# Phytoplankton bloom dynamics in Liverpool Bay

N. Greenwood, R.M.Forster, S.J.Cutchey, D.K.Mills, D.B.Sivyer and D.J.Pearce
Centre for Environment, Fisheries & Aquaculture Science, Lowestoft
www.cefas.co.uk
J. Howarth
Proudman Oceanographic Laboratory, Liverpool
www.pol.ac.uk

## Introduction

Liverpool Bay is a turbid, shallow (20 m) and tidally energetic (min. range: 2.7 m, max. range: 9.7 m) coastal embayment of the Irish Sea that receives nutrient inputs from the estuarine area of the river Mersey as well as from coastal sewage discharges. Cefas has developed SmartBuoy, a moored platform to provide high frequency surface measurements of chemical, physical and biological parameters (Table 1) which are published in near real-time to the internet (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), coordinated by the Proudman Oceanographic Laboratory (POL).

*Figure 1. Location of SmartBuoy in Liverpool Bay.*

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

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

## Acknowledgements

This work has been funded by Defra (contracts A1228 and AE004). SmartBuoy data has been provided by the Cefas Marine Observations Systems team. We would like to thank the Proudman Oceanographic Laboratory and the crew of the RV Prince Madog. Access to RS imagery was supported by the ESA MarCoast project.

## References

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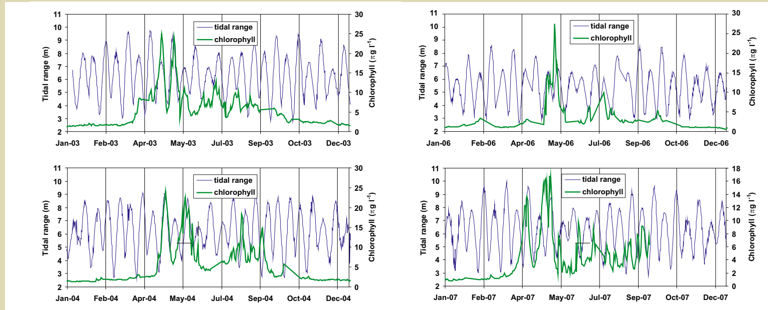


*Figure 2. Time series of tidal range and chlorophyll for 2003, 2004, 2006 and 2007. Blooms often initiate at neap tides when tidal energy is lowest and reach their maximum concentration at spring tides when tidal energy disperses the bloom.*

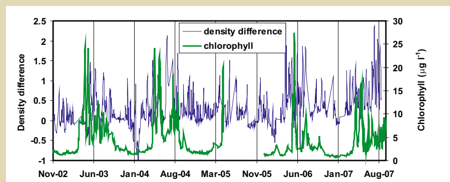


*Figure 3. Time series of density difference (bottom minus surface) and chlorophyll. There is recurrent and strong vertical stratification in Liverpool Bay.*

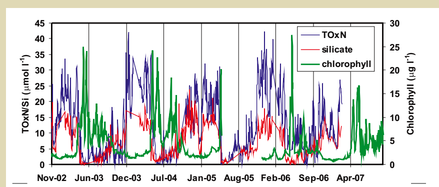


*Figure 4. Time series of chlorophyll, total oxidisable nitrogen (TOxN) and silicate. The onset of the spring bloom results in a rapid draw down of nutrients. There are significant pulses of both nutrients throughout the summer from riverine input.*

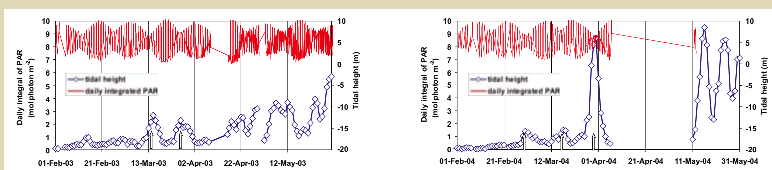


*Figure 5. Daily surface mixed layer depth irradiance in 2003 and 2004. The neap/spring cycle is important in controlling the amount of suspended particulate matter in the water which affects the underwater climate.*

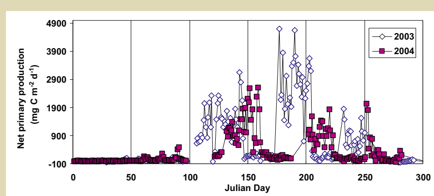


*Figure 6. Mean daily net production for 2003 and 2004. From day 55 (2003) and day 60 (2004) onwards, irradiance and temperature conditions become more favourable so that net gains of carbon are possible on most days, except at peak spring tides when high $K_d$ reduced irradiance to below the compensation point.*

## Materials and methods

The SmartBuoy in Liverpool Bay is located in a grid of sampling stations (Figure 1). Samples are collected at the grid stations for determination of salinity, suspended load, nutrients and chlorophyll and results are used to calibrate the electronic sensors.

Bottom density was calculated from conductivity and temperature measurements near the seabed (POL). Primary production was estimated using the model of Forster *et al.* (2006).

Daily MODIS satellite images of chlorophyll a concentration at the surface of the water column were obtained by Ifremer and processed using the OC5 algorithm of Gohin *et al.* (2002) for case-II waters.

Tidal range was derived from tide gauge measurements at Gladstone Dock, Liverpool in 2003, 2004 and 2007 and at Llandudno in 2006.

## Results

- Both tides and the vertical density structure of the water column influence the underwater light climate and consequently the occurrence of the algal blooms
- Bloom formation and dispersion is influenced by tidal energy
- Spring phytoplankton blooms are supported by the winter nutrient pool
- Small phytoplankton blooms appear regularly throughout the summer supported by pulses of nutrients and a favourable light climate

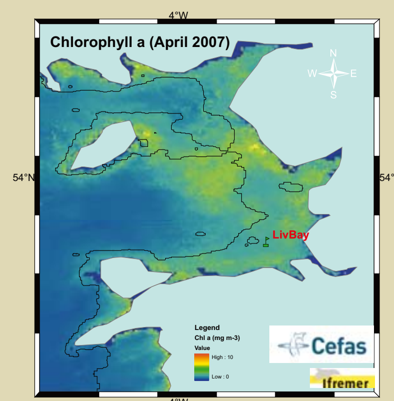


*Figure 7. Chlorophyll concentration in Liverpool Bay in April 2007 from satellite images (MODIS, OC5 algorithm). High chlorophyll concentrations are observed close to the coast.*

## Conclusions

The combination of observations from ships, buoys, bottom landers and remote sensing are providing new insights into the Liverpool Bay ecosystem structure and function and a better understanding of the response to anthropogenic nutrient inputs. This provides the evidence on which to carry out more robust assessments of eutrophication.