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Assessing the Vulnerability of Marine Ecosystems in the Context of Climate Change

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1. INTRODUCTION

The paper analyzes the tools for establishing the ecological status of marine ecosystems in the context of climate change. The novelty of the paper is the use of mapping applications to obtain information on the intended study location such as: data on the physical properties of ecosystems, how many types of habitats, lists of indicators and links to relevant publications and reports. The working tools are specialized programs. The results are descriptive indicators of the analyzed ecosystems: Biota, Phytoplankton, Benthic flora, Fauna, Benthic fauna, ichthyofaunal, Marine mammals, Seabirds, the number of indicators per related water column habitats, the number of indicators on seabed habitats, the number of indicators per habitat type for specific and non-specific taxonomy, the number of indicators depending on the existing pressures in the area. As a working method, we can highlight both frequently used tools (the risk matrix, the vulnerability) and a new tools (software) for assessing the state of the environment, which allows the assessment of the health of marine systems. The methods used can be validated for different locations. The following were analyzed: ecosystem status characteristics, pressures and impacts, risk matrix for a marine ecosystem, risk assessment, anthropogenic impact on marine ecosystems, a model and descriptive indicators of good ecological status of the ecosystem, as well as vulnerability. The obtained results are: the descriptive indicators for Black Sea marine ecosystem, the assessment of ecological status of the marine ecosystem, the risk matrix and vulnerability.

1.1.The impact of climate change on biodiversity: The Black Sea is a very well monitored aquarium but the information obtained from the monitoring stations decreases as the depth of the sea basin increases. Research has shown that the temperature in 2019 was 4^0 C higher than in 2014. This has a negative impact on wildlife. There has also been a decrease in the size of phyto biomass due to climate change. Fish species have disappeared, which will be reflected as a negative economic impact in this area, for fish farming.

1.2. Description of marine water regimes: From the studies offered by the Maritime Hydrographic Directorate of Constanta, the Constanta Port Authority, the Constanta Environmental Protection Agency, the Constanta Chamber of Commerce and Industry, the Ministry of Environment, the Dobrogea-Littoral Water Directorate of Constanta, the National Agency for Mineral Resources and the National Fisheries Agency [3] information on water regimes containing marine ecosystems has been established. Depending on the hydro geological and climatic conditions, in the Black Sea basin and in the coastal areas, habitats of community importance are developed - the marine area of the Danube Delta, Sfantu Gheorghe, the dunes from Agigea, the submerged beaches from Eforie-Nord and Eforie-Sud, marine area Capul Tuzla, Vama Veche, Costinesti, 23 August, Cap Aurora, Costinesti, 2 Mai and areas with special avifauna protection-Razim, Sinoe, Tasaul, Siutghiol, Techirghiol, Black Sea [3] .

1.3. Anthropic impact on marine ecosystems: The influence of the activities carried out in the area of marine ecosystems can be analyzed on the following categories: maritime traffic activities-consisting of administrative-territorial activities, port and dam constructions, navigable signals, ferry signals-boats industrial economic activities; restrictive activities in navigation areas; activities in areas with resource exploitation; fishing activities; prohibited fishing areas at certain times of the year.

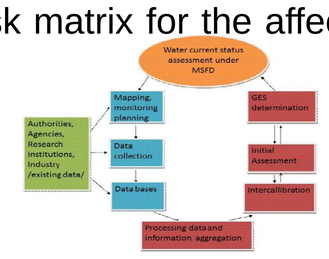
2. MATERIAL AND METHODOLOGY

2.1. Risk assessment in marine ecosystems

***The risk-disaster correlation*:**The environment is a broad concept that describes our biophysical surroundings. It includes air, water, soil, and living organisms such as plants and wildlife. The link between environmental risk assessment and disaster risk is system exposure, vulnerability and hazards .

2.2. Model and descriptive indicators of the good ecological status of ecosystems

The vulnerability of the ecosystems, the descriptive indicators of the good ecological status are analyzed and the risk matrix for the affected ecosystems is established.a)**Vulnerability of marine ecosystems; b) Good Environmental Status of marine ecosystems GES**



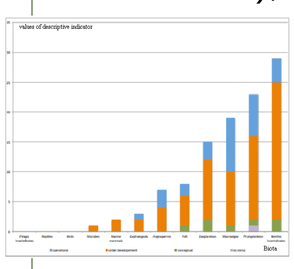
2.3.The risk matrix

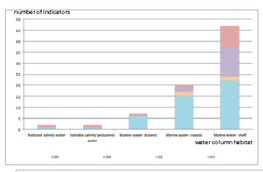
2.4. Choosing the location using map applications- maps (DEVOT Tools)

Descriptive indicators-Biota, Non-native species

2.5. Applications- Tools for assessing the state of the environment

The DEVOTools and NEAT instruments are known. Among the tools developed, it can highlight new free software, called NEAT (*New Environmental Assessment Tool*), which allows the assessment of the health of marine systems.





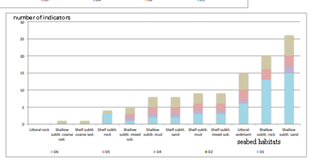
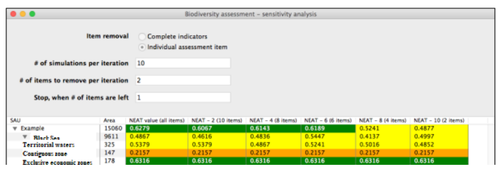
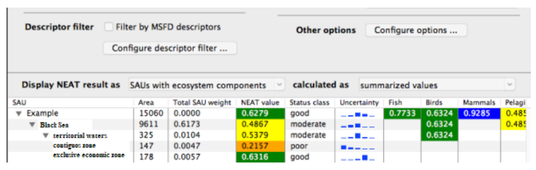


Table 1. Black Sea Risk Matrix by GES. [9]

Descriptive / GES Characteristics	Black Sea
D1-Biodiversity/ Phytoplankton	Moderate
D1-Biodiversity / Fish	Moderate
D1-Biodiversity / Mammals and reptiles	Moderate-High
D1-Biodiversity / Marine Birds	High
D1-Biodiversity / Predominant habitats	Moderate-High
D2-Non-native species	High
D3-Commercial fish & crustaceans	High
D7-hydrographic conditions/Marine food chain	High
D5-Eutrophication	Moderate
D6-Integrity	High
D8-Contaminants	Moderate-High
D9-Contaminants in fish & shellfish	Moderate
D10-Marine waste	High
D11-Underwater noise	High





4.RESULTS

The results obtained with NEAT are: description of each indicator, data on ecosystem assessment (Fig. 11), sensitivity analysis on areas (Fig.12). It was divide area of interest (Black Sea) into smaller parts (territorial waters, contiguous zone, exclusive economic zone) using biogeographic or environmental criteria. For each area we have a NEAT value (for different number of items). Risk assessment matrix for:Soil quality, water pollution, Soil degradation, degradation of natural habitats, to human components.

Table 3. Risk assessment matrix for Soil Quality.

Risk component	Severity	Magnitude	Persistence of impacts	Cumulative and synergistic effects	Probability	Risk/Type of risk
Transport	4	3	3	3	4	52- Very high risk
Oil rigs	3	2	3	2	4	40- Very high risk
Oil industry	4	4	3	3	4	56- Very high risk

Table 4. Risk assessment matrix for water pollution.

Risk component	Severity	Magnitude	Persistence of impacts	Cumulative and synergistic effects	Probability	Risk/Type of risk
Oil spills	2	2	2	3	2	18-Medium risk
Waste	2	1	3	3	4	36- Very high risk
Wastewater discharges	3	2	2	1	4	32-Higher risk
Ballast water discharges	4	3	4	3	4	56- Very high risk

Table 5. Risk assessment matrix for Soil degradation.

Risk component	Severity	Magnitude	Persistence of impacts	Cumulative and synergistic effects	Probability	Risk/Type of risk
Hydrocarbons	4	3	3	3	2	26-Higher Risk
Waste	3	3	4	2	4	48- Very high risk
Erosion	4	3	4	3	4	56- Very high risk

Table 6. Risk assessment matrix for degradation of natural habitats.

Risk component	Severity	Magnitude	Persistence of impacts	Cumulative and synergistic effects	Probability	Risk/Type of risk
Ballast water discharges	4	4	4	3	4	64- Very high risk
Ship waste	3	2	3	3	4	44- Very high risk
Treated water discharges	3	2	2	1	4	32- Higher Risk

Table 7. Risk assessment matrix for risks to human components.

Risk component	Severity	Magnitude	Persistence of impacts	Cumulative and synergistic effects	Probability	Risk/Type of risk
Port industry	4	3	3	3	4	52- Very high risk
Ballast water	4	3	4	3	4	56- Very high risk
Waste	3	3	3	2	3	33- Very high risk
Hydrocarbons	4	3	2	2	2	22- Medium risk

5. CONCLUSIONS

The areas exposed to risk in the Black Sea, where the indicators that define the good ecological status have values exceeded the recommended ones, are those delimited on the NE side of the Romanian coast (beyond Constanta- Gura Buhaz, Portita-Sfantu Gheorghe-Sulina). The global risk matrix is given in Table 8. By processing the indicators, indices result, which relate to different value scales and have a standardized interpretation. The qualitative measurement of the consequences is achieved by framing in five levels of severity (1. Insignificant: for the population, insignificant injuries; for ecosystems, some minor adverse effects on a few species or parts of the ecosystem, short-term and reversible; socio-political, insignificant without cause for concern.; 2. Minor; 3. Moderate; 4. Major; 5. Catastrophic), an internationally accepted methodology and used in risk assessment studies.

6. **ACKNOWLEDGEMENT**

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