1. First stakeholder survey

1.1 Summary:

The first stakeholder survey was conducted to get a first estimate on the main gaps in the current Baltic Sea monitoring, and novel methods to fill them. Furthermore, on the base of the replies, the second and more comprehensive survey was designed.

In a FUMARI workshop, a list of the most important stakeholders regarding the marine environmental assessment and its implementation in the Baltic Sea was generated. This list contained ministries and institutions (i.e. Environmental Ministries) in all Baltic countries. The stakeholder survey was sent to this list using the platform survey monkey. The survey was accessible from 24.10. to 05.11.2018.

The survey comprised three questions regarding the gaps in the current Baltic Sea monitoring and novel methods to fill these gaps.

Nine replies were received on the survey:

* 9 replies (Swedish Agency for Marine and Water Management, SMHI, Finnish Ministry of the Environment (YM), HELCOM, Aarhus University, Klaipeda University, Seanalytics AB).
* Many stakeholders replied that they feel unsure to reply to our survey “because they are not experts”, or “not experts in respect to give a holistic view of the entire Baltic monitoring”.
* Some replied that gap analyses are ongoing elsewhere.

2.2 Detailed questions and responses:

Question 1 **Please list the five most critical gaps of the current Baltic marine monitoring programs with regard to legal requirements. Please list your answers in order of relevance (1=highest).**	
Reply 1	1. There are still gaps in the HELCOM core indicator lineup. 2. The temporal resolution of the monitoring (in situ) in near-coastal island dense archipelago areas is not frequent enough 3. The spatial resolution of the monitoring is too poor to allow for e.g. linkage of water quality to the condition/health of benthic habitats 4. Benthic marine biodiversity is not properly addressed in the monitoring programme, and it has consequences for planning and management of marine areas, and for the Habitats Directive reporting. 5. Marine litter and underwater noise are not monitoring well enough at the moment
Reply 2	1. Monitoring of benthic habitats (other than soft bottom fauna). 2. Structured, fit for purpose, monitoring of species (distribution, abundance...) 3. Opportunistic monitoring (monitor multiple parameters at the same time) to enhance cost effectiveness and efficiency. 4. Monitoring to support MPA management.
Reply 3	1. Fishing discard ban enforcement 2. Better monitoring of wintering offshore seabirds 3. More focus on indicators of the effects of dangerous substances 4. Continuous monitoring of dissolved oxygen, for model calibration

	5. Monitoring of continuous and impulsive noise
Reply 4	1. Extent of benthic habitats habitat quality - in terms of species occurrence on hard bottoms 2. lack in spatial resolution for several parameters species composition plankton 3. Introduction of non indigenous species
Reply 5	1. Lack of taxonomic resolution and taxonomic inconsistency 2. Missing in-situ and remote sensor network for collecting biological data 3. Missing approaches to predict biological patters and processes 4. Missing data (e.g. too sparse spatio-temporal sampling, and absence of trait data to monitor functional status) 5. Missing integration of scientists, monitoring programes and stakeholders of the biological information generated in the monitoring
Reply 6	1. Monitoring of impacts of harmful substances; 2. Monitoring of marine litter, especially micro-litter and its impacts; 3. Monitoring of impacts of underwater noise; 4. Sufficiently frequent monitoring of water column oxygen conditions as well as carbon system and acidification parameters; 5. Picoplankton and bacterioplankton monitoring.
Reply 7	1. Macrophytobenthos monitoring in the southeastern Baltic Sea coast and transitional waters (especially in Latvia and Lithuania) is performed relatively seldom (every 3 years), there is a limited budget dedicated for the monitoring and the monitoring sites are not accurately fixed (GPS and a boat drift make position error up to 20-50 m), which makes status evaluation not very clear, especially in very patchy bottoms stretching for 2-4 km along gentle slope till maximum vegetation colonization depth (15-16 m) in the coastal waters. 2. The indicators based on macrophytobenthos for transitional waters have not been successfully tested with pressure gradients in Lithuania, Latvia and Poland. Low relationships between indicators and pressures could be due to low number of samples within a gradient of pressure (e.g. water transparency, chlorophyll a) and/or interaction with other environmental factors such as wave exposure and salinity. 3. There is a lack of indicators for benthic habitats. Several related criteria (species distribution, habitat extent, etc.) have not been developed yet according to the Marine strategy water directive.
Reply 8	1. Too few observations to produce precise indicators 2. Almost no measurements of organic matter 3. Coordination of monitoring activities for eutrophication with higher trophic levels, e.g. fish monitoring 4. Maintaining high quality of monitoring data after consultants take over routine monitoring 5. Harmonisation of monitoring methods for biological parameters across countries or even within countries
Reply 9	1. Funding 2. Spatial coverage 3. Coverage of biological/biodiversity monitoring 4. Low number of intensive stations 5. Few long-term observation stations
Question 2:	

Please state, which (if any) novel methods could enhance the Baltic marine monitoring. Please also indicate if you think that this method would improve coverage (e.g. spatial, or in terms of covering important organism groups), cost effectiveness, or reliability.	
Reply 1	1. EO (Earth Observations) and other remote sensing methods would explode spatial coverage for some basic variables. 2. Automatic sensors and water quality analyzers should be more widely used on Freight ships (spatial/temporal coverage), 3. DNA-barcoding may enhance biodiversity monitoring significantly.
Reply 2	1. Automated systems with sensors + loggers/direct data export would make it possible to overcome the spatial and temporal gaps described in point 2. FI/Baltic Sea states should consider the possibility to join forces in the development of new sensors and automated monitoring systems
Reply 3	Satellite and passive monitoring methods. These allow for higher spatial coverage for lower cost, and can supply several countries with data at once.
Reply 4	Oxygen sensors on gliders. Better use of citizen science for bird data. More amphipod indicator organisms. All would improve data coverage and resolution at little additional expense.
Reply 5	remote sensing & eDNA
Reply 6	In general I believe we need to promote the use of machines instead of humans to collect data. There are two important advantages in this technology shift. First machines generate much more information, second machine create more consistent information. However, there are many challenges associated with such development, which need to be addressed (e.g. data management and provenance, technological dependencies, etc). IMHO, methods with potential for use in Baltic monitoring include 1. DNA-based monitoring (incl. metabarcoding, eDNA) 2. Image and sonar-based remote sensing 3. integrated modelling approaches (e.g. combination of mechanistic biophysical models with statistical species distribution models)
Reply 7	Use of autonomous devices for monitoring of pelagic parameters. Most importantly, cost-efficiency will be increased if combine different observational programs (environmental monitoring, operational oceanography, impact monitoring of maritime activities, etc.)
Reply 8	3D acoustic methods could enhance benthic habitat including macrophytobenthos monitoring. However, comprehensive analysis is needed how this method would improve in different aspects. For hard bottom habitat monitoring in a very patchy bottom, development of fixed site monitoring, which could be easily found by divers or ROV and strong enough to withstand very exposed coast to cyclonic waves, may increase the accuracy of measurements.
Reply 9	Scanning FlowCytoMetry for fast and more accurate monitoring of plankton communities. This method is far cheaper than traditional methods and will allow for improved coverage in time and space. DIC, pCO_2, pH and total alkalinity measurements. Novel instruments have been developed in recent decades that produce more reliable information on the carbonate system. Autonomous Underwater Vehicles (AUVs) for monitoring benthic vegetation in combination with improved image analysis techniques constitute a more cost-efficient method than today's survey.

Question 3: **Do you think any novel monitoring method could replace an existing one in the near future (1 to 5 years)? If yes, which?**	
Reply 1	Yes/No. I think that the existing empiric data collection probably needs to be kept at the present level, to provide sufficient ground trothing data (of remote sensing data) and as a back up for possible problems that might occur when using data from automated sensor systems. But the data we would get from the new systems would provide a huge improvement in data quality/resolution.
Reply 2	Autonomous gliders should replace CTD via vessel right now, but it takes time to get rid of the RVs
Reply 3	5 years, remote sensing
Reply 4	Nope, I think for the next 5 years we should work towards "integration" of new methods in conventional monitoring programmes. In cases where we see added value of the new methods and redundancy with a conventional method we can phase out the unnecessary method. I believe this may take app. 5-15 years.
Reply 5	I do not believe that novel methods completely replace any existing on in the near future. Instead, the novel methods could increase the reliability and confidence of assessments. And in some cases will reduce the workload spent using classical methods.
Reply 6	It is hard to state if these methods will replace existing ones, but both methods will definitely improve existing monitoring and understanding about changes in the benthic habitats.
Reply 7	FlowCytometry can partly replace phytoplankton microscopy for the quantitative assessment of the plankton community. Novel pH sensors based on colormetric reactions can replace pH electronic sensors. AUVs with image analysis can replace diver transects.

2. Second stakeholder survey

2.1 Summary:

The second stakeholder survey was conducted to collect detailed stakeholder opinions on the main gaps in Baltic Sea monitoring and methods, which can be used to fill these. Based on the results of the first stakeholder survey, a detailed survey was designed by the FUMARI consortium, to:

a) Specify the shortcomings in the Baltic Sea monitoring regarding the directives MSFD, WFD and BSAP to assess the good status of the Baltic Sea region (including lacks in the regulation by legislation, as well as its implementation).
b) Identify novel methods, which have the potential to supplement and/or replace currently applied methods.

The online survey was designed using Netigate and sent to 42 key stakeholders working in the field of Baltic status assessment (these were identified by the FUMARI project team). Furthermore, the survey was disseminated over various websites and platforms like the websites of the FUMARI project team or in meetings and conferences. The aim was to reach out to as many stakeholders as possible to collect their opinions on this topic. The survey was accessible from 21.03 to 20.05.2019.

We decided to keep the whole survey anonymous, since the first survey indicated that some stakeholders are not willing to give a public statement (since they don't feel like experts or don't have a holistic view on the Baltic monitoring).

The survey comprised 30 general and detailed questions, which are listed in detail in the Supplementary Material A-2.

2.2 Results:

31 completed survey replies were submitted, most of them from Germany (11) and Sweden (11), followed by Finland (4) and Latvia (2). Estonia, Lithuania and Poland were represented by one reply each. Most of the replies came from stakeholders with their expertise in the Environmental Management working with HELCOM and the MSFD (21) and working with the WFD (7). About half the repliers were working in Baltic Sea research (16).

17 stakeholders replied that "Good status cannot be assessed satisfactory because certain priority areas or pressures in the Baltic Sea marine region are not adequately covered by the existing Descriptors/Quality elements/Baltic Sea Action Plan Objectives" and most of them proposed new thematic categories or stressors that should be observed. Most frequent new thematic categories included dumped munitions, climate change and the damage caused by fishing gear to the sea bottom.

30 stakeholders replied that "the existing indicators used in current Baltic Sea monitoring do not sufficiently cover the assessment of the thematic categories set by existing legislation", 29 of them made suggestions for improvements. The thematic categories mentioned most often were Biodiversity (9), Marine litter (6), Food webs (5) and Sea-floor integrity (5).

Regarding novel methods with the potential to improve Baltic monitoring, stakeholders suggested the Moving Vessel Profiler (MVP), Active Biomonitoring using Blue Mussels, Argo Floats, Gliders, the passive sampler CHEMCATCHER, Unmanned Aerial Vehicles, Earth Observation and DNA barcoding (see Supplementary Material A-2).