Supplementary materials:

Potential sources of bias in the climate sensitivities of fish otolith biochronologies

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List of scientific publications reviewed for the establishment of the magnitude of the environmental effect on the growth of fish in the mixed-effects models:


File S1. Age error matrices for short-lived species. Rows indicate simulated “true” fish age and columns indicate simulated interpretation of age used in the sclerochronological study.

File S2. Age error matrices for long-lived species. Rows indicate simulated “true” fish age and columns indicate simulated interpretation of age used in the sclerochronological study.

Fig. S1. Average bias in the environmental effect estimates obtained from the 1000 simulation runs under different ageing error scenarios (rows) and assumed sampling schemes (n per year, columns).

Tab. S1. Average bias in the environmental effect estimates obtained from the 1000 simulation runs under different ageing error scenarios. The simulated parameter of the environmental effect was 0.08.
<table>
<thead>
<tr>
<th>Species</th>
<th>Ageing error scenario</th>
<th>Mean estimate for environmental effect</th>
<th>Average bias [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short-lived</td>
<td>perfectly aged</td>
<td>0.0810</td>
<td>1.2</td>
</tr>
<tr>
<td>Short-lived</td>
<td>no bias</td>
<td>0.0733</td>
<td>-8.4</td>
</tr>
<tr>
<td>Short-lived</td>
<td>bias (-1)</td>
<td>0.0865</td>
<td>8.2</td>
</tr>
<tr>
<td>Short-lived</td>
<td>bias (-10%)</td>
<td>0.0781</td>
<td>-2.4</td>
</tr>
<tr>
<td>Short-lived</td>
<td>bias (+1, -10%)</td>
<td>0.0582</td>
<td>-27.3</td>
</tr>
<tr>
<td>Long-lived</td>
<td>perfectly aged</td>
<td>0.0801</td>
<td>0.2</td>
</tr>
<tr>
<td>Long-lived</td>
<td>no bias</td>
<td>0.0344</td>
<td>-57.0</td>
</tr>
<tr>
<td>Long-lived</td>
<td>bias (-1)</td>
<td>0.0346</td>
<td>-56.8</td>
</tr>
<tr>
<td>Long-lived</td>
<td>bias (-10%)</td>
<td>0.0333</td>
<td>-58.3</td>
</tr>
<tr>
<td>Long-lived</td>
<td>bias (+1, -10%)</td>
<td>0.0337</td>
<td>-57.9</td>
</tr>
</tbody>
</table>
Fig. S2. Root-mean-squared error (RMSE) of the environmental effect parameter estimates calculated for models (M1) fitted on data gathered under different sampling schemes, focused on collecting 10 fish per year in different age at capture (AAC) ranges, and different ageing error scenarios for the short-lived species. Rounded RMSE and number of successfully fitted models (in parenthesis) are given for each AAC range. Minor difficulties were encountered when performing the analyses for the oldest age groups, which were not sufficiently represented in the simulated data set (N<10 per year).
Fig. S3. The wavelet coherency (color gradient) and phase between biochronology (Year random effect time series) obtained from the otolith growth model (M2) of the short-lived species and time series of the environmental variable used in the simulation. The model was fitted on data gathered with different ageing error scenarios and assumed sampling schemes. Time and wavelet period (in years) are indicated on X and Y-axis, respectively. The 5% significance level of coherence from the 1000 Monte Carlo randomizations is shown with the thick black contour. The relative phase relationship is indicated with arrows (with
biochronology in-phase pointing right, the anti-phase pointing left, and lead of biochronology by 90°, pointing straight down). The cut-off value for plotting phase arrows was set to $R^2=0.7$.

Fig. S4. The wavelet coherency (color gradient) and phase between biochronology (Year random effect time series) obtained from the otolith growth model (M2) of the long-lived species and time series of the environmental variable used in the simulation. The model was fitted on data gathered with different ageing error scenarios and assumed sampling schemes. Time and wavelet period (in years) are indicated on X and Y-axis, respectively. The 5% significance level of coherence from the 1000 Monte Carlo randomizations is shown with the
thick black contour. The relative phase relationship is indicated with arrows (with biochronology in-phase pointing right, the anti-phase pointing left, and lead of biochronology by 90°, pointing straight down). The cut-off value for plotting phase arrows was set to $R^2=0.7$.

Fig. S5. Mean coefficient of correlation (R) between time series of environmental variable used in the simulation and biochronology obtained from the otolith growth models fitted on data gathered under different sampling schemes, focused on collecting 10 fish per year in different age at capture (AAC) ranges, and different ageing error scenarios for the short-lived species. R and the number of successfully fitted models (in parenthesis) are given for each AAC range. Minor difficulties were encountered when performing the analyses for the oldest and youngest age groups, which were not sufficiently represented in the simulated data set (N<10 per year).