Journal of Environment and Aquatic Resources. 5: 1-9 (2020)

doi: 10.48031/msunjear.2020.05.01

Preliminary Report on the Size-specific Variation in Length-weight Relationship, Relative Condition Factor, and Gonad Maturation of Bigeye Scad *Selar crumenopthalmus* (Bloch, 1793) in the northern Sulu Sea, Philippines

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ABSTRACT

A preliminary investigation on the size-specific variation in the length-weight relationship, relative condition factor, and gonad maturation of Bigeye scad, *Selar crumenopthalmus*, was conducted from April to May 2018 in the northern Sulu Sea, Philippines. A total of 435 samples were collected using a ring net. The results showed a shift from isometric to negative allometric growth pattern, good condition, and earlier maturation in males in *S. crumenopthalmus*. These findings help us understand some aspects of the *S. crumenopthalmus* population in the area; however, further research needs to be conducted with increased sampling duration and frequency.

Keywords: growth, allometry, northern Sulu Sea, length classes

INTRODUCTION

The Bigeye scad *Selar crumenopthalmus* is a commercially important marine fish species caught in the coastal waters of the Philippines throughout the year and contributes to over 5% of the country's total capture fisheries production (BFAR, 2016). Hand lines, ring nets, purse seines, and trawls are used to catch this species which is primarily utilized as food and is considered as a cheap source of protein for low-income families in the country (Trinidad et al., 1993). Although other commercially important fish species are well-studied, information on *S. crumenopthalmus* in the country is scant (Dalzell and Peñaflor, 1989; Baclayo et al., 2016; Echem and Miñoza, 2017). At present, marine fishery resources in the country have come under increasing threats of pollution, overexploitation, and habitat degradation which have biological, ecological, and societal implications (DA-BFAR, 2004).

Length-weight relationship, relative condition, and gonad maturation are important tools in fisheries biology, management, and stock assessment to understand fish populations and their dynamics (Anderson and Gutreuter, 1983). The length-weight relationship is important in the calculation of an equation of growth in length into an equation of growth in weight (Pauly, 1983) while condition factors show the degree of fitness, gonad development, and suitability of the fish in their habitat (Tesch, 1968).

Thus, the present study was conducted to investigate the size-specific changes in the length-weight relationship, relative condition factor, and gonad maturation of *S. crumenopthalmus* in the northern Sulu Sea, Philippines which will contribute in the development of appropriate management and conservation strategies of this commodity.

MATERIALS AND METHODS

Sample size and data collection

A total of 435 specimens were collected from April (n=271) to May (n=164) 2018 in the northern Sulu Sea waters within the jurisdiction of the province of Antique, Philippines (Fig. 1) on-board a commercial fishing vessel using ring net (mesh size: 1cm). The standard length (mm) and total weight (g) were measured using a ruler (precision: 0.1cm) and digital top loading balance (precision: 0.1g), respectively. The standard length of collected fish ranged from 9.3cm to 17.3cm; thus, for this study, the fish were classified into three length classes with an interval of 4cm. The length classes were 9.1cm to 12.0cm, 12.1cm to 15.0cm, and 15.1cm to 18.0cm. The fish samples were disposed of properly after the necessary data were collected.

Length-weight relationship and relative condition factor

The relationship between length and weight of the fish was estimated using the equation $W = aL^b$, where a and b are coefficients, L is the standard length (cm), and W is the wet body weight. The value of constant a and the slope b were estimated from the log-transformed values of length and weight using the logarithmic form of length-weight relationship through linear regression analysis. The analysis of the length-weight relationship was done for all length classes and pooled data. Moreover, the linear relationship between *log a* and *b* was used to determine whether the coefficients that were generated in this study were comparable with other published coefficients in www.fishbase.org (Froese and Pauly, 2018).

On the other hand, the relative condition factor was calculated for every length class using the equation: $K_n = W/aL^b$ (Le Cren, 1951; Froese, 2006), where W is the total body weight, aL^b is the calculated or expected weight of a fish in that length calculated using the regression coefficients. The fitness of the fish species is assumed when the relative condition factor is equal or close to 1 (Jisr et al., 2018).

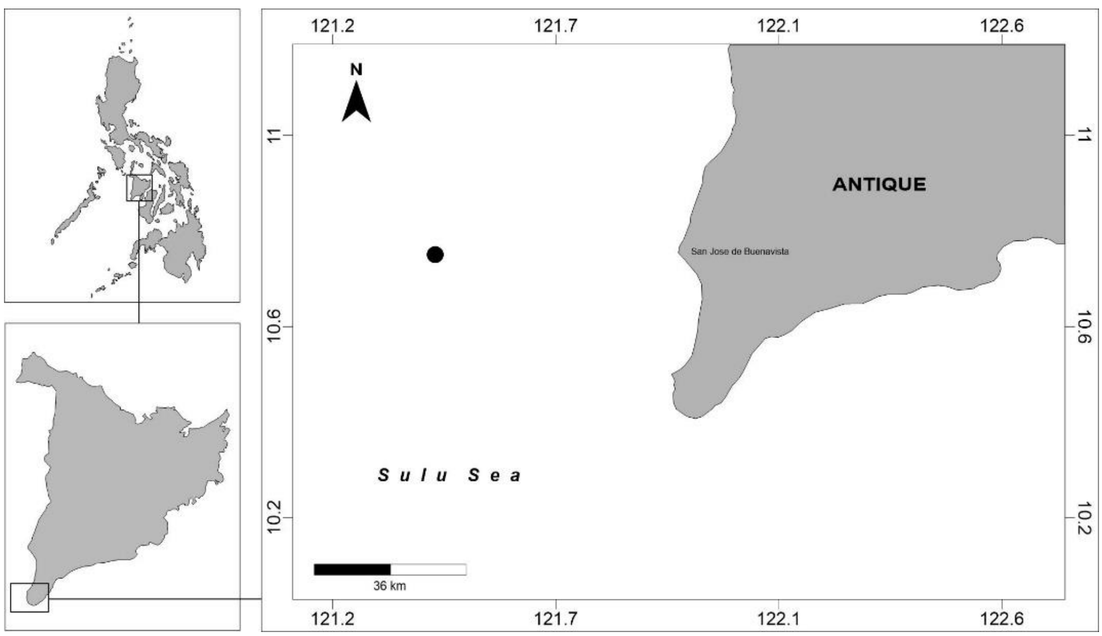

Figure 1. Map showing the sampling site in the northern Sulu Sea.

Histological analysis of gonads

Twelve gonad samples (six males and six females) from each length class were used for histological analysis. Live fish samples were dissected and gonads were removed and preserved using Bouin's fixative. The preserved samples were then transferred to 70% Ethyl Alcohol after 24h. The samples preserved in ethanol were brought to the Microtechnique Laboratory, University of the Philippines Visayas for histological analysis. The samples were cut, with the middle portion of the gonad used for analysis, dehydrated in ethanol series, cleared in toluene series, embedded in paraffin wax, and made into blocks. Cross-sections of 6µm (testis) and 7µm (ovary) thick were cut using a microtome, mounted, hydrated, stained with Delafield's Haematoxylin, and counterstained with Eosin.

The prepared slides were analyzed in a light microscope and photomicrographs were taken in 40x magnification and 10x magnification for testis and ovary sections, respectively. Maturity stages of the gonads were classified as immature, maturing, mature, and spent following Nuñez and Duponchelle (2009) and Brown-Peterson et al. (2011).

Data analysis

The computed *b* values of the length-weight relationship in every length class and pooled data were tested for significant difference from isometric growth (b=3) using t-test. Also, the relative condition factor values for every length class were compared using analysis of variance (ANOVA) and tested for significant difference from the expected value of one using t-test. All statistical tests were done using PAST software version 3.18 software (Hammer et al., 2001) at 95% confidence level.

RESULTS AND DISCUSSION

The standard lengths of the fish samples ranged from 9.3cm to 17.3cm. In April 2018, 88.19% of all fish collected belonged to the 9.0-12.0cm length class while there were only 9.96% and 1.85% for the 12.1-15.0cm and 15.1-18.0cm length class, respectively. On the other hand, in May 2018, 74.39% of fish collected belonged to the 12.0-15.0cm length class while there were 17.68% and 7.93% for the 15.0-18.0cm and 9.0-12.0cm length class, respectively. In the two sampling months, 57.93% of all fish collected belonged to the length class 9.0-12.0cm while 34.25% and 7.82% belonged to the length class 12.0-15.0cm and 15.0-18.0cm, respectively.

The length-weight relationships of the different length classes are shown in Table 1. The *b* values were 3.31, 3.00, 2.51, and 2.68 for the pooled data, length classes 9.1-12.0cm, 12.1-15.0cm, and 15.1-18.0cm, respectively. All *b* values were found to be significantly different from isometric growth (p<0.05), except in length class 9.1-12.0cm. The *b* value in the pooled data indicated positive allometric growth while that of length classes 12.1-15.0cm and 15.1-18.0cm indicated negative allometric growth. Moreover, parameters from the regressions were tested for wiping off the outline data and were found to be highly correlated (R^2=0.98).

Table 1. Length-weight relationships in different length-classes of *Selar crumenopthalmus* in the northern Sulu Sea*.

Size class	n	a	95% Confidence Limits	b	95% Confidence Limits	R^2
9.1-12.0 cm	252	0.02	0.011-0.031	3.00	2.800-3.209	0.77
12.1-15.0 cm	149	0.08	0.035-0.163	2.51	2.216-2.801	0.66
15.1-18.0 cm	34	0.05	0.006-0.472	2.68	1.883-3.479	0.59
Pooled	435	0.01	0.008-0.010	3.31	3.260-3.354	0.98

**n*, number of samples; *a*, intercept; *b*, slope; R^2, coefficient of determination.

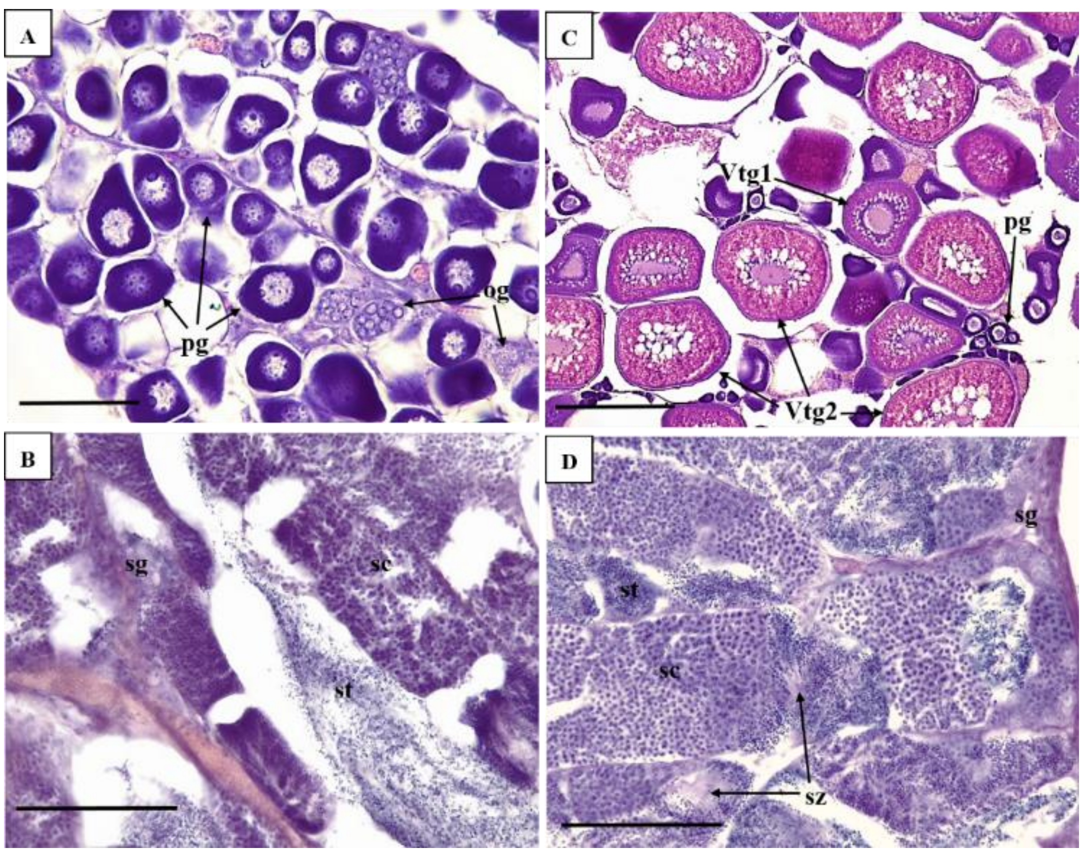

Figure 2. Photomicrographs of gonad cross-sections of length class 12.0-15.0cm (A, immature female; B, mature male) and 15.1-18.0cm (C, maturing female; D, mature male) of *Selar crumenopthalmus* collected in the northern Sulu Sea. pg, primary growth oocyte; vtg1, primary vitellogenic oocyte; vtg2, secondary vitellogenic oocyte; sg, spermatogonia; sc, spermatocyte; st, spermatid; sz, spermatozoa. Scale bar=100μm.

Furthermore, the highest relative condition factor value was recorded in length class 12.1-15.0cm at 1.01±0.01 followed by length class 15.1-18.0cm at 0.99±0.01 while the lowest was recorded in length class 9.1-12.0cm at 0.99±0.01. They were found to be not significantly different ($p>0.05$) in every length class and to the expected value of one. On the other hand, no gonads were collected from the smallest length class 9.0-12.0cm. Males of the length class 12.1-15.0cm were all maturing while females were all immature. Furthermore, in the 15.1-18.0cm length class, all males were mature and females were maturing.

The growth pattern exhibited by *S. crumenopthalmus*, a shift in isometry to negative allometry, may be a result of ontogenetic changes and nutritional condition. Adult *S. crumenopthalmus* assumes an elongate body that is moderately compressed and fusiform in shape which may affect the value of b. Froese's (2006) report that small specimens in the sample were in better nutritional condition at the time of sampling indicates that the collected samples were in good condition, under the assumption that more full-bodied and heavier fish at a given length indicates better condition. The gradual rise in condition with increasing length usually indicates allometry (Weatherley, 1959). As observed in this study, the condition of fish showed that the bigger length classes had higher relative condition factor values than the smallest length class. Also, the change in growth pattern and condition may have been due to the onset of gonad development. The negative allometric growth in mature individuals with an increasing b value from 2.51 in length class 12.1-15.0cm to 2.68 in length class 15.1-18.0cm may have been a result of the progression of gonad maturation, contributing to the increase in the "plumpness" of mature individuals.

Interestingly, the pooled data showed that the fish exhibited positive allometric growth (b=3.31). This implies that the fish becomes relatively stouter or deeper-bodied as it increases in length (Froese, 2006). The analysis of pooled data in determining length-weight relationships may result in the overestimation of the value of b since the growth patterns of fish have been reported to change with different growth stanzas (Froese, 2006; Jin et al., 2015). This explains why positive allometric growth was obtained in the analysis of pooled data which is a clear deviation from the isometric to negative allometric growth pattern observed in every length class.

Furthermore, it had been found that a male *S. crumenopthalmus* matured earlier than a female. The same has been reported by Iwai et al. (1996) and Clarke and Privitera (1995) but the results of Fadzly et al. (2017) show otherwise while Gallardo-Cabello et al. (2017) reported that both sexes attain sexual maturity at almost the same size.

Length at first maturity was reported to be at 12cm standard length in Indonesia (Siwat et al., 2016) and 19.39cm-21.76cm fork length in Maldives (Fadzly et al., 2017).

CONCLUSION AND RECOMMENDATIONS

These preliminary findings seem to indicate that the growth pattern of *S. crumenopthalmus* from isometry (in the juvenile stage) to negative allometry (in the mature stage) is a result of its condition and gonad maturation. However, future investigation should be conducted wherein the estimation of length-weight relationships and condition factors will encompass samples of a wider size range and a longer period of sampling, that is at least a year. Furthermore, studies on the reproductive biology and population dynamics of the species are recommended for appropriate management and conservation.

ACKNOWLEDGMENT

The author is thankful to the local government officials of San Jose de Buenavista, Antique for facilitating the on-board sampling, the fishermen and crew who helped during the collection of samples, and to Mr. Godwin Marcelino and Mr. Sagrado Magallanes for the company. The help of Mr. Condrado Manglal-an in the preparation of histological slides is appreciated.

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