The following supplement accompanies the article

Functional relationship between harp seal body condition and available prey in the Barents Sea

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Supplement. Exploration of possible confounding effect of the "date" and "year" variable.

Due to limited temporal overlap between sampled blubber thickness between years, there is a possibility that the date and the year variable are confounded, with the implication that the reduced blubber thickness observed in 2006 and 2011 is a sampling artifact. Two simulation examples have been created to explore this.

Example 1:
We simulated data from a model with a seasonal effect and a year effect. We could have constructed any function for this, but a natural choice was to simulate from our original fitted GAM. We constructed a data set from the following fitted model, using the original data:

Blubber thickness = intercept + s(length):sex + s(date) + s(year).

The estimated responses for this model are presented in Fig. S1.

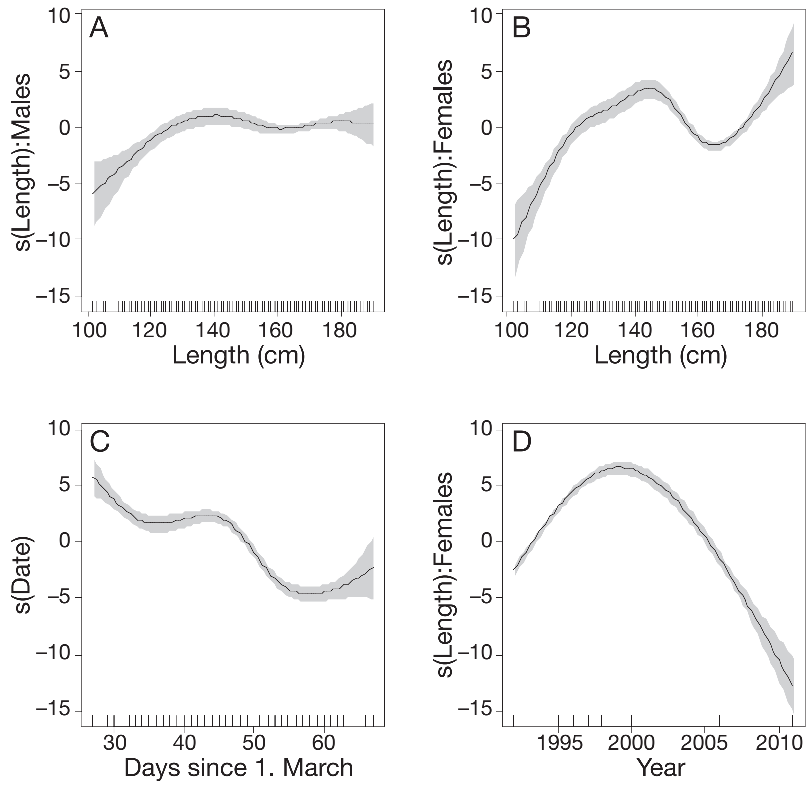

Fig. S1. Estimated smooth (s) showing the relationship between dorsal blubber thickness of age 1+ yr harp seals taken in the southeastern Barents Sea and (A) male length, (B) female length, (C) date (days elapsed since 1 March), and (D) sampling year using the original data set. Shaded areas show the 95% confidence intervals.

Our simulated example contained the covariates date and year only. The length effect was fixed. The estimated responses shown Fig. S1C,D were used as functions for the simulation. For each year we generated synthetic blubber thickness data for the whole seasonal range, i.e., from 1 March to early May. This seasonal range was selected to correspond with the seasonal range of the real data set. For each date a number of samples were created. Generating more samples for each date would naturally improve the model fit. We chose to simulate only 5 samples for each date, as this would make it more challenging for the model-fitting. The data generation was carried out by simulating from a normal distribution. The mean and standard deviation was the predicted mean and predicted standard deviation of the original GAM model. Fitting a GAM to the full synthetic model reproduces, not surprisingly, Fig. S1C,D. The estimated response from the synthetic data is shown in Fig. S2.

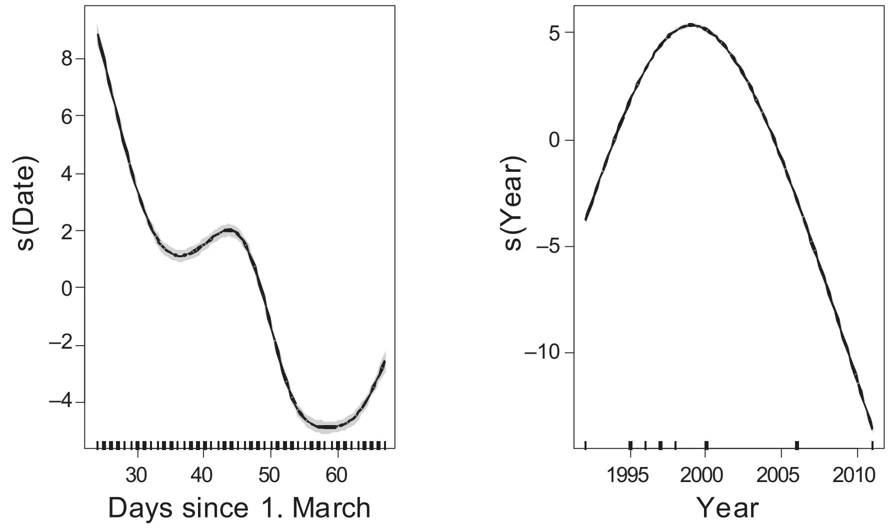

Fig. S2. Estimated smooth functions (s) showing relationship between date and year and the simulated blubber thickness using the data set with full temporal resolution. Shaded areas show the 95% confidence intervals.

Next we removed samples from the data set with full temporal resolution to match our real data. That is, for 1992 we removed the simulated data for all dates except the dates for which we have data in our real data set. The same was done for all the other years, so the temporal resolution of the simulated data and the real data were identical. If a serious confounding effect between date and year were present, we should not be able to reproduce the response shown in Fig. S1C,D. The estimated response of the new subset is shown in Fig. S3 and we see that the model is capable of reproducing the date and year effect very well, even when the data set is heavily subsampled with reduced temporal resolution.

Thus, we believe that this demonstrates that the GAM is capable of discerning between year and date effects despite a marked reduction in sample size, indicating that the reduced blubber thickness observed in 2006 and 2011 is not a sampling artifact.

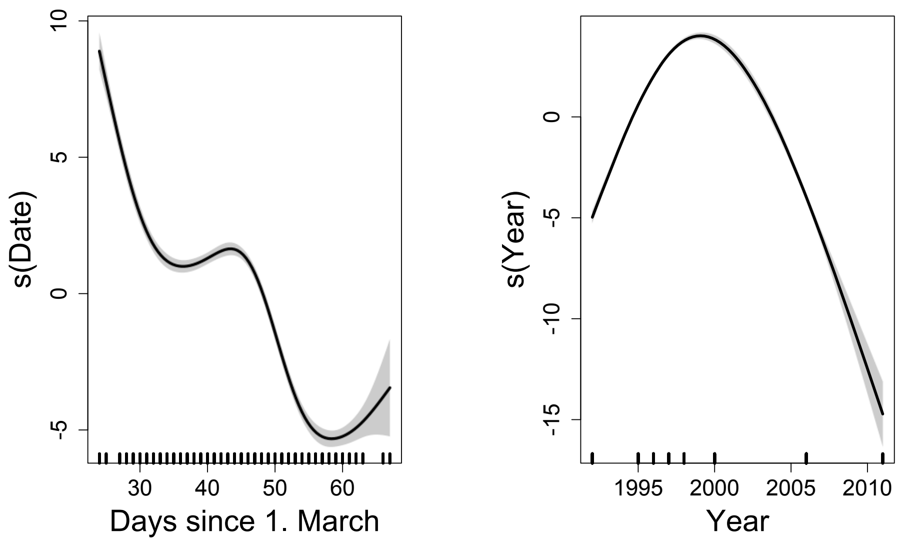

Fig. S3. Estimated smooth functions (s) showing relationship betwen date and year and the simulated blubber thickness using the data set with reduced temporal resolution. Shaded areas show the 95% confidence intervals.

Example 2:
We also explored the variation of the estimated smoothed responses by bootstrap evaluation. The number of rows in the original data matrix was N. N individuals were sampled with replacement from the original data matrix. The model was fitted using the bootstrap sample. This was repeated 300 times and for each time we obtained an estimated date and year response. If the variables were seriously confounded, the estimated responses using the bootstrap sample would show a high degree of variability. Fig. S4 shows the mean effect of the date and year covariates obtained from the 300 bootstrap realizations of the original data. The variability of the estimated responses was very small and, for the year effect, the response was significantly lower in 2011 than in 2000. The confidence limits were larger around 2011, but even when the large confidence intervals were considered, the year effect was evident.

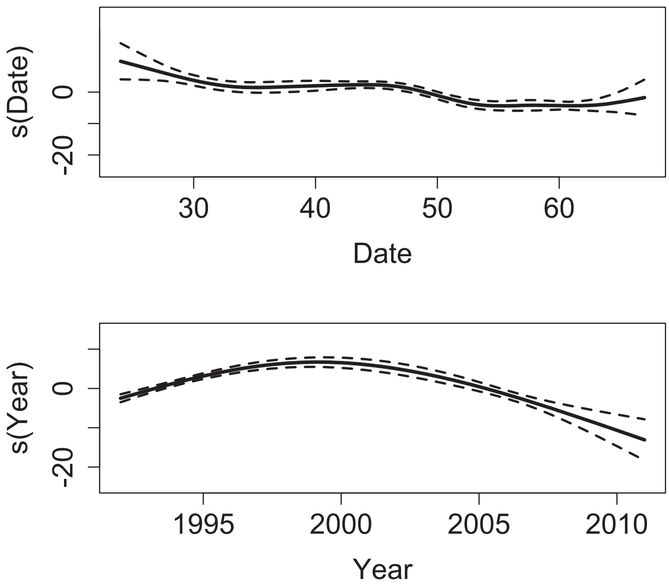

Fig. S4. Estimated smooth functions (s) of date and year (with 95% confidence interval) using 300 bootstrap realizations of the original data. N individuals were resampled from the original data matrix.

As a counter example when the confounding effect might be significant, we performed a similar bootstrap procedure, but only 50 rows of the data matrix was sampled with replacement. The model was fitted to the small bootstrap sample and 300 replicates of the estimated date and year response were obtained. The size of the sparse bootstrap data set was about 20 times smaller than the original data. In this scenario we would expect the confounding effect to be significant, since the temporal resolution is sparse, due to the low number of samples. Fig. S5 shows the mean response of the date and year covariates obtained from the 300 bootstrap realizations of the original data using the small bootstrap sample. The variability of the estimated responses was much larger in this example and the year effect was not significantly different in 2011 compared to any of the other years.

We believe that this also demonstrates that the sample size was large enough to detect significant inter-annual differences and that the reduced blubber thickness observed in 2006 and 2011 is not a sampling artifact.

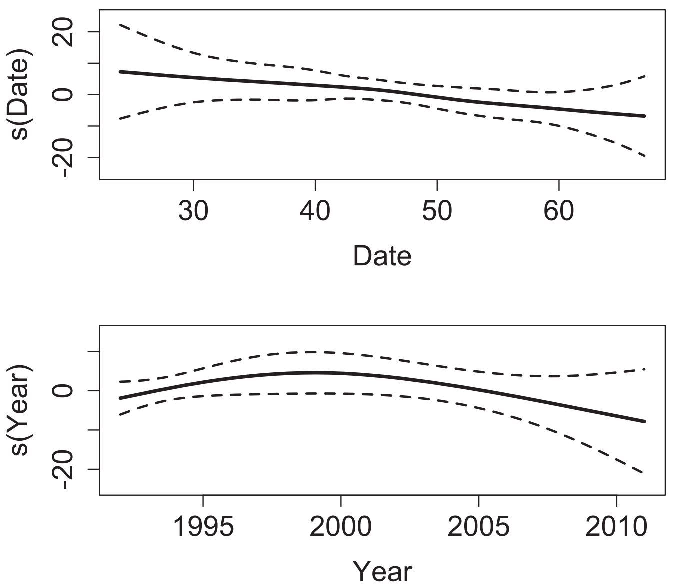

Fig. S5. Estimated smooth functions (s) of date and year (with 95% confidence intervals), using 300 bootstrap realizations of the original data. The number of individuals resampled from the original data matrix was 50.