Theme Session L


ICES CM 2003/L:01

Spectral absorption and fluorescence characteristics of the Baltic Sea phytoplankton

Jukka Seppälä

The fundamental differences in spectral properties between algal groups are well established and can be used as a starting point in the identification of algal groups. Here, I will review the seasonal variability in spectral absorption and fluorescence characteristics of living phytoplankton in the northern Baltic Sea, and study their relation to phytoplankton community structure. Especially the phycoerythrin and phycocyanin fluorescence seem to be relevant indicators for picocyanobacteria and filamentous cyanobacteria, respectively.

Due to variable fluorescence and acclimation of pigmentation, deriving the biomass of spectral groups using the spectral fluorescence of multicomponent natural samples is not trivial and calls for advanced algorithms. For this purpose, multivariate methods (e.g. partial least squares, PLS) seem superior to univariate methods (e.g. classical least squares). PLS is especially applicable when signals from different constituents are overlapping, the background noise is high and variable, and not all of the optically active compounds are known. With experimental data, PLS -model was noted to give the best predictions for all spectral taxonomic groups - and with the accuracy needed for algal bloom detection. However, the success of PLS -model with other data-sets is not self-evident as these models are extremely sensitive to the calibration data-sets.

Possibilities for online detection of spectral phytoplankton groups by absorption and fluorescence methods will be critically examined.

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ICES CM 2003/L:02

Ferrybox measurements of phytoplankton dynamics in a hypernutrified estuary (Southampton Water, UK)

S. E. Holley, J. Waniek, and D. J. Hydes

The “Ferrybox” dataset (1999–present) provides a context for detailed process studies in an estuarine environment. This autonomous system records plankton blooms, with reduced aliasing of timing and peak biomass, in the hypernutrified system of Southampton Water. A ferry, making up to 16 crossings a day, records temperature, salinity, fluorescence, position and turbidity data every second and relays 10-minute summaries of data back in near real time. Poor weather may restrict bloom development in the estuary through changes in light levels and disruption of the water column resulting in interannual variability in the timing and magnitude of spring bloom development. Net heat flux, which combines the effects of wind, solar radiation, temperature differences between air and water and cloud cover, has been calculated for this area and can be used as a proxy for spring bloom initiation. The 2001 “Ferrybox” data show a typical pattern of bloom development for Southampton Water with a spring bloom followed by a series of summer blooms each associated with the neap tide. However, chlorophyll levels remained low in 2002 and this atypical year challenges our understanding of the system.

Keywords: Ships-of-opportunity, Ferrybox, phytoplankton, Southampton Water.

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Optoelectronic method of plankton monitoring and fish stock feed base assessment


The Laser Plankton Meter TRAP-7A is suggested to monitor plankton as fish stock feed base from ship-of-opportunity or as remote sensing mean. TRAP-7A estimates plankton concentration and size up to the depth of 2000 m being a part of a sensor suite on CTD-probe, undulating towed vehicles, buoy or on ship board flow-through system. TRAP-7A uses optical electronic sensor and shadow method of measurements. Plankton particles pass between the emitter and the photo-receiver, their shadow sizes are recorded on the photo-receiver. Software enables the calculation of the biomass of registered plankton particles using their equivalent spherical diameters and shape coefficients for mass species. Other optical plankton counters also use similar method, but the TRAP-7A has following advantages: a) measuring the volume is performed by optical means, so plankton behaviour is not effected by flow channel configuration; b) perfect contrast of particle shadow and eliminating of parasite illumination are achieved as infra-red laser is used; c) a 128x1 array of photodiodes excludes the influence of plankton particles degree of transparency on the results of their size measurements; d) using of the pulse laser and the photo-receiver with memory permits to make rapid photos of the measuring volume content; f) there is no necessity to measure water flow speed, as the value of the total measuring volume is constant at any speed. The latest plankton monitoring data are presented, including data collected in the Okhotsk and Caspian Seas.

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Prediction of the annual cycle of phytoplankton production in the North East Atlantic


SeaWiFS satellite measurements of ocean colour, available for the whole globe on a weekly basis, are routinely converted into estimates of chlorophyll a concentration using calibration algorithms. These calibration algorithms are validated using bottle measurements collected in clear, open ocean waters, where chlorophyll a concentrations are low. The North East Atlantic has large areas of coastal and polar waters, where these calibration algorithms do not work well. Thus, although the satellite measurements describe the broad-scale patterns in chlorophyll a concentration, quantitative agreement between satellite estimates and bottle measurements is poor. The actual relationship between bottle measurements and satellite estimates is complex and varies with water characteristics, which in turn vary with depth and time of year. We therefore model bottle measurements as a function of SeaWiFS estimates, depth and time of year, using three-dimensional thin plate regression splines. The resulting model provides plausible predictions in time and space, which capture the main features of both the satellite and bottle data.

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Development of the operational observation system of harmful algal blooms as a BOOS project

Seppo Kaitala

Since the Global Ocean Observing System (GOOS) was created in 1991, the Baltic Operational Oceanographic System (BOOS) was developed the conception as a regional initiative. BOOS constitutes a close co-operation between national
governmental agencies in the countries surrounding the Baltic Sea. The premier task is to integrate the existing systems into a uniform entity in order to meet the users’ demands for high quality operational oceanographic services and to minimize the production costs.

The Baltic Sea is a unique continental sea. Today the Baltic Sea is eutrophied and the blooms of harmful plankton algae are annual phenomena. The blooms are harmful to the marine ecosystem as well as to the recreational and economic use of the marine resources.

BOOS is based on the existing marine scientific research and monitoring.

In order to establish an integrated operational forecast system for the Baltic Sea as an operational observation system of harmful algal blooms, the work will focus on the special demands for rapid data delivery, data exchange and user-friendly product dissemination.

In HABWARN project the operational system should include:

- Nutrient, temperature, salinity and chlorophyll-$a$ monitoring with research and ship of opportunity vessels, mooring systems and coastal stations.
- Satellite monitoring of algal blooms with novel satellite sensors (e.g. MODIS and MERIS).
- Phytoplankton species monitoring from the Baltic Sea areas with special emphasis on the harmful and toxic species.
- Monitoring of cyanobacterial hepatotoxin nodularin in the Baltic Sea to improve the data sampling system procedures and to develop further a common early warning harmful algal bloom information system under BOOS.

Keywords: harmful algal blooms, operational monitoring systems.

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ICES CM 2003/L:07

Remote sensing of chlorophyll $a$ in the Baltic Sea together with automated fluorometer measurements

Totti Takio, Jenni Vepsäläinen, Seppo Kaitala, and Vivi Fleming

Optical remote sensing of ocean colour using empirical blue-green ratio algorithms is a tempting method to monitor the distribution and abundance of chlorophyll $a$ as an index of phytoplankton biomass in the upper illuminated water layers. The remotely sensed signal is influenced by the absorption and backscattering characteristics of the water and of its dissolved and particulate matter. The main optically active component in water is chlorophyll $a$ which has distinct absorption bands in the visible region of the electromagnetic spectrum. In the Baltic Sea the concentrations of coloured dissolved organic matter (CDOM) and suspended material from allochthonous sources are high and create a need to apply locally developed band ratio algorithms. Moderate Resolution Imaging Spectroradiometer (MODIS) satellite instrument was used together with high frequency automated fluorometer measurements (Alg@line system) to retrieve the abundance and concentration of chlorophyll $a$ during the annual spring bloom in 2001. Fluorometer onboard merchant ships offers an excellent source for accurate in situ reference data.

Keywords: Remote sensing, chlorophyll $a$, MODIS, Baltic Sea, fluorometer.

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Alg@line – 10 years of innovative phytoplankton monitoring and research in the Baltic Sea

Heidi Hällfors and Eija Rantajärvi

During 2003 Alg@line celebrates its ten-year anniversary as a full-time joint operational monitoring and information service in the Baltic Sea. The ‘ship-of-opportunity’ (SOOP) approach, i.e. unattended measurements and sampling on ferries and cargo ships, forms the backbone of Alg@line. The main objective of Alg@line is the monitoring of the phytoplankton community and harmful algal blooms. In addition to an almost real-time reporting on algal blooms, the collected data is used for scientific research. By taking the spatio-temporal dimensions better into account the automated sampling is able to give more adequate information on changes in the plankton community than traditional methods. The data enables the research of the ecology of phytoplankton species and also facilitates the detection of possible invasions of new and potentially harmful species.

In this paper the Alg@line approach is explained. Additionally, the suitability of the utilised method and the collected data for investigating the ecology and distribution of phytoplankton species is evaluated using ten years of experience, and insights gained through a study on the northern Baltic dinoflagellate community.

Keywords: Monitoring, phytoplankton, Baltic Sea, unattended sampling, dinoflagellates.

Upwelling in the Gulf of Finland (along the Tallinn-Helsinki ferry line in 1997–2002)

Lauri London and Urmas Lips

Temperature and salinity data collected automatically at 4–5 m depth along the SOOP (ship-of-opportunity) transect Tallinn-Helsinki was used for the identification of upwelling events near the opposite coasts of the Gulf of Finland. The upwelled water, since it originates from the deeper layers below the seasonal thermocline, is usually cold and rich in nutrients. The upwelling appears when along-shore winds are blowing: in the Gulf of Finland, the eastern winds cause upwellings near the Estonian coast and the western winds – near the Finnish coast. For identification of upwelling events, the near-coast water temperature was compared to the mean water temperature across the whole gulf. Successive temperature transects were analysed to describe initiation and development of observed upwelling events. Common characteristics and peculiarities of upwellings near the topographically different coasts of the gulf are given. A method is developed to estimate the intensity of upwelling events (upwelling index) for every crossing. The seasonal course of this index reveals when and how intense upwelling events did occur. The results are in a good agreement with across-shore Ekman transport estimates. Finally, an integrated upwelling index characterizing the total cold water (and the nutrients) flux intensity during a certain time period was calculated. The integrated upwelling index (calculated as a cumulative sum of indexes starting from 1 May) can be used in a model to forecast the intensity of blue-green algae blooms in the Gulf of Finland.

Keywords: upwelling, Gulf of Finland, ship-of-opportunity, blue-green algae blooms.

An evaluation of methods for obtaining water column integrated samples of filamentous cyanobacteria in the Baltic Sea

Lisa Almesjö and Carl Rolff

In this study we investigated the influence of hose diameter when collecting surface-water integrating samples of filamentous cyanobacteria and image analysis as a tool for estimating the total length of filaments during a summer
bloom in the Northern Baltic Proper. We sampled filamentous cyanobacteria (*Aphanizomenon* sp. and *Nodularia spumigena*) on three occasions at a coastal station in the Baltic proper during the summer 2002, using four plastic hoses with the inner diameters 1.3, 2.5, 3.3 and 4.9 cm, to get integrated samples of the surface water. Six replicates were taken with each hose on each occasion. Total filament length of *Aphanizomenon* sp. and *N. spumigena* were estimated by manual counting with an inverted microscope and filaments of *Aphanizomenon* sp. were also estimated with the image analysis program Leica Qwin. Total filament length of *Aphanizomenon* sp. per volume of water from the different sampling occasions, hoses and methods of estimating filament length were compared by 3-way ANOVA. There were no significant differences neither between types of hoses nor methods of estimation (manual counting - image analysis) or any interaction effects between these factors. The only significant effect arose from the different sampling occasions (P<0.001). Our results suggest that hoses with different inner diameters sample filamentous cyanobacteria equally well, and that image analysis gives the same estimates of filament length as traditional manual counts. Image analysis is faster and automatically provides additional information such as statistical distributions and individual filament lengths.

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**ICES CM 2003/L:11**

**Development and distribution of plankton observed with a FerryBox system for monitoring coastal waters**

Henning Wehde, Wilhelm Petersen, Michail Petschatnikov, Friedhelm Schroeder, and Franciscus Colijn

Ships-of-opportunity like ferries offer cheap and reliable measuring platforms to make automatic observations of coastal waters. Results of observations made on a route between Cuxhaven (Germany) and Harwich (UK) which is covered every night are presented. The FerryBox system has sensors and analysers for the parameters salinity, pH, oxygen, turbidity, fluorescence, ammonium, nitrate/nitrite, o-phosphate and silicate. Strong gradients in both nutrients, and turbidity can be easily observed in the coastal vicinity on both sides of the transect. This study will focus on the distribution and development of phytoplankton which is strongly influenced by the physical environment. The observations in the North Sea clearly show low winter values in chlorophyll *a* over most part of the transect, nearby coastal effects of riverine loadings, and patchy distribution of algal blooms along the transect in spring and summer. Data for different algae groups measured by excitation with different wavelengths are analysed and compared with pigment analysis and cell countings.

Keywords: plankton monitoring, FerryBox system, plankton development, plankton distribution, North Sea.

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**ICES CM 2003/L:12 Withdrawn**

**ICES CM 2003/L:13**

**Spatial mapping of chlorophyll concentration in the Baltic Sea through the assimilation of satellite data with ship-of-opportunity observations**

Jouni Pulliainen, Jenni Vepsäläinen, Seppo Kaitala, Kari Kallio, Eija Rantajärvi, and Sampsa Koponen

Unattended flow-through fluorometers are currently operatively employed in the Baltic Sea to provide information on chlorophyll *a* concentration and distribution. This information is collected on a daily basis by merchant and passenger vessels operating in the region (automated Alg@line sampling system). The observations can be used for the general assessment of the status of the Baltic Sea, as chlorophyll *a* (chl-*a*) concentration is one of the key factors of water quality. However, the spatial coverage of these ship-of-opportunity data is restricted to transects cruised by vessels. Space-borne optical spectrometers, such as SeaWiFS and MODIS, provide daily remote sensing reflectance observations correlated to chl-*a* concentration of surface water layer. These data are available whenever cloud conditions permit. Spectrometers can be used for the mapping of chl-*a* using empirical or semi-empirical algorithms.
However, their accuracy is limited in the brackish waters of the Baltic Sea due to the relatively high turbidity and yellow substance (CDOM) level. The optimum method to apply satellite data is the assimilation of remote sensing observations with *in situ* data. This is demonstrated in this investigation by introducing a method that takes advantage of the high accuracy of Alg@line transect data together with the full spatial coverage of satellite observations. It is shown that the developed method significantly improves the quantitative regional water quality assessment accuracy when compared with the use of (a) only the transect data or (b) only the space-borne data.

Keywords: Remote sensing, MODIS, SeaWiFS, chlorophyll *a*, CDOM, fluorometer.

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