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SOCIO-ECONOMIC ASSESSMENT OF INDICATOR-BASED MARINE BIODIVERSITY MONITORING PROGRAMMES AND METHODS

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Contents

1 Introduction

Ambitious policy goals in terms of what has to be achieved with regard to maintenance and conservation of marine biodiversity are set by European Community's directives, such as the Marine Strategy Framework Directive, (MSFD; 2008/56/EC) (EC, 2008), Water Framework Directive (WFD; 2000/60/EC) (EC, 2000), Habitats Directive (HD; 92/43/EEC) (EC, 1992), and Birds Directive (BD; 2009/147/EC) (EC, 2009), as well as international conventions including Regional Sea Conventions (RSC), for example the Convention on the Protection of the Marine Environment in the Baltic Sea Area (Helsinki Convention). These policy goals and tasks are translated into the national legislation of EU member states or into the legislation of the Contracting Parties of the RSC including their provisions on implementation.

To follow trends and changes on status of the marine biodiversity and to monitor progress towards achieving the policy targets it is necessary to carry out regular assessment using specially designed schemes and tools where indicators form the core element of the assessment. Conceptually use of indicators as a tool for assessment of marine environment has been enforced by the EU Decision 2010/477/EU while other directives have set the key criteria or principles of the assessment. The MARMONI project aims at developing marine biodiversity indicators which would deliver relevant information to assess the extent of achievement of the biodiversity policy goals.

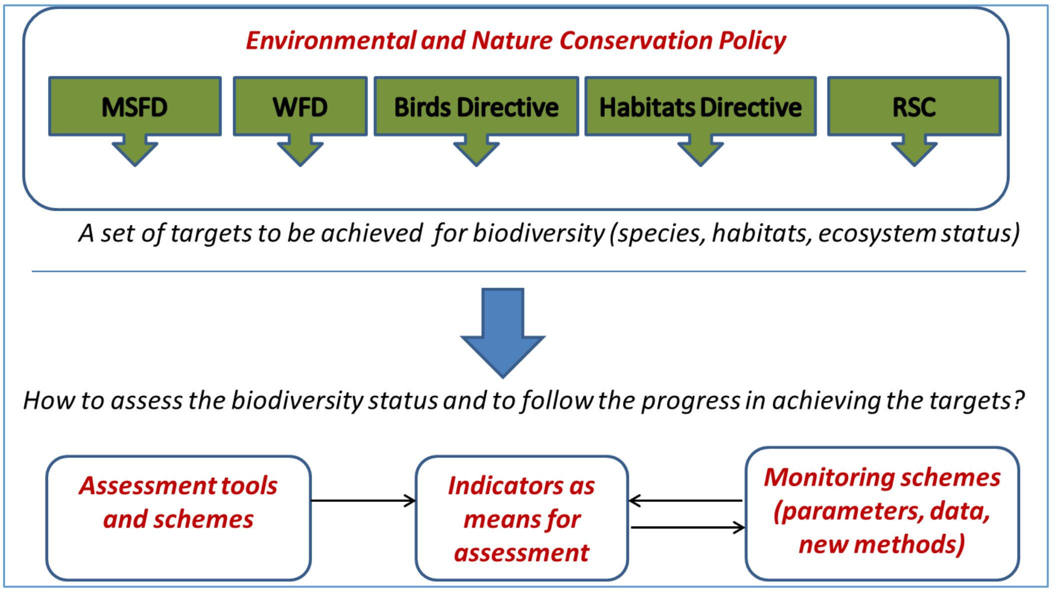

Figure 1.1. MARMONI framework for assessment of biodiversity (Source: MARMONI Project)

The key limiting factor for designing and developing marine biodiversity indicators is monitoring programme/s, which needs to provide data on parameters for building relevant indicators. Data are collected by different monitoring methods that can be by already well-established methods in the region or new methods tested as a part of the MARMONI project. Consequently, alternatives how to obtain data for parameters and indicators are created. Such situation gives an opportunity to evaluate available monitoring data collection alternatives in terms of cost effectiveness.

The assessment of cost-effectiveness aims at identification of the least cost way for reaching predefined aims of the monitoring programme. In case of the MARMONI project, we aimed at identifying the least cost way to ensure compliance primarily with the MSFD requirements on assessment of the good environmental status according to the set of criteria and indicators for Descriptor 1 on Biodiversity (EC Decision 2010/477/EU).

To carry out systematic and comparable assessment in the project's countries a methodology document and calculation tool (in Excel) has been developed as part of the project's Action A5 "Assessment of monitoring programmes and applied methods". The methodology explains concept and approach for assessing cost implications of building policy (e.g. MSFD) compliant monitoring program or scheme, including, introduction of new monitoring parameters and/or methods for the marine biodiversity monitoring.

The methodology and its test results were presented at the international workshop "Towards indicator based, cost effective and policy compliant monitoring and assessment of the marine biodiversity in the Baltic Sea (TotalBio)" held on 7-8 May, 2014 in Tallinn, Estonia.

This Report presents approach and results of the socio-economic assessment of marine biodiversity monitoring programmes which are developed to deliver data for new biodiversity indicators with the purpose of assessing good environmental status.

2 Marine Biodiversity Policy Framework

2.1 European Union: Habitat and Birds Directives, Water Framework Directive, Marine Strategy Framework Directive.

The Habitat Directive (HB) and Birds Directive (BD) are long-standing legal frameworks in the EU, which aim at protecting defined species and habitats that are of European importance. Both of these directives require member states to establish protected areas for safeguarding valuable species and habitat types as well as ensure that they are at a favourable conservation status throughout their natural range within the EU. Favourable conservation status (FSC) is defined as the range and areas of the listed habitats, and the range and population of the listed species that are to be maintained or restored to a position where they are viable.

The assessment of the conservation status of species and habitats of community importance is carried out on the member state level. It is implemented according to the requirements of the article 12 of the BD and the article 17 of HD. In the frame of the MARMONI project, the assessment was carried out at four project area level which included also transboundary areas, e.g., the Gulf of Riga. The FCS assessment was carried out for those species and habitats, for which there are reporting obligations under the BD and HD and which were regularly occurring in the particular study area. The species not occurring in the particular study area were not considered even if they occurred in the member state in question or in other MARMONI project areas.

During the project it was concluded that parameters used for the FCS assessment are often similar or originated from the same data sources as those used in the Good Environmental Status (GES) assessment, and vice-versa. Thus monitoring programmes established to ensure sufficient data availability to comply with the reporting requirements under one directive can make an important contribution to the collecting of data compliant also with the reporting requirements of another directive (Aunins and Martin, 2014).

The Water Framework Directive (WFD) aims at reaching good ecological status of freshwaters and coastal waters. The good ecological status of coastal waters means that biological quality elements such as phytoplankton, macroalgae and angiosperms, and benthic invertebrate fauna, show low levels of disturbance resulting from human activity. For implementation of the WFD, a number of indicators were developed for the coastal areas, e.g., benthic quality index (BQI). The WFD also provides an input for the development of the biodiversity indicators, as data collected for specific parameters can be used for multiple purposes.

The Marine Strategy Framework Directive (MSFD) is the most recent water protection policy and the first EU legislative instrument targeted to the protection of marine biodiversity, since it contains the explicit regulatory objective that "marine biodiversity is maintained by 2020", as the cornerstone for achieving Good Environmental Status (GES). The MSFD defines the GES on the basis of 11 qualitative descriptors which are specified by the criteria and indicators given in the EU Decision 2010/477/EU. The descriptor 1 is dedicated to the biodiversity - “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 climate conditions”. The Decision 2010/477/EU requires that the assessment is carried out at species, habitat and ecosystem level.

The MSFD also requires that member states establish and implement coordinated monitoring programmes for the on-going assessment of the environmental status of their marine waters. These monitoring programmes are to be compatible within the Baltic Sea region or its sub-regions, and they shall build upon relevant assessment and monitoring systems laid down by the other Community Directives. The methodology for monitoring activities is expected to be consistent across the region. It is clear, that these monitoring programmes are to serve the updating of developed set of biodiversity indicators.

Development of indicators and the biodiversity assessment tool of the MARMONI project focused on the descriptor 1 – Biodiversity. Nevertheless, the work also contributes to the assessment needs with regard to other aspects of GES, e.g., D4 on food web; D5 – eutrophication; D6- sea floor integrity.

2.2 HELCOM Baltic Sea Action Plan

The cooperation on marine environmental issues around the Baltic Sea is coordinated in the frame of the implementation of the Helsinki Convention for which a governing body called Helsinki Commission was set-up (HELCOM). When adopting the HELCOM Baltic Sea Action Plan (BSAP; HELCOM, 2007) the Baltic Sea countries agreed on an ambitious goal – to restore good ecological status of the Baltic Sea marine environment by 2021. One of the four key goals of the BSAP is to reach favourable conservation status of marine biodiversity.

BSAP's overall goal of a favourable conservation status of the Baltic Sea biodiversity is described by the following three ecological objectives:

- natural marine and coastal landscapes,
- thriving and balanced communities of plants and animals, as well as
- viable populations of species.

In order to make the ecological objectives operational and to assess how the objectives have been achieved, core indicators are developed to enable comparison of monitoring data and assessment results across the entire Baltic Sea region. The HELCOM work on the core set of indicators in frame of the two projects CORESET and CORESET II was organised in the same time period as implementation of the MARMONI project. Active communication and coordination between the HELCOM and MARMONI expert groups was established. As the result, several MARMONI indicators have directly or indirectly contributed to the development of methodology for the HELCOM core biodiversity indicators.

2.3 National policies in the project's countries

The national policies and goals for protection of biodiversity mirror to large extent the EU and RSC marine policy and corresponding goals and targets.

Designation of marine protected areas (MPAs) has been one of the first marine nature protection measures to protect valuable marine and coastal habitats and species. The process has been stimulated by RSC and EU directives (HB and BD). Both policy frameworks promote the establishment of protected areas in marine waters. The EU Natura 2000 network protects certain natural habitats and species having importance at EU level, whereas the HELCOM MPAs network aims to protect marine and coastal habitats and species specific for the Baltic Sea. For Latvia, the HELCOM MPAs and Natura 2000 MPAs cover the same area, whereas there is a slight difference in other project countries.

The first river basin management plans (RBMPs 2009-2015) developed according to the WFD include environmental issues relevant for coastal waters. Key issues addressed by these plans were eutrophication and pollution of hazardous substances. Biodiversity was addressed indirectly - considering state of the biological elements in terms of abundance and composition or diversity or other aspects. The WFD sets an ambitious goal – to achieve good ecological status of coastal waters by 2015. At the same time the assessment of the RBMPs performed by the European Commission indicates that although progress towards the objective of good status is expected by 2015, but it will not be achieved for a significant proportion of water bodies (EC, 2012). This conclusion is also relevant to coastal waters of the project's countries where most of the coastal waters are reported not to hold good status (EEA, 2012). The report prepared by the European Commission (EC, 2012) points out also deficiencies in the monitored quality elements.

According to requirements of the MSFD, the project's countries have started already in 2013-2014 to work on their national Programmes of Measures - a key tool designed to achieve or maintain good environmental status of marine waters. Before that, member states had to implement a set of actions: initial assessment of the current environmental status of national marine waters and the environmental impact and socio-economic analysis of human activities in marine waters; a determination of good environmental status; establishing environmental targets and associated indicators. The work on establishment of monitoring programme had to be accomplished by 2014. Based on the outcomes of these previous actions, the member states are elaborating the Programme of Measures which is also for the first time the most comprehensive policy document targeting the needs of the safeguarding marine biodiversity.

The MARMONI work on indicators contributed to shaping of the existing marine biodiversity monitoring programmes or establishing new ones in those project countries where marine biodiversity has not been monitored.

3 Marine Biodiversity Monitoring Programmes and Development of Indicators

Monitoring activities performed in the frame of regular national programmes or surveys provide data obtained either by sampling, observations, calculations or other scientifically sound monitoring methods. The availability of monitoring data on required parameters is a key limiting factor for designing and developing marine biodiversity indicators. At the same time, indicators that are selected and agreed based on research activities might streamline the existing and future monitoring activities to make them more policy-relevant or cost-effective.

The analysis carried out in the MARMONI project at the beginning of the project showed that the existing national monitoring programmes did not provide adequately data for the assessment of the status of marine biodiversity in a way as required by the MSFD. Some elements of existing monitoring programs could be used, but considerable changes are required regarding both the used methodology (parameters, indicators, monitoring methods) and data collection strategy (spatial and temporal issues of the data collection). The initial assessment reports of 2012 on the current environmental status of national marine waters also revealed a large gap between the parameters monitored currently and the needs to comply with the MSFD requirements.

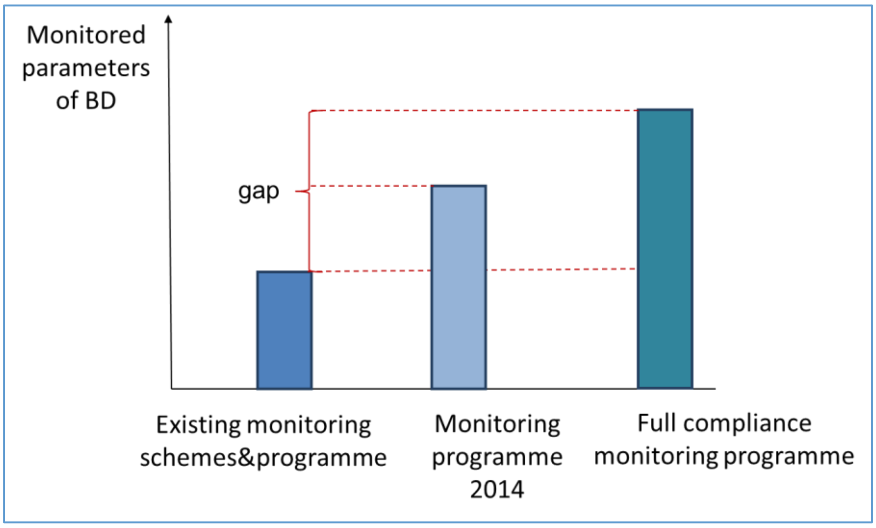

Figure 3.1. Development of MSFD compliant monitoring programme in terms of monitored parameters for biodiversity assessment (Source: MARMONI project)

There are various reasons for deficiencies in the marine biodiversity monitoring programmes. Historically the marine protection policies have been focusing on reducing eutrophication and managing commercial fish resources while biodiversity was not a priority issue. Moreover, the limited budgets allocated for monitoring and a lack of strong, legally binding policy requirements held back the project's countries to expand the monitoring activities in the sea. Furthermore, a lack of tested and validated monitoring methodologies did not stimulate the enhancement of the monitoring programmes on national scale.

According to the Article 11 of the MSFD the member states shall establish by July 2014 and implement coordinated monitoring programmes for the ongoing assessment of the environmental status of their marine waters and regular updating of targets. The monitoring programmes shall be compatible within marine regions or subregions and shall build upon, and be compatible with, relevant provisions for assessment and monitoring laid down by Community legislation. The information needs to be provided in accordance with Annex III and with the criteria and methodological standards defined in the EC 2010/477/EU.

The table 3.1 presents an overview prepared at the end of the MARMONI project (in Spring of 2015), on coverage of various marine biodiversity features as well as criteria and indicators of the assessment of GES as defined by the EC Decision (EC, 2010) by the national monitoring programmes of the project's countries. Although almost all criteria and organism groups as well as habitats are covered by the national monitoring programmes of one or several countries, the gap still exist to achieve fully compliant monitoring programmes in all project's countries.

Table 3.1. Coverage of marine biodiversity features and GES criteria and indicators of the Descriptor 1 by the national monitoring programmes of the project's countries (*Source: MARMONI project*)

Functional sub-groups of the marine biodiversity MSFD criteria and related indicators for D1 Biological diversity	Pelagic communities (Water column habitats)	Benthic (Sea bed) habitats	Phytoplankton	Zooplankton	Angiosperms	Macro-algae	Invertebrate bottom fauna	Fish	Birds	Mammals
1.1. Species distribution										
1.1.1. Distributional range			FI, LV	FI, LV		FI, LV, EE	FI, LV	FI, SE*	FI, SE* LV, EE	FI, SE* EE
1.1.2. Distributional pattern within the latter, where appropriate			LV	LV		LV, EE	FI, LV		FI, LV	FI, EE
1.1.3. Area covered by the species (for sessile/benthic species)						FI, LV EE	LV			
1.2 Population size										
1.2.1. Population abundance and/or biomass, as appropriate			FI, LV	FI, LV			FI, LV	FI, SE	FI, SE EE	FI, SE EE
1.3 Population condition										
1.3.1. Population demographic characteristics				FI			FI, LV	FI, SE	FI, SE EE	FI, SE
1.3.2. Population genetic structure, where appropriate										
1.4. Habitat distribution										
1.4.1. Distributional range	FI, LV	FI, SE**			EE	FI, EE	FI			
1.4.2. Distributional pattern	LV	SE**			EE		FI			
1.5. Habitat extent										
1.5.1. Habitat area	FI, LV	FI, SE			SE, EE	FI, SE EE				
1.5.2. Habitat volume, where relevant	FI, SE LV					FI		SE		
1.6. Habitat condition										
1.6.1. Condition of the typical species and communities		SE, LV			SE, EE	FI, SE EE	FI, SE	SE		
1.6.2. Relative abundance and/or biomass, as appropriate	SE, LV	LV	SE	SE	EE	FI	FI	SE		
1.6.3.Physical, hydrological and chemical conditions	FI, LV	FI, LV SE***					SE***			
1.7. Ecosystem structure										
1.7.1. Composition and relative proportions of ecosystem components (habitats and species)	FI, SE		SE	SE				SE, EE		

Explanations concerning Sweden (SE): ** No tailored monitoring but distribution can be assessed based on data on population size; ** Occasional surveys, but no regular monitoring; *** Included as supporting parameters in some monitoring of benthic invertebrate fauna.*

4 Objectives and Scope of the Socio-Economic Assessment

Necessity for a socio-economic assessment is arising from the condition that public financial resources are limited or insufficient in every country and sector. Whereas a demand to deliver appropriate data and information for evaluation of policy implementation is laid down in most of the policy documents (HB; BD; WFD; MSFD; HELCOM, national laws). Thus, the demand for data and information to perform adequate and comprehensive assessments has substantially increased over the past years.

The socio-economic assessment can help developers of the marine monitoring programme to explore links between the delivered data (for indicators and parameters) and the costs necessary for their delivery. Furthermore, the assessment can support identifying the least-cost way for monitoring and assessing the state of marine biodiversity to ensure compliance with various reporting requirements and delivering proper policy evaluations. The economic assessment can also be performed to choose among alternative options (e.g. monitoring methods, indicators) for achieving the same need, to be it related to carrying out policy review or assessing state of the biodiversity. Clearly, this can lead to better use of the limited resources allocated to the marine monitoring activities.

The overall aim of the MARMONI socio-economic assessment is to support building of cost-efficient and policy-compliant marine biodiversity monitoring programmes in the project's countries to comply with the MSFD requirements (see the chapter 3) and also to serve the needs of other biodiversity related directives as well as commitments to RSC.

The general approach of the socio-economic assessment is built on the MARMONI project's ambition to develop new and innovative indicators for the key biodiversity functional groups as well as to test them in practice for the assessment of GES and FCS. But the MARMONI project developed and tested also new monitoring or survey (field data collection) methods. Therefore the socio-economic assessment has the focus on these both aspects – indicators (and related parameters) and methods.

The specific aims of the socio-economic assessment are:

- to assess cost implications of building policy compliant (i.e., MSFD) indicator based marine biodiversity monitoring program,
- to evaluate the socio-economic impact of introducing new monitoring **methods** for data collection within the marine biodiversity monitoring (e.g. whether there is potential for reducing the costs),
- to analyse the socio-economic impact of including new monitoring **indicators** and corresponding data and methods for marine biodiversity monitoring (e.g. what are the costs of providing "better" information for assessing the state of biodiversity).

The MARMONI project did not work on optimal design of the monitoring programme (e.g. number of monitoring sites and sampling frequency). Consequently, the socio-economic assessment didn't aim identifying optimal solutions concerning these issues. The spatial coverage and sampling frequency were only used as variables to calculate the monitoring costs and to identify the socio-economic impact.

The MARMONI project did not aim to develop a complete list of indicators covering all possible aspects of the marine biodiversity, or to fulfil all assessment needs set by different policy instruments. Instead, the aim was to fill major gaps concerning marine biodiversity indicators and to propose new innovative approaches for increasing the cost-effectiveness of monitoring and assessment of marine biodiversity and for collecting new types of data, thus supporting the modernization of national marine monitoring programmes. Such project's aim determined also the scope of the economic assessment.

Table 4.1. Overview on MARMONI new indicators and methods and their relevance for the socio-economic assessment[1]

Functional groups	Number of ready indicators	Methods	Relevance for the socio-economic assessment
Fishes	4	No new methods were tested.	No alternatives to be analysed due to: • lack of current fish (biodiversity) indicators, • no new methods developed.
Birds (wintering, breeding, migratory birds, impacts on birds)	16	2 new methods were tested: *Automatic identification of birds using aerial RGB imaging; Thermal imaging along with RGB imaging to improve detection of birds*. However, the methods are not ready as alternatives to the current methods.	No alternatives to be analysed because: • all bird indicators cover different aspects, they are not alternatives; • no new functional methods developed by the project end. The economic assessment was performed to identify the major cost positions of the bird monitoring.
Benthic (vascular plants, bottom fauna, habitat)	15	8 new methods were tested, 4 were evaluated as ready for application: *Aquatic Crustacean Scan Analyser (ACSA) image recognition software; Using beach wrack for assessing coastal benthic biodiversity; Simplified grab method using a small Van Veen grab; Further development of the drop-video method and the combination of drop-video and small Van Veen grabs.*	Alternatives for the analysis: • several alternative new indicators; • *manual versus automated Macoma b. analysis* method; • diving versus drop video method for phytobenthos analysis.
Pelagic (phytoplankton; zooplankton)	8	7 new methods were tested, 2 were evaluated as ready for application: *Automated zooplankton analysis; Satellite observations in phytoplankton bloom indicators).*	Alternatives for the analysis: • several alternatives of new indicators; • *manual versus automated zooplankton analysis* method.

The socio-economic assessment was implemented for the key functional groups addressed by the MARMONI project (benthic, pelagic, birds, fish, and seals). Since there were no new monitoring methods developed (thus, no alternatives to be analysed), for monitoring of seals or fishes, only partial socio-economic assessment was implemented for these groups – focusing on assessment of the monitoring costs and indicating relevant cost positions and variables. The same stands for the socio-economic assessment for the bird indicators.

The key variables determining the monitoring programme are indicators for assessment; parameters that are monitored; monitoring methods; and monitoring intensity (see also the figure below). It aims to ensure compliance with the policy requirements and needs achieving acceptable confidence level of the obtained data at the least cost way. The compliance, confidence and costs form the core of the socio-economic assessment (see also the figure below).

The methodology of the socio-economic assessment is described in details in the next chapter.

[1] The details of the MARMONI indicators and methods, please read in the publication: Martin G. et al. 2015. *The MARMONI approach to marine biodiversity indicators Volume I: Development of indicators for assessing the state of marine biodiversity in the Baltic Sea within the LIFE MARMONI project*. Estonian Marine Institute Report Series, No. 16.

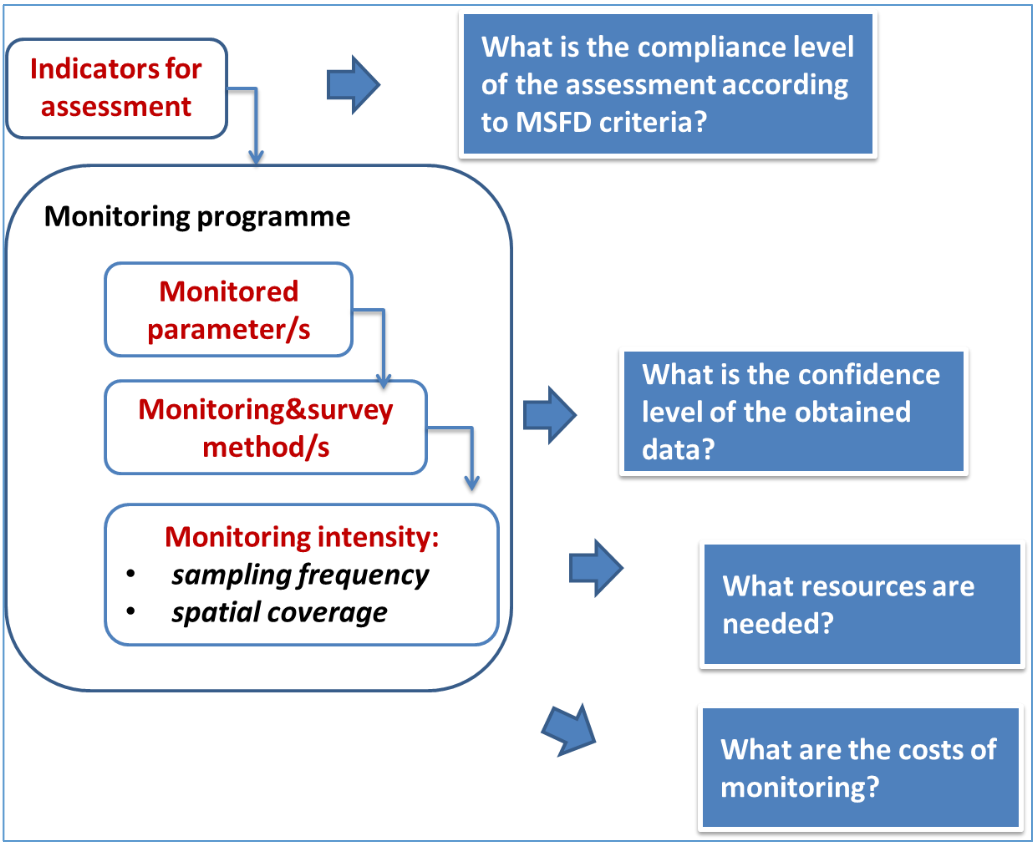

Figure. 4.1. The core elements of the socio-economic assessment. (Source: MARMONI project)

5 Methodology of the Socio-Economic Assessment

5.1 Scenarios (alternatives) for the socio-economic analysis

The socio-economic impact of complying with the policy needs and introducing new monitoring indicators and methods was assessed by analysing different alternatives or scenarios. Here, the scenarios are defined as current (baseline) and/or hypothetical monitoring programs/schemes of the marine biodiversity. Due to specifics and practices of the monitoring activities in the region, the analysis is performed by monitoring scheme(s) for specific functional groups (e.g. fish, benthic, pelagic, birds). The scenarios are built taking into account actual situation of the current monitoring system or particular indicator work in the project and the project's country.

Three scenarios are analysed:

1. Current monitoring (baseline) scenario (*"Current"*) – the monitoring program/scheme with the current monitoring indicators, parameters and methods used for the MSFD "Initial assessment", Habitats Directive, other related needs;
2. Compliance scenario with currently used methods (*"Compl_current"*) – monitoring program/scheme compliant with the policy (e.g. MSFD) needs with the currently used[2] monitoring methods;
3. Compliance scenario including (also) new methods (*"Compl_new"*) – monitoring program/scheme compliant with the policy (e.g. MSFD) needs when including also new (tested and proposed by the MARMONI project) monitoring methods instead of current methods.

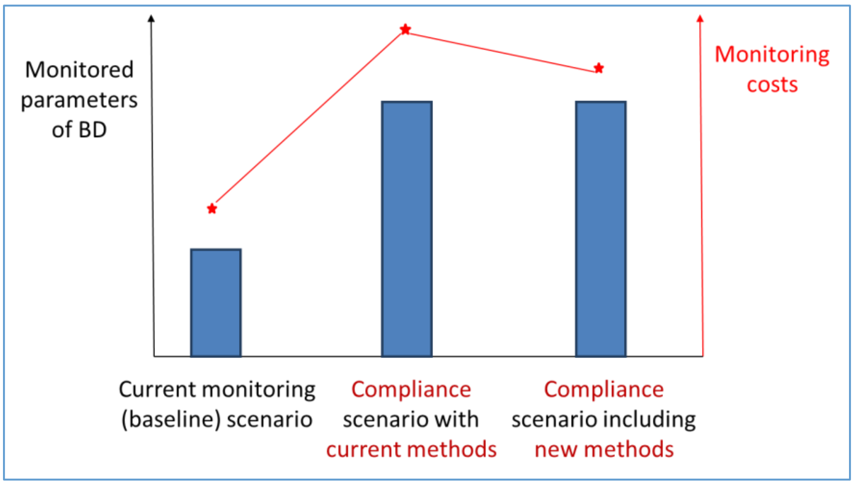

Figure 5.1. Scenario approach for the analysis of monitoring programs/schemes (Source: Pakalniete K., MARMONI project.)

As can be seen, the scenarios are built around marine biodiversity (i) indicators ("current" and "new") and their parameters and (ii) methods ("current" and "new") – see also the Table 5.1 below.

The main difference between the 2nd and the 1st scenario is seen in the indicators, where the 2nd scenario includes additional (MARMONI/CORESET) indicators to achieve compliance with the policy (e.g. MSFD) needs. The difference could be also caused due to the need to extend geographical coverage or to increase sampling frequency.

[2] Exceptions might be for new indicators if there is no current monitoring method (then the new method could be considered).

The main difference between the 3rd and the 2nd scenario is seen in the monitoring methods, where the 3rd scenario explores implications of new methods as alternatives to the current ones. Comparison of the scenarios allows eliciting implications in terms of both the current versus policy compliant monitoring program/scheme (e.g. difference between the 2nd and 1st scenario) and the current versus combined (current plus new) monitoring methods (difference between the 3rd and 2nd scenario).

Table 5.1. General approach for building scenarios for the assessment.

		Methods	
		CURRENT	(Current and) NEW
Indicators	CURRENT	Current (Baseline) [1]	
	(Current and) NEW	Compl_current [2]	Compl_new [3]

The "baseline" or "current monitoring scenario" (*"Current"*) consists of a list of "current" indicators monitored with the current methods (segment 1 in the table above).

The compliance scenario with currently used methods (*"Compl_current"*) consists of a list of (current, MARMONI and CORESET) indicators that allow reaching compliance with the requirements for the biodiversity status assessment, and that are monitored with the current methods (segment 2 in the table). Exceptions might be for new indicators if there is no current monitoring method (then the new method could be considered).

The compliance scenario including (also) new methods (*"Compl_new"*) consists of a list of (current and MARMONI) indicators that allow reaching compliance and that are monitored with new methods where available or current methods otherwise (only where new methods are not available).

When the scenarios are assessed in terms of costs the interpretation is as follows:

([1])	Total costs of the current monitoring program/scheme
([2])	Total costs of the Compl_current monitoring program/scheme
[(3)]	Total costs of the Compl_new monitoring program/scheme
([2]-[1])	Cost implications of policy compliant monitoring program/scheme
([3]-[2])	Cost implications of introducing the new methods

The costs' assessment is explained in more details in next chapters.

Where more than one new monitoring indicator or method is available for the same "feature" of biodiversity (for which the status assessment is necessary) these alternatives can be tested within the "compliance scenarios"[3] against proposed assessment criteria (explained in the next chapter). This aims to identify the most cost-efficient among alternative new indicators and methods.

5.2 Criteria for assessment of the scenarios

The following criteria are used for the socio-economic assessment of the scenarios:

- Costs of the monitoring scenario (analysed monitoring program/scheme);
- Compliance to the requirements for assessing state of biodiversity (for an analysed functional group);

[3] *"Compl_curent"* for testing alternative new indicators and alternative current methods, *"Compl_new"* for testing alternative new methods.

- Confidence of considered monitoring methods to deliver information that it allows compliant status assessment.

Each criterion is explained below.

Costs

Each scenario consists of a list of biodiversity indicators, its parameters and methods for monitoring them (built based on principles described in the previous chapter). Thus the costs of each scenario are calculated summing up costs of each indicator–parameter–method in the scenario.

Primary policy aim is to identify potential for cost saving by introducing new monitoring methods (see the figure 5.1), thus the most cost-effective among the current as well as alternative new methods (for the same purpose) are investigated.

Estimating and comparing total costs of the Current and Compliance_current scenarios allow indicating increase in the costs to achieve compliance.

Compliance

The compliance is viewed against the MSFD GES criteria and associated indicators (EC, 2010). The proposed indicators, monitoring parameters and methods should provide information that allows the status assessment of (a functional group of) biodiversity according to these GES criteria and associated indicators (compliant status assessment).

The compliance scenario (*"Compl_current"*) allows assessing cost implications of complying with the policy requirements for monitoring and status assessment. To reach the compliance, the list of indicators (for an analysed functional group) may consist of combination from the currently used and new (proposed by the project) indicators.

Such cases may be expected where full compliance (to cover the GES criteria) cannot be ensured even with the new indicators. Approach for assessing the compliance level for each indicator and scenario is presented in the information box below).

Information box 5.1: Assessment of COMPLIANCE level for monitoring indicators.

To what extent a monitoring indicator allows achieving compliance with the GES criteria and indicators of status assessment (to "cover" the GES criteria and indicators) – assessment with a relative scale from 0 to 4, where:

0 "no compliance at all", 1 "low compliance", 2 "moderate level of compliance", 3 "good compliance", 4 "excellent/full compliance".

The assessment is developed based on expert judgement. Each monitoring indicator is assigned an individual score, and an average score is calculated for each scenario to indicate its level of compliance. Experts agreed that "3" is the lower bound for satisfactory/optimal confidence.

Confidence

Introducing new monitoring methods may create not only changes in the costs but also deliver different information for the biodiversity status assessment.

Due to situation that various methods may provide different information about the same monitored "feature" of the biodiversity, the information provided by each method needs to be assessed in some way. In economic terms it can be expressed as "value of information" for decision-making, but it usually involves rather complex analysis.

A simplified approach is used in this assessment to characterise monitoring methods in terms of information quality they provide for assessing state of the biodiversity. "Confidence" level is assessed (see the information box below) for each monitoring method, and it can be calculated afterwards for each scenario. The scenarios can be compared then based on the confidence level.

Information box 5.2: Assessment of CONFIDENCE level of monitoring methods.

Confidence in appropriate status assessment (with the given monitoring indicator & parameter) when using the given monitoring method is assessed based on expert knowledge with a relative scale from 0 to 4, where: 0 "no confidence at all", 1 “low confidence”, 2 “moderate level of confidence", 3 “good level of confidence", 4 "excellent/full confidence".

The assessment is developed based on expert judgement. Average score for each scenario is calculated based on the individual scores of each method in the scenario. When alternative new methods are available for the same “feature” of the biodiversity, their confidence scores indicate which method provides better information for status assessment.

Experts agreed that “3” is the lower bound for satisfactory/optimal confidence.

5.3 Summary assessment of the scenarios

Three summary indicators are used for assessing and comparing the scenarios:

1. Costs/Compliance ratio,
2. Costs/Confidence ratio,
3. Total cost-efficiency of the scenario.

Costs/Compliance ratio

This ratio indicates cost-effectiveness of analysed monitoring scenarios (programs/schemes). The effectiveness is commonly estimated towards pre-defined “target”, which in the given case is the compliance with monitoring requirements to provide information for the assessment of marine biodiversity status.

It is calculated for each scenario based on total costs and compliance level (average score) of the scenario. Introducing alternative new biodiversity indicators and monitoring methods (for covering the same GES criteria) may provide range of (sub)scenarios with different costs and compliance scores and the ratio.

The ratio shows costs per one Compliance score (the lower ratio – the more cost-effective programme/scheme).

Costs/Confidence ratio

This ratio indicates cost-effectiveness in terms of “better” quality information for the assessment of marine biodiversity status.

It is calculated for each scenario based on total costs and confidence level of the scenario (average score from individual confidence levels of the included monitoring methods). Introducing alternative new monitoring methods (for the same “feature” of the biodiversity) may provide range of (sub)scenarios with different costs and confidence scores and the ratio.

The ratio shows costs per one Confidence score (the lower ratio– the more cost-effective programme/scheme).

Total cost-efficiency of the scenario

The total cost-efficiency of each scenario is calculated as follows:

$$\boldsymbol{TotCE_{Scen\_i}} = \frac{\boldsymbol{Costs\_i}}{(\boldsymbol{Score_{Compliance\_i}} + \boldsymbol{Score_{Confidence\_i}})\ /\ \boldsymbol{2}}$$

where

i – a scenario (Current, Compl_current or Compl_new).

The *scores* are calculated as part of the scenario analysis. Such comprehensive assessment allows optimising a monitoring program/scheme in terms of cost-efficiency where the efficiency takes into account both – compliance and confidence for status assessment.

5.4 Implementation of the socio-economic assessment

A step-wise approach was implemented for the analysis and assessment of the scenarios including the following steps:

Step 1: Describing Indicators, Parameters and Methods;

Step 2: Characterising monitoring design and resource needs;

Step 3: Calculating monitoring costs (for each indicator and its parameter(s), with current and new methods, if available);

Step 4: Building and assessing alternative monitoring scenarios.

A common Excel-based template was developed, which was used as a tool for compiling relevant information and performing calculations to assess the scenarios. Its structure (sheets) follows to the proposed steps of the analysis. For practical reasons the analysis was performed separately for each case study on the socio-economic assessment for particular functional or sub-functional group (for example zooplankton, wintering birds, phytobenthos, seals, etc). The general template was slightly adjusted to each case to respond to the monitoring practices.

5.4.1 Step 1: Describing Indicators, Parameters and Methods

Each Indicator, Parameter and Method included in the analysis is described by specific characteristics. Most information on characteristics of the indicators – parameter – methods is common from perspectives of various project's countries. Therefore the elaborated descriptions for various countries analysed contain only minor differences.

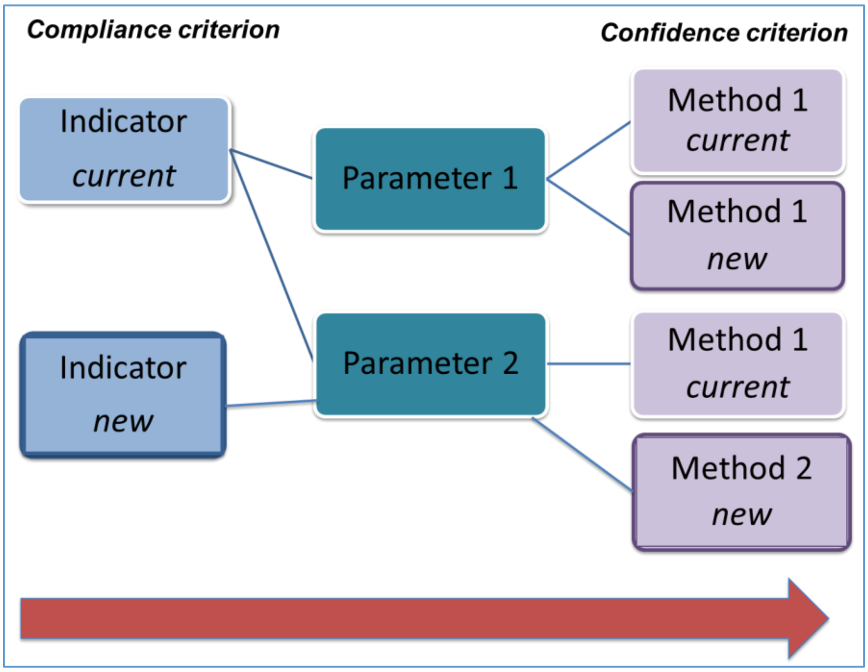

Figure 5.2. Subject of the assessment. (Source: MARMONI project)

The compliance and confidence for each indicator and monitoring method was assessed at this stage of work. When describing the indicators relevant experts on the current and new indicators provided the assessment with regard to the criterion on compliance (see the chapter 5.2). Similarly, the assessment of monitoring methods with regard to the criterion on confidence was performed by the experts involved in the development of the new methods as well as being familiar with the current methods. The developed assessments concerning the compliance were harmonised afterwards among the involved experts from the project's countries. The assessment on the confidence was carried out at the project's country/partner level, since it can differ among the countries due to existing experience and stage of the development of the method.

5.4.2 Step 2: Characterising monitoring design and resource needs

This step aimed to compile relevant information for characterising monitoring design and resource needs, which forms a basis for calculating the monitoring costs afterwards.

The variables relate to:

- scope e.g. monitoring frequency per year (times per year), spatial coverage (number of stations/size of monitored area);
- resource needs (e.g. equipment, supplies, types of travel costs, man-day needs for various types of work) for (i) field work, (ii) lab analysis/data treatment, (iii) GIS/modelling, (iv) data management, reporting.

The GIS/modelling and data management is considered here only how far it relates to generating data for indicators (not assessment of the state of biodiversity).

As field works are combined to collect samples for a number of parameters in some of the countries, additional characterisation is given with regard to such combined monitoring campaigns to derive appropriate unit costs per sample.

5.4.3 Step 3: Calculating monitoring costs

This step aims to compile relevant information for estimating monitoring costs <u>for each analysed indicator-parameter-method</u>. The costs are calculated based on: the monitoring design & resource variables (from previous step).

The costs are grouped by types of activities and relevant aspects of monitoring design:

- field works:
    - sampling frequency (often determined by the monitoring parameter or indicator, e.g., certain species or habitant can be monitored only once per year during relevant season),
    - spatial coverage (number of stations, area monitored),
- laboratory works - sample or data treatment and analysis,
- modelling and calculation works – if relevant,
- data management and reporting on the obtained indicator/s – parameter.

Types of inputs for which the cost data are collected and the costs are estimated relate to:

- rent of ship/plane (use of own ship is also considered as an option),
- equipment – durable goods,
- supplies (chemicals, laboratory tools, etc.),
- personnel – based on salary rates of specific category's staff in the organisation, or subcontracted experts,
- travel - travel to the monitoring sites, accommodation, per diem etc.,
- other costs (if relevant) – e.g., training, certification,
- fixed costs (o) – are assumed as certain percentage of the direct costs or set in relation to the personnel costs.

5.4.4 Step 4: Building and assessing the monitoring scenarios

This step involves:

1. Compiling a list of biodiversity indicators, their parameters and methods for monitoring them for **the baseline scenario** (*Current*) – according to the current monitoring programme/scheme. Calculating Compliance, Costs and Confidence as well as summary assessment for the scenario.
2. Compiling a list of biodiversity indicators, their parameters and methods for the **compliance scenario** *Compl_current* that the list allows reaching maximum compliance with the GES criteria for status assessment of analysed functional group(s). Selecting current monitoring methods for each indicator and parameter (or new methods were the current ones are not available). Calculating Compliance, Costs and Confidence as well as summary assessment indicators for the scenario.
3. <u>If there are alternative new indicators</u> – introducing alternative new indicators (together with methods for monitoring them) for the same "feature" of the biodiversity in the compliance scenario *Compl_current* and testing effect of each alternative indicator on the scenario in terms of Compliance, Costs and Confidence as well as summary assessment indicators of the scenario. This task is relevant where more than one new (MARMONI) indicator is developed for the same "feature" of the biodiversity and the same GES criterion and indicator. <u>If there are alternative current monitoring methods</u> (e.g. ship counts and plane counts for birds) the one what is used in a country is selected.
4. Introducing new monitoring methods in the *Compl_current* scenario (=> *Compl_new*) for indicators & parameters with new methods available. Calculating Compliance, Costs and Confidence as well as summary assessment indicators for the scenario. <u>If there are alternative new methods</u> – introducing alternative methods for the same indicator & parameter and testing effect of each alternative method on the scenario in terms of Compliance, Costs and Confidence as well as summary assessment indicators of the scenario. This task is relevant where more than one new (MARMONI) method is developed for the same indicator & parameter.

6 The socio-economic assessment of monitoring for bird indicators – the Latvian case study

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6.1 Introduction

The socio-economic assessment for the MARMONI bird indicators was conducted in Latvia as the development of these indicators was led and tested in the project by the Latvian Fund for Nature and the Society of Ornithologists of Latvia. The monitoring of marine birds takes place in different seasons. The socio-economic assessment focused on the indicators for wintering birds, which are also included in the national marine monitoring programme for the first time. An impact of the key pressures on the birds could be also monitored; however the monitoring scheme/-s for these indicators has not been developed yet for the country (Table 6.1).

Table 6.1. An overview on the MARMONI indicators and related monitoring parameters and methods for the marine birds

Functional group	Indicator	Parameter	Method
Wintering birds (6 indicators)	4.1 Abundance index of wintering waterbird species	• Number of birds per site or area of selected wintering waterbird species at **coastal & inshore** areas; • Number of birds per site/area of selected wintering waterbird species at **offshore** areas	Coastal ground count
	4.2 Wintering waterbird index (WWBI)		Ship count
	4.3 Wintering indices for waterbirds of different feeding guilds (WWBIFG)		Plane count
	4.6 Distribution of wintering waterbird species		Aerial imaging - new method, was not sufficiently developed by the end of the project
	4.7 Distribution of wintering waterbirds (multi-species)		
	4.8 Distribution of wintering waterbirds of different feeding guilds (multi-species)		
Breeding birds (4 indicators)	4.4 Abundance index of breeding waterbird species	• Number of birds per site/area of selected wintering waterbird species at **coastal** areas	Monitoring scheme is the same as for monitoring wintering birds from the coast (2 times per season)
	4.5 Breeding waterbird index (BWBI)		
	4.9 Distribution of breeding waterbird species		
	4.10 Breeding success: clutch and brood size of breeding species	• Clutch size - the mean number of eggs per nest • Brood size - the number of juveniles per a breeding female	Monitoring scheme (frequency, area of the monitoring) is not yet developed in Latvia
Migratory birds	4.11 Age/sex ratio of waterbird species (ARI/SRI)	• Age ratio - as the proportion of juveniles in the postbreeding population • Sex ratio - dividing the number of females with the number of males	
All types (pressure on certain bird species)	4.12 Proportion of oiled waterbirds	Proportion (%) of oiled birds from all birds collected in the specific survey	
	4.13 Abundance index of beached birds	Abundance of beached birds in a focal year relative to the abundance of beached birds at the base year (time period), or it is standardised as a density – the number of counted beached	

		birds (individuals) per route unit.	
	4.14 Abundance index of by-caught birds	A number of birds drowned per 1000 m of fishing net per day	
	4.15 Indicator on condition of waterbirds	A body condition index based on condition of the pectoral flight muscles and the presence and quantity of subcutaneous and intestinal fat depots.	
	4.16 Feeding pressure on waterbird food sources	A number of “bird days” per area unit.	

6.2 Definition of the wintering waterbird indicators

A set of the wintering waterbird indicators include the following six indicators[4]:

- **Abundance index of wintering waterbird species (*MARMONI indicator N. 4.1*) - single species indicator** that reflects the population level (abundance at the species level) in the wintering season of the particular species. 26 species are relevant for this indicator in the Baltic Sea.
- **Wintering waterbird index (WWBI) (*MARMONI indicator N. 4.2*) - multi species indicator** that reflects the state of the wintering waterbird community. Single species indices of up to 26 species are used to build this indicator. WWBI describes the composition and relative proportions of ecosystem components at the ecosystem level, and the condition of the typical species of the habitat at the habitat level.
- **Wintering indices for waterbirds of different feeding guilds (*MARMONI indicator N. 4.3*) – a multi-species indicator** that reflects the state of specific feeding guilds within the wintering waterbird communities. Separate indices for four guilds are developed: the benthic herbivore index, the benthic invertebrate feeder index, the fish feeder index and the gull (surface feeder) index.
- **Distribution of wintering waterbird species (*MARMONI indicator N. 4.6*) - a single species indicator** that reflects the distribution (population range and distribution pattern within the range at the species level) in the wintering season of the 26 species relevant for this indicator in the Baltic Sea
- **Distribution of wintering waterbirds (multi-species) (*MARMONI indicator N. 4.7*) - a multi-species indicator** that reflects the distribution of wintering waterbirds. All species of divers, grebes, cormorants, swans, geese, ducks, mergansers, coots and auks are pooled for this indicator. This approach describes the composition and relative proportions of ecosystem components at the ecosystem level as well as the performance of frequently occurring species of the habitat at the habitat level, in a spatially explicit way.
- **Distribution of wintering waterbirds of different feeding guilds (multi-species) (*MARMONI indicator N. 4.8*) - a multi-species indicator** that reflects the distribution of specific feeding guilds of wintering waterbirds. Separate grids for four guilds were developed: benthic herbivores, benthic invertebrate feeders, fish feeders and gulls (surface feeders). These guilds describe the condition of the typical species of the habitat at the habitat level as well as the composition and relative proportions of ecosystem components at the ecosystem level.

[4] Martin G., Fammler H., Veidemane K., Wijkmark N., Auniņš A., Hällfors H. and Lappalainen A. 2015. The MARMONI approach to marine biodiversity indicators. Volume II: List of indicators for assessing the state of Marine biodiversity in the Baltic sea developed by the Life MARMONI project. Estonian Marine Institute Report Series No. 16. Page: 52.

Depending on the species for which the indicator is calculated, it may respond to different pressures including eutrophication, oil pollution, shipping, hazardous substances, fishing pressure, bycatch, hunting, fisheries discards, coastal development, wind energy, sand and gravel extraction, and climate change. However, it is impossible to separate these effects. The indicators are scalable and can be used at all scales: locally, regionally, nationally or throughout the Baltic Sea area. Distribution indicators also reflect situation locally.

6.3 Policy relevance of the indicators

The Marine Strategy Framework Directive (MSFD) and related Commission Decision 2010/477/EU require assessing biodiversity (Descriptor 1) at three ecological levels: species, habitat (community) and ecosystem level. The wintering marine waterbirds indicators developed by the MARMONI project support the biodiversity assessment according to the following criteria and indicators:

1.1 Species distribution

Distributional range (1.1.1)

Distributional pattern within the latter, where appropriate (1.1.2)

1.2 Population size

Population abundance and/or biomass, as appropriate (1.2.1)

1.6 Habitat condition

Condition of the typical species and communities (1.6.1)

1.7 Ecosystem structure

Composition and relative proportions of ecosystem components (habitats and species) (1.7.1).

Additionally, the single species indicators (4.1 and 4.6) also support the assessment needs of the HD (the Article 17 Report on Habitat type 1110 and 1170) and the BD (the Article 12 Report).

The indicators 4.1 - 4.3 contribute also to the HELCOM CORESET indicator *"Abundance of waterbirds in the wintering season"*.

6.4 Design of the monitoring scheme

Data needed for the MARMONI wintering waterbirds indicators can be obtained by the following monitoring methods: coastal ground counts, counting from ship, counting from plane and aerial imaging (see also the figure 6.1). The latter method is considered as a new method to collect data for such type of the indicators. When fully developed the method is expected to provide unbiased and more precise data compared to other methods. During the MARMONI project the method of aerial imaging was tested, however it was not sufficiently developed to be included in the monitoring scheme. Therefore the cost-effectiveness for the scenario *current* versus *new* method was not calculated.

The current conventional method of the coastal ground counts means that ornithologists take a walk along the coast and record a number of present single bird species. The method requires a large group of ornithologists to cover the whole coastline of the country in a relatively short time period. This type of method can be also implemented by involving trained volunteers. The coastal ground counts of the wintering waterbirds shall be implemented annually (January-February).

The counting from ship is also current method defined as recording of the present single bird species by ornithologists from ships taking specifically designed routes (transects). The method also requires having a group of (trained) people on board for counting birds in shifts. The ship counts are planned based on sun angles and period of the visibility. As winters in the Baltic Sea are characterised by short days, the ship count for bird species is problematic due to short period of appropriate day light.

The monitoring from plane is preferred to ship counts if large areas need to be surveyed. It is organised along transects recording the taken route in GPS. The recognised bird data initially are recorded in a dictaphone, then transferred to other digital formats. Weakness of the method is that rare species can be overlooked and identification of similar species can be problematic.

The monitoring methods for the bird species are very weather dependent. In particular counting by plane needs clear and calm weather conditions. Moreover, if marine waters are covered by ice, birds are not present in such conditions and monitoring activities cannot be carried out in that year. Therefore the monitoring by plane or ship shall be implemented three times in 6-year period.

Each of the current methods records wintering waterbird species in certain spatial area. Coastal ground counts cover narrow coastal water area up to 1 km from shoreline (max visibility). Therefore the other methods shall be used to obtain data for area more away from the shore. At the same time, ships cannot navigate close to the coast thus ground counts are essential to have full set of the data. Thus, the available current methods (ground counts and ship or plane counts) cannot be considered as *alternatives* in the cost-effectiveness assessment.

Since field data from counting of wintering waterbirds are collected at the single species level, the data can be used also to calculate the multispecies indicators (see the figure 6.1).

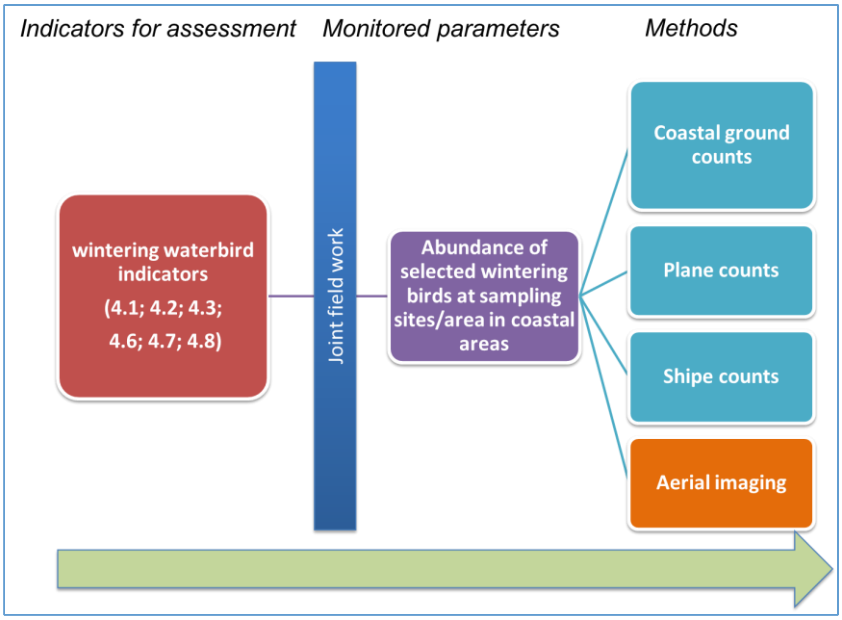

Figure 6.1. Approach to structure a monitoring scheme on wintering waterbirds: from indicators of assessment to monitoring methods. (Source: MARMONI project)

The monitoring of wintering waterbirds in Latvia

In Latvia, the monitoring programme of wintering water birds has been introduced due implementation of the MSFD requirements. Till that the coastal and marine bird counts had been implemented in frame of various projects (e.g. designation of marine protected areas, investigation of potential areas for wind energy production, voluntary activities of the ornithological society).

During the MARMONI project a compliance monitoring scheme for wintering waterbirds was elaborated and it was included in the national MSFD monitoring programme of the country. This group of birds shall be monitored in January-February. The coastal ground counts covering almost 500 km of the coastline of Latvia shall be implemented annually while plane counts shall be implemented three times in a 6-year period. Due to short daylight, the ship count is not used for wintering bird counts in Latvia.

6.5 Costs of monitoring for the indicators

Monitoring costs to obtain indicator's value relate to various types of activities - field work to collect data on bird species, office work to treat the data on relevant monitored parameter/-s, modelling work to obtain indexes, data management and reporting. Depending on the usual practice of the monitoring institute, indirect costs (called also as fixed or overhead costs) are calculated as certain percentage of either personnel or total direct costs of the monitoring.

6.5.1 Field work to collect data

The number of the birds per site/area of selected wintering waterbird species at coastal/inshore/offshore areas are collected and then used to compute values for all indicators. Thus, the field work is joint for all 6 MARMONI indicators. To obtain the necessary field data both methods – coastal ground and plane counts are implemented.

The coastal ground counts are implemented on almost 500 km long coastline. One or two teams of 5 persons are set up to cover the area. A person can monitor about 10 km stretch per day, thus in total 50 km are observed per team per day. The cost positions of field work are travel costs (fuel, accommodation, per diem, etc.), including use of a car to drive to/from area, equipment for each ornithologist (e.g., binocular, telescope, computer), smaller inventory and supplies for each person (e.g., dictophones, tripod, GPS), as well as labour costs (salary for days in the field). It has been estimated that the Latvian coastal area can be monitored by 5-person team within 10 days (or 50 man-days).

The plane counts are implemented to cover all Latvian marine waters, including exclusive economic zone. Although such full scale monitoring has not yet been implemented in the country, experts have estimated that the monitoring area can be covered by 10 flights. Such campaign takes 10 days (500 km are observed per day, 3 hours per day of efficient counting is usual practice). The plane is rented on hourly-basis (additional time, c.a. extra 50%, for unfavourable weather conditions is accounted in its hourly price). The plane carries 3 specially trained ornithologists. The ornithologists are supplied with light binocular, dictophones, GPS, clinometer, safety costume. Thus, besides the rent of plane, other general cost positions are similar to ground counts (e.g. travel costs, costs of equipment, inventory and supplies, labour costs).

6.5.2 Treatment of the field data to obtain parameter values

This work involves office equipment and labour costs for both monitoring methods. A computer with standard office software as well as with ArcGIS software is required.

With regard to the coastal ground counts, 1 day observation data can be treated in 0.5 day, thus it is estimated that 25 man-days are needed to treat recorded data from one monitoring campaign for all national coastal waters. In addition, 20 days on average are needed per campaign for communications with experts involved in the field work (for collection and interpretation of the data).

With regard to the plane counts, 2 days are necessary for treating data of 1 flight day. It involves listening of the field records and documenting the information in a specified template.

6.5.3 Modelling of data

In order to obtain values for the MARMONI indicators GIS data modelling is implemented. Advanced computer with ArcGIS and TRIM (TRends and Indices for Monitoring data) software is needed to generate values for abundance indicators (4.1-4.3). Density surface modelling approach – GAM (generalised additive models) is implemented to obtain values for distribution indicators (4.6-4.8.). The required software is available for free. The modelling is implemented by a person skilled in statistical analysis with GIS tools using the given software.

The GIS modelling requires about 40 man-days to compute the indicator *4.1 Abundance index of wintering waterbird species* covering the whole area and additional 2 days for each of the multi-species indicator on the abundance (4.2 and 4.3). Another 30 days are required to perform the GIS modelling for the indicator *4.3 Distribution of wintering waterbird species* and additional 2 days for each of the multi-species indicator on the distribution (4.6-4.8.). It needs to be noted that amount of the days required for the GIS work is not dependent on size of the area covered by field work.

6.5.4 Data management and reporting

Data management and reporting involve such costs' positions as labour costs and costs for office equipment. There is no difference in the resource needs for the data management and reporting between the methods. Around 20 man-days are accounted per year in total for the data management and reporting.

6.5.5 Estimated monitoring costs for the indicators

Table 6.2 presents estimated monitoring costs (covering the whole Latvian coastal and, where relevant, offshore area) for each wintering watersbirds indicator. The costs are calculated there taking each indicator individually, thus the field data collection and treatment costs are accounted for each indicator.

The column 2 presents total costs of all monitoring activities required for obtaining a value for an indicator (as a single campaign). Data from both coastal and offshore areas are needed to calculate the indicator *4.1. Abundance index of wintering waterbird species*. The same applies to the indicators 4.2 and 4.3. Regarding the indicator *4.6 Distribution of wintering waterbird species* and corresponding indicators 4.7 and 4.8*,* only data from offshore areas (collected by plane) are needed for these indicators. Thus, their calculated monitoring costs are lower.

It should be noted that the monitoring frequency differs for the two monitoring methods – coastal counts are implemented annually whereas offshore counts three times in a 6-year period (which is not the same as each second year). Thus a 6-year period is more appropriate for estimating costs of a monitoring scheme. The column 3 of the table 6.2 presents the total costs for a 6-year period for each indicator (taken individually). The coastal counts are accounted every year, the offshore counts – three times in the 6-year period.

Table 6.2. Estimated monitoring costs for the MARMONI wintering waterbirds indicators (Source: Calculation based on data collected as part of the case study)

Indicator	Total costs for the indicator (as a single campaign) (€)	Total costs for 6-year period (€)
[1]	[2]	[3]
4.1 Abundance index of wintering waterbird species	99 437*	398 279
4.2 Wintering waterbird index (WWBI)	100 437*	404 284
4.3 Wintering indices for waterbirds of different feeding guilds (WWBIFG)	100 437*	404 284
4.6 Distribution of wintering waterbird species	73 348**	220 045
4.7 Distribution of wintering waterbird species (multi-species)	74 349**	223 048
4.8 Distribution of wintering waterbirds of different feeding guilds (multi-species)	74 349**	223 048

* based on one set of the coastal data and one set of offshore data

** based on one set of offshore data

Around 50% of the total costs are related to the field data collection. The costs are similar for the coastal (ground) and offshore (plane) counts, but their costs' structure differ – the largest costs' share of the coastal ground count is related to the personnel costs (around 60%), but they make only around 30% for the plane count while 45% of its costs relate to the rent of plane.

In many other Baltic Sea countries and internationally, the ornithologists are involved in the monitoring of birds on a voluntary basis. The required skills of an amateur ornithologist are sufficient for the requirements of the coastal ground counts of the waterbirds. However, the possibility to involve ornithologists in on a voluntary basis in national monitoring depends on a stage of development and tradition of the bird watching in the country. For Latvia, the field work considers involvement of the ornithologists on the professional basis, therefore the personnel costs makes large share.

The data treatment costs compose around 15% of the total costs, the costs of GIS modelling – around 10-15% (depending on the indicator).

The table 6.3 presents the costs for each indicator calculated as average costs per year. It shows the costs break-down by the main costs' positions (e.g. equipment, personnel etc.), and by the types of monitoring activities (e.g. field work, data treatment, GIS modelling etc.).

It needs to be stressed that all indicators are computed based on data from joint field work. When estimating costs of a national monitoring scheme including various indicators the field work and data treatment costs are accounted once only, and only additional costs of computing each additional indicator (4.2-4.8) are accounted in addition. The total calculated costs of an indicator- based national monitoring scheme for Latvia including all 6 MARMONI wintering waterbirds indicators range in **73 000 EUR on average per year** or around **438 000 EUR for a 6-year monitoring period**.

Although it was concluded that the new monitoring method – the aerial imaging is not developed enough to be analysed as an alternative to the current methods (for offshore counts), its field work costs were estimated as a part of the study. The results indicate that the field work costs of the new method are in the same range as the costs for counts from plane. The amount of man-days needed to treat collected data and to carry out modelling for obtaining indicator values could not be estimated by the end of the project. Thus, the new method was not included in the socio-economic assessment.

Table 6.3. Monitoring costs for wintering water birds indicators as average costs per year, by the main costs' types (€/year) (Source: Calculation based on data collected as part of the case study)

NOTE! The field work and data treatment is joint for all indicators, thus these costs are accounted once.

INDICATOR			PARAMETER	METHOD		Costs per year (EUR) by the main costs' positions, incl. for:								Costs per year (EUR) by the main types of activities, incl. for:					
No	Name	Category	Name	Category	Name	Plane	Equip	Supplies	Personnel	Travel	Other costs	Indirect costs	TOTAL	Field work	Data treatment	GIS/ Modelling	Data manag-ement	Indirect costs	TOTAL
4.1	Abundance index of wintering waterbird species	New	Number of birds per site/area of selected wintering waterbird species **at coastal areas**	Current	Coastal ground count	0	2864	478	21000	3228	200	5554	**33323**	13950	5 514	6581	1725	5554	**33323**
4.1	Abundance index of wintering waterbird species	New	Number of birds per site/area of selected wintering waterbird species **at offshore areas**	Current	Plane count	15000	408	111	10910	88	1000	5509	**33057**	17389	5 105	3 290	1 763	5509	**33057**
4.2	Wintering waterbird index (WWBI)	New	Number of birds per site/area of selected wintering waterbird species at **coastal** and **offshore** areas.	Current	The same methods as for Ind.4.1.		84		750			167	**1001**			348	486	167	**1001**
4.3	Wintering indices for waterbirds of different feeding guilds (WWBIFG)	New	Number of birds per site/area of selected wintering waterbird species at **coastal** and **offshore** areas.	Current	The same methods as for Ind.4.1.		84		750			167	**1001**			348	486	167	**1001**
4.6	Distribution of wintering waterbird species	New	Number of birds per site of selected wintering waterbird species at **offshore** areas	Current	The same methods as for Ind.4.1.		390		2625			603	**3618**			2610	405	603	**3618**
4.7	Distribution of wintering waterbird species (multi-species)	New	Number of birds per site of selected wintering waterbird species at **offshore** areas	Current	The same methods as for Ind.4.1.		42		375			83	**500**			174	243	83	**500**
4.8	Distribution of wintering waterbirds of different feeding guilds (multi-species)	New	Number of birds per site of selected wintering waterbird species at **offshore** areas	Current	The same methods as for Ind.4.1.		42		375			83	**500**			174	243	83	**500**

6.6 Socio-economic assessment of the indicator-based monitoring scheme

The aim of the wintering waterbirds' monitoring scheme is to comply with the needs of the MSFD for the assessment of GES as well as to deliver data for the assessment needs of the HB and BD. It is also expected that such monitoring methods are used that provide reliable data for the assessment indicators. Moreover, the monitoring activities should be performed with the least costs for society.

As described in Chapter 5, the economic assessment is built on three criteria: Costs, Compliance and Confidence. The "compliance" criterion allows characterising the extent to which the assessment indicator and/or the set of indicators ensure compliance with the GES criteria and indicators for Descriptor 1 (Biodiversity) of the MSFD. The "confidence" criterion aims characterising accuracy of the monitoring methods used to obtain data for the indicators. The "compliance" scores (from 0-4) assigned to the indicators are not country specific, whereas the "confidence" scores assigned to the monitoring methods may differ among the countries since they depend on the monitoring practice and experience in a monitoring institute.

As mentioned earlier the wintering waterbirds indicators didn't exist before the MARMONI project as well as the national marine monitoring programme for wintering waterbirds was not in place in Latvia. Thus, there was no "baseline scenario" for the analysis. Taking into account also the current lack of alternative new monitoring methods, only the compliance scenario with currently used monitoring methods was analysed.

Costs of the monitoring scenario "Compliance with the current methods" ("Compl_current")

The average costs per year (presented in the table 6.3) were used as basis for estimating the costs of the scenario. The field data collection and treatment costs are accounted once only in the total costs of the scenario. The total calculated costs of the scenario are **73 000 EUR on average per year or** around **438 000 EUR for a 6-year monitoring period**. It needs to be stressed that the offshore monitoring (the only monitoring necessary for the indicators 4.6-4.8 and necessary also for all other indicators) needs to be carried out three times per 6-year period. Thus, when planning the funding, the budget allocation needs to be adjusted to the year when the offshore monitoring is implemented.

"Compliance" assessment of the indicators

As mentioned above the wintering waterbirds indicators did not exist before the MARMONI project in Latvia. Consequently, the compliance assessment comparing the current (baseline) and new indicators is impossible.

Table 6.4 shows assessment of the "compliance" of the MARMONI wintering waterbirds indicators against the MSFD GES criteria and indicators. The assessment is based on expert opinion of the project's experts.

It can be concluded overall that the MARMONI project has developed a set of the wintering waterbirds indicators complementing each other. The exceptions are the indicators 4.2 and 4.3, which respond to the same GES criteria with the same "compliance" rate. However this aspect was not significant in the cost-effectiveness assessment because the indicator 4.3 is built on the data and work results of other indicators thus its additional costs are relatively small. Furthermore, the indicator 4.2 provides integrated information in a form of the abundance of all wintering birds, while indicator 4.3 specifies the information according the group of species.

Table 6.4. "Compliance" assessment of the MARMONI wintering waterbirds' indicators against the MSFD GES criteria and indicators of the Descriptor 1. (Source: Assessment based on expert opinion)

The used assessment scale: 0 "no compliance at all", 1 "low compliance", 2 "moderate compliance", 3 "good compliance", 4 "excellent/full compliance".

NOTE! The average "compliance" score is calculated to show the score per one GES criterion/indicator (on average).

GES criteria and indicators relevant for assessing status of WINTERING BIRDS		4.1	4.2	4.3	4.6	4.7	4.8	Best score of compliance with the GES Indicator
1.1 Species distribution	1.1.1.	0	0	0	**4**	0	0	**4**
	1.1.2.	0	0	0	**4**	0	0	**4**
1.2 Population size	1.2.1.	**4**	0	0	0	0	0	**4**
1.3 Population condition	1.3.1.	**0**	**0**	**0**	**0**	**0**	**0**	**0**
1.6 Habitat condition	1.6.1.	**3**	**4**	**4**	0	**4**	**3**	**4**
	1.6.2.	**0**	**0**	**0**	**0**	**0**	**0**	**0**
1.7 Ecosystem structure	1.7.1.	0	**3**	**3**	0	**3**	**4**	**4**
Average Compliance score per indicator for each indicator:		**1.00**	**1.00**	**1.00**	**1.14**	**1.00**	**1.00**	
Average Compliance score per criterion for each indicator:		**1.40**	**1.40**	**1.40**	**1.60**	**1.40**	**1.40**	
Average score of the "set" of assessment indicators to comply with all GES criteria and indicators of the Descriptor 1:								**2.86**
Average score of the "set" of assessment indicators to comply with all GES criteria of the Descriptor 1:								**3.20**

Almost all indicators have the same average "compliance" score (1.0) except the indicator 4.6, for which it is slightly higher. As can be seen, each indicator allows covering two GES criteria or indicators, however they differ among the assessment indicators.

When assessing the "compliance" score to comply with all the GES criteria and indicators of the Descriptor 1, which requires a "set" including all indicators, the average "compliance" score for such a "set" is 2.86. This is higher score than for each indicator taken individually. Moreover, it comes close to the score "3", which was agreed by experts as a minimum score for optimal/satisfactory compliance. The "gap" lies in two GES criteria and indicators, which are not covered by any of the assessment indicators (the GES criteria and indicators 1.3.1 and 1.6.2).

"Confidence" assessment of the monitoring methods

Table 6.5 shows the assessment of the "confidence" of the monitoring methods to deliver data for deriving the indicator values. The assessment is based on expert opinion of the project's experts from Latvia. Currently there are no alternative new monitoring methods developed for the wintering water birds indicators. The aerial imaging was tested however it still needs further development to deliver appropriate data for these indicators. Thus only the existing methods were considered for the scenario analysis and the cost-effectiveness for the scenario the *current* versus *new* method was not estimated.

The assessment shows that both current methods have good or even excellent "confidence" (e.g. the maximum score "4" for the coastal ground count). The average score for a scheme (considering all indicators) is 3.25.

Table 6.5. "Confidence" assessment of the monitoring methods to provide data for the wintering waterbirds' indicators. (Source: Assessment based on expert opinion)

The used assessment scale: 0 "no confidence at all", 1 "low confidence", 2 "moderate confidence", 3 "good confidence", 4 "excellent/full confidence".

Methods	Group	4.1	4.2	4.3	4.6	4.7	4.8
Coastal ground count	Current	4	4	4	These indicators are only for offshore areas.		
Plane count	Current	3	3	3	3	3	3
Average score		3.5	3.5	3.5	3	3	3

Total cost-efficiency of an indicator-based monitoring scheme

The table 6.6 presents the calculated "costs/compliance ratio", "costs/confidence ratio" and "cost-efficiency ratio" of the *scenario "compliance using the current monitoring methods"* (see the chapter 5.3 for more information about the ratios). The former two show costs (EUR on average per year) per one unit (score) of the compliance/confidence. The latter considers both at the same time – the compliance and the confidence for the GES assessment.

The assessments are developed including all the MARMONI indicators in the monitoring scheme (the column 2). The third column of the table provides the same estimates when the indicator 4.3 is excluded from the monitoring scheme. As can be seen, it has negligible impact on the calculated ratios. Moreover, as explained earlier, the indicator 4.3 provides additional information for the status assessment.

Since all indicators build on joint field data collection and treatment, which compose around 50% of the total costs of the scenario, inclusion of additional indicators in the scenario causes relatively small increase in the costs. At the same time, the "compliance" score improves considerably. Thus the "cost/compliance ratio", as well as the "total cost-efficiency" of such scenario is better.

Table 6.6. Summary on the economic estimates for the *scenario "Compliance using the current monitoring methods"* (Source: Calculation based on data collected as part of the case study.)

The scenario *"Compl_current"* **Assessments used in the EA**	**With all (6) MARMONI indicators**	***Excluding the indicator 4.3***
Costs of the scenario (EUR), as average costs per year	73 000	*71 999*
"Compliance" score for the scenario (in a scale from 0-4)	2.86	*2.86*
Confidence score for the scenario (in a scale from 0-4)	3.25	*3.20*
Costs / Compliance ratio	**25 550**	*25 200*
Costs / Confidence ratio	**22 461**	*22 500*
Total cost-efficiency ratio	**23 906**	*23 773*

6.7 Summary on the results and conclusions

- Since there has been no national monitoring for the marine wintering waterbirds previously in Latvia, there was no "baseline scenario" for the analysis. The "compliance scenario" is built from 6 new indicators, which were developed as a part of the MARMONI project, since there were no appropriate indicators in Latvia nor in the Baltic Sea region overall before. The new indicators are complementary to build compliant monitoring program since they together allow addressing better the biodiversity status assessment needs prescribed by the MSFD (according to the GES criteria and indicators). With regards to the monitoring methods, due to the current lack of fully developed new monitoring methods, only the (compliance) scenario with the current monitoring methods was analysed.

- The estimated costs for implementing national-scale wintering waterbirds monitoring with appropriate frequency (the scenario *"Compl_current"*) range in 73 000 EUR on average per year or around 438 000 EUR for a 6-year period, which is the reporting period for the MSFD as well as for the HD and BD.
- All the indicators build on joint field data collection and treatment, which compose around 50% of the costs. Inclusion of additional indicators in the monitoring scheme increases the costs only slightly while it improves the "compliance" assessment (score) considerably. Thus the cost-effectiveness in terms of compliance as well as the total cost-efficiency of such scheme improves.
- Assessment of the "confidence" of the current methods shows good or even excellent "confidence" (e.g. the maximum score 4 for the coastal ground counts). The new method – aerial imaging (for offshore counts) could also provide reliable data however it needs further development. Also full costs of the new method need further work (e.g. estimating man-time needed for the data treatment and modelling to obtain indicator values).
- In terms of compliance with the GES criteria and indicators of the Descriptor 1, each assessment indicator allows covering two GES criteria or indicators, but the covered criteria and indicators differ. Thus, the assessment indicators are seen as complementary in this regard. The estimated "compliance" score of the whole "set" of the assessment indicators is close to "good compliance" (score 3). There are however two GES indicators (1.3.1 and 1.6.2), which are not covered by any of the included assessment indicators.

7 The socio-economic assessment of monitoring for the zooplankton indicators – case studies in Finland and Latvia

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7.1 Introduction

The socio-economic assessment for the indicator-based monitoring for the MARMONI zooplankton indicators was conducted in Finland and Latvia. Within the framework of the MARMONI project experts worked on four zooplankton biodiversity indicators (see table 7.1). Three of them are recommended to be included in the new national marine monitoring programmes. All pelagic MARMONI indicators are state indicators to be used as a determinant of whether the biodiversity of the environment, as demonstrated by the indicator, is in Good Environmental Status (GES) or not.[5]

Table 7.1. An overview on the MARMONI indicators and related monitoring parameters and methods for zooplankton.

Indicator	Parameter	Methods
3.7 Copepod biomass	Total biomass of copepods determined as a number of individuals per m³ and multiplied with individual weight of copepods.	Zooplankton microscopical analysis Or Automatic image analysis
3.10 Zooplankton mean size versus total stock (MSTS)	Zooplankton abundance and size determined as a number and size of individuals per m³.	
3.9 Microphagous mesozooplankton biomass	Biomass of microphagous mesozooplankton determined as number of individuals per m³ and multiplied with individual weight of microphagous.	Zooplankton microscopical analysis
3.8 Zooplankton diversity	*The indicator is not ready to be utilized as a biodiversity indicator. Further studies are needed to determine how species diversity is related to ecological processes and pressures.*	

7.2 Definition of the zooplankton indicators

A set of the zooplankton indicators includes the three indicators and they are defined as[6]:

- **Copepod biomass** - an indicator reflects the status of copepods, the members of the zooplankton community which are the most important for maintaining good growth conditions for pelagic fish stocks. Zooplankton is affected by changes in primary production,

[5] Martin G., Fammler H., Veidemane K., Wijkmark N., Auniņš A., Hällfors H. and Lappalainen A. 2015. *The MARMONI approach to marine biodiversity indicators. Volume II: List of indicators for assessing the state of Marine biodiversity in the Baltic sea developed by the Life MARMONI project*. Estonian Marine Institute Report Series No. 16. Page: 52.

[6] Martin G., Fammler H., Veidemane K., Wijkmark N., Auniņš A., Hällfors H. and Lappalainen A. 2015. *The MARMONI approach to marine biodiversity indicators. Volume II: List of indicators for assessing the state of Marine biodiversity in the Baltic sea developed by the Life MARMONI project*. Estonian Marine Institute Report Series No. 16. Page: 52.

indicative of eutrophication as well as changes in the structure and abundance of the fish community can indicate overfishing. Copepods as selective feeders, can directly affect both the phytoplankton and zooplankton species composition and have the potential to affect the biodiversity of these communities. The indicator is calculated as total biomass of copepods in mg/m^3, or alternatively, the percentage of copepods of the total zooplankton biomass.

- **Microphagous mesozooplankton biomass** - the indicator reflects changes in the zooplankton community in relation to environmental pressures. Eutrophication favours small sized phytoplankton and detritus production, which in turn favours small-sized herbivorous and detritivorous zooplankton, i.e. microphagous zooplankton. The indicator is based on the idea that abundant microphagous mesozooplankton indicates a limitation in the ability of the zooplankton community to transfer energy from primary producers to higher trophic levels. The indicator is calculated using abundance of microphagous feeders present in mesozooplankton community and their individual weights (mg/m^3), averaged over growth season.

- **Zooplankton mean size vs. total stock (MSTS)** - this indicator reflects changes in the zooplankton community in relation to environmental pressures. This indicator is based on the idea that zooplankton mean size and total biomass (or abundance), when examined together, provide more information than when the parameters are considered separately. Abundant zooplankton with a large mean size would indicate good feeding conditions for zooplanktivorous fish as well as high potential grazing pressure on phytoplankton. On the other hand, combinations such as small total stock, or small mean size, or both would indicate a limited ability of zooplankton to transfer energy to higher trophic levels.

  The indicator is presented as a ratio between the mean size of zooplankton community and total stock where the mean size of the zooplankton community is calculated by dividing the biomass of the whole community by the number of zooplankton individuals and the total stock is defined as total zooplankton abundance (number of zooplankton individuals) or total biomass of all species together.

7.3 Policy relevance of the indicators

The MSFD and related Commission Decision 2010/477/EU require assessing biodiversity (Descriptor 1) at three ecological levels: species, habitat (community) and ecosystem level. The zooplankton indicators developed by the MARMONI project support the biodiversity assessment according to the following criteria and indicators:

1.2 Population size

Population abundance and/or biomass, as appropriate (1.2.1)

1.3 Population condition

Population demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity rates, survival/ mortality rates) (1.3.1);

1.6 Habitat condition

Condition of the typical species and communities (1.6.1)

Relative abundance and/or biomass, as appropriate (1.6.2)

The indicators also serve for the assessment needs associated with Descriptor 4 on the marine food webs, criterion 4.3 on Abundance/distribution of key trophic groups/species.

The MARMONI indicator 3.10 is comparable to the HELCOM CORESET indicator “Zooplankton mean size and abundance”.

7.4 Design of the monitoring scheme

Data needed for the MARMONI zooplankton indicators can be obtained from routine marine and coastal monitoring programmes carried out in the countries. Routine monitoring is implemented according to the Manual for Marine Monitoring in the COMBINE Programme of HELCOM[7]. The Manual is updated once a year. Annual (once a year) sampling provides sufficient data for the calculation of the indicators, but a need for higher sampling frequency should be investigated and, if proved, considered in the future to capture adequately seasonal variations in the data. The zooplankton samples can be collected during the same monitoring surveys when samples for assessing other marine parameters (e.g. phytoplankton, macrozoobenthos, physico-chemical parameters, etc.) are collected.

Zooplankton samples are collected by vertical tows from either ~5 m above the bottom to the surface (shallow stations, ≤ 30 m) or in depth layers (deep stations, ≥ 30 m). A 100 µm WP2 net (diameter 57 cm) equipped with a flow meter is used. The collected samples are preserved upon collection in formalin and later analysed in a laboratory.

In laboratory, the samples are analysed to obtain the data on abundance of the species (number of zooplankton individuals) and species composition. Then the biomass is defined using individual wet weights as defined in HELCOM manual. The obtained parameters e.g., abundance, species composition and biomass of zooplankton, are used to describe the temporal trends, however, the GES boundaries have not been set for these parameters.

Two methods can be applied to obtain the data on abundance of species and scpecies composition: a microscopical analysis involving manual counting and species identification by use of microscope or by an automatic image analysis method using a scanner or camera and suitable software. The ZooImage software was enhanced for use in the Baltic Sea by the experts of Finnish Environment Institute (SYKE) within the MARMONI project. Biomass is estimated using individual wet weights.

With regard to laboratory works for each MARMONI indicator, the requirements vary:

- Indicator 3.7 - the minimum requirement for the taxonomic resolution in the sample analysis is to taxa (group) level, meaning that copepods have to be counted as their own group. Species identification is not needed.
- Indicator 3.9 - it is important that the zooplankton species composition in the samples is analysed to the highest taxonomic resolution possible (preferably to species level). Species identification is needed.
- Indicator 3.10 - there is no minimum requirement for the taxonomic resolution in the sample analysis because the only required data is the number of individuals and the total volume of the biomass. Species identification is not needed.

Annual (once a year) sampling provides sufficient data for the calculation of the MARMONI indicators, but a higher sampling frequency would probably be better due to decreasing the variation in the data. However, experts have not yet estimated what would be the optimum sampling frequency. For calculating the HELCOM CORESET indicator on zooplankton, the data are restricted to the summer period (June-September) as the most representative in the datasets of the Baltic Sea countries.

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[7] http://helcom.fi/action-areas/monitoring-and-assessment/manuals-and-guidelines/combine-manual.

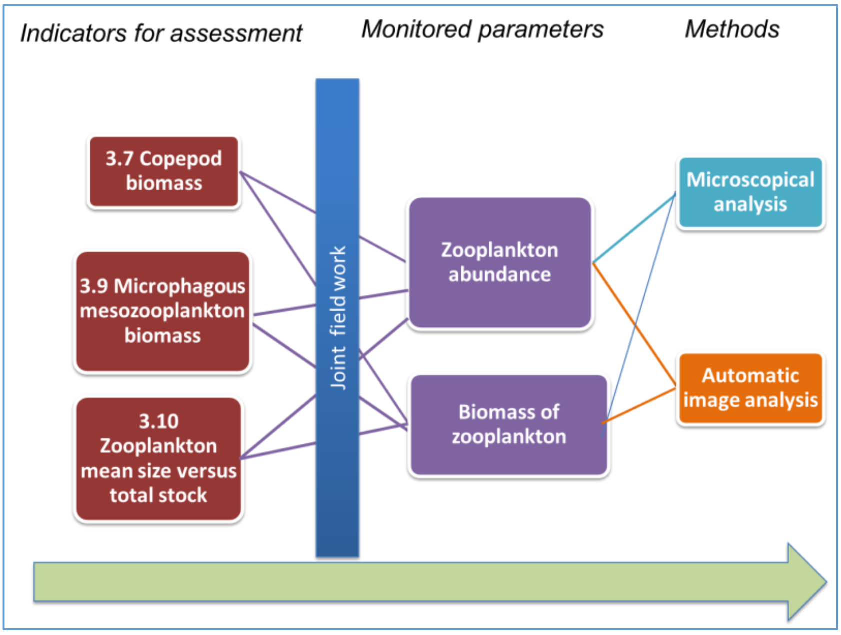

Figure 7.1. Approach to structure a monitoring scheme on zooplankton: from indicators of assessment to monitoring methods (Source: MARMONI project)

7.4.1 Monitoring of zooplankton in Finland

In Finland, monitoring of zooplankton in the open Baltic Sea has been carried out regularly since 1979. The new Finnish monitoring programme 2014-2020 foresees that the zooplankton monitoring is organised by the SYKE in the open Baltic Sea and the Regional Environment Centres in coastal waters. Data and information presented in this case study relate to the monitoring and indicator work of SYKE in the open Baltic Sea covering 17 monitoring stations. The field works are carried out twice a year (in spring and summer) at 11 stations, while once a year samples are taken at 6 stations. Three samples (replicates) are taken at each station.

The samples are collected according to the field work method as defined in the Manual for Marine Monitoring in the COMBINE Programme of HELCOM (see the description earlier). Zooplankton sampling is carried out in a joint monitoring campaign when samples for assessing other marine parameters (e.g. phytoplankton, chemical parameters, etc.) are collected by use of the Aranda ship owned by SYKE.

Up till now the field work results are used to obtain data on abundance of species, composition of species and biomass. Traditionally, counting and identification of the zooplankton species are done in laboratory using a microscope. The zooplankton biomass is estimated using individual wet weights as defined in HELCOM manual.

The new method of automatic image analysis was tested in the MARMONI project and is proposed to be considered for new national monitoring programme. The new method includes the following steps: 1) samples are scanned to get images; 2) data processing with ZooImage software for semi-automatic image analysis is run to measure the length of individuals, then to estimate biomass. The new method delivers data for the MARMONI indicators 3.7 and 3.10 while the problem for the indicator 3.9 is to define species composition for small-sized species.

7.4.2 Monitoring of zooplankton in Latvia

Since 1993, the Latvian Institute of the Aquatic Ecology implements monitoring of the zooplankton; however the frequency and density of the network vary over years depending on available funding. The marine monitoring programme delivers data on abundance of species, species composition and biomass of zooplankton.

Zooplankton sampling is carried out in a joint monitoring campaign when samples for assessing other marine parameters (e.g. phytoplankton, chemical parameters, chlorophyll a) are collected. The new monitoring programme 2014-2020 includes 15 monitoring sites for zooplankton to be sampled 6 times per year in the period 2014-2015 and 9 times per year in the period 2016-2020. The whole sampling network includes 49 marine and coastal monitoring sites. Marine including coastal water monitoring programme is implemented by the Latvian Institute of Aquatic Ecology.

The zooplankton samples are collected according to the field work method as defined in the Manual for Marine Monitoring in the COMBINE Programme of HELCOM (see description earlier).

During the MARMONI project the three new MARMONI zooplankton indicators were tested with the current monitoring method, i.e., microscopical analysis. The new method of automatic image analysis was not tested for the MARMONI indicators; however, the new method is recognised as feasible to be tested and implemented in the country in the future.

7.5 Costs of monitoring for the indicators

Monitoring costs to obtain the indicators' value relate to various types of activities: field work to collect samples, laboratory work to obtain data on relevant monitored parameter/s, data management and reporting. Depending on the usual practice of the monitoring institute, indirect costs (called also as fixed or overhead costs) are calculated as certain percentage of either personnel or total direct costs of the monitoring.

7.5.1 Field work to collect samples

The MARMONI zooplankton indicators are calculated based on the currently monitored parameters - abundance of the species, species composition and biomass. This means that **no additional field work costs** are generated due to introduction of the MARMONI indicators. Thus, the field work costs are accounted in the socio-economic assessment once only for the zooplankton monitoring scheme.

The cost positions of the field work are rent/use of the vessel, sampling equipment (e.g., Zooplankton sampler), smaller inventory and supplies (e.g., bottles, formalin, clothing for field work, filter for filtering seawater), travel costs (fuel, accommodation, per diem, etc.), as well as labour costs (salary for days in the field). The same person takes zooplankton and phytoplankton samples, therefore the costs related to the personnel and travel are divided between both monitoring schemes equally.

As the joint sampling campaigns are carried out in both countries to collect various samples (e.g. also for phytoplankton), only a share of the field work costs are attributed to the zooplankton monitoring (based on a share in the total number of various samples collected in a campaign).

The new monitoring scheme in Finland has the following variables for the costs' estimation: 14 open Baltic Sea sampling sites on average with three replicates in each site are monitored twice a year (i.e., 84 zooplankton samples per year are obtained). Due to joint campaign, the sampling activity takes 16 man-days each time. Thus, 8 man-days are attributed to calculate the costs of the zooplankton monitoring scheme.

The new monitoring scheme in Latvia has the following variables for the costs' estimation: 15 sampling sites are monitored 9 times per year (with 1 sample per site), thus 135 samples are obtained per year. In Latvia each sampling campaign takes around 7 days, 3.5 man-days are attributed to calculate the costs of the zooplankton monitoring scheme.

7.5.2 Laboratory work to treat samples and obtain parameter values

Laboratory work involves such costs' positions as costs for equipment and supplies to treat samples and labour costs. The needed equipment and laboratory supplies differ between the current and the new method. It also may differ between laboratories, depending on their practice to treat the zooplankton samples. The current method requires having a microscope including camera and other or set of stereo-microscope, inverted microscope with camera. In Latvia, smaller equipment and supplies include Stempel-pipette (2 mL) and Bogorov camera. In Finland, smaller equipment and supplies include Utermöhl settling chamber (10 ml) and round cover class, Folsom splitter, Petri dishes. A laboratory worker is supplied with lab coat and gloves. The laboratory also needs to be equipped with a computer with standard software for recording the obtained values of parameters. The laboratory equipment and supplies are used solely for the analysis of zooplankton samples.

The new method requires an office type of scanner with possibility to zoom image (e.g. scanner Epson Perfection V750) or a photo camera with appropriate zooming options, a computer and special software (ZooImage) for semi-automatic image analysis. The ZooImage – software was enhanced within the MARMONI project by the Finnish Environment Institute and recommended as an alternative method for the obtaining data for at least 2 indicators MARMONI indicators.

The personnel (labour) costs were estimated based on the following man-day needs: a one sample can be analysed per a man-day with the current method whereas three samples can be analysed per a man-day with the new method. When using the current method, it needs to be noted that precision of the results depends greatly on expertise of the analyst. The high quality skills of the personnel are required for identification of the species.

7.5.3 Data management and reporting

Data management and reporting, including costs for calculating the indicator value, involve such costs' positions as labour costs and costs for office equipment. A number of man days for this type of activity depends on a number of samples. The costs involve work on inserting data in a data base, calculating an indicator, assuring data quality and preparing the annual report with regard to monitoring and indicator. For the new method additional man-days are considered to check accuracy and up-date of the software with new species.

7.5.4 Estimated monitoring costs for the indicators

Table 7.2 presents estimated monitoring costs of zooplankton in open Baltic Sea in Finland and whole marine and coastal waters in Latvia for all indicators together calculated as average costs per year. It shows the costs break-down by the main costs' positions (e.g. equipment, personnel etc.), and by the type of monitoring activities (e.g. field work, data treatment, GIS modelling etc.). All indicators are calculated based on the same field work and laboratory analysis. A choice of the method determines the laboratory costs and also the data management costs.

The field data collection costs compose a major share of the total calculated costs. Although the ship costs are shared with other marine monitoring schemes (for phytoplankton, physico-chemical parameters, etc.), they still make up to 50% of the total costs for the zooplankton monitoring in Finland and about 25% of the total costs for Latvia. The share of the field work costs would decrease if the zooplankton samples were collected at all monitoring stations covered by a monitoring campaign (e.g. in 49 instead of 15 in Latvia and in 50 on average instead of 17 in Finland), but it would then increase the laboratory costs to analyse larger number of samples.

The laboratory work involving mainly personnel costs constitutes another important share of the total calculated costs if the work is carried out with the current method, i.e., manual counting and species identification by use of microscope. When analysing the cost positions of laboratory work, the largest share is composed by labour costs. High personnel costs also increase indirect costs (in particular, if they are estimated based on personnel costs like for Finland).

The current method requires a qualified and experienced laboratory worker to be able to carry out species identification. Considering the number of samples that need to be analysed per year the laboratory work would require 84 man-days in Finland and 135 man-days in Latvia (out of potential 220 man days on average per year). Thus the number of samples to be analysed could be increased without additional personnel costs if assuming that a one full-time employed person needs to be paid anyway to maintain capacity for performing the zooplankton monitoring. However, the full-time work load for zooplankton expert/s can be also ensured but involvement in the analysis of samples from another programmes and surveys, e.g., coastal monitoring scheme Finland or specific research programme's or projects in both countries.

The current method also needs expensive laboratory equipment, such as stereo-microscope with camera, which makes about 15-20% of the laboratory costs. The equipment is used for the zooplankton analysis solely. It is not fully employed with the considered number of samples to be analysed per year.

The costs of data management and reporting differ between both methods. Data processing (i.e., entering data manually in a data base) is a task to be carried out when the current method is applied. When the zooplankton automatic analysis is applied data processing is an integral part of the laboratory work. About 10 man-days are allocated for the preparation of the monitoring report for both methods. 5 man-days are allocated to check the accuracy of the ZooImage software and to improve a training set for species identification, including an up-date with new species.

There are considerable costs that are not accounted in the developed estimates. They relate to maintaining and developing appropriate capacity to perform the zooplankton monitoring. These are costs related to taxonomic work, inter-calibration internationally, regular acquiring literature/information on developments in the field, travel costs for attending international meetings, courses etc. Rough estimate indicates that such costs can be substantially, for example, about 35 000 EUR per year for the assessed monitoring scheme in Finland.

Table 7.2. Monitoring costs for the zooplankton indicators in Finland and Latvia as average costs per year, by the main costs' types (€/year) (Source: Calculation based on data collected as part of the case study)

NOTE! The field work and the laboratory work is joint for all three indicators, thus these costs are accounted once.

<table>
<tr><th colspan="3">INDICATOR</th><th>PARAMETER</th><th colspan="2">METHOD</th><th colspan="7">Costs per year (EUR), by the main costs' positions, incl. for:</th><th colspan="5">Costs per year (EUR) by the main types of activities, incl. for:</th></tr>
<tr><th>No</th><th>Name</th><th>Category</th><th>Name</th><th>Category</th><th>Name</th><th>Ship</th><th>Equipment</th><th>Supplies</th><th>Personnel</th><th>Travel</th><th>Indirect costs</th><th>TOTAL</th><th>Field work</th><th>Laboratory work</th><th>Data management</th><th>Indirect costs</th><th>TOTAL</th></tr>
<tr><td colspan="18">FINLAND</td></tr>
<tr><td>3.7</td><td>Copepod biomass</td><td>New</td><td>Copepod biomass</td><td rowspan="2">Current</td><td rowspan="2">Zooplankton microscopical analysis</td><td rowspan="2">15 546</td><td rowspan="2">4 073</td><td rowspan="2">598</td><td rowspan="2">16 641</td><td rowspan="2">576</td><td rowspan="2">12 678</td><td rowspan="2">50 082</td><td rowspan="2">19 770</td><td rowspan="2">15 343</td><td rowspan="2">2 321</td><td rowspan="2">12 648</td><td rowspan="2">50 082</td></tr>
<tr><td rowspan="2">3.9</td><td rowspan="2">Microphagous mesozooplankton biomass</td><td rowspan="2">New</td><td rowspan="2">Microphagous mesozooplankton abundance, and biomass</td></tr>
<tr><td rowspan="2">New</td><td rowspan="2">Automatic image analysis</td><td rowspan="2">15 546</td><td rowspan="2">1 617</td><td rowspan="2">660</td><td rowspan="2">4 133</td><td rowspan="2">576</td><td rowspan="2">3 141</td><td rowspan="2">25 673</td><td rowspan="2">19 770</td><td rowspan="2">1473</td><td rowspan="2">1 289</td><td rowspan="2">3 141</td><td rowspan="2">25 673</td></tr>
<tr><td>3.10</td><td>Zooplankton mean size versus total stock (MSTS)</td><td>New</td><td>Zooplankton abundance, size and biomass</td></tr>
<tr><td colspan="18">LATVIA</td></tr>
<tr><td>3.7</td><td>Copepod biomass</td><td>New</td><td>Copepod biomass</td><td rowspan="2">Current</td><td rowspan="2">Zooplankton microscopical analysis</td><td rowspan="2">9 205</td><td rowspan="2">3601</td><td rowspan="2">453</td><td rowspan="2">17 760</td><td rowspan="2">387</td><td rowspan="2">6281</td><td rowspan="2">37 687</td><td rowspan="2">13 649</td><td rowspan="2">15 273</td><td rowspan="2">2 484</td><td rowspan="2">6281</td><td rowspan="2">37 687</td></tr>
<tr><td rowspan="2">3.9</td><td rowspan="2">Microphagous mesozooplankton biomass</td><td rowspan="2">New</td><td rowspan="2">Microphagous mesozooplankton abundance, and biomass</td></tr>
<tr><td rowspan="2">New</td><td rowspan="2">Automatic image analysis</td><td rowspan="2">9205</td><td rowspan="2">1 810</td><td rowspan="2">678</td><td rowspan="2">4602</td><td rowspan="2">387</td><td rowspan="2">3 336</td><td rowspan="2">20 018</td><td rowspan="2">13 649</td><td rowspan="2">1 004</td><td rowspan="2">2029</td><td rowspan="2">3 336</td><td rowspan="2">20 018</td></tr>
<tr><td>3.10</td><td>Zooplankton mean size versus total stock (MSTS)</td><td>New</td><td>Zooplankton abundance, size and biomass</td></tr>
</table>

7.6 Socio-economic assessment of the indicator-based monitoring scheme

The aim of the zooplankton monitoring scheme is to comply with the needs of the MSFD for the assessment of GES. It is also expected that such monitoring methods are used that provide reliable data for the assessment indicators. Moreover, this should be performed with the least costs for society. Thus, all three MARMONI indicators are taken into account for assessing the cost-efficiency of the monitoring scheme.

As described in Chapter 5, the economic assessment is built on three criteria: Costs, Compliance and Confidence. The “compliance” criterion allows characterising the extent to which the assessment indicator and/or the set of indicators ensure compliance with the GES criteria and indicators for Descriptor 1 (Biodiversity) of the MSFD. The “confidence” criterion aims characterising accuracy of the monitoring methods used to obtain data for the indicators. The “compliance” scores (from 0-4) assigned to the indicators are not country specific, whereas the “confidence” scores assigned to the monitoring methods may differ among the countries since they depend on the monitoring practice and experience in a monitoring institute.

Costs of the monitoring scenarios

The *current monitoring (baseline) scenario* is not analysed due to the lack of existing indicators that would comply with the assessment requirements of the MSFD (for the Descriptor 1). Therefore only compliance scenarios with the MARMONI indicators are considered in this analysis. The average costs per year (presented in table 7.2) were used as basis for estimating costs of two compliance scenarios – with the currently used method and with the new method.

The total calculated costs for the monitoring scenario *“Compliance with currently used methods” (“Compl_current”)* including the three MARMONI indicators are **50 082 EUR on average per year in Finland and 37 687 EUR on average per year in Latvia**. The costs for Finland are calculated only for the monitoring of the open-sea waters, thus the costs of coastal monitoring need to be accounted in addition.

It needs to be stressed that three indicators are computed based on data from a joint field work and laboratory work. These costs are accounted once only.

The results show that the costs of the new method - the automatic image analysis are lower (by around 50%) than the costs of the currently used manual method with microscope. The total calculated costs for the monitoring scenario *“Compliance with new methods”* (*“Compl_new”*) are **25 673 EUR on average per year in Finland** and **20 018 EUR on average per year in Latvia**.

The cost calculation is based on the sampling intensity (number of samples and monitoring frequency) as specified for the new marine monitoring programmes in the countries. The new monitoring programme of Latvia foresees to collect zooplankton samples 9 times per year. If reducing the sampling frequency to 4 times per year (June-September), it would lead to cost reduction by about 50%. The reduced sampling is considered to be sufficient to calculate the MARMONI and HELCOM CORESET indicators at this moment. However, due to the remaining compliance gaps with regard to the criterion and indicators for the GES assessment and innovative character of the recently developed indicators, higher sampling frequency is still essential for future work on indicators. The criterion for density of the monitoring stations for zooplankton indicators are not specified, thus the cost implications with regard to this variable is difficult to calculate.

The total calculated costs of *“Compliance with new methods”* (*“Compl_new”*) do not taken into account shortcoming of the new method with regard to the data requirements for the MARMONI indicator 3.9. Although the indicator 3.9 needs that the zooplankton species composition in the samples is analysed to the highest taxonomic resolution it also contributes to the same MSFD criteria as the indicator 3.7 (see table 7.4.).

Table 7.3. Total calculated monitoring costs of the scenarios as average costs per year (€/year) (Source: Calculation based on data collected as part of the case study)

Scenarios	**Finland**	**Latvia**
Compliance scenario with currently used methods (*“Compl_current”*)	**50 082 EUR**	**37 687 EUR**
Compliance scenario including new methods (*“Compl_new”*)	**25 673 EUR**	**20 018 EUR**

“Compliance” assessment of the indicators

Table 7.4 shows the assessment of the “compliance” of the zooplankton indicators against the MSFD GES criteria and indicators. The assessment is based on expert opinion of the project’s experts.

The best *Compliance* score is for the indicator 3.10 as it covers larger number of GES criteria relevant for zooplankton assessment. Since all the indicators can be calculated with the same costs, from the economic point of view they all can be used in monitoring and status assessment practice (there is no need to choose among them). In particular since each provides additional relevant information for analysing and assessing the status.

GES indicators 1.1.1, 1.1.2, 1.3.2 and 1.7.1 are also seen as relevant for the zooplankton status assessment, but none of the new (MARMONI) indicators allows covering these GES indicators.

Summary score for the "Compliance scenarios" (2.2 if considering coverage of all GES criteria and 1.9 if considering coverage of all GES indicators) is below the "good compliance level" (the score 3 according to the scale used in this assessment).

Table 7.4. “Compliance” assessment of the indicators against MSFD GES criteria and indicators of the Descriptor 1. (Source: Assessment based on expert opinion)

The used assessment scale: 0 “no compliance at all”, 1 “low compliance”, 2 “moderate compliance”, 3 “good compliance”, 4 “excellent/full compliance”.

NOTE! The average “compliance” score is calculated to show the score per one GES criterion/indicator (on average).

GES criteria and indicators relevant for assessing status of soft bottom macrofauna		**3.7**	**3.9**	**3.10**	**Best score of compliance with the GES Indicator**
1.1 Species distribution	1.1.1.	0	0	0	**0**
	1.1.2.	0	0	0	**0**
1.2 Population size	1.2.1.	4	4	4	**4**
1.3 Population condition	1.3.1.	0	0	3	**3**
	1.3.2.	0	0	0	**0**
1.6 Habitat	1.6.1.	0	0	4	**4**
	1.6.2.	4	4	0	**4**
1.7 Ecosystem structure	1.7.1.	0	0	0	**0**
Average Compliance score per <u>indicator</u> for each indicator		**1.0**	**1.0**	**1.4**	
Average Compliance score per <u>criterion</u> for each indicator		**1.6**	**1.6**	**2.2**	
Average score of the “set” of assessment indicators to comply with all GES <u>criteria and indicators</u> of the Descriptor 1:					**1.9**
Average score of the “set” of assessment indicators to comply with all GES <u>criteria</u> of					**2.2.**

the Descriptor 1:	

"Confidence" assessment of the monitoring methods

Table 7.5 shows the assessment of the "confidence" of the monitoring methods to deliver data for deriving the indicator values. The assessment is based on expert opinion of the project's experts.

Since the new method (the automatic image analysis) was developed and tested in Finland, the experts from the Finnish Environment Institute were asked to assess the "confidence" of the method. Latvian Institute of Aquatic Ecology had tested the new method out of scope of the MARMONI project. Taking into account their experience their scores assigned to the new method are lower.

The assessment shows that the current method has "excellent confidence" for delivering data for all three MARMONI indicators. The "confidence" is seen lower for the new method. Development of the new method is still in progress, and some improvement in the performance of the software can be expected in the future. However, concerning small-sized taxa (for the indicator 3.9), the software will not be able to meet the necessary determination accuracy of microscopical species. This is because the microphagous species are the smallest taxa in the zooplankton community, and are, thus, more difficult for proper identification with the semi-automatic image analysis method. Consequently, the current method needs to be applied to deliver appropriate data for the MARMONI indicator 3.9.

Moreover, as GES criterion 1.1 requires GES assessment at the species level, the monitoring programme needs to be implemented with the current method to some extent. Furthermore, the ZooImage software needs to be adjusted with information about region-specific species, also needs to be updated with new species over time.

Table 7.5. "Confidence" assessment of the monitoring methods to provide data for the zooplankton indicators. (Source: Assessment based on expert opinion)

The used assessment scale: 0 "no confidence at all", 1 "low confidence", 2 "moderate confidence", 3 "good confidence", 4 "excellent/full confidence".

Methods	**Group of method**	**3.7**	**3.9**	**3.10**	**Average score per scheme**
Zooplankton microscopical analysis	Current (both countries)	4	4	4	**4**
Automatic image analysis	New/Finland	3	2	4	**3**
Automatic image analysis	New/Latvia	2	1	3	**2**

Total cost-efficiency of an indicator-based monitoring scheme

The table 6.6 presents the calculated "costs/compliance ratio", "costs/confidence ratio" and "cost-efficiency ratio" of the *scenarios "compliance using the current monitoring methods"* and *"compliance using the new monitoring methods"* (see the chapter 5.3 for more information about the ratios). The former two ratios show costs (EUR on average per year) per one unit (score) of the compliance/confidence. The latter considers both at the same time – the compliance and the confidence for the GES assessment.

Despite the lower "confidence" assessment of the new method, the total calculated cost-efficiency of the monitoring programme is higher for the *"compliance scenario using the new monitoring method"* since the costs of the new method are considerably lower. However, with decreasing "confidence" score for the new method, the cost-efficiency becomes similar for both scenarios (see the result for

Latvia with the "confidence" score "2" for the new method). It highlights relevance of sufficient development and update of the new method (e.g. the software) that it provides reliable results to be it more beneficial than the current method. As well as other aspects besides this cost-efficiency (as explained earlier) need to be considered, thus combination of both methods would be needed for compliant and cost-effective monitoring program.

Table 7.6. Summary on the economic assessment of the indicator-based zooplankton monitoring scenarios in Finland (Source: Calculation based on data collected as part of the case study)

The scenarios **Assessments used in the Economic Assessment**	**Compliance scenario with currently used method (*"Compl_current"*)**	**Compliance scenario including new method (*"Compl_new"*)**
Costs of the scenario (EUR), as average costs per year	**50 082**	**25 673**
"Compliance" score for the scenario (in a scale from 0-4)	1.9	1.9
Confidence score for the scenario (in a scale from 0-4)	4	3
Costs / Compliance ratio	***26 710***	***13 692***
Costs / Confidence ratio	***12 520***	***8 558***
Total cost-efficiency ratio	***17 049***	***10 533***

Table 7.7. Summary on the economic assessment of the indicator-based zooplankton monitoring scenarios in Latvia (Source: Calculation based on data collected as part of the case study)

The scenarios **Assessments used in the Economic Assessment**	**Compliance scenario with currently used methods (*"Compl_current"*)**	**Compliance scenario including (also) new methods (*"Compl_new"*)**
Costs of the scenario (EUR), as average costs per year	**37 687**	**20 018**
"Compliance" score for the scenario (in a scale from 0-4)	1.9	1.9
Confidence score for the scenario (in a scale from 0-4)	4	2
Costs / Compliance ratio	***20 100***	***10 676***
Costs / Confidence ratio	***9 422***	***10 009***
Total cost-efficiency ratio	***12 830***	***10 322***

7.7 Summary on the results and conclusions

- The zooplankton monitoring has been implemented in Finland and Latvia before the MARMONI project. However, there were no indicators which would allow the assessment needed for the MSFD. The zooplankton indicators were not sufficiently developed for the evaluation of the GES during the "Initial Assessment". Therefore, there was no "*baseline scenario"* for the analysis.
- A set of the zooplankton indicators was developed within the frame of the MARMONI project. The three out of four zooplankton indicators are ready to be used for the GES assessment based on data delivered by the national monitoring programmes. The "*compliance scenario*" was built from these three new indicators. However, they don't cover fully all relevant GES criteria and indicators according to the MSFD requirements. Therefore further work is needed to develop indicators to overcome these gaps.

- Since all the three zooplankton indicators can be calculated with the same costs they all can be used for the status assessment without creating cost implications. In particular, since each provides additional relevant information for analysing and assessing status of the biodiversity. Based on the monitoring intensity (number of sampling stations and monitoring frequency) specified for the new national monitoring programmes for 2014-2020, the total calculated costs for the monitoring scenario "*Compliance with currently used methods*" (*"Compl_current"*) are 50 082 EUR on average per year for Finland and 37 687 EUR on average per year for Latvia. For Finland only the costs of open-sea monitoring are estimated.
- The current method requires a qualified and experienced laboratory worker to be able to carry out species identification. Taking into account the number of samples that need to be analysed per year with the considered monitoring intensity, the laboratory work would require 84 man-days in Finland and 135 man-days in Latvia (from 220 working days on average per year). Thus the number of samples to be analysed could be increased without additional personnel costs if assuming that a one full-time employed person needs to be paid anyway to maintain capacity for performing the zooplankton monitoring. However, the full-time work load for zooplankton expert/s can be also ensured but involvement in the analysis of samples from another programmes and surveys, e.g., coastal monitoring scheme Finland or specific research programme's or projects in both countries.
- As part of the MARMONI project a new laboratory method for zooplankton monitoring was developed and tested. The automatic image analysis by the ZooImage software was enhanced. Therefore the socio-economic impact of introducing the new monitoring method was evaluated. The results show that the total calculated costs of the new method are lower (by around 50%) than the costs of the currently used method using microscope. The total calculated costs for the monitoring scenario *"Compliance with new methods"* (*"Compl_new"*) are 25 673 EUR on average per year for Finland and 20 018 EUR on average per year for Latvia.
- The new method can be recommended as an alternative method for obtaining data for at least 2 MARMONI indicators – the indicator 3.7 and 3.10. However, the current method needs to be applied to deliver data for the indicator 3.9 since the microphagous species are the smallest taxa in the zooplankton community and are, thus, more difficult for proper identification with the semi-automatic image analysis method.
- The current method is also needed to ensure calibration and verification of the new method. Moreover, as the GES criterion 1.1 requires GES assessment at the species level, the monitoring programme needs to be implemented with the current method to some extent. Furthermore, the ZooImage software needs to be adjusted with information about region-specific species, also updated with new species over time.
- With appropriate "confidence" and due to lower costs the new method is more cost-efficient than the current method. However, as noted above, other aspects besides the cost-efficiency need to be considered, thus combination of both methods would be needed for compliant and cost-effective monitoring program.
- Zooplankton monitoring in particularly laboratory work including species identification requires specific qualification of the laboratory worker (knowledge on zooplankton and skills in species identification). Furthermore, certain field work and laboratory equipment is used solely for the zooplankton monitoring. Indirect costs are also related to taxonomic work, inter-calibration internationally, regular acquiring literature/information on developments in the field, travel costs for attending international meetings, courses etc. Therefore, a monitoring institution has a minimum cost level for having and maintaining a capacity to implement zooplankton monitoring at any monitoring intensity.

8 The socio-economic assessment of monitoring for the phytobenthos indicators – a case study in Sweden

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8.1 Introduction

The socio-economic assessment for the MARMONI indicators 2.1 "*Accumulated cover of perennial macroalgae*" and 2.2 "*Accumulated cover of submerged vascular plants*" was conducted in Sweden, as the indicators and related new monitoring method was developed and tested in the pilot area in Sweden by the experts of research company **"**AquaBiota Water Research". The MARMONI indicator 2.1 "*Accumulated cover of perennial macroalgae*" could be also calculated in Latvia and Finland as relevant monitoring activities are included in the new national marine monitoring programme.

8.2 Definition of the indicators

The indicators[8] belong to the group of benthic indicators addressing the status of coastal benthic habitats. Eutrophication is the main pressure reflected by both indicators.

Indicator 2.1 *"Accumulated cover of perennial macroalgae"* reflects the quantity of the perennial macroalgae community (phytobenthos) measured as accumulated cover, thus indicating the quantity of biodiversity as the amount of species living on and among the algae. It quantifies the biodiversity of **shallow hard bottoms**. The measured unit is accumulated %-cover and the assessment unit is the total aggregated accumulated cover within a predefined monitoring area. For calculation the cover of each species is summed including all layers and overlapping species.

Indicator 2.2 *"Accumulated cover of submerged vascular plants"* reflects the quantity of the submerged vascular plant community measured as accumulated cover, thus indicating the quantity of biodiversity as the abundance and volume of the vascular plant community and associated species. It indicates biodiversity quantity on **shallow soft bottoms in more sheltered areas**. All species of submerged vascular plants are included in this indicator, both eelgrass (*Zostera*) meadows and mixed stands of taxa such as e.g. *Stuckenia, Potamogeton*, and *Myriophyllum*.

8.3 Policy relevance of the indicators

The Marine Strategy Framework Directive (MSFD) and related Commission Decision 2010/477/EU require assessing biodiversity (Descriptor 1) at three ecological levels: species, habitat (community) and ecosystem level. The MARMONI indicators 2.1 "*Accumulated cover of perennial macroalgae*" and 2.2 "*Accumulated cover of submerged vascular plants*" support the biodiversity assessment on habitats according to the following criteria and indicators:

- 1.5 Habitat extent
    - Habitat volume (1.5.2)
- 1.6 Habitat condition
    - Condition of the typical species and communities (1.6.1)
    - Relative abundance and/or biomass, as appropriate (1.6.2)

[8] Martin G., Fammler H., Veidemane K., Wijkmark N., Auniņš A., Hällfors H. and Lappalainen A. 2015. *The MARMONI approach to marine biodiversity indicators. Volume II: List of indicators for assessing the state of Marine biodiversity in the Baltic sea developed by the Life MARMONI project*. Estonian Marine Institute Report Series No. 16. Page: 34.

Additionally, the indicator also supports the assessment needs for the Habitat Directive, respectively the indicator 2.1 is related to the reed habitat (1170) and the indicator 2.2 is related to the sublittoral sandbanks (1110).

8.4 Design of the monitoring scheme

MARMONI indicators 2.1 and 2.2 focus on the assessment of biodiversity in shallow water areas. Consequently, a monitoring scheme shall be established for the coastal waters. A number of stations depends on an area to be monitored. If the area is homogeneous, fewer stations are needed and vice versa. During the MARMONI project the Swedish experts did not yet developed requirements for the design including the density of the stations for monitoring phytobenthos species. Therefore, the case study on socio-economic assessment deals with the assessment of current and new methods when implementing monitoring campaign covering 30 stations. During the MARMONI project method was tested in more 800 stations in 2011 and 2012.

Monitoring of the phytobenthos (species and habitats) is implemented to obtain the parameter on percentage of the cover of the individual perennial macroalgae or individual submerged vascular plant species. The monitoring is implemented once a year during the vegetation season, in summer up to early autumn (maximum field work season up to 60 man-days).

The current method is that sampling is implemented by diving along transects. The diver takes video and collects samples. During the MARMONI project both MARMONI indicators were tested with a new monitoring method – drop video. The current method is designed to collect detailed data with high taxonomic resolution from a small number of stations whereas the newly proposed biotope and habitat monitoring methods are designed to collect less detailed data with lower taxonomic resolution from a much larger number of stations. The new method is proposed since it minimize time and personnel needed per station and since only small vessels are needed (no other crew than the people performing monitoring is needed).

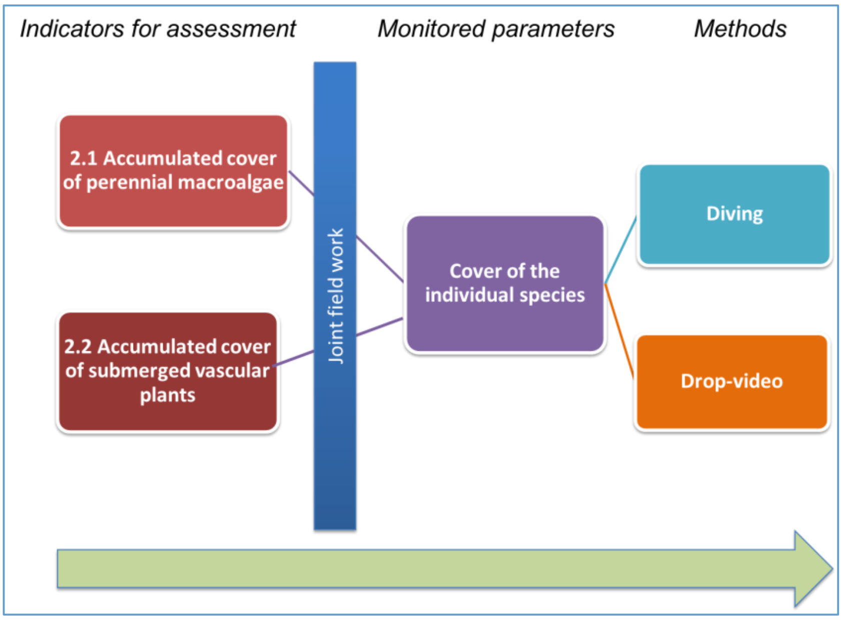

Figure 8.1. Approach to structure a monitoring scheme on phytobenthos: from indicators of assessment to monitoring methods (Source: MARMONI project)

8.5 Costs of monitoring for the indicators

Monitoring costs to obtain the indicator's value relate to various types of activities: field work to collect samples, laboratory work to obtain data on relevant monitored parameter/s, data management and reporting. Depending on the usual practice of the monitoring institute, indirect costs (called also as fixed or overhead costs) are calculated as percentage of either personnel or total direct costs of the monitoring.

8.5.1 Field work to collect samples

The joint field work either by use of the current method (diving) or the new method (drop-video) delivers data needed for both indicators.

Diving in transects is commonly used to monitor phytobenthos communities. The video observations are carried out from the coastline to the maximum depth with benthic vegetation in a corridor of about five meters width at both sides of the transect. The method requires involvement of the crew – two phytobenthos experts and a boat driver. The method has been agreed and described in HELCOM guidelines 1999[9].

Drop-video is a visual survey method for benthic vegetation and epifauna as well as benthic substrate. The drop-camera can be operated from a small vessel with a staff of two people – a phytobenthos expert and a boat driver. One person operates the boat while another one operates the camera and performs the survey. Only a few minutes are needed at each station. A list of typical species that should be possible to detect with drop-video is developed. Interpretation of the recordings can be performed directly during the re-cording in field or afterwards in laboratory. However, the video interpretation in laboratory is recommended. In order to enable identification of more filamentous species a fork or a grab can be used for collection of algae samples. Algal samples were identified on-board whenever possible or brought back for identification in laboratory if needed.

The cost positions of the field work are rent/use of the boat and travel costs (fuel, accommodation, per diem, etc.) for both methods. The current method requires diving equipment (including diving suite, Oxybox, video camera) and computer for storage of the data, GPS, and other smaller supplies) The new method requires drop video camera, computer, grab sampler, GPS and other smaller supplies.

For the case study, a typical field work day has been used to compare and assess the methods. While approximately 3 stations can be sampled in one day using the current method, approximately 30 stations can be sampled in a day using the new method. The case study is calculated for covering 30 monitoring stations. Field surveys of phytobenthos should be performed during the vegetation season, thus maximum 60 man days per year could be allocated to the field work.

8.5.1 Laboratory work to treat samples and obtain parameter values

The laboratory work is the same for the both methods. The recorded films are analysed in laboratory by personnel with good knowledge of benthic species and the surveyed habitats of the area. It is estimated that about 12 samples (records) can be analysed per day to obtain data the required data for the indicators. A computer with standard software is needed for analysing the records. Additionally, a microscope and smaller equipment (petri dishes, pincers) are needed for detailed assessment of the collected samples.

8.5.2 GIS modelling

In order to deliver data for both MARMONI indicators, GIS modelling and production of maps are implemented. A computer with special software is required. It has been estimated that about 10 man-days are needed for this type of the activity. The modelling efforts are not directly linked to a number of samples, but rather to the monitored area.

[9] HELCOM. 1999. *Guidelines for monitoring of phytobenthic plant and animal communities in the Baltic Sea.* Annex for HELCOM COMBINE programme. 12 p. Compiled by Sara Bäck, Finnish Environment Institute.

8.5.3 Data management and reporting

Data management and reporting include positions on labour costs and office equipment. Another 10 man-days are estimated to complete a data base analysis and prepare a report on the indicators.

8.5.4 Estimated monitoring costs for the indicators

Table 8.1 presents estimated monitoring costs of phytobenthoss for the MARMONI indicators as average costs per campaign covering 30 sampling stations in Sweden. It shows the costs break-down by the main costs' positions (e.g. equipment, personnel etc.), and by the types of monitoring activities (e.g. field work, data treatment, GIS modelling etc.).

The costs are counted once as all activities for obtaining values of the indicators are implemented together. The monitored parameter is "coverage of the individual species" independently on the sea bottom structure. The obtained monitoring data are selected from the data base or data set for building the indicator value accordingly.

Around 40% of the total calculated costs are related to the field data collection for the new method, while only about 7% of the total costs are related to field work when new method is employed. As the field work costs involve personnel costs, it also generates the fixed costs as these positions are bound.

As about 30 samples can be taken in 1 day with new method versus 2 samples per day, the length of the field work has implications on the travel costs as well as on the ship/boat costs which used according the needed time.

Table 8.1. Monitoring costs for the MARMONI indicators as average costs per campaign covering 30 sampling stations in Sweden, by the main costs' types (€/year) (Source: Calculation based on data collected as part of the case study)

NOTE! The costs are counted once as all activities for obtaining values of the indicators are implemented together.

INDICATOR			PARAMETER	METHOD		Costs per year (EUR), incl. for:							Costs per year (EUR), incl. for:				
No	Name	Category	Name	Category	Name	Ship	Equipment	Supplies	Personnel	Travel	Indirect costs	TOTAL	Field work	Laboratory work	Data management	Indirect costs	TOTAL
FINLAND																	
2.1	Accumulated cover of perennial macroalgae	New	Cover of the individual perennial macroalgae species	Current	Diving	3 500	282	59	18 480	2 525	10 781	**35 564**	15 064	2 555	2 988	10 781	**35 564**
2.1	Accumulated cover of perennial macroalgae	New	Cover of the individual perennial macroalgae species	New	Drop-video	350	125	41	10 248	140	5 944	**16 847**	1 122	2 555	2 988	5 944	**16 847**
2.2	Accumulated cover of submerged vascular plants	New	Cover of the individual submerged vascular plant species	Current	Diving												
2.2	Accumulated cover of submerged vascular plants	New	Cover of the individual submerged vascular plant species	New	Drop-video												

8.6 Socio-economic assessment of the indicator-based monitoring scheme

The aim of the monitoring of the phytobenthos is to comply with the needs of the MSFD for the assessment of GES. It is also expected that such monitoring methods are used that provide reliable data for the assessment indicators. Moreover, this should be performed with the least costs for society.

As described in Chapter 5, the economic assessment is built on three criteria: Costs, Compliance and Confidence. The "compliance" criterion allows characterising the extent to which the assessment indicator and/or the set of indicators ensure compliance with the GES criteria and indicators for Descriptor 1 (Biodiversity) of the MSFD. The "confidence" criterion aims characterising accuracy of the monitoring methods used to obtain data for the indicators. The "compliance" scores (from 0-4) assigned to the indicators are not country specific, whereas the "confidence" scores assigned to the monitoring methods may differ among the countries since they depend on the monitoring practice and experience in a monitoring institute.

Costs of the monitoring scenarios

The average costs per monitoring campaign including 30 stations (presented in table 8.1) were used as basis for estimating costs of the two of the scenarios. As mentioned above, all activities for obtaining values of the indicators are implemented together; therefore the costs are accounted once.

The total calculated costs for the monitoring scenario "*Compliance with currently used methods*" (*"Compl_current"*) including the both MARMONI indicators 2.1 and 2.2 are **35 564 EUR on average per campaign or around 1 186 EUR per station.**

The results show that the costs of the new method of drop- video are significantly lower (around 50%) than the costs of the currently used diving method. The total calculated costs for the monitoring scenario *"Compliance with new methods"* (*"Compl_new"*) are **16 847 EUR on average per campaign or around 561 EUR per station.**

This indicates that the new method is more cost-effective than the current method. It is especially more cost-effective when compared the field work costs of the current and the new methods. The average cost for one transect (station) is about 753 EUR, but he average cost for one drop-video station is estimated to about 37 EUR.

"Compliance" assessment of the indicators

Table 8.4 shows the assessment of the "compliance" of the MARMONI phytobenthos indicators against the MSFD GES criteria and indicators. The assessment is based on expert opinion of the project's experts.

Both indicators respond to the same two criteria out of five Descriptor 1 GES criteria as well as the same indicators. Therefore, the indicators have the same average "compliance score" (1.2). As the indicators reflect on different type of habitats (soft bottom and hard bottom), they cannot be seen as alternatives.

Although there is a need for a "set of indicators" which would comply with all relevant GES criteria and indicators of the Descriptor 1, such a set has not been established with regard to phytobenthos indicators. Consequently, the assessment on the "compliance" is rather incomplete.

Table 8.2. "Compliance" assessment of the indicators against MSFD GES criteria and indicators of the Descriptor 1. (Source: Assessment based on expert opinion)

The used assessment scale: 0 "no compliance at all", 1 "low compliance", 2 "moderate compliance", 3 "good compliance", 4 "excellent/full compliance".

NOTE! The average "compliance" score is calculated to show the score per one GES criterion/indicator (on average).

GES criteria and indicators relevant for assessing status of soft bottom macrofauna		2.1	2.2	Best score of compliance with the GES Indicator
1.1 Species distribution	1.1.1.	0	0	**0**
	1.1.2.	0	0	**0**
	1.1.3	0	0	**0**
1.2 Population size	1.2.1.	0	0	**0**
1.3 Population condition	1.3.1.	0	0	**0**
	1.3.2.	0	0	**0**
1.5 Habitat extent	1.5.2	4	4	**4**
1.6 Habitat condition	1.6.1.	4	4	**4**
	1.6.2.	4	4	**4**
1.7 Ecosystem structure	1.7.1.	0	0	**0**
Average Compliance score per indicator for each indicator:		**1.2**	**1.2**	
Average Compliance score per criterion for each indicator:		**2.0**	**2.0**	
Average score of the "set" of assessment indicators to comply with all GES criteria and indicators of the Descriptor 1:				**1.2**
Average score of the "set" of assessment indicators to comply with all GES criteria of the Descriptor 1:				**2.0**

"Confidence" assessment of the monitoring methods

Table 9.5 shows the assessment of the "confidence" of the monitoring methods to deliver data for deriving the indicator values. The assessment is based on expert opinion of the project's experts. The new method was developed and tested for both MARMONI indicators.

The assessment shows that the current method has "excellent confidence". Although assessed at "good confidence" level, the score is lower for the new method. The drop video method may not be as precise as diving in terms of taxonomic resolution, especially in very diverse areas. It may be difficult or impossible to distinguish between some species (e.g. several species of filamentous algae) with the new method.

Table 8.3. "Confidence" assessment of the monitoring methods to provide data for the MARMONI phytobenthos indicators. (Source: Assessment based on expert opinion)

The used assessment scale: 0 "no confidence at all", 1 "low confidence", 2 "moderate confidence", 3 "good confidence", 4 "excellent/full confidence".

Methods	**Group of method**	**2.1**	**2.2**
Diving	Current	4	4
Drop-video	New	3	3

Total cost-efficiency of an indicator-based monitoring scheme

The table 8.4 presents the calculated "costs/compliance ratio", "costs/confidence ratio" and "cost-efficiency ratio" of the *scenarios "compliance using the current monitoring methods"* and *"compliance using the new monitoring methods"* (see the chapter 5.3 for more information about the ratios). The former two show costs (EUR on average per year) per one unit (score) of the compliance/confidence. The latter considers both at the same time – the compliance and the confidence for the GES assessment.

Despite of the lower confidence of the new method, the costs/confidence ratio as well as total cost-efficiency of the monitoring programme is higher for the *"compliance scenario using the new monitoring methods".*

Table 8.4. Summary on the economic assessment of the indicator-based phytobenthos monitoring scheme in Sweden (Source: Calculation based on data collected as part of the case study)

The scenarios **Assessments used in the Economic Assessment**	**Compliance scenario with currently used methods (*"Compl_current"*)**	**Compliance scenario including (also) new methods (*"Compl_new"*)**
Costs of the scenario (EUR), as average costs per campaign	**35 564**	**16 847**
"Compliance" score for the scenario (in a scale from 0-4)	1.2	1.2
Confidence score for the scenario (in a scale from 0-4)	4	3
Costs / Compliance ratio	***29 637***	***14 040***
Costs / Confidence ratio	***8 891***	***5 616***
Total cost-efficiency ratio	***13 679***	***8 023***

8.7 Summary on the results and conclusions

- The phytobenthos monitoring or mainly habitat mapping has been implemented in Sweden and other Baltic Sea countries; however, collected parameters were not suitable to the assessment needs according to the MSFD. The phytobenthos indicators were not ready to be used for the evaluation of the GES during the initial assessment. Therefore, a "*baseline scenario"* was not available for the analysis.
- Two phytobenthos indicators were developed by Swedish experts of the "AquaBiota Water Research" in the frame of the MARMONI project. They are ready to be used for GES assessment based on the data delivered by the national monitoring programmes. The "*compliance scenario*" is built from these two new indicators, yet, not providing the "good compliance level" with regard to the relevant MSFD criteria and indicators. Consequently, new efforts in indicator development are needed to further enhance the situation.
- During the MARMONI project a new field work method for phytobenthos monitoring was developed and tested. Thus, the socio-economic impact of introducing the drop-video method was evaluated. The results show that the total calculated costs of the new method are lower (around 50%) than the costs of the currently used diving method. Based on the sampling campaign including 30 monitoring sites, the total calculated costs for the "*Compliance scenario with currently used methods*" are 35 564 EUR on average per campaign and "*Compliance scenario with new methods*" are 16 847 EUR on average per campaign. The "*Compliance scenario with new methods*" has higher cost-effectiveness with regard to all three ratios: costs/compliance ratio", "costs/confidence ratio" and "cost-efficiency ratio".
- The new method has higher cost-effectiveness due to the savings on time in the field work. As suitable field season for the phytobenthos monitoring is limited, the time saving is beneficial to

be able to cover the larger area with the available capacities in the monitoring institutions. At the same time it provides larger number of samples (records) to be treated by qualified laboratory staff to cover their full time work load. While one field work team within the season can collect maximum 1800 samples (max 60 days per year, 30 samples per day), the laboratory worker can treat about 2640 samples per year (12 samples per day, 220 man-days per year).

- Although assessed at “good confidence” level, the “confidence” score is lower for the new method. The drop video method may not be as precise as diving in terms of taxonomic resolution, especially in very diverse areas. This needs to be considered as the monitoring programme will need to support the development of new indicators to ensure the better compliance with all relevant MSFD criteria and indicators.

9 The socio-economic assessment of monitoring for the indicator on "Population structure of Macoma balthica" – case studies in Finland and Latvia

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9.1 Introduction

The socio-economic assessment for the MARMONI indicator 2.9 "*Population structure of Macoma balthica*" was conducted in Finland and Latvia, as the indicator was developed and tested in the pilot areas of both countries. The monitoring parameters for the indicator are included in the new national marine monitoring programmes of both countries.

9.2 Definition of the indicator

This indicator[10] describes the size distribution of *Macoma balthica*, the dominant, long-lived bivalve on soft bottoms in the northern Baltic Sea. Occurrence of new recruits, juveniles, as well as adults in all year classes in a population of *Macoma balthica* indicates that no severe disturbance has taken place and that the population is in a good state. The lack of juveniles or a year class of adults demonstrates adverse conditions.

As the natural size distribution of *Macoma balthica* varies geographically and also by depth, targets have to be adjusted to local conditions. The indicator reacts to several disturbances such as eutrophication, harmful substances or physical disturbance.

9.3 Policy relevance of the indicator

The Marine Strategy Framework Directive (MSFD) and related Commission Decision 2010/477/EU require assessing biodiversity (Descriptor 1) at three ecological levels: species, habitat (community) and ecosystem level. The indicator 2.9 "Population structure of *Macoma balthica*" supports the biodiversity assessment according to the following criteria and indicators:

- 1.3 Population condition
  - Population demographic characteristics (e.g. body size or age class structure, sex ratio, fecundity rates, survival/ mortality rates) (1.3.1);
- 1.6 Habitat condition
  - Condition of the typical species and communities (1.6.1)
  - Relative abundance and/or biomass, as appropriate (1.6.2)

Additionally, the indicator also supports the assessment needs for MSFD descriptors *D4 Food web* (4*.3 Abundance/distribution of key trophic groups/species*) and *D6 Sea floor integrity* (*6.2 Condition of benthic community*).

The indicator also contributes to the HELCOM CORESET indicator "*Population structure of long-lived macrozoobenthic species*", which reflects the status of both soft and hard bottom communities.

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[10] Martin G., Fammler H., Veidemane K., Wijkmark N., Auniņš A., Hällfors H. and Lappalainen A. 2015. *The MARMONI approach to marine biodiversity indicators. Volume II: List of indicators for assessing the state of Marine biodiversity in the Baltic sea developed by the Life MARMONI project*. Estonian Marine Institute Report Series No. 16. Page: 52.

9.4 Design of the monitoring scheme

Data needed for the MARMONI indicator 2.9 can be obtained by size measurements of *Macoma balthica* in samples from regular marine and coastal monitoring programmes. The necessary field work is the same as to collect data on abundance and biomass of the soft bottom macrofauna and the relevant indicator, i.e., Brackish Water Benthic Index (BBI) in Finland or Benthic Quality Index (BQI) in Latvia. Consequently, there are no additional efforts of field work in order to collect samples for the MARMONI indicator 2.9. Monitoring of the macrozoobenthos is usually performed once per year. The samples can be also collected during the same monitoring surveys when samples for assessing other marine parameters (e.g. phytoplankton, zooplankton, etc.) are collected.

Length measurements of *Macoma balthica* can be carried out after sorting the species and counting abundances of macrofauna species in laboratory. Currently, the length measurements of *M. balthica* are done manually using stereomicroscope for small individuals or Vernier calliper for larger individuals. A new method, tested in the MARMONI project in Finland, applied semi-automated image analysis, including scanning of samples and subsequent data processing, with image data software (ACSA or ImageJ) to measure the size of individual specimens.

For calculation of the indicator value only individuals larger than 5 mm are included, to avoid the high variation caused by alterations in the number of settling recruits. The indicator value is the median length of *M. balthica* larger than 5 mm. To obtain a reliable estimate of the population size distribution the density of adult *M. balthica* should be at least 100 individuals per square meter.

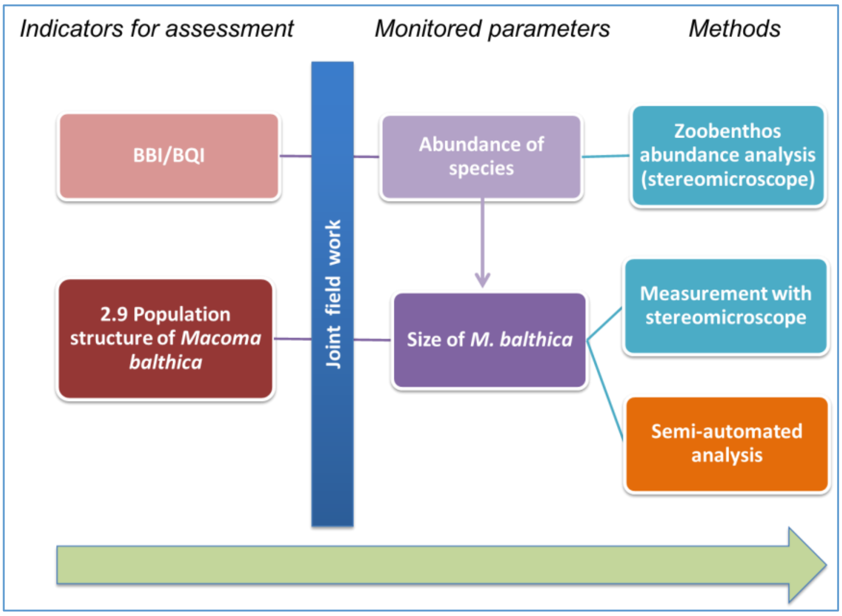

Figure 9.1. Approach to structure a monitoring scheme on soft bottom macrofauna: from indicators of assessment to monitoring methods (Source: MARMONI project)

9.4.1 Monitoring of macrozoobenthos in Finland

In Finland, the coastal water monitoring of soft bottom macrofauna is organised by the Regional Environment Centres, administered by the Ministry of the Environment. The field work is carried out either by Regional Environmental Centres using own or rented boats or outsourced to consulting companies. The field works are carried out once per season – from June till September. The current national monitoring programme has identified in average 360 coastal monitoring sites to be sampled annually. Up till now the coastal field work results are used to obtain data for the indicator on state of soft-bottom macrofauna expressed as Brackish Water Benthic Index (BBI).

Samples are taken using a 0.1 m^2 Van Veen grab (1 grab) or five pooled 0.025 m^2 Ekman grabs per station and sieved using a 0.5 mm mesh. The species determination and counting of abundance of macrofauna species are done in laboratory using a stereomicroscope.

The MARMONI indicator 2.9 “Population structure of *Macoma balthica*” is a new component of the national monitoring in Finland introduced to increase the compliance with the MSFD. In this exercise same number of samples as for the BBI calculations is used for the cost assessment of this indicator, even though the number of samples is likely to be reduced when operationalizing the indicator. At the moment, the sampling frequency for optimizing the indicator 2.9 *M. balthica* is not known.

Traditionally the size of *M. balthica* is measured manually using stereomicroscope or vernier calliper. The new method of semi-automated image analysis was tested in the MARMONI project and is proposed to be considered for new national monitoring programme. The new method includes the following steps: 1) samples are scanned to get images; 2) data processing with software (ASCA or ImageJ) for semi-automatic image analysis is run to measure the size of individuals. When the new method was tested it was recognised that error measurements can occur depending on the quality of the images. Therefore some quality-checking is required by manual measurements.

9.4.2 Monitoring of macrozoobenthos in Latvia

In Latvia, an indicator on Benthic Quality Index (BQI) has been used to assess the state of soft bottom macrofauna in the Gulf of Riga as well as in the open Baltic Sea of Latvian waters. The marine monitoring programme delivers data on abundance of species and biomass of macrofauna. The new monitoring programme includes 45 monitoring sites for macrozoobenthos to be sampled annually. Marine including coastal water monitoring programme is implemented by the Latvian Institute of Aquatic Ecology.

The samples are collected in May in a joint trip to collect samples for other chemical and biological parameters. Samples are taken by 0.1 m^2 Van Veen grab - 3 grabs per site. Samples are sieved using a 0.5 mm mesh. Counting of abundance of macrofauna species is done in laboratory by use of stereo-microscope.

During the MARMONI project the new MARMONI indicator 2.9 “Population structure of *Macoma balthica*” was tested with the current monitoring method, i.e., manually. The new method of semi-automated image analysis was not tested in Latvia; however, the new method is recognised as feasible to be tested and implemented in the country in future. As an alternative to a scanner, Latvian researchers consider to take images with photo camera.

9.5 Costs of monitoring for the indicators

Monitoring costs to obtain the indicator’s value relate to various types of activities: field work to collect samples, laboratory work to obtain data on relevant monitored parameter/s, data management and reporting. Depending on the usual practice of the monitoring institute, indirect costs (called also as fixed or overhead costs) are calculated as percentage of either personnel or total direct costs of the monitoring.

9.5.1 Field work to collect samples

The size measurement of *M. balthica* is carried out when samples of soft bottom macrofauna have been collected, treated, and the abundance of species counted. This means that **no additional field work costs** are generated due to introduction of the MARMONI indicator. Nevertheless, the field work costs to collect samples from defined number of monitoring stations have been estimated and reflected in the socio-economic assessment of the soft bottom macrofauna monitoring schemes.

The cost positions of the field work are rent/use of the vessel, sampling equipment (e.g., van Veen grab, sieves), smaller inventory and supplies (e.g., containers for emptying the grab and for storing grabbed samples, formalin, clothing for field work), travel costs (fuel, accommodation, per diem, etc.) , as well as labour costs (salary for days in the field). Depending on the vessel 1 or 2 persons are needed for collecting the samples.

The monitoring scheme in Finland has the following estimated variables for the costs' analysis: in average 360 coastal sampling sites per year are set in the scheme, 4 samples in average are collected daily and thus field work was estimated to 90 days in total. The sampling period is actually shorter than 90 days, when several teams collect the samples at same time. The field work is calculated solely for the need to collect soft-bottom macrofauna samples.

The monitoring scheme in Latvia has the following determinants for the costs: 45 samples are collected in 7 days, thus in average 6-7 samples per day. As the joint sampling campaign to collect different samples is organised, the field work costs include only a share of the costs attributed to the soft bottom macrofauna monitoring (based on a number of samples collected per trip).

9.5.2 Laboratory work to treat samples and obtain parameter values

Laboratory work involves such costs' positions as costs for equipment and supplies to treat samples and labour costs. The needed equipment and laboratory supplies differ between the current and the new method. The current method requires having a stereo-microscope, a set of forceps, a Vernier calliper, petri dishes as well as a lab coat and gloves. The laboratory needs to be equipped with a computer with standard software for recording the obtained values of parameters.

The new method requires an office type of scanner with possibility to zoom image (e.g. scanner Epson Perfection V750) or a photo camera with appropriate zooming options, a computer and special software (ACSA or ImageJ) for semi-automatic image analysis. The Aquatic Crustacean Scan Analyser (ACSA) – software was developed within the MARMONI project by the Finnish Environment Institute and recommended as an alternative method for size measurement of the bivalves.

The personnel (labour) costs were estimated as per 1 man-day to treat a sample and to calculate the index based on abundance of species (BBI or BQI).

The personnel costs for laboratory works related to the MARMONI indicator 2.9 are solely dedicated to measure size of the *Macoma balthica* as an additional action. It was estimated that about 10 samples per man-day can be treated with the current method (manual measurements) and 20 samples per man-day can be treated with new method (semi-automated image analyses).

To obtain data for the MARMONI indicator 2.9 in Finland, it would take another 36 or 18 man-days depending on the method, based on the sample number used in this exercise. In Latvia, the estimated man–days are about 3.5 days for the current method and about 1.7 days with the new. The latter figure is theoretical as the new method has not been tested in the country.

9.5.3 Data management and reporting

Data management and reporting, including costs for calculating the indicator value, involve such costs' positions as labour costs and costs for office equipment. There is no difference in the resource needs for data management and reporting between the current and the new method. Around 10 man-days are accounted per year in total for the data management and reporting.

9.5.4 Estimated monitoring costs for the indicators

Table 9.1 presents estimated monitoring costs of soft bottom macrofauna in Finland (covering coastal waters) and Latvia (covering coastal and marine area) for each indicator calculated as average costs per year. It shows the costs break-down by the main costs' positions (e.g. equipment, personnel etc.), and by the types of monitoring activities (e.g. field work, data treatment, GIS modelling etc.).

The frequency of the sampling is once per year in both countries. However, the density of the sampling station network is set by each country individually. Consequently, the total number of the collected samples as well as number of samples collected daily is different. These factors determine the cost volume.

Around 50% of the total costs are related to the field data collection on soft bottom macrofauna in Finland. As the joint sampling action to collect different samples is organised in Latvia, the field work costs include only a share of the costs attributed to the soft bottom macrofauna monitoring. Therefore, the field work costs constitute about 14% of the total costs of the soft bottom macrofauna monitoring in Latvia. The costs of laboratory works compose around 22-23% of the total costs in Finland, and around 62-64% of the total costs in Latvia (depending on the indicator).

Table 9.1. Monitoring costs for the soft bottom macrofauna indicators in Finland and Latvia as average costs per year, by the main costs' types (€/year) (Source: Calculation based on data collected as part of the case study)

NOTE! The field work and a part of the laboratory work is joint for both indicators, thus these costs are accounted once.

INDICATOR			PARAMETER	METHOD		Costs per year (EUR), by the main costs' positions, incl. for:							Costs per year (EUR) by the main types of activities, incl. for:				
No	Name	Category	Name	Category	Name	Ship	Equipment	Supplies	Personnel	Travel	Indirect costs	**TOTAL**	Field work	Laboratory work	Data management	Indirect costs	**TOTAL**
FINLAND																	
FI-BBI	Brackish water benthic index (BBI)	Current	Abundance of soft bottom macrofauna	Current	Zoobenthos abundance analysis	172 170	3 492	1 695	120 014	738	91 211	**389 320**	208 906	84 559	4 645	91 211	**389 320**
2.9	Population structure of Macoma balthica	New	Size of the M.balthica	Current	length measurement by stereomicroscope or vernier calliper		291	531	12 765		9 701	**23 289**		8 943	4 645	9 701	**23 289**
2.9	Population structure of Macoma balthica	New	Size of the M.balthica	New	size measurement by semi-automated image analysis		195	543	8 692		6 606	**16 036**		4 785	4 645	6 606	**16 036**
LATVIA																	
LV-BQI	Benthic Quality Index (BQI)	Current	Abundance of soft bottom macrofauna	Current	Zoobenthos abundance analysis	177	2 207	650	15 382	802	3 844	**23 062**	3 535*	14 685	998	3 844	**23 062**
2.9	Population structure of Macoma balthica	New	Size of the M.balthica	Current	length measurement by stereomicroscope or vernier calliper		157	32	2 307		499	**2 994**		1 497	998	499	**2994**
2.9	Population structure of Macoma balthica	New	Size of the M.balthica	New	size measurement by semi-automated image analysis		110	44	1 645		360	**2 159**		801	998	360	**2 159**

9.6 Socio-economic assessment of the indicator-based monitoring scheme

The aim of the soft bottom macrofauna monitoring scheme is to comply with the needs of the MSFD for the assessment of GES. It is also expected that such monitoring methods are used that provide reliable data for the assessment indicators. Moreover, this should be performed with the least costs for society. Thus, both indicators (the current BBI/BQI and the new MARMONI indicator 2.9) are taken into account for assessing the cost-efficiency of the monitoring scheme.

As described in Chapter 5, the economic assessment is built on three criteria: Costs, Compliance and Confidence. The "compliance" criterion allows characterising the extent to which the assessment indicator and/or the set of indicators ensure compliance with the GES criteria and indicators for Descriptor 1 (Biodiversity) of the MSFD. The "confidence" criterion aims characterising accuracy of the monitoring methods used to obtain data for the indicators. The "compliance" scores (from 0-4) assigned to the indicators are not country specific, whereas the "confidence" scores assigned to the monitoring methods may differ among the countries since they depend on the monitoring practice and experience in a monitoring institute.

Costs of the monitoring scenarios

The average costs per year (presented in table 9.1) were used as basis for estimating costs of the three scenarios. The total calculated costs for *current monitoring (baseline) scenario* including only costs for the current indicator on index on abundance of the soft bottom macrofauna species (BBI or BQI) are **389 320 EUR on average per year in Finland** (see the table 9.2) and **23 062 EUR on average in Latvia** (see the table 9.3)**.** The number of samples (360 in Finland and 45 in Latvia) is one of the determining variables of the difference in size of the total calculated costs.

The total calculated costs for the monitoring scenario "*Compliance with currently used methods*" (*"Compl_current"*) including the current indicator and the MARMONI indicator 2.9 are **412 609 EUR on average per year in Finland** and **26 050 EUR on average per year in Latvia**.

It needs to be stressed that both indicators are computed based on data from a joint field work and a part of the laboratory work. These costs are accounted once only, and only additional costs of the new MARMONI indicator 2.9 are accounted in addition. The costs of the additional indicator in the total calculated costs of the monitoring scheme with the current method constitute of about 6% in Finland and 12% in Latvia or with the new method - 4% in Finland and 9% in Latvia.

The results show that the costs of the new method of size measurement by semi-automated image analysis are lower (around 30%) than the costs of the currently used manual measurement method. This indicates that the new method is more cost-effective than the current method. Therefore, the total calculated costs for the monitoring scenario *"Compliance with new methods"* (*"Compl_new"*) are **405 356EUR on average per year in Finland** and **25 220EUR on average per year in Latvia**.

Table 9.2. Total calculated monitoring costs of the scenarios as average per year in Finland (€/year) (Source: Calculation based on data collected as part of the case study)

Indicators / Scenarios	FI-BBI	2.9	TOTAL
Current monitoring (baseline) scenario (*"Current"*)	389 320	-	**389 320**
Compliance scenario with currently used methods (*"Compl_current"*)	389 320	23 289	**412 609**
Compliance scenario including (also) new methods (*"Compl_new"*)	389 320	16 036	**405 356**

Table 9.3. Calculated monitoring costs of the scenarios as average per year in Latvia (€/year) (Source: Calculation based on data collected as part of the case study)

Indicators / Scenarios	LV -BQI	2.9	TOTAL
Current monitoring (baseline) scenario (*"Current"*)	23 062	-	**23 062**
Compliance scenario with currently used methods (*"Compl_current"*)	23 062	2 994	**26 056**
Compliance scenario including (also) new methods (*"Compl_new"*)	23 062	2 159	**25 220**

"Compliance" assessment of the indicators

Table 9.4 shows the assessment of the "compliance" of the soft-bottom macrofauna indicators against the MSFD GES criteria and indicators. The assessment is based on expert opinion of the project's experts.

Table 9.4. "Compliance" assessment of the indicators against MSFD GES criteria and indicators of the Descriptor 1. (Source: Assessment based on expert opinion)

The used assessment scale: 0 "no compliance at all", 1 "low compliance", 2 "moderate compliance", 3 "good compliance", 4 "excellent/full compliance".

NOTE! The average "compliance" score is calculated to show the score per one GES criterion/indicator (on average).

GES criteria and indicators relevant for assessing status of soft bottom macrofauna		**FI-BBI LV-BQI**	**2.9 Population structure of Macoma balthica**	**Best score of compliance with the GES Indicator**
1.1 Species distribution	1.1.1.	0	0	**0**
	1.1.2.	0	0	**0**
	1.1.3	0	0	**0**
1.2 Population size	1.2.1.	0	0	**0**
1.3 Population condition	1.3.1.	0	3	**3**
	1.3.2.	0	0	**0**
1.6 Habitat	1.6.1.	4	4	**4**
	1.6.2.	3	2	**3**
1.7 Ecosystem structure	1.7.1.	2	0	**2**
Average Compliance score per indicator for each indicator:		**1.0**	**1.0**	
Average Compliance score per criterion for each indicator:		**1.8**	**1.8**	
Average score of the "set" of assessment indicators to comply with all GES criteria and indicators of the Descriptor 1:				**1.33**
Average score of the "set" of assessment indicators to comply with all GES criteria of the Descriptor 1:				**2.40**

Both indicators respond to two criteria and with the two indicators together respond to three out of five Descriptor 1 GES criteria seen as relevant for soft-bottom macrofauna, and are thus complementing each other. The indicators have the same average "compliance score" (1.0). When assessing "the compliance" score to comply with all relevant GES criteria and indicators of the

Descriptor 1 which requires a "set" including both indicators, the average "compliance score for such a "set" is 1.33. This is higher score than for each indicator taken individually. However, further development work on indicators is needed to ensure the optimal/satisfactory compliance of the GES assessment with regard to soft bottom macrofauna.

"Confidence" assessment of the monitoring methods

Table 9.5 shows the assessment of the "confidence" of the monitoring methods to deliver data for deriving the indicator values. The assessment is based on expert opinion of the project's experts. Currently, there is no alternative method for calculating BBI or BQI values. The new method was developed for MARMONI indicator 2.9.

Since the new method was developed and tested in Finland, the experts from the Finnish Environment Institute were asked to assess the confidence of the method by assigned the score. Latvian Institute of Aquatic Ecology has not yet tested the new method. Therefore, the same score as assigned by the Finnish experts were used for the cost-efficiency analysis of the monitoring scheme in Latvia.

The assessment shows that both current methods have "excellent confidence". Although assessed at "good confidence" level, the score is lower for the new method. The semi-automated image analysis method is accurate if images are of good quality, but errors may occur when the quality of images is lower. Development of the scanning procedure could improve the quality of images, thus increasing accuracy and reducing error measurements. An option to use a photo camera instead of the scanner is also considered by the Latvian monitoring experts.

Table 9.5. "Confidence" assessment of the monitoring methods to provide data for the soft-bottom macrofauna indicators. (Source: Assessment based on expert opinion)

The used assessment scale: 0 "no confidence at all", 1 "low confidence", 2 "moderate confidence", 3 "good confidence", 4 "excellent/full confidence".

Methods	Group of method	BBI/BQI	2.9
Zoobenthos abundance analysis	Current	4	
Length measurement by stereomicroscope or vernier calliper	Current		4
Semi - automated image analyses	New		3

Total cost-efficiency of an indicator-based monitoring scheme

The table 9.6 and 9.7 present the calculated "costs/compliance ratio", "costs/confidence ratio" and "cost-efficiency ratio" of the three scenarios of the soft bottom macrofauna monitoring schemes in Finland and Latvia, respectively (see the chapter 5.3 for more information about the ratios). The former two ratios show costs (EUR on average per year) per one unit (score) of the compliance/confidence. The latter considers both at the same time – the compliance and the confidence for the status assessment.

While the total calculated costs of the current scenario are lower than both compliance scenarios, the economic assessment according to the costs/compliance ratio shows higher cost-effectiveness of the *scenario "Compliance using the new monitoring method"* in both countries. The lower confidence score of the new method impacts the "costs/confidence ratio" resulting that the same scenario has lowest the "total cost-efficiency ratio". However, the differences between the both compliance scenarios in terms of the three criteria are in a range of 2-12% in case of Finland and 5-10% in case of Latvia.

Table 9.6. Summary on the economic assessment of the indicator-based soft bottom macrofauna monitoring scenarios in Finland (Source: Calculation based on data collected as part of the case study)

The scenarios / Assessments used in the Economic Assessment	Current monitoring (baseline) scenario (*"Current"*)	Compliance scenario with currently used methods (*"Compl_current"*)	Compliance scenario including (also) new methods (*"Compl_new"*)
Costs of the scenario (EUR), as average costs per year	389 320	412 609	405 356
"Compliance" score for the scenario (in a scale from 0-4)	1	1.3	1.3
Confidence score for the scenario (in a scale from 0-4)	4	4	3.5
Costs / Compliance ratio	**389 320**	**309 457**	**304 017**
Costs / Confidence ratio	**97 330**	**103 152**	**115 816**
Total cost-efficiency ratio	**155 728**	**154 728**	**167 734**

Table 9.7. Summary on the economic assessment of the indicator-based soft bottom macrofauna monitoring scenarios in Latvia (Source: Calculation based on data collected as part of the case study)

The scenarios / Assessments used in the Economic Assessment	Current monitoring (baseline) scenario (*"Current"*)	Compliance scenario with currently used methods (*"Compl_current"*)	Compliance scenario including (also) new methods (*"Compl_new"*)
Costs of the scenario (EUR), as average costs per year	23 602	26 596	25 760
"Compliance" score for the scenario (in a scale from 0-4)	1	*1.3*	*1.3*
Confidence score for the scenario (in a scale from 0-4)	4	4	3.5
Costs / Compliance ratio	**23 602**	**19 542**	**18 915**
Costs / Confidence ratio	**5 765**	**6 514**	**7 206**
Total cost-efficiency ratio	**9 225**	**9 771**	**10 436**

9.7 Summary on the results and conclusions

- The monitoring of soft bottom macrofauna has been implemented in Finland and Latvia before the adoption of the MSFD. Macroinvertebrates are one of the biological elements for assessing the good ecological status in coastal waters according to the requirements of the WFD. Due to earlier started work in the frame of the WFD, the Brackish Water Benthic Index (BBI) in Finland and Benthic Quality Index (BQI) in Latvia have been developed and used as the indicators for assessment of the GES of the soft bottom macrofauna. The BBI/BQI indicator forms a "*baseline/current scenario"* in the analysis.
- During the MARMONI project a new indicator (2.9 "*Population structure of Macoma balthica*") to comply with another criterion of the MSFD was developed. Combining complementary to each other indicators (the current and the new indicator) the "compliance scenario" is built for the

socio-economic assessment. Both indicators are computed based on data from a joint field work and a part of the laboratory work. These costs are accounted once only, and only additional costs of the new MARMONI indicator 2.9 are accounted in addition. As the result an increase in the total calculated costs of the "compliance" scenario compared to the "current scenario" is minor – by 6% in Finland and 13% in Latvia.

- During the MARMONI project a new laboratory method for measuring size of the *Macoma balthica* was developed and tested. The new method applied semi-automated image analysis, including scanning of samples and subsequent data processing, with image data software (ACSA or ImageJ) to measure the size of individual specimens. The results show that the total calculated costs of the new method are lower (around 30-40%) than the costs of the currently used method using microscope. The total calculated costs for the monitoring scenario *"Compliance with new methods"* (*"Compl_new"*) are 16 036 EUR on average per year in Finland and 2 159 EUR on average per year in Latvia.
- The new method has higher cost-effectiveness due to the savings on the personnel and equipment in the laboratory. This means less man-days or work-load of the staff in charge of the macrofauna analysis. Considering the sampling intensity in the case of Latvia as defined by the new soft-bottom macrofauna monitoring programmes the replacement of the current method with the new method might cause institutional capacity implications, if the work load is reduced.
- While the total calculated costs of the baseline/current scenario are lower than both compliance scenarios, the economic assessment according to the *costs/compliance ratio* shows higher cost-effectiveness of the *scenario "Compliance using the new monitoring method"* in both countries. The lower confidence score of the new method impacts the "costs/confidence ratio" resulting that the same scenario has lowest the "total cost-efficiency ratio". However, the difference between the both compliance scenarios in terms of the total cost-efficiency is in range of 6-8% in both countries.

10 Conclusions and Recommendations

Indicator-based monitoring programmes

- New marine biodiversity monitoring programmes/schemes aim to comply with the needs of the MSFD for assessment of GES according to the defined criteria and indicators. While the marine monitoring activities have been implemented to different extents and scales in the project's countries, the activities were not targeted to provide data according to the indicator needs. The initial assessment on the GES according to MSFD confirmed that the availability of the monitoring data did not ensure their applicability for the GES assessment. The major disconnection between monitoring and assessment is a lack of the biodiversity indicators that would comply with the assessment requirements of the MSFD (for the Descriptor 1). Therefore, bridging monitoring activities with assessment needs will enhance achievement of the aim of the monitoring programmes/schemes.
- The socio-economic assessment addressed marine monitoring programmes/schemes with regard to the key functional groups dealt within the MARMONI project (benthic, pelagic, birds) for which new biodiversity indicators were developed. The case studies on the socio-economic assessment were performed for those functional groups (wintering waterbirds, zooplankton, phytobenthos, and soft bottom macrofauna) for which not only indicators but also new monitoring methods were developed, tested and recommended for use in monitoring.
- The socio-economic assessment was based on the following three criteria for the assessment of the monitoring programmes/schemes: *"costs"* of the monitoring programme/scheme, *"compliance"* of an indicator based monitoring programme/scheme to the requirements for assessing GES with regard to the biodiversity, "*confidence"* of applied monitoring methods to deliver information that it allows compliant status assessment.
- MARMONI project did not work on optimal design of the monitoring programme (e.g. number of monitoring sites and sampling frequency). Consequently, the socio-economic assessment didn't aim identifying optimal solutions concerning these issues. The spatial coverage and sampling frequency were only used as variables to calculate the monitoring costs. However, these variables are major determinants of the costs as well as the total cost-efficiency of the programme.

Costs of the monitoring scenarios

- Socio-economic analysis aimed to assess three scenarios: 1) a baseline (current) scenario using existing biodiversity assessment indicators, 2) a policy compliance scenario including new indicators and applying the current monitoring methods, 3) a policy compliance scenario including new indicators and applying new monitoring methods. Data on monitoring design and costs for relevant types of monitoring activities were gathered to perform the analysis on case studies.
- Results from collecting data and calculating costs of the monitoring programmes/schemes show that the cost structure differs among monitoring programmes/schemes of the analysed functional groups. Nevertheless, field work costs have a major share in the total calculated costs for all analysed case studies. Therefore, new field methods (e.g., drop-video) are developed or the monitoring campaigns are organised jointly (zooplankton, soft bottom macrofauna) to reduce costs per sample/area covered. Moreover, it is important that the observations/samples can deliver data needed for multiple GES criteria and indicators.
- The labour intensive laboratory work for treatment and analysis of the data constitutes a significant share of resource needs for zooplankton and soft bottom macrofauna monitoring. Consequently, new methods based on automatic image analysis were developed by the MARMONI project to increase the cost-effectiveness. The assessment of the total calculated

costs of the policy compliance scenarios revealed that the monitoring scenario using a new method instead of the current one is least costly in the analysed case studies, thus provides cost saving potential for the future to increase cost-effectiveness of the monitoring programmes.

- Monitoring, in particularly laboratory work involving species identification, requires specific qualification of the laboratory worker (e.g., knowledge on species and habitats as well as skills in species identification). Furthermore, certain field work and laboratory equipment is used solely for the monitoring of particular biodiversity component. Indirect costs are also related to taxonomic work, inter-calibration internationally, regular acquiring literature/information on developments in the field, travel costs for attending international meetings, courses etc. Therefore, a monitoring institute has a minimum cost level for having and maintaining a capacity to implement monitoring at any monitoring intensity.
- The established methodology for socio-economic assessment can help to build an optimal monitoring programme when the best use of the equipment and staff resources shall be determined. An increase in the total costs for the policy compliance monitoring programme can be justified by the increase in the cost-effectiveness in terms of the costs per sample or monitored area. However, the knowledge on the optimum spatial and temporal requirements for the monitoring data to calculate indicator values is a prerequisite.

***"Compliance"* assessment of the indicators**

- MARMONI project did not aim to develop a complete list of indicators covering all possible aspects of the marine biodiversity, or to fulfil all the assessment needs set by different policy frameworks. Instead, the aim was to fill major gaps concerning marine biodiversity indicators. The socio-economic assessment of the monitoring programmes/ schemes based on the indicator approach mirrors this position. The *compliance* assessment reveals that the indicator-based monitoring schemes of the analysed functional groups/subgroups are below good compliance towards MSFD GES criteria and indicators. The set of wintering bird indicators is the most advanced in this regard covering 4 out of 5 GES criteria and 5 out of 7 indicators.
- The analysis shows that adding new biodiversity assessment indicators commonly creates relatively small increase in the costs or doesn't cause additional costs at all. Moreover, although addressing similar GES criteria/indicators for the Descriptor 1, the developed assessment indicators address different functional groups or subgroups important for the biodiversity.
- In order to achieve better compliance with the MSFD and other policy requirements, further support for science and research is needed for the indicators' development work in upcoming years. This work is closely linked to the monitoring activities - provided data types, their temporal and geographical coverage. It requires permanent involvement of monitoring experts in research activities as well as supply of monitoring data with high resolution. Costs for the development of a policy compliant indicators' set shall be foreseen either as a share in the total costs of the monitoring programme or as additional costs allocated to particular research programmes or studies.

"Confidence" assessment of the monitoring methods

- The results show that confidence assessment for the same new method can differ among countries. The country, which has developed new method, assigns higher confidence to that method. Therefore joint capacity building and training for countries would be recommendable to ensure that new methods are better acknowledge in other countries too.
- While new methods are targeted to save monitoring costs, monitored parameters with regard to the taxonomic resolution are not the same what are delivered by the current methods. As demonstrated for some of the indicators (e.g., concerning zooplankton), the

current monitoring method is still necessary to satisfy needs for indicators assessing status at species level. Moreover, it is recommendable also that the current methods are included in monitoring for calibration and verification of the new methods. Furthermore, the monitoring using the current methods might provide relevant knowledge to deliver new assessment indicators.

Total cost-efficiency of an indicator-based monitoring scheme

- Although the new methods analysed by the case-studies have lower confidence to deliver data and information that it allows compliance assessment for GES, the costs is an important factor determining the total cost-efficiency of a monitoring program/scheme. Significantly lower cost-efficiency ratio is obtained when the new method reduces the man-time necessary for monitoring works substantially.
- When developing the marine monitoring programme it need to be recognising that a monitoring institution has a minimum cost level for developing and maintaining a capacity (in terms of both – human resources and equipment)to implement monitoring at any monitoring intensity. Thus, the cost-efficiency of the monitoring programme improves if the field, laboratory and data treatment work is balanced towards efficient use of at least minimum capacity of the institution.
- As illustrated by the case studies, the new indicators build on joint field data collection and/or treatment, thus new indicators can be added often without increase in the costs. In order to increase cost-efficiency of an indicator-based monitoring programme, the maximisation of the use of monitoring data towards covering gaps of assessment needs to be further encouraged and supported.

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