Fjord model for evaluating measures against eutrophication - a case study

Birger Bjerkeng
Norwegian Institute for Water Research, NORWAY

A dynamic simulation model for deep fjords has been developed and adapted to the inner Oslo fjord, situated in the south-east part of Norway. The fjord consists of two main basins, about 150m deep, with the deeper parts closed off from each other and towards the outer fjord by sills at 50 and 20 m depth respectively. The fjord receives sewage from about 800,000 inhabitants in the Oslo region. After 1984 most of the sewage pass through chemical treatment plants that remove 90-95% of phosphorus.

The model divides the fjord in horizontally integrated basins, in contact with each other and with an outer boundary. Each basin consists of a number of layers. Vertical mixing between the layers of each basin and horizontal transports between basins are dynamically coupled to the density field within each basin and to the difference in density fields of interconnected basins.

Phytoplankton consist of two separate entities with different characteristics ("diatoms" and "flagellates"). Primary production is controlled by light, temperature, nitrogen and phosphorus and for diatoms also by silicate. Bacteria grows on DOC excreted by phytoplankton. Zooplankton grazes phytoplankton and bacteria, and mussels graze all groups. The model also includes simple empirical descriptions of particle sinking and degradation in water and sediment under different oxygen regimes.

The model is driven by land runoff, weather conditions and conditions on the outer boundary. Submerged discharges of fresh water or sewage are included as sources of pollution and of vertical mixing. It will be possible to specify injection of brackish water into the deep water as a measure to speed up vertical mixing and deep water renewal.

The model is calibrated against an extensive set of monitoring data from the Oslo fjord. It can then be applied to different discharge situations, estimating the effect of planned measures. Examples of such measures are nitrification and denitrification in treatment plants, further phosphorus removal and discharge of fresh or brackish surface water in the deeper layers to increase circulation and improve deep water renewal.

This kind of model can only give an approximate representation of the main features of the real system, and there are many uncertain factors involved. Still, such models can hopefully contribute to a better basis for management decisions by showing long-term net effects of interrelated non-linear responses to changes imposed on the real fjord system.