Performing First Integrative Evaluation of the Ecological Status of Romanian Black Sea Waters Using Nested Environmental Status Assessment Tool (NEAT) *(Oana Marin, Laura Boicenco, Valeria Abaza, Elena Bișinicu, Valentina Coatu, Mădălina Galațchi, Luminița Lazăr, Andra Oros, Elena Pantea, Cristina Tabarcea, George Țiganov, Oana Vlas)*	**"Cercetări Marine" Issue no. 50** **Pages 108 - 125**	**2020**

PERFORMING FIRST INTEGRATIVE EVALUATION OF THE ECOLOGICAL STATUS OF ROMANIAN BLACK SEA WATERS USING NESTED ENVIRONMENTAL STATUS ASSESSMENT TOOL

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ABSTRACT

The integrated assessment of the ecological status of marine waters is considered the ultimate goal under Marine Strategy Framework Directive in order to provide an overview of the current ecological state of the marine environment. The aim of this paper is to provide the first integrative evaluation of the ecological status of Romanian Black Sea waters. The Nested Environmental Status Assessment Tool (NEAT) uses an ecosystem-based approach, excluding the *"one-out, all-out"* (OOAO) very restrictive principle. For the Romanian Black Sea waters case study, NEAT version 1.4 was tested. The current evaluation was performed based on more than 50 indicators, aggregated into the evaluation in a comparable and systematic way. The evaluation was performed under 7 out of the total 11 descriptors according to MSFD: D1 (Biodiversity), D2 (Non-indigenous species/current evaluation performed only for non-native zooplankton species), D3 (commercial fish, both pelagic and demersal), D5 (Eutrophication), D6 (seafloor integrity), D8 (Contaminants) and D9 (Contaminants in biota). The assessment period was 2012 – 2017. The study area was divided into four Spatial Assessment Units (SAUs): variable salinity, coastal, shelf and offshore waters. NEAT classifies each SAU from ecological point of view relying on the considered ecosystem component and habitat type.
Key-Words: Marine Strategy Framework Directive, integrative methods, ecological status, Romanian Black Sea waters.

AIMS AND BACKGROUND

The holistic Nested Environmental status Assessment Tool (NEAT) was developed for supporting the integrated assessment of the ecological

status of marine waters. For the Romanian Black Sea waters previous studies were dedicated to the assessment of the ecological status under Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive) (MSFD) criteria, but without an integrated approach for all descriptors. For the moment, NEAT is considered the most integrative tool that directly serves the purposes of MSFD. The requirements of MSFD and Commission's Decision 848/2017 for the Member States is to define the environmental status of marine waters under their jurisdiction based on specific criteria and methodological standards.

NEAT is a software designed by DEVOTES project for performing environmental assessments. NEAT is an acronym for "Nested Environmental status Assessment Tool" and the software is an implementation of NEAT as a biodiversity assessment tool used for assessing the environmental status of marine areas according to the European Marine Strategy Framework Directive (MSFD) http://www.devotes-project.eu/neat. NEAT uses an ecosystem-based approach, excluding the *"one-out, all-out"* (OOAO) very restrictive principle. An overall assessment of the ecological status of marine ecosystems (including species and habitats) was performed also in 2018 based on the same national data set (2012 – 2017), but the approach was not an integrative one. Each ecosystem component was separately evaluated, so the next step for the Romanian Black Sea waters is intended to be the aggregation of results, in order to have an overview of the ecological status. However, the present study will make certain references to the latest ecological status assessment (Boicenco *et al.*, 2018) to highlight the differences and understand whether NEAT is a suitable tool for future assessments of the ecological status of the marine environment.

The aim of this paper is to present the first integrated large-scale assessment of the Romanian Black Sea waters ecological status based on several ecosystem components and descriptors, in accordance with MSFD principles.

EXPERIMENTAL

NEAT evaluates the ecological status based on five classes adopted from the assessment scheme of the Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy Water Framework Directive (WFD). So, it should be noted from the outset that NEAT does not use two classes as established in MSFD. Each class is assigned to a specific color in accordance with the ecological status and to WFD principles: High (blue); Good (green); Moderate (yellow); Poor (orange); Bad (red).

In order to properly evaluate the ecological status of the Romanian Black Sea waters based on NEAT principles, some predefined steps were followed:

1) Firstly, the assessment period was established. For the current evaluation NEAT was applied on national data from 2012 to 2017.
2) The next step was to define the Spatial Assessment Units (SAUs). For the Romanian Black Sea waters, the study area was divided into four SAUs (Fig. 1):

- **BLK_RO_RG_TT03 - Variable salinity waters** - waters with variable salinity located in the northern part under the direct influence of the Danube, from the river mouths into the Black Sea, south to Portita by 30 m depth. The waters are delimited by the average seasonal salinity up to 8.0 PSU and annual average up to 14.5 PSU;
- **BLK_RO_RG_CT - Coastal waters** - coastal waters located from the central part of Romanian seashore to south (Portiţa to Vama Veche), from the baseline to 30m isobath. The waters are delimited by the seasonal average salinity 8 - 16 PSU and annual average up to 16.0 PSU;
- **BLK_RO_RG_MT01 - Shelf waters** - marine waters between 30 and 200 m depth; waters inside and outside the continental shelf, delimited by the average seasonal and annual salinity in the range of 16 - 17.5 PSU;
- **BLK_RO_RG_MT02 - Offshore waters** – marine waters delimited by the average seasonal and annual salinity higher than 17.5 PSU, at depths of at least 200 meters (Mihailov *et al.*, 2014).

3) For evaluation purpose, the total area (expressed in square kilometers) was established for each SAU:

- Variable salinity waters: 1359 km^2
- Coastal waters: 1040 km^2
- Shelf waters: 20165 km^2
- Offshore waters: 7058 km^2

Total area of the Romanian Black Sea waters (Black Sea_RO): 29662 km^2.

4) Then, the identified habitats in each SAU were pre-defined, as follows:

- Pelagic habitats
- Benthic habitats (rocky and sedimentary).

For a more concise evaluation, for benthic habitats, four broad habitat types were identified, according to EUNIS marine habitat classification 2019: Infralittoral rock and biogenic reef, Infralittoral sands, Circalittoral sands and Offshore circalittoral muds and mixed sediments.

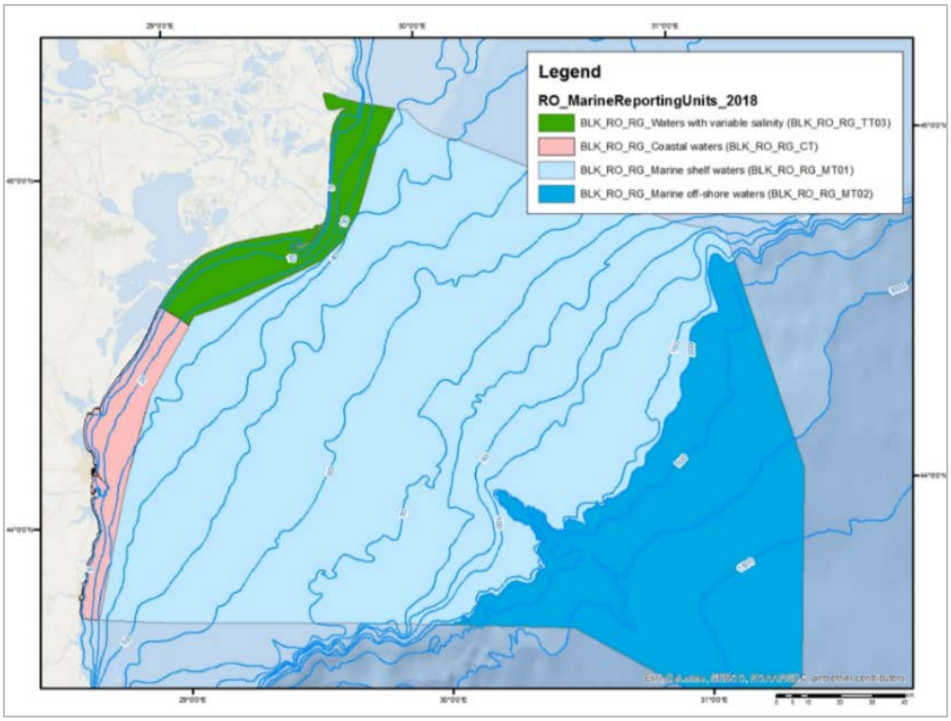

Fig. 1. Romanian Black Sea waters – Spatial assessment units (SAUs) (original)

Furthermore, five special habitats, sub-types of the broad habitat types mentioned above, were also analyzed: Infralittoral rock with photophilic algae, Infralittoral rock with *Cystoseira*, Infralittoral sands with *Zostera*, Circalittoral muds with *Mytilus galloprovincialis* and Offshore circalittoral muds and mixed sediments with *Modiolula phaseolina* (accepted name according to WORMS).

5) The fifth step is considered to be the establishment of the ecosystem components submitted for evaluation.

For the current evaluation, following elements were considered:

- biological components (macroalgae, seagrasses, benthic macroinvertebrates, phytoplankton, zooplankton, pelagic and demersal fish).
- chemical data (nutrients, contaminants in water, sediments and biota).

6) Choosing the descriptors with appropriate available data.

The current evaluation was performed under seven out of the total eleven descriptors of the MSFD: D1 (Biodiversity, including benthic habitats), D2 (Non-indigenous species/current evaluation performed only for non-native zooplankton species), D3 (commercial fish, both pelagic and demersal), D5

(Eutrophication), D6 (seafloor integrity), D8 (Contaminants), D9 (Contaminants in biota).

7) Establishing the appropriate ecological indicators.

For the Romanian Black Sea waters, the current evaluation was based on more than 50 indicators aggregated into the evaluation in a comparable and systematic way. Around 40 indicators were considered enough for adequate assessment of the ecological status (Borja *et al.*, 2019). The indicators are considered the basis of the assessment, therefore the establishment of threshold values is very important, the evaluation being exclusively based on these values. Each indicator is associated with an ecosystem component, so these indicators must be representative for the analyzed ecosystem components.

RESULTS AND DISCUSSION

For the Romanian Black Sea waters ecological evaluation, the latest available NEAT version (NEAT v.1.4) was applied. For the holistic assessment, two types of treatments were performed:

I. weighting by SAU surface area (expressed in square kilometers as mentioned above);
II. filtering MSFD descriptors.

Three overall assessments for each SAU (waters with variable salinity, coastal, shelf and offshore waters) were performed:

1. an assessment depending on ecosystem components;
2. an assessment depending on habitat type (for both broad habitat types and sub-types);
3. an assessment filtering by each of the seven MSFD descriptors (D1, D2, D3, D5, D6, D8, D9).

The results of all ecological analyses were expressed as summarized values, meaning a final NEAT value for each SAU, and in the end for the entire Romanian Black Sea waters is provided.

First assessment: SAU + ecosystem components evaluation (calculated as summarized values); weight by SAU area

After the integration of the assessment results, the global NEAT value is 0.744 indicating a good ecological status for the environmental components in the Romanian Black Sea waters. However, demersal fish, nutrients in water column, phytoplankton and macroalgae communities are, according to NEAT evaluation, the most impacted ecological components in Romanian Black Sea waters. In opposition, the zooplankton communities, contaminants' concentration in sediments and biota are in high ecological status, whilst the benthic macroinvertebrates and contaminants concentration in water column, in a good ecological status (Table 1).

Second assessment: SAU + habitats evaluation (calculated as summarized values); weight by SAU area

Regarding NEAT evaluation based on habitat type, it was observed that the most impacted habitats in Romanian Black Sea waters are the rocky benthic habitats generated by the phytobenthic communities. Thus, the specific sub-type Infralittoral rock with photophilic algae is in bad ecological status, whilst the special sensitive habitats generated by the key species *Cystoseira barbata* and *Zostera noltei* are in moderate ecological status (Table 2). However, constant monitoring of these phytocoenosis is absolutely necessary in order to see the future evolution of the overall ecological status. Changes may occur due to specific anthropogenic activities in coastal area (dam construction, beach-nourishment, etc.).

These two sensitive phytobenthic species, *C. barbata* and *Z. noltei*, have a key ecological role for the marine environment and are very sensitive to anthropogenic disturbing factors (Marin *et al*., 2013). They were recently included in the Red List of endangered marine species, because these habitats have a particularly important ecological functions for the coastal area.

Benthic broad habitat types (infralittoral sand, circalittoral sand, circalittoral mud, offshore circalittoral mud and offshore circalittoral mixed sediments) were assessed based on their biotic communities using M-AMBI*(n) (Sigovini *et al.*, 2013), although only two special sub-types were clearly defined: circalittoral mud with *Mytilus galloprovincialis* and Offshore circalittoral mud and mixed sediments with *Modiolula phaseolina*. Assessment results showed all habitats in good ecological status, although the subtype circalittoral mud with *Mytilus galloprovincialis* was exactly at the lower limit of good ecological status ($EQR_{M\text{-}AMBI}$ = 0.68) (Boicenco *et al*., 2018; Abaza *et al.*, 2018) (Table 2). Further work is necessary on developing classification systems for other habitat subtypes occurring on the benthic broad habitat types that will better define their ecological status.

Third assessment: NEAT evaluation filtering by MSFD Descriptors (calculated as summarized values); weight by SAU area

The final NEAT assessment includes all the ecosystem components and indicators associated to the equivalent Descriptor. The results are presented in Table 3. Generally, the worst ecological status assignation is for Descriptor 3, according to the commercial fish evaluation. Based exclusively on 2012 – 2017 national data, the other descriptors associated components are in better ecological status, but future evaluations are needed to confirm or infirm this theory.

Table 1. NEAT assessment results for all SAUs based on ecosystem components; weighting by SAU surface
Colors indicate the ecological status: High: blue; Good: green; Moderate: yellow; Poor: orange; Bad: red

SAU	Area (km^2)	total SAU weight	NEAT value	Ecological Status	Phytoplankton	Zooplankton	Seagrasses	Macroalgae	Benthic macroinvertebrates	Water column Nutrients	Pelagic fish	Demersal fish	Water column Contaminants	Sediments Contaminants	Biota Contaminants
BS_RO	**29662**		**0.744**	**good**	**0.366**	**0.889**	**0.503**	**0.348**	**0.678**	**0.256**	**0.509**	**0.183**	**0.732**	**0.817**	**0.824**
Variable salinity	1359	0.046	0.686	good	0.513	0.773			0.673	0.010	0.470		0.725	0.776	
Coastal	1040	0.035	0.613	good	0.453	0.712	0.503	0.348	0.711	0.064	0.550	0.127	0.723	0.800	
Shelf	20165	0.681	0.685	good	0.348	0.649			0.677	0.299		0.184	0.733	0.825	0.824
Offshore	7058	0.238	0.944	high		0.944									

Table 2. NEAT assessment results for all SAUs based on habitat type; weighting by SAU surface
Colors indicate the ecological status: High: blue; Good: green; Moderate: yellow; Poor: orange; Bad: red

SAU	Area (km^2)	total SAU weight	NEAT value	Ecological Status	Infralittoral sands	Infralittoral rock with photophilic algae	Circalittoral sands	Circalittoral muds	Offshore circalittoral muds with *Modiolula phaseolina*	Benthic habitats	Pelagic habitats	Infralittoral sands with *Zostera*	Infralittoral rocks with *Cystoseira*	Circalittoral muds with *Mytilus galloprovincialis*
BS_RO	**29662**		**0.744**	**good**	**0.666**	**0.196**	**0.727**	**0.670**	**0.755**	**0.749**	**0.808**	**0.531**	**0.499**	**0.600**
Variable salinity	1359	0.046	0.686	good	0.691			0.655		0.776	0.622			
Coastal	1040	0.035	0.613	good	0.569	0.196	0.727	0.700		0.744	0.609	0.531	0.499	
Shelf	20165	0.681	0.685	good					0.755	0.748	0.637			0.600
Offshore	7058	0.238	0.944	high							0.944			

Table 3. NEAT assessment results for all SAUs filtering by MSFD Descriptors; weighting by SAU surface
Colors indicate the ecological status: High: blue; Good: green; Moderate: yellow; Poor: orange; Bad: red

SAU	NEAT value	Ecological Status class	Phytoplankton	Zooplankton	Seagrasses	Macroalgae	Benthic macroinvertebrates	Water column Nutrients	Pelagic fish	Demersal fish	Water column Contaminants	Sediments Contaminants	Biota Contaminants
MSFD D1													
BS_RO	**0.656**	**good**	**0.072**	**0.529**	**0.503**	**0.360**	**0.678**						
Variable salinity	0.672	good	0.532	0.747			0.673						
Coastal	0.592	moderate	0.331	0.454	0.503	0.360	0.711						
Shelf	0.658	good	0.100	0.521			0.677						
MSFD D2 (evaluation performed only for *Mnemiopsis leidyi*)													
BS_RO	**0.925**	**high**		**0.925**									
Variable salinity	0.700	good		0.700									
Coastal	0.821	high		0.821									
Shelf	0.720	good		0.720									
Offshore	0.944	high		0.944									
MSFD D3													
BS_RO	**0.198**	**bad**							**0.509**	**0.183**			
Variable salinity	0.470	moderate							0.470				
Coastal	0.366	poor							0.550	0.127			
Shelf	0.184	bad								0.184			

SAU	NEAT value	Ecological Status class	Phytoplankton	Zooplankton	Seagrasses	Macroalgae	Benthic macroinvertebrates	Water column Nutrients	Pelagic fish	Demersal fish	Water column Contaminants	Sediments Contaminants	Biota Contaminants
MSFD D5													
BS_RO	**0.667**	**good**	**0.684**	**0.780**		**0.313**	**0.678**	**0.256**					
Variable salinity	0.643	good	0.474	0.960			0.673	0.010					
Coastal	0.651	good	0.698	0.883		0.313	0.711	0.064					
Shelf	0.669	good	0.696	0.766			0.677	0.299					
MSFD D6													
BS_RO	**0.673**	**good**			**0.503**	**0.360**	**0.678**						
Variable salinity	0.673	good					0.673						
Coastal	0.599	moderate			0.503	0.360	0.711						
Shelf	0.677	good					0.677						
MSFD D8													
BS_RO	**0.765**	**good**									**0.732**	**0.817**	**0.720**
Variable salinity	0.759	good									0.725	0.776	
Coastal	0.774	good									0.723	0.800	
Shelf	0.765	good									0.733	0.825	0.720
MSFD D9 (evaluation performed only for *Mytilus galloprovincialis*)													
BS_RO	**0.919**	**high**											**0.919**
Shelf	0.919	high											0.919

Phytoplankton is one of the basic biological quality elements in the Water Framework Directive (WFD) and of great concern in four MSFD's descriptors: Biodiversity (D1), Non-Indigenous Species (NIS) (D2), Food (trophic) chain (D4) and Eutrophication (D5) (Commission Decision EU 2017/848). The phytoplankton biomass was the indicator used for environmental status assessment of pelagic habitats. The results for all coastal and shelf waters showed a moderate to poor ecological status for phytoplankton ecosystem component based on SAU evaluation. The analysis at pelagic habitat level showed good environmental status, many indicators, as phytoplankton, mesozooplankton, NIS, pelagic fish, water column nutrients, with different ecological status being integrated in NEAT assessment results by SAU weight (Table 2).

Zooplankton community metrics are functions of changing natural environmental factors and respond to a gradient of mixed anthropogenic pressures (Varkitzi *et al.,*2018). For this ecosystem component, NEAT evaluation under MSFD **Descriptor 1** indicates a moderate overall status for the Black Sea. Analyzing all SAUs, waters with variable salinity were assessed in good ecological status, while coastal and shelf waters were in moderate ecological status (Table 3). In the previous study (Boicenco *et al.,* 2018), the zooplankton component was analyzed differently, taking into consideration the seasonal variations of both mesozooplankton and copepods biomass indicators and the percentages that characterize each water body. Therefore, in cold season the zooplankton component was in good ecological status according to both indicators in all SAUs, while in the warm season the assessment on the above-mentioned indicators showed a poor ecological status. The NEAT approach is different, evaluating the zooplankton component as an overall, integrating both indicators and season and because of that, the results were different.

Also, the macrophyte communities are in a poor ecological status, taking into consideration that are mainly formed by opportunistic species. A high uniformity degree in terms of species diversity can be noticed nowadays along the Romanian Black Sea coast. Only punctually a higher specific diversity can be observed, especially in the southern part of the Romanian shore. The seagrass populations are in moderate ecological status (Table 3), but at the same time they were in a fragile balance in the last years due to various anthropogenic activities.

For **Descriptor 2**, the only available data for the moment are the ones for zooplankton invasive species (namely for *Mnemiopsis leidyi*). So, for Descriptor 2 the data are deficient, and additional indicators are needed for a more specific evaluation. Anyway, based on this ecosystem component, the variable salinity and shelf waters were classified in good ecological status, whilst coastal and offshore waters are in high ecological status (Table 3). As

the approaches to the two assessment are different (Boicenco *et al.*, 2018 and present study), there were differences regarding the ecological classification of water bodies. Under current NEAT evaluation, the provided data took into consideration the seasonality of collected data while for the last report (Boicenco *et al.*, 2018), the evaluation considered only the marine reporting units and not the season.

The assessment under **Descriptor 3** was performed for commercial fish, both pelagic and demersal. As a general consideration, fish are mobile species, some are migratory and, in this case, it is very difficult to assess the general state of a fish stock. Based on the best available data, the assessment for pelagic zone indicates a moderate status. But, among other factors, the lack of technical capacity to exploit sprat (*Sprattus sprattus*) along the Romanian coast has an influence on the ecological assessment of pelagic fish. For the demersal area, the status is bad (Table 3). This can be correlated with the period of intense fishing, but nowadays demersal fish communities are recovering from a period of over-exploitation from the past. Current fisheries management measures are delivering improvements and good environmental status is likely to be achieved in the future if these measures are maintained.

For **Descriptor 5**, indicators based on eutrophication showed good status for all SAUs weighted by area (Table 3). For the variable salinity SAU corresponding to the Danube's direct influence area, we observed the bad status for nutrients (D5C1, primary) continuously discharged by the rivers from the NW and the moderate one for the chlorophyll *a* concentrations (D5C2, primary) as the direct effect of this input. Next, the high status of the dinoflagellates *Noctiluca scintillans* (D5C3, secondary) raised concerns on the indicator suitability for this SAU, acknowledging that it occurs at higher salinities (generally not in estuaries) (Turkoglu, 2013). Also, because moderate *Noctiluca* biomass are indicative of a degraded ecosystem in the form of an intermediate production state between the low production but healthy pristine state and the highly productive but degraded eutrophic state (Oguz and Velikova, 2010) we consider that might not be an appropriate indicator for the variable salinity area.

Generally, the criteria evaluation is in line with the last country's assessment in the MSFD reporting cycle (Boicenco *et al.*, 2018). However, that report considered the overall status as non-GES based on the integrated assessment according to BEAST (Black Sea Eutrophication Assessment Tool) and the roughly estimation of the affected surface (51%). The two opposing results are mainly due to the thin border of the eutrophication status of the Black Sea's nowadays and its regime shifts (Oguz and Velikova, 2010) (Daskalov *et al.*, 2017). That makes difficult to address the issue particularly due to the inadequate monitoring frequency and coverage in terms of habitats approach (Boicenco *et al.*, 2018).

The evaluation under **Descriptor 6** is performed only based on biotic indicators. The considered ecosystem components were phytobenthic (macroalgae and seagrasses) and zoobenthic communities. Although the ecological status is good for the variable salinity and shelf waters and moderate for the coastal waters (Table 3), additional pressure data are required for the correlation of the biotic indices with pressures. For the moment, NEAT offers an evaluation based only on biological data for Descriptor 6 (Table 3). As D 6 is a pressure descriptor, future assessment of spatial extent of habitat types adversely affected by physical disturbance must be considered.

For **Descriptor 8**, for contaminants data (2012-2017), heavy metals and organic pollutants, determined in three matrices (seawater, sediment, biota), the results of testing NEAT shows high and good status of the assessment units, based on the integrative approach (Table 3).

For the heavy metals group, including copper, cadmium, lead, nickel and chromium, the assessment for each element, matrix and for the whole group of metals, that was produced in 2018 for the evaluation according to Art. 17 of MSFD, (Boicenco *et al.,* 2018) shows an overall similarity with NEAT results. Although, some exceptions for particular elements, matrices and assessment areas were noticed, due to the fact that *"one out, all out"* principle was applied at that time, and not an integrative tool, like CHASE (Andersen *et al.,* 2016), or NEAT. The applied methodology for assessing GES was to compare 75th percentile of monitoring data against regulated or proposed target values. If 75th percentile value is below Environmental Quality Standards (EQS) the status is good, if not, the status is bad, without taking into consideration the variation ranges of concentrations (between best and worst).

For example, the 2018 evaluation of the heavy metals' indicator in water, following data processing for the period 2012-2017, reflected in the vast majority of cases a good ecological status (Boicenco *et al.,* 2018). The percentage exceeding the quality standards for heavy metals was insignificant, below the threshold of 25% determined for GES, excluding cadmium in the waters with variable salinity, where 26% of the samples presented slight overheads of the regulated value.

Also, the 2018 assessment of the heavy metals' indicator in sediment, following data processing for the period 2012-2017, reflected in the vast majority of cases a good ecological status (Boicenco *et al.,* 2018). However, copper revealed a bad condition in sediments from marine and variable salinity waters, cadmium in variable salinity areas, and nickel in all areas investigated. Sediments accumulate over time contaminants from the water column, and heavy metals concentrations are strongly dependent on the granulometry of sediment, as well as the organic substance content. It should be mentioned, however, that especially in the case of nickel, the concentrations characterizing the natural background can normally be higher in marine sediments from the

Black Sea area (Secrieru and Secrieru, 2002), compared to the recommended threshold values, therefore in the case of heavy metals in sediment, the assessment of the ecological status at the level of indicators must be made with caution and taking into account the specificities of the area (Oros, 2019). For organic contaminants, the results are quite different. Three groups of organic pollutants (organochlorine pesticides, polychlorinated biphenyls and polyaromatic hydrocarbons) were taking into consideration for the assessment. In assessment done in 2018, over 50% of the evaluated compounds exceeded the quality standards in more of 25 % of the analyzed samples, in water and about 25% in sediment. As the *"one out, all out"* principle was applied for the evaluation according to Art. 17 of MSFD, the overall result was bad, both in water and sediment. This approach is quite simplistic by comparing with NEAT. As for heavy metals the applied methodology for assessing GES was to compare 75th percentile of monitoring data against regulated or proposed target values. If 75th percentile value is below EQS, the status is good, if not, the status is bad. As NEAT uses 5 quality classes it allows to evaluate the contaminants level not only against maximum admissible level but also against best and worst values, giving another weight to the obtained result. The values of NEAT indices reflect the differences observed in 2018 assessment as their values are higher in sediment comparing to water.

For **Descriptor 9**, NEAT results (high status) confirm the results of 2018 assessment both for heavy metals and organic contaminants (Table 3). The analysis of the data for the period 2012 – 2017 shows that toxic heavy metals (cadmium, lead) had in marine mollusks of commercial interest a good ecological status, the 75th percentile value being below the maximum allowable values for human consumption provided in European legislation. In the case of lead, there was no surpassing of the maximum allowable value in the mollusks analyzed during the period 2012 – 2017, while in the case of cadmium there were surpasses of the threshold value in only 3% of the investigated samples (Boicenco *et al*., 2018). Same results were obtained for organic contaminants, where the 75th percentile values were below the maximum allowable concentration for human consumption provided in European or national legislation in less of 25% of the analyzed samples. Most of the organochlorine pesticides (HCB, lindane, heptachlor, aldrin, dieldrin, DDT) exceeded the limit in 2.2 to 11.36% of the analyzed samples, PCBs in 5.71% of the cases, while benzo[a]pyrene did not exceed the limit at all. Only endrin exceeded the maximum allowable values for human consumption in 20.45%, but this value still allows to classify it in good status according to the methodology developed to assess the status of Black Sea ecosystem in respect to MSFD (Boicenco *et al.,* 2018).

A multivariate cluster analysis (PRIMER-e v.7.0.13) was performed to test the similarities between overall NEAT results based on data from all assessment areas (weighting by SAU area) and habitat NEAT values. Bray-Curtis similarity (square root data transformation; cophenetic correlation 0.83) showed that overall NEAT clusters with pelagic habitat. Pelagic habitats contribute to a greater extent to the overall evaluation (Fig 2).

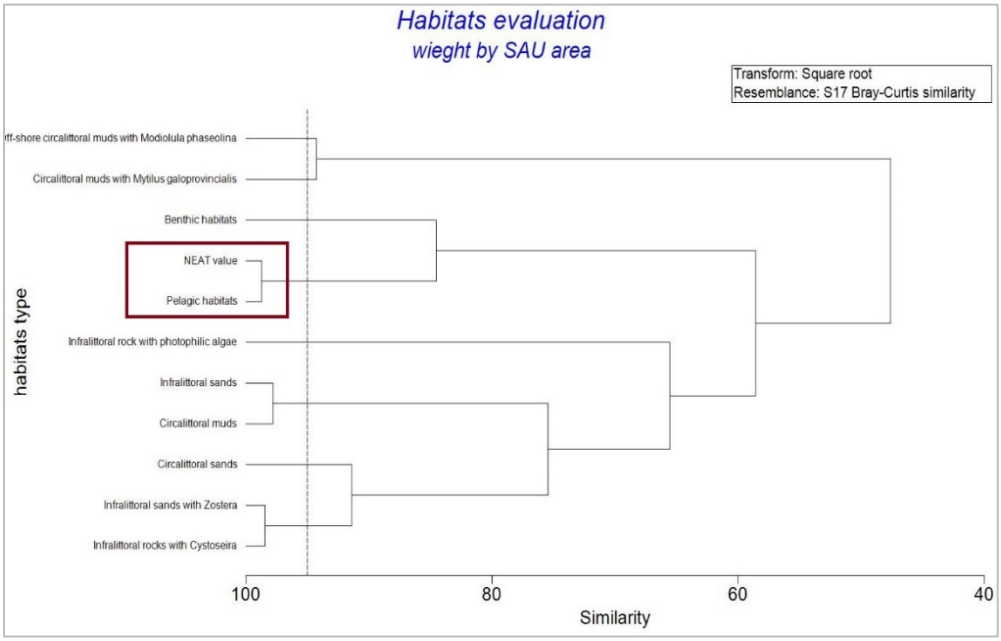

Fig. 2. Cluster analysis of NEAT results on all SAUs (weighting by SAU area)

CONCLUSIONS

Nested Environmental status Assessment Tool (NEAT) uses five classes scale (bad, poor, moderate, good, high) adopted from the assessment scheme of the Water Framework Directive (WFD). The previous assessment of the ecological status used two classes (GES and non-GES) based on Marine Strategy Framework Directive (MSFD) requirements. This is one essential aspect that must be mentioned in order to understand the differences that have appeared between the two evaluations (NEAT assessment and the non-integrated method used in the previous studies). So, the differences can be explained by the fact that the two approaches are quite different, NEAT being an integrated tool. Also, for some indicators the threshold values must be revised, since the establishment of threshold values is very important, the evaluation being exclusively performed based on these values.

Some of the descriptors need additional data. It is the case of descriptor 6, that requires validation of M-AMBI*(n) index (used for the assessment of benthic macroinvertebrates) and Ecological Index (used for the assessment of the phytobenthic communities) with pressure data and integration of the assessments made under descriptors D2, D3, D5, D6 (both physical disturbance and physical loss), D7 and D8 for assessment of adverse effects from anthropogenic pressures on habitat condition. Also, for the moment, descriptor 2 is deficient in terms of indicators and data. More data related to other invasive species need to be integrated, since the current evaluation is based exclusively on zooplankton data (*Mnemiopsis leidyi*). Also, additional indicators must be developed considering the benthic species and the effect of NIS on benthic habitats. Furthermore, for a final evaluation of descriptor 1, the results from other descriptors must be integrated, since the biodiversity descriptor shows the final ecological status of all ecosystem components.

For the moment, NEAT was tested based only on 2012 – 2017 data sets, with their limitations, but it must be underlined that the assessment itself is a dynamic process. In the future, once certain changes may appear, such as development of additional indicators or new benthic habitats evaluation, the overall assessment might change. In conclusion, it is desirable to test NEAT further, for instance on smaller areas, where anthropic influence is well known against "clean" areas, in order to evaluate better the worst and best values that should be used to provide a good evaluation with this tool.

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