CHARM
CHANNEL INTEGRATED APPROACH FOR MARINE RESOURCE MANAGEMENT

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

Claudia Halsband-Lenk
Stefano Ciavatta
Claire Widdicombe

PML | Plymouth Marine Laboratory

5th IZPS
Pucón, Chile, March 2011

CHARM 3 - history

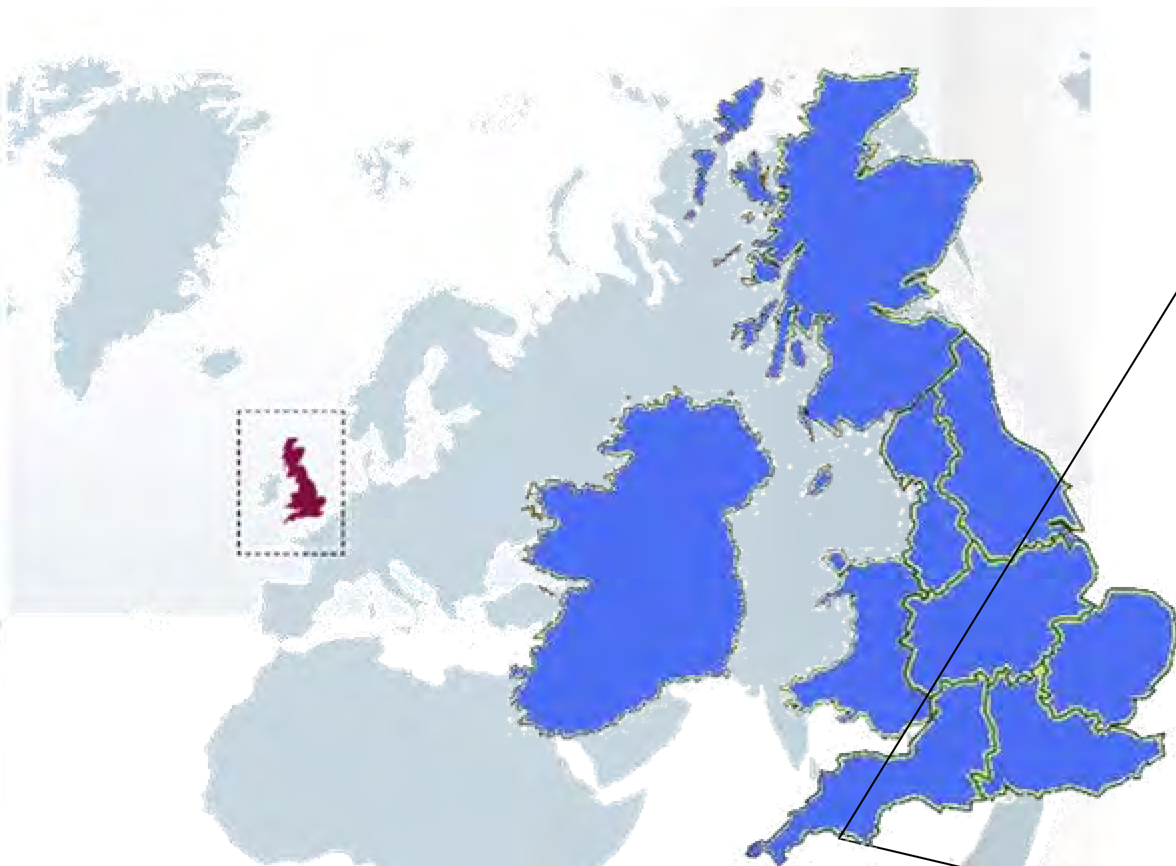
- CHannel integrated Approach to marine Resource Management
- phases 1 & 2: multidisciplinary approach to marine living resource management
- assessment of key marine species and their habitats in the *eastern* Channel
- develop management tools to predict human impacts
- Product: Channel Habitat Atlas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

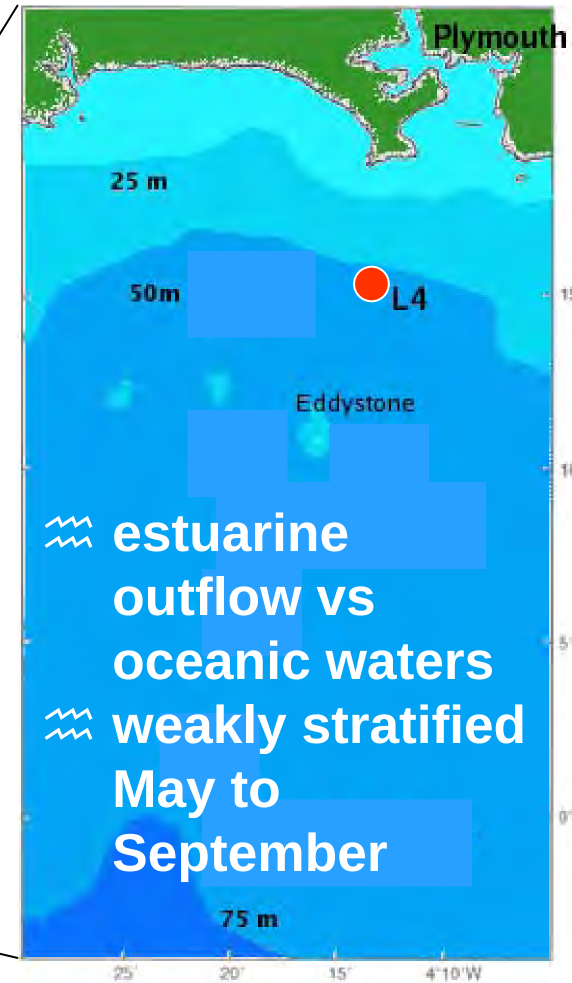
CHARM 3 WP 2.1 plankton

- 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)



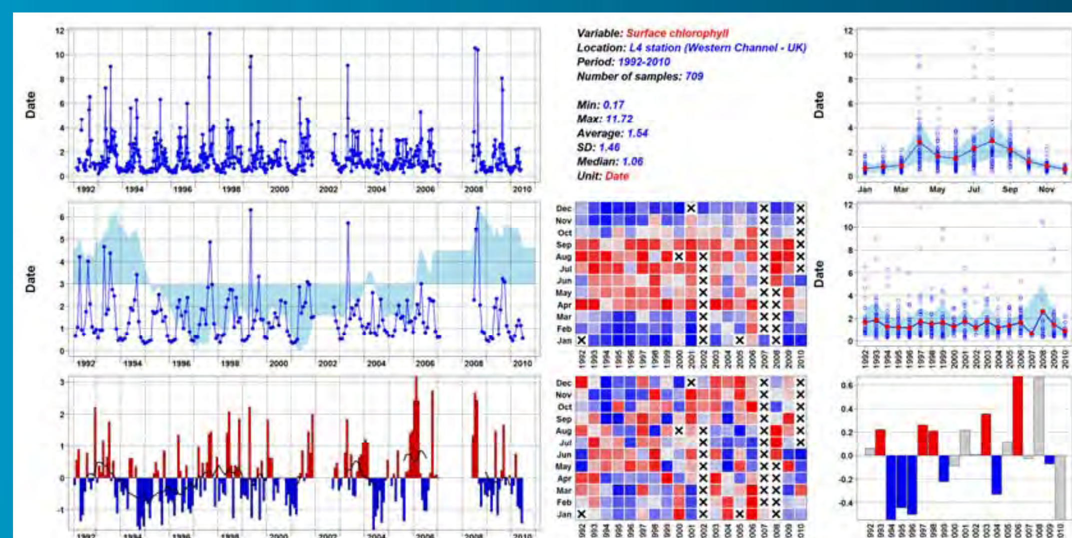


- estuarine outflow vs oceanic waters
- weakly stratified May to September

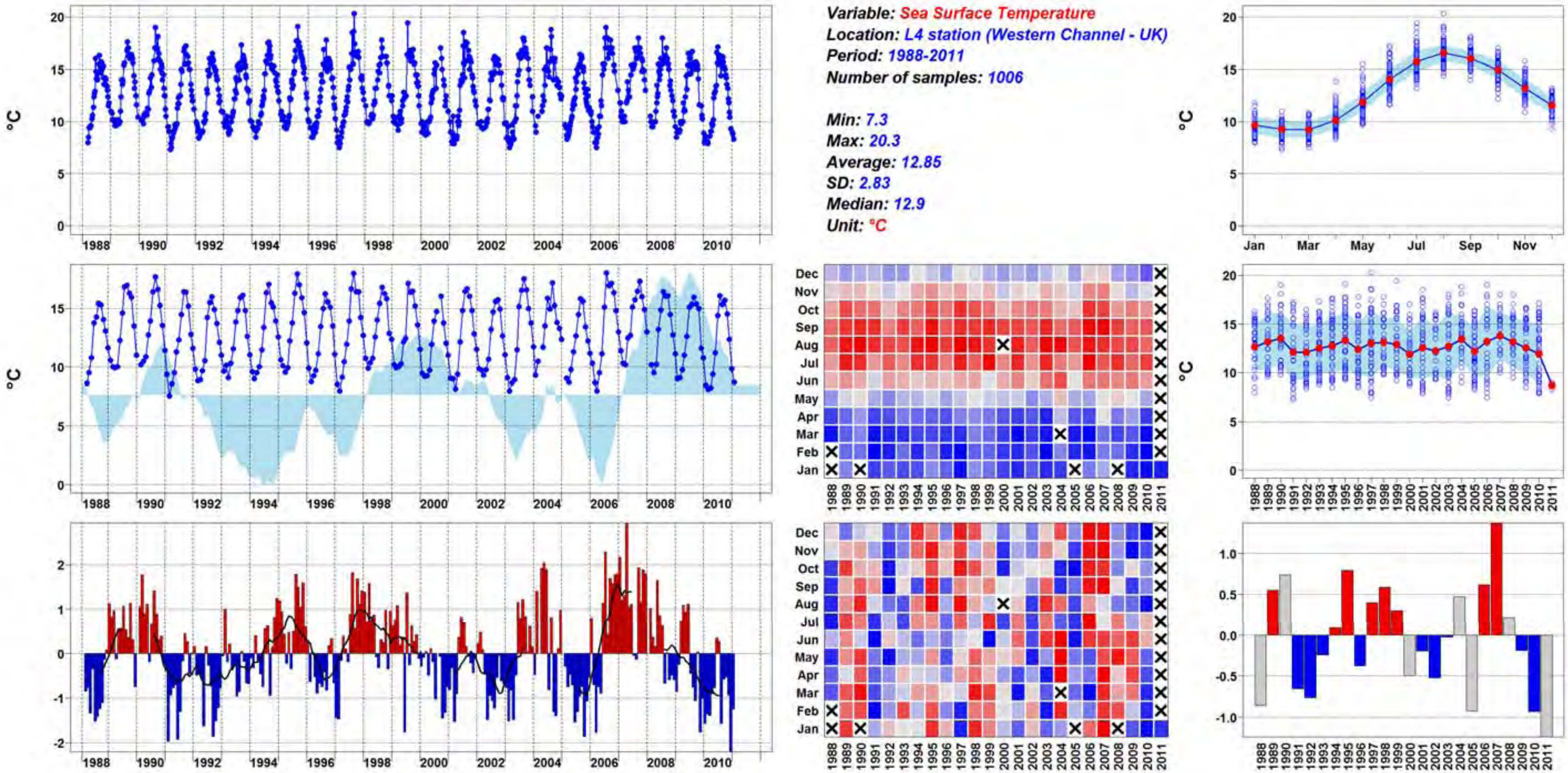
Time Series analysis

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

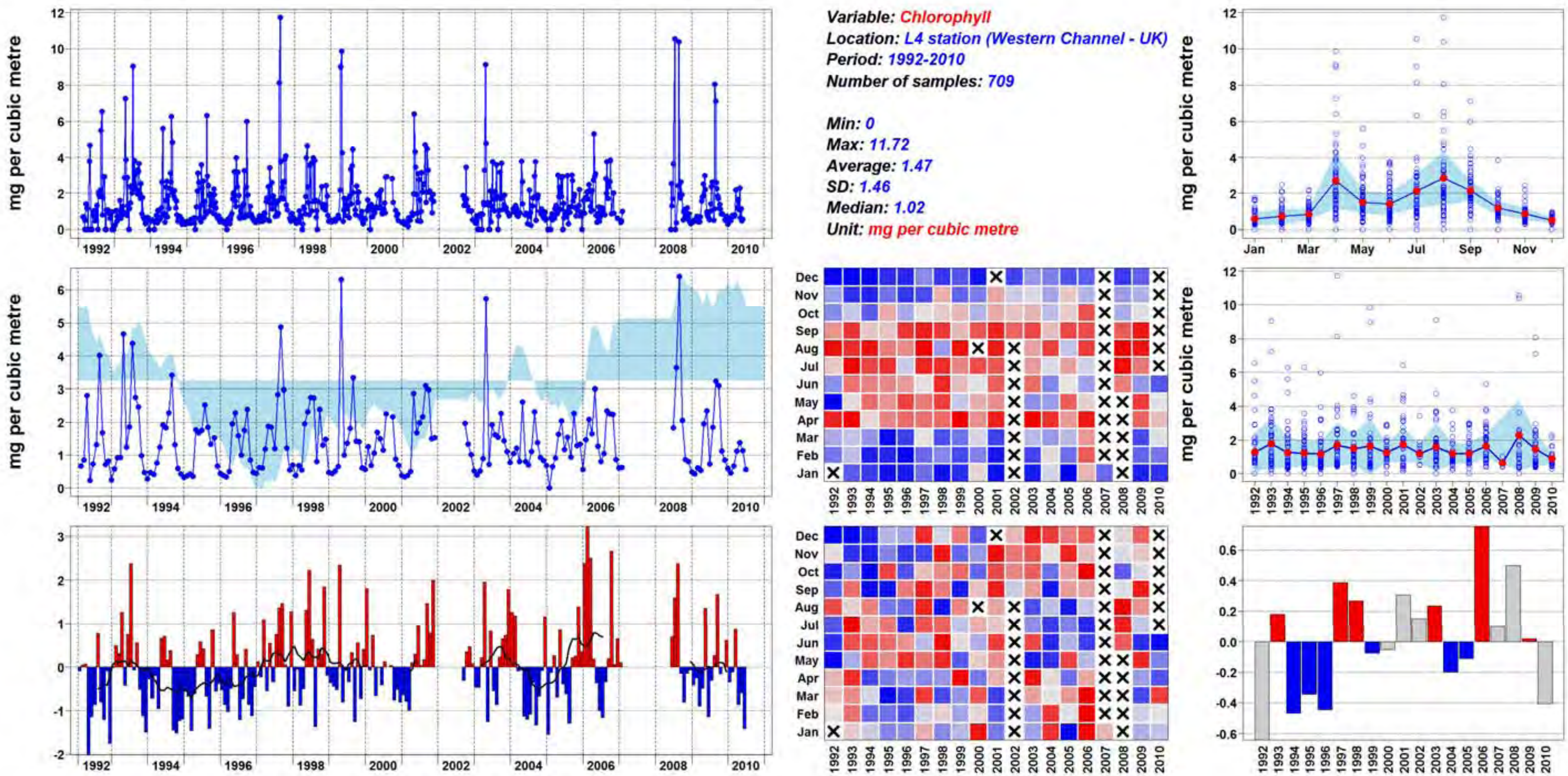
R-package developed
by Damien Eloire



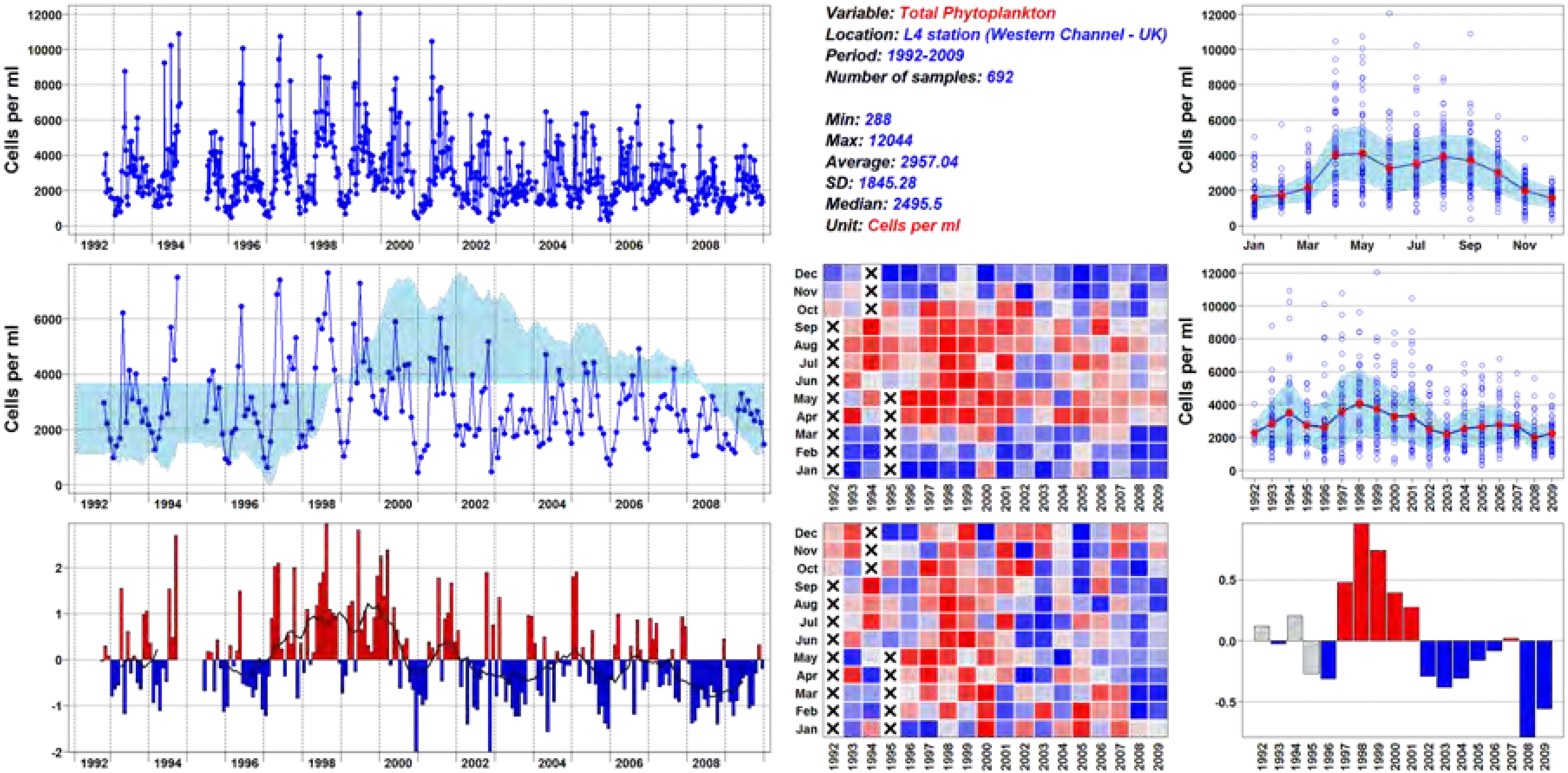
Temperature



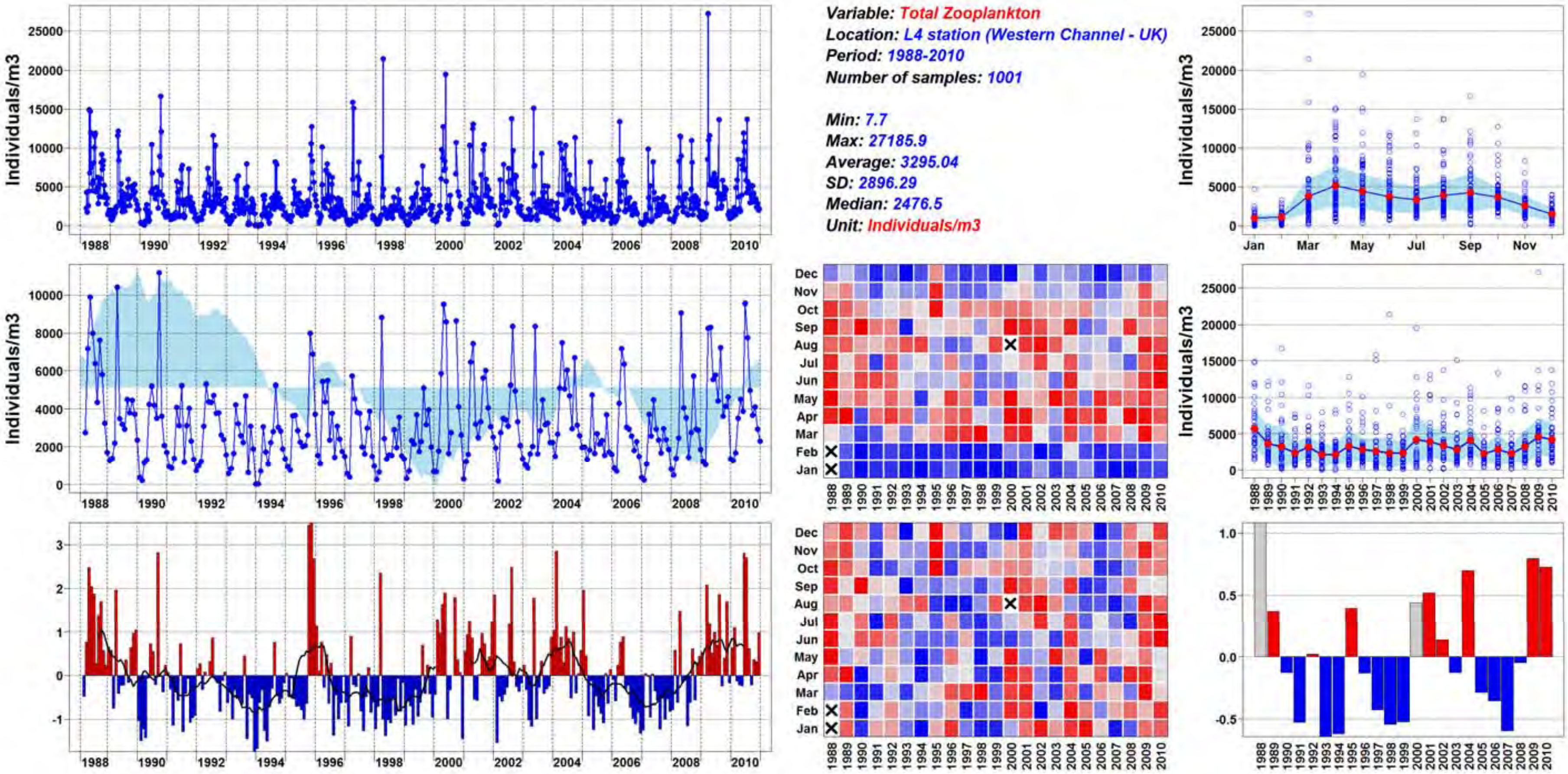
Chlorophyll



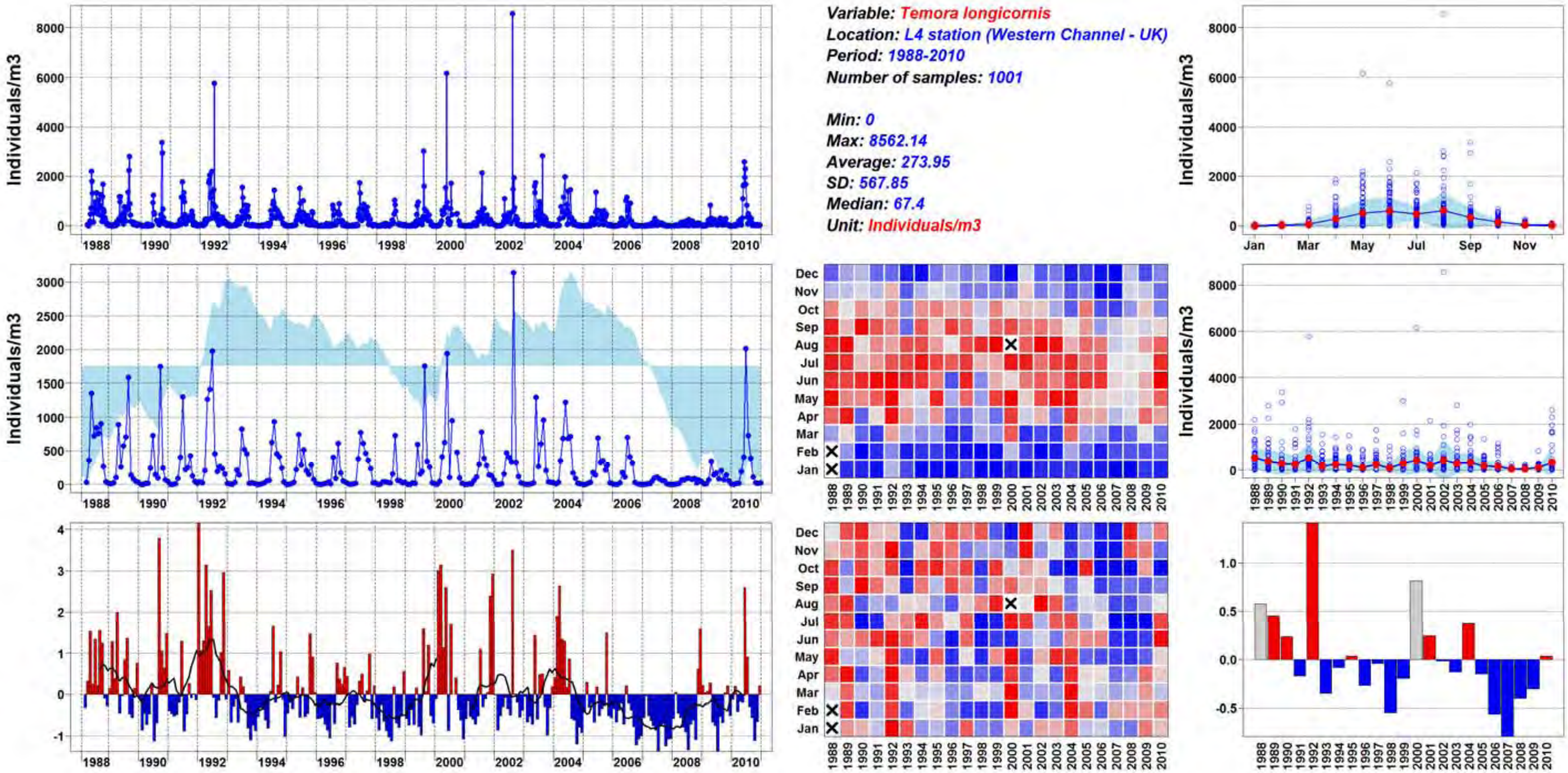
Total phytoplankton



Total zooplankton



Temora longicornis



L4 Special Issue, JPR 32 (5) 2010

- 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*

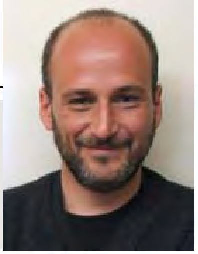
Dynamic Harmonic Regression

Estuarine, Coastal and Shelf Science 91 (2011) 411–422

Contents lists available at ScienceDirect

Estuarine, Coastal and Shelf Science

journal homepage: www.elsevier.com/locate/ecss



Exploring the long-term and interannual variability of biogeochemical variables in coastal areas by means of a data assimilation approach

Stefano Ciavatta[a,b,*], Roberto Pastres[c]

[a] Plymouth Marine Laboratory, Prospect Place, Plymouth PL1 3DH, United Kingdom
[b] EuroMediterranean Centre for Climate Change, Consorzio Venezia Ricerche, Via della Libertà 12, 30175 Venezia, Italy
[c] Department of Environmental Sciences, Informatics and Statistics, University Cà Foscari of Venice, Dorsoduro 2137, 30123 Venezia, Italy

A R T I C L E I N F O

Article history:
Received 21 March 2010
Accepted 28 November 2010
Available online 3 December 2010

Keywords:
time series analysis
Kalman filter
water quality monitoring
lagoon of Venice

A B S T R A C T

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 Fixed 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 a 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 sound 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.

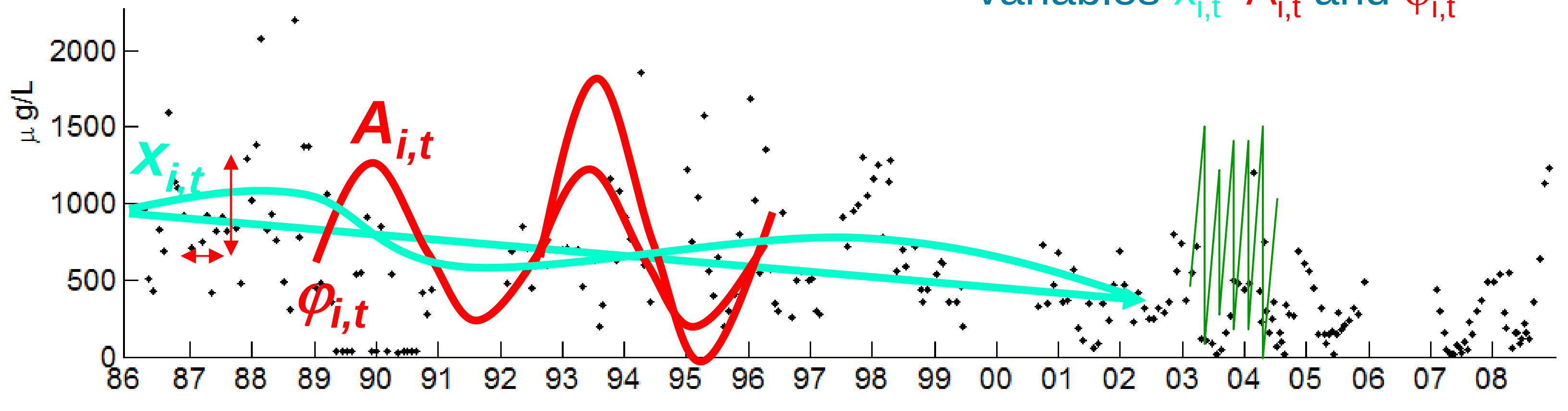
Dynamic Harmonic Regression

A time series model $$y_t = T_t + S_t + e_t$$

data = Trend + Seasonality + error

$$S_t = \sum_{i=0}^{R} \left(A_{i,t} \cos(\omega_i t + \varphi_{i,t}) \right)$$

→ estimation of time variables $x_{i,t}$ $A_{i,t}$ and $\varphi_{i,t}$



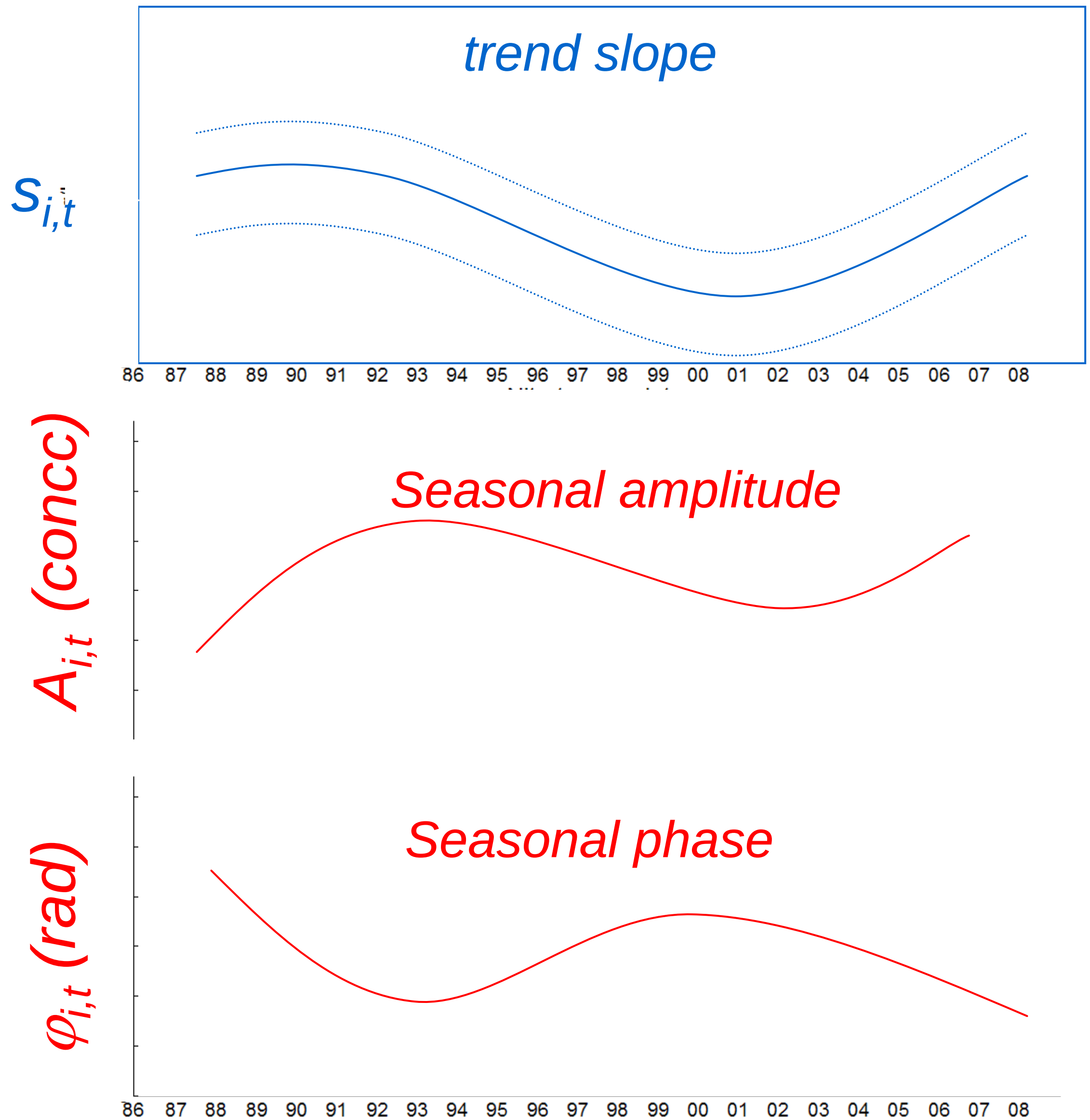
Time

Dynamic Harmonic Regression

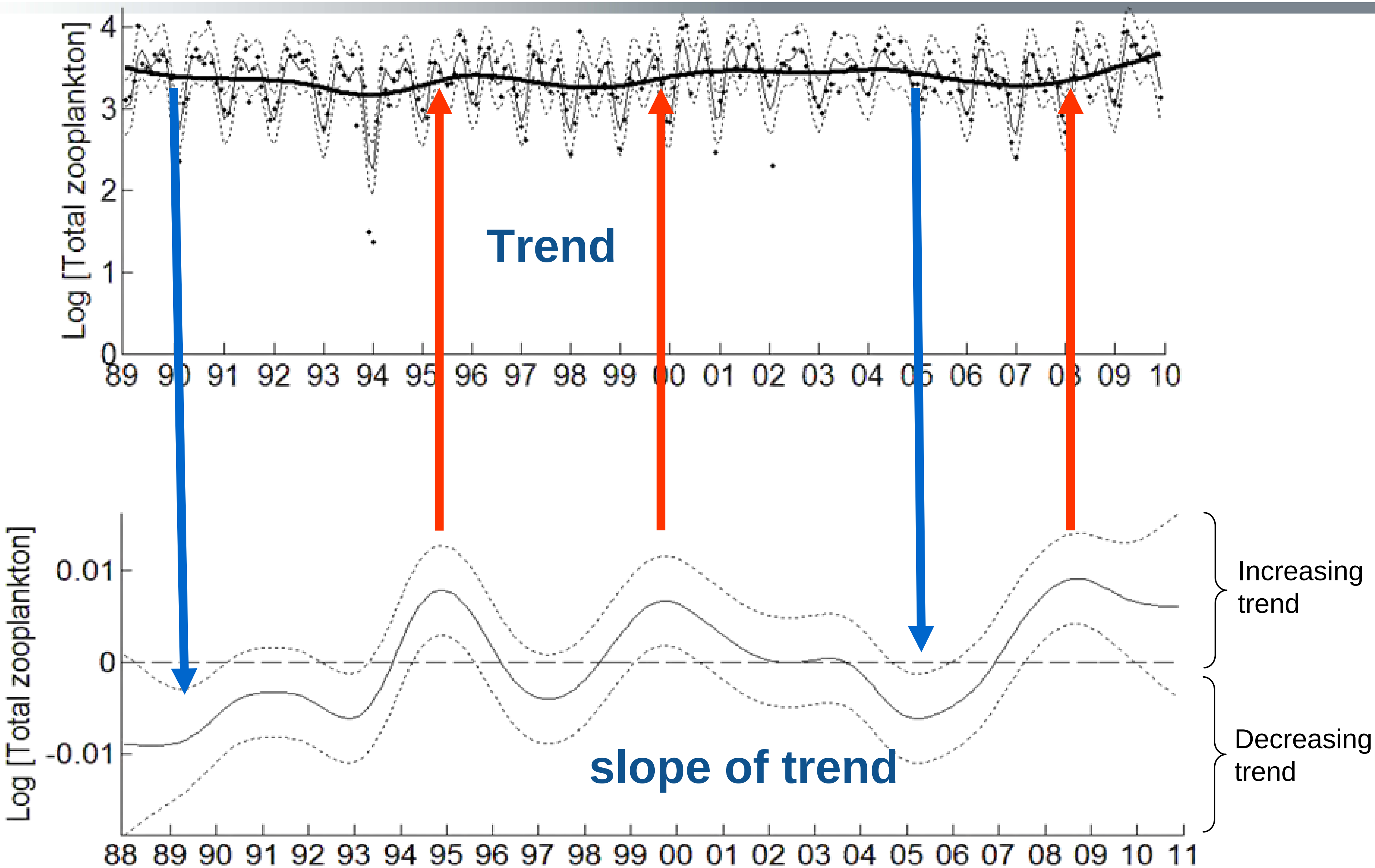
Statistically significant changes in mean levels

Changes in peak values (minima & maxima)

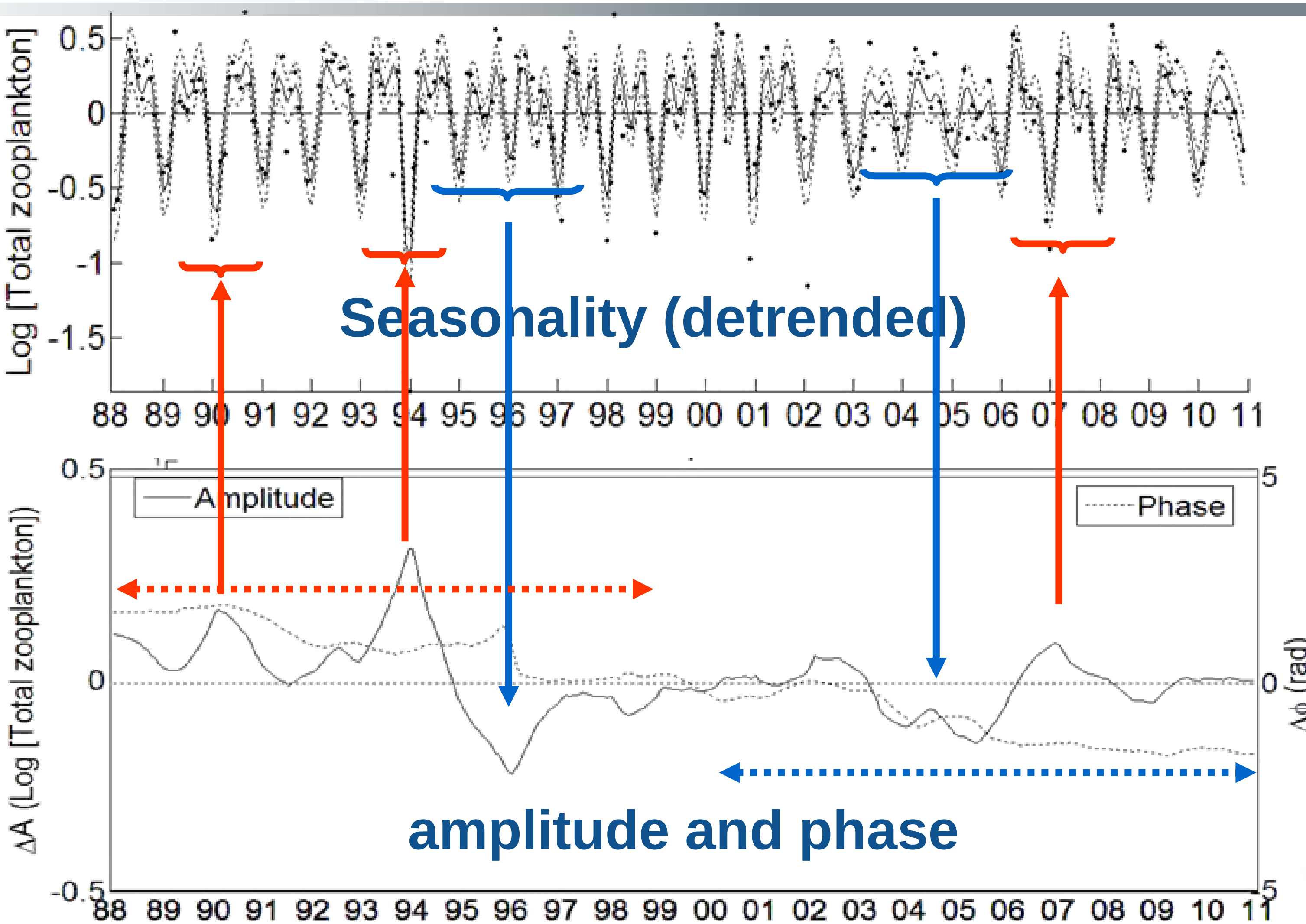
Changes in timing (phenology)



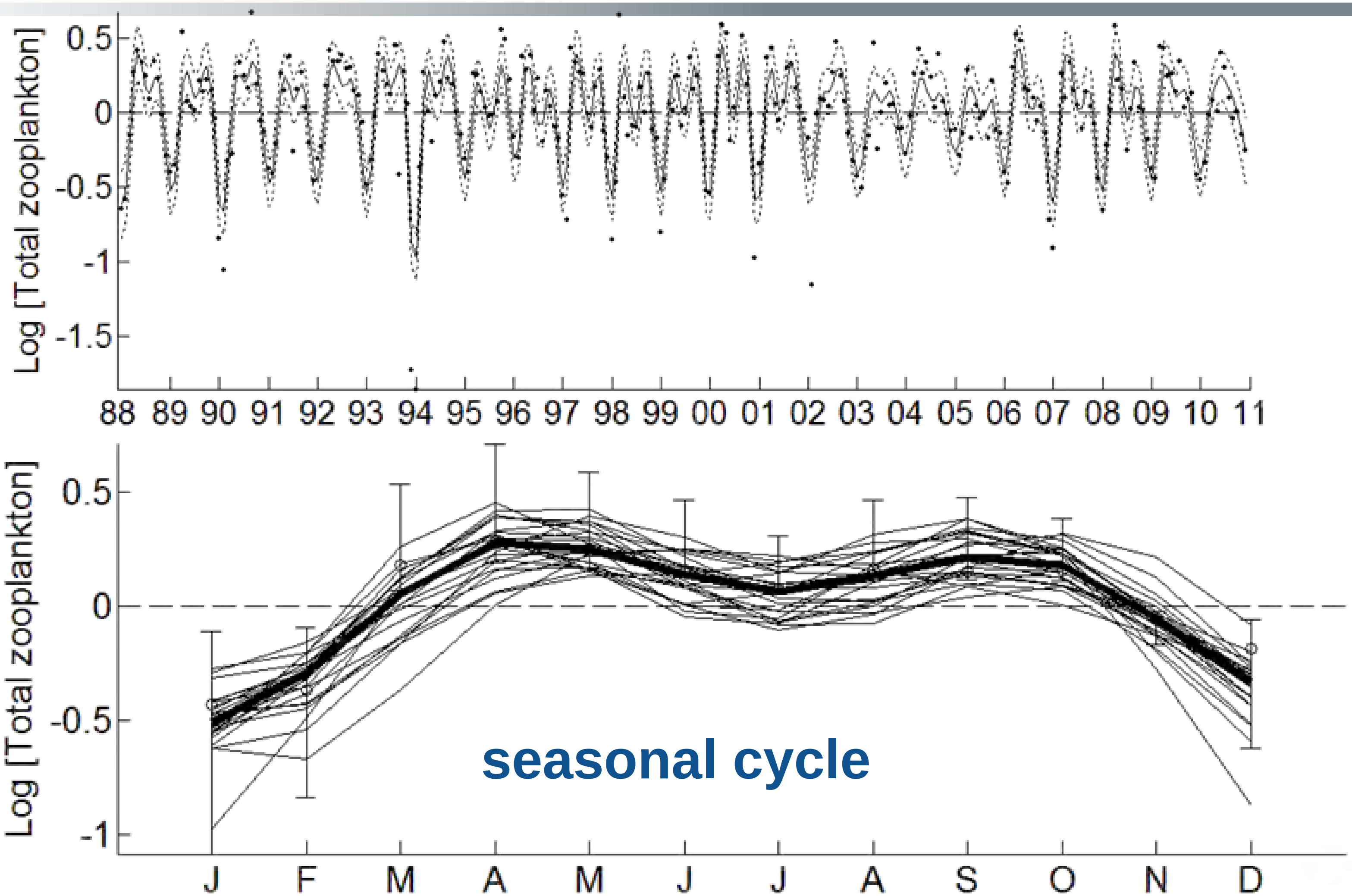
Total zooplankton



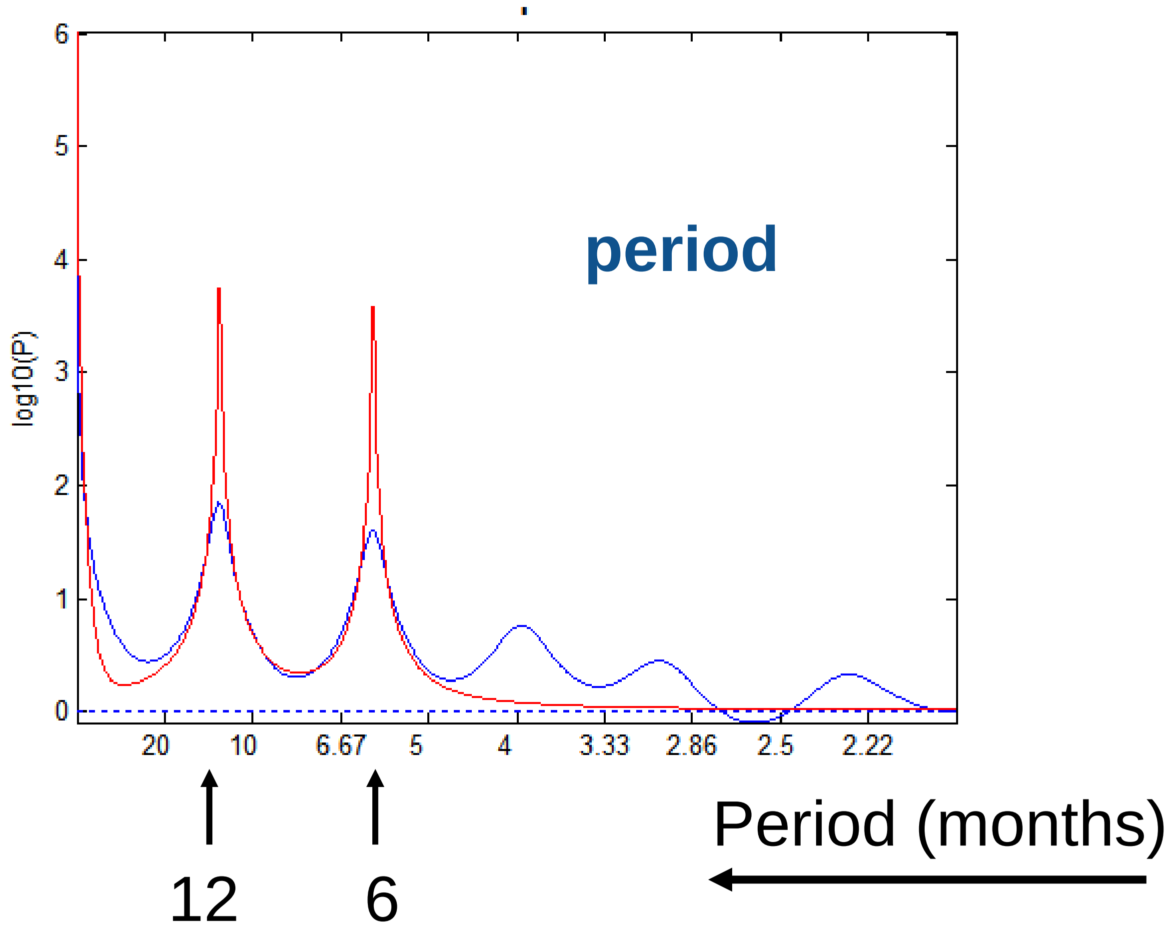
Total zooplankton



Total zooplankton



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

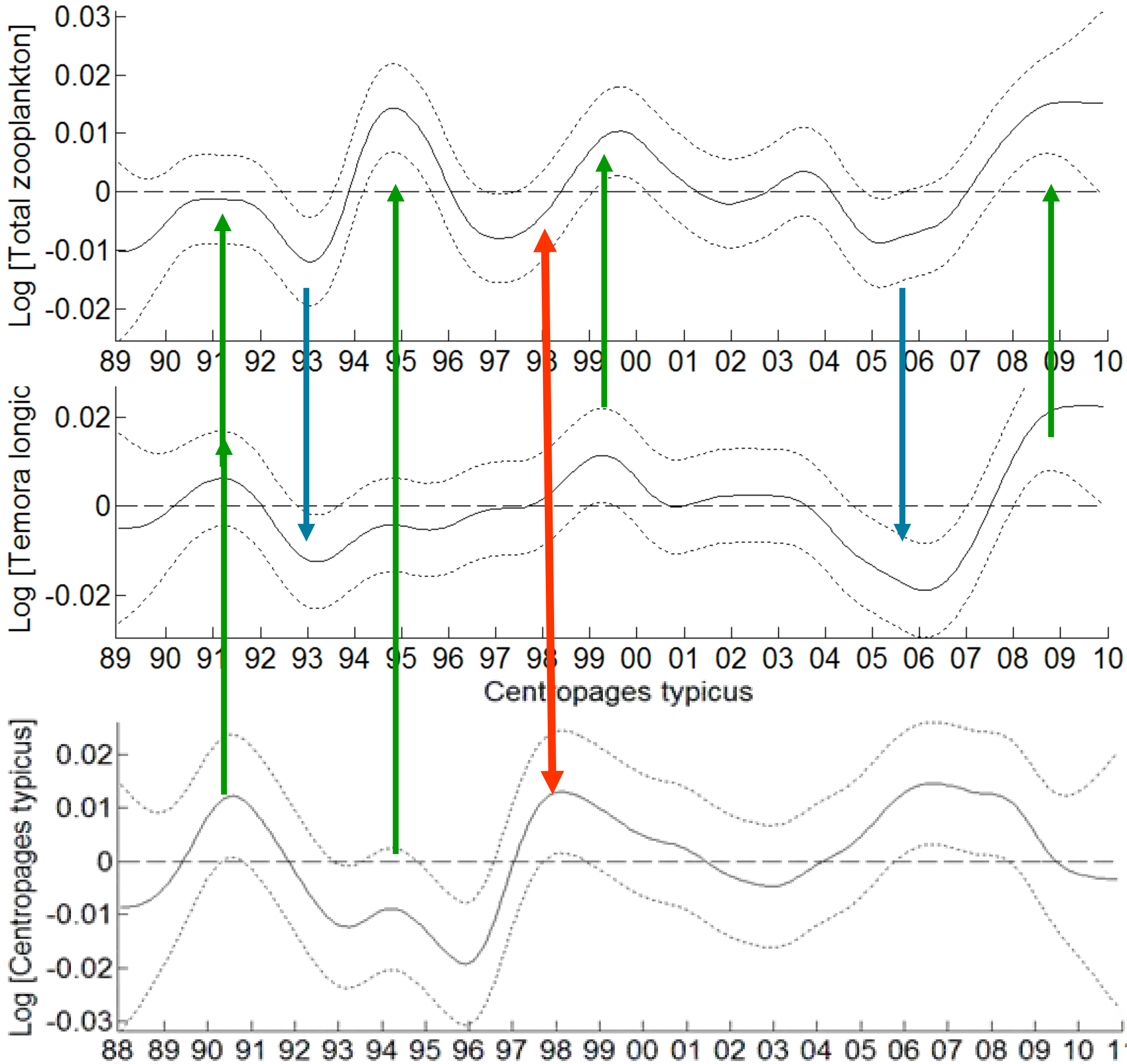
Total zooplankton

Temora longicornis

(cold, neritic)

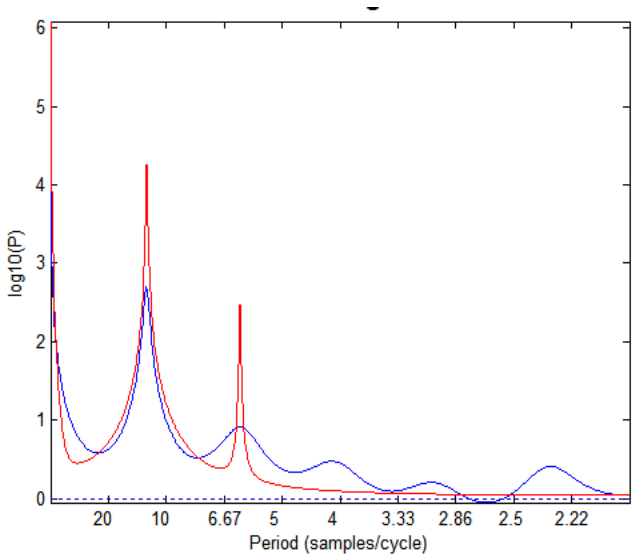
Centropages typicus

(warm, oceanic)

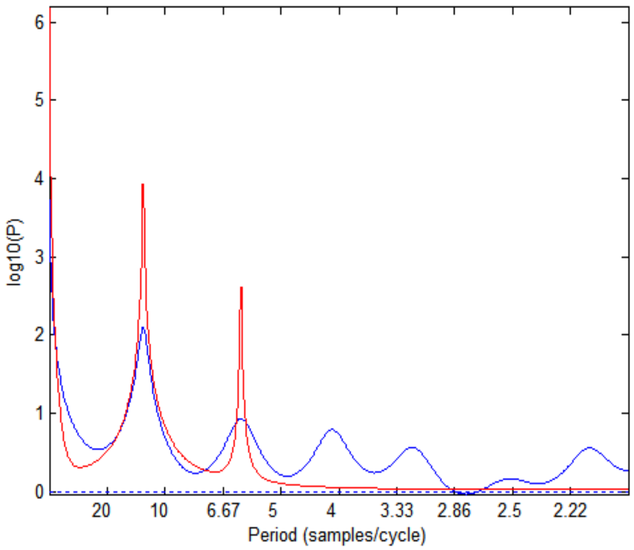


annual peaks

Temora longicornis



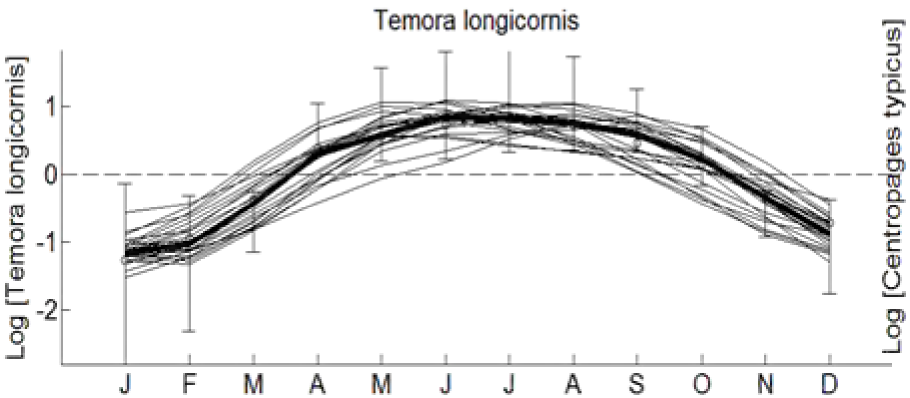
Centropages typicus

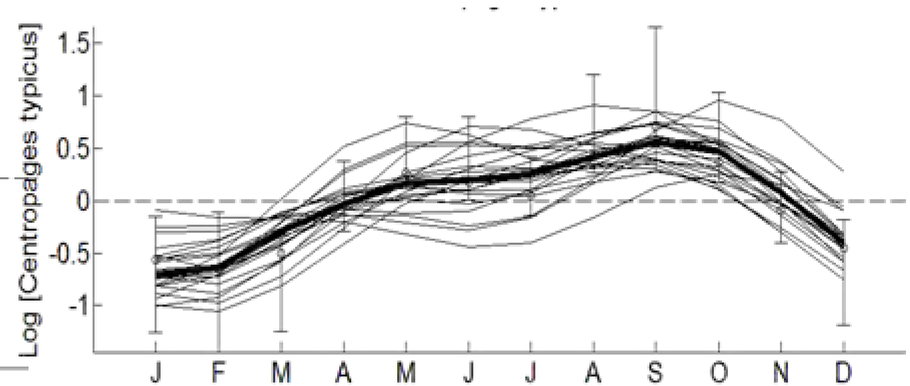


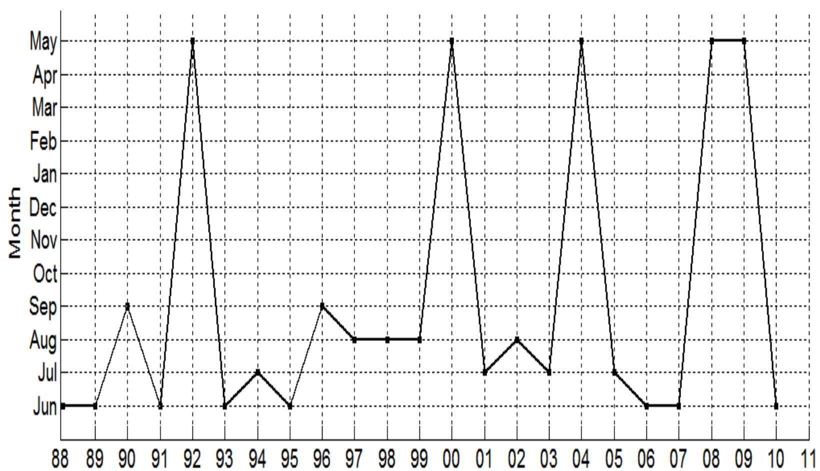
timing

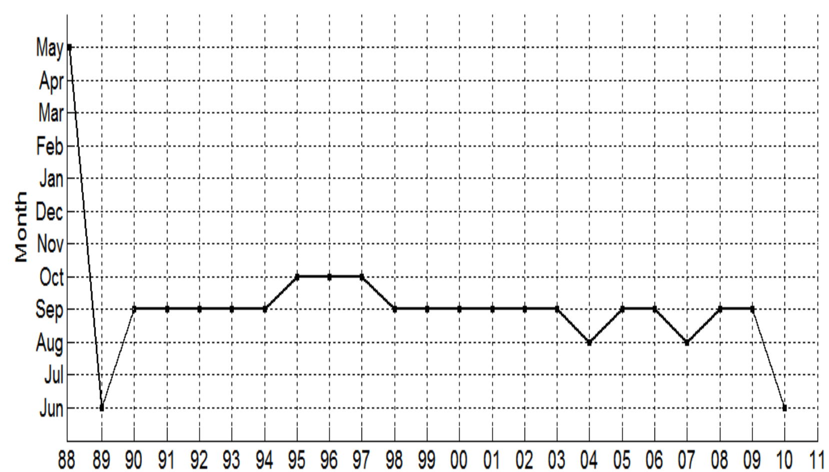
Temora longicornis

Centropages typicus







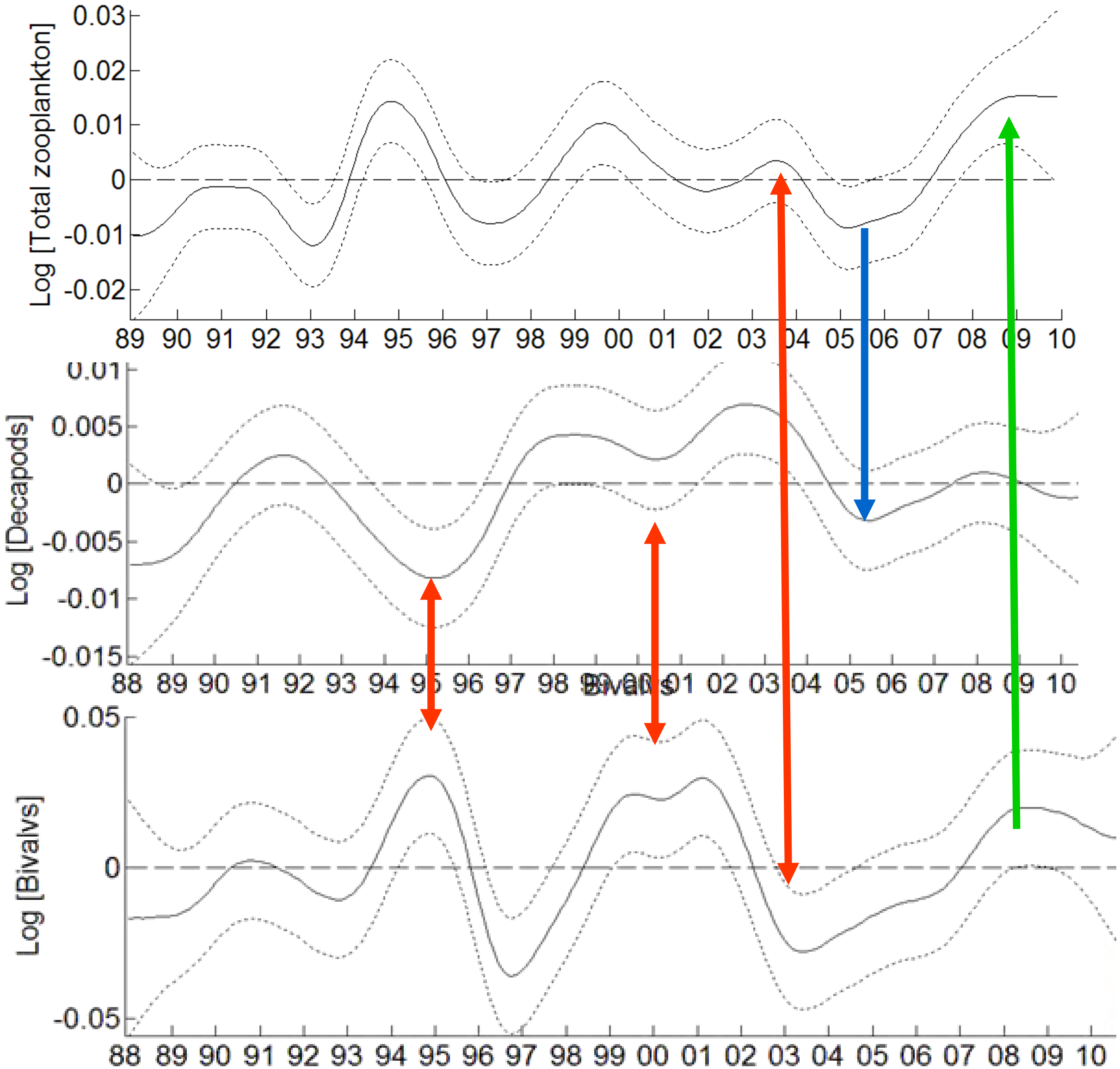


meroplankton

Total zooplankton

decapods

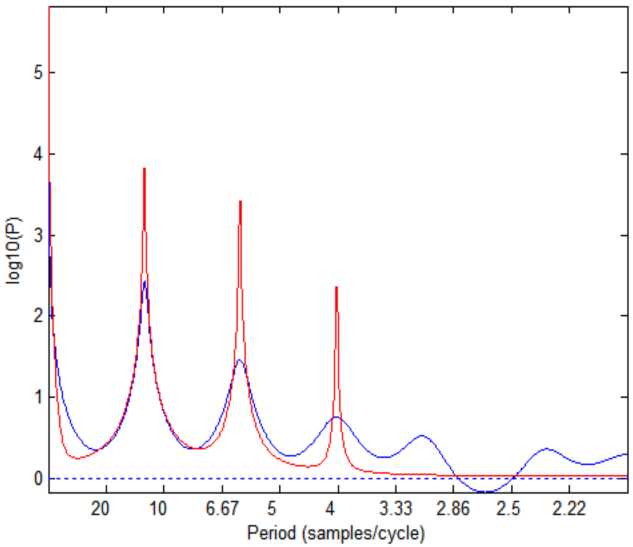
bivalves

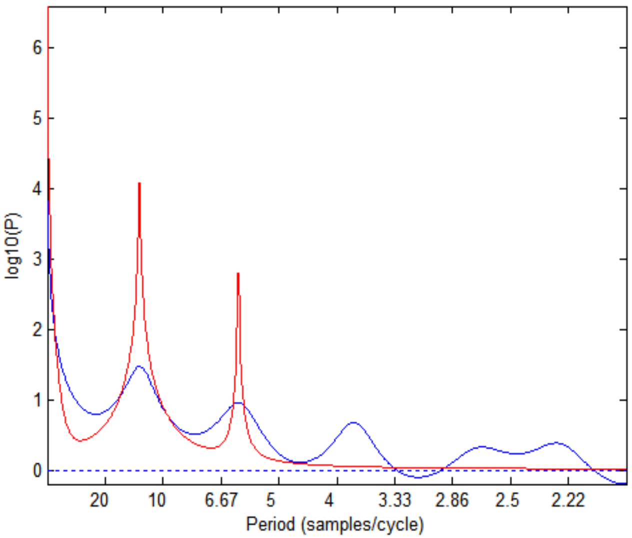


annual peaks

Decapoda

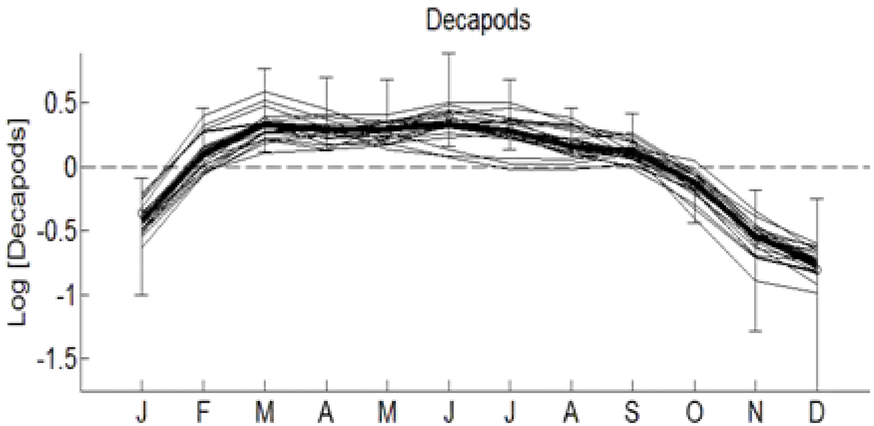
Bivalvia

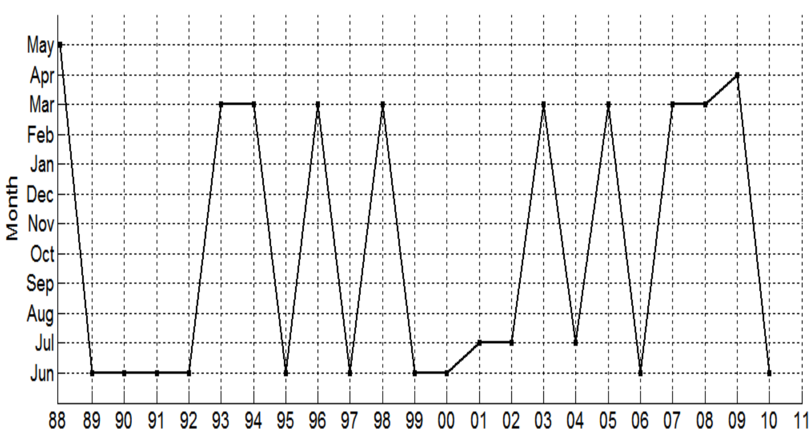




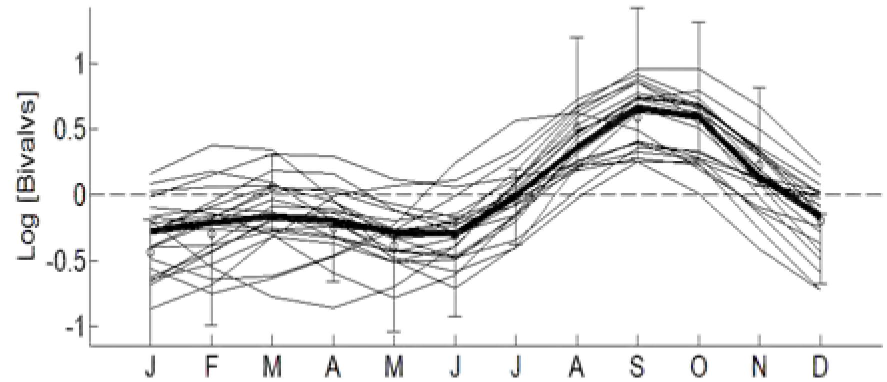
timing

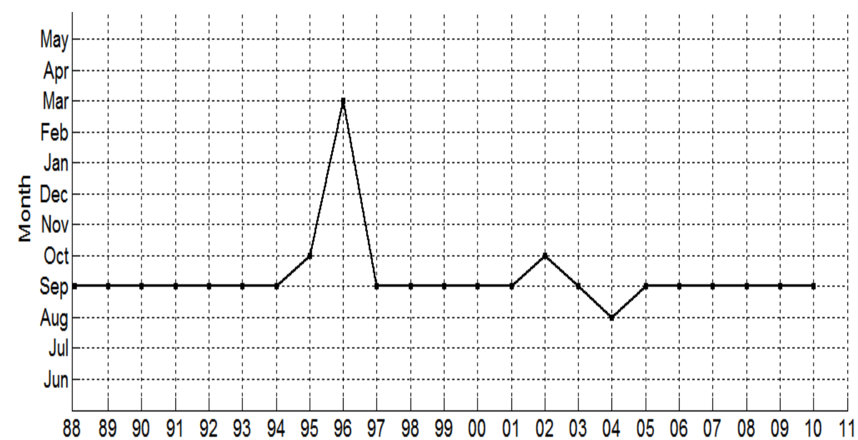
Decapoda





Bivalvia



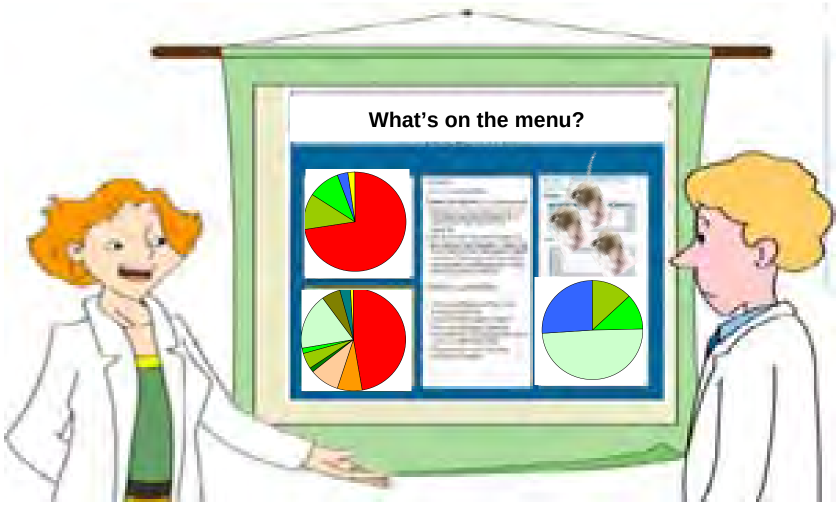


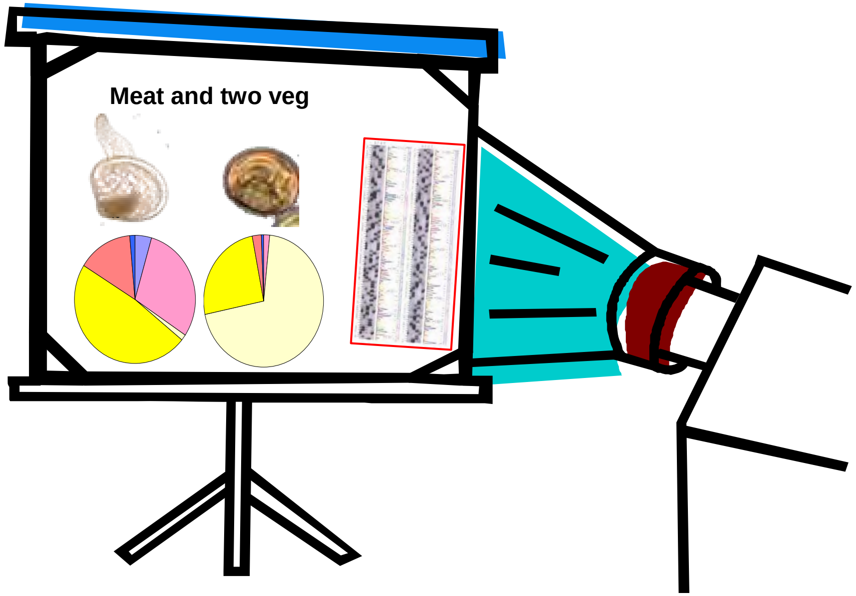
More on meroplankton:

- Elaine Fileman et al.

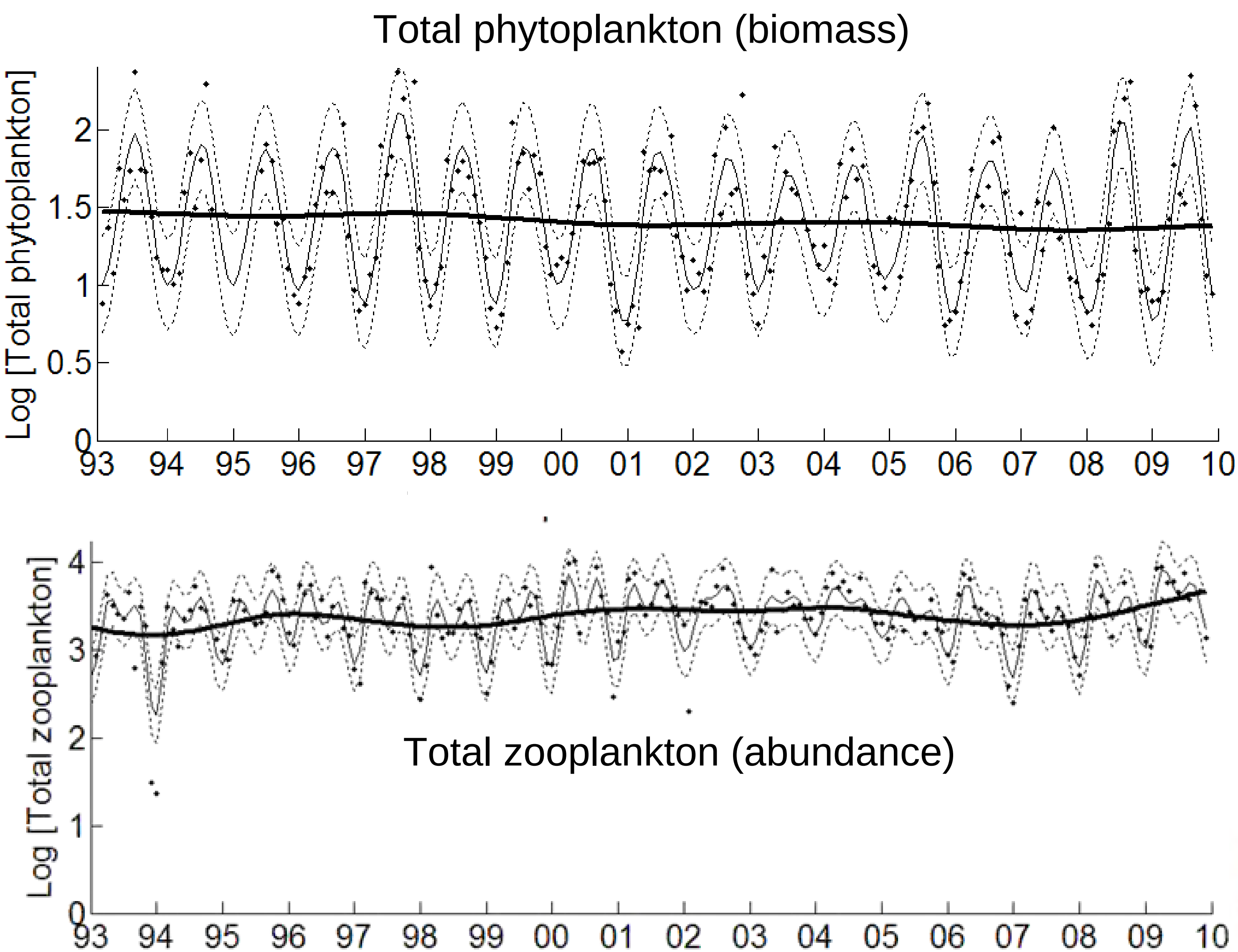
  poster S9-7016

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

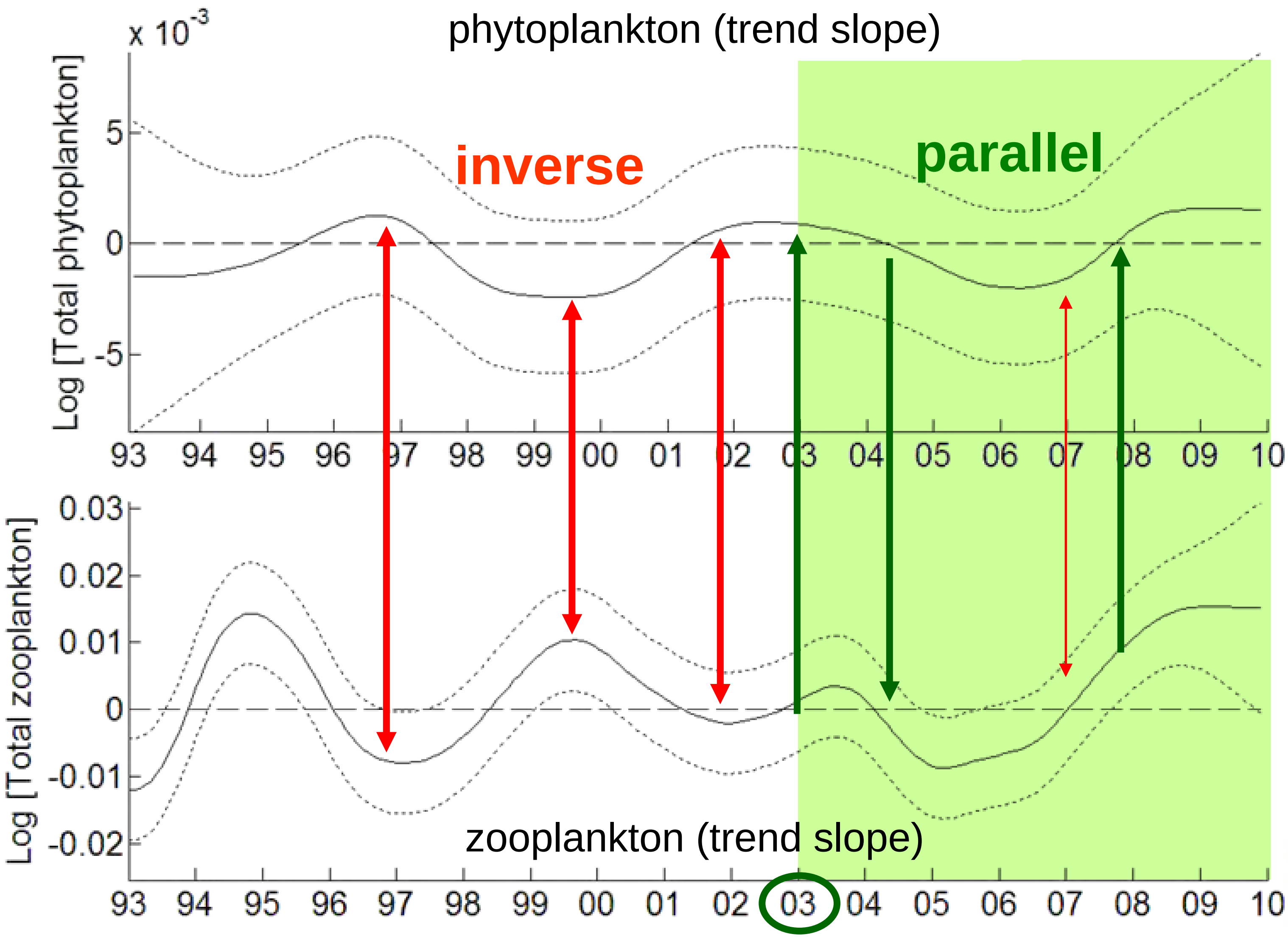




Trophic relationships



Trophic relationships



Trophic relationships

Spearman rank correlations of trend slopes

total zooplankton	total phytoplankton	SST	Nitrate	Phosphate	Silicate
1993-2002	**-0.40**	**-0.33**	**-0.93**	**-0.92**	**-0.80**
2003-2010	**0.78**	**-0.71**	**0.22**	**0.68**	**0.33**

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

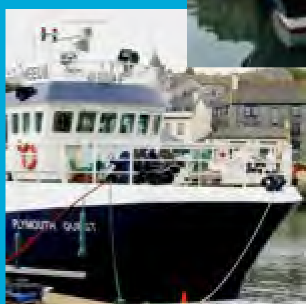
- Total of 65 zooplankton taxa
- >150 phytoplankton taxa
- Suite of environmental variables (T, Sal, Chl, nutrients, wind, NAO…)

⇨ many more analyses to do

⇨ Multivariate analyses → was there a shift in dominance?

⇨ Contact: clau1@pml.ac.uk

Acknowledgements



THANK YOU

GRACIAS

CHARM 3 is an INTERREG IV project; a France (Channel) – England cross-border European cooperation programme, co-financed by the ERDF (total budget 5 825 462 €)

The Western Channel Observatory is funded by NERC Oceans 2025

J. Fishwick and T. Smyth (PML) provided temperature and chlorophyll data. Thanks to the crews of RV Quest and RV Sepia for sampling and to Dave Conway, Andrea McEvoy and Rachel Harmer for assistance in zooplankton identification.