Turkish Journal of Fisheries and Aquatic Sciences 8: 79-85 (2008)

Diel Variations on the Fish Assemblages at Artificial Reefs in Two Different Environments of the Aegean Sea (Western Coast of Turkey)

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Received 29 May 2007
Accepted 16 January 2008

Abstract

Determination of diel variations of fish assemblages around artificial reefs may provide a better understanding of the ecological and biological process occurring in these man-made structures, as well as more accurate evaluation of their effectiveness. The aim of this study was to determine the diel variations of the fish assemblages on artificial reefs on muddy and sea grass meadow areas of Western coast of Turkey (Aegean Sea). To determine the diel variations, visual census were conducted according to a time schedule (06:00-07:00, 12:00-13:00, 18:00-19:00 and 24:00-01:00) by SCUBA divers in August 2004. Counts were made as three replicates during each time period. A total of 27 fish species belonging to 10 families were recorded in DAR. At GÜAR, 27 fish species belonging to 13 families were recorded. The lowest species (3 in both sites) and individual numbers (4 in GÜAR and 9 in DAR) were recorded at night (24:00-01:00 period) observations in both sites while the highest numbers were recorded at 06:00-07:00 at DAR (16 species and 838 individuals) and at 12:00-13:00 at GÜAR (11 species and 1068 individuals). Biomass values changed between 293 g and 20,600 g in DAR. The lowest value recorded at night and highest value at 12:00-13:00 period. In GÜAR, the lowest and the highest values were recorded during morning observations. In result of study, it was found that fish assemblages showed significant diel variations in both environments.

Key words: fish composition, visual census, artificial reef, Aegean Sea.

Introduction

Monitoring and assessment of artificial reefs to evaluate their effectiveness had gained great importance in recent years (Borton and Kimmel, 1991; Seaman and Jensen, 2000). More accurate description of fish fauna, abundance and biomass and monitoring of changes of these variables by yearly, seasonally and daily may provide better understanding on ecological and biological process in this structure. Most of the studies aimed for determination of fish assemblages at artificial reef had been made during day time (e.g. Charbonnel *et al*., 2002; Lök *et al*., 2002; Relini, 2000). This may result in lower estimate of fish assemblages. The literature on diel activity of fish are common mainly at coral reefs (Colton and Alevizon, 1981; Helfman, 1978; Hobson, 1965; 1972; Hobson *et al*., 1980) and scarce at artificial reefs (Santos *et al*., 2002). Difficulties and logistic problems may play important roles in carrying out this kind of study.

The objective of this study is to determine the variations of fish assemblage during the diel cycle in terms of number of species, abundance and biomass. We specifically compared variations of fish assemblage on ARs deployed on muddy and sea grass habitats.

Material and Methods

Site and Artificial Reef Descriptions

Dalyanköy is located in the Bay of Ildır (Central Aegean Coast of Turkey), 100 km west of İzmir (Figure 1). Dalyanköy artificial reef (DAR) site is approximately 700 m off-shore and at depth of 20-21 m. The bottom between 1 and 30 m depth is covered by sea grass (*Posidonia oceanica* (L.) Delile) and muddy at deeper depths. There is not any natural reef in 800 m proximity.

ARs were constructed from concrete modules in two designs. Fifty hollow cubic modules: 100 cm x 100 cm x 100 cm, (1 m³), weighed approximately 735 kg in air (385 kg in water) and had 15 cm column width. Another 50 modules had cross shaped design; measures and volume were the same like the hollow cubic modules. But weight was 569 kg in air (298 kg in water) and column width was 10 cm. Drawings and some other details can be found in Lök *et al*. (2002). ARs were deployed at 20-21 m depths in four sets and each set consisted of 25 hollow cubic or cross shaped units in September 1995. Each reef set was 50 m from adjacent set.

Gümüldür and Ürkmez are neighbouring coastal villages located in Gulf of Kuşadası, 60 km south of İzmir. AR sites in Gümüldür-Ürkmez coast are

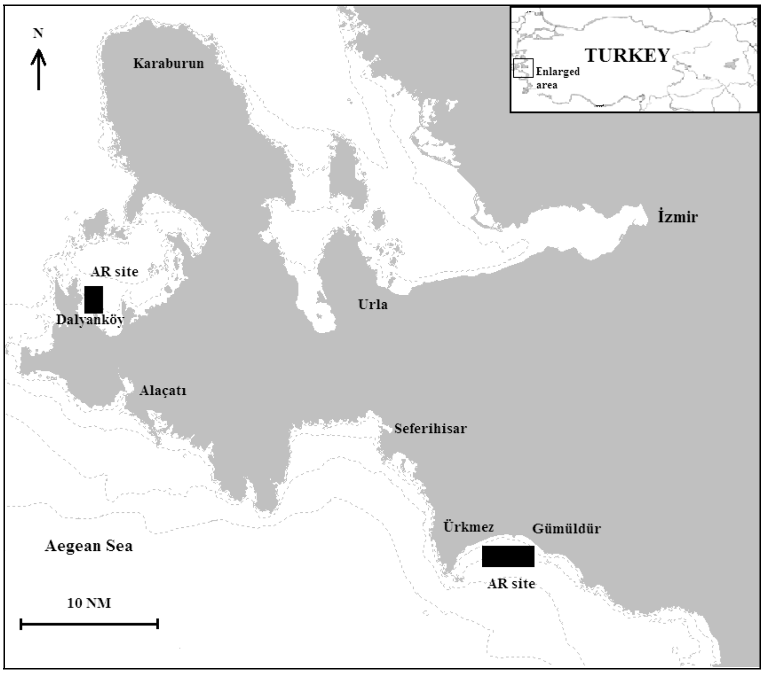

Figure 1. Study locations.

approximately 600 m offshore and parallel to shore. Sea bottom between 0-5 m is sandy; 5-15 m is covered by *P. oceanica* meadows and than muddy zone extending to deeper areas. Nearest natural reef is located 1 nautical mile south-east of AR site. These ARs were also constructed from concrete modules in two designs. 180 hollow cubic concrete modules were constructed by Gümüldür Municipality; each measured 120 cm x 120 cm x 120 cm, occupied 1.7 m^3, weighed approximately 1,365 kg in air (715 kg in water) and had 25 cm column width. These 180 reef modules were deployed in 9 reef sets (each set has 20 modules) at 18-21 m depths in October 1998. Ürkmez Municipality was also constructed 160 pentagon-dome shape modules; each side of pentagon is 80 cm and height is 150 cm, occupied approximately 2 m^3, weighed 1575 kg in air (825 kg in water) and had 25 cm column width. Distances between reef sets in both sites were approximately 200 m.

Wind conditions in Gümüldür-Ürkmez AR (GÜAR) site were worse than Dalyanköy, because this site is open to southward. DAR site is located in a Bay and an only north wind affects the site. Horizontal underwater visibility varied between 15-30 m in Dalyanköy and 5-20 m in Gümüldür-Ürkmez in general. Small scale commercial and recreational fishery activities exist in both areas.

Sampling

Observations were carried out between 3–6 August in DAR and 8–11 August in GÜAR. To determine diel variations in fish assemblages in both sites, visual census methods were used, as described by Harmelin-Vivien *et al*. (1985), Borton and Kimmel (1991), Bohnsack *et al*. (1994), according to a time schedule 00:00-01:00 (night), 06:00-07:00 (morning), 12:00-13:00 (midday), and 18:00-19:00 (afternoon). Visual count continued until all fish counted. Fast and large fishes were first censused and than cryptic and small species were counted. Fish assemblages in four time periods were sampled for fish composition, abundance and fish size estimation. The names of fish species in this paper are according to Fisher *et al*., (1987). The method of abundance groups for enumeration of fish schools and the size group method for size estimations described by Harmelin-Vivien *et al*. (1985) were used in visual census. Three replicates were conducted for both sites during all sampling period.

Total census was made by divers in all observation periods. Diving time was approximately 10 min for day diving and 15 min for night dives. Our anxiety during night dives was to frighten some fishes. For this reason, we made a plan to reduce possible negative effects of voice (generated by SCUBA equipment) and light. Each dive was started approximately 20 m away from the reef buoy. Underwater lights were kept off until arrival to reef set. While one diver was using 100 watt halogen light and leading a second diver, second diver was recording fish to plate under small light attached to his/her own mask.

Divers (authors) in this study have minimum ten years diving and observation experience in artificial reef sites. Furthermore, they have experience in fish size estimation during last two years in study areas.

Analyses

Statistical analyses were carried out using SPSS Version 11.0 for Windows®. Biomass estimation was made using individual length estimates and length to weight conversion formulas. Length to weight conversion formulas belongings to all fish species could not be obtained from one literature. For this reason, different literatures were used (Rafail, 1972; Bauchot and Bauchot, 1978; Magnusson and Magnusson, 1987; Chauvet, 1991; Dulcic *et al*., 1994; Dulcic and Kraljevic, 1996; Gonçalves *et al*., 1997; Manooch and Potts, 1997; Merella *et al*., 1997; Stergiou and Moutopoulos, 2001; Taskavak and Bilecenoglu, 2001; Abdallah, 2002; Moutopoulos and Stergiou, 2002; Koutrakis and Tsikliras, 2003; Valle *et al*., 2003). Where there was not any available conversion formula, the formula of nearest fish with the most similar body shape was used. Data were obtained from visual counts were non-parametric. For this reason, data were converted to $\log_{10}$ and these converted data analyzed for homogeneity of variance. After that all converted data were analyzed by using the One-Way ANOVA. Jaccard and Bray-Curtis similarity indices were used to measure of the similarity of the structure of fish communities in both AR sites following Washington (1984).

Results

Assemblage Structure in DARs

A total of 27 species (3935 fishes) belonging to 10 families were recorded in 36 censuses during 3 sampling days (Table 1). Labridae (10 species) and Sparidae (8 species) were the dominant families in the fish community (67% of the species pool). The lowest values of number of species, abundance and biomass were recorded during night observations while the highest values were recorded at morning observations (Figure 2). Differences between mean values of number of species, abundance and biomass belonging to four time periods were found significant ($P<0.05$). Distribution of species according to diet was 77.8% carnivore, 18.5% omnivore and 3.7% herbivore.

Nine labrid species (Table 1) were never seen during night diving except one individual of *L. merula*; but most of these species were encountered under the canopy of sea grass around ARs at night. *S. cretense* was also not observed at night dives. *C. chromis* and *S. maena* showed peaks in the morning and midday, with lowest value at night. *D. puntazzo*

Table 1. Fish species censused in Dalyanköy AR site during all observation periods. Fish species, common name and diet are according to Fisher *et al*. (1987)

	Species	Common name	Diet[1]	Economic value[2]	Total number	Biomass (kg)
1	*Serranus scriba*	Painted comber	Car.	R	74	6.23
2	*Mullus surmuletus*	Striped red mullet	Car.	C	4	0.29
3	*Boops boops*	Bogue	Omn.	C R	1	0.01
4	*Dentex dentex*	Common dentex	Car.	C R	3	0.95
5	*Diplodus annularis*	Annular seabream	Car.	C R	145	2.59
6	*Diplodus sargus*	White seabream	Car.	C R	20	3.38
7	*Diplodus vulgaris*	Two-banded seabream	Car.	C R	271	18.55
8	*Lithognathus mormyrus*	Striped seabream	Car.	C R	5	0.56
9	*Diplodus puntazzo*	Sharpsnout seabream	Omn.	C R	25	8.96
10	*Spondyliosoma cantharus*	Black seabream	Omn.	C R	15	0.98
11	*Spicara maena*	Blotched picarel	Car.	C R	1,687	161.83
12	*Chromis chromis*	Damselfish	Car.		3,344	6.96
13	*Labrus merula*	Brown wrasse	Car.	R	58	7.91
14	*Labrus viridis*	Green wrasse	Car.		47	12.73
15	*Coris julis*	Rainbow wrasse	Car.	R	22	0.48
16	*Symphodus rostratus*	Beakednose wrasse	Car.		9	0.12
17	*Symphodus mediterraneus*	Axillary wrasse	Car.		26	0.36
18	*Symphodus melanocercus*	Black-tail wrasse	Car.		61	0.45
19	*Symphodus ocellatus*	Wrasse	Car.		2	0.02
20	*Symphodus roissali*	Five-spotted wrasse	Car.		9	0.11
21	*Symphodus tinca*	Peacock wrasse	Car.		63	2.91
22	*Symphodus doderleini*	Wrasse	Car.		10	0.16
23	*Sparisoma cretense*	Parrot fish	Omn.		6	0.24
24	*Parablennius rouxi*	Black-banded blenny	Her.		3	0.00
25	*Parablennius gattorugine*	Tompot blenny	Omn.		7	0.08
26	*Tripterygion tripteronotus*	Black-head blenny	Car.		4	0.00
27	*Scorpaena porcus*	Black scorpionfish	Car.	C	14	2.39
	Total				3,935	239.25

1 Diet: Car carnivore, Her herbivore, Omn omnivore
2 Economic value: C commercial, R recreational

was observed only at night and morning periods with peak value at night. *M. surmuletus, B. boops*, *D. dentex*, *P. rouxi* and *T. tripteronotus* occurred in rather low quantities. For this reason, their diel pattern is not clear. All other species displayed a relatively consistent abundance pattern during all observation periods. For sparids, abundance and biomass declined, but number of species remained almost the same during the last day of the observations.

Assemblage Structure in GÜARs

Twenty-seven species (3,460 fishes) belonging to 13 families were recorded in 36 census during 3 sampling days (Table 2). Sparidae (7), Labridae (4), Serranidae (3) and Scorpaenidae (3) were dominant families in the fish composition (63%).

The lowest values of number of species and abundance were recorded at night and afternoon for biomass (Figure 3). The highest values of biomass

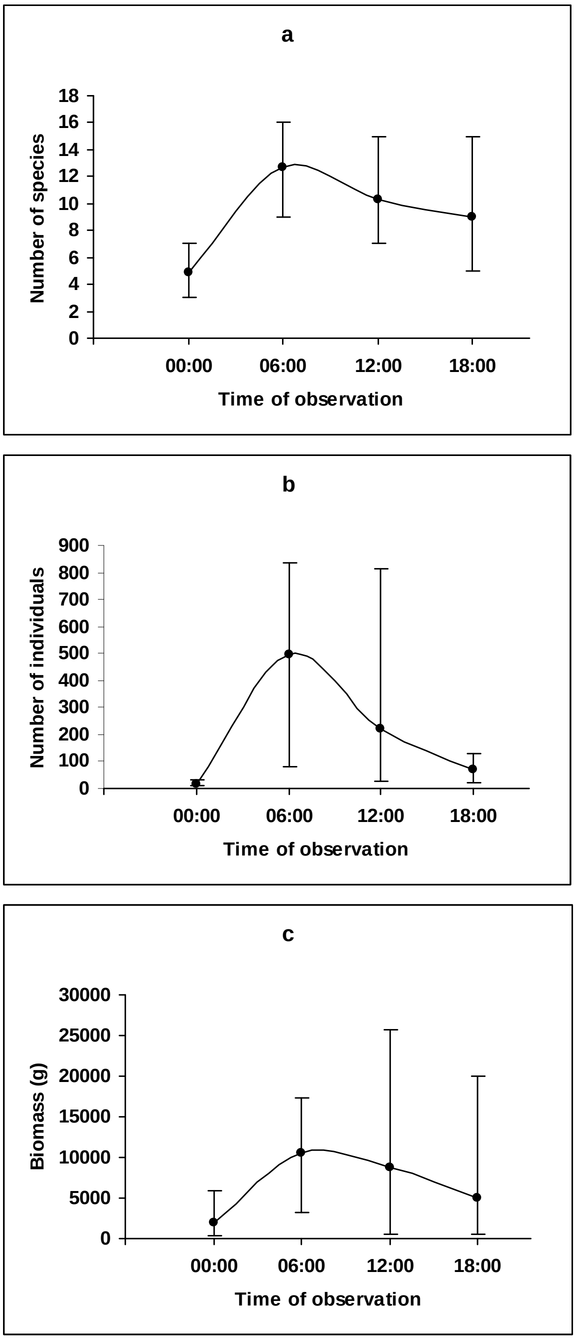

Figure 2. Mean changes of number of species (a), number of individuals (b) and biomass (c) according to observation periods in DAR. Vertical bars represent the range between minimum and maximum values.

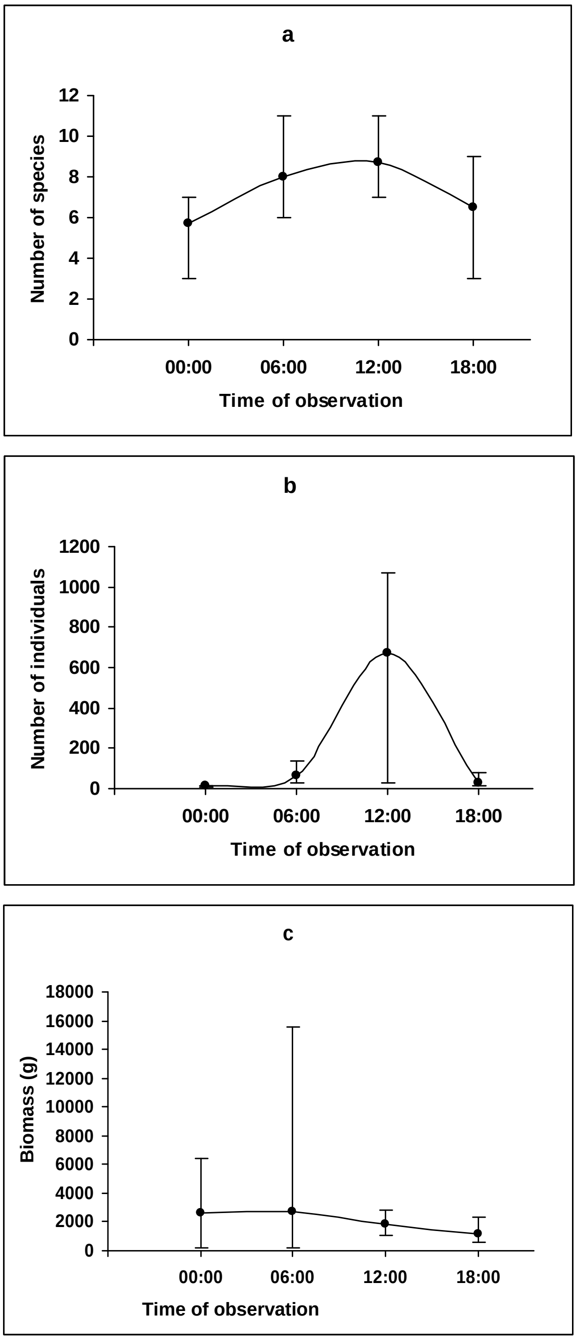

Figure 3. Mean changes of number of species (a), number of individuals (b) and biomass (c) according to observation periods in GÜAR. Vertical bars represent the range between minimum and maximum values.

Table 2. Fish species censused in Gümüldür-Ürkmez AR sites during all observation period. Fish species, common name and diet are according to Fisher *et al*. (1987)

	Species	Common name	Diet[1]	Economic value[2]	Total number	Biomass (kg)
1	*Muraena helena*	Mediterranean moray	Car.		3	0.1
2	*Conger conger*	European conger	Car.		1	0.03
3	*Serranus cabrilla*	Comber	Car.	R	75	3.67
4	*Epinephelus costae*	Goldblotch grouper	Car.	C R	5	3.9
5	*Epinephelus marginatus*	Dusky grouper	Car.	C R	6	0.52
6	*Apogon imberbis*	Cardinal fish	Car.		5	0.01
7	*Lichia amia*	Leerfish	Car.	R	1	13.86
8	*Sciaena umbra*	Brown meagre	Car.	C	19	6.1
9	*Mullus barbatus*	Red mullet	Car.	C	2	0.43
10	*Mullus surmuletus*	Striped red mullet	Car.	C	9	0.36
11	*Dentex dentex*	Common dentex	Car.	C R	7	4.03
12	*Diplodus annularis*	Annular seabream	Car.	C R	11	0.32
13	*Diplodus sargus*	White seabream	Car.	C R	6	0.59
14	*Diplodus vulgaris*	Two-banded seabream	Car.	C R	216	12.09
15	*Oblada melanura*	Saddled seabream	Omn.	C R	16	2.75
16	*Diplodus puntazzo*	Sharpsnout seabream	Omn.	C R	9	5.46
17	*Sarpa salpa*	Salema	Her.	C R	17	2.54
18	*Chromis chromis*	Damselfish	Car.		2,705	4.62
19	*Coris julis*	Rainbow wrasse	Car.	R	3	0.11
20	*Symphodus tinca*	Peacock wrasse	Car.		1	0.07
21	*Thalossoma pavo*	Ornate wrasse	Car.	R	42	0.64
22	*Symphodus doderleini*	Wrasse	Car.		44	0.17
23	*Parablennius rouxi*	Black-banded blenny	Her.		144	0.12
24	*Tripterygion tripteronotus*	Black-head blenny	Car.		1	0.00
25	*Scorpaena porcus*	Black scorpionfish	Car.	C	72	5.33
26	*Scorpaena scrofa*	Red scorpionfish	Car.	C	35	12.12
27	*Scorpaena notata*	Small red scorpionfish	Car.	C	5	0.02
	Total				3,460	79.95

1 Diet: Car carnivore, Her herbivore, Omn omnivore.
2 Economic value: C commercial, R recreational.

were determined at night and during morning observation. But a big *L. amia* individual (approx. 1 m total length and 13 kg) was observed during morning census. If we exclude this individual, mean value of biomass at morning observation will be slightly higher than afternoon period. The highest values of number of species and abundance were recorded during midday observations. While differences between mean value of number of species and abundance in comparisons of four observation periods were found significant ($P<0.05$), differences between biomass values were found insignificant ($P>0.05$). Distribution of species according to diet was 85.2% for carnivore, 7.4% for omnivore and 7.4% for herbivore.

All other sparid species except for *D. annularis* and *D. vulgaris* were observed only at night while all labrids, *C. chromis, P. rouxi, S. scrofa* and *S. notata* were not observed during night time. Although abundance of *S. umbra* showed similarity during night, morning and midday periods, it was not encountered in afternoon. *S. porcus* showed peak value in afternoon, with the lowest value at night. *S. cabrilla* and *D. vulgaris* displayed a relatively consistent pattern during all periods. Because of low abundances, diel patterns of other species are not clear.

Comparisons of Habitat Assemblages

Habitat assemblages based on number of species, abundance and biomass for overall and observation periods were compared in DAR and GÜAR. Number of species (27) was the same in both sites but compositions of species were different. Each site has 15 different and 12 common species (42 species in total). Similarity indices of fish communities in both sites were found 28.57% with Jaccard and 65.31% with Bray-Curtis. Since Bray-Curtis index is including the number of individuals into the analysis, similarity between fish communities was found high but similarity was found very low when we used Jaccard index, because this index expresses the percentage of species shared in common (Washington, 1984). GÜAR has 3 more families (13) than DAR (10). While Labridae and Sparidae were dominant with 10 and 8 species in DAR, respectively, Sparidae was dominant with 7 species in GÜAR and followed by Labridae (4), Serranidae (3) and Scorpaenidae (3).

In general, comparison of both sites according to mean values of number of species, abundance and biomass, differences was not found significant ($P>0.05$). Differences between mean values of number of species, abundance and biomass at night and midday observations in both sites were not found significant (P>0.05). But for the morning data, differences between all values were found significant (P<0.05). For the afternoon data, differences between abundance values were found significant while differences in number of species and biomass were not significant (P>0.05).

Diet compositions were similar in both sites, but the ratio of carnivore species in GÜAR (85.2%) was higher than that in DAR (77.2%) and omnivore species has higher ratio in DAR (18.5%) in comparison to that in GÜAR (7.4%).

Discussion

Fish assemblages showed diel variations in both environments. This is the first study on determination of diel variations of fish assemblages at the ARs in Aegean and Mediterranean Seas. We found a similar study belonging to Santos *et al*. (2002) who conducted it at the Atlantic Coast of Portugal. We can compare fish assemblages in GÜAR thanks to this study, because some characteristics of their artificial reef area have similar conditions to GÜAR site (muddy environment and 21 m depth). Fish assemblage variations during the day are similar in both studies. Numbers of species and abundance (density in Santos' paper) have peak values at midday period and during at night observations. Sparidae is dominant family in both studies, but we determined more species than Santos' study (27 vs. 18). This may be due to different visual census methods and biogeographically conditions.

Significant variation in diurnal abundances at the four time periods (09:00 – 12:00 – 15:00 – 18:00) had been found by Colton and Alevizon (1981) in Bahamian coral reef fish assemblage. If we consider similar time period in our study, our results support their findings.

C. chromis and *S. maena* have a major role in increasing and decreasing of abundance and biomass between observation periods at DAR. This species is forming schools during day time and feed on zooplanktons and they prefer to hide into reef units and under the canopy of sea grass at night. As these two species, all labrids have a clear diel activity pattern. They prefer to hide during the night (Santos *et al*., 2002) while they are active, seeking food during the day. Helfman's (1978) suggest is that the timing of activities is a familial characteristic in general.

C. chromis has also an important place at high abundance at GÜAR during day time. Variation of biomass between observation periods at GÜAR is mainly due to Sparidae species. Especially existence of big *D. dentex*, *D. sargus*, *D. puntazzo* and *S. salpa* during the night is to increase the biomass of this observation period. Because of the existence of these carnivores, small fish such as *P. rouxi*, *T. tripteronotus*, *S. doderleini*, *T. pova* and *C. chromis* hide to crevices of artificial reef units.

Although difference of the fish assemblage (size, abundance and biomass) was not found significant between two environments, the similarity of community structures was found very low (28.57%). This difference may be due to location, type and quantity of surrounding substrates and isolation from similar habitats (Bohnsack *et al*., 1991).

E. marginatus is an endangered (EN – A2a) species. Six individuals belonging to this species were recorded at GÜAR during study period. This species uses artificial reefs as a shelter and feeding area according to our underwater observations. Artificial reefs can be used conservation tool for this species.

This study was carried out in a short period because of some limitations (e.g. logistics, weather conditions, diving equipment). But the study had showed that fish assemblages in both environments have clear diel variations. Results should considered at the evaluation of artificial reef effectiveness. To determine diel activity patterns of fish according to the feeding habits, longer study time, hourly observation periods and stomach analysis should be taken into account as done by Hobson (1965).

Acknowledgments

This project was supported by The Scientific and Technical Research Council of Turkey (Project No: TBAG-2275). We thank to B. Rüzgar and E. Ergün for logistic support and crews of the Research Vessel (EGESÜF) O. Öner and A. Aksade. We also thank G. Metin, İ. Aydın, E. Özvatan and T. Laleli for their help during the cruise and N. Güneş and M. Bilecenoğlu for assistance with data analysis and H. Özbilgin for his help in preparing the manuscript in English.

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