Short Communication:
Length-weight relationships of yellowfin and bigeye tuna from the South China Sea

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Introduction

Tuna has become the most important commercial fishery and a major economic contributor to Vietnam's central provinces such as Khanh Hoa, Phu Yen, and Binh Dinh (Nguyen *et al.*, 2013; Nguyen and Jolly, 2018). Landings in 2019 were 16,207 metric tons accounting for USD $720 million in exported value, corresponding with 13.3% exported value of marine fisheries (VASEF, 2020). Historically, tuna were caught using longline targeting yellowfin and bigeye species, however fishermen have switched using handlines with artificial light since 2012 due to higher catching performance (Nguyen and Tran, 2014). The tuna resource is exploited year-round, on offshore fishing grounds in the South China Sea (Nguyen *et al.*, 2013).

Given important tuna fishery in Vietnam, developing effective management guidelines for yellowfin and bigeye tuna is difficult because very little biological and demographic information has been documented (WCPFC, 2011). The study on the LWR is necessary and a primary process in order to conduct studies on fish stocks assessment.

Materials and methods

Tunas were collected in the South China Sea using gillnets and handlines with artificial light. All fishing gillnets were deployed and retrieved onboard the commercial F/V *KH97939TS*, measuring 18,47m LOA from March 25 to April 14, 2019. The experimental gillnets were 960 m in length and 44.7 m in height with 160 mm stretched mesh sizes. Handlings sampling was carried out onboard the commercial F/V *BĐ95930TS*, measuring 15.7 m LOA between March 26 and July 12, 2019 with 10 days break each month (from 11th to 19th of lunar month) to avoid low catch rates during the full moon phases.

All tunas captured by handlines and a majority of tunas captured by gillnets were weighted totally (wet weight) nearest 0.1 kg and measured total length (TL) nearest cm. The LWRs were estimated using a linear regression, following the equation log W=log(a)+blog(TL), after logarithmic transformation from the equation $W=aTL^b$, where W is the weight, TL is the total length, *a* is the intercept and *b* is the slope of the power equation. Prior to fitting regression analysis, outliers were examined and removed using log(W) versus log(TL) plots (Froese, 2006). Log(a) and b were performed using function y=lm(logW~logTL, data=Dat), and the 95% confidence interval (CI) were estimated using *confint* function in R. Additionally, the Kolmogorov-Smirnov two-sample Z test was used to compare length-weight relationships between yellowfin and bigeye tuna.

Results and discussion

A total of 607 tunas was caught during the period of study including 394 yellowfin tuna and 213 bigeye tuna. Gillnets caught 273 fish, and handlines caught 334 specimens. Most large fish (100 cm or/and 22.5 kg) were caught by handlines, while all smaller fish were captured by gillnets. These species were caught in sufficient numbers to be included in the analysis.

Estimated LWR parameters were

$W_Y = 0.0000198TL^{2.973}$ (CI: a= 0.0000156 – 0.0000251, b= 2.922 – 3.023), $R^2 = 0.971$ and $W_B = 0.0001359TL^{2.61}$ (CI: a = 0.0001064 – 0.0001736, b= 2.555 – 2.665); $R^2 = 0.977$

for yellowfin and bigeye tunas, respectively. The regression analysis of all LWRs were statistically significant for both species ($p<0.0001$). There were significant differences in LWRs between species (Kolmogorov-Smirnov two-sample test, D = 0.22, $p<0.0001$), in that bigeye tuna were about 5 kg heavier than yellowfin tuna at the same length when they were from about 70 cm long.

Although sustainable exploitation of yellowfin and bigeye tunas would have clear benefits, developing effective management guidelines for these species is difficult because there is no information on its biological characteristics (WCPFC, 2011). The first time the LWR parameters for yellowfin and bigeye tunas, an very important commercial species in the waters of Vietnam were documented. This study filled the scientific information gaps in elementary biological knowledge and provided useful information of ichthyofauna to support to the further sustainable fisheries development and management.

The values of *b* for both species fell in the expected range, 2.5 – 3.5 (Froese, 2006). In this study, we sampled fish larger than 41 cm, the coefficient of determination (R^2) could be improved and the regression model estimated a greater accuracy for log(a) and b values if there were a full range of fish length including fish < 41 cm (Froese, 2006). While parameters a obtained from our study were consistent with studies conducted in other areas, b values were slightly smaller than those estimations (Cort *et al.,* 2015). Several factors affect the accuracy of the LWR, i.e. condition of fish caught in different seasons, sex, length range, sample sizes, stomach fullness, and fitting methods (Froese, 2006). Therefore, these differences in *b* values could be attributed to a single factor or to a combination of multiple factors (Cort *et al.,* 2015).

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