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Real-time Prediction System of Bathing Water Quality at Bray, Co. Wicklow, Ireland

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Real-time Prediction System of Bathing Water Quality at Bray, Co. Wicklow, Ireland

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Background

Variations in water quality at recreational bathing beaches can have significant impacts with respect to compliance with related water quality standards, such as Directive 76/160/EEC. The "Blue Flag" award which bases its water quality standards upon the guideline E.coli levels of Directive 76/160/EEC, has become the measure of recreational value of bathing areas. Loss of such designations can have significant impacts with respect to local tourist economies. A revised Bathing Water Directive (Directive 2006/7/EC) came into force in 2006 and will supersede the existing 1976 Directive with effect from December 2014.

The revised Directive gives stronger focus on the protection of public health, a proactive approach to the management of bathing water quality and greater public participation. It establishes stricter microbiological standards for two new parameters, Intestinal Enterococci (I.E.) and Escherichia coli (E.coli). The directive introduces a new classification system determined on the basis of a four-year period instead of the monitoring results from a single bathing season. This will give a balanced rating that allows for the discounting of short-term pollution incidents. However, discounting is facilitated in the revised directive by an understanding of water quality variation and the ability to provide real-time prediction of faecal indicator organisms (FIOs) at bathing beaches.

This paper presents findings of the SMART COASTS research project (www.smartcoasts.eu), that develops a real-time predictive model of bathing water quality, using physically-based integrated catchment and coastal modelling tools.

Keywords: integrated model, bathing water quality, real-time predictions

Study Area

The study is being undertaken at Bray, Co. Wicklow, where the River Dargle discharges to the Irish Sea (Figure 1). The beach is of national recreational and heritage value and is a designated EU bathing site, serving a rapidly growing population at Bray town (32,000 in 2006) as well as nearby towns and villages. The Dargle catchment, with an area of 133 km^2, is characterised in its upland catchment by bog and forestry and downstream, arable, sheep, dry stock and dairy farming together with an urbanised fraction make up the land use.

Another pressure on the bathing water quality at Bray beach is sewage discharges. The untreated wastewater from Bray town is discharged through a long-sea outfall (approximately 1.5km offshore Bray beach) and is a source of pollution, particularly when easterly winds prevail.

In addition, during storm events raw sewage is sometimes pumped through a pipe adjacent to the North wall of Bray harbour.

Methodology

Development of an integrated catchment-coastal model

The study uses a physically-based suite of flow and water quality models developed by the Danish Hydraulic Institute (DHI).

Firstly, a rainfall-runoff catchment model of the Dargle catchment was developed using the MIKE11 flow model and ECOLAB (the water quality module). Inputs to the model include digital elevations (from a DEM) for catchment delineation, rainfall, temperature, wind, flow and water quality data. The catchment model simulates diffuse and point source flow and concentrations of E.coli and I.E.

Following this, a coastal model for the near-shore waters of Bray was constructed using the three-dimensional hydrodynamic MIKE3 model coupled with the water quality model ECOLAB. The model uses bathymetric data to form the finite volume mesh and tidal elevations and wind data as boundary conditions to drive the model. Flow velocity and water quality data were used to calibrate the models. The coastal model simulates the transport of E.coli and I.E. discharged from a number of sources in the study area (long and short-sea sewage outfalls at Bray, discharges from other sewage plants in the study area, the Dargle river outflow and direct discharges into the coastal waters).

The catchment and coastal models are internally-linked (integrated) so that river discharges from the Dargle catchment forms an inflow boundary into the coastal model.

Data Collection

To facilitate the calibration and validation of the catchment and coastal models, a comprehensive set of data is required. The installation of 20 sensors in the Dargle catchment (Figure 1) to measure, river flow and a suite of meteorological parameters was completed for this purpose in 2011. An extensive data collection is in progress for the current bathing season and is due to be completed by September 2012. This includes the following:

(i) Dargle river sampling:

Sensor data is telemetrically delivered to an online database where an interactive viewing facility for continuous monitoring of the time-series data is available. In addition, sampling programmes provide monthly baseline, weekly and storm related concentrations of E.coli and I.E at 10 locations in the river.

(ii) Marine Sampling:

Water speed and direction was measured using a bed-mounted Acoustic Doppler Current Profiler (ADCP), at 6 selected monitoring sites for the duration of neap and spring tidal cycles. Hourly samples of E.coli and I.E. were collected at 8 marine locations (Figure 1) for the duration of both a spring and neap tidal cycles. These are complemented by vertical profiles of temperature and salinity to detect the salinity and temperature differences caused by the riverine inflow into marine waters.

Development of web-based predictive tool for bathers and stakeholders

The calibrated integrated catchment-coastal model will feed into a data-base (Figure 2), along with forecasts of rainfall, temperature (obtained from the Irish Meteorological Services) and tidal elevations (from MIKE global tidal model), E.coli and I.E. predicted loads. The predicted temporal and spatial distributions of E.coli and I.E in the near-shore coastal waters will be used to forecast water quality at the designated bathing site at Bray. The information will be disseminated to the public and stakeholders (Beach Manager, Local Authority) via the internet (Figure 3).

Results

Preliminary model results show a reasonable match to the observed hydrodynamic patterns in the coastal waters. The flow is predominantly in the North-South direction but deflected around Bray Head and drawn into near-shore zone of Bray.

Figure 4 shows the distribution of E.coli at four stages of the tidal cycle in response to discharges from two wastewater outfalls in the study area.

Data collected during the bathing season June – September 2012, will be used to calibrate and validate the model and will be available for the final manuscript, if accepted.

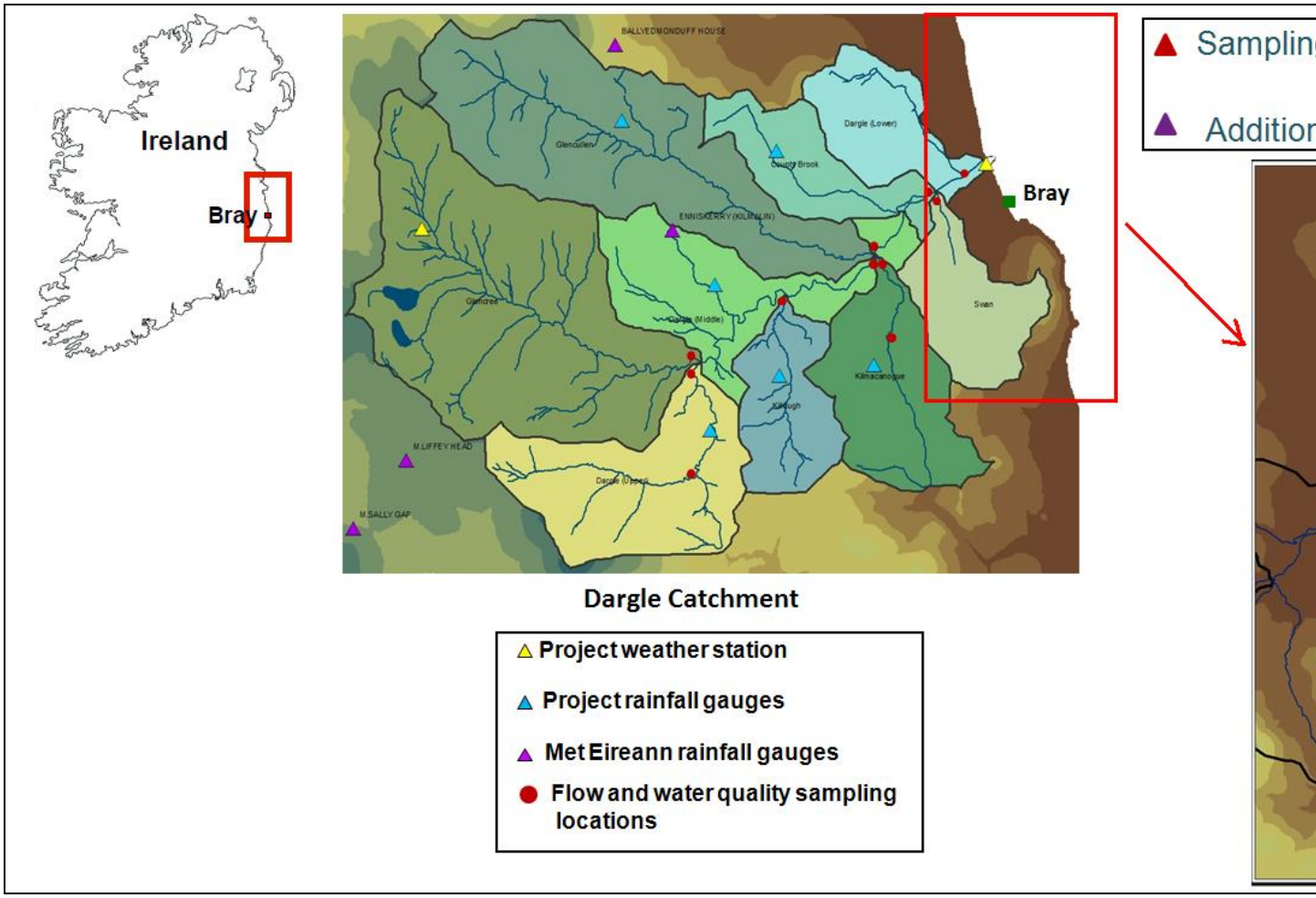

Figure 1: Study Area: Dargle catchment with sensors locations, marine sampling locations (right)

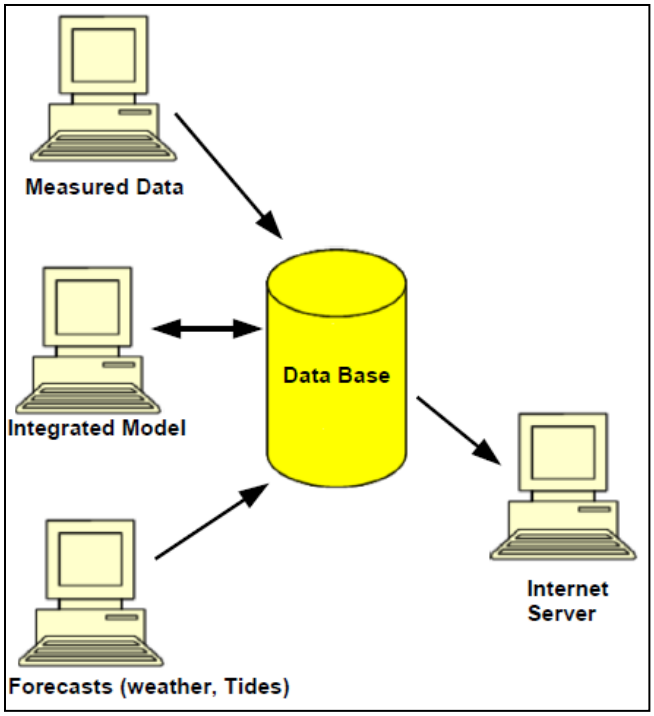

Figure 2: Components of the predictive bathing water quality model

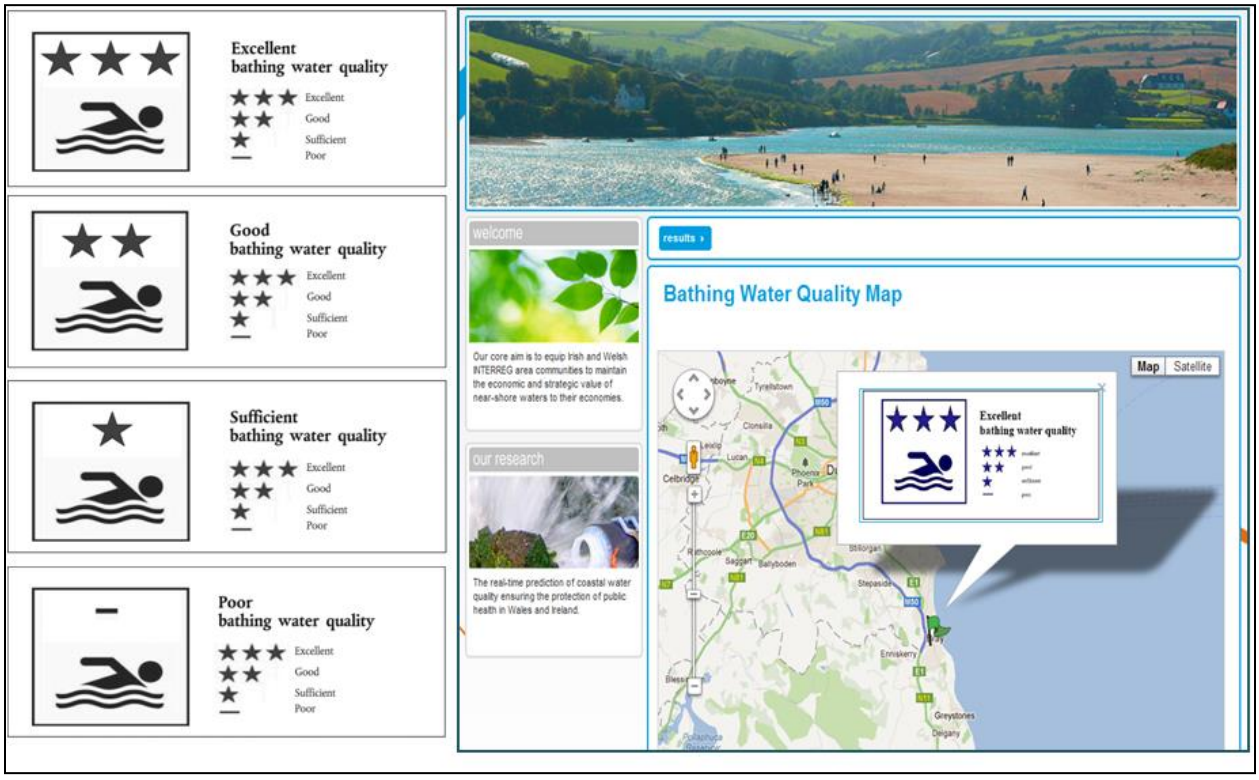

Figure 3:Web-based predictive tool of bathing water quality for Bray, Co. Wicklow

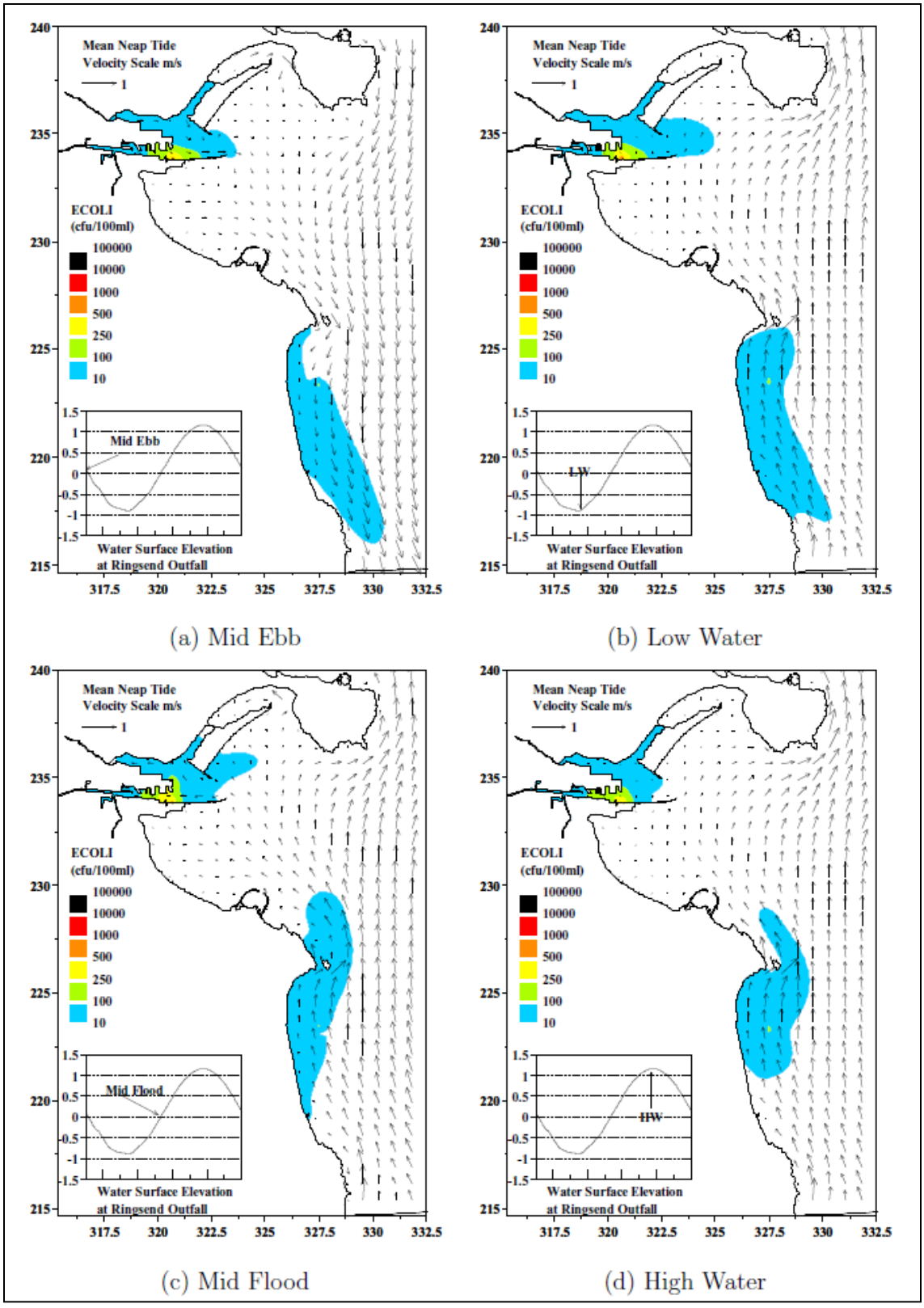

Figure 4: E.coli distribution at four stages of a mean neap tidal cycle