Marine microbial communities in UK waters from phylogenetic studies to remote sensing

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INTRODUCTION

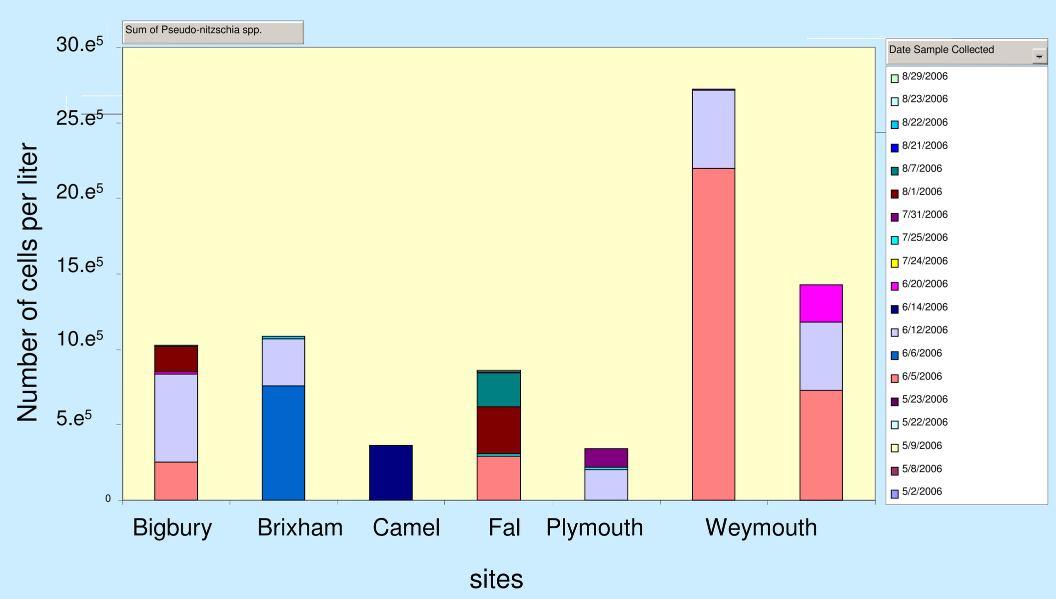
The sea provides many goods and services (e.g. food, recreation, etc.). There is a need to safeguard the marine ecosystem and to achieve sustainability in respect of human use. Knowing the main human pressures and understanding their impacts is essential to develop and implement effective measures of environmental quality. Generally, the state of an ecosystem can be assessed by monitoring its components and/or attributes. Parameters such as overall system performance are also highly relevant but are neither precise nor easy to measure. State and impact indicators are therefore utilised widely in global and regional assessments and have proven useful in detecting and quantifying deteriorating environmental quality so that appropriate management action may be taken.

	Phytoplankton	Bacteria	Archaea
Importance for ecosystem status	High	High	?
Indicative of ecosystem changes	Yes	?	?
Regular monitoring	Yes	No	No
Analytical tools	Molecular biology Flow cytometry Remote sensing	Molecular biology	Molecular biology
Level studied	Communities Species	Communities	Communities

APPLIED SCIENCE IN AQUATIC MICROBIAL ECOLOGY AT Cefas

Monitoring Phytoplankton included the harmful algae

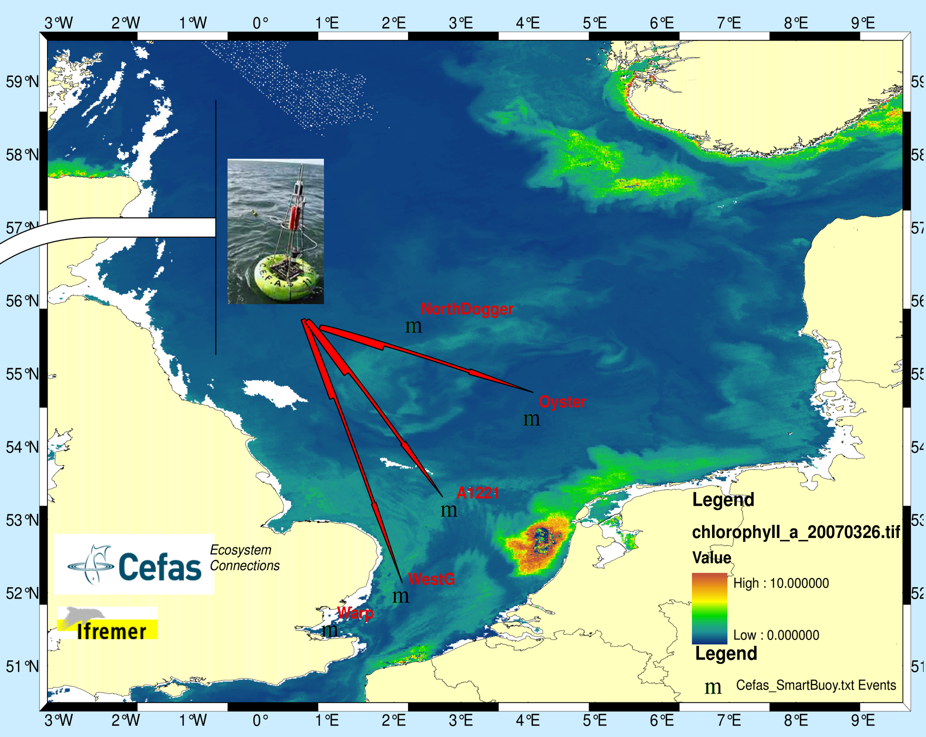
Following the Water Framework Directive, and other legislation, phytoplankton biomass is regularly measured in UK waters. Chlorophyll a extraction has now been combined with remote detection of blooms from buoys and satellite. These new approaches have the advantage of being independent of the sampling network and allow the dynamics of phytoplankton blooms to be followed directly on different geographical scales. Furthermore, other techniques to estimate the biodiversity of the phytoplankton composition, including toxic and non toxic algae, is now taking place to support the traditional identification by light microscopy.



Main sites of Pseudo-nitzschia blooms in UK waters in 2006

Research and development on *Pseudo-nitzschia*, domoic acid producer (cause of amnesiac shellfish poisoning)

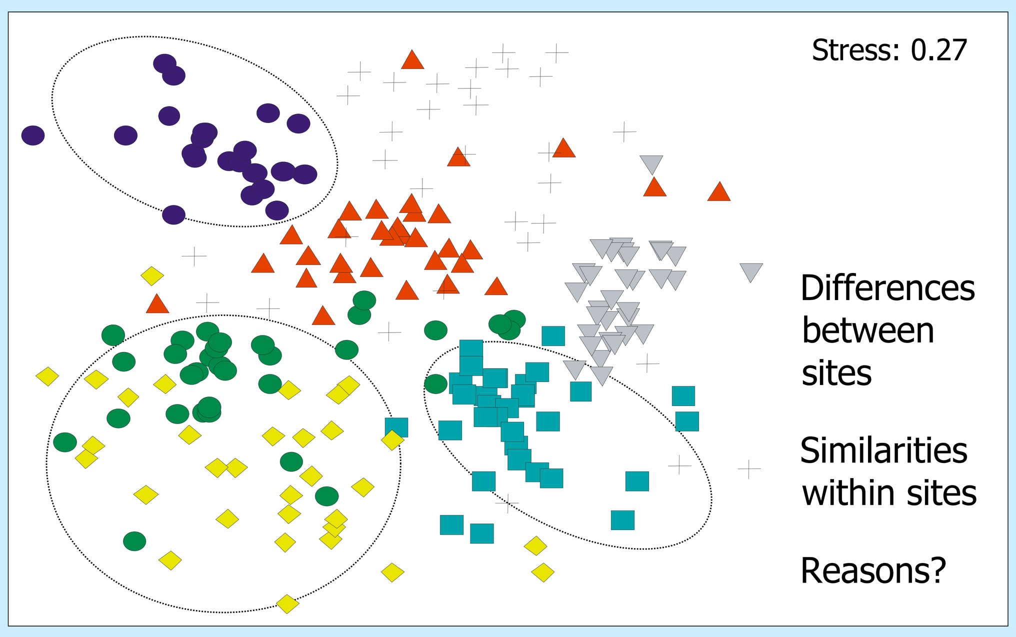
In UK coastal waters, during the last 2 years, the monitoring programme has shown an increase in numbers, distribution areas and bloom periods of *Pseudo-nitzschia* sp. The species composition of this diatom has been rarely studied.
Molecular tools (ARISA, clone libraries, flow cytometry) are being developed to identify the different species using fixed samples from monitoring programmes around the UK coast and from SmartBuoys (North Sea, Liverpool Bay). Additionally, new strains during occasional cruises are regularly isolated to study the population genetic of *Pseudo-nitzschia pungens* in collaboration with the Department of Protistology and Aquatic Ecology, University of Ghent (Dr. Vywerman, G. Casteleyn).



Remote sensing image of a phytoplankton bloom in the North Sea in March 2007

Response of microbial communities to natural and man-made impacts

The diversity of benthic bacterial and archaeal communities is being studied at Cefas, utilising different fingerprinting methods. Fingerprinting methods are combined with multivariate statistics to study the response of these communities to environmental changes induced naturally or by human activity. The statistical methods include nonmetric multidimensional scaling (MDS) and Canonical Correspondence Analysis (CCA) to clarify how specific communities and specific microbial phylotypes respond to changes in their environment.



Virtual MDS Plot of fingerprints of different stations within small-scale spatial variation

Sediment
- Heterogeneous environment, local habitat characteristics
- Prevention of dispersal ➡ Biogeography
- Physical environmental conditions ➡ large scale patterns
- Food sources, local disturbances (natural or man-made) ➡ small scale patterns

Benthic microbial communities
Diversity of communities and distribution of species
➡ Ecological roles
➡ Impact consequences

Influence of ecological factors on assemblages and scale of variation
➡ Prediction of community change between areas

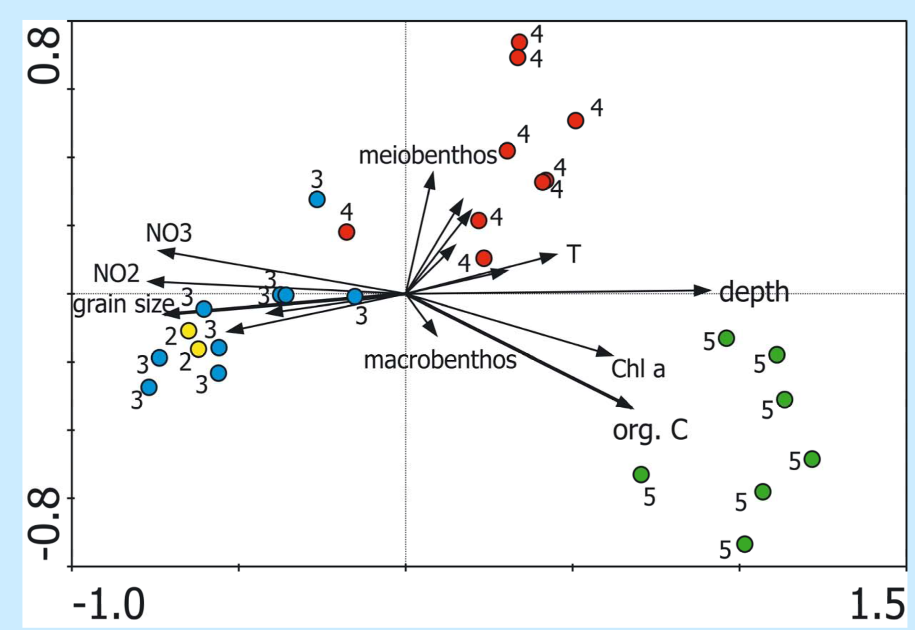
Study site: Oyster Ground, North Sea, 54°4′ N / 4°′ E;
- Small scale variation of bacterial and archaeal communities
- Link to variation in multicellular ecosystem components and habitat characteristics
- Prediction of community patterns by quality and quantity of carbon sources?

Eutrophication
Increased rate of organic matter supply to an ecosystem due to
- Inorganic nutrient enrichment
- Input of allochthonous organic carbon or pollutants (e.g. fish farming)
- Decrease in water turbidity
- Decline in grazing pressure
- Other factors

➡ Proliferation and toxicity increase of harmful algal blooms
➡ Hypoxia and anoxia
➡ Altered routes/fluxes of organic and inorganic matter cycling
➡ Disruption of food webs
➡ Impacts on biogeochemical cycling and trophic relationships

Benthic microbial communities
Unique transformations in biogeochemical cycles
Community structure and function affected by eutrophication

Study site: Scotland, fish farm; contribution to EU funded project: Coastal Ocean Benthic Observatory
- Linkage of changes in bacterial and archaeal communities and appearance of certain phylotypes with enrichment gradient
- Specific responses on impact by specific phylotypes or functional groups?



Virtual **C**anonical **C**orrespondence **A**nalysis biplot on DGGE fingerprinting profiles within a gradient of organic carbon using organic carbon (org.C), chlorophyll a (Chl a), depth, macrobenthos and meiobenthos community, grain size, and the nutrients nitrate (NO3), nitrite (NO2). Circles indicate bacterial communities, and numbers near the symbols indicate the sampling station (2-5). Arrows indicate the direction of increasing values of the respective variable, and the length of arrows indicates the degree of correlation of the variable with community data. Such a plot shows how populations diverge according to the combination of factors affecting them.

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