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PRELIMINARY STUDY ON THE DISTRIBUTION OF *POSİDONİA OCEANİCA* ALONG THE DARDANELLE STRAIT

Abstract
Posidonia meadows, being one of the most reliable bioindicators of a disturbed environment, were investigated in Dardanos Bay (Dardanelles Strait). This site deserves attention due to both excessive anthropogenic impacts and natural hydrodynamics of the strait. Providing information that can be extrapolated to the northern extension of Posidonia oceanica towards the Marmara Sea was also aimed. Lower limit was marked in order to be used for long-term monitoring. Several parameters such as meadow cover, meadow density, and type of limit were noted according to the standardized in situ measurements. The lower limit is situated at 17 m depth, meadow cover average value is 47.47 % and the percentage of plagiotropic rhizome is 51.82%. The phenological and lepidochronological property were also analyzed. Finally the Ecological Quality Ratio was calculated and the values between 0.42-0.52 correspond to a "poor" vitality for Dardanos meadow, according to the BiPo index.

Key-words: *Posidonia oceanica*, Dardanelles Strait, phenology, lepidochronology

Introduction

Magnoliophytes have a considerable ecological weight in coastal environments; many of them are ecosystem engineers, or at least key species. This is so for the Mediterranean. Among the other Magnoliophyte species, *Posidonia oceanica* (L.) Delile, is the most abundant seagrass in the Mediterranean Sea covering about 38.000 km^2 of coastal off shore sandy and rocky areas (Pergent-Martini & Pergent, 1994; Green & Short, 2003; Pergent, 2007). Its distribution is fairly well recorded (Green & Short, 2003). However, until Meinez *et al.* (2009) recorded the distribution of *P. oceanica* in the north-eastern side of Mediterranean basin and in the Marmara Sea, it was unclear particularly at the narrow Dardanelle Strait where Aegean Sea meets the Marmara Sea.

On the other hand an "Action Plan for the conservation of marine vegetation in the Mediterranean Sea" has been adopted by the Contracting Parties to Barcelona Convention in 1999 (UNEP-MAP-RAC/SPA, 1999). The Med*Posidonia* Programme that was initiated by RAC/SPA in partnership with the Total Corporate Foundation for Biodiversity and the Sea aims to obtain additional information on the presence and evolution of *P. oceanica* meadows in four Mediterranean countries (Algeria, Libya, Tunisia and Turkey) with a view to using these data to elaborate and/or adjust their conservation and sustainable use of biodiversity programs and to enhance capacity-building of national teams in order to ensure long-term monitoring (Pergent *et al*., 2013). We aimed to determine the distribution and condition of *Posidonia* meadows located at Dardanos Bay along the Dardanelle Strait in order to contribute to the existing data and to set up a long-term monitoring infrastructure. The phenological and lepidochronological properties of the meadows were analyzed. Lower limit was marked. Several parameters such as meadow cover, meadow density, and type of limit were noted according to the standardized in situ measurements.

Material and Methods

The study was performed in Dardanos Bay (Dardanelles Strait, Çanakkale, Northwestern part of Turkey) in February-May 2014. This bay deserves attention due to both excessive anthropogenic impacts and natural hydrodynamics of the strait.

Cirik *et al.* (2006) determined the lower limits of the meadow by means of SCUBA diving and GPS positioning. The monitoring system, standardized by Pergent el al. (2007), was set up along the lower limit of the meadow. Fifteen markers were placed with 10 m intervals, on the edge of the lower limit (Tab. 1 and Fig. 1), in order to follow any changes or evolution (Pergent, 2007; Boudouresque *et al.*, 2012). The precise position of each marker was recorded and density, bottom cover, percentage of plagiotropic rhizomes and exposure or burial of rhizomes was measured according to Pergent (2007). The types of limits (progressive, sharp C+, sharp C-, sparse or regressive) were also recorded. Three orthotropic rhizomes were collected at each station. Reference station was chosen at 15m depth, to assess the vitality of the meadow. The upper limit of the meadow was determined. The samples, which were collected from upper, lower and reference limits, were preserved for laboratory analysis. Phenologic and lepidochronologic measurements of the samples were done in the laboratory. All these parameters were integrated in standardized grid to determine the vitality of the meadow according to Pergent (2007) (Tab. 1 to 3).

All data were analyzed by one-way analysis of variance (ANOVA) with Tukey's multiple comparison tests. The differences were considered significant when $p<0.05$. Before the ANOVA, all data were checked for homogeneity of variance (Levene's test for equal variances) and normal distribution (Anderson–Darling test) using the PASW STATISTICS 19 software for Windows (IBM SPSS Inc., Chicago, IL).



Fig. 1: The study area and the locations of the markers.

Tab. 1: Evaluation of the type of lower limit (Pergent, 2007).

Type of limit	Description	
Progressive	Plagiotrophic rhizome in front of the limit	High
Sharp High Cover	Sharp limit with meadow cover >25 %	Good
Sharp Low Cover	Sharp limit with meadow cover < 25 %	Moderate
Sparse	Shoot density < 100 shots/m2 and cover 15 %	Poor
Regressive	Dead mate in front of the limit	Bad

Tab. 2: Standardized values of deep of lower limit (m), bottom cover (%) and Plagiotrophic rhizomes (%) (Pergent, 2007).

	High	Good	Moderate	Poor	Bad
Depth of Lower Limit (m)	>34.2	34.2 – 30.4	30.4 – 26.6	26.6 – 22.8	<22.8
Leaf cover (%)	>35	35 – 25	25 – 15	15 – 5	< 5
Plagiotrophic rhizomes (%)	>70	70-30	< 30		

Tab. 3: Standardized values of foliar surface (in cm^2 per shoot), number of leaves produced per year and rhizome elongation (in mm per year) at reference depth (-15m) (Pergent, 2007).

	High	Good	Moderate	Poor	Bad
Foliar surface (cm^2 $shoot^{-1}$)	>362	362 – 292	292 – 221	221 – 150	<150
Number of leaves produced (y^{-1})	>8.0	8.0 – 7.5	7.5 – 7.0	7.0 – 6.5	<6.5
Rhizome elongation (mm y^{-1})	>11	11 – 8	8 – 5	5 – 2	<2

Results

Firstly, we searched for markers which had been set up eight years ago. It was discovered that, only four markers out of fifteen were at their original positions and 11 makers were forced out of their positions. Also, *Caulerpa racemosa,* invasive alien green algae, was observed between 17 – 25 m depth along the Dardanos Bay (Fig. 2).



Fig. 2: *Caulerpa racemosa* which distributed along the lower limit of the meadow.

The representative portion of the lower limits of the meadow equipped with fifteen markers and photographs of each marker were taken in order to provide the most precise reference base. It was found out that the lower limit was at 17 m depth and the meadow showed sparse distribution. The depth of lower limit of *Posidonia* meadow is classified as poor (See Tab. 3) according to Pergent (2007). The markers' coordinates and main characteristics of the meadow around the markers were shown in Table 4.

Tab. 4: GPS locations and main characteristics of the meadow where marked out in Dardanos Bay

No	Latitude	Longitude	Cover (%)	Density (fascicles m^{-2})	Plagiotropic rhizome (%)	Exposure (cm)
1	40º04'42.80''N	26º21'12.30''E	28	45	44	-1,5
2	40º04'42.34''N	26º21'11.45''E	20	35	46	-1
3	40º04'41.50''N	26º21'11.90''E	52	70	34	-2
4	40º04'40.43''N	26º21'11.48''E	72	132	67	-2
5	40º04'39.30''N	26º21'10.60''E	60	100	54	-1,5
6	40º04'38.12''N	26º21'10.44''E	32	45	66	-1,5
7	40º04'37.40''N	26º21'09.67''E	48	52	42	-1
8	40º04'36.44''N	26º21'09.65''E	64	85	57	-1,5
9	40º04'35.63''N	26º21'09.40''E	60	60	58	-1,5
10	40º04'34.70''N	26º21'09.00''E	48	77	39	-1,5
11	40º04'33.60''N	26º21'08.70''E	40	96	40	-2
12	40º04'32.70''N	26º21'08.20''E	48	45	44	-2
13	40º04'32.07''N	26º21'07.76''E	36	50	58	-2
14	40º04'31.40''N	26º21'07.91''E	32	26	57	-2
15	40º04'30.60''N	26º21'08.08''E	72	102	47	-1,5

The meadow density of lower limit varied from 26 - 102 shoots m^{-2}; with an average of 64.93 ±28.72 shoots m^{-2}. The cover ratio of meadow ranged from 20 to 72 % with an average value of 47.47 ±16.06 %. The average plagiotropic rhizome ratio was found as 51.82 ±12.13 %. The exposures of the rhizomes were measured between -2 to -1 cm.
The shoots were sampled along the lower limit, the reference depth and the upper limit for phenological and lepidochronological analysis. The average number of leaves produced annually was 6.46 ±0.50 and the average growth rate of the rhizomes was 6.56 ±0.44 mm yr^{-1}. The average leaf number was found 5.7 ±0.6 $fascicles^{-1}$. Average length and width measured as 34.48±12.37 cm and 1.00±0.15 cm. The leaf area index (LAI) changed from 26.84±12.46 to 45.89±16.6 cm^2 m^{-2}. At the reference depth, the average foliar index was found 153.30±20.76 cm^{-2}.$fascicles^{-1}$. The LAI was also calculated as 39.38±14.49 cm^{-2} m^{-2}. The samples which were collected from upper limit showed us that, the average leaf number was changed from 4.25±0.71 to 4.63±0.52 $fascicles^{-1}$. The maximum LAI was calculated as 23.84±11.19 cm^{-2} m^{-2} (Tab. 5).

Tab. 5: Phenological parameters measured at Dardanos Bay at the lower limit, 15 m depth (reference site) and upper limit level.

	Lower Limit			Reference depth (15m)			Upper Limit		
	Adults	**Intermed.**	**Global**	**Adults**	**Intermed.**	**Global**	**Adults**	**Intermed.**	**Global**
Nb leaves ($shoot^{-1}$)	3.5±0.3	3.0±0,5	5.7±0.6	3.7±0.6	3.0±0.0	3.3±0.5	4.6±0.5	4.3±0.7	4.4±0.6
Length (cm)	43.7±10.1	29.2±10.1	36.5±12.4	38.8±8.5	33.1±14.8	35.9±12.1	24.7±8.8	25.4±11.6	25.1±10.2
Width (cm)	1.0±0.2	1.0±0.1	1.0±0.2	1.0±0.2	1.0±0.1	1.1±0.1	1.0±0.1	1.0±0.1	1.0±0.1
Coefficient A (%)	49.9±17.4	7.4±14.7	28.7±16.2	8.8±13.6	3.6±6.7	6.2±10.8	58.9±14.7	24.7±9.1	41.8±21.2
F.surf.($cm^{-2}shoot^{-1}$)	128.4±37.9	81.4±35.3	209.7±36.6	141.8±22.1	164.7±34.8	153.2±30.8	102.4±32.5	117.2±52.1	109.8±43.4
LAI (cm^2 m^{-2})	45.9±16.6	26.8±12.5	36.4±17.4	43.1±12.6	35.7±15.1	39.4±14.5	23.6±9.5	23.8±11.2	23.7±10.2

The lepidochronological analysis of the meadow is summarized in Table 6. The maximum growth of the rhizome was found 7.89 ±0.60 mm for lower limit, 6.82±0.72 mm for reference limit and 6.42 ±0.89 mm for upper limit. According to Pergent (2007) the health of the meadow was found weak.

Tab. 6: The number of scales per cycle and speed growth of the rhizomes at lower, reference and upper limits in the Dardanos Bay.

	The lower limit		Reference limit (15m)		The upper limit	
Lepidochoronological year	**Number of Scales**	**Growth of rhizomes (mm yr^{-1})**	**Number of Scales**	**Growth of rhizomes (mm yr^{-1})**	**Number of Scales**	**Growth of rhizomes (mm yr^{-1})**
2013	6.81±0.60	3.89±0.93	2.25±0.45	6.10±0.90	3.63±0.50	3.72±0.50
2012	6.06±1.12	5.89±1.69	4.06±0.77	5.71±1.30	3.13±0.34	5.43±0.54
2011	6.25±1.48	7.44±1.81	3.31±0.48	5.34±1.02	3.00±0.00	6.42±0.89
2010	6.31±1.35	7.89±0.60	3.38±0.50	6.82±0.72		
2009	6.50±1.83	7.56±0.88	4.06±0.85	7.63±0.74		
2008	6.75±1.84	7.24±1.34	3.13±0.34	6.04±1.03		

Discussion

According to our results, *P. oceanica* meadows along the Dardanos Bay, exhibit a weak vitality. The standardized BiPo index was used to evaluate and compare the vitality of the meadows (Bund and Somolini, 2007; Lopez y Rojo *et al.*, 2010). The Ecological Quality Ratio (EQR) was calculated and compared to the standardized scale (Tab.7). The Ecologic Quality Ratios were found between 0.42 to 0.52.

Tab. 7: Evaluation of Ecological Quality Ratio (EQR) using BiPo index. H=High, G=Good, M=Moderate, P=Poor and B=Bad

	Lower Limit				Reference Depth (15 m)	
	Depth (m)	**Type**	**Cover (%)**	**Plagio (%)**	**Foliar surface (cm^{-2} $shoot^{-1}$)**	**Number of Scales**
Values	17	M	47.47	51.82	153	3.35
EQR	0.43 (P)	0.53(P)	0.48 (P)	0.52 (P)	0.42 (P)	0.42 (P)

According to standardized values, the vitality of the meadows was determined as “poor”. There are local purse-seiners fishing heavily along Karaliman, Güzelyalı and Dardanos line, during the season. That’s why we couldn't find markers which were located in 2005 and the meadow didn’t get a chance to expand the lower limit due to the stress. We conclude that, the coast guard controls should be increased for this region (Karaliman, Güzelyalı and Dardanos Bay) and the area where the meadow is dense has to be preserved legally. In addition, the citizens of Çanakkale should be informed by scientist about *Posidonia* meadows, a public awareness should be raised.

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