THEME 4: Noise

This is a deliverable from the BalticBOOST project that was coordinated by HELCOM and co-financed by the European Union in 2015-2016 as part of the programme DG ENV/MSFD Action Plans/2016.

WP 4.1 Deliverable 2: Proposal for a regional monitoring programme of continuous noise

Partner: [1] Swedish Defence Research Agency (FOI)

Authors: Peter Sigray[1], Mathias Andersson[1], Emilia Lalander[1]

Contents

1. Introduction

One of the aims of BalticBOOST theme 4 was to identify the mechanisms needed to develop a regional monitoring programme of continuous underwater noise. This was done based on the outcomes from the EU LIFE+ project Baltic Sea Information on the Acoustic Soundscape (BIAS). BIAS started in September 2012 and was directed towards the Descriptor 11 and especially Criterion 11.2: "Continuous low frequency sound". The project aimed at the establishment of a baseline soundscape map of the Baltic Sea for 2014 and to develop a regional implementation plan for this with regional standards, methodologies, and tools allowing for cross-border handling of acoustic data and the associated results.

The BIAS project aimed to include all phases of implementation of a joint monitoring programme across national borders (Figure 1). One year of measurements were performed in 2014 with help of 38 acoustic sensors deployed across the Baltic Sea by six nations. The measurements, as well as the post-processing of the measurement data, were subject to standard field procedures, quality control and signal processing routines, all established within BIAS based on the recommendations by the MSFD CIS TG Noise [1]. The measured acoustic data on low frequent continuous noise are used as input to the model that produces noise maps for the project area, which will provide the first views of the Baltic Sea soundscape variation on a monthly basis over a year. In parallel, a GIS-based online tool is being designed for handling and visualizing both the measured data and the modelled.

The BIAS project ended in August 2016, and one of the outputs of the project was the BIAS implementation plan. The implementation plan summarizes experiences learned during BIAS, and propose future management activities. The current version of the regional monitoring programme, that makes a part of the implementation plan, is presented in this document.

The Monitoring Programme has been considered by the HELCOM State and Conservation Working Group in 2016 (State & Conservation 4-2016) and further work on the regional monitoring programme is envisaged for 2017-2018 including i.e. final agreement on location of stations, as part of the Work Plan for State and Conservation for 2017-2018.
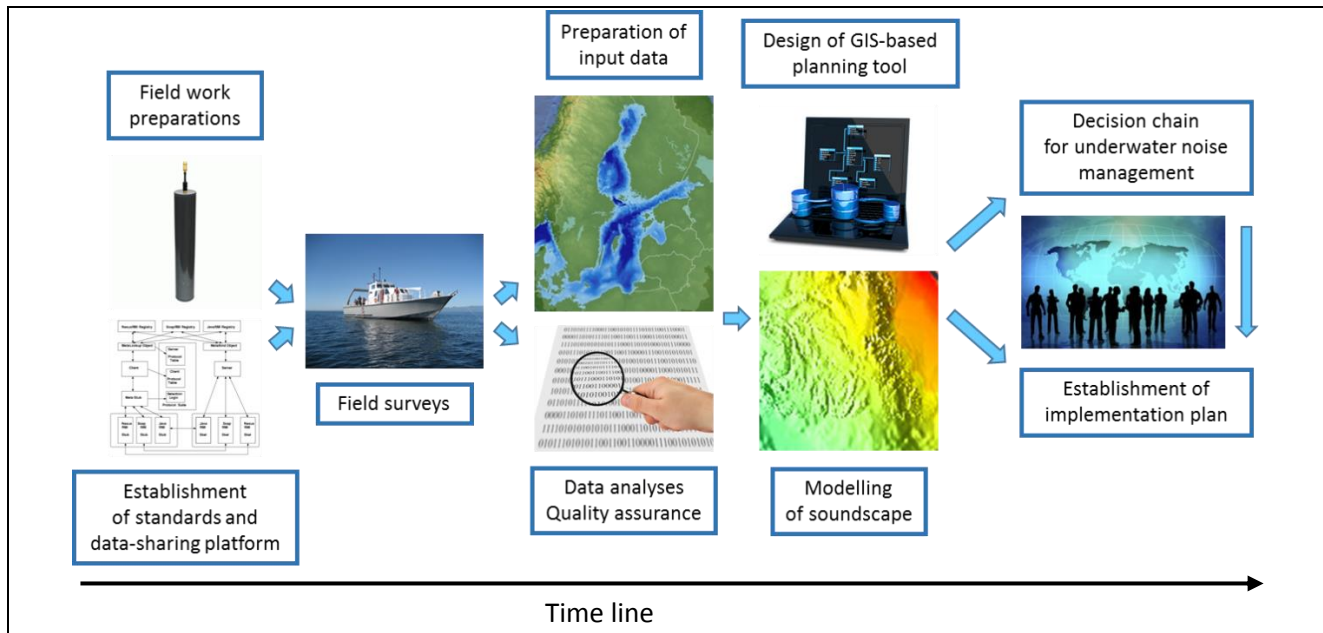
Figure 1. The actions of the EU LIFE+ project Baltic Sea Information on the Acoustic Soundscape, 2012-2016. The black line shows the current phase of the BIAS project.

2. Monitoring the underwater soundscape

Underwater continuous low frequency sound may be directly observed through *in situ* acoustic measurements of noise levels. These measurements yield data of the acoustic level with high temporal resolution over a wide frequency range. The measured data contain noise generated by anthropogenic as well as natural (known and unknown/unspecified) sound sources, such as ships, marine infrastructures, wave breaking, rainfall, or ice.

Sound may also be monitored employing soundscape models, based on data for the natural and anthropogenic sound sources (see above), which are known or believed to influence the soundscape. Data are also needed in the model to describe the environmental properties (bathymetry and sea bed sediments) and conditions (e.g. water stratification and speed of sound). These models require measured data for calibration and verification, but also for making it possible to model/include natural noise which otherwise cannot be fully characterized in a model. Models have the benefit of providing information over a larger spatial coverage of an interest region and, hence, act as a complement to measurements.

For a complete view of the soundscape, both these monitoring methods need to be combined. In BIAS, this has been realized with a web-based tool designed for handling and visualizing the results from the monitoring programme of BIAS. One objective of the tool is to be used for future monitoring of underwater noise in the Baltic Sea. The modelled soundscape maps can be explored visually in a GIS interface of the tool, allowing the user to focus on any arbitrary location within the BIAS project area and compare maps of different time periods, various noise frequencies, and statistical measures. The tool currently holds data for the BIAS field programme year 2014, but is prepared for importing measurement data or modelled soundscape maps from monitoring efforts in the years to come.

For more information on the BIAS measurement procedures, sensor requirements and handling of sensors as well as data, please refer to the BIAS Standards for Noise Measurements [2]. In the same manner, standard procedures for the digital data (signal) processing is compiled in the BIAS Standards for Signal Processing [3].

2.1 Suggested monitoring approach

Based on the experiences made in BIAS the monitoring activities for underwater noise in the Baltic Sea are suggested to follow a strategy with a periodically occurring and alternating minor and major assessment.

Minor assessment: acoustic measurements should be undertaken at the prioritized measurement locations (Figure 2), with the aim to maintain the observational records for all Baltic Sea subbasins and follow up the noise levels measured during earlier years in accordance with Indicator 11.2.1 In order to extend the observations at the measurement locations to full Baltic Sea scale, the latest version of the soundscape model can be used with updated information on ship traffic and environmental conditions for the current year. If the process of invoking the new input data into the model is made as automatic as possible, this modelling effort does not necessarily imply any extraordinary work load. Rather, by fairly straightforward means the use of a model will facilitate the detection of various characteristics and patterns in acoustic sound level in areas distant from the measurement locations, and enable a larger scale spatial evaluation of the underwater soundscape as well as comparisons to auxiliary information on e.g. biological values. The measured data should, therefore, also be used to estimate the compatibility of the soundscape model results produced with the current year's conditions for noise, ship traffic and ship characteristics, and weather and climate.

Major assessment: a large effort assessment effort with extensive field measurement programme ("new BIAS") will be done with several years interval replacing that specific year the minor assessment. These time intervals are determined by the need for extended monitoring efforts based on the yearly observed or modelled results (minor assessment), or by the need for specific actions or results dictated by e.g. the MSFD roadmap. The major measurement campaign aims to collect the necessary amount of data in order to carefully calibrate the soundscape model towards the full range of acoustic characteristics in all the subbasins of the Baltic Sea. In addition to the larger work load associated with the field survey and post-survey data processing, this effort also encompasses (in the same manner as BIAS) the compilation of background input data to the model, the model calibration, and the model runs for monthly soundscape maps. Although the measurement campaign takes one year, the total time to prepare the field work, compile the data and produce the soundscape maps is estimated to take two-three years.
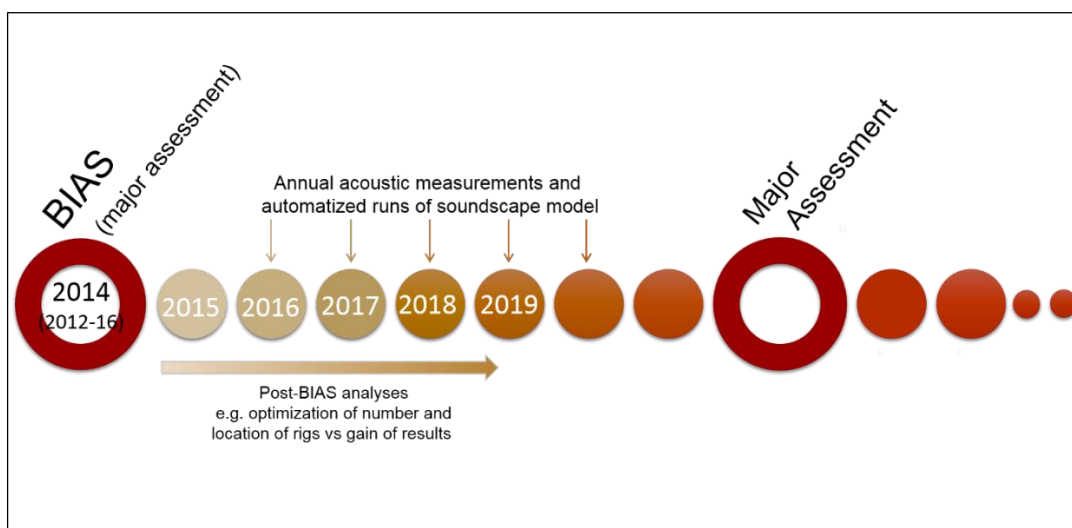

Figure 2. Schematic view of the monitoring strategy with minor assessment as smaller circles and major assessments as large circles. The shaded arrow denotes the years after BIAS when several aspects need to be further investigated in order to further adjust and optimize the monitoring. The major assessments should be accustomed to either the need for extended monitoring efforts based on the results observed or modelled on the yearly basis or to a fixed time period of e.g. 6-year.

2.2 Monitoring locations for minor and major assessments

Each nation participating in BIAS has, based on the BIAS experience selected at least one priority location for hydrophone measurements which are presented in Figure 3. This network of locations (11 suggested prioritized locations) is considerably smaller than the one during the BIAS project, but covers the main subbasins of the Baltic Sea, and regions of various soundscape character. The measurement activity at these locations varied between nations during 2015, but was for most nations fully resumed in 2016 (Table 1). These locations are suggested for minor assessments.

For a major assessment a similar measurement set-up as was used in the BIAS field survey in 2014 could be applied. 38 acoustic sensors were then located in a range of environments representing two different main soundscape categories; category A was used for measuring the background noise at a distance far-away from the shipping lane while category B was used for ship signature in order to calibrate the soundscape model (Figure 3). These categories were defined based on ship traffic density as well as on environmental background data such as bathymetry and seabed sediments. The rig locations were also adjusted to general military or shipping lane regulations, and areas subject to trawling activities, strong currents, or extreme ship traffic were avoided.

Table 1. Status of the acoustic measurements during the years following the BIAS field survey in 2014, where "-" signifies no measurements and "✓" means that hydrophones has been deployed at one or more of the nationally prioritized locations.

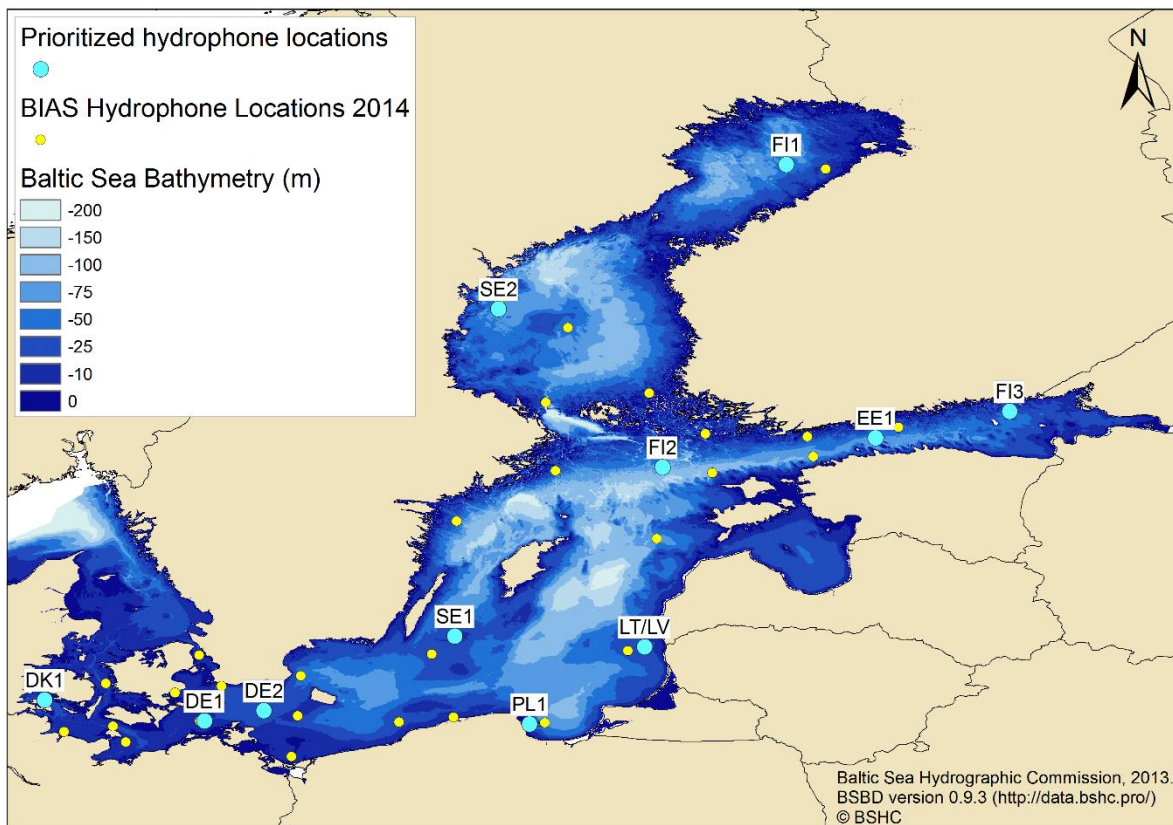| Year	Denmark	Germany	Poland	Estonia	Finland	Sweden	Latvia / Lithuania
2015	-	-	✓	✓	✓	partly	-
2016	✓	✓	✓	✓	✓	✓	?

Figure 3. Selected prioritized locations for the minor assessment shown in blue dots, while the measurement location used in the BIAS project are shown with yellow dots.

3. Cost estimates

The following estimate is based on numbers delivered by the beneficiaries of BIAS. The costs assumes that already available autonomous sensors procured in the BIAS project are used. The cost estimates summarized below are given for the field work associated with the Minor Assessment (State and Conservation 6J-2). This includes labor costs, ship costs and travel expenses for deploying 12 rigs in the Baltic Sea. On top of this, costs for regional coordination, handling the web-based tool and data management will be added.

4. Deployment and data handling

Each country participating in BIAS have specified the costs for deploying the rigs at the prioritized locations, presented in Table 2.

Table 2. Cost estimates in euro (€) of minor assessment field surveys for the prioritized locations.

	Denmark	Germany	Poland	Estonia	Finland	Sweden	Latvia/ Lithuania
Labor cost per deployment	5 769	2 900	3 500	7 680	24 100	14 824	3 500
Sum ships and consumables per deployment	1 544	12 300	2 250	5 200	15 318	17 294	2 250
Sum travel expenses per deployment	221	300	750	280	3 035	1 824	750
Total cost per deployment	7 534	15 500	6 500	13 160	42 453	33 941	6 500
Yearly cost: four deployments DK, DE, PL, EE, two deployments FI, SE	30 136	62 000	26 000	52 640	84 906	67 882	26 000

5. Modelling

Routine modelling plays a central part in the proposed Minor Assessment. These will be used to assess the soundscape on a regional scale as well as to understand observed changes in the soundscape, such as an observed trend. The cost estimate of modelling is in the range 25 to 35 k€. This cost will be shared among the Member States of HELCOM. It should be underlined that this does not take into account preliminary work to set-up the model, adapting HELCOM AIS data to the model, delivery of data to external servers, meetings or internal archiving.

6. References

[1] Monitoring Guidance for Underwater Noise in European Seas, PART I - EXECUTIVE SUMMARY & RECOMMENDATIONS, http://publications.jrc.ec.europa.eu/repository/handle/JRC88733

[2] BIAS standards for noise measurements, https://biasproject.files.wordpress.com/2013/11/bias_standards_v3-2.pdf

[3] BIAS standards for signal processing, https://biasproject.files.wordpress.com/2015/06/bias_sigproc_standards_v1-8.pdf