POSIDONIA OCEANICA MONITORING SYSTEM ON THE COAST OF AEGEAN SEA OF TURKEY

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Abstract – Seagrass monitoring is a basic tool for measuring the condition of meadows in parallel to the environmental conditions. *Posidonia oceanica* meadows are very sensitive to anthropogenic effects. In the present study, two monitoring stations of *Posidonia oceanica* meadows were established on the Aegean coasts of Turkey in the years 2018 and 2019, at 26 m depth in Ildır Bay (İzmir, Turkey), and at 33 m depth in Kara Ada (İzmir, Turkey). The *P. oceanica* meadows upper and lower limits were defined by balisage systems. In the laboratory, lepidochronological, morphometric, and phenological parameters were also studied.

Introduction

Posidonia oceanica (L.) Delile (Magnoliophyta) is the most widespread species which is endemic to the Mediterranean Sea [1, 2]. *P. oceanica* grows between 0 to 40 meters deep. These meadows constitute a key ecosystem and have an important ecological role. They also stabilize the sediment, protect the beaches from erosion and has a positive effect on the clarity of water [3,4,5]. *P. oceanica* is a perennial species growing vegetatively by means of long-lasting rhizomes [6,7]. Lateral growth of established *P. oceanica* beds is very slow, i.e. 1÷6 cm yr^{-1} [8]. According to this growth rate, the expansion from a single seed to a circular bed of 27 m radius would take about 600 years [9].

P. oceanica meadows are very sensitive to anthropogenic effects. As a result, the decline in the distribution of P. *oceanica* meadows has started, especially since the 1960s. This regression is dramatic, especially around large urbanized areas and port facilities [10, 11, 12, 13, 14, 15]. *P. oceanica* is an effective biological indicator for predicting the status of coastal marine ecosystems [16,17,18].

Seagrass monitoring is a basic tool for measuring the condition of meadows and environmental conditions. It is also very important for early detection in case of deterioration of *P. oceanica's* condition. Monitoring is also a necessary method for all kinds of preventive or improvement works. Since the 1980s, diminishing has been observed in seagrass meadows, monitoring programs have been established for 31 seagrass species in more than 40 countries. Monitoring activities are essential tool for determining the situation of the *P. oceanica* meadows.

In the present study, two monitoring stations of *Posidonia oceanica* meadows were established on the Aegean coasts of Turkey in the years 2018 and 2019, at 26 m depth

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in Ildır Bay (İzmir, Turkey), and at 33 m depth in Kara Ada (İzmir, Turkey). The *P. oceanica* meadows upper and lower limits were defined by balisage systems. In the laboratory, lepidochronological, morphometric, and phenological parameters were also studied.

Materials and Methods

Two monitoring stations of *Posidonia oceanica* meadows were established on the Aegean coasts of Turkey as a part of the national Integrated Marine Pollution Monitoring Programme (MoEU, Turkey) (Figure 1). Scuba equipment, GPS, 11 concrete markers (about 15÷20 kg per marker), 33 iron stakes (about 1 m long), 11 iron stakes for photography (about 1.5 m long), and 11 PVC numbered plates were used to established the underwater monitoring station [19]. One underwater digital camera, one compass, diving computer, one PVC underwater slate, and one quadrate (60 cm x 60 cm) were also used for scientific measurements.

Three teams with two divers in each team have set up the *P. oceanica* lower limit monitoring system. The first step was finding the appropriate lower limit for the system. After that, the concrete blocks placed through the limit and stabilized with 1 m iron sticks. Subsequently, the photo stakes were nailed in front of blocks (1,5 m), numbers and small buoys were tied to blocks. Position of the markers and the photo-stakes in the two monitoring stations (Ildır Bay and Kara Ada) of *P. oceanica* meadows on the Aegean coasts of Turkey were given in Figures 2 and 3. Panoramic views of some markers of the two monitoring stations were also given in Figures 4 and 5.

The materials were collected by a quadrate (60 cm x 60 cm) divided into 9 quadrats (20 cm x 20 cm) per station for lepidochronological and phenological measurements [19], and samples were preserved in 2÷5 % formaldehyde in sea water, and later it was measured in the laboratory.

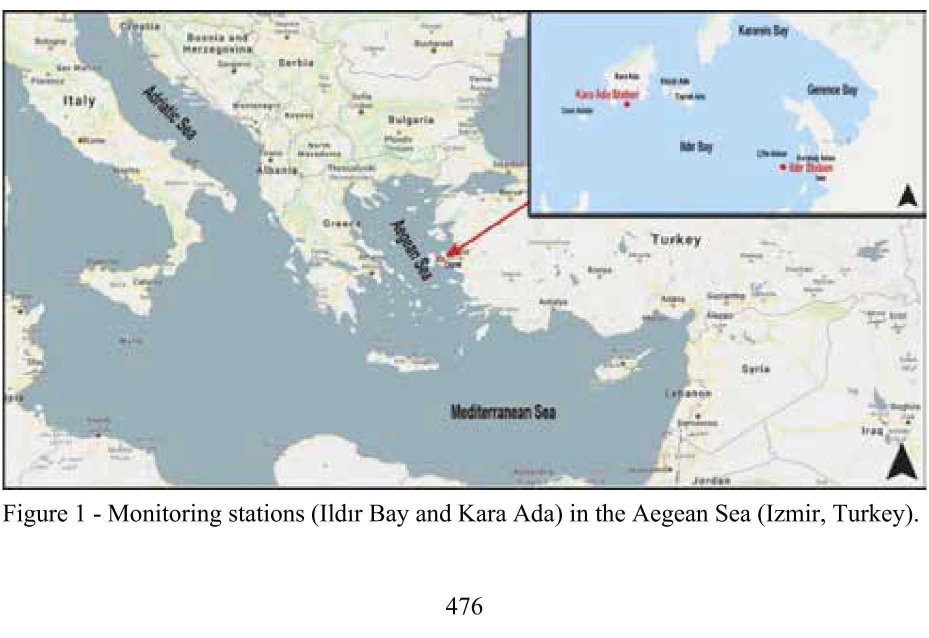

Figure 1 - Monitoring stations (Ildır Bay and Kara Ada) in the Aegean Sea (Izmir, Turkey).

Figure 2 - Position of the markers and the photo-stakes in the Ildır Bay (İzmir, Aegean coasts of Turkey) (B: marker, P: photo-stakes).

Figure 3 - Position of the markers and the photo-stakes in Kara Ada (İzmir, Aegean coasts of Turkey) (B: marker, P: photo-stakes).

Figure 4 - Panoramic views of some markers (2,4,7,8) in the Ildır Bay monitoring station (İzmir, Aegean coasts of Turkey) in the year 2018.

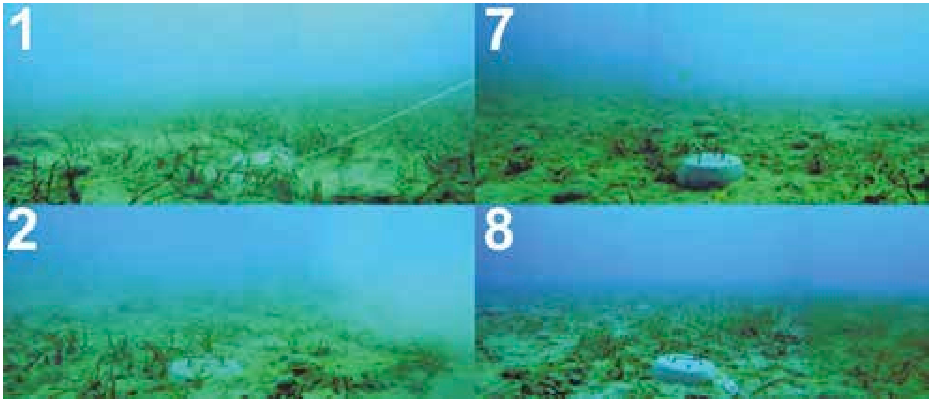

Figure 5 - Panoramic views of some markers (1, 2, 7, 8) in Kara Ada monitoring station (İzmir, Aegean coasts of Turkey) in the year 2019.

Results

In the context of the national Integrated Marine Pollution Monitoring Programme (MoEU, TR), two monitoring stations were recently established at Ildır and Kara Ada (İzmir, Aegean Sea, Turkey) during the years 2018 and 2019. These two pilot studies are among the first monitoring exercises on the meadows included in the national monitoring program of Turkey. The baseline results and the status of *P. oceanica* were given in the present study.

Ildır Bay Monitoring Station (İzmir, Aegean coasts of Turkey)

At the Ildır station, having the average depth of 25.1 ± 0.3 m and the density of the shoots 87.9 ± 23.9 shoot/m^2, coverage was 26.8 ±0.1 %, horizontal rhizome percentage was (plagiotropic rhizome) 96.1 ± 0.1 % (Table 1). According to these results, Ildır station status was regarded as poor. Lepidochronological analysis behind the lower limit in the Ildır Bay station was given in Table 2.

Table 1 - Main characteristics of the *Posidonia oceanica* monitoring station in the Ildır Bay (İzmir, Aegean coasts of Turkey) (P: Poor, M. Moderate, H: High).

Scientific measuring	**2018 results**	**2018 Ecological Status**	**2019 results**	**2019 Ecological Status**
Depth (m)	25.1 ±0.3	P	25.1 ±0.3	P
Density of shoots (m^2)	87.9 ±23.9	P	50.9±26.4	P
Coverage (%)	26.8 ±0.1	M	13.4±0.1	M
Horizontal rhizome (%)	96.1 ±0.1	H	29.1±0.2	M
Type of Limit	Sparse	M	Sparse	P

Table 2 - Lepidochronological analysis behind the lower limit at the *Posidonia oceanica* monitoring station in the Ildır Bay (İzmir, Aegean coasts of Turkey).

Lepidochronological year	**Number**	**Number of scales**	**Growth of rhizomes (mm)**
2018	10	8.8±1.9	3.4±0.7
2017	8	9.1±1.5	3.3±0.8
2016	4	9.0±0.0	3.6±0.4
2015	1	9.0	3.8

Kara Ada Monitoring Station (İzmir, Aegean coasts of Turkey)

At the Kara Ada station, the average depth was 32.9 ±0.2 m and the density of the shoots was 75.8 ±14.7 shoot/m^2 and the coverage was 25.5 ± 0.1 %, horizontal rhizome percentage was (plagiotropic rhizome) 50.0 ±0.2 % (Table 3). According to these results, Kara Ada station status regarded between moderate and good. Lepidochronological analysis behind the lower limit in Kara Ada station was given in Table 4.

Table 3 - Main characteristics of the *Posidonia oceanica* monitoring station in Kara Ada (İzmir, Aegean coasts of Turkey) (P: Poor, M. Moderate, G: Good).

Scientific measuring	**2019 results**	**2019 Ecological Status**
Depth (m)	32.9 ±0.2	G
Density of shoots (m^2)	75.8 ±14.7	M
Coverage (%)	25.5 ±0.1	G
Horizontal rhizome (%)	50.0 ±0.2	G
Type of Limit	Sparse	P

Table 4 - Lepidochronological analysis behind the lower limit at the *Posidonia oceanica* monitoring station in Kara Ada (İzmir, Aegean coasts of Turkey).

Lepidochronological year	Number	Number of scales	Growth of rhizomes (mm)
2018	10	8.7±1.8	2.8±0.9
2017	8	8.0±1.6	3.2±0.6
2016	5	6.8±0.8	3.2±0.7
2015	1	11.0	3.7

Discussion

In the present study, two monitoring studies of *Posidonia oceanica* meadows were made from two different stations, and at different depths (Ildır Bay: 25.1 ± 0.3 m, and Kara Ada: 32.9 ±0.2 m) on the Aegean coasts of Turkey. Ildır Bay monitoring station baseline measurements were done in 2018 and monitoring was continued in 2019, the highest value of the shoot density was found in 2018 (87.9±23.9 shoot/m^2) than 2019 (50.9±26.4 shoot/m^2), and the highest value of the horizontal rhizome (plagiotropic rhizome) was also found in 2018 (96.1±0.1 %) than 2019 (29.1±0.2 %). According to the measurements the ecological value decreases in Ildir Bay station. Kara Ada monitoring station baseline measurements were done in 2019, and the highest value of the shoot density and the horizontal rhizome (plagiotropic rhizome) were found as 75.8 ±14.7 shoot/m^2 and 50.0 ±0.2 %, respectively.

Several phenological studies of *Posidonia oceanica* meadows were made in Foça [20], Sığacık Bay [21], and Engeceli Bay [22] on the Aegean coasts of Turkey. The phenological studies of *P. oceanica* meadows from two shallow depths (1÷3 m and 4÷7 m) in the Sığacık Bay were made, and the highest values of the shoot density (max. 880 shoots/m^2) and leaves (7420 leaves/ m^2) was found at the 4÷7 m depth in December [21].

Three different depths (0÷5 m, 5÷10 m, and 10÷15 m) in Engeceli Bay were studied, and the highest value of the shoot density (max. 540±25 shoots/m^2) was found at 0÷5 m depth [22].

Monitoring station of *P. oceanica* meadows was also established from two stations in Foça at two different depths (Toprak Su Camp station: 22.2 m, and Hamamlık station: 16.5 m) [20]. The lowest and highest values of the shoot density were found in Toprak Su Camp station (34 shoots/m^2 and 192 shoots/m^2) than Hamamlık station (50 shoots/m^2 and 150 shoots/m^2) in Foça [20]. According to this study, two monitoring station (Toprak Su Camp and Hamamlık) were found as the poor ecological status class.

Turbidity increase, limits the light penetration and restrains the photosynthesis of the meadows and causes a regression at lower limit [23]. The decline in shoot density of *P. oceanica* could indicate a withdrawal at lower limit in Ildır Bay station [24]. The reason for this is thought to be due to the aquaculture activities in the vicinity but it is not certain, more detailed research is needed for this purpose.

Conclusion

Posidonia oceanica is a sensitive species and, it is mainly affected by anthropogenic activities (domestic and industrial sewage outfalls, tourism, urbanization, harbors, yachting, fish farm, etc.) in the last years. Monitoring studies of the *P. oceanica* meadows are very important, and the monitoring studies are should be made to widespread in the Mediterranean coasts and Turkey.

These are preliminary results and it should be continued to monitor for future state of the *P. oceanica* meadows. As for effective monitoring, this should be done over a period of time depending on the objective. If it is for the quality of the environment the time should be at least 5÷8 years, for impact control of marine construction it is 1÷2 years [25].

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