

HARMONIZE

Threshold Value Concept Assessment framework for impulsive noise for immediate application in all EU regions – Part II: Technical aspects

EU Project HARMONIZE

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1 Introduction

Building on trans-regional cooperation, HARMONIZE supports the feasibility of the assessment framework for impulsive noise in all marine regions of the EU on the basis of

- a) the consideration of existing best practices,
- b) the identification and consideration of specific regional requirements
- c) the definition of criteria and boundary conditions to ensure comparability and interpretability of assessments.

A key activity in HARMONIZE is the consideration of exemplary regional case studies for a data-based evaluation of the regional applicability of the assessment framework.

It can be seen that an assessment of the time-dependent availability of unaffected habitats and marine regions by impulsive sound on the basis of the noise registries in all EU regions and subregions is directly feasible.

For the implementation of the Commission's requirements, TG Noise previously provided technical reports such as, a) the TG Noise guidance (3 parts): [3], [4], [5] and b) the assessment method for impulsive noise DL1 [1].

A comparison of all available assessment approaches so far (Interim Report [8]), has demonstrated that they are comparable to each other and include elements that may be adjusted to reach a generalized assessment framework for immediate application.

It is obvious that all assessment strategies, as already shown in the Harmonize Interim Report [8] follow a comparable structure and use the regional noise registries as a basis for monitoring, the accurate determination of the exposed area is necessary in all concepts, see also discussion in [8]. A generalized assessment is therefore possible.

According to commission decision [6] and taking note of SWD 2020, the technical guidance given by TG-Noise (2014, DL1, DL3), the ongoing fruitful discussions in the drafting groups as well as results from the Harmonize-Project, an assessment framework for immediate application by all member states is proposed.

This document briefly outlines the generalized assessment procedure for applying the threshold values. Recommendations on how to deal with uncertainties in noise registry data, how to "properly" calculate sound propagation, and specific guidance on how to determine exposure will be addressed in another report.

2 Assessment framework for Threshold Value settings

2.1 General assessment procedure

The starting point for the assessment procedure is document DL1 [1]. In this section, a stepwise procedure is described, which will lead to a general assessment using currently available data.

The general procedure (see Figure 1) is described by the following steps, based on [9] and [10]:

- Definition of the Management Area (MA)
- Determination of the assessment area/habitat of the indicator species.
- Evaluation of completeness and quality of the data.
- Consideration of biological threshold values for impulse noise for indicator species.
- Selection of a propagation model to estimate effect ranges.
- Determination of the temporal and spatial noise pressure map.
- Calculation of exposure map using assessment area/habitat and noise pressure map and determining the exposed area (% area and time exposed).
- Assessment of the environmental status based on threshold values for tolerable temporal and spatial exposed area/habitat.

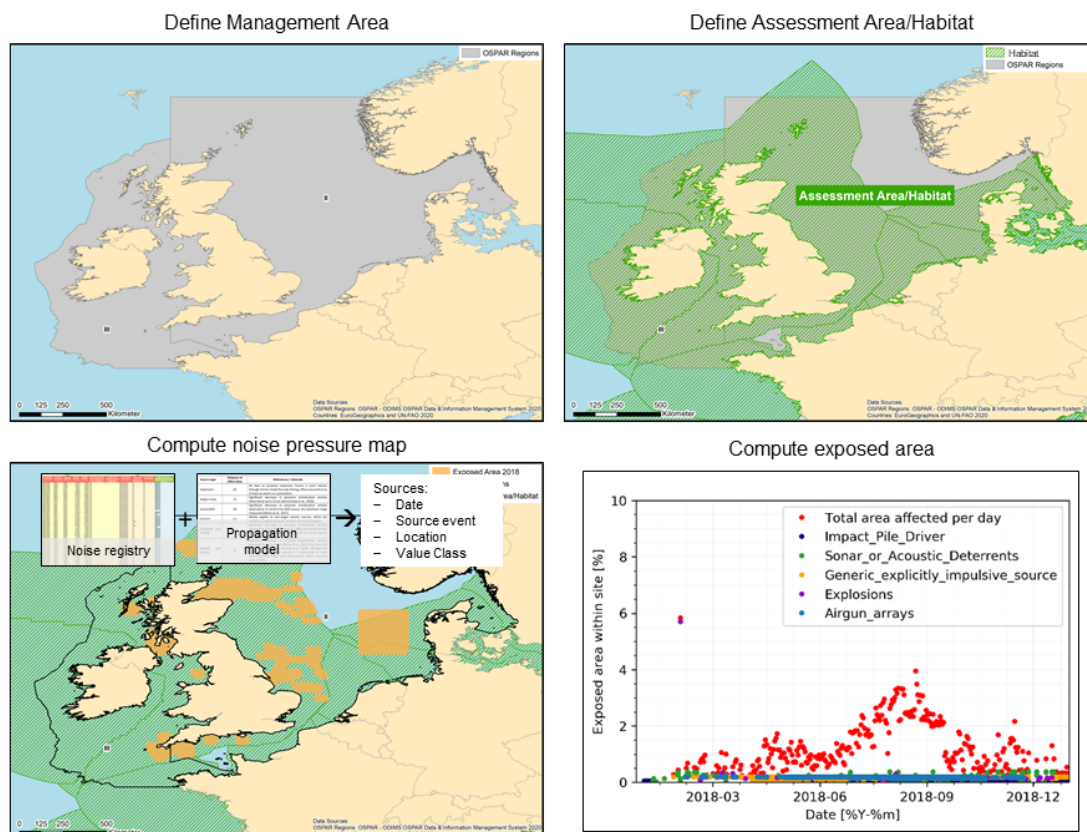


Figure 1: Illustration of the general assessment procedure.

Remark on thresholds for GES:

Depending on seasonal specificities, e. g. calving season, the proportion of area for special protection areas may be reduced to keep the area in GES.

2.2 Noise registries - D11C1 monitoring

As part of the implementation of the MSFD, regional noise registries have been established in cooperation between EU Member States and regional marine conventions since 2015, providing the data basis for the assessment of Good Environmental Status with respect to underwater noise. In HARMONIZE, all impulsive noise data reported to regional noise registries have been quality checked and harmonized for evaluation (Figure 2).

Hence, the basis of the assessment are the noise registries. The member states report impulsive noise events in the respective agreements, such as HELCOM, OSPAR, ACCOBAMS

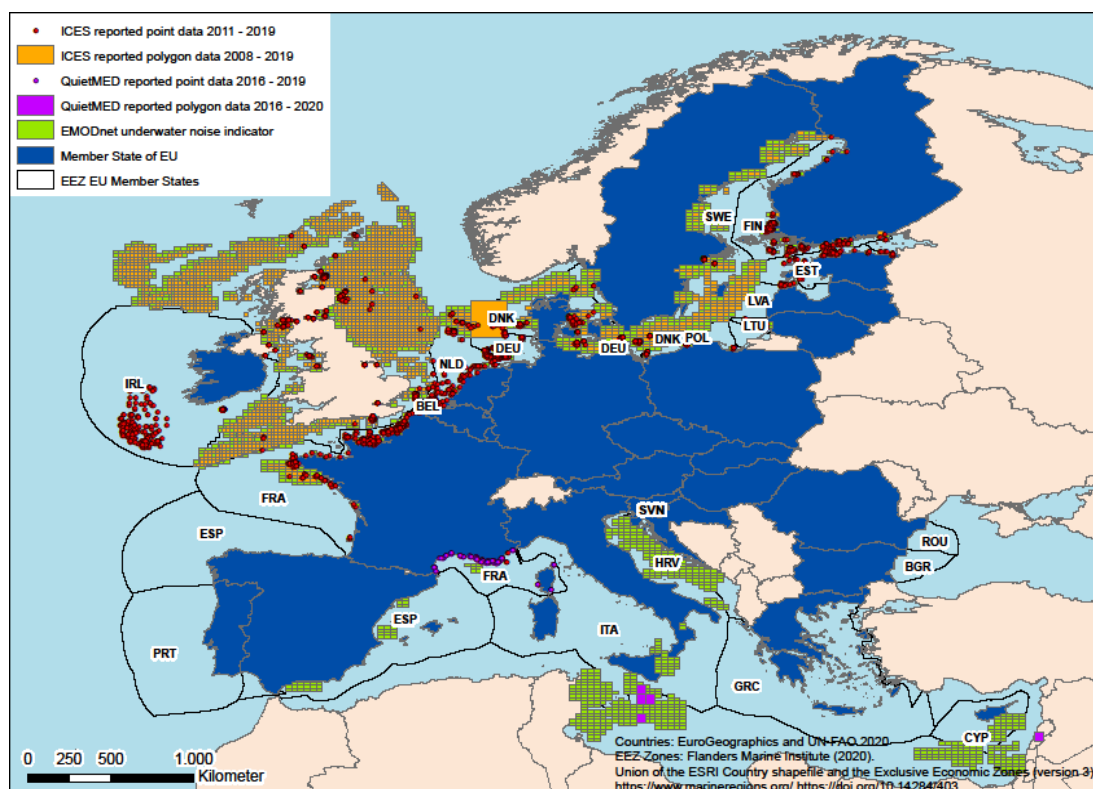


Figure 2: Data reported within the publicly available datasets.

The classification of noise sources proposed by TG Noise is summarised in Table 1 and Table 2. Three noise classes are distinguished: multiple impulsive noise events, such as those produced by pile driving and airguns, single events, such as explosions, and continuous sound events, such as sonars.

Table 1: Registration of specific source level (energy source level SL_E [dB] re $1 \mu Pa^2 m^2 s$ (single events) and source level re $1 \mu Pa^2 m^2$) into classes proposed by TG Noise in [5]. Calculated from 1000 m levels (SEL, SPL) with propagation loss 46 dB (shallow water).

	SL_E [dB] re $1 \mu Pa^2 m^2 s$ multiple impulsive source	SL_E re $1 \mu Pa^2 m^2 s$ single impulsive source	SL dB re $1 \mu Pa^2 m^2$ non-pulse sounds
Very low	186 – 210	210 – 234	176 – 200
Low	211 – 220	235 – 244	201 – 210
Medium	221 – 230	245 – 254	211 – 220
High	230	255 – 264	221
Very high		265	

The threshold value above which noise sources are included in the noise registry was derived from studies on marine mammals, using disturbance as the assessment basis for multiple impulsive noise events and continuous noise. For explosions, TTS was considered as the basis for assessment. A distance to the source of 1000 m was

defined for which the named threshold values apply and then are converted to a monopole energy source level¹ with a propagation loss (shallow water) of 46 dB. In relation to the 1000 m level the classification described in [5] where a SEL (single event level) of 140 dB re 1 $\mu\text{Pa}^2\text{s}$ to 164 dB re 1 $\mu\text{Pa}^2\text{s}$ for multiple pulses and for single pulses, such as explosions, a SEL of 164 dB re 1 $\mu\text{Pa}^2\text{s}$ to 188 dB re 1 $\mu\text{Pa}^2\text{s}$, are both categorized as very low.

Table 2: Registration of specific source level (which may be classified) and related physical quantities into classes proposed by TG Noise in [5].

	SL _E [dB] re 1 $\mu\text{Pa}^2\text{m}^2\text{s}$ generic explicitly impulsive source	SL [dB] re 1 $\mu\text{Pa}^2\text{m}^2$ sonar or acoustic deterrents	SL _{zp} [dB] re 1 $\mu\text{Pa}^2\text{m}^2$ Airgun arrays	Explosions [eq. TNT charge mass kg]	Pile driving [hammer energy MJ]
Very low	186 – 210	176 – 200	209 – 233	0.008 – 0.210	- 0.28
Low	211 – 220	201 – 210	234 – 243	0.220 – 2.1	0.29 – 2.80
Medium	221 – 230	211 – 220	244 – 253	2.11 – 21	2.81 – 28
High	230	220	253	22 – 210	28
Very high				210	

With this data base it is now possible to perform an assessment that includes spatial as well as temporal components, according to the units of measurements for the criteria of Com. dec 2017.

D11C1: Number of days per quarter (or per month if appropriate) with impulsive sound sources; proportion (percentage) of unit areas or extent in square kilometers (km²) of assessment area with impulsive sound sources per year:

2.3 Options for Level for Onset of Biologically (Significant) Adverse Effects (LOB(S)E)

The options for applying the LOBE were discussed in the DL2 group of the TG Noise. The level of registration of sound events was defined as the basis for the LOBE, which means that as soon as an event falls into the range of the noise registry value classes, it is assumed that it has a potential for biological adverse effect.

Remark:

The baseline for noise assessment was set by marine mammal studies, so if other important species are studied, LOBE may need to be adapted, especially to properly size an affected area.

¹ The monopole energy source level, also called energy source level or the sound exposure source level re 1 $\mu\text{Pa}^2\text{m}^2\text{s}$ in a specified direction is equal to sound exposure level re 1 $\mu\text{Pa}^2\text{s}$ at a distance of 1 m from a hypothetical point source, placed in the (hypothetical) infinite uniform lossless medium. Definitions are described in ISO 18405, [15].

2.4 The exposed area/habitat concept

To describe the exposed area/habitat we first introduce a spatial function $F_j(x_i; t_j)$, which on the one hand represents the acoustic source data from the noise registry (energy source level, source level, source classes, etc.) at the geographic location x_i at time t_j and on the other hand is a proxy for the received levels (sound exposure level SEL resp. sound pressure level SPL) again for time and spatial location.

The time steps t_j are days according to the entries in the noise registry. In total 365(366) days per calendar year.

The exposed area E_A can now be introduced, which results from

$$E_A(t_j) = \int_A A(F_j(x_i, t_j) > LOBE) \cdot dx_i \quad (1)$$

where A is a descriptor for the area of interest as a function of $F_j(x_i; t_j)$. The exposed area E_A is a fraction of the area A where the function $F_j(x_i; t_j)$ exceeds LOBE.

The area A can be a grid cell, describing e. g., an area of a pulse block day or a region or subregion (entire management area).

Analogous to the above description, the exposed habitat at a specific day t_j can now also be described. For this we introduce the function $W_{Habitat}(x_i)$, which represents a description of the habitat (either multiple-species or single-species habitat). This function has two pairs of values, zero for no habitat and one for habitat, which are assigned by the spatial coordinates.

$$E_H(t_j) = \int_A A(F_j(x_i, t_j) > LOBE) \cdot W_{Habitat}(x_i) \cdot dx_i \quad (2)$$

The area of the habitat A_H can be calculated as

$$A_H = \int_A A \cdot W_{Habitat}(x_i) \cdot dx_i \quad (3)$$

Explanatory note:

In the event that regions do not represent a habitat 100% of the total area but only with a lower probability, a convention could be used to assign habitats, e. g. all areas with a probability of being a habitat greater than X% are assigned to a habitat. This determination must be made by marine biologists in the respective regions. Approaches which imply a spatial weighting of the Habitat can be considered as weighting function $W_{Habitat}(x_i)$ from zero to 1 which may be based on PUHA, population density data, MPA. Figure 3 and Figure 4 show which statements can be made through combination of habitat information and noise propagation.

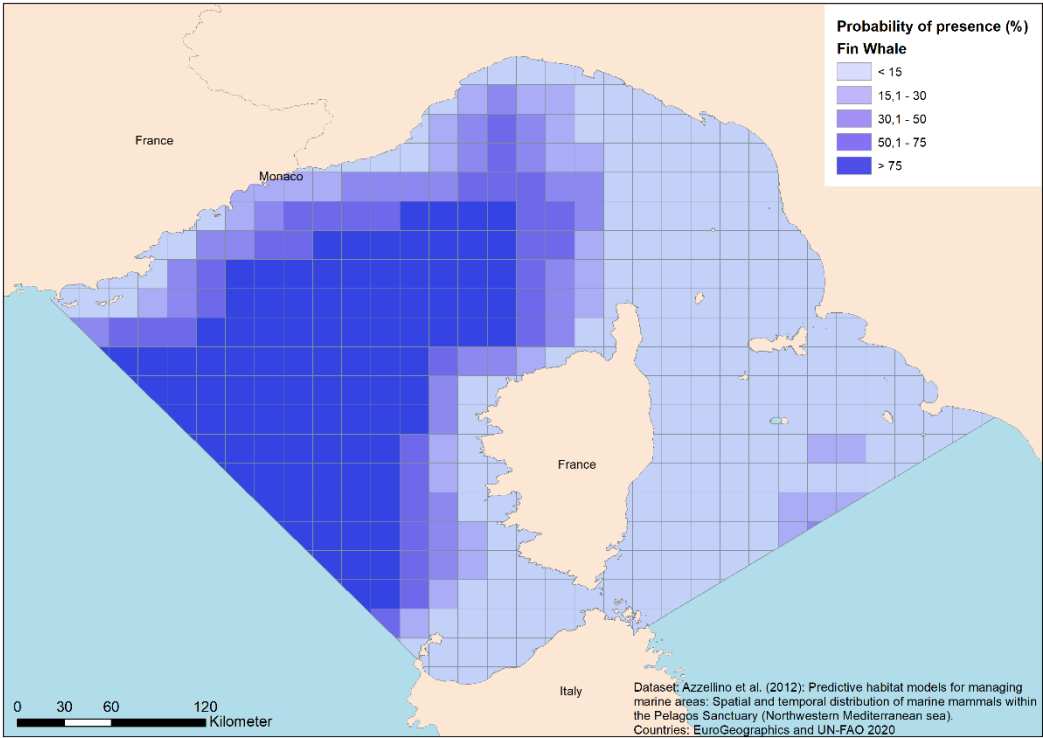


Figure 3: Habitat of fin whales - probability of presence [14].

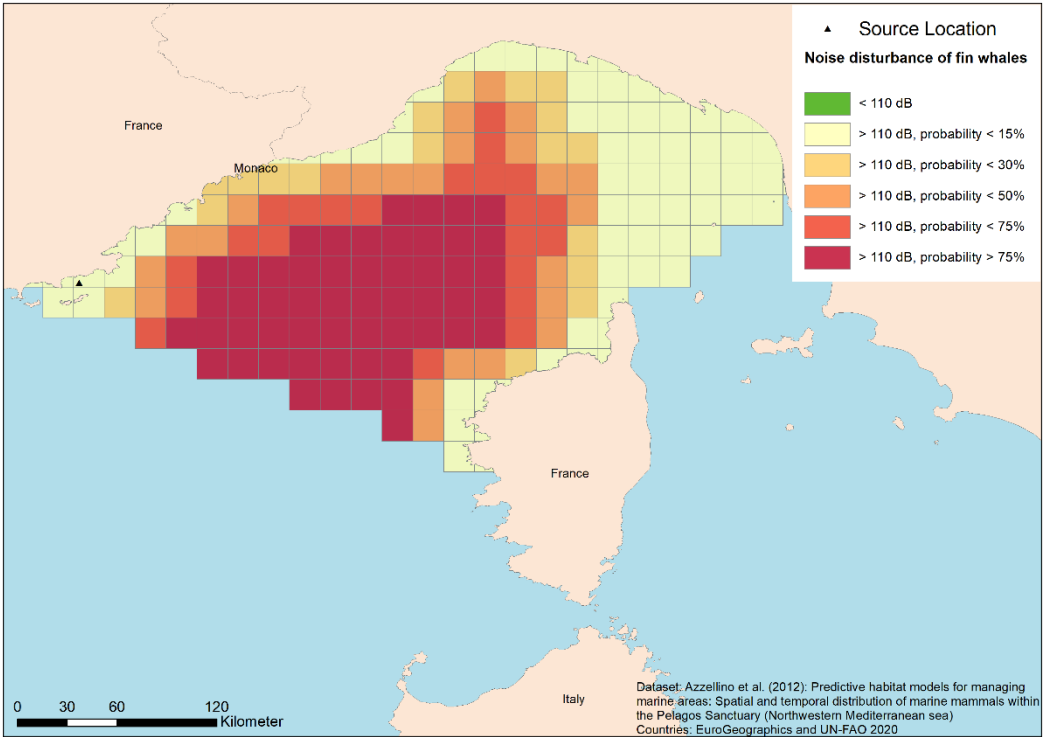


Figure 4: Noise disturbance and potential habitats of Fin whales [8], [14].

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2.4.1 Activity resp. source level-based description

Since the reported sources can be assigned to grid cells (e.g. UK blocks, ICES sub rectangles), an area-based assessment is feasible.

With the help of the data from the noise registry, the exposed area can now be determined in temporal terms.

The reported areas have additionally assigned attributes such as sound classes and sound types, which can be included in the analysis. Thus, among other things, a sound type level per area (grid cell) and day can be determined.

Explanatory note:

When determining the exposed area, it must be considered that several events can take place in one block on the same day, see Figure 5. In this case, the area of the block is only considered once due to the fact that the events are only reported on a daily basis (Pulse Block Days). A summation of the block areas leads to inaccuracies as a result of simultaneity of events. The number of events per sound class or the cumulative sound energy can be used as an attribute of the source strength.

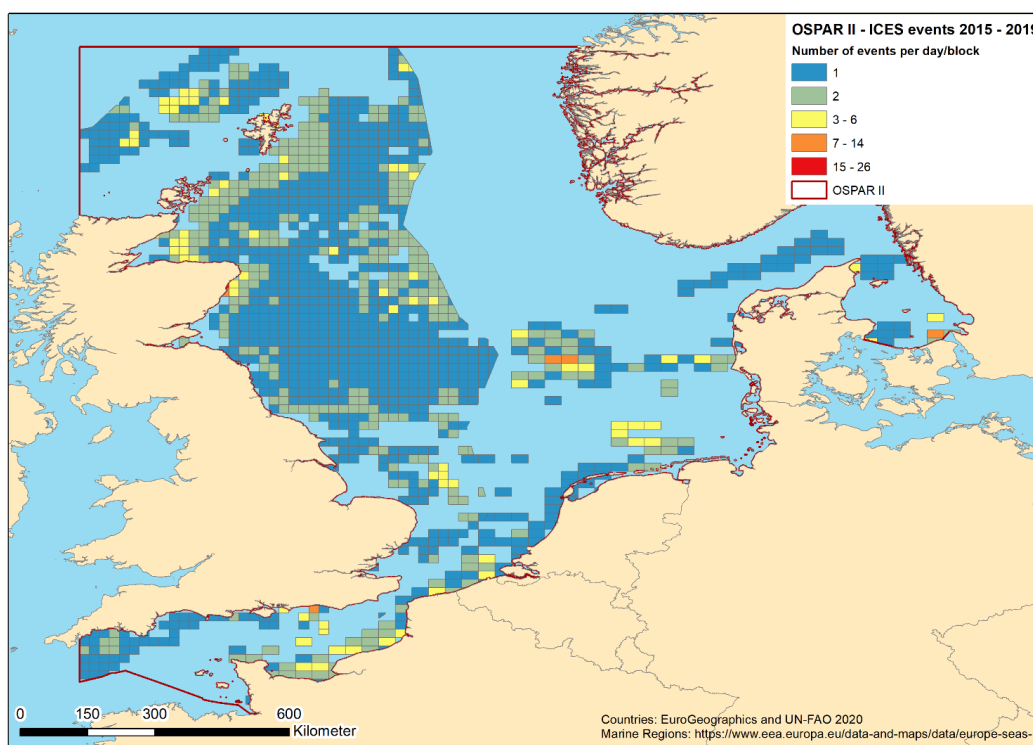


Figure 5: Distribution of registered noise events from 2015 to 2019, with the maximum number of events per day and block.

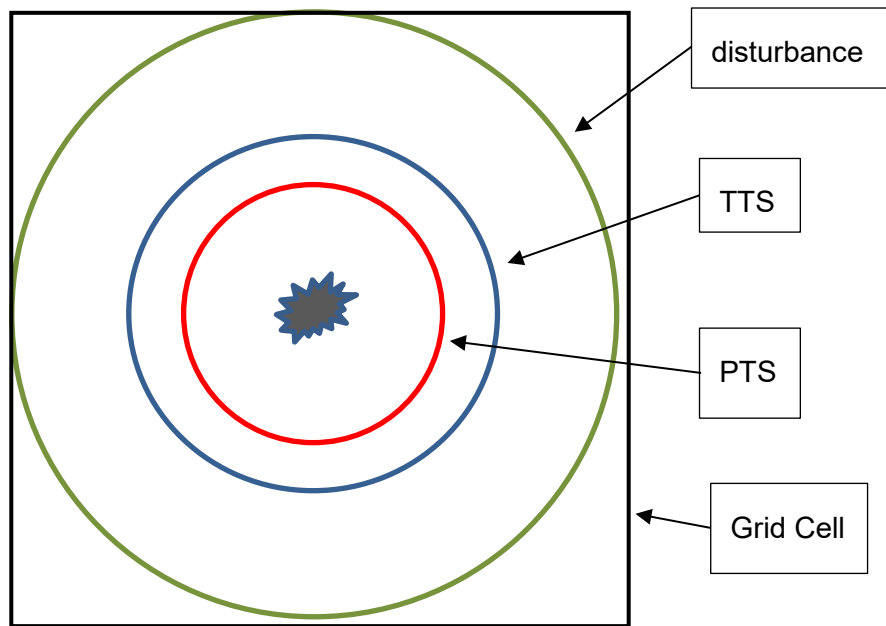


Figure 6: Exposed area depending on disturbance, TTS, PTS in relation to a grid cell.

Explanatory note:

If the dimension of the grid cells is of magnitude of the expected effective areas for disturbance, TTS or PTS, as illustrated in Figure 6, statements could be made about exposed areas and habitats directly on the basis of the registered sound data without propagation calculation.

2.4.2 Received level-based description

Using the information from the noise registry and the description of the propagation, exposed areas or exposed habitats can be determined, see example diagram hereafter.

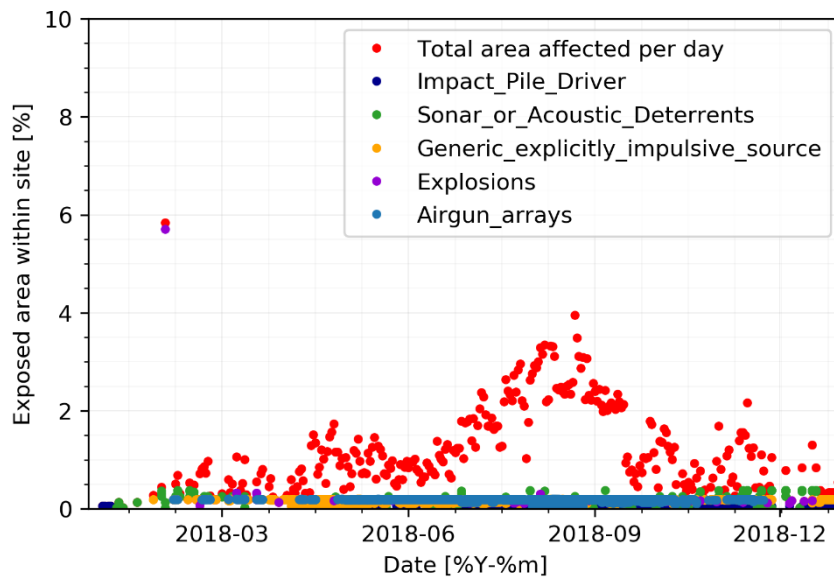


Figure 7: Exemplary exposed area per day during the year 2018

It is recommended to use standardized procedures for the respective sea areas in order to be able to compare assessments over the years, i.e.

- Propagation calculation by threshold levels Lobe, as described in Section 2.3.
- Consideration of constant empirical effect ranges, as e.g. carried out by OSPAR.

2.5 Remark on TV Options for GES

TVs can be set on the percentage of tolerable areas and tolerable duration of exposure, according to the priority requirements of EU regions. The options for setting thresholds are under discussion in the TG Noise Groups DL2 and DL4.

The overall target is to avoid adverse effects on population level by setting criteria on spatial and temporal availability of undisturbed habitat. Option could be:

tolerable: less than X% of Habitat area per day → ("limitation of simultaneously affected Habitat")

tolerable: less than X% of Habitat area for a maximum of y days per month/quarter/year → ("limitation of long term affected Habitat"; "avoidance of Hot Spots")

3 Glossary

ACCOBAMS	The Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic area
D11C1	Descriptor 11, Criterion 1 as laid out in Commission Decision (EU) 2017/848
D11C2	Descriptor 11, Criterion 2 as laid out in Commission Decision (EU) 2017/848
DEPONS	Disturbance Effects on the Harbour Porpoise Population in the North Sea
Directive 92/43/EEC	Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (art 1 k)
EEZ	Exclusive Economic Zone
EMODnet	European Marine Observation and Data Network
EU	European Union
GES	Good Environmental Status
HELCOM	Helsinki Convention for the Protection of the Baltic Sea Environment
ICES	International Council for the Exploration of the Sea
ISO	International Organization for Standardization
MPA	Marine Protection Area
MRU	Marine Reporting Unit
MS	Member States
MSFD	Marine Strategy Framework Directive
Natura 2000	EU-wide network of protected areas for the conservation of endangered habitats and species
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
PCoD	Population Consequences of Disturbance
PUHA	Potentially Usable Habitat Area
TG-Noise	Technical Group on Underwater Noise
TNO	Netherlands Organisation for applied scientific research
QUIETMED	A joint programme on underwater noise (D11) for the implementation of the Second Cycle of the MSFD in the Mediterranean Sea
QUIETMED2	A Joint programme for GES assessment on D11- noise in the Mediterranean Marine Region

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