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Erhan Mutlu
Akdeniz University, emutlu@akdeniz.edu.tr, Antalya-Türkiye
Barış Akçalı
Dokuz Eylül University, baris.akcali@deu.edu.tr, İzmir-Türkiye

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ORCID ID	0000-0002-6825-3587	0000-0002-7341-0196
Corresponding Author	Erhan Mutlu	

SEASONAL MACRO-FLORAL DISTRIBUTION ON SOFT BOTTOMS IN A GULF OF A METROPOLITAN PROVIDENCE, İZMIR, AEGEAN SEA

ABSTRACT

Macro seaweeds were collected seasonally with a beam trawl from seven fixed stations in infralittoral of Gulf of Izmir to study spatiotemporal distribution of macrobenthic flora and their ecology during 2009-2010 years. A total of 6 floral species were found during the study. They were composed of an endemic marine phanerogam, *Posidonia oceanica*, and 5 seaweeds. The marine plants were distributed almost separately in different sectors of the gulf. Maximum average biomass was estimated for *Codium bursa*, followed by *Ulva lactuca*, *Codium vermilara* and dead leaves of *Posidonia oceanica*. *Codium vermilara* was found only in the inner gulf (sector), three algal seaweeds were found in the middle gulf, and *Codium bursa* and *Posidonia oceanica* in the outer gulf. A significant factor was the sector because each sector had different segmentation of the bottom depths. There was no seasonal difference even though each species contributed to the total biomass in different season. Flora assemblages were oriented with sectors of the gulf, which explained with two components. The first component was as follows: near-bottom water density followed by sea surface density was then correlated with the macrophyte biomass. Temperature of sea surface and near-bottom waters was negatively correlated with flora assemblages formed. The second component was followed by that pH of sea surface and near-bottom waters negatively correlated with the macro-seaweed communities which was positively and slightly correlated with seafloor depth and dissolved oxygen of near-bottom waters.

Keywords: Macrobenthic Flora, Spatiotemporal Distribution, Ecology, Aegean Sea, İzmir Gulf

1. INTRODUCTION

Seagrasses and seaweeds are a good indicator of healthy marine environments [1]. Seagrass shoot density determines the ecological status of the Mediterranean marine environment [2 and 3]. Beds of *Posidonia oceanica* (Linnaeus) Delile, 1813 comprise the climax community in a spatial expansion process of the organisms' establishment [4]. Seaweeds also act as oxygen producers, habitat and refuge, food sources, competition with invasive macrophytes, protectors of prey, a niche for many marine organisms, and sediment trapper [1, 5, 6, 7 and 8]. In addition, the presence of seagrass and seaweeds greatly enhances invertebrate and fish production and alters food webs at low-nutrient sites compared to unvegetated areas [9]. Hence, the knowledge of the status of seagrasses is a vital component

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of the strategy development process for marine ecologists, biologists, species managers, and protectors [3, 10 and 11].

Nevertheless, depending on the species blooms of seaweeds have a lot of negative effects beside some of them are good indicator for the ecosystem healthy as the same effects occur in the other marine vertebrate and invertebrate taxa. Macroalgae that washed on shores decay and generates bad odour, high biomass can eradicate the biodiversity, decay of the macroalgae can create anoxic conditions [12, 13, 14, 16, 17 and 18].

One of the important consequences of eutrophication is the blooming of marine plants [19, 20, 21, 22 and 23]. Macroalgal blooms have negative effects on ecosystem; generating anoxic conditions, accumulate at beaches and produces bad odour etc. Therefore, this phenomenon threatens the human activities, commercial fishing and ecosystem biodiversity [17, 15, 12, 24, 14, 21, 25, 16, 13, 18 and 26]. Similar effects were observed for the megabenthic fauna for a bad or moderate ecosystem, such as inner gulf of Izmir [27].

Opportunistic macroalgae species are discriminated by the high amounts of nutrient uptake [28, 29, 30, 31, 32 and 33]. The species that creates blooming, according to Scanlan et al. [28], are mostly *Enteromorpha*, *Ulva*, *Chaetomorpha* or *Cladophora*. However, some other green, brown and red macroalgae species can also overgrow to an irritating amount. Opportunistic macroalgae such as *Ulva* and *Enteromorpha* cannot live where dense-water movements occur and the depths where turbidity limits the light intensity [34]. In many regions, macroalgal blooms peak in the spring and late summer. Especially the peak is seen at the end of summer. For this reason, it is recommended that sampling be done during this period in monitoring programs [28].

Depending on the increase in the population in the coastal areas, there is an increase in the amount of nutrient salt as a result of marine discharges and intensive use of the coast [35, 36 and 37]. This situation causes eutrophication especially in coastal areas and closed bays.

Spatio-temporal distribution of density and plant traits provide with knowledge to sustain the organisms, such as a species rapidly responding to the environmental parameters in change a year [38, 39, 40, 41, 42 and 43]. Therefore, population dynamics of the vital species are required to determine in different regions of the marine ecosystem.

However, few studies were attended to the Turkish coast of the Aegean Sea on the macroflora and a lesser extends to the species-environment relation on İzmir Gulf [44, 45 and 46]. The present study is scoped to outline the spatial (depth and habitats, and sectors of the Gulf; inner, middle, and outer gulf) and temporal (season) distribution and ecology (hydrographics, physicochemical and sedimentary characteristics) of the macrobenthic flora in the infralittoral of the Izmir Gulf. Regarding to the ecological importance of the flora and the historical lack of comprehensive information on their distribution and ecology in İzmir Gulf, the aim of this study is to provide baseline information on bathymetric and seasonal distribution and biodiversity patterns (i.e. density, wet weight and richness) of the seaweed assemblages in soft bottoms of the lower continental shelf, between 10m and 50m in the sectors having different trophic levels of the waters and sedimentary contents of a semi-closed gulf, Izmir Gulf under anthropogenic influences.

2. RESEARCH SIGNIFICANCE

The present study contains a broad-scale baseline and preliminary results on the spatiotemporal floral quantitative and qualitative distribution in Izmir Gulf, during a period of which the sampling dates were organically loaded and disturbed in the gulf. The future works could be referred to the present research.

Highlights:

- The floral distribution was categorized depending on the sub-regions of the Gulf.
- This distribution correlated with the pollution levels rather than bottom depths.
- The Gulf was very poor in the floral diversity on soft bottoms.

3. STUDY AREA

The study area was well described with environmental measures in time and space by Mutlu [27]. The study area included the infralittoral zone of the Gulf of İzmir, Aegean Sea (Figure 1). The minimum sampling depth was 10m and the maximum depth was 50m. The bottom of the station L6 was vegetated by *Posidonia oceanica* and LG with rather larger sized-empty shells referring to the actual size of the shell species. The rest of the stations had ordinary soft sediment bottoms as usual. Near-bottom and sea surface water salinity was around 39 PSU all the year with an exception of lower salinity than 33 PSU at station L6 in February whereas sea surface salinity was around 19 PSU. Sea surface salinity was lower in February than in the other sampling months. Water temperature varied seasonally between 15^{o}C in February-April and 27^{o}C in July. The near-bottom water temperature never exceeded 23^{o}C throughout the year. Sea surface temperature increased from 14-15^{o}C in February through 18^{o}C in April to 27^{o}C in July and then decreased to 18^{o}C in November. The temperature had same values in sea surface and near-bottom waters in November. Inherently, water density varied depending on water temperature and salinity. Dissolved oxygen concentration in sea surface and near-bottom water varied between hypoxic determined with a threshold by Vaquer-Sunyer and Duarte [47] in July through around hypoxic in November, particularly in the inner gulf, and oxic conditions in February-April.

Physical parameters were coordinated in the PCA ordination according to the seasons on PCA1 axis (Figure 1). Seasonal parameters were water temperature and oxygen content. The first PCA axis was explained with a percent variance of 51.3 (Figure 1). On PCA2 axis, the bottom depth was effective first, followed by pH of the water. The parameters explained the PCA2 axis with a variance of 16.9% (Figure 1). In other words, bottom depth was classified within each season along PCA2 axis. It was hereby noticed that the dissolved oxygen was very low in July, followed by November compared to April and February (Figure 1).

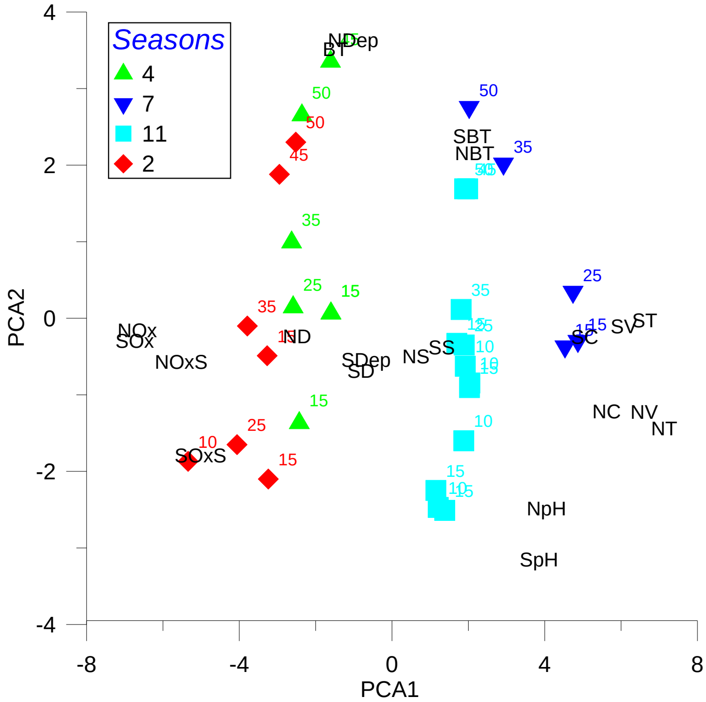


Figure 1. Seasonal (2:February, 4:April, 7:July, and 11:November) PCA ordination of the physical parameters normalized for the study area (sea surface, Sx and near-bottom, Nx waters for T:Temperature, S:salinity, D:density and Ox:oxygen and pH:pH) Labels above symbols were bottom depths

During the sampling date, the gulf was strictly influenced by the anthropogenic sources of the metropolitan Izmir. Therefore, Yelekçi et al., modeled 3D-hydrodynamic also including the chemical parameters from the data measured during the present study and the results agreed with the measurements [48]. In her thesis, surface chl-*a* varied between 0.3mg/m^3 in outer gulf and 3mg/m^3 in inner gulf (extreme amount of 23.7mg/m^3) in April 2009, overall between 0 and 0.3mg/m^3, but was rather high (7mg/m^3) in inner and middle gulf in July, and November when average chl-*a* measured 4mg/m^3 in inner and middle gulf with maxima (10mg/m^3), and between 0 and 2mg/m^3 in outer gulf, 6mg/m^3 in inner gulf in February 2010 when the study was influenced by freshwater inputs at station L6 (Figure 2). Nutrients; surface dissolved inorganic nitrogen varied between 0.5 and 0.7 µM, uniformly around 0.5 µM in July and November (extreme 10 µM.), and between 0 and 0.5 µM (8 µM) in February 2010. Surface PO_4 varied between 0 and 0.1 µM in outer gulf all the year, and increased to 2 µM in inner and middle gulfs in April 2009, to maxima (3 µM) in inner gulf in July and November, and in inner and middle gulf in February 2010 [48].

Çinar et al., summarized sedimentary characteristics of the study area as follows: total organic carbon (TOC) content of the sediment varied between 30-45mg/g (3-4.5% denoting organically heavy polluted area at a critical value of 3%, in the inner gulf. The TOC then decreased sharply through middle gulf to outer gulf (TOC<2.5%), which was still higher than that in undisturbed sediments (<1%) [49, 50 and 51]. Sand content was low in the inner and middle gulfs compared to that in the outer gulf whereas there was a moderate content of clay in the inner and middle gulfs where the highest clay content occurred in the outer deep waters [49].

4. MATERIAL AND METHODS

Seaweed specimens were collected seasonally with a beam trawl and dredge from seven standard stations in infralittoral of Gulf of Izmir (Figure 2). Seasonal samplings were conducted in April 2009, July, November and February 2010. Standard seasonal stations had a seafloor depth; L1 having 10-15m, L2 25m, L3 35m, L4 45m L5 50m, L6 15m and L7 15m isobaths. There were further non-seasonal stations; Gülbahçe cove (LG) at 20m, Narlıdere (LN) at 10m, Bostanlı (LB) at 10m and Urla Bay (LZ) at 15m isobaths (Figure 2).

The beam trawl was used for sampling all stations whereas the dredge only at station L6 seasonally to compare the difference in gear efficiency at catching vegetative composition and quantification. Both gears were deployed particularly at L6 that *Posidonia oceanica* overspread, at LG. Both gears which had a 1.20m-opening width, and were donated with a net having 6 mm mesh size and 4m long were towed on the ground for 15 minutes at a vessel (R/V "*Koca Piri Reis*") speed of 1.5-2.5 knots. During the towing, GPS outputs were recorded at the period of every 2 minutes. At the end of towing completed with the recovery of the gear on deck, the CTD (Seabird of GO inc) with rosette water sampler was casted from surface to the near-bottom depth to measure basic physical parameters of the water column. After towing was completed, materials in net content were sorted out to flora and fauna. Onboard, floral specimens were identified at species level. For *Posidonia oceanica*, dead (brown) and live (green) leaves were sorted out. Wet weight measured by an electronic balance having a precision of 0.01 kg after blotting the specimens on drying paper for 5 minutes were recorded.

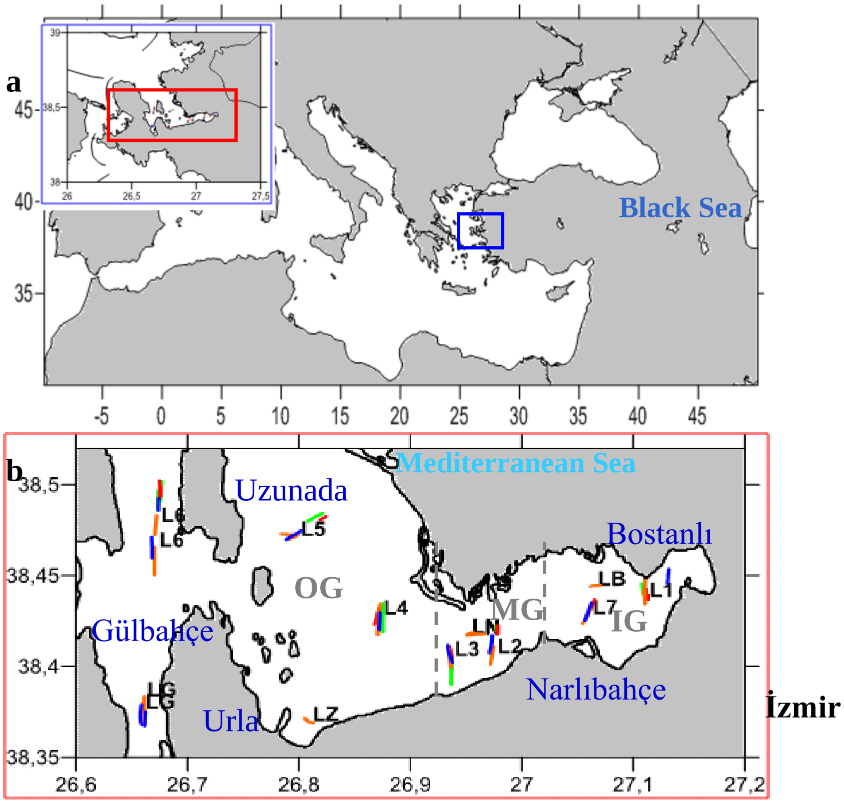


Figure 2. Study area (a:in blue and red frames) and seasonal sampling stations (b:green, April 2009, red:July, Orange:November, and blue:February 2010) in the inner gulf (IG), middle gulf (MG) and outer gulf (OG) of İzmir Gulf

Data standardization for the quantification of vegetative specimens was then performed by converting weight to biomass (kg/ha) over the swept area of the gears with the dragging distance calculated from the GPS records.

Physical environmental parameters of water columns were formed in a matrix of the sea surface and near-bottom water temperature (°C), salinity (PSU), density (σ_t), dissolved oxygen (ml/l) and pH for determining the ecology of the epifloral assemblages.

The Gulf was divided into three sections; inner gulf, middle gulf and outer gulf. The study area was restricted up to the middle parts of the outer gulf. The seasonal sampling stations were located only in the inner (stations L1, L7), middle gulf (L2-L3), and outer gulf (L4-L6) (Figure 2).

Statistical treatment and interpretation of the floral and environmental parameters were performed using the following multivariate analyses. Environmental parameters were subjected to Principal Component Analysis (PCA) to figure out the spatiotemporal characterization of the study area. The biomasses were then $\log_{10}$-transformed to generate triangle matrix of Bray-Curtis similarity for the application of the cluster analysis for figuring out the distribution of the stations and interaction of the species using the PRIMER (PRIMER, vers.6+). The triangle similarity matrix was subjected to one-way PerMANOVA and Monte Carlo to test the differences among the months, bottom depths and the sectors of the gulf (Figure 2) [52]. Two-way PerMANOVA (factors; season and bottom depth) only was applied to the matrix to see the interaction of the factors since each sector had no sampling bottom depth. Furthermore, the difference in gear efficiency to catch flora was tested using PerMANOVA. Canonical Correspondence Analyses (CCA) were applied to a matrix set of biomasses of the floral species with a corresponding matrix of the environmental parameters to cluster the stations and to see the relationship of species, and species-ecological parameters and the variation of the CCA axes was tested by Monte Carlo test using the CANOCA (vers. 4.5) [53]).

5. RESULTS AND DISCUSSION

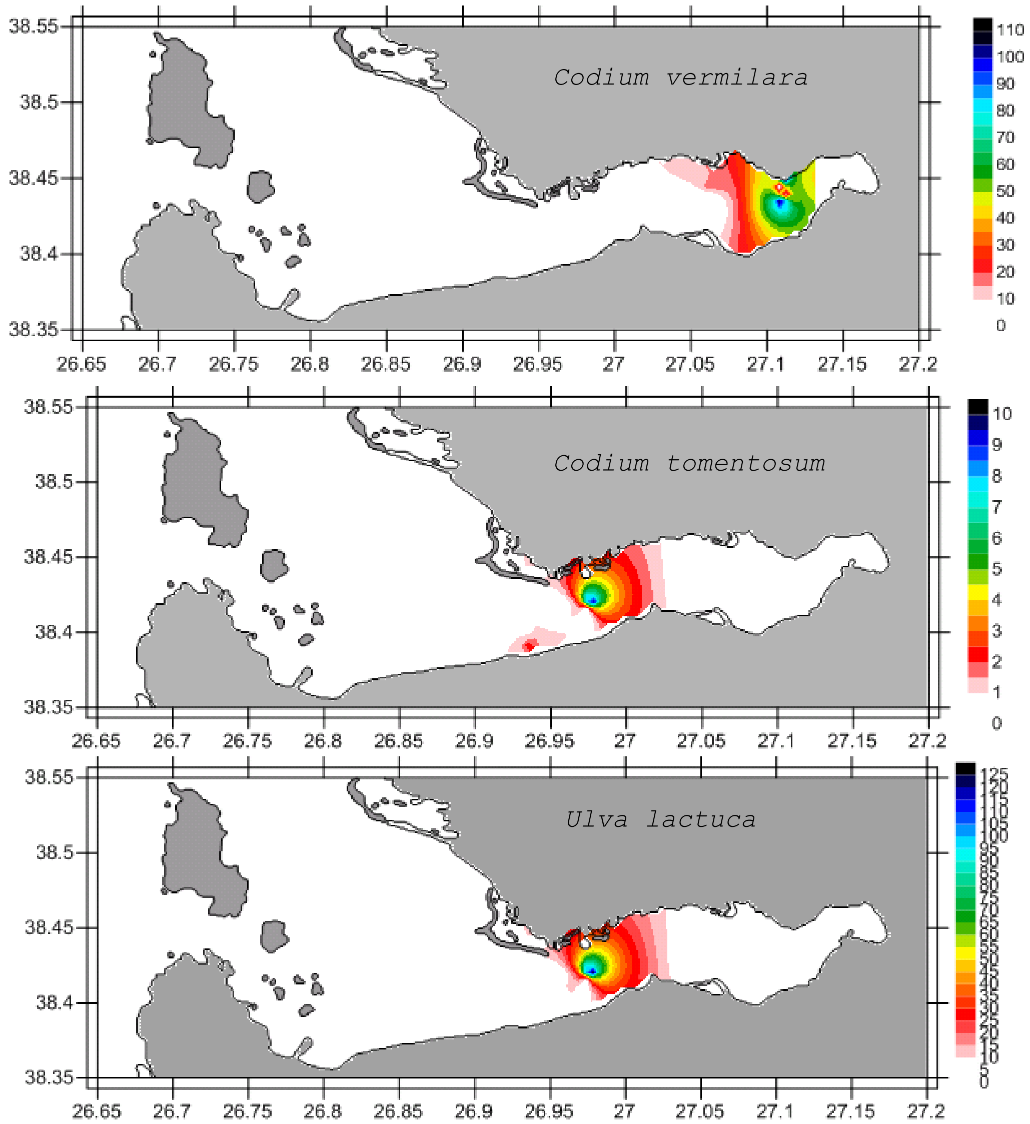
There was no significant difference in catch of seaweeds between the sampling gears of beam-trawl and dredge at $p<0.05$ (Table 1). However, it is apparently seen during the sampling that *Codium bursa* was captured only by the dredge (42 ind/haul in April, 22 ind/haul in July, 6 ind/haul in November, and 135 ind/haul in February). *Codium bursa* is hard sessile stuck tightly to the bottoms, and the beam-trawl was not effective to catch them since the dreg scraped the bottoms.

Table 1. Summary of PerMANOVA analysis to test the difference in efficiency to catch macro seaweeds between sampling gears of beam-trawl and dredge. The number of the permutated iteration is 35, and p denotes the significance value of the PerMANOVA and p(MC) the values of Monte Carlo test. The bold p-value showed that there is a significant difference at $p<0.05$

Source	df	SS	MS	F	p	p(MC)
Gear	1	185.63	185.63	0.4239	0.679	0.686
Residual	6	2627.1	437.85			
Total	7	2812.7				

Codium spp is a perennial green macroalgae which grows on holdfasts on rocks. The thallus disappears in autumn and winter only the basal disc remains [54]. Proliferation of the *Codium* spp. occurs in late summer and early autumn [55]. Melo et al., finds that *Codium* biomass gets higher in July and August 2017 and decreased in January and April 2018 [56].

However, there were no floral materials at L4, L5, LG, and LZ (Figure 2). A total of 6 floral species were found during the study. They were composed of an endemic marine phanerogam, *Posidonia oceanica*, and 5 seaweeds (Macroalgae) (Table 3 and Figure 3). The marine plants were distributed almost separately in different sectors (the stations) of the gulf (Figure 3). Maximum average biomass was estimated for *Codium bursa*, followed by *Ulva lactuca*, *Codium vermilara* and dead leaves of *Posidonia oceanica* (Figure 3). *Codium vermilara* was found only in IG, three algal seaweeds were found in MG, and *Codium bursa* and *Posidonia oceanica* in OG (only at L6).



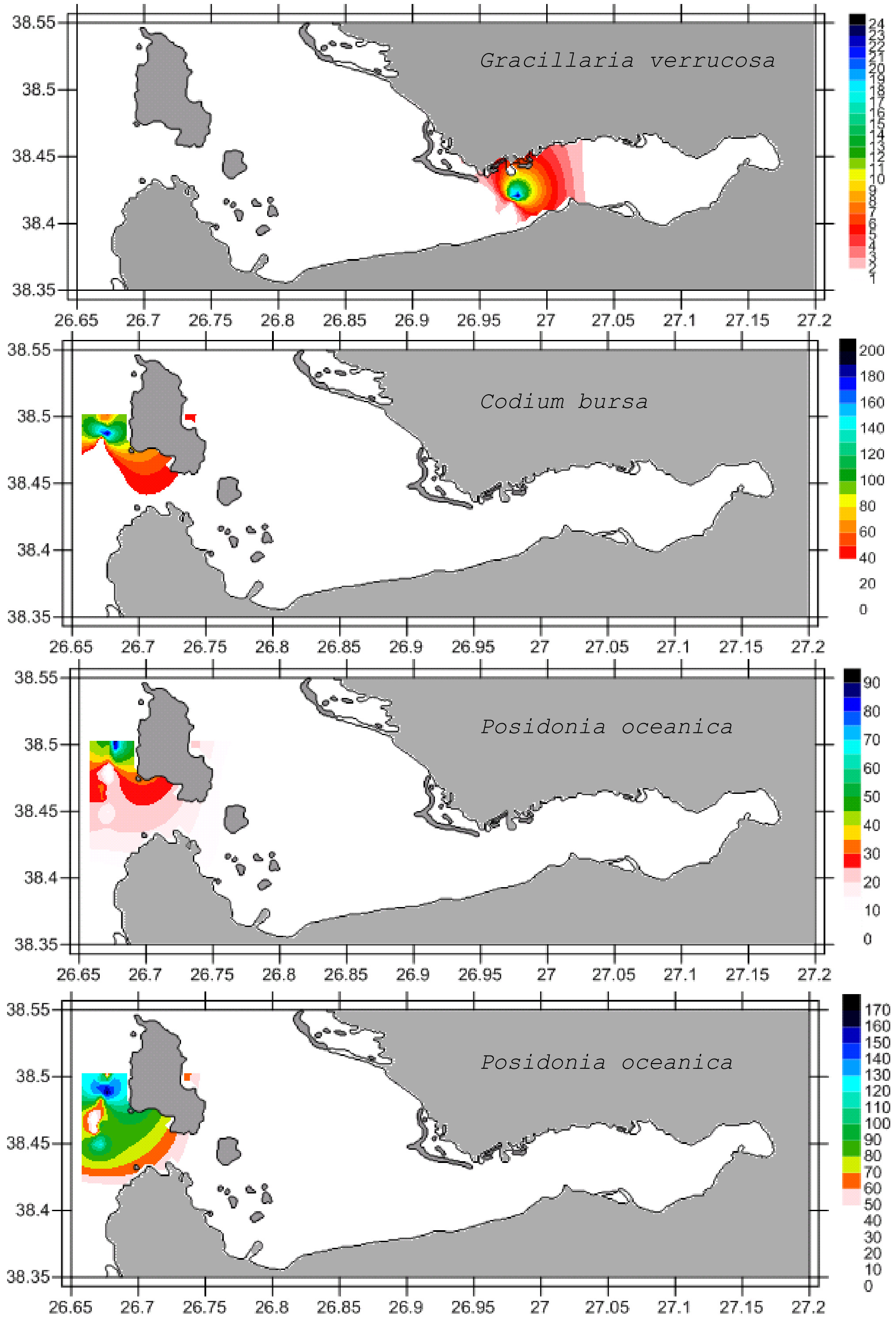


Figure 3. Distribution of biomass (kg/ha on color scale bar) averaged on seasons of the seaweeds in the Izmir Gulf

Extensive *Ulva* blooms are seen in various publications [44] and national press in the Gulf [57, 58, 59, 60 and 61]. However, in this study, biomass values of *Ulva* and *Gracillaria* species, which are opportunistic species, were limited, as the sampling method and sampling depth were deeper than 10 meters.

Codium vermilara, *C. tomentosum* and *Ulva lactuca* species belonging to the class Ulvophyceae show intense distribution especially in the inner gulf region [44]. It is thought that this situation is due to the nutrient density in the bay. It was determined that *P. oceanica* species started to show distribution from the seagrasses towards the outer gulf. Since the nutrient values in this region are less than in the inner gulf, it allows species such as *P. oceanica* to live. In addition, *Codium bursa* species was detected in certain amounts at the ends of seagrass meadows and in the meadow.

Seasonal biomasses of the marine plants were given in Table 2. The highest biomass was estimated in February, followed by July for *Codium bursa*, and *Codium vermilara* which had the highest biomass in November was devoid in April-July. *Codium tomentosum* was however found only in April during the present study, similar almost for *Gracillaria verrucosa* (Table 2). Biomass of dead leaves of *Posidonia oceanica* was at maxima in July, followed by February while the biomass of live leaves was at maxima in July, followed by April (Table 2). *Ulva lactuca* peaked in biomass in April while there was very low biomass in other seasons.

Table 2. Seasonal average biomasses (kg/ha: X±SD) of the seaweeds and their abbreviations (Abb.) used in the statistical analyses. Bold p value showed that there is significant difference at $p<0.05$

Species/Months	Abb.	February	April	July	November
Codium bursa	*C bur*	39.7±21.9	8.1±26.1	20.8±26.1	0.36±18.5
Codium vermilara	*C ver*	5.6±7.9	0±0	0±0	11.7±6.6
Codium tomentosum	*C tom*	0.0±0.0	2.3±0.7	0±0	0±0
Gracillaria verrucosa	*G ver*	0.1±1.6	4.5±1.9	0±0	0±0
Posidonia oceanica (dead)	*P oceD*	26.7±32.3	9.6±38.6	92.3±38.6	13.5±27.3
Posidonia oceanica (live)	*P oceL*	9.7±7.9	14.1±9.5	16.1±9.6	0.9±6.7
Ulva lactuca	*U lac*	0.3±8.4	23.9±10.1	0.03±10.0	0.05±7.1

According to the results of the study, the detected species seem mostly close to the middle gulf. However, at a depth of 0-5 meters in the inner gulf coasts, opportunistic species such as *Ulva, Enteromorpha, Codium, Gracillara* etc. can be found at higher rates. Nevertheless, the species and biomass in these areas could not be determined since the sampling can be done deeper than 10 meters. Macroalgae distribution is higher in these shallow regions as a result of the decrease in light transmittance due to the nutrient density in the bay. Especially in the northern part of the bay, where there are wide shallows, opportunistic macroalgae species cause blooms in certain seasons (such as spring and late summer), causing undesirable results. Similar case was observed for the megabenthic fauna for a bad or moderate ecosystem of the inner and middle sectors of Izmir Gulf [27].

Based on the biomass, species composition was significantly different among the bottom depths, and sectors of the gulf at $p<0.05$ (Table 3). However, there was no significant seasonal difference in the composition (one-way PerMANOVA, Table 3). Two-way PerMANOVA (seasons and bottom depth) affirmed that there was no significant seasonal difference, but a significant depthwise difference was there (Table 3). Indeed, a significant factor was the sector even though the bottom depth was trended along with the sectors since species composition was different at the same depth of the different sectors (Figure 2 and Figure 3). This was due to differences in measures of the physicochemical parameters of the waters among the sectors (Figure 1).

Table 3. Summary of one-way PerMANOVA analysis to test the difference in biomass of the macro seaweeds among seasons (a), seafloor depths (b), the gulf sectors (c), and two-way PerMANOVA (seasons and seafloor depths). Number of the permutated iteration is 999, and p denotes significance value of the PerMANOVA and p(MC) the values of Monte Carlo test

a, Source	df	SS	MS	F	p	p(MC)
Season	3	13598	4532.8	0.96843	0.492	0.516
Residual	34	$1.5*10^5$	4680.6			
Total	37	$1.7*10^5$				
b						
Depth	5	29384	5876.9	1.3119	0.028	0.066
Residual	32	$1.4*10^5$	4479.8			
Total	37	$1.7*10^5$				
c						
Sectors	2	19304	9651.8	2.2017	0.002	0.002
Residual	35	$1.5*10^5$	4383.8			
Total	37	$1.7*10^5$				
d						
Season	3	14386	4795.3	1.0861	0.258	0.337
Depth	5	30172	6034.4	1.3667	0.021	0.055
Season x Depth	12	53908	4492.4	1.0175	0.407	0.454
Residual	17	75058	4415.2			
Total	37	$1.7*10^5$				

The cluster analysis verified the species composition arranged by the sectors (Figure 4). The IG contributed by *Codium vermilara* discriminated the MG mostly by *Ulva lactuca* from the OG by *Codium bursa* and *Posidonia oceanica* (Figure 4).

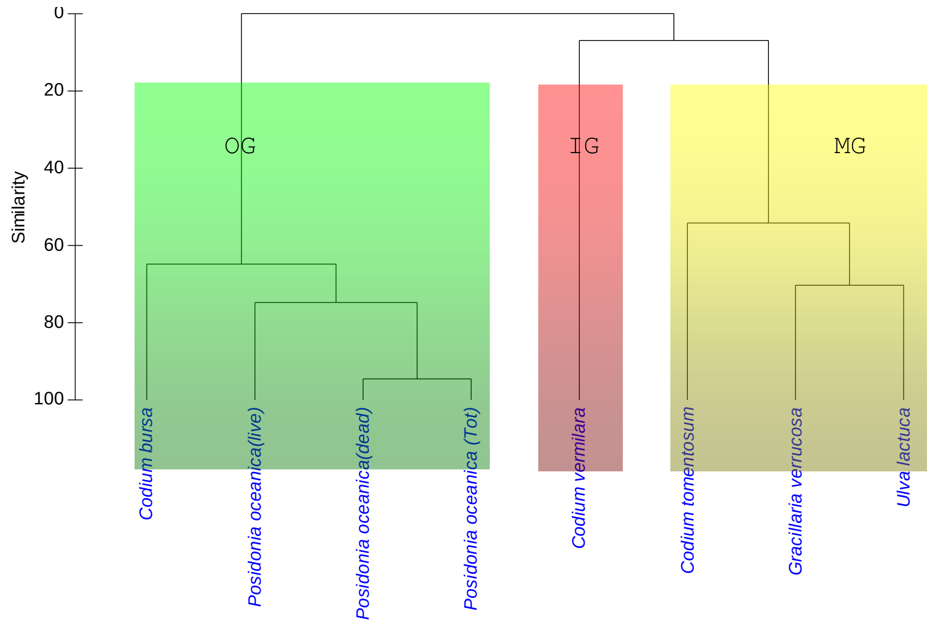


Figure 4. Cluster analysis based on $\log_{10}$-tranformed biomass subjected to the Bray-Curtis similarity index for a dendogram showing interaction between species of the seaweeds

Eutrophication in Izmir Bay, especially the inner part, spreading through the outer part. Phosphate is the main cause for eutrophication in the inner part of the bay. Nutrient levels of middle and inner bay was relatively higher. The phosphate was relatively high in Bostanlı (Izmir Bay) (26.97 μgL^{-1}) in the Aegean Sea, and where were also the opportunistic green algae *Ulva* and *Cladophora* as dominant species [46]. According to Taşkın et al., the Ecological Status Class (ESC) of Bostanlı (Aegean Sea, İzmir Bay) was "bad" and the highest coverage of Ecological Status Group II (opportunistic taxa) was also in this station (51.2%) [46]. *Ulva* spp blooms seen at various eutrophic places; Venice lagoon, North-western Mediterranean, Quequen Argentina, Brittany coast [62, 63 and 65]. Similar ecosystem status occurred based on the megabenthic fauna in the inner gulf of Izmir [27]. However, the macrophyte communities or assemblages oriented primarily with the sectors corresponding to the seafloor depths on the CCA plot (Table 4 and Figure 5). A significance level of 80.7% and 96.7% reached to a statistical significance level of 95% by CCA3, which suggested that the components was be simply explained for the factors assembling the macrophytes for species data, and species-environment relation based on biomass, respectively. On CCA1 axis, near-bottom water density followed by sea surface density was then correlated with the macrophyte biomass. Temperature of sea surface and near-bottom waters was negatively and correlated with floral assemblages formed on the CCA1 axis (Table 4 and Figure 5). This discrimination was explained with a percent variance of 42.9% and 51.4% for species data, and species-environment relation based on biomass, respectively on CCA1 axis, and was significantly approved by Monte Carlo test (F=6.006, p=0.002) at p<0.05. On CCA2 axis, pH of sea surface and near-bottom waters negatively correlated with the macro-seaweed communities which was positively and slightly correlated with seafloor depth and dissolved oxygen of near-bottom waters (Table 4 and Figure 5). All discriminations were significantly explained by a cumulative variance 76.2% and 91.3% for species data, and species-environment relation based on biomass, respectively on CCA2, and was proofed by Monte Carlo test (F=3.658, p=0.004) (Table 4 and Figure 5).

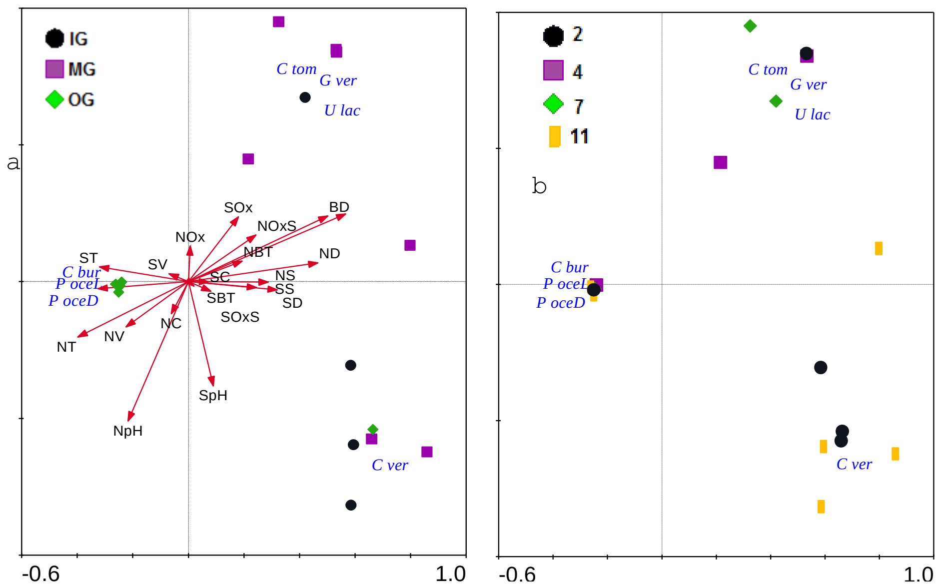


Figure 5. Triplot of CCA of the sampling stations classified by the gulf sectors (sectors:IG, inner gulf:MG, middle gulf, and OG:outer gulf) (a) and seasons (2:February, 4:April, 7:July, and 11:November) (b), -environmental parameters (Prefixes for the abbreviations: S, sea surface, and N:Near-bottom water, T: Temperature °C, S: salinity PSU, D: density, σ_t and Ox: oxygen mg/l, OxS: saturated oxygen, pH: pH, V: velocity of sound cm/s, and BD; bottom depth m), and - seaweed species relation based on $\log_{10}$(X+1)-transformed biomass of the floral specimens (see Table 2 for abbreviations of the macro seaweeds)

Izmir bay has a high level of pollution and the nutrient concentration is increasing through the inner part to outer [66, 67, 68, 69, 70 and 71].

Macroalgae can store nutrients and remove from the environment in eutrophic waters [72]. This mechanism can use for removing the excessive nutrients from the sea by harvesting the macroalgae. Gathering the *U. lactuca* in Denmark showed that the 56% of Nitrogen and 39% of phosphorous removed from the ecosystem [73]. The beaches that existed in the inner area of the Izmir Bay in previous years were closed with a barrier by making a coastal arrangement. For this reason, the macroalgae, which were previously thrown to these beaches by waves and currents, are shattered by hitting the embankments made today and excess nutrient salts cannot be removed from the environment. This cycle, on the other hand, causes more intense and more macroalgae and phytoplankton blooms by increasing the nutrient salts in the environment [46, 74 and 75]. The Gulf is in such a vicious circle.

Table 4. Summary of statistical measures of the characteristics of floral species biomass in relation to the environmental variables (Prefixes for the abbreviations: S, sea surface, and N; Near-bottom water: T; Temperature °C, S; salinity PSU, D; density, σ_t and Ox; oxygen mg/l, OxS; saturated oxygen, pH; pH, V; velocity of sound cm/s, and BD; bottom depth m) for the CCA

Variables	CCA 1	CCA 2
ST	-0.3190	0.0524
SS	0.2443	-0.0215
SD	0.3188	-0.0298
SV	-0.0698	0.0279
SBT	0.0207	-0.0166
SpH	0.0897	-0.3736
SOx	0.1792	0.2322
SOxS	0.0809	-0.0350
NT	-0.3963	-0.1982
NS	0.2869	-0.0021
ND	0.4647	0.0668
NV	-0.2234	-0.1623
NBT	0.1928	0.0736
NpH	-0.2164	-0.4994
NOx	0.0067	0.1278
NOxS	0.2423	0.1673
BD	0.5002	0.2350
Eigen values	0.988	0.767
Species-environment correlations	0.995	0.979
Cumulative percentage variance		
of species data	42.9	76.2
of species-environment relation	51.4	91.3

Macroalgal blooms can also lead the declining of seagrasses at local scale and decrease the biodiversity [76]. As seen on the results *P. oceanica* only seen at outer bay of the study site (Figure 3). There were dense *P. oceanica* meadows seen at middle bay (Narlıdere) in 1980s (Pers. comm. Kemal Can Bizsel). Those meadows were disappeared because of eutrophication and turbidity. The weak point of this study is that 0-10 meters depth could not be sampled because of technical difficulties such as marineport and harbour region. In the Bay of Izmir, especially in the inner and middle regions, intense macroalgae distribution occurs at the first 0-5 meters depth. Therefore the distribution maps (Figure 3) do not show macroalgae distribution in the interior region.

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CONFLICT OF INTEREST

The authors declared no conflict of interest.

FINANCIAL DISCLOSURE

The present study was carried out to estimate qualification and quantification of the benthic macrophytes conducted by me as task manager within framework of a project (grant no: SINHA 107G066) funded by TUBITAK.

DECLARATION OF ETHICAL STANDARDS

The authors of this article declare that the materials and methods used in this study do not require ethical committee permission and/or legal-special permission.

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