SMARTBUOY: A MARINE ENVIRONMENTAL MONITORING BUOY WITH A DIFFERENCE

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Background

SmartBuoy has been developed to provide a platform that can reliably and cost effectively collect physical, biological and chemical data over extended periods (> 1 yr) with the temporal resolution necessary to detect the rapid changes that characterise our shelf-seas. Its introduction into the UK marine monitoring programme is important for the development of an effective monitoring strategy for improved assessment of nutrient status and ecosystem responses against a background of increased concern over the health of European coastal seas. The value of the SmartBuoy approach has been demonstrated in recent sediment transport studies (Mills *et al*., 2002; Rutgers van der Loeff *et. al*., 2002), focused on the role of storm induced resuspension.

The SmartBuoy Approach

A unique aspect of the SmartBuoy is the built in redundancy for key measurements. For example, plant nutrient concentrations are derived water samples collected using an automated water sampler (Aqua Monitor) and also by the NAS2E *in-situ* nutrient analyser. Currently, nitrate is measured (hourly) whilst nitrate and silicate are measured (daily) on preserved water samples. Water samples can also be analysed for phytoplankton biomass and species composition as well as for gravimetric determination of suspended matter concentration. Such measurements on discrete water samples can be used to validate or calibrate sensor derived measurements. Measurements of salinity, temperature, irradiance and chlorophyll fluorescence are also made in parallel. Meteorological variables can also be measured on SmartBuoy.

Figure 1: SmartBuoy alongside after deployment showing the surface met sensor package.

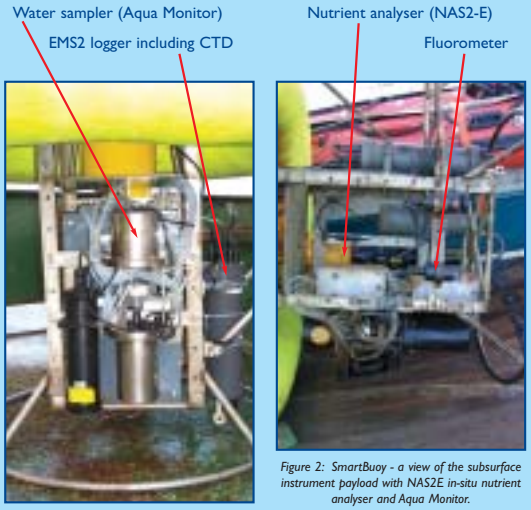

Figure 2: SmartBuoy - a view of the subsurface instrument payload with NAS2E in-situ nutrient analyser and Aqua Monitor.

Appropriate Strategy

As part of a joint UK-Netherlands collaborative programme a SmartBuoy was deployed in Dutch coastal waters over a 25 month period. Data presented in Figure 3 is from Noordwijk 10 and shows a continuous record over an 18 month period that exhibits variability on a range of different time scales. Inter-annual variability is demonstrated in the records for plant nutrients (Figure 3f) chlorophyll concentration (Figure 3e) and temperature (Figure 3c). Over-winter maxima and summer minima in plant nutrients are the inverse of chlorophyll where low winter values are followed by a spring peak and a series of smaller summer blooms. There is also evidence of short term variability particularly in turbidity (Figure 3b) and the vertical attenuation coefficient (Kd; Figure 3c). The wave climate recorded nearby (Meetpost Noordwijk) shows the general relationship between increased wave height and turbidity. For example, the extreme wave heights in May 2000 were associated with force 10 winds and a large increase in turbidity (see Mills *et al*., 2002).

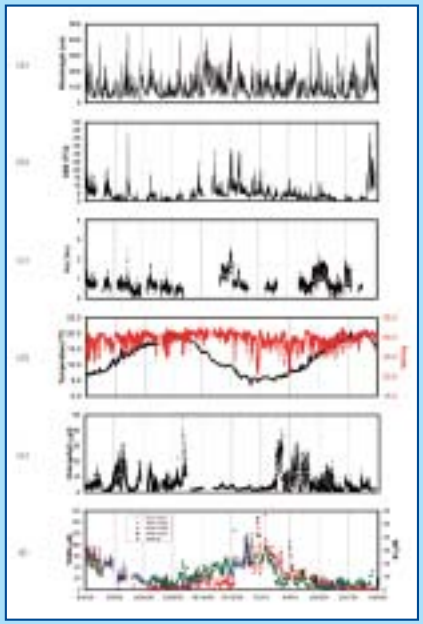

Figure 3. Time series data from Noordwijk 10 showing (a) significant wave height, (b) turbidity measured using an optical backscatter sensor, (c) the vertical attenuation coefficient (Kd) derived from measures of downwelling irradiance at 1 and 2 m depth, (d) salinity and temperature, (e) chlorophyll concentration and (f) plant nutrient data. Total oxidisable nitrate (nitrate + nitrite) was measured using the NAS2E in-situ nutrient analyser as well as on preserved water samples (WMS TOXN) together with silicate (WMS Si). Data collected from a vessel alongside the buoy is also shown (RIKZ TOXN).

Smart Control and Data Acquisition

SmartBuoy Data acquisition and control is performed by ESM controllers, which employ a distributed data acquisition technique comprising several linked autonomous sub-modules. This makes for a highly robust system designed to withstand catastrophic failure of individual modules. Each SmartBuoy sub-module acquires and stores data and then makes the data packet available to the main ESM controller. Data are then replicated between the main controller and individual modules. SmartBuoy data are stored on high-capacity removable memory in the form of Compact Flash cards.

Software

The ESM generates a data email and transfers it to a satellite transceiver. Data then goes to a user designated mailbox at the users site. The SmartBuoy software package acquires the necessary ESM information from the email, retrieves the deployment record from the database, and checks the email for the correct sensors and any spurious characters. The current calibrations from the database are then applied to the values in the email and from calibrated data added to the telemetry result table on the database. The program also generates graphics for the internet and intranet websites (**http://www.cefasdirect.co.uk/monitoring,** Pearce *et al*., 2002).

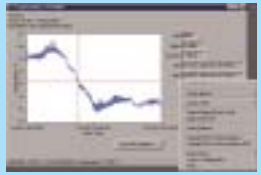

Figure 6: Graph of temperature data with statistics, moveable cursors and multi-function menu.

Figure 5: Database record for a sensor (allows access to calibration details).

The sophisticated Smart Buoy software environment is designed for secure reliable data processing of a data stream from just a single buoy up to large multiple buoy monitoring network.

Telemetry - World Wide Real Time Data

The buoy is equipped with a sophisticated telemetry system that is highly integrated with the data archive, dissemination and visualisation software installed at base. Generally SmartBuoy utilises a satellite data transport system to enable wide area cover and global reach. A GPS receiver is included to provide position data with every transmission. If the SmartBuoy moves out of its 'watch-circle' an out-of-position alert is automatically generated and disseminated by email message as an operators option. Other telemetry options include UHF radio modems.

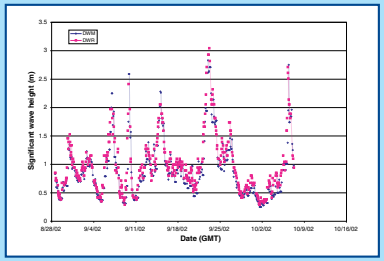

Figure 7: Significant wave height as measured by SmartBuoy's Directional Wave Monitoring (DWM) system and a WaveRider Buoy during sea trials.

The Future

Additional parameters

New developments will enable SmartBuoy to meet a wider range of emerging needs. In particular, a new directional wave monitoring system for SmartBuoy is at an advanced stage of development with sea trials underway. This additional SmartBuoy capability will be commercially available in 2003.

Increased endurance

A third generation of SmartBuoy is currently in an advanced state of development and has been enhanced to specifically address the issue of both macro and micro-scale biofouling. In addition, SmartBuoy 3 has been re-designed to:

- enable increased operational efficiency,
- minimise surface area to reducing opportunities for fouling,
- aid deployment, recovery and servicing,
- further increase reliability and data return,
- widen the geographical application of the buoy,
- increase payload capacity.

The net effect will be to drive down operational cost while improving data quality and reliability.

References

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