CARTOGRAPHIC REPRESENTATION OF DATA IN MARINE BENTHOLOGY

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RESUME'. On donne des exemples d'exploitation des données benthologiques par "trend-surface analysis", une technique polynomiale de représentation cartographique.

INTRODUCTION. Representation of ecological variables on topographic maps is an effective technique for displaying relationships among them. Values of environmental parameters or species abundances may be mapped as well as factor-, component- or canonical variate-scores in order to draw contour plots by eye (GOODALL, 1954; FINCHAM, 1971). However, these contour plots are subjective two-dimensional representations of surfaces, which are often very irregular because of local variations in a large-scale pattern. Trend-surface analysis (TSA) is a cartographic technique for defining the mathematical function (surface) which better fits the observed values of the mapped variable, separating their random or local fluctuations from the overall pattern (trend). TSA was developed in geological research (GRANT, 1957; DAVIS, 1973), but it has also been used in biological works (SOKAL, 1965; SNEATH, 1967; GITTINS, 1968; MEAD and PIKE, 1975). This paper provides a description of the method and an example of its application in a study on marine benthos.

METHODS. Macrozoobenthos (28 stations, 60 species) from the Bay of Augusta (Sicily) was analysed by the RQ autovectorial techniques to derive factor-scores for the observations. TSA was performed using the F1 scores and the arbitrary topographic coordinates of each station. A least squares method was choosed to fit polynomial surfaces to the observed factor-scores. Polynomial surfaces were computed up to fifth degree, i.e. the highest degree allowed by the number of observations. According to GITTINS (1968), observed values of the mapped variable may be represented as

$$T(X_i,Y_i) = t(X_i,Y_i) + e_i$$

where (X_i,Y_i) are the coordinates of the station i, $t(X_i,Y_i)$ is the trend and e_i is the deviation on the trend, which can be both random and due to higher order components. The trend (polynomial surface) may be expressed as

$$t(X_i,Y_i) = a_{00}+a_{10}X+a_{01}Y+a_{20}X^2+a_{11}XY+a_{02}Y^2+.....+a_{pq}X^pY^q$$

Analysis of variance (ANOVA) was used to test the goodness of fit of polynomial surfaces to observed data. Although ANOVA cannot be regarded

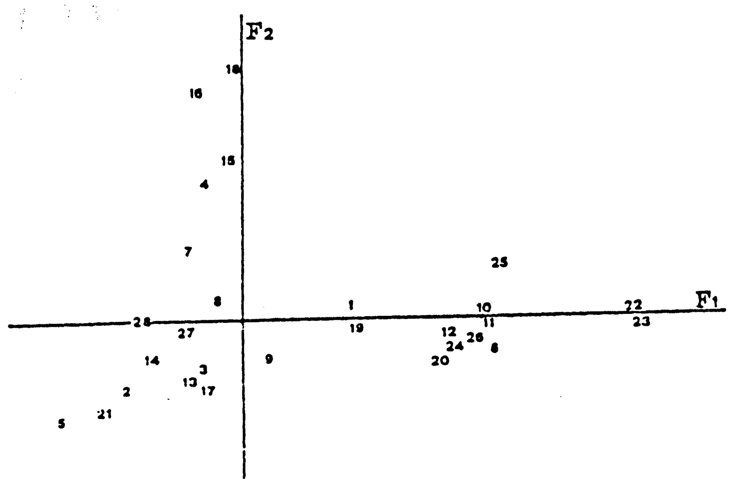

FIG. 1

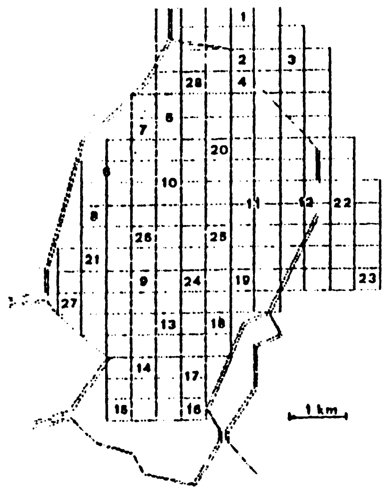

Fig. 2

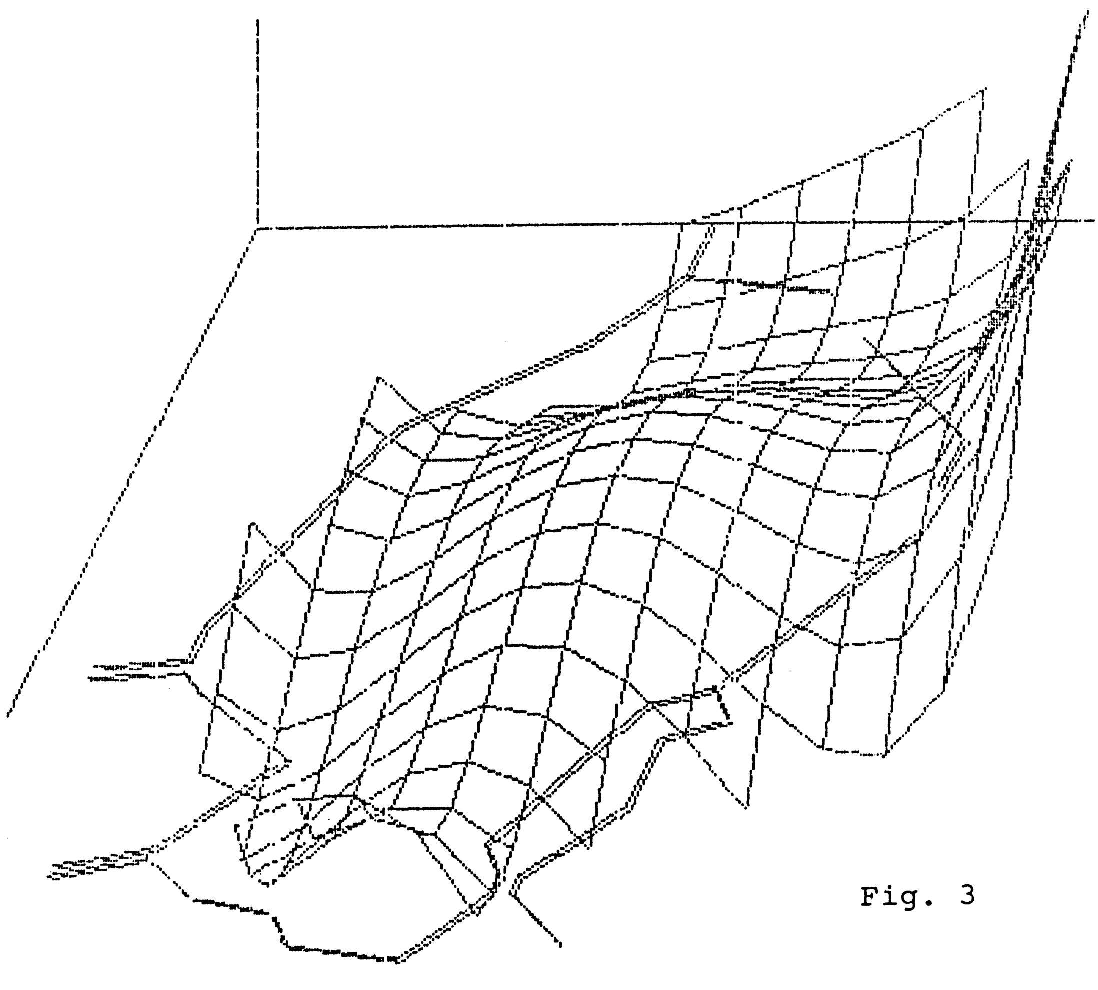

Fig. 3

as rigorous, since deviations e_i usually do not meet the assumptions underlying this method, it provides an estimate of the improvement in fit achieved using higher degree polynomial surfaces. The best fitting trend-surface was represented in axonometric view. Both calculations and plotting were carried out by means of computer programs developed by the authors.

RESULTS. The ordination of stations is shown in Fig. 1. First two factors account respectively for 20.76% and 12.17% of total variance. In the space of F1 two outer stations (22 and 23) and a compact cluster of stations (those in the middle of the harbour) are opposed to the others; F2 segregates stations 16 and 18. The polynomial surface which better fits to F1 scores, i.e. which has higher ANOVA confidence level (P=.998, 85.74% variance explained), is the quartic one. Trend-surface is hollow, with an elevation in the middle, in the area corresponding to the harbour center and is steep at its borders, mainly on the sea side (Figg. 2 and 3).

DISCUSSION. The RQ ordination model shows clearly that a cenocline extends from the outer stations to the innermost ones, corresponding to a "confinement" and pollution gradient. In addition to the obvious differences between outside and inside stations, a special cenotic configuration is observed in the middle of the harbour. This region, whose singularity is due to frequent dredging, is effectively represented by the central elevation in the trend-surface, whereas the steeper slope on the sea side describes the main cenotic discontinuity. In conclusion, TSA is a valuable tool in describing the complex features of factor, component or canonical variate analysis, since trend-surface projections, especially in axonometric view, may summarize ordinations and make easier to understand them at first glance. Moreover, when TSA is carried out on continuous variables (e.g. physical or chemical ones), it may provide cartographic representations which are useful not only on the descriptive standpoint, but also for their predictive value.

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