Deliverable 2.1 of BONUS FUMARI

Structure of the review on novel monitoring methods

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28 February 2019

Introduction

The BONUS FUMARI project aims to provide a proposal for a renewed monitoring system of the Baltic Sea marine environment. As the basis of this proposal, a review of the current gaps in monitoring, as well as a review of novel monitoring methods to complement these gaps will be conducted. To increase the overall impact, suggestions of stakeholders are integrated at all stages of the work.

The review of novel monitoring methods will provide an overview on methods, which are suitable to supplement the current monitoring system in order to enhance spatial coverage, temporal resolution, cost-effectiveness and sensitivity. Therefore, the novel methods will be characterized and rated in their reliability, added value, applicability and cost-effectiveness using specific parameters, which are nominated and described in this document.

Developing a list of descriptive parameters

During the kick-off meeting of the project, different kinds of monitoring gaps and related types of novelty were identified. Therefore, the monitoring addressed in this project, related terms and types of gaps/novelties were specified in a terminology document. Considering this classification, the parameters to describe novel methods were defined in a multi-step process.

First, the parameters for method characterization were specified considering HELCOM monitoring manuals and method descriptions in Birk et al. (2012). Second, the parameters to rate the methods in terms of their reliability, added value, applicability and cost-effectiveness were developed including approaches of Hering et al. (2018), Nygård et al. (2016) and Oinonen et al. (2016). Ultimately, a spreadsheet was designed, including all proposed parameters grouped into categories.

After internal revisions at UDE, a draft of the spreadsheet was sent to the BONUS FUMARI consortium. The Work Package (WP) leads and WP2 participants commented on this, and their suggestions and amendments were integrated. The last step was a final revision of the parameter list by the WP2 team.

This work resulted from the BONUS FUMARI project which has received funding from BONUS (Art. 185), which is jointly funded by the EU, the Academy of Finland and the Swedish Research Council Formas.

Results

The terminology document provides a proposal of key terms for the BONUS FUMARI project in order to assure a harmonized use of terms (and related concepts) across all project outcomes. Since different policies, using slightly varying concepts and sets of terms, require the monitoring of the Baltic Sea, a common terminology is needed for our project-internal collaboration. In this document, key terms used in the different policy directives are collected and a common terminology is proposed. Therefore, a hierarchical framework to introduce the proposed terms is used, building on the concept of indicators as the basic unit for which data are acquired in environmental monitoring. Furthermore, three types of monitoring gaps and related novelties are defined.

The terminology document is annexed to this deliverable and terms relevant for this deliverable are listed in Box 1.

Box 1: *Extract of the terminology document, including all defined terms relevant for this Deliverable.*

Descriptors are thematic categories addressing characteristic ecosystem features relevant for the assessment and classification of status, but may also be used in assessments of 'climate change' or 'ecosystem services'.

Quality elements are ecosystem elements, which describe the status of the ecosystem. They include biological, physical, chemical, hydrological or morphological elements. The term quality element is used in the WFD, synonyms used in the context of the MSFD are criteria element or monitoring element.

Criterions constitute the properties of the quality elements, which are used to describe the status. Criterion is used in the MSFD, whereas indicative parameter is used in the WFD.

Indicators constitute specific attributes of each criterion, which can be measured, and which allow to follow subsequent change in the *criterion* over time. They represent the smallest unit of ecosystem assessment and need to be specified in terms of their spatial and temporal coverage and the matrix/habitat of measurement.

Type 1 gap is defined as an indicator, which is not sufficiently monitored using the currently applied methods. This may occur when the acquired data do not meet the desirable quality or quantity, or when there are no acquired data for an indicator.

Type 1 novelty encompasses novel monitoring methods providing data to fill the type 1 gap. Type 1 novelty methods provide, for instance, better data quality, spatio-temporal coverage or cost-efficiency than currently applied methods.

Type 2 gap is defined as an appropriate indicator, which is missing for the assessment of status, either because a currently applied indicator is inadequately reflecting the descriptor, or because no indicator for the descriptor has been established so far.

Type 2 novelty encompasses novel monitoring methods providing data to fill the type 2 gap. These novel methods acquire data for an indicator, which has not been measured so far.

Type 3 gap is defined as an aspect of the ecosystem (comparable to descriptors), which is currently not considered in applied monitoring at all. Such additional aspects may be 'climate change' or 'ecosystem services'.

Type 3 novelty encompasses monitoring methods providing data to fill the type 3 gap, accounting for the monitoring of aspects for the Baltic Sea, which have not been considered before.

The parameters to characterize and rate novel monitoring methods of Type 1 and 2 were organised as follows:

i. The first section is for characterizing the novel methods. It is divided into the parts 'general information', 'field sampling' (split into single samples and the whole sampling occasion), 'sample treatment', 'data treatment' and 'data storage and management', with different fields of information specified in each part. This first section only addresses the novel methods.
In case one novel method is relevant for multiple indicators, the details for each indicator is specified in each field, where applicable.
ii. The second section is for the rating of novel methods, which will be performed in comparison to the currently applied methods. Therefore, information on these parameters will be provided for the novel methods and the currently applied methods. The parts for the rating include 'reliability', 'indicative value' (for Type 2 novelty only), 'added value', 'applicability' and 'cost-efficiency'.
The list of parameters is provided in Table 1.

***Table 1**: Defined parameters for characterization and rating of the novel monitoring methods*

Method characterization		
Category	**Item**	**Description**
General	Name of expert	Your name
	Name of novel method	How is this method called?
	Already applied in (countries)	If this method is already applied, please indicate in which countries
	Application planned in (countries)	If this method is planned to be applied, please indicate in which countries
	Relevant descriptor(s)	Which descriptors can be monitored using this method?
	Relevant quality element(s)/criterion(a)/ indicator(s)	Which quality elements/criteria/indicators can be monitored using this method?
	Type of novelty	Enhanced data on already used indicator(s) (Type 1); monitoring of new indicator(s) (Type 2)
	Currently applied method(s) replaced/improved	Which method is currently applied to monitor these quality elements/criteria/indicators and in which country is it applied?
	Manual/handbook/publication/standard of novel method	Where is a manual and/or a standard (e.g. CEN, OECD, ISO) for the novel method accessible? Please add the reference and its link in the table and additionally provide the file

Method characterization		
Category	**Item**	**Description**
Field sampling - single sample	Single sampling/surveying description	Short description of the sampling/surveying process. Please specify for each of the different quality elements/criteria/indicators, if applicable (also in the following descriptions)
	Sampling/surveying equipment	Which devices are used for the sampling/surveying? Please give a short description of their operation
	Habitat sampled/surveyed	Is the sampling/surveying conducted in the air, open water column, sediment, biota, …?
	Sample size/surveyed area	Volume of sample/surveyed area
	Number of spatial replicates	Number of replicates per sampling/surveying occasion
Field sampling - sampling occasion	Description of sampling occasion	Please provide a short description of the sampling occasion
	Time of the year	In which month(s) of the year is the sampling/surveying occasion conducted?
	Number of temporal replicates	Number of sampling/surveying occasions per year
	Spatial resolution	What is the spatial resolution obtained by each sampling/surveying occasion?
Sample treatment	Sample/survey data preparation	Short description of the sample/survey preparation after sampling
	Equipment for sample/survey data preparation	Which devices are used for the sample/survey data preparation?
	Processing/lab measurements of prepared sample/survey data	Short description of the processing after sample/survey data preparation to obtain conclusive data on the indicator
	Equipment for sample/survey data processing	Which devices are used for the sample/survey data treatment?
	Results of sample treatment	What kind of data are obtained by the treatment of the sample/surveying data?
Data treatment	Data quantification and conversion	How are the data processed to obtain quantitative/qualitative information on the measured quality element/criterion/indicator, which are comparable between sampling occasions, i.e. data quantification and conversion (incl. formulas)? This also concerns the calculation of indices / metrics.
	Data aggregation	How are the obtained data aggregated in time and space for the assessment of the specific quality element/criterion/indicator?
	Quality assurance/quality control	Are any QA/QC protocols in place or under development for this for the method?
Data storage & management	Data quantity	Is the produced amount of data low (no need to external storage capacity) or high (need for external storage capacity)? In case it is high, please estimate the data amount (bytes).
	Data storage and management (in case of high data amount)	Is there infrastructure to store and process the data (local, national, international)?
	Open access	Are the data open access? If yes, please provide the link.

Method characterization		
Category	**Item**	**Description**
Data storage & management	Metadata descriptions	Are metadata descriptions available for data storage and management? If yes, please provide the link.
Reliability	Default rate	How often are no data generated at a sampling/surveying occasion due to malfunction (in percent)?
	Accuracy	How reliable are the generated data in terms of precision (statistical variability) and trueness (in percent)?
Indicative value (for Type 2 novelty only)	Information on functional processes (relevant for Type 2 novelty)	On which functional processes of the marine ecosystems does the novel indicator give information?
	Relation to stressors (relevant for Type 2 novelty)	Which relation to stressors/descriptors does the new indicator have and does it give information on stressor intensity?
Added value	Data enhancement	In what way are the obtained data more appropriate than data using the current method(s), if there are any?
	Acquisition of additional information	What additional information does the new method provide, which are not required, but informative?
Applicability	Advantages	Advantages in comparison to the current/novel method(s)
	Limitations/disadvantages	Implementation barriers of the method and disadvantages in comparison to the current/novel method(s)
	Comparability of data to current method(s)	Are the obtained data comparable to the data obtained from current method(s)? Yes/No; if not, please describe the differences
	Environmental impact	Which impact does the sampling/surveying have on the environment/organisms (including health and safety risks)?
Cost-efficiency	Investment costs	Please estimate the costs for initial, one time investments such as equipment and training of personnel skills. If not known, provide estimate in relation to current method (stating orders of magnitude).
	Monitoring costs	Please estimate the monitoring costs for one year (once the set-up investments have been done). If not known, provide estimate in relation to current method (stating orders of magnitude).
	Time required	Please estimate the time required for sampling, sample treatment and data treatment of each sample (if multiple samples, indicate how many samples).
	Monitoring of multiple quality elements/criteria/indicators	Can this method be used to monitor multiple quality elements/criteria/indicators at the same time and using a field sample? Please indicate, which.

Method characterization		
Category	**Item**	**Description**
Cost-efficiency	Availability of expertise and equipment	Are the skills and equipment needed to use this method already available in most of the Baltic Sea countries, or easy to acquire (i.e. equipment can be bought off-the-shelf, required training is not long)? Please indicate if availability is high (already available), moderate (easy/fast to acquire), or low (laborious to acquire).

To address novel monitoring methods of Type 3, another approach is necessary. The parameters to review the monitoring of newly proposed descriptors were specified follows:

First, the necessity of monitoring the new descriptor is outlined, including the political and environmental management context. Second, the reasons for the incapability of the current monitoring system to depict this descriptor is presented (e.g. missing indicators). Thereon, novel indicators for the descriptor are specified, and it will be evaluated, which novel methods are feasible to monitor these indicators.

Next steps

A spreadsheet containing all parameters will be forwarded to the WP2 team, whereof each person is responsible for specific novel methods. A provisional list of the responsible persons is provided in **Table 2** 2. These experts will fill the spreadsheet using specified data sources (including a set of keywords for database-search). Furthermore, there will be a stakeholder survey in the course of WP1, asking for gaps in the current monitoring and potential novel methods to fill these. These proposed novel methods will complement the information collated by the spreadsheet.

The collated information will then be analysed and finally made available using an online database and a review/conventional article. The schedule for WP2 is outlined in Table 3.

Table 2: *Responsibilities within the WP2 consortium of the BONUS FUMARI project*

WP2 responsible person	Affiliation	Novel method(s)
Jenni Attila	SYKE	Remote sensing/Earth Observations, Finnish autonomous monitoring, Alg@line & automated stations
Olli-Pekka Mattila	SYKE	Drones
Timo Pyhälahti	SYKE	Citizen science
Anna Willstrand Wranne	SMHI	FerryBox, Argo float, Moving Vessel Profiler
Leoni Mack	UDE	Isotope tracing, methods to monitor microplastics
Florian Leese	UDE	DNA-based methods (eDNA, DNA barcoding, …)
Antonia Liess	HH	Methods to monitor ecosystem services

***Table 3**: Schedule for the WP2 of the BONUS FUMARI project*

Deadline	Task
D2.1: Structure of the review	
21 Dec 2018	Definition of general terminology for whole project
31 Jan 2019	Definition of types of novel methods
31 Jan 2019	Identification of experts for specific novel methods
31 Jan 2019	Spread sheet - Specification of parameters for characterization and rating
15 Feb 2019	Partner feedback on spread sheet
28 Feb 2019	Submission of deliverable
D2.2: Searchable online database on novel monitoring methods	
29 Mar 2019	Identification of data sources (incl. keywords for database-search)
30 Apr 2019	Gathering information/data for spread sheet - WP2 partners
17 May 2019	Inclusion of stakeholder suggestions into spread sheet (based on returns of WP1 survey)
31 May 2019	Identification of methods (special focus on methods capable to fill the gaps identified in WP1)
28 Jun 2019	Analysis of methods collated in the spread sheet
28 Jun 2019	Set up of online database
31 Jul 2019	Submission of deliverable
D2.3: Manuscript for a review paper	
31 Oct 2019	Draft of manuscript
29 Nov 2019	Revision of manuscript
20 Dec 2019	Submission of deliverable
D2.4: Policy brief	
31 Mar 2020	Draft of policy brief
31 Mar 2020	Revision of Policy brief
31 Mar 2020	Submission of deliverable

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TERMINOLOGY

Objective

This document provides a proposal of key terms for the BONUS FUMARI project in order to assure a harmonized use of terms (and related concepts) across all project outcomes.

Introduction

The BONUS FUMARI project aims to provide a proposal for a renewed monitoring system of the Baltic Sea. Different policies require the monitoring of the Baltic Sea, each built on slightly varying concepts and terminologies. In this document, we collect the key terms used in the different policy directives and propose a common terminology to be used in the BONUS FUMARI context. We use a hierarchical framework to introduce the proposed terms, building on the concept of *indicators* as the basic unit for which data are acquired in environmental monitoring. Furthermore, we specify the three types of *monitoring gaps* expected to be potentially replaced by novel monitoring methods.

General terms

Status refers to the qualitative condition of the ecosystem. It is categorized into different classes, whereas the achievement or preservation of a **good status** is the main environmental objective of the different directives. Synonyms used in current monitoring concepts are *(good) environmental status* (Marine Strategy Framework Directive - MSFD), *(good) ecological status* (Water Framework Directive - WFD) and *(favourable) conservation status* (Habitats Directive).

Monitoring is the acquisition of environmental data relevant for the classification of the *status*.

Monitoring methods are techniques to acquire environmental data to assess and classify *status*.

Novel monitoring methods are *monitoring methods*, which are not in general use or have only been applied in some regions/by some countries of the Baltic Sea.

State monitoring is the continuous observation of an ecosystem to get an overview on its *status* and to detect long-term changes. In case of the achievement of *good status* of an ecosystem component, conducting *state monitoring* is sufficient. The term *state monitoring* is used in the MSFD, whereas *surveillance monitoring* is used in the WFD.

Target and measure monitoring is the supplementary *monitoring* of areas and ecosystem elements failing *good status* and the *monitoring* of the pressures being responsible for this risk. For instance, it constitutes the *monitoring* of additional sampling stations or a higher sampling frequency, to assess progress towards achieving *good status* and to establish local management options. The term *target and measure monitoring* is used in the MSFD, whereas *operational monitoring* is used in the WFD.

Investigative monitoring is the targeted *monitoring* to identify the causes for failing *good status*, as well as to determine the magnitude and effect of accidental pollution. The term *investigative monitoring* is used in both WFD and MSFD.

Hierarchical framework of terms used for the monitoring of the Baltic Sea

As defined above, *monitoring methods* acquire environmental data to assess and classify *status*. The basic unit for the assessment of *status* is the *indicator* (see below). We thus propose to establish the review of *novel monitoring methods* against this basic assessment unit, using a hierarchical framework, which comprises the various categorical levels of monitoring (Figure 1).

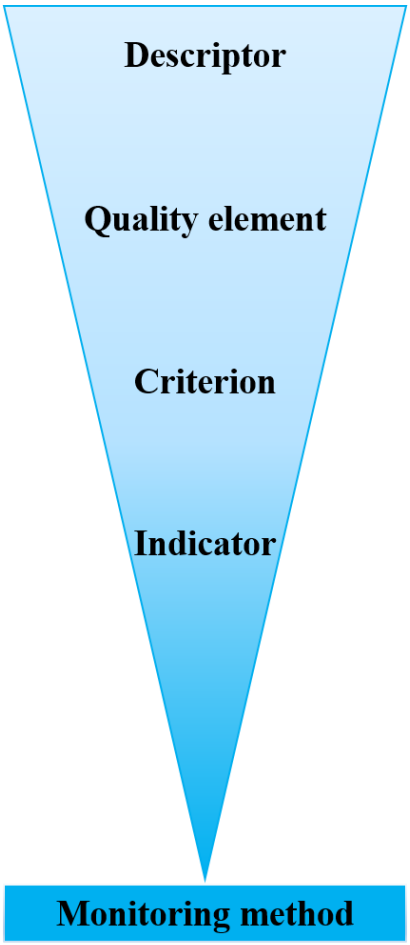

Figure 1: Proposed BONUS FUMARI terminology scheme for the hierarchical organization of the terms used in environmental monitoring.

Descriptors are thematic categories addressing characteristic ecosystem features relevant for the assessment and classification of *status*, but may also be used in assessments of 'climate change' or 'ecosystem services'.

The MSFD defines eleven *descriptors*: Biodiversity, non-indigenous species, commercial fish, food webs, eutrophication, sea-floor integrity, hydrographical conditions, contaminants and pollution effects, contaminants in fish and seafood, marine litter and underwater noise/energy.

Quality elements are ecosystem elements, which describe the *status* of the ecosystem. They include biological, physical, chemical, hydrological or morphological elements. The term *quality element* is

used in the WFD, synonyms used in the context of the MSFD are *criteria element* or *monitoring element.*

Criterions constitute the properties of the *quality elements*, which are used to describe the *status*. *Criterion* is used in the MSFD, whereas *indicative parameter* is used in the WFD.

Indicators constitute specific attributes of each *criterion*, which can be measured, and which allow to follow subsequent change in the *criterion* over time. They represent the smallest unit of ecosystem assessment and need to be specified in terms of their spatial and temporal coverage and the matrix/habitat of measurement. The term *indicator* is used in the MSFD. The term *metric* can be regarded as a synonym.

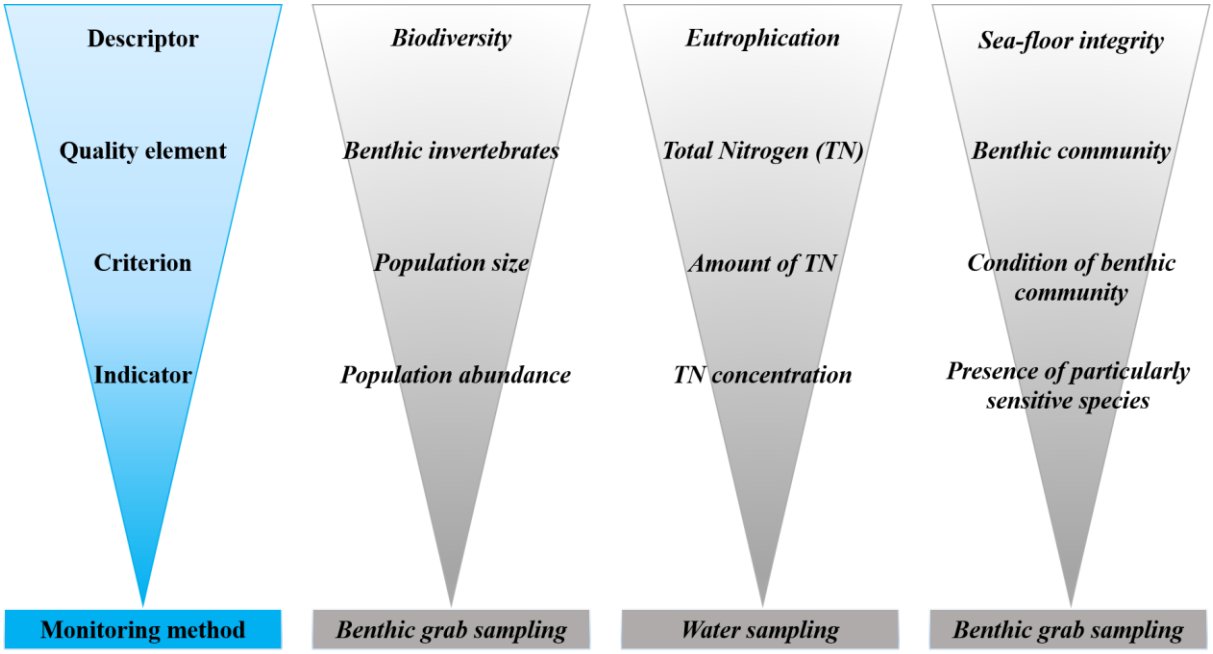

Figure 2: Examples for using the BONUS FUMARI terminology.

Types of monitoring gaps and related novelties

Type 1 gap is defined as an *indicator*, which is not sufficiently monitored using the currently applied methods. This may occur when the acquired data do not meet the desirable quality or quantity, or when there are no acquired data for an *indicator*.
This gap is furthermore divided into Type 1A: insufficient spatial coverage of monitoring; Type 1B: insufficient temporal resolution of monitoring; Type 1C: other insufficiencies.

Type 1 novelty encompasses *novel monitoring methods* providing data to fill the T*ype 1 gap*. *Type 1 novelty* methods provide, for instance, better data quality, spatio-temporal coverage or cost-efficiency than currently applied methods.

Type 2 gap is defined as an appropriate *indicator*, which is missing for the assessment of *status*, either because a currently applied *indicator* is inadequately reflecting the *descriptor,* or because no *indicator* for the *descriptor* has been established so far.

Type 2 novelty encompasses *novel monitoring methods* providing data to fill the *Type 2 gap*. These novel methods acquire data for an *indicator*, which has not been measured so far.

Type 3 gap is defined as an aspect of the ecosystem (comparable to *descriptors*), which is currently not considered in applied *monitoring* at all. Such additional aspects may be 'climate change' or 'ecosystem services'.

Type 3 novelty encompasses *monitoring methods* providing data to fill the *Type 3 gap*, accounting for the monitoring of aspects for the Baltic Sea, which have not been considered before.

Moreover, following gaps are in development:

Type 4 gap is defined as insufficient regulations on data storage or handling.

Type 5 gap is defined as an indicator, which is in development but not yet operational or decided upon.

Type 6 gap is defined as a missing coordination of monitoring between the countries.

Type 7 gap is defined as the insufficient monitoring due to costs, which are too high.

Related literature

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