Spatio-temporal changes of biodiversity indices in the bathyal demersal assemblages of the Ionian Sea

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Abstract: Spatio-temporal analysis of biodiversity indices estimated in the bathyal demersal species assemblages of the Ionian Sea has been performed. Data were collected during 16 trawl surveys carried out from 1995 to 2010 as part of the international MEDITS project funded by EC. In the Apulian sector a significant increase of species richness and a significant decrease of evenness have been detected. In the Southern Calabrian sector a significant decrease of evenness has been detected while a positive trend has been found for the Simpson index. GAM's have then been applied to explain the dependence of the indices in terms of time and space.

Keywords: Spatio-temporal analysis, biodiversity, deep-sea assemblages, Generalized Additive Models, Mediterranean.

1. Introduction

Loss of biodiversity, and its possible consequences on both ecosystem functioning and services, has promoted the assessment and monitoring of species diversity in marine ecosystems. Research on the deep-sea assemblages has been also carried out in the Ionian Sea during the last years (D'Onghia et al., 1998, 2003, 2004). The previous studies indicate depth and geographical area as the main factors influencing the fauna assemblages of the Ionian Sea. In this context, a spatio-temporal analysis of the biodiversity indices estimated in the bathyal demersal species assemblages of the Ionian Sea has been performed in order to monitor the diversity in the bathyal demersal assemblages in two geographic areas of the Ionian Sea.

2. Materials and Methods

Data were collected during 16 trawl surveys carried out from 1995 to 2010 as part of the international MEDITS project funded by EC (Bertrand et al., 2000). The samples analyzed come from a total of 260 and 236 hauls carried out in the Apulian and Southern Calabrian sectors respectively, between 200 and 800 m in the spring season (May-June). In each sector, the biodiversity indices of Margalef (species richness, $\boldsymbol{d}$),

	Species richness (d)		***Pielou's evenness (J)***		***Simpson index (λ)***	
parameters	*estimate*	*p-value*	*estimate*	*p-value*	*estimate*	*p-value*
intercept	2.754	<0.000	0.651	<0.000	4.637	<0.000
smooth terms	*df*	*p-value*	*df*	*p-value*	*df*	*p-value*
s(lon, lat)	24.108	<0.000	22.650	<0.000	22.830	0.006
s(year)	6.863	<0.000	3.155	<0.000		

Table 1: GAM's estimates for the indexes ***d***, ***J*** and ***λ***: estimates of the parametric terms, and degrees of freedom of the non-parametric ones with respective p-values.

Pielou (evenness, ***J***) and Simpson (***λ***) were estimated using density data (N/km^2) obtained for a total of 117 and 110 species collected in the demersal assemblages of the Apulian and Southern Calabrian sectors respectively. Data analysis was carried out as part of OBAMA project funded by MIUR. The trawl geographic coordinates were considered as the main spatial information contained in the data. Such information is redundant with the sector specification and the depth measurement. GAMs were applied to analyze the indices variation in terms of time and space. The choice between competitive models, characterized by different combinations of response distributions, link functions and predictors, was performed in terms of effects significance and overall model fit.

3. Results

While ***d*** and ***J*** could be considered Gaussian in the GAM specification, the Gamma assumption allowed to account for the asymmetry observed in the empirical distribution of the Simpson index. Table 1 reports the results for the models chosen to represent the three biodiversity indices. Species richness shows significant nonlinearity of both spatial and temporal effects.
As can be seen in Fig. 1 (a) the species richness index shows an increasing temporal evolution with a peak around 1998.
Level curves in Figure 2 (a) represent the spatial behaviour of this index confirming smaller values in deeper waters. Time has a slightly negative effect on Pielou's evenness (Fig. 1, b) and the nonlinearity of the spatial component appears to be strongly significant. Level curves in Figure 2 (b) represent the spatial behaviour of this index with values increasing with depth.
Time does not have a significant impact on the Simpson index and the spatial behaviour shows some peculiarities with respect to the other two, with different evidence between areas.

4. Concluding remarks

The present study shows changing values in the species richness related to time and geographic area. The spatial pattern confirms a decreasing diversity with depth reported in previous studies (D'Onghia et al., 2003, 2004). The increase in the species diversity

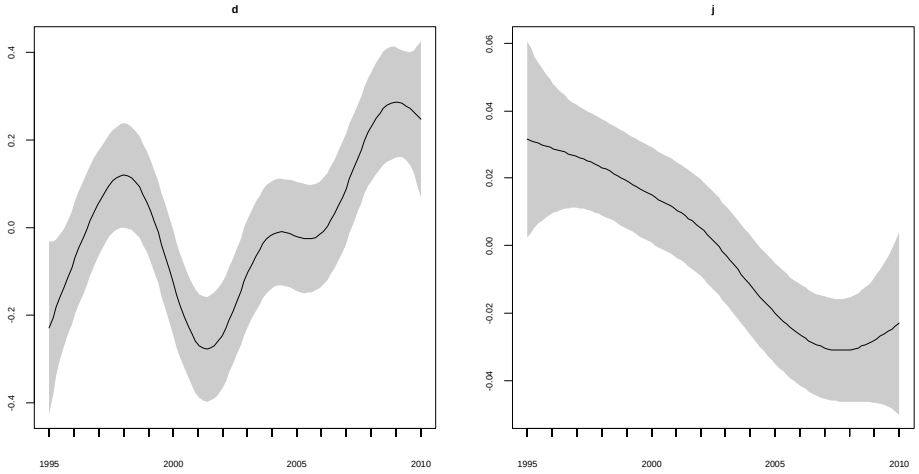

Figure 1: GAM estimates of the time effect for the species richness ***d*** and the Pielou's evenness ***J***.

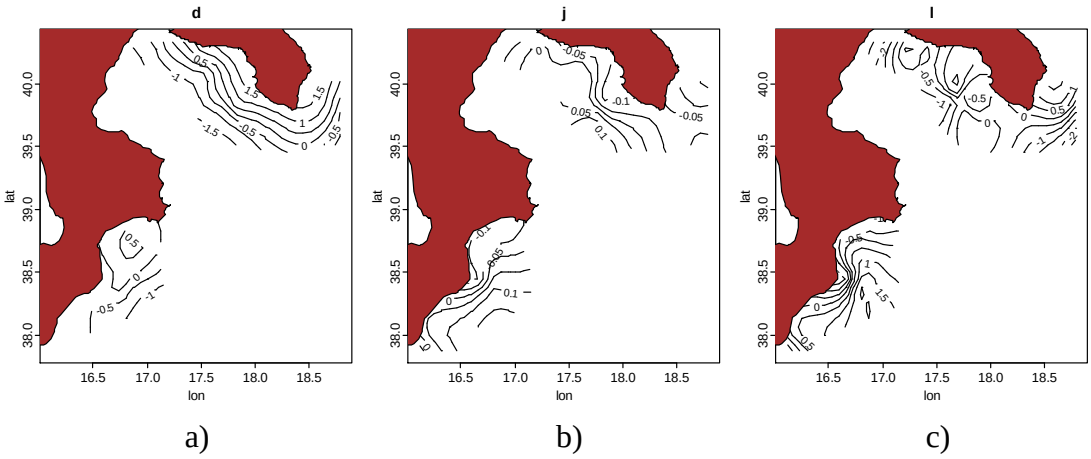

Figure 2: Gam estimates of the spatial effect for the indexes a) ***d*** (richness), b) ***J*** (evenness) and c) lambda (Simpson Index).

with time can be related to the new species recorded in the last years as already reported in the Ionian Sea (Maiorano et al., 2010). The variation observed in the evenness index does not reveal a significant difference between the two geographic areas while a different pattern was observed for the Simpson index mostly probably due to the environmental conditions and fishing pressure between Apulian and Calabrian areas (Capezzuto et al., 2010).

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