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Ecology and distribution of macrophytic red algae from the Romanian Black Sea coast

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ABSTRACT: The unique nature of the Black Sea, as the Europe's most isolated marine area, has as consequence the existence of a unique ecosystem, which was considered relatively stable until four decades ago. From the late 1960-s until now, various events affected the biological diversity and living resources. The Black Sea ecosystem, in its NW corner, has changed under the influence of human activities. Taking in consideration, a new approach of such studies is absolutely necessary in order to estimate the major modifications that occurred in the state of macrophytobenthos, under the influence of harmful factors that disturbed the quality of marine environment and biodiversity. The present paper shows the data obtained after a 10 year long survey, compared with previous data, in order to point out the changes of this major component of the ecosystem. The red algae were collected from various types of hard substratum. From each sample, algae were identified and representative individuals were kept for the herbarium collection. The biomass estimation was also made. Due to the new created ecological conditions, the actual algal communities consist of a small number of species, which show considerable biomass: some of them display a degree of cover up to 80%. Appropriate ways of conservation would be the improvement of physico-chemical conditions of coastal waters and maintenance of the under water marine reserve "Vama –Veche" in the south part of Romanian coast.

Key words: Romanian Black Sea coast, macrophytobenthos, red algae, Rhodophyta

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INTRODUCTION

The unique nature of the Black Sea, as the Europe's most isolated marine area, has as consequence the existence of a unique ecosystem, which was considered relatively stable until four decades ago. From the late '60-s until now, events occurred that affected the biological diversity and living resources (Bologa *et al.* 1995).

The Black Sea ecosystem, in its NW corner, has changed under the influence of human activities (Zaitzev & Mamaev 1997; Bologa 2001).

Unfortunately very few research has been carried out today regarding the present state of the macroalgal flora (Sava *et al.* 2003; Bologa & Sava 2006). Taking in consideration, a new approach of such studies is absolutely necessary in order to establish the major modifications that occurred in the state of macrophytobenthos, under the influence of harmful factors that disturbed the quality of marine environment and biodiversity.

MATERIAL AND METHODS

Sampling stations. One of the most important conditions for the development of macrophytes is the presence of a hard substratum, of various types. Therefore, the selection of study sites considered as principal criteria the presence of a rocky, natural or artificial bottom. In some cases, the algae were collected from the shells of mussels that

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covered the whole surface of rocky bottoms. The location of the sampling station covered a length of over 60 km, between Constanta to 2 Mai, close to Bulgarian border (table 1., fig. 1).

The research has been carried out between 1996 and 2007, in different periods of the year, both in warm and in cold season, in order to collect macroalgal species that develop all year round together with the species that could only be found in certain periods of the year.

Qualitative determinations. Samples for qualitative determinations have been collected from various depths between 0.5 and 3 m, in plastic bags, together with a label, mentioning place and time of collection. All samples were brought fresh in the laboratory, carefully washed from sediments and associated fauna, and sorted out in three main groups: Chlorophyta (green algae), Phaeophyta (brown algae) and Rhodophyta (red algae). Species identification was made macroscopically where possible, but for difficult genera, microscopic examination was necessary. Scientific papers and special determination key for macroalgae were used (Athanasiadis 2001; Bouduresque *et al*. 1992; Celan & Serbanescu 1959; Peterfi & Ionescu 1979; Sava 2006). Representative individuals were kept for herbarium collection of the Constanta University.

Quantitative measurements. For accurate results regarding the major modification of the macrophytobenthos, quantitative determinations are also necessary giving the possibility to appreciate biomass dynamics of these algae during the last years, comparative with previous decades.

The method used for quantitative measurements is a classical one, and in order to be adequate, certain requirements were respected, taking in consideration that sometimes sampling can be difficult. This is due to irregular and diverse type of substratum. However, algal samples must be representative for the studied algal population.

In present work, the method of squares was used, using a metallic frame that covered a surface of 100 cm^2. Three samples were collected from each station, transect and depth and each one was introduced in plastic bags and labelled. Samples were brought fresh into the laboratory, washed for the associated fauna and sediments, and dried in oven at 105°C. The estimation of biomass was calculated from the mean weight of the three samples and appreciated as dry weight.

RESULTS AND DISSCUTION

Qualitative results. In the samples collected during ten years of study, 10 Rhodophyta were found, as shown in the following list.

Fig. 1. The location of sampling stations along the Romanian Black Sea coast

RHODOPHYTA

Ordo BANGIALES
- Fam. Bangiaceae
  1. *Porphyra leucosticta* Thur.(Fig.2)
  2. *Bangia fuscopurpurea* (Dillw.) Lyngb.

Ordo CRYPTONEMIALES
- Fam. Corallinaceae
  1. *Corallina officinalis* L.

Ordo RHODIMENIALES
- Fam. Champiaceae
  1.*Lomentaria clavellosa* (Thurn.) Gail.

Ordo CERAMIALES
- Fam. Ceramiaceae
  1. *Ceramium rubrum* (Huds.) C. Ag. (Fig.3)
  2. *Ceramium elegans* (Roth.) Ducl.
  3. *Ceramium diaphanum* (Lightf.) Roth.
  4. *Callithamnion corymbosum* (Ducl.) Ag.
- Fam. Rhodomelaceae
  1. *Polysiphonia elongata* (Huds.) Harv.

Ordo GIGARTINALES
- Fam. Phyllophoraceae
  1. Phyllophora pseudoceranoides (Gmel.) Newr. et A.Tayl. (syn. *P. membranifolia* (Good. et Wood.) J. Ag

Table 1. Sampling stations of macrophytobenthos, with indication of transects and depths

No.	Sampling station	Transect	Bottom type	Sampling depth
1.	Constanta	Cazino	Rocky -natural	0.5 to 1 m
		Trei Papuci	Rocky- natural	0.5 to 1 m
		Pescarie	rocky / tetrapods natural and artificial	0.5 to 4 m
2.	Agigea		rocky -natural	0.5 to 1 m
3.	Eforie Nord		rocky / tetrapods – natural and artificial	0.5 to 1 m
4.	Eforie Sud		dam	0.5 to 3 m
5.	Costinesti		rocky- natural	0.5 to 3 m
6.	Mangalia		rocky / tetrapods –natural and artificial	0.5 to 3 m
7.	2 Mai		Rocky –natural	0.5 to 5 m

Table 2. Number of macroalgal red species along the Romanian Black Sea coast identified between 1977 and 2002

Authors/number of species	Bavaru, 1977 (Bavaru, 1977)	Vasiliu, 1980-1995 (Vasiliu, 1996)	Sava,1995-2002 (Sava, 2002)
	41	**24**	**10**

Compared with previously reported results, it is very evident that the number of species decreased over the years (table 2).

Analysing both the present list and the table, several observations result:

- about the exact number of species of red macrophytes, opinions differ from author to author, as a result of incertitudes created by some forms and varieties and by the consideration of microscopic forms;
- red algae are sensitive to pollution and their number has also decreased over the years, but some genera of red algae (*Ceramium*) can also develop in eutrophic waters, sometimes covering the hard substratum up to 90%;
- another obvious fact is the lack of perennial species: only one such species was found in the samples (*Polysiphonia*). *Phyllophora* sp. has been found in various locations along the shore during field trips, on the beach, teared out from their rocky bottom probably during storms;
- the positive sign that can be pointed out is the reappearance of species that were considered lost for many years, such as *Lomentaria clavellosa*, but unfortunately, no exact data about its location and biomass could be achieved, as the thalli were collected from the beach, teared away from the rocky bottom.

It is evident that the benthic algal flora has endured a gradual, but continuous decline and the accentuation of this decline is not only due to natural factors but mainly to anthropogenic ones. Also, another important feature is the uniform aspect of the present vegetation and the fact that the new algal communities consist of a very small number of species. Nevertheless some of them evinced considerable biomass.

Fig. 2. *Porphyra leucosticta* Thur.

Table 3. Total biomass of Rhodophyta (red algae) between 2000 and 2005 (g/m^3)

Year	Red algae g/m^3
2000	17,845
2001	17,910
2002	20,802
2003	18,010
2004	21,772
2005	7,830
TOTAL	104,169

Quantitative results. The qualitative data are completed with quantitative ones, recorded between 2000-2005 allowing a better understanding of the structure and functioning of the algal populations. The evolution of biomass since 2000 is indicated in the table 3.

The maximum value of biomass of the red algae (21,722 g/m^2) occurred in 2004, with slightly differences compared with previous years, whereas in 2005 a reduced biomass was significant, with more than half values registered, compared to thatones observed in 2000. This situation could be related to the amelioration of the marine ecosystem state along the Romanian shore in recent years, that could have beneficial consequences on the whole algal vegetation.

Usually high biomass of green algae were registered at Romanian shore, due to species belonging to the genera *Ulva*, *Enteromorpha* and *Cladophora* that develop all year round, together with *Ulothrix* and *Urospora* that develop only during the cold season (spring and autumn). Thus, it has to be point out that high biomasses of red algae are almost entirely owed to the species of *Ceramium*, found on rocky bottom the entire year. During the spring time, *Porphyra*, and sometimes *Polysiphonia* and *Callithamnion* contributed quantitatively. Only in the warm season these last two mentioned species were found in appreciable quantities in samples. This can be explained by high capacity of both asexual and sexual reproduction in *Ceramium* species. So they can easily and quickly populate the rocky bottoms, sometimes even completely.

CONCLUSIONS

Due to severe environmental degradation of the Black Sea ecosystem in general and of its NW sector in special, macrophytobenthos deserve a notable attention, as a key component of coastal waters.

The impoverishment of the vegetation, started in the 1950's and became very evident since 1970, is due to known natural and human causes which deteriorated the quality

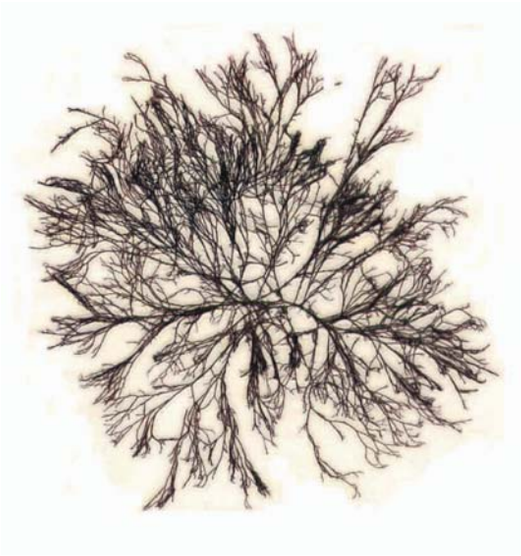

Fig. 3. *Ceramium rubrum* (Huds.) C. Ag.

of the marine environment (massive frosts registered in some years, progressive degradation of the marine coastal environment due to erosion, impurification of seawater quality due to increasing eutrophication, extension of hypoxia and even anoxia.

These changes affected not only the macrophytobenthos, but all biological components of the ecosystem, e.g. the structure and the functioning of benthic and pelagic communities, as well the qualitative and quantitative state of all phyto and zoocommunities.

Anthropogenic disturbances are still present, changing, directly and indirectly the ecosystem and community structure, by replacement of some phytocoenoses by others.

Recent observations confirmed: qualitative decline (lower number of species), the almost disappearance of perennial species (brown and red algae, especially) this fact has as a consequence disappearance of associated or epiphytic species and the uniformity of algal belts, that consist mainly of opportunistic species with a short life cycle.

The Romanian Black Sea coastal zone has been subjected to severe ecological disturbance during the last five decades; as a result of complex and multiple anthropogenic pressures together with unfavourable natural factors, a considerable reduction of macroalgal species within the general decline of biodiversity took place.

Future needs for improving the existing situation may consider:

- continuous biodiversity monitoring in order to enable observations of all changes that might occur,
- continuous observation of the evolution of physical and chemical parameters of shallow waters, with

valuable information upon the environment quality but also upon the expected amelioration of the marine ecosystem state,
- implementation of the projects for rapid but realistic rehabilitation programmes,
- the maintenance of the Marine Reserve 2 Mai –Vama Veche in the south part of he Romanian Black Sea coast, and its extension across the Bulgarian border, in order to extend the interest in conserving biodiversity in both countries, and increasing the possibility of more sound related projects and reconstruction plans.

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REZIME

Ekologija i rasprostranjenje crvenih makroalgi duž obale Crnog Mora u Rumuniji

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Crno more, najizolovanija marinska oblast u Evropi, predstavlja jedinstveni ekosistem. Od šestdesetih godina do danas ovde je došlo do promena biološkog diverziteta i prirodnih resursa. U severo-zapadnom delu obale ekstenzivne promene se dešavaju pod uticajem čoveka. U ovom radu porede se podaci sakupljeni poslednjih 10 godina sa onima od ranije koji se tiču makrofitskog bentosa, da bi se ukazalo na promenu ove važne komponente ekosistema. Sakupljene su crvene alge sa različitih čvrstih supstrata. Uzorci su određeni i sačuvani u harbarskim kolekcijama. Urađena je i procena biomase. Rezultati pokazuju da se u novonastalim ekološkim uslovima javljaju zajednice algi sa manjim brojem vrsta, pri čemu pojedine vrste čine veliki deo biomase i bentosnog pokrivača (do 80%). Odgovarajuće mere zaštite su neophodne radi unapređivanja fizičko-hemijskih uslova vode priobalja, kao i radi održavanja marinskog rezervata "Vama –Veche" u južnom delu rumunske crnomorske obale.

Ključne reči: Rumunska crnomorska obala, makrofitobentos, crvene alge, Rhodophyta