MODELLING ORGANIC MATTER OXIDATION UNDERNEATH A MEDITERRANEAN MUSSEL FARM

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Abstract
Mussel biodeposits accumulation and oxidation were studied by means of 3 different numerical models: an early diagenetic model, a population dynamic model and a deposition model. Models were applied at a long-line farm located in the Northern Adriatic Sea by using a dedicated set of field data. Both field data and model results showed that biogeochemical alterations induced by the mussel farm are markedly lower compared to the extent of the impacts commonly reported for fish cages. Nevertheless, a model sensitivity test indicate that organic matter flux, sediment geochemistry and nutrient recycling can vary remarkably as a function of the stock of the mussels and the environmental forcings scenario considered.
Keywords: Aquaculture, Models, Organic Matter, Bivalves, Adriatic Sea

Introduction During the last two decades, shellfish production raised questions concerning the environmental impact and sustainability of shellfish farms, at both local and regional scales [1]. Numerical models have proven to be useful science-based tools for site-selection and ecological carrying capacity assessment [2]. Models capable to represent the interactions of mussel biodeposition with sedimentary redox processes are currently lacking in the field of aquaculture, although monitoring techniques based on biogeochemical measures were found to be more cost-efficient than the ones based on macrofaunal community structure [3]. The main objective of this work was to study the applicability of a novel approach to model the interaction between mussel farm biodeposition, sediment geochemistry and nutrient recycling.

Methods Vertical profiles of sediment porosity, and concentrations of organic carbon, NH_4^+, NO_3^{2-}, SO_4^{2-}, dissolved inorganic P, Mn^{2+} and Fe^{2+} were collected at a mussel farm located off-shore Chioggia (approximately 20m depth). Two field campaigns were carried out at two stations located underneath the farm, in February and July 2007. Radiometric dating analysis was carried out on cores collected underneath the lines in order to assess the sedimentation rate. N:C and P:C elemental ratios were determined on the faeces produced from a set of individuals (180) collected from a marked rope along 8 field campaigns (July 2006 - May 2007). A current-meter was deployed from July to September 2006 and from April to May 2007. Mussel density and husbandry practices were estimated on the basis of regular interviews with the farmers [4]. The standing-stock of the mussels and the production of biodeposits were simulated through a population dynamic model (PDM) of *M. galloprovincialis* [5]. The OM rain underneath the mussel farm was estimated by means of 3D particle tracking models [6]. Aerobic and anaerobic pathways of organic matter (OM) oxidation were modelled by means of a 1D reaction-transport early diagenetic model [7]. The diffusive fluxes of dissolved constituents at the sediment-water interface were calculated on the basis gradients of their concentrations. Model application was carried out in three steps: 1)the flux of OM from the farm was estimated through an inverse use of the early diagenetic model: this was calibrated by minimising the distance between predicted profiles and field data, under a set of constraints; 2)the OM flux from the farm was independently estimated by coupling the population dynamic and particle-tracking models; 3)different sensitivity tests were carried out, in order to study the potential impact of the mussel farm, associated with the different scenarios of mussel standing-stock, bathymetry and hydrodynamic regimes.

Results and discussion The flux of OM originated by the farm, estimated by calibrating, Fig. 1, the early-diagenesis model was of approximately 15 g C m^{-2} y^{-1}, lower but comparable with the fluxes estimated by coupling the population dynamic and particle-tracking models (Fig. 1). These fluxes are lower than the range measured by [8] underneath a mussel farm located in a Canadian lagoon, 20-150 g C m^{-2} y^{-1}. Results from the particle tracking model indicate that ~ 95% of OC deposited within 500m from the farm boundaries, on a total surface of 6.5 km^{-2}. As regards oxygen penetration depth, TS concentrations and dissolved nutrients profiles, results indicate that the impact of a mussel farm per unit area is markedly lower than the one induced by finfish cage farming. However, the overall impact of OM oxidation on the N and P cycles can be regarded as significant, given the extension of the licensed areas. Results from the sensitivity tests, indicate that the entity of the impact can vary dramatically in response to the scenario considered, suggesting the potential use of this type of models as decision support tools for site-selection and farm dimensioning.

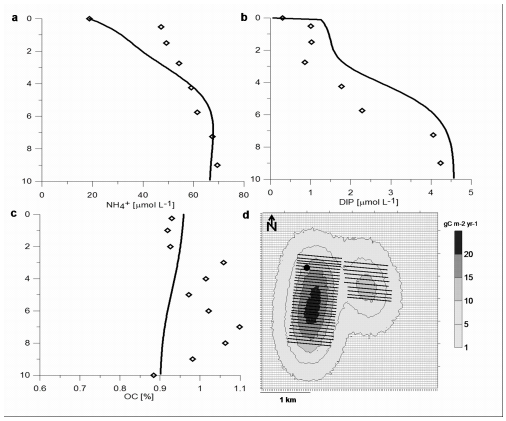

Fig. 1. A-c) Early diagenetic model calibration: predicted profiles versus field data; d) Population dynamic model and particle tracking model results.

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