Under-water light regime and SPM: a multiple grain-size model and SmartBuoy observations

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Introduction

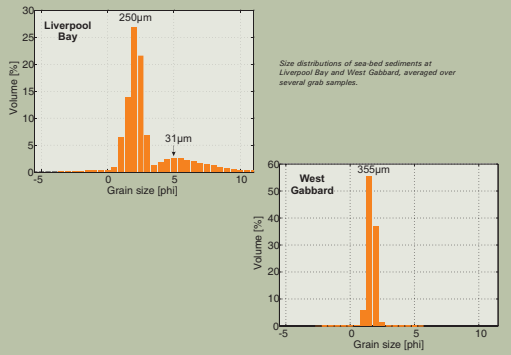
Coupled physical-biogeochemical models are used to increase our understanding of marine ecosystem structure and function. The under-water light regime in coastal seas is still poorly predicted, with implications for the modelled growth response of phytoplankton. The main cause is inaccurate representation of suspended particulate matter (SPM) concentrations (e.g., Allen, 2007).

Recent high quality, high-resolution time series of SPM concentrations and light attenuation, observed by SmartBuoy in UK coastal waters (Mills *et al.*, 2003), provide a unique test bed for model development.

The **main aims** of the study are to:
- Test a new SPM model
- Test a light-attenuation formulation (Baker & Lavelle, 1984)

Study sites

Sea-bed sediments



Size distributions of sea-bed sediments at Liverpool Bay and West Gabbard, averaged over several grab samples.

SPM model

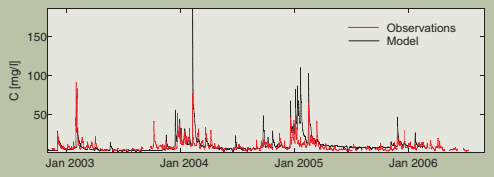
Model description

Hydrodynamics
- One-dimensional General Ocean Turbulence Model (GOTM, Burchard *et al.*, 1999)
- Wave observations from WaveNet (www.cefas.co.uk/wavenet)

SPM
- Advection-diffusion equation
- Multiple, non-cohesive size fractions
- Temperature dependence of the kinematic viscosity
- Pickup:
  - Currents and gravity waves
  - Diffusion from reference concentration
  - Fines regulated by coarse fraction

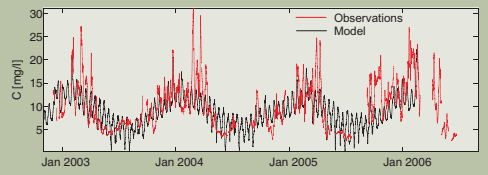
Results

Surface concentrations: Liverpool Bay
- Good reproduction of the seasonal cycle
- Reproduction of response to individual storms



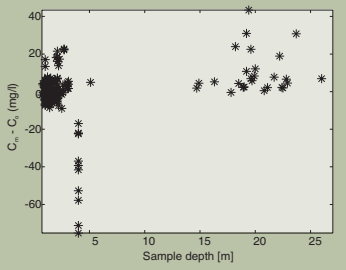
Surface SPM concentration, Liverpool Bay, 25 hr moving average (see www.cefas.co.uk/monitoring for further details)

Surface concentrations: West Gabbard
- Reasonable reproduction of the seasonal cycle
- Summer spring-neap tidal variability over-estimated
- Temperature-dependent kinematic viscosity determines 50% of seasonal variability



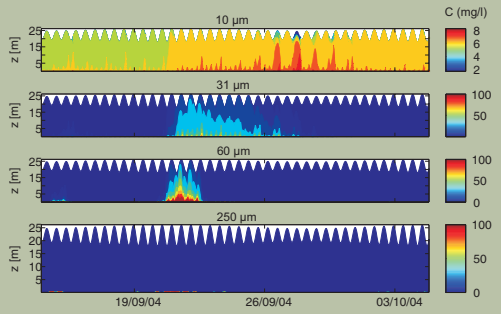
Surface SPM concentration, West Gabbard, 25 hr moving average

Water-column concentrations: Liverpool Bay
- Model performance at depth is comparable to that at the surface
- Hence, assumed ratio between size fractions in the sea bed is reasonable



Difference between modelled and observed concentration (water samples) as a function of depth

Spring-neap cycle with storm
- Fine fractions more evenly distributed vertically
- Fine fractions take much longer to settle
- Surface and bottom concentration maxima are alternating



Modelled size-dependent response to a storm, Liverpool Bay.

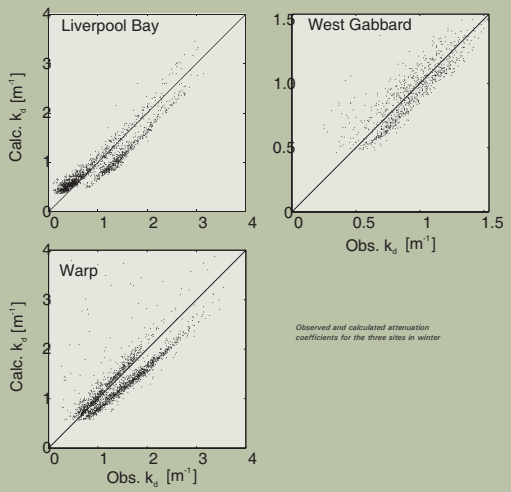
Light attenuation

Light-attenuation formulation

- Baker & Lavelle (1984)
- Multiple grain-size fractions
- Correction for shape of grains
- Dependence on wave length of light
- Input: observed, bulk SPM concentration from SmartBuoy

Results: attenuation at three sites

- Calculated values mostly fall within 0.5 m^{-1} of the observations



Observed and calculated attenuation coefficients for the three sites in winter

Conclusions

The SPM model gives a good representation of the seasonal variations in SPM concentrations at the SmartBuoy sites. Although improvements are possible (e.g., inclusion of memory of the sea bed, inclusion of cohesion), the present version is expected to give improved predictions of the under-water light regime when implemented in a full 3D ecosystem model together with the Baker & Lavelle (1984) light-attenuation method. The outcome should be an improved simulation of the response of phytoplankton to nutrient inputs.

Acknowledgements

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The Cefas sedimentology team carried out the grain-size analyses of sea-bed samples.

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