Biol. Mar. Medit. (2006), 13 (4): 206-209

S. Debono[1], J.A. Borg[2]

[1] Nature Protection Unit, Malta Environment and Planning Authority, Floriana, Malta
[2] Department of Biology, University of Malta, Msida, Malta

USE OF *POSIDONIA OCEANICA* AS A BIOINDICATOR OF ECOLOGICAL STATUS FOR MALTESE COASTAL WATERS

Abstract

Data on Posidonia oceanica *attributes from Maltese Coastal waters are available from a number of research studies and environmental monitoring programmes. As part of Malta's obligations for implementing the European Union's Water Framework Directive, the Malta Environment and Planning Authority participated in an intercalibration exercise, involving Mediterranean countries that are also EU member states, aimed at ensuring comparability of different methods for the classification of coastal waters using* P. oceanica *as bioindicator. Data on* P. oceanica *attributes (shoot area, shoot biomass and shoot density), collected during the period 1999 to 2004 from 19 sites in Malta and Gozo, were analysed using Analysis of Variance and Principal Component Analysis to identify differences in values of seagrass attributes between the different sites surveyed. The output from the statistical analyses was used to derive values of the Ecological Quality Ratio (EQR) for the five status classes (high, good, moderate, poor or bad). Of the 19 sites considered, 2 sites were classified as having 'high' status, 14 sites had 'good' status, 2 sites had 'moderate' status, and 1 site had 'poor' status. None of the sites were classified as having 'bad' status; however, this was attributed to the lack of* P. oceanica *data from localities that represented highly degraded coastal areas. The results obtained are discussed in the light of knowledge of the environmental characteristics of the sites surveyed, and recommendations for development of a national method for assessing and classifying the ecological status Maltese coastal water, based on a larger data set and inclusion of additional seagrass descriptors, are proposed.*

Key-words: *Ecological status classification, environmental monitoring, Maltese Islands*, Posidonia oceanica*, Water Framework Directive.*

Introduction

The Water Framework Directive (WFD), adopted by the European Union in 2000, obliges EU member States to assess and monitor the ecological status of water bodies across Europe through the use of Biological Quality Elements (BQEs), and to classify the waters in one of five status classes: *high, good, moderate, poor or bad*. In the Mediterranean region, the endemic seagrass *Posidonia oceanica* was selected (amongst others) as a BQE for marine coastal waters, owing to its widespread distribution and sensitivity to disturbance (Pergent-Martini *et al*., 2005). As part of the its Common Implementation Strategy (CIS), the EU also requires close collaboration between different member states to ensure European-wide comparability of methods used to classify the water bodies. To achieve this, EU member states were required to undertake an intercalibration exercise. In the meantime, no procedure had yet been adopted in Malta to assess and monitor the ecological status of coastal waters around the Maltese Islands. The aim of the present work was to test the Maltese method for classifying coastal waters, using a given set of *P. oceanica* descriptors, as established by the Geographical Intercalibration Group for the Mediterranean (Med GIG).

Materials and methods

Studies of *P. oceanica* undertaken between 1999 and 2004 were reviewed for availability of data on three seagrass attributes, namely shoot density, shoot area and shoot biomass, identified by the Med GIG for the intercalibration exercise. To avoid potential confounding effects, data was only selected from studies in which sampling was carried out within a given sampling period (spring or summer) and from a narrow depth range (9 m - 12 m). Using these selection criteria, data on *P. oceanica* morphometric descriptors available from a total of 23 coastal sites around the Maltese Islands (see Fig. 1) were selected for the analysis.

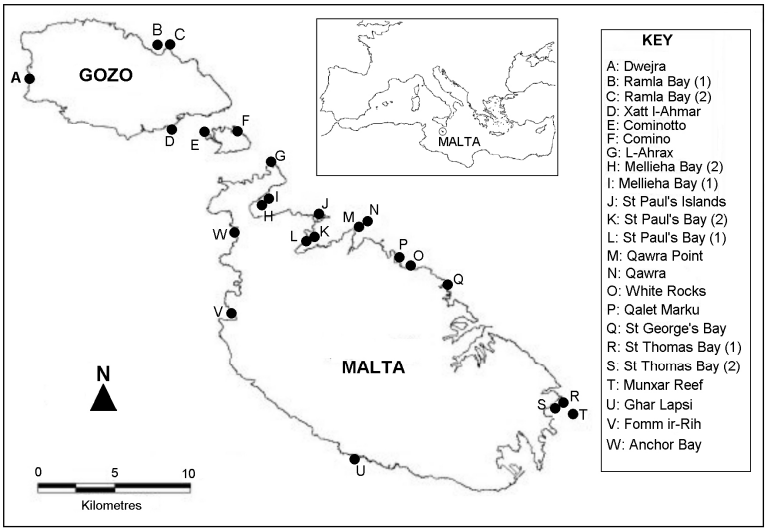

Fig. 1 - Map of the Maltese Islands showing the locations from where *P. oceanica* data used in the present work, had been collected.

The available data were first analysed using Analysis of Variance (ANOVA) to test for significant differences in the three *P. oceanica* attributes between different sites. In the analysis, data for the *P. oceanica* attributes, which are known to exhibit seasonal variation (shoot area and shoot biomass; e.g. see Borg and Schembri, 1995), were analysed separately by season; while data for meadow density, which does not exhibit seasonal variation (e.g. Buia *et al.*, 2000) was analysed collectively. Where significant differences were detected by the ANOVA, post hoc Student-Neuman-Keuls (SNK) tests were carried out to identify the source of difference. Data on shoot density and shoot area collected in summer were then analysed using Principal Components Analysis (PCA) to test for grouping of sites (see Romero *et al.*, 2005). It was not possible to include shoot biomass in the multivariate analysis, since data for this attribute had been collected in spring. The results from ANOVA and PCA, together with data of the physico-chemical characteristics of the sites (Axiak, 2004), were then used to categorise the 19 different sites into the five status classes. Values of the Ecological Quality Ratio (EQR) were then calculated, using the equation below:

$$EQR = \left(\frac{Y_1}{X_1} + \frac{Y_2}{X_2} + ... + \frac{Y_n}{X_n} \right) \times \left(\frac{1}{n} \right)$$

Where: X_1 = maximum mean value of the first *P. oceanica* attribute recorded from the reference condition; Y_1 = mean value of the first *P. oceanica* attribute recorded from any other condition being compared with the reference; X_n = maximum mean value of the nth *P. oceanica* attribute recorded from the reference condition; Y_n = mean value of the nth *P. oceanica* attribute recorded from any other condition being compared with the reference; n = number of different *P. oceanica* attributes used.

Results

The results of one-way ANOVA indicated significant differences for the three *P. oceanica* attributes between the different sites considered. Results of PCA using data of the two *P. oceanica* attributes from 19 sites, together with the estimated EQR values for the respective sites, enabled the setting of class boundaries (Fig. 2) and classification of the sites as shown in Table 1. The highest mean values of shoot area and shoot density were recorded from Ramla Bay. These were used as reference conditions for the estimation of EQRs, from which the final classification of sites was produced.

Tab. 1 - Proposed classification and estimated EQR values for the 19 sites. The site labels are the same ones used in Fig. 1.

Status	Site		EQR
High	B	Ramla (1)	**0.89**
	C	Ramla (2)	**0.82**
Good	H	Mellieha Bay (1)	**0.70**
	I	Mellieha Bay (2)	**0.66**
	P	Qalet Marku	**0.73**
	E	Cominotto	**0.72**
	F	Comino	**0.72**
	U	Ghar Lapsi	**0.74**
	M	Qawra Point	**0.75**
	D	Xatt l-Ahmar	**0.76**
	V	Fomm ir-Rih	**0.69**
	G	l-Ahrax	**0.69**
	A	Dwejra	**0.62**
	O	White Rocks	**0.66**
	J	St Paul's Islands	**0.65**
	R	St Thomas Bay (1)	**0.64**
Moderate	S	St Thomas Bay (2)	**0.54**
	Q	St George's Bay	**0.53**
Poor	W	Anchor Bay	**0.45**
Bad		N/A	**N/A**

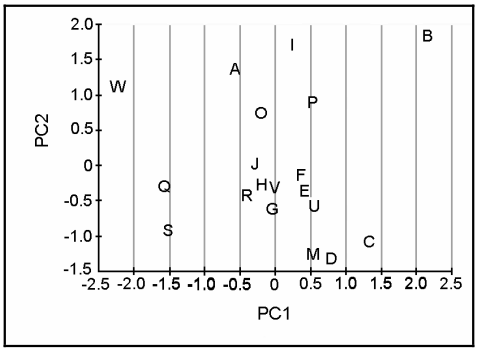

Fig. 2 - PCA ordination of the 19 sites using data of shoot area and shoot density (see Figure 1 for interpretation of labels used). Percentage variation explained by PC1 and PC2 = 50.7% and 49.3% respectively.

Most of the sites considered in the present study were classified as having 'good' status, two sites were classified in each of the 'high' and 'moderate' status classes, and a single site was classified as having 'poor' status. None of the 19 sites was classified as having 'bad' status.

Discussion and conclusions

The present work was entirely based on *P. oceanica* data that was available from local studies held in the past. Although several studies on the morphology of *P. oceanica* have been carried out in the Maltese Islands, relatively few qualified for use in the present study since the data had to fit the preset criteria (i.e. water depth at the sampling stations, sampling period and timescale of data, amongst others). The present results show that it is possible to use univariate and multivariate analysis to group sites based on values of *P. oceanica* attributes for the setting of status class boundaries as required by the WFD. There is also corroboration between the resulting classification and information on physico-chemical characteristics for the respective sites. For example, nutrient levels in the water column are higher (Axiak, 2004) at sites that classified as having 'poor' and 'moderate' status, hence showing that the various status classes are indicative of anthropogenic pressure.

Present results showed that most of the sites were classified as having 'good' status, whereas few sites classified as having 'poor', 'high' or 'moderate' status, and no site classified as having 'bad' status. The use of data for only two *P. oceanica* attributes, together with the small number of sites representing the 'high', 'moderate', 'poor' and 'bad' status classes in the statistical analyses may render the analyses insufficiently robust, and as such the present work should be considered as preliminary. Therefore inclusion of additional *P. oceanica* attributes (e.g. percentage plagiotropic to orthotropic rhizomes, percentage necrosis of leaves, and shoot epiphyte biomass) and sites in the analysis, would render the procedure sufficiently robust for assessing and monitoring the ecological status of Maltese coastal waters.

Acknowledgments

We are grateful to the Authors of works from which data were considered for the present study.

References

AXIAK V. (2004) - Monitoring programme for coastal waters; seventh report June 2003, March 2004. Malta: unpublished report, Environmental Protection Directorate, Pollution Control Co-ordinating Unit, MEPA: 70pp.

BORG J.A., SCHEMBRI P.J. (1995) - Preliminary data on bathymetric and temporal changes in the morphology of a Maltese *Posidonia oceanica* (L.) Delile meadow. *Rapp. Comm. Int. Expl. Sc. Mer Médit.,* **34**: 20.

BUIA M.C., GAMBI M.C., ZUPO V. (2000) - Structure and functioning of Mediterranean seagrass ecosystems: an overview. *In*: Pergent G., Pergent-Martini C., Buia M.C., Gambi M.C. (eds), Proceedings 4th International Seagrass Workshop, *Biol. Mar. Medit*., **7** (2): 167-190.

PERGENT-MARTINI C., LEONI V., PASQUALINI V., ARDIZZONE G.D., BALESTRI E., BEDINI R., BELLUSCIO A., BELSHER T., BORG J.A., BOUDOURESQUE C.F., BOUMAZA S., BOUQUEGNEAU J.M., BUIA M.C., CALVO S., CEBRIAN J., CHARBONNEL E., CINELLI F., COSSU A., DI MAIDA G., DURAL B., FRANCOUR P., GOBERT S., LEPOINT G., MEINESZ A., MOLENAAR H., MANSOUR H.M., PANAYOTIDIS P., PEIRANO A., PERGENT G., PIAZZI L., PIRROTTA M., RELINI G., ROMERO J., SANCHEZ-LIZASO J.L., SEMROUD R., SCHEMBRI P., SHILI A., TOMASELLO A., VELIMIROV B. (2005) - Descriptors of *Posidonia oceanica* meadows: Use and application. *Ecol. Indic.,* **5**: 213–230.

ROMERO J., ALCOVERRO T., MARTINEZ-CREGO B., PEREZ M. (2005) - The seagrass *Posidonia oceanica* as a quality element under the Water Framework Directive: POMI, a multivariate method to assess ecological status of Catalan coastal waters. Working document of the POMI group, University of Barcelona and Centre d'Estudis Avancats de Blanes (CSIC); 15pp.