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Biodiversity in western part of the Fethiye Bay

Fethiye Körfezi'nin batısında biyoçeşitlilik

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Abstract

In this study, the influence of the artificial configuration on the biota in the Marina and surrounding region in the western inner part of the Fethiye Bay by means of biodiversity and hydrographic characteristics of the region is determined. 15 SCUBA and 3 skin dives have been performed in a zigzag manner to determine the marine biodiversity and detailed distribution of the facieses and different depths and substrates were examined. There is a thin and relatively less saline surface layer rich in nutrient and organic material in the study region. This layer also contains high organic materials which indicates terrestrial input due to fecal coliform. In addition weak current velocity causes accumulating high of suspended material in the water column as visibility is very low in the bottom. According to current measurements during the study period, current velocity with 3.4cm/s is very weak, and its direction is mainly northeast and east. In these negative conditions, biodiversity and natural ecosystem of the bay is damaged in long term seriously.

Keywords: Biodiversity, Fethiye Bay, SCUBA

Introduction

Generally new constructions with artificial materials modify irreversible results in the long term. Understanding natural processes and the effects of mankind are only possible by determining the biodiversity of an environment. The most important clue of damaged environment especially in a [1]marine environment is decreasing biodiversity (Margalef, 1968). For this reason before constructing a structure such as a marina pontoon etc the effects on the ecosystem should be determined.

Biodiversity studies have been performed especially in some special protected area such as Datça-Bozburun and Gökova (Okuş *et al*. 2004, Okuş *et al*., 2005). In this study, the effects of artificial buildings on the ecosystem and possible damage are determined in a small area. In order to determine the effects of additional pontoons that is planned to be construted at the marina located in the western part of the Fethiye Bay, an oceanographic study was realized. This oceanographic study consists of hydrographic measurements and observation of biodiversity by divers who are specialized on marine biology.

An important advantage of diving observations is the determination of the visual conditions. According to general observations of the divers, the level of visibility of the water column in the study area is very low. Their observations show that there is very intense suspended sediment in water column and silty sediment at the bottom. Solid waste pollution from marina activity, fishery and houses has affected distribution of the species. Especially, the solid waste pollution of upkeep and repair activity is observed in the region near the slipway. In addition, it is also observed that anchoring damaged the deep flora and fauna distribution.

Material and Method

In order to determine the marine biodiversity at the western part of the Fethiye Bay, 15 SCUBA and 3 skin dives were performed in 25-27 February 2006 (Figure 1). The diving program included 4 groups, each consisting of two or three divers, twice a day, one in the morning and one in the afternoon, and most of the time 8 dives were achieved daily. The starting and ending coordinates of each group were determined by GPS. One of the groups carried an underwater video system to document characteristics of the region and to record the components of biodiversity while another group carried a professional digital underwater photography system. The aim of the video recordings and photographs is to document different species, the state of bottom structure, the distribution and condition of the facieses, the

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biodiversity, and the effect of mankind. In order to obtain a detailed distribution of the biodiversity and facieses, groups moved in a zigzag manner and different depths were surveyed during the study. Data gathered (the species name -if unidentified the characteristics- distribution area or strategy, density etc.) have been noted on slides and when necessary, sampling was performed regarding minimum damage to the organism. Unidentified species were studied aboard and presented to the knowledge and experience of the whole team. If the identification is certain the specimen is returned to its habitat.

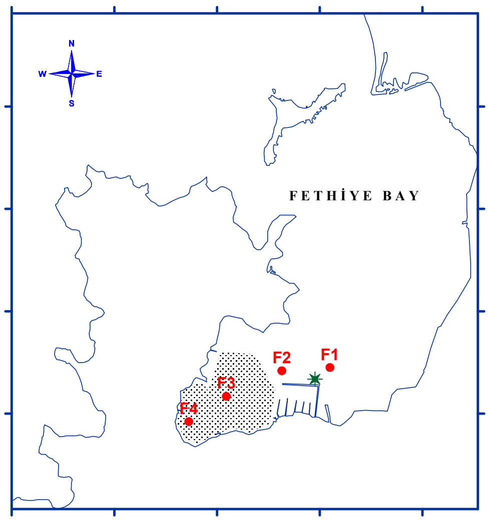

Figure 1. Study region and stations (hydrological stations; circle, ADCP station; star) (dotted region indicates diving zone).

Organisms, which could not be identified during the field study were fixed with neutralized formaldehyde solution to 4-5% final concentration and brought to the laboratory. Unidentified sponge samples, which could not be identified during the field studies, were protected with ethyl alcohol solution to %70 after fixation. In the laboratory, all organisms were identified to the lowest possible taxonomic level (usually species) using a stereomicroscope and a compound microscope.

In order to determine quality of the water column hydrographic parameters at four stations (Figure 1) were measured on 25 February 2006. Temperature and salinity data were obtained by using SBE25 Sealogger CTD self contained memory card. The current measurement was realized with 300kHz Work Horse ADCP at depth of 12m shown with star in Figure 1. The current measurements were recorded almost 1 day duration with 1 minute interval between 15:35 Saturday 25th February 2006 and 21:30 Sunday 26th February 2006. The average data was taken as ensemble 5 minutes after taking off bad data.

The water samples at each station were taken at standard oceanographic depths (0.5m, 5m, 10m, and 2m above bottom) as 5 L volume Niskin bottles. Dissolved oxygen analyses were determined with Winkler method (Greenberg *et al*., 1985). The samples for nutrient analysis were saved in deep freeze at –20 ºC and required analyses are made in laboratory. Nitrate, phosphate and silicate concentrations were obtained by using Bran+Luebbe AA3 autoanalyser. Chlorophyl concentrations were determined by using a method improved by Parsons *et al*. (1984). Fecal coliform and fecal streptococci were studied as indicators of bacteriological pollution at all studied depths.

Results and Discussion

Physical Properties

The temperature and salinity profiles indicate that there is a thin surface layer in the studied region (Figure 2). Salinity of the surface water is relatively low. The surface temperature is in the range of 17.4-18.0°C and salinity is in the range of 34.5-39psu. The temperature decreases suddenly before 4 m depth and then slowly decreases to 16.2°C. The salinity is almost the same (39psu) below 1-2m depth. Surface temperature decreases from inner part of the Bay (station F4) to the outer part of the Bay (station F1).

The reason of this is that the atmospheric heat affects the water column in the inner part of the region which is shallower and protected. It is observed that the salinity in outer part (station F1) is lower than that of in the inner part (station F4). This indicates that the cold and fresh water which is considered to be coming from the canals in east part of the bay is more effective at the station F1.

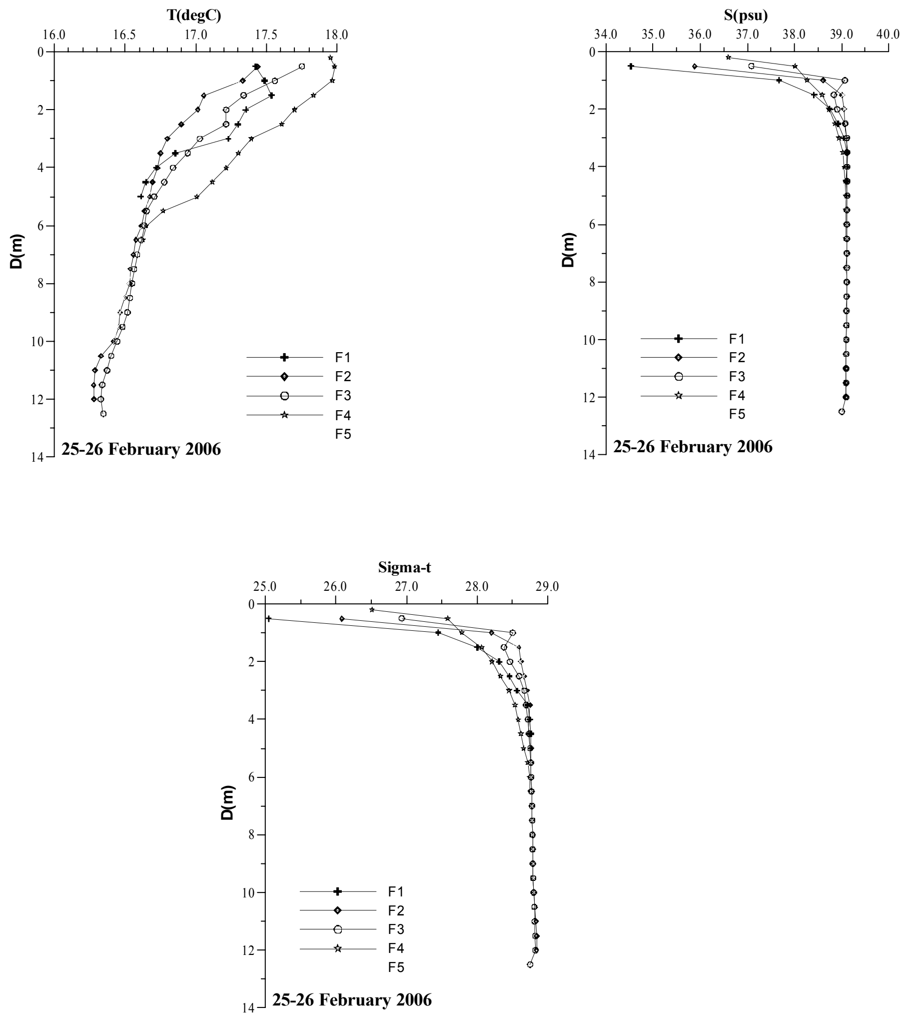

Figure 2. Temperature, salinity and sigma-t profiles

The mean current speed of each measured depths for the first two hours is given in Table 1. The maximum current speed is just above 10cm/sec. The average current speed as a function of depth changes between 2.3 and 4.6 cm/sec and the mean value of the all depths is 3.4cm/sec.

Table 1. The minimum, maximum and average values of current speed at each measured depth.

Depth(m)	Min.v(cm/s)	Max.v (cm/s)	Mean v (cm/s)	S.D.
3	0,3	9,3	3,4	2,4
4	0,7	8,2	4,1	1,9
5	1,2	7,9	3,1	1,5
6	0,1	4,6	2,3	1,3
7	1,5	11,4	4,6	2,5
8	1,2	7,8	3,7	1,9
9	0,5	6,3	2,6	1,7
10	0,1	10,2	3,3	2,5
Average	0,7	8,7	3,4	

The current speed does not vary along the vertical distrubution. For this reason, the current values at 5m depth are choosen to represent the water column current velocity.As it can be seen from the time series of the current speed and direction given in Figure 3, there is a weak current in the bay. The current direction during the first two hours was towards northeastern and its speed was about 3.5cm/sec. After these two hours, while the current speed was slower (nearly 1cm/sec) with small fluctuation, current direction was generally towards east but not stable. Progressive current velocity diagram (Figure 4) indicates that current was in the northeast direction at the beginning of the observation, later on, it directed towards northwest and north, and then between 22:00 and the end of the observation, the current direction was mostly toward east. Total movement was rather short since the current speed was small and the current direction changed frequently.

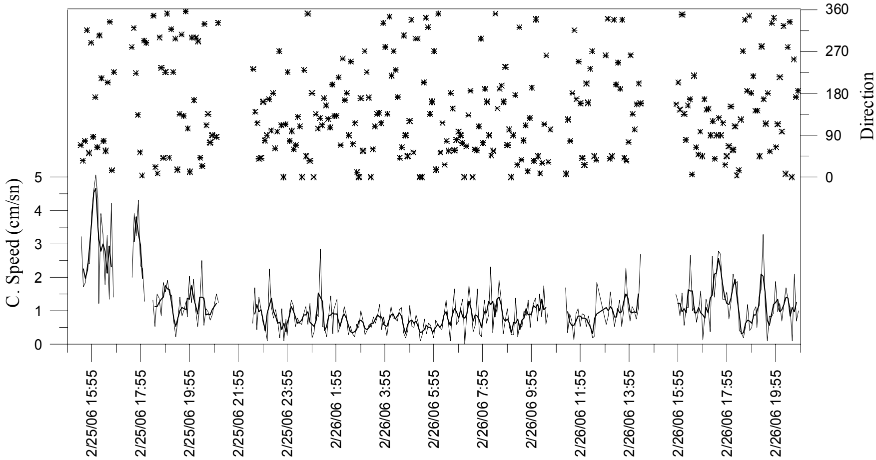

Figure 3. Time series of the current speed and directions

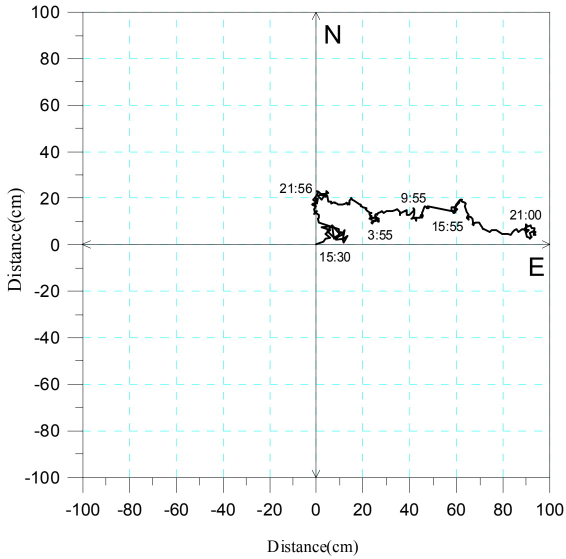

Figure 4. Progressive current velocity vectors

Hydrochemical Properties

The distribution of the nutrient in the bay (Figure 6 and Table 2) shows that nutrient values represent the winter conditions in general. Nitrate + nitrit values are in the range of 0.01-0.33 µM. The maximum values are observed in the surface water, suggesting that fresh water rich in nutrient inputs from the canals to the bay. The other point is decrease of the nutrient values along the outer (station F1) to inner (station F4) part of the bay. A similar distribution is observed for total nitrogen, silicate and phosphate values. Especially silicate distribution obviously shows that the maximum values were found in surface water and higher values were in outer part of the region. Due to weak currents, suspended matter is resident in water column.

Table 2. The chemical parameters measured in water column.

	Depth (m)	**DO (mg/L)**	**Chl a (µg/L)**	**NO2+NO3 (µM)**	**TN (µM)**	**P(µM)**	**TP (µM)**	**Si (µM)**
F1	0.5	9.44	8.35	0.33	2.16	0.22	0.45	31.06
	5	8.17	1.06	0.02	1.17	0.08	0.23	1.22
	10	7.90	1.29	0.02	1.30	0.13	0.21	1.04
F2	0.5	9.71	7.85	0.29	1.93	0.24	0.36	27.53
	5	8.34	2.35	0.07	1.05	0.09	0.18	5.13
	12	7.26	2.47	0.02	0.94	0.09	0.16	0.98
F3	0.5	8.89	6.27	0.08	1.48	0.19	0.30	18.55
	5	8.00	1.24	0.04	1.32	0.12	0.24	2.17
	11	7.93	2.62	0.03	1.33	0.08	0.26	1.18
F4	0.5	8.96	3.14	0.07	1.10	0.76	0.22	7.11
	6	7.67	1.44	0.01	1.05	0.14	0.26	1.30

Chlorophyl a

Chlorophyl a distrubitions indicate that the maximum value was observed in surface at the station F1 located in the outer part of the studied region. The values decreased from the station F1 to the station F4. It means that a fresh water including high organic material and rich nutrient in the area comes from outer part of the bay.

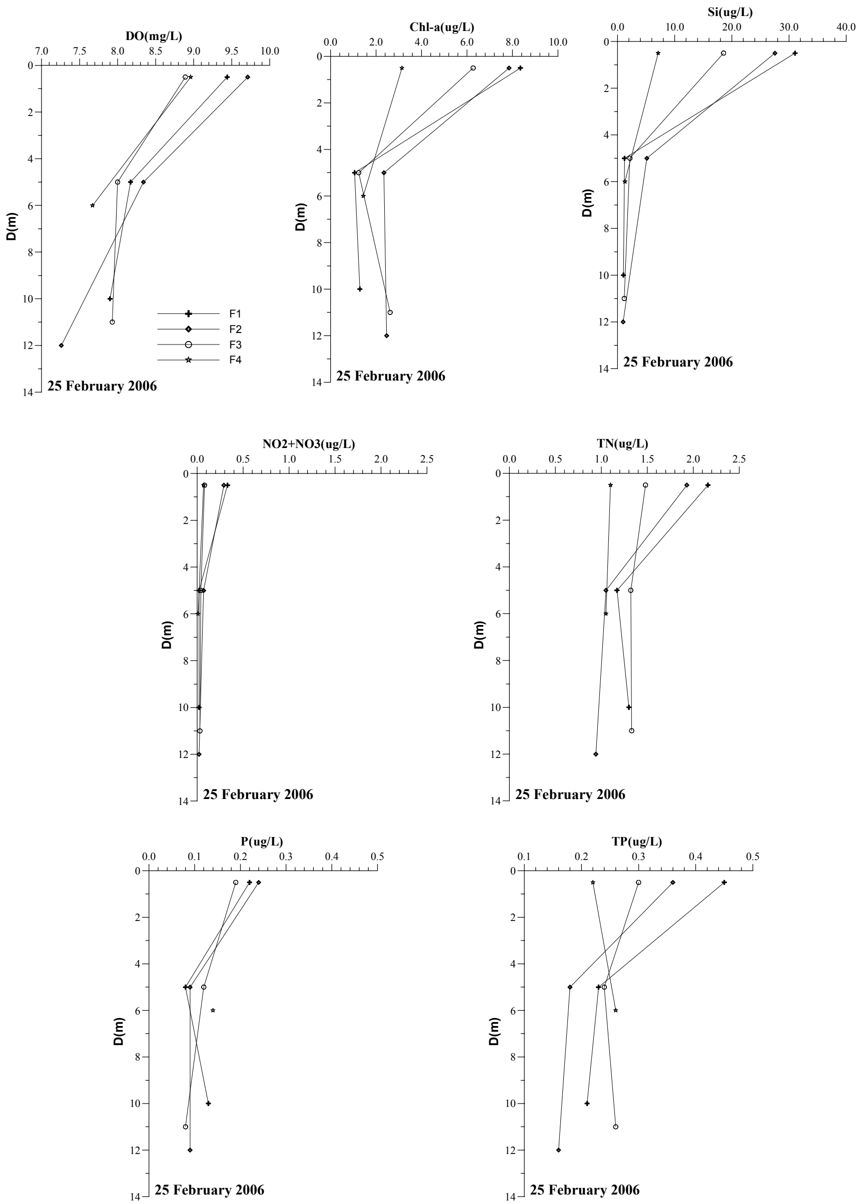

Figure 5. Dissolved oxygen and nutrients profiles.

Chlorophyl a concentrations below the surface are also high in water column, and are around 1-1.5 µg/L, compared to seasonal conditions. In general, these values confirm sinking high organic material to the lower depth.

Bacteriologic Pollution

Fecal coliform and fecal streptococci were choosen as bacteriological pollution indicators in order to determine the antrophogenic input to the studied region (Table 3). In fact, detailed information of bacteriological pollution has to be determined in every month. Especially, it is considered that, the samples in summer months clearly identify the effects of yacht tourism to the bay. On the other hand the samples in rainy season indicate that there is no imported antrophogenic input to the bay. But numbers of fecal coliform and fecal streptococci in surface water of the stations near the Marina compare to the other stations comes from yacht.

Table 3. Bacteriologic pollution indicators value (CFU/100 ml)

		CFU/100 ml	
	Depth (m)	**Fecal Coliform**	**Fecal Streptococci**
F1	0.5	4	2
	5	0	0
	10	0	0
F2	0.5	24	16
	5	0	2
	12	0	2
F3	0.5	12	6
	5	0	1
	11	0	0
F4	0.5	4	4
	6	0	0

Biodiversity

A total of 118 species belonging to 10 taxonomic groups are detected in the study area (Table 4, Figure 6). The most diverse group is fishes with a ratio of 26%. The distribution of fishes is generally round and beneath the pontoons. The second important group is Mollusca (17%) and they are also more diversified around pontoons. On the other *Hexaplex trunculus,* a detritus feeder is densely distributed on the silt bottom. Other important groups are Tunicata and Arthropoda. The list of species identified is given in Table 5.

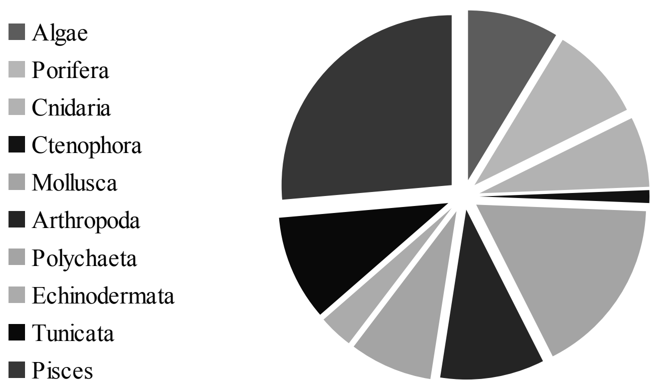

Figure 6. Pie diagram of the taxonomic groups.

In general macrobenthic life is detected at the upper 4m, while *Gobius* species were observed on the silt sediment.

The species composition indicates characteristics of an environment rich in organic material. The most abundant species, which are listed above, are mainly filter feeders. Tunicata (*Phallusia mamillata*, *P. nigra*, *Clavelina lepadiformis*, *C. nana*, and *Microcosmus sabatieri)*, Cirripedia species *(Balanus* spp., and *Veruca stroemit),* Porifera *(Haliclona mediterranea and Chondrilla nucula)*, Polychaeta (*Hermodice carunculata*, and *Sabella spallanzanii)*, Terebellidae (sp.), Bryozoa (sp) and *Mytilus galloprovincialis*.

Distribution of *M. galloprovincialis* is particularly interesting, since this Black Sea species distribution is known to be limited to İzmir Bay. This finding is a good biological evidence of organic pollution in the research area, together with enhanced freshwater input to the ecosystem. In addition, determination of two lessepsian species from Brachyura (*Thallamita poissonii*, *Charybdis helleri*) points out alterations in natural faunal characteristics. Detrital feeding regime of both species is another evidence of organic pollution in the study area. *Enteromorpha* sp. that dominates the flora of the region tolerates pollution, and therefore it can be use as another pollution indicator.

Table 4. Distribution of species number in taxonomic groups

Taxonomic group	Number of species	Ratio %
Algae	10	8
Porifera	11	9
Cnidaria	9	8
Ctenophora	1	1
Mollusca	20	17
Arthropoda	12	10
Polychaeta	9	8
Echinodermata	4	3
Tunicata	12	10
Pisces	31	26
Total	118	

The slipway region had a relatively higher diversity in Fethiye Bay. *Lophelia pertusa* is intensively distributed in this area. Tunicata (*Phallusia mammillata* ve *Phallusia nigra*) and Porifera (*Chondrilla nucula*) species are also distributed at the hard substratum on the mud in the same area. On the other hand relatively less species are found in the marina. Intense total suspended sediment over the mud bottom prevents the distribution of the species. The only observation of distributed species is *Gobius* species in the muddy area. The thin surface layer of freshwater regulated distribution pattern of the species, while also enabled a significant *M. galloprovincialis* biomass in the region.

Over the port stakes and beneath the pontoons of the marina intense Tunicata (*Botryllus schlosseri, Clavelina lepadiformis, Halocynthia papillosa Microcosmus sabatieri*, *Microcosmus sulcatus,Phallusia mammillata* ve *Phallusia nigra*), Molusca (*Anomia ephippium, Arca noae, Chama* sp. *Mytilus galloprovincialis, Ostrea edulis* ve *Spondylus gaederopus*) Crustacea (*Verruca stroeim* and *Balanus* sp. 1) and Bryozoa species distribution was observed. This high diversity localized in a relatively small area resulted in accumulation of fish and crab species in this region for feeding purposes.

Conclusion

Physical and hydrochemical data show that different water characteristics were observed in the area. In the surface, the relatively fresh water having several meters thickness includes rich nutrient and organic matter. *M. galloprovincialis* biomass is also found in this layer. At the bottom, although there is no difference in physical characteristics of water, visibility is very low due to high suspension material because the current velocity is very slow.

The diving observations indicate that in Fethiye inner port, fresh water input comes from the irrigation canals transports siltation to the region and generally the muddy layer of 1.5-2 meters thickness at the bottom displays continuity in spatial distribution. In general the sediment is characterized by silt and mud. Rocks, graveled and sands are observed only in several narrow sections.

No fasies of any kind of species was observed in the studied region. The distributions of protected macroscopic algae were not found and there was no mark of presence. It is obvious that destruction in the region reflects long term effects. Small *Posidonia* pieces were observed merely however these pieces might have imported. Under normal conditions, it is expected to observe the development of algae on hard substrata; however the presence of suspended matter in deep water and continuous destruction of the environment hinder the macroscopic algae development.

Morover the most evident problem is solid waste pollution in the area. Unfortunately, this waste pollution such as many kinds of metal pieces, tins, glasses, nylon bag, rubber, etc observed over the sediment has mostly affected the species richness and abundancy.

Table 5. Species list distrubited in the region

ALGAE	*Cladophora* sp.
	Enteromorpha sp.
	Flabellia petiolata (Turra) Nizamuddin
	Padina pavonica (Linnaeus) Thivy, 1960
	Amphiroa sp.
	Lithophyllum racemus (Lamarck) Foslie, 1901
	Lithophyllum stictaeforme (J.E. Areschoug) Hauck, 1878
	Peyssonnelia sp.
	Phyllophora sp.
	Schimmelmannia sp.
PORIFERA	*Agelas oroides* (Schmidt, 1864)
	Aplysina aerophoba Nardo, 1843
	Chondrilla nucula Schmidt, 1862
	Cliona sp.
	Crambe crambe (Schmidt, 1862)
	Dysidea sp.
	Haliclona mediterranea Griessinger, 1971
	Ircinia muscarum (Schmidt, 1862)
	Leucosolenia sp.
	Petrosia ficiformis (Poiret, 1798)
	Spirastrella cunctatrix Schmidt, 1868
CNIDARIA	*Anemonia viridis* (Forskål, 1775)
	Actinaria (sp.)
	Caryophyllia sp.
	Cerianthus membranacea (Spallanzani, 1784)

Table 5. Contunied

	Cerianthus sp.
	Cladocora caespitosa (Linnaeus, 1758)
	Lophelia pertusa (Linnaeus, 1758)
	Eudendrium sp.
	Pachycerianthus sp.
CTENOPHORA	*Mnemiopsis leidyi* (A. Agassiz, 1965)
MOLLUSCA	*Chiton* cf. *olivaceus* Spengler, 1797
	Chiton sp.
	Bittium latreillii (Payraudeau, 1826)
	Bittium reticulatum (da Costa, 1778)
	Cerithium scabridum Philippi, 1848
	Cerithium vulgatum Bruguière, 1792
	Gibbula cf. *magus* (Linnaeus, 1758)
	Hexaplex trunculus (Linnaeus, 1758)

Özet

Fethiye Körfezi içinde yer alan liman ve Marina çevresinde biyolojik çeşitlilik ve hidrografik durum tespit edilerek bölgedeki doğal olmayan yapıların, biota üzerine etkileri belirlenmeye çalışılmıştır. Biyoçeşitlilik ve detaylı fasiyes dağılımlarını belirleyebilmek için 15 scuba ve 3 serbest dalış yapılarak ve dalışlarda zikzak çizilerek, farklı derinlikler ve substratlar incelenmiştir. Çalışılan bölgede yüzeyde ince bir tabaka halinde görece daha az tuzlu ve besin elementlerince daha zengin bir su bulunmaktadır. İçerdiği fekal koliformdan dolayı karasal girdiye işaret eden bu tabaka organik madde açısından da zengindir. Dipte bir kaç metre kalınlığındaki tabakada ise görüşü engelleyecek şekilde yoğun askıda katı madde bulunması dikey karışımın kısıtlı olmasından ve aşırı karasal girdilerden kaynaklanmaktadır. Çalışma süresince yapılan akıntı ölçümüne göre de akıntı yönü başlıca kuzeydoğu, kuzey ve doğu yönlerine doğru ortalama 3.4cm/sn değeriyle oldukça zayıftır. Tespit edilen türlere ve dağılımlarına göre bu olumsuz şartlarda körfezdeki biyoçeşitlilik ve doğal ekosistem ciddi ölçüde zarar görmüştür

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