

## **Length-weight and length-length relationships, and condition factor of the pelican barracuda *Sphyraena idiestes* Heller and Snodgrass, 1903 (Perciformes: Sphyraenidae) in the Gulf of California, Mexico**

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The pelican barracuda (*Sphyraena idiestes*) is a fish species commonly found in the southeastern Pacific and occasionally in the Gulf of California (González-Acosta et al. 2013). Recently, information on maximum and minimum lengths and weights, growth and trophic ecology, have been reported for the first time for pelican barracuda from the northern Mexican Pacific, including 15 (10 immature) specimens from four localities in the Gulf of California (González-Acosta et al. 2015). New records from the western coast of the Gulf of California show the pelican barracuda is captured locally throughout the year, with abundant peaks during the autumn-winter seasons (October-February; F. O. Lopez-Fuerte, personal observation). Thus, the aim of this study is to provide updated information on the length-weight (LWR) and length-length (LLR) relationships and condition factor for this species in the Gulf of California.

From December 2015 to April 2016, monthly field trips were conducted to catch pelican barracuda specimens in coastal waters near Santa Rosalia, Baja California Sur, Mexico (27°19'45.14" N, 112°15'13.40" W). Fish were captured using a fishing line and trolls deployed along the coastline, or from a 27-ft fishing boat. All fish caught (n=140: 76 males, 64 females) were identified as *S. idiestes* following Béarez's (2008) identification keys. The standard length (SL) and total length (TL) of each specimen were measured to the nearest millimeter using a fish measuring board. The weight of each specimen was recorded to the nearest 0.1 g. Sex was determined through macroscopic observation of the gonads.

All data collected were subjected to statistical analysis by calculating the length-weight relationship (Le Cren 1951), which can be expressed as:  $W = aTL^b$ , where  $W$  = weight (g) and  $TL$  = total length (cm). In this case, the relationship between  $TL$  and  $W$  was calculated for males and females separately by transforming  $W$  and  $TL$  data to logarithmic values and fitting them to the linear equation:  $\log W = \log a + b \log TL$ , using the least squares method with  $a$  as the interception between the regression line and the y-axis, and  $b$  the slope of the regression line. Extreme data values were identified and eliminated from the analysis by graphing log-transformed length and weight data (Froese et al. 2011). A student's  $t$ -test (Zar 2010) was conducted to assess whether the LWR  $b$ -values differed from those indicative of isometric growth ( $b = 3.0$ ).

The  $TL$ - $SL$  relationship was determined by simple linear regression ( $TL = a + b SL$ ). In addition, the relative condition factor was calculated as:  $Kn = W We^{-1}$ , where  $W$  = weight (g) and  $We$  = the weight predicted by the LWR (Le Cren 1951). To test whether  $Kn$  values differed between months, a one-way analysis of variance (ANOVA) was performed. All statistical analyses were conducted using the R program (R Core Team 2016).

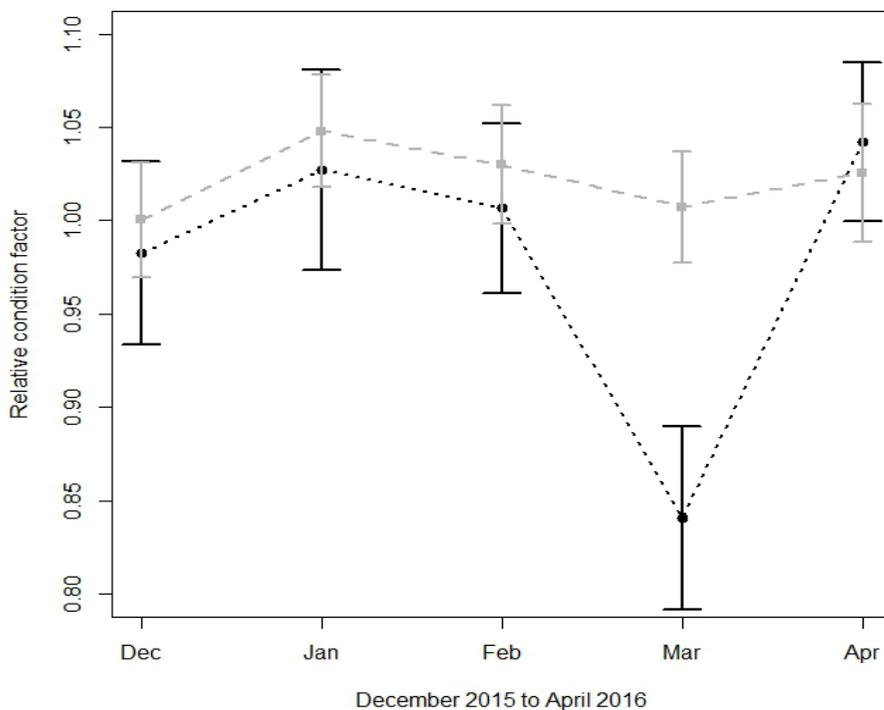
Sample size ( $n$ ),  $TL$  and  $W$  value ranges, and LWRs' ( $a$  and  $b$ ) parameters for *S. idiaestes* are presented in Table 1. Male pelican barracudas (40.5-54 cm  $TL$  and 35-46.5 cm  $SL$ ) comprised 54.2% of the total sample. The male group showed a significant positive power function between  $TL$  and  $W$  ( $r^2=0.90$ ), and between  $TL$  and  $SL$  ( $TL=3.19 + 1.08 SL$ ;  $r^2=0.93$ ). Female pelican barracudas (40.5-60 cm  $TL$  and 35.5-53 cm  $SL$ ) comprised 45.8% of the overall sample and displayed a robust positive power function between  $TL$  and  $W$  ( $r^2=0.91$ ) and between  $TL$  and  $SL$  ( $TL=1.91 + 1.11 SL$ ;  $r^2=0.96$ ). The overall sample showed a significant positive power function between  $TL$  and  $W$  ( $r^2=0.91$ ). Regression analyses describing the relation of  $TL$  and  $W$  derived a  $b$  value distinct from 3.0 for males ( $b=2.57$ ;  $t$ -test,  $P<0.05$ ), which indicates an allometric growth pattern; whereas for females the  $b$  value did not differ from 3.0 ( $b=3.04$ ,  $t$ -test,  $P>0.05$ ), suggesting isometric growth.

TABLE 1.—Length-weight (LWR) and length-length (LLR) relationships for *Sphyrna idiaestes* caught in waters off Santa Rosalia, Baja California Sur, Mexico between December 2015 and April 2016.

Sex	n	TL range (cm)	W range (g)	a	95% IC of a	b	95% IC of b	r <sup>2</sup>
Males	76	40.5-54	262-592	0.0206	0.0100 0.0429	2.57	2.37 2.75	0.90
Females	64	40.5-60	259-959	0.0032	0.0014 0.0074	3.04	2.83 3.25	0.91
Pooled	140	40.5-60	259-959	0.0057	0.0034 0.0950	2.90	2.76 3.03	0.91

n, number of specimens;  $TL$ , total length;  $W$ , weight;  $a$ , intercept;  $b$ , regression slope;  $r^2$ , coefficient of determination; IC, confidence intervals.

The male pelican barracudas' relative condition factor did not change from month-to-month ( $F_{(4, 71)}=1.54, p>0.05$ ), but fluctuated close to 1 throughout the study period (Figure 1). In contrast, the relative condition factor of females varied significantly in different months ( $F_{(4, 59)}=11.27, p<0.05$ ), reaching values close to 1 from December 2015 to February 2016 that decreased in March (0.84) before attaining their highest values in April (1.04) (Figure 1).



**FIGURE 1.**—Monthly variation of the relative condition factor ( $Kn$ ) of *Sphyræna idiaestes* caught in waters off Santa Rosalia, Baja California Sur, Mexico between December 2015 and April 2016. The vertical lines indicate 95% confidence intervals of  $Kn$ . The circles and dotted black line correspond to females, while the squares and hatched grey line correspond to males.

The LWR  $b$  values obtained for male and female pelican barracudas are within the range of 2.5-3.49 reported for other barracuda species (González-Acosta et al., 2015), including *S. idiaestes*. However, the  $b$  value for the male pelican barracudas reported here was significantly different from 3, indicating allometric growth. This condition suggests that individuals become thinner as they grow in length (Anderson and Neumann 1996). Comparatively-speaking, the  $b$  value determined for females was not significantly different from 3, which suggests an isometric growth and indicates that their body shape does not change during development (Ricker 1975, Froese 2006). The differences observed in the  $b$ -value (3.19) reported previously for the pelican barracuda by González-Acosta et al. (2015) and those reported here for males (2.57), females (3.04) and pooled data (2.9) (Table 1), may result from the combined effect of the use of SL vs. TL (in the present study), as well as sample size ( $n=15$  vs.  $n=140$ ), interval lengths, sex ratio and sampling location.

Also, the differences in the overall mean Fulton's condition factor of 0.574, previously reported for this species (González-Acosta et al. 2015) could be the result of the sample size and the seasonal abundance pattern of the pelican barracuda. *Kn*-mean values reported here (0.989 for males and 0.984 for females), indicate suitable environmental conditions for *S. idiaestes* in this area in relation to sexual maturity as well as the good fitness of the specimens examined. Froese (2006) pointed out that in adult fish the condition factor shows consistent temporal changes: decreasing during periods of food shortage and increasing towards the spawning season, before plummeting during the females' spawning season and rising again immediately after it. Therefore, in the Gulf of California, the spawning of female *S. idiaestes* could occur in March, when the species displays the lowest *Kn*-value (Figure 1) with significant weight loss (Le Cren 1951). The macroscopic examination of the gonads in our specimens allowed us to confirm such condition, since their size increased from mid-February to early March. Therefore, the highest *Kn*-values for the females recorded in April 2016 could correspond to an immediate period of recuperation once spawning has taken place.

This study provides updated information on the LWR and LLR parameters and the relative condition factor previously reported for *S. idiaestes*, supported by a larger sample size than those previously used. However, further studies are needed to obtain length and weight data from specimens distributed along the species size range.

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