FIRST NATIONAL WORKSHOP ON *Posidonia oceanica* (L.) Delile ON THE COASTS OF TURKEY

19-20 September 2013, Gökçeada, TURKEY

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PREFACE

As the Turkish Marine Reserach Foundation, we are proud of organizing the First National Workshop on *Posidonia oceanica* on the coast of Turkey, 19-20 September 2013, in a beautiful town on Gökçeada.

Posidonia oceanica is one of the most importamt primary producers in the Mediterranean Sea and an endemic marine phanerograme of the Mediterranean Basin. *Posidonia* meadows are considered as the lung of the ecosystem due to high oxygen production. Besides, it forms suitable substrates and shelter areas for other species.

Our aim of this workshop is to exchange information and ideas between scientists, fishermen, divers, coastal planners, environmentalists, NGO's, so that there will be fruitful coopertaion among these stakeholders in the future for the protection and deveoping action plans for this species and habitats. In addition, we will prepare a national road map an an implementation plan for the national strategy.

This species is under the protection in Turkey. However, they are declining in number due to coastal infrastructure, bottom trawling, beach set nets, gill nets, anchoring, turbidity and pollution. That is why we need an action plan at the national level in harmony with the regional one.

The Mediterranean Sea is a cradle of the civilization – this means that it is important for marine biodiversit and for which concerted protection at the regional even global level is needed, before losing its rich ecosystem and magnificent water, which is natural capital, insurance for the future.

I am sincerely thankful to **Prof. Dr. Yelda AKTAN TURAN**, for her effort in organizing this workshop and editing the book, as well as **Prof. Dr. Veysel AYSEL**. Besides, I am grateful to **Mr. Aybars ALTIPARMAK** who is a national Focal Point for Regional Activity Center Special Protected Areas (RAC/SPA) in Tunis for the Turkish Ministy of Forestry and Water Affairs. Finally, RAC/SPA allocated fund to this workshop and I am also very thankful to **Mr. Abderrahmen GANNOUN**, Director of RAC/SPA.

10 September 2013
Gökçeada, TURKEY
Prof.Dr. Bayram ÖZTÜRK
Director, TÜDAV

Posidonia oceanica (L.) Delile on the coasts of Turkey

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Plant Biology and Ecology

Introduction

The importance of the *Posidonia oceanica* ecosystem began to be realised in the 1950s, and since then many studies have been conducted by Mediterranean countries. At first, most studies were aimed using various biometric methods to examine phenological parameters which would provide identification by means of the plant's biology, ecology and reproduction (Molinier and Picard, 1952; Augier and Boudouresque, 1970; Giraud, 1977a; 1977b; Giraud, 1979; Pergent and Pergent-Martini, 1983-84; 1988). In the past fifty years, rapidly increasing and diversifying research has been directed towards identifying the threats to *P. oceanica* ecosystems and vegetation losses. Also, the use of ecological indices (EQI, MaOI) as bioindicators for monitoring water quality in line with the Water Framework Directive has made the protection and preservation of the species obligatory, and all Mediterranean countries including Turkey have signed international agreements.

In Turkey, the first researchers to recognize the importance of *P. oceanica* were Pergent, Boudouresque and Meinesz. The first study was carried out by Pergent on the flowering of the plant in the Gulf of Izmir (Pergent, 1985). In the same period, Boudouresque attracted attention to the topic of research on the plants of Turkey, and a report was made with drawings on flowers collected by Aysel on the coastline of Çandarlı-Aliağa (Aegean Sea), but this remained unpublished (Thelin and Boudouresque, 1985). This was followed by phenological and biochemical studies in the Gulf of Izmir (Cirik *et al.,* 1987). Between then and 1993, no significant work on the plants is to be found.

After a study of phenology and flowering on the Urla coastline, and a second study in 1993-94 in Sığacık (Dural and Pergent, 2001), monthly changes in vegetation in the plants by depth was investigated at the same time (Dural, 1998). During these years, a study was conducted on the effects of the damage done to the plants by fishing methods (Hoşsucu *et al.,* 1997). Later, in a study carried out in the area of the Gulf of Izmir by scuba diving in 52 sectors and 76 snorkel dives, the plants were examined for vegetation structure and lower limits, as well as for phenological characteristics (Dural, 2003). This was followed by monitoring such phenological parameters as the density, shoot length, leaf biometry and biomass of plants collected at depths of 8-10m at 17 stations along the Aegean coast (Figure 1) (Dural *et al.,* 2012).

Figure 1. Sampling sites of *P. oceanica* 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 (Dural *et al.,* 2012)

The use of various specific parameters based on the vegetation of *P. oceanica* in studies performed in the whole Mediterranean is of great importance. These are mostly on descriptors of shoot density and lower limits (Pergent-Martini *et al.,* 2005). About eight of the approximately 15 parameters and study topics figured in studies carried out in Turkey up to 2003, and others have started to be used more recently in various works.

This section deals with information based on studies carried out at the above-mentioned local sites such as Sığacık (Dural, 2010), Gümüldür (Dural and Aysel, 2007), and Ayvalık and Bodrum (Dural, 1998-99, unpublished research notes), and updated from studies performed after 1998 at Sığacık and in the Gulf of Izmir (Dural, 1998, 2003; Dural *et al.*, 2012).

Morphological, anatomical features and vegetation structure

Posidonia oceanica has a lifespan of many years thanks to its long-lived underground body (rhizome), which is firmly attached to the ground, taking up nutrients through its roots. These rhizomes do not contain chlorophyll; they are 1 cm thick and usually compressed; they continuously produce shoots and are usually covered with the persistent, fibrous remains of old leaf sheaths (Figure 2, 3).

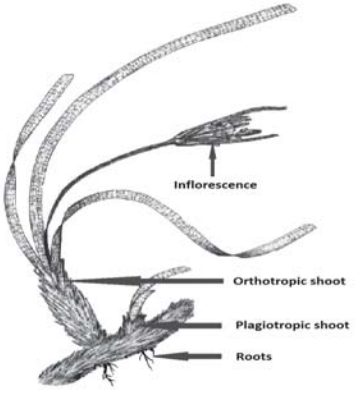

Figure 2. *Posidonia oceanica* plant (original)

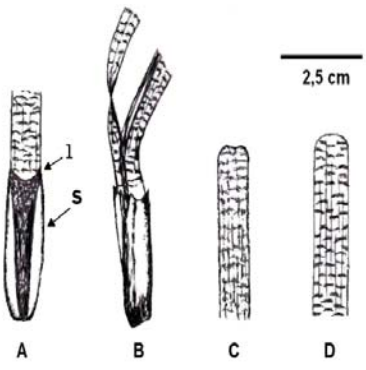

Figure 3. Sheath and leaf on a shoot. A. old leaf and basal area; S: sheath, l: ligula, B. a leaf bundle surrounded by persisting scale; C. an intermediate leaf with emarginate tip D: old leaf with obtuse tip (Dural, 2010)

Each shoot has 4-8 leaves nested together, completing a cycle in one year. The outer leaf is the oldest and the inmost leaf is the newest. Leaves can live for between seven and twelve months, and have been measured by lepidochronological analysis to have an estimated net pirmary production of 203-708 g of dry weight $m^{-2}.year^{-1}$ (Pergent and Pergent-Martini, 1991). *P. oceanica* meadows produce 5110 l O_2. $m^{-2}.year^{-1}$ in daylight, and therefore have been called the lungs of the Mediterranean.

The tips of mature leaves are emarginate and those of old leaves are obtuse; their edges are straight (Figure 3). Towards the end of summer, the place of the old leaf on the outside is taken by a new leaf, so that the number of leaves on a shoot remains the same. After leaves are shed, only the sheath remains on the shoot; the underground rhizome gradually loses these sheaths, leaving only the black scars of these sheaths. Sheaths and rhizomes decay little and can persist within a matte for millennia (>4,600 years, using ^{14}C method; in Boudouresque *et al.,*1980) (Pergent *et al.,* 1989). Sheath scars are important for estimating the age of a rhizome. Annual production can be calculated from the distance between the two thickest sheaths and the biomass. This is equivalent to an annual cycle (Pergent *et al.,* 1992, 1997). Internodes are 1-8mm, and show periodic differences. From each node (generally ones where the internode distance is long), a hairy root 8-10cm in length emerges (Figure 2). The sheaths are also important in classifying leaf age (Giraud, 1977b).

An examination of the plant's anatomical structure shows in a cross-section of the rhizome on the outside a cutinized epidermis, and below that a cortex layer of compact parenchymatic cells which get smaller towards the centre (Figure 4. A-B). The parenchymatic tissue contains aerenchyma cells and in the centre lacunal areas. The cells get larger from the outside inwards. Some of these contain starch or tannin (Figure 4B-C). Walls of epidermal cells are usually thickened and lignified. The exodermis is distinct and usually has more than one layer of cells with a thickened wall and suberized middle lamella (*e.g. Posidonia* and *Halophila*) (Kuo and den Hartog, 2006). The outer surface of the leaf blade is covered with a cuticle in between epidermal cells containing chloroplasts. Many of the mesophylic tissue cells contain tannin, and aerenchyma cells can be seen to increase in size towards the centre. Immediately below the epidermis packets of schlerenchymatic cells can be seen on the sides up to the tip, which give strength to the leaf (Figure 4D).

A productive shoot is the beginning of the next living rhizome. The plants produce two types of shoots, vertical (orthotropic) and horizontal (plagiotropic) (Meinesz *et al*., 1991). The tangled growth of these from the sea bottom towards the surface is called "*matte*" (Giraud, 1977b). The rhizomes in the upper part of the matte are living. This matte can sometimes reach a thickness of 1.5 metres (Figure 5). A thickness of 4 metres has been reported for certain local areas in the Mediterranean (Kuo and Hartog, 2006). Vertical shoots usually occur at the centre of the matte, while horizontal shoots develop at the edges, and play a role in the rapid spread of the plant. *P. oceanica* meadows can cope, through vertical rhizome growth, with sedimentation rates that do not exceed 4-5 cm yr^{-1} and are very sensitive to erosion (Diaz-Almela and Duarte, 2008). Old leaves shed in autumn collect in the intermatte or in hollows in calm sea and speed the formation of organic matter when they mix with the sediment and decay (Figure 6). Some are carried to the shore by waves and strong currents and form heaps. This supports the development of dense and healthy vegetation, and is often seen on the Aegean coast of Turkey.

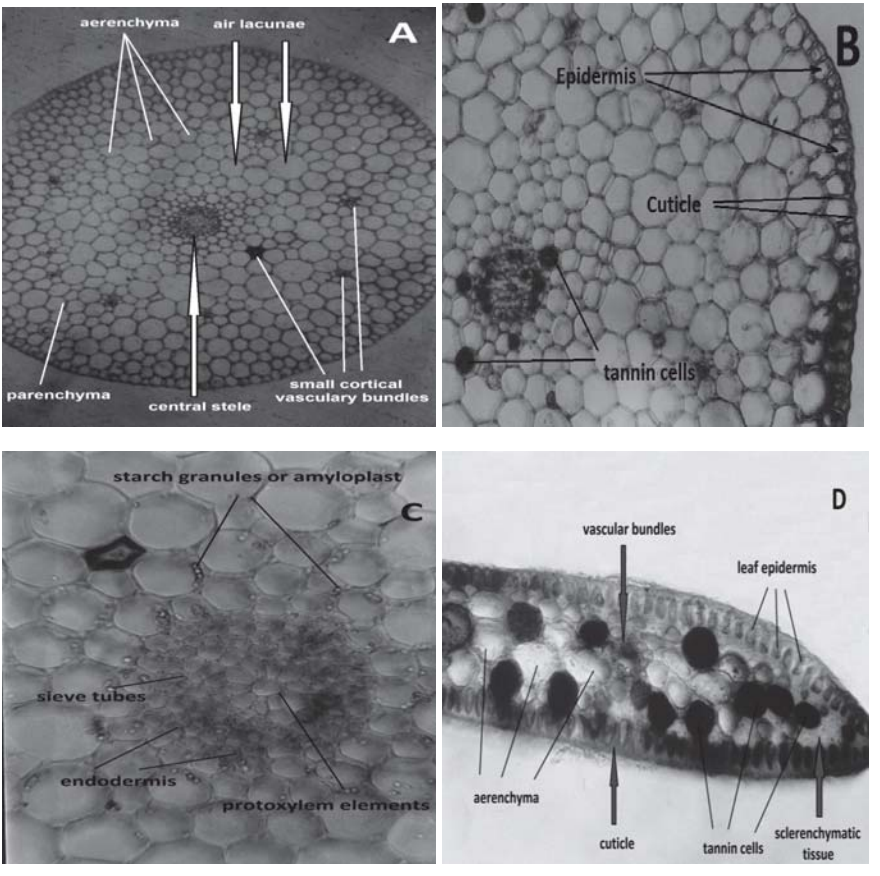

Figure 4. Transverse section showing a stem (A-B), central stele leaf (C) and leaf blade (D) (original)

Figure 5. Matte structure in shallow coastal water in Gümüldür
(Aegean Sea) (original)

Figure 6. Broken-off leaves filling the intermatte (original)

The plants are not found at the mouths of rivers or at freshwater inflows, or in places under threat of pollution such as the inner part of the Gulf of Izmir (the inner bay), or ports and fishing harbours. They are very common in the clear waters of broad and shallow bays. As the matte level rises, it reaches full maturity. At this stage, the plant can do harm to itself and begins to die in the shallower water. In the Gulf of Izmir, sampling on a slope of 3-7^{o} on the Ilıca-Menteş coast (Figure 7) showed that the upper limit of plants was a depth of 50-100 cm, and in summer leaves began to float on the surface and were damaged by the strong sunlight (Dural, 2003). In the same sampling area observations from October 2012 showed that vegetation which in 1998 had been at a depth of 60 cm had raised the sea bed in the intervening 14 years so that sunlight damage to leaves was causing the plants to die and leaving a dead matte. In some places in anoxic sandy-muddy sediment at a depth of 30 cm or less, a community of *Cymodocea nodosa* was seen to become dominant (Figure 8). Attention was drawn to this evolution of *Posidonia* meadows on calm coasts by Boudouresque and Meinesz (1982) (Figure 9).

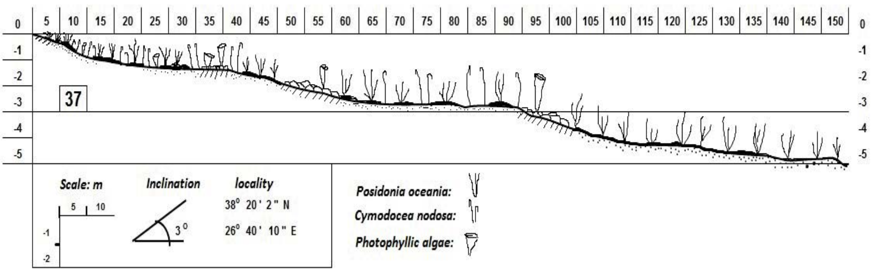

Figure 7. Topographic profile of *Posidonia oceanica, Cymodocea nodosa* and other phytobenthic communities on the coast of Ilıca-özbek (Gulf of İzmir) (Dural, 2003)

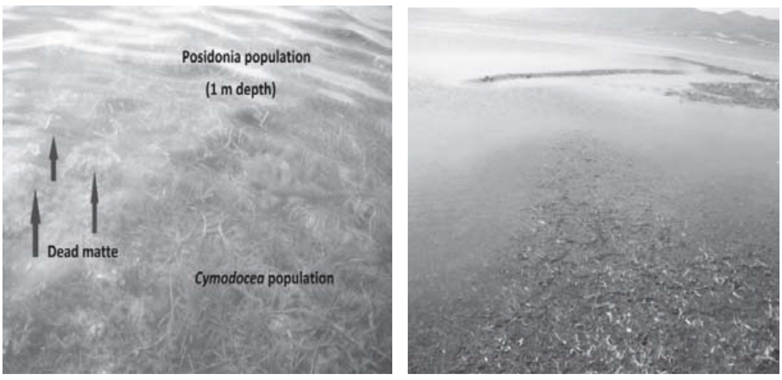

Figure 8. *P. oceanica* on the coast of Ilıca (Gulf of İzmir) (original, 2012)

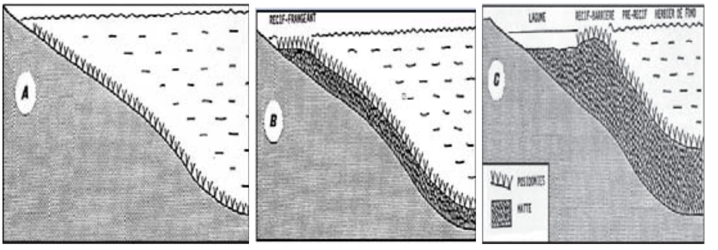

Figure 9. Evolution of *Posidonia oceanica* meadows in calm areas (according to Boudouresque and Meinesz, 1982)

The following two sections will deal with the general structure, habitat characteristics (sediment and bottom structure) and ecological conditions (depth, light, substrate) of *P. oceanica*, and with its vegetative and sexual reproduction.

Vegetative parameters

Various studies established the vegetative parameters of *Posidonia oceanica* in the Mediterranean (Giraud, 1977a, b; 1979; Giraud *et al.,* 1977; Panayotidis and Giraud, 1981;Thelin and Bedhomme, 1983; Thelin *et al.,* 1985; Pergent and Pergent-Martini, 1988). They included principally meadow typology, biomass, shoot density and leaf phenology. This basic knowledge was added to in studies of reproductive structure (Giraud, 1976; Pergent *et al.*, 1989) and epiphytic communities (Boudouresque *et al.,* 1981; Mazzella and Ott, 1984), and the determination of environmental factors (Meinesz *et al.,* 1991; Leoni *et al.,* 2006), among many other topics.

Here, we will mention some basic studies performed in Turkey which have made use of these basic characteristics.

Shoot density and shoot length

As stated above, the oldest records of phenology and flowering in Turkey were given by Pergent (1985) for the coast of Urla. Later, these records were compared with data from Sığacık Bay and five stations on the Mediterranean coasts of Algeria and France (Dural and Pergent, 2001). According to these records, plants collected in the Turkish locations of Urla (U2) and Sığacık (S2) came into the category of 'anormal' regarding depth, according to Pergent *et al.,*(1995) (Table 1).

Table 1. Main phenological parameters measured in different regions of the Mediterranean at 2 m depths (Dural and Pergent, 2001)

Parameter	Sıgacık Bay (S2) (Turkey)	Urla-Iskele (U2) (Turkey)	La Marsa (Algeria)	Port-Cros (France)	Banyuls (France)
Density (shoot.m^{-2})	353	510	476	645	1163
Leaf number (no.m^{-2})	4.4	6.5	5.6	5.8	5.1
LAI (m^{2}.m^{-2})	2.0	8.8	7.8	13.3	5.8

The plant’s leaves reach their maximum length in the spring and summer, and the height of the canopy can exceed 1 m depending on the ecological characteristics of the shoreline. At some stations in the Gulf of Izmir, a sheath with old leaves of 55 mm, leaf lengths of 105 cm (the coast of Ilıca), and a leaf width of 1.1 cm (Karaburun) have occasionally been reported. Also, in sampling on the Menteş-Ilıca coast, measured leaf and shoot lengths in *Posidonia* beds were large. It was found that various phenological parameters at this station were greater than elsewhere (Dural, 2003) (Table 2).

Table 2. Leaf and shoot lengths of *Posidonia* beds at 0.6-3 m depths in the Gulf of Izmir, Ilıca coast (Sector: 37) in July1998 (modified from Dural, 2003)

Depth	**0.6-1 m**	**3 m**
Shoot length (cm)	15.8	10
Orthotropic shoot (%)	95	98
Max. leaf length (cm)	100	105
Adult leaf length (cm)	56.29	65.19

The suspended matter in the water reduces clarity and obstructs the penetration of light to the depths. According to results obtained from various localities along the coast of the Aegean Sea, the measurements at a depth of 5 m showing supra-normal values at Karaburun-Büyükada (1408 shoots/m^2) and Akburun (1296 shoots/m^2) are worthy of note (Dural, 2003). The highest shoot density 848 shoots/m^2 (supra-normal density) and shoot length (10.9 cm) at a depth of 10 m were reported from Çeşme (Dural *et al.,* 2012) (Table 1). The beds with the lowest (abnormal) densities were measured on the South Aegean coast (Bodrum-Paşatarlası) and the Gulf of Izmir (Inceburun) Dural *et al.,* 2012) (Table 4). These values were obtained from different depths (1, 3, 5, 10, 15, 20, 25, 30 and 33 m) in the Gulf of Izmir (52 stations), and at Sığacık (Eşek Adası) and Gümüldür, including monthly sampling at these depths at the Sığacık station (Dural, 1998). Knowing that density declines with increasing depth (Pergent *et al.,* 1995), the density classification at each depth must be treated separately. Thus, the stations on the coast must be compared separately at each depth down to the plants’ lower limits. Apart from the Gulf of Izmir (Dural, 2003), there is no study making comparisons at all depths along the Aegean coast. However, as stated above, phenological notes have been compiled for the Aegean for certain depths (8-10m) by Dural *et al.,* (2012).

Leaf phenology

The oldest information on leaf phenology was given along with data on flowering for the Gulf of Izmir (the coast of Urla) (Pergent and Pergent-Martini, 1983-1984). Phenological findings from shallow depths were compared with sampling from Banyuls-sur-Mer and Port-Cros (France) (Pergent and Pergent-Martini, 1988), and later from La Marsa (Algeria) and Sığacık in Turkey at 2 m and 5 m (S2 and S5) (Dural and Pergent, 2001) (Table 1). The structure and biometry of the leaf shoots in both study areas exhibit similar seasonal variations; they correspond to a classical phenomenon observed in *Posidonia oceanica*. Conversely, the mean values appear to indicate that the vitality of the seagrass meadow is higher at Urla-Iskele (U2), in particular for the two shallow stations U2/S2 (Dural and Pergent, 2001) (Table 3).

Thus, the mean number of leaves per shoot is always higher at stations U2 and U5 as compared to stations S2 and S5. Similarly, the Leaf Area Index is four times higher at station U2 than at station S2. This last parameter, however, is identical at stations U5 and S5 due to the longer mean length of the adult leaves at the latter station. The coefficient A values are generally higher at Urla-Iskele, which would appear to indicate a greater level of herbivory (Dural and Pergent, 2001).

According to Dural *et al.* (2012), the number of leaves sampled at 17 stations at depths from 8 to 10 m was greatest at Station 9 (Çeşme) (5035 ± 1606 no.m^{-2}), and least at Paşatarlası, Station 17(Bodrum) (992 ± 167 no.m^{-2}) (see stations, Figure 1) (Figure 10).

Table 3. Main phenological parameters measured from adult and intermediate *P. oceanica* leaves between December and April at the five stations examined (Dural and Pergent, 2001)

Parameter	Urla-Iskele U1			Urla-Iskele U2			Urla-Iskele U5		
	Adult	Interm	Total	Adult	Interm	Total	Adult	Interm	Total
Leaf number (no.m^{-2})	3.5	2.6	6.1	3.6	2.9	6.5	3.2	2.6	5.8
Mean length (mm)	345.1	249.4	-	293.7	267.8	-	208.8	174.0	-
Foliar index (cm^2.shoot^{-1})	114.8	64.0	178.8	98.8	72.9	171.8	57.7	38.9	96.6
Leaf Area Index (m^2.m^{-2})	9.5	5.3	14.8	5.0	3.7	8.8	2.6	1.7	4.3
Coefficient A (%)	78.9	13.6	51.3	71.7	21.0	48.8	78.3	16.6	50.6

	Sıgacık Bay S2			Sıgacık Bay S5		
	Adult	Interm	Total	Adult	Interm	Total
Leaf number (no.m^{-2})	2.4	1.9	4.4	3.0	1.8	4.8
Mean length (mm)	238	144.4	-	324.8	164.4	-
Foliar index (cm^2.shoot^{-1})	39.2	17.2	56.4	70.5	24.1	94.6
Leaf Area Index (m^2.m^{-2})	1.4	0.6	2.0	3.7	1.2	4.9
Coefficient A (%)	30.1	31.1	30.5	38.2	37.5	37.9

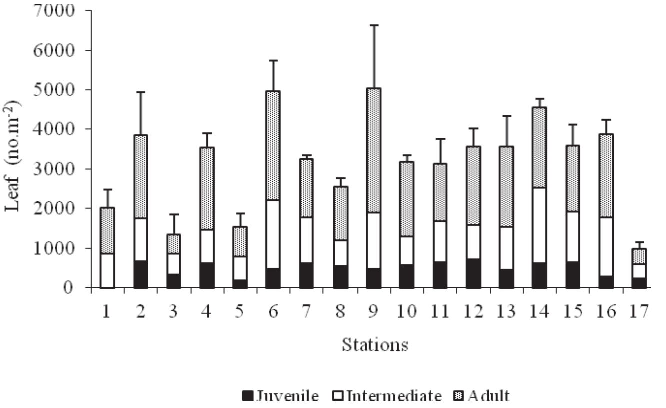

Figure 10. Variation in leaf numbers for each age classes by stations (mean ± standard error) (Dural *et al.,* 2012)

As suggested by Giraud (1977 b), this result clearly reiterates that plants start growing in length as of February and especially in the spring. The highest value of total leaf length was 35 cm at station 4 (Hekim Island) and station 9 (Çesme). Adult leaf length was higher at station 9 (Çesme) than at the others (Figure 11). Leaf width varied between 0.89 ± 0.04 and 0.62 ± 0.02 cm at the stations. The highest value of total leaf area index (13.8 ± 4.6 $m^2.m^{-2}$) was found at station 6 (Karaburun) (Figure 12). The lowest value was found at station 17 (1.6 ± 0.3 $m^2.m^{-2}$). The variance of leaf area index of the intermediate (2.542*; $p<0.05$) and adult stages (F=3.473**; $p<0.01$) between stations was statistically significant. Station 6 (Karaburun) is outside Izmir Bay and one of the cleanest parts of the seas around Izmir because of the very strong currents. Shoot density was also found to be in the supranormal range (779 $shoots.m^{-2}$) (Table 4), and lower limits extended to 33 m. 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. The variance 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 (Gumuldur). Shoot density, leaf number, biomass and leaf area index were also high at this station (Dural *et al.,* 2012).

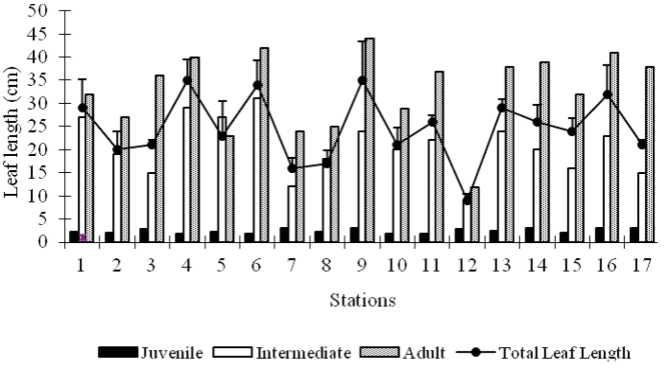

Figure 11. Variation in leaf length in each age class and a total leaf length by stations (mean ± standard error) (Dural *et al.,* 2012)

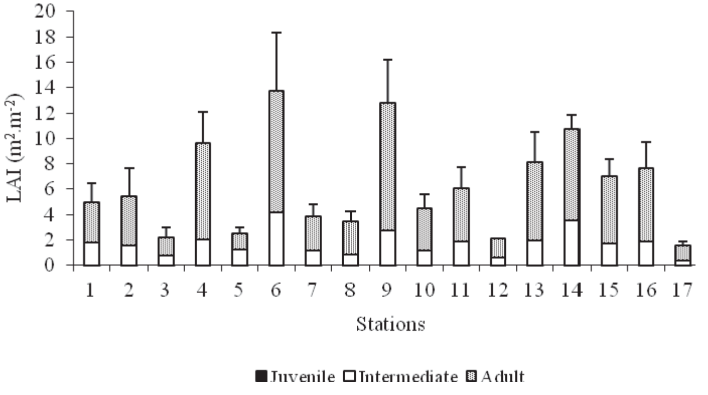

Figure 12. Variations in leaf area index in each age class by stations (mean ± standard error) (Dural *et al.,* 2012)

Gümüldür is subjected to tourism impacts and coastal development. Alien algal species such as *Caulerpa racemosa* (Forsskal) J. Ag. 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 $m^2.m^{-2}$ at the stations. Brown tissue area index was the highest at station 2 (Aliaga). Aliaga is subjected to heavy pollution impacts such as a refinery and a power plant. Plant density, however, was still in the supra-normal range (Table 4).

Biomas

Total biomass showed a maximum value at station 9 (6294 ± 615 g $dw.m^{-2}$) and a minimum at station 1 (Ayvalik) (711± 46 g $dw.m^{-2}$) (Figure 13). 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 (Dural *et al.*, 2012).

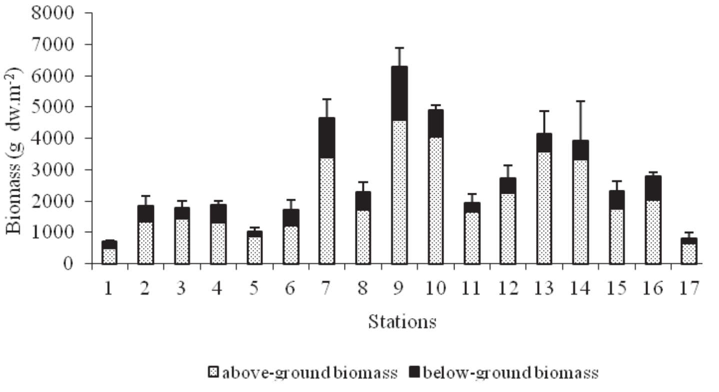

Figure 13. Variations in biomass by stations (mean ± standard error) (Dural *et al*., 2012)

Table 4. General description of the stations and shoot density classification of *P. oceanica* meadows (Dural *et al.,* 2012)

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)

Sexual reproduction parameters

As observations of the flowering and fruiting of *Posidonia oceanica* in the Mediterranean basin were few until 1985, the data obtained up to that date were highly significant. Six records of flowering and fruiting were known from Spain, 25 from France, four from Italy, one from Egypt, two from Tunisia and three from Turkey (Thelin and Boudouresque, 1985). However, research later gathered pace, and records of flowering and fruiting can be found from other areas. In Turkey, observations at 3 m at Gümüldür were carried out in 2006, and flowering and fruiting was monitored in research at a depth of 2-7 m at Sığacık between January and April 1993 (Dural and Pergent 2001; Dural, 2010), (Figure 14).

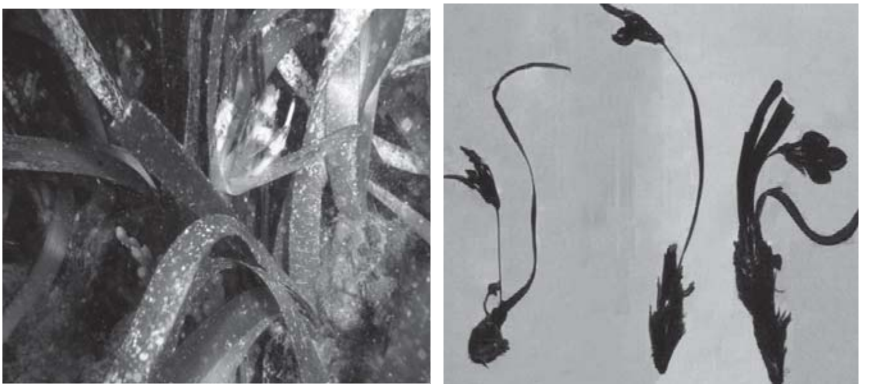

Figure 14. *P.oceanica* flowers (left) and development from flower to fruit (right) (February-April, 1993; Sıgacık 5m) (original)

Structure of flowers and flowering

Considering the general characteristics of flowers and fruit, the peduncle is compressed, 10-20 cm long and 2.5-3.5 mm wide, with a distinct cylindrical central vein (Figure 15A). Flowers are 2.5-4.5 mm long, with no ligula, there are 1-4 heads; each head is composed of 3-5 hermaphroditic flowers, the highest of which generally has a reduced gynoecium (sterile flower) (Figure 15B). There are three stamens, at the tip the arista is slightly ekstrors, the connective is wide, obovate or obchordate, and 5 mm in length (Hartog, 1970) (Figure 15C).

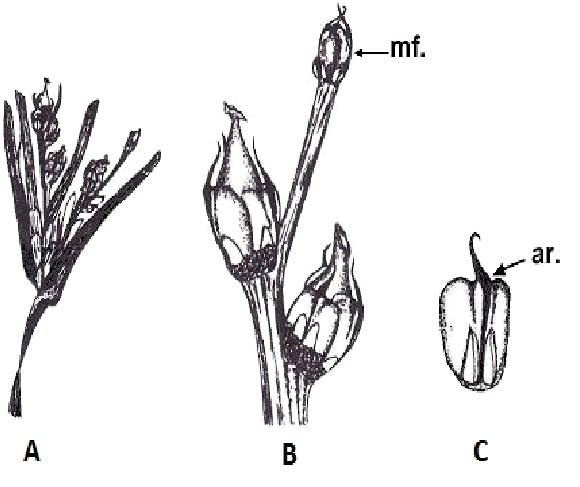

Figure 15. Phenological appearances of the flowers of *P. oceanica.* A: inflorescence with two combined spike orders; B: hermaphrodite flowers (below); mf: male flower (sterile); C: andrecium; ar: arista (Dural, 2010)

The gynoecium is 6 mm long; the ovary is elongate-ovoid, compressed, with a divided stigma. The fruit is ovoid, the pericarp is fleshy and green, when dry blackening and splitting irregularly at the bottom; the seed is oblong. The embryo is straight and green, largely fleshy, an obtuse basal tip forming on the hypocotyl carries a primary root, and the apical tip is surrounded by a well-developed polyfilous plumule (Hartog, 1970).

Flowering begins in September, and fruit forms from fertile flowers and ripens, continuing until the end of May. Fruits are green while they are in the water, but blacken after becoming detached. Air spaces in the pericarp enable the fruit to float freely on the water surface. The pericarp begins to break up and splits from the base, and the seeds sink to the bottom and immediately germinate (Hartog, 1970). Hydrodynamic factors carry flowers, or after May ripening fruits, on the waves to the shore, where they decay and mix with the sediment. In exceptional circumstances germination may occur in sheltered coastal pools, and first the cotyledon and after that a few leaves appear from the plumule. Immediately below these leaves, adventive roots develop from the basal part of the hypocotyls as the primary roots (Dural, 1998; Dural, 2010) (Figure 16C).

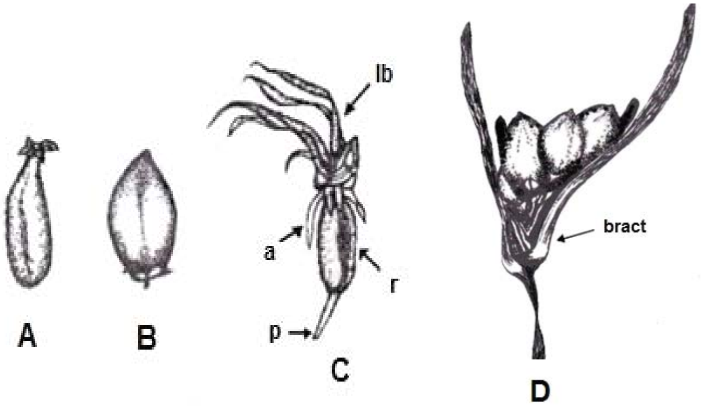

Figure 16. Phenological appearances of the fruits of *P. oceanica.* A: young fruit; B: mature fruit; C: approximately one month r: raphe, l.b: first leaf bundle, p: primary root, a: adventive root, D: mature fruits (Dural, 2010)

The hypothesis that flowering was scarce in the data published previously stems from insufficient observations rather than the scarcity of flowers (Giraud, 1977 b). Despite the fact that there were few studies on flowering in the past (Giraud, 1976; Giraud, 1977a), flowers have been observed in many localities in the Mediterranean recently, speeding up studies on sexual reproduction (Pergent *et al.,* 1989; Caye and Meinesz, 1984) as well as on vegetative production (Buia *et al.*, 1992; Pergent *et al.,* 1994). In Turkey, after the first study performed on this topic, (Pergent and Pergent-Martini, 1984), a second work showed the flowering and fruiting of *P. oceanica* with research at Akkum (Sıgacık Bay) (Dural and Pergent, 2001). The flowering shoot ratio is low (0.5 to 3.4%); it decreases with increasing depth in Urla and appears stable in Sıgacık Bay. However, the values from the two localities are similar (Table 5) (Dural and Pergent, 2001). In Sıgacık Bay, flowering percentages were computed for the inflorescences only, but the spike orders were determined taking into consideration all the flowers. The total number of inflorescences for all the replicas at both stations was 115, of which 91 were in a 2-spike order, 18 in a 1-spike order and 6 in a 3-spike order (Table 6).

Table 5. Meadow density and percentage of plants flowering at study stations (Dural and Pergent, 2001)

	Urla-Iskele			Sığacık Bay	
	Station U1	**Station U2**	**Station U5**	**Station S2**	**Station S5**
Meadow density (shoot.m^{-2})	830	510	450	353	518
Flowering shoots (shoot.m^{-2})	25.0	17.0	1.9	7.4	11.5
Flowering (%)	3.1	3.4	0.5	2.1	2.2

Table 6. Number of spikes with orders of 1, 2, 3 per inflorescence (1-7 m depths). H: hermaphrodite; M: male flowers (Dural and Pergent, 2001; Dural, 2010)

	Order of spikes						Fertile flowers number	Total flowers number
	Spike no 1		**Spike no 2**		**Spike no 3**			
Number of spikes	18		91		6		-	-
Sexuality	H	M	H	M	H	M	-	-
Number of flowers	24	7	306	28	30	5	360	400
%	6	1.7	76.5	7	7.5	1.2	-	-

Fruit development

At Urla Iskele (Station U1), the number of aborted flowers is very low; indeed, of the 45 flowering shoots recorded/tagged in October, 43 exhibited young fruit the following month (fructification rate exceeding 95%). It should be noted, however, that there occurs a substantial decrease in the number of flowering events observed *in situ* after the month of November. This is most probably linked to the hydrodynamic conditions at this shallow station. At this station, fructification is very rapid as large fruit are observed as early as January (Table 7). In Sıgacık Bay, the samples collected over a period of 5 months had a total of 400 flowers, 360 of which were fertile (fructification rate of 90%). Most of the flowers borne on the inflorescences were arranged in a two-spike order. The first large fruit (>15 mm) were observed in April at station S2 and in March at station S5 (Dural and Pergent, 2001).

Table 7. Evolution in the reproductive structures (flowers and fruits) over time. The number of structures measured is indicated in parentheses (Dural and Pergent, 2001)

Months	Size of reproductive structures (mm)		
	Urla-Iskele U1	Sıgacık Bay S2	Sıgacık Bay S5
September	-	-	-
October	6.9 (10)	-	-
November	10.6 (5)	-	-
December	11 (1)	4.5 (13)	4.3 (74)
January	23 (1)	-	5.4 (110)
February	-	5.2 (23)	6.3 (48)
March	-	-	7.9 (64)
April	-	8.0 (7)	16.5 (19)

As suggested by Giraud (1977b), this result clearly reiterates that plants start growing in length as of February and especially in the spring. No meaningful relations between leaf length and flowering, leaf length and shoot density, or the number of leaves and flowering were observed in the populations of either 1-3 m or 4-7 m depths (Table 8).

Table 8. Water temperature, shoot density, number of flower bundles, inflorescences and percentage of flowering at two depth intervals by months (Dural and Pergent, 2001)

Months	Temperature (°C)	Shoot Density.m^{-2}		Number of flower bundles.m^{-2}		Flowering (%)		Number of inflorescences.m^{-2}	
		1-3m	4-7m	1-3m	4-7m	1-3m	4-7m	1-3m	4-7m
December	15.8	524	880	26.2	9.1	3.8	10.9	20	96
January	15.8	464	412	-	3	-	33	-	136
February	16	260	540	10.8	8.4	9.2	11.8	24	64
March	15.5	284	468	-	5.8	-	17	-	80
April	16.5	232	288	19.3	10.2	5.1	9.7	12	28

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Distribution of *Posidonia oceanica* (L.) Delile at various localities: Gulf of İzmir and Aegean Sea

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Introduction

Studies of sea grasses in the world began in the 18th century with König, Rupresh and Archerson, and accelerated in the 19th century with the records of den Hartog (1970). Grenier was the first to study the most widespread and best-known species in the Mediterranean, *Posidonia oceanica*, and since then, there have been many studies and publications on various aspects (ecology, physiology, matte-structure, flowering-fruiting, phenology, fauna-flora species assemblages, biochemical composition, environmental impacts, distribution and mapping, epiphytic coverage *etc*.) of this species. Research in Turkey in this plant began to gather pace after 2000.

Although *P. oceanica* is recognised as a species endemic to the Mediterranean, it is known to extend along part of the Atlantic coast of Spain and Portugal. The first records of the occurrence of the species in the Dardanelles dates from 1883 (Hartog, 1970). There is mention in Güner and Aysel's (1986) Marmara Algal Flora project and in the observation and research notes of Aysel (1985-1986) of the occurrence of *P. oceanica* in the Dardanelles and Sea of Marmara, at Erdek, Seddülbahir, Kilitbahir, and Soğandere (25.12.1984), and even of drift material being found on the shore at Beykoz during research in the Bosphorus (24.7.1985). More recently, Yüksek and Okuş (2004), Cirik *et al.,* (2006) and Meinezs *et al.,* (2009) have recorded the spread of the species to nearby localities. The plant shows a wide distribution in these places and all over the Aegean shoreline.

In this chapter, the first section will deal with information derived from an overview of the research mentioned above (Dural, 1998; Dural *et al.,* 2012), but will concentrate on the Gulf of Izmir (Dural, 2003).

Distribution of *Posidonia oceanica* vegetation in the Gulf of Izmir

The Gulf of Izmir is one of the largest inlets in the Mediterranean Sea, with a surface area of 200 km^2 and a water capacity of 11.5 billion m^3. It was formerly divided into three sections – the inner, middle and outer gulf – for its ecological and hydrogeographical characteristics, but more recently it has been regarded as having two sections – inner and outer (İZSU, 2013) (Figure 1). However, in terms of the biological and ecological characteristics of the seagrass meadows, it has been divided into four sections (Dural, 2003) (Figure 2). Because of the differences between transects on the islands and on the mainland, this area has been divided into zones. In the Gulf, all meadows including *P. oceanica* on the mainland coast and the islands were researched: a total of 52 transects by scuba dives and other areas by 76 snorkel dives, and, distributions were shown (Dural, 2003). In Table 1, these transects are grouped by zone, and numbered.

Table 1. Classification of research transects in the Gulf of Izmir by region

1.Region	2. Region	3. Region	4. Region
A.Island sectors			**A.Island sectors**
T1-3: Taş Island			F47,48: Fener Island
P7-14: Pınallı Island			O50: Orak Island
Y10-13: Yassıca Island			Hy51,52: Hayırsız Island
E15-17: Eşek Island			
A18,19: Akça Island			
Hk20-23: Hekim Island			
B.Coastal sectors	**B.Coastal sectors**	**B.Coastal sectors**	**B.Coastal sectors**
H4:Hastane Island	Mo26: Mordoğan	M5: Menteş	Fb46: Fener cape
Ui5: Urla İskele	Kp27: Kaynarpınar	Oi36: Özbek Iskele	Od49: Orak döküntü
Une6: Urla nebioğlu	Ab28: Akburun	Ö37: Özbek	Tu53: Tuzla
M24: Mentes	Dk29: Domuzlukaya	Gö38: Gülbahçe-Özen	
Aç25: Aşıklar Çeşmesi	Dt30: Değirmentepe	G39: Gülbahçe	
	Br31: Burgaz	Ib40: Inceburun	
	Db32: Dalyan cape	Ök41: Özgürkamp	
	Ba33: Büyükada	Db42: Dalyan cape	
	Kb34: Kanlıkaya cape	Huk43:Huzurkamp	
		Db44: Dalyan cape	
		Kb45: Kum cape	

The area is located in the central Aegean Sea on Turkey's west coast, and is the most researched area of the Aegean coastline. In the north, the distance from the shoreline to the open sea varies between 3 and 5 km; it includes the basin of the Tuzla and Gediz rivers, and is 5 to 6 metres in depth. The shallow coasts are characterized mostly by *Cymodocea nodosa* (Ucria) Aschers., and in places *Zostera* communities, and *Posidonia* does not occur on shallow coasts. The bottom is composed of sand and silt, and is more suitable for sampling by free-diving than by scuba diving. These shallow coasts obstruct the current systems of the Gulf, so that they play an important role in the food chain, sheltering and nourishing many living things. The inner Gulf is under heavy pressure from industrial and domestic waste. For this reason, along a line from Karşıyaka to Konak, only *Zostera marina* L. and *Zosterella noltii* Hornem. can occasionally be found, and in places and at depths of 2-6 m, *Cymodocea nodosa*. In the area from the inner Gulf towards Narlıdere and Sahil Evleri, almost no *Posidonia* meadows are to be found, but from here towards the outer Gulf the plant's distribution and lower limits increase (Figure 9).

The Gulf of Izmir is a productive area for plants and so makes a great contribution to the food chain, with sea-meadow species covering the coastline with very few breaks. In the west (Balıklıova-Mordoğan-Karaburun) and north-east (Hacılar limanı-Foça) the Gulf has a rocky substrate, apart from a few bays. The military areas (Menteş and Uzunada) together with the islands of Urla have a rocky substrate. From the inner Gulf along the boundaries of Urla, the coast is more stable and sandy. The Menteş peninsula is as mentioned rocky, but from Gülbahçe Bay to Mordoğan there are sandy areas, and reef barriers where the upper limit for plants is 1-3 m. From Balıklıova and Mordoğan, the upper limit varies between 3 and 7 m, and plants are found all along the coast without a break (Figure 3). This can be ascertained by snorkelling as well as by scuba diving, and the existence of *Posidonia* beds is best shown by the plant debris that accumulates on the shore between stations. Samples were collected by a method which we first developed for multi-purpose research on plants. Underwater measurements were made and bed structure was ascertained, and then samples were taken, by the use of GPS, underwater compass, depth meter, and 20x20 or 25x25 cm square grids. Using these instruments from the shoreline towards the open sea in a particular direction down to the lower limit, changes in vegetation and topographic structure were noted for different depths (*e.g.* 1, 3, 5, 10, 15,20, 25, 30 and 35 m); wheel turns were noted on an underwater bicycle (Figure 4), and the bottom distance and slope were calculated. Plant sampling by the transect method and drawing of the bottom profile was carried out according to Meinesz *et al.,* (1981) and Meinesz and Simonian (1983).

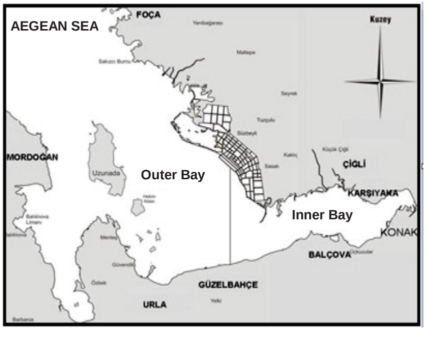

Figure 1. Division of the Gulf of Izmir (İZSU, 2013)

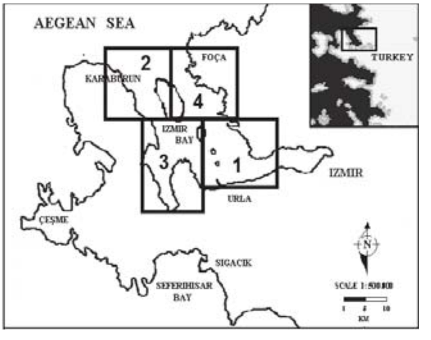

Figure 2. Division of the Gulf of Izmir according *to Posidonia oceanica* vegetation (modified from Dural, 2003)

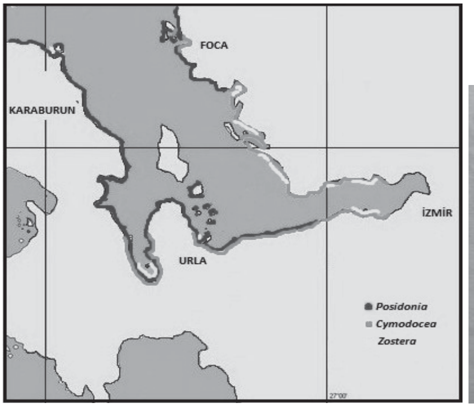

Figure 3. Distribution of seagrass meadows in the Gulf of Izmir

Figure 4. The underwater bicycle, used to measure bottom distances (Original) (Dural, 2003).

Taking the average of all 52 transects in the Gulf, the bottom distance from the shoreline to the lower limit was 178 m, and the upper limit average distance was 34 m. The difference between the two measurements was calculated as 144 m, and shows the distribution of the plants *(Posidonia* only). The average depth for the lower limit in the Gulf is 17 m, and the upper limit is 3.6 m. The highest upper limits were found off Karaburun-Burgaz (10 m) and on the side of Foça-Orak Island facing the open sea (12 m). It was seen that when using the underwater bicycle hollows and mounds were included in the distance so that the distance recorded could be too long. Although the bottom distance was calculated as 144 m, errors could arise because of mounds (matte) and hollows (intermatte), and so the calculated distance was reduced to 130 m to take account of this. The total length of coastline in the Gulf is approximately 400 km. Excluding the inner gulf (about 60 km) and the northern coast, it can be said that the remaining approximately 300 km of coastline and the 130 m bottom distance give an area of approximately 39 km^2 covered in beds of *Posidonia* only. This does not include the areas covered with other species up to the upper limits of *Posidonia* (Gülbahçe Bay and the coast of Tuzla-Dalyan in the north).

Posidonia beds are present in all Mediterranean countries and collectively occupy 2.5-4.5 million ha. This constitutes nearly 25% of the Mediterranean basin where the water depth is less than 50 meters (Diaz-Almela and Duarte, 2008). Italy, with 157 sites, has the most researched coast and an estimated 122 049 ha of *Posidonia* beds, which constitute 44.11% of the Mediterranean total (Diaz-Almela and Duarte, 2008). Thus, on a 320 km stretch of coast on the Adriatic coast of Italy facing the Ionian Sea in the Apulia region alone, an area of 330 km^2 is covered with *Posidonia* beds (Constantino *et al*., 2010). A table in Natura 2000 lists countries in order of area, with Italy in the first rank (Diaz-Almela and Duarte, 2008). The table includes data from Turkey, with findings from the Gulf of Izmir (Table 2). On the basis of this information, it can be said that the 200 km^2 Gulf of Izmir has a plant cover of 39 km^2 (3900 ha), which is 19.50% of the total of the Gulf, and 1.39% of the Mediterranean total. On a distribution map, Turkey is included with other countries at a rate of

1-9% of total surface area (Figure 5). However, if research were to be conducted on the coast starting from the important section of the Sea of Marmara and the Dardanelles by using sensitive scanning methods (side-scan sonar) or by very close transects using depthmeters, underwater compasses, *etc*., and not just from point distribution data from the Aegean and Mediterranean (Levantine) coasts, the surface area of plant cover along the coast of Turkey would reach a much higher value. This is shown by the fact that local sampling work in Turkey by the above-mentioned researchers has found a very dense distribution of the plants from the north to the shores of the Mediterranean.

Table 2. Percentage distribution of the total surface area of *Posidonia* beds in Natura 2000 including a re-calculation of the Gulf of Izmir (modified from Diaz-Almela and Duarte 2008)

BIOGEOGRAPHICAL REGION/ COUNTRIES	Nº OF SITES	ESTIMATED SURFACE IN NATURA 2000 (HA)	% OF TOTAL SURFACE IN NATURA 2000
Italy	157	122,049	43,5
Spain	70	70,029	24,95
Greece	71	57,514	20,49
France	18	25,999	9,26
Turkey (Izmir Bay)	52	3,900	1,39
Cyprus	4	952	0,34
Malta	1	118	0,04
Slovenia	1	6	0,002
TOTAL (MEDITERRANEAN)	374	280,568	100

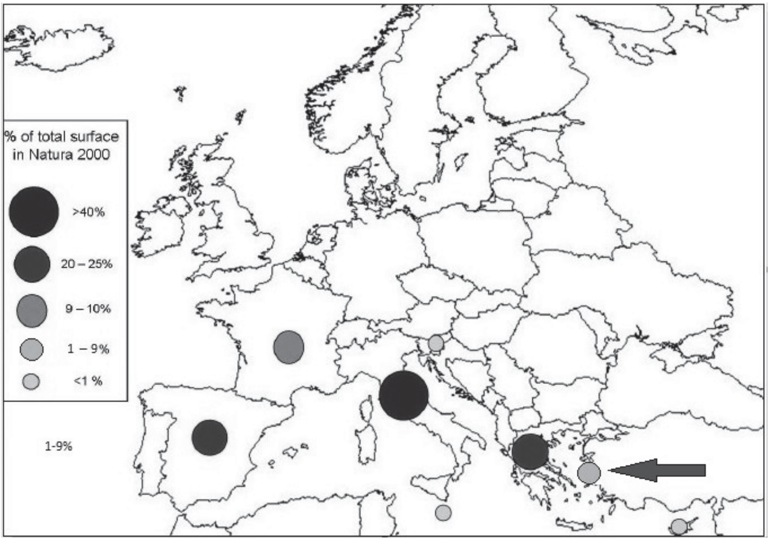

Figure 5. Percentage distribution of the total surface area of *Posidonia* beds in Natura 2000 (modified from Diaz-Almela and Duarte 2008).

Distribution of *Posidonia oceanica* vegetation at various localities in the Aegean Sea

The Aegean Sea has a coastline of 2805 km excluding islands, which is shared between Turkey and Greece. Apart from the Gulf of Izmir, this coast includes several important gulfs such as those of Edremit, Çandarlı, Sığacık, Kuşadası, Güllük, Gökova and Hisarönü, as well as many bays.

In a study by Dural *et al.*, (2012), sampling was performed to give a partal idea of the situation along the Aegean Sea coast, although not as intensively as in the Gulf of Izmir. Plants were studied at 17 stations at depths of 8-10 m along the coast from Ayvalık to Bodrum, but because of the great length of this coastline it was not possible to record all parameters (upper and lower limits, limit type, phytobenthic profile, phenological characteristics relating to depth, *etc*.) characterizing the vegetation at these points. However, local sampling and observations carried out from time to time and at different points since 1993 have indicated that in areas of open sea away from dense human coastal settlement, vegetation shows a healthy structure. At the same time however, it has been found that shorelines facing the open sea are generally rocky and become immediately deep, so that while flowering plant vegetation exists at greater depths, it does not always have a homogeneous or stable structure. In this way, it has been established that the composition of algal flora and flowering plants shows important differences from the bays and gulfs.

After the Gulf of Edremit in the north of the Aegean Sea comes Ayvalık. Ayvalık has a great variety of shore structure and the organisms sheltered on its substrates include *Posidonia* beds and their ecosystems. The upper limit of plants begins from a depth of 7-10 m. The bottom is rocky, and has a heterogeneous structure arising from hollows. Plants form scattered communities in these hollows, and the lower limit occurs suddenly when the coral cuts it off like a wall. Where the wall ends a more stable sandy bottom continues from 40 m towards deeper water, and colonies of sponges and gorgons are encountered from place to place on the rocky substrate (Figure 7).

Figure 6. Ayvalık (Delimemet rocks) coralligenous zone (original, 45 m)

Figure 7. Ayvalık (Delimemet kayalıkları) coralligenous zone. *Paramuricea clavata* and *Eunicella cavolonii* colonization (original; 45-48m.)

After the coast of Çandarlı towards the coast of Aliağa and Foça, the bottom has a more stable quality. When we come to these coasts, the vegetation on the shores of the mainland and that of the islands shows considerable differences. On the Foça island of Hayırsız, proceeding with the underwater bicycle towards the mainland on a bearing of 120^o by the underwater compass, plants are encountered at a bottom distance of 26 m and a depth of 5 m (the upper limit). From the upper limit towards the depths for a distance of 140 m, homogeneous beds can be seen to a depth of 9.8 m, after which the plants begin to thin out. At a total measured bottom distance of 310 m from the shore, we reach the lower limit at a depth of 17.3 m. (Figure 8). Down to these depths, surface and bottom water temperature was measured at 20 ^{o}C on 22.10.99.

On the side of Hayırsız Island facing the sea the lower limit of plants is reached at a bottom distance of 270 m and a depth of 26 m on a bearing of 300^o. The upper limit begins at a bottom distance of 87 m from the shore and at a depth of 5.4 m. From this point on, intermatte and following that a reef of up to 5 m in height are seen. This reef ends at a bottom distance of 90 m and a depth of 9 m, at the end of which at 9.5 m there is an open area (intermatte) with a width of approximately 10.5 m. At the end of this, a homogeneous bed begins at a distance of 17.5 m, at a depth of 10 m. At the end of this again, a 9 m intermatte channel can be observed. After this at a distance of 19 m, further homogeneous beds are encountered. This in turn is cut again by a further intermatte channel which is 5.2 m in width. At the end of this, homogeneous beds continue for a distance of 31.5 m and to a depth of 24-24 m, and finally they cease at a depth of 26 m (Figure 9).

This example indicates that the vegetation on coasts facing the open sea is more affected by bottom currents than is the vegetation of coasts facing the mainland, and that the effects of this extend to a depth of more than 15 m.

Even if evaluation studies of plants on the islands of the Aegean Sea are carried out along with studies of those on the nearby mainland shoreline, the vegetation structure may show significant differences, such as those mentioned above. Apart from Gökçeada and Bozcaada, smaller islands are named after the coast to which they are close (for example Ayvalık, Foça, Urla, Karaburun and Çeşme Island). Whether for phycological or phytobenthic studies, this grouping has made work in this area easier.

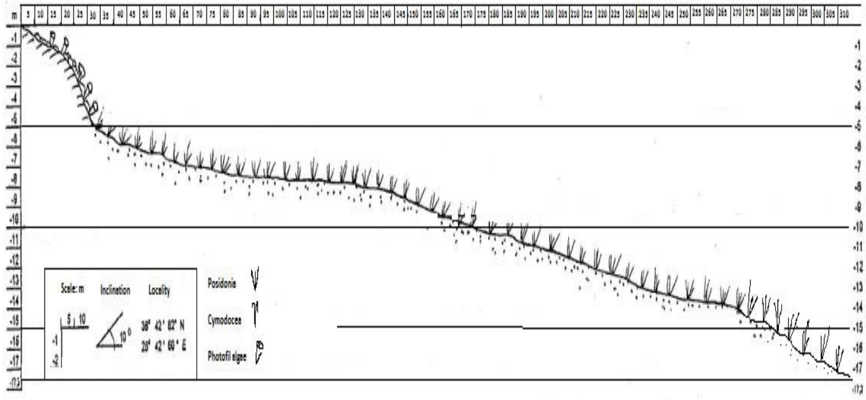

Figure 8. Topographic and phytobenthic profile of the coast of Foça-Hayırsız Island on a bearing of 120°

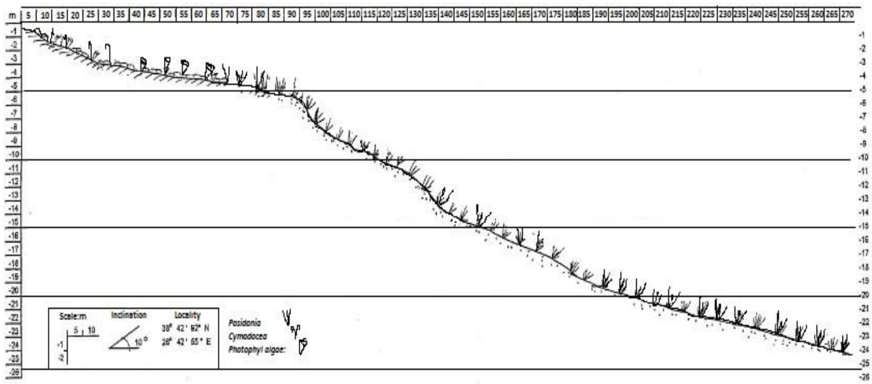

Figure 9. Topographic and phytobenthic profile of the coast of Foça-Hayırsız Island on a bearing of 300°

Sediment Types, Water Temperature and Salinity

Sediment Types

Samples of sediment were taken at a depth of 10 cm where plants were being sampled between the years 1996 and 1999 from north to south from all local stations on the Aegean Sea coast where research was being carried out and from the 52 stations in the Gulf of Izmir. Analysis was carried out according to the structure analysis method of Compton (1962). Sediments of different origins were passed through micrometric sieves according to the diameter of their particles, and the following classification was used.

1. I. Class gravel-sand (1400µ)
2. II. Class gravel-sand (710 µ)
3. Coarse-medium sand (425 µ)

4. I. Class fine-medium sand (150 µ)
5. II. Class fine-medium sand (75 µ)
6. Coarse silt (38 µ)
7. Medium-fine silt-clay (<38-2 µ)
8. Organic detritus and shell

Gulf of Izmir: The proportion of grade 7 sediment was found to be high in zone 2., while it was higher in zones 3 and 4 than in zones 1 and 2, compared to the level of grade 1 and 2 sediments. This suggests that the sediment structure of the beds starting from the canopy of the meadows does not show similarity with the sediment structure of the intermatte. That is, the sediment of the bed where the sampling of plants was carried out is different from the sediment of the intermatte. *Posidonia* beds pull down the smallest particles from the water to the bottom with the characteristics of the filtration system of their leaves. Here, algal epiphytes play a big role. In this way, sediment with the smallest structure including organic matter contributes to the formation of the bed of the matte. Under natural conditions, rain water in the inner and middle gulf areas (zones 1 and 3) continually raises the level of the bottom with the sediment brought by numerous streams and canals. This in turn causes the fine structured particles to concentrate on the surface of the sediment. The stations of the inner and middle Gulf have a high level of turbidity at a depth of 10 m, and in places with or without plants on the bottom, the sediment with fine particles, or mud, is stirred up by the smallest movement of the water and coats any flat area including the leaves of the plants. This has a negative impact on the development of the plants by obstructing photosynthesis.

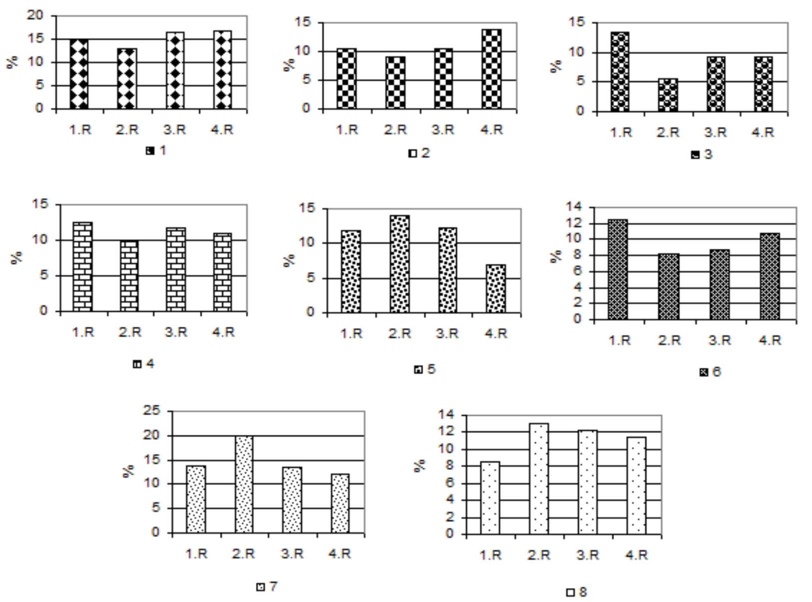

Figure 10. Regional variations in the proportions of sediment structures by stations in the Gulf of Izmir.

Aegean Sea: In the Aegean Sea as in the Gulf of Izmir, research was performed by similar methods at stations such as Aliağa, Mersin Koyu, Eşek Adası, Çeşme, Alaçatı, Kuşadası, Gerence and Sığacık. However, in a study by Dural *et al.,* (2012), the bottom structure of a number of stations in the Gulf of Izmir and stations in the Aegean Sea was characterized as sand-gravel or sand-silt (see Chapter 1, Table 4). This being so, samples taken from various localities for different research purposes at the same station showed greater or smaller differences in sediment type. For example, sediments of grades 1 and 2 (gravel-sand) was obtained in the highest proportions (35.19 and 32.24%) in the Aegean Sea and the Gulf of Izmir from samples taken from Hekim Island at coordinates 38^{o} 26’ 08” N and 26^{o} 46’ 24” E. (Hoşsucu *et al*., 1997), while in a different study the average of samples taken from four different points at the same station were found to be of sediments type 1 and 2 (12.7 and 13.8%) (Dural, 2003). The same was observed in sampling at Karaburun. That is, while the surface of the intermatte has a structure of gravel and sand, (see Chapter 1, Table 4), the first and second classification values of the sediment at the base of the beds was found to be lower (2.56 and 1.24%) (Figure 11).

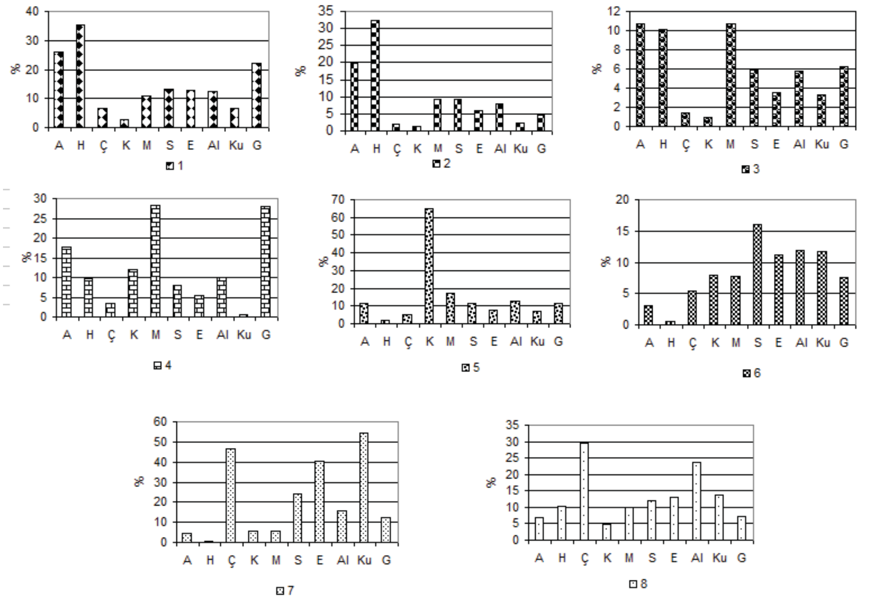

Figure 11. Structure proportions of sediments (according to **l**ocation of sample sites in the Aegean Sea. A: Aliağa H: Hekim Island Ç: Çeşme K: Karaburun M: Mersin Bay S: Sığacık Bay E: Eşek Island Al: Alaçatı Ku: Kuşadası G: Gerence)

Water Temperature and Salinity

Water Temperature: In the Mediterranean basin the optimum temperature for the development of *Posidonia* is between 20 and 22 ^{o}C, and the minimum and maximum are 10 and 29 ^{o}C (Phillips and Menez, 1988; Mayot *et al.,* 2005). The temperature values of the gulfs and bays are different from those of the open sea, and this plays an important role in the growth and distribution of the plants. In the Gulf of Izmir, marine flowering plants are exposed to radiation, and surface temperatures reach 28 to 30 ^{o}C, so that dying has been observed in the shallow waters and on reef barriers (see Chapter 1, Figure 8). Thus, the temperature variations in the gulf and especially in shallow parts (min:10 ^{o}C, max: 30 ^{o}C) are known to be much greater than areas of the open sea (Dural, 1990). In the same way, surface water temperatures on the Menteş shore of Gülbahçe Gulf were measured as min:13 ^{o}C max: 27.8 ^{o}C in 2007. In the Gulf of Izmir in general, temperature values down to a depth of 20 m for August 2003 were found to be 19-26 ^{o}C; below 20 m the temperature stabilized at 17 ^{o}C. In the inner and middle gulf temperatures fell to 25-26 ^{o}C, and towards the outer gulf they fell to 23-24 ^{o}C (Pazı and Öztürk, 2004).

In Sığacık Gulf, which is located to the south of Izmir, variations in water temperature (min: 15.8 ^{o}C, max: 22 ^{o}C) are not great, as the depth of the water is greater and there are fewer inlets on the mainland coast. On the coast of Akkum, annual average temperature values measured the year round at different depths (5, 10, 15 and 20 m) were as follows: 5 m: 18.09 ^{o}C; 10 m: 16.32 ^{o}C; 15 m: 17.75 ^{o}C and 20 m: 18 ^{o}C. The average Secchi depth was measured as 23.29 m (Dural, 1998). At sampling carried out in the stations in the Aegean Sea between April and June 1999, water temperature values determined for depths of 8-10 m were 14-20 ^{o}C (see Chapter 1, Table 4). Water temperatures of 28.4 ^{o}C measured on open coastlines in the Levant Sea were equivalent to those on the shallow reef barriers of the Gulf of Izmir (Çelebi *et al.*, 2006). For this reason, the growth of *Posidonia* plants is reduced from the southern Aegean Sea to the Mediterranean as in shallow waters, in line with the increase in temperature and salinity. It is thought that in these regions the temperature factor plays a relative role in the fact that the plant's upper limits begin at greater depths.

Salinity: The average salinity of the Aegean Sea is between 35 and 39‰. Significant differences in salinity values are not found between stations located on the open sea coast and those in open bays and inlets, as is the case with temperature. Nevertheless, in certain particular areas (the coast of Tuzla) it can rise above 40 ‰ (Kutlu and Büyükışık, 2007). In spite of this, factors such as evaporation and rainfall cause changes in the seasonal salinity concentrations. In the Gulf of Izmir there are significant variations in salinity because of the heat and the fact that there are many river basin environments such as the Gediz delta which provide a freshwater inflow. Tuzla and its surroundings are getting steadily shallower as a result of the sedimentation in this basin. Values measured in the years between 1987 and 1990 in coastal waters only a few metres deep in the inner parts of the Gulf were found to vary between 22 and 31.5‰ at stations number 4-9, as can be seen in Figure 12. Furthermore, the fresh water and sediment brought to the inner Gulf as rain water and domestic and industrial waste until the big canal project at the beginning of the 21st century have given rise to the formation of a high level soft anoxic layer. In addition to this, the fall in salinity has limited the growth of stenobiontic *Posidonia* beds. Under normal conditions, the plants are able to live in conditions of 36.5-39.5 ‰ salinity, and the finding that in isolated areas in the north in places such as the Marmara Sea and the Dardanelles they are able to survive in a salinity of 21.5-28 ‰ is significant (Meinesz *et al.*, 2009). The salinity on the east Mediterranean coast of Turkey (the Levant Sea) is reported to have a value of between 39 and 39.6‰ (Çelebi *et al.*, 2006), and it can be said that the high salinity levels along with the high temperatures limit the growth of the plant.

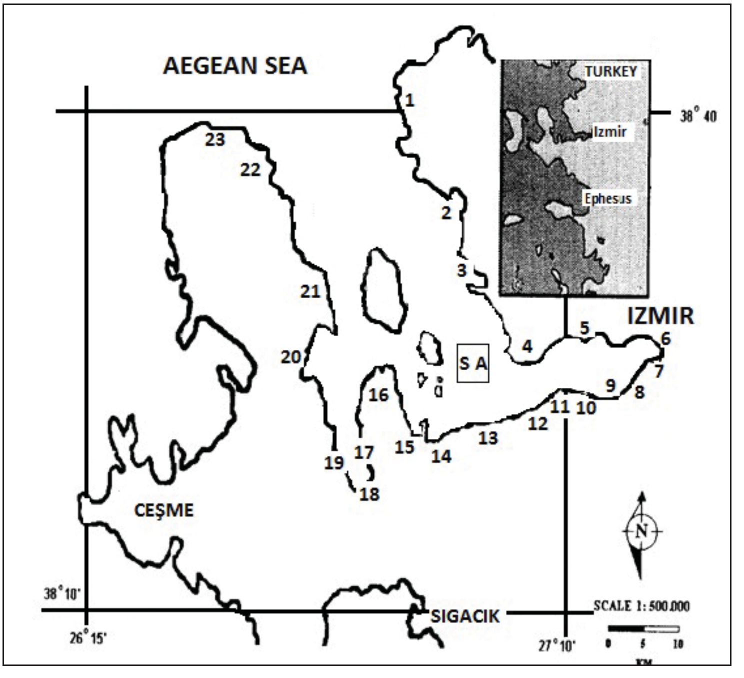

Figure 12. Salinity values for some research stations in the Gulf of Izmir. 1. Foça (38.6‰) 2. Kırdeniz (29.3‰) 3. Tuzla (38.7‰) 4. Bostanlı (‰ 31.5) 5. Karşıyaka (‰29.8), 6. Bayraklı (23.8‰), 7. Alsancak (21.7 ‰) 8. Konak (26.7‰) 9. Göztepe (28‰) 10. İnciraltı (37.5‰ 11. Sahilevleri (37.8‰), 12. Güzelbahçe (38.4‰) 13. Aşıklarçeşmesi (37.8‰) 14. Urla (38.6‰) 15. Çeşmealtı (‰38.2) 16. Menteş (‰38.7) 17. Özbek (38.2‰) 18. Ilıca (38.4‰) 19. Gülbahçe (‰38) 20. Balıklıova (38.7‰), 21. Mordoğan (39.5‰) 22. Karaburun (39.3‰) 23. Kanlıkaya (39‰) (modified from Dural, 1990)

Lower Limits

In environments which are anoxic due to pollution and eutrophication, principally reduction in light intensity and a fall in oxygen values to less than 5 mg/lt slows the growth of plants by a reduction in photosynthesis. An optimum environment for growth is 7 mg/lt of oxygen (den Hartog, 1970). It was observed that places which showed the greatest reduction in the lower limit were places which were suffering from the effects of pollution and eutrophication (Dural and Aysel, 2007). At depths where the light intensity is low, the few leaves are unable to get enough light for photosynthesis, and the result is that they cannot produce oxygen in quantities to transfer to the rhizome, so that the sediment becomes anoxic. On coasts where there is dense human population and settlement, a variety of pollutants reduces the water quality and increases turbidity, and thereby causes the lower limit of the plants to recede. Lower limit types in the Gulf of Izmir fall into the category of "*regressive limit*" or '*type 1*' in the classification of Meinesz and Laurent (1978), because the above-mentioned effects extend as far as the outer part of the Gulf (Dural, 2003), (Figure 13).

Posidonia vegetation in the Mediterranean generally occurs at depths down to 38-48 m in different sea types according to light conditions on sandy or muddy bottoms where hard and rocky coasts end (Boudouresque *et al.*, 2006). On the Aegean Sea shores of Turkey, these lower limits were higher than those in offshore areas, such as 35 m in Ayvalık (station 1) and 38 m in Sigacık (Figure1, Station 13). In Izmir Bay, the lower limits of *P. oceanica* meadows showed a gradient from the inner part to the outer part (8.5 m in the inner bay and 33 m in the outer bay) (Dural, 2003) (Figure 14).

Figure 13. '*regressive limit*' limit type found at Gulf of Izmir stations (Urla-Balıklıova coasts) (original)

The minerals and sediments brought in as domestic and industrial waste along with rain water by the approximately nineteen streams and canals where population is at its densest levels (areas as far as stations numbers 4-11) in the inner part of the Gulf have brought the bottom to an anoxic state just as they have raised its level. In particular, the Melez River has played a large part in this, carrying a heavy load of industrial and domestic waste and depositing it in the sea, where it was measured in sampling between the years 1987 and 1990 between stations numbers 6 and 7 (Bayraklı-Alsancak). It is known that the bottom mud from the basin was deposited off Hekim Island and Tuzla when cleaning operations were being carried out in the 1990s, and this area was selected as a dumping ground. Thus, when the deep sea flora of the Urla islands (Akçaada, Pırnallı, Yassıcada ve Hekim Adası) and the surrounding area was studied between 1987 and 1990, the benthic habitats were observed to show a rich variety of coralligenous fauna and floral species (Dural, 1990). In particular *Posidonia* meadows formed a heterogeneous cover because of the rocky character of the bottom, and was found down to a depth of 25-28 m. However, when dredgers dumped mud here brought from the Melez River, the sea bed structure not only of the Urla islands and their surroundings but of a much wider area was irretrievably damaged. This was shown in a very clear way by sampling carried out in the same area in new studies in the sea meadow project covering the years 2000-2003. Unfortunately, natural lower limit values in the middle gulf had receded in ten years from 25-28 m to 11-18 m, and the reduction in the productivity of the area of approximately 35.7% represents a significant loss. This shows that the distribution of beds in the Gulf is being damaged not by natural factors resulting from its location but from environmental threats of human origin.

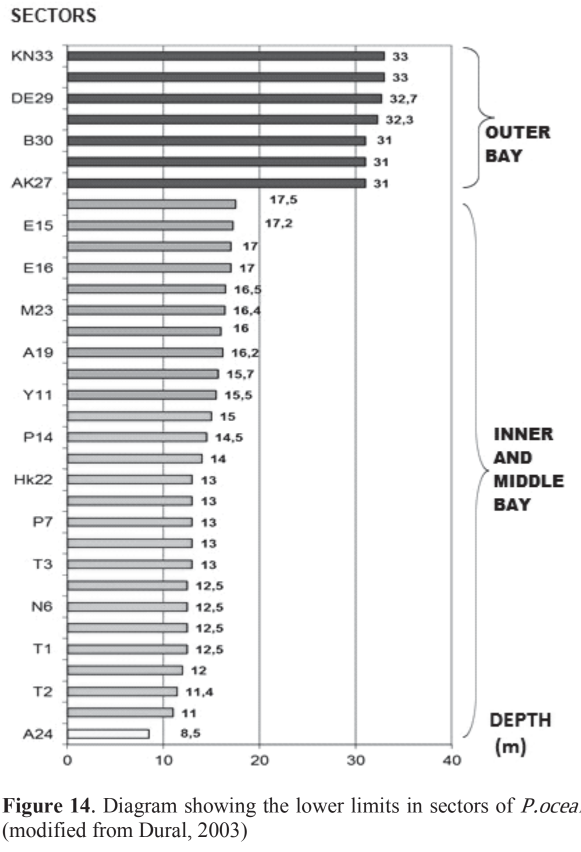

Figure 14. Diagram showing the lower limits in sectors of *P.oceanica* research in the Gulf of Izmir (modified from Dural, 2003)

When we assess studies carried out since 1990 on the density and especially the lower limits of *Posidonia* beds, it is possible to predict the future state of the Gulf of Izmir. Thus, places with lower limits of less than 5-10 m are places under threat from heavy pollution, a situation which as Figure 14 shows is hardly to be found in the Gulf outside the inner part. Aşıklar Çeşmesi is the crossover point between the inner and middle gulf in that the limit for plants is between 5 and 10 m (Figure 15). Towards the inner gulf, plants gradually decrease and eventually disappear altogether, while in the direction of the middle gulf they gradually increase. The highest lower limit values in the Gulf were obtained for region 2, and these are among the highest values obtained in the course of any studies in any region of the Aegean Sea.

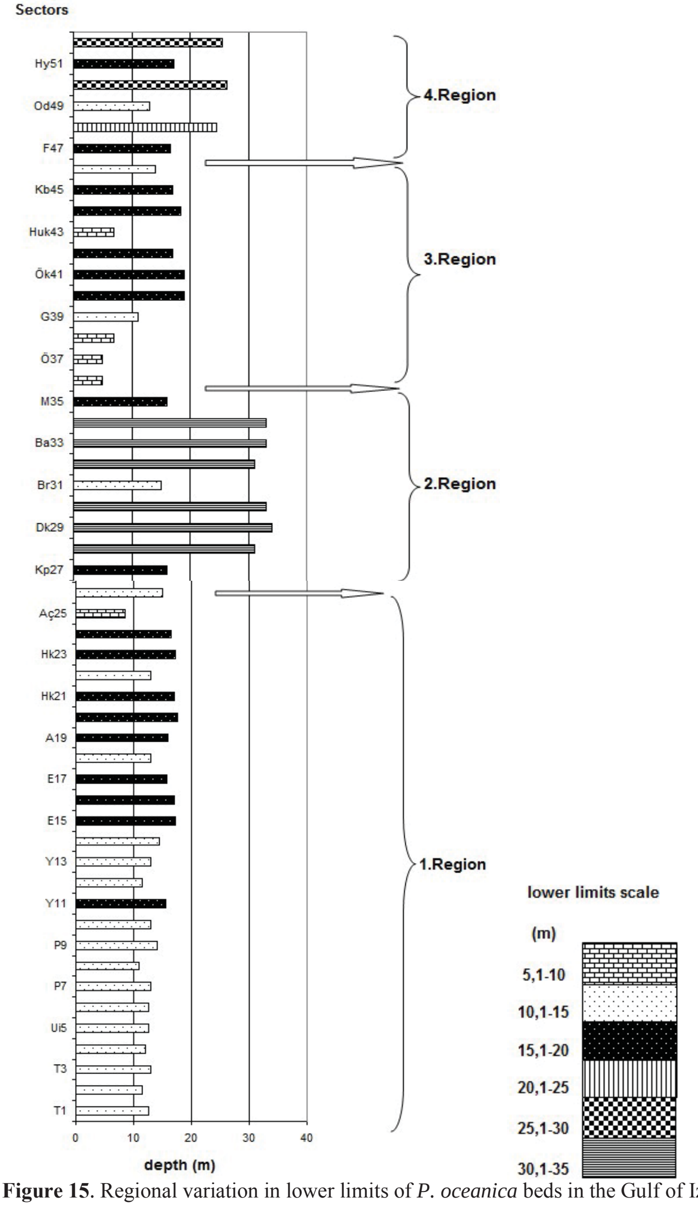

Figure 15. Regional variation in lower limits of *P. oceanica* beds in the Gulf of Izmir (Dural, 2003)

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Distribution of *Posidonia oceanica* (L.) Delile in the Sea of Marmara

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Abstract

In the Mediterranean Basin, the richest benthic coastal ecosystem and the most widespread is the seagrass bed of the Magnoliophyta *Posidonia oceanica*. This endemic species form very dense beds between 0 and 40 m deep. *P. oceanica* growth is very slow (3 cm.y^{-1}) and its reproduction by seeds is very rare. *Posidonia oceanica* beds are very sensitive to disturbances caused by human activity (*e.g.* coastal development, pollution, turbidity, anchoring) and their loss has been observed in a number of regions.

The aim of this study is to better know the distribution of *P. oceanica* in the Dardanelle straits and the Sea of Marmara. In this research the new distribution zones of *Posidonia oceanica*, has been determined around Dardanelle Strait (Dardanos) and Sea of Marmara (Island of Pasalimani) by using marking method. In these zones, the concrete blocks have been put with getting the coordinates by GPS (Global Positioning System) at the deepest border of *P. oceanica* meadows. The temperature capture equipment was settled one of the concrete blocks for getting continuous measurements.

The development process of *P. oceanica* committed to time and temperature variations could be monitor like the other Western Mediterranean Countries by the help of these two reference stations.

Introduction

Posidonia oceanica is the most important seagrass species in the Mediterranean Sea. This species exists between 11^{0}C – 29^{0}C temperatures, salty and clean waters at 0-40m depths. Seagrasses provide oxygen by photosynthesis, capture the particles and sediments for regulating the sea floor by long leaves. The dead leaves of *P. oceanica* create banquets at the shoreline by currents and waves. These structures conserve the shoreline and prohibit the erosion besides a lot of marine species live by the help of these structures. Seagrasses shelter a lot of epibiont species (Boudouresque and Meinesz, 1982; Cirik and Cirik, 1999).The seaweeds and invertebrates live on the leaves and rhizomes of *Posidonia oceanica*. Some fishes and sea urchins fed on these organisms.
Posidonia meadows well developed in shallow enclosed bays and their leaves reach to surface (Figure 1).

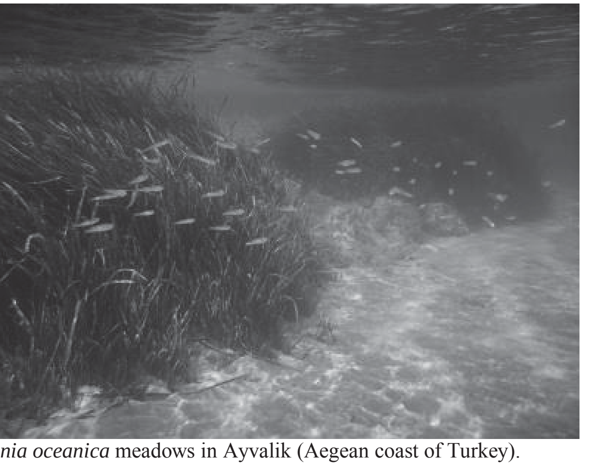

Figure 1. *Posidonia oceanica* meadows in Ayvalik (Aegean coast of Turkey).

The dead *Posidonia* leaves accumulate in seashores and they constitute banquets. This structure protects the seashore from erosion. This natural hummus is sometimes misinterpreted as pollution by some of the managers and they are removed, so the coastline's natural protection power disappears (Figure 2).

Figure 2 a,b. Dead *Posidonia oceanica* leaves banquets in Ayvalik Cunda.

Sometimes a biological structure which looks like a tennis ball can be seen in beaches. It was thought that these structures were made by marine animals for many years. Whereas, the dead *Posidonia* leaves separates into filaments and flocculate around the rhizomes by the wave movements, formed these structures (Figure 3).

Figure 3. The “tennis ball” structures made by *Posidonia oceanica* in beaches.

Posidonia oceanica constitutes a veritable underwater forest, the density of which can reach 1000 leaves per square meter, with 8 leaves measuring 80 to 100 cm long per shoot. Rhizome stem develops horizontally in 4-6 mm thickness and slightly flatten. The stalks of the fallen leaves stay on the stem like a lamina. 5 to 7 leaves gathered together like a bunch at the tip of the rhizome stem. The width of the leaves is 7-11 mm and length 40-120 cm. The ribbon shape leaves have parallel veins. 6-10 leaves grow from every vegetative node in a year. The life expectancy of the leaves is 5 to 13 months. Rhizome grows 5-12 cm horizontally, 0.3 – 7 cm vertically in a year (Figure 4) (Hartog, 1970; Larkum *et al*., 1989; Haznedaroğlu, 1999). Florescence occurs in late winter. Fruits are look like olive (Figure 4) (Caye and Meinesz, 1984; Boudouresque *et al*. 1990; Giraud, 1977).

Posidonia oceanica may show both vegetative and generative growth with seeds. Flower buds begin to appear from September. Florescence can occur between October to December. The composite flowers have a lot of pistils and stamens. The pollens reach to the pistil with the currents. The stigmat part of pistil has a indented shape for catching the pollens (Figure 4). The fruits thrive and rippen through the winter. The rippen fruits may detach from the plant and fallen to the bottom in May-June. They look like an olive with shape, size and color (Figure 4). They can swim 10 15 days in the water. Thus they may move distant places by the help of currents. The unique seed placed in a suitable substrate and become germinate after the fruit part decomposed from seed. However, the suitable conditions may not be occurring every year so this generative growth may not be happened.

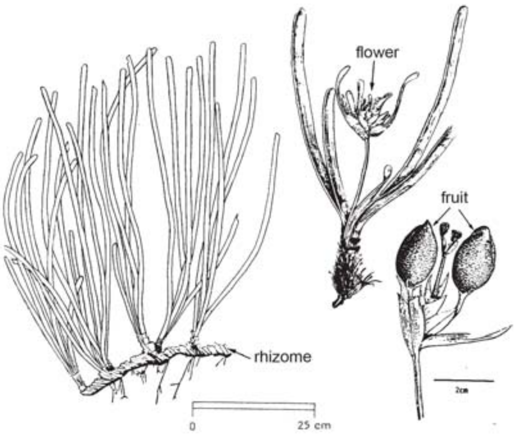

Figure 4. *Posidonia oceanica* morphology; Rhizome, Fruit and flower (Fischer *et al.,*1987).

About the northeastern Mediterranean Basin boundaries of the *Posidonia* beds, contradictory information are available in the general descriptions of the repartition of this seagrass. It is mostly absent in the Dardanelles Strait and Sea of Marmara (Hartog, 1970, Fischer *et al.,* 1987, Boudouresque and Meinesz 1982). Recently, this species was found in the Sea of Marmara (Green and Short, 2003) without any precise information about this northeastern spot (a large point seems to indicate its presence in the west of Istanbul). In 2004, an isolated bed of *Posidonia oceanica* was found in the middle and southern parts of the Sea of Marmara (Yüksek and Okus, 2004).

Posidonia oceanica can live in salinities between 33 ‰ - 39 ‰ (Gobert *et al.* 2006; Sanchez-Lizaso *et al.* 2008) and temperatures between 9^{o}C and 29^{o}C (Boudouresque and Meinesz 1982). Meinesz *et a.l* (2009) found that *P. oceanica* is living in salinities between 21.5-28‰ at the Dardanelle Strait and Marmara Sea. These conditions are extraordinary for *Posidonia oceanica*. They could not spread under salinities 37 ‰ around the river mouths. *Posidonia oceanica* distribution within the Mediterranean Sea is Alboran Sea at west side, Punta Chullera-Cala Sardina (Andalucia, Spain) at northern border, and the south border Sebkha-bou-Areg near Chaffarines island (between Morocco and Spain).The short term mesocosm experiments under controlled conditions *Posidonia oceanica* can tolerate low salinity conditions. They found that, under the salinity 29 %0 in 15 days *Posidonia oceanica* died (Fernandez – Torguemada and Sanchez- Lizaso, 2005).

Since the1970's, repetitive surveys of the seagrass beds became an important way to assess the general health of littoral water. They led to stress the relative importance of different causes of the major negative impacts such as the increase of turbidity due to different causes of pollution, definitive destructions of habitat by constructions on the sea, physical disturbance by fishing trawls, anchoring or use of explosives. More recently the effects of the global change on the hydrologic conditions of the Mediterranean Basin (temperature, salinity, currents) can affect the deepest and geographical boundaries of the *Posidonia oceanica* beds and need a particular survey.

Material and Methods

We quantified the distribution of *Posidonia oceanica* in the Dardanelles Strait and in the Marmara Sea through SCUBA diving observations, beach surveys, discovering large beds in the straits of Dardanelles and isolated populations in the Sea of Marmara. In order to study the distribution of *Posidonia oceanica* all along the Marmara Sea coasts, we collected information about the presence of *Posidonia oceanica* meadows from fishermen and divers in 2004–2005 (awareness by brochures and posters). A total of 30 days of direct surveys were undertaken from the Dardanelles Strait to the West coasts of the Marmara Sea (Gemlik peninsula in the South and Tekirdag in the North: Fig. 5) to record the occurrence of beached dead seagrass material. A total of fourteen surveys by SCUBA diving were performed in zones of potential presence of *Posidonia oceanica* (dead leaves on the coast) and in places where *Posidonia oceanica* was recorded (the first isolated bed of *Posidonia oceanica* has been found in the central southern part of the Marmara Sea by Yuksek and Okus, (2004). For any *Posidonia oceanica* bed discovered, the shallow and deep limits as well as the extension along the shore were localized by GPS. Hydrological data available in the vicinity of each recorded meadow were gathered. The temperature variations recorded with "Water Temperature Data Logger" for one year with 2 hours interval.

Figure 5. Study area

Figure 6. Temperature data logger.

In order to understand the level of genetic isolation of the newly discovered *Posidonia* meadows we assessed the clonal diversity and the genetic affinity with other Mediterranean populations. Meinesz *et al*. (2009) found that the *Posidonia oceanica* populations from Marmara Sea and Dardanelle Strait are different from the other populations from Mediterranean. The decreasing of the allele number has been seen in *Zostera noltii* and *Cymodocea nodosa* which is distributed at temperate seas in same latitude. Clonal diversity also varies at a limit of a species distribution (Billingham *et al*., 2003). Moreover, although all the populations analyzed appeared to be isolated, this is particularly evident in the Marmara Sea and the Dardanelles Strait, where no migrants from other populations were detected. Genetic data clearly show that the population of the Marmara Sea is isolated since a long time (Table 1).

Table 1. Summary of genetic data for the five populations analyzed (Meinesz *et al.* 2009)

	N	*G*	*G/N*	*L*	*A*	Fis	H_e	H_0	Wt	*M*	Ass
Erdek Latitude 40 28 Longitude 27 40	30	9	0.30	6	21	−0.704	0.246	0.426	***	–	–
Dardanos Latitude 40 02 Longitude 26 04	30	24	0.80	7	24	−0.073	0.263	0.288	NS	–	–
Küçukkuyu Latitude 39 31 Longitude 26 32	30	11	0.37	6	24	−0.189	0.213	0.261	NS	1 Dar	3 Dar
Lesbos (Eftalou) Latitude 39 22 Longitude 26 12	18	13	0.72	6	22	−0.306	0.234	0.314	**	–	1 Erd
Dikili Latitude 39 09 Longitude 26 47	30	14	0.47	7	25	0.017	0.231	0.234	NS	2 Ntu	2 Ntu

N: number of samples; *G*: number of genotypes; *L*: number of polymorphic loci; *A*: number of alleles; H_e: expected heterozygosity; H_0: observed heterozygosity, Wt: Wilcoxon test for heterozygosity excess significant at 99% (***), 95% (**) or not significant (NS); *M*: number of first generation migrants and population of origin; Ass: number of genotypes assigned to any other population.

Results

The *Posidonia oceanica* limits have been determined in the Dardanelle Strait and Marmara Sea with the support of a TUBITAK Project (103Y181). According to this study, approximately 31 km long noncontinuous sparse distribution of *Posidonia oceanica* meadows (from the European side of the Dardanelle Strait starting the Cape of Seddulbahir to Kilya bay) was determined. At the Anatolian side it is starting from Cape Kum to Cape Nara which is approximately 35 km long (Figures 7-8).

After determining the distribution of *Posidonia oceanica* in the Dardanelles Strait and Sea of Marmara, two reference stations were chosen for monitoring the situation of the meadows with concrete blocks (Figure 9) similar as like the other Mediterranean countries (Bertrand *et al.*, 1988; Meinesz, 1977; Pergent, 1991).

Posidonia oceanica populations are weak and sparse in the European side of Dardanelle strait because of currents. However, the Anatolian side populations are well developed, therefore the banquettes can be seen at Dardanos shore line. Interview surveys with fishermen, scuba searches, trawling were done to find *P. oceanica* meadows in the Marmara Sea and South Marmara Islands (Ekinlik, Avşa, Marmara, Paşalimanı). As a result of this search, *P.oceanica* meadows were found at Pasalimani island, west of the Kapidag peninsula (Ocaklar, Narli), at 2-7 m depth. *P. oceanica* meadow spreads along the 3.13 km at Pasalimani island coastline with the area of 35.1 hectare and 8 km long at Kapidag peninsula.

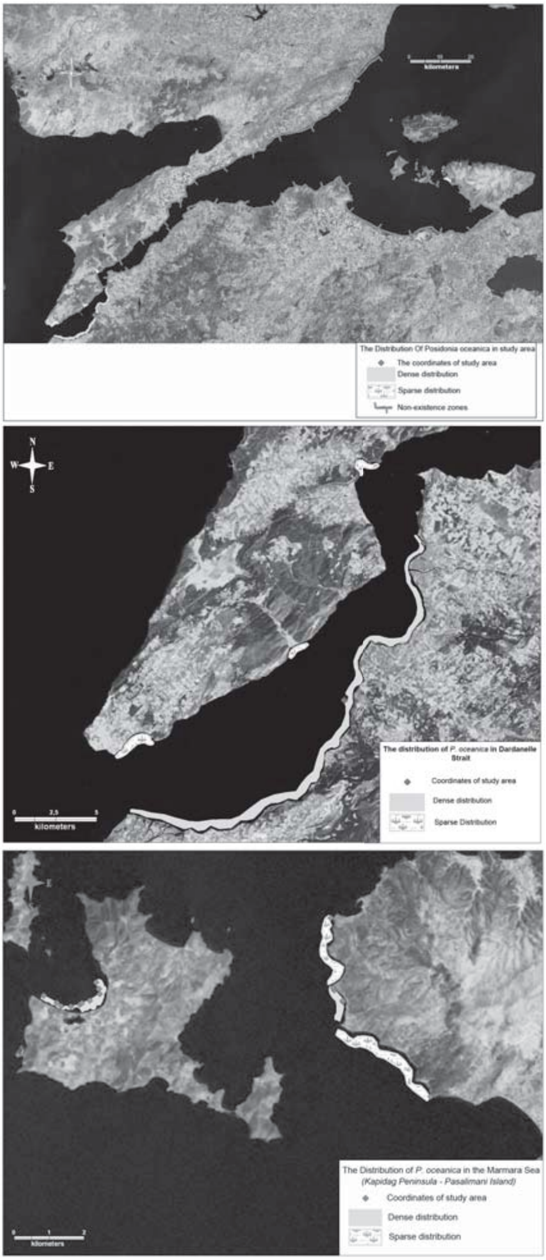

Figure 7. The distribution of *P. oceanica* in study area.

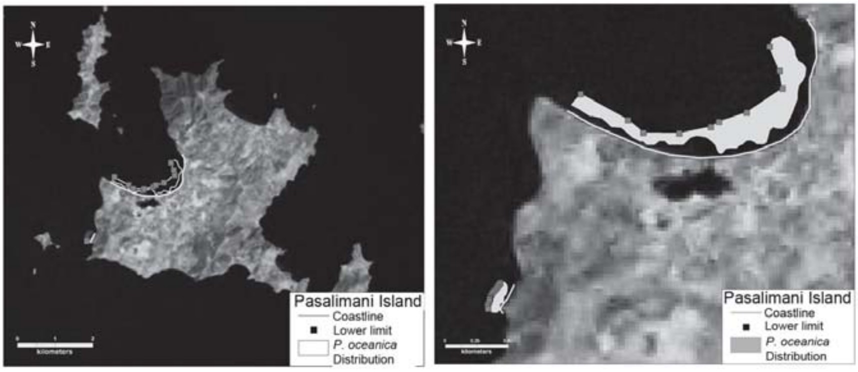

Figure 8. Detailed distribution of *P. oceanica:* Dardanelle Strait, Sea of Marmara and Pasalimani Island.

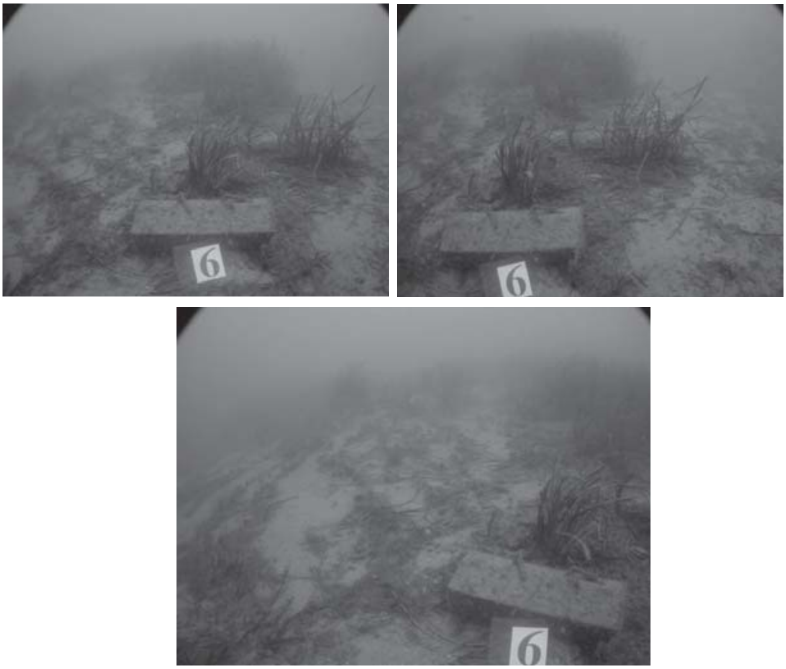

Figure 9. The monitoring stations at Dardanelles Strait.

Posidonia oceanica has a potential of long distance dispersal in theory but the genotypes of the Marmara and Mediterranean Sea populations are different from each other. Its dispersion occurs in two ways, fragmentation of rhizomes and with seeds. The rhizomes cannot disperse long distances because of negative buoyancies. Besides, rhizomes which planted deeper than their usual depth couldn't survive in experimental studies. (Molenaar and Meinesz, 1991). Fruits can float 15 days before releasing the seeds therefore they have high dispersal potential. However, the surface currents should be the Aegean to

Marmara for delivering the fruits but from the Holocene period this current is in the opposite direction.

Posidonia oceanica is an exceptional and perennial species; it can live thousands of years with the vegetative proliferation of the same individual (Marba and Duarte, 1998). When the environmental conditions are suitable for vertical growing, the new plant occurs from the dead nods of rhizome. It is determined that, the rhizomes are directly 4590 ± 140 years old from now (Boudersque *et al.*, 1980; Mateo *et al.*, 1997) and indirectly 6000 – 7000 years old (Mateo *et al.*, 1997).

These rare characteristics showed that, the meadows of *Posidonia oceanica* in the Sea of Marmara exist since Holocene period. The meadows of Marmara Sea are sparse and continue 5-6 km coastline. *Posidonia oceanica* meadows grow rather slow, 1-6 cm/year (Meinesz and Lefevre, 1984; Marba and Duarte, 1998). According to this growth rate, forming a 27 m Radius meadow from a single seed takes 600 years (Kendrick *et al.*, 2005). When the growth rate, distribution characteristics, rhizome width and genetic data of *Posidonia oceanica* meadows of Marmara Sea are evaluated, it is thought that, this population exists in Marmara Sea since the middle of Holocene period.

Posidonia oceanica, which has an important biological and ecological function, is an important plant, but negatively affected by a variety of human activities: harbour and marina constructions, land fill at coastline, marine discharges, sea bottom dredging *etc*. Therefore, the area where the dense meadow exits has to preserve with legally.

The causes which is listed above has been identified that, *Posidonia oceanica* meadows increasingly disappearing and their dispersion limits are decreasing. Additionally, this plant grows very slowly (1-6 cm/year). Thus, maximum attention has to show to protect this species. The transplantation experiment has been done in Western Europe. But it is a difficult, time consuming and expensive work. The success from this work is not feasible.

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Setting up the Medposidonia Programme along Turkish coastline

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Abstract

The MedPosidonia programme aims to obtain additional information on the presence and evolution of Posidonia meadows (*Posidonia oceanica*) in four Mediterranean countries (Algeria, Libya, Tunisia and Turkey). Actions in Turkey were performed in two sites: Gökçeada Island and Mersin. The cartography of the shallow water habitats (0 to -10 m) has been carried out by remote sensing in each site. The lower limit was located along more than a one-kilometer distance by SCUBA diving and GPS positioning. A standardized monitoring system was set up along this lower limit of the *Posidonia* meadow. Two shoots are collected at the back of each marker and a sediment core is extracted centrally. Phenology and lepidochronology are measured in the laboratory, as well as grain size and organic matter content of the sediment. All these parameters were integrated in standardized grid to assess the vitality of the meadow

Introduction

Seagrass meadows are considered among the most important marine ecosystems, for biodiversity, ecological and economic reasons (Phillips and Mc Roy, 1980; Costanza *et al*., 1997; Duarte, 1999). *Posidonia oceanica* an endemic Mediterranean species, grows in extensive beds covering around 25% of the seabed between 0 and 50 m depth (Pasqualini *et al*., 1998). This seagrass is considered as an engineer species and plays a major role in coastal equilibrium (Boudouresque *et al*., 2012).

In order to avoid loss and degradation of the seagrass meadows and other important vegetal assemblages, an “Action Plan for the conservation of marine vegetation in the Mediterranean Sea” has been adopted by the Contracting Parties to the Barcelona Convention in 1999 (UNEP-MAP-RAC/SPA, 1999). If mapping the distribution of a seagrass meadow, and comparing it with previous maps, seems to provide a reliable basis for inferring changes over time in the surface area of the meadow (McKenzie *et al.*, 2001; Boudouresque *et al.*, 2012), ancient maps are unfortunately not available, in most parts of the Mediterranean Sea.

The MedPosidonia programme, initiated by the Regional Activity Centre for Specially Protected Areas (RAC/SPA) in partnership with the Total corporate Foundation, was aimed to obtain additional information on the presence and evolution of Posidonia meadows (*Posidonia oceanica*) in four Mediterranean countries (Algeria, Libya, Tunisia and Turkey) with a view to using these information 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.

In the framework of this program Turkish coastline is of specific interest due to the fact that it seems to include the Northwestern (Meinesz *et al.*, 2009) and Southeastern limits (Celebi *et al.*, 2006) of extension of this species. In the context of global change, the extension of *Posidonia oceanica* meadows could move quickly, as soon as the vitality of the plant (Marba and Duarte, 2010; Pergent *et al.*, 2012). Several actions were carried out and especially mapping, setting up monitoring systems and assessing vitality in two sites, located in the vicinity of these limits of extension.

Material and methods

The activities were performed in two sites: the first, in June 2008, in the Northwestern part of Turkey, near the Dardanelles Strait (Gökçeada Island - Yıldız Bay) and the second, in October 2008, in Southeastern part of Turkey (area of Mersin - Turgutlar Bay).

The Gökçeada Island, and more particularly a stretch of its Northwestern coast, was identified as a potential site for the creation of a marine protected area according to its important biodiversity (Öztürk and Öztürk, 2003). The coasts of the Mersin area correspond to the Southeastern limit of extension of the Posidonia meadow in the Mediterranean. The geographical limit of extension of this species seems related to a too high water temperature during summer (Celebi *et al.*, 2006). Also within the global climate change context, it appears of particular relevance to monitor the evolution of this particular Posidonia meadow.

The cartography of the shallow water habitats (0 to -10 m) has been carried out by remote sensing in each site, using a QUICKBIRD image (pixel of 0.6 m) for the Yıldız Bay and an IKONOS image (pixel of 1 m) for the Turgutlar Bay.

The lower limit was located along more than a one-kilometer distance by SCUBA diving and GPS positioning. A standardized monitoring system was set up along this lower limit of the Posidonia meadow (Boudouresque *et al.*, 2000; Pergent *et al.*, 2007). This consists in setting eleven fixed markers every five metres, on the edge of the lower limit, in order to follow any changes (progression or regression) or evolution (Pergent-Martini *et al.*, 2005; Boudouresque *et al.*, 2012). The precise position of each marker is recorded (microcartocraphy), while density (40x40 cm quadrat on the upper limit and reference depth of 15 m, and 20x20 cm quadrat on the lower limit), cover ($1m^2$

quadrat), percentage of plagiotropic rhizomes and shoot baring are measured. The depth (Vyper, Sunto© - precision ± 10 cm) and type of limit (progressive, sharp high cover, sharp low cover, sparse or regressive) are also given. Horizontal and vertical views are taken by video in order to have an as precise as possible representation of the limit (Pergent *et al.*, 2007). Two shoots are collected at the back of each marker and a sediment core is extracted centrally. Phenology and lepidochronology are measured in the laboratory, as well as grain size and organic matter content of the sediment. In the Yıldız Bay, additionnal scientific measurements were made at a reference station (-15 m) to assess the vitality of the meadow and adjacent water bodies (Pergent, 2007).

All these parameters were integrated in standardized grid to assess the vitality of the meadow (Pergent, 2007; Tables 1 to 8).

Table 1. Evaluation of the depth of the lower limit

	High	Good	Moderate	Poor	Bad
Depth (m)	>34.2	34.2 to 30.4	30.4 to 26.6	26.6 to 22.8	<22.8

Table 2. Evaluation of the type of the lower limit

Type of limit	Description	
Progressive (PR)	Plagiotropic rhizome in front of the limit	High
Sharp High Cover (HC)	Sharp limit with meadow cover > 25%	Good
Sharp High Low (LC)	Sharp limit with meadow cover < 25%	Moderate
Sparse (SP)	Shoot density < 100 shoots/m^{-2} and cover < 15%	Poor
Regressive (RE)	Dead matte in front of the limit	Bad

Table 3. Evaluation of the density of the meadow according to the depth (simplified)

Depth (m)	High		Good			Moderate			Poor			Bad	
1	>	1133	1133	to	930	930	to	727	727	to	524	<	524
3	>	1005	1005	to	808	808	to	612	612	to	415	<	415
5	>	892	892	to	709	709	to	526	526	to	343	<	343
7	>	792	792	to	623	623	to	454	454	to	284	<	284
9	>	703	703	to	547	547	to	391	391	to	235	<	235
11	>	624	624	to	481	481	to	338	338	to	195	<	195
13	>	554	554	to	423	423	to	292	292	to	161	<	161
14	>	522	522	to	397	397	to	272	272	to	147	<	147
15	>	492	492	to	372	372	to	253	253	to	134	<	134
16	>	463	463	to	349	349	to	236	236	to	122	<	122
17	>	436	436	to	328	328	to	219	219	to	111	<	111
19	>	387	387	to	289	289	to	190	190	to	92	<	92
21	>	344	344	to	255	255	to	165	165	to	76	<	76
23	>	305	305	to	224	224	to	144	144	to	63	<	63
25	>	271	271	to	198	198	to	125	125	to	52	<	52
27	>	240	240	to	175	175	to	109	109	to	43	<	43
29	>	213	213	to	154	154	to	95	95	to	36	<	36
31	>	189	189	to	136	136	to	83	83	to	30	<	30
33	>	168	168	to	120	120	to	72	72	to	24	<	24
35	>	149	149	to	106	106	to	63	63	to	20	<	20
37	>	133	133	to	94	94	to	55	55	to	17	<	17
39	>	118	118	to	83	83	to	48	48	to	14	<	14
40	>	111	111	to	78	78	to	45	45	to	13	<	13

Table 4. Evaluation of foliar surface (in cm^2 $shoot^{-1}$) between June and July; for other season a corrective coefficient is applied

	High	Good	Moderate	Poor	Bad
Reference depth (-15 m)	> 362	362 to 292	292 to 221	221 to 150	< 150

Table 5. Evaluation of rhizome elongation (in mm $year^{-1}$)

	High	Good	Moderate	Poor	Bad
Reference depth (-15 m)	> 11	11 to 8	8 to 5	5 to 2	< 2

Table 6. Evaluation of organic matter in the sediment (in percentage, fraction <0.063 mm)

	High	Good	Moderate	Poor	Bad
Reference depth (-15 m)	< 2.5	2.5 to 3.5	3.5 to 4.6	4.6 to 5.6	< 5.6

Table 7. Evaluation of Silver concentration ($mg.g^{-1}$ DW), blade of adult leaves between June and July)

	High	Good	Moderate	Poor	Bad
Reference depth (-15 m)	< 2.5	2.5 to 3.5	3.5 to 4.6	4.6 to 5.6	< 5.6

Table 8. Evaluation of Mercury concentration ($mg.g^{-1}$ DW), blade of adult leaves between June and July)

	High	Good	Moderate	Poor	Bad
Reference depth (-15 m)	< 0.035	0.035 to 0.053	0.053 to 0.067	0.067 to 0.092	< 0.092

Results

The cartography of the main habitats and bottom types of Yıldız Bay highlights a “return river” which occupies the central part of the bay (Figure 1A). It is classically delimited by a *Posidonia oceanica* meadow while extensive rocky substrates are located along coastlines. Off the coast, the *Posidonia oceanica* meadow grows untill 28m depth (lower limit).

In Turgutlar site, the *Posidonia oceanica* meadow develops in the central part of the bay, between 5 and 14 m depth. Unvegetated soft substrates are observed in the shallow part of the bay while rocky substrates are present along the coast (Figure 1B). Their extension in the Northeastern part of the Bay corresponds to pebbles provided by a small coastal river.

The *Posidonia oceanica* cartographies are reported on a Geographical Information System (ArcGIS 10) and transform to be readable on Google Earth software.

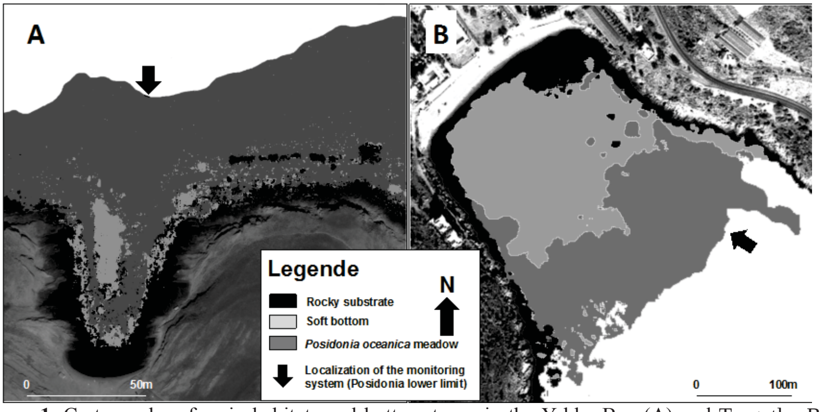

Figure 1. Cartography of main habitats and bottom types in the Yıldız Bay (A) and Turgutlar Bay (B)

For each site, a representative portion of the lower limits of *Posidonia oceanica* meadow is equipped with 11 markers, a precise plan is drawn up, and underwater photographs of the limit of the *Posidonia oceanica* meadow are taken at each marker, in order to provide the most precise possible reference base (Figure 2).

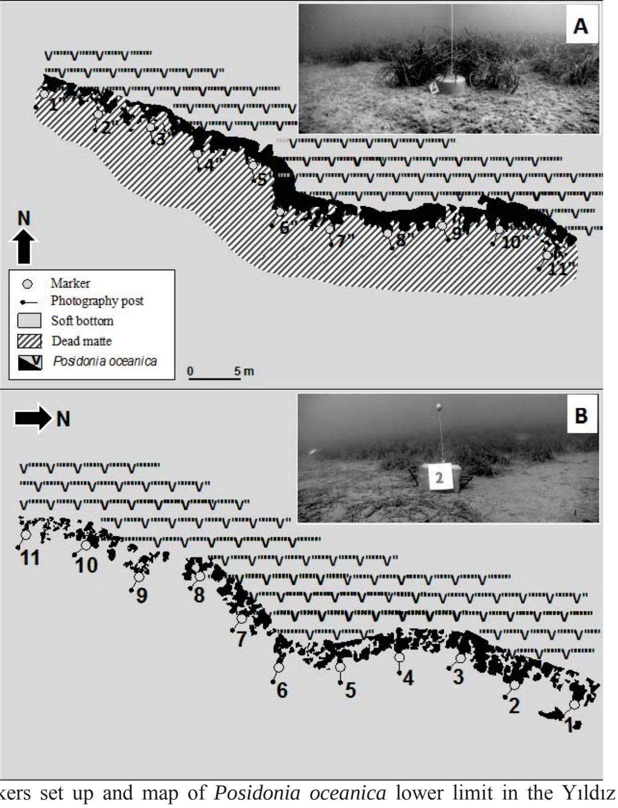

Figure 2. Markers set up and map of *Posidonia oceanica* lower limit in the Yıldız Bay (A) and Turgutlar Bay (B)

In Yıldız Bay, the lower limit is situated between 25.5 and 27.4 m depth and corresponds to a regressive limit (dead matte in front of the limit). The meadow density behind the limit varies from 42 to 117 shoots m^{-2}; with an average of 77±13 shoots m^{-2}. The cover of the limit ranges from 30 % to 80 % with an average value of 51±10 %. The silting of the orthotropic shoots, which made up nearly all the meadow, is high (4.3±1.0 cm on average) and the percentage of plagiotropic rhizome is very important 80.2±9.7 %.

The shoots sampled all along the lower limit are subjected to phenological (Table 9) and lepidochronological studies. The average number of leaves produced annually is 6.2±1.0 and the growth rate of the rhizomes is 5.4±1.4 mm yr^{-1}.

Granulometric analysis of the sediment gives a bimodal frequency histogram and the average size of the sediment particles is 1.41 mm corresponding to coarse sand. The percentage of organic matter (in the fraction <0.063 mm) is very important (15 %).

Table 9. Phenological parameters measured at Gökçeada Island at the lower limit level and at 15 m depth (reference site)

	Yıldız Bay (lower limit)			Yıldız Bay (-15 m)		
	Adults	Intermed.	Global	Adults	Intermed.	Global
Nb leaves.shoot^{-1}	3.3 ± 0.6	2.4 ± 0.5	5.7 ± 0.9	4.4 ± 0.3	2.2 ± 0.3	6.6 ± 0.4
Length (mm)	448.0 ± 52.6	527.0 ± 74.7	487.3 ± 65.3	495.8 ± 23.1	528.0 ± 61.1	511.7 ± 45.6
Width (mm)	10.1 ± 0.3	9.3 ± 0.4	9.7 ±0.4	9.6 ± 0.2	8.7 ± 0.2	9.2 ±0.3
Coefficient A (%)	16.0 ± 10.3	10.0 ± 13.9	12.6 ± 9.9	52.9 ± 11.6	3.0± 4.4	36.3 ± 7.9
F. surf. ($cm^2.shoot^{-1}$)	140.9 ± 18.5	115.4 ± 23.4	256.3 ± 32.9	207.5 ± 14.5	101.8 ± 14.8	309.2 ± 17.7
L.A.I. ($m^2.m^{-2}$)	1.0 ± 0.2	0.9 ± 0.2	1.9 ± 0.4	3.9 ± 0.6	1.8 ± 0.4	5.7 ± 0.9

The *Posidonia oceanica* meadow observed in the reference site (-15 m depth) of Yıldız Bay corresponds to a continue plain meadow. It grows on a relatively sharp slope and the presence of several rocks is observed. The meadow density is 198±2 shoots.m^{-2} and varies between 188 and 206 shoots.m^{-2}; the percentage of plagiotropic rhizomes is 26.2±8.2 % and the silting of the orthotropic shoots is high (5.8±0.9 mm).

The shoots sampled at this reference site are subjected to phenological (Table 9) and lepidochronological studies. The average number of leaves produced annually is 5.8±1.0 and the growth rate of the rhizomes is 4.4±1.2 mm.yr^{-1}.

In Turgutlar site, the lower limit, situated between 13.0 and 14.5 m depth, could be also characterized as a regressive limit but the extension of dead mattes are relatively limited (2 or 3 meters wide) and numerous plagiotropic rhizomes are observed in front of the limit (recolonization?). The meadow density behind the limit varies from 192 to 383 shoots m^{-2}; with an average of 283±35 shoots m^{-2}. The cover of the limit ranges from 10 % to 70 % with an average value of 43±13 %. The silting of the orthotropic shoots is lower (3.4±1.9 mm) while the percentage of plagiotropic rhizomes is weak (8.8±3.9 %).

The shoots sampled all along the lower limit are subjected to phenological (Table 10) and lepidochronological studies. The average number of leaves produced annually is 7.2±1.2 and the growth rate of the rhizomes is 4.8±1.5 $mm.yr^{-1}$.

Granulometric analysis of the sediment gives a unimodal frequency histogram with a average size of the sediment particles of 0.68 mm (coarse sand). The percentage of organic matter (in the fraction <0.063 mm) is important (5 to 6 %).

Table 10. Phenological parameters measured at Mersin area (Turgutlar)

	Turgutlar Bay		
	Adults	Intermed.	Global
Nb $leaves.shoot^{-1}$	2.5 ± 0.2	1.1 ± 0.2	3.3 ± 0.2
Length (mm)	216.9 ± 16.7	81.0 ± 6.6	151.4 ± 32.8
Width (mm)	8.9 ± 0.3	8.9 ± 0.8	8.9 ±0.3
Coefficient A (%)	60.0 ± 14.3	0.0 ± 0.0	41.2 ± 9.9
F. surf. ($cm^2.shoot^{-1}$)	47.6 ± 5.6	9.1 ± 1.9	56.0 ± 6.2
L.A.I. ($m^2.m^{-2}$)	1.2 ± 0.1	0.2 ± 0.1	1.4 ± 0.1

Discussion

Due to their location, clothe to the limit of distribution of the specie, these meadows exhibit a weak vitality, especially for the Posidonia meadow of Mersin region. The use of standardized indexes (POSID and BiPo) appears as good mean to evaluate and to compare the vitality of the meadows (PNUE-PAM-CAR/ASP, 2009 ; Lopez Y Royo *et al.*, 2010). For each site an Ecological Quality Ratio (EQR) is calculated and compared to a standardized evaluation scale (Table 11).

Table 11. Evaluation of the Ecological Quality Ratio and corresponding status of the water body according to European Water Framework Directive

	High	Good	Moderate	Poor	Bad
Ecological Quality Ratio	1.00 to 0.90	0.90 to 0.75	0.75 to 0.55	0.55 to 0.30	0.30 to 0.00

The values highlight a “moderate” vitality for Yıldız Bay, with a mean EQR of 0.449 for POSID index and 0.052 for BiPo index, while the values recorded in Tugutlar Bay correspond to a “poor” vitality with a mean EQR of 0.367 for POSID index and 0.359 for BiPo index; Table XIII).

Table 12. Evaluation of Ecological Quality Ratio using POSID and BiPo index in Gökçeada Island and Mersin area. H=High, G=Good, M=Moderate, P=Poor and B=Bad. EQR= Ecological Quality Ratio

* : The type of lower limit is adapted from Table 2

POSID index	Density ($shoot.m^{-2}$)	Depth (%)	Surface ($cm^2.shoot^{-1}$)	Rhiz. growth (mm)	O.M. (%)	Hg ($\mu g.g^{-1}$)	Ag ($\mu g.g^{-1}$)
Depth	-15 m	L. limit	-15 m	-15 m	L. limit	-15 m	-15 m
Compartment	Shoot	Meadow	Leaf	Rhizome	Sediment	Leaf	Leaf
Yıldız Bay	198.4 (P)	27 (M)	309.2 (G)	4.4 (P)	15.2 (B)	0.069 (H)	0.17 (H)
Turgutlar Bay	282.6 (M)	15 (B)	112.0 (B)	4.8 (P)	5.6 (P)	0.093 (B)	0.05 (H)

BiPo index	Limit depth	Type of limit*	Density ($shoot.m^{-2}$)	Surface ($cm^2.shoot^{-1}$)
Depth	Lower limit	Lower limit	15 m	15 m
Compartment	Meadow	Meadow	Shoot	Leaf
Yıldız Bay (values)	27	Regressive	198	309
Yıldız Bay (EQR)	0.63	0.21	0.41	0.96
Turgutlar Bay (values)	14	Regressive	283	112 (/summer)
Turgutlar Bay (EQR)	0.27	0.21	0.65	0.31

Nevertheless, in despite of this weak vitality, in both cases, the meadows exhibit signs of recolonization (plagiotropic rhizomes) and very low level of contamination (Table 12). Moreover, the future evolution of these reference sites will contribute to a better knowledge of the resilience of *Posidonia oceanica* meadow in climatic change context.

Finally, the MedPosidonia programme appears as a successful initiative in terms of (i) biodiversity conservation, through enhancing the knowledge of one of the most important Mediterranean habitats, (ii) implementation of the Action Plan for the conservation of marine vegetation in the Mediterranean Sea, (iii) national teams capacity-building, (iv) initiation of cooperation mechanisms between scientists, managers and the private sector, under the overall umbrella of an inter-governmental institution (UNEP/MAP-RAC/SPA), (v) acquisition of new data for areas where Posidonia meadows are poorly known, and (vi) setting up of a monitoring network based on standardized protocols that can be easily extended to other sites in the region.

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Posidonia oceanica (L.) Delile epiphytes with particular reference to bryozoans

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Introduction

Posidonia oceanica, endemic to the Mediterranean Sea, plays a significant role in temperate and tropical coastal marine systems. This most valuable ecosystem along the Mediterranean coast has been protected by both national and European frameworks. In Turkey, trawling activities are completely prohibited in some bays, gulfs and protected areas. Fishing regulations that supply indirect protection for the species, also limit the activity near the shore (Can and Demirci, 2012).

In the Mediterranean Sea, *P. oceanica* meadows are climax community well adapted to environment characterized by low nutrient concentration (Gobert *et al.*, 2006). Seagrass ecosystems, which provide nutrient recycling, oxygen production and shoreline protection, and offer suitable substrate for settlement and growth for number of sessile organisms, are characterized by high biodiversity and productivity. However, the excessive organic matter derived from human activity has led to decline or in some cases completely destructs seagrass beds, as well as deterioration of water and sediment peculiarities (Delgado *et al.*, 1997; Pergent *et al.*, 1999; Cancemi *et al.*, 2000; Russell *et al.*, 2005; Leoni *et al.*, 2006; Marbà *et al.*, 2006). In the *Posidonia* meadows near to fish farm activity, shoot size, leaf growth rate and the number of leaf per shoot decreased mainly due to herbivore pressure, light reduction, sediment redox changes and carbon budget imbalances in plant (Alcoverro *et al.*, 1995; Ruiz *et al.*, 2001; Alcoverro *et al.*, 2004; Kocak *et al.*, 2011). The changes in species composition of epiphytic assemblages and their relative abundances, epiphyte load, shoot density, leaf shoot biomass, ash content of the epiphytes and nitrogen concentration of leaves are the monitoring tools to evaluate the anthropogenic input. However, the low species richness in a disturbed location could be related to water quality parameters as well as several natural factors such as depth gradients, grazing, seagrass features and local hydrodynamics (Cornelisen and Thomas, 2004; Balata *et al.*, 2007; Prado *et al.*, 2007a; Ben Brahim *et al.*, 2010; Martínez-Crego *et al.*, 2010; Kocak *et al.*, 2011). Moreover, the biomass of *P. oceanica* and its epiphytes and its contribution to N uptake can vary seasonally (Lepoint *et al.*, 2007).

Seagrass rhizomes characterized by sciophilous and long living epiphytes are steadier and long-living structures. Conversely, leaves consisted of photophilous and ephemeral species represent a relatively unstable substrate controlled by the life cycle of the plant. There is an inverse relationship between abundance of epiphytic algae which is more abundant near leaf apex and invertebrates such as bryozoans are common epiphytes of *P. oceanica* (Borowitzka *et al*., 2006; Ben Ismail *et al*., 2010). Nevertheless, available substratum for settlement is restricted by decreasing shoot density and leaf biomass. Shoot density was highly related with sampling depth and locality (Kocak *et al*., 2011). In the Mediterranean Sea, the density ranged from 652 ± 19.5 to 681 ± 33.2 shoots.m^{-2} and from 583 ± 27.9 to 601 ± 22.7 shoots.m^{-2} at 10 and 20 m depth, respectively (Nesti *et al*., 2009). Leaf and rhizome epiphytes may respond differently to anthropogenic disturbance. While leaf epiphytes varied between impacted and reference meadows, the rhizome epiphyte did not show sensitivity to this kind of disturbance (Balata *et al*., 2008). Therefore, leaf epiphytes have been widely investigated for several species of seagrass (Piazzi *et al*., 2004; Pardi *et al*., 2006; Tsirika *et al*., 2007; Martínez-Crego *et al*., 2010).

The sensitivity of seagrass epiphytes

The sensitivity of seagrass epiphytes makes them a useful sentinel species to detect ecological status of coastal waters. Human activities such as fish farming (Delgado *et al*., 1997; 1999; Ruiz *et al*., 2001; Apostolaki *et al*., 2011), sewage and agricultural runoff (Hauxwell *et al*., 2003) can alter the composition and abundance of the epibiota (Martínez-Crego *et al*., 2010). Epiphytes assemblages on leaves and rhizomes playing an important role in seagrass ecosystem give a fundamental contribution to the primary production and food resource for many organisms. However, heavy epiphytes growing on *P. oceanica* leaves hinders ammonium (NH_4^+) and nitrate (NO_3^-) uptake of seagrass leaves from the water column (Apostolaki *et al*., 2012). *Posidonia* leaves and their epiphytes have important role in transfer of nitrogen from the water column to the benthic component. The contribution of epiphytes to the leaf community uptake changed between 8% and 51% and showed great seasonal variations (Lepoint *et al*., 2007). Epiphyte composition and abundance are mainly controlled by nutrient availability, physical constraints (hydrodynamic flows, sediment features) and biological interactions (grazing by herbivores, dispersion and competition) (Ruiz *et al*., 2009). The leaf epiphyte biomass close to the sites of aquaculture activities and of nutrient inputs showed increase due to increasing N availability (Lepoint *et al*., 2007; Martínez-Crego *et al*., 2008; Prado *et al*., 2008). However, according to Terrados and Medina Pons (2008), epiphyte load was not a sensitive indicator of anthropogenic nutrient loading in Cabrera Archipelago National Park (Balearic Island, Western Mediterranean) at both 7m and 17m depths. In contrary to epiphyte load, nitrogen concentration in *P. oceanica* leaves was found higher in the disturbed site than in two selected reference sites at shallow meadows. In the list created for potential indicators of seagrass response to increasing human-induced environmental stressors, N and P content in seagrass tissues has been described as a sensitive indicator (Martínez-Crego *et al*., 2008).

Substrate availability and the life cycle of *P. oceanica* play a key role in epiphytic community. Significant differences in species richness and coverage of epiphytes on *Posidonia* leaves of different ages may explain the importance of substrate and larval availability of epiphytic organisms in the ecosystem. In general, anthropogenic impacts interfere with natural patterns which significantly influence epiphytic composition. These natural patterns include depth gradients (Mazzella *et al*., 1989; Bedini *et al*., 2003; Kocak *et al*., 2011), spatial heterogeneity from small to large scales (Piazzi *et al*., 2004; Balata *et al*., 2007), herbivory (Tomas *et al*., 2005; Ruiz *et al*., 2009; Martínez-Crego *et al*., 2010; Ben Brahim *et al*., 2010), sea grass features such as leaf length and shoot density (Mazzella *et al*., 1989; Martínez-Crego *et al*., 2010), or meadow structure (Healey and Hovel, 2004).

The *P. oceanica* density was inclined to decrease along the depth gradient which is not correlated with the environmental status of sites. In particular, Leaf Area Index (LAI) values dropped towards deep station because of decreased meadow density. LAI is not only affected by the shoot density but also by the leaf length and width. However, higher values (5.67 ± 0.58 $m^2.m^{-2}$) of LAI for adult leaves in the deepest station at the control site were reported by Kocak *et al*., 2011. The adult leaf surface area also increased along the depth gradient and higher values were recorded during summer (Tsirika *et al*., 2007). Depth independent spatial variability at different scales may be impressed both natural heterogeneity (*i.e.* herbivory, morphological features, short-term fluctuations in hydrodynamic forces) and environmental quality (*i.e.* different source of pollution and their interactions). Many indicators are precise response to environmental changes at one location. However, some of them showed low sensitivity to stress and high heterogeneity at smaller scales. Significant differences between impacted and control sites in shallow meadows were not correlated to the environmental status of deep meadows. In other words, epiphyte communities in deep meadows respond more clearly to environmental differences than in shallow meadows where high natural variability are effective (Martínez-Crego *et al*., 2008; 2010).

In large-scale processes including geographical pattern, differences in light and nutrient conditions are well known sources of variability for seagrass meadows (Alcoverro *et al*., 1995). Small scale processes are influenced by local environmental properties such as characteristics of canopy, shoot density, local hydrodynamic flows and consequently dispersal, settlement and recruitment of propagules (Tsirika *et al*., 2007; Nesti *et al*., 2009). In addition to variability in the scale of meters, biotic and abiotic interactions have influence on the seagrass epiphytes (Michael *et al*., 2008). Long term monitoring studies with large number of replicates in a small scale have important input for prediction of how local changes will be effective on epiphyte assemblages. The study carried out north-west Mediterranean Sea showed that there were no significant differences among habitats in the same geographic area in terms of number of species on leaf and rhizome assemblages (Balata *et al*., 2007). However, the total percentage cover of organisms on leaves was found to be significantly different among habitats. Both number of species and percentage cover of these species on the leaf and rhizome parts showed a large variability among meadows and at small spatial scale within each meadow (Vanderklift and Lavery, 2000; Piazzi *et al*., 2004; Balata *et al*. 2007). Although *P.oceanica* meadows in the same area were characterized by patchy distribution of epiphytic organisms, this assemblage was more homogenous at large scale. This situation could be explained by both geographical and local processes which are important in forming epiphytes on *Posidonia oceanica* leaves (Pardi *et al*., 2006)

Epiphyte communities in shallow meadow are subjected to physical disturbance (current and wave action), herbivore pressure and variability of light intensity and temperature (Martínez-Crego *et al*., 2010). Either shallow meadows or sea grass beds near fish farming cages are represented by significantly shorter leaves. Regarding the control and impact meadows, “A” coefficient values changed among sites in the range of 42% to 70%, respectively (Kocak *et al*., 2011). The numbers of bites taken by the herbivorous fish *Sarpa salpa* were greater on the leaves subjected to additional nutrient input (Balata *et al*., 2010). The loss of apical part of the leaves is associated with reducing algal species richness (Martínez-Crego *et al*., 2010). On the other hand, the leaf growth habit of two different *Posidonia* species, *P. sinuosa* and *P. australis* were also effective on the species richness and coverage of epiphytes (Trautman *et al*., 1999). Species richness and epiphytic biomass in the oldest leaf part displayed significant differences among sites. In some cases increase of few species on the leaves under enriched condition may not be reduced by intense grazing (Balata *et al*., 2010).

Bryozoans as a leaf and rhizomes epiphytes

Bryozoans are one of the most common sessile organisms of the epiphytic community of *P. oceanica* meadows (Piazzi *et al*., 2004; Pardi *et al*., 2006). Epiphytic bryozoans were qualitatively described in various Mediterranean regions (Harmelin, 1973; Hayward, 1974a; Balduzzi *et al*. 1983; Castritsi-Catharios and Ganias, 1989; Chimenz *et al*. 1999; Kocak *et al*. 2002; Balata *et al*., 2007; Nesti *et al*. 2009).

Although the growth pattern of bryozoan epiphytes was affected by the flexibility and duration of the substratum, remaining in small colonies and beginning to reproduction activity in small size are their adaptation strategies to live on *P. oceanica* leaves (Hayward, 1974a). *Posidonia* leaves shed in autumn and spring period with a lot of epiphytic organisms on them. In contrast to other host species such as *Laminaria digitata* and *Fucus serratus*, *P. oceanica* offers suitable substrate for approximately 100 bryozoan species growing on it. It provides smooth and flexible hard substratum for bryozoan species (Hayward, 1974a). Some of them are endemic for the Mediterranean Sea (Hayward, 1974b). The restricted distribution of the bryozoan species on the distal part of the leaves could be related to their settlement time whether it is prior to the period of rapid plant growth or later (Hayward, 1974a). Rhizomes presented with higher species richness could be considered a more stable system with respect to leaves (Occhipinti Ambrogi, 1986; Nicoletti *et al*., 1995; Kocak *et al*., 2002). *Copodozum planum, Pherusella tubulosa, Microporella ciliata, Crisia fistulosa, Schizomavella hastata* and *Reptadeonella violacea* were found denser on rhizome communities with regard to those developed on the leaves along the coast of Tunisia (Ben Ismail *et al*., 2010). *Scizobrachiella sanguinea* also exhibited greater abundance on the rhizomes in treated patches (Balata *et al*., 2010) and adult colonies of this species inhabited preferentially sciaphilic habitats (Mariani *et al*., 2005). *Calpensia nobilis* is another species covering rhizomes with a thick encrustation particularly under high hydrodynamic conditions (Occhipinti Ambrogi, 1986; Cigliano *et al*., 2007). When *C. nobilis* was present on the rhizome, a significant increase was determined in rhizome growth rate. Furthermore, its colony size was positively correlated with rhizome growth rate (Colmenero and Sanchez Lizaso, 1997). Among the epibiont bryozoan species found on *P. oceanica* meadows along the northern Cyprus coast, the frequency of *P. tubulosa, Aetea lepadiformis, Electra posidoniae, Onychocella marioni, C. nobilis, Chilidonia pyriformis, Scrupocellaria bertholleti, Puellina innominata, Exechonella antillea, Hippaliosina depressa, Escharina vulgaris* were found to be greater than 50% (Kocak *et al*., 2002).

Colonization of bryozoan epiphytes on *P. oceanica* meadows depends on stochastic events and factor acting in the meadows at various spatial and temporal scales such as dispersal of larvae, grazing and competition (Nesti *et al*., 2009). In the coastal marine environments, epiphytes of *P. oceanica* are sensitive to anthropogenic disturbance originating from discharge areas and react more rapidly to the changes in water column respect to meadow phenology and structure (Giovanetti *et al*., 2010). Therefore, the epiphyte communities have been used as an early warning indicator of stress occurring in a meadow and its neighborhood (Leoni *et al*., 2006; Balata *et al*., 2008). On the taxonomic composition of epiphytic assemblages, macrograzers and nutrient availability were main responsible for observed differences in the structure of epiphytic assemblages (Prado *et al*., 2007b). Among bryozoans, *E. posidoniae* and *Aetea truncata* were widely distributed on the leaf stratum. Although *E. posidoniae* is a characteristic epiphyte on *P. oceanica* leaves (Balata *et al*., 2007), it was rare or absent in the meadow near Bari and Brindizi along the Adriatic Sea. This situation was explained by the competition with the spirorbid polychaete *Janua pagenstecheri* for space (Occhipinti Ambrogi, 1986). The percentage cover of leaf epiphyte bryozoan species such as *E. posidonia* and *Fenestrulina malusii* were found higher in the enriched conditions with ammonium and nitrate comparing to reference site (Balata *et al*., 2010). Among the species identified from the Chios sample, *E. posidonia* was rare and *Fenestrulina joannae* were not found at all samples. *Chorizopora brongniartii, Haplopoma impressum, Puellina gattyae, E. vulgaris and Tubulipora* sp. were the dominant species in epiphytic communities in terms of both number of colonies and covered area of each species. Furthermore, *C. brongniartii* colonies covered larger areas, comprising 35% of the total area (Hayward, 1974a). According to Martínez-Crego *et al*. (2010), the responses of epiphytic bryozoan communities to environmental changes were more clearly observed in deep meadows with respect to shallow ones where *M. ciliata, Umbonula ovicellata, Crisia occidentalis*, *Mimosella gracilis*, *Bugula germanae* and *Bowerbankia gracilis* were not present. Furthermore, *Aetea sica* was determined as a typical species of healthy sites in contrast to *B. gracilis.* Along the coastline of the Gulf of Gabes (Tunisia), *Amathia lendigera* and *Beania hirtissima* were also found in control locations (Ben Brahim *et al*., 2010). In a study carried out in the Tuscan Archipelago National Park (Tyrrhenian Sea and Ligurian Sea, Italy), *E. posidoniae* and *A. truncata* were more abundant on the leaf assemblages in the shallower site where the rhizome assemblages were composed by *A. truncata*, *Callopora lineata* and *F. malusii*. In the meadow at deeper site, *Tubulipora* sp., *Collarina balzaci* and

Scrupocellaria reptans were found and the latter species showed a tendency to increase from the shallow to the deep site (Nesti *et al*., 2009).

Leaf and rhizome assemblages can respond in different ways to the same disturbance or their responses change according to different kinds of disturbances prevailing among the meadows or within the meadows at a small scale. Although the mean abundance values of bryozoans did not show significant differences between disturbed and control location (Piazzi *et al*., 2004), species composition and related coverage on seagrasses may be useful to clarify the factors controlling the distribution pattern of epiphytic assemblages.

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Epiphytic macroalgal assemblages of *Posidonia oceanica* (L.) Delile in Turkey

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Abstract

In this study, macroalgal assemblages of *Posidonia oceanica* from the Dardanelles (Sea of Marmara) and the Ayvalık (Aegean coast of Turkey) have been studied. 87 taxa (28 Phaeophyceae, 43 Rhodophyta and 16 Chlorophyta) were reported.

Introduction

Five marine fanerogams known in the Aegean coast of Turkey are; *Halophila stipulacea* (Forsskål) Ascherson, *Cymodocea nodosa* (Ucria) Ascherson, *Posidonia oceanica* (L.) Delile, *Zostera marina* L. and *Zostera noltei* Homermann (Taşkın *et al*., 2008). There are several studies that examine *P. oceanica* meadows spreading out along the coast of Turkey (Meinesz *et al*., 2009; Cirik *et al*., 2010; Dural, 2010; Koçak *et al*., 2011; Dural *et al*., 2012).

P. oceanica and *C. nodosa* are very important host plants for macroalgae. However, the studies carried out on epiphytic macroalgal flora of seagrasses are very limited in Turkey. Dural *et al*. (2011) studied associated algal communities living on marine phanerogams on the Black Sea coast in Sinop (Turkey). Moreover, epiphytic green algal assemblages found on *P. oceanica* collected from the Aegean coast of Turkey were studied by Akçora *et al*. (2012). Several studies including macroalgal assemblages of *P. oceanica* from the Turkey coast have been conducted by Öztürk (1993), Taşkın and Öztürk (2007), Taşkın (2008).

In the other countries along the Mediterranean Sea, epiphytic macroalgal communities have been studied by different researchers (Van der Ben, 1971; Battiato *et al*., 1982; Cinelli *et al*., 1984; Mazzella and Ott, 1984; Buia *et al*., 1985, 1989; Mazzella *et al*., 1989; Soto Moreno, 1992; Frada' - Orestano *et al*., 1993; Boudouresque, 1968, 1974; Boudouresque *et al*., 1981; Piazzi *et al*., 2002; Jacquemart and Demoulin, 2008). 74 epiphytic macroalgal taxa were reported on the rhizomes of *P. oceanica* meadows in the western Mediterranean Sea (Piazzi *et al*., 2002).

In the present paper, epiphytic macroalgal assemblages of *P. oceanica* have been studied on the samples collected from the Dardanelles (Sea of Marmara) and the Ayvalık (Aegean coast of Turkey) and 87 species (28 Phaeophyceae, 43 Rhodophyta and 16 Chlorophyta) were found.

Materials and Methods

Samples were collected by snorkelling and SCUBA-diving from the Dardanelles (Sea of Marmara) and the Ayvalık (Aegean coast of Turkey) during 2009-2012. Specimens were preserved in 4% buffered formalin-seawater solution. Macroalgae on leaf and rhizome were sorted and identified to the lowest possible taxonomic rank.

Results and Discussion

A total of 87 (28 Phaeophyceae, 43 Rhodophyta and 16 Chlorophyta) macroalgal taxa found on *P. oceanica* were identified at both species and infraspecies level (Table 1, Figure 1). The most common groups are belonging to Phaeophyceae (*Cladopsiphon* spp, *Giraudia sphacelarioides, Halothrix lumbricalis* and *Sauvageaugloia griffithsiana*), Rhodophyta (*Callithamnion corymbosum*, *Falkenbergia rufolanosa*, *Jania rubens*, *Laurencia obtuse*) and Chlorophyta (*Caulerpa racemosa* var. *cylindracea* and *Flabellia petiolata*). In this study, 58 taxa from Dardanelles and 62 taxa from Ayvalık were recorded. Among epiphytic macroalgal assemblages of *P. oceanica* 27 taxa (30%) were found on the leaf and 63 taxa (70%) were recorded on the rhizomes (Figure 2).

Table 1. Species list of epiphytic macroalgal assemblages of *P. oceanica*.

Taxa	Sampling station		*P. oceanica*	
	Dardanelles	Ayvalık	Leaf	Rhizome
Phaeophyceae				
Asperococcus bullosus J.V. Lamouroux	+		+	
Cladosiphon contortus (Thuret) Kylin	+	+	+	
Cladosiphon irregularis (Sauvageau) Kylin		+	+	
Cladosiphon mediterraneus Kützing	+	+	+	
Cladosiphon zosterae (J.Agardh) Kylin	+	+	+	
Cutleria multifida (Smith) Greville		+	+	
Dictyopteris polypodioides (A.P. De Candolle) J.V. Lamouroux	+	+		+
Dictyota dichotoma (Hudson) J.V. Lamouroux var. *dichotoma*	+	+		+
Dictyota linearis (C.Agardh) Greville		+		+
Eudesme virescens (Carmichael *ex* Berkeley) J.Agardh	+	+	+	
Feldmannia irregularis (Kützing) G. Hamel		+	+	
Giraudia sphacelarioides Derbés *et* Solier	+	+	+	

Halopteris filicina (Grateloup) Kützing	+	+		+
Halopteris scoparia (L.) Sauvageau	+	+		+
Halothrix lumbricalis (Kützing) Reinke		+	+	
Hincksia mitchelliae (Harvey) P.C. Silva	+	+	+	
Mesogloia leveillei (J.Agardh) Meneghini	+		+	
Microcoryne ocellata Strömfeld	+		+	
Myrionema orbiculare J.Agardh	+	+	+	
Padina pavonica (L.) Thivy		+		+
Protectocarpus speciosus (Børgesen) Kuckuck *ex* Kornmann	+		+	+
Punctaria latifolia Greville	+			+
Punctaria plantaginea (Roth) Greville	+			+
Punctaria tenuissima (C.Agardh) Greville	+		+	+
Sauvageaugloia divaricata (Clemente) Cremades	+	+	+	
Sphacelaria cirrosa (Roth) C.Agardh	+		+	
Sphacelaria rigidula Kützing	+	+	+	
Sphacelaria tribuloides Meneghini	+	+	+	
Subtotal	22	20	20	10
Rhodophyta				
Acrochaetium daviesii (Dillwyn) Nägeli	+		+	
Acrochaetium microscopicum (Nägeli *ex* Kützing) Nägeli	+	+	+	
Aglaothamnion tenuissimum (Bonnemaison) Feldmann-Mazoyer	+			+
Anotrichium barbatum (C.Agardh) Nägeli	+	+		+
Anotrichium tenue (C.Agardh) Nägeli		+		+
Antithamnion tenuissimum (Hauck) Schiffner	+			+
Boergeseniella fruticulosa (Wulfen) Kylin	+	+		+
Botryocladia boergesenii Feldmann		+		+
Botryocladia botryoides (Wulfen) Feldmann		+		+
Callithamnion corymbosum (Smith) Lyngbye	+	+		+
Ceramium ciliatum var. *robustum* (J.Agardh) Feldmann-Mazoyer	+	+		+

Ceramium flaccidum (Kützing) Ardissone	+	+	+	
Chylocladia verticillata (Lightfoot) Bliding		+		+
Crouania attenuata (C.Agardh) J.Agardh	+	+		+
Dasya ocellata (Grateloup) Harvey		+		+
Dasya rigidula (Kützing) Ardissone	+	+		+
Erythrotrichia carnea (Dillwyn) J.Agardh	+	+	+	
Eupogodon planus (C.Agardh) Kützing	+			+
Falkenbergia rufolanosa (Harvey) Schmitz (Tetrasporophyte of *A. armata* Harvey)	+	+		+
Grateloupia filicina (J.V. Lamouroux) C.Agardh		+		+
Halopithys incurva (Hudson) Batters		+		+
Herposiphonia secunda (C.Agardh) Ambronn f. *secunda*		+		+
Herposiphonia secunda f. *tenella* (C.Agardh) M.J. Wynne		+		+
Heterosiphonia crispella (C.Agardh) M.J. Wynne	+	+		+
Hypnea musciformis (Wulfen) J.V. Lamouroux		+		+
Hypoglossum hypoglossoides (Stackhouse) F.Collins *et* Hervey		+		+
Jania longifurca Zanardini	+			+
Jania rubens (L.) J.V. Lamouroux	+	+		+
Laurencia obtusa (Hudson) J.V. Lamouroux	+	+		+
Lomentaria clavellosa (Turner) Gaillon		+		+
Lophosiphonia obscura (C.Agardh) Falkenberg	+	+		+
Monosporus pedicellatus (Smith) Solier		+		+
Nitophyllum punctatum (Stackhouse) Greville	+	+		+
Peyssonnelia rubra (Greville) J.Agardh	+			+
Peyssonnelia squamaria (S.G. Gmelin) Decaisne	+	+		+
Phyllophora crispa (Hudson) P.S. Dixon	+			+
Polysiphonia furcellata (C.Agardh) Harvey		+		+

Polysiphonia opaca (C.Agardh) Moris *et* De Notaris		+		+
Polysiphonia scopulorum Harvey	+			+
Pterothamnion plumula (J. Ellis) Nägeli	+			+
Rhodophyllis divaricata (Stackhouse) Papenfuss	+			+
Stylonema alsidii (Zanardini) Drew	+	+	+	
Wrangelia penicillata (C.Agardh) C.Agardh		+		+
Subtotal	27	33	5	38
Chlorophyta				
Acetabularia acetabulum (L.) P.C. Silva		+		+
Anadyomene stellata (Wulfen) C.Agardh		+		+
Caulerpa racemosa (Forsskål) J. Agardh var. *cylindracea* (Sonder) Verlaque, Huisman & Boudouresque		+		+
Caulerpa racemosa (Forsskål) J. Agardh var. *racemosa*		+		+
Chaetomorpha aerea (Dillwyn) Kützing	+			+
Chaetomorpha linum (O.F. Müller) Kützing	+			+
Cladophora dalmatica Kützing	+		+	+
Cladophora glomerata (L.) Kützing		+		+
Cladophora pellucida (Hudson) Kützing	+			+
Cladophora prolifera (Roth) Kützing	+			+
Flabellia petiolata (Turra) Nizamuddin	+	+		+
Phaeophila dendroides (P.L. *et* H.M. Crouan) Batters	+	+	+	
Pseudochlorodesmis furcellata (Zanardini) Børgesen	+			+
Ulva clathrata (Roth) C. Agardh		+		+
Umbraulva olivascens (P. Dangeard) Bae *et* I.K. Lee	+			+
Valonia macrophysa Kützing		+		+
Subtotal	9	9	2	15
Total	**58**	**62**	**27**	**63**

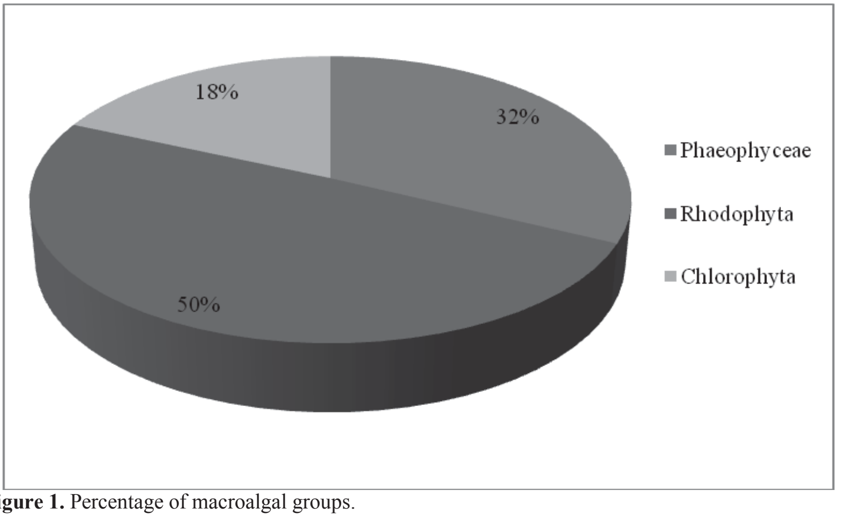

Figure 1. Percentage of macroalgal groups.

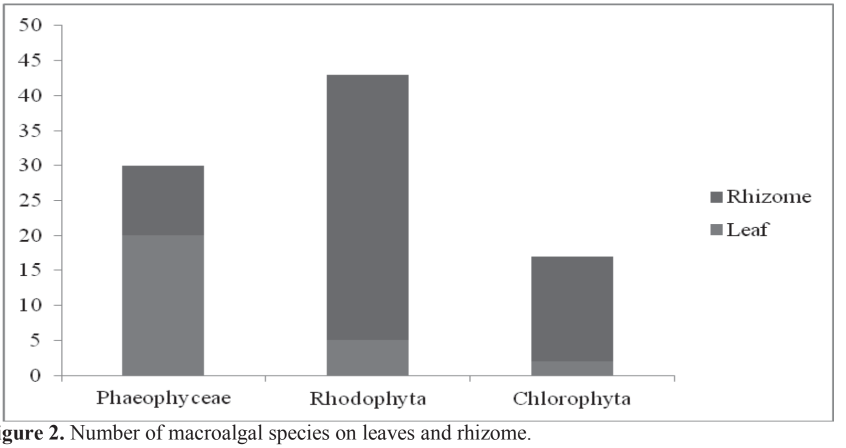

Figure 2. Number of macroalgal species on leaves and rhizome.

According to Piazzi *et al*. (2002) 74 epiphytic macroalgal species (8 Phaeophyceae, 59 Rhodophyta and 7 Chlorophyta) were noted on *P. oceanica* rhizomes in the western Mediterranean Sea. In the present study, 63 species (10 Phaeophyceae, 38 Rhodophyta and 15 Chlorophyta) were found on *P. oceanica* rhizomes.

The studies dealing with epiphytic macroalgal assemblages of *P. oceanica* from the coast of Turkey are very limited. Recently, Akçora *et al.* (2012) reported 12 epiphytic green algal species on *P. oceanica* meadow between Çandarlı and Dilek Peninsula (the Aegean coast of Turkey). As a conclusion, *P. oceanica* offers favourable substrate for green and red algal species while leaves are important for brown algal communities (especially members of Chrodariaceae) (Figure 3).

Figure 3. Meadow of *P. oceanica* (Ayvalık, Turkey).

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Polychaetes (Annelida: Polychaeta) associated with *Posidonia oceanica* (L.) Delile along the coasts of Turkey and Northern Cyprus

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Abstract

This review indicates that *Posidonia oceanica* meadow sustains high polychaete diversity: 394 species belonging to 44 families have been reported from the Turkish and Cypriot coasts so far. Five species were excluded from the list as their occurrences in the Mediterranean Sea are questionable. Syllidae, Sabellidae and Spionidae are the most speciose families in the meadow. The diversity and functional roles of polychaetes change in the leaf and rhizome strata. The number of species reported on *P. oceanica* varied according to the areas; 316 species in the Aegean Sea, 55 species in the Mediterranean Sea and 242 species in Cyprus. Four species (possibly five, including *Lysidice margaritacea*) were reported as borers in *P. oceanica*: *Lysidice ninetta*, *L. collaris*, *Nematonereis unicornis* and *Marphysa fallax*. The maximum polychaete species richness, density and biomass were calculated as 58 species 0.1.m^{-2}, 4290 ind.m^{-2} and 21.4 g wet weight.m^{-2} in the area (Izmir Bay, Aegean Sea), respectively. A total of 21 alien species belonging to 13 families were reported on *Posidonia oceanica* beds. The common alien species in the area is *Linopherus canariensis*. Sixteen species have been well established in the area and two species (*Paraprionospio coora* and *Chaetozone corona*) are cryptogenetic species.

Introduction

Posidonia oceanica is the Mediterranean seagrass that forms dense meadows at depths down to 40 m. This plant is long-lived and covers all the littoral of the Mediterranean, except for some areas such as the eastern part of the Levantine basin due to high temperature (Pérès, 1984; Celebi *et al*., 2007). Its meadows constitute the climax community of coastal ecosystems (Covazzi Harriague *et al*., 2006). This species constitutes the unique biogenic structure, *matte*, resulting from growth of rhizomes engaged with roots and detritus (Tomasello *et al*., 2009). *Posidonia oceanica* beds possess a wide range of ecological roles in the region: acting as a refuge for biota; producing enormous quantities of vegetal matter (up to 3000 gC m^{-2} yr^{-1}) that even feeds the deep-water fauna (as drifting material); constituting a spawning or nursery ground for many species including fish; producing high amount of oxygen (up to 14 litres per square meter a day); traping and stabilizing sediment; reducing hydrodynamism; and protecting beaches from erosion by means of banquettes that its dead leaves form (Ott, 1980; Boudouresque *et al*., 2012).

Posidonia oceanica meadows represent a unique substrate with a high spatial complexity that supports a variety of microhabitats for benthic organisms. Two strata exist within the plant canopy; the leaf stratum and the rhizome-sediment stratum (Gambi *et al*., 1995). Because of different ecological conditions prevailing in the strata (*i.e*. hydrodynamism, light penetration), four species assemblages can be distinguished: the leaf epifauna, the rhizome epifauna, the root-associated sediment infauna and the vagile fauna (Bianchi *et al*., 1989). These assemblages are structured by a variety of benthic organisms, mainly polychaetes, crustaceans and molluscs. *Posidonia oceanica* meadows have specific polychaete assemblages characterized by high diversity and evenness, showing little affinity with unvegetated bottoms (Somaschini *et al*., 1994; Ergen *et al*., 2006). The leaf epifauna are mainly dominated by filter-feeders (mainly Serpulidae and Sabellidae) or herbivores (mainly Syllidae, Nereididae), whereas root-associated infauna comprised surface or subsurface deposit-feeders such as spionids, cirratulids, capittellids and terebellids. The carnivore species such as polynoids and dorvilleids use both leaf and rhizome layers of the phanerogame (Gambi *et al*., 1995; Ergen and Çınar, 1997).

Several studies were carried out to assess the polychaete fauna associated with *P. oceanica* beds in the western Mediterranean Sea (*i.e*. Alós, 1983; Colognola *et al*., 1984; Giangrande, 1985; Gambi *et al*., 1989; 1995). However, similar data are scarce and fragmented in the eastern Mediterranean. Only two papers (Ergen, 1986; Ergen *et al*., 1988) specifically described polychaetes inhabiting *P. oceanica* meadows on the coast of Turkey. However, polychaetes living in *P. oceanica* beds were encountered in some general faunistic and ecological studies covering a wide range of habitats (*i.e.* Çınar, 2005; Ergen *et al.*, 2006).

This paper gives an inventory of polychaete species that have been reported on *P. oceanica* meadows on the Turkish and Cypriot coasts so far.

Methodology

The species identified to the genus or family levels in the papers were not included in the present paper. The Aegean, Mediterranean and Cypriot coasts were considered seperately and the first record of the species in each area was given in Table 1.

Results and Discussion

A total of 394 species belonging to 44 families were reported in *Posidonia oceanica* beds along the coasts of Turkey and Northern Cyprus (Table 1). The occurrences of some species such as *Phyllodoce madeirensis* (cited by Çınar and Ergen, 1999), *Sphaerosyllis erinaceus* (Ergen *et al*., 1994), *Syllis cornuta* (Ergen and Çınar, 1997; Çınar and Ergen, 1999) and *Hydroides norvegicus* (Geldiay and Kocataş, 1972) are questionable in the Mediterranean and in this habitat. Therefore, these species were not included in Table 1.

Polychaetes are known to be an important group in *Posidonia oceanica* meadows. In the *P. oceanica* matte formation, polychaetes account for 48% and 67% of the total number of zoobenthic species and populations, respectively (Harmelin, 1964). Harmelin (1964) and Somaschini *et al.* (1994) reported 161 and 171 polychaete species in this formation, respectively. Borg *et al.* (2006) demostrated that dead *P. oceanica* matte supported a significantly higher number of species and abundance of motile macroinvertebrates than living matte. The polychaete diversity largely changes in the leaf and rhizome strata of *P. oceanica*. The rhizome stratum with its complex structure supports higher diversity than leaf stratum, due to the more stressful physical conditions, competition with other taxa, or predation pressure (Gambi *et al.*, 1992). Gambi *et al.* (1995) found a total of 101 polychaete species in the rhizome stratum and 79 species in the leaf stratum. Mazzella *et al.* (1989) reported 50 vagile polychaete species, comprising 21% of total number of zoobenthic species in the leaf stratum. Some polychaete species also represent daily vertical migrations between the leaf and rhizome strata. Low polychaete abundances were encontered in the leaf stratum during the day, mainly because of presence of their pradators such as *Diplodus annularis* and gobids (Sánchez-Jerez *et al.* 1999).

Among the families found along the Turkish and Cypriot coasts, Syllidae account for 21% (84 species) of the total number of species, followed by Sabellidae and Spionidae (Figure 1). Seven families were represented by only one species. Syllidae were reported to be the most dominant family in the leaf stratum of *P. oceanica* in terms of the number of species (more than 35%) and abundance (more than 40%) (Colognola *et al.*, 1984; Giangrande, 1985; Mazzella *et al.*, 1989; Gambi *et al.*, 1989; Alós, 1983). The number of syllid species found on *P. oceanica* vary among regions; 39 species were found on the western Mediterranean coast (Sardá, 1991), 68 species on the Aegean Sea coast (Çınar and Ergen, 2002) and 52 species on the Cypriot coast (Çınar, 2003a).

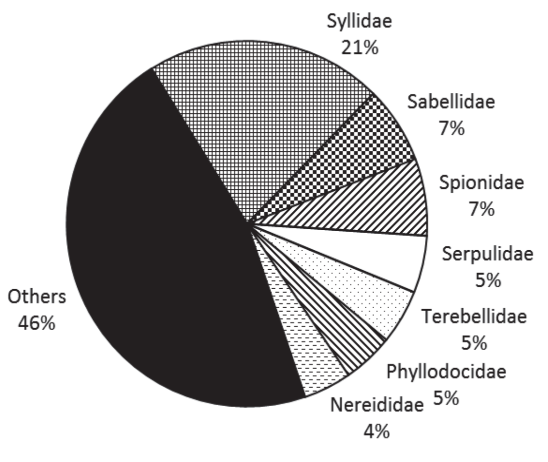

Figure 1. Dominance of polychaete families by the number of species.

Table 1. List of polychaete species on *P. oceanica* meadows from the coasts of Turkey and Northern Cyprus. The first reference indicating the presence of the species on *P. oceanica* is included. * indicates alien species.

	Aegean Sea	Mediterranean Sea	Northern Cyprus
APHRODITIDAE			
Laetmonice hystrix (Savigny in Lamarck, 1818)	+ Ergen, 1976	-	+ Çınar, 2005
Pontogenia chrysocoma (Baird, 1865)	+ Ergen, 1976	-	+ Çınar, 2005
POLYNOIDAE			
Harmothoe areolata (Grube, 1860)	+ Ergen, 1976	-	
Harmothoe impar (Johnston, 1839)	+ Çınar & Ergen, 1999	+ Ergen & Çınar, 1997	+ Çınar, 2005
Harmothoe spinifera (Ehlers, 1864)	+ Çınar & Ergen, 1999	-	+ Çınar, 2005
Lepidonotus clava (Montagu, 1808)	+ Ergen, 1976	-	+ Çınar, 2005
Malmgreniella lilianae Pettibone, 1993	-	-	+ Çınar, 2005
Malmgreniella ljungmani Pettibone, 1993	-	-	+ Çınar, 2005
Malmgreniella lunulata (Delle Chiaje, 1841)	+ Doğan *et al.*, 2005	-	-
Subadyte pellucida (Ehlers, 1864)	+ Çınar & Ergen, 1999	-	+ Çınar, 2005
SIGALONIDAE			
Euthalenessa oculata (Peters, 1854)	-	-	+ Çınar, 2005
Fimbriosthenelais zetlandica (McIntosh, 1876)	-	-	+ Çınar, 2005
Pelogenia arenosa (Delle Chiaje, 1841)	-	+ Ergen & Çınar, 1997	+ Çınar, 2005
Sigalion mathildae Audouin & Milne Edwards, 1834	-	+ Ergen & Çınar, 1997	+ Çınar, 2005
Sthenelais boa (Johnston, 1839)	+ Ergen *et al.*, 1994	-	-
PHOLOIDAE			
Pholoe inornata Johnston, 1839	+ Çınar & Ergen, 1999	-	+ Çınar, 2005
CHRYSOPETALIDAE			
Arichlidon reyssi (Katzmann, Laubier & Ramos, 1974)	+ Çınar & Dağlı, 2013	-	-
Chrysopetalum debile (Grube, 1855)	+ Ergen, 1976	+ Ergen & Çınar, 1997	+ Çınar, 2005
AMPHINOMIDAE			
Chloeia venusta Quatrefages, 1865	+ Doğan *et al.*, 2005	-	-
Hermodice nigrolineata Baird, 1870	+ Ergen *et al.*, 1994	+ Ergen & Çınar, 1997	+ Çınar, 2005
**Linopherus canariensis* Langerhans, 1881	+ Çınar, 2009	+ Ergen & Çınar, 1997	+ Çınar, 2005
EUPHROSYNIDAE			
Euphrosyne foliosa Audouin & Milne Edwards, 1833	-	-	+ Çınar, 2005
LACYDONIIDAE			
Lacydonia miranda Marion & Bobretzky, 1875	+ Çınar & Dağlı, 2013	-	+ Çınar, 2005
Paralacydonia paradoxa (Fauvel, 1913)	+ Ergen *et al.*, 2004	-	+ Çınar, 2005
PHYLLODOCIDAE			
Eulalia clavigera (Audouin & Milne Edwards, 1834)	+ Çınar & Ergen, 1999	-	+ Çınar, 2005
Eulalia mustela Pleijel, 1987	-	-	+ Çınar, 2005
Eulalia tripunctata McIntosh, 1874	-	-	+ Çınar, 2005
Eumida sanguinea Oersted, 1843	+ Çınar & Dağlı, 2013	+ Ergen & Çınar, 1997	+ Çınar, 2005
Hesionura coineaui (Laubier, 1962)	-	-	+ Çınar, 2005
Hesionura elongata (Southern, 1914)	-	-	+ Çınar, 2005
Mysta picta (Quatrefages, 1865)	+ Aydın *et al.*, 2007	-	+ Çınar, 2005
Nereiphylla paretti Blainville, 1828	+ Ergen, 1976	-	+ Çınar, 2005
Nereiphylla pusilla (Claparède, 1870)	+ Çınar & Ergen, 1999	-	-
Nereiphylla rubiginosa (Saint-Joseph, 1888)	-	-	+ Çınar, 2005
Notophyllum foliosum (Sars, 1835)	-	-	+ Çınar, 2005
Paranaitis kosteirensis (Malmgren, 1867)	+ Çınar & Dağlı, 2013	-	+ Çınar, 2005
Phyllodoce lineata (Claparède, 1870)	+ Çınar & Dağlı, 2013	-	-
**Phyllodoce longifrons* Ben-Eliahu, 1972	-	+ Çınar & Dağlı, 2012	-
Phyllodoce maculata (Linnaeus, 1767)	+ Çınar *et al.*, 2004	-	+ Çınar, 2005
Phyllodoce mucosa Örsted, 1843	+ Çınar & Ergen, 1999	+ Ergen & Çınar, 1997	-
Pseudomystides limbata Saint-Joseph, 1888	+ Çınar & Dağlı, 2013	-	+ Çınar, 2005
Pterocirrus macroceros (Grube, 1860)	+ Çınar & Ergen, 1999	-	+ Çınar, 2005
HESIONIDAE			
Gyptis propinqua Marion & Bobretzky, 1875	-	-	+ Çınar, 2005

Hesione splendida Savigny, 1818	-	-	+[Çınar, 2005]
Hesiospina aurantiaca (Sars, 1862)	+[Çınar & Dağlı, 2013]	-	-
Oxydromus pallidus Claparède, 1864	+[Koçak & Katağan, 2005]	-	-
Podarkeopsis galangaui Laubier, 1961	+[Çınar & Dağlı, 2013]	-	-
Syllidia armata Quatrefages, 1865	+[Çınar & Ergen, 1999]	-	+[Çınar, 2005]
PILARGIDAE			
Ancistrosyllis groenlandica McIntosh, 1879	+[Çınar & Dağlı, 2013]	-	-
Pilargis verrucosa Saint-Joseph, 1899	+[Doğan *et al*., 2005]	-	+[Çınar, 2005]
Sigambra tentaculata (Treadwell, 1941)	+[Doğan *et al*., 2005]	-	-
SYLLIDAE			
Myrianida benazzi (Cognetti, 1953)	+[Çınar & Ergen, 2002]	-	-
Myrianida brachycephala (Marenzeller, 1897)	+[Çınar & Ergen, 2002]	-	+[Çınar *et al*., 2003]
Myrianida edwarsi (Saint-Joseph, 1887)	+[Çınar & Ergen, 2002]	-	+[Çınar *et al*., 2003]
Myrianida langerhansi (Gidholm, 1967)	+[Çınar & Dağlı, 2013]	-	-
Myrianida prolifer (O. F. Müller, 1788)	+[Ergen *et al*., 1994]	+[Ergen & Çınar, 1997]	-
Myrianida quindecimdentatus (Langerhans, 1884)	+[Çınar & Ergen, 2002]	-	-
Paraprocerastea crocantinae San Martín & Alós, 1989	+[Çınar & Ergen, 2002]	-	-
Proceraea aurantiaca Claparède, 1868	+[Çınar & Ergen, 2002]	-	+[Çınar *et al*., 2003]
Proceraea picta Ehlers, 1864	+[Çınar & Ergen, 2002]	-	+[Çınar *et al*., 2003]
Brania arminii (Langerhans, 1881)	+[Çınar & Ergen, 2002]	-	+[Çınar *et al*., 2003]
Brania pusilla (Dujardin, 1839)	+[Çınar & Ergen, 2002]	-	-
Exogone dispar (Webster, 1879)	+[Çınar & Ergen, 2002]	-	+[Çınar *et al*., 2003]
Exogone naidina Örsted, 1845	+[Çınar & Ergen, 2002]	-	-
Exogone rostrata Naville, 1933	+[Çınar & Ergen, 2002]	-	+[Çınar *et al*., 2003]
Exogone verugera (Claparède, 1868)	+[Çınar & Ergen, 2002]	-	+[Çınar *et al*., 2003]
Exogone caribensis San Martín, 1991	+[Çınar & Dağlı, 2013]	-	-
Exogone cognettii Castelli, Badalam. & Lardicci, 1987	+[Çınar & Dağlı, 2013]	-	-
Exogone gambiae Lanera, Sordino & San Martín, 1994	+[Çınar & Dağlı, 2013]	-	-
Salvatoria clavata (Claparède, 1863)	+[Çınar & Ergen, 2002]	-	+[Çınar *et al*., 2003]
Salvatoria euritmica (Sarda, 1984)	+[Çınar & Ergen, 2002]	-	+[Çınar *et al*., 2003]
Salvatoria limbata (Claparède, 1868)	-	-	+[Çınar *et al*., 2003]
Salvatoria vieitezi (San Martín, 1984)	+[Çınar & Ergen, 2002]	-	+[Çınar *et al*., 2003]
Salvatoria yraidae (San Martín, 1984)	+[Çınar & Ergen, 2002]	-	-
Parapionosyllis brevicirra Day, 1954	+[Çınar & Ergen, 2002]	-	-
Parapionosyllis gestans (Pierantoni, 1903)	+[Çınar & Ergen, 1999]	-	-
Parapionosyllis minuta (Pierantoni, 1903)	+[Çınar & Ergen, 2002]	-	-
Sphaerosyllis austriaca Banse, 1959	+[Çınar & Ergen, 2002]	-	+[Çınar *et al*., 2003]
Sphaerosyllis boeroi Musco, Çınar & Giangrande, 2005	-	-	+[Musco *et al*., 2005]
Sphaerosyllis cryptica Ben-Eliahu, 1977	+[Çınar & Ergen, 2002]	-	-
Sphaerosyllis hystrix Claparède, 1863	+[Çınar & Ergen, 2002]	-	+[Çınar *et al*., 2003]
Sphaerosyllis pirifera Claparède, 1868	+[Çınar & Ergen, 2002]	-	+[Çınar *et al*., 2003]
Sphaerosyllis taylori Perkins, 1981	+[Çınar & Ergen, 2002]	-	-
Sphaerosyllis thomasi San Martín, 1984	+[Çınar & Ergen, 2002]	-	-
Prosphaerosyllis xarifae Hartmann-Schröder, 1960	+[Çınar & Dağlı, 2013]	-	+[Çınar *et al*., 2003]
Amblyosyllis formosa (Claparède, 1863)	-	-	+[Çınar & Ergen, 2003]
Parehlersia ferrugina (Langerhans, 1881)	+[Çınar & Ergen, 2002]	-	+[Çınar & Ergen, 2003]
Eusyllis assimilis Marenzeller, 1875	+[Çınar & Ergen, 2002]	-	+[Çınar & Ergen, 2003]
Eusyllis blomstrandi Malmgren, 1867	+[Çınar & Ergen, 2002]	-	-
**Eusyllis kupfferi* Langerhans, 1879	-	-	+[Çınar & Ergen, 2003]
Eusyllis lamelligera Marion & Bobretzky, 1875	+[Çınar & Ergen, 2002]	-	+[Çınar & Ergen, 2003]
Odontosyllis ctenostoma Claparède, 1868	+[Çınar & Ergen, 2002]	-	+[Çınar & Ergen, 2003]
Odontosyllis fulgurans (Audouin & M. Edwards, 1833)	+[Çınar & Ergen, 2002]	+[Ergen & Çınar, 1997]	+[Çınar & Ergen, 2003]
Odontosyllis gibba Claparède, 1863	+[Çınar & Ergen, 2002]	-	-
Opisthodonta longocirrata (Saint-Joseph, 1886)	+[Çınar & Ergen, 2002]	-	-
Opisthodonta morena Langerhans, 1879	-	-	+[Çınar & Ergen, 2003]
Opisthodonta serratisetosa (López, San Martín & Jimenez, 1997)	-	-	+[Çınar & Ergen, 2003]
Nudisyllis divaricata (Keferstein, 1862)	-	+[Ergen & Çınar, 1997]	-
Nudisyllis pulligera (Krohn, 1852)	+[Çınar & Ergen, 2002]	-	-
Synmerosyllis lamelligera (Saint-Joseph, 1886)	+[Çınar & Ergen, 2002]	-	+[Çınar & Ergen, 2003]
Brevicirrosyllis weissmanni (Langerhans, 1879)	-	-	+[Çınar & Ergen, 2003]

Syllides bansei Perkins, 1981	+Çınar & Ergen, 2002	-	-
Syllides fulvus (Marion & Bobretzky, 1875)	+Çınar & Ergen, 2002	-	+Çınar & Ergen, 2003
Branchiosyllis exilis (Gravier, 1900)	+Çınar & Ergen, 2002	-	+Çınar & Ergen, 2003
Eurysyllis tuberculata Ehlers, 1864	+Çınar & Ergen, 2002	-	+Çınar & Ergen, 2003
Haplosyllis spongicola (Grube, 1855)	+Çınar & Ergen, 2002	-	+Çınar & Ergen, 2003
Plakosyllis brevipes Hartmann-Schröder, 1956	-	-	+Çınar & Ergen, 2003
Syllis alternata Moore, 1908	+Çınar & Ergen, 2002	-	+Çınar & Ergen, 2003
Syllis amica Quatrefages, 1865	+Çınar & Ergen, 1999	+Ergen & Çınar, 1997	-
Syllis armillaris (O. F. Müller, 1776)	+Çınar & Ergen, 2002	-	+Çınar & Ergen, 2003
Syllis beneliahuae (Campoy & Alquézar, 1982)	+Çınar & Ergen, 2002	-	+Çınar & Ergen, 2003
Syllis bouvieri sensu San Martín, 1984	+Çınar & Ergen, 2002	-	+Çınar & Ergen, 2003
Syllis columbretensis (Campoy, 1982)	+Çınar & Ergen, 2002	-	+Çınar & Ergen, 2003
Syllis compacta Gravier, 1900	+Çınar & Ergen, 2002	-	-
Syllis corallicola Verrill, 1900	+Çınar & Ergen, 2002	-	+Çınar & Ergen, 2003
Syllis cruzi Núñez & San Martín, 1991	+Çınar & Dağlı, 2013	-	-
Syllis garciai (Campoy, 1982)	+Çınar & Ergen, 2002	+Ergen & Çınar, 1997	+Çınar & Ergen, 2003
Syllis gerlachi Hartmann-Schröder, 1960	+Çınar & Ergen, 2002	-	+Çınar & Ergen, 2003
Syllis gerundensis (Alós & Campoy, 1981)	-	-	+Çınar & Ergen, 2003
Syllis gracilis Grube, 1840	+Çınar & Ergen, 2002	-	+Çınar & Ergen, 2003
Syllis hyalina Grube, 1863	+Çınar & Ergen, 2002	+Ergen & Çınar, 1997	+Çınar & Ergen, 2003
Syllis jorgei San Martín & Lopez, 2000	+Çınar & Ergen, 2002	+Ergen & Çınar, 1997	+Çınar & Ergen, 2003
Syllis krohni Ehlers, 1864	+Çınar & Ergen, 2002	-	+Çınar & Ergen, 2003
Syllis parapari San Martín & Lopez, 2000	+Çınar *et al.*, 2004	-	-
Syllis pontxioi San Martín & Lopez, 2000	+Çınar & Ergen, 2002	-	+Çınar & Ergen, 2003
Syllis prolifera Krohn, 1852	+Çınar & Ergen, 2002	-	+Çınar & Ergen, 2003
Syllis rosea (Langerhans, 1879)	+Çınar & Ergen, 2002	-	-
Syllis torquata Marion & Bobretzky, 1875	+Çınar & Ergen, 2002	-	+Çınar & Ergen, 2003
Syllis variegata Grube, 1860	+Çınar & Ergen, 2002	+Ergen & Çınar, 1997	+Çınar & Ergen, 2003
Syllis vittata (Grube, 1840)	+Çınar & Ergen, 1999	-	-
Syllis westheidei San Martín, 1984	+Çınar & Ergen, 1999	-	-
Trypanosyllis aeolis Langerhans, 1879	+Çınar & Ergen, 1999	-	-
Trypanosyllis coeliaca Claparède, 1868	+Çınar & Ergen, 1999	-	+Çınar & Ergen, 2003
Trypanosyllis zebra (Grube, 1840)	+Ergen, 1976	-	+Çınar & Ergen, 2003
Xenosyllis scabra (Ehlers, 1864)	+Çınar & Ergen, 2002	-	+Çınar & Ergen, 2003
NEREIDIDAE	-	-	-
Alitta succinea (Frey & Leuckart, 1847)	+Koçak & Katağan, 2005	-	-
Composetia costae (Grube, 1840)	+Ergen, 1976	-	+Çınar, 2005
Composetia hircinicola (Eisig, 1870)	+Ergen *et al.*, 2000	-	+Çınar, 2005
**Ceratonereis mirabilis* Kinberg, 1866	-	+Çınar, 2009	+Çınar, 2005
Leonnates aylaoberi Çınar & Dağlı, 2013	+Çınar & Dağlı, 2013	-	-
Micronereis variegata Claparède, 1863	+Ergen *et al.*, 2000	-	-
Neanthes caudata (Delle Chiaje, 1828)	+Ergen *et al.*, 2000	+Ergen & Çınar, 1997	+Çınar, 2005
Neanthes irrorata (Malmgren, 1867)	+Ergen *et al.*, 2000	-	+Çınar, 2005
Nereis falsa Quatrefages, 1865	+Ergen *et al.*, 2000	-	
Nereis pelagica Linneaus, 1758	+Ergen, 1986	-	+Çınar, 2005
Nereis rava Ehlers, 1868	+Ergen, 1976	-	+Çınar, 2005
Nereis zonata Malmgren, 1867	+Ergen, 1986	-	+Çınar, 2005
Perinereis cultrifera (Grube, 1840)	+Ergen, 1976	-	+Çınar, 2005
Platynereis coccinea (Delle Chiaje, 1841)	-	-	+Çınar, 2005
Platynereis dumerilii (Audouin & M. Edwards, 1833)	+Ergen, 1986	+Ergen & Çınar, 1997	+Çınar, 2005
**Pseudonereis anomala* Gravier, 1900	-	-	+Çınar, 2005
Websterinereis glauca (Claparède, 1870)	-	-	+Çınar, 2005
GLYCERIDAE			
Glycera alba (O. F. Müller, 1776)	+Çınar *et al.*, 2004	-	-
Glycera capitata Örsted, 1842	+Ergen *et al.*, 1994	-	-
Glycera lapidum Quatrefages, 1866	+Çınar *et al.*, 2004	-	+Çınar, 2005
Glycera fallax Quatrefages, 1850	+Aydın *et al.*, 2007	-	+Çınar, 2005
Glycera tesselata Grube, 1863	-	-	+Çınar, 2005
Glycera tridactyla Schmarda, 1861	+Ergen, 1976	-	-
Glycera unicornis Savigny in Lamarck, 1818	+Doğan *et al.*, 2005	-	+Çınar, 2005

GONIADIDAE			
Glycinde nordmanni (Malmgren, 1865)	+ Çınar & Dağlı, 2013	-	-
Goniada emerita Audouin & Milne Edwards, 1833	+ Ergen, 1976	-	+ Çınar, 2005
Goniada maculata Örsted, 1843	+ Çınar & Dağlı, 2013	-	+ Çınar, 2005
NEPHTYIDAE			
Inermonepthys inermis (Ehlers, 1887)	-	-	+ Çınar, 2005
Micronephthys stammeri (Augener, 1932)	+ Koçak & Katağan, 2005	-	+ Çınar, 2005
Nephtys caeca (Fabricius, 1780)	+ Ergen *et al.*, 1994	-	-
Nephtys hombergii Savigny, 1818	+ Ergen *et al.*, 1994	+ Ergen & Çınar, 1997	-
Nephtys hystricis McIntosh, 1900	+ Çınar *et al.*, 2004	-	-
Nephtys incisa Malmgren, 1865	+ Aydın *et al.*, 2007	-	-
EUNICIDAE			
**Eunice antennata* (Savigny, 1820)	-	+ Ergen & Çınar, 1997	-
Eunice harassii Audouin & Milne Edwards, 1833	+ Çınar & Ergen, 1999	-	-
Eunice pennata (O. F. Müller, 1776)	-	-	+ Çınar, 2005
Eunice torquata Quatrefages, 1865	+ Ergen, 1976	-	+ Çınar, 2005
Eunice vittata (Delle Chiaje, 1829)	+ Ergen, 1976	-	+ Çınar, 2005
Euniphysa italica Cantone & Gravina, 1992	+ Çınar & Dağlı, 2013	-	-
**Lysidice collaris* Grube, 1870	+ Çınar & Ergen, 1999	-	+ Çınar, 2005
Lysidice ninetta (Audouin & Milne Edwards, 1833)	+ Çınar & Ergen, 1999	+ Ergen & Çınar, 1997	+ Çınar, 2005
Marphysa bellii (Audouin & Milne Edwards, 1833)	+ Çınar & Ergen, 1999	-	+ Çınar, 2005
Marphysa fallax Marion & Bobretzky, 1875	+ Çınar & Ergen, 1999	+ Ergen & Çınar, 1997	+ Çınar, 2005
Marphysa sanguinea (Montagu, 1815)	+ Çınar & Ergen, 1999	-	-
Nematonereis unicornis (Grube, 1840)	+ Çınar & Ergen, 1999	+ Ergen & Çınar, 1997	+ Çınar, 2005
Palola siciliensis (Grube, 1840)	+ Çınar & Ergen, 1999	-	+ Çınar, 2005
LUMBRINERIDAE			
Hilbigneris gracilis (Ehlers, 1868)	+ Doğan *et al.*, 2005	+ Ergen & Çınar, 1997	+ Çınar, 2005
Lumbricalus adriatica (Fauvel, 1940)	+ Kurt *et al.*, 2007	-	-
Lumbrinerides amoureuxi Miura, 1980	-	-	+ Çınar, 2005
Lumbrineriopsis paradoxa (Saint-Joseph, 1888)	+ Kurt *et al.*, 2007	-	+ Çınar, 2005
Lumbrineris coccinea (Renier, 1804)	+ Çınar & Ergen, 1999	+ Ergen & Çınar, 1997	+ Çınar, 2005
Lumbrineris geldiayi Car. Parra, Çınar & Dağlı, 2011	+ Çınar & Dağlı, 2013	-	-
Lumbrineris latreilli Audouin & M. Edwards, 1834	+ Ergen *et al.*, 2004	-	+ Çınar, 2005
Lumbrineris nonatoi Ramos, 1976	+ Kurt *et al.*, 2007	-	+ Çınar, 2005
Scoletoma emandibulata mabiti (Ramos, 1976)	+ Çınar & Ergen, 1999	-	-
Scoletoma fragilis (O. F. Muller, 1776)	+ Ergen, 1976	-	-
Scoletoma funchalensis (Kinberg, 1865)	+ Kurt *et al.*, 2007	-	-
Scoletoma impatiens (Claparède, 1868)	+ Kocataş, 1978	-	-
Scoletoma tetraura (Schmarda, 1861)	+ Doğan *et al.*, 2005	-	+ Çınar, 2005
ONUPHIDAE			
Aponuphis bilineata (Baird, 1870)	+ Çınar & Dağlı, 2013	-	+ Çınar, 2005
Aponuphis brementi Fauvel, 1916	+ Ergen *et al.*, 1994	-	+ Çınar, 2005
Aponuphis fauveli, Rioja, 1918	+ Çınar & Dağlı, 2013	-	-
Nothria conchylega (M. Sars, 1835)	-	+ Ergen & Çınar, 1997	-
**Onuphis eremita oculata* Hartman, 1951	+ Çınar & Dağlı, 2012	-	-
Paradiopatra bihanica Intes & Le Loeuff, 1975	-	-	+ Çınar, 2005
Paradiopatra quadricuspis (Sars, 1872)	-	-	+ Çınar, 2005
DORVILLEIDAE			
Dorvillea rubrovittata (Grube, 1855)	+ Çınar & Ergen, 1999	+ Ergen & Çınar, 1997	+ Çınar, 2005
**Dorvillea similis* (Crossland, 1924)	-	+ Çınar, 2009	-
Pettiboneia urciensis Campoy & San Martín, 1980	+ Çınar & Dağlı, 2013	-	+ Çınar, 2005
Protodorvillea kefersteini (McIntosh, 1869)	+ Doğan *et al.*, 2005	-	+ Çınar, 2005
Schistomeringos neglecta (Fauvel, 1923)	+ Çınar & Ergen, 1999	-	-
Schistomeringos rudolphii (Delle Chiaje, 1828)	+ Koçak & Katağan, 2005	-	+ Çınar, 2005
OENONIDAE			
Arabella geniculata (Claparède, 1868)	-	-	+ Çınar, 2005
Arabella iricolor (Montagu, 1804)	+ Ergen *et al.*, 1994	-	+ Çınar, 2005
Drilonereis filum (Claparède, 1868)	+ Çınar & Dağlı, 2013	-	+ Çınar, 2005
Notocirrus scoticus, *sensu* Ramos, 1976	-	-	+ Çınar, 2005

ORBINIIDAE			
Naineris laevigata (Grube, 1855)	+[Çınar & Ergen, 1999]	-	+[Çınar, 2005]
Protoaricia oerstedii (Claparède, 1863)	+[Çınar & Ergen, 1999]	-	-
Scoloplos armiger (O. F. Muller, 1776)	+[Emig *et al.*, 2005]	-	+[Çınar, 2005]
Scoloplos chevalieri candiensis Harmelin, 1969	-	-	+[Çınar, 2005]
SPIONIDAE			
Aonides oxycephala (Sars, 1862)	+[Doğan *et al.*, 2005]	-	+[Çınar, 2005]
Aurospio banyulensis (Laubier, 1966)	+[Dağlı *et al.*, 2011]	-	-
Laonice bahusiensis Söderström, 1920	+[Dağlı *et al.*, 2011]	-	-
Laonice cirrata (M. Sars, 1851)	+[Doğan *et al.*, 2005]	-	+[Çınar, 2005]
Laubieriellus salzi (Laubier, 1970)	+[Dağlı *et al.*, 2011]	-	+[Çınar, 2005]
Microspio mecznikowianus (Claparède, 1868)	+[Dağlı *et al.*, 2008]	-	-
**Paraprionospio coora* (Ehlers, 1901)	+[Dağlı *et al.*, 2011]	-	-
Polydora coeca (Örsted, 1843)	+[Ergen *et al.*, 1994]	-	-
**Polydora cornuta* Bosc, 1802	+[Koçak & Katağan, 2005]	-	-
Polydora hoplura Claparède, 1869	+[Çınar & Dağlı, 2013]	-	-
Prionospio cirrifera Wiren, 1883	+[Çınar & Ergen, 1999]	-	-
**Prionospio depauperata* Imajima, 1990	+[Çınar & Dağlı, 2013]	-	-
Prionospio dubia Day, 1961	+[Doğan *et al.*, 2005]	-	-
Prionospio ehlersi Fauvel, 1928	-	-	+[Çınar, 2005]
Prionospio fallax Soderstrom, 1920	+[Ergen *et al.*, 1994]	-	-
Prionospio maciolekae Dağlı & Çınar, 2011	+[Doğan *et al.*, 2005]	-	-
**Prionospio pulchra* Imajima, 1990	+[Çınar & Dağlı, 2013]	-	-
Prionospio steenstrupi Malmgren, 1867	+[Dağlı *et al.*, 2011]	-	+[Çınar, 2005]
Pseudopolydora antennata (Claparède, 1870)	+[Koçak & Katağan, 2005]	-	-
Pseudopolydora pulchra (Carazzi, 1895)	+[Dağlı *et al.*, 2008]	-	-
Scolelepis bonnieri (Mesnil, 1896)	+[Doğan *et al.*, 2005]	-	-
Scolelepis cantabra (Rioja, 1918)	+[Aydın *et al.*, 2007]	-	+[Çınar, 2005]
Scolelepis tridentata (Southern, 1914)	+[Dağlı *et al.*, 2011]	-	-
Spio decoratus Bobretzky, 1870	+[Koçak & Katağan, 2005]	-	+[Çınar, 2005]
Spio filicornis (O. F. Muller, 1776)	+[Çınar & Ergen, 1999]	-	-
Spiophanes bombyx (Claparède, 1870)	+[Doğan *et al.*, 2005]	-	-
Spiophanes kroyeri Grube, 1860	+[Dağlı *et al.*, 2008]	-	-
PARAONIDAE			
Aricidea assimilis Tebble, 1959	+[Aydın *et al.*, 2007]	-	+[Çınar, 2005]
Aricidea catherinae Laubier, 1967	+[Çınar & Dağlı, 2013]	-	+[Çınar, 2005]
Aricidea cerrutii Laubier, 1967	+[Emig *et al.*, 2003]	-	+[Çınar, 2005]
Aricidea claudiae Laubier, 1967	+[Aydın *et al.*, 2007]	-	-
Aricidea pseudoarticulata Hobson, 1972	+[Çınar & Dağlı, 2013]	-	-
Cirrophorus branchiatus Ehlers, 1908	+[Doğan *et al.*, 2005]	-	-
Cirrophorus furcatus (Hartman, 1957)	+[Çınar & Dağlı, 2013]	-	-
Levinsenia demiri Çınar, Dağlı & Açik, 2011	+[Çınar & Dağlı, 2013]	-	-
Levinsenia gracilis (Tauber, 1879)	+[Doğan *et al.*, 2005]	-	+[Çınar, 2005]
Levinsenia materi Çınar & Dağlı, 2013	+[Çınar & Dağlı, 2013]	-	-
Paradoneis armata Glemarec, 1966	-	-	+[Çınar, 2005]
Paradoneis lyra (Southern, 1914)	+[Ergen *et al.*, 2004]	-	+[Çınar, 2005]
CHAETOPTERIDAE			
Spiochaetopterus costarum (Claparède, 1870)	+[Çınar & Dağlı, 2013]	-	-
MAGELONIDAE			
Magelona alleni Wilson, 1958	+[Çınar & Dağlı, 2013]		
Magelona minuta Eliason, 1962	+[Doğan *et al.*, 2005]		
Magelona papillicornis Müller, 1858		+[Ergen & Çınar, 1997]	
POECILOCHAETIDAE			
Poecilochaetus serpens Allen, 1904	+[Çınar & Dağlı, 2013]		
FLABELLIGERIDAE			
Brada villosa (Rathke, 1843)	+[Ergen *et al.*, 1994]		
Diplocirrus glaucus (Malmgren, 1867)		+[Çınar & Dağlı, 2013]	
Flabelligera affinis M. Sars, 1829	+[Çınar & Dağlı, 2013]	+[Ergen & Çınar, 1997]	
Piromis eruca (Claparède, 1870)	+[Ergen, 1986]	+[Ergen & Çınar, 1997]	+[Çınar, 2005]
CIRRATULIDAE			

Aphelochaeta filiformis (Keferstein, 1862)	+Çınar & Dağlı, 2013		
Caulleriella alata (Southern, 1914)	+Emig *et al.*, 2003		+Çınar, 2005
Caulleriella bioculata (Keferstein, 1862)	+Çınar & Dağlı, 2013		+Çınar, 2005
Chaetozone corona Berkeley & Berkeley, 1941	+Çınar & Ergen, 2007		
Cirriformia tentaculata (Montagu, 1808)			+Çınar, 2005
Monticellina heterochaeta (Laubier, 1961)	+Aydın *et al.*, 2007		+Çınar, 2005
Protocirrineris chrysoderma (Claparède, 1870)	+Ergen, 1976		
FAUVELIOPSIDAE			
Fauveliopsis fauchaldi Katzmann & Laubier, 1974			+Çınar, 2005
ACROCIRRIDAE			
Acrocirrus frontifilis (Grube, 1860)			+Çınar, 2005
Macrochaeta clavicornis (M. Sars, 1835)	+Çınar *et al.*, 2004		+Çınar, 2005
SCALIBREGMIDAE			
Asclerocheilus intermedius (Saint-Joseph, 1894)			+Çınar, 2005
Scalibregma celticum Mackie, 1991			+Çınar, 2005
Scalibregma inflatum Rathke, 1843	+Çınar & Ergen, 1999		+Çınar, 2005
Sclerocheilus minutus Grube, 1863	+Çınar & Ergen, 1999		+Çınar, 2005
COSSURIDAE			
Cossura soyeri Laubier, 1963	+Çınar & Dağlı, 2013		
CAPITELLIDAE			
Capitella capitata (Fabricius, 1780)	+Koçak & Katağan, 2005		+Çınar, 2005
Capitomastus minima (Langerhans, 1880)	+Çınar & Dağlı, 2013		
Dasybranchus caducus (Grube, 1846)			+Çınar, 2005
Dasybranchus gajolae Eisig, 1887	+Ergen *et al.*, 1994		+Çınar, 2005
Heteromastus filiformis (Claparède, 1864)	+Aydın *et al.*, 2007		
Mediomastus capensis Day, 1961			+Çınar, 2005
Mediomastus cirripes Ben-Eliahu, 1976	+Çınar & Dağlı, 2013		
Neopseudocapitella brasiliensis Rullier & Amoureux, 1979	+Çınar *et al.*, 2004		+Çınar, 2005
Notomastus aberans Day, 1957	+Çınar & Dağlı, 2013		+Çınar, 2005
Notomastus latericeus M. Sars, 1851	+Emig *et al.*, 2003		+Çınar, 2005
Notomastus lineatus Claparède, 1870			+Çınar, 2005
Notomastus mossambicus (Thomassin, 1970)		+Çınar & Dağlı, 2013	
Notomastus profundus Eisig, 1887	+Ergen *et al.*, 1994		
Pseudoleiocapitella fauveli Harmelin, 1964	+Doğan *et al.*, 2005	+Ergen & Çınar, 1997	+Çınar, 2005
MALDANIDAE			
Chirimia biceps (M. Sars, 1861)	+Ergen *et al.*, 1994		+Çınar, 2005
Euclymene collaris (Claparède, 1870)	+Çınar & Dağlı, 2013	+Ergen & Çınar, 1997	+Çınar, 2005
Euclymene lumbricoides (Quatrefages, 1865)	+Ergen *et al.*, 1994	+Ergen & Çınar, 1997	
Euclymene oerstedi (Claparède, 1863)	+Ergen, 1976	+Ergen & Çınar, 1997	+Çınar, 2005
Euclymene palermitana (Grube, 1840)	+Doğan *et al.*, 2005		
Leiochone leiopygos (Grube, 1860)			+Çınar, 2005
Leiochone tricirrata (Bellan & Reys, 1967)			+Çınar, 2005
Macroclymene santandarensis (Rioja, 1917)	+Doğan *et al.*, 2005	+Ergen & Çınar, 1997	+Çınar, 2005
Maldane sarsi Malmgren, 1865			
Nicomache lumbricalis (Fabricius, 1780)	+Aydın *et al.*, 2007		+Çınar, 2005
Petaloproctus terricola Quatrefages, 1865	+Ergen *et al.*, 1994		+Çınar, 2005
Praxillella praetermissa (Malmgren, 1866)	+Doğan *et al.*, 2005		+Çınar, 2005
Rhodine loveni Malmgren, 1865	+Çınar & Dağlı, 2013		+Çınar, 2005
OPHELIIDAE			
Armandia cirrhosa Philippi, 1861	+Doğan *et al.*, 2005		+Çınar, 2005
Armandia polyophthalma Kukenthal, 1887	+Ergen, 1986		
Ophelia roscoffensis Augener, 1910	+Çınar *et al.*, 2004		
Ophelina cylindricaudata (Hansen, 1878)			+Çınar, 2005
Polyophthalmus pictus (Dujardin, 1839)	+Çınar & Ergen, 1999	+Ergen & Çınar, 1997	+Çınar, 2005
Tachytrypane jeffreysii McIntosh, 1879	+Çınar *et al.*, 2004		+Çınar, 2005
STERNASPIDAE			
Sternaspis scutata (Renier, 1807)	+Çınar & Dağlı, 2013		
OWENIIDAE			
Galathowenia oculata (Zachs, 1922)	+Çınar & Dağlı, 2013		

Owenia fusiformis Delle Chiaje, 1842	+ Koçak & Katağan, 2005	+ Ergen & Çınar, 1997	
SABELLARIIDAE			
Sabellaria spinulosa Leuckart, 1849	+ Ergen *et al.*, 1994		
Lagis koreni Malmgren, 1866	+ Ergen *et al.*, 1994		
Pectinaria auricoma (O. F. Müller, 1776)			+ Çınar, 2005
AMPHARETIDAE			
Amage adspersa (Grube, 1863)	+ Çınar *et al.*, 2004		
Ampharete acutifrons (Grube, 1860)	+ Doğan *et al.*, 2005		
Amphicteis gunneri (M. Sars, 1835)	+ Ergen *et al.*, 1994		+ Çınar, 2005
Anobothrus gracilis (Malmgren, 1866)	+ Çınar & Dağlı, 2013		
Melinna palmata Grube, 1870	+ Ergen *et al.*, 1994	+ Ergen & Çınar, 1997	+ Çınar, 2005
Sabellides octocirrata (M. Sars, 1835)	+ Çınar & Dağlı, 2013		
TEREBELLIDAE			
Amaeana trilobata (Sars, 1863)			+ Çınar, 2005
Amphitrite cirrata (O. F. Müller, 1771)	+ Çınar & Ergen, 1999		
Amphitrite rubra (Risso, 1828)	+ Ergen *et al.*, 1994		+ Çınar, 2005
Amphitrite variabilis (Risso, 1826)			+ Çınar, 2005
Axionice maculata (Dalyell, 1853)			+ Çınar, 2005
Eupolymnia nebulosa (Montagu, 1818)	+ Çınar & Ergen, 1999		+ Çınar, 2005
Eupolymnia nesidensis (Delle Chiaje, 1828)			+ Çınar, 2005
Lanice conchilega (Pallas, 1766)	+ Ergen, 1976		+ Çınar, 2005
Lysilla loveni Malmgren, 1866	+ Çınar & Dağlı, 2013		
Neoamphitrite edwardsi (Quatrefages, 1865)	+ Ergen *et al.*, 1994		+ Çınar, 2005
Nicolea venustula (Montagu, 1818)	+ Çınar & Ergen, 1999		+ Çınar, 2005
Parathelepus collaris (Southern, 1914)			+ Çınar, 2005
Pista cretacea (Grube, 1860)	+ Ergen, 1976		
Pista cristata (O. F. Müller, 1776)	+ Çınar & Ergen, 1999		+ Çınar, 2005
**Pista unibranchia* Day, 1963	+ Çınar & Dağlı, 2013	+ Ergen & Çınar, 1997	
Polycirrus aurantiacus Grube, 1860	+ Çınar & Ergen, 1999		+ Çınar, 2005
Polycirrus haematodes (Claparède, 1864)	+ Çınar & Ergen, 1999	+ Ergen & Çınar, 1997	+ Çınar, 2005
Terebella lapidaria Linnaeus 1767	+ Ergen *et al.*, 1994		
Thelepus cincinnatus (Fabricius, 1780)	+ Çınar & Ergen, 1999		
TRICHOBRANCHIDAE			
Octobranchus lingulatus (Grube, 1863)	+ Çınar & Dağlı, 2013		
Terebellides stroemi M. Sars, 1835	+ Doğan *et al.*, 2005		
Trichobranchus glacialis Malmgren, 1865	+ Çınar & Dağlı, 2013		+ Çınar, 2005
SABELLIDAE			
Amphicorina armandi (Claparède, 1864)	+ Doğan *et al.*, 2005		+ Çınar, 2005
Amphiglena mediterranea (Leydig, 1851)	+ Çınar & Ergen, 1999	+ Ergen & Çınar, 1997	+ Çınar, 2005
Bispira mariae Lo Bianco, 1893	+ Çınar & Ergen, 1999	+ Ergen & Çınar, 1997	+ Çınar, 2005
**Branchiomma bairdi* (McIntosh, 1885)			+ Çınar, 2005
Branchiomma bombyx (Dalyell, 1853)	+ Çınar & Ergen, 1999	+ Ergen & Çınar, 1997	+ Çınar, 2005
Branchiomma lucullanum (delle Chiaje, 1828)			+ Çınar, 2005
**Branchiomma luctuosum* (Grube, 1869)			+ Çınar, 2005
Branchiomma moebii Knight-Jones, 1994			+ Çınar, 2005
Chone collaris Langerhans, 1880	+ Çınar & Ergen, 1999	+ Ergen & Çınar, 1997	+ Çınar, 2005
Chone duneri Malmgren, 1867	+ Çınar & Ergen, 1999	+ Ergen & Çınar, 1997	
Chone dunerificta Tovar-Hernández, Licc. & Giang., 2007	+ Çınar & Dağlı, 2013		
Chone filicaudata Southern, 1914	+ Çınar & Ergen, 1999	+ Ergen & Çınar, 1997	+ Çınar, 2005
Chone gambiae Tovar-Hernández, Lic. & Giangrande, 2007	+ Çınar & Dağlı, 2013		
Demonex langerhansi (Langerhans, 1884)			+ Çınar, 2005
Demonax tenuicollaris (Grube, 1870)	+ Çınar & Ergen, 1999		
Euchone pseudolimnicola Giangrande & Licci., 2006	+ Çınar & Dağlı, 2013		
Euchone rosea Langerhans, 1884	+ Aydın *et al.*, 2007		+ Çınar, 2005
Euchone rubrocincta (Sars, 1861)			+ Çınar, 2005
Euchone southerni Banse, 1970			+ Çınar, 2005
Fabricia stellaris adriatica (Banse, 1956)	+ Çınar & Dağlı, 2013		
Jasmineira elegans Saint-Joseph, 1894			+ Çınar, 2005
Megalomma vesiculosum (Montagu, 1815)	+ Çınar & Ergen, 1999	+ Ergen & Çınar, 1997	+ Çınar, 2005

Pseudopotamilla reniformis (Müller, 1771)	+[Çınar & Ergen, 1999]		+[Çınar, 2005]
Pseudofabricia aberrans Cantone, 1970			+[Çınar, 2005]
Sabella pavonina Savigny, 1822	+[Çınar & Ergen, 1999]		+[Çınar, 2005]
Sabella spallanzanii (Viviani, 1805)	+[Çınar & Ergen, 1999]		
SERPULIDAE			
Hydroides helmatus (Iroso, 1921)	+[Çınar & Ergen, 1999]		+[Çınar, 2005]
Hydroides niger Zibrowius, 1971	+[Çınar & Ergen, 1999]		+[Çınar, 2005]
Hydroides pseudouncinatus pseudouncinatus Zibrowius, 1971	+[Ergen *et al*., 1994]		
Josephella marenzelleri Caullery & Mesnil, 1896	+[Ergen *et al*., 1994]		
Placostegus chrystallinus sensu Zibrowius, 1968			+[Çınar, 2005]
Protula tubularia (Montagu, 1803)	+[Ergen *et al*., 1994]		
Salmacina dysteri (Huxley, 1855)	+[Ergen *et al*., 1994]		
Serpula concharum Langerhans, 1880	+[Çınar & Ergen, 1999]		+[Çınar, 2005]
Serpula vermicularis Linnaeus, 1767	+[Ergen, 1976]		+[Çınar, 2005]
Spirobranchus lamarckii (Quatrefages, 1865)	+[Çınar & Ergen, 1999]		
Spirobranchus polytrema (Philippi, 1844)	+[Çınar & Ergen, 1999]		+[Çınar, 2005]
Spirobranchus triqueter (Linnaeus, 1767)	+[Çınar & Ergen, 1999]		+[Çınar, 2005]
Vermiliopsis infundibulum (Gmelin, 1788)	+[Çınar & Ergen, 1999]		+[Çınar, 2005]
Vermiliopsis labiata (G. O. Costa, 1861)	+[Çınar & Ergen, 1999]		+[Çınar, 2005]
Vermiliopsis striaticeps (Grube, 1862)	+[Çınar & Ergen, 1999]		+[Çınar, 2005]
Janua pagenstecheri (Quatrefages, 1865)	+[Çınar & Ergen, 1999]		+[Çınar, 2005]
**Janua steueri* (Sterzinger, 1909)		+[Çınar, 2009]	
Neodexiospira pseudocorrugata (Bush, 1904)	+[Çınar & Ergen, 1999]		+[Çınar, 2005]
Pileolaria militaris (Claparède, 1868)	+[Knight-Jones *et al*., 1994]	+[Ergen & Çınar, 1997]	+[Çınar, 2005]
Simplaria pseudomilitaris (Thiriot-Quiev., 1965)	+[Çınar & Ergen, 1999]		

Dominant species

Posidonia oceanica sustains a dense colonization of different zoobenthic species, which seems to share its microhabitats so evenly that, unlike other biotopes, no single species become conspicuously dominant on this phanerogam (Çınar, 2003b). Syllids were known to play important roles in *P. oceanica* meadows. Mazzella *et al*. (1989) reported a high dominance of this family (65% of total polychaete abundance) on *P. oceanica* beds near Ischia (Tyrrhenian Sea). The syllid population density on *P. oceanica* reached up to 3950 ind.m^{-2} on the Cypriot coast (Çınar, 2003a), whereas it was estimated as 13625 ind.m^{-2} in the Aegean Sea (Çınar 2003b). *Sphaerosyllis taylori*, *S. tetralix*, *Salvatoria clavata*, *Syllis variagata*, *S. prolifera*, *S. jorgei* and *Eurysyllis tuberculata* were reported to be common and abundant syllid species on *P. oceanica* (Gambi *et al*., 1984; Mazzella *et al*., 1989; Sardá, 1991; Çınar and Ergen, 2002; Çınar, 2003a). *Syllis jorgei* that was the characteristic species in the *P. oceanica* meadows on the Cypriot coast formed a relatively dense population (max. 1050 ind.m^{-2}, 27% of the total syllid population) (Çınar, 2003a). Gambi *et al*. (1989) reported that *S. clavata* and *S. tetralix* comprised 23% of total number of polychaete specimens found in the foliar stratum of *P. oceanica* in Sardinia. The small-sized serpulids such as *Pileolaria militaris* and *Janua pseudocorrugata* can also be dominant components of the leaf stratum community (Alós, 1983). In the rhizome stratum, *Sphaerosyllis hystrix*, *Amphiglena mediterranea* and *Exogone naidina* accounted for almost 21% of total polychaete abundance (Giangrande, 1985). In the matte formation, *Aponuphis bilineata* (14% of total polychaete abundance), *Notomastus latericeus* (9%) and *Eunice vittata* (8%) were the most dominant species (Harmelin, 1969). Dağlı *et al*. (2011) reported that the most abundant spionid species in the Aegean Sea were *Prionospio maciolekae* (cited as *P*. cf.

multibranchiata, 25% of the spionid specimens) and *Aurospio banyulensis* (22%). The most dominant nereidid species were found to be *Platynereis dumerilii* (55% of total number of nereidid specimens) and *Nereis zonata* (40%) (Ergen *et al.,* 1988; Çınar and Ergen, 2001). The maximum density of *P. dumerilii* was estimated as 1700 ind. m^{-2} and that of *N. zonata* as 1500 ind.m^{-2}. *Protodorvillea kefersteini* (9.5%), *Aricidea cerrutii* (9.4%) and *Paradoneis ilvana* (5.7%) were also reported to be dominant species in the meadow (Covazzi Harriague *et al*., 2006). Belgacem *et al.* (2011) found that dominant vagile species change according to seasons; i*.e. Amphicorina armandi* and *Syllis gracilis* were dominant in spring; *Pontogenia chrysocoma*, *Lepidonotus clava* and *Goniada emerita* in autumn.

Community parameters

The community parameters for polychaetes in a *P. oceanica* meadow in Izmir Bay were maximally estimated as 58 species 0.1.m^{-2} (number of species); 4290 ind.m^{-2} (density); 4.83 (Shannon-Weiner's Diversity Index); 0.98 (Pielou's Evenness Index); and 21.4 g wet weight.m^{-2} (biomass) (Ergen *et al*., 2006). The polychaete density and biomass in the rhizome stratum of the meadow were reported to be 601 ind.m^{-2} and 187 mg AFDWm^{-2} (Covazzi Harriague *et al*., 2006).

Number of polychaete species found on Posidonia oceanica

The highest number of polychaete species (316 species) associated with *Posidonia oceanica* were encountered on the Aegean coast of Turkey, the lowest number (55 species) on the Mediterranean coast of Turkey (Figure 2). The reason for this big difference in the species richness is mainly due to the magnitude of effort that has been performed in the areas. In the Aegean Sea, 23 papers dealt with polychaetes on *P. oceanica*, whereas only three papers (Ergen and Çınar, 1997; Çınar, 1999; Çınar and Dağlı, 2012) reported polychaetes on *P. oceanica* meadows on the Mediterranean coast of Turkey. On the coast of Northern Cyprus, 242 polychaete species were encountered (Çınar *et al*., 2003; Çınar and Ergen, 2003; Çınar, 2005). Combiling data from the Mediterranean coast of Turkey and Northern Cyprus show that a total of 259 polychaete species were reported on *P. oceanica* in the Levantine Sea.

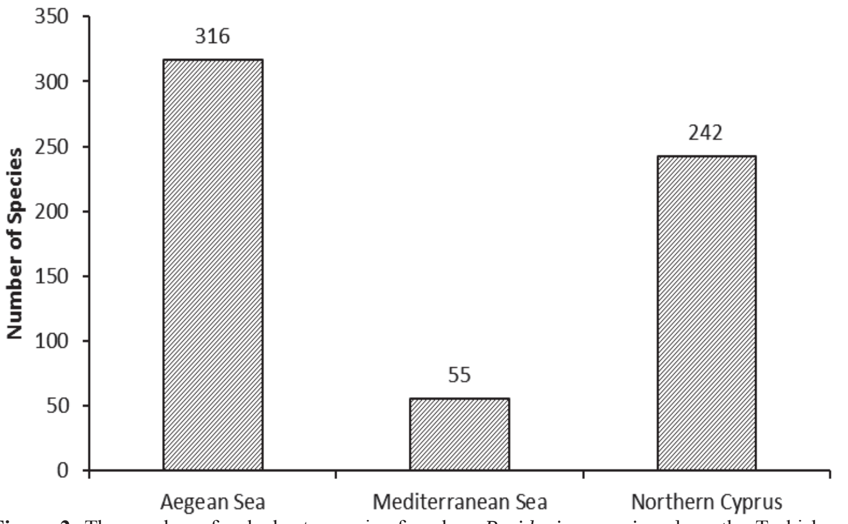

Figure 2. The number of polychaete species found on *Posidonia oceanica* along the Turkish and Cypriot coasts.

Borers on Posidonia oceanica

Four eunicid species, *Lysidice ninetta*, *L. collaris*, *Nematonereis unicornis* and *Marphysa fallax* are the specific borers of *Posidonia oceanica* scales (Gambi *et al*., 2005). All these species occur on the coasts of Turkey (Ergen and Çınar, 1997; Çınar and Ergen, 1999) and Northern Cyprus (Çınar, 2005). The other *Lysidice* species, *L. margaritacea*, that was only reported from the Mediterranean coast of Turkey (Kurt Şahin and Çınar, 2009), could also be a borer of *P. oceanica*. They use their strong, chitinous jaws to bore into scales and create distinct traces (Figure 3). In general, *L. collaris* was noted to be the most frequent borer species, while *M. fallax* are very rare (Gambi *et al*., 2000). *Lysidice collaris* prefers the shallow water (<15 m), whereas *L. ninetta* dominates deep waters (>20 m) (Gambi, 2002). These species inhabit *P. oceanica* meadows under different environmental situations including depth range, bed typology, shoot density and potential human influence (Gambi *et al*., 2005). All polychaete borers infest dead scale tissues and are considered to be detritivores (Gambi *et al*., 2003). Borers are capable of modifying the scale structure by mass removal and scale fragmentation, thus contributing to the formation of small-sized detritus that is more available to other consumers (Gambi *et al*., 2000; Gambi, 2002).

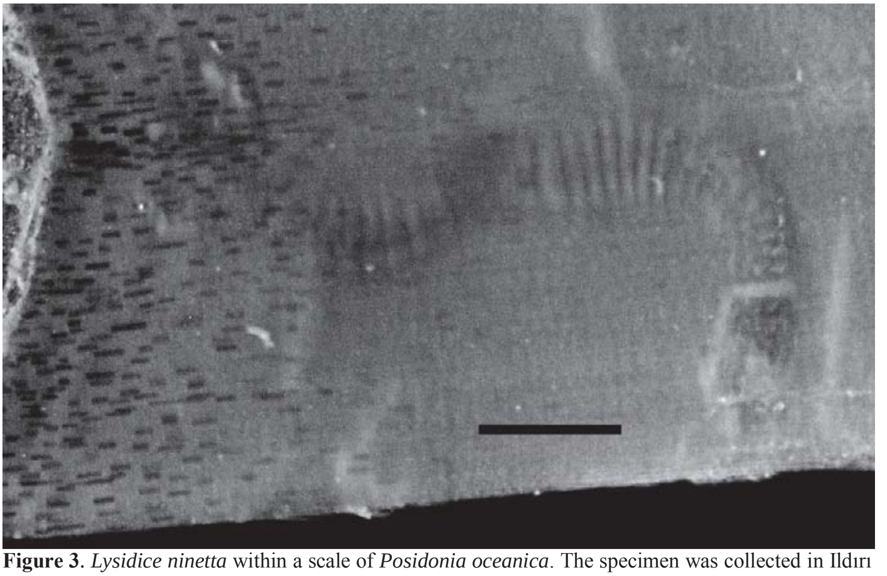

Figure 3. *Lysidice ninetta* within a scale of *Posidonia oceanica*. The specimen was collected in Ildırı Bay at 5 m on 23 August 2004. Scale bar: 1 mm (Photographed by Melih Ertan Çınar).

Alien Polychaeta Species on Posidonia oceanica

A total of 21 alien polychaete species belonging to 13 families were reported on *Posidonia oceanica* beds in the area: 11 species in the Aegean Sea, 8 species in the Mediterranean Sea and 7 species in Cyprus (see Table 1 and Figure 4). The family Spionidae has the highest number of species (4 species), followed by Capitellidae (3 species). Among the species, *Linopherus canariensis* was found on the meadows on all coasts (Aegean, Mediterranean and Cyprus); *Phyllodoce longifrons*, *Eunice antennata*, *Dorvillea similis*, *Notomastus mossambicus* and *Janua steueri* solely on the Mediterranean coast; *Onuphis eremita oculata*, *Paraprionospio coora*, *Polydora cornuta*, *Prionospio depauperata*, *Prionospio pulchra*, *Neopseudocapitella brasiliensis* and *Chaetozone corona* solely on the coast of the Aegean Sea; *Eusyllis kupfferi*, *Pseudonereis anomala*, *Branchiomma bairdi* and *Branchiomma luctuosum* solely on the Cypriot coast. Nineteen species have been well established in the area and two species (*Paraprionospio coora* and *Chaetozone corona*) are cryptogenetic species. Among the established species, *Ceratonereis mirabilis*, *E. antennata*, *D. similis*, *N. mossambicus*, *P. cornuta*, *P. anomala*, *B. bairdi* and *B. luctuosum* were classified as invasive or potentially invasive species (Zenetos *et al*., 2010). However, high dominance values of these species were not reported on *P. oceanica* up to date. For example, *P. cornuta* formed dense populations in the polluted soft substratum near harbours [*i.e.* Alsancak Harbour, 3170 ind.m^{-2} (Çınar *et al*., 2005)] and estuaries [*i.e.* Golden Horn, 4340 ind.m^{-2}, (Çınar *et al*., 2009)], but was represented by only one individual on *P. oceanica* collected at stations near fish farms in Ildırı Bay (Koçak and Katağan, 2005). These alien species were also reported on a variety of hard and soft substrata in the region (Çınar *et al*., 2011).

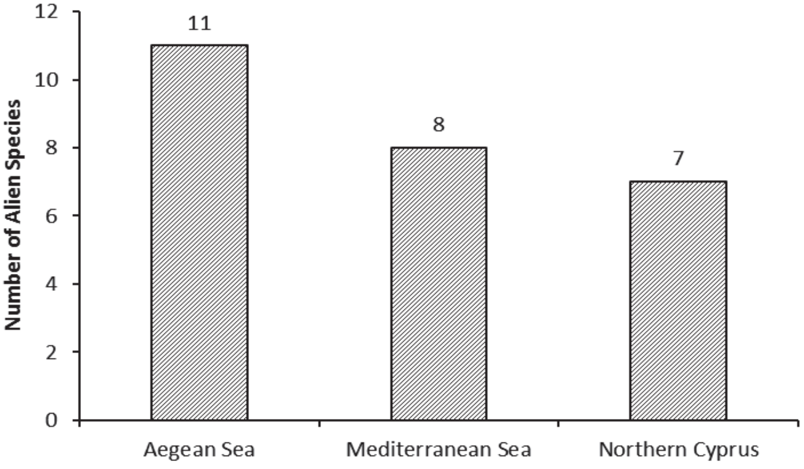

Figure 4. The number of alien polychaete species found on *Posidonia oceanica* meadows in the areas.

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Molluscs associated with *Posidonia oceanica* (L.) Delile on the coasts of Turkey

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Abstract

As a result of evaluating the studies conducted along the Turkish seas, a total of 251 molluscan species associated with *Posidonia oceanica* meadows, belonging to 4 classes (Polyplacophora, Gastropoda, Bivalvia and Scaphopoda) and 80 families were determined. Gastropoda represented with the maximum number (156) of species followed by Bivalvia (80) Polyplacophora (10) and Scaphopoda (5). Pyramidellidae and Rissoidae were the most dominant families with 27 (11%) and 22 (9%) species respectively. Trochidae and Veneridae (11 species, 4% each) were other dominant families followed by Mangeliidae (10 species, 4 %).

Introduction

Seagrasses, marine flowering plants, which have key ecological roles in coastal ecosystems and can form extensive meadows supporting high biodiversity, are widely distributed along temperate and tropical coastlines of the world (Short *et al*., 2007). These plants affecting coastal zone features with respect to wave attenuation and stabilization of coastal areas as they enhance sediment stability by preventing re-suspension (Gacia and Duarte, 2001). On the other hand, seagrasses provide an important nursery area for many species that support offshore fisheries and for adjacent habitats such as salt marshes, shellfish beds, coral reef sand mangrove forests (Short *et al*., 2007).

Posidonia oceanica is one of the five species of Phanerogams occurring in the Mediterranean basin. This endemic Mediterranean species forms dense meadows up to 45 m depth (Procaccini *et al*., 2003) and has importance as other seagrass species for coastal ecosystems and humans as it has ecological (nursery or permanent habitat for many species, production of oxygen *etc*.), physical (trapping sediment, help increasing transparency of coastal waters, reducing coastal erosion *etc*.) and economic roles (high biological production, maintaining water quality *etc*.) (Terrados and Duarte, 2000; Gacia and Duarte 2001; Boudouresque *et al*., 2012). Besides of all these, *P. oceanica* meadows has dramatically regressed especially since 1950s (Boudouresque *et al*., 2012). Factors responsible for this regression could be summarized as building coastal structures (direct or indirect effects as hyper sedimentation or erosion), river inputs (salinity changes, nutrient and salinity inputs), decrease of water transparency (reduction in photosynthesis), excessive nutrients and chemical contaminants on the ecosystem (growth problems *etc*.), destructive effects of anchoring and trawling, coastal aquaculture (excessive organic matter, anoxity, increase epiphytes/reduction photosynthesis), effects of introduced species (competition with *Caulerpa* species and grazed by *Siganus luridus*) and overgrazing (increasing of population of *Paracentrotus lividus*) (Cancemi *et al*., 2003; 2005; Beqiraj *et al*., 2008; Díaz-Almela *et al*., 2008; Holmer *et al*., 2008; Molenaar *et al*., 2009; Terlizzi *et al*., 2010; Kiparissis *et al*., 2011; Ozvarol *et al*., 2011; Boudouresque *et al*., 2012). On the other hand, in order to predict anthropogenic pressures on the ecosystem, new indexes (*e.g.* BiPo,POMI) using *P. oceanica* have been proposed recently (Lopez y Royo *et al*., 2010; Mascaró *et al*., 2012).

Faunal assemblages associated with *P. oceanica* meadows have been well documented by many authors (Harmelin, 1964; Sanchez-Jerez *et al*., 1999; Borg *et al*., 2006; Covazzi Harriague *et al*., 2006; Beqiraj *et al*., 2008; Como *et al*., 2008; Francour *et al*., 2009; Belgacem *et al*., 2011; Bendini *et al*., 2011). Besides, specific studies on the molluscan communities in association with *P. oceanica* have also been carried out in the different localities of the Mediterranean (Spada, 1971; Templado, 1984; Bonfitto, *et al*., 1998; Peñas and Almera, 2001; Solustri *et al*., 2002; Vetere *et al*., 2006; Albano, and Sabelli, 2012; Belgacem, 2013).

Association of molluscan species with *P. oceanica* meadows in Turkish seas has not already been studied yet specifically. Data of the present study has been basically derived from the researches carried out on the benthic fauna of certain areas including *P. oceanica* meadows. Studies on the distribution of molluscan groups or species of definite localities involving *P. oceanica* meadows have also been utilized in this study. Revealing the mollusc species which are in association with *P. oceanica* seagrass meadows along the Turkish seas by evaluating of aforementioned studies is the aim of this paper.

Material and Method

Benthic researches carried out along the Turkish seas conducted on the biotopes containing *P. oceanica* meadows were evaluated within the frame of this study. Costello *et al*. (2012) were taken into consideration for systematic order of the species. List of these species and related references were given in Table 1.

Results and Discussion

A total of 251 molluscan species belonging to 4 classes and 80 families were determined as a result of evaluating of the benthic studies performed on the Turkish seas conducted on the biotopes comprising *P. oceanica* meadows (Table 1).

Table 1. List of the molluscan species associated with *Posidonia oceanica* meadows on the Turkish coast (AS: Aegean Sea, LS: Levantine Sea; * indicate alien species).

Species	Reference	Sea
POLYPLACOPHORA		
Neoloricata		
Acanthochitonidae		
Acanthochitona fascicularis (Linnaeus, 1767)	10,6,17	AS
Callochitonidae		
Callochiton septemvalvis (Montagu, 1803)	17	AS
Chitonidae		
Chiton (*Rhyssoplax*) *olivaceus* Spengler, 1797	12,6,17	AS
Chiton (*Rhyssoplax*) *corallinus* (Risso, 1826)	17	AS
Ischnochitonidae		
Ischnochiton (*Ischnochiton*) *rissoi* (Payraudeau, 1826)	12,6	AS
Lepidochitonidae		
Lepidochitona (*Lepidochitona*) *cinerea* (Linnaeus, 1767)	10,6,17	AS
Lepidochitona (*Lepidochitona*) *furtiva* (Monterosato, 1879)	17,19	AS
Lepidochitona (*Lepidochitona*) *monterosatoi* Kaas & Van Belle, 1981	6,17	AS
Leptochitonidae		
Leptochiton bedullii Dell'Angelo & Palazzi, 1986	17,19	AS
Leptochiton cimicoides (Monterosato, 1879)	17	AS
GASTROPODA		
Neritimorpha		
Neritidae		
Smaragdia viridis (Linnaeus, 1758)	8,5	AS
Vetigastropoda		
Calliostomatidae		
Calliostoma laugieri laugieri (Payraudeau, 1826)	5	AS
Fissurellidae		
Diodora italica (Defrance, 1820)	5	AS
Diodora gibberula (Lamarck, 1822)	5	AS
Emarginula octaviana Coen, 1939	5	AS
Haliotidae		
Haliotis tuberculata tuberculata Linnaeus, 1758	5	AS
Phasianellidae		
Tricolia miniata (Monterosato, 1884)	15	LS
Tricolia pullus pullus (Linnaeus, 1758)	8,5	AS
Tricolia speciosa (Mühlfeld, 1824)	8,5	AS
Tricolia tenuis (Michaud, 1829)	8,5	AS

Scissurellidae		
Scissurella costata d'Orbigny, 1824	5	AS
Sinezona cingulata (O. G. Costa, 1861)	5	AS
Trochidae		
Clanculus corallinus (Gmelin, 1791)	8,5	AS
Clanculus cruciatus (Linnaeus, 1758)	5	AS
Clanculus jussieui (Payraudeau, 1826)	5	AS
Gibbula adansonii (Payraudeau, 1826)	5	AS
Gibbula albida (Gmelin, 1791)	5	AS
Gibbula ardens (Von Salis, 1793)	8,5	AS
Gibbula fanulum (Gmelin, 1791)	8,5	AS
Gibbula umbilicalis (da Costa, 1778)	8,5	AS
Gibbula varia (Linnaeus, 1758)	5	AS
Jujubinus exasperatus (Pennant, 1777)	8,5	AS
*Jujubinus striatus (*Linnaeus, 1758)	8,10,5	AS
Caenogastropoda		
Anabathridae		
Nodulus contortus (Jeffreys, 1856)		AS
Barleeiidae		
Barleeia unifasciata (Montagu, 1803)	8	AS
Buccinidae		
Chauvetia brunnea (Donovan, 1804)	19	AS
Chauvetia turritellata (Deshayes, 1835)	8,10, 19	AS
Engina leucozona (Philippi, 1843)	8	AS
Euthria cornea (Linnaeus, 1758)	8	AS
Pollia scacchiana (Philippi, 1844)	8	AS
Caecidae		
Caecum armoricum de Folin, 1869	19	AS
Caecum auriculatum de Folin, 1868	4	AS
Caecum clarkii Carpenter, 1859	4	AS
Caecum subannulatum de Folin, 1870	4	AS
Caecum trachea (Montagu, 1803)	4	AS
Parastrophia asturiana de Folin, 1870	4	AS
Cerithiidae		
Bittium latreillii (Payraudeau, 1826)	8,10,14	AS
Bittium lacteum (Philippi, 1836)	19	AS
Bittium reticulatum (da Costa, 1778)	8,10	AS
Bittium submamillatum (de Rayneval & Ponzi, 1854)	8	AS

Cerithium vulgatum Bruguière, 1792	8,12,10	AS
Cerithiopsidae		
Cerithiopsis jeffreysi Watson, 1885	20	AS
Cerithiopsis minima (Brusina, 1865)	8,20	AS
Cerithiopsis tubercularis (Montagu, 1803)	8,20	AS
Dizoniopsis coppolae (Aradas, 1870)	20	AS
Columbellidae		
Columbella rustica (Linnaeus, 1758)	8	AS
Mitrella gervillii (Payraudeau, 1826)	19	AS
Conidae		
Conus ventricosus Gmelin, 1791	8	AS
Costellariidae		
Vexillum (Pusia) ebenus (Lamarck, 1811)	8	AS
Vexillum (Pusiolina) granum (Forbes, 1844)	8	AS
Drilliidae		
Crassopleura maravignae (Bivona, Ant. in Bivona, And., 1838)	19	AS
Epitoniidae		
Epitonium clathrus (Linnaeus, 1758)	8,20	AS
Epitonium muricatum (Risso, 1826)	20	AS
Epitonium turtonis (Turton, 1819)	20	AS
Eulimidae		
Eulima glabra (da Costa, 1778)	8,20	AS
Melanella boscii (Payraudeau, 1826)	20	AS
Melanella polita (Linnaeus, 1758)	8,20	AS
Melanella stalioi (Brusina, 1869)	20	AS
Parvioris ibizenca (Nordsieck, 1968)	20,18	AS
Sticteulima jeffreysiana (Brusina, 1869)	20	AS
Vitreolina curva (Monterosato, 1874)	20	AS
Vitreolina incurva (Bucquoy, Dautzenberg & Dollfus, 1883)	20	AS
Vitreolina philippi (de Rayneval & Ponzi, 1854)	20	AS
Fasciolariidae		
Fusinus pulchellus (Philippi, 1844)	19	AS
Fusinus syracusanus (Linnaeus, 1758)	8	AS
Horaiclavidae		
Haedropleura secalina (Philippi,1844)	8	AS
Haedropleura septangularis (Montagu, 1803)	19	AS
Iravadiidae		
Hyala vitrea (Montagu, 1803)	12	AS

Mangeliidae		
Bela brachystoma (Philippi, 1844)	8,21	AS,LS
Bela menkhorsti van Aartsen, 1988	21	AS
Bela nebula (Montagu, 1803)	8,7,21	AS
Bela zonata (Locard, 1892)	8	AS
Mangelia attenuata (Montagu, 1803)	8,7,21	AS
Mangelia barashi (van Aartsen & Fehr-de Wal, 1978)	21	LS
Mangelia costata (Pennant, 1777)	21	AS
Mangelia costulata Risso, 1826	8,21	AS,LS
Mangelia stosiciana Brusina, 1869	19,21	AS
Mangelia unifasciata (Deshayes, 1835)	8,7,21	AS,LS
Mitridae		
Mitra cornicula (Linnaeus, 1758)	19	AS
Mitromorphidae		
Mitromorpha olivoidea (Cantraine, 1835)	8	AS
Muricidae		
Bolinus brandaris (Linnaeus, 1758)	8	AS
Hexaplex trunculus (Linnaeus, 1758)	8,12,10	AS
Muricopsis (*Muricopsis*) *cristata* (Brocchi, 1814)	8	AS
Ocinebrina aciculata (Lamarck, 1822)	8	AS
Trophonopsis muricata (Montagu, 1803)	8	AS
Typhinellus labiatus (de Cristofori & Jan, 1832)	19	AS
Nassariidae		
Cyclope neritea (Linnaeus, 1758)	12,3	AS
Nassarius incrassatus (Strøm, 1768)	8,10	AS
Nassarius pygmaeus (Lamarck, 1822)	8,10	AS
Naticidae		
Euspira pulchella (Risso, 1826)	8	AS
Raphitomidae		
Raphitoma echinata (Brocchi, 1814)	8,7	AS
Raphitoma horrida (Monterosato, 1884)	19	AS
Raphitoma linearis (Montagu, 1803)	8,10	AS
Rissoidae		
Alvania cimex (Linnaeus, 1758)	8	AS
Alvania cancellata (Da Costa, 1778)	19	AS
Alvania colossophilus Oberling, 1970	2	LS
Alvania datchaensis Amati & Oliverio, 1987	8,19	AS
Alvania discors (Allan, 1818)	8	AS

**Alvania dorbignyi* (Audouin, 1826)	8	AS
Alvania fractospira (Oberling, 1970)	18	LS
Alvania geryonia (Nardo, 1847)	8,10,19	AS
Alvania lineata Risso, 1826	8	AS
Alvania mamillata Risso, 1826	8,10	AS
Manzonia crassa (Kanmacher, 1798)	19	AS
Pusillina lineolata (Michaud, 1832)	19	AS
Pusillina radiata (Philippi, 1836)	19	AS
Rissoa auriscalpium (Linnaeus, 1758)	8,10,19	AS,LS
Rissoa membranacea (J. Adams, 1800)	8	AS
Rissoa monodonta Philippi, 1836	8,19	AS
Rissoa splendida Eichwald, 1830	8,10	AS
Rissoa variabilis (Von Mühlfeldt, 1824)	8	AS
Rissoa ventricosa Desmarest, 1814	8	AS
Rissoa violacea Desmarest, 1814	8	AS
**Rissoina bertholleti* Issel, 1869	10	AS
Rissoina bruguieri (Payraudeau, 1826)	8,19	AS
Scaliolidae		
**Finella pupoides* Adams A., 1860	8,11	AS
Strombidae		
**Conomurex persicus* (Swainson, 1821)	1	AS,LS
Tonnidae		
Tonna galea (Linnaeus, 1758)	8	AS
Triphoridae		
Marshallora adversa (Montagu, 1803)	8,20	AS
Metaxia metaxae (delle Chiaje, 1828)	20	AS
Monophorus erythrosoma (Bouchet & Guillemot, 1978)	8,20,18	AS
Monophorus perversus (Linnaeus, 1758)	8,20	AS
Similiphora similior (Bouchet & Guillemot, 1978)	20	AS
Turritellidae		
Turritella turbona Monterosato, 1877	19	AS
Heterobranchia		
Haminoeidae		
Haminoea hydatis (Linnaeus, 1758)	8	AS
Weinkauffia turgidula (Forbes, 1844)	8	AS
Chromodorididae		
Felimare picta (Schultz in Philippi, 1836)	23	LS
Mathildidae		

Mathilda gemmulata Semper, 1865	18	AS
Pyramidellidae		
Chrysallida emaciata (Brusina, 1866)	25	AS
Chrysallida excavata (Philippi, 1836)	25	AS
Chrysallida fenestrata (Jeffreys, 1848)	25	AS,LS
Chrysallida intermixta (Monterosato, 1884)	25	AS
Chrysallida interstincta (J. Adams, 1797)	19	AS
**Chrysallida maiae* (Hornung & Mermod, 1924)	25	LS
Chrysallida obtusa (Brown, 1827)	25	AS,LS
Chrysallida suturalis (Philippi, 1844)	25	AS
Chrysallida terebellum (Philippi, 1844)	25	AS
Eulimella ventricosa (Forbes, 1844)	19	AS,LS
Liostomia clavula (Lovén, 1846)	26	AS
Odostomella doliolum (Philippi, 1844)	19	AS
Odostomia acuta Jeffreys, 1848	26	AS,LS
Odostomia conoidea (Brocchi, 1814)	10,26	AS,LS
Odostomia conspicua Alder, 1850	26	AS
Odostomia lukisii Jeffreys, 1859	26	LS
Odostomia scalaris MacGillivray, 1843	19	AS
Odostomia unidentata (Montagu, 1803)	19,26	AS,LS
Ondina anceps Gaglini, 1992	26	AS
Ondina diaphana (Jeffreys, 1848)	26	AS
Ondina vitrea (Brusina, 1866)	26	AS,LS
**Syrnola fasciata* Jickeli, 1882	11	AS
Turbonilla hamata Nordsieck, 1972	19	AS
Turbonilla jeffreysii (Jeffreys, 1848)	19	AS
Turbonilla pusilla (Philippi, 1844)	19	AS
Turbonilla rufa (Philippi, 1836)	19	AS
Turbonilla striatula (Linnaeus, 1758)	19	AS
Scaphandridae		
Roxania utriculus (Brocchi, 1814)	10	AS
BIVALVIA		
Protobranchia		
Nuculanidae		
Nuculana pella (Linnaeus, 1767)	8,13	AS
Nuculidae		
Nucula nitidosa Winckworth, 1930	9,13	AS
Nucula nucleus (Linnaeus, 1758)	12,3,10,13	AS

Nucula sulcata Bronn, 1831	9	AS
Solemyidae		
Solemya togata (Poli, 1791)	9	AS
Pteriomorphia		
Anomiidae		
Anomia ephippium Linnaeus, 1758	9	AS
Arcidae		
Anadara polii (Mayer, 1868)	9	AS
Arca noae Linnaeus, 1758	9,12,10	AS
Arca tetragona Poli, 1795	9	AS
Barbatia barbata (Linnaeus, 1758)	9	AS
Limidae		
Limaria loscombi (G.B. Sowerby I, 1823)	9	AS
Mytilidae		
Dacrydium hyalinum (Monterosato, 1875)	16	AS
Gibbomodiola adriatica (Lamarck, 1819)	9,13	AS
Modiolula phaseolina (Philippi, 1844)	8,9,10,13	AS
Modiolus barbatus (Linnaeus, 1758)	9,12,10,13	AS
Musculus costulatus (Risso, 1826)	8,9,12,13	AS
Musculus discors (Linnaeus, 1767)	16	AS
Musculus subpictus (Cantraine, 1835)	9,10	AS
Mytilaster lineatus (Gmelin, 1791)	9	AS
Mytilus galloprovincialis Lamarck, 1819	10	AS
Noetiidae		
Striarca lactea (Linnaeus, 1758)	8,9,13	AS
Ostreidae		
**Crassostrea gigas* (Thunberg, 1793)	13	AS
Pectinidae		
Aequipecten opercularis (Linnaeus, 1758)	9,22	AS
Flexopecten flexuosus (Poli, 1795)	13	AS
Flexopecten hyalinus (Poli, 1795)	8,9,13,22	AS
Mimachlamys varia (Linnaeus, 1758)	9,13	AS
Talochlamys multistriata (Poli, 1795)	9,22	AS
Propeamussiidae		
Parvamussium fenestratum (Forbes, 1844)	9,22	AS
Heterodonta		
Cardiidae		
Acanthocardia echinata (Linnaeus, 1758)	8	AS

Acanthocardia paucicostata (G.B. Sowerby II, 1834)	8,9,13	AS
Papillicardium papillosum (Poli, 1791)	8,9,13	AS
Parvicardium exiguum (Gmelin, 1791)	8,9,10,13	AS
Parvicardium scabrum (Philippi, 1844)	13	AS
Parvicardium scriptum (Bucquoy, Dautzenberg & Dollfus, 1892)	9	AS
Carditidae		
Cardita calyculata (Linnaeus, 1758)	9	AS
Cardites antiquatus (Linnaeus, 1758)	8,9,13	AS
Centrocardita aculeata (Poli, 1795)	8	AS
Glans trapezia (Linnaeus, 1767)	8,9,12	AS
Corbulidae		
Corbula gibba (Olivi, 1792)	8,9,12,10,13	AS
Galeommatidae		
Galeomma turtoni [Anonymous], 1825	9	AS
Gastrochaenidae		
Rocellaria dubia (Pennant, 1777)	9,12	AS
Hiatellidae		
Hiatella arctica (Linnaeus, 1767)	9,12	AS
Kelliidae		
Kellia suborbicularis (Montagu, 1803)	9	AS
Kelliellidae		
Kelliella miliaris (Philippi, 1844)	9	AS
Lasaeidae		
Scacchia oblonga (Philippi, 1836)	9	AS
Lucinidae		
Anodontia (*Loripinus*) *fragilis* (Philippi, 1836)	8,9,12,10,13	AS
Ctena decussata (O. G. Costa, 1829)	8,9	AS
Loripes lucinalis (Lamarck, 1818)	9,3,13	AS
Lucinella divaricata (Linnaeus, 1758)	12,10	AS
Myrtea spinifera (Montagu, 1803)	8,9,12,3,13	AS
Mactridae		
Spisula subtruncata (da Costa, 1778)	9,10	AS
Montacutidae		
Kurtiella bidentata (Montagu, 1803)	9,12,10	AS
Myidae		
Sphenia binghami Turton, 1822	9	AS
Pandoridae		
Pandora pinna (Montagu, 1803)	9	AS

Psammobiidae		
Gari costulata (Turton, 1822)	9	AS
Semelidae		
Abra alba (W. Wood, 1802)	3,9,12,10,13	AS
Abra nitida (Müller, 1776)	13	AS
Abra segmentum (Récluz, 1843)	8,9	AS
Abra prismatica (Montagu, 1808)	12,13	AS
Tellinidae		
Gastrana fragilis (Linnaeus, 1758)	12	AS
Arcopagia balaustina (Linnaeus, 1758)	8,13	AS
Moerella donacina (Linnaeus, 1758)	8,9,13	AS
Serratina serrata (Brocchi, 1814)	13	AS
Tellina distorta Poli, 1791	9	AS
Tellina nitida Poli, 1791	9,3	AS
Tellina pulchella Lamarck, 1818	8,12,13	AS
Thraciidae		
Thracia distorta (Montagu, 1803)	9	AS
Thracia phaseolina (Lamarck, 1818)	9	AS
Thyasiridae		
Thyasira flexuosa (Montagu, 1803)	9,12	AS
Veneridae		
Callista chione (Linnaeus, 1758)	9	AS
Chamelea gallina (Linnaeus, 1758)	8,9	AS
Clausinella fasciata (da Costa, 1778)	13	AS
Dosinia lupinus (Linnaeus, 1758)	3	AS
Gouldia minima (Montagu, 1803)	8,9,12,13	AS
Irus irus (Linnaeus, 1758)	9	AS
Pitar rudis (Poli, 1795)	8,9,12,13	AS
Polititapes aureus (Gmelin, 1791)	3	AS
Timoclea ovata (Pennant, 1777)	9	AS
Venus casina Linnaeus, 1758	8	AS
Venus verrucosa Linnaeus, 1758	8,9,12	AS
SCAPHOPODA		
Dentaliidae		
Antalis dentalis (Linnaeus, 1758)	8	AS
Antalis inaequicostata (Dautzenberg, 1891)	8,24	AS
Antalis vulgaris (da Costa, 1778)	8,24	AS
Gadilidae		

Dischides politus (Wood S., 1842)	24	AS
Fustiariidae		
Fustiaria rubescens (Deshayes, 1825)	8	AS

References: 1: Tringali and Villa, 1990; **2:** Buzzurro and Greppi, 1996; **3:** Doğan, 1998; **4:** Öztürk and Ergen, 1999; **5:** Öztürk and Ergen, 2000; **6:** Öztürk *et al*., 2000; **7:** Öztürk, 2001; **8:** Erol Özfuçucu *et al*., 2003; **9:** Doğan, 2005; **10:** Koçak and Katağan, 2005; **11:** Öztürk and Can, 2006; **12:** Aydın *et al*., 2007; **13:** Doğan *et al*., 2007a; **14:** Doğan *et al*., 2007b; **15:** Falakalı Mutaf *et al*., 2007; **16:** Önen and Doğan, 2007; **17:** Öztürk *et al*., 2007a; **18:** Öztürk *et al*., 2007b; **19:** Öztürk *et al*., 2008a: **20:** Öztürk *et al*., 2008b; **21:** Öztürk *et al*., 2008c; **22:** Doğan *et al*., 2008; **23:** Türkmen and Demirsoy, 2009; **24:** Öztürk, 2011; **25:** Öztürk *et al*., 2011; **26:** Öztürk *et al*., 2013.

Among the classes of Mollusca determined, Gastropoda accounted for up to 62% (156 species) of the total species followed by Bivalvia (80 species) and Polyplacophora (10 species) with the percentage of 32 and 4 respectively (Figure 1). Scaphopoda (5 species) was represented with the percentage of 2.

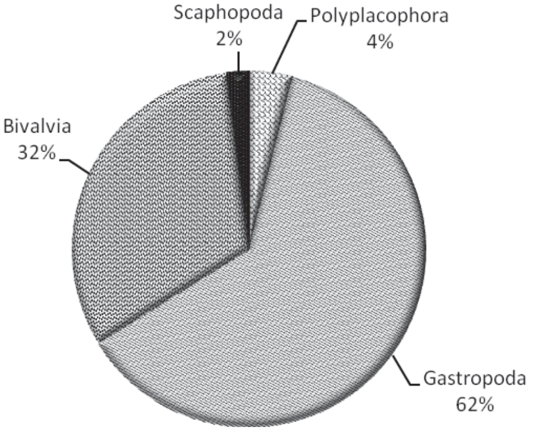

Figure 1. Relative dominance of the classes of the phylum Mollusca in *P. oceanica* meadows along the Turkish seas.

Among the families detected in the present study belonging to various classes of Mollusca, Pyramidellidae was the most dominant group (27 species) with the percentage of 11 (Figure 2). Rissoidae was another dominant group (22 species-9%) followed by Trochidae and Veneridae (11 species and 4% each). Mangeliidae (10 species and %4) Eulimidae, Mytilidae (9 species and 4% each), Tellinidae (7 species and 3%) and Cardiidae (6 species and 2%) were other dominant families. Remaining 69 families had (130 species) 56% of total number of species (Figure 2).

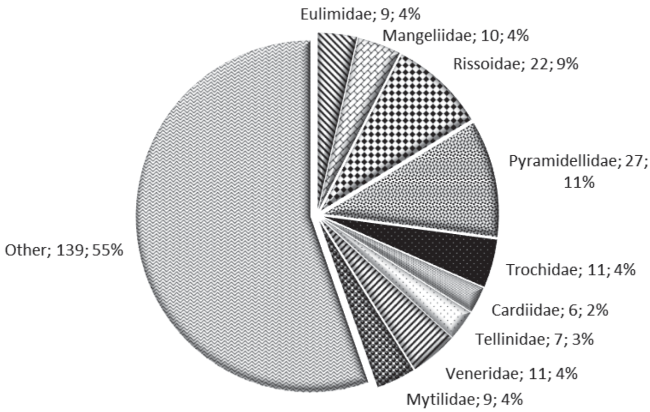

Figure 2. Relative dominance of the families belonging to the various classes of the phylum Mollusca in *P. oceanica* meadows along the Turkish seas.

There is great difference between the numbers of molluscan species associated with *P. oceanica* meadows in the Levantine and the Aegean coasts of Turkey. Although 244 species were reported from the Aegean coasts, there are only 19 species determined from the Levantine coasts of Turkey as a result of the present study (Table 1). This situation could be attributed to the less number of studies performed in the Levantine coasts of Turkey in comparison with the Aegean coasts. Besides, difference in coastal length of both seas (the Aegean part of Turkey: 2833 km, the Levantine part: 1542 km) and absence of *P. oceanica* meadows eastward in the Turkish Levantine Sea, after the point of 36˚09' N, 33˚26' E which has been attributed to physical parameters of the sea water in that area such as high temperature (Celebi *et al.*, 2006) are might be another reasons for different number of molluscan species encountered in these seas in association with *P. oceanica* meadows.

Maximum number of molluscan species (98) determined in the study performed by Erol Özfuçucu *et al.* (2003) (Figure 3) in the Aegean Sea in a seasonal basis between October 2001 and August 2002 at 9 station, with presence of *P. oceanica* meadows in 8 stations. Another detailed study in which 51 bivalve species reported in the *P. oceanica* meadows was conducted by Dogan (2005) at 101 stations in the Aegean Sea. Among the 101 stations of the study, 21 of them consisted of *P. oceanica* meadows. Within the frame of a study which aimed to make an atlas of the marine mollusc species of Turkey, implemented by Öztürk *et al*. (2008), 34 molluscan species in association with *P. oceanica* were reported. In the study that effects on the fish farms on the marine ecosystem were investigated by Koçak and Katağan (2005) 31 molluscan species were reported from the bottoms with *P. oceanica*. Doğan *et al.* (2007) also reported 31 bivalve species from the bottoms consisting *P. oceanica* in a study in which the bivalve fauna of Ildır Bay determined. Within the remaining 21 studies evaluated in the present study, 13 of them represented with less number (1 to5) of molluscan species in association with *P. oceanica* meadows (Figure 3).

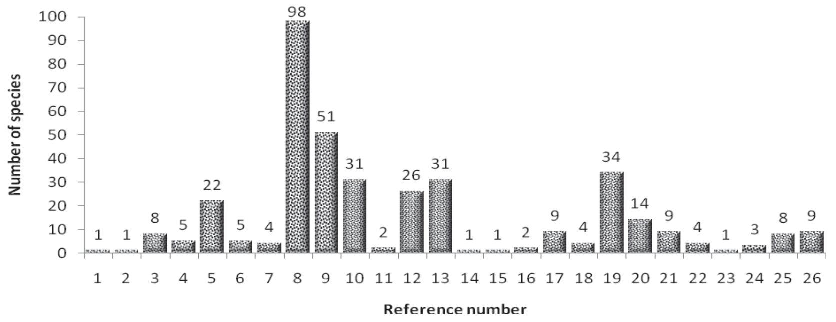

Figure 3. Number of species determined by evaluating studies (**1:** Tringali and Villa, 1990; **2:** Buzzurro and Greppi, 1996; **3:** Doğan, 1998; **4:** Öztürk and Ergen, 1999; **5:** Öztürk and Ergen, 2000; **6:** Öztürk *et al*., 2000; **7:** Öztürk, 2001; **8:** Erol Özfuçucu *et al*., 2003; **9:** Doğan, 2005; **10:** Koçak and Katağan, 2005; **11:** Öztürk and Can, 2006; **12:** Aydın *et al*., 2007; **13:** Doğan *et al*., 2007a; **14:** Doğan *et al*., 2007b; **15:** Falakalı Mutaf *et al*., 2007; **16:** Önen and Doğan, 2007; **17:** Öztürk *et al*., 2007a; **18:** Öztürk *et al*., 2007b; **19:** Öztürk *et al*., 2008a: **20:** Öztürk *et al*., 2008b; **21:** Öztürk *et al*., 2008c; **22:** Doğan *et al*., 2008; **23:** Türkmen and Demirsoy, 2009; **24:** Öztürk, 2011; **25:** Öztürk *et al*., 2011; **26:** Öztürk *et al*., 2013).

As a result of evaluating 26 studies performed along the Aegean and the Mediterranean coasts of Turkey, *Acanthochitona fascicularis, Chiton olivaceus* and *Lepidochitona cinerea* were the most frequent species within the Polvplacophora as they were reported in three different studies each. *Jujubinus striatus, Chauvetia turritellata, Bittium latreillii, Cerithium vulgatum, Bela nebula, Mangelia attenuata*, *Mangelia unifasciata, Hexaplex trunculus, Alvania geryonia, Rissoa auriscalpium* and *Monophorus erythrosoma* were frequent species belonging to the classes Gastropoda as each of these species took place in three studies as well. Among the molluscan species distributing along the coasts of Turkey which are in association with *P. oceanica* meadows, the bivalve species; *Corbula gibba*, *Anodontia* (*Loripinus*) *fragilis, Myrtea spinifera* and *Abra alba* were the most frequent species. Each of these species were reported in five different studies. *Nucula nucleus, Modiolula phaseolina*, *Modiolus barbatus*, *Musculus costulatus*, *Flexopecten hyalinus, Parvicardium exiguum, Gouldia minima* and *Pitar rudis* were other frequent bivalve species as each of these took place in four different studies. Concerning these results, it should be considered that some of the studies taken into account in the present study, dealt only with certain molluscan groups.

In the similar studies performed in the Mediterranean, it can be seen that certain molluscan species are common and/or abundant in the *P. oceanica* meadows. According to Harmelin (1964), the bivalve species; *Striarca lactea*, *Plagiocardium papillosum, Venus verrucosa* and *Lima hians* are the most common mollusc species in association *P. oceanica* meadows. Templado (1984) pointed out that *Jujubinus exasperatus* is the most common species in the *P. oceanica* beds. *Bittium latreilli* was mentioned as the most abundant molluscan species in the rhizome zone of *P. oceanica* in Bonfitto *et al.* (1998) while Solustri *et al*. (2002) also indicate that *B. latreilli* is the most dominant species in association with *P. oceanica* beds in the eastern Adriatic. In a study carried out by Beqiraj *et al.* (2008) on the Albanian coasts of Adriatic, *Bittium reticulatum,* *P. papillosum, Nucula sulcata, Pitar rudis, J. exasperatus, Smaragdia viridis* and *Abra alba* were mentioned as the most common species of *P. oceanica* meadows while *B. reticulatum* and *P. papillosum* were determined as the most abundant species by those researchers. Albano and Sabelli (2012) reported *J. exasperatus* and *B. latreilli* as two of the most common species distributing on the leaves and the rhizomes of *P. oceanica*.

Alvania dorbignyi, Rissoina bertholleti, *Finella pupoides*, *Conomurex persicus*, *Chrysallida maiae*, *Syrnola fasciata* and *Crassostrea gigas* are the exotic species determined in the present study in association with *P. oceanica* meadows along the Turkish Seas (Table 1). All of these species belong to the classes Gastropoda except *C. gigas* which is an ostreid bivalve species.

Further studies should be implemented to improve our knowledge for protection the sea grass *P. oceanica* which is a very important component of the Mediterranean ecosystem as it is mentioned above. Besides, taking proper steps for conservation this indispensable species seems inevitable.

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Crustaceans associated with *Posidonia oceanica* (L.) Delile on the coasts of Turkey

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Abstract

A total of 273 crustacean species belonging to 78 families and 7 order living in *Posidonia oceanica* were determined in the studies which were conducted on the Turkish coasts. Aegean Sea coast ranked first if the crustacean biodiversity taken into account. Dardanelles and Mediterranean coast shared the second and third places respectively. The amphipods *Ampelisca diadema*, *Ampithoe ramondi*, *Microdeutopus stationis*, *Dexamine spinosa*, *Ericthonius brasiliensis*, *Leucothoe spinicarpa*, *Gammarella fucicola*, *Caprella acanthifera*, *Phtisica marina*, the tanaidacean *Leptochelia savignyi*, and the decapods *Athanas nitescens*, *Hippolyte inermis*, *Lysmata seticaudata*, *Galathea bolivari*, *Galathea intermedia*, *Pagurus anachoretus*, *Pagurus cuanensis*, *Pisidia bluteli*, *Pisidia longimana*, *Pilumnus hirtellus* were the most common and characteristic species in the biotopes of *Posidonia oceanica* on Turkish Coasts.

Introduction

Posidonia oceanica (hereafter *P. oceanica*) also known with *Cymodocea* sp. and *Zostera* sp. as Seagrasses, provides shelter and food source for many vertebrate and invertebrate species. Because of this, it has a great importance for biological diversity in the Mediterranean coastal regions (Garcia-Raso, 1990). Among invertebrates living in association with seagrasses, crustaceans with high number of species diversity, abundance and biomass form one of the most important groups and provide high amount of food resource for fish populations (Bell and Harmelin-Vivien, 1983; Edgar and Shaw, 1995).

This Mediterranean endemic seagrass shows a distribution on the whole Mediterranean littoral zone except the Suez and Gibtaltar canals entrances. There are various studies directly or indirectly related with the crustaceans living in the *P. oceanica* throughout the Mediterranean Sea (Garcia-Raso, 1990; Sánchez-Jerez *et al*., 2000; Zakhama-Sraïeb *et al*., 2006; Michel *et al*., 2010; Sturaro *et al*., 2010).

P. oceanica has also a continuous distribution, from Dardanelles Strait on the north Aegean sea, up to Bay of Mersin on the Levantine coast of Turkey (Celebi *et al*., 2007). Furthermore, some patches of *P.oceanica* has been reported from the Marmara sea (Green and Short, 2003). One of the earliest of the taxonomic studies, including these areas on Turkish coasts was conducted by

Holthuis (1961), in which he investigated the decapod crustacean species and reported some of them from *P.oceanica* vegetation. Geldiay *et al*. (1970) reported two amphipod species among the dead *P. oceanica* leaves on the supralittoral zone beside the other species. Kocataş and Katağan (1978) investigated the amphipod species of Turkey and reported more than 30 species among the *P. oceanica* meadows. Kocataş (1981) encountered 3 stomatopod species in the *P. oceanica* beds on Aegean coast of Turkey. Katağan (1983) carried out a study about the cumacean species in the *P. oceanica*. Two alien decapod species, *Metapenaeopsis aegyptia* Galil, 1990 and *Thalamita poissonii* (Audouin, 1826) were reported from Aegean and Levantine coasts of Turkey (Yokeş and Galil, 2006; Yokeş et al., 2007). In addition to the above, Ergen *et al*. (1988), Katağan *et al*. (2001) and Ateş *et al*. (2004) took the *P. oceanica* beds as a base subject in their studies and investigated the polychaeta, amphipod and decapod species living in and between the meadows.

The purpose of this study is to review the crustacean species, living in *P. oceanica* beds in a single paper and to reveal the distribution of species on the Turkish coasts.

Material and Method

The previous studies that contain *Posidonia oceanica* biotope on the Turkish coast were evaluated with library research in this study. The systematic order of Martin and Davis (2001) were taken into consideration to form the list of species below.

Results and Discussion

A total of 273 crustacean species belonging to 78 families and 7 order were determined in previous studies (Table 1).

Table 1. List of the encountered crustacean species in the *P. oceanica* biotope on the Turkish coast (DS: Dardanelles Strait, AC: Aegean Sea coast, MC: Mediterranean Sea coast; *, indicate alien species. The depth range of some species which is not mentioned in the publications were not given in the table).

Species	Depth range (m)	Sea	Reference
Leptostraca			
Nebaliidae			
Nebalia bipes (O. Fabricius, 1780)	7-9	AC	22
Stomatopoda			
Nannosquillidae			
Nannosquilloides occultus (Giesbrecht, 1910)	15-20	AC	5
Squillidae			
Rissoides desmaresti (Risso, 1816)	15-20	AC	5
Squilla mantis (Linnaeus, 1758)	20-25	AC	5
Amphipoda			

Ampeliscidae			
Ampelisca dalmatina Karaman, 1975	5	AC	22
Ampelisca diadema (Costa, 1853)	7-21	DS, AC	8, 17, 22, 23, 29
Ampelisca gibba Sars, 1883	13	DS	29
Ampelisca multispinosa Bellan-Santini & Kaim-Malka, 1977	8	AC	12
Ampelisca planierensis Bellan-Santini ve Kaim-Malka, 1977	9	AC	22
Ampelisca pseudosarsi Bellan-Santini & Kaim-Malka,1977	21	AC	23, 13
Ampelisca pseudospinimana Bellan-Santini & Kaim-Malka, 1977	5-21	AC	17, 22, 23, 13
Ampelisca rubella A. Costa, 1864	-	DS, AC	7, 8, 13
Ampelisca ruffoi Bellan-Santini & Kaim-Malka, 1977	15	DS	29, 13
Ampelisca sarsi Chevreux, 1888	13	AC	12
Ampelisca spinipes Boeck, 1861	20	AC	13
Ampelisca tenuicornis Liljeborg, 1855	27	AC	13
Ampelisca unidentata Schellenberg, 1936	-	DS, AC	8
Haploops dellavallei Stebbing, 1893	10-20	AC	13
Amphilochidae			
Amphilochus brunneus Della Valle, 1893	25-30	AC	4
Amphilochus neapolitanus Della Valle, 1893	21	AC	7, 23, 13
Amphilochus picadurus J.L. Barnard, 1962	15	DS	29, 13
Gitana sarsi Boeck, 1871	16	AC	23, 13
Ampithoidae			
Ampithoe helleri Karaman, 1975	-	AC	7
Ampithoe ramondi (Audouin, 1826)	5-21	DS, AC	7, 8, 15, 22, 23, 29, 13
Cymadusa crassicornis (Costa, 1857)	5	DS, AC	15, 22
Aoridae			
Aora spinicornis Afonso, 1976	5-9	AC	7, 17, 22, 13
Autonoe longipes (Liljeborg, 1852)	-	AC	4
Autonoe spiniventris Della Valle, 1893	5-37	AC	13
Lembos websteri Bate, 1857	5	AC	22, 13
Microdeutopus algicola Della Valle, 1893	9-25	AC	4, 22, 13
Microdeutopus anomalus (Rathke, 1843)	15	DS, AC	4, 17, 29, 13
Microdeutopus bifidus Myers, 1977	13	DS	29, 13
Microdeutopus chelifer (Bate, 1862)	1-15	DS, AC	4, 29, 13
Microdeutopus gryllotalpa Costa, 1853	13-21	DS, AC	23, 29
Microdeutopus obtusatus Myers, 1973	-	AC	17, 13
Microdeutopus stationis Della Valle, 1893	0.5-20	AC	4, 7, 8, 11, 17
Microdeutopus versiculatus (Bate, 1856)	7-15	DS, AC	17, 22, 29, 13

Aristiidae			
Perrierella audouiniana (Bate, 1857)	20-30	AC	4
Atylidae			
Atylus guttatus (Costa, 1851)	5-30	AC, MC	4, 22
Atylus massiliensis Bellan-Santini, 1975	10	AC	17, 13
Biancolinidae			
Biancolina algicola Della Valle, 1893	-	AC	8, 13
Calliopiidae			
Apherusa bispinosa (Bate, 1857)	5-7	AC	22, 23, 13
Apherusa chiereghinii Giordani-Soika, 1950	7	AC	7, 23, 13
Apherusa mediterranea Chevreux, 1911	10	AC	13
Apherusa vexatrix Krapp-Schickel, 1979	8-13	AC	12
Colomastigidae			
Colomastix pusilla Grube, 1861	30-35	DS, AC	4, 8, 17, 13
Corophiidae			
Apocorophium acutum (Chevreux, 1908)	7-15	DS, AC	17, 22, 29, 13
Leptocheirus bispinosus Norman, 1908	12	AC	13
Leptocheirus guttatus (Grube, 1864)	7	AC	7, 8, 23, 13
Leptocheirus mariae Karaman, 1973	13	DS	29, 13
Leptocheirus pectinatus (Norman, 1869)	21	AC	23
Leptocheirus pilosus Zaddach, 1844	-	DS	8, 13
Medicorophium runcicorne (Della Valle, 1893)	20	AC	13
Cyproideidae			
Peltocoxa gibbosa (Sciecke, 1977)	8	AC	19
Peltocoxa marioni Catta, 1875	10-40	AC	4, 23, 13
Dexaminidae			
Dexamine spiniventris (Costa, 1853)	1-7	AC, MC	4, 23, 13
Dexamine spinosa (Montagu, 1813)	1-21	DS,AC, MC	4, 7, 8, 22, 23, 29, 13
Dexamine thea Boeck, 1861	13-15	DS	29, 13
Guernea coalita (Norman, 1868)	7-16	AC	4, 23, 13
Tritaeta gibbosa (Bate, 1862)	15-35	AC, MC	4, 13
Eusiridae			
Eusirus longipes Boeck, 1861	20	AC	13
Gammaridae			
Elasmopus brasiliensis (Dana, 1855	-	AC	17
Elasmopus pocillimanus (Bate, 1862)	5	DS, AC	7, 15, 17, 22
Elasmopus rapax Costa, 1853	-	AC	8
Gammarus aequicauda (Martyinov, 1931)	8	AC	11

Hyalidae			
Hyale crassipes (Heller, 1866)	-	DS	15
Hyale camptonyx (Heller, 1866)	1	AC	4
Hyale schmidtii (Heller, 1866)	-	AC	7, 8, 17
Hyale stebbingi Chevreux, 1888	-	AC	8
Iphimediidae			
Coboldus nitior Krapp-Schickel, 1974	3	AC	13
Iphimedia minuta G.O. Sars, 1882	6	AC	13
Ischyroceridae			
Ericthonius brasiliensis (Dana, 1855)	13-21	DS,AC	7, 8, 17, 23, 29, 13
Ericthonius difformis Milne-Edwards, 1830	-	DS,AC	8
Ericthonius punctatus (Bate, 1857)	5-7	DS,AC	8, 17, 22, 23, 13
Jassa marmorata (Holmes, 1903)	15	DS	15, 29
Jassa ocia (Bate, 1862)	27-29	AC	13
Leucothoidae			
Leucothoe incisa Robertson, 1892	25-30	AC	4, 17, 13
Leucothoe lilljeborgii Boeck, 1861	7-21	AC	22, 23, 13
Leucothoe richiardii Lessona, 1865	-	AC	8, 13
Leucothoe spinicarpa (Abildgaard, 1789)	5-21	DS,AC	4, 7, 8, 22, 23, 29, 13
Leucothoe venetiarum Giordani- Soika, 1950	-	AC	8, 13
Leucothoe procera Bate, 1857	7-9	AC	22
Leucothoe oboa Karaman, 1971	20-25	AC	4
Liljeborgiidae			
Liljeborgia dellavallei Stebbing, 1906	7-40	DS,AC	3, 4, 22, 23, 13
Liljeborgia psaltrica Krapp-Schickel, 1975	20-25	AC	4
Lysianassidae			
Hippomedon massiliensis Bellan-Santini, 1965	9-13	DS,AC	22, 29
Lepidepecreum longicornis (Bate & Westwood, 1862)	25-30	AC	4
Lysianassa caesaera Ruffo, 1987	21	DS,AC	7, 8, 23, 13
Lysianassa costae (Milne-Edwards, 1830)	7	AC	23, 13
Lysianassa pilicornis (Heller, 1866)	16-40	AC	4, 23, 13
Lysianassa plumosa Boeck, 1871	35-40	AC	4, 13
Lysianassina longicornis (Lucas, 1849)	20-40	AC, MC	4, 13
Orchomene humilis (Costa, 1853)	7-21	DS,AC	8, 23, 29, 13
Orchomene similis (Chevreux, 1912)	7-35	AC	13
Maeridae			
Maera grossimana (Montagu, 1808)	5-21	DS,AC	8, 22, 23, 29, 13
Maera inaequipes (Costa, 1857)	0.5-5	AC	7, 8, 11, 13

Maera pachytelson Karaman & Ruffo, 1971	5	AC	13
Maera sodalis Karaman & Ruffo, 1971	-	AC	17
Maera hirondellei Chevreux, 1900	1-20	AC, MC	4
Melitidae			
Gammarella fucicola (Leach, 1814)	0.5-15	DS,AC	7, 11, 17, 22, 23, 29, 13
Oedicerotidae			
Deflexilodes griseus (Della Valle, 1893)	20	AC	12
Deflexilodes subnudus (Norman, 1889)	13	DS	4, 29
Monoculodes carinatus (Bate, 1857)	20-25	AC	4, 13
Monoculodes gibbosus Chevreux, 1888	21	AC	23,13
Perioculodes aequimanus (Korssman, 1880)	15	DS	29
Perioculodes longimanus (Bate & Westwood, 1868)	5-7	AC	4, 22, 23,13
Pontocrates arenarius (Bate, 1858)	7	AC	4, 8, 23
Synchelidium longidigitatum Ruffo, 1947	13	AC	12, 13
Synchelidium maculatum Stebbing, 1906	10-30	AC	4
Westwoodilla rectirostris (Della Valle, 1893)	9	AC	22,13
Phliantidae			
Pereionotus testudo (Montagu, 1808)	7	AC	8, 22,13
Photidae			
Gammaropsis maculata (Johnston, 1828)	13-15	DS,AC	8, 29
Gammaropsis ostroumowi Sowinski, 1898	13	DS	29, 13
Megamphopus brevidactylus Myers, 1976	13	DS	29
Photis longipes (Della Valle, 1893)	-	AC	8
Phoxocephalidae			
Harpinia antennaria Meinert, 1890	10	AC	23,13
Harpinia crenulata (Boeck, 1871)	7-9	AC	22
Harpinia dellavallei Chevreux, 1910	9-35	DS,AC	4, 22, 29,13
Metaphoxus fultoni (Scott, 1890)	30-35	AC	4,13
Metaphoxus gruneri Karaman, 1986	5	AC	13
Metaphoxus pectinatus (Walker, 1896)	10-40	AC	4
Metaphoxus simplex (Bate, 1857)	5-10	DS,AC	22, 23, 29,13
Paraphoxus oculatus (Sars, 1879)	13	DS	29
Phoxocephalus aquosus Karaman, 1985	13	DS	29
Podoceridae			
Podocerus variegatus Leach, 1814	-	AC	8
Pontogeneiidae			
Eusiroides dellavallei Chevreux, 1899	-	AC	8
Pontoporeiidae			

Bathyporeia phaiophthalma Bellan-Santini, 1973	7-15	DS,AC	23, 29
Stenothoidae			
Stenothoe bosphorana Sowinsky, 1898	20-25	AC	4
Stenothoe elachista Krapp Schickel, 1975	10-13	DS,AC	23, 29,13
Stenothoe monoculoides (Montagu, 1815)	5-15	DS,AC	8, 22, 23, 29,13
Stenothoe tergestina Nebesski, 1880	5	AC	8, 22,13
Talitridae			
Orchestia mediterranea Heller, 1865	Supralittoral	AC	9
Orchestia montagui Audouin, 1826	Supralittoral	AC	3, 9
Orchestia stephenseni Cecchini, 1928	Supralittoral	AC	3
Urothoidae			
Urothoe elegans (Bate, 1857)	15-21	DS,AC	23, 29,13
Urothoe intermedia Bellan-Santini & Ruffo, 1986	13-15	DS	29
Urothoe poseidonis Reibish, 1905	8	AC	12
Urothoe pulchella (Costa, 1853)	7-15	DS,AC	23, 29
Caprellidae			
Caprella acanthifera Leach, 1814	5-16	DS,AC	8, 17, 22, 23, 29, 13
Caprella grandimana (Mayer, 1882)	5	AC	8, 22
Caprella rapax Mayer, 1890	5-16	DS,AC	22, 23, 29, 13
Pariambus typicus (Krøyer, 1884)	10-15	AC	13
Parvipalpus linea Mayer, 1890	10	AC	13
Phtisica marina Slabber, 1749	5- 20	DS,AC	8, 17, 11, 22, 23, 29, 13
Pseudolirius kroyerii (Haller, 1879)	7-21	AC	23
Pseudoprotella phasma (Montagu, 1804)	16	AC	7, 23, 13
Isopoda			
Anthuridae			
Anthura gracilis (Montagu, 1808)	15	DS	29
Cirolanidae			
Eurydice affinis Hansen, 1905	8-20	AC	12
Gnathiidae			
Gnathia vorax (Lucas, 1849)	7	AC	17, 22
Limnoriidae			
Limnoria tripunctata Menzies, 1951	13	AC	12
Holognathidae			
Cleantis prismatica (Risso, 1826)	-	AC	7
Idoteidae			
Idotea balthica (Pallas, 1772)	-	DS	15
Stenosoma capito (Rathke, 1837)	7	AC	22

Janiridae			
Bagatus stebbingi Monod, 1933	5-9	AC	7, 22
Janira maculosa Leach, 1814	15	DS	29
Sphaeromatidae			
Cymodoce hanseni Dumay, 1972	13	AC	12
Cymodoce spinosa (Risso, 1816)	5	AC	17, 22
Cymodoce tuberculata Costa in Hope, 1851	7	AC	22
Cymodoce truncata Leach, 1814	7	AC	22
Dynamene torelliae Holdich, 1968		AC	7
Lekanesphaera monodi (Arcangeli, 1934)	8	AC	12
Tanaidacea			
Apseudidae			
Apseudopsis latreillii (Milne-Edwards, 1828)	15	DS	29
Leptocheliidae			
Leptochelia savignyi (Kroyer, 1842)	5-15	DS, AC	7, 17, 22, 29
Tanaidae			
Tanais dulongii (Audouin, 1826)	-	AC	17
Cumacea			
Bodotriidae			
Eocuma sarsii (Kossmann), 1880	-	AC	6
Iphinoe serrata Norman, 1867	-	AC	17
Iphinoe tenella G.O. Sars, 1878	7-9	AC	17, 22
Vaunthompsonia cristata Bate, 1858	-	AC	6
Diastylidae			
Diastylis rugosa G.O. Sars, 1865	-	AC	6, 17
Nannastacidae			
Cumella limicola Sars, 1879	5-9	AC	22
Decapoda			
Alpheidae			
Alpheus dentipes Guerin, 1832	0-15	DS, AC, MC	1, 7, 28
Alpheus glaber (Olivi, 1792)	-	AC	14, 17
Alpheus macrocheles (Hailstone, 1885)	10-24	AC, MC	14, 16, 18, 21
Athanas nitescens (Leach, 1814)	0-27	DS, AC	1, 7, 17, 14, 16, 18, 21, 22, 28
Automate branchialis Holthuis & Gottlieb, 1958	-	AC	14
Synalpheus gambarelloides (Nardo, 1847)	25	AC	14, 21
Crangonidae			
Crangon crangon (Linnaeus, 1758)	24	AC	14, 16
Philocheras bispinosus (Hailstone, 1835)	24-27	AC	14, 16, 18

Philocheras sculptus (Bell, 1847)	24-27	AC	16, 18
Hippolytidae			
Hippolyte garciarasoi d'Udekem d'Acoz, 1996b	9-21	AC, MC	14, 16, 21
Hippolyte inermis Leach, 1815	0-27	DS, AC, MC	1, 7, 14, 16, 18, 21, 28
Hippolyte leptocerus (Heller, 1863a)	8-24	AC	14, 16, 28
Hippolyte longirostris (Czerniavsky, 1869)	0-1	AC, MC	1, 7
Lysmata seticaudata (Risso, 1816)	5-27	AC, MC	14, 16, 17, 18, 21, 22
Eualus cranchii (Leach, 1817)	0-15	DS, AC	1, 7, 14, 28
Palaemonidae			
Palaemon adspersus Rathke, 1837	10	AC	14, 21
Palaemon elegans Rathke, 1837	0-27	AC, MC	1, 14, 18
Palaemon longirostris longirostris H. Milne-Edwards, 1837	8	AC	14, 16
Palaemon serratus (Pennant, 1777)	0-24	AC, MC	1, 14, 16
Palaemon xiphias Risso, 1816	0-10	AC, MC	1, 14, 21
Palaemonetes antennarius (H. Milne Edwards, 1837)	10	AC	14, 21
Pandalidae			
Pandalina brevirostris (Rathke, 1843)	24	AC	14, 16
Penaeidae			
**Metapenaeopsis aegyptia* Galil, 1990	4	MC	20
Processidae			
Processa edulis edulis (Risso, 1816)	0-1	AC, MC	1, 17
Processa elegantula Nouvel & Holthuis, 1957	-	AC	14
Processa macrodactyla Holthuis, 1952	21-27	AC	16, 18
Processa macrophthalma Nouvel & Holthuis, 1957	5-27	AC, MC	14, 16, 18, 22
Processa modica Williamson & Rochanburanon, 1979	5-25	AC	14, 16, 18, 21
Processa nouveli nouveli Al-Adhub & Williamson, 1975	13-15	DS, AC	17, 28
Solenoceridae			
Solenocera membranacea (Risso, 1816)	24	AC	16
Callianassidae			
Gourretia denticulata (Lutze, 1937)	-	AC	14
Calliax lobata (de Gaillande & Lagardére, 1966)	13	DS	28
Upogebiidae			
Upogebia pusilla (Petagna, 1792)	10-27	AC	17, 14, 18
Diogenidae			
Calcinus tubularis (Linnaeus, 1767)	0-10	AC, MC	1, 10, 26
Clibanarius erythropus (Latreille, 1818)	0-1	MC	1
Dardanus calidus (Risso,1827)	25	AC	27

Diogenes pugilator (Roux, 1829)	1-15	DS, AC	22, 27, 28
Paguristes eremita (Linnaeus, 1767)	1-25	DS, AC	14, 22, 27, 28
Paguristes syrtensis de Saint Laurent, 1971	5-25	AC	14, 16, 21, 22
Galatheidae			
Galathea bolivari Zariquiey Alvarez, 1950	0-27	AC, MC	1, 14, 16, 18, 21, 26
Galathea intermedia Lilljeborg, 1851	5-25	DS, AC	14, 16, 18, 21, 27, 28
Galathea squamifera Leach, 1814	2-18	AC	14, 18, 26
Galathea cenarroi Zariquiey Álvarez, 1968	0-2,5	AC	26
Paguridae			
Anapagurus bicorniger A. Milne-Edwards & Bouvier, 1892	20-25	AC	2
Anapagurus chiroacanthus (Liljeborg, 1856)	13-15	DS	28
Anapagurus petiti Dechancé & Forest, 1962	21	AC, MC	14, 16
Cestopagurus timidus (Roux, 1830)	0-15	DS, AC	2, 26, 28
Pagurus alatus Fabricius, 1775	15	DS, AC	14, 28
Pagurus anachoretus Risso, 1827	0-21	AC, MC	1, 14, 16, 18, 21, 26
Pagurus chevreuxi (Bouvier, 1896)	10-25	AC, MC	14, 21
Pagurus cuanensis Bell, 1846	2-27	AC, MC	14, 16, 18, 21, 26, 27
Pagurus forbesii Bell, 1845	2-38	AC	14, 18, 26
Pagurus prideaux Leach, 1815	-	AC	14
Porcellanidae			
Pisidia bluteli (Risso, 1816)	0-25	DS, AC	14, 15, 16, 17, 22, 26, 28
Pisidia longimana (Risso, 1816)	0-8	AC, MC	1, 7, 16, 17, 18, 22, 26
Porcellana platycheles (Pennant, 1777)	0-1	MC	1
Dromiidae			
Dromia personata (Linnaeus, 1758)	25	AC	21
Epialtidae			
Acanthonyx lunulatus (Risso, 1816)	0-1	AC, MC	1, 7
Lissa chiragra (Fabricius, 1775)	-	AC	14
Pisa hirticornis (Herbst, 1804)	21-24	AC	14, 16
Pisa muscosa (Linnaeus, 1758)	10	AC	14, 21
Pisa nodipes (Leach, 1815)	0-1	MC	1
Pisa tetraodon (Pennant, 1777)	0-1	MC	1
Eriphiidae			
Eriphia verrucosa (Forskal, 1775)	0-1	MC	1
Ethusidae			
Ethusa mascarone (Herbst, 1785)	10-27	AC	14, 18, 21
Grapsidae			
Pachygrapsus marmoratus (Fabricius. 1787)	0-1	MC	1

Pachygrapsus transversus (Gibbes, 1850)	0-1	MC	1
Inachidae			
Achaeus cranchii Leach, 1817	5-24	DS, AC	14, 16, 18, 28
Achaeus gordonae Forest & Zariquiey, 1955	0-1	MC	1
Achaeus gracilis O. G. Costa, 1839	5	AC	14, 17, 18
Inachus dorsettensis (Pennant, 1777)	10-24	AC	14, 16, 18
Macropodia czernjawskii (Brandt, 1880)	21-24	AC	14, 16
Macropodia linaresi Forest & Zariquiey Alvarez, 1964	25	AC	14, 21
Macropodia longipes (A.Milne Edwards & Bouvier, 1899)	-	AC	14
Macropodia longirostris (Fabricius, 1775)	13	DS, AC	14, 28
Macropodia rostrata (Linnaeus, 1761)	21-27	AC	14, 16, 18
Leucosiidae			
Ebalia cranchii Leach, 1817	-	AC	14
Ebalia deshayesi Lucas, 1846	24	AC	16
Ebalia edwardsii Costa, 1838	25	AC	14, 21
Ebalia tuberosa (Pennant, 1777)	21	AC	14, 16
Ilia nucleus (Linnaeus, 1758)	13	DS, AC	14, 28
Majidae			
Eurynome aspera (Pennant, 1777)	-	AC	14
Maja crispata Risso, 1827	0-1	MC	1
Maja squinado (Herbst, 1788)	9-25	AC	14, 16, 21
Parthenopidae			
Parthenope massena (Roux, 1830)	25-27	AC	14, 18, 21
Pilumnidae			
Pilumnus minutus De Haan, 1835	8	AC	14, 16
Pilumnus hirtellus (Linnaeus, 1761)	0-25	DS, AC, MC	1, 7, 14, 15, 17, 18, 21, 22, 28
Pilumnus spinifer H. Milne- Edwards, 1834	15	DS	28
Pirimelidae			
Pirimela denticulata (Montagu, 1808)	-	AC	14
Sirpus zariquieyi Gordon, 1953	25	AC	14, 21
Polybiidae			
Liocarcinus corrugatus (Pennant, 1777)	13-16	DS, AC	14, 16, 17, 28
Liocarcinus maculatus (Risso, 1827)	10-27	AC	16, 18
Liocarcinus pusillus (Leach, 1815)	-	AC	14, 17
Liocarcinus navigator (Herbst, 1794)	15	DS, AC	14, 28
Liocarcinus vernalis (Risso, 1816)	13	DS	28
Portunidae			
**Portunus pelagicus* (Linnaeus, 1758)	0-1	MC	1

**Thalamita poissonii* (Audouin, 1826)	0-12	AC, MC	1, 24
Varunidae			
Brachynotus foresti Zariquiey Alvarez, 1968	2	MC	25
Brachynotus sexdentatus (Risso, 1827)	-	AC	17
Xanthidae			
Xantho granulicarpus Forest, 1953	0-1	MC	1
Xantho poressa (Olivi, 1792)	0-15	DS, AC, MC	1, 7, 28
Xantho pilipes H. Milne- Edwards, 1867	13-15	DS	28

1, Holthuis, 1961; **2,** Geldiay and Kocataş, 1970; **3,** Geldiay *et al*., 1970; **4,** Kocataş and Katağan, 1978; **5,** Kocataş, 1981; **6,** Katağan, 1983; **7,** Ergen *et al*., 1988; **8,** Katağan *et al*., 2001; **9,** Kocataş *et al*., 2001; **10,** Koçak *et al*., 2001; **11,** Aslan and Balkıs, 2003; **12,** Erol Özfuçucu, G., Katağan, T., Yaramaz, Ö., 2003; **13,** Sezgin, M., 2003; **14,** Ateş *et al*., 2004; **15,** Yurdabak, 2004; **16,** Ateş *et al*., 2005; **17,** Koçak and Katağan, 2005; **18,** Ateş *et al*., 2006; **19,** Sezgin *et al*., 2006; **20,** Yokeş and Galil, 2006; **21,** Ateş *et al*., 2007; **22,** Aydın *et al*., 2007; **23,** Sezgin *et al*., 2007; **24,** Yokeş *et al*., 2007; **25,** Özcan, 2007; **26,** Koçak and Katağan, 2008; **27,** Balkıs and Kurun, 2008; **28,** Aslan-Cihangir and Pancucci-Papadopoulou, 2011a; **29,** Aslan-Cihangir and Pancucci-Papadopoulou, 2011b

The majority of species (89%) are belonged to two groups; Amphipoda (143 species, 52%) and Decapoda (102 species, 37%). The other groups (Leptostraca, Stomatopoda, Tanaidacea, Cumacea, and Isopoda) had only 11% of total number of species (Figure 1). Amphipoda and Decapoda, which have been well studied groups with high number of species were composed the main groups in most of the studies taken into consideration. On the other hand, the groups of Leptostraca, and Stomatopoda are represented by a small number of species on Turkish coasts. Tanaidacea, Cumacea, and Isopoda were less studied taxonomically in Turkish seas. Because of these two reasons, they constitute only 11% of the total number of crustacean species (28 species).

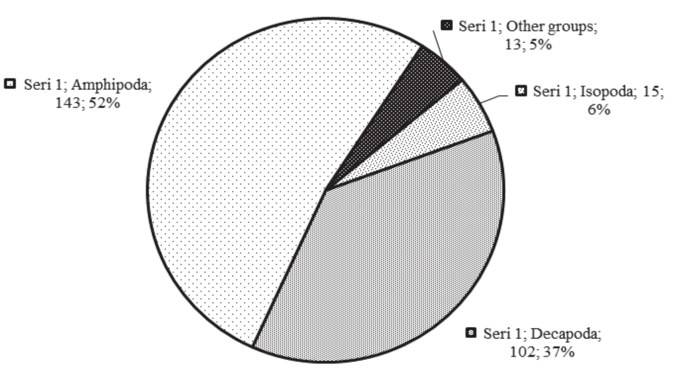

Figure 1. Relative dominance (%) of the systematic groups by number of species.

The crustacean species *Ampelisca diadema*, *Ampithoe ramondi*, *Microdeutopus stationis*, *Dexamine spinosa*, *Ericthonius brasiliensis*, *Leucothoe* *spinicarpa*, *Gammarella fucicola*, *Caprella acanthifera*, *Phtisica marina*, *Leptochelia savignyi*, *Athanas nitescens*, *Hippolyte inermis*, *Lysmata seticaudata*, *Galathea bolivari*, *Galathea intermedia*, *Pagurus anachoretus*, *Pagurus cuanensis*, *Pisidia bluteli*, *Pisidia longimana*, *Pilumnus hirtellus* were characteristic species in *P. oceanica* biotopes on Turkish Coasts. Also three decapod species were indo pasific immigrant (*Metapenaeopsis aegyptia, Portunus pelagicus*, *Thalamita poissonii*).

The *P. oceanica* meadows on the Aegean coast is the most diverse biotope (235 species) among those in the Dardanelles (78 species) and Mediterranean coast (41 species) (Figure 2). This situation has been caused by two reason; 1) Aegean sea is the most studied sea among the Turkish seas, 2) it has the longest coastline with different substratum types, physical and chemical features.

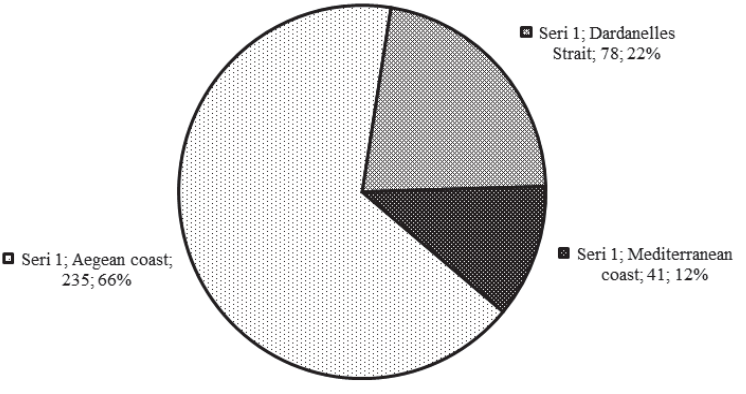

Figure 2. The distribution of crustacean species of by the seas.

There were published reports particularly on *P. oceanica* about the species diversity of crustaceans. Ergen *et al*. (1988) were studied the *P. oceanica* beds on Aegean coast and found the amphipods *Ericthonius brasiliensis* and *Ampithoe ramondi* were most abundant species in the sampling stations. Katagan *et al*. (2001) also found *A. ramondi* (34%) and *E. brasiliensis* (5%) with other nine amphipod species (*Dexarmine spinosa*, 8%; *Caprella acanthifera,* 6%; *Elasmopus pocillimanus*, 5%; *Gammaropsis maculata*, 5%; S*tenothoe monoculoides*, 4%; *Maera inaequipes*, 3%; *Lysianassa costae*, 3%; *Ericthonius difformis*, 3%; and *Caprella grandimana*, 2%) most dominant by the number of individuals. Ateş *et al*. (2004) determined 69 decapod species on Aegean coast at thirty stations. The most abundant decapod species were *H. inermis*, *L. seticaudata*, *A. nitescens*, *P. macropthalma*, *G. bolivari*, *P. cuanensis* and *G. intermedia.* Also, the researchers indicated that *P. oceanica* beds in the Aegean Sea which is under the influence of Black sea and Mediterranean waters are more diverse then the western mediterranean ones (Garcia Raso, 1990).

Besides, there were also studies that contain stations with the various biotopes including *P. oceanica.* Aslan-Cihangir and Pancucci-Papadopoulou

(2011a) determined the highest species diversity in the stations located on *P. oceanica* beds in Dardanelles Strait. The same result was also reported in the study about benthic amphipods made by Sezgin *et al*. (2007). However, Ateş *et al*. (2007) conducted a study on biotopes including photophilic algea, *P. oceanica*, mud, sand and coralligenous in Gökova Bay. The stations on *P. oceanica* showed the second highest number of species and individuals just behind the photophilic algea biotopes.

Although nearly all of the species identified were sampled from various depths in the water, a small percentage of them collected from supralittoral zone. The amphipods *Orchestia montagui*, *Orchestia mediterranea* and *Orchestia stephenseni* were reported out of water under the *P. oceanica* litter (Geldiay *et al*., 1970; Kocataş *et al*., 2001). This shows that *P. oceanica* support the biological diversity not only in the water but also out of it on the shore.

As a result, *P. oceanica* meadows like coralligenous beds (Bakır and Katağan, 2005) support the richest community both in terms of species and individuals among the Mediterranean benthic communities and significantly increase biological diversity in areas where available.

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Sipunculans associated with *Posidonia oceanica* (L.) Delile on the coasts of Turkey and Northern Cyprus

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Abstract

Sipunculan species associated with *Posidonia oceanica* meadows along the Turkish and Cypriot coasts were reviewed based on the available literature. A total of 14 sipunculan species were reported from the meadows in the region up to date. *Aspidosiphon* (*Aspidosiphon*) *misakiensis* (50.1%), *Phascolosoma* (*Phascolosoma*) *stephensoni* (53.7%) and *Aspidosiphon* (*A.*) *muelleri* (78%) were the most dominant species in the Aegean, Mediterranean and Cypriot coasts, respectively. The most frequent species was *Aspidosiphon* (*A.*) *muelleri* on the coasts of the Aegean Sea and Northern Cyprus, and *Aspidosiphon* (*A.*) *misakiensis* on the coasts of the Mediterranean Sea. The alien sipunculans on *P. oceanica* were *Apionsoma* (*A.*) *misakianum*, *Aspidosiphon* (*A.*) *mexicanus*, *Aspidosiphon* (*A.*) *elegans* and *Phascolosoma* (*P.*) *scolops.*

Introduction

Posidonia oceanica, a seagrass species endemic to the Mediterranean Sea, extends from the surface to about 40 m depth. This species is included in the Barcelona convention list of protected species. It forms highly productive meadows playing a crucial role in coastal ecosystems dynamics (Boudouresque *et al.,* 2006). *P. oceanica* is known to host diversified sipuncula assemblages in the western (Saiz Salinas, 1986) and eastern (Açik, 2011) Mediterranean Sea. Due to its long, broad leaves and scaled rhizomes penetrating well into the sediment that provide a number of microhabitats and refuge from predators, *P. oceanica* allows different species to occupy various ecological niches in a same habitat. It constitutes spawning ground area, provides food via the high primary production of the plants and epiphyte algae, controls sedimentary flows, stabilizes coastal area and protects the beaches from erosion (Stoner, 1980; Orth *et al.,* 1984; Mazzella *et al.,* 1992; Boström *et al.,* 2006; Bedini *et al.,* 2011).

Posidonia oceanica forms dense meadows on sandy bottoms of the Mediterranean basins, except in the warm water of Levantine Sea (Mersin and Iskenderun Bays, the coasts of Syria, Lebanon and Israel). However, a small patch of this meadow was recently reported from the Sea of Marmara (near Erdek) (Meinesz *et al.,* 2009).

Few studies on the sipuncula fauna inhabiting *P. oceanica* have been carried out along the coasts of Turkey and Northern Cyprus. A total of 14 sipunculan species were reported from this meadow in the region up to date (Açik *et al.,* 2005; Açik, 2007; 2008a; 2009; 2010a; 2010b and 2011).

The aim of this study is to present data on sipunculan species inhabiting the *P. oceanica* meadows distributed along the coasts of Turkey and Northern Cyprus, and to give some notes on their morphological and distributional features.

Methods

Sipunculan species reported from the *Posidonia oceanica* meadows along the Turkish and Cypriot coasts were only taken into account. The dominance and frequency values of species were determined based on data given in the papers.

Results and Discussion

Aegean coasts of Turkey

A total of nine sipunculan species belonging to four families (Golfiingidae, Phascolionidae, Phascolosomatidae and Aspidosiphonidae) were reported to be associated with *P. oceanica* on the Aegean coasts of Turkey (Table 1). Among the species, *Aspidosiphon* (*A.*) *misakiensis* (50.1%) was the most dominant species (Figure 1A). In the area, three species [*Aspidosiphon* (*A.*) *muelleri* (48%), *Golfingia* (*G.*) *vulgaris vulgaris* (46%) and *Aspidosiphon* (*A.*) *misakiensis* (36%)] were categorized as ‘Common’ and the others as ‘Rare’.

Faunistic analysis of benthic samples collected from Ildır and Gerence Bays yielded a total of 95 specimens belonging to 3 species (Açik, 2007). The most dominant (96.8%) and frequent species (87.5%) in the area was *A.* (*A.*) *muelleri* (Table 1).

Açik (2008a) reported a total of 7 species and 223 specimens belonging to 4 families from the Turkish Aegean coast. *A.* (*A.*) *misakiensis* was the most dominant species, comprising 35.9% of the total number of specimens. As a result of Soyer (1970)’s frequency index values, 2 species could be classified as ‘Constant’ (F≥50%), 1 species as ‘Common’ (F between 25 and 49) and 4 species as ‘Rare’ (F<25) (Table 1).

A total of 4 species and 6 specimens were determined in Izmir Bay by Açik (2009). The most dominant species were *Onchnesoma steenstrupii steenstrupii* and *Thysanocardia procera* (33.3%). One species was ‘Constant’ (Table 1).

In Kuşadası Bay, 3 species and 219 specimens were found on *P. oceanica* (Açik, 2010b). The most dominant (87.7%) and frequent species (100%) was *A.* (*A.*) *misakiensis* (Table 1).

Mediterranean coasts of Turkey

Nine sipunculan species were reported on *P. oceanica* from the area. *Phascolosoma* (*P.*) *stephensoni* and *A.* (*A.*) *misakiensis* comprised up to 91.2% of the total sipuncula populations (Figure 1B). In the area, two species

[*Aspidosiphon* (*A.*) *misakiensis* (64%) and *Onchnesoma steenstrupii steenstrupii* (52%)] were categorized as 'Constant', two species [*P.* (*P.*) *stephensoni* (48%) and *Golfingia* (*G.*) *vulgaris vulgaris* (44%)] as 'Common' and the others as 'Rare'.

A total of 6 species and 19 specimens were found in the Fethiye-Göçek Specially Protected Area (Açik, 2010a). The most dominant species were *Onchnesoma steenstrupii steenstrupii* and *A.* (*A.*) *misakiensis* (26.3%) (Table 1). Three species were 'Constant' (Table 1).

Açik (2011) identified a total of 7 species and 1149 specimens on *P. oceanica* from the Mediterranean coast of Turkey. The most dominant species in the study area was *P.* (*P.*) *stephensoni* (54.5%), followed by *A.* (*A.*) *misakiensis* (37.7%) and *Onchnesoma steenstrupii steenstrupii* (5.7%). The most frequent species (66.7%) in the area was *A.* (*A.*) *misakiensis* (Table 1).

Northern Cyprus

Faunistical analysis of *Posidonia oceanica* samples collected from Northern Cyprus (0–15 m) at 13 stations yielded 5 sipunculan species belonging to 3 families (Golfingiidae, Phascolosomatidae and Aspidosiphonidae) (Açik *et al.,* 2005). *Aspidosiphon* (*A.*) *muelleri* was the most dominant (78%) and frequent species (91.7%) in the area (Table 1; Figure 1C).

Table 1. The sipunculan species and their number of specimens, dominance and frequent values found on *Posidonia ocenica* meadows along the coasts of Turkey and Northern Cyprus.

Studies	Sampling area	Species	Number of specimens	Dominant value (%)	Frequent value (%)
		AEGEAN SEA			
Açik, 2007	Ildır and Gerence Bays	*G.* (*G.*) *vulgaris vulgaris*	1	1,1	12,5
		O. steenstrupii steenstrupii	2	2,1	12,5
		A. (*A.*) *muelleri*	92	**96,8**	**87,5**
Açik, 2008a	Aegean coast	*G.* (*G.*) *vulgaris vulgaris*	48	21,5	**54,8**
		O. steenstrupii steenstrupii	10	4,5	16,1
		P. (*P.*) *strombus strombus*	1	0,4	3,2
		P. (*I.*) *tuberculosum*	6	2,7	9,7
		P.(*P.*) *agassizii agassizii*	2	0,9	6,5
		A. (*A.*) *misakiensis*	80	**35,9**	35,5
		A. (*A.*) *muelleri*	76	34,1	51,6
Açik, 2009	Izmir Bay	*G.* (*G.*) *vulgaris vulgaris*	1	16,7	25
		O. steenstrupii steenstrupii	2	**33,3**	25
		T. procera	2	**33,3**	**50**
		A. (*A.*) *muelleri*	1	16,7	25
Açik, 2010b	Kusadasi Bay	*G.* (*G.*) *vulgaris vulgaris*	19	8,7	57,1
		P.(*P.*) *stephensoni*	8	3,7	57,1
		A. (*A.*) *misakiensis*	192	**87,7**	**100**
		MEDITERRANEAN SEA			
Açik, 2010a	Fethiye-Göçek Specially Protected Area	*G.* (*G.*) *vulgaris vulgaris*	3	15,8	**50**
		N. (*N.*) *rimicola*	1	5,3	25
		O. steenstrupii steenstrupii	5	**26,3**	**50**
		P.(*P.*) *stephensoni*	1	5,3	25
		A. (*A.*) *misakianum*	4	21,1	25
		A. (*A.*) *misakiensis*	5	**26,3**	**50**

Açik, 2011	Southern coast of Turkey	*G.* (*G.*) *vulgaris vulgaris*	17	1,5	42,9
		O. steenstrupii steenstrupii	66	5,7	52,4
		P. (*I.*) *tuberculosum*	1	0,1	4,8
		P. (*P.*) *stephensoni*	626	**54,5**	52,4
		A. (*A.*) *mexicanus*	5	0,4	4,8
		A. (*A.*) *elegans*	1	0,1	4,8
		A. (*A.*) *misakiensis*	433	37,7	**66,7**
NORTHERN CYPRUS					
Açik *et al.*, 2005	Cypriot coast	*G.* (*G.*) *vulgaris vulgaris*	1	2	8,3
		P.(*P.*) *agassizii agassizii*	3	6	16,7
		P.(*P.*) *scolops*	5	10	16,7
		P.(*P.*) *stephensoni*	2	4	16,7
		A. (*A.*) *muelleri*	39	**78**	**91.7**

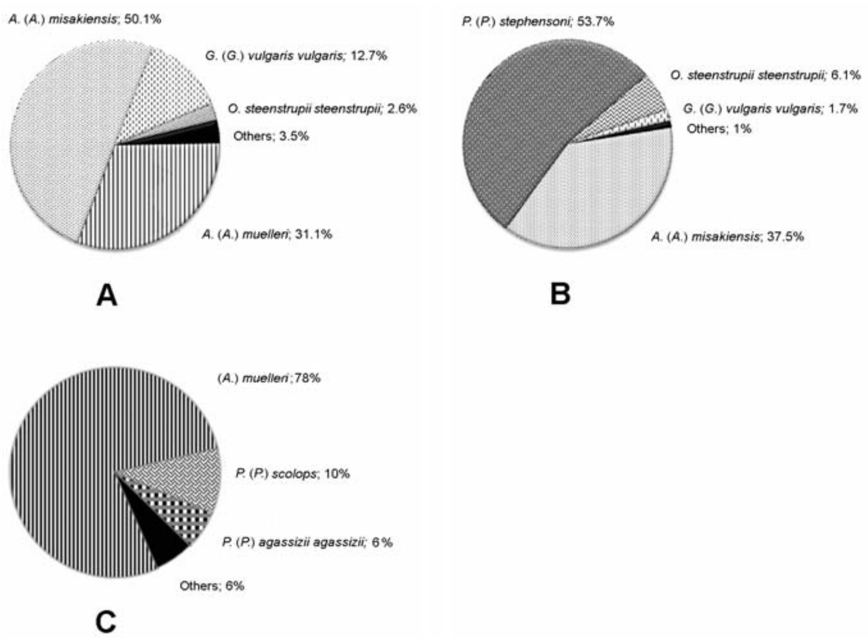

Figure 1. The dominant species found in *Posidonia oceanica* samples in the Aegean Sea **(A)**, Mediterranean Sea **(B)** and Northern Cyprus **(C)**.

The morphological and distributional features of the species are given below.

Golfingia (Golfingia) vulgaris vulgaris (de Blainville, 1827)

Description: Trunk cylindrical; skin smooth, translucent (Figure 2A). Both ends of trunk with dark brown or black papillae. Introvert with spine-like, dark, scattered hooks. Four retractor muscles. Nephridiopores at level of anus. Two reddish black eye spots present.

Distribution: Northeast Atlantic Ocean, northwest Pacific Ocean, Indian Ocean (Saiz Salinas, 1993a); Mediterranean Sea and Red Sea (Cutler, 1994; Açik, 2011).

***Thysanocardia procera* (Moebius, 1875)**

Description: Skin smooth with fine ridges (Figure 2B). Tentacles surrounding bilobed nuchal organ. Two retractor muscles fused for much of their length, originating in posterior third of length. Contractil vessel with villi. Nephridiopores at level to anus or slightly in front of it.

Distribution: North Atlantic Ocean and Mediterranean Sea (Saiz Salinas and Villafranca Urchegui, 1990).

***Nephasoma* (*Nephasoma*) *rimicola* (Gibbs, 1973)**

Description: Body wall smooth, semi-transparent (Figure 2C). Introvert shorter than trunk length. Hooks arranged in rings. Nephridiopores anterior to anus. Two reddish eye spots present.

Distribution: Southwestern England and Mediterranean Sea (Cutler, 1994; Açik, 2010a).

***Phascolion (Isomya) tuberculosum* Théel, 1875**

Description: Trunk cylindrical; skin semi-transparent (Figure 2D). Holdfast papillae lack dark proteinized borders. Introvert with large, broad, recurved hooks. Two retractor muscles, of equal width, attached at near posterior part of trunk. Nephridiopore posterior to anus.

Distribution: Indian Ocean, western Pacific Ocean, Mediterranean Sea (Saiz Salinas and Villafranca Urchegui, 1990; Saiz Salinas, 1993b; Açik, 2011); and Atlantic Ocean (Murina and Sørensen, 2004).

***Phascolion (Phascolion) strombus strombus* (Montagu, 1804)**

Description: Body wall semi-transparent (Figure 2E). Distinct proteinized borders on holdfast papillae. Introvert with claw like, pointed hooks. Ventral retractor muscles much thinner than dorsal pairs. Intestine in loose loops without spiral. Single nephridium located at right side of ventral nerve cord.

Distribution: North Atlantic Ocean, Arctic Ocean, Pacific Ocean, Mediterranean Sea, Red Sea (Cutler *et al.*, 2004) and southwest Indian Ocean (Cutler and Cutler, 1996).

***Onchnesoma steenstrupii steenstrupii* Koren and Danielssen, 1875**

Description: Pear-shaped or barrel-shaped trunk various coloured: grey, yellow, orange, rusty red (Figure 2F). Small papillae covering surface of trunk. Keel-like structures in posterior end of trunk. Only one retractor attached at posterior part of body. Spindle and wing muscle absent. Anus located near mouth. Intestine with several coils. Nephridia single, elongate.

Distribution: Atlantic Ocean, western Pacific Ocean, southwest Indian Ocean, Mediterranean Sea (Cutler, 1994; Açik, 2011) and Red Sea (Pancucci-Papadopoulou *et al.,* 1999).

***Phascolosoma (Phascolosoma) agassizii agassizii* Keferstein 1866**

Description: Body wall opaque (Figure 2G). Introvert with irregular dark pigmented bands. Hook with variable clear streak; triangle usually indistinct; unidentate, sometimes with small secondary tooth. Rings of hooks fewer than 50. Two pairs of retractors present. Spindle muscle arising in front of anus, attached to posterior end of trunk. Two dark eye spots present.

Distribution: North Pacific Ocean, Indian Ocean, subtropical eastern Atlantic Ocean and Mediterranean Sea (Cutler, 1994).

***Phascolosoma (Phascolosoma) scolops* (Selenka & de Man 1883)**

Description: Body wall opaque (Figure 2H). Introvert with regular pigmented bands. Papillae distributed over entire trunk; mid-trunk papillae small, those on both ends of trunk large. Preanal papillae dome-shaped to mammiform, reddish brown. Hook with visible triangle and clear streak, arranged in less than 25 rings. Two characteristic dark lines crossing clear area of each hook. Two pairs of retractors present. Spindle muscle well-developed, attached to posterior end of trunk. Two dark eye spots present.
Distribution: Indo-West Pacific area, Red Sea, eastern Atlantic Ocean (Cutler, 1994) and Mediterranean Sea (Pancucci-Papadopoulou *et al.,* 1999).

***Phascolosoma (Phascolosoma) stephensoni* (Stephen, 1942)**

Description: Body wall opaque, light brownish (Figure 2I). Preanal and posterior papillae cone-shaped, smooth, red in colour; those on mid-trunk small, hemispherical. Hooks with distinct streak, triangular space and crescent. Most hooks with distinct secondary tooth. Two pairs of retractors present. Two black eye spots present.
Distribution: Western and northwestern Indian Ocean, eastern Atlantic Ocean, western Pacific Ocean, and Mediterranean Sea (Cutler, 1994; Açik, 2011).

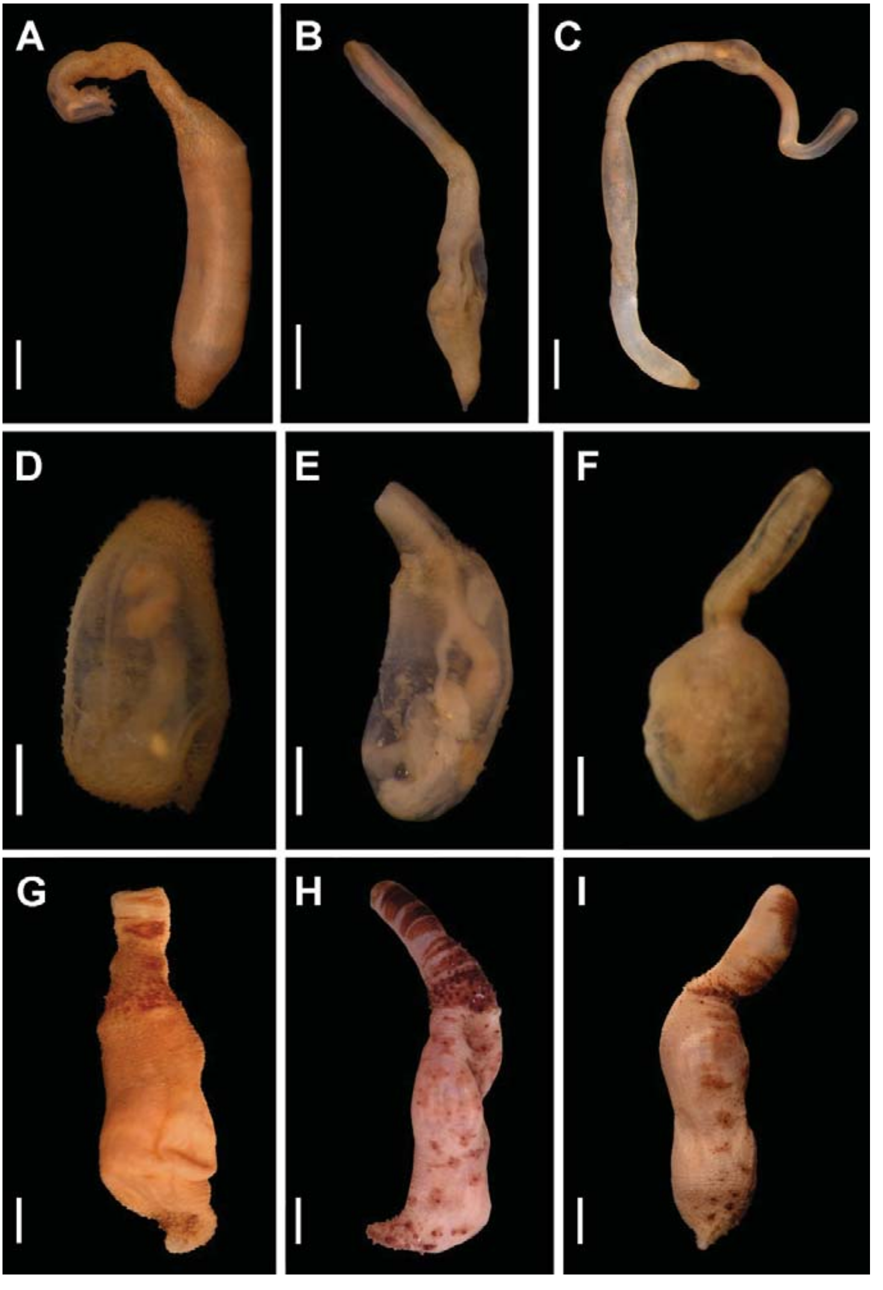

Figure 2. External morphology of species. **A.** *Golfingia* (*G.*) *vulgaris vulgaris* **B.** *Thysanocardia procera* **C.** *Nephasoma* (*N.*) *rimicola*. **D.** *Phascolion* (*I.*) *tuberculosum* **E.** *Phascolion* (*P.*) *strombus strombus*. **F.** *Onchnesoma steenstrupii steenstrupii* **G.** *Phascolosoma* (*P.*) *agassizii agassizii*. **H.** *Phascolosoma* (*P.*) *scolops* **I.** *Phascolosoma* (*P.*) *stephensoni*. Scale bars: A = 1 mm, B = 1 mm, C = 1 mm, D= 0.5 mm, E= 0.4 mm, F= 0.5 mm, G= 1.5 mm, H= 2 mm, I= 1 mm. (From Açik, 2010b; 2011, Açik *et al.*, 2005)

Apionsoma (*Apionsoma*) *misakianum* (Ikeda, 1904)

Description: Body wall thin, semi-transparent (Figure 3A). Small, numerous brown papillae on posterior part of trunk. Small hooks with basal spinelets (4–5) on introvert. Four thin retractor muscles originating near middle of trunk, both pairs close to ventral nerve cord. Bi-loped nephridia usually similar in size, free; mostly orange in colour; in some specimens, nephridia unequal in size. Nephridiopores located in front of anus. Two black eye spots present.

Distribution: Indian Ocean, Pacific Ocean, western Atlantic Ocean (Cutler, 1994), and Mediterranean Sea (Açik, 2011).

Aspidosiphon (Akrikos) mexicanus (Murina, 1967)

Description: Body wall thin, light yellowish. Anal shield weakly developed (Figure 3B). Caudal shield not clear. Tail-like structure on posterior part of trunk. Introvert at typical angle (45–50) with main trunk axis. Intestinal spiral attached to the posterior part of trunk by spindle muscle. Nephridiopores posterior to anus.

Distribution: Western Atlantic Ocean, Indian Ocean and Mediterranean Sea (Pancucci-Papadopoulou *et al.,* 1999; Açik, 2011).

Aspidosiphon (Aspidosiphon) elegans (Chamisso and Eysenhardt, 1821)

Description: Body wall thin, transparent or semi-transparent. Ungrooved anal shield granulous. Caudal shield usually weakly developed. Dark brown bidentate compressed hooks on rings located on distal part of introvert (Figure 3C). Dark conical hooks scattered on proximal part of introvert. Nephridia orange or dark brown. Two black eye spots present.

Distribution: Western Pacific Ocean, Indian Ocean, western Atlantic Ocean, Red Sea (Cutler, 1994); and Mediterranean Sea (Wesenberg-Lund, 1957; Açik, 2011).

Aspidosiphon (Aspidosiphon) misakiensis Ikeda, 1904

Description: Body wall semi-transparent. Anal shield without grooves or furrows (Figure 3D). Caudal shield with vague radial grooves. Spine-like papillae scattered on introvert. Light brown bidentate hooks in rings followed by scattered unidentate hooks. Gut loosely wound in ill-defined coils. Two retractors joined for most of their length, arising very close to posterior end of trunk. Nephridiopores posterior to anus or at same level. Two black eye spots present.

Distribution: Pacific Ocean, eastern and western Atlantic Ocean and Mediterranean Sea (Cutler, 1994; Açik, 2011).

Aspidosiphon (Aspidosiphon) muelleri **Diesing, 1851**

Description: Body wall thin, semi-transparent. Anal and caudal shield black-brown in colour and grooved (Figure 3E). Spine-like papillae scattered on introvert. Longitudinal musculature continuous. Light brown bidentate hooks in rings followed by scattered unidentate hooks. Retractor muscles attached at near posterior part of trunk. Anus and nephridiopores placed at same level.

Remarks: According to Cutler and Cutler (1989), Cutler (1994) and Açik (2008a) *Aspidosiphon* (*A.*) *muelleri kovalevskii* is a junior synonym of *A.* (*A.*) *muelleri*. Therefore, the report of *A.* (*A.*) *muelleri kovalevskii* from the Cypriot coast by Açik *et al.* (2005) was assigned to *A.* (*A.*) *muelleri*.

Distribution: Northeastern Atlantic Ocean, eastern Pacific Ocean, Mediterranean Sea, Red Sea (Cutler, 1994; Açik *et al.*, 2005); and Indian Ocean (Saiz Salinas, 1993a).

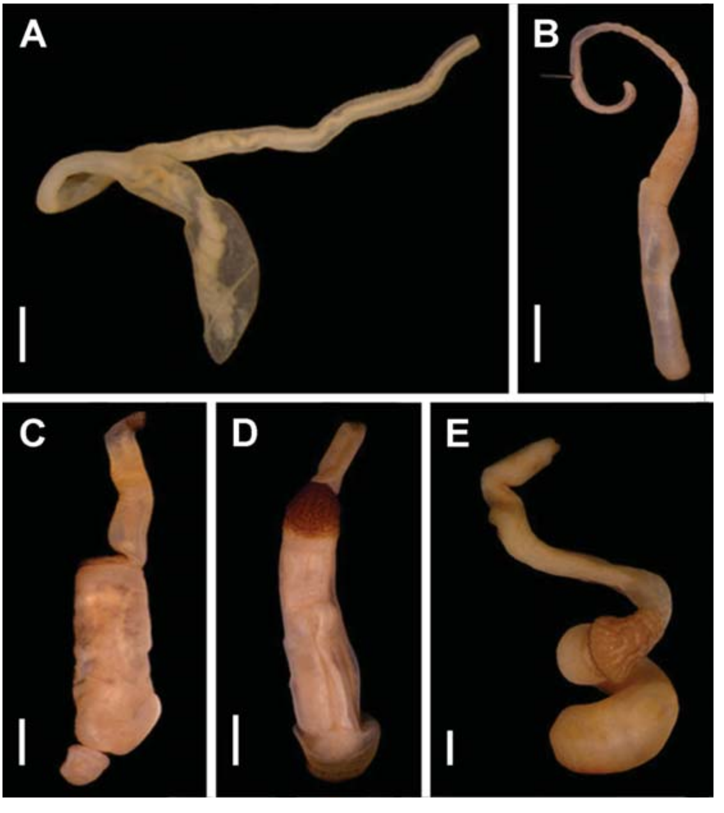

Figure 3. External morphology of species. **A.** *Apionsoma* (*A.*) *misakianum*. **B.** *Aspidosiphon* (*A.*) *mexicanus* **C.** *Aspidosiphon* (*A.*) *elegans* **D.** *Aspidosiphon* (*A.*) *misakiensis* **E.** *Aspidosiphon* (*A.*) *muelleri*. Scale bars: A= 0.5 mm, B = 3 mm, C = 1 mm, D = 1 mm, E = 0.5 mm. (From Açik, 2011)

Alien sipunculan species on *Posidonia oceanica*

A total of 6 alien sipunculan species belonging to 3 families have been reported from the whole Mediterranean basins up to date, of which 4 species [*Apionsoma* (*A.*) *misakianum*, *Phascolosoma* (*P.*) *scolops, Aspidosiphon* (*A.*) *mexicanus* and *A.* (*A.*) *elegans*] have become established in the region and 2 species [*Apionsoma* (*A.*) *trichocephalus* and *Phascolion* (*P.*) *convestitum*] are casual (Çinar *et al.,* 2011; Zenetos *et al.,* 2010).

Three alien species [*A.* (*A.*) *misakianum*, *A.* (*A.*) *mexicanus* and *A.* (*A.*) *elegans*] were found on *Posidonia oceanica* in the Mediterranean coast of Turkey (Açik, 2010a; 2011), and one species [*P.* (*P.*) *scolops*] in the Cypriot coast (Açik *et al.,* 2005). *Aspidosiphon* (*A.*) *elegans,* which is a bio-eroder species, might pose a risk to the erosion of limestone in shallow waters (Açik, 2008b). When it attains to a high population density in the area, it may cause serious damage to calcareous structures.

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Juvenile fish assemblages around Gökçeada Island (North Aegean Sea, Eastern Mediterranean): *Posidonia oceanica* (L.) Delile meadows, rocky and bare sand areas

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Introduction

Habitats have important ecological roles for fishes and serve as spawning, nursery and feeding grounds. In many parts of the world, the fish assemblages inhabiting seagrass beds are more diverse and abundant than those inhabiting bare substrata (*e.g.* Bell *et al.*, 1988; Bell and Pollard, 1989; Ferrell and Bell, 1991; Ruiz *et al.*, 1993; Connolly, 1994a, b; Guidetti, 2000; Guidetti and Busotti, 2000, 2002; Bell *et al.*, 2001; Moran *et al.*, 2003).

Several authors have hypothesised that the structural complexity and productivity of seagrass beds could explain these differences, with seagrass providing shelter from predators and abundant food (Adams, 1976_a; Orth and Heck, 1980; Bell and Westoby 1986a, b; Bell and Pollard, 1989; Guidetti and Bussotti, 2002). Seagrass mainly support small species inhabiting cryptic habitats, juvenile stages of species that inhabit other habitat as adults (including many commercially important species) and some adults of large mobile fish (Bell and Harmelin-Vivien, 1982; Blaber *et al.*, 1992; Francour, 1997; Guidetti and Bussotti, 1998). On the other hand, adults of large mobile fish, or species gaining protection through schooling or by camouflage against sediments, are typically most abundant on bare habitats (Bell and Pollard, 1989).

Fish assemblages of *Posidonia oceanica* beds in the western Mediterranean Sea have been studied. But information is scarce for the eastern Mediterranean where most works on littoral fishes relates to rocky areas (Guidetti, 2000; Harmelin-Vivien *et al.*, 2005). The coastal water around Gökçeada Island is an important area with different habitat types for resident and temporary fish species. This study aimed to investigate the fish community structure in *P. oceanica* and rocky and bare habitats around Gökçeada Island.

Materials and Methods

Study area

Gökçeada Island locates in the North Aegean Sea (25º40'E- 26º02'E; 40º05'N- 40º14'N) (Figure 1). The North Aegean Sea is separated from the

South Aegean by the archipelago of the Cyclades Islands. It is characterised by a wide shelf in the northern part and the North Aegean Trough, which extends from southwest to northeast (Kourafalou and Barbapoulos, 2003) and reach 1600 m depth. The Black Sea Waters, flowing from the Dardanelles strait, is the most significant quantity of water mass input for the North Aegean Sea. These massive waters of 8.8-25°C and 31.8-38.3 psu affect the uppermost layer (20-30 m depth) and are modified, moving westward and southward, by mixing with the intermediate waters of Levantine origin, a warm and highly saline water originating from the South Aegean to the Levantine basins, extending down to 350-400 m depth (Theocharis and Georgopoulos, 1993; Pazi, 2008).

Sampling

The sampling was carried out from March 2003 to April 2004 in the three habitat types (*Posidonia oceanica* beds, rocky and bare sand areas) around Gokceada Island. Samples were collected with gill net (mesh size: 22 mm; 120 m*2.4 m) and trammel net (mesh size: 18 mm; 180 m x 0.9 m) which set from 5 to 15 m and sampling was made six times for each month. During each month from each habitat using a 35 m long beach seine (each of them covering a surface of ~ 0.1 ha). Net depth at the beginning of wings was 40 cm, and 250 cm at the central part together with the sac. The mesh size was 6 mm in the wings and 4 mm at the central sac. The net was hauled along the shore (50 m), and from offshore to the coast (50 m): the two hauls were pooled and represent a single sample. The number of individuals of each species was determined in laboratory of Marine Research Station in Gökçeada Island. Community structure was specified by diversity (H), species richness (D), evenness (J) and dominance (C) (Odum, 1971).

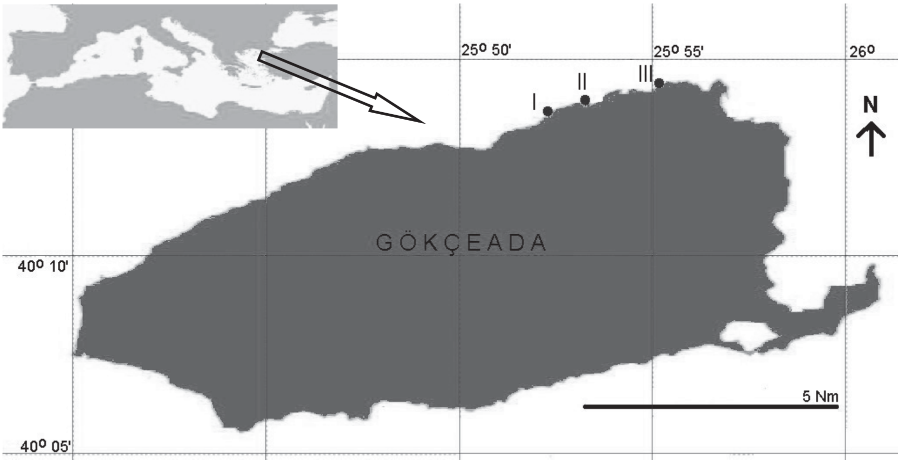

Figure 1. Sampling stations around Gökçeada Island. Habitat types of sampling stations were *Posidonia oceanica* meadows (I); bare sandy (II) and rocky (III).

Results and Discussion

Seventy species belonging to 32 families were collected around Gökçeada Island, with 49 species collected from *Posidonia oceanica* bed, 45 species from sandy habitat and 43 species from rocky areas (Table 1). Species richness was higher in seagrass meadow than in rocky and sandy habitats. The highest species number was determined in the Sparidae and Labridae families.

E.encrasicouls, S. cabrilla, M. surmuletus, D. annularis, P. acarne, P. erythrinus, C. julis, S. ocellatus, G. cobitis, G.niger, A. sphynx, L. aurata, A. boyeri, A. hepsetus, S. notata, S.porcus, C. lucernus were common species collected from all habitat types around Gökçeada Island. With regard to necto-benthic fish species; *S. ocellatus*, *S. salpa* and *D. vulgaris* were typical necto-benthic species living in *P. oceanica* seagrass meadows and rocky areas in the Mediterranean coastal waters (Bell and Harmelin-Vivien, 1982; Francour, 1997; Guidetti and Bussotti, 1998; Keskin and Ünsal, 1998).

The number of fish species, diversity indices (Figure 2) and total abundance were higher in seagrass meadows than in sandy habitat when disregarding open water species (*e.g. A. hepsetus*, *O. labeo* and *L. aurata*), which represented the majority of fish collected in all habitats, the abundance of the necto-benthic species was greater in seagrass beds than in sandy habitat. Many researchers have suggested that the complex structure of the seagrass meadows provide food and shelter from predators for resident and temporary species (*e.g.* Orth and Heck, 1980; Bell *et al.*, 1988; Bell and Pollard, 1989; Ferrell and Bell, 1991; Connolly, 1994a; Edgar and Shaw, 1995a). As mentioned by several authors (Guidetti and Bussotti, 2000; Guidetti and Bussotti, 2002) these small open-water species use seagrass meadow as a refuge during the night to escape predators, no difference is observed between habitats during the day time. On the other hand; Necto-benthic species such as *S. ocellatus* and *S.* cinereus (Labridae) exhibited a clear preference for the seagrass beds. In the Mediterranean Sea, Labridae is the dominant family in *Posidonia oceanica* meadows (Francour, 1997) and in *Cymodocea nodosa* and *Zostera noltii* meadows (Guidetti and Bussotti, 2000). In *Posidonia oceanica* meadow, two factors are often proposed to explain the presence of wandering adult individuals: the largest range of bathymetric distribution and the proximity of rocky areas (Bell and Harmelin-Vivien, 1982; Francour, 1994, 1997). In *P. oceanica*, the meadows extend from the surface to 40 m depth, and the fish assemblages are quite different between shallow and deep waters (Francour, 1994). Labridae (*Symphodus tinca*) and Sparidae (*Diplodus annularis*, *Sarpa salpa*) move to shallow water (*S. tinca*, *D. annularis*) or to deep water (*S. salpa*) to reproduce (see Francour, 1997 and references cited therein). On the other hand, large predators such as *Dicentrarchus labrax* and *Diplodus sargus* move from neighbouring rocky area to meadow to feed.

In the present study, most of species were caught in the all habitats. Ferrell and Bell (1991) suggested that the differences in the fish assemblages between seagrass and unvegetated habitat can also depend on how far unvegetated sites are from eelgrass. Around the island, most of the seagrass meadows are closely interspersed with sandy patches and rocky areas. This high level of fragmentation could explain the high proportion of species collected from the all habitats. However, the high abundance of necto-benthic species in seagrass reinforces the idea that seagrass beds around Gökçeada Island is play an important ecological role as provider of food and shelter for juvenile and sub-adult fishes.

Table 1. Number of specimens (N) of each species in the three different habitats, and number of fish species sampled in each of the three habitats around Gökçeada Island. RD: relative abundance; PD: Presence degree; A: mean abundance

	***Posidonia oceanica* meadows**		**Rock**		**Bare sand**					
	N	**RA**	**N**	**RA**	**N**	**RA**	**N**	**RA**	**PD**	**A**
Engraulis encrasicolus	4	0.06	12	0.18	5	0.03	21	0.07	3	7.0
Belone belone	-	-	-	-	1	0.01	1	0.00	1	1.0
Nerophis ophidion	6	0.09	-	-	2	0.01	8	0.03	2	4.0
Syngnathus acus	24	0.35	-	-	-	-	24	0.08	1	24.0
Syngnathus thple	6	0.09	-	-	-	-	6	0.02	1	6.0
Antonogadus megalokynodon	7	0.10	-	-	-	-	7	0.02	1	7.0
Gaidropsarus mediterraneus	2	0.03	-	-	-	-	2	0.01	1	2.0
Phycis phycis	0	-	3	0.05	1	0.01	4	0.01	2	2.0
Serranus cabrilla	54	0.78	29	0.44	4	0.02	87	0.27	3	29.0
Serranus hepatus	3	0.04	-	-		-	3	0.01	1	3.0
Serranus scriba	8	0.12	2	0.03	-	-	10	0.03	2	5.0
Pomatomus saltator	-	-	-	-	1	0.01	1	0.00	1	1.0
Lichia amia	-	-	-	-	4	0.02	4	0.01	1	4.0
Trachurus trachurus	1	0.01	-	-	2	0.01	3	0.01	2	1.5
Sciaena umbra	6	0.09	3	0.05	0	-	9	0.03	2	4.5
Mullus barbatus	3	0.04	-	-	20	0.11	23	0.07	2	11.5
Mullus surmuletus	18	0.26	75	1.13	140	0.77	233	0.74	3	77.7
Boops boops	125	1.81	100	1.51	-	-	225	0.71	2	112.5
Dentex dendex		-	1	0.02	2	0.01	3	0.01	2	1.5
Diolodus sargus	45	0.65	14	0.21	-	-	59	0.19	2	29.5
Diplodus annularis	251	3.64	145	2.18	43	0.24	439	1.39	3	146.3
Diplodus puntazzo	168	2.43	173	2.61	-	-	341	1.08	2	170.5
Diplodus vulgaris	1028	14.90	720	10.85	18	0.10	1766	5.57	3	588.7
Lithognathus mormyrus		-	-	-	22	0.12	22	0.07	1	22.0
Oblada melanura	100	1.45	59	0.89	6	0.03	165	0.52	3	55.0
Pagellus acarne	24	0.35	53	0.80	45	0.25	122	0.38	3	40.7
Pagellus erythrinus	38	0.55	34	0.51	7	0.04	79	0.25	3	26.3
Sarpa salpa	830	12.03	791	11.92	782	4.31	2403	7.58	3	801.0
Sparus aurata	2	0.03	-	-	-	-	2	0.01	1	2.0
Spondyliosoma cantharus	10	0.14	-	-	-	-	10	0.03	1	10.0
Spicara maena	12	0.17	41	0.62	-	-	53	0.17	2	26.5
Spicara smaris	-	-	2	0.03	-	-	2	0.01	1	2.0
Chromis chromis	96	1.39	328	4.94	-	-	424	1.34	2	212.0
Coris julis	168	2.43	103	1.55	1	0.01	272	0.86	3	90.7
Symphodus cinereus	359	5.20	125	1.88	10	0.06	494	1.56	3	164.7
Symphodus mediterraneus	41	0.59	12	0.18	-	-	53	0.17	2	26.5

Symphodus ocellatus	1956	28.35	1157	17.43	21	0.12	3134	9.89	3	1044.7
Symphodus roissali	78	1.13	24	0.36	-	-	102	0.32	2	51.0
Symphodus rostratus	32	0.46	-	-	-	-	32	0.10	1	32.0
Symphodus tinca	49	0.71	15	0.23	-	-	64	0.20	2	32.0
Trachinus draco	-	-	-	-	7	0.04	7	0.02	1	7.0
Uranoscopus scaber	-	-	3	0.05	49	0.27	52	0.16	2	26.0
Gobius bucchichi	-	-	21	0.32	104	0.57	125	0.39	2	62.5
Gobius cobitis	1	0.01	6	0.09	119	0.66	126	0.40	3	42.0
Gobius geniporus	-	-	3	0.05	38	0.21	41	0.13	2	20.5
Gobius niger	1	0.01	15	0.23	182	1.00	198	0.62	3	66.0
Pomatoschistus marmoratus	-	-	22	0.33	92	0.51	114	0.36	2	57.0
Zosterisessor ophiocephalus	-	-	10	0.15	278	1.53	288	0.91	2	144.0
Aidablennius sphynx	42	0.61	19	0.29	2	0.01	63	0.20	3	21.0
Lipophrys pavo	48	0.70	25	0.38	-	-	73	0.23	2	36.5
Parablennius incognitus	16	0.23	7	0.11	-	-	23	0.07	2	11.5
Parablennius sanguinolentus	24	0.35	13	0.20	-	-	37	0.12	2	18.5
Parablennius tentacularis	63	0.91	34	0.51	-	-	97	0.31	2	48.5
Sphyraena sphyraena	-	-	-	-	3	0.02	3	0.01	1	3.0
Callionymus pusillus	1	0.01	-	-	-	-	1	0.00	1	1.0
Chelon labrosus	-	-	-	-	144	0.79	144	0.45	1	144.0
Liza aurata	80	1.16	37	0.56	495	2.73	612	1.93	3	204.0
Liza ramada	-	-	-	-	174	0.96	174	0.55	1	174.0
Liza saliens	3	0.04	-	-	236	1.30	239	0.75	2	119.5
Oedalechilus labeo	-	-	-	-	664	3.66	664	2.10	1	664.0
Atherina boyeri	42	0.61	57	0.86	87	0.48	186	0.59	3	62.0
Atherina hepsetus	1009	14.62	2314	34.86	14259	78.54	17582	55.48	3	5860.7
Scorpaena notata	3	0.04	1	0.02	1	0.01	5	0.02	3	1.7
Scorpaena porcus	9	0.13	24	0.36	62	0.34	95	0.30	3	31.7
Chelidonichthys lucerna	3	0.04	6	0.09	2	0.01	11	0.03	3	3.7
Arnoglossus laterna	-	-	-	-	3	0.02	3	0.01	1	3.0
Arnoglossus thori	-	-	-	-	6	0.03	6	0.02	1	6.0
Bothus podas podas	-	-	-	-	9	0.05	9	0.03	1	9.0
Pegusa impar	-	-	-	-	2	0.01	2	0.01	1	2.0
Diplagogaster bimaculata	1	0.01	-	-	-	-	1	0.00	1	1.0
Total number of specimens	6900		6638		18155		31693			
Total number of species	49		43		45					

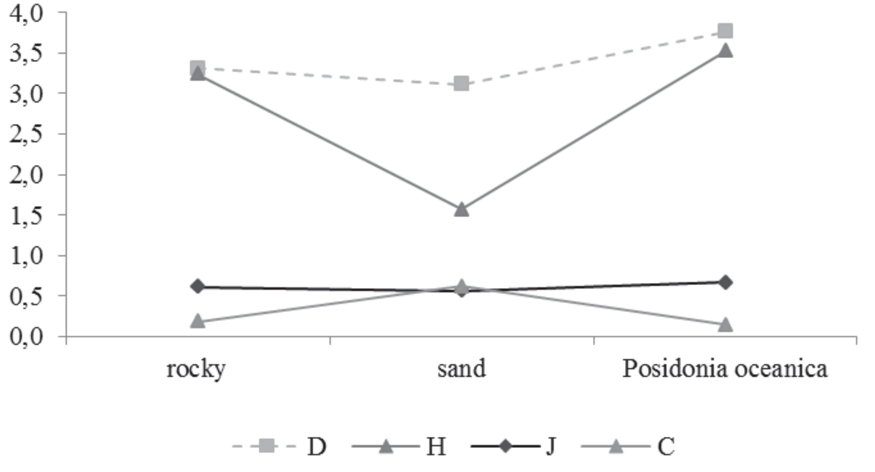

Figure 2. Evenness (E), species richness (D), diversity (H') and dominance (C) indices around Gökçeada Island by habitat types.

Around Göçeada Island, 41 of the 70 fish species, composed 80% of the total number of specimens, are considered in Turkey as economical species (Table 2). The importance of seagrass beds for economically important species was reported in the other areas (Kikuchi, 1974; Orth and Heck, 1980; Adams, 1976a; Connolly, 1994a, b; Edgar and Shaw, 1995a, b; Guidetti and Bussotti, 2002). This study showed that the nearshore waters (0-15 m) around Gökçeada Island are used as a nursery area by juveniles of the economic value. Even if there are some regulation on habitat protection as Yıldız Bay Marine Park, management regulation on habitats is not sufficient. In addition to; the current fishery regulation for small scale fishery around the Island should be revised to sustain a non-destructive fishery. Harbour or marina building should be prohibited to preserve from destruction. Domestic discharge is another threat to the welfare of seagrass meadows around Gökçeada Island.

Table 2. List of the economically most important fish species recorded in the all habitats. N: Number of specimens. C%: dominancy of species by the total number of commercial specimens; W%: dominancy of species by the total number of whole specimens.

Families	Commercial species	N	C%	W%
Engraulidae	*Engraulis encrasicolus*	21	0.08	0.07
Belonidae	*Belone belone*	1	0.00	0.00
Gadidae	*Gaidropsarus*	2	0.01	0.01
	Phycis phycis	4	0.02	0.01
Serranidae	*Serranus cabrilla*	87	0.34	0.27
	Serranus hepatus	3	0.01	0.01
	Serranus scriba	10	0.04	0.03
Pomatomidae	*Pomatomus saltator*	1	0.00	0.00
Carangidae	*Lichia amia*	4	0.02	0.01
	Trachurus trachurus	3	0.01	0.01

Sciaenidae	*Sciaena umbra*	9	0.03	0.03
Mullidae	*Mullus barbatus*	23	0.09	0.07
	Mullus surmuletus	233	0.90	0.74
Sparidae	*Boops boops*	225	0.87	0.71
	Dentex dendex	3	0.01	0.01
	Diolodus sargus	59	0.23	0.19
	Diplodus annularis	439	1.70	1.39
	Diplodus puntazzo	341	1.32	1.08
	Diplodus vulgaris	1766	6.83	5.57
	Lithognathus mormyrus	22	0.09	0.07
	Oblada melanura	165	0.64	0.52
	Pagellus acarne	122	0.47	0.38
	Pagellus erythrinus	79	0.31	0.25
	Sarpa salpa	2403	9.29	7.58
	Sparus aurata	2	0.01	0.01
	Spondyliosoma cantharus	10	0.04	0.03
Centracanthidae	*Spicara maena*	53	0.20	0.17
	Spicara smaris	2	0.01	0.01
Uranoscopidae	*Uranoscopus scaber*	52	0.20	0.16
Sphyraenidae	*Sphyraena sphyraena*	3	0.01	0.01
Mugilidae	*Chelon labrosus*	144	0.56	0.45
	Liza aurata	612	2.37	1.93
	Liza ramada	174	0.67	0.55
	Liza saliens	239	0.92	0.75
	Oedalechilus labeo	664	2.57	2.10
Atherinidae	*Atherina boyeri*	186	0.72	0.59
	Atherina hepsetus	1758	67.9	55.4
Scorpaenidae	*Scorpaena notata*	5	0.02	0.02
	Scorpaena porcus	95	0.37	0.30
Triglidae	*Chelidonichthys lucerna*	11	0.04	0.03
Soleidae	*Pegusa impar*	2	0.01	0.01
Total individual number of commercial		2586	100	81.6
Total individual number of whole species		3169		100
Number of commercial species		41		
Number of whole species		70		

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Importance of *Posidonia oceanica* (L.) Delile to the ecological evaluation of marine waters

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Abstract

Macroalgae and angiosperms are proposed as biological elements to measure the ecological status of coastal waters and transitional systems by EU Water Framework Directive (WFD, 2000/60/EC). *Posidonia oceanica* is a very important species in the Mediterranean eco-region. In this paper, some macrophyte indices and importance of *Posidonia oceanica* to the ecological evaluation of marine waters are evaluated.

Introduction

Lately, marine ecosystems are under dangerous by anthropogenic pollution. European Union was the declaration of EU Water Framework Directive (WFD, 2000/60/EC) to assess the ecological status of aquatic environments of Member States. The first step was to define water typologies, reference areas and classification systems (Sfriso and Facca, 2011). The ecological status (chemical and biological) of the aquatic environments are classified under five categories (bad, poor, moderate, good, high) (Figure 1). Benthic invertebrates, phytoplankton, macroalgae and angiosperms are proposed as biological elements to measure the ecological status of coastal waters and transitional systems by EU Water Framework Directive.

A few macrophyte indices were proposed by some researchers: *Posidonia oceanica* multivariate index (POMI), Cartography of Littoral and uppersublittoral rocky-shore communities (CARLIT), Ecological Evaluation Index (EEI), and Macrophyte Quality Index (MaQI) (Orfanidis *et al*., 2001; Ballesteros *et al*., 2007; Romero *et al*., 2007; Sfriso *et al*., 2007). Recently, two indices [CARLIT and Ecological Evaluation Index (EEI)] have been intercalibrated by MEDGIG.

In the present paper, some macrophyte indices and importance of *Posidonia oceanica* to the ecological evaluation of marine waters are evaluated.

Ecological Quality Categories	Class Boundaries
BAD	0-0,20
POOR	0,21-0,40
MODERATE	0,41-0,60
GOOD	0,61-0,80
HIGH	0,81-1

Figure 1. Ecological statusof the aquatic environments

Results and Discussion

Posidonia oceanica is an endemic species of the Mediterranean Sea and distributed between surface to 44 m depth in the clearest waters [Malta, France (Var, Corsica)] (Gobert *et al*., 2009). Some indices set up on *Posidonia oceanica*: PosWare (system for coastal water classification according to WFD;, Buia *et al*., 2005), POMI (*P. oceanica* multivariate index), Valecian CS (Fernandez Torquemada *et al*., 2006), BIPo (Biotic index using *P. oceanica*, Lopez y Royo 2008) and PREI (*P. oceanica* Rapid Easy Index, Gobert *et al*., 2009).

P. oceanica multivariate index (POMI) is based on the combination, through principal component analysis, of physiological, morphological, structural and community level (Romero *et al*., 2007). BIPo and PREI are the easiest because they both require the determination of the lowest numbers of parameters (Sfriso and Facca, 2011). The PREI is based on five metrics: (1) shoot density, (2) shoot surface, (3) E/L (ratio between epiphytic biomass and leave biomass) measured on shoots sampled at the same depth; (4) depth of the lower limit and (5) type of this limit (regressive, progressive or stable) (Gobert *et al*., 2009). However, this index is not advantage because of leaf counting, surface area measurement and epiphytic biomass/leaf biomass ratio determination in laboratory is very time-consuming and expensive (Sfriso and Facca, 2011).

Orfanidis *et al*. (2001) proposed a new macrophyte index to assess the ecological status of coastal and transitional waters in the Mediterranean Sea. Marine benthic macrophytes (macroalgae and angiosperms) were used as bioindicators of marine ecosystem and they were split two main ecological state groups (ESG I and ESG II). The first group (ESG I) are included thick leathery, calcareous, crustose seaweeds and seagrasses (*Posidonia oceanica* and *Cymodocea nodosa*), and the second group (ESG I) are included opportunistic macroalgae (sheet-like, filametous and coarsely branched species). *P. oceanica* was mentioned as a member of good/high quality of the ecological status (Orfanidis *et al*., 2011).

Sfriso *et al*. (2009) given validation of the Macrophyte Quality Index (MaQI) that has two versions [Expert Macrophyte Quality Index (E-MaQI) and Rapid Macrophyte Quality Index (R-MaQI)] to assess the ecological status of Italian marine transitional environments. Both expert (E-MaQI) and rapid (R-MaQI) macrophyte quality index are only suitable for transitional environments.

R-MaQI can be applied in field by using model in Figure 2. In the presence of angiosperms the environment assessment depends on their percent coverage and the percentage of sensitive species on the total number of taxa (Sfriso and Facca, 2011).

	Species score			Calcareus epiphytes	Quality classes (Score/EQR)				Notes
	Opportunistic 0	Indifferent 1	Sensitive 2						
Macroalgae	<75%[1]		≥25%	PP	0.9			1	Dominant coverage of aquatic angiosperms and sensitive macroalgae
	75-85%		15-25%	P	0.7		0.8	0.9	No total coverage of lasminar Ulvaceae [2]
	>85%		≤15%	R-(A)	0.6	0.6	0.7		Absence of dominant species on annual basis
	Total coverage <5%		2 specie		0.5				
	Total coverage ≤5%	Seasonal blooms of Rhodophyta	≤2 specie	≤ 1specie	0.4				Seasonal blooms of Gracilariaceae and/or Solieriaceae, mainly in a pleustofitic form
		Seasonal blooms of Chlorophyta	≤2 specie		0.3				Seasonal blooms of Ulvaceae and/or Cladophoraceae, mainly in a pleustofitic form that then collapse
	Total coverage <5%		1	0					Presence of a very low coverage [3]
			0		0.2				
	A				0.1				Absence of macrophytes
Angiosperms	*Ruppia cirrhosa, R. maritima, Nanozostera noltii*				A	<50%[4]	50-100%		They can be present starting from the "Moderate" class (score: 0.6).
	Zostera marina					<25%	25-75%	>75%	
	Cymodocea nodosa				A		<25%	≥25%	
	Posidonia oceanica				A			P	

A = Absent/s; R = Rare; P = Present, PP = Abundant

(1) Per cent species number.

(2) During bloom periods some Chlorophyta (i.e. *Chaetomorpha linum*, some Cladophoraceae and filamentous Ulvaceae, or more rarely Rhodophyta (*Gracilaria* spp., *Polysiphonia* spp., etc.) can exhibit a high coverage but they do not collapse.

(3) The Xanthophycea: *Vaucheria* spp. can exhibit a coverage up to 100%. Seasonal growth of Rhodophyta and/or Phaeophyceae which are not able to bloom.

(4) Per cent species coverage.

Figure 2. Rapid macrophyte quality index (R-MaQI) scheme (Sfriso and Facca, 2011).

CARLIT was proposed on the basis of macrophyte distribution monitoring along the coastline by Ballesteros *et al.* (2007). Later, Mangialajo *et al.* (2008) modified it (Table 1). However, this index is only suitable for rocky coastline.

Table 1. CARLIT of the main community categories modified by Mangialajo *et al*. (2008).

	Category	**Description**	**Sensitivity level**
Seagrasses	*Posidonia* reef	Barrier and fringing reefs of *Posidonia oceanica*	20
	Cymodocea nodosa	*Cymodocea nodosa* meadows	20
	Zostera noltii	*Zostera noltii* meadows	20
Populations with *Cystoseira*	Trottoir	Build-ups of *Lithophyllum byssoides*	20
	Cystoseira brachycarpa/crinita/elegans	Populations of *Cystoseira brachycarpa/crinita/elegans*	20
	Cystoseira balearica	Populations of *C. balearica*	20
	Cystoseira sheltered	Populations of *Cystoseira foeniculacea/barbata/spinosa*	20
	Cystoseira amentacea/mediterranea 5	Continuous belt of *Cystoseira amentacea/mediterranea*	20
	Cystoseira amentacea/mediterranea 4	Almost continuous belt of *Cystoseira amentacea/mediterranea*	19
	Cystoseira amentacea/mediterranea 3	Abundant patches of dense stands of *C. mediterranea/stricta*	15
	Cystoseira amentacea/mediterranea 2	Abundant patches of dense stands of *Cystoseira amentacea/mediterranea*	12
	Cystoseira compressa	Populations of *C. compressa*	12
	Cystoseira amentacea/mediterranea 1	Rare scattered plants of *Cystoseira amentacea/mediterranea*	10
Populations without *Cystoseira*	Dictyotales/Stypocaulaceae	Populations of *Padina*/*Dictyota*/ *Dictyopteris*/*Taonia*/*Halopteris* (as *Stypocaulon*)	10
	Corallina	Belt of *Corallina elongata* without *Cystoseira*	8
	Encrusting corallines	Belt of *Lithophyllum incrustans*, *Neogoniolithon brassica-florida* and other encrusting corallines	6
	Mytilus	Mussel (*Mytilus galloprovincialis*) beds without *Cystoseira*	6
	Pterocladiella/Ulva/Schizymenia	Mixed population of *Pterocladiella/Ulva/Schizymenia*	6
	Ulva /*Cladophora*	Populations of *Ulva* and *Cladophora*	3
	Cyanobacteria /*Derbesia*	Populations dominated from Cyanobacteria and *Derbesia tenuissima*	1

Conclusions

Macroalgae and angiosperms are very important biological elements to measure the ecological status of coastal waters and transitional systems as well as benthic invertebrates and phytoplankton. Green algae *Ulva* spp., *Cladophora* spp. related to high trophic waters (Fig. 3) while many red algae, brown algae and angiosperm sensitive to pollution (Fig. 4). Green algae *Ulva lactuca* and *Cladophora* spp., and red alga *Gracilaria gracilis* prefer bad or poor marine waters. Brown alga *Cystoseira*, calcareus red algae, *Cymodocea nodosa, Zostera spp.* and *Posidonia oceanica* prefer good or high marine waters.

Posidonia oceanica is distributed on the Aegean and western Mediterranean coasts of Turkey, however it is not known from the eastern Mediterranean coast of Turkey. It was also reported from Sea of Marmara. This species is under dangerous by anthropogenic pollution.

Figure 3. Green alga *Ulva lactuca* (İzmir Bay, Aegean coast of Turkey).

Figure 4. *Posidonia oceanica* and some macroalgae (Ayvalık, Aegean coast of Turkey).

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Industrial researches on *Posidonia oceanica* (L.) Delile

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Abstract

Posidonia oceanica is an endemic sea grass in the Mediterranean Sea. It is of great importance in the Mediterranean ecosystem. Besides its beneficial roles in the Mediterranean ecosystem, vast amount of compounds from *P. oceanica* that are applicable in many industrial processes have been published in the scientific literature. This chapter reviews industrially important scientific reports on *P. oceanica.* Since it has vital importance for the Mediterranean Sea, the papers reviewed here are mainly related to the detritus of *P. oceanica*: especially its dead leaves. In conclusion, the compounds and products from *P. oceanica* could be alternative natural renewable materials for different industrial fields.

Introduction

Posidonia oceanica is an endemic sea grass in the Mediterranean Sea (Figure 1). This species is widely known as Neptune Grass or Mediterranean tape weed. *Posidonia oceanica* is of great importance for the ecosystem of the Mediterranean Sea (Montefalcon, 2009) since it is a "habitat forming" species in the Mediterranean Sea. It provides nursery grounds for the juveniles of a lot of commercially important fishes and vertebrates (Red List, 2012.2). It also produces oxygen via photosynthesis and therefore, in some Mediterranean countries, it is known as "lung of the Mediterranean Sea". This seagrass also plays important roles in the prevention of coastal erosion against hurricanes and temperate storms (Pinna, 2007; Wood *et al.*, 1969). Moreover, it contributes to the cycling of trace elements in the coastal areas (Sanz-Lázaro *et al.*, 2012). The leaves of *P. oceanica* are consumed by many grazers (Pinna, 2007). Besides the ecosystem based contributions of *P. oceanica*, it is also widely accepted as one of the important bioindicator for the sea water quality (Pergent-Martini and Pergent, 2000; Bhattacharya *et al.*, 2003; Montefalcone, 2009). Inasmuch as *P. oceanica* meadows host many different biota, the community level health of these habitats can give important clues about the environmental alterations (Ruiz *et al.*, 2001; Montefalcone, 2009). Unfortunately, the meadows of *P. oceanica* in the Mediterranean Sea are under threat because of various reasons such as direct and indirect human activities that affect the quality of water (Delgado *et al.*, 1999; Ceccherelli *et al.*, 2007). The main parameters on the reduction of *P.*

oceanica meadows can be classified under two categories: biotic (epibiosis, grazing, invasive species etc) and abiotic factors (light, salinity, temperature, nutrients etc) (Bellan-Santini *et al.*, 2002). One of the factors on the reduction of *P. oceanica* meadows was reported as the effect of the killer algae *Caulerpa taxifolia* (de Villèle and Verlaque, 1995).

Figure 1. Underwater view of a *Posidonia oceanica* meadow in Dikili-Turkey.
Photo: Levent Cavas ©

Some reports related to the interactions between another invasive seaweed *Caulerpa racemosa* var. *cylindracea* and *P. oceanica* existed in the scientific literature (Deudero *et al.*, 2011) since this invasive species is more abundant around *P. oceanica* meadows (Cavas and Yurdakoc, 2005) (Figure 2). However, in a very recent study by Glasby (2013), it has been mentioned that *C. taxifolia* does not have adverse impacts on the coverage of *Posidonia australis* and *Zostera capricorni*. Based on this report, it could now be considered that the effects of invasive *Caulerpa* members on the reduction of *P. oceanica* might be speculative.

Figure 2. *Caulerpa racemosa* var.*cylindracea* in *Posidonia oceanica* meadows. Photo: Levent Cavas©.

Reduction of meadows of *P. oceanica* may result in deleterious effects such as decreasing biodiversity in the Mediterranean Sea. Therefore, the protection studies and also regular monitoring studies are of paramount importance not only for this endemic sea grass but also for the health of the Mediterranean ecosystem.

The interests on natural sustainable and renewable materials have taken interests of scientists in the recent years. Regarding *P. oceanica*, like other terrestrial plants, this sea grass defoliates seasonaly. The beaches hosting intensive *P. oceanica* meadows are partially covered by dead leaves of the *P. oceanica* (Figure 3).

According to Pergent *et al.* (1997), the total primary production of *P. oceanica* in the Mediterranean basin alone has been estimated in the range of 5×10^6 – 5×10^7 ton per year. Actually, accumulation of the dead leaves of *P. oceanica* on the beach creates a special ecosystem. For example, some bird species construct nests on these dead leaves and detritus-scavenging species can be found within these wrecks (Bellan-Santini *et al.*, 2002). Therefore, banks of these dead leaves can also be considered as important special habitats for many species. Moreover, settlement of the dead leaves on the beach especially in winter seasons protects beaches from strong winter winds/stroms. Therefore, the dead leaves on the beaches are of great importance. However, the existence of dead leaves throughout all seasons on active beaches causes esthetic and hygienic problems. Therefore, these dead leaves are generally collected and burned in touristic zones of Turkey. Since these problems are valid for all the Mediterranean countries, many investigators have proposed alternative industrial and biotechnological solutions for the evaluation of these dead leaves or dead materials originated from *P. oceanica*. This chapter reviews the scientific reports on the material development/evaluation by using *P. oceanica* originated dead materials.

Figure 3. The dead leaves of *Posidonia oceanica*. Photo: Levent Cavas©.

Materials and Methods

The scientific reports mentioned in the present chapter were found by using below search engines:

- http://www.webofknowledge.com/
- http://www.ncbi.nlm.nih.gov/pubmed
- http://www.sciencedirect.com

The term "*Posidonia oceanica*" was entered to the above mentioned search engines. The last check for the papers was done on 24 May 2013. Therefore, the results here reflected papers published before this date. The total numbers of papers existed in these search engines were 139 for PubMed and 1420 for Web of Knowledge and 2189 for Science Direct. Many of the papers found were mainly related to biology, ecology, conservation of this seagrass. We selected industrial based 54 papers where *P. oceanica* is used to review in this chapter. The papers selected were classified into below subgroups:

- Adsorption
- Engineering
- Biotechnology/Biochemistry

- Agriculture

The patents where *P. oceanica* was directly or indirectly used were also searched by using spesific search engines and they were discussed under the title of patents.

Adsorption studies by using *Posidonia oceanica*

The releases of industrial wastes from different industries into the aquatic ecosystems without treatments are one of the important environmental issues in last decades. The resistance of the industrial wastes to the natural degradations such as sun and microbial degradation causes deleterious effects on the aquatic organisms. For example, formation of dye layer on the surface of an aquatic ecosystem such as lake or river can prevent the penetration of sun light to water body of the systems which causes inhibition of phosynthesis in the photosynthetic organisms (Raghuvanshi *et al.*, 2004; Cengiz and Cavas, 2008). The dyes and pigments have important part among released wastes. For instance, over 7×10^5 tons of dyes and about 10,000 different types are used all around the world and approximately 10–15% of the total produced dyes are released into the aquatic environments without applying any treatment methods (Senthilkumaar *et al.*, 2006; Hoda *et al.*, 2006; Bukallah *et al.*, 2007; Cengiz and Cavas, 2008). Therefore, industrial aquatic wastes from different industries have to be treated before their release into the aquatic environments. These highly resistant chemicals can be reached to human food through food chains. There are many different methods to treat these wastes such as adsorption, flocculation, electro-floatation, precipitation, electro-kinetic coagulation, ion exchange, membrane filtration, electrochemical destruction, irradiation, ozonation and Katox treatment method involving use of activated carbon and air mixtures (Bekçi *et al.*, 2009). Among these treatment methods, adsorption method has some advantages compared to other treatment methods. Inasmuch as the cost of the used materials in the adsorption is generally lower and the application of the adsorption is easier compared to other methods, adsorption has superiority to other treatment methods.

In the scientific literature, there have been numerous scientific reports on adsorption by using various types of adsorbents. The authors of these publications often select low cost materials such as agricultural wastes. Different parts of *Posidonia oceanica* were also proposed by many investigators for removal of many different chemicals from industrial effluents as it was mentioned in this part of this chapter. In order to characterize the adsorption capacity of an adsorbent, conventional adsorption method is generally applied by many researchers. First of all, the low cost material is dried and then ground. The particle size of the adsorbent is measured and then adsorbents are placed into a solution where the chemical that to be removed from solution by adsorption. In initial experiments, the equilibrium time is followed and determined. After determining equilibrium time, the experimental data is evaluated by using different kinetic models (pseudo-first-order, pseudo-second-order etc) and isotherm models (Lagmuir, Freundlich, Dubinin-Radusckevich etc). Thermodynamic parameters, ΔG, ΔH and ΔS, could also be found by using van’t

Hoff equation. Scanning electron microscopy and FT-IR are other characterization methods for raw and chemical loaded adsorbent. In recent papers, a more robust model, artificial neural network, was also proposed to evaluate the adsorption based data (Cavas *et al.*, 2011; Demir *et al.*, 2012).

This part of the chapter summaries the adsorption studies where *P. oceanica* is used. A list of the papers can be found in Table 1. The *P. oceanica* is used as an adsorbent for removal of cadmium(II) (Pinzon *et al.*, 2004), phenol (Ncibi *et al.*, 2006a), anionic direct solophenyl brown AGL and ionic reactive cibacron red FNR (Ncibi *et al.*, 2006b), methylene blue (Ncibi *et al.*, 2007a; Dural *et al.*, 2011; Cavas *et al.*, 2011; Demir *et al.*, 2012; Ben Douissa *et al.*, 2013), basic blue 41 (Chadlia and M'henni, 2007), c.i. reactive red 228 (Ncibi *et al.*, 2007b), copper ions (Gabaldon *et al.*, 2007; Alvarez-Hornos *et al.*, 2008; Izqulerdo *et al.*, 2010; Izqulerdo *et al.*, 2012), nickel (Gabaldon *et al.*, 2008), anionic and non-ionic surfactant (Ncibi *et al.*, 2008a), cibacron red (Mahjoub *et al.*, 2008), azo direct dye solophenyl brown (Ncibi, 2008), alpacide grey (Ncibi *et al.*, 2008b), alpacide yellow (Ncibi *et al.*, 2009a), chromium (Ncibi *et al.*, 2009b), yellow 59 (Guezguez *et al.*, 2009), methyl violet (Cengiz and Cavas, 2010), ammonium (Wahab *et al.*, 2010, Jellali *et al.*, 2011), phosphorus (Wahab *et al.*, 2011a), lead (Dridi-Dhaouadi *et al.*, 2011; Allouche *et al.*, 2011), yellow 44 acid (Dridi-Dhaouadi *et al.*, 2011), orthophosphate (Wahab *et al.*, 2011b), 2,4 dichlorophenol (Demirak *et al.*, 2011), uranium (Aydin *et al.*, 2012), astrazon red (Ncibi *et al.*, 2009c; Cengiz *et al.*, 2012) and hexavalent chromium (Krika *et al.*, 2012).

Table 1. The researches where *P. oceanica* proposed as an adsorbent (The papers are ordered based on their publication year)

Adsorbent	Removal Material	Maximum Adsorption Capasity	Method	Equilibrium Time – Kinetic model	Reference
Dead leaves of *P. oceanica*	Cadmium (II)	57.1 mg/g (Langmuir and Freundlich model)	CAP* (batch)	20 minutes	Pinzon *et al.* (2004)
P. oceanica fibres	Phenol	2.05 mg/g (for pH 5) 3.08 mg/g (for 150 mg/L) (Redlich–Peterson model)	CAP* (batch)	48 hours, Pseudo second-order model	Ncibi *et al.* (2006a)
P. oceanica leaf sheath fibres	Anionic Direct Solophenyl Brown AGL and ionic Reactive Cibacron Red FNR	3.081 mg/g (for direct dye) and 4.252 mg/g (for reactive dye) (Freundlich model)	CAP* (batch)	24 hours	Ncibi *et al.* (2006b)
P. oceanica fibres	Methylene blue	4.91 mg/g (Langmuir, Redlich–Peterson)	CAP* (batch)	10 minutes, Pseudo second-order model	Ncibi *et al.* (2007a)
Raw and Carboxymethyl	Basic blue 41	929 mg/g for untreated and 3214	CAP* (batch)	60 minutes, Pseudo first-	Chadlia and

ated *P. oceanica*		mg/g for a treated sample (Langmuir model)		order reaction,	M'henni (2007)
P. oceanica fibres	C.I. Reactive Red 228	5.74 (Langmuir model)	CAP* (batch)	6 hours, Lagergren first-order (for raw) and pseudo second-order model (for acid pre-treated)	Ncibi *et al.* (2007b)
P. oceanica,	Copper	Efficiency 98.8% (at 20 mg/dm^3 Cu concentration)	Fixed bed study	-	Gabaldon *et al.* (2007)
P. oceanica and organic sediment	Copper	56.7 mg/g (Langmuir model)	CAP* (batch)	-	Alvarez-Hornos *et al.* (2008)
P. oceanica and peat	Nickel	5.10 mg/g (Batch equilibrium isotherm)	CAP* (batch)	Fixed-bed method	Gabaldon *et al.* (2008)
P. oceanica biomass	Anionic and non-ionic surfactant	2.77 mg/g (Langmuir isotherm model)	CAP* (batch)	3 hours	Ncibi *et al.* (2008a)
P. oceanica fibres	Cibacron Red	0.53 mg/g (Freundlich model)	CAP* (batch)	48 hours, Pseudo second-order equations	Mahjoub *et al.* (2008)
P. oceanica fibres	Azo direct dye Solophenyl Brown	3.999 mg/g (Langmuir model)	CAP* (batch)	24 hours	Ncibi (2008)
P. oceanica fibres	Alpacide grey	10.152 mg/g (Pseudo second-order model-calculated q_e)	CAP* (batch)	24-48 hours, Pseudo second-order model	Ncibi *et al.* (2008b)
P. oceanica leaf sheaths	Alpacide yellow	5.38 mg/g for 50 mg/L (Redlich–Peterson and Langmuir model)	CAP* (batch)	48 hours, Pseudo second-order model	Ncibi *et al.* (2009a)
P. oceanica fibres	Cr(VI)	2.50 mg/g (Brouers–Sotolongo model)	Brouers–Sotolongo equation by statistics software "SPSS 13.0"	3 hours, Pseudo second order model	Ncibi *et al.* (2009b)
P. oceanica	Yellow 59	Powdered activated carbon 95 mg/g (Freundlich model)	CAP* (batch)	600 minutes, Pseudo second order model	Guezguez *et al.* (2009)
P. oceanica	Copper	85.78 mg/g (Langmuir model) – 56.70 mg/g (Column)	CAP* (batch)+ A column study	---	Izqulerdo *et al.* (2010)
Dead leaves of *P. oceanica*	Methyl violet	119.05 mg/g (Langmuir model)	CAP* (batch)	Pseudo second-order	Cengiz and Cavas

				model	(2010)
P. oceanica fibres	Ammonium	2.68 mg/g (Langmuir model)	CAP* (batch)	30 minutes, Pseudo second-order model	Wahab *et al.* (2010)
P. oceanica fibres	Phosphorus	3.03 mg/g	Dynamic flow tests using a continuous stirred tank reactor	Dynamic continuous-flow adsorption system (80% efficiency)	Wahab *et al.* (2011a)
Raw *P. oceanica* and the cellulose extract from raw *P. oceanica*	Lead and Yellow 44 acid dye	7.45 mg/g (Langmuir model)	CAP* (batch)	Pseudo second-order model	Dridi-Dhaouadi *et al.* (2011)
Dead leaves of *P. oceanica*	Methylene blue	285.7 mg/g (Langmuir model)	CAP* (batch)	60 minutes, Pseudo second-order model	Dural *et al.* (2011)
P. oceanica fibres	Ammonium	1.974 mg/g (Langmuir model)	CAP* (batch)	120 minutes, Pseudo second-order-reaction model,	Jellali *et al.* (2011)
P. oceanica leaves	Pb(II)	140 mg/g (Langmuir model)	CAP* (batch)	Pseudo first-order-reaction model	Allouche *et al.* (2011)
Dead leaves of *P. oceanica*	Methylene blue	482.6 mg/g (Thomas model)	Thomas and Artificial Neural Network	Fixed-bed method	Cavas *et al.* (2011)
P. oceanica fibres	Orthophosphate	7.45 mg/g (Langmuir model)	CAP* (batch)	Pseudo second-order	Wahab *et al.* (2011b)
P. oceanica fibres	2,4 dichlorophenol	1.11 mg/g (Langmuir model)	CAP* (batch)	6 hours, Pseudo second-order-reaction model	Demirak *et al.* (2011)
Dead leaves of *P. oceanica*	Uranium	9.81 mg/g (Dubinin-Radushkevic model)	CAP* (batch)	Pseudo second-order-reaction model	Aydin *et al.* (2012)
Dead leaves of *P. oceanica*	Methylene blue	10.06 mg/g (Langmuir isotherm)	Artificial Neural Network/ Conventional adsorption protocol (batch)	30 minutes	Demir *et al.* (2012)
P. oceanica and peat	Copper (II) ions	85.78 mg/g (Langmuir model)	CAP* (batch)	-	Izqulerdo *et al.* (2012)
Dead leaves of *P. oceanica*	Astrazon Red	68.97 mg/g (Langmuir model)	CAP* (batch)	Pseudo second-order	Cengiz *et al.* (2012)

				model	
Dead leaves of *P. oceanica*	Hexavalent Chromium	22.77 mg/ g (Langmuir model)	CAP* (batch)	4 hours, pseudo-second-order	Krika *et al.* (2012)
Extracted cellulose from *P. oceanica*	Methylene 25 Blue (MB)	0.955 mmol/g (Langmuir isotherm)	CAP* (batch)	>20 min, pseudo-second-order	Ben Douissa *et al.* (2013)

* Conventional adsorption protocol

Engineering based studies on *Posidonia oceanica*

The uses of *Posidonia oceanica* residues in engineering field are limited compared to other fields. The researches on the use of *P. oceanica* residues are related to chemical modification (Chadlia and M'henni, 2010), energy (Cocozza *et al.*, 2011), development of reinforced composite materials (Khiari *et al.*, 2011), wave energy and wave-induced flow reduction modeling (Manca *et al.*, 2012) and increasing wettability of *P. oceanica* samples (Salapare *et al.*, 2013).

Chadlia and M'henni (2010) studied the chemical modification of *P. oceanica* residues by using cyclic anhydrides. They reported that chemically modified *P. oceanica* residues could show slightly higher thermal stability compared to that of raw material.

The fibrous portion of *P. oceanica* dead leaves was proposed as a source of energy by Cocozza *et al.* (2011) since the heating values of the fibrous portion of *P. oceanica* dead leaves were found very close to other biofuels. Moreover, the researchers also recommended production of compost from *P. oceanica* residues. Reducing the sodium content and electrical conductivity of the compost was also recommended by Cocozza *et al.* (2011). The compost material is proposed to be used in organic agriculture by researchers. Cocozza *et al.* (2011) underlined in their study that *P. oceanica* based residues have ecological importance therefore they should not be collected from non-touristic beaches.

Reinforcement of the industrial composites is of great importance. The materials that are used in the natural and biodegradable reinforcements are also important and promising materials in the engineering field. Khiari *et al.* (2011) proposed lignocellulosic fibres from *P. oceanica* balls as reinforcement materials for a commercial biodegradable thermoplastic matrix. They used FT-IR and XPS for the characterization of lignocellulosic fibers. The morphology of the reinforced materials was studied by using scanning electron microscopy. Based on their results, it could be said that *P. oceanica* originated lignocellulosic particles could increase thermo-mechanical properties of the thermoplastic material, therefore, this natural material could be used as a reinforcement agent.

Coastal erosion is a big problem in the coastal countries. Therefore, the studies on the preventing or analyzing of coastal erosion are important. Manca *et al.* (2012) studied wave energy and wave induced flow reduction by constructing an artificial *P. oceanica* meadow in an artificial experimental medium. They showed that shallow *P. oceanica* meadows could provide a big contribution to preventing coastal erosion by reducing wave energy. However, although the meadows could not get rid of large waves, they provide sediment stabilization.

Increasing of wettability is one of the aims in the biosorbent development for removal of undesirable materials from aqueous solutions. Salapare *et al.* (2013) studied hydrophilic properties of *P. oceanica* materials. The authors investigated the superhydrophilic properties of *P. oceanica* by argon and oxygen plasma treatments. They reported that superhydrophilic surfaces could be obtained from argon plasma treatment.

Bioactive Agents from *Posidonia oceanica*

The residues of *Posidonia oceanica* have not only been proposed for adsorption and engineering fields, but also they have been recommended for biotechnology area because of the bioactive compounds. From the published reports it could be said that the bioactive compounds such as sesquiterpenoids and phenolics could be extracted and evaluated in many industrial processes.

Antibacterial and antifungal activities from *P. oceanica* were studied by Bernard *et al.* (1989). They showed that the extracts have bio-activities on Gram (+ and-) bacteria and a special yeast (*Malassezia furfur*).

Ballesteros *et al.* (1992) investigated the screening of antibacterial, antifungal, antiviral, cytotoxic and antimitotic compounds in 71 species of marine macrophytes from the Central Mediterranean. One of the sea grass studied by Ballesteros *et al.* (1992) was *P. oceanica*. According to their report, *P. oceanica* extract showed only antifungal activity on *Candida albicans* and *Aspergillus niger*.

Orhan *et al.* (2006) studied *in vitro* antiprotozoal activity of Turkish freshwater and marine macrophyte extracts. They reported that ethanolic extract of *P. oceanica* showed antileishmanial activity with an IC_{50} value of 8 μg/mL.

Chadlia and M'henni (2006) investigated the carboxymethylation of cellulose extracted from *P. oceanica*. They reported that best organic solvent was n-butanol. According to X-ray analysis the structure of the carboxymethylated cellulose was totally amorphous.

Haznedaroglu and Zeybek (2007) studied the concentrations of phenolic compounds from the extract of *P. oceanica*. They reported the concentrations of gentisic acid, caffeic acid, chicoric acid, vanilin, coumaric acid, ferulic acid and cinnamic acid in *P. oceanica*. Based on their comments, it could be said that *P. oceanica* extract could exhibit anti-HIV and immunostimulant, antitumor, antioxidant and antibacterial properties.

Antidiabetic, antioxidant and vasoprotective effects of *P. oceanica* extract in alloxan stimulated diabetic rats were studied by Gokce *et al.* (2008). Blood glucose lowering effect of the extract was reported by the researchers. Since decreased antioxidant system parameters and vasoprotective effects were observed in the *P. oceanica* supplemented groups, they commented that antidiabetic and vasoprotective effects of the extract are not related to antioxidant system.

Antioxidant and anticholinesterase activities were investigated by Murat *et al.* (2009). Ferric reducing antioxidant power of *P. oceanica* extract and its percent inhibition against AChE were given as 0.228 and 11.6, respectively.

Molina-Quintero *et al.* (2010) reported the existence of a multicopper oxidase with two subunits, PpoA (laccase activity) and PpoB (tyrosinase associated with melanin synthesis) in marine bacterium *Marinomonas mediterranea* that is taken place in the microbiota of *P. oceanica*.

Kesraoui *et al.* (2011) studied *in vitro* antioxidant activities of free and bound phenolic compounds (FPC and BPC) from *P. oceanica* leaves. They reported high phenolic compounds in FBC and BPC as 328 mg/g and 407 mg/g, respectively. Higher antioxidant activity in BPC compared to FBC was also reported by investigators. Based on their experimental results, they recommended *P. oceanica* leaves as a natural preservative for foods and also preventive agent against lipid peroxidation observed in marine products.

Hammami *et al.* (2012) investigated the antibacterial effects of crude extracts from *P. oceanica*. They showed significant antibacterial activity of the crude extract of *P. oceanica* against *Pseudomonas aeruginosa* compared to *Escherichia coli, Staphylococcus aureus* and *S. epidermidis*. They also reported a new compound, methylated sesquiterpene, in their paper.

Phenolic compounds in *P. oceanica* were classified based on theory of information entropy by Castellano *et al.* (2012). They also associated the classified phenolic compounds with bioactivities and also antioxidant properties of compounds which have previously been reported by other investigators.

Panno *et al.* (2013) studied the mycoflora in *P. oceanica*. They showed that some of the species characterized within mycoflora of *P. oceanica* have an ability to produce tannases and they could degrade and detoxify lignocellulose residues. The biotechnological properties could be associated with enzymatic reactions medium where high salt concentrations were reported.

Agricultural Studies on *Posidonia oceanica*

The *Posidonia oceanica* residues have also been suggested for their utilization in agricultural field.

Castaldi and Melis (2002) proposed that leafy deposits of *P. oceanica* could be utilised for production of compost. They found that the compost had no pathogenic microorganism, the levels of heavy metals were in acceptable limits and the chemical parameters of the compost exhibited promising carbon, nitrogen and phosphorus contents.

In other study by Castaldi and Melis (2004), a compost that contained *P. oceanica* was prepared. It was proposed as a growing media for *Lycopersicon esculentum* Mill. According to their results, the compost significantly increased plant height, fruit weight, volume and diameter.

Serio *et al.* (2004) investigated the use of *P. oceanica* as a growth substrate for cherry tomato. The researchers observed that no statistical difference between total yields of cherry tomatoes growed in rockwool (control substrate) and *P. oceanica* was existed. On the other hand, they observed significantly increased fruit diameter size and vitamin C levels in the samples which were growed in *P. oceanica* medium compared to control medium.

Cocozza *et al.* (2011) studied the production of compost from *P. oceanica* and the heating value of *P. oceanica* residues as it was mentioned in the engineering section. They showed in their study that the heating value obtained from *P. oceanica* residues were very close to those of other biofuels. They also investigated the compost production by using these biowastes and very good compost parameters were reported but they recommended the lowering of Na contents and electrical conductivity during preparation of compost from *P. oceanica*.

Patents related to *Pocidonia oceanica*

Some patents related to usage of *Posidonia oceanica* have also up to date been submitted to different patent offices. *Posidonia oceanica* has been offered as an insulation agent (Andreucci and Ferrazzini, 2010; Meier, 2012), plant or soil substrate (Meier, 2010), input material in production of pulp for the production of paper (Benvegnu' and Pez, 2013), chicoric acid source for anti-diabetes (Andary *et al.*, 2013), source of diterpene for preparation of liposome (Coulthurst and Seabrook, 2006), anti-microbial extract for production of special polymer (Craver and Seabrook, 1999), antifouling extract for special polymer (Seabrook and Stockum, 2011) and biodegradable active ingredient for coatings (Mertsch *et al.*, 2011a; Mertsch *et al.*, 2011b).

Conclusion

Posidonia oceanica is an important seagrass for the ecosystem of the Mediterranean Sea. Besides its biological importances for marine biodiversity, it also provides paramount contributions to the coastal erosion. Its dead leaves and formed balls from fibres have been proposed for many industrial purposes in the scientific literature. Although this biological waste could be used for many industrial processes, it should be noted that this beach waste is of great importance for protection of sands on the beach against winter storms. Moreover, this dead leaves also form an ecosystem for many living organisms on the beaches. However, these dead leaves are collected from touristic zones for cleaning of the beaches at the end of the spring seasons. This chapter never proposes to collect these dead leaves from natural areas where the beaches are not actively used for all seasons. On the other hand, since these dead leaves are generally burned to get rid of them, they could be used in many industrial processes as they were mentioned in this chapter. We strongly recommend that the industrial collection of these dead leaves and formed balls from fibres must be based on official permission that must be taken from official authority of the country such as ministry of agriculture or ministry of environment. The regular monitoring of this species should also be carried out by intra- and international research institutes since this species is one of the endangered species in the Mediterranean Sea.

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National strategy of the conservation of the *Posidonia oceanica* (L.) Delile beds in Turkish waters

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Abstract

Posidonia oceanica, Mediterranean endemic seagrass, has significant positive effects on marine environment. There is an increasing effort all around the Mediterranean Basin to protect this indicator species which is also the most important habitat type in the Mediterranean. In this framework many global, regional and national organizations such as UNEP, EU, RAC-SPA, Greenpeace, WWF, Ramoge *etc*. and many universities take part in protection activities.
Turkey, as an EU candidate country and as a signatory to many international conventions on protection of threatened and endangered species and habitats (CBD, Barcelona, Bern, CITES *etc*.), take many steps on protection of *Posidonia* meadows.

Introduction

Although *Posidonia oceanica* is the dominant seagrass with a coverage of approximately 50,000 km^2 along Mediterranean, its population trend seems to be decreasing due to anthropogenic pressure (Bethoux and Copin-Motegut,1986) (Figure 1). On the other hand, *Posidonia oceanica* is in the category of Least Concern (LC) within IUCN Global Red List as a result of its wide geographical distribution and it is also emphasized by IUCN that there is an estimated coverage loss of 446 km^2 over last 100 years. Therefore, there is no doubt that it needs protection all over the Mediterranean.

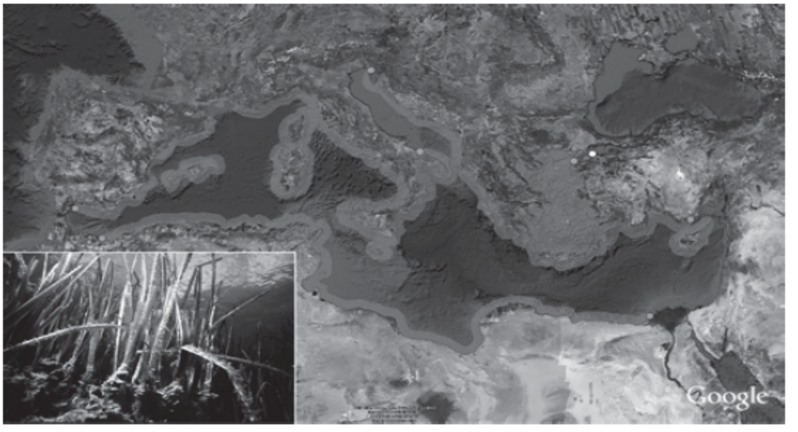

Figure 1. Distribution of *Posidonia oceanica* in the Mediterranean Sea;
the green dots correspond to the limits of the species' range; the white dot to the "relict site" in the Sea of Marmara.

Posidonia meadows are the primary indicator species with their sensitivity to water quality and turbidity. They are the "light-meters" of the Mediterranean. *Posidonia* takes such an important role within the ecosystem that there are many terms reflecting their niche within the ecosystem: "Carbon Sinks" (Pergent *et al.,* 2012) for their ability in carbon fixation and storage; "Oases of the Mediterranean" (MedPosidonia Project Theme, 2008) for their ability to shelter hundreds of species; "The Lungs of the Mediterranean" for their ability to generate 10 L. Oxygen/m^2/day. "Natural Jetty" for their ability to reduce the wave and hydrodynamic force and fight against erosion.

Steps taken to protect Posidonia oceanica *regionwide*

After national initiatives to protect *Posidonia* meadows initiated in early 80's, European Union takes the lead in 1992 with the Habitats Directive (92/43/CEE of May 21,1992) and designated *Posidonia* meadows as one of the priority habitats for EU Countries. All EU countries take serious measure within the framework of this legislation. With concordance to the Habitats Directive, Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) under the umbrella of Council of Europe keeps *Posidonia oceanica* as "Strictly Protected Flora Species (Annex-I)" and calls signatory parties to protect the species and its natural habitat strictly. Moreover, the Water Framework Directive (WFD) adopted in 2000, is a major text that structures water policy in EU states. The WFD sets procedures on improving and recovering the quality of water and the main target is setting the aquatic environment "in good ecological status" by 2015. To assess the good ecological status of water bodies, the WFD makes the implementation of monitoring programmes compulsory. In this regards, bio-indicators carry a special role to be used as a biological quality element and a Comprehensive *Posidonia* Index will be developed to be used as monitoring parameters.

In addition, “United Nations Environment Programme - Mediterranean Action Plan (UNEP-MAP)” via “Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (Barcelona Convention) and its relevant protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean (Biodiversity Protocol)” with a geographical coverage of the whole Mediterranean, adopted an action plan especially on marine vegetation in 1999: “Action Plan for conservation of marine vegetation”. Regional Activity Center for Specially Protected Areas (RAC-SPA), acting under UNEP-MAP, coordinates all relevant activities within the region in line with “SAP BIO” (Strategy and Action Plan on Biodiversity) and “Action Plan for Conservation of Marine Vegetation”.

Posidonia oceanica, is in the list of threatened and endangered species (Annex II) within Barcelona Convention and its relevant protocol on biodiversity. All threatened and endangered species are under protection with Article 11 (paragraph 3 and 5) and Article 12 of the Biodiversity Protocol by statements such as; “taking, killing, possession, transport, trade and exhibition for commercial purposes of these species and their products should be prohibited” and “all riparian countries; should adopt cooperative measures to ensure threatened and endangered species, should ensure the maximum possible protection and recovery of species listed in Annex and should prohibit the destruction of threatened species and their habitats.” Moreover, all parties are kindly invited to take serious measures to protect *Posidonia* meadows at national level.

Therefore, Convention and Protocol stands for establishing the general legal framework and suitable international platform to enhance regional cooperation between riparian countries, and RAC-SPA acts as the organization and the tool to facilitate and coordinate all scientific and administrative work within the Basin. In this sense, RAC-SPA figures out the priorities to protect marine vegetation as: inventory of species and mapping, identification of threats, establishment of monitoring networks, strengthen collaboration and exchange of experience within region and support creation of protected areas for *Posidonia* meadows.

The organization, RAC-SPA, fulfills a huge information gap between south and north, west and east Mediterranean, also takes the lead on protection of the endangered species along Mediterranean Basin. Beyond “Action Plan for Conservation of Marine Vegetation”, there are other 8 Action Plans of RAC-SPA for threatened species of the region (Monk seals, Marine turtles, Cetaceans, Annex-II bird species, Cartilaginous fish, Invasive Alien Species, Corraligenous and calcareous bio-concretions). In the year 2012, RAC-SPA validated the Action Plan on Marine Vegetation and designated a working programme for 2012 - 2017.

Inventory and monitoring activities seem to be the prior action emphasized in the action plan. Monitoring is an important task to see the past and valid situation of *Posidonia* beds and observe overall change by years. Being one of the best indicators to observe the change in physical and chemical conditions (Ph, temperature, salinity, turbidity *etc.*) of the marine environment, monitoring of *Posidonia* meadows is also used to observe the effects of climate change to the marine environment. There are two major monitoring systems: the seagrass monitoring network (SeagrassNet), set up at early 2000's, covering all species of seagrass around the world and the Posidonia Monitoring Network (RSP in French), launched in the Mediterranean in early 80's (Boudouresque *et al.*, 2006), which is especially for *Posidonia oceanic*a. In general, RSP is the major tool and network for the Mediterranean and RAC-SPA also uses RSP network and its protocols indeed.

MedPosidonia Project: Best Practice for Regional Cooperation & National Contribution

In the framework of the Action Plan on Marine Vegetation, a sub-regional project for the inventorying, mapping and monitoring of *Posidonia* meadows in Algeria, Libya, Tunisia and Turkey (MedPosidonia Project) has been implemented over a three-year period (2006-2008).

The Project aims at collecting information on the presence and evolution of *Posidonia* meadows in selected sites and training national teams to make them able to pursue these tasks in the future.

Two project sites were selected in Turkey: the nothern limit (Mersin) and the southern limit (Gökçeada). Two national teams were formed with attending experts from relevant universities. *Posidonia* mapping exercise was held for two sites to observe the change within the limits of *Posidonia* beds in time. The monitoring of the mapped area is also important to observe the effects of global warming to *Posidonia* beds.

Steps taken to protect Posidonia oceanica nationwide

With an extensive (app. 4477 km. excluding islets (Aegean & Turkish Mediterranean)) Mediterranean coastline, Turkey presents exceptional conditions for the development of large seagrass beds. During the MedPosidonia Project studies held at the Gökçeada Island and the Mersin area, in collaboration with RAC SPA, Turkish Ministry of Forestry and Water Affairs, Istanbul University Fisheries Faculty and the Middle East Technical University Institute of Marine Sciences respectively, also confirm the importance of these formations.

Being a signatory country to many international conventions on protection of threatened species (Bern Convention, Barcelona Convention and Convention on Biological Diversity), Turkey also take necessary measures to protect *Posidonia oceanica* with national legislation:

Turkey has regulation on impact studies under Environment Law No. 2872 dated 9.8.1983 and with by-law on Environment Impact Assessment (EIA) (17.07.2008 dated and #26939 official gazette). The text sets out a list of projects, which may give rise to an impact study and the elements, which must appear in it, and describes the procedures and the authorities responsible for the decision. Projects, which require an impact study, are the building of thermal power and nuclear power stations, refineries, ports (for handling boats of over 1,350 tons), pipelines, storing facilities, industrial or naval repair units. For smaller developments, such as building reservoirs used as ballast tanks, fishing ports, marinas or breakwaters, only a (smaller) preliminary study is needed. If this preliminary note concludes that there is sizeable damage, the full procedure of an impact study must be gone through. The full procedure is also necessary in all ‘sensitive’ areas (*e.g.* national parks, protected areas, marine resource production sectors *etc*.).

Although seagrass meadows are not specifically concerned by EIA Turkish regulation, they are protected in the national legal framework by the “Circular on Water Products (18.08.2012 dated and #28388 official gazette)". *Posidonia oceanica* is protected with the Circular by Article 10, stating that all listed species (including *Posidonia oceanica*) are totally protected and hunting of relevant species are strictly forbidden.

“GEF-IV: Strengthening the System of Marine and Coastal Protected Areas of Turkey Project”

The Project, aims to facilitate the expansion of the national system of marine and coastal protected areas and to improve its management effectiveness. It was officially commenced in May 2009 and will end in April 2014. The Project will have achieved the following three outcomes: responsible institutions have the capacities and internal structure needed for prioritizing the establishment of new Marine and Coastal Protected Areas (MCPAs) and for more effectively managing existing MCPAs, financial planning and management systems for cost effective management of MCPAs by replicating the activities from six pilot project sites: Islets of Ayvalık, Foça, Gökova, Fethiye-Göcek, Köyceğiz-Dalyan and Datça-Bozburun.

As an example, economical value of the ecosystem services provided from *Posidonia* meadows in one of the project sites: Foça SPA (6.7 km^2) was calculated to be 8.442.230 TL/year from erosion prevention and 654 TL/year from uptaking CO_2 emissions. By replicating this kind of information, significance of *Posidonia* meadows shall be emphasized effectively.

Conclusion

There are many organizations working on protection of *Posidonia oceanica*. But, RAC-SPA under Barcelona Convention and UNEP-MAP, seems to be the most effective working organization across Mediterranean. Although organizing scientific expertise, collecting and compiling information and administrative coordination is done by RAC-SPA, there is always a need of effective cooperation and collaboration from all riparian countries.

Turkey, as a signatory party to many international conventions, protects *Posidonia oceanica* by national legislation: “Circular on Water Products”. Turkish national legal framework is and should be supported by valid scientific data by regional and national projects such as MedPosidonia and GEF-IV: Strengthening the System of Marine and Coastal Protected Areas of Turkey Project”.

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