Long-term and interannual variability of zooplankton at a coastal station in the Western English Channel

Claudia Halsband-Lenk
Stefano Ciavatta
Claire Widdicombe
CHARM 3 - history

- CHannel integrated Approach to marine Resource Management
- phases 1 & 2: multidisciplinary approach to marine living resource management
- assessment of key marine species and their habitats in the *eastern* Channel
- develop management tools to predict human impacts
- Product: Channel Habitat Atlas (2009)
- Phase 3: western Channel & *plankton* added
CHARM 3 WP 2.1 plankton

- Inventory of characteristic plankton taxa
- Historical data sets (SAHFOS CPR survey, PML time series, Ifremer coastal network surveys)
- Phenologies
- Relationships with environment along longitudinal gradients
PML Plankton Time Series at L4

- Western Channel Observatory (UK monitoring)
- Weekly sampling (SST, optical, chemical, biological parameters)
- Microscopic analysis of all planktonic taxa (> 2μm)
  - Zooplankton: 1988-2010
  - Phytoplankton: 1992-2009
- Depth 55 m
- Vertical tow (WP-2, 200 μm mesh)
estuarine outflow vs oceanic waters
weakly stratified May to September
Time Series analysis

- raw data
- monthly averages & anomalies, seasonal cycles
- Phenologies and long-term changes
- Biodiversity patterns (→ comparisons with other sites)
- Benthic-pelagic interactions (meroplankton)

R-package developed by Damien Eloire
Temperature

Variable: Sea Surface Temperature
Location: L4 station (Western Channel - UK)
Period: 1988-2011
Number of samples: 1906

- Min: 7.3
- Max: 20.3
- Average: 12.85
- SD: 2.83
- Median: 12.9

Unit: °C
Total phytoplankton

Variable: Total Phytoplankton
Location: L4 station (Western Channel - UK)
Period: 1992-2009
Number of samples: 692

Min: 288
Max: 12044
Average: 2957.04
SD: 1645.28
Median: 2485.5
Unit: Cells per ml
Total zooplankton

Variable: Total Zooplankton
Location: L4 station (Western Channel - UK)
Period: 1988-2010
Number of samples: 1001

Min: 7.7
Max: 27186.0
Average: 3295.04
SD: 2896.29
Median: 2476.5
Unit: Individuals/m3
Temora longicornis
Phytoplankton dynamics in the western Channel
- C. Widdicombe, D. Eloire, D. Harbour, R.P. Harris & P.J. Somerfield

Temporal variability and community composition of zooplankton
- D. Eloire, P.J. Somerfield, D.V.P. Conway, C. Halsband-Lenk, R.P. Harris & D. Bonnet

Seasonal dynamics of meroplankton assemblages
- J.M. Highfield, D. Eloire, D.P.V. Conway, P. Lindeque, M.J. Attrill & P.J. Somerfield
Exploiting the long-term and interannual variability of biogeochemical variables in coastal areas by means of a data assimilation approach

Stefano Caiatta\textsuperscript{a,1,}, Roberto Pastres\textsuperscript{c}

\textsuperscript{a} Plymouth Marine Laboratory, Prospect Place, Plymouth PL1 3DH, United Kingdom
\textsuperscript{b} EuroMediterranean Centre for Climate Change, Consorzio Veneto Ricerche, Via della Libertà 12, 30174 Venice, Italy
\textsuperscript{c} Department of Environmental Sciences, Information and Statistics, University of Venice, Dorsoduro 3121, 30123 Venice, Italy

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\textbf{ABSTRACT}

Dynamic Harmonic Regression (DHR) models are applied here to the investigation of the interannual changes in the trend and seasonality of biogeochemical variables monitored in coastal areas. A DHR model can be regarded as a time-series component model, where the phases and amplitudes of the seasonal component, as well as the trend, are parameters that vary with time, reflecting relevant changes in the evolution of the biogeochemical variables. The model parameters and their confidence bounds are estimated by data assimilation algorithms, i.e., the Kalman filter and the Filtered Interval smoother. The DHR model structure is here identified by a preliminary spectral analysis and a subsequent minimization of the Bayesian Information Criterion, thus avoiding subjective choices of the frequencies in the seasonal component. The methodology was applied to the investigation of the long-term and interannual variability of ammonia, nitrate, orthophosphate and chlorophyll-a monitored monthly in the lagoon of Venice (Italy) during the years 1986–2008. It was found that the long-term evolutions of the biogeochemical variables were characterized by non-linear patterns and by statistically significant changes in the trend. The seasonal cycles of all the variables were characterized by marked interannual variability. In particular, the changes in the seasonality of chlorophyll and nitrate were significantly related to the changes in the seasonality of water temperature at the study site and of nutrient concentrations in river discharges, respectively. These results indicate that the methodology could be a useful alternative to more traditional approaches for investigating the impacts of changes in environmental and anthropogenic forcings on the evolution of biogeochemical variables in coastal areas.
Dynamic Harmonic Regression

A time series model

\[ y_t = T_t + S_t + e_t \]

data = Trend + Seasonality + error

\[ S_t = \sum_{i=0}^{R} (A_{i,t} \cos(\omega_i t + \varphi_{i,t})) \]

→ estimation of time variables \( x_{i,t} \), \( A_{i,t} \) and \( \varphi_{i,t} \)
Dynamic Harmonic Regression

Statistically significant changes in mean levels

Changes in peak values (minima & maxima)

Changes in timing (phenology)
Total zooplankton

Trend

Increasing trend

Decreasing trend

slope of trend
Total zooplankton

Seasonality (detrended)

amplitude and phase
Total zooplankton

seasonal cycle
Total zooplankton
Proportion of variance explained

- *Temora longicornis*: $R^2=0.88$
- Decapoda: $R^2=0.85$
- Dinoflagellates: $R^2=0.82$
- Bivalvia: $R^2=0.76$
- Diatoms: $R^2=0.74$
- *Centropages typicus*: $R^2=0.73$
- Phyto-flagellates: $R^2=0.66$
copepods

Total zooplankton

Temora longicornis  
(cold, neritic)

Centropages typicus  
(warm, oceanic)
annual peaks

Temora longicornis

Centropages typicus
Temora longicornis  Centropages typicus

timing
meroplankton

Total zooplankton

decapods

bivalves
annual peaks

Decapoda

Bivalvia
Decapoda

Bivalvia

timing
More on meroplankton:

Elaine Fileman et al.  
poster S9-7016

Pennie Lindeque et al.  
Friday 9:40 am S9-6959
Trophic relationships

Total phytoplankton (biomass)

Total zooplankton (abundance)
Trophic relationships

phytoplankton (trend slope)

zooplankton (trend slope)

inverse

parallel
### Trophic relationships

#### Spearman rank correlations of trend slopes

<table>
<thead>
<tr>
<th></th>
<th>Total phytoplankton</th>
<th>SST</th>
<th>Nitrate</th>
<th>Phosphate</th>
<th>Silicate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total zooplankton</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1993-2002</td>
<td>-0.40</td>
<td>-0.33</td>
<td>-0.93</td>
<td>-0.92</td>
<td>-0.80</td>
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<tr>
<td>2003-2010</td>
<td>0.78</td>
<td>-0.71</td>
<td>0.22</td>
<td>0.68</td>
<td>0.33</td>
</tr>
</tbody>
</table>

*nutrient data 2000-2010 only*
Conclusions

- DHR useful tool for plankton time series analysis
- identified years with positive and negative trends in abundance
  - *T. longicornis* contributes to peaks in total zooplankton
- identified timing of annual peaks (phenologies)
  - *Temora* (May/June; exceptions) vs *Centropages* (Sep)
  - bivalves more consistent seasonal cycle than decapod larvae
- inversion of relationship between phyto- and zooplankton in 2003
- shift in relationship between zooplankton and nutrients
- antagonistic responses of meroplankton (decapods and bivalves)
- more analyses needed to identify taxa responsible for shifts
Potential MSc or PhD project

- Total of 65 zooplankton taxa
- >150 phytoplankton taxa
- Suite of environmental variables (T, Sal, Chl, nutrients, wind, NAO…)

- many more analyses to do
- Multivariate analyses → was there a shift in dominance?

Contact: clau1@pml.ac.uk
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