Peer-reviewed and Open access journal
ISSN: 1804-4999 | www.academicpublishingplatforms.com
The primary version of the journal is the on-line version

ATI - Applied Technologies and Innovations
Volume 11 | Issue 1 | 2015 |pp.9-15
DOI: http://dx.doi.org/10.15208/ati.2015.02

Evaluation of ecological quality of Albanian rocky shore waters using macroalgae as bioindicators

Sonila Gogo
Faculty of Natural Sciences, University of Tirana, Albania

e-mail: sonilagogo3@gmail.com
postal address: str. Bulevardi Zogu I, Tiranë, Albania 1001

Ecological Evaluation Index (EEI) is an important tool that uses phytobenthos as bio indicator for assessing quality of coastal and transitional rocky shore waters. This method is considered by The Water Framework Directive (WFD, 2000/60/EC) to achieve the Ecological Status of water bodies by monitoring temporal changes in communities of benthic macroalgae.

In this study destructive sampling was performed on macrophytobenthic populations of the upper infralittoral zone. The aim of the study was to estimate the ecological status, using EEI and to know the composition of these floristic communities in space and time. Samples were taken seasonally for two years from 8 rocky shore stations in Albania (three stations in Adriatic and five stations in Ionian Sea). 62 taxa were identified and the diversity indexes were calculated. All sites were characterized by anthropogenic disturbance of different degrees. A gradient of Ecological Statuses from "low" to "high" was noticed seasonally passing from North to South stations.

Keywords: Macroalgae, ecological status, distructive sampling, upper infralitoral, Albania

Citation: *Gogo, S., 2015. "Evaluation of ecological quality of Albanian rocky shore waters using macroalgae as bioindicators", Applied Technologies and Innovations, Vol.11(1), pp.9-15, http://dx.doi.org/10.15208/ati.2015.02*

Introduction

According to the European Water Framework Directive (WFD, 2000/60/EE), benthic plants (phytobenthos) represent a reliable indicator of the trophic status of a coastal area. These plants are also used as tools (biological quality element) for the evaluation of the ecological quality of coastal water bodies (Panayotidis et al., 2007). These waters together with transitional waters are some of the most productive ecosystems on the Earth with high values for the society. Although information regarding subtidal communities on hard substrates is limited because of high anthropogenic activities and impact (pollution, modification etc.), macroalgae found in low depth (<1m) on rocky substrate (hard bottom macroalgae of the upper infralittoral zone) are considered to represent one of the best indicators of water quality (Panayotidis et al., 2007). Broad-scale mapping studies of these communities, together with information on the biological and environmental tolerances of different species and assemblages, constitute an important management tool needed for the ecological assessment of sustainability of these habitats (Dı´az et al., 2004). Responses of seaweed communities to common anthropogenic disturbances in coastal areas have been summarized by Orfanidis et al. (2001).

Some studies on communities of rocky substrates have been conducted through the years in Mediterranean sea like in Ligurian coasts of Italy (Asnaghi et al., 2009) Adriatic coasts of Croatia (Iveša et al., 2009) and Slovenia (Orlando-Bonaca et al., 2008), Ionian coasts of

ISSN: 1804-4999

Greece (Orfanidis et al., 2001), leaving Albanian coasts to be explored for the first time in such research for both Adriatic and Ionian coasts of the country.

The aim of the study is to estimate the ecological status, using the Ecological Evaluation Index (EEI) and to know the composition of floristic communities in space and time.

Ecological Evaluation Index - the concept

In order to evaluate shifts in marine ecosystems structure and function, ecological evaluation index (EEI) is introduced. EEI is an index used for evaluating anthropogenic impact/stress to benthic macroalgae communities. It is expressed as a numerical value ranging from 2 to 10, indicating the overall ecological status (ES) of transitional and coastal waters (Orfanidis et al., 2001) shown in Table 1.

TABLE 1. THE NUMERICAL SCORING SYSTEM FOR THE EVALUATION OF ECOLOGICAL STATUS OF TRANSITIONAL AND COASTAL WATERS

Numerical value of ecological categories	Ecological Evaluation Index (EEI)
High = 10	[≤ 10 - >8] = High
Good = 8	[≤ 8 - >6] = Good
Moderate = 6	[≤ 6 - >4] = Moderate
Low = 4	[≤ 4 - >2] = Low
Bad = 2	[2] = Bad

Source: Orfanidis et al. 2001.

TABLE 2. MATRIX BASED ON THE MEAN ABUNDANCE (%) OF ESGS TO DETERMINE THE ECOLOGICAL STATUS OF TRANSITIONAL AND COASTAL WATERS

Mean abundance (%) of ESG II \ Mean abundance (%) of ESG I	0 - 30	> 30 - 60	> 60
> 60	BAD	LOW	MODERATE
> 30 - 60	LOW	MODERATE	GOOD
0 - 30	MODERATE	GOOD	HIGH

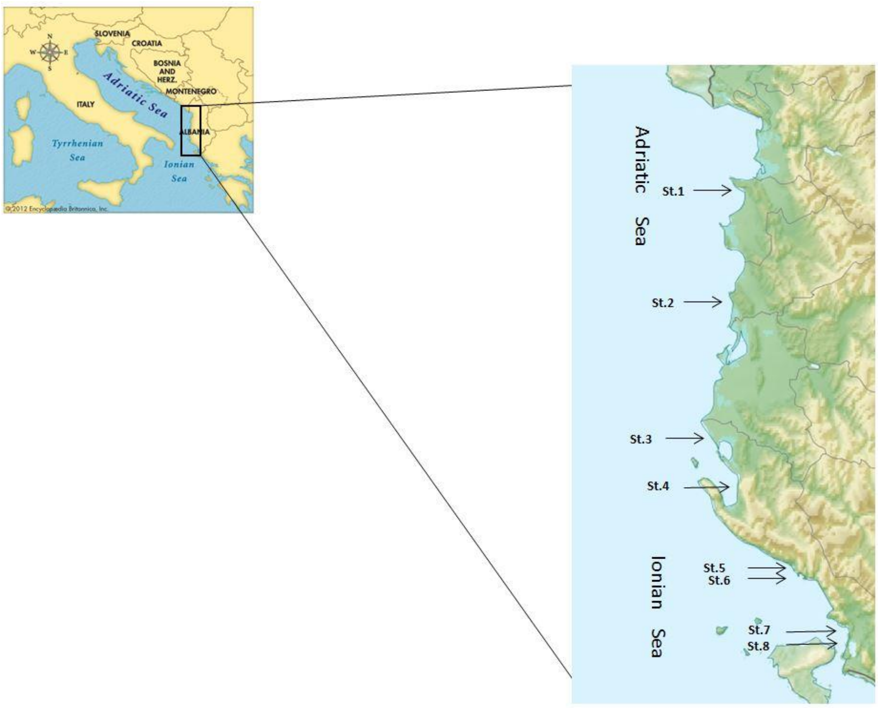
Marine benthic macroalgae are classified in two ecological state groups, ESG I and ESG II, which represents species groups in different ecological states, pristine and degraded. ESG I includes seaweed species with a thick or calcareous thallus, low growth rates and long life cycles (late successionals), whereas the ESG II includes sheet-like and filamentous seaweed species with high growth rates and short life cycles, opportunistic (Orfanidis et al., 2003). Depending on the mean abundance of species from these two groups in a given community, ecological categories (ESC) are detected ranging from 'bad' to 'high' ecological status of the community (Table 2).

The study area and sampling

The Albanian coastline has a total length of about 470 km, of which two thirds border Adriatic Sea and one third the Ionian Sea. The Adriatic coast is characterized by lowlands and wide coastal plains, created in part by sediments of several rivers. This zone is the most populated part of the country, and human impact, urbanization, water pollution and other activities have continuously degraded the natural values of the landscape.

The Ionian coastline is mostly rocky and deep, characterized by a high diversity of landscapes, steep and inaccessible cliffs, small bays and gravel beaches. In the Ionian coastal area there are only small traditional villages or towns. This area represents most valuable tourist resource for Albania, especially because of the many places of un-spoilt natural beauty.

FIGURE 1. MAP OF SAMPLED LOCATIONS ALONG ALBANIAN COASTLINE



Source: Encyclopaedia Britannica, Inc., Google Earth.

In this study destructive sampling was performed on macrophytobenthic populations of Chlorophyceae, Fucophyceae and Rhodophyceae of the upper infralittoral zone.

Eight stations (St.1 - Shen Pjeter, St.2 - Pl-Gjeneral, St.3 - Vl-Triport, St.4 - Vl-Jonufra, St.5 - H-Gji, St.6 - H-Potam, St.7 - Sarande Gji, St.8 - Sarande Manastir) were sampled seasonally (April, June and September/October of 2011 and 2012) in order to monitor different seasonal aspects of the vegetation (Figure1). St.1, St.2 and St.3 are located on Adriatic Sea while all other stations on Ionian Sea. All stations are characterized by rocky substratum with different coverage on macroalgae assemblages.

These stations were chosen to have different gradients of anthropogenic impact in order to observe the changes in functional groups of macroalgae. The higher anthropogenic impact is observed in St.4 where many constructions are build, St.5 which is a harbor and St.7 located in touristic area. The other stations have lower (St.2) or no impact (St.3, St.6, St.8). Sampling was performed on the upper infralittoral zone (0-60 cm) by using a quadrat 20cmx20cm (400 cm²) which is considered the representative minimal sampling area for infralittoral communities in the Mediterranean (Boudouresque, 1971).

ISSN: 1804-4999

Data analysis

At laboratory, before identification took place, material from the sample was poured at a dish 20x20 similar to the quadrat that was used for collection. The abundance of species was estimated as % cover in the sampling area (4 cm2 = 1% of the sampling area) in horizontal projection (Boudouresque, 1971). The total coverage by definition cannot exceed 100% while, because of macroalgal vertical stratification, total cover usually exceeds 100% (Bianchi et al., 2004). Macroalgae were identified at least to genus level. After they were classified into ESG I and ESG II according to Orfanidis et al. (2001), by calculating the pooled means of three replicates. Where identification down to species level was not possible, organisms were aggregated into groups of similar morphological and functional characteristics (Littler and Littler, 1984) in order to avoid artificial dissimilarity between stations thus not affecting the Ecological Evaluation Index.

The Shannon-Wiener species diversity index, H' (Shannon and Weaver, 1949) (by log *e* in the calculation), the Margalef species richness (d) (Legendre et al., 1976) and evenness, Pielou's J' (Pielou, 1975) (by log *e* in the calculation) were calculated, for each sampling station using each replicate's abundances higher than 0.2%. Calculations were done using PRIMER 5 software package (Clarke and Gorley, 2001).

Results

From the results 62 taxa were identified: 25 Fucophyceae, 22 Rhodophyceae and 15 Clorophyceae. Number of species varied from 16 species in St. 4 to 36 species identified in St.3. One species was found for the first time in the Albanian coasts, *Radicilingua thysanorhizans* (Holmes) Papenfuss.

During 2011 species richness (S) varied from 4 to 17. The lowest number found in Sept. for St.5 and St.7. St.5 had also the lowest evenness (J') 0.38 and the lowest Shannon-Wiener diversity (H') 0.52. The highest species richness was found in St.3 July. Shannon-Wiener diversity (H') was the highest in St.2 during April 2.23 together with the highest evenness 0.87.

From the comparison of ESG I mean coverage for the year 2011 (Table 3), an increasing ESC from April to September was detected in the majority of stations. In three stations, out of eight analyzed, ESC increased form low to moderate (St.2, St.3 and St.5), one station had ESC increased from moderate to good (St.6) and one station (St.8) had ESC increased from moderate to high. In addition station 1 (St.1) passed seasonally from moderate to low and again moderate ecological class and station 4 (St.4) had no changes in ESC with seasonality. For St.2 these changes were mainly related to high abundance of ESG II green macroalgae *Ulva laetevirens* in April which was substituted during July and September from high abundance of red ESG I macroalgae *Haliptilon virgatum*. In April St.3 was dominated by high abundance species *Gelidium crinale* and epiphytic species of ESG II which had lower abundance in July and September. These months were dominated by ESG I algae *Cystoseira compressa, C. crinita* and *Haliptilon virgatum*. Station 5 (St.5) had high abundance of ESG II sp. *Ulva laetevirens* in April which included it in low ESC while July and Sept. were characterized by higher number of ESG I species dominated by *Corrallina elongata* and *Jania rubens*. Moderate ESC values were found during April and July for station 6 (St.6) which had high number of species from both groups (ESG I and ESG II). Different situation was noticed in September where St.6 had good ESC value with high abundance of ESG I sp. *Jania rubens*. For St.8 ESC values for 'high' state were related to high presence of ESG I sp. *Jania rubens* during Sept.

During 2012 species richness (S) varied from 3 to 21. The lowest number was found in St.7 Oct. and the highest in St.3 April and Oct. together with the highest Shannon-Wiener diversity (H') in all three seasons: during April 2.39, July 2.24 and Sept. 2.39. The highest evenness 0.93 was found in St.5 Sept..The lowest Shannon-Wiener diversity (H') 0.44 was found in St.6 during Oct.

From the comparison of ESG I mean coverage for the year 2012 (Table 4), was also detected an increasing ESC from April to September/October in the majority of stations.

TABLE 3. ESTIMATION OF EEI AND THE EQUIVALENT ESC FROM THE ABUNDANCE OF ESG AT EACH STATION IN EVERY COLLECTED SEASON DURING 2011

Location	Mean coverage of ESG I (%)	Mean coverage of ESG II (%)	ESC	EEI	Spatial scale weighted EEI and equivalent ESCs
(St.1) Shen Pjeter_April	16	26	Moderate	6	[≤ 6 - >4] = Moderate
(St.1) Shen Pjeter_July	18	44	Low	4	[≤ 4 - >2] = Low
(St.1) Shen Pjeter_Sept.	16	11	Moderate	6	[≤ 6 - >4] = Moderate
(St.2)Plazhi I Gjener_April	31	40	Moderate	6	[≤ 6 - >4] = Moderate
(St.2) Plazhi I Gjener_July	21	22	Moderate	6	[≤ 6 - >4] = Moderate
(St.2) Plazhi I Gjener_Sept.	28	13	Moderate	6	[≤ 6 - >4] = Moderate
(St.3) Triport_April	16	43	Low	4	[≤ 4 - >2] = Low
(St.3) Triport_July	22	12	Moderate	6	[≤ 6 - >4] = Moderate
(St.3) Triport_Sept.	12	9	Moderate	6	[≤ 6 - >4] = Moderate
(St.4) Jonufra_April	28	7	Moderate	6	[≤ 6 - >4] = Moderate
(St.4) Jonufra_July	12	14	Moderate	6	[≤ 6 - >4] = Moderate
(St.4) Jonufra_Sept.	29	7	Moderate	6	[≤ 6 - >4] = Moderate
(St.5) Himare Port_April	12	50	Low	4	[≤ 4 - >2] = Low
(St.5) Himare Port_July	29	5	Moderate	6	[≤ 6 - >4] = Moderate
(St.5) Himare Port_Sept.	10	3	Moderate	6	[≤ 6 - >4] = Moderate
(St.6) Himare Potam_April	18	19	Moderate	6	[≤ 6 - >4] = Moderate
(St.6) Himare Potam_July	24	20	Moderate	6	[≤ 6 - >4] = Moderate
(St.6) Himare Potam_Sept.	37	9	Good	8	[≤ 8 - >6] = Good
(St.7) Sarande Gji_May	34	21	Good	8	[≤ 8 - >6] = Good
(St.7) Sarande Gji_July	7	37	Low	4	[≤ 4 - >2] = Low
(St.7) Sarande Gji_Sept.	23	5	Moderate	6	[≤ 6 - >4] = Moderate
(St.8) Sarande Manastir_May	60	85	Moderate	7	[≤ 6 - >4] = Moderate
(St.8) Sarande Manastir_July	44	20	Good	8	[≤ 8 - >6] = Good
(St.8) Sarande Manastir_Sept.	63	8	Very good	10	[≤ 10 - >8] = Very good

TABLE 4. ESTIMATION OF EEI AND THE EQUIVALENT ESCS FROM THE ABUNDANCE OF ESGS AT EACH STATION IN EVERY COLLECTED SEASON DURING 2012

Location	Mean coverage of ESG I (%)	Mean coverage of ESG II (%)	ESC	EEI	Spatial scale weighted EEI and equivalent ESCs
(St.1) Shen Pjeter_May	19	39	Low	4	[≤ 4 - >2] = Low
(St.1) Shen Pjeter_July	31	32	Moderate	6	[≤ 6 - >4] = Moderate
(St.1) Shen Pjeter_Sept.	25	35	Low	4	[≤ 4 - >2] = Low
(St.2)Plazhi I Gjener_April	17	53	Low	4	[≤ 4 - >2] = Low
(St.2) Plazhi I Gjener_July	26	17	Moderate	6	[≤ 6 - >4] = Moderate
(St.2) Plazhi I Gjener_Sept.	56	58	Moderate	6	[≤ 6 - >4] = Moderate
(St.3) Triport_May	14	56	Low	4	[≤ 4 - >2] = Low
(St.3) Triport_July	39	30	Good	8	[≤ 8 - >6] = Good
(St.3) Triport_Oct.	22	42	Low	4	[≤ 4 - >2] = Low
(St.4) Jonufra_May	19	6	Moderate	6	[≤ 6 - >4] = Moderate
(St.4) Jonufra_July	16	5	Moderate	6	[≤ 6 - >4] = Moderate
(St.4) Jonufra_Oct.	32	3	Good	8	[≤ 8 - >6] = Good
(St.5) Himare Port_May	5	21	Moderate	6	[≤ 6 - >4] = Moderate
(St.5) Himare Port_Aug.	9	11	Moderate	6	[≤ 6 - >4] = Moderate
(St.5) Himare Port_Oct.	10	7	Moderate	6	[≤ 6 - >4] = Moderate
(St.6) Himare Potam_May	10	15	Moderate	6	[≤ 6 - >4] = Moderate

ISSN: 1804-4999

TABLE 4. ESTIMATION OF EEI AND THE EQUIVALENT ESCS FROM THE ABUNDANCE OF ESGS AT EACH STATION IN EVERY COLLECTED SEASON DURING 2012

Location	Mean coverage of ESG I (%)	Mean coverage of ESG II (%)	ESC	EEI	Spatial scale weighted EEI and equivalent ESCs
(St.6) Himare Potam_Aug.	46	1	Good	8	[≤ 8 - >6] = Good
(St.6) Himare Potam_Oct.	38	0.5	Good	8	[≤ 8 - >6] = Good
(St.7) Sarande Gji_May	15	30	Moderate	6	[≤ 6 - >4] = Moderate
(St.7) Sarande Gji_Aug.	5	31	Low	4	[≤ 4 - >2] = Low
(St.7) Sarande Gji_Oct.	38	8	Good	8	[≤ 8 - >6] = Good
(St.8) Sarande Manastir_May	24	26	Moderate	7	[≤ 6 - >4] = Moderate
(St.8) Sarande Manastir_Aug.	67	32	Good	8	[≤ 8 - >6] = Good
(St.8) Sarande Manastir_Oct.	86	0.2	Very good	10	[≤ 10 - >8] = Very good

More specifically, in St.2 ESC increased from low state to moderate state mainly due to decrease of red algae *Rytiphlaea tinctoria*. St.4 changed ESC from moderate during April and July to good state during Oct. due to the presence of red macroalgae *Jania rubens*. The same macroalgae increased ESC from moderate to good in St.6 and from good to high in St.8. In St.5 were detected no changes from moderate ESC with seasonality. Meantime St.1, St3. and St.7 had no specific trend of ESC with seasonality but high presence of *Cystoseira compressa and Jania rubens*, both ESG I, were found during July in St.1 and St.3 making this the season with the highest ESC for these stations. In contrary St.7 in July had low ESC due to high abundance of ESG II specie *Gelidium spinosum*.

Discussion

In general, the usage of macroalgae communities along Albanian rocky shore sites as bioindicators of water quality reflects differences in revers soil/nutrient input and anthropogenic disturbances between Adriatic and Ionian Sea. Rivers inflow to Adriatic Sea stations are higher than Ionian Sea. During heavy rain season (April and September) soil and nutrient input increases giving the opportunity to macroalgae with structural and functional characteristic of ESG II, like *U. laetevirens* (Arévalo et al., 2007) and *R. tinctoria,* to have higher abundance in these sites. The high dynamic of macroalgae communities compositions in Adriatic stations, reflects also in higher ESG II macroalgae species number and diversity.

Moreover, anthropogenic impact (urbanisation, touristic activities) plays a major role in macroalgae species composition and distribution by shifting ecosystems from pristine to degraded state, where opportunistic species dominate (Orfanidis et al., 2001), affecting in this way ecological quality of waters (Mangialajo et al., 2007). This impact can be seen in the macroalgae identification analysis of St.5, St.6 and St.7 which are all in Ionian Sea. St.5 is a harbour with high human disturbance during the year and high abundance of *Ulva laetevirens*, a species that reflects high organic pollution to marine vegetation (Arévalo et al., 2007; Pinedo et al., 2007). St.6 has no human influence and the site has a continuous water circulation related to nearby Bistrica river, with very clean water, giving the opportunity to macroalgae with structural and functional characteristic of ESG I, like *Jania rubens*, to have higher abundance. ESC in St.6 showed seasonal ecological state moderate to state good. St.7 is characterized by high human impact (touristic activities) during July as the station is located below vacation hotels in the beach exposing this station to sewage input. During both years of sampling, July had the lowest ESC as a result of *Gelidium spinosum* (macroalgae of ESG II) found in high abundance by being so the main species for ranking the station with "low" ESC.

According to the results of the studied sites we can conclude that using composition of macroalgae communities as bioindicators of water quality, reflected an ecological status which varied temporary and spatially. A gradient of ecological status from "low" to "high" was generally noticed spatially passing from north (Adriatic Sea) to south (Ionian Sea) stations. This gradient can be attributed to soil/nutrient input by rivers that are higher in Adriatic Sea stations and lower in Ionian Sea stations. Temporary, anthropogenic disturbance reflects its impact in macroalgae communities shifts from ESG I to ESG II species.

References

Arévalo R., Pinedo S. and Ballesteros E., 2007. "Changes in the composition and structure of Mediterranean rocky-shore communities following a gradient of nutrient enrichment: Descriptive study and test of proposed methods to assess water quality regarding macroalgae", Marine Pollution Bulletin, Vol.55 (1-6), pp.104-113

Asnaghi V., Chiantore M., Bertolotto R.M., Parravicini V., Cattaneo-Vietti R., Gaino F., Moretto P., Privitera D. and Mangialajo L., 2009. "Implementation of the Euro-pean Water Framework Directive: natural variability associated with the CARLIT method on the rocky shores of the Ligurian Sea (Italy)", Marine Ecology-an Evo-lutionary Perspective, Vol.30, pp.505-513

Bianchi C.N., Pronzato R., Cattaneo-Vietti R., Benedetti Cecchi L., Morri C., Pansini M., Chemello R., Milazzo M., Fraschetti S. and Terlizzi A. et al., 2004. "Hard bottoms. In Mediterranean Marine Benthos: A Manual of Methods for its Sampling and Study", In: Gambi, M.C. and Dappiano, M. (Eds.), Societa` Italiana di Biologia Marina, Vol.11, Genova, pp.185-215

Boudouresque C.F., 1971. "Méthodes d' etude qualitative et quantitative du benthos (en particulier du phytobenthos)", Téthys, Vol.1, pp.79-104

Clarke K.R., and Gorley R.N., 2001. "PRIMER v5: User manual/tutorial", Plymouth, UK: Primer-E Ltd., Plymouth Marine Laboratory, pp.91

Dı´az R.J., Solan M. and Valente R.M., 2004. "A review of approaches for classifying benthic habitats and evaluating habitat quality", Journal of Environmental Management, Vol.73, pp.165-181

Iveša L., Lyons D.M. and Devescovi M., 2009. "Assessment of the ecological status of north-eastern Adriatic coastal waters (Istria, Croatia) using macroalgal assemblages for the European Union Water Framework Directive", Aquatic Conservation: Marine Freshwater Ecosystem, Vol.19, pp.14-23

Legendre L. and Legendre P., 1976. "E´ cologie nume´rique. I: Le traitement multiple deˆs donne´es e´cologiques", Masson, Paris

Littler M.M. and Littler D.S., 1984. "Relationships between macroalgal functional form groups and substrata stability in a subtropical rockyintertidal system", Journal of Experimental Marine Biology and Ecology, Vol.74, pp.13-34

Mangialajo L. Ruggieri N. Asnaghi V. Chiantore MC. Povero P. Cattaneo Vietti R., 2007. Ecological status in the Ligurian Sea: the effect of coastline urbanisation and the importance of proper reference sites, Marine Pollution Bulletin, Vol.55, pp.30-41

Orfanidis S., Panayotidis P. and Stamatis N., 2001. "Ecological evaluation of transitional and coastal waters: a marine benthic macrophytes-based model", Mediterranean Marine Science, Vol.2, No.2, pp.45-65

Orfanidis S., Panayotidis P. and Stamatis N., 2003. "An insight to the ecological evaluation index (EEI), Ecological Indicators, Vol.3, pp.27-33

Orlando-Bonaca M., Lipej L. and Orfanidis S., 2008. "Benthic macrophytes as a tool for delineating, monitoring and assessing ecological status: the case of Slovenian coastal waters", Marine Pollution Bulletin, Vol.56, No.4, pp.666-676

Panayotidis P., Tsiamis K. and Salomidi M., 2007. "Ecological quality of coastal waters: a case study in Saronikos Gulf (Attica, Greece)", Proceedings of the 10th International Conference on Environmental Science and Technology, 5-7 September, Kos Island, Greece

Pielou E.C., 1975. "Ecological Diversity", John Wiley and Sons, New York, pp.165

Pinedo S., Garcia M., Satta M.P., De Torres M. and Ballesteros E., 2007. Rocky shore communities as indicators of water quality: A case study in the Northwestern Mediterranean. Marine Pollution Bulletin, 55 (1-6), pp.126-135

Shannon C.E. and Weaver W., 1949. "The Mathematical Theory of Communication" University of Illinois Press, Urbana, Illinois, pp.177

ISSN: 1804-4999