Baltic Marine Environment Protection Commission

Group for the Implementation of the Ecosystem Approach
Gothenburg, Sweden, 10-11 May 2016

GEAR 14-2016

Document title	Update on HELCOM work on underwater noise towards common principles for environmental targets
Code	3-7
Category	CMNT
Agenda Item	Activities of relevant HELCOM projects or processes
Submission date	19.4.2016
Submitted by	Secretariat
Reference	

Background

HELCOM 37-2016 adopted the 'Regional Baltic Underwater Noise Roadmap 2015-2017' as included in Annex 3 to the Outcome of HELCOM 37-2016. The Roadmap is based on five steps aiming to prepare a knowledge base towards a regional action plan on underwater noise in 2017/2018 to meet the objectives of the 2013 Ministerial Meeting, and of the EU MSFD for HELCOM countries being EU Member States. Step 3 aims at 'Based on the compilation of information on impacts of noise (1.1), investigate the possibility to use species specific tolerance to define Good Environmental Status / develop environmental targets based on common principles'.

This document aims at providing an update of the HELCOM work conducted so far and the further work planned on underwater noise, towards defining levels of underwater noise in the Baltic Sea that are consistent with GES for sound sensitive populations. A draft report on the identification of the spatial and temporal distributions of noise sensitive species and habitats in the HELCOM area and the organisation of a two-day workshop exploring and recommending principles for defining levels of underwater noise consistent with GES for sound-sensitive species for underwater noise constitute the focus of this document.

In addition, an overall summary on HELCOM work on underwater noise is provided, i.e. the drafting of a proposal for a regional monitoring programme of ambient noise, the work on the establishment of the OSPAR/HELCOM registry of impulsive events and the work on survey of possible measures to manage and mitigate relevant impacts of underwater noise in the Baltic Sea. The work on the registry is being developed in the frame of HELCOM regular work, while other activities presented in this document are conducted under HELCOM coordinated EU co-financed BalticBOOST project, theme 4 on Underwater noise.

A draft report presenting the rationale for identifying Baltic species which have the potential to be impacted by noise together with a preliminary identification of biologically sensitive areas was submitted to STATE & CONSERVATION 4-2016 (doc. 6J-1) for their consideration. The document also supplies a prioritized list of noise sensitive species based on the following criteria: hearing sensitivity, known (or suspected) noise impact on the species, threat status, commercial value, and data availability. For each of the prioritized species the distribution of species and biologically sensitive areas is presented based on available data. Finally, a map compiling identified sound sensitive areas is presented. Identifying target species and sensitive areas are the first steps towards investigating and defining levels of underwater noise in the Baltic that are consistent with GES for sound sensitive populations. The document is planned to be finalized by June 2016.

The provisional draft programme of the workshop was shared with the HELCOM EN-Noise, Pressure (PRESSURE 4-2016, doc. 3-4) and State and Conservation (STATE&CONSERVATION 4-2016, doc. 6J-1) Working Groups for their contribution by 6 May 2016.

HOD 49-2015 agreed that HELCOM joins the OSPAR registry of impulsive noise and on the need to clarify hosting of the database and condition of hosting and noted that the work on reporting details is still ongoing and is aimed to be finalized by HELCOM EN-Noise in close cooperation with OSPAR and ICES (Outcome of HOD 49-2015, par. 4.33). Already in STATE & COSERVATION 2-2015 (Outcome of STATE & CONSERVATION 2-2015, para 4J-13) it was agreed that the work on the impulsive noise indicator should be closely linked to the development of a regional registry of impulsive noise. The registry will compile information on occurring licenced events (i.a. pile driving, controlled explosions from naval operations) that release energy in the Baltic Sea, contributing to the definition of sound hot spot areas which will ultimate enable determining sustainable levels of impulsive sound for identified priority species. The ongoing meeting of the Pressure WG (19-21 April) will discuss a number of issues related to the work on underwater noise.

Finally, a draft regional monitoring programme of continuous noise as suggested by outcomes from the EU LIFE+ project Baltic Sea Information on the Acoustic Soundscape (BIAS) project, including cost estimates, was recently submitted to STATE & CONSERVATION 4-2016 (doc. 6J-2 Rev 1) for consideration.

Action required

The Meeting is invited to take note of the information, note the overall progress in HELCOM to address underwater noise and in particular note and consider the ongoing work on principles for setting targets.

The Meeting might wish to use this information when discussing environmental targets under Agenda Item 4.

Update on HELCOM work on underwater noise

Steps towards defining levels of underwater noise consistent with GES for sound-sensitive species

Draft report on spatial and temporal distributions of noise sensitive species and habitats

A task to be conducted under the BalticBOOST project, theme 4 on Underwater noise, is to identify the spatial and temporal distributions of noise sensitive species and habitats in the HELCOM area. For the identified species, it is proposed to develop in a first step spatial-temporal biological calendars, identifying areas and seasons that are biologically sensitive based on information of spawning, nursing, birthing etc. for the individual species.

A draft report presenting the rationale for identifying Baltic species which have the potential to be impacted by noise based on the hearing capabilities of the animals as well as on how they use and react to sound was presented to STATE and CONSERVATION 4-2016. The document also includes a proposed priority list of noise sensitive species based on the following criteria:

- **Hearing sensitivity**: for a species to be susceptible to impacts of noise outside of the immediate vicinity of the sound source it must be able to detect sound;
- **Impact of noise**: a species might be able to detect and produce sound within a range of frequencies, but it may not be very sensitive to noise disturbance, or it may react to noise even if the frequency spectrum is outside the frequency of best hearing or sound production of the species.
- **Threat status:** populations already threatened by impacts from other sources, such as eutrophication or hazardous chemicals, may be more susceptible to detrimental effects from noise. Threat status is based on information from the HELCOM red list of Baltic Sea species in danger of becoming extinct (2013).
- **Commercial value:** noise effects on species with high commercial value can potentially affect the economy of an industry such as the fishing industry or on a smaller scale recreational industry relying on the presence of marine mammals.
- **Data availability:** if little or no knowledge is available on either, hearing sensitivity or noise impact or if little or no data are available on spatial distribution, a species is not included at this stage.

Based on these criteria the following species were proposed as prioritized: harbour porpoise, harbour seal, Baltic ringed seal, grey seal, cod and herring (see Table 1). For each of the prioritized species the distribution of species and biologically sensitive areas is presented based on available data. Finally, a draft map compiling identified sound sensitive areas is presented in the report.

Identifying target species and sensitive areas are the first steps towards investigating and defining levels of underwater noise in the Baltic that are consistent with GES for sound sensitive populations. The knowledge of population effects of noise is however scarce. National noise regulations in some countries (e.g. Germany and Denmark) have therefore focused on prohibiting noise exposures to individuals above target noise levels for impulsive sounds (e.g. impact pile-driving) that have been identified as causing effects such as hearing loss or aversive behaviour in the species in question. Identifying sound sensitive species and setting target noise levels based on knowledge on hearing sensitivity, and impact of noise on the species in areas of biological importance for the species would be one way of improving the environmental status of a population without having direct knowledge of the effects of noise on the population. The way forward in terms of setting noise targets for GES will be discussed at two international workshops later this year, one is organised by TG Noise and the other by BalticBOOST (see below).

The draft report was submitted to STATE & CONSERVATION 4-2016 (doc. 6J-1) where initial proposals for its improvement where suggested. Further feedback from the Contracting Parties on the criteria for identifying noise sensitive species, on the proposed list of priority species, on the compilation map, available national data or projects that could support the development of the maps on biological sensitive areas, is requested by 6 May 2016, since the report is planned to be finalized by June 2016 (Outcome of STATE & CONSERVATION 4-2016, par.6J.1-6J.5).

Table 1. List of priority marine species based on the five criteria: 1) Hearing sensitivity, 2) Impact of noise, 3) Threat status, critically endangered (CR), vulnerable (VU), near threatened (NT), and least concern (LC), 4) Commercial value, and 5) Data availability. Each criteria is ranked based on relevance according to available knowledge as: high (red), medium (yellow), low (green), negligible (grey), or unknown (white).

	Hearing sensitivity	**References**	**Impact of noise**	**References**	**Threat status**	**Commercial value**	**Data availability**	**References**
Harbour porpoise (*Phocoena phocoena*)	Hearing sensitivity covering a wide frequency range (4-150 kHz)	*Andersen, 1970; Kastelein et al., 2002 and 2010*	TTS and behavioural changes have been investigated in relation to two types of impulsive noise (pile-drining and air-gun), and to loger duration octave band noise, as well as in relation to acoustic harrasment devices.	*Lucke et al. (2009); Kastelein et al. (2012a); Popov et al. (2011); Tougaard et al., 2009; Brandt et al., 2011; Dähne et al., 2013; Teilmann and Carstensen, 2012; Olesuik et al., 2002; Brandt et al., 2013; Coram et al., 2014*	CR/VU	NEGLIGIBLE	Data is available for the Southern Kattegat-Belt Sea harbour porpoise subpopulation, but for the Baltic Sea harbour porpoise subpopulation, data is not yet available from the SAMBAH project.	*Hammond et al. 2002, 2013; Teilmann, 2008; Sveegaard et al. 2011a; Sveegaard et al., 2011b*
Harbour seal (*Phoca vitulina vitulina*)	Hearing sensitivity covering a wide frequency range (2-30 kHz)	*Kastak and Schusterman , 1998; Møhl, 1968; Reichmuth et al., 2013*	PTS and TTS have been investigated in relation to both impulsive noise and noise of longer duration. Strong avoidance responses have not been documented in seals, but startle responses have been documented to sounds with a high rise time. Effects of masking on signal recognition has been studied in a single sea lion.	*Kastak et al., 2008; Kastak et al., 2005, Kastelein et al., 2012b Harris et al., 2001; Blackwell et al., 2004; Edren et al., 2010; Götz and Jannick, 2011; Cunningham et al., 2014;*	VU/LC		Distribution data is available for part of the harbour seal population in the Baltic.	*Dietz et al., 2012; BALSAM, 2015*
Baltic ringed seal (*Pusa hispida botnica*)	Hearing sensitivity covering a wide frequency range (1-40 kHz)	*Terhune and Ronald, 1975; Sills et al., 2015*	There are no studies for ringed seals alone, but knowledge from harbour seals and other pinnipeds can serve as a guide at this stage.		VU		Distribution data is available for part of the ringed seal population in the Baltic.	*BALSAM, 2015*
Grey seal (*Halichoerus grypus*)	Low frequency hearing sensitivity less than described for other seal species in the Baltic. Frequencies of best hearing (20-30 kHz)	*Ridgway and Joyce, 1975*	There are no studies for grey seals alone, but knowledge from harbour seals and other pinnipeds can serve as a guide at this stage.		LC		Distribution data is available for part of the grey seal population in the Baltic.	*Dietz et al., 2012; BALSAM, 2015*

Cod (*Gadus morhua*)	Hearing sensitivity covering low frequencies (below 300 Hz)	*Chapman and Hawkins, 1973; Offut, 1974*	PTS, TTS and injury in non-auditory tissue, has not been investigated in cod, but the overlap between cod communication sounds anthropogenic noise could result in masking. Catch rate of cod went down after the use of an air-gun also, suggesting some behavioural reaction.	*Rowe and Hutchings, 2004; Engås et al., 1996; Wahlberg, 1999*	VU	HIGH	One major spawning area for the Easter Baltic cod stock can be identified.	*Warnar et al., 2012; HELCOM red list species data sheet 2013, Gadus morhua*
Herring (*Clupea harengus*)	Hearing sensitivity covering low frequencies (below 1 kHz)	*Enger, 1967*	Herring in an area appeared to move to greater depth after the use of an air-gun.	*Slotte et al., 2004*	LC	HIGH	Spawning areas in the western part of the Baltic can be identified for herring.	*Warnar et al., 2012*

HELCOM workshop to explore the possibility to determine acceptable levels of underwater noise for marine species

A two day HELCOM BalticBOOST workshop on underwater noise is to be organized by HELCOM on 5-6 October 2016. The workshop aims to explore possibility to determine acceptable levels of underwater noise for marine species according to the Regional Baltic Underwater Noise Roadmap 2015-2017 adopted by HELCOM 37-2016. More specifically, the workshop is to investigate the possibility to use species specific tolerance to define Good Environmental Status / develop environmental targets based on common principles in the Baltic Sea, based on the available information on impacts of noise.

The expected outcomes will contain recommendations for common principles for defining GES/ developing environmental targets for continuous and impulsive underwater noise (e.g. the possibility to define a maximum allowable impact on marine animals to achieve GES) in the Baltic Sea.

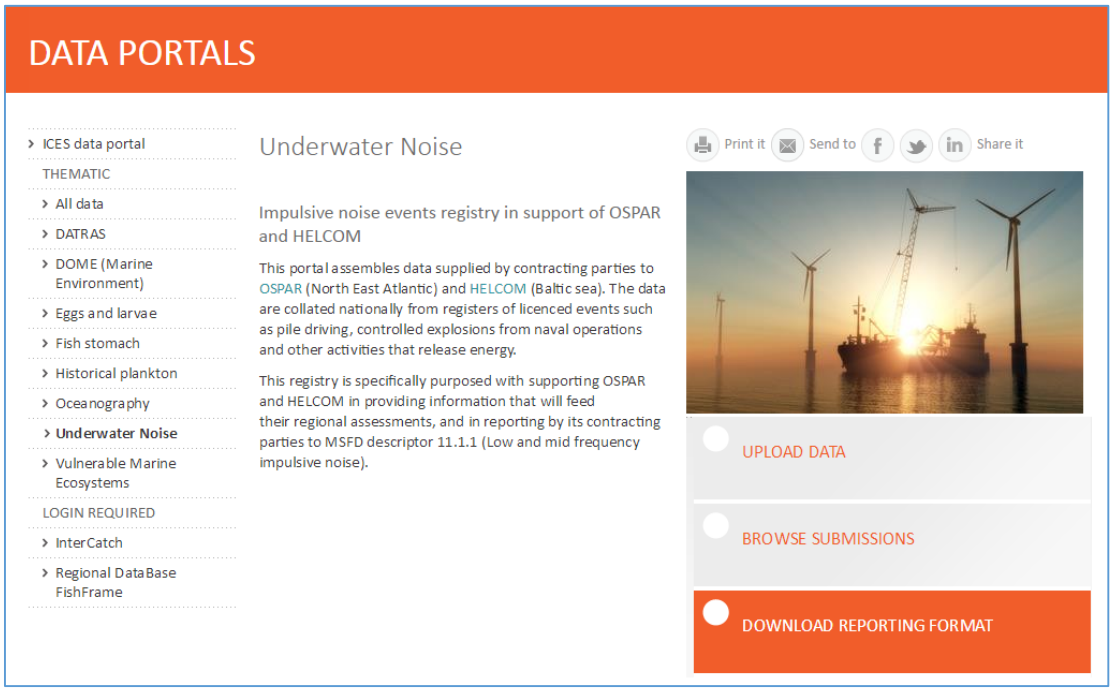
The provisional draft programme of the workshop was shared with the HELCOM EN-Noise, Pressure (PRESSURE 4-2016, doc. 3-4) and State and Conservation (STATE&CONSERVATION 4-2016, doc. 6J-1) Working Groups for their contribution by 6 May 2016.

State of work on impulsive sound and the register of occurrence of impulsive noise events

Following HOD 49-2015 agreement on HELCOM joining the OSPAR registry of impulsive noise, further work has been conducted and the beta version of the 'Impulsive noise events registry in support of OSPAR and HELCOM' hosted by ICES is already available (please note that at this stage only data from the OSPAR area are contained).

The Impulsive noise events registry in support of OSPAR and HELCOM is to contain data supplied by HELCOM and OSPAR Contracting Parties related to activities requiring licenses such as pile driving, controlled explosions from naval operations and other activities that release energy.

The reporting format to be used to upload data to the portal is available to download in the data portal (please see snapshot below). It consists of an Excel file that converts data to an XML file that can be uploaded to the database. It does not require commercially sensitive information i.e. company names or exact seismic measurements, and therefore, by transforming the national data records to the international format it is possible to address any possible concerns from national stakeholders. More detailed information on the reporting format is provided in Annex 1.



Survey of possible measures to manage and mitigate relevant impacts of underwater noise in the Baltic Sea

A survey of possible measures to manage and mitigate relevant impacts of underwater noise in the Baltic Sea is to be addressed as part of the BalticBOOST Theme 4. For that purpose a draft report has been prepared containing a compilation of the reviews internationally available on underwater noise mitigation measures. The report together with a questionnaire to be filled in by the Contracting Parties to identify which of the listed measures are nationally implemented, planned to be or have the potential to be implemented in the future, was submitted to PRESSURE 4-2016 for consideration (doc. 3-5). The questionnaire is included as Annex 2 of this document.

State of work on ambient noise: proposal for a regional monitoring programme

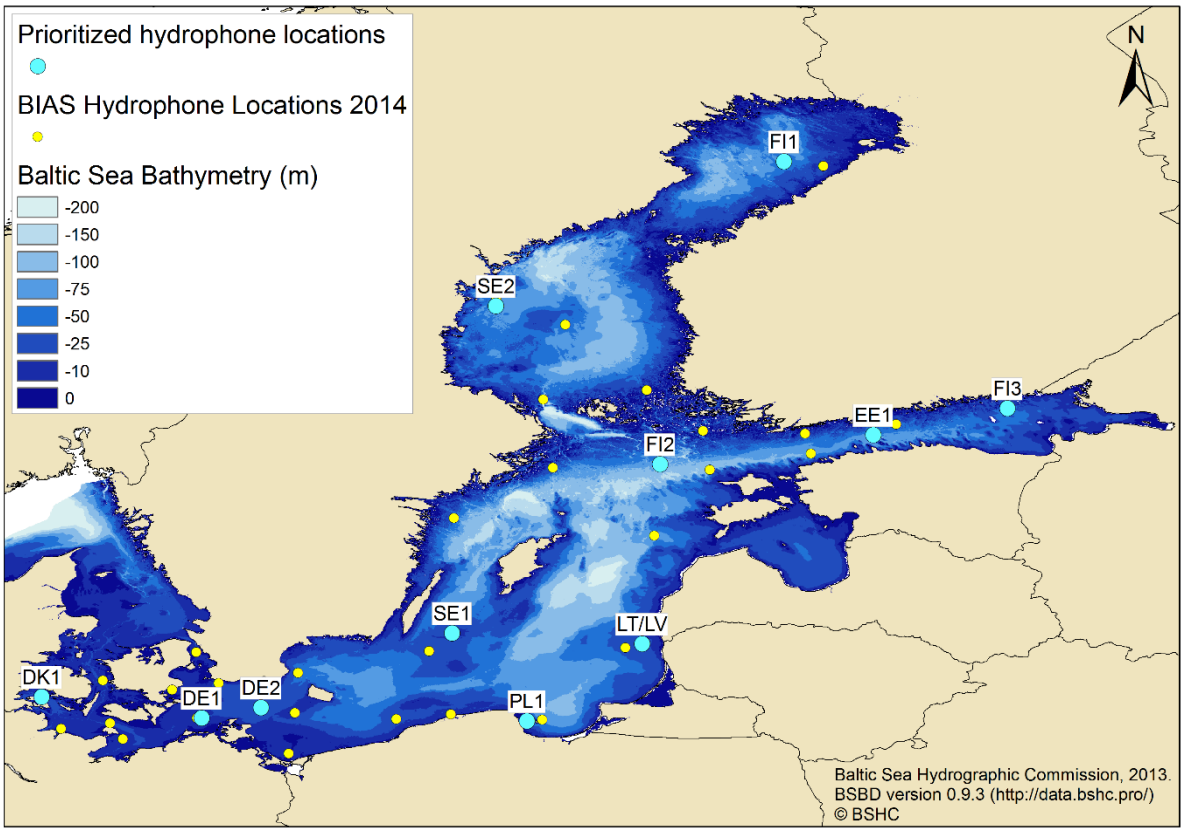
Another aim of BalticBOOST theme 4 on Underwater noise is to identify the mechanisms needed to develop a regional monitoring programme of continuous noise. This will be based on outcomes from the EU LIFE+ project Baltic Sea Information on the Acoustic Soundscape (BIAS). A draft regional monitoring programme as suggested by outcomes from the BIAS project was presented to STATE & CONSERVATION 4-2016 (doc. 6J-2 Rev.1) for consideration, including a draft cost estimation.

The proposed programme is 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 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.

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 the following figure (blue dots: selected prioritized locations for the minor assessment; yellow dots: measurement location used in the BIAS project).



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 countries during 2015, but was for most of them fully resumed in 2016 (see table below). These locations are suggested for minor assessments.

	Country	DK	DE	PO	ES	FI	SW	LV	LT	RU
Year	2015	-	-	✓	✓	✓	Partly	-		?
	2016	✓	✓	✓	✓	✓	✓	?		?

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 (see previous Figure). 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.

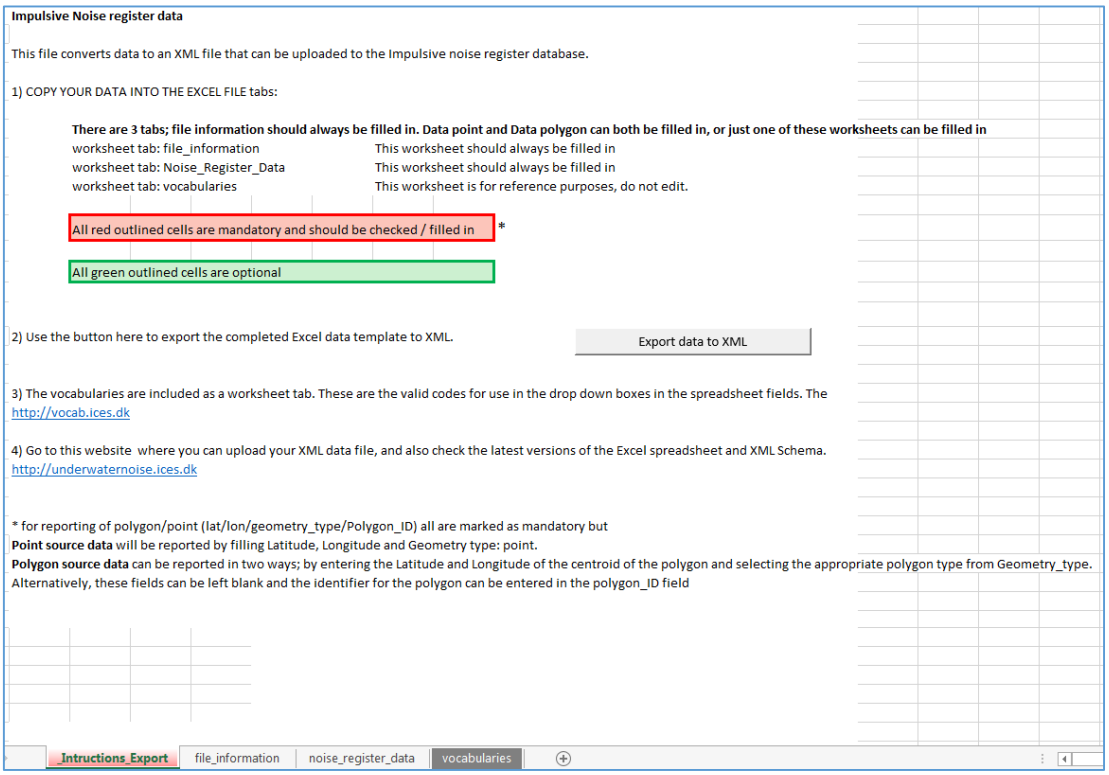
When considering the proposal at STATE & CONSERVATION 4-2016 Latvia proposed to cover biologically sensitive areas for regional monitoring, whereas Estonia supported continuation of underwater noise monitoring as described in the document. Nevertheless, more information is needed to decide on monitoring strategies and location of monitoring stations. At the moment only VMS and AIS data is considered for monitoring and modelling purposes, but also other activities, e.g. intense boating areas have to be taken into account.

STATE & CONSERVATION 4-2016 supported the continuation of the ongoing monitoring and agreed that there is a need to have a monitoring programme on ambient noise, however that it is too early to decide on

specific monitoring locations. The meeting agreed to consider the issue at the upcoming State and Conservation meeting (Outcome of STATE & CONSERVATION 4-2016, par.6J.8-6J.10).

Annex 1 - Reporting format for impulsive noise events

The Excel file contains four sheets with: (i) instructions on how to export national data to the database ('Intructions_Export'); (ii) information on the country providing the data ('file_information'); (iii) information on the event ('noise_register_data'); and (iv) valid codes to be used in the drop down boxes in the spreadsheet fields ('vocabularies') (please see snapshot below of the Excel file).



Information to be provided is either mandatory (red outline, i.a. latitude/longitude of the station) or optional (green outline, i.a. mitigation measures). The following tables compile the reporting format to be used to load data to the registry.

Column header	**Content**
Country (ISO 1366 code)	The country where the source was registered. Codes are provided in the 'vocabularies' spreadsheet
Organization (EDMO code)	Organization who is reporting the data. EDMO codes (European Directory of Marine Organisations) are provided in the 'vocabularies' spreadsheet

The system enables two options to report data: point source data (i.e. latitude, longitude and geometry type) or polygon source data. Polygon source data can be reported in two ways; by entering the Latitude and Longitude of the centroid of the polygon and selecting the appropriate polygon type from 'Geometry_type'. Alternatively, these fields can be left blank and the identifier for the polygon can be entered in the 'Polygon_ID' column.

Column header	Content
Start_date (ddmmyyyy)	Start date of the detection in YYYYMMDD format
End_date (ddmmyyyy)	End date of the detection in YYYYMMDD format
Latitude (WGS84)	To report point source data. The latitude of the detection in decimal degrees, using WGS84
Longitude (WGS84)	To report point source data.The longitude of the detection in decimal degrees, using WGS84
Geometry_type (Point, UK license blocks,	Please see explanation above

ICES sub-rectangles, German naval polygon)	
Polygon_ID (ICES sub-rectangle ID or Regional Polygon ID)	Please see explanation above

Column header	Content	
Source_event (vocab list)	One of these options is to be chosen based on the source of the event (also provided in the 'vocabularies' sheet and in ICES website): - Airgun arrays - Explosions - Generic explicitly impulsive source - Impact pile driver - Sonar or acoustic deterrents.	
Value (from list: NA/very_low/low/medium/high/very_high)	One of these options is to be chosen based on the source and duration of the event (also provided in the 'vocabularies' sheet and in ICES website): not available, very low, low, medium, high or very high.	
	- Airgun arrays:	
	NA	Not available
	Very low	209-233 dB re 1 µPa m
	Low	234-243 dB re 1 µPa m
	Medium	244-253 dB re 1 µPa m
	High	253 dB re 1 µPa m
	- Explosions:	
	NA	Not available
	Very low	8g – 210g
	Low	220g – 2,1kg
	Medium	2,11kg – 21kg
	High	22kg – 210kg
	Very high	210kg and above
	- Generic explicitly impulsive source:	
	NA	Not available
	Very low	186-210 dB re 1 µPa$_2$ m$_2$s
	Low	211-220 dB re 1 µPa$_2$ m$_2$s
	Medium	221-230 dB re 1 µPa$_2$ m$_2$s
	High	230 dB re 1 µPa$_2$ m$_2$s and above
	- Impact pile driver:	
	NA	<280kJ
	Very low	290kJ – 2,8MJ
	Low	2,81MJ – 28MJ
	Medium	>28MJ
	High	
	- Sonar or acoustic deterrents:	
	NA	Not available
	Very low	176-200 dB re 1 µPa m
	Low	201-210 dB re 1 µPa m
	Medium	211-220 dB re 1 µPa m
	High	220 dB re 1 µPa m and above
Sound_mitigation_bool (yes/no)	Choose 'yes' or 'no'.	

The following data are optional (outlined in green in the Excel reporting format):

Column header	Content
NMS_type (from list:	Types of noise mitigation systems (NMS) to be chosen among these

BBC/SBC/IHC/HSD/HEP/COF/ CBBCIHC/CBBCHSD/CBBCCOF /Other)	options:	
	BBC	Big Bubble Curtain
	SBC	Small Bubble Curtain
	IHC	I H C - Noise Mitigation System
	HSD	HydroSoundDamper
	HEP	Pile-in-Pile Jacket
	COF	Cofferdamm
	CBBCIHC	Combined BBC and I H C-NMS
	CBBCHSD	Combined BBC and HSD
	CBBCCOF	Combined BBC and Cofferdamm
	Other	Other system or other combination
Sound_measurement_bool (yes/no)	Choose 'yes' or 'no'.	
SEL (dB re 1µPa²s)	Sound Exposure Level expressed in dB re 1 µPa²s	
Lpeak (dB re 1µPa)	Peak Level expressed in dB re 1 µPa²s	
Distance_to_pile (metres, decimal)	Distance to the pile	
Type_hammer (Model number of hammer used, e.g. S-2000, 3000S)	Model of the hammer used	
Max_energy (Kj)	Maximum energy reached during the event	
Source_Spectra (UNIT to be determined)	The frequency band of the event (format to be determined)	
Duty_cycle (decimal)	The percentage of the duration the signal was active	
Start_time (hhmm)	Start time of the event transmission	
Duration (seconds, integer)	The duration of the event in seconds	
Directivity (decimal)	A Q value representing the directivity of the sound source	
Source_depth (metres, decimal)	Approximate depth, in metres, of the sound source	
Platform_speed (Knots, decimal)	Speed of the platform recording the event	
Remarks (free text)	Any free text comments or additional supporting information	

Information to be provided is either mandatory (red outline, i.a. latitude/longitude of the station) or optional (green outline, i.a. mitigation measures). Annex contains the very same reporting format to be used to upload data to the HELCOM registry.

Annex 2 – National questionnaire on underwater noise mitigation measures

Nation *Fill in*	**Measures** Describe type	**Limits on maximum level** Yes/ No If yes, specify	**Status April 2016** (implemented/ planned 20xx / potential measures)
General considerations	☐ **Refraining from applying activities** ☐ **Exclusion of noise generating activities for a certain time period** ☐ **Restriction** of anthropogenic underwater noise to **a certain level** ☐ **Exclusion** of noise generating activities **from certain areas** (e.g., by transferring of shipping lanes); ☐ **Spatio-temporal exclusion or limitation of noise causing activities** ☐ Usage of **alternative techniques** ☐ **Modification** of operational state of noise source, e.g., reducing ship speed. Other ☐ *Fill in*	☐	☐
Shipping	**Design considerations** ☐ **Ship design** ☐ **Propeller design** ☐ **Hull design** **Onboard machinery** ☐ **Onboard machinery** and vibration control measures, ☐ **Request information on airborne sound levels** ☐ **Use of diesel-electric propulsion** ☐ **Use of four-stroke engines** ☐ **Use of vibration isolation mounts** **Additional technologies for existing ships** ☐ **Install new propellers** ☐ **Install wake conditioning devices** ☐ **Install air injection to the propeller** **Operational and maintenance considerations** ☐ **Clean the propeller** ☐ **Maintain smooth hull surface** ☐ **Reduce ship speed** ☐ **Optimize the combination of shaft speed and propeller pitch** **Other** ☐ *Fill in*	☐	☐

Pile driving	☐ **Big bubble curtain (BBC)** ☐ **Little bubble curtain (LBC)** ☐ **Isolation casings** ☐ **Dewatered cofferdams** ☐ **Hydro Sound Dampers** **Alternatives to Impact Pile Driving which emits less noise:** ☐ **Vibratory Pile Driving** (Vibropiling) ☐ **Drilled foundations** ☐ **Gravity base foundation** ☐ **Floating Wind Turbines** ☐ **Bucket foundations** Additional noise mitigation concepts: ☐ **High frequency – low energy piling** ☐ **Mandrel piles** ☐ **Slit piles** ☐ **Silent pile driving** – prolonged pulse duration Other ☐ *Fill in*	☐	☐
Seismic surveys	**Mitigation during the planning phase** ☐ **Avoidance of sensitive areas** ☐ **Avoid surveys** during sensitive time periods ☐ Consider simultaneous and cumulative impacts ☐ Assess the **impact on marine mammals** ☐ Determine the **size of the exclusion zone** (safety/mitigation zone) ☐ Minimise airgun sound and sound propagation **Mitigation during operations** ☐ Pre shoot watch during specified time interval (e.g. 60 min) ☐ Use acoustic deterrent devices ☐ **Soft start** (ramp up) ☐ Restrict the usage of airguns during line changes ☐ Use **marine mammal observers** ☐ Define **visual monitoring procedures** ☐ Use **passive acoustic monitoring** systems ☐ Use **active acoustic monitoring** ☐ Make **aerial surveys before and after** the seismic survey ☐ Sound baffling using **screens of air bubbles** ☐ Mitigation for Other Species **Post Survey Measures** ☐ MMO reports and sharing of data ☐ Post survey monitoring (in areas where baseline data is poor) ☐ Impulsive noise monitoring (noise registry)	☐	☐

	Alternatives to seismic ☐ Marine Vibroseis / marine vibrators ☐ "Teles" – a Marine Siren ☐ Low-frequency Acoustic Sources ☐ Deep-towed Acoustic/Geophysical System ☐ Low Impact Seismic Array ☐ Underwater Tuneable Organ-pipe ☐ Electromagnetic Surveys ☐ Gravity and Gravity Gradiometry ☐ Shear Wave Generators Other ☐ *Fill in*		
Explosions	☐ *Fill in*	☐	☐
HF impulsive sources (echo sounders)	☐ *Fill in*	☐	☐
Dredging	☐ *Fill in*	☐	☐
Sonar	☐ *Fill in*	☐	☐
Other	☐ *Fill in*	☐	☐