Monitoring Protocols Templates for Marine Protected Areas

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This document is developed within the framework of the project MARMAPS which aims to raise awareness on the importance of conserving the valuable Black Sea ecosystems, engage a large number of target groups in the region in the creation of decision support system for maritime spatial planning to foster spatial conservation and restoration measures for marine biodiversity. The project will improve the stakeholders' access to open scientific data and tools through environmental electronic eFolio, involve them in capacity building to ensure the uptake of conservation prioritisation framework for marine protected areas, and exploit the opportunities for cross-border collaboration. In addition to the eFolio decision support tool, the partners from the Black Sea countries have provided a selection of information on the management of marine protected areas coming from a review of world experience and practices.

The monitoring protocols for marine protected areas (MPAs) outline the elements and parameters of a framework for observation and management of the protected marine ecosystems. The protocols help reveal the extent to which the conservation objectives of the MPAs are being successfully achieved. We present in this document a basic model for monitoring protocol, some basic templates which are not site-specific but can be further elaborated and adapted to realities in the existing and future marine protected areas and networks in the Black Sea basin. The basic model draws on the experience of EU countries and global achievements.

The monitoring framework and the associated protocols help to get a clear picture of the marine ecosystems, and how they are being affected by the protection. For many years, monitoring has focused primarily on commercially important fish species and this has been the main way of assessing whether an MPA or marine reserve is functioning successfully. These data are important, but do not reveal all the factors that might affect the species or their environment. Frameworks are now being built for monitoring whole ecosystems, using protocols and review, from which experts and managers can understand more clearly what is happening to the sea and the life in it, to assess what state it is in and how it is changing. The suggested monitoring templates use this approach because of its benefits and advantages. They comprise parameters of the biota and the physical parameters of the marine environment. The monitoring framework and the associated monitoring protocols can be built around different themes such as representativeness of habitats, habitat composition and condition, climate change, key species, water quality, marine pollution, etc. Combinations are also possible according to needs and local conditions. A distinction is also made between ecological and socio-economic monitoring. The topics included in the protocols for a given MPA depend on the specific conditions, the protection objectives and the requirements of the regulators and local communities.

The templates for monitoring protocols and the annexes can serve a large target group of stakeholders and end-users in the Black Sea basin – environmental managers, rangers, administrators, representatives of various authorities, scientists, fishermen, divers, marine sportsmen, local communities, etc.

About the project

Marine protected areas (MPAs) are increasingly becoming an important management tool to protect species and habitats globally. Monitoring is an essential component of resource management by providing science-based information to guide key management decisions like prioritizing conservation strategies, proper allocation of resources, and ultimately, whether or not these marine protected areas are meeting their intended objectives.

The project *Open environmental eFolio for joint maritime spatial planning and conservation of the valuable Black Sea Basin marine ecosystems* (MARMAPS), https://marmaps.bsnn.org/, is supported by the Interreg NEXT Black Sea Basin Programme 2021-2027. MARMAPS aims to improve knowledge on how to conserve the valuable ecosystems of the Black Sea by providing digital tools for collaborative planning and restoring marine biodiversity. The project envisages support for the establishment of a network of MPAs in the Black Sea basin and a mechanism for exchange and long-term support between members of the target groups and end-users to promote biodiversity and nature protection, as well as improved capacity for planning, monitoring, reporting and governance of MPAs.

Marine protected areas that are formally recognized are required to develop a management plan with a monitoring and evaluation element. This model monitoring protocol aims to provide suggestions for technical guidance to a wide group of stakeholders in developing site-based monitoring plans to complement existing management plans or create new ones. This model can serve as a basis for guidance on standardized monitoring objectives, sampling design, indicators, and methodology. The document can be of use to environmental protection authorities and conservation experts, managers on all levels, marine scientists, researchers, students etc. who collect monitoring data.

Introduction

Marine Protected Areas and Protected Area Networks for the Black Sea resource management

The Black Sea marine resources are increasingly being stressed by human activities resulting in nutrient overabundance, high exploitation of living resources and unstable environmental state. The use of Marine Protected Areas (MPAs) as a strategy for conserving marine resources is widely used in many regional seas but in the Black Sea basin it is not sufficiently developed. In line with the targets set by the EU and the Convention on Biological Diversity, the MARMAPS project strives to provide solutions and tools that enhance the regional conservation capacity, further supporting scientifically sound and transparent approaches to achieving conservation objectives. Therefore, the goal of the project is to protect and promote biodiversity and natural heritage by supporting marine conservation initiatives at the regional level. MARMAPS raises awareness of the importance of conserving the Black Sea's valuable ecosystems and to engage decision-makers in the development of maritime spatial planning solutions that promote the conservation and restoration of marine biodiversity. This is achieved by improving access to open scientific data and tools, and by involving stakeholders in improving the conservation framework for marine protected areas (MPAs) at the sea basin level.

Monitoring for MPA management

MPA management requires information to assess whether MPAs are meeting their objectives and goals of improving resource status. Monitoring can provide the information that management need on the status of MPAs and how the resources are changing over time. The information gained by monitoring is needed for adaptive management.

The monitoring framework and monitoring protocols help to offer key insights into marine environments, such as how protection affects their biodiversity. Through this, we can find out if the MPAs are meeting their objectives. For many years, most monitoring has been done on populations of species that are fished and this has been the main way we evaluated if a MPA or marine reserve was protecting them. This data is still important but does not reveal all the factors that might be affecting them or their environment. By monitoring whole ecosystems using the protocols and review, we can see more of what is there, assess what condition it is in, and how it is changing. We can then record progress and find the best ways to use our resources for conservation. The monitoring framework and protocols can be built around different themes such as habitat representation, habitat composition and condition, climate change, key species, water quality, marine pollution etc. The themes monitored at place depend on the local environment and the aspirations of national authorities and local communities.

Ecological and Socioeconomic monitoring

Monitoring should include both ecological and socioeconomic monitoring. While ecological monitoring provides information on resources, socio-economic monitoring will provide information on people and how they benefit or are affected by the establishment of MPAs. To improve management and the chances for success, we need socio-economic monitoring. Through ecological monitoring, data including the status of the marine resources are collected periodically and used to evaluate whether the management measures are indeed contributing to improve conditions. On the other hand, socioeconomic monitoring provides information that can help us improve our understanding of the link between the condition of an MPA and its impacts on the socio-cultural, economic, and political wellbeing of individuals, households, communities, groups, and organizations connected to the MPAs.

Monitoring protocol

This outline of a sample monitoring protocol attempts to describe the entire process of developing a monitoring programme. The model protocol suggests ideas about the methodologies and indicators as well as the initial preparation that needs to take place and the reporting once the monitoring has produced some results. The model document can serve as a basis for developing real protocols and programmes for specific MPAs. The document can be used as a guide to prepare a monitoring plan for MPAs.

Objectives of monitoring

The objectives of monitoring of the Black Sea ecosystems, species and habitats are to assess how successful and efficient management strategies are in improving resource conditions and to provide the information to managers to help them promote adaptive management of MPAs. Monitoring objectives should reflect goals outlined in the management plan of an MPA. The data collected by monitoring can be used for producing annual reports and annual action plan. At the national or regional level, the data could be used to assess MPAs across the nation or the region.

The monitoring of MPAs in the Black Sea basin is also expected to answer questions relating to the condition of resources and the views and behaviour of people using the resources.

- Ecological and socioeconomic conditions of an MPA site that has been designated as a monitoring site
- Differences in ecological conditions inside and outside a marine protected area and among sites
- Ecological and socioeconomic characteristics of an MPA over time compared with conditions outside the MPA
- The role of stakeholders in resource extraction and effective enforcement of an MPA
- The role of stakeholders in the management of MPAs and the resources

What is measured and how

1. Understanding the characteristics of target MPAs that we will monitor

Before making a monitoring plan, it is necessary to gain clear understanding on:

- Location and area
- Management Objectives
- Managing body / Socio-cultural structure / Jurisdictions / Legislation / Type of management (Surveillance, monitoring, etc.)
- Types of resource uses
- Existing information on ecological/socioeconomic conditions including cultural and traditional values

The objectives of monitoring as well as the indicators and methods to measure these indicators were discussed by the project teams.

- Ecological and socioeconomic conditions of marine protected area that has been designated as a monitoring site
- Differences in ecological conditions inside and outside a marine protected area and among sites
- Ecological and socioeconomic characteristics of an MPA over time compared with conditions outside the MPA
- The role of stakeholders in resource extraction and effective enforcement of an MPA
- The role of stakeholders in the management of MPAs and the resources
- Managing body / Socio-cultural structure / Jurisdictions / Legislation /T ype of management (Surveillance, monitoring, etc.)

2. What do we measure to determine whether the objectives of the MPA are being achieved?

Some basic indicators selected with expert support are listed in the table below and ecological indicators have been designed for measurement.

General Indicator	Measurable Indicator	Survey Method
Fish species -demersal, pelagic etc. fish species (e.g. turbot, plaice, gobies)	• Species density (No. of fish/m^2) • Species biomass (kg of fish/m^2)	Underwater visual census by snorkel or scuba • Belt transect (5m x 50m) along 50m transect. • Five x 50 m transects per station
Benthic community	• % Benthic communities (e.g. bivalves, snails, etc.) (genus level) • % Benthic cover (Sand, Rubble, Carbonate, macroalgae, turf, etc.)	Photo quadrat method by snorkel or scuba • Photo quadrat (0.5m x 0.5m) every meter per/transect • Five x 50 m transects per station • 3 stations per MPA and Control site (each
	• Benthic species recruitment (genus level) (Number of colonies/m^2) • Size of individual recruits)	Underwater visual census by scuba • Belt transect (0.3m x 10m at the beginning of each 50m transect, See above)
Invertebrates (high value for commercial and subsistence)	• Species density e. g. molluscs, crustaceans (Number of individual/m^2)	Underwater visual census by snorkel or scuba • Belt transect (2 x 50m) of each 50m
Sea grass community	Species cover	Georeferenced drop camera observations, scuba diving sampling and georeferenced scuba diving photo and video transects Quadrat method by snorkel or scuba • Quadrat (0.5m x 0.5m) every 5 meter at the first 20m of each 50m transect (i.e., 5
Sediment	Organic and inorganic sediment weight (mgcm^2/d)	Sediment traps • 2 sediment traps (5.08cm diameter)/station
Visibility	Horizontal or vertical visibility in meter at seabed	Use of Secchi disc
Temperature	Water temperature (°C)	Data logger deployed at the site that records every 20 minutes

Socioeconomic indicators can be selected based on the assessment objectives and need to be identified by the assessment team. These indicators will form the basis for the creation of the questions that will be asked. Below is a list of suggested indicators and methods to measure them. Key informant interviews are a common method in qualitative research, particularly when exploring complex social issues or gaining insights into specific contexts.

A household survey is a data collection method where information about the characteristics of households and individuals within a population is gathered through a sample of those households. This data is then used to estimate characteristics of the larger population using statistical methods. Essentially, it is a way to understand how people live, what they own, how they spend their money, and other socio-economic factors by asking questions to a representative group of households. A household survey is a questionnaire distributed to a sample of households in a population, allowing interviewers to gather information from respondents.

Key informants are individuals with specialized knowledge or experience relevant to a research topic, often identified for their expertise, insider perspective, or position of influence within a community or organization. They are considered reliable sources of information and insights, offering valuable perspectives that can enhance understanding of a subject under study.

General Indicators	Indicators	Suggested Methods
Demographics	Number of people in household	Household survey
	Number of visitors	Key informants
	Age	Household survey
	Marital status	Household survey
	Occupation	Household survey
	Sources of household income	Household survey
Coastal and Marine Activities	Number of males and females who fish or harvest	Household survey
	Types of important fish and invertebrates for household use, consumption, sale, and cultural value	Household survey
	Average frequency of fishing and harvesting by household members	Household survey
Threats/Opportunities	Perceived conditions of marine resources	Household survey, Key informant interview
	Perceived threats/Opportunities to MPA	Household survey, Key informant interview,
	Perceived solutions to threats to MPA	Household survey, Key informant interview, Focus group discussion
Management	Benefits of MPA to household and community	Household survey, Key informant interview, Focus group discussion

	Number of MPA supporters	Household survey
	Awareness of rules and regulations	Household survey
	Management effectiveness	Household survey, Key informants, Focus group discussion
	Level of enforcement	Household survey, Key informant interview

When planning a monitoring program, different combination of indicators in the table can be used depending on management objectives of the MPA, interests of stakeholders, cost, and capacity.

Other important indicators

On the other hand, there may be other indicators that managers may wish to measure depending on their interests and site-specific objectives. These indicators may include salinity, influence of river mouths, nutrient level, predators and level of compliance with the law and regulations. For MPAs that are established to support fishermen's income, their catch or catch per unit of effort is an important indicator to measure. Data on catch are critical so that the benefits of MPAs can be demonstrated and such information can be used to secure long-term support from resource users. The methods to measure the different indicators that have not been presented should be determined by seeking for technical assistance from experts.

How to conduct monitoring

1. Reconnaissance site visits

Before you set up the monitoring program, it is necessary to conduct initial reconnaissance surveys of target MPAs, reference sites and surrounding areas to gain preliminary information such as boundary markers of MPAs and number of households nearby and other basic demographics of the area, type of habitats, size, resources, and accessibility for monitoring.

2. Sampling design

Ecological monitoring

The following sampling design is used for ecological monitoring.

- Reference (Control) site:

For each MPA, a “reference” area with similar habitat will be selected outside the MPA, within proximity of the MPA for comparison of data collected.

- Number of Stations:

  At each MPA and reference site, a minimum of three stations per major habitat type are randomly selected, preferably using software or other random-selection technique. GPS coordinates for these stations are recorded and repeatedly visited for subsequent surveys.

- Transects:

  Five 50-m transects for each station will be placed during each survey, with 2 to 3 meters between the end of one transect and the start of the next.

Socioeconomic monitoring

For socioeconomic monitoring, based on the assessment objectives and the identified indicators, the assessment team will need to design questions for household surveys as well as questions and topics for key informant interviews and focus group discussions. The survey respondents and sampling approach should be determined based on the objectives, available number of staff, their capacity, time, and fund. The sampling approach could either be random or non-random sampling. It is recommended to consult experts for finalizing sampling design.

Formation of study team/determine duties/training

Ecological monitoring

To conduct ecological monitoring, the following personnel are required.

- Boat driver—remains with the boat while the divers are in the water
- One diver—Fish visual census (to be capable to identify fish species on scuba)
- One diver—Laying transects tapes following the diver doing the fish census and winding transect tapes once all the data have been collected
- One diver—getting pictures of quadrats along the transects
- One diver-invertebrates survey (to be capable to identify invertebrate species on scuba)
- One diver-recruits survey (to be capable to identify recruits at genus level on scuba)

If the number of people is limited, then monitoring can be conducted by a minimum of three people. One is the boat driver while two will be doing field surveys. They would have to lay the tape and count the fish, then take photos of quadrates and count invertebrates after that. So, while it is possible to do monitoring with 3 people, it would take longer. The safety of the divers needs to be considered when doing surveys and divers need to have diving buddies.

Extracting data from photo quadrats requires personnel who can identify benthic organisms.

Socioeconomic monitoring

For socioeconomic monitoring the following personnel is needed.

- Trained team leader — Taking the lead by preparing/planning for the monitoring and redeveloping monitoring objectives based on the assessment objectives and other needs for management, supervising development of data collecting tools, which may include household survey questionnaires, semi-structured questions for key informant interviews, and focus group discussion, arranging field logistics, data collecting, training team members, analysing, and reporting results
- Team member(s) recruited from assessment community, preferably 2 (must have a clear and unbiased mind set) —Support team leader with the above tasks, collect and analyse data
- Other team members (at least 4-must have a clear and unbiased mind set) - Data collection. 3 teams of 2 people (this includes the local team members)
- Data manager - Data entry and analysis
- Both for ecological and socioeconomic monitoring, proper briefings and trainings have to be provided before data collection.

Monitoring equipment, cost and time required

Ecological monitoring

Ecological monitoring equipment such as boat, diving gear, digital camera with housing, GPS, 50m transect tape, 50cm x 50cm PVC quadrat, slate and underwater data sheets, and sediment traps are needed. To process sediments, it may be necessary to bring specimen to an institute that is equipped with the proper equipment for weighing and processing the sediments. The recurring costs for monitoring include fuel, salary, food and drinks, underwater data sheets, etc. (Please see detail in Appendix 1). A group of 5 divers can complete 3 stations, which means that it requires 2 days to survey the 3 stations in each MPA with 3 stations and its reference sites.

Socioeconomic monitoring

For socioeconomic monitoring, materials such as questionnaires, pens, clip boards, recorder, household list, and maps are needed. In dealing with the data, computers and software for data analysis/management are needed. For each monitoring, costs incurred include those for transportation, salary, printing, and food. One pair of surveyors may be able to complete surveys for six households per day, but this would vary depending on the length of the questionnaire and the availability of household members to be interviewed.

Monitoring frequency

Ecological monitoring should be conducted according to the following frequency based on the indicator being measured:

- Benthic community: Every 2 years
- Seagrass: Every 2 years
- Invertebrates: 2 times per year
- Fish species: 2-4 times per year

Socioeconomic study should occur every 3-5 years, unless there are drastic changes at the site that influence existing socioeconomic conditions. If such changes do occur, a socioeconomic assessment is required sooner than the recommended 3-5 years to capture the changes.

Draft a monitoring plan and pre-test

Based on the information obtained, a monitoring plan needs to be prepared. This includes, monitoring objectives, indicators, methods, sampling design, monitoring frequencies, survey team structure, necessary equipment, and budget.

It is highly recommended that a pre-test be conducted prior to refining indicators, methods, survey team structure and other details. Based on the results of the pre-test, the monitoring plan can be revised and consultation made with those who are experienced in monitoring. When necessary, further trainings must be provided to survey team.

Process to obtain consensus from stakeholders

It is important to obtain consensus on monitoring plan of the site from relevant stakeholders such as state government, community leaders, and resource users such as fishers and tourism operators. The consensus is needed so that monitoring activities can be conducted with the support from the different stakeholders. The consultation will include explanation of objectives, methods and expected outcomes of monitoring. Consultation can be conducted by holding targeted meetings, using printed materials and mass media such as TV and radio programs to provide information to the public. Public meetings are also useful to learn about the interests and concerns the people have on environment and resources.

Conducting monitoring work

Once the monitoring plan is approved and budget is secured, the survey team can initiate monitoring according to the monitoring plan.

Check the quality of monitoring

Always make sure all the necessary data are collected and recorded on data sheets before leaving the sites. Data should be entered into a database such as Access or a spreadsheet such as Excel, as soon as possible. Special care should be taken to avoid errors in data entry. Original data sheets should be stored in safe place so that researchers can consult, when necessary, in future. Simple descriptive analysis after entering data may help detect errors in the data entry. Process for backing up data should be developed.

Data management

When the monitoring plan is prepared, it is important to determine how to manage the data from monitoring. Management of data include: 1) the way in which data are forwarded by whom to what institute; 2) the way in which data are stored and analysed; 3) the way in which information is shared among what kinds of stakeholders (those who collect data, decision makers, resource users, scientists, etc.).

It is recommended that the head of the monitoring team in each MPA forward the data to national and regional authorities. The database manager at national and regional level will store, compile, and analyse data to extract information useful for data management.

Feedback of monitoring results to management

The results of the monitoring need to be communicated back to management and stakeholders and communities. The results can inform management whether they are meeting their management objectives. Therefore, it is important to schedule regular meetings where monitoring results are presented and discussed.

Black Sea national authorities' role in monitoring, regional perspectives

Black Sea national authorities must regulate the MPAs and their networks, develop management plans and make management agreements on both national and transborder level. The Black Sea Commission has the role to assist states in MPA networks monitoring, it is recommended that the states work with BSC to design their monitoring programs and to manage their data. The EU institutions and regulatory authorities can support the monitoring and management process of MPAs.

Funding

It is recommended to make a green fee available to assist states' monitoring. For each state, their monitoring program to measure effectiveness of their MPAs would require technical assistance from EU institutions and the BSC, cross-border collaboration and funding. The states would need funding to support state monitoring programs, funding for salary, equipment and supplies would be needed. Therefore, a reliable and steady funding to national governments from a green fee would allow them to focus on state needs rather than rely on grants. Grants have certain priorities for funding and those do not necessarily match with the monitoring needs of state MPAs.

Process of revision

The monitoring protocol can be revised through discussions among members of the MPAs networking partners. Ministries of environment and tourism can guide and assist the process.

Conclusions

Monitoring is fundamental to the effective management of Marine Protected Areas (MPAs), providing essential evidence to understand ecological conditions, track changes and evaluate the success of management actions. A well-designed monitoring programme enables managers to detect emerging pressures and identify trends in biodiversity and resource use, allowing them to make timely, informed decisions.

What is measured and how depends on the objectives and ecological characteristics of each MPA. Monitoring may focus on habitats, species, water quality, human activities or socio-economic indicators, with standardised methods being used to ensure consistency and comparability over time. Clear protocols, appropriate spatial and temporal scales, and scientifically robust sampling designs are vital components of this process.

Equally important is the manner in which monitoring is conducted, from the planning of fieldwork and the training of personnel to ensuring safety and coordinating logistics. Different approaches, such as diver surveys, remote sensing, automated sensors or citizen science, can be combined to maximise data quality and coverage. The choice of equipment must be carefully balanced against available resources and long-term sustainability, taking into account the associated cost and time requirements.

Finally, an effective monitoring system relies on robust data management, including proper storage, quality control, analysis and interpretation. Transparent and accessible data enable adaptive management, support collaboration among institutions and demonstrate the ecological and socio-economic benefits of MPAs to stakeholders and decision-makers.

Annexes

Annex 1. Description of ecological monitoring

Fish Size and Abundance

Fish size and abundance will be conducted visually while diving or snorkelling. Fish within 2.5 m of either side of the 50m transect will be recorded by species, size (cm) and number of individuals. Target fish species are those that local people consume and/or that have economic and ecological importance. Target species recorded should be listed on the fish list. The survey is replicated for the four remaining transects. To minimize interference by the individual laying the transect tape, the fish surveyor should swim slightly ahead of the tape as it is being laid. The survey and tape laying should be done at the same depth. This results in a sampling area of 250m2 per transect.

Benthic communities

Starting at 0m and then at every meter interval, a 0.50 x 0.50 m quadrat will be photographed along the 50 m transect in the field. In the laboratory, the photo will be analysed. For each picture frame, five randomly selected points are overlaid on the photograph and the substrate underneath each point is identified (to the genus level) and recorded.

Before beginning the survey, a photograph of the site and station name, data collector, coordinates, and other relevant information should be taken. At the beginning of each transect, a photo of the individual's hand raising the number of fingers that correspond to the transect number. This helps in organizing the photos once they have been downloaded onto a computer for extraction.

Recruitment

Recruit surveys will be conducted using a belt transect of an area of 0.3m x 10m (only the first 10m of each of the 5 transects). All recruits will be measured to the nearest 0.5 cm and recorded. If possible, the recruit will be identified to the lowest taxonomic level possible. If taxonomic skills are lacking, the recruits will be only recoded as benthic recruits. This will be replicated along the four remaining transects. This equals to a sample area of 3m2 per transect.

Invertebrate size and abundance

Invertebrates will be identified, measured, and recorded along a 2m x 50m transect. A 1-m long stick or pipe will be used to measure the size of the belt transects. Those species to be monitored should be listed on the invertebrate list. Survey will be replicated along the four remaining transects.

Seagrass Survey

Monitoring of seagrass will be conducted along the five transects used for the other surveys. Starting from zero, every 5 m interval, a 0.5m x 0.5m quadrat will be placed on the side of the transect and surveyed. For each transect, five quadrats will be surveyed, which means, only the first 20 m of the 50 m transect will be used for the seagrass surveys. Each species in the quadrat and their percent cover will be recorded.

Sedimentation Study

The study of sedimentation rate will be conducted on MPAs that are close to watershed drainage areas and are affected from land-use change. A gradient moving away from the mouth of the river toward the MPA will be established and sediment traps will be deployed along the gradient. The number of stations along the gradient will vary depending on the community type along gradients and changes in communities along the gradient. Stations will be established at sites where communities change along the gradient. For each station, two sediment traps with the size of 5.08 cm diameter will be deployed at few meters apart from each other. The traps are established at the same depths throughout the site and are replaced about every month. Sediment samples collected from the traps will be dried and weighed to obtain total sedimentation rates (mg DW cm^{-2} d^{-1}), then re-weighed after treatment with 10% hydrochloric acid to remove carbonate to obtain the carbonate fraction, and then burned at 600°C for 2 hours to remove organic matter, to obtain the organic matter fraction. The remaining weight will be used to estimate terrestrial (inorganic non-carbonate) sediments.

The traps are fabricated using the pipes and pipe caps, where individual pipes are capped on one end. Once the stations are determined, rebar is hammered about two-thirds of the way into the substrate at a fixed location identified using GPS coordinates and the trap is attached to the rebar with the open end facing up at a depth of about three meters.

Sediment Processing

Once the traps have been collected in the field, transfer the sample from trap into a 1000 mL beaker and use a small hose to remove excess water and refill with new water. Let the sample sit overnight or until all sediment is at the bottom of the beaker. Repeat rinsing of the sample and let it sit overnight three times. Once the sample has been rinsed thoroughly, transfer to a 50 0mL beaker and let it settle overnight. Once the sediment has settled, remove as much water as possible from the sample and transfer to 50mL-beaker (that has been weighed and recorded) and dry in dryer at 60°C for 24 hours, remove, weigh, and record the sample for 1st weight.

Place back into 1000 mL beaker and add muriatic acid diluted at 9 parts water to 1 part acid or 8 parts water to 2 parts acid (depending on calcium content of sample) with water for a minimum time of 1 hour. Remove and rinse sample using similar method discussed above, making sure to prevent sediment from being removed, add more water, leave overnight and repeat. Repeat this step three times to remove all acid traces. Transfer to ceramic bowl (that has been weighed and recoded) and dry for 24 hours at 60°C. Once sample has been dried, remove to weigh and record the sample weigh (2nd weighting). After weight has been recorded, place in furnace to burn for 2 hours at 600°C. After sample has dried, obtain and record weight (3rd weighing).

Visibility

Measurement of horizontal visibility near seabed will be taken by using a Secchi disc with tape measure at each monitoring station when fish counting is conducted and at each station of sediment traps when traps are replaced.

Temperature

Temperature data logger, will be deployed at each MPA. Data logger will be set with intervals of 20 minutes and collected every 3 months.

Equipment and Supplies

- Boat
- Boat fuel
- Dive gear for all divers
- Five 50m transect tape (plus a spare)
- 0.5mx0.5m PVC quadrat designed with a camera mount
- Camera and housing
- 1-m stick or pipe
- Slate, underwater data sheets and pencils, scale for recruits
- GPS and batteries
- Food and water
- First Aid Kit
- Secchi disc with a tape measure

- Sediment traps (2” schedule-40 water pipe (5.08cm diameter, cut to 12”), 2” Pipe Caps, Rebar (cut to 1 meter), Cable ties.

Laboratory Equipment for Sediment Processing

- Electronic weight scale to 10-4 g accuracy
- Drying oven
- Graduated beakers 900mL, 300mL, 50mL
- 1-Liter plastic transfer containers
- Ceramic bowl with minimum 40mL capacity
- High temperature laboratory furnace oven

Budget Planning:

Recurring costs:

- Fuel
- Salary
- Food and drink
- Equipment maintenance
- Underwater data sheets and pencils

One-time costs:

- GPS
- Slates
- First Aid Kit
- Transect tapes
- Camera and housing

Supplies

- Questionnaires
- Pens
- Clip boards
- Recorders-key informant and/or focus group interviews (optional)
- Household list
- Map (if necessary)
- Computers
- Software for data analysis and management

Expense

- Transportation
- Printing
- Pens
- Clip boards
- Food
- Recorders
- Analytical software (if it is preferred)
- Contractor(s)- if no one is available to produce study
    - To take the lead of the study
    - To be a team member

Annex 2. Citizen science for monitoring water quality

1. Introduction

Monitoring marine ecosystems is essential for assessing environmental health, tracking biodiversity trends, and supporting conservation and policy decisions. Involving citizen science enhances data collection capabilities, public engagement, and environmental awareness. This report outlines a framework for implementing a community-inclusive marine monitoring program, with specific protocols for biological and environmental water quality parameters.

2. Objectives

- To establish a cost-effective, scalable, and scientifically robust monitoring program.
- To integrate citizen science into long-term marine ecosystem observation.
- To track key biological and environmental indicators of water quality.

3. Key Components of the Monitoring Program

3.1. Site Selection

- Identify coastal and nearshore sites with ecological significance, accessibility, and stakeholder interest.
- Include both protected and non-protected areas for comparative analysis.

3.2. Citizen Scientist Training

- Provide training workshops and online modules covering:
    - Sampling techniques
    - Data recording and submission
    - Safety and ethical guidelines
- Use simple tools such as smartphone apps, field kits, and visual ID guides.

4. Monitoring Protocols

4.1. Biological Parameters

Parameter	Method	Frequency
Phytoplankton abundance and diversity	Water samples collected with plankton nets; identified via microscopy or app-based recognition	Monthly

Macroalgae and seagrass cover	Photographic transects and quadrat surveys	Seasonal
Benthic fauna (e.g., mollusks, echinoderms)	Visual or photographic surveys during low tide or shallow dives	Biannually
Marine litter	Beach and underwater clean-ups with categorization (OSPAR/UNEP methods)	Monthly

4.2. Environmental Parameters

Parameter	Method	Frequency
Temperature	Digital thermometer or temperature loggers	Continuous (loggers) or weekly
Salinity	Refractometer or conductivity sensor	Weekly
pH	Handheld meters or colorimetric test kits	Weekly
Dissolved Oxygen (DO)	DO meter or chemical titration kits	Weekly
Turbidity	Secchi disk or turbidity tube	Weekly
Nutrients (nitrate, phosphate)	Test kits or lab analysis of collected samples	Monthly

5. Data Management and Validation

- Use open-access platforms (e.g., iNaturalist, CitSci.org, or custom apps) for data submission.
- Implement quality control through expert review, photo verification, and periodic cross-checks with professional sampling.
- Encourage feedback and visual dashboards to engage citizen contributors.

6. Reporting and Policy Integration

- Compile findings into seasonal and annual reports.
- Share data with local authorities, environmental agencies, and research institutions.
- Use results to inform marine spatial planning, pollution control, and public education campaigns.

Annex 3. Phytoplankton, pico-phytoplankton & Meso-zooplankton

1. Sampling surveys

The first specific objective of the project is to carry out an intergraded monitoring programme of the phytoplankton, picoplankton and zooplankton communities in the Black Sea. For this, the first step of monitoring implementation is the sampling surveys. The sampling surveys will be seasonal for a period of one year in defined study areas (east, south, west, north), covering two different study zones: (i) the coastal and (ii) the shelf. Phytoplankton/Pico-phytoplankton and mesozooplankton sampling surveys shall be conducted during the same day, aiming at collecting both communities' samples before midday. In particular,

1.1 Phytoplankton and pico-phytoplankton

The phytoplankton / picoplankton samples will be collected using water sampler at the defined sampling stations at defined depths and an additional integrated sample. From each sampling depth we will collect two replicate samples of 500 mL from each sampling depth following scientifically well accepted and approved methodologies (Sommer et al. 2015; OSPAR, 2016). The sampling and analysis shall be carried out to one of the replicated samples (the 2nd shall be kept as a spare).

Phytoplankton monitoring guidelines are relevant for several indicators of phytoplankton community as an umbrella term (pico-phytoplankton and nano- and micro-phytoplankton) developed and used in MSFD and WFD. Following this common procedure is a means of establishing common basis for European comparable assessments of environmental status. The guidelines aim to ensure the delivery of consistent, high-quality phytoplankton data (composition, abundance, biovolume, biomass, diversity) that can be used to evaluate the state of each of the indicators. Sampling under these guidelines should also support in producing assessments that distinguish between the various drivers of change in the phytoplankton community.

Picoplankton sampling is identical to the sampling for nano- and microplankton, but the preservation method is different. We will use the fluorescent microscopy method according to Sommer et al (2015) samples will be preserved using paraformaldehyde and will be analyzed as soon as possible to avoid degradation of fluorescent pigments. Final concentration will be 0.2% paraformaldehyde. The samples will be stored in the dark at 4°C. The phytoplankton samples for nano- and micro- phytoplankton immediately after sampling will be preserved using Lugols' solution (e.g. Sommer et al. 2015; OSPAR 2016) and will be stored in dark glass or other appropriate bottles. If needed Lugol's solution will be added in samples lost the 'cognac'-like color of Lugols' solution.

1.2 Meso-zooplankton

For mesozooplankton sampling the Standard Plankton Net (WP2 nets 200 μm mesh) will be used along with adjusted flowmeters for volume estimation during net tows. Samples will be collected through vertical tows and will be preserved immediately with buffered formaldehyde (4%) (1 part 37% formaldehyde solution and 9 parts water; buffered to pH 8-8.2 with borax).

1.3 Supporting environmental parameters that will be measured for the best interpretation of plankton data

Together with phytoplankton and pico-phytoplankton samples, two water samples for nutrients (ortho-phosphates, nitrites, nitrates, ammonium, silicates) as well as for chlorophyll-a will be collected using water sampler at the defined sampling stations. The collected water samples will be kept cool in the field and will be transfered as soon as possible to the laboratory for further analysis.

2. Analysis

The second step of monitoring implementation is sample analysis for obtaining specific data that will be further analyzed to assess the target questions. In particular,

2.1 Phytoplankton and picoplankton analysis

Microscopy analysis

Phytoplankton identification for individuals > 3 μm was based on taxonomic keys and counting was done using the inverted microscope method (EN: 15972:2011) which prescribes that at least 500 cells should be counted in each sample, at least 50 cells should be counted for dominant taxa and that single cells should be counted within colonies. Before enumeration, the phytoplankton samples will be settled in sedimentation chambers for the appropriate time. For the biomass estimation, the dimensions of 30 individuals of each abundant species will be measured using a digital microscope camera (Nikon DS-L1). Mean cell volume estimates will be calculated using appropriate geometric formulae (Hillebrand et al. 1999).

Fluorescence microscopy will be used to estimate the abundance of picoplankton. More specifically, ten ml of the prefiltered (64 μm) subsample will be fixed with formaldehyde, incubated for 24 h (at 4 °C in the dark), filtered onto black Nuclepore filters (0.2 μm pore size) and stained with DAPI (Porter and Feig 1980). The filters will be observed using a Nikon ECLIPSE TE2000-S fluorescence microscope under ultraviolet and green excitation at 1000X. As mentioned above picoplankton identification and, hence, species composition is not possible without molecular analysis. Thus, the pico-phytoplankton metrics for assessing the ecological water quality will be given at the group level.

Finally, the epifluorescence microscopy along with literature review will be applied in order to specify the trophic type of the identified taxa including phytoplankton and pico-phytoplankton. Each of the recorded taxa will be classified in one of the following categories according to their trophic preferences i.e. (1) autotrophic, (2) heterotrophic, (3) mixotrophic, and (4) not known/specified.

Data analysis

In order to assess the phytoplankton and pico-phytoplankton taxonomic biodiversity in the selected samples under the MSFD requirements for the qualitative descriptors of Pelagic Habitats (D1C6), alpha diversity indices will be computed using the «Vegan» package in R environment. More analytically, different estimators (Richness presented as the number of taxa identified in a given sample, Shannon-Wiener Index (H’), Simpson’s Index (1-D), Pielou’s Evenness Index (J’), Berger-Parker’s Dominance Index BP’) will be computed that represent different aspects of alpha diversity. In case that the taxa will be determined to different levels (e.g. species, genus or family level) during the identification process, they will be treated as equal following the Heino & Soininen (2007) approach.

Beta-diversity is a metric of differences in community composition between sites/samples that creates a link between local diversity (alpha-diversity) and the regional species pool (gamma-diversity) and thus provides a powerful framework for studying diversity patterns at various spatiotemporal scales (Mousing et al. 2016). To assess phytoplankton and pico-phytoplankton beta diversity of the study area, Rao's quadratic entropy will be estimated. Furthermore, Baselga’s (2010) approach which suggests that beta diversity expressed as Sorensen multiple-site dissimilarity (bSOR) is partitioned into two components: spatial turnover in species composition, measured as Simpson dissimilarity (bSIM) and variation in species composition due to nestedness (bNES) measured as nestedness-resultant fraction of Sorensen dissimilarity will be used to investigate the changes in community composition in relation to spatial, temporal and environmental gradients.

Finally, the structural patterns in taxonomic composition will be investigated and depicted by performing a non-metric multidimensional scaling analysis (NMDS) and the relationships between taxonomic richness and the measured abiotic variables will be assessed using multivariate statistical methods such as Canonical Correlation Analysis.

As mentioned above, the identification of non-indigenous phytoplankton and pico-phytoplankton taxa presents significant scientific limitations due to their morphological plasticity along with their cosmopolitan distribution. However, it will be attempted to establish a list with non-indigenous species for every site of the study area. Further information like harmful algal species and endemic species will be included in the list in order to sufficiently review the D2 of the study area.

2.2 Meso-zooplankton

Microscopy analysis

In the laboratory mesozzoplankton samples will be stereoscopically and microscopically analysed for taxonomic identification down to the lowest possible level (e.g., species) with the use of proper taxonomic keys. For each taxon picture will be taken using cameras incorporated at the microscope. Following the methodology described in (HELCOM Guidelines for monitoring of mesozooplankton) abundance will be estimated through the analysis of the sample under the stereoscope and biomass will be calculated using proper equations.

Data analysis

Data Analysis for mesozooplankton will include the estimation of Biodiversity Indices (Alpha diversity: species richness, Shannon, Simpson, Pielou evenness; Beta diversity: Rao's quadratic entropy and Importance value index) that have already been used to develop a water quality index based on the MSFD requirements. Multivariate analyses (PCA, NMDS, cluster analysis) to determine spatial and seasonal patterns as well as Indicator Species Analysis in order to identify key species or groups indicative of water mass characteristics or environmental pressures, as well as the presence of non indigenous species will be applied.

2.3 Estimation of Chlorophyll-a

For chlorophyll-a estimation an up-to-date laboratory methodology according to international standards will be applied such as the Jeffrey and Humphrey (1975) method. Furthermore, the 90th percentile will be calculated, followed by the assessment of ecological status of each sampling station based on the WFD guidelines.

2.4 Estimation of total and dissolved nutrient in the water column

Total and dissolved nutrients will be determined in filtrates by employing colorimetric methods, following the analytical procedure described by Hansen and Koroleff (Grasshoff et al. 1999). Briefly, nitrates, nitrites, ammonium, silicate and orthophosphates will be determined after the filtration of water samples through 0.45 μm membranes while total nitrogen and acid hydrolysable phosphorus will be determined in unfiltered samples. The colorimetric method (4500-NO2-B) will be applied for the nitrate estimation, the phenate method (4500-NH3-F) for the estimation of the ammonium and the persulfate method (4500-N-C) for the estimation of total nitrogen after the digestion of unfiltered samples. As regard the soluble reactive phosphorus and the silicates, they will be determined colorimetrically by applying the ascorbic method while total phosphorus will be measured after the digestion of unfiltered samples with sulfuric acid/ammonium persulfate (4500-P-E).

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Annex 4. Details of Socioeconomic Monitoring

Indicators and Methods

Indicators are selected based on the assessment objectives and need to be identified by the assessment team. These indicators will form the basis for the creation of the questions that will be asked.

The different methods for doing a socioeconomic study are described below:

- Secondary data are documents, reports, or any collected information that can be helpful in identifying gaps in existing knowledge in preparation for the assessment.
- Key informant interview involves experienced and/or knowledgeable individuals who can provide information for larger population such as a state. This semi-structured interview allows the interviewer(s) to deeply explore certain topics and allows the key informants to freely express and present the information that is needed.
- Focus group discussion is a type of a "semi-structured interview" resulting in qualitative data. This usually involves a selected group (4-10) of people who share a common background or knowledge. These discussions are based on a set of open-ended questions or discussion topics to generate qualitative information as well as to interact with each other to reach a consensus.
- Household survey is a questionnaire that has specific questions with the result of mostly quantitative data.

Data collection and entry design

Based on the assessment objectives and the identified indicators, the assessment team will need to design questions for household surveys as well as questions and topics for key informant interviews and focus group discussions. These questions will need to be specific and straight forward to get a direct answer to the assessment objectives. Household data collection is a method that should be used at all times and depending on how much is known, key informant interviews and/or focus group discussions can also be used. These two types of methods are used to collect qualitative and more in-depth data and information. Once the questions are designed and pre-tested, the sampling approach should be determined. The sampling approach could either be random or non-random sampling.

The design of database is important because it will be used for storing data as well as for data analyses. Codes will need to be developed along with the database especially for the household data collection which can be done on an Excel spread sheet or SPSS or any other statistical analysis software. The analysis of the data will need to include the comparison of the quantitative data from the household surveys and/or focus group discussions.

Frequency of monitoring

A socioeconomic study should occur every 3-5 years, unless there are drastic changes at the site that influence existing socioeconomic conditions. If such changes do occur, a socioeconomic assessment is required sooner than the recommended 3-5 years in order to capture the changes.

Personnel

Team members	Tasks
Trained team leader	Taking the lead by preparing/planning for the monitoring and redeveloping monitoring objectives based on the assessment objectives and other needs for management, supervising development of data collecting tools (which may include household survey questionnaires, semi-structured questions for key informant interviews, and focus group discussion, arranging field logistics, data
Team member(s) recruited from assessment community, preferably 2 (must have a clear and	Support team leader with the above tasks, collect and analyse data
Other team members (at least 4-must have a clear and unbiased mind set)	Data collection. 3 teams of 2 people (this includes the local team members). It is ideal for those who collect data to be part of data entry. Members of the data collection team can work with the data manager on data entry.
Data manager	Data entry and analysis

Supplies

- Questionnaires
- Pens
- Clip boards
- Recorders-key informant and/or focus group interviews (optional)
- Household list
- Map (if necessary)
- Computers
- Software for data analysis and management

Expenses

- Transportation
- Printing
- Pens
- Clip boards
- Food
- Recorders
- Analytical software (if it's preferred)
- Contractor(s)- if no one is available to produce study
    - To take the lead of the study
    - To be a team member

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