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**Analisi della prateria a *Posidonia oceanica* (L.) Delile (*Najadales*,  
*Potamogetonaceae*) della “Baia di Brucoli (SR)” (Sicilia sud-orientale)\***

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RIASSUNTO

Vengono presentati i risultati di uno studio condotto su una prateria di barriera (*récif barrière*) a *Posidonia oceanica* (L.) Delile, presente nella baia di Brucoli, frazione del comune di Augusta (SR) (Sicilia, Italia). Tale prateria risale fino in superficie formando il *récif barrière* caratterizzando così un particolare ambiente di retro prateria con un basso regime idrodinamico e con caratteristiche lagunari. Le osservazioni e i campionamenti sono stati effettuati in nove stazioni distribuite lungo 3 transetti.

Al fine di caratterizzare tale posidonieto e fornire un quadro del suo attuale stato di salute, nonché una base di dati utilizzabili per un futuro monitoraggio, è stata effettuata l'analisi morfometrica, fenologica e lepidocronologica della prateria.

I risultati mostrano che tale prateria è nel suo insieme alquanto disturbata da diversi impatti antropici (scarico fognario, detriti e acque fangose immesse dal canale Porcaria). Inoltre, non essendo stati riscontrati peduncoli fiorali sui rizomi analizzati né frutti spiaggiati, si può supporre che almeno negli ultimi 8-12 anni non sia avvenuta riproduzione sessuata. Complessivamente, da questo studio è risultato che tale area necessita di urgenti misure di tutela, al fine di poter preservare un così importante ecosistema.

Parole chiave: *Posidonia oceanica*, Brucoli, Fenologia, Lepidocronologia, Sicilia sud-orientale.

SUMMARY

**Analysis of the *Posidonia oceanica* (L.) Delile (*Najadales*, *Potamogetonaceae*) meadow of the “Bay of Brucoli” (sud-eastern Sicily)**

The results of a study carried out on a barrier meadow (*récif barrière*) of *Posidonia oceanica* (L.) Delile occurring in the Bay of Brucoli (Syracuse, SE Sicily) are presented. The meadow rises to the surface forming a “*récif barrière*”, a very particular formation present only in very sheltered zones with shallow bottom (Augier and Boudouresque, 1970; Boudouresque *et al.*, 1985b). Both observations and samples were made in 9 stations along 3 transects. In order to characterize the

meadow and give information on its health state morphometric, phenological and lepidochronological analyses were made. From the study it resulted that the meadow was very disturbed due to anthropogenic impact (sewage, immission of debris and muddy waters from the Porcaria river). Moreover, since in all samples studied no flower peduncles were found and taking into consideration that the average age of the rhizomatous system was estimated of about 9 years ( $9.47 \pm 4.06$ ), we can conclude that at least in the last 8-12 years the environmental conditions were not suitable for *P. oceanica* flowering. From this study it resulted that the area needs a major protection to preserve such an important ecosystem.

Key words: *Posidonia oceanica*, Brucoli, Phenology, Lepidochronology, SE Sicily.

\* Nota presentata dal socio Giovanni Furnari nella seduta del 13/04/2012.

## INTRODUCTION

The *Posidonia oceanica* meadows play a biological and physical crucial role for the coastal and marine environments and they constitute a complex ecosystem that also serves to stabilize both the shoreline and sea bottoms. It was actually estimated that the decline of only one meter of meadow can cause the loss of 15-18 m of coastline (Mazzella *et al.*, 1986).

In the Mediterranean Sea, *Posidonia* meadows cover about 4% of sandy infralittoral substrates, between the surface and 30-40 m depth (Molinier & Picard, 1952), and within the photophilic vegetation represent the climax stage that is the stage of maximum structural and functional complexity. To maintain over the time the climax stage means keeping almost unchanged the delicate balance achieved by all the mechanisms involved in the functioning of the ecosystem. However, different types of natural and human disturbance can alter such balances and

trigger, especially in *Posidonia* meadows, processes of regression up to cause, in more or less short periods of time (depending on the intensity and duration of the disturbance), their disappearance.

The coastline of Brucoli, equidistant from the cities of Catania and Syracuse, is located in a geographical environment unique because of its historical and natural values as well for particular landscape aspects. This coastal strip is submitted to a landscape bond (GURS Palermo - Friday, June 27, 2008 - No. 29).

The area is marked off in the south and the south-west by a natural basin that starts from the peninsula where the village of Brucoli stands and goes as far as Mount Taurus, while in the north-west it is bounded by the plateau of the Gisira that with the above mentioned peninsula delimit the once navigable Porcaria channel. The seashore is then broken by the estuary of the channel, 25 to 30 m wide, and shows cliffs sloping towards the sea forming jagged inlets.

The submerged vegetation of the Bay of Brucoli is characterized by a *Posidonia oceanica* meadow. This meadow rises to the surface forming a “*récif barrière*”, a formation that creates a lagoon environment with a low hydrodynamic regime, between the meadow and the coastline.

Thanks to the presence of this meadow the Bay of Brucoli is included in the Nature 2000 network as a Site of Community Importance named: “*SIC-ITA090026 Fondali di Brucoli – Agnone.*”

The bay of Brucoli is an area worthy of environmental protection. It shows, westward the village, eastward summer residences, while in the stretch of coast facing north, characterized by sandy substrate, it presents, especially in the summer, intense boating activities with small and medium size boats.

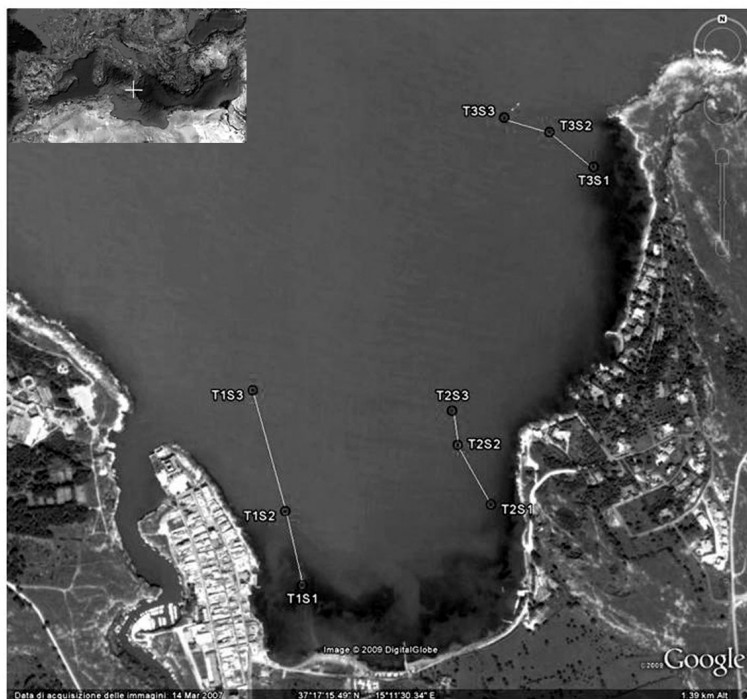
For over forty years, in fact, the maritime village and its coast are frequented for bathing reasons by people who established their summer residence there, moving the economy based on fishing for centuries to the building that has become more and more profitable. Thus, there are clear signs of an environmental degradation due to anthropogenic pressure and the bay is now a non-bathing zone by the presence of sewage.

In order of protection, this area has been classified by decree 30/may/2008 as “Site of Public Interest” area, including the “coast of Brucoli” hanging in the town of Augusta, and such assignment is published in the Official Gazette of the Region of Sicily of 27/06/2008 - N. 29 (first part).

The data existing on marine benthic flora and vegetation of that area are rather scarce and fragmentary and there are no specific studies on the *Posidonia oceanica* meadow of the Bay of Brucoli.

## MATERIALS AND METHODS

In June 2010 were carried out a series of extensive explorations, by SCUBA diving, throughout the area in order to obtain some physiographic features of the meadow mainly concerning the bathymetric evolution of both upper and lower limits and the typology of the meadow. There were chosen 3 transects significant from the point of view of the vulnerability of the sites (as defined by Bardat *et al.*, 1997) referred to as T1, T2, T3, located and oriented as shown in Fig. 1.



**Fig.1** - Area studiata con ubicazione dei transetti e delle relative stazioni.

**Fig.1** - Location of both transects and stations in the studied area.

Along each transect were selected 3 sampling stations near the upper limit (S1), the intermediate limit (S2) and the lower limit of the meadow (S3), respectively, that is in the three levels statistically significant and corresponding to the areas in which generally the meadow is subdivided from an ecological point of view (Fig. 1; Table I).

Transect	Station	Latitude North	Longitude East	Depth in m
T1	T1S1	37°16'59.70"	15°11'23.52"	-1
	T1S2	37°17'4.80"	15°11'22.05"	-5
	T1S3	37°17'13.13"	15°11'19.22"	-14
T2	T2S1	37°17'5.25"	15°11'39.99"	-2
	T2S2	37°17'9.36"	15°11'37.10"	-6
	T2S3	37°17'11.72"	15°11'36.60"	-12
T3	T3S1	37°17'28.50"	15°11'48.96"	-1
	T3S2	37°17'30.91"	15°11'45.11"	-6
	T3S3	37°17'31.91"	15°11'41.17"	-10

**Tabella I** - Dati relativi alle stazioni campionate

**Table I** - Data of sampled stations

In each station were carried out:

- ✓ the visual estimate of per cent cover of *Posidonia oceanica*;
- ✓ the direct count of the number of shoots present within a square of 40 x 40 cm (counting was repeated in five different points in the same station);
- ✓ a detailed photographic documentation.

For the subsequent study in the laboratory, in each station, were taken 20 shoots with rhizomes, avoiding to sample the dichotomous ones and choosing at least 10 with orthotropic rhizomes, for a total of 180 shoots. The shoots were taken at a distance of approximately 50-100 cm from each other. For each station 10 shoots were used for analyzing phenological orthotropic rhizomes and 10 were used for the lepidochronological analysis [limited solely to the determination of the annual cycles and the mean number of scales per year (Catra *et al.*, 2007; 2009)].

All shoots sampled were labeled and stored in a solution of sea water and 5% formalin for subsequent study in the laboratory. The data collected for each station were reported in report cards in Excel 2007 for processing.

For the laboratory analysis it was applied the method described by Buia *et al.* (2003).

Each leaf shoot was split into individual leaves, respecting the order of insertion (alternately distichous). The leaves were numbered from the center outward distinguishing them in young, intermediate and adult. The following parameters were measured per shoot:

- number of leaves per shoot (divided into young, intermediate and adult);
- length and width of each leaf;
- length of the leaf base (present only in mature leaves);
- length of the green tissue and, when present, also that of the brown tissue;
- apex state (intact or broken);

On the basis of these data the following phenological parameters were estimated:

- Mean number of leaves per shoot (calculated with and without young leaves);
- Mean leaf area for each shoot (cm<sup>2</sup>/shoot);
- LAI per station (m<sup>2</sup>/m<sup>2</sup>);
- Coefficient "A" (indicating the impact of the environment on the leaves) equal to the ratio between broken apices and the total number of leaves (expressed in per cent):
- Coefficient "A" of each shoot tested (based on mature and intermediate leaves);
- Mean value of Coefficient "A" per station.

Moreover, the coefficient "A" calculated on the mature leaves, was related to the percentage of the brown tissue if present and of all data dealing with leaves mean values per transect and bathymetric level were calculated.

The lepidochronological study was carried out on the 90 orthotropic rhizomes collected (10 for each station) in order to determine, per each station, bathymetric level and transect, the average age of rhizomes and the average number of scales produced per annual cycle year before the year 2010 (Catra *et al.*, 2007).

## RESULTS

### DESCRIPTION OF THE MEADOW

The *Posidonia* meadow develops inside the bay of Brucoli (SR) and extends, west of the bay, as far as about 600 m from the coast, and about 300 m to the east. The upper limit of the meadow is about 60-80 m from the coastline and from this limit it forms a “*récif barrière*”, thus characterizing a lagoon environment where the waters result to be very quiet (Moliner & Picard, 1952). The area comprised between the “*récif barrière*” and the coastline is characterized by sandy bottoms colonized by *Cymodocea nodosa* (Ucria) Ascherson, *Caulerpa prolifera* (Forsskål) J.V Lamouroux and *Caulerpa racemosa* (Forsskål) J. Agardh v. *cylindracea* (Sonder) Verlaque, Huisman *et* Boudouresque.

West of the bay, the coastline is heavily urbanized mainly during the summer. Near the northwest boundary of the *Posidonia* meadow, it flows the Porcaria stream located west of the city center. It pours fresh water and large amounts of debris that make irregular the sea bottom and particularly turbid waters for the high amount of suspended material.

The *Posidonia* meadow develops in the bathymetric range between 1 (upper limit) and 16 m depth (lower limit). That zone is characterized by different kinds of bottom like “sandy-muddy”, “sandy on rock”, “muddy on rock” and, in a very limited zone, “*matte*” on rock.

The upper limit keeps always at 60-80 m of distance from the coastline and at a depth varying between 0.5 and 2 m, while the lower limit develops from -10 m and -16 m. In all transects, the lower limit is clear-cut, that is characterized by a sudden interruption of the meadow, by the presence of both orthotropic and plagiotropic rhizomes and by the absence of “*matte*”, except in the transect n.3, where at the lower limit a “*matte*” occurs.

According to the evaluation scale of the water transparency proposed by Pergent *et al.* (1995), based on the average depth of the lower limit of *Posidonia oceanica* meadows, the waters of the studied area are classified as “turbid waters”, the lower limit of *P. oceanica* meadow being -10 to -16 m.

### DESCRIPTION OF STATIONS AND PHENOLOGY OF *P. OCEANICA*

#### TRANSECT 1 (T1)

The transect 1 lies in the port area of the bay within 100 m from the city center along the W-E direction. It extends over a length of about 426 m with an average gradient of 3%; the meadow settles on a sandy/muddy substrate making no “*mattes*”. As a whole, the meadow appears “sparse bed”, excepted for the first m of depth.

STATION 1 - T1S1 (37 ° 16'59.70” N - 15 ° 11'23.52” E - 1m) - (Table II).

It is located about 150 m from the coast and about 30 m from the upper limit of the meadow, along the S-N direction. The bottom is sandy and where the meadow is absent it is colonized by *Caulerpa racemosa* v. *cylindracea*. In this area the meadow reaches the surface forming a “*récif barrière*”.

The meadow shows an absolute density of  $450.00 \pm 15.93$  shoots/m<sup>2</sup>, and consequently belongs to the type II (“dense beds”) of Giraud’s classification (1977). Considering that the meadow in this station shows a total cover of the 90%,

it has a relative density of 405.00 shoots/m<sup>2</sup>.

More recently, Pergent *et al.* (1995) and Pergent-Martini & Pergent (1996), on the basis of bibliographic data, made a further classification of meadows, relating the density to depth and other environmental factors, such as turbidity and human disturbance. Using this classification, the meadow in this station appears to be “very disturbed” and with an “abnormal density” in showing values below 822 shoots/m<sup>2</sup> (the “normal” values for a “bed in equilibrium” at this depth are between 934 and 1158 shoots/m<sup>2</sup>).

In the ten shoots on which the observations were conducted, a total of 56 leaves (4 of which young, 19 intermediate and 33 adults) were recorded with an average of 5.6 leaves per shoot (5.2 if we exclude the young ones). The average length of leaves resulted 52.07 cm for adult, 51.20 cm for the intermediate and 1.58 cm for the young leaves. The mean length of brown tissue was 12.68 cm for adult leaves and 5.37 cm for the intermediate ones.

The mean leaf area of each shoot was 226.37 cm<sup>2</sup> while the mean value of coefficient “A” (percentage of broken apices) was to 65.38%, with values of 93.94% for adult leaves and 15.79% for the intermediate ones. The total LAI of the station was 10.19 m<sup>2</sup>/m<sup>2</sup>.

In orthotropic rhizomes a number of annual cycles varying from 2 (found in 2 rhizomes) to 4 (found in 1 rhizome) with an average of 2.88 ± 0.60 cycles per rhizome, was recorded.

The average number of scales found in each cycle varied from a minimum of 5 for the year 2009, to a maximum of 7.11 for 2008, while the average number of scales per rhizome was 6.23 ± 1, 73. From the study of the leaf insertions scars it was possible to infer an average age of sampled rhizomes of 6.44 years, with the oldest rhizome dating to 1998.

No flower peduncles were found.

Date		25/06/2010		Locality		Brucoli										
Latitude		37°16'59.70"N		Transect		1										
Longitude		15°11'23.52"E		Station		1										
Type of bottom		Sandy		Depth in m		1										
				Total cover %		90										
				Type of limit												
Density																
		Values in five replicates					Absolute density		DS (±)		Graaf's classification (1977)			Relative density/m <sup>2</sup>		
No of shoots present in 1600 cm <sup>2</sup>		72	69	75	70	74	72,00		2,55		Very dense	Dense	Sparse	Very sparse	Semi-bed	
No of shoots per m <sup>2</sup>		450	431	469	438	463	450,00		15,93			x				405,00
Leaf phenology																
Leaf type		Young		Intermediate					Adult					Total		
No leaves per 10 shoots		4		19					33					56		
Width and length (cm)		Width	Total length	Width	Total length	Length of green tissue	Length of brown tissue	No broken apices	Width	Total length	Length of green tissue	Length of brown tissue	Length of the base	Length of the blade	No broken apices	
		Mean values	1,58	1,58	0,91	51,20	44,27	5,37	3	0,89	52,07	35,55	12,68	3,85	47,83	31
		DS (±)	1,31	1,37	0,11	29,39	24,80	9,39	0,07	21,41	18,46	11,94	1,06	21,42		
		Coefficient "A" (% of leaves with broken apex)							15,79					93,94		65,38
		Mean number of leaves per shoot (the young ones excluded)		1,90 ± 1,10					3,30 ± 1,16					5,20 ± 1,81		
		Mean values of leaf area (m cm <sup>2</sup> )		84,76 ± 54,10					141,62 ± 37,95					226,37 ± 54,03		
		LAI (m <sup>2</sup> /m <sup>2</sup> )		3,81					6,37					10,19		

**Tabella II** – Dati fenologici relativi alla stazione 1 del transetto 1 (T1S1).

**Table II** - Phenological data of the station 1 of the transect 1 (T1S1).

STATION 2 - T1S2 (37 ° 17'4.80" N - 15 ° 11'22.05" E - 5m) - (Table III).

It is located about 160 m from the station 1. In this area the meadow settles on sandy bottoms.

The meadow shows an absolute density of  $343.75 \pm 26.88$  shoots/m<sup>2</sup> which corresponds to the relative one, since in this station the total cover is of 100%. On this basis, this meadow belongs to the type III ("sparse beds") of the Giraud's classification (1977). On the basis of Pergent *et al.* (1995) and Pergent-Martini & Pergent (1996) classification, this meadow is a "very disturbed bed" with an "abnormal density" in showing values below 413 shoots/m<sup>2</sup> (the "normal" values for a "bed in equilibrium" at this depth are between 525 and 749 shoots/m<sup>2</sup>).

In the ten shoots on which the observations were conducted, a total of 54 leaves (4 of which young, 21 intermediate and 29 adults) were recorded with an average of 5.4 leaves per shoot (5 if we exclude the young ones). The average length of leaves resulted 55.42 cm for adult, 57.00 cm for intermediate and 3.80 cm for the young leaves. The mean length of brown tissue was 10.40 cm for adult leaves and 3.62 for the intermediate ones.

The mean leaf area of each shoot was of 223.91 cm<sup>2</sup> while the mean value of coefficient "A" (percentage of broken apices) was equal to 42.0% with values of 68.97% for the adult leaves and 4.76% for intermediate ones. The LAI of the station was 7.70 m<sup>2</sup>/m<sup>2</sup>.

In orthotropic rhizomes a number of annual cycles varying from 2 (found in 4 rhizomes) to 5 (found in 1 rhizome) with an average of  $2.9 \pm 0.99$  cycles per rhizome was recorded.

The average number of scales found in each cycle varies from a minimum of 5 recorded for the year 2009, to a maximum of 9 for 2005, while the average number of scales per rhizome is  $6.31 \pm 1.87$ . In this station it was possible to infer an average age of sampled rhizomes of 6.33 years, with the oldest rhizome dating to 2002.

No flower peduncles were found.

Date		25/06/2010		Locality		Brucoli									
Latitude		37°17'4.80"N		Transect		1									
Longitude		15°11'22.05"E		Station		2									
Type of bottom		Sandy		Depth in m		5									
				Total cover %		100									
				Type of limit											
Density															
		Values in five replicates				Absolute density		DS (#)		Giraud's classification (1977)			Relative density/m <sup>2</sup>		
No of shoots present in 1600 cm <sup>2</sup>		51	54	60	59	51	55,00	4,30	Very dense	Dense	Sparse	Very sparse		Semi-bed	
No of shoots per m <sup>2</sup>		319	338	375	369	319	343,75	26,88			X				
Leaf phenology															
Leaf type	Young		Intermediate				Adult				Total				
No leaves per 10 shoots	4		21				29				54				
Width and length (cm)	Width	Total length	Width	Total length	Length of green tissue	Length of brown tissue	No broken apices	Width	Total length	Length of green tissue	Length of brown tissue	Length of the base	Length of the blade	No broken apices	
Mean values	0,75	3,80	0,80	57,00	52,01	3,62	1	0,81	55,42	41,52	10,40	3,32	51,92	20	
DS (#)	0,19	0,36	0,09	28,09	25,93	7,09		0,12	28,87	31,50	7,66	1,30	28,71		
Coefficient "A" (% of leaves with broken apex)							4,76							68,97	42,00
Mean number of leaves per shoot (the young ones excluded)							2,10 ± 0,74							2,90 ± 0,74	5,00 ± 1,05
Mean values of leaf area (in cm <sup>2</sup> )							97,35 ± 55,75							126,57 ± 90,84	223,91 ± 77,20
LAI (m <sup>2</sup> /m <sup>2</sup> )							3,35							4,35	7,70

**Tabella III** – Dati fenologici relativi alla stazione 2 del transetto 1 (T1S2).

**Table III** - Phenological data of the station 2 of the transect 1 (T1S2)



STATION 3 - T1S3 (37 ° 17'13.13" N-15 ° 11'19.22" E - 14m) - (Table IV).

It is located about 260 m away from the station 2. In this area the meadow settles mainly on muddy bottoms.

The meadow shows an absolute density of  $177.50 \pm 16.89$  shoots/m<sup>2</sup>, thus belonging to the IV type (“very sparse beds”) of Giraud’s classification (1977), while since in this station it shows a total cover of 50%, its relative density is of 88.75 shoots/m<sup>2</sup>.

On the basis of Pergent *et al.* (1995) and Pergent-Martini & Pergent (1996) classification, in this station the meadow appears “disturbed bed” and with a “lower sub-normal density” showing values between 151 and 263 shoots/m<sup>2</sup> (the “normal” values for a “bed in equilibrium” at this depth are between 263 and 487 shoots/m<sup>2</sup>).

In the ten shoots on which the observations were conducted, a total of 57 leaves (5 of which young, 19 intermediate and 33 adult) were recorded with an average of 5.7 leaves per shoot (5.2 excluding the young ones). The average length of the leaves resulted 48.24 cm for adult, 60.04 cm for the intermediate and 2.00 cm for the young ones. The mean length of the brown tissue was of 0.76 cm for adult leaves, while no brown tissue was found in intermediate leaves.

The mean leaf area of each shoot was of 233.27 cm<sup>2</sup> while the mean value of coefficient “A” (percentage of broken apices) was equal to 48.08% with values of 72.73% for the adult leaves and 5.26% for intermediate ones.

The LAI of the station was 4.14 m<sup>2</sup>/m<sup>2</sup>.

In orthotropic rhizomes a number of annual cycles varying from 1 (found in 2 rhizomes) to 7 (found in 1 rhizome) with an average of  $2.55 \pm 1.81$  cycles per rhizome was recorded. The average number of scales found in each cycle varied from a minimum of 4.56 for the year 2009, to a maximum of 10 for 2003, while the average number of scales per rhizome was  $5.60 \pm 1, 70$ . In this station it was possible to infer an average age of sampled rhizomes of 8.66 years, with the oldest rhizome dating to 1991.

No flower peduncles were found.

Date		25/06/2009		Locality		Brucoi									
Latitude		37°17'13.13"N		Transect		1									
Longitude		15°11'19.22"E		Station		3									
Type of bottom		Muddy		Depth in m		14									
				Total cover %		50									
				Type of limit		Clear-cut									
Density															
		Values in five replicates				Absolute density	DS (±)	Giraud's classification (1977)	Relative density (%)						
No of shoots present in 1600 cm <sup>2</sup>	25	32	28	27	30	28,40	2,70	Very dense							
No of shoots per m <sup>2</sup>	156	200	175	169	188	177,50	16,89	Dense	Sparse	Very sparse	Semi-bed	88,75			
Leaf phenology															
Leaf type	Young		Intermediate					Adult					Total		
No leaves per 10 shoots	5		19					33					57		
Width and length (cm)	Width	Total length	Width	Total length	Length of green tissue	Length of brown tissue	No broken apices	Width	Total length	Length of green tissue	Length of brown tissue	Length of the base	Length of the blade	No broken apices	
	Mean values	0,78	2,00	0,88	60,04	58,23	0,00	1	0,90	48,24	43,39	0,76	4,10	44,51	24
DS (±)	0,19	1,58	0,09	20,23	19,95	0,00		0,06	22,13	23,23	2,10	0,99	22,12		
Coefficient "A" (% of leaves with broken apex)							5,26							72,73	48,08
Mean number of leaves per shoot (the young ones excluded)			1,90 ± 0,57										3,30 ± 0,67	5,20 ± 1,03	
Mean values of leaf area (in cm <sup>2</sup> )			101,32 ± 36,42										131,94 ± 51,06	233,27 ± 49,83	
LAI (m <sup>2</sup> /m <sup>2</sup> )			1,80										2,34	4,14	

Tab. IV – Dati fenologici relativi alla stazione 3 del transetto 1 (T1S3).

Tab IV - Phenological data for the station 3 of the transect 1 (T1S3)

## TRANSECT 2 (T2)

The transect 2 lies 500 m from the city center along the W-E direction and 400 m from T1.

It extends over a length of about 213 m with an average gradient of 4.7%; the meadow settles on a sandy-muddy / rocky substrate and as a whole appears “very rarely”.

STATION 1 - T2S1 (37 ° 17'5.25" N-15 ° 11'39.99" E - 2m) - (Table V).

This station is located about 55 m away from the west coast of the bay. In this area the meadow settles on sandy/rocky bottom.

It shows an absolute density of  $431.25 \pm 20.73$  shoots/m<sup>2</sup> which corresponds to the relative one, since in this station the total cover is of 100%. On this basis, this meadow belongs to the type II (“dense beds”) of the Giraud’s classification (1977). On the basis of the Pergent *et al.* (1995) and Pergent-Martini & Pergent (1996) classification, the meadow in this station appears as a “very disturbed bed” with an “abnormal density” in showing values below 646 shoots/m<sup>2</sup> (the values “normal” for a “bed in equilibrium” at this depth are between 758 and 982 shoots/m<sup>2</sup>).

In the ten shoots on which the observations were conducted, a total of 41 leaves (2 of which young, 16 intermediate and 23 adult) were recorded with an average of 4.1 leaves per shoot (3.9 excluding the young ones). The average length of leaves resulted 55.95 cm for adult, 56.19 cm for the intermediate and 2.50 cm for the young leaves. The mean length of the brown tissue was 10.75 for adult leaves and 3.69 cm for the intermediate ones.

The mean leaf area of each shoot was of 182.19 cm<sup>2</sup> while the mean value of coefficient “A” (percentage of broken apices) was 69.23% with values of 100% for adult leaves and 4% for the intermediate ones. The LAI of the station was 7.86 m<sup>2</sup>/m<sup>2</sup>.

In orthotropic rhizomes a number of annual cycles varying from 2 (found in 2 rhizomes) to 7 (found in 1 rhizome) with an average of  $3.66 \pm 1.5$  cycles per rhizome was recorded.

The average number of scales found in each cycle varied from a minimum of 4 for the year 2005, to a maximum of 6.60 for 2006, while the average number of scales per rhizome was  $5.27 \pm 1.81$ . In this station it was possible to infer an average age of sampled rhizomes of 10.88 years, with the oldest rhizome dating to 1991.

No flower peduncles were found.

Date		25/06/2010		Locality		Brucoli									
Latitude		37°17'5.25"N		Transect		2									
Longitude		15°11'39.99"E		Station		1									
Type of bottom		Sandy/Rocky		Depth in m		2									
				Total cover %		100									
				Type of limit											
Density															
Values in five replicates					Absolute density	DS (±)	Giraud's classification (1977)				Relative density (%)				
No of shoots present in 1600 cm <sup>2</sup>	68	65	74	68	70	69,00	3,32	Very dense	Dense	Sparse		Very sparse	Semi-bed		
No of shoots per m <sup>2</sup>	425	406	463	425	438	431,25	20,73		X				431,25		
Leaf phenology															
Leaf type	Young			Intermediate				Adult				Total			
No leaves per 10 shoots	2			16				23				41			
Width and length (cm)	Width	Total length	Width	Total length	Length of green tissue	Length of brown tissue	No broken apices	Width	Total length	Length of green tissue	Length of brown tissue	Length of the base	Length of the blade	No broken apices	
	Mean values	0,55	2,50	0,84	56,19	51,84	3,69	4	0,86	55,95	41,43	10,75	3,77	52,19	23
DS (±)	0,35	2,83	0,14	22,68	23,05	5,72		0,10	20,32	18,05	8,26	0,86	20,32		
Coefficient "A" (% of leaves with broken apex)							25,00							100,00	69,23
Mean number of leaves per shoot (the young ones excluded)				1,60 ± 0,84				2,30 ± 0,67				3,90 ± 0,57			
Mean values of leaf area (in cm <sup>2</sup> )				78,49 ± 40,75				103,70 ± 49,27				182,19 ± 43,11			
LAI (m <sup>2</sup> /m <sup>2</sup> )				3,38				4,47				7,86			

**Tab. V** – Dati fenologici relativi alla stazione 1 del transetto 2 (T2S1).

**Tab V** - Phenological data for the station 1 of the transect 2 (T2S1)

STATION 2 - T2S2 (37 ° 17'9.36" N - 15 ° 11'37.10" E, - 6m) - (Table VI).

It is located about 140 m away from the station 1 of the same transect. In this area the meadow settles on sandy/muddy bottom.

It shows an absolute density of 291.25 ± 23.33 shoots/m<sup>2</sup> which corresponds to the relative one, since in this station the total cover is of 100%. On this basis, this meadow belongs to the type IV (“very sparse beds”) of Giraud’s classification (1977).

On the basis of Pergent *et al.* (1995) and Pergent-Martini & Pergent (1996) classification the meadow in this station appears as a “very disturbed bed” with an “abnormal density” in showing values below 367 shoots/m<sup>2</sup> (the “normal” values for a “bed in equilibrium” at this depth are between 479 and 703 shoots/m<sup>2</sup>). In the ten shoots on which the observations were conducted, a total of 48 leaves (3 of which young, 14 intermediate and 31 adult) were recorded with an average of 4.8 leaves per shoot (4.5 excluding the youth leaves). In this station the average length of the leaves was 62.34 cm, 67.93 cm and 2.97 cm for the adult, intermediate and young leaves, respectively. The mean length of brown tissue was 9.55 cm for adult leaves and 1.64 cm for the intermediate ones.

The mean leaf area of each shoot (was of 240.86 cm<sup>2</sup> while the mean value of coefficient “A” (percentage of broken apices) was 62.22%, with values of 74.19% for adult leaves and 35.71% for the intermediate ones. The total LAI of the station was 7.02 m<sup>2</sup>/m<sup>2</sup>.

In orthotropic rhizomes a number of annual cycles varying from 2 (found in 1 rhizome) to 5 (found in 3 rhizomes) with an average of 3.9 ± 0.99 cycles per rhizome, was recorded.

The average number of scales found in each cycle varied from a minimum of 4.80 recorded for the year 2009 to a maximum of 7.29 recorded for 2006, while the average number of scales per rhizome was 6.05 ± 1.64. In this station it was inferred an average age of rhizomes of 9.60 years, with the oldest rhizome dating to 1996.

No flower peduncles were found.

Date		25/06/2010		Locality		Brucoli									
Latitude		37°17'9.36"N		Transect		2									
Longitude		15°11'37.10"E		Station		2									
Type of bottom		Sandy/Muddy		Depth in m		6									
						Total cover %		100							
						Type of limit									
Density															
Values in five replicates					Absolute density		DS (#)		Giraud's classification (1977)						
No of shoots present in 1600 cm <sup>2</sup>	45	43	52	44	49	46,60	3,78	Very dense	Dense	Sparse	Very sparse	Semi-bed	Relative density/m <sup>2</sup>		
No of shoots per m <sup>2</sup>	281	269	325	275	306	291,25	23,63				X		291,25		
Leaf phenology															
Leaf type	Young		Intermediate					Adult					Total		
No leaves per 10 shoots	3		14					31					48		
Width and length (cm)	Width	Total length	Width	Total length	Length of green tissue	Length of brown tissue	No broken apices	Width	Total length	Length of green tissue	Length of brown tissue	Length of the base	Length of the blade	No broken apices	
	0,80	2,97	0,87	67,93	65,94	1,64	5	0,87	62,34	48,84	9,55	3,96	58,37	23	
DS (±)	0,17	1,86	0,07	27,85	26,62	2,73		0,07	19,30	20,05	7,06	0,76	19,75		
Coefficient "A" (% of leaves with broken apex)							35,71							74,19	62,22
Mean number of leaves per shoot (the young ones excluded)			1,40 ± 0,52					3,10 ± 0,32					4,50 ± 0,53		
Mean values of leaf area (in cm <sup>2</sup> )			83,17 ± 39,66					157,69 ± 34,79					240,86 ± 51,46		
LAI (m <sup>2</sup> /m <sup>2</sup> )			2,42					4,59					7,02		

**Tab. VI** – Dati fenologici relativi alla stazione 2 del transetto 2 (T2S2).

**Tab VI** - Phenological data for the station 2 of the transect 2 (T2S2)

STATION 3 - T2S3 (37 ° 17'11.72" N - 15 ° 11'36.60" E, -12 m) - (Table VII).

It is located about 73 m away from station 2. In this area the meadow settles on a muddy/rocky bottom. It shows an absolute density of  $243.75 \pm 20.73$  shoots/m<sup>2</sup> which corresponds to the relative one, since in this station the total cover is of 100%. On this basis, this meadow belongs to the type IV (“sparse beds”) of Giraud’s classification (1977).

On the basis of the Pergent *et al.* (1995) and Pergent-Martini & Pergent (1996) classification this meadow appears as a “disturbed bed” with a “lower sub-normal density” in showing values between 213 and 325 shoots/m<sup>2</sup> (the “normal” values for a “bed in equilibrium” at this depth are between 325 and 549 shoots/m<sup>2</sup>).

In the ten shoots on which the observations were conducted a total of 57 leaves (6 of which young, 19 intermediate and 32 adult) were recorded with an average of 5.7 leaves per shoot (5.10 if we exclude the young ones). The average length of leaves resulted 48.76 cm, 65.97 cm and 1.38 cm for the adult, intermediate and young leaves, respectively. The mean length of the brown tissue was 5.87 cm and 3.11 cm in adult and intermediate leaves, respectively.

The mean leaf area of each shoot was of 239.43 cm<sup>2</sup> while the mean value of the coefficient “A” (percentage of broken apices) was 70.59% with values of 93.75% for the adult leaves and 31.58% for intermediate ones. The total LAI of the station was 5.84 m<sup>2</sup>/m<sup>2</sup>.

In orthotropic rhizomes a number of annual cycles varying from 3 (found in 3 rhizomes) to 16 (found in 1 rhizome) with an average of  $6.9 \pm 4.58$  cycles per rhizome was recorded.

The average number of scales found in each cycle varied from a minimum of 3.5 recorded for the year 1998 to a maximum of 9 for 1995, while the average number of scales per rhizome was  $5.88 \pm 2.25$ . In this station it was inferred an average age of 19.50 years of rhizome, with the oldest one dating to 1974.

No flower peduncles were found.

Date		25/06/2010		Locality		Brucoli			
Latitude		37°17'11.72"N		Transect		2			
Longitude		15°11'36.60"E		Station		3			
Type of bottom		Rocky/Muddy		Depth in m		12			
				Type of limit		Clear-cut			
				Total cover %		100			
Density									
Values in five replicates				Absolute density		DS (#)			
Graud's classification (1977)				Very dense		Dense			
No of shoots present in 1600 cm <sup>2</sup>				35		39,00			
No of shoots per m <sup>2</sup>				219		243,75			
Very dense				Dense		Sparse			
Very sparse				Semi-bed		Relative density/m <sup>2</sup>			
X				243,75					
Leaf phenology									
Leaf type		Young		Intermediate				Adult	
No leaves per 10 shoots		6		19				32	
Total length		0,73		1,38		0,86		65,97	
Width		0,10		1,29		0,07		15,76	
Length of green tissue		0,07		15,76		15,22		4,56	
Length of brown tissue		0,07		15,76		15,22		4,56	
No broken apices		6		31,58		93,75		70,59	
Mean values		0,91		48,76		38,83		5,87	
DS (#)		0,08		23,00		22,41		6,47	
Coefficient "A" (% of leaves with broken apex)		0,08		23,00		22,41		6,47	
Mean number of leaves per shoot (the young ones excluded)		1,90 ± 0,57		3,20 ± 1,03		5,10 ± 1,10		239,43 ± 52,54	
Mean values of leaf area (in cm <sup>2</sup> )		108,59 ± 34,05		130,84 ± 63,60		239,43 ± 52,54		5,84	
LAI (m <sup>2</sup> /m <sup>2</sup> )		2,65		3,19		5,84			

**Tab. VII –** Dati fenologici relativi alla stazione 3 del transetto 2 (T2S3).

**Tab VII -** Phenological data for the station 3 of the transect 2 (T2S3).

**TRANSECT 3 (T3)**

The transect 3 lies outside of the bay facing east. It extends over a length of about 223 m with an average gradient of 4%; the meadow settles on a sandy-rocky substrate and showing a “matte” at its lower limit. The meadow as a whole appears “very sparse”.

STATION 1 - T3S1 (37 ° 17'28.50” N - 15 ° 11'48.96” E, - 1 m) - (Table VIII).

This station is located about 100 m away from the east coast of the bay. In this area the meadow settles on both a dead “matte” and rocky substrate.

It shows an absolute density of 531.25 ± 43.08 shoots/m<sup>2</sup>, and belongs to the type II (“dense beds”) of Giraud’s classification (1977). Considering that the meadow in this station shows a total cover of 90%, its relative density is 217.50 shoots/m<sup>2</sup>.

On the basis of Pergent *et al.* (1995) and Pergent-Martini & Pergent (1996) classifications, the meadow in this station appears as “very disturbed bed” with an “abnormal density” in showing values below 822 shoots/m<sup>2</sup> (the “normal” values for a “bed in equilibrium” at this depth are between 934 and 1158 shoots/m<sup>2</sup>).

In the ten shoots on which the observation were conducted, a total of 63 leaves (8 of which young, 26 intermediate and 29 adults) were recorded with an average of 6.3 leaves per shoot (5.50 excluding the young ones).

The average length of leaves resulted 36.43 cm for adult, 35.67 cm for the intermediate and 2.34 cm for the young leaves. The mean length of brown tissue was 9.07 cm and 1.31 cm for adult and intermediate leaves, respectively.

The average leaf area of each shoot (average LAI) was 170.08 cm<sup>2</sup> while the mean value of coefficient “A” (percentage of broken apices) was 61.82% with values of 93.10% for the adult leaves and 26.92% for the intermediate ones. The LAI of the station was 9.04 m<sup>2</sup>/m<sup>2</sup>.

In orthotropic a number of annual cycles varying from 1 (found in 1 rhizome) to 7 (found in 1 rhizome) with an average of 4.00 ± 1.65 cycles per rhizome was recorded.

The average number of scales found in each cycle varied from a minimum of 4.00,

for the year 2003, to a maximum of 7.67 for 2006, while the average number of scales per rhizome is  $6.61 \pm 1.86$ . In this station it was possible to infer an average age of sampled rhizomes of 6.11 years, with the oldest rhizome dating to 2000. No flower peduncles were found.

Date		25/06/2010		Locality		Brucoli									
Latitude		37°17'28.50"N		Transect		3									
Longitude		15°11'48.96"E		Station		1									
Type of bottom		Rocky/Matte		Depth in m		1									
				Total cover %		90									
				Type of limit											
Density															
		Values in five replicates				Absolute density	DS (±)	Giraud's classification (1977)			Relative density/m <sup>2</sup>				
No of shoots present in 1600 cm <sup>2</sup>		75	86	94	83	87	85,00	6,89	Very dense	Dense		Sparse	Very sparse	Semi-bed	
No of shoots per m <sup>2</sup>		469	538	588	519	544	<b>531,25</b>	<b>43,08</b>		<b>X</b>				478,13	
Leaf phenology															
Leaf type	Young		Intermediate				Adult				Total				
No leaves per 10 shoots	8		26				29				56				
Width and length (cm)	Width	Total length	Width	Total length	Length of green tissue	Length of brown tissue	No broken apices	Width	Total length	Length of green tissue	Length of brown tissue	Length of the base	Length of the blade	No broken apices	
	Mean values	0,90	2,34	0,90	35,67	32,44	1,31	7	0,89	36,43	24,43	9,07	2,93	33,50	27
DS (±)	0,23	1,34	0,08	16,55	15,61	3,80		0,08	12,37	13,67	6,35	0,48	12,38		
Coefficient "A" (% of leaves with broken apex)						26,92								93,10	<b>61,82</b>
Mean number of leaves per shoot (the young ones excluded)			2,60 ± 0,97				2,90 ± 1,10				5,50 ± 1,96				
Mean values of leaf area (in cm <sup>2</sup> )			83,24 ± 32,81				86,84 ± 35,98				170,08 ± 30,98				
LAI (m <sup>2</sup> /m <sup>2</sup> )			4,42				4,61				9,04				

**Tab. VIII** – Dati fenologici relativi alla stazione 1 del transetto 3 (T3S1).

**Tab VIII** - Phenological data for the station 1 of the transect 3 (T3S1).

STATION 2 - T3S2 (37 ° 17'30.91" N - 15 ° 11'45.11" E - 6 m) - (Table IX).

It is located about 120 m away from the station 1 of the same transect. In this area the meadow settles on the sandy bottom.

It shows an absolute density of  $435.00 \pm 23.63$  shoots/m<sup>2</sup>, and consequently belongs to the type II (“dense beds”) of Giraud’s classification (1977). Considering that the meadow in this station shows a total cover of 50%, it has a relativity density of 217.50 shoots/m<sup>2</sup>.

On the basis of the Pergent *et al.* (1995) and Pergent-Martini & Pergent (1996) classifications, the meadow at this station appears as “disturbed bed” and with “lower sub-normal density” in showing values below 479 shoots/m<sup>2</sup> (The “normal” values for a “bed in equilibrium” at this depth are between 479 and 703 shoots/m<sup>2</sup>). In the ten shoots on which the observations were conducted a total of 77 leaves (10 of which young, 26 intermediate and 41 adult) were recorded with an average of 7.7 leaves per shoot (6.70 excluding the young leaves). In this station the average length of the leaves was 69.01 cm, 52.60 cm and 3.02 cm for the adult, intermediate and young leaves, respectively. The mean length of the brown tissue was 6.28 cm for the adult leaves (no brown tissue was found in the intermediate leaves).

The mean leaf area of each shoot was of 375.35 cm<sup>2</sup> while the mean value of coefficient “A” (percentage of broken apices) was 53.73% with values of 73.17% for the adult leaves and 23.08% for the intermediate ones. The total LAI of the station was 16.33 m<sup>2</sup>/m<sup>2</sup>.

In orthotropic rhizomes a number of annual cycles varying from 2 (found in 1 rhizome) to 9 (found in 1 rhizome) with an average of  $4.37 \pm 2.26$  cycles per rhizome, was recorded.

The average number of scales found in each cycle varies from a minimum of 5.50 recorded for the year 2004, to a maximum of 8 recorded for 2005, 2002 and 2001 while the average number of scales per rhizome was  $6.88 \pm 2.10$ . In this station it was inferred an average age of rhizomes of 9 years, with the oldest rhizome dating to 1997.

No flower peduncles were found.

Date		25/06/2010		Locality		Brucoli								
Latitude		37°17'30.91"N		Transect		3								
Longitude		15°11'45.11"E		Station		2								
Type of bottom		Sandy		Depth in m		6								
				Total cover %		50								
				Type of limit										
Density														
Values in five replicates				Absolute density		DS (±)								
No of shoots present in 1600 cm <sup>2</sup>	71	64	74	68	71	69,60	3,78							
No of shoots per m <sup>2</sup>	444	400	463	425	444	435,00	23,63							
				Girau's classification (1977)										
				Very dense	Dense	Sparse	Very sparse							
							Semi-bed							
						Relative density/m <sup>2</sup>								
						217,50								
Leaf phenology														
Leaf type	Young		Intermediate				Adult			Total				
No leaves per 10 shoots	10		26				41			77				
Width and length (cm)	Width	Total length	Width	Total length	Length of green tissue	Length of brown tissue	No broken apices	Width	Total length	Length of green tissue	Length of brown tissue	Length of the base	Length of the blade	No broken apices
	Mean values	0,78	3,02	0,90	52,60	51,75	0,00	6	0,94	69,01	58,14	6,28	4,56	64,42
DS (±)	0,24	1,67	0,11	34,19	34,00	0,00		0,06	25,16	24,68	7,51	1,17	25,10	
Coefficient "A" (% of leaves with broken apex)							23,08				73,17	53,73		
Mean number of leaves per shoot (the young ones excluded)			2,60 ± 0,97				4,10 ± 0,88			6,70 ± 1,42				
Mean values of leaf area (in cm <sup>2</sup> )			126,22 ± 52,26				249,13 ± 75,51			375,35 ± 87,32				
LAI (m <sup>2</sup> /m <sup>2</sup> )			5,49				10,84			16,33				

Tab. IX – Dati fenologici relativi alla stazione 2 del transetto 3 (T3S2).

Tab IX - Phenological data for the station 2 of the transect 3 (T3S2).

STATION 3 - T3S3 (37 ° 17'31.91" N - 15 ° 11'41.17" E, - 10 m) - (Table X).

It is located about 100 m away from the station 2 along the NW-SE direction.

In this area the meadow settles on both a dead “matte” and rocky substrate.

It shows an absolute density of  $347.50 \pm 34.97$  shoots/m<sup>2</sup>, and consequently belongs to type III (“sparse beds”) of Giraud’s classification (1977). Considering that the meadow in this station shows a total cover of the 90%, it has a relative density of 312.75 shoots/m<sup>2</sup>.

On the basis of Pergent *et al.* (1995) and Pergent-Martini & Pergent (1996) classification the meadow in this station appears as a “disturbed bed” with “lower sub-normal density” in showing value below 349 shoots/m<sup>2</sup> (the “normal values” for a “bed in equilibrium” at this depth are between 349 and 573 shoots/m<sup>2</sup>).

In the ten shoots on which the observations were conducted a total of 63 leaves (2 of which young, 24 intermediate and 37 adult) were recorded with an average of 6.3 leaves per shoot (6.10 excluding the young leaves). The average length of leaves resulted 52.70 cm for the adult leaves, 67.77 cm for the intermediate and 3.50 cm for the young ones. The mean length of the brown tissue was 8.92 cm for adult leaves and 0.63 cm for the intermediate ones.

The mean leaf area of each shoot was of 308.34 cm<sup>2</sup> while the mean value of coefficient “A” (percentage of broken apices) was 55.74% with values of 70.27% and 33.33% for the adult leaves and intermediate leaves, respectively. The LAI of the station was 10.71 m<sup>2</sup>/m<sup>2</sup>.

In orthotropic rhizomes a number of annual cycles varying from 2 (found in 2 rhizomes) to 6 (found in 1 rhizome) with an average of  $4.00 \pm 1.51$  cycles per

rhizome, was recorded.

The average number of scales found in each cycle varies from a minimum of 5.25, for the year 2009, to a maximum of 7.60 for 2006, while the average number of scales for rhizome was of  $6.40 \pm 2.00$ . In this station was inferred an average age of rhizomes of 7.75 years, with the oldest rhizome dating to 2001.

No flower peduncles were found.

Date		25/06/2010		Locality		Brucoli										
Latitude		37°17'31.91"N		Transect		3										
Longitude		15°11'41.17"E		Station		3										
Type of bottom		Rocky/Matte		Depth in m		10										
				Type of limit		Clear-cut										
				Total cover %		90										
Density																
		Values in five replicates				Absolute density		DS (±)		Grauf's classification (1977)		Relative density/m <sup>2</sup>				
No of shoots present in 1600 cm <sup>2</sup>		48	56	63	53	58	55,60	5,59	Very dense	Dense	Sparse	Very sparse	Semi-bed			
No of shoots per m <sup>2</sup>		300	350	394	331	363	347,50	34,97			X			312,75		
Leaf phenology																
Leaf type		Young		Intermediate				Adult				Total				
No leaves per 10 shoots		2		24				37				63				
Width and length (cm)		Width	Total length	Width	Total length	Length of green tissue	Length of brown tissue	No broken apices	Width	Total length	Length of green tissue	Length of brown tissue	Length of the base	Length of the blade	No broken apices	
Mean values		0,70	3,50	0,85	67,77	66,50	0,63	8	0,94	52,70	39,21	8,92	3,84	48,86	26	
DS (±)		0,28	0,71	0,10	22,32	22,10	1,76		0,06	24,81	25,90	8,20	0,69	24,94		
Coefficient "A" (% of leaves with broken apex)								33,33						70,27		55,74
Mean number of leaves per shoot (the young ones excluded)				2,40 ± 0,52								3,70 ± 0,82		6,10 ± 0,99		
Mean values of leaf area (m cm <sup>2</sup> )				138,96 ± 28,22								169,38 ± 73,34		308,34 ± 57,69		
LAI (m <sup>2</sup> /m <sup>2</sup> )				4,83								5,89		10,71		

Tab. X – Dati fenologici relativi alla stazione 3 del transetto 3 (T3S3).

Tab X - Phenological data for the station 3 of the transect 3 (T3S3).

## DISCUSSION

The bottom occupied by the *Posidonia* meadow slopes very slightly. The average slope is 3.9% from the upper to the lower limit of the meadow.

Due to the settlement in a shallow bottom, in the bay of Brucoli the *Posidonia* meadow forms a “*récif barrière*”, a very particular formation present only in very sheltered zones with shallow bottom (Augier and Boudouresque, 1970; Boudouresque *et al.*, 1985b) delimiting towards the coastline a lagoon zone with a muddy bottom where a *Cymodocea nodosa* meadow settles.

The bay of Brucoli is thus characterized by a *C. nodosa* meadow, from the coastline to about 60-100 m, where, at about -0.70 m, the upper limit of the *Posidonia* meadow is located.

The lower limit of the meadow, according to the transects is located between -10 and -16 m, and it is always of the clear-cut limit type. It is not very deep although the morphology and structure of the bottom maintain the same characteristics also below that depth. The lower limit of clear-cut type and the shallow depth in which it is located are, according to Meinesz & Laurent (1978) and Pergent *et al.* (1995), closely related to the limited transparency of coastal waters that according to the scale proposed by Pergent *et al.* (1995), in the studied area, should be classified as “turbid waters”. This turbidity may be related to several causes, such as debris resulting from the building operations, the tourist devotion of the area, the sewage



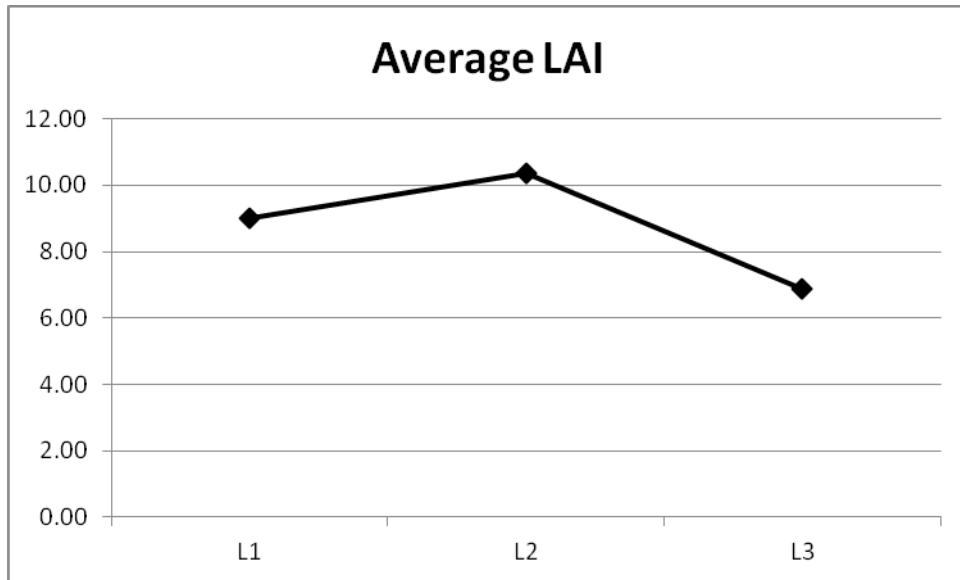
system of the built-up area and the fine material from the river Porcaria.

Furthermore, the large boats traffic within the channel moves large amounts of mud the normal diffusion of which outside the Bay is strongly prevented by the hydrodynamic regime that affects the bay.

Since there are no historical scientific data on this meadow it is not possible to make any considerations on the current dynamics of the lower limits. However, the finding of a dead “*matte*” in the deepest station of transect T3, does suggest a regression of the meadow, even if it presents also in that transect a lower limit of clear-cut type.

On the basis of the values of the absolute density calculated in different stations according to Giraud’s (1977) classification, the 44.4% of the meadow resulted “dense”, the 33.3% “very sparse” and the 22.2% “sparse” while on the basis of the values of the absolute density calculated according to Pergent’s classification, the 55.55% of the meadow resulted “very disturbed” with “abnormal density” (AD) and the 44.44% “disturbed” with a “lower sub-normal density” (LSD). The last values put better in evidence the suffering state of the meadow. In fact, in all the transects, in the superficial stations, the meadow is classified as “very disturbed” with “AD”, as well as in the stations at intermediate depth, with the exception of the transect 3, located in the outer zone of the bay, where the meadow resulted “disturbed” with “LSD”, while at the greater depths of all three transects, the meadow resulted “disturbed” with “LSD”. The suffering state of the meadow seems to be always related to the high amount of material in suspension which, besides reducing the transparency of the water, alters the normal rhythm of sedimentation causing, mainly in the inner stations, its silting up and the consequent death of the plant.

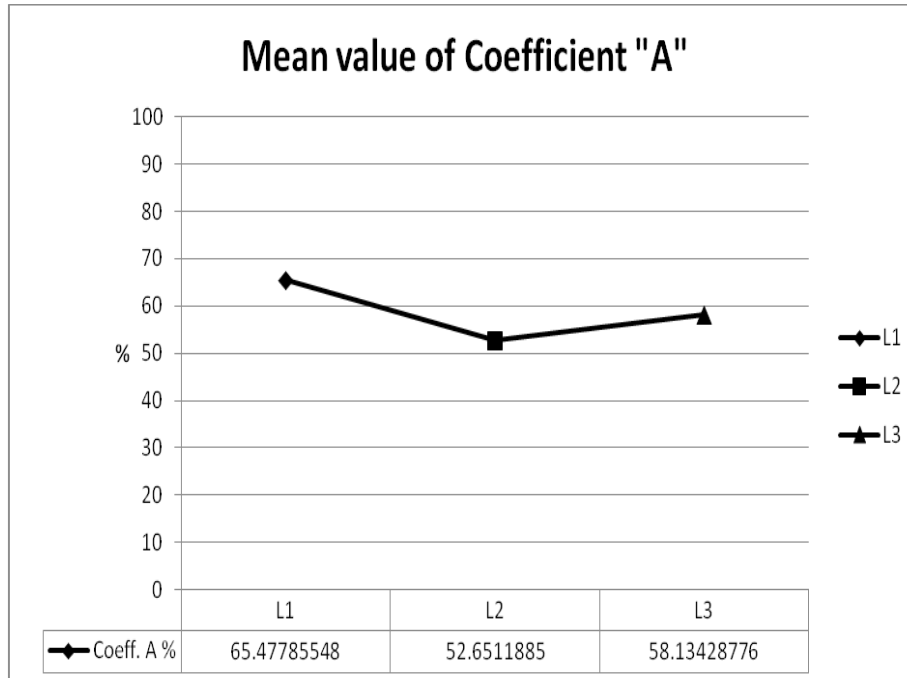
According to Buia *et al.* (2003) the normal values of the leaf area index (LAI) of superficial meadows (between 3 and 8-10 m depth) should be between 6.16 and 29  $\text{m}^2/\text{m}^2$  and those of deep meadows (below 25 m depth) between 1.1 and 2.6  $\text{m}^2/\text{m}^2$ . On the basis of the above values, the meadow here studied, in showing values of LAI of 9.03  $\text{m}^2/\text{m}^2$  near the surface, 10.35  $\text{m}^2/\text{m}^2$  at intermediate depth and 6.90  $\text{m}^2/\text{m}^2$  at the highest depth (that, however, does not exceed -16 m), can be considered in equilibrium (Fig. 2).



**Fig. 2** – Variazioni dell'indice di superficie fogliare (LAI) medio calcolato per livello batimetrico.  
**Fig. 2** - Variations of the average leaf area index (LAI) calculated per each bathymetric level.

According to Buia *et al.* (2003) the number of leaves per shoot should be, normally, 8. In the whole area studied, the average number of leaves per shoot resulted 5.2, below the normal value indicated by Buia *et al.* (2003). However, it should be pointed out that according to Dolce *et al.* (1996) and Di Dato *et al.* (2000), the number of leaves produced by the rhizome per year is not programmed but casual at all, thus introducing a casualness that raised questions about the events or mechanisms that regulate the production of leaves.

The coefficient "A", which expresses the combined effect of the mechanical action of the hydrodynamism on the leaves and the grazing of herbivores, does not result coherent with the depth of the stations. In fact, the percentage of broken apices was the highest at higher levels (coeff. "A" equal to 65.47%), decreased at intermediate depths (52.65%), but presented a higher value at greater depths (58.13%) (Fig. 3).



**Fig. 3** – Variazione del Coefficiente "A" medio calcolato per livello batimetrico

**Fig. 3** – Variations of the average Coefficient "A" calculated per each bathymetric level.

The coefficient "A", normally, should decrease with increasing depth. This was observed only in transect 2, while in other transects, it showed high values near the surface which decreased at intermediate depths and increased at lower levels. This trend is probably due to the type of the meadow and the intense traffic of boats and particularly to anchoring that causes the breaking of leaves, thus increasing the value of the coefficient "A". In fact, the highest value was found in the transect located in the most central part of the bay subject to a severe boats passing. This is also supported by the comparison between the coefficient "A" of adult leaves and the percentage of brown tissue of the same leaves. In fact, relatively low values of the percentage of brown tissue often correspond to high values of the coefficient "A".

The lepidochronological study, focused only on the identification of annual rhizomes cycles and the number of scales produced for each cycle, allowed the estimation for the entire meadow of an average value of  $3.93 \pm 2.37$  cycles per rhizome with an average production of  $6.13 \pm 1.97$  scales per rhizome. The number of cycles for rhizome, estimated within each bathymetric level, presented significant variations correlated to depth. In fact, it was growing from the upper layer (mean value of  $3.41 \pm 1.19$  cycles) to the intermediate (mean value of  $3.68 \pm 1.54$  cycles) to the deepest (mean value of  $4.59 \pm 3.53$  cycles).

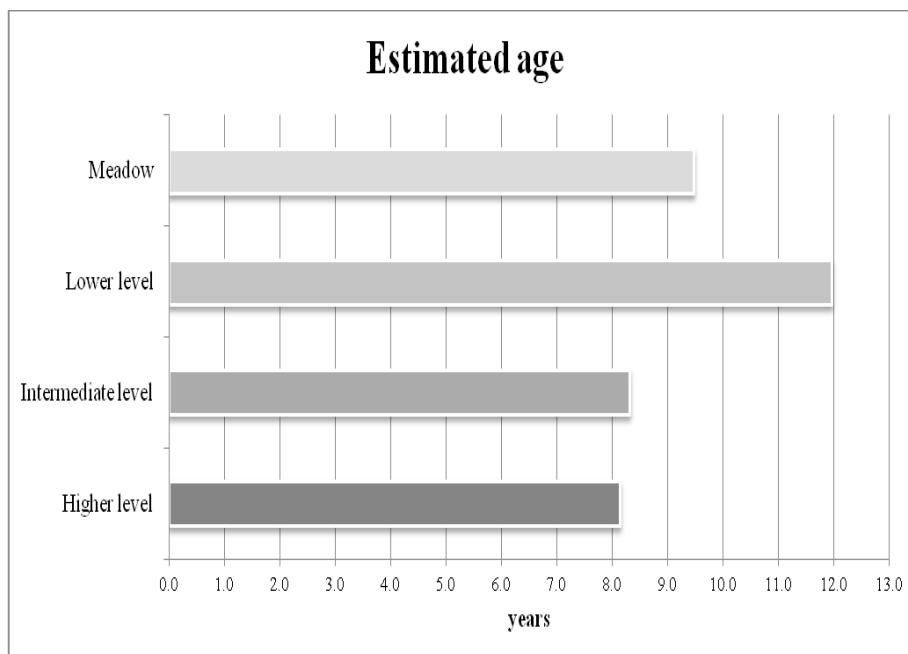
Conversely, estimating the mean number of cycles per transect it was possible to highlight that mean values were lower in transect 1 ( $2.79 \pm 1.20$  cycles) and higher in transect 2 ( $4.86 \pm 3.16$  cycles), indicating a state of greater disorder in the area adjacent to the town as well as at lower depths.

The mean number of scales per rhizome, estimated within each sampling

bathymetric level, did not present significant variations as a function of depth. It was, in fact, found an average of  $6.04 \pm 1.88$  scales at the top level,  $6.41 \pm 1.89$  at the intermediate depths, and  $5.97 \pm 2.10$  at the lowest depths. Estimating the average number of scales per rhizome within each transect it was possible to check a slightly higher mean number of scales in transect 3 with  $6.64 \pm 1.97$  scales per rhizome, while the lowest value was recorded in transect 2 with  $5.79 \pm 2.01$  scales per rhizome. According to Dolce *et al.* (1996) and Di Dato *et al.* (2000), the production of scales per cycle is casual so that more caution should be paid in considering the relation between scales production and the health of the meadow.

The longevity of the rhizomatous system, estimated on the basis of the number of leaf scars on rhizomes, resulted greater at the deepest level with an average of about 12 years ( $11.97 \pm 6.54$ ) while resulted of about 8 years at the highest and intermediate levels ( $8.14 \pm 2.46$  and  $8.31 \pm 1.74$ , respectively). That indicates a slower turnover of the rhizomatous system at the highest depths (Fig. 4). Estimating the age course in the three transects was observed that in the transect 2, the rhizomatous system was more longevous ( $13.33 \pm 5.38$  years) in comparison with transects 1 and 3 ( $7.48 \pm 1.17$  and  $7.62 \pm 1.45$  years, respectively).

It should be noted that in all samples studied no flower peduncles were found. That, lets to conclude that, since the average age of the rhizomatous system was estimated of about 9 years ( $9.47 \pm 4.06$ ), at least in the last 8-12 years the environmental conditions were not suitable for *P. oceanica* flowering. The turnover of the meadow was therefore assured, probably, only by vegetative reproduction.



**Fig. 4** – Età approssimativa del sistema rizomatoso.

**Fig. 4** – Inferred average age of rhizomes

In conclusion, the meadow of the Bay of Brucoli, which falls within the Site of Community Importance called “*ITA090026 – Fondali di Brucoli - Agnone*”, even if little extended, is an ecosystem of high naturalistic value since it forms a barrier meadow (“*récif barrière*”) typical of shallow water.

Since no specific studies on the *Posidonia oceanica* meadow of the Brucoli Bay do exist, the results of this study represent a basis for a future evaluation of the dynamics of the meadow and of the possible alterations. Moreover, they allow to assess the present health of the meadow which is presumed in regression or, at least, not in expansion, since it shows, as a whole, conditions of pain like the area in which it is located. As above mentioned, such a pain is probably related to the reduced transparency of the water caused by many factors such as the discharge into the sea of waste materials and sewage, the tourist dedication of the area and the fine material coming from the river Porcaria.

Furthermore, the hydrodynamic regime of the bay doesn't facilitate the spread of suspended material, thus altering the normal rate of sedimentation and causing an alteration of the density of the meadow. We can then say that this meadow is undoubtedly experiencing a human pressure on two levels: disturbance of the rate of sedimentation and change in the nutrient regime due to immission of wastewater. Therefore, to protect the health of the meadow, the entire Bay and its shoreline, the treatment of urban waste water and a more careful regulation of the use of the channel Porcaria should have priority. That, would normalize the rate of sedimentation and would make the water less muddy thus helping a regular growth of plants of *Posidonia oceanica* and progression of the meadow. Finally, it should be desirable that periodic morphometric and phenological studies of the meadow should be made, in order to monitor its dynamism.

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