Baltic Marine Environment Protection Commission

Working Group on the State of the Environment and Nature Conservation

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Background

When considering a proposal on the assessment methodology for low frequency underwater noise in HOLAS III as well as the German reservation on the matter, STATE & CONSERVATION 14-2021 agreed that, while acknowledging the reservation by Germany, the work under EN Noise and the BLUES project can continue, so as to not jeopardize the possibility to include an assessment of continuous noise in HOLAS III, should a methodology and threshold values not become available from EU TG Noise in time to be included in the HOLAS III assessment (Outcome of STATE & CONSERVATION 14-2021, para. 4J.291 - 4J.301). Subsequently, GEAR 24-2021 discussed that this indicator is one of those for which the EU process is not fully aligned with existing HOLAS III/HELCOM deadlines, and agreed on the contingency as presented in presentation 5 (Outcome of GEAR 24-2021, para. 5.25-5.26). In view of these decisions EN-Noise agreed to further advance on the assessment methodology, to include masking and potentially disturbance (thresholds expressed as fixed sound pressure levels). Thus, Germany amended the assessment methodology proposed to STATE & CONSERVATION 14-2021, which was opened for commenting to the network. Input was provided by Denmark, Finland, and Sweden. The views in EN-Noise on whether to include sensitive habitat areas or not were divided. Thus, all references to MPA's or sensitive habitat areas were removed from the document and a separate German proposal on this assessment component is to be submitted to this Meeting. The further revised document was again shared with the network. Finland supported the further revised document.

This document outlines the status concerning the monitoring status and priority of the input of low frequency underwater noise in the HELCOM region, and summarizes the proposed evaluation methodology and threshold values for the HOLAS III assessment, following recent discussion in EN-Noise.

Action requested

The Meeting is invited to consider and endorse the proposed approach to establish threshold values for use of the low frequency underwater noise indicator in the HOLAS III assessment.

Proposed approach to establish threshold values for the indicator on continuous low frequency anthropogenic sound

Indicator name
Continuous low frequency anthropogenic sound
Scale of assessment for HOLAS III and rational
A variety of marine species is known to be adversely affected by the input of continuous underwater noise. Impacts range from interference with reception of other sounds (masking) to behavioural disturbance and effects on the physiology of animals (cardiovascular responses and elevated stress hormone levels). Whereas masking is well documented for some species studied in captivity, there is comparatively little quantitative information available on disturbance and physiological effects. Focus of the assessment in HOLAS III will therefore be on potential for masking effects. For effects to occur there needs to be both a pressure (the noise) and one or more receivers (noise sensitive animals). The current state of the art regarding assessment, exemplified by the JOMOPANS and JONAS projects (OSPAR area) is that reliable methods are available to assess the pressure from continuous noise. This pressure is evaluated by modelling and assessing the fraction of time where underwater noise in a specific location is dominated by anthropogenic sources relative to being dominated by natural sources, such as wind and waves. This can be done for the entire Baltic, creating frequency specific pressure maps, which are to be used as input to HOLAS III. Furthermore, the JOMOPANS and JONAS projects offer outlines of a methodology to assess risk of impact by combining pressure maps with information about distribution and sensitivity of noise sensitive species. The primary limiting factor for assessment of risk of impact is availability of good information about spatiotemporal distribution of indicator species. The methodology will thus only be applied to HOLAS III if reliable data on indicator species is available. A similar discussion is ongoing in OSPAR, where the expert group OMMEG has given advice on use of harbour porpoise density estimates for impulsive noise risk assessment[1], upon a recent request from OSPAR ICG-Noise. In the advice from OMEEG it was stressed in particular that uncertainties in population density data must be dealt with appropriately. This advice is also relevant for the consideration of mammals and other noise sensitive species in the Baltic Sea. The assessment will be based on maps of underwater continuous noise from natural and anthropogenic sources developed specifically for HOLAS III and based on measurements obtained by countries and made available for assessment requirements in the HELCOM continuous noise database hosted by ICES. The assessment will allow for a transparent evaluation of the pressure in terms of the spatial explicit metrics of relative contribution of anthropogenic sources vs. natural sources of noise in selected and representative frequency bands. Suitable thresholds should be defined such that they may be clearly linked to values that represent levels at which species identified as sensitive to underwater noise, are not adversely affected.
Spatial coverage of the indicator for HOLAS III
For HOLAS II a continuous underwater noise indicator was developed based on modelled soundscape data from the BIAS project. Briefly, this indicator expressed the normalised difference between modelled median noise levels (current condition) and a reference condition estimated as the upper 10th percentile of the noise distribution measured in a location little affected by anthropogenic noise. This was done for the two frequency bands 63 Hz and 125 Hz, in accordance with guidance from the European Commission. Since BIAS and HOLAS II the assessment methodology and sound modelling capabilities have evolved considerably. This is most clearly seen in the JOMOPANS project and sister-project JONAS, where anthropogenic noise and natural

[1] OMMEG (2020): Advice request from ICG-Noise to OMMEG: use of harbour porpoise density estimates for impulsive noise risk assessment.

noise are now modelled independently, which allows for an assessment of the relative dominance of one source over the other. Good environmental status (GES) is associated with natural sources (wind and waves) dominating in an area most of the time, whereas GES is compromised if anthropogenic sources dominate in an area.

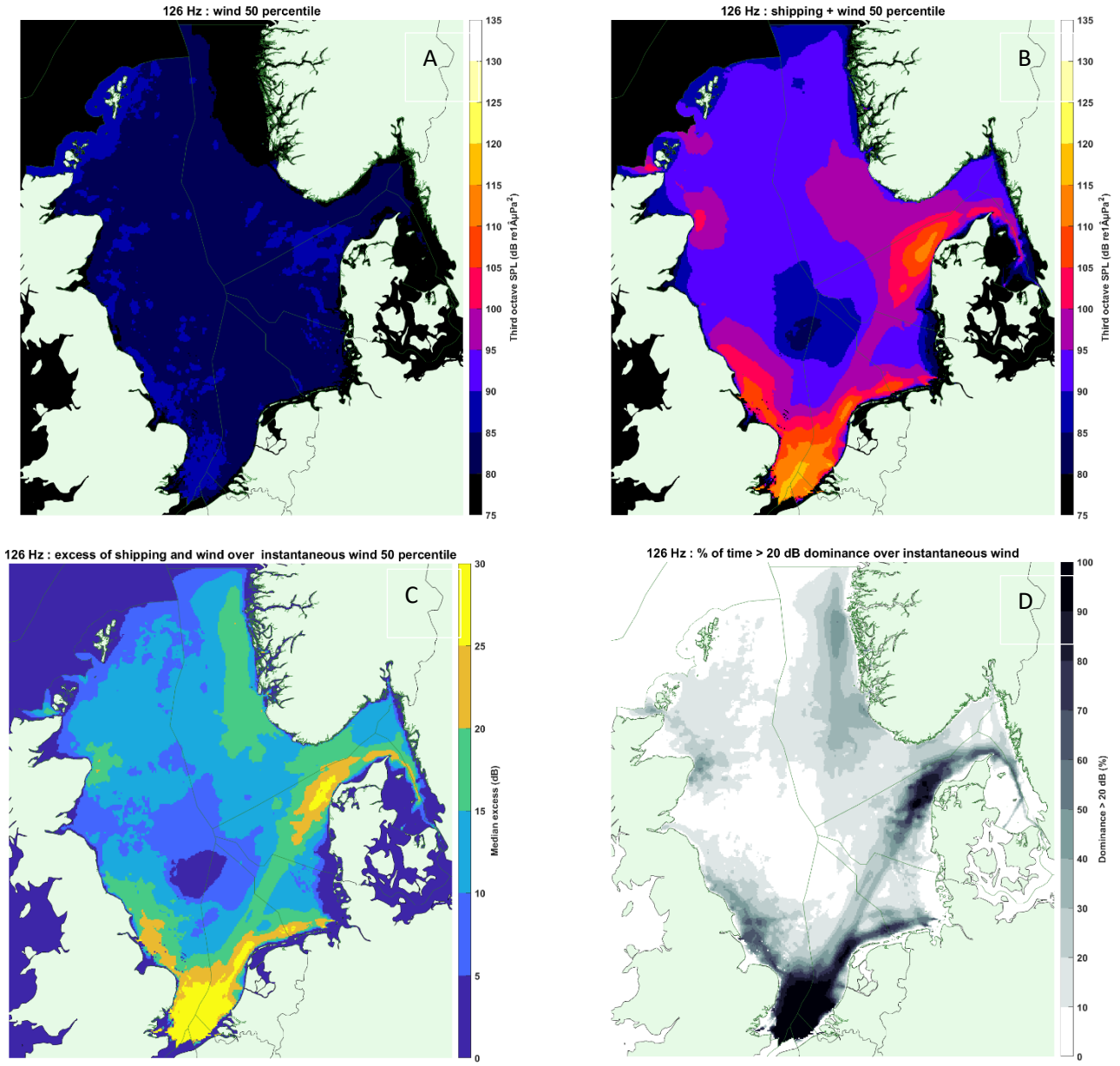

Figure 1. Examples of maps illustrating the different steps towards the pressure map (dominance) for the 125 Hz EU MSFD band. A) Monthly median noise level from natural sources alone (median of the reference condition). B) Monthly median noise level from natural and anthropogenic sources (median of the current condition). C) Monthly median of the excess level. D) Dominance: percent of time the excess level is above 20 dB (same as percent of time the current condition is above the high-risk level, where high-risk level is the reference condition + 20 dB). Maps from the JOMOPANS project.

The modelling is illustrated in figure 1 with maps produced by JOMOPANS for the North Sea. Basis for the mapping is a model of natural noise (reference condition, figure 1A), modelled from meteorological data on wind and waves. The current condition (figure 1B) is estimated by modelling the noise emission of individual sources (in the case of JOMOPANS ships with AIS and/or VMS transmitters) and adding this to the reference condition. However, for the assessment the ratio between the natural and current condition will be estimated in addition, expressed as the excess level (figure 1C). The excess level expresses the amount (in dB) that the current condition is above the

reference condition. By definition, the natural + anthropogenic noise can never be lower than the natural noise alone. The excess can be estimated over longer periods, such as one month or one year, but can also be evaluated on a very short time scale (seconds), leading to estimation of the dominance parameter (figure 1D). In this case, the dominance expresses the percent of time (out of a month or a year) that the current condition is elevated above the reference condition by some pre-selected amount. In the map below the cut-off is 20 dB, i.e. figure 1D indicates the percentage of time when the ship's noise caused an elevation of the noise level in that particular point in the map by 20 dB or more. It is seen that the dominance for the selected example (125 Hz third-octave band, July 2019) ranges from below 10% in for example the central North Sea and most of Kattegat, to above 90% in the English Channel and the shipping route north of Skagen.

For the HELCOM region information has been gathered on important habitats that are available for the purpose of assessment of impacts of impulsive and continuous noise on the marine ecosystem and presented in BSEP, 167 (Fig 2). The knowledge on sensitive species and sensitive areas may have improved since then, so that the most recent information should be used in HOLAS III. Guidance on this should be obtained from appropriate expert networks, in particular EG-MAMA and FISH.

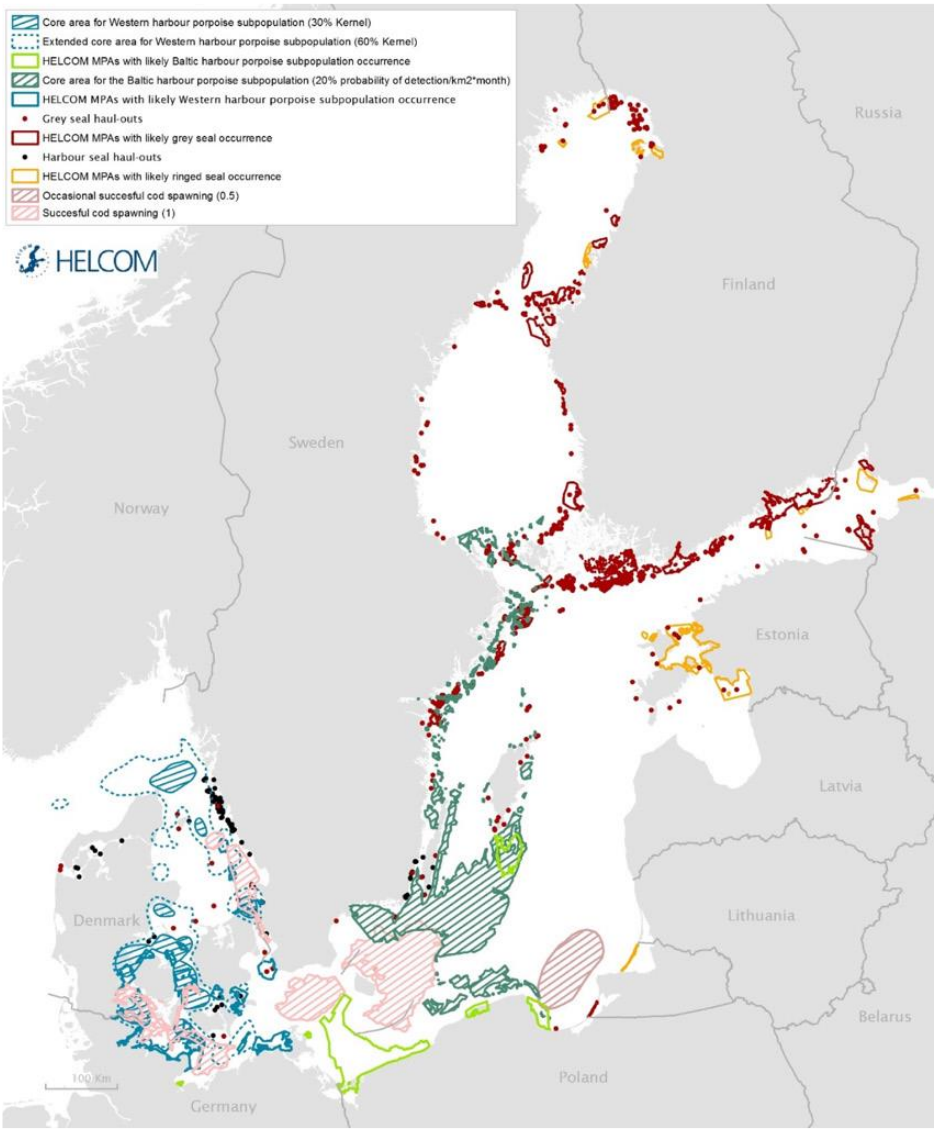

Fig 2. Noise sensitive areas in the Baltic Sea derived from biological data on species sensitive to underwater noise so far identified. (Source: HELCOM 2019. Noise sensitivity of animals in the Baltic Sea. Baltic Sea Environment Proceedings N° 167).

Methodology to be applied for HOLAS III and rational

The assessment framework is based on evaluation of the effect that ship noise has on the signal to noise ratio available to communicating animals. This is done through the excess level as introduced in JOMOPANS, and through total sound pressure levels as done in HOLAS II.

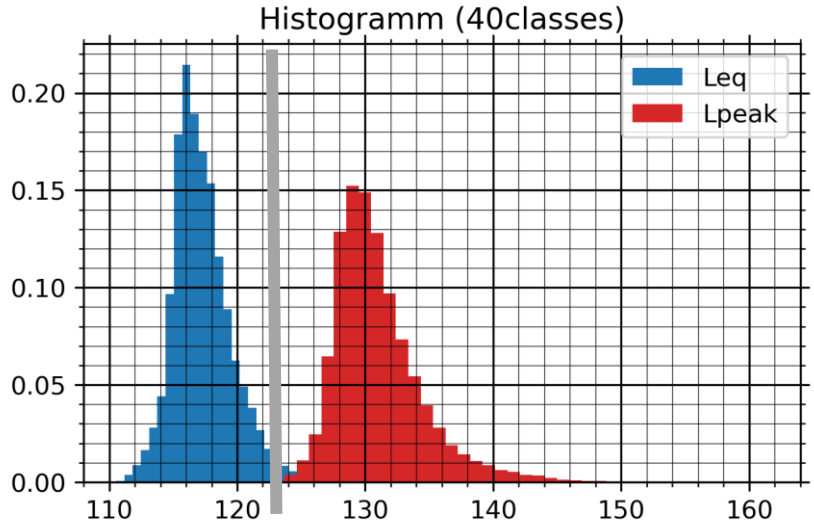

Figure 3: Histogram of the sound pressure level (10-20kHz, green line symbolises a limit value that must not be exceeded, this is above the maximum achievable natural background noise in this area, e.g. +6 (10) dB)

For the assessment of the anthropogenic sound emission, absolute sound pressure levels above the natural background noise are applied, as schematically shown in Figure 3. This offers the possibility to verify the acoustic conditions also by measurement campaigns, which would be necessary for the proof of success of measures to be applied in further steps to reduce the impact on the marine environment. Furthermore, it offers the possibility to directly compare the results of the evaluation of HOLAS II with HOLAS III.

The assessment can be conducted for the entire HELCOM region as a whole, but can also be subdivided into subareas, as long as the area of the individual subareas is sufficiently large to provide robust statistics. This is secured by including a sufficiently large number of grid cells, the fundamental unit of the soundscape modelling, in each subarea. The lower size limit for a robust assessment has not been investigated yet, but is likely to be on the order of some hundreds of square kilometres.

New soundscape maps, specifically modelling the dominance, will be produced by the HELCOM BLUES[2] project and used in the assessment for HOLAS III. Anthropogenic sources will in the first place be ships with AIS and/or VMS transmitters, but additional sources, such as operating offshore wind farms can be included if reliable input data can be obtained. Modelling will be performed by the French company Quiet Oceans and be based on monitoring data submitted by countries to the HELCOM continuous noise database, hosted by ICES. Maps are created for sound pressure levels, natural noise and defined acoustic metrics (e.g. excess level, exceedance level).

The monthly maps of dominance can be used directly in an integrative assessment by HOLAS III but can also be used in a specific assessment of GES in the Baltic Sea as a whole, or separated into subbasins. Such assessment in subareas is illustrated in figure 5, again based on JOMOPANS data from the North Sea. Here, the subdivision is based on the OSPAR assessment areas (figure 5A). For each subarea the spatiotemporal distribution of the dominance variable can be condensed into the pressure curve (figure 5B). The pressure curve expresses combinations of time and area where the dominance is high. A curve extending to the lower left is indicative of a subarea where the dominance in general is low (most parts of the subarea dominated by natural noise sources, most of the time), whereas ship noise becomes increasingly dominating as the curve moves towards the upper right corner. A single

[2] The "HELCOM Biodiversity, Litter, Underwater noise and Effective regional measures for the Baltic Sea" (HELCOM BLUES) project is led by HELCOM and co-funded by the European Union. More information at https://blues.helcom.fi.

(scalar) index, which characterizes the pressure from underwater noise in the subarea, is found in the area below the pressure curve. This index, calculated for each of the six subareas of the North Sea, is shown in figure 5C.

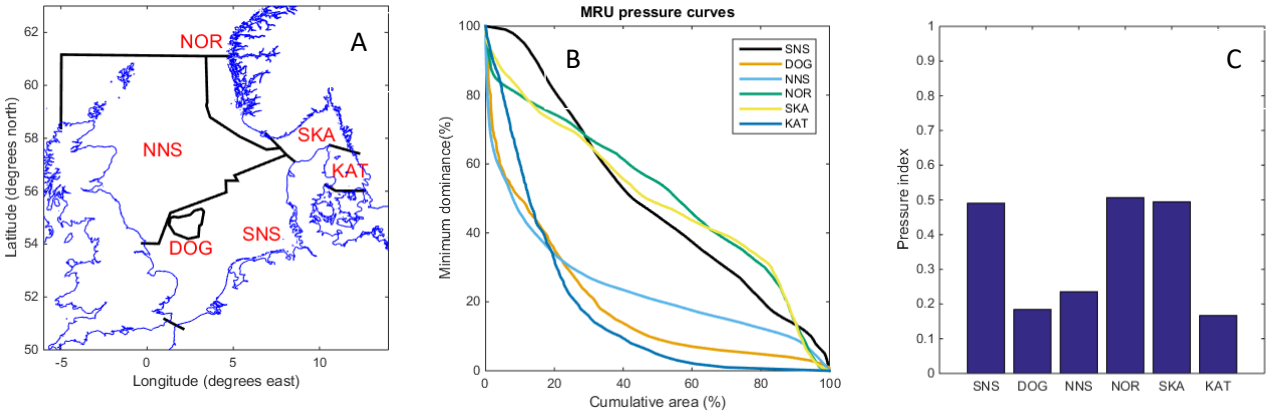

Figure 5. The JOMOPANS pressure index calculated for different Marine Reporting Units (MRUs) of the North Sea. A) The six different MRUs (OSPAR assessment areas) used in the analysis: southern North Sea (SNS), northern North Sea (NNS), Dogger bank (DOG), Norwegian Trench (NOR), Skagerrak (SKA) and Kattegat (KAT). B) Pressure curves for the individual MRUs. C) Pressure index (= area below pressure curve) for the six different MRUs.

Threshold value setting logic and rational

Discussions about threshold values for GES with respect to low frequency underwater noise is currently ongoing at the EU level (TG-Noise). Decisions regarding thresholds to be used in HOLAS III must be aligned with this process and hence cannot be taken at this time. However, the suggested approach to threshold values for GES is that they should be based on the pressure index described above and thus express a maximally tolerated dominance of anthropogenic noise, averaged across time and geographical subarea. Thresholds may differ between different indicator species/groups and may differ from other regional seas, but should be constant within the HELCOM area within each indicator species/group, and should be chosen in a way that they apply to as many species/groups as possible, to fulfil the target of evolving measures to reduce the risk of impact on the entire marine ecosystem.

There is currently no methodology available to determine the value of the GES threshold values from first principles, for example based in a maximal allowed impact on the population level, as the link between effects of noise on individual animals and the development of populations (such as long-term survival and reproduction) is not described. The threshold values must therefore be established in a precautionary way from the exposure data (modelled or measured). Threshold values should be furthermore established in a way that will allow to reduce the impact of continuous noise on the ecosystem, to introduce suitable measures and to monitor their effectiveness.

Threshold value(s)

It is technically possible to include calculations both for behaviour (absolute thresholds) and masking (dynamic thresholds) in HOLAS III. This will also provide information on the possible differences between the two methodologies. Soundscape maps will be made in cooperation with Quiet Oceans and they can contain anthropogenic and natural noise separately. Once maps are available, absolute or dynamic threshold values can be extracted.

Other significant issues that need to be addressed or presented to State and Conservation

A number of key decisions remain. These relate to input data and the methodology itself, including threshold values for GES, but also to how information about noise sensitive species (indicator species) is best included in the assessment.

Sound pressure levels and excess level used for calculation of dominance

The concept of dominance, newly introduced by JOMOPANS, can be applied to relative levels as well as to absolute levels defining a threshold, see e.g. masking (BIAS 2014) of cods. The advantage is a condensed information on the dominance depending on the time period considered and the area of interest (sub-basin, MPA, etc.).

In the calculation of dominance, which is the input to both the pressure map and the pressure index, a lower limit of excess level must be selected. By definition, excess is always greater than 0 dB, as 0 dB corresponds to total absence of anthropogenic noise. Dominance is therefore calculated as the percent of time the excess level is above some pre-defined level. In the example above, this level was set at 20 dB, which corresponds to a considerable deterioration of conditions for acoustic communication. Other (lower) values can be selected, but at the risk of saturation of the analysis. If the level is selected too low, the analysis will saturate, as some anthropogenic noise is present in most parts of the Baltic Sea. Based on preliminary experience from JOMOPANS, the value of 20 dB is therefore suggested as one of the evaluation thresholds to be considered in HOLAS III. However, it is central to point out that this value is not the threshold for GES, but a required step in the assessment procedure.

Based on the preliminary experience of JOMOPANS and the discussion at EN Noise, **we further propose to consider the excess level based on an absolute sound pressure level of 6 or10 dB above the upper 5th percentile of the natural noise (assessed monthly) for the area in question. If scientifically sound information is available on other thresholds, e.g. for Baltic cod, or seals and harbour porpoises, these could also be taken into account, e.g. for special MPAs.** The advantage of this definition is that the sound pressure levels can be verified by measurement, allowing the efficiency of measures to be evaluated.

Inclusion of noise sensitive species information

Assessments will be made for representative indicator species, such as those outlined in the "Noise sensitivity of animals in the Baltic Sea" (Baltic Sea Environment Proceedings 167). In the first place, this will be done by assessing noise in frequency bands considered most important to the individual indicator species, thereby generating species-specific (or species-group-specific) pressure maps and pressure indices. The pressure maps can further be used in combination with maps of animal distribution, in order to identify areas of greatest overlap between noise sensitive species and anthropogenic noise (risk-based assessment). Such overlay with distribution data requires, however, that sufficiently good information is available on the indicator species. Preferably, the maps representing species information should be expressed as habitat suitability, rather than simply the observed occurrence of animals, as the latter maps may contain gaps in present distribution due to an already present negative effect of the ship noise. It is currently debated whether such maps can be made available in time to be included in the HOLAS III assessment.

Latest indicator report or (for new indicators) initially completed indicator template

The latest pre-core indicator report dates back to 2016. This will be updated at a later stage.