

Supplementary material

Table S1 – Effect of using different dates for the onset of gonadal maturation in Eq. (2). Thus, instead of starting at September 1, we tested the effects of starting to sum the temperatures (DD) from different dates representing the onset of gonadal maturation to the mean spawning date.

Metric	Onset of gonadal maturation	R^2	p
DD	July 1	0.01	0.012*
DD	July 15	0.01	0.035*
DD	August 1	0.01	0.098
DD	August 15	0.00	0.258
DD	September 1	0.00	0.758
DD	September 15	0.00	0.616
DD	October 1	0.01	0.143
DD	November 1	0.02	0.003**
DD	December 1	0.05	<0.001***

Note. * $p < .05$, ** $p < .01$, *** $p < .001$

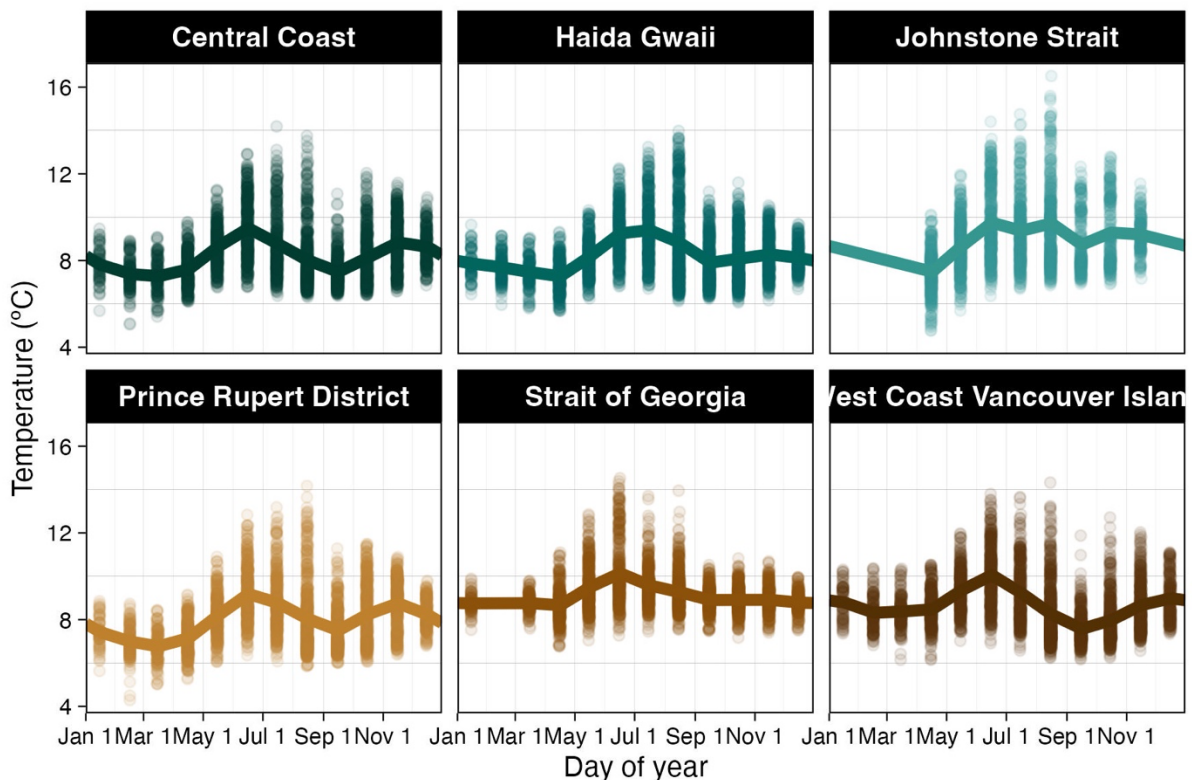


Figure S1 – Average monthly Simple Ocean Data Assimilation (SODA) temperature (dots) and the average daily interpolation (lines) for each of the six spawning locations based on the seasonal depth distributions experienced by Pacific herring as in Table 1. Note that this figure shows the monthly and daily averages for all years, even though our analyses used the annual data. The acronyms and colours for the spawning regions can be found in the caption of Fig. 1.

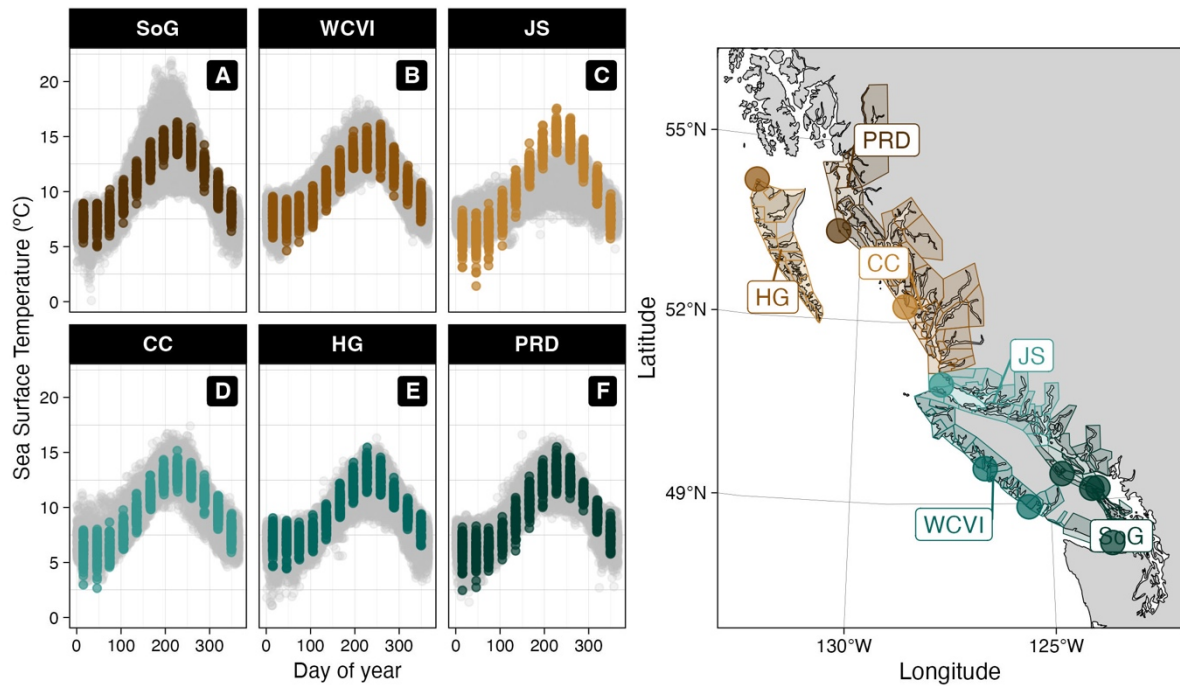


Figure S2 – Average surface temperature for each of the six spawning regions (A-F, colours as in Fig. 1). Grey points correspond to the Lighthouse data, and the coloured data corresponds to the SODA temperature for the shallowest depth (5.01 m). The right map: the coloured polygons correspond to the definition of each of the six spawning regions to extract the SODA temperatures (as in Fig. 1), whereas the coloured circles correspond to the locations of the Lighthouse stations. Note: some regions only have one Lighthouse station (e.g. HG), whereas others have several (e.g. SoG).

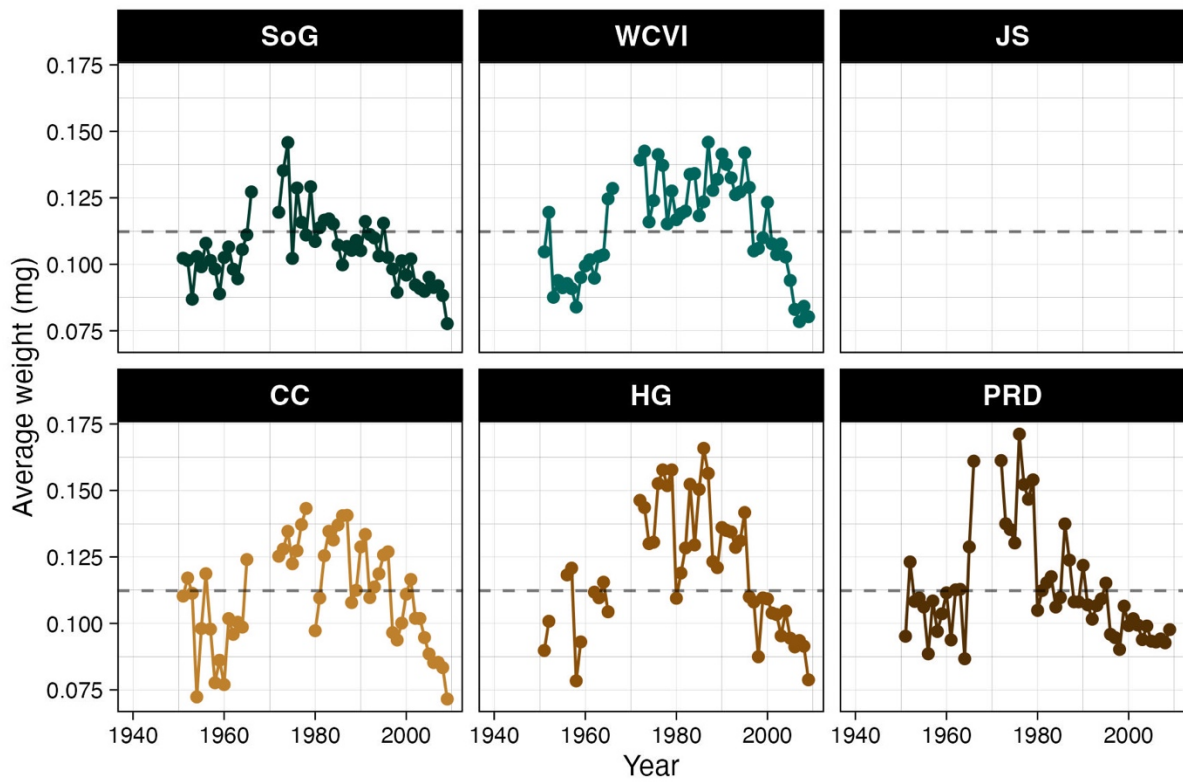


Figure S3 – Average spawner weight for each of the six spawning locations. Dashed. Grey line represents average weight. The acronyms and colours for the spawning regions can be found in the caption of Fig. 1.

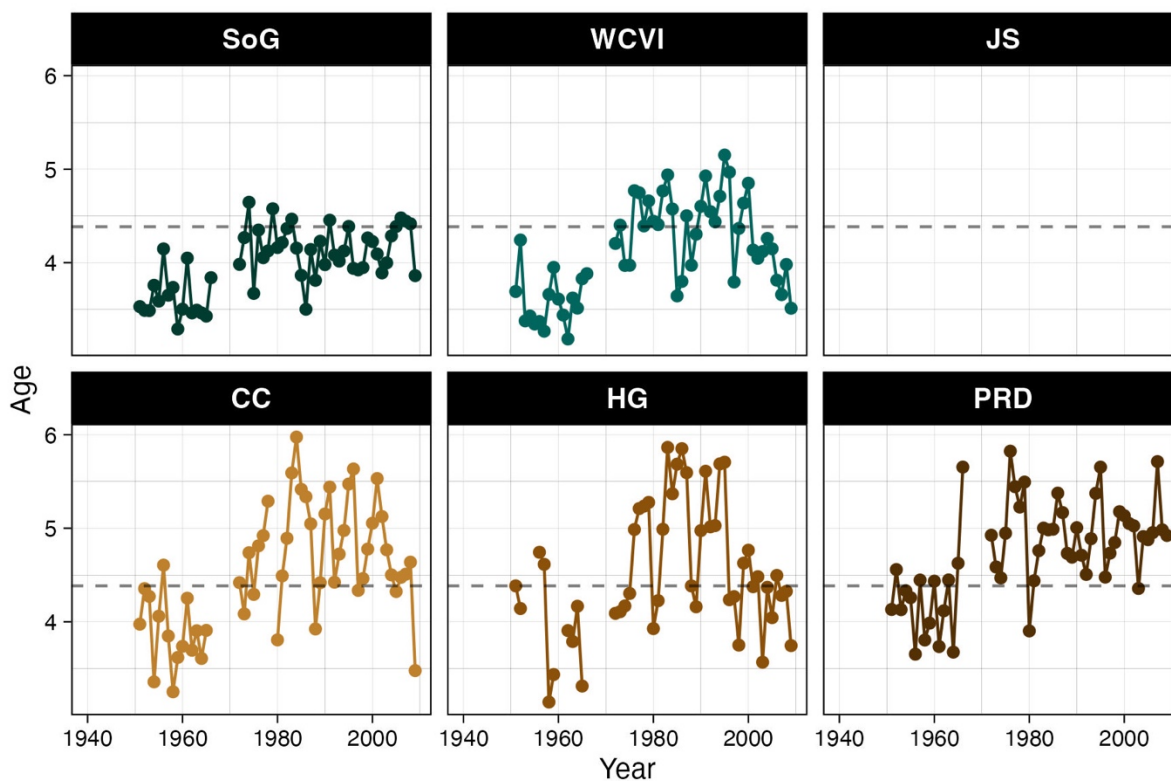


Figure S4 – Average spawner age for each of the six spawning locations. Dashed. Grey line represents average age. The acronyms and colours for the spawning regions can be found in the caption of Fig. 1.

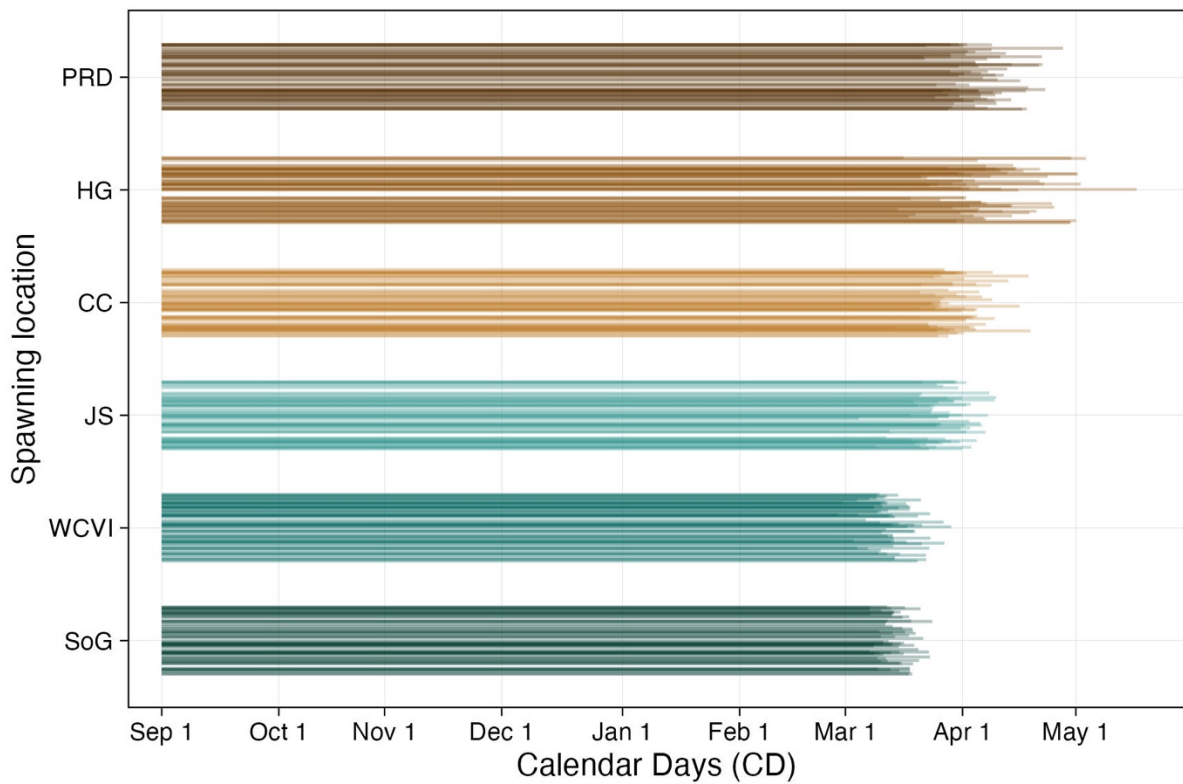


Figure S5 – Spawning time from the onset of gonadal maturation (Sep 1, day of year 244) to the spawning date for each of the six spawning locations. Jittering has been applied on the y axis of the data (0.3°) to facilitate the reading of the plot. The acronyms and colours for the spawning regions can be found in the caption of Fig. 1.

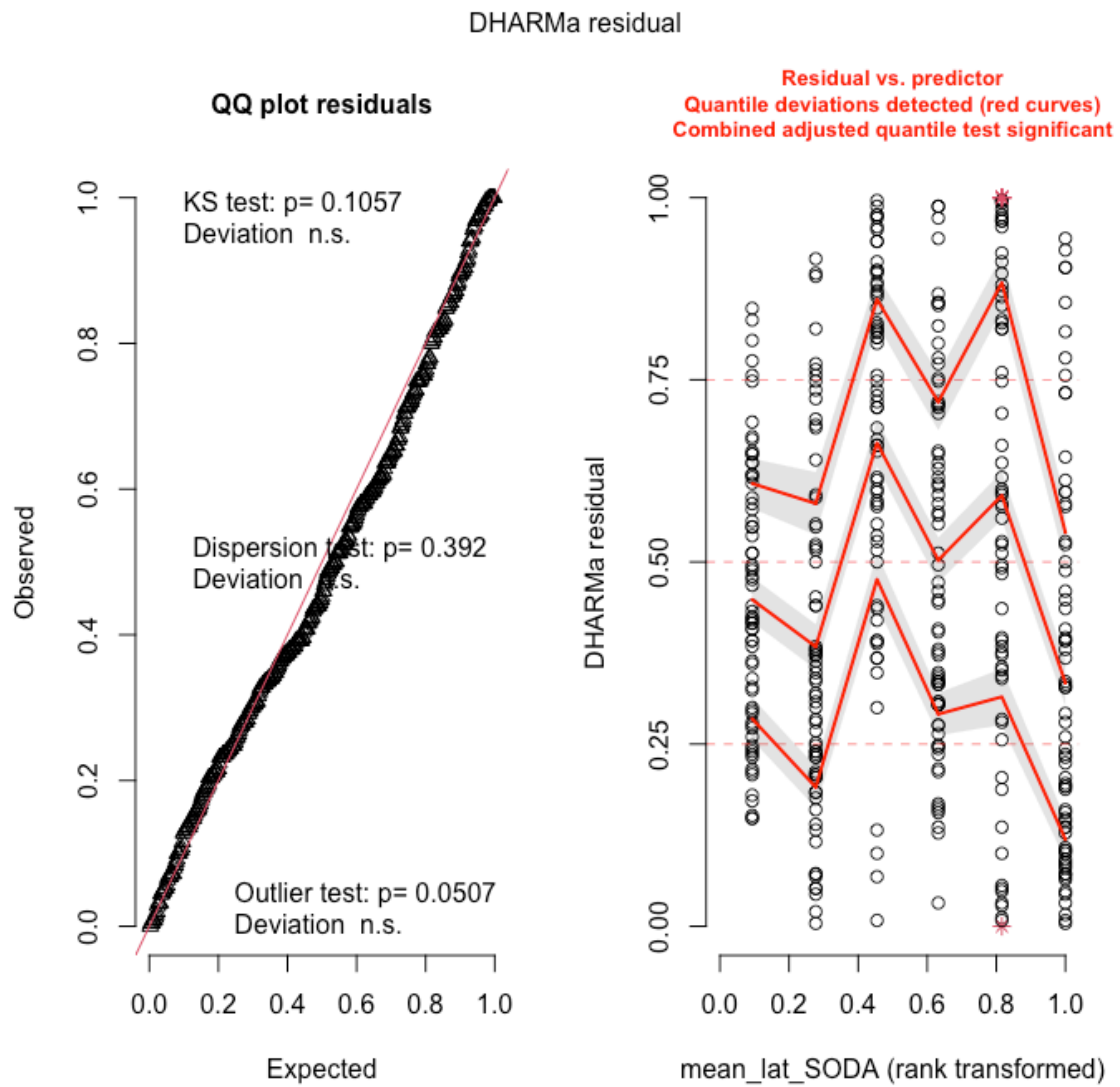


Figure S6 – Residuals from the model in Eq. (2) with Calendar Days (CD) as the response variable. Output from the DHARMA package (Hartig 2022).

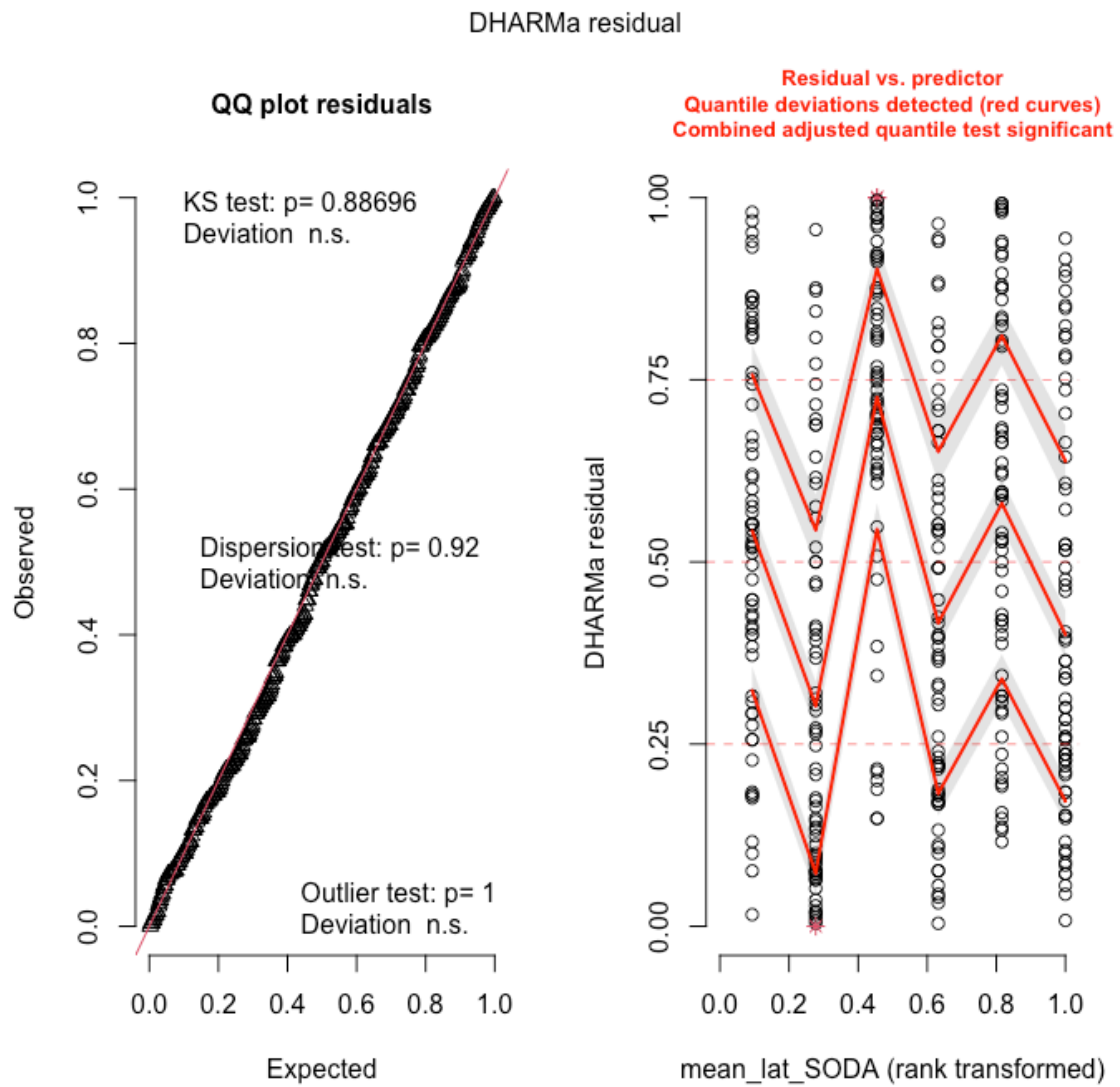


Figure S7 – Residuals from the model in Eq. (2) with Degree-Days (DD) as the response variable. Output from the DHARMA package (Hartig 2022).

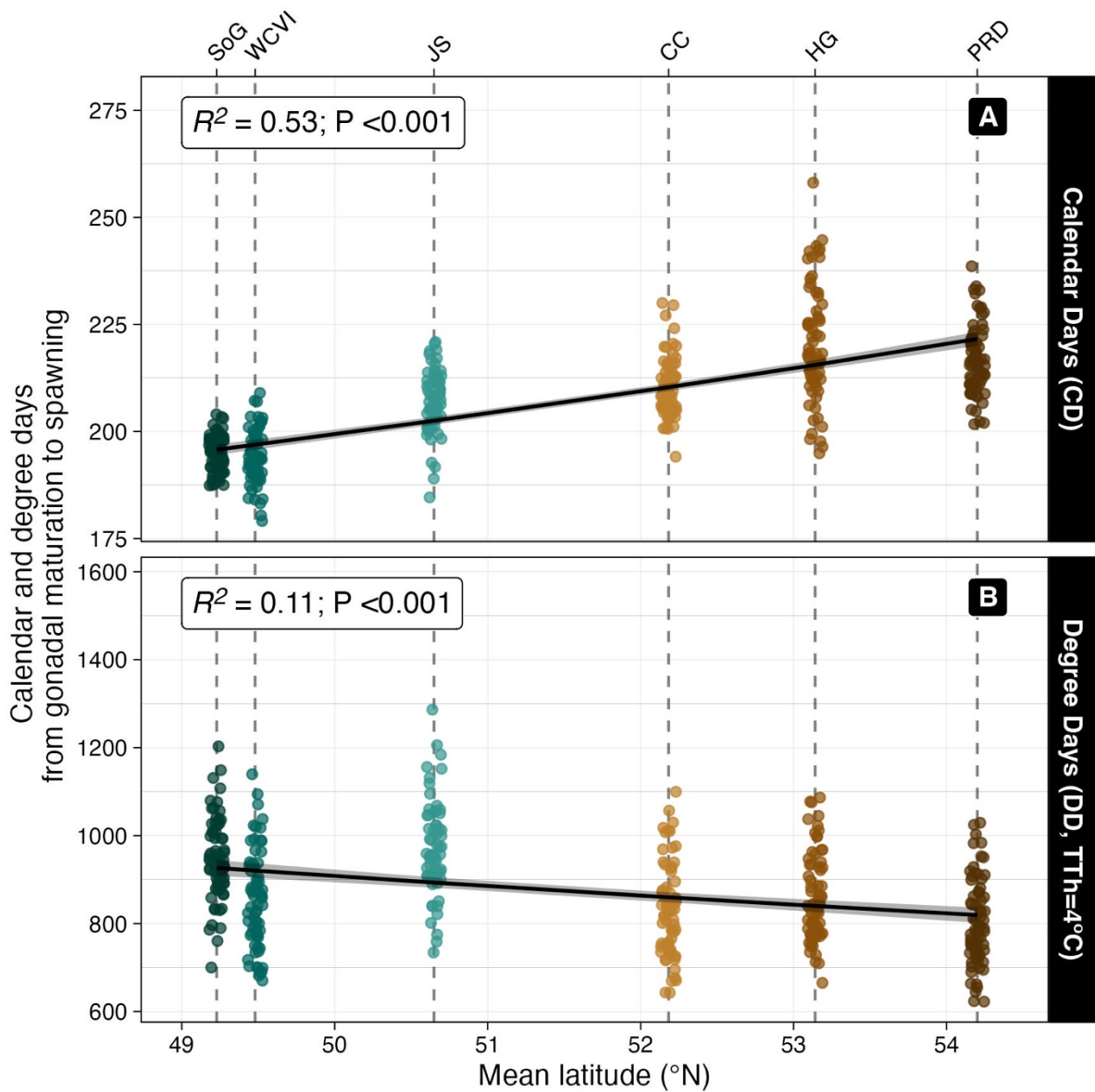


Figure S8 – Spatial variation in spawning for $T_{Th} = 4\text{ °C}$. A comparison of time to mean spawning as calendar days (CD, top), and degree days (DD, bottom) with mean latitude of each of the six spawning locations. Dashed lines show significant linear trends in CD and DD to spawning with year; grey areas show the 95% confidence interval around the prediction. Jittering has been applied on the x axis of the data (0.3°) to facilitate the reading of the plot. The acronyms and colours for the spawning regions can be found in the caption of Fig. 1.

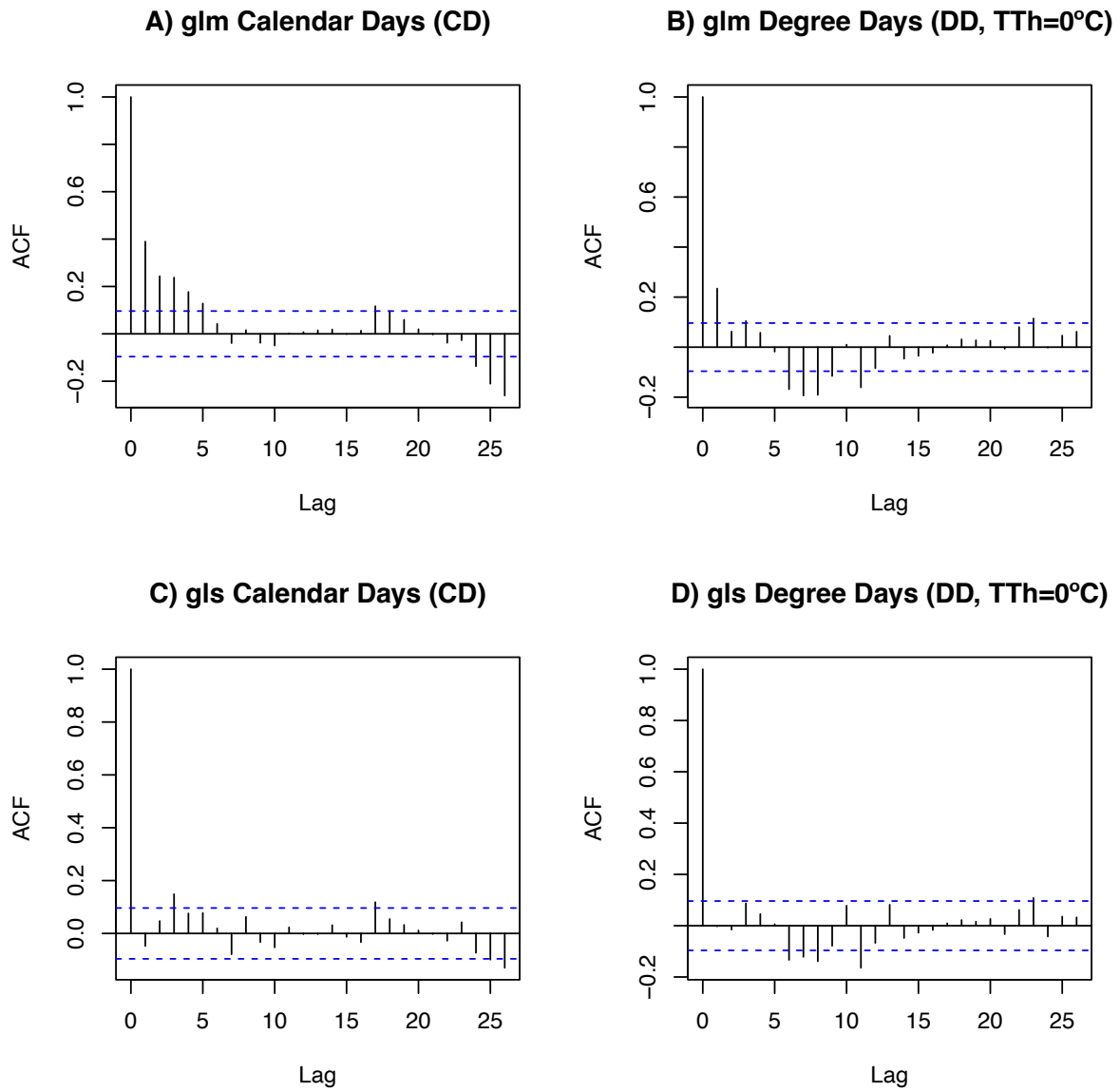


Figure S9 – Autocorrelation function plots for Eq. (3) run as a GLM (A and B) or a GLS (C and D) model for both CD (A and C) and DD (B and D). Note: the patterns in the temporal autocorrelation seen in the GLM models (A and B) disappears when using a GLS model (C and D).

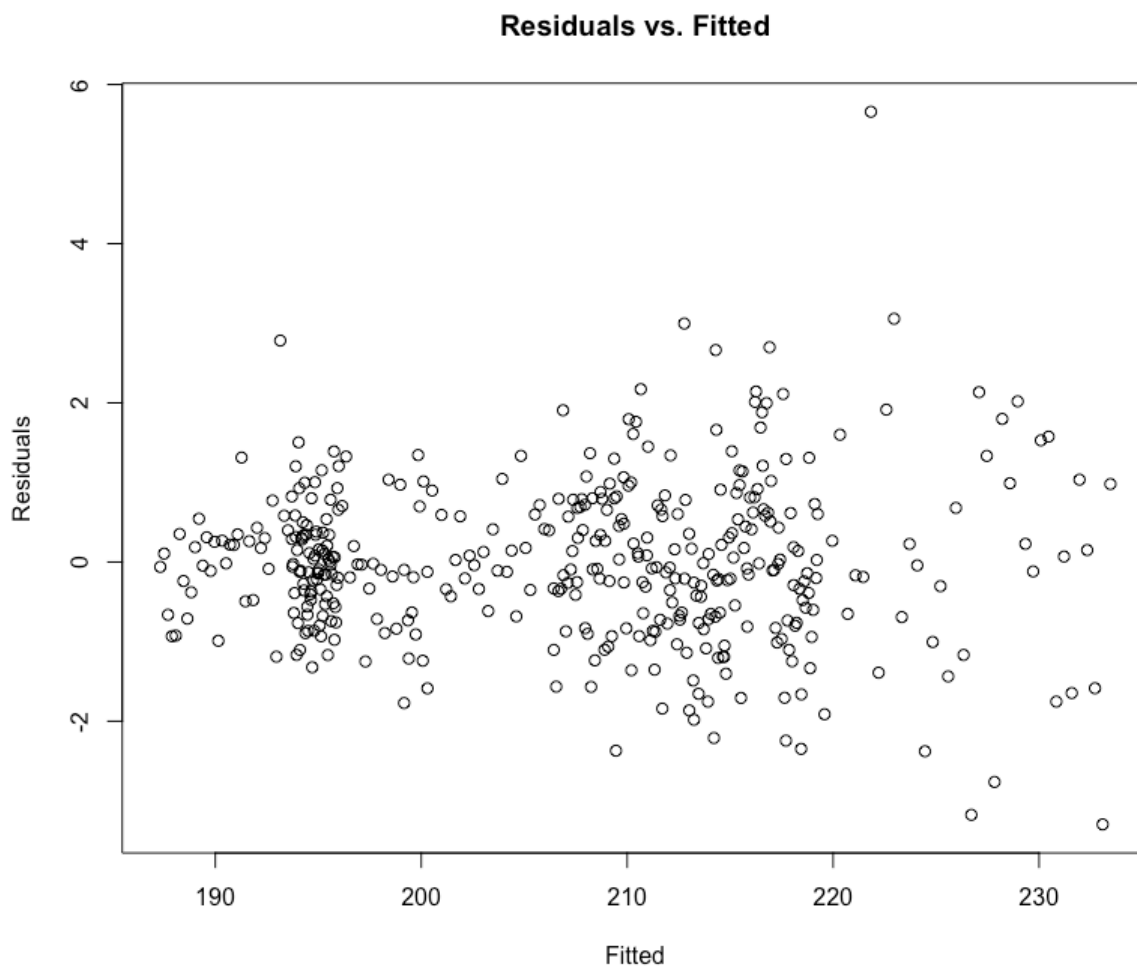


Figure S10 – Normalised residuals from the model in Eq. (3) with Calendar Days (CD) as the response variable.

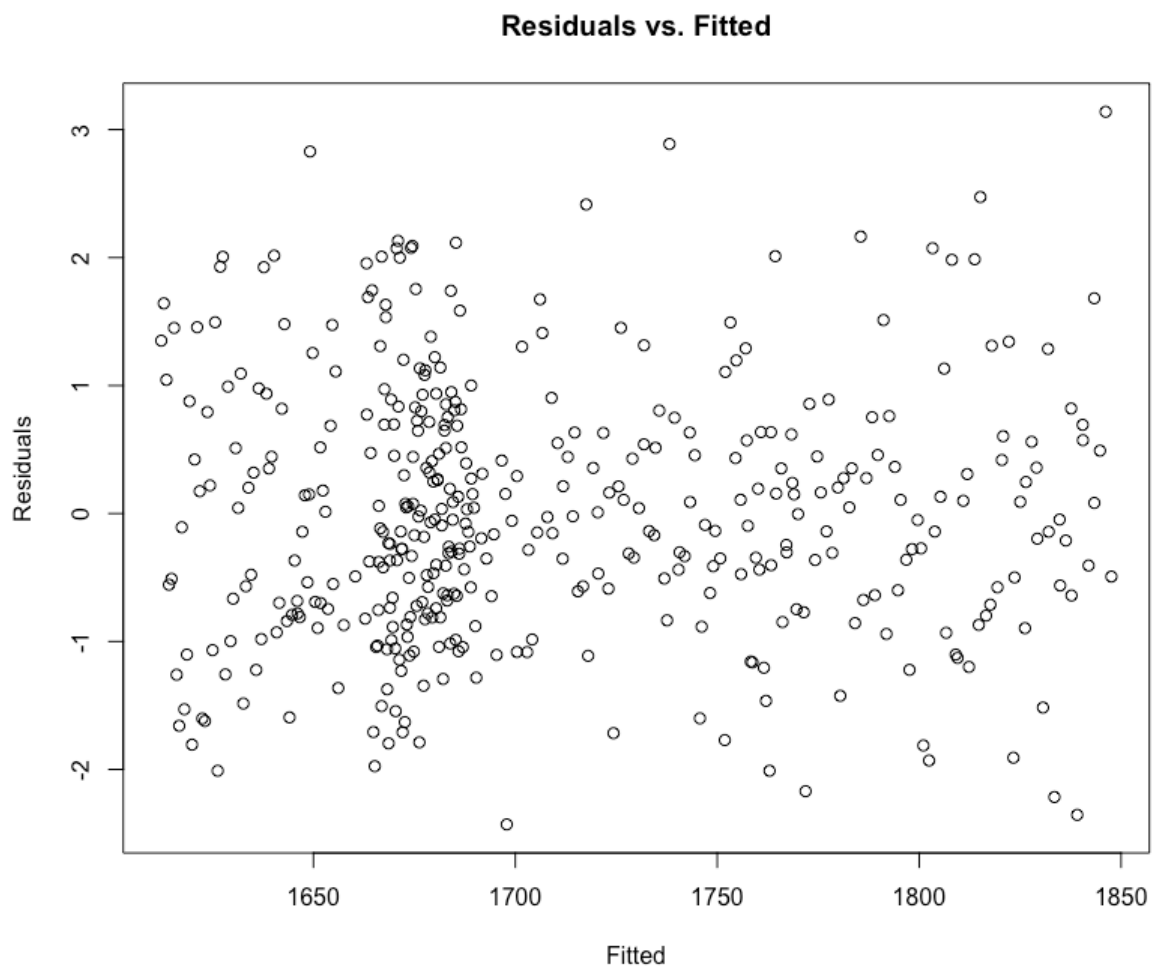


Figure S11 – Normalised residuals from the model in Eq. (3) with Degree-Days (DD) as the response variable.

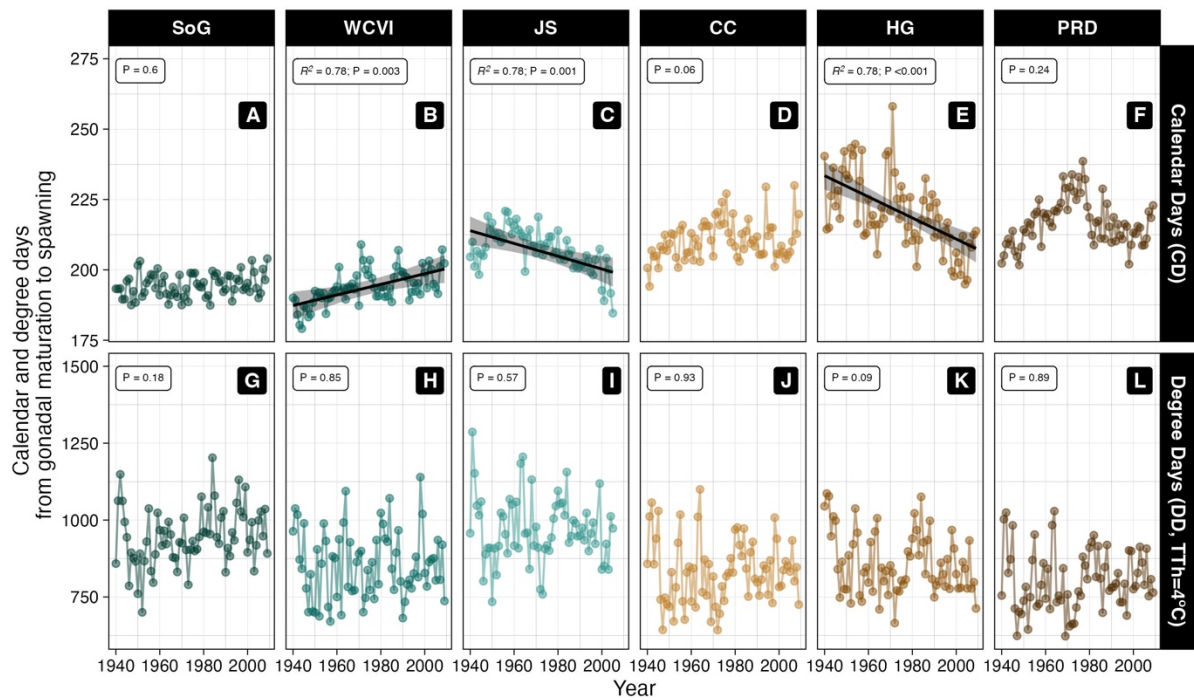


Figure S12 – Temporal variation in spawning for $T_{Th} = 4^{\circ}\text{C}$. A comparison of yearly time to mean spawning as calendar days (CD, A-F), and degree-days (DD, G-L), using September 1 as the gonadal maturation start-date, for each of the six spawning locations. Dashed lines show significant linear trends in CD and DD to spawning with year; grey areas show the 95% confidence interval around the prediction. The acronyms and colours for the spawning regions can be found in the caption of Fig. 1.

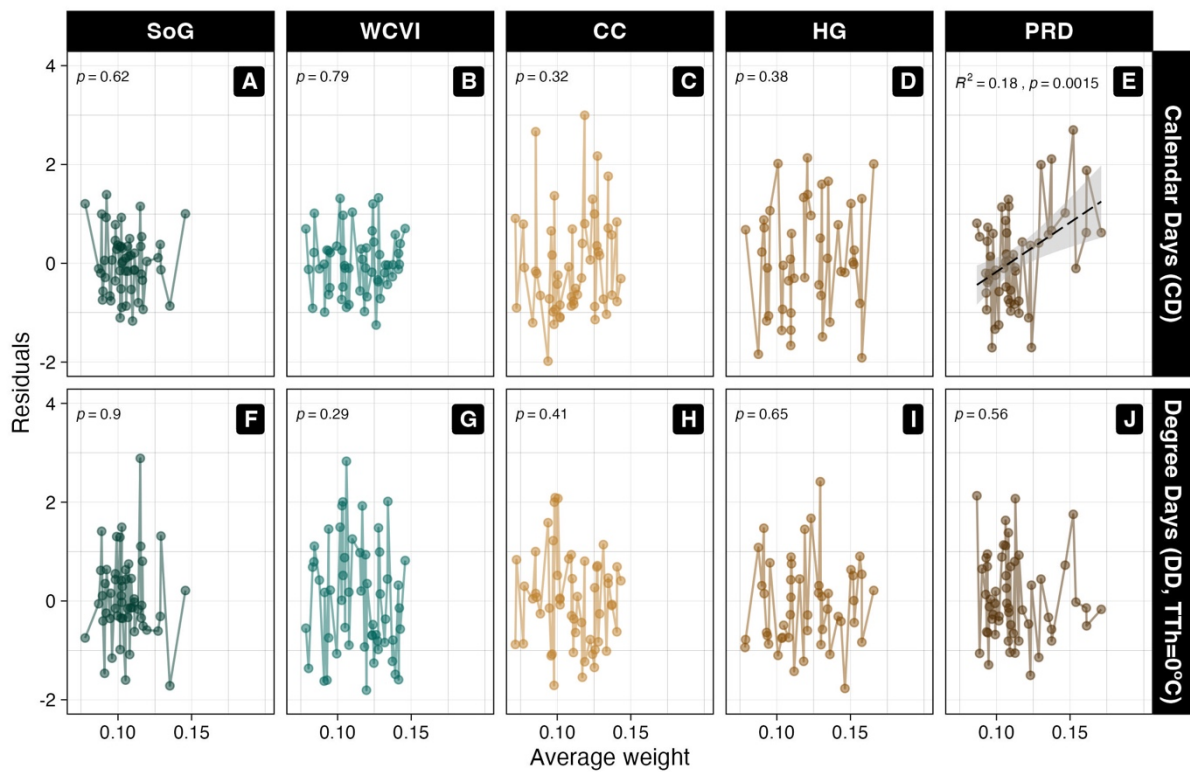


Figure S13 – Temporal variation in the normalised residuals from the linear model in explaining the spawning time calendar days (CD, A-F), and degree-days (DD, G-L), through year and region (Eq. 3) against average weight of spawners. September 1 was used as the gonadal maturation start-date, for each of the six spawning locations. Dashed lines show significant and non-significant linear trends in CD and DD to spawning with year; grey areas show the 95% confidence interval around the prediction. The acronyms and colours for the spawning regions can be found in the caption of Fig. 1.

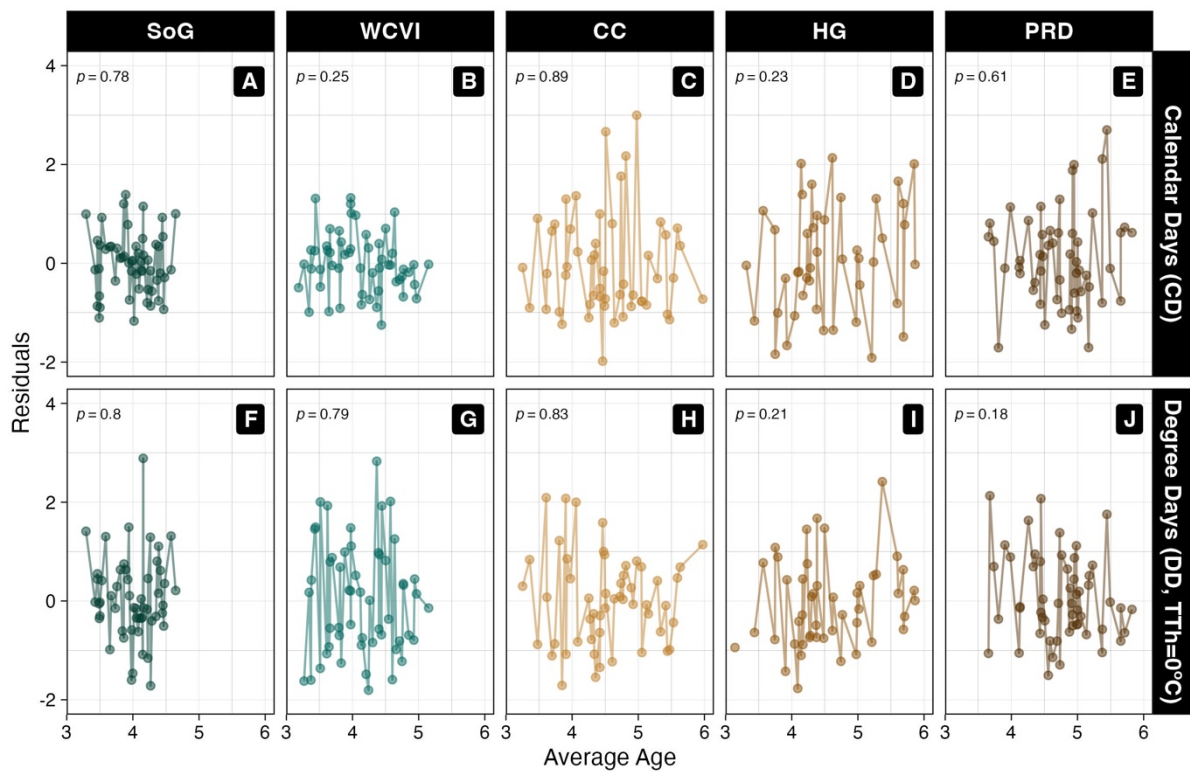


Figure S14 – Temporal variation in the normalised residuals from the linear model explaining the spawning time calendar days (CD, A-F), and degree-days (DD, G-L), through year and region (Eq. 3) against average age of spawners. September 1 was used as the gonadal maturation start-date, for each of the six spawning locations. Dashed lines show significant and non-significant linear trends in CD and DD to spawning with year; grey areas show the 95% confidence interval around the prediction. The acronyms and colours for the spawning regions can be found in the caption of Fig. 1.

References

- Hartig F (2022) DHARMA: Residual Diagnostics for Hierarchical (Multi-Level / Mixed) Regression Models. Book R package version 0.4.6. R Foundation for Statistical Computing