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ORIGINAL RESEARCH

Life history of *Paralabrax callaensis* (Starks, 1906) in Las Piñas Fishing Cove, Manabí, Ecuador

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ABSTRACT. The southern rock bass (*Paralabrax callaensis*) is one of the main demersal species caught by artisanal fishers in Ecuador. However, local information on its life history is limited, prompting a study of its age, growth, and reproduction to provide data supporting the sustainable management of the species. A total of 162 specimens were collected from artisanal fisheries in Las Piñas fishing cove, Manta, Ecuador, between May 2018 and April 2019. Six age groups were identified based on the annual rings observed in otoliths (*saggitae*). The average total length (TL) of males was 32.1 ± 6.2 cm, while that of females was 33.7 ± 7.1 cm, $L_\infty = 67.59 \pm 0.02$ cm (95% CI) and $K = 0.21$ year^{-1} ± 0.01 (95% CI). The length-weight relationship showed a value of $b = 2.94$ for combined sexes, indicating an isometric growth pattern. Regarding reproduction, the sex ratio was 1.05M:1F, not differing significantly from the expected ratio. The gonadosomatic index (GSI) reached its highest values during transitional months, while the lowest values were observed during the dry season (June-November). The size and age at sexual maturity were estimated at $L_{50} = 33.63$ cm TL and $A_{50} = 3.24$ years for combined sexes. Results provide key biological information about *P. callaensis*, revealing its vulnerability due to its slow growth and late maturity.

Key words: Artisanal fishing, fish age and growth, sexual maturity.

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Historia de vida de *Paralabrax callaensis* (Starks, 1906) en la caleta pesquera Las Piñas, Manabí, Ecuador

RESUMEN. El mero sureño (*Paralabrax callaensis*) es una de las principales especies demersales capturadas por pescadores artesanales en Ecuador. Sin embargo, la información local sobre su ciclo de vida es limitada, lo que motiva un estudio de su edad, crecimiento y reproducción para proporcionar datos que respalden el manejo sustentable de la especie. Se colectó un total de 162 especímenes provenientes de pesquerías artesanales en la caleta pesquera Las Piñas, Manta, Ecuador, entre mayo de 2018 y abril de 2019. Se identificaron seis grupos de edad con base en los anillos anuales observados en otolitos (*saggitae*). La longitud total promedio (LT) de los machos fue de 32.1 ± 6.2 cm, mientras que la de las hembras fue de 33.7 ± 7.1 cm, $L_\infty = 67.59 \pm 0.02$ cm (IC del 95%) y $K = 0.21$ año^{-1} ± 0.01 (IC del 95%). La relación longitud-peso mostró un valor de $b = 2{,}94$ para ambos sexos, lo que indica un patrón de crecimiento isométrico. En cuanto a la reproducción, la proporción sexual fue de 1,05M:1F, sin diferir significativamente de la proporción esperada. El índice gonadosomático (IGS) alcanzó sus valores máximos durante los meses de transición, mientras que los mínimos se observaron durante la estación seca (junio-noviembre). La talla y la edad de madurez sexual se estimaron en L_{50} = 33,63 cm LT y A_{50} = 3,24 años para ambos sexos. Los resultados proporcionan información biológica clave sobre *P. callaensis*, revelando su vulnerabilidad debido a su lento crecimiento y madurez tardía.

Palabras clave: Pesca artesanal, edad y crecimiento de los peces, madurez sexual.

INTRODUCTION

Age and growth studies form the fundamental basis of population dynamics models used in fisheries analysis (Morales-Nin 1992), particularly in structured models that consider the age distribution within the population. Similarly, one of the most critical aspects of stock assessment in fisheries studies is determining the size at sexual maturity (Militelli and Rodrigues 2011). Furthermore, fishing pressure can significantly affect fish reproduction, highlighting the importance of understanding annual variations in size and sexual maturity (Castro-Moreira et al. 2023).

The serranids are a family of marine carnivorous fish that inhabit tropical, subtropical, and temperate waters worldwide, primarily on continental shelves (Allen et al. 1995; Lucano-Ramírez et al. 2022; Costa 2024). The bathymetric distribution of serranids is influenced by their tendency to inhabit deeper waters up to 300 m as they grow (Thomson et al. 2000). Members of this family play a crucial role in artisanal, recreational, and industrial fisheries worldwide. They hold significant economic value, particularly in coastal areas where they are highly prized. Additionally, some smaller species are in high demand in the aquarium trade (Aburto-Oropeza et al. 2008; Lucano-Ramírez et al. 2022).

The southern rock bass*, Paralabrax callaensis* (Starks, 1906), is a demersal species distributed from Colombia to Peru (Jiménez Prado and Beárez 2004). In Ecuador, it is commonly known as ‘Perela’ and is caught by the artisanal fleet operating in coastal areas using bottom longlines. *Paralabrax callaensis* is highly valued by artisanal fishers in Las Piñas cove, since fishing is their main source of income (Ferrin and Alcívar 2021). Their catches, along with other target and bycatch species, are sought after for their quality and low-cost, making them important for local consumption (Mendoza-Nieto et al. 2022). Globally, *P. callaensis* exhibits a significant lack of information, particularly in Ecuador, where essential aspects of its biology and population dynamics remain insufficiently studied. Its classification as ‘Data Deficient’ by the IUCN reflects this gap, complicating the assessment of fishing impacts on its populations. The absence of detailed studies on its growth, age, and reproduction has hindered the implementation of sustainable management measures. This study provides key information that could help address these limitations.

MATERIALS AND METHODS

Sample collection

The study area was located in the coastal region of Las Piñas-Manabí (0° 59′35.58″S-80° 51′ 25.88″W) (Figure 1). Specimens were randomly collected from catches made by different boats of the artisanal fleet, which operate within 8 nautical miles. These boats go fishing during the night and early morning, returning to the port in the morning hours. Samples were collected between May 2018 and April 2019. The capture method involved fiberglass boats equipped with bottom longlines and hooks size No. 8 and 9, using local Clupeidae or Caranguidae species, *Opisthonema* spp. or *Auxis* spp., respectively, as bait. The selected fish were transported for analyses to the Biology Laboratory of the Universidad Laica Eloy Alfaro de Manabí in Manta, using isothermal containers with ice.

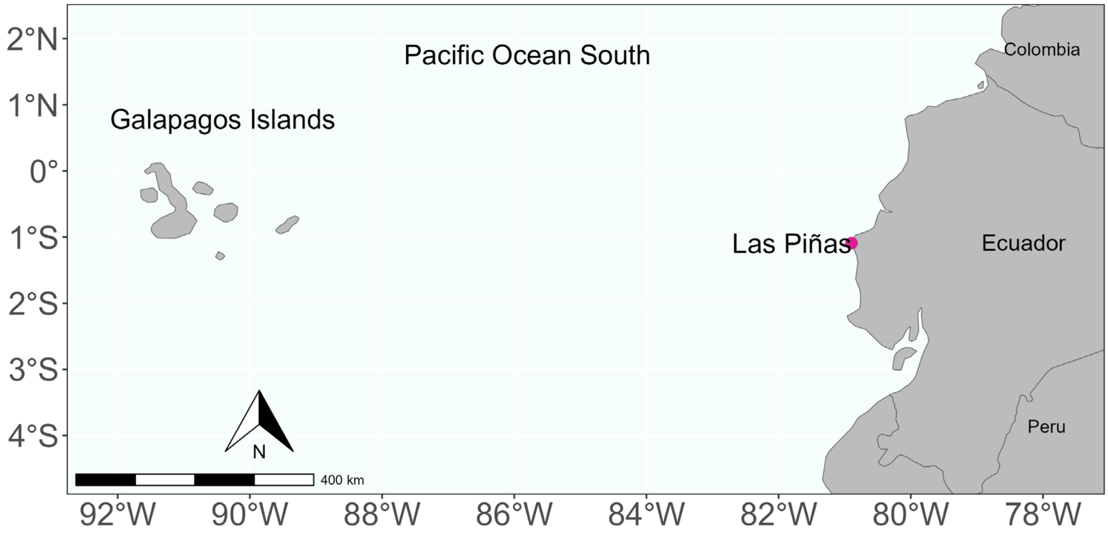

Figure 1. Samples collection area in Las Piñas fishing cove, Ecuadorian Pacific. The red dot represents the landing site.

Sample processing

In the laboratory, the total length (TL) of each specimen was measured using an ichthyometer with 0.1 cm precision. The total weight (TW), gutted weight, and gonad weight were recorded using an electronic scale with 0.1 g precision. The sex was identified through macroscopic observation of the gonads, while stages of sexual maturity were identified following the scale for *P. humeralis* from Sánchez and Galvez (2015). After collecting the morphometric data, *sagittae* otoliths were extracted, cleaned with water and ethanol, dried, and stored in Eppendorf tubes (Morales-Nin 1992).

Accuracy and bias between readers

The age was estimated by counting annual rings in *sagitta* otoliths, following a pattern of alternating bands: one calcified (opaque) and one less calcified (hyaline), clearly observed without the need for staining. In case of difficulty in counting the bands near the edge, a transverse cut was made to the otolith using a low-speed Isomet cutter, obtaining sections of 0.2 to 0.3 mm. The reading was performed with a stereoscopic microscope and digital camera, using transmitted and reflected light at 40× magnification.

To validate the use of the otolith as an indicator of fish size, the relationship between the total length of the fish and the otolith radius was evaluated using a correlation analysis. Otoliths were analyzed by two readers independently to verify the accuracy of the readings (Campana 2001). The percentage of agreement between two readers (PA), average percentage error (APE), and the coefficient of variation (CV) were calculated as:

- Percentage of Agreement between readers (Goldman, 2005):

$$PA = \frac{Number\ of\ agreements}{Number\ of\ vertebrae\ read} \times 100$$

- Average Percentage Error (APE) (Beamish and Fournier 1981):

$$APE = \frac{1}{N}\sum_{j=1}^{N}\left[\frac{1}{R}\sum_{i=1}^{R}\frac{(|X_{ij} - \overline{X}_j|)}{\overline{X}_j}\right] \times 100$$

- Coefficient of Variation (Chang, 1982):

$$CV = \frac{\sqrt{\sum_{i=1}^{R} \frac{(X_{ij} - X_j)^2}{R - 1}}}{X_j} \times 100$$

where N is the number of samples, R is the number of readings made from each sample, X_{ij} is the age (or the number of rings) determined for specimen j, and $\overline{X_j}$ is the average of ages determined for each sample.

The Bowker symmetry test was used to check for systematic bias between readers, and the Cailliet et al. (1983) plot was used to observe the readings. Precision indices and bias analysis were calculated using the FSA package (Ogle 2018).

The periodicity of growth ring formation in the otoliths was not directly validated through marginal increment analysis. However, various studies on species of the genus *Paralabrax*, such as *P. clathratus*, *P. humeralis*, *P. maculatofasciatus*, and *P. nebulifer*, have demonstrated that otolith rings correspond to annual increments, validated using methods such as oxytetracycline marking and marginal edge analysis, with some studies conducted under ecological conditions similar to those of the present research (Love et al. 1996; Andrews et al. 2005; Williams et al. 2012; Goicochea Vigo et al. 2014; Walker et al. 2020). Additionally, methodological reviews on age determination in fish and the microstructure of otoliths support the annual interpretation of rings in serranids and other tropical fish species (Campana and Neilson 1985; Campana 2001; Piddocke et al. 2015). Therefore, this study assumed that the alternation of an opaque band and a hyaline band represents one year of growth.

Age and growth

The length-weight relationship was estimated using the allometric equation of Ricker (1975):

$$W = a.TL^b$$

where W is the total weight of the specimen (g), TL is the total length (cm), and a and b are constants. Values of a and b were obtained by fitting the linearized equation $\log_{10}(W) = \log_{10}(a) + b \log_{10}(TL)$ using the least squares method (Munro and Pauly 1983). The existence of significant differences in exponents b between sexes was verified using the slope comparison procedure (Zar 2014). These exponents were compared with a value of 3 using the Student's t-test (t):

$$t = \frac{b - 3}{Eb}$$

where b is the slope, 3 is the isometric constant, and Eb is the slope error. If the value of $b = 3$, the growth is considered isometric; if $b \neq 3$, it is considered allometric.

To estimate the growth parameters of *P. callaensis*, a Bayesian multimodel approach (Nicole et al. 2024) was applied using the Bayesgrowth package (Smart 2020; Smart and Grammer 2021) adjusting the age and total length data to the following growth models:

- von Bertalanffy (1938) Growth Model (VBGM):

$$L_t = L_0 + (L_\infty - L_0)(1 - e^{(-K_t)})$$

- Gompertz Growth Model (GGM) (Gompertz 1825):

$$L_t = L_0\, e^{log}\left(\frac{L_\infty}{L_0}\right)(1 - e^{(-K_t)})$$

- And the Logistic Growth Model (LGM) (Ricker 1979):

$$L_t = \frac{(L_\infty \times L_0 \times e^g)}{L_\infty + L_0 + e^{g-1}}$$

where L_t is the length at a given age, L_∞ is the asymptotic length, K and g are growth coefficients, and L_0 is the length at birth.

Each model has its own growth coefficient (*K* in von Bertalanfy and Gompertz models; *g* in the Logistic model). These growth coefficients are incomparable among models, while parameters L_∞ and L_0 have the same interpretation in them (Smart et al. 2016). The Bayesgrowth package in R uses length at birth (L_0) instead of the theoretical age at birth (t_0), which is traditionally used in fish growth models. To select the most appropriate model, the LOOIC or leave-one-out cross-validation information criterion was used, in which a lower value of the index means a better fit of the model to the data.

The study employed Bayesian methods based on Markov Chain Monte Carlo (MCMC) for estimating growth parameters. The analysis used MCMC with NUTS (No-U-Turn Sampler), implemented in Stan via the Rstan package in R, an efficient variant of Hamiltonian Monte Carlo (HMC). Four parallel chains were run, each with 10,000 iterations (Table 1), including a burn-in period of 5,000 iterations. MCMC convergence diagnostics were assessed using the Gelman-Rubin statistic (R^ < 1.01), trace plots to confirm chain mixing, and autocorrelation plots.

Reproduction analysis

The sex ratio was compared with the expected 1M:1F using the *chi*^{2} (χ^2) test. For the estimation of the size at sexual maturity (L_{50}), a generalized binomial model was applied, where a value of 0 was assigned to immature organisms and a value of 1 to the mature ones, using the 'Estimate_Len_Maturity' package (AquaticLifeHistory):

$$P(l) = P_{max}\left(1 + e^{-\ln\left(\frac{L - L_{50}}{L_{95} - L_{50}}\right)}\right)$$

where P_{max} is the proportion of mature individuals, and L_{50} and L_{95} correspond to the lengths at which 50% and 95% of individuals have reached sexual maturity, respectively.

The reproductive cycle was estimated through the monthly analysis of the gonadosomatic index (GSI):

$$GSI = \frac{(Pg)}{(Pt)} \times 100$$

where *Pg* is the gonad weight and *Pt* is the total weight.

Statistical analyses were performed after verifying normality using the Kolmogorov-Smirnov test and homoscedasticity using Levene's test, with a significance level of 0.05. When normality or homoscedasticity was not achieved, the Wilcoxon U-test or the Kruskal-Wallis test was used as appropriate. Analyses were conducted using the Statgraphics Centurion XVIII (Statgraphics.net) and R (R Core Team 2021) packages.

Table 1. Parameters and prior distributions used in the Bayesian analysis of age and growth of *Paralabrax callaensis*. L_∞: asymptotic length, L_0: initial length at birth, and *K*: growth constant.

Parameter	Distribution	Tipe	Prior
L_∞	Normal: N(μ, σ)	Informative	72 cm TL, maximum recorded in literature (Eschmeyer and Herald 1983)
L_0	Normal truncated: N(0, ∞)	Regularizing	0.001, for cases where no information is available in the literature (Smart 2021)
K	Uniform: U(0, 1)	Non-informative	No prior information; with a high limit to avoid bias
σ	Uniform: U(0, 100)	Non-informative	No prior information; residual error with a conservative limit

RESULTS

A total of 164 specimens of *P. callaensis* were collected. The average TL for males was 32.6 ± 6.4 cm standard deviation (SD), with a range from 21.0 to 48.0 cm, while the average for females was 33.7 ± 7.1 cm, with a range from 20.3 to 51.2 cm (Figure 2). The average weight of males was 484.0 ± 298.2 g, with a range from 130.6 to 1,300.9 g, while the average weight of females was 545.9 ± 347.1 g, with a range from 125.1 to 1,463.8 g. No significant differences were found in TL or TW between males and females (U-test = 3157.0, p = 0.6808).

The length-weight relationship for combined sexes using the potential model was weight (g) = 0.015 $TL^{2,951}$ ($r^2 = 0.98$) with $b = 2.95$ and 95% CI: 2.88-3.02. The exponent for the relationship between length and eviscerated weight, $b = 2.93$ with 95% CI: 2.85-3.01. The coefficients of the relationships between total or eviscerated weight and length did not significantly differ from 3 (Student's t-test = 1.418, df = 149, p = 0.158), indicating that the growth type was considered isometric (Figure 3).

The linear relationship between the otolith radius and the total length of the fish was estimated by excluding 18 otoliths since the borders used for measuring the radius length were broken. The equation obtained for otolith radius was = 0.106 Lt + 1.338 ($r^2 = 0.82$, $p < 0.01$) (Figure 4). To estimate fish ages, 145 *sagitta* otoliths were read, selecting the otolith from each pair in the fish that provided the best visualization of growth rings. The average percentage of error APE = 1.89, PA = 92.36, CV = 1.83, Bowker test ($\chi^2 = 9.0$, df = 3, p = 0.029) (Figure 5). The Mann-Whitney test showed no significant differences in age structure between males and females (U = 2,450.0, p = 0.998), indicating similar distributions between sexes. Out of the 164 *P. callaensis* specimens collected, only 145 pairs of readable otoliths were used for age evaluation. Six age groups were identified, with the following average lengths (TL): age 1 (15.0 cm), age 2 (24.67

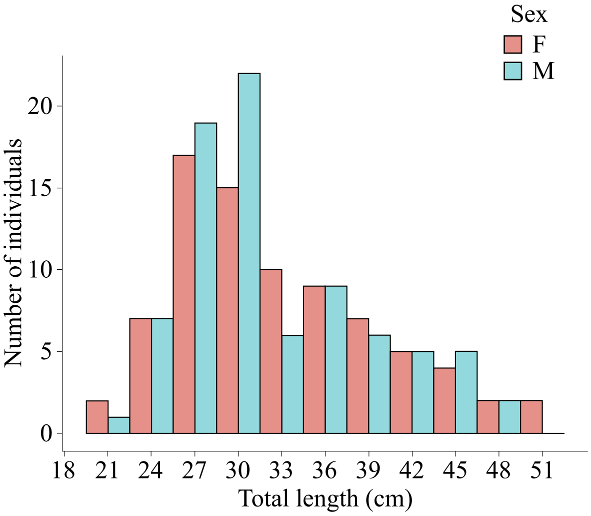

Figure 2. Size structure by sex of *Paralabrax callaensis* landed at Las Piñas cove, Manta, Ecuador, between May 2018 and April 2019. F = females; M = males.

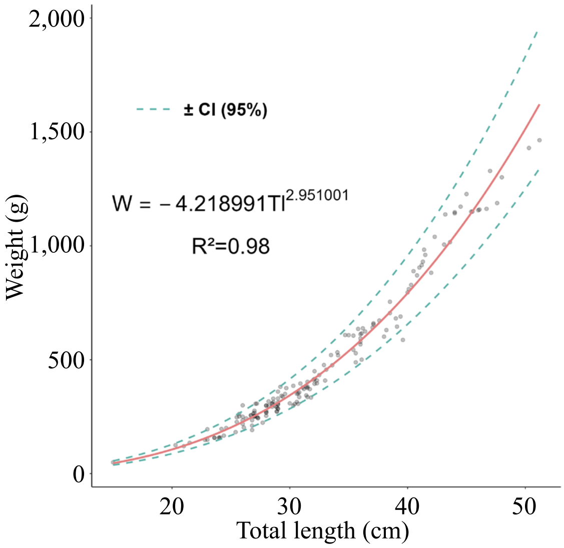

Figure 3. Length-weight relationship for combined sexes of *Paralabrax callaensis* landed at Las Piñas cove. The red line represents the allometric growth model of weight as a function of length. R^2, or coefficient of determination, shows how well the model explains the variability in weight. Dashed blue lines define the confidence interval (CI) of predictions.

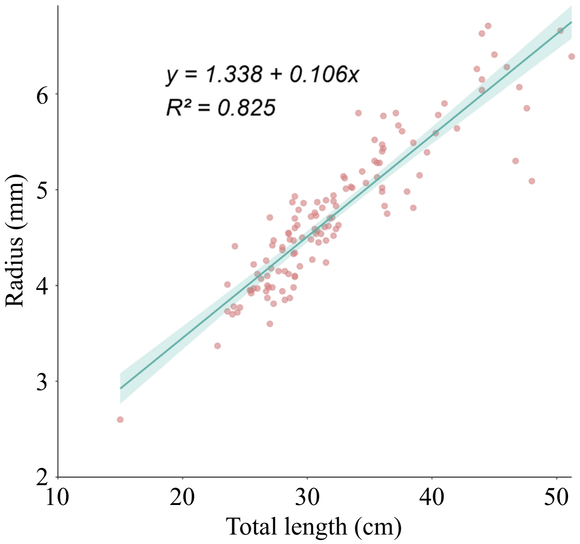

Figure 4. Relationship between otolith radius and total length of *Paralabrax callaensis*, caught in Las Piñas Cove, Manabí. The trend line represents the linear regression model describing the increase in otolith radius as a function of fish length. R^2 indicates the quality of the model fit. Light blue band shows 95% confidence interval.

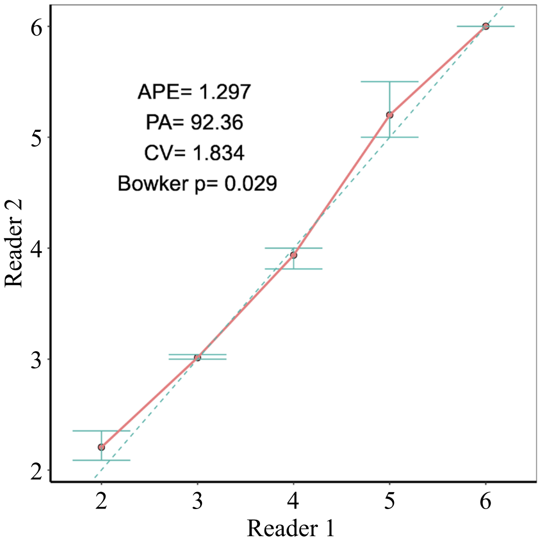

Figure 5. Age bias plot for *Paralabrax callaensis* showing agreements in age determination between two independent readers. Agreements were evaluated using Bowker's symmetry test, the Average Percent Error (AP), the Percentage of Agreement between Readers (PA), and the Coefficient of Variation (CV), along with the mean values (± standard error). Dashed blue line represents the 1:1 equivalence as a reference.

± 1.9 cm), age 3 (31.8 ± 2.9 cm), age 4 (37.9 ± 3.1 cm), age 5 (42.5 ± 2.7 cm), and age 6 (46.3 ± 1.9 cm). Most specimens were in age group 3, and no specimens younger than one year were observed.

The multimodal analysis showed that the von Bertalanffy model provided the best fit. According to this model, a growth rate of approximately 10 cm per year was estimated, with the growth rate decreasing as age increases. From the sixth year onward, the species is considered to reach a length close to 50 cm TL, which represents about 80% of L_∞ (Table 2; Figure 6). The Gompertz and logistic models did not fit the data well.

The observed sex ratio was 1.05M:1F, which did not differ significantly from the expected ratio ($\chi^2 = 0.024$, $p > 0.875$), and this trend remained consistent throughout all sampled months. The monthly analysis of the GSI of *P. callaensis* revealed that months of greatest males reproductive activity were April, October, and November, while the lowest values were observed between May and August. Females reached their highest IGS values in February, April, September, October, and November, also showing reduced reproductive activity from May to August, coinciding with males during the dry season (Figure 7). Statistical analysis (K-W = 53.13, $p < 0.01$) confirmed significant differences among monthly GSI values.

In the sample analyzed, 60.74% of individuals were classified as immature, while 39.26% were considered mature. The mean size at sexual maturity (L_{50}) was estimated at 33.63 ± 0.56 cm TL for the entire population, with specific values of 34.67 ± 0.78 cm TL for males and 32.54 ± 0.76 cm TL for females. It was observed that 58.75% of the females and 64.63% of the males captured were below the size at sexual maturity. Furthermore, the mean age at sexual maturity (A_{50}) was estimated at 3.24 ± 0.08 years for combined sexes, with values of 3.06 ± 0.46 years for males and 3.17 ± 0.30 years for females (Figure 8).

Table 2. Comparing growth models for combined sexes of *Paralabrax callaensis* based on Bayesian analysis and model fitting. Estimated parameters (L_∞ and K) for the von Bertalanffy, Gompertz, and Logistic models. Values ± standard error. The LOOIC (leave-one-out information criterion) and Wi (model weight) values are shown with the von Bertalanffy model highlighted in bold as the best fit, based on the lowest LOOIC value and a Wi of 1.

	Parameter			
Model	L_∞	K	LOOIC	Wi
von Bertalanffy	67.59 ± 0.02	0.21 ± 0.00	828.25	1
Gompertz	54.74 ± 0.03	0.99 ± 0.01	1,107.27	0
Logistic	71.92 ± 0.04	0.52 ± 0.00	1,605.36	0

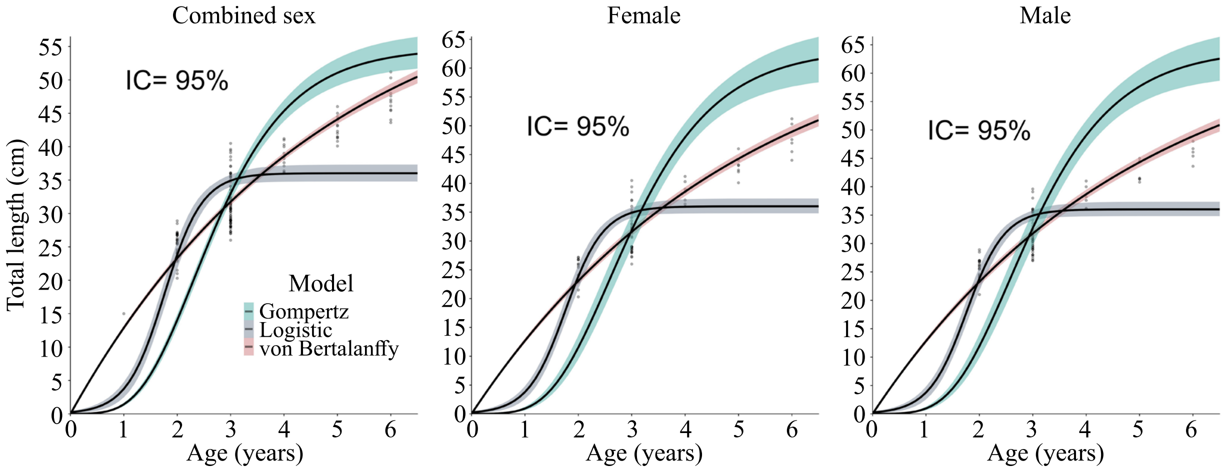

Figure 6. Adjusted growth curves for *Paralabrax callaensis* in combined sexes, using Gompertz, Logistic, and von Bertalanffy models, with 95% confidence intervals (shaded areas). Points represent observed data.

DISCUSSION

In this study, the size range of *P. callaensis* (20.3 to 51.2 cm TL) fell within the range reported by Elías and Coello (2016), who documented sizes between 16.0 and 72.0 cm TL for *Paralabrax* spp. in the Santa Elena Peninsula, Ecuadorian Sea, although they did not specify the species. The latter range was also higher than the one reported by Tomalá Tomalá (2023) for *Paralabrax* spp. in the same region (between 24.5 and 32.2 cm TL).

Regarding the sex ratio, this study found that it did not differ significantly from a 1F:1M ratio. However, Elías Méndez (2016) found a strong bias towards females in their study in the Santa Elena Peninsula coast, Ecuador (1.86F:1M).

The observed length-weight relationship in both sexes, revealed that *P. callaensis* possesses isometric growth. Compared to other species of *Paralabrax*, the value of *b* in *P. callaensis* was very close to that reported by Pondella II et al. (2003) for *P. auroguttatus* in the Gulf of California, with a slightly higher *b* value over 3. Studies conducted on the Serranidae family showed var-

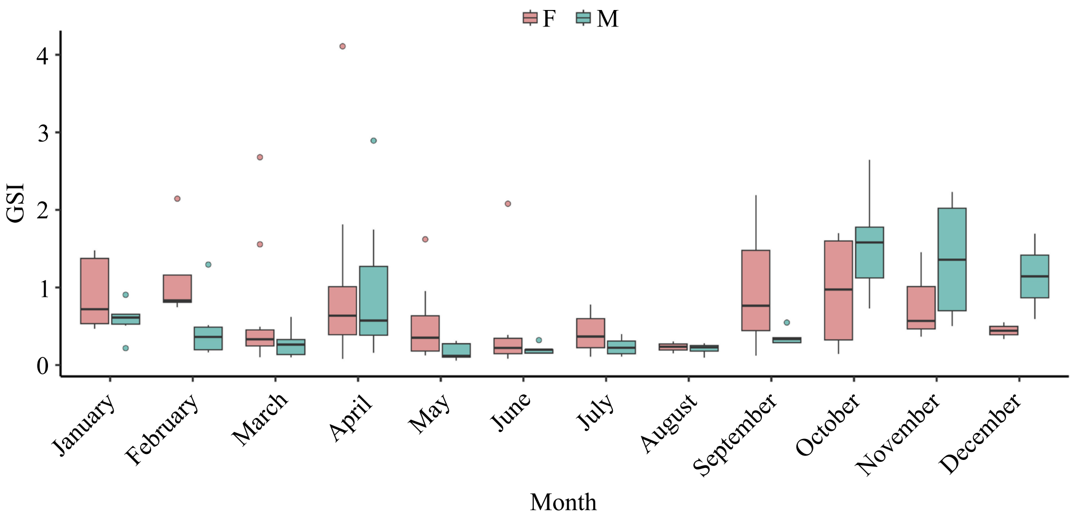

Figure 7. Monthly variation of gonadosomatic index (GSI) in *Paralabrax callaensis*. F = females, M = males. The boxplot shows the median (central line), the 25% and 75% quartiles (box limits), and the interquartile range (box height), with whiskers representing the minimum and maximum values. Outliers (extreme values) are shown as individual symbols.

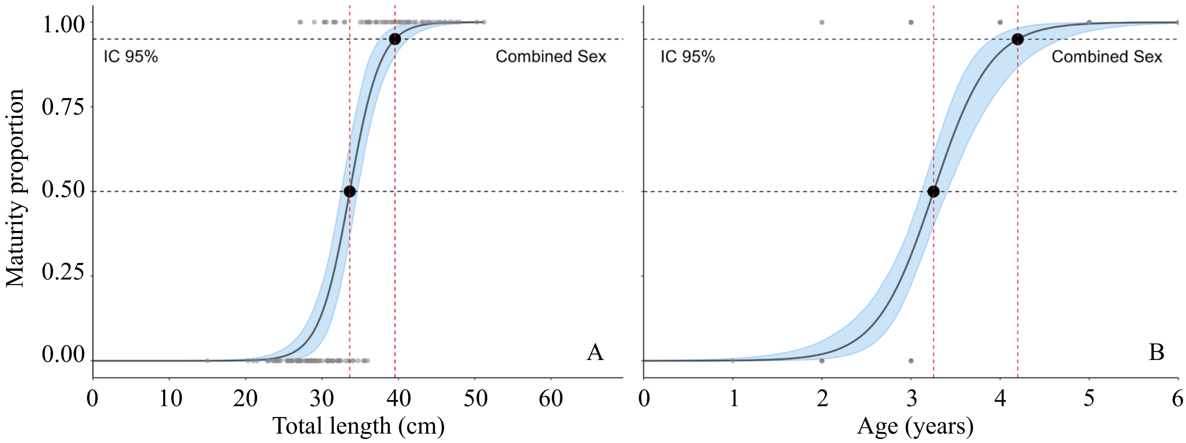

Figure 8. Size (A) and age (B) at sexual maturity for combined sexes of *Paralabrax callaensis*. The black midpoint represents L_{50}, the upper and lower gray points correspond to the observed size and age values, and the light blue band represents the confidence intervals.

iable results for coefficient *b*, which may reflect changes among species, but also variations in food availability across different locations, even for the same species. For instance, it was reported that for *Paralabrax* spp. evaluated in Santa Elena Peninsula, Ecuadorian coast, the *b* coefficient reached 2.81 for females and 2.91 for males, both indicating negative allometric growth (Elías and Coello 2016). On the other hand, Chong Montenegro (2014) reported negative allometric growth in *P. albomaculatus* from Galápagos Islands, with values of 2.95 for females and 2.79 for males. In comparison to other species of *Paralabrax*, Avilés Quevedo (2005) reported a *b* coefficient of 2.92 for *P. maculatofasciatus*. Meanwhile, Cordes and Allen (1997) reported values for *P. clathratus* with

$b = 3.27$ in the Enchanted Islands and Bahia de Los Ángeles in the Gulf of California, Mexico. Froese (2006) mentioned that when the b coefficient approaches 3, individuals increase in length at the same rate as their weight.

The estimated reader error for the otolith rings (APE) in this study is within the acceptable range (10%) as proposed by Campana (2001). When comparing the relationship between the otolith radius and total length, this study found a good correlation, supporting the use of the otolith to determine the age of this species. Similarly, Goicochea Vigo et al. (2014) reported a determination coefficient $r^2 = 0.80$ for *P. humeralis*, a value very close to that obtained in the present study.

The absence of organisms younger than one year and the low representation of older individuals in the samples could be due to a capture bias towards individuals of intermediate ages. These limitations in size coverage justify the use of Bayesian statistics to estimate growth parameters, since this methodology allows the incorporation of prior information and handles the uncertainty associated with incomplete data, providing more robust estimates (Czaia and García del Hoyo 2003; Moltó et al. 2020).

In this study, the value of L_∞ is very similar to that reported by Goicochea Vigo et al. (2014) for *P. humeralis* in the Callao Sea, Peru ($L_\infty = 68.5$ cm TL), and to that estimated by Love et al. (1996) for *P. clathratus* in California ($L_\infty = 69.8$ cm). On the other hand, Araya and Medina (2006) documented a higher $L_\infty = 71.35$ cm TL for *P. humeralis* in northern Chile. In contrast, several studies reported lower L_∞ values, such as Araya et al. (2015) who found a value of 63.2 cm TL for *P. humeralis* in northern Chile, and Slanzi (2003) estimated a $L_\infty = 52.35$ cm TL for this species in the same region. Aguilar et al. (2003) documented an $L_\infty = 43.6$ cm TL using modal progression for *P. humeralis* in Chile. For *P. auroguttatus*, Pondella II et al. (2001) reported a $L_\infty = 47.4$ cm TL in the northern Gulf of California, and Danemann and Ezcurra (2008) indicated a $L_\infty = 51.2$ cm TL in Bahia de los Ángeles, Mexico, which was significantly lower than the 30 cm SL for *P. maculatofasciatus* reported by Andrews et al. (2005) in Bahia de Los Angeles, Baja California, Mexico.

The von Bertalanffy model proved to be the most suitable for describing the growth of *P. callaensis*, as it accurately captures the deceleration in later stages and the expected asymptotic limit. However, it is less effective in representing growth during larval or early juvenile stages (Vasbinder and Ainsworth 2020). In contrast, Gompertz and Logistic models, which are better suited for organisms with early maturation and accelerated initial growth (Flinn and Midway 2021), underestimated growth in the initial, middle, and advanced stages, producing curves with early inflections that fail to adequately reflect the deceleration at older ages.

Regarding the growth rate (K), although it resembled values observed in other studies, there were slight differences. For example, Araya and Medina (2006) reported a $K = 0.170$ for *P. humeralis* in northern Chile, while Goicochea Vigo et al. (2014) documented a $K = 0.094$ for the same species in Peru. Notably higher values were found by Danemann and Ezcurra (2008) for *P. auroguttatus* in Bahia de Los Ángeles, Mexico ($K = 0.332$), and by Aguilar et al. (2003) ($K = 0.4$) for *P. humeralis* in Chile. In contrast, Love et al. (1996) reported a $K = 0.06$ for *P. clathratus* in California, similar to the $K = -0.05$ reported by Slanzi (2003) for *P. humeralis* in northern Chile. Observed differences in L_∞ and K values among species of the same genus in different regions can be explained by a combination of environmental, genetic, and methodological factors. Variations in environmental parameters such as temperature, salinity, and food availability, along with genetic adaptations specific to each region, significantly influence growth patterns and the maximum size attained by the species (Taylor 1958; Pauly 1980; King 2007; Ulloa Ibarra et al. 2023). Additionally, factors related to life strategies, such as prioritizing rapid growth in areas with high predation pressure, also contribute to these differences (Froese and Pauly 1999). These differences have been reported in studies such as Sammons (2021), which found that while the growth of *P. maculatofasciatus* is relatively similar among areas, there were significant variations in L_∞ and k between populations in the Gulf of California (GOC) and the Pacific.

Methodological discrepancies, resulting from the use of techniques such as modal progression or cohort analysis, can lead to notable variations in the estimates of these parameters (Leonce-Valencia 1996; Sparre and Venema 1997), as well as anthropogenic impacts, including intensive fishing. Nevertheless, *P. callaensis* is a year-round species captured using bottom hooks, a technique widely adopted by artisanal fishermen in the Manabí area (Ramírez-Ormaza et al. 2024). The fishing pressure may have a significantly impact since, given physiological conditions that vary across its distribution, exposing the species to overfishing will tend to result in the disappearance of the older age group (Revelo 1993).

GSI values of *P. callaensis*, for both males and females, indicated a similar dynamic to that reported by Elías Méndez (2016) for *Paralabrax* spp. in the Gulf of Guayaquil, where the lowest reproductive activity was also observed in July and August, and reproductive peaks occurred in September and November. In contrast, for *P. albomaculatus*, a species found in the Galápagos Islands, has a reproductive period is concentrated between November and January, with a possible extension from October to March (Salinas-de-León et al. 2017). Similarly, Guerrero Bernal (2016) documented that *P. nebulifer* has an active reproductive season from May to September in the Gulf of Ulloa, Mexico. On the other hand, Eraso Ordoñez (2018) reported that *P. auroguttatus* exhibited a seasonal reproductive cycle, spawning between February and June for both sexes in the northern Gulf of California. Differences in reproductive periods between *P. callaensis* and similar species in other regions can be attributed to the need for adaptation to seasonal environmental events to maximize reproductive success, whether due to regular fluctuations or migrations inherent to their life cycle (Ysla-Guzmán et al. 2021). Factors such as water temperature, food availability, and local oceanographic conditions directly influence reproductive synchronization (Lowerre-Barbieri et al. 2011). In regions like Ecuador, with marked environmental seasonality, the presence of El Niño phenomenon and its anomalies in sea surface temperature intensify these changes, affecting both the physiology of species and their reproductive patterns (Pörtner and Peck 2010; Ruperti et al. 2015; Breaker et al. 2016; Mendoza-Nieto et al. 2023).

When comparing mean capture sizes of females and males during the analyzed period with the mean size at sexual maturity, 58.75% of females and 64.64% of males were found to be below that size, indicating that they were being caught before reaching sexual maturity. These findings are in contrast to those reported by Elías and Coello (2016) in the Gulf of Guayaquil, where 68.9% of females and 83.1% of males of *Paralabrax* were above the minimum legal size (L_{50} = 40.0 cm TL for females and L_{50} = 42.2 cm TL for males), suggesting a higher level of reproductive protection in that area. This difference could be explained by the inclusion of two species from the *Paralabrax* genus, in Elías and Coello's study (*P. callaensis* and *P. humeralis*) which may exhibit different sexual maturity characteristics, or by a greater fishing pressure in Las Piñas cove compared to the outer estuary of the Gulf of Guayaquil. Studies conducted in different regions show significantly varying L_{50} values. For example, in the Gulf of California, Eraso Ordoñez (2018) reported a sexual maturity length of 33.1 cm TL for males and 36.5 cm TL for females *P. auroguttatus*, reflecting a greater variability in maturity sizes compared to data obtained in this study. Likewise, Salinas-de-León et al. (2017) reported a first sexual maturity length of 37 cm TL for *P. albomaculatus* in Galápagos Islands, a value similar to that found for *P. callaensis* in this region of Ecuador. Meanwhile, the age of sexual maturity was within the range reported by Love et al. (1996)

with males and females *P. clathratus* reaching 2 and 3 years, respectively. This suggests that species of the same genus, despite being distributed across different regions, may exhibit similar reproductive patterns, demonstrating that the size at sexual maturity depends not only on the specific characteristics of each species but also on the local environmental conditions influencing the growth and maturation of individuals. This underscores the importance of considering these factors to understand variations in reproductive parameters across species and regions.

Overfishing poses a serious risk to *P. callaensis* due to its slow growth and late maturation. In Las Piñas, more than 50% of catches are below maturity size. Implementing minimum catch sizes, seasonal closures during key reproductive periods, and promoting selective fishing gear would contribute to the sustainability of the species and the well-being of fishing communities that depend on it. The study lacked young and older specimens, which may have biased the growth estimates. It is recommended to expand sampling, validate growth rings, and assess the relationship with environmental factors such as El Niño. Additionally, identifying reproductive and growth patterns could benefit from complementary methodologies, such as gonadal histology analysis or genetic markers.

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Conflict of interest

The authors declare no conflicts of interest.

Author contributions

Lissette Vera-García: data collection-conducted field and laboratory sampling; data analysis- performed the statistical and data analysis. Adrián A. Lucas-Fernández: data collection-conducted field and laboratory sampling; data analysis- performed the statistical and data analysis. Kléver Mendoza-Nieto: study design and hypothesis formulation-defined the study approach and objectives; data analysis-performed the statistical and data analysis. José J. Alió: study design and hypothesis formulation-defined the study approach and objectives; data analysis-performed the statistical and data analysis. Jesús Briones-Mendoza: data analysis-performed the statistical and data analysis. Manuscript drafting and preparation: all authors contributed to drafting the manuscript. Critical review and final approval: all coauthors reviewed and approved the final manuscript.

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