The following supplement accompanies the article

Temporal changes in plankton of the North Sea: community shifts and environmental drivers

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Supplement. 1. Environmental variables
All the variables included in the analyses are presented in Table S1. The source of the dataset and the time-span and area they cover are also mentioned

Table S1. Summary of environmental variables used in this work

Variable	**Start**	**End**	**Area**	**Sub-Area**	**Source**
Net Transport	1970	2008	North Sea	Central North Sea	IMR
Northward Transport	1970	2008	North Sea	Central North Sea	IMR
Salinity	1970	2008	North Sea	Central North Sea	ICES
Sea Surface Temperature	1970	2008	North Sea	Central North Sea	ICES
Southward Transport	1970	2008	North Sea	Central North Sea	IMR
Total Nitrogen	1988	2008	North Sea	Central North Sea	ICES
Total Phosphorus	1988	2008	North Sea	Central North Sea	ICES
Total Silica	1988	2008	North Sea	Central North Sea	ICES
Ammonium	1988	2008	North Sea	Central North Sea	ICES
Cloud Cover	1970	2008	Dutch Coast	De Kooy	KNMI
Humidity	1970	2008	Dutch Coast	De Kooy	KNMI
Precipitation	1970	2008	Dutch Coast	De Kooy	KNMI
Sea Level Pressure	1970	2008	Dutch Coast	De Kooy	KNMI
Solar Radiation	1970	2008	Dutch Coast	De Kooy	KNMI
Temperature	1970	2008	Dutch Coast	De Kooy	KNMI
Wind Speed	1970	2008	Dutch Coast	De Kooy	KNMI
Wind.Direction	1970	2008	Dutch Coast	De Kooy	KNMI
Den Helder Sea Level	1970	2008	Dutch Coast	Den Helder	KNMI
Solar.Irradiance	1970	2008	North Sea	Global	KNMI
Sunspots	1970	2008	North Sea	Global	ROB
Hurrel North Atlantic Oscillation winter index	1970	2008	Global	Global	CGD
Northern Hemisphere Temperature anomaly	1970	2008	Global	Global	HCCR
Net Transport	1970	2008	North Sea	Southern North Sea	IMR
Northward Transport	1970	2008	North Sea	Southern North Sea	IMR
Salinity	1970	2008	North Sea	Southern North Sea	ICES
Sea Surface Temperature	1970	2008	North Sea	Southern North Sea	ICES
Southward Transport	1970	2008	North Sea	Southern North Sea	IMR
Total Nitrogen	1988	2008	North Sea	Southern North Sea	ICES
Total Phosphorus	1988	2008	North Sea	Southern North Sea	ICES
Total Silica	1988	2008	North Sea	Southern North Sea	ICES
Ammonium	1988	2008	North Sea	Southern North Sea	ICES

Sources:
IMR – Norway's Institute Of Marine Research http://www.imr.no/en
ICES – International Council For The Exploration Of The Sea. http://www.ices.dk/indexfla.asp; http://www.ices.dk/datacentre/guidelines.asp
KNMI – Roya Netherlands Meteorological Institute. http://www.knmi.nl/index_en.html
ROB – Royal Observatory Of Belgium. http://www.observatory.be/
HCCR – Hadley Center For Climate And Research. http://www.metoffice.gov.uk/hadobs/
CGD – Climate Global Dynamics Division. http://www.cgd.ucar.edu/cas/jhurrell/indices.html

Supplement 2. Principal Component Analyses comparison

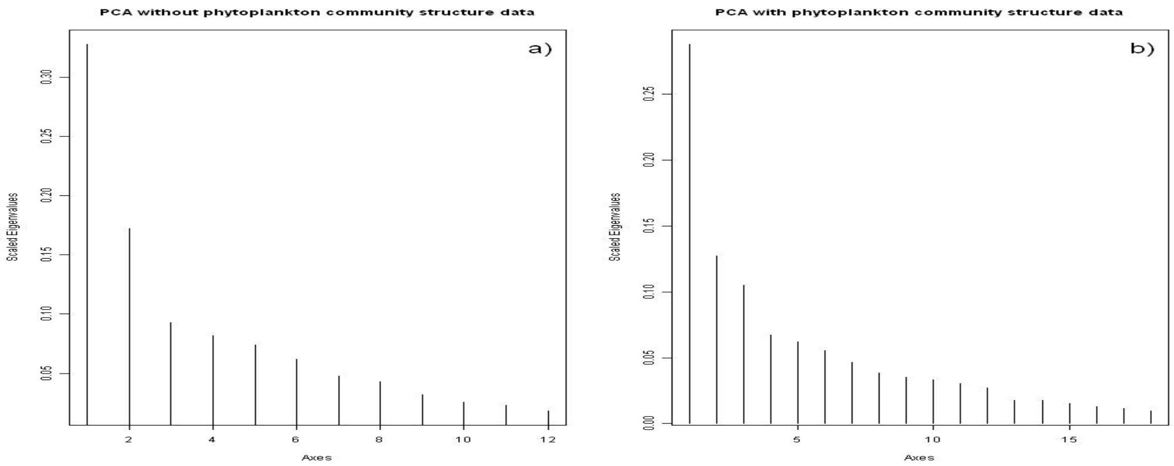

Fig. S1. Scree plots for the two PCAs, showing the scaled eigenvalues for the different axes in both PCAs. See PCA results in the main article

In this Supplement, PCA1 refers to the Principal Component Analysis that excludes phytoplankton composition data, and PCA2 to the PCA that includes these data:
The patterns represented by the first two PCs are very similar in both analyses, as shown by the position of each variable in a two-dimensional space (Fig. S2). The different variables are clustered around the ordination space, and each different set of variables are clustered by area, which means that the patterns of same variables are similar in the different areas. The only clear exception is the assemblages of cold-water copepods in the English Channel, which is clearly separated from the other two areas in both PCAs.

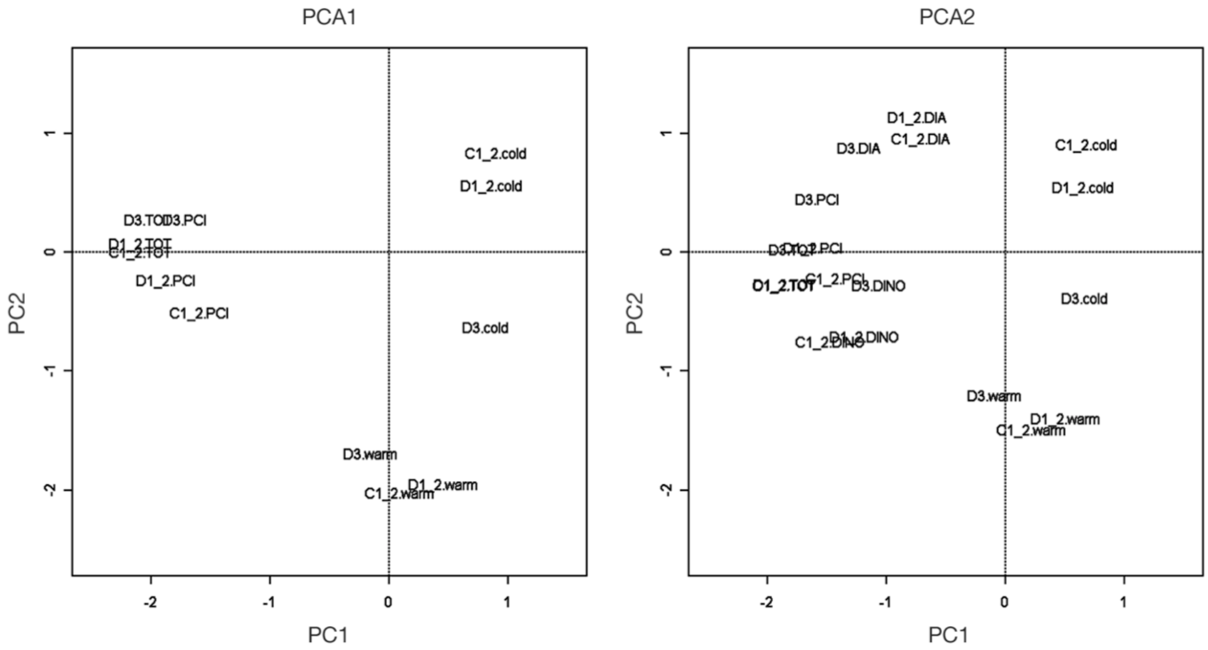

Fig. S2. PCA plots of both PCAs, PCA1 excludes dinoflagellate and diatom abundances while PCA2 includes them

At a loading value of 0.7, commonly considered to indicate an important variable for a PC, the second PC of PCA1 would be clearly related to copepod community structure in the Central North Sea (Table S2), and also in the English Channel, while PC1 would be related with everything else.

In PCA2 (Table S2), according to this criterion, the first PC represented the patterns of total abundance of phytoplankton (Phytoplankton Colour Index, PCI), zooplankton (total number of copepods), and phytoplankton community composition (diatoms and dinoflagellate abundances) in the three areas.

The second PC represented a trend of the community composition of both phyto- and zooplankton in the three areas; and the third PC represented a different trend that is highly related to community composition of both phyto- and zooplankton, and to phytoplankton abundance, particularly in areas C1_2 and D1_2.

Table S2. Loadings of different variables on both PCAs. Values in *italics* indicate less important variables. Important variable in **bold**

	PCA1		PCA2		
Scores	PC1	PC2	PC1	PC2	PC3
C1_2.warm	0.091	**-2.034**	0.217	**-1.500**	**1.011**
C1_2.cold	**0.896**	**0.830**	0.681	**0.900**	-0.209
D1_2.warm	**-1.962**	0.457	0.506	**-1.407**	**0.947**
D1_2.cold	**0.863**	0.559	0.652	0.545	-0.212
D3.warm	-0.153	**-1.691**	-0.086	**-1.203**	**0.796**
D3.cold	**0.812**	0.625	0.669	-0.380	0.226
C1_2.PCI	**1.593**	-0.516	**-1.858**	-0.281	-0.170
D1_2.PCI	**1.869**	-0.238	**-1.845**	-0.278	-0.304
D3.PCI	**1.713**	0.277	**-1.786**	0.025	-0.190
C1_2.TOT	**-2.088**	-0.008	**-1.424**	-0.227	**0.897**
D1_2.TOT	**2.083**	0.068	**-1.613**	0.030	**0.728**
D3.TOT	**-2.021**	0.277	**-1.574**	0.453	0.172
C1_2.DIA			**-0.708**	**0.950**	**1.360**
D1_2.DIA			**-0.738**	**1.134**	**1.210**

D3.DIA			**-1.220**	**0.883**	0.093
C1_2.DINO			**-1.468**	**-0.762**	**-0.727**
D1_2.DINO			**-1.182**	**-0.714**	**-0.921**
D3.DINO			**-1.059**	-0.275	**-0.775**

Supplement 3. Post-hoc seasonal decomposition

PC1 and PC2 were subjected to seasonal decomposition in order to verify the shift in seasonal patterns suggested by the analyses.

This was done by means of a Generalized Additive Model (GAM) using Month in a smoothing function and comparing it with an alternative GAM using different Month smoothers for each detected regime.

PC1: The model accounting for different regimes fitted better the original data as the adjusted R^2 was higher for this model.

Unique Month smoother – R^2adj = 0.791
One Month smoother per regime: R^2adj = 0.808

The AIC method however did not select this model as the best because of the penalization caused by using more degrees of freedom (three smoothers instead of one) increased the AIC value which became less negative.

Unique Month smoother: AIC = –217.69 df = 9
One Month smoother per regime: AIC = –190.05 df = 5

As we are not looking to predict data, but for a better fit to the seasonal patterns, in this case we used the R^2 value to select the best model.

The seasonal patterns as seen in the model fit (Fig. S3) coincided with the ones seen in the raw data, the period 1985-1990 having a stronger signal during the summer months and weaker in the winter months than in the previous period. The last period, post-1990, the seasonal oscillation is clearly smaller (Fig. S3).

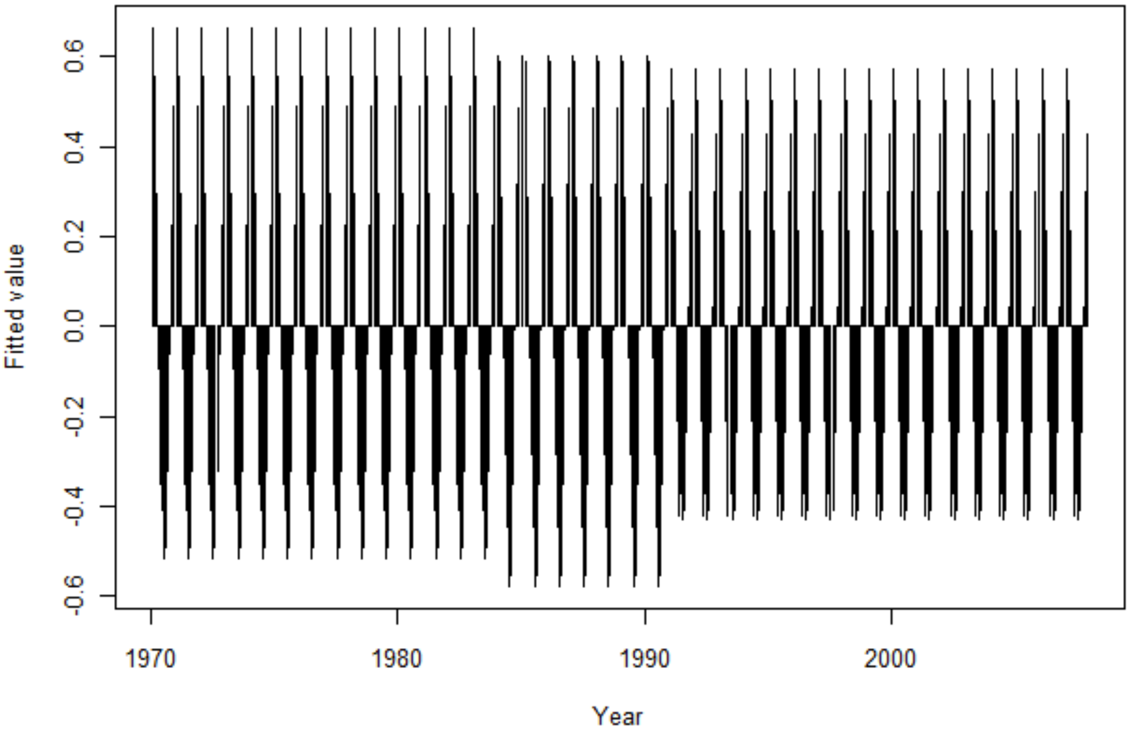

Fig. S3. Result of the model using different seasonal smoothers per regime to explain PC1. See text for explanation

PC2: The model accounting for different regimes did not fit the original data better.

Unique Month smoother: R^2adj = 0.576
One Month smoother per regime: R^2adj = 0.575

This indicates that the source of regime changes is contained in the long-term signal, not the seasonal pattern. If the seasonal pattern was the cause of the detected regimes a better fit would be shown by the seasonal smoother that considered regime changes. The adjusted R^2 is smaller for the model of the seasonal patterns of PC2. This may also indicate the importance of the long term signal in PC2, as opposed to PC1, in which most of the data variation is explained by the seasonal smoother.