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# THE *POSIDONIA OCEANICA* (L.) DELILE MEADOW OF PORTOVENERE (GULF OF LA SPEZIA, EASTERN LIGURIAN SEA)

**Abstract** - The present status of the small *Posidonia* meadow in the Channel of Portovenere (Gulf of La Spezia, eastern Ligurian Sea) is described. Mapping was performed and the meadow and plants were investigated. Large expanses of dead «matte» widely distributed along the channel testify to an ancient meadow that is no longer present. Today the *Posidonia* meadow exists only on the side of the channel close to Palmaria Island. This meadow, even if it is very small, is in good condition on the western side. In the eastern part signs of a regression trend and disturbances produced by anchoring were found and were well evidenced by the coefficient AM. This parameter was developed from Giraud's coefficient A (Giraud, 1977) separating leaves broken by unknown causes. In the western part of the meadow where clean offshore waters coming through the mouth of the channel can reach the meadow, *Posidonia* showed a better status.

**Key words** - Benthos, *Posidonia oceanica*, regression, coefficient AM, anchoring, Ligurian Sea.

**Riassunto** - *La prateria di Posidonia di Portovenere (Mar Ligure orientale).* In questo lavoro sono descritte le principali caratteristiche della prateria di *Posidonia* del Canale di Portovenere (Mar Ligure orientale) e dei fondali prospicienti. Lo studio ha consentito di rilevare la diffusa presenza di «matte morta» in tutto il canale di Portovenere indice di una vasta prateria ormai scomparsa. La prateria di Portovenere, l'unica sopravvissuta nel Golfo di La Spezia, copre una superficie di circa 2500 $m^2$ ed è classificabile negli stadi III e IV di Giraud (Giraud, 1977). Questa prateria, per quanto di limitata estensione, mostra diversi livelli di degrado: il versante prossimo all'imboccatura del canale è in discrete condizioni grazie all'apporto di acque dal largo, mentre il lato orientale, più interno e ridossato, presenta segni di disturbo dovuto soprattutto agli ancoraggi di piccole imbarcazioni. Questa differenza è ben evidenziata dal Coefficiente AM, sviluppato dal Coefficiente A di Giraud (Giraud, 1977) separando le foglie rotte da cause ignote da quelle palesemente brucate.

**Parole chiave** - Benthos, *Posidonia oceanica*, regressione, coefficiente AM, ancoraggio, Mar Ligure.

## INTRODUCTION

Many authors have pointed out the great importance of *Posidonia oceanica* L. (Delile), the dominant seagrass of the Mediterranean Sea (Duarte, 1991), and its different roles in the maintenance and dynamics of marine coastal environments (Colantoni *et al.*, 1982; Augier, 1986; Stevenson, 1988). The world-wide regression phenomena (Molenaar and Caye, 1993) of phanerogam meadows due to human and natural factors (Clarke and Kirkman, 1989; Livingston, 1984) have been a strong reason for the development of monitoring programmes as tools to test the health of coastal environments (Augier, 1986).
Nevertheless, data on the present extension, organisation and structure of many meadows are not available, so monitoring studies often refer to ancient descriptive information rather than to present quantitative databases.
In the last ten years in Italy, particularly along the Ligurian Sea (Boyer *et al.*, 1995; Bussotti and Guidetti, 1996; Davico and Matricardi, 1995; Matricardi, 1995; Stoppelli and Peirano, 1996; Gongora Gonzales *et al.*, 1996), studies on *Posidonia* meadows have increased, partly as a consequence of catastrophic events. A general regression trend due to various human activities (Ridolfi, 1990; Sandulli *et al.*, 1994) has been observed as a common feature of all Ligurian meadows. In a recent review discussing and quantifying the decline of *P. oceanica* along the Ligurian coast, Peirano and Bianchi (1995) focused on the deficiency and discontinuity of quantitative data on the present status of *P. oceanica* beds.
The meadow of Portovenere, first reported in the literature by Bianchi and Peirano (1995), is an example of this lack of information. Except for a preliminary study performed by De Biasi *et al.* (1997) it has never been mapped or investigated, even though the meadow is very close to the border of the Cinque Terre marine park and subjected to high human impact.
The present work aims to describe the main features of the meadow of Portovenere and the nearby bottoms, map its extension, and present data as an initial base for monitoring programmes. Coefficient AM, developed from the well-known Giraud's coefficient, was used to verify disturbance of the meadow.

## MATERIALS AND METHODS

The Channel of Portovenere is located in the western part of the Gulf of La Spezia and separates Palmaria Island from the village of Portovenere. Between 5 and 7 July 1995, scuba diving transects were performed along three lines strung across the channel. Distances were computed by marks along the ropes,

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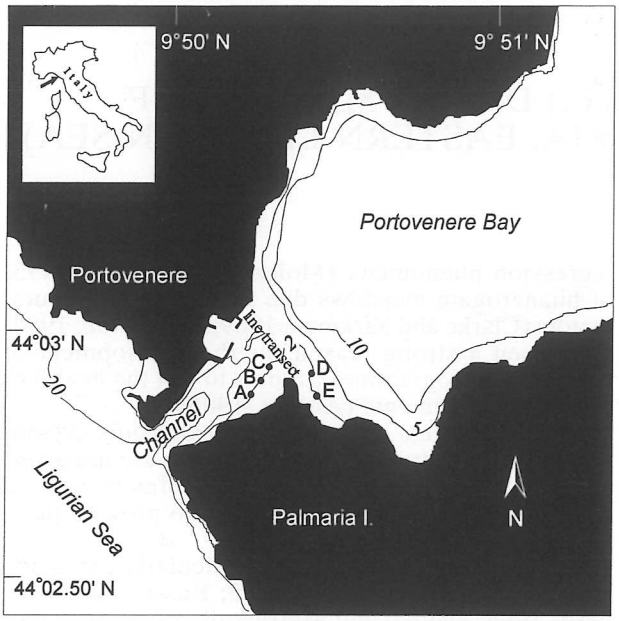


Fig. 1 - Study area. Letters indicate sampling stations and the line crossing the Channel of Portovenere represents the diving transect.

which were stretched as tightly as possible between fixed datum points.
Macroepibenthic communities along the Channel were described and the *Posidonia* meadow was mapped. The main macrobenthic assemblages were identified by a physiognomic approach (Kenchington, 1978) considering only conspicuous species which were large-sized or dominant in terms of number, biomass or cover. Transects were performed from Portovenere to Palmaria Island and were carried out by two different researchers to reduce observer bias. Only one of the transects is reported.

The extension of the meadow was mapped along the lines and locating limits during snorkelling observations by land-referenced compass bearings from technical maps Nos. 11 and 12 of the Comune of Portovenere (scale 1:1000).
Five sampling stations (A, B, C, D, E) were positioned within the meadow at 2 meters depth (Fig. 1). The percent cover of *Posidonia* was estimated by visual census (Romero, 1986). Density (number of shoots/$m^2$) was estimated by the «quadrat relevé» method, with five replicates for each station. In every station, phenological data were calculated for 10 orthotropic rhizomes. Leaf Area Index (LAI) was calculated according to Drew (1971).
Coefficient A was first calculated according to Giraud (1977). It was then re-calculated and modified counting only leaves broken by unknown causes, as first proposed by Torricelli and Peirano (1997). The name proposed here for this new index is coefficient AM. Leaves clearly damaged by animals were considered in the grazing index. Grazers were identified according to Boudouresque and Meinesz (1983).

## RESULTS

The cross section of the transect from Portovenere to Palmaria Island is shown in Fig. 2 together with some observations on the main features of the communities between 0 and 6 m depth.
The coast of Portovenere where we started the transect was steep and rocky. The benthos on these rocks was the photophilic algal community of sheltered substrata (AFC), mainly represented by *Cystoseira* sp. (Csp.) and *Halopteris scoparia* (L.) Sauvageau. At the base of the slope, 5.5 m deep, there was a sandy bottom with shell debris (mainly *Venus verrucosa* L.) and scattered pebbles and small rocks covered by the algae *Padina pavonica* (L.) Lamouroux (Pp), *Dictyota dichotoma* (Hudson) Lamouroux and *Codium bursa* (L.) C. Agardh.

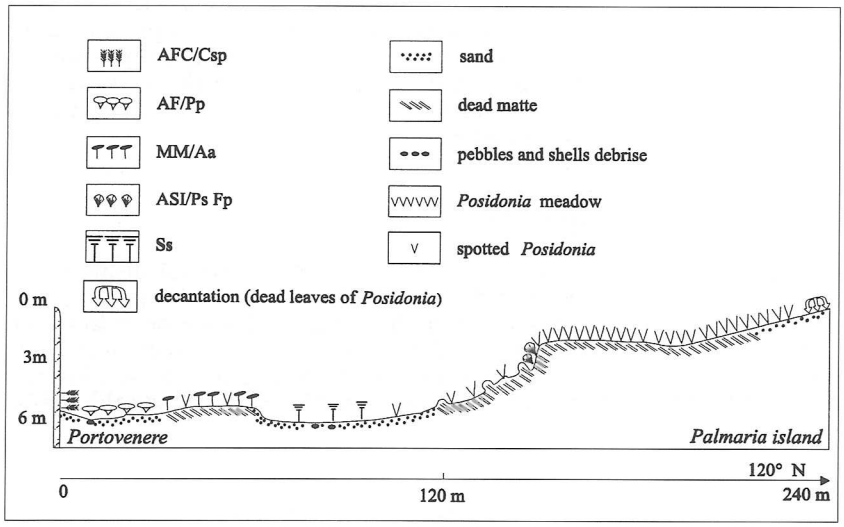


Fig. 2 - Schematic drawing of benthic communities across the Channel of Portovenere. (For the targets see text.)

The density and cover of algae displayed high variability and patchiness. The most abundant animals were the echinoids *Arbacia lixula* (L.), *Paracentrotus lividus* (Lamarck) and *Sphaerechinus granularis* (Lamarck).
At a distance of 10 meters from the slope, on sandy bottom, small rocks covered with the algae *Dasycladus vermicularis* (Scopoli) Krasser and *Codium vermilara* (Olivi) Delle Chiaje, the sponge *Crambe crambe* (Schmidt), the bryozoan *Schizoporella errata* (Watersand) and the ascidian *Phallusia mamillata* (Cuvier) determined a local increase of diversity.
Thirty meters from the slope, dead matte of *Posidonia* was found. It was covered with a thin layer of sand and shell debris and was interrupted by isolated spots of sand. Very few *Posidonia* shoots and *Acetabularia acetabulum* (L.) Silva (MM/Aa) lived on it.
This landscape with matte and sandy spots characterised the sea bottom up to a distance of 60 meters, where a step 30 cm high was found. After this step, bare sand with pebbles and debris replaced the dead matte. The polychaete *Sabella spallanzanii* (Gmelin) (Ss) was abundant, being represented by up to 6-8 individuals very close each other.
In areas with dim light conditions – steps in the matte, crevices – the green algae *Halimeda tuna* (Ellis et Solander) Lamouroux, *Flabellia petiolata* (Turra) Nizamuddin and *Valonia utricularis* (Roth) C. Agardh, the red algae *Lithophyllum frondosum* (Dufour) Furnari, Cormaci et Alongi, Peyssonneliaceae and a few sponges were observed. The dominant species were Peyssonneliaceae and *F. petiolata* (ASI/Ps Fp).
A mirror-like situation existed at the site 110 m away, where, after a step similar to the previous one, matte replaced bare sand. Sparse bundles and trailing rhizomes of *Posidonia* were arranged in small patches irregularly distributed on dead matte.
The front of the meadow was located at a distance of 150 meters (4.5 meters depth). The forefront of the matte was exposed, forming a winding step 10 cm high where rhizomes displayed vertical growth and almost no horizontal growth. The deep part of the meadow was on matte and the shallow part was on sand. The upper limit was 7 meters from the shore, almost reaching the surface and forming a barrier reef («récif barrier») more developed in the part of the meadow toward Portovenere Bay.
The living meadow was estimated to cover about 25,000 $m^2$ on the side of the channel toward Palmaria Island. A map of its distribution is provided in Fig. 3.
The percent cover of *Posidonia* changed in the five stations, being about 65-85% in the stations toward the mouth of the Channel of Portovenere and less than 40% in the stations toward the bay. The average density was usually from 280 to 320 shoots m-1, with the highest values recorded in stations E and C.
The meadow can be considered to be between stages III and IV according to the Giraud classification (Giraud, 1977). The number of leaves per shoot was low in all stations. Leaf length and LAI had low variability and low values compared to other areas (Mazzella *et al.*, 1989). Minima were in stations toward the bay, which also showed the highest variance within replicates.

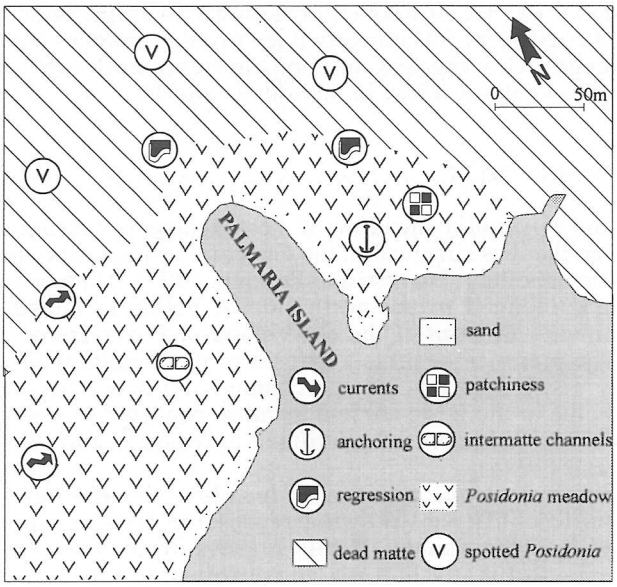


Fig. 3 - Map of the present distribution of the *Posidonia* meadow close to Palmaria Island. Symbols were according to Meinesz *et al.*, 1983 and De Biasi, 1999).

Coefficients A and AM, leaf length and grazing index are shown in Fig. 4. Coefficient A was high in all stations. Conversely, values of coefficient AM were high in station E (65%) and low in stations D (26%)

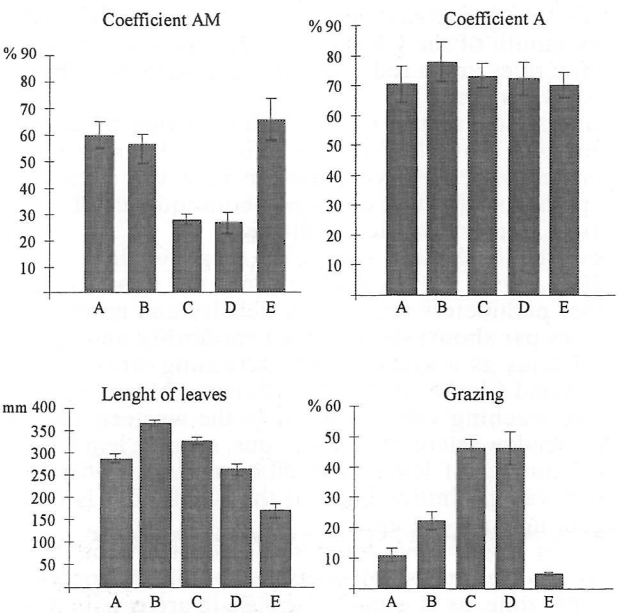


Fig. 4 - Plot of coefficient AM, coefficient A, leaf length and grazing. Bars indicate standard deviation (five replicates were considered).

and C (27%). Moreover, in station E the high values of coefficient AM corresponded to a minimum of leaf length. Grazing had an opposite trend, with higher values (about 45%) in stations C and D.

## CONCLUSIONS

The *Posidonia* meadow of Portovenere is the only one that has survived in the Gulf of La Spezia and its surroundings (Bianchi and Peirano, 1995). At present it is reduced to the north side of Palmaria Island, directly in front of the old village of Portovenere.
The presence of large expanses of dead matte widely distributed all over the channel and in the bay is a clue to the large ancient meadow reported by Issel (1912) and recently mentioned by Bianchi and Peirano (1995).
Surveys on the plants, the meadow and the dead matte confirmed that the regression trend is ongoing. The causes of this regression may be ascribed to many factors whose roles are not clear. After the construction of the naval base, and later the industrial port, urban activities increased and the geomorphology of the littoral and sediment dynamics of the Gulf were deeply changed, with a resulting increase in water pollution and a drop in water transparency (Baldi and Marri, 1992). Turbidity, in particular, is one of the most important factors causing the diminution of seagrass cover (Neverauskas, 1988; Pirc, 1984) and the death of the meadows, with no chance of recovery (Peirano and Bianchi, 1995).
Results from the meadow of Portovenere confirm this, showing better health in the western part of the meadow, probably as a result of different local hydrodynamic conditions. Clear offshore waters are transported into Portovenere Bay by incoming currents which increase in speed as they cross the narrow mouth of the Channel, producing low sedimentation rates and a reduction in water turbidity (Baldi and Marri, 1992).
Comparison of the relatively high value of coefficient AM with leaf length evidenced that a large number of leaves were broken near the apex. We hypothesise that this could be a consequence of these strong hydrodynamic conditions.
Towards the eastern side of the meadow close to the island, cover values declined and the values of the other parameters (especially density and number of leaves per shoot) showed high variability among the replicates as a symptom of increasing stress (Warwick and Clarke, 1993). Coefficient AM was high as well, reaching values similar to the western side of the meadow but in eastern stations, average leaf length and number of leaves per shoot also showed minimum values, indicating that the whole leaf is damaged, not just the apex.
Leaves might have been subjected to mechanical disturbance since small boats are commonly anchored in this zone, as is usually the case in areas with tourist activities (Toccaceli, 1990). This is confirmed by the lost ropes and anchors commonly found on the sea bottom during scuba dives. In summertime up to 40 boats of different sizes can be counted at anchor on the meadow and nearby. Where anchoring (stations C and D) is not common because of continuous boat traffic, leaf length was high and coefficient AM displayed its minimum value.
Coefficient AM is very easy to calculate and showed itself to be a remarkable tool for describing the disturbance affecting the meadow of Portovenere. Together with leaf length, coefficient AM proves the presence of mechanical disturbance more than the usual coefficient A, whose values also include data on grazing pressure which, when relevant, can mix up the meaning of the index.

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