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APPLICATION OF A G.I.S. TO THE MANAGEMENT OF MARINE PROTECTED AREAS: CARTOGRAPHY OF INFRALITTORAL FRINGE COMMUNITIES AS ENVIRONMENTAL HEALTH INDICATORS

Abstract

As a tool of Marine Protected Area management, the cartography, supported by a G.I.S., of the distribution of some superficial algae in a portion of coastline along the Portofino M.P.A. is presented. Cystoseira *spp., and other species from Ulvales order, indicators of water quality, have been utilized to characterise the environmental health of this area; their distribution underlines the good environmental health conditions on the southern front of the Promontory, along with a very localised disturbance associated to the small urban settlings present in the area.*

Keywords: Cystoseira, *Ulvales, G.I.S., Marine Protected Area (M.P.A.), coastal management, environmental health*

Introduction

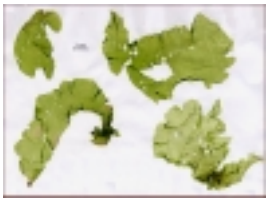
The coastal zone, representing the interface between land and sea, is subject to strong impacts due to the urbanisation of the coast, the touristic pressure and the transportation by sea of different substances. The virtual absence of tides in the Mediterranean Sea forces upper infralittoral communities to be in a very narrow fringe and always in contact with the superficial waters, whose quality is affected by the presence of floating pollutants (mostly tensioactives and hydrocarbons), often abundant in highly anthropised zones.

Fig.1: *Cystoseira* spp. superficial belt

The brown algae *Cystoseira* spp., characterising some of the most productive communities in the Mediterranean Sea (Ballesteros, 1989), are very sensitive to this kind of pollution. In particular, the species typical of this very shallow habitat, tend to disappear from urban areas (Arnoux & Bellan-Santini, 1972; Bellan & Bellan-Santini, 1972; Belsher & Boudouresque, 1974; Bellan-Santini & Desroisier, 1976; Verlaque & Tine, 1979 ; Soltan et al., 2001). Both *C. amentacea* and *C. mediterranea*, typical of high hydrodynamic conditions, are recognized as absolutely protected species in the Annex I of the Bern Convention (1979), on the conservation of wild life and its biotopes in Europe, and as species of Community Interest in the Annex V of the council directive 92/43/EEC of 21 May 1992, on the conservation of natural habitats and of wild fauna and flora.

The composition of superficial algal communities is related to environmental factors such as light and hydrodynamism, but is also a good indicator of environmental health of Mediterranean coastal waters (Cormaci & Furnari, 1991; Giaccone, 1991; Soltan *et al*., 2001). Their cartography, supported by a G.I.S, is a useful tool in the coastal management. Furthermore, the census of these most productive and sensitive communities is important, especially in areas where severe accidental pollution may occur, to help identify when and where protective actions are needed.

The cartography of the distribution of the following conspicuous algae, considered good monitors of particular environmental conditions, has been settled along in the Portofino Marine Protected Area (M.P.A.):



Cystoseira amentacea (C. Agardh) Bory var. *stricta* Montagne, characteristic species of the *Cystoseiretum strictae* Molinier 1958 association (Fig. 1). The big dimensions of the fronds provide shade and shelter to a very diversified community of algae and invertebrates (Bellan Santini, 1969; Mangialajo *et al*., 2003). This species is very sensitive to floating pollutants;

Cystoseira compressa (Esper) Gerloff *et* Nizamuddin, characterized by a wider ecological range (Fig. 1); where conditions are not favourable for the *Cystoseiretum strictae*, it tends to substitute the characteristic species (Giaccone, 1986);

Enteromorpha spp. and *Ulva* spp., which tend to form mono or paucispecifical communities in nutrient-rich waters (Rizzi Longo & Giaccone, 1974, Fig. 2).

Fig. 2: *Ulva laetevirens* and *Enteromorpha intestinalis*

Materials and methods

Two rocky areas on the Portofino Promontory M.P.A., Punta Chiappa and Baia di S. Fruttuoso, have been investigated. The coastline was divided into 242 sectors of homogeneous substratum, 20 m in length each, measured *in situ* using a decametre (Blachier *et al*., 1998; Mari *et al*., 1998; Meinesz *et al*., 2001). Sectors were identified according to various factors, such as slope and nature of substratum, geographical orientation and hydrodynamism (estimated by the vertical height of the area colonised by *Chthamalus* spp.). The quantification of the conspicuous species was expressed by percentage of linear covering; both the presence of anthropic wastes and hydrocarbon residues have been carefully monitored. The exact location of the borders of each sector was recorded on the digitalized magnifications of the coastline, elaborated from UTM regional ortophotomaps S. Margherita Ligure and S. Rocco (scale of 1:10,000). Data obtained were inserted into a G.I.S. (MapInfo) and were used to create a Data Base, containing the descriptive files of every sector of the georeferenced coastline.

For each conspicuous species we calculated the percentage of presence and of linear covering only in sectors considered favourable to its growth; sectors considered not favourable were omitted selecting them from the Data Base in Structured Query Language (S.Q.L.). This method permitted to decrease the importance of natural variability, due to environmental factors: in good environmental health conditions, we expect to have 100% cover of *C. amentacea* var. *stricta*, in those stretches of coastline characterised by high hydrodynamism, non vertical substratum (for good fixation of thallus), and southern geographical orientation (for a good illumination). Much lower values suggest the presence of a disturbance. The Data processing permitted to elaborate highly detailed and easy to consult thematic maps showing the distribution of conspicuous species and of anthropic wastes.

Results and Discussion

The high percentage of *Cystoseira amentacea* var. *stricta* recorded in areas characterized by high hydrodynamism, non-vertical substratum and good light conditions pointed out a general good environmental situation. It was present in 97,9% of sectors, with a mean cover of 72,8% (Table 1). On the other hand, the concomitant massive presence of *Cystoseira compressa*, might be an indication of a regressive evolution of the *Cystoseiretum strictae* (*sensu* Giaccone, 1986, Fig. 3).

Tab. 1: Percentage of sectors where each species is present (A), percentage of covered coastline (B) and percentage of presence of anthropic wastes (C) in the sectors considered favourable to the growth of each species.

Edaphic and climatic factors	N° of sectors	Species	A	B	C
High hydrodynamism, geographical orientation SE, S, SW, non vertical substratum	47	*Cystoseira amentacea* var. *stricta*	97,9	72,8	0
		Cystoseira compressa	78.7	35.0	
Low hydrodynamism, non vertical substratum	68	*Cystoseira compressa*	14,7	0,8	13.2
		Ulva spp., *Enteromorpha* spp.	75,0	30,0	

A comparison of *Cystoseira* spp. coverage was performed among Punta Chiappa, West and East side of the San Fruttuoso Bay, using for each site thirteen out of the overall 47 "favourable" sectors. Analyses of variance was performed in order to evaluate differences at the species level (between *C. amentacea* var. *stricta* and *C. compressa*) and at a geographical level (three different sites).

Tab. 2: Analysis of Variance on 13 sectors for each site presenting high hydrodynamism, good illumination and non vertical substratum

Source of variation	Sum of Squares	Degrees of Freedom	Mean Square	F	P		Denominator
Species	38168.21	1	38168.210	65.47	**0.0000**	***	Residual
Site	5975.31	2	2987.657	5.13	**0.0083**	**	Residual
SpeciesXSite	12757.67	2	6378.835	10.94	**0.0001**	***	Residual
Residual	41972.84	72	582.9562				
Total	98874.03	77					

Cystoseira amentacea is significantly more abundant than *C. compressa* (Tab. 2). Also the spatial distribution of the two species is different (significant SpeciesxSite interaction): SNK test on the interaction between Species and Sites shows that while the distribution of *C. amentacea* is significantly different in the three sites, for *C. compressa* there is no significant difference. *C. amentacea* is more abundant in Punta Chiappa and shows a decrease moving to the East side of S. Fruttuoso Bay, in contrast to an increase of *C. compressa* (Fig. 4).

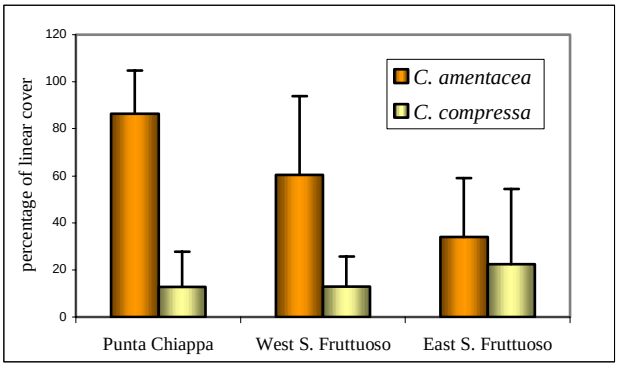


Fig. 4: Mean percentage of linear cover of both *Cystoseira amentacea* and *C. stricta* in the three different sites of Portofino MPA.

In sectors with low hydrodynamism, the *Cystoseira* spp. are virtually lacking (*C. compressa* covers only 0,8% of the potential coastline, and other calm-mode *Cystoseira* species are absent) and are substituted by dense populations of the ubiquitous species *Corallina elongata* Ellis et Solander. Herein, associations dominated by *Ulva laetevirens* Areschoug and *Enteromorpha intestinalis* (L.) Nees are frequently found. All this suggests a very localized disturb maybe due to the intake of fresh waters, either of natural or anthropic source, in areas with low

hydrodynamism (Rizzi-Longo & Giaccone, 1974). The anthropisation of these sectors is confirmed by the presence of wastes (Fig. 2). Yet, hydrocarbon residues are absent in all the studied area (just a very small quantity was found in a rockpool in the southern front of the Promontory).

The cartography realised is a good starting point for further studies in this area, in order to monitor the evolution in time of superficial algal assemblages.

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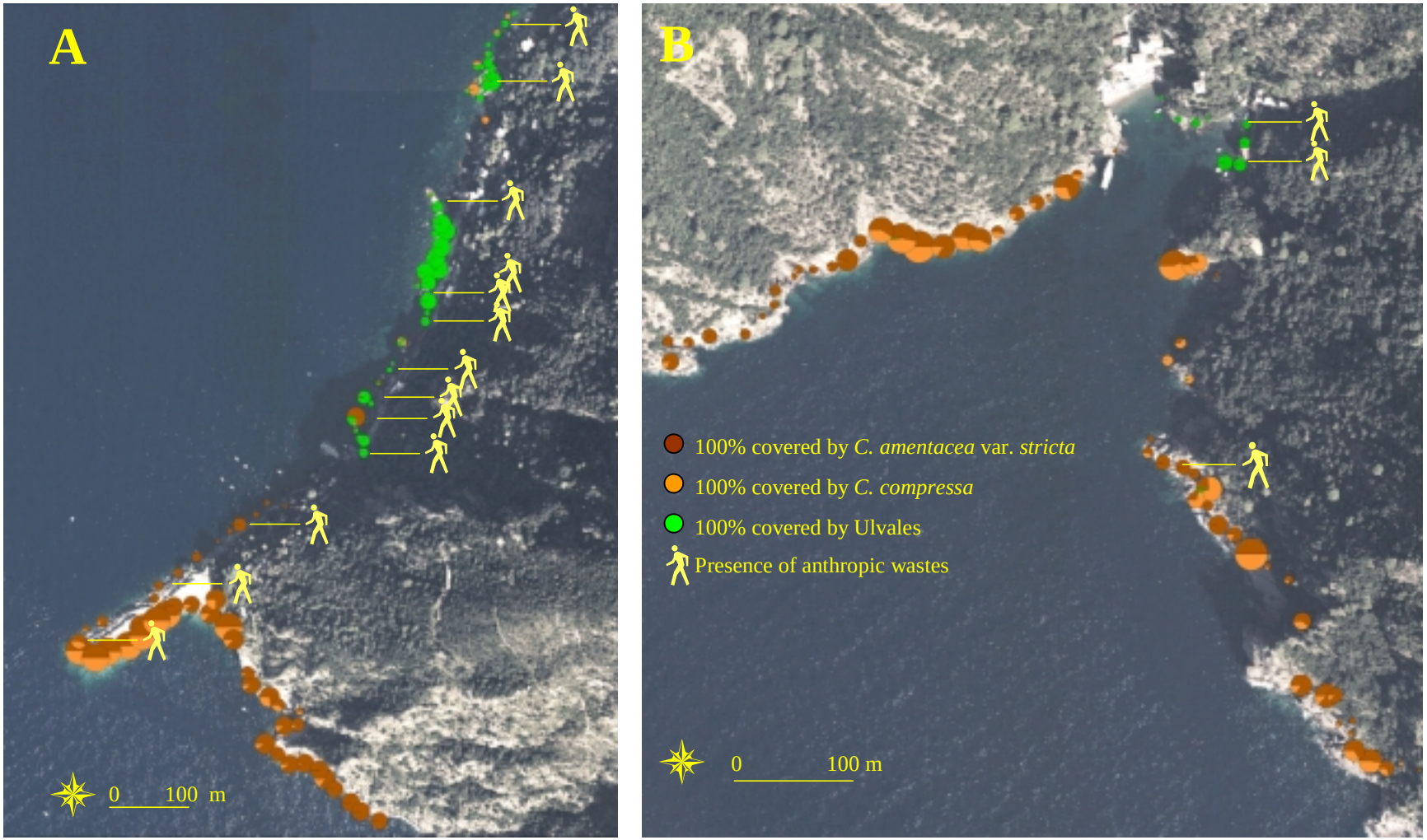

Fig. 3: Thematic maps showing the distribution of *C. amentacea* var. *stricta*, *C. compressa*, Ulvales and anthropic wastes in all the sectors cartographied in Portofino: A) Punta Chiappa; B) S.Fruttuoso Bay, West and East sides.