PROGRESSIVE DECLINE AND PRESENT TREND OF THE ROMANIAN BLACK SEA MACROALGAL FLORA

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ABSTRACT

The importance of the macrobenthic flora – algae and phanerogames – in the general bioproductivity of the marine environment, especially in shallow waters, became more and more evident from both ecological and economic point of view.
The causes of the progressive quantitative and qualitative decline of the macrophytobenthos starting in the '50ies to '60ies lie in the synergic action of several unfavourable natural and anthropogenic factors which became more prominent since 1970.
The general eutrophication of the Black Sea waters, especially along the Romanian coast, as a direct consequence of the Danubian nutrient input and the main N-S circular current, has to be considered particularly between 1960 and 1990.
The assessment of the present trend of the marine macroalgoflora is based on historical data (dating back in 1935) and updated field data until nowadays.
Basically, starting with 1990, in spite of diminished number of species, during the last decades a trend of quantitative recovery of some more tolerant Chlorophyta and Rhodophyta to persistent eutrophication has been registered as considerable biomasses, on several beaches between Mamaia (in spite of sandy bottom) and Vama Veche, e.g. in 2003 and at a lower extent in 2004.
Some species considered until recently as disappeared, such as *Lomentaria clavellosa* (Rhodophyta), have been found again.
Most common green algae (*Ulva* and *Enteromorpha*) intensely developed high quantities, especially at the southern Romanian shore, until 2005.

KEY WORDS: Black Sea, Romanian shore, macrophytobenthos, decline, present trend

INTRODUCTION

The complex and numerous implications of the marine macroalgal flora, such as population explosion / decline, biodiversity, involvement in nutrient's removal in a natural environment, efficiency as water cleaning agent, living resource aimed at food, industrial and medical uses, etc., have been often reviewed (e.g. CHARLIER and MORAND, 2003, MORAND and MERCERON, 2005).

The importance of the macrobenthic flora – algae and phanerogames – in the general bioproductivity of the marine environment, especially in shallow waters, became more and more evident from both ecological and economic point of view (BOLOGA, 1986).

Along the Romanian Black Sea shore, the compact, discontinuous and variable rocky bottom characterizes the supra-, medio-, and infralittoral between Cap Midia (44^0 $20^{'}$ N) and Vama Veche (43^0 $45^{'}$ N). This substratum constitutes the most varied environment of the benthic domain. The macrophytes constitute at their turn another peculiar living substratum. The interspecific relationships between benthic macro- and microphytes, as well as between those and associated fauna, enable ample ecological interrelations.

The rocky supralittoral of the Romanian shore – of sarmatic limestone – is less interesting as to macrophytes.

The rocky mediolittoral has special features in the Black Sea, with a width comprised between 2 and 10 m. The qualitative enrichment of the macroflora starts with depth. Representative for these depths are populations of *Enteromorpha intestinalis* (L.) Link and *E. linza* (L.) J. Ag. during the whole year, and those of *Porphyra leucosticta* Thur. in winter.

The rocky infralittoral shows a biotope with large physical variations, as to the aspect and extension of the substratum. The substratum offered by the algoflora allows the installation of the associated fauna, according to the duration of this living substratum. For example, the species *Cystoseira barbata* (Good. et Wood.) Ag., *Laurencia coronopus* J. Ag., *Phyllophora brodiaei* (Turn.) J. Ag., *Ph. membranifolia* (Good. et Wood) J. Ag. and *Ph. nervosa* (DC) Grev. are perennial, and others seasonal.

The Black Sea macroalgoflora totalized by 1967 277 species out of which 74 Chlorophyta, 3 Xanthophyta, 71 Phaeophyta and 129 Rhodophyta (ZINOVA, 1967). Two species of monocotyledonatae higher plants, *Zostera marina* L. and *Z. nolti* (syn. *Z. nana* Roth.) have to be added to this inventory.

Some 30 years later, along the Romanian marine shore only a total of 143 macrophytes (45 Chlorophyta, 2 Xantophyta, 27 Phaeophyta, 69

Rhodophyta) and the above mentioned *Zostera* species have been recorded (BAVARU *et al.*, 1991).

This impoverishment was noticed in many rocky bottom areas (CELAN, 1977, 1981; CELAN and BAVARU, 1973, 1978; CELAN *et al.*, 1979; CELAN and BOLOGA, 1983; SKOLKA *et al.*, 1980; BAVARU, 1970, 1981; BAVARU and VASILIU, 1985; BOLOGA, 1989; SAVA *et al*., 2003) and can be considered within the general ecological unbalance which determines the present decrease of biodiversity in the Black Sea and especially in its north-western part (GABLE, 2000; BOLOGA, 2002; BOLOGA *et al*., 1995).

The causes of this alarming decline of the macroalgal vegetation lie in the synergic action of several natural and anthropogenic unfavourable factors which became more prominent in the above mentioned decades.

Massive frosts in the winters 1971/72, 1978/79 and 1984/85 (BAVARU, 1988) as well as occasionaly more recently (Fig. 1), caused the freezing of shallow waters up to the horizon, for several months, creating an unusual Arctic look. The movement of the created ice blocks have "mowed" the still existing large belts of *Cystoseira barbata* and *C. crinita* f. *bosphorica* (Sauv.) Zinova et Kalugina (syn. *C. bosphorica* Sauv.). These two perennial brown algae have previously populated the rocky bottom at depths between 1 to 5-6 m, developing a large biocoenosis of associated flora and fauna. The ecological role and the concomitant special economic importance of these algal fields have been severly affected by their quantitative decline.

Mainly between 1970 and 1980 the silting of the rocky bottom of the southern part of the Romanian littoral due to hydrotechnical works (dams, extension of harbours, new touristical stations) caused a major anthropogenic impact. High quantities of suspended solid matter (limestone, clay, a.o. terrigen materials) clogged the substratum, preventing most macrophytes from populating these biotopes.

In addition, the decline of the quality of sea water, especially the increase in turbidity and the implicit decrease of light penetration into the water column, have profoundly altered the normal development of the macroalgoflora.

Fig. 1 - Recent frost at Constanta / Trei Papuci beach in January, 2005

The general eutrophication of the Black Sea waters, especially along the Romanian coast, as a direct consequence of the Danubian nutrient input and the main N-S circular current, has to be added particularly since the '60ies until the '90ies.

The previous continuously recorded increasing eutrophication, seriously harming all marine life, has only favoured a few number of more tolerant genera, such as *Enteromorpha* Link, *Cladophora* Kutz., *Ceramium* Roth., which presently fill all available niches.

The phenomenon described as "eclipses" (CELAN, 1989) and including the temporary disappearance and subsequent re-appearance of some species is characteristic for the Black Sea and can also be noted along the Romanian littoral.

The inventory of benthic macrophytes along the Romanian shore was reviewed end of the '90ies, with respect to the categories proposed by the International Union for Conservation of Nature (IUCN). On this basis, and considering national concerns regarding endangered species, a comprehensive red list of extinct and endangered, rare and insufficiently known benthic macrophytes from the Romanian Black Sea sector has been compiled

(BOLOGA and BAVARU, 1998/99). Out of the total of those previously recorded 143 species, the list comprised:

- 24 extinct and endangered species (6 Chlorophyta, 6 Phaeophyta, 12 Rhodophyta),
- 42 rare species (13 Chlorophyta, 2 Xanthophyta, 9 Phaeophyta, 18 Rhodophyta),
- 4 insufficiently known species (1 Phaeophyta, 3 Rhodophyta).

Nevertheless certain recent achievements regarding biodiversity (PETRANU *et al*., 1997) and the necessity of its protection and conservation along the Romanian littoral have also considered the quantitative and qualitative decline of the macrophytobenthos (ABAZA *et al*., 2004).

The present paper updates field research results on the distribution and development trends of the Romanian Black Sea macroalgal flora resumed after 1990, in agreement with recent findings on the recent changes in the state of the marine ecosystem (NICOLAEV *et al*., 2004).

MATERIAL AND METHODS

Sampling stations

The development of marine macroflora is influenced by numerous natural and anthropic factors. Among the natural ones, the nature of the bottom is very important. Therefore, as the substratum decisively conditions the distribution of macrophytobenthos, the algae have been sampled along the southern rocky sector of the Romanian shore, from several stations / transects (Table 1, Fig. 2).

Table 1

Sampling stations of macrophytobenthos, with indication of transects and depths

No.	Sampling station	Transect	Natural /artificial bottom type	Sampling depth
1	Constantza	Cazino (Fig. 3)	Rocky	0.5 to 1 m
		Trei Papuci (Fig. 4)	Rocky	0.5 to 1 m
		Pescarie (Fig. 5)	Rocky / tetrapods	0.5 to 4 m
2	Agigea		Rocky	0.5 to 1 m
3	Eforie Nord		Rocky / tetrapods	0.5 to 1 m
4	Eforie Sud		Dam	0.5 to 3 m
5	Costinesti (Fig. 6)		Rocky	0.5 to 3 m
6	Mangalia		Rocky / tetrapods	0.5 to 6 m
7	2 Mai (Fig. 7)		Rocky	0.5 to 5 m

Fig. 2 - The Romanian Black Sea coast with seaweed sampling stations

Fig. 3 - Rocky bottom off Constantza Cazino

Fig. 4 - Rocks with seaweeds at Constantza – Trei Papuci

Fig. 5 - Rocky bottom next to the dam at Constantza – Pescarie

Fig. 6 - Rocky bottom at Costinesti

Fig. 7 - Rocky bottom at 2 Mai

Sampling of algal material has been carried out between 1996-2005, several times a year, in both cold and warm seasons, in order to get informed on all vegetation periods.

Both qualitative and quantitative assessments have been undertaken (Fig. 8).

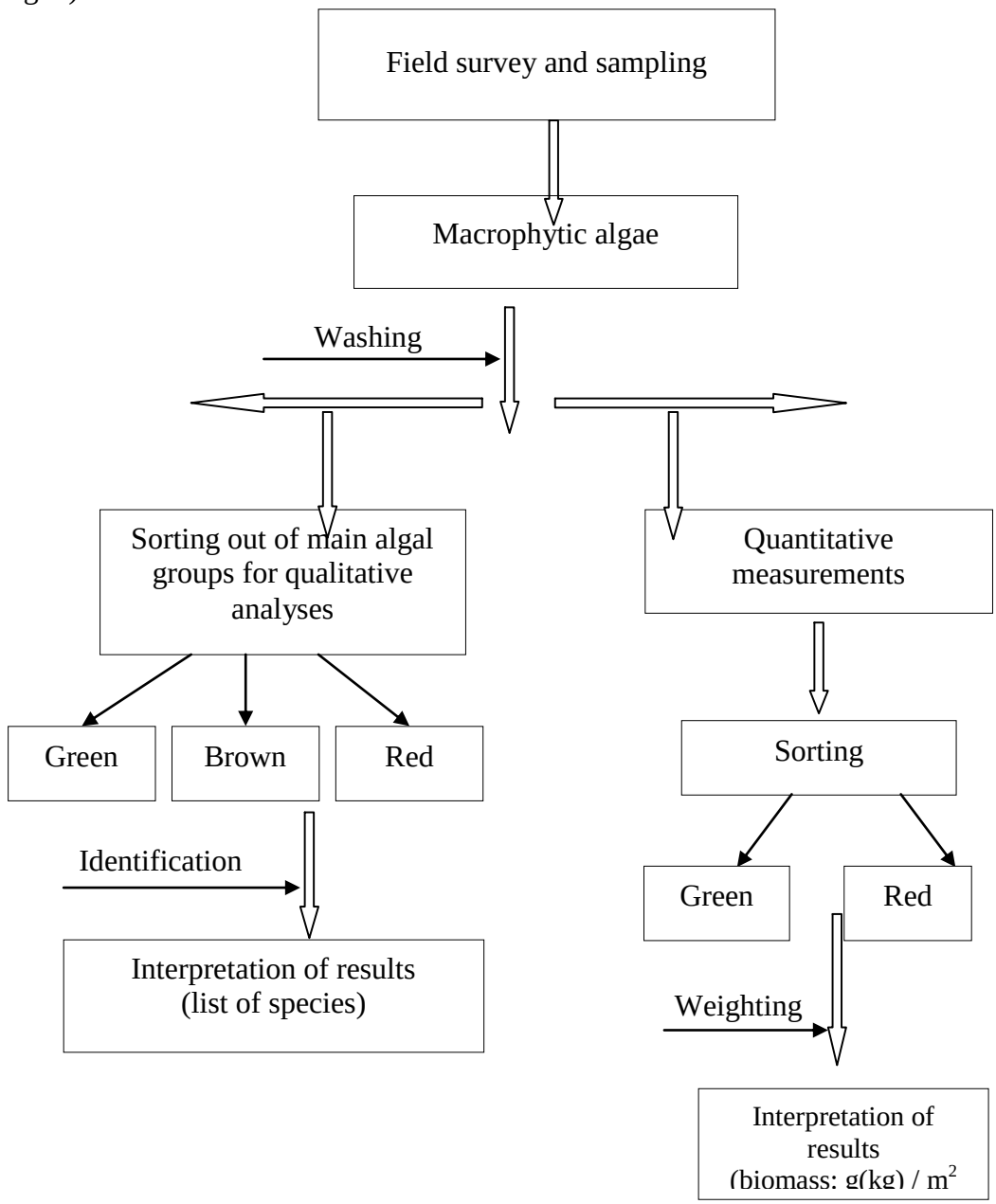

Fig. 8 - Schematic work methods

Qualitative determinations

For qualitative determinations algae have been collected from dephts between 0.5 to 6 m. Samples have been collected in plastic bags and labeled (place and time of collection). Fresh algal samples have been brought into the laboratory and washed for sediments and associated fauna. They have been sorted out according to the main algal groups: green (Chlorophyta), brown (Phaeophyta) and red (Rhodophyta). After species identification, significant examplaires have been kept in herbarium collection.

The fresh algae have been determined by means of algological handbooks and scientific literature (CELAN and SERBANESCU, 1959; BLIDING, 1963; HOECK, 1963; PETERFI and IONESCU, 1976, 1977, 1979, 1981; FISCHER *et al*., 1987; BOUDOURESQUE *et al*., 1992; GODEANU, 1995; ATHANASIADIS, 2001; KRISTIANSEN, 2001; PEDERSEN, 2001). Whenever possible species identification has been achieved based on macroscopic characteristics, but for more difficult genera, such as *Cladophora, Enteromorpha, Ceramium*, by microscopic ones.

Quantitative measurements

Due to intense anthropic activities along the Romanian littoral during the last 20 to 25 years and related changes of biocoenosis structure in general, the macrophytobenthos has suffered quantitative modifications as well.

Therefore, beside the species identification, an assessment of the biomass dynamics of these algae during the last decade has also been envisaged (Fig. 8).

In order to estimate as real as possible the correct field situation, the method has to be adequate and respect certain requirements:

- adequate sampling procedure,
- algal samples should be representative for the studied algal population,
- usually the algal populations are studied by using the method of squares, namely square frames of adequate dimensions (according to type of substratum and population characteristics),
- random sampling, not from "representative" sites,
- often macrophytes sampling is more difficult because the substratum is very diverse and irregular (stones, rocks, dams, tetrapods, groins) and the vegetation is not uniformly distributed (Fig. 5).

So, for quantitative measurements, three samples have been collected from each station / profile, introduced in plastic bags and labeled (sampling

place and date). Sampling has been performed by means of a metalic frame of 10 cm each side, corresponding to a surface of 100 cm^2. The estimated biomass resulted from the mean weight of three collected samples from each depth (UNESCO, 1973; BOLOGA, 1989).

All samples have been brought fresh into the laboratory – in refrigeration box, in order to avoid their alteration during the warm season.

The algae have been separated into dominant main groups (green and red) and their biomass estimated by drying of biological material in oven at 105^0 C and expression of biomass as dry weight.

RESULTS AND DISCUSSION

Historical considerations

From the qualitative point of view, since 1935, along the Romanian littoral the above mentioned total number of macrophytes decreased with time to 77. Between 1970 and 1980 only 69 species have been still registered. According to another assessment, in the late '90ies out of the previous total only 38 Chlorophyta, 1 Xantophyta, 14 Phaeophyta and 41 Rhodophyta have been identified. This observation evinced the obvious qualitative decline of macrophytobenthos along the Romanian littoral. During the last seven decades the progressive impoverishment of macroalgal flora considerably increased, with various negative effects on the whole coastal ecosystem. In 1989 only the southern Romanian littoral evinced higher specific diversity: according to that survey, 24 taxa (1 Cyanophyta, 11 Chlorophyta, 2 Phaeophyta and 10 Rhodophyta) have been identified (BOLOGA, 1989). This decline stands also for the quantitative aspect. The impoverishment of the vegetation, especially after 1970, is due to known natural and anthropic causes which deteriorated the quality of the marine environment (e.g. massive frosts, silting of the rocky bottom with suspended matter, decrease of light penetration in the water column due to same suspensions, increase of eutrophication (BOLOGA, 1987/88).

Along with increasing eutrophication, marked qualitative changes have been recorded in the structure and functioning of the macrophytobenthos starting with the earliest records until end 2000.

Due to large amount of suspended particles and plankton, the transparency of sea water has significantly decreased. The position of the compensation depth changed as a result, and bottom seaweeds growing deeper than 7 to 8 m became shaded. This accounted for the large decline of macrophytes, in spite of high nutrient levels.

So, because of the variability of the ecological factors, these changes of the ecosystem and community structure led to the replacement of some phytocoenoses by others. The consequence was a change in the seasonal and multiannual dynamics of the algal communities.

The interaction of various anthropogenic factors on the vegetation induced different results, ranging from structure simplification to complete disappearance (CELAN, 1977; BOLOGA, 1989; BAVARU *et al*., 2001). The most obvious consequence followed landslides due to construction works (dams, barrages, ways), when the algal carpet was covered by sand and/or mud. Under such circumstances, the communities of *Cystoseira* Ag. have been replaced by *Cladophora* or *Ceramium,* these macrophytes being usually encountered in the narrow fringe near the shore itself at depths less than 3 to 5 m, where species tolerant to eutrophication such as *Enteromorpha intestinalis*, *E. prolifera* (Ö. Műll), *Cladophora vagabunda* (L.) Hoeck, *Ceramium elegans* etc. occurred.

The uniform aspect of the present vegetation was imposed by the total, or quasitotal, disappearance of an important number of species during the second half of the last century (30 to 50 years).

Remarkable was the almost complete disappearance of the former extended belts of *Cystoseira barbata*, sometimes associated with *C. crinita* f. *bosphorica* (syn. *C. bosphorica*), previously dominating the southern half of the Romanian coast, displaying an important ecological role, mainly as substratum and shelter for various other epiphytic macroalgae and animals, especially fish; the disappearance of numerous brown and red algae is therefore mainly related to the reduction of those *Cystoseira* fields.

Among the high number of recently disappeared Phaeophyta and Rhodophyta the species of *Laurencia* Lamour. deserved special consideration.

Considerable diminution of phanerogames *Zostera marina* and *Z. nolti* (eelgrass) was also observed in former decades. In the last 30 years the standing stock of eelgrass, has decreased tenfold in shallow water. Eelgrass served as a favourable biotope for many species of invertebrates and fish. The main reason for the degradation of *Zostera* communities was the mobilizing of silt when dredging in the coastal zone.

The benthic algal flora has endured a gradual, but continuous decline since 1946 / 1950 (CELAN, 1977, 1981; CELAN *et al*., 1969; CELAN and BAVARU, 1973); the accentuation of this decline during the last three to five decades is due to natural and anthropogenic factors that have disturbed the quality of the marine environment (BOLOGA, 1989).

The restructuring of algal life imposed by environmental changes severely influenced the flora diversity, seasonal alternance and abundance, as well as its seasonal and annual production (BOLOGA, 2001).

Following eutrophication, the production of some persisting macrophytes increased. The free substratum, previously populated by *Cystoseira*, with a slow growth rate, has been occupied with time by species with short life cycle, more or less seasonal, but with fast growth.

The most frequent species belonged to the genera *Enteromorpha* and *Ceramium*, as well as, at a lower extent, *Ulva* L. (in the southern sector), *Cladophora*, *Porphyra* Ag. and *Callithamnion* Lyngb. (Table 2).

From the common total of species only this low number determined the physiognomy of marine vegetation; the rest does not appear at a general overview either due to their very small or microscopic size, or due to their negligible weight (*Cystoseira*).

The green algae *Enteromorpha intestinalis* and *E. linza* "conquered" little by little more and more surfaces, creating a first belt of vegetation. *E. flexuosa* (Wulf.) J. Ag. and *E. prolifera* added sometimes to first mentioned ones, in the warm season. An interesting phenomenon proved to be the distribution of *Enteromorpha* species at depths previously considered as inaccessible (up to 6 m).

Usually, *Enteromorpha* species are mixed in this belt of green algae with species of *Cladophora*, especially *Cl. sericea* (Huds.) Kűtz. and sometimes *Cl. albida* (Huds.) Kütz. and *Cl. laetevirens* (Dillw.) Kűtz. Occasionally *Bryopsis plumosa* (Huds.) Ag. (in the warm season) and *Entocladia viridis* Reinke (endophyte in the cellular membranes of *Ceramium* species) have been observed.

After the green algae belt, absolute dominants, starting with low depths up to 8 to 9 m, are species of *Ceramium*. They occupy almost all substrata, contributing, with *Enteromorpha*, to the physiognomy of the present vegetation. The most common and productive species of the genus *Ceramium* are *C. elegans* Dukl., *C. arborescens* J. Ag. and *C. diaphanum* (Lightf.) Roth. Less spread is *C. rubrum* (Huds.) Ag. which develops mainly in spring.

Other common species during various seasons of the year, with lower quantitative weight, are *Polysiphonia denudata* (Dillw.) Kűtz., *P. elongata* (Huds.) Harv., *Callithamnion corymbosum* (J. E. Smith) Lyngb. and *Lomentaria clavellosa* (Turn.) Gail.

From the quantitative point of view, the stocks of the main macrophytes suffered along the Romanian shore a continuous decline.

The biomass of *Cystoseira* (*C. barbata* and *C. bosphorica*) diminished from 5,400 t fresh weight in 1971, to 757 t in 1973, and 120 t in 1979, and nearly complete disappearence in the '90ies.

The biomass of *Phyllophora* Grev. (*Ph. brodiaei*, *Ph.nervosa*, *Ph. membranifolia*), which in 1971/72 totalized 1,344.000 t fresh weight in the

"Zernov's field" in the NW Black Sea, was estimated in the Romanian shelf in the same period to only 5,900 t f.w.

Table 2

Main marine macrophytobenthos species
along the Romanian Black Sea shore end '90ies

CHLOROPHYTA
Ulva lactuca
Enteromorpha intestinalis
E. linza
E. flexuosa
E. prolifera
Cladophora albida
Cl. sericea
Cl. laetevirens
Bryopsis plumosa
Entocladia viridis Reinke *
PHAEOPHYTA
Cystoseira barbata **
C. bosphorica **
Striaria attenuata *
RHODOPHYTA
Porphyra leucosticta
Lomentaria clavellosa
Ceramium arborescens
C. diaphanum
C. elegans
C. rubrum
Callithamnion corymbosum
Polysiphonia denudata
P. elongata
Phyllophora brodiaei **
Ph. membranifolia **
Ph. nervosa **
Laurencia coronopus
PHANEROGAMA
Zostera marina *
Z. nana Roth *

*) rare
**) extinct and endangered

The observations on the macrophytes have been completed also as to their vertical distribution. A biomass increase was registered at about 3 m depth, where under more stable conditions *Ceramium* became dominant. But the biomasses of the presently most common seaweeds, with short life –

cycles, are not comparable with the previous biomasses of *Cystoseira* fields until end '80ies.

Data on the macrophytic biomasses along the Romanian shore evinced that instead of the previous richer, more stable vegetation, a different one, with other qualitative composition, physiognomy and production, developed under new environmental pressure in the shallow waters; its main characteristics consisted in the reduced number of species.

Although numerically (qualitatively) reduced, the remaining species revealed appreciable productions on available rocky bottoms; the usual algal populations, consisting mainly in species of *Enteromorpha* and *Ceramium*, covered this substrate up to 80%.

Since 1990 the marine macrophytes evinced a slight recovery tendency, proven by quite impressive stranded biomasses visible on various beaches between Mamaia and Vama Veche.

The increase of eutrophication and its related negative consequences favoured the development of only a limited number of resistant genera, which persisted and proliferated (*Enteromorpha, Cladophora, Ceramium, Porphyra, Callithamnion*).

The recovery of algal life continued to be delayed not only by eutrophication, but also by various other human activities. In the ’70ies and the ’80ies, the littoral of the western Black Sea coast beared ample transformation directly related to harbour, industry and tourism development (SKOLKA *et al*., 1980). These constructions brought huge amounts of terrigenous material into the sea, contributing to the increase of suspended matter in the shallow waters with the mentioned ecological consequences. Therefore the decrease of macrophytobenthos has continued to an alarming extent.

Recent data

Qualitative aspects

Following macrophytes have been collected and identified along the Romanian Black Sea coast during the last decade (1996-2005):

CHLOROPHYTA

Ord. ULVALES

Fam. Ulotrichaceae

1. *Ulothrix implexa* (Kutz) Kutz
2. *Ulothrix flacca* (syn. *U. pseudoflacca* Wille) Dillw.Thur

Fam. Ulvaceae

1. *Ulva rigida* Ag. (Fig. 9)
2. *Enteromorpha intestinalis* (L.) Link (Fig. 10)
3. *Enteromorpha flexuosa* (Wulf. et Roth) J.Ag.
4. *Enteromorpha compressa* (L.) Grev.
5. *Enteromorpha linza* (L.) J.Ag.
6. *Enteromorpha prolifera* (O.F.Mull) J.Ag.

Ord. CLADOPHORALES

Fam. Cladophoraceae

1. *Cladophora vagabunda* (L.) Hoeck (Fig.11)
2. *Cladophora albida* (Huds.) Kutz
3. *Cladophora sericea* (Huds.) Kutz
4. *Cladophora laetevirens* (Dillw.) Kutz
5. *Cladophora dalmatica* Kutz.
6. *Chaetomorpha aerea* (Dillw.) Kutz

Fam. Acrosiphonaceae

1. *Urospora penicilliformis* (Roth.) Aresh

Ord. BRYOPSIDALES

Fam. Bryopsidaceae

1. *Bryopsis plumosa* (Huds.) Ag. (Fig.12)

PHAEOPHYTA

Ord. ECTOCARPALES

Fam. Ectocarpaceae

1. *Ectocarpus siliculosus* (Dillw) Lyngb (Fig. 13)
2. *Ectocarpus confervoides* (Roth) Le Jolis

Ord. SCYTOSIPHONALES

Fam. Scytosiphonaceae

1. *Scytosiphon lomentaria* (Lyngb)J.Ag. (Fig. 14)

Ord. PUNCTARIALES

Fam. Punctariaceae

1. *Punctaria latifolia* Grev. (Fig.15)

Ord. FUCALES

Fam. Cystoseiraceae

1. *Cystoseira barbata* (Good et Wood) Ag. (Fig. 16)

RHODOPHYTA

Ord. BANGIALES

Fam. Bangiaceae

1. *Porphyra leucosticta* Thur in Le Jol (Fig. 17)
2. *Bangia fuscopurpurea* (Dillw.) Lyngb.

Ord. CRYPTONEMIALES

Fam. Corallinaceae

1. *Corallina officinalis* L. (Fig. 19)

Ord. RHODIMENIALES

Fam. Champiaceae

1.*Lomentaria clavellosa* (Thurn.) Gail.

Ord. CERAMIALES

Fam. Ceramiaceae

1. *Ceramium rubrum* (Huds.)C. Ag (Fig. 18)
2. *Ceramium elegans* (Roth.) Ducl (Fig. 20)
3. *Ceramium diaphanum* (Lightf.) Roth
4. *Callithamnion corymbosum* (Ducl.) Ag. (Fig. 21)

Fam. Rhodomelaceae

1. *Polysiphonia elongata* (Huds) Harv (Fig. 22)

Ord. GIGARTINALES

Fam. Phyllophoraceae

1. *Phyllophora pseudoceranoides* (Gmel) Newr. et A.Tayl (syn. *P. membranifolia* (Good et Wood) J.Ag

The decreasing number of macroalgal species between 1977 and 2005 is evinced per phylla (Table 3).

The distribution of seaweeds is directly influenced by various factors: seabed, climate (temperature), light penetration, water chemistry (salinity), a.o.; each modification of ecological status (water quality) induces changes of the macroalgoflora.

Fig. 9 - *Ulva rigida* Ag.

Fig. 10 - *Enteromorpha intestinalis* (L.) Link.

Fig. 11 *Cladophora vagabunda* (L.) Hoek.

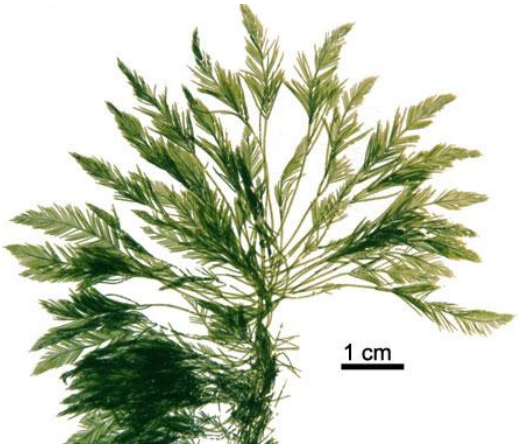

Fig. 12 *Bryopsis plumosa* (Huds.)Ag.

Fig. 13 - *Ectocarpus siliculosus* (Dillw.) Lyngb.

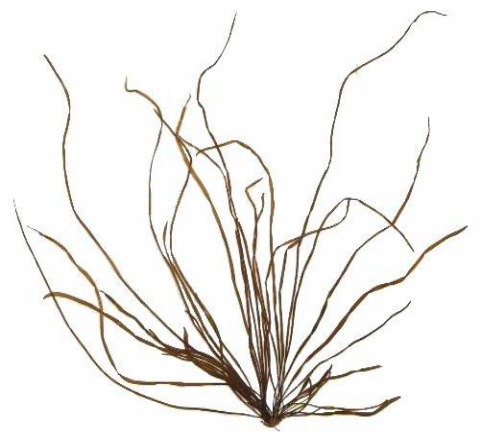

Fig. 14 - *Scytosiphon lomentaria* (Lyngb)J.Ag.

Fig. 15 - *Punctaria latifolia* Grev.

Fig. 16 - *Cystoseira barbata* (Good et Wood) Ag.

Fig. 17 - *Porphyra leucosticta* (Dillw.) Lyngb.

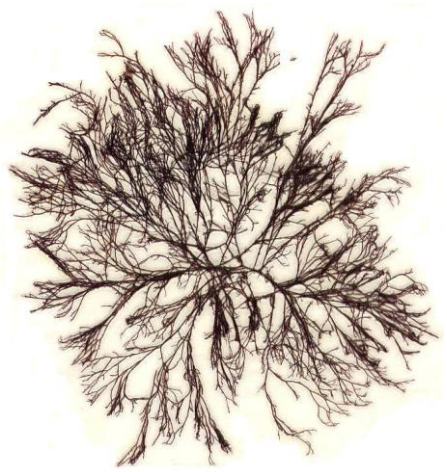

Fig. 18 - *Ceramium rubrum* (Huds.) C. Ag.

Fig. 19 - *Corallina officinalis* L.

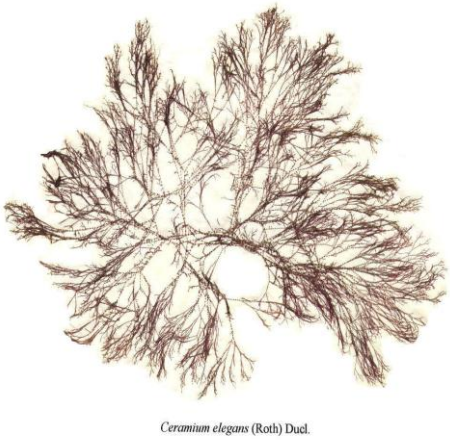

Fig. 20 - *Ceramium elegans* (Roth) Ducl. Fig. 21 - *Callithamnion corymbosum* (Ducl.)Ag

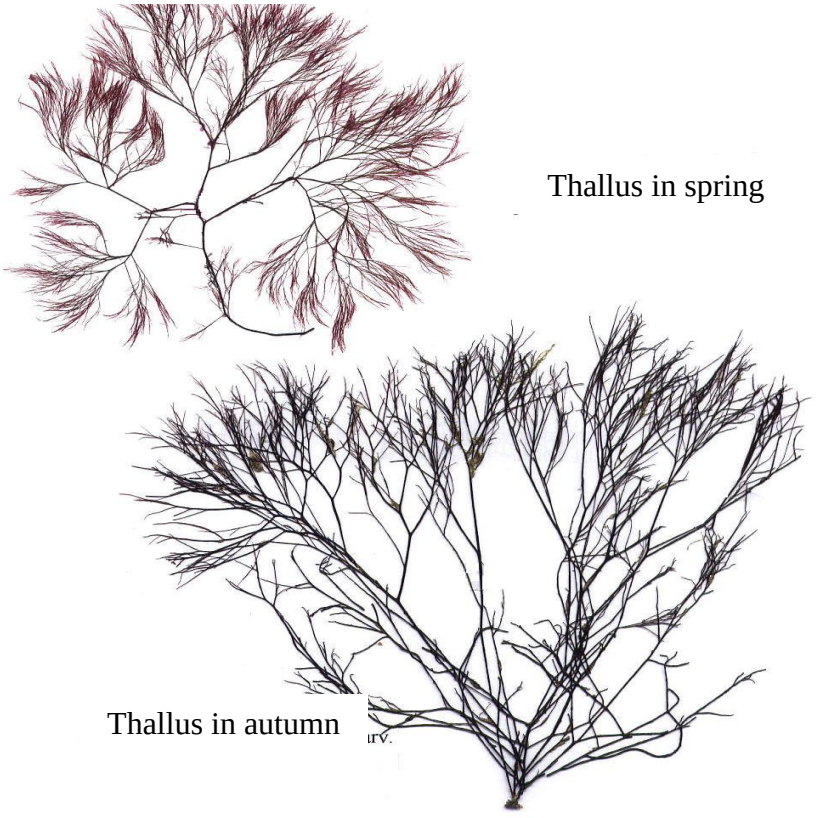

Fig. 22 - *Polysiphonia elongata* (Huds.)Harv.

Table 3

Number of macroalgal species between 1977-2005

Phyllum	Bavaru (1977) 1977	Vasiliu (1996) 1976-1995	Sava & Bologa 1996-2005
Chlorophyta (green algae)	31	22	16
Phaeophyta (brown algae)	14	9	5
Rhodophyta (red algae)	41	24	10
Total	86	55	31

The present qualitative observations evince the low specific diversity of this flora and its progressive decline with time.

Table 3 enables following remarks:

- there are different opinions concerning the precise number of seaweeds along the Romanian shore due to incertitudes created by some forms and varieties and by the consideration of microscopic forms; microscopic macrophytes (epiphytes) have not been considered in this paper;
- most species belong to the green algae, possibly because of eutrophication which generally harms marine life, but also favourizes a reduced number of resistent genera which do proliferate at present;
- less numerous are the brown algae, all species being found only during the cold season;
- the red algae are the most sensitive to pollution: as a matter of fact about 30 species are missing nowadays compared to 1977; they are also the most numerous on the list of disappeared, extinct or rare species;
- the single sampled perennial species belong to the genus *Polysiphonia*;
- the perennial algae *Cystoseira barbata* (brown) and *Phyllophora pseudoceranoides* (red) have been found during field trips, in various locations along the shore, stranded on the beach, teared out from their rocky bottom during strong storms,
- an obviously positive sign is the reappearance of some missing species lastly considered disappeared, such as the red alga *Lomentaria clavellosa* (Thurn.) Gail.

Quantitative aspects

The bioproductive importance of the macrophytobenthos in the marine coastal area is very high. In order to understand the structure and functioning of macroalgal populations, qualitative data have to be completed with quantitative ones, namely the characteristics of the algal biomass and its temporary evolution.

Sampling took place in the infralittoral, mainly in the upper infralittoral, with permanently submerged rocky bottoms hosting the richest macroalgal vegetation.

The evolution of dominant green and red algal biomass has been evinced during the last 10 years of investigation.

For a complete image of the present state of the macrophytes along the Romanian Black Sea coast, as well as to grasp characteristic aspects each year, the evolution of total biomass of both green and red algae, in all sampling sites, is illustrated (Fig. 23).

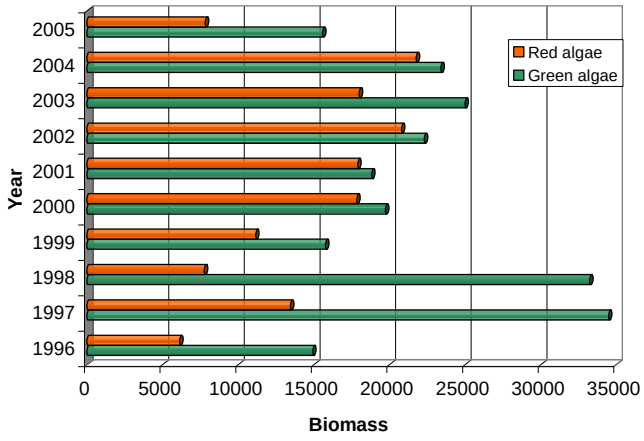

Fig. 23 - Annual evolution of biomass (g/m^2) of green and red algae along the Romanian littoral between 1996 and 2005

It is evident that the green algae prevailed permanently, the quantities of red algae being always lower during the whole mentioned period.

The highest development of green algae took place in 1997, than in 1998, with half values in 1999 and under 25,000 g/m^2 until 2005.

As to the red algae, their values increased in 1996 and 1997, decreased below 10,000 g/m^2 in 1998 and increased again until 2002. After a slight decrease again in 2003, next year their biomasses reached the maximum value of 21,772 g/m^2 for the entire period of investigations.

These observations confirm the fact that the green algae are the dominant group along the Romanian shore. This weight is mainly due to species belonging to the genera *Ulva*, *Enteromorpha* and *Cladophora*, together with *Ulothrix* and *Urospora* in spring. High biomasses of red algae are almost entirely owed to species of *Ceramium*, other genera playing a minor role in this respect (Fig. 24).

The species of *Ceramium*, with a high capacity of both asexuate and sexuate reproduction, do easily and quickly populate the rocky bottoms, which sometimes they may cover completely.

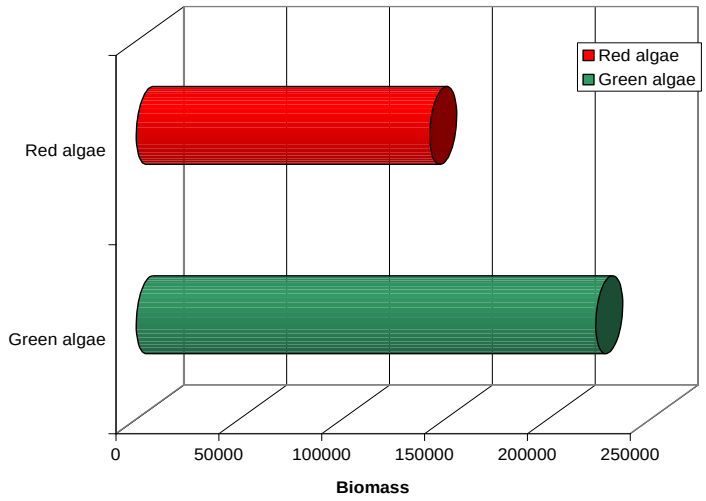

Fig. 24 - Total biomass (g/m^2) of green and red algae along the Romanian shore between 1996 and 2005

The high biomasses of green and red algae also confirm that in eutrophised coastal waters, such as the Romanian ones, the representatives of these algal groups develop very well, the nutrient excess in the environment enabling their massive development (Fig. 25, 26).

Fig. 25 - Mass development of green algae (*Enteromorpha*) at Constanta / Trei Papuci in October, 2004

Fig. 26 - Green algae (*Ulva* and *Enteromorpha*) at 2 Mai in July, 2005

CONCLUSIONS

1. During the last five decades the Black Sea basin has suffered numerous anthropic pressures which induced significant changes in its ecosystems, mainly the coastal ones.
2. The consequences of these pressures are felt also by the macrophytobenthos along the Romanian shore.
3. The literature search since 1940/50 has proven an obvious progressive decline of the macroalgal specific diversity and modifications of biomasses.
4. From the qualitative point of view there is a quite poor macroalgal flora nowadays.
5. The green algae (Chlorophyta) are the most numerous, showing their adaptability to living conditions offered by impure eutrophised seawater in the coastal sector.
6. The fewest are the brown algae (Phaeophyta), all species emerging only in the cold season.
7. The most affected by pollution are the red algae (Rhodophyta). They seem to be the most sensitive to environmental changes, about 30 species missing today compared to 1977. The red algae are the most numerous on the Red list of disappeared, extinct, rare and insufficiently known macrophytes in the Romanian coastal waters.
8. After the quasidisappearance of *Cystoseira* species, the number of other perennial algae is very low, the single species found during sampling being the species of *Polysiphonia* (Rhodophyta).
9. Quantitatively the green algae dominated the entire investigated period 1996 to 2005, with a maximum development in 1997 and 1998, but with high biomasses stranded on the beaches also in 2003 and 2004. It has to be stressed that their weight was owed to several genera of green algae: *Enteromorpha*, *Cladophora* and *Ulva*, together with *Ulothrix* and *Urospora* during spring. The considerable biomasses of red algae are due almost exclusively to only one genus: *Ceramium*, the others producing very few quantities.
10. According to literature data since 2000 a certain improvement of the quality of transitional and coastal waters has been evinced, as to a slight decrease of nutrients, even if their concentrations exceed those before the start of eutrophication in the ’60ies to ‘70ies.
11. This amelioration of the state of the marine ecosystem could have beneficial consequences on the algal vegetation along the Romanian shore, e.g. the reappearance of some species missing from long time and considered as disappeared, such as *Lomentaria clavellosa* (Rhodophyta).

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