Norrie, Hurst, and Miller. supplementary materials: Environmental and Biological Drivers of Otolith Trace Element Composition in Staghorn Sculpin *(Leptocottus armatus*)

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Supplementary Tables

Table S1. Mean otolith increment widths (± SEM) of fish from each tank

Temperature	pH	Increment Width
11.5	Ambient	0.64 (± 0.23)
	Medium	0.93 (± 0.26)
	Low	0.95 (± 0.17)
14	Ambient	0.86 (± 0.27)
	Medium	1.19 (± 0.22)
	Low	0.59 (± 0.23)

Table S2. Results of linear models examining covariates of final length, final mass, length specific and mass specific growth rates (LSGR and MSGR), and length–weight residuals (LWR) for Mn:Ca, Co:Ca, and Mg:Ca.

TE:Ca	Covariate	Temp x pH x covariate	pH x covariate	Temp x covariate	Temp pH	Covariate	pH	Temp	Model adjusted R^2
Mn:Ca	Final Length	$F_{2,42} = 1.06$, $p = 0.36$	$F_{2,42} = 0.08$, $p = 0.93$	$F_{1,42} = 3.49$, $p = 0.07$	$F_{2,42} = 0.21$, $p = 0.81$	$F_{1,42} = 5.53$, $p = 0.02$	$F_{2,42} = 0.38$, $p = 0.69$	$F_{1,42} = 2.04$, $p = 0.16$	0.062
	Final Mass	$F_{2,41} = 0.97$, $p = 0.38$	$F_{2,41} = 0.62$, $p = 0.55$	$F_{1,41} = 3.12$, $p = 0.07$	$F_{2,41} = 0.36$, $p = 0.75$	$F_{1,41} = 5.32$, $p = 0.03$	$F_{2,41} = 0.07$, $p = 0.93$	$F_{1,41} = 1.98$, $p = 0.15$	0.036
	LSGR	$F_{2,42} = 3.39$, $p = 0.04$	$F_{2,42} = 6.25$, $p = 0.004$	$F_{1,42} = 0.42$, $p = 0.52$	$F_{2,42} = 1.78$, $p = 0.18$	$F_{1,42} = 5.47$, $p = 0.02$	$F_{2,42} = 6.18$, $p = 0.006$	$F_{1,42} = 1.05$, $p = 0.31$	-0.018
	MSGR	$F_{2,41} = 0.81$, $p = 0.45$	$F_{2,41} = 0.40$, $p = 0.68$	$F_{1,41} = 1.25$, $p = 0.27$	$F_{2,41} = 1.00$, $p = 0.38$	$F_{1,41} = 0.86$, $p = 0.36$	$F_{2,41} = 0.01$, $p = 0.99$	$F_{1,41} = 0.82$, $p = 0.37$	-0.075
	LWR	$F_{2,42} = 0.35$, $p = 0.71$	$F_{2,42} = 2.00$, $p = 0.15$	$F_{1,42} = 0.07$, $p = 0.79$	$F_{2,42} = 0.13$, $p = 0.87$	$F_{1,42} = 0.02$, $p = 0.88$	$F_{2,42} = 0.02$, $p = 0.98$	$F_{1,42} = 0.48$, $p = 0.49$	-0.11
Co:Ca	Final Length	$F_{2,42} = 3.78$, $p = 0.03$	$F_{2,42} = 0.01$, $p = 0.97$	$F_{1,42} = 5.35$, $p = 0.03$	$F_{2,42} = 0.63$, $p = 0.54$	$F_{1,42} = 2.42$, $p = 0.13$	$F_{2,42} = 0.20$, $p = 0.83$	$F_{1,42} = 0.09$, $p = 0.76$	0.100
	Final Mass	$F_{2,41} = 1.61$, $p = 0.21$	$F_{2,41} = 0.13$, $p = 0.93$	$F_{1,41} = 2.02$, $p = 0.15$	$F_{2,41} = 0.78$, $p = 0.46$	$F_{1,41} = 0.82$, $p = 0.37$	$F_{2,41} = 0.04$, $p = 0.96$	$F_{1,41} = 0.29$, $p = 0.59$	-0.023
	MSGR	$F_{2,41} = 2.20$, $p = 0.12$	$F_{2,41} = 1.13$, $p = 0.33$	$F_{1,41} = 0.56$, $p = 0.46$	$F_{2,41} = 0.78$, $p = 0.46$	$F_{1,41} = 2.03$, $p = 0.16$	$F_{2,41} = 0.61$, $p = 0.56$	$F_{1,41} = 0.30$, $p = 0.79$	-0.074
	LSGR	$F_{2,42} = 2.20$, $p = 0.12$	$F_{2,42} = 1.13$, $p = 0.33$	$F_{1,42} = 0.56$, $p = 0.46$	$F_{2,42} = 0.78$, $p = 0.46$	$F_{1,42} = 2.03$, $p = 0.16$	$F_{2,42} = 0.61$, $p = 0.56$	$F_{1,42} = 0.30$, $p = 0.79$	0.019
	LWR	$F_{2,42} = 1.61$, $p = 0.21$	$F_{2,42} = 0.58$, $p = 0.56$	$F_{1,42} = 0.01$, $p = 0.93$	$F_{2,42} = 0.79$, $p = 0.46$	$F_{1,42} = 0.61$, $p = 0.54$	$F_{2,42} = 0.02$, $p = 0.88$	$F_{1,42} = 0.33$, $p = 0.57$	-0.082
Mg:Ca	Final Length	$F_{2,42} = 4.75$, $p = 0.01$	$F_{2,42} = 1.15$, $p = 0.32$	$F_{1,42} = 3.54$, $p = 0.07$	$F_{2,42} = 0.94$, $p = 0.40$	$F_{1,42} = 1.70$, $p = 0.20$	$F_{2,42} = 0.19$, $p = 0.83$	$F_{1,42} = 0.15$, $p = 0.70$	0.138
	Final Mass	$F_{2,41} = 2.56$, $p = 0.06$	$F_{2,41} = 0.82$, $p = 0.45$	$F_{1,41} = 1.17$, $p = 0.22$	$F_{2,41} = 1.28$, $p = 0.29$	$F_{1,41} = 1.43$, $p = 0.24$	$F_{2,41} = 0.11$, $p = 0.90$	$F_{1,41} = 0.09$, $p = 0.76$	0.049
	MSGR	$F_{2,41} = 0.42$, $p = 0.66$	$F_{2,41} = 1.17$, $p = 0.32$	$F_{1,41} = 0.10$, $p = 0.75$	$F_{2,41} = 1.97$, $p = 0.15$	$F_{1,41} = 1.42$, $p = 0.24$	$F_{2,41} = 0.38$, $p = 0.93$	$F_{1,41} = 0.00$, $p = 0.99$	-0.043

	LSGR	$F_{2,42} = 0.04$, $p = 0.96$	$F_{2,42} = 1.14$, $p = 0.33$	$F_{1,42} = 2.31$, $p = 0.14$	$F_{2,42} = 0.20$, $p = 0.82$	$F_{1,42} = 2.35$, $p = 0.13$	$F_{2,42} = 0.62$, $p = 0.65$	$F_{1,42} = 0.12$, $p = 0.73$	-0.049
	LWR	$F_{2,42} = 1.64$, $p = 0.21$	$F_{2,42} = 0.84$, $p = 0.44$	$F_{1,42} = 0.11$, $p = 0.75$	$F_{2,42} = 1.33$, $p = 0.28$	$F_{1,42} = 0.20$, $p = 0.82$	$F_{2,42} = 0.02$, $p = 0.98$	$F_{1,42} = 0.02$, $p = 0.90$	-0.063

Table S3. Results of the linear models examining covariates of final length, final mass, length specific and mass specific (MSGR) growth rates, and length weight residuals (LWR) for each trace element calcium ratio (TE:Ca) investigated in this work.

TE:Ca	**Covariate**	**Temp x pH x covariate**	**pH x covariate**	**Temp x covariate**	**Temp pH**	**Covariate**	**pH**	**Temp**	**Model adjusted R^2**
Sr:Ca	Final Length	$F_{2,42} = 0.07$, $p = 0.93$	$F_{2,42} = 0.98$, $p = 0.39$	$F_{1,42} = 5.64$, $p = 0.02$	$F_{2,42} = 2.18$, $p = 0.13$	$F_{1,42} = 22.84$, $p = 0.00$	$F_{2,42} = 0.38$, $p = 0.69$	$F_{1,42} = 5.52$, $p = 0.02$	0.362
	Final Mass	$F_{2,41} = 0.17$, $p = 0.84$	$F_{2,41} = 0.53$, $p = 0.59$	$F_{1,41} = 5.77$, $p = 0.02$	$F_{2,41} = 2.75$, $p = 0.08$	$F_{1,41} = 18.45$, $p = 0.00$	$F_{2,41} = 0.38$, $p = 0.69$	$F_{1,41} = 4.79$, $p = 0.03$	0.330
	LSGR	$F_{2,42} = 0.33$, $p = 0.72$	$F_{2,42} = 0.73$, $p = 0.49$	$F_{1,42} = 0.34$, $p = 0.56$	$F_{2,42} = 1.31$, $p = 0.28$	$F_{1,42} = 1.63$, $p = 0.21$	$F_{2,42} = 0.24$, $p = 0.79$	$F_{1,42} = 3.49$, $p = 0.07$	-0.006
	MSGR	$F_{2,41} = 1.00$, $p = 0.38$	$F_{2,41} = 1.81$, $p = 0.18$	$F_{1,41} = 0.88$, $p = 0.35$	$F_{2,41} = 2.15$, $p = 0.13$	$F_{1,41} = 1.57$, $p = 0.22$	$F_{2,41} = 0.28$, $p = 0.76$	$F_{1,41} = 3.54$, $p = 0.07$	0.095
	LWR	$F_{2,42} = 1.45$, $p = 0.25$	$F_{2,42} = 1.91$, $p = 0.16$	$F_{1,42} = 0.12$, $p = 0.73$	$F_{2,42} = 2.28$, $p = 0.12$	$F_{1,42} = 0.90$, $p = 0.35$	$F_{2,42} = 0.31$, $p = 0.73$	$F_{1,42} = 3.51$, $p = 0.07$	0.092
B:Ca	Final Length	$F_{2,42} = 1.52$, $p = 0.23$	$F_{2,42} = 0.75$, $p = 0.48$	$F_{1,42} = 0.07$, $p = 0.79$	$F_{2,42} = 2.31$, $p = 0.11$	$F_{1,42} = 7.19$, $p = 0.01$	$F_{2,42} = 0.35$, $p = 0.71$	$F_{1,42} = 1.60$, $p = 0.21$	0.127
	Final Mass	$F_{2,41} = 2.62$, $p = 0.09$	$F_{2,41} = 0.77$, $p = 0.47$	$F_{1,41} = 0.04$, $p = 0.85$	$F_{2,41} = 3.18$, $p = 0.05$	$F_{1,41} = 4.18$, $p = 0.05$	$F_{2,41} = 0.87$, $p = 0.43$	$F_{1,41} = 1.04$, $p = 0.31$	0.149
	LSGR	$F_{2,42} = 0.02$, $p = 0.99$	$F_{2,42} = 0.17$, $p = 0.85$	$F_{1,42} = 0.28$, $p = 0.60$	$F_{2,42} = 1.46$, $p = 0.24$	$F_{1,42} = 2.60$, $p = 0.12$	$F_{2,42} = 0.29$, $p = 0.75$	$F_{1,42} = 1.32$, $p = 0.26$	-0.058
	MSGR	$F_{2,41} = 0.41$, $p = 0.67$	$F_{2,41} = 2.38$, $p = 0.11$	$F_{1,41} = 0.99$, $p = 0.33$	$F_{2,41} = 2.39$, $p = 0.10$	$F_{1,41} = 2.40$, $p = 0.13$	$F_{2,41} = 0.82$, $p = 0.45$	$F_{1,41} = 0.98$, $p = 0.33$	0.093

	LWR	$F_{2,42} = 0.08$, $p = 0.92$	$F_{2,42} = 3.03$, $p = 0.06$	$F_{1,42} = 0.17$, $p = 0.68$	$F_{2,42} = 2.13$, $p = 0.13$	$F_{1,42} = 0.21$, $p = 0.65$	$F_{2,42} = 0.53$, $p = 0.59$	$F_{1,42} = 4.62$, $p = 0.04$	0.069
Ba:Ca	Final Length	$F_{2,42} = 3.86$, $p = 0.03$	$F_{2,42} = 2.14$, $p = 0.13$	$F_{1,42} = 0.49$, $p = 0.49$	$F_{2,42} = 2.45$, $p = 0.10$	$F_{1,42} = 6.22$, $p = 0.02$	$F_{2,42} = 0.83$, $p = 0.44$	$F_{1,42} = 6.77$, $p = 0.01$	0.284
	Final Mass	$F_{2,41} = 2.69$, $p = 0.08$	$F_{2,41} = 1.83$, $p = 0.17$	$F_{1,41} = 0.35$, $p = 0.56$	$F_{2,41} = 2.71$, $p = 0.08$	$F_{1,41} = 5.13$, $p = 0.03$	$F_{2,41} = 0.71$, $p = 0.50$	$F_{1,41} = 5.54$, $p = 0.02$	0.234
	LSGR	$F_{2,42} = 0.82$, $p = 0.45$	$F_{2,42} = 0.59$, $p = 0.56$	$F_{1,42} = 0.09$, $p = 0.77$	$F_{2,42} = 1.66$, $p = 0.20$	$F_{1,42} = 0.72$, $p = 0.40$	$F_{2,42} = 0.62$, $p = 0.54$	$F_{1,42} = 5.05$, $p = 0.03$	0.040
	MSGR	$F_{2,41} = 0.05$, $p = 0.95$	$F_{2,41} = 1.14$, $p = 0.33$	$F_{1,41} = 0.44$, $p = 0.51$	$F_{2,41} = 1.69$, $p = 0.20$	$F_{1,41} = 1.58$, $p = 0.22$	$F_{2,41} = 0.57$, $p = 0.57$	$F_{1,41} = 4.44$, $p = 0.04$	0.043
	LWR	$F_{2,42} = 2.99$, $p = 0.06$	$F_{2,42} = 0.26$, $p = 0.78$	$F_{1,42} = 0.01$, $p = 0.92$	$F_{2,42} = 2.87$, $p = 0.07$	$F_{1,42} = 0.06$, $p = 0.81$	$F_{2,42} = 0.79$, $p = 0.46$	$F_{1,42} = 1.04$, $p = 0.31$	0.094

Supplementary figures

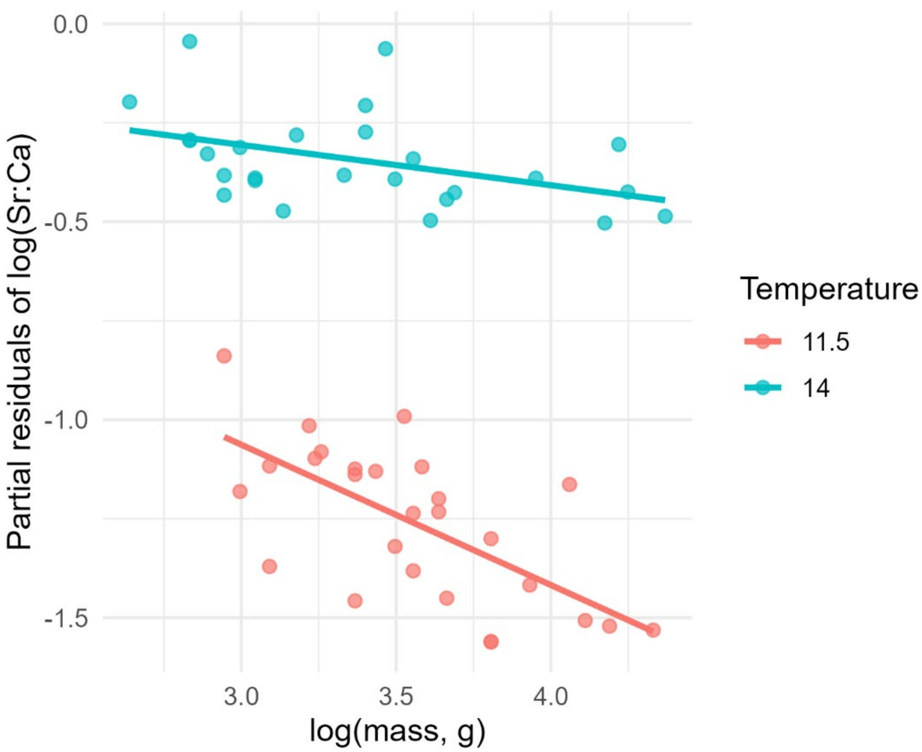

Figure S1. Partial residuals from the linear model relating log(Sr:Ca) to log(mass) and temperature. Points show partial residuals and lines show fitted relationships for each temperature. This plot illustrates the size–temperature structure present in the model.

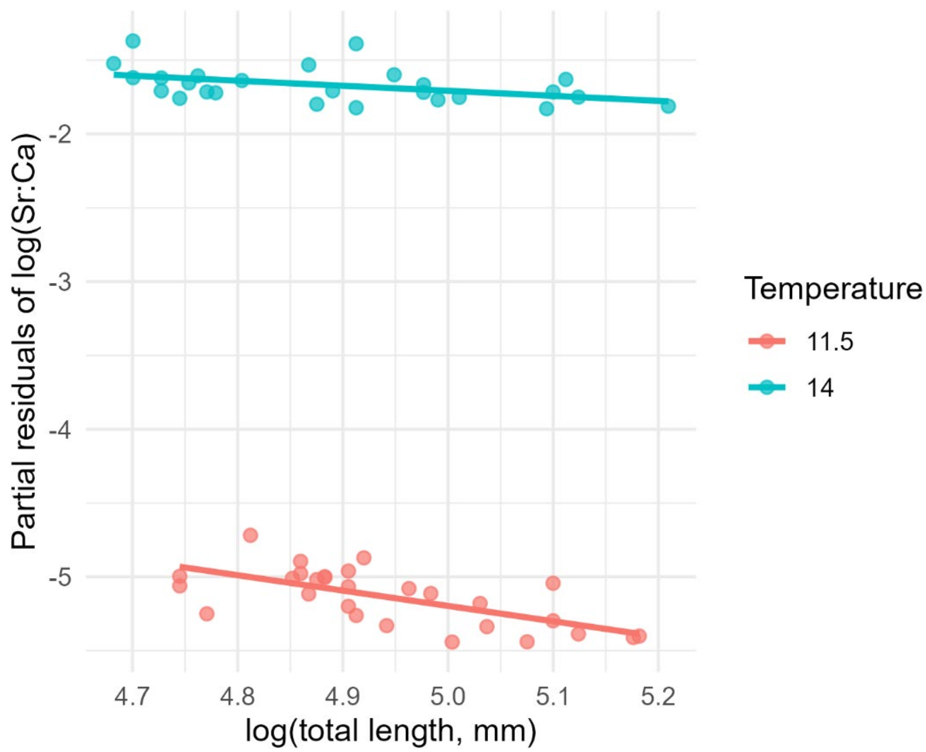

Figure S2. Partial residuals from the linear model relating log(Sr:Ca) to log(total length) and temperature. Points represent partial residuals and lines represent fitted relationships for each temperature. This plot shows the relationship between size and Sr:Ca within each temperature treatment.

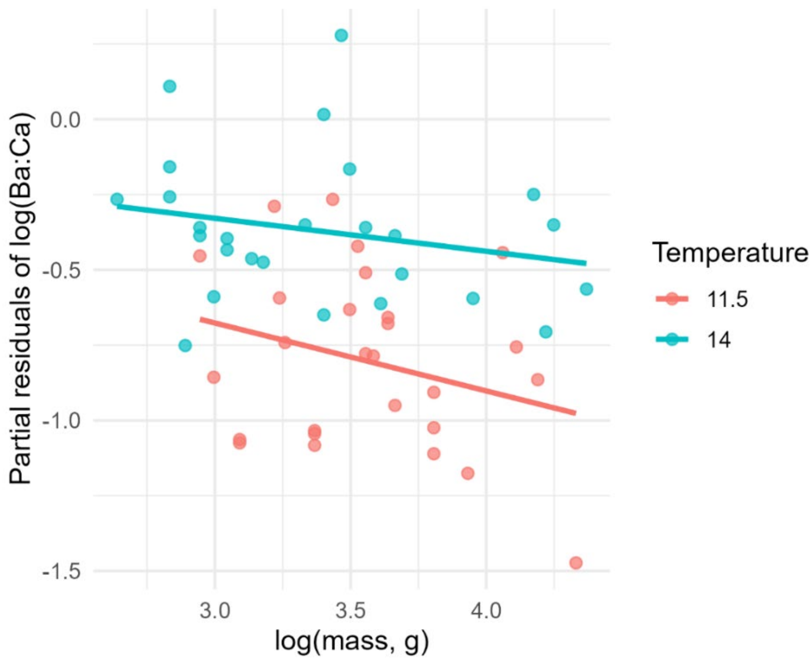

Figure S3. Partial residuals from the linear model relating log(Ba:Ca) to log(mass) and temperature. Points show partial residuals and fitted lines are shown for each temperature. This plot provides the diagnostic view of the mass–Ba:Ca relationship used in the model comparison.

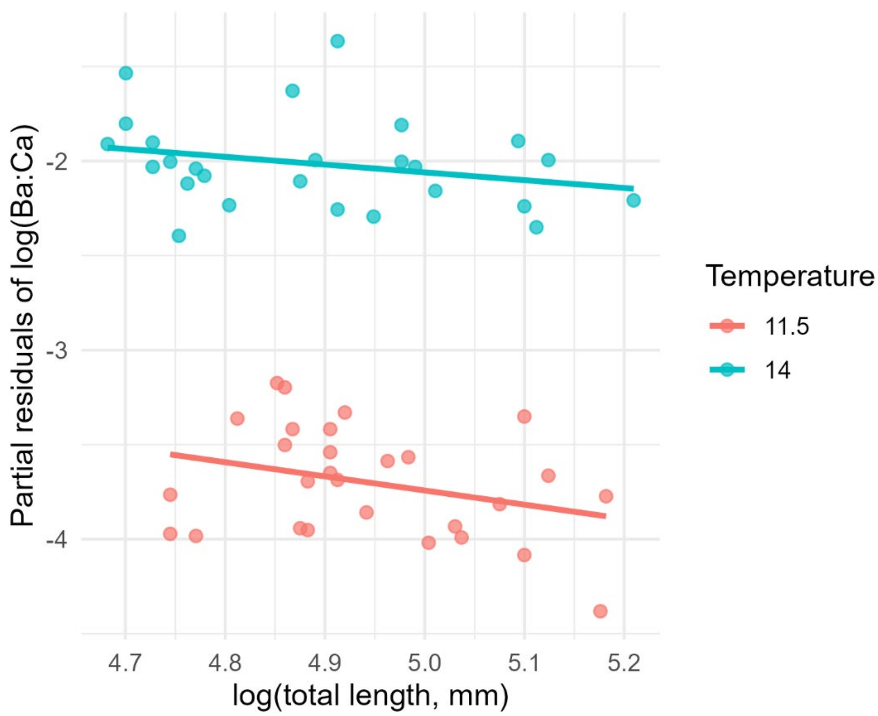

Figure S4. Partial residuals from the linear model relating log(Ba:Ca) to log(total length) and temperature. Points show partial residuals and lines show fitted relationships for each temperature. This plot provides the diagnostic view of the length–Ba:Ca relationship.