DIRECT GRADIENT ANALYSIS OF THE MOLLUSCAN COMMUNITY AT THE MARINE-LAGOONAL ENVIRONMENTAL TRANSITION AT KALLONI SOLAR SALTWORKS (NE AEGEAN SEA, GREECE)

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Abstract
A direct gradient analysis technique (CCA) was employed for the investigation of (a) the spatial organisation of the molluscan community and (b) the environmental factors structuring the molluscan community, at the part of Kalloni solar saltworks that is in the immediate vicinity of the sea (Kalloni Gulf, NE Aegean Sea). The molluscan community and environmental parameters were sampled at four sites, on a seasonal basis during 2004. The strong environmental gradient that exists across space between the gulf and pond2 site, structures the molluscan community in the study area. Species composition spatial variations imply a marine-lagoonal environmental transition, typicaly observed in coastal lagoons. Sediment type, organic matter % and chloroplastic pigments concentration were found to be among the key components of the environmental gradient in the study area, as has also been observed in natural coastal lagoons.
Keywords : Mollusca, Biodiversity, Lagoons, Aegean Sea.

Introduction
Solar saltworks comprise man-made systems, where a salinity gradient is maintained along a sequence of interconnected ponds for the production of salt by solar evaporation. On the other hand, the ecosystems of solar saltworks are extremely heterogeneous and consequently of great ecological importance and scientific interest [1]. However, solar saltworks ecosystems, in particular the benthic subsystem, have not been sufficiently studied. The aim of this paper is to employ a direct gradient analysis technique [2] for the investigation of the spatial organisation of the molluscan community as well as the evaluation of the environmental factors structuring the molluscan community at the part a solar saltworks that is in the immediate vicinity of the sea.

Materials and methods
The study area is Kalloni solar saltworks (Kalloni Gulf, Lesvos Island, NE Aegean Sea, Greece). The molluscan community was sampled at four sites, on a seasonal basis during 2004. Environmental variables [water column salinity and temperature, sediment type (measured as sand %), water column and sediment chloroplastic pigments concentration, sediment organic matter %] were also measured. Canonical correspondence analysis [3] was applied to assess the statistical associations between the molluscan abundance data (response variables) and the space aspect of the sampling design, coded as dummy variables (explanatory variables). Environmental variables were projected *post hoc* into the ordination plot (supplementary variables).

Results
Canonical correspondence analysis (CCA) ordination of the biotic data of all seasons (Fig. 1), performed with explanatory variables representing the spatial aspect of the sampling design, revealed that the differences between sites explained a large part of the total inertia of the biotic data (total inertia=2.292, sum of all canonical eigenvalues=0.821, p=0.001). Two different groups of abundant species (>1 ind. m^{-2}) can be distinguished: one group of marine and marine/estuarine species that are associated with the gulf site and, to a lesser extent, with the channel site and a second group of marine/estuarine and typical lagoonal species that are associated with the pond sites. The first axis of the ordination diagram corresponds to a strong spatial gradient that exists between the gulf site and the pond2 site (eigenvalue=0.589, explained 25.7% of total inertia or 71.8% of the total explainable inertia, p=0.001). The second axis corresponds to a comparatively weaker spatial gradient that exists between the gulf site and the channel site (eigenvalue=0.186, explained 8.1% of total inertia or 22.8% of the total explainable inertia). The environmental variables that were best correlated with the primary spatial gradient are the sediment type and organic matter %, whereas sediment chloroplastic pigments concentration correlated best with the secondary spatial gradient.

Discussion
The strong environmental gradient that exists across space between the gulf and pond2 site, structures the molluscan community in the study area. Species composition spatial variations imply a marine-lagoonal environmental transition, typicaly observed in coastal lagoons [4]. Sediment type, organic matter % and chloroplastic pigments concentration were found to be among the key components of the environmental gradient in the study area, as has also been observed in natural coastal lagoons [5].

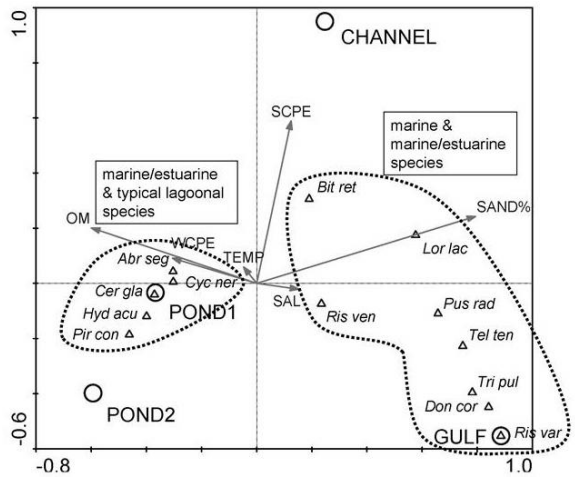

Fig. 1. CCA ordination of the biotic data of all seasons, performed with explanatory variables representing the spatial aspect of the sampling design, with environmental variables projected post hoc into the ordination plot as supplementary variables. The explanatory variables (GULF, CHANNEL, POND1 & POND2 sites) are indicated by open circles, whereas the supplementary variables [water column (WCPE) and sediment (SCPE) chloroplastic pigments, sediment type (SAND%) and organic matter (OM), water column salinity (SAL) and temperature (TEMP)] are indicated by arrows. Molluscan species are indicated by open triangles. Only the most abundant species are shown (*Abra segmentum*, *Bittium reticulatum*, *Cerastoderma glaucum*, *Cyclope neritea*, *Donacilla cornea*, *Hydrobia acuta*, *Loripes lacteus*, *Pirenella conica*, *Pusillina radiata*, *Rissoa variabilis*, *Rissoa ventricosa*, *Tellina tenuis*, *Tricolia pullus*).

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