AQUACULTURAL WASTE DISPERSION MODELLING IN EASTERN LIGURIAN COASTAL WATERS

M.G. Magaldi (1), A.M. Doglioli (2), P. Vasallo (3)

1) RSMAS-MPO, University of Miami, Miami, USA; 2) IPN-M-DHI, University of Genova, Genova, Italy; 3) DIFERRE, University of Genova, Genova, Italy

INTRODUCTION

The Eastern Ligurian coastal waters are a precious resource for several human activities: navigation, tourism, fishing and, more recently, aquaculture. Many political and societal conflicts can arise from the contrast between the high historical pressures and the need for an appropriate management of natural resources. In this framework, an understanding of the local sea water circulation and its impact on transport and fate of pollutants and bacteria is needed to correctly manage the maritime activities of the area.

Mathematical models are useful tools for evaluating the environmental impact following dispersion of pollutants from recorded point sources (cf. CEM (2002)). Although a network of measurement stations has been developed for the coastal water area (cf. Garuti et al. 1999; Giovanni et al. 1997; Peschkes et al. 1997; Dudley et al.; 2001; CEM (2002), models for Mediterranean Sea are generally lacking. Nevertheless, the project EUROMED project (www.euro-med.org) in the Mediterranean is one of the key positions currently asked for modeling the environmental effects of fish cage farming.

The three-dimensional (3D) numerical model has been developed by the University of Genova in order to simulate the dispersion of aquacultural wastes on the basis of coastal wind driven circulation and fish input (Doglioli et al., 2004). A SAWMIMA model has been used to take into account the biodegradation of settled matter.

In the numerical simulations the dispersion of fish matter and fixed wastes, released from the fish farm (see Fig. 1), was evaluated in different environmental conditions: with and without changing the mixing rates. Estimates of the dispersion pattern of organic carbon have been calculated using a high resolution local grid.

METHODS

The Lagrangian Assessment Marine Pollution three-dimensional model, LAMP3D, is a single particle Lagrangian model. At each time step a particle with a velocity vector moves from its position a new one. The total velocity is constituted of two components:

* U is the flow field representing the mean of the transported process, calculated in barotropic approximation by the Princeton Ocean Model (POM, O'Reilly 1995).

* V is a stochastic fluctuation which is related to the turbulence intensities and characteristics of these smaller eddies that are not included in U itself.

Furthermore, LAMP3D is able to provide vertical profiles by using POM vertically averaged flow field to compute a theoretical vertical profile of the finite bottom with a specific property is assigned to each single numerical particle. Since numerous studies have demonstrated alterations of the composition and degradation in nutrients (cf. Brown et al. 1993; cf. Foster and Webster 1997) and estuarine carbon, only the mixing process is considered. The particle is saved into the file and subject to the LAMP3D code which is used to calculate the concentration at the location (see Fig. 1).

RESULTS

The AQUA fish farm is located offshore Lavagna (Ligurian Sea, NW Mediterranean) on the 40-ma bathymetric line (Fig. 1). The hydrography and wind condition has been simulated using the model, and with climatological data obtained by a barier strow water current data taken by the Italian Air Force (Climatologia, 2000). The analysis shows the presence of three wind trends in the sectors of North-East (NE), North-East South (SSE), and South-Eat South (SSW). The NE wind is more frequent than the other two directions during the whole year, mainly in winter, while the SSW wind is the strongest.

The NE and SSW wind field is shown in Fig. 2 with the coast moving westward. In contrast, with SSW wind the mussel current intensifies as a consequence of wind accumulation toward the coast and it is possible to have a record of the current direction for each point of the coast.

The numerical results are in agreement with field data taken in the area (cf. Doglioli et al., 2004).

Below the cages the current intensity decreases almost linearly with depth and the different rates of decrease in speed depend on wind intensity and direction. Floating particles remain mainly confined in the fish farm area and readily sink being about identical to sinking rates.

As a consequence, higher organic carbon concentrations correspond to most stressed sediment (Fig. 3). Nevertheless, simulations with time varying wind forcing (both in direction and intensity) suggest that the sediment is well mixed and is not affected by the current gradients.

Patterns of fish sediment nutrients' experimental data agree with model observations under wind transport and current direction. Both field and modelled data are in agreement.

CONCLUSIONS

LAMP3D model, upgraded with heuristic models, improved its capability to help fish farm management and decision making. At present the studied zone, modelled without waste released in sediment compartment and never exceeded the superior benthic water in environmental risk assessments. However, field measurements of Mediterranean environment parameters could improve the predictive capacity of the model and will permit to validate the model on a regional scale. Collaboration with farmers is essential for input parameters value and field data collection.

REFERENCES


CEM (2002) (Central Electoral Office of Marine Environment and Marine Environmental Monitoring), Rome, Italy.


Fig. 1 Location of the fish farm respect to the numerical grid.

![Fig. 1 Location of the fish farm respect to the numerical grid.](image1)

![Fig. 2 LAMP3D flow chart with the new heuristic models.](image2)

![Fig. 3. The fish farm for the organic carbon.](image3)

![Fig. 4 Waste indicators.](image4)

![Fig. 5 Annual frequency for the wind direction.](image5)

![Fig. 6 Depth averaged current (m/s) and elevation (m) fields calculated for NE wind in the POLD grid.](image6)

![Fig. 7 Organic carbon concentration at the bottom total dissolved (organics) and state of sediment (degraded carbon).](image7)