Supplementary Materials for

**Temporal dynamics in zooplankton δ13C and δ15N isoscapes for the North Atlantic Ocean: Decadal cycles, seasonality and implications for predator ecology**

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7 Figures and 3 Tables

Chart, scatter chart

Description automatically generatedFigure S1. Daily climatology of chlorophyll *a* concentrations inferred from ocean colour measured by MODIS-AQUA satellite for the geographical points 60°N / 38°W (blue line) and 54°N / 20°W (red line), being located in the sub-polar and westerly biomes, respectively. Light grey boxes represent the season as defined in this study (minus 10 days for tissue turnover rates), during which the ecosystems are assumed to be relatively stable.

A picture containing scatter chart

Description automatically generated

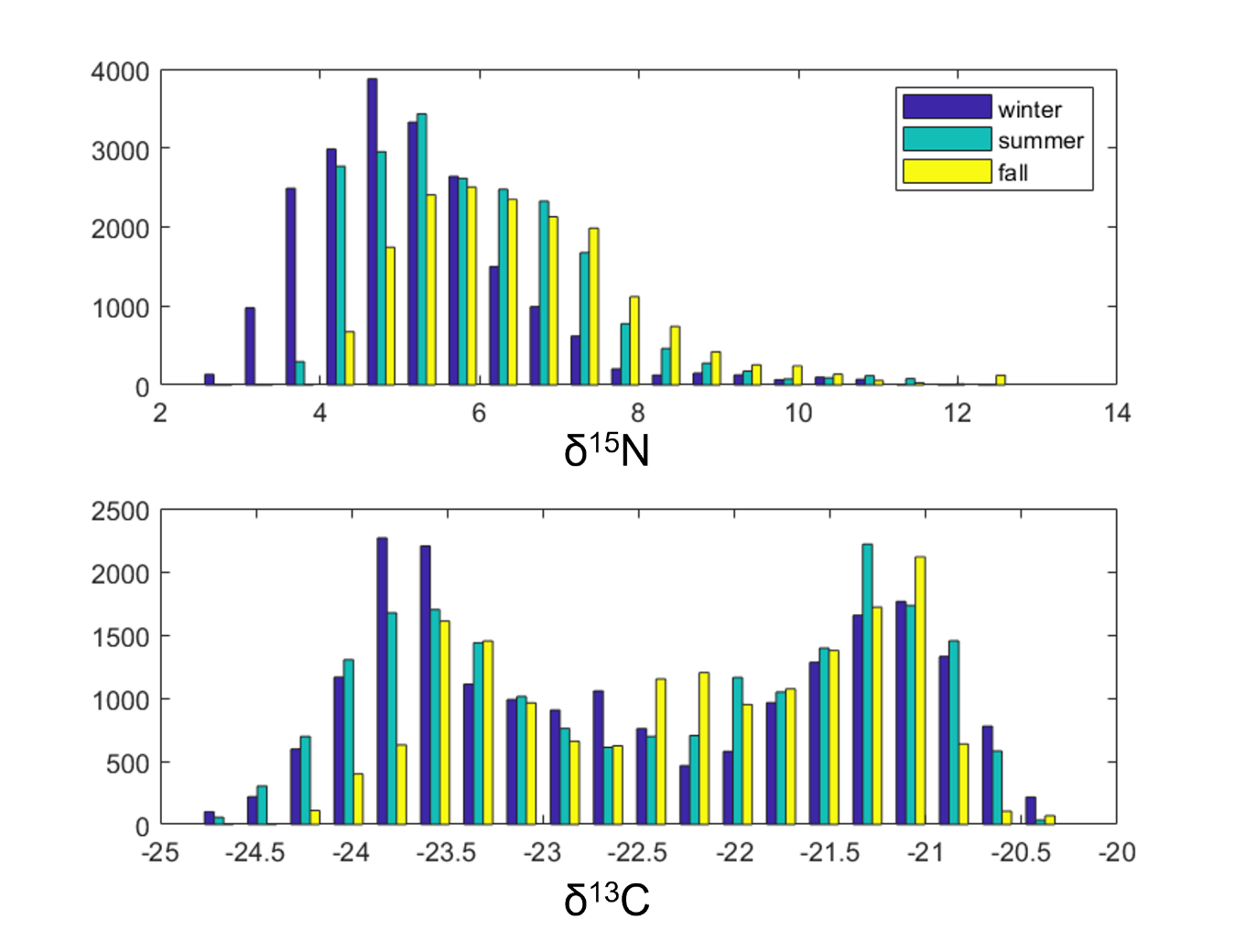
Figure S2. Delaunay triangulation mesh for the North Atlantic Ocean (> 40°N; *n*= 4306).

Chart, scatter chart

Description automatically generatedFigure S3. Scatter plots + linear regressions of seasonal observational stable isotope data vs modelled data (A) using season as a random effect and (B) doing prediction with the yearly models using seasonal predictors.

Chart, histogram

Description automatically generatedFigure S4. Histograms of δ15N and δ13C values measured in *Calanus* copepods.

Figure S5. Histograms of modelled δ15N and δ13C values for three seasons.

Chart

Description automatically generated

Figure S6. Boxplots of modelled δ15N and δ13C values for each cluster.

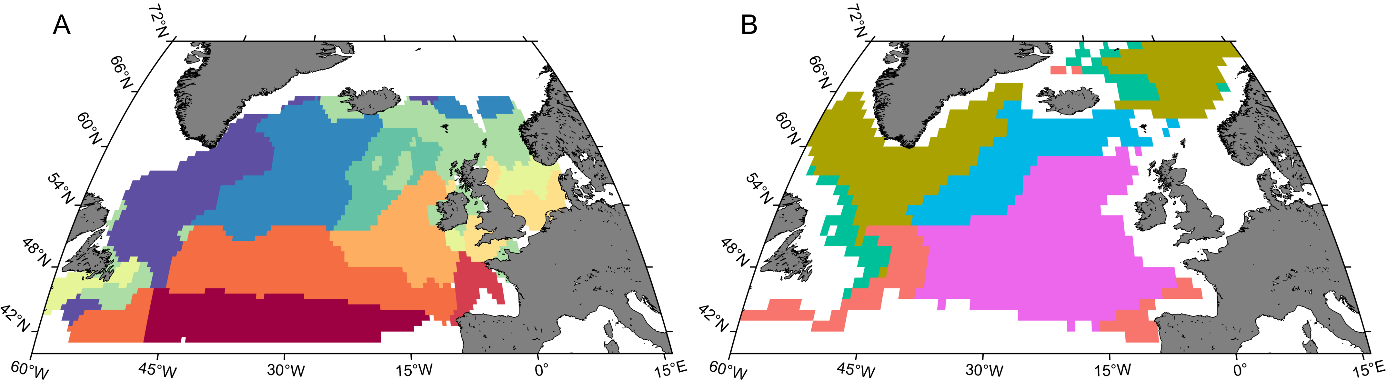


Figure S7. A) ecoregions defined in Beaugrand et al., 2019, based on zooplankton community composition and environmental variables and B) clusters defined in this study based on isotopic trajectory path.

Table S1. Description of the parameters used in the isoscape modelling.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Parameter** | **Value range** | **Spatial resolution** | **Transformation** | **Notation** | **Data source** |
| Sea surface temperature (°C) | 0.93 – 16.04 | 0.05° |  | SST | marine.copernicus.eu/ |
| Chla concentrations (mg m-3) | 0.2 – 3.05 | 25 km | Logged; capped at [0.2 ; -] | chla | globcolour.info/ |
| Net primary productivity (mgC m-2 d-1) | 9.48 – 1947.63 | 0.25° |  | NPP | http://sites.science.oregonstate.edu/ocean.productivity/ |
| Wind speed (m s-1) | 5.77 – 14.41 | 0.25° |  | Wind | marine.copernicus.eu/ |
| Mixed layer depth (m) | 10.61 – 150 | 0.083° | Logged; capped at [- ; 150] m | MLD | marine.copernicus.eu/ |
| Distance to 200 m isobath (km) | 50.01 – 700 | 2 km | Capped at [50 ; 700] km | dist | ETOPO1, NOAA |

Table S2. Description of some of the model formulas tested. The main idea behind the model selection process was to keep the models as simple as possible to be able to interpret the smoother shape and to do not overfit the observations data. In order to achieve that, only a few interaction terms were tried and the number of knots controlling the wiggliness of the smoother was kept low. All the models were described here were developed using the frequentist GAM package ‘mgcv’.

|  |  |  |  |
| --- | --- | --- | --- |
| Model formula | AIC | Deviance explained | Total edf |
| δ13C ~ s(sst) + ti(chla,wind) + s(dist) | 1582.8 | 44.9% | 17.82 |
| δ13C ~ s(sst) + ti(mld,wind) + s(dist) | 1588.4 | 42.9% | 22.09 |
| δ13C ~ s(sst) + ti(mld,chla) + s(dist) | 1582.5 | 43% | 20.41 |
| δ13C ~ ti(mld, chla, k=4) + s(sst, k=5) + s(dist, k=3) | 1552.9 | 43.8% | 16 |
| \*δ13C ~ s(chla, k=5) + s(sst, k=5) + s(dist, k=3) + wind | 1496.2 | 46.7% | 12 |
|  |  |  |  |
| δ15N ~ ti(chla,mld) + s(wind) + s(sst) + s(dist) | 1794.1 | 43.6% | 29.37 |
| δ15N ~ ti(chla,wind) + s(mld) + s(sst) + s(dist) | 1791.1 | 43.9% | 23.81 |
| δ15N ~ ti(chla, wind, k=4) + s(mld, k=5) + s(sst, k=5) + dist | 1697.9 | 48.9% | 19 |
| δ15N ~ s(chla, k=4) + s(mld, k=5) + s(sst, k=5) + s(wind, k=6) + dist | 1706.7 | 47.8% | 18 |
| \*δ15N ~ chla + s(mld, k=3) + s(sst, k=5) + s(wind, k=5) + dist | 1703.5 | 47.1% | 13 |

Table S3. Results of Watson's two-sample test of homogeneity performed on SI data between clusters.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Cluster #1 | Cluster #2 | Cluster #3 | Cluster #4 |
| Cluster #1 | - |  |  |  |
| Cluster #2 | 6.48\*\*\* | - |  |  |
| Cluster #3 | 4.27\*\*\* | 0.43\*\*\* | - |  |
| Cluster #4 | 9.75\*\*\* | 2.36\*\*\* | 0.89\*\*\* | - |
| Cluster #5 | 0.90\*\*\* | 9.23\*\*\* | 4.35\*\*\* | 13.08\*\*\* |