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# A Meramod<sup>®</sup> model approach for the Environmental Impact Assessment (EIA) of the off-shore aquaculture improvement in the Alghero Bay (North western Sardinia, Italy)

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**ABSTRACT:** Marine fish farming generates particulate wastes which are dispersed in the sea environment. To deal with this problem, particulate waste dispersion models have been developed to predict the effects of fish cage culture. In this study, we evaluated the seabed deposition of a fish farming facility located in the central western Mediterranean by using the Meramod<sup>®</sup> model. The objectives were first to assess the actual scenario, and second to forecast the possible impact due to the forthcoming enlargement of the farming area with the addition of new fish cages. By computing the hydrodynamic measurements and the daily amount of feed recorded between July and December 2006, the impact seabed surfaces forecasted by the model increased from 5.6ha in the actual scenario, up to 7.3ha in the future. The model estimated a maximum level of total solid flux deposition of 3,800g/m<sup>2</sup>bed/year and a maximum level of total carbon flux deposition of 1,350g/m<sup>2</sup>bed/year for both scenarios. Furthermore, the model predicted that the installation of 4 new fish cages (with an hypothetical mean daily amount of feed of 50kg/cage) will produce a total solid and carbon flux deposition levels ranging 0-400 and 0-150g/m<sup>2</sup>bed/year respectively, under the new fish cages location.

**Key words:** Meramod-modelling, Marine aquaculture, Waste solids, Sardinia, Mediterranean Sea.

**INTRODUCTION** – Cage fish farming in coastal waters produces considerable amounts of particulate organic wastes in the form of both unconsumed feed and fecal matter. The dispersion of wastes and their subsequent deposition on the surrounding seabed can produce enriched sediments, which result in deoxygenation of the bottom water, and can have detrimental effects on the health of benthic organisms and environments (Yokoyama *et al.*, 2006). Such habitat deterioration often generates negative consequences for fish farming management itself. The degree and extent of impacts from fish farming have been previously investigated worldwide and it has been demonstrated that the impacts on benthic environments are localized (Brown *et al.*, 1987; Gowen *et al.*, 1991). The extent to which the seabed is affected depends both on the type and quantity of particulate materials being released from the cage site and on the local physical conditions such as bathymetry and prevailing water currents. Particulate waste dispersion models can provide a cost-effective approach to evaluate wastes releases in site selection and biomass limits in terms of local environmental capacity. They can also be helpful in supporting decision-making for environmental regulation and management by testing several pre-production scenarios for given environmental situations (Corner *et al.*, 2006). Across Europe, several modelling strategies have been

designed to enable predictions for managing environmental impacts of marine aquaculture (Henderson *et al.*, 2001). In Scotland, the Depomod<sup>®</sup> model (Cromey *et al.*, 2002), from which Meramod<sup>®</sup> originates, is now widely used for the Environmental Impact Assessment (EIA) and to estimate the likely seabed deposition (SEPA, 2001). The aim of this study, therefore, was to assess the likely seabed deposition of fish farm wastes by using the Meramod<sup>®</sup> model in order to evaluate the actual scenario and the forthcoming enlargement of a fish farming facility located in the Alghero Bay.

**MATERIAL AND METHODS** – The study was carried out between July and December 2006 at the fish farming facilities of “La Maricoltura Alghero s.r.l.” located in the Alghero Bay (North western Sardinia, Lat 40°33’43.9”N, Long 8°16’09.0”E). During the study period this fish farm occupied a surface area of about 2.5 ha, on a 38 m water depth average and some 116,000 seabass (*Dicentrarchus labrax*) and 380,000 seabream (*Sparus aurata*) being reared in 9 “tension-legs” cages (REFA<sup>®</sup>). Cage volume was 800m<sup>3</sup> (5 cages) and 2,500m<sup>3</sup> (4 cages) with a fish density ranging 0.4 to 4.0kg/m<sup>3</sup> and the provided daily feed ratio ranging 40-190kg/cage with a total daily average of 98kg/cage. The solids deposition on seabed arising from the fish farm and associates changes in the benthic community were estimated by the application of the Meramod<sup>®</sup> model, Version 1.4 (see Cromey *et al.*, 2002 for details). This models has a structure made up of the following components: grid generation module, particle tracking module, flux-deposition-degradation module, and benthic response. Grid generation module generates an array (with 25m cell resolution) used by subsequent modules containing bathymetry, cage (number and volume) and sampling position. The particle tracking and flux-deposition-degradation module describe the transport of particles from the surface to the seabed and calculate the total flux (g/m<sup>2</sup>/year) of waste solid and carbon with degradation processes (G-Model sub-module). Information of feed input allows the definition of the solids loading arising from the fish farm. Particles are subject to settlement through the water column while being advected in 2 dimensions by hydrodynamic data. Three data sets are implemented into the model and each set represents a layer with different current amplitude and direction. Hydrodynamic data were collected from July to December 2006 by using a Sensor Data Current Meters (model SD 2000) at 3 different depths in the water column: -5, -15 and -25m from the surface, respectively. The Meramod<sup>®</sup> model was used to assess both the actual scenario and a forthcoming situation represented by an enlargement of the farming area (about 8ha), with the addition of 4 new submersible fish cages having a volume of about 2,500 m<sup>3</sup> and a hypothetical mean daily amount of feed of 50 kg/cage.

**RESULTS AND CONCLUSIONS** – Figures 1 and 2 show, respectively, the results obtained from the application of the Meramod<sup>®</sup> model to the actual scenario and the forthcoming enlargement of “La Maricoltura Alghero” fish farm. Current velocity recorded in the sampling period (July-December 2006) ranged between 0.1 and 30.4 cm sec<sup>-1</sup>

Figure 1. Total solid flux deposition (g solids/m<sup>2</sup>bed/year) forecasted by the Meramod<sup>®</sup> model for the actually scenario of the fish farm studied.

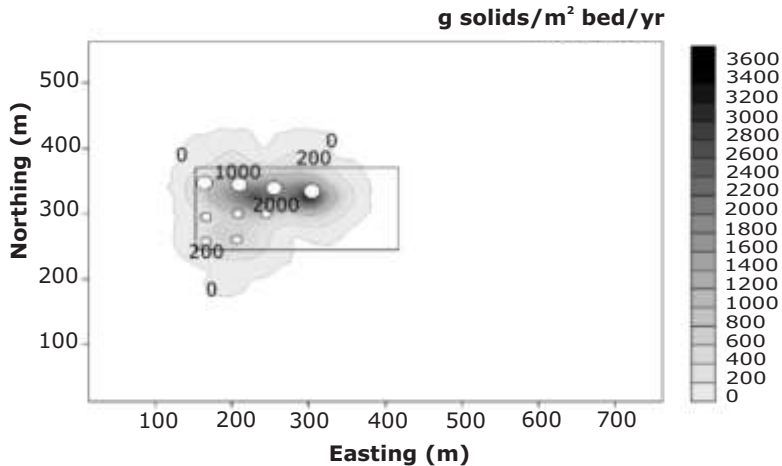
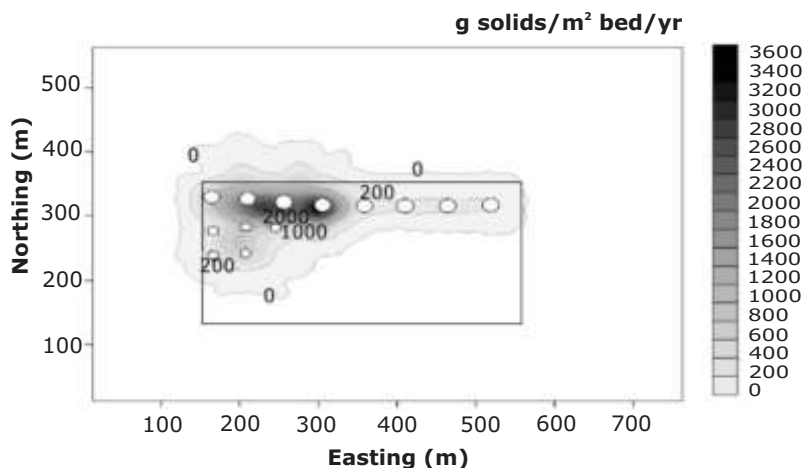


Figure 2. Total solid flux deposition (g solids/m<sup>2</sup>bed/year) forecasted by the Meramod<sup>®</sup> model for the future enlargement of the fish farm studied.



at 5 m depth, between 0.1 and 7.6 at 15m, and between 0.1 and 5.1 at 25m from the water surface, respectively. Mean current direction ranged between 264 and 316 magnetic degree within the water column, and the maximum level of total solid flux deposition forecasted by the model was about 3,800 g/m<sup>2</sup>bed/year for both scenarios.

The impacted seabed surface was mainly located just under the fish farming facilities and increased from an area of about 5.6ha in the actual scenarios (Figure 1) to 7.3ha in the hypothetical future situation (Figure 2). The degradable fractions of total deposition were 76 and 78%, respectively. The maximum level of total carbon flux deposition predicted was equal to 1,350g/m<sup>2</sup> bed/year for both scenarios, while the percentages of degradable carbon fraction amounted to 80 and 82% for each scenarios, respectively. The installation of 4 new fish cages with a hypothetical mean daily amount of feed of 50kg/cage will increase the impact seabed surface to about 1.7ha, with a total solid and carbon flux deposition levels of about 0-400g/m<sup>2</sup>bed/year and 0-150g/m<sup>2</sup>bed/year, respectively, under the new supposed fish cages location (Figure 2). In conclusion, this application of the Meramod<sup>®</sup> model in Sardinian waters confirms once more its role as a potential tool to enable better the predictive capability of impact from large marine cage fish farming on the seabed surface, and to improve objectivity in the regulatory decision-making processes. As the benthic response module included in the model can also forecast the effects of the solids deposition on the benthic community (by predicting variations of the biodiversity indices), further research is needed to validate these putative variations of the benthic environment below and in the neighbourhood of the fish farming facilities investigated.

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