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Supplementary material

Age and size compositions, habitats, growth and reproductive characteristics of a terapontid (*Pelates octolineatus*) in coastal waters

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Temperature-related seasonal growth curve

The sine curve (SC)-based seasonal growth curve employed in this study to describe the relationship between the length and age of the females and males of *P. octolineatus* was

$$L_j = L_\infty \left\{1 - \quad \left[-\left(k_1 + k_2[t_j - t_0]\right)\left(t_j - t_0 + \frac{C}{2\pi}\left[S(t_j) - S(t_0)\right]\right)\right]\right\}$$

where L_j and t_j are the length and age respectively of fish j, L_∞ is the asymptotic length, k_1 and k_2 are parameters that determine the rate at which the expected length approaches its asymptote, t_0 is the age at which the length of the fish is expected to be zero, $S(t) = \sin[2\pi(t - t_c)]$, *C* is a constant and t_0 serves as the phase that shifts the SC with respect to the age *t*. That is, t_c determines the time within the year at which growth is at a maximum or minimum.

To relate length at age to a temperature-based growth curve, rather than assuming that $S(t)$ was a SC with an annual cycle, the function $S(t)$ was re-specified as a periodic function of age *t* with an annual cycle based on water temperature. For this, a cubic spline with a 12-month period was fitted to the mean monthly water temperatures for the marine bays from which the fish had been collected, allowing the expected water temperature that fish of age *t* were likely to experience in this environment to be calculated. The predicted values of water temperature were scaled to lie in the range of –1 to 1. For this, if $T(t)$ represents the scaled temperature at the time of the year when the fish has an age of *t*, then

$$T(t) = \frac{2Temp - Temp_{max} - Temp_{min}}{Temp_{max} - Temp_{min}}$$

where $Temp_{min}$ and $Temp_{max}$ are the minimum and maximum of values predicted by the cubic spline at any time within the 12-month period, and *Temp* is the value of temperature at time *t* predicted by the fitted cubic spline. Thus, to express the influence of temperature on the growth of the fish, $S(t) = \sin[2\pi(t - t_c)]$ was replaced with $S(t) = T(t - t_c)$ in the above seasonal growth model.

The temperature-related seasonal model was fitted to the lengths at age for (1) females, (2) males and (3) all fish by maximising the log-likelihood using the software program, R (R Core Team 2012). All growth models were constrained to ensure that growth rates did not become negative, i.e. fish did not shrink. Trends in residuals from the fitted models were examined to assess whether the curves adequately described the distributions of the lengths at age. A bootstrapping analysis was undertaken within the software package R for these data sets, by drawing 5000 random samples (with replacement) from the data and refitting the model. The 2.5 and 97.5 percentiles of the resulting parameter estimates were accepted as approximate 95% confidence limits for the parameter.

The quality of the fits obtained for the lengths at age for the females and males using the SC-based and temperature-related seasonal growth models were compared by calculating the Akaike Information Criterion (AIC) (Burnham and Anderson, 2001), with the model that produced the lowest value of AIC being considered as the one that, taking the number of parameters into account, provided the best description of the lengths at age for *P. octolineatus*.

The temperature-related seasonal growth models captured the seasonal changes in the lengths at age of females and males (Veale 2013). Comparisons of the residual plots (Veale 2013) and AIC values for this seasonal growth model for the females and males with those for the traditional and enhanced von Bertalanffy curves for the corresponding sexes (Table S1) demonstrated that, taking into account the increase in model complexity, the fits to the lengths at age of both sexes were improved by using the temperature-related seasonal growth curve. Although values of the lengths at age predicted by the SC-based seasonal growth curve and the temperature-related seasonal growth curves were very similar, i.e. the curves could not be distinguished when plotted (Veale 2013), comparison of the AIC values for the two seasonal growth curves for the females and males of *P. octolineatus* in the marine bays demonstrated that the SC-based seasonal model (SC seasonal growth model) provided the better description of the relationships between the lengths at age and the ages of both sexes (Table S1). The two seasonal growth curves followed similar paths.

Table S1. Parameters (±95% confidence intervals), negative log-likelihood (NLL) and Akaike's information criterion (AIC) for the fits for the temperature-related seasonal growth models, fitted to the lengths at ages of female and male *Pelates octolineatus* in the marine bays

L_∞ is the asymptotic total length (mm), t_0 is the hypothetical age (years) at which fish would have zero length, k_1 and k_2 represent the coefficients of the linear relationship of *k* with age, and *C* relates to the seasonality in growth. *n*, sample size. Predicted temperatures used when fitting the model were calculated using a cubic spline with a 12-month period that had been fitted to the mean monthly water temperatures for the waters from which the fish had been collected

		Females		Males	
Model	Parameter	Estimate	95% CI	Estimate	95% CI
Temperature-related seasonal model	L_∞	215	(213, 216)	202	(200, 204)
	k_1	0.000166	(0.000149, 0.000182)	0.00037	(0.000351, 0.000413)
	t_0	−0.75	(−0.75, −0.74)	−0.75	(−0.77, −0.73)
	k_2	0.19	(0.18, 0.19)	0.20	(0.19, 0.21)
	C	1.18	(1.17, 1.18)	1.18	(1.17, 1.18)
	t_c	0.18	(0.18, 0.18)	0.18	(0.18, 0.18)
	NLL	11623		10394	
	AIC	23273		20802	
	n	2851		2567	

References

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