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RESEARCH ARTICLE

The status of sensitive ecosystems along the Aegean coast of Turkey: *Posidonia oceanica* (L.) Delile meadows

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Abstract

This study was carried out to evaluate the phenological changes resulting from external impacts on *Posidonia oceanica* meadows along the Aegean coast. Triplicate samples were collected from 17 stations at 8 and 10 m depths by SCUBA diving between April and June 1999. The water temperature was measured and sediment type was determined in the stations. The phenological parameters; shoot density, leaf number, leaf area index, leaf surface area, brown tissue surface area and total biomass were investigated. One of the most important descriptors of *Posidonia*, shoot density, showed supranormal values at the seven of the meadows while only two of them showed abnormal values. Beside the natural factors such as water temperature and sediment types, the possible environmental or antrophogenic impacts on phenological characters of *Posidonia* meadows were discussed.

Keywords: *Posidonia* meadows, antrophogenic impacts, phenology, biomass, Aegean Sea.

Introduction

Seagrasses constitute one of the most productive marine ecosystems and cover large areas in the Aegean Sea. There is a worldwide loss of these valuable ecosystems resulting from direct human impacts, including mechanical damage, eutrophication, aquaculture, siltation, effects of coastal construction, food web alterations; and indirect human impacts including adverse effects of climate change (Duarte 2002; Latorre 2005).

The impacts of negative environmental factors on coastal ecosystems have been studied intensively by several authors. These include trawling (Ardizzone and Pelusi 1984), coastal development (Meinesz *et al.* 1991), harbours (Pergent *et al.* 1991), Chernobyl radionuclides (Calmet *et al.* 1991), aquaculture activities (Pergent *et al.* 1999), climate change (Short and Neckles 1999), ghost fishing (Ayaz *et al.* 2004), wastewater discharges (Bryars and Neverauskas 2004), mucous aggregates (Lorenti *et al.* 2005), tourism impacts (Petrosillo *et al.* 2006) and anchoring (Giulia *et al.* 2007). Short and Wyllie-Echeverria (2000) estimated that approximately 12,000 km^2 of seagrass meadows was destructed worldwide between 1985 and 1995 due to the heavy impact of human activities.

Posidonia oceanica is an endemic species and represents one of the most productive Mediterranean ecosystems (Boudouresque *et al.* 1989). *P. oceanica* has been used as a bioindicator because of its ecological role, wide distribution, and sensitivity to changes in the littoral region (Bhattacharya *et al.* 2003). It is considered as a BQE (biological quality element) for the assessment of the ecological status of water bodies as defined in the Water Framework Directive (Romero *et al.* 2007), because of its sensitivity to anthropogenic pressure.

The present work identifies the phenology of seagrass, *P. oceanica,* meadows at 17 locations along the Aegean Sea coast, and the findings are discussed according to the external impacts on the coastal ecosystems.

Materials and Methods

The study was carried out along the Aegean coast of Turkey, between 37°01′ N and 39°21′ N at 17 stations between April and June 1999 (Figure 1). Three sampling sites from the North Aegean, ten from the Middle Aegean and four from the South Aegean with different sediment types were selected (Table 1). Work at sea was mostly carried out from the research vessel *Hippocampus*, owned by the Fisheries Faculty of Ege University. The sampling was carried out at depths of 8-10 m by SCUBA diving. The lower limits of the meadows were also determined by SCUBA diving. Sediment type was determined according to Compton (1962). Water temperature at the sampling depth was measured.

Figure 1. Location of sample sites in the Aegean Sea. 1. Ayvalık 2. Aliağa 3. Foça 4. Hekim Island 5. Inceburun 6. Karaburun 7. Gerence 8. Eşek Island 9. Çeşme 10. Alaçatı 11. Mersin Bay 12. Teke Cape 13. Sığacık Bay 14. Gümüldür 15. Kuşadası 16. Turgutreis 17. Paşatarlası

Quantitative samplings, randomly placed in the seagrasses meadow were performed by SCUBA diving, using a metal frame 25x25 cm (Pergent 2007). The whole settlement within the frame, including both roots and rhizomes, down to 30 cm above the bottom level was sampled (Francour 1985). The total leaf number per shoot was counted by classifying them according to Giraud's classification as juvenile, intermediate or adult (Giraud 1977). Shoot density of *Posidonia* meadows was classified as abnormal (less than 237-294 shoots.m^{-2} for 8, 9 and 10 m), subnormal (between 237-406 shoots.m^{-2} for 8, 9 and 10 m), normal (between 349-630 shoots.m^{-2} for 8, 9 and 10 m) and supranormal ranges (more than 573-630 shoots.m^{-2} for 8, 9 and 10 m) according to the density scale of Pergent *et al.* (1995).

Table 1. General description of the stations and shoot density classification of *Posidonia oceanica* meadows

Stations	Region	Latitude	Longitude	Depth (m)	Temp (°C)	Sediment Type	Shoot Density Classification (shoots.m^{-2})
1.Ayvalık	North Aegean	39° 21' N	26° 35' E	10	14	Rock Sand	Normal (480)
2.Aliağa	North Aegean	38° 49' N	26° 56' E	9	15.5	Sand-Gravel	Supranormal (741)
3.Foça	North Aegean	38° 41' N	26° 44' E	9	14.5	Sand-Silt	Subnormal (307)
4.Hekim Island	Middle Aegean	38° 26' N	26° 46' E	10	17	Sand-Silt	Normal (507)
5.Inceburun	Middle Aegean	38 ° 24' N	26° 37' E	9	16	Sand-Silt	Abnormal (261)
6.Karaburun	Middle Aegean	38° 40' N	26° 26' E	8	14	Sand-Gravel	Supranormal (779)
7.Gerence	Middle Aegean	38° 28' N	26° 25' E	10	17	Sand-Silt	Supranormal (624)
8.Eşek Island	Middle Aegean	38° 36' N	26° 20' E	10	14.5	Sand-Gravel	Normal (416)
9.Çeşme	Middle Aegean	38° 20' N	26° 17' E	10	15.5	Sand-Gravel	Supranormal (848)
10.Alaçatı	Middle Aegean	38° 15' N	26° 23' E	10	14	Sand-Gravel	Normal (469)
11.Mersin Bay	Middle Aegean	38° 15' N	26° 25' E	10	14	Sand-Gravel	Normal (507)
12.Teke Cape	Middle Aegean	38° 05' N	26° 35' E	8	14.5	Sand-Gravel	Normal (496)
13.Sığacık Bay	Middle Aegean	38° 12' N	26° 40' E	10	16	Sand-Gravel	Supranormal (576)
14.Gümüldür	South Aegean	38° 01' N	27° 04' E	10	18	Sand-Gravel	Supranormal (817)
15.Kuşadası	South Aegean	37° 51' N	27° 14' E	8	20	Sand-Silt	Normal (576)
16.Turgutreis-Bodrum	South Aegean	37° 00' N	27° 14' E	10	19.5	Sand-Silt	Supranormal (667)
17.Paşatarlası-Bodrum	South Aegean	37° 01' N	27° 26' E	8	16	Sand-Silt	Abnormal (277)

Leaf lengths and leaf widths (to the nearest cm) were recorded and leaf area index (LAI) was estimated for the different age classes. Brown tissue area index (BTAI) was calculated (Buia *et al.* 1992). Shoots in each quadrate were examined for epiphyte area index (EAI). For biomass determinations, below-ground and above-ground parts were separated. Epiphytes were removed with the aid of a razor blade, the shoots, leaves, roots and rhizomes were dried at 80°C to the constant weight and biomass was expressed as g dw.m^{-2}. One-way Analysis of Variance (ANOVA) was used to test the significance of differences between sampling sites.

Results

Sediment Types and Water Temperature

Sediment types (sand, silt, gravel, rock) are presented for each sampling station (Table 1). The sediment type around Ayvalık has a rocky and sandy structure while Aliağa, Karaburun, Eşek Island, Çeşme, Alaçatı, Mersin Bay, Teke Cape, Sığacık and Gümüldür have a mixture of sand and gravel. *P. oceanica* showed generally weaker growth in sandy-silty sediment types such as that at Foça, Inceburun and Paşatarlası stations.

Lower Limits

The meadows extended to shallower areas in small bays and coves. In Izmir Bay, the lower limits of *P. oceanica* meadows showed a gradient from the inner part to the outer part (8 m in the inner bay and 33 m in the outer bay). However, these lower limits were higher than those in offshore areas, such as 35 m in Ayvalık (station 1) and 40 m in Sığacık (station 13).

Shoot Density and Shoot Length

The highest mean values of shoot density and shoot length were 848 ± 232 (M±SE) shoots.m^{-2} and 10.9 ± 3.3 cm, respectively, at station 9 (Çeşme) (Figure 2). The lowest value of density was 261 ± 56 shoots.m^{-2} at station 5 (Inceburun) while the lowest shoot length measured was 3.6 ± 0.4 cm at station 12 (Teke Cape). The difference of shoot density between stations was found to be statistically significant (‘one way’ANOVA; F=2,858; $p<0.01$). Shoot density was found to be in the supranormal range (848 shoots.m^2) in station 9 (Çeşme) (Table 1). In spite of the severe impacts on the meadows such as fishing, coastal development and tourism in Çeşme, these impacts were mitigated by the strong currents at the sampling sites. Thus, Çeşme was determined as the least impacted area in this study. Shoot density, shoot length, leaf length, leaf number and biomass were found to be the highest at this station.

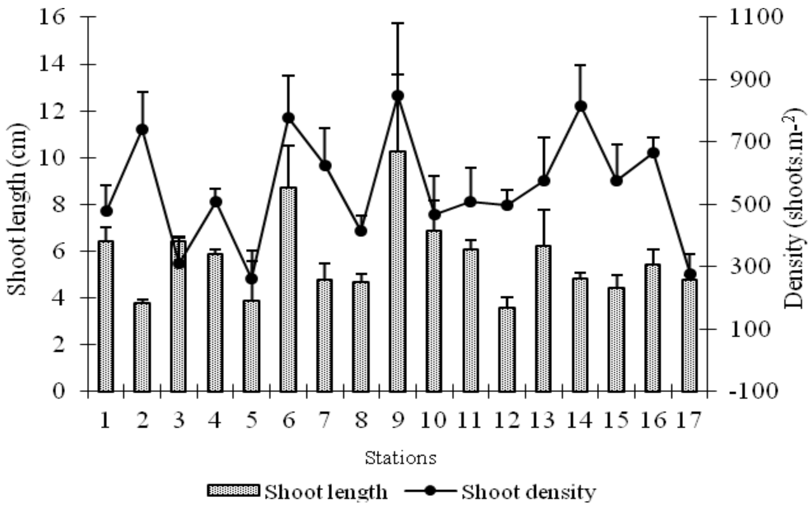

Figure 2. The variation in shoot density and shoot length according to the stations (mean ± standard error)

Greater shoot densities were also found at station 14 (Gümüldür), station 6 (Karaburun) and station 2 (Aliağa) than at other stations. The station 14 (Gümüldür) is subjected to coastal development and tourism impacts, although it is not impacted by fishing and aquaculture. Nevertheless, shoot density was high. Station 6 (Karaburun), at the outermost point of Izmir Bay, is affected by the strong waves and currents all along that part of the coast, making it one of the areas at least risk of environmental damage.

Station 2 (Aliağa), in spite of being in the northern Aegean within the impacted area of a heavy industry with a ship breaking yard, a power station and a petrol refinery, did not show any great damage at the sampling station, which was situated outside the bay. Shoot density and leaf area index were low and classified as subnormal (307 shoots.m^{-2}) at station 3 (Foça) (Table 1).

Foça has a dense human population and tourism activities. It is one of the areas at risk from wastewater discharge and fishing. Stations where shoot densities were normal were station 15 (Kuşadası), station 11 (Mersin Bay) and station 12 (Teke Cape). Station 12 (Teke Cape) is far from the pollution sources and is an important fishing area; a reason for the fact that it had the lowest value of shoot length may be mechanical damage by fishing. Station 5 (Inceburun) is situated in Izmir Bay and subjected to intensive impact of pollution and also of aquacultural activities. Seven fish farms were in operation inside the bay on the coast.

Leaf numbers were highest at station 9 (Çeşme) (5035 ± 1606 no.m^{-2}), and lowest at station 17 (Paşatarlası, Bodrum) (992 ± 167 no.m^{-2}) (Figure 3). The meadow in Paşatarlası was classified as abnormal. This station is impacted by tourism activities and coastal development. The difference between leaf number of intermediate (F=3,341**) and adult (F=3,293**) plants were found to be statistically significant ($p<0.01$), but the difference of juvenile leaf number between stations was found to be statistically insignificant (Figure 3).

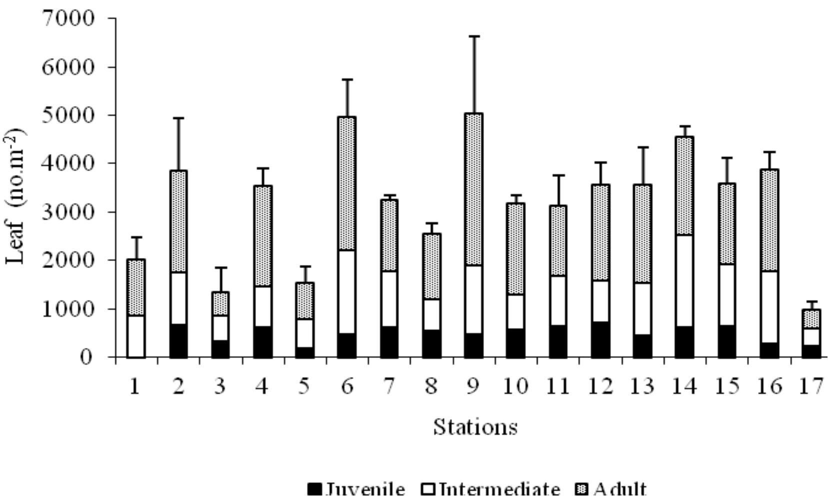

Figure 3. The variation in leaf numbers at each age classes according to the stations (mean ± standard error)

The highest value of total leaf length was 35 cm at station 4 (Hekim Island) and station 9 (Çeşme) (Figure 4). Adult leaf length was greater at station 9 (Çeşme) than the others. The difference of intermediate (F= 2.739**) and adult leaf (F=2.594**) lengths between stations was significant ($p < 0.01$). Station 4 (Hekim Island), is situated in the outer part of Izmir Bay. Total leaf length was the highest and shoot density was still within the normal values, in spite of the impacts of overfishing, dynamite fishing and mud dumping from the Melez River in the 1990's.

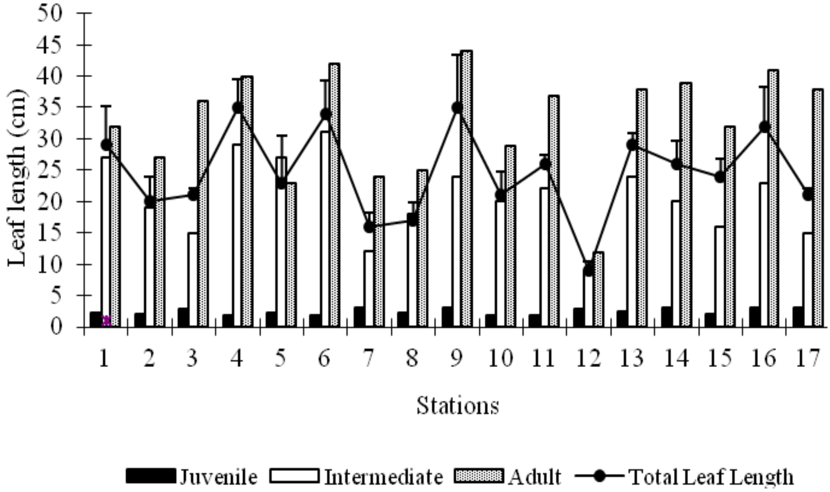

Figure 4. The variation in leaf length at each age classes and a total leaf length according to the stations (mean ± standard error)

Leaf width varied between 0.89 ± 0.04 and 0.62 ± 0.02 cm (Figure 5). The highest value of total leaf area index (13.8 ± 4.6 $m^2.m^{-2}$) was found at station 6 (Karaburun) (Figure 6). The lowest value was found at station 17 (1.6 ± 0.3 $m^2.m^{-2}$). The difference of leaf area index of the intermediate (2.542*; $p < 0.05$) and adults ($F=3.473$**; $p < 0.01$) between stations was statistically significant. Station 6 (Karaburun) is outside Izmir Bay and one of the cleanest parts around Izmir because of the very strong currents. Shoot density was also found to be in the supranormal range (779 $shoots.m^{-2}$) (Table 1), and lower limits extended to 33 m.

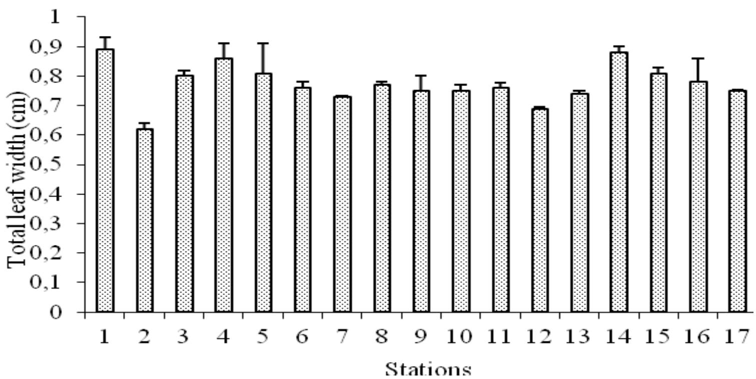

Figure 5. The variations in leaf width according to the stations (mean ± standard error)

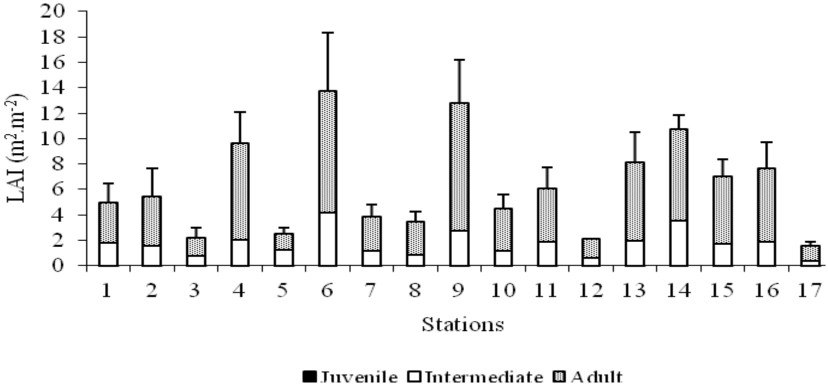

Figure 6. The variations in leaf area index at each age classes according to the stations (mean ± standard error)

Epiphyte Area Index and Brown Tissue Area Index

The epiphyte area indexes were found to be highest (8.03 ± 0.2 $m^2.m^{-2}$) at station 14 and lowest (0.16 ± 0.01 $m^2.m^{-2}$) at station 12 (Figure 7). The difference of epiphyte area index between stations was found to be statistically significant (F=3.114**; $p < 0.01$). The highest value was found at station 14 (Gümüldür). Shoot density, leaf number, biomass and leaf area index were also high at this station.

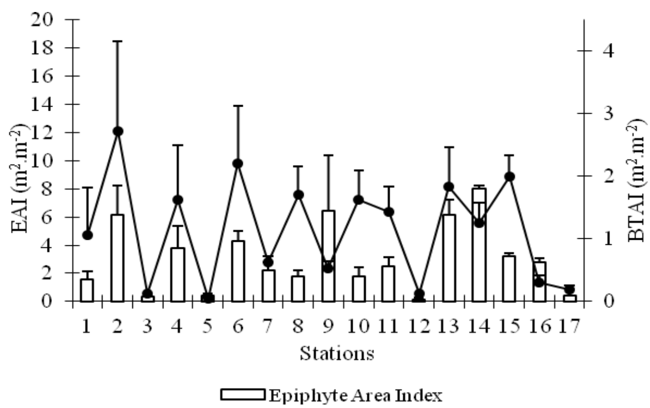

Figure 7. The variations in epiphyte area index and brown tissue area index according to the stations (mean ± standard error)

Gümüldür is subjected to tourism impacts and coastal development. Alien algal species such as *Caulerpa racemosa* showed dense distribution in the sandy substrates of this station. Gümüldür is one of the most productive areas in the Aegean Sea.

Brown tissue area index was measured at between 2.72 ± 1.4 and 0.05 ± 0.0098 $m^2.m^{-2}$ (Figure 7). Brown tissue area index was the highest at station 2 (Aliağa). Aliağa is subjected to heavy pollution impacts such as a refinery and a power plant. Plant density, however, was still in the supranormal range (Table 1).

The mucilage aggregates in the water column settle on meadows and cover the plants, generally beginning from a depth of 10 m in Ayvalık, Seferihisar, İzmir Bay and Bodrum.

Biomass

Total biomass showed a maximum value at station 9 (6294 ± 615 g $dw.m^{-2}$) and a minimum at station 1 (Ayvalık) (711± 46 g $dw.m^{-2}$) (Figure 8). A significant difference was found in biomass above and below ground (F=3,214**; $p<0.01$). Below-ground biomass represented about 22% of total biomass.

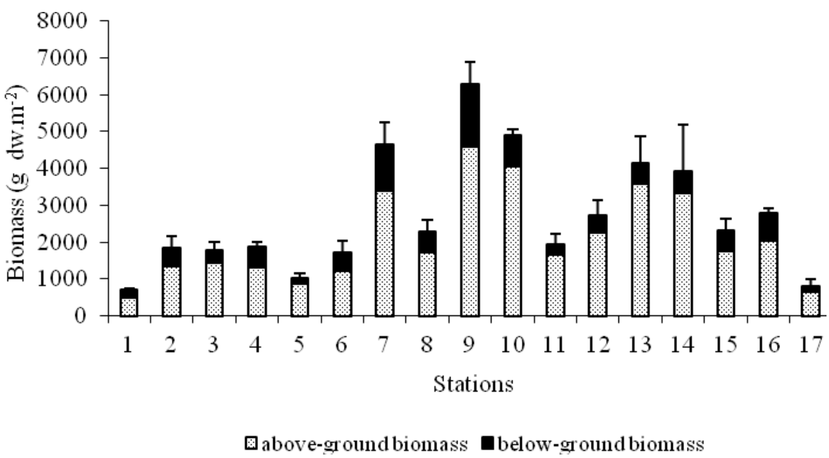

Figure 8. The variations in biomass according to the stations (mean ± standard error)

Discussion

P. oceanica meadows are very sensitive to disturbances, and are affected by direct and indirect environmental factors in coastal areas. The water temperature varied between 14°C and 20°C in the sampling stations, which is within the range reported for optimum growth (7 and 20°C) by Phillips and Menez (1988).

In this study, mixed assemblages of *P. oceanica*, *Cymodocea nodosa* and a green alga *Caulerpa racemosa* were found, with the exception of stations 2 to 8.

C. nodosa growth in the Mediterranean is reported in several studies. This plant can colonize different types of environment, such as open coastal waters, coastal lagoons and estuaries, and form monospecific and mixed stands, in association with other seagrasses such as *P. oceanica* and *Zostera* spp. (Buia and Marzocchi 1995). In our study, *P. oceanica* was determined to be the dominant seagrass on the Aegean Sea coast. The presence of *C. racemosa* was reported as one of the possible causes of decline in shoot density and cover of the seagrass meadows at Port-Cros Island, Meditarranean Sea (Bonhomme *et al.* 2010a).

The highest values of shoot density were found at station 9 (Ceşme). Shoot density was found at supranormal ranges in seven of the sampling locations. Anthropogenic impacts were intensive in most of the sampling areas. However, the good condition of these meadows might be an indicator of good hydrodynamic factors such as deep currents.

Leaf numbers were the lowest at station 17 (Paşatarlası, Bodrum). Seagrass bed density was markedly lower than that at the other stations and was classified as "abnormal" shoot density. This station is impacted by anthropogenic factors such as tourism activities, coastal development and pollution. Inceburun (station 5) is situated in Izmir Bay and subjected to intensive impact of pollution (Dural *et al.* 1997) and also of aquaculture activities (Şahin 2003) (Table 2). Seven fish farms were in operation inside the bay on the coast between Urla and Karaburun. The highest value of leaf length was determined at stations 4 and 9. Station 4 (Hekim Island) is situated in the outer part of Izmir Bay. Both shoot density and cover conspicuously declined at the lower limits of seagrass in a national park in a Mediterraneaen pristine locality, but the cause of which is unclear (Bonhomme *et al.* 2010b).

Mud from the mouth of the Melez River in Izmir Bay was dumped into deep areas around Hekim Island in the 1990s (Table 2). The lower limit of *Posidonia,* which had been 26-28 m in 1987, had retreated to 19-20 m by 1998-99. Previously existing coralligenous biocenosis had completely disappeared. But total leaf length and shoot density showed that the meadow was in good condition (Table 2), in spite of overfishing and dynamite fishing (Dural *et al.* 1997). This may result from deep currents or other hydrodynamic factors.

Total biomass showed a maximum value at station 9 and a minimum at station 1. Illegal boat seine and longline fishing regularly takes place in Seferihisar Bay (station 13) and at Ayvalık and nearby islands. However, although dense seagrasses protect vagile and epiphytic organisms from predators, they cannot provide protection from mechanical damage. A huge variety of organisms on and around the leaves and even in the sediment are affected. In beach seining (boat seine fishing) in the Aegean, plants pulled up by nets were found to shelter a high variety of fauna and flora (Dural *et al.* 1998). Urbanization-related untreated waste is discharged and the effect diffuses into the surrounding waters.

Many adverse environmental factors affected Turgutreis (station 16), but shoot density was still high because the station is located in an area with strong currents.

Shoot density was determined to have abnormal values at two of the selected stations, while seven of them showed normal values. The other stations were found to be supranormal values. Shoot density and leaf biometry are indicative of the health status of *P. oceanica*, and therefore show the deteriorative impacts of environmental conditions. In addition, it is an important source of information concerning the dynamics and vegetative growth of the meadows (Pergent-Martini *et al.* 2005). Seagrass degradation had been attributed to direct reduction in light and high concentrations of organic matter in sediment resulting from aquaculture activities (Ruiz *et al.* 2001; Dural and Aysel 2007). The productivity of *P. oceanica* meadows is affected not only by anthropogenic factors. Apart from the direct or indirect effects of human activities, such factors as the natural substrate of the coast (rock, sand, silt, or mud), geomorphology, hydrodynamic factors (wind, or surface or bottom currents) or temperature affect the colonization and spread of the plants to an important degree. In the northwestern Mediterranean, four possible factors were considered for the decline in shoot density and cover of *Posidonia* meadows; direct and indirect effects of North Atlantic oscillation, rise in relative sea level, seawater warming and the presence of introduced algae (Bonhomme *et al.* 2010a).

Anthropogenic factors have more effect on meadows in semi-closed areas. Eutrophication causes decreased light intensity and increased epiphyte biomass, thus destroying the meadows directly. Increases in nutrients in the water column and sediment forming an anoxic medium result the destruction of the meadow. The most destructive impact on meadows is industrial pollution. The growth and recruitment dynamics of seagrasses as well as man-made and/or natural disturbances create complex spatial configurations of seagrasses on large spatial scales (Böstrom *et al.* 2006). The disturbances in phenological parameters of the meadows show differences between sampling sites, probably due to anthropogenic and hydrological factors.

P. oceanica meadows cover large areas along the coasts of Turkey and are damaged by many adverse anthropogenic impacts. These impacts are grouped into four main categories such as coastal development and tourism, industrial development and pollution, fishing and aquaculture, and alien species. The destruction of these sensitive ecosystems by fishing in Izmir Bay (the Aegean Sea) has been reported in a number of studies (Dural *et al.* 1998; Tosunoğlu *et al.* 2003). Izmir Bay is subjected to intensive pollution, and the lower limits of *P. oceanica* have decreased to 8 m in the inner part of the bay (Dural *et al.* 2001). Table 2 summarizes the risk factors and their impacts on *P. oceanica* meadows on the Turkish coast as shown in several studies. These factors have shown increasing or decreasing trends of impact for over twenty years.

Table 2. The impacts and significance of environmental issues on *Posidonia oceanica* meadows on Turkish coast of the Aegean Sea

Issue / Problem	Status / Trend	Impact / Significance	References
1) Professional or amateur fishing (on coralligenous biotopes and *Posidonia* beds)	Problem at all coralligenous sites in the country. Increasing. Aegean Sea: (especially Ayvalık and nearly islands, Seferihisar Bay in North and central Aegean Coast, Datça and Bodrum surroundings).	Mechanical damage caused by trawling at a depth of 50 m. The risk of tearing fishing nets in coralligenous biotopes is high; nevertheless fishermen undergo this risk knowingly or unknowingly, and sensitive biotopes are often threatened by nets catching on *Posidonia* meadows.	(Dural and Aysel 2007)
2) Aquaculture	Coastal aquaculture takes place over *Posidonia* meadows. Deterioration of water quality and decline of seagrasses. Aquaculture has been rapidly increasing in the last few years in Izmir Bay (Balıklıova-Mordogan, Gülbahçe), Çandarlı Bay, Central Aegean (Ildır Bay, and around Çeşme) and in the Southern Aegean (around Bodrum). But the farms are to be moved to offshore areas recently.	Local pollution affects nearby habitats. The resulting turbidity prevents sufficient light from reaching the leaves of *Posidonia*, causing the death of both leaves and rhizomes. The impacts have decreased with different production alternatives or combined aquaculture such as algae-bivalves.	(Şahin 2003; Koçak and Katagan 2005; Dural *et al.* 2007)

Table 2. Continued

Issue / Problem	Status / Trend	Impact / Significance	References
3) Coastal development and coastal tourism. Urbanization and tourism-related construction along the coast and untreated wastewater	Overall a serious problem due to lack of coastal zone management plans. Increasing impact on *Posidonia* meadows along Aegean Sea coast.	In human settlements the structure of nature is altered to such an extent that no wildlife can maintain their existence. It is preferred to dump mud at sea rather than disposing of it in a way that does not cause harm land. Mud from the mouth of the Melez River in Izmir Bay was dumped into deep areas around Hekim Island in the middle of the Bay in the 1990s.	(Kocataş *et al*. 1984; Türkman 1986; Büyükışık and Erbil 1987; Dural *et al*. 1997; Dural *et al*. 2006)
4) Sand extraction - manipulation of natural shore structure	Overall a serious problem. Construction is increasing parallel to population growth and there is increasing demand for sand as it is the main building material. Slows advance of seagrass rhizomes and obstructs new colonisation. It is common in Izmir Bay.	When sand dynamics are interfered with, seagrass colonization is prevented, and sedimentation is slowed. This in turn prevents colonization by new fauna and flora. The few sand-living algal species cannot survive, and the food chain is destroyed in areas affected by erosion caused by sand extraction.	(Kaska *et al*. 2002)

Table 2. Continued

Issue / Problem	Status / Trend	Impact / Significance	References
5) Mucous aggregates	A serious problem especially in spring and summer.	Indirect effects on *Posidonia* in littoral region. It covers the beds and limits photosynthesis. Common especially in Ayvalık and around Bodrum.	(Dural and Aysel 2007)
6) Alien species immigrants and invasive algae species (by shipping, Lessepsian migration, through Gibraltar, etc.)	The distribution of invasive *Caulerpa* spp. has result the deformation of the natural dynamics and biodiversity in the Mediterranean. *C. prolifera* and *C. racemosa* have been found on the southern Aegean Coast and Levantine Sea. *C. taxifolia*, which threatens the Mediterranean, spreads from an aquarium as the result of an accident. The large numbers of studies on this species in the Mediterranean have not prevented its spreading. A particular threat is the rapid colonisation of *C. racemosa* from the south towards the northern coasts.	*C. taxifolia*, which has the best pigment system among algae, is able to live to a depth of 60 m and make efficient use of environmental factors, and thus is a more serious threat in the Mediterranean than other invasive species. Recruitment failure in natural stocks. There is evidence that they establish more rapidly in deteriorated habitats, like over-exploited fishing grounds and degraded Posidonia meadows. Its effect is linked to the level of changes in the environment and loss of vulnerable and rare native species.	(Aysel and Dural 1998; Çınar *et al.* 2005; Zenetos *et al.* 2005)

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Türkiye'nin Ege Denizi kıyıları boyunca hassas ekosistemlerin durumu: *Posidonia oceanica* (L.) Delile yatakları

Özet

Bu araştırma, Ege Denizi kıyılarında bulunan *Posidonia oceanica* yataklarının çevresel etkilerden kaynaklanan fenolojik değişimlerinin incelenmesi amacıyla yürütülmüştür. Örnekler Nisan ve Temmuz ayları arasında (1999) üç tekrarlı olarak 17 istasyondan ve 8-10 m derinliklerden SCUBA dalışla toplanmıştır. İstasyonlarda su sıcaklığı ölçülmüş ve sediment tipi belirlenmiştir. Fenolojik parametrelerden; sürgün yoğunluğu, yaprak sayısı, yaprak alan indeksi, yaprak yüzey alanı, kahverengi doku yüzey alanı ve toplam biyokütle incelenmiştir. *Posidonia* yataklarında en önemli belirleyicilerden biri olan sürgün yoğunluğunun, 7 istasyonda supranormal iken 2 istasyonda abnormal değerlerde olduğu tespit edilmiştir. Sediment yapısı ve su sıcaklığı gibi doğal faktörlerin yanısıra, *Posidonia* yataklarının fenolojik karakteri üzerinde olası çevresel veya antropojenik etkiler tartışılmıştır.

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