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Benthic processes and coastal aquaculture: merging models and field data at a local scale

Daniele Brigolin (1,3), Christophe Rabouille (2), Bruno Bombled (2), Silvia Colla (1), Roberto Pastres (1,3), and Fabio Pranovi (1)

(1) University of Venice, Environmental Sciences Informatics and Statistics, Venezia Mestre, Italy (brigo@unive.it), (2) LSCE/IPSL, Laboratoire des Sciences du Climat et de l'Environnement CEA-CNRS-UVSQ, Gif-sur-Yvette, France, (3) Bluefarm S.r.l., Via delle Industrie 15, Venezia Marghera, Italy

Shellfish farming is regarded as an organic extractive aquaculture activity. However, the production of faeces and pseudofaeces, in fact, leads to a net transfer of organic matter from the water column to the surface sediment. This process, which is expected to locally affect the sediment biogeochemistry, may also cause relevant changes in coastal areas characterized by a high density of farms. In this paper, we present the result of a study recently carried out in the Gulf of Venice (northern Adriatic sea), combining mathematical modelling and field sampling efforts. The work aimed at using a longline mussel farm as an in-situ test-case for modelling the differences in soft sediments biogeochemical processes along a gradient of organic deposition. We used an existing integrated model, allowing to describe biogeochemical fluxes towards the mussel farm and to predict the extent of the deposition area underneath it. The model framework includes an individual-based population dynamic model of the Mediterranean mussel coupled with a Lagrangian deposition model and a 1D benthic model of early diagenesis. The work was articulated in 3 steps: 1) the integrated model allowed to simulate the downward fluxes of organic matter originated by the farm, and the extent of its deposition area; 2) based on the first model application, two stations were localized, at which sediment cores were collected during a field campaign, carried out in June 2015. Measurements included O_2 and pH microprofiling, porosity and micro-porosity, Total Organic Carbon, and pore waters NH4, PO4, SO4, Alkalinity, and Dissolved Inorganic Carbon; 3) two distinct early diagenesis models were set-up, reproducing observed field data in the sampled cores. Observed oxygen microprofiles showed a different behavior underneath the farm with respect to the outside reference station. In particular, a remarkable decrease in the oxygen penetration depth, and an increase in the O_2 influx calculated from the concentration gradients were observed. The integrated model described above allowed to extend the simulation over the entire farmed area, and to explore the response of the prediction to changes in water temperature.