HIGH FREQUENCY MONITORING IN LIVERPOOL BAY; VARIABILITY OF SUSPENDED MATTER, NUTRIENTS AND PHYTOPLANKTON

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Background

SmartBuoy awaiting deployment

Liverpool Bay is a turbid, shallow and tidally energetic coastal embayment of the Irish Sea that receives nutrient inputs from the estuarine area of the Mersey as well as from coastal sewage discharges. Traditional ship-based surveys provide good spatial resolution but poor temporal resolution of the episodic changes occurring in this highly dynamic area. CEFAS has developed SmartBuoy, a moored platform to provide high frequency surface measurements of chemical, physical and biological parameters which are published in near real-time to the internet (Mills *et al*, 2002, www.cefas.co.uk/monitoring). SmartBuoy has been operational in the North Sea since 2000 and a SmartBuoy has been deployed in Liverpool Bay since November 2002 as part of the Liverpool Bay Coastal Observatory Programme (Proctor *et al*, 2004, www.cobs.pol.ac.uk), co-ordinated by the Proudman Oceanographic Laboratory (POL). The high-frequency measurements provided by SmartBuoy in Liverpool Bay will better resolve the full scale of temporal variability and increase the evidence base and confidence when making formal assessments of eutrophication in the area.

Approach

SmartBuoy is a platform which collects high-frequency measurements of chemical, physical and biological variables in near-surface waters (Table 1). The SmartBuoy in Liverpool Bay is located in a grid of sampling stations (Figure 1). There are approximately nine cruises a year during which the mooring is serviced and samples are collected at the grid stations for determination of salinity, suspended load, nutrients and chlorophyll.

Table 1: Details of the SmartBuoy payload, variables measured and sampling frequency.

Instrument/Sensor	Variable	Sample frequency
Multi-channel logger and system controller with telemetry, interfaced with various sensors	Salinity Temperature Chlorophyll fluorescence Turbidity PAR irradiance at 1m and 2m	1Hz in 2 x 10 minute bursts/hour
Aqua Monitor water sampler	TOxN (total oxidisable nitrogen) Dissolved silicate Suspended load Phytoplankton counts and composition	Up to daily
NAS-2E and NAS-3X in-situ nitrate analyser	TOxN (total oxidisable nitrogen)	2 hourly

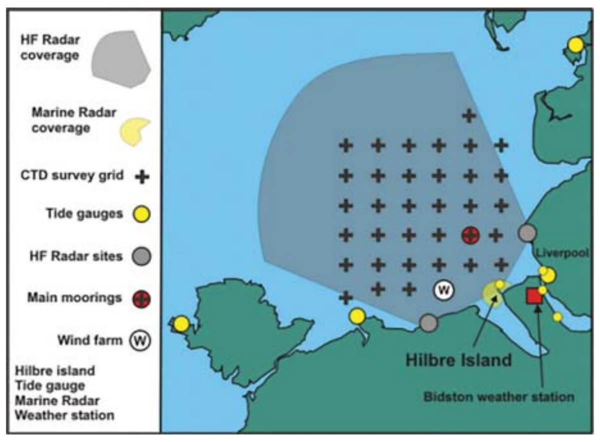

Figure 1: Location of SmartBuoy (main moorings) and sampling sites in the study area.

Results

Tidal, seasonal and inter-annual variability in the measured parameters is evident in the time series plots. Turbidity is generally highest and more variable in the winter months of October to April (Figure 2a). The OBS sensor is calibrated using the results from the gravimetric determination of suspended load from the Aqua Monitor samples. This reveals that suspended load concentrations reached a maximum of 220 mgl^{-1} in 2003 and 340 mgl^{-1} in 2004. The vertical attenuation coefficient calculated from downwelling PAR (Photosynthetically Active Radiation) measured at at 1m and 2m, closely follow the turbidity results (Figure 2b). The major factor controlling Kd is the concentration of fine suspended minerogenic material; high suspended load leads to high attenuation and therefore low penetration of light into the water column.

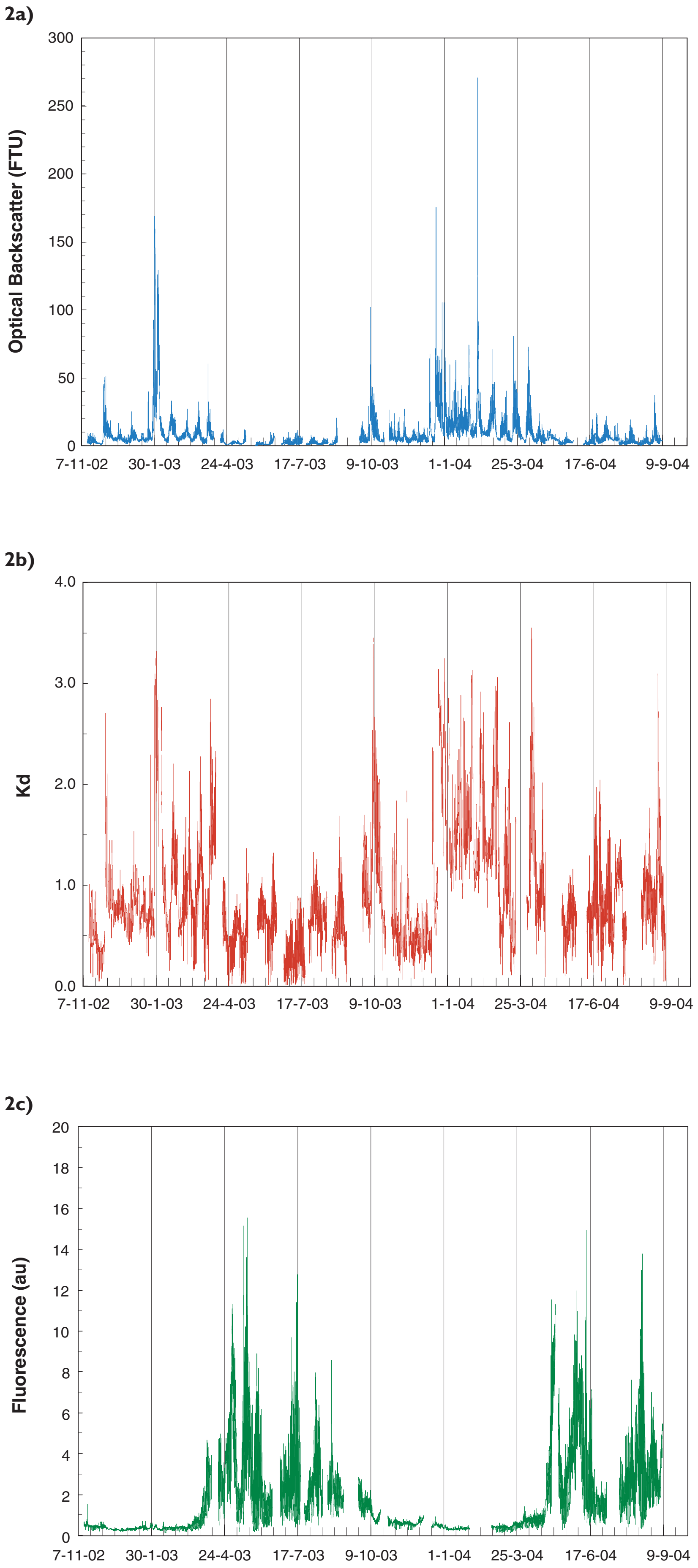

*Figure 2: Time series of **a)** optical backscatter, **b)** vertical attenuation coefficient Kd and **c)** chlorophyll fluorescence measured at the surface in Liverpool bay*

The spring bloom in 2003 started in mid-April and was later in 2004, starting at the beginning of May. Chlorophyll fluorescence values were similar in both years and decreased to over-winter levels during October (Figure 2c). Analysis of water samples for phytoplankton species composition revealed that diatoms dominated during the spring bloom in April 2003, with cell concentrations reaching 0.8 x 10^6 cells l^{-1} (Figure 3). The concentration of diatoms then decreased whilst flagellate cell numbers increased, reaching a maximum of over 1 x 10^6 cells l^{-1} at the end of August. Two harmful algal bloom species, *Dinophysis acuminata* and *D. Norvegica*, were found to be present.

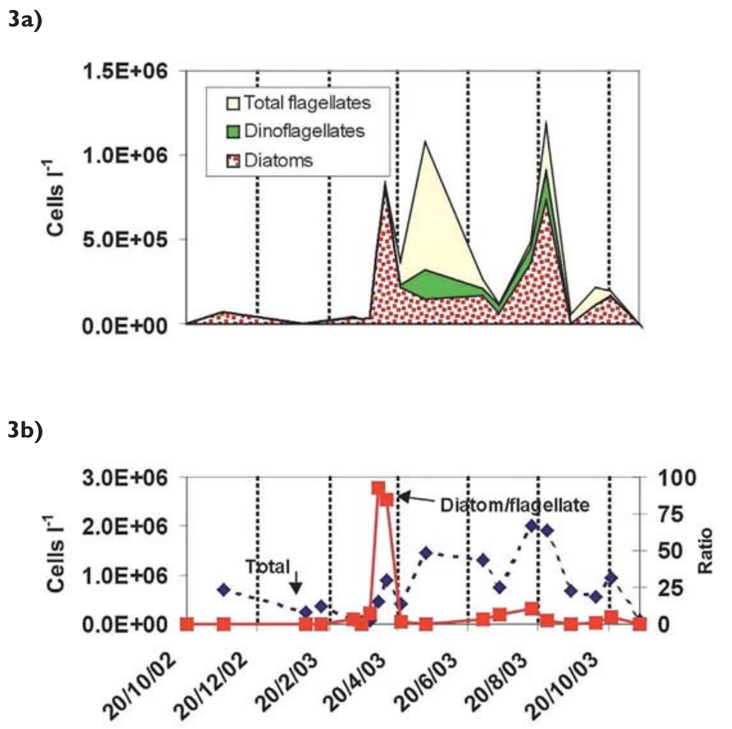

*Figure 3: Time series of **a)** phytoplankton biomass as cell numbers for the major taxonomic groups and **b)** total cell numbers and the diatom to flagellate ratio in Liverpool Bay.*

Winter maxima and summer minima of TOxN and silicate are evident at the SmartBuoy site (Figure 4). Liverpool Bay is hyper-nutrified during the winter; peak over-winter TOxN concentrations reached over 35 µM in 2002/3 and over 60 µM in 2003/4. Peak Si concentrations reached over 20 µM in the winter of both years. There is substantial short-term variability in the high frequency TOxN record obtained from the NAS, which is driven by freshwater inputs.

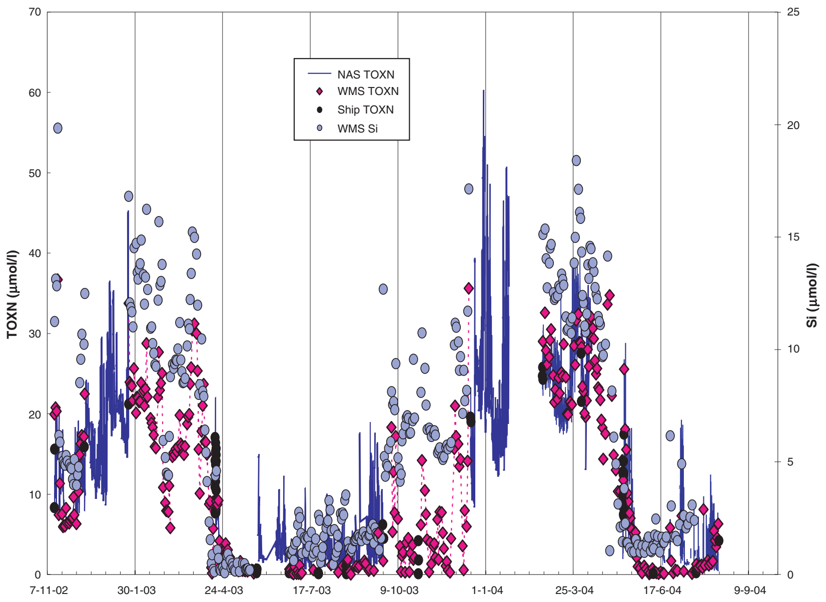

Figure 4: Plant nutrient concentrations measured at the surface in Liverpool Bay. Data shown are from the NAS, water sampler and discrete samples

Winter nutrient data are of specific interest with regard to formal assessments of eutrophication for OSPAR. Data from the SmartBuoy have been compared to winter nutrient data collected using ship-based surveys (Figure 5a). The data from the SmartBuoy lie within the spread of historic ship-based data. However, results from the SmartBuoy in 2002 give a median and mean of 16 µM (Figure 5b) compared to a mean of 10 µM and a median of 12 µM for ship-based observations. Concentrations of TOxN measured by the SmartBuoy in 2003 were greater than in 2002, with a mean and median of 22 µM. Concentrations of TOxN in both years therefore exceeded the OSPAR threshold of 10.8 µM.

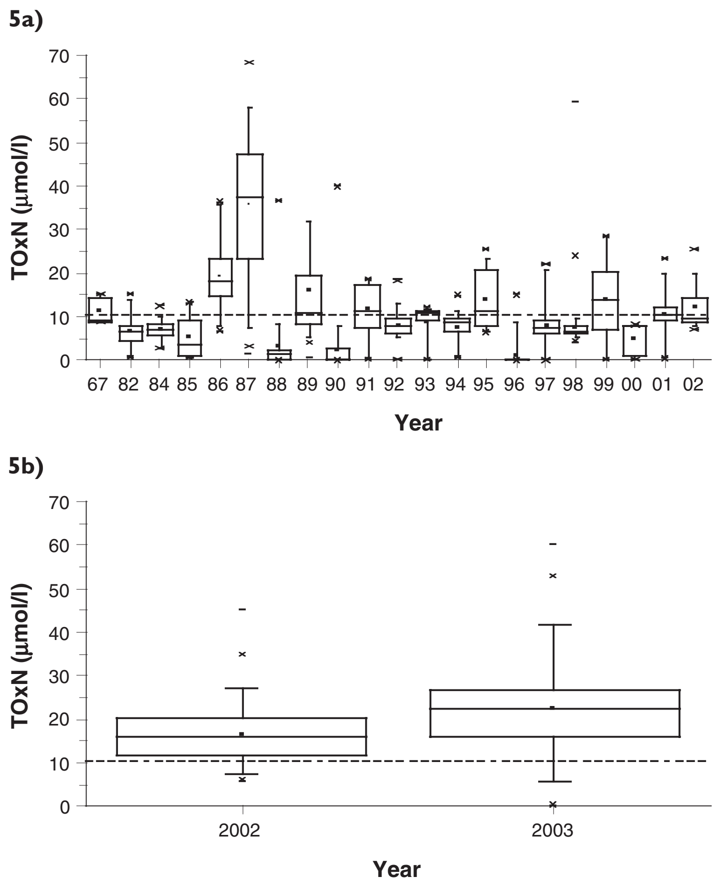

*Figure 5: Box plots of winter TOxN concentrations in Liverpool Bay from **a**) ship-based measurements from a wide range of programmes and **b**) from the in-situ analyser, water sampler and discrete samples. Dotted Line is the t10.8 µM threshold TOxN concentration for the OSPAR region of Irish Sea/Liverpool Bay*

Discussion and Conclusions

The data clearly demonstrate that there is substantial temporal variability, hourly, seasonally and annually, in the parameters measured. Suspended load concentrations reach a maximum over the winter, leading to high attenuation of light. During the same period, nutrient concentrations are elevated and in 2002 and 2003, concentrations of TOxN exceeded the OSPAR threshold. Nutrient concentrations fall in April/May associated with an increase in the concentration of phytoplankton. Diatoms dominate during the first month of the bloom after which flagellate cell numbers increase.

A second SmartBuoy is to be deployed in Liverpool Bay in May 2005. Data from both buoys will be compared to assess the spatial variability of the measured parameters.

References

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