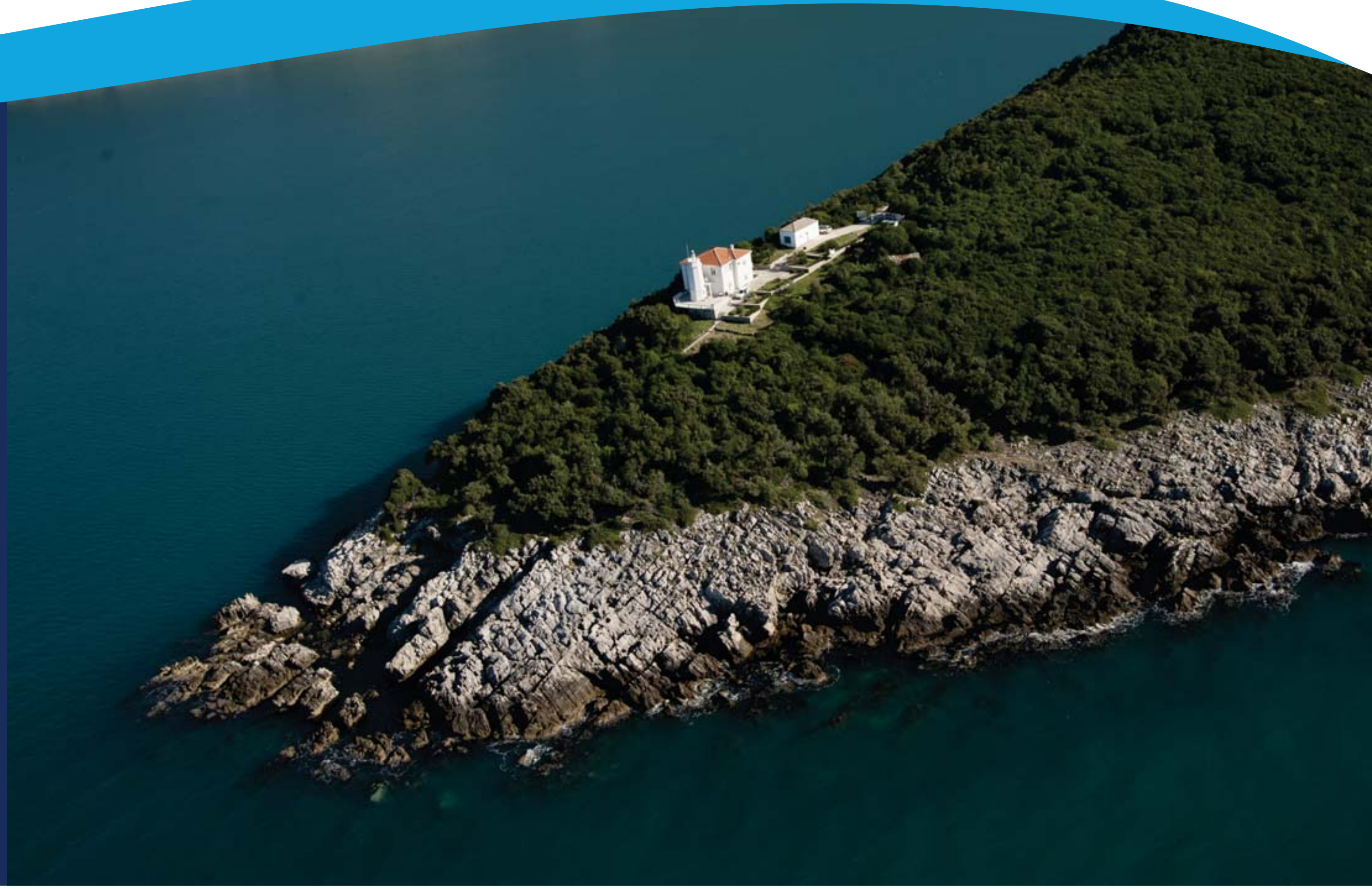
Implementation of the ecosystem approach in the Adriatic through marine spatial planning



The State and Pressures of the Marine Environment **in Montenegro**

UN environment programme
Mediterranean Action Plan Barcelona Convention
PAP/RAC
SPA/RAC
Montenegro Ministry of Ecology, Spatial Planning and Urbanism

Impressum

Project coordinators:	Marina Marković, MSc, PAP/RAC. Aleš Mlakar, PhD, PNAM, Ivana Stojanović, Ministry of Ecology, Spatial Planning and Urbanism
Habitats:	Milena Bataković, Mihailo Jovičević
Fish – pelagic:	Milica Mandić, PhD, Institute of Marine Biology, Ana Pešić, PhD, Institute of Marine Biology
Fish – demersal:	Mirko Đurović, PhD, Institute of Marine Biology
Eutrophication and contamination:	Ana Mišurović, MSc
Marine litter:	Milica Mandić, PhD, Institute of Marine Biology
Landscapes:	Aleš Mlakar, PhD, PNAM, Nika Cigoj Sitar, PNAM
Data and images:	Mihailo Jovičević; Nika Cigoj Sitar, PNAM
Translator:	Assia Barić
Cover design:	swim2birds.co.uk
Graphic design:	Ljudomat
Cover photo:	Montenegrin coast © Slaven Vilus

The report was prepared as part of the GEF Adriatic project, funded by the Global Environment Facility (GEF).

For citation:

UNEP/MAP-PAP/RAC i MEPU (2021). The State and Pressures of the Marine Environment in Montenegro. Authors (alphabetically): Bataković Milena, Cigoj Sitar Nika, Đurović Mirko, Jovičević Mihailo, Mandić Milica, Marković Marina, Mišurović Ana, Mlakar Aleš, Pešić Ana, Stojanović Ivana. Ur: PAP/RAC – GEF Adriatic project. pp. + attachments

Table of contents

List of tables

List of graphs

List of figures

List of maps

1. Introduction

The state and pressures of the marine environment in Montenegro have been analysed through the project “Implementation of the Ecosystem Approach in the Adriatic Sea through Marine Spatial Planning”(the GEF Adriatic Project). The GEF Adriatic Project is a subregional project carried out in Albania and Montenegro with the aim of restoring the ecological balance of the Adriatic Sea by implementing the ecosystem approach and marine spatial planning.

The project’s added value comes from ensuring the integration of two key management frameworks established by the Barcelona Convention – the ecosystem approach and marine spatial planning, by:

- Developing a methodology for the use of the ecosystem approach implementation results for the construction of marine spatial planning (MSP);
- Testing the developed methodology in the construction of marine spatial planning for selected areas;
- Building the capacity of project countries for the implementation of such an integrated approach.

In this manner, the GEF Adriatic Project is accelerating the implementation of the Integrated Coastal Zone Management Protocol and the Integrated Monitoring and Marine Ecosystem Assessment Programme (IMAP) which is crucial for the implementation of the ecosystem approach in the Mediterranean.

The assessment methodology of the state and pressures of the marine environment has been tested in this study through the spatialization of data obtainable from the implementation of the marine environment integrated monitoring program. Data obtained in this manner can, *inter alia*, be used in marine spatial planning. This method was initially developed by the pilot project “Defining the Methodological Framework for Marine Spatial Planning in the Bay of Kotor” (2016/017) and adapted for this study.

2. Legal and Methodological Background

Various material sources based on the ecosystem approach have been used as the basic methodological framework for the development of this study. The following is an overview of the most important ones.

2.1. International Legal Sources

2.1.1. Barcelona Convention

The Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (Barcelona Convention) serves as the legal framework for the Mediterranean Action Plan (MAP) which has 22 contracting parties: Albania, Algeria, Bosnia and Herzegovina, Croatia, Cyprus, Egypt, the European Community, France, Greece, Israel, Italy, Lebanon, Libya, Malta, Monaco, Montenegro, Morocco, Slovenia, Spain, Syria, Tunisia and Turkey. The Convention has been complemented with seven specific protocols. Together with the Convention, they stand as the most important international instrument for the protection and preservation of the Adriatic Sea.

At their 15th meeting, held in January 2008 in Almería (Spain), the Contracting Parties to the Barcelona Convention adopted the so-called ecosystem approach (EcAp) which, through the Barcelona Convention, implemented the Marine Strategy Framework Directive (MSFD 2008/56/EC) throughout the whole Mediterranean region, with the final objective being the achievement of good environmental status of the Adriatic Sea and coastal region (Decision IG 17/5).

Implementing EcAp in the Mediterranean region is one of the basic principles of UNEP/MAP and the Barcelona Convention, and the ecosystem approach has been integrated into all UNEP/MAP policies and activities. The implementation of the GEF Adriatic Project is a significant step for Montenegro in its integrated implementation of the ecosystem approach, and other international acts such as the Marine Strategy Directive.

2.1.2. Protocol on Integrated Coastal Zone Management

The Protocol on Integrated Coastal Zone Management is the seventh protocol of the Barcelona Convention which was adopted on 21 January 2011 in Almería (Spain) and which entered into force on 24 March that same year. The ICZM Protocol is the first supranational legal instrument which mandates integrated coastal zone management by taking into account spatial planning, the protection of natural environments and habitats, the protection of cultural heritage, as well as policies for sustainable development, agriculture, fishing, tourism and other economic activities in the coastal area. The Protocol is the basis for improving the legislation on development planning in contracting parties of the Barcelona Convention. To date 12 countries and the European Union have ratified the Protocol which makes its implementation mandatory on a national level because the Protocol has been integrated into the countries' domestic legal systems, and is legally above the law.

The main purpose of the Protocol is to provide a legal framework which will ensure that national legislations of Mediterranean countries integrate the principles of integrated coastal zone management. This entails the facilitation of rational planning which takes into account the landscapes and values of living habitats, economic, social and cultural development, the stability and integrity of coastal ecosystems, sustainable use of natural resources, the effects of natural hazards (in particular of climate change), and coherence between public and private initiatives and between all decisions by public authorities, at the national, regional and local levels. The Protocol is significant because it belongs to international instruments characterized by their obligation to produce results, as opposed to having an obligation to use best efforts.

One of the key principles of the Protocol is the implementation of the ecosystem approach in order to ensure sustainable development of the coastal zone, both the land and sea area (Article 6). Thus, the Protocol is one of the fundamental legal frameworks for the implementation of EcAp in the coastal zone, especially the land area. In comparison with the Marine Strategy Framework Directive (and all other regional initiatives such as Helcom, Ospar, etc.), EcAp stands out with its introduction of ecological objective 8: "Coastal ecosystems and landscapes" (Chapter 3.1.1) for which implementation frameworks have been established in most Articles, particularly Articles 8 and 16.

In addition, the state of the marine environment largely depends on anthropogenic pressures and influence from land, thus, while planning measures for achieving good environmental status of the marine region, the following integration principles stipulated by the Protocol should be taken into account:

- Overview of the entire ecosystem within the defined limits of the coastal area from Article 2 of the Protocol which defines the coastal zone as "the geomorphologic area either side of the seashore in which the interaction between the marine and land parts occurs in the form of complex ecological and resource systems made up of biotic and abiotic components coexisting and interacting with human communities and relevant socio-economic activities";
- Establishment of a multilevel management mechanism which will ensure sector policy coordination and facilitate policy implementation on lower administrative levels; and
- Harmonization and timely regulation of activities on land and sea, i.e. taking preventive actions concerning the only thing that can be effectively managed in the ecosystem, and that is its use by man.

2.1.3. Marine Strategy Framework Directive

Directive 2008/56/EC of the European Parliament and Council of 17 June 2008, establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive, SL L 164, 25 June 2008; hereinafter: MSFD), stipulates the need for Member States to implement the necessary measures for achieving or maintaining good environmental status of the marine region by 2020 at the latest. The Directive sets up a common framework and objectives for the prevention, protection and conservation of marine living habitats against harmful human activities.

MSFD determines the characteristics of good environmental status of the marine region (hereinafter: GESMR) with 11 qualitative descriptors: biological diversity, non-indigenous species, commercially exploited fish and shellfish, marine food webs, eutrophication, sea-floor integrity, hydrographical conditions, concentrations of contaminants, contaminants in fish, marine litter, introduction of energy (Table 2.1). Each descriptor is defined through a series of criteria and associated indicators.

Table 2.1: MSFD Descriptors

MSFD Descriptors (D1 – D11)	
D1.	Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions.
D2.	Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems.
D3.	Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.
D4.	All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.
D5.	Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters.
D6.	Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.
D7.	Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.
D8.	Concentrations of contaminants are at levels not giving rise to pollution effects.
D9.	Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards.
D10.	Properties and quantities of marine litter do not cause harm to the coastal and marine environment.
D11.	Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.

2.2. National Strategy for Integrated Coastal Zone Management in Montenegro

The National Strategy for Integrated Coastal Zone Management in Montenegro has been developed through the work of the Coastal Area Management Programme of Montenegro (CAMP Montenegro), in cooperation with the Ministry of Sustainable

Development and Tourism[1], and The Mediterranean Action Plan of the United Nations Environment Programme (UNEP/MAP) and its Priority Actions Programme/Regional Activity Centre (PAP/RAC). The Strategy has developed a strategic framework for the sustainable development of the coastal region in Montenegro by integrating spatial and development solutions for advancing economic, social and environmental performances of marine living habitats. By defining a set of concrete measures and actions in the Strategy Action Plan, a dynamic framework for the implementation of the Special Purpose Spatial Plan and the reform of the coastal resources management system has been created.

A key analytic basis used in the Strategy's design was the vulnerability assessment developed in accordance with the vulnerability of individual segments of living habitats. The analyses were carried out mostly on the land part of the coastal zone, although some segments included the sea as well. These analyses served as expert guidelines for determining the area where conditions for coastal fringe expansion have been met. The coastal fringe refers to the coastal zone where construction is either limited or restricted, in accordance with the ICZM Protocol.

The analysis of the state and pressures of the marine environment follows previous analyses carried out in the process of the Strategy's development, but with more detail regarding the marine zone and methodological improvements in the form of the ecosystem approach implementation.

2.3. The Ecosystem Approach

The ecosystem approach emerged several decades ago but only gained attention with the adoption of the Convention on Biological Diversity (1995) as the central principle in the implementation of the Convention (COP 5 Decisions: Decision V/6, 2000; CBD, 2004; Lakičević i Tatović, 2012. The ecosystem approach is a strategy for the integrated management of land, water and living resources that provides sustainable delivery of ecosystem services in an equitable way (UNEP 2011). Instead of examining single issues, the ecosystem approach recognizes ecological systems as a rich mix of interdependent elements that interact with each other in important ways. This is particularly important for oceans and coasts because these ecosystems provide human communities with valuable resources and functions. By applying the ecosystem approach one takes into account how nature works and the benefits (ecosystem services) it offers, as well as how to involve people in the decision-making process (Scottish Natural Heritage 2010). The objective of the ecosystem approach is not financial gain but the optimal use of the ecosystem without damage.

The basic principles of the ecosystem approach are (COP 5 Decisions: Decision V/6, 2000; Lakičević i Tatović, 2012):

1. The objectives of management of land, water and living resources are a matter of societal choices.
2. Management should be decentralized to the lowest appropriate level.
3. Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems.
4. Recognizing potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context. Any such ecosystem-management programme should:
   - Reduce those market distortions that adversely affect biological diversity;
   - Align incentives to promote biodiversity conservation and sustainable use;
   - Internalize costs and benefits in the given ecosystem to the extent feasible.
5. Conservation of ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the ecosystem approach.
6. Ecosystems must be managed within the limits of their functioning.
7. The ecosystem approach should be undertaken at the appropriate spatial and temporal scales.
8. Recognizing the varying temporal scales and lag-effects that characterize ecosystem processes, objectives for ecosystem management should be set for the long term.
9. Management must recognize that change is inevitable.

[1] The current Ministry of Ecology, Spatial Planning and Urbanism

10. The ecosystem approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity.
11. The ecosystem approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices.
12. The ecosystem approach should involve all relevant sectors of society and scientific disciplines.
13. An important part of the ecosystem approach's conception is marine planning/management.

The importance of the ecosystem approach has also been recognized in important international legislation, such as the Protocol on Integrated Coastal Zone Management in the Mediterranean, the Marine Strategy Framework Directive (2008/56/EC), and the Directive establishing a framework for maritime spatial planning (2014/89/EU).

The ecosystem approach does not differ from the comprehensive planning approach which is the result of integrated processing of space/living habitats, the economy and society. Besides its use and definition, it is important to emphasize that the ecosystem approach is place-based, meaning it requires spatial information processed through a geographic information system (GIS) which makes it applicable in modern spatial planning.

UNEP/MAP Ecosystem Approach

The Contracting Parties to the Barcelona Convention have committed to the implementation of the ecosystem approach (EcAp) through the UNEP/MAP system as a strategy for the comprehensive integrated management of activities related to marine and coastal ecosystems, with the final objective being the achievement of good environmental status of the Adriatic Sea and coastal region.

At the 17th meeting of the Contracting Parties to the Barcelona Convention (COP 17, 2012), the Contracting Parties agreed (through Decision IG 20/4) on an overall vision and goals for EcAp, on ecological objectives, operational objectives and indicators for the Mediterranean. A six-year cyclic review process of EcAp implementation was also established, covering the period 2016-2021. It has been systematized in the Integrated Monitoring and Assessment Programme (IMAP[2]), with 11 ecological objectives and 27 related indicators (four of which are candidate indicators, Table 3.1). These indicators represent tools for monitoring the condition of living habitats, while real change of the condition of habitats and systems can be fully accomplished by implementing strategies, plans and programmes, as was envisioned by the Protocol on Integrated Coastal Zone Management in the Mediterranean.

The 11 ecological objectives of IMAP are:

- EO1 Biodiversity
- EO2 Non-indigenous species
- EO3 Commercial species
- EO4 Marine food webs
- EO5 Eutrophication
- EO6 Sea-floor integrity
- EO7 Hydrographic alterations
- EO8 Coastal ecosystems and landscapes
- EO9 Contaminants
- EO10 Marine litter
- EO11 Underwater noise

By adopting EcAp, all parties to the Barcelona Convention have committed to cooperate in order to achieve good environmental status of the marine region, and to implement integrated marine and coastal zone management which seeks a balance between the use and conservation of natural resources. In other words, the adoption and implementation of EcAp ensures the achievement of fundamental MSFD objectives in the Mediterranean. There are, however, certain discrepancies between the elements determining good environmental status of the marine region in EcAp ecological objectives and MSFD descriptors (Table 3.2) The key difference lies in the addition of coastal ecosystems and areas in EcAp ecological objectives, which are not part of MSFD. In addition, specific objectives and indicators for four EcAp ecological objectives (commercially exploited fish and shellfish; marine food webs; sea-floor integrity; underwater noise) have yet to be officially adopted.

[2] UNEP(DEPI)/MED WG.420/4: Draft Integrated Monitoring and Assessment Programme/Guidance – https://wedocs.unep.org/rest/bitstreams/8456/retrieve

Table 2.2: Ecological objectives and indicators (IMAP)

IMAP Ecological objectives (EO)	Indicators
EO1. Biodiversity Biological diversity is maintained or enhanced. The quality and occurrence of coastal and marine habitats and the distribution and abundance of coastal and marine species are in line with prevailing physiographic, hydrographic, geographic and climatic conditions.	State indicators ▪ Habitat distributional range ▪ Condition of the habitat's typical species and communities ▪ Species distributional range (marine mammals, seabirds, marine reptiles) ▪ Population abundance of selected species (marine mammals, seabirds, marine reptiles) ▪ Population demographic characteristics – body size, age class structure, sex ratio, fecundity rates, survival/mortality rates
EO2. Non-indigenous species Introduction of invasive non-indigenous species has been minimalized. The effect of non-indigenous, particularly invasive, species on the ecosystem is limited.	Pressure indicator ▪ Trends in abundance, temporal occurrence, and spatial distribution of non-indigenous, particularly invasive, species, notably in risk areas
EO3. Commercial species Populations of selected commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.	State indicator ▪ Spawning stock biomass Pressure indicators ▪ Total landings ▪ Fishing mortality ▪ Fishing effort ▪ Catch per unit of effort (CPUE) or Landing per unit of effort (LPUE) ▪ Bycatch of vulnerable and non-target species
EO4. Marine food webs	*To be further developed*
EO5. Eutrophication Human-induced eutrophication is prevented, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom waters.	Pressure indicators ▪ Concentration of basic physical and chemical parameters and key nutrients in water column ▪ Chlorophyll-a concentration in water column
EO6. Sea-floor integrity	*To be further developed*
EO7. Hydrographic alterations Negative impact of new structures is minimal and does not adversely affect larger coastal and marine ecosystems.	Pressure indicator ▪ Location and extent of the habitats impacted directly by hydrographic alterations

IMAP Ecological objectives (EO)	Indicators
EO8. Coastal ecosystems and landscapes The natural dynamics of coastal areas are maintained. The coastal zone is in good condition.	Pressure/state indicators ▪ Length of coastline subject to physical disturbance due to the influence of man-made structures ▪ Land-use change (candidate)
EO9. Pollution Contaminants cause no significant impact on coastal and marine ecosystems and human health.	Pressure indicators ▪ Concentration of key harmful contaminants in seawater, sediment, and biota ▪ Level of pollution effects of key contaminants where a cause and effect relationship has been established ▪ Occurrence, origin (where possible), extent of acute pollution events and their impact on biota affected by this pollution ▪ Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels in commonly consumed seafood Percentage of intestinal enterococci concentration measurements within established standards
EO10. Marine litter Marine and coastal litter do not adversely affect coastal and marine environment	Pressure indicators ▪ Trends in the amount of litter washed ashore and/or deposited on coastlines (including an analysis of its contents, spatial distribution and, where possible, source). ▪ Trends in the amount of litter in the water column including microplastics and on the seafloor ▪ Trends in the amount of litter ingested by or entangling marine organisms focusing on selected mammals, marine birds, and marine turtles (candidate)
EO11. Underwater noise	Pressure indicators ▪ Proportion of days and geographical distribution where loud, low, and mid-frequency impulsive sounds exceed levels that are likely to entail significant impact on marine animal (candidate) ▪ Levels of continuous low frequency sounds with the use of models as appropriate (candidate)

Table 2.3: Comparison of MSFD descriptors and IMAP ecological objectives

MSFD descriptors	IMAP ecological objectives
D1. Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions.	EO1. Biological diversity is maintained or enhanced. The quality and occurrence of coastal and marine habitats and the distribution and abundance of coastal and marine species are in line with prevailing physiographic, hydrographic, geographic and climatic conditions.
D2. Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystem.	EO2. Introduction of invasive non-indigenous species has been minimalized. The effect of non-indigenous, particularly invasive, species on the ecosystem is limited.
D3. Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.	EO3. Populations of selected commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.
D4. All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.	*EO4. Marine food webs*
D5. Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters.	EO5. Human-induced eutrophication is prevented, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom waters.
D6. Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected. (Descriptor 6 or D6)	*EO6. Sea-floor integrity*
D7. Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.	EO7. Negative impact of new structures is minimal and does not adversely affect larger coastal and marine ecosystems.
-	EO8. The natural dynamics of coastal areas are maintained. The coastal zone is in good condition.
D8. Concentrations of contaminants are at levels not giving rise to pollution effects.	EO9. Contaminants cause no significant impact on coastal and marine ecosystems and human health.
D9. Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards.	
D10. Properties and quantities of marine litter do not cause harm to the coastal and marine environment.	EO10. Marine and coastal litter do not adversely affect coastal and marine environment
D11. Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment. (Descriptor 11 or D11)	*EO11. Underwater noise*

3. Working Methods

The working methods are based on the **Marine Vulnerability Assessment in the Bay of Kotor: Methodological Guidelines** (PAP/RAC, MSDT, 2017), with additional adjustments. The analysis of the state and pressures of the marine environment includes three of the four basic steps defined by the study (Figure 3.1) which represent complete units that include various information which can be used for other activities in the area of habitat protection and marine spatial planning. It should be noted that terms used in this analysis are often employed in numerous different ways and contexts in professional circles. Below is a set of definitions for the terms used in this analysis, followed by a methodological explanation.

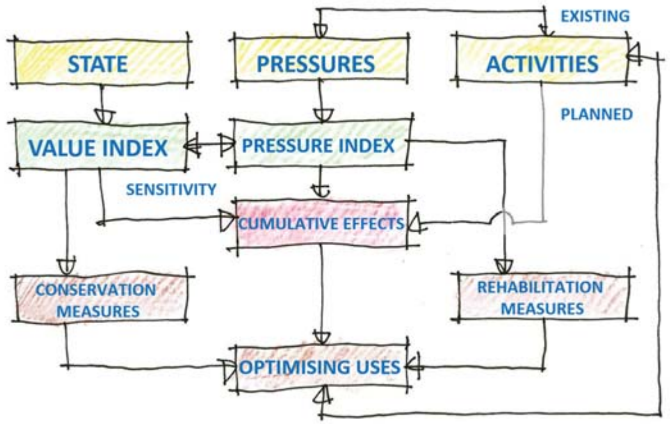


Figure 3.1: Schematic representation of the assessment flow
(adapted from: Marine vulnerability assessment in the Bay of Kotor: Methodological guidelines, PAP/RAC, MSDT, 2017)

1. **Identification** includes mapping basic data based on IMAP objectives and indicators:
   - of the **environmental state** showing existing natural and constructed features of the marine area (habitat, species and landscape diversity);
   - of existing **pressures** exhibiting the use of marine space (e.g. fishing effort), and physical and chemical characteristics of the marine environment resulting from existing human activities, i.e. the use of space (eutrophication, contamination, marine litter).
2. The environmental state and pressures are **evaluated** by defining the value index and impact index:
   - the **value index** reflects the level of the existing quality of the environment, i.e. individual areas, and it is primarily based on information on the environmental state, and sometimes pressures, whereby the presence of value elements determines the form of protection (formal protection based on sector regulations or planning category);
   - **pressure level** means the intensity of pressures in certain physico-chemical characteristics of the marine environment, where a high level of pressures indicates the need to remediate and/or reduce pressures.
3. Determining the threat level means assessing **cumulative effects** (degree, scope and significance) of pressures on the marine environment, primarily its biological characteristics, which depends on the environmental value, pressure levels and assessment of sensitivity to pressures, indicating the possible need for spatial location and/or technological optimizations in activity planning. Vulnerability analysis, as an additional, more complex analysis of the assessment of the impact of future activities, was not performed as part of this analysis.
4. The analysis resulted in defined **recommendations** for sector or planning **protection** or **remediation**, which could serve as the basis for the formulation of planning objectives and basic concepts of sea use (development and protection of the marine environment).

Analysis per ecological objectives includes contents/steps outlined below. The idea behind the working method is a uniform basic methodological framework that also facilitates a flexible analysis. Detailed analysis, text structure, and concept of data preparation and overlap (creating complex information), and assessment methods have been adapted to the specifics of each ecological objective and indicator.

The study was prepared in the manner where individual areas (ecological objectives) were analysed as much as available information allows. Thus the level of detail varies from objective to objective, as well as spatial unit to unit. The lack of data is partly supplemented by expert evaluation.

3.1. Recording: indicators, state and pressure description

This study is based on ecological objectives and indicators (Table 2.1). They can be further divided into those which show the **state** and those indicating **pressures**.

It should be noted that these are indicators of the state of living habitats primarily used for monitoring. These indicators cannot be necessarily used for specific spatial analysis of anthropogenic influence and habitat vulnerability. The final set of indicators used in this study are the result of the assessment of their use for analyzing natural value and impact indexes, marine spatial planning and data availability (Table 3.1). Some indicators are thus used in a customized way, and additional indicators have also been introduced.

The study has shown that ecological objectives and indicators cannot encompass all aspects relevant for marine spatial planning:

- Indicators and objectives concerning cultural heritage are missing.
- The ecological objective *Coastal ecosystems and landscapes* is based on quantitative indicators, while qualitative indicators are important for marine spatial planning, which can be used to illustrate and monitor the value and recognizability of a landscape. It is also important that beaches, apart from water quality (*Percentage of intestinal enterococci concentration measurements within established standards*), have not been treated as a specific spatial phenomenon. For that reason, landscape quality has been introduced as an indicator in this analysis.

Climate change has not been treated as a special form of pressure, but has been introduced separately through the analysis of other pressures. A further analysis of the influence of climate change on various segments of the marine environment will certainly constitute a significant step forward in the methodological sense.

The following table (Table 3.1) lists indicators according to ecological objectives, as well as additional indicators taken into account during the preparation of this study. Ecological indicators *marine food webs* (EO4), *sea-floor integrity* (EO6), and *underwater noise* (EO11) have not been analysed because of a lack of data. The ecological objective *biodiversity* (EO1) has been divided into several components according to MSFD descriptors, due to its complexity. The analysis of fish species combines the ecological objectives of *biodiversity* and *commercially exploited fish and shellfish.*

Further details on the use of indicators is given within the framework of the analysis of each specific ecological objective.

Indicator analysis in the study includes:

- An introductory explanation as to why certain indicators have or have not been used, and their connection to MSFD descriptors;
- Indicator description, explanation of the type of information illustrating the state of living habitats, and further references to more detailed explanations of the indicator;
- A short critical description and visual depiction of the current state.

Within the framework of objective/indicator analysis regarding eutrophication (EO5), contamination (EO9), and marine litter (EO10), based on criteria (see individual chapters), the pressure level has also been indicated according to 5 or 6 value thresholds:

	The assessment of pressures from the eutrophication of marine habitats (EO5) and contaminants (EO9):		Assessment of pressure from marine litter:	
	1	No pressure	1	Insignificant or small pressure
	2	Insignificant pressure	2	Moderate pressure
	3	Moderate pressure	3	High pressure
	4	High pressure	4	Very high pressure
	5	Very high pressure	5	Unacceptable pressure
	Additional assessment from contamination analysis:			
	6	Unacceptable pressure		

The scale of pressure levels is not uniform but adjusted to the specifics of the indicator analysis, i.e. the actual range of pressure level..

Table 3.1: Ecological objectives and indicators

ECOLOGICAL OBJECTIVES and indicators	Note
EO1 Biodiversity	✓
a) Habitats	✓
Habitat distributional range (1)	
Condition of the habitat's typical species and communities	
b) Species	✓
a) Dolphins	
b) Turtles	
c) Birds	✗
Species distributional range (3)	
Population abundance of selected species (4)	
d) Fish	✓
Spatial distribution of species (3)	
Species distributional range - sardines (3)	
Population size of certain species (4)	
Population dynamics (5)	
e) Shellfish	✗
Species distributional range (3)	
Population abundance of selected species (4)	
EO3 COMMERCIAL SPECIES	✓
Spawning stock biomass - anchovies (7)	
Landings (8)	
Fishing mortality (9)	
Fishing effort (10)	
Catch per unit of effort or landing per unit of effort (11)	
Bycatch of vulnerable and non-target species (12)	
EO4 MARINE FOOD WEBS	✗
EO5 EUTROPHICATION	✓
Concentration of basic physical and chemical parameters and key nutrients in water column (13)	
Chlorophyll-a concentration in water column	
TRIX index	
EO6 -FLOOR INTEGRITY	✗
EO7 HYDROGRAPHIC ALTERATIONS	✗
Location and extent of the habitats impacted directly by structural alterations and/or circulations caused by them: traces of structure effect (15)	
EO8 COASTAL ECOSYSTEMS AND LANDSCAPES	✓
Length of coastline subject to physical disturbance due to the influence of man-made structures (16)	
Land-use change (25)	
Landscape quality	
EO9 POLLUTION	✓
Concentration of key harmful contaminants in seawater, sediment, and biota (17)	
Level of pollution effects of key contaminants where a cause and effect relationship has been established (18)	
Occurrence, origin (where possible), extent of acute pollution events and their impact on biota affected by this pollution (19)	
Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels in commonly consumed seafood (20)	
Percentage of intestinal enterococci concentration measurements within established standards (21)	
EO10 MARINE LITTER	✓
Trends in the amount of litter washed ashore and/or deposited on coastlines (including an analysis of its contents, spatial distribution and, where possible, source) (22)	
Trends in the amount of litter in the water column including microplastics and on the seafloor (23)	
Trends in the amount of litter ingested by or entangling marine organisms focusing on selected mammals, marine birds, and marine turtles (24)	
EO11 UNDERWATER NOISE	✗
Proportion of days and geographical distribution where loud, low, and mid-frequency impulsive sounds exceed levels that are likely to entail significant impact on marine animal (26)	
Levels of continuous low frequency sounds with the use of models as appropriate (27)	

Explanation:

The number in parenthesis beside the indicator is the indicator ordinal number from the Integrated Monitoring and Assessment Programme (UNEP(DEPI)/MED WG.420/4).

The sign "Note" in the column indicates:

- S State indicator.
- P Pressure indicator.
- \+ Not from the Programme, additional indicator.
- ✓ Analysed in the study.
- ✗ Not analysed in the study, data not available/sufficient or another indicator has been used

Illustrations of the state and pressures have been adjusted to the specific nature of indicators and data availability:

- Data on habitats show their distribution in precisely defined ranges, i.e. according to specific categories – types of habitat;
- Data on fish species, eutrophication, contamination and marine litter show their distribution according to informative intervals. Illustrations have been prepared using interpolation values for monitoring and/or research sites. Inverse distance weighted interpolation has been used[3]. IDW interpolation makes the assumption that things that are close to one another are more alike than those that are farther apart. To predict a value for any unmeasured location, IDW uses the measured values surrounding the prediction location. The measured values closest to the prediction location have more influence on the predicted value than those farther away. IDW assumes that each measured point has a local influence that diminishes with distance. It gives greater weight to points closest to the prediction location, and the weight diminishes as a function of distance, hence the name inverse distance weighted. In this regard, it was necessary to define transverse interpolations as well as have a minimum amount of data randomly distributed within the defined scope. When estimating the level of eutrophication and contamination due to the relatively low density of monitoring sites available for the entire coast, and in order to obtain a more accurate and reliable map using interpolation, it was necessary to include additional correction points where pollutant pressure levels were assigned based on expert assessment. It should be noted that due to the lack of data and use of additional points these are only approximate illustrations.
- Landscape data has been prepared by dividing the analysed area into smaller spatial units. These units are based on recognizable spatial units (bay, coastal parts and characteristics, distance to shore), and their boundaries (and consequently delimitation of values) are not precise, only indicative.

3.2. Value assessment

Landscape value assessment determines vitality (natural and economic), experience (beauty) and/or stability (health) of space. The starting point can be:

- Conservation – the value assessment is used to establish protective measures;
- Development – the value assessment shows potential for developing the use of space/activities.

The value index shows the current quality of the living habitat i.e. its individual part, and it is determined by:

- **The established state**: elements (characteristics, landscapes, spatial situations, occurrences) with higher value are either naturally preserved, rare, healthy, exceptional, typical, harmonious, diverse, or have educational or symbolic value.
- **Impact (pressure)**: elements (characteristics, landscapes, spatial situations, occurrences) with higher value are at risk of being lost or threatened by significant range reduction or change of characteristics.

Value assessment is based on indicators that show the state of biodiversity (EO1) and landscape quality (EO8). Specific evaluation criteria (characteristics) have been established for each indicator based on which five landscape value categories have been determined:

Value assessment		
	1	Very low value
	2	Low value
	3	Moderate value
	4	High value
	5	Very high value

Spatial illustration of the value index depicts the landscapes/occurrences that need conservation. Conservation can be formal, based on sector regulations, and/or planned, which then needs to be integrated into marine spatial planning.

[3] Inverse distance weighted interpolation (https://pro.arcgis.com/en/pro-app/latest/help/analysis/geostatistical-analyst/how-inverse-distance-weighted-interpolation-works.htm)

The value assessment, conducted according to ecological objectives (outlined in the following chapters) includes:

- A short explanation of the value assessment conceptualization;
- A table detailing the criteria (characteristics) based on which individual value assessment is assigned (exceptional features, typical features, complex connectivity, state of preservation, ecosystem value, scientific or research value and other values);
- A short commentary on the results (general value assessment, differences between individual areas of evaluation).

3.3. Impact assessment

The impact assessment shows current circumstances, without planned (already defined in the spatial planning documentation) or potential activities/operations. For the purposes of this study, impact assessment within the framework of the ecological objective *biodiversity* (EO1) refers to the loss of habitat and species, in accordance with 10 impact assessment value categories:

Impact assessment	
1	No impact or insignificant impact
2	
3	Moderate impact
4	
5	High impact
6	
7	Very high impact
8	
9	Unacceptable impact
10	

The value assessment depends on:

- **Current pressures** (contamination): elements (characteristics, landscapes, spatial situations, occurrences) that are at higher risk are those exposed to various pressures (contamination, physical pressure);
- **Sensitivity**: elements (characteristics, landscapes, spatial situations, occurrences) that are at higher risk are those that are subject to changes resulting from given pressures.

The assessment is also important for areas valuable for its exceptional or typical features, complex connectivity, state of preservation, rareness or other features, because it points to the possibility of loss of those features, regardless of existing pressures.

The impact assessment has been prepared by combining relevant data (graphic layers) on the state/value index and pressures. The assessment has been done (in separate tables) by giving additional ratings to the value assessment (from 0-2) for each present pressure indicator, given the expected influence of said pressure on the biological characteristics of individual elements in the marine environment. Apart from indicators, the impact assessment takes into account other relevant data affecting the level of impact that is not included in the indicators (e.g. built structures on the coast in the habitat impact assessment).

The impact assessment includes:

- An explanation of the impact assessment conceptualization;
- A table detailing the criteria (characteristics, contamination levels, habitat value) based on which individual impact assessment is assigned;
- A short commentary on the results (general impact assessment, differences between individual areas of the Bay of Kotor, result usability).

The study conclusion outlines a combined impact assessment that features both habitat and fish impact assessments.

3.4. Recommendations

Recommendations given individually per ecological objective can include:

- Protective measures: if the assessment concludes they are necessary, the conservation area can be suggested – formal based on sector regulations and/or planning category;
- Recommendations for remediation: if the assessment concludes that the pressure is above acceptable levels, remediation measures are suggested;
- Guidelines for drafting the marine spatial plan and other spatial planning documentation: guidelines for solution optimization, warning to avoid some areas, in general and/or for individual activities.

4. Biodiversity: Habitats

4.1. Introduction

Biodiversity stands for the diversity of living organisms, including, *inter alia,* land, terrestrial, marine and other water ecosystems and ecological complexes that they are part of, which includes the diversity of species and ecosystems. Loss of biodiversity means loss of species, ecosystems and genetic diversity, which naturally affects the human population. Habitats represent one of the main components of biodiversity and as such are of particular value for monitoring and preservation. Their value can be seen from several different aspects – ecological, economic, the role their physical presence plays, etc. The most valuable habitats, such as seagrass beds and coralligenous habitats, are significant sites of marine biodiversity because they represent nursery habitats and feeding grounds for commercial marine species that use them for reproduction and spawning. In addition, seagrass beds protect from erosion, clean sea water, and are gaining significance in blue economy. They are often called the lungs of the sea. Coralligenous communities attract tourists who like to dive due to the diversity of marine organisms that live there. Other marine habitats, like rocky, sandy or muddy habitats, though less significant compared to seagrass beds and coralligenous habitats, provide favourable living conditions to many organisms.

Within the framework of ecological objective 1 (**EO1**), which concerns biodiversity, it has been established that achieving good environmental status of the marine environment means the following for the Mediterranean region: "Biological diversity is maintained or enhanced. The quality and occurrence of coastal and marine habitats and the distribution and abundance of coastal and marine species are in line with prevailing physiographic, hydrographic, geographic and climatic conditions." A further special operational objective (1.4) has been established for habitats: "Crucial coastal and marine environments are not lost."[4] Marine and coastal habitats are directly impacted by various anthropogenic activities that result in physical damage, such as infrastructure construction, fishing, marine transport, as well as indirectly impacted from contamination of the marine environment, climate change and the appearance of new invasive species. EO1 and operational objective 1.4 form the basis for undertaking measures aimed at the protection, maintenance or improvement of the state of important marine and coastal habitats, and they are compatible with **Descriptor 1 – Biodiversity** of the Marine Strategy Framework Directive (Chapter 2.3, Table 2.3)

4.2. Indicators and state description

While assessing the environmental state of the marine ecosystem of the Montenegro territorial waters, including the Bay of Kotor, from the point of view of habitats within the EO1 framework, the application of the adopted indicator 1 ecosystem approach is relevant (Table 4.1).

Table 4.1: Indicator for habitat state assessment

Indicator (CI)	Indicator type	MSFD indicator
Habitat distributional range (CI1)	State	Habitat distribution

Within the EO1 framework the second adopted ecosystem approach indicator "Condition of the habitat's typical species and communities" (CI2) has not been implemented due to a lack of data on the state of typical species and communities characteristic of the marine ecosystem of Montenegro territorial waters, including the Bay of Kotor, at the level required by the methodology for indicator implementation. However, while assessing the value of habitat location, the expert has taken into account the available information on the presence of certain species (by large the species listed in Annex II of the SPA Protocol of the Barcelona Convention), which have been outlined in Annex 4.1.

[4] „Decision IG.21/3 – Implementing MAP ecosystem approach roadmap: Mediterranean Ecological and Operational Objectives, Indicators and Timetable for implementing the ecosystem approach roadmap"

The ecosystem indicator Habitat distributional range (CI1) provides information on the state of the geographic distribution of certain habitat types in an area. For the purposes of this report, the CI1 assessment uses existing data on habitat spatial distribution. The interpretation of benthic habitat types has been presented in the "hybrid" map (Map 12.1, Annex 4.2), developed within the GEF Adriatic Project[5] according to the revised EUNIS classification (SPA/RAC – UN Environment, 2019), and as compilation of data from several sources:

- The Bay of Kotor area: RAC/SPA – UNEP/MAP, 2013 Ecological quantitative description of Boka Kotorska Bay marine area (Montenegro). By Golder Associates. Ed. RAC/SPA – MedMPAnet Project, Tunis: 82 pp + Appendices;
- područje Ratca i Platamuna: UNEP/MAP-RAC/SPA, 2016 Montenegro: Platamuni and Ratac areas. Mapping of marine key habitats and initiation of monitoring network. By Torchia G., Pititto F., Rais C., Trainito E., Badalamenti F., Romano C., Amosso C., Bouafif C., Dragan M., Camisassi S., Tronconi D., Macic V., Sghaier Y.R. & Ouerghi A. Ed. RAC/SPA – MedKeyHabitats Project, Tunis: 77 pp + Annexes;
- The area of Stari Ulcinj: interpretation of ortho-photo image with a resolution of 0.2 m from 2017 in the infralittoral and mediolittoral zone (current project);
- The area of Katič and the rest of the coastal area ending with the circalittoral zone: Fant, M., Polato, F., Rzaničanin, A., Molinari, A., Bernat, P. & Mačić, V. 2012). Start up of "Katič" MPA in Montenegro and assessment of marine and coastal ecosystems along the coast. DFS, Technical report, Jun-July 2012;
- Offshore circalittoral zone, upper and lower bathyal and abyssal for the epicontinental shelf: Military map of sea floor sediments.

CI1 is a significant indicator of the habitat state that makes it possible to get an overall picture of the volume of potential impact when assessed during a specific time period. The implementation of this indicator for the purposes of this document has resulted in an initial assessment of the state, considering that information from earlier periods for comparison purposes is not available, and thus it is not possible to reach a more precise conclusion on the increase or decrease of the area of habitat types present in the territorial waters of Montenegro, including the Bay of Kotor. It should also be noted that Kotor and the Risan Bay, Platamuni, Katič, Stari Ulcinj Island and Ratac have been thoroughly mapped in previous research by sonar and diving, while data for the remaining part of the Bay of Kotor area and the open sea has been presented on a hybrid map based on the aforementioned resource.

Current state

Map 4.1 outlines the following habitat types in the sea of Montenegro. A more detailed overview of habitat types in the Bay of Kotor is given on Map 4.2.

Table 4.2 outlines the area of the following habitat types present until the end of the circalittoral zone6 in Montenegro:

[5] The interpretation of habitat types uses three classification levels which are explained in more detail in Annex 5.1 herein.

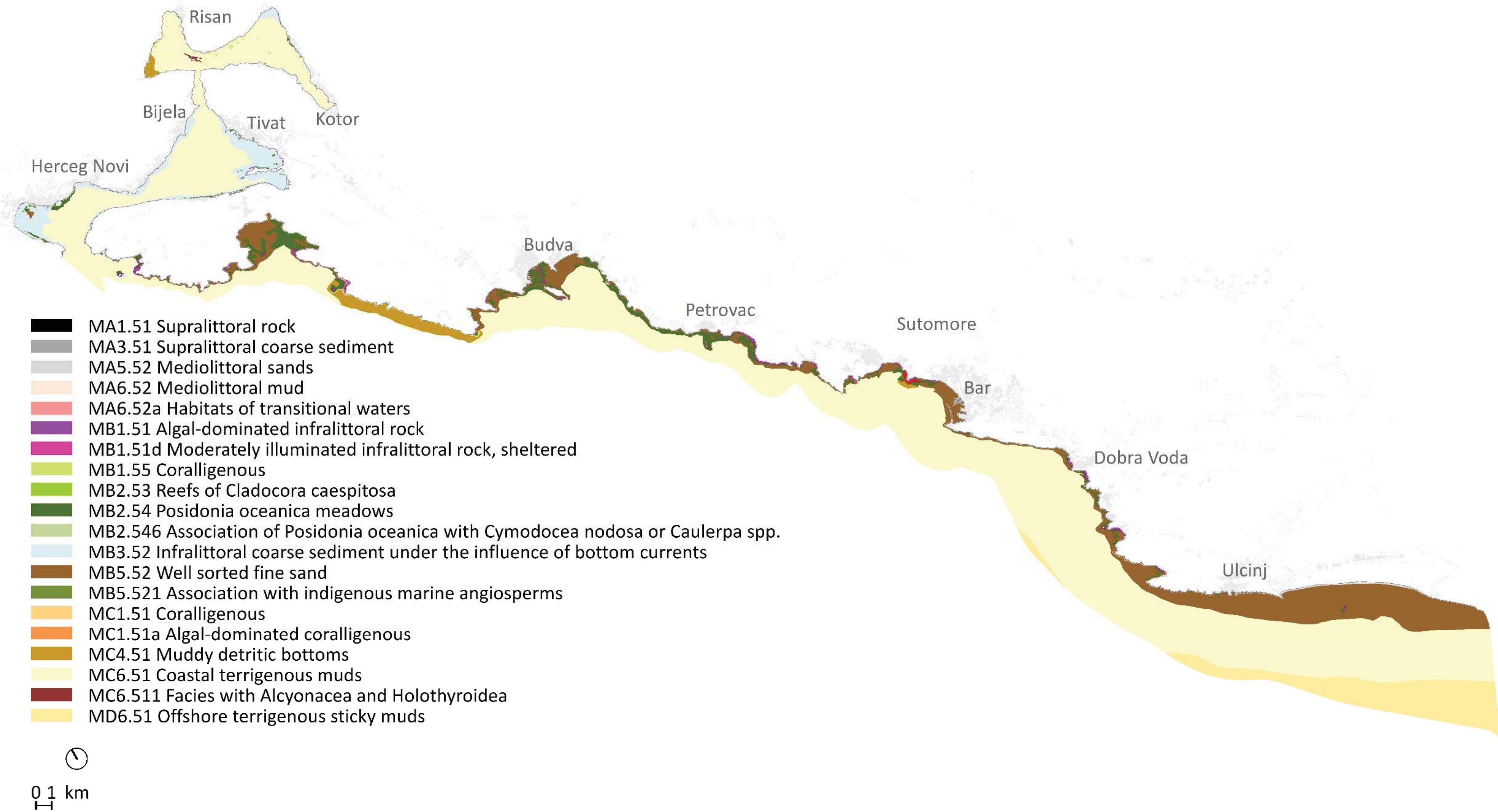
[6] The overall share of habitat types in Table 5.2 has been calculated in relation to the overall surface of the sea floor until the end of the circalittoral zone due to insufficient precise data from outside the circalittoral zone which has not been gathered in accordance with the mapping methodology used in mapping the coastal area (which encompasses the littoral, infralittoral and circalittoral zones). Data from outside the circalittoral zone comes from the military map of sea floor sediments which is not reliable for interpreting the distribution of habitats in accordance with the used classification for habitat types.

Table 4.2: Habitat types

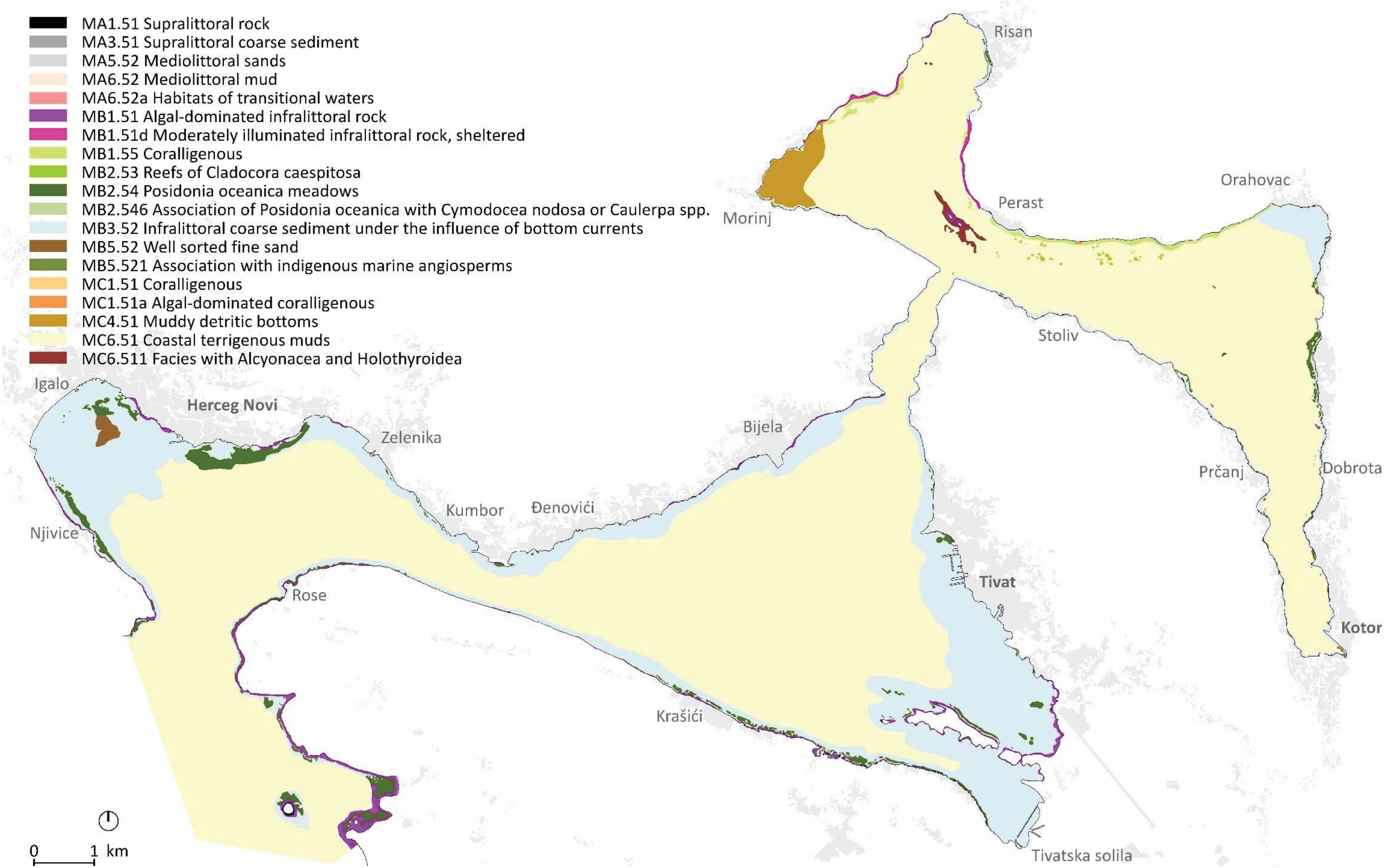
Habitat name	Surface area (ha)	Percentage %
Littoral	698.66	1.167
MA1.5 Littoral rock	328.42	0.5487
MA1.51 Supralittoral rock	328.42	0.5487
MA2.5 Littoral biogenic habitats	0.57	0.0009
MA2.51 Lower mediolittoral biogenic habitat	0.57	0.0009
MA2.51a Deposits of dead macrophyte leaves	0.57	0.0009
MA3.5 Littoral coarse sediment	71.09	0.1188
MA3.51 Supralittoral coarse sediment	71.09	0.1188
MA4.5 Littoral mixed sediment	0.16	0.0003
MA4.51 Supralittoral mixed sediment	0.16	0.0003
MA5.5 Littoral sand	272.36	0.4551
MA5.51 Supralittoral sand	203.16	0.3395
MA5.52 Mediolittoral sand	69.19	0.1156
MA6.5 Littoral sludge	26.08	0.0436
MA6.52 Mediolittoral sludge	26.08	0.0436
MA6.52a Transitional water habitats	26.08	0.0436
Infralittoral	10,105.39	16.8849
MB1.5 Infralittoral rock	693.25	1.1583
MB1.51 Algae-dominated infralittoral rock	609.28	1.0180
MB1.51a Well lit infralittoral rock, exposed	49.64	0,083
MB1.51d Moderately lit infralittoral rock, sheltered	13.08	0.022
MB1.52 Invertebrate-dominated infralittoral rock	10.23	0.0171
MB1.55 Coralligenous biocenosis	73.12	0.1222
MB1.56 Semi-dark caves and pits	0.62	0.0010
MB2.5 Infralittoral biogenic habitats	1,462.28	2.4433
MB2.53 *Cladocora caespitosa* reefs	4.74	0.0079
MB2.54 *Posidonia oceanica* meadows	1,457.54	2.4354
MB2.541 *Posidonia oceanica* meadows on hard substrata	20.93	0.035
MB2.542 *Posidonia oceanica* meadows on soft substrata	0.13	0.001
MB2.546 *Posidonia oceanica* and *Cymodocea nodosa* or *Caulerpa* spp. association	0.09	0.001
MB3.5 Infralittoral coarse sediment	1,707.30	2.8527
MB3.52 Infralittoral coarse sediment under the influence of seafloor currents	1,707.10	2.8524
MB3.53 Infralittoral gravel	0.21	0.0003
MB5.5 Infralittoral sand	6,242.55	10.4306
MB5.52 Fine-sorted fine sand	6,242.55	10.4306
MB5.521 Indigenous marine angiosperm association	0.96	0.002
Circalittoral zone	49,044.62	81.9477
MC1.5 Circalittoral rock	6.78	0.0113
MC1.51 Coralligenous biocenosis	6.78	0.0113
Algae dominated coralligen	0.51	0.001
MC4.5 Circalittoral mixed sediment	806.23	1.3471
MC4.51 Muddy detritic seabed	806.23	1.3471
MC6.5 Circalittoral muddy sediment	48,231.62	80.5893
MC6.51 Coastal terrigenous sludges	48,231.62	80.5893
MC6.511 *Alcyonacea* and *Holothyroidea* communities	15.39	0.026
Total	**59,848.67**	**100.00**

* Surface area calculated with GIS based on existing data on seafloor habitat distribution until the end of the circalittoral zone.

Map 4.1: Habitat type distribution map (until the end of the circalittoral zone)



Map 4.2: Habitat type distribution in the Bay of Kotor



The most widespread habitat type in the sea of Montenegro is coastal terrigenous sludge which makes up 81% of the overall seafloor surface (until the end of the circalittoral zone)[7]. Out of the rare habitat types significant for protection, coralligenous habitats make up 0,14% of the seafloor area, and they are very important in terms of conservation. This important habitat type is present in the Bay of Kotor area, and the biggest communities can be found in the Luštica-Donji Grbalj area, including the capes Jaz and Rep, and the Vučja Vala site (near Valdanos).

Seagrass beds make up 2,47% of the total seafloor surface and locations of particular importance are the Traše bay, area in front of Budva, wider Katič zone including Buljarica, Platamuni, Valdanos. Apart from significant habitat types present at certain locations, many species protected under national and international legal frameworks have also been found. 21 species protected by the national legal framework have been found in the Platamuni area (Environmental Protection Agency, Montenegro, 2014). A total of 44 plant and 135 animal species were registered during research conducted in this area in 2015. Among those 12 are species protected under the SPA BD Protocol (Annex II), and two are listed as species whose exploitation must be regulated (SPA BD Protocol Annex III). 42 different benthic invertebrates have been identified in the Ratac area. Among them Porifera *Sarcotragus foetidus* and the mollusc *Tonna galea* listed in Annex II of the SPA BD Protocol: A list of endangered species, and the sponge *Spongia officinalis* is listed as a species whose exploitation should be regulated (Annex III of the SPA BD Protocol and the Bern Convention).

Figure 4.1: *Posedonia oceanica* habitat (UNEP/MAP-RAC/SPA, 2016)

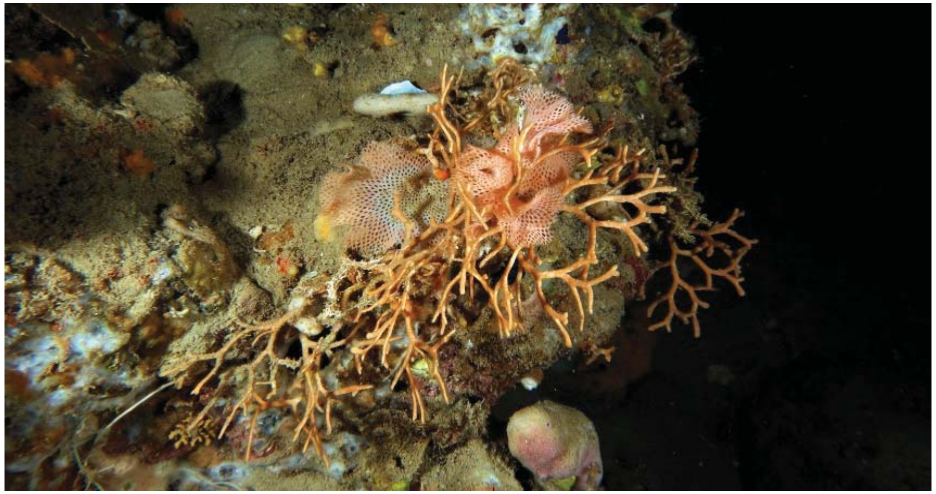


Figure 4.2: Coralligenous habitat (UNEP/MAP-RAC/SPA, 2016)

7 The overall share of habitat types in the Table has been calculated in relation to the overall surface of the sea floor until the end of the circalittoral zone due to insufficient precise data from outside the circalittoral zone which has not been gathered in accordance with the mapping methodology used in mapping the coastal area (which encompasses the littoral, infralittoral and circalittoral zones). Data from outside the circalittoral zone comes from the military map of sea floor sediments which is not reliable for interpreting the distribution of habitats in accordance with the used classification for habitat types.

Figure 4.3: Infralittoral rock (UNEP/MAP-RAC/SPA, 2016)

The presence of rare species (*Lithophaga lithophaga*), along with significant habitat types, has been identified in the Katič area, and a total of eight protected species of algae, mollusks, crustaceans, echinoderms and fish have been registered.

The Bay of Kotor

The most widespread habitat type in the Bay of Kotor is coastal terrigenous sludge which makes up 74.3% of the overall seafloor surface. Coralligenous habitats are present in the Bay of Kotor at six locations (Strp, Perast, around the western part of Perast, around the islands of Sveti Đorđe and Gospa od Škrpjela, Dražin vrt and Verige). Other smaller coralligenous associations are located in the central and northern part of the Kotor-Risan Bay (where they sometimes appear as a mosaic with Sciaphilic algae and coastal terrigenous silt). Associations of particularly rare coralligenous species *Savalia savaglia* and *Leptogorgia sarmentosa* are present in Dražin Vrt and encompass an area of about 5,000 m^2. 25 pits with the possible presence of live Cladocora aggregations are located mostly in the central part of the Kotor-Risan Bay. When it comes to seagrass beds in the Bay of Kotor, a significant location is Dobrota because there they occupy an area of 21,000 m^2 in total. Other significant locations are Novski zaliv, Igalo-Njivice and Mamuli-Luštica. During the survey of the Bay of Kotor, two locations identified as having the greatest biodiversity, in terms of the presence of other benthic species, were Sveti Đorde (with a mosaic of coralligenous communities and coastal terrigenous silt, 10 species from the Annex of the SPA/BD Protocol and one rare species) and Verige (biocenosis of coastal terrigenous silt, seven species from the Annex of the SPA/BD Protocol and two rare species). Also, high levels of biodiversity were recorded at locations around the island of Gospa od Škrpjela, Sopot, Dražin Vrt (6 species from the Annex of the SPA/BD Protocol) and Strp (5 species from the Annex of the SPA/BD Protocol and 1 rare species).

Since detailed field data was collected and mapped only for the Bay of Kotor-Risan, Platamuni, Ratac, Katič and the island of Stari Ulcinj, and that for the rest of the area data was obtained by satellite imagery and a small number of surveys, data on habitat areas in this document are a combination of information available at the time. Data on habitat areas obtained in this manner should be supplemented or corrected by data on new sites that is important for habitat protection and that should be collected further in more detailed research.

4.3. Assessment

The current state of marine habitats in Montenegro has been surveyed by determining their value in accordance with the defined methodological approach in Chapter 3.2. With this in mind, criteria based on the level of protection established for the observed habitat types by the relevant national and international regulations have been used for habitat assessment. Regarding the national legislative framework, the current draft of the Habitat Catalogue was considered, which forms the basis for drafting the Bylaw listing habitats and species for which environmental network areas in Montenegro have been determined (reference lists), in accordance with the Law on Nature Protection and The Habitats Directive. Also, the list of habitats from the Reference List of Marine Habitat Types,[8] which have been recommended for the application of protection measures in accordance with the SPA BD Protocol, as well as the European Red List of marine habitats, was used as a basis. The following assessment criteria has also been included: scarcity of habitats, level of habitat distribution (including the estimated extent of the impact of existing pressures on habitats at a given location, in accordance with the requirements of indicator CI1) and habitat representativeness. An overview of criteria applied to habitat value assessment can be found in Table 4.3.

Table 4.3: Criteria for habitat value assessment

Value Assessment	Criteria
1 Very low value	The habitat (community) is valuable from the aspect of protection, i.e. the obligation for its protection has been determined by national regulations or the Habitats Directive or they have been included in the list of habitats for inventory for the purpose of determining areas of interest for conservation in the Mediterranean according to the SPA BD Protocol. However its protection is not absolutely mandatory, it can be used on a sustainable basis, and is widespread and representative.
2 Low value	The habitat (community) is valuable from the aspect of protection, i.e. the obligation to protect it has been determined by national regulations, the Habitats Directive, the SPA BD Protocol or it contains strictly protected species in the community, its distribution area is small, its occurrence is not uncommon.
3 Moderate value	The habitat (community) is of exceptional value from the aspect of protection, i.e. the obligation for its protection has been determined by national regulations, the Habitats Directive, the SPA BD Protocol, its area is small and/or it occurs very rarely and/or is a priority for protection.
4 High value	The habitat (community) is valuable from the aspect of protection, i.e. the obligation for its protection has been determined by national regulations or the Habitats Directive or they have been included in the list of habitats for inventory for the purpose of determining areas of interest for conservation in the Mediterranean according to the SPA BD Protocol. However its protection is not absolutely mandatory, it can be used on a sustainable basis, and is widespread and representative.
5 Very high value	The habitat (community) is valuable from the aspect of protection, i.e. the obligation to protect it has been determined by national regulations, the Habitats Directive, the SPA BD Protocol or it contains strictly protected species in the community, its distribution area is small, its occurrence is not uncommon.

[8] RAC/SPA – UNEP/MAP, 2019 An updated reference list of marine habitats which will be included in the National List of Habitats for Inventory, in order to determine areas of interest for conservation in the Mediterranean

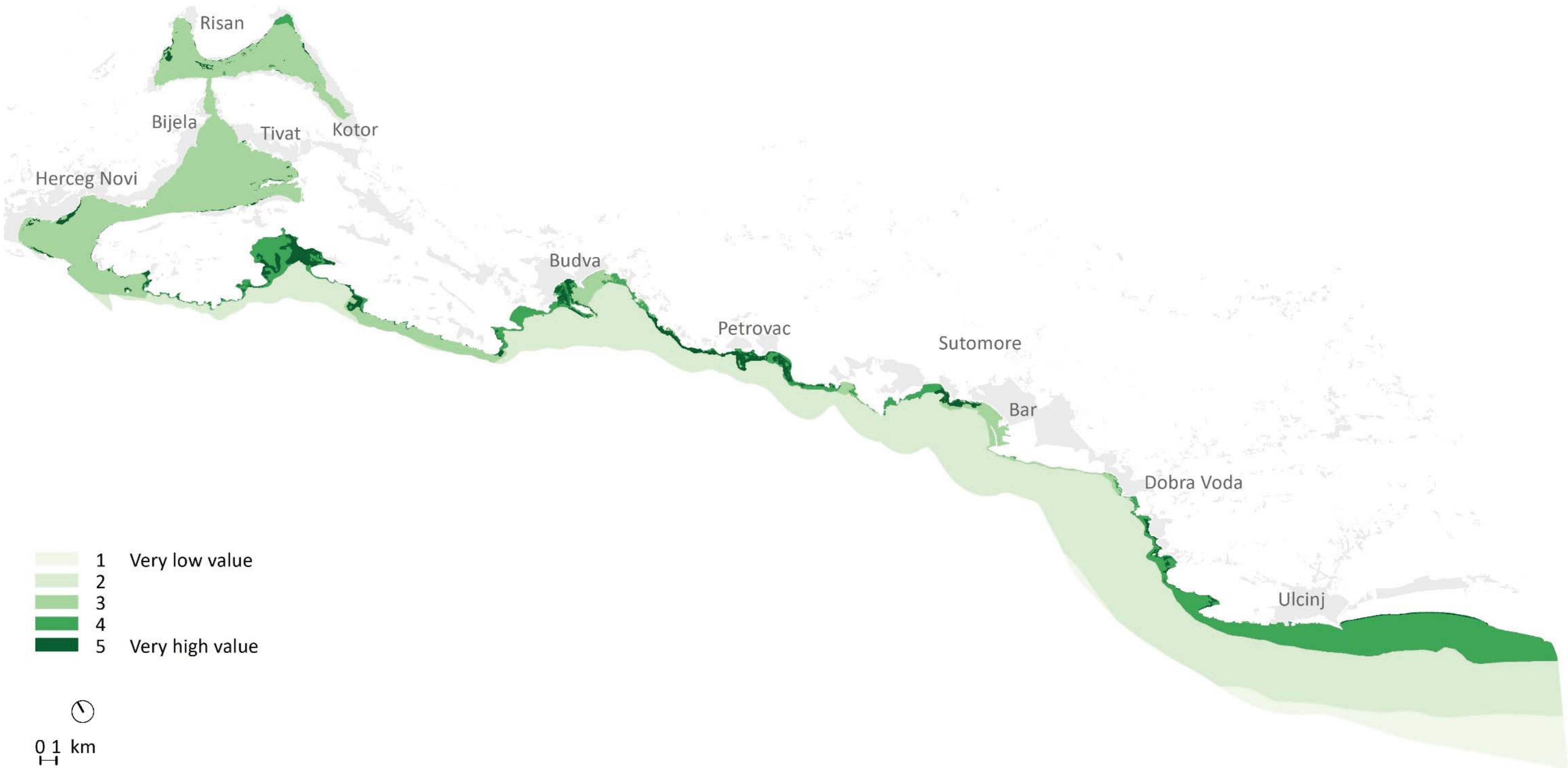
By applying such evaluations and the criteria related to them, individual habitat types present in the marine environment of Montenegro were assessed by assigning them the appropriate numerical value on a scale of 1-5. Exceptionally, due to rarity in occurrence, a narrow range of distribution and importance, coralligenous communities were given the highest value rating, i.e. a score of 5 in all locations. In addition, the assessment of the habitat of *Posidonia oceanica* took into account the distribution area and related integrity and conservation prospects, so areas where meadows are not complete and located in front of beaches with high levels of anthropogenic pressure from tourism activities have been rated 4 (except the zones in front of Budva where, despite the intensity of meadow activities, they are complete and assessed as very valuable from the aspect of protection), while in other locations (future marine protected areas, Bay of Kotor and zones where the distribution is complete and uninterrupted) they have been categorized as grade 5. Also, the same principle in terms of the location where it occurs has been applied in habitat assessment of fine-sorted fine sand and coastal terrigenous sludge. When it comes to the widespread habitat of coastal terrigenous sludge, bearing in mind the importance and sensitivity of the Bay of Kotor, the aforementioned has been given a score of 3 in the Bay area, while the rest of the sea area has been given a score of 2.

Habitats outside the circalittoral zone have been rated 1 because they are not in the Habitats Directive and because they are widespread. The environmental conditions of these habitats are such that they are generally characterized by lower biodiversity compared to habitats at shallower depths, however, the composition of these habitats may contain significant species in need of protection, including coralligenous communities, so for these habitat types there is a higher degree of uncertainty because the deep sea has not been explored so far, thus the assessment for the purposes of this document is only indicative. Data from outside the circalittoral zone comes from the military map of sea floor sediments which is not reliable for interpreting the distribution of habitats in accordance with the used classification for habitat types. Areas outside the scope of the circalittoral zone, although recorded and assessed, have not been included in this document, for reasons stated above.

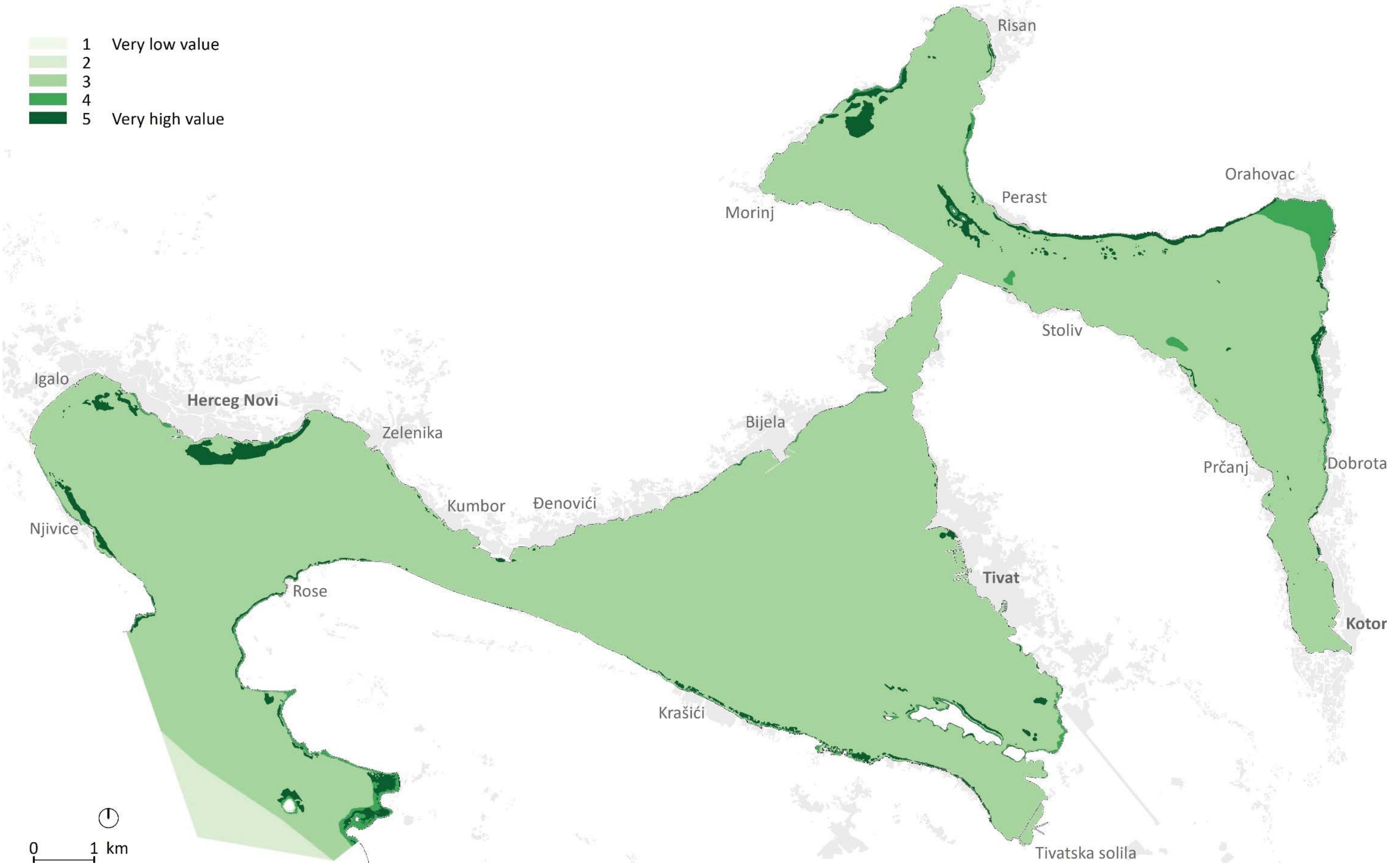
Table 4.4: Assessment of habitat types

Habitat type	Value
MA1.51 Supralittoral rock	2
MA2.51 Lower mediolittoral biogenic habitat	4
MA3.51 Supralittoral coarse sediment	3
MA4.51 Supralittoral mixed sediment	2
MA5.51 Supralittoral sand	4
MA5.52 Mediolittoral sand	5
MA6.52 Mediolittoral sludge	4
MB1.51 Algae-dominated infralittoral rock	4
MB1.52 Invertebrate-dominated infralittoral rock	4
MB1.55 Coralligenous biocenosis	5
MB1.56 Semi-dark caves and pits	5
MB2.53 *Cladocora caespitosa* reefs	5
MB2.54 *Posidonia oceanica* meadows	4
MB2.54 *Posidonia oceanica* meadows	5
MB3.52 Infralittoral coarse sediment under the influence of seafloor currents	3
MB3.53 Infralittoral gravel	2
MB5.52 Fine-sorted fine sand	3
MB5.52 Fine-sorted fine sand	4
MC1.51 Coralligenous biocenosis	5
MC4.51 Muddy detritic seabed	3
MC6.51 Coastal terrigenous sludge	2
MC6.51 Coastal terrigenous sludge*	3
MD1.51 Offshore invertebrate-dominated infralittoral rock	1
MD4.51 Offshore circalittoral detritic seabed	1
MD5.51 Offshore circalittoral detritic sand	1
MD6.51 Offshore terrigenous sticky sludge	1
ME6.51 Upper batial sludge	1
MF6.51 Sandy sludge	1
MG6.51 Abyssal sludge	1

Map 4.3: Habitat value assessment (until the end of the circalittoral zone)



Map 4.4: Habitat value assessment in the Bay of Kotor



4.4. Impact Assessment

The impact of threats to habitats was assessed in accordance with the methodological approach defined in Chapter 3.3. With this in mind, habitat impact refers to the existing risk of loss of property and/or extinction of habitats or species that are part of the habitat, and depends on the value of the habitat, existing pressures (contamination) and sensitivity to them. High vulnerability indicates the need to reduce or prevent pressures (contamination) and take protective measures.

The impact assessment takes into account pressures for which data is available, that originate from: eutrophication, contamination, and pressures originating from land-based activities (construction), marine litter and physical damage (anchorages, farms). Habitat impact assessment is based on determining the interdependence of habitat values (derived from habitat characteristics; Chapter 4.3), and the existing cumulative pressures and susceptibility of habitat types to these pressures. The impact of pressures on individual habitat types was assessed on a scale of 0-1, where 0 indicates that the pressure is not significant and 1 that the pressure is significant. This assessment is accompanied by an assessment of the habitat value, giving an overall assessment of the threat, as follows:

- **Eutrophication** leads to an increase in nutrients (phosphates and nitrates), which causes phytoplankton to overgrow and consequently reduces water transparency which causes higher oxygen consumption. Seaweed communities are particularly sensitive to this change in condition. Eutrophication has been estimated to exert pressure on most habitats up to the circalittoral zone, including coralligenous habitats from the circalittoral zone.
- **Contamination** puts pressure on all habitats and species that are part of the habitat. Marine organisms absorb toxic substances that in various ways negatively impact the normal functioning of organisms.
- Activities on land (construction) generate direct or indirect pressures on marine habitats. Direct pressures lead to the physical destruction of habitats while indirect pressures cause negative effects such as waste water, or in the case of marinas and ports, increased levels of contamination in the water and/or sediment. In assessing exposure and vulnerability, only direct impacts were taken into account (indirect impacts were measured through eutrophication and contamination), in such a way that a greater extent of impacts of this type of pressure was associated with habitats in front of urban areas, ports and marinas, than habitats located where there is no presence of these structures, or habitats that are at greater depths.
- **Marine litter** has a significant negative impact on the overall marine ecosystem. When it comes to habitats, the most visible impact concerns direct physical or mechanical damage. In addition, the possibility of "attenuating" benthic organisms (especially sessile or semi-sessile) on the seabed, and reducing the presence of oxygen in sediments caused by waste, has been determined, which prevents the exchange of gases with the waters above them. This can lead to changes in the composition of the biota on the seabed. Marine litter is a vector for the transmission of invasive species. However, it has been recorded that waste on the seabed can serve as a basis for the development of benthic biocenoses, and although this might even be considered a positive effect, it can lead to an "overlap" of existing biocenoses and change their composition. Despite all this, the long-term threat to benthic organisms and habitats is still relatively unknown. In the assessment of marine litter impact on habitats in relation to the ranking of marine litter presence (see Chapter 9), the impact assessment scale of 0-2 was applied (where 0 indicates that the pressure is not significant, 1 that the pressure is significant and 2 that the pressure is very significant or high). The reached conclusion is that marine litter impacts all habitats because they are an integral part of the marine ecosystem which species also use. When it comes to the extent of that impact, the vulnerability of habitats to physical destruction was taken into account, and such habitats were rated with a score of 2 (seagrass, coral and algae habitats). Next, the area of habitat distribution in relation to the extent of marine litter was also taken into account, thus the impact on valuable habitats that have a very narrow distribution was also rated with 2 due to their occupation of the same space.
- **Physical damage** (anchorages, mariculture farms) generates habitat degradation, especially for algae habitats, seagrass habitats and coralligenous habitats. Therefore, the assessment of pressures on these habitats was marked as 1.

Impact assessments of individual habitat types, concerning each of the above groups of pressures, are shown in Table 4.5, and their spatial distribution is shown on maps 4.5 to 4.9.

The total vulnerability (on a scale of 1-10) was obtained by combining habitat value assessments and assessments of the impact levels of individual pressure groups, as shown in Table 4.5 and Maps 4.10 and 4.11.

[1] See Chapter 7.

[2] See Chapter 8.

[3] See Chapter 9.

Table 4.5: Habitat impact assessment

Habitat type	Habitat value	Impact of eutrophication	Impact of contamination	Impact of land-based activities (construction)	Impact of marine litter		Physical damage (anchorages, mariculture farms)
Additional assessment value		0 or 1	0 or 1	0 or 1	0 or 1 or 2		0 or 1
Impact category/assessment		**4/5[1]**	**4/5/6[2]**	**Area**	**4**	**5[3]**	**Area**
MA1.51 Supralittoral rock	2	1	0	1	1	2	0
MA2.51 Lower mediolittoral biogenic habitat	4	1	1	1	2	2	1
MA3.51 Supralittoral coarse sediment	3	0	1	1	1	1	0
MA4.51 Supralittoral mixed sediment	2	0	1	1	1	1	0
MA5.51 Supralittoral sand	4	0	1	1	1	2	0
MA5.52 Mediolittoral sand	5	1	1	1	1	2	0
MA6.52 Mediolittoral mud	4	1	1	1	1	2	0
MB1.51 Algae-dominated infralittoral rock	4	1	1	1	1	2	1
MB1.52 Invertebrate-dominated infralittoral rock	4	1	1	1	1	2	0
MB1.55 Coralligenous biocenosis	5	1	1	1	2	2	1
MB1.56 Semi-dark caves and overhangs	5	1	1	1	2	2	0
MB2.53 *Cladocora caespitosa* reefs	5	1	1	1	2	2	1
MB2.54 *Posidonia oceanica* meadows	4	1	1	1	2	2	1
MB2.54 *Posidonia oceanica* meadows*	5	1	1	1	2	2	1
MB3.52 Infralittoral coarse sediment under the influence of bottom currents	3	1	1	1	1	2	1
MB3.53 Infralittoral pebbles	2	1	1	1	1	2	0
MB5.52 Well-sorted fine sand	3	1	1	1	1	2	0
MB5.52 Well-sorted fine sand	4	1	1	1	1	2	0
MC1.51 Coralligenous	5	1	1	1	2	2	1

Habitat type	Habitat value	Impact of eutrophication	Impact of contamination	Impact of land-based activities (construction)	Impact of marine litter		Physical damage (anchorages, mariculture farms)
Additional assessment value		0 or 1	0 or 1	0 or 1	0 or 1 or 2		0 or 1
Impact category/assessment		**4/5[1]**	**4/5/6[2]**	**Area**	**4**	**5[3]**	**Area**
MC4.51 Muddy detritic seabed	3	1	1	1	2	2	1
MC6.51 Coastal terrigenous muds	2	0	1	0	1	1	0
MC6.51 Coastal terrigenous muds*	3	0	1	0	1	1	0
MD1.51 Offshore circalittoral rock invertebrate-dominated	1	0	1	0	1	1	0
MD4.51 Offshore circalittoral detritic bottoms	1	0	1	0	1	1	0
MD5.51 Offshore circalittoral sand	1	0	1	0	1	1	0
MD6.51 Offshore terrigenous sticky muds	1	0	1	0	1	1	0
ME6.51 Upper bathyal muds	1	0	1	0	1	1	0
MF6.51 Sandy muds	1	0	1	0	1	1	0
MG6.51 Abyssal muds	1	0	1	0	1	1	0

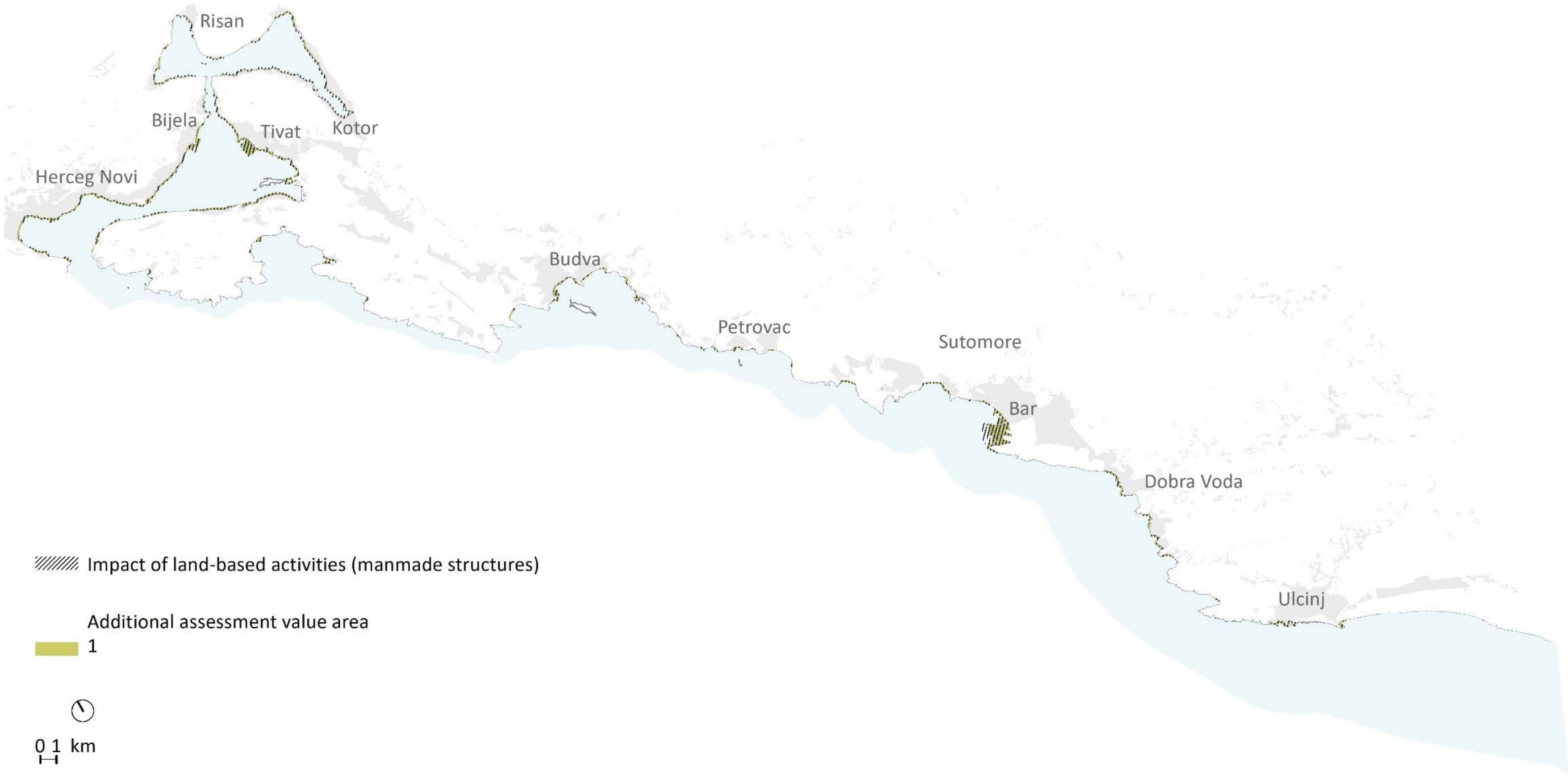
The resulting assessment was classified into one of ten endangerment assessment value classes:

Impact assessment	
1	No impact or insignificant impact
2	
3	Moderate impact
4	
5	High impact
6	
7	Very high impact
8	
9	Unacceptable impact
10	

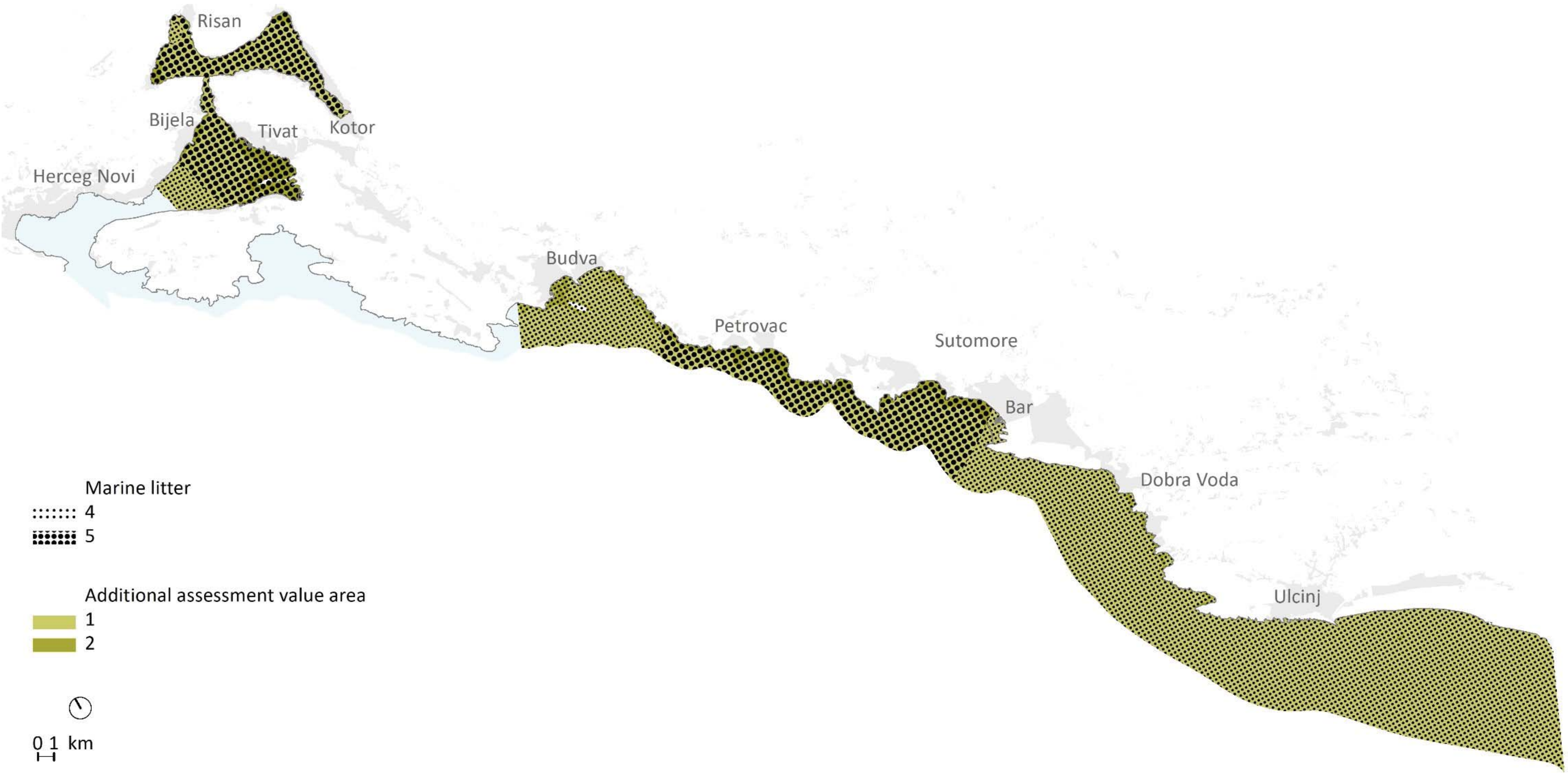
Map 4.5: Impact of eutrophication

Map 4.6: Impact of contamination

Map 4.7: Impact of land-based activities (manmade structures)

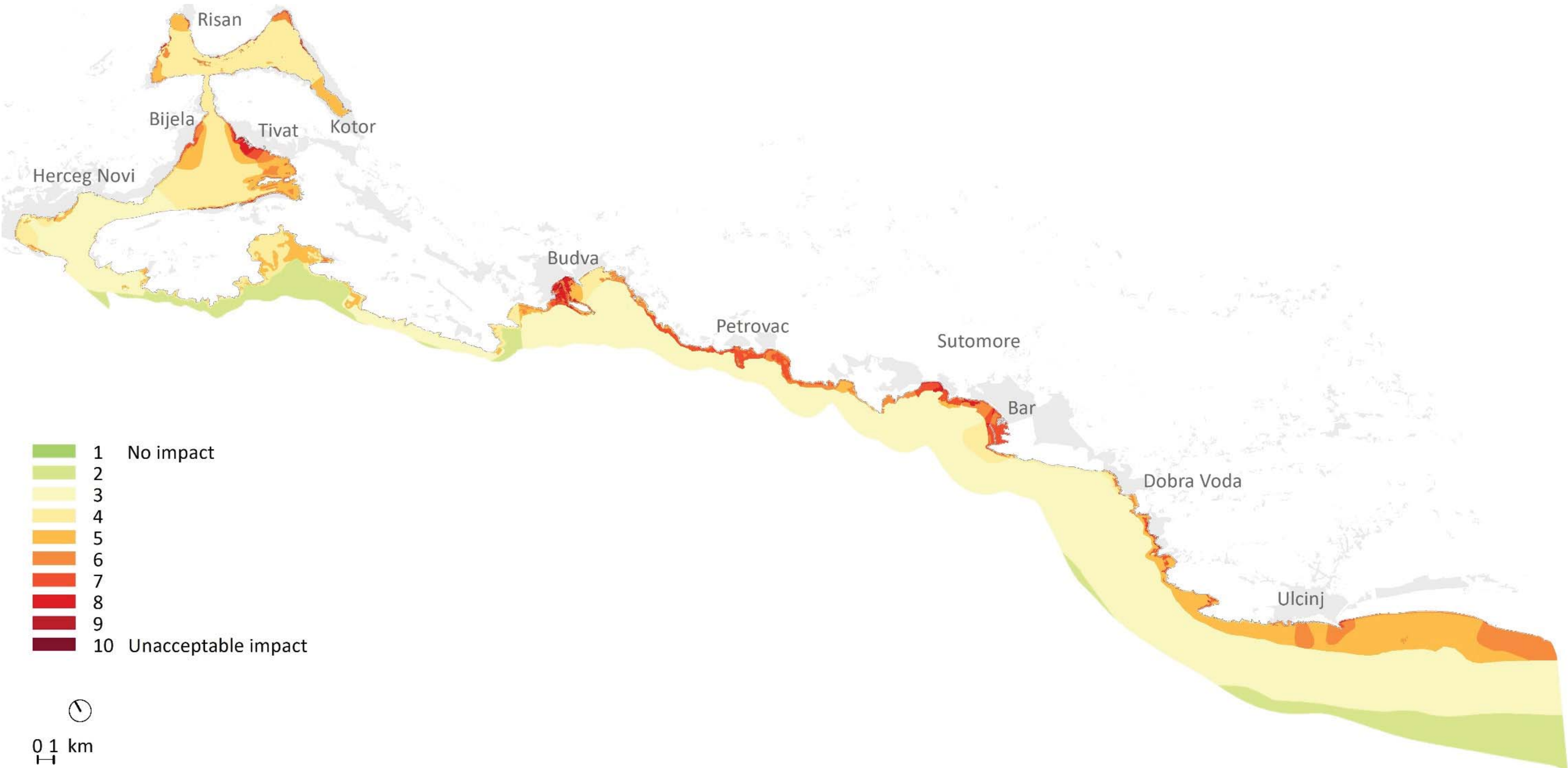


Map 4.8: Impact of marine litter

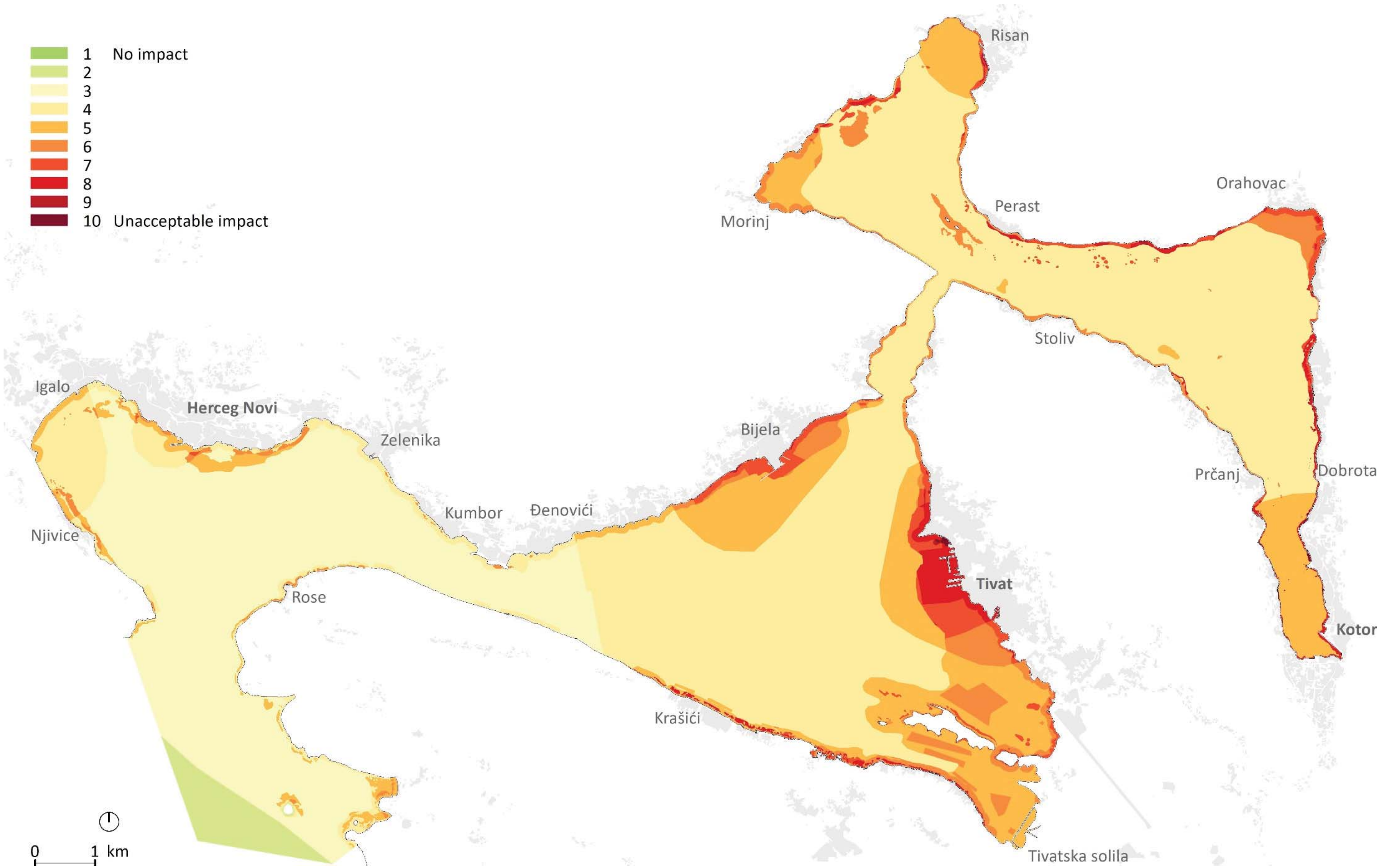


Map 4.9: Physical damage (anchorages, mariculture farms)

Map 4.10: Overall habitat value assessment (until the end of the circalittoral zone)



Map 4.11: Overall habitat value assessment in the Bay of Kotor



Based on the pooling of habitat endangerment results with respect to individual pressure groups (eutrophication, contamination, pressures arising from land-based activities (built-up areas), marine litter and physical damage (anchorages, farms), a map of cumulative habitat type endangerment has been produced which shows that habitat types in front of urbanized areas, and ports and marinas are such as: Kotor, Dobrota, Perast, Orahovac, Risan, Tivat, Krašić, Bijela, Budva, Petrovac, Sutomore, Bar and the area between Dobra Voda and Ulcinj, are significantly more endangered compared to the rest of the marine environment.

4.5. Recommendations

Conservation recommendations

In accordance with the defined status of endangerment of the marine environment, it is necessary to take measures that completely eliminate or minimize the anthropogenic impacts of activities that take place in the marine ecosystem of Montenegro. Based on previous research, analysis and consideration of valuable areas, it is necessary to establish sectoral and/or planning protection, which includes the integration of appropriate measures into the spatial plan, for the following areas:

1. Protected areas in the sea (Nature parks), Platamuni, Katič and the Island of Stari Ulcinj (announcement in progress), and Sopot and Dražin vrt (preliminary conservation in progress)

In order to protect valuable species and habitats, activities are currently underway to declare three marine protected areas, as follows: Platamuni, Katič and Stari Ulcinj Island. Conservation is planned for all three areas, in the Nature Park category (category IV protected area). A nature park is a vast natural or partially cultivated area of land and/or sea, which is characterized by a high level of biodiversity and/or valuable geological features with significant landscape, cultural and historical values and ecological features of national and international importance. Any type of work, actions or activities that endanger the characteristics, values and role of the park are strictly forbidden. In relation to the presence of valuable habitats and species, zoning was performed in all three marine protected areas (in larger areas – protection regime II, and for less protection – protection regime III; protection regime I as the most restrictive was not specified anywhere), and preliminarily allowed and prohibited activities by protection zones were determined as follows:[9]

Activities allowed in parts of the protected area assigned the protection regime II are:

- Commercial and sport-recreational fishing with floating longlines and angling tools that do not come into contact with the seabed and do not damage species and habitats on the seabed, and in accordance with the conditions issued in fishing licenses, with priority given to holders of commercial fishing licenses;
- Installation and use of underwater diving trails for the interpretation of nature – a maximum of 2 trails in separate parts of protection zone II, which will be determined based on appropriate expert assessment;
- Controlled scientific research and monitoring of natural processes;
- Controlled visits for educational, recreational and tourist purposes, exclusively in part II of the protection zone, which will be determined on the basis of an appropriate expert assessment;
- Protective, remedial and other necessary measures for area conservation;
- Implementation of special intervention measures for the protection of the marine ecosystem;

Prohibited activities under the protection regime II:

- Fishing, with the exception of fishing with floating longlines and fishing gear which does not come into contact with the seabed and does not damage the species and habitats on the seabed, and in accordance with the conditions issued in fishing licenses, with priority given to commercial fishing license holders;
- Use of natural resources;

[9] "Protection Study for Platamuni Nature Park" Draft, Agency for Nature and Environmental Protection, November 2020.

- Anchoring vessels;
- Movement of motor-powered vessels at speeds exceeding 10 knots, except for official steering vessels and competent services for the control and inspection of activities at sea;
- Mariculture;
- Erection or construction of facilities;
- Change of surface purpose;
- Dispersing, capturing, harassing and killing animal and plant species;
- Settlement of allochthonous and invasive species;
- Undertaking works that could damage species, habitats and archaeological heritage;
- Use of substances that may endanger the vitality and fundamental natural values of the marine ecosystem;
- Accidental or intentional disposal or dumping of municipal and other waste;
- Damage to underwater geological and geomorphological values;
- Reducing the number of wild species;
- Pollution or endangerment of the sea.

Level III protection regime – sustainable use, implies selective and limited use of natural resources, which enables functional-ecological connections and preserves the integrity of the protected area.

Allowed activities under the protection regime III are:

- Commercial and sport-recreational fishing, in accordance with the regulations governing sea fishing, until the conditions for the introduction of restrictions can be met, based on scientific data of targeted research of fishery resources in the protected area, to be defined in the Protected Area Management Plan, fishing permits and regulations for sea fishing;
- Movement and stopping of motor-powered vessels;
- Arranging and using hiking and recreational trails on land;
- Controlled installation and construction of one adventure park and one take-off and one landing point (zone) for paragliding;
- Interventions for the purpose of restoration, revitalization and overall improvement of the protected area;
- Scientific research and monitoring of natural processes;
- Implementation of protective and remedial measures;
- Intervention measures for ecosystem protection in the event of natural disasters and accidents.

Prohibited activities under the protection regime III are::

- Erection or construction of facilities that pollute, damage or endanger the marine and coastal ecosystem, natural habitats and species;
- Change of surface purpose;
- Dispersing, capturing, harassing and killing animal species;
- Settlement of allochthonous species.

Allowed activities in the buffer zone are:

- Construction of facilities in accordance with the valid spatial planning documentation, along with the application of conditions and guidelines for nature protection, as well as environmental protection measures related to spatial planning and project documentation, are carried out through the strategic impact assessment and environmental impact assessment procedures;
- Construction of a system for the collection/drainage and treatment of waste water, with the abolition of the use of septic tanks and absorption wells;
- Development of activities and projects for agro-ecotourism with the construction of facilities of small accommodation capacity, with low "space consumption" in zones defined by appropriate planning documentation.

Prohibited activities in the buffer zone are:

- Construction of facilities that pollute groundwater and surface water with their wastewater or if the efficiency of their treatment system is below the legally prescribed standards and quality parameters;

- Construction of facilities and performance of work, actions and activities which cause wastewater to be discharged without treatment into the underground (septic tanks and wells);
- Construction of facilities that lead to significant degradation of natural habitats

Also, for the areas near Sopot and Dražin vrt, a preventive protection procedure was initiated until the development of the Protection Study, as stipulated by the Law on Nature Protection (Official Gazette of Montenegro 54/16).

The preliminarily assessed category of protection for this area is the category of special nature reserve (category IV according to IUCN) which represents land or sea areas, or land and sea areas of special importance due to the uniqueness, rarity or representativeness of natural values, and which includes endangered habitat wildlife such as plants, animals and fungi, where man lives in harmony with nature and which is protected in order to preserve natural conditions and values. A special nature reserve can be in a natural, semi-natural or anthropogenic area. Performing work, actions and activities that may impair the properties of protected area are strictly prohibited in a special nature reserve. Work, actions and activities performed on the basis of a permit in accordance with the management plan are allowed in a special nature reserve.

Visits for the purpose of monitoring the status of nature, education or tourism are allowed in the special nature reserve following the approval of the manager, provided that the populations of wild species of animals and the habitats of wild species of plants, animals and fungi are not disturbed.

Based on preliminary expert recommendations for this area, the following should be prohibited: activities that may violate the primary values of protected sites and affect their original characteristics, hydrogeological works, construction of marine infrastructure, disposal and storage of all types of waste and surplus land, deliberate introduction and spread of non-indigenous plant and animal species, disturbance, capture and killing of animals, commercial fishing, mariculture, changing natural values of the area, any change in existing morphology of the terrain, anchoring (throwing anchors physically breaks and destroys present corals and other organisms). This prohibition should also be marked in nautical charts.

While tourist, educational, recreational and general cultural purpose visits can be permitted, recreational use (active and passive forms of recreation) in areas intended for recreation and excursions is allowed to the extent that it does not endanger the protected natural good, as well as intervention measures to protect ecosystems from natural disasters and accidents.

2. Tivat Saline Special Nature Reserve

Lagoons as a habitat type are rare in Montenegro. In addition to Tivat Saline, they include Buljarica, part of Velika plaža and Ulcinjska Solana.

The area in front of Tivat Saline should also be protected as an area in front of a nationally protected location, by limiting activities such as construction, embankment and urbanization.

3. Other areas with valuable and potentially valuable habitats

Through the activities of the "Establishment of the marine protected area Katič in Montenegro" Project, and assessment of marine and coastal ecosystems along the coast of Montenegro" (Screening of Coastal Area Volume 1 – Technical Report, 2012), other possible valuable habitats have been recognized, taken from the CAMP Project, and located in the following areas:

- Mamula Bay to Cape Mačka – Area 1;
- Cape Trašte to Platamuni – Area 2;
- Katič – Area 3;
- Cape Vulujica to the town of Dobre Vode – Area 4;
- Cape Komina to Cape Stari Ulcinj – Area 5;
- Valdanos Bay to U. Velike – Area 6;
- Seka Đeran and southern Velika Plaža to the Bojana delta – Area 7.

Based on the above-mentioned localities, detailed research has been conducted in the meantime, for areas whose status determination is in progress, as already mentioned, as follows: Platamuni (area 2), Katič (area 3) and the island of Stari Ulcinj (areas 5 and 6). In addition, concerning the above mentioned areas containing potentially valuable habitats, further research for the purpose of determining the suitability for formal protection, is recommended for the following:

- Mamula Bay to Cape Mačka – Area 1;
- Cape Vulujica to the town of Dobre Vode – Area 4;
- Seka Đeran and southern Velika Plaža to the Bojana delta – Area 7.

In addition to the above, the following locations can be singled out as valuable marine habitats (assigned the value 5): Trašte Bay, the area in front of Ratac, the area in front of Budva – Budvanska Tunja. Even though sporadic surveys have been done for these areas, detailed surveys have not yet been conducted except for the Ratac area.

Also, significant habitats such as sandy habitats (which stretch along the coast in Montenegro and which include beaches such as Plavi horizonti, Petrovac, Čanj, Velika plaža, Sutomore, Slovenska plaža, Bečići, etc.), sea caves (on the stretch Luštica-Donji Grbalj and in the area of Ulcinj, of which Volujica, Plava Špilja, Krekavica are especially interesting) and pits require certain protection measures.

The area in front of Velika plaža should also be treated with special care in terms of not planning any activities that may additionally threaten such locations, especially construction and urbanization, embankment, military use, construction of marinas, ports, and regulation of outlets.

Therefore, wider areas of potentially valuable habitats and areas of valuable marine habitats are sites that need special treatment through activity planning. For activities that cover locations of valuable marine habitats, no activities should be planned that may additionally threaten present habitat types, in particular:

- construction and urbanization;
- embankment;
- discharges;
- anchoring (above coralligenous communities and Posidonia meadow communities);
- military use;
- ports and marinas.

It is also necessary to limit the scope of tourist activities as well as mariculture activities, in some cases, for fish and shellfish. For wider areas of potentially valuable habitats, the same measures as previously mentioned are recommended as prevention, until more detailed research is conducted in order to consider the possibility of planning for these locations or further confirming the presence of valuable habitat types.

It is important to note that so far more detailed research on habitat distribution has been carried out in some locations in open seas and the Kotor-Risan part of the bay, while for the rest of the bay area detailed research has not been conducted, much like for the significant part of the open sea. These could also become additional sites included in future protection measures.

Habitat conservation measures

Underwater seabeds of Posidonia and seagrass communities are common in Montenegro but due to their sensitivity they suffer the greatest pressure from waste discharges and tourist activities, therefore it is necessary to ensure the following:

- Installation of wastewater treatment plants as described in the EO Eutrophication part;
- Remediation of marine litter as given in the chapter on marine litter, and contamination as given in the chapter on pollutants;
- Control and planning of anchorages outside the area of distribution or if it that is not possible due to navigation safety issues, to provide for the use of eco-buoys that serve as moorings;
- Minimization, restriction and control of construction, embankment and tourism development activities;
- Control and limitation of the presence of cruisers in the bay;
- Control of waste discharges from ships;
- Avoiding locations where this habitat type is present for mariculture planning and set up;
- Prohibiting the use of fishing gear in the habitat area, which may damage Posidonia meadows;

- Establishing protected areas in the sea where Posidonia meadows are the most representative;
- Improving the waste management system.

When it comes to coralligenous biocenoses in the context of current status maintenance, the following is necessary:

- Solving the issue of wastewater discharge (within EO Eutrophication);
- Remediation of marine litter as outlined in the chapter on marine litter, and contamination as given in the chapter on contamination;
- Minimizing, restricting and controlling construction activities, embankments and tourism development activities;
- Control and limitation of the presence of cruisers in the bay;
- Control of diving activities;
- Monitoring and more intensive control and application of penal policies in fishing, primarily for illegal fishing methods;
- Prohibiting fishing gear in the habitat area, which may damage it;
- Avoiding locations where this habitat type is present for mariculture planning and set up;
- Control and planning of anchorages outside the habitat area;
- Establishing protected sea areas where coralligenous communities are most representative.

Improving the waste management system. Sea caves are a particularly important habitat type and in the context of their protection it is necessary to monitor the quality of sea water, prohibit construction and filling in places where there are sea caves, prohibit waste disposal in cave openings, educate diving guides and diving instructors on the value of sea caves, and limit the number of visits/divers.

When it comes to other valuable habitats (which were not specifically mentioned, and which were graded 4 and 5 in this analysis), the measures to be implemented are monitoring of seawater quality, restriction and control of construction activities, embankments and tourism development, fishing gear that can cause damage, avoiding mariculture planning (for habitats with algae presence and coastal detritic seabeds), prevention and control of waste disposal, as well as resolving wastewater issues. Additionally, sandy and pebble supralittoral and mediolittoral beaches should be covered with deposits of natural origin (marine vegetation and boulders).

In general, the activities of backfilling, exploitation of oil and gas, and the exploitation of mineral raw materials, are not acceptable in the Bay of Kotor due to their impact on habitats. When it comes to the open sea, prior detailed research of areas for which there is no data should be planned before such activities are undertaken, and measures and benefits should be accordingly defined. Dredging activity is also not acceptable except at already existing locations of ports and marinas that are already under significant pressure from contamination.

Also, it is necessary to remediate marine litter as described in the chapter on marine litter, and contamination as described in the chapter on contamination, in terms of improving the protection of all habitats.

5. Biodiversity: Fish

5.1. Introduction

The first ecological objective (EO 1) lays down the responsibility of attaining a good ecological status of marine biodiversity via three special objectives relating to species:

- 1.1 – species distribution is preserved;
- 1.2 – selected species population size is preserved;
- 1.3 – selected species population conditions are preserved.

Although fish are not included in the IMAP biodiversity processing segment, economically significant (commercial) fish species representing an important segment of biodiversity will be analysed using the ecological objective 1 indicators. Additionally, bearing in mind that marine fisheries have a broad impact on marine ecosystems, this chapter will address both EO1 and EO3 (fisheries) together. Namely, the ecological objective 3 stipulates that the achievement of a good ecological status requires that "populations of selected commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock".

An analysis of the relevant pelagic and demersal species is made in accordance with the aforementioned objectives.

Data on pelagic fish species were collected on the Montenegro coastline open sea area as part of the MEDIAS (*Mediterranean International Acoustic Survey*) and the FAO AdriaMed (*Scientific Cooperation to Support Responsible Fisheries in the Adriatic Sea*) surveys between 2014-2016, while data on demersal species were collected as part of the MEDITS survey (*Mediterranean International Trawl Survey*) for the same period. Survey results are used to assess the target species abundance and any changes over the years, as well as to identify pressures causing biomass decrease, which usually result from human activity. The survey results presented here are exceptionally significant as they provide the basis for assessing the species' endangerment and vulnerability, as the prerequisite for planning future activities on the Montenegro coastline open sea.

Ecological objectives 1 and 3 are compatible with the descriptors in the EU Marine Strategy Framework Directive **D1 Biodiversity (fish component)** and **D3 Commercial species** (Table 2.3 in Chapter 2).

5.2. National and regional significant commercial fish species status monitoring programme

The CNR-ISMAR scientific institute in Ancona has been conducting acoustic surveys of the abundance and spatial distribution of pelagic resources since 1976, namely those of small bluefish in the Adriatic Sea. These surveys were initially conducted only in the Italian part of the northern Adriatic Sea, followed by an increase in the surveyed surface and a joint pilot survey in the waters of Italy, Slovenia and Croatia in 2001. In 2002, the Institute of Oceanography and Fisheries in Split began its own acoustic survey of the eastern part of the GSA 17, while the Ancona CNR ISMAR and the Institute of Marine Biology conducted their first acoustic survey in Montenegro in 2002, followed by surveys in 2004 and 2005. As of 2007, this survey has been continually carried out in Slovenia as well, and the **MEDIAS** project, as part of the EU Data Collection Directive (EU DCF), was initiated in the same year.

Following previous experiences in Montenegro, the need to expand the surveys to Albania was noted. The continental shelf of these two countries is very narrow and has no barriers between the Bay of Kotor and Vlorë. The distribution of small bluefish within these confines should occur at a similar dynamics. In addition to covering the continental shelf of Montenegro and Albania, the biomass assessment concerns an area comparable to the southwestern side of the Adriatic Sea (GSA 18) which has been monitored since 1987; in this way, the GSA 18 part of the Adriatic Sea can be compared on both sides, separated by a very deep southern Adriatic basin.

Acoustic data collection within the MEDIAS project was conducted via a network of transects placed perpendicularly to the coast at intervals of approximately 10 nautical miles. The transects cover the area from the Bay of Kotor (Montenegro) to Vlorë (Albania), 1-1.5 nautical miles from the coast to a depth of up to 200 m, covering the most important small bluefish distribution area. It is not possible to monitor lesser depths (<80 metres) on the north of Montenegro as those depths are too close to the coast, while the minimum depth at the south of Montenegro, in front of Ulcinj, is 15 metres.

Acoustic data collection took place 24 hours a day along the survey transects. The electroacoustic equipment used consisted of the Simrad EK60 which operates at 38, 120 and 200 kHz. The acoustic data were analysed and processed individually for each mile using the standard echo-integration technique (Simmonds and McLennan, 2005). Vessel speed during the survey was 9.5 knots (4 knots during trawling), while the integration results were calculated per each nautical mile. The data set resulting from the acoustic survey (acoustic data, catch data, vessel position) is processed via the SV Miriak Echoviev. In order to determine the size and species composition in the area, 4 experimental trawlings took place per day at different times of day and in different lighting conditions. The network construction is set out in the MEDIAS protocol and is standardised for the entire Mediterranean (MEDIAS Handbook, 2019).

In 2006, 2008, and from 2010 onwards (until 2017), in parallel with acoustic surveys, the daily egg and larva production method, **DEPM** (*Daily Egg Production Method*), began to be used in the waters of Montenegro and Albania, spreading to the entire GSA 18 after 2014. This method is used throughout the Mediterranean Sea to assess **the biomass of the adult spawning population** for anchovy and sardine.

Data collected during **MEDITS** was used for the demersal species of red mullet (*Mullus barbatus*), hake (*Merluccius merluccius*) and shrimp (*Parapenaeus longirostris*). This data collection method is independent from fisheries ("fishery-independent data"). Between June and July of each year, these surveys are carried out on the territorial sea area and epicontinental belt of Montenegro, at a surface of approximately 5,000 km^2 and depths of 10-800 metres. Catch is taken on 10 randomly determined positions, evenly spaced according to depth zones, namely those of 10-50 metres, 50-100 metres, 100-200 metres, 200-500 metres and 500-800 metres. The same experimental fishing nets are always used in these surveys – the type GOC73 trawl, specifically constructed for this purpose, with a mesh diameter of 22 mm (in diagonal). Identification, counting and weighing of all macrofauna species is carried out for each catch. For target species, in accordance with the MEDITS protocol, sex determination and macroscopic gonad staging is conducted as well.

5.3. Indicators

Data used for the assessment of the ecological status of the Montenegro coastline open sea marine ecosystem in respect of the commercial species status and fisheries pressures, within the EO1 and EO3 framework, comprises data on the spatial distribution and daily production of early developmental stages of anchovy (*Engraulis encrasicolus*), the spatial distribution and adult population biomass of anchovy, sardine (*Sardina pilchardus*) and other pelagic fish species (OPS). The demersal species processed include red mullet (*Mullus barbatus*), hake (*Merluccius merluccius*) and shrimp (*Parapenaeus longirostris*).

Due to the significance of marine aquaculture development on the Montenegro coastline open sea, an additional vulnerability and benefit analysis for mariculture development was carried out within the processing of the ecological objectives 1 and 3. In doing so, fish farming was not regarded solely as a pressure (within the context of achieving good marine conditions), but also as a significant commercial activity for which the benefit assessment was made. An analysis of this kind can serve as an example of a benefit assessment which can be made for other activities within sea use planning.

An overview of all indicators and methods of their processing (where applicable) is presented in Table 5.1.

Within the **Ecological objective 1 (biodiversity)**, the processed and presented indicators refer to the spatial distribution of species (CI3), population size for selected species (CI4) and population dynamics (CI5).

Table 5.1: Indicator overview

Indicator	Indicator type	MSFD indicator	Processing
BIODIVERSITY – FISH (pelagic and demersal resources)			
Species spatial distribution (CI3)	Status	Species range	
Anchovy – *Engraulis encrasicolus*			✓
Sardine – *Sardina pilchardus*			✓
Other pelagic species			✓
Red mullet – *Mullus barbatus*			✓
Hake – *Merluccius merluccius*			✓
Shrimp – *Parapenaeus longirostris*			✓
Population size for certain species (CI4) – EO1	Status	Population size	
Anchovy – *Engraulis encrasicolus*			✓
Sardine – *Sardina pilchardus*			✓
Other pelagic species			×
Red mullet – *Mullus barbatus*			✓
Hake – *Merluccius merluccius*			✓
Shrimp – *Parapenaeus longirostris*			✓
Population dynamics – body size, age class structure, sex ratio, fecundity rates, survival/mortality rates (CI5)	Status	Population status	
Anchovy – *Engraulis encrasicolus*			✓
Sardine – *Sardina pilchardus*			✓
Other pelagic species			×
COMMERCIAL SPECIES			
Spawning stock biomass (CI7)	Status	Spawning stock biomass (biomass index)	
Anchovy – *Engraulis encrasicolus*			✓
Red mullet – *Mullus barbatus*			✓
Hake – *Merluccius merluccius*			✓
Shrimp – *Parapenaeus longirostris*			✓

Indicator	Indicator type	MSFD indicator	Processing
BIODIVERSITY – FISH (pelagic and demersal resources)			
Total landing (CI8)	Pressure	Level of pressure from fishing activities (fishing mortality, relationship between catch and biomass indices)	
Anchovy – *Engraulis encrasicolus*			✓
Sardine – *Sardina pilchardus*			✓
Red mullet – *Mullus barbatus*			✓
Hake – *Merluccius merluccius*			✓
Shrimp – *Parapenaeus longirostris*			✓
Fishing mortality (CI9)	Pressure		
Red mullet – *Mullus barbatus*			✓
Hake – *Merluccius merluccius*			✓
Shrimp – *Parapenaeus longirostris*			✓
Fishing effort (CI10)	Pressure		
Anchovy – *Engraulis encrasicolus*			✓
Sardine – *Sardina pilchardus*			✓
Red mullet – *Mullus barbatus*			✓
Hake – *Merluccius merluccius*			✓
Shrimp – *Parapenaeus longirostris*			✓
Catch per unit effort or landing per unit effort (CI11)	Pressure		
Anchovy – *Engraulis encrasicolus*			✓
Sardine – *Sardina pilchardus*			✓
Red mullet – *Mullus barbatus*			✓
Hake – *Merluccius merluccius*			✓
Shrimp – *Parapenaeus longirostris*			✓
By-catch of vulnerable and non-target species (CI12)	Pressure		
Samo tekstualni opis vrsta iz kočarskih ulova		*	✓
Red mullet – *Mullus barbatus*			✓
Hake – *Merluccius merluccius*			✓
Shrimp – *Parapenaeus longirostris*			✓

Remarks for the table:

- Indicators with the CI label refer to common indicators (CI).
- Indicators with the × label have not been processed due to lack of available data.

* Age class structure and longitudinal structure of the population (the ratio of individual fish larger than the average value at which sexual maturation occurs, the medium maximum length of all species collected via commercial surveys, 95th percentile of the length distribution recorded during non-commercial field surveys, length at first sexual maturity).

Acoustic data were used to determine the spatial distribution of pelagic species and population size, and were analysed and processed mile by mile via the standard echo-integration method (Simmonds & McLennan, 2005). Sardine and anchovy stock status assessment was carried out via the SAM programme *(State-Space Assessment Program)* which has been incorporated into the FLR *(Fisheries Library in R)* (Kell *et al.*, 2007) in the "FLSAM" package format.

The „*swept-area*" methodology (Souplet 1996) was used to determine the spatial distribution and population size of demersal species, and has been standardised per surface unit (square kilometre) to obtain the relative biomass and relative abundance for each species according to position. The methodology used to assess the status of demersal species relating to the aforementioned indicators is that of XSA (*Extended Survivor Analysis*) for the year 2014, and SS3 (*Stock Synthesis 3*) for 2015 and 2016.

Within the framework of the **Ecological objective 3 (fisheries),** indicators relating to the following were processed and presented: population dynamics (CI5), spawning stock biomass (CI7), total landing (CI8), fishing mortality (CI9), fishing effort (CI10), catch per unit effort or landing per unit effort (CI11), and by-catch of vulnerable and non-target species (CI12).

Spawning Stock Biomass (SSB) is the ratio of fish of reproductive age in a population. Biomass assessment over many years of surveys done in the same locations and at the same pace can provide an accurate picture of the population status, and together with other parameters of the adult population, it provides MSY results, i.e. data on the annual quota (amount) of target species catch. In fact, the MSY represents the maximum theoretical fish stock yield which can be continually exploited on average at existing environmental conditions without a significant negative impact on the spawning stock biomass of the species in question. In order to achieve a good environment status (GES), keeping the SSB at a sustainable level is indispensable, i.e. fishing mortality must be kept below or equal to MSY.

Several benchmarks (parameters) exist for the processing of the SSB indicators, and these benchmarks can be processed and are used as a basis for the stock status assessment. The most significant ones include:

- B_{lim} – the defined spawning stock biomass (SSB) level below which there is a significant risk of a serious reduction of the spawning stock biomass, or stock dynamics are unknown.
- B_{msy} – the defined spawning stock biomass (SSB) at which maximum sustainable yield (MSY) is achieved due to a fishing mortality rate of F_{msy}. For fish stock undergoing continuous exploitation at a level of F_{msy}, the value of B_{msy} is defined based on long-term data. Importantly, the value of B_{msy} is subject to change due to natural fluctuation in the species' biomass and interaction, particularly pelagic ones.

The assessment of the total annual catch of a target species is crucial for the assessment of the aforementioned parameters, and forms, alongside scientific data, the basis for the definition of limits to the biomass and amount of resources available for exploitation.

This document provides numerical biomass data for pelagic and demersal species. The pelagic species of sardine and anchovy, i.e. the adult part of their populations, are highly migratory species, traversing great distances over short time spans, and belong to the shared stocks of the Adriatic Sea, subject to fishing by all Adriatic country fleets. Therefore, the stock status assessment for these species covers the entire Adriatic Sea. Stock status assessments were carried out via the SAM programme *(State-Space Assessment Program)* which has been incorporated into the FLR *(Fisheries Library in R)* (Kell *et al.*, 2007) in the "FLSAM" package format.

The DEP method for surveying the daily anchovy egg and larva production was used within and for the purposes of the anchovy spawning stock biomass assessment. Data obtained via this method can aid in the understanding of the mechanisms by which natural changes affect the reproductive biology and survival rate of small bluefish early stages (Somarakis *et al.*, 2004; van der Lingen & Castro, 2004). The DEP methodology (DEPM) used to assess anchovy biomass entails detailed surveys of target species spawning zones, daily egg and larvae production, adult individual processing (analyses of fecundity, spawning frequency, sex ratio) and abiotic environmental factor analysis (hydrography).

This was the data used to display the spatial distribution and spawning zones of anchovy on the Montenegro coastline open sea for the period 2014-2016.

Results obtained from the daily egg and larva production surveys are only available for the anchovy as the MEDIAS surveys are only carried out in the summer in Montenegro – during the anchovy spawning season. Regrettably, DEPM surveys are not carried out for the sardine due to a lack of funds and the need to carry out the entirety of such surveys in the winter, i.e. during the sardine spawning season.

For demersal species, the SSB is the combined mass of all individuals capable of further reproduction, i.e. sexually mature individuals, in a species' stock. The SSB is assessed on the basis of the following data: individual number estimate according to age class groups, average individual mass estimate per age class group and the estimate of sexually mature individuals per each age class group. The SSB assessment is obtained using *stock assessment* models for specific species, within the framework of the GFCM working groups on stock assessment of pelagic or demersal stock (WGSAD, WGSAP) (UNEP/MAP, 2017).

Total landing is defined as the part of the catch which is kept, and does not include waste (*discard*).

Fishing mortality (F) is the current mortality rate of individual fish dying as a consequence of fishing, which can be expressed as the number of individuals or as a biomass. As a technical term, it refers to the proportion of fish removed from the population, i.e. stock in a specific time span (usually one year) (FAO, 1997).

The following is significant for determining fishing mortality:

- actual fishing mortality on a certain area within a certain time span (usually one year) – F_{curr} – assessed on the basis of data on catch, certain fishing gear selectivity, etc.;
- maximum sustainable yield (MSY);
- fishing mortality rate at which a maximum sustainable yield of F_{msy} is achieved.

For pelagic resources, the F_{msy} value is used as an indicator of fishing mortality and as a benchmark for the entire Adriatic Sea. If the value of the current total fishing mortality of F_{curr} is below the agreed-upon benchmark of F_{msy}, the stock is considered to be sustainably exploited. If the value of the current total fishing mortality of F_{curr} is higher than the agreed-upon benchmark of F_{msy}, the stock is considered to be overfished, and overfishing graduation is based on the following relations: $F_{curr}/F_{msy} \leq 1.33$ – low overfishing rate, $1.33 < F_{curr}/F_{msy} < 1.66$ – moderate overfishing rate, and $F_{curr}/F_{msy} \geq 1.66$ – high overfishing rate.

For demersal species, instead of F_{msy}, the **$F_{0.1}$** is usually applied and represents the fishing mortality rate at which the slope of the catch per recruit curve is equal to one tenth (1/10) of the curve slope at its origin. This approach is used in the context of the GFCM, at the regional level.

Fishing effort is the amount of time, i.e. fishing capacity (e.g. gross tonnage) used for harvesting fish and other marine organisms. Fishing effort is the assessment of fishing pressure exerted by fishing activities on fish stock (UNEP/MAP, 2017). Fishing effort is often expressed as the total fishing time or the total amount of a given fishing gear used in a certain fishing area during the time span in question. When multiple fishing gear is used, standardisation via a shared unit is necessary for the assessment of the total fishing effort (FAO, 1997).

Catch or landing per unit effort (CPUE) is the relative measure of fish stock abundance and can be used to estimate the relative abundance indices. It can also be used as an indicator of fishing efficiency, in terms of abundance and in terms of economic value. In its basic format, the CPUE is expressed as the biomass of individual fish caught per each unit of applied effort for a given species or stock. In other words, it is the total catch/landing of a given species divided by the total fishing effort: kg or number of individual fish per longline hook. A declining trend for this indicator may suggest overfishing, while harmonised values may indicate sustainable yields (UNEP/MAP, 2017).

Vulnerable and non-target species by-catch refers to the sea turtle, marine mammal, shark and sea bird catch rate. Trend analyses (i.e. occurrence, spatial distribution etc.) of accidental vulnerable species catch indicates the impact of various fishing activities on this component of the marine ecosystem (UNEP/MAP, 2017).

5.4. Pelagic species status

Pelagic fish (small bluefish) represents a strategic marine resource everywhere in the world. Sardine, *Sardina pilchardus*, and anchovy, *Engraulis encrasicholus*, are very important for fisheries in the Adriatic and together make up approximately 41% of the total marine fishery catch in the Adriatic (the 1970-2005 period, FAO, Fishstat data). On the eastern coast of the Adriatic Sea, sardine is a far more common catch, while the ratio of sardine to anchovy on the west side catch has varied over time, albeit with a far greater ratio of anchovy. This catch ratio also depends on market demand: there is much greater demand for anchovy in Italy, and the reverse on the eastern coast.

5.4.1. Anchovy (Engraulis encrasicolus)

Anchovy, *Engraulis encrasicolus* (Linnaeus, 1758), is the only representative of the Engraulidae family on the northeastern Atlantic and Mediterranean area (Hureau & Monod, 1973). It belongs to the pelagic species group (small bluefish) and, together with the sardine (*Sardina pilchardus*), it is one of the most important marine resources in the world. Anchovy is a widely distributed species in the entire Adriatic, and is one of the most important commercial species. It is found in bays, channels and the open sea, from the Gulf of Trieste to the Strait of Otranto, except for areas at great depths (Sinovčić, 2000). Many studies have been made in the preceding decades to assess whether different subspecies or sub-populations of anchovy exist in the Adriatic, which would result in different management measures. Levi *et al.* (1994) recognise two separate anchovy stocks, according to a growth analysis based on otolith reading, as do Bembo *et al.* (1996) based on gene allelle structure and morphometric features. On the other hand, many authors caution against the use of morphological data in population structure studies (Tudela, 1999, and more recently, Magoulas *et al.*, 2006) and have identified the presence of two different stocks in the Mediterranean, one characterised by a high frequency in the Adriatic Sea (greater than 85%). Additionally, the results of the EU project STOCKMED indicate the existence of one anchovy stock in the GSA 17 and in the western section of the GSA 18 (Fiorentino *et al.*, 2014). More recently, Ruggeri *et al.* (2016) analysed genetic markers in anchovy samples from the Adriatic and Tyrrhenian Sea and found no clear evidence of the existence of two different anchovy populations in these areas.

Figure 5.1: Anchovy, *Engraulis encrasicolus* (Linnaeus, 1758) – adult individual fish (top), and larvae (bottom)

5.4.1.1 Spatial distribution and daily production of early developmental stages of anchovy (spawning)

The distribution of the early developmental stages of anchovy (eggs and larvae) is represented as the spatial distribution of the abundance of individual fish per m^2 of the sea surface, while the anchovy biomass – SSB is represented as the number of individual fish per m^2 of the sea surface per day, i.e. as the value of the daily egg and larva production.

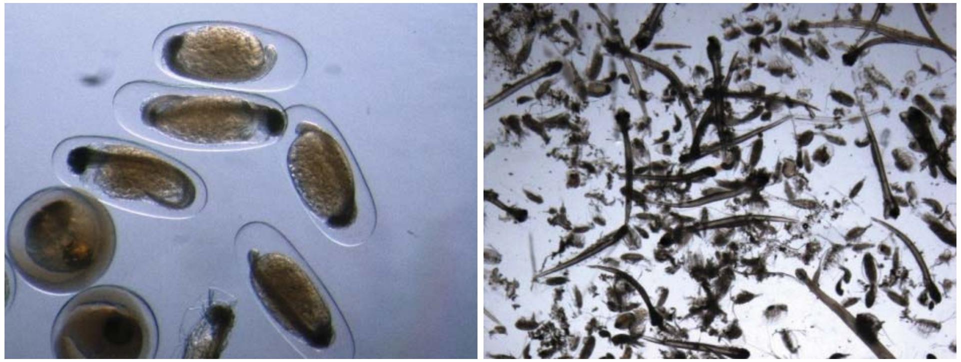


Figure 5.2: Anchovy eggs (left) and larvae (right) in a plankton sample

In this analysis, solely the representation of anchovy egg abundance (spawning) was used, as the number of individual fish per m^2 of sea water surface.

The SSB numerical values are provided for the entire surface of the Adriatic Sea because anchovy is a highly migratory species, because the stock in question in the Adriatic Sea is shared, and because stock management measures for small bluefish, including anchovy, are adopted jointly.

Status – open sea

Data on the spatial distribution of species indicate where in the sea the species find the best conditions for procreation, growth and development. The spatial distribution and abundance of early developmental stages of economically important fish species is the basis for the biomass assessment for a given species, and represents an important population status indicator. It is worth noting that simultaneous continuous monitoring of the adult population status throughout the entire open sea area is indispensable as well in order to provide complete, consolidated data which would enable the creation of an accurate representation of fish stocks and the pressures exerted upon them.

Map 5.2 represents anchovy egg abundance (spawning) as the number of individual fish per m^2 of sea water for the period of 2014-2016. Analyses were made on a total of 25 positions throughout each survey year, at depths ranging from 30-200 metres, i.e. to the boundaries of the continental shelf.

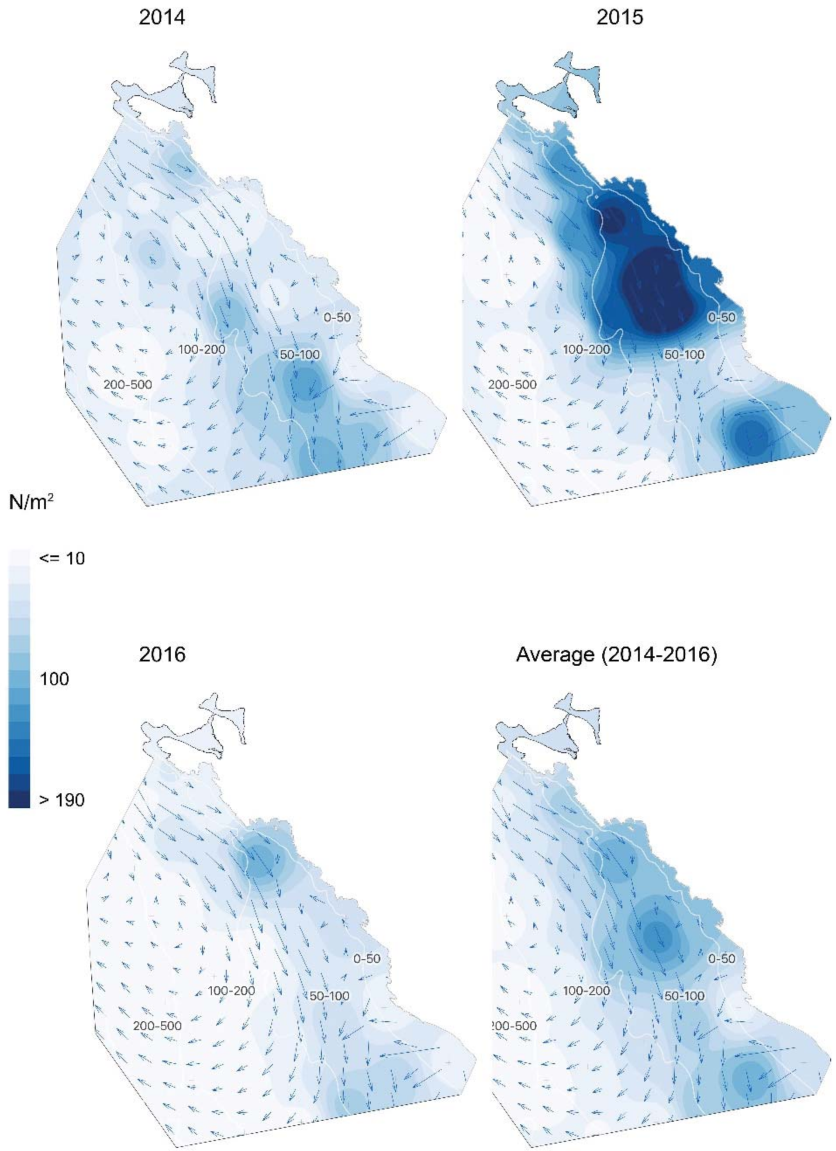
The analysis of the results of the anchovy spatial distribution survey demonstrated that, during 2014, the abundance of early developmental stages of anchovy ranged between 0-113 eggs/larvae per m^2 of sea surface. The abundance was significantly higher throughout 2015 and ranged between 0-313 eggs/larvae per m^2, while it reached its lowest levels in 2016 – between 0-101 eggs/larvae per m^2. It is noteworthy that in 2014, only one position was negative regarding early anchovy stage occurrence, while in 2015 and 2016 that number was 7 and 8, respectively. Negative positions were located at greater depths, averaging between 150-200 metres of depth.

To assess the daily production of eggs and larvae, which is the basis for the assessment of the spawning stock biomass (SSB), it is necessary to calculate the natural mortality of early anchovy stages, the separate duration of each development stage and the age of each stage discovered in the samples. Data on daily egg and larva production is based on the resulting data, by applying the DEPM model, and their assessment over a number of consecutive years enables the identification of the target species spawning zones (Map 5.3).

The analysis of the results of daily egg and larva production demonstrated a daily production of 0-151, 0-176 and 0-41 eggs and larvae per m^2 per day in 2014, 2015 and 2016, respectively. The average daily production value was 21.2 eggs/larvae per m^2 of sea surface in 2014, 20 in 2015 and 5.7 in 2016. These values are obtained via the regression method using the following input data: the individual fish abundance per each surveyed position and the natural mortality of early developmental stages of anchovy.

By comparing our results with the data available for the same area of research and by using the same methodology, it was determined that the daily production in 2014, 2015 and 2016 was significantly lower than that in 2006 and 2008, when the average daily egg production values amounted to 42.25 and 110.16, respectively (Mandić *et al.*, 2015). A comparison of the average values of daily anchovy egg production with that in other parts of the Mediterranean Sea indicates that the daily production of anchovy eggs and larvae in the waters of Montenegro is significantly lower than that in the rest of the Mediterranean Sea, with the exception of the central part of the Ionian and Aegean Sea (Somarakis *et al.*, 2004, Somarakis *et al.*, 2012) where the daily production of eggs and larvae amounts to 8-25 per m^2 per day. Recent data demonstrate that the daily production of anchovy eggs in the Aegean Sea is 36.52 eggs per m^2/day (Taylan and Hossucu, 2016).

Map 5.1: Anchovy egg and larva distribution (N/m^2)



The daily production of anchovy eggs and larvae materially depends on sea water temperature, namely, the higher the temperature, the shorter the duration of the developmental stages. In the southern Adriatic, sea water temperatures are significantly higher than those in most of the Mediterranean Sea, which partly causes a lower daily egg and larva production. Additionally, given that anchovy is a pelagic species with pronounced migration and biomass variation over the years, long-term surveys of broad areas are necessary to provide the most accurate daily egg and larva production estimates possible.

A detailed analysis of all represented cartographic displays of the spatial distribution of early developmental stages of anchovy indicates the existence of two spawning zones for this species on the Montenegro coastline open sea area. The first, smaller zone is located on the stretch of water between Bigovo Cove and the Bay of Budva, while the second, larger and most significant zone lies on the stretch between Cape Crni rt and the Albanian border. In both zones, the distribution of early anchovy stages is noted from relatively small depths (almost from the coastline) to an isobath of approximately 100 metres, i.e. the continental shelf area. This fact is confirmed by the 2013 survey locating one more significant spawning zone on the border between the Montenegrin and Albanian territorial waters (Zorica *et al.*, 2018).

Anchovy egg distribution is significantly affected by environmental factors (particularly temperature and salinity), as well as several oceanographic conditions such as water currents, freshwater input, water exchange, nutrient load etc. The above factors significantly influence the adult population, namely the time and location of their reproduction.

The position and spatial distribution of anchovy eggs and larvae materially depend upon sea water currents due to the fact that early developmental stages (used for the SSB assessment via the DEPM method) are incapable of independent movement, meaning that their position in the water is conditioned by various sea water movements (currents, winds etc.). Nonetheless, owing to the relatively brief period of egg and larva development (ranging from 2-5 days depending on temperature) and the quick achievement of the post-larval stage (the stage when individual fish move and feed independently), the spatial distribution is also materially conditioned by high primary production zones and areas conducive to the nourishment of adult individual fish.

Status – Bay of Kotor

The distribution of the early developmental stages of anchovy in the Bay of Kotor area is represented as the spatial distribution of individual fish abundance per m^2 of sea surface. Data sampling and processing methodology for the early developmental stage analysis is the same as that for the open sea. Data on the spatial distribution of species indicate where in the bay the species find the best conditions for procreation, growth and development.

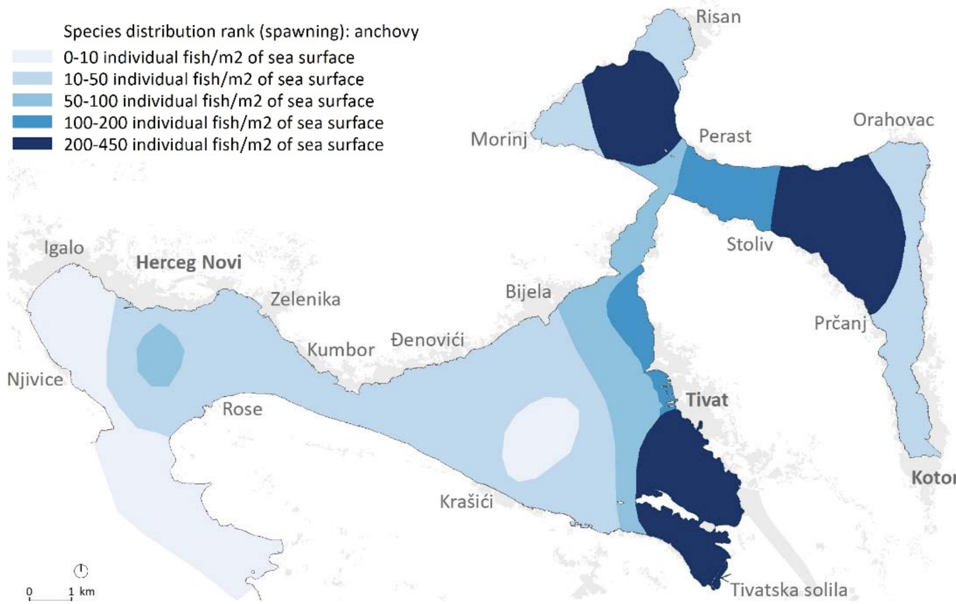
Map 5.3 represents anchovy egg abundance (spawning) as the number of individual fish per m^2 of sea water. This representation is the result of overlaying all available results of the three-year survey of anchovy distribution in the Bay of Kotor area (2006-2008). Regrettably, after the aforementioned period, regular surveys of early developmental stages of anchovy in the Bay of Kotor area were not carried out. Only surveys of specific parts of the bay were conducted depending on the needs of specific projects.

Anchovy spawning indicates the existence of **two main hotspots of the presence of this species – the Bay of Kotor and the Bay of Tivat** – with exceptionally high spawning intensity throughout the survey period. Significant spawning was detected in the **Bay of Risan** as well. Spawning in the rest of the bay took place at a relatively lower intensity. The available data on anchovy spawning in the Bay of Kotor area was processed within the project "*Marine Vulnerability Assessment in the Bay of Kotor – Methodological Guidelines*", a cooperation between the Ministry of Sustainable Development and Tourism, Montenegro and the PAP/RAC Priority Actions Programme/Regional Activity Centre (PAP/RAC, MORT (2017)), with more information available in that document.

Periods of the highest spawning intensity, as well as locations where egg abundance will be the greatest are generally linked to zones of high productivity, especially when conditions for the nourishment of the adult population are the most favourable (Somarakis *et al.*, 2004; Martin *et al.*, 2008).

Data represented in this document indicate that the anchovy spawning status was stable throughout several years of surveys, but continuous surveys of the same locations are indispensable for the preservation of existing resources, adequate monitoring of the anchovy population status and the implementation of any necessary protection measures.

Map 5.2: Anchovy distribution (spawning) on the Bay of Kotor area (2006–2008)



5.4.1.2 The spatial distribution and status of the adult anchovy population (CI 3/4/5)

The biomass, i.e. the size of the adult anchovy population was assessed using the acoustic method, the echo-survey, within the MEDIAS project (*Mediterranean International Acoustic Survey*) and the FAO AdriaMed project (*Scientific Cooperation to Support Responsible Fisheries in the Adriatic Sea*). This survey was initiated in 1976 in the northern part of the Adriatic Sea (the west side of the GSA 17), with successive increases in the surface undergoing surveying (GSA 18, Figure 5.3). **The results point to significant biomass fluctuation over the years, with a falling trend in overall biomass**. This is primarily the consequence of natural fluctuations in the biological features of this short-lived species which has a high natural mortality rate and offspring (recruits) heavily influenced by environmental factors, and is also the consequence of great fishing effort in the Adriatic Sea.

Due to the particularities of the Adriatic Sea compared to the rest of the Mediterranean, all countries with access to the Adriatic Sea carry out their own pelagic resource surveys presented during the annual GFCM meetings („*General Fisheries Commission for the Mediterranean*"). Due to the fact that pelagic resources are shared between countries on the Adriatic Sea (*„shared stocks"*), the SSB assessment is carried out based on all available data from the fisheries sector and data collected during Adriatic-wide scientific expeditions.

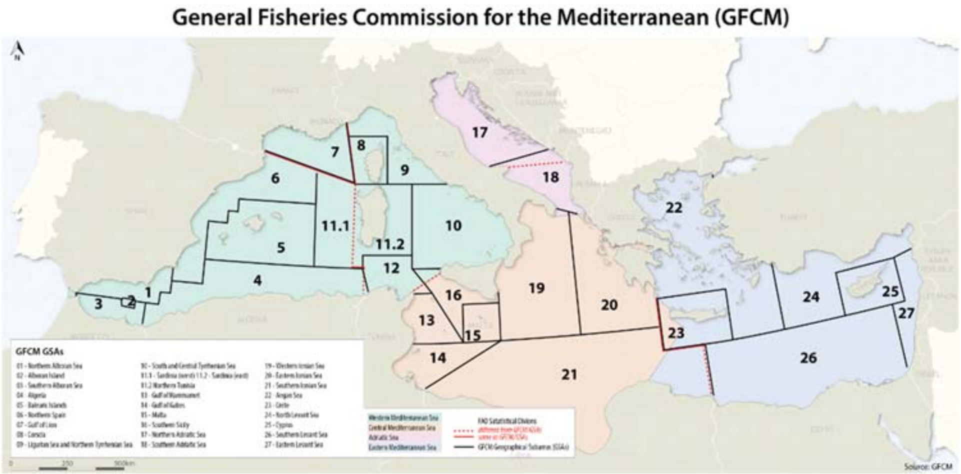


Figure 5.3: Mediterranean Sea division into geographic sub-units with the aim of managing the fisheries sector. The southern Adriatic Sea is the GSA 18 area. (Source: GFCM)

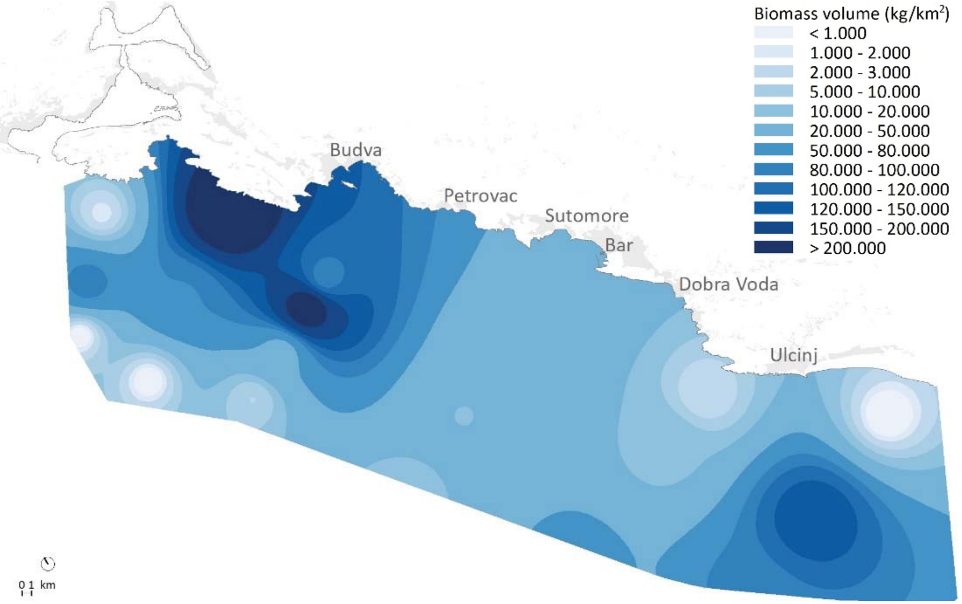
Anchovy SSB assessments for the entire area of the Adriatic Sea significantly changed in values throughout history. The largest biomass was noted in the 1970s (284,930 tons), while the first significant biomass decline was noted in 1987 (43,391 tons). The stock recovered after that period, with an estimated anchovy biomass of 194,269 tons in 2005. As of 2005, the anchovy biomass in the Adriatic displays a constant decreasing trend. Estimates for 2015 and 2016 amount to 78,433 and 57,469 tons, respectively (Angelini, S. *et al.*, 2017). The spatial distribution of the adult anchovy population in 2015 and 2016 is displayed on maps 5.3 and 5.4.

Regarding the SSB values for the entire Adriatic Sea area, a benchmark of B_{lim} was determined to amount to 45,936 tons. Data gathered from professional fishermen provide a fishing mortality rate of as much as 1.43 (F_{curr}), which is significantly higher than the recommended fishing mortality rate (0.64 for F_{msy}).

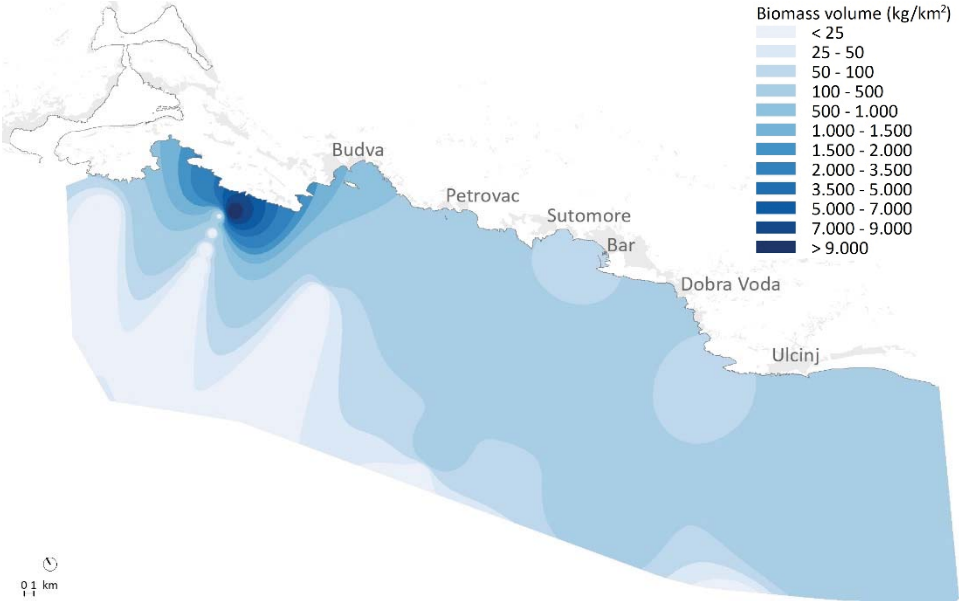
In summary, the data indicate that the Adriatic Sea anchovy biomass is overexploited and overfished.

As the adult population biomass assessment via the acoustic method is carried out for the entire Adriatic Sea, it is not possible to extract the biomass values solely for the Montenegrin waters from the total data. Maps 5.3 and 5.4 display the spatial distribution of the biomass, i.e. the anchovy biomass density (kg/km^2) during 2015 and 2016, in front of the Montenegrin coast up to an isobath of 200 metres. As these are highly migratory species, survey results for these two years show great differences. In 2015, there were no positions which did not record the presence of individual fish of this species and the density ranged from 3.87 to 266,760.8 kg/km^2, with an average value of 17,816.55 kg/km^2. In 2016, this species was recorded on only 42% of the surveyed positions, and the density ranged from 0.25 to 10,321.07 kg/km^2, with an average value of 319.43 kg/km^2. In both survey years, the greatest anchovy density was recorded in the area in front of Platamuni, while a great concentration was detected in the area in front of Ulcinj in 2015.

Map 5.3: Adult anchovy spatial distribution assessment based on data from one survey in 2015



Map 5.4: Adult anchovy spatial distribution assessment based on data from one survey in 2016



The distribution of anchovy length frequency in the catch, i.e. body size for the 2014-2016 period, displayed a range of 5.0-14.4 cm (medium value 10.0 ± 1.4 cm TL), while individual weight displayed a range of 0.66–20.96 g, with a medium value of 6.2 ± 2.9 g. Female fish length displayed a range of 6.5-14.4 cm TL, with a medium length of 10.2 ± 1.3 cm TL, while their weight was 1.30–20.96 g (medium value of 6.6 ± 2.9 g). Male fish displayed nearly the same medium length value of 10.1 ± 1.2 cm TL (7.5-13.2 cm TL), while their individual weight was somewhat lower than that of the females, 6.4 ± 2.5 g (2.64 to 14.7 g).

Females outnumbered males and the total collected sample composition in 2014-2016 was 59% female, 32% male, and 6% indeterminate. The female/male ratio was 60% to 40% in 2014, 68% to 32% in 2015, and 67% to 33% in 2016 in favour of female fish. Female fish were more numerous in all length groups. The length at which the first sexual maturity was achieved was estimated to be 9.3 cm TL for both sexes together, i.e. 9.4 cm TL for females and 9.1 cm TL for males. The highest gonadosomatic index (GSI) value, marking the most intensive spawning, was recorded in May (4.74 for female fish and 4.97 for male fish) with an additional spawning peak in August (4.62 for female fish and 3.99 for male fish). Individual fish age was determined based on otolith readings and indicates that the majority of the population undergoing fishing belongs to the age class group of 1 year of age, with over 80% of the individuals processed, followed by the age class group of 0 year, and a very small number in the age class group of 2 years, while the number of individuals belonging to the age class group of 3 years of age is practically negligible.

Due to the overexploitation of pelagic stock and with the aim of ensuring the sustainable use of resources with a maximum sustainable yield (MSY), the European Commission adopted the "Regulation of the European Parliament and the Council establishing a multi-annual plan for small pelagic stocks in the Adriatic Sea and the fisheries exploiting these stocks". A proposal for this Regulation was adopted in 2017, initiating intensive work on the harmonisation and definition of measures for the sustainability of fisheries resources. Additionally, a Plan for the management of small bluefish resources in the Adriatic Sea was adopted on the GFCM level, of which

Montenegro is a full member (Recommendation GFCM/42/2018/8 on further emergency measures in 2019-2021 for small pelagic stocks in the Adriatic Sea (geographical sub-areas 17 and 18), determining the maximum yield and other measures for the management of these resources. Measures concerning resource management are defined for the entire Adriatic Sea area and entail limits to the number of fishing days for each vessel exploiting pelagic resources; a prohibition on anchovy and sardine harvesting during breeding periods; a prohibition on fishing for vessels longer than 12 metres in defined feeding and spawning zones, etc.

Alongside Albania and Slovenia, Montenegro is a country occupying an **exceptionally small proportion of the total pelagic resource exploitation (below 1%)**, with almost all of the catch based in central and northern Adriatic, and carried out by Italy and Croatia. A disproportionate distribution of fishing effort in the Adriatic Sea of this kind results in differences in the implementation of management measures for different GFCM member states, whereby the measure on limiting small bluefish catch to 2014 levels does not apply to Montenegro (Article 5 determining that the rule does not apply to countries with a 2014 catch of less than 2500 tons). Consequently, Montenegro can continue to develop its pelagic resource exploitation fleet in compliance with other measures ensuring sustainable resource exploitation (stock protection during breeding periods with a total prohibition on harvesting, fishing prohibition for large purse-seine vessels within the Bay of Kotor and within 3 Nm or an isobath of 50 m on the open sea, etc.).

5.4.2. Sardine – adult population

The sardine is a widely distributed species, populating the eastern Atlantic Sea from Iceland and the North Sea to the coast of Senegal, the Mediterranean and the Adriatic Sea, and also found less frequently in the western Mediterranean, the Marmara Sea and the Black Sea (Whitehead *et al.*, 1989). It is found throughout the Adriatic Sea, more often along the coastline and in channels compared to the open sea, and more frequently in the northern and central Adriatic Sea compared to the southern Adriatic Sea. It is an economically significant species. It is fished via purse seine vessels, midwater trawls, shore seines (*letnja trata*, *migavica*) and gill nets (*vojga*).

The sardine is a pelagic, highly migratory species exemplified by large, dense shoals. It reaches depths of up to 250 m, but mainly stays at depths of 25-55 m during the day or 15-35 m during the night. Its average length is 15-20 cm, reaching a maximum of 25 cm in the Mediterranean. It reaches sexual maturity near the end of its first year (at approximately 12 cm of length), and all individuals are sexually mature at 14 cm of length. It spawns from mid-autumn to the end of winter at a depth of 30-150 m (Škrivanić & Zavodnik, 1973), but mainly between 60-120 m (Karlovac, 1967, Vučetić, 1975, Kačić, 1980). Females extrude between 5,300 and 38,500 eggs, depending on their age. The eggs are pelagic. The sardine mainly feeds on planktonic crustaceans, but also other larger planktonic animals (Jardas, 1996).

Despite certain variations in the morphometric, meristic and ecological features of the Adriatic sardine stock, allosomic and mitochondrial research demonstrated insufficient genetic heterogeneity (Carvalho *et al.*, 1994), as did the cytochrome b gene analysis (Tinti *et al.*, 2002). Based on scientific fact and the information that most Italian vessels registered in the GSA 18 carry out their fishing activities in the GSA 17, it was decided that the entire Adriatic Sea should be treated as a single area, with sardine stock status assessment carried out for the entire GSA 17-18 area.

Figure 5.4: Sardine

5.4.2.1 Spatial distribution and status of the adult sardine population (CI3)

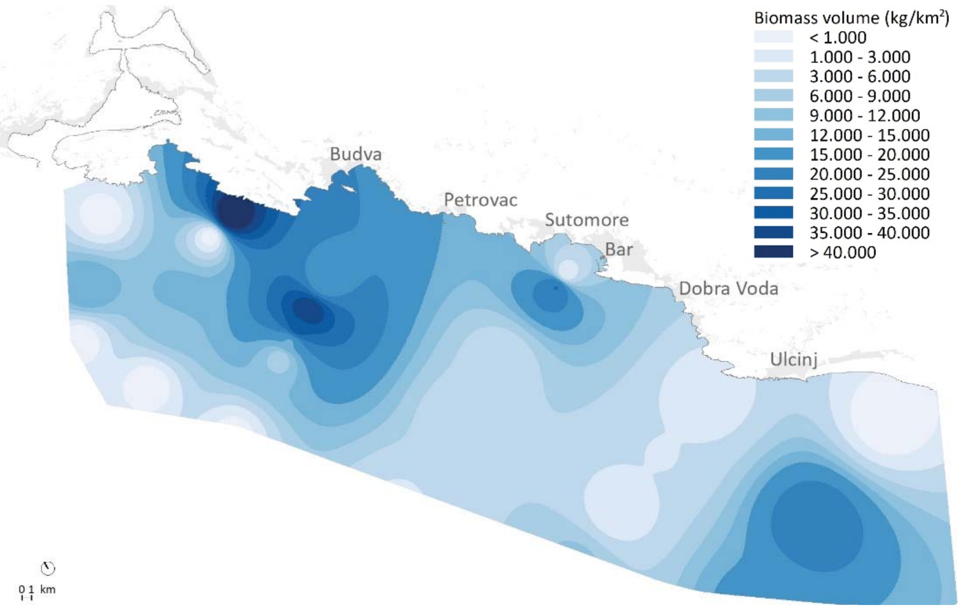
The size of the adult sardine population (CI4)

The biomass, i.e. the size of the adult part of the sardine population was assessed via the acoustic method. The results point to significant biomass fluctuation over the years, with a falling trend in overall biomass. This is primarily the consequence of natural fluctuations in the biological features of this species which is short-lived, has a high natural mortality rate, and the offspring (recruits) of which are heavily influenced by environmental factors; and is also the consequence of great fishing effort in the Adriatic Sea.

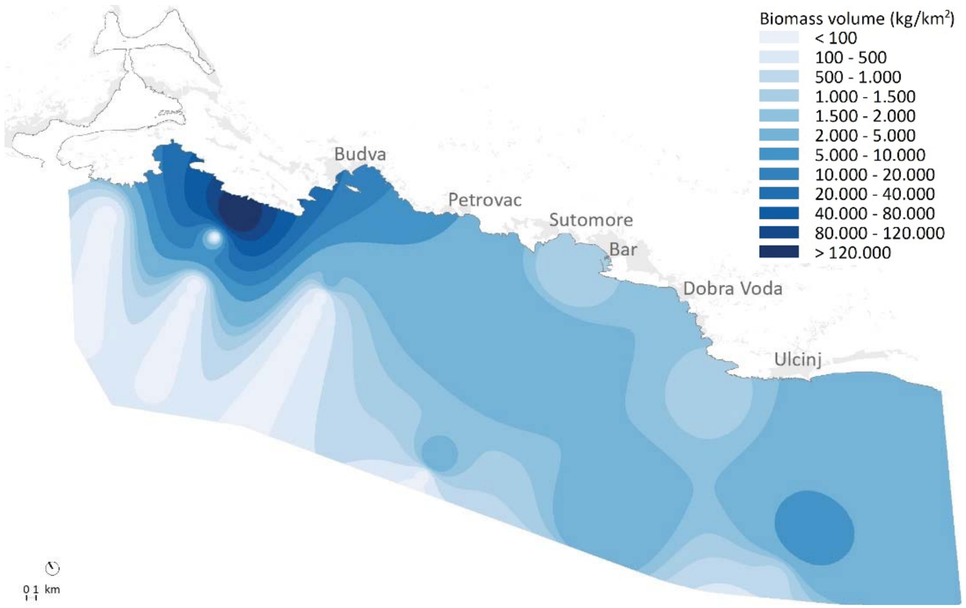
The spatial distribution of the adult sardine population in 2015 and 2016 is displayed on maps 5.5 and 5.6.

As with anchovy, it is not possible to extract biomass values solely for the Montenegrin water part from the total data because the biomass assessment is carried out for the entire Adriatic Sea area. Maps 7.4.2.1 and 7.4.2.2 display the spatial distribution of the biomass, i.e. the sardine biomass density (kg/km^2) during 2015 and 2016, in front of the Montenegrin coast up to an isobath of 200 metres. In 2015, there were no positions where individual fish of this species were not recorded as present, and the density ranged from 2.52 to 46,467.8 kg/km^2, with an average of 3,309.22 kg/km^2. In 2016, as for anchovy, the presence of sardine was recorded on only 42% of the surveyed positions, and the density ranged from 3.86 to 160,035.33 kg/km^2, with an average value of 4,952.9 kg/km^2. In both survey years, the greatest sardine density was recorded in the area in front of the Platamuni coast, while a great concentration was detected in the area in front Budva and Ulcinj in 2016.

Map 5.5: Adult sardine spatial distribution assessment based on data from one survey in 2015



Map 5.6: Adult sardine spatial distribution assessment based on data from one survey in 2016



The distribution of sardine length frequency in the catch, i.e. body size for the period of 2014-2016 displayed a range of 6.4-23.0 cm TL (medium value 13.0 ± 2.1 cm TL), while individual weight displayed a range of 1.7- 46.6 g, with a medium value of 17.3 ± 7.9 g. Female fish length displayed a range of 7.1-23.0 cm TL, with a medium length of 13.4 ± 2.0 cm TL, while the weight was 3.2-46.6 g (medium value of 18.8 ± 8.3 g). Male fish length displayed a range of 7.3-16.8 cm TL (average length 13.1 ± 1.8 cm TL), while individual weight displayed a range of 3.3- 35.1 g with an average value of 16.9 ± 6.6 g.

Females somewhat outnumbered males and the total collected sample composition in 2014-2016 was 50% female, 45% male, and 5% indeterminate. The female/male ratio was 52% to 48% in 2014, 48% to 52% in 2015, and 55% to 45% in 2016 in favour of female fish. The length at which the first sexual maturity was achieved was estimated to be 9.8 cm TL for both sexes together, i.e. 9.37 cm TL for females and 9.23 cm TL for males. The highest gonadosomatic index (GSI) value for female fish, marking the most intensive spawning, was recorded in November (4.76), with an additional spawning peak in January (4.64), while the reverse was noted for males, with the highest GSI value in January (4.17) and an additional peak in November (3.96).

Individual fish age was determined on the basis of otolith readings via standardised methodology used throughout the Adriatic Sea (AdriaMed, 2015), and indicates that the majority of the population undergoing fishing belongs to the age class group of 0 to 1 years, with over 90% of the individuals processed, followed by the age class group of 2 years, and a very small, practically negligible percentage in the age class group of 3 years. This age distribution within the population is anticipated as older, larger individual fish are more strongly affected by fishing activities and are more vulnerable to fishing mortality.

In summary, as with the adult part of the anchovy population, data indicate that the Adriatic Sea sardine biomass is overexploited and overfished. Nevertheless, as with anchovy, measures for the protection of pelagic resources in the Adriatic Sea adopted on the GFCM level do not apply to Montenegro due to its extremely low ratio in total fisheries on the Adriatic Sea.

5.4.3. Other pelagic species

Sardine and anchovy are the main species targeted by commercial fishing, meaning the pressure on their populations is the highest. Consequently, biomass assessment surveys and stock status assessment are carried out for these two species. Other pelagic species present in catch made by purse seines, trawls and pelagic trawls represent by-catch, i.e. they are not the targeted species, but they do have a certain value and can be placed on the market.

The following species were present in pelagic trawl catches during the MEDIAS survey in the period of 2014-2016 in addition to the target species and survey subjects of sardine and anchovy: Atlantic horse mackerel *Trachurus trachurus*, Mediterranean horse mackerel *Trachurus mediterraneus*, *Spicara smaris*, *Spicara flexuosa* and *Spicara maena*, bogue *Boops boops* and twait shad *Alosa fallax.* All species were fished intermittently as individuals and spatial distribution maps for them cannot be produced. The above species are not target species for fisheries, and represent by-catch, meaning that their populations are not greatly impacted by fisheries, and stock status assessment for their populations in the Adriatic Sea is not carried out.

Certain population dynamics parameters, i.e. biological parameters, were collected for the bogue (*Boops boops*) within regular marine fishery resource monitoring in Montenegro.

The distribution of bogue length frequency in the catch, i.e. body size for the period 2014-2016. displayed a range of 9.0-33.3 cm TL (medium value of 16.0 ± 2.7 cm TL), while individual weight displayed a range of 6.0- 423.3 g, with a medium value of 40.1 ± 20.9 g. Female fish length displayed a range of 10.0-29.9 cm TL, with a medium length of 16.1 ± 2.7 TL, while the weight was 9.3-156.3 g (medium value of 40.9 ± 19.4 g). Male fish length displayed a range of 9.9-33.3 cm TL (average length of 15.9 ± 2.7 cm TL), while individual weight displayed a range of 6.0- 423.0 g with an average value of 39.2 ± 23.3 g.

Females somewhat outnumbered males and the total collected sample composition in 2014-2016 was 58% female, 39% male, and 3% indeterminate. The female/male ratio was 57% to 41% in 2014, 57% to 38% in 2015, and 60% to 37% in 2016 in favour of female fish, while the remainder was composed of individuals of indeterminate sex. The length at which the first sexual maturity was achieved was estimated to be 15.0 cm TL for both sexes together, i.e. 14.9 cm TL for females and 14.3 cm TL for males. The highest gonadosomatic index (GSI) value, marking the most intensive spawning, was recorded in February for both sexes, at 4.17 for males and 4.07 for females.

5.5. Pelagic resource status valuation

Valuation represents the existing quality of the living habitat, i.e. the part of it within the processed indicators, and is assessed based on the defined status and existing pressures, with the aim of emphasizing the necessity of protection, preservation and improvement of certain marine living habitat parts, depending on the value level.

The valuation was carried out on the basis of data relating to indicators CI3 and CI7, by defining specific valuation criteria. In accordance with scientific research results, the area value for these indicators was determined as a range between very low (1) to very high (5).

Separate valuation was carried out for each segment of the analysed pelagic resources, namely:

- anchovy spawning spatial distribution;
- adult anchovy spatial distribution;
- adult sardine spatial distribution.

The total valuation was carried out while taking into account the frequency of the greatest values for all pelagic resource segments together, with consideration of the relevant matrices.

Valuation of the anchovy spawning spatial distribution

The valuation was made with reference to the spatial distribution and spawning intensity of anchovy. Valuation, i.e. abundance (spawning intensity) distribution for anchovy was carried out in accordance with numerous references handling the same matter. In general, each abundance of 50-100 eggs per m^2 is considered to indicate a significant spawning intensity, while an abundance greater than 100 individuals per m^2 is considered to indicate high intensity (Somarakis *et al.*, 2006, Merker and Vujošević, 1972). Value criteria for anchovy spawning is displayed in Table 5.2.

Table 5.2: Anchovy spawning values (N/m^2)

Value assessment		Criterion
1	Very low value	Very low spawning intensity/biomass zone: 0 to 10 eggs per m^2
2	Low value	Low spawning intensity/biomass: 10-50 eggs per m^2
3	Moderate value	Moderate spawning intensity/biomass: density of 50 to 100 eggs per m^2
4	High value	High spawning intensity/biomass zone: from 100 to 200 eggs per m^2
5	Very high value	Highest spawning intensity/biomass zone: density of more than 200 eggs per m^2

The zones most significant for anchovy spawning were determined by applying the aforementioned criteria and value combination for 2014, 2015 and 2016. They include areas of the bays of Risan, Kotor and Tivat, as well as the open sea area between Petrovac and Sutomore. The spatial distribution of significant zones is displayed on Map 5.7.

Valuation of the adult anchovy population spatial distribution

The valuation was carried out with reference to the spatial distribution and biomass, i.e. density of the adult part of the population (kg/km^2) on the open sea. Spatial zones ranging from an estimated low biomass intensity to an estimated very high biomass intensity were determined by interpolating data in the GIS. Due to low amounts of data and significant differences in catch volume in 2015 and 2016, valuation was carried out separately for each year. This enabled the determination of zones which may represent the greatest population concentration, regardless of the overall catch weight.

For 2015, the valuation was carried out using the scale displayed in Table 5.3, while the scale in Table 5.4 was used for 2016.

Table 5.3: Adult anchovy population distribution values in 2015

Value assessment	Criterion
1 Very low value	Very low biomass intensity zone: below 1,000 kg/km^2
2 Low value	Low biomass intensity zone: 1,000-5,000 kg/km^2
3 Moderate value	Moderate biomass intensity zone: density between 5,000-50,000 kg/km^2
4 High value	High biomass intensity zone: density between 50,000-100,000 kg/km^2
5 Very high value	Very high biomass intensity zone: density higher than 100,000 kg/km^2

Table 5.4: Adult anchovy population distribution values in 2016

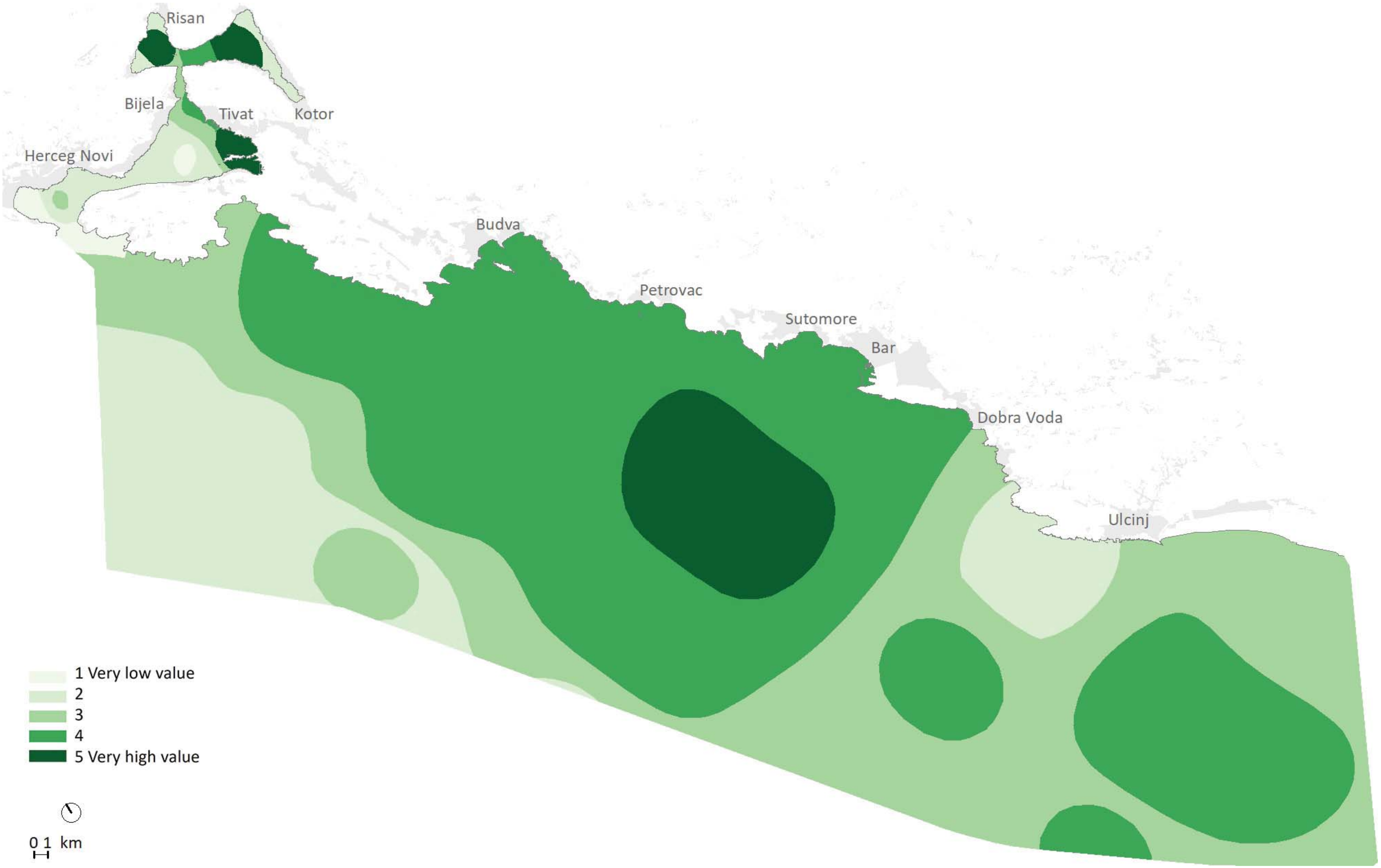
Value assessment	Criterion
1 Very low value	Very low biomass intensity zone: below 10 kg/km^2
2 Low value	Low biomass intensity zone: 10-100 kg/km^2
3 Moderate value	Moderate biomass intensity zone: density between 100-2,000 kg/km^2
4 High value	High biomass intensity zone: density between 2,000-7,000 kg/km^2
5 Very high value	Very high biomass intensity zone: density higher than 7,000 kg/km^2

The total spatial distribution of the most significant adult anchovy population zones was made by combining the values for 2015 and 2016 according to the matrix displayed below, by highlighting the highest values for a given year within the combined value. The spatial representation of the most valuable anchovy zones is displayed on Map 5.8.

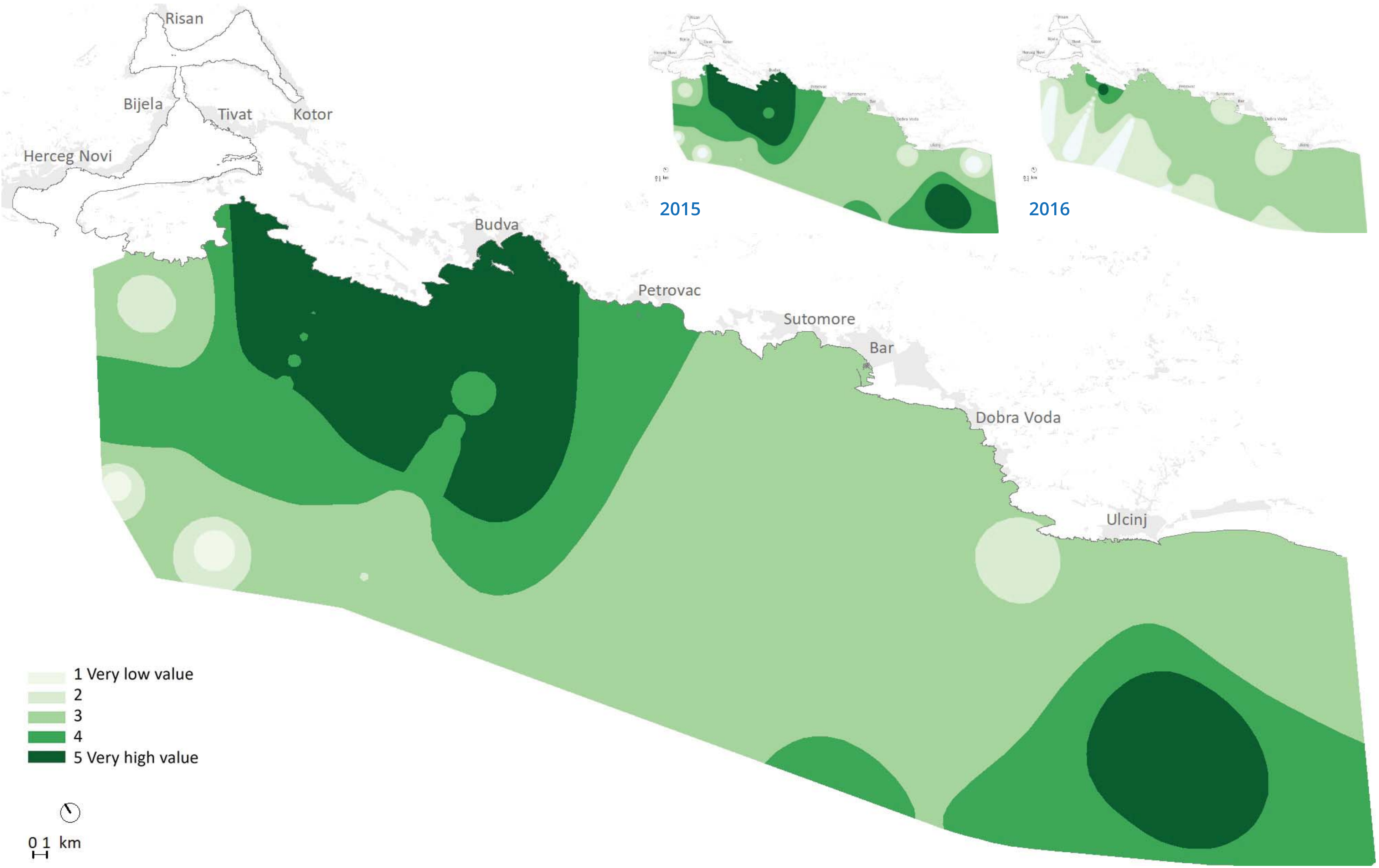
Values in 2015

Values in 2016	1	2	3	4	5
1	1	2	3	4	4
2	2	2	3	4	5
3	3	3	3	4	5
4	4	4	4	4	5
5	4	5	5	5	5

Map 5.7: Value assessment – anchovy spawning on the open sea



Map 5.8: Value assessment – adult anchovy on the open sea



Valuation of the adult sardine population spatial distribution

As in the case of anchovy, valuation was carried out with reference to the spatial distribution and biomass, i.e. density of the adult part of the population (kg/km^2) on the open sea. Spatial zones ranging from an estimated low biomass intensity to an estimated very high biomass intensity were determined by interpolating data in the GIS. The valuation principle was identical to that for adult anchovy, by valuating each year separately.

For 2015, valuation was carried out using the scale displayed in Table 5.5, while the scale in Table 5.6 was used for 2016.

Table 5.5: Adult sardine population distribution values in 2015

Value assessment		Criterion
1	Very low value	Very low biomass intensity zone: below 1,000 kg/km^2
2	Low value	Low biomass intensity zone: 1,000-3,000 kg/km^2
3	Moderate value	Moderate biomass intensity zone: density between 3,000-15,000 kg/km^2
4	High value	High biomass intensity zone: density between 15,000-30,000 kg/km^2
5	Very high value	Very high biomass intensity zone: density higher than 30,000 kg/km^2

Table 5.6: Adult sardine population distribution values in 2016

Value assessment		Criterion
1	Very low value	Very low biomass intensity zone: below 100 kg/km^2
2	Low value	Low biomass intensity zone: 100-1,000 kg/km^2
3	Moderate value	Moderate biomass intensity zone: density between 1,000-5,000 kg/km^2
4	High value	High biomass intensity zone: density between 5,000-11,250 kg/km^2
5	Very high value	Very high biomass intensity zone: density higher than 11,250 kg/km^2

The total spatial distribution of the most significant adult sardine population zones was made by combining the values for 2015 and 2016 according to the matrix displayed below, by highlighting higher values for a given year within the combined value. The spatial representation of the most valuable sardine zones is displayed on map 5.9.

Values in 2015

Values in 2016	1	2	3	4	5
1	1	2	3	4	4
2	2	2	3	4	5
3	3	3	3	4	5
4	4	4	4	4	5
5	4	5	5	5	5

Total value of pelagic species spatial distribution

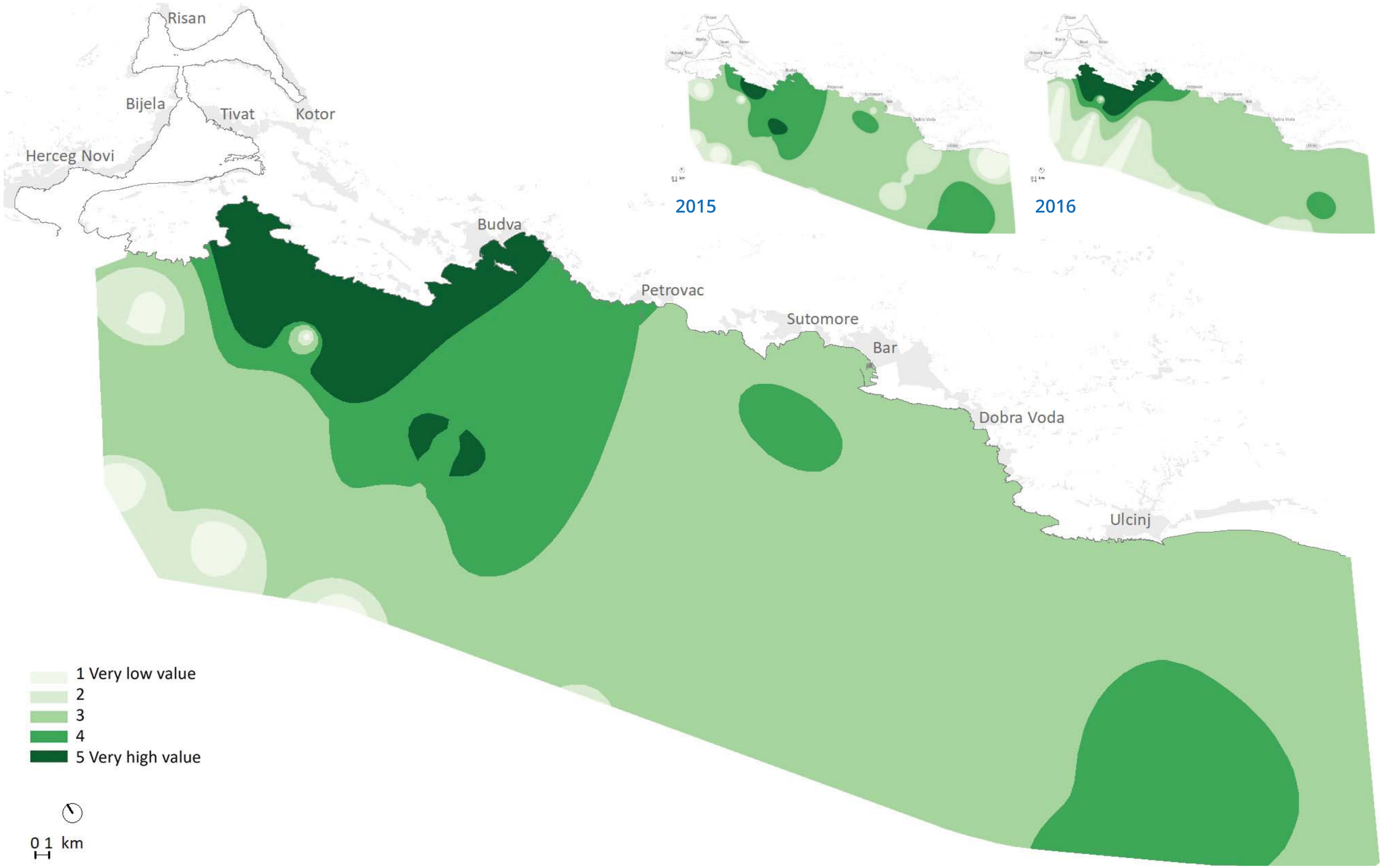
The total valuation (Map 5.10) was carried out according to the principle of combining valuable areas of the early developmental stages of anchovy, adult anchovy and sardine. The combination was prepared according to the same matrix used for the year-based value combination. This means that the input values have equal weight in the generation of the total value.

The spatial distribution of the early developmental stages of anchovy indicates two valuable spawning zones in the Bay of Kotor area – the first one in the **Bay of Kotor** and the second one in the **Bay of Tivat**. Significant spawning was identified in the area of the Bay of Risan as well, while spawning intensity in the remaining part of the bay can be determined as moderate or relatively low.

On the open sea, the analyses confirm the existence of two valuable anchovy spawning zones. The first, smaller zone, is located on the stretch between **the Bigovo Cove and the Bay of Budva**, while the other, larger and more important zone, is located on the stretch between **Cape Crni rt and the Albanian border**. In both zones, the distribution of early anchovy stages is noted from relatively small depths (almost from the coastline) to an isobath of approximately 100 metres, i.e. the entire continental shelf area.

The position and spatial distribution of anchovy eggs and larvae materially depend on sea water currents and other sea water movement due to the fact that early developmental stages are incapable of independent movement, but their position in the water is conditioned by various sea water movements (currents, winds etc.). Nonetheless, owing to the relatively brief period of egg and larva development (ranging from 1.5-5 days depending on the temperature) and the quick achievement of the post-larval stage (the stage when individual fish move and feed independently), the spatial distribution is materially conditioned by high primary production zones and zones conducive to the nourishment of adult individual fish as well.

Map 5.9: Value assessment – sardine on the open sea



Map 5.10: Total pelagic resource value assessment

The spatial distribution and presence of early fish stages materially depend on, among other things, larvae behaviour, food availability, feeding zone proximity and habitat structure. Considering the fact that seaweed meadows are one of the most important feeding zones for a large number of fish species (Perez-Ruzafa *et al.,* 2004, Guidetti P., 2000), larvae composition surveys in the shallow areas of the open sea are necessary to assess the presence and abundance of the early stages of commercial fish species. Data presented for early anchovy stages have confirmed that the most valuable reproduction zones are located on the stretch from Petrovac to Bar, i.e. in the proximity of the future Montenegro marine protected area (Katič).

The spatial distribution of the adult anchovy and sardine population indicates the existence of two most valuable zones with equally valuable population density. The first high biomass density zone for both species is located on the **Platamuni – Budva** stretch, while the other one in the area in front of **Ulcinj**. The high density hotspots of the adult part of the anchovy population largely overlap with spawning hotspots, i.e. intensive anchovy reproduction zones.

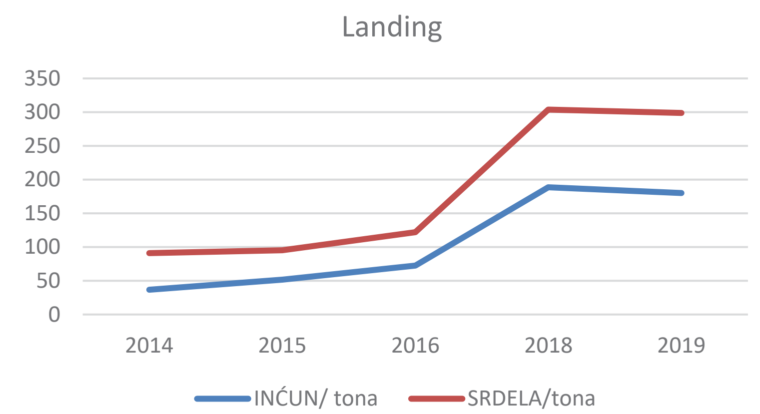
However, it should be underlined that sardine and anchovy are highly migratory species and that their distribution significantly varies within short time spans. Additionally, these short-lived fish display high natural fluctuation, noticeable at the annual level. Therefore, zones displayed here are preliminary and do not exclude the existence of other significant pelagic species areas.

5.6. Fishing impact on pelagic resources

The fishing impact on pelagic resources is represented by an analysis of four indicators: landing (CI8), fishing mortality (CI9), fishing effort (CI10) and catch per unit effort (CI11).

Total landing (CI8)

Landing represents the amount, i.e. the weight of catch which has been "removed" from the sea and unloaded onto the shore. The volume of small bluefish fished in Montenegro is nearly negligible in comparison to catch made by other Adriatic countries. In the Bay of Kotor, small bluefish is mostly fished using traditional small-scale coastal fishing gear typical for this area, i.e. shore seine nets and small purse seines. Vessels fishing small bluefish using pelagic trawls are not present in Montenegro, while purse seiners fishing in the open sea are few (under 10 vessels). According to data collected via catch logbooks filled in by fishermen, an increased anchovy and sardine catch was recorded as of 2014 (36.69 tons of anchovy, 91.05 tons of sardine), with a significant increase in 2018 (188.74 tons of anchovy; 303.75 tons of sardine; most likely due to the data reporting method), and a small drop in 2019. (Graph 5.1)



Graph 5.1: Anchovy and sardine catch landing between 2014 and 2019

Fishing mortality (CI9)

The average fishing mortality value (F) for anchovy individuals aged 1 or 2 years, and sardine individuals aged 1-3 years, for the entire dataset on the level of the entire Adriatic Sea displayed continuous growth from the beginning of the time series used for stock status assessment (the sardine fishing mortality in 1975 was F=0.09), until 2011 when the anchovy fishing mortality reached a value of F=1.31, or 2014 when the sardine fishing mortality reached its maximum value of F=1.683. After 2011, anchovy fishing mortality varied until 2016 when it reached its maximum value of F=1.43. Data from 2016 onwards show a mild decrease in the fishing mortality value (F=1.075 in 2018 for anchovy, F=1.30 in 2016 for sardine), which may result from natural fluctuations and biological features of the species themselves, but may also be the result of management measures adopted and implemented in the preceding years. The data was obtained using the SAM model for the entire dataset on the level of the Adriatic Sea.

Fishing effort (CI10)

Fishing effort is a measurement displaying the volume of the fishing activities performed. This parameter can be calculated using a combination of different input parameters, and signifies the amount of time (days of fishing) and fishing capacity (GT – gross tonnage) used for fishing. Fishing effort is a measurement which enables the assessment of fishing activity pressure on fish stocks.

Sardine and anchovy are species which are fished together, i.e. they are present in the same catch and cannot be fished selectively, namely, targeting only one of these two species is not possible. They are fished with the same vessels and the same fishing gear.

As previously stated, small bluefish in Montenegro is mostly fished on the area of the Bay of Kotor, using traditional fishing gear: shore seine nets and small purse seines. Vessels using shore seine nets are typically small, under 5 metres of average length and with a small gross tonnage (1 on average). The number of fishing days made by these vessels predominantly depends on weather conditions as this type of fishing requires calm weather without waves. Additionally, the number of fishing days for small bluefish fishing is limited to 144 days per year, according to the management plan for the Adriatic Sea. These vessels are not equipped with satellite tracking systems (VMS or AIS) and the distribution of their fishing effort cannot be displayed via graphs or figures. In terms of open sea catch, the number of purse seiners is less than 10, while vessels using pelagic trawl nets are not present in Montenegro. Figure 5.4 displays the fishing effort distribution for two purse seiners which performed fishing activities during 2019. It shows that vessels mainly fish in Montenegrin territorial waters and leave national waters only to a small extent, while fishing activity is distributed in the central and southern parts of national waters.

The total number of fishing days for purse seine nets in 2017 was 464, with an active vessel capacity (gross tonnage) of 268.11 GT, while the total number of fishing days for purse seine nets in 2018 was 537 with an active vessel capacity (gross tonnage) of 299.65 GT. The total number of seine net fishing days in 2017 was 437, with a total active vessel capacity of 15.04 GT, while the total number of fishing days in 2018 was 580, with an active vessel capacity (gross tonnage) of 28.45 GT.

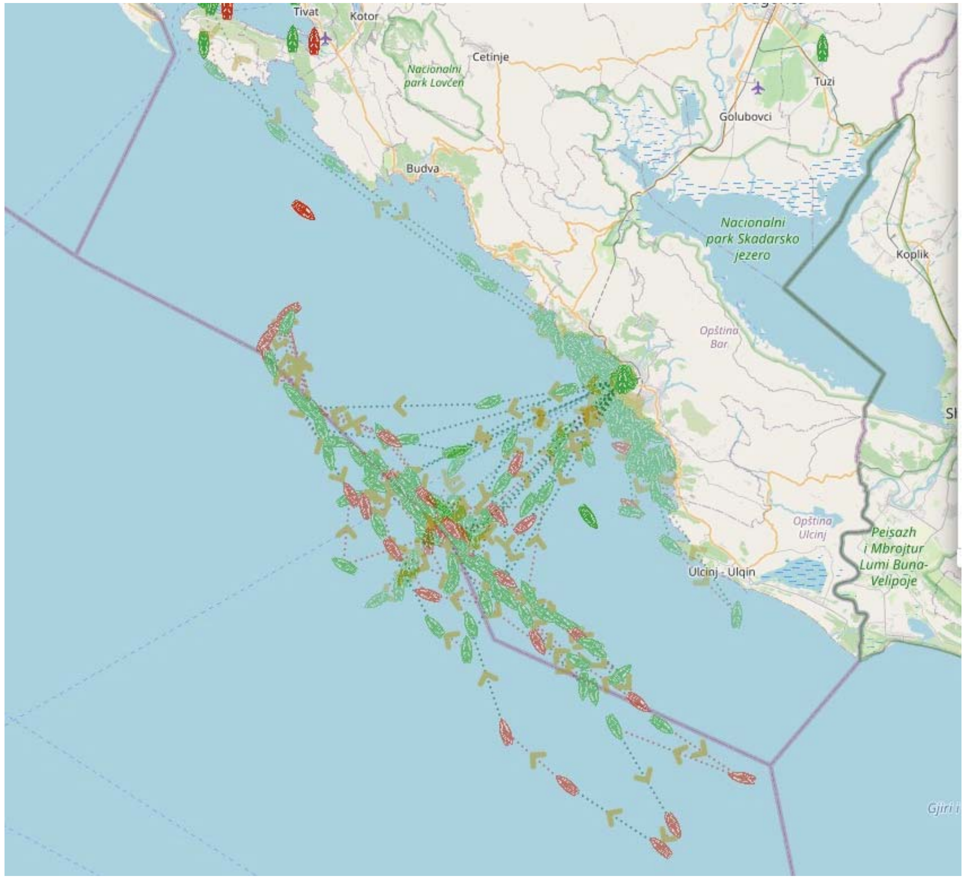
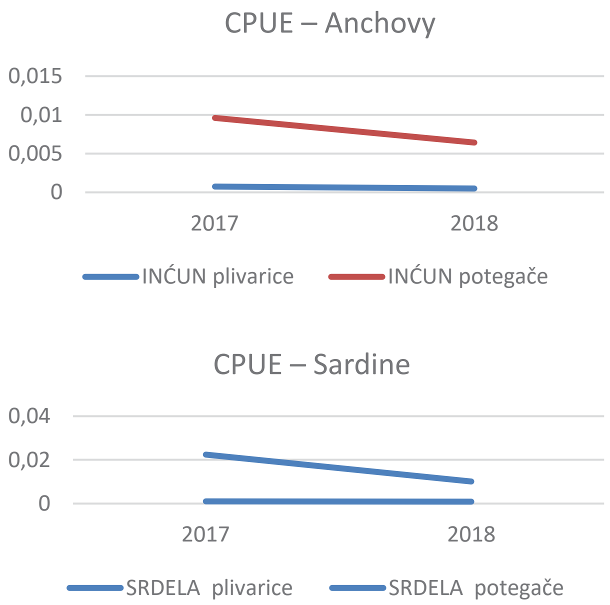


Figure 5.5: Purse seiner vessel distribution in Montenegro
(Source: VMS, Directorate for Fisheries, Ministry of Agriculture, Forestry and Water Economy)

Catch per unit effort (CI11)

Fishing effort is combined with catch data to assess the catch per unit effort (CPUE). Catch per unit effort (CPUE) is a relative measurement of fish stock abundance which can be used to assess absolute abundance, and is an indicator of fishing efficiency in terms of both volume and economic value. Catch per unit effort can be expressed as the harvested biomass per unit of effort applied (e.g. kg/100 metres of netting; kg/number of longline hooks). The decreasing trend in CPUE value could indicate excessive exploitation, while fixed values may indicate sustainable fishing.

The CPUE values for anchovy and sardine show a mild decreasing trend for seine nets, while purse seine catch shows almost the same levels of CPUE. In 2017, the CPUE value for the purse seine anchovy catch was 0.00076, while the same value was 0.00051234 in 2018. The CPUE value for the seine net anchovy catch was 0.00962 u 2017, while the same value was 0.00642 in 2018. Graph 5.2 displays the values for 2017 and 2018.



Graph 5.2: CPUE values for anchovy and sardine in 2017 and 2018

5.7. Pelagic resource endangerment

Endangerment is a representation of the assessed status per processed fish species in relation to various existing pressures which endanger fish stocks. In the endangerment assessment, an analysis of pelagic resource endangerment and exposure to pressures was carried out by "overlaying" results processed within the scope of the ecological objectives of eutrophication (EO5), contamination (EO9), marine litter (EO10) and fisheries pressures (EO3).

In assessing the eutrophication pressures, only very high pressure areas were taken into account. In assessing contamination pressures, high, very high and unacceptable pressure areas were taken into account. In assessing marine litter impact, very high and unacceptable impact areas were taken into account.

Fishing pressure assessment was performed by taking into account fishing position zones, the area between Rose and Arza Cape where purse seine fishing is permitted, and the spatial distribution of purse seiners during open sea fishing, using data provided by the VMS system (Vessel Monitoring System) of the Directorate for Fisheries, Ministry of Agriculture, Forestry and Water Economy. The EO3 (CI8, CI9, CI10, CI11 i CI12) indicators were used as additional information for pressure assessment as they provide insight into the total fishing pressure on existing resources and can be used to assess the endangerment of existing resources, and to emphasise the necessity of introducing measures to protect fishing stocks.

Endangerment valuation was performed by giving additional ratings to the value assessment (from 0-2) for each pressure factor, taking into account the expected impact of that pressure onto pelagic resources. Endangerment ratings for each of the pressure groups above are displayed in Table 5.7, while their spatial distribution is displayed on maps from 5.11 to 5.14.

Table 5.7: Endangerment assessments for pelagic resources

	Eutrophication impact	Contamination impact	Marine litter	Fishing effort			
Value of additional assessment	0 or 1	0 or 1	0 or 1	0 or 1	0 or 1	0 or 1 or 2	
Class/impact assessment	5	4/5/6	4/5	Fishing post	Purse seine fishing area	Purse seiner fishing area	
Value						Lower intensity	Greater intensity
1	0	0	0	0	0	0	0
2	0	0	0	1	0	1	1
3	1	1	1	1	1	1	2
4	1	1	1	1	1	2	2
5	1	1	1	1	1	2	2

The resulting assessment was classified into one of ten endangerment assessment value classes:

Impact assessment	
1	No impact or insignificant impact
2	
3	Moderate impact
4	
5	High impact
6	
7	Very high impact
8	
9	Unacceptable impact
10	

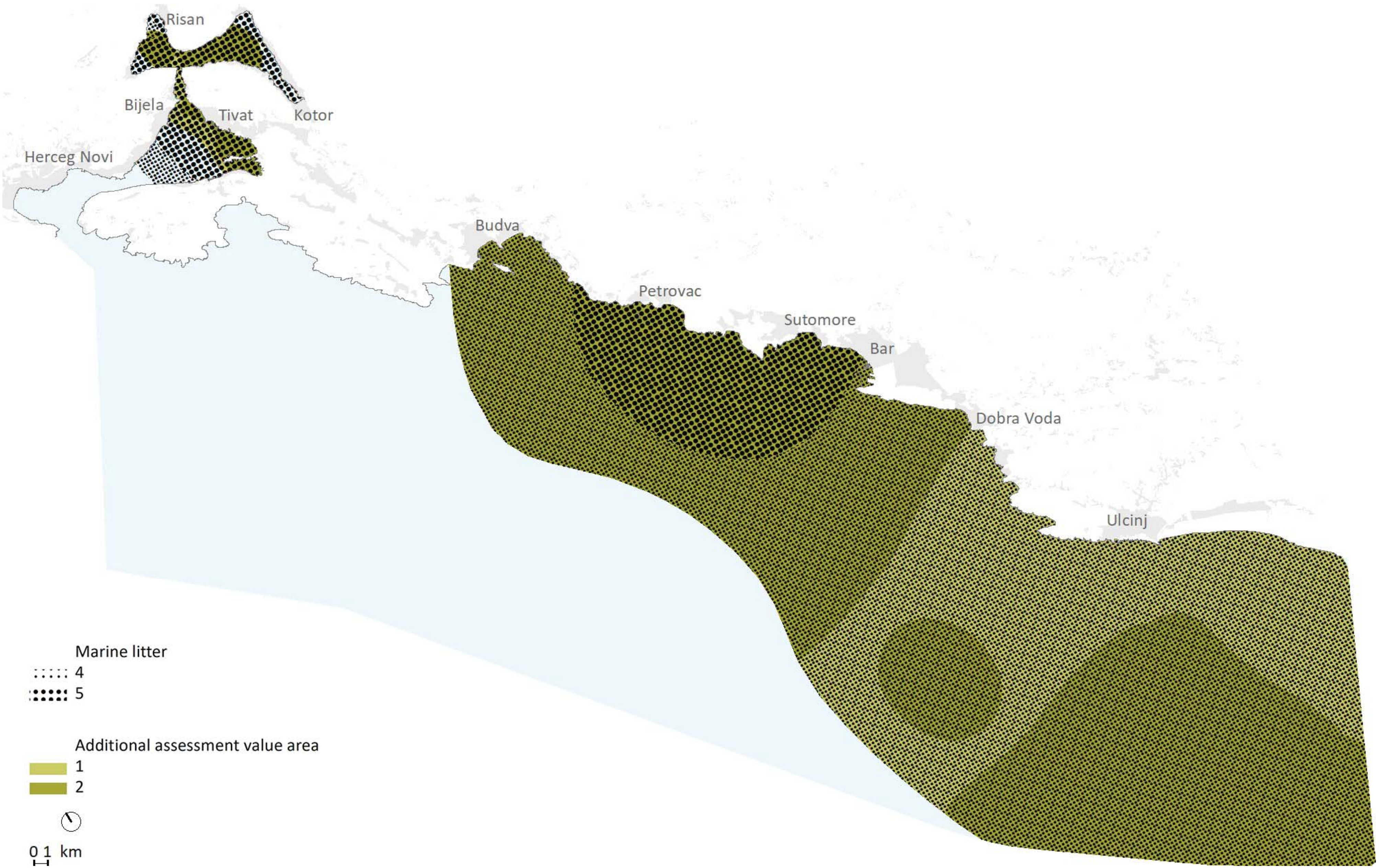
Endangerment models were prepared according to the principle of overlaying relevant data (*layers*) with the total values for pelagic resources and pressures in the GIS.

The spatial representation of pelagic resource endangerment is displayed on maps 5.15 and 5.16.

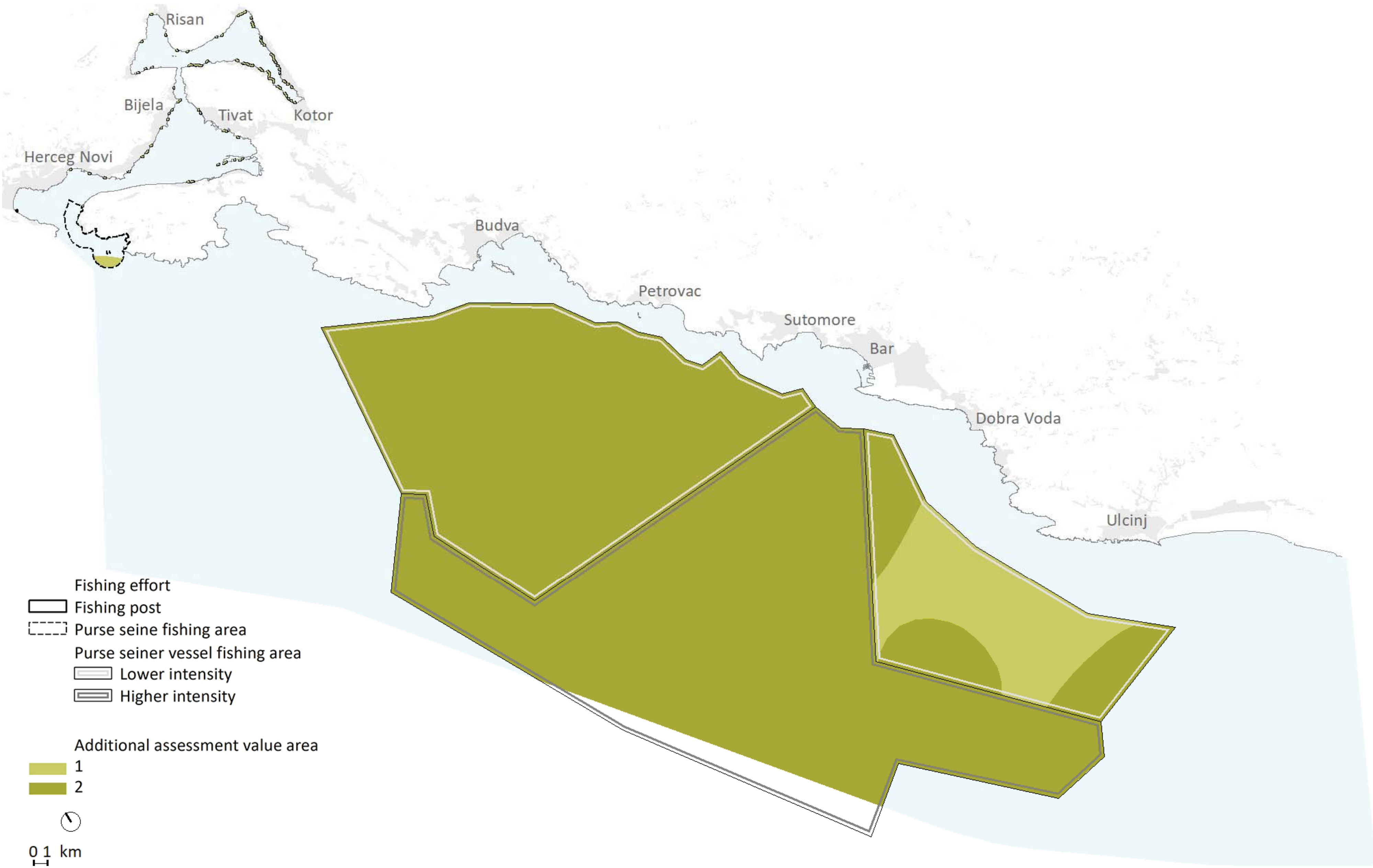
Map 5.11: Eutrophication impact

Map 5.12: Contamination impact

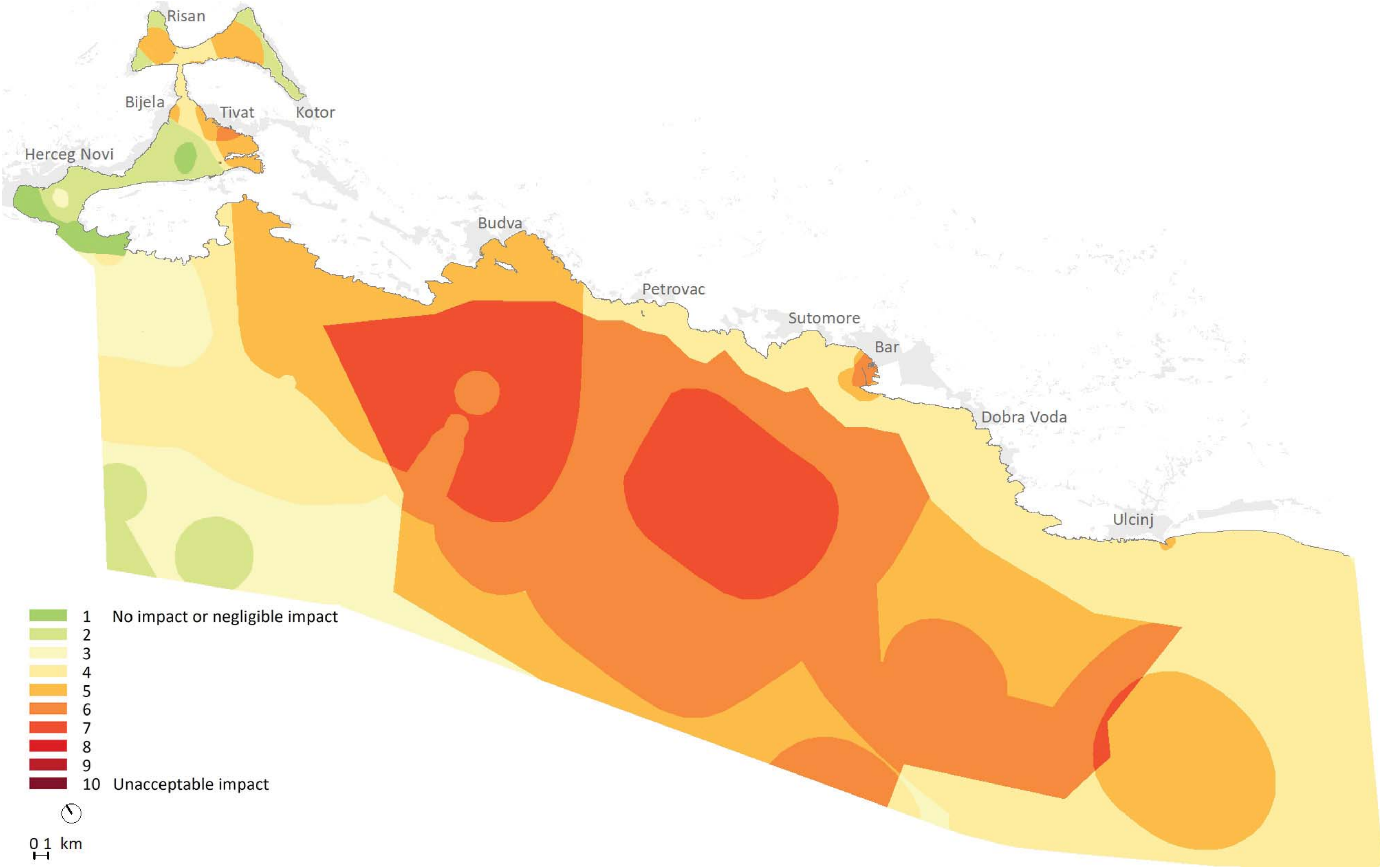
Map 5.13: Marine litter impact



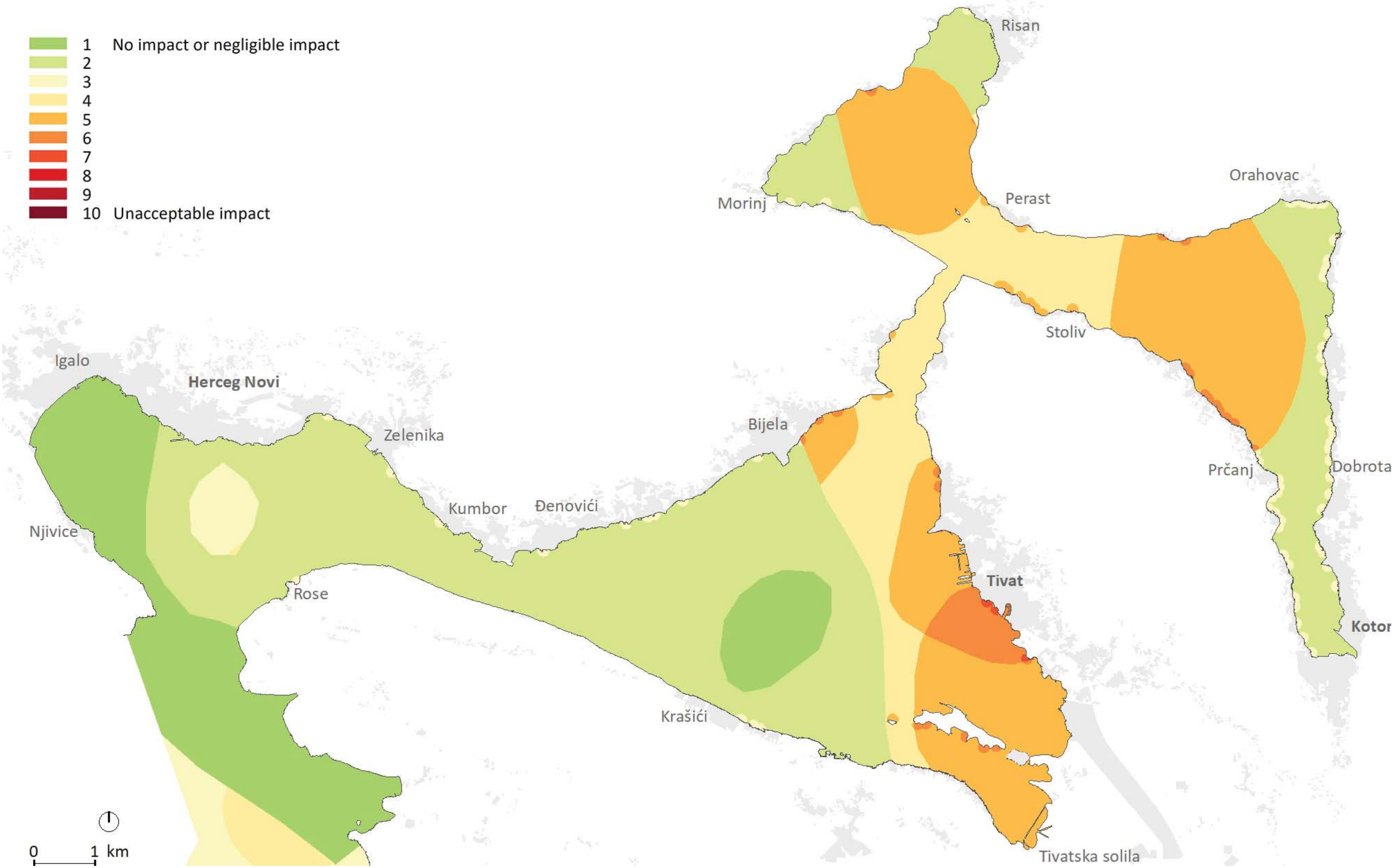
Map 5.14: Fishing effort impact



Map 5.15: Total pelagic resource endangerment assessment



Map 5.16: Total pelagic resource endangerment assessment for the Bay of Kotor



5.8. Demersal species status

The demersal species status assessment was carried out for three key species: hake (*Merluccius merluccius*), red mullet (*Mullus barbatus*) and shrimp (*Parapenaeus longirostris*). Data from the Montenegro coastline for the biomass spatial distribution analysis for the three species above were collected for the period 2014-2016, using MEDITS data. Although resource status is monitored via national fisheries resources monitoring as well, MEDITS data were used due to its long-standing collection uniformity and unique methodological approach on the level of the Adriatic Sea and the Mediterranean Sea in general. Data is solely available for the open sea area due to the fact that trawling is prohibited on the Bay of Kotor area, which is consequently not covered by MEDITS.

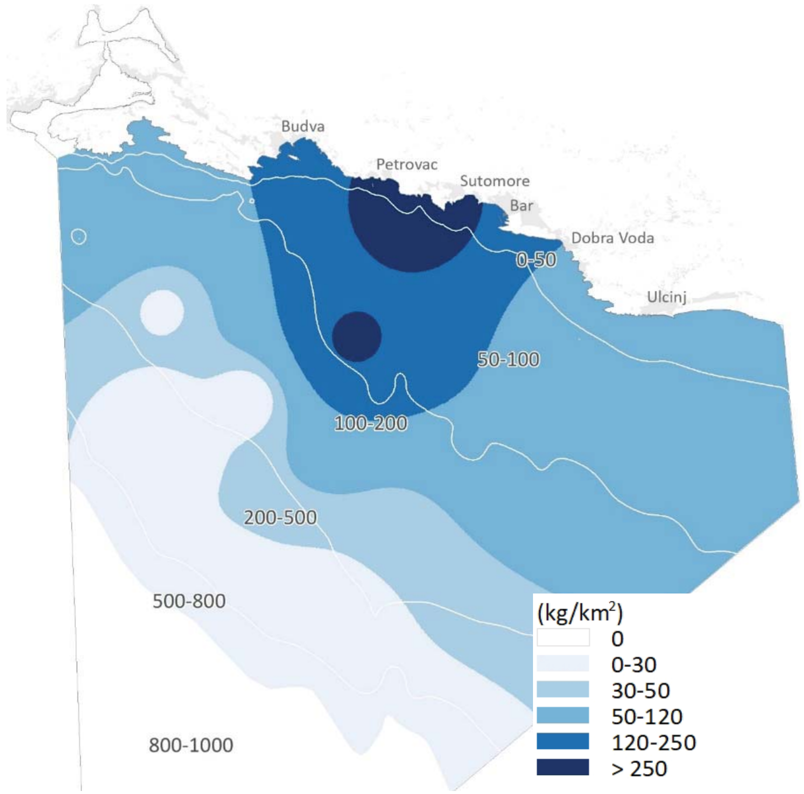
According to the MEDITS protocol, sampling is carried out every year on 10 positions. Data collected for the biomass of each species per position was processed as well, and the medium biomass value for all three years was taken into account in the general assessment. Considering the fluctuations in biomass in the course of a given year, which may have multiple causes including excessive overfishing, various temperature oscillations during the years, spawning time and other factors, the medium biomass value for all three years provides the most realistic representation of the status for a particular period.

5.8.1. Red mullet – *Mullus barbatus*

The red mullet (*Mullus barbatus*) population is one of the most valuable demersal resources on the Montenegro coastline. A high red mullet biomass density is present in the area between Platamuni and Volujica at a depth of 40-110 metres (Map 5.17). The largest biomass starts from 353.5 kg/km^2 at depths of 40-50 metres, dropping slightly to 276.79 kg/km^2 on that area at depths of 70-80 metres, all the way to 100.33 kg/km^2 at a depth of approximately 100-120 metres. Elsewhere on the Montenegro coastline, its biomass ranges from 12-24 kg/km^2 at depths of 150-270 metres, and is very small at greater depths, but is present throughout the surveyed area. The medium biomass for the entire surveyed area at a surface of 5,000 km^2 was 87.01 kg/km^2. Compared to the GSA 18 where Montenegro belongs, **the resulting value is twice that of the medium biomass for GSA 18 – the southern Adriatic Sea (13.89 kg/km^2), significantly larger than the biomass assessed for the northern and central Adriatic Sea (GSA 17) which amounts to 32.42 kg/km^2 (Tserpes *et al.*, 2019).**

Spawning stock biomass (SSB) was assessed via the SS3 method (*Stock Synthesis 3*) for 2015, and amounts to 4,203 t (33rd percentile: 1,238 t, 66th percentile: 1,958 t), and to 6.757 t (33rd percentile: 1,746 t, 66th percentile: 2,590 t) for 2016. The total spawning stock biomass for 2014 was calculated due to the usage of a different stock assessment method. The red mullet SSB calculated for the entire Adriatic Sea (GSA 17 and 18) was 18,394 t (33rd percentile: 3,977 t, 66th percentile: 5,382 t).

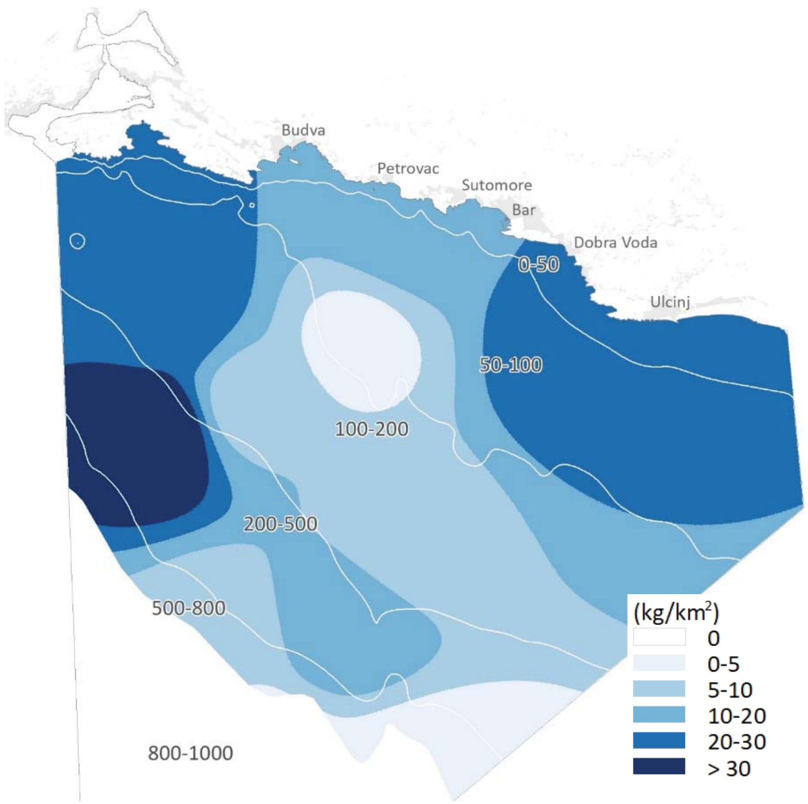
Map 5.17: Demersal fish species biomass distribution – red mullet



5.8.2. Hake (*Merluccius merluccius*)

As in the case of the red mullet, the hake biomass analysis was performed on the MEDITS programme dataset, i.e. the medium values for the survey period of 2014-2016. Two high hake biomass hotspots were identified on the Montenegro coastline area, on the stretch above the entrance to the Bay of Kotor at depths of 160-300 metres with a biomass of 36.95-28.43 kg/km^2, and on the area from Bar to Ulcinj at depths of 50-100 metres with average biomass values of 16.87-25.25 kg/km^2 (Map 5.18).

Map 5.18: Demersal fish species biomass distribution – hake



Hake biomass concentration is the greatest in the part of the Montenegro coastline located on a small section of the unique south Adriatic Sea continental slope. This area, and north towards the Jabučka kotlina, records the largest hake biomass in the Adriatic Sea, which corresponds to earlier hake surveys within the MEDITS programme (Piccinetti *et al.* 2012), meaning that our findings fully match this data and provide a picture of the significance of the hake as a shared resource in the Adriatic Sea. A partial or complete absence of hake was noted in the remainder of the Montenegro coastline, particularly in areas with high red mullet biomass (between Budva and Bar).

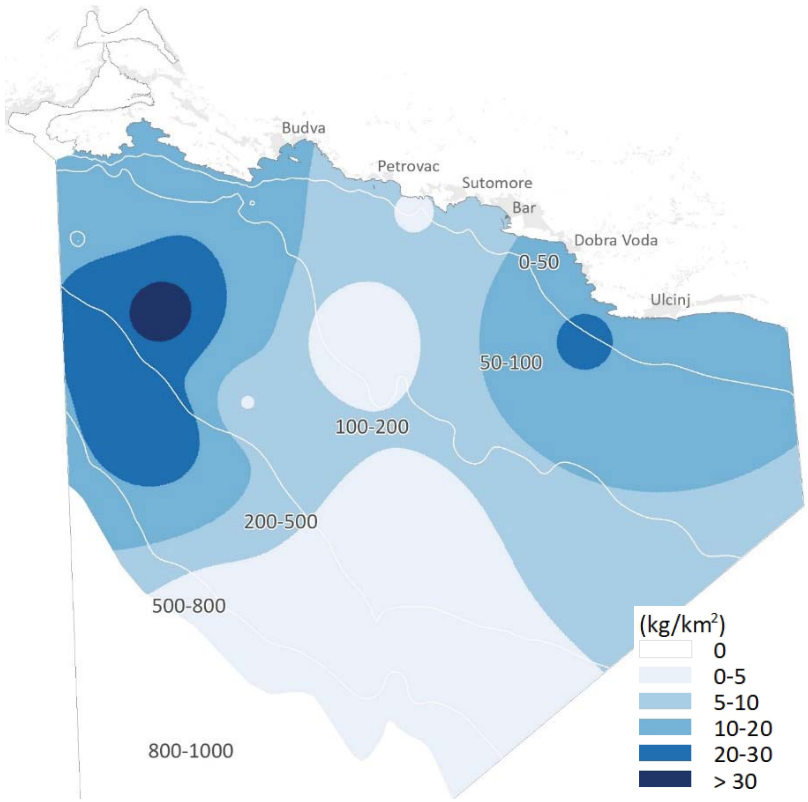
Spawning stock biomass (SSB) for the entire Adriatic Sea was assessed via the SS3 method (*Stock Synthesis 3*) for 2015, and amounts to 29,208 t (33rd percentile: 62,042 t, 66th percentile: 101,766 t), and to 59,335 t (33rd percentile: 100,271 t, 66th percentile: 159,352 t) for 2016. The total spawning stock biomass for 2014 was not calculated due to the usage of a different stock assessment method.

5.8.3. Shrimp – *Parapenaeus longirostris*

As in the case of the other two processed species, the shrimp biomass analysis was performed on the MEDITS programme dataset, i.e. the medium values for the survey period of 2014 -2016. Two high shrimp biomass hotspots were identified on the Montenegro coastline area, on the stretch above the entrance to the Bay of Kotor at depths of 100-250 metres with a biomass of 34.90-29.48 kg/km^2, and on the area between Bar and Ulcinj at depths of 50-100 metres with average biomass values of 21.17-16.50 kg/km^2 (Map 5.19).

Shrimp presence in the remainder of the Montenegro coastline is exceedingly small, and they are completely absent from the stretch between Bar and Budva and deeper. A comparison of all three maps reveals that shrimp and hake are present in approximately the same areas, while their presence is negligible or completely lacking in areas with a high red mullet biomass index.

Map 5.19: Demersal fish species biomass distribution – shrimp



Spawning stock biomass (SSB) for the entire Adriatic Sea was assessed via the SS3 method (*Stock Synthesis 3*) for 2015, and amounts to 426 t (33rd percentile: 440 t, 66th percentile: 641 t), and to 1,644 t (33rd percentile: 1,028 t, 66th percentile: 1,589 t) for 2016. The total spawning stock biomass for 2014 was not calculated due to the usage of a different stock assessment method.

5.9. Demersal resource distribution valuation

As in the case of pelagic species, the valuation was carried out with reference to the density of the adult part of the population (kg/km^2) on the open sea. Spatial zones ranging from an estimated low biomass intensity to an estimated very high biomass intensity were determined by interpolating data in the GIS. Valuation was performed for each species individually (taking into account the average values in 2015/2016), and by merging all values for all species.

Valuation for the hake was performed using the scale displayed in Table 5.6, and results are displayed on Map 5.20. Valuation for the red mullet was performed using the scale in Table 5.9, and results are displayed on Map 5.21. Valuation for the shrimp was performed using the scale displayed in Table 5.10, and results are displayed on Map 5.22.

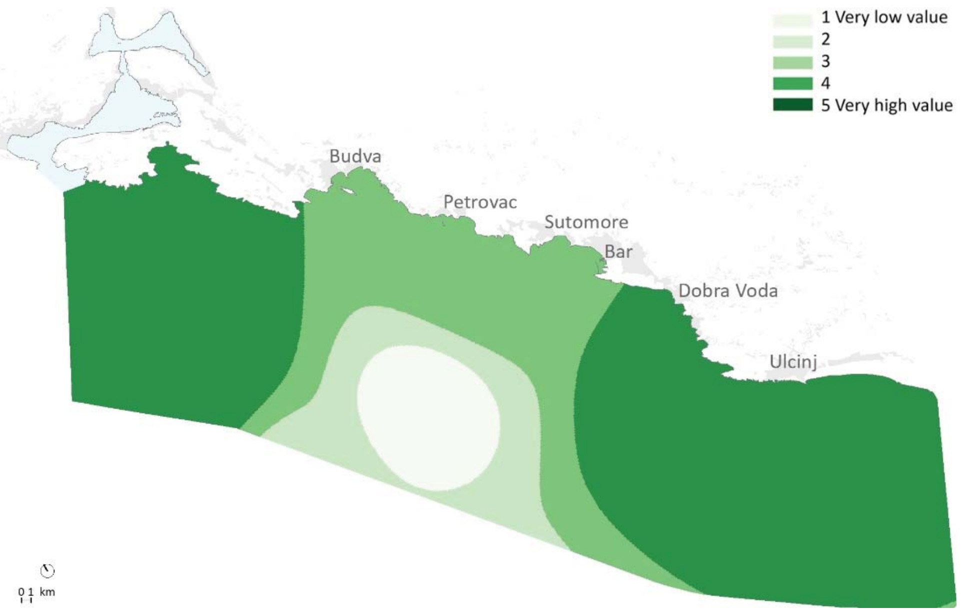
Table 5.8: Valuation criteria – hake (*Merlucius merlucius*)

Value assessment		Criterion
1	Very low value	Very low biomass intensity zone: 0-5 kg/km^2
2	Low value	Low biomass intensity zone: 5-10 kg/km^2
3	Moderate value	Moderate biomass intensity zone: 10-20 kg/km^2
4	High value	High biomass intensity zone : 20-30 kg/km^2
5	Very high value	Very high biomass intensity zone: > 30 kg/km^2

Table 5.9: Valuation criteria – red mullet (*Mullus barbatus*)

Value assessment		Criterion
1	Very low value	Very low biomass intensity zone: 0-5 kg/km^2
2	Low value	Low biomass intensity zone: 5-20 kg/km^2
3	Moderate value	Moderate biomass intensity zone: 20-50 kg/km^2
4	High value	High biomass intensity zone : 50-120 kg/km^2
5	Very high value	Very high biomass intensity zone: > 120 kg/km^2

Map 5.20: Distribution valuation – hake (*Merlucius merlucius*)



Map 5.21: Distribution valuation – red mullet (*Mullus barbatus*)

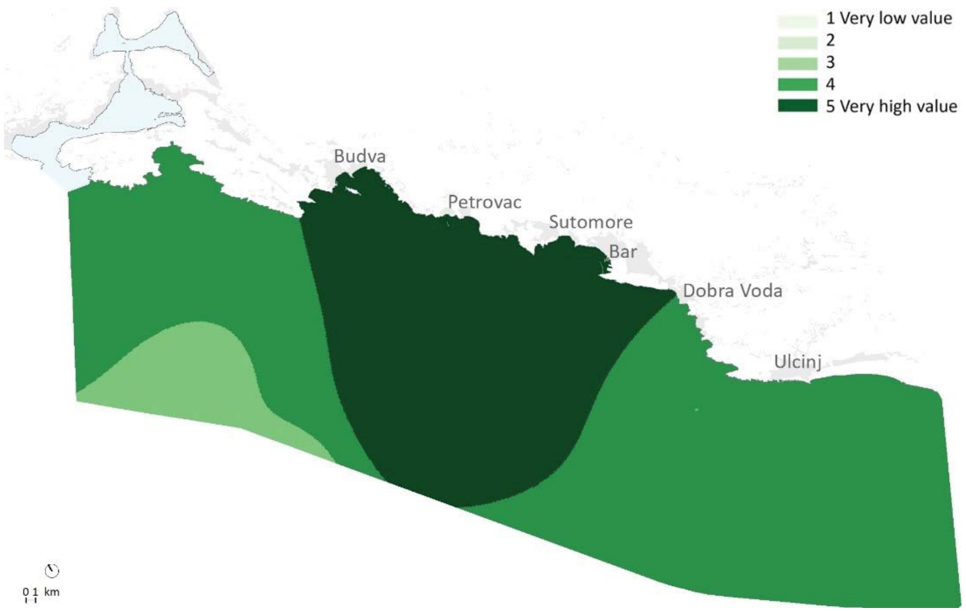
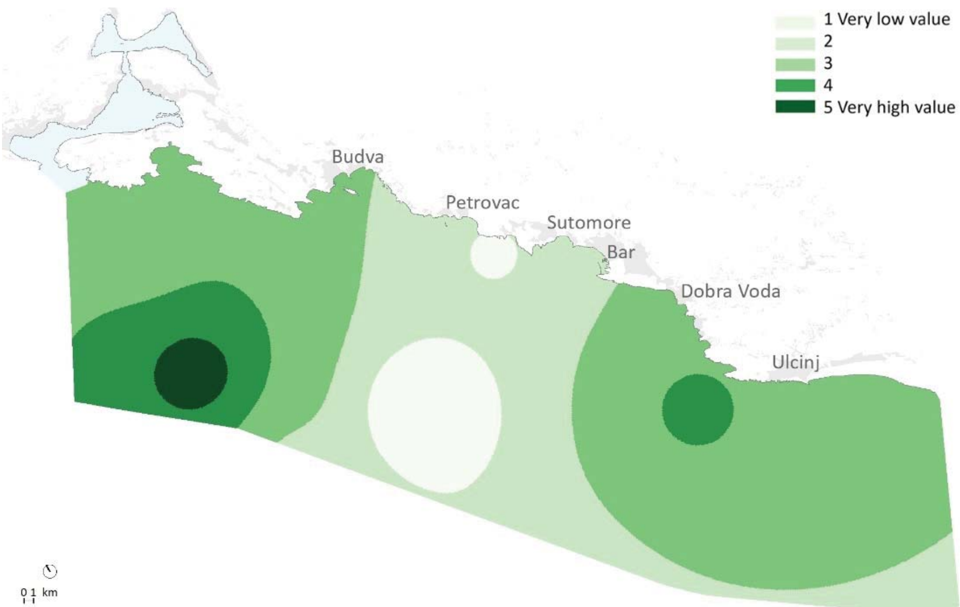


Table 5.10: Valuation criteria – shrimp (*Parapenaeus longilostris*)

	Value assessment	Criterion
	1 Very low value	Very low biomass intensity zone: 0-5 kg/km^2
	2 Low value	Low biomass intensity zone: 5-10 kg/km^2
	3 Moderate value	Moderate biomass intensity zone: 10-20 kg/km^2
	4 High value	High biomass intensity zone: 20-30 kg/km^2
	5 Very high value	Very high biomass intensity zone: > 30 kg/km^2

Map 5.22: Distribution valuation – shrimp (*Parapenaeus longilostris*)



The total valuation was performed by combining the valuable areas for all three analysed species. The combination was prepared according to the matrix displayed below by highlighting higher values for a given year within the combined value. This means that input values have equal weight in the generation of the total value. The spatial representation of the most valuable sardine zones is displayed on map 5.23.

Value for the shrimp (columns); **Value for the hake/red mullet** (rows)

	1	2	3	4	5
1	1	2	3	4	4
2	2	2	3	4	5
3	3	3	3	4	5
4	4	4	4	4	5
5	4	5	5	5	5

The area with higher recorded hake biomass intensity is located in the northern and southern zones of the open sea. A very high shrimp biomass value was recorded in the open zone towards the territorial sea limit in front of Platamuni. The most significant zones are those with very high red mullet biomass values from Cape Jaz to Dobra Voda. This area has been determined as the most valuable demersal resource biomass area.

Map 5.23: Total demersal species value assessment

5.10. Fishing impact on demersal species

5.10.1. Red mullet

The nominal fishing effort calculated for red mullet is equal to the one for hake and shrimp, and was obtained by multiplying 429.54 BT with 910 fishing days in the Montenegro fishing fleet, amounting to 390,881.40.

The total red mullet landing in Montenegro was 39.6 t in 2014, 37.0 t in 2015 and 38.3 t in 2016. Landing is calculated on the basis of fishing logbooks, i.e. catch reports created by fishermen and submitted to the Ministry of Agriculture and Rural Development.

The fishing mortality benchmark of $F_{0.1}$, was assessed via the XSA method for 2014, with a value of 0.42, and the SS3 method for 2015 (0.43) and 2016 (0.48).

The current fishing mortality rate of F_{curr} for 2014, assessed via the XSA method, is 0.48, while in 2015 and 2016 it was assessed via the SS3 method and amounts to 0.30 and 0.24, respectively.

Based on the ratios between $F_{curr}/F_{0.1}$, red mullet can be considered to have displayed a low rate of overfishing in 2014 ($F_{curr}/F_{0.1}$ = 1.14), and sustainable fishing in 2015 and 2016 (0.71 and 0.50, respectively). As the SSB value was above the 66th percentile in the entire 2015-2016 period, it can be stated that red mullet displayed relatively high biomass values.

Montenegro participates in red mullet fishing in the GSA 18 area with 3-5% of the total catch. The largest catch was done by the Italian fleet (85-87%). According to data for 2016, on the level of the entire Adriatic (GSA 17 and 18), the share of Montenegro in the total red mullet catch is a mere 1%.

5.10.2. Hake

The nominal fishing effort calculated for the hake is equal to that for the red mullet and shrimp, and was obtained by multiplying 429.54 BT with 910 fishing days in the Montenegro fishing fleet, amounting to 390,881.40.

Hake landing amounted to 43.8 t in 2014, 38.4 t in 2015, and 39 t in 2016. Landing is calculated on the basis of fishing logbooks, i.e. catch reports created by fishermen and submitted to the Ministry of Agriculture and Rural Development.

The fishing mortality benchmark of $F_{0.1}$ was assessed via the XSA method for 2014, with a value of 0.18 for GSA 18, and the SS3 method for the entire Adriatic Sea (GSA 17+18) for 2015 (0.21) and 2016 (0.21).

The current fishing mortality rate of F_{curr} for 2014, assessed via the XSA method for the GSA 18, is 0.85, while in 2015 and 2016 it was assessed via the SS3 method on the level of the entire Adriatic Sea and amounts to 0.48 and 0.33, respectively.

Based on the ratios between $F_{curr}/F_{0.1}$, hake can be considered to have displayed a high degree of overfishing in 2014 ($F_{curr}/F_{0.1}$ = 4.72) in the GSA 18, as well as in 2015 throughout the Adriatic Sea ($F_{curr}/F_{0.1}$ = 2.29), while in 2016 it displayed moderate overfishing ($F_{curr}/F_{0.1}$ = 1.57). As the SSB value was below the value of the 33rd percentile in the entire 2015-2016 period, it can be stated that the hake displayed a relatively low biomass value.

In 2014, Montenegro occupied **2% of the total hake catch on the level of the southern Adriatic Sea**, followed by 1.6% in 2015 and 1.1% in 2016 on the level of the entire Adriatic Sea. The highest catch in the GSA 18 was done by the Italian fleet (88% in 2014), with 72-74% on the level of the entire Adriatic Sea.

5.10.3. Shrimp

The nominal fishing effort calculated for the shrimp is equal to the one for the hake and red mullet, and was obtained by multiplying 429.54 BT with 910 fishing days in the Montenegro fishing fleet, amounting to 390,881.40.

Shrimp landing amounted to 28.2 t in 2014, 31 t in 2015, and 32 t in 2016. Landing is calculated on the basis of fishing logbooks, i.e. catch reports created by fishermen and submitted to the Ministry of Agriculture and Rural Development.

The fishing mortality benchmark of $F_{0.1}$, was assessed via the XSA method for 2014, with a value of 0.76 for GSA 0.18, and the SS3 method for the entire Adriatic Sea (GSA 17+18) for 2015 (0.90) and 2016 (0.90).

The current fishing mortality rate of F_{curr} for 2014, assessed via the XSA method for the GSA 18, is 1.64, while in 2015 and 2016 it was assessed via the SS3 method on the level of the entire Adriatic Sea and amounts to 2.26 and 0.43, respectively.

Based on the ratios between $F_{curr}/F_{0.1}$, shrimp can be considered to have displayed a high degree of overfishing in 2014 ($F_{curr}/F_{0.1}$ = 2.16) in the GSA 18, as well as in 2015 on the level of the entire Adriatic Sea ($F_{curr}/F_{0.1}$ = 2.26), while in 2016 it displayed sustainable fishing ($F_{curr}/F_{0.1}$ = 0.43). As the SSB value in 2015 was below the value of the 33rd percentile, it can be stated that shrimp displayed a relatively low biomass value that year. The 2016 assessment showed a relatively high biomass value, above the 66th percentile.

In 2014, Montenegro occupied 3% of the total shrimp catch on the level of the southern Adriatic Sea, followed by 2% in 2015 and in 2016 on the level of the entire Adriatic Sea. In the GSA 18, the largest catch was done by the Italian and Croatian fleets (approximately 30%).

5.10.4. By-catch

An analysis of by-catch or discard in the Montenegro fleet trawler catch was performed for the period 2018-2019. The analysis covered catch made by a total of 56 trawlers. Each trawler provided data from two net fishing sessions, with the medium by-catch volume value for their total catch amounting to 15.9365 kg, and a medium by-catch percentage value for the total catch amounting to 18.44%. The total number of all registered species of fish, crab, shellfish and other benthic organisms is 77.

Species most commonly found in the by-catch include: *Dentex macrophtalmus, Scyliorhinus canicula, Mullus barbatus, Parapenaeus longirostris, Spicara flexuosa, Pagellus erythrinus, Citharus linguatula, Trachurus trachurus, Merluccius merluccius and Boops boops.* The most commonly represented, non-commercially interesting species include *Scyliorhinus canicula* and *Spicara flexuosa*.

Commercial species are present in the by-catch, and part of them is returned into the sea if the individuals are too small or damaged (*M. barbatus, M. merluccius, B. boops, P. erythrinus, T. trachurus*), or if the catch volume of a given species is too large (*P. longirostris*).

Table 5.11 provides a list of all species registered in the by-catch.

Table 5.11: List of by-catch species in trawler catch on the Montenegro coastline

Species		
Alosa fallax	*Loligo vulgaris*	*Scorpaena scrofa*
Argentina sphyraena	*Lophius budegassa*	*Scyliorhinus canicula*
Aspitrigla cuculus	*Lophius piscatorius*	*Sepia elegans*
Blennius ocellaris	*Macroramphosus scolopax*	*Sepia officinalis*
Boops boops	*Marthasterias glacialis*	*Sepia orbignyana*
Calappa granulata	*Merlangius merlangus*	*Sepiola sp.*
Callanthias ruber	*Merluccius merluccius*	*Serranus cabrilla*
Capros aper	*Microchirus ocellatus*	*Serranus hepatus*
Cepola macrophthalma	*Mullus barbatus*	*Solea solea*
Chelidonichthys lucerna	*Mullus surmuletus*	*Spicara flexuosa*
Citharus linguatula	*Octopus vulgaris*	*Spicara smaris*
Conger conger	*Pagellus acarne*	*Spondyliosoma cantharus*
Corallium rubrum	*Pagellus bogaraveo*	*Squilla mantis*
Dentex macrophthalmus	*Pagellus erythrinus*	*Synodus saurus*
Diplodus annularis	*Pagurus prideaux*	*Tonna galea*
Eledone moschata	*Parapenaeus longirostris*	*Torpedo marmorata*
Engraulis encrasicolus	*Pecten Jacobaeus*	*Torpedo torpedo*
Eutrigla gurnardus	*Phycis blennoides*	*Trachinus radiatus*
Gobius niger	*Phycis phycis*	*Trachurus mediterraneus*
Holothuria poli	*Raja asterias*	*Trachurus trachurus*
Holothuria tubulosa	*Raja miraletus*	*Trigla lyra*
Ilex coindetii	*Rhizostoma pulmo*	*Trigloporus lastoviza*
Lepidorhombus whiffiagonis	*Rossia macrosoma*	*Trisopterus minutus*
Lepidotrigla cavillone	*Sardina pilchardus*	*Uranoscopus scaber*
Liocarcinus depurator	*Scorpaena notata*	*Venus verrucosa*
	Scorpaena porcus	*Zeus faber*

5.10.5. Demersal resource endangerment

The demersal species endangerment was assessed according to the same principle as that of pelagic resources (Chapter 5.7), by "overlaying" results processed within the scope of the ecological objectives of eutrophication (EO5), contamination (EO9), marine litter (EO10) and fisheries impact (EO3).

The fisheries pressure assessment was performed relative to the spatial distribution of trawlers during open sea fishing, using data available from the VMS system (Vessel Monitoring System) of the Directorate for Fisheries, Ministry of Agriculture, Forestry and Water Economy (Map 5.25).

Endangerment valuation was performed by giving additional ratings to the value assessment (from 0-2) for each pressure factor, taking into account the expected impact of that pressure on demersal resources. Endangerment ratings concerning each of the pressure groups above are displayed in Table 5.7, while their spatial distribution is displayed on maps from 5.11 to 5.14.

Table 5.12: Endangerment assessments for demersal species

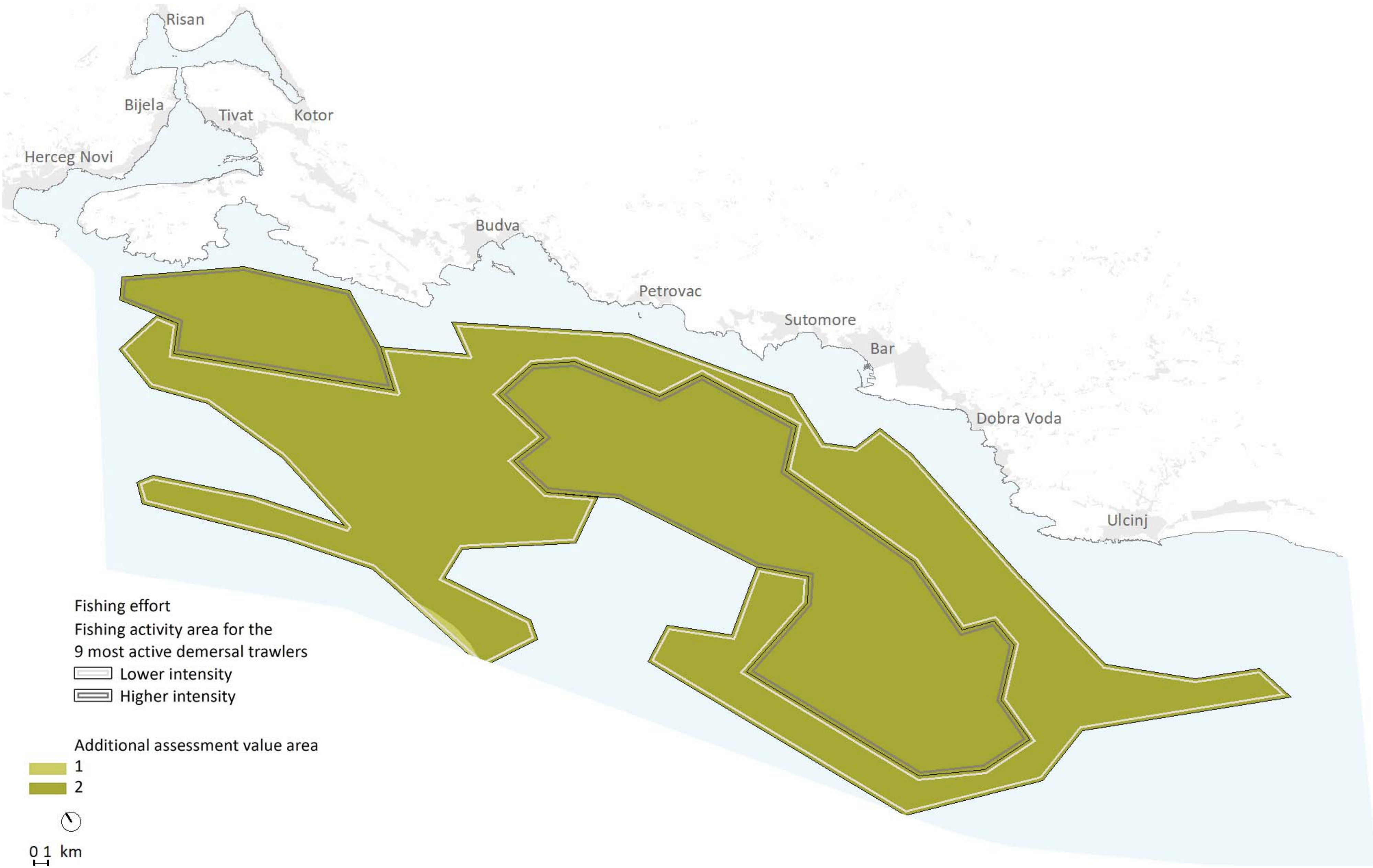
	Eutrophication impact	Contamination impact	Marine litter	Fishing effort	
Additional assessment value	0 or 1	0 or 1	0 or 1 or 2	0 or 1 or 2	
Class/impact assessment	5	4/5/6	4/5	Fishing activity area for the 9 most active demersal trawlers	
Value				Lower intensity	Greater intensity
1	0	0	0	0	0
2	0	0	0	1	1
3	1	1	1	1	2
4	1	1	2	2	2
5	1	1	2	2	2

The resulting assessment was classified into one of ten endangerment assessment value classes:

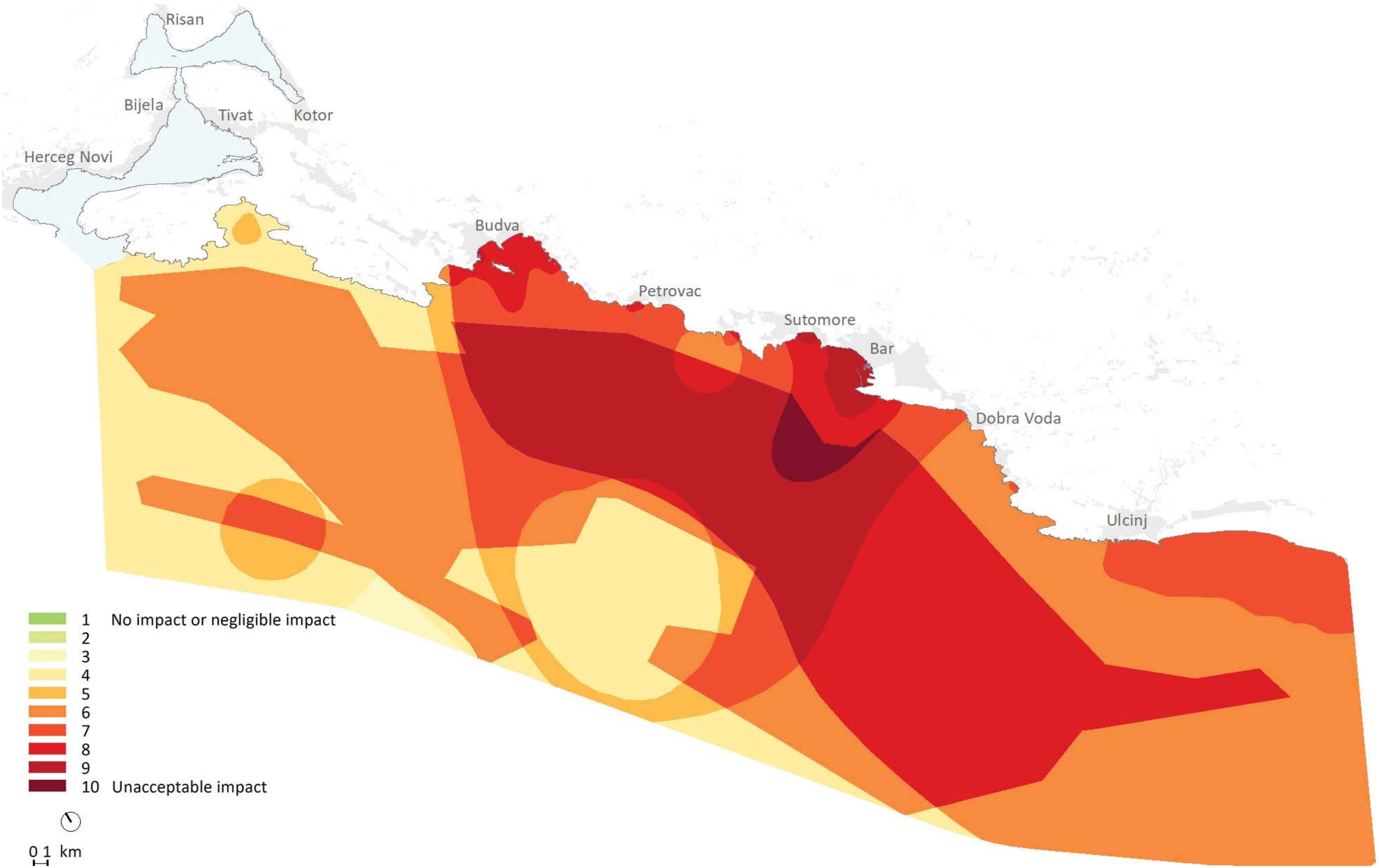
Impact assessment	
1	No impact or insignificant impact
2	
3	Moderate impact
4	
5	High impact
6	
7	Very high impact
8	
9	Unacceptable impact
10	

Endangerment models were prepared by overlaying relevant data (*layers*) with total values for demersal resources and pressures in the GIS. The spatial representation of pelagic resource endangerment is shown on maps 5.15 and 5.16.

Map 5.24: Fishing effort impact



Map 5.25: Total demersal resource endangerment assessment



5.11. Conclusion

The Adriatic Sea is an area of intense pressure on fishing resources, particularly pelagic ones. Data available provides the basis for the conclusion that anchovy and sardine are undergoing overfishing on the level of the entire Adriatic Sea. Nevertheless, the share of Montenegro in total fishing activities is lower than 1%. Therefore small bluefish fishing restriction measures do not apply to Montenegro.

However, national measures ensuring sustainable resource exploitation are in force in Montenegro, and include stock protection during breeding with a total harvesting prohibition, as well as fishing prohibition for large purse seiners within the Bay of Kotor and within 3 Nm or an isobath of 50 m on the open sea.

Red mullet is the most significant demersal species in Montenegro. The red mullet biomass value is significantly higher than that estimated for the central or southern Adriatic Sea. Although the catch intensity on the level of Montenegro does not exert significant pressures on the entire biomass, national measures ensuring sustainable resource exploitation are important, including a total prohibition of trawling in the Bay of Kotor.

6. Coastal Ecosystems and Landscapes

6.1. Introduction

The diversity of the coastal area represents natural wealth and a significant resource that contributes to tourist recognizability and attractiveness. Human influence on the landscape has created cultural patterns that form an element of cultural identity and heritage. Landscapes are exposed to anthropogenic transformations that often lead to negative changes. The processes that mostly affect the landscape are urbanization and infrastructure development, leading to landscape fragmentation. Inadequate positioning of tourist and recreational facilities in the most valuable parts of coastal areas leads to the disappearance of natural habitats and the homogenization of landscapes.

The sea forms a special part of the landscape. The coastal area (land) and the sea next to it is considered as an indivisible spatial (perceptual, functional, ecological) whole.

The goal of having a good environmental status is: "*To maintain natural dynamics of the coastal area and preserve coastal ecosystems and landscapes*." The ecological objective has no predecessor in any MSFD descriptor.

6.2. Indicators and state description

The following indicators are used:

Table 6.1: Indicator for landscape state assessment

Indicator (CI)	Indicator type	MSFD indicator
Length of coastline subject to physical disturbance due to the influence of man-made structures (CI16)	State Pressure	-
Landscape quality	State	-

The Integrated Monitoring and Assessment Programme (UNEP (DEPI)/MED WG.420/4) also includes the candidate indicator of **land use changes**. Timed data on the purpose of space (actual and planned) are the basis for any spatial planning. Unfortunately, there is no usable official data for the application of this indicator. The first serious construction mapping was prepared under the 2012 CAMP project, but data from the Corine Land Cover for this level of analysis are not adequate, due to the bad resolution.

The purpose of the indicator “Length of coastline subject to physical disturbance due to the influence of man-made structures (CI16)” is:

- Quantification of the extent and spatial distribution of the artificially modified coast (coastal artificialization);
- Improved understanding of the impact of manmade structures on coastal dynamics.

This indicator is focused on impacts, but it is also linked to the implementation of specific measures to reduce negative impacts and inform about achieving good environmental status.

Manmade structures are considered to be:

- coastal protection structures (structures with the basic function of protecting parts of the coast);
- ports and marinas;
- landfills or coastal wetlands used for recreation, agriculture, industrial construction, expansion of ports or airports (land claim);
- impervious surface of urban areas – buildings, asphalted, paved and similar surfaces).

The integrated monitoring and assessment programme is focused on quantitative indicators. These indicators do not allow assessment of the impact on the visual and functional quality of an area. For sea and the coastal area planning, it is also important to preserve/develop the value of the landscape, its recognizability, therefore an additional qualitative, general indicator of the **quality of the landscape** has been assessed (see chapter 6.3. Evaluation).

Basis for assessing coastal physical changes

The assessment of coastal physical changes due to the influence of manmade structures was prepared based on:

- **the calculation of the length and extent of the built land along the coast** according to the data prepared as part of the CAMP project in 2012: For the purpose of this analysis, the coastline was generalized with the aim of avoiding unrealistic data on the length of the coast due to its anthropogenic parts (piers, marinas, ports) and indentation of the rocky coastline (Figure 6.1). The extent of the built land is calculated in the zone 100 m from the shore. It should be noted that within the constructed area, green areas can be included, and the coastal zone can be significantly artificially altered outside the construction.
- **records of physical changes of the coastline itself** (UNEP/MAP-PAP/RAC, 2020): Parts of the coast, which have been artificially altered, have been recorded, i.e. if there are manmade structures in the zone 10 m from the coastline – breakwaters, coastal walls, concrete terraces, buildings, waterfronts, promenades, coastal roads, ports and marinas. The artificial alteration of the coast has therefore been recorded in detail. For the purpose of this analysis, a special coastline has been defined, which in places deviates from the official coastline that is otherwise used in this study.

An overview of the extent of individual coastal types and coastline is given in Table 6.2, and the spatial distribution on maps 6.1 and 6.2. The calculation was prepared for the area of the Bay of Kotor (up to Mamula) and the open sea, and within that area for two more relevant locations – from Cape Trašte to Cape Platamuni and the urbanized area from Dobra voda to Utjeha.

Figure 6.1: Method of calculating the length of land built along the coast: the overlap of the constructed parts of the construction area (red polygons in the orthophoto) and the generalized shoreline gives the length of the constructed shore (red line)

Map 6.1: Physical coastal changes due to the influence of manmade structures

Map 6.2: Physical coastal changes due to the influence of manmade structures in the Bay of Kotor

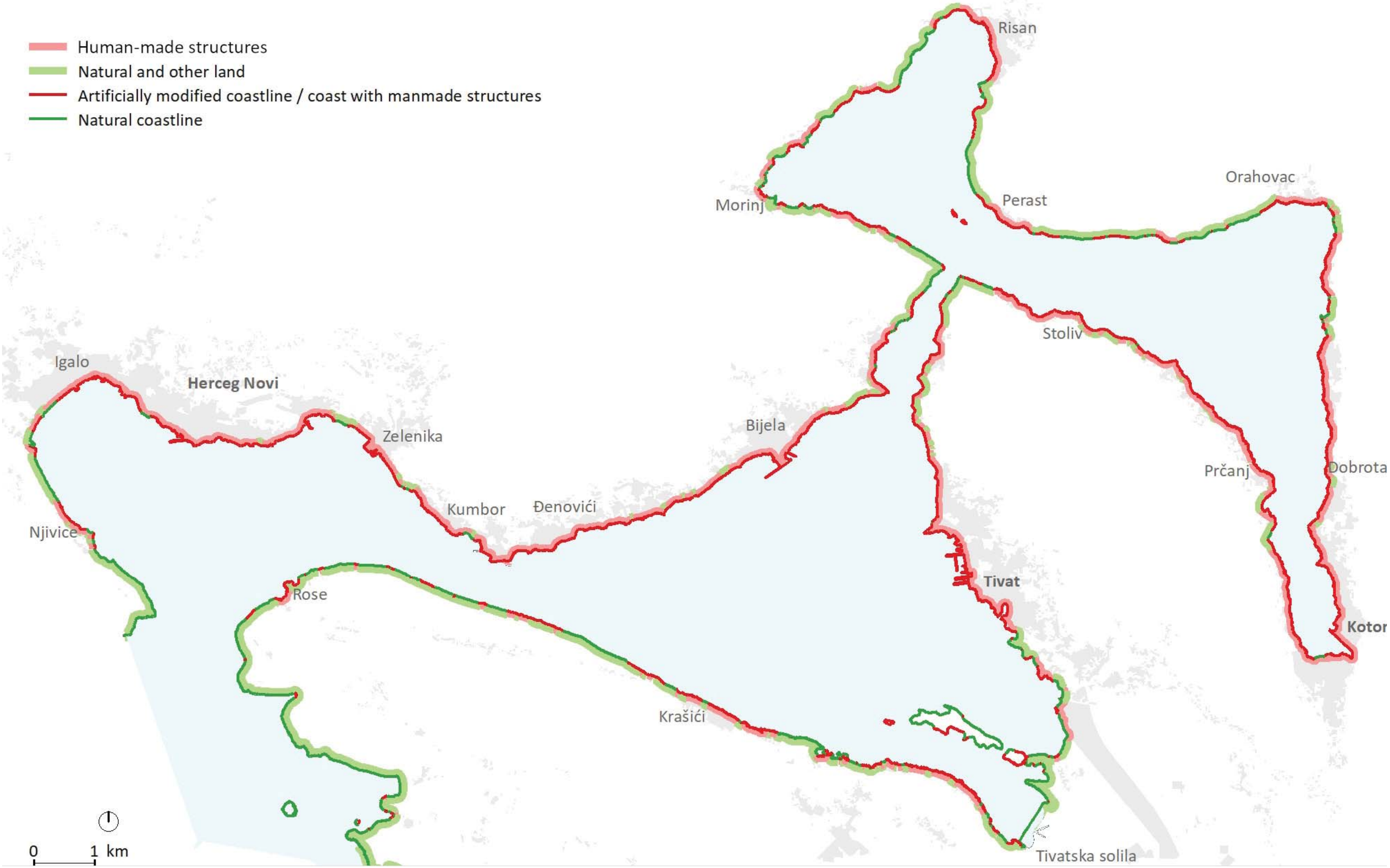


Table 6.2: Length and extent of coastal physical changes due to the influence of manmade structures

Coastal type	Generalized[10] coastline length (m)	Construction surface area[1] in the zone 100 m from the coast (ha)
Bay of Kotor (until Mamula)		
Manmade structures	55,369.77	467.99
Natural and other land[12]	45,862.57	567.09
Total	101,232.34	1,035.08
Share of manmade structures	54.70%	45.21%
Area from Mamula to Bojana		
Manmade structures	25,173.03	269.49
Natural and other land	125,867.09	1,283.80
Total	151,040.12	1,553.28
Share of manmade structures	16.67%	17.35%
Area from Cape Trašte to Cape Platamuni		
Manmade structures	28.24	0.65
Natural and other land	16,473.57	168.27
Total	16,501.81	168.92
Share of manmade structures	0.17%	0.39%
Area from Dobre vode to Utjeha		
Manmade structures	4,681.76	46.22
Natural and other land	5,136.60	55.36
Total	9,818.36	101.59
Share of manmade structures	47.68%	45.50%
Total		
Manmade structures	80,542.80	737.47
Natural and other land	171,729.66	1,850.88
Total	252,272.46	2,588.36
Share of manmade structures	31.93%	28.49%

Coastline type	Coastline length (m)
Bay of Kotor (until Mamula)	
Artificially modified coastline/coast with manmade structures[11]	86,016.15
Natural coastline	37,876.36
Total	123,892.51
Share of artificially modified coastline	69.43%
Area from Mamula to Bojana	
Artificially modified coastline/coast with manmade structures	24,407.55
Natural coastline	173,760.43
Total	198,167.98
Share of artificially modified coastline	12.32%
Area from Cape Trašte to Cape Platamuni	
Artificially modified coastline/coast with manmade structures	141.15
Natural coastline	18,844.11
Total	18,985.26
Share of artificially modified coastline	0.74%
Area from Dobre vode to Utjeha	
Artificially modified coastline/coast with manmade structures	3,881.55
Natural coastline	10,462.70
Total	14,344.25
Share of artificially modified coastline	27.06%
Total	
Artificially modified coastline/coast with manmade structures	110,423.70
Natural coastline	211,636.79
Total	322,060.49
Share of artificially modified coastline	34.29%

[10] Without islands.

[11] Breakwaters, coastal walls, concrete terraces, buildings, waterfronts, promenades, coastal roads, ports and marinas.

[12] Forest, *macchia* shrubland, rocky landscape, agricultural land, beaches.

Figure 6.2:
Rocky natural coast along the natural area on the slopes (forest, macchia, rocky terrain) (Luštica)

Figure 6.3:
Natural beaches along the coastal alluvial plains (Buljarica)

Figure 6.4:
Manmade structures on the coast

Figure 6.5:
Temporary structures

Figure 6.6:
Constructed coastal area along the natural hinterland (Ploče beach)

Figure 6.7:
Beaches and partly built coastline along the urban area (Kumbor)

Figure 6.8:
Natural rocky
coastal terrain along the urban
area
(Dobra voda)

Figure 6.9:
Seafront
(Tivat)

The natural preservation of the coast is valuable in itself, thus in principle, all manmade structures can be considered as a type of natural degradation. However, not all created structures create the same level of physical change of the coast, but have different influences on the perceptual, functional and ecological characteristics of the coast, which should be kept in mind when assessing the condition and planning of newly created structures.

Coastal area types

The Marine Vulnerability Assessment of the Bay of Kotor: Methodological guidelines (PAP/RAC, MSDT, 2017) contains rough mapping of the coastal area in the Bay of Kotor, which takes into account the character of the area and the criterion of coastal physical changes due to the influence of manmade structures. Such an analysis does not take into account only one spatial characteristic (for example, construction), but a broader, overall impression of the manmade structures or artificial alteration (artificialization) of space. In case of construction data, the area, which is considered to have been created/changed, is narrower, limited to buildings or urban areas. In case of information on the type of landscape, urban areas also cover groups of buildings that are located in the 100 m zone. The entire 100 m wide zone has not been constructed, but the density of buildings is so high that the area can no longer be considered natural and/or various manmade structures are located outside the recorded constructed area (roads, walls, parking lots, fortified coast, temporary and simple buildings). The 100 m zone from the shore can be divided into the types listed in Table 6.3 and Figures 6.10 – 6.17. Their spatial distribution is shown on map 6.3.

Figure 6.10:
Natural area (forest, macchia)
without or with individual
objects
(Luštica)

Figure 6.11:
Natural area (forest, macchia,
rocky terrain) with a built
coastal road and individual
facilities
(Risan Bay)

Figure 6.12:
Cultural area - salt pans
(Tivat salt pans)

Figure 6.15:
Urban area with fully
constructed coastline
(ports, marinas, shipyard)

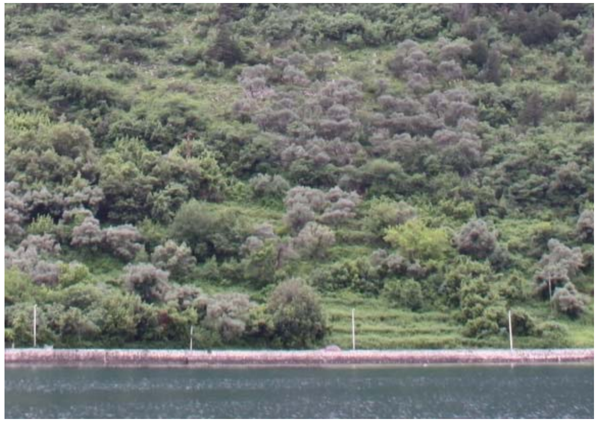


Figure 6.13:
Cultural area (agricultural land)
with a constructed coastal road

Figure 6.16:
Artificially widened parts of the
coast through sea embankment
(Tivat Airport)

Figure 6.14:
Urban area with partly
constructed/altered coastline
(Kumbor)

Figure 6.17:
Degraded area - quarry
(Lipci)

Map 6.3: Degraded area – quarry (Lipci)

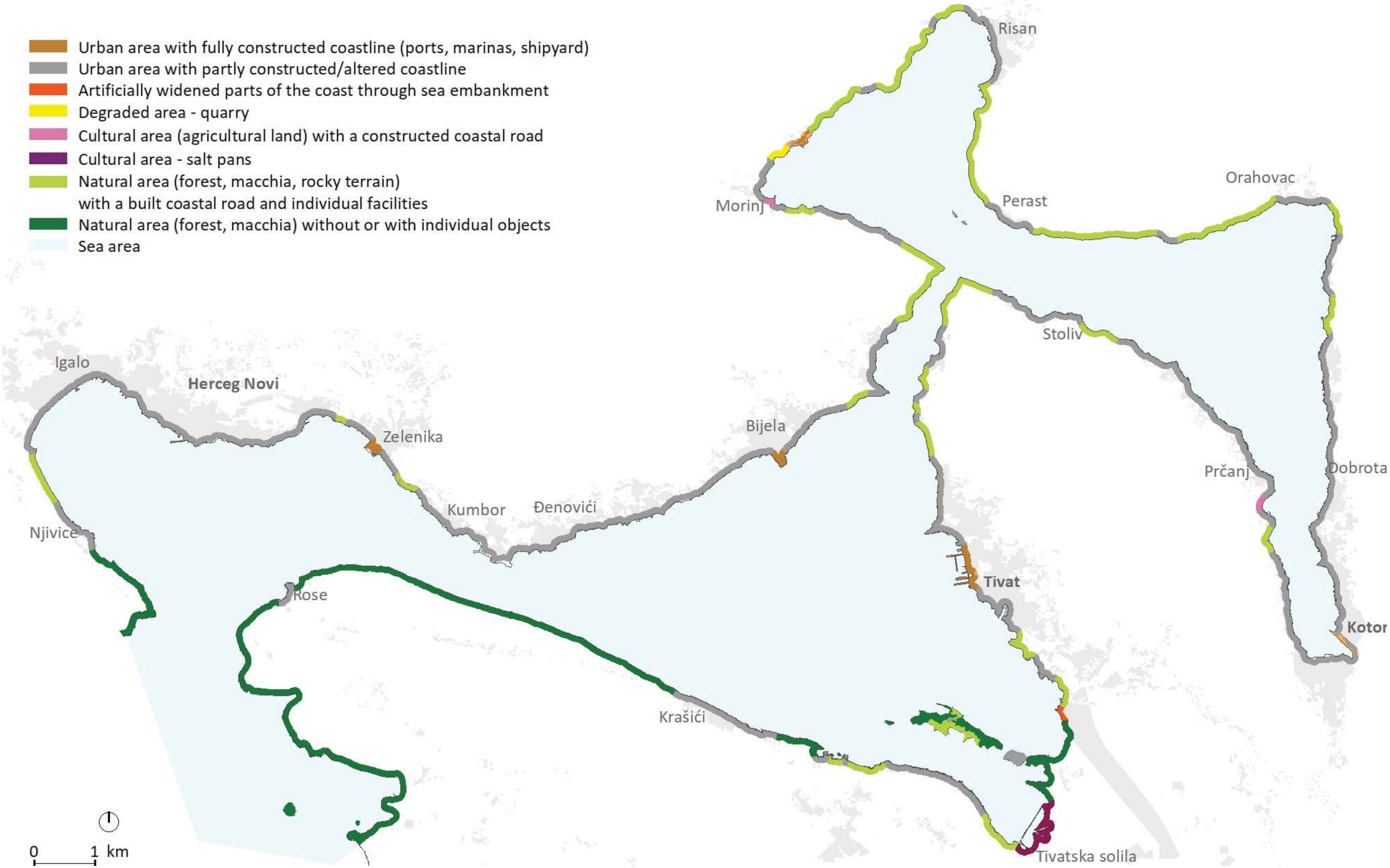


Table 6.3: Length and extent of physical change of the coast due to the influence of manmade structures in the Bay of Kotor (up to Mamula) by type of coastal area

Coastal type	The length of the coastline measured 50 m from the coast[13]	Area in the zone 100 m from the coast[14]
Natural area (forest, macchia) without or with individual objects	21,264 m	211.12 ha
Natural area (forest, macchia, rocky terrain) with a built coastal road and individual facilities	22,442 m	224.89 ha
Cultural area - salt pans	1,851 m	19.23 ha
Cultural area (agricultural land) with a constructed coastal road	480 m	5.02 ha
Urban area with partly constructed/altered coastline [6]	56,899 m	583.69 ha
Urban area with fully constructed coastline (ports, marinas, shipyard)[6]0	2,816 m	28.28 ha
Artificially widened parts of the coast through sea embankment(airport)[15]	267 m	2.78 ha
Degraded area - quarry[6]	402 m	4.05 ha
Total	106,421 m	1,079.06 ha
Total artificially altered coastline	60,384 m 56.67%	618.80 ha 57.34%

Assessment of coastal physical changes

Taking into account data on constructed land and the length of the coast (Table 6.2 left), out of the total of 252 km of Montenegrin coast[16], 80.5 km consists of manmade structures, i.e. 32 % of the coast. In the Bay of Kotor (up to Mamula), out of the 101 km of the total coastline about 55.5 km consists of manmade structures, i.e. 54,5%. Along the open sea, out of the 151 km of the total coastline about 25 km consists of manmade structures, i.e. 16,5 %. There are big differences along the coast. From Cape Trašte to Cape Platamuni, there are almost no manmade structures, and in the stretch from Dobra voda to Utjeha, 47.5% of the coast has been built.

Taking into account the data on constructed land and the developed area in the zone 100 m from the coast, of a total of 2,588 ha 737 ha has been built, i.e. 28,5 %. In the Bay of Kotor (up to Mamula), out of the 1.035 ha of the coastline about 468 ha consists of manmade structures, i.e. 45 %. Along the open sea, out of the 1.553 ha of the total coastline about 25 km consists of manmade structures, i.e. 17,5 %. From Cape Trašte to Cape Platamuni, only 0.65 ha of the land is built, and in the zone from Dobra voda to Utjeha, 46 ha has been built, i.e. 44.5 % of the coast.

The length of the coast measured along the coastline is much larger than the generalized line – a total of 332 km of coastline (Table 6.2 right), which indicates a fairly large indentation of anthropogenic and natural coastline. Artificially altered coastline or coast with the present manmade structures in the zone 10 m from the coastline amounts to 110.5 km, i.e. 34%. In the Bay of Kotor (up to Mamula), a total of 86 km out of 124 km consists of such altered coastline, i.e. as much as 69.5%, and from Mamula to Bojana about 24.5 km out of 198 km, i.e. 12,5 %. In the zone from Dobra voda to Utjeha, 27% consists of such altered coastline.

The analysis by type of coastal area in the Bay of Kotor (Table 6.3) gives a generally similar picture as the analysis of constructed land. The total artificially altered coastline

[13] For the purposes of this analysis, the length of the coast was measured 50 m from the shoreline and is considered as the average length of the reference zone 100 m from the shore. Length and area include the island of Sv. Marko without the small islets.

[14] The relevant information is considered applicable to the narrower coastal zone 100 m wide, and not literally for the coastline (meaning for the land and sea meeting point).

[15] Data taken as the sum of the total length and area of the artificially modified coast.

[16] Length of the generalized coastline (see Figure 6.1).

(urban area with part or completely built/altered coastline, artificially expanded parts of the coast by sea embankment and degraded area) amounts to 57%. It should be noted that the information on the extent of the type of area is informative. Within an "urban area with a partially built/fortified coast", not all areas are constructed or impervious (due to generalization, green areas, forest remnants and agricultural areas between manmade structures may be included). On the other hand, there are manmade structures (coastal roads, individual buildings) in natural and cultural space.

The amount of total altered coastline according to different analyses looks similar at first glance, but the real information on the extent of physical coastal changes can be obtained through joint observation of the spatial distribution of all data, taking into account the method of such data preparation.

An important finding for the Bay of Kotor (Map 6.2) is that the artificially modified coastline, i.e. coast with manmade structures, is located largely outside the area of constructed land. Reverse situations, where natural shores are located alongside constructed land, are much rarer. T<his also explains the large difference in the share of the built-up land l (54.5%) and the share of artificially modified coastline (69.5%). Thus coastal physical changes are not related exclusively to urban areas.

The situation is very different in the open sea. It is a typical stretch from Dobra voda to Utjeha, where the urban area is spread out along the natural rocky coast (Figure 6.8). The share of the constructed land is significantly higher (47.5%) than the share of the artificially modified coastline (27%). In that case, although the coastline itself is formally undeveloped, it cannot be considered a natural coast due to the immediate construction in its hinterland.

Regardless of methodological differences and simplification of records, it is clear that the scope of coastal physical changes due to the influence of manmade structures is large and that the volume of total coastal changes is realistically higher than the numbers in Table 6.2. It is not negligible that data on construction is dated (from 2012), and having in mind the significant construction work done in recent years, the volume of manmade structures is likely much higher.

Some physical changes can be noticed at more than two thirds of the Bay of Kotor due to the influence of the manmade structures, and half of the 100 m coastal zone has been built. Along the open sea, the amount of physical coastal change is significantly lower. On average, the facilities are further away from the coastline than in the Bay of Kotor, so the volume of construction in the 100 m zone is smaller, but the space between the coastline and the first line of facilities in some parts has still been changed due to beach infrastructure and other facilities.

The problem is not only the total length/area of manmade structures, but also:

- a large range of dispersed construction, which creates a much greater impression of the physical alteration of the coast. Due to the smaller spatial limitation, this dispersion along the open sea is higher than in the Bay of Kotor and this, together with unfavourable architectural solutions, represents the biggest problem of urbanization of the coast of Montenegro;
- High density construction, without green areas in some settlements, which represents unfavourable urban solutions, and in the long run leads to a lack of absorbent and green areas as a solution to the growing problem of climate change.

6.3. Assessment

The "landscape quality" indicator was prepared on the basis of landscape assessment. Assessment of landscape areas means determining the vitality (natural and economic), experiential value (beauty) and stability (health) of landscapes (Marušič, 1998).

The assessment criteria are:

- **Natural conservation**: areas with preserved natural elements are more valuable, i.e., where space is perceived as originally natural;
- **Diversity**: areas with a greater diversity of elements are more valuable, where there is greater diversity of forests, indented coastline, combinations of forest, landscape and water, combinations of fields and settlement patterns;
- **Spatial order**: areas with a higher degree of spatial order are more valuable, i.e. the presence of spatial order elements such as repetition, rhythm, direction, gradation (with a high degree of spatial order; for example, terraced areas with recognizable repeating patterns);

- **Harmony**, which is marked as the most important criterion in evaluating the experiential value of landscape areas, essentially combines all previous criteria, especially diversity and spatial order: more valuable are areas where the landscape is the result of a good transformation of natural conditions, i.e. a high degree of adaptation to existing natural conditions, and recognizable areas;
- **The symbolic meaning of natural and cultural elements of the landscape**: more valuable areas are recognized at the national and regional level.

Symbolic meaning can come from natural (e.g. geomorphological phenomena, mountain areas, island archipelago) and cultural (e.g. terraced areas, areas with rich architectural heritage and cultural monuments) elements of the landscape.

The assessment was prepared on the basis of data on coastal physical changes due to the impact of manmade structures, data on the area from the Spatial Plan for special purposes of the coastal area (2018) and expert bases (maps 6.4 and 6.5), orthophotos and photographs of the coast taken as part of the CAMP project.

The values have been determined according to the criteria laid out in Table 6.4.

Figure 6.18: Example of very low value – industrial area (Lipci)

Table 6.4 : Criteria for landscape value assessment

Value assessment		Criteria
1	Very low value	Industrial, port and degraded areas where culture/natural elements have been lost. Maritime zone in front of degraded areas and ports.
2	Low value	Settlements and tourist zone areas without peculiarities, public space and green areas or containing inappropriate scale and typology. Built or undeveloped coastline. Maritime zone in front of urbanized areas and the middle of the bay.
3	Moderate value	Areas of intertwined natural and cultural landscapes and small settlements. Areas where cultural elements are present but not preserved or are indistinct, natural areas with less biodiversity. Settlements and tourist zone areas with a larger share of green areas and with areas of harmonious scale and typology. Partly natural coastline. Maritime zone in front of these areas.
4	High value	Areas with recognizable, distinct, preserved characteristics. Natural areas with greater biodiversity and conservation levels, areas with a prominent cultural landscape, examples of a specific combination of landscape elements. Areas which reflect great visibility of space, interesting views. Naturally preserved coast. Sea surface extending from green intersections, bay transition areas, bay surface areas, areas of significant views.
5	Very high value	Exceptional areas with special, prominent characteristics and/or symbolic significance - natural (areas of interesting relief forms) or culturally conditioned preserved landscape (dry stone walls, terraces, docks, traditional olive groves), including areas of historic urban and rural area. The sea surface that surrounds these areas, straits, naturally preserved bays, and areas of the most significant views.

Figure 6.19: Example of low value – settlements without urban concepts, peculiarities and undeveloped coastline (Krašići)

Figure 6.20: Example of moderate value – a relatively harmonious size settlement, with a larger share of green areas and partly natural coastline (Kumbor)

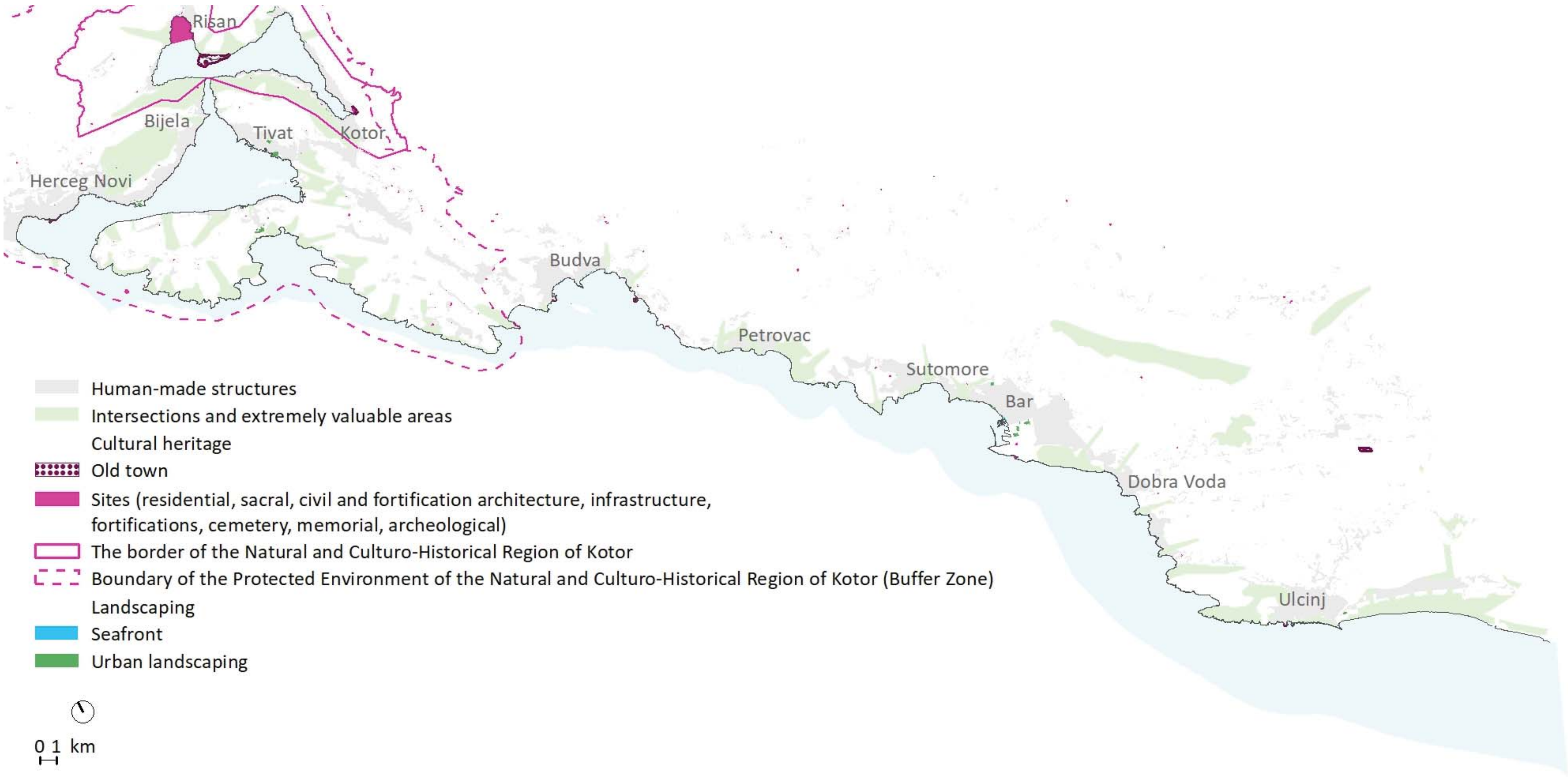
Figure 6.21: Example of high value – a region of intertwining natural and traditional cultural elements (Kostanjica)

Figure 6.22: Example of high value – naturally preserved slopes and attractive rocky shores (Platamuni)

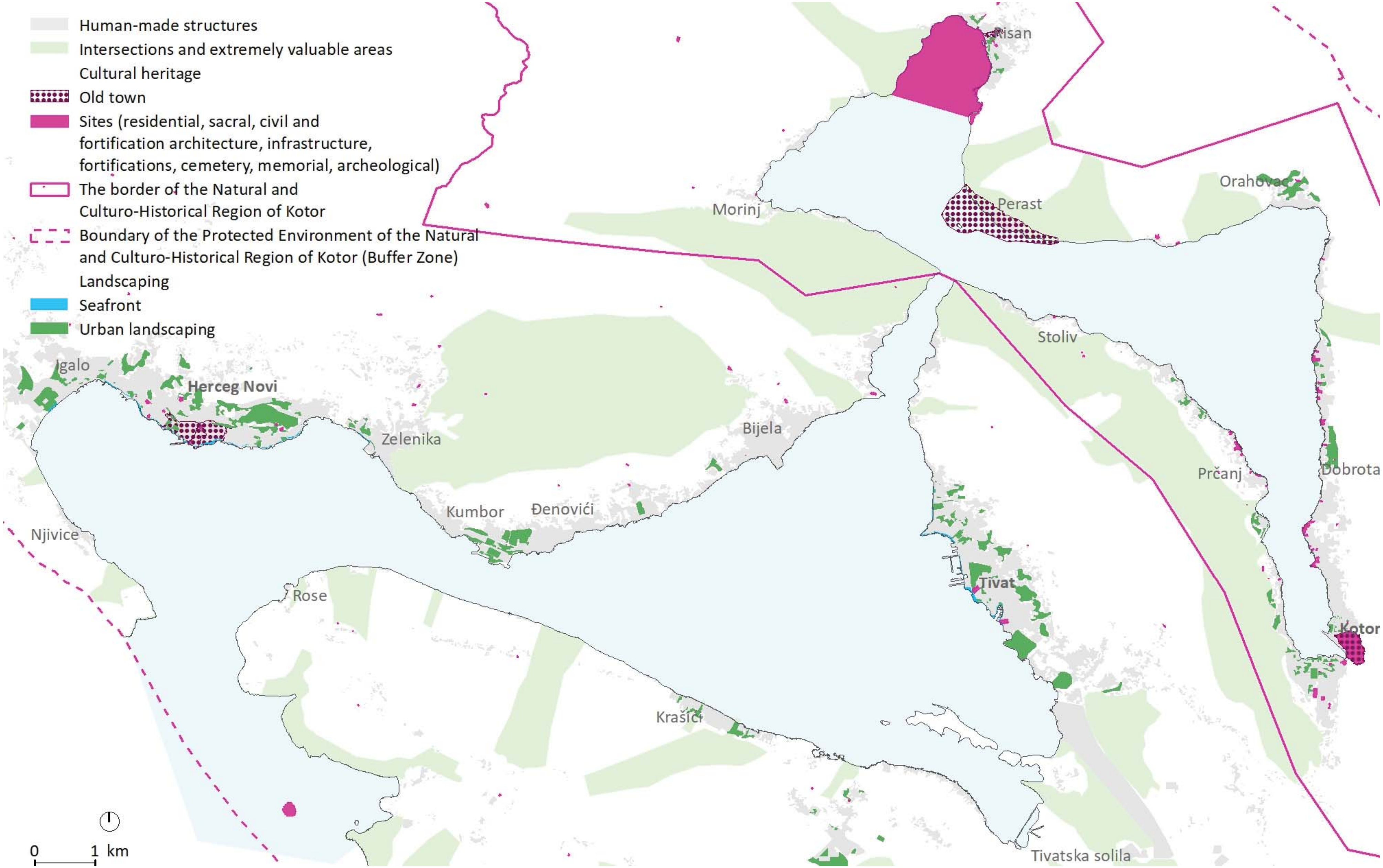
Figure 6.23: Example of very high value – an exceptional area with special, prominent cultural characteristics and symbolic significance (Perast)

Figure 6.24: Example of very high value – an exceptional natural area – beaches (Kraljičina plaža)

Map 6.4: Key data on the area from the Spatial Plan for Special Purposes of the Coastal Area (2018) and expert bases

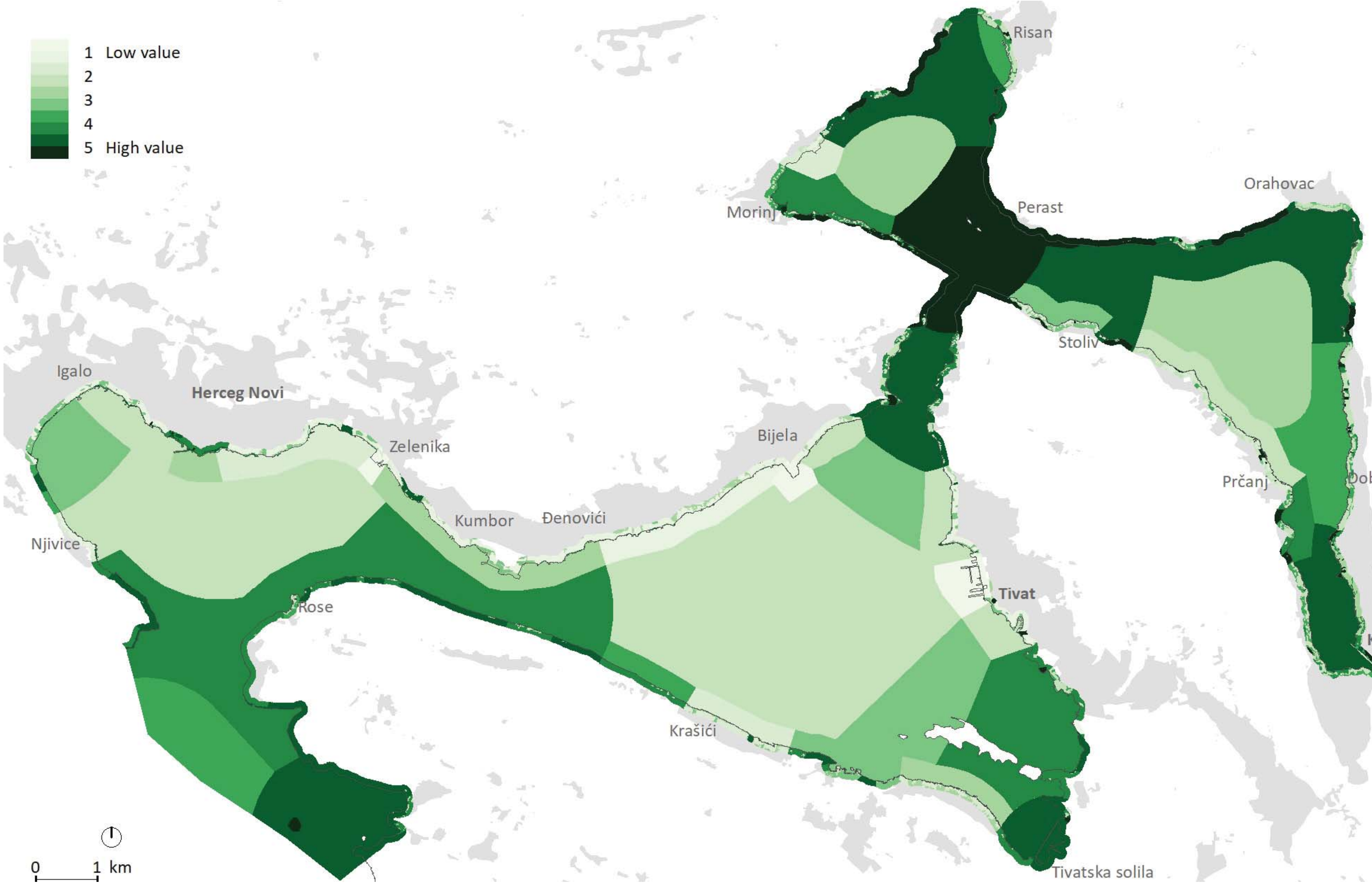


Map 6.5: Key data on the area from the Spatial Plan for Special Purposes of the Coastal Area (2018) and expert bases in the Bay of Kotor



Map 6.6: Landscape value assessment

Map 6.7: Landscape value assessment in the Bay of Kotor



The estimate of the value of the area is shown on maps 6.6 and 6.7. Due to the processing in the study Marine vulnerability assessment in the Bay of Kotor: Methodological guidelines (PAP/RAC, MORiT, 2017), the evaluation of the Bay of Kotor area is treated in more detail than high sea areas, and includes the evaluation of the coastal zone. Serious assessment of the coastal zone along the entire coastline exceeds the scope of this study (as it requires mapping and field survey), therefore only a general evaluation of the marine area has been prepared, taking into account the characteristics of the coast. It should be emphasized that for the purposes of spatial planning at different levels, a more detailed typology and assessment of the entire coastline is needed.

The area of the Bay of Kotor is characterized by steep, in some places rocky, slopes, and intertwining natural landscapes (forests, macchia, rocky terrains) and urban areas. There are no agricultural cultural areas along the coast, only the remains of terraces can still be seen in some places. The Bay of Kotor is characterized by cultural and historical areas with old towns (Kotor, Perast, Risan) and facilities that, together with the landscape environment, define the landscape quality of this area. Unfortunately, the newly created manmade structures have caused irreversible damage to the landscape, loss of habitat and biodiversity, and strongly affected the configuration of the natural coastline in most of the bay area.

The Bay of Kotor and Risan is an area of rocky slopes of very high value. The Novsko-Tivat Bay is relatively less attractive in the regional sense due to less prominent coastal indentation and a large volume of manmade structures. Dispersed construction and dense areas without a clear urban concept and public space are especially problematic. Luštica is characterized by an area of macchia and a large-scale forest without significant landscape features, but the great value of this area lies in its natural conservation without the presence of manmade structures.

The open sea coastline is characterized by bare hilly terrain and wooded slopes on limestone, interrupted by strokes of manmade structures and partially built areas. Special types of landscape are beaches and coastal and flooded alluvial plains. The value of the high sea area is very diverse. Particularly valuable are the areas of naturally preserved slopes and attractive rocky shores (Luštica, Platamuni, Dubovica, Crni rt), intertwining natural and cultural/historical areas (Budva, Sv. Stefan, Ulcinj) and beaches that are not burdened with manmade structures.

These areas are the complete opposite of those where urbanization has gone beyond professional and common sense – without a clear urban concept (based on either historical/heritage features or contemporary, sustainable trends), dispersed or too dense without public space and green spaces, inappropriate scale and architecture (Budva, Bečići, Dobra voda, Utjeha).

6.4. Recommendations

Conservation recommendations

Enforcing special additional measures for the formal protection of the Bay of Kotor landscape does not make sense because the area of the Kotor – Risan Bay is already under the protection of the UNESCO Natural and Cultural-Historical Region of Kotor. It is therefore important to strictly follow the rules for the area, along with the buffer zone.

The proposed marine conservation area (see Chapter 5.5) – Platamuni Nature Park – includes a part of the coastal area, so that formal protection would have positive outcomes like the preservation of landscape features. In this sense, it would be important that the boundaries of the proposed nature parks Katič (area along the stretch Buljarica – Dubovica – bays of Pećin and Čanj – Crni rt) and Stari Ulcinj include the land zone. This zone should not be a general buffer, but a meaningfully wide zone defined on the basis of regional characteristics.

For other valuable landscape areas (see below) it should be determined whether planned protection is sufficient or some formal/sectoral protection is still needed.

Remediation recommendations

The biggest problem of the coastal area are inadequately urbanized areas. Remediation of these areas can significantly improve the characteristics of less valuable landscape areas. The National Strategy for Integrated Coastal Zone Management in Montenegro (2015) assumes two priority actions:

- Preparation of manuals for remediation planning and restoration of inadequately urbanized areas and implementation of professional development programs; and
- Realization of a remediation pilot project and restoration of inadequately urbanized areas.

Guidelines for drafting the marine spatial plan and other spatial planning documentation

When preparing spatial planning documentation at all levels, which also applies to marine spatial planning, it is mandatory to develop a landscape plan or include landscaping solutions, harmonized with the overall planning solution, which should contain a clear concept of development and conservation of significant/recognizable landscapes, certain conditions for the development of activities/interventions, as well as guidelines for the development and protection of areas characterized by their need for special protection. Landscaping can go beyond the traditional conservation concept, meaning that where necessary, the approach to creating new landscapes is assessed as necessary/meaningful.

Special attention should be paid to:

- The preparation of more detailed typologies and assessment of the entire coast, together with the sea;
- Landscape in the narrow coastal area, planning of green systems and landscape-architectural arrangements of open space in settlements, arrangements of coastline and beach hinterlands, creation of green conservation zones between beaches and urbanized areas, architectural design of beach facilities and areas for the remediation of degradation;
- Creating and building manmade structures along the coast as a whole, having in mind not only functional, but also perceptual/aesthetic and environmental characteristics;
- In addition to protected/valuable areas in the sea (habitats), appropriate spatial planning solutions on land are necessary, in a way that creates sustainable spatial units of land and sea;
- Applying the coastal fringe as one of the basic instruments for the preservation of the coastal area, which in terms of the development of tourist capacities is not a limitation, but a potential for creating a quality landscape-architectural arrangement.

The Spatial plan for special purposes of the coastal area (2018) also includes the landscape plan. It would be useful to upgrade these starting points with the extension of regional planning solutions from land to sea.

It is especially important to leave green penetrations – intersections between manmade structures. These penetrations do not stop on the shore, but extend into the hinterland and the sea. With such intersections, continuous construction along the coast is prevented. In that way, the recognizability and completeness of the settlement is ensured, the orientation in space is improved and the natural link between the coast and the hinterland is enabled. In addition to having visual benefits, this enables a quality tourist and residential environment, more favourable microclimatic conditions, and the preservation of biodiversity.

Based on the assessment, broader areas for the protection of significant/vulnerable marine areas have been defined – closed areas of inalienable (natural and cultural) interaction of land and sea in the Bay of Kotor:

- Mamula – Žanjice bay;
- Prevlaka – Rose;
- Sv. Marko – Tivatska solina;
- Morinj;
- Verige – Sv. Đorđe – Gospa od Škrpjela – Perast;
- Kotor.

In the open sea, such areas consist of:

- Mamula – Luštica;
- PlatamuniM
- Jaz beach – Budva – Sv. Nikola – Sv. Stefan;
- Buljarica – Dubovica – Pećin bay;
- Čanj – Crni rt – Ratac – Sutomore;
- Ulcinj – rt Đeran.

Landscape conservation mostly refers to favourable spatial planning (strategic) solutions and architectural and landscape solutions (detailed design and construction) on land and sea. These areas should be protected from uncontrolled individual construction and intensive tourism development, while the potential for different types of development, complementary to tourism development, should be recognized.

7. Assessment of Anthropogenic Impacts on the Trophic Status of Marine Environments

7.1. Introduction

Eutrophication is the process resulting from the enrichment of water ecosystems with nutrients, especially nitrogen (N) and phosphorus (P) compounds, which leads to the rapid growth and primary production of algae biomass and changes to the nutrient content balance, thereby effecting a change in the balance between the organisms present, and water quality deterioration. The intensification of the growth of phytoplankton algae is the consequence of an increased input of nutrient salts from external sources into the illuminated layer of the water column. A slight increase in sea nutrient recharge may be beneficial for marine organism growth, while excessive recharge may have negative consequences due to increased oxygen consumption (oxygen consumption for the respiration processes of an increased number of organisms, as well as for the dissolution processes of decomposing organic matter). When an undesirable impact level is achieved, ecosystem degradation takes place, and its potential for the provision of services decreases. Changes in the ecosystem may be caused by natural processes, but may also be due to anthropogenic impacts, primarily as a consequence of intensive urbanisation of the coastline area without adequate sewage and urban waste water purification. Although such impacts need not be harmful on their own, the change in the balance of organisms in an ecosystem's structure, and the change in the ecosystem's functioning and service capacity are key factors worthy of concern.

A good living habitat status in relation to eutrophication is defined in the following manner: "*Human-induced eutrophication is prevented, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom water.*" Common indicators for the monitoring of impacts leading to eutrophication and for monitoring the marine environment status in relation to the harmful effects of eutrophication, namely the *concentration of nutrients in the water column* (CI 13) and the *concentration of chlorophyll a in the water column* (CI 14), are key instruments for the implementation of an ecosystemic approach.

The trophic index (TRIX) is, in addition to nutrient and chlorophyll *a* content, an additional indicator for determining the eutrophication rate. It represents the numerical value of the eutrophication rate for coastal waters, displayed on a trophic scale from 2 to 10 units according to Vollenweider *et al.* For the purposes of sea use planning, and in accordance with the ecosystemic approach of the Barcelona Convention, in addition to the prescribed indicators listed above, the assessment of the living habitat status and trends concerning the EO5 (eutrophication) relied on an expert assessment of the impact of urban waste water based on information on the number of urban waste water outlets and the hydrographic features of sea areas (see Chapter 7.2.1).

The **ecological objective EO5** overlaps with the Marine Strategy Framework Directive (2008/56/EC) MSFD/GES descriptor of **D5 Eutrophication.**

7.2. Status description

The most important feature of sea water is the presence of a high salt content. Its concentration in world seas averages around 35 grams per 1,000 grams of sea water. During rainy periods, salinity on the water surface decreases to only a few grams per 1,000 grams of water in certain areas, notably in the Bay of Kotor. Freshwater input contributes to this phenomenon, such as that from the rivers Sutorina, Opačica and Ljuta, the Nemila stream, Risanska Rijeka, Sopot, the Morinj springs, Škurda, Gurdić and other smaller submarine springs.

Salinity concentrations and sea water density are vital for water type identification, the basis for determining acceptable water eutrophication limits.

Table 7.1: Mediterranean sea water types according to density and salinity (UNEP(DEPI)/MED WG.417/Inf.15 part 1.)

	Type I	Type IIA, IIA Adriatic	Type IIIW	Type IIIE	Type Island-W
st (density)	< 25	25 < d < 27	> 27	> 27	All range
Salinity	< 34.5	34.5 < S < 37.5	> 37.5	> 37.5	All range

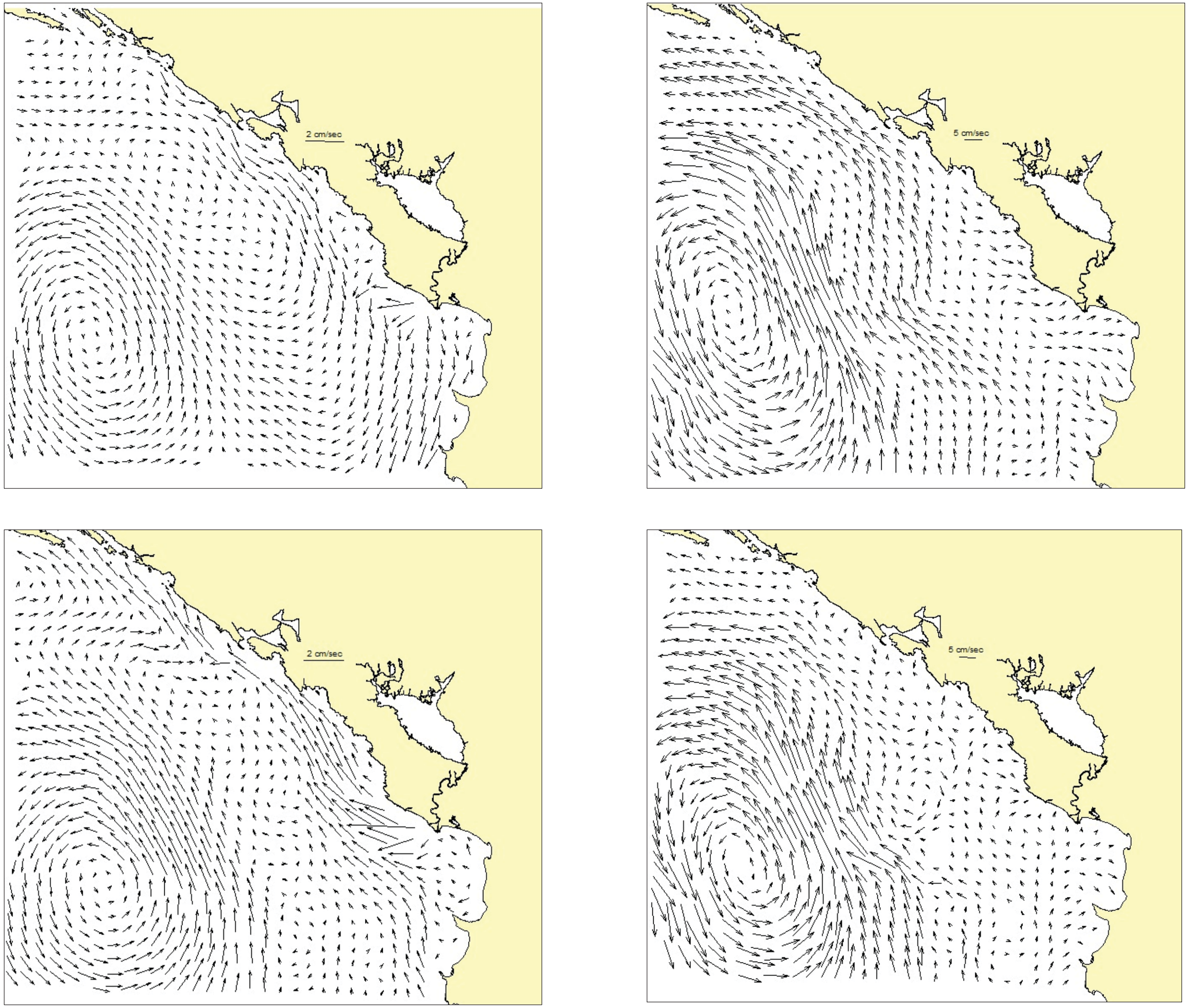
Based on this water type classification, coastal Montenegrin waters outside the bay area can be said to belong to the Type IIA Adriatic and Type IIIW Adriatic, while waters around the Bojana estuary and in the Bay of Kotor belong to Type I during periods of great freshwater input (i.e., “mixed waters”).

Water quality is also affected by sea currents. Those in the Adriatic Sea primarily result from gradient currents (caused by density-salinity distribution), while those caused by winds, marine tides, free oscillation currents and inertia currents build upon the former.

Separate images for each season for the surface and the seabed on Figure 7.1 show sea water currents in the Montenegrin part of the Adriatic Sea in 2003-2011, for winter and summer in the surface and bottom layer by applying the AREG model, made for the “Strategic Living Habitat Impact Assessment for the Exploration and Production of Hydrocarbon for Offshore Montenegro” of the Montenegro Ministry of Economy, which used old data from the Hydrographic Institute of the Republic of Croatia (HHI) in Split. Marine current data were mainly collected and processed via two studies: “Preliminary Report for Sewage System Solutions on the Montenegro Coastline” (“*Preliminarni izvještaj za rješenje kanalizacije Crnogorskog primorja*”) and “Oceanographic Features of the Sea From the Bay of Kotor to the Bojana Estuary” (“*Okeanografske karakteristike mora od Boke Kotorske do ušća rijeke Bojane*”).

A basic feature of southern Adriatic Sea currents is upwelling in the winter. The current direction in the entire profile, from surface to seabed, is fully parallel along the coast, while water body transport moves from south-east to north-west. Current intensity varies per month, climate type of the year and depth.

In the summer, water body movement has a different direction and a stronger intensity, especially on the surface. Current speed notably decreases as depth increases, and the general current flow direction is east and south-east. Unlike winter, the tidal impact is noticeable in the summer. In spring and autumn, there are noticeable crosscurrents with a higher flow frequency from the coast to the open sea. The flow per layer differs in speed, direction and salinity.



Summer: surface currents

Summer: seabed currents

Winter: surface currents

Winter: seabed currents

Figure 7.1: Representation of sea water currents on the surface and at the seabed – AREG MODEL (2003-2011)

Considering the existing hydrographic conditions, the sea water eutrophication process on the open part of the coast **is significantly lower** than that in the closed aquatorium of the Bay of Kotor due to multiple reasons. Sea water salinity in the coastal part is significantly higher throughout the year in relation to the Bay of Kotor, where the freshwater and nutrient input is significantly higher, which stimulates the growth of phytoplankton and marine flora. Additionally, the speed of the current and of sea water mixing significantly contributes to the lesser density of phytoplankton and to sea water eutrophication, except on individual closed locations, such as the Port Milena Channel and the Bar, Budva and Ulcinj harbour aquatoriums.

7.2.1. Pressures

In general, significant pressures on the coastal area of Montenegro include:

- urbanisation of the coastal area of the Bay of Kotor and the part of the coast outside of the bay, which causes an increased input of organic matter into the marine environment, mainly due to inadequate municipal infrastructure for liquid and solid waste (a large part of sewage waste water and septic tanks are not connected to central sewage systems and waste water purification facilities; there exist illegal solid waste dumps and landfills...);
- increase in the number of tourists;
- maritime tourism increase, without adequate infrastructure for the reception of liquid and solid waste from vessels;
- increase in beach capacities without adequate on-site sanitation;
- influx of organic matter via torrents and tributaries.

Considering the lack of major industrial and agricultural pollutants in the coastal part of Montenegro, as nearly all terminated their activities in the past ten years, urban waste water produced by households and tourists has the most significant impact on sea water quality.

Although the population size increase is relatively low, the number of tourists drastically increases every year, which poses a significant burden on local sewage capacities and increases the costs of their construction and maintenance. This especially refers to Budva, where the number of tourists during the tourist season is 76.7 times greater than the number of residents (see Table 7.2).

Table 7.2: Population size and number of tourists in 2018

Municipality	Population size 2018	Number of tourists 2017	Number of tourists 2018	Increase in the no. of tourists/pop. size 2018
Bar	43,693	175,102	315,346	7.2
Budva	20,982	848,443	1,537,321	76.7
Herceg Novi	30,690	294,636	407,137	13.5
Kotor	22,050	112,789	98,115	4.4
Tivat	14,774	96,384	122,537	8.3
Ulcinj	21,106	189,097	22,652	1.1
Total	**153,295**	**1,716,451**	**2,095,979**	

Table 7.3 provides an overview of burden on the Bay of Kotor marine environment and the part of the coast outside the bay caused by nutrients during and out of tourist season in accordance with data from the Water Management Basis of Montenegro ("Vodoprivredna osnova CG", 2003), supplemented by new population size data (MONSTAT) and effluent emission data (CETI).

In addition to nutrient input via urban waste water, tributary contributions, included in the marine ecosystem monitoring programme, are noteworthy as well. The average flow rate of the river Bojana before the Ada Bojana Island is ca. 640-660 m^3/s or 208,013,760,000 m^3/year, depending on the year. Bojana is the second largest Adriatic tributary (1,472 m^3/s) after the river Po in Italy. Its basin surface is ca. 18,000 km^2. Sutorina River is another significant watercourse, flowing via Sutorinsko Polje into Igalo Bay at Herceg Novi. According to the Institute for Hydrometeorology and Seismology, its average flow rate is ca. 1,3 m^3/second, i.e. 40,996,800 m^3/per year. Its basin surface is 25 km^2.

In addition to the aforementioned watercourses, torrential streams and tributaries including Opačica, the Nemila stream, Manitovac, Repaje, Orahovački potok, Ljuta, Škurda, Gurdić, Plavda and other smaller torrents in the Bay of Kotor contribute to the increase of organic matter in the marine environment of the bay, particularly during periods when these watercourses are active.

Table 7.3: Marine environment burden in the Bay of Kotor and the coastal part of the seashore caused by nutrients during and out of tourist season[17]

Basin	Settlement	Pollution origin	Tourist season SM (kg day⁻¹)	Tourist season BPK_5	Tourist season N	Tourist season P	Tourist season ES	Out of tourist season SM (kg day⁻¹)	Out of tourist season BPK_5	Out of tourist season N	Out of tourist season P	Out of tourist season ES
ADRIATIC DRAINAGE BASIN DIRECT DRAINAGE BASIN BAY OF KOTOR RIVIERA BAY	Herceg Novi	Population	3,871	4,223	844	210	70,384	1,715	1,871	374	93	31,183
		Industry	408	283	6	1	4,717	408	283	6	1	4,717
		Total emission	4,279	4,506	850	211	75,101	2,123	2,154	380	94	35,900
	Tivat	Population	1,752	1,913	383	95	31,871	639	698	140	35	11,626
		Industry	52	56	11	3	933	52	56	11	3	933
		Total emission	1,804	1,969	394	98	32,804	691	754	151	38	12,559
	Kotor	Population	2,444	2,668	533	134	44,468	1,236	1,349	269	68	22,484
		Industry	3	4	1	0	67	3	4	1	0	67
		Total emission	2,447	2,672	534	134	44,535	1,239	1,353	270	68	22,551
	Total for the bay	Population	8,067	8,804	1,760	439	146,723	3,590	3,918	783	196	65,293
		Industry	463	343	18	4	5,717	463	343	18	4	5,717
		Total emission	8,530	9,147	1,778	443	152,440	4,053	4,261	801	200	71,010
ADRIATIC DRAINAGE BASIN COASTAL SEA	Budva	Population	3,409	3,718	744	186	61,967	677	738	148	37	12,300
		Industry	22	14	4	1	233	22	14	4	1	233
		Total emission	3,431	3,732	748	187	62,200	699	752	152	38	12,533
	Bar	Population	4,672	5,097	1,020	254	84,950	1,811	1,997	399	100	33,283
		Industry	1,077	1,472	19	5	24,533	1,077	1,472	19	5	24,533
		Total emission	5,749	6,569	1,039	259	109,483	2,888	3,469	418	105	57,816
	Ulcinj	Population	3,644	3,975	795	199	66,250	1,399	1,526	305	76	25,433
		Industry	927	245	14	2	4,083	927	245	14	2	4,083
		Total emission	4,571	4,220	809	201	70,333	2,326	1,771	319	78	29,516

[17] Data from the Water Management Basis of Montenegro ("Vodoprivredna osnova CG", 2003), supplemented by new population size data (MONSTAT) and effluent emission data (CETI)

Table 7.4: Organic matter input from the Bojana and Sutorina tributaries

Parameter	Susp. solidsTSS t/year	BPK5 BOD5 t/year	Total nitrogen TN t/year	Total phosphorus TP t/year
Bojana River	32,293	28,256	5,046	605.5
Sutorina	4,099	49	29	0.04
TOTAL	36,392	28,305	5,075	605.54

The results show that the tributary inflow, particularly that of the Bojana River, is considerably larger than the total input of all sewage systems (Table 7.4).

Urban discharge outlets

Out of six municipal centres in the coastal area, only four regional centres have waste water purification facilities, namely those for the municipality of Herceg Novi in Meljine in the Bay of Kotor, a shared facility for Kotor and Tivat in Đuraševići, with purified water discharge into the open sea in the Bay of Trašte, and the PPOV ("waste water purification facility") "Vještica" for Budva and the surrounding settlements in the inland of Bečići and Rafailovići, which discharges purified water into the open sea in the Bay of Kotor via an existing outlet at Zavala. Ulcinj and Bar do not yet have purification facilities, meaning that they only provide primary treatment to waste water and discharge it into the open sea via long sewage outlets. In addition to the main sewage outlets, there is a large number of local ones, discharging waste water at small depths.

The sewage system in Budva

Of all coastal municipalities, Budva has the highest quality used waste water drainage system, as it is used by nearly 100% of the urban population. Currently, the Budva Municipality does not have a unique sewage system for coastal settlements. There are three separate sewage systems for Budva, Sveti Stefan and Petrovac.

The **Budva** sewage system receives all used waste water from the Budva area (from Stari grad to Rafailovići) which is transported to the PPOV "Vještica" in the inland of Rafailovići. Following tertiary treatment, purified water is returned and discharged into the sea at Zavala via an existing submarine outlet with a length of 2,550 m, behind Sveti Nikola Island at a depth of 40 metres. Nearly 100% of the urban population of Budva is connected to the Budva PPOV "Vještica" with a PE of 110,000, while the currently unconnected settlements of Sveti Stefan, Buljarica and Petrovac are also scheduled to connect to it. The waste water purification facility has been operational as of 2014, but with a large number of malfunctions.

The Sveti Stefan subsystem collects used waste water from the settlements of Kamenovo and Pržno, followed by Miločer, Sveti Stefan, Galije and Šumet in the inland up to PS Sveti Stefan and a submarine outlet at a depth of 40 m, with a capacity of 209 l/s and a length of 1,600 m. Due to illegal construction, the southern part of the sewage collector has been cut off, causing occasional faecal water discharge onto a beach, heavily impairing the image of Sveti Stefan and the health of the bathers.

There are two illegal waste water outlets in the Sveti Stefan zone – the sewage outlet of the Pržno settlement, including hotels "Maestral" and "Villa Miločer", located behind a small cape on the southern side of the beach, and another sewage outlet transporting used waste water from the former resort of "Kosovo", discharging into a nearby stream and the sea via a septic tank outlet.

The **Petrovac** outlet is 1,400 m long and terminates at a depth of 40 m, with a capacity of 80 l/s.

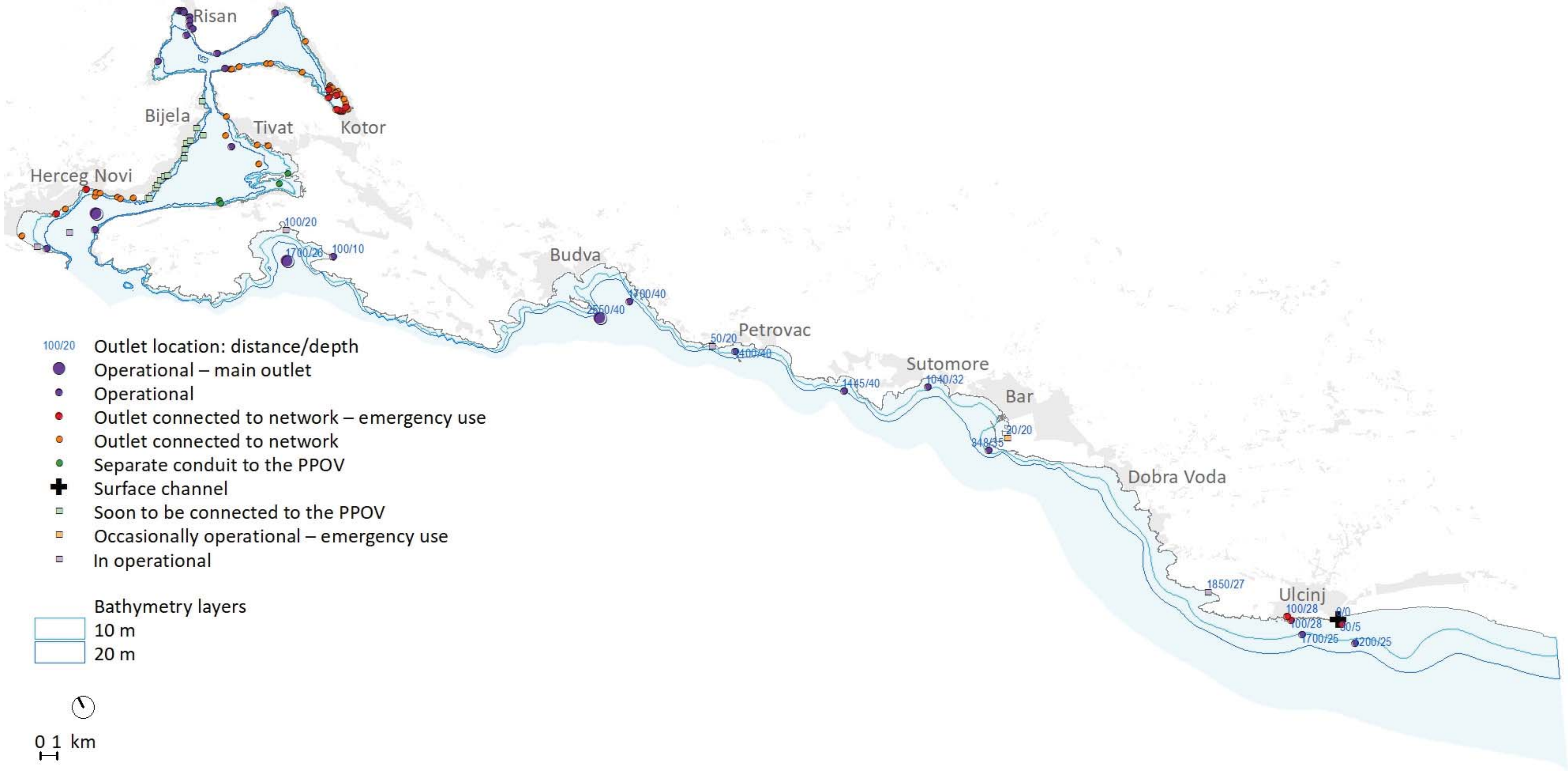
The **Perazića Do** outlet is 100 m long, constructed for the requirements of a new hotel complex, but not yet operational as the hotel complex is unfinished.

It should be noted that the PPPN OP provides for a new special sewage outlet for Cove Jaz-Prijevor (the agglomeration of Budva 3).

The sewage system in Bar

There are three separate sewage systems on the Bar area, collecting used waste water from Čanj, Sutomore and Bar, and there are plans for a sewage system for the agglomeration of Bar 4: Kunje (Bušat, Komina).

Map 7.1: Urban discharges on the open sea



The urban sewage system of **Bar** is envisioned separately. Many storm drains for heavy precipitation drainage have been constructed, terminating in coastal outlets. The coastal collector for waste water evacuation leads from the Šušanj settlement to the Topolica pumping station, on to the main pumping station in the port (PS Volujica), and via a pumping pipeline to the outlet after leaving the Volujica Tunnel. The submarine pipeline on the tunnel outlet is 348 m long, located at a depth of 34 m, with a capacity of 500 l/s. It takes waste water out of the harbour into the open sea. PS Volujica is noted for frequent malfunction causing direct waste water discharge into the Bar Port via an emergency outlet. A new, expanded sewage system in Bar for agglomerations 1 and 2 provides for the upgrading of the existing sewage system and Volujica submarine outlet into a 68,600 PE PPOV. A sewage network construction for agglomeration 3 is planned as well, for the following settlements: Dobre vode, (Nišice), Bištine, Dubrava, Utjeha and Pičurice with a 1,000 m discharge into the sea.

The **Sutomora** sewage system comprises the used waste water collector from the entrance into the Golo brdo tunnel; Ratac pumping station, PS Botun and the tunnel. A completed 1,040 m long submarine outlet ending at 32 m, of a capacity of 175 l/s is operational, but PS Botun is frequently inoperative, discharging waste water in the pumping station zone rather than via the tunnel.

Čanj Cove comprises a coastal collector, a pumping station (PS) for mechanical pretreatment, and a submarine pipeline exiting into the sea at a depth of 40 m, 1,445 m long, with a capacity of 85 l/s. Construction is planned of a separate PPOV with a PE of 1,000 for Čanj Cove, and the Bar 1 agglomeration.

The sewage system in Ulcinj

Ulcinj has a combined sewage system. Due to poor operation of existing facilities and an incomplete sewage system, waste water from the pumping station PS 1 on Pristan is frequently directly discharged into the sea near the busiest beaches. The existing sewage system in Ulcinj collects urban water as well.

The tourist facilities on Velika Plaža, Valdanos and Ada Bojana, as well as villages in the inland of the Ulcinj Municipality, are not connected to this system. Facilities constructed until now include the main gravity collector leading to the Pristan pumping station on Mala plaža, and a mechanical treatment facility on the same location, though the latter is inoperational and transports waste water to the PS Port Milena. This location (on the Port Milena estuary) also comprises a marine outlet with a capacity of 370 l/s and a length of 1,100 m.

A number of collectors and an 1,850 m marine outlet for waste water collection and transport have been constructed in the Valdanos tourist complex. The Đeran outlet on Velika plaža is 1,200 m long and ends at a depth of ca. 25 m.

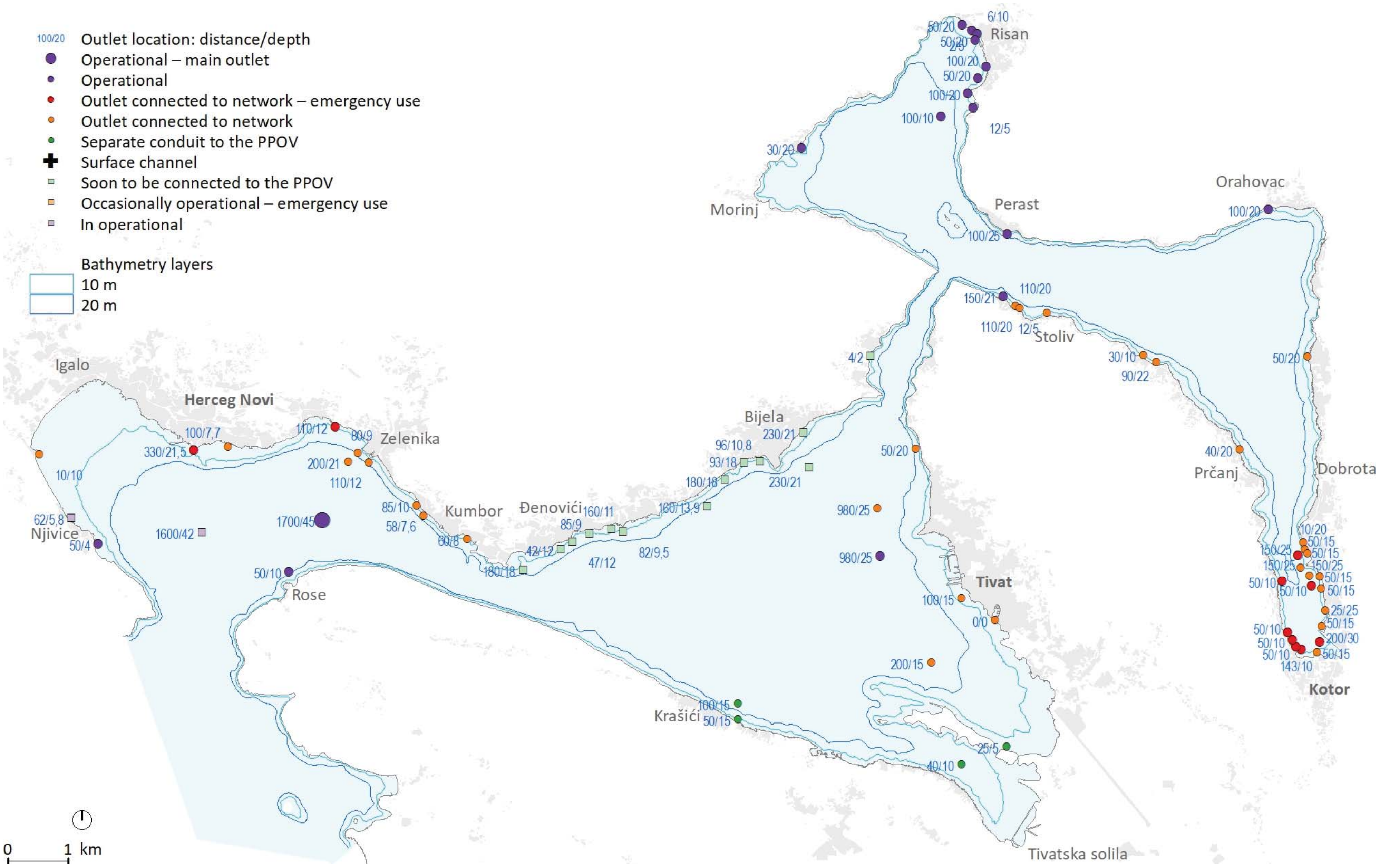
Waste water from the "Albatros" hotel are taken into a septic tank before discharge into the sea. Waste water from the "Galeb" hotel discharge into the sea after passage through a septic tank and disinfection. Hotels on Velika plaža, the hotel resort on Ada and some private housing settlements not part of the sewage system use septic tanks for discharge into so-called drainage fields, directly into the Bratica stream, Port Milena or other channels and streams.

A solution for the Ulcinj sewage system is provided in the "Montenegro Urban Waste Water Management Plan (2020-2035)" ("*Plan upravljanja komunalnim otpadnim vodama u Crnoj Gori (2020-2035)*"). Stage one, by the end of 2021, comprises sewage network construction in Kodre, Bijela Gora, Totoši and Donja Bratica. Stage two includes a PPOV with a PE of 37,500 on a roundabout with an outlet at Pristan. Water currently transported via the Đeran outlet should be taken to the PPOV, and returned to the Pristan outlet. A new sewage network is planned for Gornji Štoj, Donji Štoj and Velika plaža, also via the roundabout PPOV, greatly reducing eutrophication in the Port Milena Channel.

The Bay of Kotor sewage systems

The Bay of Kotor is the largest fjord in the Mediterranean. The total surface of the Bay of Kotor is 87.33 km^2, its maximum depth is 60 m, while its average depth is 27.3 m. The length of the Bay of Kotor is 28.13 km, and the length of the coast of the bay is 105.7 km. In terms of proper sea water quality, the Bay of Kotor, as a relatively enclosed area with a reduced possibility of water self-purification, requires the so-called tertiary treatment of waste water discharged into the sea, which entails the removal of nitrates and phosphates after the primary (mechanical) and secondary (biological) purification, and water evacuation outside of the Bay with a completed sewage infrastructure covering the entire coast and inland area of the Bay of Kotor.

Map 7.2: Outlets in the Bay of Kotor



Urbanisation of the coastal area of the Bay of Kotor causes increased input of organic matter into the marine environment (input via untreated urban waste water, solid waste input reaching the sea), i.e. increased eutrophication. In the Bay of Kotor, 87 larger sewage outlets have been registered, along with several smaller outlets and a large number of septic tanks, although some of them are already connected to the sewage system and placed out of commission, but smaller local outlets are still operational. Of particular concern is the fact that most existing sewage outlets are located at smaller depths near the coast where the PAR index (Photosynthetically Available Radiation)[18] is relatively high, promoting the growth of green algae in the water layer. In karst terrain conditions, such as that of the Montenegro coastline, pollution from individual sources directly washes into the sea, especially during heavy rain.

The current state of the sewage systems of cities in the Bay of Kotor has changed significantly since 2016 due to the placement into operation of the waste water purification facility of **PPOV Trašte** for Kotor and Tivat, and in 2018 that of **PPOV Meljine** for the Herceg Novi Municipality, although outlets on the north-east arm have not yet been connected.

The Kotor – Trašte sewage system

This sewage system transports waste water from Kotor and the Kotor and Tivat industrial zones into the open sea. It stretches from Peluzica to Kavalin in Dobrota, and the "Splendid" hotel across the bay (Prčanj). Sewage outlets in Risan (4) are not connected to the sewage system. The Kotor sewage system features separate atmospheric and faecal water drainage. The most important part of the sewage system is the Peluzica pumping station. Its terrestrial section is over 11 km long, with a 1,800 m long submarine outlet in Trašte (shortened from 3,600 to 1,800 m following an accident). Out of 46 submarine outlets in Kotor, 17 are connected to the PPOV, as are 8 emergency outlets, i.e. 6,456 consumers (20.99%). In Tivat, 5 of 10 outlets are connected, with 13,287 consumers (43%). Large, new residential buildings are usually connected, while smaller separate buildings use septic tanks or small-scale local outlets. In 2019, the stage one waste water of the Luštica Bay tourist complex was connected to the Trašte outlet. Seljanovo, a large outlet in Tivat with a PE of 40,000, is not connected, but still uses its existing outlet into Tivat Bay.

Sewage system Herceg Novi – Meljine

The existing waste water sewage system is based on the main assembly collector within the "Pet Danica" promenade from Igalo to Meljine, to which the new, "eastern" collector arm is connected (at the location of the main pumping station at the Meljine roundabout), transporting waste water from Bijela to Meljine. Secondary and tertiary sewage networks are constructed on the Igalo-Meljine area, with connections for the Podi and Sutorina settlements. The largest urban agglomerations in this area include: Igalo, Herceg-Novi, Topla I, Topla II and Topla III, and Savina, with high population densities compared to the rest of the municipality. A sewage system partly exists in Bijela and on some parts of the riviera. The urban sewage network, managed by the company "Vodovod i kanalizacija" Herceg-Novi d.o.o., is 70 m in length, with five pumping stations and 34 submarine outlets, which should be disconnected when the completed "eastern" collector arm to Bijela becomes operational.

The PPOV Meljine for the Herceg Novi Municipality sewage system with 66,300 PE and a 1,600 m outlet became operational at the start of 2018, but the north-eastern part of the municipality is as of yet not connected to it due to the need to check the integrity of the new sewage pipeline. Until now, the sewage system which previously lead to the Forte Mare outlet has been connected: Igalo, Savina, Zelenika i Meljine. Connecting the settlement of Kumbor (Porto Novi) is underway, and other settlements all the way to Bijela are expected to be connected as well. Hotels and the settlement in Njivice are not connected, although that is provided for in the PPPN for the OP with the aim of protecting the quality of the water and medicinal mud in the Bay of Igalo. The impacts of its placement into operation will become apparent in subsequent periods.

There are no current plans for connecting **Risan and Perast** to existing sewage systems, and separate PPOVs are planned for them. A decision is pending as to whether the **Orahovac and Dražin Vrt** will be connected to the Kotor system in

[18] Sun, Jindong; Nishio, John N.; Vogelmann, Thomas C. (1997-12-05): HYPERLINK "http://pcp.oxfordjournals.org/content/39/10/1020.full.pdf+html" Green Light Drives CO2 Fixation Deep within Leaves

Dobrota, or whether a separate local water purification system will be constructed, although they belong to the Kotor-Tivat 1 agglomeration according to the Sewage System Construction Programme and PPOV of 2019. A separate local water purification system is planned for Morinj and Kostajnica as well.

In addition to the aforementioned pressures from sewage outlets whereby waters are discharged into the marine environment after purification, it should be noted that **there are 28 other local outlets in the Herceg Novi Municipality, 13 in the Tivat Municipality, and 29 smaller ones in the Kotor Municipality**, as well as larger local ones **not yet connected to the sewage system**. Importantly, none of these are connected to a waste water purification facility, meaning the quality of the discharged waste water does not comply with standards for waste water discharge into the natural recipient. **The introduction of a requirement to connect existing facilities onto existing sewage networks in a certain period** should be promoted. Construction of new residential or tourist facilities **without securing an urban infrastructure**, i.e. without connection to the sewage network and PPOV, should be stopped as well.

7.2.2. Status monitoring

In accordance with the MEDPOL programme, eutrophication is monitored within the Coastal Sea Ecosystem Status Monitoring Programme (“*Program praćenja stanja ekosistema priobalnog mora*”), part of the 2008 Montenegro Living Habitat Monitoring Programme (“*Program monitoringa životne sredine Crne Gore*”), after the founding of the Environmental Protection Agency of Montenegro, and until 2008 in accordance with the Water Quality Control Programme (“*Program kontrole kvaliteta voda*”), Law on Waters (Republic of Montenegro Official Gazette 16/95 and 27/07), and Regulation on the Classification and Categorisation of Waters (Republic of Montenegro Official Gazette, 14/96).

A process of harmonising national monitoring with the Barcelona Convention ecosystemic approach and the implementation of the Integral Monitoring Programme (Decision IG. 22/7) is ongoing. The monitoring program includes analyses and results needed for marine ecosystem status reports by using the agreed-upon EcAp indicators CI 13 and 14, via monitoring the following key parameters:

A – concentration of basic physical-chemical parameters and nutrients in water and chlorophyll *a*;

B – phytoplankton (total abundance, main plankton group abundance).

As of 2016, marine water eutrophication is monitored at 7 locations in the Bay of Kotor and 6 coastal sea locations outside the bay with a reference point at the mouth of the bay. In 2017, monitoring was carried out from April to June and in November and December. In 2018, it was carried out from January to May and from July to December. In 2019, the eutrophication program was carried out from January to April (May and June are missing), and continued from July to the end of the year (December) due to the lengthiness of tender procedures. Consequently, monitoring did not cover the min. 6 months of measurement per year, nor did it (fully) cover April and May, the season of the so-called “algal bloom”, caused by increased nutrient content and sea temperature rise. Measurements were made only at two depth levels: surface and seabed.

Chlorophyll *a* concentration in the water column

Chlorophyll *a* concentration is the basic indicator for rating the eutrophication degree. High chlorophyll *a* values indicate increased phytoplankton production. Chlorophyll *a* concentration is measured spectrophotometrically, and expressed in µg/l. The trophic status ratings in relation to chlorophyll *a* content according to the UNEP/MAP are displayed in Table 7.5.

Table 7.5: Marine environment trophic status ratings in relation to chlorophyll *a* values

UNEP 1994*	Oligotrophic	Mesoeutrophic	Eutrophic	Hypereutrophic
Chlorophyll -*a* µg/l	< 1	1–5	5–10	> 10

* UNEP(DEC)/MED WG.231/14 30 April 2003 JAMP Eutrophication Monitoring Guidelines: Chlorophyll a in Water, OSPAR Commission

High nutritive salt concentrations lead to excess phytoplankton production, which increases the organic matter content above the ecosystem's decomposition capacity. This leads to the emission of unpleasant odours, free oxygen consumption and negative impacts on all other biocenosis components – zooplankton, nekton, benthic organisms etc. Clorophyll *a* is used as a phytoplankton biomass indicator as it enables the determination of the marine ecosystem trophic status rate. All green plants contain chlorophyll *a* which makes up 1-2% of plankton algae dry weight. This enables the expression of phytoplankton biomass via photosynthetic pigment concentration. Water temperature and light intensity increase in April and May. Simultaneously, nutrients are present in sufficient quantities in the photic zone due to water level mixing after winter circulation and nutrient input via precipitation and submarine springs.

These conditions are ideal for the rapid and intensive development of phytoplankton, i.e. the so-called „algal bloom", especially in the bay area during April and May. This phenomenon occasionally occurs in the Bay of Kotor, particularly in the Kotor bay part, Orahovac and Risan Bay.

Table 7.6 provides an overview of minimum and 99th percentile – P90 values measured for chlorophyll *a* in the 2016-2019 period for locations in the Bay of Kotor and the coastal part of the open sea (the colours in the table correspond to the indicated water trophic status classes according to chlorophyll *a* content in table 7.5 by the UNEP/MAP).

The most indicative year for the assessment of the eutrophication status in the last four years is **2018** due to the fact that measurements were made from January to May and from July to December at locations in the Bay of Kotor and on the open sea. Figure 7.2 shows the change in chlorophyll *a* content per month and location during 2018.

The results displayed show that most individual measurements were within the ranges for oligotrophic and mesoeutrophic environments. The highest chlorophyll *a* concentrations in the bay part were measured in March and April, with the exception of data for December at the Risan site surface sample, which amounted to 7.83. The highest measured values on the open part of the coast were mostly taken in December, except in the Port of Bar, where the highest values were recorded in April and May. It is worth noting that, although it was not measured as part of national monitoring, the Port Milena channel location, which was analysed within a channel remediation project, indicates that this location may be among the worst-affected.

Based on several years' worth of data, as part of the UNEP/MAP, the Eutrophication Working Group has proposed benchmark and limit values for chlorophyll *a* for various Mediterranean areas for the eutrophication rate assessment per sea water type. Table 7.7 displays the proposed benchmark and limit values for chlorophyll *a* for the assessment of eutrophication in the Mediterranean Sea, according to the UNEP (DEPI) MED WG. 417/Inf.15.

Therefore, taking into account the proposed limit values and the probable water types in Montenegro, it is worth noting that recent measurements indicate good and, at certain locations, moderate status.

Table 7.6: Overview of 90th percentile and minimum measured chlorophyll *a* concentrations according to UNEP/MAP

LOCATIONS IN THE BAY OF KOTOR

Mjerna mjesta		KOTOR KO E-1		RISAN RI		TIVAT TV E-2		HERCEG NOVI E-3		Sv. NEĐELJA OS-3		IBM OS-1		IGALO 1	
Parameter	Year	min	P90	min	P90	min	P90	min	P90	min	P90	min	P90	min	P90
Chlorophyll -*a* µg/l	2016	0.1	2.03	0.1	4.60	0.03	3.7	0.1	0.1	0.03	3.30	0.16	2.82	0.1	1.72
	2017	0.22	0.408	0.12	1.03	0.05	1.404	0.05	0.05	0.05	1.34	0.26	2.736	0.05	1.38
	2018	/	/	0.27	5.086	0.2	3.0	0.05	0.05	0.03	3.36	0.9	3.12	0.05	2.52
	2019	0.1	3.75	0.05	3.61	0.56	3.35	0.6	0.6	0.27	1.82	0.34	3.85	0.6	1.60

COASTAL SEA LOCATIONS

Mjerna mjesta		BUDVA E-4		L. BAR - Marina E-5		ULCINJ E-6		ADA BOJANA- E-7		LUŠTICA Mamula MNE-08	
Parameter	Year	min	P90	min	P90	min	P90	min	P90	min	P90
Chlorophyll -*a* µg/l	2016	0.13	0.63	0.13	0.80	0.11	0.51	0.03	0.46	0.03	0.62
	2017	0.05	0.357	0.13	0.207	0.05	1.05	0.05	0.96	0.4	0.40
	2018	0.42	2.60	0.11	3.0	0.17	2.14	0.17	1.359	0.24	2.04
	2019	0.05	0.967	0.1	1.66	0.1	1.72	0.1	1.182	0.05	1.194

Figure 7.2: Chlorophyll *a* concentrations in the Bay of Kotor and on the open sea (Marine Ecosystem Monitoring Report for 2018 EPA) with marked limits for oligotrophic (1) and mesoeutrophic (5) marine environments

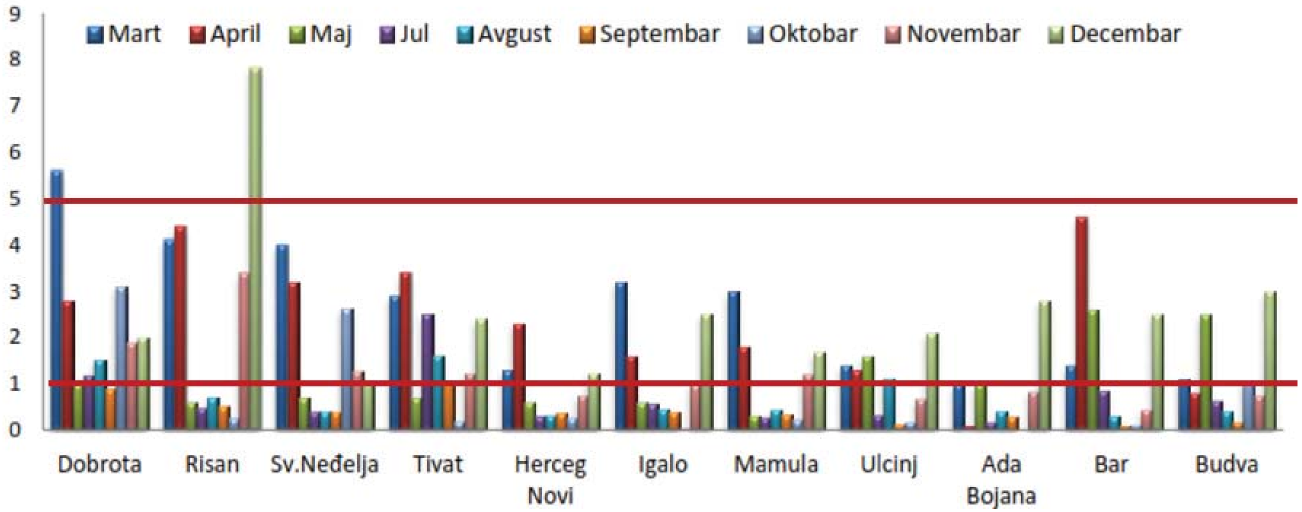


Table 7.7: Proposed benchmark and limit values for chlorophyll a on the Mediterranean Sea (G – geometrical mean; G/M-status – good/moderately good eutrophication status)

Coastal waters typology	Benchmark conditions Chla (μg/l)		Limit values Chla (μg/l) for G/M status	
	G – average	90% percentile	G – average	90% percentile
Type I	1.4	3.39	6.3	17.7
Type FF-fr-SP		1.28		3.50
Type II-A Adriatic	0.33	0.8	1.5	4.0
Type II B Tyrrhanian	0.32	0.77	1.2	2.9
Type III-W Adriatic			0.64	1.7
Type III-W Tyrrhenian			0.48	1.17
Type III W FR-SP		0.79		1.89
Type III E		0.1		0.4

Trophic index

The trophic index – TRIX (Vollenweider *et al.*, 1998) can be used as a **supplemental index** for the preliminary coastal sea trophic status assessment concerning the eutrophication status, taking into account the benefits and limitations entailed by the determination of this indicator (Primpas and Karydis, 2011). The TRIX index is applied as an indicator integrating several variable parameters – eutrophication agents – into a numerical value which enables the comparison of data on the trophic status of the marine environment[19]. The TRIX index is calculated by applying the following formula:

$$TRIX = \frac{log_{10}(ChA \cdot aD\%O \cdot minN \cdot TP) + k}{m}$$

where:

- Chla = chlorophyll *a* concentration in μg/L;
- aD %O = oxygen expressed as the absolute percentage value of deviation from saturation;
- DIN = dissolved inorganic nitrogen, N-(NO_3+NO_2+NH_4), expressed in μg/l;
- TP = total phosphorus expressed in μg/l;
- k=1.5; m = 10/12 = 0.833.

Water classification according to the TRIX index value is made in the following way (Table 7.8):

< 4 excellent trophic status, low phytoplankton production, water status – excellent,

4-5 good trophic status, increased phytoplankton production, occasional increased sea water turbidity and colouration; water status – good,

5-6 moderately good trophic status and moderately good water status,

6-8 poor trophic status, high phytoplankton production, sea water colouration, water status – poor,

8-10 unacceptably bad trophic water status.

[19] Indicator Guidance Factsheets for Contaminants (EO9) and Eutrophication (EO5), MEDPOL 2016
National Action Plan Update Guidelines [UNEP(DEPI)/MED WG.393/10] determine the criteria for the assessment of hotspot locations and vulnerable areas.

Table 7.8: Trophic status rating table according to Vollenweider (colouring in accordance with Table 7.5)

TRIX – index	Water Status	Colour
2–4	Excellent	
4–5	Good	
5–6	Average	
6–8	Bad	
8–10	Unacceptable	

Although the TRIX index is not a CI per se, it encompasses several parametres which cause eutrophication, meaning that, in addition to chlorophyll *a*, it provides a more realistic picture of marine ecosystem trophic status.

An overview of maximum and minimum 90th percentile values of the TRIX index, i.e. an assessment of the marine environment trophic status, is provided in Table 7.9.

Marine environment eutrophication analysis data in the Bay show that the highest TRIX index values as the 90th percentile shift between 5 and 6 (good to moderately good trophic status), most frequently at **Dobrota by the Marine Biology Institute ("Institut za biologiju mora", IBM), the Port of Bar and Ulcinj.** The lowest 90th percentile TRIX index values are recorded at Mamula and Budva, mainly lower than 4 (excellent to good trophic status).

Table 7.9: Overview of 90th percentile and minimum measured concentrations of the TRIX index for coastal sea locations in Montenegro in the 2016-2019 period

LOCATIONS IN THE BAY OF KOTOR

Measuring points		KOTOR KO E-1		RISAN RI		TIVAT TV E-2		HERCEG NOVI E-3		Sv. NEĐELJA OS-3		IBM OS-1		IGALO 1	
Parameter	Year	min	P90	min	P90	min	P90	min	P90	min	P90	min	P90	min	P90
TRIX µg/l	2016	2.1	3.92	1.6	3.60	1.8	1.76	2.5	3.2	1.5	3.42	2.9	3.52	1.2	3.5
	2017	3.2	3.488	1.4	4.38	2.0	4.14	1.86	3.75	2.1	3.877	3.6	4.88	1.5	4.927
	2018	/	/	2.8	4.81	3.4	4.92	2.9	4.12	2.7	4.657	3.5	5.46	2.7	4.118
	2019	3.3	4.79	2.5	4.59	3.1	4.64	3.4	4.49	2.7	4.396	3.3	4.60	2.7	4.33

LOCATIONS OUTSIDE THE BAY PART OF THE COASTAL SEA

Measuring points		BUDVA E-4		L. BAR - Marina E-5		ULCINJ E-6		ADA BOJANA- E-7		LUŠTICA Mamula MNE-08	
Parameter	Year	min	P90	min	P90	min	P90	min	P90	min	P90
TRIX µg/l	2016	2.6	3.74	2.4	3.5	2.5	3.58	2.7	3.6	1.64	3.58
	2017	1.76	3.555	1.7	3.862	1.8	3.395	1.73	3.64	1.97	3.335
	2018	3.1	4.855	2.5	5.123	2.9	5.067	2.9	4.63	3.2	4.505
	2019	1.5	3.91	2.5	4.381	2.4	4.65	2.4	4.38	2.1	3.829

The highest TRIX index values on the open part of the coast were recorded at the Port of Bar and Ulcinj (moderately good trophic status), while values on other locations outside the bay area, as both maximum values and as the 90th percentile, were below 5 (excellent to good trophic state) in the 2016-2019 period. Yearly averages in the preceding period (until 2016) showed an oligotrophic to mesoeutrophic, i.e. good ecological status respective to the UNEP/MAP ratings, with occasional very high maximum measured concentrations on nearly all locations. It should be highlighted that chlorophyll *a* and TRIX index concentrations from 2016 to 2019 for locations in the Kotor and Tivat Bay are reduced compared to the preceding period (from 2008), most likely as the consequence of the cessation of operations of certain industrial facilities, as well as connecting a part of the sewage outlets of Kotor, Tivat and Herceg Novi to the sewage system and PPOV.

7.3. Pressure level assessment

The rate of impact on the marine environment caused by nutrient inflow is expressed via the marine environment trophic status rating in relation to the TRIX index and chlorophyll *a* values in the 2016-2019 period, obtained within the Coastal Sea Ecosystem Status Monitoring Programme conducted by the Environmental Protection Agency. Due to discontinuity in marine environment monitoring implementation, which also affects the adequacy of the level of data detail necessary for this testing type, an expert assessment of the total cumulative pressure on the marine environment was carried out, taking into consideration other available data, as well as the natural characteristics of the Bay and the area outside it.

The spatial distribution of pressures was analysed via GIS tools – value interpolation (see Chapter 3.1). The interpolation basis consisted of measuring points from the Programme (Table 7.6 and 7.9), for which ratings were provided based on monitoring results. Due to a relatively low density of these locations available for the entire coastline, and in order to obtain a more precise and accurate cartographic representation using interpolation, it was necessary to include additional, corrective points where values for the level of pressure on the marine environment trophic status were assigned based on expert assessment, taking into account the following:

- **Urban waste water outlets** which are the greatest source of pressure on the marine environment. Therefore, in order to assess the impact, urban waste water outlets were mapped (Maps 7.2 and 7.3) and an expert assessment provided of the intensity of impacts generating marine environment endangerment depending on their features – outlet type, distance from the coastline, and depth of urban waste water discharge. In doing so, the population density of the location on the coast, the existing tourist capacities, beaches, port, marina and quay locations were all taken into account.
- **Bathymetric and hydrodynamic features**, to assess the actual total pressure exerted by urban waste water considering the marine environment's vulnerability to pollution. Bathymetric and hydrodynamic data were taken from publicly available data, and data from a number of projects such as CAMP, ADRICOSM, ADRICOSM STAR, PORTODIMARE and others. Particular attention was given to sea water currents on the assessment site, as well as to changes in water currents depending on the testing period, and freshwater influx via tributaries, atmospheric drains etc.
- **Expert experiences** gathered via the implementation of previous monitoring, research and investment projects by Montenegrin and international institutions.

The interpolation was carried out based on a total of 150 points in space. Bearing in mind the aforementioned criteria, anthropogenic pressure assessment (impact level), on these points was made on a scale of 1-5 (Table 7.10). The interpolation resulted in a continuous value scale. For the purposes of clarity, the representation consists of 9 intervals (showing intervals in pairs of two for ratings from 1 to 4).

It must be noted that the highest rating was given to areas which potentially exhibit the highest pressure level, which could lead to occasional or more permanent high sea water trophic status, exclusively considering the marine environment status in Montenegro. These should not be viewed as zones of the highest possible eutrophication.

Table 7.10: Assessment of anthropogenic pressures on the trophic status of marine environments (pressure level)

Rating		Criteria
1	No pressure	Areas with low (or non-existent) anthropogenic impacts on marine trophic status, no significant submarine outlets nor influx of nutrients from the land; with an estimated good water circulation, i.e. locations away from the coast – open sea. For measuring points: TRIX index < 4; Chla < 2
2	Negligible pressure	Area with a smaller number of outlets, no significant impact on sea water trophic status, with an estimated good water circulation. For measuring points: TRIX index 4-5; Chla 2-3
3	Moderate pressure	Area with a moderate number of outlets and/or outlets with purification; occasional impacts of nutrients from the land on sea water trophic status, including tributaries; an estimated reduced water circulation. For measuring points: TRIX index 5; Chla 3-4
4	High pressure	Area with numerous of outlets; occasional impacts of nutrients from the land on sea water trophic status, including tributaries; an estimated reduced water circulation. For measuring points: TRIX index 5-6; Chla 4-5
5	Very high pressure	Area with numerous outlets and significant impact of nutrients from the land on sea water trophic status; an estimated poor water circulation. For measuring points: TRIX index > 6; Chla < 5

Results

Following the application of the aforementioned criteria, the spatial distribution of areas exposed to anthropogenic pressure from nutrients from land is displayed on Map 7.3.

Locations assigned a rating of 1 include the stretch from the entrance into the Bay of Kotor to Platamuni and the Trsteno Cove, a part of the thinly populated coast from Reževići to Čanj, Maljevik Cove, a part of the sea from Dobre vode to Kruč and the open sea at more than 5 km from the coast at the stretch from Dobre vode to Bojana. The fact that Luštica is currently uninhabited contributes to this status, as does the great sea depth directly by the coast with no sewage outlets and no significant nautical tourism structures, except those for small vessels. Nevertheless, according to the PPPN for the 2018 OP, the construction of tourist complexes on the Luštica peninsula and in Trašte Cove is scheduled and may adversely affect the marine ecosystem. In the Bay of Kotor, this is a narrow band by Ljuta and a part of the uninhabited coast from Dražin vrt to Perast.

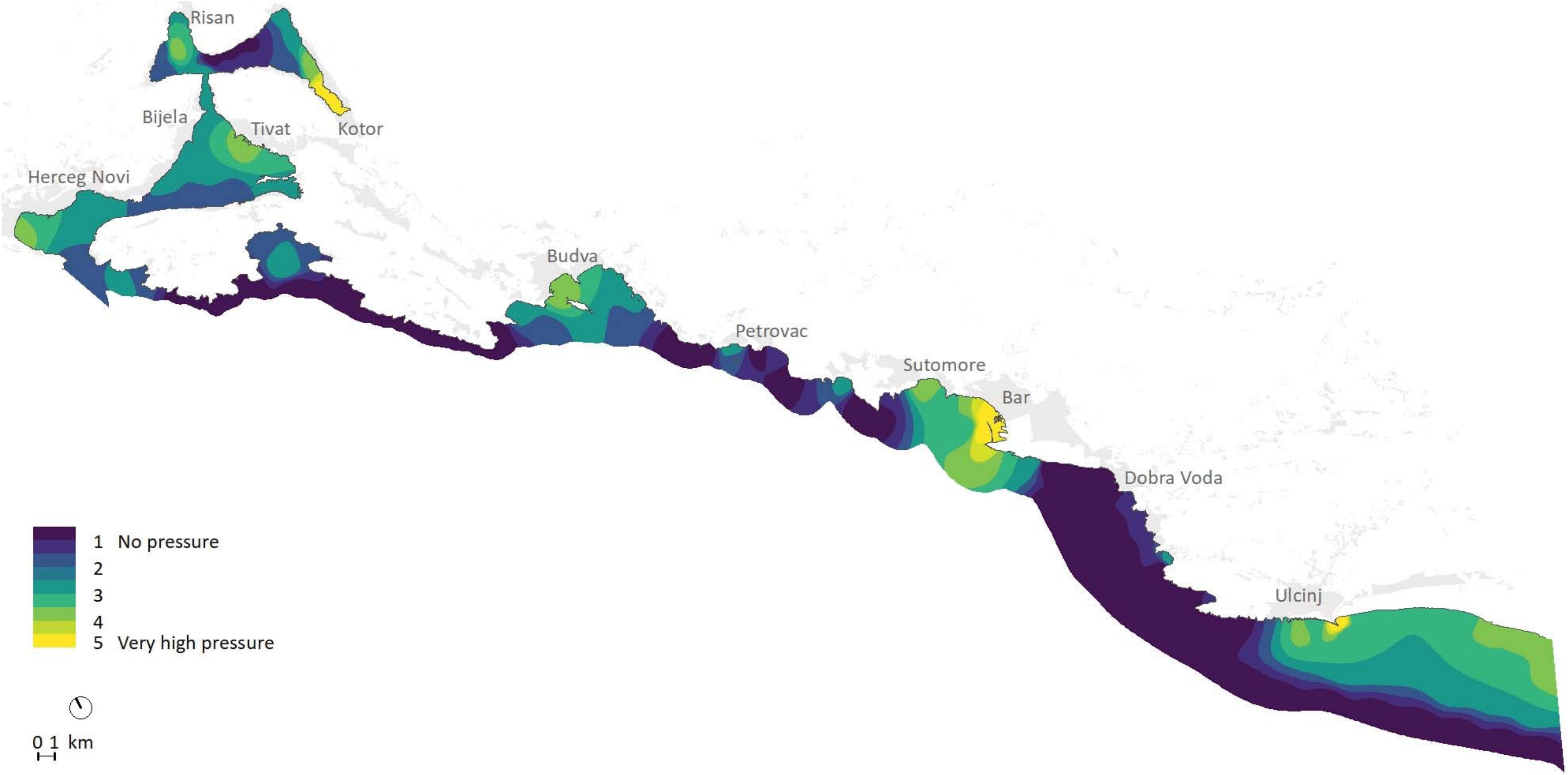
Locations assigned a rating of 5 in the Bay of Kotor comprise the narrow part of the bay at the Port of Kotor to the IBM in Dobrota, and those assigned a rating of 4 are the locations of Igalo, Zelenika, the coast at Kumbor and the Bay of Risan. As previously stated, the greatest contributor to this is nutrient input via unconnected urban waste water outlets or private facility septic tank percolation, as well as nutrient input via tributaries and groundwater from the inland. This condition is also significantly affected by the closedness of the bay, its shallow depth and poor sea water exchange. The most significant generator of the growth of the burden on the marine environment is the constant growth of tourism and settlement along the coast, which is not followed by the establishment of a sewage infrastructure at the necessary speed.

At the open part of the coast, locations assigned a rating of 5 include the aquatorium of the port and marina of Bar and the waters in the Port Milena Channel. A rating of 4 was mostly assigned to the locations of ports and discharges from major sewage outlets such as: Budva-Bečići, the central part of the Bay of Bar and Sutomore, the location of the sewage outlet next to Volujica, the location of Ada Bojana. The intensified pressure assessment is significantly affected by the influx of nutrient-rich freshwater from the Bojana River, the non-regulated outlets of hotels at Velika plaža Beach which are drained into Port Milena, the input of sewage waste water via the Bratica stream, as well as the input via torrential streams and channels bringing pollution into the coastal part of the aquatorium. Underwater outlets on the open part of the coast are mainly located at greater distances from the coast and at depths of over 20 m.

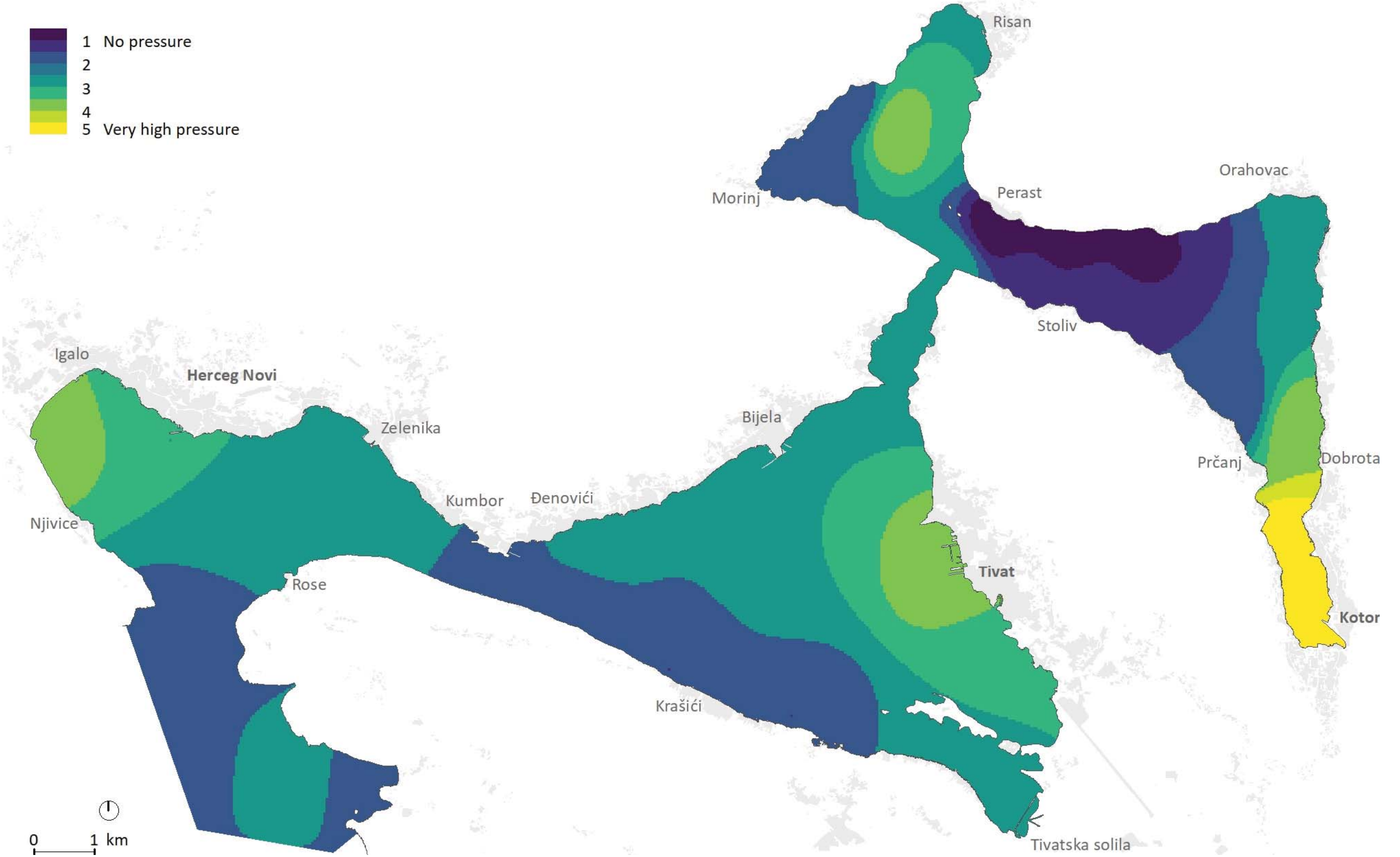
Most locations were assigned a rating of 3 and include: monitoring points in the centre of the bays of Kotor, Tivat and Herceg-Novi, the locations of Đeran, Ulcinj, Mala plaža, Petrovac, and the locations of Sveta Neđelja, Uvala Trašte and Orahovac, as well as locations in their immediate vicinity.

A rating of 2 was assigned to the monitoring locations of the coastal sea in the Bay of Budva and Sveti Stefan and Mamula.

Map 7.3: Impact level assessment regarding the Montenegro marine environment trophic status



Map 7.4: Impact level assessment regarding the Bay of Kotor marine environment trophic status



7.4. Recommendations

In accordance with the requirements of the Barcelona Convention and the Marine Strategy Framework Directive and Member State efforts to achieve a good marine environment status, rigorous application of the List of mandatory requirements of the SAP-MED and Regional plans for the EO-5 (Table 7.11) is necessary, as is the forming of a legal infrastructure for their implementation.

1. **Planning for the construction of a complete infrastructure for the collection and treatment of urban waste water via:**

- construction of a sewage system and purification facilities for urban waste water for all agglomerations in the Bay of Kotor. To that effect, connection of urban waste water outlets in Trašte and the settlements of Ljuta, Orahovac and Dražin vrt to the sewage system, construction of separate small-scale local purifyers for Risan and Perast, as well as the settlements of Muo, Prčanj, Stoliv and Markov Rt, where possible;
- remediation and connection to the central sewage system of numerous small individual sewage outlets in the Bay of Kotor which remain unconnected;
- connection of individual buildings with septic tanks onto the new sewage system;
- acceleration of the connection of all settlements in the Herceg Novi Municipality to the new collector system connected to the Meljine waste water purification facility. Mandatory connection of the hotel resort in Njivice;
- construction of new sewage systems and waste water purification facilities for all new tourist complexes (e.g. Luštica Bay and others), if they cannot be connected to existing ones;

Table 7.11: List of mandatory requirements of the SAP-MED and Regional plans for the EO-5

No.	List of mandatory requirements of the SAP-MED and Regional plans for the EO5
	EO5
1	Promotion of separate collection of atmospheric water and urban waste water
2	Promotion of effluent reuse with the aim of water resource preservation
3	Coastal towns and urban agglomerations with more than 100,000 residents connected to the sewage system
4	Ensuring all agglomerations with over 2,000 residents are connected to the sewage network and purify waste water before releasing it into the living habitat
5	Reduction of nutrient input originating from agriculture and mariculture in areas where they contribute to pollution
6	Removal of all waste water from industrial facilities which are a source of nutrients and suspended solids
7	Prevention of direct or indirect impact of excessive nutrient input and enrichment of the marine ecosystem
8	Food industries, listed in Appendix I, releasing more than 4,000 PE into a water body, must abide by the following requirements: HPK 160 mg/l, TOC 55 mg/l and BPK5 30 mg/l of effluent
9	Measures necessary for the establishment of an adequate sewage system and waste water purification facility implemented with the aim of preventing the input of pollution loads and riverine inputs
	Legislative institutional framework
10	Limiting the concentrations of main nutrients in the marine environment to ensure their concentrations do not lead to eutrophication, in accordance with the ECAP requirements
11	Adoption of emission limit values (ELV) for BPK5 in urban waste waters, after the purification facility in accordance with the requirements of the "regional instruction for the reduction of BPK5 in urban waste waters"
12	In case of food industry waste water discharge into the sewage system, the competent authority will lay down an ELV in accordance with the work process and the purification facility emission size
13	Implementation of adopted ELV on waste water values and on the monitoring of treated urban waste water input into the living habitat
14	Control of PPOV discharge and implementation of the appropriate measures in accordance with national regulations
15	Report on the implementation of measures for the reduction of BPK5 emissions from urban waste and their efficiency

- in the part of the coastal sea outside the bay, carrying out the planned activities for connecting all local sewers to the PPOV, prevention of their discharge into the sea via emergency outlets, as is frequently done in Bar, Sutomore, Ulcinj...
- construction of a sewage system for Ulcinj and Velika plaža with a waste water purification facility for all the hotels constructed, where it is currently discharged into Bratica and Port Milena. Remediation of the Port Milena Channel after connection to the sewers, in accordance with the completed project of dredging its bottom and disposing of the contaminated mud at the Hije landfill, or connecting it to the River Bojana with a channel in accordance with the existing project, which is part of the Ulcinj spatial plan currently in force.
- connection of catering establishments and individual houseboats onto the sewage system (alternatively, requirement to install separate home waste water purification devices)

2. Strict compliance with the implementation of criteria for distance from the coast. Special protection of water spring areas in the coastal zone. Prevention of solid waste input into sea water and the seabed via:

- Permanent remediation of old landfills for the urban waste of Herceg Novi on Orjen (Pode I and II) to prevent the contamination of groundwater, surface water and the sea by organic matter input by percolation from contaminated surfaces, where percolated water is drained into the Bay of Risan.
- Remediation of existing, non-regulated solid waste landfills near the coast and inland and prevention of solid waste input into the marine environment, such as that during the 2010 flooding.
- Before making a decision on the construction of a solid waste sanitation landfill for the Herceg Novi Municipality at Duboki Do, it is necessary to investigate the possible impacts of the planned landfill on groundwater and the marine environment of the Bay of Kotor.

3. Ensuring that no construction is planned near locations of particular importance for mariculture which could jeopardise the quality of water necessary for mariculture.

- In doing so, care must be given to both preventing adverse impacts on farming locations and adverse impacts on the marine environment which may be generated by the fisheries themselves, particularly in the Bay of Kotor.

4. Control and supervision measures preventing the discharge of waste and ballast waters from ships and yachts throughout the Bay of Kotor, particularly in Kotor, Tivat and Herceg Novi.

- Therefore, the construction of ballast water reception and treatment facilities is a prerequisite for the permanent solution of problems generated by this impact group.
- Kotor Port is particularly problematic as it is located in the part of the bay with very poor water circulation, while the pollution-based pressure due to urban waste water and ship-cruiser contamination discharge is increasing. Therefore, defining marine environment reception capacities and a strict regime of arrival into and departure from the port are recommended.

5. Construction of new port capacities and vessel renovation locations.

- Construction of new port capacities and vessel renovation locations is not recommended in undeveloped/*greenfield* areas from the viewpoint of preserving marine biodiversity and sea water eutrophication.

8. Contaminants in the Marine Environment

8.1. Introduction

The **ecological objective EO9** is one of the objectives concerning the good environmental status of sea water, and relates to the presence of priority organic and inorganic contaminants in sea water, sediment and biota, affecting both sea water quality and all living organisms within it. This primarily refers to the list of contaminants defined by the Barcelona Convention and the LBS Protocol: heavy metals (Hg, Cd, Pb), PCBs, organochlorine pesticides (aldrin, dieldrin, HCB, lindane, DDT metabolites), polycyclic aromatic hydrocarbons – PAHs, polychlorinated biphenyls – PCBs, aluminium (Al) and organic carbon (TOC) measured in water for the purposes of restoration to normal levels.

A good environmental status (GES) for the ecological objective EO9 is defined as: „**Contaminant concentration levels do not lead to significant harm from contamination to marine ecosystems and human health**".

The application of ecological objective **EO9** is compatible with the application of **descriptors D8 – contaminants and D9 – contaminants in seafood** of the EU Marine Strategy Framework Directive.

8.2. Indicators

The decision of the Barcelona Convention Contracting Parties IG.22/7 on the application of an Integrated Monitoring and Assessment Programme (IMAP) and relevant assessment criteria, including the application of standards recommended in the Integrated Monitoring and Assessment Programme Guidance (IMAP) prescribes the application of five key indicators within the scope of the EO9 ecological objective (Table 8.1).

Table 8.1: Indicators for the achievement of ecological objective EO9 in accordance with the MSFD (UNEP(DEPI)/MED IG.22/10))

Environmental objective EO9	Operational objective	Indicator
Contaminants cause no significant impact on coastal and marine ecosystems and human health	9.1 Priority contaminant concentration kept within acceptable limits without increase	Common indicator 17 – Concentration of key harmful contaminants measured in the relevant matrix (biota, sediment, sea water)
	9.2 Discharged contaminant impact reduced to minimum	Common indicator 18 – Level of pollution effects of key contaminants where a cause and effect relationship has been established
	9.3 Acute pollution incidents prevented and their impacts reduced to minimum	Common indicator 19 – Occurrence, origin (where possible), extent of acute pollution events (e.g. slicks from oil, oil products and hazardous substances), and their impact on biota affected by this pollution (petroleum hydrocarbon spills)
	9.4 Known harmful contaminant levels in main seafood types do not exceed defined standards	Common indicator 20 – Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels in commonly consumed seafood
	9.5 Bathing and other recreational purpose water quality is not harmful to human health	Common indicator 21 – Percentage of intestinal enterococci concentration measurements within established standards

Of the above indicators, **this material will be processed** using the environmental indicator **17** – *Concentration of key harmful contaminants measured in the relevant matrix*, for which usable data is more or less available within the framework of marine environment monitoring programmes implemented so far, as well as in other relevant sources, as explained in this document. It should be emphasised that only sediment and biota data will be used for the status assessment based on indicator 17. Within the capacities of the existing marine environment monitoring, for the purposes of this analysis, application of environmental indicators 18, 19, 20 and 21 is not possible.

Criteria used for the status assessment are prescribed by the UNEP/MAP (UNEP(DEPI)/MED 439/15 – Pollution Assessment Criteria and Thresholds), as well as the OSPAR guide "The Convention for the Protection of the Marine Environment of the North-East Atlantic" (OSPAR), displayed below in tables 8.3-8.5.

8.2.1. National marine ecosystem status monitoring

The Montenegro national marine ecosystem monitoring programme encompasses monitoring the quality of the coastal sea at a distance of one nautical mile from the coast, and it has been programmatically and methodologically developed according to the requirements of the following national regulations: The Environmental Law (Republic of Montenegro Official Gazette 48/08, 21/09, 40/11, 27/14, 52/16), the Water Act (Republic of Montenegro Official Gazette 27/07, 48/15, 52/16, 84/18), the Regulation on the Classification and Categorisation of Surface and Ground Water (Republic of Montenegro Official Gazette 02/07), the Marine Environment Protection Law (73/19) and the Ordinance on the Method and Time-limits for Surface Water Status Assessment (25/19), the requirements of relevant EU directives, the European Environment Agency (EEA) guidebook "Eurowaternet: Technical Guidelines for Implementation in Transitional, Coastal and Marine Waters", and the accompanying reporting instruction (WISE-SoE Reporting on Transitional, Coastal and Marine Waters), as well as the MEDPOL marine environment monitoring programme within the scope of the implementation of the Barcelona Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (BC) and its four accompanying Protocols, of which the Protocol for the Protection of the Mediterranean Sea Against Pollution from Land-Based Sources and Activities (the LBS Protocol) bears particular relevance for the reduction of contamination originating from land. The second five-year period report according to the LBS Protocol for Montenegro, the "National Land-Based Sources Emissions Inventory Report for Montenegro 2018" has been completed (NBB 2018) and submitted to the UNEP/MAP.

Data on contaminant content in sea water and sediment in Montenegro has been collected since the introduction of the Marine Ecosystem Monitoring ("national" monitoring) in 2008, twice per year, by the Environment Agency. "National" contaminant monitoring locations mainly entail *hot spot* locations, ports and vulnerable coastal sea locations, including:

- ports: Herceg Novi, Tivat, Kotor, Risan, Budva, Bar, Ulcinj;
- *hot spots*: Dobrota at the IBM, the Bijela Shipyard and the Porto Montenegro Marina;
- coastal sea and vulnerable area locations: Port Milena and Ada Bojana with a reference point at the entrance to the Bay of Kotor at the Mamula Island and Dobra Luka on Luštica.

A list of all locations with coordinates is provided in Annex 8.1.

Monitoring of the following contaminants takes place at the aforementioned locations, in accordance with regulations (Table 8.2):

Table 8.2: Monitored contaminant overview

Indicator		Medium
Heavy metals	Hg, Pb, Cd, Ni, Cu, Zn, Mn, As and Cr, TBT	Water, sediment
Chlorinated hydrocarbons	Pesticides and PCBs	Water, sediment
Petroleum hydrocarbons	Phenols	Water, sediment
	Mineral oils	Water, sediment
	(TOC, VOC, SVOC)	Water, sediment
Aromatic hydrocarbons	PAHs	Water, sediment
	Dioxins, DL-PCBs	Sediment

The Nature and Environment Protection Agency of Montenegro (NEPA) conducts marine ecosystem monitoring by commissioning the following competent national institutions: the Centre for Ecotoxicological Research (CETI), the Institute of Marine Biology, Kotor (IBM), and the Institute for Hydrometeorology and Seismology (IHMS). Due to financial constraints, the "Marine Ecosystem Monitoring Program" was not implemented in 2012 and 2013, while only heavy metals measurements in the sediment (and not in water nor biota) were carried out in 2014 and 2015, at a reduced number of locations. As of 2016, contaminant monitoring has been harmonised with the IMAP requirements and implemented by the Centre for Ecotoxicological Research, albeit in different time periods during the year and with a varying number of samples.

Additionally, in the previous period, marine ecosystem monitoring was also implemented via projects with the International Atomic Energy Agency – IAEA (RER/7/003 Marine Environmental Assessment of the Mediterranean Sea) UNEP-MAP&IAEA of 2005-2007 and via implementation of the Adricosm Star project with the Italian Ministry of Environment, Land and Sea of 2007-2010.

In the absence of national monitoring data for certain years, data collected during the implementation of other projects was used in the creation of this document, such as: Study of the "0" environmental status for the locations of: Kumbor-Porto Novi, Porto Montenegro, Luštica Bay, the Project of the Remediation of the Shipyard Bijela, the Adricosm-Star project, the UNIDO Project of the Rehabilitation of the Port Milena Channel – VECTON 2013 and Limnos 2016, and others.

8.3. Pressures

The greatest pressures on the Montenegrin sea in relation to contaminant input are caused by:

- port activities, bulk cargo transhipment, petroleum products, chemicals etc.;
- marinas, ship and other vessel overhaul;
- accidental pollution in the sea (but also on land);
- sea traffic, pollution discharge from ships;
- contaminant input due to runoff from polluted land areas contaminated by, first and foremost, industrial activities;
- direct discharge of contaminated waste water or solid waste matter from industrial facilities in the coastal area;
- contamination input via tributaries and the Bojana River.

Open sea

In the part of the Montenegrin coast outside of the bays, in relation to sediment concentration, there are four *hot spot* locations where water and sediment undergoes continuous monitoring within the *hot spot* and trending location monitoring: the port and marina in Budva, the port and marina in Bar, followed by Port Milena and Ada Bojana.

The Port of Bar is one of the largest point sources of coastal sea contamination. Contaminant emission stems from various activities: mechanisation labour, hazardous substance warehouses, bulk cargo, the Volujica quarry, sand production, alumina and bauxite transport etc. In Bar Port and the industrial zone, various contaminated (e.g. used oil and oiled material) and non-contaminated waste (plastics, metal (Al, Cu), glass, cardboard, waste wood, rubble, scrap iron) is made. Most solid and liquid waste is taken by the Bar company "Hemosan".

Figure 8.1: Hazardous substance tanks, port terminal and marina in Bar Port

Potential contamination sources comprise hazardous liquid storage facilities (acetic acid, phosphoric acid, base oil), freezers (ammonia), petroleum product decanting sites, natural gas reservoirs, cement silos, reservoirs (sodium oxide, caustic soda, alumina), bulk cargo (bauxite, lead ore) etc. Eight 127,000 m^3 fuel reservoirs have been built in the Port of Bar (gasoline, diesel, LPG and heating oil). Several large-scale accidents, including an oil spill from a moored tanker in the port aquatorium, and a sodium hydroxide spill from a tanker truck on the pier, took place ca. ten years ago.

The **Bar Marina** is located in the centre of Bar Bay, at a very favourable geographical and geo-traffic position, covering 100,000 m^2 of the aquatorium, with an operative coast length of 3,703 m and 8 piers, 1-9 m deep. It can accommodate the largest VIII category vessels over 18 m long, has a capacity of 900 moorings, 500 of which are commercial, and 400 belonging to locals.

The Special Use Spatial Plan for the Coastal Area (PPPN OP) by 2030 includes plans for a large-scale expansion of the Port of Bar, as well as the construction of a new port in Bigovica Cove for hazardous material.

The **Port of Bigovica** is intended for transhipment and storage of hazardous substances and cargo. The construction of 36 reservoirs with 2,000-20,000 m^3 and 14 tanks for wine, oil, phosphoric acid, machine oils etc. A petroleum product terminal with 5 reservoirs of 2,500-5,000 t is planned as well. A terminal for explosive substances is also planned for Bigovica Port.

In addition to the above, the Ionian Adriatic Pipeline is planned to pass via **Volujica**, which conflicts with the planned development of Bigovica and possibly adds to the potential danger of accidents, although the gas pipeline itself does not contaminate the environment.

In addition to the aforementioned potential dangers of accidents and marine ecosystem contamination, it must be noted that **oil and gas drilling exploration** on the coastal sea territory of Montenegro is in its beginning. Namely, in 2016 and 2017, based on the Law on Exploration and Production of Hydrocarbons, contracts on the award of concessions for the exploration and production of hydrocarbon were signed with the companies Eni and Novatek, assigning it blocks 4, 5, 9, and 10, and the company Energean Oil & Gas, assigning it blocks 30 and 26 (Figure 8.2). The total surface of the concession area of the Eni and Novatek company is ca. 1,200 km^2, and that of the Energean company is ca. 360 km^2 (surfaces highlighted in blue on Figure 8.2).

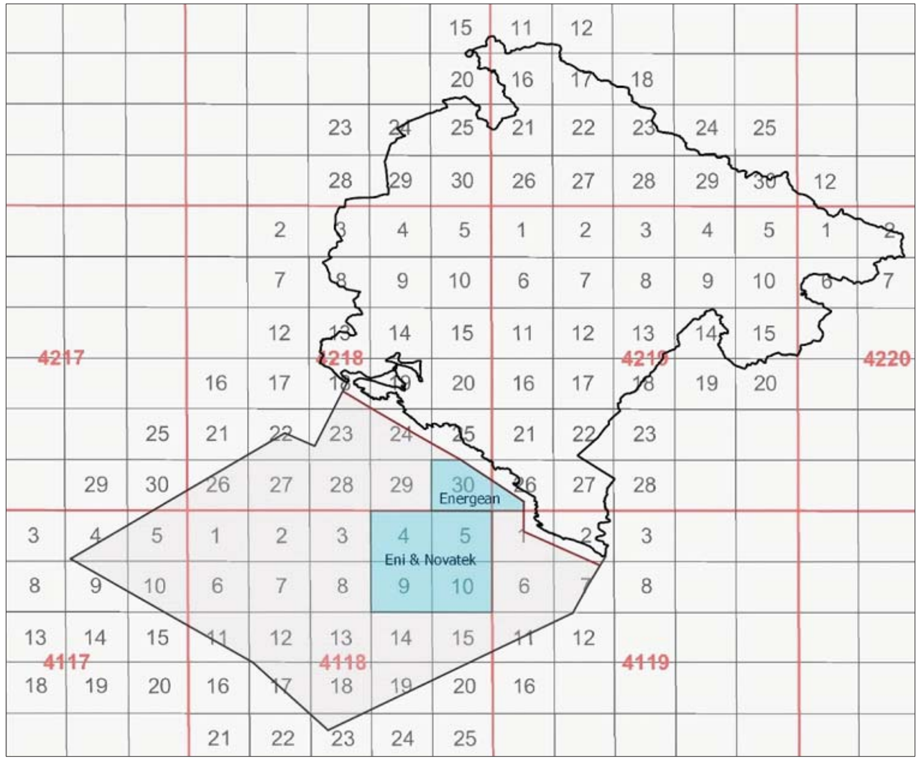


Figure 8.2: Concession areas for oil and gas exploration in Montenegro (Source: Montenegro Hydrocarbon Administration)

The Eni and Novatek company has announced the start of operations on two exploration wells: a deeper (oil) well is planned for a distance of ca. 27 km from the coast, while a shallower (gas) well is planned for ca. 10 km from the coast. Operations on the exploration wells are expected to take up ca. 6 months. The Energean company needs to find a partner by the end of 2021, and then decide on whether they will use exploration wells or not.

The Port of Budva with the Budva Marina is another monitored *hot spot*. Tourism development expansion in recent years has increased the capacities of the Budva port and marina, which significantly contributes to the increase in the contamination of these two locations, primarily with PAHs, VOCs, TPHs and mineral oils.

Figure 8.3: The city port and marina in Budva

Contamination at the *hot spot* location of the ***Bojana River estuary***, i.e. the vulnerable area location of the ***Ada Bojana Island***, has been monitored from the start of the programme during several scientific research projects. This location is affected by direct contaminant input via the Bojana River.

The location of the vulnerable area of **Port Milena** is one of the more important *hot spots*.

A relatively lower level of pressure is noted on locations on the narrow coastal area outside of the Bay of Kotor. **Petrovac** and its port, beach and existing hotel capacities is particularly vulnerable, considering the location of the potentially protected area of Katič Island, along with Buljarica Cove, where construction is planned for important tourist complexes resembling Porto Montenegro, Luštica Bay or Porto Novi, which entails the construction of a marina and other accompanying facilities which could cause sediment and sea water contamination in case of an accident.

The Bay of Kotor

In the case of the Bay of Kotor, existing or former industrial facilities and objects previously related to military activities and vessel overhaul exert the greatest pressure on contaminant input. This primarily refers to the activities of the former **Arsenal Overhaul Institute in Tivat** (now the location of Porto Montenegro) which has, during its century-long military vessel and other equipment overhaul operations, significantly contributed to the high level of soil, sediment and water contamination in the Tivat Port aquatorium and Tivat Bay. Arsenal ceased operations in 2005, which was followed by a partial location remediation by hazardous substance removal, cleaning and backfills – concreting the contaminated location. Part of the contaminants remains in the sediment as they were not dredged during reconstruction. The tourist complex of **Porto Montenegro** was constructed on that site, with no significant additional contaminant percolation or runoff from the location at the moment.

The Bijela Shipyard site is currently the most problematic site in the Bay of Kotor. The location of the shipyard is contaminated by grit waste from ship sandblasting, which is classified under hazardous waste. The land on the site is mixed with grit and soaked with waste mineral oils, heavy metals, PCBs, PAHs, TBTs and other substances which have contaminated the sediment and the groundwater in contact with the sea. Due to the seriousness of this contamination, the creation and implementation of a remediation project for this site is under way, financed by the World Bank.

Figure 8.4: Porto Montenegro – the site of the former Arsenal Overhaul Institute

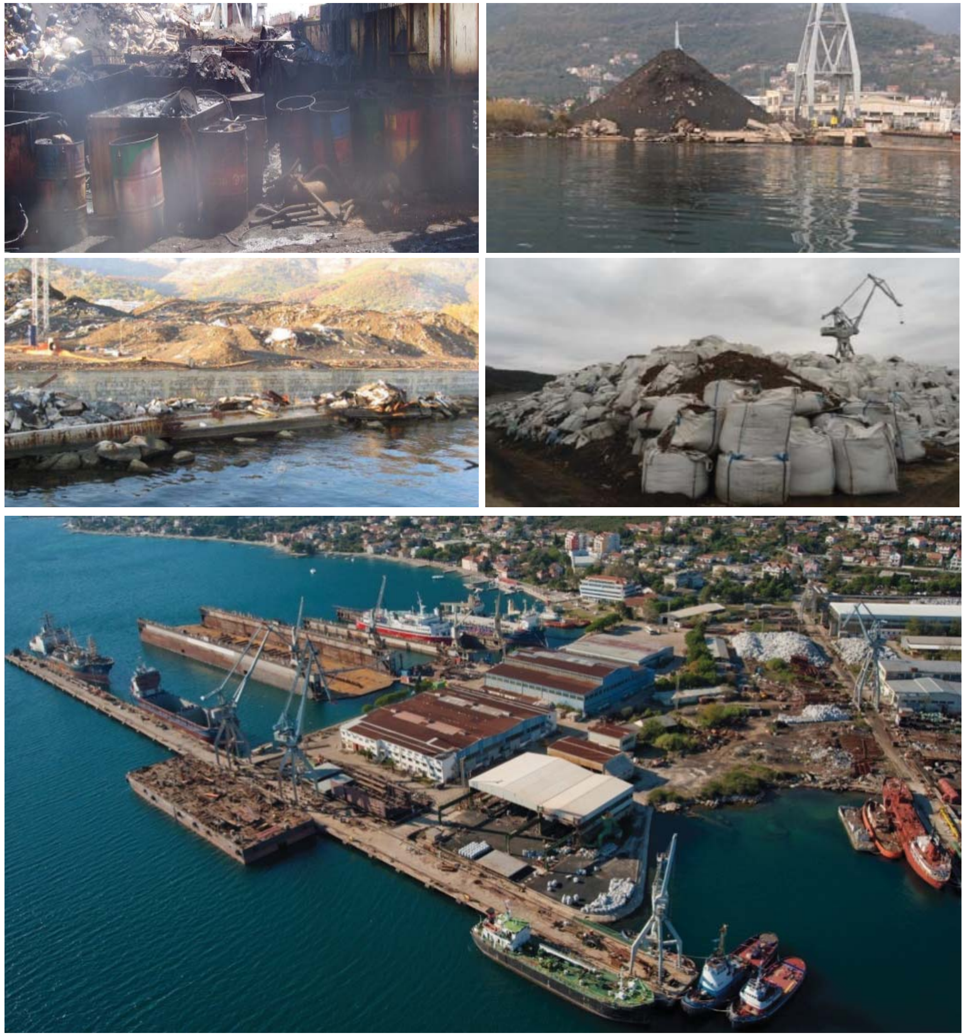


Figure 8.5: The Bijela Shipyard and grit

The shipyard ceased operations in 2015 and partially cleaned the location where, after full remediation, construction of a new overhaul centre for the Porto Montenegro Marina yachts is planned. The export of used grit and other solid hazardous waste has begun, but it has not been completed yet and the location has not yet been remediated. The soil, soaked in petroleum products, and the sediment contaminated over a long period of time, remain problematic. The project calls for a total excavation of 141,648 t of polluted land, 110,000 t of which is grit. The selected solution entails the excavation and exporting of all contaminated soil and grit, while clean grit is immobilised on site and used for the site's remediation. Additionally, a curtain injection towards the sea is planned in order to prevent contamination with inland groundwater contaminated by TPH, TBT and heavy metals and petroleum products. Alongside the above, from August to October 2018, supplemental tests of the terrain surfaces, groundwater, aquatorium and sediment were carried out to assess whether sediment dredging is necessary. All operations are expected to be completed by the end of 2021.

The **industrial zone in Kotor** („Autoremont", detergent factory „Rivijera", „Daido metal" and others) was the third major contaminant source. These industries have relocated to Grbaljsko polje, but the consequences of many years of their operation and contamination are still present, albeit to a much smaller extent. Other former military sites in the Bay of Kotor (Kumbor, the bases on Luštica, Kobila etc.) connected to military or port activities, were also exposed to contaminant pollution during a longer period of time. All port aquatoriums in the Bay also show elevated contents of heavy metals, PAHs and TBT compounds, and mineral oils of petroleum origin – TPH, VOC.

The input of toxicants linked to agricultural activities (pesticides) is not pronounced in the Bay of Kotor nor on the open part of the coast as there are no surfaces in the surroundings marked by intensive agricultural production, and such production in this region is mainly done in a traditional way as well. However, DDT metabolites are still present on certain locations, as it was widely used after World War 2 for mosquito and other insect control for malaria prevention, particularly in the surroundings of Ulcinj and the Bojana delta.

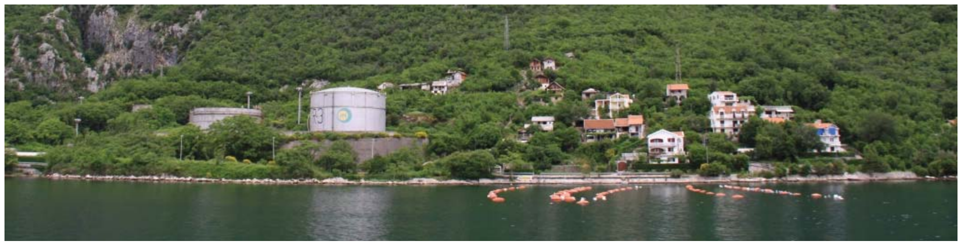


Figure 8.6: Petroleum product warehouse in Lipci near Risan

Alongside the above, petroleum product warehouses (tanks) are located in **Lipci near Risan**, and are currently not active but pose a potential hazard for the marine ecosystem of the Bay.

In addition to the main contamination sources, the Bay of Kotor and the port aquatoriums of the ports of Kotor, Risan, Tivat, Zelenika and Herceg Novi, as well as a large number of smaller harbours and mooring sites, are the sites of overhaul and painting of small boats and other activities with a contaminating effect (PAHs, TBTs, TPHs) on the marine aquatorium of the Bay of Kotor. It should also be noted that there are occasional environmental accidents during overhaul in the Porto Montenegro Marina and at the Bijela Shipyard, as well as oil contamination accidents caused by unknown perpetrators (vessels) which also contribute to the total pressure on the Bay of Kotor. In 2017, the construction of the new "Porto Novi" tourist complex began on the site of the military complex in Kumbor, comprising the construction of a marina, a port and tourist facilities. Such activities, as well as the future activities of this complex, are a potential contamination hazard for this site.

Torrential streams and atmospheric drains are major contributors as well, particularly during heavy rain periods, and input significant volumes of contaminants from roads, illegal waste dumps, and the former Herceg Novi landfills on the slopes of Orjen, which percolate via groundwater into the Bay of Risan. In addition to the above, it should be noted that numerous transformer substations in Tivat, the Bijela Shipyard and other CEDIS locations along the entire coast, still store old transformers and capacitors filled with pyralene (PCBs), which pose a great danger to the Bay of Kotor ecosystem due to their high persistency and bioaccumulative properties.

8.4. Contaminant concentration in sediment, biota and water

8.4.1. Threshold value determination for contaminants

To determine the biota and sediment contamination rate, the use of methodologies for the application of criteria for the assessment of hazardous substances in the Mediterranean, and of methodologies for the development of criteria for threshold value determination for contaminants listed in UNEP documentation (DEPI)MED WG.427/Inf.3. and UNEP(DEPI)/MED 439/15 – Pollution Assessment Criteria and Thresholds, is recommended.

The methodology proposes two thresholds (T_0 i T_1) for sediment and biota: T_0 defines contaminant concentration on "unaffected locations" where environment degradation is not expected, while T_1 is the contaminant concentration threshold above which adverse impacts on the environment and human health are expected (ERL). A contamination level between T_0 and T_1 (Graph 8.1) does not pose a significant risk to the environment and human health (BAC).

Therefore, contamination rate determination is carried out according to the concentration threshold values laid down by the UNEP/MAP for the Mediterranean Sea, in accordance with the OSPAR Convention approach, whereby **values for the assessment of acceptable concentrations (BAC)** of organic contaminants (chlorinated hydrocarbons and PAHs) have been defined (tables 8.3, 8.4).

The UNEP/MAP (i.e. OSPAR) criteria for metals, PAHs, PCBs and organochlorine pesticides in marine sediments are displayed in tables 8.3, 8.4 and 8.5.

Graph 8.1: Transition points for metals, PAHs and chlorinated hydrocarbons in sediment

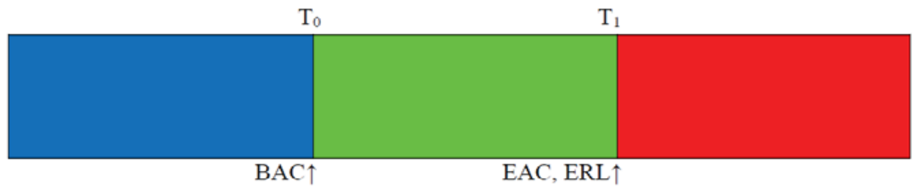


Table 8.3: UNEP/MAP criteria for metals in sediments (UNEP(DEPI)/MED 439/15)

Parameter	Sediment (µg/kg dw)		
Metals	***Med BC***	***Med BAC***	***ERL***
Cadmium	85	127.5	1,200
Mercury	53	79.5	150
Lead	16,950	25,425	46,700

OSPAR Sediment contaminant criteria (µg/kg dw)			
Metals	***BC***	***BAC***	***ERL***
Arsenic	15,000	25,000	/
Chromium	60,000	81,000	81,000
Copper	20,000	27,000	34,000
Nickel	30,000	36,000	/
Zinc	90,000	122,000	50,000
TBT	/	/	/

Table 8.4: UNEP/MAP criteria for PAHs in marine sediments (UNEP(DEPI)/MED 439/15)

Parameter	Sediment (µg/kg dw)		
	OSPAR BC	***OSPAR BAC***	***ERL***
Naphtalene	5	8	160
Acenaphthylene	/	/	/
Acenaphthene	/	/	/
Fluorene	/	/	/
Phenanthrene	4	7,3	240
Anthracene	1	1,8	85
Fluoranthene	7,5	14,4	600
Pyrene	6	11,3	665
Benzo(a)anthracene	3,5	7,1	261
Chrysene	4	8	384
Benzo (k) fluoranthene	/	/	/
Benzo(a)pyrene	4	8,2	430
Benzo(g,h,i)perylene	3,5	6,9	85
Indeno(1.2.3-cd)pyrene	4	8,3	240

Table 8.5: OSPAR criteria for PCB congeners and organochlorine pesticides in marine sediments

Parameter	Sediment (μg/kg dw)			
	BC	*BAC*	*EAC*	*ERL*
PCB congeners				
PCB 28	0.05	0.22	1.7	/
PCB 52	0.05	0.12	2.7	/
PCB 101	0.05	0.14	3.0	/
PCB 105	0.05	/	/	/
PCB 118	0.05	0.17	0.6	/
PCB 138	0.05	0.15	7.9	/
PCB 153	0.05	0.19	40	/
PCB 156	0.05	/	/	/
PCB 180	0.05	0.10	12	/
Pesticides				
Lindane	0.05	0.13	/	3.0
α-HCH	/	/	/	/
DDE (p,p')	0.05	0.09	/	2.2
Hexachlorobenzene	0.05	0.16	/	20
Dieldrin	0.05	0.19	/	2.0

8.4.2. Sediment contamination

Contaminated sediment is a long-lasting source of sea water contamination, and one of the main causes of the accumulation of toxicants in bioindicators and biota in the sea, which may affect human health via the food chain. Sediment migrates due to marine currents and tides (ca. 3.5 m/s), as well as during the passage or anchoring of ships, which may lead to contamination transport from *hot spots* to broader sections of the aquatorium.

A ***high sediment contamination rate*** by **Hg, Pb, PCBs and PAHs (benzo-a-pyrene (BaP)** has been detected on locations in the Bay of Kotor including: Dobrota next to the Institute of Marine Biology (IBM), the Port of Kotor, the port and marina in Tivat, Herceg Novi and the Bijela Shipyard. Sediment contamination has also been detected on locations in the Port of Risan, but not in concentrations exceeding the maximum allowed concentrations (UNEP/MAP and OSPAR; tables 8.3-8.5), except for mercury content, which shows a contamination rate requiring dredging of the contaminated sediment (Annex 8.2).

The most polluted locations outside of the bays are the port aquatoriums of the Bar and Budva. Sediment in the ports of Bar and Budva are contaminated by the following heavy metals: As, Hg, Cd, Pb, Cu, Pb, Zn exceeding the BAC and ERL, and occasionally PAHs, benzo-a-pyrene (BaP) and PCBs (Annex 8.2).

Samples taken in 2020 per transect show a significantly lower rate of contamination by metals and organic pollutants than samples tested as part of previous monitoring activities (2008-2019). Sampling spots include locations relatively far from the coast, i.e. from contamination sources, industrial waste water, solid waste, traffic, industry, ship anchorages and overhaul sites. The Pb and Cd content shows the greatest deviation from standard values, while other metals are below the BAC. There is a notable absence of the organic contaminants of PAHs, PCBs and pesticides in all tested samples.

Comparison of sediment quality data for *hot spot* locations outside of the bays with locations in the Bay of Kotor reveals a significant difference. **Namely, the sediment contamination rate in the Bay of Kotor is still multiple times higher than that in the coastal sea part outside of the bay**, even though two of the most prominent polluters ceased operations 5 or more years ago (the Arsenal in Tivat 15 years ago and the Bijela Shipyard 5 years ago), but the contaminated sediment has not been dredged, meaning it continues to cause significant contamination to these locations and to the entire bay itself.

An overview and contamination ratings for sediment contaminants for the period 2016-2019 is provided in tables 8.6, 8.7 and 8.9.

8.4.3. Biota contamination

An analysis of data related to the contamination of biota, shellfish – mussels (*Mytillus galoprovincialis*) – and fish shows insufficient data from the beginning of monitoring activities both per number of locations and per monitoring series length. Additionally, locations monitored within the farm monitoring for the Ministry of Agriculture, Forestry and Water Economy mainly mismatch with contaminant monitoring locations within marine environment monitoring. In 2016, experimental biomarker determination was carried out only for acetylcholinesterase activity in mussel gill tissue, and damage to the genetic material of shellfish hemocyte (*Mytillus galoprovincialis*) using the comet assay and micronucleus test at five locations: Dobrota IBM,Tivat, Orahovac (RF), Bijela Shipyard and Stoliv. The highest contaminant pressure has been discovered in Tivat and Bijela, and the lowest in Orahovac and Dobrota. Shellfish contaminants were not examined.

In 2017, shellfish at the same locations were monitored for contaminant content as prescribed by the UNEP/MAP: Cd, Hg, Pb, organochlorine pesticides and PCBs, chlorobenzene, PCDDs and PCDFs, as well as organotin compounds, though they have not been standardised by the UNEP/MAP-OSPAR. For the 2018 and 2019 monitoring, the number of locations increased to the following eight: Dobrota IBM, Bijela Shipyard, Risan Port, Herceg Novi Port, Budva Port, Bar Port and Port Milena, and fish were monitored as well, on the following locations: IBM-Dobrota, Bijela Shipyard, Herceg Novi Port, Risan Port, Porto Montenegro, Ulcinj – Port Milena, Bar Port and Budva Port.

Based on the entire resulting dataset, the Cd content in samples of the tested biota from all locations was below the BAC, except for the Port of Bar where it exceeded the BAC. The Hg content in all samples was below the BAC, while the Pb content exceeded the EAC in the **Port of Tivat** and the BAC in the ports of Bar and Kotor, and remained < BAC on all other locations. The 7 PCB congener content exceeded the BAC on all locations, except Stoliv and the Port of Budva where it was < BAC. Organochlorine pesticide was not detected on any of the locations, while the PAH, i.e. BaP content was on the BAC level on all locations except Stoliv where it was < BAC (Annex 8.3).

An overview and contamination ratings for contaminants in the biota for the

Table 8.6: Concentration rating for contaminants in the sediment and biota at hot spot and trending locations based on measurement results for the period 2016-2019

* LD – Method detection limit

National monitoring locations	2016-2020		Contaminant concentration rating
Port of Kotor HS	Biota	Reference substances	Levels of heavy metals Cd and Hg were < BAC, while Pb was > BAC, identical to the content of the contaminants $\sum$7CBs and CES and PAHs, while organochlorine pesticide content was not detected at levels < LD*.
Very fine sediment 0.032-0.125 mm – 72.5% and 21.9% 0.125-0.5 mm		Note	This location was only monitored in the last 2 years, meaning it cannot be used as a representative location for rating.
	Sediment	Reference substances	Heavy metals contamination: Cd, Hg, Cu, Ni, Cd, Pb, Cr, and organic contaminants PCBs, TBT and PAHs determined by monitoring over several years. The rate of contamination by Cd, Pb, Hg, PAHs and PCB exceeded concentrations > ERL under UNEP/MAP and OSPAR.
		Note	–
Dobrota – IBM OS-1	Biota	Reference substances	Levels of the contaminants Cd, Hg and Pb in the monitoring period of 2018 and 2019 were at the BAC level, as was the PCB and PAH content in shellfish.
Very fine sediment 0.032-0.125 mm – 75.5% and 23.9% 0.125-0.5 mm		Note	The location was monitored for a long period of time, but demonstrated somewhat higher contaminant levels.
	Sediment	Reference substances	Heavy metals contamination: Hg, Cu, Ni, Zn, Ni, Cd, PCBs, ppDDE, MBT, TBT, PCBs, PAH. The rate of contamination with Hg, Pb and PCBs exceeded concentrations > ERL under UNEP/MAP and OSPAR.
		Note	The location was monitored for a long period of time but demonstrated somewhat higher contamination levels.
Orahovac OS-2	Biota	Reference substances	All tested parameters for shellfish at the RF location for shellfish mariculture were at levels < BAC, except Cd and PCBs, which were occasionally at levels > BAC. This location was monitored for water quality parameters as a vulnerable area, rather than for contaminants. Shellfish biotests confirmed low levels of contamination.
		Note	This location has been used for farming at the drinking water spring for Kotor over many years.
	Sediment	Reference substances	This location is not monitored within contaminant monitoring, rather it is monitored as a reference point for the monitoring of shellfish farms without sediment analysis. Sea water quality was occasionally monitored as the OS-2 vulnerable area.
		Note	There are no data on sediment contamination.
Stoliv	Biota	Reference substances	All measured contaminant values arroding to the UNEP/MAP were at levels < BAC except for Cd content which was at levels > BAC.
		Note	Data originate from a farming site which is not continuously monitored within the contamination monitoring programme.
	Sediment	Reference substances	No data on sediment or water quality exist for the location, and it was monitored only in May of 2017.
		Note	Data originate from a farming site which is not continuously monitored within the contamination monitoring programme.

National monitoring locations	2016-2020		Contaminant concentration rating
Port of Risan RI Very fine sediment 0.032-0.125 mm – 72.6% and 26.9% 0.125-0.5 mm	Biota	Reference substances	The content of Cd,Hg and Pb was at BC and BAC levels, while organic contaminants ∑7CBs, PAHs and pesticides were at levels > BAC for a longer time period.
		Note	Small dataset on the location.
	Sediment	Reference substances	Of the contaminants tested, Hg and ∑7CBs exceed the ERL, while the other ones remain at levels > BAC.
		Note	The location was used as a bulk cargo port for many years.
Porto Montenegro HS Very fine sediment 0.032-0.125 mm – 78.2% and 21.5% 0.125-0.5 mm	Biota	Reference substances	The contaminant content of Cd, Hg and Pb in the monitored period was at levels < BAC, while the organic contaminant levels were > BAC.
		Note	The location was occasionally monitored as a rating for the Tivat location. Small number of samples.
	Sediment	Reference substances	High heavy metals contamination: Hg, Cu, Ni, Pb, Zn, Ni, Cr, As, MBT, DBT, TBT, P∑7CBs, and PAHs. The content of PAHs – BaPs significantly exceeded the >> ERL UNEP/MAP and OSPAR. The level of contamination with Pb, Zn, Hg, PCBs and PAHs exceeded the ERL. Sediment contamination also spreads to sea water and biological organisms and threatens the waters of the nearby bathing site.
		Note	As many as 15 years after operations ceased, the sediment contamination continues to exceed the ERL thresholds as the sediment has not been dredged.
Port of Tivat Very fine sediment 0.032-0.125 mm – 78.2% and 21.5% 0.125-0.5 mm	Biota	Reference substances	This location is very similar to the previous one as the content of Cd and Hg in the observed period was at the levels of the BC and BAC, but the contamination rate by Pb exceeded the EAC, with the remaining parameters at levels < BAC.
		Note	Small amount of data on the location.
	Sediment	Reference substances	Heavy metals contamination over many years: Hg, Cu, Ni, TBT and PCBs, PAHs. The content of Hg and ∑7CBs is > ERL according to the UNEP/MAP and OSPAR , and that of OTC and Cr contamination exceeds the target values of the BAC.
		Note	The Hg level has been decreasing in recent years.
Bijela Shipyard HS Very fine sediment 77.4% > 0.125 mm – 53.3% and 11.6% > 0.125-0.5 mm	Biota	Reference substances	The Cd, Hg and Pb content detected in shellfish in the 2017-2020 period was at levels < BAC, as was the organochlorine pesticide content, but the PCB and PAH content was at levels > BAC.
		Note	The organotin compound contamination rate is high, but is not rated according to the UNEP/MAP.
	Sediment	Reference substances	Very high heavy metals contamination over many years: Hg, Cu, Ni, Pb, Zn, Cd, Cr, As, Sn, Se, MBT, DBT, TBT, PAHs, PCBs. The contamination level of Pb, Hg, Cu, Cr, Ni, TBT, PCBs and PAHs substantially exceeded the maximum allowed concentrations >> ERL UNEP/MAP and OSPAR, while the Cd content is at levels > BAC.
		Note	The sediment was not dredged after the closing of the shipyard.

National monitoring locations	2016-2020		Contaminant concentration rating
Port of Herceg Novi HS 70.7% of very fine sediment 0.063-0.125 mm and 26.26% 0.125-0.5 mm	Biota	Reference substances	The content of the heavy metals Cd, Hg and Pb was at levels < BAC, while the content of PCBs and PAHs was at the level of the BAC. Pesticides are at the level of the BC.
		Note	Small amount of data.
	Sediment	Reference substances	Levels of contamination by Hg, Pb, Cu i TBT were above > ERL according to the UNEP/MAP and OSPAR, while PCBs and PAHs > EAC. Pesticide levels were at the BC or < LD.
		Note	–
Luštica – Mamula MNE 08 Very fine sediment 0.032-0.125 mm 72.2%	Biota	Reference substances	Contaminant content in the biota at the Mamula location was not monitored.
		Note	–
	Sediment	Reference substances	Sediment quality at the entrance to the Bay of Kotor in the 2016-2020 period is mainly satisfactory. All contaminant values were mainly < BAC, except for Hg > BAC in the 2008-2014 period and in 2017. Sediment samples in 2020 show similar results.
		Note	–
Luštica – Dobra luka ER 67% > 0.125 mm and 30.5% > 500 mm	Biota	Reference substances	Contaminant content at Dobra Luka was not monitored as part of sediment monitoring.
		Note	–
	Sediment	Reference substances	Sediment quality at the reference location was at levels < BAC.
		Note	–
Port of Budva HS 76.6% of very fine sediment of 0.063-0.125 mm and 20.2% 0.125-0.5 mm	Biota	Reference substances	Metal content in the biota was at levels < BAC as were the concentrations of PCBs and PAHs, while pesticides were below LD.
		Note	Small amount of data.
	Sediment	Reference substances	The levels of contamination by PCBs were > ERL, while those by PAHs > BAC < ERL. The level of OH pesticide contamination was within acceptable limits of BAC ili < LD. Moderate heavy metals contamination: Pb, Cd, Ni, As, Cu and Cr in the period 2016-2020 < BAC, while the content of Hg > ERL.
		Note	The Budva-Jaz site was not covered by sediment and biota contamination control – only that of sea water.

National monitoring locations	2016-2020		Contaminant concentration rating
Port of Bar – HS and E-5 Very fine sediment 0.032.-0.125 mm 84.5%	Biota	Reference substances	Heavy metals content data for Cd i Hg in the biota show levels < BAC, while contamination levels for Pb > ERL, i.e. EAC. Contamination by PCBs and PAHs was at the levels of BAC < ERL, and that by OH pesticides at levels < BAC, or < LD.
		Note	Small amount of data.
	Sediment	Reference substances	For the period of 2016-2020, at the HS location, high levels of contamination by Hg, Pb, Cd above the ERL, as well as Cu, Ni, As, and Zn were detected. The concentrations of PCBs were > ERL, and those of PAHs > BAC < ERL, while those of OH pesticides were at levels > BAC, < LD. The nearby E-05 location exhibited moderate heavy metals contamination by: Hg, Pb, Cd, as well as Cu, Ni, As and Cr in the period of 2014-2017 > BAC.
		Note	The location wasn't monitored after 2017.
Port Milena OS-5 Very fine sediment 0.032-0.125 mm – 95.32% and 3.9% 0.125-0.5 mm	Biota	Reference substances	The content of heavy metals Cd, Hg, Pb in the observed period was at levels < BAC, as was the content of the contaminants PCBs, PAHs and organochlorine pesticides.
		Note	Small amount of data.
	Sediment	Reference substances	The sampling location is on the north-west (NW) side of Đeran Cape, before reaching the estuary of Port Milena, with waste water from Solana, the hotel, settlement and stream of Bratica, with a low sediment contamination rate – Hg, Cd and Pb at levels < BAC. In the 2016-2019 period, Cr and Ni >> than the ERL, which is interpreted as a natural feature of the geological structure. The content of PCBs and PAHs was at levels < BAC, and that of pesticides below the limits detectable by this method.
		Note	–
Ada Bojana OS-6 or E-7 96.1% of very fine sediment 0.063-0.125 m	Biota	Reference substances	Biota was monitored at the location only in the last 2 years. The content of Cd, Hg and Pb and PAHs was at levels < BAC, while that of PAHs was at levels > BAC.
		Note	Small amount of data.
	Sediment	Reference substances	At the OS-6 location, in the 2016-2019 period, high concentrations were detected for Cr and Ni > ERL (natural content), while concentrations of Cd, Pb and Hg were at levels < BAC, as were the concentrations of PCBs and OH-pesticides. During the measurement period, the PAHs were at levels < BAC, < LD. At the E-7 location, in 2016-2019, elevated heavy metals content was detected for Cr and Ni > BAC < ERL (geochemical origin), while that of Hg < BAC. The contents of organic pollutants PAHs, PCBs, TBTs and OH pesticides were at BC levels.
		Note	–

Table 8.7: Concentration rating for contaminants in sediment based on measurement results within the GEF Adriatic project (2019)

Sediment sampling locations	2019	Contamination rating
Luštica Transect T-1, 2, 3	Reference substances	Sediment quality at the entrance to the Bay of Kotor T-1 in 2019 is satisfactory. All values for contaminants Pb, Cd and Hg < BAC at all three locations, as well as those for PAHs and pesticides < BAC, while PCBs equaled BAC at location 1, and < BAC at locations 2 and 3.
	Note	All three sediment sample locations on open – deep sea more than 5 m from the coast show relatively high sediment purity, as all tested parameters were BC or < BAC. Biota contaminants were not examined.
Transekt Budva T-4, 5, 6	Reference substances	The T-4 location, next to the Port of Budva, exhibits moderate heavy metals contamination by: Hg, Cu, Pb, Cd, Ni, As and Cr in 2016-2020 < BAC, identical to the nearby location of E-06, while all parameters on location T-4 (Cd, Pb, Hg, and PCBs) were < BAC in 2020. On all three transect locations in 2020, Cd > BC < BAC and Pb, Hg < BC, while PAHs, PCBs and pesticide levels were < BAC.
	Note	All three sediment sample locations on open – deep sea more than 5 m from the coast show relatively high sediment purity, as all tested parameters were < BC or < BAC. Biota contaminants were not examined.
Transekt Petrovac T-7, 8, 9, 10	Reference substances	Sediment analysis at T-7 of the Petrovac transect in 2019 shows that the parameters tested at location T-7, Dubovica at Petrovac of Pb, Hg, PAHs, PCBs < BAC except for Cd > BAC < ERL, which points to relatively low heavy metals contamination. Location T-8 on the open sea had a relatively low contamination rate for Pb, Hg, and Cd below BAC. Location T-9 showed levels of Hg and Cd < BAC, and Pb > BAC < ERL, and organic parameters at levels < BAC.
	Note	Point T-7 is affected by the Port of Budva.
Port of Ulcinj Transect T-11, 12, 13, 14	Reference substances	In 2019, all the measured heavy metals and organic contaminant values were below BAC concentrations. The location at transects T-12 shows somewhat elevated lead concentrations – Pb > BAC < ERL, which indicates that its presence may affect biological organisms. Hg and Cd content was < BAC. Only T-13 locations per transect show somewhat elevated lead concentrations with Pb > BAC < ERL, indicating that its presence may affect biological organisms. Hg and Cd content was < BAC. Organic parameters at levels < BAC.
	Note	Mildly elevated Pb concentrations are most likely the consequence of input via the Bojana River.
Velika plaža Bojana Estuary Transect T-15, 16, 17	Reference substances	Data from the T-15 of 2019 indicate that all tested parameters were < BAC. Only T-16 locations per transect show somewhat elevated lead concentrations with Pb > BAC < ERL, indicating that its presence may affect biological organisms. Hg and Cd content was < BAC. Organic parameters < BAC.
	Note	Elevated Pb concentrations at locations more distant from the coast are most likely the consequence of input via the Bojana River.

8.5. Contaminant pressure level ratings

Ratings of the levels of contaminant pressure are primarily based on mean values (for the period 2016-2020) of concentrations of contaminant groups and their relationship according to the defined threshold values (BAC, ERL/EC), as shown in Table 8.8. Considering the ratio of contaminants exceeding the allowed concentrations, score assignment per measuring location was done on a scale of 1 to 6 (Table 8.9), separately for both biota and sediment. The overal rating assigned is the result of expert assessment, taking sediment and biota results into consideration separately. Valuation was performed by defining the location with the overall maximum ratings awarded (Bar – biota 4, sediment 6), and valuation of other measuring locations was calibrated in relation to it:

- Locations with maximum ratings for sediment and biota of 3 and 4, respectively, are awarded a total rating of 6;
- Locations with maximum ratings for sediment and biota of 2, are awarded a total rating of 5;
- Locations with maximum ratings for sediment and biota of 1, are awarded a total rating of 4;
- The total rating for locations with a sediment rating of 5 is done in the same way.

The spatial distribution of results was carried out by interpolating values (see Chapter 3.1) assumed to be homogenous in terms of hydrodynamic conditions. The interpolation basis is formed by national monitoring locations and ratings for those locations (Table 8.9). Due to a relatively low density of these locations available for the entire coastline, and in order to obtain a more precise and accurate cartographic representation using interpolation, it was necessary to include additional, corrective points where values for the level of pressure by contaminants were assigned based on expert assessment, taking into account the following:

- data from earlier (prior to 2016), occasionally implemented monitoring programmes, research and projects;
- coast/aquatorium type, taking into account that the adverse effects of contamination are more prominent in enclosed aquatoriums of ports or straits;
- bathymetry conditions, considering the decrease of the direct impact of existing contamination accompanying the increase in depth.

The interpolation resulted in a continuous value scale. For the purposes of clarity, the representation consists of 10 intervals (showing intervals in pairs of two for ratings from 1 to 4).

Table 8.8: Criteria for the assessment of contaminant pressure levels for biota and sediment

Rating		Criteria
1	No pressure	All parameters at a level below the BAC (or only one at the level of the BAC). No parameters at the levels of ERL/EC.
2	Negligible pressure	Two or more parameters at the level of the BAC. Other parameters below the BAC. No parameters at the levels of ERL/EC.
3	Moderate pressure	Only one parameter at the level of the ERL (if it repeatedly exceeds the permitted values +1)
4	High pressure	Two parameters at the level of the ERL (if they repeatedly exceed the permitted values +1)
5	Very high pressure	Three parameters at the level of the ERL.
6	Unacceptable pressure	Three or more parameters at the level of the ERL, of which one or more significantly exceed the prescribed standards

By applying this approach, Map 8.1 provides a spatial representation of the assessment of the levels of contaminant pressure on the marine environment (sediment, biota) in the period 2016-2020, by applying the common environment indicator 17.

It is important to note that the scopes of the represented pressure zones are for information purposes only, created as the result of the described interpolation in the GIS, rather than the result of precise particle dispersion models.

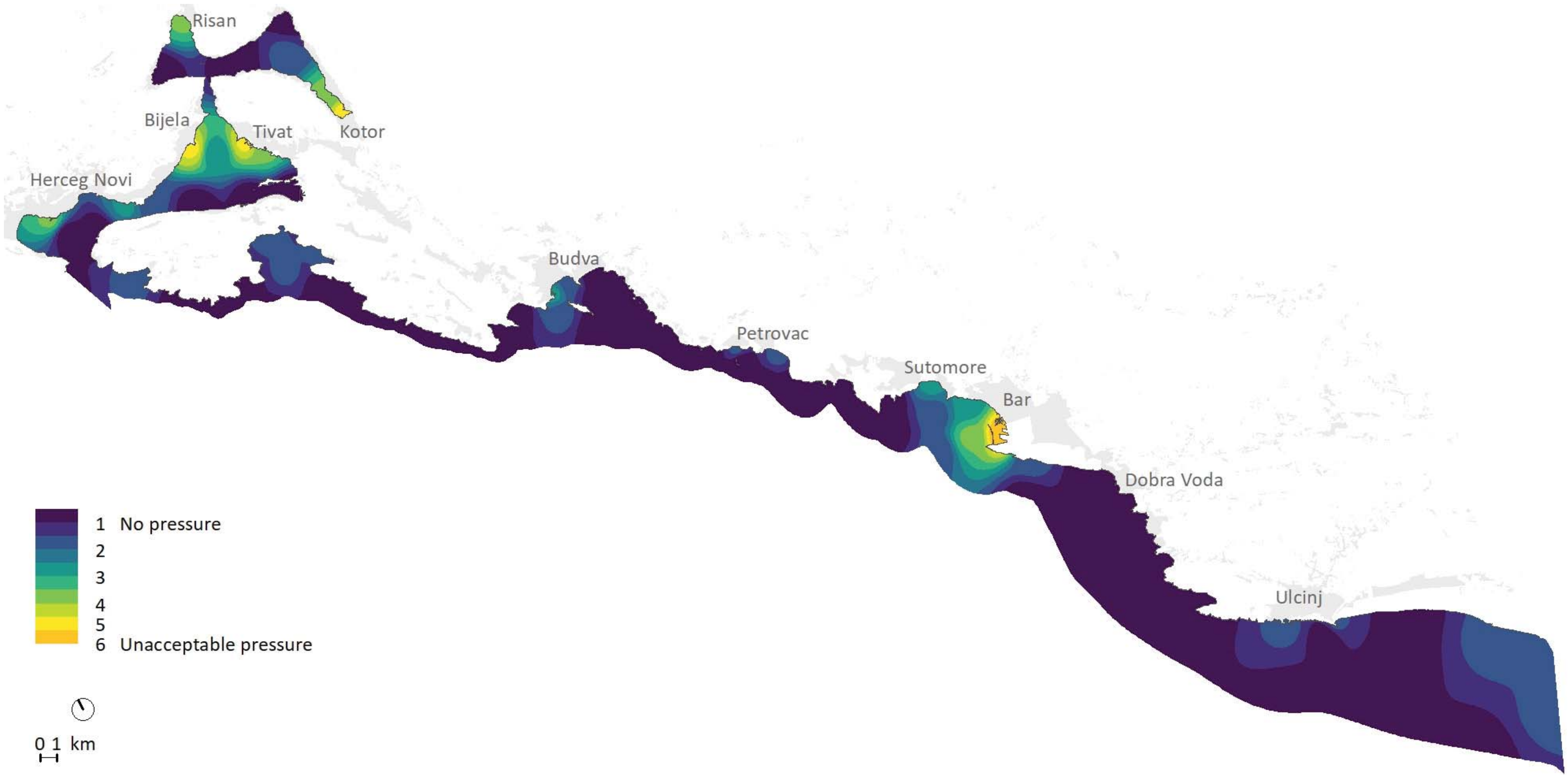
Table 8.9: Assessment of the levels of contaminant pressure on the marine environment for the period 2016-2019 on the basis of the UNEP/MAP ecological criteria for rating

Blue coloring: < BAC
Green coloring: >BAC and < ERL
Red coloring: ERL (EC for biota) and >> ERL

	Cadmium		Mercury		Lead		$\sum$7CBs ICES		Benzo(a)pyrene		Pesticides: HCB, Lindane, DDTs		Rating of pressure on sediment and biota 1-6		Total rating
µg/kg dw	Biota	Sediment	Biota	Sediment	Biota	Sediment	Biota	Sediment	Biota	Sediment	Biota	Sediment	Biota	Sediment	
National monitoring Locations (2016–2020)															
Port of Kotor	755.5	397.7	75.0	910.0	5,116.5	77,666.7	9.94	85.15	3.30	1,592.33	< LD	< LD	2	6	5
Dobrota-IBM	852.0	235.0	96.3	900.0	1,528.5	56,500.0	11.07	17.25	2.80	430.00	< LD	< LD	1	6	4
Orahovac	825.3	/	110.3	/	1,140.3	/	5.90	/	*	/	< LD	/	1	/	1
Stoliv	1,167.0	/	117.0	/	1,583.0	/	< 2	/	< 3	/	< LD	/	1	/	1
Port of Risan	824.0	180.0	112.3	496.7	992.7	31,500.0	11.37	36.50	2.20	400.00	< LD	< LD	2	5	4
Porto Montenegro	695.8	240.0	131.0	8,046.0	1,712.5	77,800.0	11.71	287.86	2.10	1,640.20	< LD	< LD	2	6	5
Port of Tivat	1,070.0	134.0	128.0	649.5	18,810.5	33,500.0	18.53	54.96	*	287.00	< LD	< LD	3	5	5
Bijela Shipyard	672.5	225.0	110.5	408.0	1,203.5	80,000.0	23.86	675.18	1.30	1,371.60	< LD	< LD	2	6	5
Port of Herceg Novi	470.0	140.0	85.0	326.7	800.0	20,000.0	14,05	134.08	3.30	682.00	< LD	< LD	2	6	5
Luštica Mamula	/	280.0	/	140.0	/	6,500.0	/	< 2	/	10.00	/	< LD	/	2	2
Luštica – Dobra luka	/	134.0	/	30.2	/	3,219.6	/	0.80	/	2.00	/	< LD	/	2	2
Port of Budva	825.3	143.0	104.7	170.0	1,680.3	26,800.0	2.40	17.56	1.50	324.00	< LD	< LD	1	4	3
Port of Bar	1,134.3	4,470.0	94.0	211.8	69,452.3	234,000.0	26.10	54.81	1.80	233.00	< LD	< LD	4	6	6
Port Milena	408.3	52.0	89.3	39.0	1,380.7	6,566.7	*	2.24	2.10	331.00	< LD	< LD	1	2	2
Ada Bojana	/	110.0	/	64.8	/	6,200.0	/	5.38	/	*	/	< LD	/	1	1

		Cadmium		Mercury		Lead		∑7CBs ICES		Benzo(a)pyrene		Pesticides: HCB, Lindane, DDTs		Rating of pressure on sediment and biota 1-6		Total rating
	µg/kg dw	Biota	Sediment	Biota	Sediment	Biota	Sediment	Biota	Sediment	Biota	Sediment	Biota	Sediment	Biota	Sediment	
Sediment sampling Location (2020,																
Luštica Transect	1		110		20		18,000		0.21		3.49		< LD		1	1
	2		100		16		18,000		0.09		2.18		< LD		1	1
	3		90		21		23,000		0.09		1.49		< LD		1	1
Budva Transect	4		90		5.4		2,800		0.24		< LD		< LD		1	1
	5		230		1.3		1,000		0.20		1.18		< LD		1	1
	6		100		12		16,000		0.08		0.91		< LD		1	1
Petrovac Transect	7		100		25		25,000		0.24		1.26		< LD		1	1
	8		100		34		25,000		0.23		0.96		< LD		1	1
	9		110		34		30,000		0.21		1.3		< LD		2	2
	10		100		16		19,000		0.041		1.01		< LD		1	1
Port of Ulcinj Transect	11		67		11		17,000		0.28		2.74		< LD		1	1
	12		82		23		6,000		0.047		2.0		< LD		1	1
	13		100		40		26,000		0,062		0.99		< LD		1	1
	14		130		31		31,000		0.064		0.89		< LD		2	2
Velika plaža Bojana Estuary Transect	15		120		26		31,000		0.27		4.48		< LD		2	2
	16		110		34		25,000		0.12		1.72		< LD		1	1
	17		130		26		31,000		0.08		2.03		< LD		2	2

Map 8.1: Assessment of levels of contaminant pressure on the marine environment for 2016-2019



The Montenegrin Littoral– the area outside of the bays

As shown in Table 8.9 and Map 8.1, the coastal section of the open part of the coastline comprises two locations where pressure by contaminants is present. The most significant of these is the **port and marina of Bar.** Additionally, pressures are present in the port and marina of **Budva.** Of these locations, sediment in the aquatoriums of the Port of Bar and the Bar Marina, as well as the wider port aquatorium, are significantly burdened by heavy metals (Cd, Cu, Pb, Hg, As, Cr i Ni), PAH and PCB compounds. As previously shown, the contamination is the consequence of numerous port activities. Budva Port and its marina also show elevated levels of sediment contamination by heavy metals, PAHs and PCBs, though less than the Port of Bar.

The **Ulcinj – Ada Bojana** area is exposed to influence from the Bojana River, i.e. activities in its immediate surroundings – activities in Skadar, the upstream of the Drim River which flows into the Bojana River, and pollution on both the Montenegrin and Albanian sides. Though no major industrial pollutants are present on this location, nor are port activities, heavy metals and PAHs are occasionally detected but do not exceed the allowed level (above ERL). Nonetheless, there is a notably high content of Cr and Ni (not monitored by the UNEP/MAP) which exceed the ERL multiple times, but this is attributed to the geochemical composition of soil in the surroundings, as there are chromium and nickel mines in the upstream part of Drim.

Other locations along the the coast outside of the bays show a low rate of sediment and sea water contamination (< BAC). Pesticide contamination was not detected at any of the locations in the coastal part in the last three years.

Contaminant content in the biota – shellfish is difficult to analyse due to the small number of tested samples from the part outside of the bays. Based on data collected in the Port of Budva, all contaminants in shellfish are at BC levels except for those of the PAHs, which were at BAC levels.

The Port of Bar showed the highest biota contamination rates as most contaminants were at levels equal to or > BAC, with lead contents exceeding the ERL standard. At the location of **Port Milena,** all contaminants were at BC levels, except for those of PAHs which were at BAC levels. No data is available for Ada Bojana, although increased contamination is not expected.

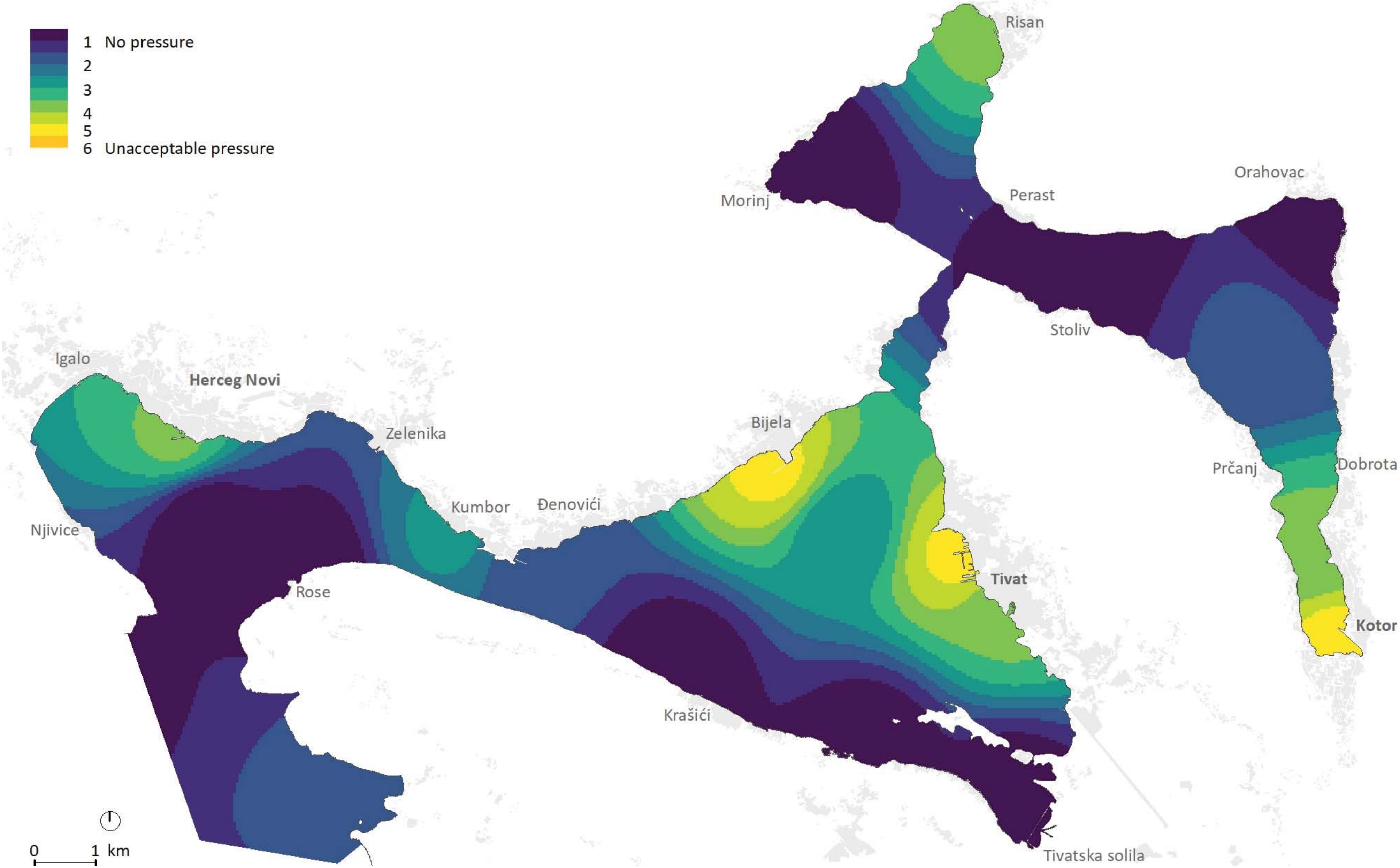
The Bay of Kotor

As indicated by the data presented in Table 8.9 and Map 8.2, the most vulnerable locations are those of **the Bijela Shipyard, Porto Montenegro and the ports of Tivat and Kotor.** Although Arsenal and Bijela have ceased their operations, they remain the largest pollutant of the sediment and biota. Terrain remediation in Bijela Shipyard, which has been soaked in petroleum products, heavy metals, PAHs and PCBs and other contaminants, has not been carried out yet, meaning contaminant runoff via rainwater into the sea is ongoing, and contaminated sediment, i.e. contaminated grit created by ship sandblasting which is deposited in the sea, has not been dredged from the bottom, although all parameters indicated that it significantly exceeded the ecologically unacceptable standards of the ERL. The Porto Montenegro location – the former "Arsenal" – still has exceedingly high levels of sediment contamination, particularly by Hg. A large volume of used grit and other waste is located in the sea on this location as well. In addition to "old" sediment contamination, the influence of vessels in the marina with its 600+ moorings must not be ignored, as oil spills are reported near the location each year, which is also visible in the BaP and PAH content on this location. Additionally, the proximity of Tivat Airport and its kerosene tanks can jeopardize the aquatorium of the Port of Tivat in case of an accident or refuelling error, which has happened in the past.

The Port of Kotor, due to its specific position and intensive maritime activity, still contains high concentrations of Hg, Pb, PCBs and PAHs in the sediment exceeding the ERL and EC. **The location in Dobrota next to the IBM** is also jeopardised by the proximity of the Port of Kotor, as contaminated sediment is transported via spring water in Kotor: Škurda and Gurdić.

Concentrations of Hg, Cu, Ni, Cr occasionally exceed the ERL, as do concentrations of PAHs > BAC < ERL, which were occasionally detected at the location of the reference point of **Mamula** at the entrance to the Bay. Considering the lack of industrial facilities in the vicinity, this is most likely the consequence of remaining pollution from military activities at the entrance to the Bay.

Map 8.2: Assessment of levels of contaminant pressure on the marine environment of the Bay of Kotor for 2016-2019



Assessment of impact on biodiversity

Based on the obtained results, an assessment of the impact on biodiversity can be provided in the following manner:

- locations with an impact level rating of 1 and 2 can be assessed as having no impact on biodiversity;
- locations with an impact level rating of 3 and 4 have a small impact on biodiversity (1);
- locations with endangerment ratings of 5 and 6 have a significant impact (2), which corresponds to Table 13.5 of the UNEP/MAP OSPAR threshold values for contaminants in sediment and biota, i.e. ERL and EAC values.

These ratings correspond to biomarker testing where the impact of the content of heavy metals, organochlorine and other pesticides, OTCs, and mineral oils was monitored via the following indicators: condition index, AChE inhibition and the micronucleus test. Results show the following impact of contaminants onto shellfish: Orahovac < IBM < Stoliv < Bijela < Tivat, meaning contaminant impact is the greatest in Tivat and the smallest in Orahovac.

8.6. Recommendations

Measures concerning the reduction of existing or the prevention of future contamination of the marine (and land) ecosystem by organic and inorganic contaminants include normative, protection and remediation measures.

1. **Improvement of the regulatory framework for toxic material contamination control, including**

- providing for the determination of standards/norms for sediment quality and biological material contamination via toxic substances in accordance with EU regulation;
- preventing and introducing **strict control of the disposal of** contaminated construction and other **waste material**, waste oils and hazardous waste into the marine aquatorium or their disposal in the coastal area;
- introducing **a strict control of the release of** ballast and bilge water and oily liquids from ships and yachts into the waters of the Bay of Kotor and provision of devices for the reception of these waters from ships and yachts in all ports in the Bay of Kotor.

2. **Protection of zones particularly vulnerable to contamination reception, primarily:**

- Springs. Springs and their zones should be protected from potential contamination by organic and inorganic contaminants with the aim of preserving them for water supply. Significant springs in the Bay of Kotor include Vrmac, Orahovac springs (Ercegovina and Cicovića kuće), Škurda, Gurdić, Risanska spilja, Morinj springs, Slatina, and Plavda, and, on the open part of the coast, Reževića rijeka, Dobre vode and the Vrelo spring in Čanj.
- Peloids. Prohibiting the construction of industrial facilities without purification near the estuary of the Sutorina River and Igalo Bay to protect medicinal mud deposits in Igalo bay, used for medical therapy, from potential contamination by organic and inorganic contaminants from industries, waste water, contaminant input via the Sutorina River, vessels or other sources. Protection from contaminant impact is also vital for the location from Ulcinj to Cape Đeran, which also features medicinal peloids (the so-called “women’s beach”).
- Shellfish farms. Ensuring that no construction is planned near locations of particular importance for shellfish farming which could jeopardise the quality of water necessary for mariculture (industrial and similar facilities). Introducing detailed control of the level of contaminant presence in the biota for farms near the Bijela Shipyard and the former Arsenal.
- Beaches. All public beach and bathing site locations must be encompassed by the planned measures of protection from the planning of industrial and other facilities which may cause water contamination by toxic and hazardous substances or microbiological contamination.

- **Distance from the coast.** Industrial facilities should not be located at a distance of less than 1 km from the sea coast and without devices for contaminant purification and neutralisation.

3. Remediation of burdened areas, including

- Remediation of the Bijela Shipyard location:
  - remediation and elimination of all hazardous waste – used grit from sandblasting mixed with contaminated soil on the shipyard location, indirectly contaminating the marine aquatorium. Elimination or neutralisation of used grit from the former Arsenal which is currently **still** being stored in the vicinity of the Porto Montenegro location;
  - remediation of groundwater contamination in Bijela, where it has been contaminated by mineral oils and petroleum hydrocarbons. It is necessary to provide for and implement a curtain injection as part of the remediation, to prevent the penetration of highly contaminated oiled groundwater from the location into the sea;
  - to relocate facilities for the reception of waste petroleum products belonging to HAMOSAN and to eliminate all hazardous waste from capacitors, transformers and other equipment containing PCB-based pyralene used as transformer oil, in accordance with the NAP for the elimination of POP substances of 2015.
- Remediation of existing **„wild" mixed waste landfills** in the coastal area (Lovanj I and II in Tivatsko polje) and illegal waste dumps on Orjen with the aim of preventing toxicant percolation and runoff via groundwater into the marine aquatorium. This primarily refers to the landfills "Pode" and "Dugonja" where waste from the Herceg Novi Municipality is deposited, as well as the "Ćafe" landfill on Volujica and the old Ulcinj landfill – "Hije" at Kruč.

4. To provide for space (in the ports of Kotor, Tivat and Herceg Novi, as well as the future yacht overhaul site in Bijela) for facilities for the reception (and treatment) of waste and bilge water. The Port of Kotor is problematic in terms of vulnerability and contamination as well, as it is located in the part of the bay with no significant water circulation, and as pressure from the remaining non-connected sewage outlets and ships-cruisers is increasing.

9. Marine Litter

9.1. Introduction

Marine litter is one of the most widespread problems facing all countries around the world. Beaches, coastal ecosystems and river basins, which form the basis of Montenegrin tourism, have been negatively affected by marine litter, and it is extremely important to reduce the amount and negative impact of waste through a collaborative, state and inter-institutional approach that relies on the strengths and resources of local communities, organizations and state institutions.

By definition, marine litter (or marine debris) is any solid material produced or processed then dumped into the sea or coastal area. It represents one of the greatest threats to the Mediterranean marine ecosystem with environmental, economic, safety, health and cultural impacts.

In some Mediterranean countries, the problem of marine litter has reached alarming levels. The amount of litter on beaches is constantly increasing, along with the increase in the amount of debris on the seabed and floating waste. Waste that reaches beaches and is transported to the sea by rivers is directly dumped as a result of various activities that take place on land; part of it arrives from ships, while a significant part ends up in the sea as a consequence of poor management of municipal waste.

In some areas of the Adriatic and the Mediterranean, the situation is deteriorating due to the specific circulation of water masses (streams) that result in the accumulation of waste in coastal areas or on beaches. A significant part of this waste can also come from neighbouring countries.

This chapter will address the ecological objective 10, which prescribes the obligation to achieve good environmental status in such a way that marine litter on the coast and sea does not adversely affect coastal and marine ecosystems. The ecological objective can be achieved through the implementation of operational objectives (10.1 and 10.2) and indicators (10.1.1, 10.1.2 and 10.2.1 – Decision IG.20/4 – Annex II):

Objective 10.1. The impact of the properties and amount of litter in the marine and coastal area have been minimized:

- **Indicator** – 10.1.1. Trends in the amount of litter that has been disposed (deposited) on the coast including analysis of composition, spatial distribution and, where possible, sources of pollution.
- **Indicator** – 10.1.2. Trends in the amount of litter in the water column, including microplastics and seabed litter.

Objective 10.2. The impact of litter on marine life is controlled to the maximum possible level:

- **Indicator** – 10.2.1. Trends in the amount of litter ingested or entangled in marine organisms, especially marine mammals, birds and turtles

In accordance with the stated goals and indicators, data on the amount, type and spatial distribution of seabed litter in the Bay of Kotor and Montenegrin open sea was used. The data was collected and processed through various projects implemented by the Institute of Marine Biology of the University of Montenegro.

Ecological objective 10 is compatible with the descriptor D10 of the EU Marine Strategy Framework Directive (MSFD).

9.2. Indicators

In the assessment of the environmental status of the marine ecosystem of the Bay of Kotor and Montenegrin open sea from the aspect of the state of quantity, type and spatial distribution of marine litter, within EO10, the application of harmonized indicators of the ecosystem approach is relevant, including trends in the amount of washed or deposited litter on shore (CI 22), trends in the amount of litter in the water column, including microplastics and seabed litter (CI23), and trends in the amount of litter swallowed or entangled in marine organisms, especially marine mammals, birds and turtles (CI24).

Each listed indicator contains adopted baseline values and defined values for achieving good environmental status (Decision IG.22/10). When it comes to beach waste, in February 2016, COP 19 of the Barcelona Convention and its protocols adopted litter reduction targets for the main items in the categorization, with special emphasis on beach litter (reduction of 20% by 2024). When we talk about seabed litter, the central goal is to keep the situation stable (compared to the estimated good environmental status by country), i.e. to reduce the amount of litter by a maximum of 10% within 5 years (Decision IG.22/10), i.e. that the percentage of reduction in the specified period be statistically significant.

Analysis and assessment of the amount and type of litter swallowed and/or entangled with marine organisms (especially sea turtles), as well as the amount and type of litter in biota, also requires a statistically significant reduction in order to achieve good environmental status, but without the specified deadlines for reaching the goal (Decision IG.22/10).

Accumulation of persistent organic pollutants, potential release of toxic compounds, transportation of foreign species to new sites, alteration/damage of seabed habitats and ingestion and/or entanglement of organisms in litter link MSFD descriptor 10 with descriptors 1, 2, 4, 6 and 8, 9. This speaks about the importance of the issue of marine litter and the cyclical impact of litter on the marine ecosystem.

EU Member States are jointly developing measures against marine litter in the framework of Regional Action Plans and through Regional Maritime Conventions. The MSFD Technical Subgroup on Marine Litter (TG ML) as an EU-level platform facilitates exchanges and cooperation between regions. As a result of the work of EU and Mediterranean working groups, data presented in this chapter was made using a standardized methodology in order to compare results and assess the situation.

Due to a lack of data for all indicators in the entire Montenegrin coast, within EO 10, the analysis was done for CI 23 only for the part related to seabed litter for the Bay of Kotor and the Montenegrin open sea (Table 9.1).

Table 9.1: Overview of indicators and their processing

Indicator	Indicator type	MSFD indicator	Processing
Marine Litter			
Beach litter (CI22)	State	Number of pieces and total weight per 100 m of transect	✖
Floating litter (CI23)	State	Number of pieces/km^2	✖
Seabed litter (CI23)	State	Number of pieces and weight/km^2 and spatial distribution	✓
Seabed litter (CI23)	State	Number of pieces and weight/100 m^2 of transect and spatial distribution	✓
Microplastics (CI23)	State	Number of pieces/km^2	✖
Biota litter	State		
Sea turtles (CI24)	State	% of individuals	✖
Ingested litter (CI24)	State	Number of pieces	✖

9.3. Seabed litter

The indicators covered in this chapter are internationally accepted, harmonized standards used in most countries around the world. The data used for the CI23 indicator (related to seabed litter) is the result of a survey conducted during MEDITS research (the Mediterranean international trawl survey – MEDITS-Handbook. Version n. 8, 2016) conducted for three years (2014, 2015 and 2016), while additional data for the Bay of Kotor was collected with a professional fishing boat during 2014, using the MEDITS research methodology, to the extent possible given the specificity of the area.

The data presented for the CI23 indicator related to seabed litter using the methodology of visual census by autonomous diving was collected in accordance with the methodology developed by the project DeFishGear (Monitoring methodology for seafloor litter (visual surveys with SCUBA/snorkelling), and presented for 2014 and 2015. The same methodology was used during the aforementioned project in all Adriatic countries and Greece, and the results presented in this chapter are comparable within the region. What is important to note is that a relatively small part of the seabed has been explored in this way, but the importance of the results comes from the fact that the area along the coast is much more polluted than the open sea, mostly as a result of the negligent behaviour of local residents and tourists. In addition, the visual census method can serve as a basis for underwater cleaning actions and can be a powerful tool in the management and protection of sensitive habitats (marine parks and reserves or spawning/feeding zones).

The spatial representation of marine litter was prepared using GIS tools – through the interpolation of numerical values at locations/transects of research (marked as white crosses on maps), i.e. by visual census. Interpolation was prepared using the IDW method (see section 3.1).

9.3.1. Status: Open sea

Data on the amount, type and spatial distribution of seabed litter for the open sea area of the Montenegrin coast was collected during the monitoring of fishery resources (MEDITS research) on a total of 10 transects during three years. The research was done with the vessel "Pasquale e Cristina" in the same locations during the month of August every year, using a specially designed trawl that all other Mediterranean countries had used in the same research. In order to estimate the density of litter (expressed as the number of pieces/km^2, or kg/km^2), an analysis was performed by applying the "swept" methodology. Litter was classified into six basic categories (plastic, rubber, textile, metal, glass/ceramics, other waste), while within each category a detailed classification was made in accordance with the MEDITS protocol (MEDITS-Handbook). Version n. 8, 2016).

Figure 9.1: Litter collected during fishery resource monitoring in the open sea

After processing the data, the quantitative and qualitative composition of litter was obtained. A total of 454 pieces of litter were found, categorized in detail in accordance with the MEDITS protocol. Litter was found on all investigated transects. The total density of litter for all transects ranged from 10.8 – 1,407 pieces/km^2, with an average value of 290 pieces/km^2 for all research years. The spatial distribution of litter by quantitative value is illustrated in Map 1. The percentage share by litter category indicates the highest pollution with artificial polymers (plastics), which in 2014 accounted for 80%, or 86% and 85.2% in 2015 and 2016, respectively. After plastics, being the dominant category (average for all years 84.1%), more significant pollution can be found for the categories of rubber (average of 5.08% for all years) and textiles (average of 5.9% for all years) (Graph 9.1).

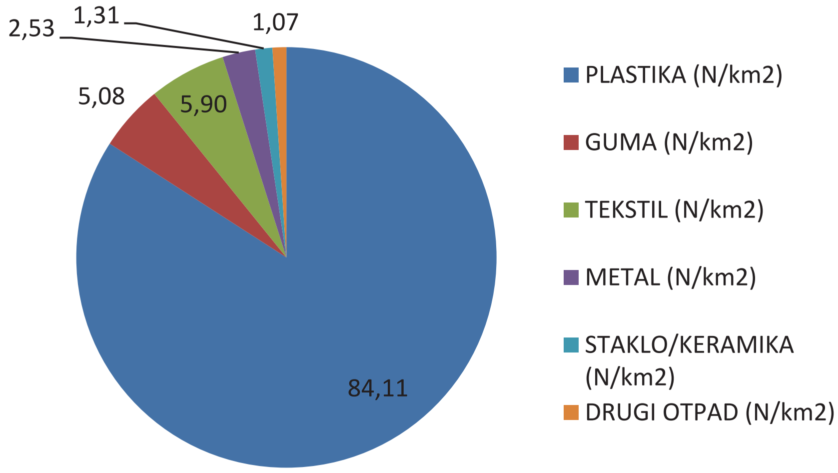
In the context of weight, the most dominant category of litter is also plastics, with a percentage of 77.4%, 84.2% and 69.05% for 2014, 2015 and 2016, respectively. The total weight of plastic litter for all transects together ranged from 0.81-699 kg/km^2 (for 2014), 0.6-103.8 kg/km^2 (for 2015) and 1.41-498.8 kg/km^2 (for 2016). The spatial distribution of litter by categories for weight values is illustrated in Map 9.2.

The analysis of the mean values of the total litter weight for all transects during the surveyed years showed an average pollution of 89.64 kg/km^2, with the largest shares belonging to the categories of plastics (73.4%) and rubber waste (16.7%). Other litter categories occupy percentage shares in the range of 1.5-3.9%. (Graph 9.2).

The highest litter density was determined in bathymetric zones:

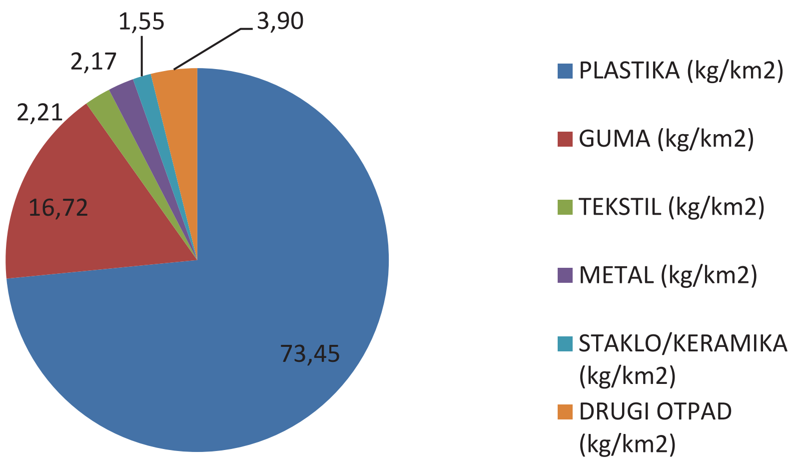
- up to a depth of 50 m;
- from the depth of 50-100 meters; and
- up to the depth of 100-200 meters, i.e. up to the boundary of the continental shelf.

Total numerical share of litter by category (N/km^2)



Graph 9.1: Total numerical share of litter by category for the period 2014-2016

Total weight share of litter by category (kg/km^2)



Graph 9.2: Total weight share of litter by category for the period 2014-2016

The largest amount of plastic and total litter (the so-called "hot spots") was identified in the area between Petrovac and Sutomore, and in the area between Bar and Ulcinj, at depths between 50 and 65 meters (Map 9.3, 9.4 and 9.5). The category of rubber waste is present both in shallower parts (up to a depth of 80 meters) and in the bathymetric zone of 200-500 and over 500 meters of depth. The largest amount of rubber waste was found in the area between Petrovac and Bar in the bathymetric zone up to a depth of 100 meters (Map 9.4 and 9.5).

This data indicates the assumption that the origin of the waste is most likely from the mainland. The analysis of individual pieces of litter and potential sources of pollution showed that most of the waste originates from the mainland (about 60%), i.e. it is a consequence of the negligent behaviour of local citizens, tourism and recreational activities, but above all poor waste management on land. It was not possible to determine the origin of about 30% of the analysed litter, while the rest originated from shipping and fishing activities.

The spatial distribution of litter can be largely conditioned by seawater flows and the influence of winds. As illustrated on Map 3, current flow is generally parallel to the shoreline, especially in the bathymetric zone 100 meters deep.

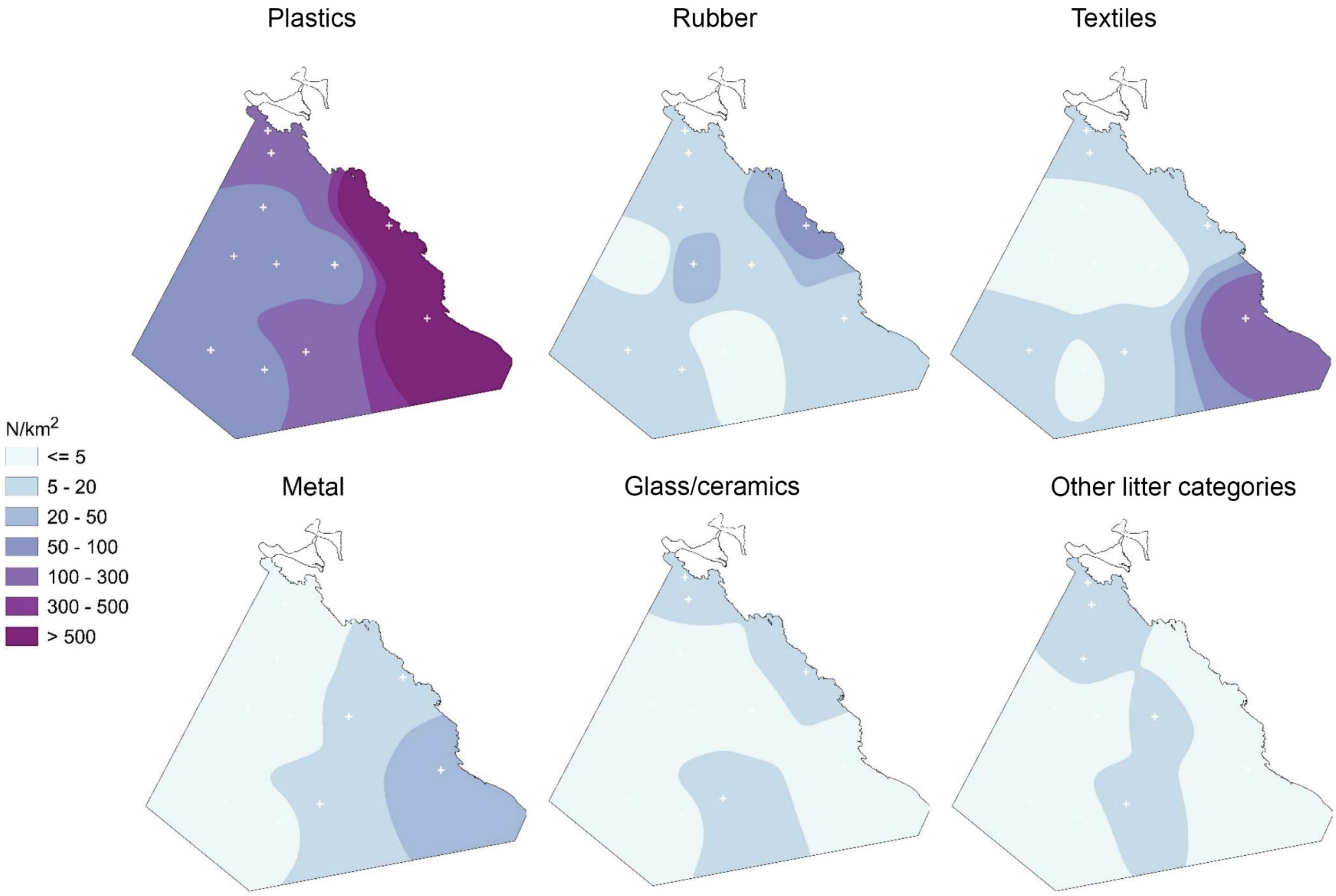
During winter, the general flow of currents along the entire depth of the Montenegrin coast is parallel to the coast and directed from SW to NW. In summer, the movement of the sea mass has the opposite direction, and the general flow of currents is from E to SE.

Such characteristics of sea currents in front of the Montenegrin coast do not contribute to litter deposition from the sea to the coast, but transport it parallel to the coast or further away. The area between Budva and Petrovac can be seen as an exception due to geographical and climatological characteristics, especially in summer when the mistral wind partly blows towards the coast and can cause transportation of litter from the open sea to bays and coves.

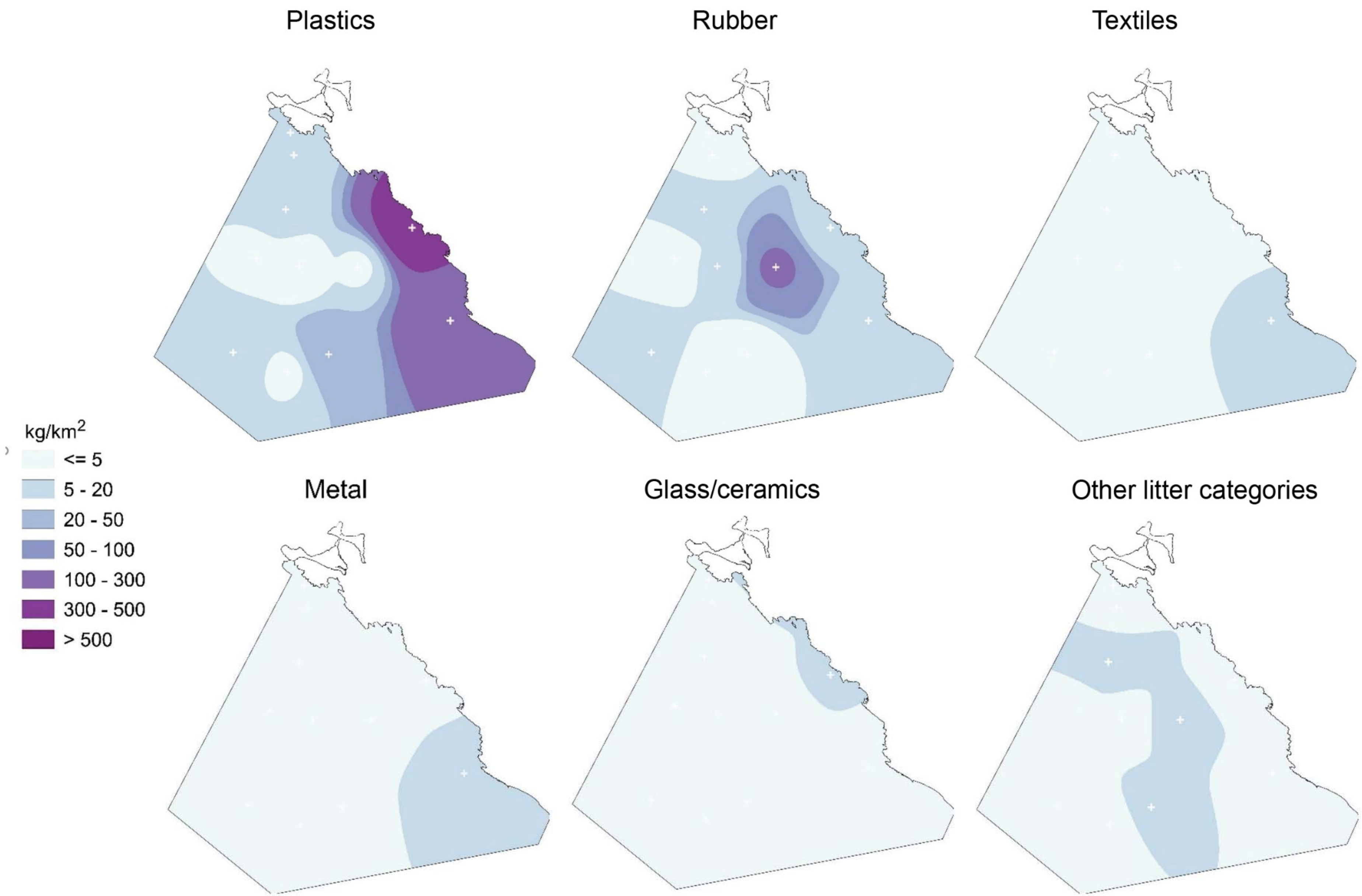
Apart from the fact that the wind affects the transport of litter floating on the surface of the sea, it also affects sea currents. In case of strong and stormy winds, wind energy in the amount of about 3% is transferred to the current. In shallow areas such as coastal zones, wind energy is transmitted in the entire column of water from the surface to the bottom. There wind currents from the surface to the bottom are formed in very short periods of time – from 2 to 3 hours. The speed of the current caused by the wind decreases from the surface to the bottom due to friction and other factors. In areas of greater depths (over 60 meters), currents caused by wind lose much of their energy, so theoretically, at a depth of 200 meters, the influence of wind is not felt. Given that a large part of Montenegrin waters are at a depth under 200 meters, the impact of winds on the flow and distribution of litter can be significant.

The general flow shown in Map 9.3 has been significantly correlated with the spatial distribution of the weight portion of litter, especially plastic which is the most dominant.

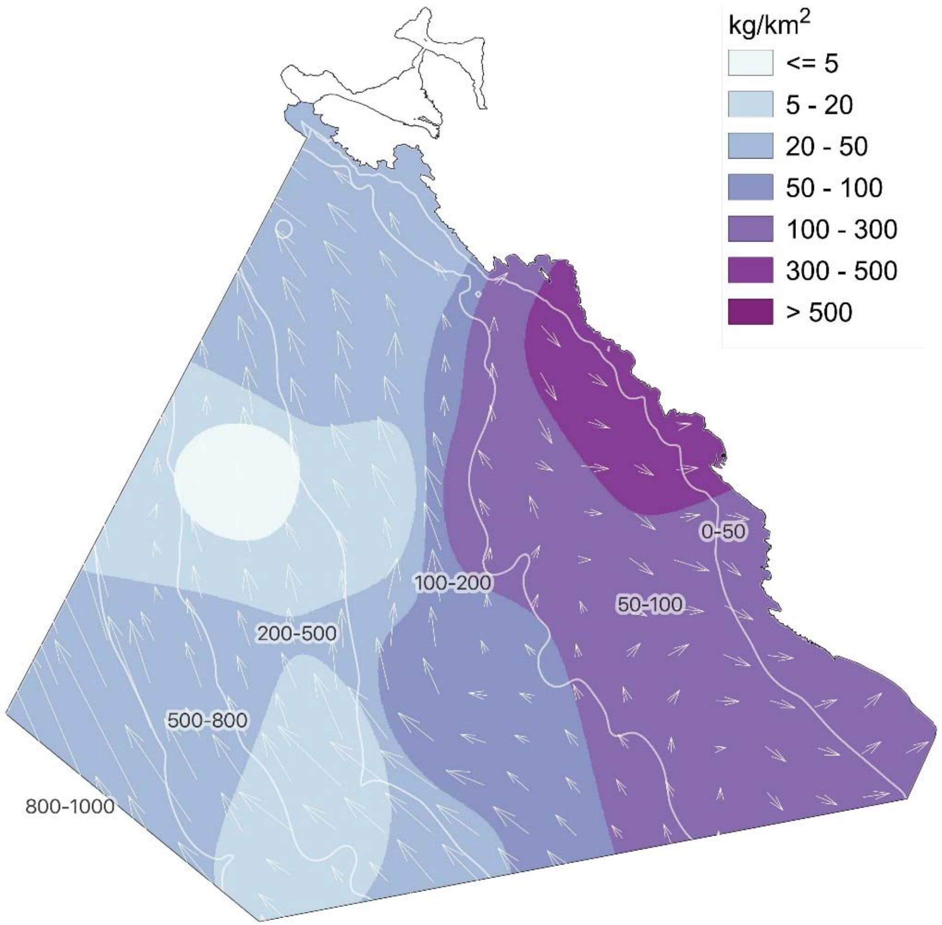
Map 9.1: Mean values of marine litter by categories (N/km^2) for the period 2014-2016

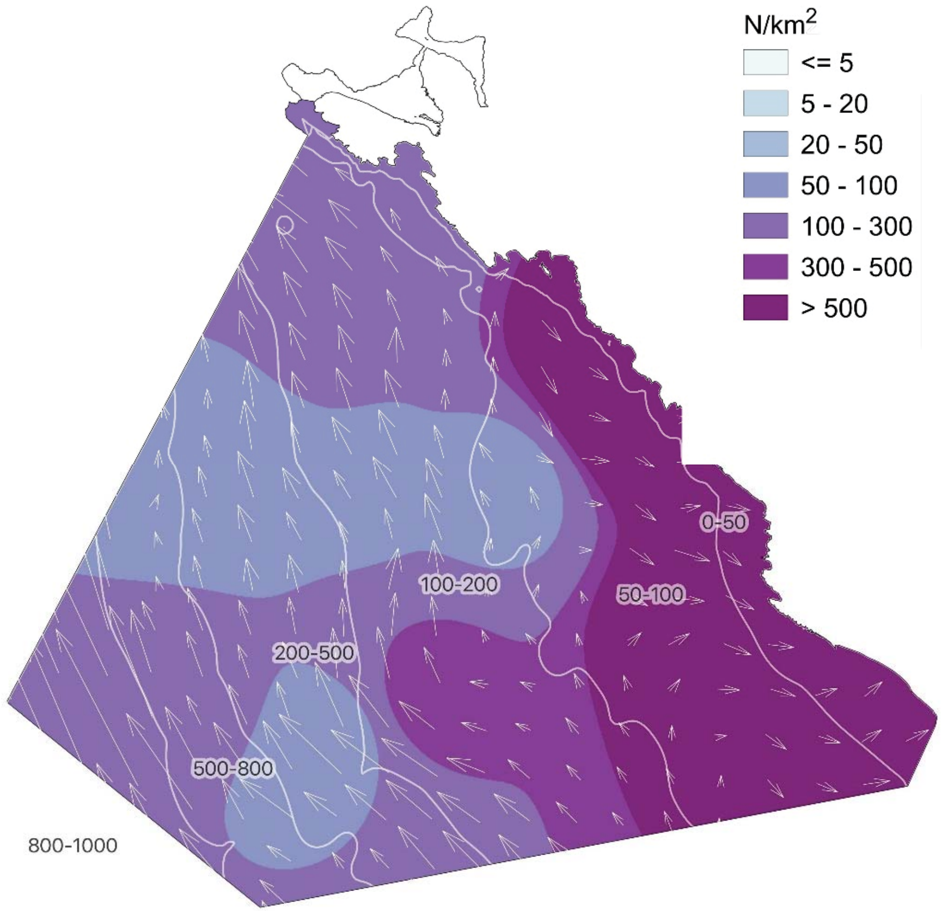


Map 9.2: Mean values of marine litter by categories (kg/km^2) for the period 2014-2016

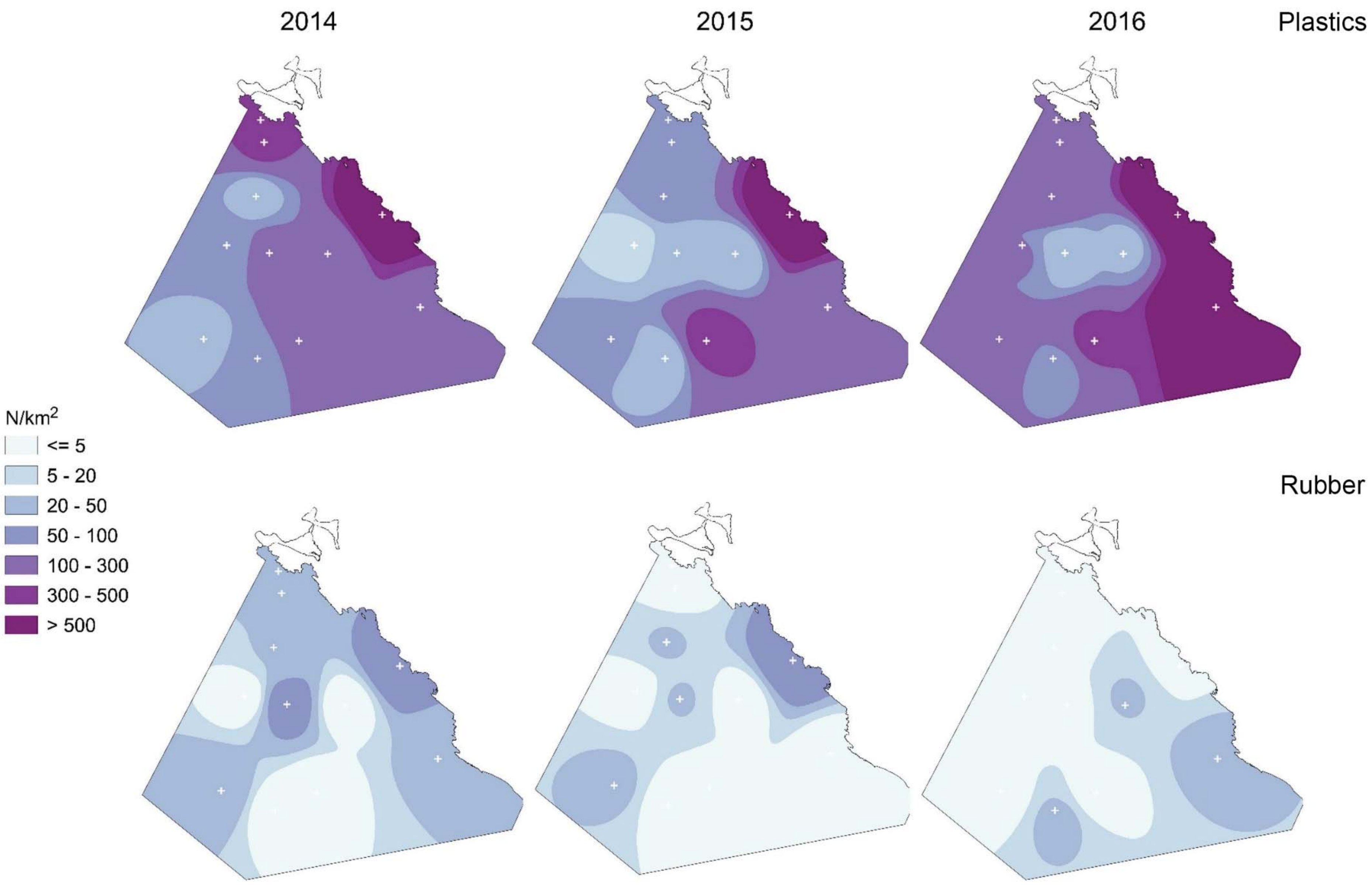


Map 9.3: Mean values of total litter (by all categories) for the period 2014-2016

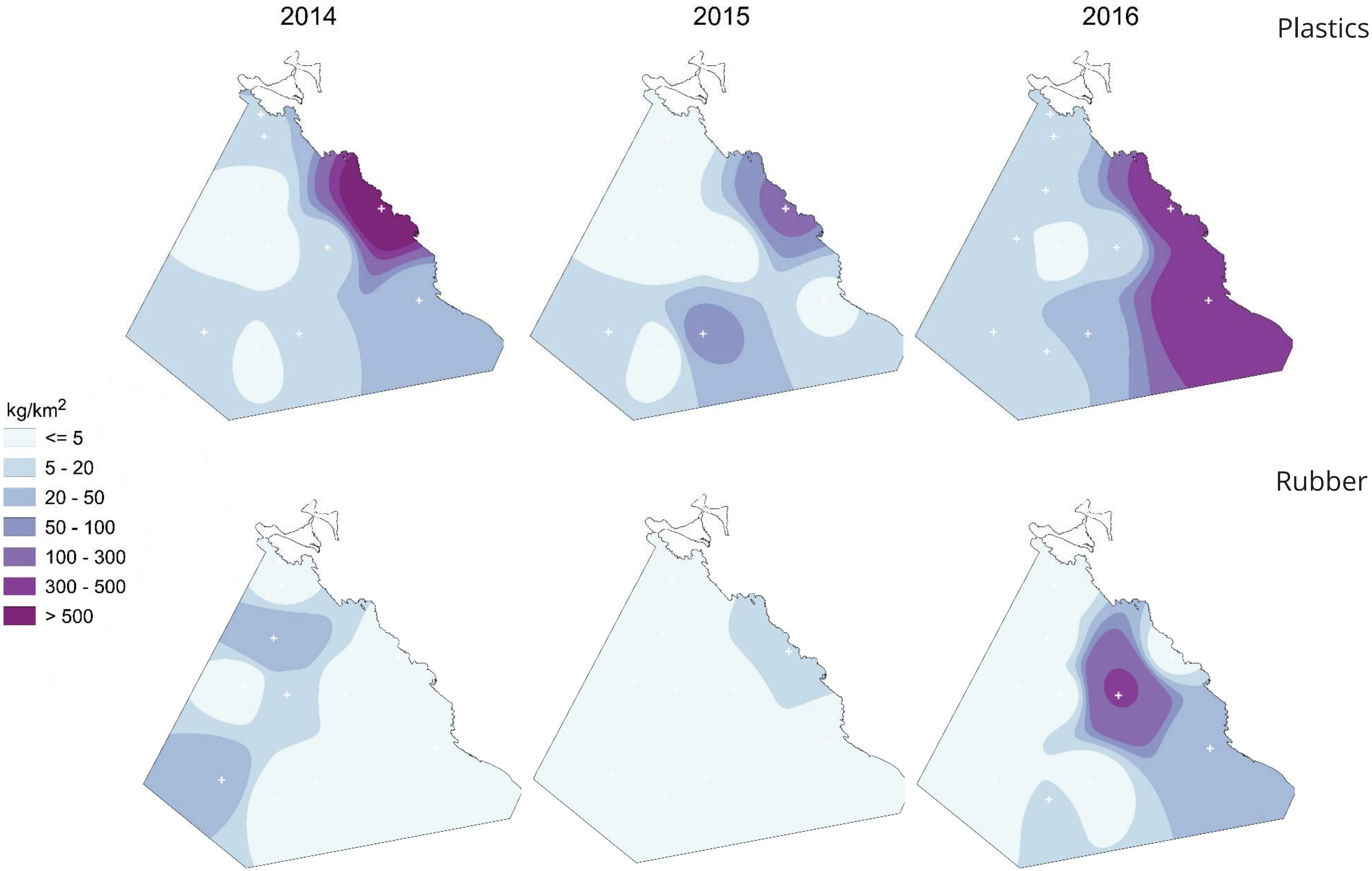




Map 9.4: Spatial distribution of dominant litter categories expressed as number/km^2 (plastics and rubber) for the period 2014-2016



Map 9.5: Spatial distribution of dominant litter categories expressed as kg/km^2 (plastics and rubber) for the period 2014-2016



An additional cause of the different distribution of litter on open seas can be the return of litter to the sea after regular trawler fishing. Namely, a significant number of fishing boats during regular fishing "catch" a significant amount of litter as well. Due to the small space on the boats (average length of all active trawlers in Montenegro is 14.99 m), the requirement for additional manpower to sort litter, the lack of disposal infrastructure, but also the negligence of a number of fishermen, litter is often returned to the sea during the sorting of fish catch on board.

Comparative analyses of the obtained results with data available for other parts of the Adriatic Sea (Strafella *et al.*, 2015, Pasquini *et al.*, 2016) show similar high rates of total litter weight, but when comparing the number of pieces/km^2, the situation in Montenegrin waters is significantly better. Still, when comparing the results with data published for other parts of the Mediterranean Sea, the southeastern part of the Adriatic, to which Montenegro belongs, is found to be one of the “hot spots” when it comes to waste pollution (Table 9.2).

The reason for the higher pollution of the Adriatic compared to most Mediterranean countries is most likely due to the intensive deposition of waste by rivers and basins into the sea. This assumption is underlined by the fact that the most polluted part of the Adriatic is the northwestern part, where the river Po is situated, while in the southeastern part a significant amount of waste is certainly caused by the rivers Bojana and Drim. Therefore, we recommended that further analyses and research of pollution sources be focused on the basins of larger rivers that flow into the sea.

In order to determine the main source of pollution, it is necessary to consider a number of factors and environmental influences, especially the circulation of water masses and the movement of winds. The main circulation of water in the Adriatic Sea occurs under the influence of warm waters that move to the north along the eastern Adriatic coast. Along the eastern Adriatic coast there is an inlet current that transports salt Levantine water to the Adriatic, while along the western coast there is a discharge of less salty water from the Adriatic.

Table 9.2: Density and proportion of seabed plastics collected during bottom trawl surveys

Area	Litter density	% of plastics	Reference
Southeastern Adriatic	290 pieces/km^2 89.64 kg/km^2	84.1% 73.4%	This study
Northern and central Adriatic (western part)	85 kg/km^2	34%	Strafella *et al.*, 2015
Northern and central Adriatic (western part)	913 pieces/km^2 82 kg/km^2	80% 62%	Pasquini *et al.*, 2016
Strait of Sicily	66 pieces/km^2	55%	Fiorentino *et al.*, 2015
Adriatic-Ionian Region	510 pieces/km^2, 65 kg/km^2	89.4%	
Sardinia (GSA[1] 11)	39 pieces/km^2	58%	Spedicato *et al.*, 2019
Gulf of Lion (GSA[1] 7)		99%	Spedicato *et al.*, 2019
Eastern Corsica (GSA[1] 8)	534 pieces/km^2	33%	Spedicato *et al.*, 2019
Cyprus (GSA[1] 25)	198 pieces/km^2	35%	Spedicato *et al.*, 2019
Aegean Sea (GSA[1] 19)	136 pieces/km^2	50%	Spedicato *et al.*, 2019
Northern and central Adriatic (eastern part) (GSA[1] 17)	112 pieces/km^2	45%	Spedicato *et al.*, 2019

[1] GSA – Geographical Sub-Area (Resolution GFCM/33/2009/2)

Gradient currents are the main cause of the general cyclone (counterclockwise) circulation, with the input current being more pronounced in winter along the eastern coast, and the outgoing current in summer along the western coast of the Adriatic. Apart from gradient currents, this rhythm is also significantly influenced by winds. Namely, the northwest wind (mistral) prevails in summer, which increases the outflow of sea water in the surface layer, while in winter the water flow is influenced by the southeast wind (jugo), which increases the incoming flow of sea water.

In addition to the general cyclone circulation, eddy currents are present in the Adriatic, especially the South Adriatic cyclonic vortex, but also eddy currents around the valley Jabučka kotlina. These eddy currents are the most probable cause of the larger accumulation of litter in the southeastern Adriatic, especially the southern coasts of Croatia and Montenegro (Spedicato *et al.*, 2019).

9.3.2. Status: Bay of Kotor

Data on the amount, type and spatial distribution of seabed litter was also processed for the Bay of Kotor. Monitoring was conducted as part of the research of fishery resources conducted by the Institute of Marine Biology for the area of the Bay of Kotor and Risan during June and July 2014.

For the Herceg Novi and Tivat bays, a rough expert assessment of the amount of litter was made, based on the analysis of data collected by trawling in the Bay of Kotor entrance area, data from underwater cleaning actions and collection of abandoned fishing tools, taking into account the amount of litter collected in the Kotor-Risan Bay.

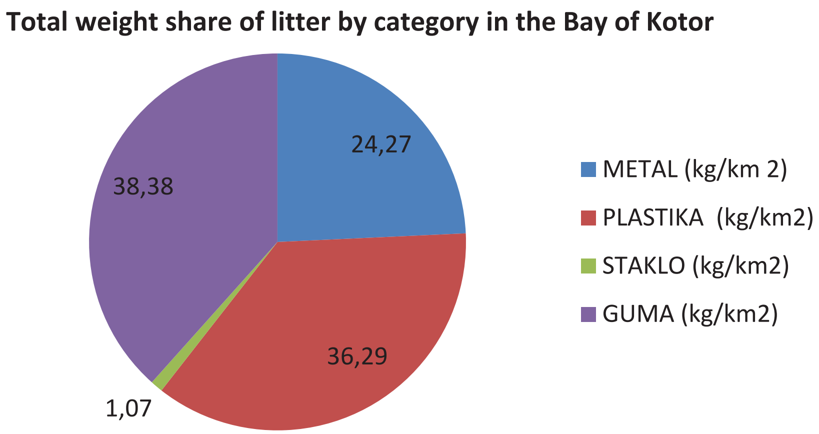
It is important to note that in the area of the Bay of Kotor, fishing is prohibited by law (Law on Marine Fisheries and Mariculture), so the assessment of the amount of litter has been carried out mostly through autonomous diving and underwater cleaning actions.

The research that was conducted in the area of the Bay of Kotor and Risan was done with the use of the fishing boat "Jovana" in the five transects of the bottom trawl survey at depths ranging from 17-38 m. Litter collected at each position, according to the protocol of the **DeFishGear** project (Vlachogianni and Somarakis, 2015), has been classified into the following categories: Plastic, Rubber, Metal, Glass. The weight of each category is expressed in kg/km^2 using the "swept" methodology.

Figure 9.2: Litter collected during fishery resource monitoring in the Bay of Kotor

Unlike the MEDITS survey, when monitoring litter in the Bay of Kotor, only data on weight was taken, without monitoring the number of pieces of litter according to the aforementioned categories.

In the context of weight, the most dominant category is rubber, with a percentage share of 38.38% for all trawling transects. The total weight of rubber waste for all transects together ranged between 402-723 kg/km^2. Out of a total of five trawling transects, rubber waste was found not found in two. In a slightly smaller share than rubber, plastics occupies a total of 36.29% for all transects. It was found in all trawling zones, with a total weight ranging between 29-402 kg/km^2. Next is metal with a percentage share of 24.27% and a weight in the range of 0.94-804 kg/km^2. As with plastic waste, metal was found in all investigated transects. The smallest share is occupied by glass with 1.07% of total waste (Graph 9.3).



Graph 9.3: Total weight share of litter by category in the Bay of Kotor

Compared to the open Montenegrin sea, the Bay of Kotor contains specific climatological, hydrological and hydrographic elements. Based on all available data, the more intense dynamics of water masses in the bay occur mainly on the surface. The most intense period is during the maximum inflow of fresh water (precipitation, inflow from land and submarine springs). During this period, intense circulation is present only on the surface up to a depth of 5 meters, which is a consequence of surface leveling, and not a constant flow system, so it is not possible to count on adequately compensating currents in deeper layers which lead to a constant change of water mass.

The flow in deeper layers is mainly the result of the influence of tidal currents, which cause a small net transport, and thus a small change in water mass in the entire basin.

Due to more intensive communication with the open sea through the passage of Cape Oštra – Cape Mirišta (2,794 meters wide), the situation in the Bay of Herceg Novi is somewhat more favourable (Mandić, 2020).

Relatively small depths in the research area, but also the specificity of the bay in terms of relief, basin shape, relatively poor communication with the open sea and the specifics of water mass dynamics, point to the origin of litter being land, that is, it is mostly due to the negligent behaviour of the local population, tourist and recreational activities and poor management of municipal waste.

It is important to note that during trawling in the bay area, only "smaller" litter pieces was sampled, i.e. there is a significant amount of bulky waste under the sea surface that cannot be extracted with fishing nets. A significant amount of bulky waste was identified during the monitoring of ghost nets which was implemented within the DeFishGear project in the Bay of Kotor in October 2014 and September 2015 (Figure 9.5).

Map 9.6: Spatial distribution of litter categories expressed as kg/km^2 for the year 2014

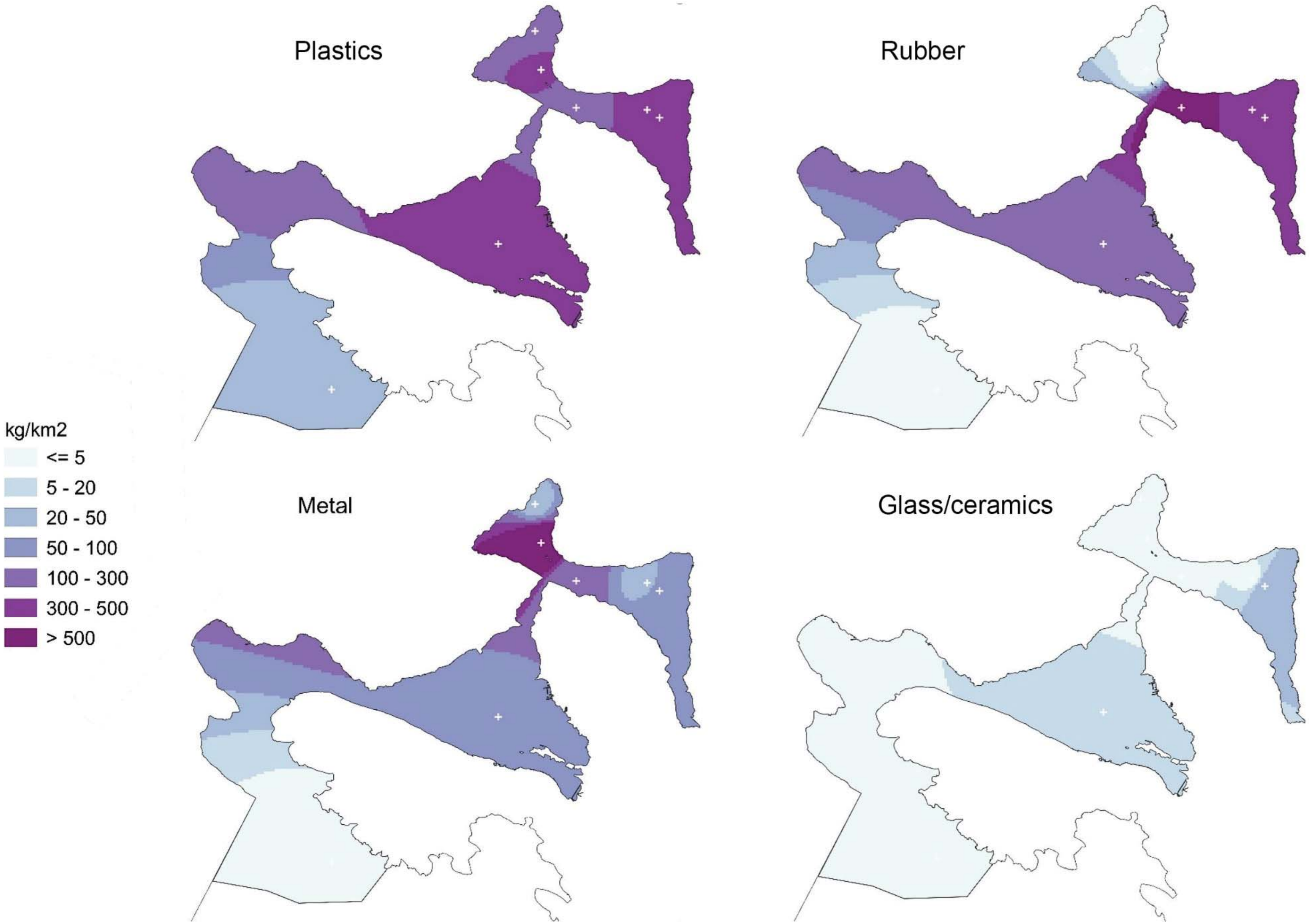


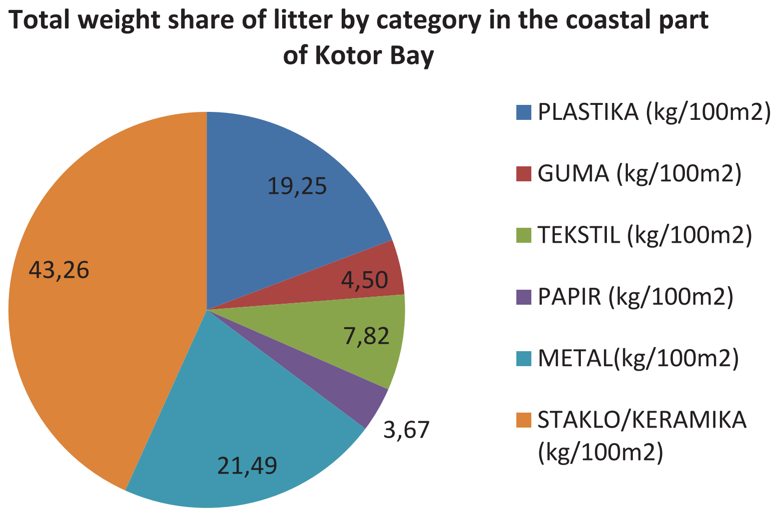
Figure 9.3: Bulky waste in the Bay of Kotor

Visual census method – autonomous diving

In addition, research of the amount, type and spatial distribution of seabed litter was conducted using the methodology of autonomous diving on three transects in the area of Kotor and Tivat bays – at the sites of Kostanjica, Strp and Sveta Neđelja. The research was conducted on a periodical basis from October 2014 to August 2015. At the site of Strp, the depth of the transect ranged from 13-24 m, at Kostanjica from 15-21 m and at Sveta Neđelja from 9-22 m.

The methodology used during the research was developed within the framework of the DeFishGear project (Vlachogianni and Kalampokis, 2015) and was recommended as the most adequate for estimating the amount, type and distribution of litter in shallow coastal zones (0-25 m depth) (Katsanevakis and Katsarou 2004).

Results of the research in the context of litter weight (kg/100 m^2) showed that the most dominant category is glass/ceramics with a total share of 43.26% for all research seasons. Next is metal (21.49%) and plastics (19.25%) (Graph 9.4, Map 9.7).



Graph 9.4: Total weight share of litter by category for the period 2014-2015

The biggest amount of litter was collected during the first survey (October 2014) when the dominant categories were glass/ceramics and metal (44.98 and 37.17%, respectively). The total amount of litter in all three investigated transects ranged from 4-20 kg /100 m^2.

In January 2015, plastics dominated with a share of 55.97%. They were followed by glass/ceramics (18.66%) and textiles (15.67%). The total weight of litter in all three investigated transects ranged from 3.757.5 kg/100 m^2.

During spring sampling (April 2015), the predominance of glass/ceramics was clear, with a total of 90.91% for all three surveyed transects. Next were plastics with 7.95%. The total weight of litter in all three investigated transects ranged from 1.5 do 5.1 kg/100 m^2.

The smallest amount of litter was found in August 2015, with three categories having a very similar share (metal with 28.76%, glass/ceramics with 26.69% and rubber with a share of 26.32%). The total weight of litter in all three investigated transects ranged from 0 to 4.64 kg/100 m^2, with a total average mean value for all transects of 0.96 kg/100 m^2. During all sampling, the biggest amount of litter was found at the Kostanjica and Sveta Neđelja sites.

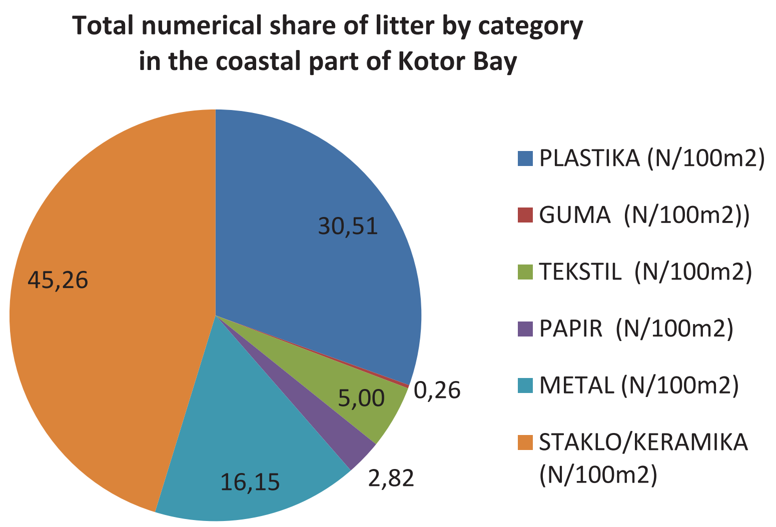
When it comes to the number of pieces of litter per 100 m^2, the dominant category is also glass/ceramics with a total of 45.26% for all surveyed seasons. Next is plastics (30.51%) and metal (16.15%) (Graph 9.5, Map 9.8).

The percentage share of categories by surveyed seasons shows the same trend as for the weight share, with the exception of spring sampling (April 2015) when the second largest amount of collected litter after glass/ceramics (52.94%) was plastics (41.18%).

As with weight monitoring, most litter amounts were collected during the first sampling (October 2014) when the maximum number of pieces was collected (21 pieces /100 m^2), while the smallest number was found in August 2015 (3.9 pieces/100 m^2). The mean value for all surveyed seasons ranged from 0-6.47 pieces/100 m^2, with a total mean value of 1.35 pieces/100 m^2. During the research, the majority of litter was found at the site of Sveta Neđelja (Map 9.7 and 9.8).

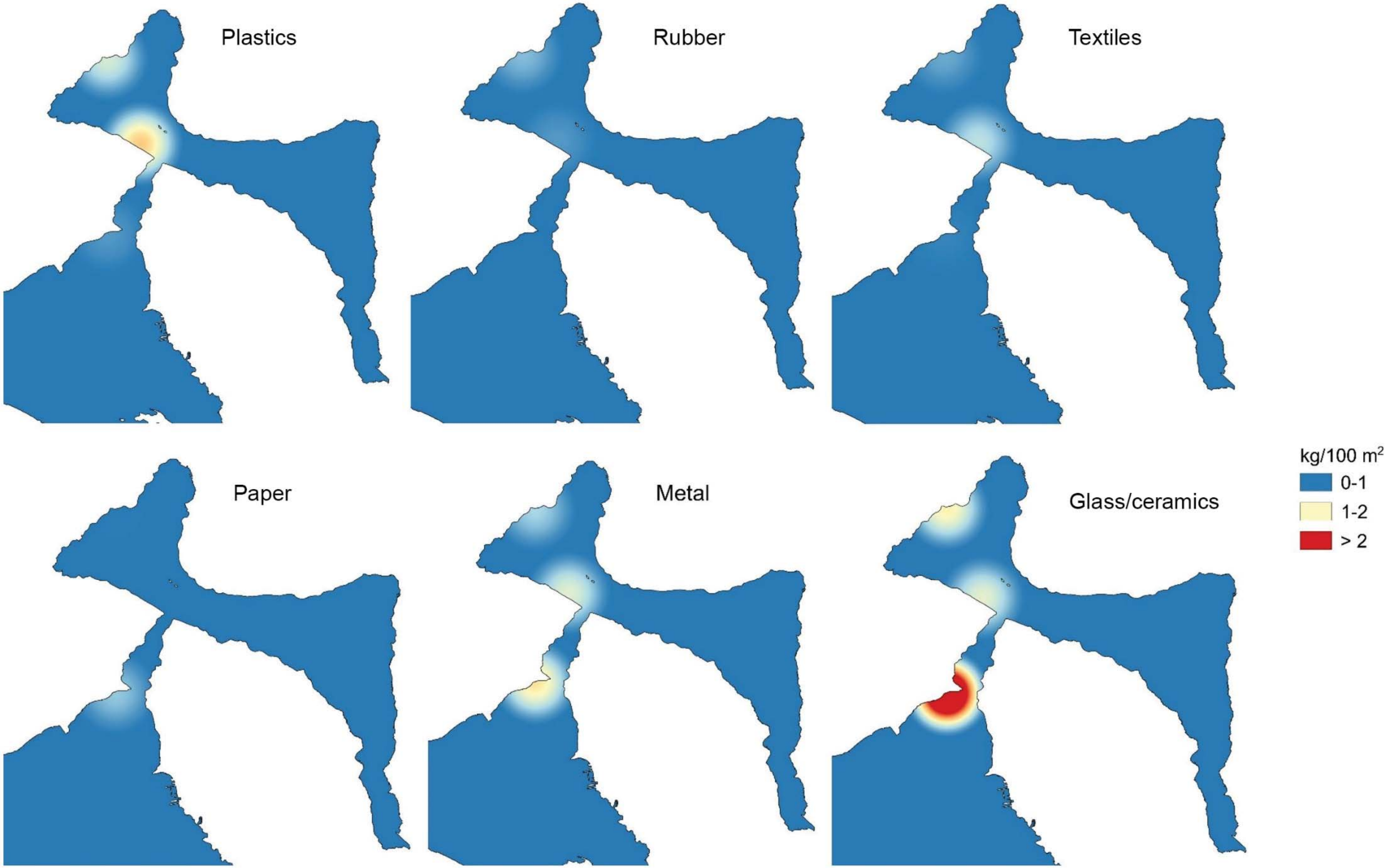
The research was conducted on 47 transects in the area of Montenegrin waters (Mačić *et al.* 2017) at depths of 0–40 meters, and it showed pollution of 0.25 pieces/100 m^2. Pollution in the amount of 0.68 pieces/100 m^2 was found in Slovenia, at depths in the range of 2-17 m (UNEP, 2015). In Greece, the study of the shallow coastal waters at depths of 0–25 m showed pollution of 0–2.51 pieces/100 m^2, with a mean value of 1.5 pieces/100 m^2 (Katsanevakis and Katsarou, 2004), which largely coincides with our results for the Bay of Kotor. Consoli *et al.* (2019) determined a level of pollution of 0.11 pieces/100 m^2 at depths between 5 and 30 meters by conducting a survey of pollution of the coastal area of the Central Mediterranean using an ROV (Remotely Operated Vehicle). The latest research on the amount and categorization of litter in the Mediterranean Sea, conducted by applying the methodology of autonomous diving in coastal areas, determined an average pollution rate of 43.55 pieces/100 m^2 for the Mediterranean Sea (Consoli *et al.* 2020).

Comparing our results with the available data for the Mediterranean, it can be determined with certainty that the coastal area is under the greatest pressure when it comes to litter, which undoubtedly leads to the conclusion that the main source of pollution comes from land, i.e. the careless behaviour of local populations and poor waste management in general.

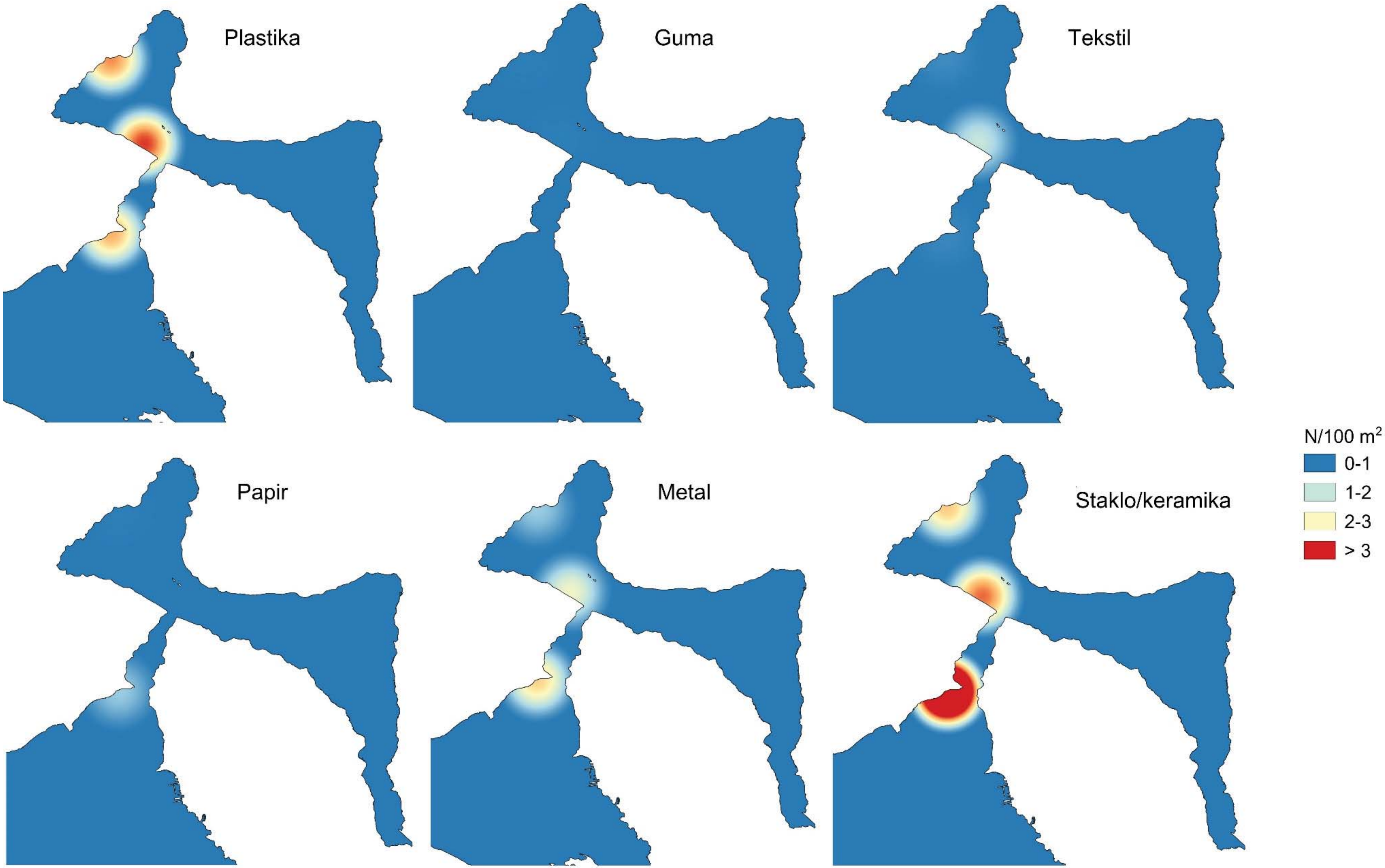


Graph 9.5: Total numerical share of litter by category for the period 2014-2015

Map 9.7: Spatial distribution of litter categories expressed as kg/100 m^2 for 2014-2015 (autonomous diving method)



Map 9.8: Spatial distribution of litter categories expressed as N/100 m^2 for 2014-2015 (autonomous diving method)



9.4. Annual input of plastic litter from land to sea

Monitoring the qualitative and quantitative status of marine litter has become increasingly popular all over the world over the last decade. Although there are already numerous data on the degree of litter pollution in different parts of the marine ecosystem, very little data and calculations refer to the sources and amount of litter (especially plastic) that reaches the sea from the land on an annual basis. Jambeck *et al.* (2015) estimated that between 4.8 and 12.7 million tons (MT) of litter reached the oceans in 2010. The biggest polluter is China with 1.32-3.53 MT of plastic litter that gets into the sea annually; followed by Indonesia, the Philippines and Vietnam. Among the Mediterranean and Black Sea countries, the largest estimated pollution originates from Algeria (0.08-0.21 MT of plastic litter per year) and Turkey (0.07-0.19 MT per year). These estimates are based on the amount of litter generated per capita per year, the percentage of plastics within it, and the percentage of poor management of plastic litter that can end up in the sea.

A detailed analysis of the data provided for 192 countries around the world (http://jambeck.engr.uga.edu/landplasticinput) found that the percentage of litter that reaches the sea is in the range of 15-40% of the total poorly managed plastic litter. Following this principle, it can be roughly estimated that the amount of plastic litter that reached the sea in Montenegro during 2010 was in the range of 662-1,766 tons per year. If there is no improvement in waste management on land, it is estimated that by 2025 this amount will increase to values ranging between 1,086-2,897 tons of waste that will end up in the sea on an annual basis.

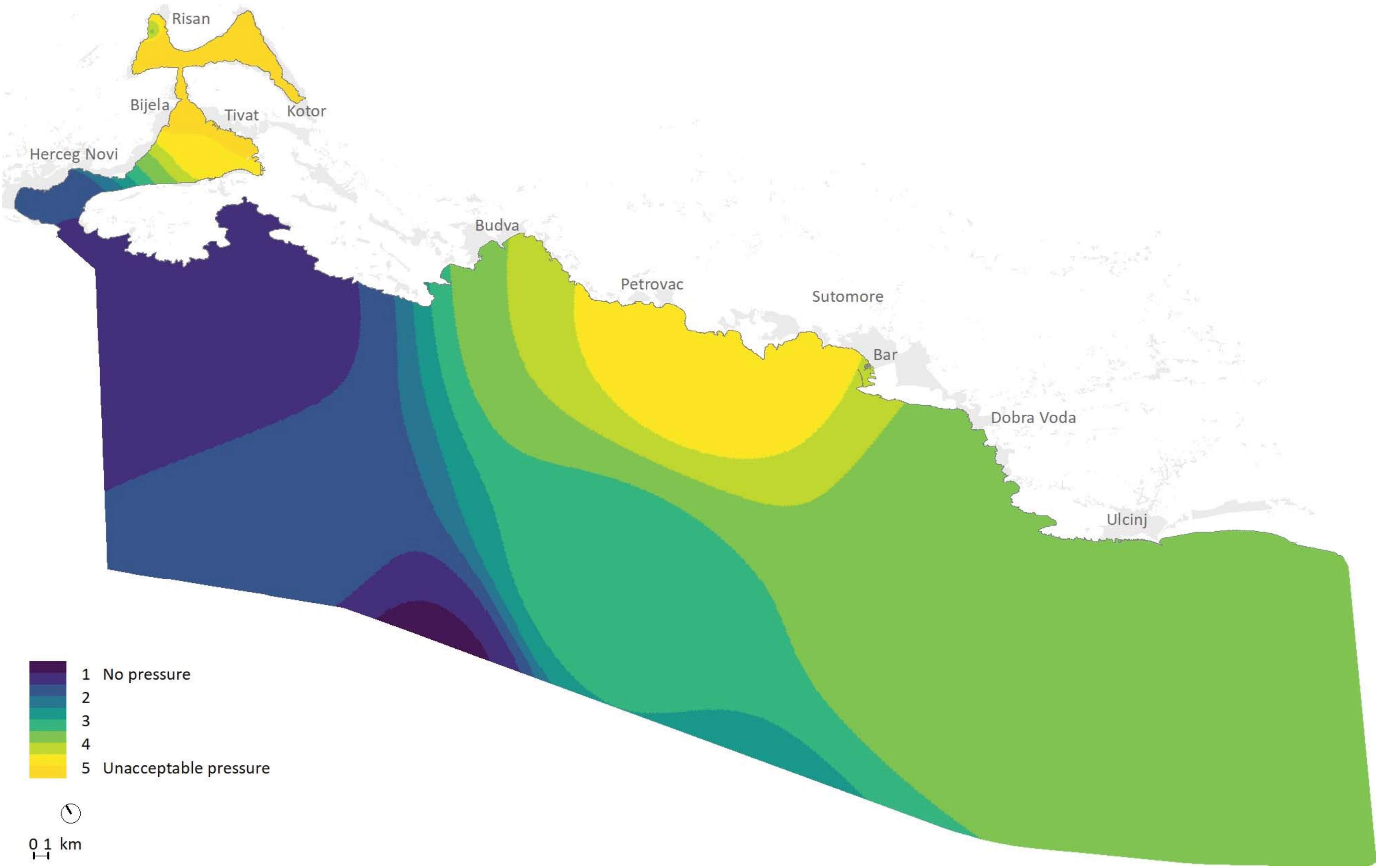
9.5. Marine Litter Pressure

Assessment of marine litter pressure was done on the basis of research results for the quantity, distribution and number of litter at surveyed positions, both for the open sea and the Bay of Kotor area. The basis for the definition of the criteria are pollution indicators, i.e. the spatial distribution of litter expressed as kg/km^2, based on which the pressure scale has been defined. The prepared scale for the assessment of pressures is based on litter expressed as kg/km^2, given that data from the Bay of Kotor does not exist in the form N/m^2.

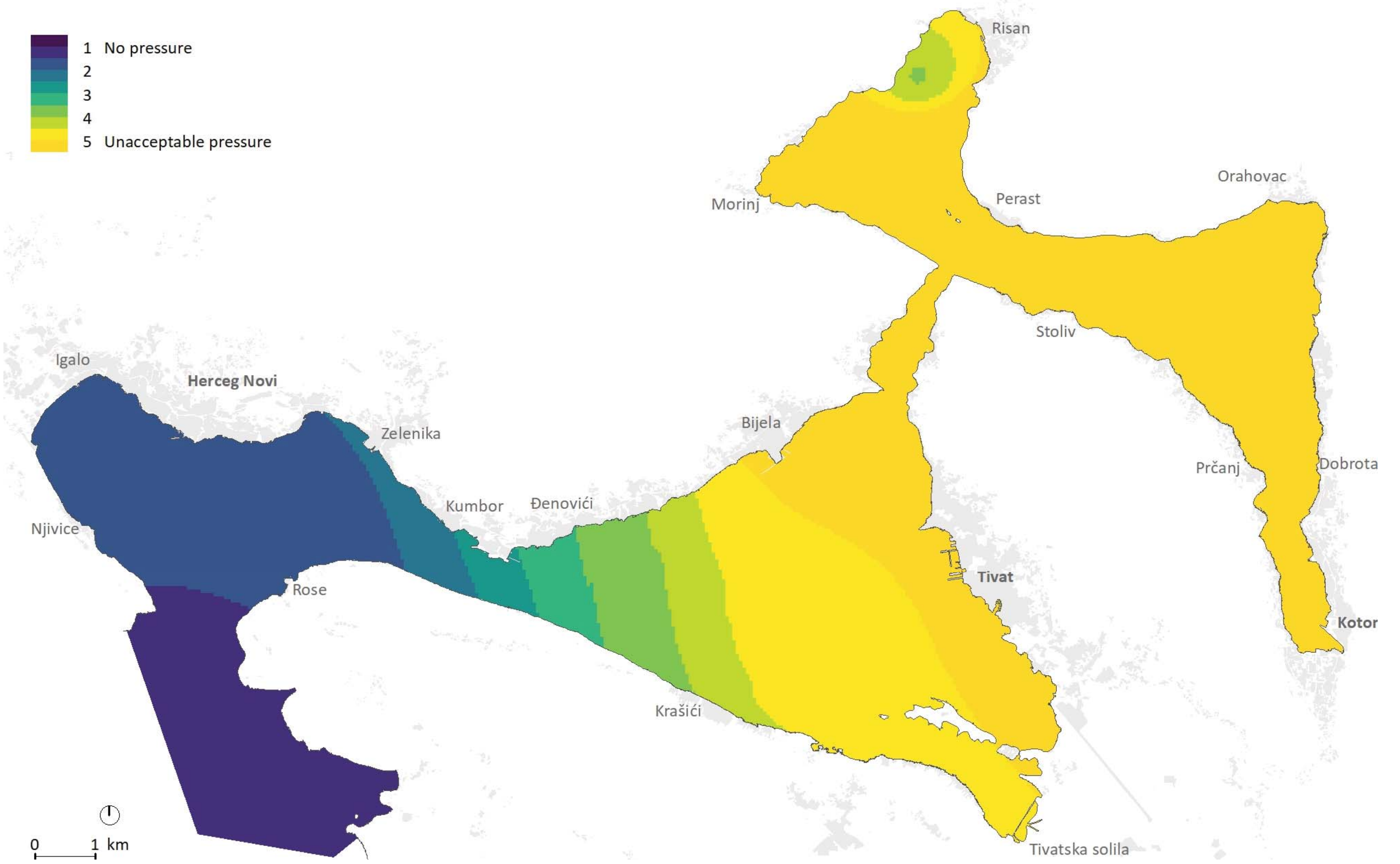
Assessment of the pressure level from marine litter is illustrated on maps 9.9 and 9.10.

Pressure assessment		Criteria (kg/km^2)
1	No pressure	0–10 10–30
2	Moderate pressure	30–50 50–70
3	High pressure	70–100 100–150
4	Very high pressure	150–300 300–400
5	Unacceptable pressure	400–500 > 500

Map 9.9: Assessment of the pressure level from marine litter in Montenegro



Map 9.10: Assessment of the pressure level from marine litter in the Bay of Kotor (based on results from 2014)



9.6. Recommendations

The results on the amount and spatial distribution of marine litter show that the amount of litter in shallow coastal areas (such as the Bay of Kotor) is significantly higher than in the open sea. The results are in line with research conducted in other areas of the Adriatic and Mediterranean, and unequivocally indicate that the state of the marine ecosystem in relation to waste pollution is worrying, and that it is necessary to introduce measures that reduce, remove and prevent marine litter as soon as possible.

The measures defined by NAP (National Action Plan for the Implementation of the LBS Protocol and its regional plans under the Strategic Action Plan for the Mediterranean (SAP-MED) to achieve good environmental status related to ECAP ecological objectives) are in line with Articles 7-10 of the RPML and, although very well defined, have not yet been fully implemented. Some of the planned measures have already been implemented: clean-up actions, implementation of the UNEP/MAP pilot project "Let's adopt a beach", improvement of knowledge and capacity relevant to marine litter management and monitoring, participation in international coastal campaigns and sea clean-up programs. Also, the National Marine Waste Monitoring Program has been prepared, and the first national monitoring activities were conducted during 2020. However, there are still very important measures to be implemented in accordance with the obligations of international conventions and regulations.

In addition, the ministers and heads of delegations of the contracting parties to the Barcelona Convention have committed (through the Naples Declaration of Ministers, UNEP/MED IG.24/22) to increase efforts to address marine litter issues in order to strengthen the regulatory framework for reducing single-use plastic products, setting ambitious quantitative targets and including mitigation measures, including microplastics, in the national marine litter monitoring program.

Some of the important measures that can be recommended in order to reduce the amount of waste in the most endangered parts of the Montenegrin coast (the so-called hot spots) are passive and active fishing for litter, as well as the involvement of professional divers in cleaning actions in those parts where important marine habitats or species of special importance can be found.

In order to reduce the amount of marine litter and its negative impact on the marine ecosystem, it is necessary to intensify the implementation of prescribed measures, amend legislation and harmonize it with already assumed obligations under international regulations and conventions, and make the national marine litter monitoring program fully operational.

10. Conclusion

10.1. Overall biodiversity impact

The overall spatial presentation of the impact of risks to biodiversity was made by combining habitat endangerment, pelagic resources and demersal resources according to the matrix below, in a way that the combined value emphasized higher values from individual endangerment maps. The spatial representation of the greatest risk is outlined on maps 10.1 and 10.2.

Assessment of the impact to pelagic/demersal resources

Habitat impact assessment

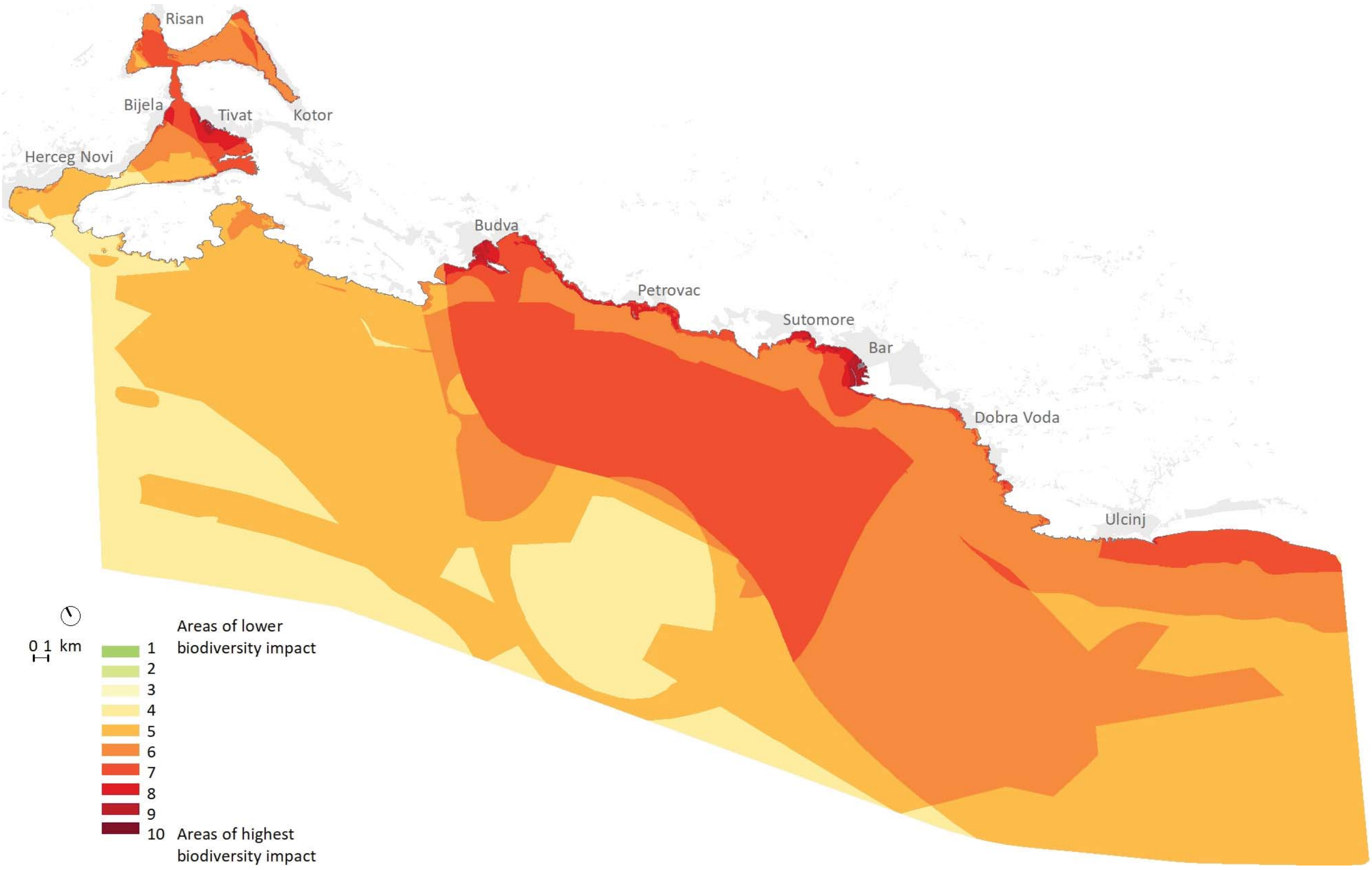
	1	2	3	4	5	6	7	8	9	10
1	1	2	3	4	4	5	5	6	6	7
2	2	3	3	4	5	5	6	6	7	7
3	3	3	4	4	5	6	6	7	7	8
4	4	4	4	5	5	6	7	7	8	8
5	4	5	5	5	6	6	7	8	8	9
6	5	5	6	6	6	7	7	8	9	9
7	5	6	6	7	7	7	8	8	9	10
8	6	6	7	7	8	8	8	9	9	10
9	6	7	7	8	8	9	9	9	10	10
10	7	7	8	8	9	9	10	10	10	10

Two types of areas stand out as the most endangered. The first areas are the highest pressures of pollutants, eutrophication, marine litter and other pressures from land where at the same time there are still more valuable habitat types (especially areas of Posidonia meadows and coral). These are the areas between:

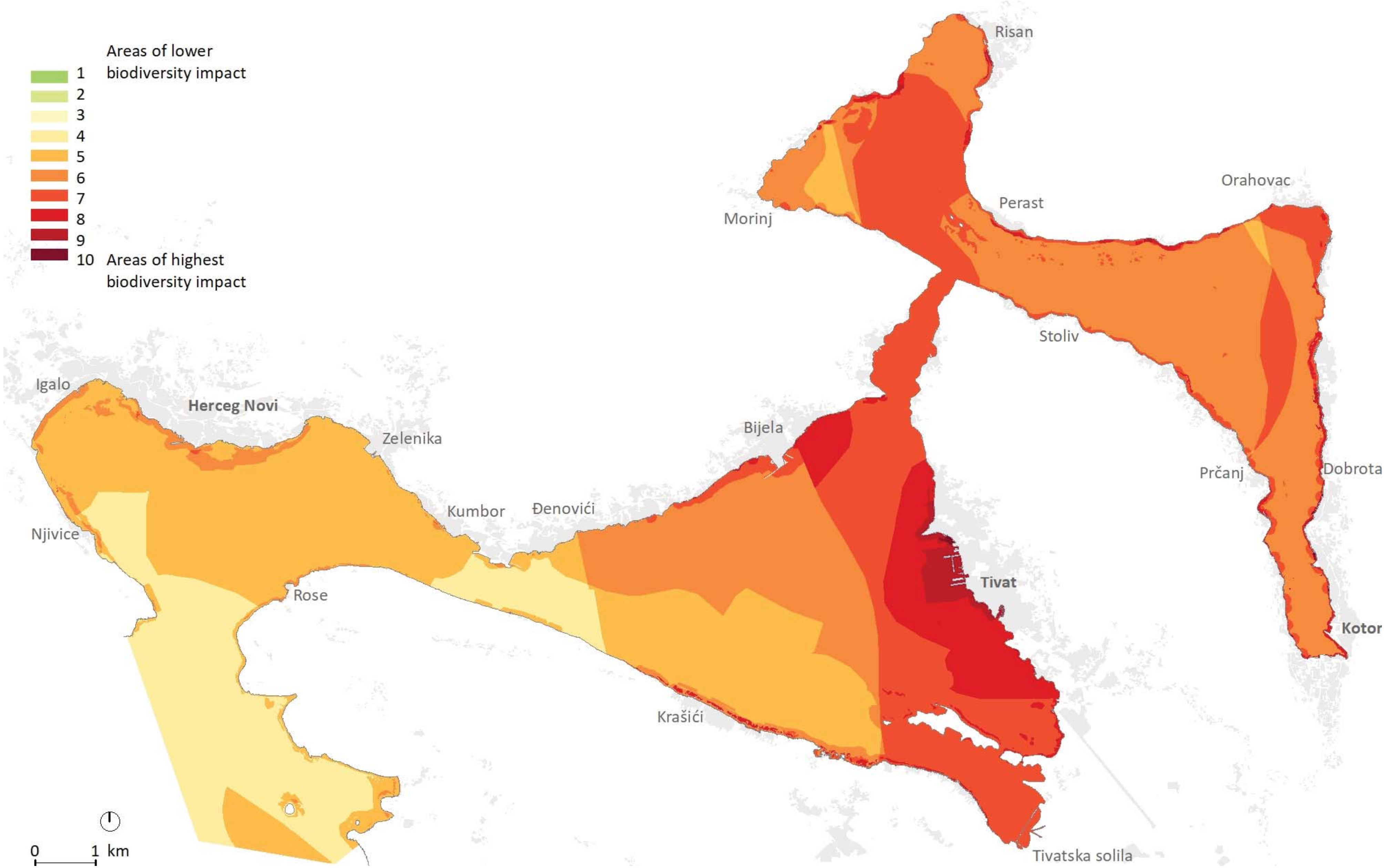
- Risan, Bijela and Tivat;
- Budva and Bar;
- Ulcinj and Bojana.

The second type of area is the common area of greatest fishing effort of pelagic and demersal species. It covers the open sea between Budva and Bar – an area of fishing for pelagic species by purse seine boats and demersal trawlers.

Map 10.1: Overall biodiversity impact



Map 10.2: Overall biodiversity impact in the Bay of Kotor



10.2. Cumulative impact of pollution

The cumulative impact of pollution was made by combining maps of the impact of pollutants in the marine environment, the impact on the trophic nature of the marine environment, and estimates of pressures from marine litter by the matrix below in such a way as to emphasize higher values from individual impact maps. The spatial representation of the largest cumulative impact of pollution is outlined on maps 10.3 and 10.4.

The Bay of Kotor area is generally under a greater cumulative impact from pollution than the open sea. This comes from relatively big sources of pollution and the closed nature of the bay. This is especially true for the areas of Kotor, Risan, Bijela and Tivat. The former Arsenal and Bijela, although no longer in operation, are still the biggest cause of sediment and biota contamination. Due to its specific position and intensive maritime activities, the Port of Kotor still contains high concentrations of Hg, Pb, PCBs and PAHs in its sediments. These are also the areas of the highest pressures levels from marine litter and nutrient input through unconnected discharges of municipal wastewater or the filtering septic tanks of private facilities.

In the open sea, the cumulative impact of pollution was highlighted in the areas of Budva, Sutomore and Bar, and from Ulcinj to Bar. The sediments of the waters of the Bar port and marina, as well as the wider waters of the port, are significantly loaded with heavy metals (Cd, Cu, Pb, Hg, As, Cr and Ni), PAHs and PCBs compounds, resulting from numerous port activities. The port of Budva with its marina also has higher levels of contamination of sediments with heavy metals, PAHs and PCBs, although to a lesser extent than the port of Bar. The area from Budva to Bar also has the highest level of pressures from marine litter and outflows of major sewage outlets. The area of Ulcinj – Ada Bojana is exposed to the influence of the river Bojana, i.e. the activities that are performed in its immediate surroundings.

Assessment of the pressure level from pollutants on the marine environment for the 2016-2019 period

Assessment of the impact of trophic levels of the marine environment in Montenegro

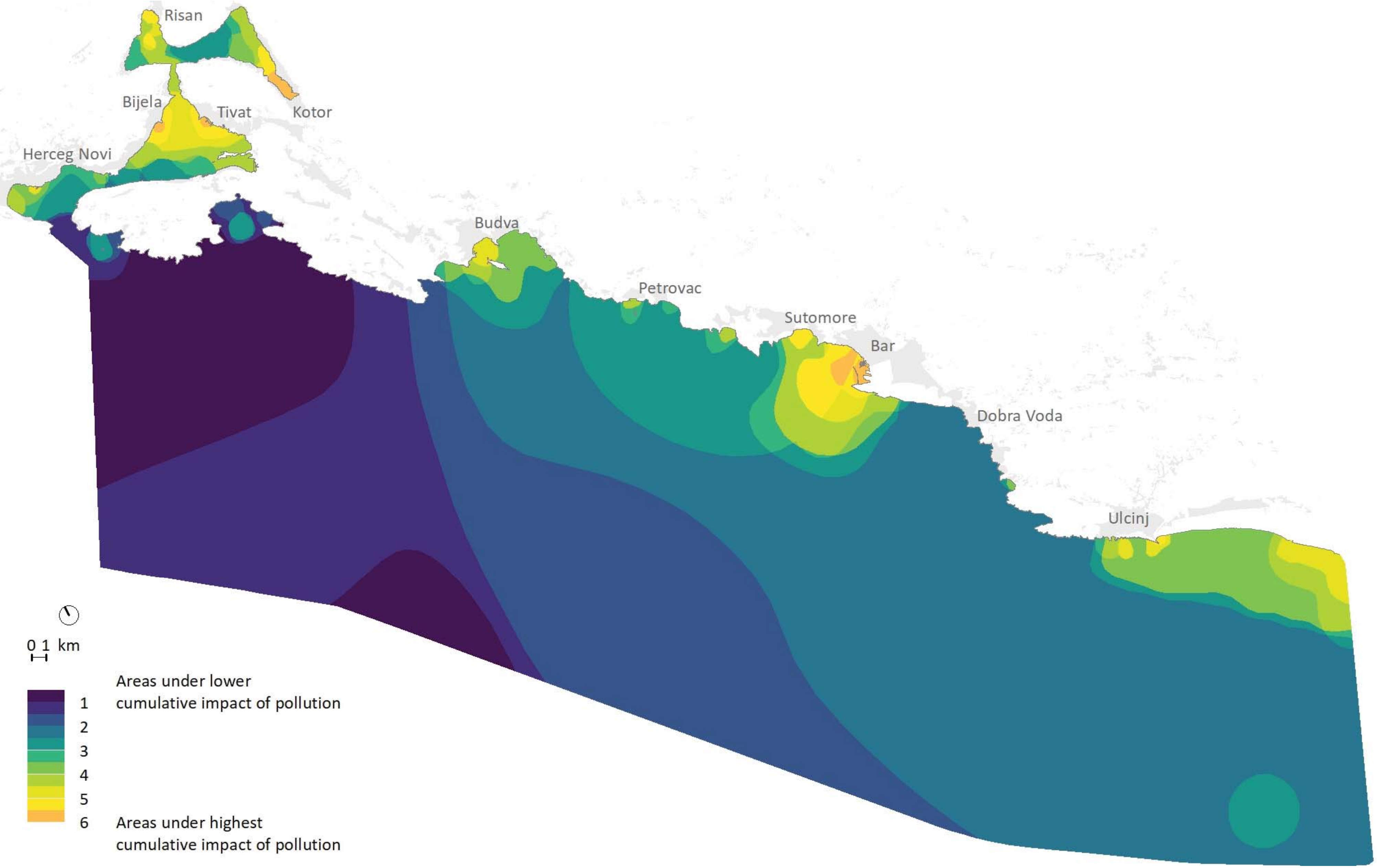
	1	2	3	4	5	6
1	1	2	4	7	8	9
2	2	3	5	8	9	10
3	4	5	6	8	10	11
4	7	8	8	9	10	11
5	8	9	10	10	11	11

Assessment of the pressure level from pollutants on the marine environment for the 2016-2019 period and assessment of the impact of trophic levels of the marine environment in Montenegro

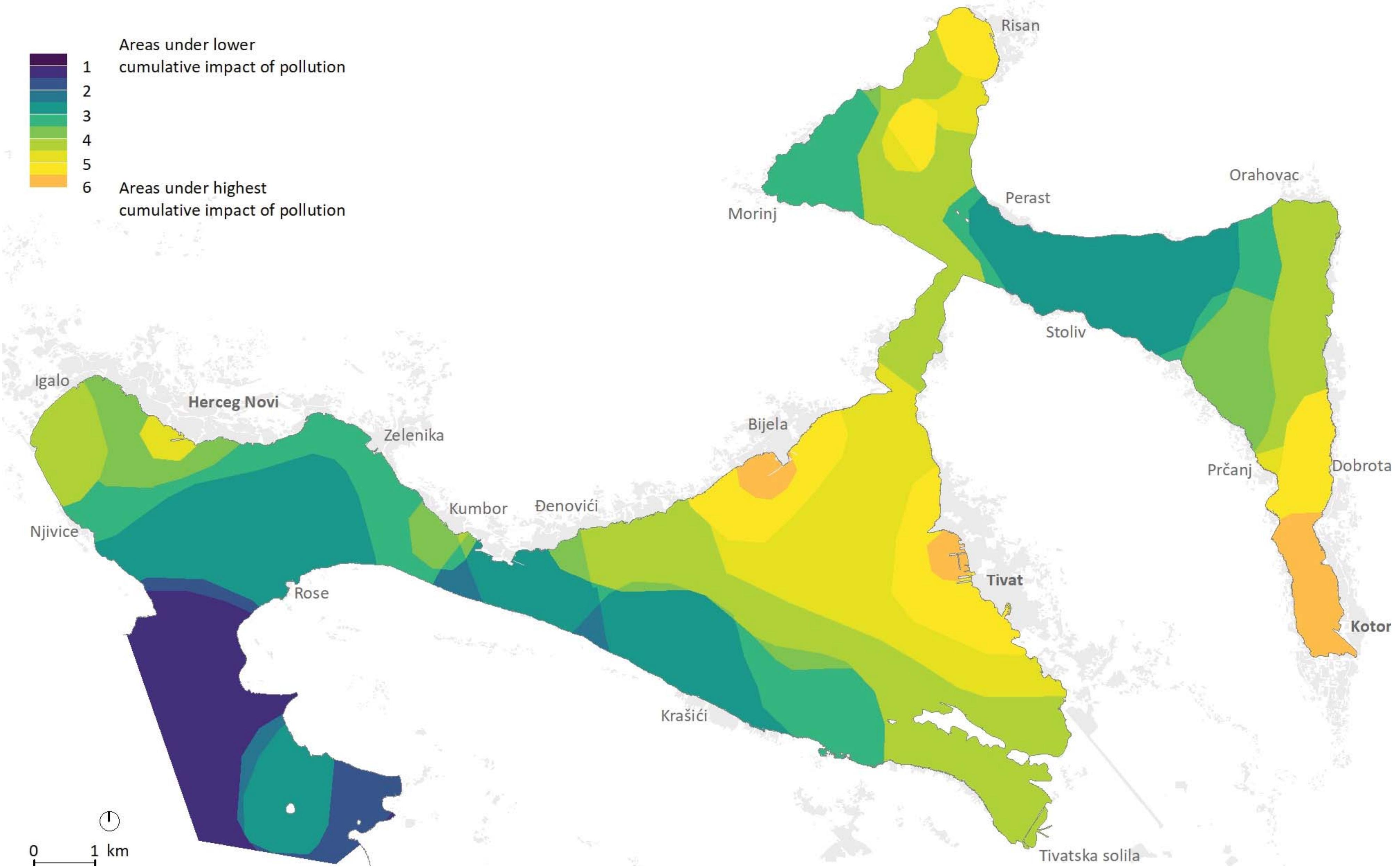
Assessment of the pressure level from marine litter in Montenegro

	1	2	3	4	5	6	7	8	9	10	11
1	1	2	3	4	5	6	7	8	9	10	11
2	2	3	4	5	6	7	7	8	9	10	11
3	3	4	5	6	7	8	8	9	9	10	11
4	4	5	6	7	8	8	9	9	10	10	11
5	5	6	7	8	8	9	9	10	10	11	11

Map 10.3: Cumulative impact of pollution



Map 10.4: Cumulative impact of pollution in the Bay of Kotor



10.3. Analysis of the state and pressures of the marine environment as the basis for protection, remedial and optimization of planning solutions

The analysis of the state and pressures of the Montenegrin marine environment shows, on the one hand, high pressures from pollutants, trophic levels, marine litter and other pressures emanating from land to sea. Due to urbanization pressures, the extent of coastal artificialization from manmade structures is big, especially in the Bay of Kotor. At least some artificiality is visible in half of the bay shore and a third of the shoreline has been built. On the other hand, the analysis shows a high degree of biodiversity in the sea, areas that are not affected by pollution and the great importance of the preserved natural coastal area without the presence of manmade structures.

The purpose of the analysis of the state and pressures is not the analysis itself, but the basis for defining protection measures (sectoral or spatial planning), remediation of polluted or otherwise degraded areas (visually, in terms of biodiversity, disturbed natural processes), and optimization of (current and future) planning solutions. The result to the findings of the analysis and recommendations for individual environmental goals should be an integral concept of protection and remediation of the marine environment. Such a concept should take the coast of Montenegro as a natural and cultural phenomenon, but also as an economic category. It should be emphasized that unfavorable development activities at sea and along the coast can not only reduce the values of natural and cultural characteristics, and increase environmental pressures, but can also reduce the region's recognizability, and contribute to irreversible degradation of space, which leads to long-term loss, in economic and other terms. All this primarily requires an adapted form of tourism, active planning of remediation and renewal of unconditionally urbanized areas, as well as the application of other measures in accordance with the National Strategy for Integrated Coastal Zone Management in Montenegro (2015).

The concept of protection and remediation should define the starting points for marine spatial planning related to:

- The establishment of protected areas in the sea;
- The protection of other important areas of biodiversity conservation;
- The conservation of shellfish farming areas/potentials;
- The protection of resources (for example peloids and medicinal mud in Igalo);
- The preservation and development of landscape characteristics;
- The restriction of activities with large impacts;
- Zones sensitive to the reception of pollution and/or eutrophication, and prevention of eutrophication and contamination;
- The remediation of hot-spot locations.

11. Bibliography

Biodiversity: Habitats

- UNEP(DEPI)/MED WG.420/4 Draft Integrated Monitoring and Assessment Guidance
- Protokol o područjima pod posebnom zaštitom i biodiverzitetu sredozemlja
- Rešenje o stavljanju pod zaštitu pojedinih biljnih i životinjskih vrsta (Sl. CG 76/06)
- RAC/SPA – UNEP/MAP, 2006. Classification of benthic marine habitat types for the Mediterranean region
- RAC/SPA – UNEP/MAP, 2013. Ecological quantitative description of Boka Kotorska Bay marine area (Montenegro). By Golder associates. Ed.RAC/SPA-MedMPAnet Project, Tunis. 82 pp + Appendices.
- RAC/SPA, 2013. Rapid Assessment Survey of coastal habitats to help prioritize the suitable new areas needing a status of protection for the development of a network of Marine and Coastal Protected Areas in Montenegro.By Badalamenti F., Garcia Charton J.A., Treviño-Otón J., Mačić V., and Cebrian D. Ed. RAC/SPA, Tunis. 56 pp. + Annexes.
- RAC/SPA, 2014. Marine biodiversity of Boka Kotorska bay pilot project on testing Ecosystem Approach (EcAp) application in Boka Kotorska bay: Executive summary. By: Slavica Petovic and Milena Batakovic. Ed. RAC/SPA, Tunis. 46 pp + Appendices
- Hrvatska agencija za okološ i prirodu, 2016. Morska staništa- Priručnik za inventarizaciju i praćenje stanja. By:T. Bakran-Petricioli. 163pp+Annex
- Boudouresque C.F., Bernand G., Bonhomme P., Charbonnel E., Diviacco G., Meinsez A., Pergent G., Pergent- Martini C. , ruitton S., Tunesi L., 2012. Protection and conservation of posedonia Oceanica meadows. Remoge and RAC/SPA publisher, Tunis 1-202.
- „Katič" Pilot Marine Protected Area Management Plan, 2010, Ministry of Sustainable Development and Tourism
- Ministry of Sustainable Development and Tourism, 2012: Start up of Katič Marine Protected Area in Montenegro and assessment of marine and coastal ecosystems along the coast,
- UNEP/MAP-RAC/SPA, 2016. Montenegro: Platamuni and Ratac areas. Mapping of marine key habitats and initiation of monitoring network. By Torchia G., Pititto F., Rais C., Trainito E., Badalamenti F., Romano C., Amosso C., Bouafif C., Dragan M., Camisassi S., Tronconi D., Macic V., Sghaier Y.R. & Ouerghi A. Ed. RAC/SPA – MedKeyHabitats Project, Tunis: 77 pp + Annexes
- Tatjana Bakran-Petricioli, 2011. Priručnik za određivanje morskih staništa u Hrvatskoj prema Direktivi o staništima EU, Državni zavod za zaštitu prirode Zagreb
- UNEP/MAP-PAP/RAC-SPA/RAC and MESPU (2021). Integrated Monitoring Programme – Montenegro. By: Milena Bataković, Olivier Brivois, Daniel Cebrian, Luka Čalić, Željka Čurović, Dragana Drakulović, Mirko Đurović, Ivan Guala, Carlos Guitart, Draško Holcer, Zdravko Ikica, Aleksandra Ivanović, Christos Ioakemidis, Aleksandar Joksimović, Darinka Joksimović, Radovan Kandić, Yakup Kaska, Jelena Knežević, Nada Krstulović, Vesna Mačić, Milica Mandić, Marina Marković, Ivana Mitrović, Branka Pestorić, Slavica Petović, Robert Precali, Darko Saveljić, Ivana Stojanović, Ivan Sekovski, Danijela Šuković, Anis Zarrouk, Marco Zenatello, Argyro Zenetos, Vladimir Živković. Eds: PAP/RAC, GEF Adriatic project. pp130 + Annexes
- UNEP/MAP-PAP/RAC-SPA/RAC and MSDT (2020): Towards GES assessment for Montenegro Biodiversity and Non-indigenous species, draft
- UNEP/MED WG.461/11. Updated Reference List of Marine Habitat Types for the Selection of Sites to be included in the National Inventories of Natural Sites of Conservation Interest in the Mediterranean
- UNEP/MED WG.482/Inf.13. Methodological Approach for mapping the interrelations between Pressures-Impacts and the Status of Marine Ecosystem Components for Biodiversity Cluster
- Agencija za zaštitu prirode i životne sredine, Podgorica, 2020: Studije zaštite za zaštićena područja Platamuni, Katič i Ostrvo Stari Ulcinj,.
- SPA/RAC–UN Environment/MAP, 2019. Updated Classification of Benthic Marine Habitat Types for the Mediterranean Region

- UNEP/MAP-RAC/SPA, 2016. Mapping of marine key habitats in the Mediterranean and promoting their conservation through the establishment of Specially Protected Areas of Mediterranean Importance. By Habib LANGAR, Cyrine BOUAFIF, Yassine Ramzi SGHAIER, Atef OUERGHI, Dorra MAAOUI. Ed. RAC/SPA – MedKeyHabitats Project, Tunis: 20 pp + sheets.
- Nacrt „Studija zaštite za Park Prirode Platamuni", Agencija za zaštitu prirode i životne sredine, novembar 2020

Biodiversity: Fish

- AdriaMed (2015). Activity Report on the AdriaMed Study Group on intercalibration of sardine otolith reading and revision of criteria in the Adriatic Sea (Split, Croatia, 8-10 April 2015). Prepared by Dr. F. Alemany.
- Angelini S., Arneri E., Belardinelli A., Biagiotti I., Bratina P., Canduci G., Colella S., Costantini I., Croci C., De Felice A., Domenichetti F., Donato F., Gašparević D., Juretić T., Leonori I., Martinelli M., Milone N., Modić T., Pallaoro A., Panfili M., Pešić A., Ikica Z., Santojanni A., Tesauro C., Tičina V.(2017). FAO GFCM Stock assessment form for small pelagic. Reference year 2016. Reporting year 2017. 40. https://gfcmsitestorage.blob.core.windows.net/documents/SAC/SAFs/SmallPelagics/2016/ANE_GSA_17-18_2016_ALB_HRV_ITA_MNE_SVN.pdf
- Bembo, D. G., G. R. Carvalho, N. Cingolani, E. Arneri, G. Giannetti & T. J. Pitcher. 1996. Allozymic and morphometric differences for two stocks of the European anchovy *Engraulis encrasicolus* in Adriatic waters. Mar. Biol. 126: 529–538.
- Bindman, A.G. (1986). The 1985 spawning biomass of the northern anchovy. California Cooperative Oceanic Fisheries Investigations Report 27, 16–24.
- Carvalho G.R., Bembo D.G., Carone A., Giesbrecht G., Cingolani N., and Pitcher T.J. (1994). Stock discrimination in relation to the assessment of Adriatic anchovy and sardine fisheries. Final Project Report to the Commission of the European Communities, EC XIV-1/MED/91001/A.
- FAO. (1997). Fisheries management. FAO Technical Guidelines for Responsible Fisheries No. 4. Rome, FAO. 82p. http://www.fao.org/3/a-y4470e.pdf
- FAO, Fisheries Department, Fishery Information, Data and Statistic Unit. FISHSTAT PLUS: Universal software for fishery statistical time series. Version 2.3.2000. http://www.fao.org/fishery/statistics/software/fishstat/en
- Deriso, R.B., Barnes, J.T., Jacobson, L.D., Arenas, P.R. (1996). Catch-at-age analysis for Pacific sardine (*Sardinops sagax*), 1983–1995. California Cooperative Oceanic Fisheries Investigations Report 37, 175–187.
- Fiorentino F., E. Massutì, F. Tinti, S. Somarakis, G. Garofalo, T. Russo, M.T. Facchini, P.Carbonara, K. Kapiris, P. Tugores, R. Cannas, C. Tsigenopoulos, B.

Patti, F. Colloca, M. Sbrana, R. Mifsud, V. Valavanis, and M.T. Spedicato, 2014. Stock units: Identification of distinct biological units (stock units) for different fish and shellfish species and among different GFCM-GSA. STOCKMED Deliverable 03: FINAL REPORT. September 2014, 310 p.

- Guidetti P. 2000. Differences Among Fish Assemblages Associated with Nearshore Posidonia oceanica Seagrass Beds, Rocky–algal Reefs and Unvegetated Sand Habitats in the Adriatic Sea. Estuarine, Coastal and Shelf Science. 50(4): 515–529.
- Hampton, I. (1996). Acoustic and egg-production estimates of South African anchovy biomass over a decade: comparisons, accuracy and utility. ICES Journal of Marine Science 53, 493–500.
- Hureau, J. C. & T. Monod. 1973. Check-list of the fishes of the north-eastern Atlantic and of the Mediterranean. UNESCO, Paris, Presses Universitaires de France, Vendôme, Vols. I – II: 1014 pp.
- Jacobson, L.D., Lo, N.C.H., Barnes, J.T. (1994). A biomass-based assessment model for northern anchovy, *Engraulis mordax*. Fishery Bulletin 92, 711–724.
- Jardas, I. (1996). Jadranska ihtiofauna. Školska knjiga, Zagreb, 165p.
- Kačić, I. (1980). Pelagic fish in the Adriatic – distribution and stock assessment. FAO Fish. Rep. 239, 21-31.
- Karlovac, J. (1967). Etude de l'ecologie de la sardine, *Sardina pilchardus* Walb., dans la phase planctonique de sa vie en Adriatique Moyenne. Acta Adriat. 13 (2), 1-112.
- Kell, L. T., Mosqueira, I., Grosjean, P., Fromentin, J.-M., Garcia, D., Hillary, R. and Scott, R. D. (2007). FLR: an open-source framework for the evaluation and development of management strategies. ICES Journal of Marine Science, 64(4), 640–646.
- Kraus, G., Koster, F.W. (2004.) Estimating Baltic sprat (*Sprattus sprattus balticus* S.) population sizes from egg production. Fisheries Research 69, 313–329.
- Levi, D., M.G. Andreoli, E. Arneri, G. Giannetti & P. Rizzo. 1994. Otolith reading as a tool for stock identification. Fish. Res. 20: 97-107.
- Magoulas A., R. Castilho, S. Caetano, S. Marcato & T. Patarnello. 2006. Mitochondrial DNA reveals a mosaic pattern of phylogeographical structure in Atlantic and Mediterranean populations of anchovy (*Engraulis encrasicolus*). Molecular Phylogenetics and Evolution 39: 734-746.
- Mandić, M., S. Regner, M. Đurović, A. Joksimović, A. Pešić, and J. Krpo-Ćetković (2015). Distribution and abundance of eggs and estimation of spawning stock biomass of anchovy, Engraulis encrasicolus (Linnaeus, 1758), in the south-eastern Adriatic Sea. J. Mar. Biol. Assoc. U.K.. Volume 95, Issue 5, 1051-1059.
- Martin, P, Bahamon, N., Sabatés, A., Maynou, F., Sánchez, P. & Demestre, M (2008): European anchovy (*Engraulis encrasicolus*) landings and environmental conditions on the Catalan Coast (NW Mediterranean) during 2000-2005. Hydrobiologia 612: 185-199 p.
- MEDIAS Handbook, April 2019 (http://www.medias-project.eu/medias/website/handbooks-menu/func-startdown/124/)
- MEDITS-Handbook. Version n. 8, 2016. International bottom trawl survey in the Mediterranean. Instruction manual. Version 8. MEDITS Working Group : 177.
- Merker, K., Vujošević, M. (1972).Density and distribution of anchovy (*Engraulis encrasicolus* L.) eggs in the Bay of Boka Kotorska (in Serbo-Croatian). Poljoprivreda i šumarstvo, 18: 15-27.
- Parker, K. (1980). A direct method for estimating northern anchovy, *Engraulis mordax*, spawning biomass. Fishery Bulletin 78, 541–544.
- Perez-Ruzafa A., Quispe-Becerra J.I., Garcia-Charton J.A., Marcos C. 2004. Composition, structure and distribution of the ichthyoplankton in a Mediterranean coastal lagoon. Journal of Fish Biology. 64(1): 202–218
- Piccinetti, Corrado & Vrgoc, Nedo & Marčeta, Bojan & Manfredi, Chiara. (2012). The Recent State of Demersal Resources of the Adriatic Sea. Acta Adriat. 5. 1-220.
- Picquelle, S.J., Hewitt, R.P. (1983.) The northern anchovy spawning biomass for the 1982–83 California fishing season. California Cooperative Oceanic Fisheries Investigations Report 24, 16–28.
- Simmonds E. J. and MacLennan D. N. (2005) Fisheries Acoustics (Blackwell Publishing, Oxford). 437 pp.
- Sinovčić, G. 2000. Anchovy, *Engraulis encrasicolus* (Linnaeus, 1758): biology, population dynamics and fisheries case study. Acta Adriat. 41: 1-54.

- Somarakis S., Palomera I., Garcıa A., Quintanilla L., Koutsikopoulos C., Uriarte A. and Motos L. (2004). Daily egg production of anchovy in European waters. ICES Journal of Marine Sciences 61, 944–958.
- Somarakis, S., Ganias, K., Siapatis, A., Koutsikopoulos, C., Machias, A, Papaconstantinou, C. (2006). Spawning habitat and daily egg production of sardine (Sardina pilchardus) in the eastern Mediterranean. Fish. Oceanogr., 15:4, 281-292.
- Somarakis, S., Palomera, I., Garcı ´a, A., Quintanilla, L., Koutsikopoulos, C., Uriarte, A., Motos, L. (2004): Daily egg production of anchovy in European waters. ICES J. Mar. Sci. 61: 944-958.
- Souplet A. (1996). Calculation of abundance indices and length frequencies in the MEDITS survey. In: J. A. Bertrand *et al.* (eds), Campagne internationale du chalutage démersal en Méditerraneé. Campagne 1995. EU Final Report, Vol. III.
- STECF, 2019. Scientific, Technical and Economic Committee for Fisheries (STECF) – Preparation for the evaluation of the list of mandatory research surveys at sea (STECF-19-05). Publications Office of the European Union, Luxembourg. 81.
- Stylianos Somarakis, Eudoxia Schismenou, Apostolos Siapatis, Marianna Giannoulaki, Argyris Kallianiotis, Athanassios Machias (2012). High variability in the Daily Egg Production Method parameters of an eastern Mediterranean anchovy stock: Influence of environmental factors, fish condition and population density, Fisheries Research, Volumes 117–118. 2-21.
- Škrivanić, A. & Zavodnik, D. (1973). Migrations of the sardine (Sardina pilchardus) in relation to hydrographical conditions of the Adriatic Sea. Netherland Journal of Sea Research 7, 7-18.
- Taylan, B, Hossucu, B. (2016). Daily Egg Production Method for spawning biomass estimates of European anchovy *Engraulis encrasicolus* (Linnaeus, 1758) in Edremit Bay (Aegean Sea). Fresenius Environmental Bulletin 25(11):4742-4746.
- Tinti F., Di Nunno C., Guarniero I., Talenti M., Tommasini S., Fabbri E. and Piccinetti C. (2002). Mitochondrial DNA sequence variation suggests the lack of genetic heterogeneity in the Adriatic and Ionian stocks of *Sardina pilchardus*. Mar. Biotech. 4: 163-172.
- Tserpes, George & Massutí, Enric & Fiorentino, F. & Facchini, Maria & Viva, Claudio & Jadaud, Angélique & Joksimović, Aleksandar & Pesci, Paola & Piccinetti, Corrado & Sion, Letizia & Thasitis, Ioannis & Vrgoc, Nedo. (2019). Distribution and spatio-temporal biomass trends of red mullets across the Mediterranean. Scientia Marina. 83. 10.3989/scimar.04888.21A.
- Tudela, S. & I. Palomera. 1999. Potential effect of an anchovy mediated pump on the vertical availability of nitrogen for primary production in the Catalan Sea (northwest Mediterranean). Journal of Sea Research 42: 83–92.
- UNEP/MAP. (2017). Agenda item 3 Review of proposed IMAP Common Indicator Guidance Facts Sheets (Biodiversity and Fisheries). IMAP Common Indicator Guidance Facts Sheets (Biodiversity and Fisheries). UNEP(DEPI)/MED WG.444/6/Rev.1. 6th Meeting of the Ecosystem Approach Coordination Group. Athens, Greece, 11 September 2017. 123 pp.
- Van der Lingen, C., Castro, L. (2004): SPACC workshop and meeting on spawning habitat and assessment of small pelagic fish, Concepción Chile, 12–16 January 2004. GLOBEC International Newsletter 10(1): 28–31.
- Vučetić, T. (1975). Synchronism of the spawning season of some pelagic fishes (sardine, anchovy) and the timing of maximum food (zooplancton) production in the central Adriatic. Pubblicazioni della Stazione Zoologica di Napoli 39 (1), 347-465.
- Whitehead, P. J. P., Bauchot, M.-L., Hureau, J.-C., Nielsen, J. & Tortonese, E. (Eds) (1989). Fishes of the North – eastern Atlantic and the Mediterranean. UNESCO, Richard Clay Ltd. Bungay (United Kingdom), Vol. I, 276-277.
- Zorica, B, Čikeš Keč, V, Pešić, A., Gvozdenović, S. Kolitari, J., and Mandić M. (2018). Spatiotemporal distribution of anchovy early life stages in the eastern part of the Adriatic Sea in relation to some oceanographic features. Journal of the Marine Biological Association of the United Kingdom. Vol 99, Issue 5. 1205-1211.

Landscapes

- CAMP Crna Gora: Analiza opšte ranjivosti (2013) Ministarstvo održivog razvoja i turizma Crne Gore, Priority Actions Programme/Regional Activity Centre
- Djokić V., Cvejić J., Lješković Mitrović S. (ur.) (2010) Kulturni predio Boka Kotorska. Univerzitet u Beogradu, Arhitektonski fakultet
- Guidelines for Landscape and Visual Impact Assessment (2002) The Landscape Institut; Institut of Enivironmental Magagement & Assessment
- Landscape Aesthetics: A Handbook for Scenery Management (1995) United States Department of Agriculture, Forest Service: http://www.fs.fed.us/cdt/carrying_capacity/landscape_aesthetics_handbook_701_no_append.pdf
- Mapiranje i tipologija predjela Crne Gore (2015) RZUP
- Marušič J. et al (1998.) Regional Distribution of Landscape Types in Slovenija: Methodological Basis. Ministry of the Environment and Physical Planning
- Nacionalna strategija integralnog upravljanja obalnim područjem Crne Gore (2015) Ministarstvo održivog razvoja Crne Gore, UNEP/MAP, PAP/RAC
- Prostorni plan posebne namjene obalnog područja (2018) RZUP, Horwath i Horwath Conuslting, MonteCEP
- Review of Existing Methods of Landscape Assessment and Evaluation (2012) The Macaulay Land Use Research Institute
- Spatial analysis on length of Montenegro's coastline occupied by human-made structures, as an input to a document on how to approach assessment of Good Environmental Status (GES) of Montenegro regarding IMAP's Common Indicator 16 (2020) UNEP/MAP-PAP/RAC

Assessment of Anthropogenic Impacts on the Trophic Status of Marine Environments

International regulations

- UNEP(DEPI)/MED IG.19/8 24 November 2009:Decision IG.20/4:
- UNEP IOC Marine_Litter_Survey_and_Monitoring_Guidelines
- UNEPMAP_ Ecosistem Approach 2012_ENG
- UNEP/MAP- SAP MED
- UNEP/MAP: ImplementatIon of the ecosystem approach In the MedIterranean (ECAP 2015)
- UNEP/MAP Decision IG.22/7, Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria
- UNEP/MAP Decision IG.20/4 Implementing MAP ecosystem approach roadmap: Mediterranean Ecological and Operational Objectives, Indicators and Timetable for implementing the ecosystem approach road map, 2015
- UNEP (DEPI) MED WG. 417/Inf. 15.
- UNEP/MAP Decision-IG.22-7-IMAP-FINAL,2015
- WG420_3 Draft Integrated Monitoring & Assessment Programme for the Mediterranean IMAP
- WG420_4 Draft Integrated Monitoring & Assessment Guidance
- WG.390-3 Working document on Common Indicators for the Mediterranean.
- WG 365 ifn 8 Development of assessment criteria Hazardous
- EcAp-MED i Regional Activity Centre for Specially Protected Areas files
- The Ecosystem Approach (EcAp) Regional Activity Centre for Specially Protected Areas
- CORMON Documents WG 426 i 427, okt. 2016.
- WG 365 ifn 8 Development of assessment criteria Hazardous Substances.
- Okvirna direktiva o moru 2008-56 hr MSFD.

- Implementing MAP ecosystem approach roadmap: Mediterranean Ecological and Operational Objectives, Indicators and Timetable for implementing
- EARS_WG3_INF4_MAP_ Integrated Monitoring Assessment Guidance EN.UNEP/MAP 2016
- State of Environment SoMMCER
- Healtz environmenteco-actionplan DCEFRA Standards. Action plan for ecosystem approach, DEFRA,2007
- DEFRA:Applying an Ecosystem Approach in Scotland: a Framework for Action (2015)
- DEFRA Natural Environment White Paper Implementation update report February 2014
- Annex S_I2000Dutch Environmental Standards
- OSPAR Further development of guidance on integrated monitoring and assessment of chemicals and biological effects
- OSPAR JAMP Eutrophication Monitoring Guidelines: Chlorophyll a in Water
- Scotland's Marine Atlas Information for The National Marine Plan.
- Quality Status Reports (QSR) – Assessment & Monitoring – Work Areas – OSPAR Commission.
- CEFAS Integrated Contaminant Monitoring, T. Maes,2010
- CEFAS Sediment user guide august 2011
- Preview of Water quality hazards and dispersion of pollutants [WorldCat.org]

Montenegrin Legislation

- Zakon o životnoj sredini (Sl.list CG br.2/16)
- Zakon o vodama (Sl.list CG br.48/15, 52/16, 84/18
- Zakon o zaštiti morske sredine (Sl.list CG.br.73/19)
- Pravilnik o načinu i rokovima utvrđivanja statusa površinskih voda (Sl.list CG br.25/19)
- Uredba o klasifikaciji i kategorizaciji površinskih i podzemnih voda (Sl.list CG br.02/07)
- Prostorni plan posebne namjene za obalno područje Crne Gore, 2018
- Pravilnik o dozvoljenim količinama opasnih i štetnih materija u zemljištu i metodama za njegovo ispitivanje („Sl. list RCG“, br. 18/97)

Used data

- Study of the hydrodynamical processes in the Boka Kotorska Bay with a finite element model, Debora Bellafiore, Antonio Guarnieri, Federica Grilli, Pierluigi Penna, Giovanni Bortoluzzi, Federico, Nadia Pinardi, Dynamics of Atmosphere sand Oceans52 (2011) 298–321
- Spatial distribution of physical, chemical and biological oceanographic properties, phytoplankton, nutrients and Coloured Dissolved Organic Matter (CDOM) in the Boka Kotorska Bay (Adriatic Sea)GEOFIZIKA VOL. 26 No. 2 20093, Alessandra Campanelli, Ana Bulatović, Marina Cabrini, Federica Grilli, Zoran Kljajić, Renzo Mosetti, Elio Paschini, Pierluigi Pennaand, Mauro Marin
- Spatial distribution of physical, chemical and biological oceanographic properties, phytoplankton, nutrients and Coloured Dissolved Organic Matter(CDOM) in the Boka Kotorska Bay (Adriatic Sea)Alessandra Campanelli1, Ana Bulatović, Marina Cabrini, Federica Grilli, Zoran Kljajić, Renzo Mosetti,, Elio Paschini, Pierluigi Penna and Mauro Marini, GEOFIZIKA VOL. 26 No. 2, 2009
- Environmental Regulations and Standard setting – Effluent Limits for Discharges – A. Karavanas, M.N. Christolis and N.C. Markatos
- Trophic conditions of marine coastal waters: experience in applying the Trophic Index TRIX to two areas of the Adriatic and Tyrrhenian seas Franco GIOVANARDI* and Richard A. VOLLENWEIDER1),J. Limnol., 63(2): 199-218, 2004
- Final Report CDM- Hydroengineering 2011-2013, B.Bijela
- Uključivanje civilnog društva u planiranje integralnog upravljanja obalnim područjem, CEED, V. Bušković, 2013
- Medtrendsblue growth trends in the Adriatic sea: the challenge of environmental protection, jan.2016
- State of the Mediterranean Marine and Coastal Environment

- Report was realized under the aegis of the United Nations Environment Programme/Mediterranean Action Plan, (UNEP/MAP).2012
- Studija CAMP MNE
- NAP MNE 2015, A. Mišurović 2015.
- Definisanje metodološkog okvira za planiranje namjene morskog područja u Bokokotorskom zalivu, PAP/RAC, 2015
- Analiza ranjivosti morske sredine u Bokokotorskom zalivu: Metodološke smjernice, PAP/RAC, 2017
- National strategy on integrated management of the coastal zone of Montenegro, NS IUOP, 2015
- Informacije o stanju životne sredine Crne Gore-EPA: 2008, 2009, 2010, 2011, 2012, 2014, 2015, 2016, 2017, 2018 godinu sa Prijedlogom mjera.
- Eutrophication of waters of Boka Kotorska Bay a Pilot Study TCH REP, EPA MNE, 2010
- Rezultati analiza školjki na uzgajalištima 2008-2019. godini
- Podaci JPMD o kvalitetu plaža od 2005- 2014, 2015 i 2016 godini
- EPA, Izvještaj Program a monitoringa stanja ekosistema priobalnog mora Crne Gore za 2014. Godinu IBM,
- Luštica Development AD „0" Stanje, CETI, 2013
- Podaci o ispitivanju kvaliteta životne sredine u vojnoj kasarni u Kumboru 2012-2014 god. CETI
- Izvjestaj o „0" stanju Brodogradilišta Bijela,CDM, CETI, 2015
- Izvještaji o realizaciji monitoringa morskog ekosistema CETI i IBM 2008-2012, i 2014-2020 godine.
- Izvještaj o stanju kvaliteta voda u Crnoj Gori za 2014. godinu HMZS,
- Studija o negativnom uticaju rasutih zagadjivaca,Lj. Radojičić, 2007,
- Osnovne karakteristike malih vodotoka crnogorskog primorja – HMZ, Elaborat, 2013
- Nacionalni Inventar emisija iz kopnenih izvora zagađenja za Crnogorsko primorje za 2018/2019 godinu -NBB- 2018 , UNEP/MAP, Nacionalni plan za implementaciju Stokholmske konvencije, UNEP/GEF 2010, 2013.
- Izvještaji CETI o realizaciji monitoringa morskog ekosistema za 2016, 2017, 2018 i 2019 godinu.
- Izvještaji CETI o realizaciji monitoringa kvaliteta voda i sedimenata po transektima 2020 god/GEF Adriatic
- Godišnji izvještaji o kvalitetu vode na plažama JPMD 2008-2019.
- EO5 Eutrofikacija IBM , 2019
- Izvještaj o provedenoj analizi procesa uzorkovanja, skladištenja uzoraka i načinu njihovog određivanja obzirom na ključne kemijske parametare eutrofikacije koje provode nacionalne institucije u Crnoj Gori te analiza rezultata usporednog ispitivanja provedenog u Crnogorskom primorju tijekom 2019. godine
- Program izgradnje kolektorskih sistema i postrojenja za tretman komunalnih otpadnih voda, MORT 2019.

Contaminants in the Marine Environment

International regulations

- UNEP(DEPI)/MED IG.19/8 24 November 2009: Decision IG.20/4:
- UNEP IOC Marine Litter Survey and Monitoring Guidelines
- UNEPMAP Ecosistem Approach 2012_ENG
- UNEP/MAP- SAP MED
- UNEP/MAP: Implementation of the ecosystem approach In the Mediterranean (ECAP 2015)
- UNEP/MAP Decision IG.22/7, Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria
- UNEP/MAP Decision IG.20/4 Implementing MAP ecosystem approach roadmap: Mediterranean Ecological and Operational Objectives, Indicators and Timetable for implementing the ecosystem approach road map, 2015
- UNEP/MAP Decision-IG.22-7-IMAP-FINAL,2015
- WG420_3 Draft Integrated Monitoring & Assessment Programme for the Mediterranean IMAP
- WG420_4 Draft Integrated Monitoring & Assessment Guidance
- WG.390-3 Working document on Common Indicators for the Mediterranean.
- WG 365 ifn 8 Development of assessment criteria Hazardous
- EcAp-MED i Regional Activity Centre for Specially Protected Areas_files
- The Ecosystem Approach (EcAp) Regional Activity Centre for Specially Protected Areas
- CORMON Documents WG 426 i 427, okt. 2016.
- WG 365 ifn 8 Development of assessment criteria Hazardous Substances.
- Okvirna direkiva o moru 2008-56 hr MSFD.
- Implementing MAP ecosystem approach roadmap: Mediterranean Ecological and Operational Objectives, Indicators and Timetable for implementing
- EARS_WG3_INF4_MAP_ Integrated Monitoring Assessment Guidance EN.UNEP/MAP 2016
- State of Environment SoMMCER
- Healtz environmenteco-actionplan DCEFRA Standards. Action plan for ecosystem approach, DEFRA,2007
- DEFRA: Applying an Ecosystem Approach in Scotland: a Framework for Action (2015)
- DEFRA Natural Environment White Paper Implementation update report February 2014
- Annex S_I2000Dutch Environmental Standards
- OSPAR Further development of guidance on integrated monitoring and assessment of chemicals and biological effects
- OSPAR JAMP Eutrophication Monitoring Guidelines: Chlorophyll a in Water
- Scotland's Marine Atlas Information for The National Marine Plan.
- Quality Status Reports (QSR) – Assessment & Monitoring – Work Areas – OSPAR Commission.
- CEFAS Integrated Contaminant Monitoring, T. Maes,2010
- CEFAS Sediment user guide august 2011
- Preview of Water quality hazards and dispersion of pollutants [WorldCat.org]

Montenegrin legislation

- Zakon o životnoj sredini (Sl.list CG br.2/16)
- Zakon o vodama (Sl.list CG br.48/15, 52/16, 84/18
- Zakon o zaštiti morske sredine (Sl.list CG.br.73/19)
- Pravilnik o načinu i rokovima utvrđivanja statusa površinskih voda (Sl.list CG br.25/19)

- Uredba o klasifikaciji i kategorizaciji površinskih i podzemnih voda (Sl.list CG br.02/07)
- Prostorni plan posebne namjene za obalno područje Crne Gore, 2018
- Pravilnika o dozvoljenim količinama opasnih i štetnih materija u zemljištu i metodama za njegovo ispitivanje („Sl. list RCG“, br. 18/97)

Used data

- Study of the hydrodynamical processes in the Boka Kotorska Bay with a finite element model, Debora Bellafiore, Antonio Guarnieri, Federica Grilli, Pierluigi Penna, Giovanni Bortoluzzi, Federico, Nadia Pinardi, Dynamics of Atmosphere sand Oceans52 (2011) 298–321
- Spatial distribution of physical, chemical and biological oceanographic properties, phytoplankton, nutrients and Coloured Dissolved Organic Matter (CDOM) in the Boka Kotorska Bay (Adriatic Sea)GEOFIZIKA VOL. 26 No. 2 20093,Alessandra Campanelli, Ana Bulatović, Marina Cabrini, Federica Grilli, Zoran Kljajić, Renzo Mosetti, Elio Paschini, Pierluigi Penna and Mauro Marin
- Spatial distribution of physical, chemical and biological oceanographic properties, phytoplankton, nutrients and Coloured Dissolved Organic Matter(CDOM) in the Boka Kotorska Bay (Adriatic Sea) Alessandra Campanelli, Ana Bulatović, Marina Cabrini, Federica Grilli, Zoran Kljajić, Renzo Mosetti, Elio Paschini, Pierluigi Penna and Mauro Marini, GEOFIZIKA VOL. 26 No. 2, 2009
- Environmental Regulations and Standard setting – Effluent Limits for Discharges – A. Karavanas, M.N. Christolis and N.C. Markatos
- Trophic conditions of marine coastal waters: experience in applying the Trophic Index TRIX to two areas of the Adriatic and Tyrrhenian seas Franco GIOVANARDI* and Richard A. VOLLENWEIDER1),J. Limnol., 63(2): 199-218, 2004
- Final Report CDM- Hydroengineerig 2011-2013, B. Bijela
- Uključivanje civilnog društva u planiranje integralnog upravljanja obalnim područjem, CEED, V. Bušković, 2013
- Medtrendsblue growth trends in the Adriatic sea: the challenge of environmental protection, jan.2016
- State of the Mediterranean Marine and Coastal Environment
- Report was realized under the aegis of the United Nations Environment Programme/Mediterranean Action Plan, (UNEP/MAP).2012
- Studija CAMP MNE
- NAP MNE 2015,A. Mišurović 2015.
- Definisanje metodološkog okvira za planiranje namjene morskog područja u Bokokotorskom zalivu, PAP/RAC, 2015
- Analiza ranjivosti morske sredine u Bokokotorskom zalivu: Metodološke smjernice, PAP/RAC, 2017
- National strategy on integrated management of the coastal zone of Montenegro ,NS IUOP, 2015
- Informacije o stanju životne sredine Crne Gore-EPA: 2008, 2009, 2010, 2011, 2012, 2014, 2015, 2016, 2017, 2018 godinu sa Prijedlogom mjera.
- Eutrophication of waters of Boka Kotorska Bay a Pilot Study TCH REP, EPA MNE, 2010
- Rezultati analiza školjki na uzgajalištima 2008-2019. godini
- Podaci JPMD o kvalitetu plaža od 2005- 2014, 2015 i 2016 godini
- EPA, Izvještaj Program a monitoringa stanja ekosistema priobalnog mora Crne Gore za 2014. Godinu IBM,
- Luštica Development AD „0” Stanje, CETI, 2013
- Podaci o ispitivanju kvaliteta životne sredine u vojnoj kasarni u Kumboru 2012-2014 god. CETI
- Izvjestaj o „0” stanju Brodogradilišta Bijela,CDM, CETI, 2015
- Izvještaji o realizaciji monitoringa morskog ekosistema CETI i IBM 2008-2012, i 2014-2020 godine.
- Izvještaj o stanju kvaliteta voda u Crnoj Gori za 2014. godinu HMZS,
- Studija o negativnom uticaju rasutih zagađivača, Lj. Radojičić, 2007,

- Osnovne karakteristike malih vodotoka crnogorskog primorja – HMZ, Elaborat, 2013
- NBB- 2018 final, UNEP/MAP, A. Mišurović,
- Nacionalni plan za implementaciju Stokholmske konvencije za period 2014-2021 godine. MORiT, 2013.
- Izvještaji CETI o realizaciji monitoringa morskog ekosistema za 2016, 2017, 2018 i 2019 godinu.
- Godišnji izvještaji o kvalitetu vode na plažama JPMD 2008-2019.
- Izvjetaj CETI o realizaciji monitoringa sedimenata po transektima, januar 2020 godine.

Marine Litter

- Consoli, P., Falautano, M., Sinopoli, M., Perzia, P., Canese, S., Esposito, V., Battaglia, P., Romeo, T., Andaloro, F., Galgani, F., Castriota, L. (2019). Composition and abundance of benthic marine litter in a coastal area of the central Mediterranean Sea. Marine Pollution Bulletin 136:243-247
- Consoli, P., Scotti, G., Romeo, T., Fossi, M.C., Esposito, V., D'Alessandro, M., Battaglia, P., Galgani, F., Figurella, F., Pragnell-Raasch, H., Andaloro, F. (2020). Characterization of seafloor litter on Mediterranean shallow coastal waters: Evidence from Dive Against Debris®, a citizen science monitoring approach. Marine Pollution Bulletin. Volume 150. https://doi.org/10.1016/j.marpolbul.2019.110763
- Decision IG.20/4. Implementing MAP ecosystem approach roadmap: Mediterranean Ecological and Operational Objectives, Indicators and Timetable for implementing the ecosystem approach roadmap. UNEP(DEPI)/MED. 25 p.
- Decision IG.22/10. Implementing the Marine Litter Regional Plan in the Mediterranean. UNEP(DEPI)/MED. 32 p.
- Fiorentino,F., Gancitano, V., Giusto, G.B., Massi, D., Sinacori, G., Titone, A., Vinci,A., Garofalo, G. (2015). Marine litter on trawlable bottoms of the strait of Sicily.. Biol. Mar. Mediterr. (2015), 22 (1): 225-228
- Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A, Narayan, R, Law, K. L. (2015). Plastic waste inputs from land into the ocean. Science, 347(6223), 768–771.
- Katsanevakis, S., Katsarou, A., (2004). Influences on the distribution of marine debris on the seafloor of shallow coastal areas in Greece (eastern Mediterranean). Water Air Soil Pollut. 159, 325–337.
- Mačić, V., Mandić, M., Pestorić, B., Gačić, Z., Paunović, M. (2017). First assessment of marine litter in shallow south-east Adriatic Sea. Fresenius Environmental Bulletin. Vol 26 No. 7/2017. 4834-4840
- Mandić, M., Đurović, M., Mačić, V., Petović, S., Joksimović, A., Pešić, A:, Joksimović, D., Pestorić, B., Huter, A:, Marković, S., Drakulović, D., Slavnić, D.,

Gvozdenović, S., Castelli, A., Peraš, I., Đorđević, N. (2020). Izvještaj o analizama i istraživanjima potencijalno pogodnih lokacija za marikulturu. Program finansiran od strane Ministarstva poljoprivrede i ruralnog razvoja Crne Gore. Institut za biologiju mora. 122p

- MEDITS-Handbook. Version n. 8, 2016. International bottom trawl survey in the Mediterranean. Instruction manual. Version 8. MEDITS Working Group : 177 pp.
- Methodology for Monitoring Marine Litter on the Seafloor (Shallow coastal waters (0–20 m). DeFishGear project. 10 pp. http://mio-ecsde.org/wp-content/uploads/2014/12/Seafloor-litter_monitoring-methodology_scuba_snorkelling_final.pdf
- Pasquini, G., Ronchi, F., Strafella, P., Scarcella, G., Fortibuoni, T., (2016). Seabed litter composition, distribution and sources in the Northern and Central Adriatic Sea (Mediterranean). Waste Manage. 58, 41–51.
- Spedicato M.T., Zupa W., Carbonara P., Fiorentino F., Follesa M.C., Galgani F., García- Ruiz C., Jadaud A., Ioakeimidis C., Lazarakis G., Lembo G., Mandic M., Maiorano P., Sartini M., Serena F., Cau A., Esteban A., Isajlovic I., Micallef R., Thasitis I. (2019). Spatial distribution of marine macro-litter on the seafloor in the northern Mediterranean Sea: the MEDITS initiative. Sci. Mar. 83S1: 257-270
- Strafella, P., Fabi, G., Spagnolo, A., Grati, F., Polidori, P., Punzo, E., Fortibuoni, T., Marceta, B., Raicevich, S., Cvitkovic, I., Despalatovic, M., Scarcella, G., (2015). Spatial pattern and weight of seabed marine litter in the northern and central Adriatic Sea. Mar. Pollut. Bull. 91, 120–127. Pasquini *et al.*, 2016
- Vlachogianni, T., Kalampokis, V. (2015). Methodology for Monitoring Marine Litter on the Seafloor (Shallow coastal waters (0–20 m) Visual surveys with SCUBA/snorkelling. IPA DeFishGear project. 10 p. http://mio-ecsde.org/wp-content/uploads/2014/12/Seafloor-litter_monitoring-methodology_scuba_snorkelling_final.pdf
- Vlachogianni, T., Somarakis, S. (2015). Methodology for Monitoring Marine Litter on the Seafloor (continental shelf) Bottom trawl surveys.IPA DeFishGear project. 7 p. http://mio-ecsde.org/wp-content/uploads/2014/12/Seafloor-litter_monitoring-methodology_continental-selves_final.pdf
- Vlachogianni, Th., Anastasopoulou, A., Fortibuoni, T., Ronchi, F., Zeri, Ch. (2017). Marine Litter Assessment in the Adriatic and Ionian Seas. IPA-Adriatic DeFishGear Project, MIO-ECSDE, HCMR and ISPRA. pp. 168

12. Annexes

Annexes to Chapter 4 Biodiversity: Habitats

Annexes to Chapter 8: Contaminants in the Marine Environment

Annex 4.1:
Habitat types present in the territorial sea of Montenegro

Habitat classification at different levels is based on a combination of the following data:

- Biological zone where the habitat type is present, namely: littoral, infralittoral, circalittoral (in some classifications, deep circalittoral is also used), bathyal and abyssal.
- Dominant particle size of the substrate, as follows: gravel or coarse sand> grain size 1 mm (coarse gravel and coarse stones); fine sand or mud sand <= 1 mm with <= 30% sludge (grain size less than 0.063 mm); mud> 30% less than 0.063 mm grain; substrate combination – a mixture of mobile substrates of different particle sizes"(Davies, Moss & Hill 2004). The structure of level 2 habitat classification has been agreed to be based on the biological zone and type of substrate (e.g. MC5-circalittoral sand).
- Each combination of depth and substrate type supports, if there is information on a distinctive set of plant and/or animal communities (e.g. MC1.51a Algae dominated coralligen)

In this way, three levels of habitat type classification were used in the revised EUNIS classification of marine habitats (SPA/RAC – UN Environment, 2019) for the purpose of habitat type interpretation, on the hybrid map and in this document, as follows:

- Level 1 – represents a combination of the biological zone and substrate (marked in blue in Table 12.1);
- Level 2 – represents a combination of the biological zone and dominant substrate size and/or dominant presence of certain taxonomic groups (marked in orange in Table 12.1);
- Level 3 – a combination of biological zone and substrate type, and if there is information about the present distinctive set of plant and/or animal communities (e.g. MC1.51a Algae dominated coralligen – marked in green in Table 12.1).

Table 12.1: Habitat types present in the territorial sea of Montenegro

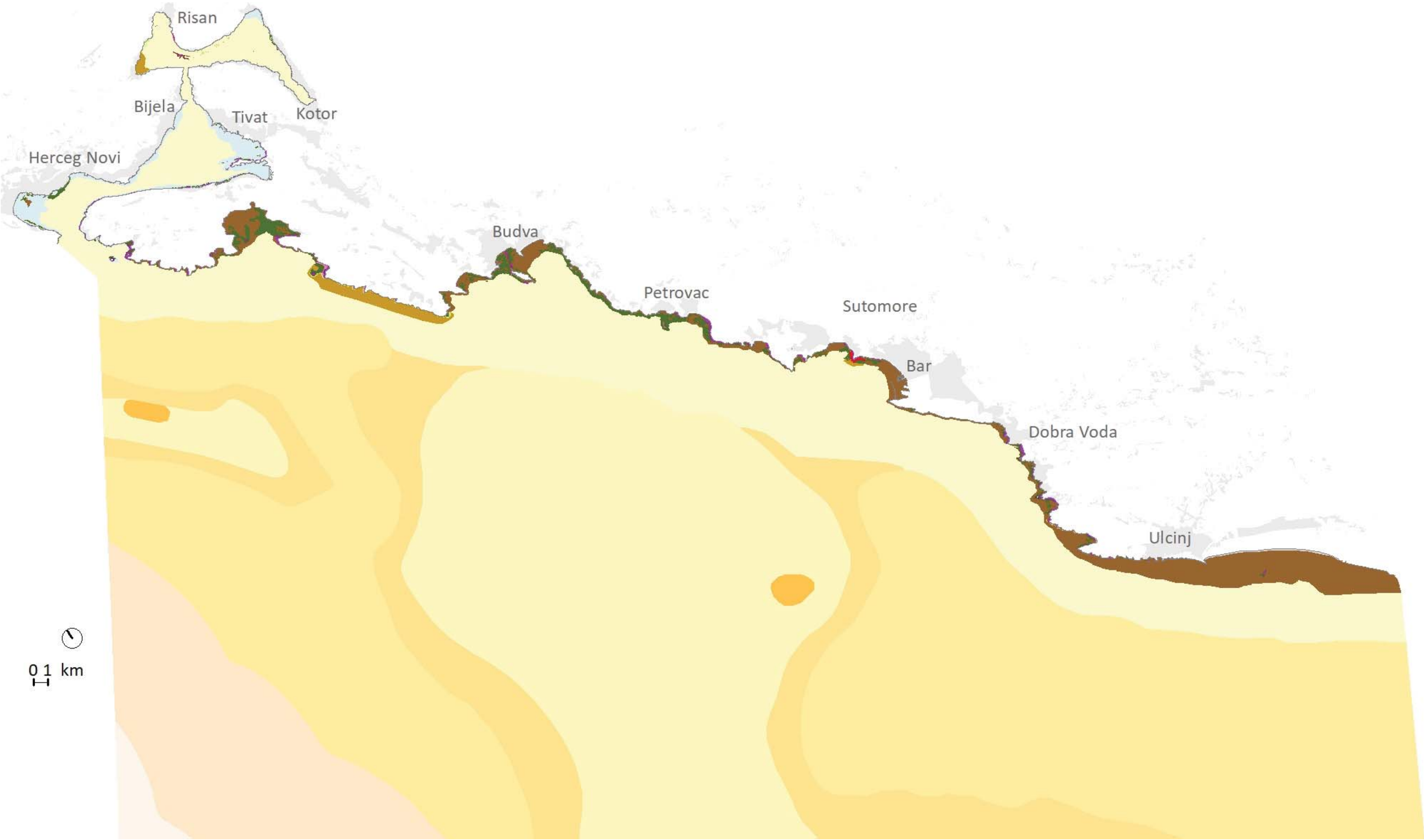
Littoral
MA1.5 Littoral rock
MA1.51 Supralittoral rock
MA2.5 Littoral biogenic habitats
MA2.51 Lower mediolittoral biogenic habitat
MA3.5 Littoral coarse sediment
MA3.51 Supralittoral coarse sediment
MA4.5 Littoral mixed sediment
MA4.51 Supralittoral mixed sediment
MA5.5 Littoral sand
MA5.51 Supralittoral sand
MA5.52 Mediolittoral sand
MA6.5 Littoral sludge
MA6.52 Mediolittoral sludge
Infralittoral
MB1.5 Infralittoral rock
MB1.51 Algae-dominated infralittoral rock
MB1.51a Well lit infralittoral rock, exposed
MB1.51d Moderately lit infralittoral rock, sheltered
MB1.52 Invertebrate-dominated infralittoral rock
MB1.55 Coralligenous biocenosis
MB1.56 Semi-dark caves and pits

MB2.5 Infralittoral biogenic habitats
MB2.53 Cladocora caespitosa reefs
MB2.54 Posidonia oceanica meadows
MB2.541 Posidonia oceanica meadows on hard substrata
MB2.542 Posidonia oceanica meadows on soft substrata
MB2.546 Posidonia oceanica and Cymodocea nodosa or Caulerpa spp. association
MB3.5 Infralittoral coarse sediment
MB3.52 Infralittoral coarse sediment under the influence of seafloor currents
MB3.53 Infralittoral gravel
MB5.5 Infralittoral sand
MB5.52 Mediolittoral sand
MB5.521 Indigenous marine angiosperm association
Circalittoral zone
MC1.5 Circalittoral rock
MC1.51 Coralligenous biocenosis
Algae dominated coralligen
MC4.5 Circalittoral mixed sediment
MC4.51 Muddy detritic seabed
MC6.5 Circalittoral muddy sediment
MC6.51 Coastal terrigenous sludges
MC6.511 Alcyonacea and Holothyroidea communities

Offshore circalittoral
MD1.5 Offshore rock
MD1.51 Offshore invertebrate-dominated infralittoral rock
MD4.5 Offshore circalittoral mixed sediment
MD4.51 Offshore circalittoral detritic seabed
MD5.5 Offshore circalittoral detritic sand
MD5.51 Offshore circalittoral detritic sand
MD6.5 Offshore circalittoral detritic sludge
MD6.51 Offshore terrigenous sticky sludge
Upper bathyal
ME6.5 Upper bathyal sludge
ME6.51 Upper bathyal sludge
Lower bathyal
MF6.5 Upper bathyal sludge
MF6.51 Sandy sludge
Abyssal
MG6.5 Abyssal sludge
MG6.51 Abyssal sludge

Annex 4.2: Hybrid map of habitats

Map 12.1: Hybrid map of habitats



MA1.51 Supralitoralne stijene
MA2.51 Donja mediolitoralna biogena staništa
MA2.51a Naslage mrtvih listova makrofita
MA3.51 Supralitoralni grubi sediment
MA4.51 Supralitoralni izmiješani sediment
MA5.51 Supralitoralni pijeskovi
MA5.52 Mediolitoralni pijesci
MA6.52 Mediolitoralni mulj
MA6.52a Staništa tranzicionih voda
MB1.51 Infralitoralne stijene sa dominirajućim algama
MB1.51a Dobro osvijetljena infralitoralna stijena, izložena
MB1.51d Umjereno osvijetljena infralitoralna stijena, zaklonjena
MB1.52 Infralitoralne stijene sa dominirajućim invertebratama
MB1.55 Koraligena biocenoza
MB1.56 Polumračne pećine i jame
MB2.53 Grebeni Cladocora caespitosa
MB2.54 Livade Posidonia oceanica
MB2.541 Livade Posidonia oceanica na kamenitoj podlozi
MB2.542 Livade Posidonia oceanica mekoj podlozi
MB2.546 Asocijacije Posidonia oceanica sa Cymodocea nodosa ili Caulerpa spp.
MB3.52 Infralitoralni grubi sediment pod uticajem struja dna
MB3.53 Infralitoralni grubi sediment pod uticajem struja dna
MB5.52 Fino razvrstani sitni pijesak
MB5.521 Asocijacije sa autohtonim morskim angiospermima
MC1.51 Koraligena biocenoza
MC1.51a Alga dominirajući koraligen
MC4.51 Muljevitia detritusna dna
MC6.51 Obalni terigeni muljevi
MC6.511 Zajednice sa Alcyonacea i Holothyroidea
MD1.51 Van obalne invertebrate dominirajuće cirkalitoralne stijene
MD4.51 Van obalno cirkalitoralno detritusno dno
MD5.51 Van obalni cirkalitorarni pijesak
MD6.51 Van obalni terigeni ljepljivi mulj
ME6.51 Gornji batijalni mulj
MF6.51 Pjeskoviti mulj

MA1.51 Supralittoral rock
MA2.51 Lower mediolittoral biogenic habitat
MA2.51a Banks of dead leaves of macrophytes (banquette)
MA3.51 Supralittoral coarse sediment
MA4.51 Supralittoral mixed sediment
MA5.51 Supralittoral sands
MA5.52 Mediolittoral sands
MA6.52 Mediolittoral mud
MA6.52a Habitats of transitional waters
MB1.51 Algal-dominated infralittoral rock
MB1.51a Well illuminated infralittoral rock, exposed
MB1.51d Moderately illuminated infralittoral rock, sheltered
MB1.52 Invertebrate-dominated infralittoral rock
MB1.55 Coralligenous
MB1.56 Semi-dark caves and overhangs
MB2.53 Reefs of Cladocora caespitosa
MB2.54 Posidonia oceanica meadows
MB2.541 Posidonia oceanica meadow on rock
MB2.542 Posidonia oceanica meadow on matte
MB2.546 Association of Posidonia oceanica with Cymodocea nodosa or Caulerpa spp.
MB3.52 Infralittoral coarse sediment under the influence of bottom currents
MB3.53 Infralittoral pebbles
MB5.52 Well sorted fine sand
MB5.521 Association with indigenous marine angiosperms
MC1.51 Coralligenous
MC1.51a Algal-dominated coralligenous
MC4.51 Muddy detritic bottoms
MC6.51 Coastal terrigenous muds
MC6.511 Facies with Alcyonacea and Holothyroidea
MD1.51 Offshore circalittoral rock invertebrate-dominated
MD4.51 Offshore circalittoral detritic bottoms
MD5.51 Offshore circalittoral sand
MD6.51 Offshore terrigenous sticky muds
ME6.51 Upper bathyal muds
MF6.51 Sandy muds

Annex 4.3: Important species

Table 12.2 shows important animal species present (mostly species listed in Annex II of the SPA Protocol of the Barcelona Convention for which it is recommended to take protective measures in accordance with the SPA BD Protocol, but also those that are protected at the national level by the Decision on placing certain plant and animal species under protection) and recorded during field research in the Bay of Kotor. Information that was available[20] on the presence of species is given in Table 12.2, and is important in the context of habitat assessment at the listed locations.

Table 12.2: Important animal species (with a focus on the Bay of Kotor)

Species	Location
Axinella sp.	Plava Špilja
	Patrolac Žanjice
	Rt Zukovac
	Rt Mačka
	Rt Žukovac
	Nerin
	Mikovića Pećina (outside the cave)
Axinella cannabina Sponge – not mobile or can join the habitat	Strp
	Verige Gospa od Anđela
	Tumbin (Drazin Vrt)
	Rt Meret
	Rt Ademov kmn
	Hrid Đeran
	Stari Ulcinj

Species	Location
	Rt Mendra
	Seka Đeran
	Rt Mačka
Axinella damicornis Sponge- not mobile or can join the habitat	Spiljice (Pristan),
	Ponta Veslo
	Uvala Velika Krekavica
	Rt Mačka
	Katič
	Stari Ulcinj
Axinella verrucosa	Rt Mačka
	Uvala Velika Krekavica
	Ponta Veslo
	Katič
	Stari Ulcinj
Axinella polypoides	Rt Ademov kmn
	Vučja jama (Valdanos)
	Hrid Đeran
	Katič
Cladocora caespitosa	Platamuni, Katic, Boka Kotorska, Os. Stari Ulcinj
Aplysina sp	Katič, Stari Ulcinj
Aplysina cavernicola	Uvala Velika Krekavica
	Ponta Veslo
Caretta caretta	U. Dobreč (caught 5 nm from the coast)

[20] Katič Pilot Marine Protected Area Management Plan, 2010, Start up of Katič Marine Protected Area in Montenegro and assessment of marine and coastal ecosystems along the coast 2012, Mapping of Marine Key Habitats and initiation of monitoring network in Montenegro 2016., Ecological quantitative description of Boka Kotorska (Kotor) bay marine area 2013.

Species	Location
Sea turtle – swims	Kotor (Skurda)
	Katič
Geodia cydonium Sponge – not mobile or can join the habitat	Iza Perasta
	Strp
	Bay of Risan
	Bay of Risan
Hippocampus hippocampus Seahorse – swims but is also linked to Posidonia, although not explicitly in the sense that it cannot be seen anywhere else	Montenegrin Littoral
Hippocampus ramulosus Seahorse – swims but is also linked to Posidonia, although not explicitly in the sense that it cannot be seen anywhere else	IBMK
	Katič
Hippocampus guttulatus	Katič
Holothuria impatiens Sea cucumber – static	Žanjice
	Prčanj (near Sv. Nikola)
Holothuria polii Sea cucumber – static	Perast
	Dobrota
	Žanjice
	Rt Kalas do
	Herceg Novi
	Sv. Stasija
	Kostanjica
	Dražin Vrt
	IBMK
	Katič
	Platamuni
Holothuria tubulosa Sea cucumber – static	Dobrota
	Rt Kalas do
	Sveti Stasija
	Rt Arza
	Dražin Vrt

Species	Location
	Perast
	Herceg Novi
	Kostanjica
	Gospa od Andjela
	Hrid Đeran
	Katič
	Os. Stari Ulcinj
*Leptogorgia sa*rmentosa Coral – static	Spiljice (Pristan)
	Verige (Gospa od Anđela)
	Tumbin (Dražin Vrt)
Luria lurida Sea snail	Risanski zaliv, Platamuni, Katič, Stari Ulcinj
Ophidiaster ophidianus Red starfish	Rt Arza
	Seka Albaneze
	Mala i Velika Krekavica
	Mikovića Pećina (outside the cave)
	Katič
	Rt Žukovac
	Ponta Veslo
	Hrid Đeran
	Crni rt
	Stari Ulcinj
Pinna nobilis Clam – palastura, an important species	IBMK
	Žanjice (rt Ograde)
	Orahovac
	Bajova Kula
	Lastva Tivatska
	Tivat
	U. Polje (Tivat)
	Baošici

Species	Location
	Žanjice
	Uvala Velika Krekavica
	Katič
	Rt Mirišta (Arza)
	Zlatna luka
	Rt Mačka
	Rt Meret
	Rt Ademov kmn
	Seka Đeran
	Uvala Nerin
	Rt Zukovac
	Hrid Đeran
Tethya auranitium	Strp
Sponge- static	Spiljice (Pristan)
Sarcotragus foetidus – dark stinging sponge	Platamuni, Uvala Velika Krekavica
	Ratac
	Ponta Veslo
	Stari Ulcinj
Tonna galea	Žanjice (rt Ograde)
Type of sea snail	Platamuni
	Katič
	Crni rt
	Stari Ulcinj
Lithophaga lithophaga – mussel	Uvala Velika Krekavica
	Katič
	Seka Albaneze
	Ponta Veslo
	Mikovića Pećina (outside the cave)
	Rt Meret
	Rt Ademov kmn

Species	Location
	Vucja jama (Valdanos)
	Rt Mendra
	Rt Mačka
Centrostephanus longispinus – sea urchin	Uvala Velika Krekavica
	Rt Žukovac
	Plava Špilja
	Rt Mirišta (Arza)
	Katič
Scyllarus arctus – small European lobster	Katič, Platamuni
Scyllarides latus – Mediterranean lobster	Katič, Platamuni
Spongia agaricina – type of sponge	Vučja jama (Valdanos)
Leptopsammia pruvoti- type of cnidaria	Uvala Velika Krekavica
	Ponta Veslo
Polycyathus muellerae	Uvala Velika Krekavica
Madracis pharensis	Uvala Velika Krekavica
Holothuria sanctori	Uvala Velika Krekavica
Paracentrotus lividus	Uvala Velika Krekavica
	Ponta Veslo
	Rt Mačka
	Katič
	Stari Ulcinj
Palinurus elephas	Platamuni, Ponta Veslo
	Stari Ulcinj
	Katič
Holothuria forskali	Platamuni, Katic
Homarus gammarus	Platamuni
Episcomitra zonata	Žukovica
Epinephelus marginatus	Platamuni, Katič, Stari Ulcinj
Sciaena umbra	Katič
Prionace glauca	Katič

Species	Location
Spongia (Spongia) officinalis	Katič, Stari Ulcinj
Spongia (Spongia) lamella	Stari Ulcinj
Umbrina cirrosa	Stari Ulcinj
Tursiops truncates	Platamuni, Katič, Stari Ulcinj
Mustelus mustelu	Katič
Isurus oxyrinchus	Katič
Dentex dentex	Katič, Stari Ulcinj
Merluccius merluccius	Stari Ulcinj

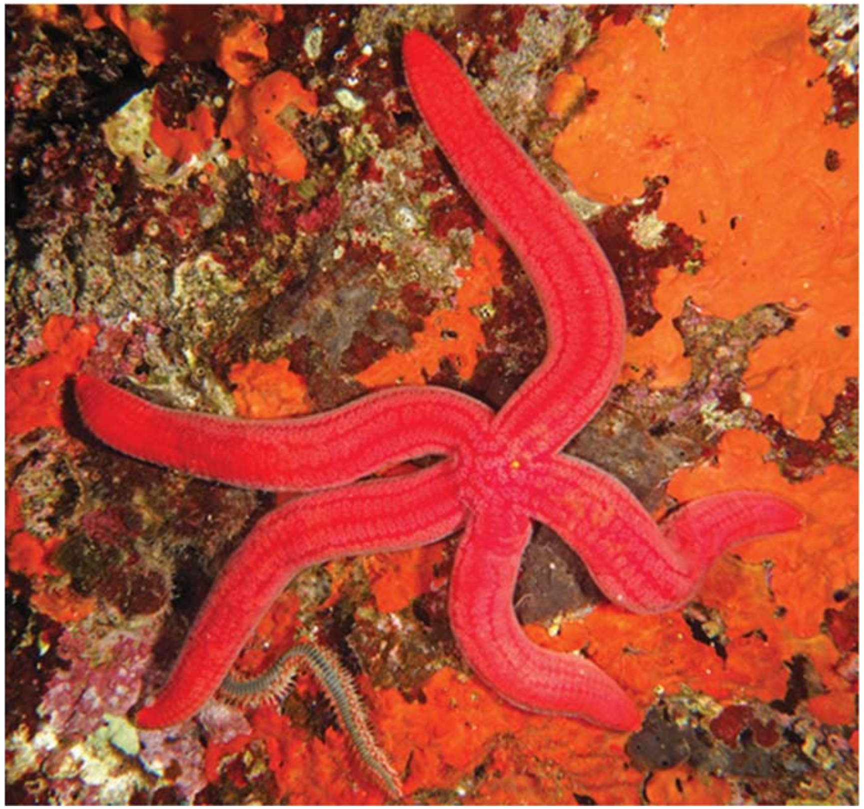
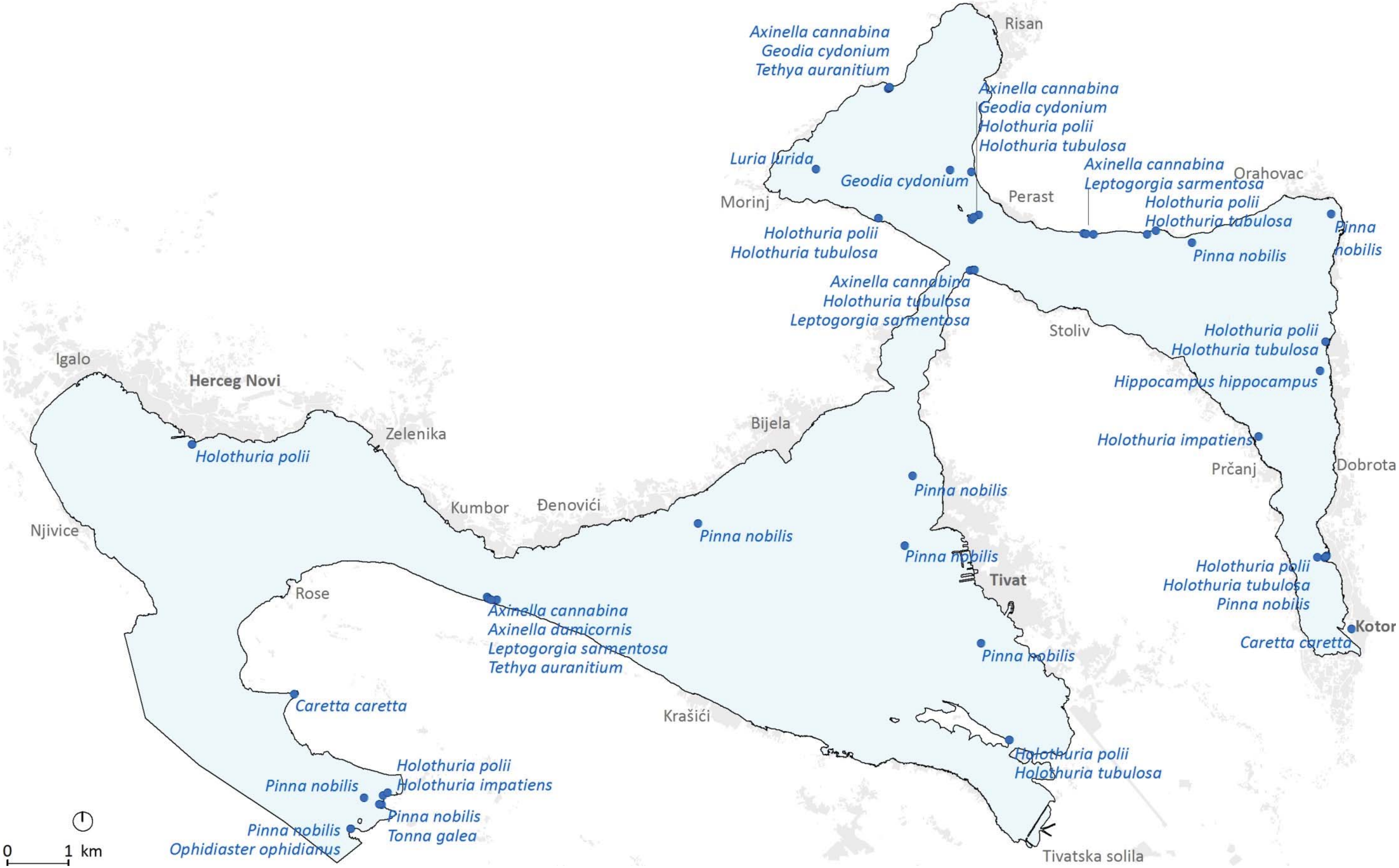


Figure 12.1: *Ophidiaster ophidianus* starfish (RAC/SPA – UNEP/MAP, 2013)

Figure 12.2: *Axinella damicornis* (RAC/SPA – UNEP/MAP, 2013. Ecological quantitative)

Map 12.2: Locations of important species present in the Bay of Kotor



Annex 8.1: Monitoring locations

Table 12.3: Contamination sampling locations 2016-2020

ID	Label	Name	Latitude N	Longitude E	Monitoring type	Category	Sampling depth (m)	Material	Note
1	HS	Kotor port	42°25.507	18°45.934	State monitoring	*Hot spot*	16	Water, sediment	
1	OS1	Dobrota IBM	42°26.178	18°45.650	State monitoring	*Hot spot*	23	Water, sediment Biota	
4	OS-2	Orahovac	42°29.094	18°45.773	State monitoring	RF for shellfish	17	Water and shellfish	Farm monitoring
5	E-1	Central Bay of Kotor	42°28'30.596	18°44'28.096	State monitoring	Trend location	34	Water	
7		Stoliv – Perast	42°28.342	18°42.495	Shellfish monitoring	Shellfish	37	Shellfish	Farm monitoring
8	RI	Central Bay of Risan	42°29.83908	18°40.97685	State monitoring	Trend location	31	Water	
8	HS	Risan port	42°30.805	18°41.640	State monitoring	*Hot spot*	9	Water, sediment Biota	
11	HS	Bijela shipyard	42°26.844	18°39.140	State monitoring	*Hot spot*	20	Water, sediment Biota	
11	HS	Bijela shipyard open	42°26'46.83"	18°39'27.13"	EIA Bijela project	*Hot spot*	31	Water, sediment	Bijela shipyard remediation project
12	E-2	Sredina Tivatskog zaliva	42°25.97675	18°39.53643	State monitoring	Trend location	38	Water	
13	HS	Porto Montenegro – Tivat	42°26.144	18°41.405	State monitoring	*Hot spot*	14	Water, sediment Biota	
13	HS	Tivat port – (Kaliman)	42°25.626	18°42.023	State monitoring	*Hot spot*	6	Water, sediment Biota	
17		Kumbor-Portonovi	42°26'9.76	18°35'37.12	EIA Kumbor project	*Hot spot*	25	Water, sediment	Not in state monitoring
25	E-3	Central bay area of Herceg Novi	42°26.28315	18°32.68382	State monitoring	Trend location	43	Water	
22	HS	Herceg Novi port	42°26.993	18°31.959	State monitoring.	*Hot spot*	13	Water, sediment Biota	
26	MNE-08	Mamula	42°22'657	18°33'21.501	State monitoring	Coastal sea	77	Water, sediment	Referent location
27	T-1	Mamula – transect	42°22.4251'	18°33.3590'	State monitoring	Coastal sea	113	Sediment	
28	ER	Luštica – Dobra luka	42°22.069	18°38.301	State monitoring	Coastal sea	12	Water, sediment	Referent location
33	T-2	Mamula – transect	42°18.7966'	18°30.8883'	State monitoring	Coastal sea	117	Sediment	
33	T-5	Budva – transect	42°13.4884'	18°46.7017	State monitoring	Coastal sea	83	Sediment	
33a	T-8	Buljarica – transect	42°09.0490'	18°56.5660'	State monitoring	Coastal sea	67	Sediment	
33b	T-12	Port Milena – transect	41°52.8620'	19°10.8190'	State monitoring	Coastal sea	55.5	Sediment	

ID	Label	Name	Latitude N	Longitude E	Monitoring type	Category	Sampling depth (m)	Material	Note
33	T-16	Ada Bojana – transect	41°48.4017'	19°16.8577'	State monitoring	Coastal sea	59	Sediment	
33	MNE-07	Luštica coastal area	41°43'39.58	019°19'15	State monitoring	Coastal sea	59	Water	
34	T-3	Mamula – transect	42°13.3296'	18°27.1066'	State monitoring	Coastal sea	217	Sediment	
34	T-6	Budva – transect	42°09.4567'	18°41.4464'	State monitoring	Coastal sea	123	Sediment	
34	T-9	Buljarica – transect	42°06.0023'	18°53.3307'	State monitoring	Coastal sea	81.5	Sediment	
34	T-10	Buljarica – transect	42°01.3947'	18°48.5450'	State monitoring	Coastal sea	86	Sediment	
34	T-13	Port Milena –transect	41°51.4060'	19°08.0140'	State monitoring	Coastal sea	77.5	Sediment	
34	T-14	Port Milena – transect	41°49.8950'	19°05.1970'	State monitoring	Coastal sea	87	Sediment	
34	T-17	Ada Bojana – transect	41°43.7272'	19°12.1037'	State monitoring	Coastal sea	83.5	Sediment	
38	E-4	Budva – Jaz	42°13.4884'	18°46.7017'	State monitoring	Trend location	24	Sediment Water	
39	HS	Budva port and marina	42°16.764	18°50.330	State monitoring	*Hot spot*	6	Water Sediment Biota	
43	MNE-06	Central Budva bay	42°13'27.29	18°46'41.81	State monitoring	Coastal sea	85	Water	
43	T-4	Budva transect	42°16.1500'	18°50.2760'	State monitoring	Coastal sea	29	Sediment	
47	T-7	Dubovica – Buljarica transect	42°10.2031'	18°57.8996'	State monitoring	Coastal sea	36	Sediment	
55	HS	Bar port and marina	42°05.444	19°05.142	State monitoring	*Hot spot*	39	Water Sediment Biota	
61	T-11	Rt Mendra – Đeran	41°54.2940'	19°13.5440'	State monitoring	Coastal sea	15.5	Sediment	
62	E-6	Ulcinj port	41°54'32	19°11'48	State monitoring	Trend location	4.5	Water Sediment	
63	OS-5	Port Milena	41°54.500	19°14.168	State monitoring	Trend location	2	Water	
63	HS	Port Milena	41°54'4.9˝	19°14'7.2˝	State monitoring	*Hot spot*	2	Water Sediment	
63	HS	Port Milena – Limnos project	41°54'6.1˝	19°14'7.9˝	PM remediation project Limnos.SLO	PM channel	2.5	Water Sediment	
65	T-15	Ada Bojana transect	41°51.5180'	19°20.0270'	State monitoring	Coastal sea	11.5	Sediment	
66	E-7	Ada Bojana	41°43'39.58	19°19'15	State monitoring	Coastal sea	18	Water	

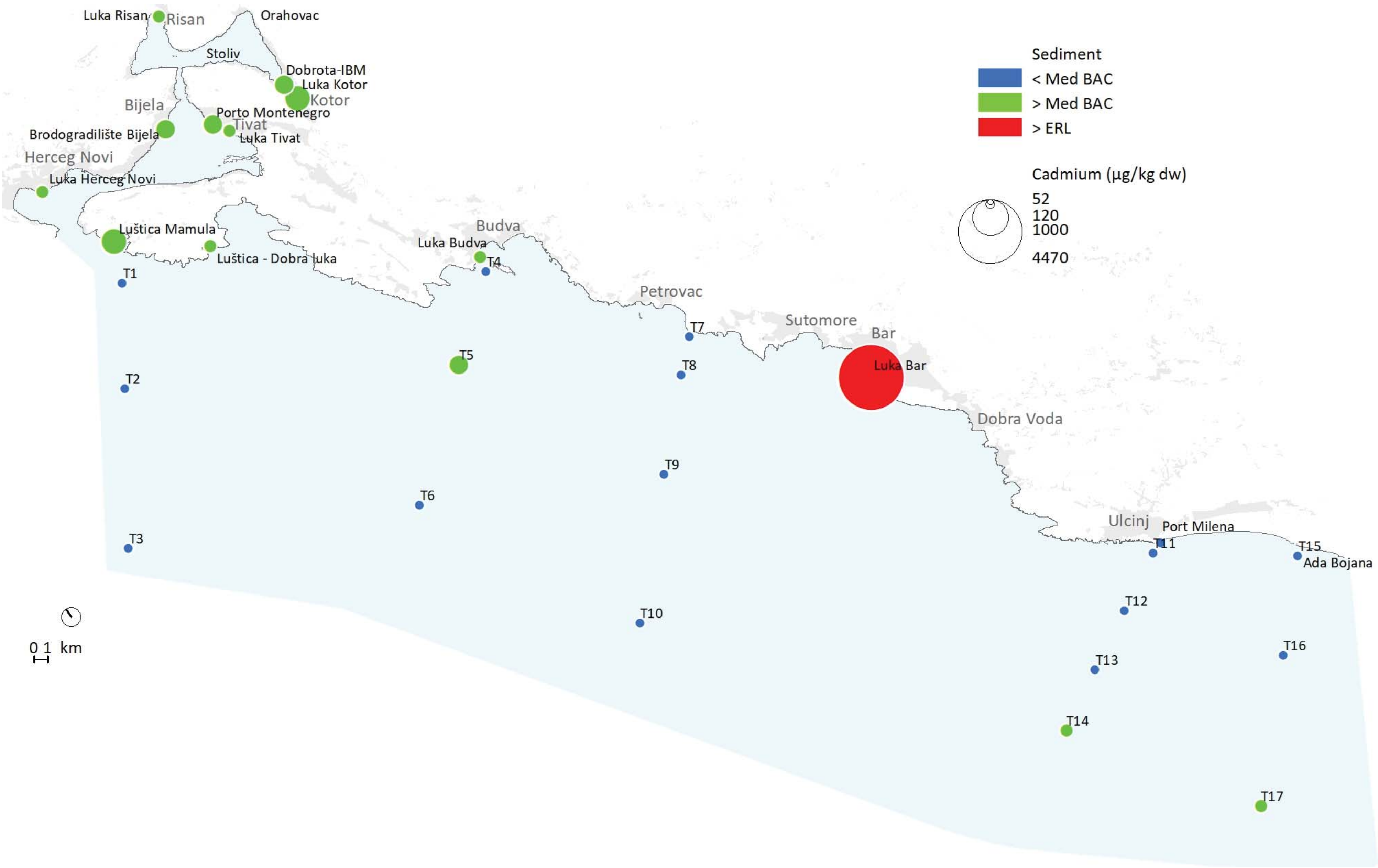
Annex 8.2: Spatial illustration of mean values measured in the sediment

The spatial illustration of measured mean values (2016 – 2020) is based on the UNEP/MAP limit values shown in Tables 8.3 and 8.4, and the recalculated values presented in Table 8.9.

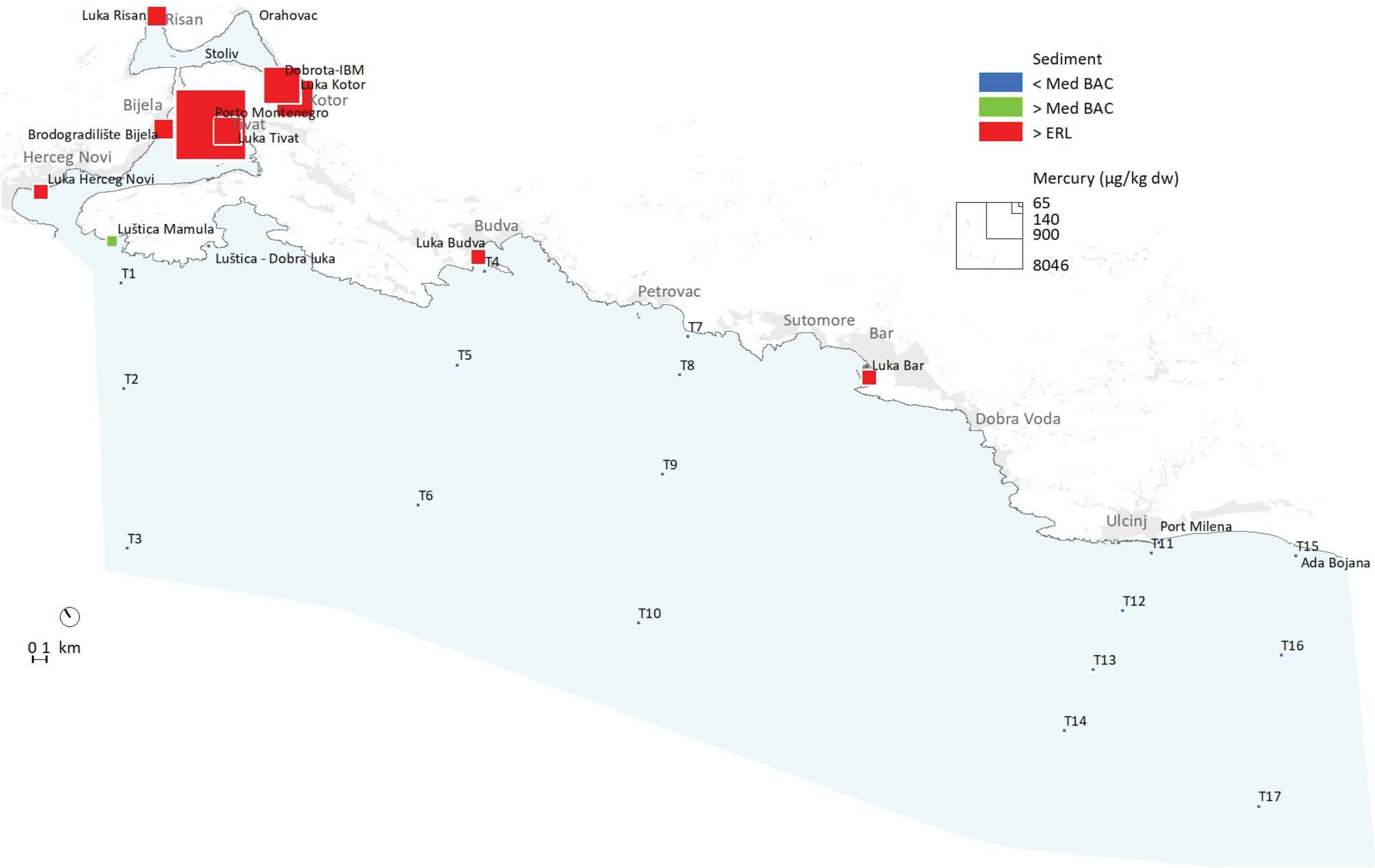
- Locations with approximately natural concentrations (BC-background concentrations) are marked in blue);
- Locations with estimated acceptable concentrations (BAC) are marked in green;
- Locations with concentrations that may have a negative impact on the environment are marked in red.

A bigger symbol also indicates higher concentration levels.

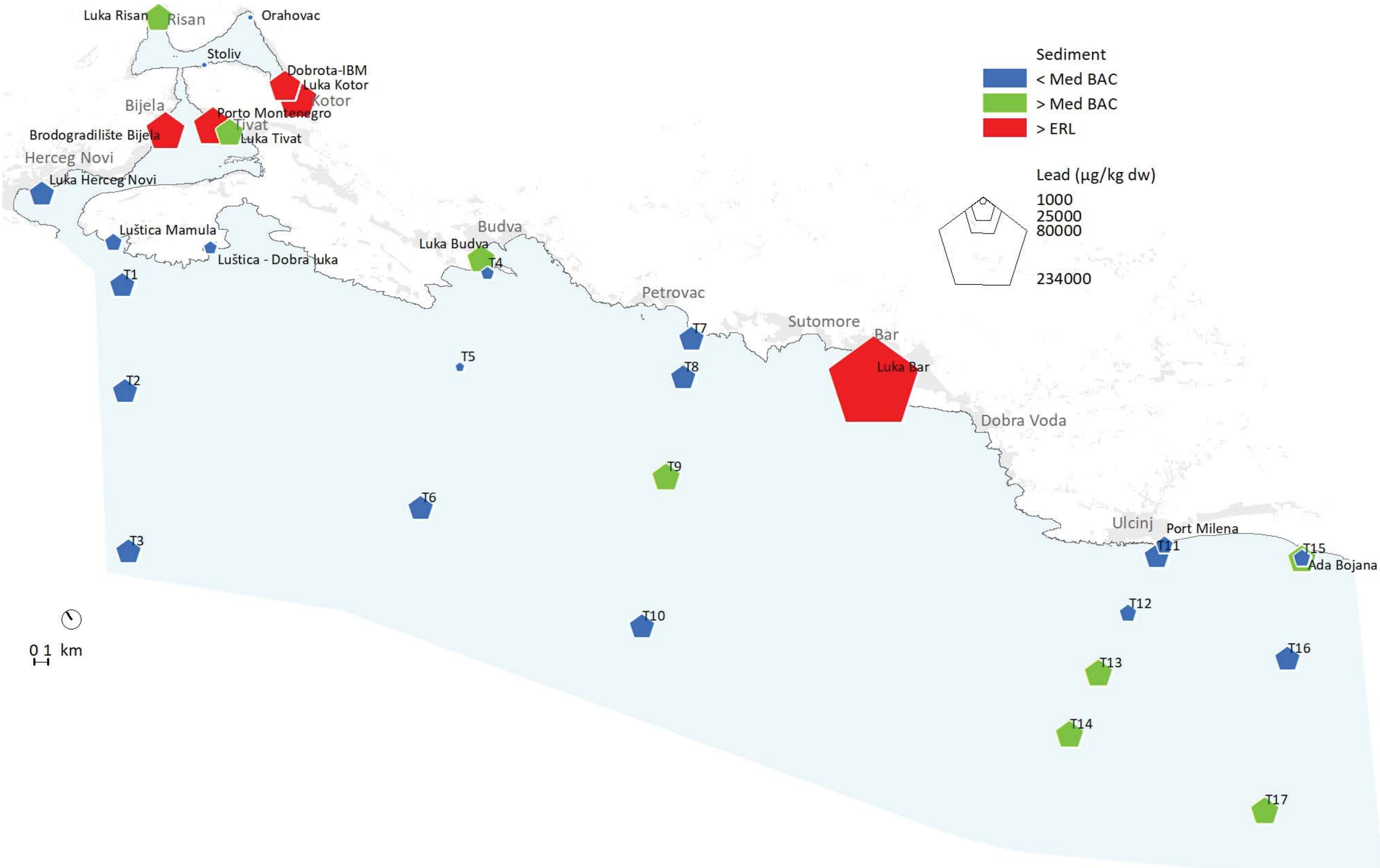
Map 12.3: Sediment: Cadmium



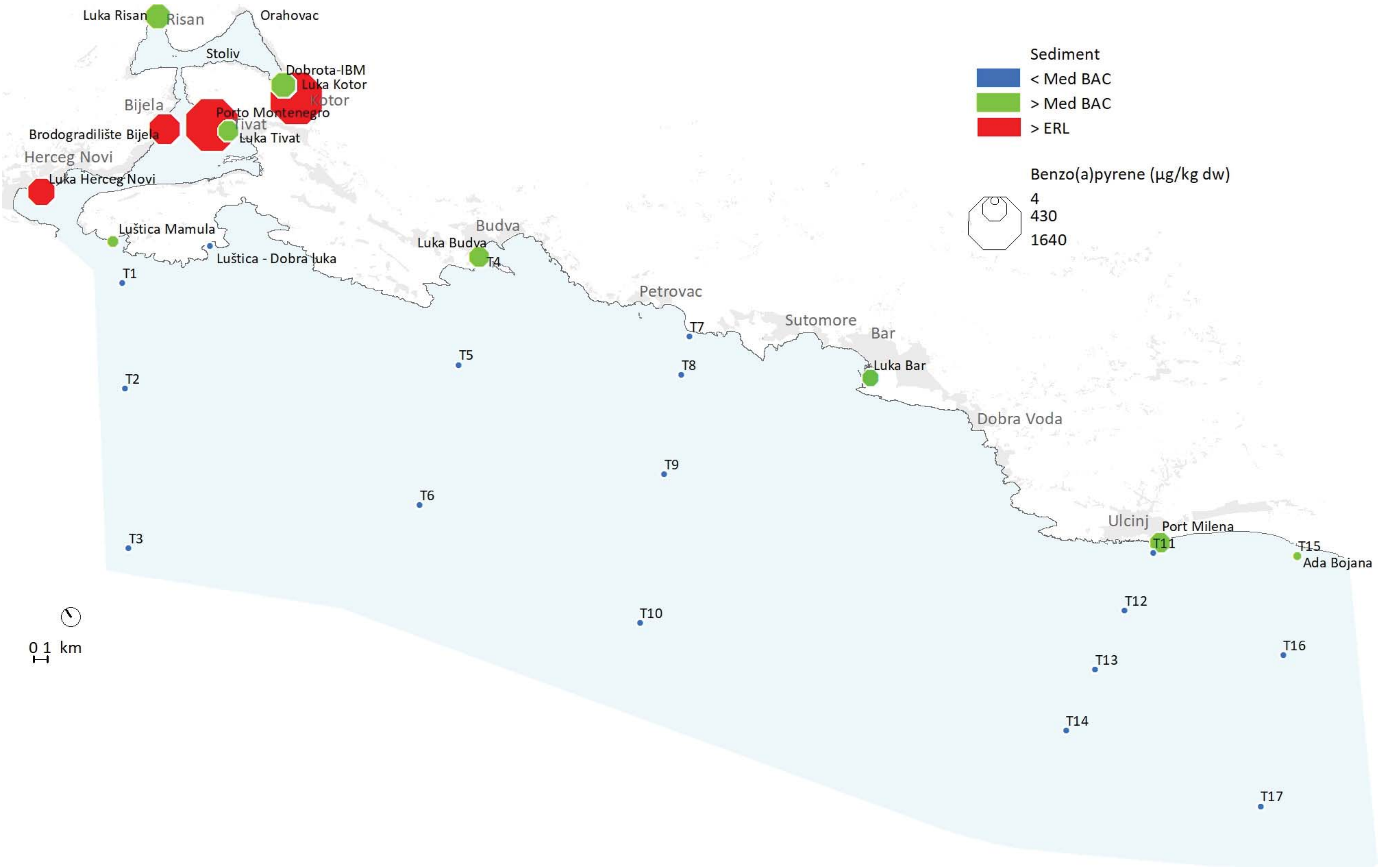
Map 12.4: Sediment: Mercury



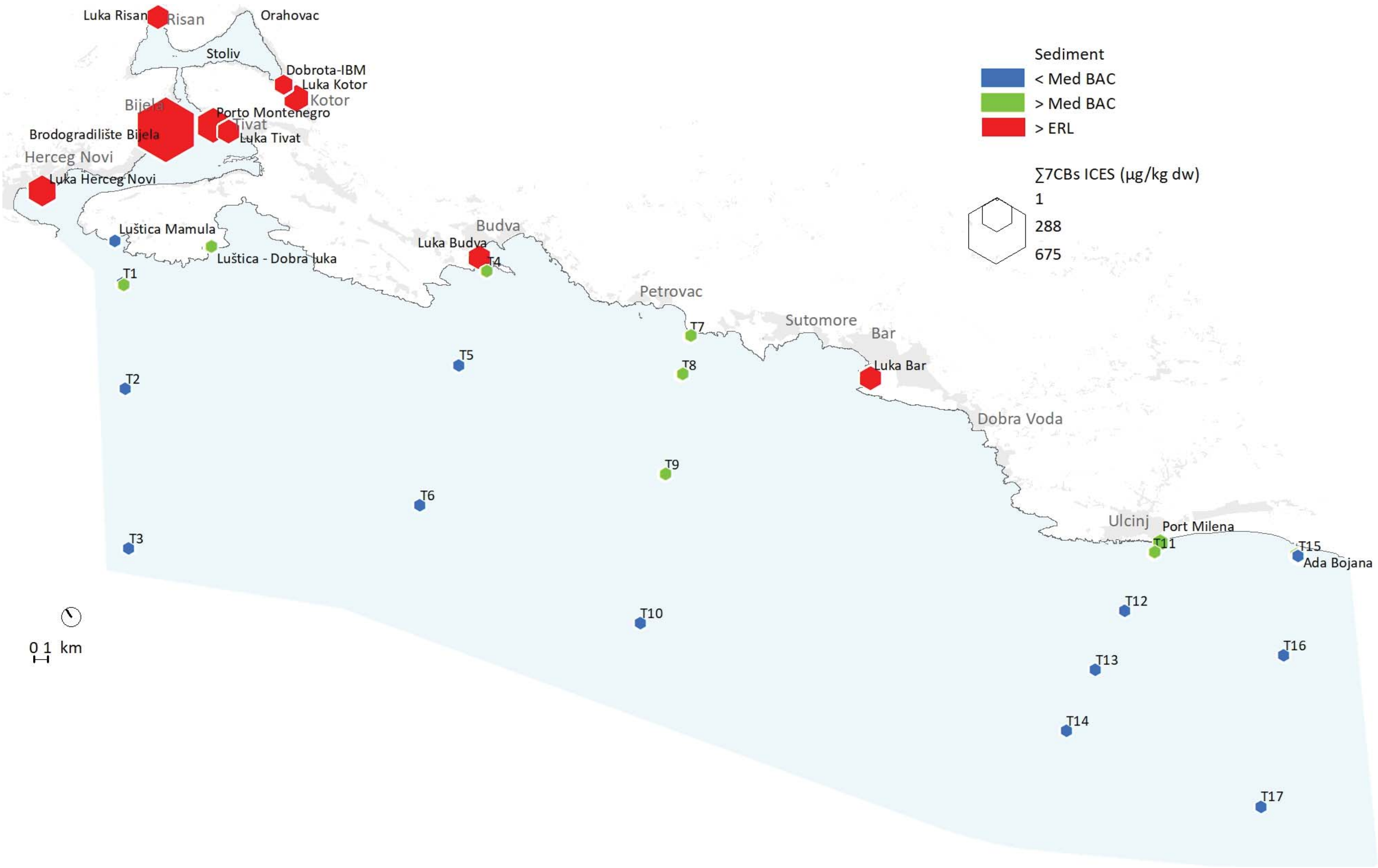
Map 12.5: Sediment: Lead



Map 12.6: Sediment: Benzo(a)pyrene



Map 12.7: Sediment: ∑7CBs ICES



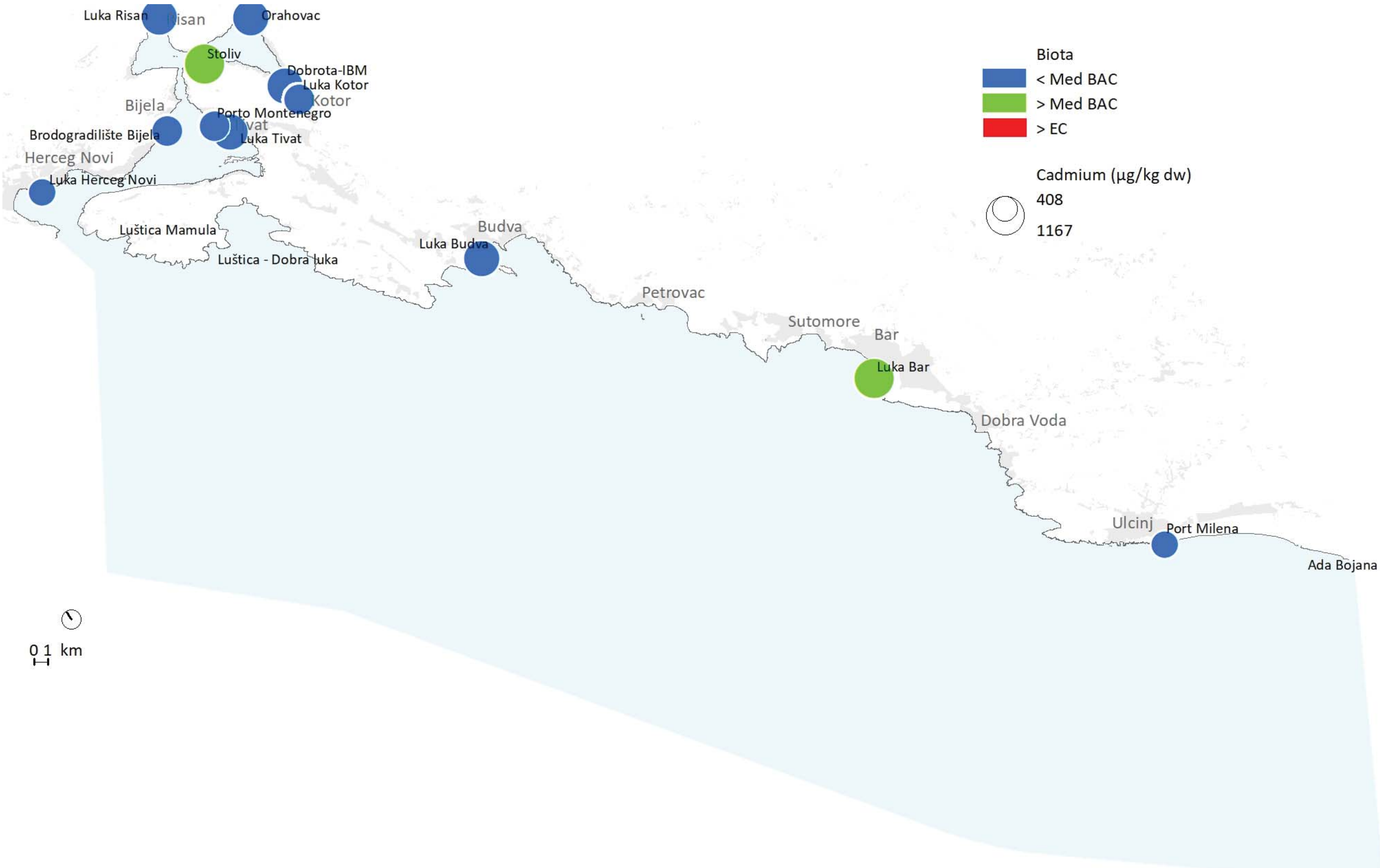
Annex 8.3:
Spatial illustration of mean values measured in the biota

The spatial illustration of measured mean values (2016 – 2020) is based on the UNEP/MAP limit values shown in Tables 8.3 and 8.4, and the recalculated values presented in Table 8.9.

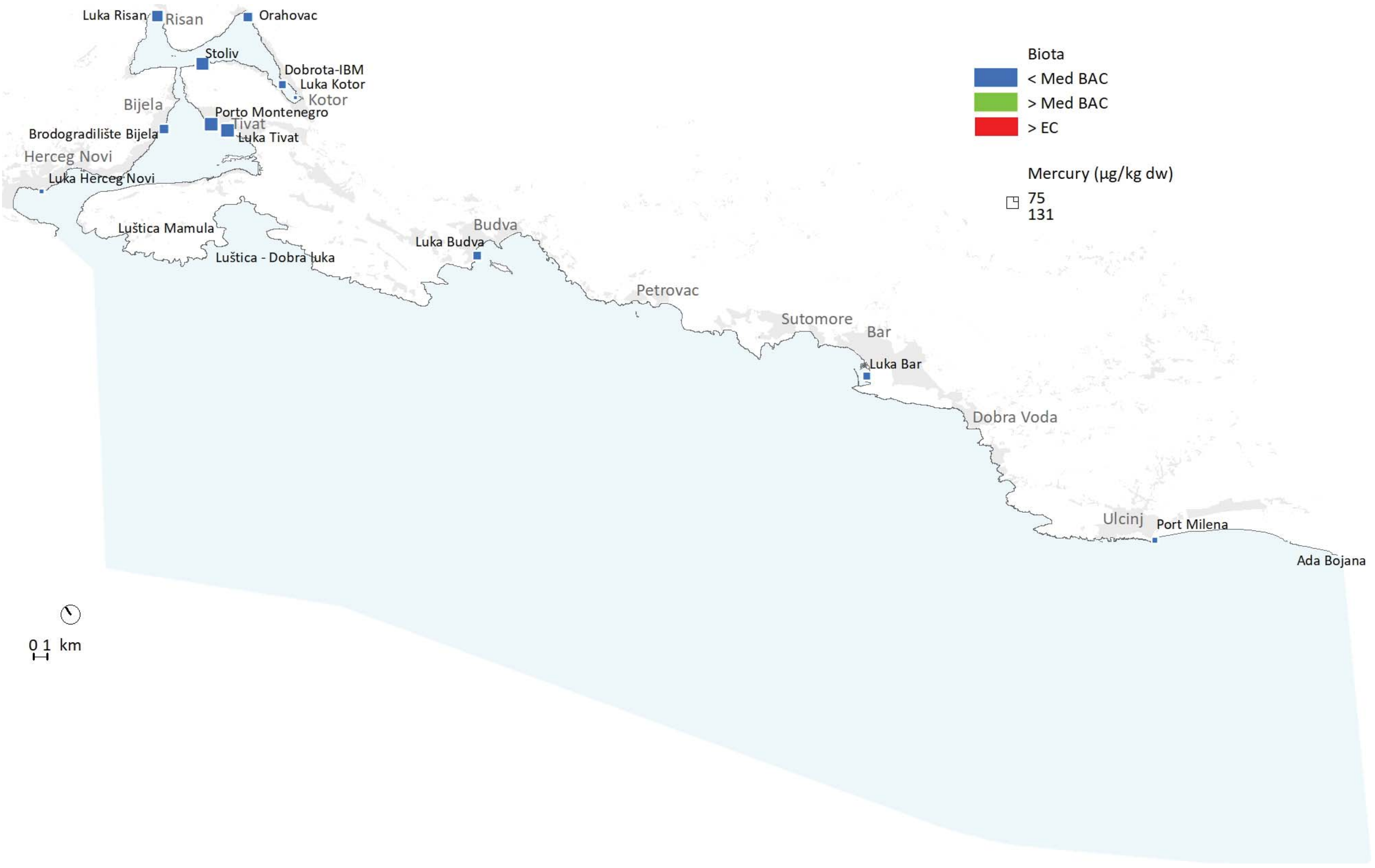
- Locations with approximately natural concentrations (BC-background concentrations) are marked in blue);
- Locations with estimated acceptable concentrations (BAC) are marked in green;
- Locations with concentrations that may have a negative impact on the environment are marked in red.

A bigger symbol also indicates higher concentration levels.

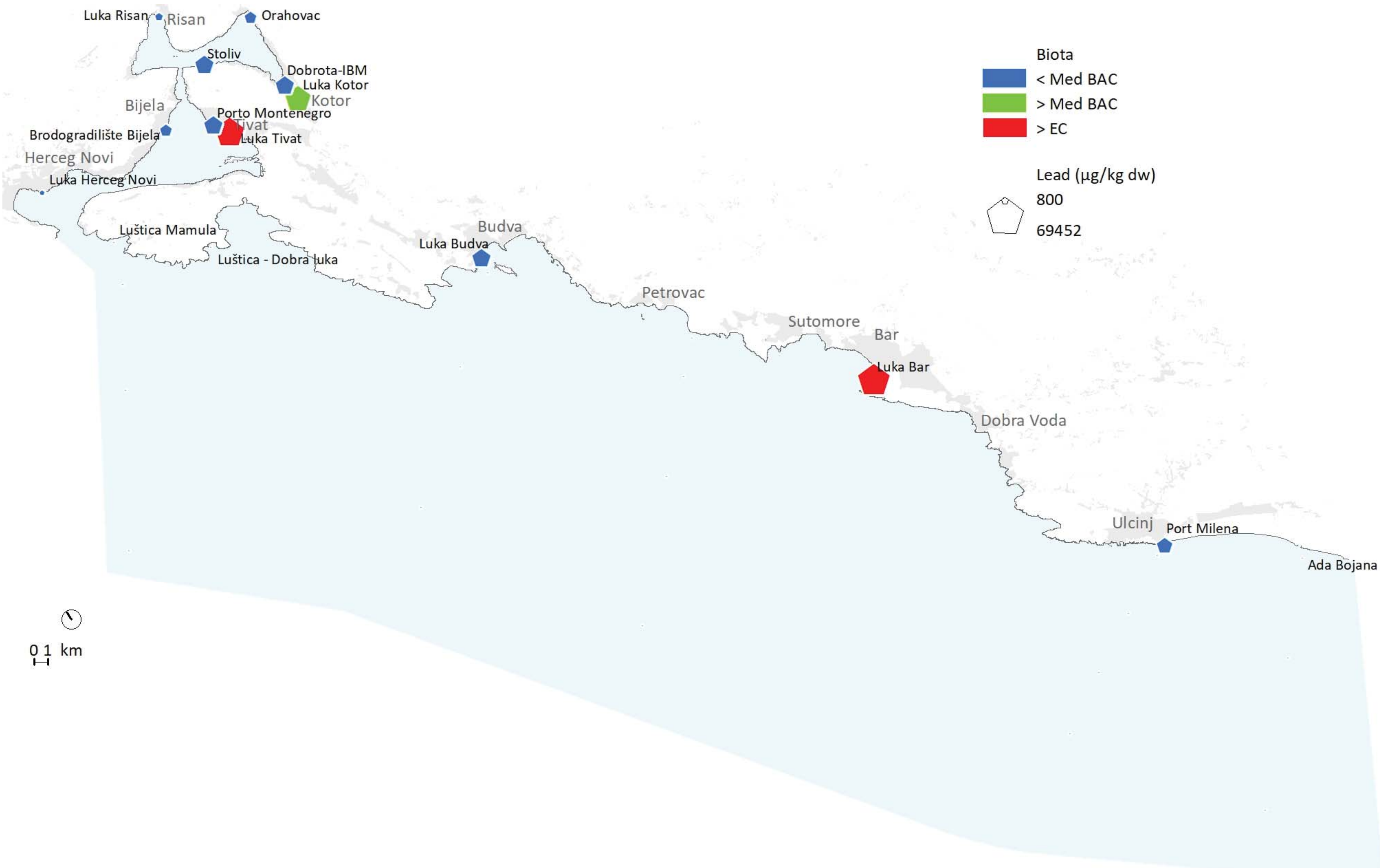
Map 12.8: Biota: Cadmium



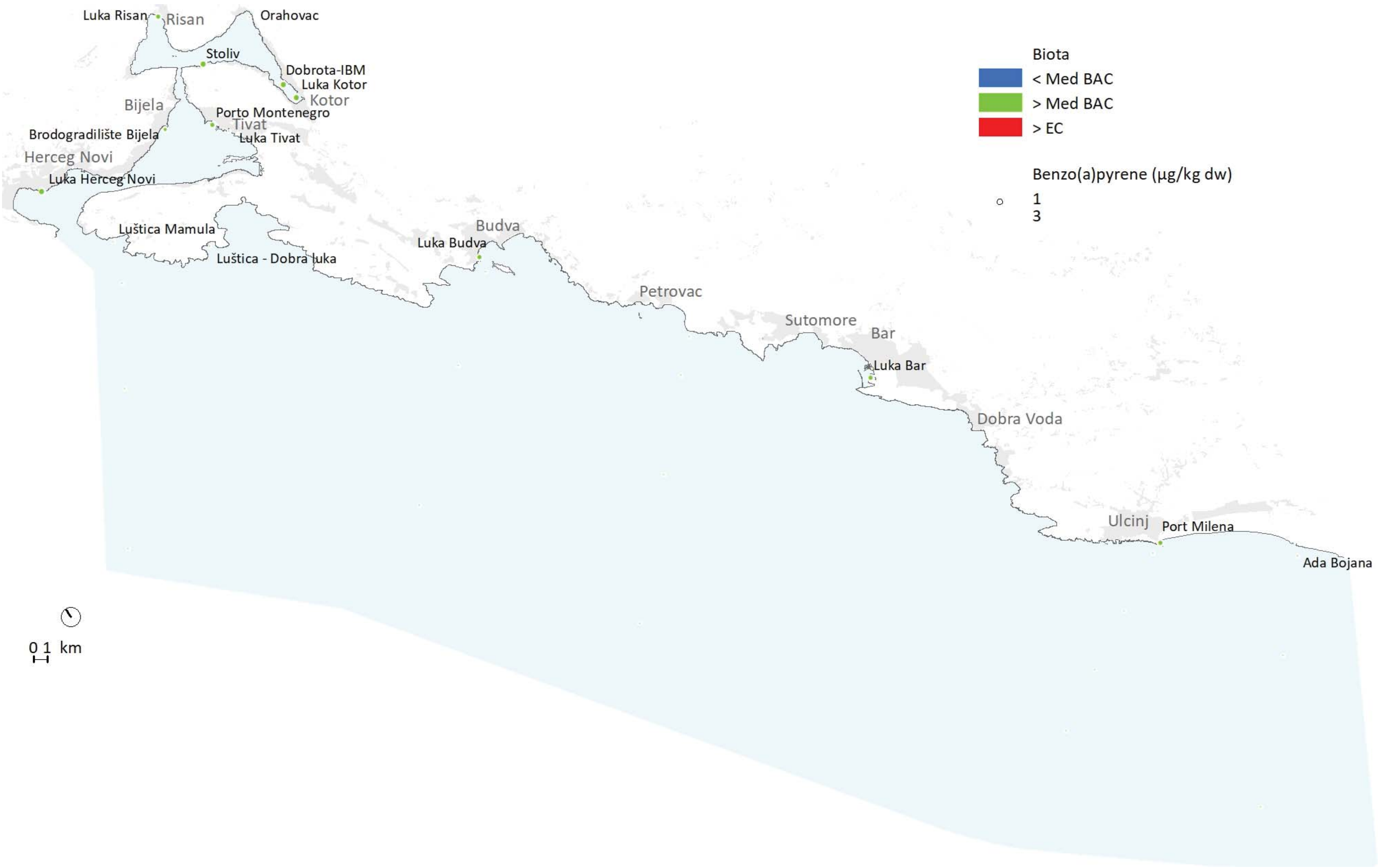
Map 12.9: Biota: Mercury



Map 12.10: Biota: Lead



Map 12.11: Biota: Benzo(a)pyrene



Map 12.12: Biota: ∑7CBs ICES

gef

ADRIATIC

Implementation of the ecosystem approach
in the Adriatic through marine spatial planning

The GEF-funded project "Implementation of the Ecosystem Approach in the Adriatic Sea through Marine Spatial Planning" (GEF Adriatic) is carried out across the Adriatic-Ionian region with focus on two countries: Albania and Montenegro.

The main objective of the project is to restore the ecological balance of the Adriatic Sea through the use of the ecosystem approach and marine spatial planning. Also, the project aims at accelerating the enforcement of the Integrated Coastal Zone Management Protocol and facilitating the implementation of the Integrated Monitoring and Assessment Program. Eventually, it will contribute to the achievement of the good environmental status of the entire Adriatic. The project is jointly lead by UNEP/MAP, PAP/RAC and SPA/RAC. In Montenegro, the project is being implemented with the coordination of the Ministry of Ecology, Spatial Planning and Urbanism. The project duration is from 2018 to 2021.

Ministry of Ecology, Spatial Planning and Urbanism
IV Proleterske brigade 19, 81000 Podgorica, Montenegro
E: ivana.stojanovic@mepg.gov.me