Mediterranean Marine Science

Vol 4, No 2 (2003)

Epiphytic Communities On Posidonia Oceanica (L.) Delile Leaves Along The North Tyrrhenian Coasts (N.W. Mediterranean Sea, Italy)

R. BEDINI, M.G. CANALI, M. BERTUCCELLI

doi: [10.12681/mms.233](https://doi.org/10.12681/mms.233)

Mediterranean Marine Science
Vol. 4/2, 2003, 99-114

Epiphytic Communities On *Posidonia Oceanica* (L.) Delile Leaves Along The North Tyrrhenian Coasts (N.W. Mediterranean Sea, Italy)

BEDINI, R., CANALI, M.G. and BERTUCCELLI, M.

Institute of Marine Biology and Ecology
p. Bovio 4, Piombino, Italy

e-mail: bedini@biomare.it

Abstract

The structure of epiphytic communities was studied from February to November 2000 at three different levels (upper limit, lower limit, central zone) in depth (- 5 to – 26 m) in five Posidonia oceanica (L.) Delile 1813 Tuscany coast meadows: Rosignano, San Vincenzo, Piombino, Punta Ala, Portoferraio (Isle of Elba). The study was focused on leaf epiphytes and epifauna. Three shoots in three plots were collected randomly in each area (nine shoots per area) in each site of each meadow. A quantitative description of the epiphytes and epifauna was carried out, regarding the three groups: Algae, Hydroids and Bryozoans, both on the outer and the inner surfaces of the leaf blade. The dynamics of communities of the leaf-stratum along a bathymetric gradient showed a seasonal variation characterized by the highest richness of epiphytes mainly in the upper limit, especially in early spring. Significant differences were demonstrated for the epiphytic communities of the external leaf-stratum both on the upper and the central limit of the studied meadows.

Keywords: Posidonia, Epiphytes, Community structure, Tyrrhenian, Mediterranean.

Introduction

Epiphyte colonization of the *Posidonia oceanica* leaf blades is very variable, both in a qualitative and in a quantitative sense. The epiphytic community appears to differ along the axis of the blade according to the age of the leaf, so that the basal region appears less colonized if compared to the apical parts (the older ones) affected by a thick epiphytic presence (MAZZELLA & RUSSO, 1989), considering also epiphyte biomass (CEBRIAN *et al.*, 1999). This is also due to the fact that the youngest parts of the leaf produce less phenolic acid, which inhibits the colonization and development of the epiphytic communities (HARRISON, 1982; HARRISON & DURANCE, 1985). In general during each season we observe an epiphytic community more differentiated in the upper limits considered, if compared to the lower limits (MAZZELLA *et al.*, 1989). Indeed along the depth gradient there is the influence of environmental factors such as the hydrodynamics, the strength of the light, the temperature that affect the settlement and the development of the epiphytes (CINELLI *et al.*, 1984; MAZZELLA & ALBERTE, 1986). What is more the epiphytic colonization concerns, to a large extent, the inner surface of the blade, because if we observe the disposition of the leaf shoots in relation to the sunlight and the hydrodynamic factor, the inner surface of adult and intermediate leaves (which are those more affected by epiphytisme) prove to be the most exposed (VAN der BEN, 1971; NOVAK, 1984; MAZZELLA & RUSSO, 1989).

Epiphyte colonization is principally controlled by biological factors such as the host plant growth and the life cycle of the epiphytes (CASOLA *et al.*, 1987; MAZZELLA & RUSSO, 1989). Variations normally observed can surely be correlated with seasonality, so the greatest development of epiphytes can be recorded from spring to the end of the summer, with the least colonization in autumn when sea storms typical of this season occur together with the physiological loss of leaves in the meadow (CINELLI *et al.*, 1984; MAZZELLA *et al.*, 1989; PERGENT *et al.*, 1995). The presence of different concentrations of fertilizers in the seawater and the values of some physical parameters (e.g. temperature and light intensity) are limiting factors for epiphyte growth. So, there will be an abundant development of epiphytes in those meadows in strongly organically polluted areas (JUPP, 1977; MENDEZ, 1994) reducing the photosynthesis and the diffusion rate of CO_2 to the seagrass (SILBERSTEIN *et al.*, 1986); epiphyte organisms can almost be considered indicators of organic pollution levels (PERGENT *et al.*, 1995). The aim of this research is the characterization of the upper and lower limits and the central area of five meadows on the Tuscany coast: Rosignano Solvay (1), San Vincenzo (2), Piombino (3), Portoferraio (Island of Elba) (4), and Punta Ala (5) (Figure 1) from the point of view of presence and abundance of epiphytes and epifauna, in order to compare those meadows interested by completely different environmental conditions.

Materials and Methods

Data acquisition was carried out within the selected meadows, according to the sampling project illustrated in Figure 2, in the period February-November 2000 in order to cover the four seasons of the year. The upper limit, the lower limit, and a central zone, were defined for each meadow, in three depth ranges. For each of these zones, three areas were randomly chosen and recorded by G.P.S. Garmin II Plus, and for each of the areas three plots were defined, about 4 m^2 in width, for leaf shoot sampling, using SCUBA equipment (GAMBLE, 1984).

A total of 81 shoots was collected in each season for each studied meadow. Subsequently all samples were analysed in the Piombino Institute of Marine Biology and Ecology laboratories, using stereomicroscopes LEICA MS5. Epifauna and epiphytes on leaf blades were described in quantitative terms, according to the Epiphyte Index (E.I.) by Morri (1991).

The question of the quantitative evaluation of the epiphytes has been studied by many authors; a bibliographic summary is presented by BOUDOURESQUE *et al.* (1977), by CASOLA *et al.* (1987) and MAZZELLA *et al.* (1989). In general the epiphytic covering is expressed as a surface covered in projection by the different species, both as absolute value (mm^2) and as percentage value of the surface of the leaf. The total covering is given by adding up the covering surface of all the species underlined (PANAYOTIDIS & BOUDOURESQUE, 1981). Usually this method requires the involvement of specialists; that is why most of the studies on epiphytes examine only one taxonomic group. The Epiphyte Index proposed by MORRI (1991) and used in this research, is a general index that allows a synthetic evaluation of the epiphyte covering surfaces. This method is based on the measurement of the leaf blade portion occupied by the epiphytes or epifauna of a certain group, ideally brought together in the same portion of the leaf. The relation between the length of the part occupied by one

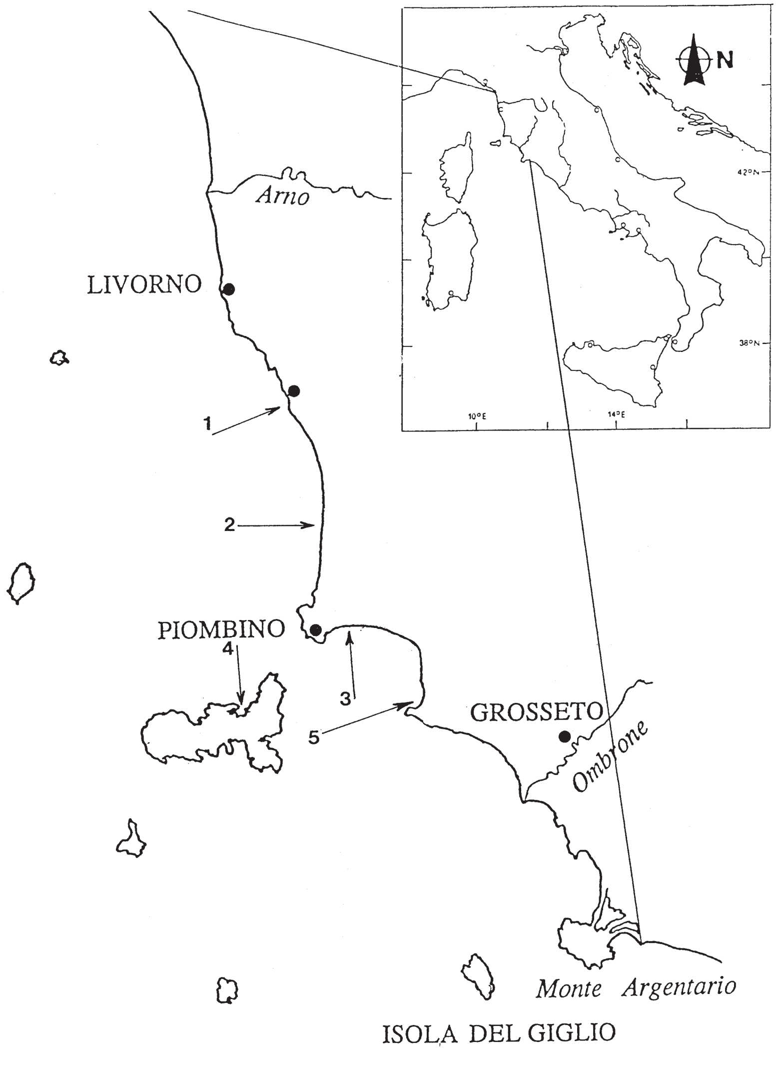

Fig. 1: Geographical distribution of the study meadows along the Tuscany coast.

of the categories considered and the overall length of the leaf, gives a number of between 0 and 1 that expresses the Epiphyte Index. That is why the E. I. is a pure number. We considered adult leaves and leaves at an intermediate stage of growth (that is those that for age and length can guest epiphytes and epifauna) of all the shoots collected during the samplings.

For each observed leaf, the inner and outer surfaces were distinguished, and epiphytes were considered for the groups of Algae (calcareous encrusting and erect Algae), Hydroids and Bryozoans. Coverings were measured using graph paper and for every category of epiphytes or epifauna an addition of the single measurements according to the

E. I. method applied was made, in order to find the length of the colonized leaf part.

Photographs of these species were taken using a NIKON F90X camera connected to stereomicroscope. Thus, total inner and total outer epiphytisme were evaluated. The variance correlated according to periods,

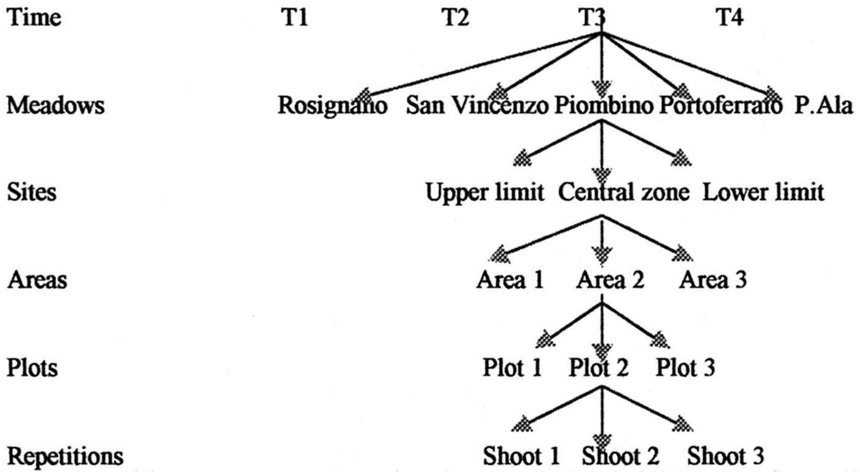

Fig. 2: Sampling project for analysis of the epiphyte spatial-temporal variance. Data were statistically treated by the variance analysis (ANOVA). Within every analysis, variances in homogeneity were evaluated by means of the Cochran test. If not homogeneous, data were transformed by $\sqrt{(x)}$, $\sqrt{(x+1)}$ e $\sqrt{[\sqrt{(x)}]}$. Season, depth, and different spatial scale variance were analysed through a five factor model of variance analysis:
Time (Season): random and orthogonal, 4 experimental levels (February, May, August, October)
Meadow: fixed and orthogonal, 5 experimental levels (Rosignano, Piombino, San Vincenzo, Portoferraio, Punta Ala)
Site: fixed and orthogonal, 3 experimental levels (upper limit, central zone, lower limit)
Area: random and nested in Meadow and Site, 3 experimental levels (area 1, 2, 3)
Plot: random and nested in Time, Meadow, Site, Area, 3 experimental levels (plot 1, 2 e 3).

different depths and different spatial scales was evaluated using a model for variance analysis (ANOVA) with 5 factors (season, meadow, site, area, plot), as described in the caption of Figure 2.

Results

The species most represented in the epiphyte coverings observed are the following:
Calcareous encrusting Algae – *Pneophyllum* sp.; *Hydrolithon farinosum* (Lamark) Howe
Erect Algae – *Dictyota dichotoma* (Hudson) Lamouroux; *Laurencia obtusa* (Hudson) Lamouroux; *Womersleyella setacea* (Hollemberg) R.B. Norris; *Corallina mediterranea* (Ellis et Solander) Aresch.; *Jania Rubens* (L.) Lamouroux
Bryozoans - *Electra posidoniae* Gautier; *Beania mirabilis* (Johnston); *Fenestrulina malusii* (Audouin); *Aetea sica* (Couch); *Disporella hispida* Fleming; *Tubulipora* sp.; *Lichenopora* sp.
Hydroids – *Sertularia perpusilla* (Clark); *Obelia geniculata* (Stechow); *Aglaophenia pluma* (Linneo). The Epiphyte Indexes were calculated comprehensively for those species listed above and others which were found in a more restricted way. We have instead overlooked those sporadic presences of epifauna, such as those represented by Tunicata (mainly *Botryllus schlosseri* (Pallas)).

Inner Leaf Surface.

Algae (Figure 3). Very low levels of algal epiphytisme were recorded at Piombino, San Vincenzo and Rosignano; however, an epiphyte index tendency to decrease from shallow to deep areas was noticed. The dynamics of season of the Epiphyte Index seems to be heterogeneous depending on the different depths and areas, and on the different series of microhabitats

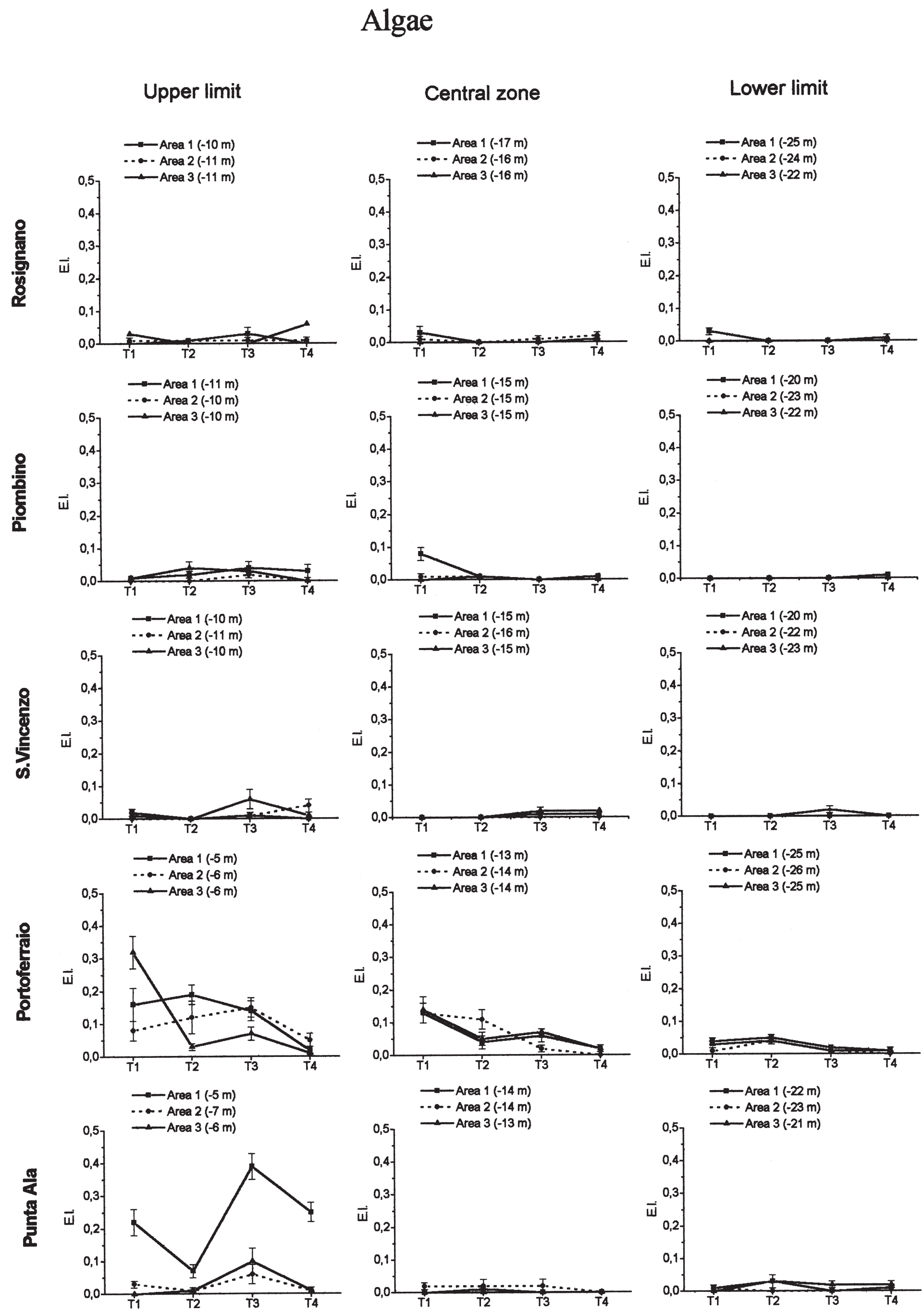

Fig. 3: Seasonal dynamics (T1 = February, T2 = May, T3 = August, T4 = October) of the Algae Epiphyte Index (E.I.) in relation to three different depth ranges (upper limit, central zone, lower limit) and to three different areas (area 1, area 2, area 3) for each of the five study meadows. Epiphyte Index refers to inner leaf blade.

within the studied meadows that offer alternative and valuable niches for the proliferation of different species (BOROWITZKA & LETHBRIDGE, 1989). For the lower limit and the central zone, the highest values of the Index were recorded in February and October. The upper limit maintains high values in all the sampling periods. Variance among the areas seems not to be relevant. At Portoferraio and Punta Ala the algal epiphytisme starts higher (higher light intensity, due to the lower depths of the upper limits and water transparency). The index decreases as depth increases. For the lower limit the maximum is in May; for the central zone maximums are in February and in August, while in the upper limit there is greater variance. Variance analysis shows the significance of season with respect to different meadows, depths and areas; therefore, a significant variance among the areas was recorded (Table 1 a).

Hydroids (Figure 4). An evident variance among meadows, depths and areas studied was recorded. At Portoferraio and Punta Ala lower levels for Hydroid epiphytes were observed, characterized by the dynamics of season that give the highest values in February and May, decreasing in the following months. The situation overall seems to be extremely heterogeneous. Variance analysis underlines significant seasonal variance with respect to different meadows and areas (Table 1 b).

Bryozoans (Figure 5). Observed variances seem to be strictly correlated to seasonality. Statistical analysis records a seasonal variance in relation to different meadows, depths and areas (Table 1c). In each of the meadows examined, for the different depths, similar dynamics can be observed, characterized by a high Epiphyte Index value in February and subsequent

Table 1

Analysis of the epiphyte index (E.I.) on the leaf inner surface in respect of period (four random periods) meadows (five meadows, fixed), depths (upper limit, central zone, lower limit, fixed), areas (three areas, random) for every combination of meadow and depth, and of different plots (three plots, random) for every combination of time (season), meadow, depth and area. For (a), C = 0.0202; for (b), C = 0.0231, for (c), C = 0.0385; for (d), C = 0.0377.

Factors	df	MS	F	P	MS	F	P	MS	F	P	MS	F	P
		(a) E.I.: algae			(b) E.I.:Hydroids			(c) E.I.: Bryozoans			(d) E.I.: total		
Time (Season)	3	0.101	3.50	0.0000	0.186	26.52	0.0000	0.078	50.74	0.0000	0.134	62.49	0.0000
Meadow	4	1.378	0.00	0.0000	0.083	0.00	0.0000	0.014	0.00	0.0000	0.086	0.00	0.0000
Site	2	1.255	0.00	0.0000	0.070	0.00	0.0000	0.132	0.00	0.0000	0.374	0.00	0.0000
Area (M x S)	30	0.121	4.16	0.0000	0.004	0.64	0.9145	0.0008	0.53	0.9754	0.006	2.93	0.0000
Plot (T x M x S x A)	360	0.012	1.78	0.0000	0.004	1.34	0.0003	0.0005	1.42	0.0000	0.001	1.69	0.0000
T x M	12	0.159	5.51	0.0000	0.027	3.84	0.0001	0.006	4.42	0.0000	0.019	9.15	0.0000
T x S	6	0.104	3.60	0.0030	0.011	1.57	0.1658	0.020	13.45	0.0000	0.030	14.3	0.0000
T x A (M x S)	90	0.029	2.36	0.0000	0.007	1.69	0.0004	0.001	2.85	0.0390	0.002	2.08	0.0000
M x S	8	0.187	0.00	0.0000	0.008	0.00	0.0000	0.007	0.00	0.0000	0.029	0.00	0.0000
T x M x S	24	0.044	1.53	0.0780	0.007	1.00	0.4714	0.002	1.74	0.0325	0.004	1.86	0.0189
Residual	1080	0.007			0.003			0.0004			0.0006		

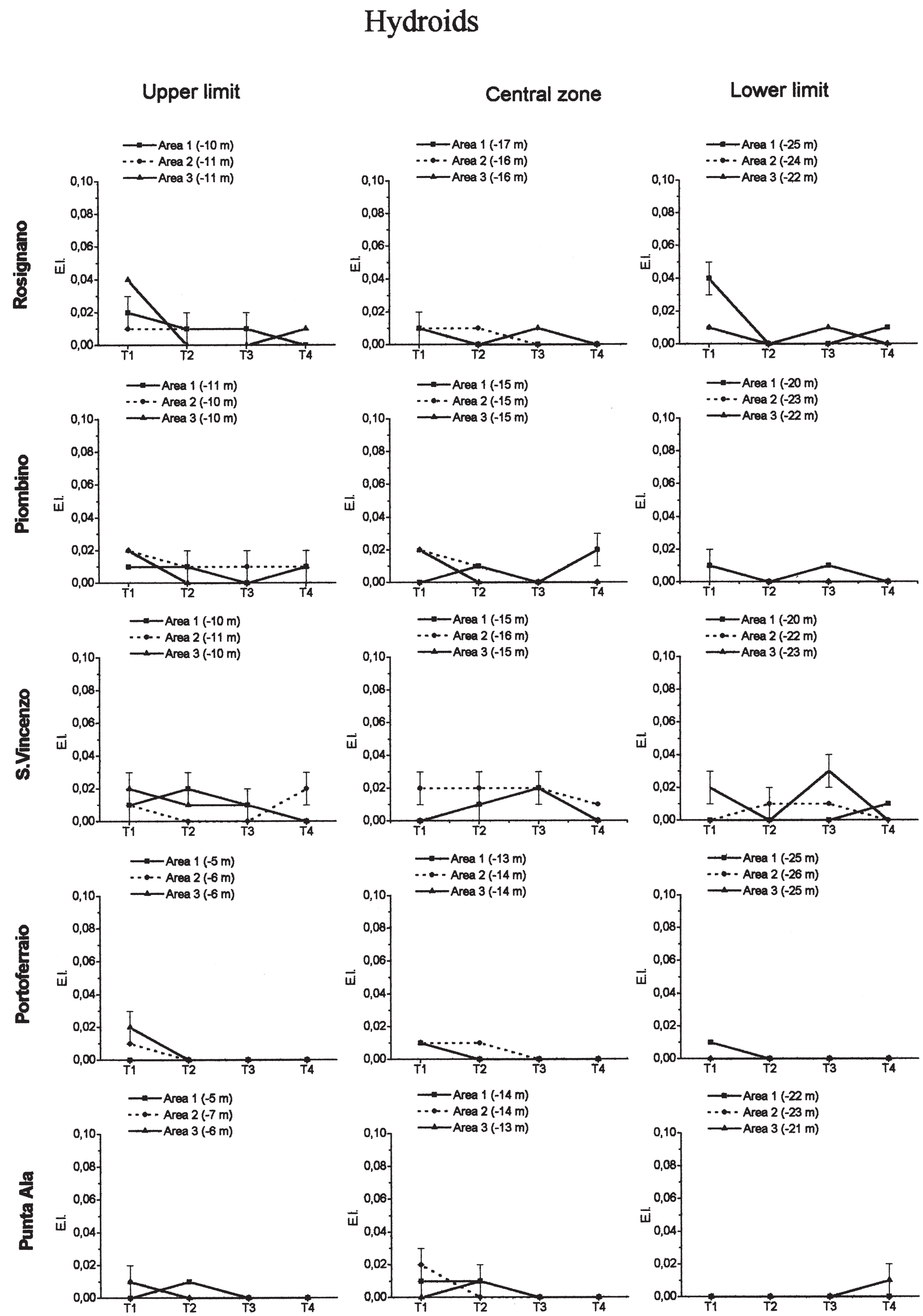

Fig. 4: Seasonal dynamics (T1 = February, T2 = May, T3 = August, T4 = October) of the Hydroids Epiphyte Index (E.I.) in relation to three different depth ranges (upper limit, central zone, lower limit) and to three different areas (area 1, area 2, area 3) for each of the five study meadows. Epiphyte Index refers to inner leaf blade.

Bryozoans

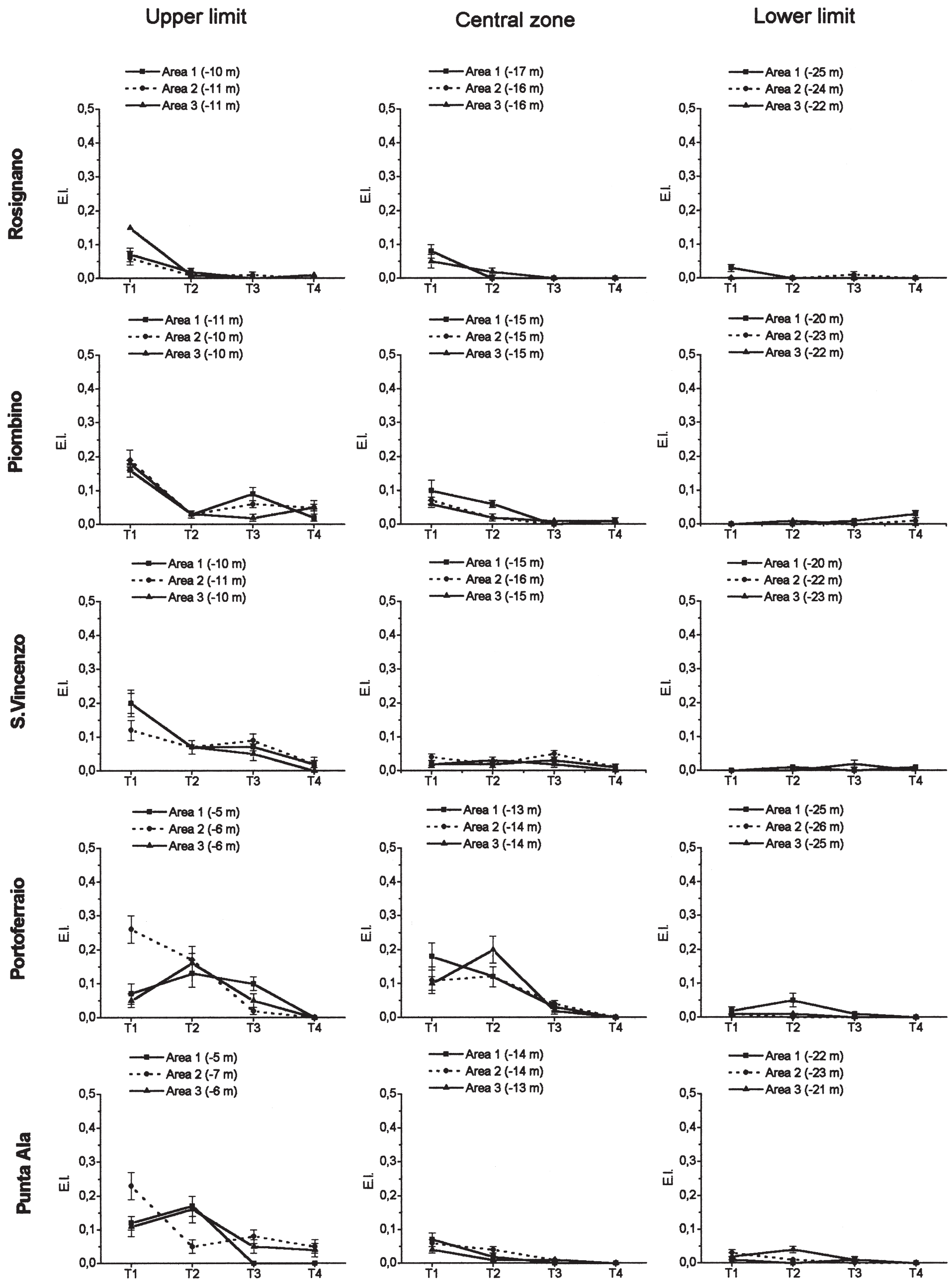

Fig. 5: Seasonal dynamics (T1 = February, T2 = May, T3 = August, T4 = October) of the Bryozoans Epiphyte Index (E.I.) in relation to three different depth ranges (upper limit, central zone, lower limit) and to three different areas (area 1, area 2, area 3) for each of the five study meadows. Epiphyte Index refers to inner leaf blade.

decrease. The minimum was recorded in August for some areas, and in October for others. At Portoferraio and Punta Ala there were also high values in May. Bryozoans seem to decrease in quantity as depth increases. Variance among areas is not significant (Table 1c).

Total Inner Epiphytisme. A seasonal trend was recorded through graphic analysis (Figure 6). For each of the meadows studied and for every depth, it was observed that inner epiphytisme had higher values in winter and then decreased in successive sampling. The maximum was in February and the minimum in October. The greatest variance was in shallow sites, especially at Portoferraio and Punta Ala; statistical analysis points to a seasonal variance connected with different meadows, depths and areas; the variance on a territorial scale (among areas) proves significant (Table 1 d).

Outer Leaf Surface.

Algae (Figure 7). The seasonal dynamics of the Epiphyte Index for inner surfaces is similar to that of outer ones. However, at Rosignano, San Vincenzo and Piombino (upper limits) a tendency of the Index to increase during summer was recorded; similarly at Portoferraio and Punta Ala, where the lower limit is summer-autumn. In the upper limits of the five meadows, a lower Epiphyte Index can be observed in relation to inner surface epiphytes; this is not true of central and deeper zones, where values are sometimes higher (e.g., Portoferraio and Punta Ala lower limits). Variance analysis highlights a significant seasonal variance with respect to the meadows, depths and areas: a significant variance among the areas was recorded (Table 2 a).

Table 2

Analysis of the epiphyte index (E.I.) on the leaf outer surface in respect of period (four random periods) meadows (five meadows, fixed), depths (upper limit, central zone, lower limit, fixed), areas (three areas, random) for every combination of meadow and depth, and of different plots (three plots, random) for every combination of time (season), meadow, depth and area. For (a), C = 0.0295; for (b), C = 0.0239, for (c), C = 0.0252; for (d), C = 0.0236.

Factors	df	MS	F	P	MS	F	P	MS	F	P	MS	F	P
		(a) E.I.: algae			(b) E.I.:Hydroids			(c) E.I.: Bryozoans			(d) E.I.: total		
Time (Season)	3	0.208	6.71	0.0004	0.0529	12.53	0.0021	0.276	24.02	0.0000	0.117	3.08	0.0315
Meadow	4	0.792	0.00	0.0000	0.3659	0.00	0.0000	0.092	0.00	0.0000	0.646	0.00	0.0000
Site	2	0.209	0.00	0.0000	0.1016	0.00	0.0000	0.441	0.00	0.0000	0.969	0.00	0.0000
Area (M x S)	30	0.079	2.56	0.0003	0.0150	0.72	0.8487	0.010	0.93	0.5814	0.067	1.78	0.0196
Plot (T x M x S x A)	360	0.011	1.85	0.0000	0.0166	1.58	0.0000	0.004	1.27	0.0022	0.013	1.61	0.0014
T x M	12	0.085	2.74	0.0033	0.0472	2.26	0.0150	0.035	3.12	0.0010	0.114	3.02	0.0000
T x S	6	0.128	4.12	0.0011	0.0225	1.08	0.3821	0.150	13.09	0.0000	0.351	9.25	0.0000
T x A (M x S)	90	0.031	2.80	0.0000	0.0209	1.26	0.0763	0.011	2.39	0.0390	0.038	2.86	0.0000
M x S	8	0.104	0.00	0.0000	0.0822	0.00	0.0000	0.040	0.00	0.0000	0.162	0.00	0.0000
T x M x S	24	0.054	1.75	0.0318	0.0337	1.61	0.0562	0.020	1.82	0.0230	0.060	1.58	0.0641
Residual	1080	0.006			0.0105			0.003			0.008		

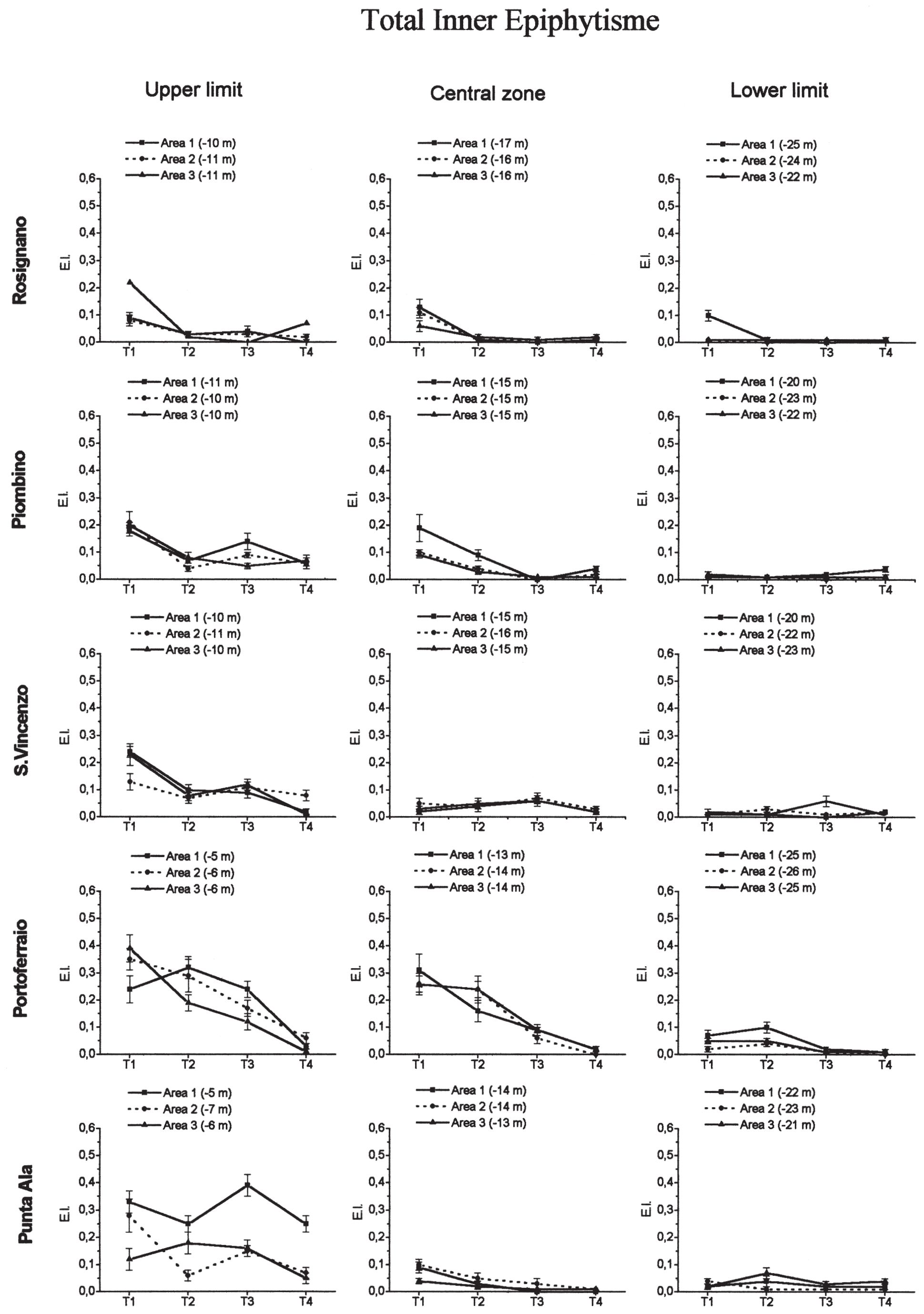

Fig. 6: Seasonal dynamics (T1 = February, T2 = May, T3 = August, T4 = October) of the total Epiphyte Index (E.I.) in relation to three different depth ranges (upper limit, central zone, lower limit) and to three different areas (area 1, area 2, area 3) for each of the five study meadows. Epiphyte Index refers to inner leaf blade.

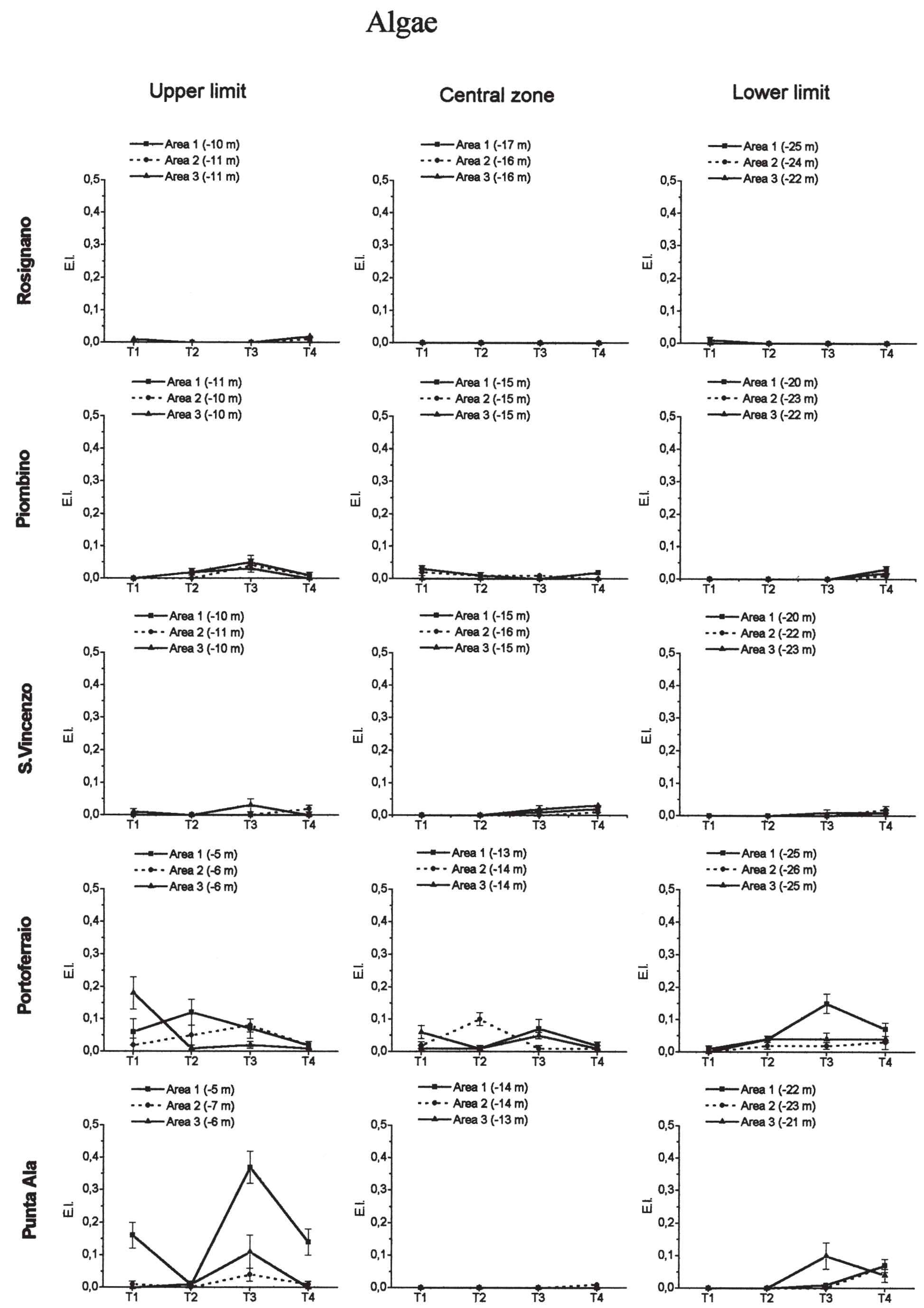

Fig. 7: Seasonal dynamics (T1 = February, T2 = May, T3 = August, T4 = October) of the Algae Epiphyte Index (E.I.) in relation to three different depth ranges (upper limit, central zone, lower limit) and to three different areas (area 1, area 2, area 3) for each of the five study meadows. Epiphyte Index refers to outer leaf blade.

Hydroids (Figure 8). Any presence was very limited. At Rosignano, Portoferraio and Punta Ala hydroids were almost absent; at San Vincenzo and Piombino low Epiphyte Index values were observed on the whole, and seasonal dynamics results were heterogeneous and related to depths and areas. Statistical analysis indicates a significant seasonal variance of the Index values with respect to different sites and depths, but territorial variance is not significant (Table 2 b).

Bryozoans (Figure 9). Seasonal dynamics of the Epiphyte Index, with respect to meadows, depths and areas, seem to be similar to those observed in relation to the inner surface of the leaf. They are, however, characterized by lower values compared with the inner surface; less variance among areas has to be pointed out. Seasonal variance of the Index values, in relation to different meadows, depths and areas, was recorded; variance among the areas is not relevant (Table 2c).

Total Outer Epiphytisme (Figure 10). In the deep zone, seasonal dynamics of the Epiphyte Index values are characterized by an increase in the passage from winter to spring-autumn. In the upper limit and in the central zone, a bigger variance in respect of meadows, depths and areas was recorded. At Portoferraio and Punta Ala variance among the areas increased remarkably in the upper limit.

In the central zone and in the upper limit the total outer epiphyte level was lower than the inner surface, mainly in the first three sampling seasons. In the lower limit at Rosignano, San Vincenzo and Piombino, the difference was not so evident; at Portoferraio and Punta Ala the opposite trend was observed in summer-autumn. The statistical analysis points to seasonal variance of the Epiphyte Index for meadows, depths and areas. Variance among the areas is significant (Table 2d).

Discussion

According to data collected in this study, epiphyte colonization mainly affects the inner surface of the leaf blade as opposed to the outer surface; this observation coincides with the greater exposure to light and water movements (MAZZELLA & RUSSO, 1989) of the inner surface, and to the decrease of epiphyte presence according to a depth gradient, consistent with literature data (CINELLI *et al.*, 1984). Particular differences are to be found at the 10-meter limit. Thus, a notable variance is demonstrated at the upper limit, or the part of the meadow subject to major natural or artificial troubles (sea-storms, waste water discharges, maritime traffic and tourist activities). Upper limit samplings occasionally seem also to be contradictory in adjacent areas. As this occurrence was often referred to in various studies regarding *Posidonia oceanica* meadows, it was considered appropriate to use the first homogeneous strip for sampling within the upper limit of the meadow, thus avoiding digitate limits or presence of swashes or spots. It is interesting to notice that leaf blades epiphytisme is well developed at the Portoferraio and Punta Ala meadows upper limit, probably because these stations are only 6 metres deep, while the upper limit of the other three studied meadows is 10 or 11 metres; the Portoferraio and Punta Ala meadows' upper limits can benefit from sunlight (for algae) and from waste water discharge fertilizers (for epiphytes generally) to more advantage than the other sites (in summer the inhabitants of San Vincenzo increase from 7.000 to 30.000!). In this study, the discovery that the lower limit in the meadow of Portoferraio is 45 metres is very important. Up to now, the deepest limit was 40 for Italian waters.

Acknowledgements

The authors thank KODAK S.p.A. for providing the colour film used to complete this study. The research was partially supported by the City Council of Piombino (Italy).

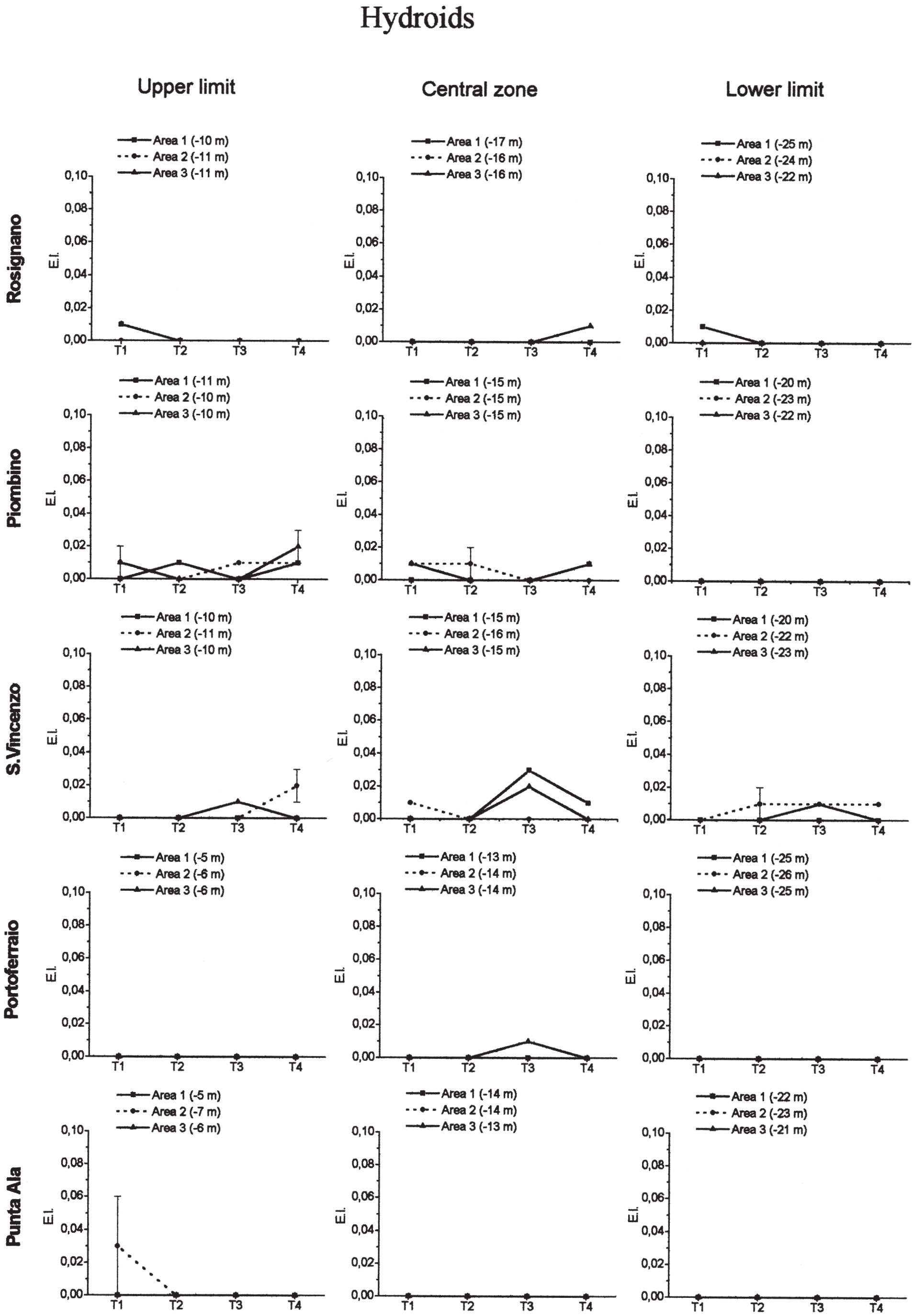

Fig. 8: Seasonal dynamics (T1 = February, T2 = May, T3 = August, T4 = October) of the Hydroids Epiphyte Index (E.I.) in relation to three different depth ranges (upper limit, central zone, lower limit) and to three different areas (area 1, area 2, area 3) for each of the five study meadows. Epiphyte Index refers to outer leaf blade.

Bryozoans

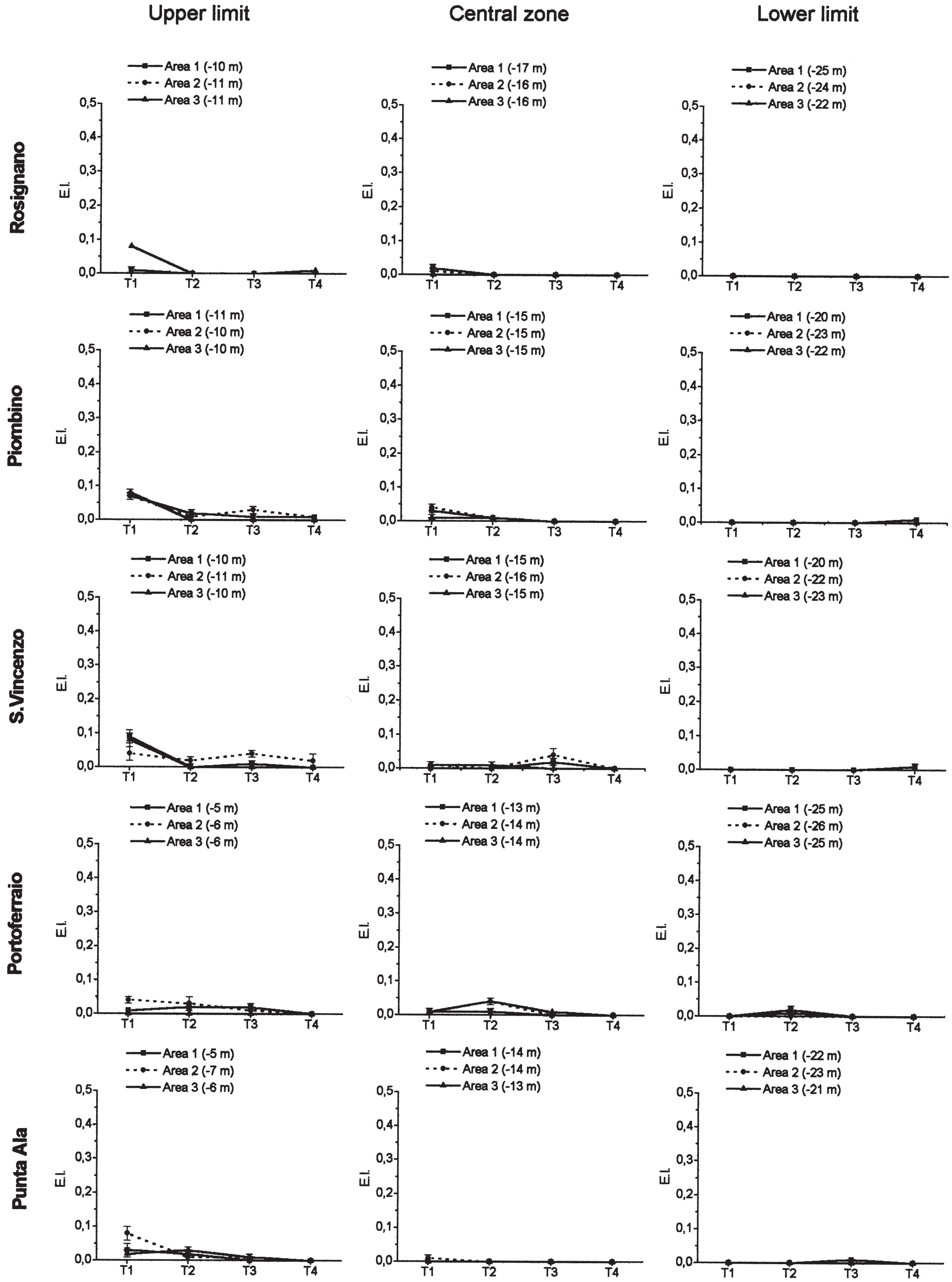

Fig. 9: Seasonal dynamics (T1 = February, T2 = May, T3 = August, T4 = October) of the Bryozoans Epiphyte Index (E.I.) in relation to three different depth ranges (upper limit, central zone, lower limit) and to three different areas (area 1, area 2, area 3) for each of the five study meadows. Epiphyte Index refers to outer leaf blade.

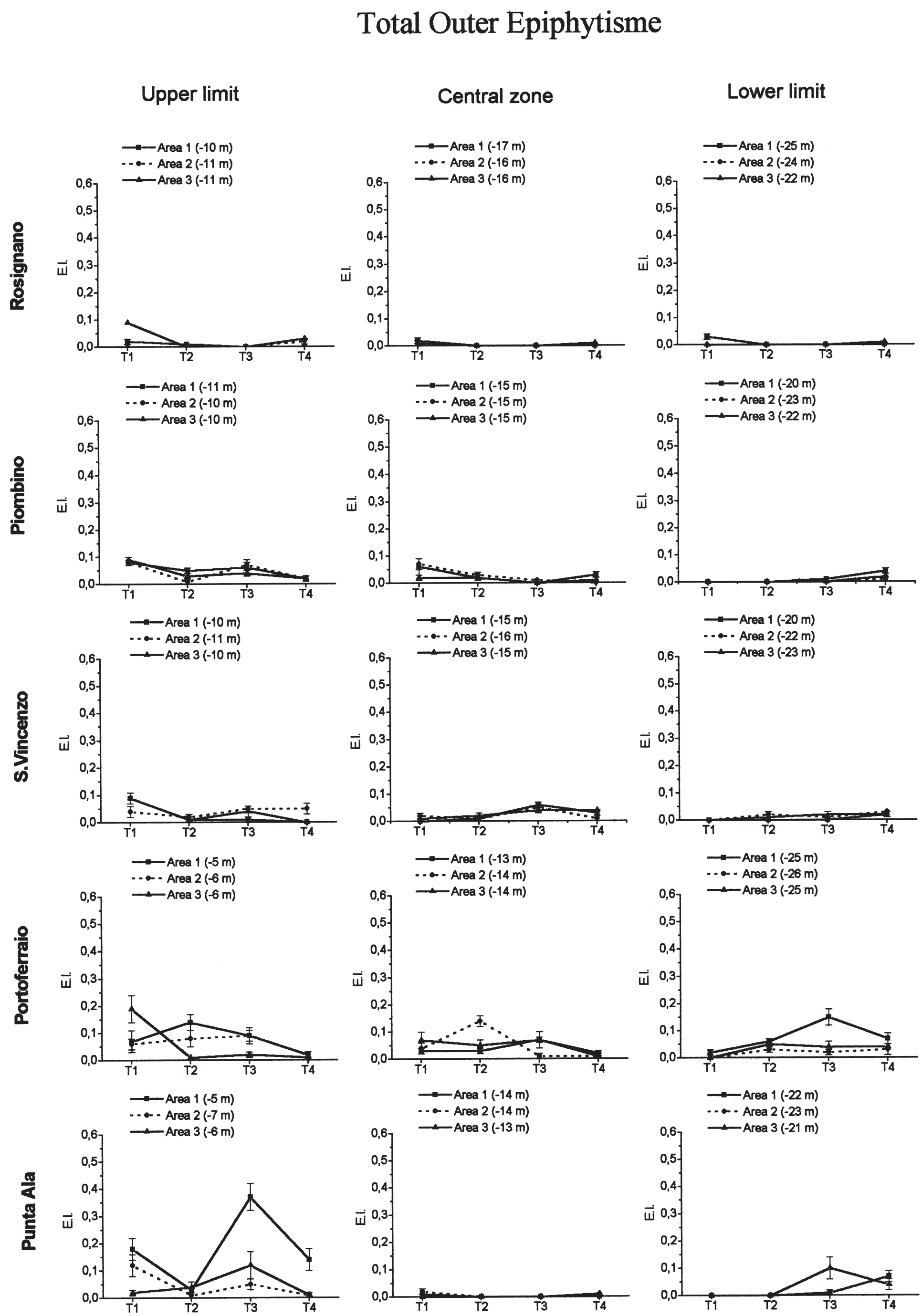

Fig. 10: Seasonal dynamics (T1 = February, T2 = May, T3 = August, T4 = October) of the total Epiphyte Index (E.I.) in relation to three different depth ranges (upper limit, central zone, lower limit) and to three different areas (area 1, area 2, area 3) for each of the five study meadows. Epiphyte Index refers to outer leaf blade.

References

BOUDOURESQUE, C.F., GIRAUD, G. & PERRET, M., 1977. *Posidonia oceanica*. Bibliographie. CNEXO et Univ. Aix-Marseille II, Fr.: 1-191.

BOROWITZKA, M.A. & LETHBRIDGE, R.C., 1989. Seagrass Epiphytes. In: Larkum A.W.D., McComb A.J. and Shepherd S.A.: Biology of Seagrasses: a treatise on the biology of seagrasses with special reference to the Australian region. Elsevier: 1-841.

CASOLA, E., SCARDI, M., MAZZELLA, L. & FRESI, E., 1987. Structure of the epiphytic community of *Posidonia oceanica* leaves in a shallow meadow. PSZNI: Mar. Ecol., Germ., 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. *Botanica Marina*, 42: 123-128.

CINELLI, F., CORMACI, M., FURNARI, G. & MAZZELLA, L., 1984. Epiphytic macroflora of *Posidonia oceanica* (L.) Delile leaves around the island of Ischia (Gulf of Naples). *1st International Workshop on Posidonia oceanica Beds*, C.F. Boudouresque, A. Jeudy de Grissac and J. Olivier (Editors), GI.S. Posidonie Publ. Fr.: 91-99.

GAMBLE, J.C. 1984. Diving. In: N.A. Holme e A.D. McIntyre (a cura di), Methods for the study of marine benthos. Blackwell Sci., Oxford (2nd edition), IBP Handbook 16: 99-139.

HARRISON, P.G. 1982. Control of microbial growth and of amphipod grazing by water-soluble compounds from leaves of *Zostera marina*. *Marine Biology*, 67: 225-230.

HARRISON, P.G. & DURANCE, C.D., 1985. Reductions in photosynthetic carbon uptake in epiphytic diatoms by water-soluble extracts of leaves of *Zostera marina. Marine Biology* 90: 117-119.

JUPP, B.P. 1977. The effects of organic pollution on benthic organisms near Marseille. *Internation. J. Environment. Studies,* 10: 119-123.

MAZZELLA, L. & ALBERTE, R.S., 1986. Light adaptation and the role of autotrophic epiphytes in primary production of the temperate seagrass, *Zostera marina* L. *Journal of Experimental Marine Biology and Ecology*, 100: 165-180.

MAZZELLA, L. & RUSSO, G.F., 1989. Grazing effect of two Gibbula species (Mollusca, Archaeogastropoda) on the epiphytic community of *Posidonia oceanica* leaves. *Aquatic Botany*, 35: 357-373.

MAZZELLA, L., SCIPIONE, M.B. & BUIA, M.C., 1989. Spatio-temporal distribution of algal and animal communities in a *Posidonia oceanica* meadow. *PSZNI: Mar. Ecol.,* 10 (2): 107-131.

MENDEZ, S., 1994. Impact des installations d'aquaculture sur les herbiers à *Posidonia oceanica:* Identification des descripteurs. Mémoire MST, Valorisation des Ressources Naturelles, Université de Corse: 1-29.

MORRI, C., 1991. Présentation d'un indice synthétique pour l'évaluation de l'épiphytisme foliaire chez Posidonia *oceanica* (L.) Delile. *Posidonia Newsletter*, 41, (1): 33-37.

NOVAK, R., 1984. A study in ultra-ecology: microorganisms on the seagrass *Posidonia oceanica* (L.) Delile. P.S.Z.N.I. *Marine Ecology* 5: 143-190.

PANAYOTIDIS, P. & BOUDOURESQUE, C.F., 1981. Aire minimale et patchiness de la flore épiphyte de *Posidonia oceanica.* Trav. sci. Parc nation. Port-Cros, Fr., 7: 71-84.

PERGENT, G., PERGENT-MARTINI, C. & BOUDOURESQUE, C.-F., 1995. Utilisation de l'herbier a *Posidonia oceanica* comme indicateur biologique de la qualité du milieu littoral en Méditerranée: etat des connaissances. *Mésogée,* 54: 3-27.

SILBERSTEIN, K., CHIFFINGS, A.W. & McCOMB, A.J., 1986. The loss of seagrass in Cockburn Sound, Western Australia. III. The effect of epiphytes on productivity of *Posidonia australis* Hook. F. *Aquatic Botany,* 24: 355-371.

VAN DER BEN, D., 1971. Les épiphytes des feuilles de *Posidonia oceanica* Delile sur les cotes francaises de la Méditerranée. *Mem. Roy. Soc. Belg.* 168: 1-101.