Supplementary material

We compared the growth trajectories of herring from this experiment with those from an earlier experiment conducted by Berg et al. (2018). For both experiments, the parental fish were collected from the same spawning ground (60°34′11.2″N, 5°0′18.9″E), northwest of Bergen, Norway. For this comparison, we only used fish from this study that followed the natural light regime at 10°C, with fish from the earlier experiment genetically identified as purebreds reared at 35 psu (Berg et al. 2018). A major difference between the two experimental protocols was that the final tank size used in the earlier experiment was 3-m diameter, and thus twice the volume of the terminal tank size in the current experiment. Herring reached a larger maximum length in the larger tank (Figure S6). Thus, the reduced growth in smaller tanks at advanced herring ages (Blaxter 1968) means that growth trends observed after age 1 should thus be interpreted with caution.

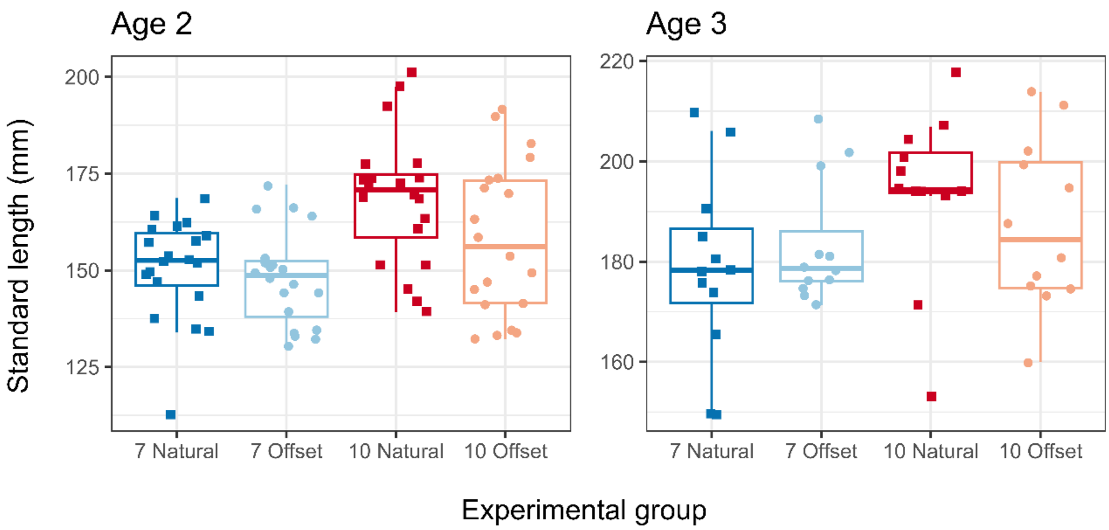

Figure S1. Standard length of individual age-2 and age-3 herring reared under different light and temperature regimes. Horizontal lines represent medians, boxes represent the interquartile range, and whiskers represent the lowest and highest observations within 1.5× the interquartile range. Individual points indicate raw data.

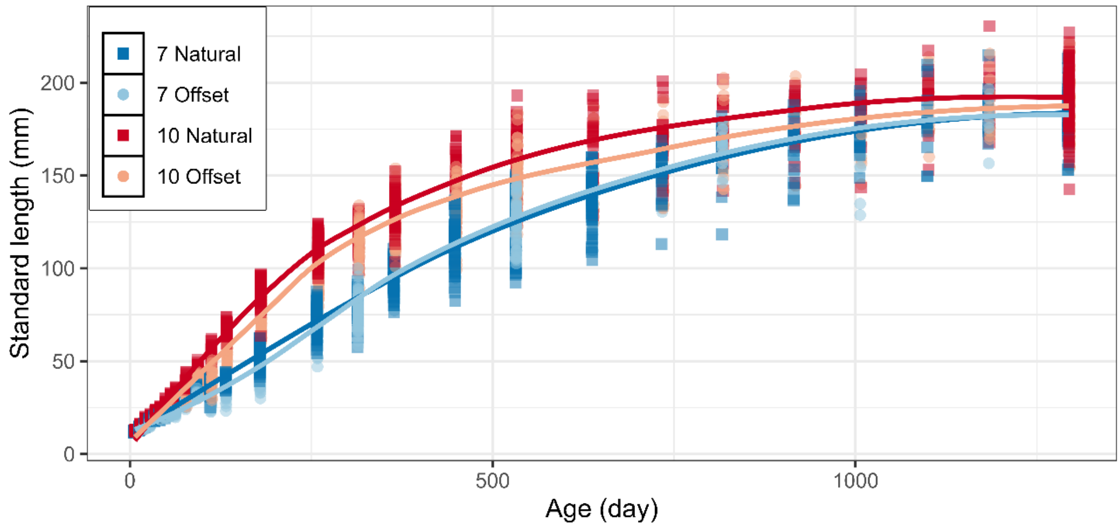

Figure S2. Growth development of herring for the 3.5 yr of the experiment displayed as changes in standard length at age reared under different light and temperature regimes. Locally weighted smoothing (loess) lines are shown.

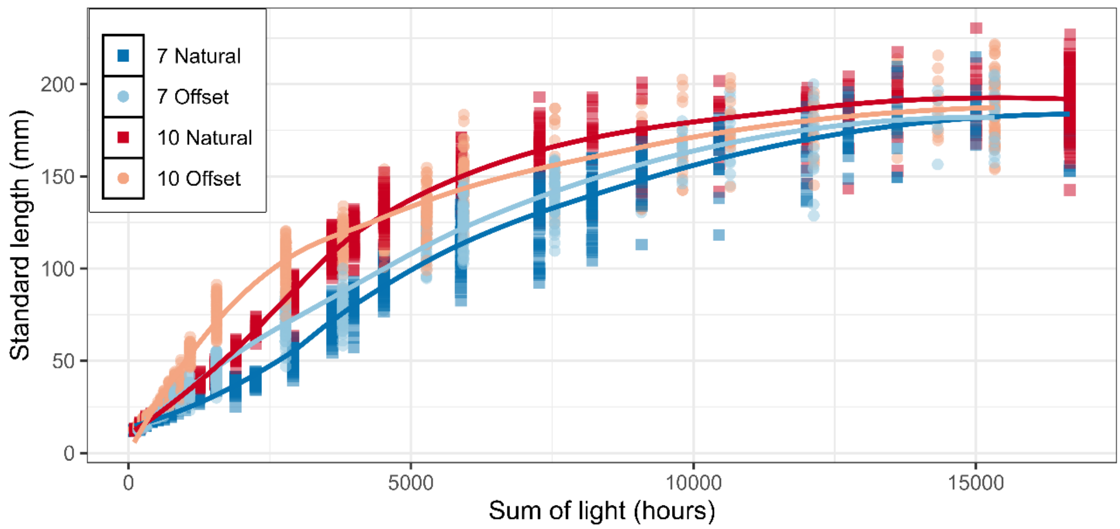

Figure S3. Growth development of herring for the 3.5 yr of the experiment displayed as changes in standard length at the experienced cumulative daylengths (sum of daylength) reared under different light and temperature regimes. Locally weighted smoothing (loess) lines are shown.

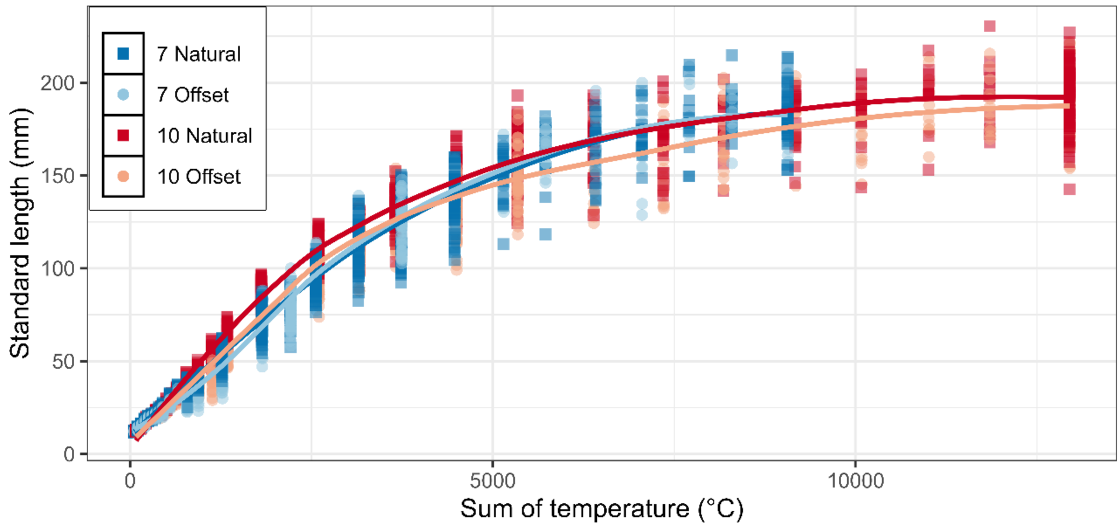

Figure S4. Growth development of herring for the 3.5 yr of the experiment displayed as changes in standard length at sum of temperature (degree-days) reared under different light and temperature regimes. Locally weighted smoothing (loess) lines are shown.

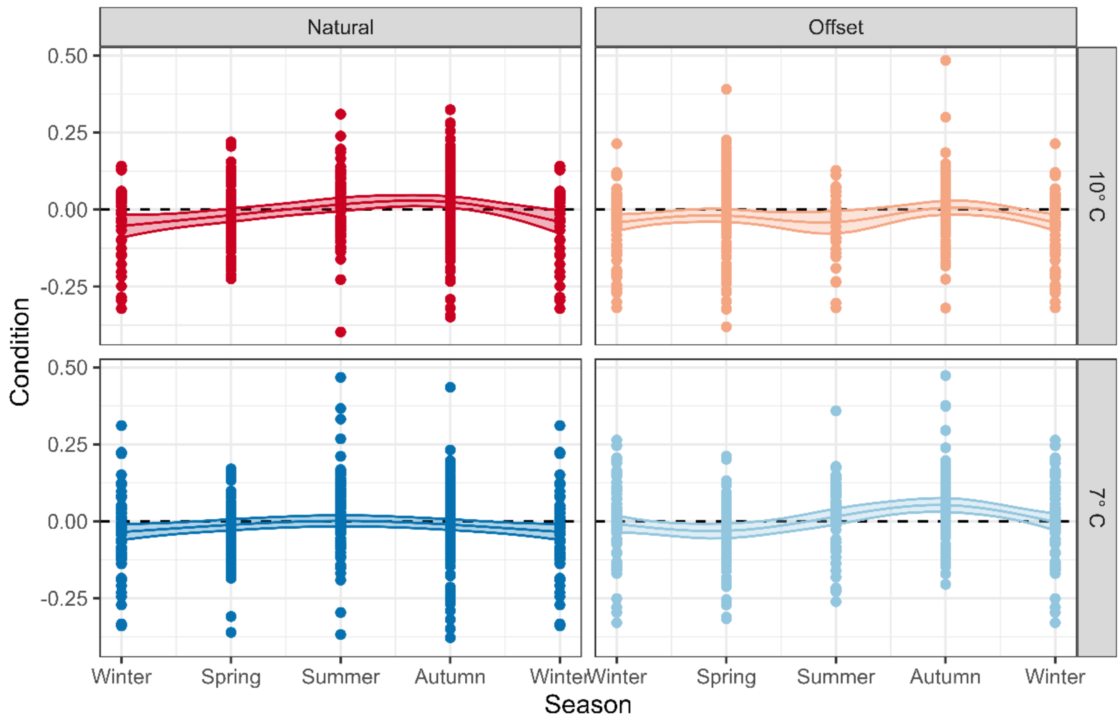

Figure S5. Residuals of the linear length-weight model are used as proxy for the somatic condition of individual herring (>55 mm) reared under varying light regimes (natural vs. offset) and temperature (7 vs. 10 °C). GAM prediction lines (Table S7) and their 95% confidence intervals are shown to indicate the seasonal variation of the condition among herring from the four experimental groups. Note that the season refers to the starting point of the season, i.e., summer/winter refer to the time of the solstices, whereas spring/autumn refers to the time of the equinox.

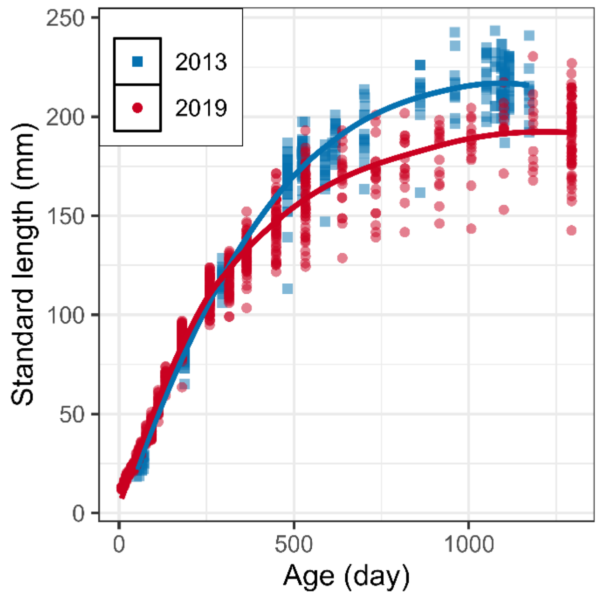

Figure S6. Comparison of standard length at age for herring of the experimental group following the natural light at 10 °C water temperature (red) against herring reared at 9 °C over three years (2013-2016, (Berg et al. 2018, Tonheim et al. 2020)) in round tanks with 3m diameter under common garden conditions (blue). Locally weighted smoothing (loess) lines are shown.

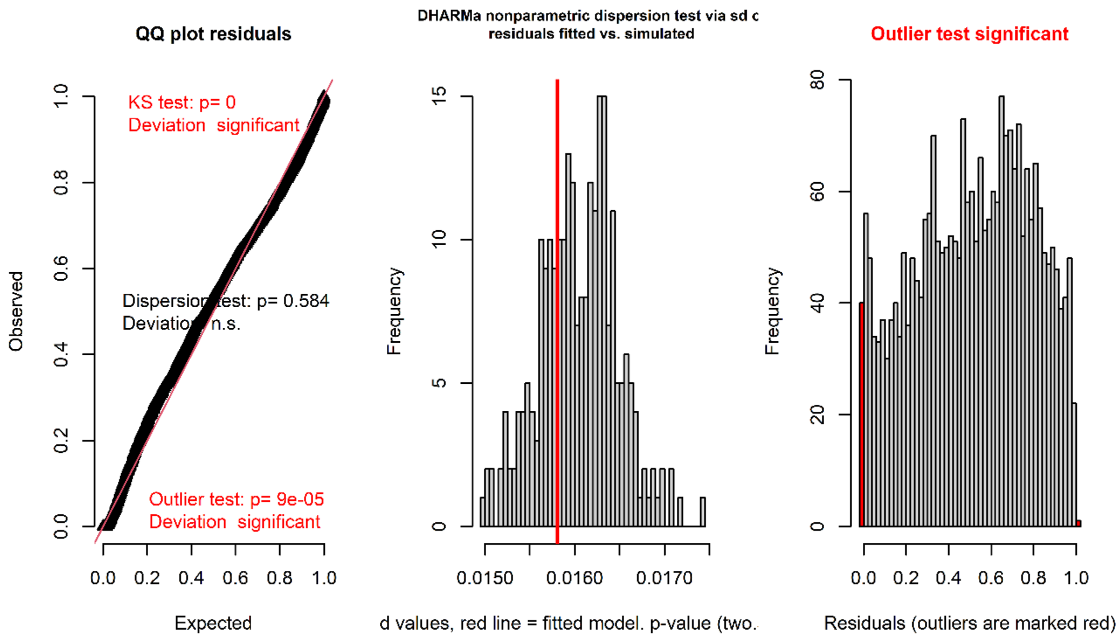

Figure S7. Model diagnostic plots for the generalized additive model to explain the standard length as a function of temperature and light using a smoother for age.

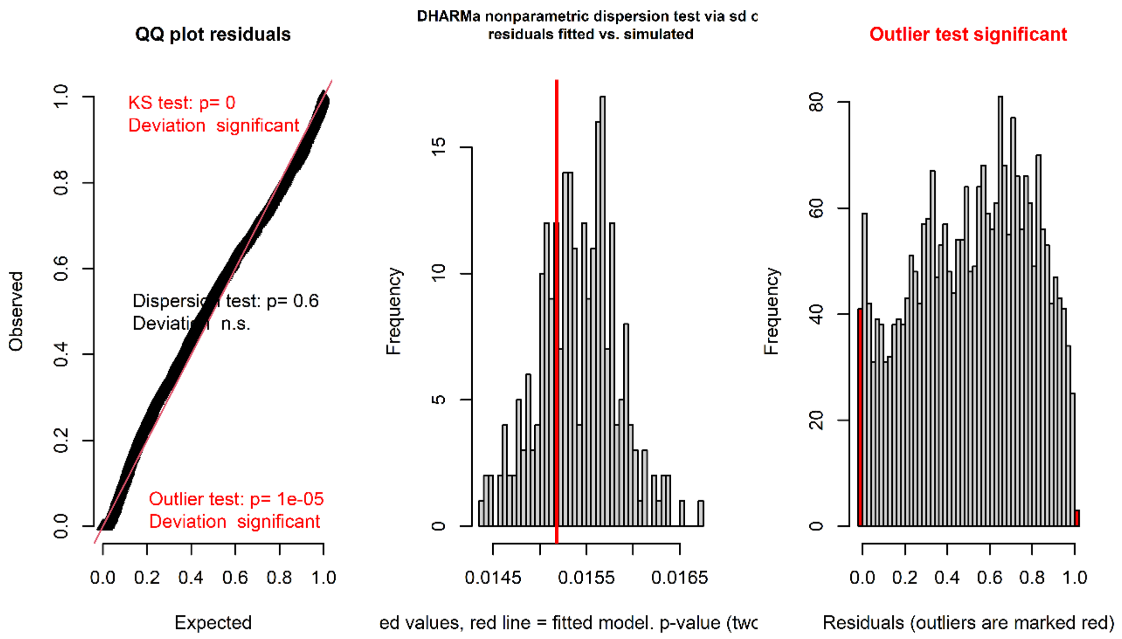

Figure S8. Model diagnostic plots for the generalized additive model to explain the standard length as a function of temperature and light using a smoother for the cumulative sum of experienced daylength.

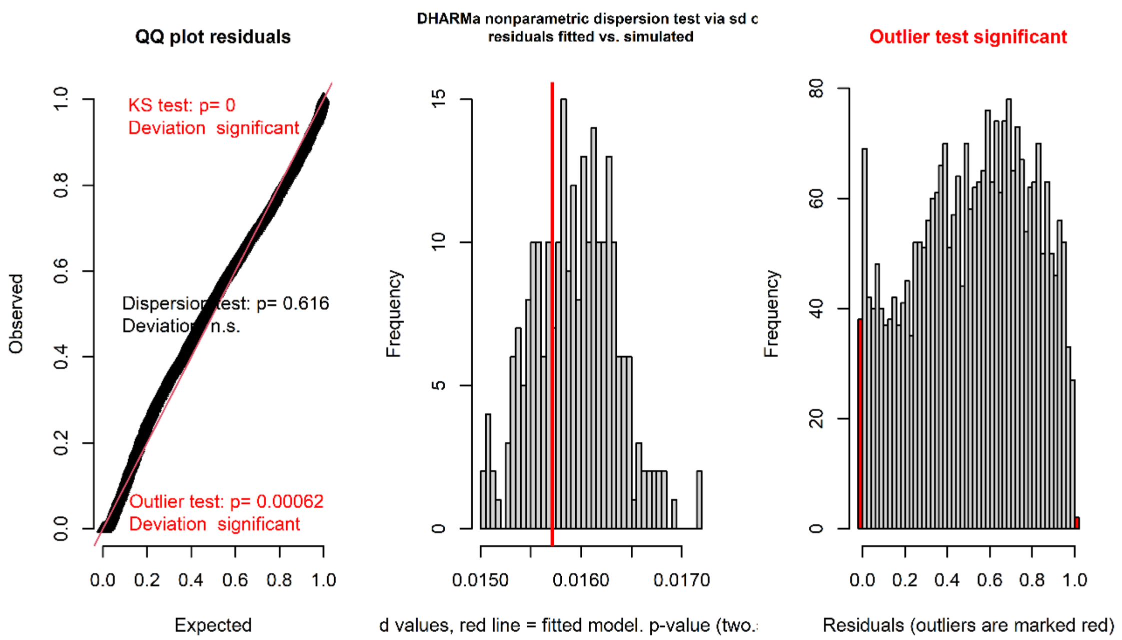

Figure S9. Model diagnostic plots for the generalized additive model to explain the standard length as a function of temperature and light using a smoother for the cumulative sum of experienced degree-days.

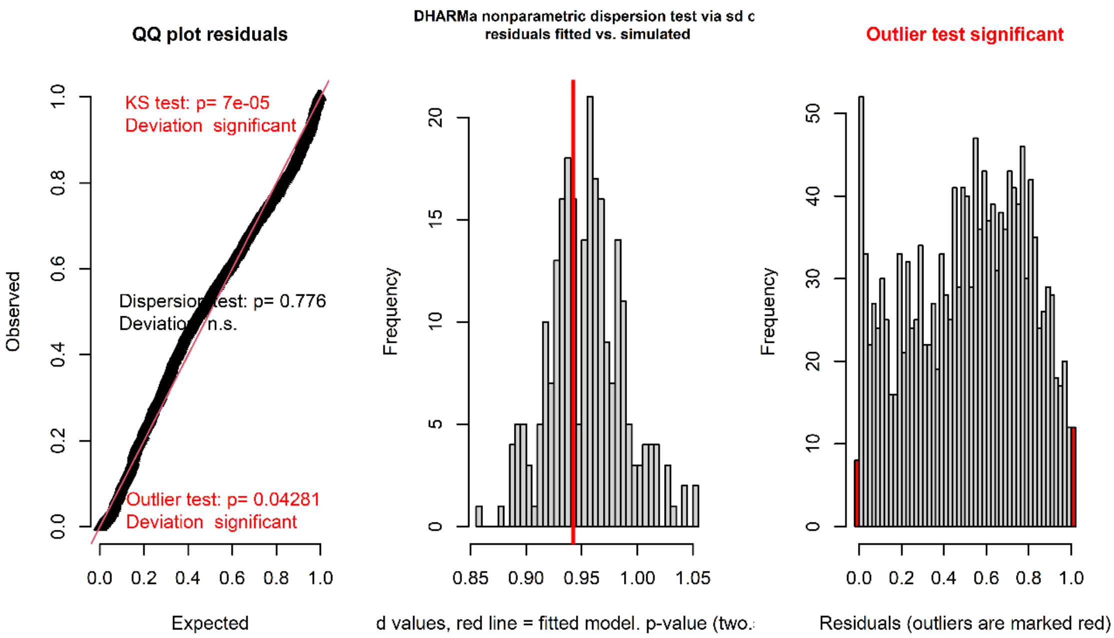

Figure S10. Model diagnostic plots for the generalized additive model to explain the seasonal effect on the somatic condition as a function of temperature and light using a smoother for the season.

Table S1. Estimated parameters of the two-way ANOVA investigated the size of herring at age 1 as function of temperature and light. The estimate value, standard error (Std.Error), degree of freedom (DF), t- and p-value are given. Adjusted R-squared = 0.743.

	Value	Std,Error	DF	t-value	p-value
(Intercept)	131.087	1.323	245	106.407	<0.001
LightOffset	-2.575	1.673	1	-1.539	0.125
Temperature7	-35.774	1.750	1	-20.447	<0.001
LightOffset:Temperature7	6.628	2.426	1	2.732	0.007

Table S2. Estimated parameters of the linear mixed-effects model explaining the standard length as function of age, temperature, and light. The estimate value, standard error (Std.Error), degree of freedom (DF), t- and p-value are given.

	Value	Std,Error	DF	t-value	p-value
(Intercept)	10.139	0.251	1021	40.413	<0.001
Day	0.352	0.003	1021	101.100	<0.001
LightOffset	0.930	0.356	6	2.615	0.040
Temperature7	-0.366	0.372	6	-0.986	0.362
Day:LightOffset	-0.066	0.005	1021	-13.048	<0.001
Day:Temperature7	-0.089	0.006	1021	-14.430	<0.001
LightOffset:Temperature7	-0.321	0.528	6	-0.607	0.566
Day:LightOffset:Temperature7	0.019	0.009	1021	2.082	0.038

Table S3. Estimated parameters of the generalized additive model explaining the standard length as function of age, temperature, and light. An interaction between the age smoother and the temperature and light regime was included. The estimate value, standard error (Std.Error), t- and p-value are given as well as the effective degrees of freedom (edf) for the age smoother. Adjusted R-squared = 0.984.

	Value	Std,Error	t-value	p-value	edf
(Intercept)	4.041	0.003	182.357	<0.001	
LightOffset	-0.098	0.005	-20.246	<0.001	
Temperature7	-0.322	0.005	-66.142	<0.001	
LightOffset:Temperature7	0.017	0.007	2.516	<0.001	
S(age)10_nat				<0.001	8.723
S(age)10_off				<0.001	8.423
S(age)7_nat				<0.001	7.745
S(age)7_off				<0.001	8.109

Table S4. Estimated parameters of the generalized additive model explaining the standard length as function of sum of daylength, temperature, and light. An interaction between the sum of daylength smoother and the temperature and light regime was included. The estimate value, standard error (Std.Error), t- and p-value are given as well as the effective degrees of freedom (edf) for the sum of daylength smoother. Adjusted R-squared = 0.985.

	Value	Std,Error	t-value	p-value	edf
(Intercept)	3.888	0.003	1123.784	<0.001	
LightOffset	0.207	0.005	42.271	<0.001	
Temperature7	-0.296	0.005	-59.816	<0.001	
LightOffset:Temperature7	-0.030	0.007	-4.305	<0.001	
S(daylength)10_nat				<0.001	7.723
S(daylength)10_off				<0.001	8.829
S(daylength)7_nat				<0.001	7.015
S(daylength)7_off				<0.001	8.900

Table S5. Estimated parameters of the generalized additive model explaining the standard length as function of sum of temperature, temperature, and light. An interaction between the sum of temperature smoother and the temperature and light regime was included. The estimate value, standard error (Std.Error), t- and p-value are given as well as the effective degrees of freedom (edf) for the sum of temperature smoother. Adjusted R-squared = 0.984.

	Value	Std,Error	t-value	p-value	edf
(Intercept)	3.982	0.003	1156.457	<0.001	
LightOffset	-0.094	0.005	-19.023	<0.001	
Temperature7	-0.075	0.005	-15.758	<0.001	
LightOffset:Temperature7	0.025	0.007	3.748	<0.001	
S(temperature)10_nat				<0.001	8.617
S(temperature)10_off				<0.001	8.400
S (temperature)7_nat				<0.001	8.557
S(temperature)7_off				<0.001	8.966

Table S6. Estimated parameters of the length-weight relationship for herring reared under different light and temperature regimes. Values provided are based in the log-transformed data. The intercept between the different light regime at corresponding temperatures did not differ significantly. The slope did not differ significantly between light and temperature regimes.

Light	Temperature	Intercept	Slope
Natural	7	-13.211	3.282
Natural	10	-13.247	3.282
Offset	7	-13.204	3.282
Offset	10	-13.240	3.282

Table S7. Estimated parameters of the generalized additive model explaining the standard length as function of somatic condition, temperature, and light. An interaction between the condition smoother and the temperature and light regime was included. The estimate value, standard error (Std.Error), t- and p-value are given as well as the effective degrees of freedom (edf) for the condition smoother. Adjusted R-squared = 0.047.

	Value	Std,Error	t-value	p-value	edf
(Intercept)	-0.010	0.007	-1.461	0.144	
LightOffset	-0.013	0.009	-1.476	0.142	
Temperature7	-0.007	0.009	-0.778	0.437	
LightOffset:Temperature7	0.037	0.012	3.014	0.003	
S(condition)10_nat				<0.001	3.058
S(condition)10_off				0.002	3.778
S(condition)7_nat				0.068	2.215
S(condition)7_off				<0.001	3.395

Table S8. Estimated parameters of the ANOVA explaining the daily mortality as function of two periods (start – 1st reallocation and 1st reallocation – 2nd reallocation), temperature, and light. The estimate value, standard error (Std.Error), degree of freedom (DF), t- and p-value are given. The model had a residual standard error = 0.057 on 10 degrees of freedom and an adjusted R-squared = 0.878.

	Value	Std,Error	DF	t-value	p-value
(Intercept)	0,319	0,035	1	9,200	<0.001
Period	-0,116	0,049	1	-2,372	0.039
LightOffset	0,253	0,040	1	6,311	<0.001
Temperature10	-0,213	0,040	1	-5,311	<0.001
Day:LightOffset	-0,273	0,057	1	-4,816	<0.001
Period:LightOffset	0,143	0,057	1	2,519	0.001
Period:Temperature10	0,319	0,035	1	9,2	0.030