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Characterization of the benthic vegetation in the Farwà Lagoon (Libya)

Pergent, G.[1*]; Djellouli, A.[2]; Hamza, A.A.[3]; Ettayeb, K.S.[3]; El Mansouri, A.A.[4]; Talha, F.M.[4]; Hamza, M.A.[4]; Pergent-Martini, C.[1] & Platini, F.[5]

[1]*University of Corsica, Faculty of Sciences, BP 52, 20250 Corte, France;* [2]*University of Tunis, Tunisia;*
[3]*The Environmental General Authority of Libya, Tripoli, Libya;* [4]*Marine Biology Research Center, Tajoura - Libya;*
[5]*Regional Activities Center for Specially Protected Areas - Tunisia;*
[*]*Corresponding author; Fax +33495462441; E-mail pergent@univ-corse.fr*

Abstract. This study forms part of the Action Plan for the Conservation of Marine Vegetation in the Mediterranean Sea (United Nation Environmental Program). It was carried out in June 2000 in the Farwà Lagoon, Libya. The mapping of the main benthic vegetation was achieved by compiling the field observations (transect method), and remote sensing of SPOT satellite images. The phytobenthos in the Farwà lagoon covers an area of 1820 ha (65%). Three benthic macrophyte species dominate, namely the marine phanerogams *Cymodocea nodosa* and *Posidonia oceanica*, and the alga *Caulerpa prolifera*.

Dead *Posidonia oceanica* leaves (litter) form veritable mounds in the vicinity of the openings leading to open sea. These leaves, which come from the coastal sea, are brought into the lagoon by currents and tides; their decomposition will lead to high oxygen consumption and the release of hydrogen sulphide.

The phenological data of *Posidonia oceanica* shoots sampled in the lagoon are similar to those from other stations in the Mediterranean.

Conversely, the lepidochronological parameters of shoots sampled in the central part of the lagoon exhibit values that are substantially higher than those generally recorded in the Mediterranean. The mean number of leaves produced annually is 9.9 (mean value for the Mediterranean: 7.5) and the rhizome growth rate is of 35.7 $mm.yr^{-1}$ (mean value for the Mediterranean: 7.5 $mm.yr^{-1}$). This hypersaline environment would seem to provide optimum growth conditions for the species *Posidonia oceanica*.

Keywords: *Caulerpa prolifera; Cymodocea nodosa*; Lepidochronology; Mapping; Phenology; *Posidonia oceanica*; Seagrass.

Introduction

Mediterranean ecosystems are of major ecological importance as compared to other biogeographical zones of the biosphere. In particular, they possess an incredible species richness that places them just below tropical ecosystems in terms of biodiversity (Ramade 1990). Thus, the Mediterranean harbours more than 1000 macroscopic marine plant species. A high percentage of these benthic species are endemic (15 to 20%; Giaccone & Geraci 1989). The status of these marine and lagoon species is often poorly understood. There may be species which are threatened by decline or even disappearance, but there are also species which make remarkable progress, some of them even in a proliferous way, as so-called invasive species (Boudouresque et al. 1995). In addition to the ecological problems that such changes may mean in terms of biodiversity, there are also economic repercussions that cannot be overlooked, notably regarding spawning and nursery grounds (Harmelin-Vivien et al. 1996).

Among the endangered plant species in the Mediterranean coastal environment, the seagrasses are particularly severely affected. Seagrasses occur throughout the world, and play a major economic and ecological role (Mc Roy & Helfferich 1980; Fortes 1989). In the Mediterranean two species, *Posidonia oceanica* (L.) Delile and *Cymodocea nodosa* (Ucria) Ascherson are responsible for a major part of the richness of coastal waters. Together with the green alga *Caulerpa prolifera* (Forsskål) Lamouroux these seagrasses form vast underwater beds and constitute key ecosystems of the Mediterranean basin (Bellan-Santini et al. 1994) as to (1) the surface area they occupy; (2) the vital ecological role they play (production and exportation of large quantities of plant matter, production of oxygen, spawning and breeding ground, source of biodiversity); (3) their action with regard to the equilibrium of the coastal environment (stabilization of soft bottoms, reduction of the force of currents and swell, protection of beaches and shores); (4) their role in integrating the overall quality of the sea water.

It is within this context that the contracting parties of the Barcelona Convention focused their attention on the incredible richness present within the Mediterranean and adopted the concept that (1) this genetic diversity should be preserved, (2) the populations should be maintained at a satisfactory level and (3) the regions of reproduction and habitats should be protected. Insofar as marine vegetation is concerned, the publication of the 'Livre Rouge Gérard Vuignier' on the threatened plant assemblages and landscapes of the Mediterranean (Anon. 1990) represented a first step towards the implementation of these resolutions. The merits of this inventory are twofold. First of all, the document provides a first synthesis of our knowledge concerning the status of the main threatened plant species, and in addition it furnishes the first tentative guidelines towards the protection and management of these species.

In the same spirit, and following the various recommendations made during the eighth meeting of the Barcelona Convention's contracting parties, the Regional Activities Centre for Specially Protected Areas initiated a feasibility study in 1995, concerning the implementation of a surveillance network of marine vegetation in several Mediterranean countries. This study is part of the Action Plan for the conservation of marine vegetation in the Mediterranean sea adopted during the 11th meeting of the Barcelona Convention's contracting parties, held in Malta in October 1999.

The objectives of this project are:

1. To implement measures towards the management and protection of marine plant species;
2. To act against the destruction of these formations, which are considered to be key components of coastal ecosystems;
3. To ensure the preservation of these formations in characteristic areas.

Due to the extension of the Libyan coastline (more than 2000 km) and the presence of extensive seagrass beds in this region, it was decided that a preliminary study was necessary in this country, notably in the lagoon of Farwà (Anon. 1982). Three main objectives were set:

- To collect information on the main benthic plants (species identification and distribution);
- To map the main habitats within the lagoon of Farwà;
- To estimate vegetation vitality especially for seagrass beds.

Material and Methods

The investigations were carried out from June 5 to 15, 2000 in the Farwà lagoon region, northwestern Lybia (11°44'40" E, 33°05'20" N; Fig. 1). The study was divided into two parts:

- Identification and localization of the main benthic assemblages and bottom types. This information was obtained using nine transects by random geo-referenced investigations (GPS location; Fig. 1).
- Analysis of phenological and lepidochronological data (see below) of *Posidonia oceanica* sampled in two sites (PO1 and PO2).

Transect method

This method consists of unrolling a tape along the bottom in a direction determined by the location of fixed landmarks. The transects thus drawn are followed and species assemblages and bottom types are identified along the entire length of the tape. All changes in vegetation, nature of the assemblage, bottom type and depth are recorded (Calvo et al. 1993).

Phenological analysis

Posidonia oceanica shoots (ten shoots per station) were sampled from two representative sectors: (1) in the vicinity of the man-made channel communicating with the sea (Station PO1), where the plants correspond to fairly new arrivals to the lagoon (short isolated rhizomes corresponding to recent natural cutting), and (2) in the beds located in the central region of the lagoon (Station PO2), where acclimatization of the plants present is considered to have occurred several decades ago (patches over than 1m^2 constituted by long rhizomes with a great number of interconnections). For each leaf shoot, the leaves were removed, while respecting the distichous insertion order, and measured according to the protocol described by Giraud (1979), including the separation into adult, intermediate and juvenile leaves, measurement of leaf length and width (blades and sheaths). Two leaf indices were calculated:

- the *foliar index*, which corresponds to the leaf surface area (in cm^2 per shoot);
- the *coefficient A*, which indicates the number of leaves having lost their apex (grazing by herbivores or due to hydrodynamic action).

Lepidochronological analysis

When *Posidonia oceanica* leaves die, only the blade falls and the shoot base or petiole remains attached to the rhizome, thus becoming what is known as a sheath

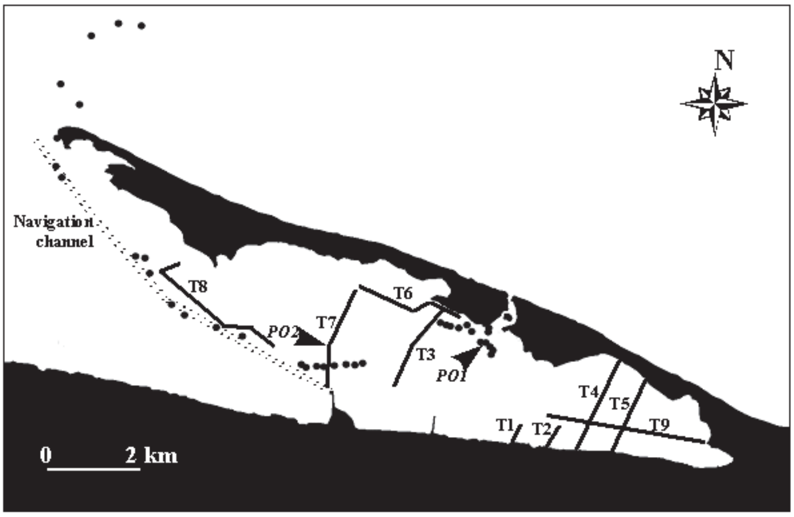

Fig. 1. Lagoon of Farwà with the position of transects and stations studied.

(Pergent-Martini & Pergent 1995). The thickness of these sheaths varies according to their insertion rank along the rhizome (cyclical variations), which have an annual periodicity with a maximum and minimum annual thickness. The study of these cycles has been termed lepidochronology (Pergent 1990). The position (rank) of maximum and minimum thickness is noted while the rhizome is cut at the point of insertion of the thinnest sheaths. Three parameters are then followed:

- Number of leaves produced annually (number of sheaths per cycle).
- Annual rhizome growth rate and production.
- Past flowering events (floral stalk remains inserted between the sheaths).

Lepidochronological analyses were performed on the same shoots as were used for the phenological study.

Mapping

The acquisition of SPOT satellite images of the Farwà region was performed on May 3, 2000. The information provided was necessary to map the assemblages and bottom types present within Farwà Lagoon using remote sensing (Belsher et al. 1988). This treatment was possible using Multiscope software (Matra Cap System®) based on the protocol established by Pasqualini et al. (1997) – linear contrast enhancement, Principal Component Analysis (PCA), classification supervised by a generalized hypercube to the coloured composition, homogenization, and calculation of surface areas. Due to the limited quality of the image, as a result of mirror reflection, manual extrapolations using Photoshop 5 (Adobe®) software were made to the final image on the basis of field data.

Results and Discussion

Main assemblages encountered

Three vegetal assemblages occupy almost the totality of the Farwà lagoon bottoms. These formations are, in decreasing order of importance:

- *Cymodocea nodosa* seagrass beds;
- *Caulerpa prolifera* beds;
- *Posidonia oceanica* in isolated patches.

These benthic macrophytes are found either forming monospecific assemblages or in mixed populations. The presence of dead *Posidonia oceanica* leaves (litter) should also be noted, which at times form veritable emergent islands within the channels leading to the open sea.

Cymodocea nodosa covers virtually all of the lagoon bottom. It grows mainly from the surface to 1 m depth forming monospecific seagrass beds. With the alga *Caulerpa prolifera*, it also forms extensive formations up to depths of 2 m and, finally, it can also be occasionally observed associated with the phanerogam *Posidonia oceanica*. *Cymodocea nodosa* grows on all types of substrate, from silt to sand, and from the surface, where it exhibits temporary emergence, to 2 m depth, where it is replaced by beds of *Caulerpa prolifera* (for instance in the navigation channel). The leaf lengths increase with depth, varying from 10 cm along the shoreline to over 40 cm in the more central regions of the lagoon. The bottom cover is rather low in the shallowest regions (10 to 30%) but usually exceeds 50% at more than 30 cm depth and reaches 80% in the central regions of the lagoon. Few fruits were observed on shoots in the eastern regions of the lagoon.

Caulerpa prolifera covers large areas within the lagoon of Farwà. At depths of 1 - 2m it forms vast assemblages with the phanerogam *Cymodocea nodosa*. The bottom cover of *Caulerpa prolifera* increases with depth. In deeper waters, and mainly on the slopes and bottom of the navigation channel, this species often forms dense, monospecific assemblages. In even deeper waters (– 2 to – 6m), it can be found associated with the marine phanerogam *Posidonia oceanica*. It should also be noted that in the central part of the lagoon, just off the small port of Farwà, mixed assemblages can be observed at depths of 1 - 2m which associate *Caulerpa prolifera*, *Cymodocea nodosa* and patches of *Posidonia oceanica*. In addition, the alga *Caulerpa prolifera* will more easily colonize substrates neighbouring the *Posidonia oceanica* litter than the phanerogam *Cymodocea nodosa* (for instance in the man-made channel).

Posidonia oceanica was observed to grow as isolated shoots or patches covering areas of 1 to 10 m^2. This species was mainly observed in three regions in the lagoon:

- In the vicinity of the man-made channel, where the plants observed are new arrivals from the open sea (natural cutting). These plants grow, or survive as isolated shoots where the channel mouth enters the lagoon. The number of individuals is low and the area they cover minimal (a few m^2);
- In the central portion of the lagoon, in particular off the small port of Farwà. This very shallow region (–1 to –2m) corresponds to the extremity of the navigation channel. The seagrass bed, mainly formed by patches of 1 to 6 m^2 originates probably from cuttings brought by the current present within the channel. It is likely that the environmental conditions allow a lasting development of this species in this region of the lagoon;
- In the navigation channel, which is 2 to 6 m deep, *Posidonia oceanica* is present in patches of variable size (up to 10 m^2). The presence of *Posidonia* within the navigation channel could be due to the fact that this channel (1) transports a large number of cuttings into the lagoon (currents), and (2) exhibits conditions (in terms of temperature and salinity) that are more stable than those of shallower biotopes.

The presence of *Posidonia oceanica* within Farwà lagoon, the salinity of which is above to that recorded in the open sea (Anon. 1982), would seem to confirm the importance of ecological factors in controlling the distribution of this species. This represents the second written record of this phanerogam in a lagoon after that of lake Bibans, which is a hypersaline lagoon located ca. 30 km to the west of the lagoon of ca. 30 km to the west of the lagoon of Farwà (Pergent & Zaouali 1992).

Mapping of the benthic vegetation

The mapping of the main benthic vegetation (phytobenthos) was achieved by compiling the field observations obtained using the transect method, and by supplementing these data with both random observations of typical regions in the lagoon, and remote sensing of SPOT satellite images.

The remote sensing allows a preliminary mapping of the main benthic vegetation and bottom types while corrections are performed manually based on the field data (Fig. 2). In light of the similar spectral response of the *Cymodocea nodosa* beds and *Caulerpa prolifera* beds, in addition to the presence of mixed assemblages of these species, it is difficult to identify these plant formations using SPOT image. In addition, the pixel size (side length of 20 m) makes it impossible to identify small formations, such as small patches of *Posidonia oceanica* (covering several m^2). In light of this, only four themes were considered:

- Emergent land;
- Soft bottoms;
- Benthic macrophytes (*Cymodocea nodosa*, *Caulerpa prolifera*, *Posidonia oceanica*);
- *Posidonia oceanica* litter.

The benthic vegetation covers 1820 ha, which represents 65% of the entire surface area studied (Table 1). Based on the field observations, the distribution of the different species encountered can be broken down as follows:

- From the surface to a depth of 1 m, *Cymodocea nodosa* forms monospecific beds;
- Between 1 and 2 m in depth, *Cymodocea nodosa* and *Caulerpa prolifera* are mixed;
- Below 2 m depth, *Caulerpa prolifera* is present as dense, monospecific formations, especially within the navigation channel;
- Large patches of *Posidonia oceanica* (2 to 4 m^2) are also observed within the navigation channel and from the end of this channel to the central region of the lagoon.

Based on the distributions from the field data (Fig. 1), the accuracy of the map is greater in the eastern portion of the lagoon as compared to the southwestern region. Nevertheless, it is clear that the *Cymodocea nodosa* seagrass beds and *Caulerpa prolifera* beds are particularly well developed in the lagoon. These benthic plant formations are probably responsible for the high oxygen levels recorded within the lagoon (Anon. 1982); they ensure a high production of plant matter and represent spawning and nursery grounds for a great number of animal species (Guerao & Abello 1996).

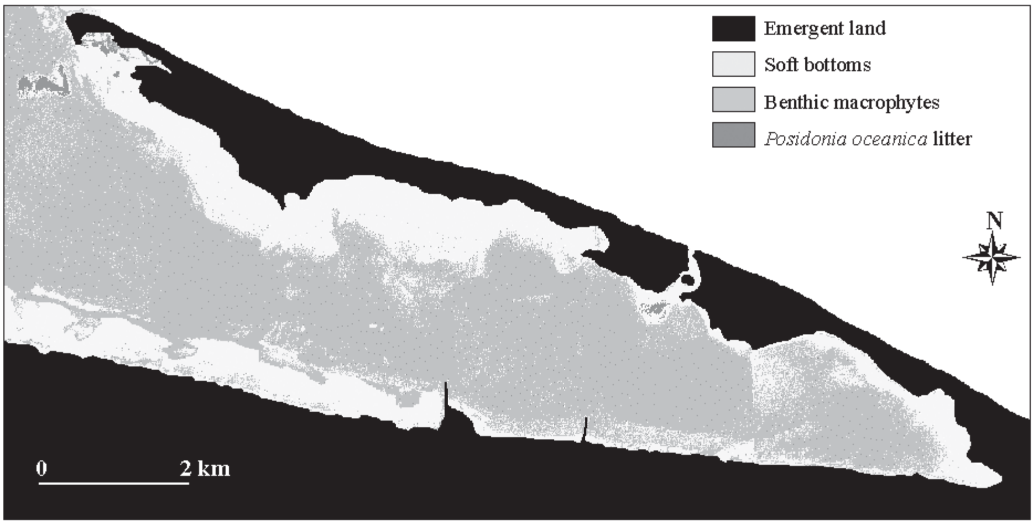

Fig. 2. Distribution of the main assemblages and bottom types within Farwà lagoon.

Phenological and lepidochronological analysis of Posidonia oceanica

The phenological analysis of *Posidonia oceanica* shoots reveals that the overall composition of the shoots is similar (in terms of the number of leaves, length of leaves, foliar index) in the two studied sites (Student test 95%, Table 2). Next to the man-made channel (PO1), however, the leaf width is statistically less (Student test 95%), whereas the coefficient *A*, which describes the number of damaged leaves, is much higher (Student test 95%).

The main phenological parameters recorded here correspond to values usually observed within the Mediterranean for similar depths and sampling season (Pergent & Pergent-Martini 1988; Pergent & Zaouali 1992). The very large leaf widths observed at station PO2, however, are among the highest recorded in the Mediterranean. It should also be noted that, for the sampling season, the values for coefficient *A* are very low, thus implying a good preservation of the leaf tips. This observation can be explained by both the weak hydrodynamic conditions (lagoon environment) and limited herbivore pressure (absence of sea urchins, few herbivorous fish).

The lepidochronological parameters reveal a significant difference between the two stations (Student test 95%, Table 3). Indeed, the number of leaves produced annually and the annual rhizome growth rates are much higher in the central region of the lagoon (Station PO2). Similarly, it is at this last site that past flowering events were recorded.

Table 1. Surface areas covered by the main assemblages and bottom types within the lagoon of Farwà.

	Surface (ha)	Percentage
Soft sediments	963	34.4 %
Benthic vegetation	1 820	65.0 %
Posidonia oceanica litter	16	0.6 %
Total	2 799	100.0 %

Table 2. Phenological parameters of *Posidonia oceanica* shoots in the vicinity of the man-made channel (PO1) and in the central part (PO2). All = adult leaves + intermediate leaves. Confidence level (95%) in brackets.

	Station PO1			Station PO2		
	Adult	Intermediate	All	Adult	Intermediate	All
Number	4.5 (± 0.7)	1.4 (± 0.3)	5.9 (± 0.7)	4.0 (± 0.4)	2.3 (± 0.3)	6.3(± 0.5)
Total length (mm)	512.5 (± 50.5)	302.1 (± 115.1)	462.6 (± 52.0)	478.2 (± 39.1)	235.2 (± 49.6)	389.5(± 42.2)
Leaf sheath length (mm)	30.9 (± 3.3)			39.1 (± 2.9)		
Width (mm)	8.5 (± 0.2)	8.4 (± 0.5)	8.5 (± 0.2)	10.7 (± 0.2)	10.6 (± 0.3)	10.7(± 0.2)
Coefficient *A* (%)	68.2 (± 20.8)	20.0 (± 26.1)	55.5 (± 19.0)	29.3 (± 17.7)	3.3 (± 6.5)	19.4(± 12.5)
Foliar index (cm^2/shoot)	196.7 (± 45.6)	34.5 (± 14.9)	231.3 (± 46.6)	204.7 (± 35.9)	57.4 (± 7.4)	262.2(± 37.5)

Table 3. Lepidochronological parameters of the *Posidonia oceanica* (n = 10) shoots sampled in the vicinity of the man-made channel (PO1) and in the central part of the lagoon (PO2). Confidence level (95%) in brackets.

	Station PO1	Station PO2
Number of sheaths per cycle	7.4 ±0.4	9.9 ±0.6
Annual rhizome growth rate (mm)	7.4 ±1.2	35.7 ±5.1
Past flowering		1998 : 1 1999 : 3

If we show the lepidochronological parameters recorded in Farwà lagoon on a graph along with these parameters from other Mediterranean sites (Figs. 3 and 4), then it becomes clear that:

- Values recorded at Station PO1 are within the range usually observed in the Mediterranean, both in terms of the number of sheaths per cycle and the rhizome growth rate (Pergent et al. 1995);
- Station PO2 exhibits values well above those generally recorded in the Mediterranean (Pergent et al. 1995). The number of sheaths per cycle was in the order of 7.5 for all of the stations combined, whereas a value of 9.9 was observed for station PO2. Similarly, the mean rhizome growth rate has been estimated to be 7.5 mm.yr^{-1} in the Mediterranean, whereas a value of 35.7 mm.yr^{-1} was recorded for station PO2.

The values for Station PO1 refer to cuttings which arrived recently from within the lagoon of Farwà; this explains why their characteristics are fairly similar to those measured at most of the open-sea sites of the Mediterranean. Conversely, after several years of acclimatization within the lagoon, the shoots sampled from Station PO2 exhibit a very high level of vitality characterized by a very high leaf production and growth rate. This hypersaline environment thus seems to present optimum growth conditions for the species *Posidonia oceanica*. The sedimentation rate could also play a role in the annual growth rate of rhizomes (Boudouresque et al. 1983).

Conclusions and Perspectives

The benthic macrophytes in the lagoon of Farwà cover an area of 1820 ha (65%). Three species dominate, namely the marine phanerogams *Cymodocea nodosa* and *Posidonia oceanica*, and the alga *Caulerpa prolifera*. These different species are present either as monospecific assemblages or as mixed populations. Their distribution within the lagoon can be described as follows:

- From the surface to a depth of 1 m, *Cymodocea nodosa* growths in monospecific seagrass beds;
- From 1 to 2 m depth, *Cymodocea nodosa* and *Caulerpa prolifera* constitute mixed formations;
- Deeper than 2 m, dense monospecific bed of *Caulerpa prolifera* is associated with patches of *Posidonia oceanica* (2 to 4 m^2); this seagrass is also present from

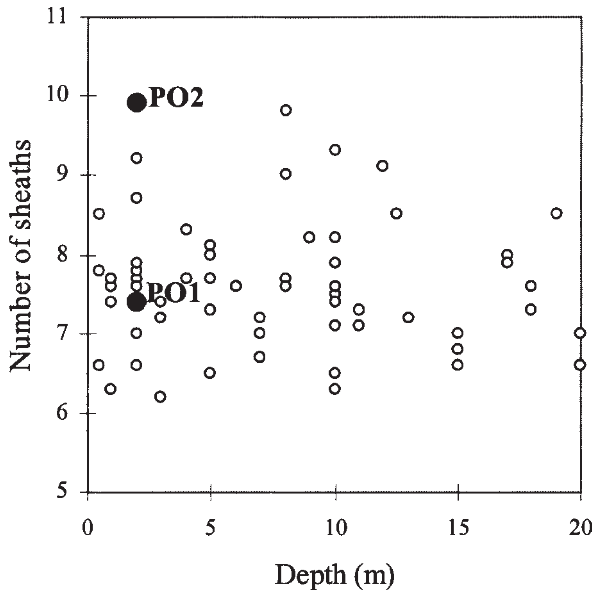

Fig. 3. Number of *Posidonia oceanica* sheaths per cycle recorded for different Mediterranean sites.

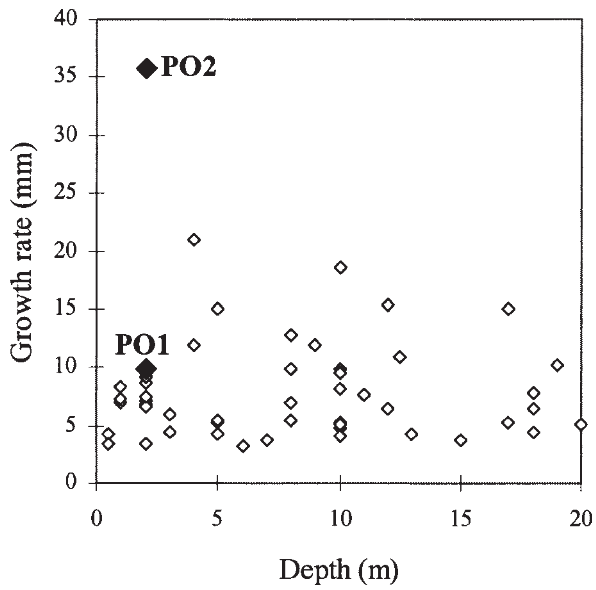

Fig. 4. Rhizome growth rates for *Posidonia oceanica* in different Mediterranean sites.

the end of the channel to the more central part of the lagoon.

The presence of dead *Posidonia oceanica* leaves (litter) should also be noted, as these form veritable mounds in the vicinity of the openings leading to open sea. These accumulations, which cover relatively small surface areas (0.6%), are a very characteristic feature of the lagoon of Farwà. The decomposition of this plant matter will lead to high oxygen consumption and the release of hydrogen sulphide (Anon. 1982). The flora and fauna are very scarce in the vicinity of these formations. These *Posidonia oceanica* leaves, which come from the marine environment, are brought into the lagoon by the currents and tides; their accumulation in the vicinity of the channels is due to reduced hydrodynamic conditions within the lagoon (settling zone).

The phenological analyses of *Posidonia oceanica* shoots sampled in the lagoon are similar to those from other stations in the Mediterranean, with the exception perhaps of the Coefficient *A* which is very low due to a low level of hydrodynamics and limited herbivore pressure. Conversely, the lepidochronological parameters of the shoots sampled (Fig. 3) from the central part of the lagoon show values which are considerably higher than those generally recorded in the Mediterranean (Pergent et al. 1995). The mean number of leaves produced annually is 9.9 against a mean value for the Mediterranean of 7.5, and the rhizome growth rate is in the order of 35.7 $mm.yr^{-1}$ against a mean value for the Mediterranean of 7.5 $mm.yr^{-1}$). Several past flowering events were also detected. This hypersaline environment would seem to provide optimum growth conditions for the species *Posidonia oceanica*.

In light of its biological, ecological and human assets, Farwà lagoon represents a reference site within the framework of the Action Plan for the conservation of marine vegetation in the Mediterranean Sea. The importance of the benthic vegetation present (bottom cover and vitality), the evaluation projects for this lagoon (aquaculture, tourism, hydrology) will need to be included in the global management scheme for this region taking into consideration the aim of Integrated Coastal Zone Management.

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References

Anon. 1982. Environmental conditions of the Farwà lagoon during 1981. *Bull. Mar. Res. Center Tripoli* 3: 23-75.

Anon. 1990. *Livre rouge 'Gérard Vuignier' des végétaux, peuplement et paysages marins menacés de Méditerranée*. UNEP/IUCN/ GIS Posidonie. UNEP, MAP Technical Reports 43.

Bellan-Santini, D., Lacaze, J.C. & Poizat, C. 1994. *Les biocénoses marines et littorales de Méditerranée, synthèse, menaces et perspectives*. Muséum National Histoire Naturelle, Secrétariat Faune Flore Publication, Paris, FR.

Belsher, T., Meinesz, A., Lefevre, J.R. & Boudouresque, C.F. 1988. Simulation of Spot satellite imagery for charting shallow water benthic communities in the Méditerranean. *Mar. Ecol. P.S.Z.N.I. (Pubblicazioni della Stazioni Zooligica di Napoli) Ser*. 9: 157-165.

Boudouresque, C.F., Meinesz, A. & Pergent, G. 1983. Mesure de la production annuelle de rhizomes dans l'herbier à *Posidonia oceanica* à Port-Cros (Var) et Galeria (Corse). *Rapp. P.V. Réun. Comm. Int. Explor. Sci. Médit*. 28(3): 135-136.

Boudouresque, C.F., Meinesz, A., Ribera, M.A. & Ballesteros, E. 1995. Spread of the green alga *Caulerpa taxifolia* (Caulerpales, Chlorophyta) in the Mediterranean: Possible consequences of a major ecological event. *Sci. Mar*. 59 (Suppl. 1): 21-29.

Calvo, S., Frada Orestano, C. & Abbadessa, P. 1993. The suitability of a topographical instrument for an integrated approach to the cartography of *Posidonia oceanica* meadows. *Oceanol. Acta* 16: 273-278.

Fortes, M.D. 1989. Seagrasses: A resource unknown in the ASEAN région. *ICLARM Education* Series 5.

Giaccone, G. & Geraci, R.M. 1989. Biogeografia delle alghe del Meditteraneo. *An. Jard. Bot. Madrid* 46: 27-34.

Giraud, G. 1979. Sur une méthode de mesure et de comptage des structures foliaires de *Posidonia oceanica* (Linnaeus) Delile. *Bull. Mus. Hist. Nat. Marseille* 39: 33-39.

Guerao, G. & Abello, P., 1996. Patterns of activity in the sympatric prawns *Palaemon adspersus* and *Processa edulis* (Decapoda, Caridea) from a shallow Mediterranean bay. *Sci. Mar*. 60: 319-324.

Harmelin-Vivien, M., Harmelin, J.G. & Francour, P., 1996. A 3-year study of the littoral fish fauna of sites colonized by *Caulerpa taxifolia* in the N.W. Mediterranean (Menton, France). In: Ribera, M.A., Ballesteros, E., Boudouresque, C.F., Gomez, A. & Gravez, V. (eds.) *Second International Workshop on Caulerpa taxifolia*, pp. 391-397. Publ. Universitat de Barcelona, ES.

Mc Roy, C.P. & Helfferich, C. 1980. Applied aspects of Seagrasses. In: Phillips, R.C. & McRoy, C.P. (eds.) *Handbook of seagrass biology: an ecosystem perspective*, pp. 297-343. Garland STPM Press, New York, NY.

Pasqualini, V., Pergent-Martini, C., Fernandez, C. & Pergent, G. 1997. The use of airborne remote sensing for benthic cartography: advantages and reliability. *Int. J. Remote Sens*. 18: 1167-1177.

Pergent, G. 1990. Lepidochronological analysis in the seagrass *Posidonia oceanica*: a standardized approach. *Aquat. Bot.*

37: 39-54.
Pergent, G. & Pergent-Martini, C. 1988. Phénologie de *Posidonia oceanica* (Linnaeus) Delile dans le bassin méditerranéen. *Ann. Inst. Océanograph.* 64(2): 9-100.
Pergent, G., Pergent-Martini, C. & Boudouresque, C.F. 1995. Utilisation de l'herbier à *Posidonia oceanica* comme indicateur biologique de la qualité du milieu littoral en Méditerranée: Etat des connaissances. *Mésogée* 54: 3-29.
Pergent-Martini, C. & Pergent, G. 1995. Lepidochronological analysis in the Mediterranean seagrass *Posidonia oceanica*: State of the art and future developments. *Oceanol. Acta* 17: 673-681.
Pergent, G. & Zaouali, J. 1992. Analyse phénologique et lépidochronologique de *Posidonia oceanica* dans une lagune hyperhaline du Sud Tunisien. *Rapp. Comm. Int. Mer Méditerranée* 33: 48.
Ramade, F. 1990. Conservation des écosystèmes méditerranéens – Enjeux et perspectives. *Les Fascicules du Plan Bleu, PNUE/PAM* 3: 1-144.

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