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"3 Dimensional Hydrodynamics and Residence Time of a Marine Lough"

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Lough Hyne in Co. Cork is Ireland's only statutory Marine Reserve and is a marine lake which is connected to the open ocean by a narrow constricted channel. A large part of the Lough has a depth of 20-25m and is oxic throughout the year. The Western Trough is 40-50m deep and experiences profound summer hypoxia below the thermocline. The concentration of dissolved oxygen (DO) decreases rapidly following the stratification of the water column by the increase in atmospheric temperature during summer and poor water circulation. The establishment of this hypoxia causes mass mortality of the benthic fauna and such a phenomenon does not occur in any other sea lochs in the UK and Ireland. The residence time (RT), i.e. the time for a water parcel within the Lough to flow out past the system boundary, of Lough Hyne is currently unknown. The RT is a crucial parameter in the description of the health of any marine system. Small to medium values of RT suggest good water exchange between the system and external waters.

In the current research project, MIKE3 software as developed by DHI (Danish Hydraulic Institute) is used to model the 3D aspects of the flow in order to better understand the behaviour of the Lough. The model is capable of resolving buoyancy-driven flows in 3-dimensions allowing accurate simulations of stratified flows. Time series of atmospheric conditions, including temperature, wind speed etc. may be applied to the model domain allowing all necessary components affecting the flow to be modelled. MIKE3 incorporates the ECOLab module which uses the results of the hydrodynamic simulation to model the dispersal of nutrients, using the advection-diffusion equation, within the model domain.

Calibration and validation of the model is currently ongoing, using measurements from long-term deployed tide gauges and a thermistor-chain inside the Lough. Discrete point measurements of DO, temperature and salinity across the Lough over individual tidal cycles have enhanced the calibration process. Initial simulations have shown the effect of the tidal channel on water levels and flows within the Lough. This narrow connection to the ocean, "The Rapids", modifies the tidal curve within the Lough substantially. The flood tide, lasting around four hours, is constricted such that high tide within the Lough is lower and later than the adjoining bay. The flood tide flows through the Rapids at a very high flow rate, resulting in large turbulence and the set up of an anticlockwise eddy circulation in the South Basin on entry into the Lough. The fate of this flood tide plume is under investigation and is considered to be the main source of interference at the thermocline resulting in periodic episodes of oxic water entering the hypolimnion. The ebb tide lasts approximately eight hours and the Rapids draw water from all depths of the South Basin during ebb flow. The Spring Tide range of the Lough is approximately 1m in comparison to 3.5m in the adjoining bay.

The preliminary RT investigation has illustrated a substantial flushing time of 80 days for the Lough, with an average RT of 25-30 days during isothermal conditions with, what is expected to be a substantial increase during stratified conditions. Current work is focussing on further calibrating the water temperature field to better reproduce the water column stratification scenario. With this, a more refined approximation of the RT and periodic pulses of oxygenated water entering the hypolimnion may be developed.