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Research Article

Seasonal Variations in the Biomass of Macro-Algal Communities from the Gulf of Antalya (north-eastern Mediterranean)

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Abstract: In this study, the seasonal variations in the macro-algal biomass in the Gulf of Antalya (north-eastern Mediterranean) were investigated. The seasonal variations of the macro-algal biomass were found to be related to the biology of the abundant species during less favourable seasons. These variations occurred usually as a result of a significant reduction in algal density [*Padina pavonica* (L.) J.V.Lamour., *Dasycladus vermicularis* (Scopoli) Krasser, *Chondrophycus papillosus* (C.Agardh) Garbay & Harper] or loss of major part of their thallus [*Cystoseira* spp., *Liagora distenta* (Mertens ex Roth) J.V.Lamour., *Liagora viscida* (Forssk.) C.Agardh]. The highest values of biomass were found to be in the unpolluted stations, while a progressive decrease in such values was observed as the effects of the anthropogenic pressure became more marked.

Key Words: Macro-algal communities, Biomass, Mediterranean Sea, Gulf of Antalya

Antalya Körfezi'ndeki Makroalg Komuniteleri Biyomasının Mevsimsel Değişimi

Özet: Bu çalışmada Antalya Körfezi'nin makro-algal biyomasının mevsimsel değişimleri verilmiştir. Makro-algal biyomasın mevsimsel değişimlerinin, uygun olmayan mevsimlerde bol bulunan türlerin biyolojileri ile bağlantılı olduğu görülmüştür. Bu değişimler genellikle bitki yoğunluğunda önemli bir azalma [*Padina pavonica* (L.) J.V.Lamour., *Dasycladus vermicularis* (Scopoli) Krasser, *Chondrophycus papillosus* (C.Agardh) Garbay & Harper] ya da tallusların büyük bir kısmının kaybı [*Cystoseira* spp., *Liagora distenta* (Mertens ex Roth) J.V.Lamour., *Liagora viscida* (Forssk.) C.Agardh] olarak ortaya çıkmıştır. Biyomasta kirlenmemiş istasyonlarda yüksek değerlere ulaşılırken, insan etkilerinin daha belirgin görüldüğü yerlerde önemli düzeyde azalış belirlenmiştir.

Anahtar Sözcükler: Makro-alg komuniteleri, Biyomas, Akdeniz, Antalya Körfezi

Introduction

Both floristic and vegetational studies on macro-algae of the Turkish coast are few in number if compared to the length of the shoreline, about 8333 km (Güner & Aysel, 1996). While the major part of these studies concentrated on the Black Sea and the Aegean Sea coast (Aysel *et al.*, 1984; Aysel & Erdugan, 1995), a few of them dealt with the Mediterranean coast (from Marmaris to Samandağı) (Zeybek *et al.*, 1993). The first papers on the Mediterranean coast are those by Karamanoğlu (1964), who studied the algal flora of Marmaris, by Zeybek (1969), who studied the marine algae commonly found from Bodrum to Finike, and by Ünal (1970), who published a list of marine algae collected at 12 stations between Fethiye and Hınzırburnu. More recently, Cirik & Öztürk (1990) reported on the algal flora of six Mediterranean stations (Fethiye, Kemer, Alanya, Akkuyu, Taşucu and Arsuz), while Cirik (1991) carried out a study on both the algal flora and vegetation of Akkuyu bay (Mersin). Similarly, quantitative studies on macro-algae from this area are also scarce and deal only with some species of economic importance found in the Aegean and Marmara seas (Aysel & Güner, 1979, 1980, 1982).

In particular, the floristic data from the Gulf of Antalya, specifically from Antalya, Kemer and Alanya were published by Ünal (1970) and by Cirik & Öztürk (1990) from Kemer and Alanya. There is no study related to the macro-algal biomass in the Gulf of Antalya. Considering the importance of macro-algal communities, both as an indicator of pollution and in public awareness, it is important to show the seasonal variations in these communities in a quantitative way. Furthermore, a slight seasonal variation in the biomass could have both positive and negative effects on economically important species. Therefore, a detailed study on the seasonal variations of the biomass of macro-algal communities was carried out in the Gulf of Antalya.

The Study Area

The Gulf of Antalya (Fig. 1) lies on the north-eastern Mediterranean coast of Turkey, between 36° 05' N and 36° 50' N and between 30° 28' E (Cape Gelidonya) and 32° 54' E (Cape Anamur). The water bodies of this gulf are similar to the Levantine basin (Güner & Aysel, 1996). In particular, both seasonal and annual mean values of water temperature are higher than those of the western Mediterranean Sea (Lüning, 1990).

The coastline is either rocky or sandy; however, the rocky shore is usually replaced by a sandy bottom of 1.0 to 5.0 m in depth from the shore. Generally, meadows of *Posidonia oceanica* (L.) Delile are common on the sandy sea floor, but it is replaced by meadows of *Cymodocea nodosa* (Ucria) Asch. in sheltered areas.

Sampling sites

Adrasan Bay is a small bay with a tourist seaside resort open to the public only during the warmer months. The rocky shore has a sandy bottom characterised by meadows of *C. nodosa*. Phaselis is a near pristine archaeological area. The shore is rocky, but the rocky shoreline becomes sandy after 2.0 m in depth. Meadows of both *C. nodosa* and *Halophila stipulacea* (Forssk.) Asch. occur in sheltered areas. Antalya is located just near a commercial harbour. The rocky shore is rich in inlets and caves. Seagrasses are not commonly found on the sandy sea floor. Side is a very popular seaside resort throughout the year. The rocky shore with a sandy bottom starting from about 3.0 m in depth is rich in sheltered inlets where meadows of *C. nodosa* is common. Tufts of *P. oceanica* are common at 4.0-5.0 m in nonsheltered areas. The Incekum shore is rather discontinuous because of the occurrence of intercalated sandy shores. In this station, meadows of *P. oceanica* can also be seen at 3.0-4.0 m in depth, but *C. nodosa* is common on muddy bottoms. Seki Beach is a pristine area. The rocky shores show sandy bottoms from 2.0-3.0 m in depth where meadows of *P. oceanica* occur.

Materials and Methods

Ten random samples from each station were collected for each season during 1995 (Fig. 1). Algal samples were collected by hand at zero to 5.0 m depth on rocky substrata where seaweed formed a dense canopy. A 25x25 cm area was marked with a square metal frame and all algal samples were collected within this area.

Samples were separated from foreign materials (e.g. stones, sand, animals) after sorting manually, and the specimens of each species were rinsed, quickly dried on blotting paper and weighed to determine the biomass with a balance to the nearest 0.1 g. Specimens unidentifiable at the genus level were weighed together and were indicated as "unidentified taxa". The values of estimated biomass do not include the wet weight of calcareous algae.

Average biomass (grams wet weight m^{-2}) was calculated by summing the weights of all sampling units and dividing the total value by ten. The mean values of each species for each station and for each season were estimated.

The values of estimated biomass (both in grams wet weight m^{-2} and in per cent), of each class (*Chlorophyceae, Fucophyceae* and *Rhodophyceae*) at each station for each season were also reported. Mean values of biomass (total biomass), average biomass, standard errors and variation coefficient were performed (Adams, 1992).

Results

The seasonal abundance of estimated biomass was variable (Table 5, Fig. 2). In fact, the mean value assessed in spring increased to the maximum value in summer and then decreased in autumn (1483.52 ± 150.37 g wet weight m^{-2}) and finally reached it's lowest value of 1056.30 ± 100.30 g wet weight m^{-2} in winter.

The wet weight of brown algae showed a maximum value of 1635.15 g wet weight m^{-2} in spring. This value decreased to 783.57 g m^{-2} in summer (Fig. 2). During autumn, the wet weight of brown algae was at the lowest yearly level, and it increased to 812.51 g wet weight m^{-2} during winter. Red algae showed a minimum value of 131.73 g wet weight m^{-2} in spring and a maximum value of 1654.92 g wet weight m^{-2} in summer. Green algae showed low biomass throughout the year, with the lowest values in winter (63.57 g wet weight m^{-2}) and in

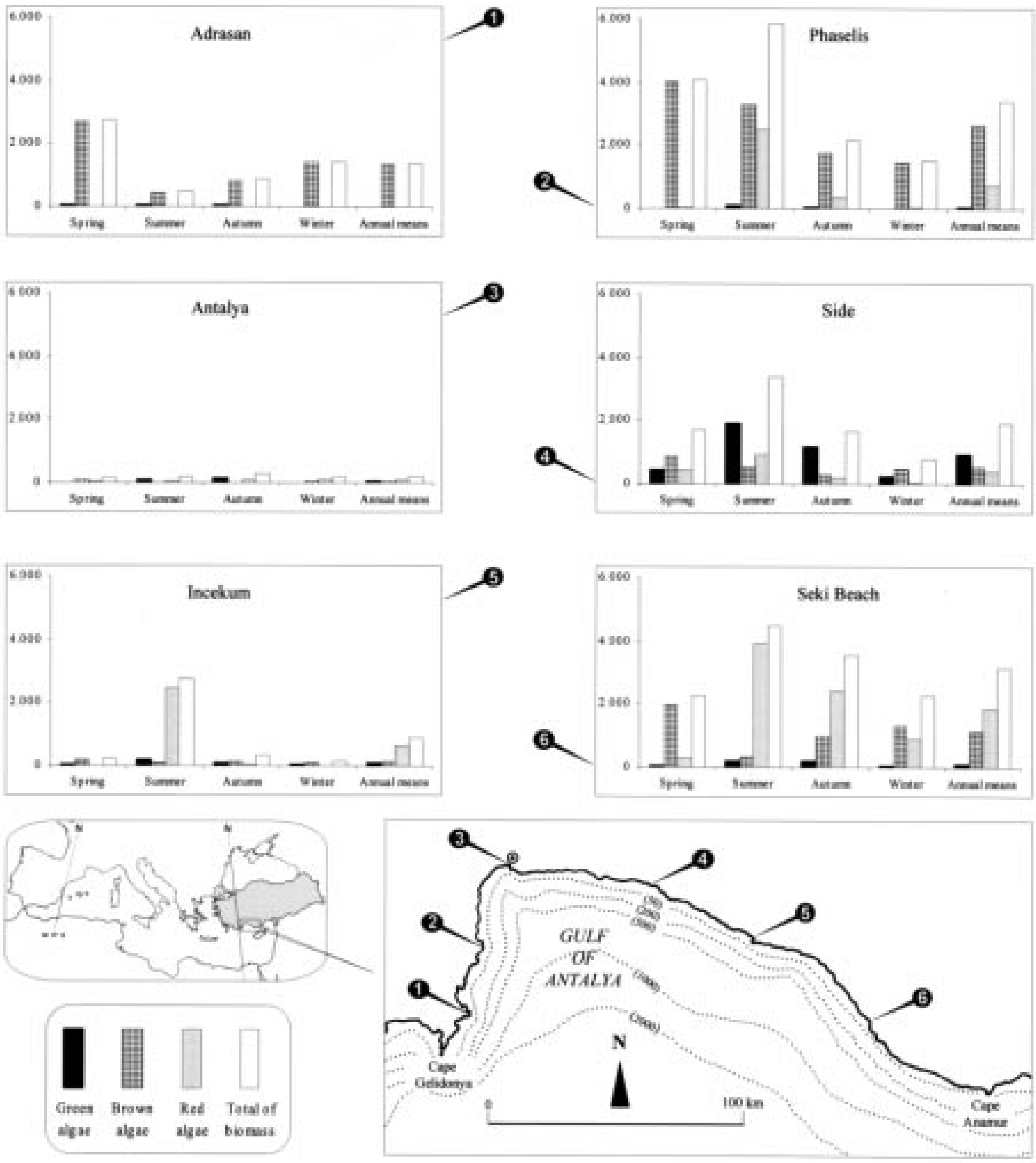

Fig. 1. Seasonal abundance (g wet weight m^{-2}) of seaweed at different locations in the Gulf of Antalya (Turkey). Below, location of the Gulf and sampled stations.

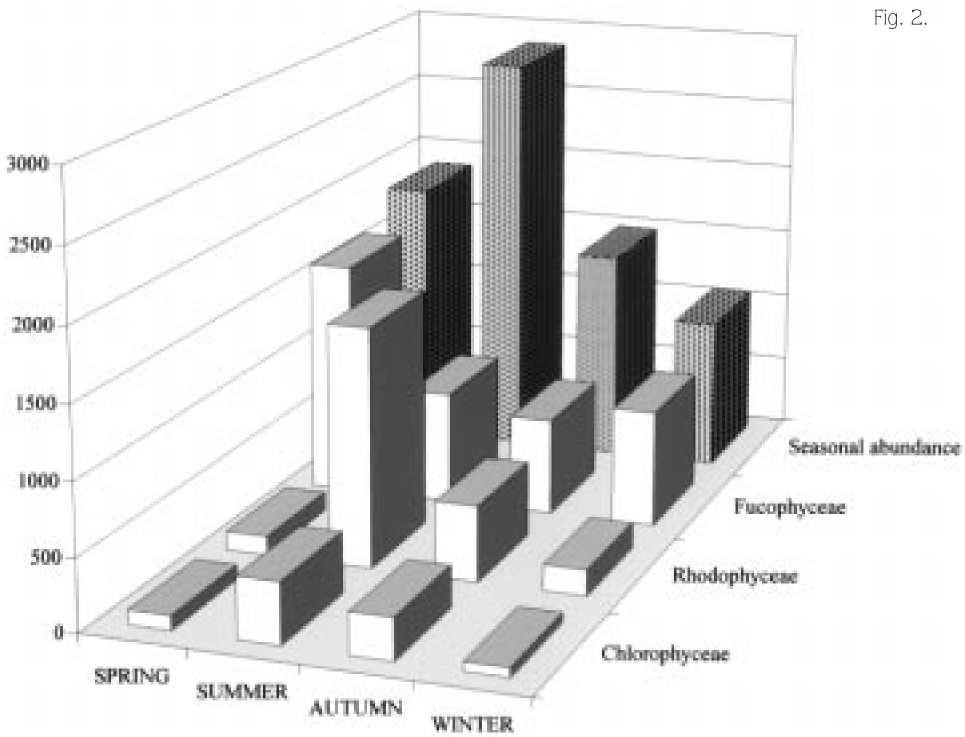

Fig. 2. Seasonal variations of biomass of seaweed in the Gulf of Antalya.

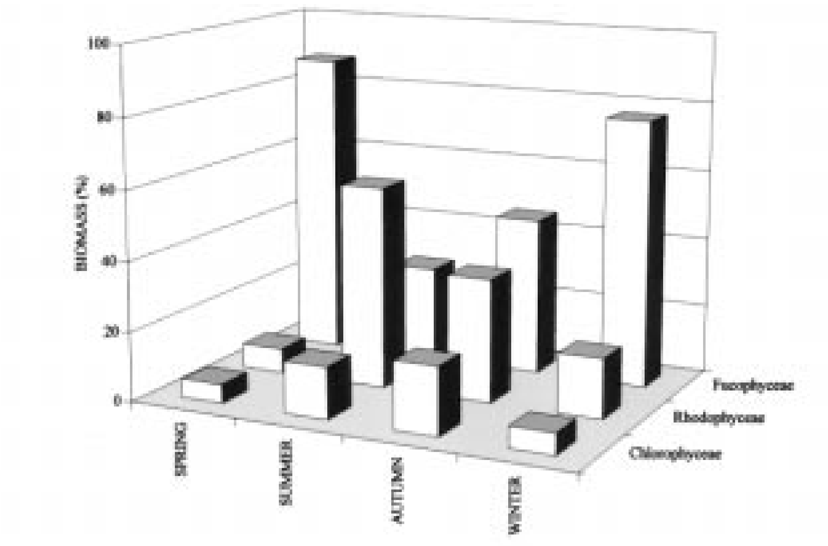

Fig. 3. Relative abundance of each class in each season in the Gulf of Antalya.

spring (99.04 g wet weight m^{-2}), and these values were slightly higher in both summer (the maximum value) and autumn with 421.20 and 286.67 g wet weight m^{-2} respectively. If we consider the relative abundance of classes (Table 5, Fig. 3), *Fucophyceae* had the lowest per cent value of biomass in summer (27.40%) and high values in both spring and winter (87.63% and 76.92%); *Chlorophyceae* had the lowest value in spring (5.31%) and the highest value in autumn (19.32%); *Rhodophyceae* showed the highest value in summer (57.87%) (the only season in which they are more abundant than the other class) and the lowest value in spring (7.06%).

In addition, the annual abundance of biomass at each station showed significant differences (Table 5, Fig. 1). The station with the greatest annual biomass was Phaselis

Table 1. Biomass (g wet weight m^{-2}) of species at each station in spring.

	Adrasan	Phaselis	Antalya	Side	İncekum	Seki Beach
CHLOROPHYCEAE						
Acetabularia acetabulum (L.) P.C.Silva	0.96	-	-	-	1.60	-
Anadyomene stellata (Wulfen) C.Agardh	20.64	9.12	-	3.04	1.76	6.88
Cladophora spp.	-	0.80	3.36	1.28	-	-
Dasycladus vermicularis (Scop.) Krasser	8.48	-	-	427.36	-	-
Enteromorpha spp.	-	-	3.04	-	11.36	18.88
Flabellia petiolata (Turra) Nizam.	-	-	-	1.92	7.04	
Halimeda tuna (J.Ellis et Sol.) J.V.Lamour.	-	2.40	0.96	3.36	35.04	5.60
Ulva laetevirens Aresch.	-	-	14.72	-	-	-
Unidentified taxa	-	1.92	-	-	0.96	1.76
FUCOPHYCEAE						
Colpomenia sinuosa (Mertens ex Roth) Derbès & Solier	-	-	14.56	-	-	358.40
Cystoseira sp.	2594.88	3566.40	21.92	667.20	122.88	1257.76
Cystoseira compressa (Esper) Gerloff et Nizam.	44.96	120.64	-	89.92	1.92	75.20
Dictyoperis polypodioides (DC.) J.V.Lamour.	-	-	-	-	4.80	-
Dictyota spp.	56.00	75.36	9.76	51.52	17.76	121.60
Padina pavonica (L.) J.V.Lamour.	15.52	220.00	10.40	66.24	12.00	99.36
Stypocaulon scoparium (L.) Kütz.	-	8.32	-	-	-	-
Taonia atomaria (Woodward) J.Agardh	10.88	21.12	15.20	-	17.76	32.48
Unidentified taxa	0.96	0.96	2.08	1.76	-	2.40
RHODOPHYCEAE						
Chondrophycus papillosus (C.Agardh) Garbary & Harper	-	-	-	-	11.36	156.48
Digenea simplex (Wulfen) C.Agardh	-	-	-	371.36	-	42.08
Hypnea musciformis (Wulfen) J.V.Lamour.	-	-	-	-	-	3.52
Laurencia sp.	-	0.96	-	-	-	5.12
Laurencia obtusa (Hudson) J.V.Lamour.	-	12.16	-	-	-	49.44
Peyssonnelia sp.	1.76	-	20.80	10.24	-	4.96
Peyssonnelia squamaria (S.G.Gmel.) Decaisne	-	-	-	19.52	-	-
Rytiphlaea tinctoria (Clemente) C.Agardh	-	-	8.16	-	-	-
Tricleocarpa fragilis (L.) Huisman & R.A.Townsend	-	2.40	-	4.96	-	-
Wrangelia penicillata (C.Agardh) C.Agardh	-	30.08	-	-	-	-
Unidentified taxa	0.64	1.28	2.40	15.04	5.12	10.56
CALCAREOUS SPECIES						
Amphiroa rigida J.V.Lamour.	10.08	1.28	-	-	1.76	-
Corallina spp.	-	1.28	861.28	149.12	841.12	1428.80
Jania rubens (L.) J.V.Lamour.	21.12	186.72	59.04	52.32	210.88	453.44

(3411.36 ± 274.61 g wet weight m^{-2}) followed by Seki Beach (3137.65 ± 152.05 g wet weight m^{-2}), whereas Antalya had the lowest value and mean. At the other three stations, the annual mean values were 1896.73 ± 152.82 g wet weight m^{-2} at Side, 1387.64 ± 139.48 g wet weight m^{-2} at Adrasan Bay and 874.54 ± 175.03 g wet weight m^{-2} at Incekum.

The most abundant species among the brown algae were *Cystoseira* sp., followed by *Padina pavonica* (L.) J.V.Lamour. (Table 6). The former species [including *Cystoseira compressa* (Esper) Gerloff & Nizam.] sampled from all stations (Tables 1-4) were abundant in all seasons with a maximum mean value of 1427.28 g wet weight m^{-2} in spring. This value was especially high at Phaselis during this season (3687.04 g wet weight m^{-2}) (Table 1). The second most abundant brown alga *P. pavonica*, showed the highest mean value of 205.39 g wet weight m^{-2} in summer, again with a maximum value of 815.36 g wet weight m^{-2} at Phaselis (Table 2). Among the red algae, the most abundant species were *Wrangelia penicillata* (C.Agardh) C.Agardh and *Chondrophycus papillosus* (C.Agardh) Garbary & Harper and the first of these were most abundant in summer [with a maximum of 2544.16 g wet weight m^{-2} at Seki Beach (Table 2)]. The latter alga was most abundant in autumn with a

Table 2. Biomass (g wet weight m^{-2}) of species at each station in summer.

	Adrasan	Phaselis	Antalya	Side	İncekum	Seki Beach
CHLOROPHYCEAE						
Acetabularia acetabulum (L.) P.C.Silva	-	-	-	-	1.92	-
Anadyomene stellata (Wulfen) C.Agardh	3.20	44.48	2.24	17.12	21.76	-
Briopsis sp.	-	0.96	5.92	-	-	-
Cladophora spp.	-	-	5.12	6.08	98.08	78.56
Dasycladus vermicularis (Scop.) Krasser	4.80	2.08	-	1859.04	-	-
Enteromorpha spp.	-	-	5.92	-	62.56	36.16
Flabellia petiolata (Turra) Nizam.	-	-	-	27.68	9.60	-
Halimeda tuna (J.Ellis *et* Sol.) J.V.Lamour.	-	0.64	2.24	21.60	10.40	11.36
Ulva laetevirens Aresch.	-	-	52.48	-	-	-
Unidentified taxa	17.12	30.24	10.56	7.04	0.96	69.28
FUCOPHYCEAE						
Cystoseira sp.	417.44	2429.28	-	371.04	25.76	112.48
Cystoseira compressa (Esper) Gerloff et Nizam.	6.88	8.16	1.28	4.16	11.36	-
Dictyota spp.	0.16	43.04	1.12	14.88	19.20	-
Padina pavonica (L.) J.V.Lamour.	2.08	815.36	15.36	155.36	27.84	216.32
Unidentified taxa	-	-	1.12	-	1.60	0.16
RHODOPHYCEAE						
Chondrophycus papillosus (C.Agardh) Garbary et Harper	-	-	-	-	-	1337.92
Digenea simplex (Wulfen) C.Agardh	-	33.28	-	-	-	-
Laurencia sp.	-	1.44	-	-	-	47.04
Laurencia obtusa (Hudson) J.V.Lamour.	-	316.32	-	-	-	-
Liagora distenta (Mertens ex Roth) J.V.Lamour.	-	-	-	330.88	983.52	-
Liagora viscida (Forssk.) C.Agardh	-	-	-	417.12	1323.36	-
Peyssonnelia sp.	0.48	-	52.96	15.04	-	-
Peyssonnelia squamaria (S.G. Gmelin) Decaisne	-	-	10.08	33.76	-	-
Tricleocarpa fragilis (L.) Huisman et R.A.Townsend	-	-	-	112.96	2.08	-
Wrangelia penicillata (C.Agardh) C.Agardh	-	2146.24	-		-	2544.16
Unidentified taxa	20.16	2.08	9.28	7.04	160.08	22.24
CALCAREOUS SPECIES						
Amphiroa rigida J.V.Lamour.	27.36	-	-	8.80	-	-
Corallina spp.	-	3.84	760.32	81.92	859.68	145.76
Jania rubens (L.) J.V.Lamour.	2.72	236.96	52.32	685.44	1419.36	1763.04

mean value of 400.83 g wet weight m^{-2}, but it was observed only at Seki Beach with 2404.96 g wet weight m^{-2} (Table 3). The most abundant green algae was *Dasycladus vermicularis* (Scopoli) Krasser, which showed the highest mean values in all seasons, reaching the maximum values in summer (310.99 g wet weight m^{-2}). [In this season, the maximum value of green algae biomass was recorded as 1859.04 g wet weight m^{-2} at Side (Table 2)].

Discussion

The seasonal variations in biomass should be related to the biology of the most abundant species. In fact, during less favourable seasons, some species such as *P. pavonica*, *D. Vermicularis* and *C. papillosus* show a noticeable reduction in plant density, while other species such as *Cystoseira* spp., *Liagora distenta* (Mertens *ex* Roth) J.V.Lamour. and *L. viscida* lose a major part of their thalli.

The significant differences in biomass were observed in different stations. The highest values were found in stations that are minimally affected by human activities. The two sites that had the highest values were Seki Beach and Phaselis. In contrast, the least values of biomass were found at Antalya in a station exposed to heavy sewage pollution, causing an extensive reduction in biodiversity. The most abundant species throughout the year was *Ulva laetevirens* Areshoug accompanied by a few thalli of brown algae *C. compressa*, *Dictyota* spp., *P. pavonica, Taonia atomaria* (Woodward) J.Agardh and red sciophilous algae belonging to the genus *Peyssonnelia*. It should be noted that the last species, which usually lives as an understory alga, lives in Antalya, as canopy algae due to the water turbidity. The low values of biomass were also found at the unpolluted station of Incekum.

Table 3. Biomass (g wet weight m^{-2}) of species at each station in autumn.

	Adrasan	Phaselis	Antalya	Side	İncekum	Seki Beach
CHLOROPHYCEAE						
Anadyomene stellata (Wulfen) C.Agardh	2.72	7.52	2.08	1.76	8.48	12.96
Briopsis sp.	-	-	6.24	0.32	5.44	-
Cladophora spp.	-	-	0.16	-	-	12.00
Dasycladus vermicularis (Scop.) Krasser	12.48	0.32	-	1166.72	-	2.24
Enteromorpha spp.	-	-	-	-	-	3.52
Flabellia petiolata (Turra) Nizam.	-	-	48.32	30.24	63.52	0.16
Halimeda tuna (J.Ellis et Sol.) J.V.Lamour.	0.48	1.12	11.68	-	20.16	17.76
Ulva laetevirens Aresch.	-	-	62.56	-	-	-
Unidentified taxa	10.72	46.72	13.60	-	20.80	127.20
FUCOPHYCEAE						
Cystoseira sp.	844.80	1177.92	4.16	235.68	109.60	913.44
Cystoseira compressa (Esper) Gerloff et Nizam.	-	3.36	7.52	-	12.00	36.64
Dictyota spp.	1.76	364.00	0.48		0.48	-
Padina pavonica (L.) J.V.Lamour.	0.48	226.08	1.44	42.88	29.76	17.28
Unidentified taxa	-	1.28	3.36	0.32	3.36	-
RHODOPHYCEAE						
Botryocladia chiajana (Menegh.) Kylin	-	-	-	-	0.64	-
Chondrophycus papillosus (C.Agardh) Garbary et Harper	-	-	-	-	-	2404.96
Digenea simplex (Wulfen) C.Agardh	-	-	-	-	19.36	-
Gelidium sp.	1.28	-	-	-	-	-
Hypnea musciformis (Wulfen) J.V.Lamour.	-	-	-	-	0.32	-
Laurencia obtusa (Hudson) J.V.Lamour.	-	332.16	-	-	0.32	-
Laurencia sp.	-	19.20	-	-	-	-
Peyssonnelia sp.	-	-	37.12	42.24	2.08	-
Peyssonnelia squamaria (S.G.Gmel.) Decaisne	-	-	11.68	58.40	-	-
Tricleocarpa fragilis (L.) Huisman et R.A.Townsend	-	-	-	93.12	34.88	-
Wrangelia penicillata (C.Agardh) C.Agardh	-	6.56	-	-	-	-
Unidentified taxa	3.52	-	72.00	3.20	-	-
CALCAREOUS SPECIES						
Amphiroa rigida J.V.Lamour.	44.00	20.80	11.52	-	-	-
Corallina spp.	-	-	1976.64	128.32	354.56	79.84
Jania rubens (L.) J.V.Lamour.	-	375.52	59.32	810.88	688.96	1543.36

Such low values depend on the edaphic characteristics of the station where, as mentioned above, the rocky shore is rather discontinuous because of the occurrence of intercalated sandy shores.

The major part of the brown algal biomass is due to *Cystoseira* spp. This can explain why the highest per cent values were recorded in both spring and winter compared to the low values recorded in summer. In fact, such species in the Mediterranean Sea characterise the photophilic vegetation on rocky substrata (Giaccone & Bruni, 1973; Ballesteros, 1992; Cormaci, 1996) showing a distinctive vegetative phenology with high vegetative growth in both winter and spring, followed by an early loss of branches in summer.

Red algae showed the highest per cent values of biomass in summer (57.87% of total biomass of that season), due to their warm environmental biogeographic affinity. However, some of the most abundant species showed a peculiar temporal distribution. For example, *C. papillosus* formed dense populations in summer and autumn at Seki Beach, while at Incekum, small and sparse populations were found only in winter and in spring. Both *L. distenta* and *L. viscida* were found at Incekum and Side only in summer (Table 2), but the values of biomass were calculated to be three times as high at Incekum than in Side. *W. penicillata* showed an explosive growth in summer at both Seki Beach and Phaselis (Table 2).

Table 4. Biomass (g wet weight m^{-2}) of species at each station in winter.

	Adrasan	Phaselis	Antalya	Side	İncekum	Seki Beach
CHLOROPHYCEAE						
Anadyomene stellata (Wulfen) C.Agardh	3.68	9.92	-	1.60	2.08	-
Cladophora spp.	-	0.48	1.44	-	0.80	1.60
Dasycladus vermicularis (Scop.) Krasser	5.92	2.08	-	249.76	-	-
Enteromorpha spp.	-	-	0.16	-	-	23.68
Flabellia petiolata (Turra) Nizam.	-	-	-	2.88	1.60	
Halimeda tuna (J.Ellis et Sol.) J.V.Lamour.	-	-	-	5.44	57.12	0.32
Ulva laetevirens Aresch.	-	-	9.28	-	-	-
Unidentified taxa	0.80	0.64	-	-	0.16	-
FUCOPHYCEAE						
Colpomenia sinuosa (Mertens *ex* Roth) Derbès et Solier	-	-	-	-	-	2.24
Cystoseira sp.	1402.4	1227.68	17.92	448.80	2.56	818.08
Cystoseira compressa (Esper) Gerloff et Nizam.	-	13.44	17.44	19.36	1.28	508.00
Dictyota spp.	30.24	184.00	0.16	8.48	75.84	9.12
Padina pavonica (L.) J.V.Lamour.	-	46.24	1.12	0.64		3.20
Stypocaulon scoparium (L.) Kütz.	-	-	-	12.16	-	-
Taonia atomaria (Woodward) J.Agardh	-	-	20.64	-	-	-
Unidentified taxa	0.96	2.88	-	-	-	0.16
RHODOPHYCEAE						
Chondrophycus papillosus (C.Agardh) Garbary et Harper	-	-	-	-	2.56	879.36
Laurencia sp.	-	13.12	0.16	1.12	1.12	1.60
Peyssonnelia sp.	0.16		64.00	24.00	0.80	-
Peyssonnelia squamaria (S.G.Gmel.) Decaisne	-	-	27.84	-	-	-
Porphyra sp.	-	-	0.32	-	-	-
Rytiphlaea tinctoria (Clemente) C.Agardh	-	-	-	-	9.60	-
Tricleocarpa fragilis (L.) Huisman et R.A.Townsend	-	-	-	1.44	-	-
Unidentified taxa	0.16	13.12	13.12	0.84	-	26.88
CALCAREOUS SPECIES						
Amphiroa rigida J.V.Lamour.	17.44	8.64	-	-	-	-
Corallina spp.	-	-	1083.52	379.04	925.28	1088.32
Jania rubens (L.) J.V.Lamour.	-	132.80	36.32	47.84	215.84	959.68

The seasonal biomass of green algae was generally rather low. However, at Side, 55% during summer and 70% during autumn of total biomass values were represented by the green algae *D. vermicularis*. This can be related to the environmental characteristics of that station, such as it's location in a sheltered area, the presence of moderate water circulation, having high water temperature or having a rocky substratum covered by a thin layer of sediments. All of these characteristics favour both the settlement and growth of the mentioned species (Cinelli, 1979; Pérez-Ruzafa & Gabriel, 1985).

Green algae also showed high values of biomass in Antalya, especially in summer (48.09%) and in autumn (51.22%). However, in this station, the most abundant species was *U. laetevirens*, an algae that prefers environments which are subject to sewage impact (Munda, 1980).

Conclusions

It is clear that the rocky substrata of the Gulf of Antalya were covered by a dense canopy of macroalgae, among which *Fucophyceae* were quantitatively dominant. The unpolluted stations showed the highest values of biomass, while such values decreased in parallel to the increase of anthropogenic pressure. Both quantitative and qualitative differences were recorded among different stations. In some, depending on peculiar edaphic characteristics, an explosive growth of some species was

Table 5. Accumulated average biomass (g wet weight m^{-2}) and per cent values of each class in each station and in each season. Seasonal abundance (last column) and annual means (below) are also reported.

	Adrasan	Phaselis	Antalya	Side	Incekum	Seki Beach	Seasonal abundance
S P R I N G							
Chlorophyceae	30.08	14.24	22.08	436.96	57.76	33.12	99.04
Fucophyceae	2723.2	4012.8	73.92	876.64	177.12	1947.20	1635.15
Rhodophyceae	2.40	46.88	31.36	421.12	16.48	272.16	131.73
Total biomass	**2755.68**	**4073.92**	**127.36**	**1734.72**	**251.36**	**2252.48**	**1865.92**
Standard Error	**± 72.58**	**± 78.47**	**± 3.10**	**± 50.85**	**± 5.91**	**± 29.49**	**± 180.88**
Coefficient of Variation	**8.33**	**6.09**	**7.58**	**9.27**	**7.43**	**4.14**	**75.09**
% biomass of Chlorophyceae	1.09	0.30	18.56	25.19	22.98	1.47	5.31
% biomass of Fucophyceae	98.82	98.55	57.18	50.53	70.46	86.45	87.63
% biomass of Rhodophyceae	0.09	1.15	24.26	24.28	6.56	12.08	7.06
S U M M E R							
Chlorophyceae	25.12	78.40	84.48	1938.56	205.28	195.36	421.20
Fucophyceae	426.56	3,295.84	18.88	545.44	85.76	328.96	783.57
Rhodophyceae	20.64	2499.36	72.32	916.80	2469.04	3951.36	1654.92
Total biomass	**472.32**	**5873.6**	**175.68**	**3400.8**	**2760.08**	**4475.68**	**2859.69**
Standard Error	**± 8.19**	**± 87.11**	**± 3.03**	**± 43.09**	**± 49.90**	**± 76.40**	**± 266.07**
Coefficient of Variation	**5.49**	**4.69**	**5.46**	**4.01**	**5.72**	**5.40**	**72.07**
% biomass of Chlorophyceae	5.32	1.33	48.09	57.00	7.44	4.36	14.73
% biomass of Fucophyceae	90.31	56.11	10.75	16.04	3.11	7.35	27.40
% biomass of Rhodophyceae	4.37	42.55	41.17	26.96	89.46	88.29	57.87
A U T U M N							
Chlorophyceae	26.40	55.68	144.64	1199.04	118.40	175.84	286.67
Fucophyceae	847.04	1772.64	16.96	278.88	155.20	967.36	673.01
Rhodophyceae	4.80	357.92	120.80	196.96	57.60	2404.96	523.84
Total biomass	**878.24**	**2186.24**	**282.40**	**1674.88**	**331.20**	**3548.16**	**1483.52**
Standard Error	**± 17.81**	**± 52.29**	**± 5.68**	**± 28.51**	**± 6.25**	**± 65.58**	**± 150.37**
Coefficient of Variation	**6.41**	**7.56**	**6.36**	**5.38**	**5.97**	**5.84**	**78.51**
% biomass of Chlorophyceae	3.01	2.55	51.22	71.59	35.75	4.96	19.32
% biomass of Fucophyceae	96.45	81.08	6.01	16.65	46.86	27.26	45.37
% biomass of Rhodophyceae	0.55	16.37	42.78	11.76	17.39	67.78	35.31
W I N T E R							
Chlorophyceae	10.40	13.12	10.88	259.68	61.76	25.60	63.57
Fucophyceae	1433.6	1474.24	57.28	489.44	79.68	1340.8	812.51
Rhodophyceae	0.32	26.24	105.44	27.40	14.08	907.84	180.22
Total biomass	**1444.32**	**1513.6**	**173.60**	**776.52**	**155.52**	**2274.24**	**1056.3**
Standard Error	**± 36.21**	**± 39.68**	**± 3.26**	**± 19.08**	**± 4.89**	**± 46.79**	**± 100.30**
Coefficient of Variation	**7.93**	**8.29**	**5.95**	**7.77**	**9.96**	**6.51**	**73.55**
% biomass of Chlorophyceae	0.72	0.87	6.27	33.44	39.71	1.13	6.02
% biomass of Fucophyceae	99.26	97.40	33.00	63.03	51.23	58.96	76.92
% biomass of Rhodophyceae	0.02	1.73	60.74	3.53	9.05	39.92	17.06
A N N U A L M E A N S							
Chlorophyceae	23.00	40.36	65.52	958.56	110.80	107.48	
Fucophyceae	1357.6	2638.88	41.76	547.60	124.44	1146.08	
Rhodophyceae	7.04	732.60	82.48	390.57	639.30	1884.08	
Total biomass	**1387.64**	**3411.84**	**189.76**	**1896.73**	**874.54**	**3137.65**	
Standard Error	**± 139.48**	**± 274.61**	**± 9.22**	**± 152.82**	**± 175.03**	**± 152.05**	
Coefficient of Variation	**63.57**	**50.91**	**30.64**	**50.96**	**126.58**	**30.65**	
% biomass of Chlorophyceae	1.66	1.18	34.53	50.54	12.67	3.43	
% biomass of Fucophyceae	97.84	77.34	22.01	28.87	14.23	36.53	
% biomass of Rhodophyceae	0.51	21.47	43.47	20.59	73.10	60.05	

Table 6. Accumulated average biomass (g wet weight m^{-2}) of seaweed at the six stations in each season.

	SPRING	SUMMER	AUTUMN	WINTER
CHLOROPHYCEAE				
Acetabularia acetabulum (L.) P.C. Silva	0.43	0.32	-	-
Anadyomene stellata (Wulfen) C. Agardh	6.91	14.80	5.92	2.88
Briopsis sp.	-	1.15	2.00	-
Cladophora spp.	0.91	31.31	2.03	0.72
Dasycladus vermicularis (Scopoli) Krasser	72.64	310.99	196.96	42.96
Enteromorpha spp.	5.55	17.44	0.59	3.97
Flabellia petiolata (Turra) Nizamuddin	1.49	6.21	23.71	0.75
Halimeda tuna (J.Ellis et Solander) J.V. Lamouroux	7.89	7.71	8.53	10.48
Ulva laetevirens Areshoug	2.45	8.75	10.43	1.55
Unidentified taxa	0.77	22.53	36.51	0.27
FUCOPHYCEAE				
Colpomenia sinuosa (Mertens ex Roth) Derbès et Solier	62.16	-	-	0.37
Cystoseira spp.	1427.28	564.64	557.52	746.16
Dictyoperis polypodioides (De Candolle) J.V. Lamouroux	0.80	-	-	-
Dictyota spp.	55.33	13.07	61.12	51.31
Padina pavonica (L.) J.V. Lamouroux	70.59	205.39	52.99	8.53
Stypocaulon scoparium (L.) Kützing	1.39	-	-	2.03
Taonia atomaria (Woodward) J. Agardh	16.24	-	-	3.44
Unidentified taxa	1.36	0.48	1.39	0.67
RHODOPHYCEAE				
Botryocladia chiajana (Meneghini) Kylin	-	-	0.11	-
Chondrophycus papillosus (C. Agardh) Garbary et Harper	27.97	222.99	400.83	146.99
Digenea simplex (Wulfen) C. Agardh	68.91	5.55	3.23	-
Gelidium sp.	-	-	0.21	-
Hypnea musciformis (Wulfen) J.V. Lamouroux	0.59	-	0.05	-
Laurencia sp.	1.01	8.08	3.20	2.85
Laurencia obtusa (Hudson) Lamouroux	10.27	52.72	55.41	-
Liagora distenta (Mertens ex Roth) J.V. Lamouroux	-	219.07	-	-
Liagora viscida (Forsskål) C. Agardh	-	290.08	-	-
Peyssonnelia sp.	6.29	11.41	13.57	14.83
Peyssonnelia squamaria (S.G. Gmelin) Decaisne	3.25	7.31	11.68	4.64
Porphyra sp.	-	-	-	0.05
Rytiphlaea tinctoria (Clemente) C. Agardh	1.36	-	-	1.60
Tricleocarpa fragilis (L.) Huisman et R.A. Townsend	1.23	19.17	21.33	0.24
Wrangelia penicillata (C. Agardh) C. Agardh	5.01	781.73	1.09	-
Unidentified taxa	5.84	36.81	13.12	9.02
CALCAREOUS SPECIES				
Amphiroa rigida J.V. Lamouroux	2.19	6.03	12.72	4.35
Corallina spp.	546.93	308.59	423.23	579.36
Jania rubens (L.) J.V. Lamouroux	163.92	693.31	579.67	232.08

observed. Except for the inner part of the gulf, where the city of Antalya is located, environmental conditions do not pose a significant threat.

Nevertheless, more studies on both the vegetal biodiversity and structure of phytobenthic communities (those with phanerogams included) are necessary in order to have a more exact evaluation of the present environmental state of the gulf. These studies should also consider the risks of future anthropogenic pressure on this location, and concentrate their efforts on preventing possible damage that could occur in the future.

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