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THE STATE OF THE PHYTOBENTHIC COMMUNITIES ALONG THE ROMANIAN BLACK SEA COAST DURING SUMMER 2016

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ABSTRACT

The work aims to present the state of the macroalgae and phanerogams communities from the Romanian Black Sea shore during the summer 2016. The samples were collected from 11 stations (from Năvodari to Vama Veche), at depths between 1 - 3 m and analyzed both qualitatively and quantitatively. The paper presents information both on perennial, sensitive species with key ecological role for the marine environment and and also for the opportunistic ones capable of developing algal deposits along the shore during the summer season. In this respect, the dominant species were: *Ulva rigida* (with a fresh biomass variation between 3.3 and 1030 g/m^2, with a maximum value recorded at Agigea), *Cladophora* sp. (with a fresh biomass variation between 0 and 816 g/m^2, with a maximum value recorded at Pescărie) and the red alga *Ceramium virgatum* (with a fresh biomass variation between 0 – 125 g/m^2, with a maximum value recorded at Costinești). Regarding the perennial key species (*Cystoseira barbata*, *Coccotylus truncatus*, *Zostera noltei*) they are currently in a regeneration period along the Romanian Black Sea coast, and the fresh biomass varies as follows: *C. barbat*a – between 5623.33 and 9355 g/m^2, *Coccotylus truncatus* (only one record of 760 g/m^2), and the marine phanerogams *Zostera noltei* between 438.33 and 1325 g/m^2.

Key-Words: macroalgae, *Phyllophora*, *Cystoseira*, *Zostera*, fresh biomass

AIMS AND BACKGROUND

Over decades, along the Romanian Black Sea shore the phytobenthic communities have suffered a serious decline as a result of the cumulative action of some unfavorable natural (winter 1971 – 1972 sea frost, strong storms) and anthropogenic factors (hydrotechnical constructions, etc.) (Vasiliu F., Müller G.I., 1973). The anthropogenic impact changes the state of an ecosystem, and turns it into an area where opportunistic R-selected species (*Ulva*, *Cladophora*, etc.) dominates

instead of the K-selected sensitive ones (*Cystoseira, Phyllophora*, etc.) (Litter M. M., Litter D. S., 1980).

The submerged vegetation represents a major component of primary producers, which forms the existence and development basis of life in marine environment, a real engine for the marine ecosystem. Taking into account the special ecological importance of the algal communities, the paper wants to present the latest information regarding the evolution of the phytobenthic communities along the Romanian Black Sea coast.

Within the Results and Discussions, updated information regarding the status of the macroalgal communities along the Romanian Black Sea coast (qualitative and quantitative aspects) will be presented, along with complex information regarding the marine phanerogams (distribution areas, biomass data), important ecosystem components with little detail for the Black Sea coastal area. Also, recent information for both opportunistic species, with an abundant development during summer season, and perennial sensitive habitat forming species, are presented. Up-to-date information, aspects regarding the evolution of the important ecological species, so-called "key species", will be included, with direct references to *Cystoseira*, *Phyllophora* and *Zostera* genres. The latter are protected species included in the Red List, according to IUCN criteria, with an extremely complex trajectory along the Romanian Black Sea coast over decades. The potential use of macrophytes and their applicability in various fields is indisputable, but for an informed approach of this aspect along the Romanian Black Sea coast and in order to avoid potential imbalances in the marine environment, it is necessary to know the current state of the species able of developing exploitable biomass, an aspect covered in the present paper.

EXPERIMENTAL

This paper analyzed data from 2016 summer season, since summer is considered to be the period of maximum development for the opportunistic species along the Romanian Black Sea coast. The samples were collected from 11 stations, along the coastal strip Năvodari - Vama Veche (Năvodari, Pescărie, Constanta North, Cazino Constanța, Agigea, Eforie South, Tuzla, Costinești, Mangalia, 2 Mai and Vama Veche) (Fig. 1), at depths between 1 and 3 meters (areas with maximum abundance along the Romanian Black Sea coast).Three samples per depth range, in three depth ranges (0-1 m, 1-2 m and 2-3 m) were collected from infralittoral macroalgal communities at each sampling station, by means of a square frame with a side of 20 cm. The present study is based on the analysis of 85 samples, collected along the entire coastal zone.

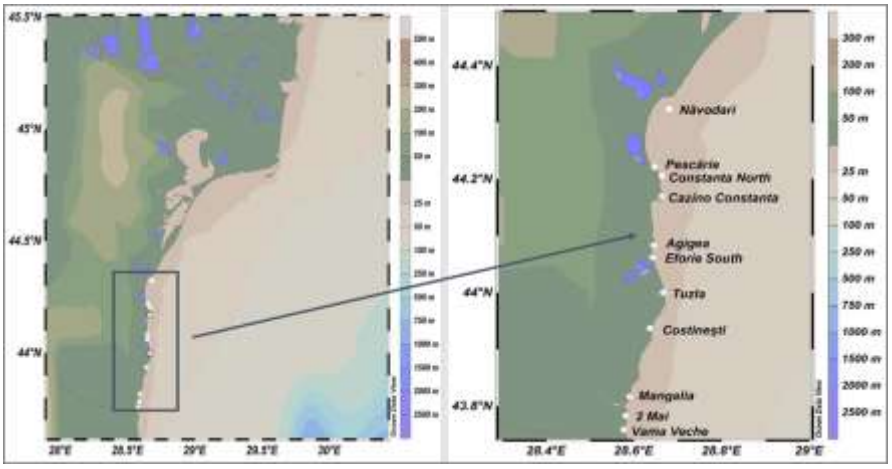

Fig. 1. Romanian phytobenthos sampling map.

Samples were placed in labeled bags (the name of the station, sampling date and depth is noted), brought into laboratory and submitted to a qualitative (species identification, species list preparation) and quantitative analysis (weighing of samples and biomass estimation by multiplying with the coefficient 25, in order to report the value at square meter). For statistical analyses, PRIMER (v.6) was used, and for the graphic representation - ODV (Ocean Data View, http://odv.awi.de, 2010) was used.

RESULTS AND DISCUSSION

The submerged vegetation is characterized during the summer season by an uniform aspect, with the proliferation of a small number of species with a very high reproductive capacity, as a normal response of benthic vegetation to summer season environmental conditions - high water temperature, large amount of nutrients and favorable water transparency. This phenomenon of diminishing regional differences has been dominant over the last decade along the Romanian Black Sea coast. A special situation is in the southern part (from Saturn to Vama Veche) and punctuated in the northern part, at Navodari and Constanta North, in the sense of observing a higher specific diversity.

In this respect, in 2016 at Pescărie, Cazino Constanţa, Agigea, Eforie Sud, Tuzla and Costineşti the submerged vegetation was characterized by a simplified patchy structure, sometime with a monospecific character. Only along the coastal line Saturn - Mangalia - 2 Mai - Vama Veche was noticed a higher specific diversity, compared to other profiles, as mentioned above. This was due to the presence of perennial species – brown alga *Cystoseira barbata* and marine phanerogam *Zostera noltei* - species with a particular ecological value for the marine environment. Also, at Constanta North, the presence of *Coccotylus truncatus* (syn. *Phyllophora brodiaei*) was reported.

Comparing the current situation with that of the previous decades, it can be stated that in the structure of the submerged vegetation appeared changes both qualitatively and quantitatively. Undoubtedly, the qualitative ones prevail, because

the current phytobenthic structure does not contain many species and even genres, compared to past decades. Thus, *Chondria*, *Laurencia* have disappeared and *Cystoseira, Phyllophora, Polysiphonia* or *Zostera* (Vasiliu F., 1984) species have been profoundly affected. All these species have a special ecological value and their decline / disappearance led to a massive change in the habitats structure in the coastal area.

The algal mass biomass is generated along the Romanian Black Sea coast by a very limited number of species and is a sesonal phenomenon (Fig.2). The biomass decreased gradually with the depth. Thus, for the Romanian shore, the highest fresh biomass was recorded between 0 and 3 m depth. Regarding the dominant species, *Ulva* species are among the first macrophytes to colonize the substrate from coastal waters with a high content of nutrients. This may due to their simple morphology and remarkable reproductive capacity (Sava D., 2006).

During summer 2016, *Ulva rigida* was a constant presence, both in the northern and in the southern part. From the ecological aspect, *Ulva rigida* is the dominant characteristic element for the photophilic infralittoral algal association *Ulva rigida – Ceramium virgatum* or *Ulva rigida – Cladophora* sp. and also the secondary element for the key association *Cystoseira barbata - Ulva rigida*, characteristic for the southern part of the Romanian Black Sea coast.

Ulva rigida distinguished in the past years not only as a constant presence along the Romanian coast, but also due to its important biomass values. This phenomenon of abundant development has been manifested since the summer of 2013. During 2010 - 2012, the dominant quantitative species was *Cladophora* sp., which experienced an impressive development (Fig.2a) due to the abnormal climatic conditions from the summer 2010, with high values of the water temperature, and an increased nutrient content, leading to fish mortality. Starting with 2012, a decrease of the fresh biomass for *Cladophora* genus was observed, so the quantitatively dominant genus in recent years was *Ulva* (namely *Ulva rigida*) (Fig.2b).

a) Algal deposit dominated by *Cladophora* in 2011 b) Algal deposit dominated by *Ulva* in 2016

Fig. 2. Mass development of some opportunistic genres.

For 2016 summer season, the dominant opportunistic species were *Ulva rigida*, *Cladophora* sp. and among the red algae, *Ceramium virgatum* (as a

consequence that *Ceramium* species have a high capacity of both asexuate and sexuate reproduction, so they can easily and quickly populate the rocky bottom, sometimes even completely) (Sava D., Bologa A.S., 1980). As mentioned above, the dominant species from a quantitative point of view was *Ulva rigida*, with the highest biomass values developed to the southern part of the Romanian coast. So, the maximum values were 1030 g/m^2 at Agigea, respectively 650 g/m^2 at Tuzla, and were recorded during June – August.

The qualitative analysis showed the dominance of *Cladophora vagabunda, C. sericea* and *C. albida,* among the species of this opportunistic genus, generally with a high biomass developed by *C. vagabunda.* The maximum value for the summer period was recorded at Pescarie (800 g/m^2), and Costinesti (650 g/m^2) (Fig.3).

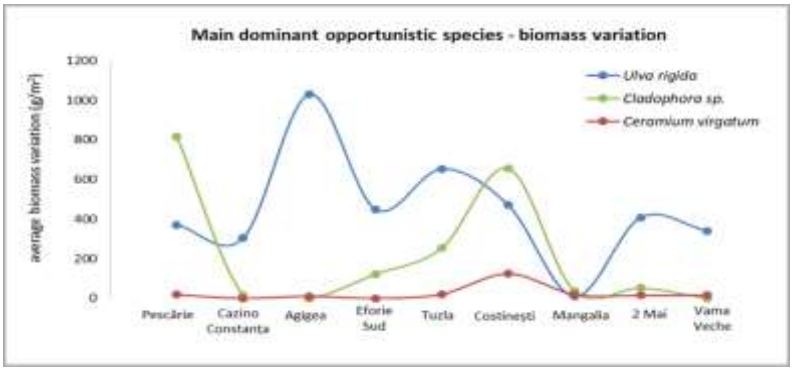

Fig. 3. Biomass variation for the main dominant opportunistic species**.**

Among the red algae, only *Ceramium virgatum* showed a notable biomass, but much lower compared to green algae, with a maximum value of only 125 g/m^2, developed at Costinesti. Other representatives of the Rhodophyta phyllum were *Callithamnion corymbosum, Polysiphonia denudata*, with a constant presence during summer season, but without significant development. The lowest biomass values for the opportunistic species were recorded at Mangalia (Fig.3). The distribution of median biomass and standard deviations pointed-out the lowest values for *Ceramium* sp. (with variations within fairly narrow limits, between 0 and 125 g/m^2), among all of the opportunistic species, and the highest for *Ulva rigida* (with a biomass variation between 10 and 1030 g/m^2). *Cladophora* sp. varies along the Romanian Black Sea coast during summer 2016 between 0 and 816 g/m^2 (Fig.4).

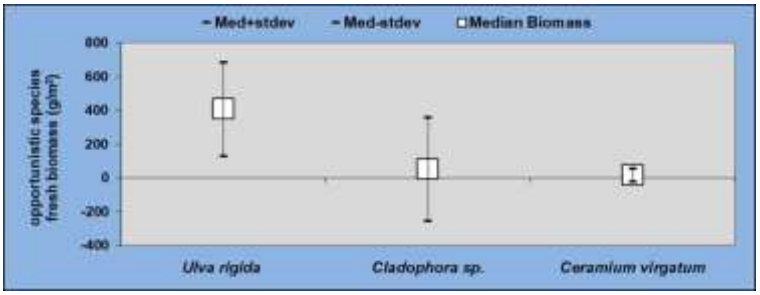

Fig. 4. Standard deviations for the main dominant opportunistic species.

Statistical analysis of biological data (with PRIMER v.6) based on opportunistic species biomass shows a strong similarity between the sampling stations, due to the clear dominance of the same phytobenthic community (*Cladophora* sp. - *Ulva* sp. - *Ceramium* sp.) during summer season and to the similar fresh biomass developed by these species along the sampling stations (Fig.5).

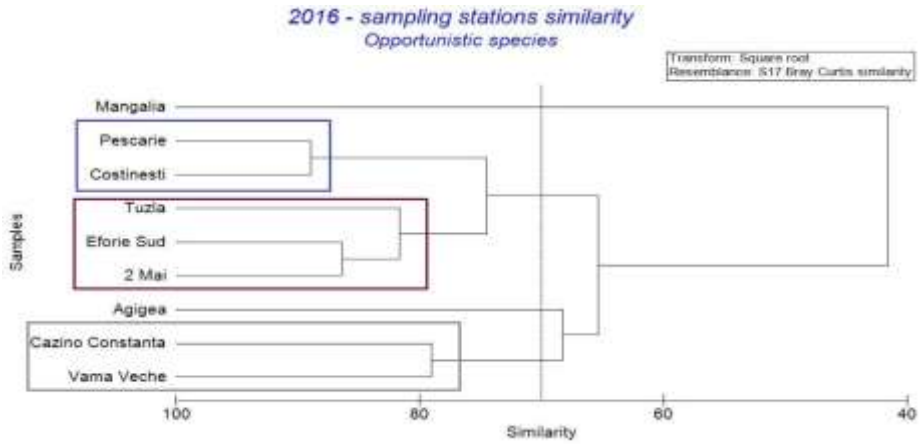

Fig. 5. Similarity between sampling stations based on opportunistic species biomass.

Macroalgae are an unique domain that maintains the biological balance in the marine environment and offers opportunities for exploration in the most diverse areas (medicine, human nutrition) able to respond in the future to the most divers problems of the society. Nutritional analysis of *Ulva* sp. shows a rich content in protein, polysaccharides, mineral and some vitamins in important percentages for this common genus. Biochemical composition of *Ulva rigida* indicates a high content in carbohydrates comparing with other opportunistic species, such as *Cladophora vagabunda* or *Ceramium virgatum* and in conclusion, an important source of so-called „ulvans" (water-soluble polysaccharides and dietary fiber). Laboratory analyses showed a high content in ulvans extracted from *Ulva rigida* collected from the Romanian Black Sea coast. Therefore, *Ulva rigida* from the Romanian part of the Black Sea can be considered a source of algal material, with the potential to be exploited, given its high reproductive capacity, ecological preferences and easy ways of sampling (grows abundantly at small depths up to 5 meters) (Rosioru D., O. Marin, 2017).

In present, along the Romanian coast, perennial species are much lower compared to past decades, both in number, distribution areas, but also as biomass values. There is a tendency to regenerate the situation of a limited number of perennial species, with an extremely important ecological role - the case of *Cystoseira barbata*, *Phyllophora* sp. or *Zostera noltei*.

Regarding the brown alga *Cystoseira barbata*, its current distribution areas are located in the southern part of the Romanian shore, a lot more reduced compared to the situation of past decades (Fig.6).

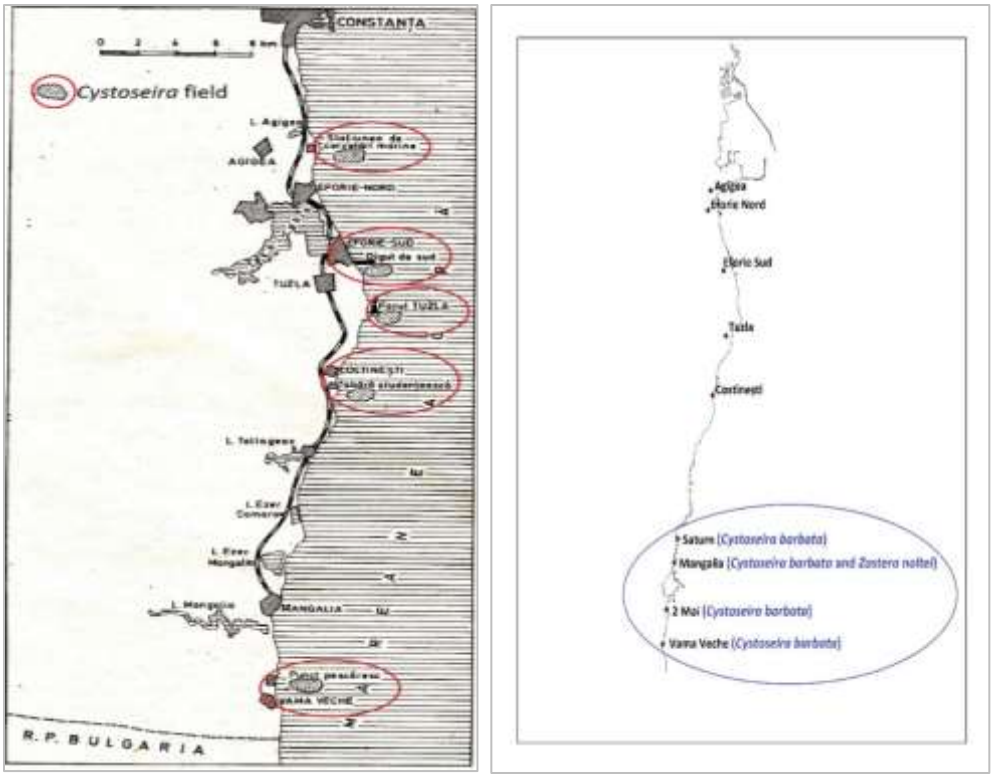

Fig. 6. *Cystoseira* sp. development areas in the 70s (left) (after Bavaru, 1972) and in 2016 (right).

Over the decades, *Cystoseira barbata* has been deeply affected by extreme natural phenomena, resulting in 80% reduction in stocks, hence its status of endangered species at the Romanian seashore, included in the Red List of protected species:

- ✓ winter 1971 – 1972 sea frost
- ✓ very low water temperatures which have disturbed the photosynthetic activity and the reproduction process of this species.
- ✓ strong storms that threw enormous amounts of mussels (estimated at 20-25,000 tons) and *Cystoseira* on the shore (Vasiliu F., Müller G.I., 1973).

The action of these natural phenomena has been doubled by the impact of anthropogenic activities, also with a negative impact. During 60s and 70s, *Cystoseira* sp. could be identified at several points along the Romanian seaside (Fig.6) with quantitative assessments of several tons (e.g. 4900-5500 tonnes of fresh biomass in 1970-1971) (Vasiliu F., 1984).

In the past years the regeneration process has been maintained and this brown alga can now be identified as well-developed fields in the southern part, at Saturn, Mangalia, 2 Mai and Vama Veche (Fig.6). The distribution area is between 1-5 meters depth, generally with an optimum between 1 and 3 meters depth. Also the references shows that the depth of 5.5 meters is the maximum one up to which this species can develop along the Romanian coast (Vasiliu F., 1984).

Regarding the depth distribution of fresh biomass for *Cystoseira barbata*, the optimum development range of 0 to 3 meters depth was analyzed. Thus, an increment of the biomass values to deeper depths, where environmental conditions are slightly more stable, can be noticed. Median biomass and standard deviations showed that the lowest biomass values were recorded between 0 and 1 meters depth (with a biomass variation between 4100 g/m^2 and 6950 g/m^2 along the sampling stations) as a consequence of the anthropogenic influences, while the the highest biomass values were between 2 to 3 meters depth (ranging from 4400 g/ m^2 up to 10300 g/m^2) (Fig.7).

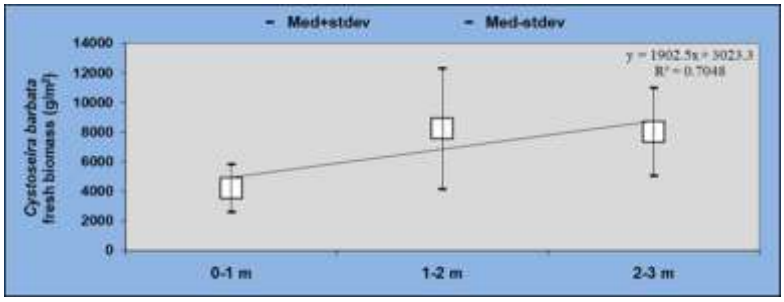

Fig. 7. *Cystoseira barbata* - standard deviation (assessment per depth).

The sampling stations assessment shows a gradual increase of the biomass values from Mangalia to Vama Veche. Thus, the lowest biomass values were recorded at Mangalia (with a variation between 4400 g/m^2 and 6950 g/m^2), and the highest at Vama Veche (with a variation between 4200 g/m^2 and 13500 g/m^2) (Fig. 8).

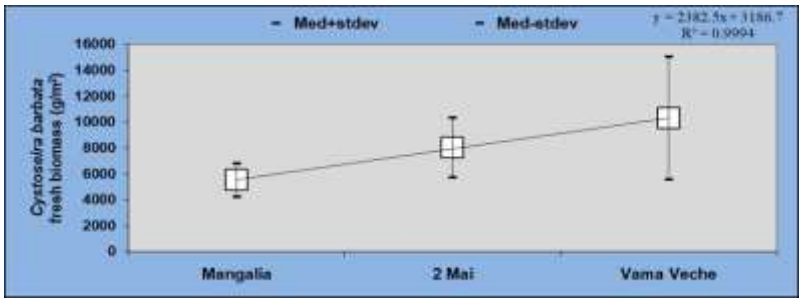

Fig. 8. *Cystoseira barbata* - standard deviation (assessment per sampling station).

At the Romanian shore, the marine phanerogams are located in coastal areas, known as being very sensitive areas, subject to a continuous anthropogenic impact. The marine phanerogam *Zostera noltei* serves as a biotope for many species of invertebrates and fish (which find there a place for feeding, breeding and defense), also helping to fix the substrate and to improve the water quality. The severe decline of the marine phanerogams along the Romanian Black Sea coast was due to uncontrolled dredging activities and eutrophication phenomenon. At present, *Zostera noltei* forms well-developed monospecific meadows, distributed between 1 to 3 meters depth, in the southern part, at Mangalia (Fig.7). The species was also identified in the northern part, at Năvodari, in association with *Stuckenia pectinata* (syn. *Potamogeton pectinatus*) and *Ruppia cirrhosa,* also between 1 to 3 meters depth.

The latter are highly competitive species that can replace *Zostera noltei*, a species highly sensitive to various types of natural or anthropogenic disruptions. The epiphytic flora for *Zostera noltei* was rich during summer 2016, consisting of specimens of the red algae *Acrochaetium secundatum* and *Colaconema thuretii.* Regarding the fresh biomass variation at Mangalia, the highest values were recorded at a depth range of 2 to 3 meters. During summer 2016, for *Zostera noltei* the fresh biomass variation was between 600 and 1800 g/m^2 (Fig. 9).

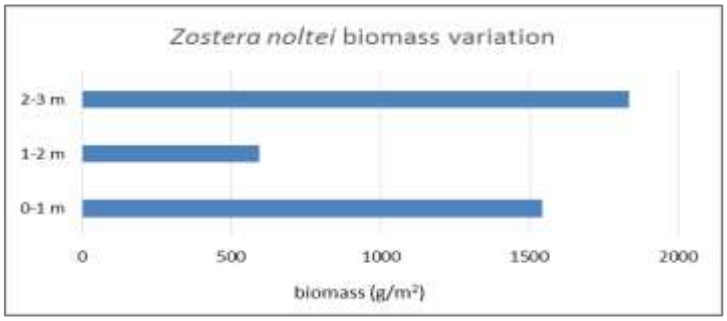

Fig. 9. *Zostera noltei* – average biomass variation in 2016 along the Romanian Black Sea coast.

Particular attention was paid to perennial species of the genus *Phyllophora*, species that no longer develop potentially exploitable biomass, identified recently only as clusters in the northern part of the Romanian shore. Thus, *Coccotylus truncatus* (syn. *Phyllophora brodiaei*) was reported in 2015 at Constanta North, with a distribution between 7 to 10 meters depth, in association with *Ceramium virgatum* (Fig.10). Regarding the quantitative assessment of this species, the fresh biomass at 7.5 meters depth was 760 g/m^2, much lower compared to previous decade assessments, when the species developed biomass with an exploitable potential. Recently, a field consisting exclusively of *Phyllophora crispa* (Fig.10) was identified at Sf. Gheorghe, at a depth of 35 m, in association with the red alga *Spermothamnion strictum* (Fig.10), also an interesting presence, with little information for the Romanian shore, although common in other countries in the *Phyllophora* communities. The references provides information about the Sf. Gheorghe area as being particularly important for sheltering red algae of the *Phyllophora* genus, part of the renowned „Zernov *Phyllophora* Field", species extremely important both ecologically and economically (Vasiliu F., Bodeanu N., 1972).

Fig.10. *Coccotylus truncatus* (left), *Phyllophora crispa* (middle) and *Spermothamnion strictum* (right).

Bray Curtis similarity (PRIMER v.6) based on biomass data confirms the strong similarity between the sampling stations from the southern part (Mangalia, 2 Mai and Vama Veche) due to the presence of the perennial species in these areas and similar biomass developed by these species. Another strong similarity was noticed, between Agigea, Costineşti and Tuzla due to the fact that these areas are dominated during summer season by the same phytobenthic association – *Ulva – Cladophora – Ceramium*. The dendrogram outlines a clear difference between the southern extreme coastline, characterized by a higher specific diversity, and the northern part, dominated by opportunistic species (Fig.11).

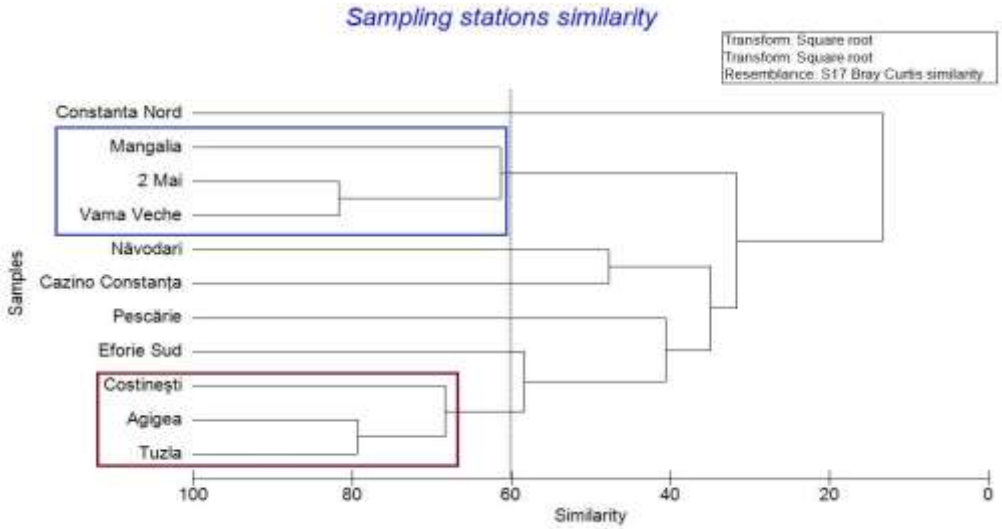

Fig. 11. Similarity between sampling stations based on fresh biomass data in 2016.

For the phytobenthic component, the graphical representation of the fresh biomass distribution along the Romanian Black Sea coast pointed out that the maximum biomass values were registered in the southern extremity of the seaside, respectively along Mangalia-2 Mai-Vama Veche. There is a clear gradient from northern to southern part of the coastline, in the sense of increasing the biomass values from Năvodari to Vama Veche, due to the high biomass values developed by *Cystoseira* and *Zostera*, incomparable with the biomass developed by opportunistic ephemeral species of the genres *Ulva* or *Cladophora* (Fig.12).

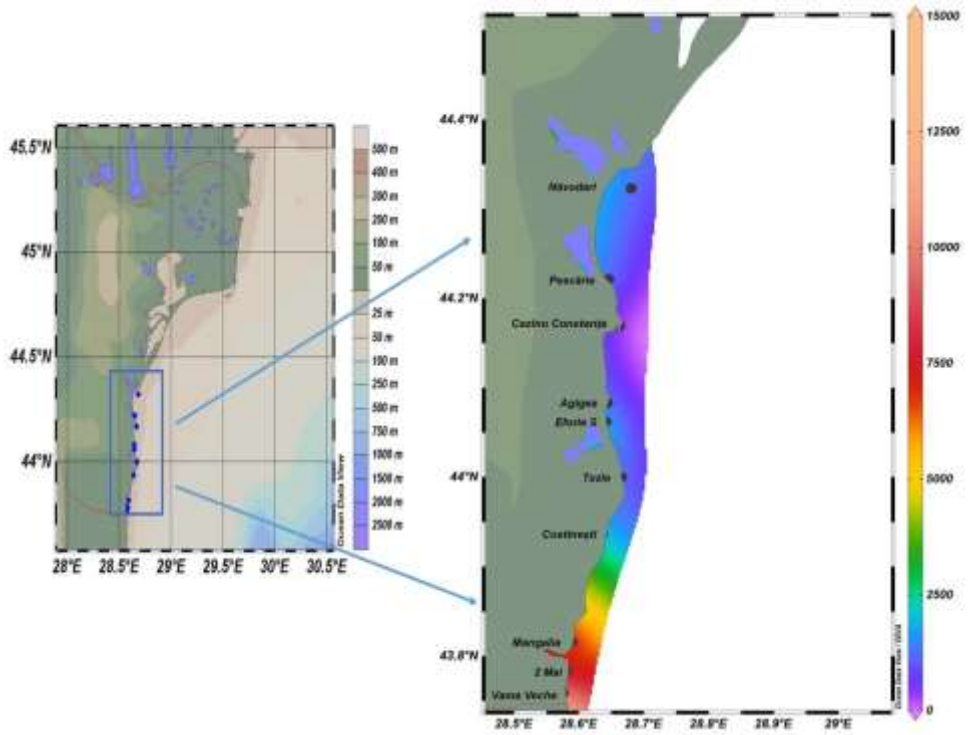

Fig.12. Graphic representation of the fresh biomass distribution along the Romanian Black Sea coast in 2016.

CONCLUSIONS

- ✓ Among the opportunistic species, the dominant were *Ulva rigida, Cladophora* sp. *Ceramium virgatum.*
- ✓ *Ulva rigida* developed the highest biomass among the opportunistic species in 2016.
- ✓ *Cystoseira barbata* can be identified in the southern part of the Black Sea coast, at Saturn, Mangalia, 2 Mai and Vama Veche.
- ✓ *Zostera noltei* was observed at Navodari and Mangalia.
- ✓ There is currently information of the existence of two *Phyllophora* species at the Romanian Black Sea coast: *Coccotylus truncatus* (identified in the Constanţa area) and *Phyllophora crispa* (identified at Sf. Gheorghe).
- ✓ In 2016, the maximum biomass values were recorded in the southern part, from Mangalia to Vama Veche.

Acknowledgments

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