

# Macroalgal epiphytes of *Posidonia oceanica* leaves: biogeographic aspects

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## SUMMARY

Epiphyte summer assemblages of *Posidonia oceanica* leaves were analyzed at regional (Sardinia) and basin (Western Mediterranean Sea) scales. Along Sardinian coasts, species composition has been evaluated at different sides (East and West), depths (5 and 25 m), and geographical sectors (North, Central-North, Central-South and South), in a total of 32 sites. Deriving data from literature, five localities at the same depth were compared, at basin scale. The community structure, at both taxonomic and biogeographic level, was analyzed to reveal spatial patterns in epiphyte assemblages. At smaller scale, the number of species varied significantly with side, sector and site, while the assemblage composition did not; the biogeographic composition did not show significant differences because of the relevant influence of Subcosmopolitan and Cosmopolitan taxa. At basin scale taxonomic and biogeographic composition of epiphyte communities did not change according to a latitudinal gradient at least dealing with Western central Mediterranean Sea.

## INTRODUCTION

Epiphytic algae are a diverse flora growing on host seagrasses. Their importance to *Posidonia oceanica* ecosystem functioning in terms of food supply for macroherbivore-detritivore species is well recognized (Gambi et al., 1992; Buia et al., 2000; Zupo, 2001). In some cases the grazing impact was found to have a stabilizing effect on the system, as the epiphytic community may negatively influence the leaf production of seagrasses (Orth and Van Montfrans, 1984). However, this latter process was never confirmed in *P. oceanica* and it could be considered as an indicator of environmental change in the functioning of the system.

A predictable succession and zonation of epiphytic taxon and assemblages are identifiable on seagrass leaves, according to the blade age-gradient and life-time,

regardless of season and depth (Casola et al., 1987; Cebrià et al. 1999). In the colonization sequence, the structure of the epiphytic community, controlled not only by the age of the leaves but also by other environmental parameters, can result different in relation to spatial and temporal scales (Mazzella et al., 1989). A strict relationship among epiphytic complexity and life span of the leaves has been evidenced (Buia et al., 2000). As leaf growth follows a seasonal pattern, with the highest rates in autumn and the lowest ones in summer (Zupo et al., 1997), the epiphyte structure reaches the highest complexity and abundance during the summer season (Buia et al., 1992). Moreover, on *P. oceanica* there are no exclusive algal species but only taxa that can be considered characteristic of seagrass blades and that are widely distributed in various geographic regions on different seagrass hosts.

Although several analyses of epiphyte assemblage were made to describe spatial and temporal patterns within *P. oceanica* beds, focused at local scale (Panayotidis, 1980; Battiato et al., 1982; Buia et al., 1985; Orlando et al., 1998; Piazzi and Cinelli, 2000), there is a lack of information on the variability in the epiphytic community at larger spatial scales, such as regional or basin ones.

The aim of this study was to examine the variability in the composition of epiphytic macroalgal assemblages at a larger range of spatial scale, through biogeographic groups in order to detect if natural change in species composition may be correlated with environmental and climatic gradients.

## MATERIALS AND METHODS

### Regional scale

Sampling was carried out during the summer 2001 along the Sardinian coasts (Fig. 1). Sampling design (Fig. 1) was focused on four spatial factors: side (East and West), geographical sector (4 adjacent coastlines, along a North-South gradient, having unequal lengths because of non homogeneous distribution of *P. oceanica* meadows), site (2 at each sector) and depth (5 and 25 m), were selected; three replicates, plots distant 50 to 150 m from each other, were randomly selected at each depth; in each plot nine shoots were sampled. In the laboratory, for each shoot only the longest leaf was examined and the presence of each epiphytic macroalgal taxon was recorded. The total number of leaves was 864.

Moreover, taxa were classed into 14 biogeographic groups according to Cormaci et al. (1982): Mediterranean (M), Pantropical (P), boreo-Atlantic (Ab), Subcosmopolitan (SC), Indo-Atlantic (IA), Circumboreal (CB), boreo-tropical Atlantic (Abt), Cosmopolite (C), Indo-Pacific (IP), Indo-Atlantic cold temperate (IAct), Atlanto-Pacific cold temperate (APct), Atlanto-Pacific (AP), Atlantic tropical (At) and Circumboreo-Austral (CBA).

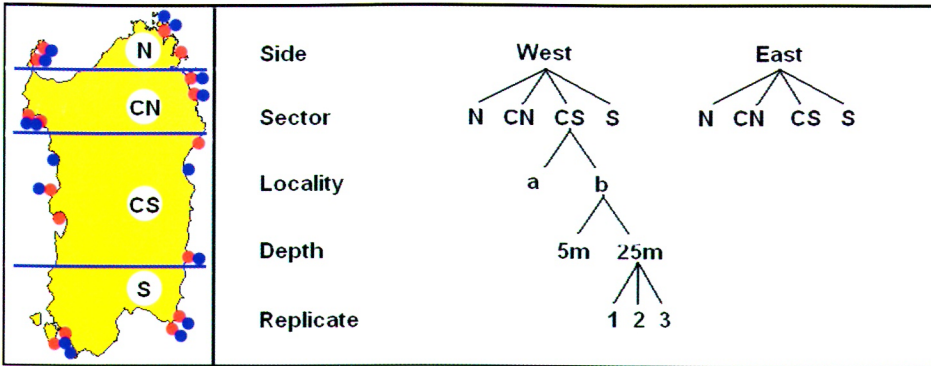


Fig. 1 - Map of Sardinia showing sides, sectors sites and depths (red dots = 5 m, blue dots = 25 m) and sampling design (N = North, CN = Central-North, CS = Central-South, S = South).

Spatial patterns of number of species and biogeographic groups were analyzed by 4-way ANOVA (Statistica package). Side and depth were considered as fixed factors, sector was randomly nested in side and was randomly nested in sector. The homogeneity of variance was tested by Cochran's test (Underwood, 1997). Multivariate analysis was also performed to examine the community structure at taxonomic level (PREMIER-E package, Clarke and Warwick, 2001). Results were represented by non-metric multidimensional scaling ordinations (nMDS) and differences in assemblage composition were tested by means of analysis of similarities (ANOSIM; Clarke, 1993) based on Bray-Curtis similarity index. The main species and biogeographic groups contributing to similarity within and dissimilarity among sides was assessed using similarity percentages (SIMPER, Clarke and Warwick, 1994).

## Basin scale

To examine the species and biogeographic compositions on larger spatial pattern, five Mediterranean localities (Fig. 2), distributed according to a latitudinal gradient, were compared using data available in literature. Season (summer) and depth (10 m) limited the analyses only to the West-central Mediterranean coasts. The five selected localities were: Trieste (45°38'N 013°40'E) (Orlando, 1998), Marseille (43°20'N 005°15'E) (Panayotidis, 1980), La Maddalena, Sardinia (41°13'N 009°25'E) (present data), Lacco Ameno, Ischia (40°45'N 013°53'E) (Battiato et al., 1982) and Correnti Island, Sicily (36°38'N 015°04'E) (Buia et al., 1985) (Fig. 2). For each locality, the Jaccard's (Jaccard, 1912) and Bray-Curtis similarity (Bray and Curtis, 1957) indices were computed in comparison with the Northern one, in order to investigate on species richness and biogeographic features.



Fig. 2 - Map of Western Mediterranean showing the 5 localities used for the analysis at basin scale. T = Trieste, M = Marseille, LM = La Maddalena, LA = Lacco Ameno, C = Correnti Island.

## RESULTS

### Regional scale

A total of 83 taxa were identified (Tab. I). The assemblage analyses showed consistent differences in species richness, both between sides, sectors and sites ( $p < 0.01$ ), regardless of the depth factor ( $p > 0.05$ ) (Tab. II); the highest number of species was recorded on the West side of Sardinia and in the Southern sector where the mean number of species was  $17.2 \pm 10.0$  in the shallow stands and  $21.8 \pm 6.2$  in the deep ones; the lowest values were  $3.5 \pm 3.1$  and  $3.5 \pm 0.8$  respectively in the shallow and deep meadows of the Central-North sector in the East side (Tab. III).

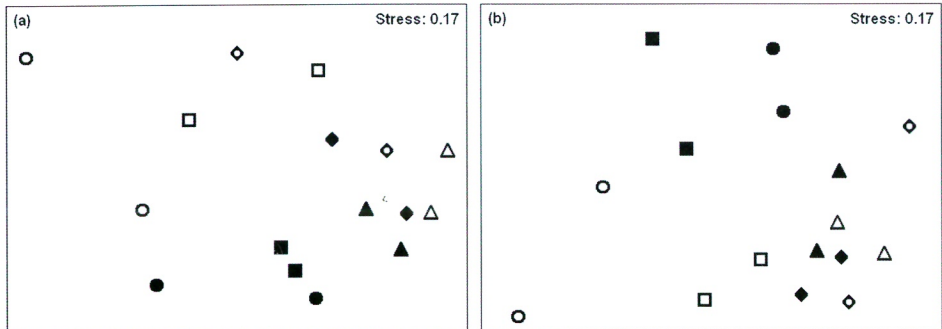


Fig. 3 - nMDS ordinations on the site centroids ( $n = 3$ ) at (a) 5 and (b) 25 metres. West (filled) and East (empty) sides and North ( $\blacktriangle$ ), Central-North ( $\circ$ ), Central-South ( $\square$ ), South ( $\diamond$ ) sectors are represented.

Tab. I - List of taxa recorded along Sardinian coasts (S) and in the five Mediterranean localities (T = Trieste; M = Marseille; LM = La Maddalena; LA = Lacco Ameno; C = Correnti Island). Biogeographic group (BG) are reported (M = Mediterranean; P = Pantropical; Ab = boreo-Atlantic; SC = Subcosmopolitan; IA = Indo-Atlantic; CB = Circumboreal; Abt = boreo-tropical-Atlantic; C= Cosmopolite; IP = Indo-Pacific; IAct = Indo-Atlantic cold temperate; APct = Atlanto-Pacific cold temperate; AP = Atlanto-Pacific; At = Atlantic-tropical; CBA = Circumboreo-Austral; is = *incertae sedis*).

	BG	S	T	M	LA	LM	C
<b>Rhodophyta</b>							
<i>Acrochaetium crassipes</i> (Børgesen) Børgesen	IA	+	-	-	-	-	-
<i>Acrochaetium daviesii</i> (Dillwyn) Nägeli	SC	+	-	+	-	-	-
<i>Acrochaetium</i> sp.	is	-	-	-	+	-	+
<i>Acrothamnion preissii</i> (Sonders) E.M.Wollaston	IP	+	-	-	-	-	-
<i>Aglaothamnion tenuissimum</i> (Bonnemaison) Feldmann-Mazoyer	M	+	-	-	-	-	-
<i>Aglaothamnion tripinnatum</i> (C.Agardh) Feldmann-Mazoyer	IA	-	-	+	-	-	-
<i>Antithamnion cruciatum</i> (C.Agardh) Nägeli	IA	-	-	-	-	-	+
<i>Antithamnion tenuissimum</i> (Hauck) Schiffrer	M	+	-	-	-	+	-
<i>Asparagopsis armata</i> Harvey	C	+	-	+	-	-	-
<i>Ceramium bertholdi</i> Funk	M	+	-	-	-	-	-
<i>Ceramium codii</i> (H.Richards) Mazoyer	SC	+	-	-	-	+	-
<i>Ceramium comptum</i> Børgesen	IA	+	-	-	-	-	-
<i>Ceramium diaphanum</i> (Lightfoot) Roth	SC	+	-	-	+	+	-
<i>Ceramium flaccidum</i> (Harvey ex Kützing) Ardissonne	C	+	-	-	-	-	-
<i>Ceramium siliquosum</i> v. <i>lophophorum</i> (Feldmann-Mazoyer) Serio	At	+	-	-	-	-	-
<i>Ceramium tenerimum</i> (G.Martens) Okamura	SC	+	-	-	-	+	-
<i>Chondria capillaris</i> (Hudson) M.J.Wynne	SC	+	-	-	-	-	-
<i>Chondria dasyphylla</i> (Woodward) C.Agardh	SC	+	-	-	-	+	+
<i>Chondria mairei</i> Feldmann-Mazoyer	M	+	-	-	-	+	-
<i>Chylocladia unistratosa</i> Ercegovic	is	-	-	+	-	-	-
<i>Chylocladia verticillata</i> (Lightfoot) Bliding	At	+	-	-	-	-	-
<i>Crouania attenuata</i> f. <i>bispora</i> (P.L.Crouan & H.M.Crouan) Hauck	M	+	-	+	-	-	-
<i>Dasya ocellata</i> (Grateloup) Harvey	IA	+	-	-	-	-	-
<i>Dasya rigidula</i> (Kützing) Ardissonne	Abt	+	-	-	-	-	-
<i>Erythrocladia violacea</i> P.Dangeard	is	-	-	+	-	-	-
<i>Erythrotrichia carnea</i> (Dillwyn) J.Agardh	C	+	+	+	-	+	-
<i>Erythrotrichia rosea</i> P.Dangeard	M	+	-	-	-	+	-
<i>Griffithsia barbata</i> C.Agardh	Abt	+	-	-	-	-	-
<i>Herposiphonia secunda</i> (C.Agardh) Ambronn	P	-	-	+	-	-	-
<i>Herposiphonia secunda</i> f. <i>tenella</i> (C.Agardh) M.J.Wynne	P	+	-	+	-	-	-
<i>Heterosiphonia crispella</i> (C.Agardh) M.J.Wynne	IA	+	+	-	-	-	+
<i>Hydrolithon - Pneophyllum</i> spp.	is	+	-	-	-	+	-
<i>Hydrolithon boreale</i> (Foslie) Y.M.Chamberlain	C	+	-	-	-	-	-
<i>Hydrolithon cruciatum</i> (Bressan) Y.M.Chamberlain	SC	+	+	-	-	-	-
<i>Hydrolithon farinosum</i> (J.V. Lamouroux) Penrose & Y.M. Chamberlain	C	-	+	+	-	-	+
<i>Hypoglossum hypoglossoides</i> (Stackhouse) F.S.Collins & Hervey	Ab	-	-	+	-	-	-
<i>Laurencia microcladia</i> Kützing	IP	+	-	-	-	+	-
<i>Laurencia minuta</i> Vandermeulen, Garbary & Guiry	M	+	-	-	-	-	-
<i>Laurencia obtusa</i> (Hudson) J.V. Lamouroux	C	-	-	+	-	-	-

<i>Lejolisia mediterranea</i> Bornet	P	+	-	-	-	-	-
<i>Lithophyllum</i> sp.	i s	-	-	-	-	-	+
<i>Lomentaria chylocladiella</i> Funk	M	+	-	-	-	-	-
<i>Myriogramme distromatica</i> Rodriguez ex Boudouresque	i s	+	-	-	-	-	-
<i>Nitophyllum punctatum</i> (Stackhouse) Greville	IA	+	-	-	-	+	-
<i>Plocamium cartilagineum</i> (Linnaeus) P.S.Dixon	SC	+	-	+	-	-	-
<i>Pneophyllum confervicola</i> (Kützinger) Y.M.Chamberlain	IA	+	-	-	-	-	-
<i>Pneophyllum fragile</i> Kützinger	C	+	+	+	+	-	+
<i>Polysiphonia brodiaei</i> (Dillwyn) Sprengel	IA	+	-	-	-	-	-
<i>Polysiphonia denudata</i> (Dillwyn) Greville ex Harvey	SC	+	-	-	-	-	-
<i>Polysiphonia dichotoma</i> Kützinger	IA	+	-	-	-	-	-
<i>Polysiphonia fibrillosa</i> (Dillwyn) Sprengel	Abt	+	-	-	-	-	-
<i>Polysiphonia foetidissima</i> Cocks ex Bornet	Ab	+	-	-	-	-	-
<i>Polysiphonia fucoides</i> (Hudson) Greville	IA	-	+	-	-	-	-
<i>Polysiphonia furcellata</i> (C.Agardh) Harvey	APct	-	+	-	-	-	-
<i>Polysiphonia lanosa</i> (Linnaeus) Tandy	i s	+	-	-	-	-	-
<i>Polysiphonia polyspora</i> (C.Agardh) Montagne	M	+	-	-	-	-	-
<i>Polysiphonia scopulorum</i> Harvey	IP	-	+	+	-	-	-
<i>Polysiphonia</i> sp.	i s	-	-	-	+	-	-
<i>Polysiphonia stricta</i> (Dillwyn) Greville	CB	+	-	-	-	+	-
<i>Polysiphonia subulata</i> (Ducluzeau) P.L.Crouan & H.M.Crouan	Abt	+	-	-	-	+	-
<i>Pterothamnion crispum</i> (Ducluzeau) Nägeli	SC	+	-	-	-	-	-
<i>Pterothamnion plumula</i> (J.Ellis) Nägeli	SC	-	-	+	+	-	-
<i>Ptilothamnion pluma</i> (Dillwyn) Thuret	IA	-	-	-	+	-	-
<i>Rhodophyllis divaricata</i> (Stackhouse) Papenfuss	Ab	-	-	+	-	-	-
<i>Sablingia subintegra</i> (Rosenvinge) Kornmann	SC	+	-	-	-	+	-
<i>Spermothamnion flabellatum</i> f. <i>disporum</i> Bornet	M	-	-	-	+	-	-
<i>Spermothamnion repens</i> (Dillwyn) Rosenvinge	Abt	+	-	-	-	-	-
<i>Stylonema alsidii</i> (Zanardini) K.M.Drew	C	+	+	+	+	+	+
<i>Stylonema cornu-cervi</i> Reinsch	AP	+	-	-	-	-	-
<i>Titanoderma corallinae</i> (P.L.Crouan & H.M.Crouan) Woelkerling, Y.M.Chamberlain & P.C.Silva	IA	-	+	-	-	-	-
<i>Titanoderma pustulatum</i> (J.V. Lamouroux) Nägeli	IA	-	+	-	-	-	-
<i>Titanoderma pustulatum</i> v. <i>confine</i> (P.L.Crouan & H.M.Crouan) Y.M.Chamberlain	IA	-	-	+	-	-	-
<b>Phaeophyta</b>							
<i>Asperococcus bullosus</i> J.V.Lamouroux	SC	+	-	-	-	-	-
<i>Cladosiphon cylindricus</i> Sauvageau	M	+	+	+	+	-	-
<i>Cladosiphon irregularis</i> Sauvageau	M	+	-	+	-	-	-
<i>Cladosiphon</i> sp.	i s	-	-	-	-	-	+
<i>Cladosiphon zosteriae</i> (J.Agardh) Kylin	Ab	-	-	-	+	-	-
<i>Dictyota dichotoma</i> (Hudson) J.V. Lamouroux	C	-	-	-	-	-	+

	BG	S	T	M	LA	LM	C
<i>Dictyota dichotoma</i> v. <i>intricata</i> (C.Agardh) Greville	SC	+	-	+	-	+	-
<i>Ectocarpus fasciculatus</i> Harvey	Ab	+	-	-	-	-	+
<i>Ectocarpus siliculosus</i> (Dillwyn) Lyngbye	C	+	-	-	+	-	-
<i>Elachista stellaris</i> Areschoug	Ab	+	-	-	-	-	-
<i>Giraudia sphaclairoides</i> Derbès & Solier	IAct	+	+	+	+	-	+
<i>Halopteris filicina</i> (Grateloup) Kützing	SC	+	-	-	-	-	-
<i>Hecatonema maculans</i> (F.S.Collins) Sauvageau	C	+	-	-	-	+	-
<i>Kuckuckia spinosa</i> (Kützing) Kornmann	Ab	+	-	-	-	-	-
<i>Myriactula arabica</i> (Kützing) J.Feldmann	i s	-	-	-	+	-	-
<i>Myriactula gracilis</i> Van der Ben	i s	-	-	+	-	-	-
<i>Myriactula rivulariae</i> (Suhr) Feldmann	IA	+	-	-	-	-	-
<i>Myrionema orbiculare</i> J.Agardh	SC	+	+	+	+	+	+
<i>Myrionema strangulans</i> Carmichael & Solier	SC	+	-	-	-	+	-
<i>Nemacystus ramulosus</i> Derbès & Solier	M	+	-	-	-	-	-
<i>Punctaria latifolia</i> Greville	CBA	+	-	-	-	-	-
<i>Ralfsia verrucosa</i> (Areschoug) Areschoug	SC	+	-	-	-	-	-
<i>Sphaclaria cirrosa</i> (Roth) C.Agardh	SC	+	-	+	-	+	-
<i>Sphaclaria plumula</i> Zanardini	SC	+	-	-	-	-	-
<i>Sphaclaria</i> sp.	i s	-	-	-	-	-	+
<i>Stictyosiphon adriaticus</i> Kützing	M	+	-	-	-	-	-
<i>Stilophora tenella</i> (Esper) P.C.Silva	SC	+	-	-	-	-	-
<b>Chlorophyta</b>							
<i>Chaetomorpha aerea</i> (Dillwyn) Kützing	i s	+	-	-	-	-	-
<i>Chaetomorpha linum</i> (O.F.Müller) Kützing	C	+	-	-	-	-	-
<i>Cladophora albida</i> (Nees) Kützing	SC	+	-	-	-	-	-
<i>Cladophora dalmatica</i> Kützing	IA	+	-	-	-	-	-
<i>Cladophora echinus</i> (Biaioletto) Kützing	IA	-	+	-	-	-	-
<i>Cladophora prolifera</i> (Roth) Kützing	IA	-	+	-	-	-	-
<i>Cladophora sericea</i> (Hudson) Kützing	SC	+	-	-	-	-	-
<i>Entocladia viridis</i> Reinke	C	+	-	+	-	-	-
<i>Phaeophila dendroides</i> (P.L.Crouan & H.M.Crouan) Batters	IA	+	-	-	-	+	-
<i>Pringsheimiella scutata</i> (Reinke) Hoehnel ex Marchewianka	SC	+	-	-	-	-	-
<i>Rhizoclonium tortuosum</i> (Dillwyn) Kützing	SC	+	-	-	-	-	-
<i>Ulothrix flacca</i> (Dillwyn) Thuret	SC	+	-	-	-	-	-
<i>Ulwella lens</i> P.L.Crouan & H.M.Crouan	IA	+	-	-	-	+	-
<i>Ulwella setchellii</i> P.J.L. Dangeard	APct	-	+	-	-	-	-

MDS ordinations (Fig. 3) showed a small separation between leaf epiphyte assemblages in West and East side of Sardinia (stress = 0.17 at both depths); a slight separation among assemblages within each side was shown only in deep stands. Consistent with ordinations, ANOSIM test showed no significant

Tab. II - ANOVA results on species richness at regional scale (\*significant values).

Source of variation	df	ms	F	p
Side	1	273.38	6.16	0.04*
Sector	6	380.40	8.58	0.00*
Site	8	44.35	3.04	0.01*
Depth	1	45.38	0.53	0.49
Side × Depth	1	22.04	0.26	0.63
Sector × Depth	6	30.40	0.35	0.89
Site × Depth	8	85.81	5.88	0.00*

Tab. III - Average and standard deviation of taxa recorded for each depth at each sector (N = North; CN = Central-North; CS = Central-South; S = South) at regional scale.

Depth	Sector	West side	East side
5 m	N	14.2 ± 4.5	16.3 ± 8.3
	CN	10.7 ± 5.8	3.5 ± 3.1
	CS	10.2 ± 1.6	6.3 ± 1.7
	S	17.2 ± 10	8.7 ± 3.1
25m	N	17.3 ± 5.5	19 ± 4.8
	CN	8.8 ± 4.6	3.5 ± 0.8
	CS	5.8 ± 2.3	9.7 ± 2.9
	S	21.8 ± 6.2	12 ± 4.2

Tab. IV - ANOVA results on biogeographic richness at regional scale (\*significant values).

Source of variation	df	MS	F	p
Side	1	31.51	4.38	0.07
Sector	6	43.40	6.03	0.01*
Site	8	7.20	3.99	0.00*
Depth	1	11.34	1.99	0.20
Side × Depth	1	12.76	2.24	0.17
Sector × Depth	6	7.41	1.30	0.36
Site × Depth	8	5.70	3.16	0.00*

differences between sides and significant differences among sectors only in deep stands ( $R = 0.62$ ,  $P < 0.1\%$ ).

SIMPER analysis identified species contributing to the similarity within and dissimilarity between each side. In shallow stands important taxa characterizing both sides were *Hydrolithon-Pneophyllum* complex and *Myrionema orbiculare*; *Giraudia*



*sphacelarioides*, mainly present in the Western meadows, had the highest contribute to differentiate West and East coasts (6.08% of total dissimilarity). Deep stands were again characterized by *Hydrolithon-Pneophyllum* complex and also by *Stylonema alsidii* (West side) and *Ceramium tenerrimum* (East side); this latter was the species contributing most to total dissimilarity between West and East sides (4.06%).

In relation to biogeographic composition of algal assemblages analysis of variance showed a significant difference only among latitudinal sectors and sites ( $p < 0.01$ ) (Tab. IV).

SIMPER analysis identified also important biogeographic groups in characterizing or differentiating sides. At both depths, Subcosmopolitan and Cosmopolitan biogeographic groups were more frequent even if with different abundance, much higher in West side for both groups; for this reason they were also the biogeographic groups which contributed more to dissimilarity between Western and Eastern coasts. Indo-Atlantic and Mediterranean groups were also important in differentiating sides.

### Basin Scale

A total of 66 species was observed (Tab. I). Marseille and La Maddalena presented the highest taxonomic and biogeographic diversity (Tab. V). These two localities showed exclusive groups: Pantropical species at Marseille and Circumboreal and boreo-tropical Atlantic species at La Maddalena. Correnti Island (the Southmost locality) presented only five biogeographic groups and lacked Mediterranean species (Fig. 4).

The five epiphytic assemblages revealed different species composition (Fig. 5a), while biogeographic composition was substantially similar by increasing the distance from a fixed locality (Trieste) ( $\text{Bray-Curtis}_{\text{Trieste-Marseille}} = 0.61$ ;  $\text{Bray-Curtis}_{\text{Trieste-Correnti Island}} = 0.54$ ) (Fig. 5b).

### DISCUSSION

Although species richness of epiphytic communities is different both at regional and basin scale, their composition does not differ significantly in relation to

Tab. V - Number of species and biogeographic groups at each locality at basin scale.

Locality	Species	Biogeographic groups
Trieste	17	7
Marseille	27	8
La Maiddalena	22	8
Lacco Ameno	14	6
Correnti Island	14	5

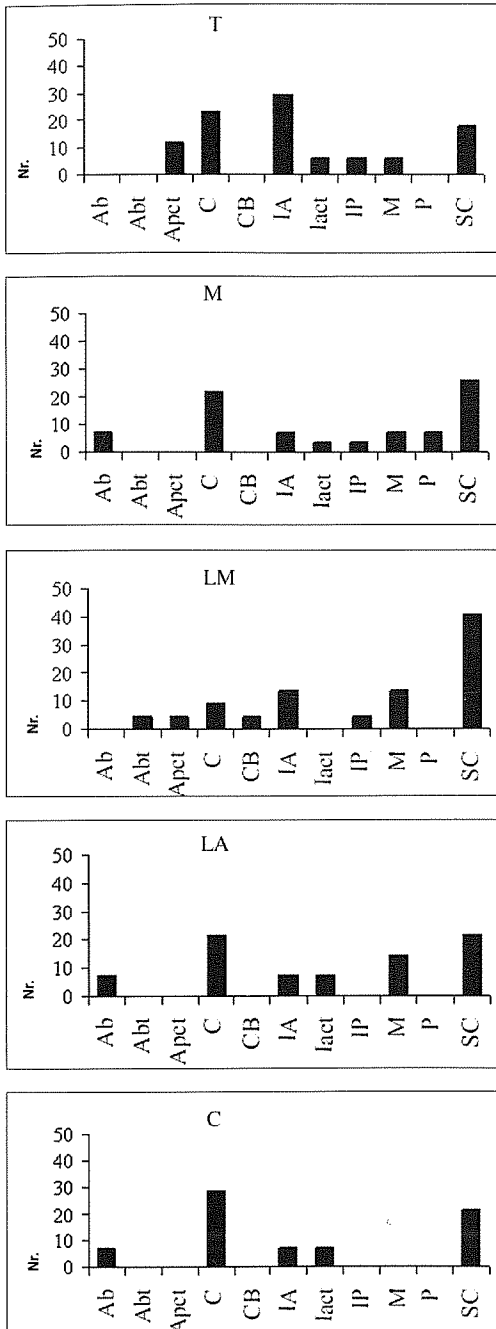


Fig. 4 - Histograms indicating the number of taxa for each biogeographic group at each locality (T = Trieste; M = Marseille; LM = La Maddalena; LA = Lacco Ameno; C = Correnti Island).

geographical gradients. Bray-Curtis' similarity indices, used to characterize the biogeographic epiphytic structure, are similar also between localities situated thousands of km apart, such as Marseille and Correnti Island. Our results do not exhibit a clear latitudinal gradient, at least for meadows present in West central Mediterranean. In fact all studied localities are characterized by "Herbier de Posidonies" species (*sensu* Boudouresque, 1984) such as *Myrionema orbiculare* and *Pneophyllum fragile*; these species belong to Subcosmopolitan and Cosmopolitan groups which are responsible of the similarity among meadows; on the contrary dissimilarity is more strictly related to some peculiar biogeographic groups, such as Indo-Atlantic mainly recorded at Trieste, Pantropical at Marseille, Circumboreal e boreo-tropical Atlantic at La Maddalena.

Our analysis represents a first attempt to compare assemblage patterns of seagrass epiphytes among meadows distant hundreds of Km and not at metric scale, within the meadow itself. Results demonstrate an homogeneity of the algal communities composition with the increasing of the spatial scale. unfortunately there are no reports on the variation of abundance and composition of seagrass epiphytic assemblages at large scale to compare with our

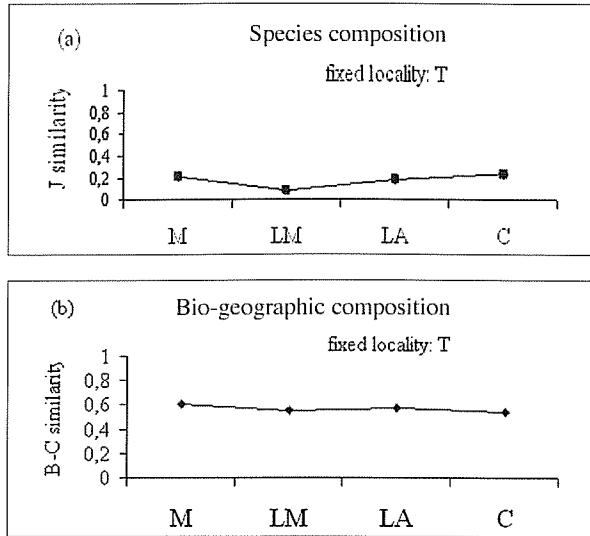


Fig. 5 - (a) Jaccard (J) similarity computed on species composition and (b) Bray-Curtis (B-C) similarity computed on biogeographic richness along North-South gradient in comparison to a fixed locality (T = Trieste; M = Marseille; LM = La Maddalena; LA = Lacco Ameno; C = Correnti Island).

results. At meadow scale, several authors found that algal epiphyte structure was homogeneous within bed samples separated by tens of cm, while differences were observed among assemblages 1 to 10 m apart (Vanderklift and Lavery, 2000); differences in epiphytic assemblages were also recorded among beds 8 km apart (Kendrick and Burt, 1997; Saunders et al., 2003). Environmental conditions at each site may differ enough to trigger marked amongst-bed differences in the epiphytic structure. However, the homogenization of environmental conditions characterizing larger areas (regional and basin scales), due to the averaging of several environmental patterns, may determine scarce differences in this type of comparisons.

Unfortunately some temporal (season) and spatial (depth) constrains limited the basin scale study to the West central Mediterranean for which literature data were available. Therefore, to confirm results obtained in this paper it could be interesting to increase the sampling effort to analyse the epiphytic assemblage at several localities in the whole Mediterranean, covering both East-West and South-North gradients.

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## REFERENCES

- BATTIATO A., CINELLI F., CORMACI M., FURNARI G., MAZZELLA L. 1982 - Studio preliminare della macroflora epifita della *Posidonia oceanica* (L.) Delile di una prateria di Ischia (Golfo di Napoli). *Nar. Sicil.*, 6 (suppl.), 1: 15-27.
- BOUDOURESQUE C.F. 1984 - Groupes ecologiques d'algues marines et phytocenoses benthiques en Méditerranée Nord-occidentale: une revue. *Giorn. Bot. Ital.*, 118 (1-2) suppl. 2: 7-42.
- BRAY J.R., CURTIS J.T. 1957 - An ordination of the upland forest communities of Southern Wisconsin. *Ecol. Monogr.*, 27: 325-349.
- BUIA M.C., CORMACI M., FURNARI G., MAZZELLA L. 1985 - Osservazioni sulla struttura delle praterie a *Posidonia oceanica* (L.) Delile di Capo Passero (Siracusa) e studio della macroflora epifita delle foglie. *Boll. Acc. Gioenia Sci. Nat. Catania*, 18 (326): 463-484.
- BUIA M.C., ZUPO V., MAZZELLA L. 1992 - Primary production and growth dynamics in *Posidonia oceanica*. *P.S.Z.N.I. Mar. Ecol.*, 13 (1): 2-16.
- BUIA M.C., GAMBI M.C., ZUPO V. 2000 - Structure and functioning of mediterranean seagrasses ecosystems: an overview. *Biol. Mar. Medit.*, 7 (2): 167-190.
- CASOLA E., SCARDI M., MAZZELLA L., FRESI E. 1987 - Structure of epiphytic community of *Posidonia oceanica* leaves in a shallow meadow. *P.S.Z.N.I. Mar. Ecol.*, 8 (4): 285-296.
- CEBRIAN J., ENRIQUEZ S., FORTES M., AGAWIN N., VERMAAT J.E., DUARTE C.M. 1999 - Epiphyte accrual on *Posidonia oceanica* (L.) Delile leaves: implications for light absorption. *Bot. Mar.*, 42: 123-128.
- CLARKE K.R. 1993 - Non parametric multivariate analyses of changes in community structure. *Aust. J. Ecol.*, 18: 117-143.
- CLARKE K.R., WARWICK R.M. 1994 - Changes in marine communities: an approach to statistical analysis and interpretation. Natural Environmental Research Council, UK, Plymouth Marine Laboratory, 144 pp.
- CLARKE K.R., WARWICK R.M. 2001 - Changes in marine communities: an approach to statistical analysis and interpretation. Primer-E, Plymouth Marine Laboratory, Plymouth.
- CORMACI M., DURO A., FURNARI G. 1982 - Considerazioni sugli elementi fitogeografici della flora algale della Sicilia. *Atti 13° Congresso SIBM. Nat. Sicil.*, 6 (suppl.): 7-14.
- GAMBI M.C., LORENTI M., RUSSO G.F., SCIPIONE M.B., ZUPO V. 1992 - Depth and seasonal distribution of some groups of the vagile fauna of the *Posidonia oceanica* leaf stratum: structural and trophic analyses. *P.S.Z.N.I. Mar. Ecol.*, 13 (1): 17-39.
- JACCARD P. 1912 - The distribution of the flora in the alpine zone. *New Phytol.*, 11: 37-50.
- KENDRICK G.A., BURT J.S. 1997 - Seasonal changes in epiphyte macro-algae assemblages between offshore exposed and inshore protected *Posidonia sinuosa* Cambridge et Kuo seagrass meadows, Western Australia. *Bot. Mar.*, 40: 77-85.
- MAZZELLA L., SCIPIONE M.B., BUIA M.C. 1989 - Spatio-temporal distribution of algal and animal communities in a *Posidonia oceanica* (L.) Delile meadow. *P.S.Z.N.I. Mar. Ecol.*, 10 (2): 107-129.
- ORLANDO M., BRESSAN G. 1998 - Colonizzazione di macroepifiti algali su *Posidonia oceanica* (L.) Delile lungo il litorale sloveno (Golfo di Trieste - Nord Adriatico). *Annali di Studi Istriani e Mediterranei*, 13/98: 109-120.
- ORTH R.J., VAN MONTERFRANS J. 1984 - Epiphyte-seagrass relationship with an emphasis on the role of micrograzing: a review. *Aquat. Bot.*, 18 (1-2): 43-69.
- PANAYOTIDIS P. 1980 - Contribution a l'étude qualitative et quantitative de l'association *Posidonietum oceanicae* Funk 1929. These Doctorat, Univ. Aix-Marseille II; 213 pp.
- PIAZZI L., CINELLI F. 2000 - Effects of the spreads of the introduced Rhodophyceae *Acrothamnion preissii* and *Womersleyella setacea* on the macroalgal community of *Posidonia oceanica* rhizomes in the Western Mediterranean Sea. *Cryptogam. Algol.*, 21 (3): 291-300.
- SAUNDERS J.E., ATTRILL M.J., SHAW S.M., ROWDEN A.A. 2003 - Spatial variability in the epiphytic algal assemblages of *Zostera marina* seagrass beds. *Mar. Ecol. Prog. Ser.*, 249: 107-115.
- UNDERWOOD A.J. 1997 - Experiments in Ecology: their logical design and interpretation using analysis of variance. Cambridge University Press, Cambridge, 504 pp.
- VANDERKLIFT M., LAVERY P. 2000 - Patchiness in assemblages of epiphytic macroalgae on *Posidonia coriacea* at a hierarchy of spatial scales. *Mar. Ecol. Prog. Ser.*, 192: 127-135.
- ZUPO V., BUIA M.C., MAZZELLA L. 1997 - A production model for *Posidonia oceanica* based on temperature. *Estuar. Coast. Shelf Sci.*, 44 (4): 483-492.
- ZUPO V. 2001. Influence of diet on sex differentiation of *Hippolyte inermis* Leach (Decapode: Natantia) in the field. *Hydrobiologia*, 449:131-140.