# STUDY OF THE N, P AND SI FLUXES UNDER ANOXIC CONDITIONS BETWEEN FISH FARM SEDIMENT AND SEAWATER. RESULTS OF A SIMULATION EXPERIMENT

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**Abstract**
Over the last decade cage fish farming has expanded rapidly particularly in the Mediterranean where Greece is currently the main producer. The aim of this paper is to explore the behaviour of such an affected area under anoxia by measuring the fluxes of ammonium, nitrite, nitrate, TDN, phosphate, TDP and silicate between the surface sediment and the overlying waters. To achieve this goal we used a prototype benthic chamber capable of sampling considerable quantities of affected undisturbed sediment along with its overlying water. The concentrations of ammonium, nitrite, TDN, phosphate, TDP and silicate rapidly increase, those of nitrate decrease. DON and DOP exhibit remarkable fluctuations.
*Keywords : Anoxia, Coastal Management, Oxygen, Redox, Sediments.*

The operation of cage fish farms is not free from environmental consequences, the most important of which is related to significant redox reactions connected with the formation of an organic rich, loose "nepheloid" sediment layer below or near the cages, consisted mainly of the food-remains together with the pellets and metabolic products from fish [1]. The aim of this work is to explore the behaviour of such a system. To achieve our goal we constructed a portable benthic chamber, capable of sampling surface sediment along with its overlying water column. After sampling, the chamber was transported from the study area to the Environmental Chemistry Laboratory of the University of Athens. The chamber allows for the water temperature and the dissolved oxygen concentration to be continuously and automatically controlled [2]. The study area is located in a coastal site near the Acheloos river estuary at the Aquaculture Center of Acheloos SA (ACEA SA). The simulation experiment lasted 9 days under set anoxic conditions where the dissolved oxygen concentration decreased rapidly from 5.0 mg/l to 0.4 mg/l, (Fig. 1a) where it remained constant.Ammonium, nitrate, nitrite, phosphate and silicate concentrations in sea water samples were determined with standard spectrophotometric methods [3]. Total Dissolved Nitrogen (TDN) and Total Dissolved Phosphorus (TDP) were determined following a persulfate oxidation [2]. Dissolved Organic Nitrogen (DON) was calculated as the difference between TDN and Dissolved Inorganic Nitrogen (DIN - sum of nitrate, nitrite and ammonium). Dissolved Organic Phosphorus (DOP) was calculated as the difference between TDP and phosphate.During anoxia we observed some remarkable changes. The concentration of $NH_4{}^+$ (Fig. 1b) increases in an impressive way. Nitrate concentration falls rapidly to near zero values (Fig. 1c) while $NO_2{}^-$ (Fig. 1d) concentration fluctuated widely before reaching near zero values. From the inorganic forms of nitrogen $NO_3{}^-$ was the prevailing species at the beginning, falling rapidly with simultaneous increase of $NH_4{}^+$, which becomes progressively the dominant species. The concentrations of $PO_4{}^{3-}$(Fig.1e) and $SiO_4{}^{4-}$ (Fig. 1f) also increased significantly. The DON was the dominant form at the end of the experiment compared to inorganic nitrogen forms which dominated at the beginning.

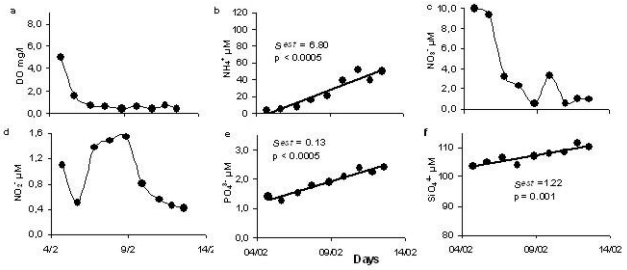


Fig. 1. The evolution of (a) dissolved oxygen, (b) ammonium, (c) nitrate, (d) nitrite, (e) phosphate and (f) silicate concentrations in the benthic chamber throughout anoxia, n=9 days.

The rapid decrease of dissolved oxygen concentration and predominance of anoxic conditions is an indication of the death of micro biota that prevailed in the ecosystem of the benthic chamber and degradation of biomass by anaerobic bacteria releasing water soluble forms of organic nitrogen and phosphorus and eventually some silicates originating from the autolysis of cells of diatoms. The release of $PO_4{}^{3-}$ through the reduction mechanism of insoluble $FePO_4$ into soluble $Fe_3(PO_4)_2$ [4] probably contributes to the increase of the concentration of phosphates, while dissolution of silicate depositions from the sediment contributes significantly to the increase of the silicate concentration. Statistical analysis of the concentrations of $PO_4{}^{3-}$, $SiO_4{}^{4-}$and $NH_4{}^+$ ( $s_{est}$ :the standard deviation about the regression line, and p value: determines whether the association between the variables is statistically significant) are shown in Figure 1 and the consideration of their ratios support the above mentioned hypotheses.

## References

1 - Belias, C., Bikas, V., Dassenakis, M., Scoullos, M., 2003. Environmental Impacts of Coastal Aquaculture in Eastern Mediterranan Bays. The case of Astakos Gulf, Greece. *ESPR- Environ. Sci. & Pollut. Res*., 10 (5): 287-295.
2 - Belias C., Dassenakis M., Scoullos M., 2006. Study of the N, P and Si fluxes between fish farm sediment and seawater. Results of simulation experiments employing a benthic chamber under various redox conditions. *Marine Chemistry*, in press.
3 - Strickland, J.D.H. & Parsons, T.R., 1968. Fisheries Research Board of Canada. A Practical Handbook of Seawater Analysis. pp. 49-52, 65-70, 71-76, 77-80, 87-92
4 - Scoullos, ÎIJ., ÎŰeri C., Dassenakis ÎIJ., Kaberi ÎŢ., 1987. Study of nutrients' behavior under extreme oxidative conditions. ÎŠ' Hellenic Symposium of Fisheries and Oceanography, Athens 11-15 May,1987 (in Greek).