Meta-analysis of growth parameters and estimation of natural mortality rate for blueline tilefish

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Methods

Due to problems with aging methods, we could not use age data for blueline tilefish to estimate growth models for the species. So we took a meta-analytic approach.

Estimating L_∞

We reasoned that we could estimate L_∞ from extensive length data, and K and t_0 from a meta-analysis. We estimated L_∞ by looking at distributions of aggregated length data used in past SEDAR assessments and the relationship with the estimate of L_∞ used in that assessment. Specifically, we determined what percent of the lengths were smaller than L_∞ for each assessment (i.e. the L_∞ quantile) and calculated the average of those values (97%). We then estimated the L_∞ value associated with this quantile in the distribution of blueline tilefish lengths.

Estimating K, t_0, and M

We constructed several different meta-analyses to estimate t_0 and K, which differed mainly in that they included different parameter estimates and often different sets of species. The preferred method is presented in the main text, while alternate methods are presented in the Appendix. For each dataset D, t_0 was estimated as the mean t_0. Since K and L_∞ are correlated, we looked at their relationship and estimated K as a function of L_∞. Both K and L_∞ were natural log transformed, and fit with a linear model. We then estimated K from the predicted value from the regression at our estimated value of L_∞. Note that lengths in the regression were in total length while we were interested in fork length, so data converted back and forth between TL and FL using meristic equations reported by Ballew and Potts (2017). M was calculated with the $Pauly_{nls-T}$ formula presented by Then et al. (2015):

$M = aK^bL_\infty^c$

where parameters $a = 4.118$, $b = 0.73$ and $c = -0.33$.

Much of the time spent on this analysis was selecting which species and data sets should be including in the meta-analysis. At the SEDAR50 Data Workshop, most members of the Life

History Working Group (LHWG) spent extensive effort looking through scientific papers to find parameter estimates and determine that aging methods were validated for each species. The species selected were deepwater species found in the US South Atlantic.

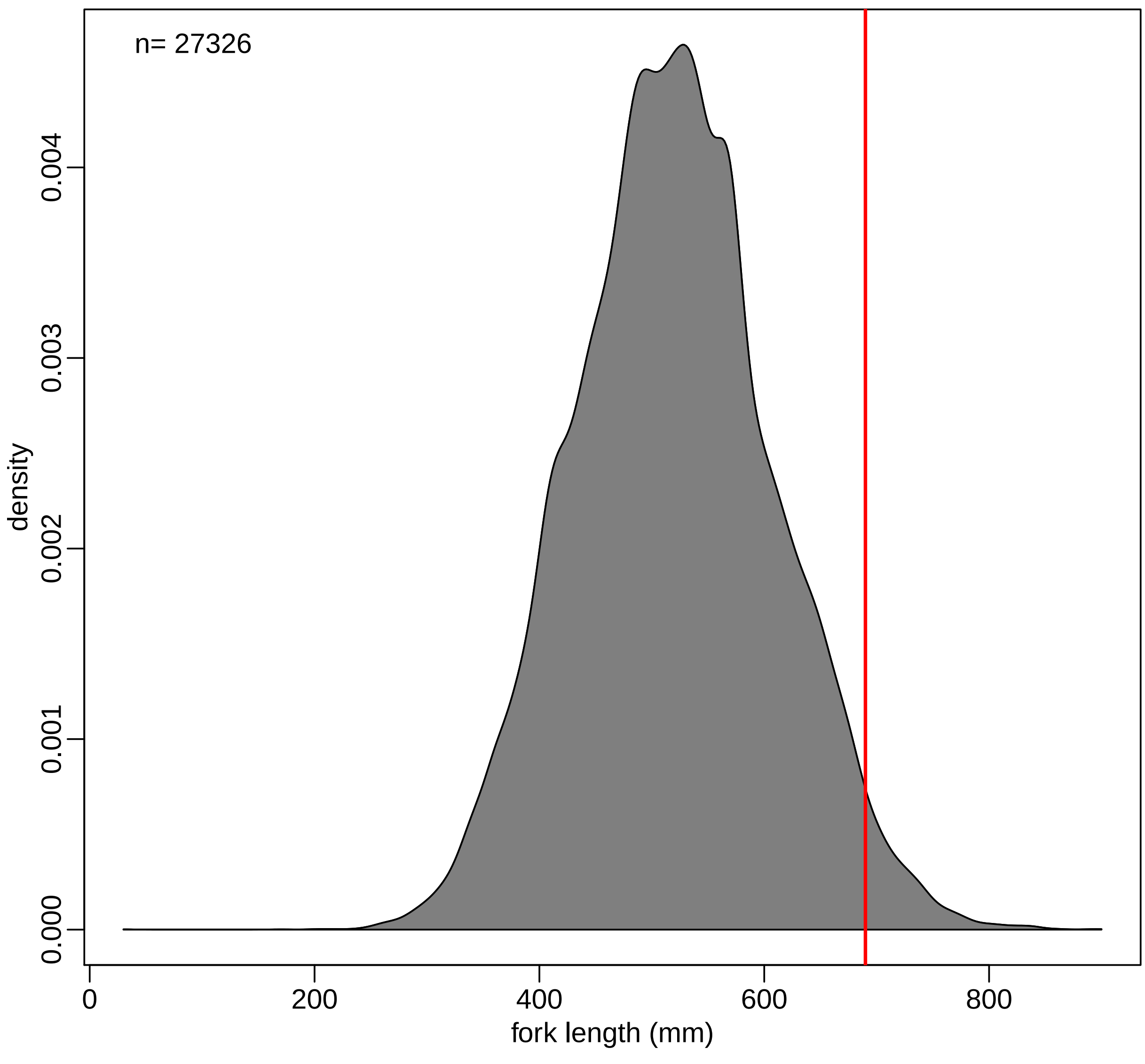
Estimating uncertainty

Estimating uncertainty in growth model parameters, the growth model, and M relied in part on a bootstrapping procedure. The steps of this procedure for each bootstrap run are described below.

1. sample with replacement from SEDAR estimates of L_∞ quantile ($n = 11$) and calculate mean L_∞ quantile
2. sample with replacement from blueline tilefish lengths ($n = 27326$; from SEDAR 32) to produce a bootstrap bootstrap distribution of lengths
3. estimate L_∞ from mean L_∞ quantile and the bootstrap distribution of lengths
4. sample with replacement, t_0 values from meta-data ($n = 13$) and estimate mean t_0 from the bootstrap sample
5. estimate K by drawing a value from a normal distribution (with mean equal to the K estimate, from the meta-data regression, and a standard deviation estimated from the residuals of that regression)
6. Draw estimates of parameters a, b, and c for the $Pauly_{nls-T}$ formula from normal distributions with means equal to the parameter estimates ($a = 4.118$, $b = 0.73$, $c = -0.33$) and standard deviations equal to the Model SE values presented by Then et al. (2014; their Table 3; $a_{SE} = 0.80$, $b_{SE} = 0.08$ and $c_{SE} = 0.08$). Use these bootstrapped parameter estimates along with the bootstrap values of K and L_∞ to estimate a bootstrap value of M.
7. repeat until 10000 bootstraps are completed

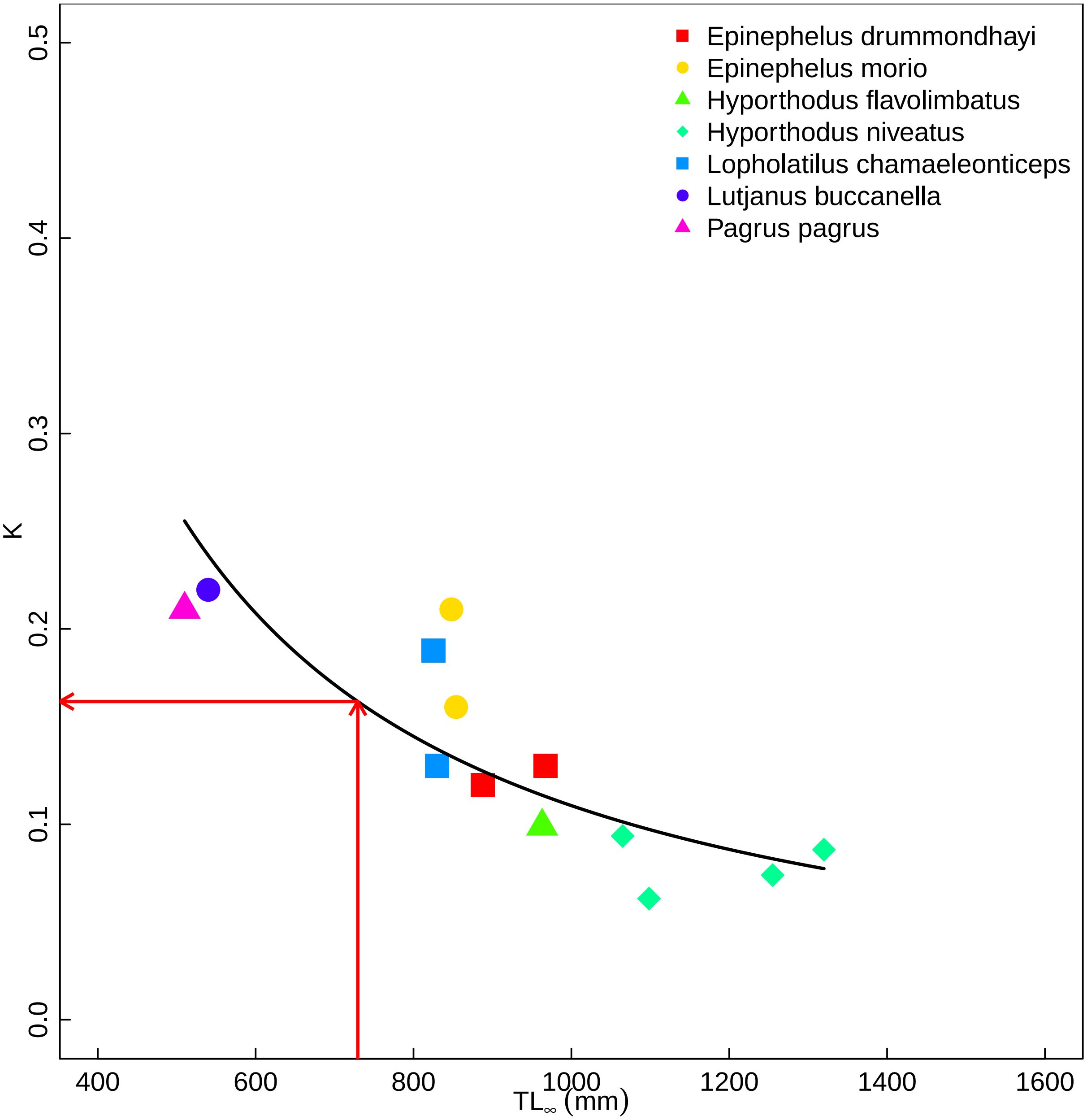
Results

The distribution of fork lengths available for blueline tilefish from SEDAR 32 is plotted below. The fork length corresponding to 97% was 690 mm FL, and thus our estimate of L_∞.



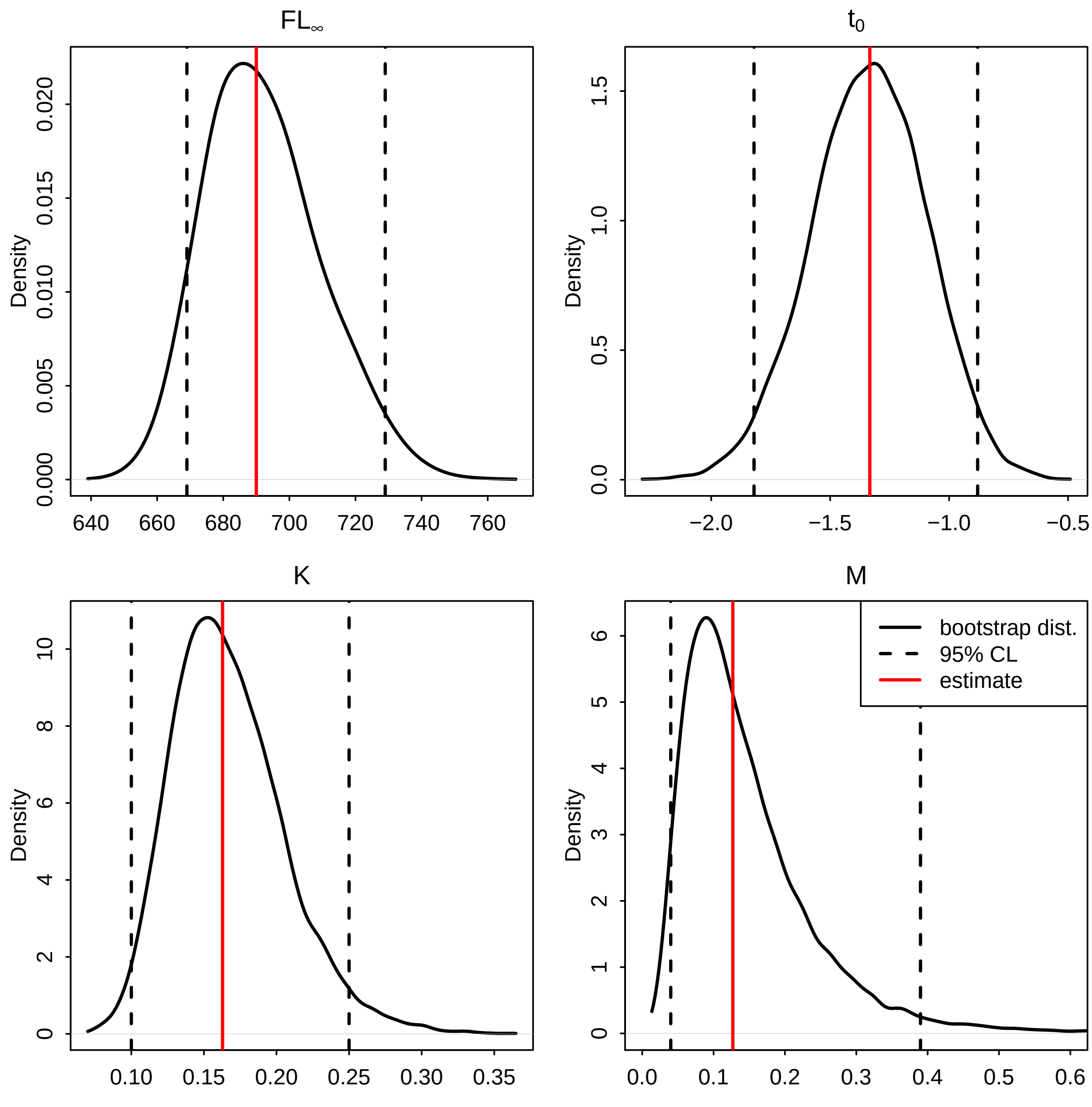
Distribution of blueline tilefish lengths. The red line indicates the estimate of L_∞.

The LHWG found 13 growth estimates for 7 species deemed appropriate to include in the meta-analysis. The resulting estimate of $t_0 = -1.33$. A scatterplot of K and L_∞ from these data, along with the fitted relationship is below.

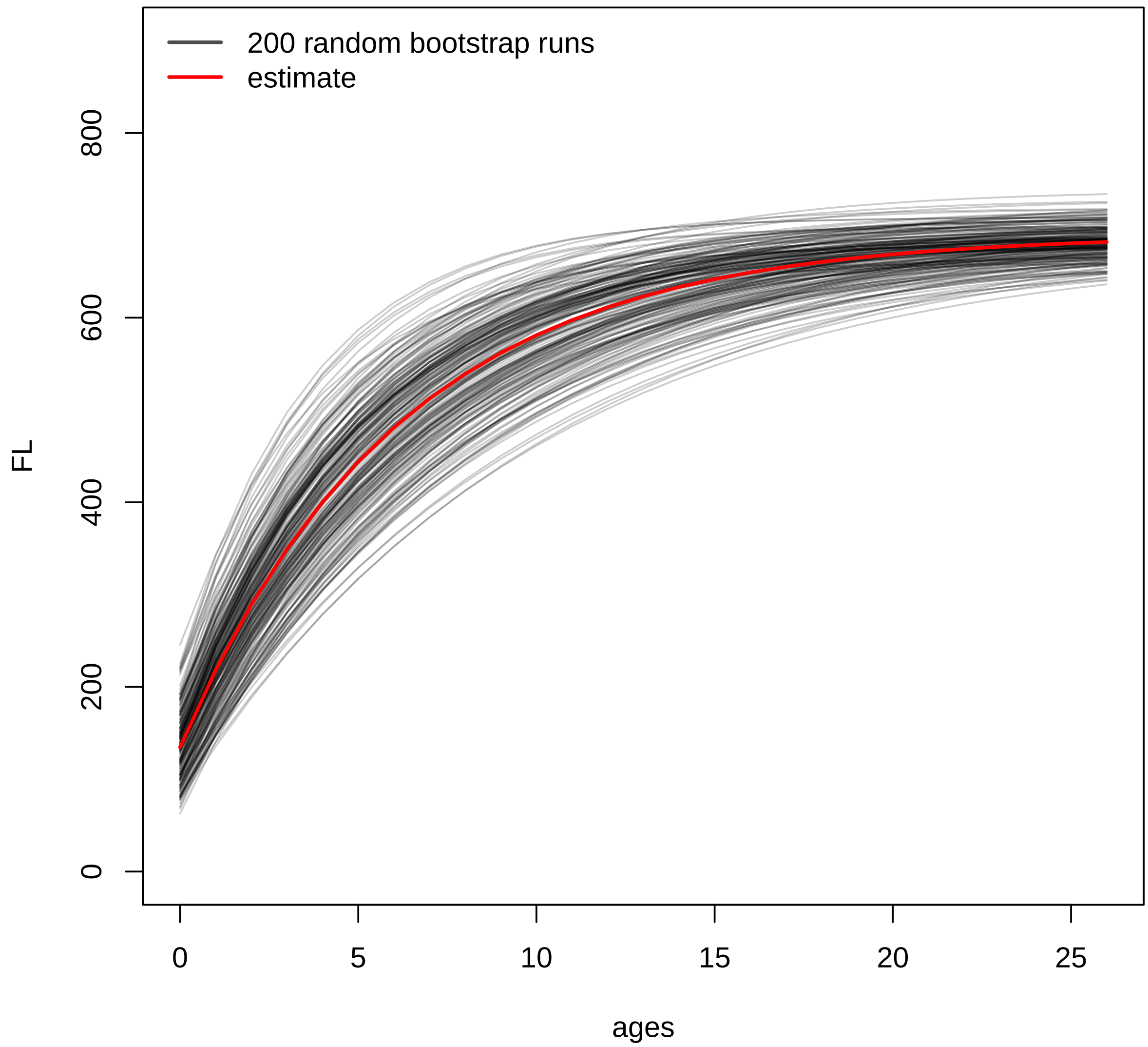


The predicted value of K, from the fitted line and our estimated L_∞ was $K = 0.16$.

Bootstrap distributions for growth parameters and M, as well as the resulting growth model are plotted below. The mode of those distributions was also calculated from the maximum density. These values, along with 95% confidence limits are presented in Table 1.



Bootstrap distributions for growth parameters and M



Estimated Von-Bertalanffy growth model, along with 200 randomly selected growth models resulting from bootstrapping.

Table 1: Parameter estimates from meta-analysis; mode, CV, and lower and upper 95% confidence limits from bootstrap distributions. FL_∞ in mm

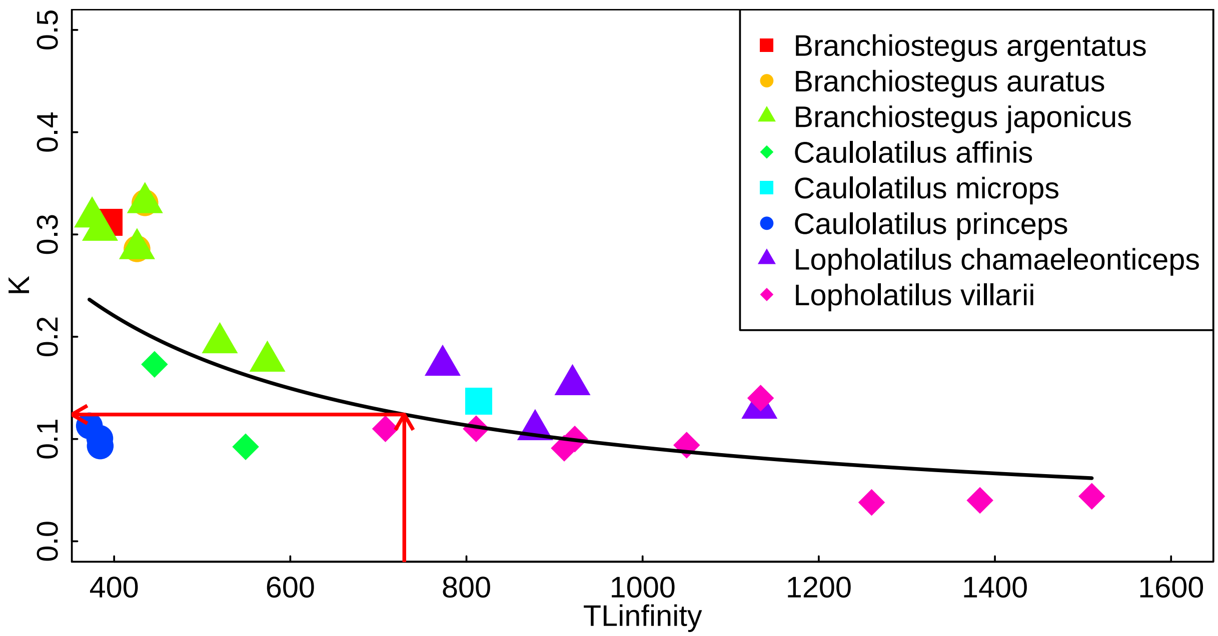
Parameter	Estimate	Mode	CV	Lower95%	Upper95%
FL_∞	690	686	0.024	669	729
t_0	-1.33	-1.31	-0.18	-1.82	-0.88
K	0.16	0.15	0.23	0.1	0.25
M	0.13	0.09	0.65	0.04	0.39

Appendix

In this appendix I explore how results might have differed if we had used different datasets for the meta-analysis.

Alternative 1: Fishbase data for Malacanthidae

The first alternative data set was to download growth data from Fishbase and filter it for family Malacanthidae. I also added estimates for *Caulolatilus princeps*. A scatterplot of K and L_∞ from these data, along with the fitted relationship is below.



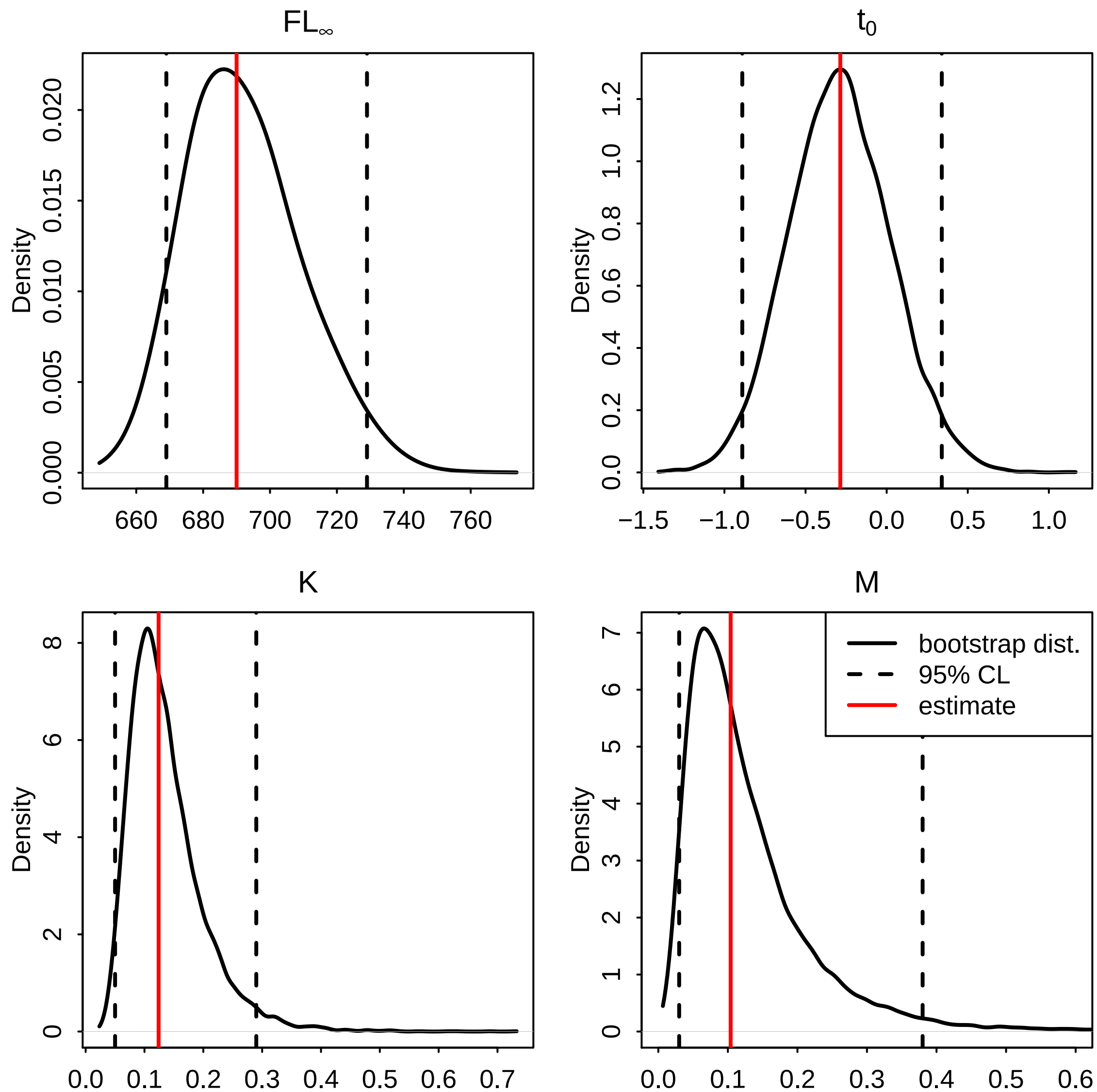


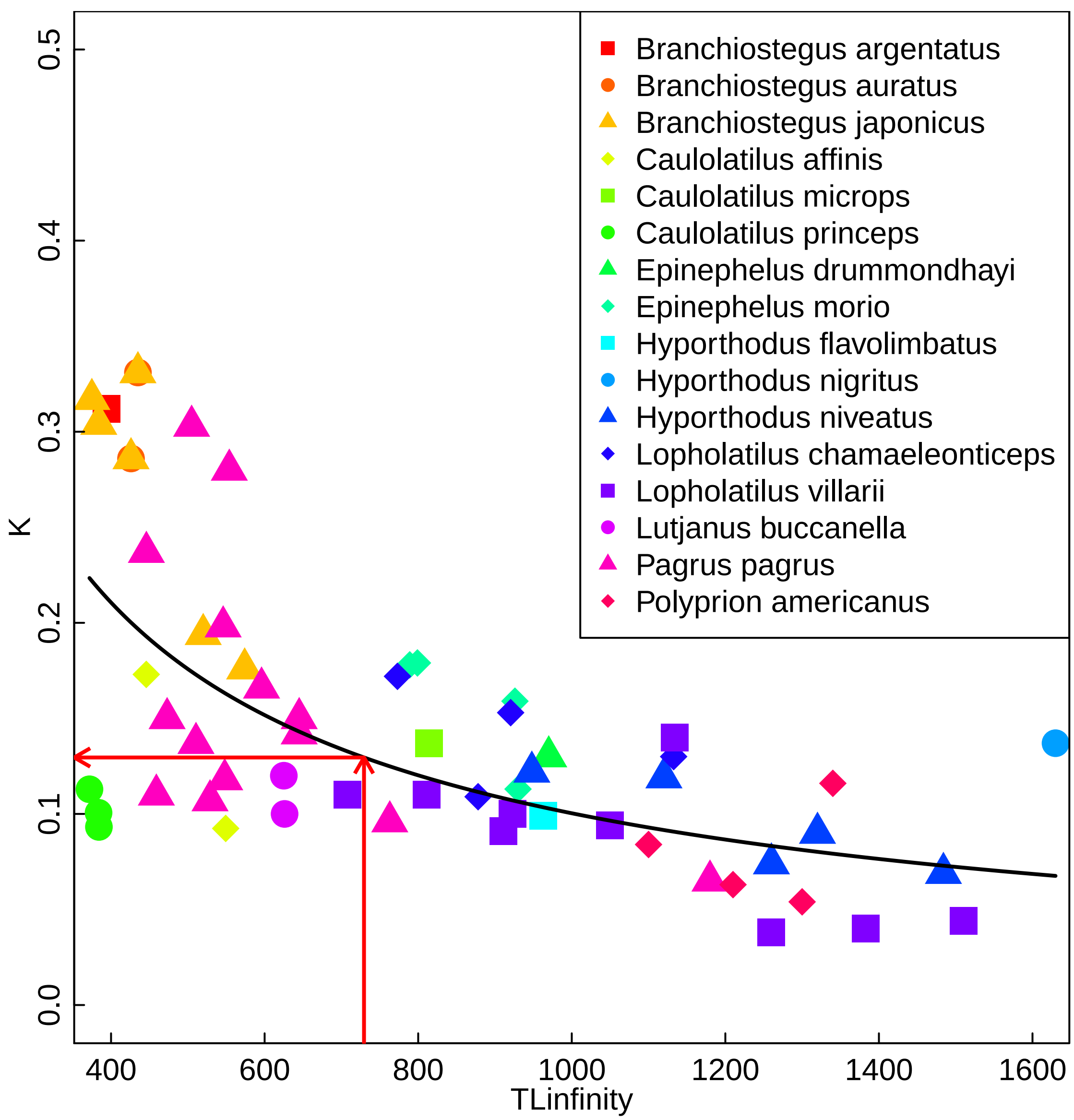
Table 2: Parameter estimates and lower and upper 95% confidence limits from bootstrapping. Data used in meta-analysis of growth parameters were for Malacanthid species from Fishbase.org, as well as *Caulolatilus princeps* data add by N. Klibansky. FL_∞ in mm

Parameter	Estimate	Mode	Lower95%	Upper95%
FL_∞	690	686	669	729
t_0	-0.29	-0.28	-0.89	0.34
K	0.12	0.11	0.05	0.29
M	0.1	0.07	0.03	0.38

Alternative 2: Fishbase data for Malacanthidae and associated species

The second alternative data set was to use the Fishbase Malacanthidae data, as well as data for associated species selected for inclusion in the meta-analysis conducted by the LHWG. A scatterplot of K and L_∞ from these data, along with the fitted relationship is below.

Growth parameter estimates to use for meta-analysis



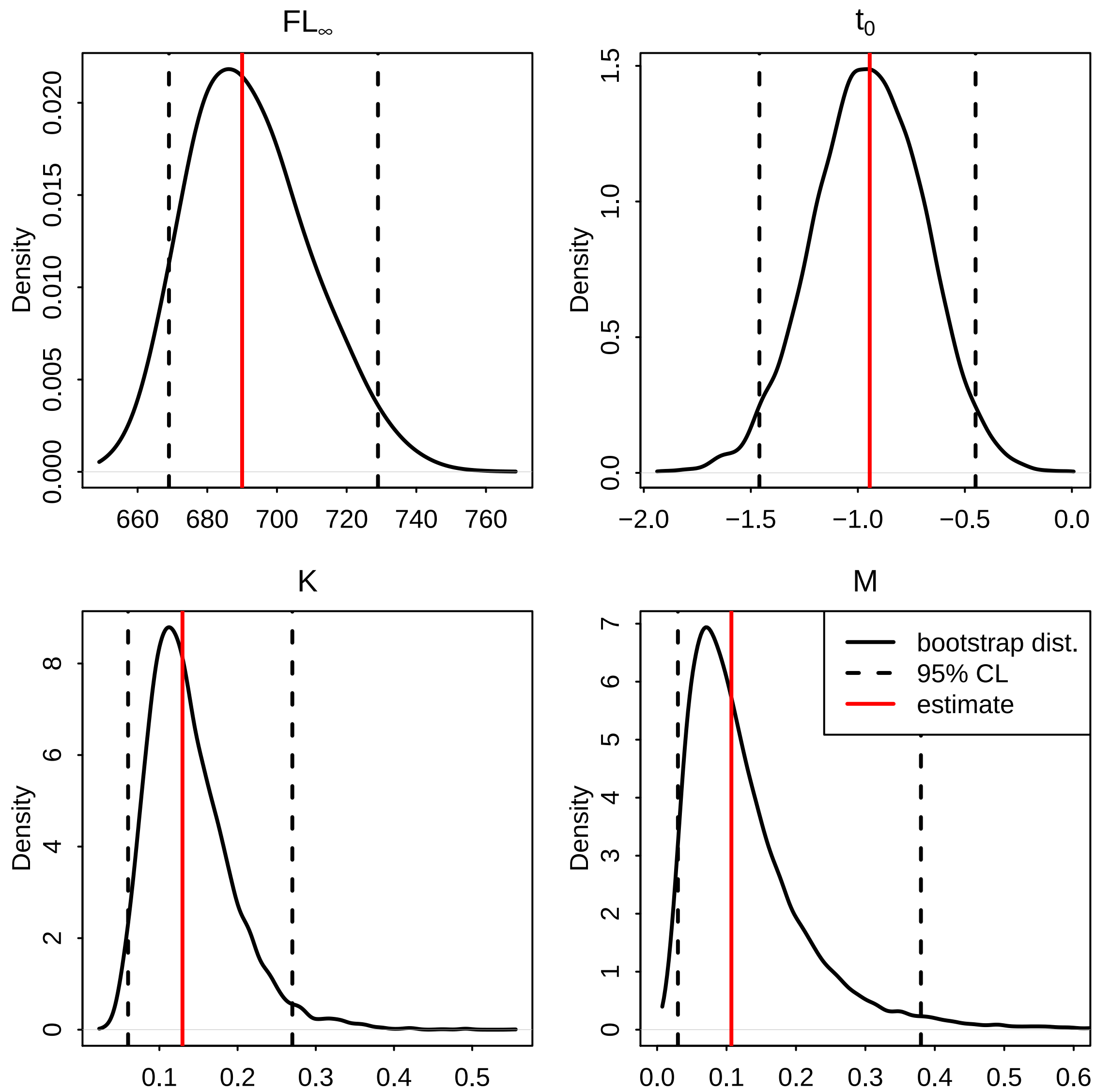
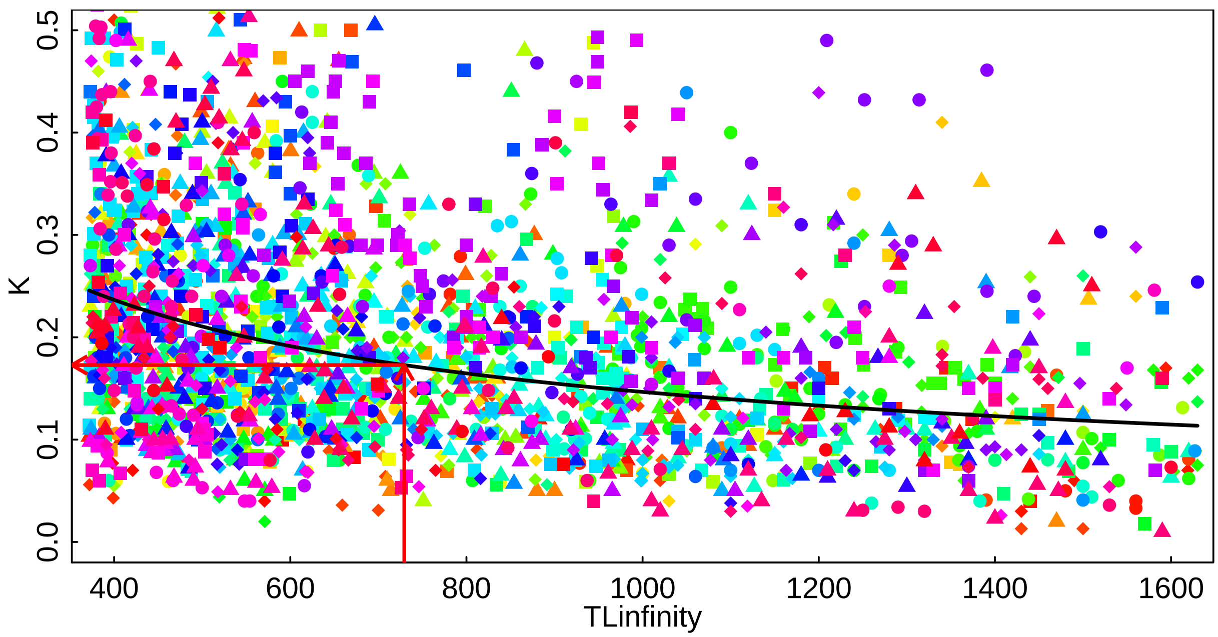


Table 3: Parameter estimates and lower and upper 95% confidence limits from bootstrapping. Data used in meta-analysis of growth parameters were for Malacanthid species from Fishbase.org, *Caulolatilus princeps* data add by N. Klibansky, as well as Fishbase.org data for species associated with blueline tilefish, selected by the Data Workshop Life History Working Group for use in their main meta-analysis. FL_∞ in mm

Parameter	Estimate	Mode	Lower95%	Upper95%
FL_∞	690	686	669	729
t_0	-0.94	-0.96	-1.46	-0.45
K	0.13	0.11	0.06	0.27
M	0.11	0.07	0.03	0.38

Alternative 3: Fishbase data for all species within a reasonable range of L_∞ values.

The third alternative data set was include all sets of growth parameters (L_∞, K, and t_0) available on Fishbase.org, that fell within the range of L_∞ values observed in the data set that included Malacanthidae and associates (372 to 1630 mm TL). A scatterplot of K and L_∞ from these data, along with the fitted relationship is below.



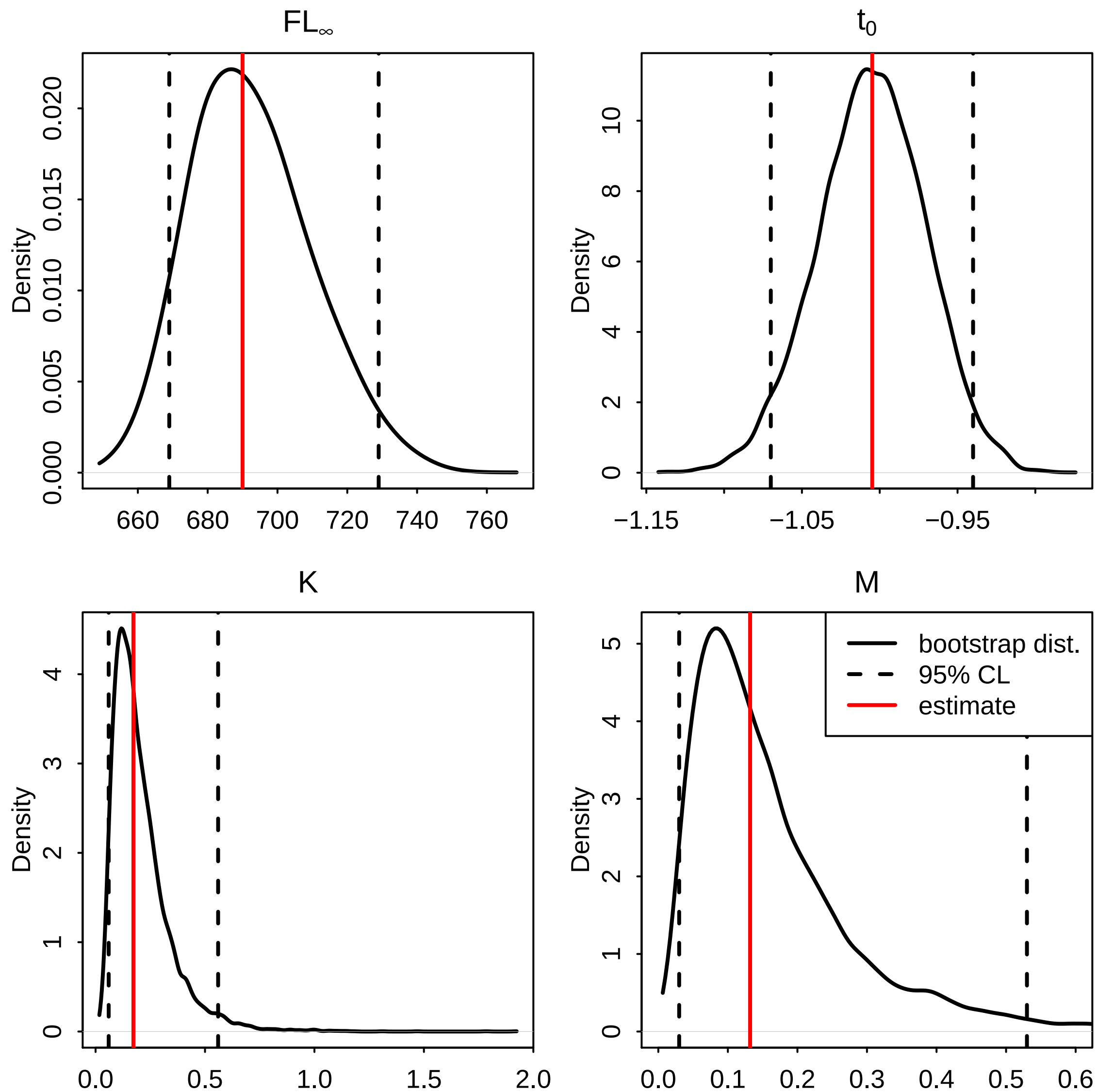


Table 4: Parameter estimates and lower and upper 95% confidence limits from bootstrapping. Data used in meta-analysis of growth parameters were all available values from Fishbase.org that fell within the range of L_∞ values observed in the data set that included Malacanthidae and associates (372 to 1630 mm TL). FL_∞ in mm.

Parameter	Estimate	Mode	Lower95%	Upper95%
FL_∞	690	687	669	729
t_0	-1	-1.01	-1.07	-0.94
K	0.17	0.12	0.06	0.56
M	0.13	0.08	0.03	0.53

Uncertainty in M

This plot shows a comparison of uncertainty around M based on two different methods; one method was presented at the post-DW webinar which did not incorporate uncertainty in the parameters of the Pauly equation, while the other method, preferred by the DW webinar panel, does.