

Statistical calibration of the Carlit index in the Pontine Island of Zannone

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Abstract: The WFD¹, adopted by the European Community requires that Member States achieve and maintain a good ecological status of all water bodies by 2015. In the marine context, the ecological status has to be quantified applying indexes based on appropriate key biological elements. The CARLIT index is a cartographic monitoring tool enabling the EQR² to be calculated using macroalgae in coastal hard bottoms as a key biological element. Here we investigate the role of *Cystoseira amentacea var. stricta*: a key macroalgae involved in the index definition. We analyze the relation between the algae presence and geomorphological characteristics of Pontine Islands coast through standard logistic regression and autologistic models to account for spatial correlation.

Keywords: bioindicator, logistic regression, autologistic model

1 Introduction

The Water Framework Directive (WFD) 2000 /60 /EC, adopted by the European Community in 2000 requires that Member States achieve and maintain a good ecological status of all water bodies by 2015. In the marine context, the ecological status has to be quantified applying indexes based on appropriate key biological elements, which allow the categorization of water bodies into five Ecological Status (ES) classes. In order to implement the WFD, several indices based on macroalgae have been proposed. One of them is the CARLIT index (Ballesteros et al. 2007), which has been adopted for the evaluation of Italian rocky coasts. A recent application of the CARLIT protocol to the entire coast of the five Pontine Islands (Lazio) revealed a good ecological status of coastal water. However, in Zannone Island, the available chemical analysis indicates a higher value than the Carlit index. In

¹Water Framework Directive 2000 /60 /EC

²Ecological Quality Ratio

this work we investigate the role of the superficial *Cystoseira amentacea var. stricta* belts (a brown macroalgae bioindicator of water quality, see Table 1). We analyze the relation between the algae presence and the geomorphological characteristics of Pontine Islands coast through standard logistic regression and autologistic models to account for spatial correlation in order to specifically evaluate the predictive capacity of these characteristics. Our report is focused on the Island of Zannone.

2 Materials and Methods

The survey was carried out through a small boat at 3-4 meters of distance from the coastline. The recorded data were obtained noting, by use of a GPS, the discontinuities of the coast concerning algal communities and geomorphological characteristics. Thus the obtained sample units are homogeneous coastal sectors. For each Island the following observed data are given: (1) Population Category (Cod-popol), label of the observed community as described in table 1; (3) Coastal Morphology categorized as BM-metric blocks, FA-high cliff, FB-low cliff and SP-beach; (4) Sensitivity to pollution level (Value), (see table 1); (5) Length of the homogenous coastal sector in meters (Length). All the information has been transferred in ArcGis software. Exploratory data analysis has been carried out for all the variables and the presence of *Cystoseira* was coded as a binary variable (0/1). The association between the latter and the observed covariates (Slope and Morphology) has been explored through the χ^2 test. The variable Slope, in this step, has been categorized as 0-30, 45-60, 75-90. These data have been aligned to a Digital Elevation Model layer with resolution 20 meters, superimposing a grid of 326 cells to Zannone coastline. This new dataset allows us to investigate the association between the algae presence and a more detailed evaluation of the Island morphology. In the combined dataset the presence of each category of *Cystoseira* coded as a binary variable, the slope, elevation and aspect of the coast are available. The coast slope and aspect have been coded into 3 and 8 categories respectively for exploratory purposes, while in models estimation slope is taken back to its original expression.

Standard logistic regression models (Agresti, 2002) are estimated on the combined dataset to evaluate the predictive capacity of morphological GIS information for the algae presence with and without discriminating by population category. As standard logistic regression does not account for spatial autocorrelation, that seems a natural feature of this type of data, results are then compared with the predictive capacity of autologistic models (Besag, 1974) estimated through pseudo-likelihood (Besag 1975, Huang and Ogata 2002). To predict algae presence each grid cell with model-estimated probability of presence larger than 0.5 is set to 1.

Category	Description	Sen. level
<i>Cystoseira brachycarpa/crinita /elegans</i>	Community dominated by <i>Cystoseira brachycarpa /crinita /elegans</i>	20
<i>Cystoseira sheltered</i>	Community dominated by <i>Cystoseira foeniculacea /barbata /humilis / spinosa</i>	20
<i>Cystoseira amentacea /mediterranea</i> 5	Continuous belt of <i>Cystoseira mediterranea /stricta</i>	20
<i>Cystoseira amentacea /mediterranea</i> 4	Almost continuous belt of <i>Cystoseira mediterranea /stricta</i>	19
<i>Cystoseira amentacea /mediterranea</i> 3	Abundant patches of dense stands of <i>Cystoseira mediterranea /stricta</i>	15
<i>Cystoseira amentacea /mediterranea</i> 2	Abundant scattered plants of <i>Cystoseira mediterranea /stricta</i>	12
<i>Cystoseira compressa</i>	Community dominated by <i>Cystoseira compressa</i>	12
<i>Cystoseira amentacea /mediterranea</i> 1	Rare scattered plants of <i>Cystoseira mediterranea /stricta</i>	10

Table 1: Summarized description and sensitivity levels of the community categories related to *Cystoseira* as reported in the methodological contribution published by ISPRA (Mangialajo et al. 2008).

3 Results

The exploratory data analysis of the observed data reported a not significant association between the presence of *Cystoseira* and the coast Morphology at the available detail, while significant relation is found with slope. When considering a more detailed representation of the Island, as given by the DEM layer, significant association are found for all *Cystoseira* communities and the morphological variables slope and aspect, categories with higher sensitivity values showing stronger association. Logistic for the algae presence without discriminating by category return high significance of slope and aspect. Through this model 23.31% of the predicted grid cells were misclassified (with 37 wrong 1's and 39 wrong 0's over 326 grid cells). For categories with sensitivity level 19 and 15 we obtain similar results with a misclassification error of 15.95% with 12 wrong occurrences and 40 wrong zeros, showing a tendency to underestimate the number of presences. For less sensitive communities the significance of slope and aspect is reduced and the logistic model produces a 26.38% of missclassified cells, with a stronger tendency to underestimate the algae presence. within the pseudolikelihood estimation approach, the autologistic model corresponds to a logistic regression model in which the number of occurrences in each cell's neighborhood (SV) is a regressor. In this study a simple first order neighborhood is adopted. For all community categories the SV shades the relations of the algae presence with slope and aspect that become not significant, however the predictive capability of such models is considerably enhanced, misclassification errors drop considerably (for the general presence of *Cystoseira* 8.59%, for highly sensitive com-

munities 2.76% and for less sensitive communities 7.36%), all models tend to slightly underestimate the presence. A poisson regression (Cameron, Trivedi, 1998) has been fitted to relate SV and slope and aspect. Results show the strong relation between these variables explaining why the presence of SV in the model hides the dependence of the algae presence on the other two.

4 Concluding remarks

All analysis confirm the relevance of morphological variables in determining the *Cystoseira* communities presence in the Zannone island with stronger influence on more sensitive ones. Accounting for spatial correlation allows a considerably more precise prediction. Future work will deal with the remaining islands of the Pontine archipelago. It is of interest to investigate other models under a Bayesian estimation approach.

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