Begrundelse for valg af fjord- og oplandsmodel Longline Environment Ltd

Consultant qualifications

Longline Environment Ltd. is a technology and consulting company based in the UK and Ireland. We have a strong connection with the European Water Framework Directive (2000/60/EC)[1] through the participation of our Chief Scientific Officer, Prof. Joao G. Ferreira, in the working group set up by the EC to develop the WFD Common Implementation Strategy, CIS 2.41 for Transitional and Coastal Waters (TCW), and numerous subsequent meetings; and with the Danish WFD context through[2] Work done by Joao G. Ferreira over 2021 and 2022 to evaluate the WFD status of the Danish TCW2. In addition, one of our staff, who will be assigned to the project, holds an M.Sc. in Forest and Nature Management from Copenhagen University. The modelling tools and integrated framework to be applied in this work have been deployed in various parts of Europe to answer eutrophication-related questions, including bottom-up and top-down control, within the soil-to-sea continuum.

Hydrodynamic modelling

The Delft3D-flow model uses fine spatial and temporal scales that allow the description of the morphological features influencing the circulation of the areas of interest. These flows are upscaled to the EcoWin (see below) domain, thus providing the basis for its transport sub-model. In addition to the detailed depiction of the bathymetry, Delft3D-flow includes the parametrisation of wind-driven, tide, and density-driven flows, by incorporating: (i) ocean open boundary conditions for level, momentum, salinity and temperature; (ii) atmospheric transference of momentum and heat; and iii) the incorporation of freshwater from the catchments draining into the target areas. Longline has successfully applied the model for multiple systems in Northern Ireland, Ireland, Indonesia, South Africa, China, and several other countries.

Application to Ringkøbing Fjord

Ringkøbing Fjord is a mostly well mixed shallow coastal lagoon that exchanges its flow with the neighbouring shelf through a narrow, sluiced inlet. Here the Delft3D-flow implementation will focus on resolving the exchange across the inlet and the level of reincorporation of the outflowing water back into the lagoon. The sharp salinity gradient between the lagoon water and the North Sea ambient water and how wind affects horizontal and vertical salinity will be carefully addressed to determine the exchange regime between the lagoon and the neighbouring shelf. Attention will be given to the timed sluice operation and the observed stratification episodes under weak wind forcing.

Ecological modelling

The EcoWin ecological model has been used for over twenty-five years, in many parts of the world, to simulate coastal and fjordic systems. It can address a variety of water quality and ecological issues, including pelagic and benthic eutrophication symptoms, and bottom-up and top-down control of aquaculture. The model uses a coarser grid than the hydrodynamic model, from which the water flows are determined, and over the last ten years has been tightly coupled with hydrological models such as SWAT—this allows EcoWin to resolve both the water circulation and the nutrient loading from land at an appropriate time and space scale. The model can be run for periods of ten years or more.

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[1] https://www.ecowin.org/ticor/documents/CIS%202.4%20COAST%20guidance.pdf

[2] Reference Conditions In Danish Coastal Waters Under The European Union Water Framework Directive. An Integrated Legal And Scientific Appraisal. Geert van Calster, Joao G. Ferreira, Kathleen Garnett, Oene Oenema

In the present project, EcoWin will be used to help evaluate management measures leading to Good Ecological Potential (GEP) in Danish Transitional and Coastal waters.

Application to Ringkøbing Fjord

EcoWin has been used to model shallow coastal lagoons[3] so the application to this fjord is appropriate. In particular, the top-down control of sand mussels (*Mya arenaria*) will be explicitly simulated through the development of a physiological model of bivalve growth and environmental effects, including bioextraction of microalgae. This will be coupled with models for benthic primary production, with an emphasis of seagrasses and seaweeds, in order to examine the effect of different nutrient input (SWAT+ model) and biofiltration scenarios on potential recovery of eelgrass. The water circulation and mixing dynamics are key to distribution of fjord properties and will be integrated in EcoWin through Delft3D.

[3] http://goodclam.com/book/Forward_Book_EN.pdf