

Otoliths, also call ear bone are bony structure having complex morphologies, which differs in each species (Fig 3). The three pairs of otolith are most commonly termed as lapillus, sagitta and asteriscus. Initiated investigation study was carried out two otolith types, i.e. astericus and sagitta. Sagitta is the largest otolith which it will be the easiest to remove and handle, containing the widest increments for clearest resolution of microstructure features. Asteriscus is the smallest, non-polish and preparation, but lack of the clearest microstructure features. Secor et al. (1991) said that the decision facing an investigator is which otolith is best resolution qualities and regularity of microstructure patterns for micro-increment analysis. Then, we chose sagitta for preliminary analysis of ageing in the present study.

The measurement of sagitta is conducted before otolith preparation. The distance recorded from rostrum to post rostrum under an ocular micrometer in micrometer unit and converted to millimeter unit (Lee et al., 1983).

Otolith preparation

Bigeye otolith was used for the preliminary study on age determination, daily ring. Lehodey et al. (1999) reported the bigeye otolith present more contrasted increments and are consequently easier to read than yellowfin and skipjack otoliths. Otolith of bigeye are embedded in polyester resin, and transverse section is made with otolith cutting machine to obtain the primordium at a otolith slice (Fig. 4). The slice is attached to a glass slide with thermoplastic glue (crystal bond), ground with wet sand paper (800 and 1200 grit) and polished with lapping film until the primordium is reached. Next, the another side of slice is removed on a hot plate and polished again. The method to emphasize the daily increment is partially decalcified with 10% HCl. Viewing sagitta section under the compound microscope, the daily ring was estimated using a total count of growth bands on the long arm (Fig. 5). Lehodey et. al. (1999) studied on age and growth of bigeye tuna by daily growth increments and tagging data, would indicate that bigeye tuna deposit one increment each day in their sagittal otoliths throughout the western and central Pacific Ocean, at least in the size range investigated (25-157 cm).

Length-length relationship

Results of the regression using the entire sample of yellowfin and bigeye from longline indicated significant relationship between HL and FL, LD1; LD1 and FL which are expressed in Table 2, Figure 7 and Figure 8.

In addition, in this study, the fishes were not separated into males and females before measurement. The length-length relationships of these tuna have not been calculated in Thai Waters before, thus they should provide basic information for future studies. There will be a need to convert length measurements to a standard measure, e.g. FL and LD_1, especially large size of tuna samples from longliner. Most tuna length are measured from the upper jaw to the first dorsal fin (LD_1) during size distribution sampling, while some tuna lengths are collected from the upper jaw to the end of operculum (HL), cause of only yellowfin and bigeye head can be provided from fisher at Phuket port, when otolith sampling in this study.

The linear relationship between otolith length and fork length was significantly correlated for yellowfin tuna ($r^2 = 0.515$, N=17, $p<0.001$). While a significant relationship of bigeye tuna and skipjack was no evident ($r^2 = 0.39$, N=6, $p>0.185$; $r^2 = 0.06$, N=12, $p>0.44$, respectively). The estimation of otolith length and fork length of yellowfin can be expressed as the equation:

$$OL = 10.110 + 4.8312FL$$

An important assumption inherent in growth studies using hardparts is that size of fish and size of hard part are closely related throughout the entire life cycle (Watson, 1967: Lagler, 1970: Smith, 1983). Although many attempts have been made to estimate the age of Atlantic bluefin tuna using skeletal hardparts, only rarely have studies examined this relationship for the purposes of back calculation. The problems related to determining age and growth of giant bulefin tuna and size of their vertebrate (N=2,116) and otolith (N=548). As bluefin tuna reach the giant-size category, the relationship between the size of both hardparts and fork length deteriorate (Lee, et al., 1983). However, this study was conducted a few data set from small size of fish (caught by purse seine), then found only fairly high correlation of r^2 between otolith and fork length of yellowfin. Our investigation on otolith measurement in the further will be conduct more samples, at least cover range of size distribution that caught by purse s eine and longline.

Otolith reading

According to 4 bigeye otoliths were observed as size range (42.4 to 56.0 cm FL) and dairy ring (82 to 121), Figs 5C and D illustrated dairy increment. The result of this was plotted and compared with the previous study in the Indian Ocean (Chantawong, et al., 1999) and Western and Central Pacific Ocean (Lehodey, et al., 1999), they descried the growth curve of small bigeye tuna, where illustrated the growth curves of bigeye tuna in Fig 6. Our result seem to be underageing and a few sample. As evidenced by the low age estimated for this study because we lacked of experience on otolith reading which distiguished individual increments or detected interrupted band.

The discovery of daily growth increments of fish otolith has been used to validate annual periodicity to determine change in growth or growth histories of individual fish and analysis of recruitment pattern and taxonomic study (Victor, 1982 ; Gutierrez and Morales-Nin, 1986). As bodily growth and otolith growth are closely linked, the increment thickness will reflect the rate of growth, recording periods of environmental and physiological stress and growth fluctuation caused by growth rate linked with metabolic slowdown (Gutierrez and Morales-Nin, 1986). The daily deposition of increment depends on circadian endocrine rhythms which are synchronized at an early age with photo-periodicity or other external daily factors (Campana and Nielson, 1985). The synchronizing stimulus must either not vary in periodicity by more than 24 hour cycles. Only environmental factor can act as synchronizer although other factors may mask or reinforce the endogenous rhythm. The daily deposition of increment should allow an extremely precise determination of age.

Otolith ageing in this study is preliminary investigation which we acquire the special skill and knowledge of age determination method. We believe this interpretation will assist the further investigation on counting and measuring growth bands in a numerous tuna samples.

ACKNOWLEDGMENT

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Table 2. *Regression results of length-length relationship of yellowfin and bigeye tuna*

Yellowfin Tuna

Regression	Intercept (s.e.)	Slope (s.e.)	Residual mean square	R^2	N
FL vs LD1	-5.772 (3.22)	3.688 (0.087)	47.78	0.750	597
LD1 vs HL	4.896 (0.754)	0.9401 (0.0221)	2.62	0.752	597
FL vs HL	-8.258 (3.035)	4.0719 (0.089)	42.41	0.779	597

BigeyeTuna

Regression	Intercept (s.e.)	Slope (s.e.)	Residual mean square	R^2	N
FL vs LD1	-15.251 (3.152)	3.6528 (0.0874)	56.77	0.894	210
LD1 vs HL	2.337 (0.638)	0.9785 (0.0185)	2.472	0.931	210
FL vs HL	-11.898 (2.897)	3.7269 (0.084)	51.0	0.904	210

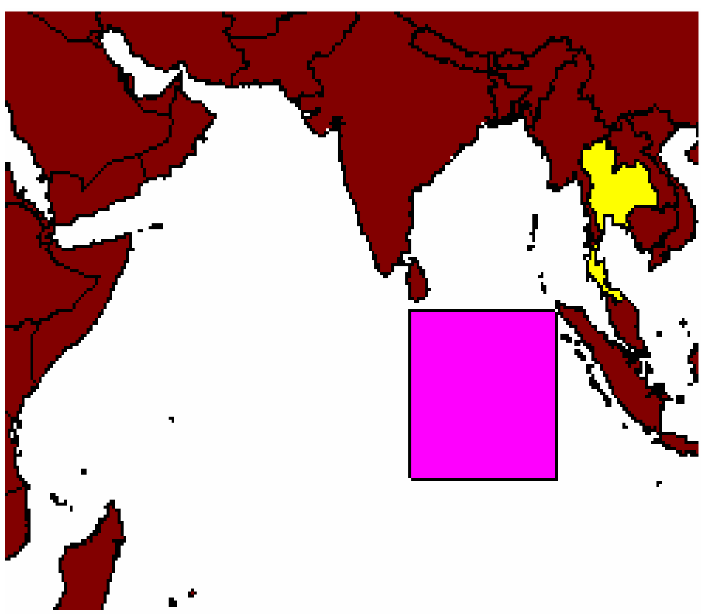

Fig. 1, *Fishing area of tuna samples in the Eastern Indian*

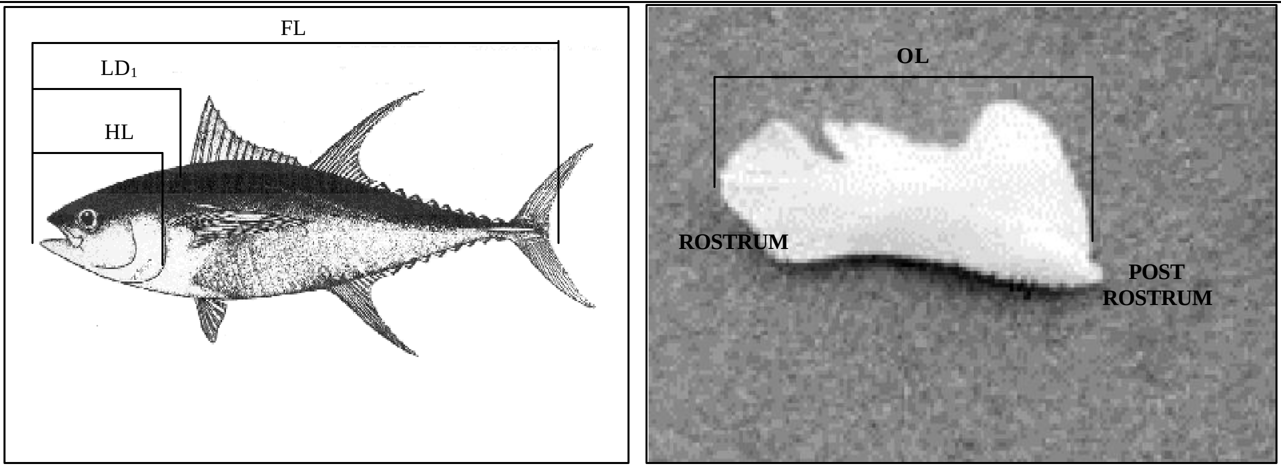

Fig. 2 *Illustrated definition of tuna length (FL= Fork Length, LD_1= Length at First Dorsal fin, HL = Head Length and OL = Otolith Length).*

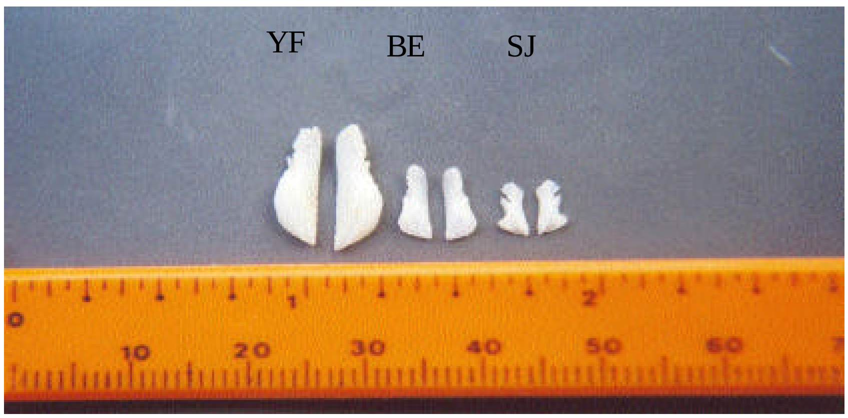

Fig. 3 *Sagitta* otoliths *of yellowfin tuna (YF, 126 cm FL), bigeye tuna (BE, 57 cm FL) and skipjack (SJ, 65 cm FL).*

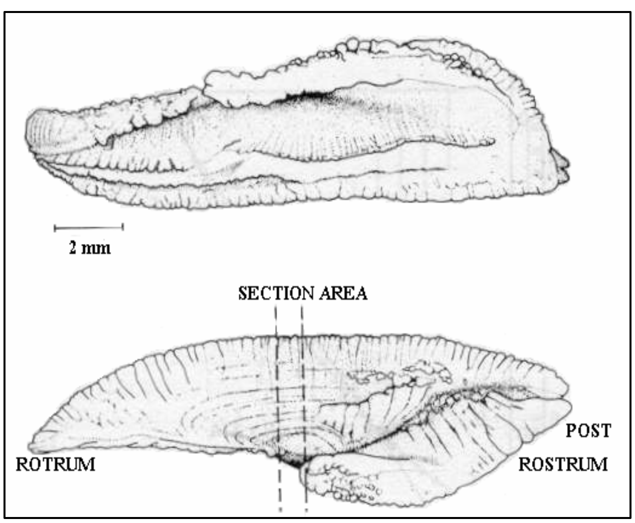

Fig. 4 *Proximal view of whole right sagitta otolith (top) and cross section of sagitta otolith (bottom) from a giant Atlantic bluefin tuna (Lee et al., 1983)*

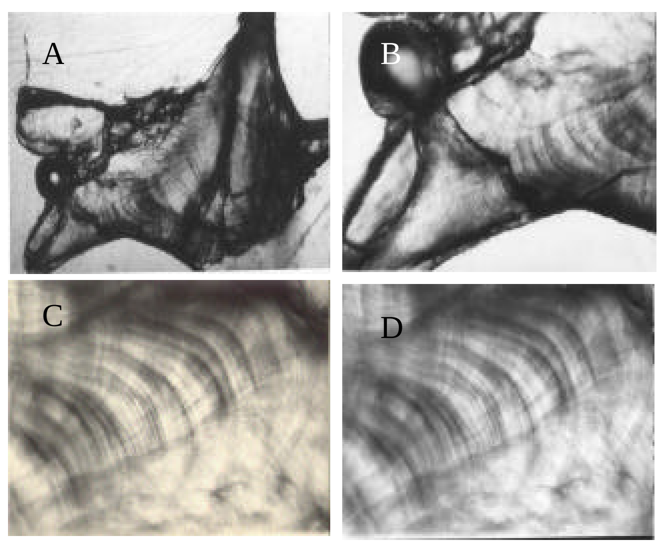

Fig. 5 *Thin transverse-section of sagittal otolith of bigeye (53 cm FL) showed the variation of increment width along the reading transect (magnification are x10 in A, x20 in B, x40 in C and D).*

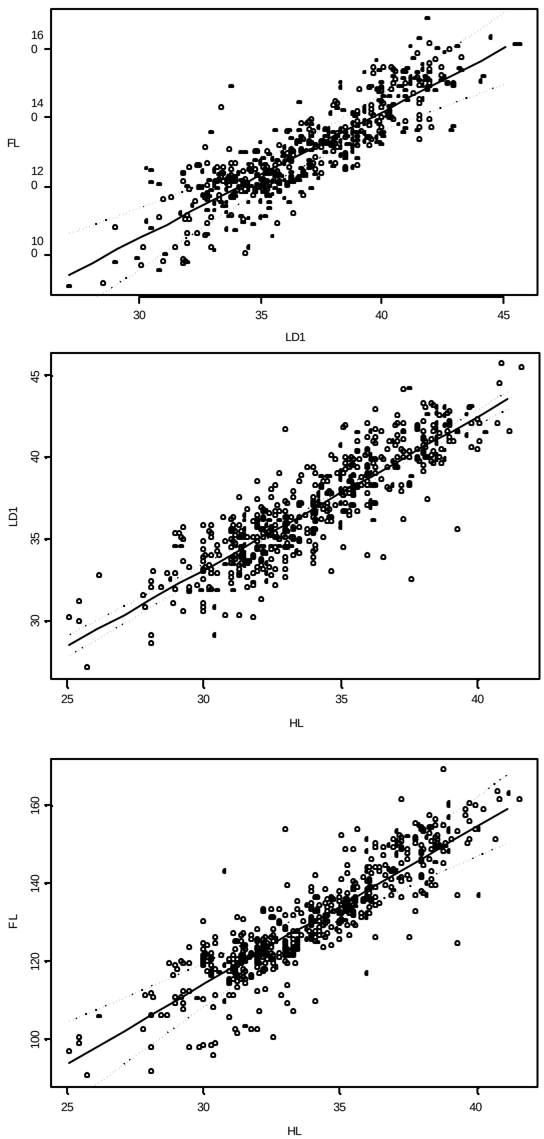

Figure 6 : *Length-length relationships for yellowfin tuna.*

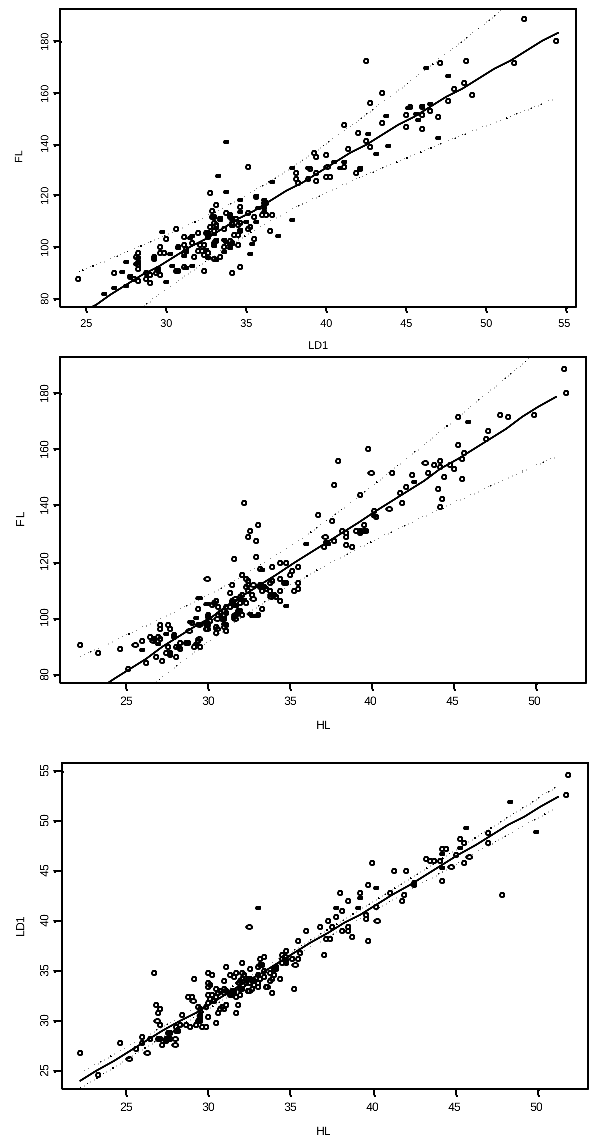

Figure 7: *Length-length relationships for bigeye tuna.*

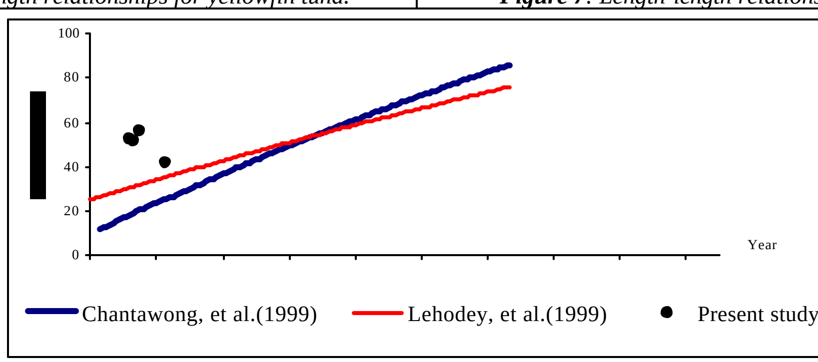

Fig. 8. *Comparison of bigeye growth estimated in present study to estimated growth curves from different authors.*